
**MEMORANDUM – COASTAL ENGINEERING REVIEW
SOUTHEAST REGION OFFICE – IMPLICATIONS OF REMOVAL OF
DISPLACED RIPRAP AND JETTY CREATION
TAR 20171**

4 May 2022

INTRODUCTION AND TECHNICAL ASSISTANCE REQUEST (TAR)

Salt River Bay National Historical Park and Ecological Preserve (SARI) is located along the north/central coast of St. Croix, United States Virgin Island (USVI) (figure 1). SARI was created by Congress in 1992 to preserve, protect, and interpret nationally significant natural and cultural resources. It contains 73 acres of National Park Service (NPS)-owned land, and its full boundaries contain a combination of marine, estuarine, and terrestrial habitats, including coral reefs, seagrass beds, an undersea canyon, and the largest remaining mangrove forest within the USVI (NPS 2008). The area of interest is on the east side of Salt River Bay and includes the Mangrove Lagoon and Hemmer Point (figure 2).

Recent hurricanes have caused ongoing erosion of Hemmer Point. A hurricane recovery/restoration project for SARI was funded in December 2021. Rock riprap placement is proposed at the tip of Hemmer Point Peninsula to stabilize the dynamic area and prevent further erosion of the peninsula. Concurrently, ongoing sediment accretion has caused the narrowing and subsequent closing, in March 2022, of the mouth of Allaine Bay (figure 3).

In this TAR, the National Park Service is requesting an evaluation of the proposed statement of work (SOW) to stabilize Hemmer Point with riprap and also an assessment to determine if the southern accretion pattern that closed the mouth of Allaine Bay will continue and extend south of Hemmer Point. There is concern that if this were to occur, it could restrict the tidal flushing of Mangrove Lagoon (shown in figure 3). Mangrove Lagoon is one of 14 known persistent bioluminescent bays worldwide (Pinckney et al. 2018) and has become an important ecotourism destination to view the bioluminescent plankton. The National Park Service is concerned that this community could be impacted if tidal flows into Mangrove Lagoon are altered significantly from further sedimentation.

This memorandum evaluates coastal data and historic imagery/maps to assess conditions at the project site and provides additional considerations for evaluating sedimentation/erosion patterns and their impacts on Allaine Bay, Hemmer Point, and Mangrove Lagoon. It also provides comments on the proposed SOW for the placement of riprap intended to facilitate the stabilization of Hemmer Point.

Figure 1. Location of SARI on St. Croix Island, USVI and Location of the Area of Interest

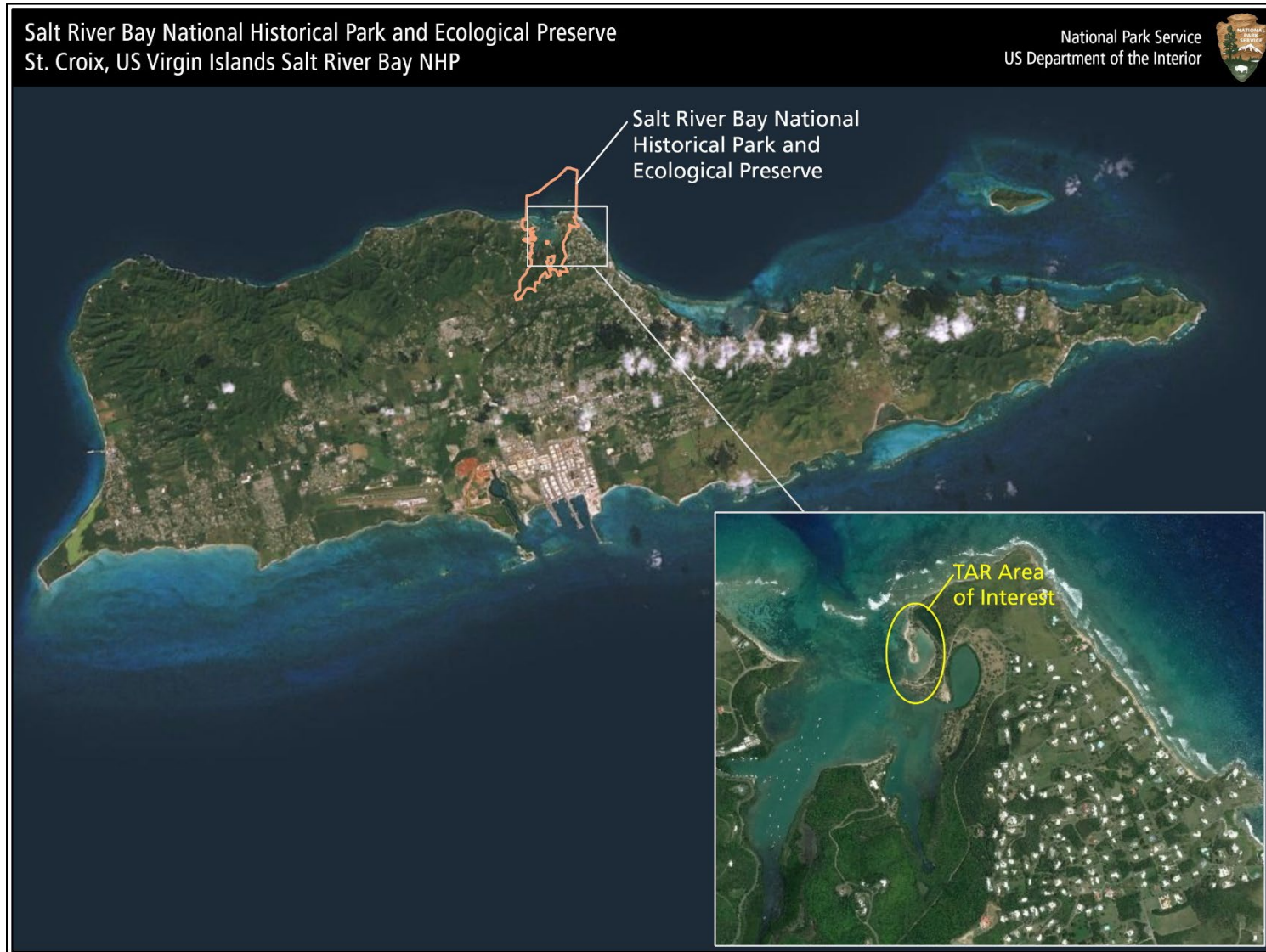
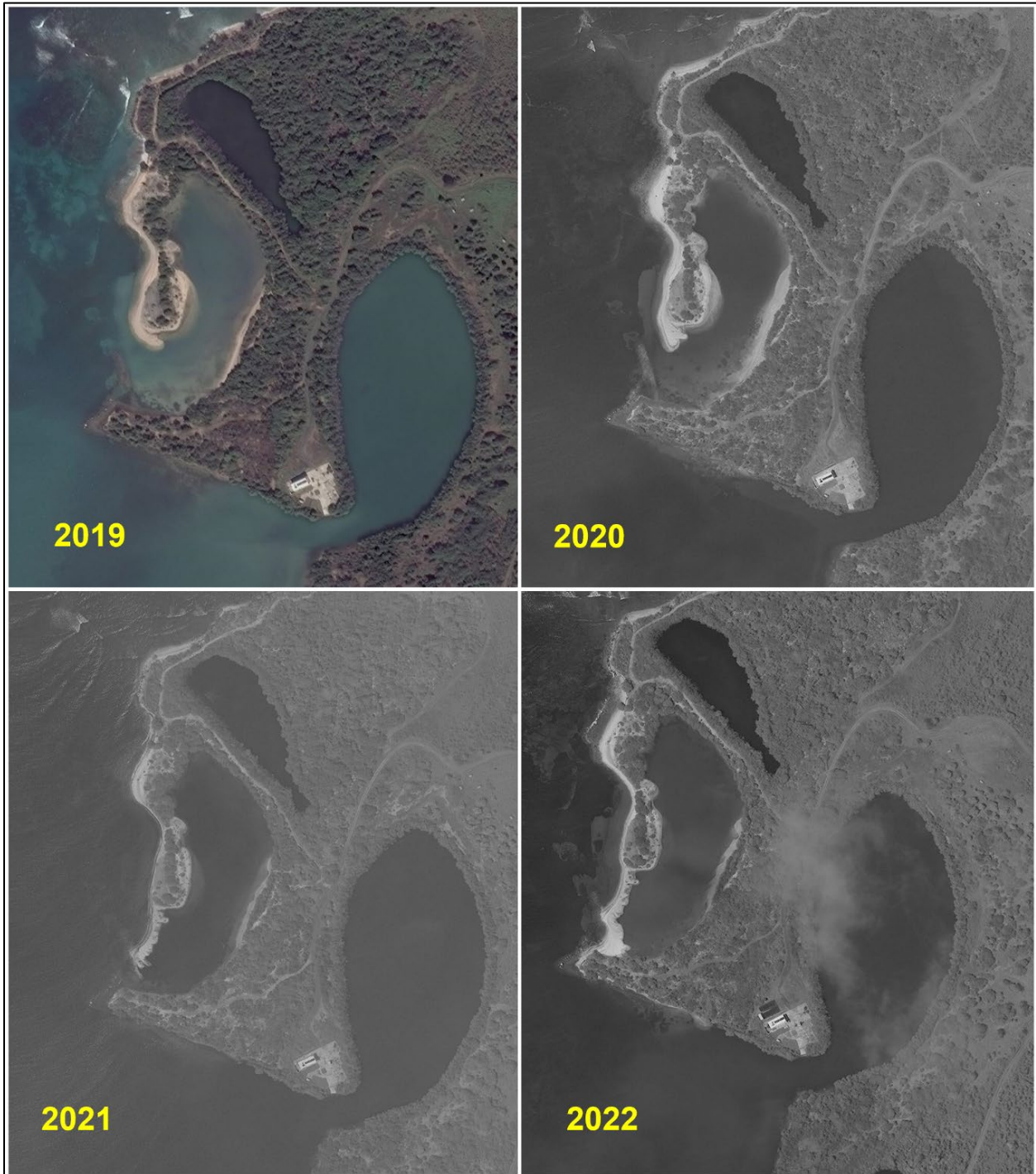


