SAIPAN SHORELINE ACCESS AND SHORELINE ENHANCEMENT ASSESSMENT (SASEA)

Island of Saipan, Commonwealth of the Northern Mariana Islands

March 2018

Prepared for:
Commonwealth of the Northern Mariana Islands
Bureau of Environmental and Coastal Quality
Division of Coastal Resources Management
Caller Box 10007
Saipan, MP 96950

Prepared by:
Sea Engineering, Inc.
Makai Research Pier
41-305 Kalanianaole Hwy
Waimanalo, HI 96795

Job No. 25573

Financial assistance provided by the Coastal Zone Management Act of 1972, as amended, administered by the Office for Coastal Management, National Oceanic and Atmospheric Administration.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The *Saipan Shoreline Access and Shoreline Enhancement Assessment (SASEA)* is a comprehensive survey of the condition of select beaches on the Island of Saipan, Commonwealth of the Northern Mariana Islands. Sea Engineering, Inc. (SEI) assessed eighteen (18) beaches along the coastline of Saipan to determine each one's vulnerability to coastal erosion and identify site-specific shoreline enhancement opportunities. The location of the beaches included in the assessment are shown in Figure 1 below.

The SASEA consisted of the following tasks:

1. Field Investigations
2. Historical Shoreline Change Analysis
3. Erosion Hazard Priority Ratings
4. Issues & Recommendations

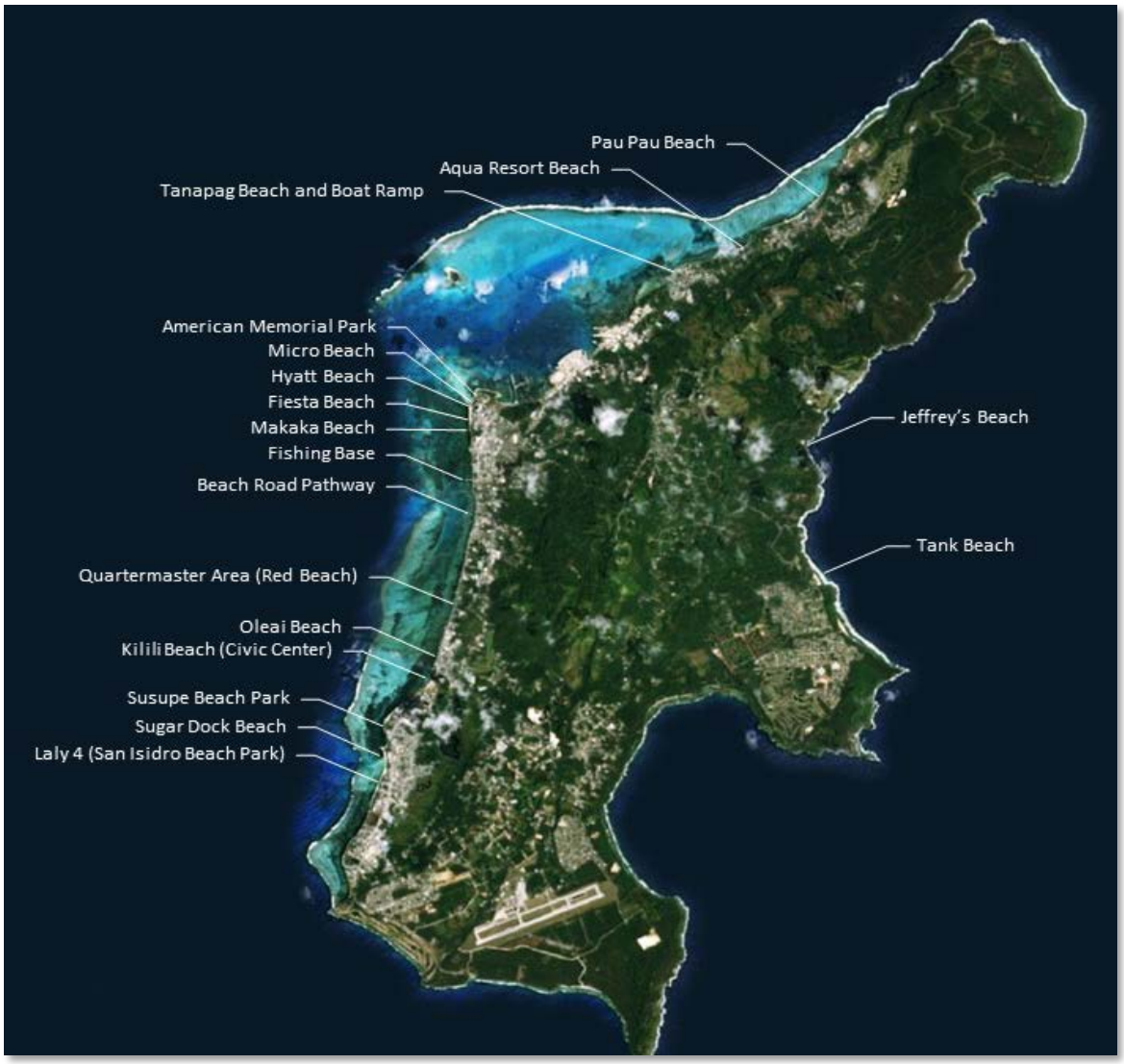


Figure 1 Location map showing beaches included in the SASEA

Field Investigations

Site visits were conducted at each beach to assess the condition of the shoreline and identify evidence of erosion or accretion, infrastructure that could be vulnerable to erosion or other coastal hazards, and issues that affect the quality of the area and/or the user experience. The site visits also identified existing uses, shoreline public access, and the condition of public amenities and infrastructure. Typical beach profiles were recorded to document the existing morphology of each beach. Field investigations provided an opportunity to identify historical evidence and potential drivers of shoreline change. The uses and amenities observed at each beach are summarized in Table 1.

Key Findings

- Most beaches exhibited some historical evidence of accretion (e.g., prograded berms).
- Some beaches exhibited historical evidence of erosion (e.g., relict erosion scarps).
- Evidence suggested that erosion may be episodic and driven by storm events.
- Shoreline public access was abundant in most areas.
- Public amenities and infrastructure were damaged and/or deteriorated at many beaches.

Historical Shoreline Change Analysis

The purpose of the historical shoreline analysis was to measure changes in beach width over time from 1999 to 2016, and identify potential historical shoreline change trends (i.e., erosion, accretion), to inform planning and decision-making. A series of historical aerial photographs was used to measure shoreline change rates and identify trends by comparing the relative positions of a specific beach feature over time. For the purposes of this assessment, the shoreline position was represented by the beach toe. Shoreline change maps and rates were produced for each of the western beaches. The results of the historical shoreline change analysis for each beach are summarized in Table 2.

Key Findings

- Approximately half of the beaches appear to be stable or accreting from 1999-2016.
- Approximately half of the beaches appear to be variable from 1999-2016.
- Erosion was greatest from 1999 to 2005. The cause of the erosion is not known.
- Accretion dominated from 2005 to 2016. The cause of the accretion is not known.

Erosion Hazard Priority Ratings

The purpose of the Erosion Hazard Priority Ratings (EHPR) was to determine the overall vulnerability of each beach to erosion and assist in the identification and prioritization of shoreline enhancement efforts. Each beach was assigned an EHPR of *Low*, *Medium*, or *High*. Ratings were based on criteria related to the physical conditions present along the shoreline, historical erosion and shoreline change trends, shoreline access, uses, popularity, development intensity, and infrastructure vulnerability.

A *medium* or *low* rating does not mean that a beach has not experienced erosion in the past or will not be vulnerable to erosion in the future. In some cases, where the beach was in a remote area, development intensity was low, or there was no infrastructure vulnerable, the EHPR was considered *medium* or *low*, even if erosion indicators were present. The EHPRs for each beach are summarized in Table 3.

Key Findings

- Six (6) beaches were assigned an EHPR of *High.* These beaches typically had public infrastructure that was either damaged or potentially vulnerable to erosion.
- Six (6) beaches were assigned an EHPR of *Medium.* These beaches typically had a moderate risk of erosion due to one or more factors (e.g., low elevation, erosion history).
- Six (6) beaches were assigned an EHPR of *Low.* These beaches were typically stable or accreting, or there was no vulnerable development or infrastructure in the backshore area.

	USES	Swimming / Wading	Snorkeling	SCUBA Diving	Fishing	Boating	Jet Skiing	Picnicking	Walking / Jogging / Biking	Land Sports	Water Sports	AMENITIES	Vehicular Access	Pedestrian Access	Parking (off-road)	Parking (paved)	Parking (off-road)	Restrooms	Palapalas (Pavilions)	Picnic Areas	Grills / Fire Pits	Trash Cans / Recycling	Pier / Dock / Harbor	Boat Ramp	Outrigger Canoe Access	Historical / Cultural Site	Playgrounds
Laly 4 (San Isidro Beach Park)		x	x		x			x		x			x	x	x		x		x	x	x						x
Sugar Dock Beach		x	x		x	x		x					x	x	x		x		x	x	x	x	x	x			
Susupe Beach Park		x	x		x			x					x	x		x			x	x	x	x				x	x
Kilili Beach (Civic Center)		x	x		x				x	x			x	x	x	x	x		x	x	x	x			x	x	x
Oleai Beach		x	x		x			x	x				x	x			x		x	x	x	x				x	x
Quartermaster Area		x	x		x				x				x	x	x	x	x			x		x				x	x
Beach Road Pathway		x	x		x			x	x				x	x	x		x		x	x		x				x	x
Fishing Base					x	x							x	x	x	x	x	x				x	x	x			
Makaka Beach		x	x		x								x	x													
Fiesta Beach		x	x	x	x		x			x	x		x	x		x							x				
Hyatt Beach		x	x	x	x	x					x		x	x		x											
Micro Beach		x	x	x	x	x	x	x	x		x		x	x		x		x	x	x	x	x				x	
American Memorial Park		x	x		x	x		x	x				x	x		x	x	x		x		x	x				x	
Tanapag Beach and Boat Ramp		x	x		x	x		x					x	x	x		x		x	x	x	x		x			x
Aqua Resort Beach		x	x		x	x																					
Pau Pau Beach		x	x		x			x					x	x		x		x	x	x	x						x
Jeffrey's Beach (Talofofo)					x									x	x		x										
Tank Beach			x		x								x	x	x		x					x				x	

Table 1 Summary of uses and amenities identified during field investigations

	1999 to 2005	2005 to 2011	2011 to 2016	1999 to 2016	HISTORICAL TREND
Laly 4 (San Isidro Beach Park)	Variable	Accretion	Accretion	Accretion	Accretion
Sugar Dock Beach	Erosion	Accretion	Variable	Variable	Variable
Susupe Beach Park	Erosion	Accretion	Accretion	Erosion	Variable
Kilili Beach (Civic Center)	Erosion	Accretion	Variable	Variable	Variable
Oleai Beach	Erosion	Accretion	Accretion	Accretion	Accretion
Quartermaster Area (Red Beach)	Erosion	Accretion	Accretion	Accretion	Accretion
Beach Road Pathway	Accretion	Variable	Accretion	Accretion	Accretion
Fishing Base	Erosion	Accretion	Erosion	Erosion	Erosion
Makaka Beach	Variable	Accretion	Accretion	Accretion	Accretion
Fiesta Beach	Variable	Accretion	Accretion	Accretion	Accretion
Hyatt Beach	Accretion	Variable	Variable	Accretion	Variable
Micro Beach	Accretion	Erosion	Variable	Variable	Variable
American Memorial Park	Variable	Variable	Accretion	Accretion	Variable
Tanapag Beach and Boat Ramp	Erosion	Variable	Accretion	Accretion	Variable
Aqua Resort Beach	Erosion	Accretion	Accretion	Accretion	Accretion
Pau Pau Beach	Erosion	Accretion	Accretion	Accretion	Accretion
Jeffrey's Beach (Talofofo)	N/A	N/A	N/A	N/A	N/A
Tank Beach	N/A	N/A	N/A	N/A	N/A

Table 2 Results of historical shoreline change analysis

	Average Reef Width	Average Beach Width	Average Backshore Elevation	Historical Shoreline Change	Evidence of Erosion	Popularity and Use Intensity	Development Intensity	Infrastructure Vulnerability	Risk to Shoreline Access	TOTAL SCORE	EHPR
Tank Beach	-2	+2	+2	N/A	+2	-1	+2	+2	+2	+9	LOW
Pau Pau Beach	+2	+1	+1	+2	+1	-2	+1	-1	+1	+6	LOW
Laly 4 (San Isidro Beach Park)	+1	+2	-1	+2	+2	-1	+1	+1	-1	+6	LOW
American Memorial Park	-1	+1	-1	+1	+1	-1	+2	+2	+1	+5	LOW
Susupe Beach Park	+1	+1	+1	+1	-1	-1	+1	+1	-1	+3	LOW
Makaka Beach	+1	+2	-1	+2	+2	-1	-2	0	-1	+2	LOW
Jeffrey's Beach (Talofofo)	-2	-2	-1	N/A	-1	+1	+2	+2	+2	+1	MEDIUM
Oleai Beach	+2	+1	+1	+1	-1	-2	0	-1	-1	0	MEDIUM
Micro Beach	-1	+2	-2	0	-2	-2	+2	+2	+1	0	MEDIUM
Aqua Resort Beach	+2	+1	+1	+1	+1	0	-2	-2	-2	0	MEDIUM
Kilili Beach (Civic Center)	+2	-1	+1	+1	-1	-2	+1	-1	-1	-1	MEDIUM
Tanapag Beach and Boat Ramp	+1	-2	-2	+2	-2	0	+1	-1	+1	-2	MEDIUM
Quartermaster Area (Red Beach)	+2	-2	+1	+1	-1	-2	-2	-1	-2	-6	HIGH
Beach Road Pathway	+2	-2	+1	+1	-1	-2	-2	-1	-2	-6	HIGH
Fiesta Beach	-1	+2	-2	+2	-1	-2	-2	-1	-1	-6	HIGH
Hyatt Beach	-1	+2	-2	+1	-1	-2	-2	-1	-1	-7	HIGH
Sugar Dock Beach	-1	0	0	+1	-1	-2	-2	-1	-1	-7	HIGH
Fishing Base	0	-2	-2	-1	-2	-2	+1	-1	-1	-10	HIGH

Criteria Definitions

Average Reef Width	Average width of fringing reef fronting the shoreline. Range: +2 if ≥ 1000 meters | -2 if ≤ 100 meters.
Average Beach Width	Average beach width along the shoreline. Range: +2 ≥ if 25 meters wide | -2 if no beach present.
Average Backshore Elevation	Average elevation in the backshore area. Range: +2 if ≥ 5 meters | -2 if ≤ 5 meters
Historical Shoreline Change	Average annual shoreline change rate from 1999 to 2016. Range: +2 if ≤ 1 meter/year | -2 if ≥ 1 meter/year
Evidence of Erosion	Physical evidence of erosion observed along the shoreline. Range: +2 if evidence of active erosion | -2 if no evidence of erosion.
Popularity and Use Intensity	Overall popularity and volume of users. Range: +2 if low frequency/use | -2 if high frequency/use.
Development Intensity	Density of development and intensity of land uses within 100 meters of the shoreline. Range: +2 if no development | -2 if densely developed.
Infrastructure Vulnerability	Presence of public infrastructure within 100 meters of the shoreline. Range: +2 if no infrastructure | -2 if high-density infrastructure.
Risk to Shoreline Access	Potential for erosion to negatively impact shoreline public access. Range: +2 if no loss of shoreline access | -2 if complete loss of shoreline access.

Table 3 Erosion Hazard Priority Ratings (EHPR)

Issues & Recommendations

Based on the results of the field investigations and historical shoreline change analysis, SEI identified key issues that affected the quality of the beaches and/or the user experience at each beach. This report includes a series of recommendations to address these issues and a discussion of potential shoreline enhancement options. Some recommendations may require the development of new data or the adoption of new rules or policies, while others may require more proactive enforcement of existing rules and policies. The general issues identified and their associated recommendations are summarized below:

General Issues & Recommended Actions

ISSUE A: KNOWLEDGE AND UNDERSTANDING OF HISTORICAL SHORELINE CHANGE

Understanding of shoreline change on Saipan is currently limited due to the lack of historical shoreline change data. Several studies have been conducted to assess historical shoreline change, primarily along the shorelines of Saipan Lagoon and Mañagaha (Yuknavage et al., 2004; Fletcher et al., 2007; U.S. Army Corps of Engineers, 2004, 2014; Greene et al., 2016, Sea Engineering, Inc., 2017). These studies were conducted using different methodologies (e.g., beach profiles v' image analysis) at different spatial and temporal scales; therefore, it is difficult to combine the results to compile an accurate history of shoreline change on Saipan. Improved knowledge and understanding of historical shoreline change would help to identify problem area and inform decision-making for future shoreline management.

Recommendations

- Establish a program to monitor long-term shoreline change.

ISSUE B: FRAMEWORK TO FACILITATE SEA LEVEL RISE ADAPTATION

Beach and shoreline erosion on many Pacific Islands is likely to be exacerbated by rising sea levels. A 2015 study found that, due to increasing sea level rise, average shoreline recession in Hawaii is expected to be nearly twice the historical extrapolation by 2050, and nearly 2.5 times the historical extrapolation by 2100 (Anderson et al., 2015). Sea level rise has the potential to impact beaches and shorelines on Saipan. Impacts may include loss of land due to erosion, and infrastructure damage due to inundation and flooding.

It is important to acknowledge the potential risks associated with sea level rise and develop policies and rules to minimize the impacts to Saipan's beaches and shorelines. Sea level rise projections are available from the National Oceanic and Atmospheric Administration (NOAA, 2017) and the U.S. Army Corps of Engineers (USACE, 2013). It may be necessary to revise the projections to account for static-equilibrium effects and regional or local conditions. Developing policies and plans to account for projected future sea level rise would reduce hazard vulnerability and increase Saipan's resilience to sea level rise and coastal hazards.

Recommendations

- Establish a methodology to monitor sea level rise.
- Require development projects to account for sea level rise.
- Consider future sea level rise in establishing shoreline setbacks.

ISSUE C: ALTERNATIVE BASELINE FOR DETERMINING SHORELINE SETBACKS

Shoreline setbacks on Saipan are currently measured from Mean High Water (MHW). MHW is commonly used to determine the boundary between public and private property, with some exceptions, and is commonly used as a baseline for measuring shoreline setbacks for coastal development. MHW is a fixed elevation that does not account for the unique physical features and localized processes that influence beach width and shoreline position. MHW also does not account for coastal inundation hazards, such as storm waves generated by typhoons, which Saipan is highly-exposed to.

Shoreline setbacks can be measured from a variety of baselines including datums (e.g., MHW), physical evidence (e.g., debris line or vegetation line), or physical features (e.g., berm or dune crest). U.S. Mainland states use a variety of different features and types of physical evidence to establish the baseline for measuring shoreline setbacks including but not limited to the ordinary high water mark (California, Washington), ordinary high tide line (New Hampshire), seasonal high water line (Florida), vegetation line (North Carolina, Michigan, Minnesota), and berm or dune crest (Alabama, South Carolina, Virginia, Ohio). Basing shoreline setbacks on physical evidence, features, or a combination of the two, would help to ensure that development and infrastructure along Saipan's shorelines are adequately set back from coastal hazards.

Recommendations

- Reference physical evidence and/or features as the baseline for shoreline setbacks.

ISSUE D: ACCOUNTING FOR SHORELINE CHANGE IN SHORELINE SETBACKS

The purpose of Saipan's shoreline setbacks is to maintain adequate space between the building footprint of a project and identified hazardous lands including floodplains, erosion-prone areas, storm wave inundation areas (§15-10-305(i), Coastal Resources Rules and Regulations). Shoreline setbacks are currently measured as specified distances inland from MHW. Setback are based on the type of the proposed use, with distances ranging from 35 feet to 150 feet (§15-10-350 (b)(c)), Coastal Resources Rules and Regulations). Setback distances are fixed and do not account for historical or projected shoreline change or sea level rise.

Hawaii has adopted a progressive policy that uses historical shoreline change rates to determine shoreline setbacks. Setbacks are based on the Average Annual Erosion Rates (AAER) developed by the University of Hawaii Coastal Geology Group. The County of Maui shoreline setbacks are based on average lot depth and can range from 25 to 150 feet, plus a distance of 50 times the AAER from the shoreline. The County of Kauai multiples the AAER times a planning period of 70 to 100 years, which represents the life expectancy of structures. In some cases, the County of Kauai also requires a 10% adjustment in the AAER to account for future sea level rise. The County of Hawaii also requires projects to design for subsidence and a 2-foot rise in water level over the next 100 years (Owens et al., 2012). Basing shoreline setbacks on historical trends would ensure that setbacks for development and infrastructure account for both current and projected vulnerability to coastal hazards.

Recommendations

- Consider adopting erosion-rate based shoreline setbacks.

ISSUE E: COMPREHENSIVE MANAGEMENT PLANS FOR HIGH PRIORITY AREAS

Saipan includes approximately 87 km of shoreline, with sandy beaches accounting for approximately 22 km (25%) of the total shoreline. The quality of Saipan's beaches and shorelines is an important component of the island's tourism-based economy. There are many different types of beaches and shorelines, each of which is exposed to unique processes that affect the overall quality of the area. Some beaches are vulnerable to erosion, whereas others are stable or accreting. Some shorelines are vulnerable to storm surge, whereas those at higher elevations are less vulnerable. Preserving and enhancing Saipan's shorelines may require the development of sub-regional management plans to address unique needs along each shoreline.

Management plans are in place in some areas including Mañagaha and the Saipan Lagoon; however, SEI is not aware of any dedicated shoreline management plans on Saipan. The geographic scope of shoreline management plans can be large (e.g., island-wide) or small (e.g., community-level). Ideally, management regions are defined by the boundaries of distinct coastal littoral processes (i.e., littoral cells). Littoral cells are geographically limited and consist of a series of sand sources (e.g., reefs, dunes, streams) that provide sand to the shoreline; sand sinks (e.g., channels, submarine canyons) where sand is lost from the shoreline; longshore transport or littoral drift that moves sand along the shoreline, and cross-shore transport that moves sand toward and away from the shoreline. The boundaries between cells are typically delineated by physical features, such as a headlands, that disrupt longshore sediment transport.

Implementing shoreline management at the littoral cell level would ensure that management strategies and plans are designed to account for and/or leverage the physical processes that are dominant within the area, and reduce potential negative impacts to adjacent cells.

Recommendations

- Identify and map littoral cells to inform management priorities.
- Develop comprehensive management plans for high priority areas.

ISSUE F: IMPACTS OF SHORELINE VEGETATION ON BERM STABILITY AND BEACH QUALITY

The presence of vegetation along the shoreline is often a sign of a stable beach, and seaward migration of vegetation can indicate that a shoreline is accreting. Healthy shoreline vegetation can also provide wildlife habitat, prevent surface water runoff, decrease wave exposure, and reduce the impacts of erosion. It is important to maintain healthy vegetation to stabilize beach berms and provide a protective buffer from coastal hazards. SEI observed several issues relating to shoreline vegetation including: clearing and grading, destruction of vegetation due to foot traffic, and loss of recreational beach area due to encroaching vegetation.

Clearing of shoreline vegetation and beach grading was observed north of Laly 4 (San Isidro Beach Park), and at Fiesta Beach and Hyatt Beach. Loss of vegetation due to pedestrian traffic was observed at Kilili Beach (Civic Center), at the location of the outrigger canoe launch site, and Hyatt Beach, at the location of the water sports concession. Loss of vegetation was also observed at Sugar Dock Beach and Pau Pau Beach, where portions of the vegetation along the berm crest had been destroyed by pedestrian and vehicle traffic.

In some cases, prolific vegetation growth can negatively impact the scenic and recreational value of a beach. This was particularly evident at Laly 4 (San Isidro Beach Park), Beach Road Pathway, and Quartermaster Area (Red Beach) (Figure 2). In some areas, the entire beach was covered by encroaching vegetation and beach users were forced to wade through the water to move laterally along the shoreline.

Figure 2 Encroaching shoreline vegetation at Quartermaster Area (Red Beach)

The benefits of maintaining healthy vegetation along the shoreline should be balanced with the need to maintain high-quality beaches and safe lateral access along the shoreline. Removal of vegetation should not be permitted in areas where the removal would negatively impact the beach or expose the backshore area to inundation or erosion; however, a reasonable amount of vegetation removal and/or maintenance should be permitted in order to maintain recreational beach areas and maintain or enhance lateral shoreline public access.

It is important to establish criteria to determine when shoreline vegetation should be removed. Criteria should include physical criteria (e.g., does vegetation interfere with natural shoreline or beach processes?), environmental criteria (e.g., does vegetation provide critical wildlife habitat?), and social criteria (e.g., will vegetation removal improve lateral public access?).

Recommendations

- Establish criteria for determining when shoreline vegetation should be removed.
- Prioritize removal of shoreline vegetation to improve lateral shoreline public access.

ISSUE G: BERM COMPACTION AND DEGRADATION DUE TO VEHICLE TRAFFIC

CNMI law prohibits any motor vehicle from entering or going upon any beach area, historic site, or tourist site within the Commonwealth. "Beach area" means those areas of unconsolidated deposits along the shore with their seaward boundary being at the low water mark or reef flat platform level extending in a landward direction not less than 150 feet (9 CMC Section 5807(b)). Despite being prohibited by law, off-road driving and parking on beach berms appears to be a common practice on Saipan.

SEI observed off-road driving and parking along berms at Sugar Dock Beach, Susupe Beach Park, Kilili Beach (Civic Center), Oleai Beach, Quartermaster Area (Red Beach), and Beach Road Pathway (Figure 3). These areas were found to have less-stable vegetation and highly-compacted soils along the berm crest. In some areas, off-road driving and parking may also damage nesting sites for threatened green sea turtles. Funding should be allocated to continue and expand the "Walk it, Don't Drive it" program to improve awareness and enforcement. Bollards, berms, or access gates should be installed at high-use beaches or beaches where vehicle strandings are frequent. Improved parking may help to reduce these impacts at high-use beaches.

Figure 3 Evidence of vehicle traffic on beach berm at Kilili Beach (Civic Center)

Recommendations

- Enforcement and education to reduce vehicle use on berms.
- Allocate funding to continue and expand the "Walk it, Don't Drive it" program.

ISSUE H: STRUCTURAL DAMAGE TO PUBLIC INFRASTRUCTURE

SEI observed several areas where public infrastructure was visibly damaged, particularly at Fishing Base and Sugar Dock (Figure 4). In both cases, the pier docks had sustained significant structural damage, presumably caused by typhoon waves. The damage may compromise the structural integrity of the structures or cause a potential risk to public health and safety.

Figure 4 Structural damage to pier at Sugar Dock

A licensed Structural Engineer should conduct an assessment to identify damage to public infrastructure, particularly at Fishing Base and Sugar Dock. The assessments should include repair recommendations and cost estimates to restore the structural integrity of the structures. It is important to engage a licensed Structural Engineer in the design phase to ensure that the design is structurally sufficient and the appropriate means, methods, and materials are used. Structural repairs could be prioritized to address public health and safety issues, economic impacts (e.g., loss of fishery or tourism revenues), environmental impacts, or aesthetic impacts.

Recommendations

- Perform a damage assessment and prioritize repairs to public infrastructure.

ISSUE I: DETERIORATED AMENITIES AT PUBLIC BEACHES AND PARKS

Amenities are an important part of the user experience at Saipan's beaches and parks. Access to basic amenities, such as trash/recycling receptacles and public restrooms, is necessary to maintain the environmental and aesthetic quality of beaches and parks. The public amenities at many beaches were in a deteriorated state and, in some cases, were completely unusable. Recreational amenities such as palapalas, picnic tables, benches, and grills/fire pits were in very poor condition, particularly at Laly 4 (San Isidro Beach Park), Sugar Dock Beach, Susupe Beach Park (Figure 5), Micro Beach, and Tanapag Beach and Boat Ramp.

Figure 5 Structural damage to palapala at Susupe Beach Park

Trash/recycling receptacles were only observed at half of the beaches. Public restrooms were rarely observed, and restrooms at Laly 4 (San Isidro Beach Park), Susupe Beach Park, Kilili Beach (Civic Center), and Pau Pau Beach were closed due to structural damage. Only one functional restroom was observed at American Memorial Park. Portable restrooms were available at Laly 4 (San Isidro Beach Park), Fishing Base, and Pau Pau Beach.

Recommendations

- Perform a damage assessment and prioritize improvements to damaged amenities.
- Repair and maintain public restroom facilities.

ISSUE J: DRAINAGE IMPACTS ON BEACH BERMS AND WATER QUALITY

Drainage impacts were observed at many of the beaches included in this assessment. Drainage types included culverts, streams, and swales formed by surface water runoff. Erosion and beach deflation were observed in areas where beach berms were bisected by drainages and surface water runoff from impervious surfaces (e.g., parking lots). Some drainages appeared to impact nearshore water quality. Algal blooms were observed at Sugar Dock Beach, Quartermaster Area (Red Beach), Beach Road Pathway (Figure 6), Makaka Beach, Fiesta Beach, Hyatt Beach, Micro Beach, and American Memorial Park.

Figure 6 Drainage impacting berm and water quality at Beach Road Pathway

Water quality also appeared to be visually impaired within the Talofofo Stream drainage at Jeffrey's Beach. A 2016 study identified Enterococci exceedances in the coastal waters at Talofofo, which have been linked to both roaming domestic and feral animals, and increase in tourists to these remote beaches, which lack public restrooms (Bureau of Environmental and Coastal Quality, 2016). Composting toilets may be appropriate in remote areas, such as Jeffrey's Beach and Tank Beach.

Recommendations

- Identify and prioritize drainage improvements.
- Install composting toilets at remote beaches (e.g., Jeffrey's Beach, Tank Beach).

ISSUE K: MARINE DEBRIS AFFECTING BEACH QUALITY

Marine debris is commonly found on beaches in the Pacific Islands. Common types of marine debris include plastics, metals, rubber, paper, textiles, and derelict fishing gear. Shorelines along the windward (east) coast of Saipan are particularly prone to the accumulation of marine debris due to their exposure to the prevailing tradewinds. SEI observed significant amounts of marine debris along the beaches at Jeffrey's Beach and Tank Beach (Figure 7).

Figure 7 Extensive marine debris on active beach at Tank Beach

The NOAA Marine Debris Program administers a grant program to support community-based marine debris removal projects. In 2015, the Micronesia Islands Nature Alliance received grant funding from NOAA to reduce littering and illegal dumping in Saipan by providing infrastructure for proper waste management, and conduct education and outreach to raise awareness about littering and marine debris. The NOAA Marine Debris Program has also funded non-profit organizations, such as Sustainable Coastlines Hawaii, to host beach cleanups and conduct educational programs in schools, businesses, government agencies, and community groups. Reducing the amount of marine debris along Saipan's shorelines would improve environmental quality and the overall visitor experience.

Recommendations

- Install and maintain trash/recycling receptacles at public beaches and parks.
- Conduct education and outreach to raise awareness about littering and marine debris.
- Coordinate community beach cleanups.

ISSUE L: PUBLIC ACCESS TO COASTAL AREAS

Coastal access on Saipan is protected by the CNMI Constitution (2 CMC §1500 et seq.). Saipan Territory Trust Code (TTC) requires a reasonable number of public roads and paths from existing or established public roads to insure public access to public lands that abut the sea or tidal areas (67 TTC § 152). The Saipan Zoning Law (SLL 16-6) also restricts activities that can negatively impact public access in some areas. The Tourist Resort (TR) Zoning District (Section 510) requires that development of properties located along the shoreline maintain a view/public access corridor of open land with a width of at least 20% of the property width parallel to the shoreline or 30 feet wide, whichever is less. The view/public access corridor shall include a publicly accessible trail at least 6 feet wide from a public right-of-way to the shoreline.

Based on observations during field investigations, public access to beaches on Saipan was abundant, with most beaches being accessible both by vehicle and by foot. There was no public vehicular access at Aqua Resort Beach, and vehicular access at Jeffrey's Beach was limited due to poor conditions along the unpaved coastal access road. Vehicular access was also limited at Hyatt Beach and Fiesta Beach due to the high-intensity development in the backshore. Off-road parking was available at many beaches, but only four beaches offered dedicated paved parking areas (Susupe Beach Park, Kilili Beach (Civic Center), Micro Beach, and Pau Pau Beach).

Lateral and perpendicular shoreline access was available at most beaches. In some areas, lateral shoreline access was limited due to lack of beach area (Fishing Base), encroaching vegetation (Quartermaster Area (Red Beach), Beach Road Pathway), or the presence of nearly-vertical sea cliffs (Jeffrey's Beach, Tank Beach). The least accessible beach included in this assessment was Aqua Resort Beach, which had no public vehicle access or perpendicular shoreline access paths in close proximity to the shoreline. There were no ADA or ABA-compliant beach accesses identified at any of the beaches included in this assessment.

Recommendations

- Improve ADA and ABA accessibility at public beach parks.
- Improve public access to Aqua Resort Beach.

ISSUE M: OCEAN SAFETY AWARENESS AND SERVICES

Drownings are a common cause of death in the waters of Saipan. Drownings are particularly common in areas that are subject to strong rip currents, which are the major cause of drowning in the CNMI. The Department of Public Safety, Boating Safety Section is responsible for responding to any water related incidents including drowning, near drowning, missing divers/fishermen, overdue divers/fishermen, boat accidents, jet ski accidents, capsized vessels, distressed vessels, etc. There were no lifeguards, lifeguard towers, educational signage, or rescue tubes observed at any of the beaches included in this assessment. Signage should be installed to educate or warn beach users about potentially dangerous ocean conditions.

Recommendations

- Increase awareness of dangerous ocean conditions.
- Update the Saipan Dive/Snorkel Brochure to include rip currents.
- Provide ocean safety services at high-use beaches.

Location-Specific Issues & Recommended Actions

Of the 18 beaches that were assessed in this report, six have been identified as having *High* EHPRs. Concept-level recommendations for these beaches are presented below. The concepts are believed to be appropriate solutions for those specific beaches; however, more detailed analyses would be necessary to determine the proper configuration for each solution.

SUGAR DOCK

Sugar Dock has sustained structural damage include spalling, cracking, and deck collapse. This condition should be considered a public health and safety issue. Access should be restricted in the short term and a repair plan should be initiated. A concrete rubble masonry (CRM) seawall on the north side of the dock shows signs of undermining. Undermined seawalls have reduced structural stability and tend to exhibit cracking as the wall settles. Cracking and sinkholes are likely to develop over the short-term, and structural repairs should be anticipated.

The undermining could also be addressed by beach nourishment, in which sand would be placed along the beach fronting the seawall. Small-scale beach nourishment could provide a short-term increase in beach volume and width on the shoreline north side of Sugar Dock. The replenished beach would provide recreational opportunities as well as a protective buffer for the backshore area and infrastructure. Beach nourishment can be expensive and requires a supply of sand that is ideally similar in character to the native beach sand. It is unclear what sand resources may be available to support beach nourishment on Saipan. Containment features or structures, such as the T-head groins that stabilize Iroquois Point beach (Figure 8), may be required to keep the sand from disappearing.

Recommendations

- Perform a damage assessment and prioritize repairs to Sugar Dock.
- Evaluate options for beach nourishment.

FISHING BASE

The seawalls surrounding Fishing Base pier are substantially damaged (Figure 9). Structural repairs to the pier are recommended for public health and safety reasons. Given the nearshore dredging and the filled backshore, Fishing Base does not appear to be a good candidate for a soft solution, such as beach nourishment. Beach nourishment could be successful in areas where a natural beach had previously formed; however, it is unlikely to be successful along this type of filled shoreline. Stabilizing structures, such as groins, might improve the stability of a beach nourishment project; however, the groins would likely extend into the deeper dredged area and could negatively affect boat traffic. A riprap or rubblemound revetment might be the most effective stabilizing structure along the Fishing Base shoreline. The revetment would fix the shoreline in place and protect the backshore from erosion threats, without affecting use of the pier and boat ramp.

Recommendations

- Perform a damage assessment and prioritize repairs to Fishing Base.
- Evaluate options for shore protection at Fishing Base.

Figure 8 T-head groins and stable beach cells at Iroquois Point (Oahu, Hawaii)

Figure 9 Structural damage to pier at Fishing Base

QUARTERMASTER AREA (RED BEACH) AND BEACH ROAD PATHWAY

Quartermaster Area (Red Beach) and Beach Road Pathway together cover 850 m of shoreline along the western side of Beach Road, which is a heavily-utilized coastal road and the main thoroughfare between Garapan and the airport. A coastal path provides lateral access along the entire shoreline. While the coastal path and Beach Road are not presently threatened by erosion, rising sea levels and the frequency of typhoons could quickly degrade this shoreline. The importance of the coastal path and Beach Road resulted in these areas having *high* EHPRs.

Figure 10 Concrete coastal path at Quartermaster Area (Red Beach)

An appropriate erosion mitigation strategy for this area might be a buried seawall, sometimes referred to as a "backstop", to protect the coastal path and maintain a protective buffer between the shoreline and Beach Road. The backstop would only become exposed during episodic erosion events, and it would then function as a seawall, protecting the backshore from further erosion. A revetment could also be used as a backstop; however, a revetment would have a much larger footprint than a buried seawall. Beach nourishment accompanied by sand stabilization structures (e.g., groins) to minimize sand movement would be an effective means for protecting the beach resource and the backshore land and infrastructure. A series of groin structures accompanied by beach fill would likely create a series of stable beach cells along this shoreline.

Recommendations

- Evaluate options for beach nourishment with stabilizing structures (e.g., groins).
- Evaluate options for permanent shore protection (e.g., seawall or revetment).

FIESTA BEACH, HYATT BEACH, AND MICRO BEACH

Fiesta Beach and Hyatt Beach received *high* EHPRs, primarily due to limited reef width, evidence of erosion, low backshore elevation, high-intensity development in the backshore area, popularity and use intensity in the area, and potential impacts of erosion on shoreline access. The backshore area consisted of a relatively flat area with sparse, low-lying vegetation. There was evidence of active erosion along shoreline, particularly at north and south ends of Hyatt Beach (Figure 11). The beach fronting both resorts had been cleared of vegetation (Figure 12). Vegetation clearing and grading of the beach berm exposes the backshore to increased risk of wave overtopping and flooding.

Micro Beach is vulnerable to erosion but received a *medium* EHPR, primarily due to the lack of development in the backshore area; however, Micro Beach can be included in this discussion since it is adjacent to Hyatt Beach, is part of a continuous beach system, and has a history of episodic erosion. In August-September 2017, a combination of typhoon waves and high tides caused severe erosion at Micro Beach. The condition of Micro Beach before and after the recent erosion event are shown in Figure 13 and Figure 14. Micro Beach may have the capacity for natural recovery through accretion but, given the history of episodic erosion, may be a good candidate for proactive erosion management.

Potential erosion management solutions for Fiesta Beach, Hyatt Beach, and Micro Beach include berm enhancement, restoration of shoreline vegetation, beach maintenance, and beach nourishment.

A berm is an elevated feature that is located on the inshore portion of a sandy beach and may be in the form of a ridge or plateau. Berms typically form during higher water level and wave conditions. Berms can serve as a reserve of sand and provide protection from wave overtopping and flooding. Berms can be further stabilized by planting appropriate native coastal vegetation. Berm enhancement and restoration of shoreline vegetation would reduce exposure to erosion while maintaining natural beach processes, sand and water movement, and public access.

Beach maintenance would likely consist of sand pushing, which is a form of passive erosion control that does not involve engineering structures. Sand pushing is a relatively simple approach that involves moving sand from the lower beach to the upper beach to reduce exposure of the backshore to wave action. Sand pushing would require an adequate supply of beach sand and may be limited to the beach immediately fronting the property.

Beach nourishment would involve placing additional sand on the existing beach. The replenished beach would provide recreational opportunities as well as a protective buffer for the backshore area and infrastructure. The beach berm could be built higher to provide further protection against inundation and coastal flooding. Beach nourishment would require a supply of sand that is similar in grain size to the native beach sand.

Recommendations

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Restore and maintain shoreline vegetation.

Figure 11 Erosion and beach narrowing at the north end of Hyatt Beach

Figure 12 Active beach cleared of vegetation at Fiesta Beach

Figure 13 Condition of Micro Bach prior to recent erosion event (July 2017)

Figure 14 Condition of Micro Bach after recent erosion event (October 2017)

PROJECT OVERVIEW

The *Saipan Shoreline Access and Shoreline Enhancement Assessment (SASEA)* is a comprehensive survey of the condition of select beaches on the Island of Saipan, Commonwealth of the Northern Mariana Islands (CNMI). The SASEA was funded by the Bureau of Environmental and Coastal Quality (BECQ), Division of Coastal Resources Management (DCRM). Financial assistance was provided by the Coastal Zone Management Act of 1972, as amended, administered by the Office for Coastal Management, National Oceanic and Atmospheric Administration. Sea Engineering, Inc. (SEI) assessed eighteen (18) beaches along the coastline of Saipan to determine each one's vulnerability to coastal erosion and identify site-specific shoreline enhancement opportunities.

The SASEA consisted of four primary tasks:

1. Field Investigations
2. Historical Shoreline Change Analysis
3. Erosion Hazard Priority Ratings
4. Issues & Recommendations

Field Investigations

The purpose of the field investigations was to assess the condition of the shoreline and identify evidence of erosion or accretion, infrastructure that could be vulnerable to erosion or other coastal hazards, and issues that affect the quality of the area and/or the user experience. A site visit was conducted at each beach, and a handheld GPS unit was used to collect location data for physical features (e.g., beach toe, top bank, erosion scarp), structures (e.g., boat ramps, piers, shore protection structures), and amenities (e.g., palapalas, picnic tables, parking lots). Field investigations evaluated and documented the following:

- General oceanographic and coastal setting
- Shoreline type and current condition
- Nearshore and offshore features
- Typical beach profiles
- Existing access, uses, and amenities
- Public and private infrastructure and buildings
- Evidence of historical and modern shoreline change (i.e., erosion or accretion)
- Vulnerability of existing infrastructure

Historical Shoreline Change Analysis

The purpose of the historical shoreline change analysis was to measure changes in beach width over time and determine historical shoreline change rates to support planning and decision-making. The analyses utilized historical aerial images from 1999 to 2016. The images were georeferenced and the shoreline reference feature - the beach toe - was digitized on each image. The location of each digitized shoreline was measured along shore-normal transects spaced approximately 20 meters (m) apart. Measuring the change in shoreline position along each transect and then dividing by the time lapse between images produced a shoreline change rate at each transect.

Erosion Hazard Priority Ratings

The purpose of the Erosion Hazard Priority Ratings (EHPR) was to establish criteria to determine the overall vulnerability of each beach to erosion and assist in the identification and prioritization of shoreline enhancement efforts. Each beach was assigned an EHPR of *low*, *medium*, or *high*. The EHPRs were determined for each beach based on conditions observed during field observations and the results of the historical shoreline change analysis. The evaluative criteria used to determine the EHPRs for each beach are shown in Table 4, below:

Table 4 Evaluative criteria for Erosion Hazard Priority Rankings (EHPR)

Average Reef Width	Average width of fringing reef fronting the shoreline. Range: +2 if ≥ 1000 m | -2 if ≤ 100 m.
Average Beach Width	Average beach width along the shoreline. Range: +2 ≥ if 25 m wide | -2 if no beach present.
Average Backshore Elevation	Average elevation in the backshore area. Range: +2 if ≥ 5 m | -2 if ≤ 5 meters
Historical Shoreline Change	Average annual shoreline change rate from 1999 to 2016. Range: +2 if ≤ 1 m/yr | -2 if ≥ 1 m/yr
Evidence of Erosion	Physical evidence of erosion observed along the shoreline. Range: +2 if evidence of active erosion | -2 if no evidence of erosion.
Popularity and Use Intensity	Overall popularity and volume of users. Range: +2 if high frequency/use | -2 if low frequency/use.
Development Intensity	Intensity of development and land uses within 100 m of the shoreline. Range: +2 if no development | -2 if densely developed.
Infrastructure Vulnerability	Presence of public infrastructure within 100 m of the shoreline. Range: +2 if no infrastructure | -2 if high-density infrastructure.
Risk to Shoreline Access	Potential for erosion to negatively impact shoreline public access. Range: +2 if no loss of access | -2 if complete loss of access.

Popularity and intensity of uses at each beach was a major factor in determining the EHPR. Popular, high-use beaches were weighted appropriately to a more urgent priority rating. Emphasis was also placed on the vulnerability of structures and facilities, as these are typically high-cost investments, and the structures are often costly to relocate or repair. Structures and facilities that were damaged or considered at-risk generated an EHPR of *high*. Restroom facilities, showers, palapalas (pavilions), and parking lots were common amenities with high valuations. Picnic tables and other movable items were given less consideration. In many cases, the beach serves as a buffer between the ocean and the coastal highway. Although the public highways are technically not part of the beaches, the proximity of the highway was a major consideration in determining the EHPR. Public infrastructure that was damaged or considered at-risk generated an EHPR of *high*.

Six (6) beaches were assigned an EHPR of *high.* These beaches typically had public infrastructure that was either damaged or potentially vulnerable to erosion. Six (6) beaches were assigned an EHPR of *medium.* These beaches typically had a moderate risk of erosion due to one or more factors (e.g., low elevation, erosion history). Six (6) beaches were assigned an EHPR of *Low*. These beaches were typically stable or accreting, or there was no vulnerable development or infrastructure in the backshore area. A *medium* or *low* rating does not mean that a beach has not experienced erosion in the past or will not be vulnerable to erosion in the future. In some cases, where the beach was in a remote area, development intensity was low, or there was no infrastructure vulnerable, the EHPR was considered *medium* or *low*, even if erosion indicators were present.

The EHPRs provide a useful baseline for assessing current conditions and should be updated periodically to account for changing conditions. The criteria used to determine the EHPRs can be modified to account for changing conditions, priorities, and/or concerns. There is no prescribed timeframe for updating the EHPRs. Updating the EHPRs on an annual basis would be labor-intensive and time-consuming. Ideally, the EHPRs would be updated every 3 to 5 years, or following a major erosion event. A 3 to 5-year update cycle would ensure that the information remains current. The recommended approach for updating the EHPRs would be to use updated aerial imagery to recalculate the historical shoreline change rates, and conduct site visits to observe current conditions and identify and new evidence of shoreline change. BECQ staff could conduct the baseline assessment to update the EHPR values and recalculate the rankings shown in Table 3. A specialist or consultant could be hired to perform a more in-depth analysis, if needed.

Beach Assessments

The purpose of the beach assessments was to compile all the information for each beach into a standalone summary report. The beach assessments are divided into five (5) subsections:

1. *Coastal Setting* – describes the regional setting, including the location of the beach, the total length of shoreline frontage, and a general description of the shoreline morphology.
2. *Shoreline Condition* – describes the characteristics of the shoreline (orientation, bathymetry, and type), and the existing uses and amenities. Typical beach profiles were recorded for each beach. The beach profiles provide a description of the representative shape and slope of the beach, and the location of physical features, such as berms, vegetation lines, and erosion scarps.
3. *Historical Shoreline Change* – describes the historical shoreline change rates for each beach and identifies potential factors that could contribute to variability in shoreline position over time.
4. *Erosion Hazard Priority Rating* – discusses the observations and criteria used to determine the EHPRs for each individual beach.
5. *Issues & Recommendations* – summarizes the issues identified during the field investigations and provides constructive recommendations to address those issues. Additional recommendations that apply to all beaches and shorelines are discussed later in the report.

Economic Setting

The CNMI economy is very dependent on tourism, which accounts for approximately 72% of CNMI Gross Domestic Product (GDP) (Marianas Visitors Authority, 2017). For fiscal year 2017, the Marianas Visitors Authority estimates that Saipan experienced 653,150 annual visitors. The highest number of visitors were from Korea (333,069) followed by China (229,389), Japan (52,227), and others (38,465). The number of visitors from China has been increasing rapidly in recent years, and that trend continues (CNMI Central Statistics Division, 2015).

The quality of Saipan's beaches and shorelines is an important component of the island's tourism-based economy. In a 2011 survey, many visitors identified beaches as one of their top reasons for visiting Saipan including Japan (84%), Korea (67%), China (82%), Russia (100%), and the U.S. and Guam (48%) (Marianas Visitors Authority, 2016). In a 2015 survey, 80% of those surveyed said their primary reason for visiting the CNMI was for pleasure/vacation and their secondary reasons were tropical climate, sea, or beach, followed by snorkeling and nature activities (Bureau of Environmental and Coastal Quality, 2016).

Local Regulatory Setting

The CNMI Constitution that guarantees public access and the right to a clean and healthy environment. The Division of Coastal Resources Management (DCRM) is the primary coastal resources management authority as enabled by the Coastal Zone Management Act of 1983 (P.L. 3-47, 2 CMC § 1500 et seq.). Regulation of coastal resources is coordinated with the CRM Agency Board, which is led by DCRM and comprised of the Division of Environmental Quality (DEQ), Department of Lands and Natural Resources (DLNR), Division of Fish and Wildlife (DLNR-DFW), the Historic Preservation Office (HPO), Commonwealth Utilities Corporation (CUC), Department of Public Works (DPW) and Department of Commerce (DOC).

Coastal zone management in the Commonwealth of the Northern Mariana Islands is coordinated by the Division of Coastal Resources Management Office (DCRM), in partnership with other key agencies including but not limited to: Division of Environmental Quality (DEQ), Department of Lands and Natural Resources (DLNR), Division of Fish and Wildlife (DLNR-DFW), the Historic Preservation Office (HPO), Commonwealth Utilities Corporation (CUC), Department of Public Works (DPW) and Department of Commerce (DOC).

Key Rules and Regulations

- Coastal Resources Management Rules and Regulations (2 CMC §1500 et seq.)
- Saipan Zoning Law of 2008 (CMC Title 10, §3511. S)
- CNMI Constitution (Articles I and XIV)

The CNMI Coastal Resources Management Rules and Regulations directs DCRM to designate Areas of Particular Concern (APCs) and establishes standards and priorities for land and water uses (§15-10-335). The *Shorelines* and *Coastal Hazards* APCs are particularly relevant to this assessment as they govern activities within 150 feet of the Mean High Water line, and within certain coastal flood hazard zones (§15-10-335 and §15-10-345). *Shoreline setbacks* are also required for coastal development (§15-10-350).

The Saipan Zoning Law (SLL 16-6, 10 CMC §3511 et seq.) establishes requirements for various activities that have the potential to affect beaches on Saipan. The Public Resource (PR) Zoning District (Section 508) is intended to protect parks, trails, and public and private lands within 150 feet of beaches. The Zoning Law also seeks to limit development within 150 feet of the shoreline to avoid impacts to natural beach processes, sand and water movement, and public access (Section 610). DCRM's Rules and Regulations surpass Zoning Law where they conflict within the Shoreline APC. The U.S. Army Corps of Engineers (Corps) maintains jurisdiction over Waters of the United States, pursuant to Section 10 of the Rivers & Harbors Act (33 U.S.C. 403; Chapter 425, March 3, 1899; 30 Stat. 1151), and Section 404 of the Clean Water Act (33 U.S.C. §1251 et seq.). DCRM and the Corps co-manage these areas, in partnership with other relevant resource agencies.

Shoreline Access

Coastal access on Saipan is protected by the CNMI Constitution (2 CMC §1500 et seq.). Saipan Territory Trust Code (TTC) requires a reasonable number of public roads and paths from existing or established public roads to insure public access to public lands that abut the sea or tidal areas (67 TTC § 152). The Saipan Zoning Law (SLL 16-6) also restricts activities that can negatively impact public access in some areas. The Tourist Resort (TR) Zoning District (Section 510) requires that development of properties located along the shoreline maintain a view/public access corridor of open land with a width of at least 20% of the property width parallel to the shoreline or 30 feet wide, whichever is less. The view/public access corridor shall include a publicly accessible trail at least 6 feet wide from a public right-of-way to the shoreline.

DCRM is mandated to provide public access to shorelines while ensuring that the natural resources are protected and managed in a sustainable manner. In 2015, DCRM published the *Public Shoreline Access Guide for Saipan, Tinian, and Rota*, which provides summary descriptions for many of Saipan's beaches, and general information and guidelines regarding shoreline safety, marine protected areas, water quality, and shoreline management. A summary of coastal access amenities on Saipan is shown in Table 5, below.

Table 5 Existing coastal access on Saipan

Type	Quantity
Shoreline available for public access	80 km
Coastal trails	12 km
ADA-compliant shoreline access routes	6
Demarcated rights-of-way to shoreline areas	9
Designated scenic vistas	8
Public parks	16
Public boat ramps	6
Public fishing piers	2

PHYSICAL AND OCEANOGRAPHIC SETTING

Geography

The Northern Mariana Islands consist of fourteen islands spanning approximately 604 kilometers (km) in the western Pacific Ocean. The Island of Saipan is situated at latitude 15°12' North and longitude 145°45' East, approximately 190 km north of the Island of Guam, and 9 km northeast of the Island of Tinian. Saipan is the largest of the Northern Mariana Islands with a total land area of approximately 115 km^2. The island is approximately 20 km long and 9 km wide.

Geology and Geomorphology

Saipan consists of a volcanic core overlain by younger limestones. Limestones and calcareous deposits dominate the surface lithology, comprising about 90 percent of the surface exposures. Volcanic rocks are exposed on the remaining 10 percent of the land surface (Carruth, 2003). The surface landforms of Saipan are separated into six principal physiographic subdivisions (Cloud and others, 1956). This assessment focused on the low-lying *western coastal plain* on the leeward (west) side of the island, and the *low terraced benches* on the windward (east) side of the island.

The leeward (west) coastline of Saipan is located on the western coastal plain, which extends from San Roque to Agingan Point. A fringing coral reef and offshore barrier reef create the Saipan Lagoon. Saipan Lagoon encompasses approximately 51.5 km^2 and is separated from the Philippine Sea by a long barrier reef about 2 miles offshore at the entrance to Tanapag Harbor. The width of the lagoon created by the reef ranges from less than 90 m to over 2.4 km. Water depths in the lagoon average 1 to 4 m. The inner lagoon floor is relatively flat and composed mostly of sand with scattered coral/algal rubble. The outer lagoon floor is also sandy but with more coral/algal rubble and rocks, particularly at the border of the barrier reef, while some areas have irregular reef rock exposed at low tides (Duenas and Swavely, 1985). The shoreline within the lagoon is lined with sandy beaches that are predominately composed of emerged calcium carbonate sands, also referred to as limesands. The limesands, and present reef and beach deposits, are of Pleistocene and Holocene age (Carruth, 2003).

The windward (east) coastline of Saipan consists of a succession of nearly horizontal limestone platforms and terraces. Much of the coastline is composed of an elevated, relatively flat limestone surface (platform) that is bounded on the seaward side by low-lying sea cliffs. The limestone platform can range in width from less than 1 m to as much as 25 m. The sea cliffs range in height from 1 to 5 m in elevation. Sandy beaches along the coastline are present in three forms: 1) wide, sandy beaches that extend into deeper water and are often connected to offshore sand fields; 2) narrow beaches located landward of flat limestone benches present at the water line; and 3) perched beaches formed on top of the limestone platform during energetic wave conditions.

Winds

The Northern Mariana Islands experience three wind conditions; tradewinds, doldrums, and typhoons. The islands lie near the boundary of the Asiatic monsoon and the belt of northeast tradewinds. The predominant winds are the tradewinds, which approach from the northeast through east-southeast sector. The tradewinds occur nearly 80% of the time and are stronger and steadier in the winter (January to May). Annually on Saipan, tradewinds blow approximately 13 to 18 km/hr 40% of the year, 20 to 30 km/hr 26% of the year, and greater than 30 km/hr 4% of the year (U.S. Army Corps of Engineers, 2004). Average annual tradewind velocity is about 17 km/hr, predominantly from the east. During the wet season (July to December), variable winds and storm/typhoon winds are more likely (Fletcher et al., 2007).

Tides

The tides in Saipan are mixed semi-diurnal with pronounced diurnal inequalities. Tide data published by Lighthouse Press (2003) shows that the mean tide range is 0.4 m and the diurnal range is 0.6 m. Tidal ranges for Saipan are shown in Table 6, below:

Table 6 Tidal ranges for Saipan (relative to mean sea level)

Datum	Elevation (m)
Mean Higher High Water (MHHW)	+0.21
Mean Higher Water (MHW)	+0.20
Mean Sea Level (MSL)	0.00
Mean Low Water (MLW)	-0.20
Mean Lower Low Water (MLLW)	-0.36

Waves

The wave climate in Saipan can be divided into two distinct wave types; seas generated by the prevailing local tradewinds, and waves from tropical storms or typhoons (either near or distant). Seas are generally referred to as the somewhat disorganized waves that are generated by winds at or near the location where they are observed. Seas generally appear scattered and "white-caps" form as the waves become too steep. Outside of the generation area, the seas transform into swell, which is characterized as a series of organized waves with continuous crests and troughs. Swell can travel long distances across the ocean and produce large surf. Wave generation is a function of wind speed, fetch (the distance over which the wind blows), and the duration of the wind. Depending on these factors and the proximity of the generation area to Saipan, seas and swell may occur together. Additionally, swells and seas generated by different events can occur simultaneously.

While the tradewind waves predominantly approach from the east, typhoon and storm waves can and do approach from other directions. Although typhoon and storm waves occur less frequently and for shorter durations, they can cause backshore inundation, flooding, and rapid shoreline recession. Although the leeward (west) coast of Saipan is partially-sheltered by a wide barrier reef, fringing reef, and shallow lagoon, the shoreline is still vulnerable to large waves during typhoons and high surf events. The windward (east) coast of Saipan is more exposed and vulnerable to inundation and storm surge as prevailing tradewinds and storms typically approach from an easterly direction. The windward (east) coast also lacks a protective fringing reef.

Currents

The primary drivers for nearshore current circulation in Saipan are the underlying North Equatorial Current, semidiurnal tidal currents, and wind-generated surface currents. The North Equatorial Current, generated by the tradewinds, generally sets in a westward direction near Saipan, with speeds of up to 1 knot (0.5 m/s). *Sailing Directions for the Pacific Islands (1976)* and available anecdotal information indicate that this current is stronger in the winter months when the tradewinds are prevalent.

Tides in Saipan are semi-diurnal with pronounced diurnal inequalities (i.e., there are two high tides and two low tides each day, each with different elevations). Tides travel in the form of a wave moving east to west through the Mariana Islands. As the tidal wave form encounters the shallow fringing reef, the wave form changes into flow which drives nearshore currents. Damlamian and Krüger (2010) developed a hydrodynamic model for the north (Tanapag), central (Garapan), and south (Chalan Kanoa) regions of the Saipan Lagoon. The model simulated circulation in each region for two scenarios: a relatively high significant wave height with a south westerly wave and wind direction representative of conditions from October to March (Scenario 1), and a relatively low significant wave height with a westerly wave and wind direction representative of conditions from April to September (Scenario 2).

The model results showed that much of the water entering the north region does so primarily over the reef with the help of wave breaking. Flow inshore through the channel was found during low spring tide when the reef was emergent or when wave energy was very small; otherwise the flow was offshore through the channel. Currents during high wave conditions were found to be greater than during low waves. Based on the circulation model, currents past Tanapag, Aqua Resort, and Pau Pau would be expected to flow alongshore toward the southwest.

The central lagoon region stretches from Sugar Dock to American Memorial Park. This region also experiences a wave driven current along the shoreline from north to south. Flow can exit the lagoon through channels at Fishing Base and Sugar Dock. The beaches from Sugar Dock to American Memorial Park are expected to experience current flow toward the south under most conditions. Laly 4, just south of Sugar Dock, also experiences currents toward the south.

