DCRM Shoreline Profile Monitoring Data Report

Saipan and Mañagaha

August 2018 – February 2021

Bureau of Environmental Coastal Quality - Division of Coastal Resources Management

Introduction

This report summarizes data collected under DCRM's Shoreline Profile Monitoring Program between June 2016 – February 2021. It is an update to the first Shoreline Profile Monitoring Data Report published on June 2018. Content from the 2018 Saipan Shoreline Access and Shoreline Enhancement Assessment (SASEA) and the 2019 Hydrodynamic Study of Saipan's Western Lagoon will be incorporated into each site's summary analysis. Due to a lack of capacity at the time, Super Typhoon Yutu (Oct 2018) effects on beach morphology were not recorded. CZM interns contributed to post-storm records in the summer of 2019. With the Coastal Planner I position filled, shoreline monitoring fully resumed on December 2019. Consistency and improvements to the program were expected with the flow of data entry captured throughout this reporting period.

Shoreline monitoring is a way to measure changes in the contour of a beach over time. Data about beach width, vegetation cover, morphology, slope, and other features are collected along a transect, a straight "study line," running perpendicular to the shoreline from an identified landward point to the submerged beach toe. By returning to the same place (known as the head stake) and comparing observations at regular intervals, one can visualize why and how much a certain beach site may be eroding (sand loss) or accreting (sand gain). Each beach site has between two and eight established transects. This current methodology, called the "Berger Level Method", results in beach profiles that are currently qualitatively compared to report the general trend from the beginning of the program to February 2021 data. DCRM is still working on the analysis method to provide quantifiable results with higher confidence. The shoreline profile change findings only account for longshore transport processes. The accretion and erosion captured from field monitoring are primarily driven by episodic high surf events. Although areas have been identified as vulnerable to sea level rise through observations, shoreline change data should not serve as evidence for sea level rise at its contemporary state. The program needs more decades to see sea level rise impacts. Nonetheless, it is important to acknowledge that sea level rise exacerbates erosion processes. This report aims to guide coastal managers and stakeholders in making informed, effective, and adaptive decisions regarding our dynamic shoreline.

Tides and seasonal trade winds influence the ever-changing nature of the shoreline. For better understanding of shoreline dynamics, we began this data collection timeframe with strong consideration of these factors to hopefully address the following questions:

- Should we be more consistent in measuring based on tide seasonality?
- What tide would be the most efficient for consistently measuring shoreline change?
- What are the trade wind conditions' effect on accretion and erosion of sensitive sites?

In addition, the aim of this report is to compare and reflect our results with supplemental data publications, the Hydrodynamic Study and SASEA, in order to ultimately address these questions. The report would aid in identifying sensitive shoreline areas in need of stabilization measures and further address coastal erosion in the CNMI.

The Shoreline Monitoring program is led by the DCRM's Planning Section, with the direction of the Coastal Planner I and valued assistance from DCRM staff volunteers, dedicated summer interns, and student interns. Interns have greatly contributed numerous hours to data collection and field work and are the basis of the program's consistency. Any questions or comments about the program or this report may be directed to shorelines@dcrm.gov.mp.

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.

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Britney E., Lance T., Marvin S.– the 2020 Summer Shoreline Interns – posing with Coastal Planner I Mary at Wing Beach.

Catherine C. and Eloise L.– the 2020-2021 NMC interns – with the rod at Quartermaster Beach.

Chioni D. - a 2020-2021 NMC intern – calibrating the rod at Sugar Dock.

Rich S., Coastal Planner II, holds the rod while Art C., Coastal Planner III, sights at AMP North in 2020.

Methods

Beach contours are measured using simple survey equipment to conduct the Berger Level method. Measurements along a transect are taken every 10 feet as well as at significant features such as vegetation boundaries, berms, wrack lines, water lines, etc. Beginning in 2016, monitoring has occurred annually, at a minimum, and opportunistically after storm events or as time allows. Sampling frequency is expected to increase with the role of the Coastal Resource Planner I ensuring more consistent data collection.

As this effort is growing, sampling methods are expected to undergo improvements for better accuracy. Sources of error may stem from the misalignment or loss of transect starting points and error in operating the equipment. The use of compass direction has been introduced in this period to lessen error by improving the direction of the transect from the head stake to the water. Consideration of the tides and trade winds is included in the recording process to relate hydrodynamic data with shoreline monitoring data.

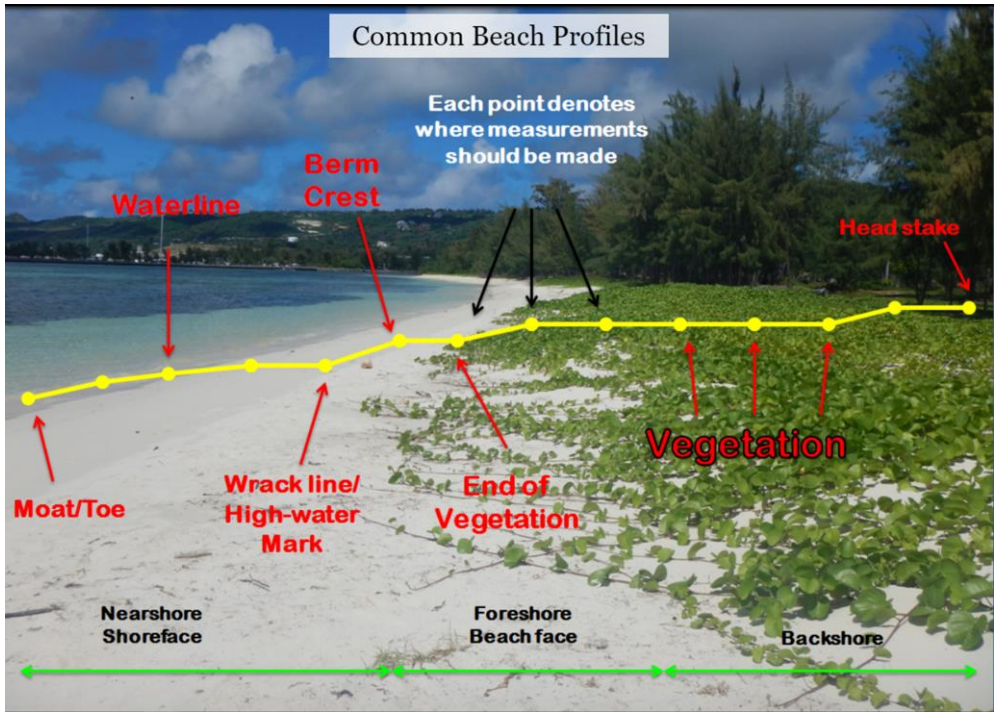
Equipment and Supplies

1. Berger Level
2. Tripod
3. Level Rod
4. Measuring Rope/ Transect Line
5. GPS (Global Positioning System)
6. Camera
7. Data Notebook
8. Extra batteries and pen
9. Compass app (may be replaced with magnetic)

Catherine, NMC intern, calibrates the Berger Level at PIC 1.

Methodology

1. Set up survey tripod and ensure that it is on a stable surface.
2. Mount level instrument by placing level on platform and tighten fastening screw underneath the platform.
3. Adjust instrument by rotating the three knobs until the bubble is centered within the circle. Once the bubble is centered, turn the instrument 45° to ensure that it is leveled.
4. Identify head stake. Use the compass direction for the transect to carefully lay out transect tape (or rope) along the beach profile.
5. Observe and record weather and time. Time is important for identifying tide.
6. As the rod holder, start at head stake then proceed every 10 feet. Call out every significant feature (Vegetation lines, beach berm, wrack line, beach toe, erosion scarps, etc.) and record the elevation at that particular feature.
7. As the sight reader, record the measurement at the crosshair at each interval and feature.



Shoreline Features in a Common Beach Profile

Shoreline features are recorded since they aid in understanding the stability of the shoreline. Most of the transect runs through the foreshore, or the portion of the shoreline that lies between high and low water mark during mean tide.

- Headstake – identified object serving as the starting point of the transect located at the backshore. The backshore usually consists of important infrastructure and relies on the foreshore to handle wave energy.
- Vegetation area – shoreline plants in the foreshore stabilizing the sand. The foreshore is capable of receiving wave run up.
- Berm – the nearly horizontal portion of the beach or backshore formed by the deposit of materials by wave action, or the vertical drop of a beach located on the nearshore. The nearshore is the beach toe to seaward, and is also important for the stabilization of the shoreline.
- Waterline – a line that marks the surface of the sea on land located within the nearshore.
- Moat/toe – point of a beach that juts out past the waterline located on the nearshore. It is exposed during low tide.

Producing beach profiles

1. Data should be recorded in the data notebook.
2. Profile readings should be recorded as follows: 0 at the start of the transect, Level Reading, and Notes.
3. When you take a measurement at a beach feature, record the beach feature. Resume taking data back on the 10 foot increments.
4. At the beginning of each sampling period, a new data sheet should be created in excel. To create a data sheet, enter the data as shown in the right.
5. Distance from Headstake (ft): The headstake reading should be zero, and measurements should be made every 10 feet and at every beach feature. After a measurement is taken at a beach feature, data should return to the 10 feet increments.
6. Average Reading (ft): The total inches divided by 12 inches.
    a. To get the total inches, you add the inches and the feet. In order to do this, you need to multiple the feet X 12 inches, then add the inches. Ex: (ft*12)+in.
7. Adjusted Average Reading (ft): This is the average reading at each distance point minus the average reading at headstake, which is zero.
8. Profile Features/ Notes: This is a text column that describes the features that were noted at a point. The description highlights areas where the slope might be irregular.

Sampling Date	Sampling Time	Weather	Team Names/Roles
2/2/2018	9:00 AM	Sunny; Breezy	Rod: RS, Level: SK & ECN, Record: FS
			Tide: 1.82 ft
Distance from Headstake (ft)	**Average Reading (ft)**	**Adjusted Average Reading (ft)**	**Profile Features/Notes**
0	2.854166667	0	
10	3.791666667	-0.9375	
19	4.625	-1.770833333	Upper wrackline
26	5.3125	-2.458333333	Lower Wrackline/ High Water Line
30	5.8125	-2.958333333	
40	6.854166667	-4	
48	7.4375	-4.583333333	Top of Moat/Toe
50	7.708333333	-4.854166667	Bottom of Moat/Toe

The data record table in Excel as described in Step 4.

9. Measure the change in elevation over the distance from the headstake by making a creating a separate table on the top and a graph:
    a. Create a table with the "Sampling Date" as the name. Place three columns for "Distance from Headstake (ft)", "Adjusted Vertical Relief (ft)", and "Profile Features." Copy and paste corresponding information from the previous table.
    b. To calculate the beach slope, select Column A: Distance from Headstake and Column B: Adjusted Level Reading, by pressing control "Ctrl" and dragging the mouse over both columns.
    c. Once the columns are selected, click "Insert", select Charts, "Scatter with Straight Line and Markers."

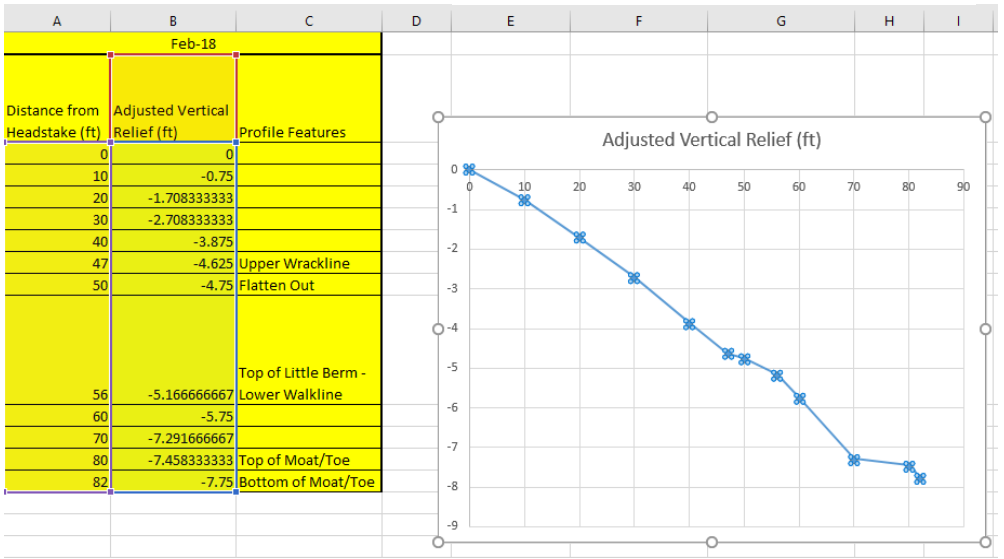
10. Change the title of the chart to "Beach Profile", add the title for the *Y Values - Adjusted Vertical Relief*, and add the title for the *X Values - Distance from Headstake.*

11. Customize the data line produced to label any input for Column C: Profile Features for each X - the Distance from Headstake:

a) Click on the data line to highlight.
b) Right click and select "Add Data Labels – Add Data Labels."
c) Click on label produced to highlight.
d) Right click and select "Format Data Labels."

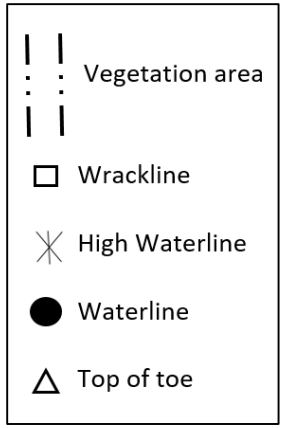
Feb-18		
Distance from Headstake (ft)	Adjusted Vertical Relief (ft)	Profile Features
0	0	
10	-0.9375	
19	-1.77083333	Upper wrackline
26	-2.45833333	Lower Wrackline/ High Water Line
30	-2.95833333	
40	-4	
48	-4.58333333	Top of Moat/Toe
50	-4.85416667	Bottom of Moat/Toe

Table for developing the graph, as described in Step 9.



The highlighted "Distance from Headstake (ft)" and "Adjusted Vertical Relief (ft)" columns are individually highlights to for generate the scatter plot found in the left, as described in Step 9.

e) In the window, go to the Label Options section, unbox all of “Label Contains” options except “Value From Cells.”
f) In the small “Data Label Range” window, highlight the cells under “Profile Features.”
g) Right click on a point with a label on the data line.
h) Click on the “Format Data Point” in the drop box.
i) Go to the paint bucket section then click “Marker.”
j) Click on “Marker Options” for the drop down options and click on “Built-In.”
k) Select the symbol based on their perspective “Profile Features” label. Symbol to feature is shown on the right.
l) Select the same color as the data line through the “Fill” option.
m) Do this for all of the other identified “Profile Features” until all are completed.



Legend of Beach Profile

The final product is a beach profile. See page 25 on “How to Read the Beach Profile.”

Monitoring Locations

DCRM's Shoreline Monitoring Program encompasses sandy beaches on Saipan, Mañagaha, Tinian, and Rota. Saipan holds the most sites, in which all of them are located within the west side of the island adjacent to the lagoon. Saipan monitoring locations are gentle to moderate sloping shorelines with transects extending from a designated head stake to the water. Inland coastal plain and low-lying developed area rely on this stretch for recreation, coastal protection, and provision (Greene, 2014).

Refer to our interactive Shoreline Monitoring Program Story Map for better resolution on the [DCRM Shoreline Monitoring Program page](#).

Saipan Sites

Pakpak		
Pakpak 1	Pakpak 2	Pakpak 3
Lat. Degrees N: 15.12319699 Long. Degrees E: 145.693875 Elevation: -4.565928 Compass direction: 270 °W	Lat. Degrees N: 15.12503497 Long. Degrees E: 145.693875 Elevation: 8.406403 Compass direction: 267 °W	Lat. Degrees N: 15.1237398 Long. Degrees E: 145.693463 Elevation: 18.42535 Compass direction: 266 °W

PIC		
PIC 1	PIC 2	PIC 3
Lat. Degrees N: 15.126967 Long. Degrees E: 145.693409 Elevation: 12.106647 Compass direction: 265 °W	Lat. Degrees N: 15.12800401 Long. Degrees E: 145.692981 Elevation: 16.459589 Compass direction: 261 °W	Lat. Degrees N: Long. Degrees E: Elevation: Compass direction: 266 °W

Hopwood

Hopwood 1

Lat. Degrees N:
Long. Degrees E:
Elevation:
Compass direction: 285 °W

Hopwood 2

Lat. Degrees N: 15.14086797
Long Degrees E: 145.697728
Elevation: 18.118422
Compass direction: 283 °W

Hopwood 3

Lat. Degrees N:
Long. Degrees E:
Elevation:
Compass direction: 293 °NW

Aquarius

Aquarius 1

Lat. Degrees N: 15.1486697
Long. Degrees E: 145.700498
Elevation: 24.946808
Compass direction: 270 °W

Aquarius 2

Lat. Degrees N: 15.14866297
Long Degrees E: 145.700498
Elevation: 24.946808
Compass direction: 272 °W

Sugar Dock

Sugar Dock South 1

Lat. Degrees N: 15.149128
Long. Degrees E: 145.700453
Elevation: 23.85194
Compass direction: 270 °W

Sugar Dock South 2

Lat. Degrees N: 15.15025
Long Degrees E: 145.70032
Elevation: 18.118422
Compass direction: 248 °W

Sugar Dock South 3

Lat. Degrees N: 15.15126
Long. Degrees E: 145.69997
Elevation:
Compass direction: 263 °W

Sugar Dock North 1

Lat. Degrees N: 15.15234103
Long. Degrees E: 145.70073
Elevation: 18.875252
Compass direction: 290 °W

Sugar Dock North 2

Lat. Degrees N: 15.152308
Long. Degrees E: 145.70053
Elevation:
Compass direction: 288 °W

Sugar Dock North 3

Lat. Degrees N: 15.15428396
Long. Degrees E: 145.700208
Elevation: 26.504326
Compass direction: 256 °W

Susupe Beach Park (SBP)

SBP 1

Lat. Degrees N: 15.15500
Long. Degrees E: 145.70013
Elevation:
Compass direction: Not recorded

SBP 2

Lat. Degrees N: 15.15576
Long Degrees E: 145.70012
Elevation:
Compass direction: Not recorded

SBP 3

Lat. Degrees N: 15.15623
Long. Degrees E: 145.70023
Elevation:
Compass direction: Not recorded

Kilili

Kilili South 1

Lat. Degrees N: 15.160259
Long. Degrees E: 145.70443
Elevation: 18.768661
Compass direction: 318 °NW

Kilili South 2

Lat. Degrees N: 15.16150
Long Degrees E: 145.70572
Elevation:
Compass direction: 305 °NW

Kilili South 3

Lat. Degrees N: 15.16233302
Long. Degrees E: 145.706439
Elevation: 17.998749
Compass direction: °

Kilili North 1

Lat. Degrees N: 15.16320
Long. Degrees E: 145.70715
Elevation:
Compass direction: 320 °NW

Kilili North 2

Lat. Degrees N: 15.16437
Long. Degrees E: 145.70813
Elevation:
Compass direction: 290 °W

Kilili North 3

Lat. Degrees N: 15.165336
Long. Degrees E: 145.708456
Elevation: 17.789307
Compass direction: 300 °NW

Oleai

Oleai 1

Lat. Degrees N: 15.16767204
Long. Degrees E: 145.709344
Elevation:
Compass direction: 290 °W

Oleai 2

Lat. Degrees N: 15.16895397
Long Degrees E: 145.709794
Elevation: 19.017784
Compass direction: 290 °W

Toyota		
Toyota 1	Toyota 2	Toyota 3
Lat. Degrees N: 15.1517080 Long. Degrees E: 145.709344 Elevation: Compass direction: 280 °W	Lat. Degrees N: 15.17438 Long Degrees E: 145.71153 Elevation: Compass direction: 288 °W	Lat. Degrees N: 15.17728 Long. Degrees E: 145.71271 Elevation: Compass direction: 290 °W

Quartermaster	
Quartermaster 1	Quartermaster 2
Lat. Degrees N: 15.18128 Long. Degrees E: 145.71358 Elevation: Compass direction: 279 °W	Lat. Degrees N: 15.18478 Long Degrees E: 145.71436 Elevation: Compass direction: 277 °W

Hafa Adai		
Hafa Adai 1	Hafa Adai 2	Hafa Adai 3
Lat. Degrees N: 15.20835897 Long. Degrees E: 145.715874 Elevation: 30.446064 Compass direction: 254 °W	Lat. Degrees N: 15.20835897 Long Degrees E: 145.715907 Elevation: 31.068859 Compass direction: 270 °W	Lat. Degrees N: 15.21010702 Long. Degrees E: 145.715881 Elevation: 29.735472 Compass direction: 253 °W

Fiesta

Fiesta 1

Lat. Degrees N: 15.21306298
Long. Degrees E: 145.715491
Elevation: 24.311337
Compass direction: 260 °W

Fiesta 2

Lat. Degrees N: 15.21430903
Long Degrees E: 145.715426
Elevation: 16.943949
Compass direction:

Fiesta 3

Lat. Degrees N: 15.21430903
Long Degrees E: 145.715426
Elevation: 16.943949
Compass direction:

Hyatt

Hyatt 1

Lat. Degrees N: 15.21540899
Long. Degrees E: 145.715591
Elevation: 19.263865
Compass direction: 261 °W

Hyatt 2

Lat. Degrees N: 15.21540899
Long Degrees E: 145.715591
Elevation: 19.263865
Compass direction: 283 °W

AMP

AMP South 1

Lat. Degrees N: 15.20835897
Long. Degrees E: 145.715874
Elevation: 30.446064
Compass direction: 310 °NW

AMP South 2

Lat. Degrees N: 15.20835897
Long Degrees E: 145.715907
Elevation: 31.068859
Compass direction: 290 °W

AMP Point 1

Lat. Degrees N: 15.219337
Long. Degrees E: 145.717165
Evaluation: 12.955928
Compass direction: 291 °W

AMP Point 2

Lat. Degrees N: 15.21943197
Long. Degrees E: 145.717342
Evaluation: 14.245499
Compass direction: 20 °N

AMP North 1	AMP North 2	AMP North 3
Lat. Degrees N: 15.2195904 Long. Degrees E: 145.718177 Evaluation: 16.983105 Compass direction:	Lat. Degrees N: 15.48997 Long. Degrees E: 145.718573 Evaluation: 14.901231 Compass direction:	Lat. Degrees N: 15.21952802 Long. Degrees E: 145.719305 Evaluation: 20.702307 Compass direction:

Pau Pau		
Pau Pau 1	Pau Pau 2	Pau Pau 3
Lat. Degrees N: 15.27147101 Long. Degrees E: 145.79136 Evaluation: 28.212759 Compass direction: 318 °NW	Lat. Degrees N: 15.25580901 Long. Degrees E: 145.780579 Evaluation: 13.931701 Compass direction: 315 °NW	Lat. Degrees N: 15.25672599 Long. Degrees E: 145.781258 Evaluation: 17.113745 Compass direction: 320 °NW

Wing	
Wing 1	Wing 2
Lat. Degrees N: 15.18478 Long. Degrees E: 145.71436 Elevation: Compass direction:	Lat. Degrees N: 15.27157604 Long. Degrees E: 145.791588 Elevation: 17.331421 Compass direction: 320 °NW

Mañagaha		
Mañagaha 1 Lat. Degrees N: Long. Degrees E: Evaluation: Compass direction:	Mañagaha 2 Lat. Degrees N: Long. Degrees E: Evaluation: Compass direction:	Mañagaha 3 Lat. Degrees N: Long. Degrees E: Evaluation: Compass direction:
Mañagaha 3B Lat. Degrees N: Long. Degrees E: Evaluation: Compass direction:	Mañagaha 5 Lat. Degrees N: Long. Degrees E: Evaluation: Compass direction:	Mañagaha 6 Lat. Degrees N: Long. Degrees E: Evaluation: Compass direction:
Mañagaha 7 Lat. Degrees N: Long. Degrees E: Evaluation: Compass direction:		

Hydrodynamic Study and SASEA findings

Hydrodynamic Study of Saipan's Western Lagoon (2019) measured waves and currents within the lagoon to develop and calibrate combined wave and hydrodynamic models of current and circulation. Waves are the dominating force for shore erosion. Wind influences the strength and direction of the waves, making it another driver of shoreline morphology. Thus, considering hydrodynamics is incremental to understanding short-term site-specific shoreline change and identifying which areas are most vulnerable to long-term erosion and accretion. Although this study was intended for oil clean ups, it is our best recent study of current directions within the Saipan Lagoon. Error in the modeling wave transformation exists due to outdated LiDAR data suggesting that no change in the lagoon bathymetry has occurred in the past seventeen years. One limitation is that the modeling does not directly address the nearshore hydrodynamics that occur along the shoreline.

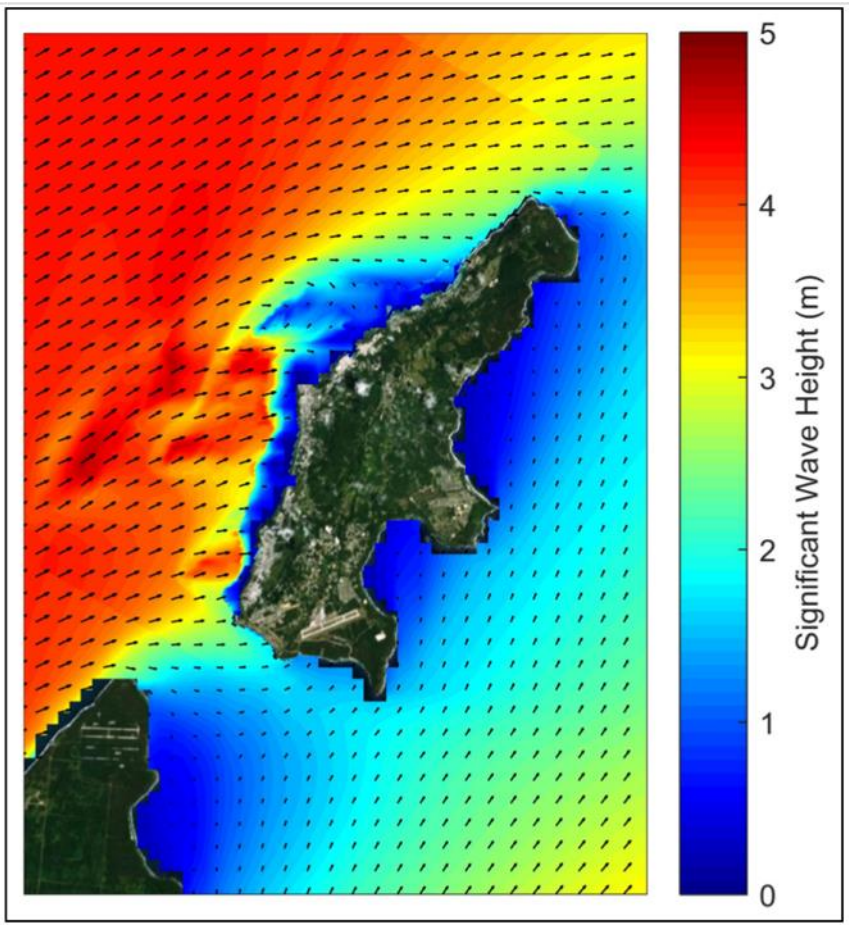
Takeaway #1 of Hydrodynamic Study: Typical winter and typhoon season wave conditions exhibit the highest wave energies that drive sediment transport processes.

The Marianas predominantly has easterly trade winds that grow stronger and steadier from January to April and get lighter and variable with intermittent trades from July to October. Typhoons generally occur during the summer typhoon months of July to October but the development and passage of tropical storms and typhoons are year-round. Typhoons approach the islands from east to west and have the ability to curve from the south to the north. Typhoon-generated waves have been observed to greatly abrade particular shorelines because wave energies intensify throughout the lagoon and wave overtopping occurs.

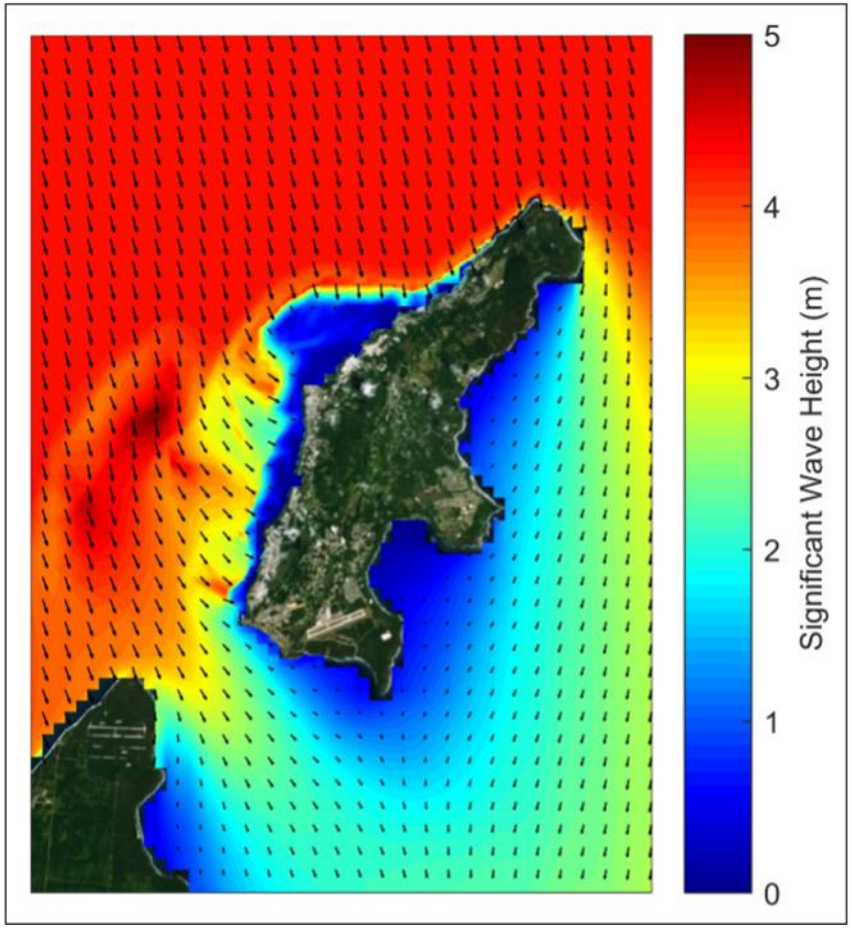
The study has produced selected five flow cases that represent the most typical conditions within the Saipan lagoon. Typical winter (northeast) and typhoon summer westerly tradewind conditions bring high wave energies into nearshore waters with influence by tidal conditions. The direction and strength of the typhoons dictate the longshore transport within the lagoon and the magnitude of impacts on a specific beach. Summer/Typhoon season tradewinds are generally weaker.

Table 2 summarizes the current flows in the Tanapag, Garapan, and Chalan Kanoa lagoons during the tides under seasonal wave conditions from the 2019 study.

Table 2. Wave Current Flow Direction during Falling and Rising Tide during Seasonal Wave Conditions		
Wave Condition	Middle of Falling Tide	Middle of Rising Tide
Typical Winter Tradewind	Tanapag Lagoon experiences the same pattern flow with stronger currents flowing from deeper sections out of the Lagoon through the main channel. Current flows from Puntan Susupe to Garapan at ~0.15 m/s. A portion of ebbing flow out of Light House Channel with max speeds of ~0.36 m/s and portions pouring out of the main channel. The flows south of Puntan Susupe travel along the coast and converges out of Sugar Dock Channel with a maximum speed of 0.21 m/s.	Tanapag Lagoon experiences the same pattern flow but with weaker currents from deeper section out of the Lagoon through the main channel. Garapan's wave flows from the southwest of AMP strongly through the Light House Channel and south down Garapan Lagoon. The velocities of the flow from Garapan weaken toward Puntan Susupe. The current floods into Sugar Dock Channel with ~0.15 m/s speeds. The incoming flow splits and continues south towards Puntan Agingan.
Summer/Typhoon Season Tradewind	SAME AS TYPICAL WINTER TRADEWIND WAVE CONDITIONS BUT WEAKER	SAME AS TYPICAL WINTER TRADEWIND WAVE CONDITIONS BUT WEAKER
Summer/Typhoon Season Westerly	Tanapag Lagoon experiences the same pattern flow that have average velocities and slighter weaker currents in and out of the main channel at ~0.25 m/s. Current flows from Puntan Susupe to Garapan at speeds up to 0.25 m/s. The stronger currents flow from deeper sections of up to 0.7 m/d out of the Light House Channel with portions out of main channel. The flows south of Puntan Susupe travel north and converges out of Sugar Dock Channel with a maximum speed of 0.64 m/s.	Tanapag Lagoon experiences the same pattern flow that have slighter weaker currents in deeper sections of the lagoon and out of the main channel at ~0.20 m/s. Garapan's current flows from Puntan Susupe to Garapan at speeds up to 0.25 m/s. The strong flow at up to 0.7 m/s out of the Light House Channel and out of main channel. The flows south of Puntan Susupe are weak due to the southward tidal currents interacting against wave driven flow to the north. There is a mix of flow into and out of Sugar Dock Channel.
1-Yr Typhoon Wave from the Southwest	The annual typhoon wave events have sufficient energy to drive currents into the lagoon and flow up north, even during rising tide. Tidal flows are overwhelmed by the energy of annual typhoon winds. Southwest waves enter directly into the lagoon and generate breaking waves at the north and south of the channel in the vicinity of Managaha Island and offshore of AMP and Garapan. Breaking waves can generate flow directed into the lagoon while large waves enter the channel and reach the northeast corner of the lagoon, generating flow inside the lagoon. The generated flow goes to the east past Pau Pau Beach and out over the reef crest. The net flow within Garapan Lagoon during westerly waves is uniformly to the north from Puntan Susupe with speeds up to 0.5 m/s then seaward out of Light House Channel with speeds of up to 1.1 m/s. Then a portion of this goes past Light House Channel and out the main channel. The section of the Garapan Lagoon south of Puntan Susupe drains toward the Sugar Dock Channel where flow exists the lagoon with a max velocity of 2.0 m/s.	



Significant wave heights direction and magnitude during southwest typhoon conditions from the SASEA

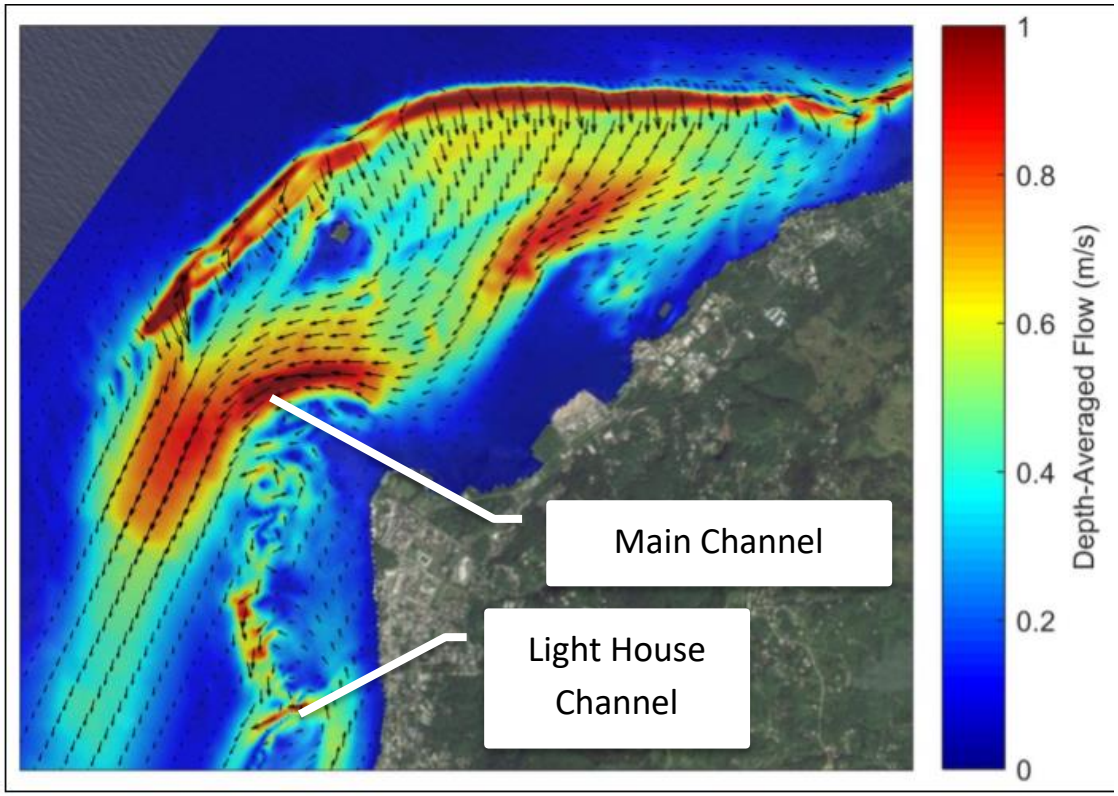


Significant wave heights direction and magnitude during north-north west typhoon conditions from the SASEA

The path and intensity of the typhoon bring relatively high significant wave heights to the west coast of Saipan. These two typhoon scenarios – the southwest and north-north west – are implemented into site-specific descriptions since they have the greatest impact on sandy shorelines. Generally, north-north west typhoon conditions greatly impact north beach sites while the southwest impact southern beach sites.

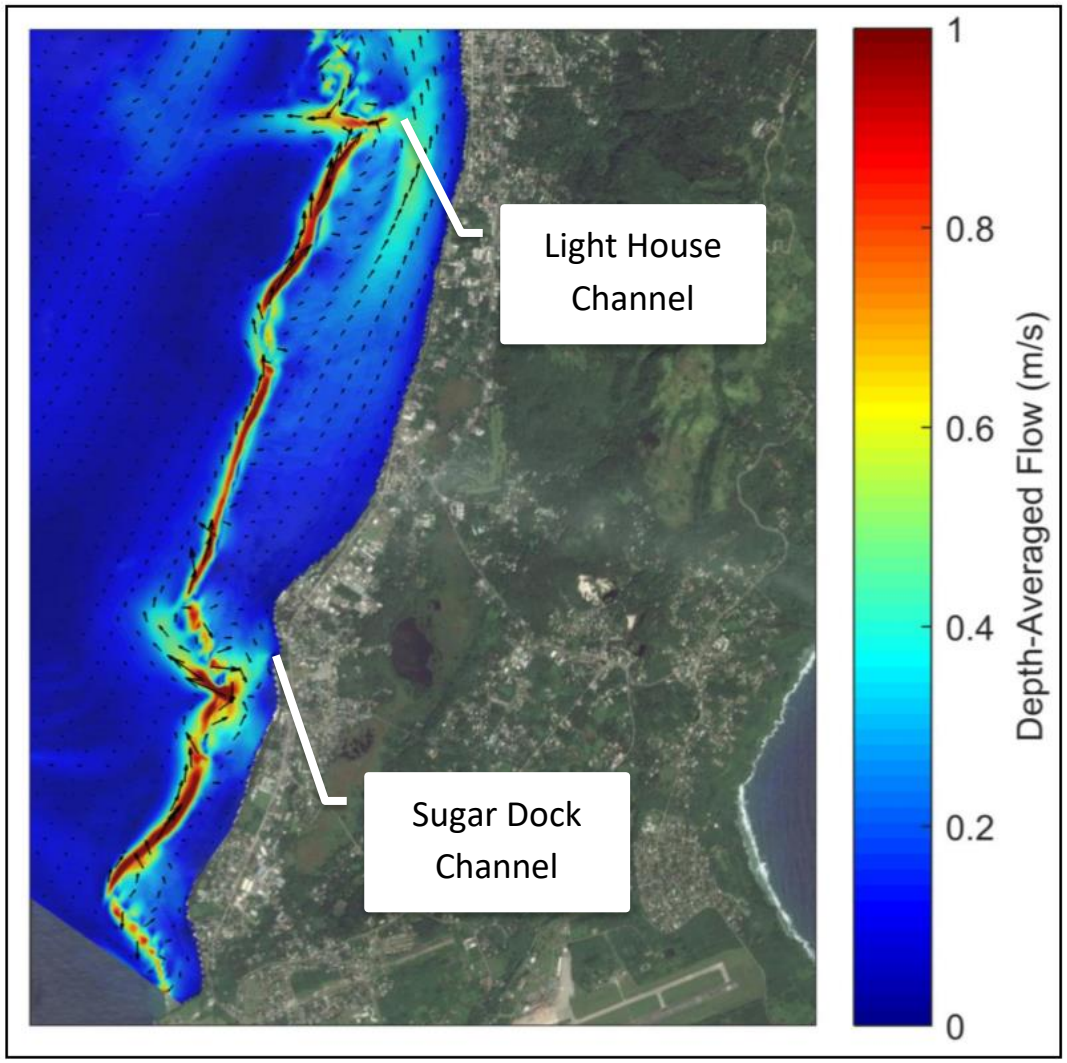
Takeaway #2 of Hydrodynamic Study: Areas close to channels are more dynamic than those better sheltered BY reef within the lagoon.

The coral reefs of the Saipan Lagoon provide coastal buffering that attenuate wave energies that enter the Lagoon. Not all of the coast have this natural barrier protection. Channels, openings between the deep ocean and the shallow Lagoon, bring high wave energy flows into the Lagoon, which in turn surges sediment transport processes. Garapan has the Main (shipping) Channel and the Light House Channel, which have strong pulls into and out of the Lagoon. The unique morphology of the reefs in this area also influences longshore transport processes.



Tanapag Lagoon is DYNAMIC due to strong flows through the Main Channel and Light House Channel.

Average flow within Tanapag Lagoon generated by the north-northwest typhoon conditions (the highest modelled wave energy condition for this area). Map extracted from the SASEA.



Average flow within Garapan Lagoon generated by southwest typhoon conditions (the highest modelled wave energy condition for this area). Map extracted from the SASEA.

Down south, the shoreline is generally sheltered by reef and the only channel is around Sugar Dock. The area close to Sugar Dock are dynamic but the rest remain stable.

Garapan Lagoon is relatively stable and the strong flow emerges from Sugar Dock.

Saipan Shoreline Access and Shoreline Enhancement Assessment (SASEA) evaluated the conditions of selected eighteen beaches on the island of Saipan. Twelve of these are DCRM shoreline monitoring sites. The study utilized the beach profiling, field investigations, and historical shoreline change analysis to determine individual erosion hazard priority ratings (EHPR). EHPR is a measure used "to determine the overall vulnerability of each beach to erosion and assist in the identification and prioritization of shoreline enhancement efforts" (SASEA, pg 2). Each DCRM shoreline monitoring site page will include the site's EHPR identified from the SASEA.

