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Planning Assistance to States Technical Report

Site Conditions in the Vicinity of Cape Blossom Kotzebue, Alaska

September 2021

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Site Conditions in the Vicinity of Cape Blossom Technical Assistance

Kotzebue, Alaska

Prepared By:

U.S. Army Corps of Engineers
Alaska District

September 2021

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EXECUTIVE SUMMARY

In 2020 a Navigation Improvement Technical Report (USACE 2020) was prepared after a General Investigation (GI) study was terminated because it did not result in an implementable plan at the project location. The GI study identified an average coastal bluff erosion rate at the project area that resulted in a risk of unsustainable future and / or deferred construction cost to maintain access to the dock. The Native Village of Kotzebue, the non-Federal sponsor, requested technical assistance under Section 22, Planning Assistance to States/Tribes (PAS) with the purpose of identifying a deep-water harbor port site that can be connected to the Cape Blossom Road.

This PAS study conducted an analysis of site conditions of the shoreline north and east of Cape Blossom. This analysis included a desktop study evaluation of coastal erosion rates based on historical aerial photography, and potential navigation channel dredge distances to the shoreline across the study area based on available bathymetry data. After the results of the desktop study identified locations with relatively low coastal erosion rates, a field visit was conducted to observe site conditions at these locations.

The study area coastline was divided up in to 7 reaches (Figure ES-1) identified by a relatively consistent erosion rate, and the same strategy was used to evaluate navigation channel lengths (Figure ES-2) assuming a channel starting at minus 26 feet (ft) Mean Lower Low Water (MLLW) and a dock facility at minus 12 ft MLLW. These depths are consistent with the channel design developed during the GI Study (USACE 2020).

The highest erosion rates were found in the reaches labeled EC, ED, EE, and EF (Figure ES1) with 50-year period land losses ranging from 1,079 to 1,951 ft. Based on the relatively lower erosion rates and shorter navigation channel lengths, the three reaches, EA, EC and EG, appeared to warrant further consideration as described below:

- North of Cape Area (NCA) 1: The coastline immediately north of Cape Blossom and the south end of Coastal reach EA appears relatively stable with a 50-yr land loss estimate that was not measurable (see Table 10), however the navigation channel and near-shore connection lengths (see Figure ES-2) are typically longer than locations east of the cape. Also, the shoreline is much less protected from waves making safe access to the coastline more difficult than areas east of the cape.
- East of Cape Area (ECA) 1: The coastline immediately east of Cape Blossom, coastal reach EB extends to the former area included in the former GI study (USACE 2019 and 2020). This reach has a relatively low erosion rate with a 50-yr land loss estimate of 175 ft. The bathymetry is also favorable which results in the shortest navigation channel and near-shore connection lengths of any of the reaches (see Figure ES-2).
- East of Cape Area (ECA) 2: The coastline farthest east within the study area in reach EG has a low erosion rate with a not measurable 50-yr land loss estimate.

The navigation channel and near-shore connection lengths are longer than at ECA1 (see Figure ES-2).

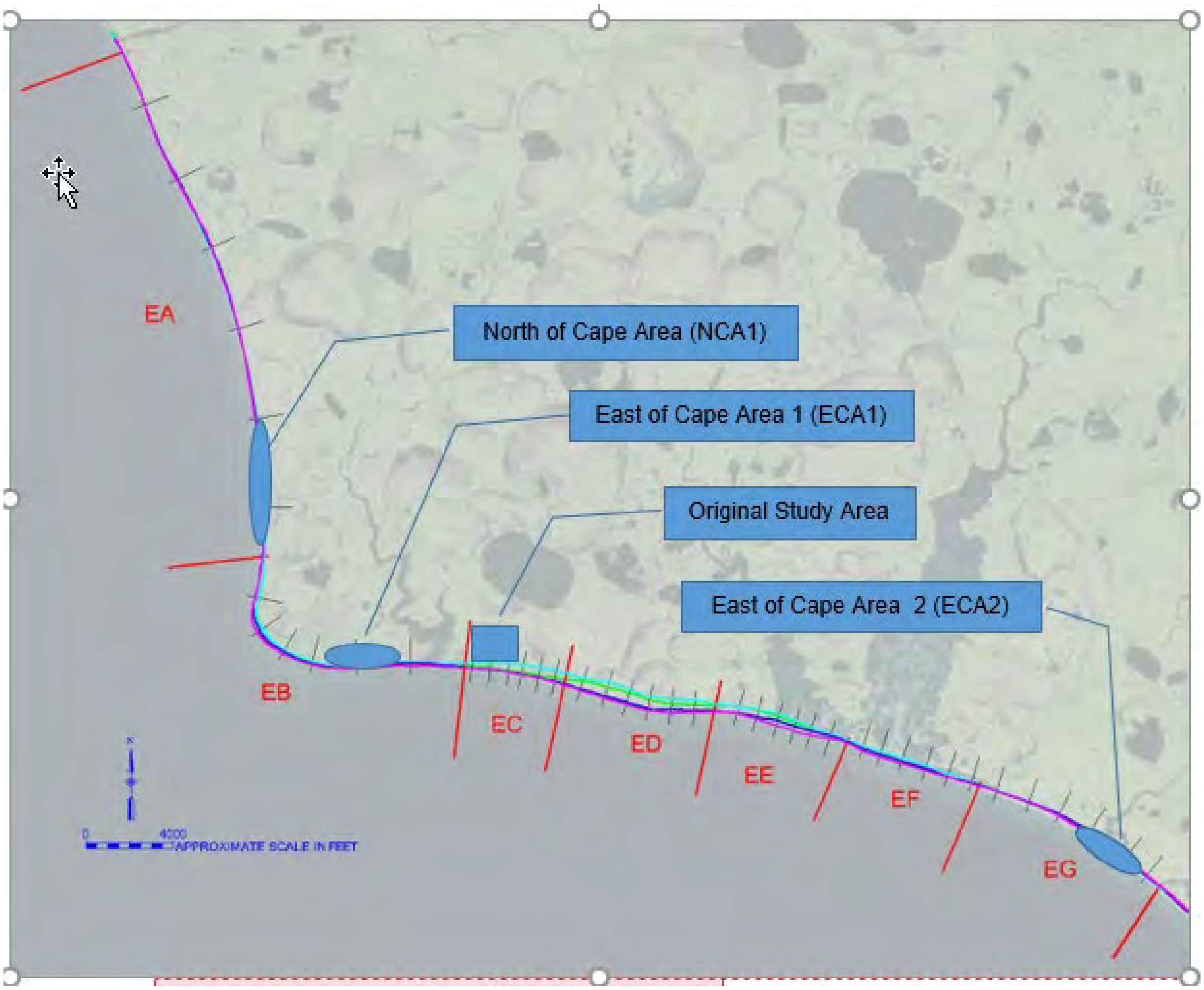

Figure ES1. Erosion Reaches and Potential Locations for Further Study

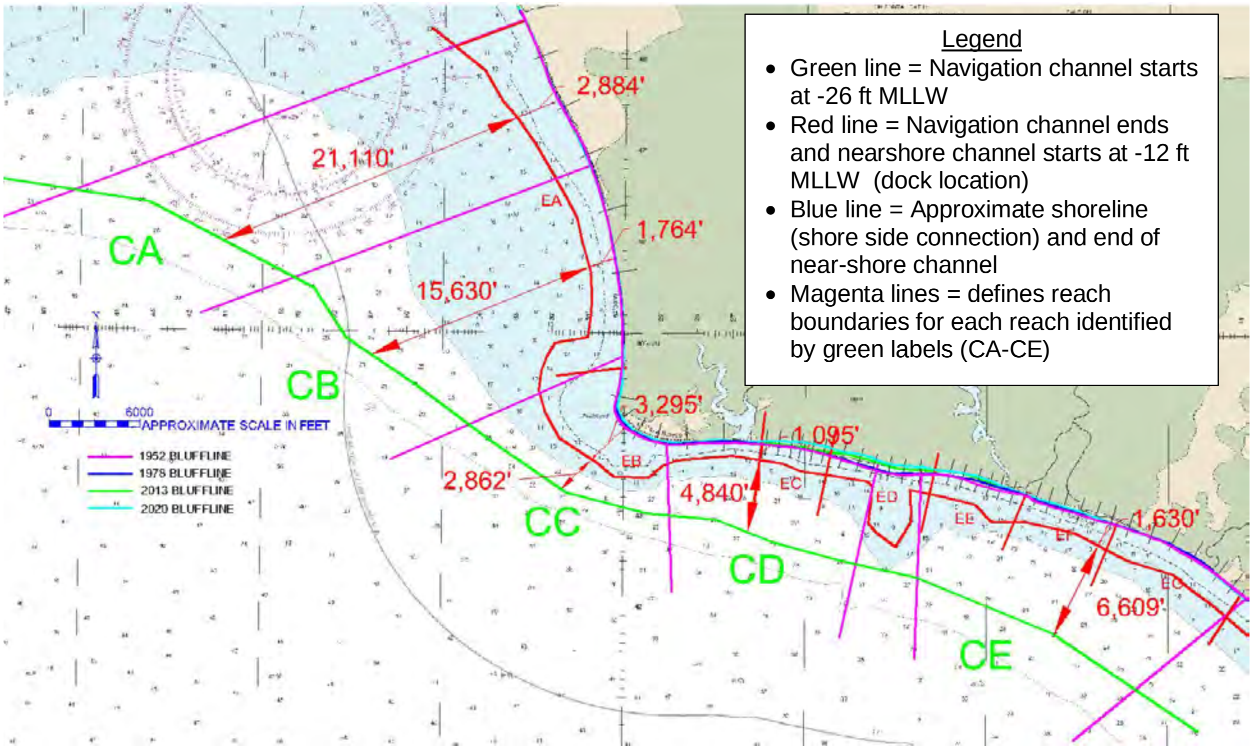

Figure ES2. Channel Length Coastal Segments and Erosion Analysis Reaches

A site visit was conducted by boat on 6 August 2021 to observe site conditions at 3 coastal locations, (ECA1, Original Study Area and ECA 2, (see Figure ES-1). The location north of Cape Blossom (NCA1) could not be visited because adverse wave height prevented safe beaching by the boat. Although this condition prevented access the non-Federal sponsor noted that they were not interested in this area as a potential future port site because of the adverse wave climate typical to this shoreline and the relatively tall coastal bluff.

Observations made during the site visit are summarized below:

- The erosion at coastal reaches at ECA1 and ECA 2 appear to be less severe than at the Original Study Area reach, however erosion was still observed at ECA1.
- Beach building processes, accretion, were observed at the location of ECA2,
- The erosion mechanisms of mechanical and thermal erosion appeared to be most prevalent or active on the shoreline bluff in the Original Study Area.
- ECA 1 has the tallest shoreline bluff of the coastal reaches observed east of Cape Blossom.
- Surficial soils within the original study area uplands were wet and poorly drained with the topography indicating a very shallow permafrost table with ice wedges and polygons

The coastal reaches NCA1 and ECA1 have the advantage of being the closest to the planned route for the Cape Blossom Road. However, there are many other considerations, a few being discussed in Section 5, that could ultimately influence selection of a location of a site or sites for a future feasibility study. For example, road access is critical for any future port location and collaboration with the Alaska Department of Transportation and Public Facilities (ADOT&PF) is critical to the evaluation for a future port location.

Unless further assessment is requested, the current PAS Study scope of work is completed after receiving comments on this draft report from the non-Federal sponsor, and a final report is prepared and released by the USACE that addresses these comments. However, a comprehensive feasibility study of one or all 3 coastal areas, or any other area, would need to be performed to further the decision concerning a future port location, and this level of effort is beyond what the PAS study authority can offer.

The feasibility study for the original site location resulted in a total cost to the non-Federal sponsor that was significantly higher than the Federal commitment for the project. A cost share analysis completed during the previous feasibility study estimated that if the proposed plan was constructed at the original site the non-Federal cost share amount would range from approximately $268M to over $392M. This range was due to the deferred construction cost of $0 to $125M to adapt to the potential coastal erosion rates over the 50-year period of analysis. The Federal share was significantly less at approximately $36.4M for the general navigation features (GNF), which was a dredged access channel to provide access to the dock. This large disparity between the cost commitment between the Non-Federal sponsor and the Federal government for the proposed plan shows that most of the project cost is for local service facilities (LSF) construction and maintenance to obtain the project benefits.

There are many other factors or considerations, other than GNF, that ultimately could or will influence a port location and design decision. As a result of the significant disparity between the non-Federal and Federal commitment to a future project, additional assessment by USACE under this PAS, if requested, should be limited to a rough-order-of-magnitude (ROM) cost evaluation for the general navigation features (GNF). This GNF cost information could be used by the non-Federal sponsor in the future to assist in developing their LSF plans and design concepts that best fits their vision for a new port at a location. After this non-Federal sponsor lead effort, a potential in-depth study by USACE would require a new request for the start of a General Investigations Study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Study Authority

The study is authorized as part of Section 22 of the Water Resources Development Act of 1974, as amended (42 U.S.C. 1962d-16), authorizes the Secretary of the Army to provide technical assistance related to the management of State water resources (hereinafter "Technical Assistance") to a State or non-Federal interest working with a State and to establish and collect fees for the purpose of recovering 50 percent of the costs of such assistance except that Secretary may accept and expend non-Federal funds provided that are in excess of such fee. Section 1156 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 2310) provides a cost sharing waiver of up to $484,000 for the non-Federal sponsor.

1.2 Background

Since 2012, at least one reach of the coastline east of Cape Blossom has been receding at a significant rate as described in the Navigation Improvement Technical Report, Kotzebue Harbor Feasibility Study, Navigation Improvements at Cape Blossom, Kotzebue, Alaska, prepared by the United States Army Corps of Engineers (USACE April 2020). The erosion rate in this reach threatens development of a proposed port at this location by increasing estimated design and construction costs, but more specifically, the ever-changing site conditions significantly increased and made it difficult to estimate with confidence operation and maintenance costs for the potential port project. The non-Federal sponsors, Native Village of Kotzebue (a Federally recognized tribe) and the City of Kotzebue, expressed concern that the project was unsustainable due to high operations and maintenance costs required to maintain access to the proposed dock as the shoreline receded.

In a letter dated October 23, 2019, the Native Village of Kotzebue, the current non-Federal sponsor, requested technical assistance under Section 22, Planning Assistance to States/Tribes (PAS) with the purpose of identifying a deep-water harbor port site that can be connected to the Cape Blossom Road that was planned to extend to the location described in the previously mentioned USACE April 2020 Technical Report. As a result, The PAS agreement between the Department of the Army and the Native Village of Kotzebue for technical assistance was executed on 11 September 2020.

1.3 Study Purpose

The USACE has prepared this PAS Technical Assistance Report to assist the Non-Federal sponsor in planning for and selecting a deep-water harbor port site. The USACE specifically studied the coastal erosion concern identified in the USACE April 2020 Technical Report. With the purpose of aiding the non-Federal sponsor in identifying potential alternative port sites by broadening the search area, analyzing constraints, and providing data analysis to enable informed decision making.

The USACE selected two site selection factors to analyze as part of this study: coastal erosion and navigation channel length. These two factors were chosen because of the impact these considerations had on design and cost previous studies. Also, since there are plans by the State of Alaska Department of Transportation and Public Facilities (ADOT&PF) to construct an all-season access road to the Cape Blossom area, the potential port location needs to have the ability to connect to this proposed road. This report includes estimates of the rates the coastline is receding, also referred to as coastal erosion rates, in the vicinity of Cape Blossom, and a discussion of other site selection factors that may influence the port location decision. The additional factors are discussed in the scope of work below.

1.4 Scope of Work

This study conducted an analysis of site conditions of shoreline north and east of Cape Blossom. This analysis included an evaluation of coastal erosion rates, and potential navigation channel dredge distances at select locations. After the results of the desktop study identified locations with relatively low coastal erosion rates, a field visit was conducted to observe site conditions at these locations. Other applicable factors to a port location decision are also discussed, such as environmental and geotechnical considerations, topography, permafrost, wetlands, surface water drainages, geological features, cultural resource sites, and land ownership. However, these evaluations were at a higher level meant to identify the most significant issues that can be identified with readily available information. This information and input from the non-Federal sponsor identified sites that are candidates for further assessment during a field visit, which was conducted in July 2021 to observe site conditions firsthand. No additional data collection or detailed analysis is considered at this time.

1.5 Project Location

The City of Kotzebue (Kotzebue) is the regional hub for the Northwest Arctic Borough, and is located 26 miles above the Arctic Circle and approximately 550 miles northwest of Anchorage, Alaska (Figure 1). Kotzebue extends across about three miles of coast on the north tip of the Baldwin Peninsula, which is bounded on the north and west by Kotzebue Sound and the east by Hotham Inlet, known locally as Kobuk Lake (Figure 2). The coastal erosion analysis area proposed for this study includes a section of coastline that extends north of Cape Blossom for about 5 miles and to the east about 8 miles (Figure 3). Kotzebue has a limited all-weather road system that is confined within and very near the village. There are no road connections to other villages Cape Blossom, or to Alaska’s road network. The ADOT&PF in cooperation with the City and Native Village of Kotzebue has resulted in the proposed construction of Cape Blossom Road (Figure 3) entering the implementation phase for the road section from Kotzebue to Sadie Creek. This road when fully constructed will terminate east of Cape Blossom (Figure 3). This termination point is at the location of the former proposed port location that was considered in a feasibility study that was eventually terminated due to a changing site condition (i.e., accelerating coastal bluff erosion) as discussed below in Section 1.6 Related Reports and Studies.