Typhoons

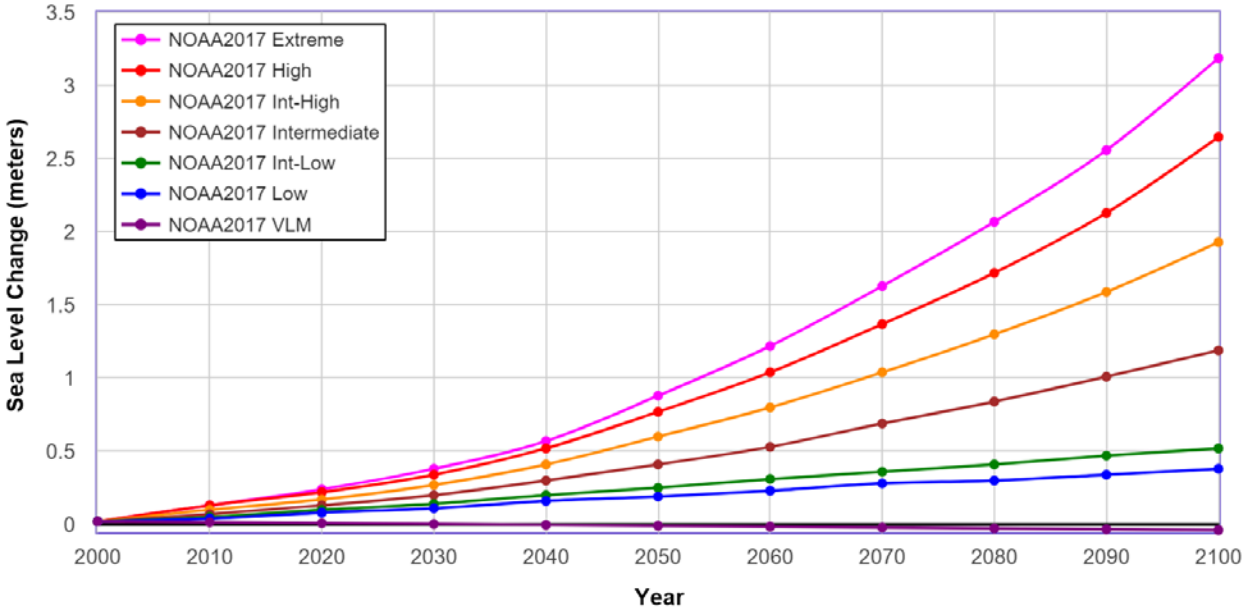
Due to its proximity to typhoon breeding grounds, Saipan is subject to the year-round passage of developing tropical storms and typhoons. The U.S. Navy's Joint Typhoon Warning Center (JTWC) best track archive indicates that 30 typhoons and 23 severe tropical storms have passed within 85 miles of Saipan between 1950 and 2013. Typhoons generally move from east to west; however, the tracks often curve so that the typhoon moves south to north, or even doubles back. Typhoons typically form south of the Mariana Islands and records show one tropical disturbance per year either originating in or passing over the Saipan/Tinian area (*Sailing Directions for the Pacific Islands, 1976*). Typhoons are more common during the summer months but can occur throughout the year.

Typhoons and tropical storms are accompanied by high winds and torrential rains. Typhoons are defined as storms with sustained wind speeds of at least 64 knots (32.5 m/s). Tropical storms are defined as having sustained wind speeds between 34 and 63 knots (17 to 32 m/s). Statistics compiled by the JTWC from 1972 to 1991 indicate that the average annual occurrence of storms with wind speeds greater than 25 knots (12.7 m/s) passing within a one-degree by one-degree square centered on Saipan is 0.7 to 0.8 per year. Typhoons are a primary driver of coastal erosion and inundation on Saipan. Storm winds can drive sea level and waves to rise up to several meters upon landfall and breaking waves can cause water levels to rise at the shoreline by up to 20% to 30% of the breaking-wave height (Marra et al., 2012). Relict storm berms and erosion scarps were observed at many of the beaches included in this assessment.

Sea Level Rise

The present rate of global mean sea level change (SLC) is +3.4 ± 0.4 mm/year (NOAA, 2017), where a positive number represents a rising sea level. SLC appears to be accelerating compared to the mean of the 20th century. Factors contributing to the rise in sea level include decreased global ice volume and warming of the ocean. The National Oceanic and Atmospheric Administration (NOAA) recently revised their sea level change projections through 2100 taking into account up-to-date scientific research and measurements. NOAA projects that global sea level rise, as shown by their "Extreme" scenario, could be as high as +3.19 m by 2100 (Figure 15).

Regional sea level can deviate from mean global sea level because of both dynamic sea level effects, resulting from oceanic and atmospheric circulation and temperature and salinity distributions, and changes in the static equilibrium sea level configuration, produced by the gravitational, elastic, and rotational effects of mass redistribution (Kopp et al., 2010). Future sea level rise may be amplified in Saipan due to static equilibrium effects, because the island is in the far field of all sources of melting land ice (NOAA, 2017).



Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2000	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2010	0.01	0.04	0.05	0.07	0.10	0.13	0.13
2020	0.01	0.08	0.10	0.13	0.17	0.22	0.24
2030	0.00	0.11	0.14	0.20	0.27	0.34	0.38
2040	-0.00	0.16	0.20	0.30	0.41	0.52	0.57
2050	-0.01	0.19	0.25	0.41	0.60	0.77	0.88
2060	-0.01	0.23	0.31	0.53	0.80	1.04	1.22
2070	-0.02	0.28	0.36	0.69	1.04	1.37	1.63
2080	-0.03	0.30	0.41	0.84	1.30	1.72	2.07
2090	-0.03	0.34	0.47	1.01	1.59	2.13	2.56
2100	-0.04	0.38	0.52	1.19	1.93	2.65	3.19

Figure 15 Sea level rise projections for Saipan (in meters) (NOAA, 2017)

Historical Shoreline Change

A series of historical aerial photographs can be used to measure shoreline change rates and identify trends by comparing the relative positions of a specific beach feature over time. Historical analysis of the shorelines included in this assessment has been undertaken and shoreline change maps and rates have been produced for each of the western beaches based on historical aerial images (Table 7).

Table 7 Aerial imagery used in historical shoreline analysis

Location	Aerial Imagery Dates					
	1999	2001	2005	2011	2012	2016
Laly 4 (San Isidro Beach Park)	x		x	x		x
Sugar Dock Beach	x		x	x		x
Susupe Beach Park	x		x	x		x
Kilili Beach (Civic Center)	x		x	x		x
Oleai Beach	x		x	x		x
Quartermaster Area (Red Beach)	x		x	x		x
Beach Road Pathway	x		x	x		x
Fishing Base	x		x	x		x
Makaka Beach	x		x		x	x
Fiesta Beach	x		x		x	x
Hyatt Beach	x		x		x	x
Micro Beach	x		x		x	x
American Memorial Park	x		x	x		x
Tanapag Beach & Boat Ramp		x	x		x	x
Aqua Resort Beach		x	x	x		x
Pau Pau Beach		x	x	x		x
Jeffrey's Beach	n/a	n/a	n/a	n/a	n/a	n/a
Tank Beach	n/a	n/a	n/a	n/a	n/a	n/a

Methodology

The analyses utilized four approximately evenly-spaced aerial images for each beach. The aerial images were georeferenced and the shoreline reference feature - the beach toe - was digitized on each image. The location of each digitized shoreline was measured along shore-normal transects spaced approximately 20 m apart. Measuring the change in shoreline position along each transect and then dividing by the time lapse between images produced a shoreline change rate at each transect. Three sets of shoreline change rates were computed between each successive set of images, as well as one set of change rates over the complete time series. This approach is particularly useful in situations where sub-trends in the data might exist as the result of specific events, such as a typhoon or new shoreline development.

The shoreline change rates were computed using the "end-point rate" method, in which only the first and last shoreline position in each time range was used. Intermediate shoreline positions were not included in the analyses. While the University of Hawaii Coastal Geology Group uses a sophisticated method of including time and space in their analyses, and the USGS's Digital Shoreline Analysis System (DSAS) program considers all shorelines over a specified time period, these can sometimes mask sub-trends in the data. On the other hand, an analysis that includes all shorelines can filter out anomalous shoreline positions.

The time period between images used in the historical shoreline analyses is important, and prior to about 2000, it was limited to available imagery, which could be several years or decades apart, particularly for remote locations. With such limited imagery, short-term trends like seasonal variations cannot be discerned.

The advent of numerous satellites providing high-resolution images has produced a great availability of recent data. While obtaining recent images to find seasonal trends may no longer be a concern, the proper time between images will likely depend on the parameters of each specific project.

For the SASEA analyses, aerial images from 1999, 2005, 2011, and 2016 were found to provide coverage over most of the beaches included in this assessment. The three northern sites were not included in the 1999 images, and part of the shoreline in Garapan was obscured by clouds in the 2011 image. In these cases, the dataset was supplemented with other aerial imagery, as close in date to the original image as possible. A brief discussion of the results of the historical shoreline change analysis is included below. The analysis results are summarized in Table 8. Historical shoreline change maps and figures for each beach are included in Appendix A.

Summary of Results

Laly 4 (San Isidro Beach Park)

This shoreline at Laly 4 (San Isidro Beach Park) experienced significant accretion over the complete time series of the analysis (1999-2016), particularly since 2005. From 2005 to 2016, the shoreline was measured to have accreted by more than 20 m near the center of the beach during that time, while accreting by about 10 to 15 m near the north and south ends of the beach. Typical annual accretion rates were measured to be between 1 and 2 m/yr from 2005 to 2016, with rates as high as about 2.5 m/yr between 2011 and 2016.

Sugar Dock Beach

The study area shoreline is divided by Sugar Dock. The shoreline south of the dock has experienced minimal change based on the 1999 and 2016 aerial images; however, including the 2005 and 2011 in the comparison shows that the same shoreline has experienced erosion rates of as much as 3 m/yr and accretion rates of up to about 2 m/yr. The accumulation of sand on the north side of Sugar Dock appears to be quite variable. The 2016 aerial image shows a significant amount of sand, while much less sand was observed during the 2017 site visit. Given the dynamics of this shoreline reach, the recent history of seawall construction, and the possibility of dredging at this location to maintain the functionality of the boat ramp, the shoreline change rates on the north side of Sugar Dock should be interpreted with caution.

Susupe Beach Park

The shoreline at Susupe Beach Park experienced erosion from 1999 to 2005 at rates of about 1 to 2 m/yr, while accreting at rates of up to about 1 m/yr thereafter. For the complete time series of the analysis (1999-2016), the beach showed moderate erosion.

Kilili Beach (Civic Center)

For the complete time series of the analysis (1999-2016), there was no appreciative change in the shoreline positions, and thus no long-term change at Kilili Beach (Civic Center). For the individual time periods within the overall analysis, the shoreline cycled between erosion and accretion, with rates of up to about 1 m/yr for either condition.

Oleai Beach

The shoreline at Oleai Beach showed erosion of up to about 0.8 m/yr from 1999 to 2005. Thereafter, the trend has generally been one of accretion at rates of up to 0.8 m/yr. There was minimal shoreline change observed over the complete time series of the analysis (1999-2016).

Quartermaster Area (Red Beach)

The shoreline at Quartermaster Area (Red Beach) showed erosion of up to about 1.0 m/yr from 1999 to 2005. Thereafter, the trend has generally been one of accretion, at rates of up to 0.8 m/yr. There was minimal shoreline change observed over the complete time series of the analysis (1999-2016).

Beach Road Pathway

The shoreline at Beach Road Pathway has very little sand. The shoreline position varied between accreting and eroding, spatially as well as temporally, from 1999 to 2011. The shoreline was measured to have accreted from 2011 to 2016 at rates up to about 1.3 m/yr. For the complete time series of the analysis (1999-2016), the shoreline showed accretion with typical rates of about 0.2 to 0.3 m/year.

Fishing Base

The shoreline at Fishing Base has almost no sand and is bisected by a 140-meter long pier. The shoreline positions varied between accreting and eroding, spatially as well as temporally, from 1999 to 2011. The shoreline was measured to have accreted from 2011 to 2016 at rates up to about 1.3 m/yr. For the complete time series of the analysis (1999-2016), long-term shoreline change was negligible. The data shows significant change along the north side of the pier.

Makaka Beach

The southern half of the shoreline at Makaka Beach exhibited mild erosion from 1999 to 2005, while the northern half exhibited accretion rates of up to 3 m/yr. The analysis showed accretion thereafter, with rates up to about 2 m/yr. For the complete time series of the analysis (1999-2016), the southern half of the shoreline accreted at a rate of about 1 m/yr, while the northern half accreted at about 2 m/yr. This pattern extended into the Fiesta Beach study area to the north.

Fiesta Beach

The northern half of the shoreline at Fiesta Beach exhibited accretion of up to 2 m/yr from 1999 to 2005, while the southern half exhibited mild erosion. The analysis showed accretion thereafter, with rates up to about 3 m/yr from 2005 to 2011. For the complete time series of the analysis (1999 to 2016), the shoreline accreted at rates of about 1 to 2 m/yr.

Hyatt Beach

The shoreline at Hyatt Beach was found to be fairly dynamic, with shoreline change patterns reversing between 2005 and 2016. Accretion and erosion rates were measured to be up to 2 m/yr within the data set. While the analysis showed the shoreline to be dynamic within the dataset, the shoreline change from 1999 to 2016 was measured to be negligible.

Micro Beach

Similar to the neighboring Hyatt and American Memorial Park beaches, the shoreline at Micro Beach was found to be fairly dynamic. The shoreline change patterns reversed between 2005 and 2012. Accretion and erosion rates were measured to be up to 3 m/yr within the dataset, slightly higher than those measured for Hyatt Beach. The shoreline change from 1999 to 2016 was also measured to be negligible. Micro Beach is vulnerable to episodic erosion events. The most recent significant erosion event at Micro Beach occurred in September 2017.

American Memorial Park

The shoreline at American Memorial Park was found to be the most dynamic shoreline included in this assessment. The west section of the shoreline has the same exposure as the adjacent Micro Beach; however, the exposure changes abruptly as the shoreline turns east toward the sand spit and Smiling Cove. Westerly waves can approach obliquely to the shoreline, creating potential for easterly sediment transport. This was observed in the historical shorelines, where substantial accretion was observed along the sand spit. Maximum accretion occurred along the east end of the sand spit from 1999 to 2016, where the shoreline accreted by a total of 106 m.

Tanapag Beach

The shoreline at Tanapag Beach was found to be mildly dynamic. The shoreline eroded at rates up to 1.5 m/yr from 2001 to 2005, and accreted with rates of up to about 3 m/yr between 2012 and 2016. The shoreline change from 1999 to 2016 was measured to be negligible.

Aqua Resort Beach

The shoreline at Aqua Resort Beach eroded from 2001 to 2005 at rates of up to about 1 m/yr. The pattern thereafter was one of mild accretion, and for the complete time series of the analysis (2001 to 2016), the beach showed minimal accretion.

Pau Pau Beach

The shoreline at Pau Pau Beach eroded from 2001 to 2005 at rates of up to about 2 m/yr. The pattern reversed from 2005 to 2016, with accretion rates of up to about 1 m/yr typical for the area. For the complete time series of the analysis (2001 to 2016), the beach showed mild accretion with rates up to about 0.5 m/yr.

	1999 to 2005	2005 to 2011	2011 to 2016	1999 to 2016	HISTORICAL TREND
Laly 4 (San Isidro Beach Park)	Variable	Accretion	Accretion	Accretion	Accretion
Sugar Dock Beach	Erosion	Accretion	Variable	Variable	Variable
Susupe Beach Park	Erosion	Accretion	Accretion	Erosion	Variable
Kilili Beach (Civic Center)	Erosion	Accretion	Variable	Variable	Variable
Oleai Beach	Erosion	Accretion	Accretion	Accretion	Accretion
Quartermaster Area (Red Beach)	Erosion	Accretion	Accretion	Accretion	Accretion
Beach Road Pathway	Accretion	Variable	Accretion	Accretion	Accretion
Fishing Base	Erosion	Accretion	Erosion	Erosion	Erosion
Makaka Beach	Variable	Accretion	Accretion	Accretion	Accretion
Fiesta Beach	Variable	Accretion	Accretion	Accretion	Accretion
Hyatt Beach	Accretion	Variable	Variable	Accretion	Variable
Micro Beach	Accretion	Erosion	Variable	Variable	Variable
American Memorial Park	Variable	Variable	Accretion	Accretion	Variable
Tanapag Beach and Boat Ramp	Erosion	Variable	Accretion	Accretion	Variable
Aqua Resort Beach	Erosion	Accretion	Accretion	Accretion	Accretion
Pau Pau Beach	Erosion	Accretion	Accretion	Accretion	Accretion
Jeffrey's Beach (Talofofo)	N/A	N/A	N/A	N/A	N/A
Tank Beach	N/A	N/A	N/A	N/A	N/A

Table 8 Results of historical shoreline change analysis

BEACH ASSESSMENT SUMMARIES

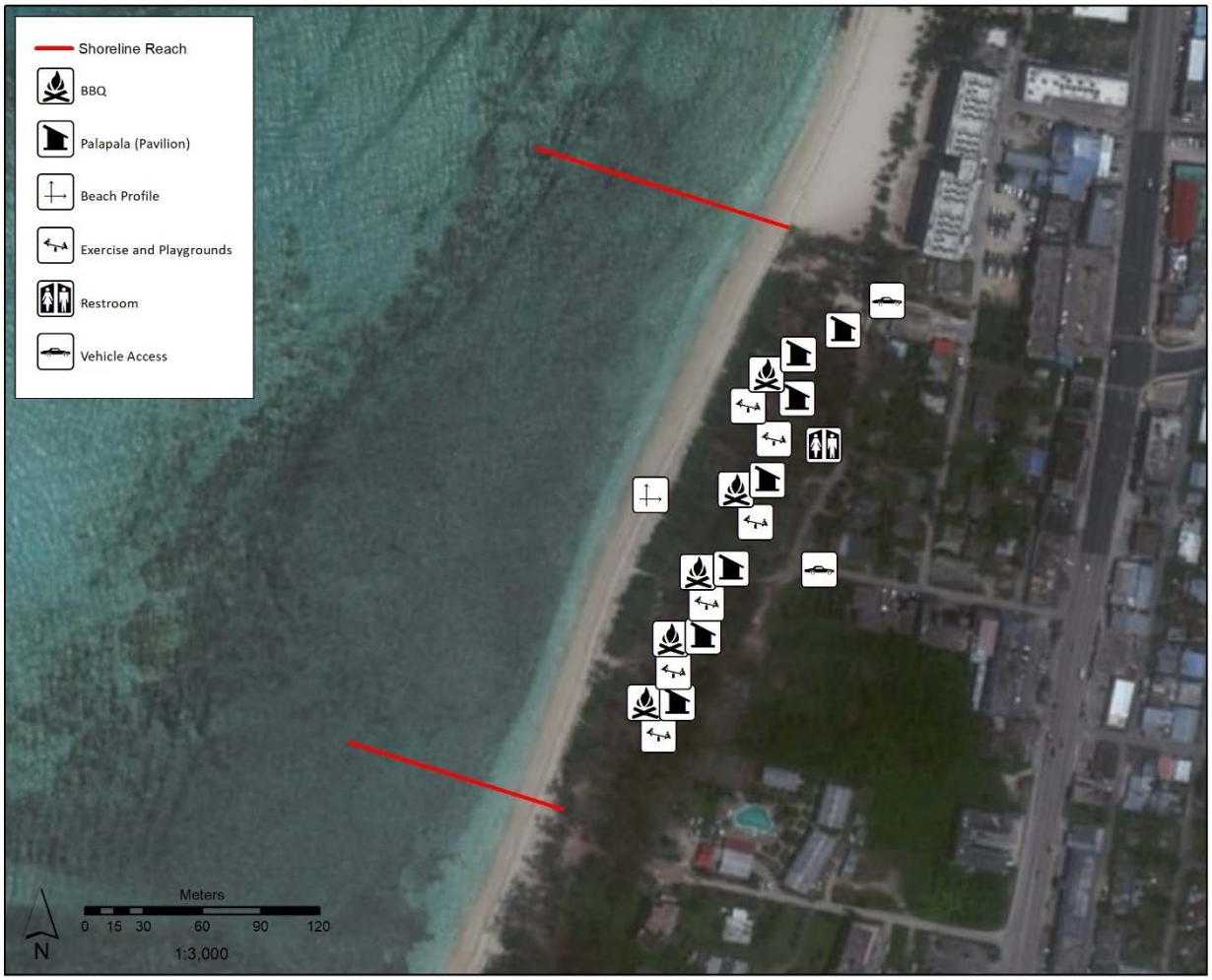
SEI assessed eighteen (18) beaches along the coastline of Saipan to determine each one's vulnerability to coastal erosion and identify site-specific shoreline enhancement opportunities. Overall, public access to beaches and coastal areas on Saipan was abundant in most areas. Several issues were identified that negatively affected the quality and overall user experience at selected beach, including but not limited to:

- Limited beach area and lateral shoreline access due to encroaching vegetation.
- Drainage impacts on beach berms and water quality.
- Lack of ocean safety services.
- Deteriorated amenities at public beaches and parks.
- Lack of ADA and ABA accessibility at public beach parks.
- Structural damage to public infrastructure.
- Lack of public restroom facilities at public beach parks.
- Berm compaction and degradation due to vehicle traffic.
- Marine debris affecting beach quality.

The purpose of the beach assessment summaries is to present a brief summary description, and key issues and recommendations for each beach. A detailed discussion of the issues identified during the field investigations, and recommendations to address those issues, is included in the final section of the report.

Laly 4 (San Isidro Beach Park)

Erosion Hazard Priority Rating - LOW



EASTING:
360218.69 meters E
NORTHING:
1674740.46 meters N
MUNICIPALITY:
Chalan Kanoa South
LENGTH:
350 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
VE (BFE = 8 feet)
LAND USES:
Park; Residential; Recreation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

Laly 4 (San Isidro Beach Park) is located on the leeward (west) coast of Saipan, north of San Antonio and south of Chalan Kanoa, and consists of approximately 350 meters of shoreline frontage. Laly 4 (San Isidro Beach Park) supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and land sports. Amenities included palapalas (8), grills/fire pits (5), playgrounds (8), and sports courts (2).

ISSUES

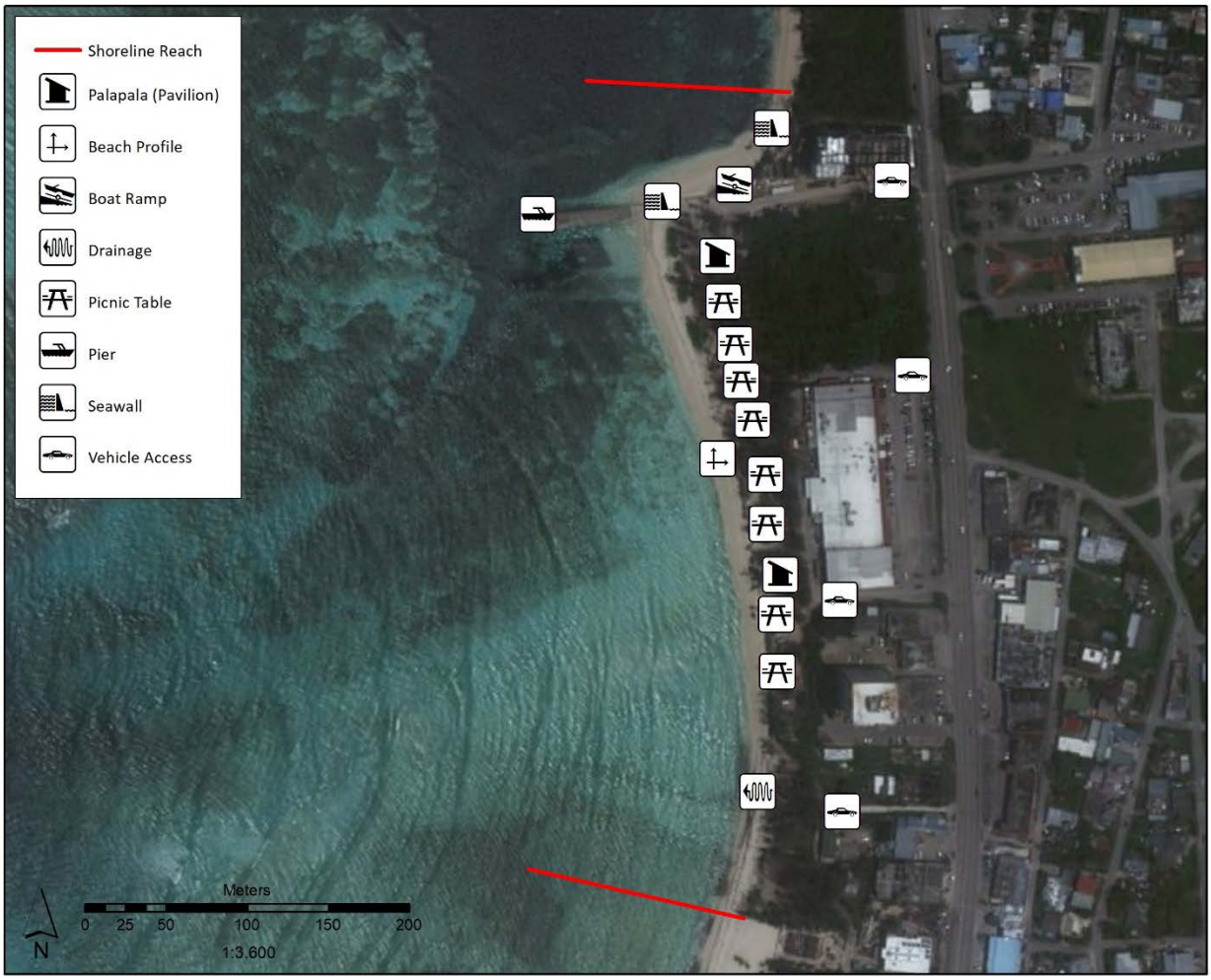
Many of the structures (e.g., palapalas, grills, benches, etc.) were in a deteriorated condition. There was only one public restroom within the park, but it was closed due to apparent structural damage. There were no trash or recycling receptacles observed within the park. The only issue that negatively affected the quality and condition of the beach was the extensive amount of transient vegetation encroaching over the active beach face.

RECOMMENDATIONS

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain trash/recycling receptacles.
- Repair and maintain public restrooms.

Sugar Dock Beach

Erosion Hazard Priority Rating - HIGH



EASTING:
360372.32 meters E
NORTHING:
1675257.12 meters N
MUNICIPALITY:
Chalan Kanoa
LENGTH:
550 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE and VE (BFE = 7 to 8 feet)
LAND USES:
Park; Residential; Transportation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Sugar Dock Beach is located on the leeward (west) coast of Saipan, north of Laly 4 (San Isidro Beach Park) and south of Susupe Beach Park, and consists of approximately 550 meters of shoreline frontage. Sugar Dock Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and boating. In addition to the public boat ramp and Sugar Dock, public amenities included palapalas (2), grills/fire pits (2), and picnic tables (8).

ISSUES

The backshore and upper berm were highly compacted due to vehicle traffic. Many of the structures (e.g., palapalas, grills/fire pits, and picnic tables) were in a deteriorated condition. There were no public restrooms observed in the area. The only issue identified as affecting the quality or condition of the area was the significant damage to Sugar Dock. The seawall protecting the north side of the dock was damaged due to undermining, and the seaward end of the dock was heavily damaged.

RECOMMENDATIONS

- Perform a damage assessment and prioritize repairs to Sugar Dock.
- Evaluate options for beach nourishment.
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain trash/recycling receptacles.

Susupe Beach Park

Erosion Hazard Priority Rating - LOW

EASTING:
360337.49 meters E
NORTHING:
1675955.59 meters N
MUNICIPALITY:
Susupe
LENGTH:
175 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE (BFE = 7 to 8 feet)
LAND USES:
Park
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

Susupe Beach Park is located on the leeward (west) coast of Saipan, north of Sugar Dock Beach South and south of Kilili Beach (Civic Center), and consists of approximately 175 meters of shoreline frontage. Susupe Beach Park supports a variety of recreational uses including swimming, wading, snorkeling, fishing, and picnicking. Park amenities included palapalas (4), grills/fire pits (5), picnic tables (4), and a playground.

ISSUES

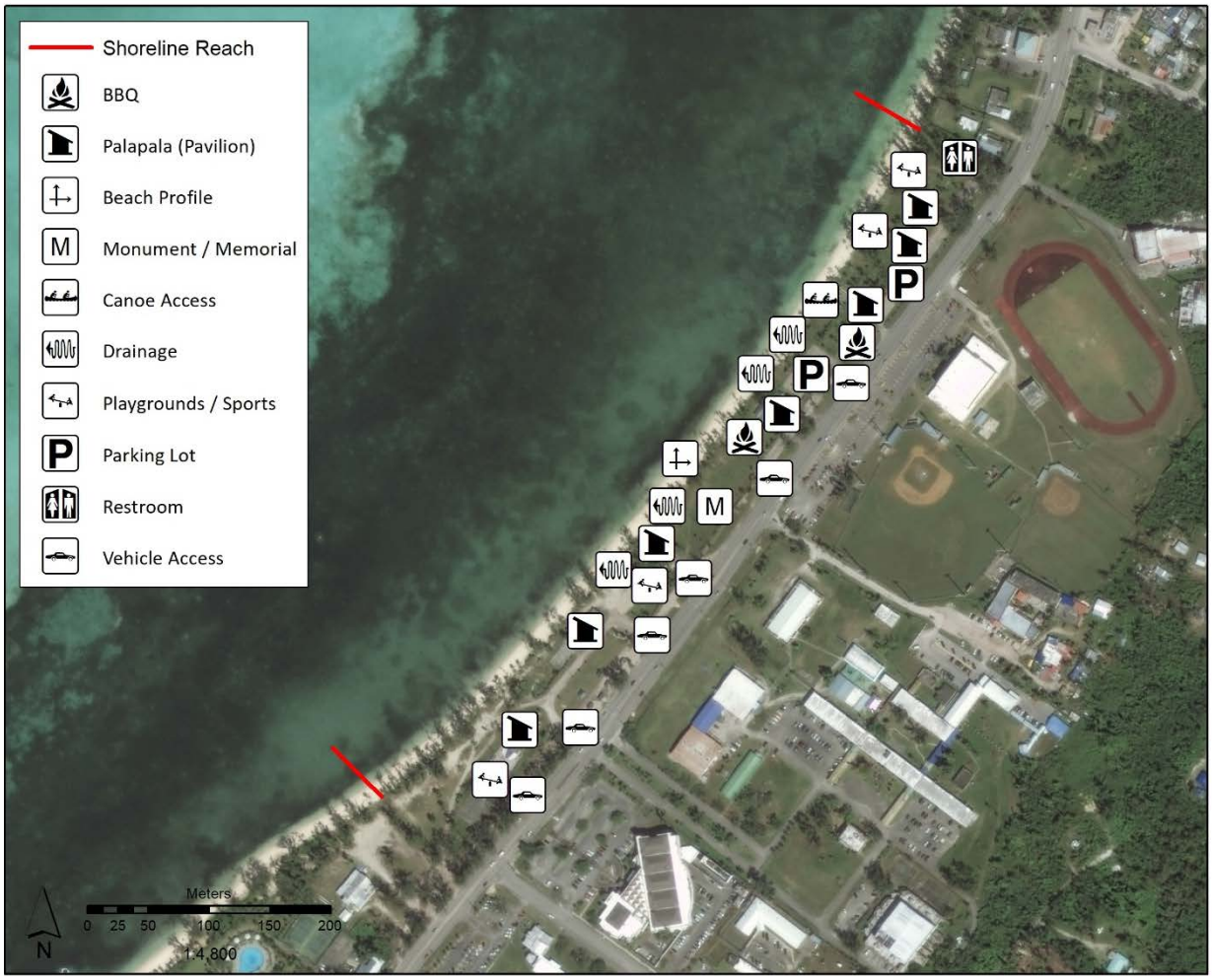
The undeveloped backshore area and upper berm were highly compacted due to vehicle traffic. Many of the structures (e.g., palapalas, grills/fire pits, benches, and picnic tables) were in a very deteriorated condition. There was only one public restroom within the park, but it was closed due to apparent structural damage. Several of the palapalas were heavily damaged and appeared to be unstable, which may present a potential risk to public health and safety.

RECOMMENDATIONS

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Install and maintain trash/recycling receptacles.
- Repair and maintain public restrooms.

Kilili Beach (Civic Center)

Erosion Hazard Priority Rating - MEDIUM



EASTING:
361012.56 meters E
NORTHING:
1676686.06 meters N
MUNICIPALITY:
Susupe; Oleai
LENGTH:
700 meters
AVERAGE BEACH SLOPE:
5 to 15 degrees
FLOOD ZONE:
AE and VE (BFE = 7 to 9 feet)
LAND USES:
Park; Transportation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Kilili Beach (Civic Center) is located on the leeward (west) coast of Saipan, north of Susupe Beach Park and south of Oleai Beach, and consists of approximately 700 meters of shoreline frontage. Kilili Beach (Civic Center) supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, picnicking, land sports, and water sports. Park amenities included palapalas (5), grills/fire pits (4), playgrounds and exercise equipment (3), and historical sites (2).

ISSUES

The undeveloped backshore area and upper berm were highly compacted. There was only one public restroom within the park, but it was closed due to apparent structural damage. The most active erosion areas appeared to be caused by surface water runoff from several drainages and parking lots, which bisected the berm and deflated the beach face. Erosion also appeared to be caused by foot traffic at the launch site for outrigger canoes.

RECOMMENDATIONS

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Identify and prioritize drainage improvements.
- Repair and maintain public restrooms.

Oleai Beach

Erosion Hazard Priority Rating - MEDIUM

EASTING:
361350.82 meters E
NORTHING:
1677281.30 meters N
MUNICIPALITY:
Oleai
LENGTH:
250 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
VE (BFE = 9 feet)
LAND USES:
Park; Transportation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Oleai Beach is located on the leeward (west) coast of Saipan, north of Kilili Beach Park (Civic Center) and south of Quartermaster Area (Red Beach), and consists of approximately 250 meters of shoreline frontage. Oleai Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, and picnicking. Public amenities included palapalas (2), grills/fire pits (2), exercise equipment (1), and a coastal access path.

ISSUES

The undeveloped backshore area and upper berm were highly compacted. There were no public restrooms observed in the area. The Oleai Beach Bar & Grill is fronted by a rock and concrete seawall. There was no evidence to indicate that the seawall is impacting beach width. There was physical evidence of erosion but it did not appear to be recent. The most active erosion appeared where the berm was bisected by surface water runoff from the unpaved parking lot.

RECOMMENDATIONS

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Install and maintain public restrooms.

Quartermaster Area (Red Beach)

Erosion Hazard Priority Rating - HIGH

EASTING:
361814.18 meters E
NORTHING:
1678881.13 meters N
MUNICIPALITY:
Oleai; Garapan South
LENGTH:
300 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
VE (BFE = 8 to 10 feet)
LAND USES:
Park; Transportation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Quartermaster Area (Red Beach) is located on the leeward (west) coast of Saipan, north of Oleai Beach and south of Beach Road Pathway, and consists of approximately 300 meters of shoreline frontage. Quartermaster Area (Red Beach) supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, and picnicking. Public amenities included picnic tables (5), benches (6), an exercise station, and a coastal access path. There are two historical monuments located in the backshore area.

ISSUES

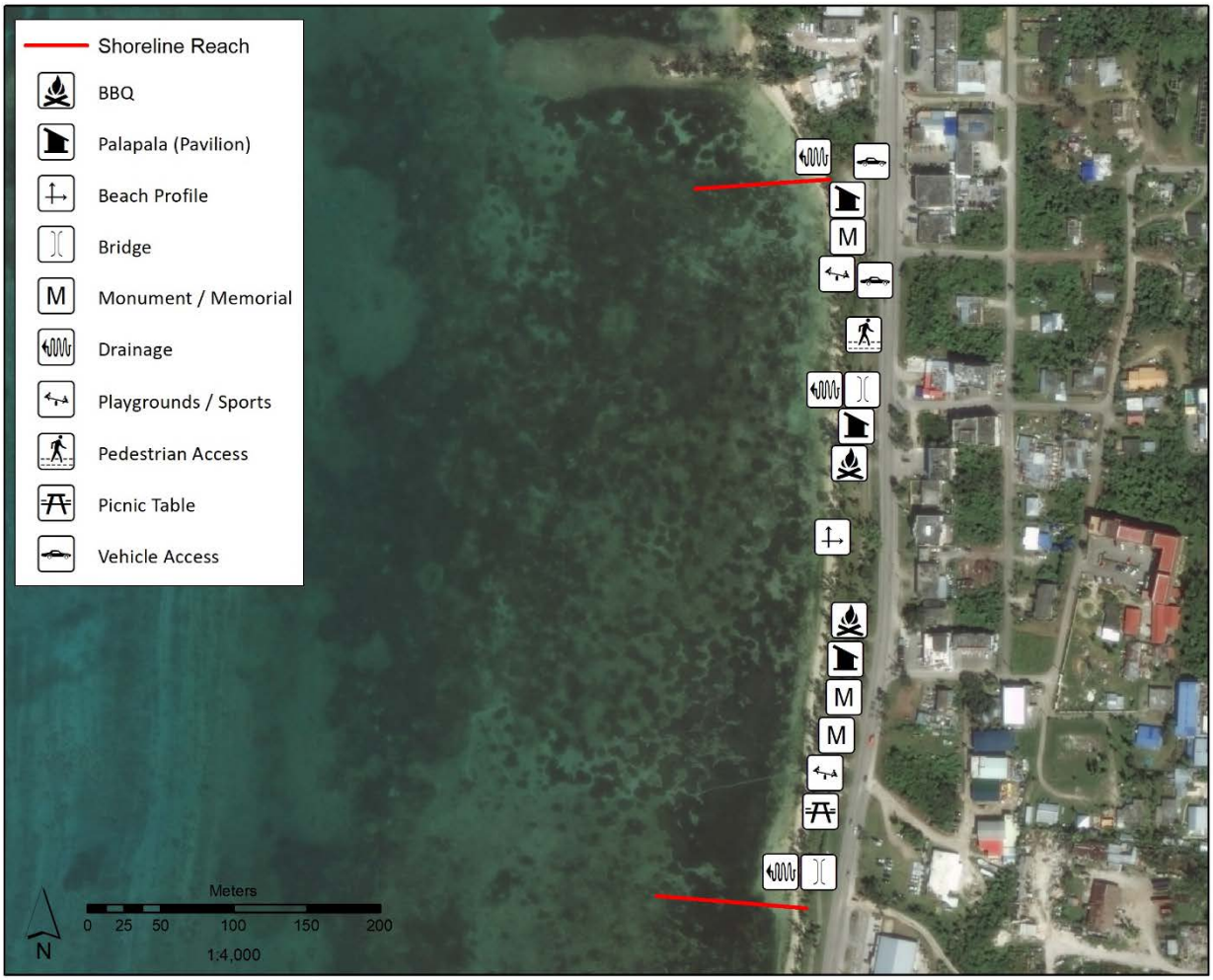
The undeveloped backshore area and upper berm were highly compacted. Most of the structures (e.g., picnic tables, benches) were in good condition. There were no public restrooms observed in the area. The beach was very narrow and significant portions were entirely covered by encroaching vegetation. Lateral shoreline access was limited as beach users were forced to wade through the water to access small pocket beaches. Erosion was observed where the berm was bisected by drainage features

RECOMMENDATIONS

- Evaluate options for beach nourishment with stabilizing structures (e.g., groins).
- Evaluate options for permanent shore protection (e.g., seawall or revetment).
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain public restrooms.

Beach Road Pathway

Erosion Hazard Priority Rating - HIGH



EASTING:
362163.11 meters E
NORTHING:
1680472.81 meters N
MUNICIPALITY:
Garapan
LENGTH:
550 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE and VE (BFE = 8 to 10 feet)
LAND USES:
Park; Transportation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Beach Road Pathway is located on the leeward (west) coast of Saipan, north of Quartermaster Area (Red Beach) and south of Fishing Base, and consists of approximately 550 meters of shoreline frontage. Beach Road Pathway supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, and picnicking. Amenities included picnic tables (5), benches (6), grills/fire pits (2), an exercise station, and a coastal access path. The 13 Fishermen Memorial Monument is located in the backshore area.

ISSUES

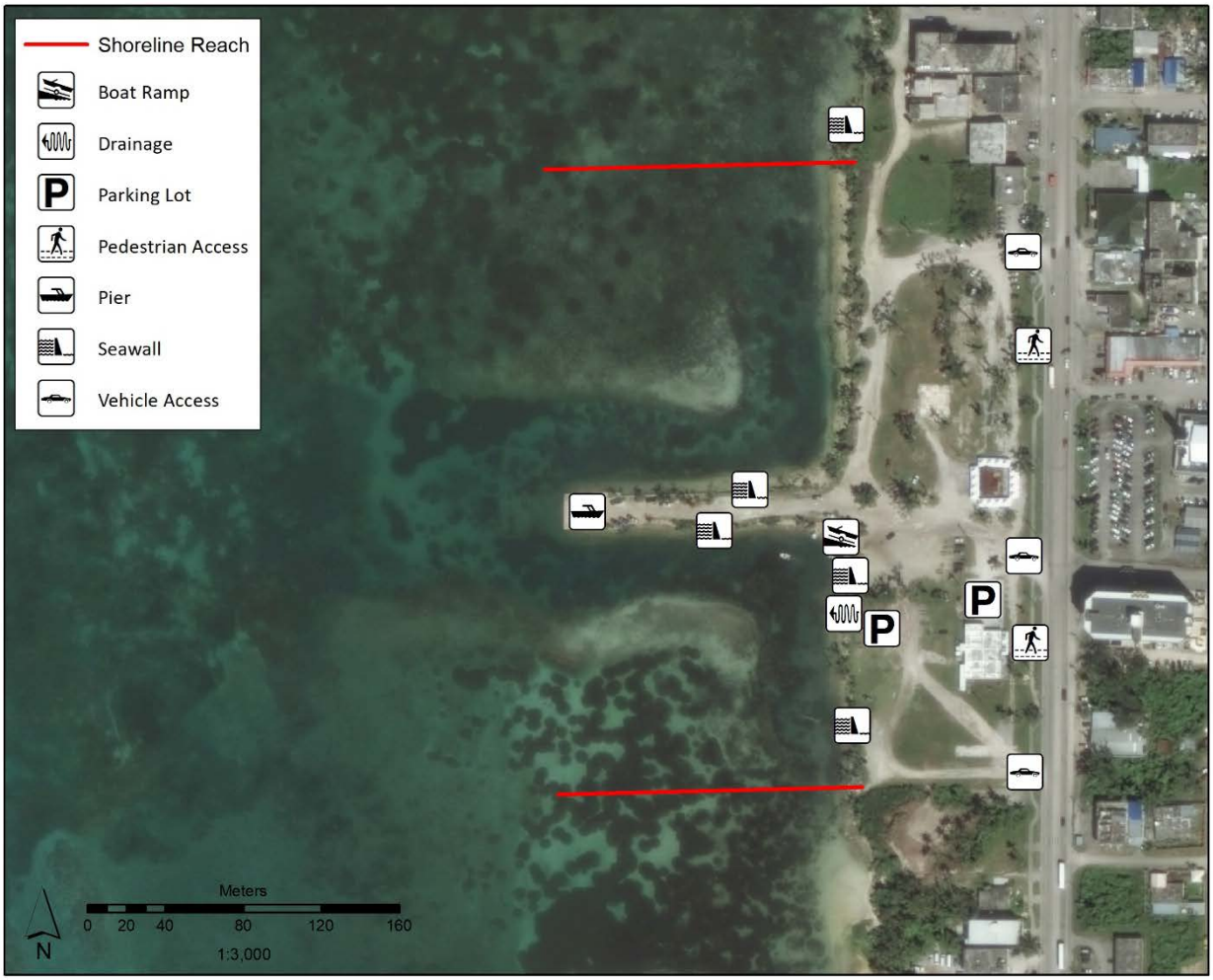
The undeveloped backshore area and upper berm were highly compacted. There were no public restrooms observed in the area. The beach was very narrow and significant portions were entirely covered by encroaching vegetation. Lateral shoreline access was limited as beach goers were forced to wade through the water to access small pocket beaches. There was physical evidence of erosion; however, the erosion did not appear to be recent. Evidence of active erosion was only observed where the berm was bisected by drainage features.

RECOMMENDATIONS

- Evaluate options for beach nourishment with stabilizing structures (e.g., groins).
- Evaluate options for permanent shore protection (e.g., seawall or revetment).
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain public restrooms.

Fishing Base

Erosion Hazard Priority Rating - HIGH



EASTING:
362100.09 meters E
NORTHING:
1681127.88 meters N
MUNICIPALITY:
Garapan
LENGTH:
350 meters
AVERAGE BEACH SLOPE:
15 to 25 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Recreation; Open Space
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Fishing Base is located on the leeward (west) coast of Saipan, north of Beach Road Pathway and south of Makaka Beach, and consists of approximately 350 meters of shoreline frontage. Fishing Base primarily supports fishing and boating activities. Public amenities included a pier, a boat ramp, and a parking area dedicated for boat trailer parking. The Garapan Public Market is located in the backshore area.

ISSUES

The undeveloped backshore area was well maintained. There were several portable public restrooms observed in the area but there were no trash or recycling receptacles. The majority of the existing structures were in a deteriorated state. There was significant structural damage to the pier and seawalls at Fishing Base. Lateral access along the shoreline was limited due to the lack of beach.

RECOMMENDATIONS

- Perform a damage assessment and prioritize repairs to Fishing Base.
- Evaluate options for permanent shore protection at Fishing Base.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.

Makaka Beach

Erosion Hazard Priority Rating - LOW

EASTING:
362037.89 meters E
NORTHING:
1682160.62 meters N
MUNICIPALITY:
Garapan
LENGTH:
300 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Commercial
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

Makaka Beach is located on the leeward (west) coast of Saipan, north of Fishing Base and south of Fiesta Beach, and consists of approximately 300 meters of shoreline frontage. Makaka Beach supports a variety of recreational uses including swimming, wading, snorkeling, and fishing. There were no public amenities observed in the area. Vehicular access to Makaka Beach was available from an unpaved road that meandered through the maritime forest. Public access was available laterally along the shoreline.

ISSUES

The undeveloped backshore area appeared to be natural and undisturbed, despite the intensity of the inshore development. There were no public restrooms or trash/recycling receptacles observed in the area. There was physical evidence of erosion in the back beach but it did not appear to be recent. The only active erosion appeared where the berm was bisected by a drainage feature.

RECOMMENDATIONS

- Identify and prioritize drainage improvements.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.

Fiesta Beach

Erosion Hazard Priority Rating - HIGH

EASTING:
362035.45 meters E
NORTHING:
1682441.89 meters N
MUNICIPALITY:
Garapan; Garapan North
LENGTH:
200 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Commercial
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Fiesta Beach is located on the leeward (west) coast of Saipan, north of Makaka Beach and south of Hyatt Beach, and consists of approximately 200 meters of shoreline frontage. Fiesta Beach supports a variety of recreational uses including swimming, wading, snorkeling, and fishing. A floating dock supports commercial diving, jet ski, and tour boat operations. Similar operations are conducted from the beach. Vehicular access to Fiesta Beach was available via a public access road located between the Fiesta Resort & Spa and the Hyatt Regency Saipan.

ISSUES

The beach has been cleared of vegetation and is actively graded and maintained by resort staff. There were no public restrooms or trash/recycling receptacles observed in the area. Fiesta Resort restroom facilities are available to the public; however, there is no signage to direct beach users to the restroom facilities. There was physical evidence of erosion along the north section of the shoreline adjacent to Hyatt Beach.

RECOMMENDATIONS

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Restore and maintain shoreline vegetation.
- Install and maintain trash/recycling receptacles.
- Provide signage to direct the public to resort restroom facilities.

Hyatt Beach

Erosion Hazard Priority Rating - HIGH

EASTING:
362055.55 meters m E
NORTHING:
1682626.65 meters N
MUNICIPALITY:
Garapan North
LENGTH:
200 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Commercial
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Wetlands
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Hyatt Beach is located on the leeward (west) coast of Saipan, north of Fiesta Beach and south of Micro Beach, and consists of approximately 200 meters of shoreline frontage. Hyatt Beach supports a variety of recreational uses including swimming, wading, snorkeling, and fishing. Commercial diving tour boat operations are conducted from the beach. Vehicular access to Hyatt Beach was available via a public access road located between the Fiesta Resort & Spa and the Hyatt Regency Saipan, with additional access available to the public at Micro Beach.

ISSUES

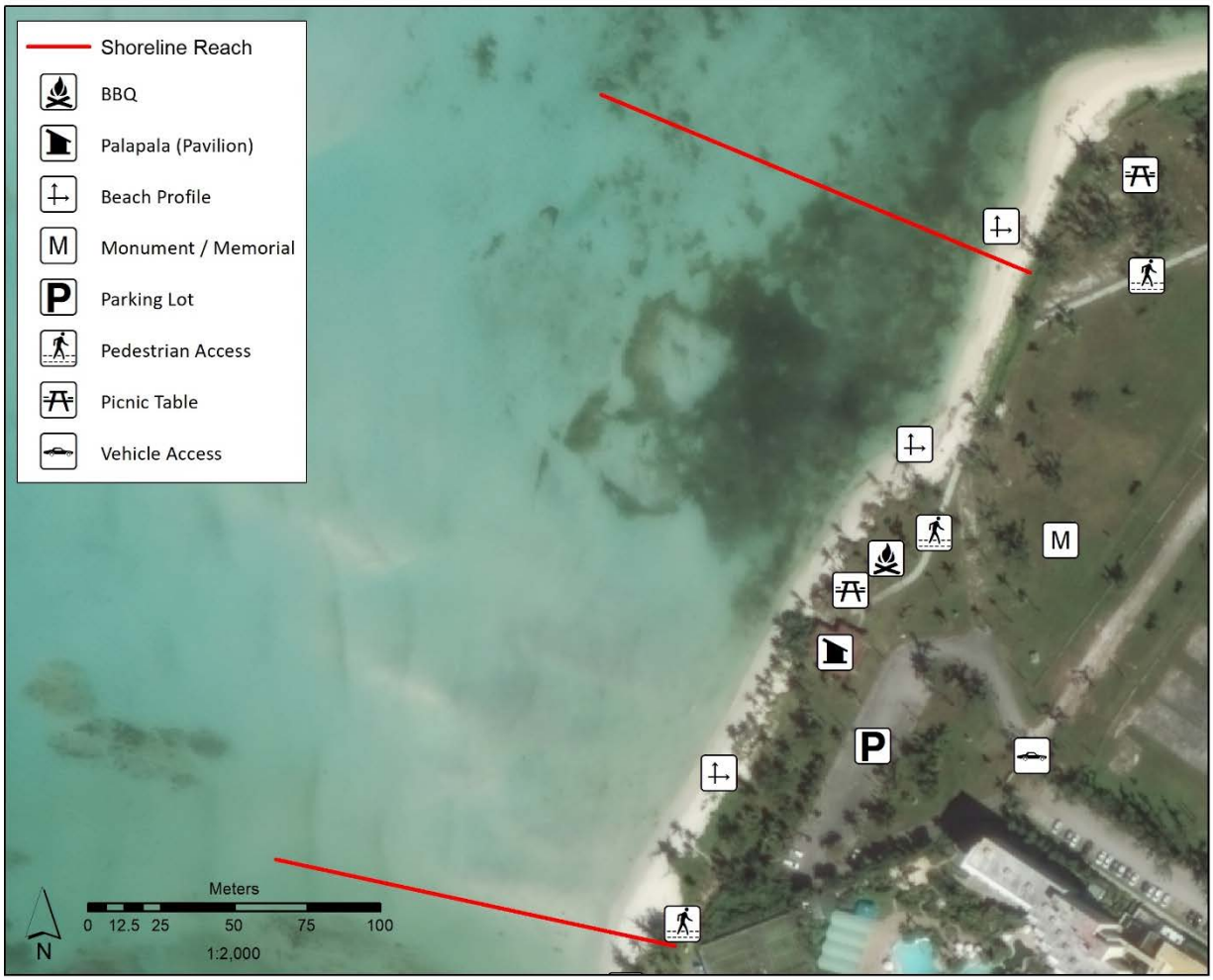
The beach was cleared of vegetation and is actively graded and maintained by resort staff. There were no public restrooms or trash/recycling receptacles observed in the area. There was physical evidence of erosion along the north section of the shoreline adjacent to Micro Beach. Additional erosion was observed adjacent to the water sports rental operation at the north end of the shoreline. Sandbags were installed to address the erosion in this area. Remnants of a collapsed pier extended from the beach into the nearshore at the north end of

RECOMMENDATIONS

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Restore and maintain shoreline vegetation.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.

Micro Beach

Erosion Hazard Priority Rating - MEDIUM



EASTING:
362109.18 meters E
NORTHING:
1682830.66 meters N
MUNICIPALITY:
Garapan North; Lower Base
LENGTH:
180 meters
AVERAGE BEACH SLOPE:
5 to 10 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Commercial; Government
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Micro Beach is located on the leeward (west) coast of Saipan, north of Hyatt Beach and south of American Memorial Park, and consists of approximately 180 meters of shoreline frontage. Micro Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, and various water sports. Park amenities included a palapala, grills/fire pits (2), and picnic tables (2). There were trash/recycling receptacles observed in the area, and a public restroom was available at American Memorial Park.

ISSUES

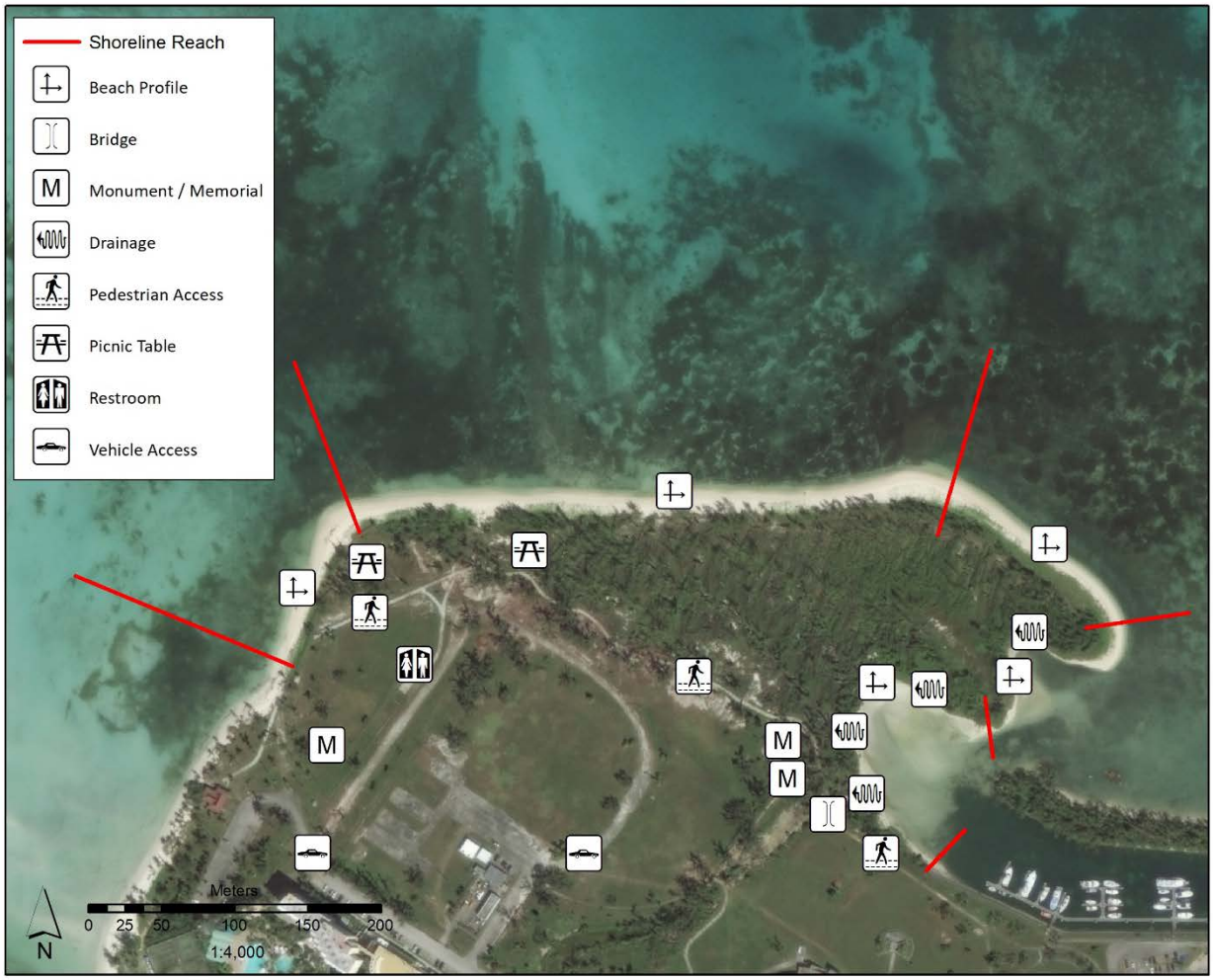
The Micro Beach shoreline appears to be fairly dynamic and vulnerable to episodic erosion. There was evidence of active erosion along the south end of the shoreline where remnants of a collapsed pier extended from the beach into the nearshore. There were dead Ironwood trees on the upper beach on the north section of the shoreline that were presumably felled by storm surge and/or high winds caused by storm surge. The beach fronting the damaged concrete path had recovered and was 35 to 40 meters wide and covered with transient vegetation at the time of the site visit.

RECOMMENDATIONS

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Repair coastal access path.
- Evaluate options to relocate the coastal access path further landward.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.

American Memorial Park

Erosion Hazard Priority Rating - LOW



EASTING:
362413.95 meters E
NORTHING:
1683017.59 meters N
MUNICIPALITY:
Lower Base
LENGTH:
1,000 meters
AVERAGE BEACH SLOPE:
5 to 10 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Government
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

American Memorial Park is located on the leeward (west) coast of Saipan, north of Micro Beach and west of Smiling Cove Marina, and consists of approximately 1,000 meters of shoreline frontage. The 133-acre park supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and various water sports. Amenities included sporting areas, picnic sites, playgrounds, and a coastal path. Trash/recycling receptacles were located throughout the park and there was a public restroom available.