Figure 2. 2019 Aerial Image of the Area of Interest (NPS 2022)



Figure 3. Aerial Imagery from 2019 through 2022 Showing the Closure of Allaine Bay (NPS 2022)



Existing Conditions

The USVI climate is controlled largely by the trade winds that vary seasonally in magnitude but are nearly unidirectional from the east/northeast, as shown in figure 4 (Roberts 2004). This wind field directly affects wave and water currents, setting up an asymmetric wave pattern from the east and an east-to-west longshore current across the northern coast of St. Croix. Hydrodynamic forces in SARI are therefore wind-dominated as well with minor influence attributable to tidal activity that has a range of less than 1 foot (Kendall et al. 2005). Surface water enters Salt River Bay over the reef crest along the east side of the park, entering proximal to the spit that protects Allaine Bay in the area of interest (Kendall et al. 2005, figure 4). From there, currents rotate and continue westward, exiting through the Salt River Canyon. Typical wave heights are 1 to 3 feet with periods of 4 to 6 seconds, predominantly from the east/northeast (Kendall et al. 2005). These physical forces set up sediment transport patterns and suggest that deposition occurs in a southern/southwestern direction in the area of interest. Energy likely slows as it encounters the shallower depths of Salt River Bay after entering over the reef, depositing material. Water depths are shown in figure 5. The data show that water depths within and directly outside of Allaine Bay are shallow, approximately -1.3 to -3.9 feet in 2014 and 2019. Elevation data within Mangrove Lagoon are sparse in 2014 but suggest shallow depths of approximately -0.3 feet. Data collected in 2019 did not include data for Mangrove Lagoon but did indicate slight elevation changes in the Allaine Bay area as compared to 2014 (NOAA 2014 and Dewberry 2020).

Orthoimagery from 2007 through 2022, available through National Oceanic and Atmospheric Administration's (NOAA's) mapping website, was downloaded and analyzed for the area of interest and is shown in figure 6. This imagery confirms an overall southern/southwestern depositional pattern, showing consistent accretion of the spit that protects Allaine Bay from 2007 to 2020. This imagery also shows that as the spit accretes, it becomes vegetated, increasing the stability of the feature. The southernmost 250 feet of the spit is unvegetated in the 2010 image, and then has well-developed vegetation with approximately 50 additional feet of southern accretion and increased width of approximately 50 feet in the 2017 image. The stability this vegetation provides is also evident because of the minimal erosion that occurred from 2017 to 2020, after the hurricane activity that occurred in 2017 during Hurricanes Maria and Irma.