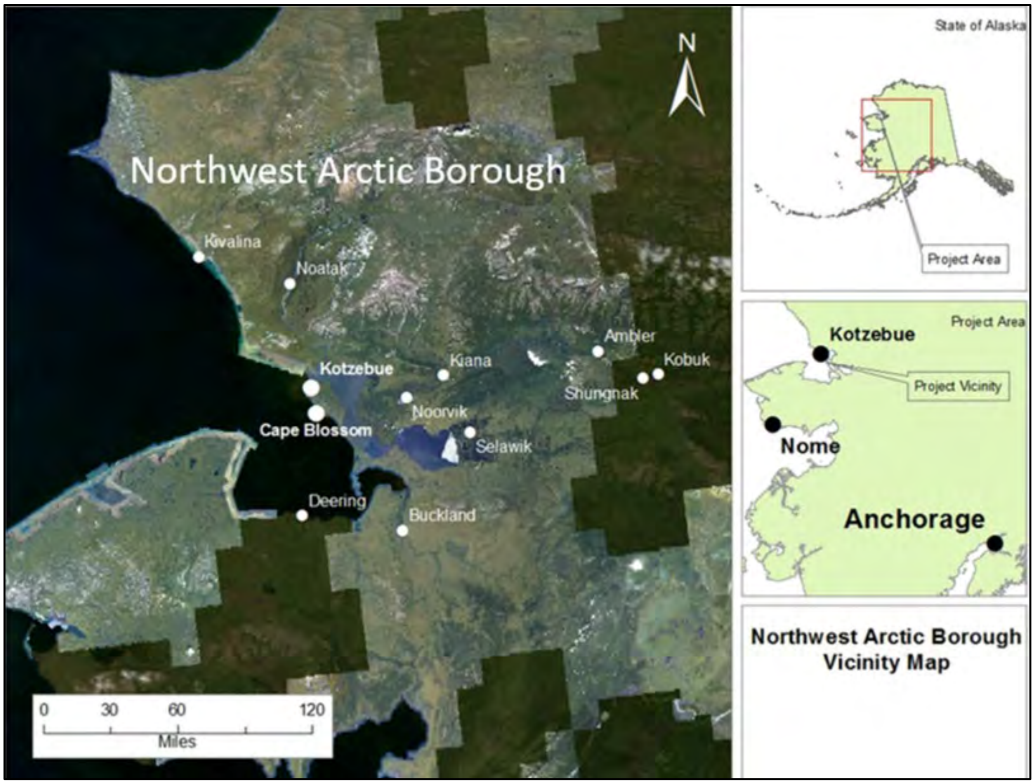

Figure 1. Vicinity Map

Figure 2. Cape Blossom Location (Satellite Image: GoogleEarth 2016)

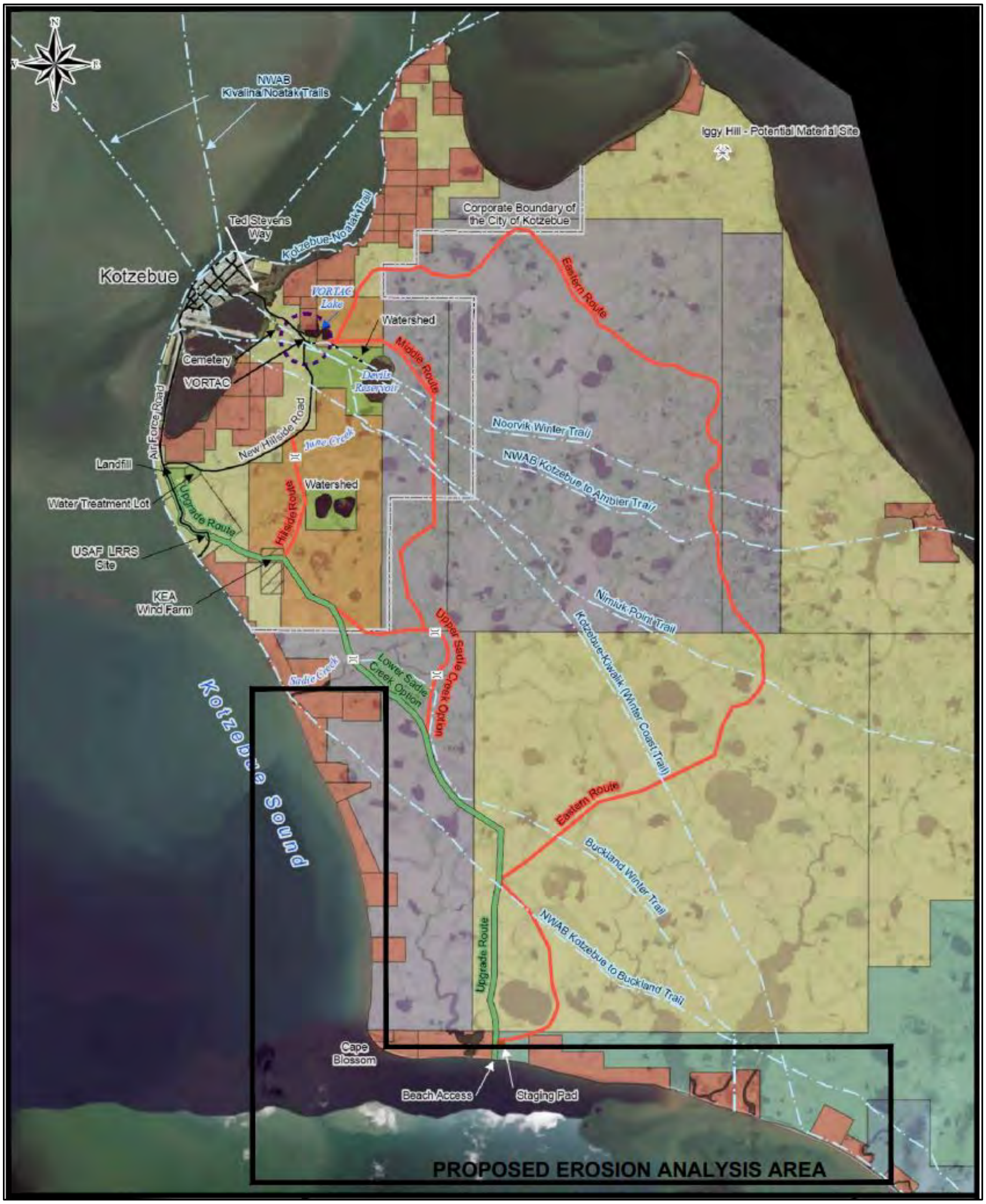

Figure 3. Coastal Erosional Analysis Area and Cape Blossom Road Route

1.6 Related Reports and Studies

Significant related reports and studies associated with developing a port at or near Kotzebue are summarized below in reverse chronological order.

In 2020 a Navigation Improvement Technical Report (USACE 2020) was prepared after a General Investigation (GI) study was terminated because it did not result in an implementable plan at the project location. This 2020 Technical Report was completed to document data generated during the GI study for future consideration.

In 2019, a draft final Integrated Feasibility Report and Environmental Assessment (IFREA) prepared during the GI study identified a changed site condition (accelerating coastal bluff erosion) that would have resulted in significant incurred cost to the local sponsors (USACE 2019). The GI study was terminated in 2019 because the coastal bluff erosion rate at the project area resulted in a risk of unsustainable future and / or deferred construction cost to maintain access to the dock. The erosion rate evaluation performed during the GI study is summarized below in Section 2.0.

Since 2011 multiple engineering and environmental assessment documents associated with the planned Kotzebue to Cape Blossom Road have been prepared and made available to the public. The project timeline, as well as the “2018-2021 Alaska Statewide Transportation Improvement Program” approved May 31, 2018, shows that the first phase of road construction for the Kotzebue to Cape Blossom Road was scheduled for Spring of 2020.

In 2004, the USACE completed an economic analysis of range of alternatives for a port at Cape Blossom. No National Economic Development (NED) plan was identified at that time. One of the recommendations included obtaining more detailed bathymetry data so that engineering designs and associated costs could be more defendable. This report noted that a successful port project would require road access from Kotzebue to Cape Blossom (USACE 2004).

In 2002, a Federal interest in the construction of navigation improvements at Cape Blossom was documented in a Section 905(b) Water Resource Development Act 1986 (WRDA 86) Analysis for Navigation Improvements for Kotzebue, Alaska (USACE 2002).

In 1983, Tetra Tech and Wright Forssen Associates produced a report for the City of Kotzebue containing recommendations and estimated costs for the development of a deep-water port at Cape Blossom (Tetra Tech et al. 1983).

In 1981, a second reconnaissance report was prepared by USACE at the request of the City of Kotzebue. This report found that navigation improvements were not economically favorable at Kotzebue. It recommended the city request help from the National Oceanic and Atmospheric Administration (NOAA) to schedule a charting mission of Kotzebue Sound in search of a natural deep-water channel to or in the vicinity of Kotzebue (USACE 1981).

In 1973, a reconnaissance report was prepared by USACE at the request of the Common Council of the City of Kotzebue. The report noted that several alternatives were physically feasible for developing a port at Kotzebue; however, the low benefit-to-cost ratios indicated the alternatives were not feasible despite secondary benefits to the socioeconomic wellbeing of the community (USACE 1973).

2.0 COASTAL EROSION EVALUATIONS

2.1 Summary of Previous Erosion Rate Analysis

The previous erosion analysis performed for the GI study used orthorectified aerial photos obtained from Quantum Spatial from flight paths completed in the years 1952, 1953, 1973, 1978 and 2013, and from DigitalGlobe, an American commercial vendor of space imagery and geospatial content, for the years 2012, 2014, 2018-May, and 2018-August.

The orthorectified photos and DigitalGlobe photos were co-located to the extent possible and bluff lines were digitized for each of the photos. Six transect lines were drawn across the shore GI study project area to measure the shoreline change between years. The erosion analysis conducted during the GI study indicated that the bluff is receding in the project area from 12 to 30.4 feet per year (ft/yr). The rate was 0 to 1.7 ft/yr before 2012, but it accelerated to approximately 30.4 ft/yr during the period from 2014 to 2018 as presented in Table 1 and shown in Figure 4.

Table 1. Bluff Erosion Rates per Transect

Photo Year	Period between photos	Transect Lines and Erosion Rate (ft)						Avg. change [ft]	Avg. rate [ft/yr]
		No. 1	No. 2	No. 3	No.4	No. 5	No. 6		
1952	0	NA	NA	NA	NA	NA	NA	NA	NA
1973	21	14.8	17.2	8.7	3.2	1.3	10.5	9.3	0.4
1978	5	NM	NM	NM	NM	NM	NM	NM	NM
2012	34	62.7	56.5	58.7	70.6	62	65.5	62.7	1.8
2013	1	14.6	10.6	22.9	25.3	31.9	23.4	21.4	21.4
2014	1	2.8	0	19.8	16.3	14.1	53.6	17.7	17.7
2018	4	94.8	108.4	101.1	146.5	154.2	123.6	121.4	30.4

Notes: NA = not applicable, NM = erosion rate too low to be measurable

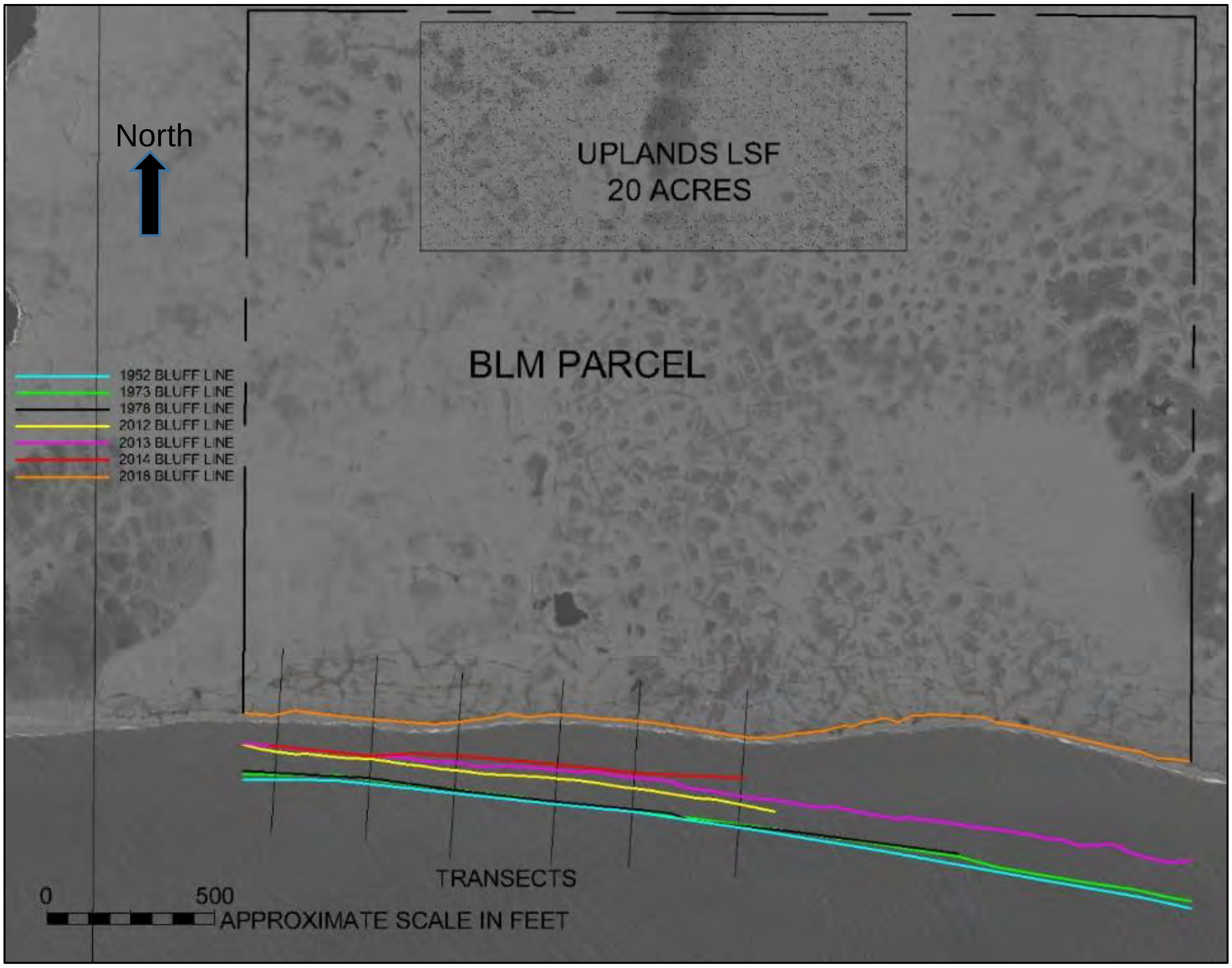

Figure 4. Shoreline Change at Former Study Area (see former study area in Figure 2 and Figure 3)

During this later 4-year period, 2014-2018, the average land loss in the project area was approximately 121 ft (see Table 1). The land loss without shoreline protection over a 50-yr period would be approximately 600 to 1,520 ft considering the erosion rate estimates remain constant.

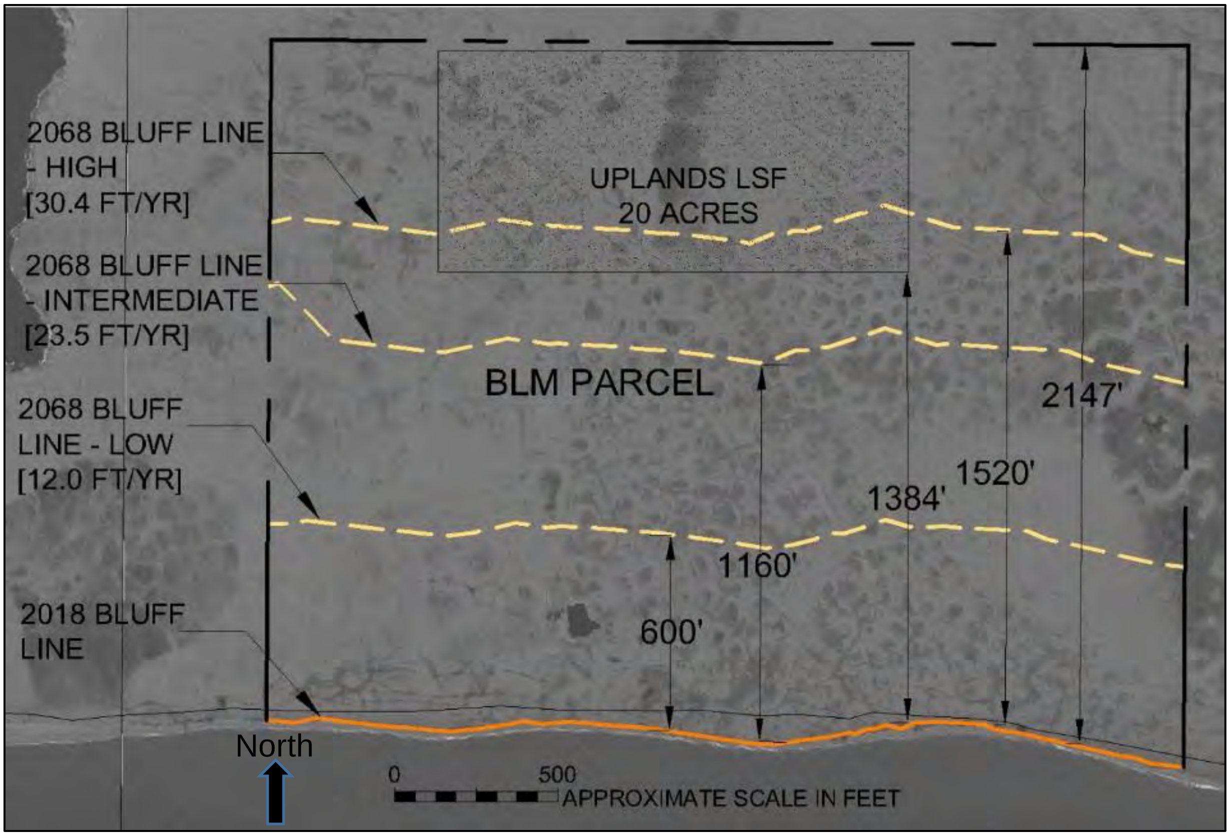

Figure 5. Former Study Area Erosion Lines and Projected 50-Year Line (August 2018 DigitalGlobe Aerial Photo, see Figure 2 and Figure 3)

2.2 Expanded Erosion Rate Analysis

2.2.1 Methodology

Since the erosion rate evaluated during the GI study threatened development of a proposed port at that location, the Native Village of Kotzebue (a Federally-recognized tribe and current non-Federal sponsor) requested that the erosion rate analysis be performed for a longer coastal reach, but still in the vicinity of Cape Blossom (see Figure 3) to assist with identifying a deep-water harbor port site that can be connected to the Cape Blossom Road.