ISSUES

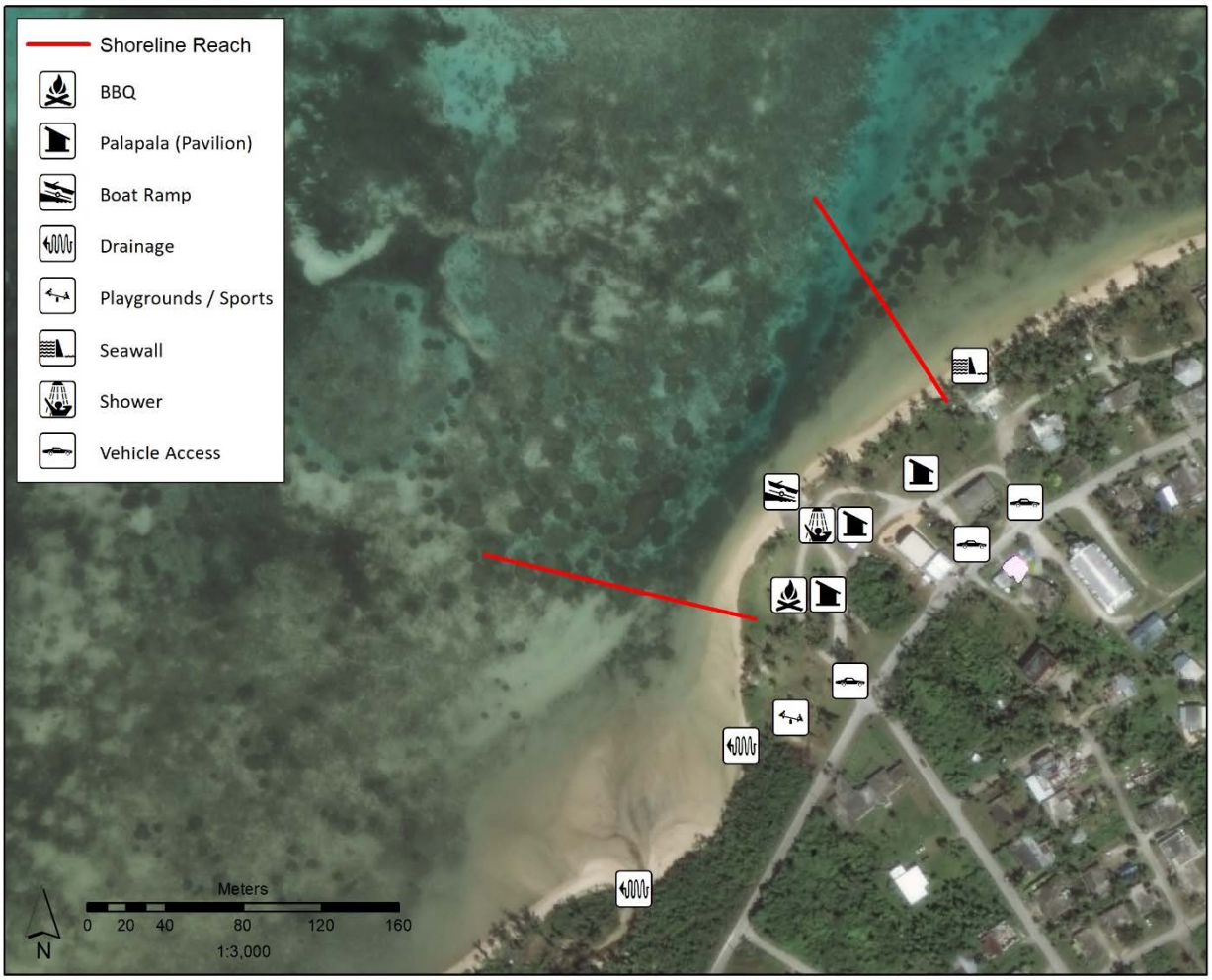
The backshore area was well-maintained and there was ample open space. The maritime forest appeared to be natural and undisturbed. Restoration work to improve wildlife habitat within the estuary is ongoing. There was some evidence of erosion along parts of the shoreline, but it appeared to be minor in nature. The majority of the shoreline appeared to stable or accreting.

RECOMMENDATIONS

- Consider dredging the entrance channel to Smiling Cove Marina to ensure safe navigation.

Tanapag Beach & Boat Ramp

Erosion Hazard Priority Rating - MEDIUM



EASTING:
366134.49 meters E
NORTHING:
1685501.16 meters N
MUNICIPALITY:
Tanapag
LENGTH:
200 meters
AVERAGE BEACH SLOPE:
5 to 10 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Conservation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Tanapag Beach is located on the leeward (west) coast of Saipan, north of American Memorial Park and south of Aqua Resort Beach, and consists of approximately 200 meters of shoreline frontage. Tanapag Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and boating. In addition to the public boat ramp, park amenities included palapalas (3), grills/fire pits (2), a playground, and an outdoor shower.

ISSUES

The backshore area was well-maintained but many of the structures (e.g., palapalas, grills/fire pits, and picnic tables) were in a deteriorated condition. There were trash receptacles available but no public restrooms were observed in the area. There was evidence of erosion but it appeared to be minor in nature and limited to the area adjacent to the drainage. The backshore topography was relatively flat inshore of the erosion scarp. There was evidence of inundation inshore of the erosion scarp.

RECOMMENDATIONS

- Identify and prioritize improvements to public amenities.
- Install and maintain public restrooms.

Aqua Resort Beach

Erosion Hazard Priority Rating - MEDIUM

EASTING:
367526.95 meters E
NORTHING:
1685995.36 meters N
MUNICIPALITY:
San Roque
LENGTH:
350 meters
AVERAGE BEACH SLOPE:
5 to 10 degrees
FLOOD ZONE:
AE and VE (BFE = 7 to 11 feet)
LAND USES:
Conservation; Commercial
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Aqua Resort Beach is located on the leeward (west) coast of Saipan, north of Tanapag Beach and south of Pau Pau Beach, and consists of approximately 350 meters of shoreline frontage. Aqua Resort Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, and boating; however, access to the shoreline is limited. The Aqua Resort Club is a private resort and shoreline access appears to be limited to resort patrons and their guests. There were no public access points or amenities observed in the area.

ISSUES

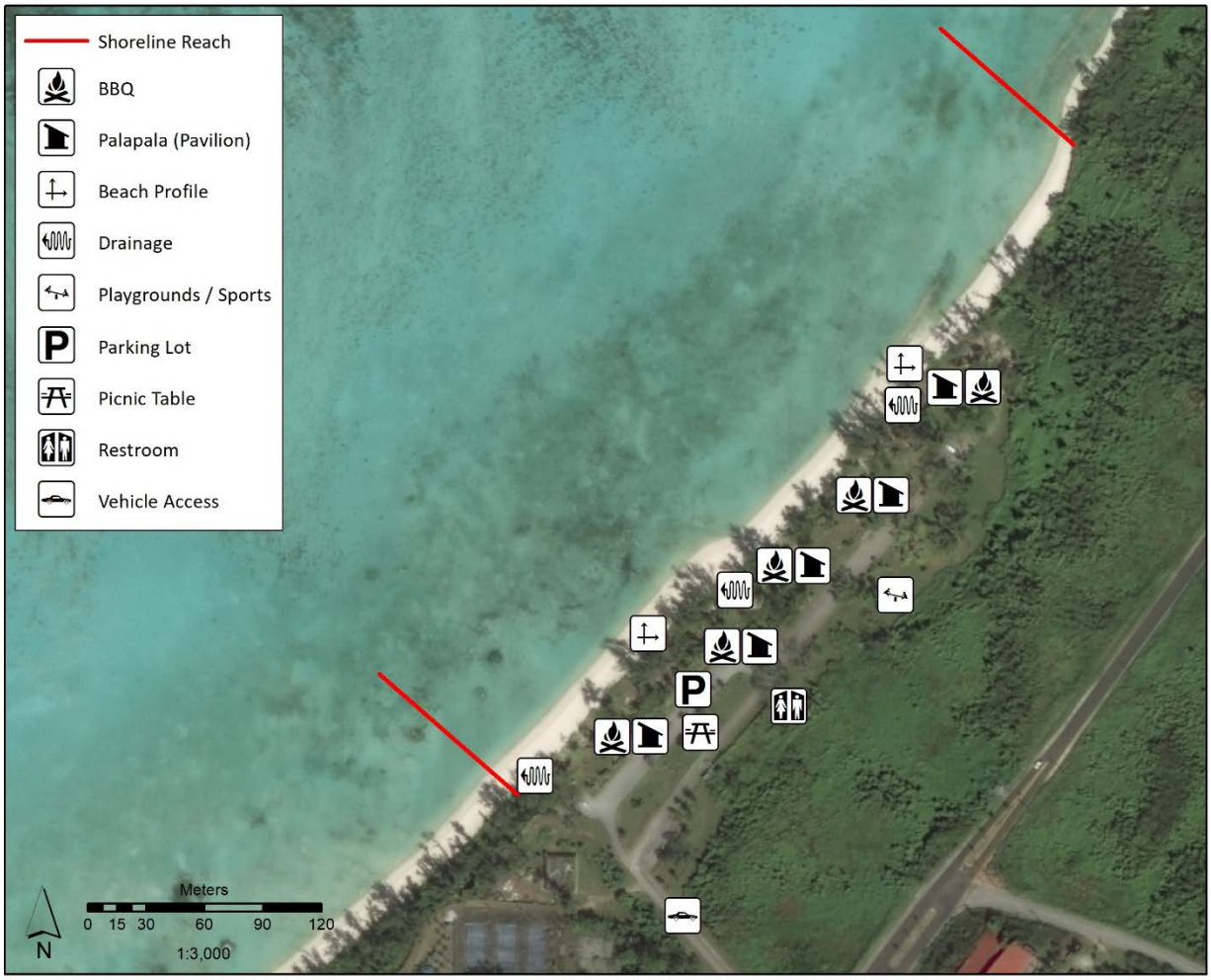
There were no trash receptacles or public restrooms observed in the area. There was evidence of active erosion along the upper berm, but it appeared to be minor. The presence of shore protection structures suggests that the area may have previously been exposed to erosion. There was no evidence to indicate that the seawall was impacting beach width. The Aqua Resort Club is a private resort and there was no public vehicular access or parking observed in the area. Shoreline access appears to be limited to resort patrons and their guests. There were no public access points or amenities observed in the area.

RECOMMENDATIONS

- Engage Aqua Resort management to improve public access to the shoreline.

Pau Pau Beach

Erosion Hazard Priority Rating - LOW



EASTING:
369066.05 meters E
NORTHING:
1687041.11 meters N
MUNICIPALITY:
As Matuis
LENGTH:
350 meters
AVERAGE BEACH SLOPE:
5 to 10 degrees
FLOOD ZONE:
AE and VE (BFE = 8 to 9 feet)
LAND USES:
Park
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

Pau Pau Beach is located on the leeward (west) coast of Saipan, north of Aqua Resort Beach and south of Wing Beach, and consists of approximately 450 meters of shoreline frontage. Pau Pau Beach supports a variety of recreational uses including swimming, snorkeling, fishing, and picnicking. Park amenities included palapalas (5), grills/fire pits (7), and a playground. Trash receptacles were located throughout the park. The park appeared to be very clean, but there are reports of trash and BBQ waste following busy weekends. There was only one public restroom within the park, but it was closed due to apparent structural damage.

ISSUES

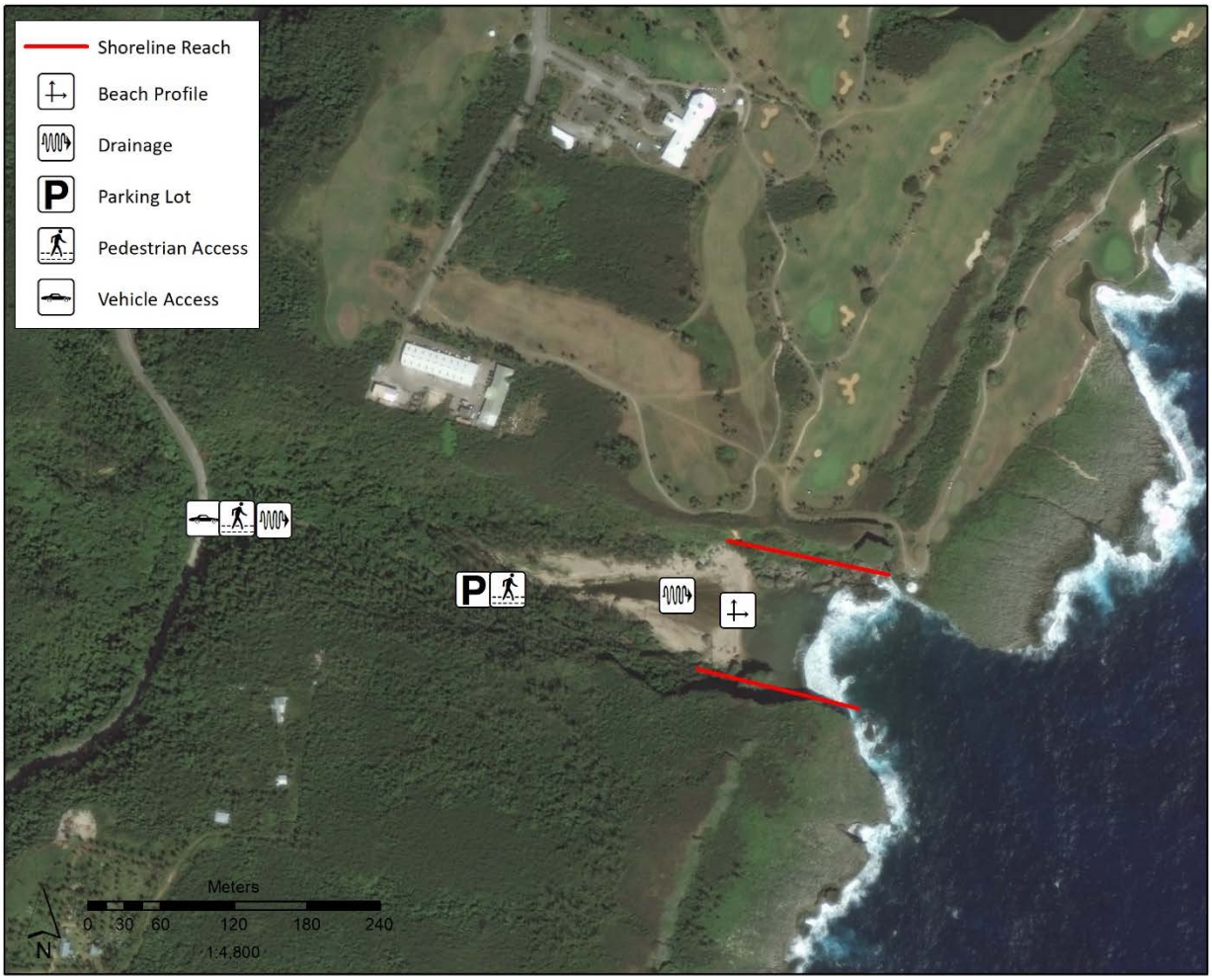
The backshore area was well-maintained and the structures appeared to be in good condition. There was evidence of active erosion along the upper berm, but it appeared to be minor. The berm was bisected at several locations by drainage features and surface water runoff from the paved parking areas. A debris field consisting of large-diameter coral cobbles was identified in the backshore area, indicating that the area had recently been inundated.

RECOMMENDATIONS

- Prioritize weekend maintenance of trash/recycling receptacles.
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Repair and maintain public restrooms.

Jeffrey's Beach

Erosion Hazard Priority Rating - MEDIUM



EASTING:
369109.97 meters E
NORTHING:
1682563.05 meters N
MUNICIPALITY:
Talofofo
LENGTH:
80 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
V (BFE = n/a)
LAND USES:
Open Space
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Wetlands
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Jeffrey's Beach is located on the windward (east) coast of Saipan, south of the Kingfisher Golf Course, and consists of approximately 80 meters of shoreline frontage. Jeffrey's Beach, the most remote and isolated shoreline included in this assessment, supports a variety of recreational uses including hiking, fishing, and sightseeing. The only access to Jeffrey's Beach is via an unpaved road located off Route 36. There were no amenities, trash/recycling receptacles, or public restrooms observed in the area.

ISSUES

Issues that affected the overall user experience at Jeffrey's Beach included limited access, lack of amenities, and the extensive amount of marine debris along the shoreline. Parking and walking along Route 36 is dangerous and hiking conditions along the unpaved access road are very poor. There were no amenities, trash/recycling receptacles, or public restrooms observed in the area. There are also concerns regarding water quality in the Talofofo Stream drainage. Heavy rain events may transport sediment and pollutants to the shoreline, which could result in excess nutrients and macroalgae in Talofofo Stream and the nearshore waters.

RECOMMENDATIONS

- Consider improvements to the coastal trail and Route 36.
- Conduct a watershed restoration project to improve water quality.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms (possibly a composting toilet).
- Coordinate beach cleanups to remove marine debris.

Tank Beach

Erosion Hazard Priority Rating - LOW

EASTING:
369560.13 meters E
NORTHING:
1678036.41 meters N
MUNICIPALITY:
Kagman
LENGTH:
450 meters
AVERAGE BEACH SLOPE:
10 to 20 degrees
FLOOD ZONE:
V (BFE = n/a)
LAND USES:
Park; Conservation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Reef
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

Tank Beach is located on the windward (east) coast of Saipan, south of Marine Beach, and consists of approximately 450 meters of shoreline frontage. Tank Beach is somewhat remote but appeared to experience frequent use. Tank Beach supports a variety of recreational uses including walking, wading, fishing, and sightseeing. Vehicular access to Tank Beach is via Tank Beach Place, an unpaved road located in the residential area of Kagman III. There was ample off-road parking available. Access to Tank Beach is via a coastal access trail from the off-road parking area.

ISSUES

Amenities were limited to the coastal access trail and a single trash receptacle. There were no public restrooms observed in the area. Food and beverages were available for purchase at a small hut located at the trailhead. Issues that affected the overall user experience at Tank Beach included the lack of amenities and the extensive amount of marine debris along the shoreline.

RECOMMENDATIONS

- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms (possibly a composting toilet).
- Coordinate beach cleanups to remove marine debris.

ISSUES & RECOMMENDATIONS

General Issues & Recommended Actions

ISSUE A: KNOWLEDGE AND UNDERSTANDING OF HISTORICAL SHORELINE CHANGE

Understanding of shoreline change on Saipan is currently limited due to the lack of historical shoreline change data. Several studies have been conducted to assess historical shoreline change, primarily along the shorelines of Saipan Lagoon and Mañagaha (Yuknavage et al., 2004; Fletcher et al., 2007; U.S. Army Corps of Engineers, 2004, 2014; Greene et al., 2016, Sea Engineering, Inc., 2017). NOAA Coral Reef Initiative Interns have also conducted field investigations to collect beach profile data at selected beaches, providing baseline data and photographs to assess shoreline change over time. Each of these studies was conducted at different spatial and temporal scales using different methodologies (e.g., beach profiles v' image analysis); therefore, it is difficult to combine the results of these studies to compile an accurate history of shoreline change on Saipan.

***Recommendation A(i):* Establish a program to monitor long-term shoreline change.**

CNMI's Coastal Resources Management Rules and Regulations require all CRM permits to ensure that adequate space be maintained between the building footprint of a project and identified hazardous lands including floodplains, erosion-prone areas, storm wave inundation areas (§15-10-305(i), Coastal Resources Rules and Regulations). Long-term shoreline change monitoring would help to identify areas that are prone to erosion, which could improve the implementation of the existing rules. Monitoring changes in shoreline position over time would also provide the data necessary to implement more progressive shoreline setbacks.

There are a variety of methods to monitor long-term shoreline change, including field-based techniques (e.g., beach profiles) and analysis-based techniques (e.g., image analysis). Field investigations can be time-consuming and labor-intensive, and interpretation of shoreline features can be somewhat subjective. It is important that staff have the necessary technical training to ensure accuracy and consistency.

An alternative approach to assessing historical shoreline change, which was used in this assessment, is to analyze historical aerial imagery to measure changes in beach width. The U.S. Geological Survey has developed a Digital Shoreline Analysis System (DSAS), a software extension to ESRI ArcGIS that enables users to calculate rate-of-change statistics from multiple historic shoreline positions. DSAS is a free software tool; however, funding would be required to purchase high-resolution imagery to enable long-term monitoring. The accuracy of the DSAS approach depends upon the quality of the images used in the analysis, and the technical ability of the user to identify and digitize shoreline positions. The DSAS approach limits the need for time-intensive field investigations, although field investigations are a useful means of ground-truthing the DSAS results. Ideally, DSAS results would be supplemented by field observations conducted by trained staff.

Maintaining a long-term shoreline change monitoring program can be challenging due to the time required to perform the analysis, and the need to provide technical training for staff. It is also important to consider the geographic scope of the monitoring program. Targeted monitoring of small sections of shoreline can provide valuable insights for individual beaches and shorelines; however, expanding the geographic scope of the program to monitor a larger area would produce a more robust dataset that would be more relevant from a policy perspective. Improved knowledge and understanding of historical shoreline change on Saipan would help to identify problem areas and inform decision-making for future shoreline management.

This work can be performed in-house or with the assistance of a professional services consultant.

1. *Perform continued aerial imagery study (i.e., DSAS).*
    - Acquire imagery. WorldView-2 (WV2) is the minimum sensor recommended with a panchromatic resolution of 0.3 to 0.5 m.
    - Imagery can be purchased from a Digital Globe reseller. The cost to purchase a single image to cover the entire island of Saipan would be approximately $6,250.
    - Additional imagery may be available through other sources, such as U.S. Army Corps of Engineers, U.S. Geological Survey, and universities.
    - Review thumbnails for images that have clear, unobstructed views of the shoreline.
    - Perform DSAS analysis to calculate shoreline rate-of-change statistics for all shorelines.
    - DSAS should be updated every 3-5 years.

2. *Perform profile measurements seasonally*
    - Ground-truth DSAS and identify seasonal or event-driven trends.
    - Establish horizontal and vertical controls for repeatability.
    - Use elevation controls to confirm backshore elevations.

Examples and References

- USGS Digital Shoreline Analysis System
- Mañagaha Island Shoreline Stability Assessment
- University of Hawaii Coastal Geology Group Historical Shoreline Change Research

ISSUE B: FRAMEWORK TO FACILITATE SEA LEVEL RISE ADAPTATION

Beach and shoreline erosion on many Pacific Islands is likely to be exacerbated by rising sea levels. A 2015 study found that, due to increasing sea level rise, average shoreline recession in Hawaii is expected to be nearly twice the historical extrapolation by 2050, and nearly 2.5 times the historical extrapolation by 2100 (Anderson et al., 2015). Sea level rise has the potential to impact beaches and shorelines on Saipan. Impacts may include loss of land due to erosion, and infrastructure damage due to inundation and flooding. Damage from extreme sea level events (e.g., king tides, storm surges, etc.) will also likely increase. While many of the beaches included in this assessment appear to be either stable or accreting, these trends could potentially change under rising sea levels. It is important to acknowledge the potential risks associated with sea level rise and develop policies and rules to minimize the impacts to Saipan's beaches and shorelines.

On June 13, 2017, the Governor of the CNMI established the CNMI Resilience Working Group, which is tasked with developing a long-term climate change adaptation plan with input from government agencies, the private sector, the community, and appropriate federal partners (Directive No. 2017-0001). The CNMI Resilience Working Group is comprised of members representing different agencies and stakeholder groups.

The State of Hawaii established the Hawaii Climate Change Mitigation and Adaptation Commission, which recently published the *Sea Level Rise Vulnerability and Adaptation Report for Hawaii*. The report focuses on sea level rise but will serve as a framework to address other climate-related threats and climate change adaptation priorities. A key component of the report is the development of detailed numerical models to estimate the potential for passive flooding, annual high wave flooding, and coastal erosion based on projected sea level rise. The report discusses the effects of projected future sea level rise on coastal hazards (i.e., passive flooding, annual high wave flooding, and coastal erosion), and the potential physical, economic, social, environmental, and cultural impacts of sea level rise in Hawaii. The report offers several recommendations for adapting to sea level rise, including:

- Support sustainable and resilient land use and community development.
- Prioritize smart urban development in areas that may be affected by sea level rise.
- Incentivize improved flood risk management.
- Enable high-value (legacy) beaches to persist with sea level rise.
- Preserve Native Hawaiian culture and communities with sea level rise.
- Protect nearshore water quality from sea level rise impacts.
- Innovative and sustainable financing/incentives to support adaptation to sea level rise.
- Research, assessment, and monitoring to support adaptation to sea level rise.
- Promote collaboration and accountability for adapting to sea level rise.

A key consideration in developing policies or rules to address sea level rise is the adoption of appropriate sea level rise projections. Sea level rise projections are available from the National Oceanic and Atmospheric Administration (NOAA, 2017) and the U.S. Army Corps of Engineers (USACE, 2013). It may be necessary to revise the projections to account for static-equilibrium effects and regional or local conditions. Developing policies and plans to account for projected future sea level rise would reduce hazard vulnerability and increase Saipan's resilience to sea level rise and coastal hazards.

Recommendation B(i): **Methodology to monitor sea level rise.**

The U.S. Army Corps of Engineers (USACE, 2011) provides guidance for calculating site-specific Relative Sea Level Change (RSLC) in their Engineering Circular EC 1165-2-212, Appendix C, and ER 1100-2-8162. A wide range of predictions for future SLR rates is given in Figure B-10 of the EC by various researchers, and the procedure produces low, intermediate, and high SLC curves following the National Research Council's (NRC) recommendation of using a multiple-scenario approach.

To facilitate calculation of site-specific SLC, the USACE has also developed a climate change website that performs the calculations presented in the EC and ER. The USACE has developed criteria for three curves which are the historic rate of SLC ("USACE Low Rate"), a modification

of the NRC-I curve ("USACE Int Rate"), and a modification of the NRC-III curve ("USACE High Rate"). NOAA SLC models have been added to the analyses presented on the website, and these rates were updated in 2017. The "NOAA Low Rate" corresponds to the "USACE Low Rate" while the "NOAA Int Low Rate" corresponds to the "USACE Int Rate." The "NOAA Int High Rate" and the "NOAA High Rate" are also included, with the "NOAA High Rate" giving the highest predictions of all the models. The website contains a database of information for the tidal stations within the USACE's jurisdiction, including Saipan, incorporating vertical land movement into the sea level change predictions. This allows the user to select a project location and project start and end years, and the website quickly calculates the projected SLC for the project site.

While the NOAA sea level rise predictions were recently updated, the predictions are subject to revision as new information is acquired and models are updated. Additionally, the applicability of the model scenario should be carefully considered. While the projections are based on the most current scientific models and measurements, discretion is necessary in selecting the appropriate scenario. Selecting the appropriate sea level change projection is a function of many parameters, including topography, coastal setting, criticality of infrastructure, potential for resilience, budget, and function. As an example, it may be best to design a power plant or hospital based on the High or Extreme rate, since those are considered critical infrastructure that would be expensive to modify and damage could have a long, far-reaching impact. On the other hand, a revetment along a coastal road or park might be designed based on a lesser rate, and the revetment could be adaptive and reconstructed as sea level rises, or the road could be relocated as part of future mitigation plans.

Recommendation B(ii): **Require development projects to account for sea level rise.**

Projects involving public infrastructure or new development should be required to consider the latest sea level projections. The USACE Sea Level Rise Calculator allows users to plot both the USACE and NOAA sea level curves in feet or meters relative to either NAVD88 or Local Mean Sea Level (LMSL) for a specified date range. The calculations can be used to evaluate potential future vulnerability based on the design life of the proposed use or development.

Recommendation B(iii): **Consider future sea level rise in establishing shoreline setbacks.**

Existing shoreline setbacks could be enhanced by considering the potential for future shoreline change due to projected sea level rise. Increasing shoreline setbacks could also reduce the potential for damage due to storm surge, which is likely to increase due to sea level rise. This approach could involve applying a buffer or multiplier to increase current shoreline setbacks based on projected sea level rise and the design life of the proposed use or development.

<u>Examples and References</u>

- U.S. Army Corps of Engineers Sea Level Rise Calculator
- Sea-Level Rise and Coastal Land Use in Hawaii
- Facing our Future: Adaptive Planning for Sea Level Rise in Maui and Hawaii Counties
- Hawaii Sea Level Rise Vulnerability and Adaptation Report
- Hawaii Climate Change Mitigation and Adaptation Commission

ISSUE C: ALTERNATIVE BASELINE FOR DETERMINING SHORELINE SETBACKS

Shoreline setbacks on Saipan are currently measured from Mean High Water (MHW), which is defined as the arithmetic mean of the high water heights observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch (NOAA, 2001).

MHW is commonly used to determine the boundary between public and private property, with some exceptions, and is commonly used as a baseline for measuring shoreline setbacks for coastal development. MHW is a fixed elevation that does not account for the unique physical features and localized processes that influence beach width and shoreline position. MHW also does not account for coastal inundation hazards, such as storm waves generated by typhoons, which Saipan is highly-exposed to.

Shoreline setbacks can be measured from a variety of baselines including datums (e.g., MHW), physical evidence (e.g., debris line or vegetation line), or physical features (e.g., berm or dune crest). U.S. Mainland states use a variety of different features and types of physical evidence to establish the baseline for measuring shoreline setbacks including the ordinary high water mark (California, Washington), ordinary high tide line (New Hampshire), seasonal high water line (Florida), vegetation line (North Carolina, Michigan, Minnesota), or berm or dune crest (Alabama, South Carolina, Virginia, Ohio). Basing shoreline setbacks on physical evidence, features, or a combination of the two, would help to ensure that development and infrastructure along Saipan's shorelines are adequately set back from coastal hazards.

The State of Hawaii implements an evidence-based approach through their Shoreline Certification program, which defines the *shoreline* as "the upper reaches of the wash of the waves, other than storm or seismic waves, at high tide during the season of the year in which the highest wash of the waves occurs, usually evidenced by the edge of vegetation growth, or the upper limit of debris left by the wash of the waves".

The State of Florida utilizes a Coastal Construction Control Line (CCCL) to reduce the vulnerability of people and infrastructure to severe storm events. The CCCL represents the landward limit of the significant damage to upland structures from water forces from a 100-year coastal storm. Structures located seaward of the CCCL are expected to be impacted by the high winds and storm surges which accompany such severe storms and therefore should be designed and built to withstand those forces.

***Recommendation C(i):* Reference a physical feature as the baseline for shoreline setbacks.**

Saipan's shoreline setbacks could be improved by using a baseline that more accurately reflects the extent of the erosion and inundation hazard along a given shoreline. Shoreline setbacks could be measured from stable features (e.g., erosion scarp, berm crest), transient feature (e.g., high tide line, ordinary high water mark, debris line, or vegetation line), or other features (e.g., cliffs, ledges). It is recommended that a qualified Coastal Geologist or Coastal Engineer assist with developing the methodology and/or identifying reference feature(s). The baseline should be resurveyed every 3 to 5 years to account for changing physical conditions along the shoreline.

Examples and References

- Hawaii Shoreline Certification Program
- Washington State Ordinary High Water Mark
- North Carolina Stable or Static Vegetation Line
- Florida Coastal Construction Control Line Program

ISSUE D: ACCOUNTING FOR SHORELINE CHANGE IN SHORELINE SETBACKS

The purpose of Saipan's shoreline setbacks is to maintain adequate space between the building footprint of a project and identified hazardous lands including floodplains, erosion-prone areas, storm wave inundation areas (§15-10-305(i), Coastal Resources Rules and Regulations). Shoreline setbacks are currently measured as specified distances inland from MHW. Setback are based on the type of zoning or proposed development with distances ranging from 35 feet to 150 feet (§15-10-350 (b), Coastal Resources Rules and Regulations). Setback distances are fixed and do not account for historical or projected shoreline change or sea level rise. Basing shoreline setbacks on historical trends would ensure that setbacks for development and infrastructure account for both current and projected vulnerability to coastal hazards.

Hawaii has adopted a progressive policy that uses historical shoreline change rates to determine shoreline setbacks. Setbacks are based on the Average Annual Erosion Rates (AAER) developed by the University of Hawaii Coastal Geology Group. The County of Maui shoreline setbacks are based on average lot depth and can range from 25 to 150 feet, plus a distance of 50 times the AAER from the shoreline. The County of Kauai multiples the AAER times a planning period of 70 to 100 years, which represents the life expectancy of structures. In some cases, the County of Kauai also requires a 10% adjustment in the AAER to account for future sea level rise. The County of Hawaii also requires projects to design for subsidence and a 2-foot rise in water level over the next 100 years (Owens et al., 2012).

***Recommendation D(i):* Consider adopting erosion rate-based shoreline setbacks.**

Erosion rate-based setbacks are not currently feasible on Saipan due to the lack of available historical shoreline change data. Erosion rate-based setbacks may also be less effective on Saipan as many beaches are currently either stable or accreting. Long-term shoreline change monitoring would help to identify areas that are prone to erosion and produce data that could be used to modify shoreline setbacks to account for erosion. Erosion rate-based setbacks would be more applicable should erosion become the dominant trend as sea levels continue to rise. Implementing erosion rate-based shoreline setbacks typically involves identification of the shoreline (e.g., datum, physical feature, reference feature), and a setback calculation based on the AAER and the dimensions of the property. For accreting shorelines, the AAER is considered to be "zero". In some cases, the shoreline setback may limit the developable area of the property, in which case modifications or exemptions can be applied.

Examples and References

- University of Hawaii Coastal Geology Group Historical Shoreline Change Research
- Hawaii Erosion Rate-based Shoreline Setbacks
- North Carolina Shoreline Setbacks

ISSUE E: COMPREHENSIVE MANAGEMENT PLANS FOR HIGH PRIORITY AREAS

Saipan includes approximately 87 km of shoreline, with sandy beaches accounting for approximately 22 km (25%) of the total shoreline. The quality of Saipan's beaches and shorelines is an important component of the island's tourism-based economy. There are many different types of beaches and shorelines, each of which is exposed to unique processes that affect the overall quality of the area. Some beaches are vulnerable to erosion, whereas others are stable or accreting. Some shorelines are vulnerable to storm surge, whereas those at higher elevations are less vulnerable. Preserving and enhancing Saipan's shorelines may require the development of sub-regional management plans to address unique needs along each shoreline.

Management plans are in place in some areas including Mañagaha and the Saipan Lagoon; however, SEI is not aware of any dedicated shoreline management plans on Saipan. The geographic scope of shoreline management plans can be large (e.g., island-wide) or small (e.g., community-level). Ideally, management regions are defined by the boundaries of distinct coastal littoral processes (i.e., littoral cells). Littoral cells are geographically limited and consist of a series of sand sources (e.g., reefs, dunes, streams) that provide sand to the shoreline; sand sinks (e.g., channels, submarine canyons) where sand is lost from the shoreline; longshore transport or littoral drift that moves sand along the shoreline, and cross-shore transport that moves sand toward and away from the shoreline. The boundary between cells is typically delineated by a physical feature, such as a headland, that disrupts longshore sediment transport. Implementing shoreline management at the littoral cell level would ensure that management strategies and plans are designed to account for and/or leverage the physical processes that are dominant within the area, and reduce potential negative impacts to adjacent shorelines.

Recommendation E(i): Identify and map littoral cells to inform management priorities.

Shoreline management strategies should, to the extent practicable, be designed to function with the natural processes within the littoral cell. Agencies and stakeholders can work collaboratively to identify issues and needs, develop management strategies, and prioritize implementation of those strategies.

This work can be performed in-house or with the assistance of a professional services consultant.

1. *Identify and characterize littoral cells.*
   - Determine criteria for establishing littoral cell boundaries.
   - Map littoral cells using a combination of geospatial data and field observations.
   - Identify and characterize the dominant physical features and processes within each cell.

2. *Conduct a needs assessment to inform management decisions.*
   - Identify data and information needs for each cell.
   - Conduct additional research as needed (e.g., numerical wave/current modeling).
   - Prioritize management plans and strategies for each cell.

Recommendation E(ii): **Comprehensive management plans for high priority areas.**
Shoreline management strategies should, to the extent practicable, be designed to function with the natural processes within the littoral cell. Agencies and stakeholders can work collaboratively to identify issues and needs, develop management strategies, and prioritize implementation of those strategies.

Examples and References

- Conservation Action Planning Handbook
- Management Plan for the Mañagaha Marine Conservation Area
- Saipan Lagoon Use Management Plan
- Hawaii Coastal Erosion Management Plan
- Beach Management Plan for Maui
- Kailua Beach and Dune Management Plan
- Washington State Shoreline Master Programs
- Waikiki Beach Special Improvement District

ISSUE F: IMPACTS OF SHORELINE VEGETATION ON BERM STABILITY AND BEACH QUALITY

The presence of vegetation along the shoreline is often a sign of a stable beach, and seaward migration of vegetation can indicate that a shoreline is accreting. Healthy shoreline vegetation can also provide wildlife habitat, prevent surface water runoff, decrease wave exposure, and reduce the impacts of erosion. It is important to maintain healthy vegetation to stabilize beach berms and act as a protective buffer from coastal hazards. SEI observed several issues relating to shoreline vegetation including: 1) clearing and grading, 2) destruction due to foot traffic, and 3) loss of recreational beach area due to encroaching vegetation.

Clearing of shoreline vegetation and grading of the beach was observed north of Laly 4 (San Isidro Beach Park), and at Fiesta Beach and Hyatt Beach. While the removal of vegetation did not appear to affect beach width at these sites, it clearly exposed the backshore infrastructure to increased risk from wave inundation and flooding. Loss of vegetation due to pedestrian traffic was observed at Kilili Beach (Civic Center), at the location of the outrigger canoe launch site (Figure 16), and Hyatt Beach, at the location of the water sports concession. Erosion was noticeably worse at these locations than the surrounding areas. Loss of vegetation was also observed at Sugar Dock Beach and Pau Pau Beach, where portions of the vegetation along the berm crest had been destroyed by pedestrian and vehicle traffic.

In some cases, prolific vegetation growth can negatively impact the scenic and recreational value of a beach. This was particularly evident at Laly 4 (San Isidro Beach Park), Beach Road Pathway, and Quartermaster Area (Red Beach) (Figure 17). In some areas, the entire beach was covered by encroaching vegetation and beach users were forced to wade through the water to move laterally along the shoreline. The State of Hawaii adopted a law establishing a “beach transit corridor” to protect the right of transit seaward of the shoreline. The law authorizes the State to require abutting landowners to remove vegetation that interferes or encroaches within beach transit corridors. The law is discretionary, which provides the State with flexibility in terms of enforcement. A similar law may be appropriate for Saipan.

Figure 16 Erosion due to foot traffic at Kilili Beach (Civic Center)

Figure 17 Encroaching shoreline vegetation at Quartermaster Area (Red Beach)

The benefits of maintaining healthy vegetation along the shoreline should be balanced with the need to maintain high-quality beaches and safe lateral access along the shoreline. Removal of vegetation should not be permitted in areas where the removal would negatively impact the beach or expose the backshore area to inundation or erosion; however, a reasonable amount of vegetation removal and/or maintenance should be permitted in order to maintain recreational beach areas and enhance lateral shoreline public access.

Recommendation F(i): Establish criteria for removal of shoreline vegetation.

It is important to establish criteria to determine when shoreline vegetation should be removed. Criteria should include physical criteria, environmental criteria, and social criteria. The intent of the criteria is to determine if the vegetation is serving any beneficial functions and weigh the potential impacts of removal. The State of Hawaii has considered the following criteria in determining when to require the removal of shoreline vegetation:

Physical Criteria

- Does vegetation encroach seaward of the shoreline?
- Is the vegetation natural and being artificially-induced (e.g., irrigated)?
- Does the encroaching vegetation interfere with natural shoreline or beach processes?

Environmental Criteria

- Does the encroaching vegetation help to stabilize a beach, berm, or dune?
- Does the encroaching vegetation include native species, non-native species, or both?
- Does the encroaching vegetation provide critical habitat for wildlife?

Social Criteria

- Will vegetation removal substantially improve lateral public access?
- Will vegetation removal increase exposure to wave-induced erosion and/or inundation?
- Will vegetation removal result in degradation or loss of critical habitat?

Recommendation F(ii): **Remove encroaching vegetation that limits shoreline access.**

Identify beaches where the user experience is degraded by encroaching vegetation. Prioritize the removal of invasive species and planting of native vegetation to stabilize berms and facilitate natural beach processes. Identify beaches where the vegetation is being damaged by clearing, grading, or pedestrian and vehicle traffic. Install signage and/or barriers to direct beach users to dedicated pathways and prohibit vehicle traffic.

Examples and References

- State of Hawaii Beach Transit Corridor
- Coastal Access in Hawaii
- NOAA Living Shorelines

ISSUE G: BERM COMPACTION AND DEGRADATION DUE TO VEHICLE TRAFFIC

CNMI law prohibits any motor vehicle from entering or going upon any beach area or historic site or tourist site within the Commonwealth. "Beach area" means those areas of unconsolidated deposits along the shore with their seaward boundary being at the low water mark or reef flat platform level extending in a landward direction not less than 150 feet (9 CMC Section 5807(b)). Despite being prohibited by law, off-road driving and parking on beach berms appears to be a common practice on Saipan.

SEI observed off-road driving and parking along berms at many of the beaches included in this assessment including Sugar Dock Beach, Susupe Beach Park, Kilili Beach (Civic Center) (Figure 18), Oleai Beach, Quartermaster Area (Red Beach), and Beach Road Pathway. These areas were found to have less-stable vegetation and highly-compacted soils along the berm crest. Vehicle strandings are reportedly common at Oleai Beach and Sugar Dock. In some areas, off-road driving and parking may also damage nesting sites for threatened green sea turtles. In 2002, DCRM initiated an interagency educational and outreach campaign called "Walk it, Don't Drive it". Bollards, access gates, and educational signage were installed to discourage beach driving.

Figure 18 Evidence of vehicle traffic on beach berm at Kilili Beach (Civic Center)

***Recommendation G(i):* Enforcement and education to reduce vehicle use on berms.**

Funding should be allocated to continue and expand the "Walk it, Don't Drive it" program to improve awareness and enforcement. Bollards, berms, or access gates should be prioritized for high-use beaches or beaches where vehicle stranding frequency has been observed to be increasing. Enhanced parking areas may also help reduce these impacts and high use beaches."

Examples and References

- "Walk it Don't Drive it"
- Black Pot Beach Park Coastal Assessment

ISSUE H: STRUCTURAL DAMAGE TO PUBLIC INFRASTRUCTURE

SEI observed several areas where public infrastructure was noticeably damaged, particularly at Fishing Base and Sugar Dock (Figure 19). In both cases, the pier docks had sustained significant structural damage, presumably caused by typhoon waves. The damage may compromise the structural integrity of the structures or cause a potential risk to public health and safety.

Figure 19 Structural damage to pier at Sugar Dock

***Recommendation H(i):* Assess damage and prioritize repairs to public infrastructure.**

A licensed Structural Engineer should conduct an assessment to identify damage to public infrastructure at Sugar Dock and Fishing Base. The assessment should include repair recommendations and cost estimates to restore the structural integrity of the structures. It is important to engage a licensed Structural Engineer in the design phase in order to ensure that the design is structurally sufficient and the appropriate means, methods, and materials are used. The Structural Engineer may request assistance from a Coastal Engineer to provide design parameters for wave forces, wave heights, and sediment transport. Structural repairs could be prioritized to address public health and safety issues, economic impacts (e.g., loss of fishery or tourism revenues), environmental impacts, or aesthetic impacts.

Inspecting shoreline structures is an important part of coastal and shoreline management. Shoreline structures such as seawalls, revetments, and groins are vital infrastructure that protects coastal property and provides a level of public safely. Given the importance of these structures, periodic inspection is necessary to evaluate their stability and functionality. While above-water conditions can be observed and assessed by engineers, maintenance workers, or even casual users, coastal structures typically have components below water that are linked to the above-water damage, and these components are rarely identified by anyone not specifically trained in underwater inspections.

Common inspections for coastal structures include:

- *New Construction Inspection* – performed immediately following construction.
- *Routine Inspection* – performed on a scheduled basis (3 to 5 years typical) until damage necessitates more frequent inspections.
- *Repair Design Inspection* – performed to quantify the extent and type of repairs necessary.
- *Repair Construction Inspection* – performed immediately following repairs.
- *Post-Event Inspection* – performed following an event such as an earthquake or typhoon.

The most common inspections for existing structures are *Routine Inspection, Repair Design Inspection,* and *Repair Construction Inspection*. These inspection types are outlined below.

1. A Coastal Engineer would perform a *Routine Inspection* to inform the client of the general condition of the structure. For coastal structures, it is typically sufficient for the Coastal Engineer to perform a visual assessment, taking notes, photographs, and measurements of general conditions. The Coastal Engineer would submit a report that documents type and extent of damage, shows typical conditions, assesses general stability, discusses the effects of the damage and impact/threat to adjacent shoreline, and makes recommendations for further monitoring or repairs. The purpose of a *Routine Inspection* is generally for determining if further inspections are warranted.

2. Depending on the results of the *Routine Inspection*, a Coastal and/or Structural Engineer would perform a *Repair Design Inspection,* which is a more detailed quantification of damage. The engineers would focus the inspection on specific areas and determining quantities necessary to design the repairs and repair methods. The engineers would submit a basis of design report, followed by construction drawings for the repair.

3. A *Repair Construction Inspection* would assess the completeness of the repair.

ISSUE I: DETERIORATED AMENITIES AT PUBLIC BEACHES AND PARKS

Amenities are an important part of the user experience. Access to basic amenities, such as trash/recycling receptacles and public restrooms, is necessary to maintain the environmental and aesthetic quality of beaches and parks. The public amenities at many beaches were in a deteriorated state and, in some cases, were completely unusable. Recreational amenities such as palapalas, picnic tables, benches, and grills/fire pits were in very poor condition, particularly at

Laly 4 (San Isidro Beach Park), Sugar Dock Beach, Susupe Beach Park (Figure 20), Micro Beach, and Tanapag Beach and Boat Ramp. Trash/recycling receptacles were only observed at half of the beaches. Public restrooms were even less common, and restrooms at Laly 4 (San Isidro Beach Park), Susupe Beach Park, Kilili Beach (Civic Center), and Pau Pau Beach were closed due to structural damage. Only one functional restroom was observed at American Memorial Park. Portable restrooms were available at Fishing Base and Pau Pau Beach. Portable restrooms were observed at Laly 4 (San Isidro Beach Park), Fishing Base, and Pau Pau Beach.

Figure 20 Structural damage to palapala at Susupe Beach Park

Recommendation I(i): **Assess damage and prioritize improvements to damaged amenities.**

Funding should be prioritized to repair damaged or deteriorated amenities, and install and maintain trash/recycling receptacles at high-use beaches. This information is presented in the beach assessments included in Appendix A. A licensed Structural Engineer should assess damaged amenities that may represent a risk to public health and safety.

Recommendation I(ii): **Repair and maintain public restroom facilities.**

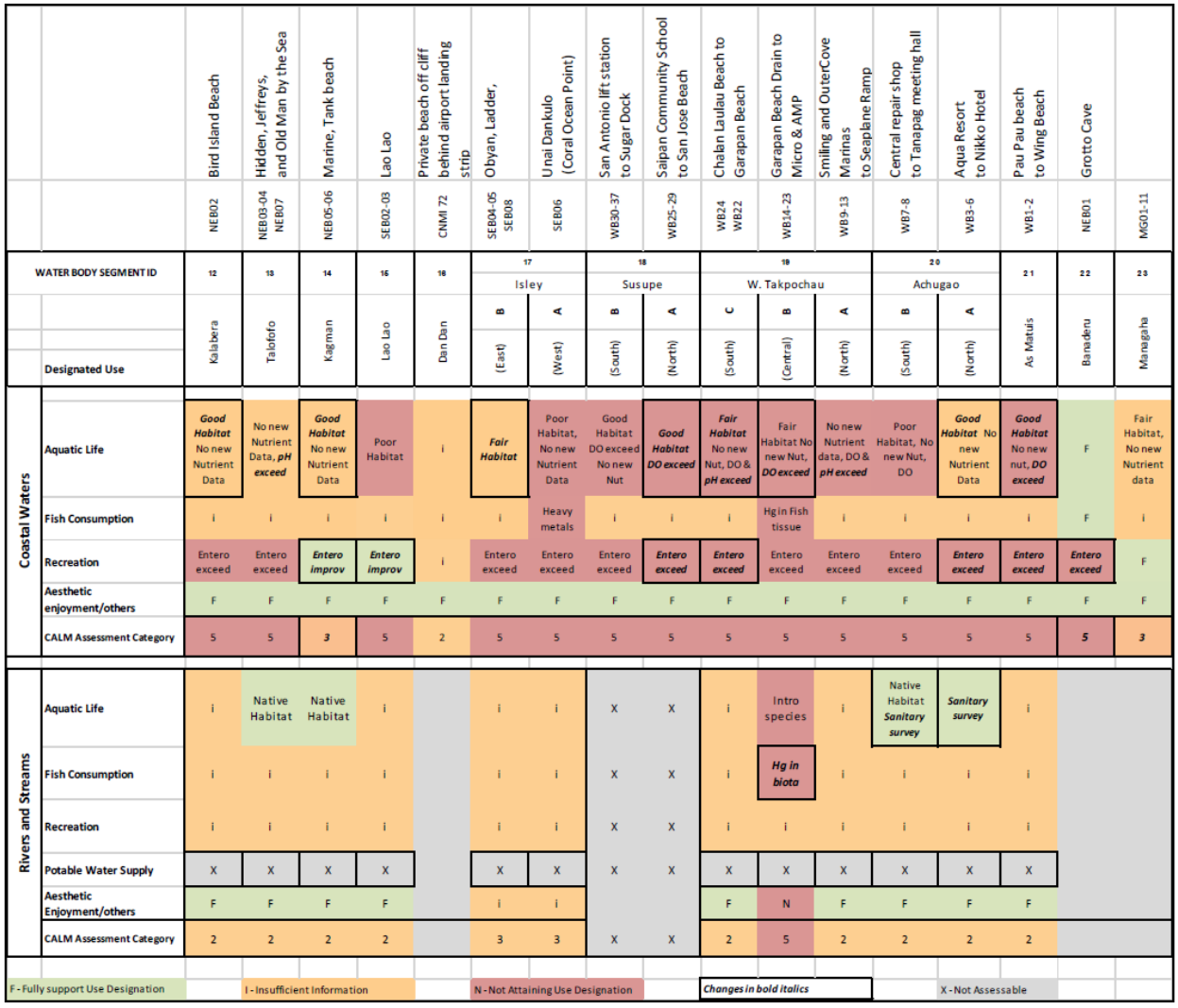
Very few functional public restrooms were identified during the site visits. It is recommended that damaged public restrooms that are connected to the public sewer system should be repaired. Composting toilets may be appropriate in remote areas or higher elevations (e.g., Tank Beach, Jeffrey's Beach).

ISSUE J: DRAINAGE IMPACTS ON BEACH BERMS AND WATER QUALITY

Drainage issues were identified at many of the beaches included in this assessment. Drainage types included culverts, stream mouths, and swales formed by surface water runoff. Erosion and beach deflation was observed in areas where beach berms were bisected by drainages and surface water runoff from impervious surfaces (e.g., parking lots). Some drainages appeared to impact nearshore water quality. Algal blooms were observed at Quartermaster Area (Red Beach) and Beach Road Pathway (Figure 21), and water quality appeared to be visually impaired within the Talofofo Stream drainage at Jeffrey's Beach. Algal blooms were also observed at Makaka Beach, Fiesta Beach, Hyatt Beach, Micro Beach, and American Memorial Park

Figure 21 Drainage impacting berm and water quality at Beach Road Pathway

BECQ conducts biennial studies to evaluate the health of CNMI waters by analyzing water quality monitoring data, the biological health of coral reefs and seagrass beds, and interpreting the impacts of mapped pollution sources caused by natural events, development, and other human activities. The most recent report was published in December 2016. A summary of the findings of the 2016 Commonwealth of the Northern Mariana Islands 303(d), 305(b) and 314 Water Quality Assessment Integrated Report is shown in Figure 22. The study corroborated that relatively large macroalgae blooms are common throughout Saipan Lagoon. The study also identified Enterococci exceedances in the coastal waters at Talofofo, which have been linked to both roaming domestic and feral animals, and increase in tourists to these remote beaches, which lack public restrooms (Bureau of Environmental and Coastal Quality, 2016). Composting toilets may be appropriate, particularly in remote areas, such as Jeffrey's Beach and Tank Beach.



		Bird Island Beach	Hidden, Jeffreys, and Old Man by the Sea	Marine, Tank beach	Lao Lao	Private beach off cliff behind airport landing strip	Obyan, Ladder,	Unai Dankulo (Coral Ocean Point)	San Antonio lift station to Sugar Dock	Saipan Community School to San Jose Beach	Chalan Laulau Beach to Garapan Beach	Garapan Beach Drain to Micro & AMP	Smiling and OuterCove Marinas to Seaplane Ramp	Central repair shop to Tanapag meeting hall	Aqua Resort to Nikko Hotel	Pau Pau beach to Wing Beach	Grotto Cave	
		NEB02	NEB03-04 NEB07	NEB05-06	SEB02-03	CNMI 72	SEB04-05 SEB08	SEB06	WB30-37	WB25-29	WB24 WB22	WB14-23	WB9-13	WB7-8	WB3-6	WB1-2	NEB01	MG01-11
WATER BODY SEGMENT ID		12	13	14	16	16	17 Isley		18 Susupe		19 W. Takpochau			20 Achugao		21	22	23
		Kalabera	Talofofo	Kagman	Lao lao	Dan Dan	B (East)	A (West)	B (South)	A (North)	C (South)	B (Central)	A (North)	B (South)	A (North)	As Matuis	Banaderu	Managaha
	Designated Use																	
Coastal Waters	Aquatic Life	***Good Habitat*** No new Nutrient Data	No new Nutrient Data, ***pH exceed***	***Good Habitat*** No new Nutrient Data	Poor Habitat	i	***Fair Habitat***	Poor Habitat, No new Nutrient Data	Good Habitat DO exceed No new Nut	***Good Habitat DO exceed***	***Fair Habitat*** No new Nut, DO & ***pH exceed***	Fair Habitat No new Nut, ***DO exceed***	No new Nutrient data, DO & ***pH exceed***	Poor Habitat, No new Nut, DO	***Good Habitat*** No new Nutrient Data	***Good Habitat*** No new nut, ***DO exceed***	F	Fair Habitat, No new Nutrient data
	Fish Consumption	i	i	i	i	i	i	Heavy metals	i	i	i	Hg in Fish tissue	i	i	i	i	F	i
	Recreation	Entero exceed	Entero exceed	***Entero improv***	***Entero improv***	i	Entero exceed	Entero exceed	Entero exceed	***Entero exceed***	***Entero exceed***	Entero exceed	Entero exceed	Entero exceed	***Entero exceed***	***Entero exceed***	***Entero exceed***	F
	Aesthetic enjoyment/others	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
	CALM Assessment Category	5	5	***3***	5	2	5	5	5	5	5	5	5	5	5	5	***5***	***3***
Rivers and Streams	Aquatic Life	i	Native Habitat	Native Habitat	i		i	i	X	X	i	Intro species	i	Native Habitat ***Sanitary survey***	***Sanitary survey***	i		
	Fish Consumption	i	i	i	i		i	i	X	X	i	***Hg in biota***	i	i	i	i		
	Recreation	i	i	i	i		i	i	X	X	i	i	i	i	i	i		
	Potable Water Supply	X	X	X	X		X	X	X	X	X	X	X	X	X	X		
	Aesthetic Enjoyment/others	F	F	F	F		i	i			F	N	F	F	F	F		
	CALM Assessment Category	2	2	2	2		3	3	X	X	2	5	2	2	2	2		

F - Fully support Use Designation | I - Insufficient Information | N - Not Attaining Use Designation | ***Changes in bold italics*** | X - Not Assessable

Figure 22 Summary of findings from 2016 CNMI water quality assessment

Recommendation J(i): **Identify and prioritize drainage improvements.**

Recommendation J(ii): **Install composting toilets at remote beaches (e.g., Jeffrey's Beach).**

Examples and References

- Conservation Action Planning Handbook (The Nature Conservancy)
- Laolao Watershed Restoration Project
- The Rain Follows the Forest (Hawaii)

ISSUE K: MARINE DEBRIS AFFECTING BEACH QUALITY

Marine debris is commonly found on beaches in the Pacific Islands. Common types of marine debris include plastics, metals, rubber, paper, textiles, and derelict fishing gear. Shorelines along the windward (east) coast of Saipan are particularly prone to the accumulation of marine debris due to their exposure to the prevailing tradewinds. SEI observed significant amounts of marine debris along the beaches at Jeffrey's Beach and Tank Beach (Figure 23).

Figure 23 Extensive marine debris on active beach at Tank Beach

The NOAA Marine Debris Program administers a grant program to support community-based marine debris removal. In 2015, the Micronesia Islands Nature Alliance received grant funding from NOAA to reduce littering and illegal dumping in Saipan by providing infrastructure for proper waste management and raising awareness about littering and marine debris through education and outreach. The NOAA Marine Debris Program has also funded non-profit organizations, such as Sustainable Coastlines Hawaii, to host beach cleanups and conduct educational programs in schools, businesses, government, and community groups.

Recommendation K(i): **Install and maintain trash/recycling receptacles at beaches/parks.**

Recommendation K(ii): **Conduct education and outreach to raise awareness about the impacts of littering and marine debris.**

Recommendation K(iii): **Coordinate community beach cleanups.**

Examples and References

- Hawaii Marine Debris Action Plan
- NOAA Marine Debris Program
- Micronesia Islands Nature Alliance
- Sustainable Coastlines Hawaii

ISSUE L: PUBLIC ACCESS TO COASTAL AREAS

Coastal access on Saipan is protected by the CNMI Constitution (2 CMC §1500 et seq.). Saipan Territory Trust Code (TTC) requires a reasonable number of public roads and paths from existing or established public roads to insure public access to public lands that abut the sea or tidal areas (67 TTC § 152). The Saipan Zoning Law (SLL 16-6) also restricts activities that can negatively impact public access in some areas. The Tourist Resort (TR) Zoning District (Section 510) requires that development of properties located along the shoreline maintain a view/public access corridor of open land with a width of at least 20% of the property width parallel to the shoreline or 30 feet wide, whichever is less. The view/public access corridor shall include a publicly accessible trail at least 6 feet wide from a public right-of-way to the shoreline. DCRM is mandated to provide public access to shorelines while ensuring that the natural resources are protected and managed in a sustainable manner.

Based on observations during field investigations, public access to beaches on Saipan was abundant, with most beaches being accessible both by vehicle and by foot. There was no public vehicular access at Aqua Resort Beach, and vehicular access at Jeffrey's Beach was limited due to poor conditions along the unpaved coastal access road. Vehicular access was also limited at Hyatt Beach and Fiesta Beach due to the high-intensity development in the backshore. Off-road parking was available at many beaches, but only four beaches offered dedicated paved parking areas (Susupe Beach Park, Kilili Beach (Civic Center), Micro Beach, and Pau Pau Beach).

Lateral and perpendicular shoreline access was available at most beaches. In some areas, lateral shoreline access was limited due to lack of beach area (Fishing Base), encroaching vegetation (Quartermaster Area (Red Beach), Beach Road Pathway), or the presence of nearly-vertical sea cliffs (Jeffrey's Beach, Tank Beach). The least accessible beach included in this assessment was Aqua Resort Beach, which had no public vehicle access or perpendicular shoreline access paths in close proximity to the shoreline. There were no ADA or ABA-compliant beach accesses identified at any of the beaches included in this assessment.

Recommendation L(i): **Improve ADA and ABA accessibility at public beach parks.**

Recommendation L(ii): **Provide public access to Aqua Resort Beach.**

Examples and References

- Public Shoreline Access Guide for Saipan, Tinian, and Rota
- Coastal Access in Hawaii

ISSUE M: OCEAN SAFETY AWARENESS AND SERVICES

Drownings are a common cause of death in the waters of Saipan. Drownings are particularly common in areas that are subject to strong rip currents, which are the major cause of drowning in the CNMI, according to Charles Guard (National Weather Service, Weather Forecast Office). Rip currents are very common in Saipan Lagoon. Damlamian and Krüger (2010) found that currents in Saipan Lagoon are greatest during high wave conditions.