Historic Overview

Many of the shoreline features in the area of interest are products of anthropogenic activity. The topographic evolution of the area of interest is presented in figure 7, showing historic maps from 1954, 1977, and 2013. Hemmer Point Peninsula was created from dredged material and Mangrove Lagoon was widened and connected to Salt River Bay between 1954 and 1977 (NPS 2008). Historic bathymetry from 1977 to 1982 (Kendall et al 2005, figure 8) indicates that depths in historic Allaine Bay ranged from 3 to 6 feet and Mangrove Lagoon was deeper, around 9 to 12 feet deep. It is not known whether the salt pond northeast of Allaine Bay closed naturally or was closed anthropogenically as part of the dredging/construction of Hemmer Point Peninsula. The 2000 map shows that the coast of Mangrove Lagoon and the pond to the northeast of Allaine Bay had greater than 65% canopy coverage of mangrove *Avicennia germanis* fringing their shoreline – with no mangroves present Allaine Bay (figure 9, Kendall et al. 2005).

Figure 4. Water Currents at Allaine Bay

In this figure, the left panel shows wind frequency and direction at SARI. Each ring of the circle marks a percentage of time that wind blew from that cardinal direction (Roberts 2004). The right panel shows a map of generalized water currents at SARI (adapted from Kendall et al. 2005).

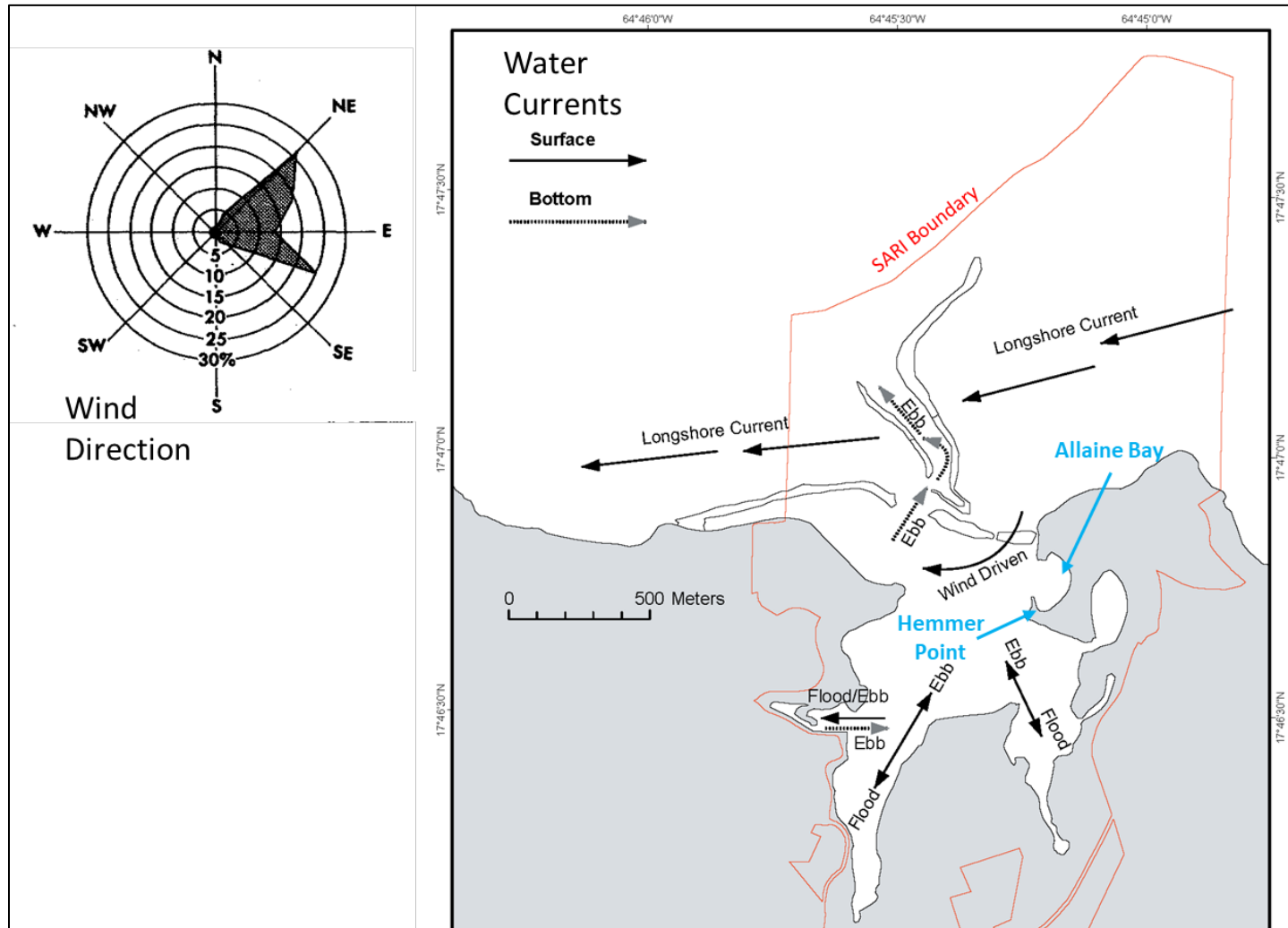


Figure 5. Water Depths at Allaine Bay

This figure presents 2014 and 2019 topobathy in the left and right panels, respectively, with 2017 orthoimagery in the center for reference. Depths are in meters (NOAA 2014 and Dewberry 2020).