Table 3: Results of historical shoreline change analysis extracted from the SASEA

	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

	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

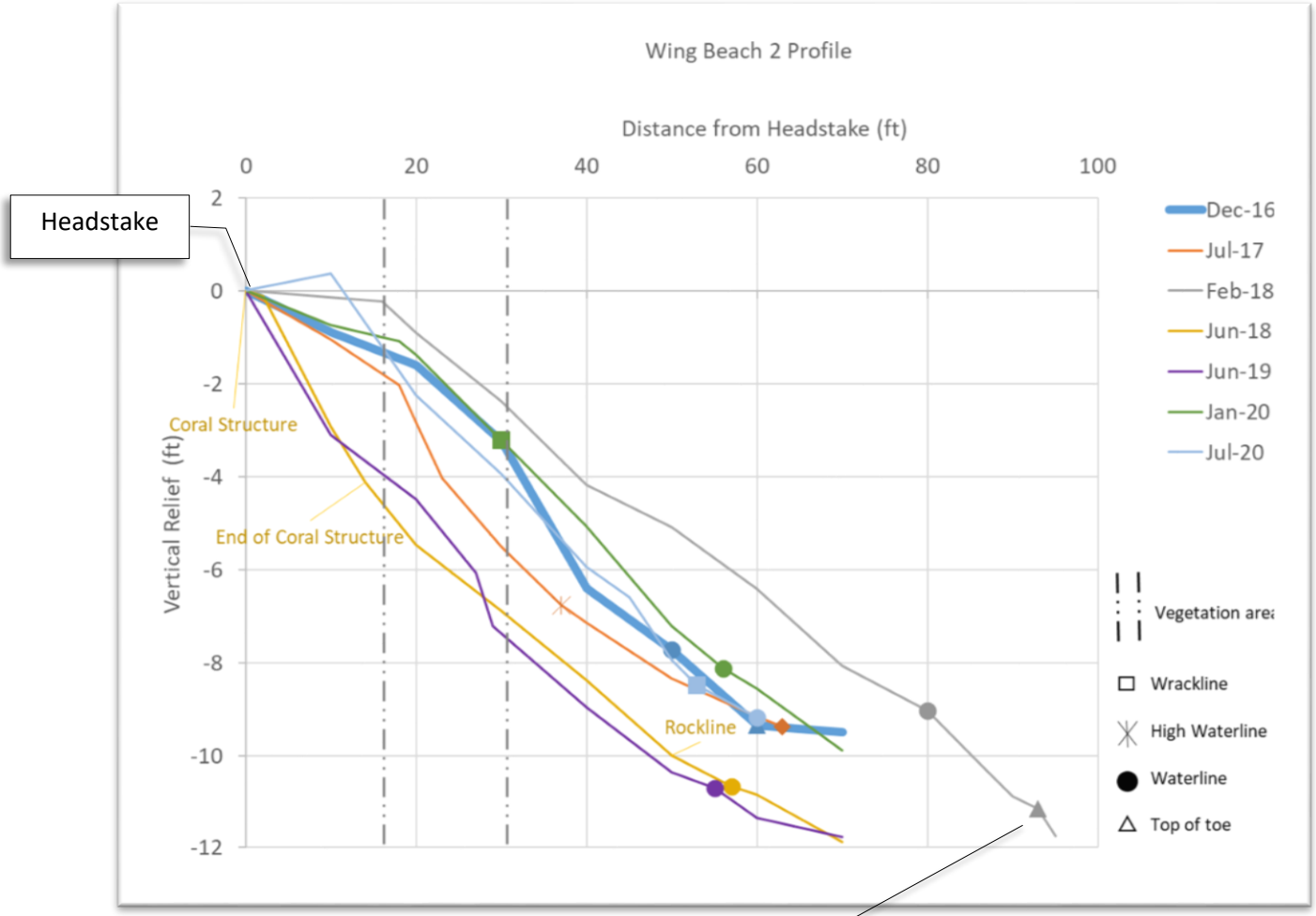
Criteria Definitions

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)

Table 4: Erosion Hazard Priority Ratings (EHPR) extracted from the SASEA

How to Read the Beach Profile



Symbology is used to indicate points where particular beach features have been detected along the transect. These beach features have been selected as importance and common indicators of shoreline profile change. The color matches the date/time of the transect taken. The symbol matches the beach feature. Vegetation area has two lines. The left indicates Start of Vegetation while the right indicates the End of Vegetation. Wrackline, high waterline, waterline, and top of toe are generally detected as one point. Note that not all beach features may be detected in a shoreline transect.

The next section will cover beach profiles for each transect lines.

The beach profile, shown on the left, captures the contour of the shoreline from the headstake (starting point inland) to the bottom of the moat/toe.

Distance from the headstake is shown vertically in relation to the elevation difference from the headstake.

Each different colored line is a data entry at a different time. For instance, a transect survey taken on Dec-16 is shown in thick blue.

Time is an important factor for shoreline monitoring because shoreline contours taken at different times will be compared to understand shoreline change.

American Memorial Park Case Study Update

In the previous shoreline report, monitoring efforts were taken opportunistically especially after storm-events. Transects observed along the southern AMP shoreline were exhibiting periods of erosion while northern AMP north shoreline transects were accreting. Interestingly enough, the most southern transect taken on December indicated accretion after the typhoon season and during the winter trade wind waves. The shoreline nearly doubled in length from the head stake to the high water line. The physical environment, however, drastically changed. The head stake, a fallen ironwood tree, and a coconut tree remained as a result by Super Typhoon Yutu. The grass has receded and the berm smoothed out. Two coconut trees were uprooted and replaced by sand. We speculate that sand from the berm in 2018 could have contributed to the new stretch of sand in 2019 or the sand pulled into the water during the typhoons were returned over time back to the shoreline. However, high wave energy events continue to abrade this shoreline and erosion appears to be chronic. The Hydrodynamic Study (2019) suggests high sediment transport during typhoon wave conditions due strong waves that pass through the main channel. The beach profile of this particular transect (found in page 82) indicates a reduced elevation from the head stake.

Picture taken on August 2018 before Yutu. The waterline is close to a row of coconut trees and slumping and appears to be occurring in places around the coconut tree roots.

Picture taken December 2019. The coconut tree at the backshore is the only surviving. The row of coconut tree are uprooted and the sand within the berm have poured into the shoreline, exposing it to long-shore transport.

Pak Pak Beach

Trend: Stable

EPHR: N/A

Average length: 60.0 ft

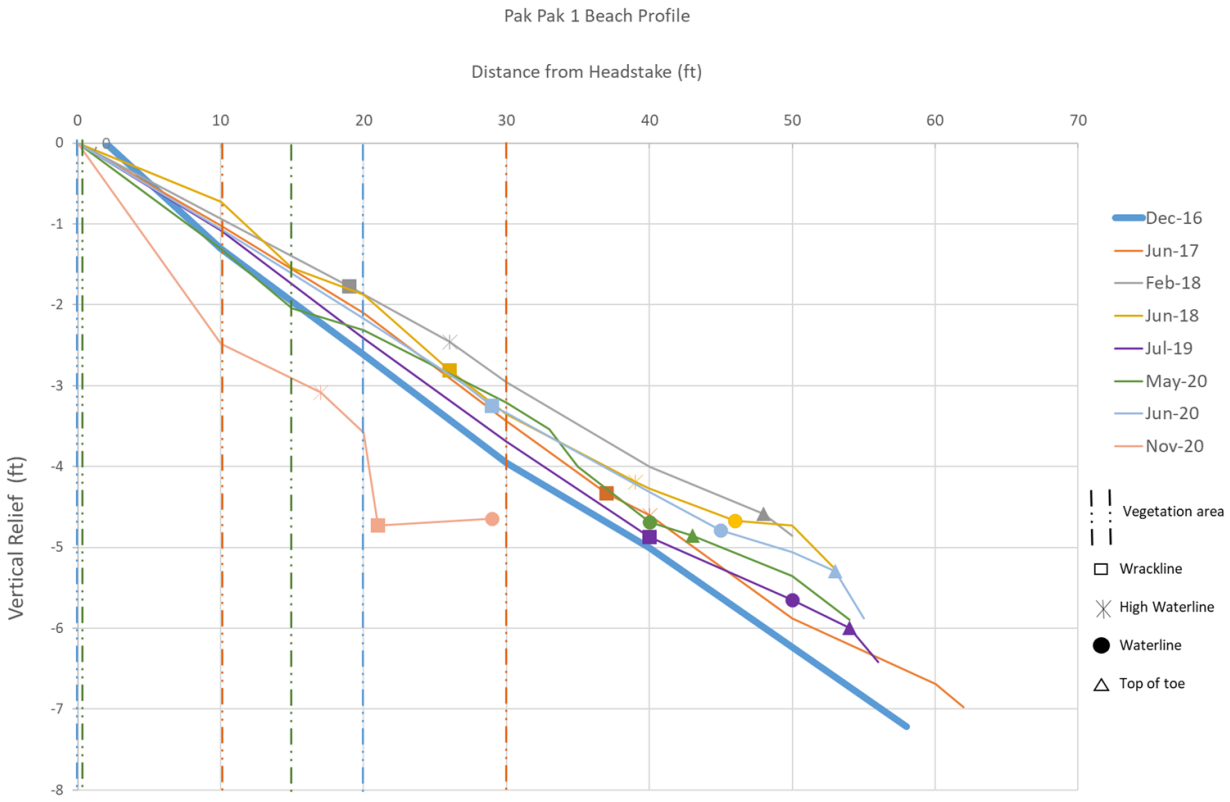
Average elevation: 7.33 ft

Pakpak 2 (2018)

Pakpak 2 (2020)

Description: Sheltered by the nearby reef (approximately 500 meters) and Agingan Point, Pak Pak Beach exhibits a stable shoreline since 2016. The above picture taken in 2018 indicates abrupt loss of beach vegetation from wave run up in picture above. Southwest typhoon conditions appear to be more damaging than north-north west especially due to the proximity of the storm.

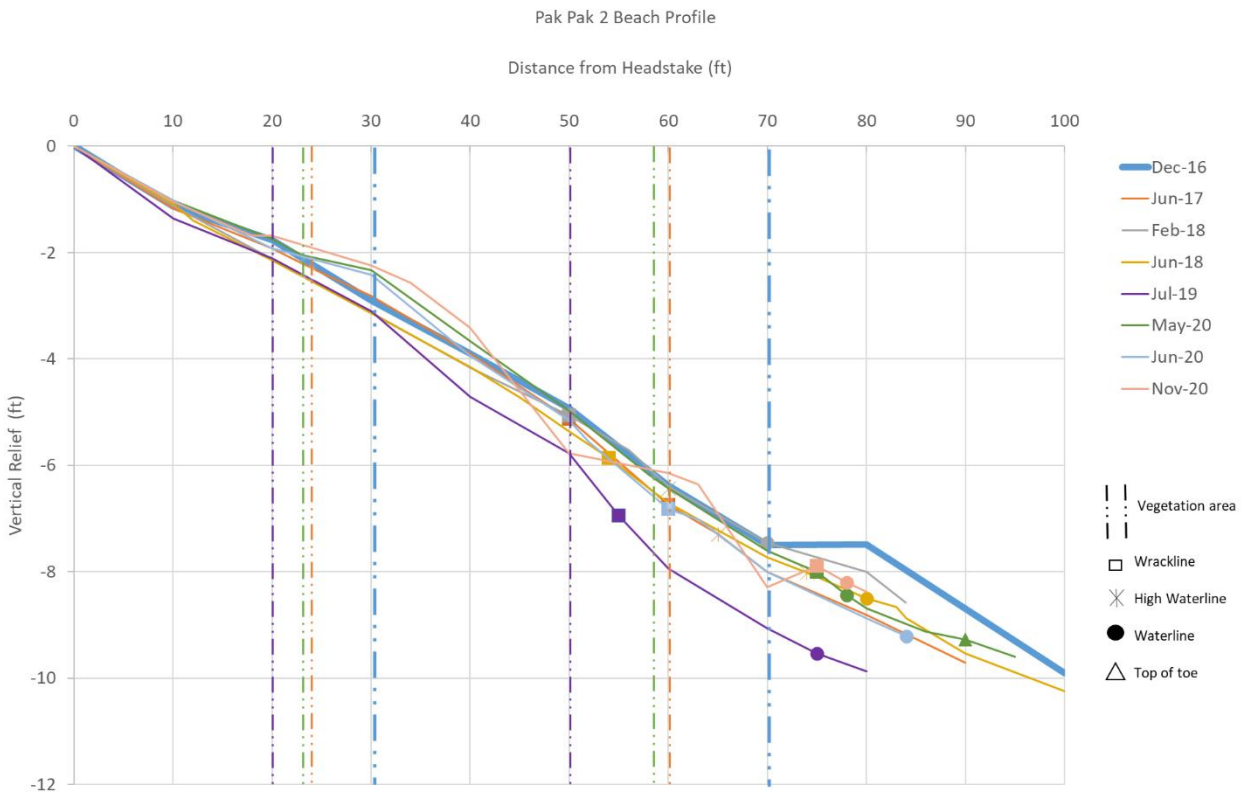
Pakpak 1



Day Recorded	Tide	Shoreline Length
Dec 12, 2016	1.39 ft	43 ft
Jun 7, 2017	1.03 ft	40 ft
Feb 2, 2018	1.87 ft	26 ft
Jun 14, 2018	1.62 ft	46 ft
Jul 2, 2019	0.69 ft	50 ft
May 15, 2020	1.15 ft	40 ft
Jul 1, 2020	0.83 ft	45 ft
Nov 6, 2020	1.04 ft	29 ft
Average		39.9 ft

Pakpak 1 appears to be generally stable. The wrackline ranges from 19 ft to 40 ft. The elevation difference from the headstake to the farthest top of toe is about 5 ft. The Nov 2020 transect is an outlier, potentially from surveyor error. The direction of the transect line may greatly contribute to a different transect captured since that area is on the corner of a curving shoreline.

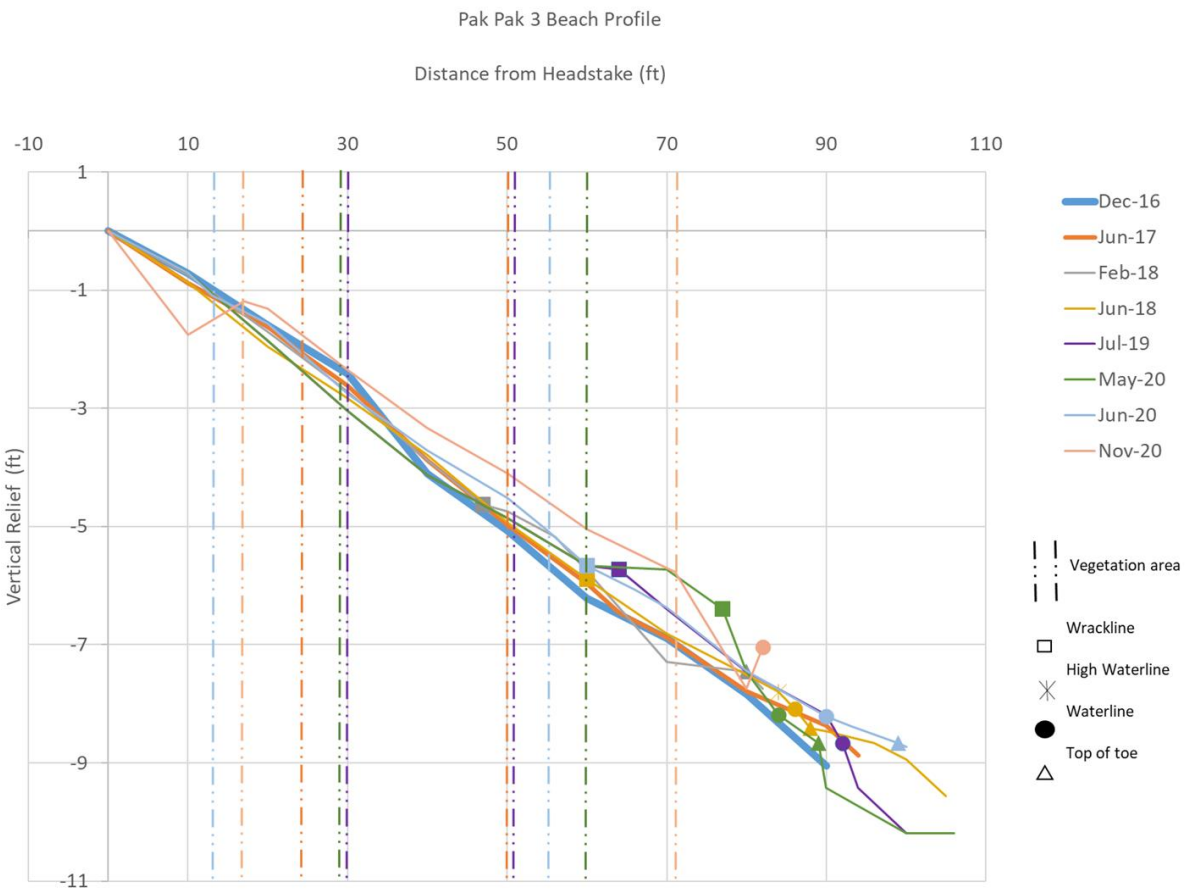
Pakpak 2



Day Recorded	Tide	Shoreline Length
Dec 12, 2016	1.72 ft	Not recorded
Jun 7, 2017	0.75 ft	65 ft
Feb 1, 2018	1.9 ft	60 ft
Jun 14, 2018	1.24 ft	74 ft
Jul 2, 2019	0.46 ft	75 ft
May 15, 2020	1.27 ft	78 ft
Jun 29, 2020	0.84 ft	60 ft
Nov 6, 2020	1.21 ft	78 ft
Average		70 ft

Pakpak 2 appears generally stable with July 2019 being an outlier. The wrackline ranges from 50 to 75 ft. The elevation difference from the headstake to the farthest top of toe is about 9 ft. Tidal influence is uncertain in the shoreline length as Feb 2018 and Nov 2020 are outliers.

Pakpak 3



Day Recorded	Tide	Length
Dec 12, 2016	1.53	Not recorded
Jun 7, 2017	0.57	65 ft
Feb 1, 2018	1.8	60 ft
Jun 14, 2018	0.97	74 ft
Jul 2, 2019	0.37	75 ft
May 15, 2020	1.31	78 ft
Jun 29, 2020	0.8	60 ft
Nov 6, 2020	1.31	78 ft
Average		70 ft

Pakpak 3 is generally stable with little variation over time. The wrackline ranges from 47 ft to 77 ft. The elevation difference from the headstake to the farthest top of toe is about 8 ft.

PIC Beach

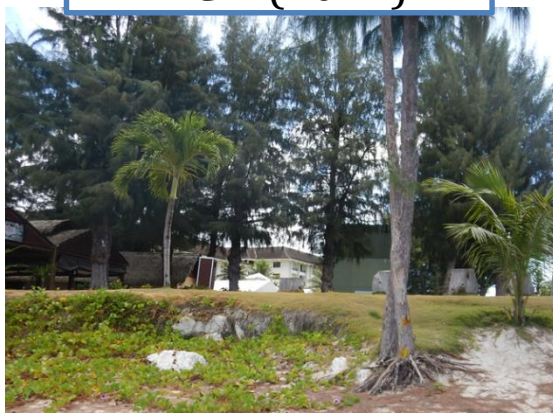
Trend: Accreting

EPHR: N/A

Average length: 55.3 ft

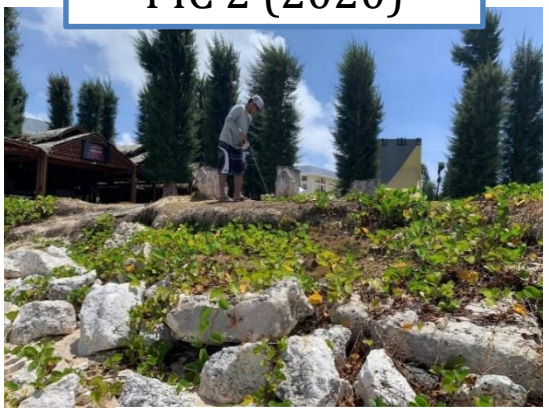
Average elevation: 9 ft

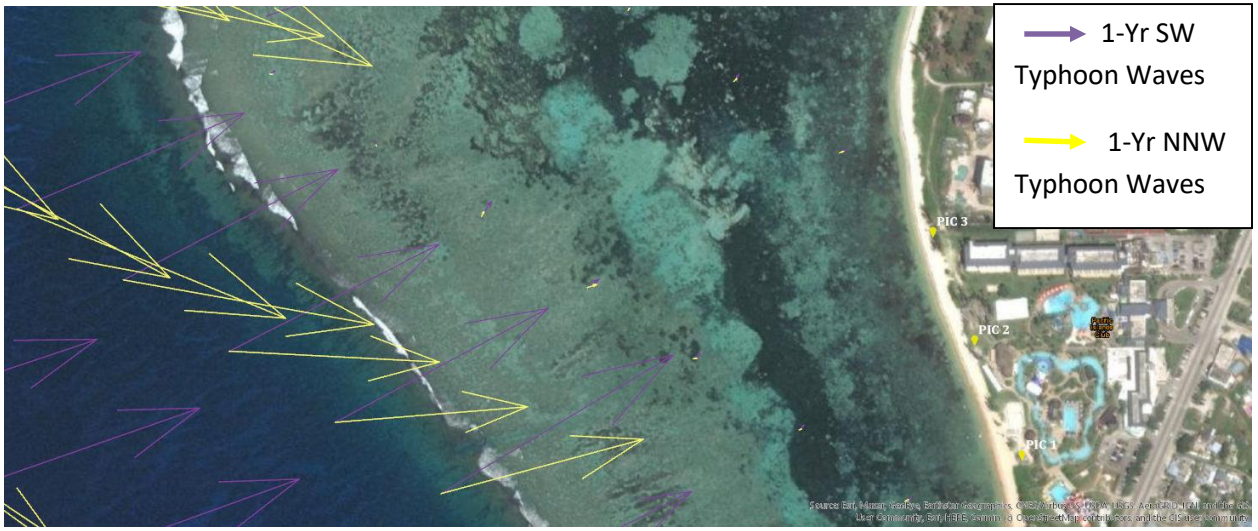
PIC 2 (2017)



PIC 2 (2018)

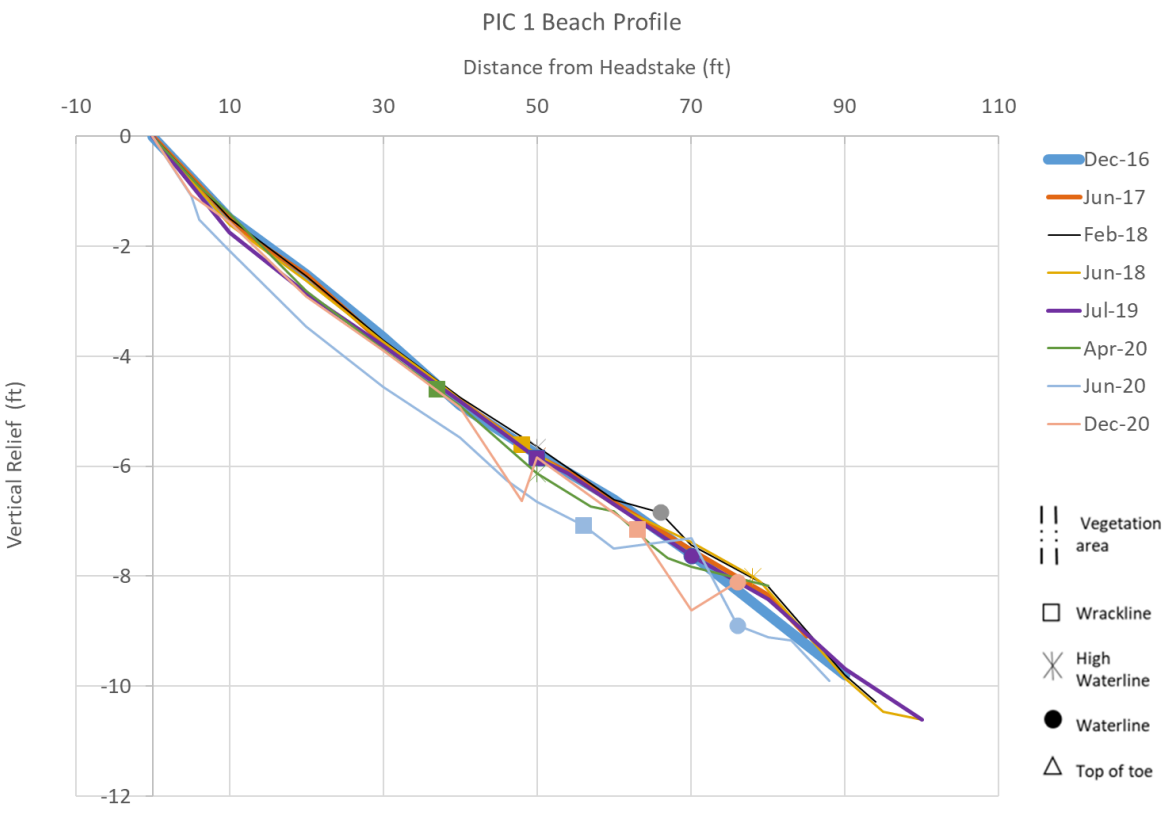
PIC 2 (2020)





PIC is adjacent to the Chalan Kanoa reef, around 500 meters away from the headstakes. This shoreline exhibits subjection to storm-induced erosion. The shoreline received some beach nourishment given its nearby commercial use. The storms of 2018 have abraded the shoreline and fell palm and ironwood trees located on the berm. South west typhoon conditions appear to be more damaging than north-north west especially due to the proximity of the storm.

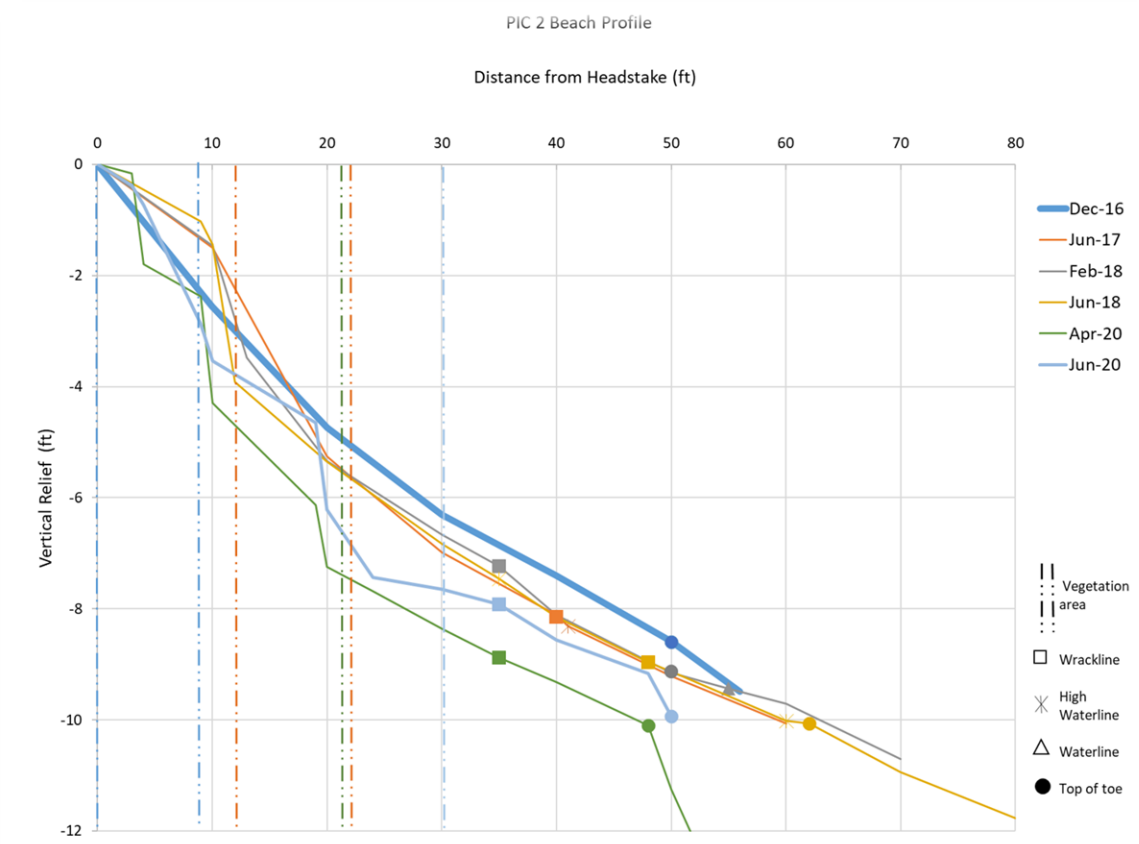
PIC 1



Day Recorded	Tide	Shoreline Length
Dec 13, 2016	1.58 ft	Not recorded
Jun 19, 2017	0.6 ft	56 ft
Feb 8, 2018	1.14 ft	66 ft
Jun 14, 2018	0.8 ft	78 ft
Jul 9, 2019	1.1 ft	70 ft
Apr 29, 2020	1.63 ft	50 ft
Jun 29, 2020	0.63 ft	76 ft
Dec 22, 2020	0.82 ft	76 ft
Average		67.4 ft

The PIC 1 berm appears to be relatively stable. The Jun-20 record is an outlier from surveyor error. Dec-20 suggests that there were abrasions in after 40 ft. The wrackline ranges from 37 ft to 56 ft. The elevation difference from the headstake to the farthest toe is around 9 ft. This beach profile lacks stabilizing vegetation due to heavy foot traffic.

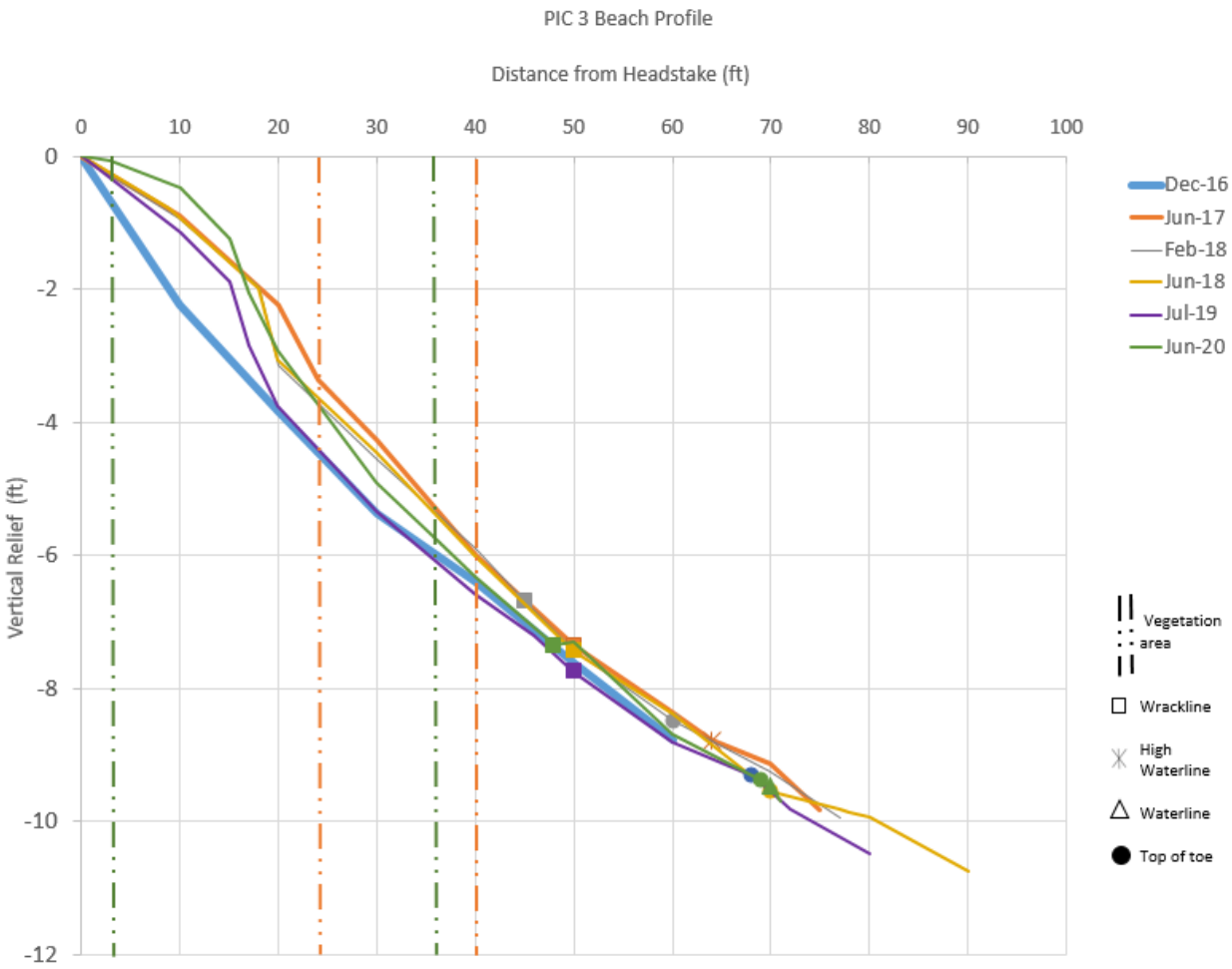
PIC 2



Day Recorded	Tide	Shoreline Length
Dec 13, 2016	1.5 ft	Not recorded
Jun 19, 2017	0.57 ft	56 ft
Feb 8, 2018	1.24 ft	66 ft
Jun 14, 2018	0.71 ft	78 ft
Jul 9, 2019	1.25 ft	70 ft
Apr 29, 2020	1.32 ft	50 ft
Jun 29, 2020	0.71 ft	76 ft
Dec 22, 2020	0.86 ft	50 ft
Average		49.3 ft

The berm has notably eroded around June 2017 when the shoreline has abraded. This berm exhibited stability when rocks were placed until Typhoon Yutu (2018) deepened the drop. The head stake acts like a good boundary of the PIC property. The loss of the head stake may indicate that the property is at a higher risk of shoreline erosion especially from storm surge. See pictures at page 31. The wrackline ranges from 35 to 48 ft. The elevation difference of the headstake to the toe is around 9 ft.

PIC 3



Day Recorded	Tide	Shoreline Length
Dec 13, 2016	1.41 ft	Not recorded
Jun 19, 2017	0.65 ft	75 ft
Feb 8, 2018	1.39 ft	60 ft
Jun 14, 2018	0.22 ft	77 ft
Jul 9, 2020	1.41 ft	46 ft
Apr 29, 2020	1.56 ft	62 ft
Jun 29, 2020	0.74 ft	69 ft
Dec 22, 2020	Not recorded	70 ft
Average		49.3 ft

PIC 3 appears fairly stable. This section of shoreline may have received some beach nourishment in the past. The wrackline ranges from 45 ft to 50 ft. The elevation difference from the headstake to the farthest top of toe is around 9 ft.

Hopwood Beach

Trend: Stable

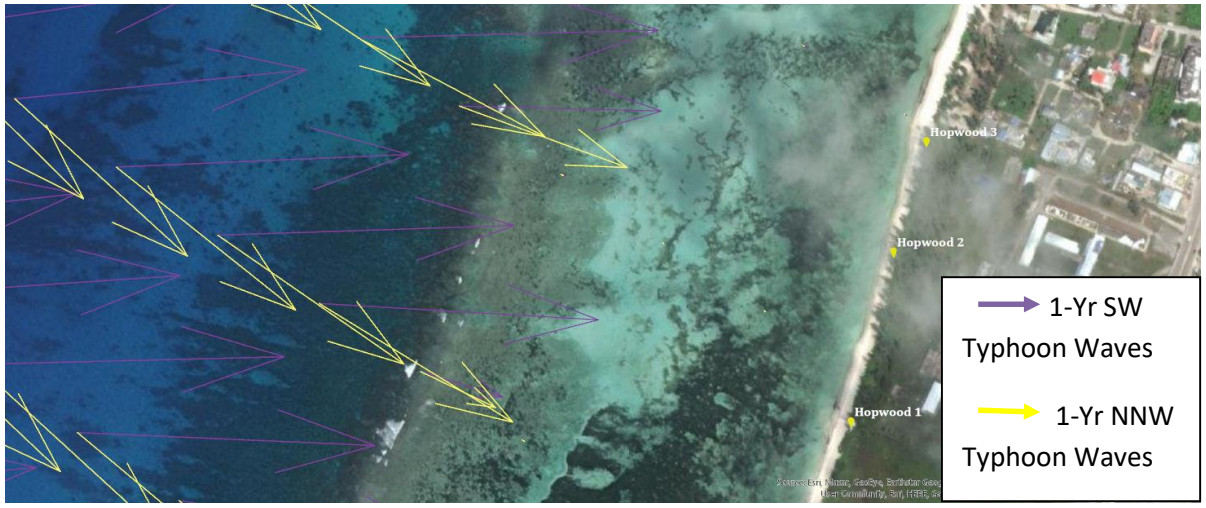
EPHR: N/A

Average length: 46.3 ft

Average elevation: 6 ft

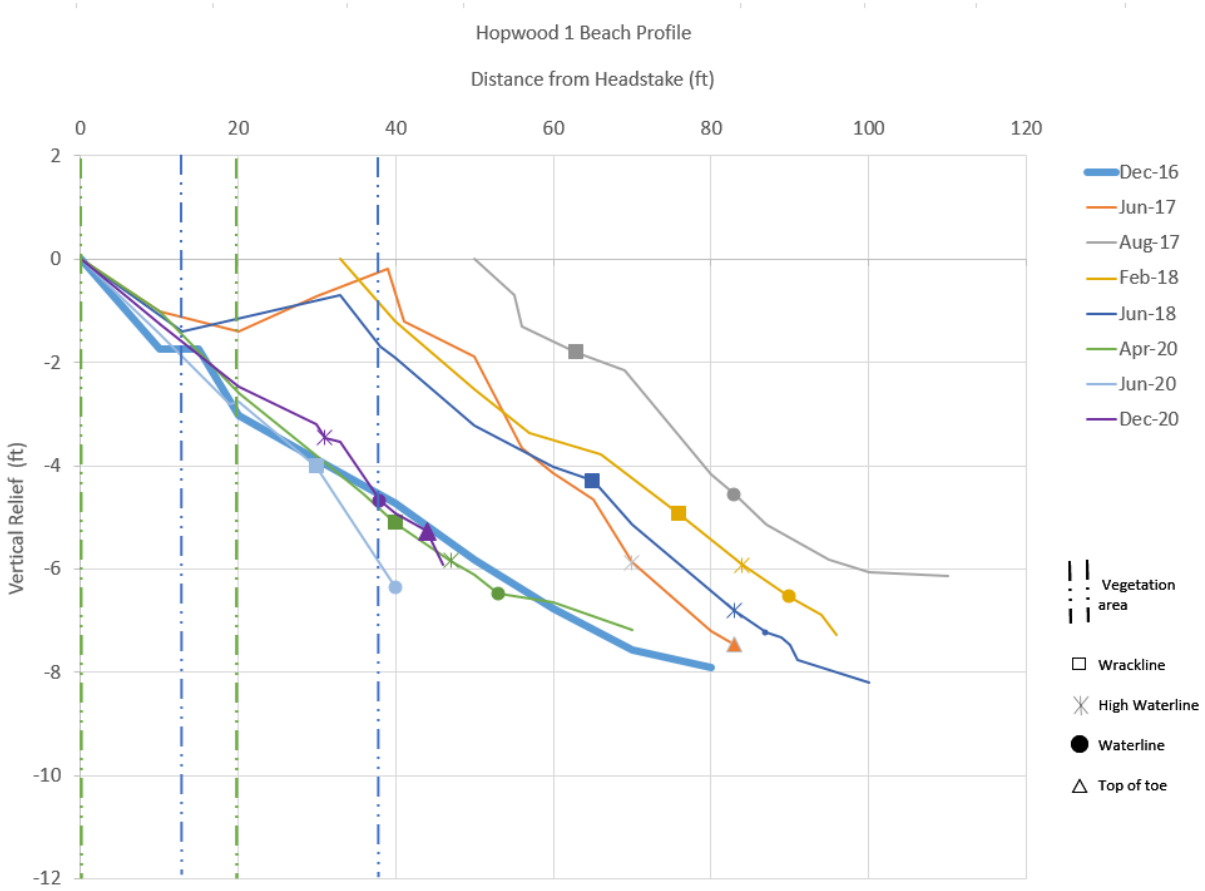
Hopwood 1 (2018)

Hopwood 1 (2020)



Adjacent to the Chalan Kanoa reef at a distance of approximately 500 meters, the Hopwood shoreline is subjected to 100-year flood and additional velocity hazard (wave action). An account from a resident suggests that this shoreline has experienced accretion since the mid-1900s; therefore, the vegetation and sand in this area may be several decades old. Shoreline is susceptible to incidental erosion, in which the beach profile may be restored after erosion generated from an extreme storm event. The vegetation line may act like a buffer for the adjacent school buildings during the storm surges. The backshore vegetation is dynamic in nature, making this area difficult for locating headstakes, increasing the likelihood of error. Wave overtopping and overwhelmed tidal flows from the channel down south may impact this site during both typhoon wave conditions. It appears that southwest conditions could greatly impact this site. Under southwest conditions, longshore could potentially be going from south to north while north-northwest conditions indicate the opposite.