The Department of Public Safety, Boating Safety Section is responsible for responding to any water related incidents 24 hours a day, 7 days a week. Such incidents include drowning, near drowning, missing divers/fishermen, overdue divers/fishermen, boat accidents, jet ski accidents, capsized vessels, distressed vessels, etc. There were no lifeguards, lifeguard towers, education signage, or rescue tubes observed at any of the beaches included in this assessment. Signage should be installed to educate or warn beach users about potentially dangerous ocean conditions, particularly in areas that are subject to strong rip currents.

Recommendation M(i): **Increase awareness of dangerous ocean conditions.**

Recommendation M(ii): **Update the *Saipan Dive/Snorkel Brochure* to include rip currents.**

Recommendation M(iii): **Provide ocean safety services at high-use beaches.**

Examples and References

- Department of Public Safety, Boating Safety Section
- Saipan Dive/Snorkel Brochure
- Hawaii Ocean Safety Website
- Rescue Tube Foundation
- Beachsafe.org

Location-Specific Issues & Recommended Actions

Of the 18 beaches that were assessed in this report, six have been identified as having *High* EHPRs based on the criteria presented earlier in Table 3. Concept-level recommendations for these beaches are presented below. The six beaches have been divided into three groups based on the recommended type of action to address the erosion threat or problem. The concepts presented below are believed to be appropriate solutions for those specific beaches; however, more detailed analyses would be necessary to determine the proper configuration for each solution. Engineering analyses to determine suitability of a particular concept would require more in-depth analyses including but not limited to a topographic/bathymetric survey, wave and circulation modeling, stability calculations, and/or sand source investigations.

SUGAR DOCK

The primary issue identified at Sugar Dock was structural damage to the pier. Spalling, cracking, and deck collapse were observed over the offshore 5 m of the pier, extending the full 10-meter width of the structure. There was evidence of previous repairs; however, these areas continue to fail, with cracking and settling extending another approximately 20 m toward shore. This condition should be considered a health and safety concern for anyone accessing or using the pier, as well as swimmers/snorkelers in the waters around the pier. Access should be restricted in the short term and a repair plan should be initiated. Sugar Dock is considered a historical site; therefore, any structural repairs would require coordination with the CNMI Division of Historic Preservation Office (HPO).

A concrete rubble masonry (CRM) seawall on the north side of the dock fronts a multi-story housing development and appears to have been constructed as part of that project. The seawall shows signs of undermining. It appears that the foundation was not constructed deep enough to account for sand loss, which is a common error in seawall construction. As the sand eroded, the base of the seawall became exposed, and wave action has caused undermining of the wall. Undermined seawalls have reduced structural stability and tend to exhibit cracking as the wall settles. Additionally, sinkholes tend to form on the inshore side of undermined seawalls as material is lost from the continued wave action. Although they were not noted at the time of the site visit, cracking and sinkholes should be expected to develop over the short-term, and structural repairs should be anticipated.

The undermining could also be addressed by beach nourishment, in which sand would be placed along the beach fronting the seawall. When sand loss is gradual and the beach has a high economic value for recreation and tourism, there may justification to replenish the littoral cell with sand from offshore or other sources. Beach nourishment can be expensive and requires a supply of sand that is ideally similar in character to the native beach sand. While sand may seem like a plentiful commodity, the reality is that good quality beach sand is in short supply. There are generally three potential sources of beach-compatible sand: inland deposits (e.g., aeolian dunes), nearshore deposits (e.g., channels, harbors), and offshore deposits.

Inland dune deposits have been used for some nourishment efforts; however, the process of transport by wind preferentially selects a naturally finer grain size; therefore, dune sand tends to be composed of grains that are too fine for many beach nourishment applications. It is unclear

what (if any) inland sand resources are available on Saipan, and if they would be compatible for beach nourishment and/or maintenance purposes. In some areas, sand may be available in the nearshore waters extending from the shoreline to the reef crest. Offshore sand deposits may be present in deeper waters beyond the reef crest. Offshore sand deposits tend to have grain sizes that are finer than many beaches, and many reef-top deposits are thin and of insufficient volume for meaningful use; however, suitable offshore deposits have been found in some cases. Offshore sand sources are not well known around Saipan, and an offshore sand source investigation may be required to identify an adequate supply of compatible beach quality sand.

Offshore sand source investigations are technically challenging, and can be very expensive. Dredging and recovery operations are also labor-intensive and expensive, but have proven to be effective. Identification of a large sand resource can offer greater flexibility in dealing with beach erosion issues. A large-scale beach nourishment project would consist of the following:

1. *Needs Assessment:* A coastal engineer would use historical shoreline trends and a site inspection to assess the need for improvements to the shoreline. Once a need is established, design and planning for beach nourishment would begin.

2. *Design and Planning:*
    a. Sand Source Investigation: Offshore sand source investigations typically require geotechnical studies, including but not limited to side-scan sonar to identify bottom composition, sub-bottom profiling to determine sand thickness, jet probing to verify thickness, and vibracoring to obtain sand samples.
    b. Design: The engineer would review historical shoreline positions and calculate a design fill template that would include berm width and elevation, beach slope, and sand volume. The final design of the beach would depend on the amount of sand available. If sand stabilizing structures are included, the structures and sand fill would be designed concurrently to achieve the most effective configuration.
    c. Environmental Review: Depending on the impacts of the project, and Environmental Assessment (EA) or an Environmental Impact Statement (EIS) may be required. Marine biology and water quality assessments are typically required in this phase.
    d. Regulatory Permitting: Necessary permit applications would be prepared and submitted to the proper agencies. Permits required for this type of work in the CNMI might include Department of the Army Section 10 (River & Harbors Act) and Section 404 (Clean Water Act), Water Quality Certification or similar.
    e. Plans and Specifications: Preparation of construction plans and specifications is necessary to engage a contractor to construct the project.
    f. Competitive Bid Process: Preparation of a request-for-bids package includes a clear explanation of project objectives, scope of services, schedule, potential budgetary limitations, and certain legal documents.

3. *Construction:* Hiring a contractor to perform the construction may require a pre-bid conference, pre-qualifications, bid acceptance and review, contractor selection, award, contract negotiations, performance reports, and change orders.

One of the factors that can limit the effectiveness of beach nourishment projects is the loss of sand due to natural processes, such as longshore and cross-shore sediment transport. Containment features or structures are sometimes necessary to maintain a stable beach cell. Some areas have natural features such as headlands or reefs that disrupt sediment transport and naturally stabilize the sand. In some cases, it may be necessary to design engineered structures to maintain a stable beach, such as the T-head groins that stabilize the beach cells at Iroquois Point (Figure 24). T-head groins decrease the amount of wave energy reaching the beach and create artificial littoral cells to stabilize the sand.

Beach nourishment could provide a short-term increase in beach volume and width on the shoreline north side of Sugar Dock. The replenished beach would provide recreational opportunities as well as a protective buffer for the backshore area and infrastructure. Nourishment of the beach south of Sugar Dock may require the addition of stabilizing structures (e.g., groins) to improve stability of the sand in this area.

Figure 24 T-head groins and stable beach cells at Iroquois Point (Oahu, Hawaii)

Recommendations

- Perform a damage assessment and prioritize repairs to Sugar Dock.
- Evaluate options for beach nourishment.

FISHING BASE

The primary facilities at Fishing Base are a pier and a boat ramp which are managed by the Department of Lands and Natural Resources. A number of relict structural features remain along the shoreline, including seawalls, piles, concrete and rock rubble, and metal debris. The shoreline, which is composed primarily of fill material, appears to have limited recreational value, with the exception of the pier and boat ramp. No sand was noted along the shoreline, and dredging around the pier and along the shoreline was apparent. The seawalls surrounding Fishing Base pier are substantially damaged (Figure 25). Structural repairs to the pier are recommended for public health and safety reasons.

Figure 25 Structural damage to pier at Fishing Base

Given the nearshore dredging and the filled backshore, Fishing Base does not appear to be a good candidate for a soft solution, such as beach nourishment. Stabilizing structures, such as groins, might improve the stability of a beach nourishment project; however, the groins would likely extend into the deeper dredged area and could negatively affect boat traffic. A riprap or rubblemound revetment might be the most effective stabilizing structure along the Fishing Base shoreline. The revetment would fix the shoreline in place and protect the backshore from erosion threats, without affecting use of the pier and boat ramp.

Recommendations

- Perform a damage assessment and prioritize repairs to Fishing Base.
- Evaluate options for shore protection at Fishing Base.

QUARTERMASTER AREA (RED BEACH) AND BEACH ROAD PATHWAY

Quartermaster Area (Red Beach) and Beach Road Pathway together cover 850 m of shoreline. The shoreline consists of a narrow sandy beach, a stand of Ironwood trees, a concrete coastal path (Figure 26), and Beach Road, which is a heavily-utilized coastal road and the main thoroughfare between Garapan and the airport. The coastal path provides lateral access along the entire length of shoreline. While the coastal path and Beach Road are not presently threatened by erosion, rising sea levels and the frequency of typhoons could quickly degrade this shoreline. The importance of the coastal path and Beach Road resulted in these areas having *high* EHPRs.

Much of the shoreline was found to be sandy beach that was largely covered by transient shoreline vegetation (Morning Glory, beach grass). Both the sand and the vegetation are ephemeral and could be completely lost during a typhoon or high surf event. Significant accretion has been measured in this area, suggesting that the shoreline may have the natural capacity to recover from an episodic erosion event.

An appropriate erosion mitigation strategy for this area might be a buried seawall, sometimes referred to as a "backstop", to protect the coastal path and maintain a protective buffer between the shoreline and Beach Road. The backstop would only become exposed during episodic erosion events, and it would then function as a seawall, protecting the backshore from further erosion. A revetment could also be used as a backstop; however, a revetment would have a much larger footprint than a buried seawall.

Beach nourishment accompanied by sand stabilization structures (e.g., groins) to minimize sand movement would be an effective means for protecting the beach resource and the backshore land and infrastructure. A series of groin structures accompanied by beach fill would likely create a series of stable beach cells along this shoreline. Similar projects utilizing tuned T-head groins have been shown to provide additional marine habitat in the nearshore, improved lateral shoreline access, stable beach forms, and backshore erosion protection, and may reduce backshore inundation during storms. T-head groins with beach nourishment have been successful at Iroquois Point, Oahu, Hawaii.

While this concept could potentially address the shoreline issues along Quartermaster Area (Red Beach) and Beach Road Pathway, it would require a significant volume of beach-quality sand. It is also anticipated that this solution would be relatively expensive.

Recommendations

- Evaluate options for beach nourishment with stabilizing structures (e.g., groins).
- Evaluate options for permanent shore protection (e.g., seawall or revetment).

Figure 26 Concrete coastal path at Quartermaster Area (Red Beach)

Figure 27 Proximity of Beach Road and Beach Road Pathway to shoreline

FIESTA BEACH, HYATT BEACH, AND MICRO BEACH

Fiesta Beach and Hyatt Beach received *high* EHPRs, primarily due to limited reef width, evidence of erosion, low backshore elevation, high-intensity development in the backshore area, popularity and use intensity in the area, and potential impacts of erosion on shoreline access. The backshore area consisted of a relatively flat area with sparse, low-lying vegetation. There was evidence of active erosion along shoreline, particularly at north and south ends of Hyatt Beach (Figure 28). The beach fronting both resorts had been cleared of vegetation (Figure 29). Vegetation clearing and grading of the beach berm exposes the backshore to increased risk of wave overtopping and flooding.

Micro Beach is vulnerable to erosion but received a *medium* EHPR, primarily due to the lack of development in the backshore area; however, Micro Beach can be included in this discussion since it is adjacent to Hyatt Beach, is part of a continuous beach system, and has a history of episodic erosion. In August-September 2017, a combination of typhoon waves and high tides caused severe erosion at Micro Beach. The condition of Micro Beach before and after the recent erosion event are shown in Figure 30 and Figure 31. Micro Beach may have the capacity for natural recovery through accretion but, given the history of episodic erosion, may be a good candidate for proactive erosion management.

Potential erosion management solutions for Fiesta Beach, Hyatt Beach, and Micro Beach include berm enhancement, restoration of shoreline vegetation, beach maintenance, and beach nourishment.

A berm is an elevated feature that is located on the inshore portion of a sandy beach and may be in the form of a ridge or plateau. Berms typically form during higher water level and wave conditions. Berms can serve as a reserve of sand and provide protection from wave overtopping and flooding. Berms can be further stabilized by planting appropriate native coastal vegetation. Berm enhancement and restoration of shoreline vegetation would reduce exposure to erosion while maintaining natural beach processes, sand and water movement, and public access.

Beach maintenance would likely consist of sand pushing, which is a form of passive erosion control that does not involve engineering structures. Sand pushing is a relatively simple approach that involves moving sand from the lower beach to the upper beach to reduce exposure of the backshore to wave action. Sand pushing would require an adequate supply of beach sand and may be limited to the beach immediately fronting the property.

Beach nourishment would involve placing additional sand on the existing beach. The replenished beach would provide recreational opportunities as well as a protective buffer for the backshore area and infrastructure. The beach berm could be built higher to provide further protection against inundation and coastal flooding. Beach nourishment would require a supply of sand that is similar in grain size to the native beach sand.

Recommendations

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Restore and maintain shoreline vegetation.

Figure 28 Erosion and beach narrowing at the north end of Hyatt Beach

Figure 29 Active beach cleared of vegetation at Fiesta Beach

Figure 30 Condition of Micro Bach prior to recent erosion event (July 2017)

Figure 31 Condition of Micro Bach after recent erosion event (October 2017)

REFERENCES

Anderson, T.R., Fletcher, C.H., Barbee, M.M., Fletcher, L.N. and Romine, B.M. (2015) Doubling of coastal erosion under rising sea level by mid-century in Hawaii. Natural Hazards, 78, 75–103

Arriola, J., Camacho, R., Chambers, D., Derrington, E., Kaipat, J., Okano, R., and Yuknavage, K. (2016). 2016 Commonwealth of the Northern Mariana Islands 303(d), 305(b) and 314 Water Quality Assessment Integrated Report. Bureau of Environmental and Coastal Quality.

Carruth, R.L. (2003) Ground-Water Resources of Saipan, Commonwealth of the Northern Mariana Islands. U.S. Geological Survey Water-Resources Investigations Report 03-4178.

Cloud, P.E., Schmidt, R.G., and Burke, H.W. (1956) Geology of Saipan, Mariana Islands. U.S. Department of the Interior. Geological Survey Professional Paper 280-A. United States Government Printing Office.

Commonwealth of the Northern Mariana Islands, Department of Commerce, Central Statistics Division (2015) 2015 CNMI Statistical Yearbook.

Damlamian, H. and Krüger, J. (2010) Three dimensional wave-current hydrodynamic model for the management of Saipan Lagoon. Saipan, Commonwealth of the Northern Mariana Islands: SOPAC, 2010.

Duenas and Swavely (1985) Saipan Lagoon Use Management Plan: Volumes 2-3. Northern Mariana Islands. Coastal Resources Management Office.

Fletcher, C.H., Barbee, M., Dyer, M., Genz, A., and Vitousek, S., (2007). Mañagaha Island Shoreline Stability Assessment, Report to the Coastal Resources Management Office, Commonwealth of the Northern Mariana Islands, Saipan, 90 p.

Greene, R. and Skeele, R. (2014). Climate Change Vulnerability Assessment for the Island of Saipan. Prepared for CNMI Office of the Governor - Division of Coastal Resources Management. Saipan: Commonwealth of the Northern Mariana Islands. 102p.

Intergovernmental Panel on Climate Change. (2013). Climate Change 2013: The Physical Science Basis - Approved Summary for Policy Makers. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC: Switzerland.

Keener, V.W., Marra, J.J., Finucane, M.L., Spooner, D., and Smith, M.H. (Eds.). (2012a). Climate Change and Pacific Islands: Indicators and Impacts. Report for the 2012 Pacific Islands Regional Climate Assessment. Washington, DC: Island Press.

Kopp, R.E.; Mitrovica, J.X.; Griffies, S.M.; Yin, J.; Hay, C.C.; and Stouffer, R. J. (2010) Dynamic and static equilibrium sea level effects of Greenland Ice Sheet melt: An assessment of partially-coupled idealized water hosing experiments. *Climatic Change*. December 2010, Volume 103, Issue 3–4, pp 619–625.

Marianas Visitors Authority (2016). Marianas Visitors Authority: 2016 Annual Report.

Marra, J.J., Merrifield, M.A., and Sweet, W.V. (2012). Sea Level and Coastal Inundation on Pacific Islands. In V. W. Keener, J. J. Marra, M. L. Finucane, D. Spooner, & M. H. Smith (Eds.). Climate Change and Pacific Islands: Indicators and Impacts. Report for the 2012 Pacific Islands Regional Climate Assessment (PIRCA). Washington, DC: Island Press.

Owens, T., Hwang, D., Bohlander, A., Benesovska, A., Buika, J., and Morrison, B. (2012) Facing our Future: Adaptive Planning for Sea-level Rise in Maui and Hawaii Counties. University of Hawaii Sea Grant College Program, NOAA Grant No. NA09OAR4170060.

Starmer, J. (2009) Northern Mariana Islands Needs Assessment for the Pacific Islands Ocean Observing System. Pacific Marine Resources Institute, Saipan, CNMI.

Sweet, W.V., Kopp, R.E., Weaver, C.P., Obeysekera, J., Horton, R.M., Thieler, E.R., and Zervas, C. (2017) Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report NOS CO-OPS 083.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service (2001) Tidal Datums and Their Applications. NOAA Special Publication NOS CO-OPS 1. Silver Spring, Maryland. June 2000.

U.S. Army Corps of Engineers Honolulu Division (2004). Saipan Lagoon Erosion Study, Saipan Island, Commonwealth of the Northern Mariana Islands.

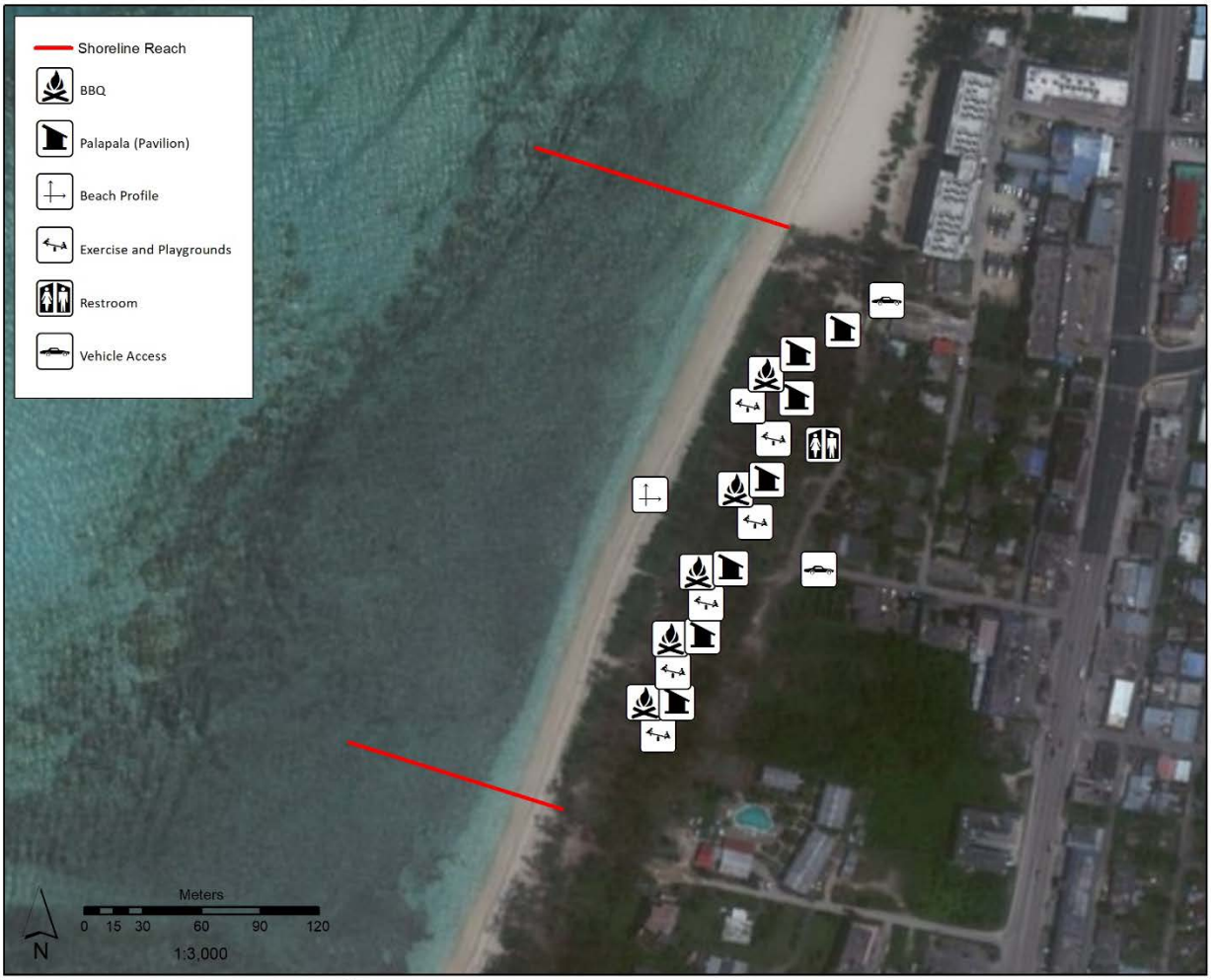
Yuknavage, K.., Stevens, H., Agulto, A., Minton, D., Lungren, I., Pakenham, A., and Sayon, C. (2004) Shifting Sands and Shifting Sands and Shoreline Change Shoreline Change at a Pacific Island at a Pacific Island. U.S. National Park National Park and Bureau of Environmental Quality, Division of Coastal Resources Management.

APPENDIX A: BEACH ASSESSMENTS

TABLE OF CONTENTS

Laly 4 (San Isidro Beach Park)

Erosion Hazard Priority Rating - LOW



EASTING:
360218.69 meters E
NORTHING:
1674740.46 meters N
MUNICIPALITY:
Chalan Kanoa South
LENGTH:
350 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
VE (BFE = 8 feet)
LAND USES:
Park; Residential; Recreation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

Laly 4 (San Isidro Beach Park) is located on the leeward (west) coast of Saipan, north of San Antonio and south of Chalan Kanoa, and consists of approximately 350 meters of shoreline frontage. Laly 4 (San Isidro Beach Park) supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and land sports. Amenities included palapalas (8), grills/fire pits (5), playgrounds (8), and sports courts (2).

ISSUES

Many of the structures (e.g., palapalas, grills, benches, etc.) were in a deteriorated condition. There was only one public restroom within the park, but it was closed due to apparent structural damage. There were no trash or recycling receptacles observed within the park. The only issue that negatively affected the quality and condition of the beach was the extensive amount of transient vegetation encroaching over the active beach face.

RECOMMENDATIONS

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain trash/recycling receptacles.
- Repair and maintain public restrooms.

Laly 4 (San Isidro Beach Park)

Municipality: Chalan Kanoa South
Easting: 360218.69 m E
Nothing: 1674740.46 m N
Length: 350 m
Inspection: June 30, 2017 (8:30 am)
Tide: 0.30 m (incoming)

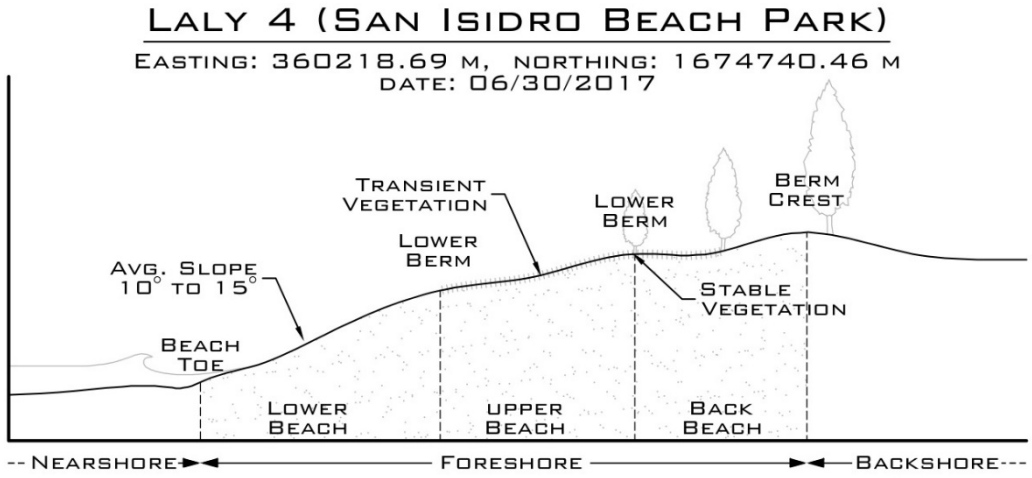
Erosion Hazard Priority Rating: LOW

Coastal Setting

Laly 4 (San Isidro Beach Park) is located on the leeward (west) coast of Saipan, north of San Antonio and south of Chalan Kanoa, and consists of approximately 350 m of shoreline frontage. The backshore area consists of an open grassy park that extends approximately 100 m inshore of the shoreline. The foreshore consists of a narrow, linear sand beach with a stable upper berm. The nearshore consists of a shallow lagoon and fringing reef. A view looking north from the south end of the beach is shown in Figure 2. A view looking south from the north end of the beach is shown in Figure 3.

Shoreline Condition

Laly 4 (San Isidro Beach Park) abuts the Saipan Lagoon and is partially protected by a shallow fringing reef that extends approximately 500 m offshore to a very shallow reef crest. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 2 m. The shoreline is west-facing at approximately 290 degrees (relative to True North). The beach is composed of fine-grain carbonate sand.



Profile 1 Typical beach profile along south section of Laly 4 (San Isidro Beach Park)

A typical beach profile was recorded along the central section of the Laly 4 (San Isidro Beach Park) shoreline (Profile 1). Photographs showing the location of the beach profile are shown in Figure 4 and Figure 5. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a narrow, exposed sand beach that progressed inshore to a transient berm along the edge of vegetation. The upper beach was gently-sloping (5 to 10 degrees) and consisted of a stable lower berm covered by transient vegetation (Morning Glory) and Ironwood saplings (Figure 6). The back beach progressed inshore to the upper berm crest, which was compacted and covered by stable vegetation with mature Ironwood trees. The backshore consisted of an open grassy area with mature Ironwood trees and soils composed of the Shioya-Urban land complex and Shioya loamy sand. The backshore topography was relatively flat inshore of the berm crest. A relict storm berm was located approximately 8 m inshore of the berm crest (Figure 7). There was no evidence of erosion or inundation inshore of the berm crest. Evidence of accretion observed during the site visit included stable berms in the foreshore, a relict storm berm in the backshore, and progressive vegetation growth seaward of the berm crest.

Laly 4 (San Isidro Beach Park) supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and land sports. Park amenities included palapalas (8), grills/fire pits (5), playgrounds (8), and sports courts (2) (Figure 8 and Figure 9). The nearshore waters are part of a jet ski exclusion zone that extends from Agingan Point to Afetna Point. Vehicular access to Laly 4 (San Isidro Beach Park) is available via two unpaved roads and ample off-road parking is available (Figure 10). Public access is available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change for Laly 4 (San Isidro Beach Park) is shown as transects 1 through 17 on Map 1. This shoreline has seen significant accretion through the time series of aerial images, primarily since about 2005. From 2005 to 2016, the shoreline was measured to have accreted by more than 20 m near the center of the beach during that time, while accreting by about 10 to 15 m near the north and south ends of the beach. Typical annual accretion rates were measured to be between 1 and 2 m/yr from 2005 to 2016, with rates as high as about 2.5 m/yr between 2011 and 2016.

Erosion Hazard Priority Rating

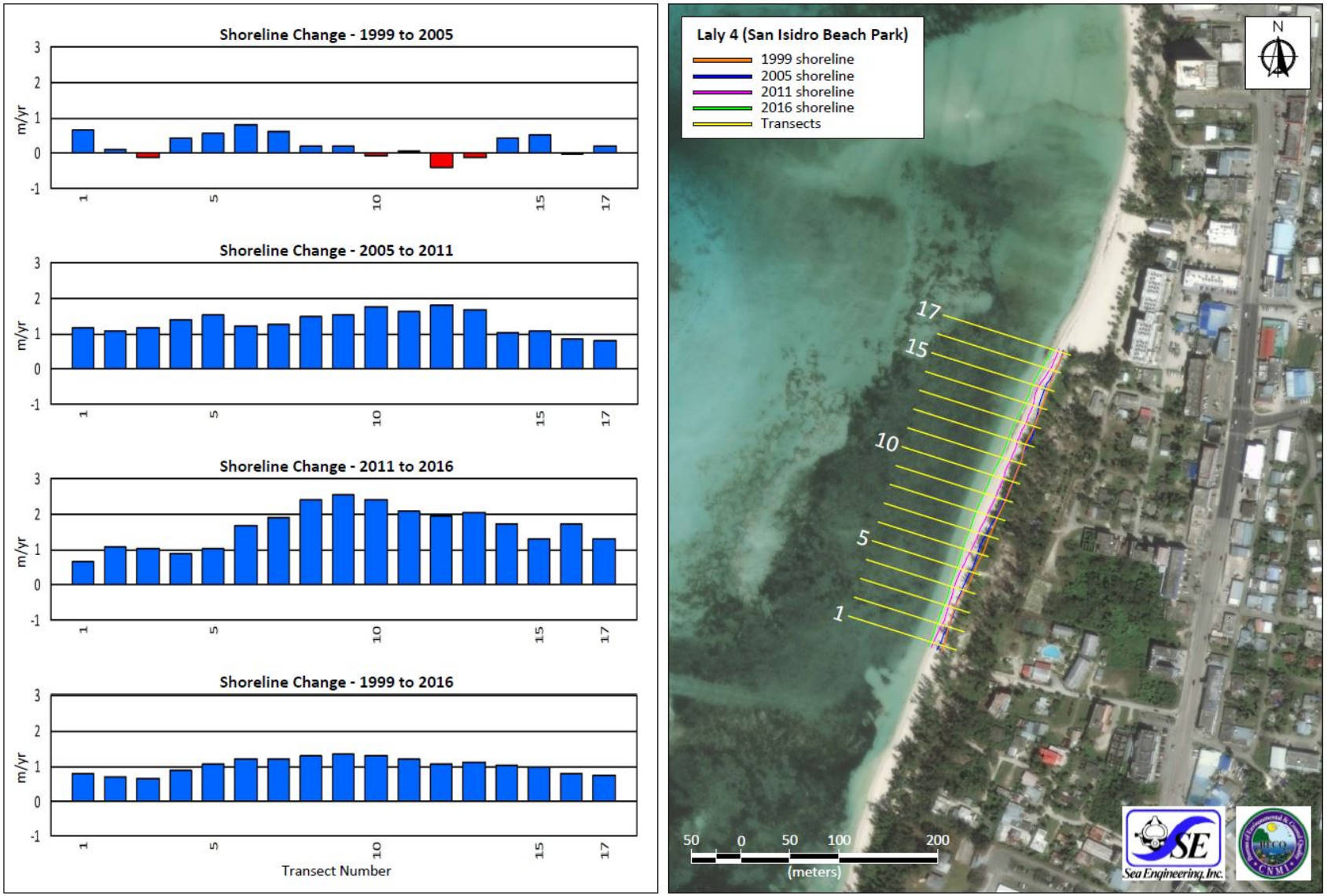
The EHPR for Laly 4 (San Isidro Beach Park) was determined to be *low*. The determination was based on presence of a protective fringing reef, lack of evidence of erosion, low-intensity development in the backshore area, and the historical shoreline change analysis, which indicated the beach is stable and accreting.

Issues & Recommendations

The grassy backshore area appeared to be well-maintained. Many of the structures (e.g., palapalas, grills, benches, etc.) were in a deteriorated condition. There was only one public restroom within the park, but it was closed due to apparent structural damage (Figure 11). There were no trash or recycling receptacles observed within the park. There was no evidence of erosion. The only issue that negatively affected the quality and condition of the beach was the extensive amount of transient vegetation encroaching over the active beach face. While this signifies a healthy, accreting beach, the encroaching vegetation significantly reduced the amount of sandy beach area available for public use.

Recommendations

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain trash/recycling receptacles.
- Repair and maintain public restrooms.



Map 1 Laly 4 (San Isidro Beach Park) historical shoreline change (1999 to 2016)

Figure 1 Laly 4 (San Isidro Beach Park), north end, looking south (6/30/2017)

Figure 2 Laly 4 (San Isidro Beach Park), south end, looking north (6/30/2017)

Figure 3 Laly 4 (San Isidro Beach Park), typical beach profile, looking south (6/30/2017)

Figure 4 Laly 4 (San Isidro Beach Park), typical beach profile, looking north (6/30/2017)

Figure 5 Laly 4 (San Isidro Beach Park), transient vegetation on active beach face (6/30/2017)

Figure 6 Laly 4 (San Isidro Beach Park), relict berms in the backshore area (6/30/2017)

Figure 7 Laly 4 (San Isidro Beach Park) public facilities (6/30/2017)

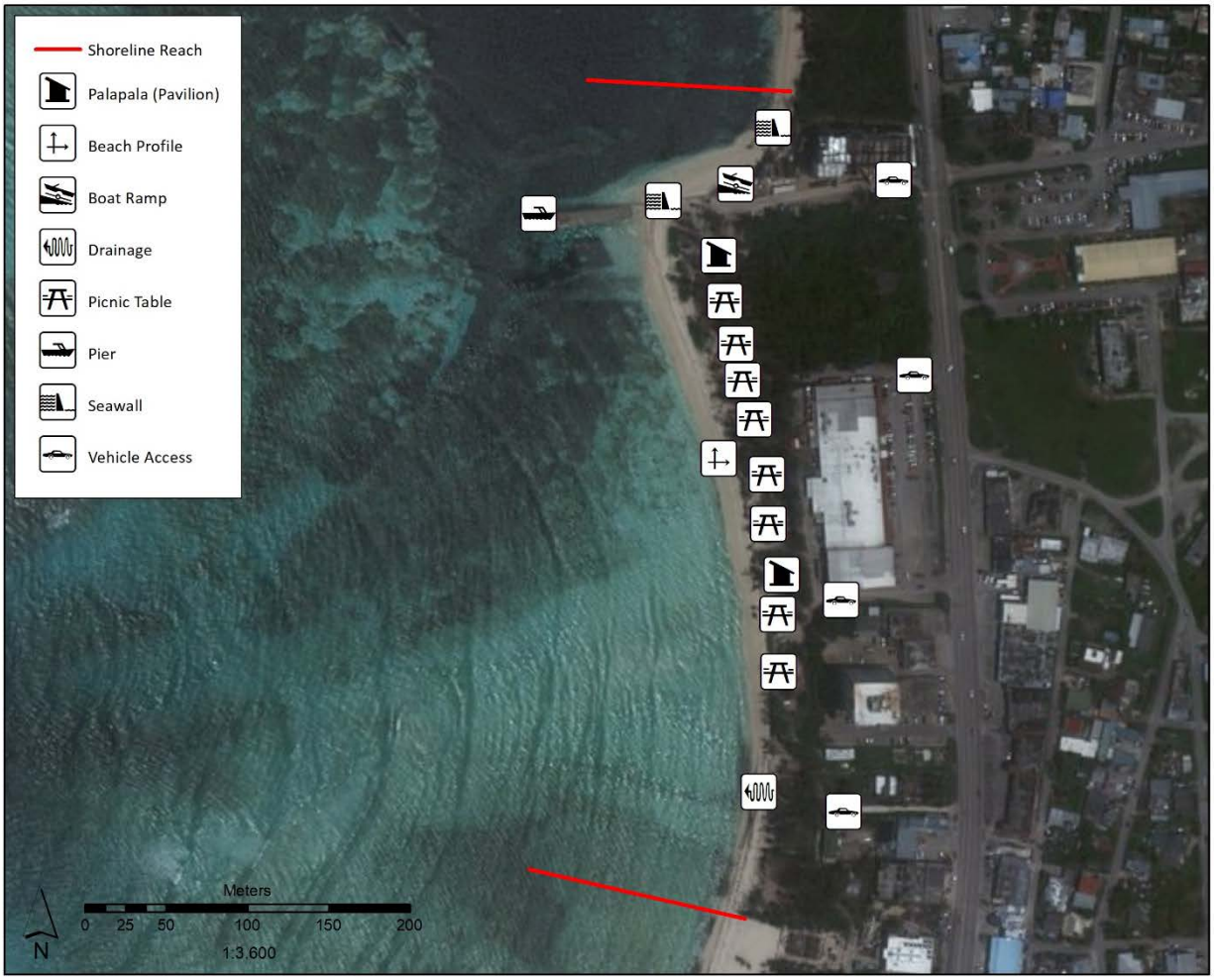
Figure 8 Laly 4 (San Isidro Beach Park) amenities in the backshore area (6/30/2017)

Figure 9 Laly 4 (San Isidro Beach Park) vehicular access road (6/30/2017)

Figure 10 Laly 4 (San Isidro Beach Park), closed public restroom (6/30/2017)

Sugar Dock Beach

Erosion Hazard Priority Rating - HIGH



EASTING:
360372.32 meters E
NORTHING:
1675257.12 meters N
MUNICIPALITY:
Chalan Kanoa
LENGTH:
550 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE and VE (BFE = 7 to 8 feet)
LAND USES:
Park; Residential; Transportation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Sugar Dock Beach is located on the leeward (west) coast of Saipan, north of Laly 4 (San Isidro Beach Park) and south of Susupe Beach Park, and consists of approximately 550 meters of shoreline frontage. Sugar Dock Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and boating. In addition to the public boat ramp and Sugar Dock, public amenities included palapalas (2), grills/fire pits (2), and picnic tables (8).

ISSUES

The backshore and upper berm were highly compacted due to vehicle traffic. Many of the structures (e.g., palapalas, grills/fire pits, and picnic tables) were in a deteriorated condition. There were no public restrooms observed in the area. The only issue identified as affecting the quality or condition of the area was the significant damage to Sugar Dock. The seawall protecting the north side of the dock was damaged due to undermining, and the seaward end of the dock was heavily damaged.

RECOMMENDATIONS

- Perform a damage assessment and prioritize repairs to Sugar Dock.
- Evaluate options for beach nourishment.
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain trash/recycling receptacles.

Sugar Dock Beach

Municipality: Chalan Kanoa
Easting: 360372.32 m E
Nothing: 1675257.12 m N
Length: 550 m
Inspection: June 30, 2017 (12:00 pm)
Tide: 0.45 m (outgoing)

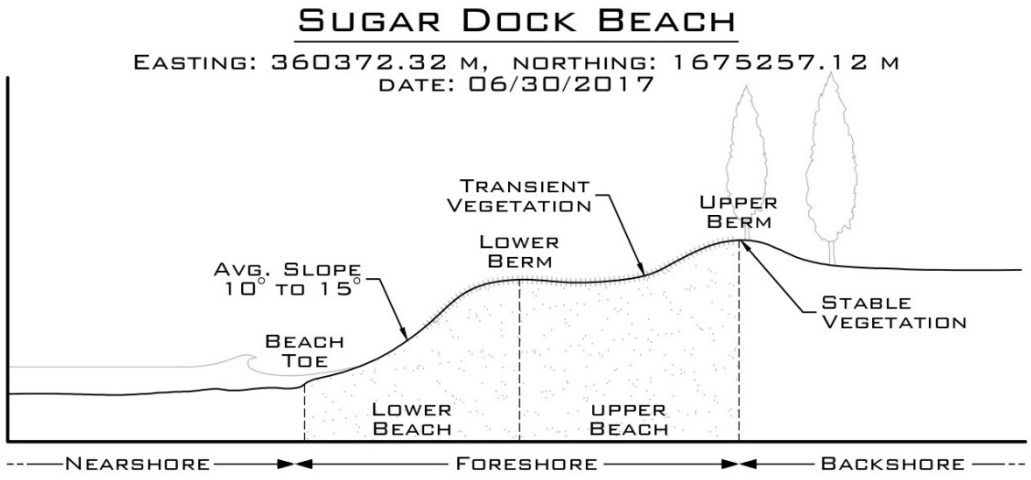
Erosion Hazard Priority Rating: HIGH

Coastal Setting

Sugar Dock Beach is located on the leeward (west) coast of Saipan, north of Laly 4 (San Isidro Beach Park) and south of Susupe Beach Park, and consists of approximately 550 m of shoreline frontage. A public dock and boat ramp are located at the north end of the shoreline. The backshore consists of an undeveloped area that extends approximately 60 m inshore of the shoreline. The foreshore consists of a narrow, linear sand beach with a stable upper berm. The nearshore consists of a shallow lagoon and fringing reef. A view looking north from the south end of the beach is shown in Figure 12. A view looking south from the north end of the beach is shown in Figure 13.

Shoreline Condition

Sugar Dock Beach abuts the Saipan Lagoon and is partially protected by a shallow fringing reef that extends approximately 500 m offshore to a very shallow reef crest. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 3 m. The shoreline is West-facing at approximately 260 degrees (relative to True North). The beach is composed of fine-grain carbonate sand. Sand grain size coarsened in a seaward direction with an accumulation of larger-diameter sand and gravel along the beach toe. For the purposes of this assessment, the Sugar Dock Beach shoreline was divided into two sections: 1) south, and 2) north.



Profile 2 Typical beach profile along south section of Sugar Dock Beach

Section 1: Sugar Dock Beach – South
The south section of the Sugar Dock Beach shoreline extends approximately 450 m from the Sandy Beach Resort north to Sugar Dock. A typical beach profile was recorded along the south section of the shoreline (Profile 2). Photographs showing the location of the beach profile are shown in Figure 14 and Figure 15. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a narrow, exposed sand beach that progressed inshore to a transient berm along the edge of vegetation. The upper beach was gently-sloping (5 to 10 degrees) with a series of discontinuous transient berms. The upper beach progressed inshore to a compacted upper berm that was covered by stable vegetation (Ironwood trees) and beach grass. The backshore consisted of an undeveloped area with mature Ironwood trees and soils composed of the Shioya-Urban land complex (Figure 16). The backshore topography was relatively flat inshore of the upper berm. Along the south section of the shoreline, the fringing reef is bisected by a sand-filled channel that is approximately 150 m wide. The channel was aligned with a drainage ditch that bisected the upper berm (Figure 17). There was evidence of active erosion adjacent to the drainage.

Section 2: Sugar Dock Beach – North
The northern section of the Sugar Dock Beach shoreline consists of the public boat ramp and Sugar Dock (Figure 18). The dock is approximately 110 m long and constructed of concrete. A flow-through system facilitates some longshore sediment transport beneath the dock (Figure 19). The shoreline on the north side of the dock is protected by a seawall constructed of grouted rock that has experienced some damage due to undermining. The public boat ramp is located on the north side of the dock. There was evidence of recent inundation inshore of the berm crest. Division of Parks and Recreation (DPR) staff were observed clearing sand from the inshore portion of the dock (Figure 20). DPR staff indicated that the backshore area is frequently inundated by storm surge during typhoons.

A seawall was constructed along the shoreline north of the boat ramp between 2014 and 2016. The seawall was constructed to protect a new multi-story public housing project (Figure 22). The seawall appeared to be damaged due to undermining (Figure 23). There was also a large pile of concrete and metal debris seaward of the seawall.

Sugar Dock Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and boating. In addition to the public boat ramp and Sugar Dock, public amenities included palapalas (2), grills/fire pits (2), and picnic tables (8) (Figure 21). The nearshore waters are part of a jet ski exclusion zone that extends from Agingan Point to Afetna Point. Vehicular access to Sugar Dock Beach is available via four paved access roads and ample off-road parking is available (Figure 22). Public access is available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Sugar Dock Beach is shown as transects 18 through 41 on Map 2. The study area shoreline is divided by Sugar Dock which is located between transects 37 and 38. Although the dock has openings that allow a limited amount of sand to pass beneath the structure, the dock effectively acts as a barrier to longshore sediment transport. The shoreline south of the dock has demonstrated minimal change based on the 1999 and 2016 aerial images; however, including the 2005 and 2011 in the comparison shows that the same shoreline has shown erosion rates of as much as 3 m/yr and accretion rates of up to about 2 m/yr.

The accumulation of sand on the north side of Sugar Dock appears to be quite variable. The 2016 aerial image shows a significant amount of sand, while much less sand was observed during the site visit. Given the dynamics of this shoreline reach, the recent history of seawall construction, and the possibility of dredging at this location to maintain the functionality of the boat ramp, the shoreline change rates on the north side of Sugar Dock should be interpreted with caution.

Erosion Hazard Priority Rating

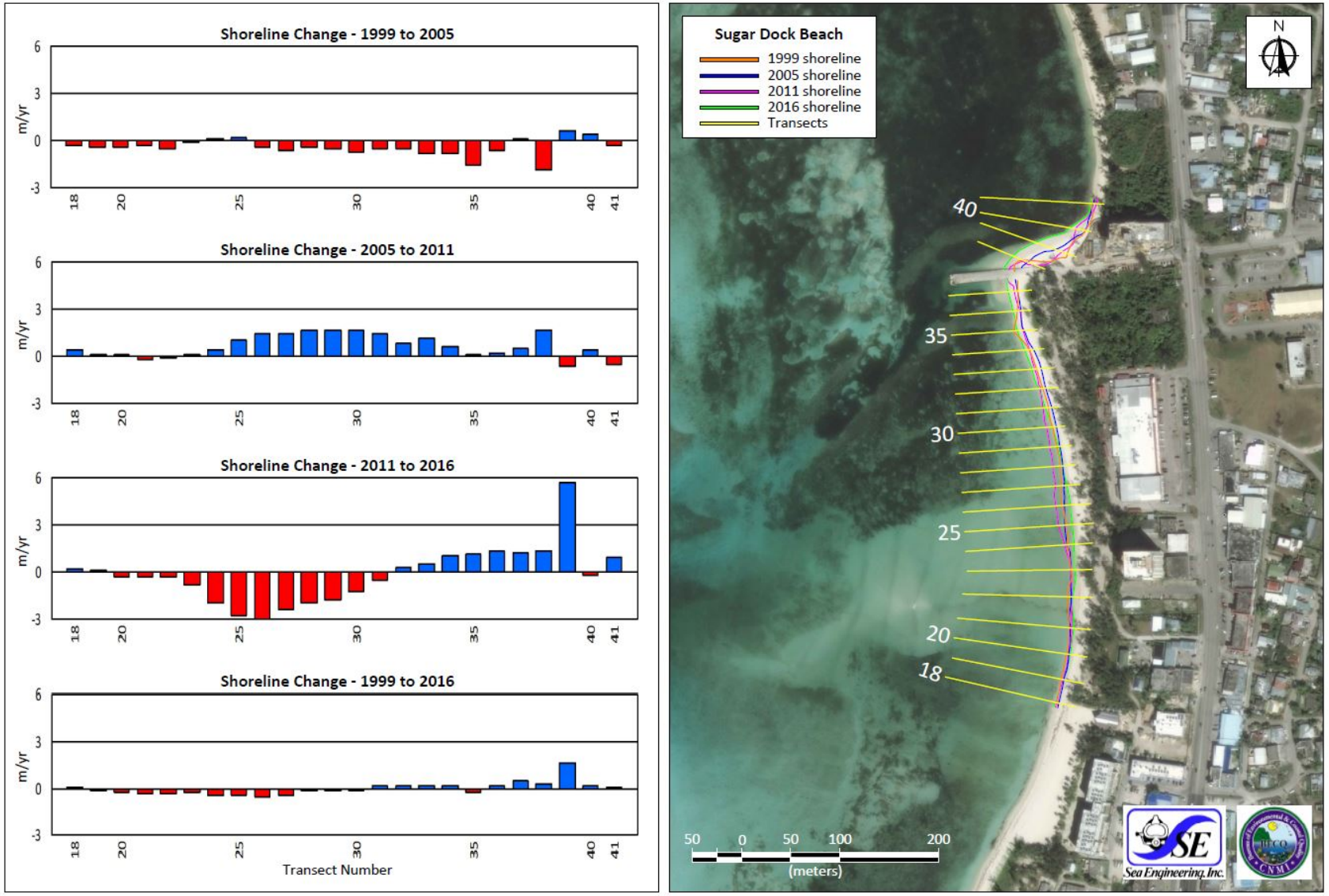
The EHPR for Sugar Dock Beach was determined to be *high*. The determination was based on evidence of erosion and wave inundation, high-intensity development in the backshore area, the popularity and intensity of use of the area, and damage to public infrastructure.

Issues & Recommendations

The undeveloped backshore and upper berm were highly compacted due to vehicle traffic. Many of the structures (e.g., palapalas, grills/fire pits, and picnic tables) were in a deteriorated condition. There were no public restrooms observed in the area. There was physical evidence of erosion but it appeared to be minor in nature and limited to the area adjacent to the drainage. The only issue identified as affecting the quality or condition of the area was the structural damage to Sugar Dock. The seawall protecting the north side of the dock was damaged due to undermining, and the seaward end of the dock was collapsed, presumably by typhoon waves (Figure 23). The seaward end of Sugar Dock appears to be unstable and should be considered a risk to public health and safety.

<u>Recommendations</u>

- Perform a damage assessment and prioritize repairs to Sugar Dock.
- Evaluate options for beach nourishment.
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.



Map 2 Sugar Dock Beach historical shoreline change (1999 to 2016)

Figure 11 Sugar Dock Beach, south end, looking north (6/30/2017)

Figure 12 Sugar Dock Beach, north end, looking south (6/30/2017)

Figure 13 Sugar Dock Beach, typical beach profile, looking south (6/30/2017)

Figure 14 Sugar Dock Beach, typical beach profile, looking north (6/30/2017)

Figure 15 Sugar Dock Beach, backshore area (6/30/2017)

Figure 16 Sugar Dock Beach, berm bisected by drainage (6/30/2017)

Figure 17 Sugar Dock Beach, public boat ramp and dock (6/30/2017)

Figure 18 Sugar Dock Beach, longshore sediment transport beneath dock (6/30/2017)

Figure 19 Sugar Dock Beach, clearing overwash deposits on dock (6/30/2017)

Figure 20 Sugar Dock Beach, backshore amenities (6/30/2017)

Figure 21 Sugar Dock Beach, new construction and seawall north of boat ramp (6/30/2017)

Figure 22 Sugar Dock Beach, seawall damage due to undermining (6/30/2017)

Susupe Beach Park

Erosion Hazard Priority Rating - LOW

EASTING:
360337.49 meters E
NORTHING:
1675955.59 meters N
MUNICIPALITY:
Susupe
LENGTH:
175 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE (BFE = 7 to 8 feet)
LAND USES:
Park
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

Susupe Beach Park is located on the leeward (west) coast of Saipan, north of Sugar Dock Beach South and south of Kilili Beach (Civic Center), and consists of approximately 175 meters of shoreline frontage. Susupe Beach Park supports a variety of recreational uses including swimming, wading, snorkeling, fishing, and picnicking. Park amenities included palapalas (4), grills/fire pits (5), picnic tables (4), and a playground.

ISSUES

The undeveloped backshore area and upper berm were highly compacted due to vehicle traffic. Many of the structures (e.g., palapalas, grills/fire pits, benches, and picnic tables) were in a very deteriorated condition. There was only one public restroom within the park, but it was closed due to apparent structural damage. Several of the palapalas were heavily damaged and appeared to be unstable, which may present a potential risk to public health and safety.

RECOMMENDATIONS

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Install and maintain trash/recycling receptacles.
- Repair and maintain public restrooms.

Susupe Beach Park

Municipality: Susupe
Easting: 360337.49 m E
Nothing: 1675955.59 m N
Length: 175 m
Inspection: June 30, 2017 (4:30 pm)
Tide: 0.20 m (outgoing)

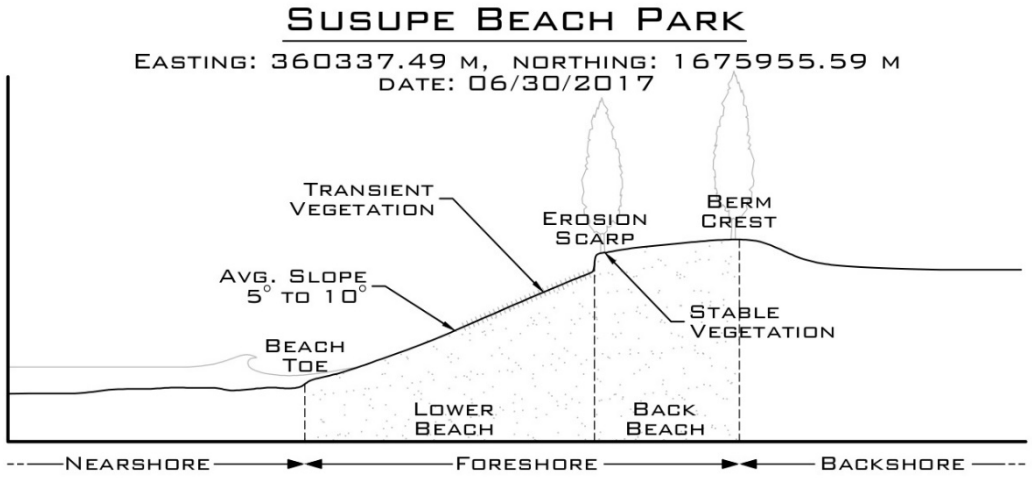
Erosion Hazard Priority Rating: LOW

Coastal Setting

Susupe Beach Park is located on the leeward (west) coast of Saipan, north of Sugar Dock Beach South and south of Kilili Beach (Civic Center), and consists of approximately 175 m of shoreline frontage. The backshore consists of a public park that extends approximately 200 m inshore of the shoreline to Beach Road. The foreshore consists of a narrow, linear sand beach with a relict erosion scarp along the upper berm. The nearshore consists of a shallow lagoon and fringing reef. A view looking north from the south end of the beach is shown in Figure 24. A view looking south from the north end of the beach is shown in Figure 25.

Shoreline Condition

Susupe Beach Park abuts the Saipan Lagoon and is partially protected by a shallow fringing reef that extends approximately 800 m offshore to a very shallow reef crest. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 2 m. The shoreline is west-facing at approximately 275 degrees (relative to True North). The beach is composed of medium to coarse-grain carbonate sand. Sand grain size coarsened in a seaward direction with an accumulation of larger-diameter sand and gravel along the beach toe.



Profile 3 Typical beach profile along central section of Susupe Beach Park

A typical beach profile was recorded along the central section of the Susupe Beach Park shoreline (Profile 3). Photographs showing the location of the beach profile are shown in Figure 26 and Figure 27. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a narrow, exposed sand beach that progressed inshore to a transient berm along the edge of vegetation. The upper beach was gently-sloping (5 to 10 degrees) and consisted of a stable berm covered by transient vegetation (Morning Glory). The back beach progressed inshore to an erosion scarp along the upper berm, which was compacted and covered by stable vegetation (mature Ironwood trees, beach grass). A historical pillbox was located on the southern end of the beach (Figure 28).

The backshore consisted of an open grassy area with mature Ironwood trees and soils composed of Shioya loamy sand (Figure 29). The backshore topography was variable and undulating from Beach Road to the berm crest. Evidence of erosion included undermining around the Ironwood root structures and observable land loss between the areas of stable vegetation. The erosion scarp along the berm crest did not appear to be active. Vegetation along the upper beach appeared to be well-established, and the presence of small Ironwood saplings on the upper beach suggests that the shoreline has likely been accreting since the last major erosion event (Figure 30). There was no evidence of erosion or inundation inshore of the erosion scarp.

Susupe Beach Park supports a variety of recreational uses including swimming, wading, snorkeling, fishing, and picnicking. Park amenities included palapalas (4), grills/fire pits (5), picnic tables (4), and a playground (Figure 31). The nearshore waters directly offshore of Susupe Beach Park are a designated marine sports area used primarily for motorized boating. The nearshore waters north of Susupe Beach Park are part of a jet ski exclusion zone. Vehicular access to Susupe Beach Park was available from the Beach Road and parking was available in a paved lot with approximately 25 stalls. Public access was available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Susupe Beach Park is shown as transects 42 through 49 on Map 3. The shoreline experienced erosion from 1999 to 2005 at rates of about 1 to 2 m/yr, while accreting at rates of up to about 1 m/yr thereafter. For the complete time series of the analysis (1999-2016), the beach shows moderate erosion.

Erosion Hazard Priority Rating

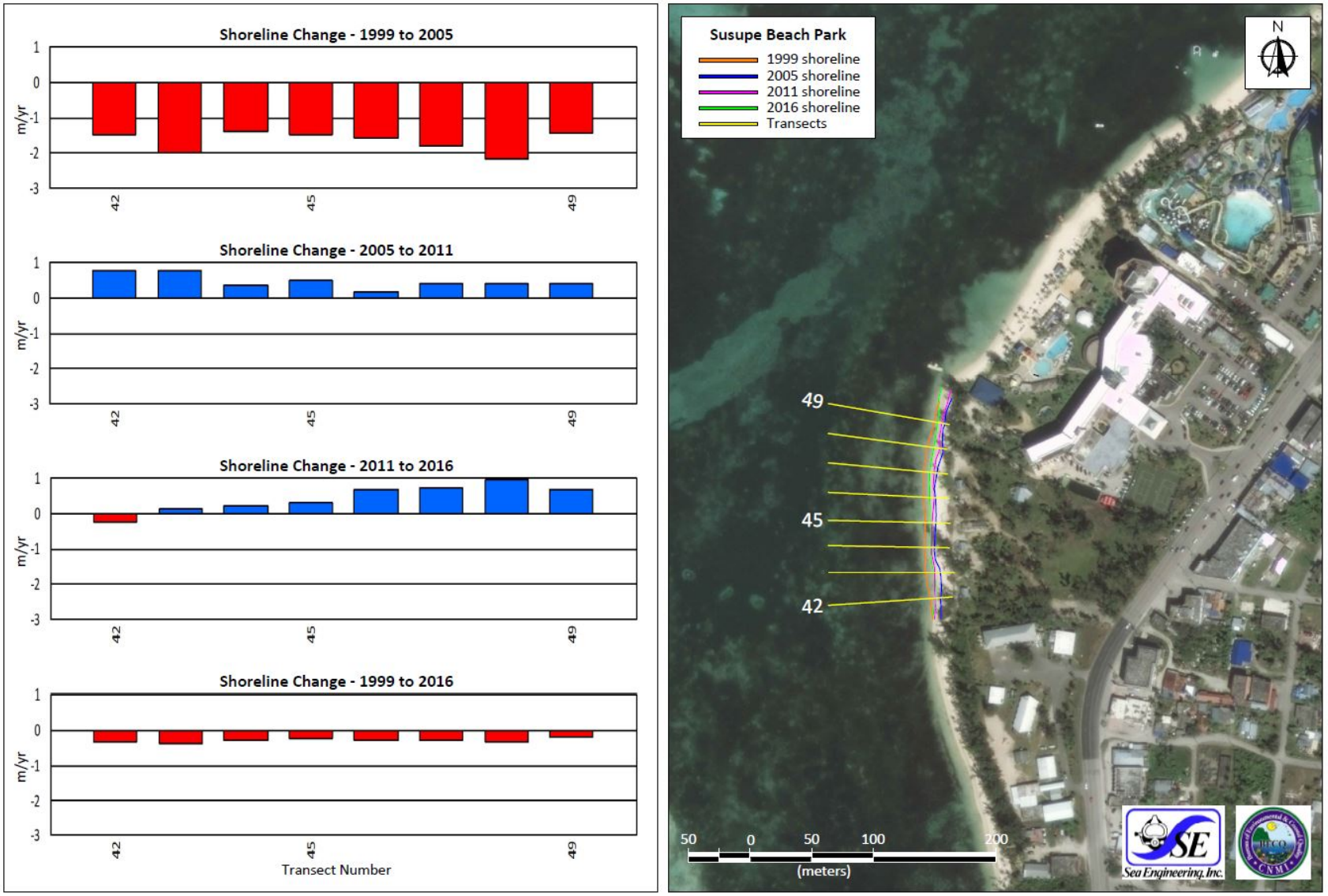
The EHPR for Susupe Beach Park was determined to be *low*. The determination was based on low-intensity development in the backshore area, lack of vulnerable infrastructure, and the historical shoreline change analysis, which indicated that, despite some historical erosion, the shoreline appears to be stable.