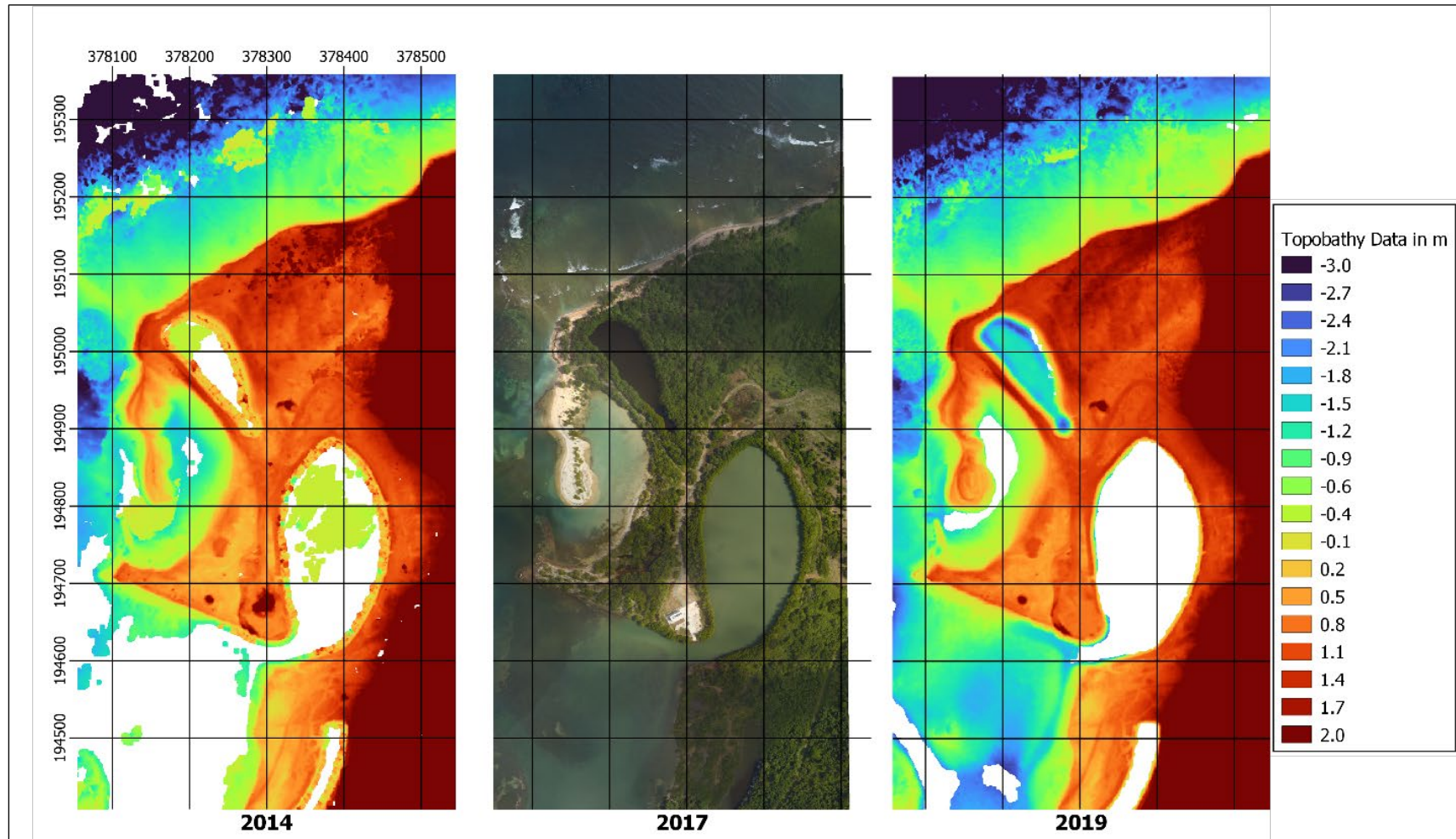


Figure 6. Accretion in the Area of Interest

The series of orthoimages below show how the spit opposite Hemmer Point Peninsula has been accreting since 2007. The southernmost extent of the spit has accreted approximately 100 feet from 2007 to 2017. The grid coordinates are NAD83 meters (NOAA 2022a).



Figure 7. Historic Topographic Maps for SARI

These historic topographic maps show the evolution of the area of interest in 1954, 1977, and 2013. Coordinates are NAD83 meters (USGS 2022).

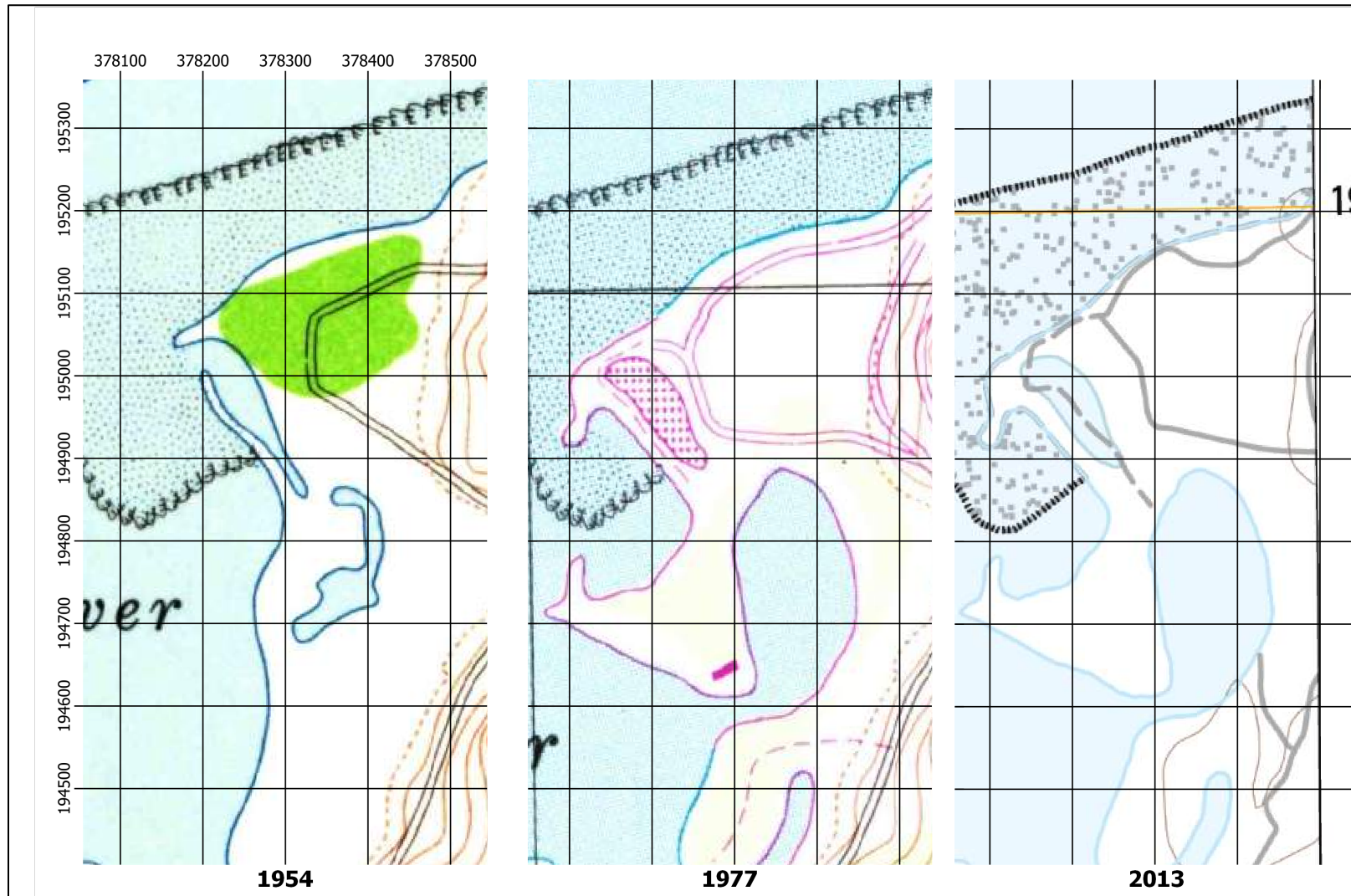


Figure 8. Historic Bathymetry for SARI (1977 to 1982)

This figure presents interpolated bathymetry for SARI based on the available soundings conducted in 1977 and 1982 from NOAA geophysical data system (GEODAS) (adapted from Kendall et al. 2005).