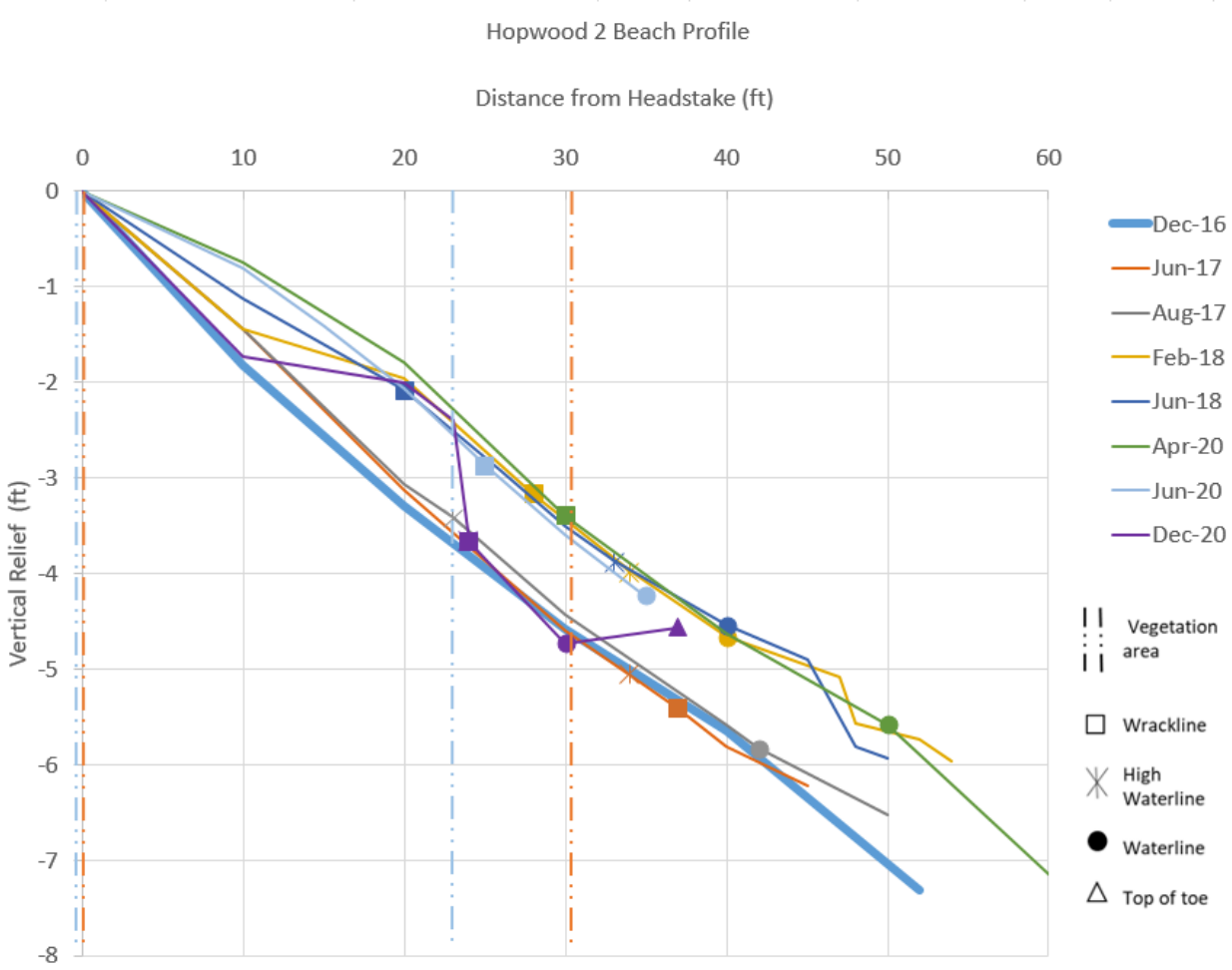
Hopwood 1



Day Recorded	Tide	Shoreline Length
Dec 13, 2016	1.06 ft	80 ft
Jun 19, 2017	0.99 ft	70 ft
Aug 21, 2017	0.84 ft	83 ft
Feb 13, 2018	1.33 ft	90 ft
Jun 15, 2018	1.42 ft	83 ft
Apr 22, 2020	0.66 ft	53 ft
Jun 26, 2020	1.67 ft	40 ft
Dec 15, 2020	0.9 ft	38 ft
Average		67.1 ft

Hopwood 1 appears eroding and has changed dramatically over the years. The wrackline ranges from 30 ft to 76 ft. Through observation, it is speculated that storm surges from powerful storms may influence the shoreline vegetation dynamics. Thus, locating the headstake, which is a tree, increases the likelihood of error. The elevation distance from the headstake to the furthest top of toe is 7 ft.

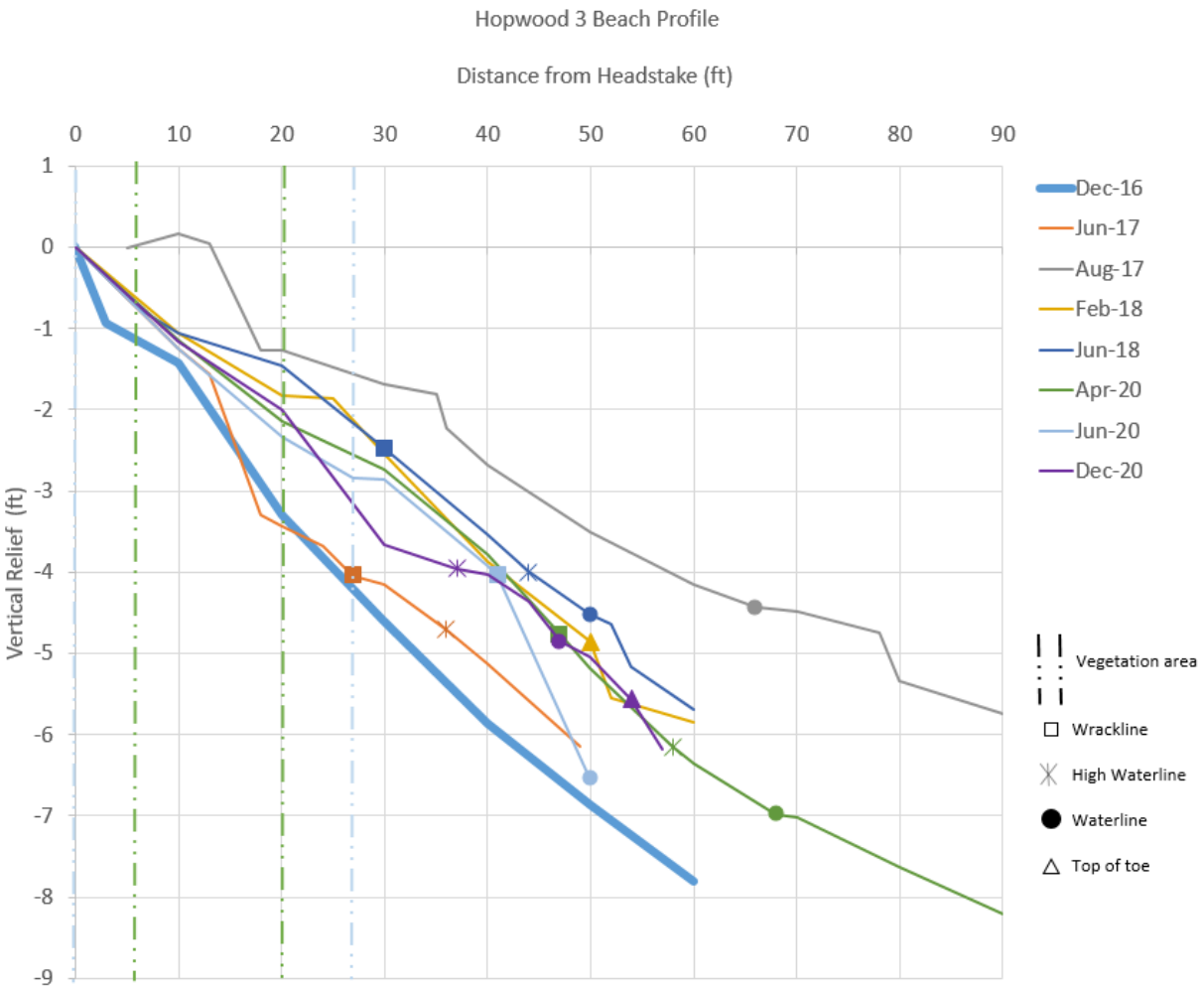
Hopwood 2



Day Recorded	Tide	Shoreline Length
Dec 13, 2016	1.17 ft	Not recorded
Jun 19, 2017	1.06 ft	34 ft
Aug 21, 2017	0.7 ft	23 ft
Feb 13, 2018	1.41 ft	40 ft
Jun 15, 2018	0.86 ft	40 ft
Apr 22, 2020	0.55 ft	50 ft
Jun 26, 2020	1.64 ft	35 ft
Dec 15, 2020	1.09 ft	30 ft
Average		36 ft

Hopwood 2 is undetermined given the misidentification of the headstake. Dec-16 through Aug-17 was the initial headstake until it went undetected after a storm event. Dec 2020 record is an outlier from surveyor error. The wrackline ranges from 20 ft to 37 ft. The high proximity to the headstake (tree line) poses sea level rise concerns. The elevation difference from the headstake to the furthest top of toe is around 5 ft.

Hopwood 3



Day Recorded	Tide	Shoreline Length
Dec 13, 2016	1.0 ft	Not recorded
Jun 19, 2017	1.13 ft	36 ft
Aug 21, 2017	0.6 ft	66 ft
Feb 13, 2018	1.47ft	Not recorded
Jun 15, 2018	1.68 ft	50 ft
Apr 22, 2020	0.39 ft	68 ft
Jun 26, 2020	1.58 ft	50 ft
Dec 15, 2020	1.25 ft	47 ft
Average		36 ft

Hopwood 3 appears to be dynamic so its status is undetermined. Its proximity to an outflow may also contribute to the variation of this shoreline. The wrackline ranges from 27 ft to 47 ft. The elevation difference from the headstake to the top of the toe is 7 ft.

Aquarius Beach

Trend: Accreting

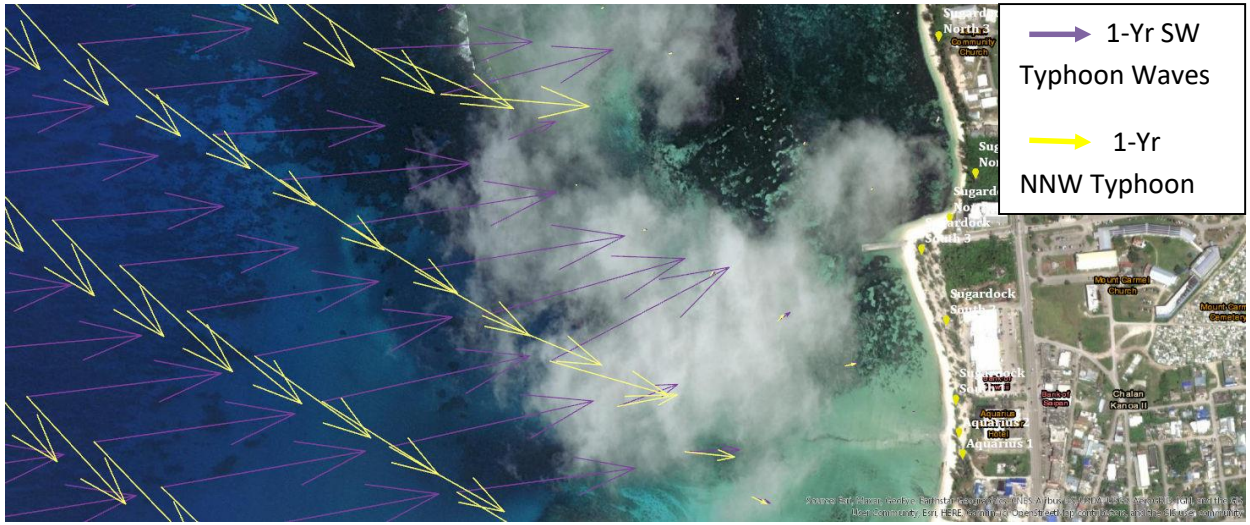
EPHR: N/A

Average length: 77.2 ft

Average elevation: 9 ft

Aquarius 2 (2017)

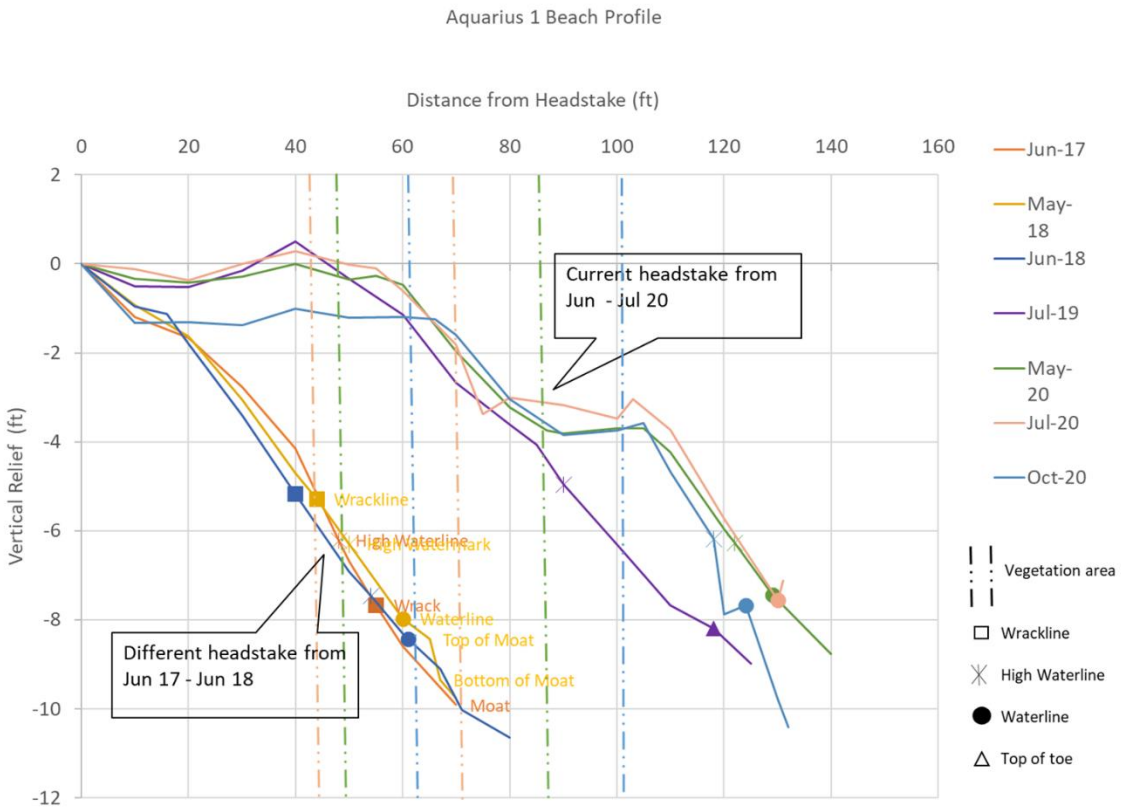
Aquarius 2 (2020)



Aquarius is parallel to the Chalan Kanoa channel, which greatly influences the flow in and out of the southern lagoon. This shoreline appears to be accreting, yet vehicular access of the berm has compacted the sandy backshore. A few years ago, there was beach nourishment that occurred.

Future data and observations may improve understanding of this on-going trend. Wave overtopping and overwhelmed tidal flows from the channel down south may impact this site during both typhoon wave conditions. It appears that southwest conditions could greatly impact this site. Under southwest conditions, longshore could potentially be going from south to north while north-northwest conditions indicate the opposite. Improvements to nearshore dynamics could explain the source of the accretion.

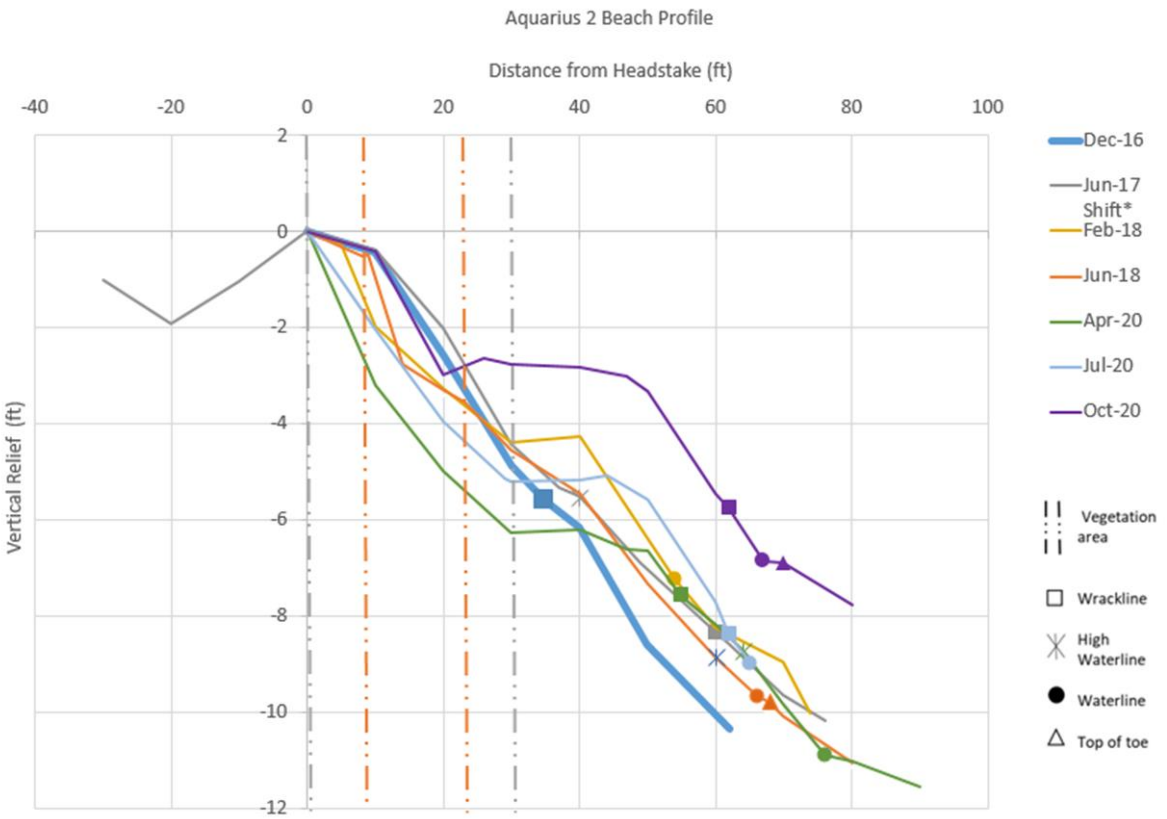
Aquarius 1



Day Recorded	Tide	Shoreline Length
Dec 19, 2016	1.86 ft	Not recorded
Jun 20, 2017	0.6 ft	48 ft
Feb 15, 2018	1.65 ft	80 ft
May 8, 2018	1.36 ft	60 ft
Jun 15, 2018	1.05 ft	61 ft
Jul 9, 2019	1.02 ft	90 ft
May 15, 2020	0.98 ft	129 ft
Jul 1, 2020	0.58 ft	131 ft
Oct 21, 2020	1.5 ft	124 ft
Average		90.4 ft

Aquarius 1 is undetermined. This transect has a history of two different headstakes. The first one, surveyed from Jun 2017 – Jun 2018, is parallel to the most recent headstake but closer to the waterline. The most recent headstake was pushed more inland. The current headstake appears to be accreting and gaining some height at the berms until Oct 2020. Oct-20 is an outlier. The wrackline has not been observed at the current headstake. However, this shoreline is long with a two berms. The distance from the headstake to the furthest top of toe is around a little bit past 8 ft.

Aquarius 2



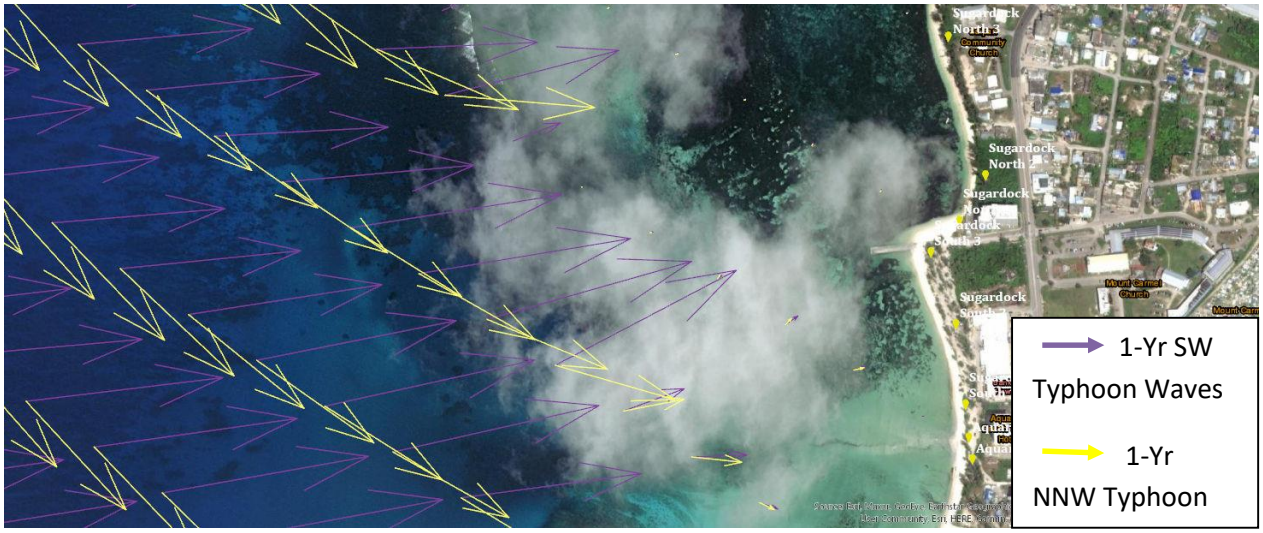
Day Recorded	Tide	Shoreline Length
Dec 19, 2016	1.67 ft	35 ft
Jun 20, 2017	0.38 ft	79 ft
Feb 15, 2018	1.54 ft	54 ft
Jun 15, 2018	1.0 ft	66 ft
Apr 22, 2020	0.43 ft	76 ft
Jul 1, 2020	0.67 ft	65 ft
Oct 21, 2020	1.38 ft	67 ft
Average		63.9 ft

Aquarius 2 appears to be accreting since July 2020. Erosion occurred from 2016 to April 2020. The wrackline ranges from 35 to 92 ft for the current headstake. This wide range may be due to the accretion of this previously eroding shoreline. The elevation distance from the headstake to the furthest top of toe is 10 ft.

Sugar Dock Beach

Sugar Dock South 3 (2018)

Sugar Dock South 3 (2019)



Trend: Variable

EPHR: High

Average length

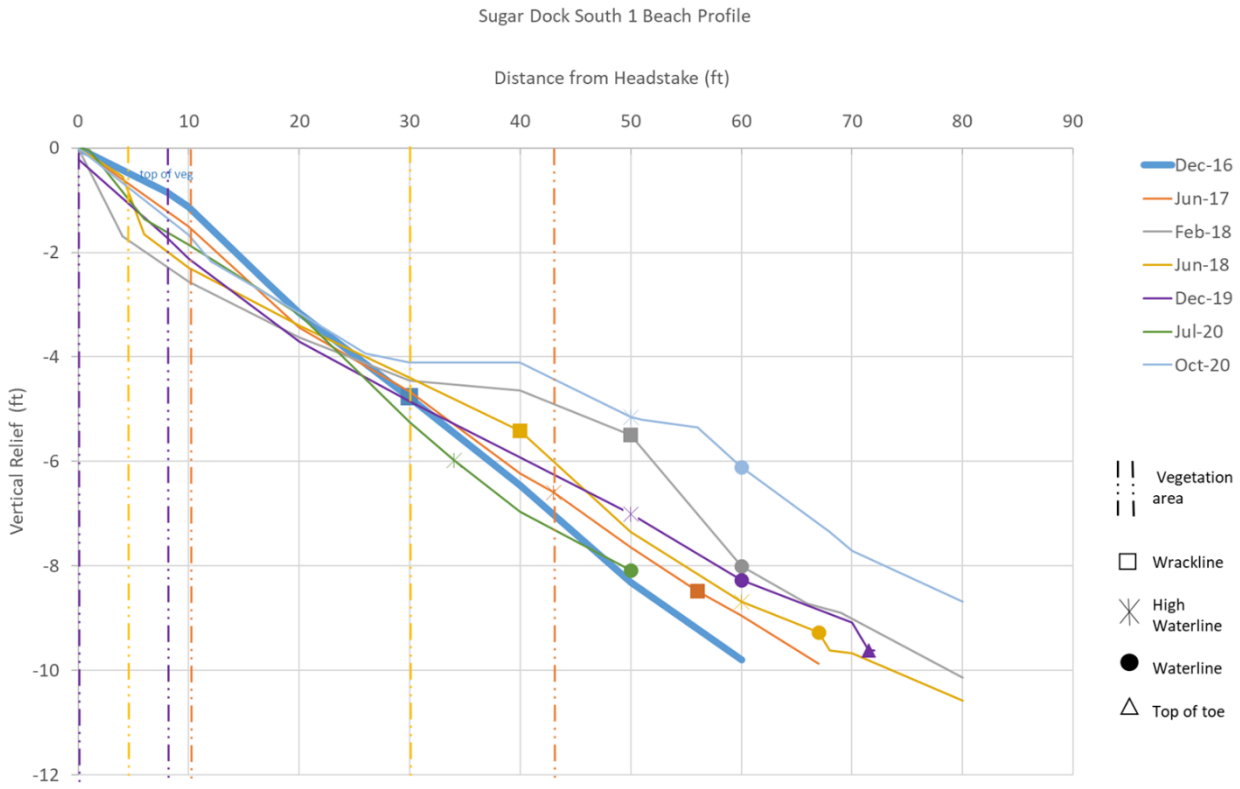
South: 63.2 ft

North: 62.8 ft

Average elevation: 9.33 ft

Parallel to the Chalan Kanoa Reef, Sugar Dock shoreline is generally eroding. The Chalan Kanoa Channel is adjacent to the southern portion. Obstruction of sediment transport from the dock infrastructure is the largest anthropogenic influence. The accumulation on the northern side of the dock poses a public access issue for boaters since the water depth is not enough to unload (see pg 46). The northern transects have less of a berm. Critical infrastructure, such as Saipan Community School and Church, are located on the backshore. Wave overtopping and overwhelmed tidal flows from the channel down south may impact this site during both typhoon wave conditions. It appears that southwest conditions could greatly impact this site. Under southwest conditions, longshore could potentially be going from south to north while north-northwest conditions indicate the opposite.

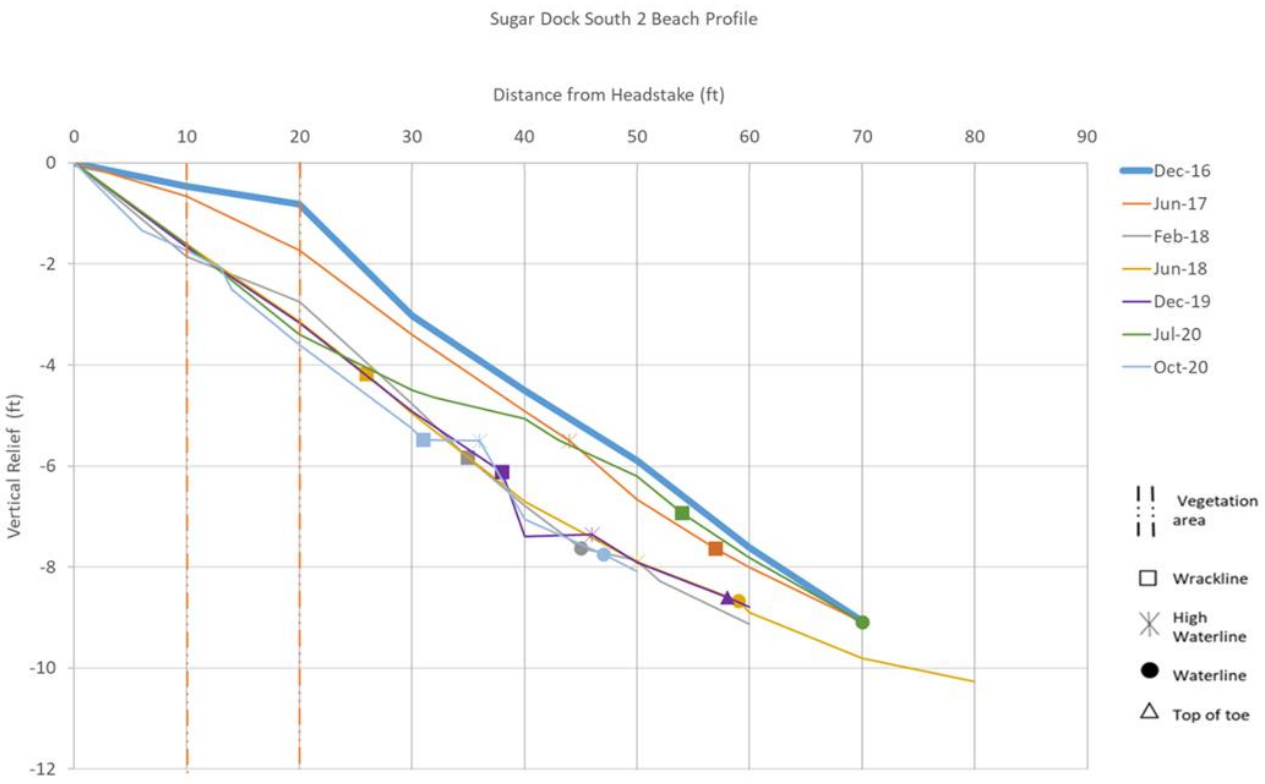
Sugar Dock South 1



Day Recorded	Tide	Shoreline Length
Dec 19, 2016	1.6	Not recorded
June 2, 2017	1.01	43 ft
Feb 22, 2018	1.36	60 ft
Jun 15, 2018	0.7	67 ft
Dec 26, 2019	1.27	60 ft
Jul 14, 2020	0.77	50 ft
Oct 21, 2020	1.27	60 ft
Average		56.7 ft

Sugar Dock 1 appears dynamic so its status is undetermined. Accretion occurred from Dec 2016 to Feb 2018. After then, it was losing the berm accumulated in Feb 2018. Then it appears to fluctuate from December 2019 through October 2020. This may suggest erosion and accretion processes (sediment deposition) both occur in this area. The wrackline ranges from 30 to 56 ft. The elevation difference from the headstake to the furthest toe is around 9 ft.

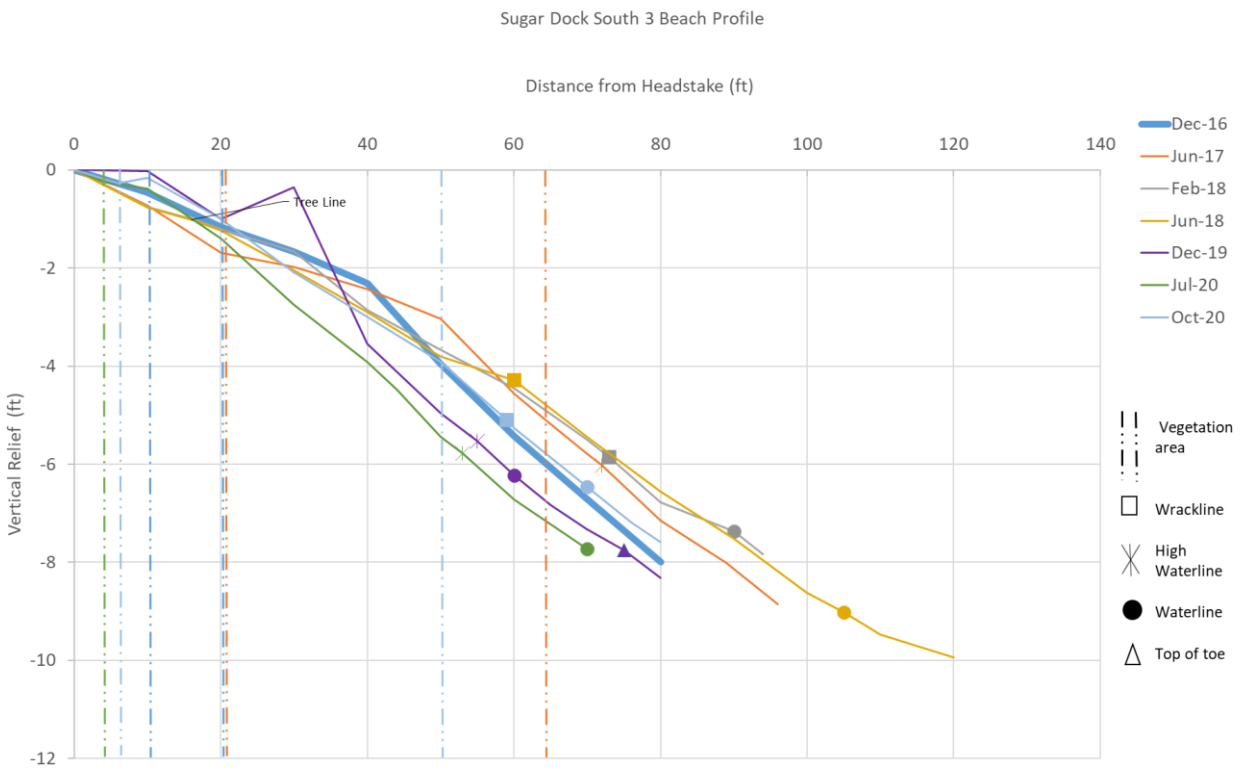
Sugar Dock South 2



Day Recorded	Tide	Shoreline Length
Dec 19, 2016	1.45 ft	Not recorded
June 20, 2017	0.23 ft	44 ft
Feb 22, 2018	1.39 ft	45 ft
Jun 15, 2018	0.45 ft	59 ft
Dec 26, 2019	1.35 ft	46 ft
Jul 20, 2020	0.85 ft	70 ft
Oct 21, 2020	1.14 ft	47 ft
Average		51.8 ft

Sugar Dock South 2 is eroding. The berm has completely worn away, so the headstake (tree) is right when the slope begins to steadily drop into the waterline. Vehicle compaction regularly occurs here and may be another physical factor to the smoothening of this shoreline. The wrackline ranges from 26 to 57 ft. The elevation difference from the headstake to the furthest top of toe is around 10 ft.

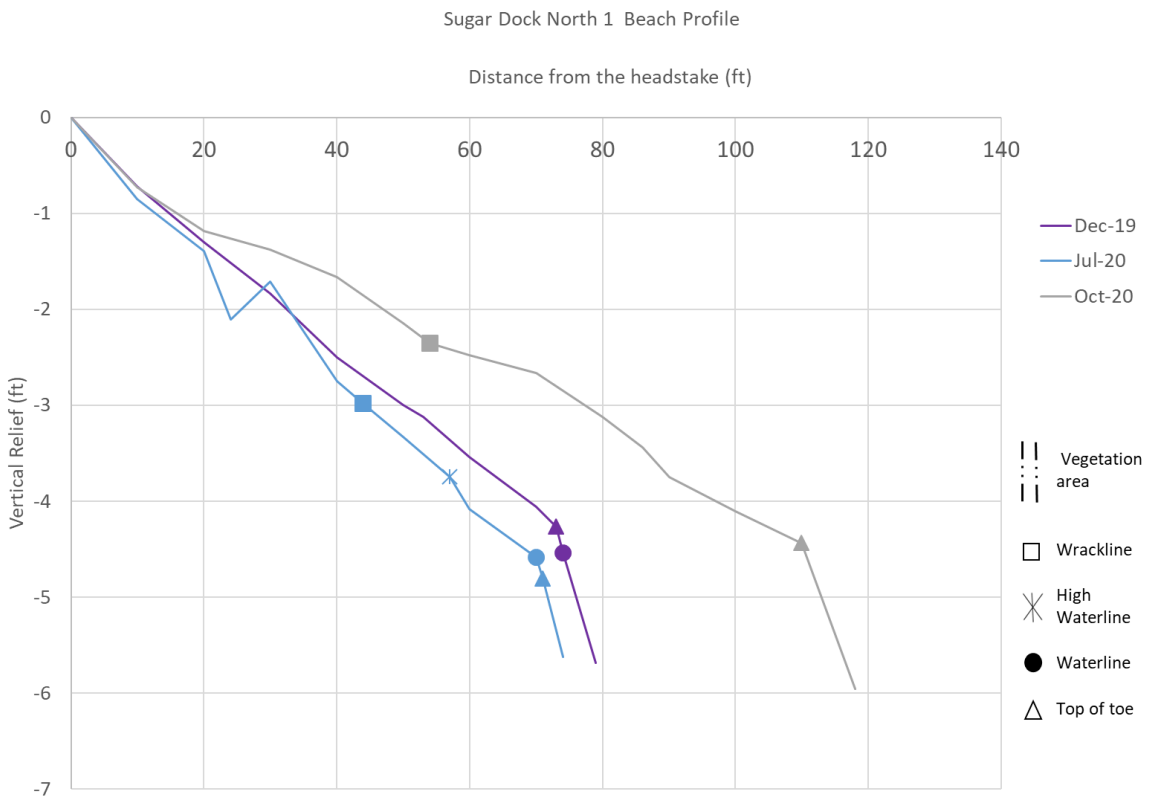
Sugar Dock South 3



Day Recorded	Tide	Shoreline Length
Dec 15, 2016	1.23 ft	Not recorded
June 20, 2017	0.28 ft	89 ft
Feb 22, 2018	1.5 ft	90 ft
Jun 15, 2018	0.33 ft	105 ft
Dec 26, 2019	1.44 ft	60 ft
Jul 14, 2020	0.83 ft	70 ft
Oct 21, 2020	0.92 ft	70 ft
Average		80.7 ft

Sugar Dock South 3 is generally eroding. The shoreline is generally getting deeper, until some naturally sediment accumulated on Oct 2020. This sediment input suggests the occurrence of sediment deposition at this area. The wrackline ranges from 59 to 89 ft. The elevation difference is from the headstake to the furthest top of toe is around 9 ft.

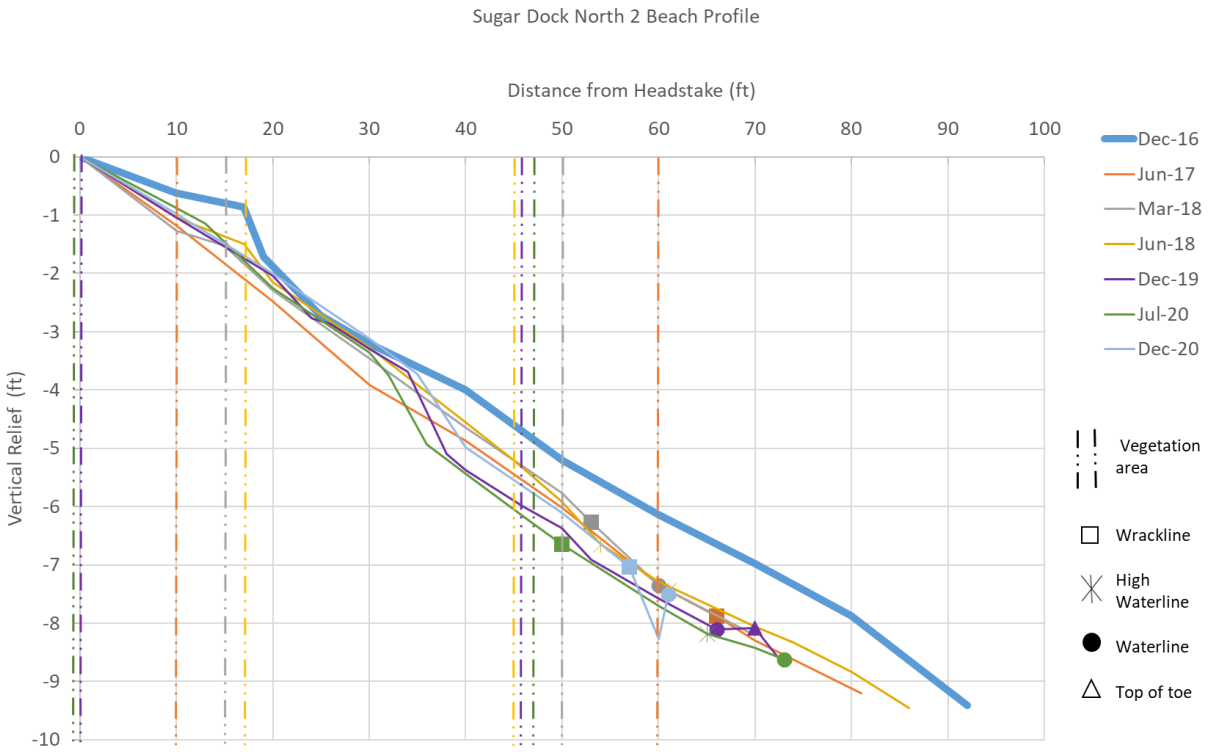
Sugar Dock North 1



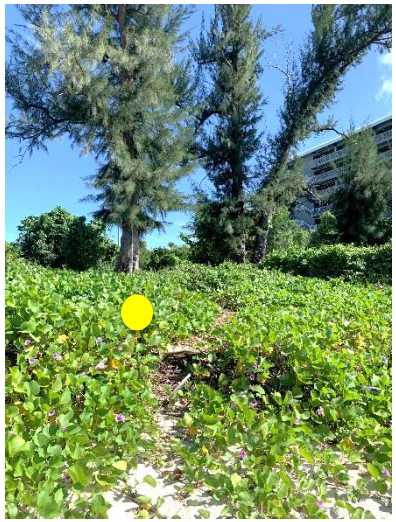
Day Recorded	Tide	Shoreline Length
Dec 27, 2019	1.32	74 ft
Jul 14, 2020	0.72	70 ft
Oct 21, 2020	1.63	Not recorded
Average		72 ft

Sugar Dock North 1 has been included into monitoring due to the residential building in close proximity. The wrackline is more of interest to planning purposes get the distance from the headstake (seawall of the residential building). High surveyor error is evident in this transect especially due to the curvature of the sand accumulation. Improved, precise transect laying will be integrated to better capture this tide-dependent shoreline. Blockage of the Sugar Dock structure has caused this area to accrete. Future dredging to recover proper function of the boating ramp will greatly reduce this shoreline profile. Wrackline ranges from 44 to 54 ft. The elevation difference is from the headstake to the furthest top of toe is around 4.5 ft.