Issues & Recommendations

The undeveloped backshore and upper berm were highly compacted due to vehicle traffic. Many of the structures (e.g., palapalas, grills/fire pits, benches, and picnic tables) were in a very deteriorated condition. There was only one public restroom within the park, but it was closed due to apparent structural damage (Figure 32). There was physical evidence of historical erosion but current evidence indicated that the beach has been accreting since the last major erosion event. The only issue identified as negatively affecting the quality of the park was the deteriorated condition of the amenities. Several of the palapalas were heavily damaged, presumably by typhoon winds. Damage included exposed rebar, concrete spalling, and roof damage (Figure 33). Several of the structures appeared to be unstable and may present a potential risk to public health and safety.

Recommendations

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Install and maintain trash/recycling receptacles.
- Repair and maintain public restrooms.



Map 3 Susupe Beach Park historical shoreline change (1999 to 2016)

Figure 23 Susupe Beach Park, south end, looking north (6/30/2017)

Figure 24 Susupe Beach Park, north end, looking south (6/30/2017)

Figure 25 Susupe Beach Park, typical beach profile, looking north (6/30/2017)

Figure 26 Susupe Beach Park, typical beach profile, looking south (6/30/2017)

Figure 27 Susupe Beach Park, historical pillbox (6/30/2017)

Figure 28 Susupe Beach Park, backshore area (6/30/2017)

Figure 29 Susupe Beach Park, vegetation growth on upper beach face (6/30/2017)

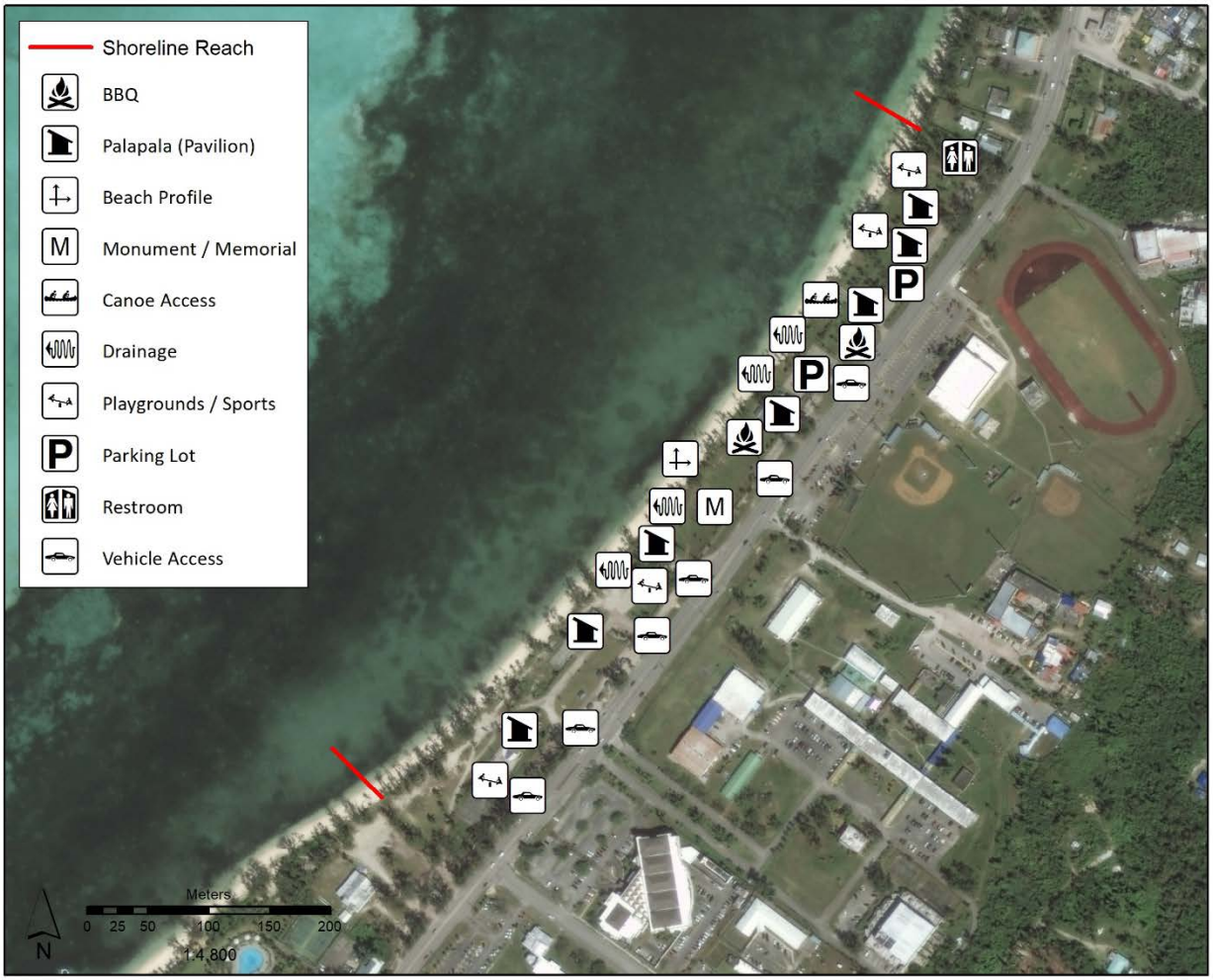
Figure 30 Susupe Beach Park, public facilities (6/30/2017)

Figure 31 Susupe Beach Park, closed public restroom (6/30/2017)

Figure 32 Susupe Beach Park, damaged palapalas (6/30/2017)

Kilili Beach (Civic Center)

Erosion Hazard Priority Rating - MEDIUM



EASTING:
361012.56 meters E
NORTHING:
1676686.06 meters N
MUNICIPALITY:
Susupe; Oleai
LENGTH:
700 meters
AVERAGE BEACH SLOPE:
5 to 15 degrees
FLOOD ZONE:
AE and VE (BFE = 7 to 9 feet)
LAND USES:
Park; Transportation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Kilili Beach (Civic Center) is located on the leeward (west) coast of Saipan, north of Susupe Beach Park and south of Oleai Beach, and consists of approximately 700 meters of shoreline frontage. Kilili Beach (Civic Center) supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, picnicking, land sports, and water sports. Park amenities included palapalas (5), grills/fire pits (4), playgrounds and exercise equipment (3), and historical sites (2).

ISSUES

The undeveloped backshore area and upper berm were highly compacted. There was only one public restroom within the park, but it was closed due to apparent structural damage. The most active erosion areas appeared to be caused by surface water runoff from several drainages and parking lots, which bisected the berm and deflated the beach face. Erosion also appeared to be caused by foot traffic at the launch site for outrigger canoes.

RECOMMENDATIONS

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Identify and prioritize drainage improvements.
- Repair and maintain public restrooms.

Kilili Beach (Civic Center)

Municipality: Susupe; Oleai
Easting: 361012.56 m E
Nothing: 1676686.06 m N
Length: 700 m
Inspection: July 1, 2017 (8:30 am)
Tide: 0.25 m (incoming)

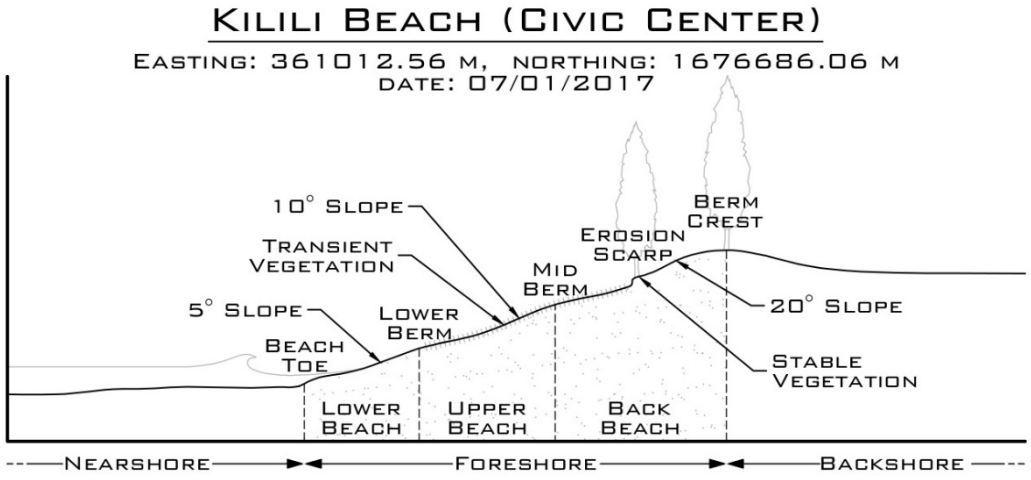
Erosion Hazard Priority Rating: MEDIUM

Coastal Setting

Kilili Beach (Civic Center) is located on the leeward (west) coast of Saipan, north of Susupe Beach Park and south of Oleai Beach, and consists of approximately 700 m of shoreline frontage. The backshore consists of a public park that extends approximately 85 m inshore of the shoreline to Beach Road. The foreshore consists of a narrow, linear sand beach with a stable upper berm. The nearshore consists of a shallow lagoon and fringing reef. A view looking north from the south end of the beach is shown in Figure 34. A view looking south from the north end of the beach is shown in Figure 35.

Shoreline Condition

Kilili Beach (Civic Center) abuts the Saipan Lagoon and is partially protected by a shallow fringing reef that extends approximately 1,200 m offshore to a very shallow reef crest. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 2 m. The shoreline is northwest-facing at approximately 300 degrees (relative to True North). The beach is composed of fine to medium-grain carbonate sand. Sand grain size coarsened in a seaward direction with an accumulation of larger-diameter sand and gravel along the beach toe.



Profile 4 Typical beach profile along central section of Kilili Beach (Civic Center)

A typical beach profile was recorded along the central section of the Kilili Beach (Civic Center) shoreline (Profile 4). Photographs showing the location of the beach profile are shown in Figure 36 and Figure 37. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a narrow, exposed sand beach that progressed inshore to a transient berm along the edge of vegetation. The upper beach was moderately-sloping (10 to 15 degrees) and consisted of a stable berm covered by transient vegetation (Morning Glory). The back beach progressed inshore to an upper berm, which was compacted and covered by stable vegetation (mature Ironwood trees, beach grass).

The backshore consisted of an open grassy area with mature Ironwood trees and soils composed of the Shioya-Urban land complex and Shioya loamy sand (Figure 38). The backshore topography was relatively flat from Beach Road to the berm crest. Evidence of erosion included undermining around Ironwood root structures and observable land loss between the areas of stable vegetation. The erosion scarp along the berm crest did not appear to be active. Vegetation along the upper beach appeared to be well-established, and the presence of small Ironwood saplings on the upper beach suggests that the shoreline has likely been accreting since the last major erosion event (Figure 39). There was no evidence of erosion or inundation inshore of the erosion scarp.

Kilili Beach (Civic Center) supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, picnicking, land sports, and water sports. Park amenities included palapalas (5), grills/fire pits (4), playgrounds and exercise equipment (3), and historical sites (2) (Figure 40 and Figure 41). The nearshore waters are a designated marine sports area used primarily for motorized boating. Vehicular access to Kilili Beach (Civic Center) was available from Beach Road. Parking was available in two paved lots with approximately 110 stalls, with additional off-road parking available (Figure 42 and Figure 43). Public access was available laterally along the shoreline. Kilili Beach (Civic Center) is used as a launch site for outrigger canoes (Figure 44).

Historical Shoreline Change

The historical shoreline change map for Kilili Beach (Civic Center) is shown as transects 50 through 85 on Map 4. For the complete time series of the analysis (1999-2016), there was no appreciative change in the shoreline positions, and thus no long-term change. For the other time periods within the overall analysis, the shoreline cycled between erosion and accretion, with rates of up to about 1 m/yr for either condition.

Erosion Hazard Priority Rating

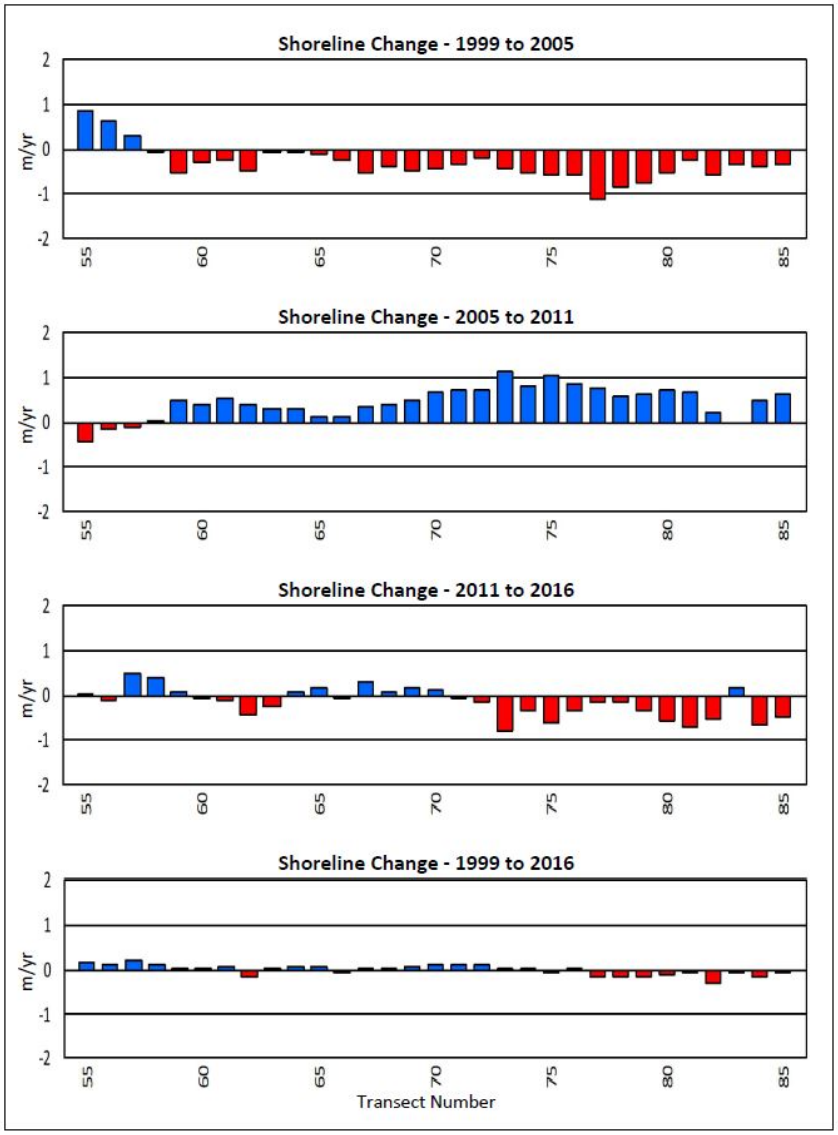
The EHPR for Kilili Beach (Civic Center) was determined to be *medium*. The determination was based on evidence of erosion, limited beach width, popularity and use intensity in the area, potential vulnerability of public infrastructure to erosion (e.g., coastal access path and Beach Road), and potential impacts of erosion on shoreline access in the area.

Issues & Recommendations

The undeveloped backshore and upper berm were highly compacted. Most of the structures (e.g., palapalas, grills/fire pits, benches, and picnic tables) were in relatively good condition. There was only one public restroom within the park, but it was closed due to apparent structural damage (Figure 45). There was physical evidence of erosion but it did not appear to be recent. The most active erosion areas appeared to be caused by surface water runoff from several drainages and parking lots, which bisected the berm and deflated the beach face (Figure 46). Erosion also appeared to be caused by foot traffic at the outrigger canoes launch site (Figure 47).

Recommendations

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize improvements to public amenities.
- Identify and prioritize drainage improvements.
- Repair and maintain public restrooms.



Map 4 Kilili Beach (Civic Center) historical shoreline change (1999 to 2016)

Figure 33 Kilili Beach (Civic Center), south end, looking north (6/30/2017)

Figure 34 Kilili Beach (Civic Center), north end, looking south (6/30/2017)

Figure 35 Kilili Beach (Civic Center), typical beach profile, looking north (6/30/2017)

Figure 36 Kilili Beach (Civic Center), typical beach profile, looking south (6/30/2017)

Figure 37 Kilili Beach (Civic Center), backshore area (6/30/2017)

Figure 38 Kilili Beach (Civic Center), stable berm and vegetation on upper beach face (6/30/2017)

Figure 39 Kilili Beach (Civic Center), backshore amenities (6/30/2017)

Figure 40 Kilili Beach (Civic Center), historical monument (6/30/2017)

Figure 41 Kilili Beach (Civic Center), paved public parking lot (6/30/2017)

Figure 42 Kilili Beach (Civic Center), unpaved vehicular access (6/30/2017)

Figure 43 Kilili Beach (Civic Center), outrigger canoe launch site (6/30/2017)

Figure 44 Kilili Beach (Civic Center), closed public restroom (6/30/2017)

Figure 45 Kilili Beach (Civic Center), erosion due to surface runoff from parking lot (6/30/2017)

Figure 46 Kilili Beach (Civic Center), erosion due to foot traffic at canoe launch site (6/30/2017)

Oleai Beach

Erosion Hazard Priority Rating - MEDIUM

EASTING:
361350.82 meters E
NORTHING:
1677281.30 meters N
MUNICIPALITY:
Oleai
LENGTH:
250 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
VE (BFE = 9 feet)
LAND USES:
Park; Transportation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Oleai Beach is located on the leeward (west) coast of Saipan, north of Kilili Beach Park (Civic Center) and south of Quartermaster Area (Red Beach), and consists of approximately 250 meters of shoreline frontage. Oleai Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, and picnicking. Public amenities included palapalas (2), grills/fire pits (2), exercise equipment (1), and a coastal access path.

ISSUES

The undeveloped backshore area and upper berm were highly compacted. There were no public restrooms observed in the area. The Oleai Beach Bar & Grill is fronted by a rock and concrete seawall. There was no evidence to indicate that the seawall is impacting beach width. There was physical evidence of erosion but it did not appear to be recent. The most active erosion appeared where the berm was bisected by surface water runoff from the unpaved parking lot.

RECOMMENDATIONS

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Install and maintain public restrooms.

Oleai Beach

Municipality: Oleai
Easting: 361350.82 m E
Nothing: 1677281.30 m N
Length: 250 m
Inspection: June 30, 2017 (5:30 pm)
Tide: 0.10 m (outgoing)

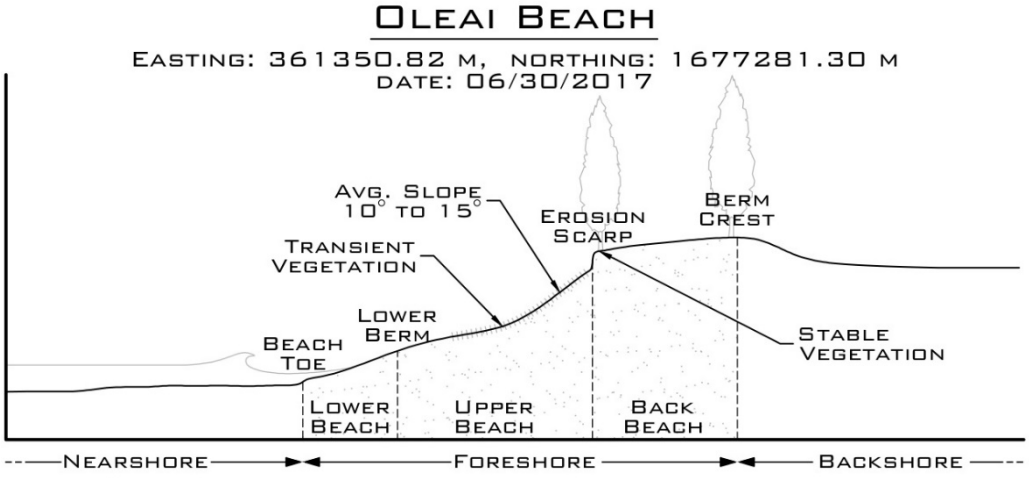
Erosion Hazard Priority Rating: MEDIUM

Coastal Setting

Oleai Beach is located on the leeward (west) coast of Saipan, north of Kilili Beach Park (Civic Center) and south of Quartermaster Area (Red Beach), and consists of approximately 250 m of shoreline frontage. The backshore consists of an undeveloped area that extends approximately 60 m inshore of the shoreline to Beach Road. The foreshore consists of a narrow, linear sand beach with a stable upper berm. The nearshore consists of a shallow lagoon and fringing reef. A view looking north from the south end of the beach is shown in Figure 48. A view looking south from the north end of the beach is shown in Figure 49.

Shoreline Condition

Oleai Beach abuts the Saipan Lagoon and is partially protected by a shallow fringing reef that extends approximately 1,200 m offshore to a very shallow reef crest. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 2 m. The shoreline is northwest-facing at approximately 300 degrees (relative to True North). The beach is composed of fine to medium-grain carbonate sand. Sand grain size coarsened in a seaward direction with an accumulation of larger-diameter sand and gravel along the beach toe.



Profile 5 Typical beach profile along central section of Oleai Beach

A typical beach profile was recorded along the central section of the Oleai Beach shoreline (Profile 5). Photographs showing the location of the beach profile are shown in Figure 50 and Figure 51. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a narrow, exposed sand beach that progressed inshore to a transient berm along the edge of vegetation. The upper beach was moderately-sloping (10 to 15 degrees) and consisted of a stable berm covered by transient vegetation (Morning Glory). The back beach progressed inshore to a relict erosion scarp along the upper berm, which was compacted and covered by stable vegetation (mature Ironwood trees, beach grass).

The backshore consisted of an open grassy area with mature Ironwood trees and soils composed of the Shioya-Urban land complex (Figure 52). The backshore topography was relatively flat from Beach Road to the upper berm. Evidence of erosion included undermining around Ironwood root structures and observable land loss between the areas of stable vegetation. The erosion scarp along the berm crest did not appear to be active. Vegetation along the upper beach appeared to be well-established, and the presence of small Ironwood saplings on the upper beach suggests that the shoreline has likely been accreting since the last major erosion event (Figure 53). There was no evidence of erosion or inundation inshore of the erosion scarp.

Oleai Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, and picnicking. Public amenities included palapalas (2), grills/fire pits (2), an exercise station, and a coastal access path (Figure 54). The Oleai Beach Bar & Grill, a popular local restaurant, is located along the southern portion of the shoreline. Vehicular access to Oleai Beach was available from Beach Road. Parking was available in an unpaved lot adjacent to the Oleai Beach Bar & Grill with additional off-road parking available. Public access was available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Oleai Beach is shown as transects 86 through 94 on Map 5. The beach showed erosion of up to about 0.8 m/yr from 1999 to 2005. Thereafter, the trend has generally been one of accretion at rates of up to 0.8 m/yr. There was minimal shoreline change observed in the aerial imagery from 1999 to 2016.

Erosion Hazard Priority Rating

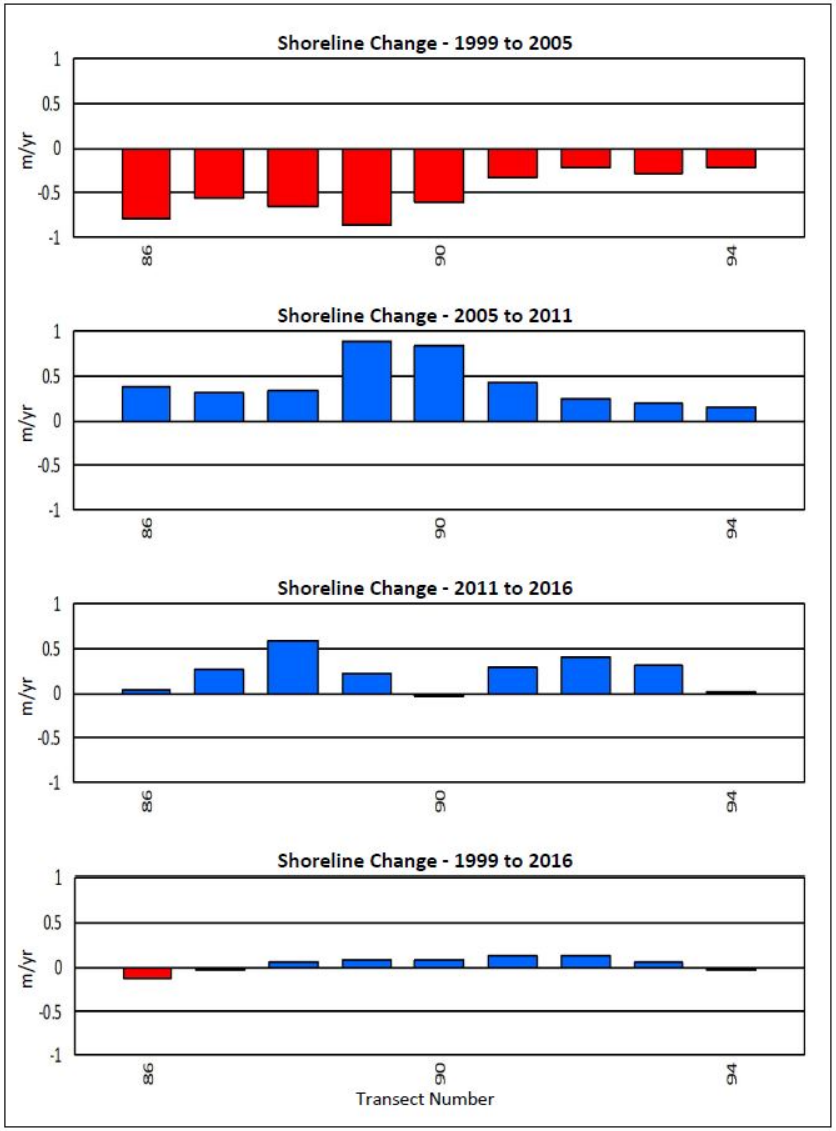
The EHPR for Oleai Beach was determined to be *medium*. The determination was based on evidence of erosion, limited beach width, popularity and use intensity in the area, potential vulnerability of public infrastructure to erosion (e.g., coastal access path and Beach Road), potential impacts of erosion on shoreline access in the area, and the historical shoreline change analysis, which indicated that the beach is stable and accreting.

Issues & Recommendations

The undeveloped backshore and upper berm were highly compacted. Most of the structures (e.g., palapalas, grills/fire pits, benches, and picnic tables) were in relatively good condition. There were no public restrooms observed in the area. The Oleai Beach Bar & Grill is fronted by a seawall constructed of rock and concrete. There was no evidence to indicate that the seawall is impacting beach width (Figure 55). There was evidence of erosion but it did not appear to be recent. The most active erosion appeared where the berm was bisected by surface water runoff from the unpaved parking lot (Figure 56 and Figure 57).

Recommendations

- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Install and maintain public restrooms.



Map 5 Oleai Beach historical shoreline change (1999 to 2016)

Figure 47 Oleai Beach, south end, looking north (6/30/2017)

Figure 48 Oleai Beach, north end, looking south (6/30/2017)

Figure 49 Oleai Beach, typical beach profile, looking south (6/30/2017)

Figure 50 Oleai Beach, typical beach profile, looking north (6/30/2017)

Figure 51 Oleai Beach, coastal access path in backshore area (6/30/2017)

Figure 52 Oleai Beach, stable berm and vegetation on upper beach face (6/30/2017)

Figure 53 Oleai Beach, backshore amenities (6/30/2017)

Figure 54 Oleai Beach, seawall fronting Oleai Beach Bar & Grill (6/30/2017)

Figure 55 Oleai Beach, flooding in unpaved parking area (6/30/2017)

Figure 56 Oleai Beach, berm bisected by surface water runoff (6/30/2017)

Quartermaster Area (Red Beach)

Erosion Hazard Priority Rating - HIGH

EASTING:
361814.18 meters E
NORTHING:
1678881.13 meters N
MUNICIPALITY:
Oleai; Garapan South
LENGTH:
300 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
VE (BFE = 8 to 10 feet)
LAND USES:
Park; Transportation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Quartermaster Area (Red Beach) is located on the leeward (west) coast of Saipan, north of Oleai Beach and south of Beach Road Pathway, and consists of approximately 300 meters of shoreline frontage. Quartermaster Area (Red Beach) supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, and picnicking. Public amenities included picnic tables (5), benches (6), an exercise station, and a coastal access path. There are two historical monuments located in the backshore area.

ISSUES

The undeveloped backshore area and upper berm were highly compacted. Most of the structures (e.g., picnic tables, benches) were in good condition. There were no public restrooms observed in the area. The beach was very narrow and significant portions were entirely covered by encroaching vegetation. Lateral shoreline access was limited as beach users were forced to wade through the water to access small pocket beaches. Erosion was observed where the berm was bisected by drainage features

RECOMMENDATIONS

- Evaluate options for beach nourishment with stabilizing structures (e.g., groins).
- Evaluate options for permanent shore protection (e.g., seawall or revetment).
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain public restrooms.

Quartermaster Area (Red Beach)

Municipality: Oleai; Garapan South
Easting: 361814.18 m E
Nothing: 1678881.13 m N
Length: 300 m
Inspection: July 1, 2017 (10:30 am)
Tide: 0.30 m (incoming)

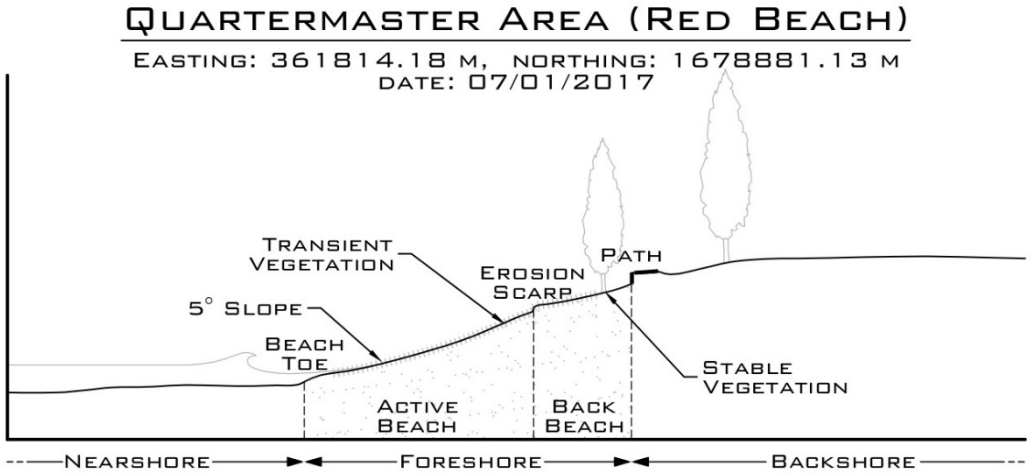
Erosion Hazard Priority Rating: HIGH

Coastal Setting

Quartermaster Area (Red Beach) is located on the leeward (west) coast of Saipan, north of Oleai Beach and south of Beach Road Pathway, and consists of approximately 300 m of shoreline frontage. The backshore consists of an undeveloped area that extends approximately 40 m inshore of the shoreline to Beach Road. The foreshore consists of a narrow, linear sand beach with a stable upper berm. The nearshore consists of a shallow lagoon and fringing reef. A view looking north from the south end of the beach is shown in Figure 58. A view looking south from the north end of the beach is shown in Figure 59.

Shoreline Condition

Quartermaster Area (Red Beach) abuts the Saipan Lagoon and is partially protected by a shallow fringing reef that extends approximately 1,000 m offshore to a very shallow reef crest. The waters surrounding the fringing reef are part of the Lighthouse Reef Trochus Sanctuary. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 3 m. The shoreline is west-facing at approximately 270 degrees (relative to True North). The beach is composed of fine to medium-grain carbonate sand. Sand grain size coarsened in a seaward direction with an accumulation of larger-diameter sand and gravel along the beach toe.



Profile 6 Typical beach profile along central section of Quartermaster Area (Red Beach)

A typical beach profile was recorded along the central section of the Quartermaster Area (Red Beach) shoreline (Profile 6). Photographs showing the location of the beach profile are shown in Figure 60 and Figure 61. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a very narrow sand beach, significant portions of which were covered by encroaching vegetation (Morning Glory and beach grass). The upper beach was moderately-sloping (10 to 15 degrees) and covered by well-established vegetation. The upper beach progressed inshore to a relict erosion scarp along the upper berm, which was compacted and covered by stable vegetation (mature Ironwood trees, beach grass). The back beach progressed inshore to the coastal access path, which appears to function as a seawall in some areas.

The backshore consisted of a narrow grassy area with mature Ironwood trees and soils composed of the Shioya loamy sand and Saipan very gravelly sandy loam (Figure 63). The backshore topography was gently-sloping from Beach Road to the upper berm. The erosion scarp along the upper berm did not appear to be active. Vegetation along the upper beach appeared to be stable. There was evidence of erosion but it did not appear to be recent. Evidence of active erosion was observed at two locations where the berm was bisected by drainage features. There was no evidence of erosion or inundation inshore of the erosion scarp.

Quartermaster Area (Red Beach) supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, and picnicking. Public amenities included picnic tables (5), benches (6), an exercise station, and a coastal access path. Quartermaster Area (Red Beach) was the site of the first large-scale tank battle of the Pacific War. There are two historical monuments located in the backshore area (Figure 64 and Figure 65). Vehicular access to Quartermaster Area (Red Beach) is available from Beach Road. Parking is available in a small paved lot with approximately 4 stalls with additional off-road parking available. Public access is available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Quartermaster Area (Red Beach) is shown as transects 95 through 115 on Map 6. The beach showed erosion of up to about 1.0 m/yr from 1999 to 2005. Thereafter, the trend has generally been one of accretion, at rates of up to 0.8 m/yr. There was minimal shoreline change observed in the aerial images from 1999 to 2016. The drainage feature at the end of Quartermaster Road has created a slight bulge in the shoreline (transect 105), which does not necessarily follow the trend of the rest of the shoreline.

Erosion Hazard Priority Rating

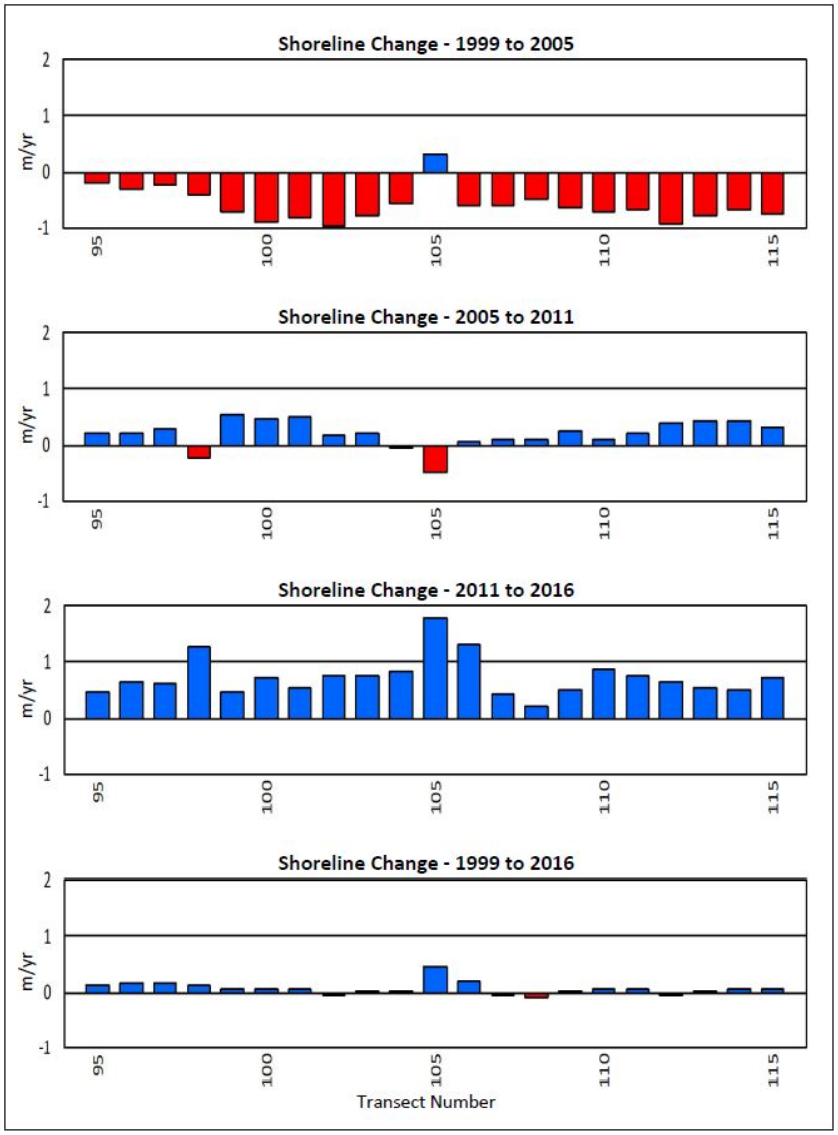
The EHPR for Quartermaster Area (Red Beach) was determined to be *high*. The determination was based on evidence of erosion, limited beach width, popularity and use intensity in the area, potential vulnerability of public infrastructure to erosion (e.g., coastal access path and Beach Road), and potential impacts of erosion on shoreline access in the area.

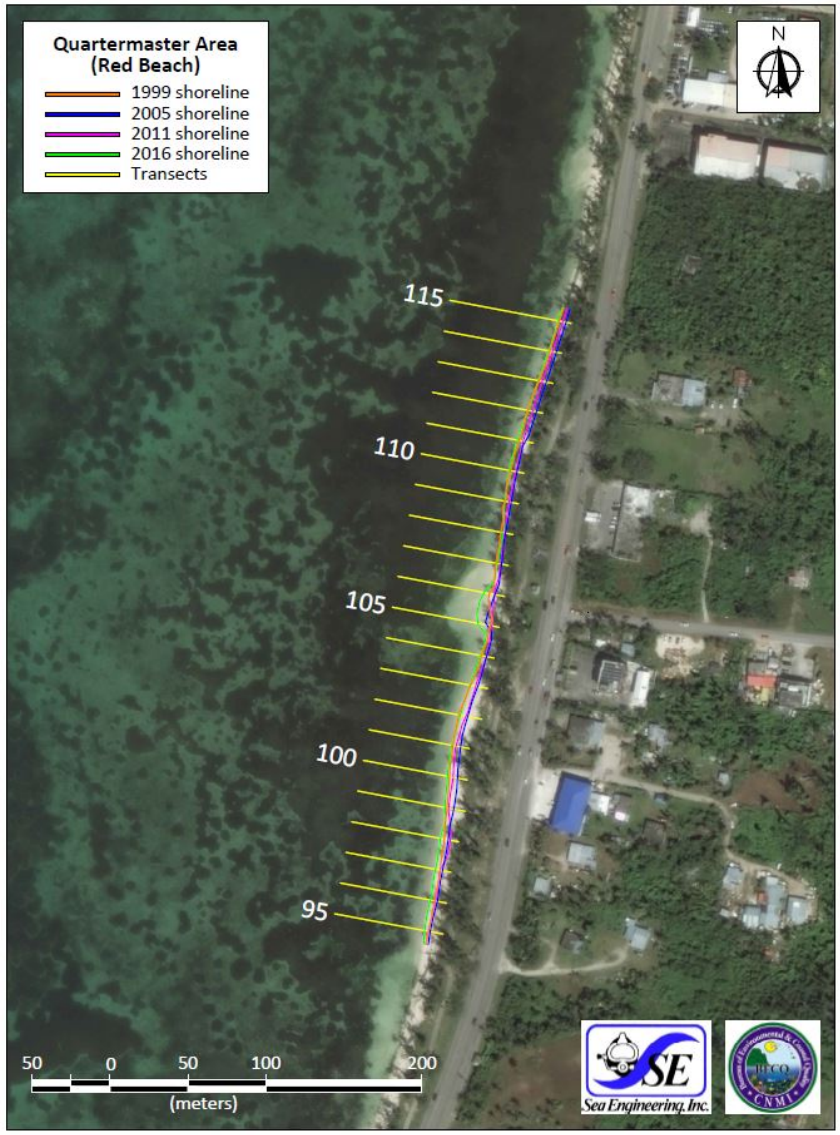
Issues & Recommendations

The undeveloped backshore area and upper berm were highly compacted. Most of the structures (e.g., picnic tables, benches) were in good condition. There were no public restrooms observed in the area. The beach was very narrow and significant portions were entirely covered by encroaching vegetation (Figure 66). Lateral shoreline access was limited as beach goers were forced to wade through the water to access small pocket beaches. The beach was widest near the drainage culvert along the central section of the shoreline. There was evidence of erosion but it did not appear to be recent. Evidence of active erosion was observed where the berm was bisected by drainage features (Figure 67).

Recommendations

- Evaluate options for beach nourishment with stabilizing structures (e.g., groins).
- Evaluate options for permanent shore protection (e.g., seawall or revetment).
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain public restrooms.





Map 6 Quartermaster Area (Red Beach) historical shoreline change (1999 to 2016)

Figure 57 Quartermaster Area (Red Beach), south end, looking north (7/1/2017)

Figure 58 Quartermaster Area (Red Beach), north end, looking south (7/1/2017)

Figure 59 Quartermaster Area (Red Beach), typical beach profile, looking north (7/1/2017)

Figure 60 Quartermaster Area (Red Beach), typical beach profile, looking south (7/1/2017)

Figure 61 Quartermaster Area (Red Beach), coastal access path (7/1/2017)

Figure 62 Quartermaster Area (Red Beach), backshore area (7/1/2017)

Figure 63 Quartermaster Area (Red Beach), historical monument (7/1/2017)

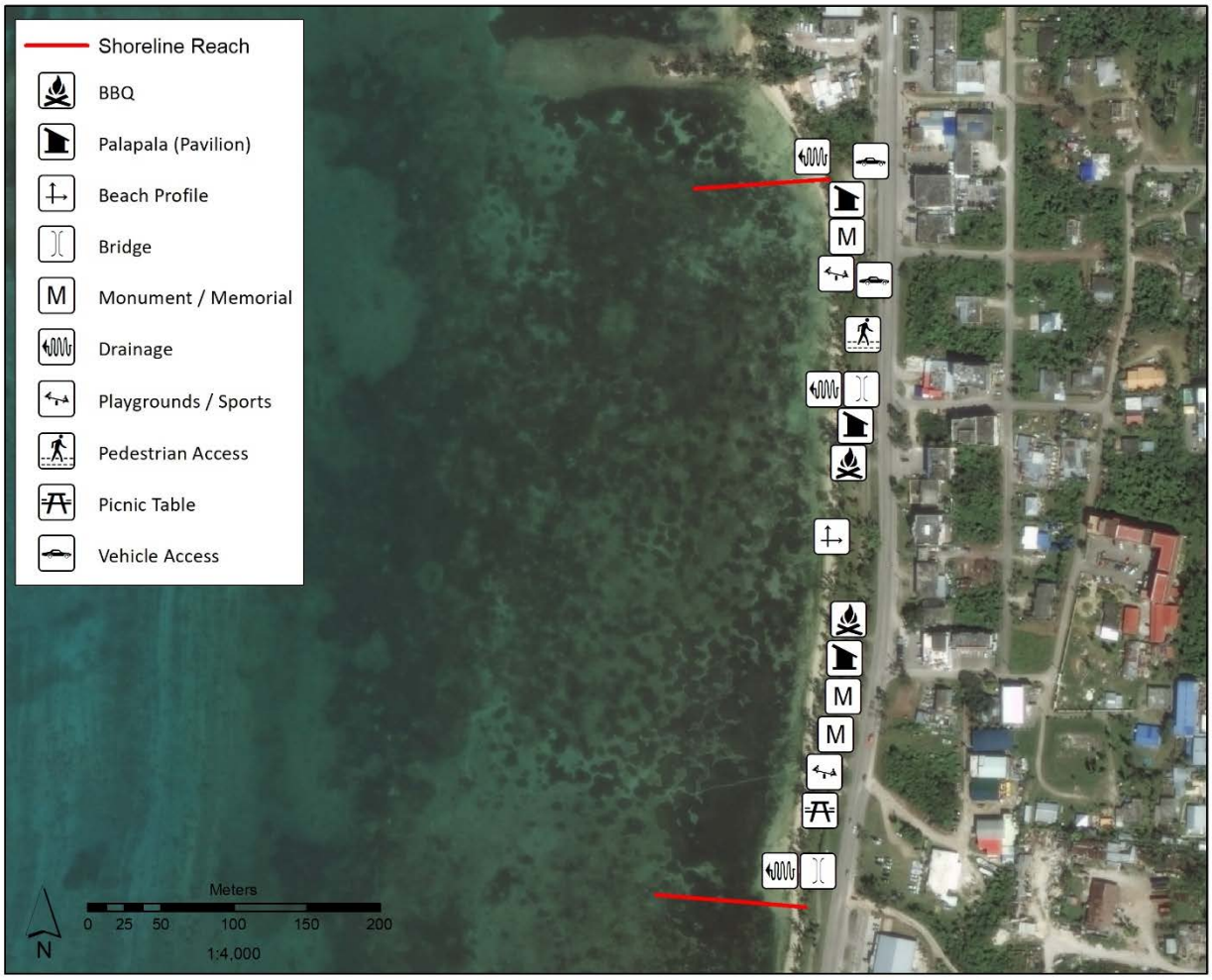
Figure 64 Quartermaster Area (Red Beach), historical monument (7/1/2017)

Figure 65 Quartermaster Area (Red Beach), vegetation encroaching over beach (7/1/2017)

Figure 66 Quartermaster Area (Red Beach), berm bisected by drainage (7/1/2017)

Beach Road Pathway

Erosion Hazard Priority Rating - HIGH



EASTING:
362163.11 meters E
NORTHING:
1680472.81 meters N
MUNICIPALITY:
Garapan
LENGTH:
550 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE and VE (BFE = 8 to 10 feet)
LAND USES:
Park; Transportation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Coastal Hazards
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Beach Road Pathway is located on the leeward (west) coast of Saipan, north of Quartermaster Area (Red Beach) and south of Fishing Base, and consists of approximately 550 meters of shoreline frontage. Beach Road Pathway supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, and picnicking. Amenities included picnic tables (5), benches (6), grills/fire pits (2), an exercise station, and a coastal access path. The 13 Fishermen Memorial Monument is located in the backshore area.

ISSUES

The undeveloped backshore area and upper berm were highly compacted. There were no public restrooms observed in the area. The beach was very narrow and significant portions were entirely covered by encroaching vegetation. Lateral shoreline access was limited as beach goers were forced to wade through the water to access small pocket beaches. There was physical evidence of erosion; however, the erosion did not appear to be recent. Evidence of active erosion was only observed where the berm was bisected by drainage features.

RECOMMENDATIONS

- Evaluate options for beach nourishment with stabilizing structures (e.g., groins).
- Evaluate options for permanent shore protection (e.g., seawall or revetment).
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain public restrooms.

Beach Road Pathway

Municipality: Garapan
Easting: 362163.11 m E
Nothing: 1680472.81 m N
Length: 550 m
Inspection: July 1, 2017 (2:30 pm)
Tide: 0.40 m (outgoing)

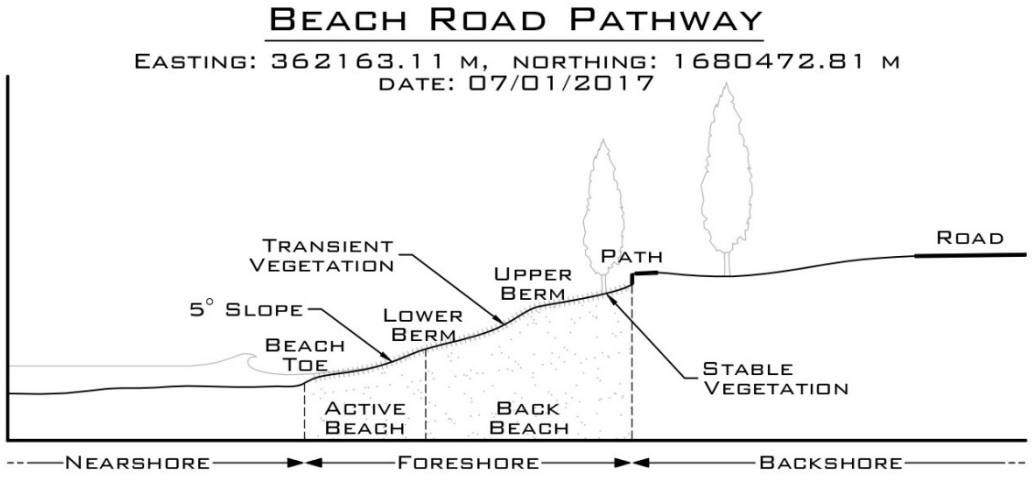
Erosion Hazard Priority Rating: HIGH

Coastal Setting

Beach Road Pathway is located on the leeward (west) coast of Saipan, north of Quartermaster Area (Red Beach) and south of Fishing Base, and consists of approximately 550 m of shoreline frontage. The backshore consists of an undeveloped area that extends approximately 35 m inshore of the shoreline to Beach Road. The foreshore consists of a very narrow, linear mixed sand and gravel beach with a stable upper berm. The nearshore consists of a shallow lagoon and fringing reef. A view looking north from the south end of the beach is shown in Figure 68. A view looking south from the north end of the beach is shown in Figure 69.

Shoreline Condition

Beach Road Pathway abuts the Saipan Lagoon and is partially protected by a shallow fringing reef that extends approximately 900 m offshore. The waters surrounding the fringing reef are part of the Lighthouse Reef Trochus Sanctuary. The fringing reef is bisected by a shore-perpendicular channel directly offshore of Beach Road Pathway. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 3 m. The shoreline is west-facing at approximately 270 degrees (relative to True North). The beach is composed of fine-grain carbonate sand. Sand grain size coarsened in a seaward direction and there was no discernable beach toe.



Profile 7 Typical beach profile along central section of Beach Road Pathway

A typical beach profile was recorded along the central section of the Beach Road Pathway shoreline (Profile 7). Photographs showing the location of the beach profile are shown in Figure 70 and Figure 71. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a very narrow sand beach, significant portions of which were covered by encroaching vegetation (Morning Glory and beach grass). In many areas, the vegetation encroached seaward of the waterline and the lower beach was submerged. The upper beach was moderately-sloping (10 to 15 degrees) and covered by well-established vegetation (Morning Glory, Coconut trees, beach grass). The upper beach progressed inshore to a relict erosion scarp along the upper berm, which was compacted and covered by stable vegetation (mature Ironwood trees). In some areas, the back beach abutted the coastal access path, which appears to also function as a seawall (Figure 72).

The backshore consisted of a narrow grassy area with mature Ironwood trees and soils composed of the Chinen-Urban land complex (Figure 73). The backshore topography was gently-sloping from Beach Road to the upper berm. The erosion scarp along the upper berm did not appear to be active (Figure 74). There was evidence of erosion including a relict erosion scarp and undermining of Ironwood root systems; however, the erosion did not appear to be recent. Evidence of active erosion was observed where the berm was bisected by drainage features (Figure 75). There was no evidence of erosion or inundation inshore of the erosion scarp.

Beach Road Pathway supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, and picnicking. Public amenities included picnic tables (5), benches (6), grills/fire pits (2), an exercise station, and a coastal access path (Figure 76). Beach Road Pathway is also the site of the 13 Fishermen Memorial Monument (Figure 77). Vehicular access to Beach Road Pathway was available from the Beach Road. There was ample off-road parking available. Public access was also available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Beach Road Pathway is shown as transects 116 through 141 on Map 7. The shoreline throughout this reach has very little sand. The shoreline position varied between accreting and eroding, spatially as well as temporally, from 1999 to 2011. The shoreline was measured to have accreted from 2011 to 2016 at rates up to about 1.3 m/yr. For the complete time series of the analysis (1999-2016), the shoreline showed accretion with typical rates of about 0.2 to 0.3 m/year.

Erosion Hazard Priority Rating

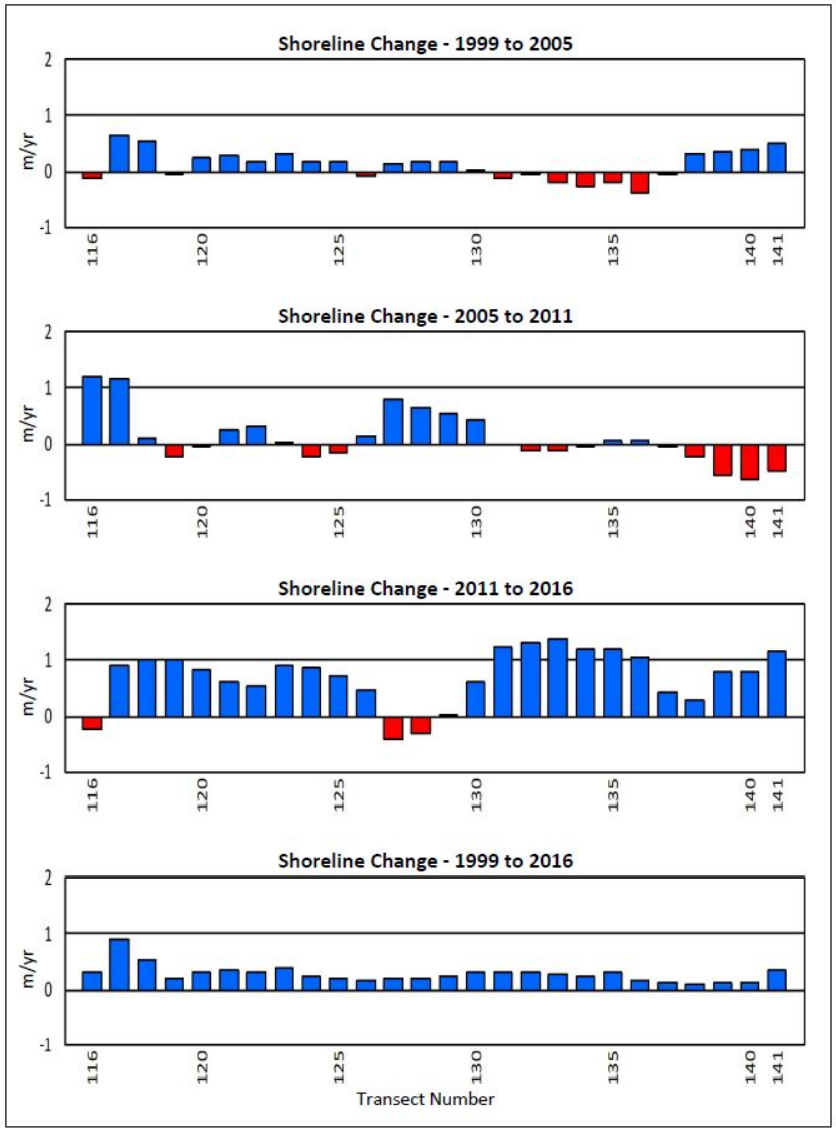
The EHPR for Beach Road Pathway was determined to be *high*. The determination was based on evidence of erosion, limited beach width, popularity and use intensity in the area, potential vulnerability of cultural resources (e.g., 13 Fishermen Memorial) and public infrastructure to erosion (e.g., coastal access path and Beach Road), and potential impacts of erosion on shoreline access in the area.

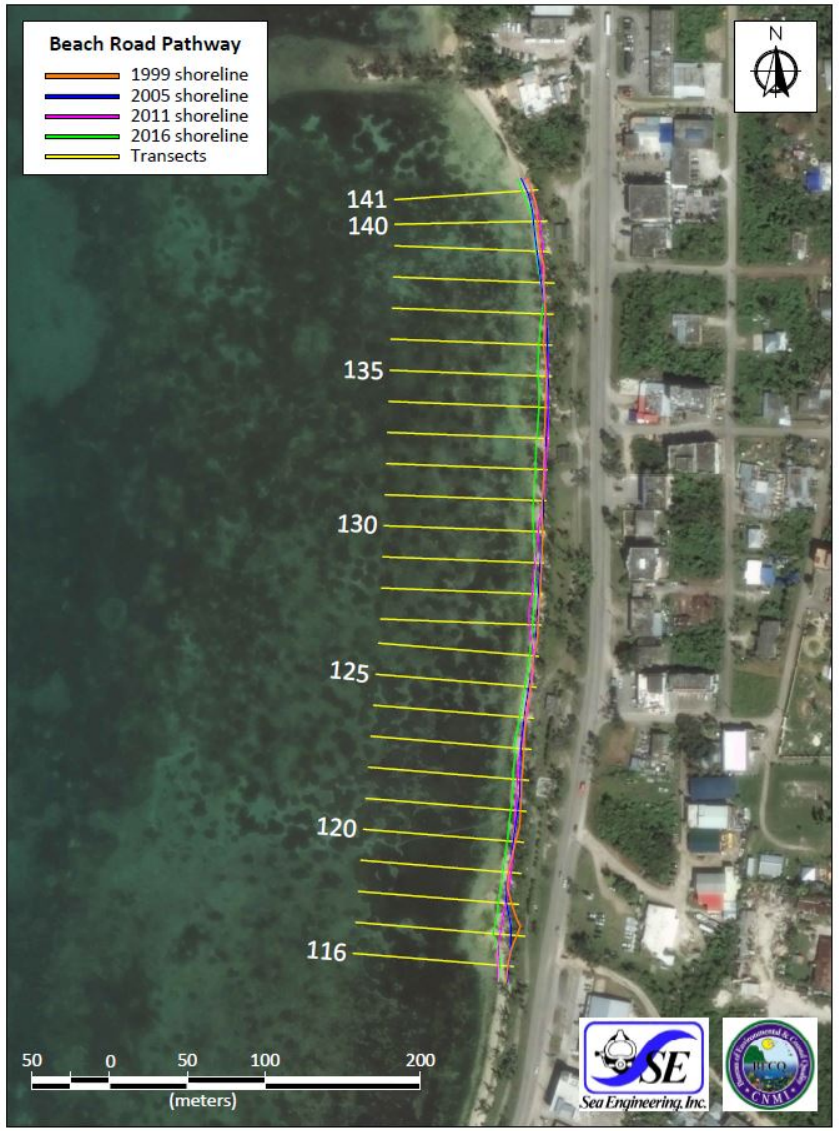
Issues & Recommendations

The undeveloped backshore area and upper berm were highly compacted. Most of the structures (e.g., picnic tables, benches) were in good condition. There were no public restrooms observed in the area. The beach was very narrow and significant portions were entirely covered by encroaching vegetation. Lateral shoreline access was limited as beach goers were forced to wade through the water to access small pocket beaches. There was evidence of erosion, including undermined Ironwood root structures and a relict erosion scarp; however, the erosion did not appear to be recent. Evidence of active erosion was only observed where the berm was bisected by drainage features.