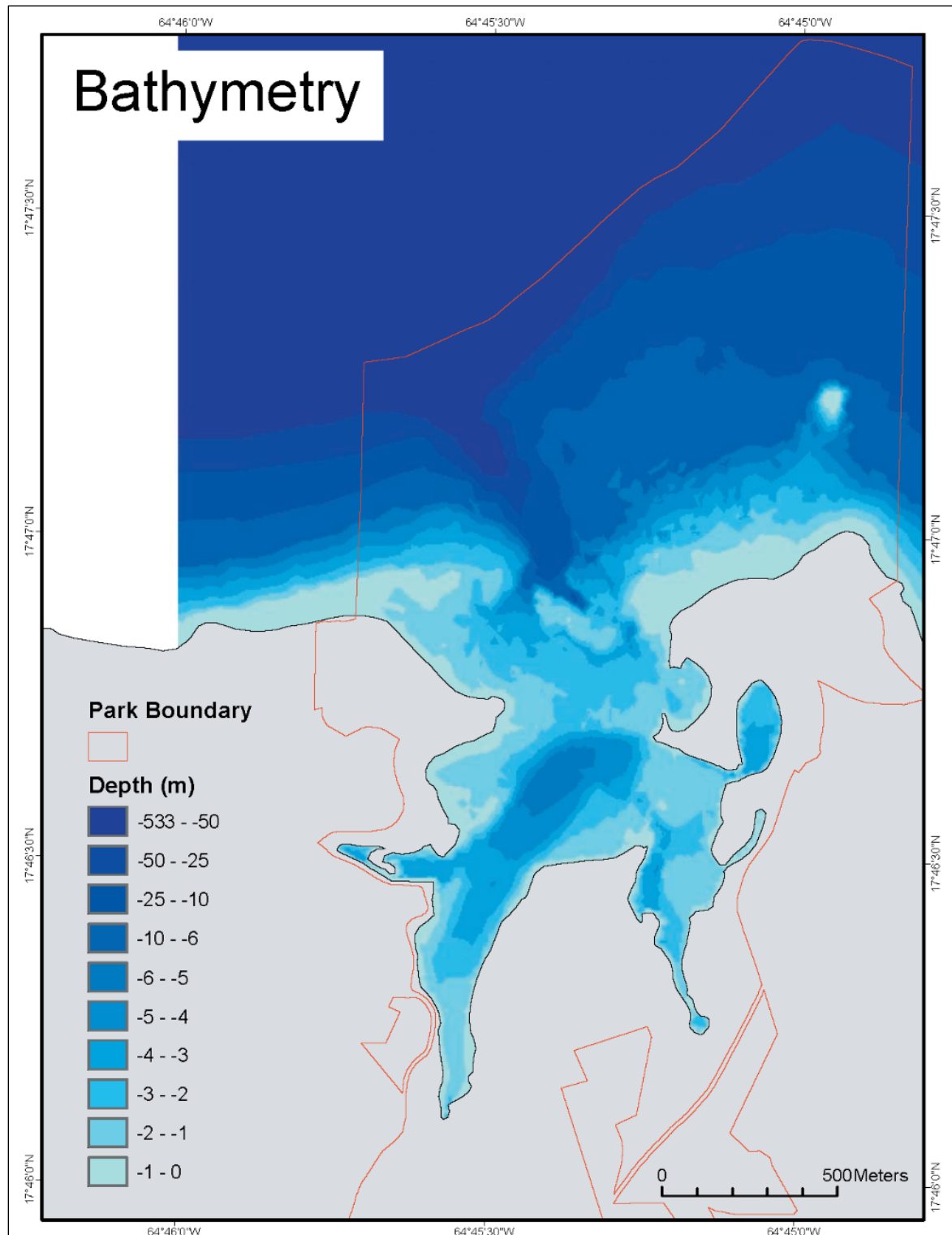
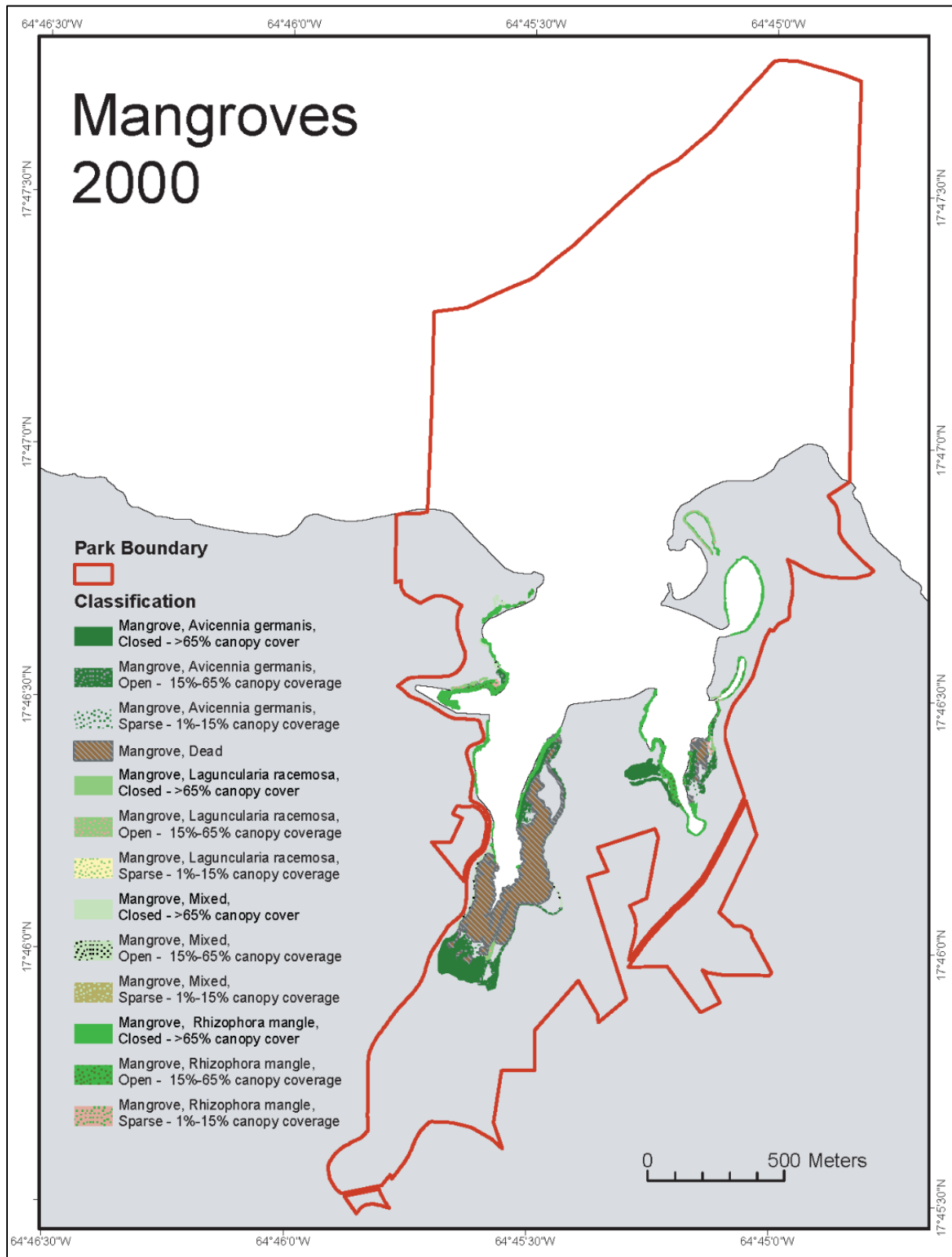