Sugar Dock North 2

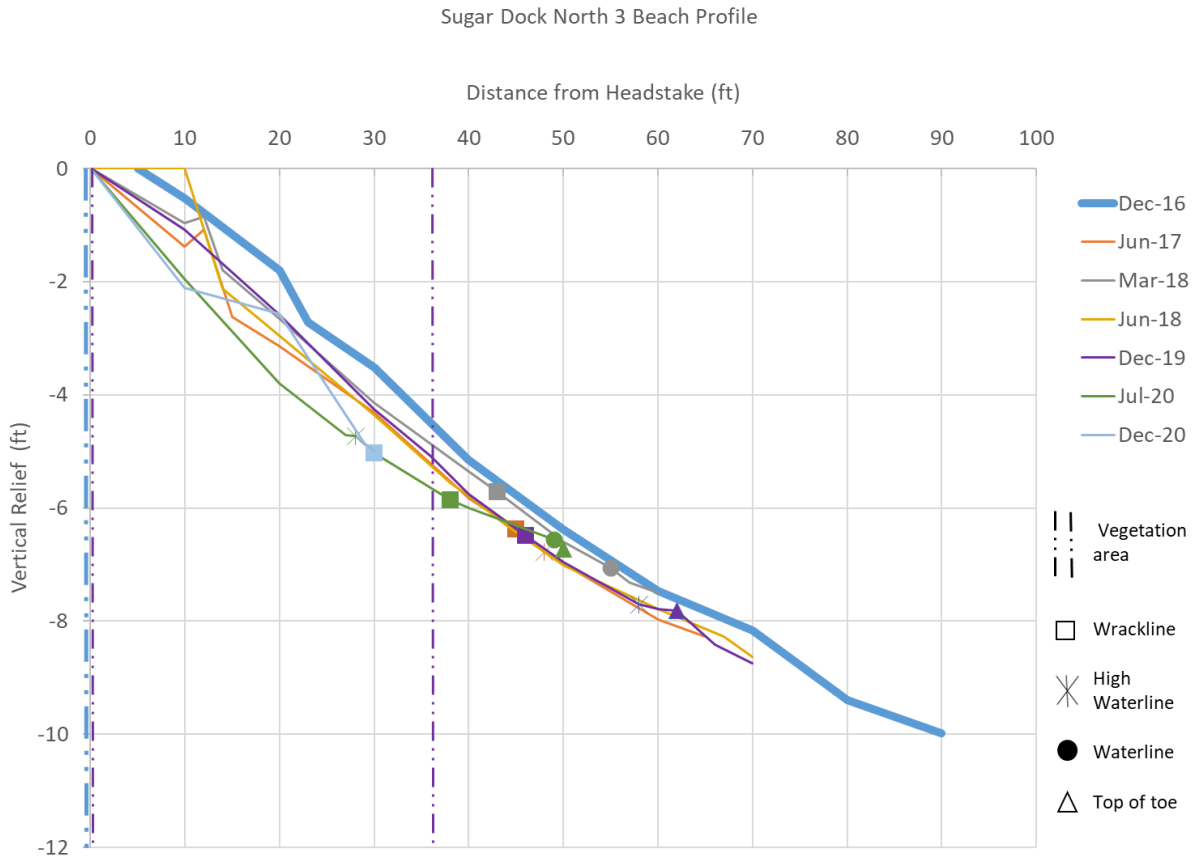


Day Recorded	Tide	Shoreline Length
Dec 14, 2016	1.5	Not recorded
Jun 20, 2017	0.7	66 ft
Mar 1, 2018	1.75	60 ft
Jun 21, 2018	0.77	54 ft
Dec 31, 2019	1.6	66 ft
Jul 14, 2020	0.66	73 ft
Dec 30, 2020	1.8	61 ft
Average		63.3 ft



Sugar Dock North 2 is generally eroding. A development of the berm indicates abrasion at around 35 feet from the headstake. The wrackline ranges from 50 to 66 ft. The elevation distance from the headstake to the furthest top of toe is around 8 ft.

Sugar Dock North 3



Day Recorded	Tide	Shoreline Length
Dec 15, 2016	1.12	Not recorded
Jun 20, 2017	0.76	48 ft
Mar 1, 2018	1.69	55 ft
Jun 21, 2018	0.76	Not recorded
Dec 31, 2019	1.54	58 ft
Jul 14, 2020	0.78	49 ft
Dec 30, 2020	1.7	Not recorded
Average		52.5 ft

Sugar Dock North 3 is eroding. The shoreline is getting steeper. The wrackline ranges from 30 ft to 46 ft. The elevation difference from the headstake to the furthest top of toe is 8 ft.

Susupe Beach Park Beach

Trend: Variable

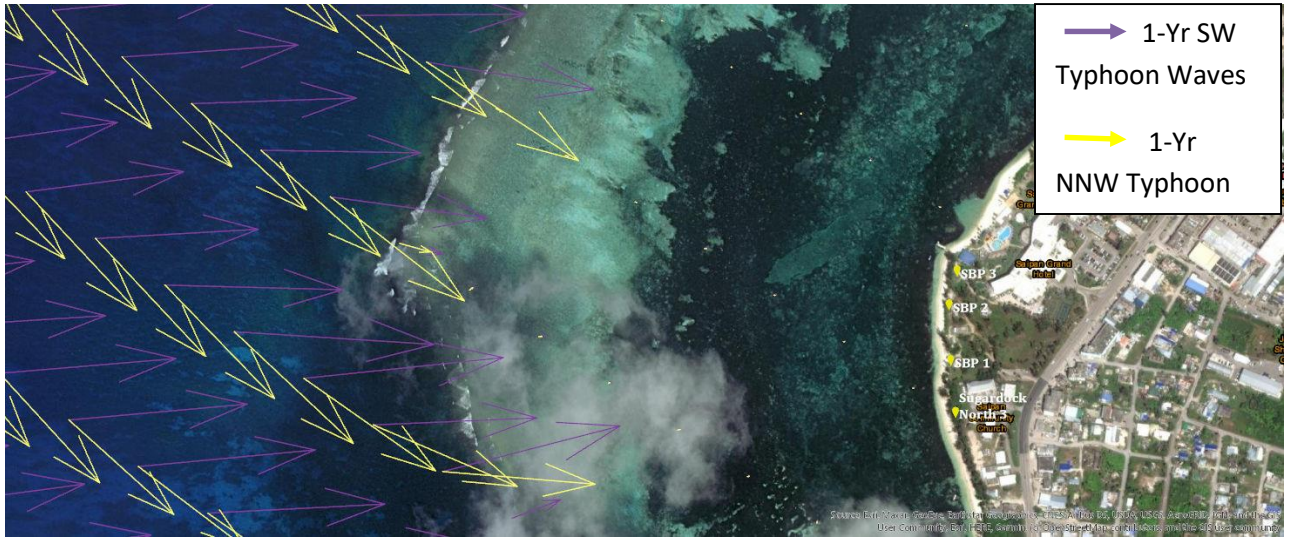
EPHR: High

Average length: 57.9 ft

Average elevation: 7.7 ft

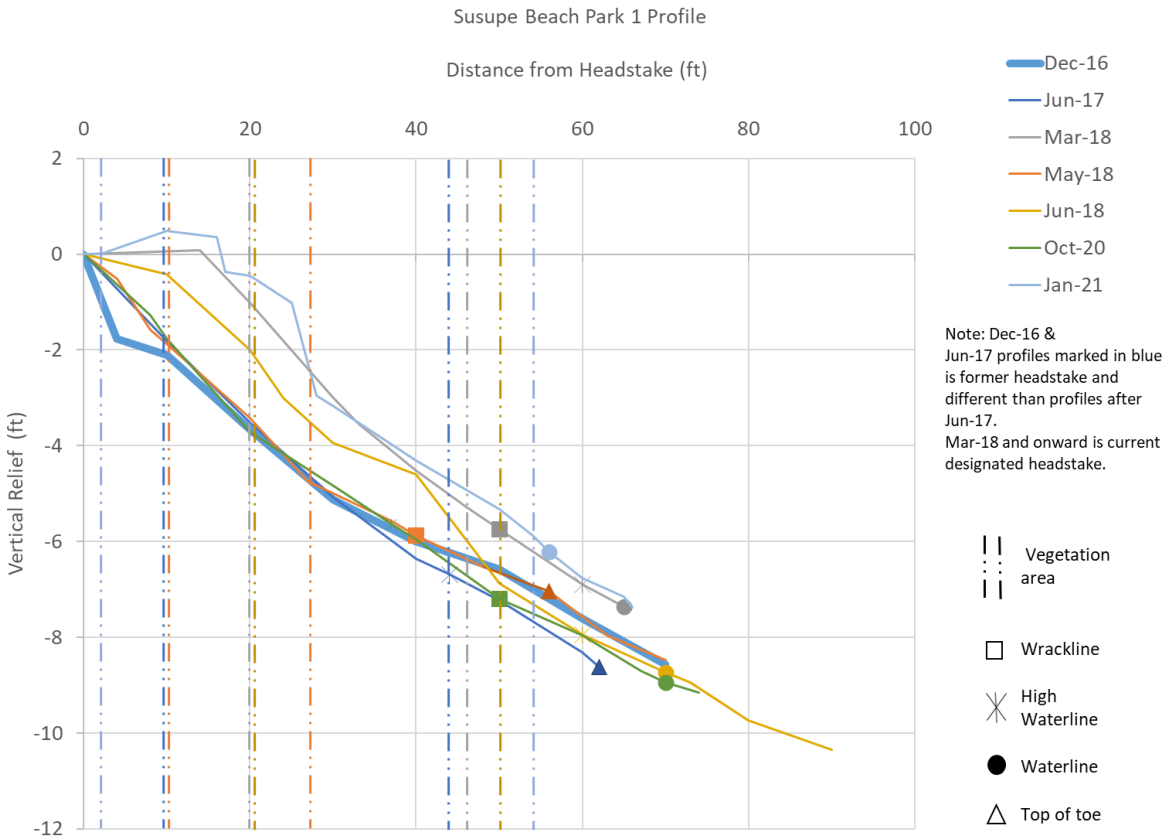
Susupe Beach Park 1 (2018)

Susupe Beach Park 1 (2020)



Nearly 800 meters away from the sheltering Chalan Kanoa Reef, Susupe Beach Park is relatively stable but may be prone to sea level rise. Backshore vegetation remains relatively stable and the ironwood trees appears to be thriving. Most of the foreshore environment is vegetated. Previous account from the Saipan's Misbehaving Beaches Story Map (2014) found that this piece of shoreline experienced vegetation loss from wave run-up observed that year. During this reporting period, access to the shoreline was limited due to the closure of the beach park due to its proximity to a COVID-19 quarantine site. Thus, only two rounds of data collection were pursued for this site this period. Wave overtopping and overwhelmed tidal flows may impact this site during both typhoon wave conditions. It appears that southwest conditions could greatly impact this site. However, improved resolution on nearshore dynamics may explain longshore processes for this area.

Susupe Beach Park – 1



Day Recorded	Tide	Shoreline Length
Dec 14, 2016	1.35 ft	Not recorded
Jun 20, 2017	0.48 ft	Not recorded
Mar 1, 2017	1.01 ft	65 ft
May 8, 2018	ft	48 ft
Jun 21, 2018	0.76 ft	73 ft
Oct 1, 2020	1.32 ft	70 ft
Jan 29, 2021	1.9 ft	66 ft
Average		64.4 ft

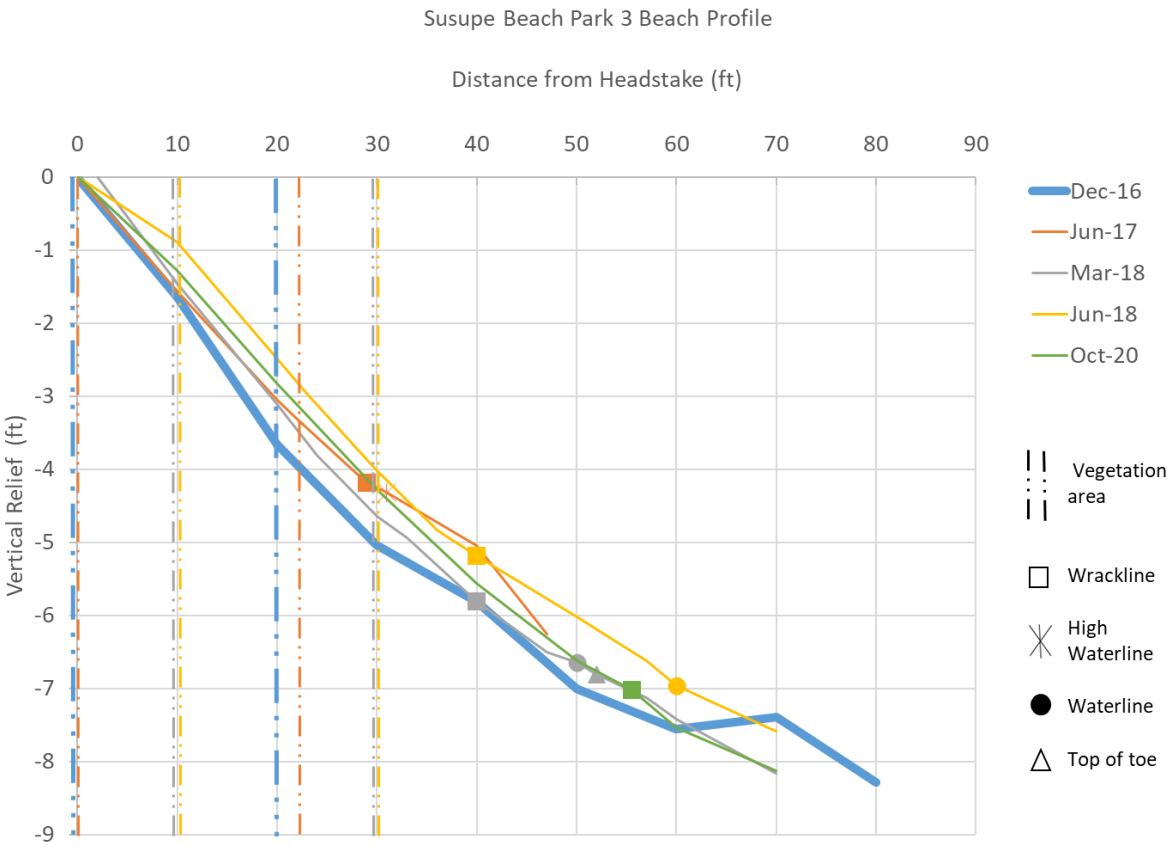
Susupe Beach Park 1 has undetermined status. Mar-18 and Jun-18 are outliers. Misidentification of the headstake may have occurred in Oct-20 and used the down slope yellow-marked tree. The wrackline ranges from 40 ft to 52 ft. The elevation difference from the headstake to the furthest top of toe is around 8 ft.

Susupe Beach Park – 2

Day Recorded	Tide	Shoreline Length
Dec 14, 2016	1.23 ft	Not recorded
Jun 20, 2017	0.6 ft	58 ft
May 8, 2018	0.8 ft	55 ft
Jun 21, 2018	1.02 ft	70 ft
Oct 3, 2020	Not recorded	76 ft
Jan 29, 2021	1.85 ft	56 ft
Average		63 ft

Susupe Beach Park 2 is relatively stable. Slight variation on the berm could be from surveyor error. The wrackline ranges from 47 ft to 70 ft. The elevation difference from the headstake to the furthest top of toe is around 8 ft.

Susupe Beach Park – 3



Day Recorded	Tide	Shoreline Length
Dec 14, 2016	1.14 ft	Not recorded
Jun 20, 2017	0.7 ft	31 ft
Mar 1, 2017	0.62 ft	47 ft
Jun 21, 2018	1.1 ft	57 ft
Oct 3, 2020	Not recorded	50 ft
Average		46.3 ft

Susupe Beach Park 3 is relatively stable. Slight variation on the berm could be from surveyor error. The wrackline ranges from 29 ft to 50 ft. The elevation difference from the headstake to the furthest top of toe is around 7 ft.

Kilili Beach

Trend: North accreting, South relatively stable

EPHR: Medium

Average length:

South: 53.7 ft

North: 73.5 ft

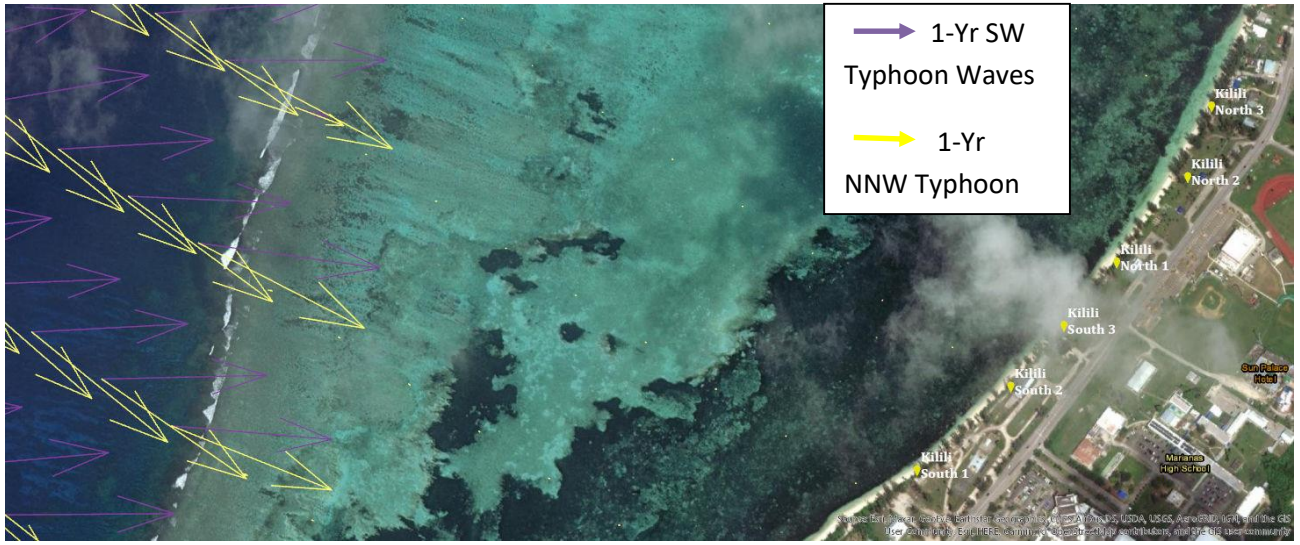
Average elevation:

South: 7.3 ft

North: 9.33 ft

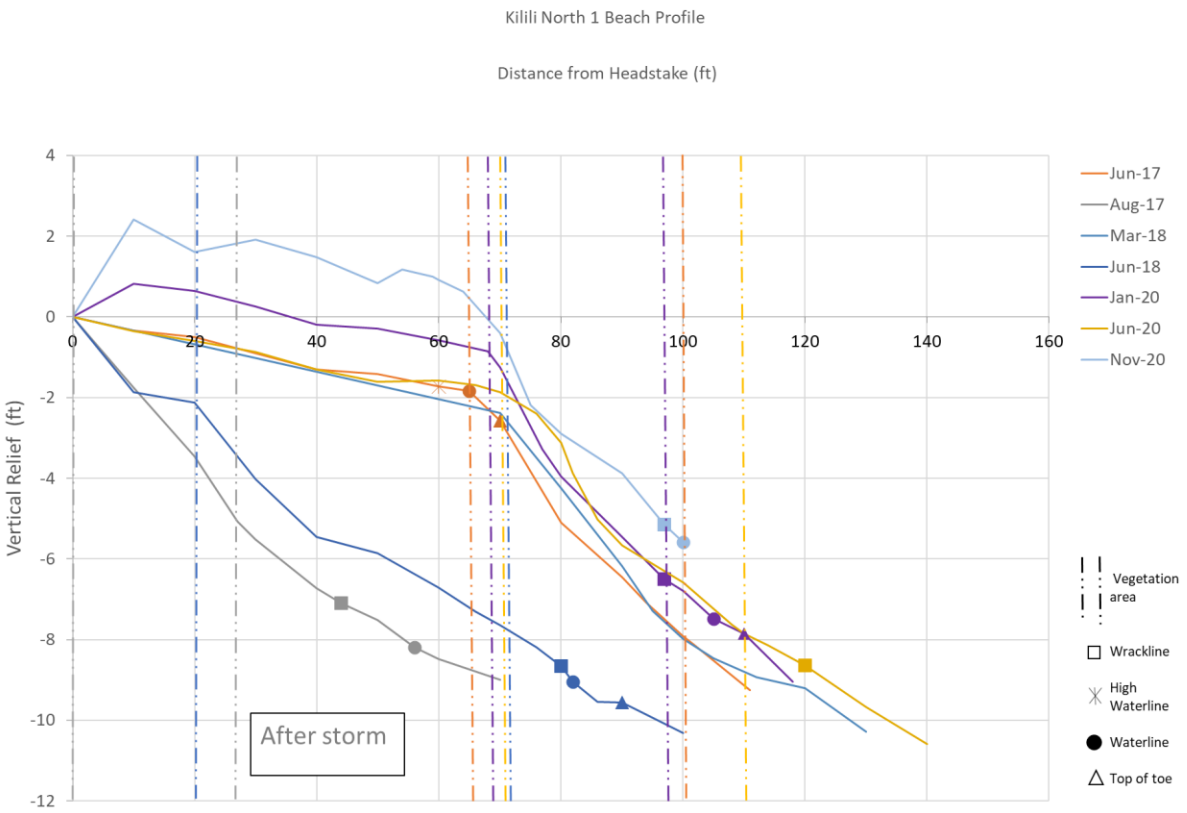
Kilili Beach South 2 (2018)

Kilili Beach South 2 (2020)



Kilili Beach is sheltered by the fringing reef, which is around 4,500 ft away. North side is accreting while the south side is relatively stable with the exception of Kilili South 1. In the beginning, it experienced erosion until it started stabilizing then accreting in 2019. An account from a cultural practitioner using this shoreline implies that this stretch of beach is at risk of storm surge during powerful storm events. It appears that southwest conditions could greatly impact this site. However, improved resolution on nearshore dynamics may explain longshore processes for this area.

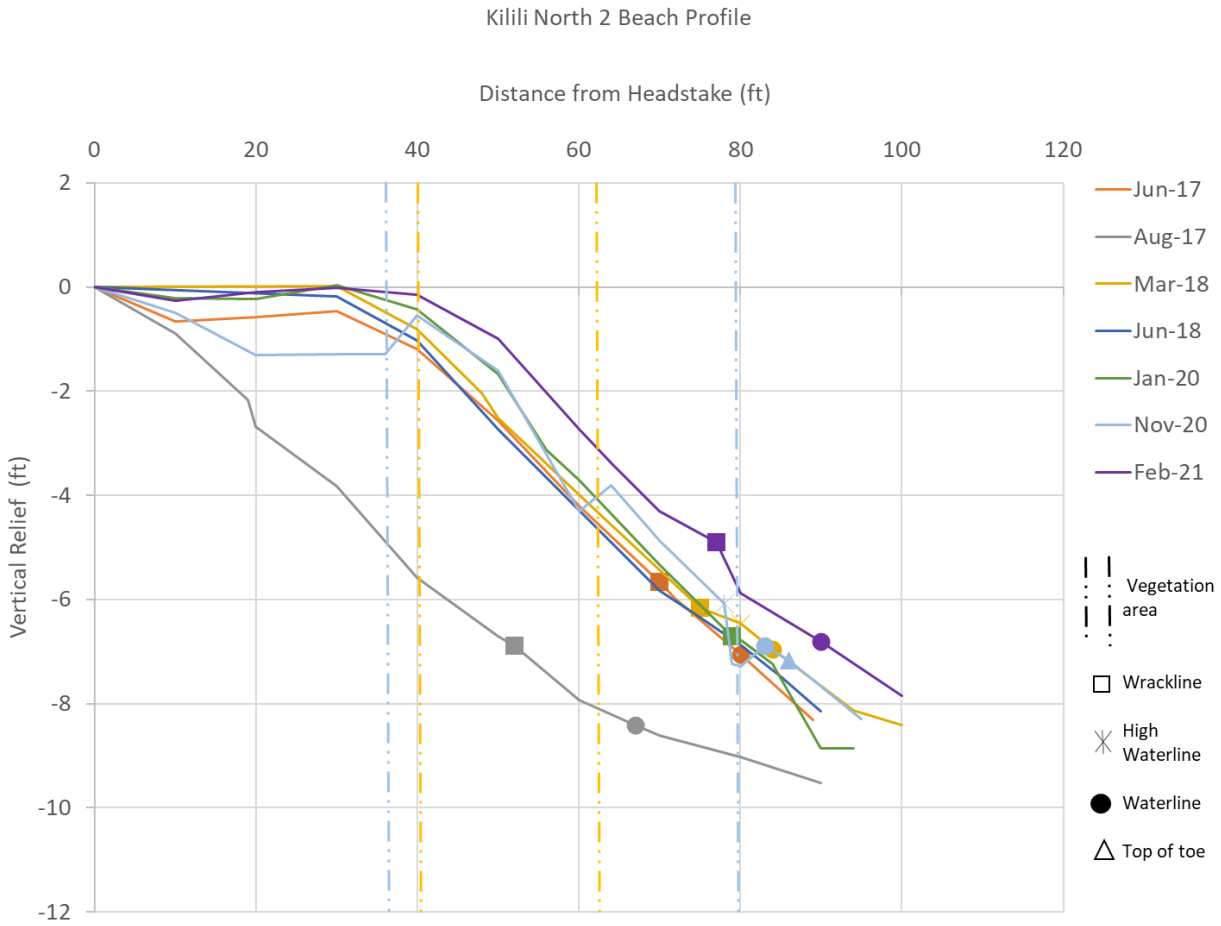
Kilili – North 1



Day Recorded	Tide	Shoreline Length
Jan 20, 2017	1.12 ft	60 ft
Jun 26, 2017	0.76 ft	102 ft
Aug 21, 2017	1.69 ft	56 ft
Mar 8, 2018	0.76 ft	112 ft
May 4, 2018	1.54 ft	Not recorded
Jun 21, 2018	0.78 ft	82 ft
Jan 13, 2020	1.82 ft	105 ft
Jun 23, 2020	0.37 ft	Not recorded
Nov 18, 2020	1.84 ft	100 ft
Average		88.1 ft

Kilili North 1 appears to be accreting. From Jun 2017, a significant volume of sediment accumulated over the years. Nov-20 seems to be an outlier based by surveyer error. The wrackline ranges from 44 to 120 ft based on this record history. The elevation difference from the headstake to the furthest top of toe is around 10 ft.

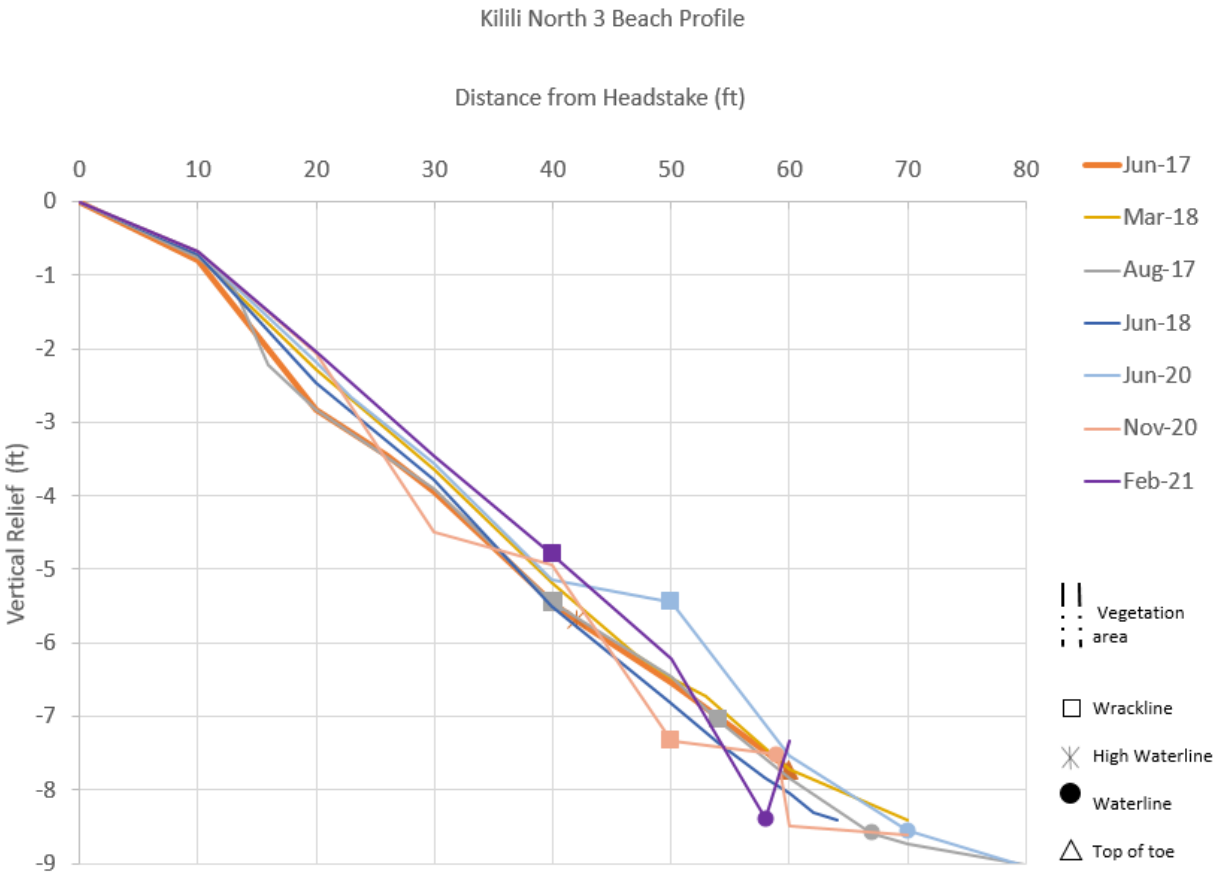
Kilili – North 2



Day Recorded	Tide	Shoreline Length
Jan 20, 2017	1.19 ft	50 ft
Jun 26, 2017	1.17 ft	72 ft
Aug 21, 2017	-0.17 ft	67 ft
Mar 8, 2018	1.66 ft	84 ft
May 4, 2018	1.3 ft	56 ft
Jun 21, 2018	1.82 ft	Not recorded
Jan 13, 2020	1.88 ft	79 ft
Jun 23, 2020	-0.18 ft	123 ft
Nov 18, 2020	1.61 ft	83 ft
Feb 22, 2021	1.33 ft	90 ft
Average		76.8 ft

Kilili North 2 is generally stable. There are discrepancies in the data caused by surveyor error. Given that the headstake is further inland, this profile is expected to be longer and indicates an estimation of the proximity to the high tide line, or wrackline, is from the pavilions. Sea level rise may be concerning factor in the erosion of this shoreline. The wrackline ranges from 50 to 79 ft. The elevation difference from the headstake to the furthest top of toe is around 7 ft.

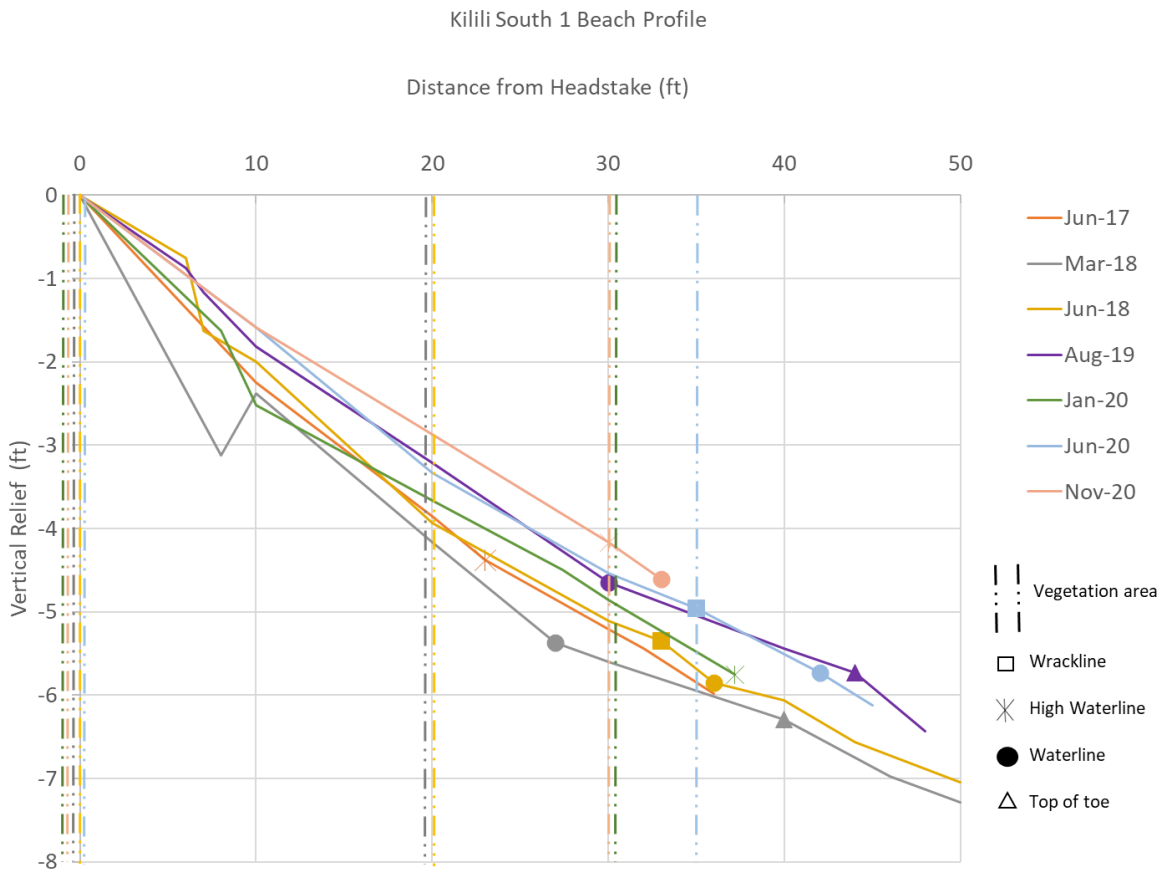
Kilili – North 3



Day Recorded	Tide	Shoreline Length
Jan 20, 2017	1.25 ft	50 ft
Jun 26, 2017	1.0 ft	42 ft
Aug 21, 2017	-0.27 ft	67 ft
Mar 8, 2018	1.44 ft	53 ft
May 21, 2018	1.37 ft	54 ft
Jan 13, 2020	1.71 ft	50 ft
Jun 23, 2020	0.01 ft	70 ft
Nov 18, 2020	1.45 ft	59 ft
Feb 22, 2021	1.35 ft	58 ft
Average		55.8 ft

Kilili North 3 appears to be stable. There are discrepancies in the data caused by surveyor error. The wrackline ranges from 40 ft to 56 ft. The elevation difference from headstake to top of toe is about 8 ft.

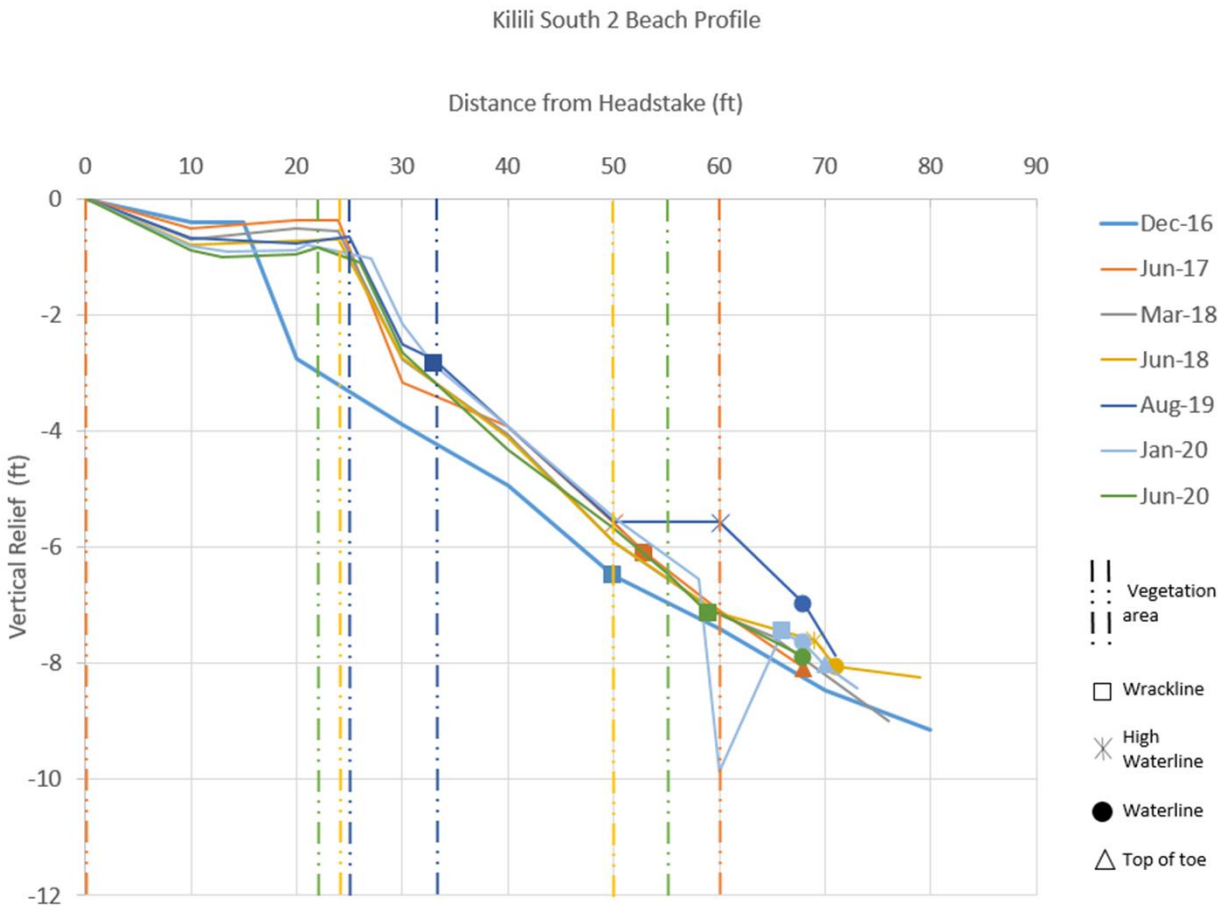
Kilili - South 1



Day Recorded	Tide	Shoreline Length
Dec 19, 2016	1.7 ft	50 ft
Jun 26, 2017	1.75 ft	42 ft
March 6, 2018	1.66 ft	67 ft
Jun 21, 2018	1.31 ft	53 ft
Aug 13, 2018	0.48 ft	54 ft
Jan 17, 2020	1.61 ft	50 ft
Jun 26, 2020	1.64 ft	79 ft
Nov 18, 2020	1.98 ft	33 ft
Average		33.7 ft

Killi South 1 appears to be accreting. A potential factor to this accretion is sediment pushed from the backshore due to foot traffic influence. The wrackline ranges from 23 ft to 40 ft. The elevation difference from the headstake to the furthest top of toe is around 6 ft.

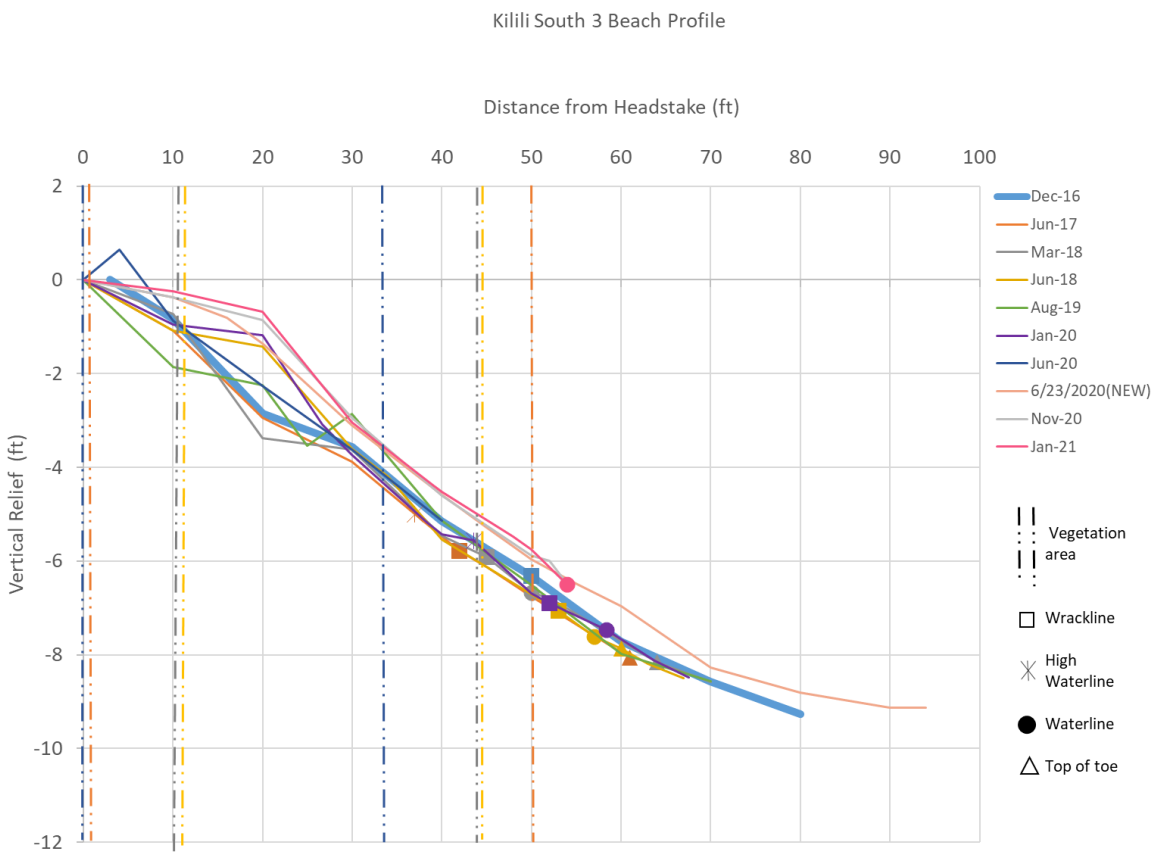
Kilili - South 2



Day Recorded	Tide	Shoreline Length
Dec 19, 2016	1.59 ft	50 ft
Jun 26, 2017	1.62 ft	42 ft
March 6, 2018	1.66 ft	67 ft
Jun 21, 2018	1.31 ft	53 ft
Aug 13, 2018	0.48 ft	54 ft
Jan 17, 2020	1.61 ft	50 ft
Jun 26, 2020	1.64 ft	79 ft
Nov 18, 2020		62.4 ft

Kilili South 2 is relatively stable. Slight variation on the berm could be from surveyor error. The wrackline ranges from 47 ft to 70 ft. The elevation difference from the headstake to the furthest top of toe is around 8 ft.