Recommendations

- Evaluate options for beach nourishment with stabilizing structures (e.g., groins).
- Evaluate options for permanent shore protection (e.g., seawall or revetment).
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Manage shoreline vegetation to increase available beach area.
- Install and maintain public restrooms.





Map 7 Beach Road Pathway historical shoreline change (1999 to 2016)

Figure 67 Beach Road Pathway, south end, looking north (7/1/2017)

Figure 68 Beach Road Pathway, north end, looking south (7/1/2017)

Figure 69 Beach Road Pathway, typical beach profile, looking north (7/1/2017)

Figure 70 Beach Road Pathway, typical beach profile, looking south (7/1/2017)

Figure 71 Beach Road Pathway, coastal access path (7/1/2017)

Figure 72 Beach Road Pathway, backshore area (7/1/2017)

Figure 73 Beach Road Pathway, erosion scarp and compacted berm (7/1/2017)

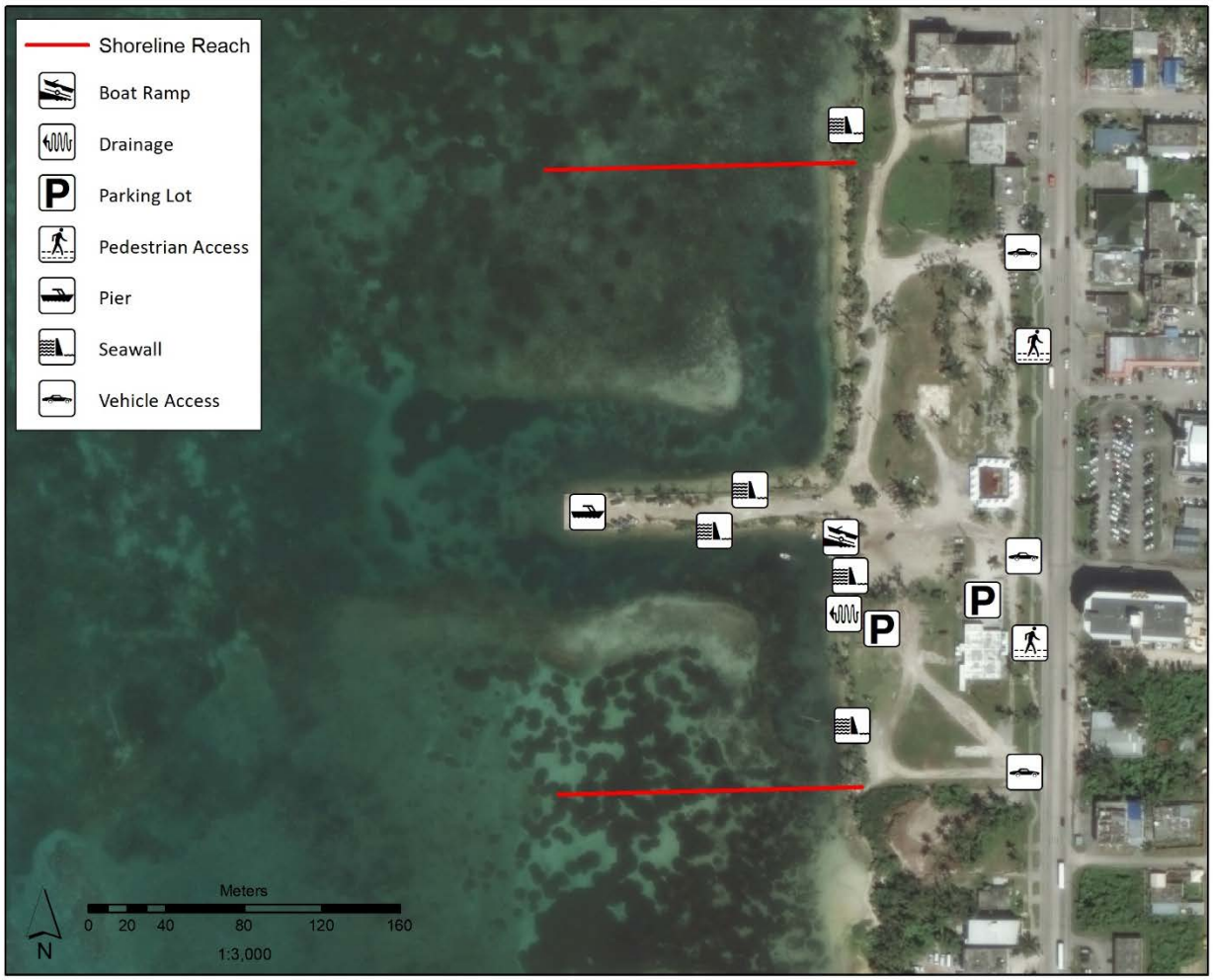
Figure 74 Beach Road Pathway, berm bisected by drainage (7/1/2017)

Figure 75 Beach Road Pathway, backshore amenities (7/1/2017)

Figure 76 Beach Road Pathway, 13 Fishermen Memorial Monument (7/1/2017)

Fishing Base

Erosion Hazard Priority Rating - HIGH



EASTING:
362100.09 meters E
NORTHING:
1681127.88 meters N
MUNICIPALITY:
Garapan
LENGTH:
350 meters
AVERAGE BEACH SLOPE:
15 to 25 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Recreation; Open Space
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Fishing Base is located on the leeward (west) coast of Saipan, north of Beach Road Pathway and south of Makaka Beach, and consists of approximately 350 meters of shoreline frontage. Fishing Base primarily supports fishing and boating activities. Public amenities included a pier, a boat ramp, and a parking area dedicated for boat trailer parking. The Garapan Public Market is located in the backshore area.

ISSUES

The undeveloped backshore area was well maintained. There were several portable public restrooms observed in the area but there were no trash or recycling receptacles. The majority of the existing structures were in a deteriorated state. There was significant structural damage to the pier and seawalls at Fishing Base. Lateral access along the shoreline was limited due to the lack of beach.

RECOMMENDATIONS

- Perform a damage assessment and prioritize repairs to Fishing Base.
- Evaluate options for permanent shore protection at Fishing Base.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.

Fishing Base

Municipality: Garapan
Easting: 362100.09 m E
Nothing: 1681127.88 m N
Length: 350 m
Inspection: July 1, 2017 (3:30 pm)
Tide: 0.35 m (outgoing)

Erosion Hazard Priority Rating: HIGH

Coastal Setting

Fishing Base is located on the leeward (west) coast of Saipan, north of Beach Road Pathway and south of Makaka Beach, and consists of approximately 350 m of shoreline frontage. The backshore consists of a largely undeveloped area that extends approximately 100 m inshore of the shoreline to Beach Road. The shoreline consists of boulders and coral fill material with various shore protection structures. The nearshore consists of a dredged channel, a lagoon, and a fringing reef. A view looking north from the south end of the shoreline is shown in Figure 78. A view looking south from the north end of the shoreline is shown in Figure 79.

Shoreline Condition

Fishing Base abuts the Saipan Lagoon and is partially protected by a fringing reef that extends approximately 1,000 m offshore. The nearshore bathymetry is shallow with average water depths ranging from 2 to 4 m. The shoreline is west-facing at approximately 270 degrees (relative to True North). For the purposes of this assessment, the Fishing Base shoreline was divided into three sections: 1) south, 2) central, and 3) north.

Section 1: Fishing Base – South
The south section of the Fishing Base shoreline extended approximately 150 m south of the pier at Fishing Base. The shoreline consisted of an eroding embankment composed of boulders and coral fill material. The upper embankment was irregular with stable vegetation (Ironwood trees) and a discontinuous erosion scarp that appeared to be actively eroding (Figure 80). There were several structures located along the shoreline including remnants of a collapsed pier, two drainage culverts, a grouted rock seawall, and a concrete boat ramp (Figure 81).

Section 2: Fishing Base – Central
The central section of the Fishing Base shoreline consisted of the Fishing Base pier, which extended approximately 140 m seaward of the shoreline (Figure 82). The pier appeared to be constructed of multiple layers of fill material consisting of boulders, rock, and coral. There was no shore protection present along the south side of the pier, which appeared to be actively eroding (Figure 83). The seaward end of the pier was armored by a seawall that appeared to be damaged (Figure 85). The north side of the pier was armored by a concrete seawall (Figure 86). Several sections of the seawall on the north side of the pier appeared to be damaged with one section having collapsed (Figure 87).

Section 3: Fishing Base – North

The north section of the Fishing Base shoreline extended approximately 200 m north of the pier at Fishing Base. The shoreline consisted of a narrow beach composed of rocks and coral fill material. The embankment was irregular with stable vegetation (Ironwood trees), intermittent outcrops of consolidated fill material, and a discontinuous erosion scarp that appeared to be actively eroding (Figure 88). A series of wooden pier pile remnants were located parallel to the shoreline. Remnants of a large collapsed concrete structure were located at the north end of the shoreline, which was armored by a concrete seawall (Figure 89). The backshore area consisted of a largely undeveloped area with mature Ironwood and Coconut trees and soils composed of the Chinen-Urban land complex (Figure 90). The backshore topography was gently-sloping from Beach Road to the shoreline.

Fishing Base primarily supports fishing and boating activities. Public amenities included a pier, a boat ramp, and a dedicated parking area for boat trailers (Figure 91). The Garapan Public Market is located in the backshore area. Vehicular access to Fishing Base was available from several points along Beach Road. Parking was available in a paved lot with approximately 30 stalls at the Garapan Public Market with ample off-road parking available. Lateral access along the shoreline was limited.

Historical Shoreline Change

The historical shoreline change map for Fishing Base is shown as transects 142 through 157 on Map 8. The shoreline throughout this reach has almost no sand and is bisected by a 140-meter long pier. The shoreline position varied between accreting and eroding, spatially as well as temporally, from 1999 to 2011. The shoreline was measured to have accreted from 2011 to 2016 at rates up to about 1.3 m/yr. For the complete time series of the analysis (1999-2016), long-term shoreline change was negligible. The data shows significant change along transect 149, which is located along the north side of the pier. The measured shoreline change at this location may be exaggerated due to the oblique orientation of the transect to the shoreline.

Erosion Hazard Priority Rating

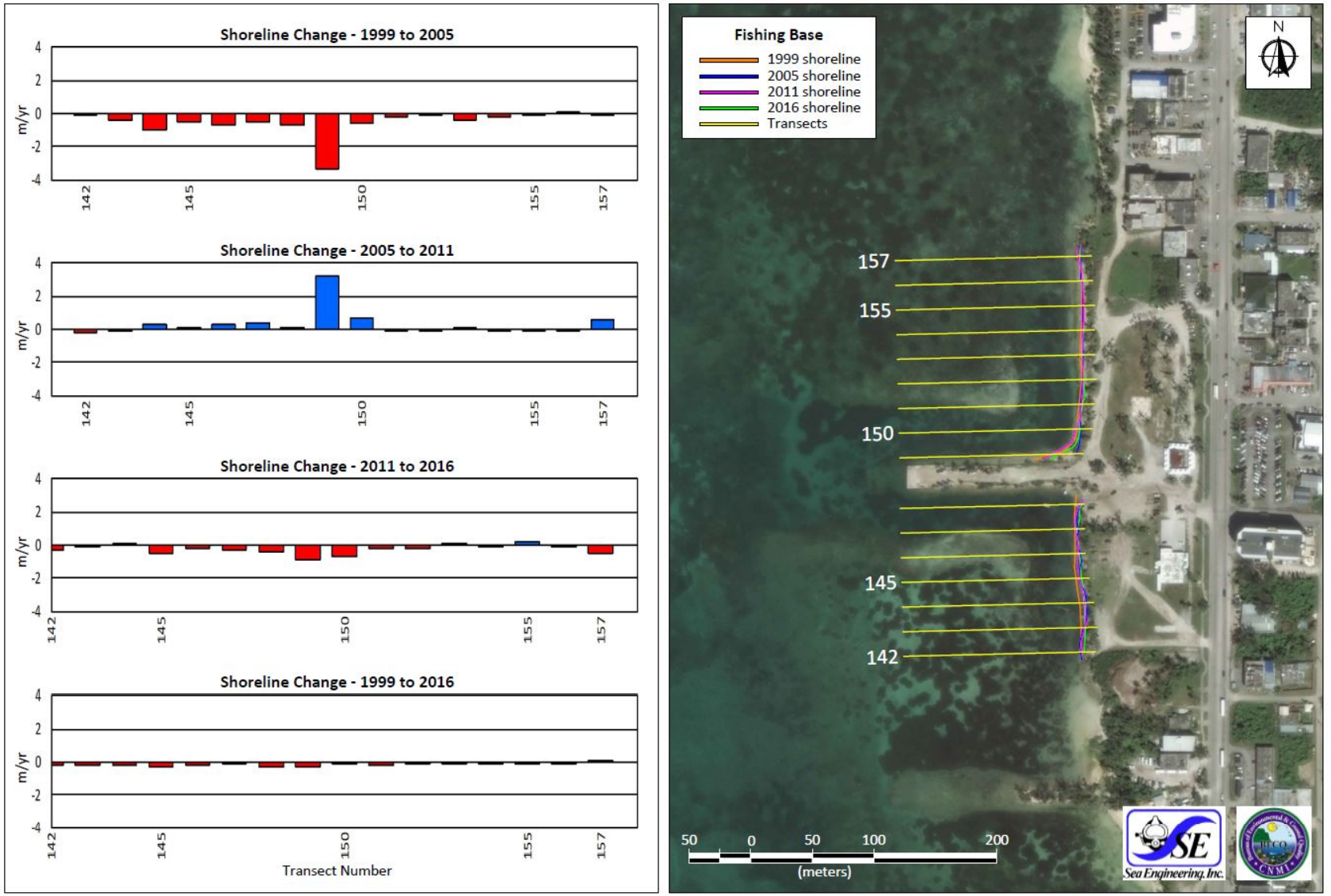
The EHPR for Fishing Base was determined to be *high*. The determination was based on evidence of erosion, absence of a beach, low backshore elevation, popularity and use intensity in the area, and damage to public infrastructure.

Issues & Recommendations

The undeveloped backshore area was well maintained. There were several portable public restrooms observed in the area but there were no trash or recycling receptacles. Many of the existing structures were in a deteriorated state. The structural damage to the pier at Fishing Base may present a risk to public health and safety.

<u>Recommendations</u>

- Perform a damage assessment and prioritize repairs to Fishing Base.
- Evaluate options for permanent shore protection at Fishing Base.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.



Map 8 Fishing Base historical shoreline change (1999 to 2016)

Figure 77 Fishing Base, south end, looking north (7/1/2017)

Figure 78 Fishing Base, north end, looking south (7/1/2017)

Figure 79 Fishing Base, active erosion along south section of shoreline (7/1/2017)

Figure 80 Fishing Base, seawall and public boat ramp (7/1/2017)

Figure 81 Fishing Base, pier, looking west (7/1/2017)

Figure 82 Fishing Base, active erosion along south side of pier (7/1/2017)

Figure 83 Fishing Base, active erosion along south side of pier (7/1/2017)

Figure 84 Fishing Base, damage at seaward end of pier (7/1/2017)

Figure 85 Fishing Base, seawalls on north side of pier (7/1/2017)

Figure 86 Fishing Base, seawall damage along north side of pier (7/1/2017)

Figure 87 Fishing Base, active erosion scarp along northern section of shoreline (7/1/2017)

Figure 88 Fishing Base, collapsed structure and seawall at north end of shoreline (7/1/2017)

Figure 89 Fishing Base, backshore area (7/1/2017)

Figure 90 Fishing Base, boat trailer parking area (7/1/2017)

Makaka Beach

Erosion Hazard Priority Rating - LOW

EASTING:
362037.89 meters E
NORTHING:
1682160.62 meters N
MUNICIPALITY:
Garapan
LENGTH:
300 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Commercial
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

Makaka Beach is located on the leeward (west) coast of Saipan, north of Fishing Base and south of Fiesta Beach, and consists of approximately 300 meters of shoreline frontage. Makaka Beach supports a variety of recreational uses including swimming, wading, snorkeling, and fishing. There were no public amenities observed in the area. Vehicular access to Makaka Beach was available from an unpaved road that meandered through the maritime forest. Public access was available laterally along the shoreline.

ISSUES

The undeveloped backshore area appeared to be natural and undisturbed, despite the intensity of the inshore development. There were no public restrooms or trash/recycling receptacles observed in the area. There was physical evidence of erosion in the back beach but it did not appear to be recent. The only active erosion appeared where the berm was bisected by a drainage feature.

RECOMMENDATIONS

- Identify and prioritize drainage improvements.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.

Makaka Beach

Municipality: Garapan
Easting: 362037.89 m E
Nothing: 1682160.62 m N
Length: 300 m
Inspection: July 2, 2017 (9:00 am)
Tide: 0.18 m (incoming)

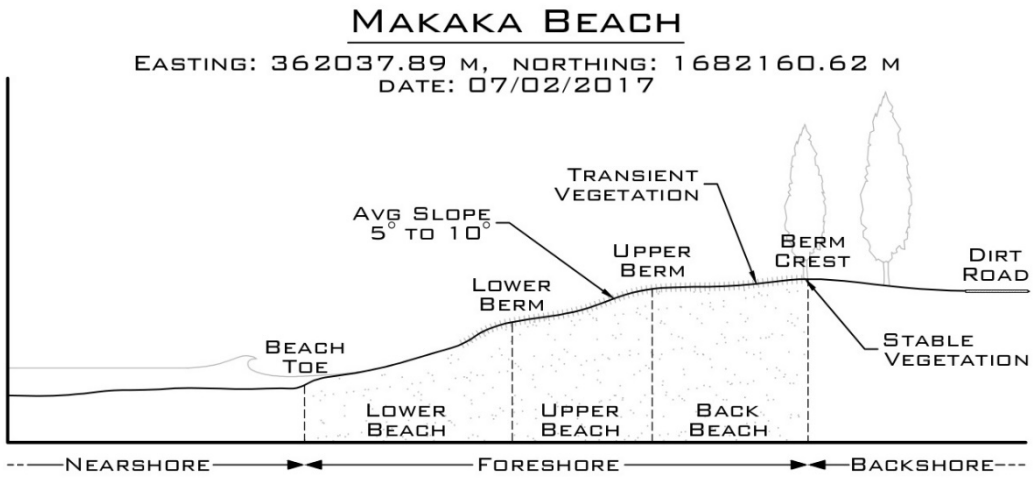
Erosion Hazard Priority Rating: LOW

Coastal Setting

Makaka Beach is located on the leeward (west) coast of Saipan, north of Fishing Base and south of Fiesta Beach, and consists of approximately 300 m of shoreline frontage. The backshore consists of an undeveloped area that extends approximately 50 m inshore of the shoreline. The inshore area consists of high-intensity resort development and is the site of the new Imperial Pacific Resort Hotel. The foreshore consists of a moderately-wide, linear sand beach with a stable upper berm. The nearshore consists of a shallow lagoon and fringing reef. A view looking north from the south end of the beach is shown in Figure 92. A view looking south from the north end of the beach is shown in Figure 93.

Shoreline Condition

Makaka Beach abuts the Saipan Lagoon and is partially protected by a shallow fringing reef that extends approximately 1,000 m offshore. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 2 m. The shoreline is west-facing at approximately 270 degrees (relative to True North). The beach is composed of very fine-grain carbonate sand.



Profile 8 Typical beach profile along central section of Makaka Beach

A typical beach profile was recorded along the central section of the Makaka Beach shoreline (Profile 8). Photographs showing the location of the beach profile are shown in Figure 94 and Figure 95. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a moderately-wide, exposed sand beach that progressed inshore to a transient berm along the edge of vegetation. The upper beach was gently-sloping (5 to 10 degrees) and consisted of a series of stable berms covered by transient vegetation (Morning Glory, Ironwood saplings) (Figure 96). The back beach progressed inshore to a relict erosion scarp along the berm crest (Figure 97).

The backshore consisted of a maritime forest with mature Ironwood trees and miscellaneous trees and shrubs, and soils composed of the Shioya-Urban land complex. The backshore topography was relatively flat inshore of the berm crest. Vegetation along the upper beach, back beach, and backshore appeared to be well-established. A relict erosion scarp was located along the berm crest; however, there was no evidence of erosion or inundation inshore of the erosion scarp. The presence of Ironwood saplings on the upper beach suggests that the shoreline has likely been accreting since the last major erosion event.

Makaka Beach supports a variety of recreational uses including swimming, wading, snorkeling, and fishing. There were no public amenities observed in the area. Vehicular access to Makaka Beach was available from an unpaved access road that meandered through the maritime forest (Figure 98). There was no available parking observed in the area. Public access was available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Makaka Beach is shown as transects 158 through 172 on Map 9. The southern half of the shoreline exhibited mild erosion from 1999 to 2005, while the northern half exhibited accretion rates of up to 3 m/yr. The analysis showed accretion thereafter, with rates up to about 2 m/yr. For the complete time series of the analysis (1999-2016), the southern half of the shoreline accreted at a rate of about 1 m/yr, while the northern half accreted at about 2 m/yr. This pattern extended into the Fiesta Beach study area to the north.

Erosion Hazard Priority Rating

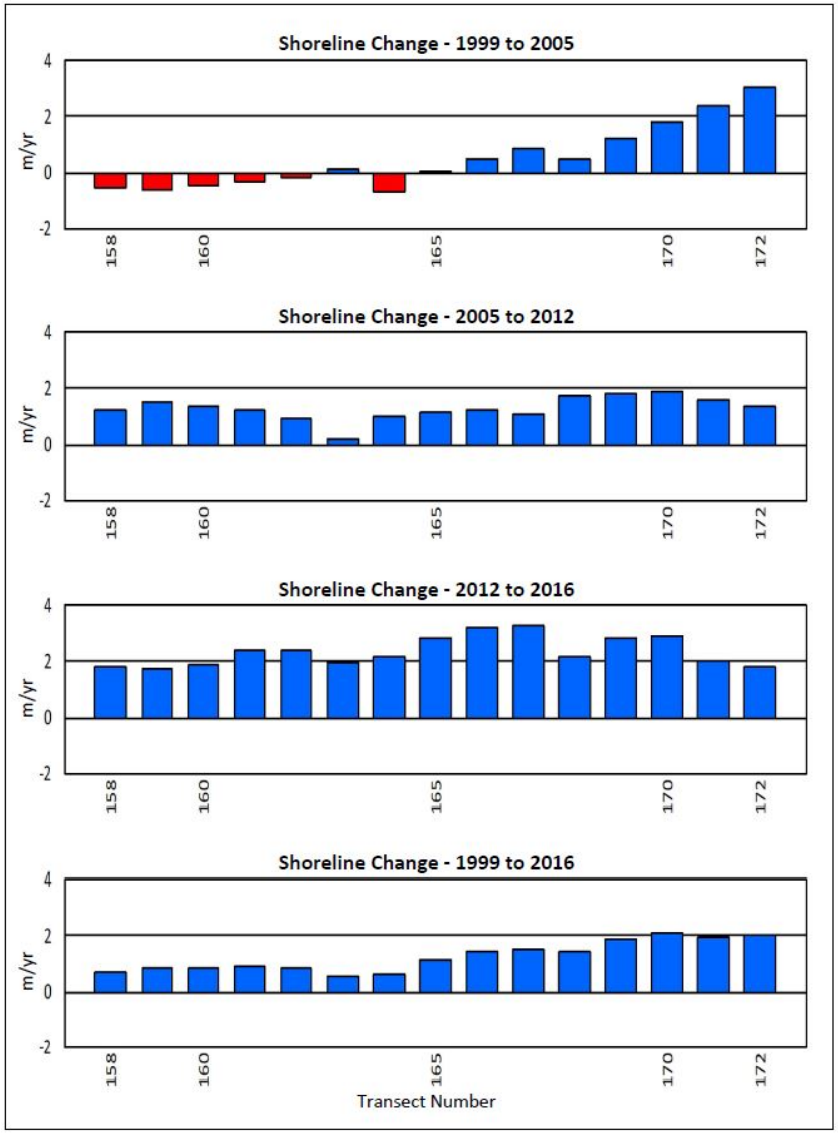
The EHPR for Makaka Beach was determined to be *low*. The determination was based on lack of evidence of erosion, stable beach width, lack of vulnerable infrastructure, and the historical shoreline change analysis, which indicated that the shoreline is stable and accreting.

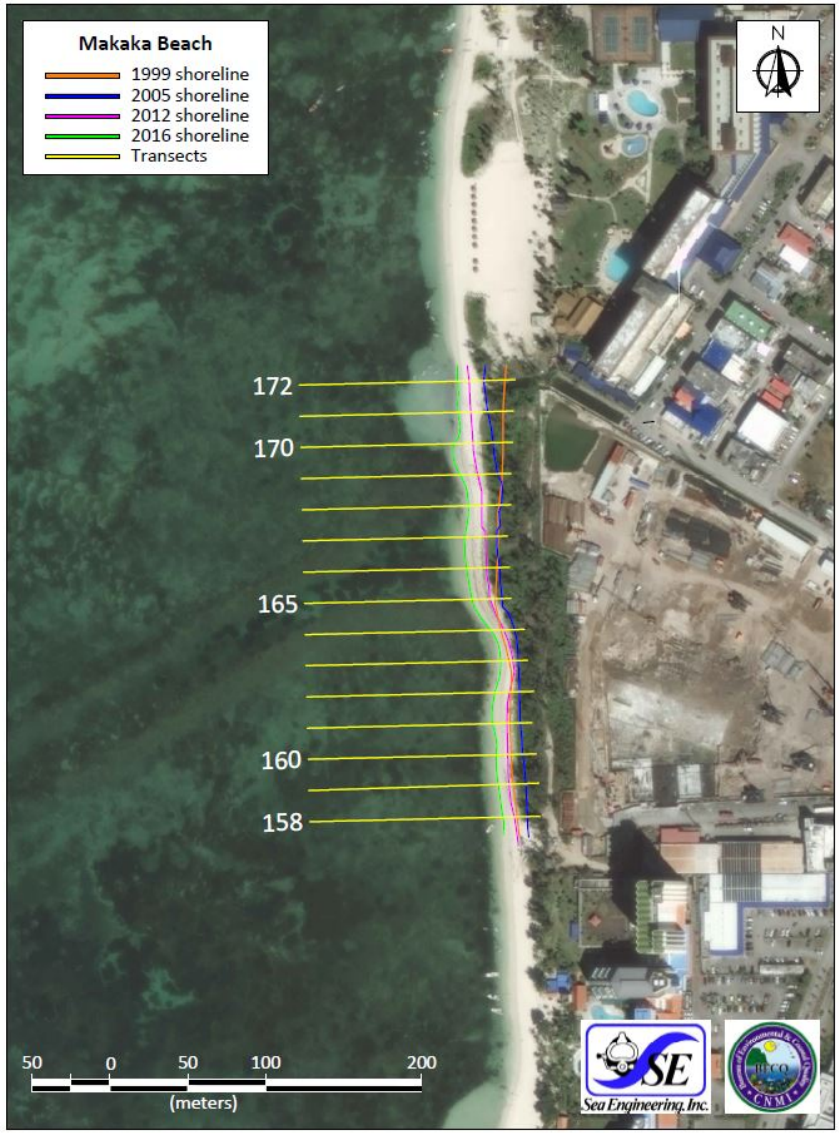
Issues & Recommendations

The undeveloped backshore area appeared to be natural and undisturbed, despite the intensity of the inshore development (Figure 99). There were no public restrooms or trash/recycling receptacles observed in the area. There was evidence of erosion along the back beach but it did not appear to be recent. The only active erosion appeared where the berm was bisected by a drainage (Figure 100 and Figure 101).

Recommendations

- Identify and prioritize drainage improvements.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.





Map 9 Makaka Beach historical shoreline change (1999 to 2016)

Figure 91 Makaka Beach, south end, looking north (7/2/2017)

Figure 92 Makaka Beach, north end, looking south (7/2/2017)

Figure 93 Makaka Beach, typical beach profile, looking south (7/2/2017)

Figure 94 Makaka Beach, typical beach profile, looking north (7/2/2017)

Figure 95 Makaka Beach, multiple berms along upper beach (7/2/2017)

Figure 96 Makaka Beach, relict erosion scarp on back beach (7/2/2017)

Figure 97 Makaka Beach, unpaved vehicle access road in backshore area (7/2/2017)

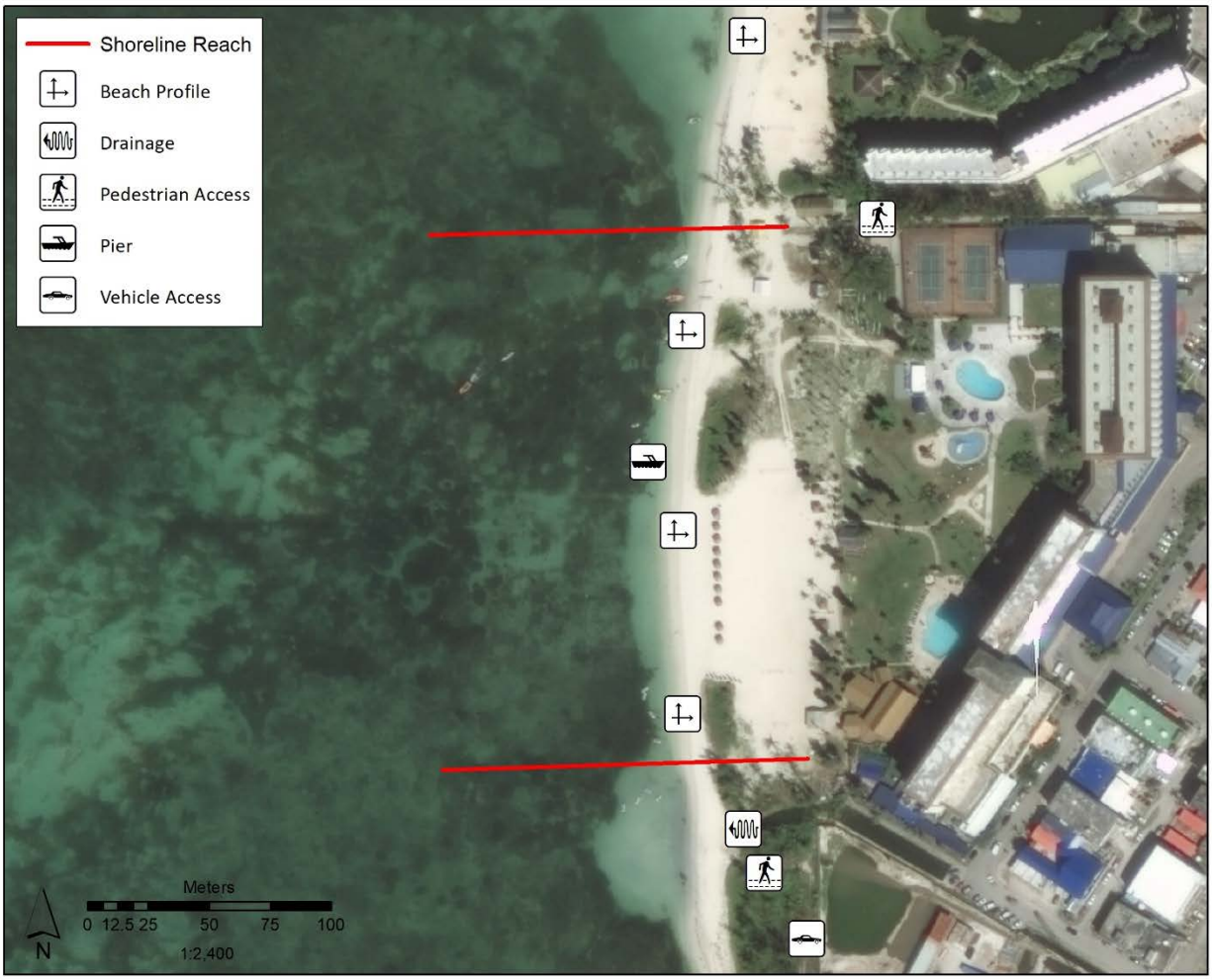
Figure 98 Makaka Beach, new resort construction in the inshore area (7/2/2017)

Figure 99 Makaka Beach, beach berm bisected by drainage (7/2/2017)

Figure 100 Makaka Beach, flood control at drainage mouth (7/2/2017)

Fiesta Beach

Erosion Hazard Priority Rating - HIGH



EASTING:
362035.45 meters E
NORTHING:
1682441.89 meters N
MUNICIPALITY:
Garapan; Garapan North
LENGTH:
200 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Commercial
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Fiesta Beach is located on the leeward (west) coast of Saipan, north of Makaka Beach and south of Hyatt Beach, and consists of approximately 200 meters of shoreline frontage. Fiesta Beach supports a variety of recreational uses including swimming, wading, snorkeling, and fishing. A floating dock supports commercial diving, jet ski, and tour boat operations. Similar operations are conducted from the beach. Vehicular access to Fiesta Beach was available via a public access road located between the Fiesta Resort & Spa and the Hyatt Regency Saipan.

ISSUES

The beach has been cleared of vegetation and is actively graded and maintained by resort staff. There were no public restrooms or trash/recycling receptacles observed in the area. Fiesta Resort restroom facilities are available to the public; however, there is no signage to direct beach users to the restroom facilities. There was physical evidence of erosion along the north section of the shoreline adjacent to Hyatt Beach.

RECOMMENDATIONS

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Restore and maintain shoreline vegetation.
- Install and maintain trash/recycling receptacles.
- Provide signage to direct the public to resort restroom facilities.

Fiesta Beach

Municipality: Garapan; Garapan North
Easting: 362035.45 m E
Nothing: 1682441.89 m N
Length: 200 m
Inspection: July 2, 2017 (9:30 am)
Tide: 0.17 m (incoming)

Erosion Hazard Priority Rating: HIGH

Coastal Setting

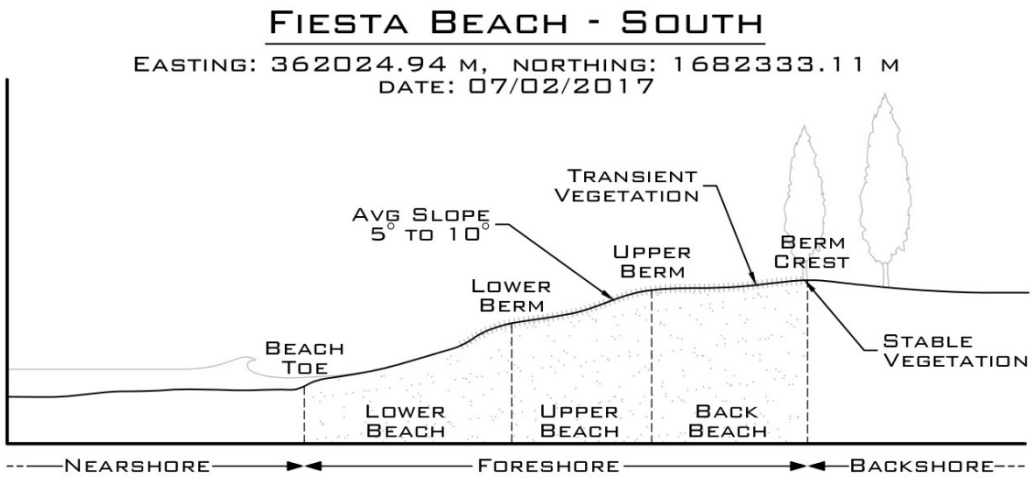
Fiesta Beach is located on the leeward (west) coast of Saipan, north of Makaka Beach and south of Hyatt Beach, and consists of approximately 200 m of shoreline frontage. The backshore consists of a graded sand beach that extends approximately 70 m inshore of the shoreline. The inshore area consists of high-intensity resort development and is the site of the Fiesta Resort & Spa. The foreshore consists of a moderately-wide, linear sand beach with a graded berm crest. The nearshore consists of a shallow lagoon and fringing reef. A view looking north from the south end of the beach is shown in Figure 102. A view looking south from the north end of the beach is shown in Figure 103.

Shoreline Condition

Fiesta Beach abuts the Saipan Lagoon and is partially protected by a shallow fringing reef that extends approximately 1,000 m offshore. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 2 m. The shoreline is west-facing at approximately 270 degrees (relative to True North). The beach is composed of very fine-grain carbonate sand. For the purposes of this assessment, the Fiesta Beach shoreline was divided into three sections: 1) south, 2) central, and 3) north.

Section 1: Fiesta Beach – South

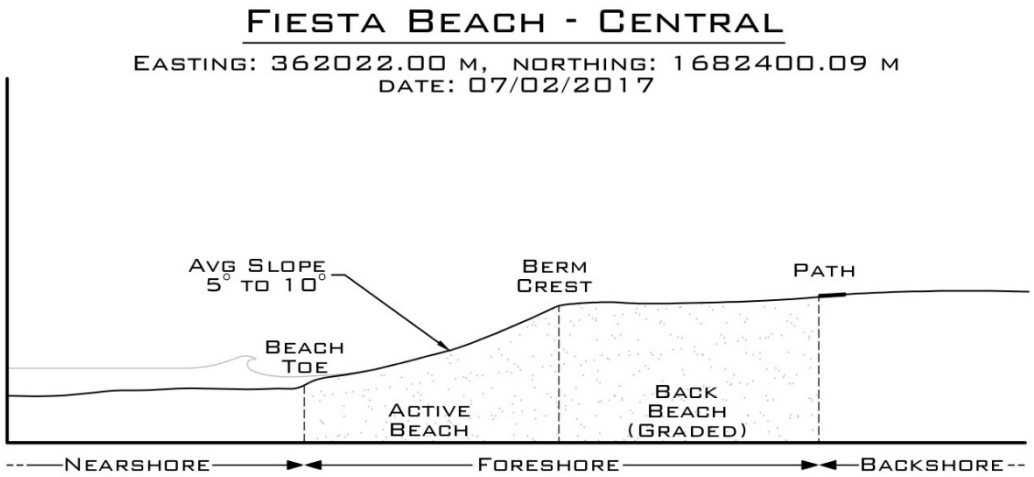
The south section of Fiesta Beach spans approximately 60 m of shoreline frontage north of Makaka Beach. A typical beach profile was recorded along the south section of the Fiesta Beach shoreline (Profile 9). Photographs showing the location of the beach profile are shown in Figure 104 and Figure 105. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a moderately-wide, exposed sand beach that progressed inshore to a transient berm along the edge of vegetation. The upper beach was moderately-sloping (10 to 15 degrees) and consisted of a stable berm covered by transient vegetation (Morning Glory, Ironwood saplings). The back beach progressed inshore to a berm crest. The backshore consisted of a graded area that was relatively flat and devoid of vegetation. There was no evidence of erosion or inundation inshore of the erosion scarp.



Profile 9 Typical beach profile along south section of Fiesta Beach

Section 2: Fiesta Beach – Central

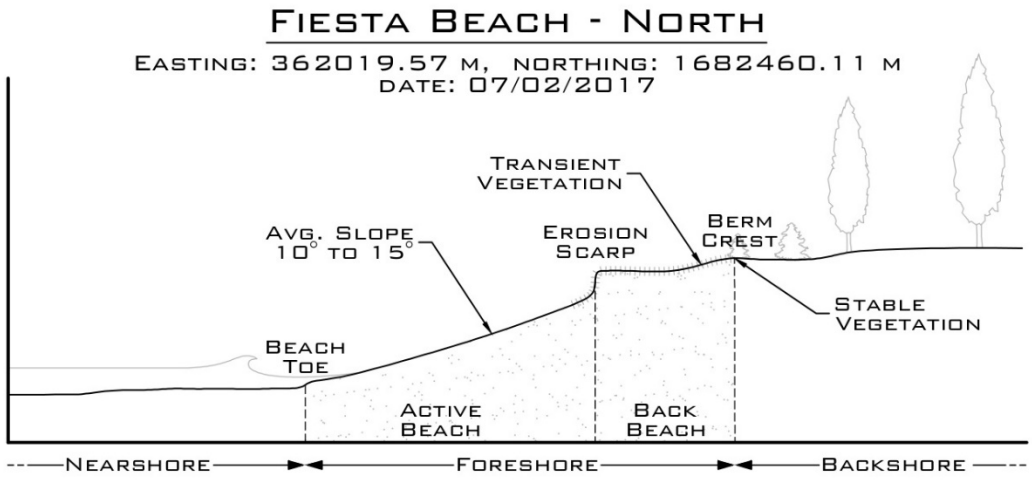
The central section of the Fiesta Beach shoreline spans approximately 80 m of shoreline frontage directly seaward of the Fiesta Resort & Spa. A typical beach profile was recorded along the central section of the Fiesta Beach shoreline (Profile 10). Photographs showing the location of the beach profile are shown in Figure 106 and Figure 107. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a moderately-wide, exposed sand beach that progressed inshore to a graded berm crest. The back beach was graded and devoid of vegetation. The back beach progressed inshore to a relatively flat grassy area in the backshore. There was no evidence of erosion or inundation inshore of the berm crest.



Profile 10 Typical beach profile along central section of Fiesta Beach

Section 3: Fiesta Beach – North

The north section of Fiesta Beach spans approximately 60 m of shoreline frontage south of Hyatt Beach. A typical beach profile was recorded along the north section of the Fiesta Beach shoreline (Profile 11). Photographs showing the location of the beach profile are shown in Figure 108 and Figure 109. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a narrow, exposed sand beach that progressed inshore to an active erosion scarp along the edge of vegetation. The back beach consisted of multiple berms covered by transient vegetation. The back beach progressed inshore to a berm crest. The backshore consisted of a relatively flat area with sparse, low-lying vegetation. There was evidence of active erosion along the scarp and inundation inshore of the erosion scarp.



Profile 11 Typical beach profile along north section of Fiesta Beach

Fiesta Beach supports a variety of recreational uses including swimming, wading, snorkeling, and fishing. A floating pier dock supports commercial diving, jet ski, and tour boat operations (Figure 110). Similar operations are conducted from the beach (Figure 111). Godfather's Beach House Bar is located in the backshore area and is open to the public (Figure 112). Vehicular access to Fiesta Beach was available via a public access road located between the Fiesta Resort & Spa and the Hyatt Regency Saipan. Public access was available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Fiesta Beach is shown as transects 173 through 184 on Map 10. The northern half of the shoreline exhibited accretion of up to 2 m/yr from 1999 to 2005, while the southern half exhibited mild erosion. The analysis showed accretion thereafter, with rates up to about 3 m/yr from 2005 to 2011. For the complete time series of the analysis (1999 to 2016), the shoreline accreted at rates of about 1 to 2 m/yr.

Erosion Hazard Priority Rating

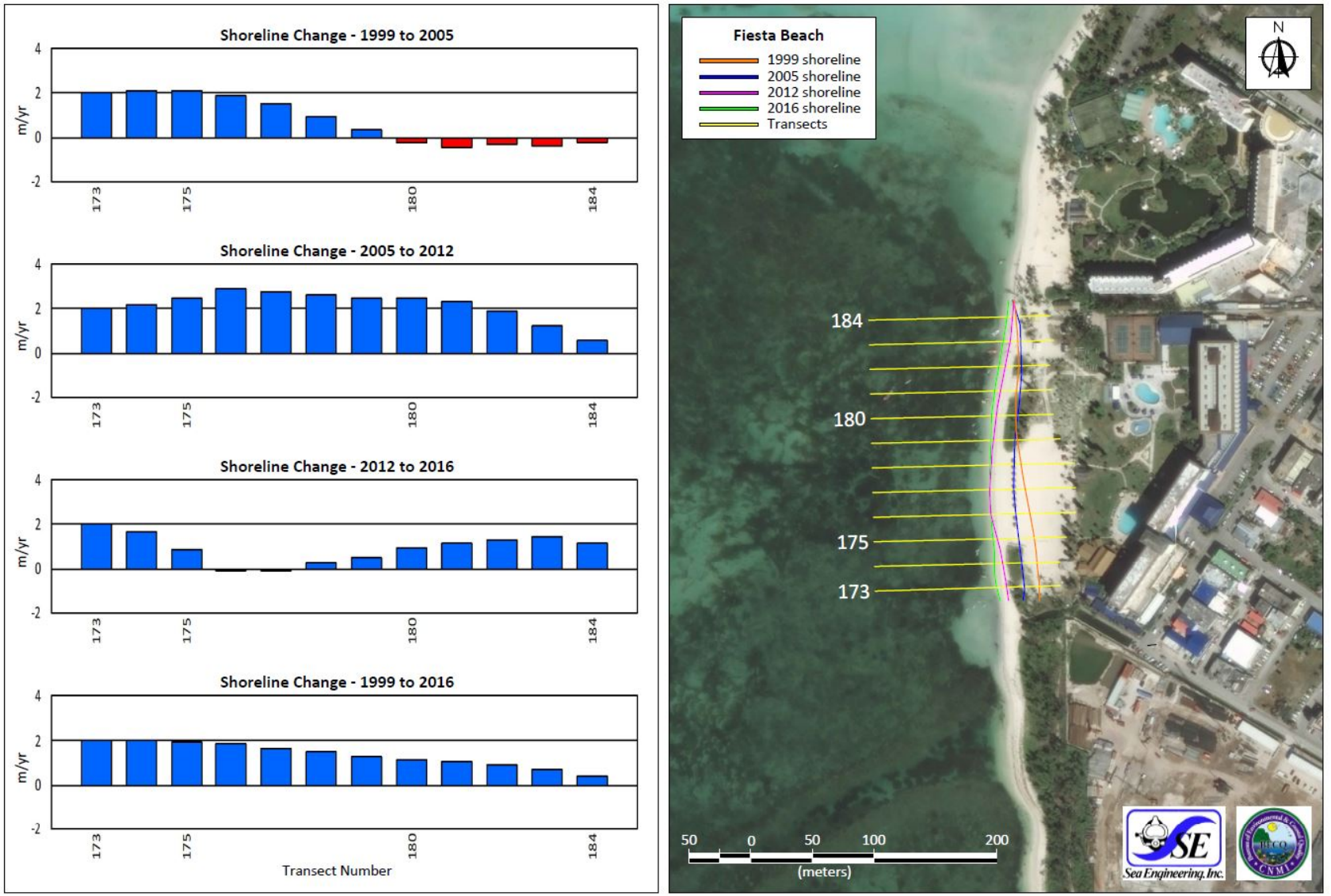
The EHPR for Fiesta Beach was determined to be *high*. The determination was based on limited reef width, evidence of erosion, low backshore elevation, high-intensity development in the backshore area, popularity and use intensity in the area, and potential impacts of erosion on shoreline access.

Issues & Recommendations

The beach had been cleared of vegetation and is actively graded and was being actively maintained by resort staff. There were no public restrooms or trash/recycling receptacles observed in the area. Fiesta Resort restroom facilities are available to the public; however, there was no signage to direct beach users to the restroom facilities. There was physical evidence of erosion along the north section of the shoreline adjacent to Hyatt Beach (Figure 113).

Recommendations

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Restore and maintain shoreline vegetation.
- Install and maintain trash/recycling receptacles.
- Provide signage to direct the public to resort restroom facilities.



Map 10 Fiesta Beach historical shoreline change (1999 to 2016)

Figure 101 Fiesta Beach, south end, looking north (7/2/2017)

Figure 102 Fiesta Beach, north end, looking south (7/2/2017)

Figure 103 Fiesta Beach, typical beach profile, south section, looking south (7/2/2017)

Figure 104 Fiesta Beach, typical beach profile, south section, looking north (7/2/2017)

Figure 105 Fiesta Beach, typical beach profile, central section, looking south (7/2/2017)

Figure 106 Fiesta Beach, typical beach profile, central section, looking north (7/2/2017)

Figure 107 Fiesta Beach, typical beach profile, north section, looking south (7/2/2017)

Figure 108 Fiesta Beach, typical beach profile, north section, looking north (7/2/2017)

Figure 109 Fiesta Beach, pier dock and swimming area (7/2/2017)

Figure 110 Fiesta Beach, tour boat operations (7/2/2017)

Figure 111 Fiesta Beach, Godfather's Beach House Bar (7/2/2017)

Figure 112 Fiesta Beach, active erosion scarp along north section of shoreline (7/2/2017)

Hyatt Beach

Erosion Hazard Priority Rating - HIGH

EASTING:
362055.55 meters m E
NORTHING:
1682626.65 meters N
MUNICIPALITY:
Garapan North
LENGTH:
200 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Commercial
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Wetlands
EROSION HAZARD PRIORITY RATING:
HIGH

DESCRIPTION

Hyatt Beach is located on the leeward (west) coast of Saipan, north of Fiesta Beach and south of Micro Beach, and consists of approximately 200 meters of shoreline frontage. Hyatt Beach supports a variety of recreational uses including swimming, wading, snorkeling, and fishing. Commercial diving tour boat operations are conducted from the beach. Vehicular access to Hyatt Beach was available via a public access road located between the Fiesta Resort & Spa and the Hyatt Regency Saipan, with additional access available to the public at Micro Beach.

ISSUES

The beach was cleared of vegetation and is actively graded and maintained by resort staff. There were no public restrooms or trash/recycling receptacles observed in the area. There was physical evidence of erosion along the north section of the shoreline adjacent to Micro Beach. Additional erosion was observed adjacent to the water sports rental operation at the north end of the shoreline. Sandbags were installed to address the erosion in this area. Remnants of a collapsed pier extended from the beach into the nearshore at the north end of

RECOMMENDATIONS

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Restore and maintain shoreline vegetation.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.

Hyatt Beach

Municipality: Garapan North
Easting: 362055.55 m E
Nothing: 1682626.65 m N
Length: 200 m
Inspection: July 2, 2017 (10:00 am)
Tide: 0.18 m (incoming)

Erosion Hazard Priority Rating: HIGH

Coastal Setting

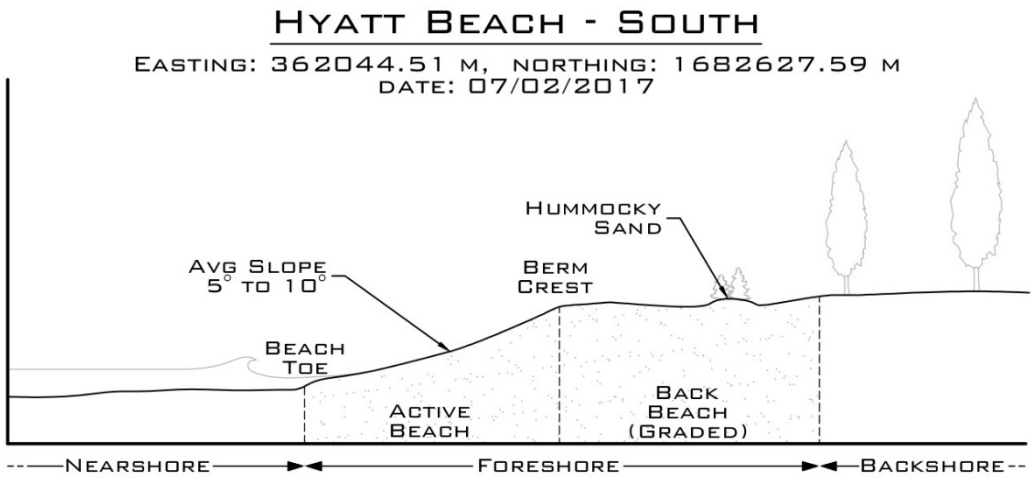
Hyatt Beach is located on the leeward (west) coast of Saipan, north of Fiesta Beach and south of Micro Beach, and consists of approximately 200 m of shoreline frontage. The backshore consists of a graded beach that extends approximately 40 m inshore of the shoreline. The inshore area consists of high-intensity resort development and is the site of the Hyatt Regency Saipan. The foreshore consists of a moderately-wide, linear sand beach with a graded berm crest. The nearshore consists of a shallow lagoon and fringing reef. Along the northern end of the shoreline, the fringing reef is bisected by a sand-filled channel that is approximately 300 m wide. A view looking north from the south end of the beach is shown in Figure 114. A view looking south from the north end of the beach is shown in Figure 115.

Shoreline Condition

Hyatt Beach abuts the Saipan Lagoon and is partially protected by a shallow fringing reef that extends approximately 1,000 m offshore. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 2 m. The shoreline is west-facing at approximately 275 degrees (relative to True North). The beach is composed of very fine-grain carbonate sand. For the purposes of this assessment, the Hyatt Beach shoreline was divided into two sections: 1) south, and 2) north.

Section 1: Hyatt Beach – South

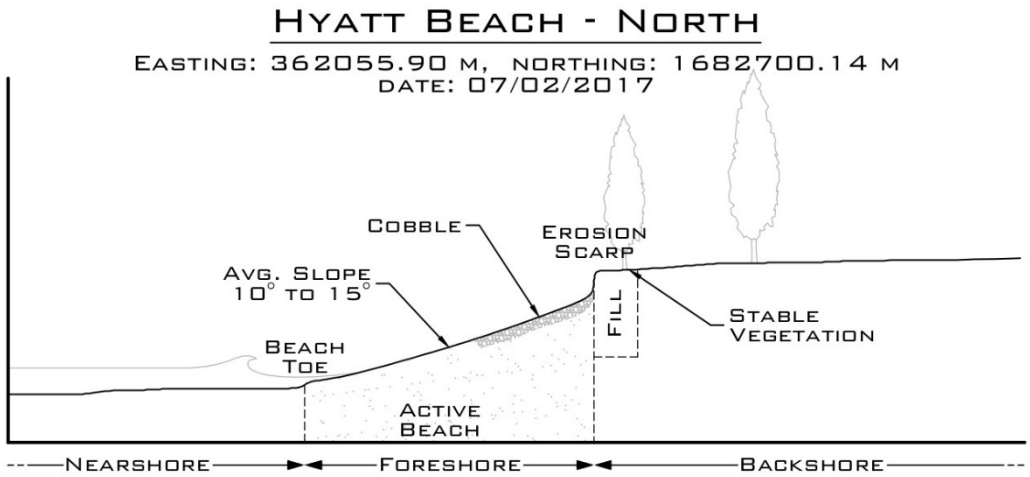
The south section of Hyatt Beach spans approximately 150 m of shoreline frontage north of Fiesta Beach. A typical beach profile was recorded along the south section of the Hyatt Beach shoreline (Profile 12). Photographs showing the location of the beach profile are shown in Figure 116 and Figure 117. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a moderately-wide, exposed sand beach that progressed inshore to a stable berm crest. The backshore consisted of a graded area that was relatively flat and devoid of vegetation. There was no evidence of erosion or inundation inshore of the berm crest.



Profile 12 Typical beach profile along south section of Hyatt Beach

Section 2: Hyatt Beach – North

The north section of the Hyatt Beach shoreline spans approximately 50 m of shoreline frontage south of Micro Beach. A typical beach profile was recorded along the north section of the Hyatt Beach shoreline (Profile 13). Photographs showing the location of the beach profile are shown in Figure 118 and Figure 119. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a narrow beach composed of sand, gravel, and coral cobble that progressed inshore to an active erosion scarp. The backshore consisted of a relatively flat grassy area. There was no evidence of erosion or inundation inshore of the erosion scarp. Remnants of a collapsed pier extended into the nearshore at the north end of the shoreline (Figure 120).



Profile 13 Typical beach profile along north section of Hyatt Beach

Hyatt Beach supports a variety of recreational uses including swimming, wading, snorkeling, and fishing. Recreational diving and tour boat operations are conducted from the beach. Vehicular access to Hyatt Beach was available via a public access road located between the Fiesta Resort & Spa and the Hyatt Regency Saipan, with additional vehicular access available at Micro Beach, to the north. Public access was available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Hyatt Beach is shown as transects 185 through 193 on Map 11. The analysis shows the beach to be fairly dynamic, with shoreline change patterns reversing between 2005 and 2016. Accretion and erosion rates were measured to be up to 2 m/yr within the data set. While the analysis showed the shoreline to be dynamic within the dataset, the shoreline change from 1999 to 2016 was measured to be negligible.

Erosion Hazard Priority Rating

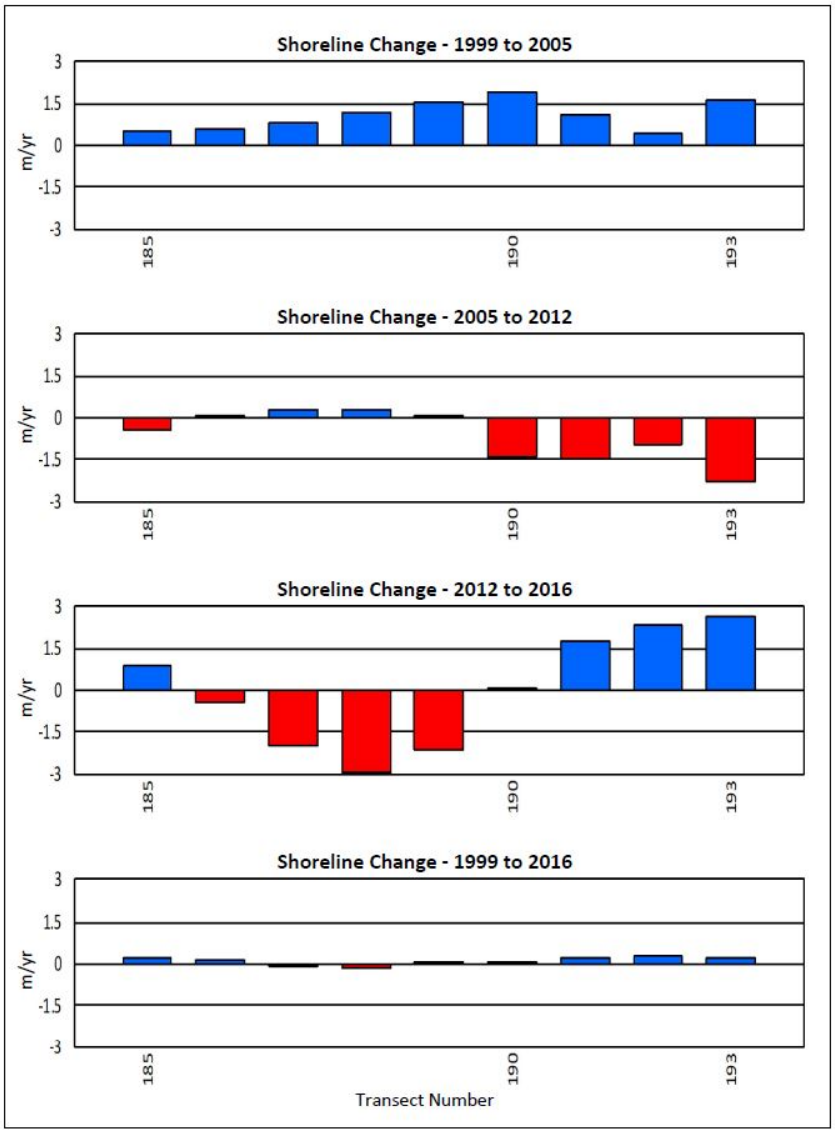
The EHPR for Hyatt Beach was determined to be *high*. The determination was based on limited reef width, presence of a large channel, evidence of erosion, low backshore elevation, high-intensity development in the backshore area, popularity and use intensity in the area, and potential impacts of erosion on shoreline access.

Issues & Recommendations

The beach was cleared of vegetation and is actively graded and maintained by resort staff. There were no public restrooms or trash/recycling receptacles observed in the area. There was evidence of erosion along the north section of the shoreline adjacent to Micro Beach. Additional erosion was observed adjacent to the water sports rental operation at the north end of the shoreline (Figure 121). Sandbags were installed to address the erosion in this area, which is presumably caused by foot traffic to and from the water sports rental operation.

<u>Recommendations</u>

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Restore and maintain shoreline vegetation.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.