Figure 9. Mangrove Distributions in SARI in 2000 (Adapted from Kendall et al. 2005)



ADDITIONAL CONSIDERATIONS AND COMMENTS

Sedimentation Patterns

Based on the historic overview and existing conditions presented in previous sections, the west side of Allaine Bay is a dynamic area with a documented history of southern accretion towards Hemmer Point (figure 3). Now that Allaine Bay has closed, Hemmer Point will likely become more stable due to this source of sand. Figure 4 shows a wind-driven current that enters in a southwest direction right along the western side of Allaine Bay and then rotates to exit in a northwestern direction. The figure also shows general flood and ebb tidal patterns; however, there is not enough detailed current/hydrodynamic information around Hemmer Point Peninsula to determine how sediment patterns will continue now that Allaine Bay has closed. Additional studies are suggested to evaluate sediment transport and hydrodynamics along the western side of Allaine Bay, along the perimeter of Hemmer Point Peninsula, and in Mangrove Lagoon.

The National Park Service is concerned about maintaining the water quality in Mangrove Lagoon because it supports a thriving bioluminescent plankton population, making Mangrove Lagoon a popular ecotourism destination. There is concern that the southern accretion pattern that closed Allaine Bay will continue south of Hemmer Point Peninsula and reduce flow to this lagoon. Concern regarding accretion of sediment at the opening of Mangrove Lagoon has been noted (Pickney et al. 2014); however, there are no historic sedimentation patterns that suggest changes in sedimentation patterns at Hemmer Point will exacerbate this concern. From what is visible in aerial imagery (figure 6) and topographic maps (figure 7), Mangrove Lagoon has maintained a relatively stable morphology since it was created. This may be attributed to the established mangroves along its shores documented in 2000 (figure 8); however, additional data are needed to confirm this.

Sediment Transport Modeling

Based on previous observations that noted that the opening to Mangrove Lagoon might become shallow enough to impact bioluminescent activity (Pickney et al. 2014), it is suggested that further data collection and modeling activities might be warranted. To evaluate the changed hydrodynamics and sediment transport around Hemmer Point peninsula and Mangrove Lagoon, a numerical modeling study is suggested using the US Army Corps of Engineers (USACE) Engineer Research and Development CSTORM Coupler system (USACE 2012) or similar. This study will use the historic accretion and southern growth of the accretion spit feature as validation for the system, and then allow forecasting to determine the likelihood of this southern accretion to cause water quality impacts in Mangrove Lagoon. It is important to note that relying on the historical stability of Mangrove Lagoon may no longer be relevant, as the accretion of material into and around Allaine Bay is likely passing further and further south. Due to the complicated nature of the overall transport system and the current conditions not being available to compare to any historic information available, this study is likely the only way to accurately predict the potential impacts on Mangrove Lagoon as requested in the TAR.

Sea Level Rise

To understand the existing coastal flood risk, the corresponding Federal Emergency Management Agency (FEMA) flood insurance study and flood insurance rate map were used to determine the base flood

elevation (BFE) for the region (FEMA 2007). The BFE represents the 100-year flood event, including the effects of both storm surge and wave heights.

To understand future coastal flood risk in the study area, relative sea level rise (RSLR) projections for the region were evaluated for the nearest NOAA tidal station, the Lime Tree Bay, VI station (9751401; NOAA 2022b). These NOAA projections are shown in table 1 for five different scenarios, described in Sweet et al. 2022. The estimated RSLR fluctuates significantly depending on the projected impacts of climate change. For a conservative approach, the recently updated 2022 NOAA Intermediate-High scenario was used to assess the conservative future risk to the area of interest. Using this projection scenario, the estimated RSLR is 1.12 feet by 2050 and 5.04 feet by 2100. Note these values are bolded in table 1. The aerial in figure 10 shows that the project features described in this memo are fully inundated during the 100-year event and will continue to flood as a result of RSLR.