Kilili - South 3



Day Recorded	Tide	Shoreline Length
Dec 19, 2016	1.59 ft	50 ft
Jun 26, 2017	1.49 ft	42 ft
March 6, 2018	1.82 ft	50 ft
Jun 21, 2018	1.09 ft	57 ft
Aug 13, 2018	0.19 ft	50 ft
Jan 17, 2020	1.76 ft	60 ft
Jun 23, 2020	-0.24 ft	94 ft
Nov 18, 2020	2.03 ft	54 ft
Jan 29, 2021	1.71 ft	54 ft
Average		56.8 ft

Kilili South 3 is dynamic and has an undetermined status, with the shoreline berm changing throughout the years. This shifting shoreline feature may suggest sediment entering and exiting the area. Due to the presence of a blocking ironwood tree, the headstake is discontinued as of June 2020; however, the newly selected headstake to replace this one is nearby and marked with yellow paint. The wrackline ranges from 42 ft to 53 ft. The elevation distance from the headstake to the furthest top of toe is 8 ft.

Oleai Beach

Trend: Eroding

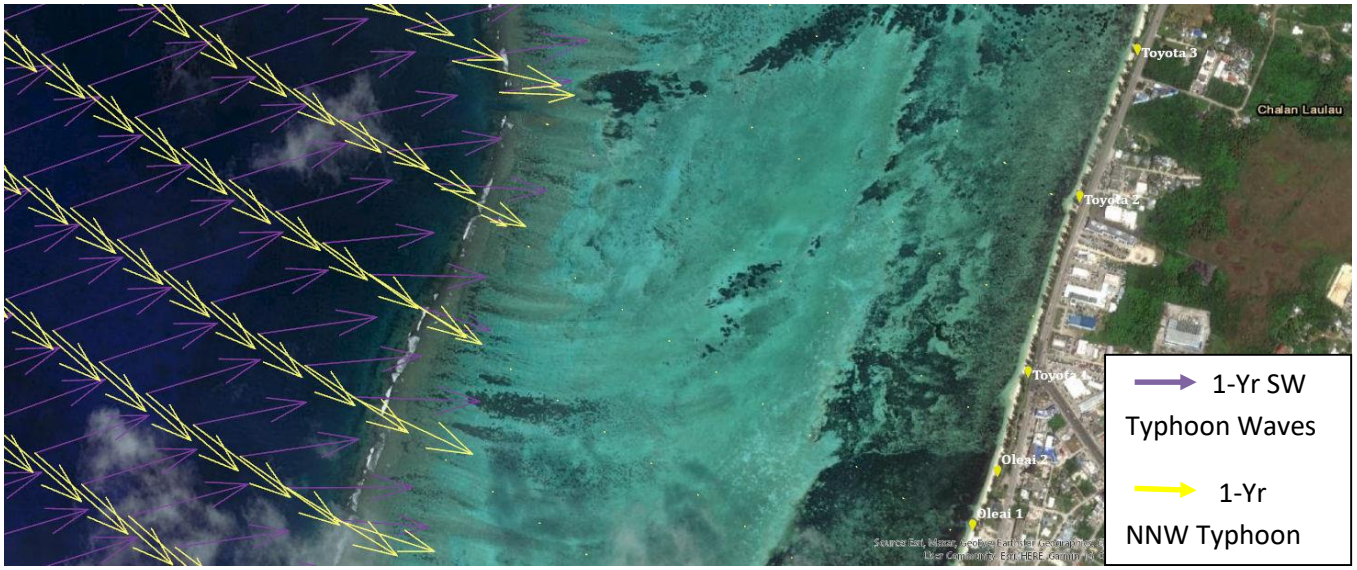
EPHR: Medium

Average length: 36.5 ft

Average elevation: 9 ft

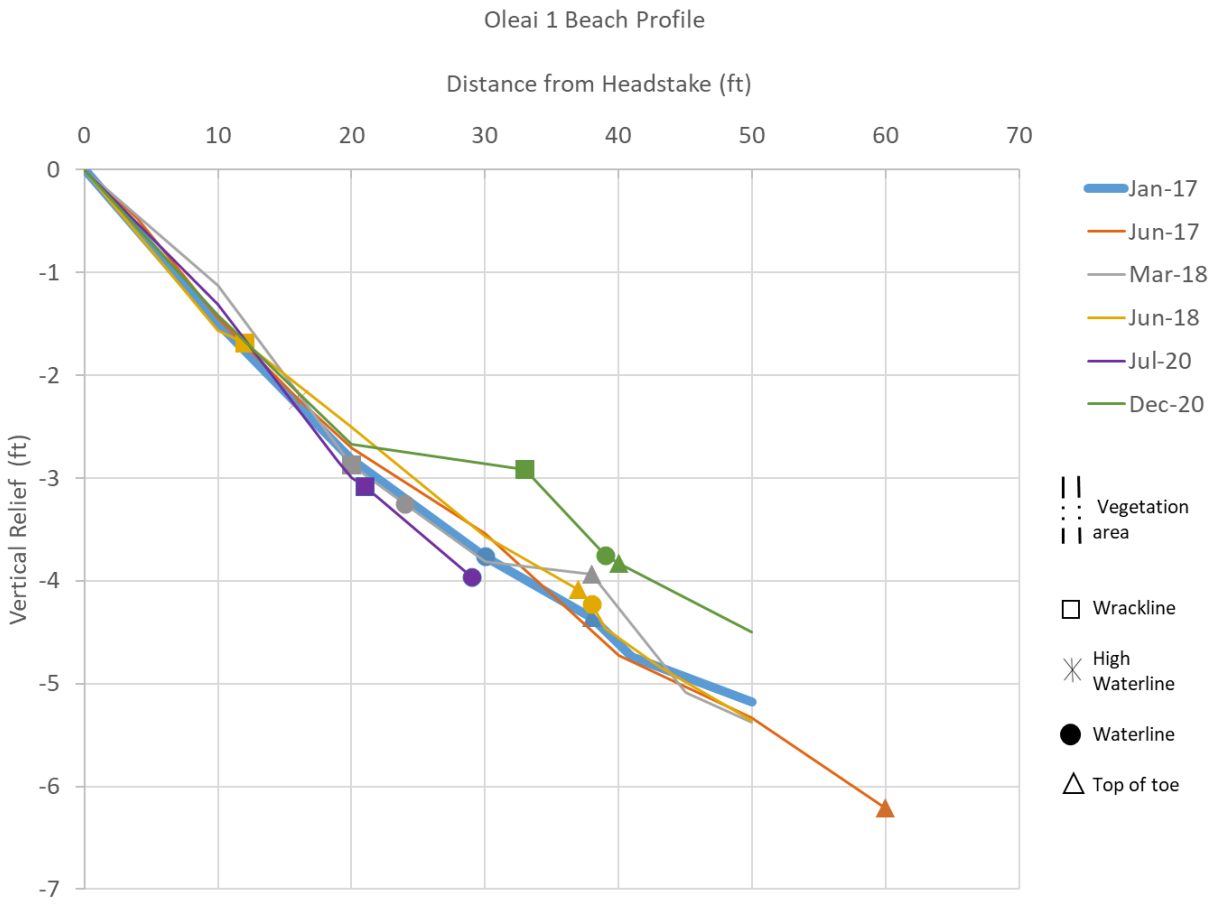
Oleai 1 (2018)

Oleai 1 (2020)



Parallel to the Garapan reef, Oleai shoreline is short and adjacent to the parking lot of Oleai Beach Bar. The restaurant facility in Oleai 1 transect is less than 50 ft away from the waterline indicating that the restaurant is vulnerable to storm surge and sea level rise. Stabilization measures are necessary to protecting the infrastructure from an encroaching waterline, so recording the shoreline positon may assist proper decision-making in addressing this issue. Wave overtopping and overwhelmed tidal flows may impact this site during both typhoon wave conditions. It appears that southwest conditions could greatly impact this site. However, improved resolution on nearshore dynamics may explain longshore processes for this area.

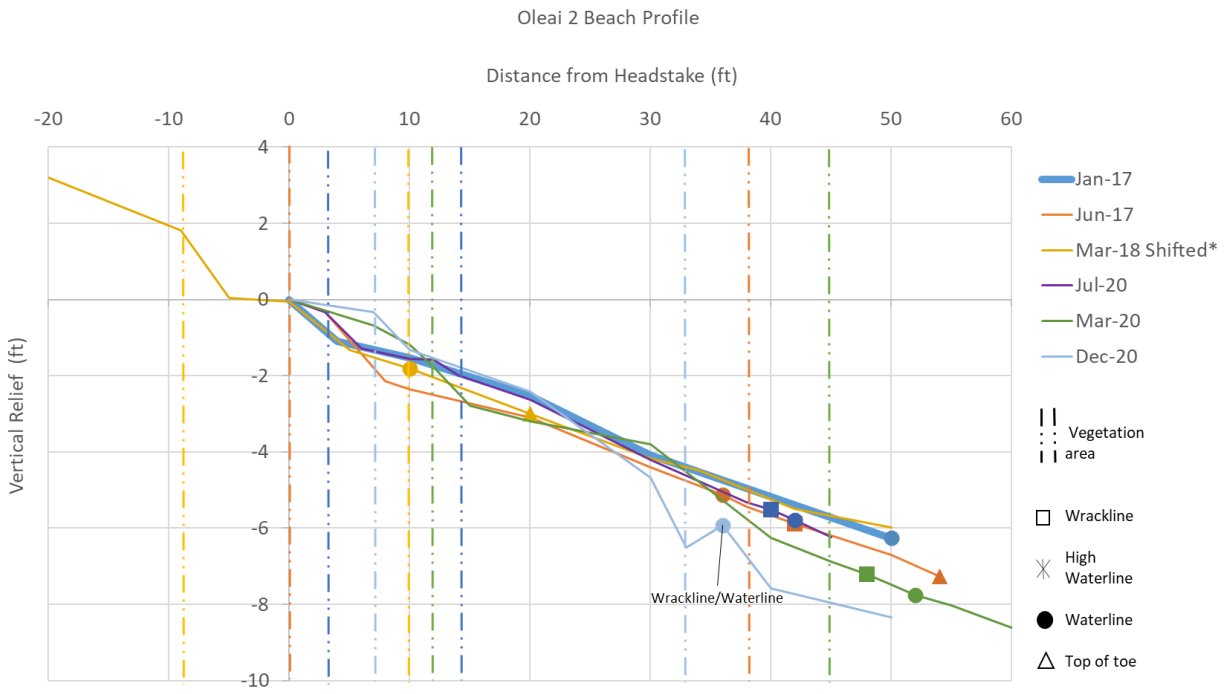
Oleai – 1



Day Recorded	Tide	Shoreline Length
Jan 20, 2017	1.36 ft	30 ft
Jun 26, 2017	0.2 ft	16 ft
Mar 8, 2018	1.57 ft	24 ft
Jun 22, 2018	1.49 ft	38 ft
Mar 13, 2020	1.64 ft	27 ft
Jul 8, 2020	1.9 ft	29 ft
Dec 18, 2020	1.19 ft	39 ft
Average		29 ft

Oleai 1 is undetermined given its dynamic nature impacted by tidal influence. The variation occurs past the 20 ft distance mark. The short length of the shoreline is concerning as the wrackline encroaches on the infrastructure. The wrackline ranges from 16 ft to 33 ft. The elevation difference from headstake to top of toe is about 6 ft.

Oleai – 2



Day Recorded	Tide	Shoreline Length
Jan 20, 2017	1.36 ft	50 ft
Jun 26, 2017	0.03 ft	36 ft
Mar 8, 2018	1.61 ft	30 ft
Jun 22, 2018	0.74 ft	58 ft
Mar 13, 2020	1.81 ft	27 ft
Jul 8, 2020	1.81 ft	29 ft
Dec 18, 2020	1.35 ft	36 ft
Average		43.9 ft

Oleai 2 is generally eroding. Oleai 2 headstake was prone to misidentification. Entries were done at the original headstake (corner of cemented foundation for sidewalk) while outliers were done at a marked tree. They are adjacent to each other but the marked tree headstake is several feet inland compared to the other. The wrackline ranges from 23 ft to 48 ft. The elevation difference from headstake to top of toe is about 7 ft.

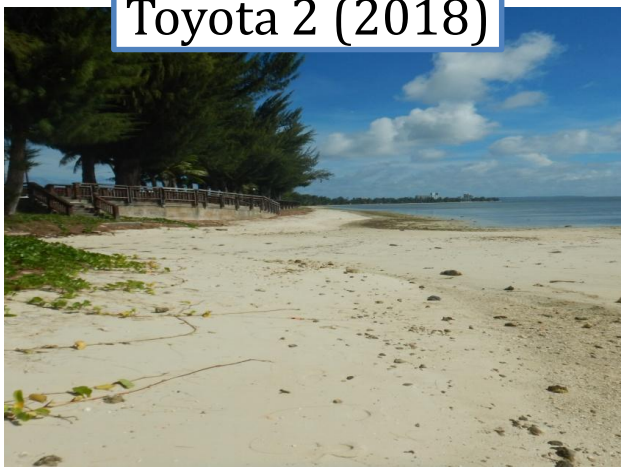
Toyota Beach

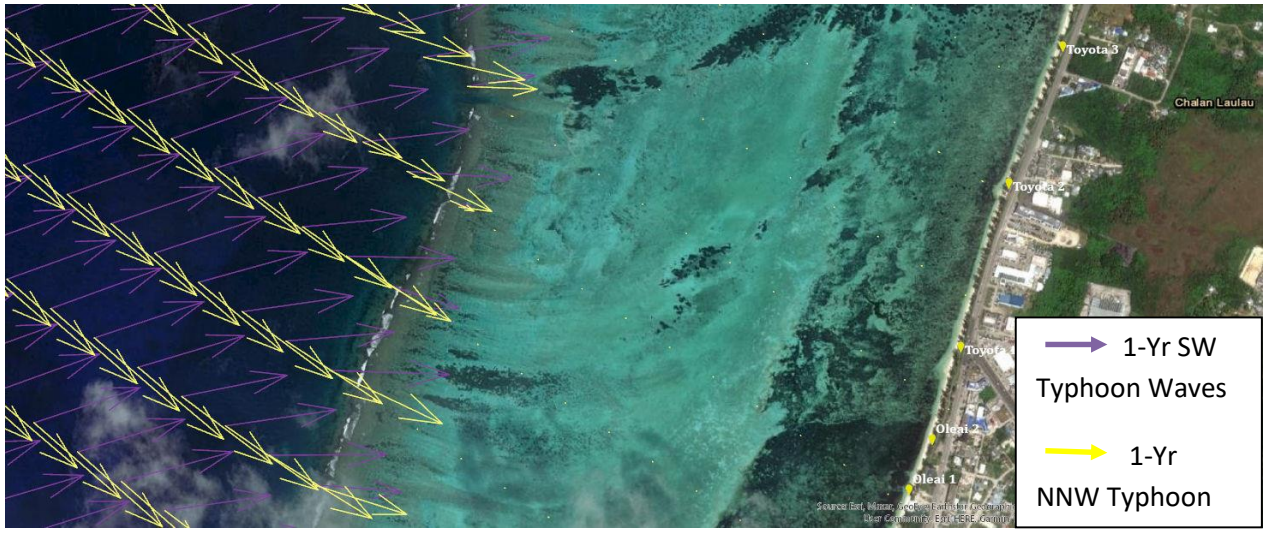
Trend: Eroding

EPHR: High

Average length: 50.5 ft

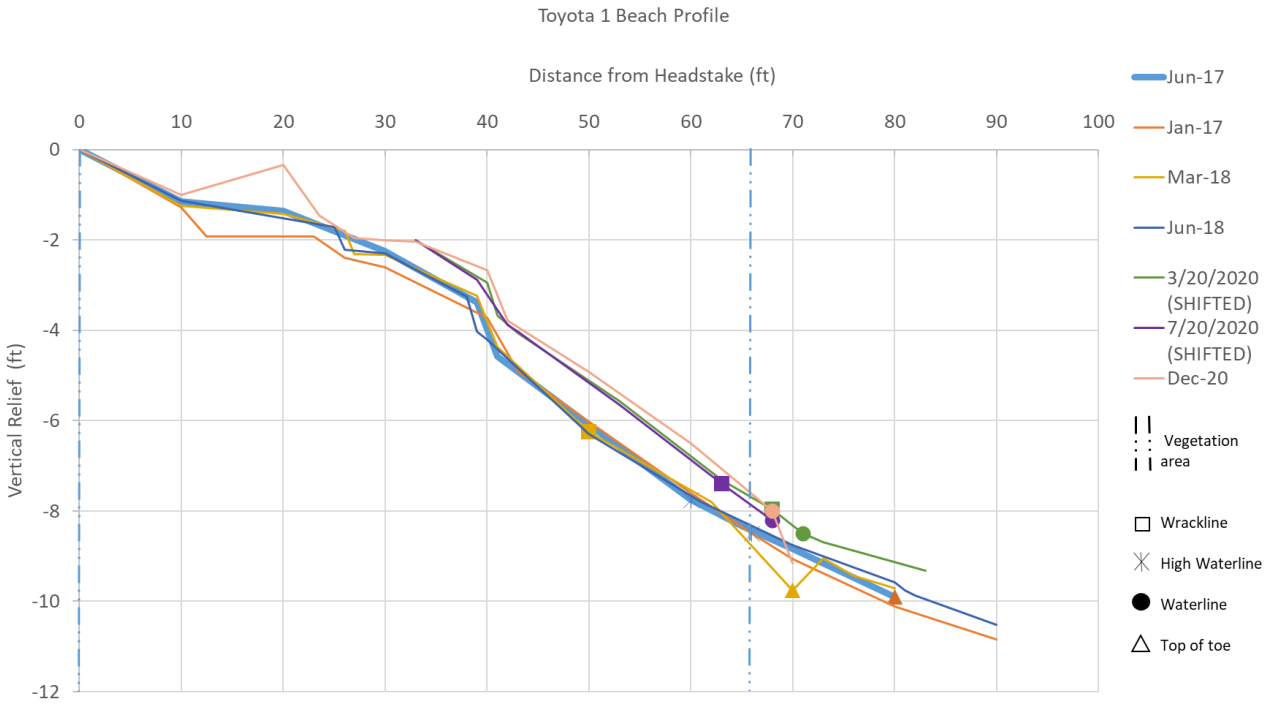
Average elevation: 9.3 ft





Toyota shoreline encompasses a portion of the Beach Road pathway with the railing and ADA pathway down to the shore. This area is prone to abrasion after storm surge events, which has historically damaged the pathway infrastructure. The toe of this shoreline is exposed during low tide. Along with erosion by storm surge, sea level rise threatens this shoreline and its highly developed backshore, the Toyota intersection and the surrounding businesses. Both typhoon conditions bring strong wave energies that greatly erode the short shoreline away. Wave overtopping and overwhelmed tidal flows may impact this site during both typhoon wave conditions. It appears that southwest conditions could greatly impact this site. However, improved resolution on nearshore dynamics may explain longshore processes for this area.

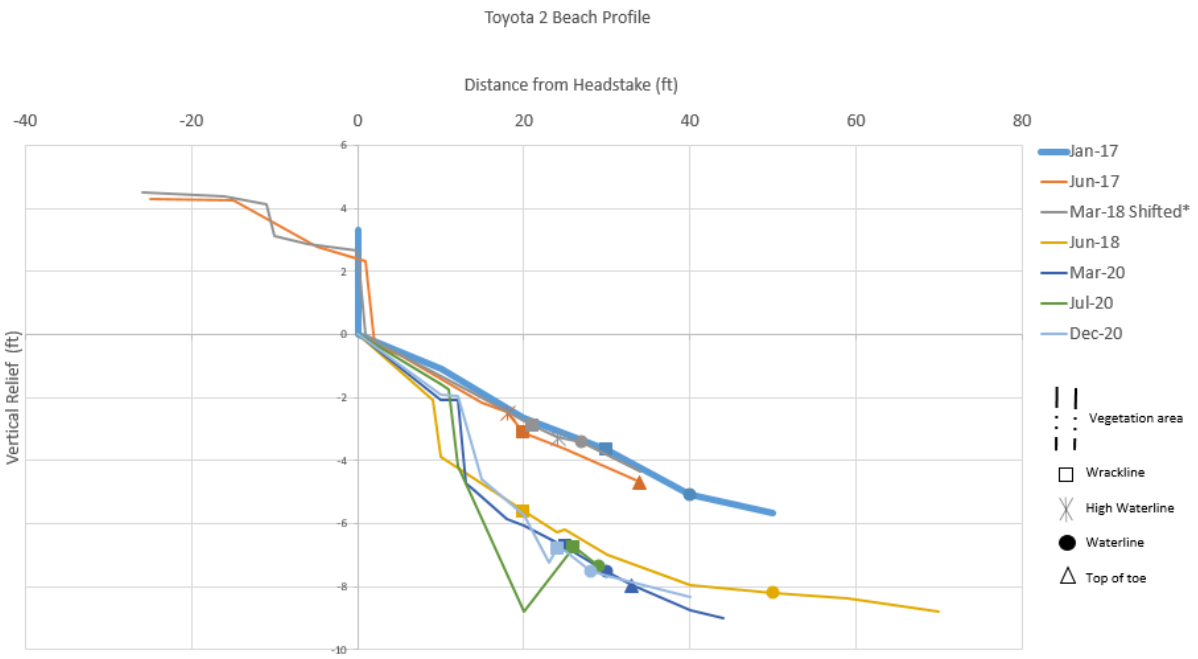
Toyota – 1



Day Recorded	Tide	Shoreline Length
Jan 27, 2017	1.15 ft	66 ft
Jun 26, 2017	-0.2 ft	60 ft
Mar 8, 2018	1.06 ft	Not recorded
Jun 22, 2018	0.56 ft	81 ft
Mar 13, 2020	1.95 ft	38 ft
Jul 8, 2018	1.8 ft	35 ft
Mar 20, 2020	1.95 ft	71 ft
Jul 20, 2020	1.8 ft	68 ft
Dec 18, 2020	1.57 ft	68 ft
Average		69 ft

Toyota 1 appears relatively stable as of now. Mis-identification of the headstake occurred in May 2020 and July 2020. They have been modified to fit the actual distance of the headstake. The wrackline ranges from 30 ft to 68 ft. The elevation difference from headstake to top of toe is about 10 ft.

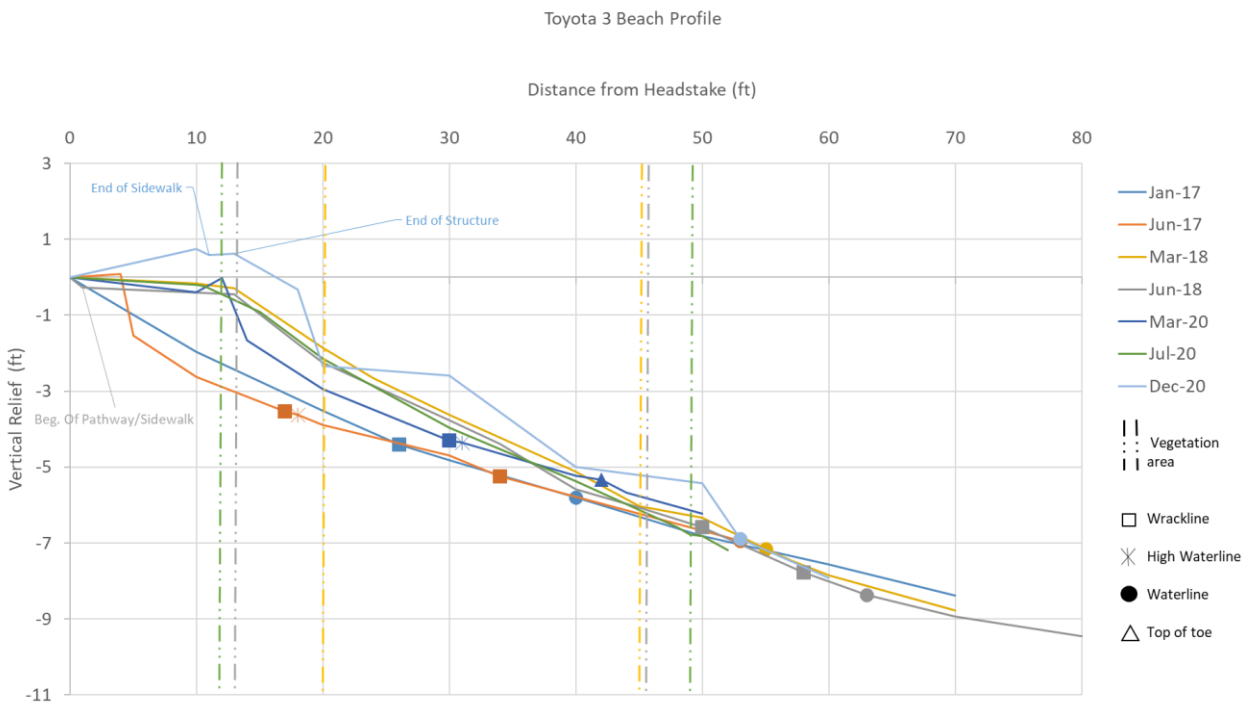
Toyota – 2



Day Recorded	Tide	Shoreline Length
Jan 27, 2017	1.23 ft	Not recorded
Jun 26, 2017	-0.39 ft	Not recorded
Mar 8, 2018	1.32 ft	53 ft
Jun 22, 2018	0.52 ft	50 ft
Mar 13, 2020	1.96 ft	30 ft
Jul 8, 2020	1.7 ft	29 ft
Average		38 ft

Toyota 2 is generally eroding since Jan 2017. This transect has been hardened to protect the berm where the tree stands. Although surveyor error is evident, strong abrasion of the shoreline happened on June 2018. The wrackline ranges from 20 ft to 30 ft. The elevation difference from headstake to top of toe is about 9 ft.

Toyota – 3



Day Recorded	Tide	Shoreline Length
Jan 27, 2017	1.31 ft	40 ft
Jun 26, 2017	-0.55 ft	18 ft
Mar 8, 2018	1.18 ft	55 ft
Jun 22, 2018	0.63 ft	63 ft
Mar 13, 2020	1.73 ft	31 ft
Jul 8, 2020	1.6 ft	52 ft
Dec 18, 2020	1.92 ft	53 ft
Average		44.6 ft

Toyota 3 appears to be generally stable with periods of erosion and accretion. The wrackline ranges from 17 ft to 50 ft. The elevation difference from headstake to top of toe is about 9 ft.

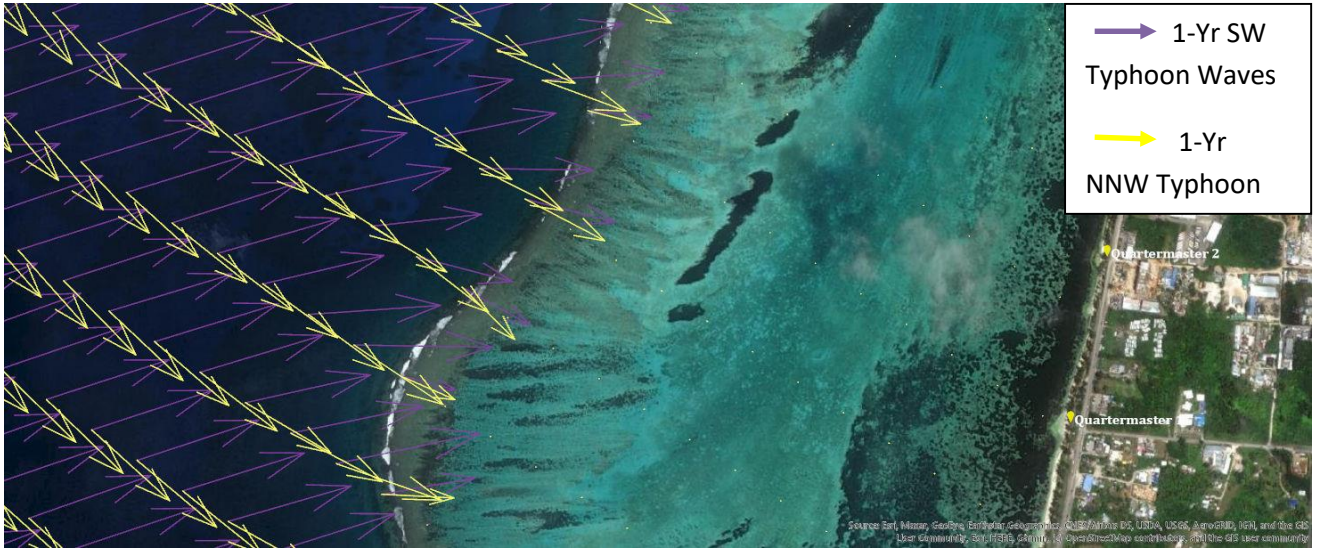
Quartermaster Beach

Trend: Relatively stable – Slowly eroding

EPHR: High

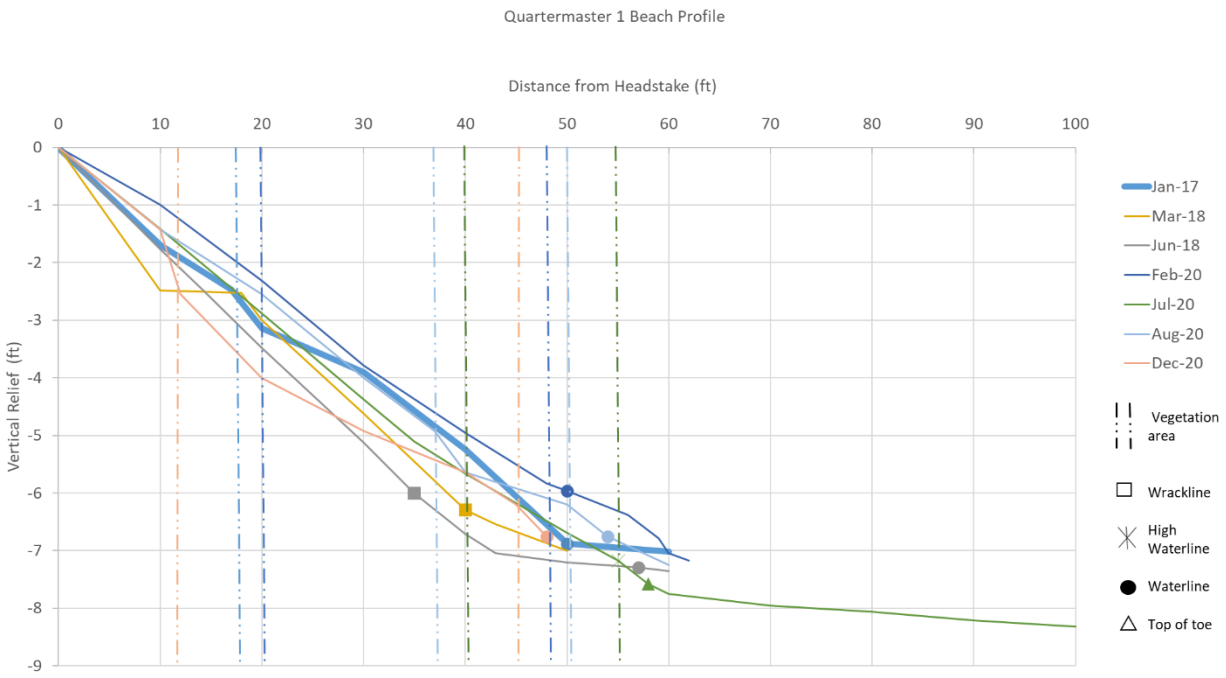
Average length: 56.2 ft

Average elevation: 7.25 ft



The Quartermaster shoreline has few sandy spots. The beach profiles suggest the area is relatively stable or dynamic since the start of this program, likely due to sediment transport influenced by flows of the Light House Channel. However, the alarming short length of this shoreline indicates high vulnerability to storm surge and sea level rise. The backshore has pre-existing critical infrastructure, including Beach Road. The headstakes are a few feet away from this infrastructure and then a several feet away from the main road. Present vegetation and seagrasses attenuate wave energy. However, other stabilization measures have been sought to address the loss of shoreline. This shoreline is moderately steep with high tidal influence. Wave overtopping and overwhelmed tidal flows may impact this site during both typhoon wave conditions. It appears that southwest conditions could greatly impact this site. However, improved resolution on nearshore dynamics may explain longshore processes for this area.

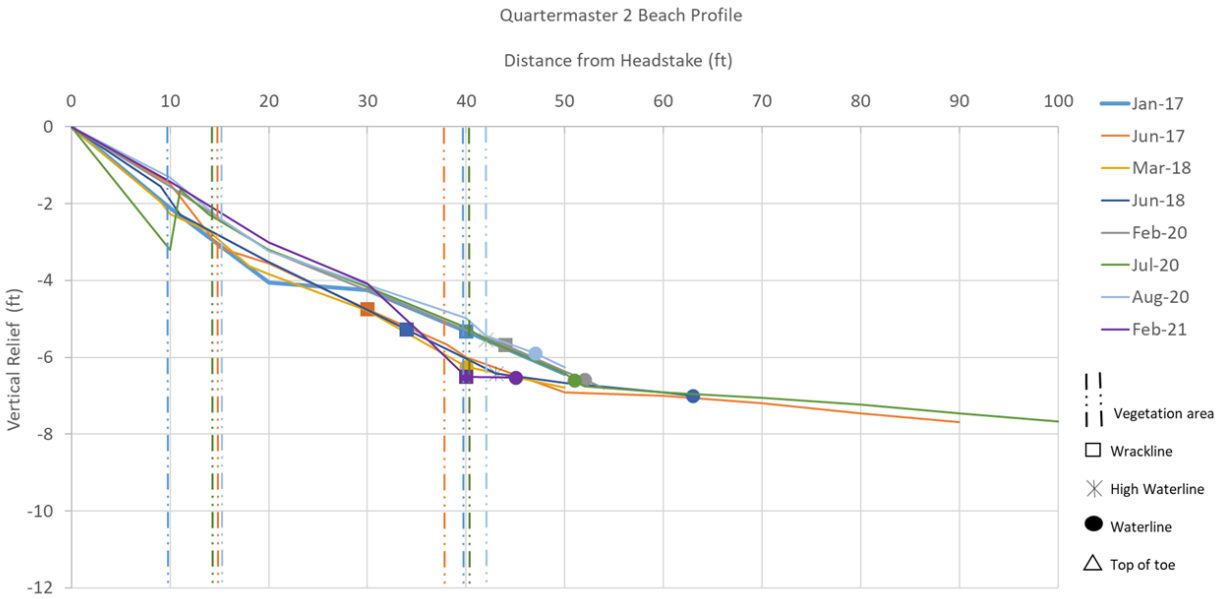
Quartermaster – 1



Day Recorded	Tide	Shoreline Length
Jan 27, 2017	1.37 ft	50 ft
Jun 6, 2017	0.54 ft	Not recorded
Mar 13, 2018	1.19 ft	43 ft
Jun 25, 2018	0.5 ft	57 ft
Feb 6, 2020	1.54 ft	56 ft
Jul 20, 2020	0.13 ft	114 ft
Aug 24, 2020	1.09 ft	54 ft
Dec 22, 2020	1.06 ft	48 ft
Average		60.3 ft

Quartermaster 1 is relatively stable, yet dynamic, with sediment entering and exiting the area. The June 2020 transect was an outlier due to the exposure of the toe from low tide influence. During low tide, the shoreline extended up to 114 ft. However, the wrackline of this transect ranges from 35 to 40 ft. The elevation difference from the headstake to the furthest recorded top of toe is 7.5 ft.

Quartermaster – 2



Day Recorded	Tide	Shoreline Length
Jan 27, 2017	1.37 ft	Not recorded
Jun 6, 2017	Not recorded	Not recorded
Mar 13, 2018	Not recorded	40 ft
Jun 25, 2018	0.84 ft	63 ft
Feb 6, 2020	1.54 ft	52 ft
Jul 20, 2020	0.13 ft	110 ft
Aug 24, 2020	1.09 ft	47 ft
Dec 22, 2020	1.37 ft	50 ft
Feb 22, 2021	1.34 ft	45 ft
Average		58.1 ft

Quartermaster 2 is relatively stable, with sediment entering and exiting the area with an encroaching wrackline. There may also be some surveyor error association with July 2020 as an outlier. In low tide, the shoreline extended to 110 ft. The wrackline of this transect ranges from 30 to 52 ft. The elevation difference from the headstake to the furthest recorded waterline (alternative to the unrecorded top of toe) is 7 ft.

Hafa Adai Beach

Trend: Accreting

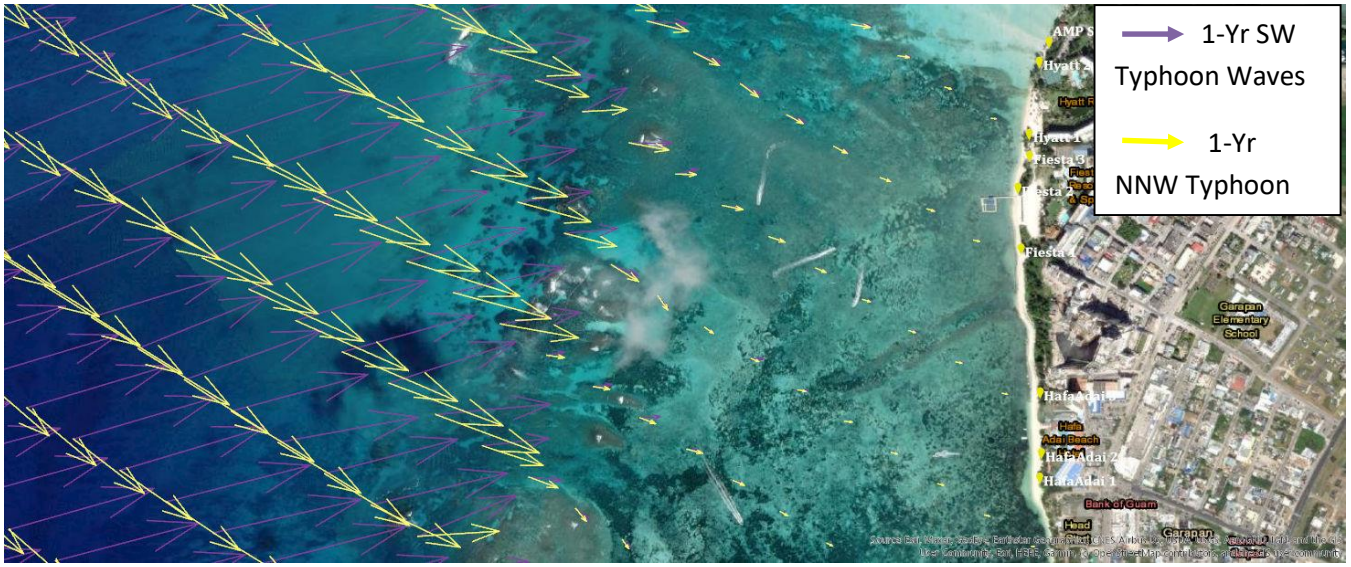
EPHR: N/A

Average length: 86.1 ft

Average elevation: 6.2 ft

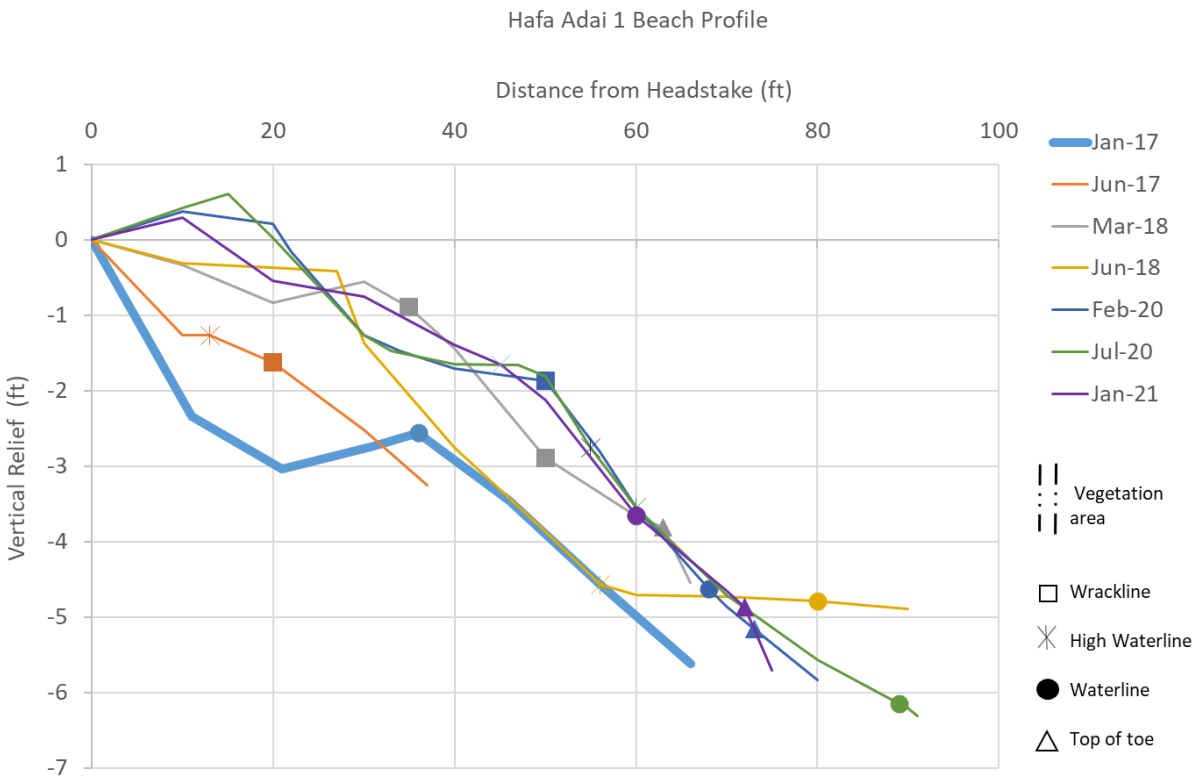
Hafa Adai 1 (2018)

Hafa Adai 1 (2020)



Located within the Garapan Lagoon and adjacent to patch reef, Hafa Adai beach appears to be accreting. This accretion brings a stark contrast when compared to Fiesta and Hyatt shoreline to the north and Garapan district shoreline to the south. There is an outfall nearby that may have some effect on the shoreline but there is insufficient evidence of its direct contribution to the accumulation. For both typhoon wave conditions, this area appears better sheltered from the patch reef than the northern sites. However, improved resolution on nearshore dynamics may explain the accretion.