The same methodology followed for the previous erosion rate analysis in the GI Study was also followed for this PAS study, except the coastal area evaluated was long enough that it was divided into 7 individual reaches labeled as “EA” through “EG” (Figure 6), and the analysis only considered the years 1952, 1978, 2013, and 2020 because those years constituted all available data. Each individual labeled reach represents a length of coastline with similar rates of erosion over the time evaluated. As a result, none of the reaches are the same length. As done in the previous analysis discussed in Section 2.2 above, 6 transect lines were drawn across the shore in each reach to measure the shoreline change between years.

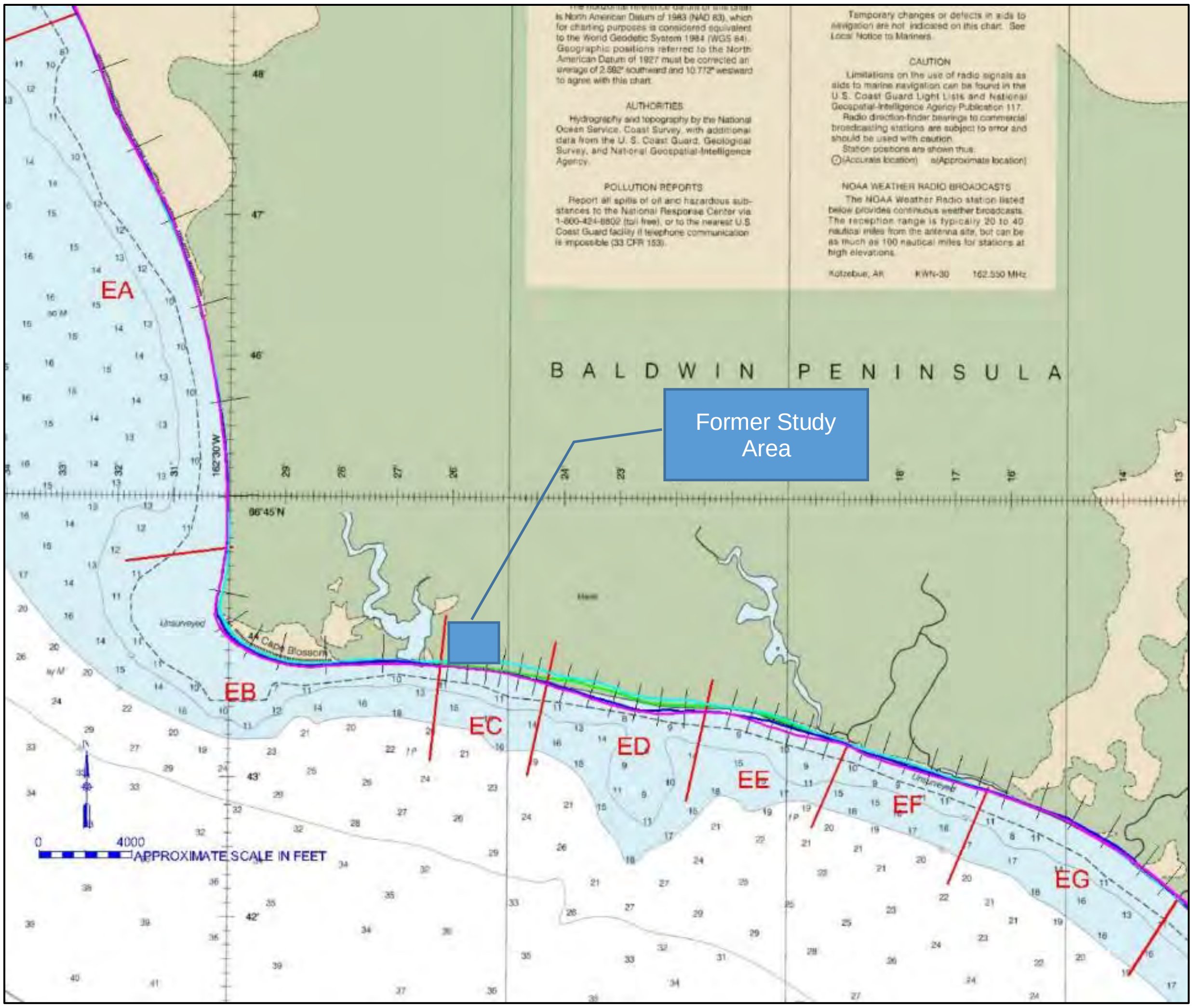

Figure 6. Coastal Erosion Evaluation Area (base map reference?)

2.2.2 Coastal Erosion Rates

<u>Coastal Reach EA</u>

Coastal Reach EA is located on the coast north of Cape Blossom (see Figure 6). It is characterized by a vegetated bluff (Figure 7) that is fronted by a mud flat that is wider than any of the other reaches. The coastline in this reach appears to be protected by the wide mud flat as evidenced by the vegetated bluffs. Variations in the digitized shoreline analysis in this area were minimal and were assumed to be a product of the difference between aerial photography quality and not indicative of erosion.

The erosion rate in this reach is minimal (Figure 8 and Table 2). These rates are so low that the land loss that may be realized over a 50-year period is assumed to be minimal.

Figure 7. Coastal Reach EA – Coast North of Cape Blossom

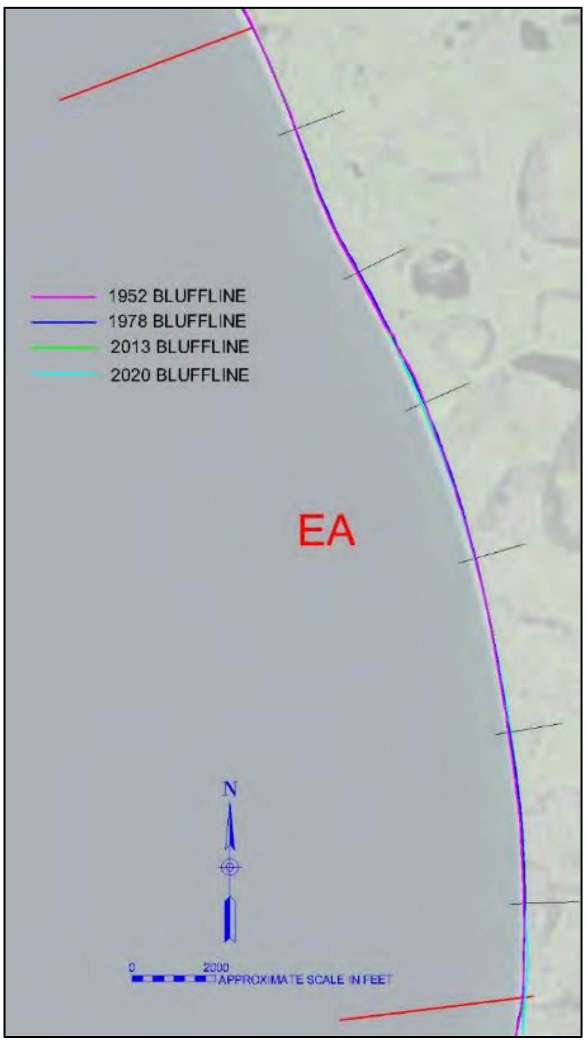

Figure 8. Area EA Erosion Lines

Table 2. Coastal Reach EA - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Photo Year	Period between photos	Transect Lines and Erosion Rate (ft)						Avg. change [ft]	Avg. rate [ft/yr]
		No. 1	No. 2	No. 3	No.4	No. 5	No. 6		
1952	0	NA	NA	NA	NA	NA	NA	NA	NA
1978	26	NM	NM	NM	NM	NM	NM	NM	NM
2013	35	NM	NM	NM	NM	NM	NM	NM	NM
2020	7	NM	NM	NM	NM	NM	NM	NM	NM

Notes: NA = not applicable, NM = erosion rate too low to be measurable

Coastal Reach EB

Coastal Reach EB covers Cape Blossom and the coast that is immediately north and east of Cape Blossom (see Figure 6). It is characterized by vegetated bluffs to the north of Cape Blossom that give way to exposed bluffs at Cape Blossom that reduce in height to a mix of vegetated and exposed bluffs (Figure 9 through Figure 11). The shoreline erosion over the years of analysis shown in Table 3. The erosion that could be realized over a 50-year period using the average rate of erosion that occurred between 2013 and 2020 is 175 feet (Figure 12).

Figure 9. Coastal Reach EB – Coast North of Cape Blossom

Figure 10. Coastal Reach EB – Cape Blossom

Figure 11. Coastal Reach EB – Coast East of Cape Blossom

Table 3. Coastal Reach EB - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Photo Year	Period between photos	Transect Line labels and Erosion Rate in (ft)						Avg. change [ft]	Avg. rate [ft/yr]
		No. 1	No. 2	No. 3	No.4	No. 5	No. 6		
1952	0	NA	NA	NA	NA	NA	NA	NA	NA
1978	26	3.9	134.8	64.6	48	48.6	130.3	71.7	2.8
2013	35	172.2	103.6	69.7	98.9	89.3	27.5	94.2	2.7
2020	7	NM	47.9	22.4	48	5.1	23.6	24.5	3.5

Notes: NA = not applicable, NM = erosion rate too low to be measurable

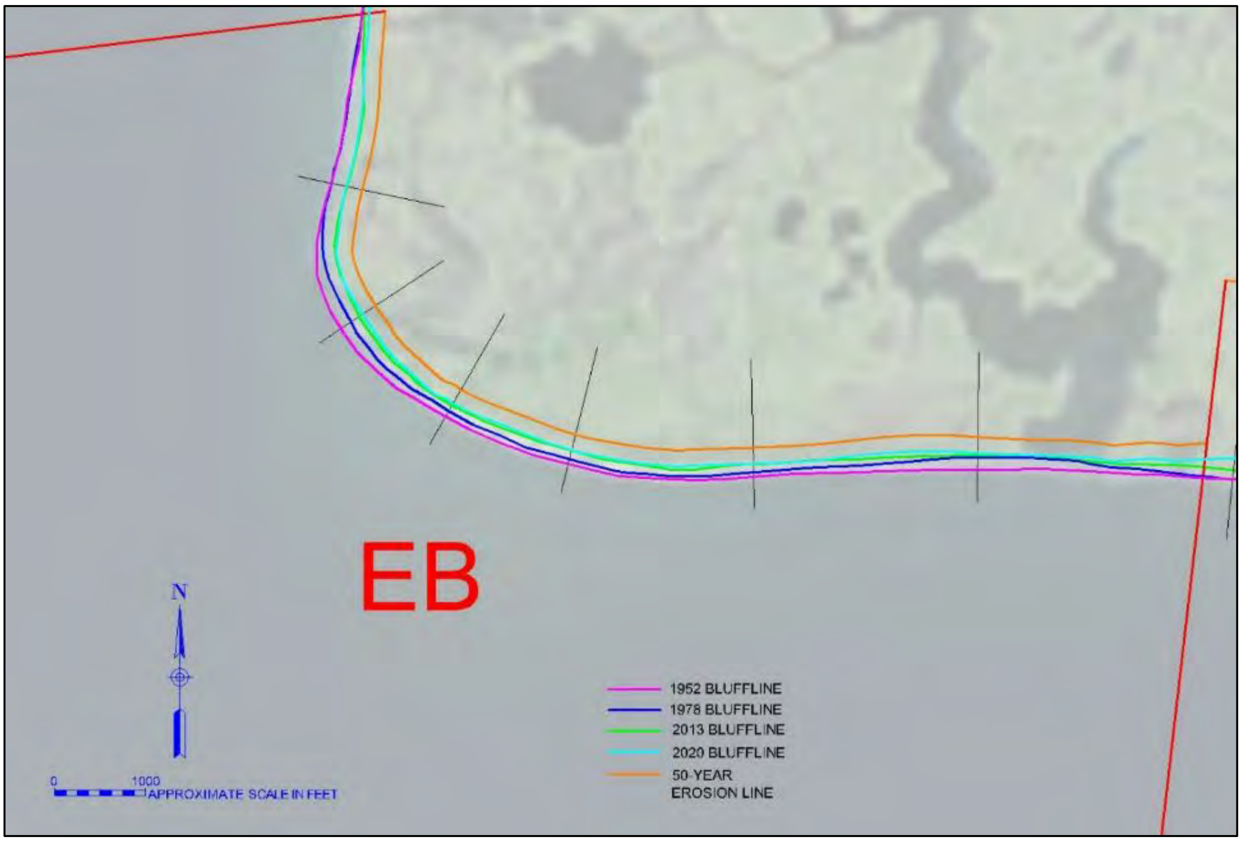

Figure 12. Area EB Erosion Lines and Projected 50-Year Line

Coastal Reach EC

Coastal Reach EC is further east of Cape Blossom than EB and encompasses the original project site from the GI study (Figure 6). Coastal Reach EC is characterized by a narrow beach, bluffs of reduced height, non-vegetated bluff face that is visibly eroding (Figure 13 and Figure 14). The shoreline erosion over the years of analysis shown in Table 12. The average erosion rate is estimated at 39 ft/yr with an average land loss 273 ft from 2013 to 2020. The land loss that could be realized over a 50-year period using this average rate of erosion is 1,951 ft (Figure 15).

Figure 13. Coastal Reach EC - Bluffs are reduced in height and are visibly eroding

Figure 14. Coastal Reach EC – Visibly eroding bluffs

Table 4. Coastal Reach EC - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Photo Year	Period between photos	Transect Line labels and Erosion Rate in (ft)						Avg. change [ft]	Avg. rate [ft/yr]
		No. 1	No. 2	No. 3	No.4	No. 5	No. 6		
1952	0	NA	NA	NA	NA	NA	NA	NA	NA
1978	26	NM	NM	8.9	20.2	21.1	31.7	13.7	0.5
2013	35	99.8	96.1	80.9	86.6	99.8	156.6	103.3	3.0
2020	7	128.6	201.8	295	345.3	353.4	314.9	273.2	39

Notes: NA = not applicable, NM = erosion rate too low to be measurable

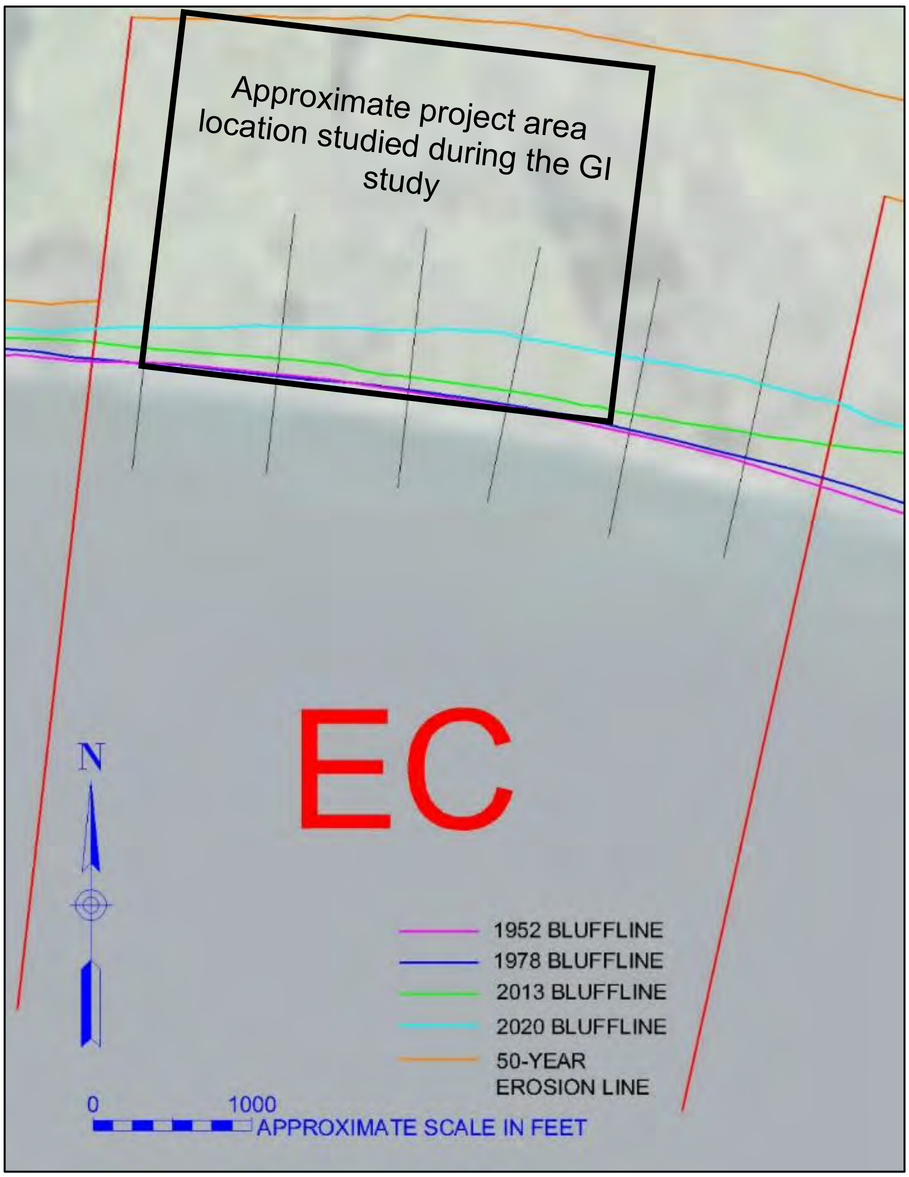

Figure 15. Coastal Reach EC Erosion Lines and Projected 50-year Line

Coastal Reach ED

Coastal Reach ED if further east of Cape Blossom than EC (Figure 6). Coastal Reach ED is characterized by exposed eroding bluffs with a widened area of shallow water in front of the bluff. Unlike Coastal Reach EA, where the mudflats appear to protect the bluff, the shallow water in this reach appears to focus wave activity. Compared to other reaches studied, Coastal Reaches EC and ED have the fastest rate of erosion. Focused wave activity is suspected to be part of the cause (Figure 16). The average erosion rate is estimated at 26.8 ft/yr with an average land loss 187 ft from 2013 to 2020. The land loss that could be realized over a 50-year period using this average rate of erosion is 1,338 ft (Figure 17).