Table 1. Relative Sea Level Rise Scenarios (Sweet et al. 2022)

Year	Low (feet)	Intermediate-Low (feet)	Intermediate (feet)	Intermediate-High (feet)	High (feet)
2030	0.38	0.42	0.43	0.47	0.49
2040	0.51	0.59	0.64	0.73	0.82
2050	0.65	0.78	0.89	1.12	1.33
2060	0.77	0.98	1.20	1.63	2.06
2070	0.89	1.19	1.57	2.35	3.05
2080	1.00	1.39	2.04	3.12	4.19
2090	1.10	1.61	2.63	4.02	5.48
2100	1.20	1.83	3.37	5.04	6.80
2150	1.70	3.01	6.46	8.51	12.11

Notes: National Tidal Datum Epoch: 1983-2001

A cross-sectional analysis was performed to visualize existing and future coastal risk along the transect. A shore perpendicular transect was established in the study area, shown in the bottom panel of figure 10, and the elevations along this transect were extracted from the NOAA topobathymetric model (National Geodetic Survey 2022). The following elevations were plotted to compare scenarios, all in VIVD09:

- The FEMA BFE100-year flood value of 10 feet (FEMA 2007)
- The mean higher high water (MHHW) datum for the NOAA Christiansted Harbor, St. Croix, VI station's (9751364) of 0.35 feet (NOAA 2022c)
- The mean lower low water (MLLW) datum for the NOAA Christiansted Harbor, St. Croix, VI station's (9751364) tidal datum of -0.40 feet (NOAA 2022c)
- The 2050 projected value of 1.12 feet for 2050, calculated by adding the NOAA Intermediate-High RSLR projection (Sweet et al. 2022) to the current MHHW datum
- The 2100 projected value of 5.39 feet, calculated by adding the NOAA Intermediate-High RSLR projection (Sweet et al. 2022) to the current MHHW datum

For reference, the peak water level measured in Christiansted Bay during Hurricane Irma was 2.04 feet (Carisio et al. 2018), which is greater than the current MHHW datum but less than the projected 2050 sea level rise scenario.

ARMORING HEMMER POINT

Evaluation of Scope of Work

The overall goal of the proposed restoration of the Hemmer Point Peninsula is to reduce erosion of the man-made peninsula, reduce the risk of impacts from storms and sea level rise to the shoreline vegetation, and increase the resiliency of the shoreline (NPS 2021).

The proposed project is described to consist of “...stabilizing the end of the peninsula using geotextile cloth and quarried stone (available on St. Croix) to be placed on the end of the existing shoreline above the high tide line” (NPS 2021). The photograph to the right shows existing conditions of undercutting and loss of vegetation at Hemmer Point, and figure 11 shows the proposed riprap placement in map and cross-section views.



Figure 10. 100-year Flooding at the Area of Interest

The aerial in this figure shows the extent of flooding for a 100-year storm using FEMA's base flood elevations, which range from 8 to 11 feet. On the aerial, Transect 1 correlates to the cross-section in the bottom panel at Hemmer Point. The bottom panel compares elevations for current water levels (MHHW, MLLW, and FEMA 100-year flood) and projected future conditions (MHHW 2050 RSLR and MHHW 2100 RSLR). All elevations are in VIVD09.

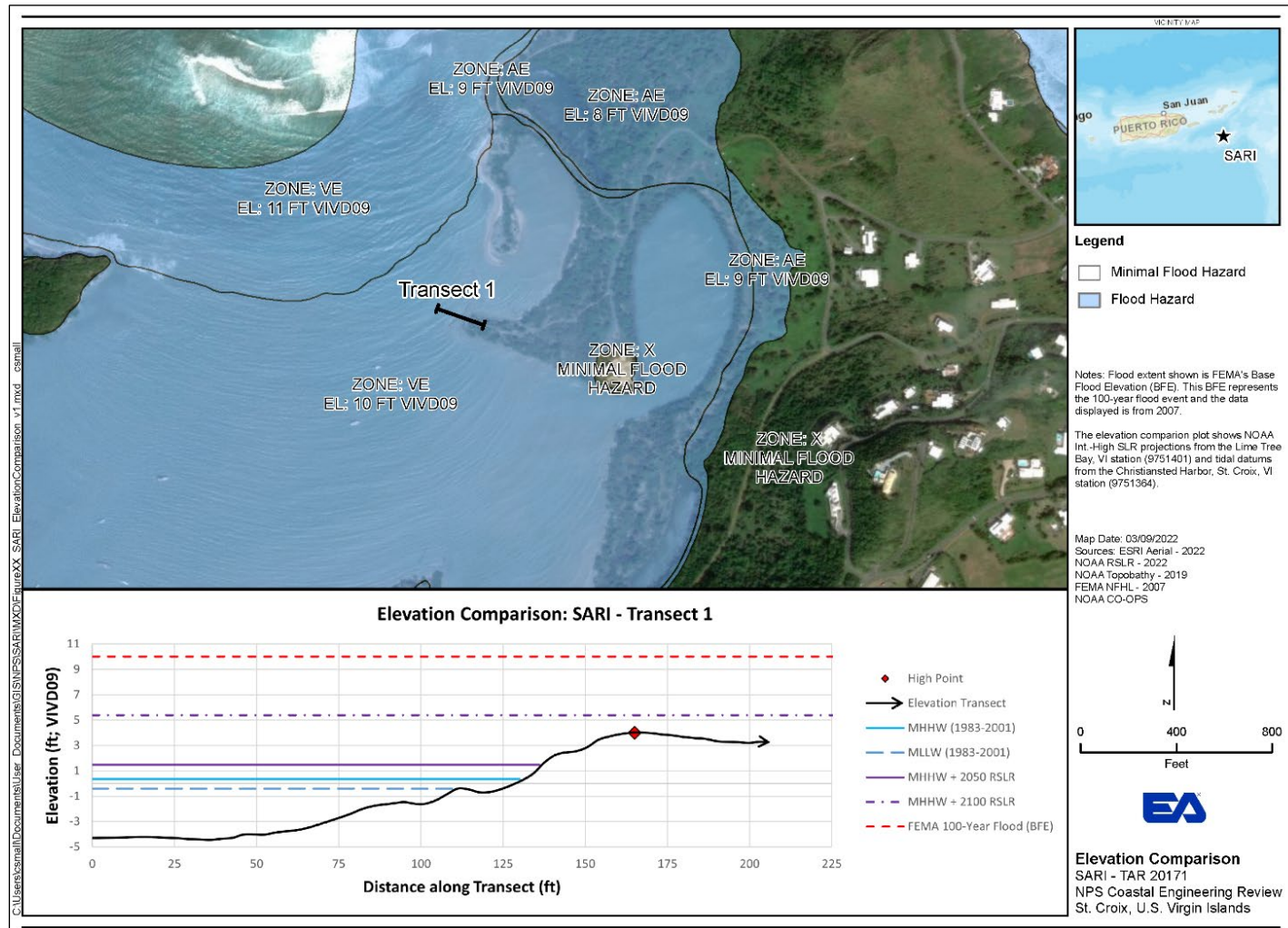
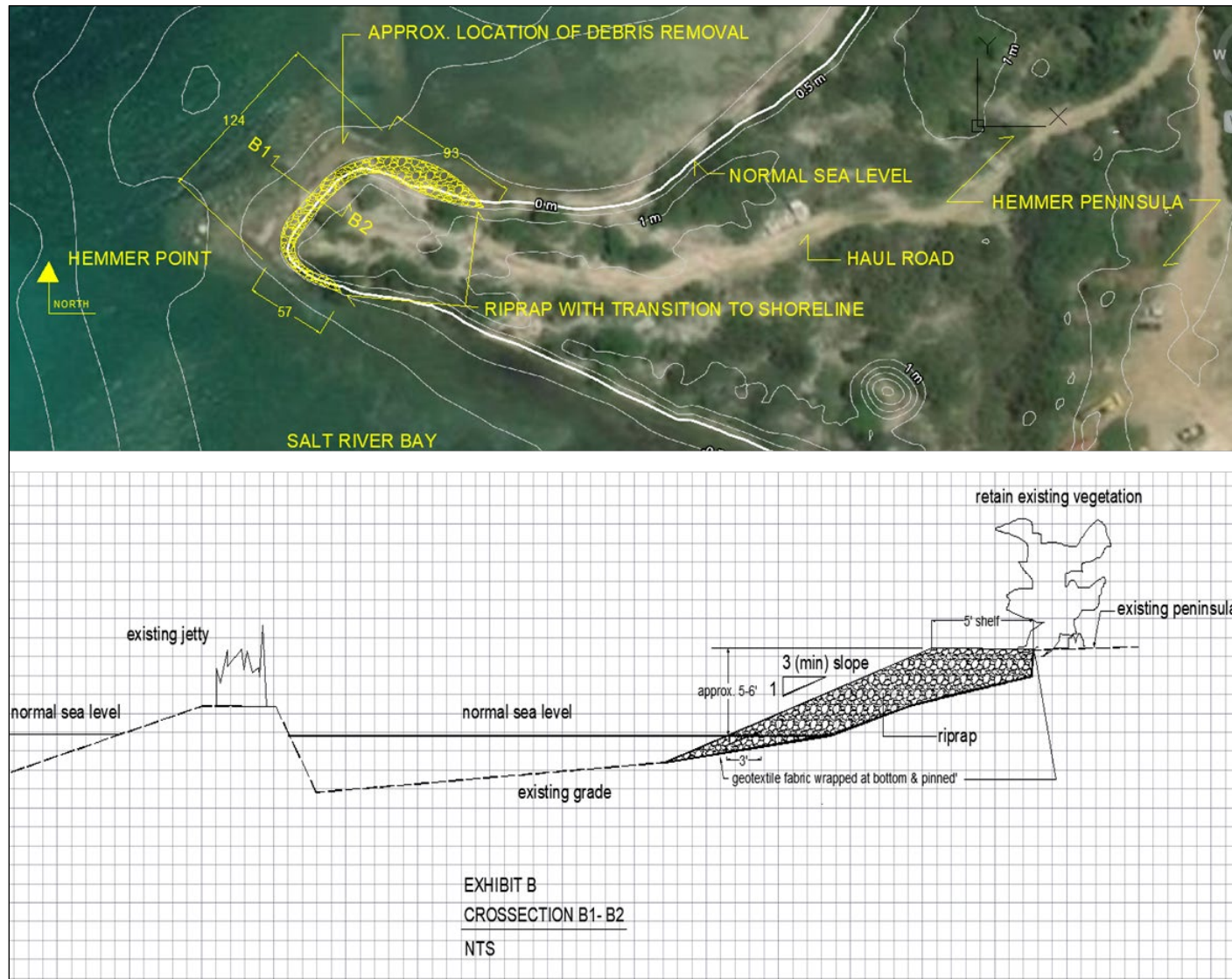