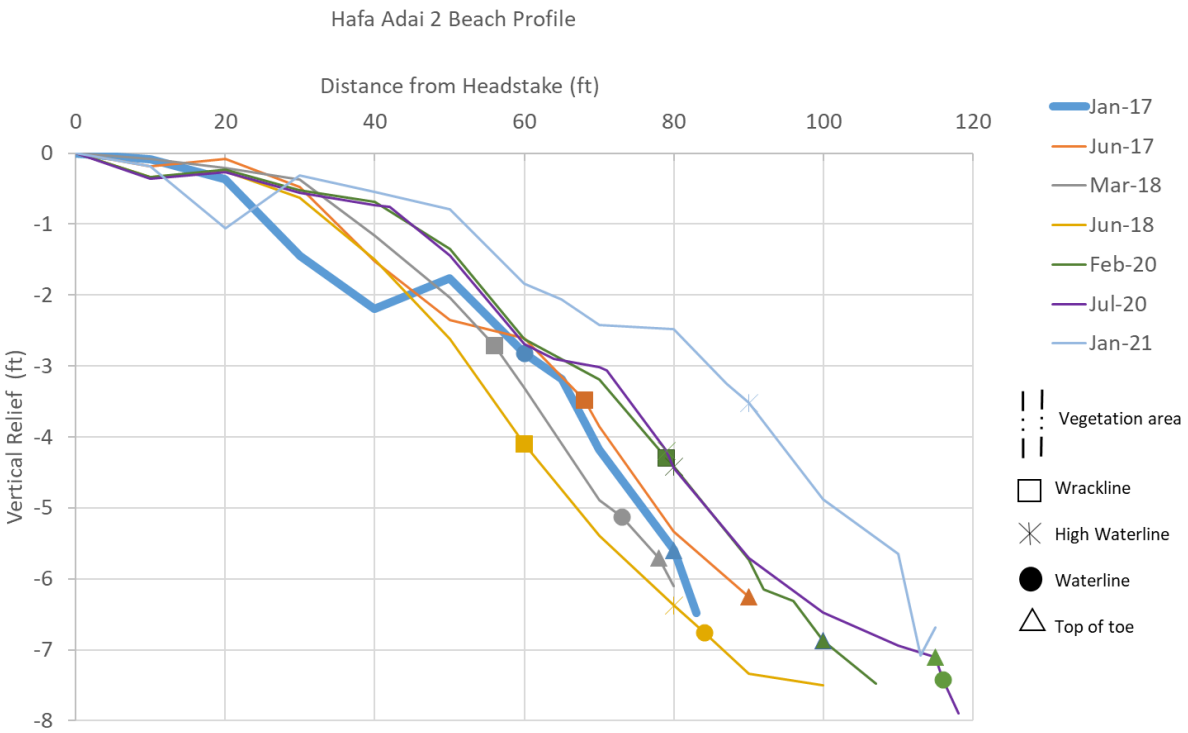
Hafa Adai – 1



Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.73 ft	36 ft
Jun 27, 2017	1.91 ft	Not recorded
Mar 13, 2018	1.37 ft	60 ft
Jun 25, 2018	0.5 ft	80 ft
Feb 28, 2020	1.54 ft	68 ft
Jul 20, 2020	0.13 ft	60 ft
Jan 12, 2021	1.31 ft	60 ft
Average		60.7 ft

Hafa Adai 1 appears to be seasonally changing so its status is undetermined. The wrackline of this transect ranges from 20 to 52 ft. The elevation difference from the headstake to the furthest recorded waterline (alternative to the unrecorded top of toe) is around 5 ft.

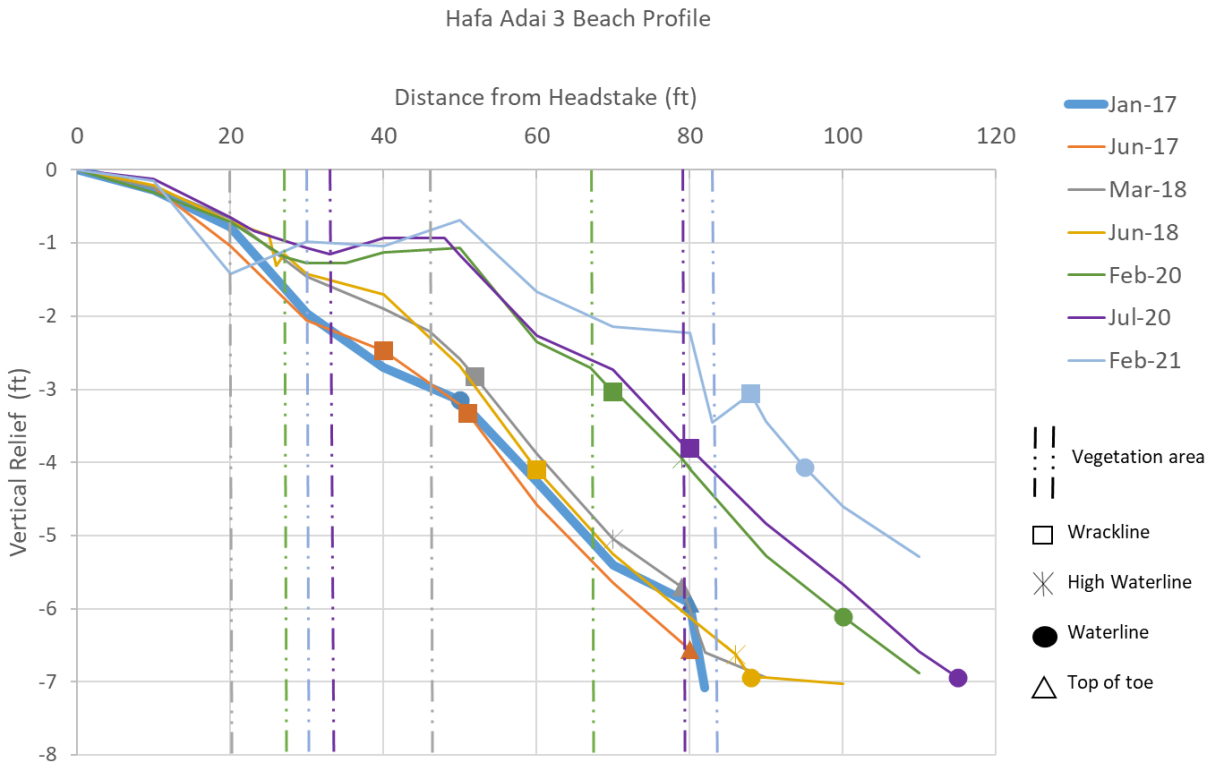
Hafa Adai – 2



Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.69 ft	60 ft
Jun 27, 2017	0.2 ft	Not recorded
Mar 13, 2020	1.35 ft	73 ft
Jun 25, 2018	0.41 ft	84 ft
Feb 28, 2020	1.1 ft	80 ft
Jul 20, 2020	-0.11 ft	116 ft
Jan 12, 2021	1.6 ft	Not recorded
Average		82.6 ft

Hafa Adai 2 appears to be accreting since Jun 2018. The wrackline of this transect ranges from 56 to 79 ft. The elevation difference from the headstake to the furthest recorded waterline (alternative to the unrecorded top of toe) is 7 ft.

Hafa Adai – 3



Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.64 ft	50 ft
Jun 27, 2017	1.95 ft	Not recorded
Mar 13, 2020	1.29 ft	70 ft
Jun 25, 2018	0.41 ft	88 ft
Feb 28, 2020	1.37 ft	100 ft
Jul 20, 2020	0.05 ft	115 ft
Feb 19, 2021	1.58 ft	95 ft
Average		86.3 ft

Hafa Adai 3 is accreting. As the shoreline has been gaining volume and length in three years, this stretch of shore naturally developed infrastructure. From July 2020 through Feb 2021, a row of ironwood trees grown and blocked the transect, making surveying difficult from Feb 2021 and onward. The wrackline ranges from 40 to 88 ft. The elevation distance from the headstake to the furthest top of toe is around 6.5 ft.

Fiesta Beach

Trend: Eroding

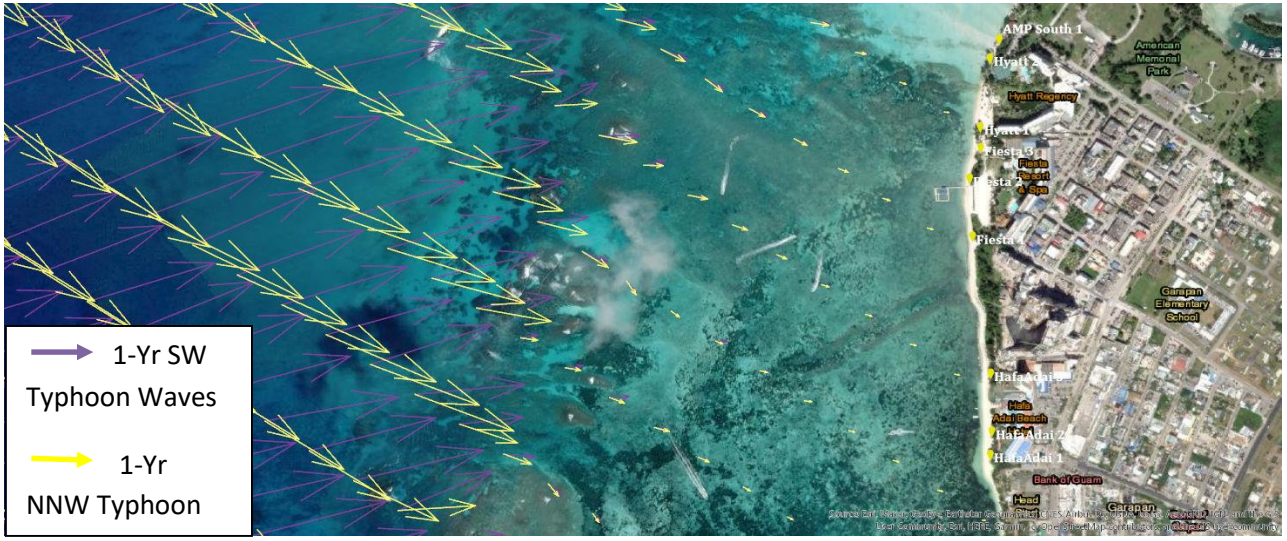
EPHR: High

Average length: 44.5 ft

Average elevation:

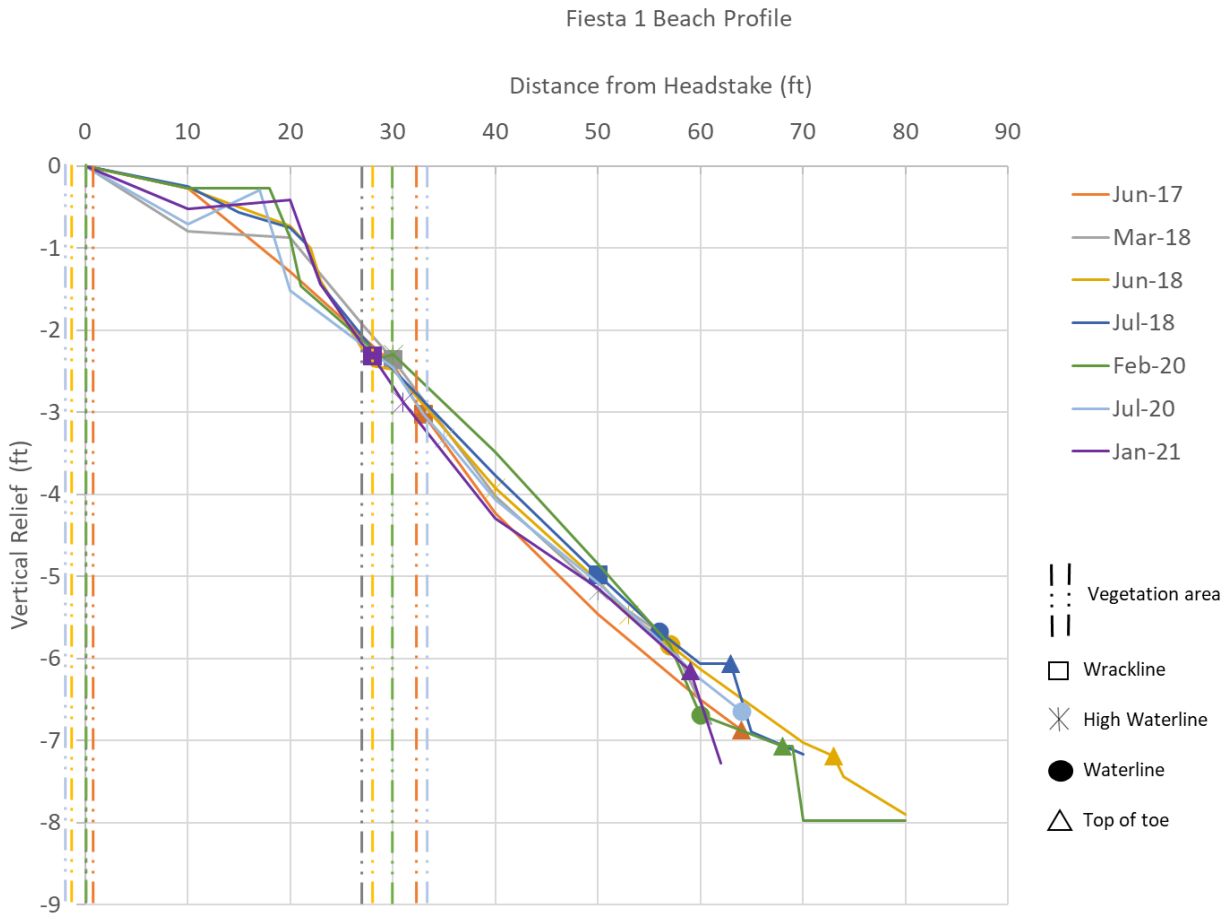
Fiesta 2 (2018)

Fiesta 2 (2020)



Unlike down south, Fiesta has less reef and seagrass protection from wave energy. Thus, this exposure enables high energy waves to erode the shoreline during storm events. Fiesta beach, like Hyatt, have steep abraded berms retreating inland that will endanger marine sports operator facilities and hotel beach amenities in the future. The south transect, bordering the IPI Casino building, is speculated to have sediment influence from the nearby outfall. Southwest typhoon conditions bring greater wave energies due to the high waves entering in through the channel. But given the potential of powerful north-northwest flows to overtop, it would be worthwhile to examine this area during or after these conditions.

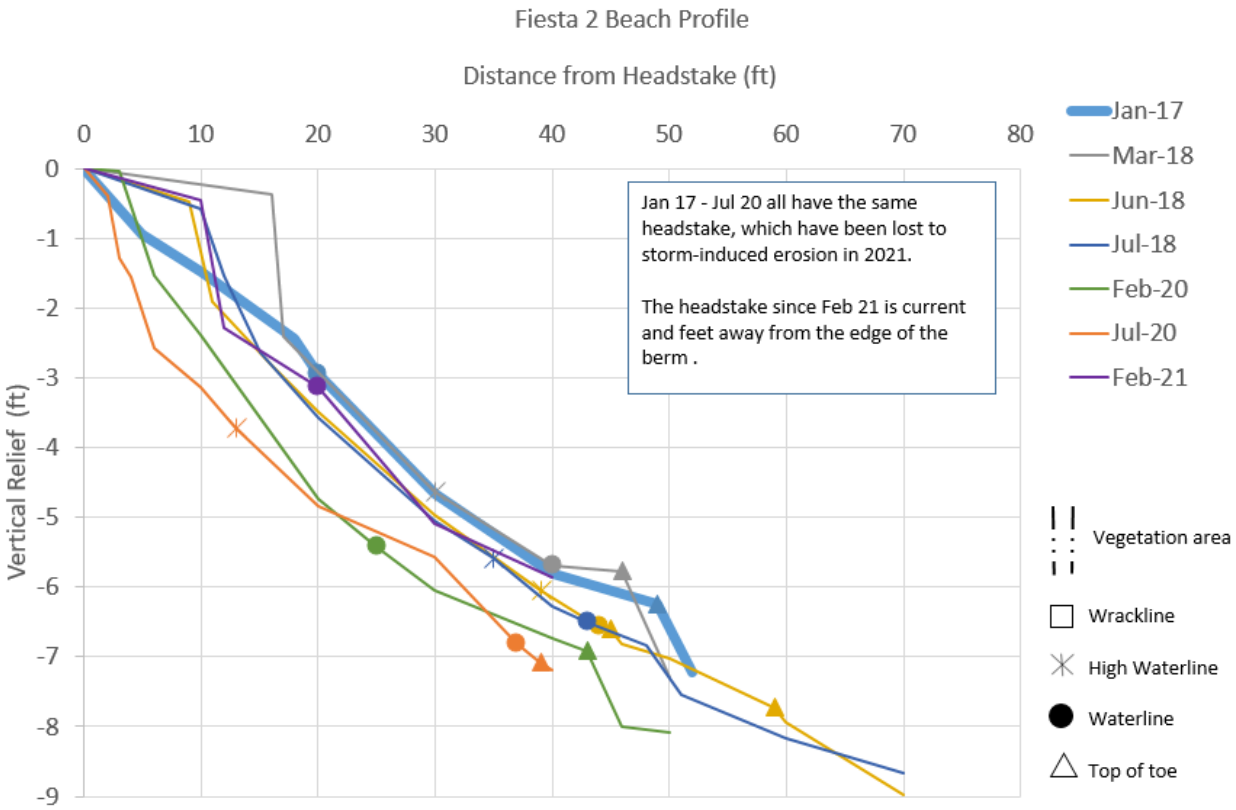
Fiesta – 1



Date Recorded	Tide	Shoreline Length
Jan 19, 2017	1.6 ft	60 ft
Jun 27, 2017	1.68 ft	Not recorded
Mar 15, 2018	1.36 ft	50 ft
Jun 28, 2018	1.01 ft	57 ft
Jul 20, 2018	0.68 ft	56 ft
Feb 28, 2020	0.68 ft	57 ft
Jul 20, 2020	0.57 ft	64 ft
Jan 12, 2021	1.77 ft	Not recorded
Average		57.3 ft

Fiesta 1 appears relatively stable. The outfall may contribute to the sediment volume of this shoreline position. The wrackline ranges from 30 to 50 ft. The elevation distance from the headstake to the furthest top of toe is around 7 ft.

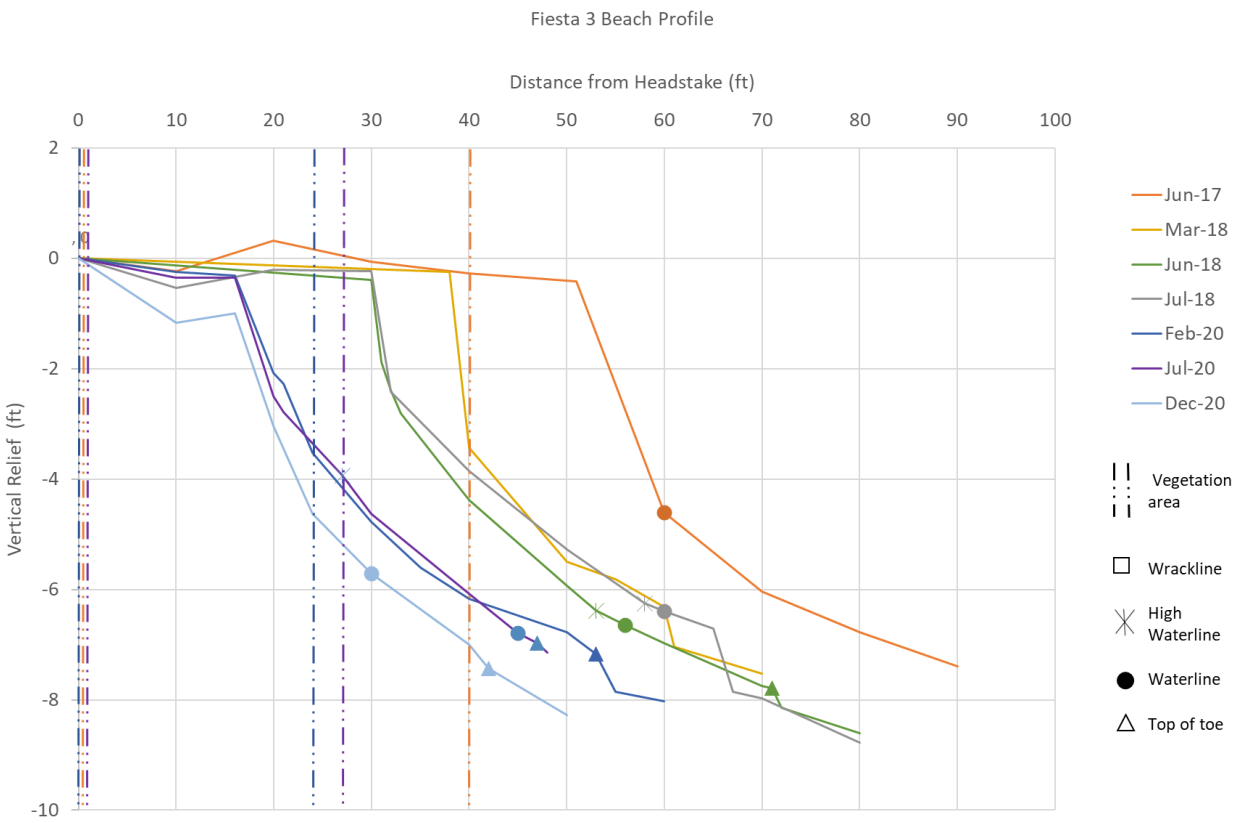
Fiesta – 2



Date Sampled	Tide	Shoreline Length
Jan 19, 2017	1.55 ft	20 ft
Jun 27, 2018	0.15 ft	Not recorded
Mar 15, 2018	1.45 ft	40 ft
Jun 28, 2018	0.95 ft	44 ft
Jul 20, 2018	0.75 ft	43 ft
Feb 7, 2020	1.54 ft	25 ft
Jul 20, 2020	0.67 ft	37 ft
Feb 19, 2021	1.47 ft	20 ft
Average		32.7 ft

Fiesta 2 is eroding and has lost headstakes throughout the recording period. The first headstake indicated a berm loss of around 10 ft from Jan 2018 through July 2020. The shoreline grew steeper, which may allow for further erosion of the shoreline. The high waterline ranges from 30 to 40 ft. The wrackline is nonexistent because there are no seagrass in the adjacent waters. High wave conditions of early 2021 has further chipped away at the berm causing trees to fall into the water. The headstake is changed to an ironwood tree nearly 10 ft inland adjacent to the previous headstake. The elevation distance from the first headstake to the furthest top of toe is around 8 ft and the second saw a decline at 6 ft.

Fiesta – 3



Day Recorded	Tide	Shoreline Length
Jun 27, 2017	1.41 ft	Not recorded
Mar 15, 2018	1.51 ft	55 ft
Jun 28, 2018	0.81 ft	56 ft
July 20, 2018	0.81 ft	58 ft
Feb 7, 2020	1.61 ft	Not recorded
Jul 20, 2020	0.67 ft	45 ft
Dec 4, 2020	1.82 ft	30 ft
Average		48.8 ft

The shoreline has drastically abraded due to the loss of the deepened berm. From 2017 – 2020, the berm has retreated ~36 ft. The berm is not as steep previously, however, it is still capable of allowing wave energy to further abrade the shoreline. The wrackline is nonexistent due to a lack of seagrass or other potential debris in the adjacent waters. The elevation distance from the headstake to the furthest top of toe is around 8 ft.

Hyatt Beach

Trend: Variable

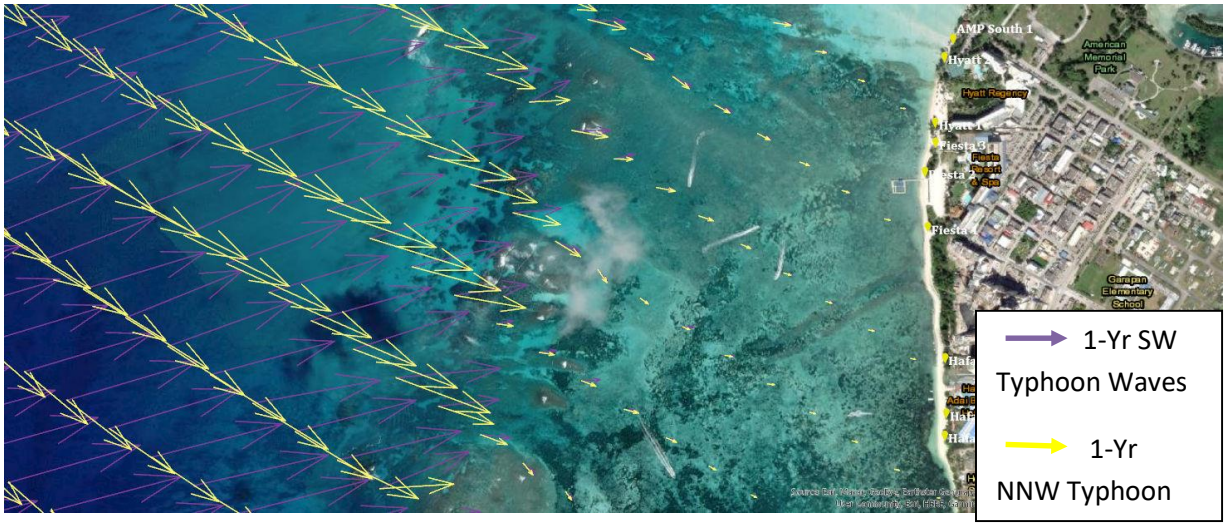
EPHR: High

Average length: 44.6 ft

Average elevation: 7 ft

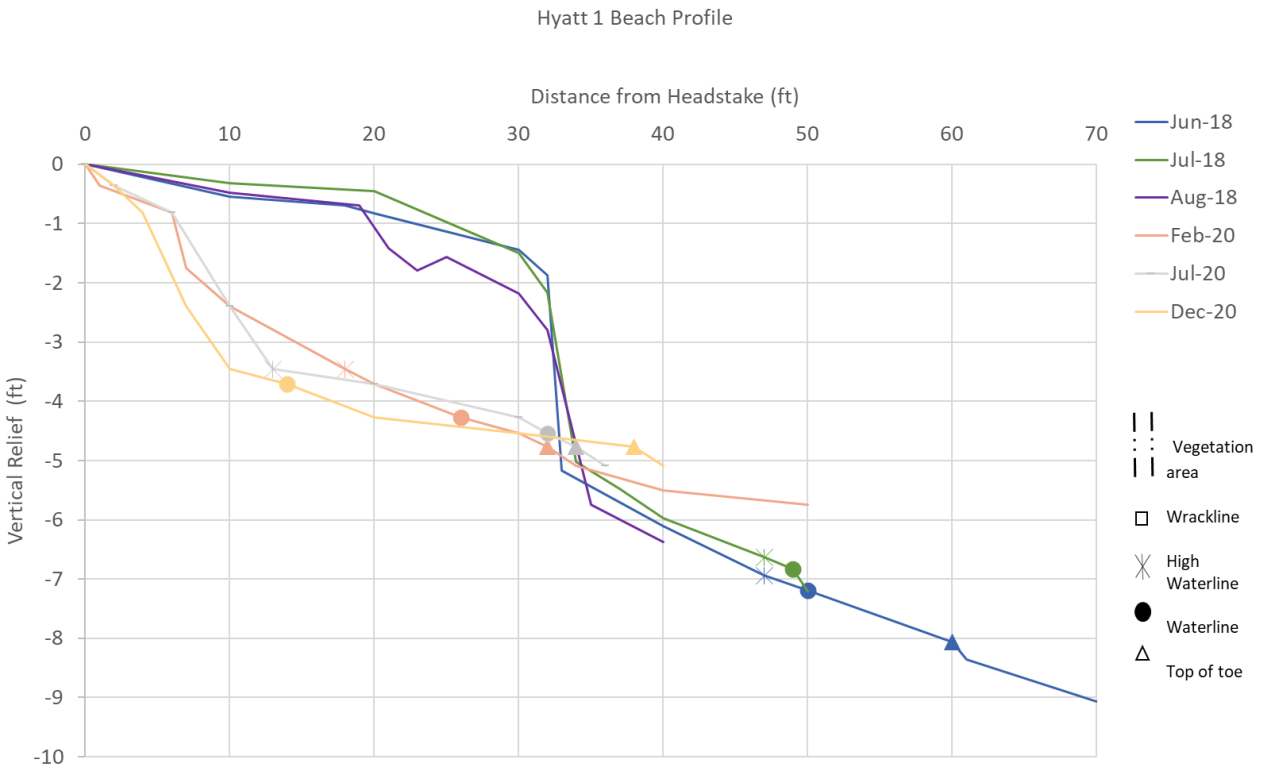
Hyatt 1 (2018)

Hyatt 1 (2020)



In 2017, Hyatt 1 had a gradually sloping sandy shoreline from the head stake, a marked coconut tree close to the hut. The storms of 2018 abraded the shoreline and exposed the roots of the ironwood, deepening the berm. After Super Typhoon Yutu, approximately 20 feet of shoreline has drastically eroded away pulling the ironwood trees that held the berm into the water. Fortunately, the head stake remains at the top of the berm. Users of the area are interested in future stabilization measures, potentially beach nourishment, for concern of further shoreline erosion. The head stake may be lost in the next high wave energy event, calling the need for stabilization measures. Similar to Fiesta, this section of shoreline is greatly exposed to storm-induced waves. Perhaps the sand could be transported north into the lagoon's waters given the same circulation pattern during all seasonal trade winds. Southwest typhoon conditions bring greater wave energies due to the high waves entering in through the channel. But given the potential of powerful north-northwest flows to overtop, it would be worthwhile to examine this area even after north-northwest conditions.

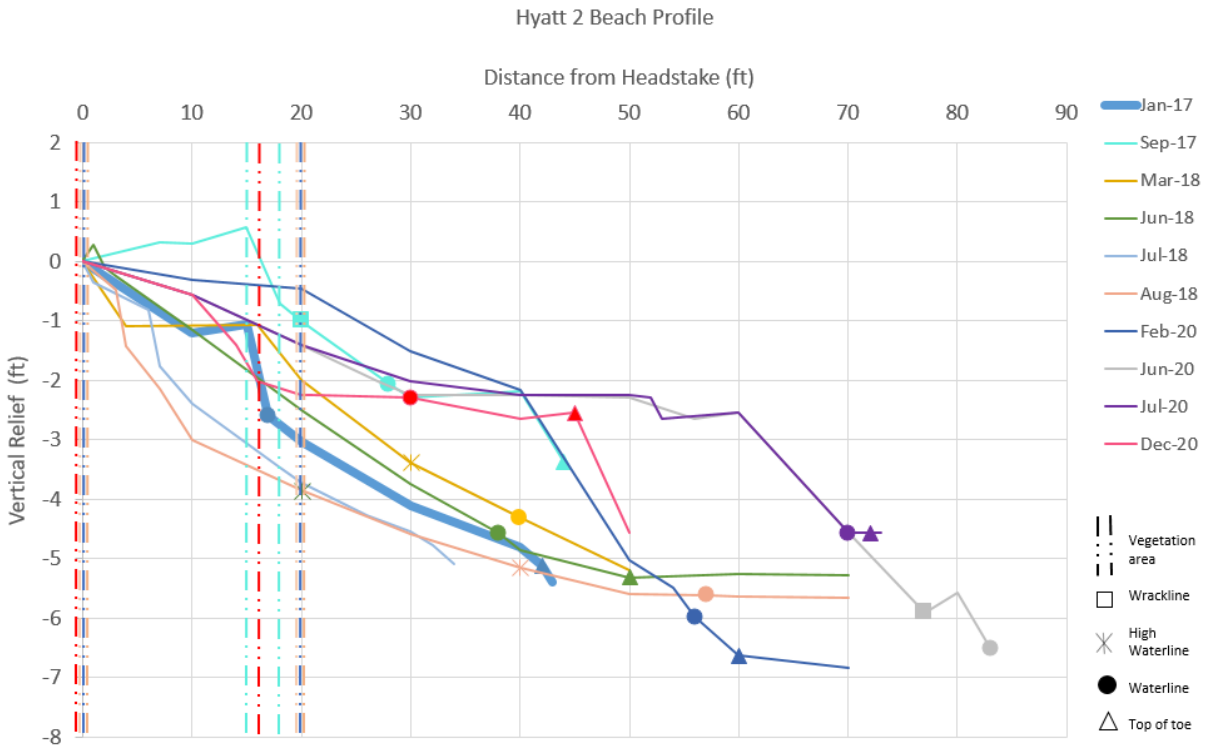
Hyatt 1



Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.48 ft	13 ft
Jun 27, 2017	0.78 ft	Not recorded
Sep 21, 2017	1.5 ft	10 ft
Mar 15, 2018	1.32 ft	20 ft
Jun 28, 2018	0.69 ft	50 ft
Jul 20, 2018	0.89 ft	47 ft
Aug 9, 2018	0.22 ft	54 ft
Feb 7. 2020	1.54 ft	26 ft
Jul 20, 2020	0.88 ft	32 ft
Dec 4, 2020	1.75 ft	14 ft
Average		41.3 ft

The shoreline has drastically abraded due to the loss of the deepened berm. From 2018 – 2020, the berm has retreated ~26 ft. The berm is not as steep previously, however, its eroded steepness may allow wave energy to further abrade the shoreline. The waterline differences are based on the difference of tides on the days. The wrackline is nonexistent because there are no natural debris available, such as seagrass, in the adjacent waters. The elevation distance from the headstake to the furthest top of toe is around 8 ft.

Hyatt 2



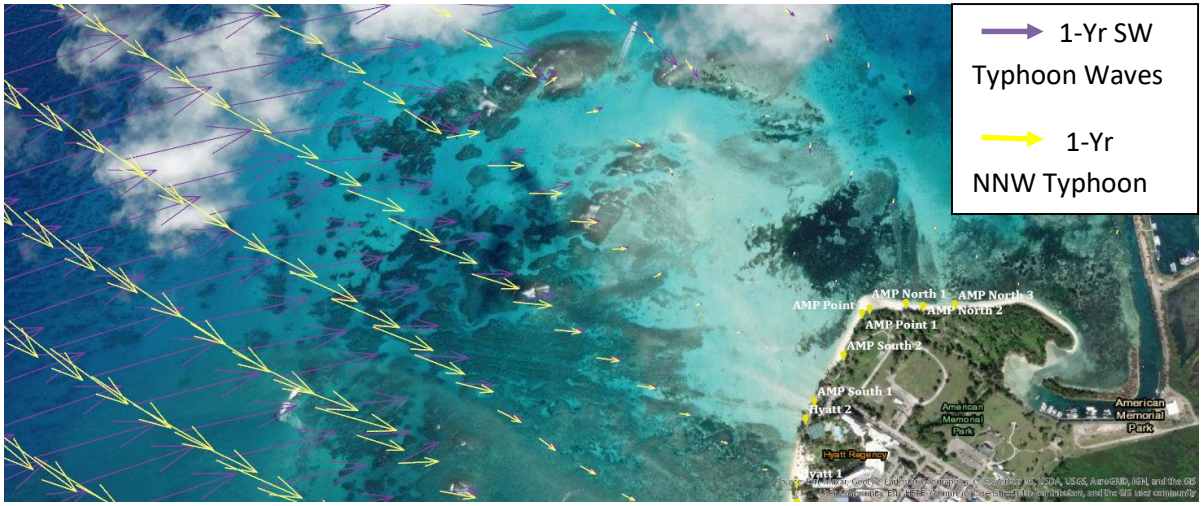
Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.43 ft	Not recorded
Jun 27, 2017	0.69 ft	Not recorded
Sep 21, 2017	Not recorded	28 ft
Mar 15, 2018	1.27 ft	40 ft
Jun 2, 2018	1.12 ft	40 ft
Jul 20, 2018	1.08 ft	26 ft
Aug 9, 2018	0.1 ft	57 ft
Feb 7, 2020	1.66 ft	56 ft
Jun 19, 2020	-0.0 ft	83 ft
Jul 20, 2020	1 ft	70 ft
Dec 4, 2020	1.59 ft	30 ft
Average		47.8 ft

Hyatt 2 is an eroding and highly dynamic transect, influenced by storm surge and tides. Sediment transport may contribute to the variation of shoreline position throughout time but the encroaching waterline and wave energy during high tide/storm events suggest this shoreline is eroding. The elevation distance from the headstake to the furthest top of toe is around 6 ft.

American Memorial Park Beach

AMP South 1 (Sept 2017)

AMP South 1 (Dec 2019)



Trend: Variable

EPHR

South: High

Point and North: Low

Average length

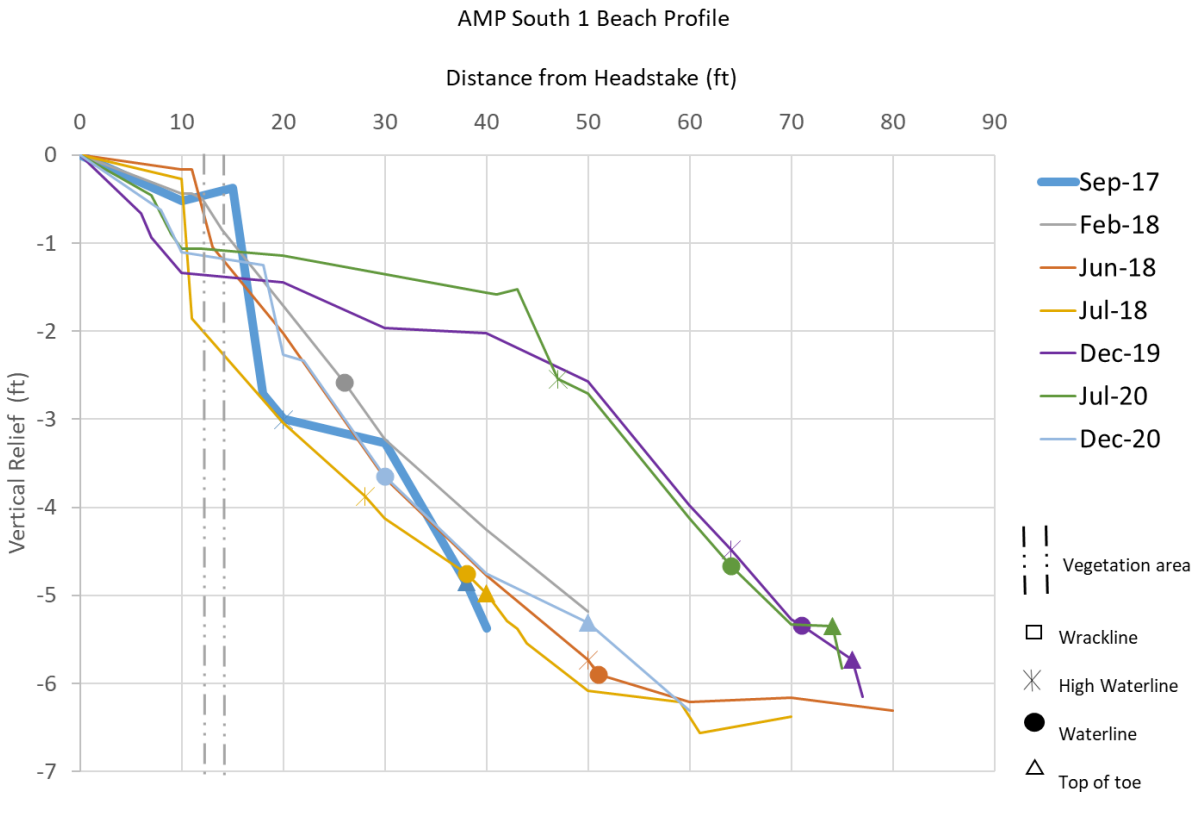
North: 61.1 ft

Point: 101.8 ft

South: 66.1 ft

The AMP shoreline – short for American Memorial Park – is dynamic. The hydrodynamics is complex due to the patch reef and Main Channel interactions. Site-specific, smaller scaled nearshore dynamic modelling may help bring better understanding of long shore processes. In the past, sections of shoreline with sidewalk, cement benches, and bathroom were badly eroding. AMP South 1 (2018) headstake has been removed due to permanent erosion from the headstake to the waterline. South 1 (2019) is now the most southern AMP transect. The southern transects are eroding while the 'point' (known as Puntan Muchot) and northern transects are accreting. Wave energies are higher during southwest typhoon conditions given that the flows enter in through the main channel.