Figure 16. Coastal Reach ED – Actively eroding bluff

Table 5. Coastal Reach ED - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Photo Year	Period between photos	Transect Line labels and Erosion Rate in (ft)						Avg. change [ft]	Avg. rate [ft/yr]
		No. 1	No. 2	No. 3	No.4	No. 5	No. 6		
1952	0	NA	NA	NA	NA	NA	NA	NA	NA
1978	26	63.3	86.4	104.5	65.4	166.8	74.4	93.5	3.6
2013	35	372.4	430.1	441.4	411.2	254.8	232.9	357.1	10.2
2020	7	118.1	219.3	155.5	172.2	224.2	234.4	187.3	26.8

Notes: NA = not applicable

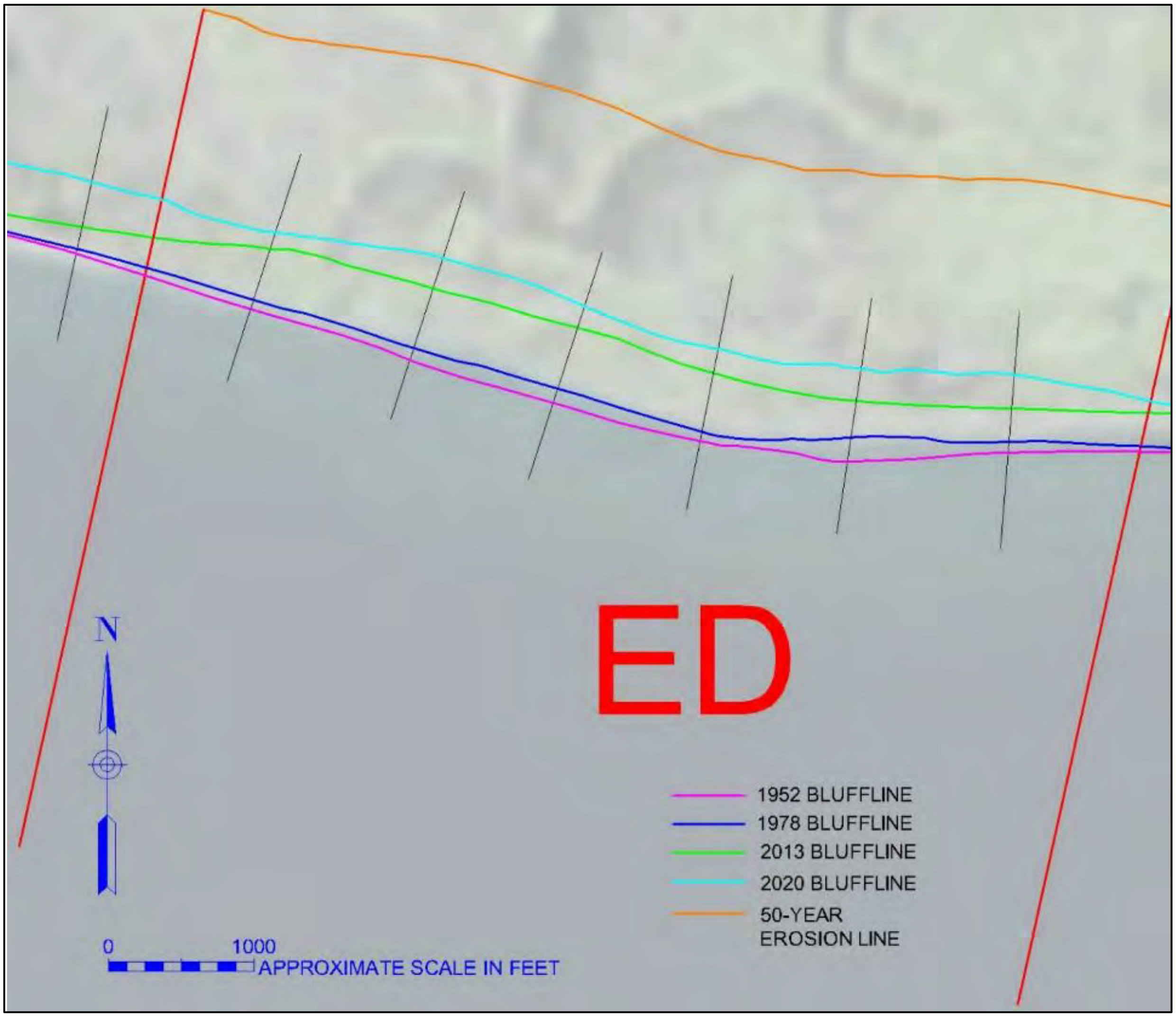

Figure 17. Coastal Reach ED Erosion Lines and Projected 50-yr Line

Coastal Reach EE

Coastal Reach EE is again further east of Cape Blossom (Figure 6) and is characterized by a combination of low exposed bluffs to non-existent bluffs that fronts wetlands and lakes (Figure 18 and Figure 19). The average erosion rate is estimated at 21.6 ft/yr with an average land loss 151.1 ft from 2013 to 2020. The land loss that could be realized over a 50-year period using this average rate of erosion is 1,079 ft (Figure 20).

Figure 18. Coastal Reach EE – Low bluff and no bluff

Figure 19. Coastal Reach EE – No bluffs – beach backed by wetlands

Table 6. Coastal Reach EE - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Photo Year	Period between photos	Transect Line labels and Erosion Rate in (ft)						Avg. change [ft]	Avg. rate [ft/yr]
		No. 1	No. 2	No. 3	No.4	No. 5	No. 6		
1952	0	NA	NA	NA	NA	NA	NA	NA	NA
1978	26	17.0	85.3	112.0	105.1	75.6	74.4	78.2	3.0
2013	35	278.7	286.6	173.0	151.4	98.4	N/A	197.6	5.6
2020	7	NM	28.7	236.8	211.9	194.5	234.4	151.1	21.6

Notes: NA = not applicable, NM = erosion rate too low to be measurable

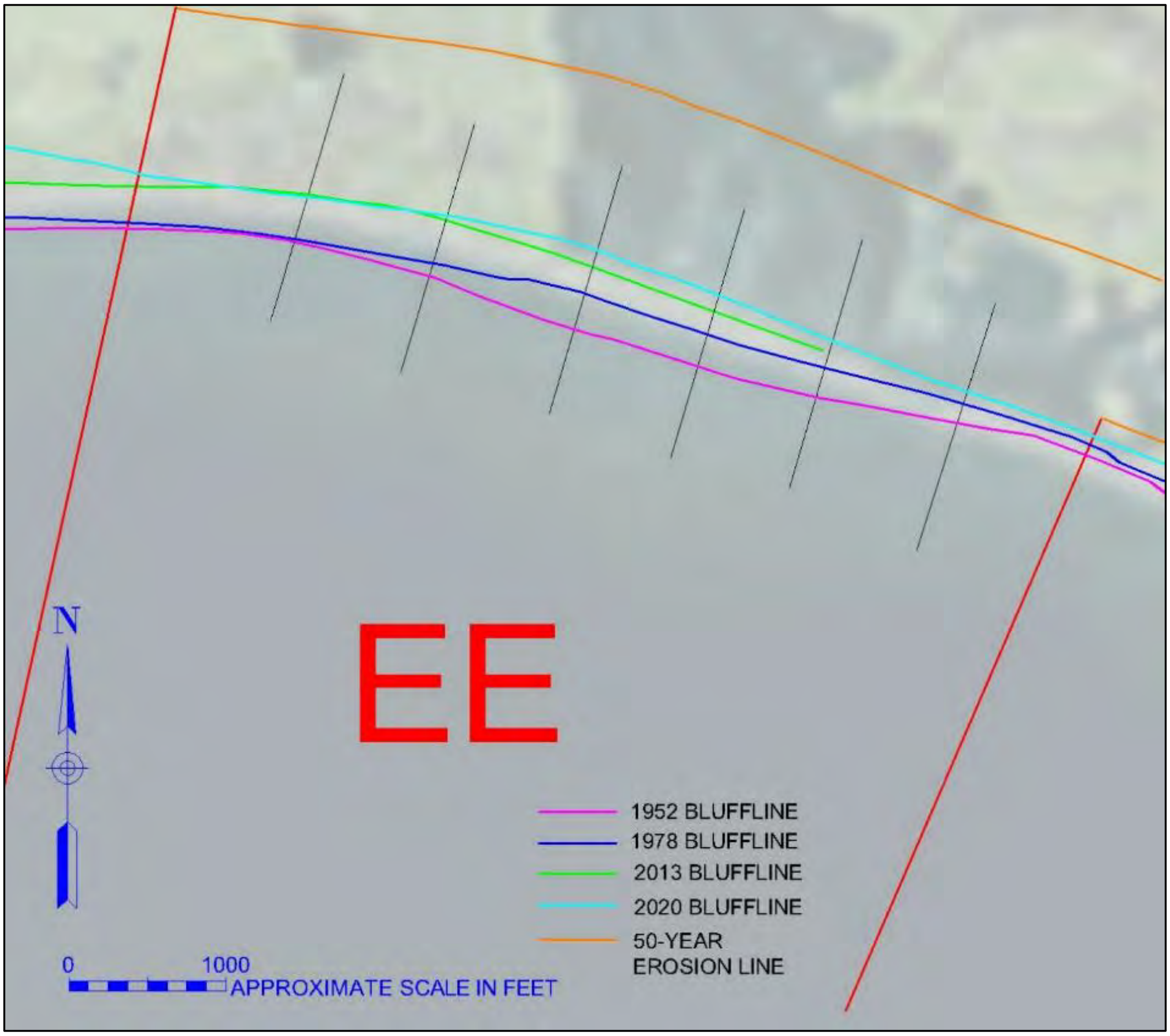

Figure 20. Coastal Erosion EE Erosion Lines and Projected 50-yr Line

Coastal Reach EF

Coastal Reach EF is again further east of Cape Blossom (Figure 6) and is characterized by narrow beaches with a few low exposed bluffs that fronts wetlands, lakes, and streams (Figure 21 and Figure 22). Aerial photography for 2013 was not available for this reach, so it was excluded from the analysis. The average erosion rate is estimated at 2.5 ft/yr with an average land loss 104.9 ft from 1978 to 2020. The land loss that could be realized over a 50-year period using this average rate of erosion is 125 ft (Figure 19).

Figure 21. Coastal Reach EF – Low berm and beach backed by wetland

Figure 22. Coastal Reach EF – Narrow beach backed by stream

Table 7. Coastal Reach EF - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Photo Year	Period between photos	Transect Line labels and Erosion Rate in (ft)						Avg. change [ft]	Avg. rate [ft/yr]
		No. 1	No. 2	No. 3	No.4	No. 5	No. 6		
1952	0	NA	NA	NA	NA	NA	NA	NA	NA
1978	26	102.9	120.6	105.7	80.7	22.3	44.2	79.4	3.1
2020	42	100.5	111.0	147.4	106.7	135.7	28.2	104.9	2.5

Notes: NA = not applicable, NM = erosion rate too low to be measurable

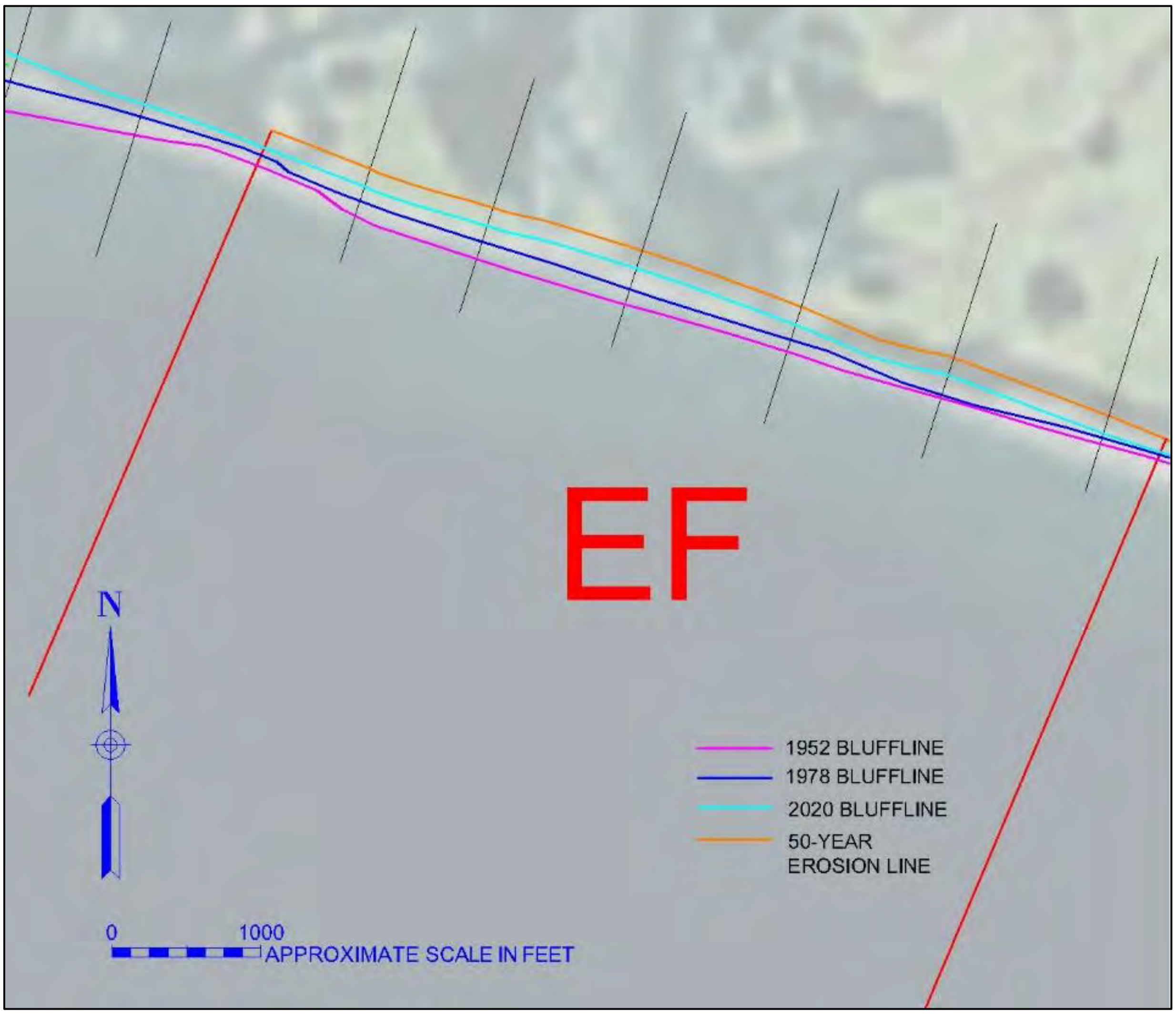

Figure 23. Coastal Reach EF - Erosion Lines and Projected 50-year Line

Coastal Reach EG

Coastal Reach EG is the furthest east in this study (Figure 6) and is characterized by low vegetated bluffs fronted by a wider beach. (Figure 24 and Figure 25). The low bluffs reduce in height until the coast is characterized by a wider, flat beach. Aerial photography for 2013 was not available for this reach, so it was excluded from the analysis. Variations in the digitized shoreline were minimal and were assumed to be a product of the difference between aerial photography quality and not indicative of erosion. This reach of the coast is stable with no measurable erosion rate (Table 8) , and the land loss that may be realized over a 50-year period is assumed minimal considering the available data.