Figure 11. Proposed Shoreline Stabilization at Hemmer Point (NPS 2021)



Comments on Armoring Hemmer Point

Armoring coastal areas with hard structures often causes erosion down-current of the structure, as well as locally around the structure itself. Hard structures contribute to the transfer of energy, which can lead to the overall removal of sediment from natural transport patterns; therefore, areas down-current do not receive the influx of material they had previously. Locally, additional erosion occurs due to wave reflection off the hard surfaces — waves encounter the structure, and energy is reversed with minimal dissipation, often creating scour at the base. Placing riprap on Hemmer Point may keep the feature at its current location; however, it would likely increase erosion down-current and at the base of the structure.

Although the scope of work provides a suggested size of riprap, it does not provide the calculations or assumed conditions used to determine this design and specification. The plans also do not show an engineer's stamp on them, so comments regarding the technical qualification of the design engineer cannot be made. It is therefore difficult to comment on whether the proposed size will adequately stabilize Hemmer Point Peninsula.

The proposed plans do not include a readable scale; however, the cross section shows the riprap extending below the "normal sea level" line. Although one cannot fully comment without a scale, and the definition of "normal sea level" is not understood, it should be noted that the MHHW elevation is +0.35 feet VIVD09 (NOAA 2022c and figure 10), and it is therefore suggested that the design be further evaluated by the design engineer to clarify whether the design intends for the riprap to be placed below MHW. Placement of riprap to an elevation down to at least the MLLW elevation is recommended to provide the desired shoreline stability, but this results in a situation that would necessitate further regulatory interactions/submittals.

CONCLUSIONS

As indicated through aerial imagery and water current data (figure 4), the area along the west side of Allaine Bay is dynamic with sedimentation patterns influenced by wind-driven currents. Allaine Bay has naturally closed, which will provide additional sedimentation and stabilization of Hemmer Point Peninsula. One cannot comment on the potential of sedimentation from Hemmer Point impacting Mangrove Lagoon as available hydrodynamic data do not include areas south or east of Hemmer Point. Additional data and/or modeling are recommended to evaluate sediment transport in these areas that could affect water quality in Mangrove Lagoon, a popular tourist destination for experiencing bioluminescence occurrences. Regardless of the potential for Hemmer Point sedimentation processes to impact Mangrove Lagoon, other processes might be at work, and previous studies have already recommended monitoring the elevation of the opening of Mangrove Lagoon and developing a hydrodynamic model to better understand factors that may affect the occurrence of bioluminescent activity within the lagoon (Pinckney et al. 2014).

The SOW to stabilize Hemmer Point Peninsula provided at the time of this TAR was in a draft form, so additional detail may now be available; however, the plans in the version reviewed for this document do not have an engineer stamp, readable scale, or calculations to support the design. Additional review of these plans is suggested to ensure that the design aligns with permits and storm conditions to provide adequate stabilization to Hemmer Point. However, given the recent accretion of material in front of Hemmer Point, the placement of riprap to prevent erosion of the point may no longer be necessary.

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