Map 11 Hyatt Beach historical shoreline change (1999 to 2016)

Figure 113 Hyatt Beach, south end, looking north (7/2/2017)

Figure 114 Hyatt Beach, north end, looking south (7/2/2017)

Figure 115 Hyatt Beach, typical beach profile, south section, looking south (7/2/2017)

Figure 116 Hyatt Beach, typical beach profile, south section looking north (7/2/2017)

Figure 117 Hyatt Beach, typical beach profile, north section, looking south (7/2/2017)

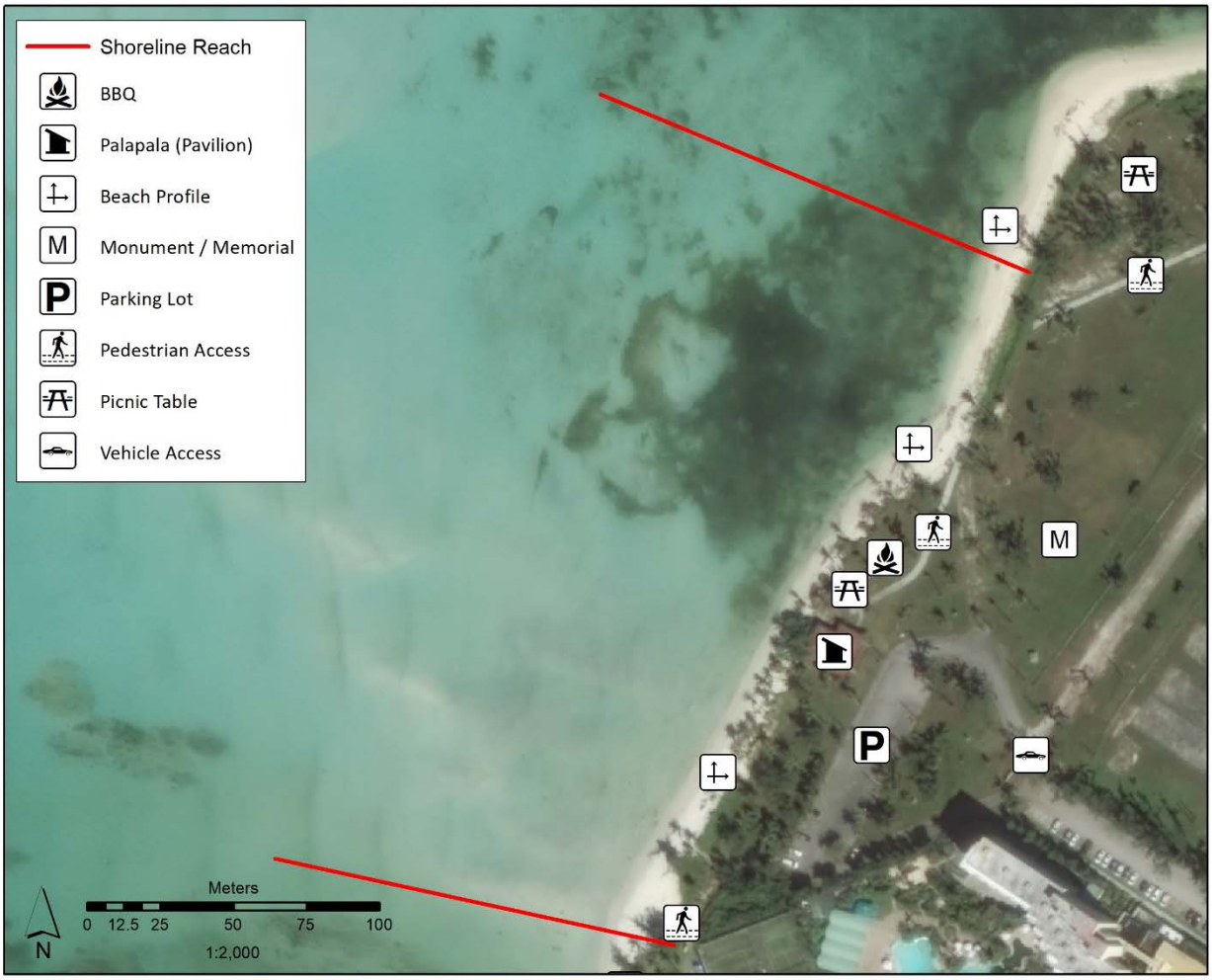
Figure 118 Hyatt Beach, typical beach profile, north section, looking north (7/2/2017)

Figure 119 Hyatt Beach, remnants of collapsed pier at north end of shoreline (7/2/2017)

Figure 120 Hyatt Beach, erosion due to foot traffic (7/2/2017)

Micro Beach

Erosion Hazard Priority Rating - MEDIUM



EASTING:
362109.18 meters E
NORTHING:
1682830.66 meters N
MUNICIPALITY:
Garapan North; Lower Base
LENGTH:
180 meters
AVERAGE BEACH SLOPE:
5 to 10 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Commercial; Government
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Micro Beach is located on the leeward (west) coast of Saipan, north of Hyatt Beach and south of American Memorial Park, and consists of approximately 180 meters of shoreline frontage. Micro Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, and various water sports. Park amenities included a palapala, grills/fire pits (2), and picnic tables (2). There were trash/recycling receptacles observed in the area, and a public restroom was available at American Memorial Park.

ISSUES

The Micro Beach shoreline appears to be fairly dynamic and vulnerable to episodic erosion. There was evidence of active erosion along the south end of the shoreline where remnants of a collapsed pier extended from the beach into the nearshore. There were dead Ironwood trees on the upper beach on the north section of the shoreline that were presumably felled by storm surge and/or high winds caused by storm surge. The beach fronting the damaged concrete path had recovered and was 35 to 40 meters wide and covered with transient vegetation at the time of the site visit.

RECOMMENDATIONS

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Repair coastal access path.
- Evaluate options to relocate the coastal access path further landward.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.

Micro Beach

Municipality: Garapan North; Lower Base
Easting: 362109.18 m E
Nothing: 1682830.66 m N
Length: 180 m
Inspection: July 2, 2017 (11:00 am)
Tide: 0.20 m (incoming)

Erosion Hazard Priority Rating: MEDIUM

Coastal Setting

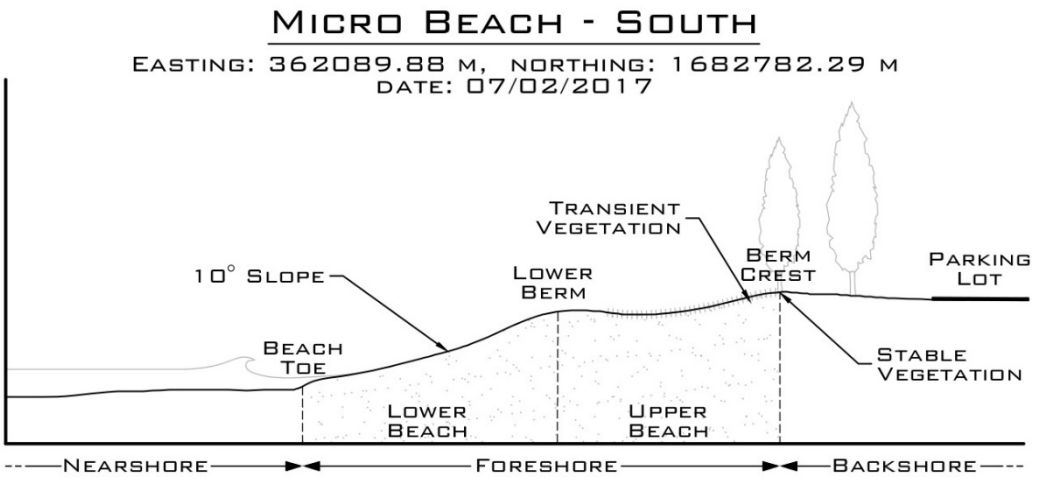
Micro Beach is located on the leeward (west) coast of Saipan, north of Hyatt Beach and south of American Memorial Park, and consists of approximately 180 m of shoreline frontage. The backshore consists of an open grassy area that extends approximately 100 m inshore of the shoreline. The inshore area consists of a public park. The foreshore consists of a moderately-wide, linear sand beach. The nearshore consists of a shallow lagoon and fringing reef. The fringing reef is bisected by a sand-filled channel that is approximately 300 m wide. A view looking north from the south end of the beach is shown in Figure 122. A view looking south from the north end of the beach is shown in Figure 123.

Shoreline Condition

Micro Beach abuts the Saipan Lagoon and is partially protected by a shallow fringing reef and barrier reef that extend approximately 1,000 m and 2,800 m offshore, respectively. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 2 m with depths increasing slightly toward the barrier reef. The shoreline is west-facing at approximately 285 degrees (relative to True North). The beach is composed of very fine-grain carbonate sand. For the purposes of this assessment, the Micro Beach shoreline was divided into two sections: 1) south, and 2) north.

Section 1: Micro Beach – South

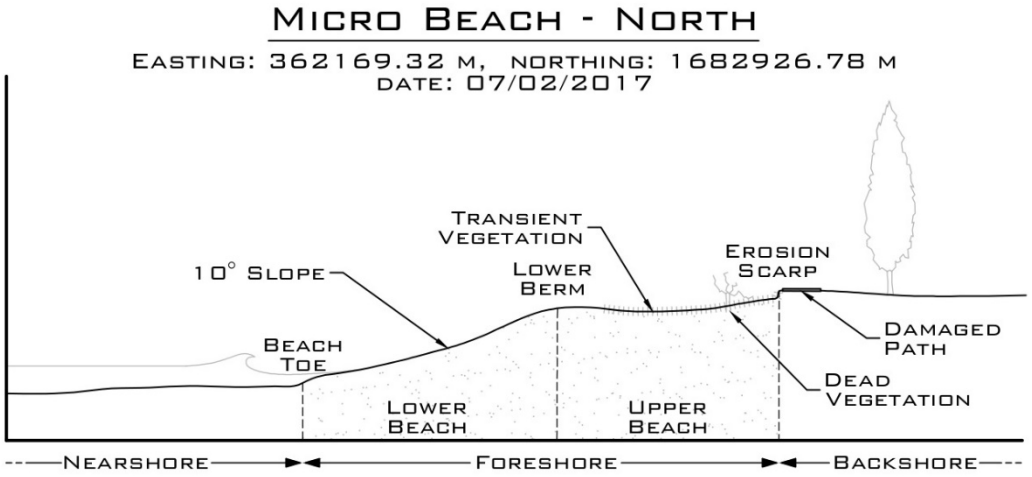
The south section of the Micro Beach shoreline spans approximately 100 m of shoreline frontage north of Hyatt Beach. A typical beach profile was recorded along the south section of the Micro Beach shoreline (Profile 14). Photographs showing the location of the beach profile are shown in Figure 124 and Figure 125. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a moderately-wide, exposed sand beach that progressed inshore to a transient berm along the vegetation line. The upper beach was slightly concave and covered by transient vegetation (Morning Glory) and mature vegetation (Ironwood, Coconut trees). The upper beach progressed inshore to a stable berm crest along the edge of the grassy backshore area. A relict erosion scarp was visible along some sections of the berm crest; however, there was no evidence of active erosion. The backshore was relatively flat and consisted of an open grassy park area and paved parking lot. There was no evidence of erosion or inundation inshore of the berm crest.



Profile 14 Typical beach profile along south section of Micro Beach

Section 2: Micro Beach – North

The north section of the Micro Beach shoreline spans approximately 100 m of shoreline frontage south of American Memorial Park. A typical beach profile was recorded along the north section of the Micro Beach shoreline (Profile 15). Photographs showing the location of the beach profile are shown in Figure 126 and Figure 127. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a moderately-wide, exposed sand beach that progressed inshore to a transient berm along the vegetation line. The upper beach was slightly concave and covered by transient vegetation (Morning Glory) and mature vegetation (Ironwood trees and saplings). The upper beach progressed inshore to a relict erosion scarp along the edge of the grassy backshore area. The backshore area was relatively flat and consisted of an open grassy park area. A concrete coastal access path terminated at the erosion scarp. A 50-meter section of the path was damaged by erosion and storm surge caused by a typhoon (Figure 128). The erosion scarp did not appear to be active and there was no evidence of recent erosion. There was no evidence of erosion or inundation inshore of the berm crest.



Profile 15 Typical beach profile along north section of Micro Beach

Micro Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, and various water sports (e.g., kite surfing, wind surfing, canoe paddling, etc.). Mañagaha, a small uninhabited islet located approximately 2,500 m from the shoreline, is also a popular SCUBA diving site. Micro Beach was the site of the first Carolinian village and served as a training site for celestial Navigation (U.S. National Park Service, 2006). There is also a historical pillbox located approximately 50 m inshore of the erosion scarp. Park amenities included a palapala, grills/fire pits (2), and picnic tables (2) (Figure 129). There were trash/recycling receptacles observed in the area, and a public restroom was available at American Memorial Park. Vehicular access was available from Micro Beach Road, a paved road that connects to Beach Road. Parking was available in a paved lot with approximately 60 parking stalls (Figure 130). Public access was available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Micro Beach is shown as transects 194 through 203 on Map 12. Similar to the neighboring Hyatt and American Memorial Park beaches, the analysis shows Micro Beach to be fairly dynamic. The shoreline change patterns reversed between 2005 and 2012. Accretion and erosion rates were measured to be up to 3 m/yr within the dataset, slightly higher than those measured for Hyatt Beach. The shoreline change from 1999 to 2016 was also measured to be negligible. Micro Beach is vulnerable to episodic erosion events. The most recent significant erosion event at Micro Beach occurred in September 2017.

Erosion Hazard Priority Rating

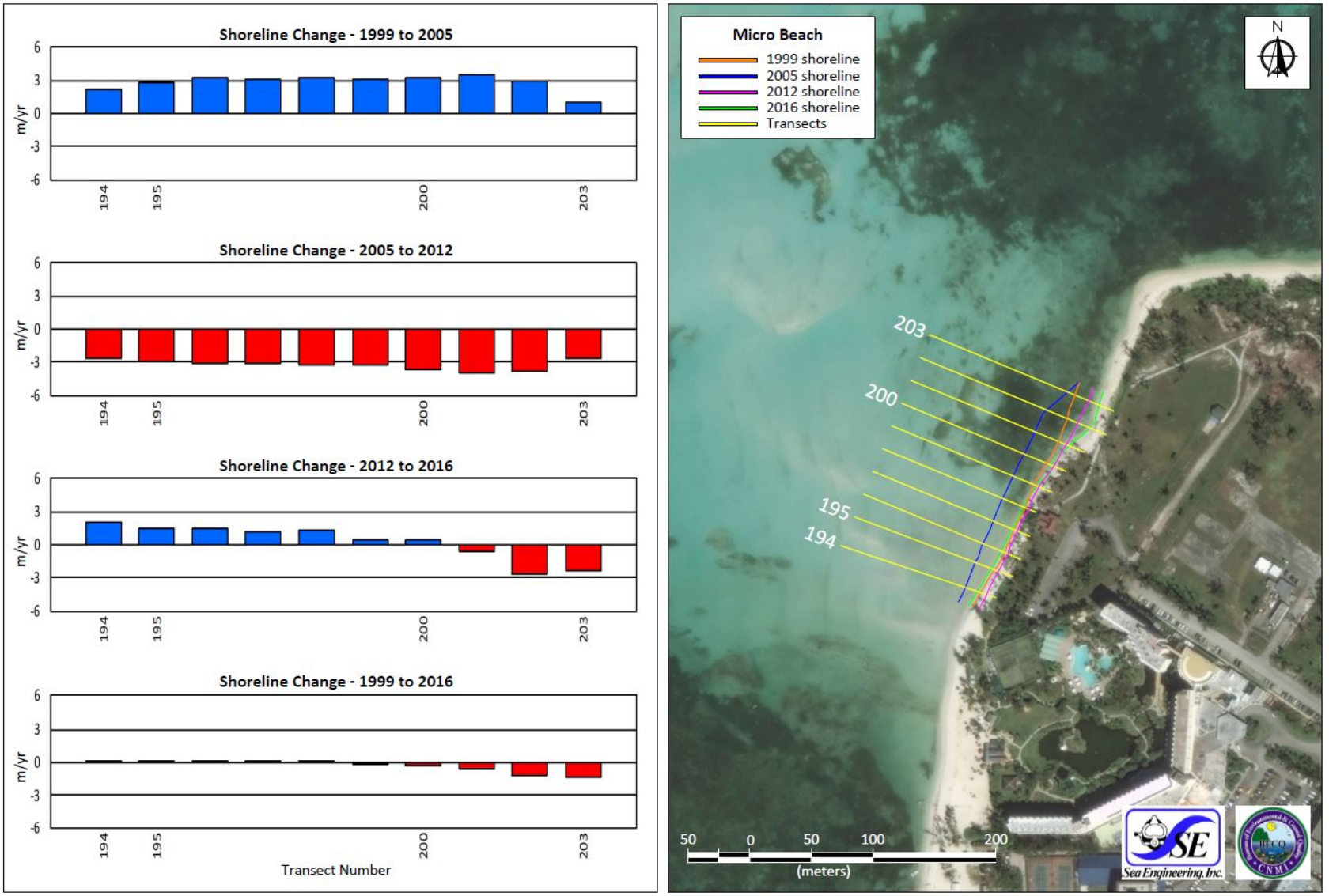
The EHPR for Micro Beach was determined to be *medium*. The determination was based on limited reef width, presence of a large channel, evidence of erosion, low backshore elevation, and popularity and use intensity in the area. Despite the history of episodic erosion, and the recent erosion at Micro Beach, the EHPR was not considered *high* due to the lack of development in the backshore area, lack of vulnerable infrastructure, and the fact that the shoreline is still accessible under erosion conditions.

Issues & Recommendations

There was evidence of active erosion along the south end of the shoreline (Figure 131). There were three dead Ironwood trees on the upper beach on the north section of the shoreline that were presumably felled by storm surge and/or high winds caused by a typhoon (Figure 132). Micro Beach appears to be fairly dynamic and is vulnerable to episodic erosion events. The beach fronting the damaged concrete path had recovered and was 35 to 40 m wide and covered by transient vegetation (Morning Glory and Ironwood saplings) at the time of the site visit (Figure 133). The presence of Ironwood saplings suggests that this section of the shoreline has been accreting since the last major erosion event.

<u>Recommendations</u>

- Evaluate options for berm enhancement, beach maintenance, and beach nourishment.
- Repair coastal access path.
- Evaluate options to relocate the coastal access path further landward.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms.



Map 12 Micro Beach historical shoreline change (1999 to 2016)

Figure 121 Micro Beach, south end, looking north (7/2/2017)

Figure 122 Micro Beach, north end, looking south (7/2/2017)

Figure 123 Micro Beach, typical beach profile, south section, looking north (7/2/2017)

Figure 124 Micro Beach, typical beach profile, south section, looking south (7/2/2017)

Figure 125 Micro Beach, typical beach profile, north section, looking north (7/2/2017)

Figure 126 Micro Beach, typical beach profile, north section, looking south (7/2/2017)

Figure 127 Micro Beach, damaged coastal access path (7/2/2017)

Figure 128 Micro Beach, backshore amenities (7/2/2017)

Figure 129 Micro Beach, vehicle access and parking in the backshore area (7/2/2017)

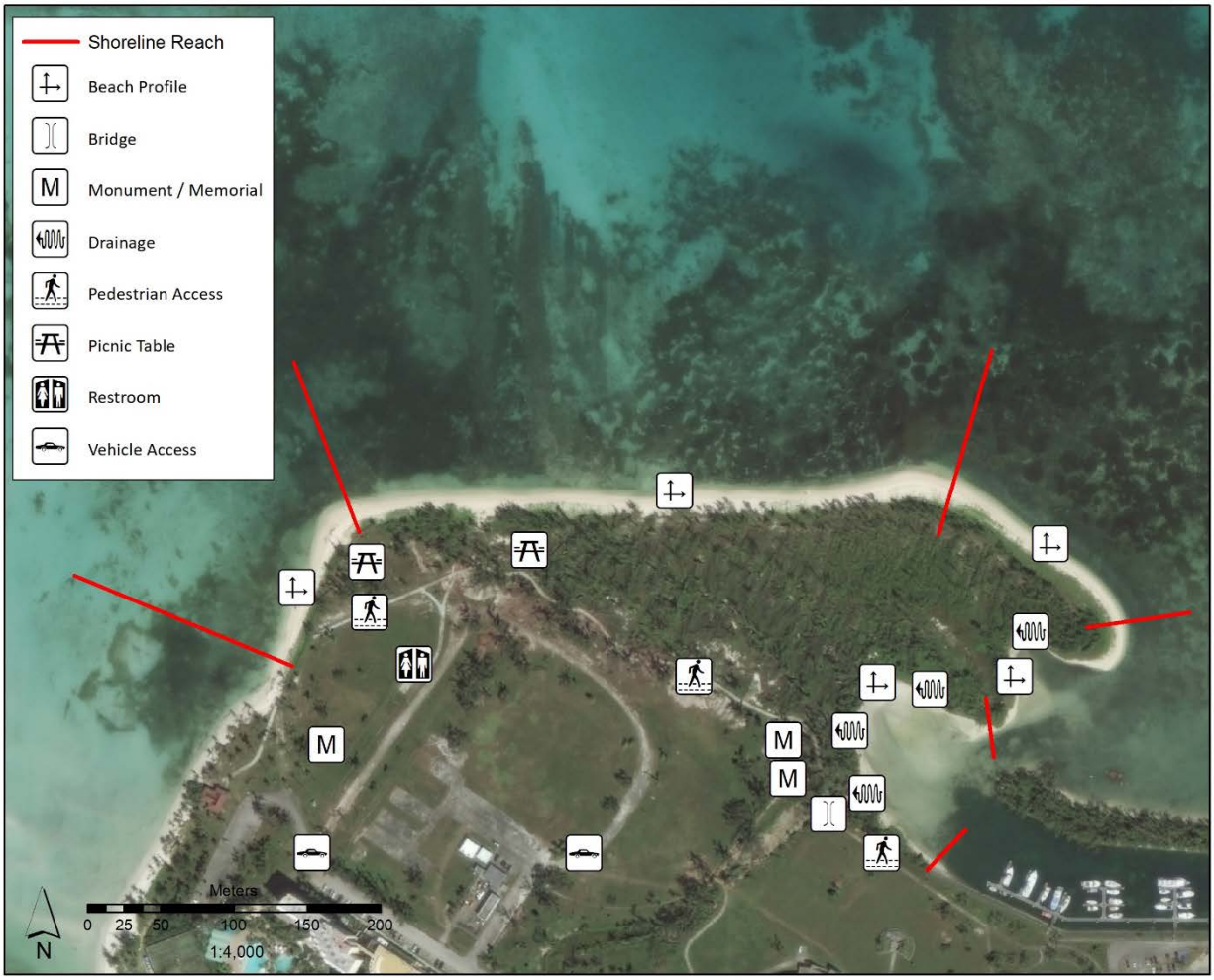
Figure 130 Micro Beach, active erosion at south end of shoreline (7/2/2017)

Figure 131 Micro Beach, felled Ironwood trees on the upper beach (7/2/2017)

Figure 132 Micro Beach, transient vegetation on upper beach (7/2/2017)

American Memorial Park

Erosion Hazard Priority Rating - LOW



EASTING:
362413.95 meters E
NORTHING:
1683017.59 meters N
MUNICIPALITY:
Lower Base
LENGTH:
1,000 meters
AVERAGE BEACH SLOPE:
5 to 10 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Government
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

American Memorial Park is located on the leeward (west) coast of Saipan, north of Micro Beach and west of Smiling Cove Marina, and consists of approximately 1,000 meters of shoreline frontage. The 133-acre park supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and various water sports. Amenities included sporting areas, picnic sites, playgrounds, and a coastal path. Trash/recycling receptacles were located throughout the park and there was a public restroom available.

ISSUES

The backshore area was well-maintained and there was ample open space. The maritime forest appeared to be natural and undisturbed. Restoration work to improve wildlife habitat within the estuary is ongoing. There was some evidence of erosion along parts of the shoreline, but it appeared to be minor in nature. The majority of the shoreline appeared to stable or accreting.

RECOMMENDATIONS

- Consider dredging the entrance channel to Smiling Cove Marina to ensure safe navigation.

American Memorial Park

Municipality: Lower Base
Easting: 362413.95 m E
Nothing: 1683017.59 m N
Length: 1,000 m
Inspection: July 3, 2017 (9:30 am)
Tide: 0.13 m (outgoing)

Erosion Hazard Priority Rating: LOW

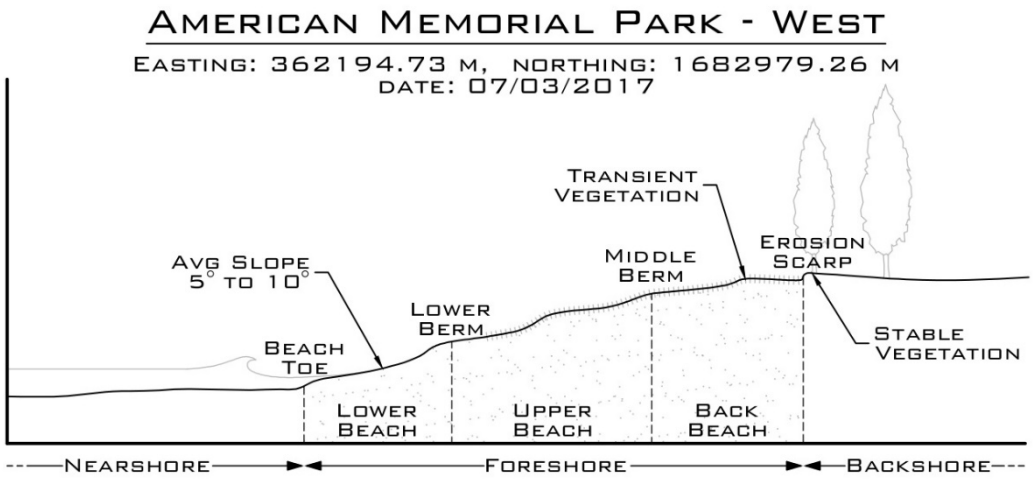
Coastal Setting

American Memorial Park is located on the leeward (west) coast of Saipan, north of Micro Beach and west of Smiling Cove Marina, and consists of approximately 1,000 m of shoreline frontage. The backshore consists of a maritime forest and a large, open, grassy park area. The foreshore consists of a narrow, linear sand beach, an ephemeral sand spit, and a shallow estuarine lagoon. The nearshore consists of a shallow lagoon, a fringing reef, and a barrier reef.

Shoreline Condition

American Memorial Park abuts the Saipan Lagoon and is partially protected by a shallow fringing reef and barrier reef that extend approximately 750 m and 2,700 m offshore, respectively. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 2 m with depths increasing slightly toward the barrier reef. The offshore waters are part of the Mañagaha Marine Conservation Area. For the purposes of this assessment, the American Memorial Park shoreline was divided into three sections: 1) west, 2) central, and 3) east.

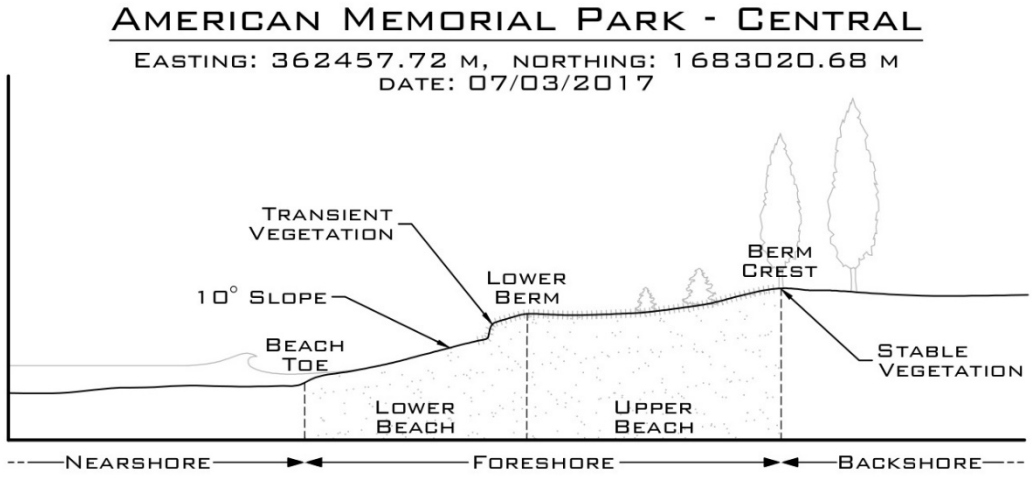
Section 1: American Memorial Park – West
The west section of the American Memorial Park shoreline spans approximately 100 m of shoreline frontage north of Micro Beach (Figure 134). The west section of the shoreline is west-facing at approximately 285 degrees (relative to True North) and the beach is composed of fine-grain carbonate sand. A typical beach profile was recorded along the west section of the American Memorial Park shoreline (Profile 16). A photograph showing the location of the beach profile is shown in Figure 135. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a moderately-wide, exposed sand beach that progressed inshore to a transient berm along the vegetation line. The upper beach was gently-sloping (0 to 5 degrees) and covered by transient vegetation (Morning Glory) and Ironwood trees and saplings. The upper beach progressed inshore to a relict erosion scarp along the edge of the grassy backshore area. There was no evidence of active erosion along the scarp. The backshore was relatively flat and consisted of an open, grassy park area with mature vegetation (Ironwood and Coconut trees) and soils composed of Shioya loamy sand.



Profile 16 Typical beach profile along west section of American Memorial Park

Section 2: American Memorial Park – Central

The central section of the American Memorial Park shoreline spans approximately 400 m of shoreline frontage (Figure 136). The central section of the shoreline (including the sand spit) is north-facing at approximately 355 degrees (relative to True North) and the beach (including the sand spit) is composed of medium to coarse-grain carbonate sand. A typical beach profile was recorded along the central section of the American Memorial Park shoreline (Profile 17). A photograph showing the location of the beach profile is shown in Figure 137. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a narrow, exposed sand beach that progressed inshore to a transient berm and erosion scarp along the vegetation line. There was evidence of active erosion along the erosion scarp. There was no evidence of erosion or inundation inshore of the erosion scarp. The upper beach was slightly concave and covered by transient vegetation (Morning Glory) and mature vegetation (Ironwood trees). The upper beach progressed inshore to a relict storm berm in the backshore area. The backshore included multiple relict berms and consisted of a maritime forest with well-established vegetation.



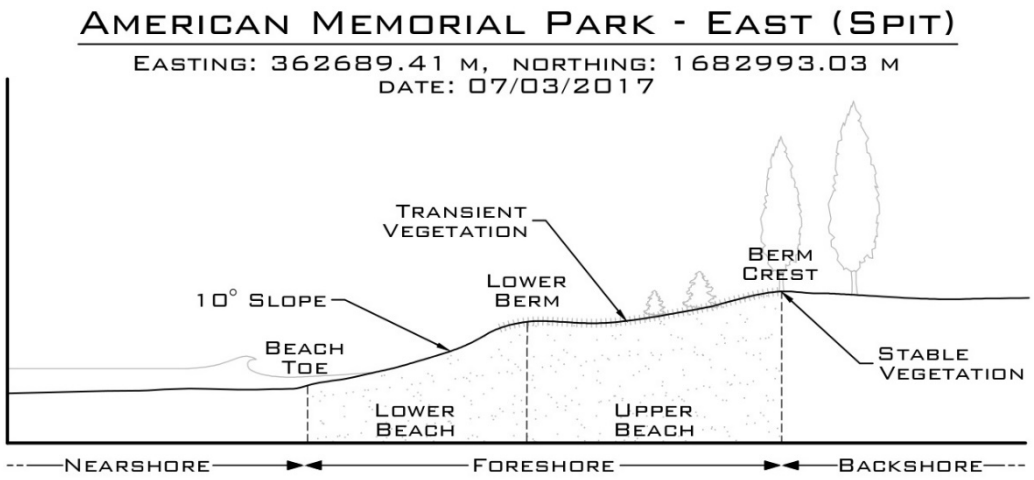
Profile 17 Typical beach profile along central section of American Memorial Park

Section 3: American Memorial Park – East (Sand Spit and Smiling Cove)
The east section of the American Memorial Park shoreline spans approximately 500 m of shoreline frontage that includes a large sand spit and Smiling Cove (Figure 138). The east section of the shoreline (inside the estuarine lagoon at Smiling Cove) is partially-sheltered, the shoreline orientation is variable, and the beach is composed of fine to very-fine-grain carbonate sand mixed with terrigenous sediment. Three (3) beach profiles were recorded along the east section of the American Memorial Park shoreline.

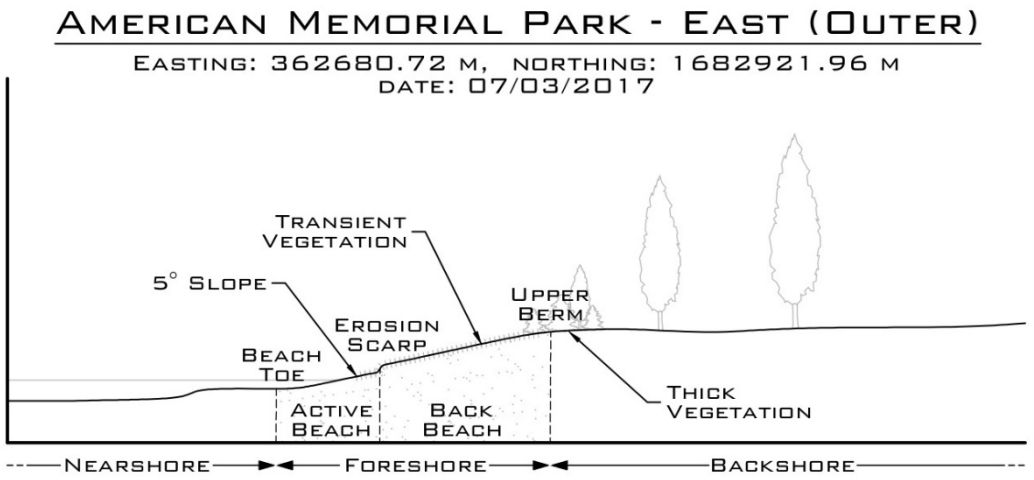
The first beach profile was located at the east end of the sand spit, outside of Smiling Cove (Profile 18). A photograph showing the location of the beach profile is shown in Figure 139. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a narrow, exposed sand beach that progressed inshore to a transient berm and erosion scarp along the vegetation line. There was evidence of active erosion along the scarp. The upper beach was gently-sloping (5 to 10 degrees) and consisted of a stable berm covered by transient vegetation (Morning Glory) and Ironwood saplings. Vegetation along the upper beach appeared to be well-established, and the presence of small Ironwood saplings on the upper beach suggests that the shoreline has likely been accreting in this area. There was no evidence of erosion or inundation inshore of the upper berm. The upper beach progressed inshore to a relict storm berm in the backshore area, which consisted of a maritime forest with well-established vegetation.

The second beach profile was located near the outer entrance to Smiling Cove (Profile 19). A photograph showing the location of the beach profile is shown in Figure 140. The lower beach was moderately-sloping (10 to 15 degrees) and consisted of a moderately-wide, prograded sand beach that progressed inshore to a transient berm along the vegetation line. There was no evidence of erosion inshore of the lower berm. The upper beach was gently-sloping (5 to 10 degrees) and consisted of a stable berm covered by transient vegetation (beach grass) and Ironwood saplings with visible marine debris lines. There was no evidence of erosion or inundation inshore of the upper berm. The upper beach progressed inshore to a relict storm berm in the backshore area. The backshore consisted of a maritime forest with well-established vegetation.

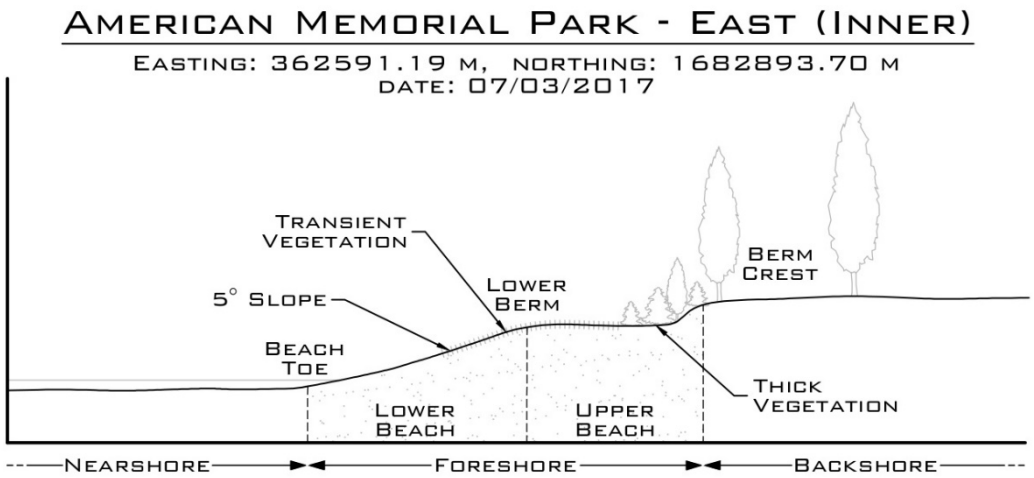
The third beach profile was located inside of Smiling Cove (Profile 20). A photograph showing the location of the beach profile is shown in Figure 141. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a narrow sand beach that was partially covered by vegetation (beach grass, mangroves). The upper beach was gently-sloping (5 to 10 degrees) and covered by stable vegetation (beach grass) with visible marine debris lines. The backshore consisted of a maritime forest with well-established vegetation. There was evidence of inundation in the forested area inshore of the beach. The shoreline was also bisected by drainage features at several locations (Figure 142). Due to the lack of exposure, there is minimal wave energy within Smiling Cove. The beach in this area appears to be primarily influenced by water levels and currents. The inner cove consisted of a very shallow sand shoal that appeared to limit navigability of the entrance channel to Smiling Cove Marina (Figure 143). Remnants of a collapsed pier were visible on the sand shoal (Figure 144). There is also 30-acre protected wetland and mangrove forest within Smiling Cove. A mangrove restoration project was observed in the area (Figure 145).



Profile 18 Typical beach profile along east section American Memorial Park (sand spit



Profile 19 Typical beach profile along east section American Memorial Park (outer cove)



Profile 20 Typical beach profile along east section American Memorial Park (inner cove

American Memorial Park is managed by the U.S. National Park Service. The 133-acre park supports a variety of recreational uses including swimming, wading, snorkeling, fishing, walking, jogging, biking, picnicking, and various water sports. There are several historical sites within the park including a Carolinian village site, pillboxes, war memorials, and a museum. Park amenities included sporting areas, picnic sites, playgrounds, and a coastal access path (Figure 146). Trash/recycling receptacles were observed throughout the park and there was a public restroom available (Figure 147). Vehicular access was available from Micro Beach Road, a paved road that connects to Beach Road. There were several paved parking areas with additional off-road parking available. Public access was available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for American Memorial Park is shown as transects 204 through 255 on Map 13. The analysis shows American Memorial Park to be the most dynamic shoreline included in this assessment. The shoreline on the west section of American Memorial Park has the same exposure as the adjacent Micro Beach; however, the shoreline soon turns east toward the sand spit and Smiling Cove. Westerly waves can approach obliquely to the shoreline, resulting in significant potential for sediment transport toward the east. This can be seen in the historical shorelines, where substantial accretion has occurred along the sand spit (transects 215 to 237). The maximum accretion from 1999 to 2016 occurred along transect 237, where the shoreline accreted by a total of 106 m.

Erosion Hazard Priority Rating

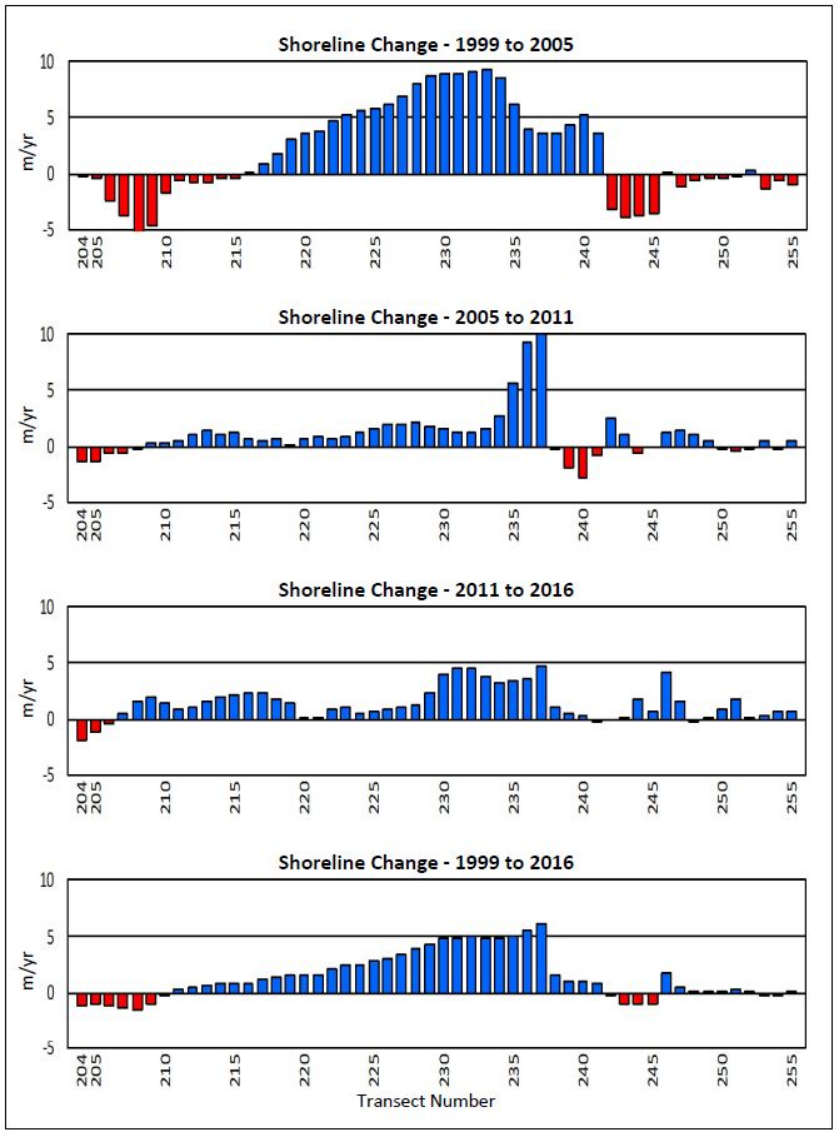
The EHPR for American Memorial Park was determined to be *low*. The determination was based on the lack of evidence of erosion, lack of development in the backshore area, lack of vulnerable infrastructure, and the fact that the shoreline is still accessible under erosion conditions.

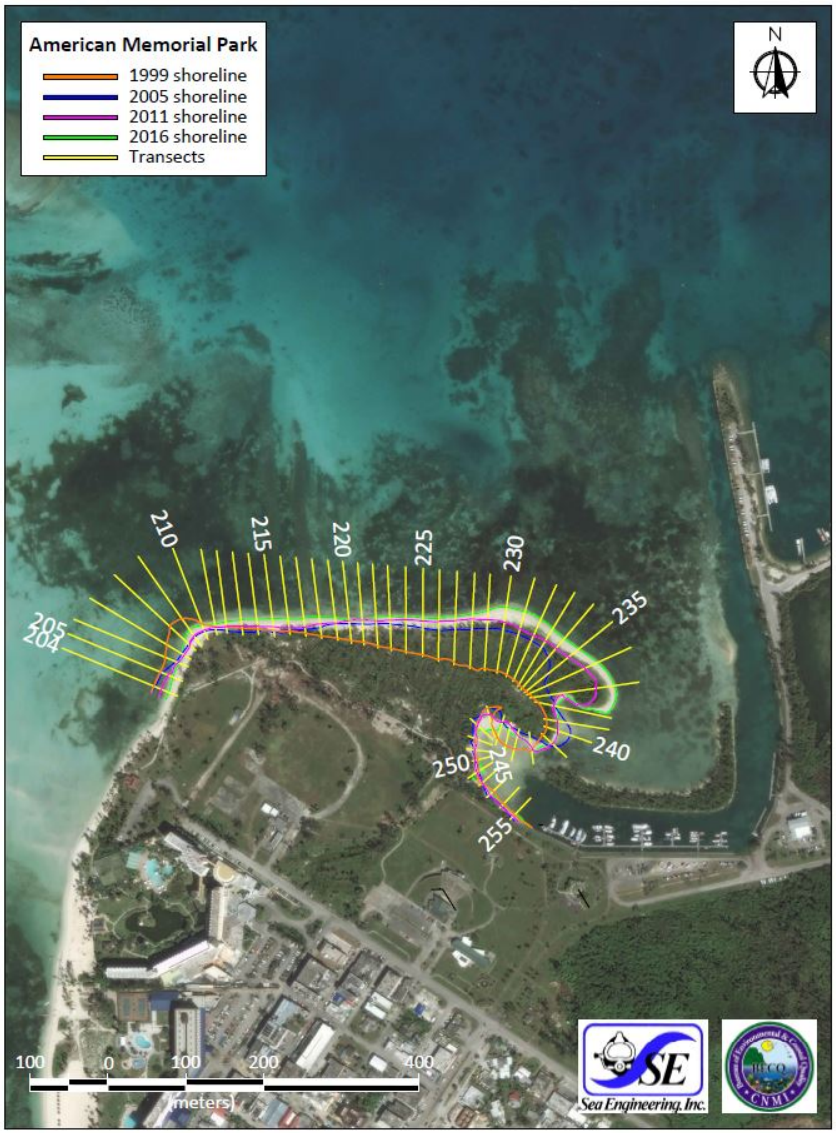
Issues & Recommendations

The backshore area was well-maintained and there was ample open space. The maritime forest appeared to be natural and undisturbed. Restoration work to improve wildlife habitat within the estuary is ongoing. There was evidence of erosion along parts of the shoreline, but it appeared to be minor in nature. Most of the shoreline appeared to stable or accreting.

<u>Recommendations</u>

- Consider dredging the entrance to Smiling Cove Marina to ensure safe navigation.





Map 13 American Memorial Park historical shoreline change (1999 to 2016)

Figure 133 American Memorial Park, west section (7/3/2017)

Figure 134 American Memorial Park, typical beach profile, west section (7/3/2017

Figure 135 American Memorial Park, central section (7/3/2017)

Figure 136 American Memorial Park, typical beach profile, central section (7/3/2017)

Figure 137 American Memorial Park, east section (sand spit) (7/3/2017)

Figure 138 American Memorial Park, typical beach profile, east section (sand spit) (7/3/2017)

Figure 139 American Memorial Park, east section (outer cove) (7/3/2017)

Figure 140 American Memorial Park, east section (inner cove) (7/3/2017)

Figure 141 American Memorial Park, stream drainage into Smiling Cove (7/3/2017)

Figure 142 American Memorial Park, sand shoal in Smiling Cove (7/3/2017)

Figure 143 American Memorial Park, pier remnants in Smiling Cove (7/3/2017)

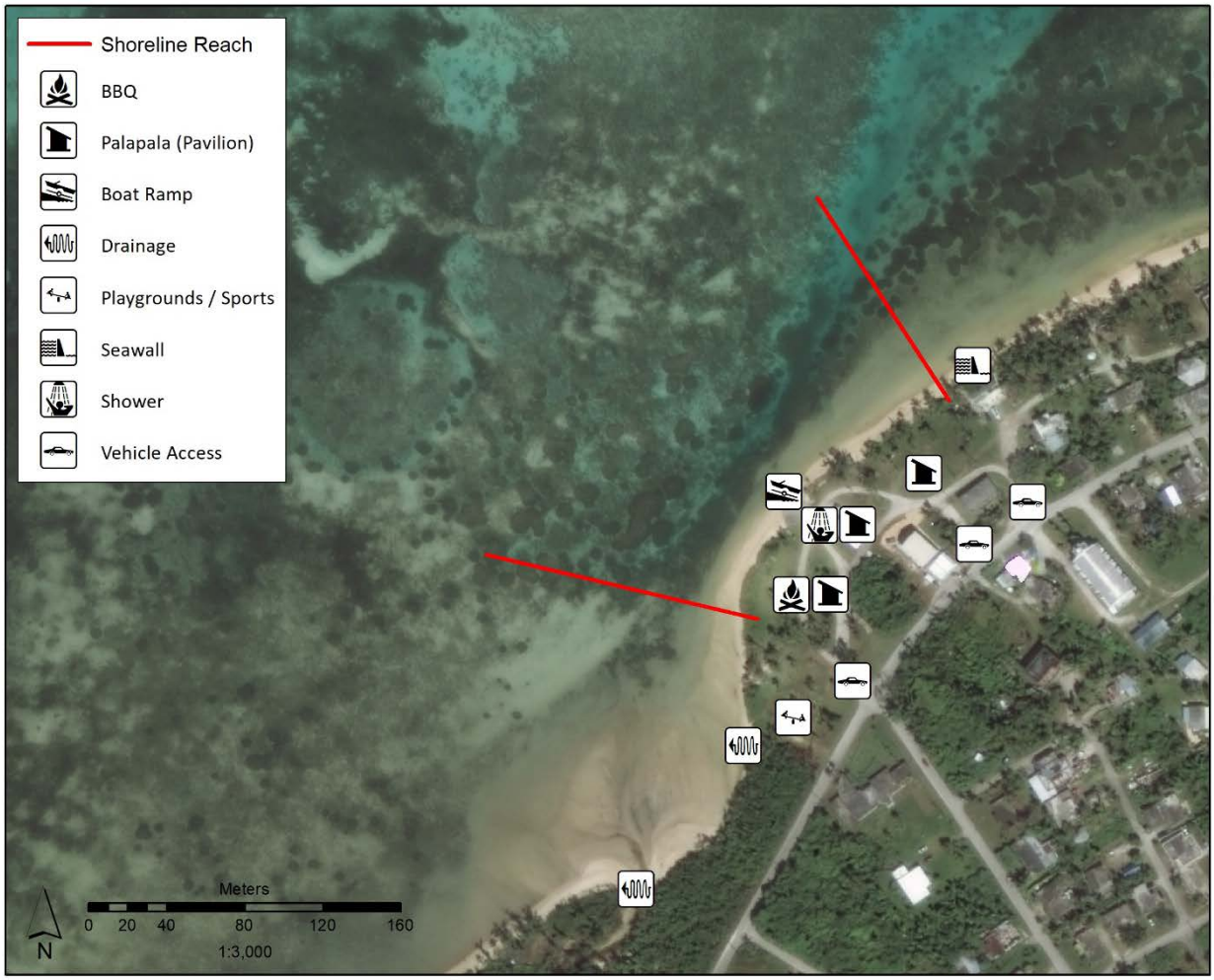
Figure 144 American Memorial Park, mangrove restoration project (7/3/2017)

Figure 145 American Memorial Park, concrete walkway and foot bridge (7/3/2017)

Figure 146 American Memorial Park, public restroom (7/3/2017)

Tanapag Beach & Boat Ramp

Erosion Hazard Priority Rating - MEDIUM



EASTING:
366134.49 meters E
NORTHING:
1685501.16 meters N
MUNICIPALITY:
Tanapag
LENGTH:
200 meters
AVERAGE BEACH SLOPE:
5 to 10 degrees
FLOOD ZONE:
AE (BFE = 7 feet)
LAND USES:
Park; Conservation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Tanapag Beach is located on the leeward (west) coast of Saipan, north of American Memorial Park and south of Aqua Resort Beach, and consists of approximately 200 meters of shoreline frontage. Tanapag Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and boating. In addition to the public boat ramp, park amenities included palapalas (3), grills/fire pits (2), a playground, and an outdoor shower.

ISSUES

The backshore area was well-maintained but many of the structures (e.g., palapalas, grills/fire pits, and picnic tables) were in a deteriorated condition. There were trash receptacles available but no public restrooms were observed in the area. There was evidence of erosion but it appeared to be minor in nature and limited to the area adjacent to the drainage. The backshore topography was relatively flat inshore of the erosion scarp. There was evidence of inundation inshore of the erosion scarp.

RECOMMENDATIONS

- Identify and prioritize improvements to public amenities.
- Install and maintain public restrooms.

Tanapag Beach & Boat Ramp

Municipality: Tanapag
Easting: 366134.49 m E
Nothing: 1685501.16 m N
Length: 200 m
Inspection: July 3, 2017 (12:00 pm)
Tide: 0.17 m (incoming)

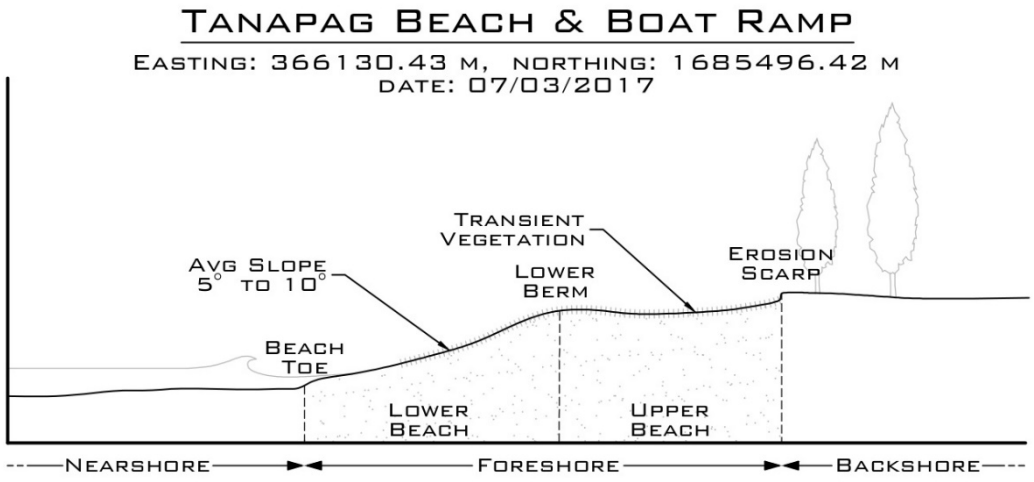
Erosion Hazard Priority Rating: MEDIUM

Coastal Setting

Tanapag Beach is located on the leeward (west) coast of Saipan, north of American Memorial Park and south of Aqua Resort Beach, and consists of approximately 200 m of shoreline frontage. A public boat ramp is located along the central section of the shoreline. The backshore consists of a public park that extends approximately 50 m inshore of the shoreline. The foreshore consists of a very narrow sand beach with a stable upper berm. The nearshore consists of a shallow lagoon and fringing reef. A view looking north from the south end of the beach is shown in Figure 148. A view looking south from the north end of the beach is shown in Figure 149.

Shoreline Condition

Tanapag Beach abuts the Saipan Lagoon and is partially protected by a shallow fringing reef and barrier reef that extend approximately 450 m and 1,500 m offshore, respectively. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 2 m. The shoreline is northwest-facing at approximately 325 degrees (relative to True North). The beach is composed of fine to medium-grain carbonate sand. Sand grain size coarsened in a seaward direction with an accumulation of larger-diameter sand and gravel along the beach toe.



Profile 21 Typical beach profile along south section of Tanapag Beach

A typical beach profile was recorded along the south section of the Tanapag Beach shoreline (Profile 21). Photographs showing the location of the beach profile are shown in Figure 150 and Figure 151. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a narrow, exposed sand beach that progressed inshore to a transient berm along the edge of vegetation. The upper beach was relatively flat (0 to 5 degrees) and covered by well-established vegetation (beach grass). The upper beach progressed inshore to an erosion scarp along the upper berm, which was compacted and covered by stable vegetation (Ironwood trees and beach grass). There was no evidence of active erosion along the erosion scarp. The backshore consisted of an open, grassy area with mature Ironwood and Coconut trees, and soils composed of the Shioya-Urban land complex and Shioya loamy sand. The backshore topography was relatively flat inshore of the erosion scarp. There was evidence of inundation inshore of the erosion scarp. A stream drainage located southwest of Tanapag Beach creates a very shallow sand shoal along the south end of the shoreline (Figure 152).

Tanapag Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, picnicking, and boating. In addition to the public boat ramp (Figure 153), park amenities included palapalas (3), grills/fire pits (2), a playground, and an outdoor shower (Figure 154, Figure 155, and Figure 156). The nearshore waters are part of a jet ski exclusion zone that extends from the Port of Saipan north to Wing Beach. Vehicular access to Tanapag Beach is available via an unpaved road and there is ample off-road parking available (Figure 157). Public access is available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Tanapag Beach is shown as transects 265 through 266 on Map 14. The analysis shows Tanapag Beach to be mildly dynamic. The shoreline eroded at rates up to 1.5 m/yr from 2001 to 2005, and accreted with rates of up to about 3 m/yr between 2012 and 2016. The shoreline change from 1999 to 2016 was measured to be negligible.

Erosion Hazard Priority Rating

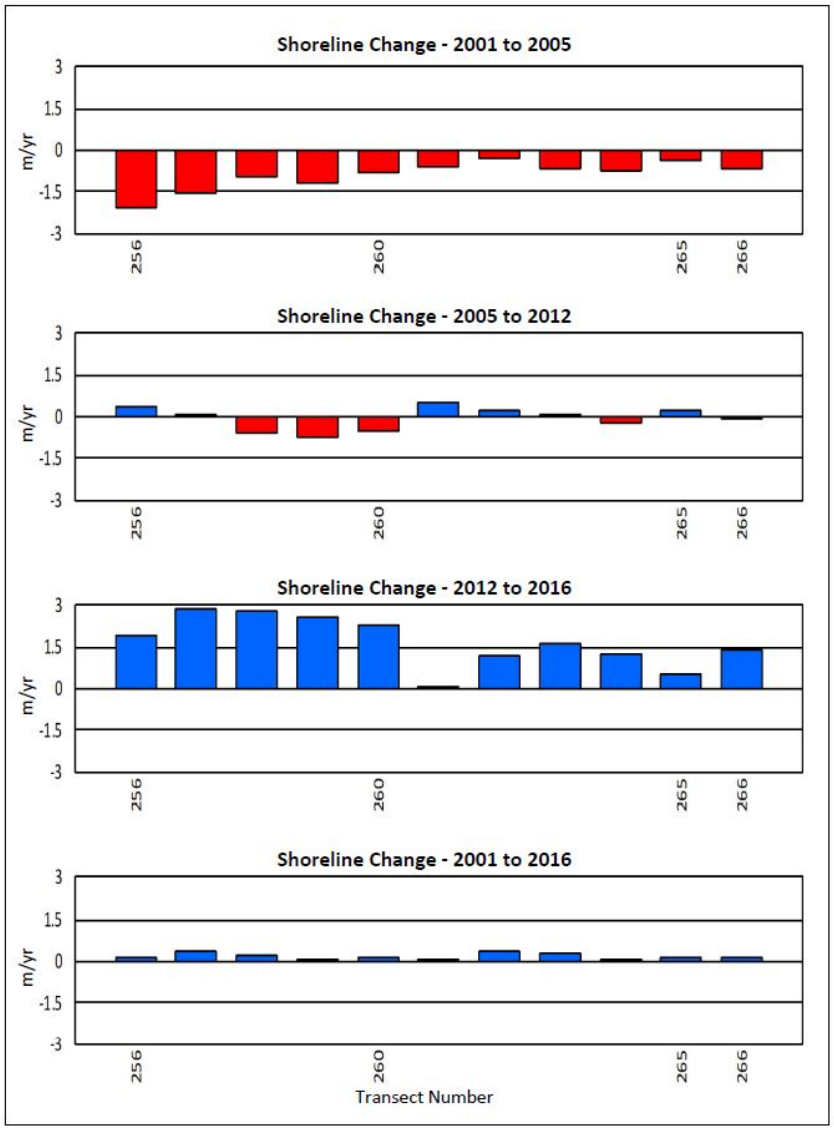
The EHPR for Tanapag Beach was determined to be *medium*. The determination was based on the lack of beach width, evidence of erosion, low backshore elevation, vulnerability of public infrastructure, and potential impacts of erosion on shoreline access.