Figure 24. Coastal Reach EG – Vegetated bluff

Figure 25. Coastal Reach EG - Vegetated bluff with waterway in back

Table 8. Coastal Reach EG - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Photo Year	Period between photos	Transect Line labels and Erosion Rate in (ft)						Avg. change [ft]	Avg. rate [ft/yr]
		No. 1	No. 2	No. 3	No.4	No. 5	No. 6		
1952	0	NA	NA	NA	NA	NA	NA	NA	NA
1978	26	NM	NM	NM	NM	NM	NM	NM	NM
2020	42	NM	NM	NM	NM	NM	NM	NM	NM

Notes: NA = not applicable, NM = erosion rate too low to be measurable

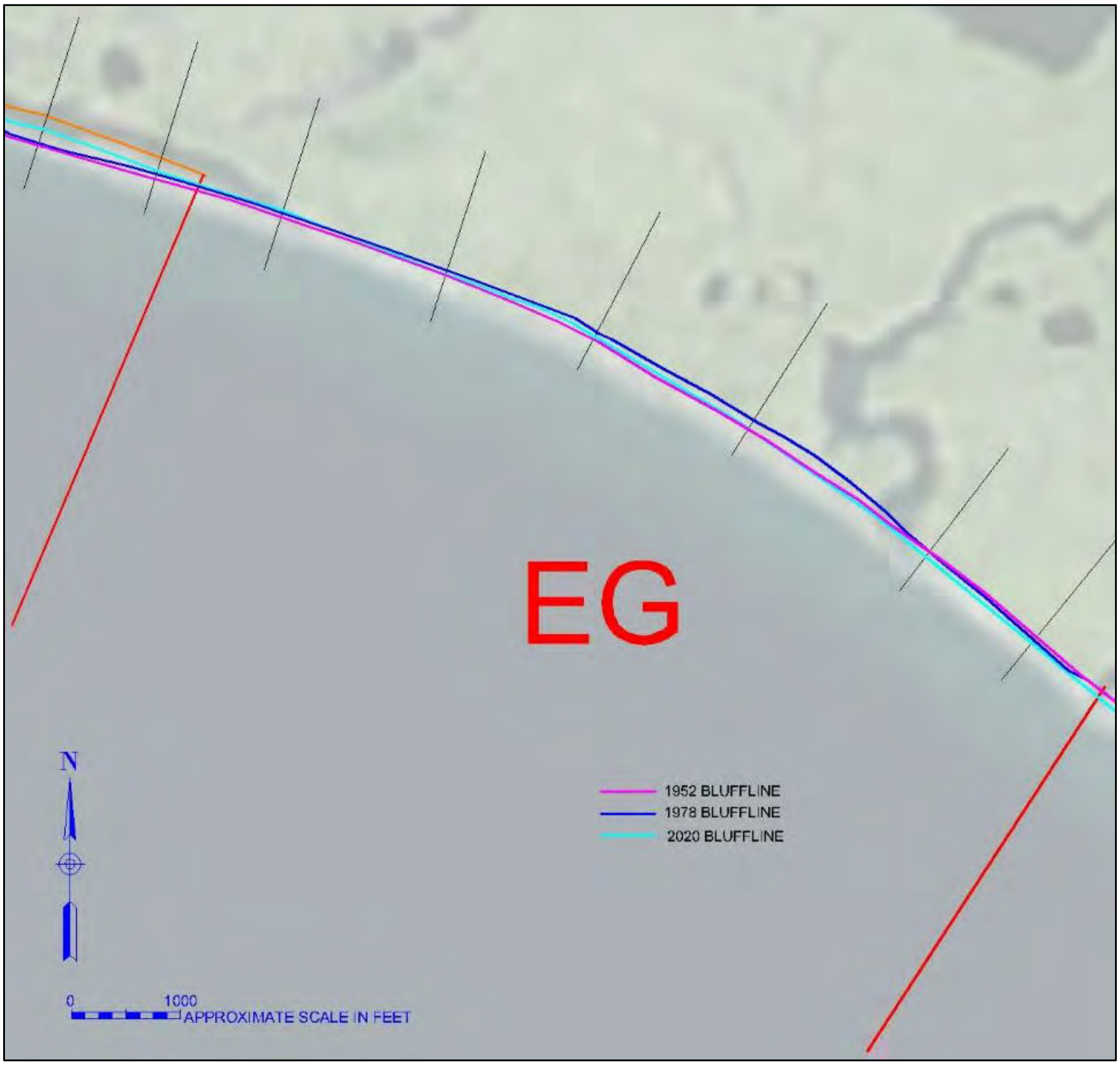

Figure 26. Coastal Reach EG – Erosion Lines

3.0 NAVIGATION CHANNEL AND NEAR-SHORE CONNECTION LENGTH ANALYSIS

3.1 Methodology

Potential navigation channel and near-shore connection lengths from a potential dock location were evaluated across the study area (Figure 27). For this analysis, the navigation channel length along a center line within reach is based on the same design depth of -26 ft Mean Lower Low Water (MLLW) with the near-shore connection length based on a dock located at the -12 ft MLLW contour. This general design was previously developed and presented in the terminated GI study (USACE 2019), carried forward in the Navigation Improvements at Cape Blossom Technical Report (USACE 2020). This channel and near-shore connection analysis is presented in more detail in the attached Appendix A.

To evaluate potential channel locations the coast was divided into 5 reaches with similar bathymetry (Figure 28) based on the National Oceanic and Atmospheric Administration (NOAA) Chart 16161. As expected the navigation channel lengths increased north of Cape Blossom to as high of 21,110 ft, were shortest at the cape at 2,862 ft, and increased to a high of 6,609 ft at the far eastern reach of the study area. The near-shore connection lengths followed a similar pattern in that they increased north and east of the cape. However, the longest near-shore connection length was at the cape itself at 3,296 ft. The estimated navigation channel and near-shore connection lengths are also presented in Table 29.

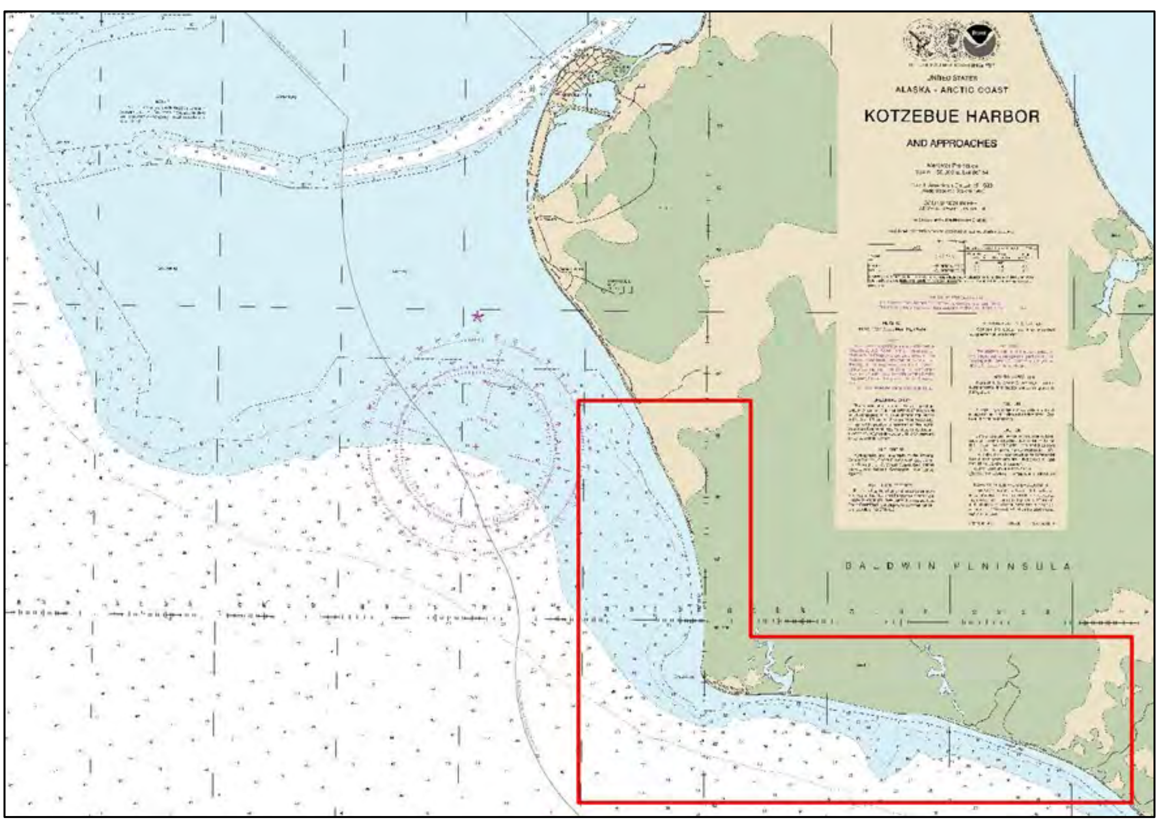

Figure 27. Coastal Study Area (NOAA Chart 16161)

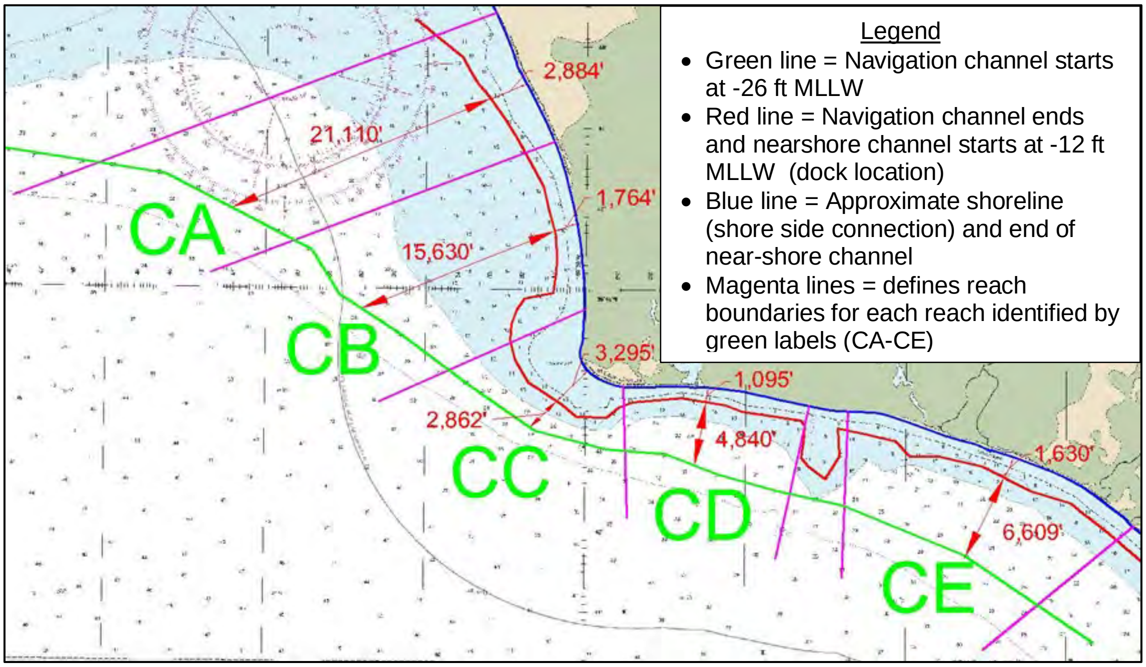

Figure 28. Channel Length Analysis Coastal Segments

Table 9. Navigation Channel and Near-Shore Connection Length

Channel Reach	Near-Shore Connection Length [ft]	Channel Length [ft]
CA	2,884	21,110
CB	1,764	15,630
CC	3,295	2,862
CD	1,095	4,840
CE	1,630	6,609

3.2 Summary - Erosion Rate, Navigation Channel and Near-Shore Length

This study analyzed a section of coastline near Kotzebue with regards to coastal erosion rates and the length of the dredged channel and shore side facility connection. This study was not an in-depth analysis for site selection; rather this analysis is intended to provide a tool to narrow the selection of possible coast locations for a future port.

Erosion Rate and 50-yr Land Loss

The coastal study area was divided into 7 reaches, EA through EG (see Figure 6). Each reach represented a section of shoreline with similar, but still somewhat variable, erosion rates for the transects within an individual reach. The similarity allowed characterization of each reach using an estimated average erosion rate, while rates for each individual transect demonstrates the variability within each individual reach. Even with this variability, the average erosion rates and 50-yr period estimate for erosion loss allows for the general characterization of each reach as presented below:

- During the former feasibility study (USACE 2019 and 2020) the study area that included a proposed port location had an estimated 50-yr land loss of 600 to 1,520 ft depending on whether the low or high erosion rate estimate was considered (see Table 1). This earlier study area is on the border between Coastal Reach EB and EC, which is a transitional area to where the erosion rate increases to the east into reach EC.
- Coastal reaches representing each end of the study area, EA and EG, appear to be the most stable shorelines with the change between aerial photograph years insignificant or not measurable (Table 10). As a result, the 50-yr period land loss was not estimated for these reaches.
- Coastal reaches EB and EF are transitional with measurable, but relatively low average erosion rates and 50-yr land loss estimates at 175 ft and 125 ft, respectively.
- The central coastal reaches EC, ED, and EE represent the most unstable shorelines in the study area based on average erosion rates ranging from 21.6 to 39 ft/yr and 50-yr land loss estimates ranging from 1,079 ft (EE) to 1,951ft (EC).

Table 10. Summary of Erosion Rates and 50-Yr Period Land Loss Estimate

Coastal Reach Label	Avg. Change / Photo Year (ft)			Avg. Rate / Photo Year (ft/yr)			50-yr Period Land Loss[1] (ft)
	1952 to 1978	**1978 to 2013**	**2013 to 2020**	**1952 to 1978**	**1978 to 2013**	**2013 to 2020**	
EA	NM	NM	NM	NM	NM	NM	NM
EB	71.7	94.2	24.5	2.8	2.7	3.5	175
EC	13.7	103.3	273.7	0.5	3.0	39	1,951
ED	93.5	357.1	187.3	3.6	10.2	26.8	1,338
EE	78.2	197.6	151.1	3.0	5.6	21.6	1,079
	1952 to 1978	**ND**	**1978 to 2020**	**1952 To 1978**	**ND**	**1978 to 2020**	
EF[2]	79.4	ND	104.9	3.1	ND	2.5	125
EG[2]	NM	ND	NM	NM	ND	NM	NM

Notes: (1) 50-yr period land loss estimate based on average erosion rate from 2013 to 2020, except for reaches EE and EG which used 178 to 2020 data
(2) A 2013 aerial photo did not extend to reaches EF and EG, so two periods of analysis (1952 to 1978 and 1978 to 2020) are reported.
NM = Change or erosion rate too low to be measurable - not measurable

Navigation Channel and Near-Shore Connection Lengths

The coastal study area was divided into 5 reaches fronted with similar bathymetry (see Figure 28). Along a center line within each reach, the navigation channel and near-shore connection lengths were estimated to a potential dock location at the -12 ft MLLW contour. Although these lengths are not based on detailed bathymetric data, general observations can be made concerning the potential impact to a future port location selection in each coastal reach.

- North of Cape Blossom, navigation channel and near-shore connection lengths increase and are the longest compared to other locations due to extensive shallow water and mud flats extending far from shore (see Figure 28 and Table 9). When considering a new port location, the cost to construct the channel and maintain it are important considerations in port selection and could potentially be more determining than a more stable shoreline.
- Although the Cape Blossom reach CC has the shortest navigation channel length due to favorably deep bathymetry, the near-shore connection length is the longest for all areas, and although the cape has a relatively low erosion rate, the high bluff at the cape could complicate access between the land and in-water facilities.
- The shortest navigation channel and near-shore connection is found in the reach identified as CD east of the cape. This reach encompasses the western portion of the erosion reach EB where the erosion rates were relatively low. These site conditions suggest that an area east of Cape Blossom and west of the erosion reach EC, which included the former study location, may be worth investigating further for a future port.
- Navigation channel and near-shore connection lengths increase immediately east of the reach CD in reach CE, but of greater concern is that the erosion rates increase significantly to the east in reaches EC, ED, and EE. However, the erosion rates decrease significantly in the eastern most reach EG indicating that this reach might be considered for further study.

3.3 Potential Coastal Reaches for Further Evaluation

Based on the relatively lower erosion rates, and shorter navigation channel and near-shore connection lengths, at least three reaches shown in Figure 29 appear to warrant further discussion. These reaches include:

- North of Cape Area (NCA) 1: The coastline immediately north of Cape Blossom and the south end of Coastal reach EA appears relatively stable (see Table 10), however the navigation channel and near-shore connection lengths (see Figure 28) are typically longer than locations east of cape.
- East of Cape Area (ECA) 1: The coastline east of Cape Blossom within EB to the former area included in the former GI study (EC) (USACE 2019 and 2020) has a lower erosion rate, plus a favorable bathymetry that results in the shortest navigation channel and near-shore connection lengths of any of the reaches.
- East of Cape Area (ECA) 2: The coastline farthest east within the study area have relatively low erosion rates with the navigation channel and near-shore connection lengths longer than at ECA1.