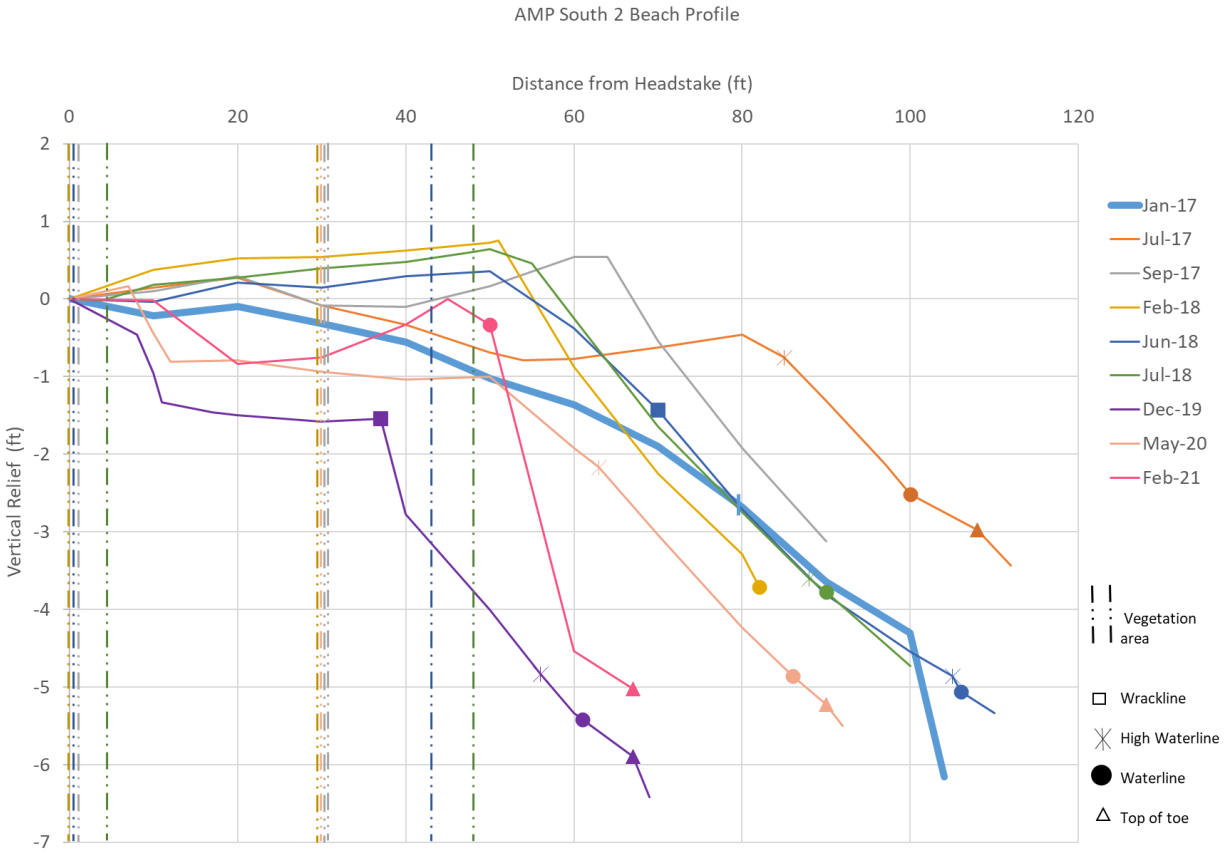
AMP South 1



Day Recorded	Tide	Shoreline Length
Sept 21, 2017	0.99 ft	20 ft
Feb 2, 2018	1.82 ft	Not recorded
Jun 28, 2018	0.01 ft	51 ft
Jul 12, 2018	0.89 ft	38 ft
Dec 11, 2019	1.62 ft	71 ft
Jul 10, 2020	0.94 ft	64 ft
Dec 14, 2020	1.47 ft	30 ft
Average		45.7 ft

As shown in the previous page, this transect has experienced significant changes since 2017. It is evident that this area is highly dynamic due to its geographical vulnerability to the hydrodynamics of the Saipan Lagoon and wave energy from powerful storms. The berm has been declining in elevation while the length shoreline appeared to be increasing until December 2020. Prior to Super Typhoon Yutu, the berm has been deepening from lesser powerful storms. In the event of Yutu, the uprooting of ironwood and coconut trees may have greatly loosened the berm, pouring fresh new sand into the toe and expanding the shoreline. The headstake itself, a once-standing ironwood tree, remains fallen and may have to be replaced in the near future. This transect is hypothesized to have seasonal sediment input while experiencing export during high wave energy events as suggested by the Dec 2020 transect line. The high waterline range is 20 ft – 64 ft.

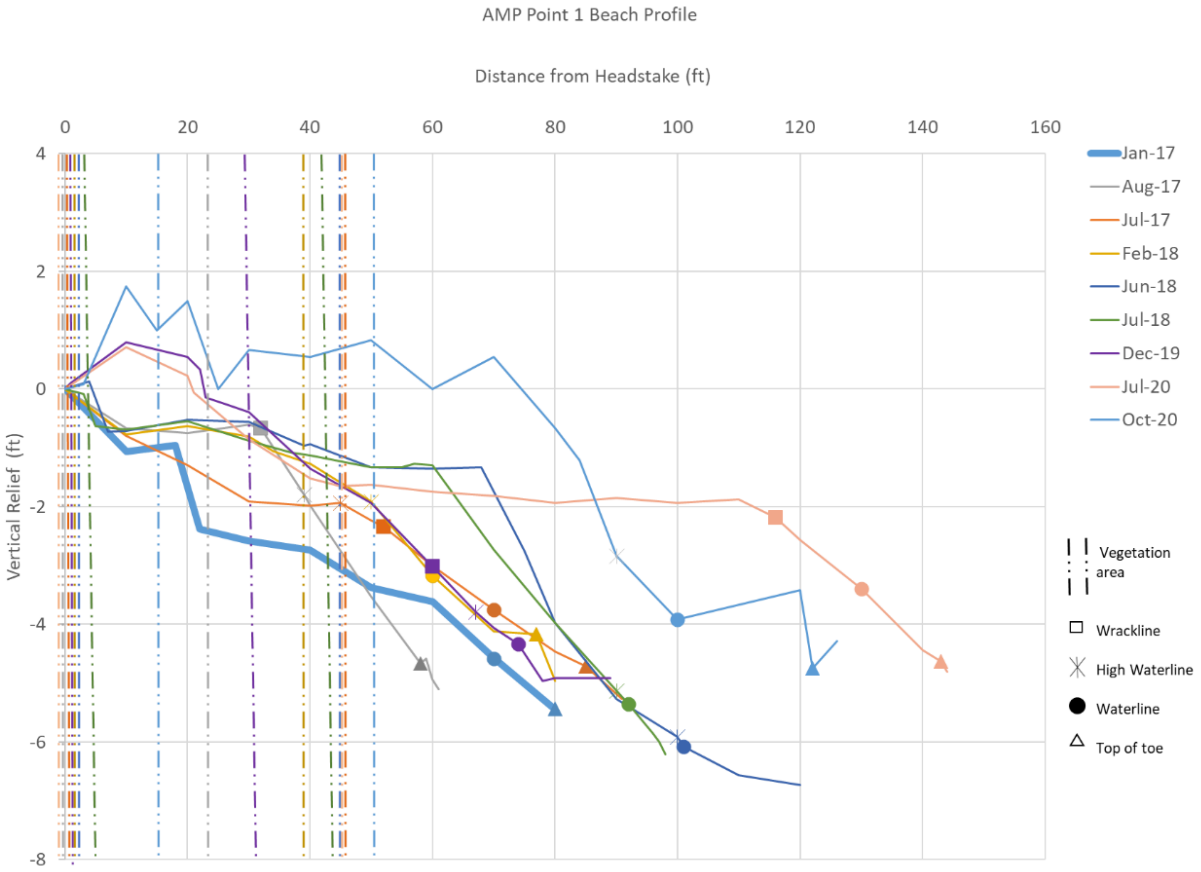
AMP South 2



Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.08 ft	80 ft
July 10, 2017	1.12 ft	97 ft
Sept 21, 2017	0.48 ft	Not recorded
Feb 2, 2018	2.02 ft	82 ft
Jun 28, 2018	-0.19 ft	106 ft
Jul 12, 2018	0.68 ft	93 ft
Dec 11, 2019	1.5 ft	61 ft
May 22, 2020	0.65 ft	86 ft
Feb 19, 2021	1.31 ft	50 ft
Average		81.9 ft

Since 2017, AMP South 2 has shown to be another dynamic transect so its status is undetermined. In 2017, the sediment input appears to increase in the summer of 2017. The typhoon season of that year abraded the shoreline. After Super Typhoon Yutu, the berm has retreated significantly and the toe is deeper and closer to the waterline. The loss of sand is great. Similar to AMP South 1, the seasonal sediment input may be a great contributor to a different shoreline position. The wrackline range is 37 to 70 ft.

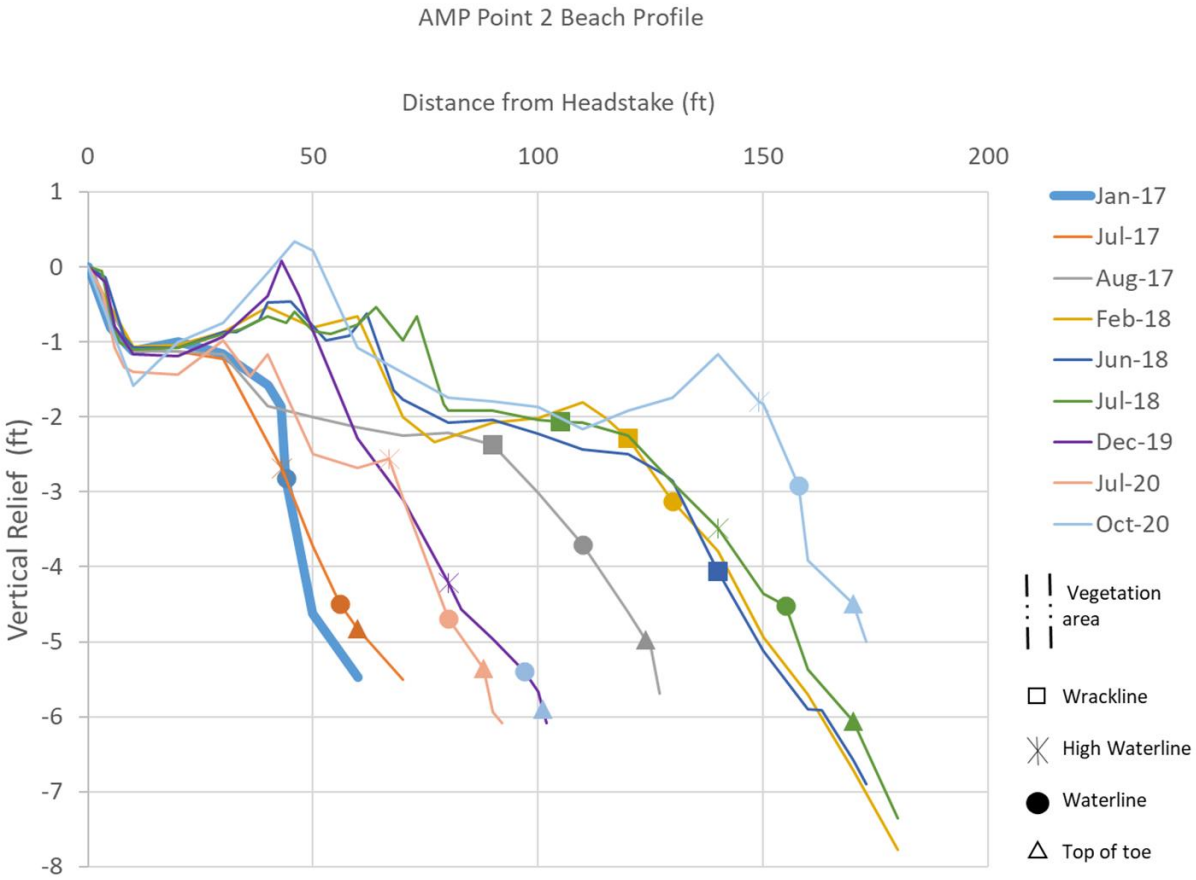
AMP Point 1



Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.27 ft	70 ft
July 10, 2017	1 ft	70 ft
Aug 7, 2017	1.95 ft	39 ft
Feb 2, 2018	1.53 ft	60 ft
Jun 28, 2018	-0.029 ft	101 ft
Jul 12, 2018	0.18 ft	96 ft
Dec 11, 2019	1.38 ft	74 ft
Jul 20, 2020	1.2 ft	130 ft
Oct 29, 2020	1.27 ft	100 ft
Average		82.2 ft

AMP Point 1 has experienced notable changes since 2017, indicating the dynamic nature of this point. After Super Typhoon Yutu, the shoreline has deepened and the berm has increased. The Oct 2020 transect data is an outlier, which may indicate surveyor error. The wrackline ranges from 32 to 116 ft, indicating that the length of this shoreline may be greatly influenced by tides.

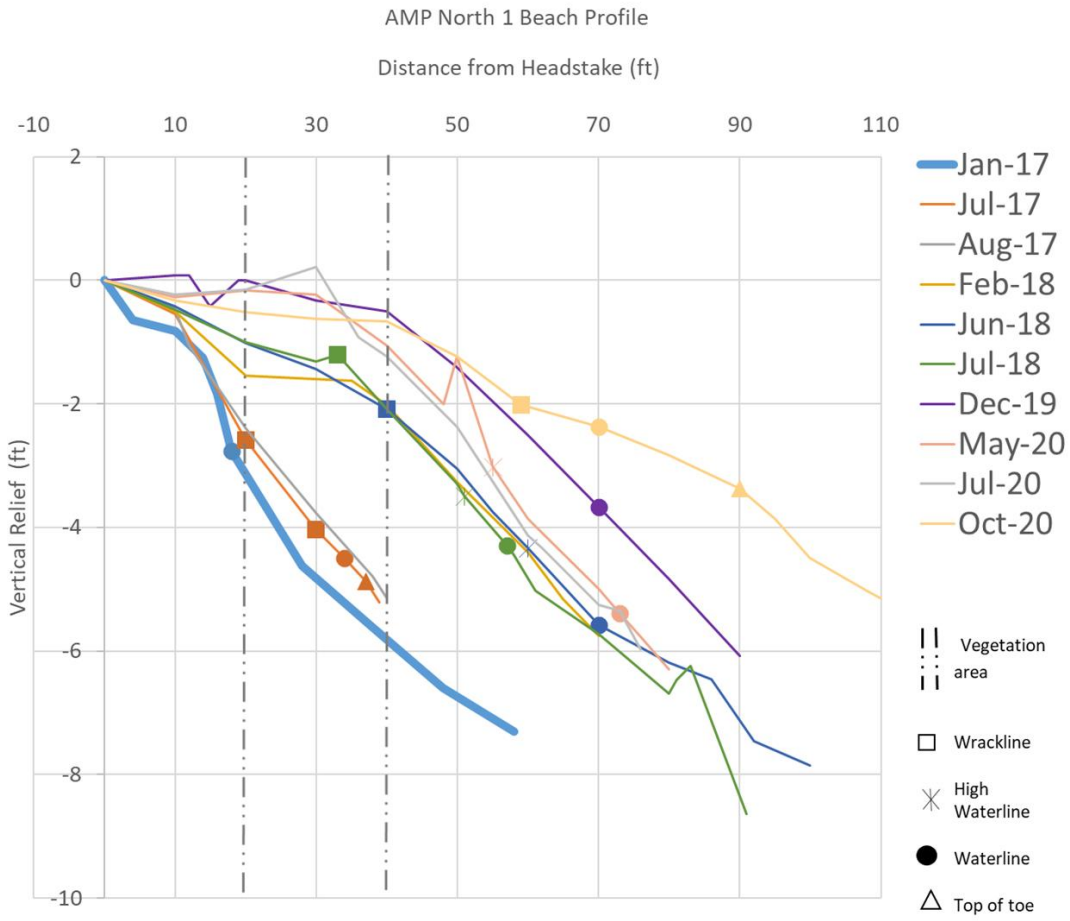
AMP Point 2



Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.16 ft	Not recorded
July 10, 2017	0.92 ft	56 ft
Aug 7, 2017	Not recorded	110 ft
Feb 2, 2018	Not recorded	130 ft
Jun 28, 2018	-0.14 ft	163 ft
Jul 13, 2018	1.18 ft	140 ft
Dec 11, 2019	1.29 ft	97 ft
Jul 10, 2020	0.74 ft	80 ft
Oct 10, 2020	1.57 ft	158 ft
Average		121.3 ft

AMP Point 2 appeared to be accreting from Jan 2017 – July 2018. After Super Typhoon Yutu, the shoreline noticeably abraded. There was a huge variation between the July 2020 and Oct 2020, which may indicate surveyor error. The high waterline ranged from 43 to 150 ft. The elevation difference from the farthest top of toe is 6 feet.

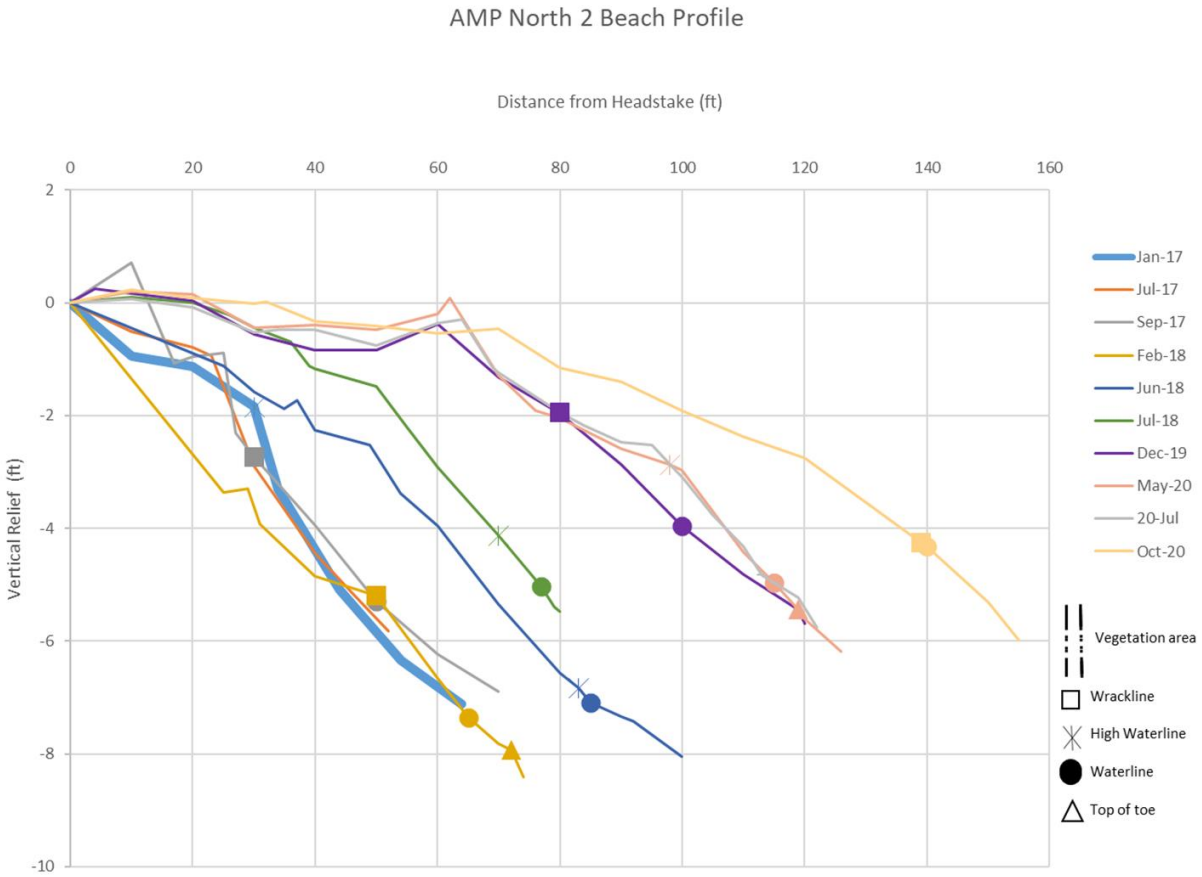
AMP North 1



Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.22 ft	58 ft
July 10, 2017	1.16 ft	34 ft
Aug 7, 2017	0.84 ft	30 ft
Feb 2, 2018	1.84 ft	35 ft
Jun 28, 2018	0.06 ft	70 ft
Jul 13, 2018	1.2 ft	57 ft
Dec 4, 2019	1.76 ft	70 ft
May 22. 2020	0.76 ft	73 ft
July 10, 2020	0.81 ft	62 ft
Oct 10, 2020	1.63 ft	70 ft
Average		57.2 ft

AMP North 1 appears to be generally accreting since Feb 2018. The shoreline length has appeared to triple in the last two years. Given the accretion, the wrackline is now at 59 feet from the headstake. The elevation difference from the farthest top of toe is 3 ft.

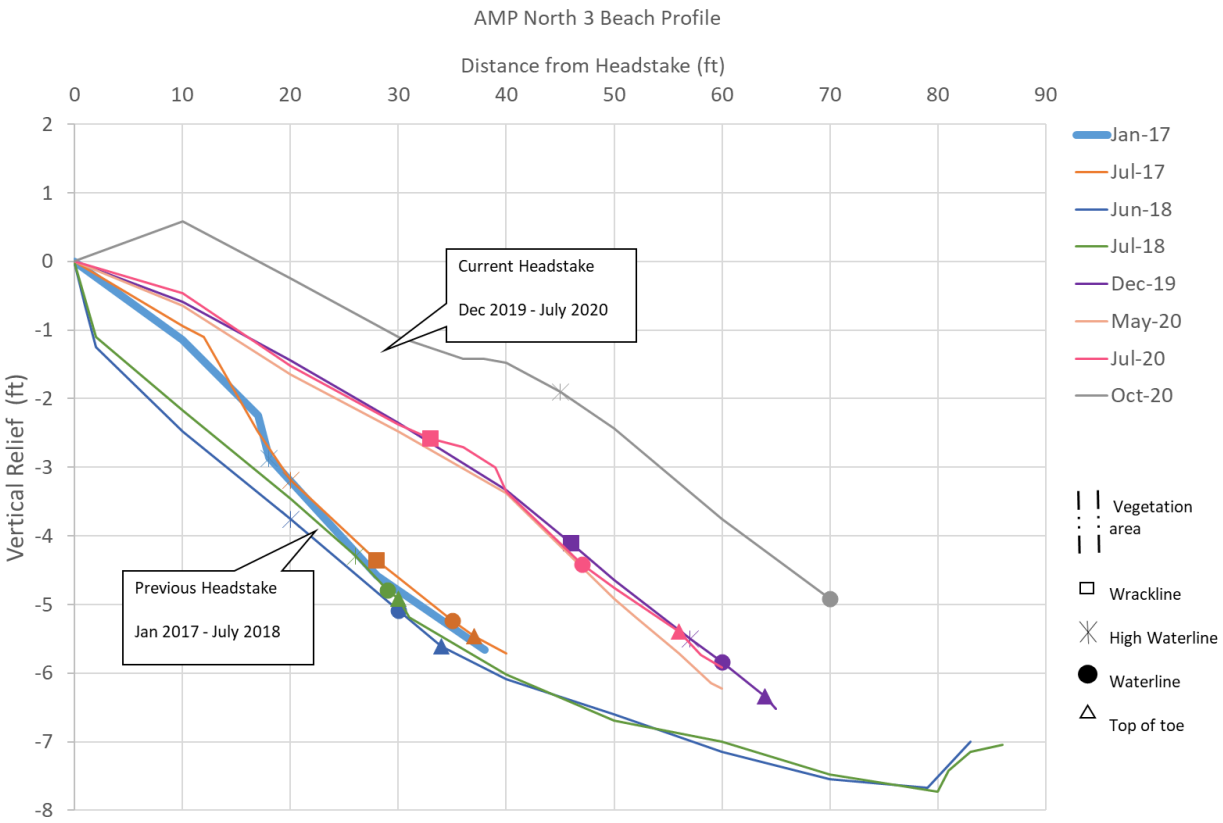
AMP North 2



Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.42 ft	64 ft
Jul 10, 2017	0.6 ft	46 ft
Sept 21, 2017	0.35 ft	50 ft
Feb 2, 2018	1.6 ft	65 ft
Jun 28, 2018	0.13 ft	85 ft
Jul 13, 2018	1.07 ft	70 ft
Dec 5, 2018	1.79 ft	100 ft
May 22, 2020	0.94 ft	98 ft
Jul 10, 2020	0.87 ft	113 ft
Oct 29. 2020	1.22 ft	140 ft
Average		83.1 ft

AMP North 2 appears to be accreting since Jun 2018. The shoreline length has doubled within the past three years. The wrackline ranges from 30 ft to 80 ft. The elevation difference from the farthest top of toe is 8 ft.

AMP North 3



Day Recorded	Tide	Shoreline Length
Jan 19, 2017	1.52 ft	Not recorded
July 10, 2017	0.52 ft	35 ft
Sept 21, 2017	Not recorded	30 ft
Feb 2, 2018	1.75 ft	20 ft
Jun 28, 2018	0.23 ft	Not recorded
Jul 13, 2018	0.97 ft	29 ft
Dec 11, 2019	1.25 ft	60 ft
May 22, 2020	1.01 ft	52 ft
Jul 10, 2020	0.95 ft	47 ft
Oct 23, 2020	0.52 ft	70 ft
Average		42.9 ft

AMP North 3 appears to be accreting. Oct 2020 appears to be an outlier compared to the previous months of 2020. Future measurements will verify this accretion.

Pau Pau Beach

Trend: Variable

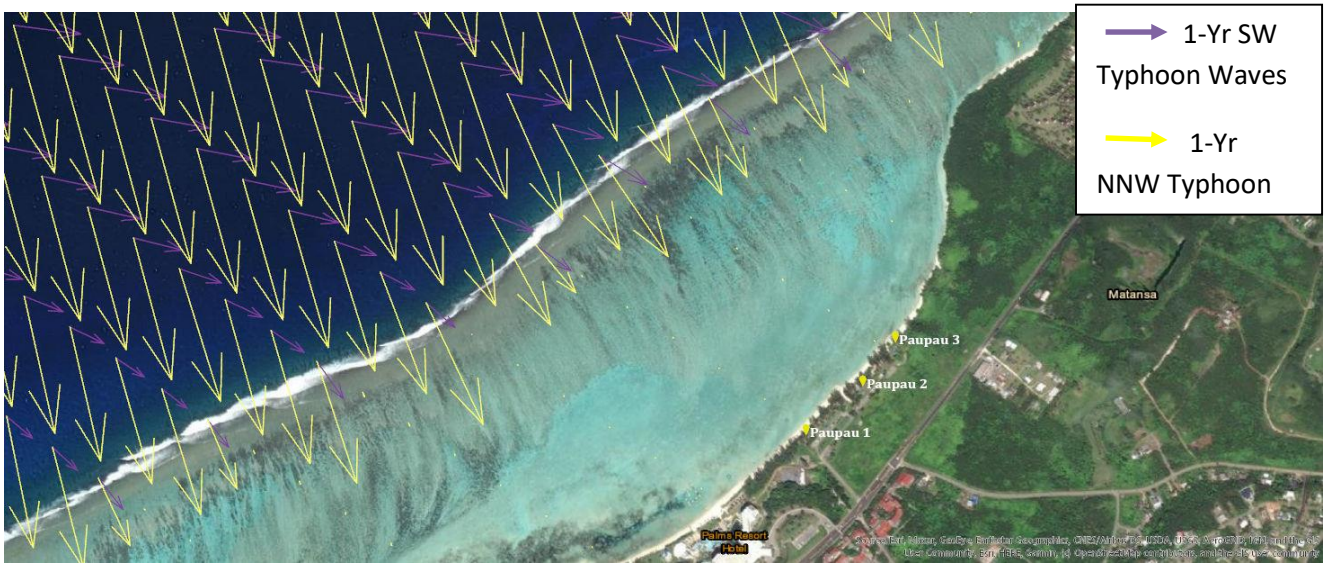
EPHR: Low

Average length: 68.7 ft

Average elevation: ~9 ft

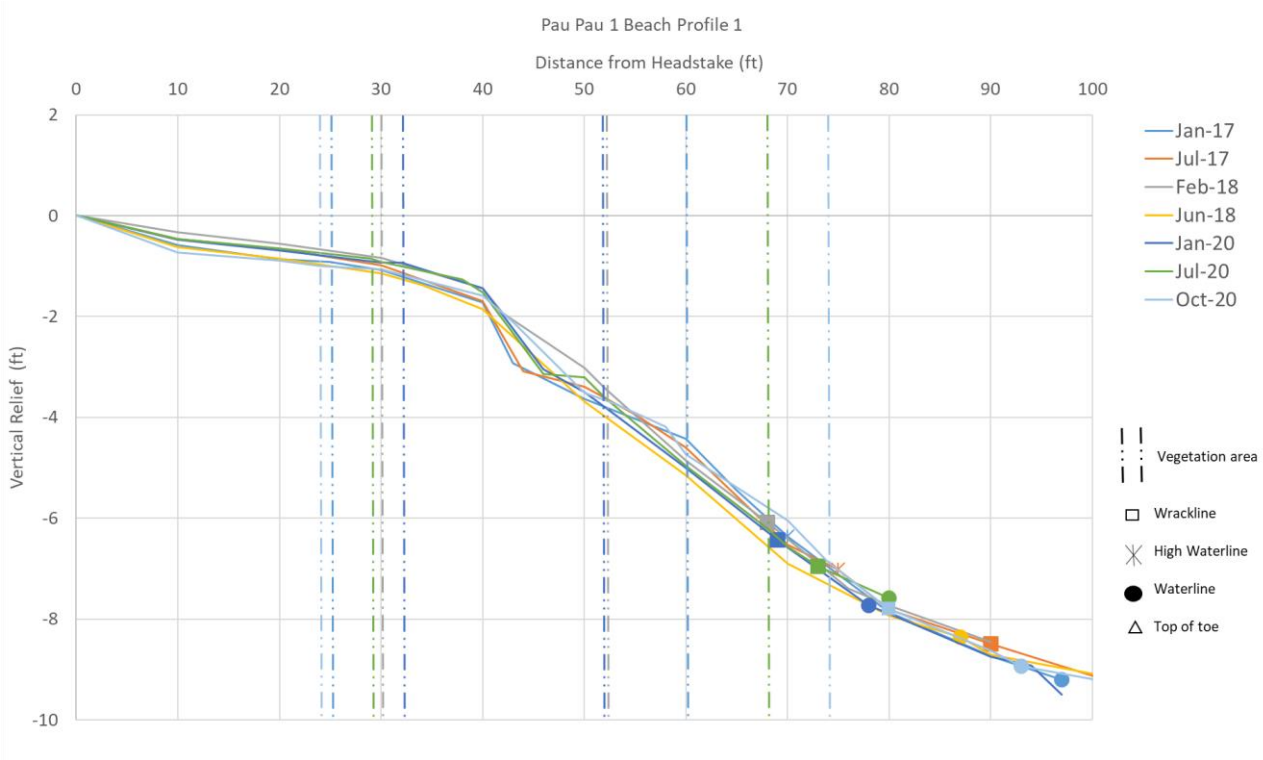
Pau Pau 3 (2018)

Pau Pau 3 (2020)



Pau Pau is generally stable with the shoreline length declining from the south to north. The nearby reef attenuates wave energy but wave overtopping may contribute to short-term erosion. Tides may influence the length of this shoreline. For both typhoon wave conditions, this area receives high wave energy. North-northwest typhoon conditions fare worse with significant wave height potential of up to 3 m.

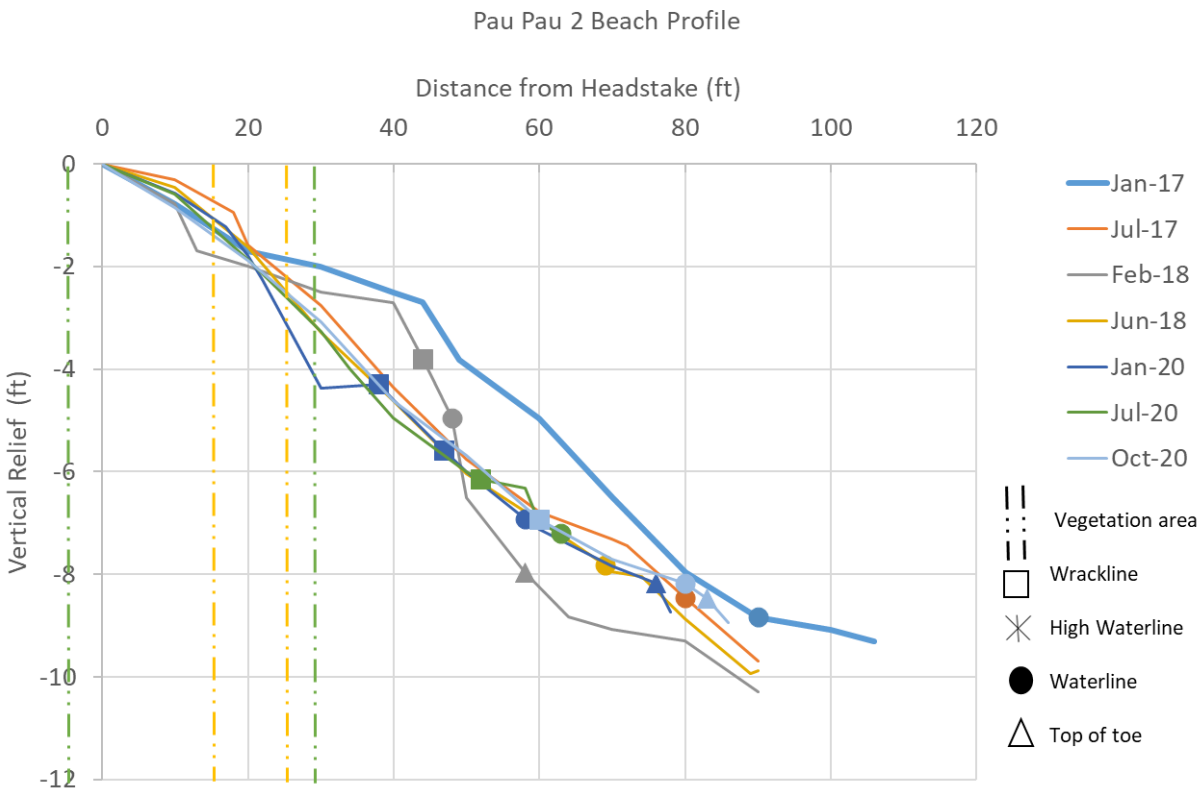
Pau Pau 1



Day Recorded	Tide	Shoreline Length
Jan 5, 2017	1.21 ft	80 ft
July 11, 2017	-0.05 ft	103 ft
Feb 9 2018	1.37 ft	No recorded
Jun 12, 2018	0.89 ft	87 ft
Jan 31, 2020	1.24 ft	78 ft
Jul 6, 2020	0.95 ft	80 ft
Oct 30, 2020	0.96 ft	93 ft
Average		86.8 ft

Pau Pau 1 transect appears generally stable. The wrackline ranges from 70 to 90 ft. The elevation difference between the headstake to the furthest top of toe is around 9 ft.

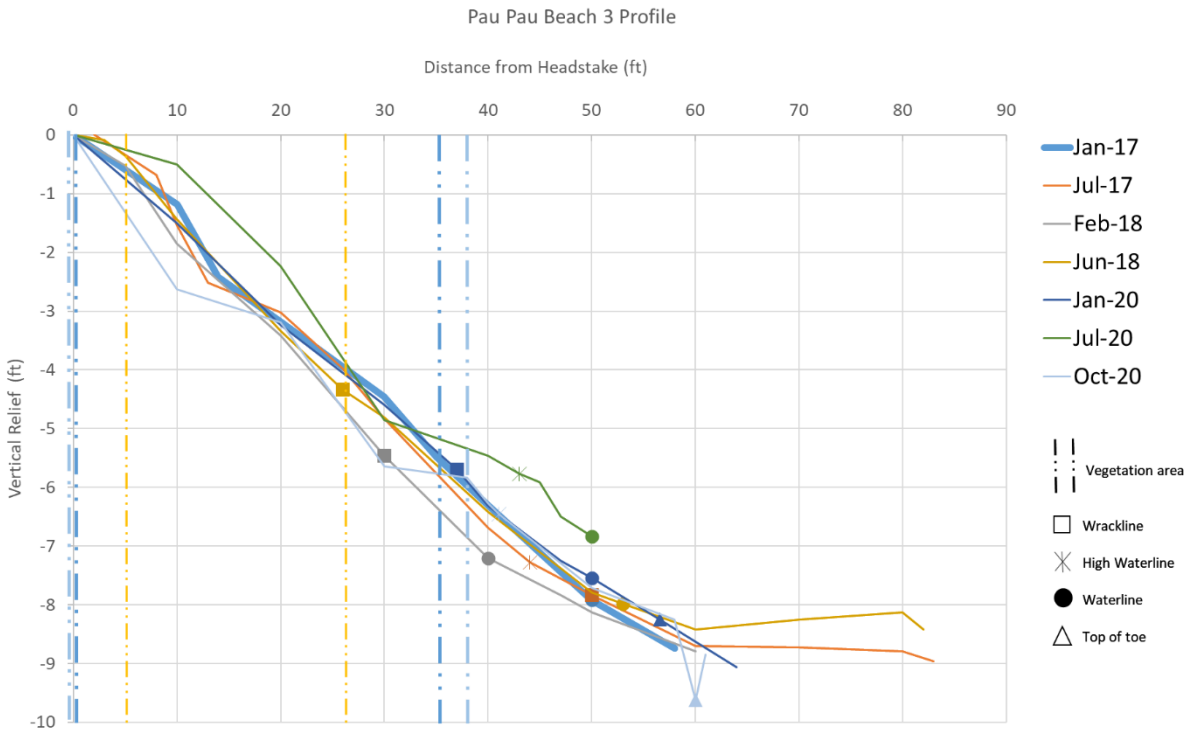
Pau Pau 2



Day Recorded	Tide	Shoreline Length
Jan 5, 2017	1.56 ft	90 ft
July 11, 2017	-0.14 ft	80 ft
Feb 9 2018	1.42 ft	48 ft
Jun 12, 2018	0.66 ft	69 ft
Jan 31, 2020	1.33 ft	58 ft
Jul 6, 2019	1.4 ft	63 ft
Oct 30, 2020	0.85 ft	80 ft
Average		69.7 ft

Pau Pau 2 transect has seen a shift in January 2017. The shoreline appears to have experienced some abrasion in Feb 2018 but then has generally stabilized over time. The wrackline ranges from 40 to 60 ft. The elevation difference between the headstake to the furthest top of toe is around 8 ft.

Pau Pau 3



Day Recorded	Tide	Shoreline Length
Jan 5, 2017	1.6 ft	50 ft
July 11, 2017	-0.16 ft	44 ft
Feb 9 2018	1.45 ft	40 ft
Jun 12, 2018	0.53 ft	53 ft
Jan 21, 2020	1.61 ft	50 ft
Jul 6, 2020	1.21 ft	50 ft
Oct 30, 2020	0.8 ft	60 ft
Average		49.6 ft

Pau Pau 3 transect is stable but appears to be more variable in shoreline position compared to the other two transects in the site. The wrackline ranges from 26 to 50 ft. The elevation difference between the headstake to the furthest top of toe is around 9.5 ft.

Wing Beach

Trend: Variable

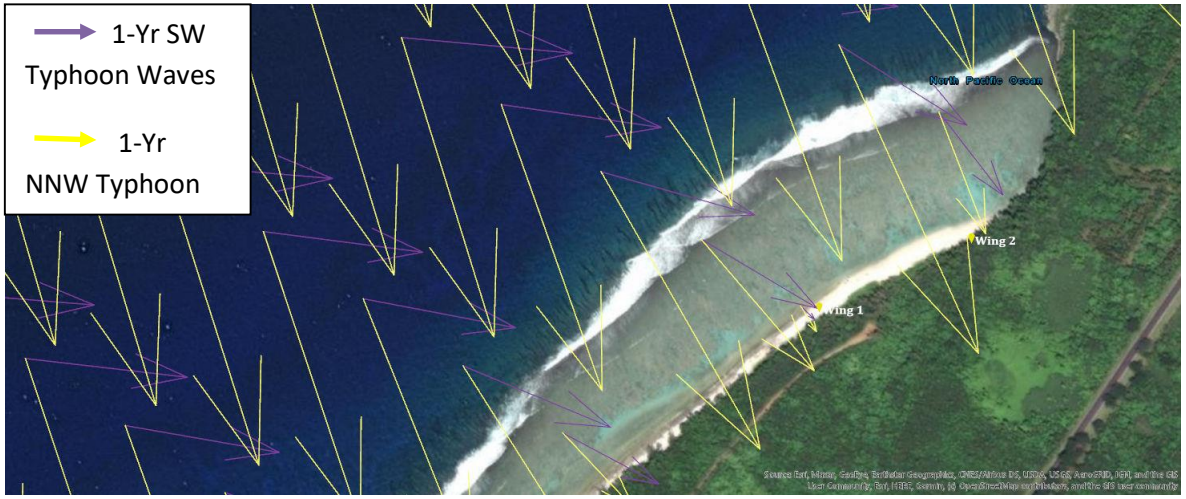
EPHR: N/A

Average length: 69.9 ft

Average elevation: 11.25 ft

Wing 2 (2018)

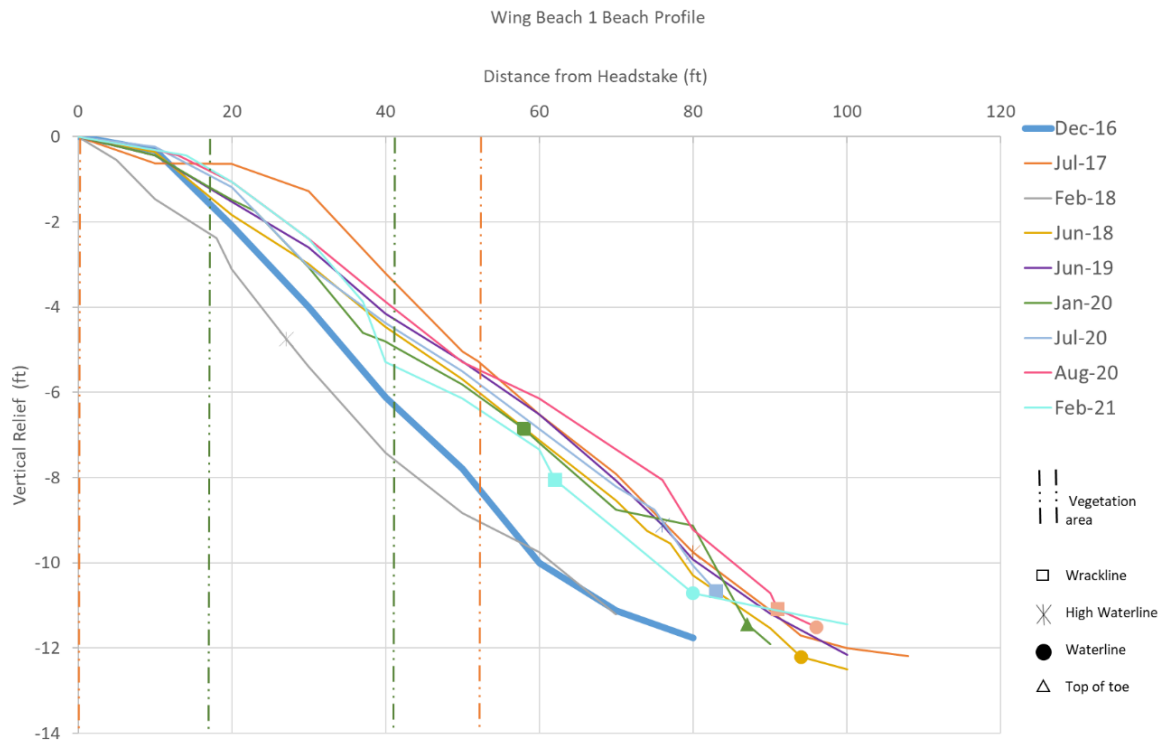
Wing 2 (2020)



As the most northern shoreline of Saipan, Wing Beach appears to have high diversity of coastal strand species and a coral rubble shoreline. Erosion is of low concern in this area despite the high potential for strong storm-induced wave energy to beat at the shoreline. Sediment input may have originated from the nearby reef, pouring sand and coral rubble inland.