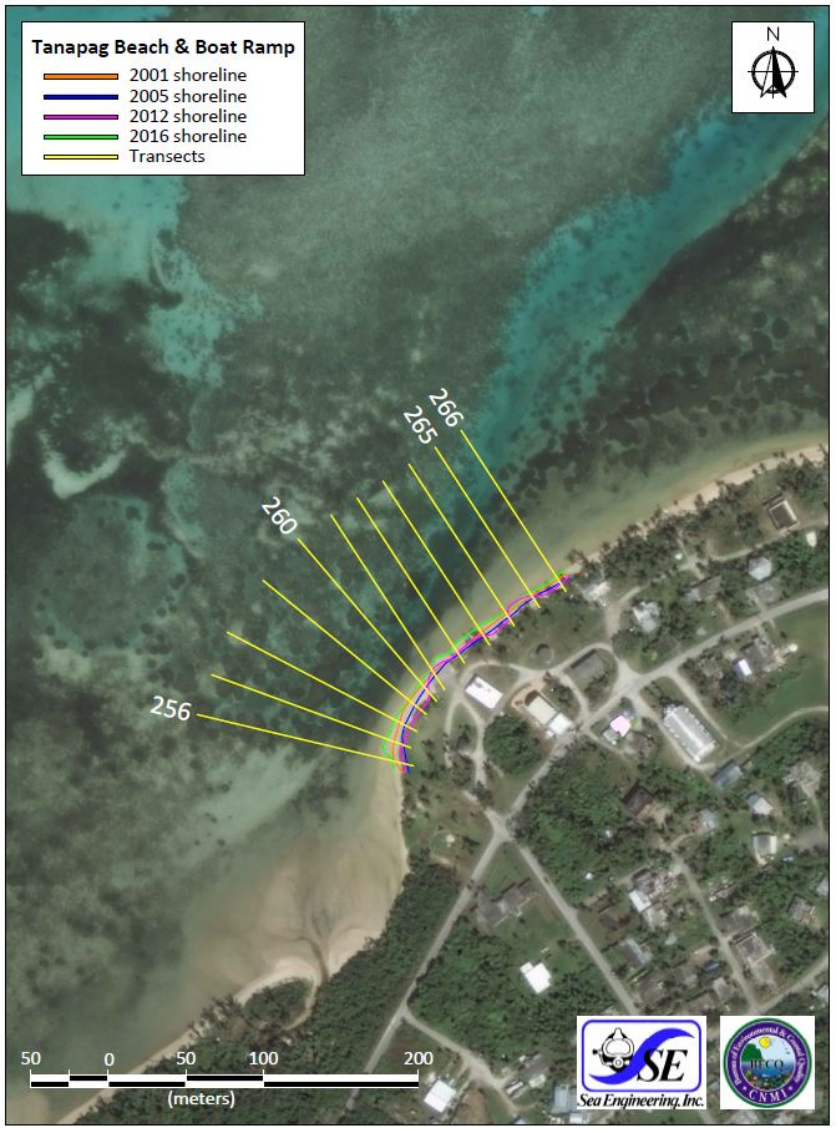
Issues & Recommendations

The backshore area was well-maintained but many of the structures (e.g., palapalas, grills/fire pits, and picnic tables) were in a deteriorated condition. There were trash receptacles available but no public restrooms were observed in the area. There was evidence of erosion but it appeared to be minor in nature and limited to the area adjacent to the drainage.

Recommendations

- Identify and prioritize improvements to public amenities.
- Install and maintain public restrooms.





Map 14 Tanapag Beach and Boat Ramp historical shoreline change (1999 to 2016)

Figure 147 Tanapag Beach, south end, looking north (7/3/2017)

Figure 148 Tanapag Beach, north end, looking north (7/3/2017)

Figure 149 Tanapag Beach, typical beach profile, south end (7/3/2017)

Figure 150 Tanapag Beach, typical beach profile, north end (7/3/2017)

Figure 151 Tanapag Beach, stream drainage and sand shoal (7/3/2017)

Figure 152 Tanapag Beach, public boat ramp (7/3/2017)

Figure 153 Tanapag Beach, backshore amenities (7/3/2017)

Figure 154 Tanapag Beach, palapala, grill, and picnic area (7/3/2017)

Figure 155 Tanapag Beach, playground (7/3/2017)

Figure 156 Tanapag Beach, vehicle access and off-road parking (7/3/2017)

Aqua Resort Beach

Erosion Hazard Priority Rating - MEDIUM

EASTING:
367526.95 meters E
NORTHING:
1685995.36 meters N
MUNICIPALITY:
San Roque
LENGTH:
350 meters
AVERAGE BEACH SLOPE:
5 to 10 degrees
FLOOD ZONE:
AE and VE (BFE = 7 to 11 feet)
LAND USES:
Conservation; Commercial
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Aqua Resort Beach is located on the leeward (west) coast of Saipan, north of Tanapag Beach and south of Pau Pau Beach, and consists of approximately 350 meters of shoreline frontage. Aqua Resort Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, and boating; however, access to the shoreline is limited. The Aqua Resort Club is a private resort and shoreline access appears to be limited to resort patrons and their guests. There were no public access points or amenities observed in the area.

ISSUES

There were no trash receptacles or public restrooms observed in the area. There was evidence of active erosion along the upper berm, but it appeared to be minor. The presence of shore protection structures suggests that the area may have previously been exposed to erosion. There was no evidence to indicate that the seawall was impacting beach width. The Aqua Resort Club is a private resort and there was no public vehicular access or parking observed in the area. Shoreline access appears to be limited to resort patrons and their guests. There were no public access points or amenities observed in the area.

RECOMMENDATIONS

- Engage Aqua Resort management to improve public access to the shoreline.

Aqua Resort Beach

Municipality: San Roque
Easting: 367526.95 m E
Nothing: 1685995.36 m N
Length: 350 m
Inspection: July 3, 2017 (1:00 pm)
Tide: 0.25 m (incoming)

Erosion Hazard Priority Rating: MEDIUM

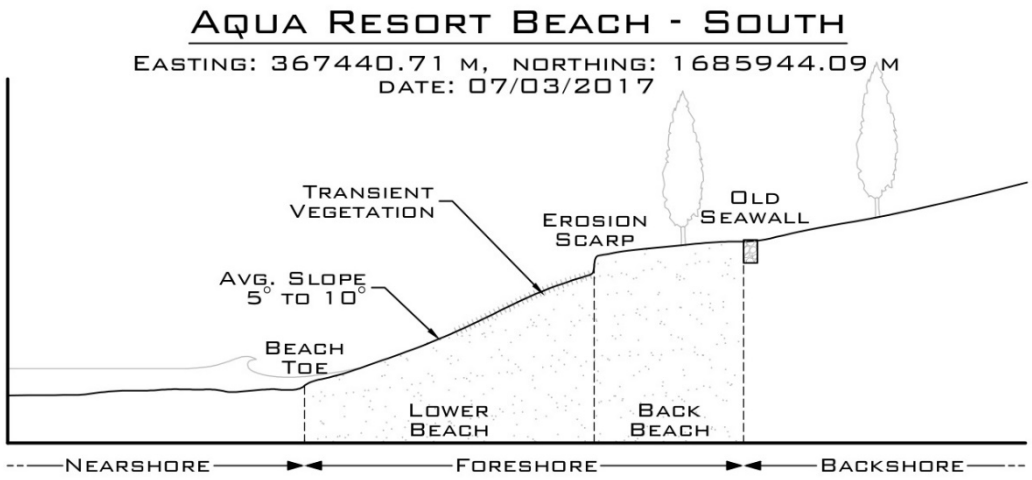
Coastal Setting

Aqua Resort Beach is located on the leeward (west) coast of Saipan, north of Tanapag Beach and south of Pau Pau Beach, and consists of approximately 350 m of shoreline frontage. The backshore consists of the Aqua Resort Club that extends approximately 150 m inshore of the shoreline. The foreshore consists of a narrow sand beach. The nearshore consists of a shallow lagoon, a fringing reef, and a barrier reef.

Shoreline Condition

Aqua Resort Beach abuts the Saipan Lagoon and is partially protected by a shallow fringing reef and barrier reef that extend approximately 200 m and 750 m offshore, respectively. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 1.5 m. The shoreline is northwest-facing at approximately 330 degrees (relative to True North). The beach is composed of fine to medium-grain carbonate sand. Sand grain size coarsened in a seaward direction with an accumulation of larger-diameter sand and gravel along the beach toe. For the purposes of this assessment, the Aqua Resort Beach shoreline was divided into two sections: 1) south, and 2) north.

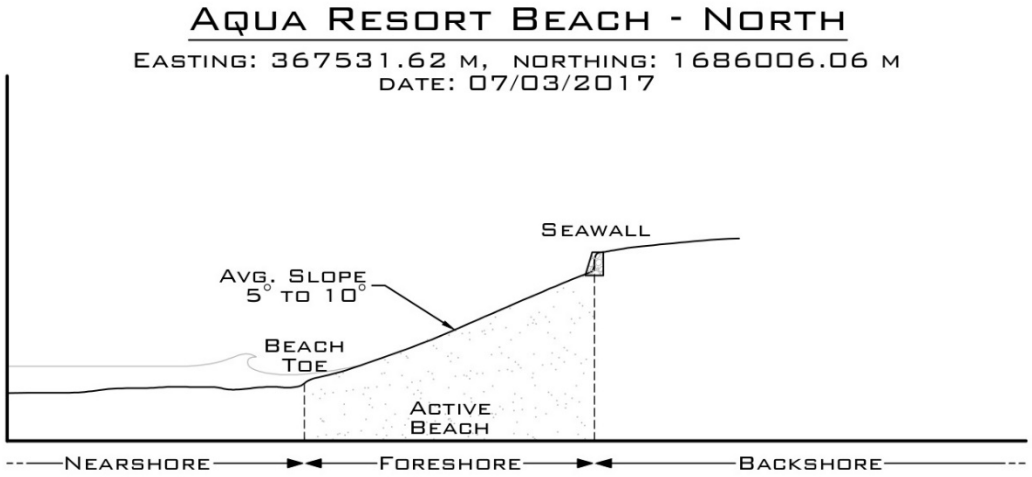
Section 1: Aqua Resort Beach – South
A typical beach profile was recorded along the south section of the Aqua Resort Beach shoreline (Profile 22). A photograph showing the location of the beach profile is shown in Figure 158. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a narrow sand beach along the edge of vegetation. The upper beach was gently-sloping (5 to 10 degrees) and covered by well-established vegetation (beach grass). The upper beach progressed inshore to an erosion scarp along the upper berm. There was evidence of active erosion along the scarp (Figure 159). The backshore consisted of a moderately-sloping grassy area with mature Ironwood and Coconut trees, and soils composed of Saipan clay and Shioya loamy sand. A grouted rock seawall extended across the length of the shoreline. Along the south section of the shoreline, an approximately 50-meter length of the seawall was buried inshore of the erosion scarp (Figure 160). The seawall became exposed near the restaurant and wooden viewing platform along the central section of the shoreline (Figure 161).



Profile 22 Typical beach profile along south section of Aqua Resort Beach

Section 2: Aqua Resort Beach – North

A typical beach profile was recorded along the north section of the Aqua Resort Beach shoreline (Profile 23). A photograph showing the location of the beach profile is shown in Figure 162. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a narrow sand beach. The upper beach was gently-sloping (5 to 10 degrees) and progressed inshore to the face of the grouted rock seawall (Figure 163). Portions of the seawall appeared to have recently constructed and extended further seaward than the north and south ends. The upper beach progressed inshore to a relict erosion scarp along the upper berm. The backshore consisted of a restaurant and wooden decks constructed inshore of the seawall (Figure 164 and Figure 165).



Profile 23 Typical beach profile along north section of Aqua Resort Beach

Aqua Resort Beach supports a variety of recreational uses including swimming, wading, snorkeling, fishing, and boating; however, public access to the shoreline is limited. The Aqua Resort Club is a private resort and there was no public vehicular access or parking observed in the area. Shoreline access appears to be limited to resort patrons and their guests. There were no public access points or amenities observed in the area. The nearshore waters are part of a jet ski exclusion zone that extends from the Port of Saipan north to Wing Beach.

Historical Shoreline Change

The historical shoreline change map for Aqua Resort Beach is shown as transects 267 through 282 on Map 15. The analysis shows that the beach eroded from 2001 to 2005 at rates of up to about 1 m/yr. The pattern thereafter was one of mild accretion, and for the complete time series of the analysis (2001 to 2016), the beach showed minimal accretion.

Erosion Hazard Priority Rating

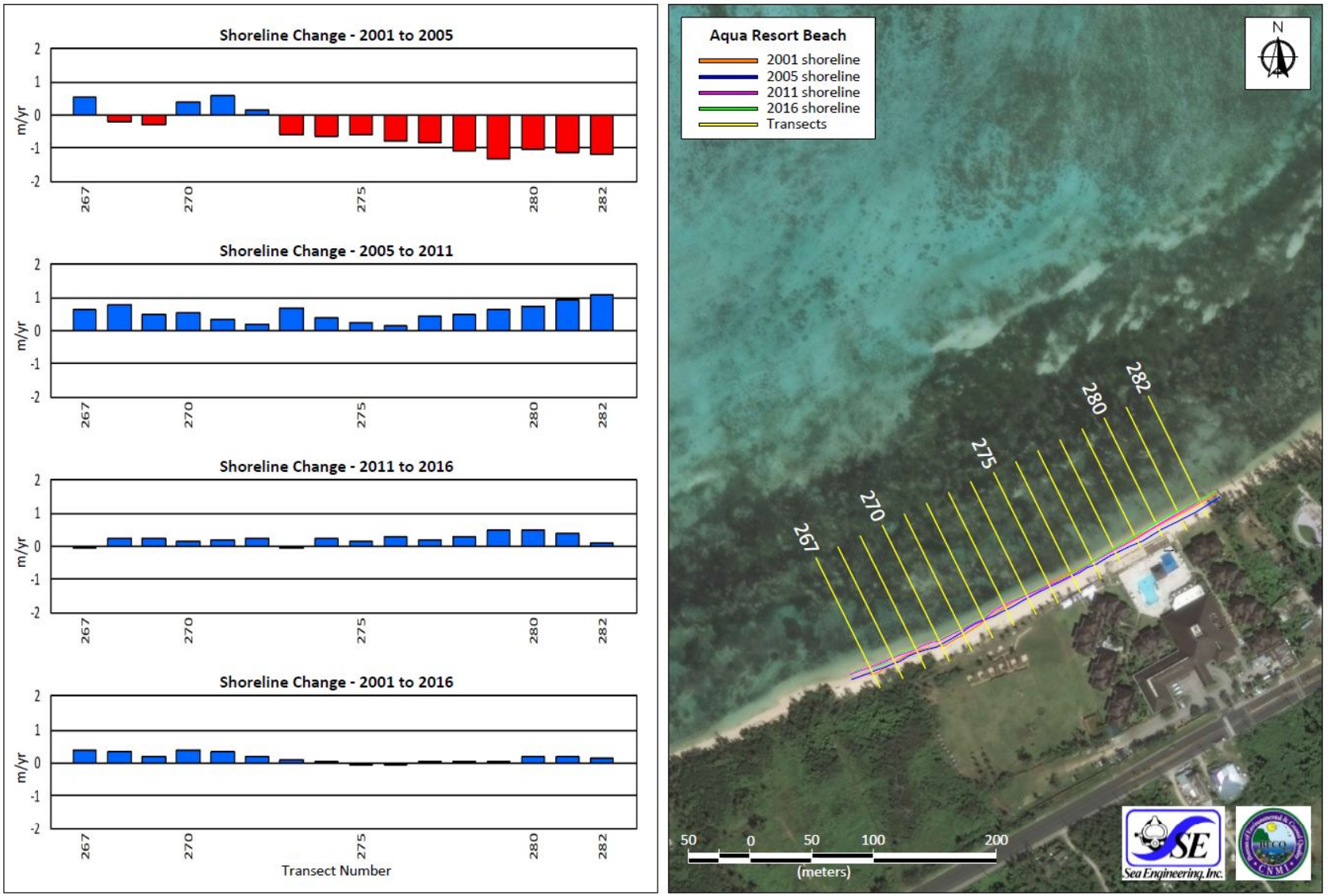
The EHPR for Aqua Resort Beach was determined to be *medium*. The determination was based on evidence of erosion, presence of shore protection structures, high-intensity development in the backshore area, and potential impacts of erosion on shoreline access, which is already limited because the backshore area is privately owned.

Issues & Recommendations

The backshore area was well-maintained and the structures appeared to be in good condition. There were no trash receptacles or public restrooms observed in the area. There was evidence of active erosion along the upper berm, but it appeared to be minor. The presence of shore protection structures suggests that the area may have previously been exposed to erosion. There was no evidence to indicate that the seawall was impacting beach width.

<u>Recommendations</u>

- Engage Aqua Resort management to improve public access to the shoreline.



Map 15 Aqua Resort Beach historical shoreline change (1999 to 2016)

Figure 157 Aqua Resort Beach, typical beach profile, south end, looking north (7/3/2017)

Figure 158 Aqua Resort Beach, active erosion scarp along upper berm (7/3/2017)

Figure 159 Aqua Resort Beach, buried seawall in backshore (7/3/2017)

Figure 160 Aqua Resort Beach, resort infrastructure and exposed portion of seawall (7/3/2017)

Figure 161 Aqua Resort Beach, typical beach profile, north end, looking south (7/3/2017)

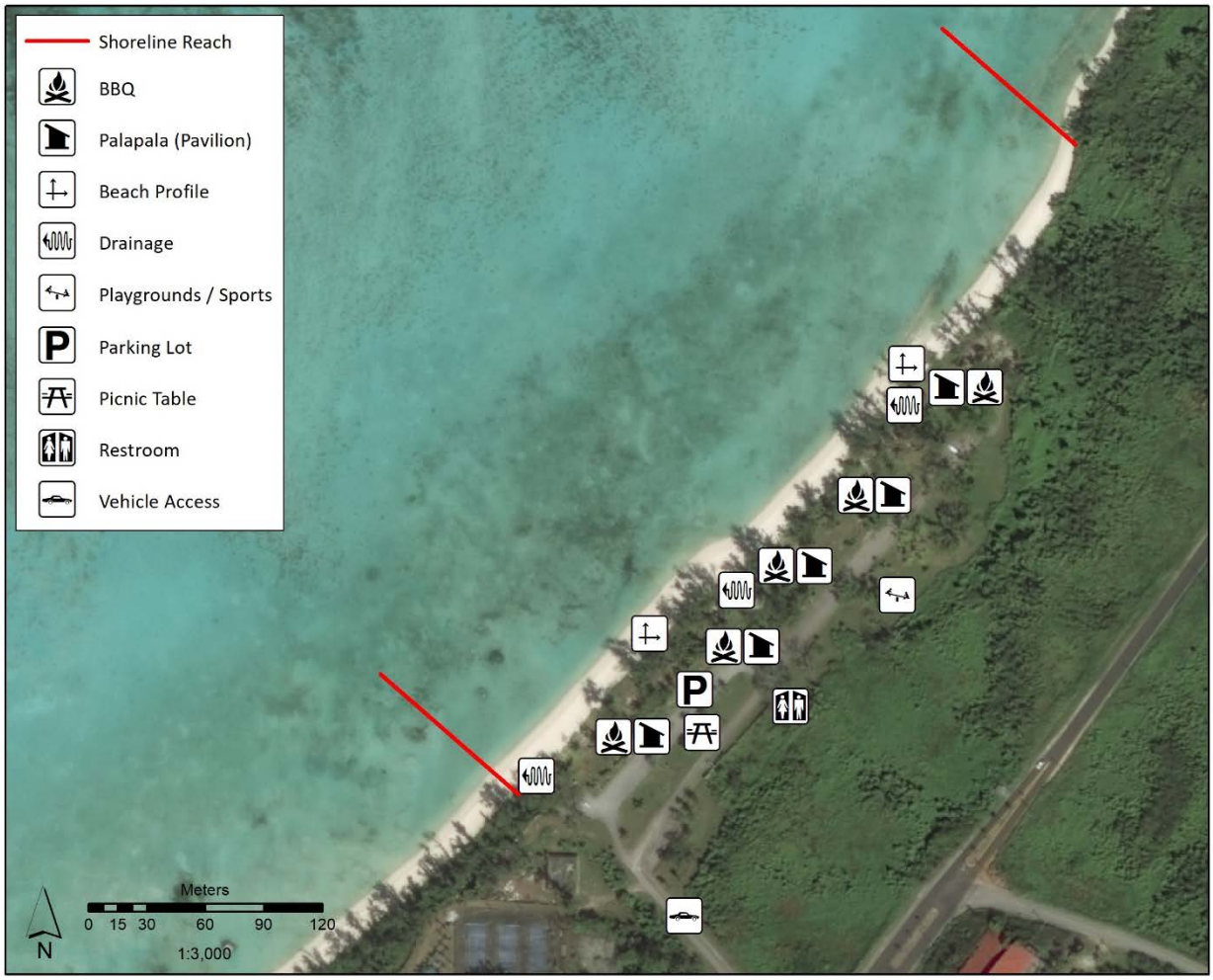
Figure 162 Aqua Resort Beach, north end, looking north (7/3/2017)

Figure 163 Aqua Resort Beach, beach profile fronting seawall, looking south (7/3/2017)

Figure 164 Aqua Resort Beach, beach profile fronting seawall, looking north (7/3/2017)

Pau Pau Beach

Erosion Hazard Priority Rating - LOW



EASTING:
369066.05 meters E
NORTHING:
1687041.11 meters N
MUNICIPALITY:
As Matuis
LENGTH:
350 meters
AVERAGE BEACH SLOPE:
5 to 10 degrees
FLOOD ZONE:
AE and VE (BFE = 8 to 9 feet)
LAND USES:
Park
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

Pau Pau Beach is located on the leeward (west) coast of Saipan, north of Aqua Resort Beach and south of Wing Beach, and consists of approximately 450 meters of shoreline frontage. Pau Pau Beach supports a variety of recreational uses including swimming, snorkeling, fishing, and picnicking. Park amenities included palapalas (5), grills/fire pits (7), and a playground. Trash receptacles were located throughout the park. The park appeared to be very clean, but there are reports of trash and BBQ waste following busy weekends. There was only one public restroom within the park, but it was closed due to apparent structural damage.

ISSUES

The backshore area was well-maintained and the structures appeared to be in good condition. There was evidence of active erosion along the upper berm, but it appeared to be minor. The berm was bisected at several locations by drainage features and surface water runoff from the paved parking areas. A debris field consisting of large-diameter coral cobbles was identified in the backshore area, indicating that the area had recently been inundated.

RECOMMENDATIONS

- Prioritize weekend maintenance of trash/recycling receptacles.
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Repair and maintain public restrooms.

Pau Pau Beach

Municipality: As Matuis
Easting: 369066.05 m E
Nothing: 1687041.11 m N
Length: 450 m
Inspection: July 3, 2017 (2:30 pm)
Tide: 0.35 m (incoming)

Erosion Hazard Priority Rating: LOW

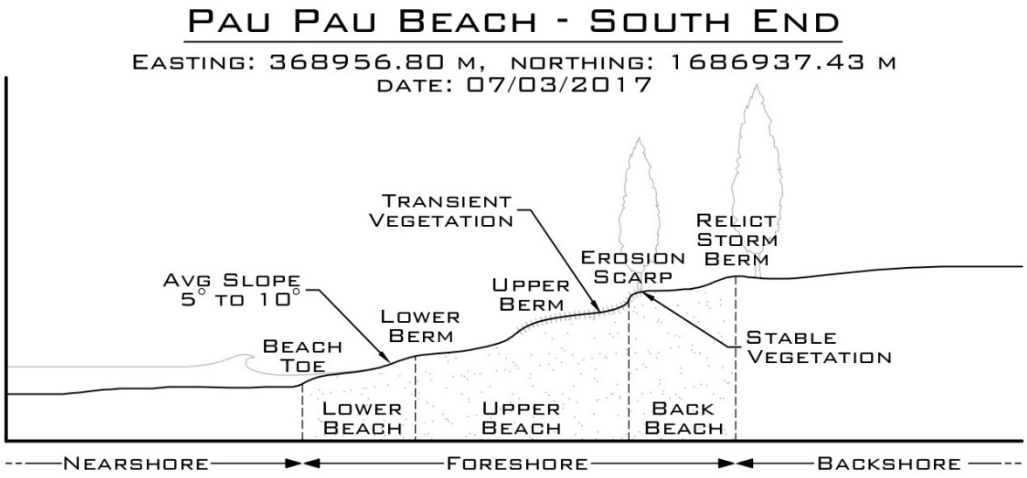
Coastal Setting

Pau Pau Beach is located on the leeward (west) coast of Saipan, north of Aqua Resort Beach and south of Wing Beach, and consists of approximately 450 m of shoreline frontage. The backshore consists of Pau Pau Beach Park, which extends approximately 80 m inshore of the shoreline. The foreshore consists of a narrow beach composed of sand and coral cobble. The nearshore consists of a shallow lagoon, a fringing reef, and a barrier reef.

Shoreline Condition

Pau Pau Beach abuts the Saipan Lagoon and is partially protected by a shallow fringing reef and barrier reef that extend approximately 100 m and 750 m offshore, respectively. The nearshore bathymetry is very shallow with average water depths ranging from 1 to 1.5 m. The shoreline is northwest-facing at approximately 315 degrees (relative to True North). The beach is composed of fine-grain carbonate sand. Sand grain size coarsened in a seaward direction with an accumulation of larger-diameter sand, gravel, and cobble along the beach toe.

A typical beach profile was recorded along the south section of the Pau Pau Beach shoreline (Profile 24). Photographs showing the location of the beach profile are shown in Figure 168 and Figure 169. The lower beach was gently-sloping (5 to 10 degrees) and consisted of a narrow beach composed of sand, gravel, and cobble. The lower beach progressed inshore to a transient berm along the edge of vegetation. The upper beach was gently-sloping (5 to 10 degrees) and covered by well-established vegetation (Morning Glory, beach grass, Ironwood saplings). The upper beach progressed inshore to an erosion scarp along the upper berm (Figure 170). There was evidence of active erosion along the scarp. The backshore consisted of a moderately-sloping grassy area with mature Ironwood and Coconut trees, variable topography, and soils composed of Shioya loamy sand. A debris field consisting of large-diameter coral cobbles was identified in the backshore area, indicating that the area had recently been inundated (Figure 171). A relict berm was located inshore of the erosion scarp. The relict berm appeared to follow the contour of the coral cobble debris field, suggesting that the berm was formed by wave action.



Profile 24 Typical beach profile along south section of Pau Pau Beach

Pau Pau Beach supports a variety of recreational uses including swimming, snorkeling, fishing, and picnicking. The nearshore waters are part of a jet ski exclusion zone that extends from the Port of Saipan north to Wing Beach. Park amenities included palapalas (5), grills/fire pits (7), and a playground (Figure 172 and Figure 173). Trash/recycling receptacles were observed throughout the park. While the park appeared very clean at the time of the site visit, BECQ indicated that trash (particularly BBQ waste) is a common issue, particularly following busy weekends.

There was only one public restroom observed within the park, but it was closed due to apparent structural damage (Figure 174). Two portable restrooms were observed in the park. Vehicular access was available via Pau Pau Beach Drive, a paved road that connects to Middle Road. Parking was available in two paved parking lots with approximately 85 stalls available (Figure 175). Public access was available laterally along the shoreline.

Historical Shoreline Change

The historical shoreline change map for Pau Pau Beach is shown as transects 283 through 305 on Map 16. The analysis shows that the beach eroded from 2001 to 2005 at rates of up to about 2 m/yr. The pattern reversed from 2005 to 2016, with accretion rates of up to about 1 m/yr typical for the area. For the complete time series of the analysis (2001 to 2016), the beach showed mild accretion with rates up to about 0.5 m/yr.

Erosion Hazard Priority Rating

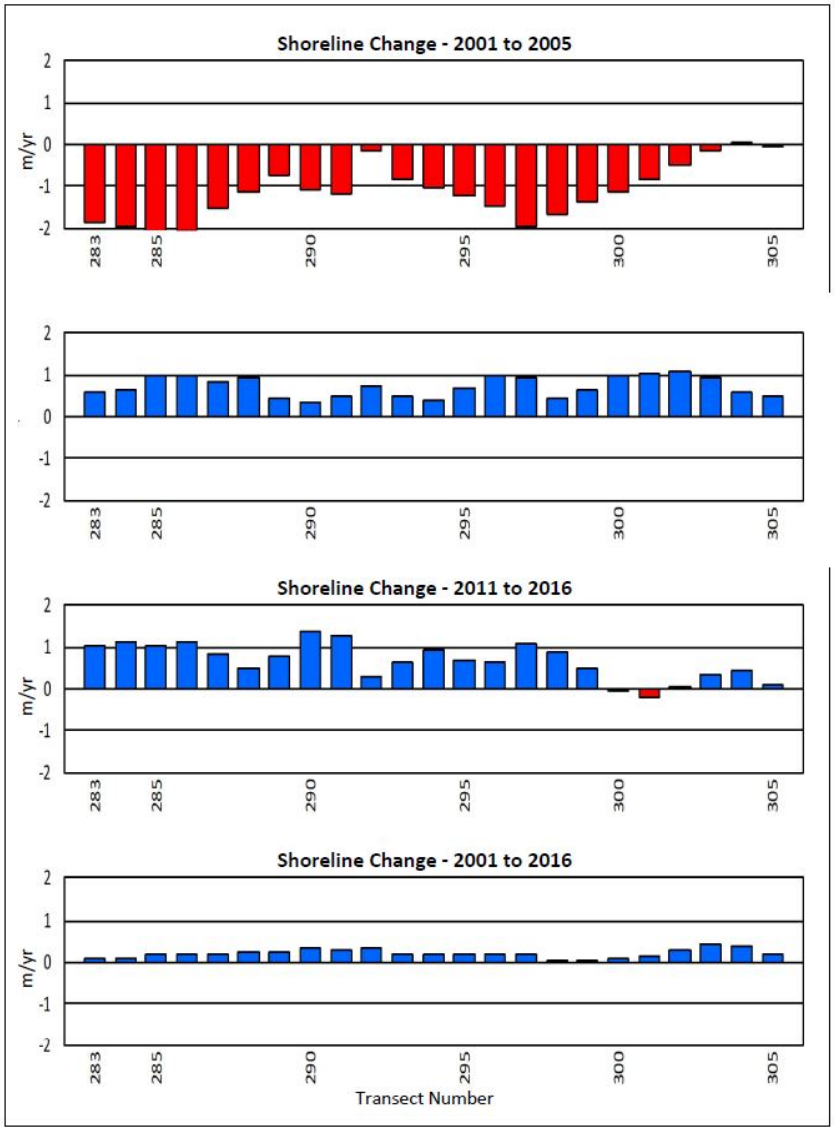
The EHPR for Pau Pau Beach was determined to be *low*. The determination was based on width of the fringing reef, stable beach width, higher backshore elevation, low-intensity development in the backshore, and the historical shoreline change analysis, which indicated that the beach is stable and accreting.

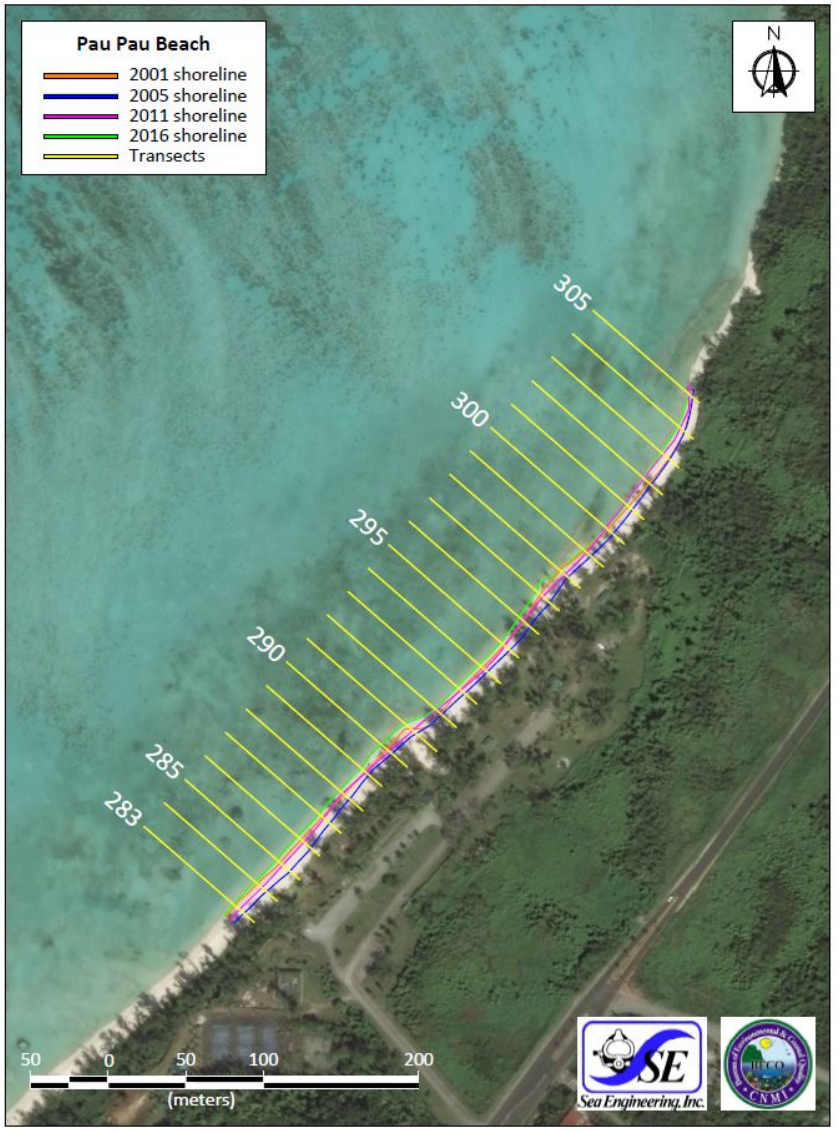
Issues & Recommendations

The backshore area was well-maintained and the structures appeared to be in good condition. There was evidence of active erosion along the upper berm, but it appeared to be minor. The berm was bisected at several locations by drainage features (Figure 176) and surface water runoff from the paved parking areas (Figure 177).

Recommendations

- Prioritize weekend maintenance of trash/recycling receptacles.
- Increase enforcement capacity and education to reduce driving and parking on berms.
- Identify and prioritize drainage improvements.
- Repair and maintain public restrooms.





Map 16 Pau Pau Beach historical shoreline change (1999 to 2016)

Figure 165 Pau Pau Beach, south end, looking north (7/3/2017)

Figure 166 Pau Pau Beach, north end, looking south (7/3/2017)

Figure 167 Pau Pau Beach, typical beach profile, looking north (7/3/2017)

Figure 168 Pau Pau Beach, typical beach profile, looking south (7/3/2017)

Figure 169 Pau Pau Beach, erosion scarp along the upper berm (7/3/2017)

Figure 170 Pau Pau Beach, coral cobble overwash deposits in backshore area (7/3/2017)

Figure 171 Pau Pau Beach, backshore amenities (7/3/2017)

Figure 172 Pau Pau Beach, playground (7/3/2017)

Figure 173 Pau Pau Beach, closed public restroom (7/3/2017)

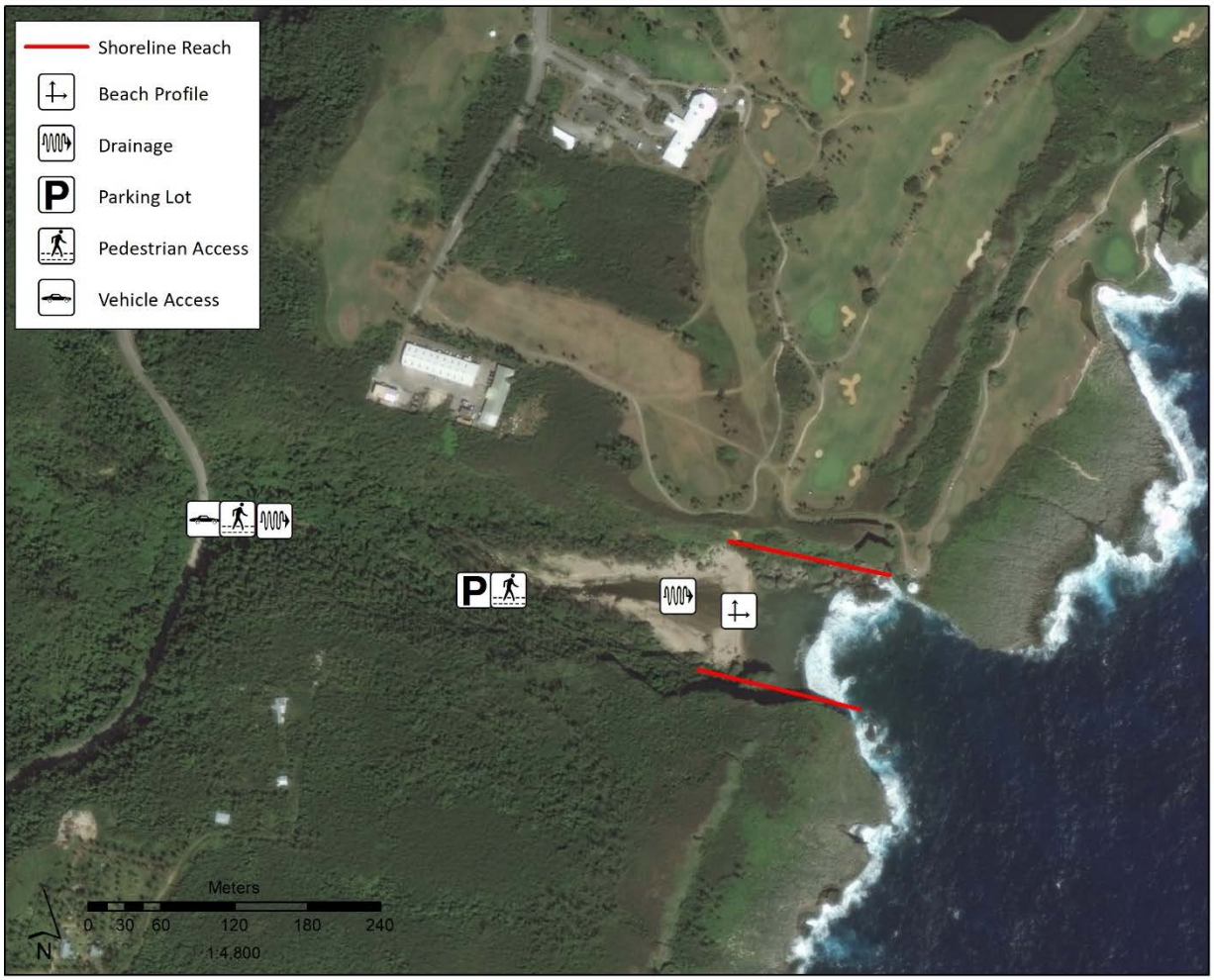
Figure 174 Pau Pau Beach, vehicle access and parking in backshore area (7/3/2017)

Figure 175 Pau Pau Beach, berm bisected by drainage (7/3/2017)

Figure 176 Pau Pau Beach, berm bisected by surface water runoff from parking lot (7/3/2017)

Jeffrey's Beach

Erosion Hazard Priority Rating - MEDIUM



EASTING:
369109.97 meters E
NORTHING:
1682563.05 meters N
MUNICIPALITY:
Talofofo
LENGTH:
80 meters
AVERAGE BEACH SLOPE:
10 to 15 degrees
FLOOD ZONE:
V (BFE = n/a)
LAND USES:
Open Space
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Wetlands
EROSION HAZARD PRIORITY RATING:
MEDIUM

DESCRIPTION

Jeffrey's Beach is located on the windward (east) coast of Saipan, south of the Kingfisher Golf Course, and consists of approximately 80 meters of shoreline frontage. Jeffrey's Beach, the most remote and isolated shoreline included in this assessment, supports a variety of recreational uses including hiking, fishing, and sightseeing. The only access to Jeffrey's Beach is via an unpaved road located off Route 36. There were no amenities, trash/recycling receptacles, or public restrooms observed in the area.

ISSUES

Issues that affected the overall user experience at Jeffrey's Beach included limited access, lack of amenities, and the extensive amount of marine debris along the shoreline. Parking and walking along Route 36 is dangerous and hiking conditions along the unpaved access road are very poor. There were no amenities, trash/recycling receptacles, or public restrooms observed in the area. There are also concerns regarding water quality in the Talofofo Stream drainage. Heavy rain events may transport sediment and pollutants to the shoreline, which could result in excess nutrients and macroalgae in Talofofo Stream and the nearshore waters.

RECOMMENDATIONS

- Consider improvements to the coastal trail and Route 36.
- Conduct a watershed restoration project to improve water quality.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms (possibly a composting toilet).
- Coordinate beach cleanups to remove marine debris.

Jeffrey's Beach

Municipality: Talofofo
Easting: 369109.97 m E
Nothing: 1682563.05 m N
Length: 80 m
Inspection: July 4, 2017 (11:00 am)
Tide: 0.08 m (incoming)

Erosion Hazard Priority Rating: MEDIUM

Coastal Setting

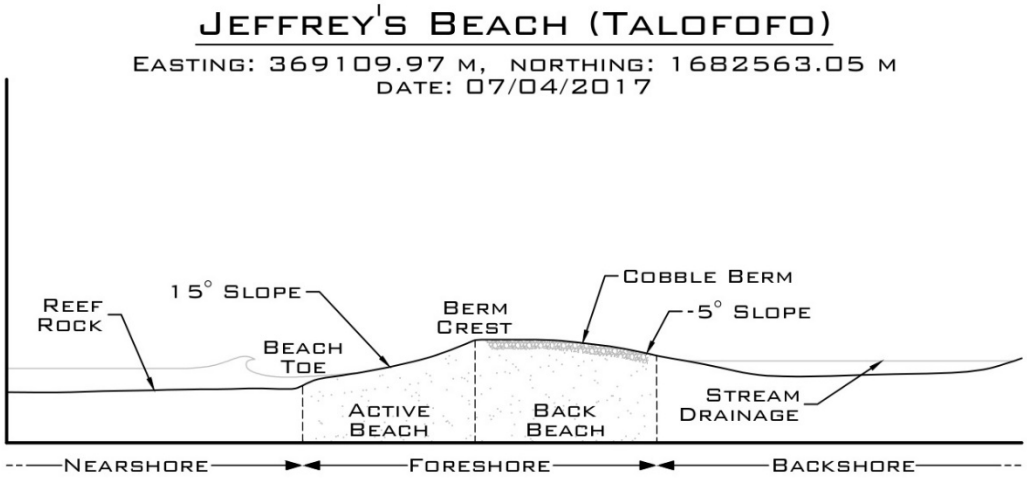
Jeffrey's Beach is located on the windward (east) coast of Saipan, south of the Kingfisher Golf Course, and consists of approximately 80 m of shoreline frontage. Jeffrey's Beach is an isolated embayment bordered by nearly-vertical sea cliffs to the north and south (Figure 178). The backshore consists of the Talofofo Stream drainage, which extends approximately 450 m inshore of the shoreline to Route 36 (Figure 179). The foreshore consists of a wide, convex beach composed of sand and coral cobble. A view of the shoreline looking north is shown in Figure 180. A view of the shoreline looking west is shown in Figure 181.

Shoreline Condition

Jeffrey's Beach abuts the Pacific Ocean and is east-facing at approximately 105 degrees (relative to True North). The shoreline is exposed to tradewind swell and storm waves generated by typhoons. A series of very shallow terraces extends approximately 60 m seaward of the shoreline before dropping off abruptly into deeper waters offshore. The beach is composed of carbonate sand, coral cobble, and terrigenous sediment supplied by Talofofo Stream.

A typical beach profile was recorded along the central section of the Jeffrey's Beach shoreline (Profile 25). Photographs showing the location of the beach profile are shown in Figure 182 and Figure 183. The lower beach was moderately-sloping (10 to 15 degrees) and composed of a mix of medium-grain carbonate sand, coral cobble, and terrigenous sediment. The lower beach progressed inshore to a transient berm crest with heavy marine debris lines (Figure 184). The back beach was downward-sloping (-5 to -10 degrees) to a rock and cobble berm at the termination of Talofofo Stream. The central section of the beach was devoid of vegetation, suggesting that it is frequently inundated.

The convex shape of the beach indicated that the beach morphology is influenced by both marine inundation and terrestrial flooding. The orientation of the debris lines and berms suggested that marine inundation was the predominant process affecting the morphology of the beach; however, it is likely that the beach shape would change dramatically during episodic flooding of the Talofofo Stream drainage. A unique feature of Jeffrey's Beach was the presence of magnetite deposits on the active beach (Figure 185). Magnetite is a black, ferrimagnetic mineral that is transported to the beach via the Talofofo Stream drainage and is concentrated by wave action and currents. A blowhole was also located on the northern side of the embayment.



Profile 25 Typical beach profile along central section of Jeffrey's Beach

Jeffrey's Beach, the most remote and isolated shoreline included in this assessment, supports a variety of recreational uses including hiking, fishing, and sightseeing. Lateral access along the shoreline is impossible due to the nearly-vertical sea cliffs to the north and south. The only access to Jeffrey's Beach is via an unpaved road located off Route 36. The road was in very poor condition with deep ruts and several flooded sections (Figure 186). The road ended at a small open area at the trailhead leading to Jeffrey's Beach (Figure 187). There was space to park several vehicles at the trailhead; however, accessing the shoreline via the unpaved road would likely require a 4-wheel drive vehicle. There was limited off-road parking available along Route 36 (Figure 188). BECQ may consider making improvements to the coastal trail and Route 36. Bollards could be installed to prohibit vehicle access and facilitate trail restoration. Road-side parking could also be installed along Route 36.

Erosion Hazard Priority Rating

The EHPR for Jeffrey's Beach was determined to be *medium*. The determination was based on the lack of a protective fringing reef, narrow beach width, and exposure to both marine and terrestrial flooding. Jeffrey's Beach is vulnerable to episodic flooding from the Talofofo Stream drainage. The EHPR was determined not to be *high* due to the lack of development in the backshore area, and lack of public infrastructure and amenities. Erosion is also unlikely to impact shoreline access at Jeffrey's Beach due to the lack of lateral access along the shoreline.

Issues & Recommendations

Issues that affected the overall user experience at Jeffrey's Beach included limited access, lack of amenities, and the extensive amount of marine debris along the shoreline. Parking and walking along Route 36 is dangerous and hiking conditions along the unpaved access road are very poor. There were no amenities, trash/recycling receptacles, or public restrooms observed in the area. There are also concerns regarding water quality in the Talofofo Stream drainage (Figure 189). Water quality could potentially be degraded due to various sources of pollution from the upland area of the watershed. Heavy rain events may transport sediment and pollutants to the shoreline, which could result in excess nutrients and macroalgae in the Talofofo Stream and the nearshore waters.

Recommendations

- Consider improvements to the coastal trail and Route 36.
- Conduct a watershed restoration project to improve water quality.
- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms (possibly a composting toilet).
- Coordinate beach cleanups to remove marine debris.

Figure 177 Jeffrey's Beach, embayment and sea cliffs, looking east (7/4/2017)

Figure 178 Jeffrey's Beach, Talofofo Stream drainage, looking west (7/4/2017)

Figure 179 Jeffrey's Beach, looking north (7/4/2017)

Figure 180 Jeffrey's Beach, Talofofo Stream drainage, looking northwest (7/4/2017)

Figure 181 Jeffrey's Beach, typical beach profile, looking north (7/4/2017)

Figure 182 Jeffrey's Beach, typical beach profile, looking south (7/4/2017)

Figure 183 Jeffrey's Beach, marine debris along the shoreline (7/4/2017)

Figure 184 Jeffrey's Beach, magnetite deposits (7/4/2017)

Figure 185 Jeffrey's Beach, unpaved coastal access road (7/4/2017)

Figure 186 Jeffrey's Beach, coastal access trailhead and parking area (7/4/2017)

Figure 187 Jeffrey's Beach, parking and access path from Route 36 (7/4/2017)

Figure 188 Jeffrey's Beach, Talofofo Stream drainage, looking east (7/4/2017)

Tank Beach

Erosion Hazard Priority Rating - LOW

EASTING:
369560.13 meters E
NORTHING:
1678036.41 meters N
MUNICIPALITY:
Kagman
LENGTH:
450 meters
AVERAGE BEACH SLOPE:
10 to 20 degrees
FLOOD ZONE:
V (BFE = n/a)
LAND USES:
Park; Conservation
AREAS OF PARTICULAR CONCERN:
Shoreline; Lagoon; Reef
EROSION HAZARD PRIORITY RATING:
LOW

DESCRIPTION

Tank Beach is located on the windward (east) coast of Saipan, south of Marine Beach, and consists of approximately 450 meters of shoreline frontage. Tank Beach is somewhat remote but appeared to experience frequent use. Tank Beach supports a variety of recreational uses including walking, wading, fishing, and sightseeing. Vehicular access to Tank Beach is via Tank Beach Place, an unpaved road located in the residential area of Kagman III. There was ample off-road parking available. Access to Tank Beach is via a coastal access trail from the off-road parking area.

ISSUES

Amenities were limited to the coastal access trail and a single trash receptacle. There were no public restrooms observed in the area. Food and beverages were available for purchase at a small hut located at the trailhead. Issues that affected the overall user experience at Tank Beach included the lack of amenities and the extensive amount of marine debris along the shoreline.

RECOMMENDATIONS

- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms (possibly a composting toilet).
- Coordinate beach cleanups to remove marine debris.

Tank Beach

Municipality: Kagman
Easting: 369560.13 m E
Nothing: 1678036.41 m N
Length: 450 m
Inspection: July 4, 2017 (2:30 pm)
Tide: 0.25 m (incoming)

Erosion Hazard Priority Rating: LOW

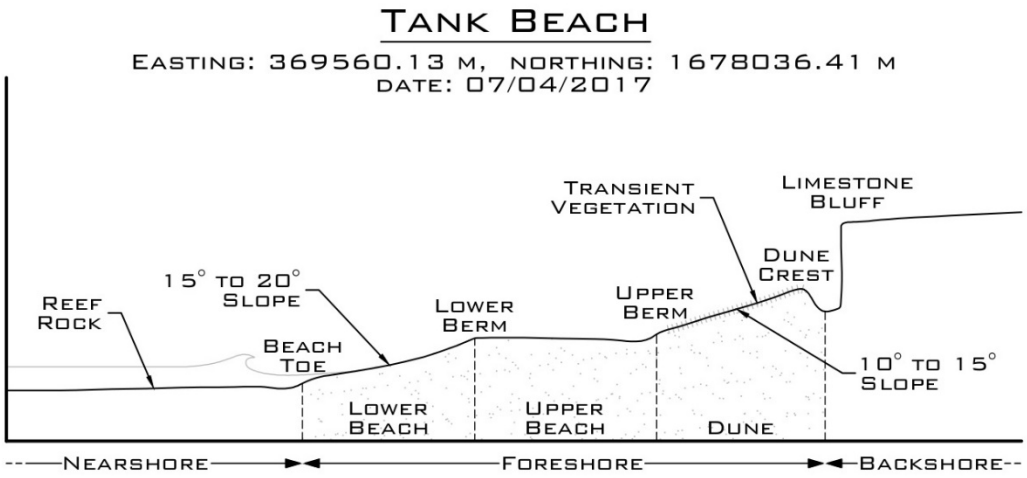
Coastal Setting

Tank Beach is located on the windward (east) coast of Saipan, south of Marine Beach, and consists of approximately 450 m of shoreline frontage. Tank Beach consists of a sand beach bordered by nearly-vertical limestone cliffs to the north and south. The backshore consists of limestone cliffs and terraces. The foreshore consists of a wide beach composed of medium-grain sand and coral cobble. A view of the south end of the shoreline looking north is shown in Figure 190. A view of the north end of the shoreline looking north is shown in Figure 191.

Shoreline Condition

Tank Beach abuts the Pacific Ocean and is northeast-facing at approximately 65 degrees (relative to True North). The shoreline is exposed to tradewind swell and storm waves generated by typhoons. A very shallow fringing reef extends approximately 100 m seaward of the shoreline before dropping off abruptly into deeper waters offshore. The beach was composed of medium-grain carbonate sand and coral cobble. A view looking north along the beach is shown in Figure 192 A view looking south along the beach is shown in Figure 193.

A typical beach profile was recorded along the central section of the Tank Beach shoreline (Profile 26). Photographs showing the location of the beach profile are shown in Figure 194 and Figure 195. The lower beach was moderately-steep (15 to 20 degrees) and composed of a mix of medium-grain carbonate sand and coral cobble. The lower beach progressed inshore to a transient lower berm with heavy coral cobble and marine debris lines. The back beach was slightly concave and progressed inshore to the upper berm along the edge of vegetation. The back beach consisted of a dune formation that was moderately-sloping (10 to 15 degrees) and backed by nearly-vertical limestone cliffs and a limestone terrace. The dune was overlaid by storm overwash deposits composed of large-diameter coral cobbles that were covered by well-established vegetation (Morning Glory). The dune was bisected by multiple drainage features (Figure 196). The drainage features exposed intermittent outcrops of lithified beach rock that appeared to be relatively continuous along the back beach (Figure 197). The lithified beach rock outcrops and wave cut notches in the exposed limestone cliffs provided evidence of a previous sea level highstand (Figure 198).



Profile 26 Typical beach profile along central section of Tank Beach

There was evidence of active erosion along the upper beach and dune, particularly in the areas where the dune was bisected by drainage features. The amount of coral cobble in the back beach indicates that Tank Beach is exposed to very high wave energy. Tank Beach is bounded by nearly-vertical limestone cliffs to the north and south, so the dominant direction of sediment transport is presumably cross-shore. A review of historical aerial images from 2005 to 2017 showed dramatic fluctuations in beach width; however, the beach appeared to be relatively stable over time.

Tank Beach is somewhat remote but appeared to experience frequent use. Tank Beach supports a variety of recreational uses including walking, wading, fishing, and sightseeing. The nearshore waters are part of the Forbidden Island Marine Sanctuary. There are two historical pillboxes built into the limestone cliffs at the north and south ends of the shoreline (Figure 200). Vehicular access is available via Tank Beach Place, an unpaved road located in the residential area of Kagman III. There was ample off-road parking available. Access to Tank Beach is via a coastal access trail from the off-road parking area (Figure 199). Lateral access along the shoreline is impossible due to the nearly-vertical sea cliffs to the north and south of the beach.

Erosion Hazard Priority Rating

The EHPR for Tank Beach was determined to be *low*. The determination was based on the presence of a protective fringing reef, very wide beach, high backshore elevation, lack of evidence of erosion, lack of development in the backshore area, and lack of vulnerable public infrastructure and amenities. Tank Beach is vulnerable to wave inundation and storm surge; however, erosion is unlikely to impact access due to the lack of lateral access along the shoreline.

Issues & Recommendations

Amenities were limited to the coastal access trail and a trash receptacle. There were no public restrooms observed in the area. Food and beverages were available for purchase at a small hut located at the trailhead. Issues that affected the overall user experience at Tank Beach included the lack of amenities and the extensive amount of marine debris along the shoreline (Figure 201).

Recommendations

- Install and maintain trash/recycling receptacles.
- Install and maintain public restrooms (possibly a composting toilet).
- Coordinate beach cleanups to remove marine debris.

Figure 189 Tank Beach, south end, looking north (7/4/2017)

Figure 190 Tank Beach, north end, looking north (7/4/2017)

Figure 191 Tank Beach, looking north (7/4/2017)

Figure 192 Tank Beach, looking south (7/4/2017)

Figure 193 Tank Beach, typical beach profile, looking north (7/4/2017)

Figure 194 Tank Beach, typical beach profile, looking south (7/4/2017)

Figure 195 Tank Beach, dune bisected by drainage (7/4/2017)

Figure 196 Tank Beach, intermittent outcrops of lithified beach rock (7/4/2017)

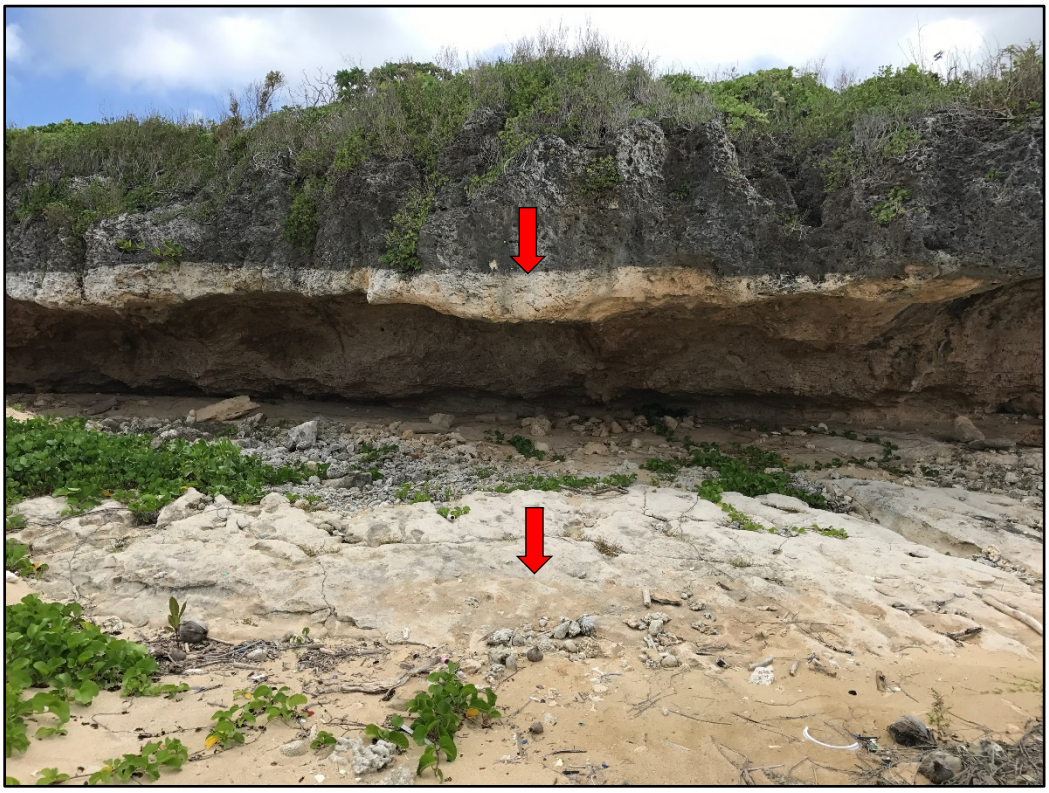


Figure 197 Tank Beach, evidence of previous sea level highstand (7/4/2017)

Figure 198 Tank Beach, coastal access trail (7/4/2017)

Figure 199 Tank Beach, historical pillbox built into limestone cliffs (7/4/2017)

Figure 200 Tank Beach, marine debris lines (7/4/2017)