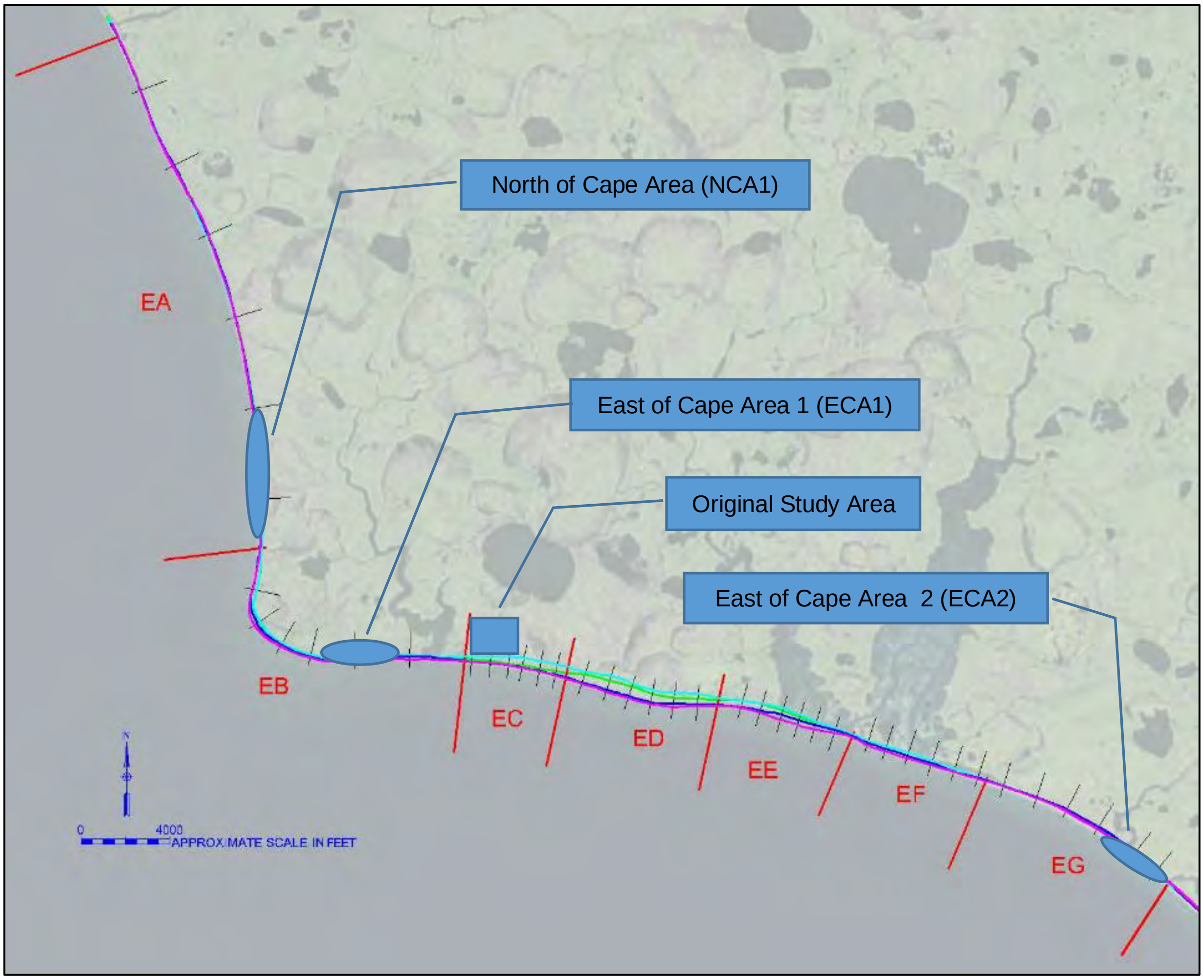

Figure 29. Potential Port Locations for Further Study

A more in-depth study of one or all 3 coastal areas (NCA, ECA1, and ECA2), or any other area, would need to be performed to further the decision concerning a future port location. This in-depth study would be similar to the original navigation improvement study, and would involve, but not be limited to evaluation of:

- Sediment transport with regards to keeping the channel open.
- Maintenance dredging requirements (frequency and volume)
- Wind at the site
- Waves at the site
- Water currents
- Ice conditions at the site
- Constructability (dredge material)

Although the evaluations listed directly above are not included in this PAS study, other factors or considerations are discussed in the next section at a high level using readily available information. These discussions are meant to identify the issues that could influence a site selection and / or a decision for further study.

4.0 SITE VISIT OBSERVATIONS

4.1 NCA1 Site observations

A site visit was conducted on 13 July 2021 to observe site conditions of the 3 locations (NCA1, ECA1, and ECA2) and the original study area identified in Section 3.0 above (see Figure 29) that appeared to warrant further assessment. A boat was used to access each site, except NCA1 as discussed below.

The site, NCA1 is located at the southern extent of coastal reach EA located north of Cape Blossom (see Figure 29). This section of shoreline was not observed during the field visit because of adverse wave conditions preventing safe beaching of the boat transporting the field team. However, the non-Federal sponsor and the City of Kotzebue personnel stated during a site visit follow-up meeting on 14 July 2021 that this section of coastline was not a desirable location for constructing a future port because of the adverse wave climate and relatively tall shoreline bluff. In addition, this section of shoreline would also have the longest navigation channel required to reach a shoreline dock (see Figure 28), and the highest associated dredge cost to maintain the channel to the dock. In addition, in-water port infrastructure would also likely have to be more robust and extensive than at the other locations east of the cape because of the adverse wave climate north of the cape.

4.2 ECA1 Site Observations

Site observations indicate that coastal erosion of the shoreline bluff and uplands is less active in this section as indicated by the erosion rates discussed above in Section 3.1. An example of the beach and bluff is shown in Figure 30. The bluffs were approximately 10’-20’ feet in height along the coast of this area. Standing water existed in the uplands while polygonal topography was visible there was less indication of thawing ice wedges and polygons then when compared to the Original Study Area. Surficial soils were wet and poorly drained with standing water throughout the uplands.


Figure 30. Looking west toward Cape Blossom along beach of ECA1

4.3 Original Study Area Observations

The shoreline bluff in the original study area rises 5 to 10 ft above the beach (Figure 31) and is subject to active erosion by both direct physical (mechanical) and thermal factors. The collapsing shoreline bluff shown in Figure 31 has a high organic content and high ice content with little, if any, material (e.g., gravel and cobbles) that would be resistant to be washed away during high tide or storm event. As a result, there is no accumulation of material at the base of the bluff to protect it from direct wave action. The bluff exposure to warmer sea water and hydraulic action from wave runup causes thermal erosion of exposed frozen ground slumping of the bluff face. Thawing ice wedges cause slumping that penetrates the bluff face as seen in Figure 32, which can enhance the erosion rate by exposing a larger bluff face area to the erosion elements.

Figure 31. Erosion along coastline looking West in the original study area.

Figure 32. Ice wedge exposed at original study area shoreline bluff.

4.4 ECA2 Observations

This area is the most eastern location in study area (Figure 29). Little to no shoreline bluff was observed in this coastal reach area. The erosion analysis presented in Section 3.1 above indicated there was no noticeable erosion in this area, and the team observed no visible signs of active erosion caused by direct wave action or thawing permafrost along the beach. There were even signs of accumulation of coastal sediments (accretion) in this coastal reach area. Slopes transitioning from the beach inland were currently maintaining established vegetation and they ranged from 14 to 26 degrees from horizontal, indicating they are stable in their current configuration. Areas with elevations higher than the adjacent lagoon were well drained and there was very little indication observed from the surficial deposits indicating large ice wedges and ice rich soils were present at the site.

Road construction to this location may be difficult and expensive due to the additional distance compared the other sites closer to the original study area. A nearby lagoon as seen in Figure 33 may represent high sedimentation rates at the shoreline which could present difficulties with sedimentation within a potential harbor. Maintenance dredging may be required routinely to deal with this issue.

Figure 33. Looking North West along the coastline from ECA2

5.0 OTHER SITE SELECTION CONSIDERATIONS

5.1 General

There are factors or considerations other than coastal erosion rate and channel length that can influence selection of a new port site for further study. These other considerations can include, but are not limited to:

- The feasibility of extending the Cape Blossom Road to the port site or an access road from a proposed port site to the Cape Blossom Road
- Subsurface site conditions (e.g., permafrost and soil types)
- Environmental resource impacts and permitting
- Cultural resources
- Landownership

5.2 Road Access Considerations

Viable access to the Cape Blossom Road would appear to be a critical consideration for any future port location south of Kotzebue. The two sites, NCA1 and ECA1 (see Figure 29), are the closest to the Cape Blossom road (see Figure 3). This relatively close proximity suggests road access is more viable than at the coastal area ECA2 simply because this area is more than 5 miles east of the currently proposed terminus of the Cape Blossom Road.

5.3 Geotechnical Considerations (soil types and permafrost)

The subsurface conditions are important factors for infrastructure development at any port location. The former study (USACE 2019 and USCAE 2020) provides information at the original port study location (see Figure 29), and although this information may not accurately portray site conditions at other potential port locations, a discussion of soil types and permafrost conditions provides the reader with an understanding of what might be encountered at these other locations.

<u>Soil Types</u>

Geotechnical and geophysical investigations were conducted near Cape Blossom which was the planned location of the project that was studied in 2019. The geotechnical investigation conducted by Alaska DOT&PF included offshore drilling of test borings extending up to -34 feet MLLW. The investigation covers about 7,000 feet of shoreline extending close to 5,000 feet out to the sea. The soils encountered indicate loose sands and soft silts with gravel inclusion. Cobbles up to 10 inches in size were observed in the cliffs of Cape Blossom and they may be present in the sediments. Peat was also encountered in the investigation which is consistent with the tundra vegetation covering the cliffs of Cape Blossom that may have been eroded. The geophysical investigation conducted by Golder Associates also reported a mantle of soft silts and loose sand material five to 20 feet thick over a denser material with bigger particle sizes. This data maybe too localized to be representative of the areas selected for further consideration (see Figure 29). However, the data might be characteristic for one of the selected sites (ECA1) because of its relatively close proximity to the GI study area. Other areas of consideration for the location of a navigation project will require in depth soil studies which may include both geophysical and soil investigations.

Permafrost

Kotzebue and the rest of the Baldwin Peninsula are in a continuous permafrost zone. The permafrost is typically ice rich as evidenced from aerial photography showing several lakes scattered throughout the Northern Baldwin Peninsula. These lakes could have resulted from the melted ice lenses. The eroding banks of the coastal reaches EC, ED and EE show several exposed ice lenses observed by the field crew that inspected the site in 2016. An example of an exposed ice lens in the eroding bluffs near Cape Blossom is shown in Figure 34.

Figure 34. Exposed Ice Lens in bluff face near Cape Blossom

The ADOT&PF Soil Investigation included borings for the proposed Cape Blossom road. The soil borings all reported frozen soils throughout the depths of the borings ranging from 14 to 24 feet below ground surface. Ice lenses were encountered in all the test borings except for soil boring 09-1207 which was drilled near Sadie Creek. The permafrost at the Cape Blossom and nearby areas is generally ice rich although it may not be very apparent in some areas. This was taken into consideration in the former study, anything that will be built uplands will disturb the permafrost and may cause excessive settlements in ice rich areas.

The uplands near coastal areas EA and EG may have somewhat thaw stable permafrost with the absence of dotted lakes. However, disturbing the vegetation will expose the frozen soils and may initiate erosion.

5.4 Environmental Resources

General considerations for each of the project's potential permutations should include the time required to coordinate with external resource agencies and to obtain specific permits and authorizations for impacts associated with the implementation of the project. Environmental data collection windows are limited by the seasonal presence of sea ice and must be taken into consideration when coordinating compliance with Federal and State environmental laws, regulations, policies, and applicable Executive Orders. Examples of prolonged environmental timelines include, but are not limited to:

- A Letter of Authorization for the inadvertent harassment of marine mammals may take as long as 15 months to issue from the National Marine Fisheries Service once the appropriate application and supporting data have been submitted.
- If the marine mammal(s) in question is/are threatened or endangered, an additional 180 days may be required to obtain a Biological Opinion from the National Marine Fisheries Service.
- Water Quality Certificates issued by the Alaska Department of Environmental Conservation may require sediment sampling of the envisioned dredge prism.
- Compliance with the Marine Protection, Research, and Sanctuaries Act may require extensive sediment sampling, testing, and analysis before open ocean dredge material disposal is available as a feasible option for the disposal of dredge material.

5.5 Cultural Resources

The information provided below includes a brief historical background summary including previous investigations and known cultural resources, as well as a concern by coastal reach discussion.

Background

Occupation of Kotzebue Sound dates to approximately 5,200 years ago (Friesen et al. 2016). *Igluġruat*, the only known village at Cape Blossom, was reported in 1800 as a fall and winter settlement with one to two houses occupied by 8 to 16 people. A second settlement, *Kaŋilik*, was east of the second slough, approximately 6 miles southeast of Cape Blossom, and was noted to consist of two houses and 16 people (Burch 1998).

The Iñupiat of Kotzebue Sound were first contacted by Europeans in 1817 when Lieutenant Otto von Kotzebue explored the area during a voyage chartered by the Russian Empire (Orth 1967). Captain Beechey of the *H.M.S. Blossom* visited the

Baldwin Peninsula area in 1827; he noted the presence of several settlements in the area (DePew et al. 2002).

In 1880, the annual Indigenous summer trade fair in Kotzebue Sound, usually held at *Sisualiq*, was held at Cape Blossom (Bockstoce 2009). That same year, the U.S. Revenue cutter *Corwin* temporarily used Cape Blossom as an inspection station, checking Euromerican vessels for contraband. The *Corwin* reported that the Cape Blossom trade fair had 1,200 people, likely composed of individuals from as far north as Point Hope and as far south at the Yukon River Delta (Burch 1998; DePew and Buzzel 2002; Gal 1986; Hooper 1884). The trade fair was moved to *Qikiqtaġruq*, near the current city of Kotzebue, around 1883 (Burch 1998).

<u>Previous Investigations and Known Cultural Resources</u>

There is one known cultural resource in the vicinity of Cape Blossom identified in the Alaska Heritage Resources Survey (AHRS). KTZ-00312 is described as “a grave and fairly recent frame structure;” it was observed during an overflight survey in 2006 (NLUR 2006:16). Several archaeological surveys have been conducted near Cape Blossom over the years. The Bureau of Indian Affairs (BIA) surveyed a Native Allotment in the area in 2009; no cultural resources were identified within the allotment (BIA 2009). Northern Land Use Research, Inc. (NLUR) conducted helicopter and pedestrian surveys for a proposed road from Kotzebue towards Cape Blossom for the ADOT&PF in 2012. They did not identify any cultural resources within the general area of where the navigation improvements would be located (NLUR 2013).

In 2016, a USACE archaeologist conducted a pedestrian survey of the Former Study Area associated with the 2020 USACE report. This included the presumed locations of the historical Iñupiaq villages of Igluġruat and Kaŋilik. No cultural resources were identified in the vicinity of Igluġruat; however, a partially standing wood-frame house and the remnants of a reindeer corral were identified in the vicinity of Kaŋilik. A grave marker was also visible at the location of KTZ-00312 from the boat used for transportation to the survey areas.

<u>Cultural Resources Concerns by Coastal Reach</u>

Cultural resources which may exist within the coastal reaches include the wrecks of a side-wheel steamer called the *John Reilly*, which was blown into the rocks 4 miles east of Cape Blossom on October 13, 1905, and two vessels, the *Defiance* and the lighter it was attempting to rescue, which sank somewhere off Cape Blossom on October 15, 1930 (BOEM 2011; NOAA 2018). An underwater survey has not been conducted in the area because annual ice scouring and strudel scouring would have removed any underwater cultural resources; however, it is possible that shipwreck debris could exist along the shoreline.

Coastal reach EA has not been archaeologically surveyed, while the entire coast of coastal reach EC has been surveyed (Figure 35). All other coastal reaches have been partially surveyed for cultural resources. Based on the above research, the USACE recommends that, in the chosen coastal reach, well-drained landforms are surveyed for the presence of cultural resources.

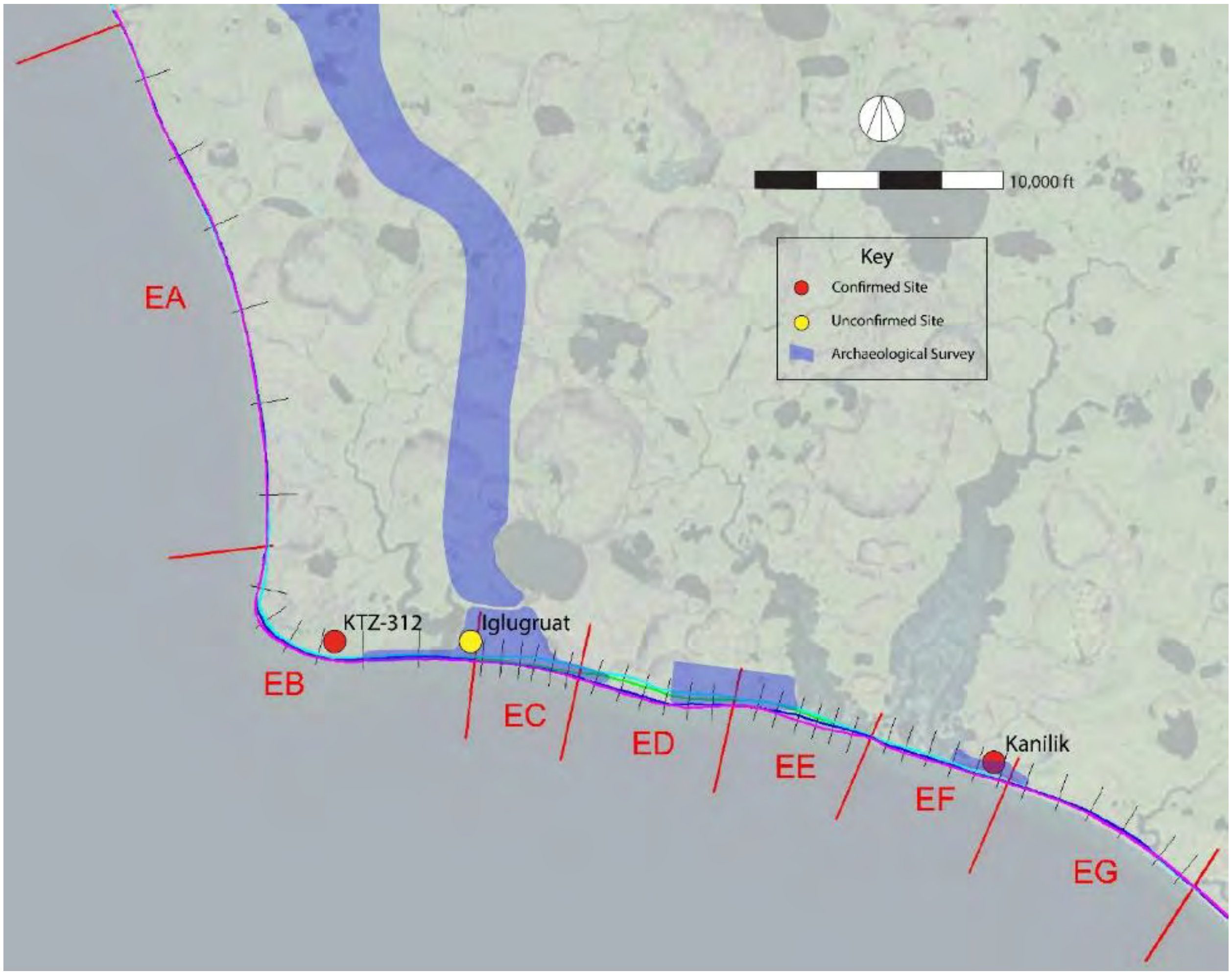

Figure 35. Cultural Resource Survey Summary Map

5.6 Real Estate

Property Owners

The property located between the City of Kotzebue and East of Cape Blossom being considered for a purpose harbor are made up of subsurface and surface lands owned by NANA Regional Corporation, Kikiktagruk Inupiat Corporation, multiple native allottees, and federally owned lands managed by the Bureau of Land Management (BLM), as displayed on Figure 36.