The southwest and northwest typhoon conditions both bring in high wave energies. The north-north wave conditions fare worse with potential of up to 4 m significant wave heights.

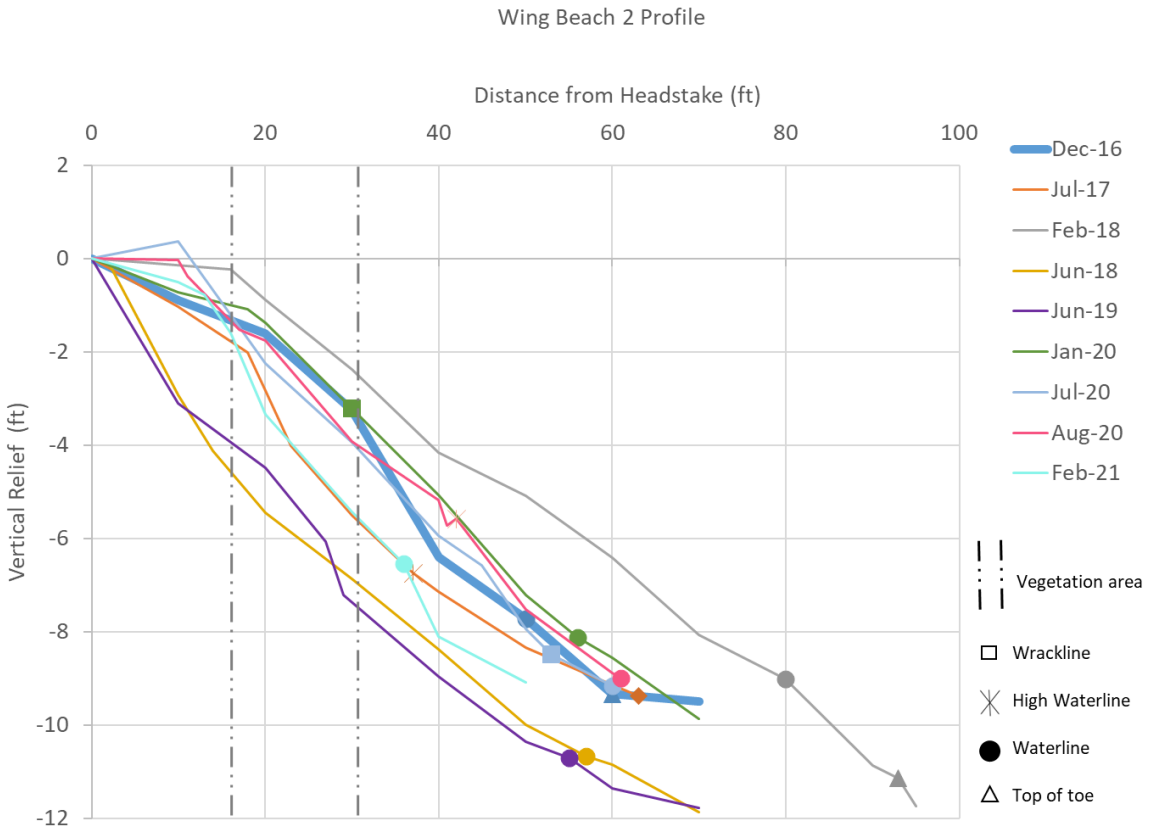
Wing 1



Day Recorded	Tide	Shoreline Length
Dec 20, 2016	1.65 ft	No record
July 11, 2017	0.25 ft	108 ft
Feb 2, 2018	1.16 ft	27 ft
Jun 26, 2018	0.68 ft	94 ft
Jun 26, 2019	0.59 ft	76 ft
Jan 31, 2020	1.6 ft	72 ft
Jul 6, 2020	0.94 ft	90 ft
Aug 10, 2020	1.28 ft	96 ft
Feb 16, 2021	1.42 ft	80 ft
Average		82.1 ft

Wing 1 transect appears generally stable. This beach profile may suggest that the shoreline experiences a good amount of sediment input and output from the influence of the nearby reef system. Feb 2018 had the most erosion while July 2017 saw the most accretion. The wrackline ranges from 58 - 91 ft. The elevation difference between the headstake to the furthest top of toe is around 11.5 ft.

Wing 2



Day Recorded	Tide	Shoreline Length
Dec 20, 2016	1.81 ft	50 ft
July 11, 2017	0.15 ft	63 ft
Feb 2, 2018	1.09 ft	80 ft
Jun 26, 2018	0.43 ft	57 ft
Jun 26, 2019	0.95 ft	55 ft
Jan 31, 2020	1.69 ft	56 ft
Jul 6, 2020	0.8 ft	60 ft
Aug 10, 2020	1.23 ft	61 ft
Feb 16, 2021	1.59 ft	36 ft
Average		57.6 ft

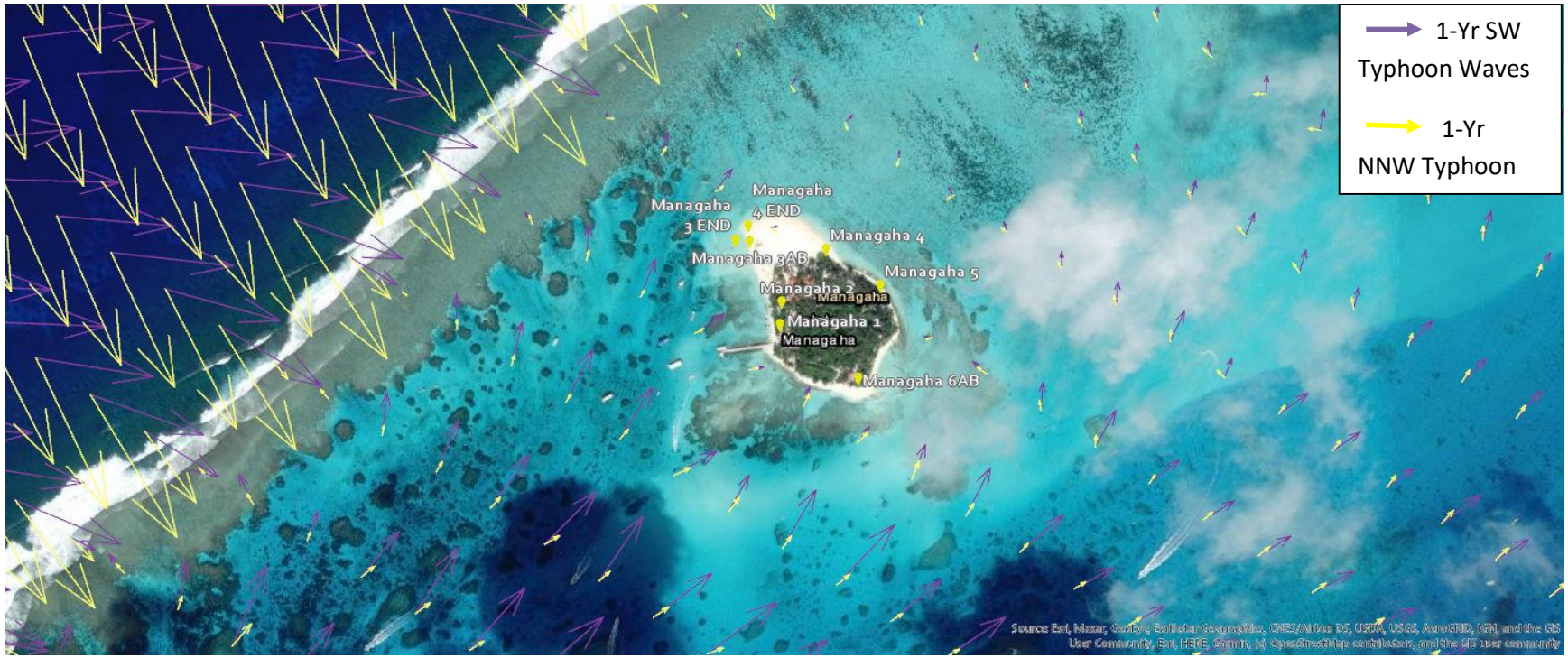
Wing 2 status is undetermined. Locating the headstake was challenging for this area given the loss of visible marking. Thus, there may be three differing headstakes for this transect. The 2020 data share the same known headstake. Based on observations from the Feb-21 record shows, a high tide with a high wave event greatly abrades the berm along this transect. With the input of coral rubble from the nearby reef, recovery to the average shoreline length is anticipated. The elevation difference between the headstake to the furthest top of toe is around 11 ft.

Mañagaha Beaches

Mañagaha experiences ocean currents from all angles as it is situated within the Saipan Lagoon. The Saipan channel is located east of the islet with the protected barrier reef to the west. In the 1990s, erosion was a concern expressed by users when the removal of WWII relicts caused a shift in the longshore processes. The eastern side, habitat to shearwater birds, is abrading away while the northwestern side has an expanding large dune-like sand bar. The Mañagaha Study (Fletcher, 2007) predicted that the island may potentially stabilize in the future. In the case it may not, stabilization efforts may be necessary to protect the eastern side.

Mañagaha Island taken by the DCRM Drone in 2020

Shoreline Monitoring on Mañagaha was conducted on 2017, 2018, and 2020. Aerial imagery was captured during these times and indicated that the sand bar has been growing. A sand berm developed and its height continues to increase. The erosion on the east side is not easily shown through aerial imagery but natural infrastructure, such as fallen ironwood trees and shoreline vegetation, and WWII relicts appear to be interacting with on-going longshore processes. Locating headstakes on the west side – especially Transect #3 (see pg 96) set on this newly developed berm – poses challenges and may be responsible for the error in the generated 3A and 3B beach profiles. Nonetheless, other beach profiles generated through Shoreline Monitoring have allowed for on the ground documentation of erosion at the east-side shoreline of the islet. Due to the high surveyor error in the Aug 2020 dataset, that was omitted.



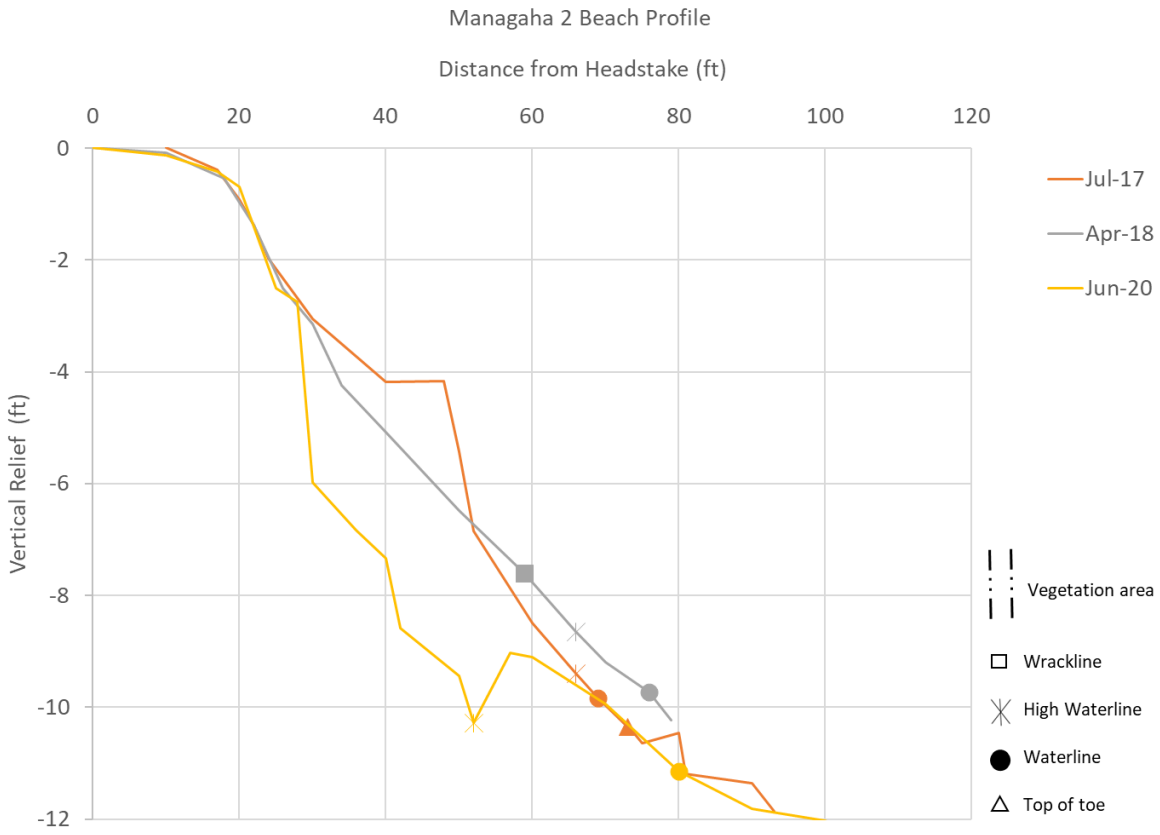
Mañagaha shorelines interact with all wave conditions within the Lagoon at all directions. The longshore transport slightly varies for the southwest and north-northwest wave conditions. During southwest conditions, longshore transport from the south is greater, which hits Transects 6A, 6B, 1, 2, 3A, and 3B. This longshore pattern seems to perpetuate the accretion occurring at Transects 3A and 3B. Transects 4 and 5 seem to be more impacted during the north-north west typhoon conditions. High wave energy occurs during the southwest typhoon condition, which appears to impact the southern part of the islet. For both conditions, the eastern side of the island appear to be eroding.

Mañagaha 1

Day Recorded	Tide	Shoreline Length
July 17, 2017	0.71 ft	43 ft
Apr 19, 2018	1.89 ft	50 ft
Jun 5, 2020	1.01 ft	50 ft
Average		48.3 ft

Mañagaha 1 transect appears to be eroding based on the steepening berm. There is a rocky segment that extends past the toe. Surveyor error may have skewed the measurements, but the headstake has remained the same. The wrackline ranges from 30 ft to 40 ft. The waterline has been fairly consistent. The elevation from the headstake to the furthest toe is 8 ft.

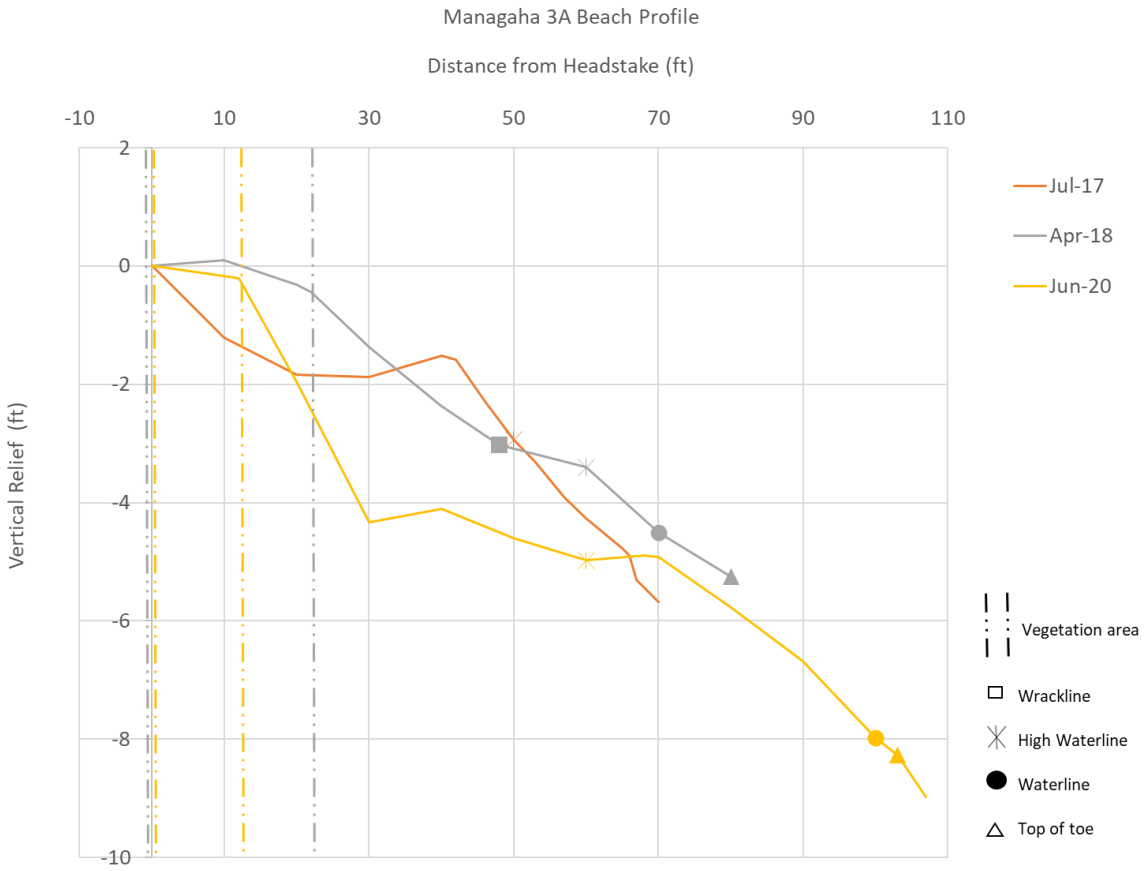
Mañagaha 2



Day Recorded	Tide	Shoreline Length
July 17, 2017	0.76 ft	69 ft
Apr 19, 2018	1.79 ft	66 ft
Jun 5, 2020	0.51 ft	52 ft
Average		66.8 ft

Mañagaha 2 transect exhibits erosion. The berm remained the same over the years but variation begins past the 25 ft distance from the headstake. Surveyor error may have scewed the measurements. The elevation from the headstake to the furthest toe is around 11 ft.

Mañagaha 3A



Day Recorded	Tide	Shoreline Length
Jul 17, 2017	0.89 ft	57 ft
Apr 19, 2018	1.66 ft	70 ft
Jun 5, 2020	0.25 ft	100 ft
Average		83.8 ft

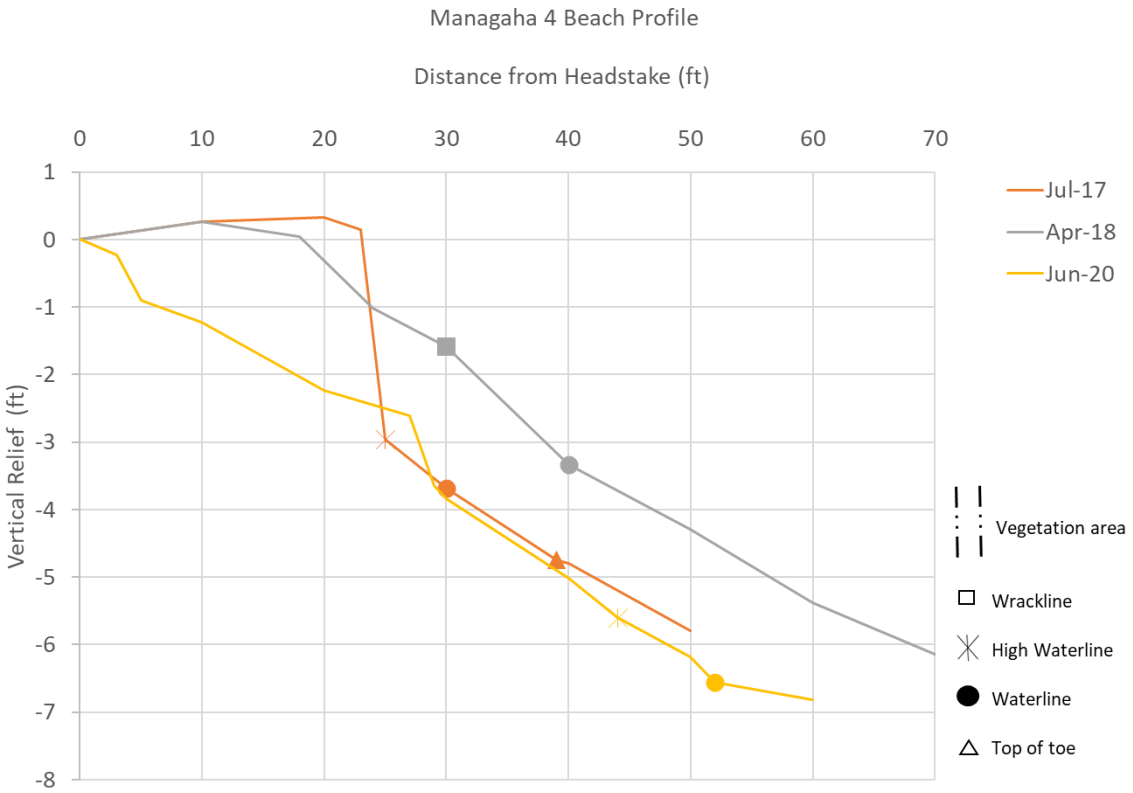
Mañagaha 3A transect has high variation due to surveyor error. The misidentification of the exact location of the headstake happen due to the loss of the physical headstake (a pole on the ground). However, despite this, the increasing length and physical observations confirm that this area is accreting. The headstake is on berm with increasing height. The elevation from the headstake to the furthest toe is around 8 ft.

Mañagaha 3B

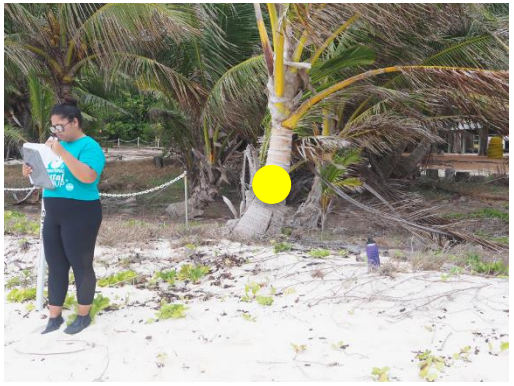
Day Recorded	Tide	Shoreline Length
Jul 17, 2017	1.27 ft	96 ft
Apr 19, 2018	1.56 ft	130 ft
Jun 5, 2020	0.92 ft	150 ft
Average		129 ft

Like Mañagaha 3A, Mañagaha 3B transect has high variation due to surveyor error, which may also be misidentification of the exact location of the headstake (which is the same as 3A). However, despite this, the increasing length and physical observation confirm that this area is accreting. The wrackline ranges from 90 to 100 ft. The headstake is on a growing berm that is getting higher.

Mañagaha 4

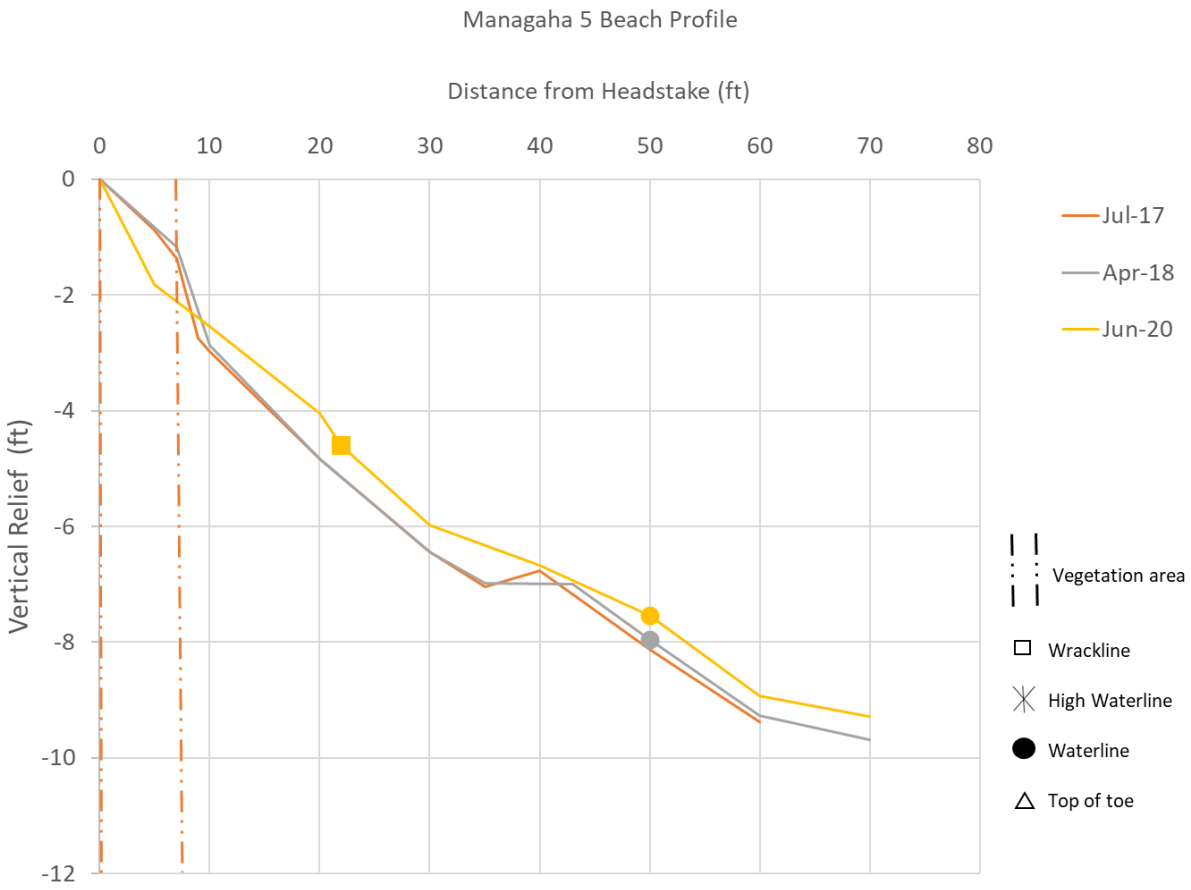


Day Recorded	Tide	Shoreline Length
Jul 17, 2017	1.05 ft	30 ft
Apr 19, 2018	1.4 ft	40 ft
Jun 5, 2020	0.72 ft	52 ft
Average		54.3 ft



Mañagaha 4 is eroding. The deep berm in Jul-17 has smoothen and retreated closer to the head stake over the years. The elevation from the headstake to the furthest toe is around 11 ft.

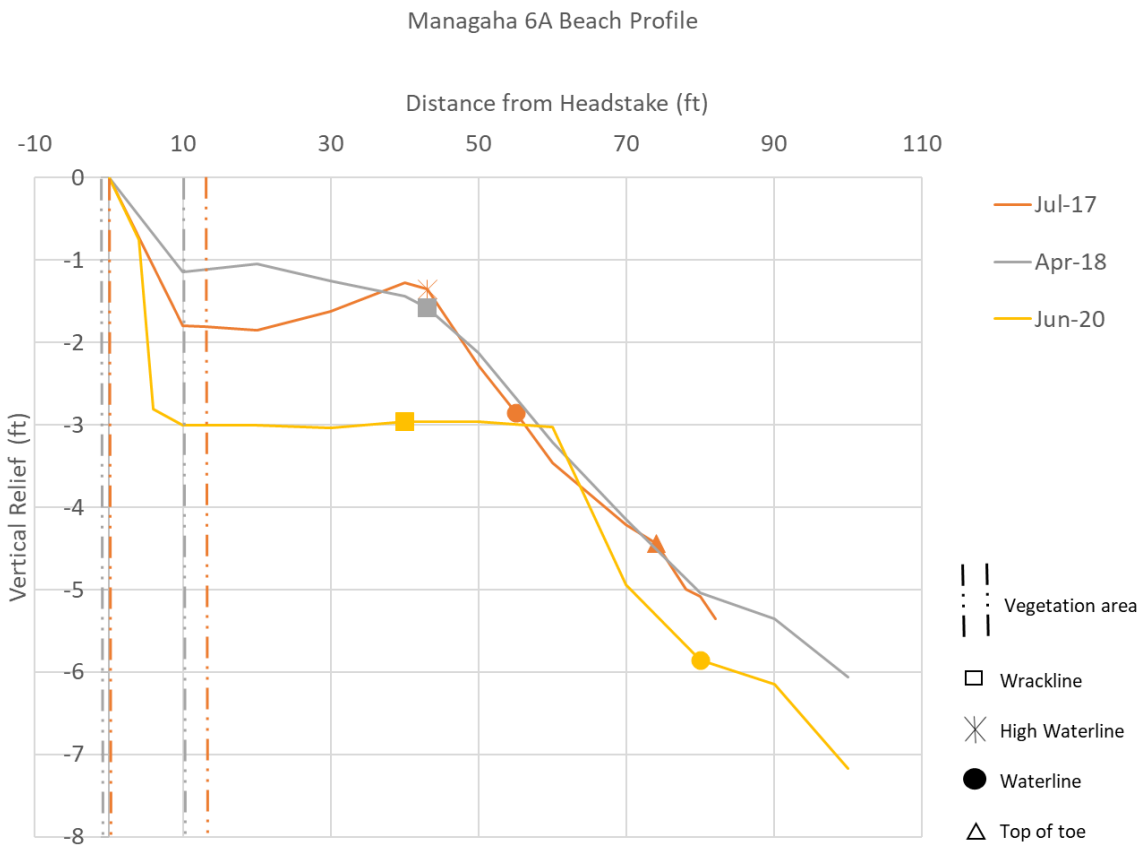
Mañagaha 5



Day Recorded	Tide	Shoreline Length
Jul 17, 2017	1.27 ft	Not recorded
Apr 19, 2018	1.04 ft	50 ft
Jun 5, 2020	Not recorded	50 ft
Average		50 ft

Mañagaha 5 appears relatively stable. Aug-20 transect record is an outlier and could be due to surveyor error. The wrackline ranges from 22 to 32 ft. The elevation from the headstake to the furthest toe is around 9 ft.

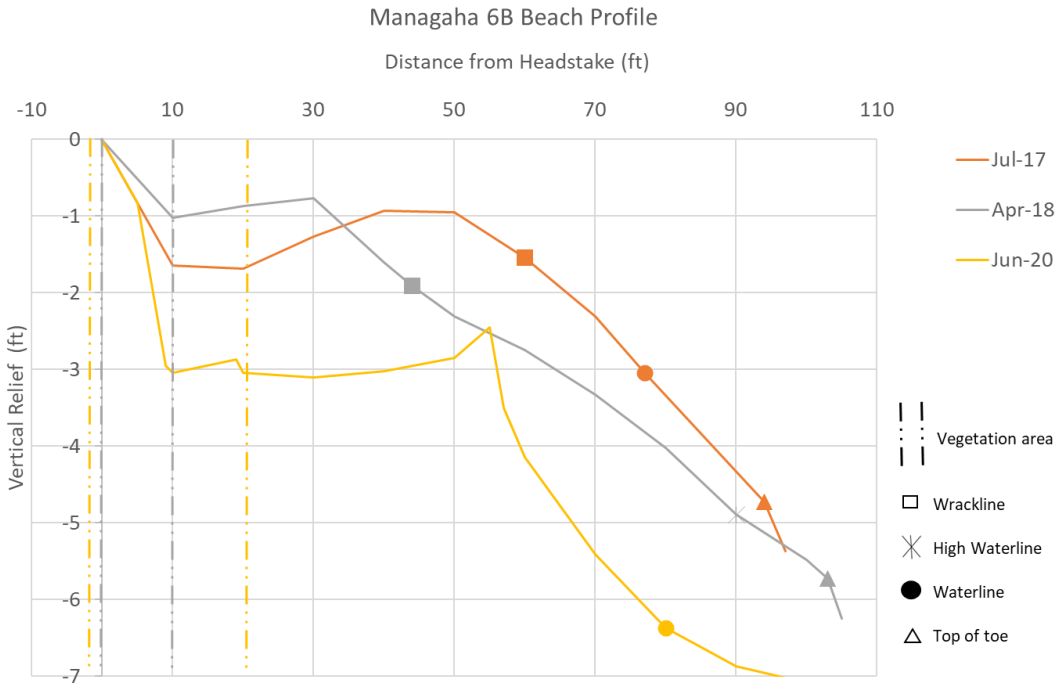
Mañagaha 6A



Day Recorded	Tide	Shoreline Length
Jul 17, 2017	1.37 ft	55 ft
Apr 19, 2018	0.89 ft	Not recorded
Jun 5, 2020	0.82 ft	80 ft
Average		55 ft

Mañagaha 6A appears to be eroding. The wrackline ranges from 40 to 43 ft. The elevation from the headstake to the furthest toe is around 6 ft.

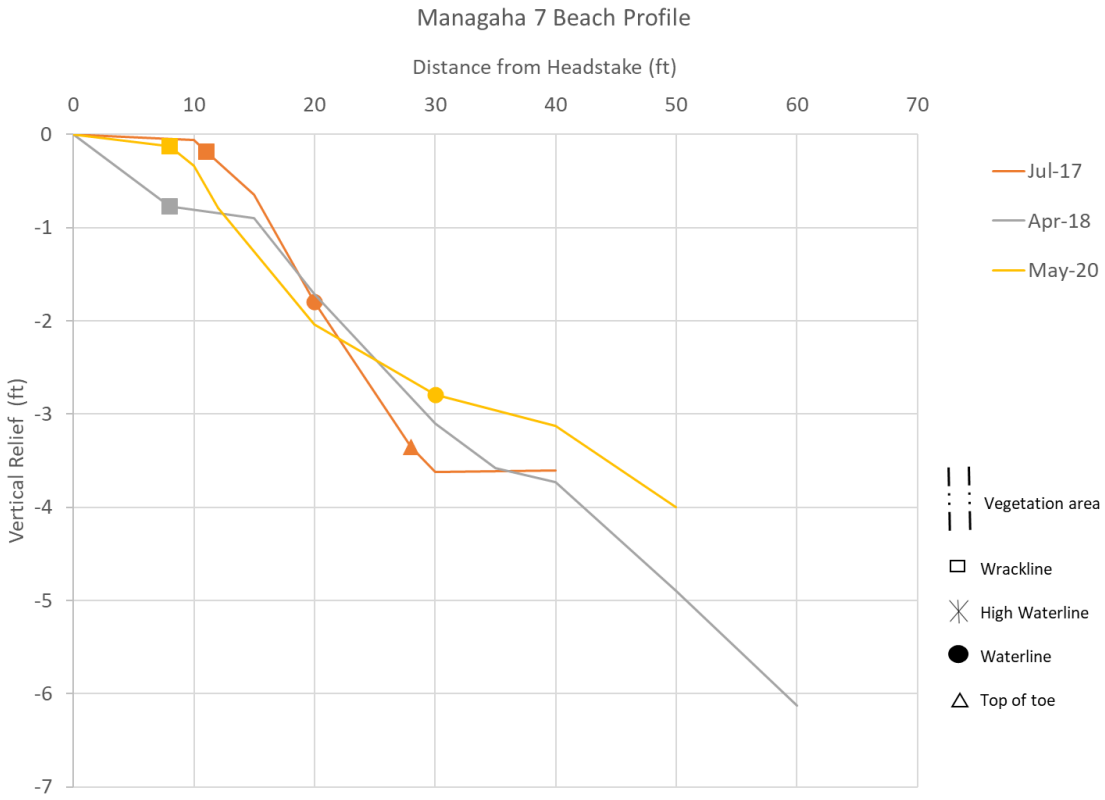
Mañagaha 6B



Day Recorded	Tide	Shoreline Length
Jul 17, 2017	1.4 ft	77 ft
Apr 19, 2018	0.83 ft	100 ft
Jun 5, 2020	Not recorded	80 ft
Average		88.3 ft

Mañagaha 6B appears to be eroding. However, there could be surveyor error in this transect. Future data entries will improve the understanding of this change trend. The wrackline ranges from 44 to 60 ft. The elevation from the headstake to the furthest toe is around 6 ft.

Mañagaha 7



Day Recorded	Tide	Shoreline Length
Jul 17, 2017	1.37 ft	20 ft
Apr 19, 2018	0.73 ft	Not recorded
May 2020	0.95 ft	30 ft
Average		25 ft

Mañagaha 7 appears to be relatively variable. Aug-20 transect record is an outlier. The wrackline ranges from 8 to 11 ft. Seasonal variation and tidal influence are potential factors for this deviation. The elevation from the headstake to the furthest toe is around 4 ft.

Summary

For the past three years, the DCRM Shoreline Monitoring team have monitored 62 transects on Saipan and Mañagaha. 18 transects have exhibited erosion from longshore transport during this time while 11 appear to be accreting. Given the dynamic nature of shoreline morphology and sediment transport, there are 25 'stable' and 8 'undetermined.' See 'Trends of Shoreline Monitoring Transects' on page 109. These trends only reflect on beach profile contour interpretations and do not directly account for sea level rise. As the program approaches a decade, sea level rise may be more detectable with the decreasing distance of the recorded wrackline data. The Oleai through Quartermaster shoreline stretch is generally stable in shoreline profile yet their short transect lengths make them vulnerable to sea level rise impacts.

The stretch from Micro Beach to Fiesta is highly eroded from high wave conditions generated during the winter and summer typhoon tradewind conditions. Other erosion hotspots include PIC 2 and Hopwood 1.

Hafa Adai and AMP transects (within the National Park Service vicinity) appear to receive sand deposition from ongoing longshore transport process.

As shoreline monitoring data collection progresses, we may have a stronger understanding of 'stable' and 'undetermined' transects.

Anticipated improvements to the program are identified but not limited to: a) the integration of the total station and drone aerial imagery for accurate surveying, b) continued use of compass direction to reduce inaccuracies when laying the transect, and c) monitoring schedule devised for sites sensitive to seasonal variation.

The last identified improvement addresses questions posited at the Introduction section. The shoreline monitoring aims to be more consistent with tide seasonality for improved recording of the wrackline before or during high tide. Sensitive sites prone to erosion and accretion will be monitored during or after higher energy wave conditions. For improved analysis, beach profile software with shoreline change rate and volume calculations capability is recommended. The calculated shoreline change rate and volume calculations would advance status determination of transects.

Recommendations for Management

The Shoreline Monitoring Report identified sources of error within the current protocol. With improved shoreline data and higher confidence, we can begin to implement site-specific shoreline set backs which DCRM has an identified need. Based on our findings, we recommend the following:

1) Developing a long term planning strategy to address Garapan shoreline's ongoing erosion

2) Encouraging affected entities to consider nature-based solution options rather than hardening when appropriate

3) Acquiring storm surge modelling data to integrate into shoreline set back requirements

4) Minimizing beach grooming maintenance at berms of eroding shorelines

5) Developing and implementing shoreline erosion outreach to affected stakeholders

Trends of Shoreline Monitoring Transects

(Dec 2016- Feb 2021)

Site	Transect	Accreting	Eroding	Stable	Undetermined
Pakpak	1			X	
	2			X	
	3			X	
PIC	1			X	
	2		X		
	3			X	
Hopwood	1		X		
	2			X	
	3				X
Aquarius	1	X			
	2	X			
Sugar Dock South	1				X
	2		X		
	3		X		
Sugar Dock North	1			X	
	2		X		
	3		X		
Susupe Beach Park	1				X
	2			X	
	3			X	
Kilili South	1	X			
	2			X	
	3				X
Kilili North	1	X			
	2			X	
	3			X	
Oleai	1			X	
	2		X		
Toyota	1			X	
	2		X		
	3			X	
Quartermaster	1			X	
	2			X	
Hafa Adai	1			X	
	2				X
	3	X			
Fiesta	1			X	
	2		X		
	3		X		
Hyatt	1		X		

	2		X		
AMP South	1		X		
	2				X
AMP Point	1				X
	2	X			
AMP North	1	X			
	2	X			
	3	X			
Pau Pau	1			X	
	2			X	
	3			X	
Wing	1			X	
	2				X
Mañagaha	1		X		
	2		X		
	3A	X			
	3B	X			
	4		X		
	5			X	
	6A		X		
	6B		X		
	7			X	

Glossary of Terms

Accretion

The gradual addition of land by deposition of water-borne sediment.

Berm

The nearly horizontal portion of the beach or backshore formed by the deposit of materials by wave action. (In the CNMI, the berm is a vertical drop.)

Berger Level

Used to accurately measure the height of an inaccessible object. Takes cross sectional picture of a beach's contour.

Drop

The point at the bottom of the berm or changes in elevation.

Erosion

The wearing away of land and the removal of beach (or dune) sediments by wave action, tidal currents, drainage, or high winds.

Foreshore

The part of the shore that lies between high and low water mark at ordinary tide.

Headstake

The starting point of a transect. Usually marked on a tree in paint.

High Waterline

The level reached by the sea at high tide.

Level Rod

Used with a leveling instrument to determine the difference in height between points.

Measuring Rope

100 ft. rope measure is laid along the shore to be profiled.

Moat or Toe

The point of a beach that juts out past the waterline. Often this is sand that is covered by water but may be exposed during low tides.

Transect

A straight line or narrow section across the earth's surface along which observations are made or measurements are taken.

Tripod

Supports or holds the Berger Level.

Vegetation Line

The first line of stable and natural vegetation, separate from grass. Also the boundary between the sand beaches.

Waterline

A line that marks the surface of the sea on land.

Wrackline

The line of debris that is left by high tide. Usually made up of eelgrass, pebbles, and litter.

Other terms

- Abrasion – the process of scraping or wearing away
- Beach Profile – cross-sectional trace of the beach from the headstake to the water
- Beach Nourishment – practice of adding sand or sediment into the beach to address erosion
- Dredging – maintenance practice of sand removal for deepening water depths for docks, harbors, or channels
- Dynamic – constantly changing
- Elevation difference – the height difference of the headstake to the beach toe
- Hydrodynamics – science revolving around the motion of fluids acting on solid bodies. For this report, it is the motion of waters surrounding the west coast of Saipan acting on corals and other physical objects in the water during wave conditions.
- Incidental erosion – a reversible process after cross-shore processes attack the shoreline during extreme events

- Outlier – observation that is at an abnormal distance from other values in a random sample from the population
- Risk – chance that something or someone will experience negative impacts from a coastal hazard
- Scarp – a drop formed by erosive forces
- Shoreline change – change in the shoreline contour by loss or gain of sand volume
- Stable/stability – a state in which the shoreline appears to return to its original condition over time even when disturbed
- Stabilization measures – known approaches to address coastal erosion, whether structural or nature-based
- Sediment transport – hydrogeological process in which waves currents push sediment into or away from coastal spaces
- Trade winds – winds that reliably blow east to west just north and south of the equator
- Wave overtopping – when waves meet a submerged reef or structure
- Wave run up – maximum vertical extent of wave uprush on a beach above the still water level

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