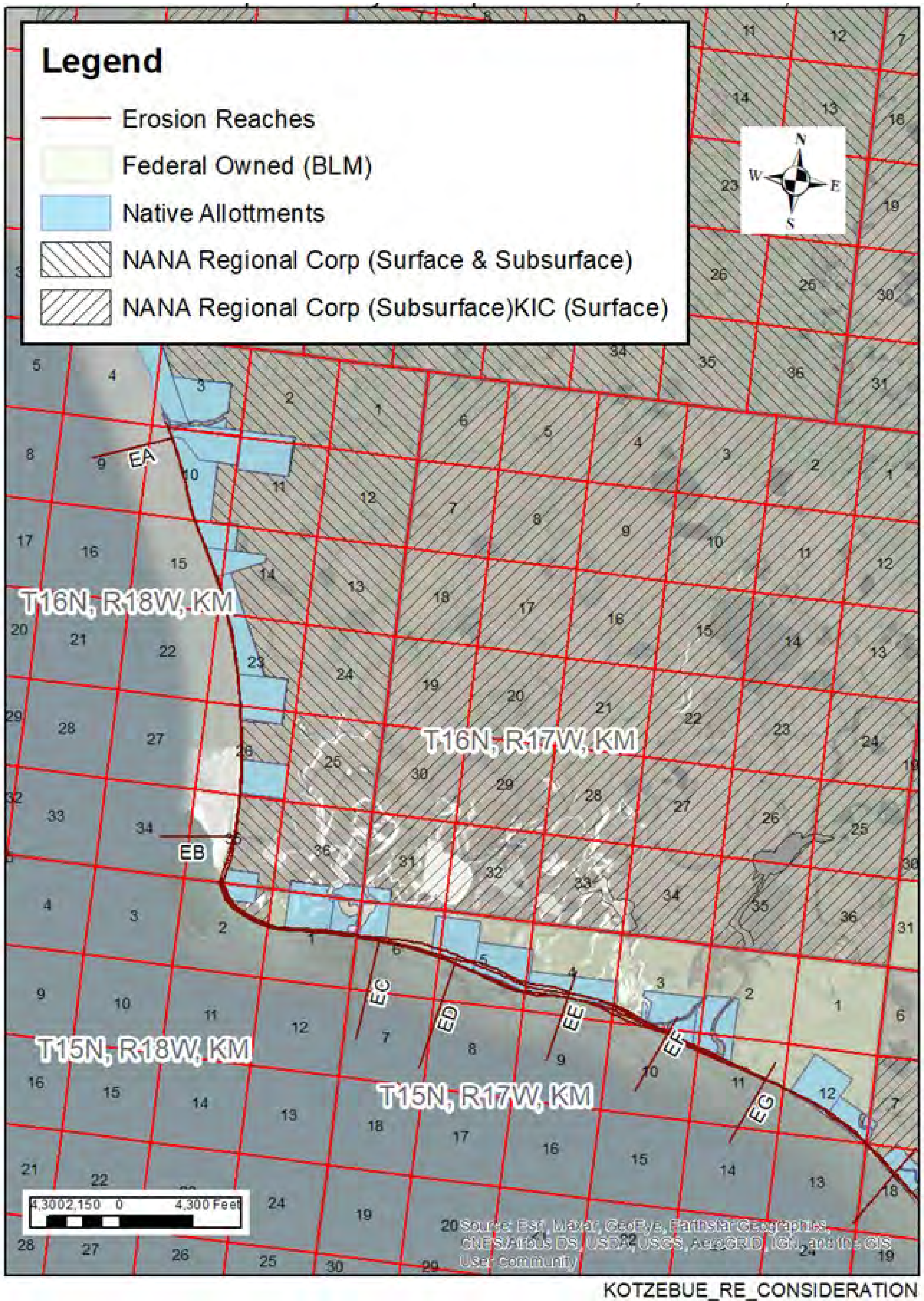

Figure 36. Landowners Map – Vicinity of Cape Blossom

Land Acquisition for General Navigation Feature (GNF) and Land Required for Local Service Facilities (LSF)

The region of land considered is identified in Figure 36 above. The Federal Government (BLM) owned properties are top-filed by the State of Alaska, Department of Natural Resources. The NFS will work directly with the BLM, if lands owned by the BLM are required for the GNF or LSF. Acquiring the land for the LSF is the responsibility of NFS, and may be required as part of a PPA, because they are necessary for project benefits to accrue.

Access to the Cape Blossom and Kotzebue Sound

The Kikiktagruk lnupiat Corporation, conveyed to the State of Alaska, Department of Transportation & Public Facilities (SOA, DOT&PF), a perpetual, full and unrestricted easement and right-of-way along, over, and across the surface estate of the following described tracts of land located in the Kotzebue Recording District, Second Judicial District, State of Alaska.

The NANA Regional Corporation, Inc., conveyed to the SOA, DOT&PF, a perpetual, full and unrestricted easement and right-of-way along, over, and across the subsurface estate of the following described tracts of land located in the Kotzebue Recording District, Second Judicial District, State of Alaska.

The U.S. Department of Transportation, Federal Highway Administration, with the consent of the U.S. Department of the Interior, Bureau of Land Management (BLM) transferred an easement to the State of Alaska (SOA), Department of Transportation and Public Facilities (DOT&PF) by a Highway Easement Deed, dated 9 September 2016. The easement shall terminate 10 years from the date of the execution of this deed by the UNITED STATES OF AMERICA in the event development of the right of way has not commenced during such period.

The easements routes are shown in Figure 37 and Figure 38.

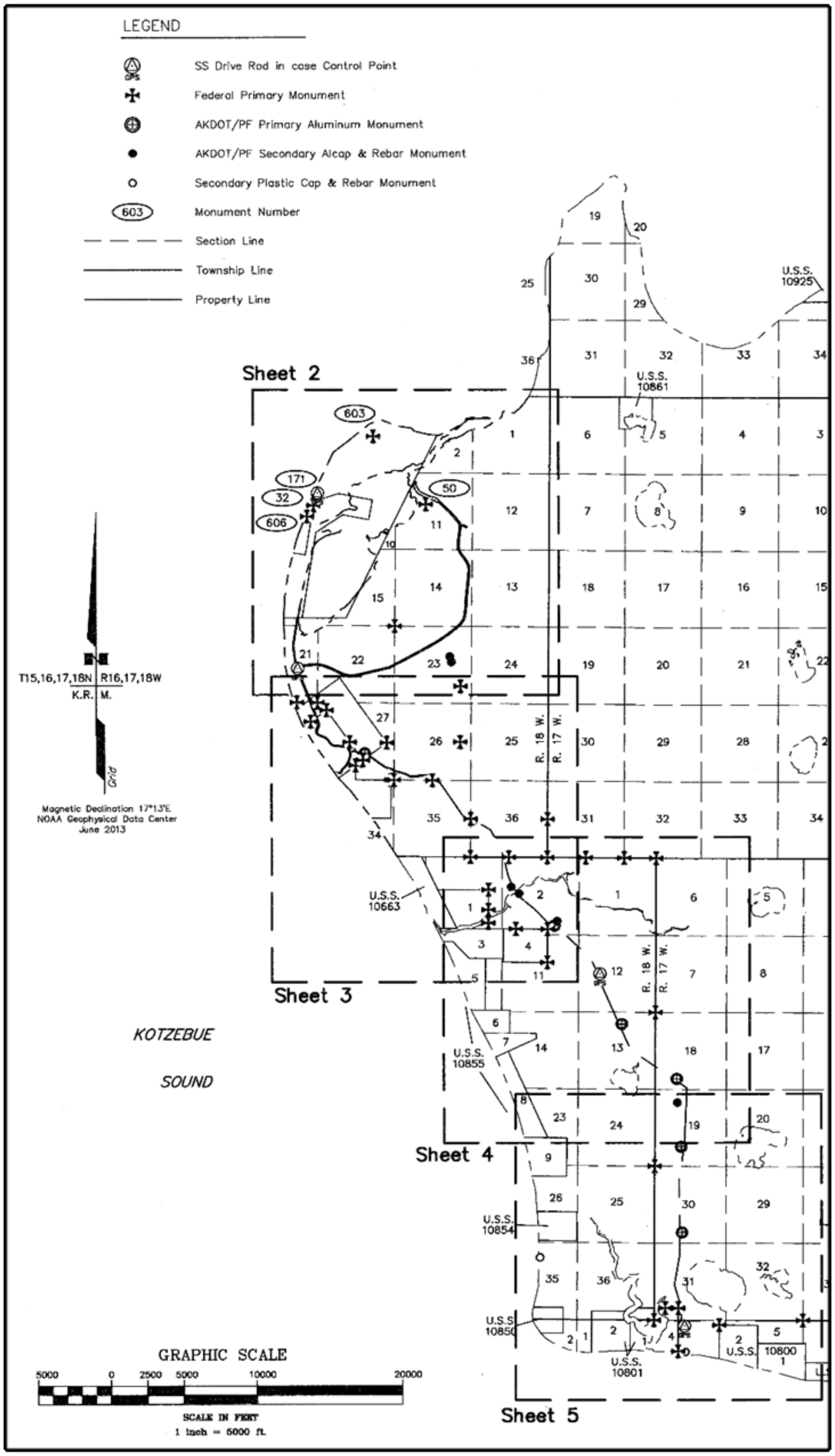

Figure 37. State of Alaska, Department of Transportation Road and ROW Route

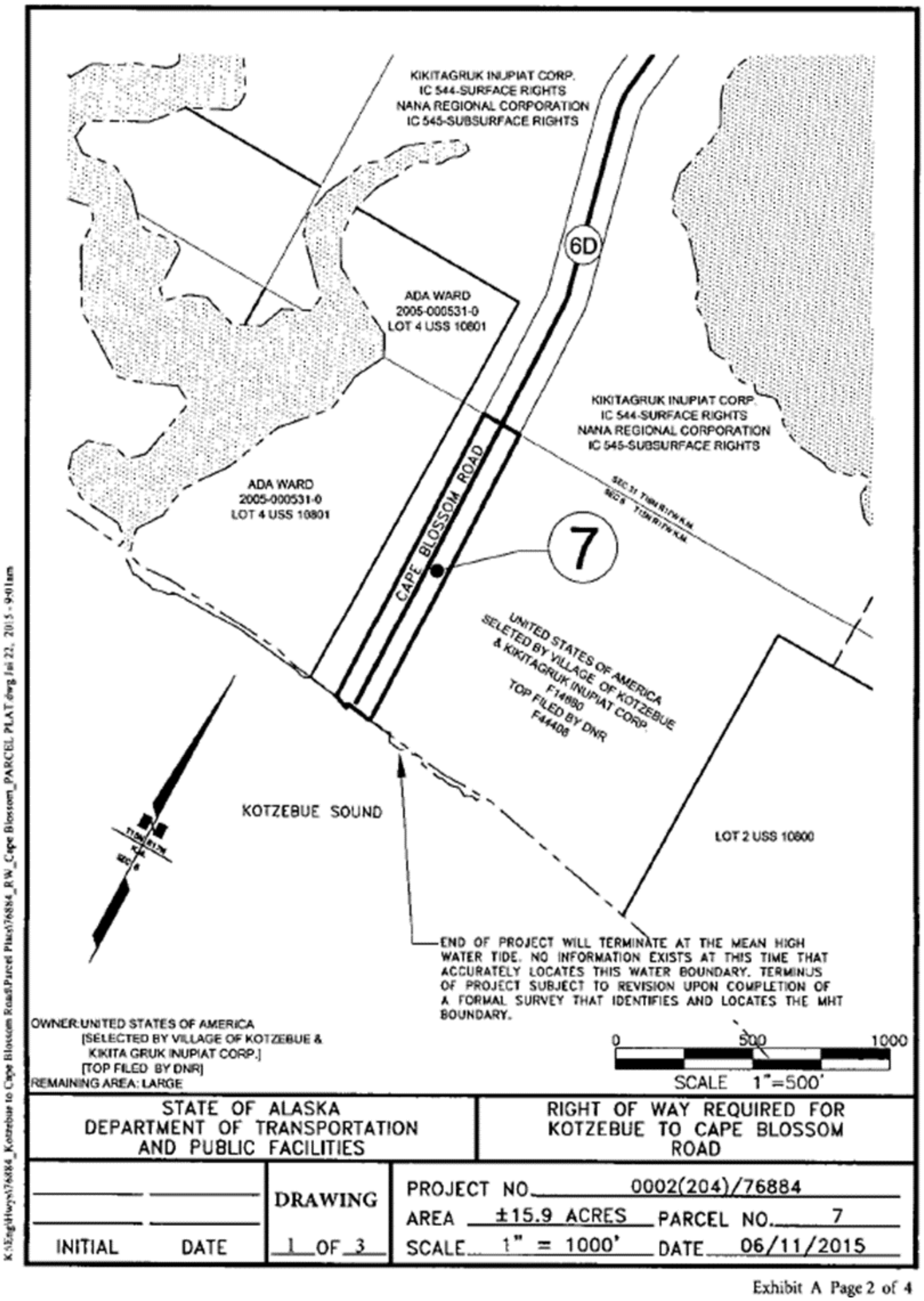

Figure 38. SOA, DOT&PF Easement over Federal Land

Navigation Servitude

The Federal government can exercise its right of navigational servitude hereunder for the construction and maintenance improvements being proposed. In addition, USACE will follow proper permitting process for excavating and/or disposing of material in navigable waters as required under Section 10 of the Rivers and Harbors Act of 1899.

Mineral Activity Impacted Present/Future
There are no current or anticipated mineral or timber activities within the vicinity of the proposed project that would affect construction, operation, or maintenance of the proposed project. No subsurface minerals or timber harvesting is expected to take place within the project area.

6.0 GENERALIZED CONCLUSIONS

The intent of this report is to provide information that can assist the non-Federal sponsor in identifying a potential port location in the vicinity of Cape Blossom. Site visits were conducted in July 2021 to observe conditions at three reaches, NCA1, ECA1 and ECA2 (see Figure 29), as well as the original site investigated previously. These sites were identified by their lower erosion rates and shorter navigation channel and near-shore connection lengths. Generalized conclusions based on the work performed to date is summarized below in Table 11.

Table 11. Generalized Conclusions

Key Port Location Considerations	**Coastal Reach Areas for further Consideration and Comments**			
	NCA1	**ECA1**	**Original Study Area**	**ECA2**
Coastal erosion 50-yr land loss estimate and Average annual rate	Minimal 50 yr land loss and annual erosion rate	175 ft / 2.8 ft/yr to 3.5 ft year	600 to 1520 ft / 12.0 to 30.4 ft/yr	Minimal 50 yr land loss and annual erosion rate with some evidence of beach building
Navigation channel length	15,630 ft	4,840 ft(1)	4,840 ft	6,609 ft
Near-shore channel length	1,764 ft	1,095 ft(1)	1,095 ft	1,630 ft
Road access	Approximately 3 miles west of proposed Kotzebue to Cape Blossom road alignment	Approximately 1 mile west of proposed Kotzebue to Cape Blossom road alignment	Kotzebue to Cape Blossom Road terminates at this location	Approximately 10 plus miles, depending on route, to reach the Kotzebue to Cape Blossom road
Shoreline bluff	20 to 40 ft tall – highest of all the sites	10 to 20 ft tall bluff highest east of the cape	5-10 ft tall bluff	Low to nonexistent bluff
Geotechnical	Subsurface conditions unknown but	Subsurface conditions unknown but	High organic and ice content soils	Subsurface conditions unknown but

	coastal bluff seems more stable than other sites	coastal bluff is receding suggesting high organic and ice content in the soils	with the most severe coastal erosion rates	coastal erosion rates minimal
Real Estate	Known Real Estate	Apparently has Real Estate ownership challenges	Known Real Estate	Actual site has favorable ownership but real estate considerations for the access road route from the Kotzebue to Cape Blossom road have not been studied
Cultural resources	Cultural resource considerations at site and for access road unknown	Has potential cultural resource considerations at site	Limited cultural resource considerations	Cultural resource considerations at site and for access road unknown
Environment permitting	Potentially lower-level effort because of close proximity to Kotzebue to Cape Blossom Road	Potentially lower-level effort because of close proximity to Kotzebue to Cape Blossom Road	The least effort because already studied - NEPA completed	Potentially highest permitting effort because of the long access road

Notes:
1) Navigation channel and near-shore channel length should be similar to what was found in the original study area

Unless further assessment is requested, the current PAS Study scope of work is completed after receiving comments on this draft report from the non-Federal sponsor, and a final report is prepared and released by the USACE that addresses these comments. However, a comprehensive feasibility study of one or all 3 coastal areas, or any other area, would need to be performed to further the decision concerning a future port location, and this level of effort is beyond what the PAS study authority can offer.

When considering this the non-Federal sponsor should understand the feasibility study for the original site location resulted in a total cost to the non-Federal sponsor that was significantly higher than the Federal commitment for the project. A cost share analysis completed during the previous feasibility study estimated that if the proposed plan was constructed at the original site the non-Federal cost share amount would range from approximately $268M to over $392M. This range was due to the deferred construction cost of $0 to $125M to adapt to the potential coastal erosion rates over the 50-year period of analysis. The Federal share was significantly less at approximately $36.4M for the general navigation features, which was a dredged access channel to provide access to the dock. This large disparity between the cost commitment between the Non-Federal sponsor and the Federal government for the proposed plan shows that most of the project cost is for LSF construction and maintenance to obtain the project benefits.

In conclusion, there are many other factors or considerations, other than the GNF covered within this report, that ultimately could or will influence a port location and design decision that are not within the purview of the Federal government. For this project because of the significant disparity between the non-Federal and Federal commitment, additional assessment by USACE under this PAS, if requested, is recommended to be limited to a rough-order-of-magnitude cost evaluation for the GNF. This GNF cost information could be used by the non-Federal sponsor in the future to assist in developing their LSF plans and design concepts that best fits their vision for a new port at a location. The next step is for the non-Federal sponsor to come back to the USACE is to develop plans and designs for a port. After this non-Federal sponsor lead effort, a potential in-depth study by USACE would require a new request and start for a GI Study.

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Planning Assistance to States Technical Report

Site Conditions in the Vicinity of Cape Blossom

Kotzebue, Alaska

Appendix A: Coastal Analysis

September 2021

US Army Corps of Engineers
Alaska District

PLANNING ASSISTANCE TO STATES
Coastal Analysis

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

This analysis looks at the rate of erosion along the coast north and east of Cape Blossom, and the dredging distance required if a channel were to be dredged. It provides the background for evaluating a potential site for navigation improvements for Kotzebue.

1.1 Background

Fuel and goods shipped to Kotzebue supply the city and outlying communities. A navigation inefficiency is associated with shipping due to a long (12-15 mile) shallow draft channel that must be transited to reach the dock at Kotzebue. A lack of sufficient draft for the ocean-going barges delivering fuel and goods results in the barges anchoring offshore in deep-water, and smaller barges lightering the fuel and goods into Kotzebue.

The Corps of Engineers performed a Navigation Improvement Study for an area east of Cape Blossom. During the study, an erosion evaluation was performed, and it became evident that the area of study was subject to high rates of erosion, making the siting of shore side facilities extremely costly.

The study was terminated and an analysis of the coastline north and further east of Cape Blossom was evaluated to see if there is a location better suited to support the shoreside facilities.

1.2 Description of the Area

Kotzebue is approximately 550 miles northwest of Anchorage, Alaska and 26 miles above the Arctic Circle (Figure 1) and is the regional hub for the northwest Arctic Borough (Figure 2). The city is located on three miles of coast on the north tip of the Baldwin Peninsula which is bounded on the north and west by Kotzebue Sound and the east by Hotham Inlet, known locally as Kobuk Lake (Figure 3).

The population of Kotzebue is 3,200 according to the 2010 Census. The region lacks road access. Kotzebue serves as a hub as it is near the discharges of the Kobuk, Noatak, and Selawik Rivers. Kotzebue and the surrounding villages are accessible via water and air in the summer and air and snow machine or dogsled in the winter.

Currently, ocean going barges anchor 12 -15 miles offshore and lighter fuel and goods to shore. Once goods arrive in Kotzebue, smaller river going barges load the fuel and goods for delivery to the surrounding villages. The purpose of this analysis is to determine the feasibility of constructing improvements that would increase the navigation efficiency for delivery of fuel and goods to Kotzebue.

South of Kotzebue, around Cape Blossom, the distance to deep water is much closer. This is the area being considered for a navigation improvement. The coast varies from high exposed bluffs, vegetated low bluffs, visibly eroding low bluffs, exposed eroding permafrost, and flat beaches backed by lakes (Figure 4 - Figure 8).

Figure 1. State of Alaska

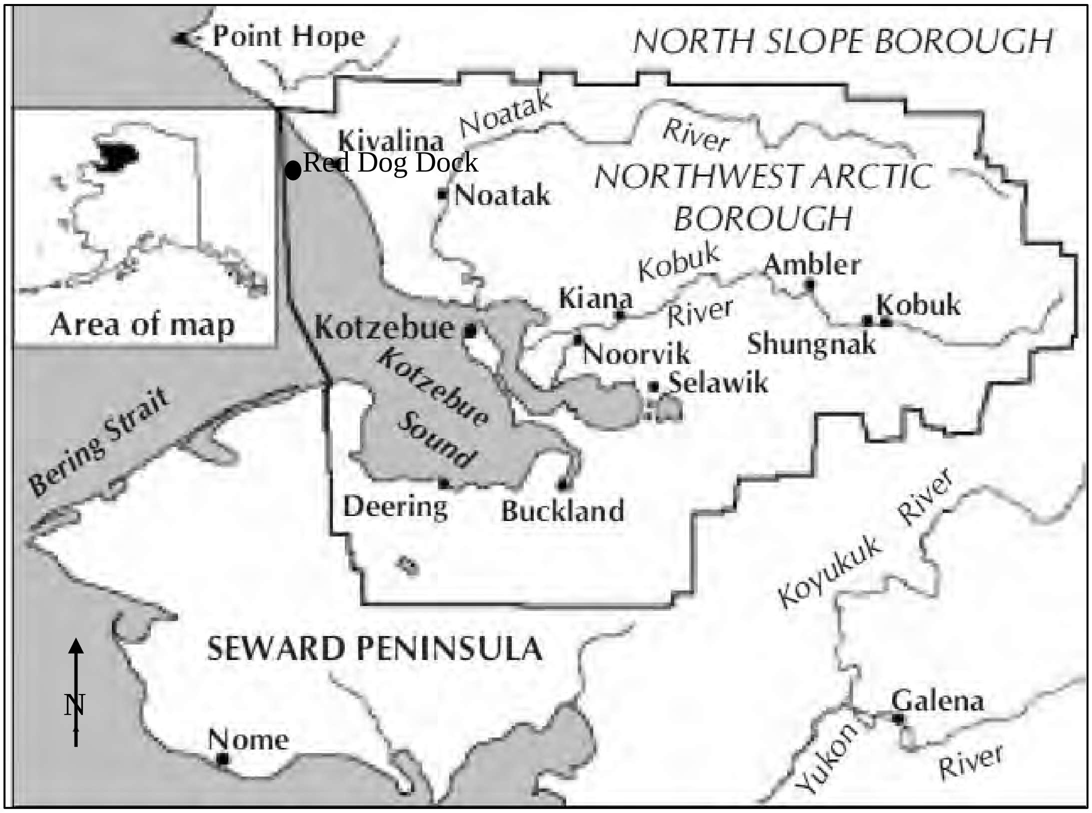


Figure 2. Northwest Arctic Borough

Figure 3. Kotzebue, Hotham Inlet, and the Kobuk River

Figure 4 Exposed bluffs near Cape Blossom

Figure 5 Exposed, actively eroding bluffs

Figure 6 Low vegetated bluffs

Figure 7 Low eroding bluff with exposed permafrost

Figure 8 Barrier beach in front of a lake. Looking towards Cape Blossom.

2.0 NEEDS AND OPPORTUNITIES

The main navigation problem at Kotzebue is inefficiency related to the ability of ocean-going barges to land at Kotzebue. A combination of lack of modern facilities and lack of sufficient draft combine to require barges to anchor offshore and lighter goods 12-15 miles to Kotzebue. Some goods are consumed within the community while others are trans-loaded onto riverine barges and shipped to outlying communities. All goods brought into Kotzebue are consumed within the region.

A secondary problem is that riverine barges are currently forced to wait for ice to go out of Hotham Inlet prior to attempting deliveries up the Kobuk River. The Kobuk River opens well in advance of Hotham Inlet, but the barges are not able to load until ice has cleared from the inlet. By this time, water levels may not be sufficient for barges to transit the river to upstream communities. This requires goods to be delivered by air, greatly increasing final prices.

Opportunities exist to increase the efficiency of delivery of goods to Kotzebue and the villages which rely on shipments from Kotzebue. If sufficient draft existed for ocean-going barges to access shore side facilities, the efficiency of these operations could be increased. The coast initially evaluated for Navigation Improvement is subject to high rates of erosion, making siting of the shore side facilities costly. A stable shoreline for construction of shore side facilities is needed to locate a site for future navigation improvements.

3.0 CLIMATOLOGY, METEOROLOGY, HYDROLOGY

3.1 Temperature and Precipitation

Kotzebue falls within the arctic climate zone, characterized by seasonal extremes in temperature (Table 1). Winters are long and harsh, and summers are short but warm. Kotzebue Sound is ice-free from early July until early October. (Alaska Department of Community and Economic Development-Kotzebue)

Table 1. Temperature and Precipitation

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Mean Min Temperature [F]	-9.5	-7.8	-6.7	5.4	26.0	39.9	49.7	47.3	37.9	20.1	4.0	-4.1
Mean Temperature [F]	-2.8	-0.8	1.1	13.3	31.9	45.7	54.6	51.7	42.3	24.3	9.1	2.3
Mean Max Temperature [F]	3.9	6.3	8.8	21.2	37.8	51.5	59.5	56.1	46.7	28.5	14.2	8.7
Mean Precipitation [Inch]	0.6	0.7	0.4	0.54	0.4	0.6	1.5	2.2	1.6	1.0	0.8	0.8
Snowfall [Inch]	9.1	9.6	5.9	5.1	1.2	0.0	0.0	0.0	0.8	6.1	10.5	11.5

3.2 Ice Conditions

Ice generally begins accumulating in the southern Chukchi Sea in October. It begins forming along the northeast coast of Russia and proceeds down the Chukchi Peninsula to Cape Dezhnev (Figure 9). Generally, by the time ice has reached Cape Dezhnev, ice is also forming along the western Alaska coast. Ice along the Russian coast generally grows faster than the ice along the Alaska coast. Ice on both coasts continues to grow until access to the Chukchi Sea is prevented by ice in the Bering Strait. Shortly after the Bering Strait is iced up the Chukchi Sea ices over.

The characteristics of the sea ice at Kotzebue are not typical of sea ice in the Chukchi Sea. Due to water depths of less than four feet offshore, the ice becomes grounded and does not move until breakup in June. Because of the lack of movement, the ice does not build up on shore or form pressure ridges close to shore. Ice can be pushed onshore during breakup if the wind is from the west.

Little information is available on ice characteristics north and east of Cape Blossom. Local reports indicate that the ice is similar to ice at Kotzebue with little riding up on shore. (Tetra Tech and Wright Forssen Associates, 1983)

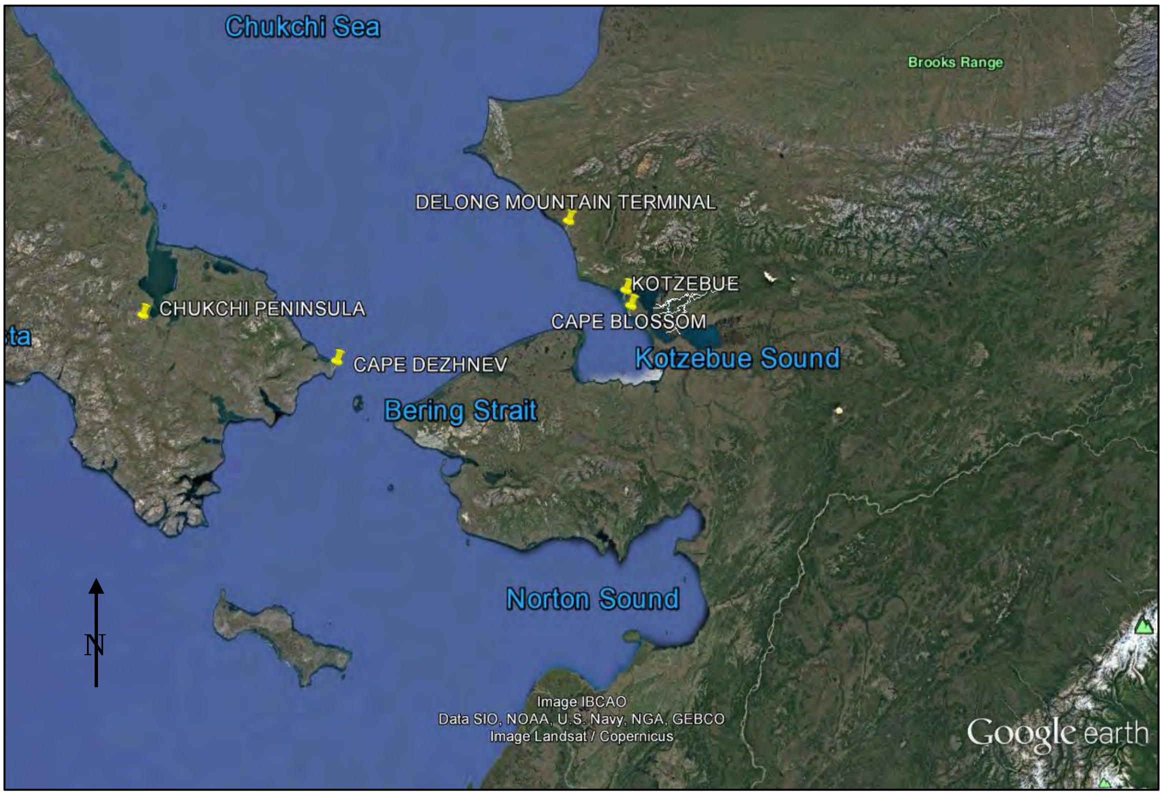


Figure 9. Location of Chukchi Peninsula, Cape Dezhnev, and Kotzebue

3.3 Tides

Kotzebue is in an area of small semi-diurnal tides with two high waters and two low waters each lunar day. The tidal parameters in Table 2 are based on Kotzebue control station 9490424 as determined by NOAA.

Table 2. Tidal Parameters - Kotzebue (9490424)

Parameter	**Elevation (feet MLLW)**
Mean Higher High Water (MHHW)	0.71
Mean High Water (MHW)	0.64
Mean Tide Level (MTL)**	0.39
Mean Sea Level (MSL)*	0.34
Mean Low Water (MLW)	0.13
Mean Lower Low Water (MLLW)	0.00

*****MSL The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch. Shorter series are specified in the name; e.g. monthly mean sea level and yearly mean sea level.

******MTL The arithmetic mean of mean high water and mean low water.

3.4 Wind

Wind information for hindcast points near Cape Blossom (Figure 10) were available through the Wave Information Study (WIS). The wind hindcast for these points was performed for the years 1985-2014 by Oceanweather Inc. (OWI) under contract to Coastal Hydraulics Laboratory (CHL) of the United States Army Corps of Engineers' (USACE) Engineering Research and Development Center (ERDC).

The wind field points near Cape Blossom are shown in Figure 10. The wind field wind roses for save point 82072 that are associated with the typical open water season are shown in Figure 11 - Figure 15.

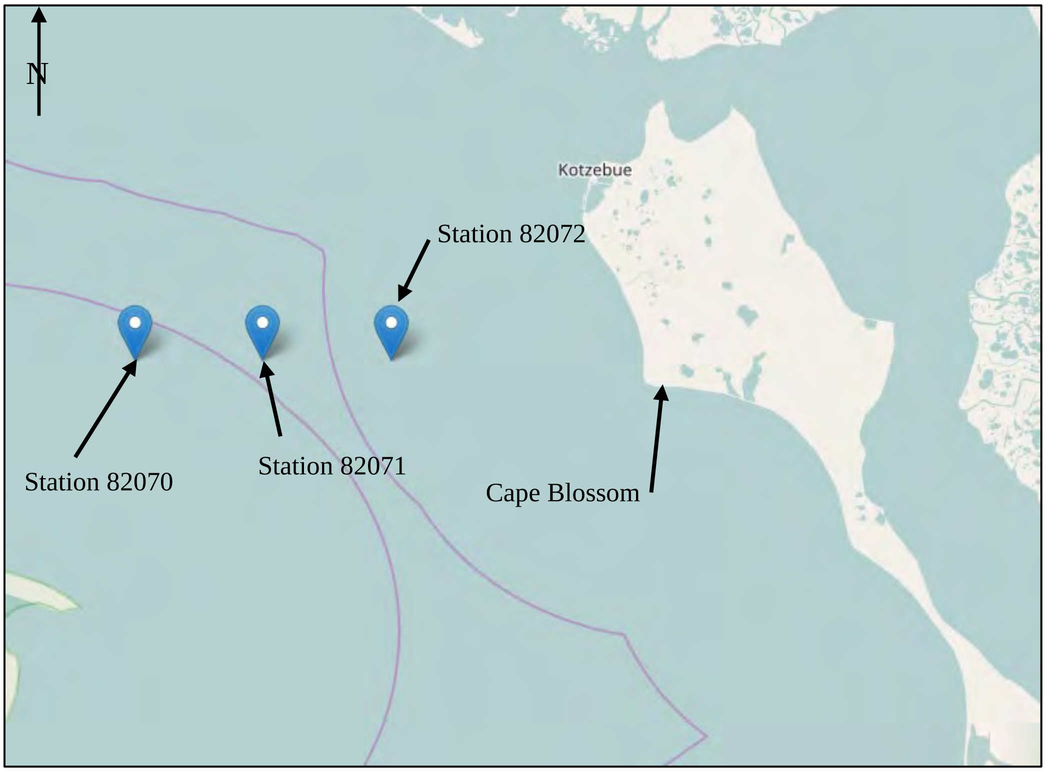


Figure 10. Location of wind save point for study

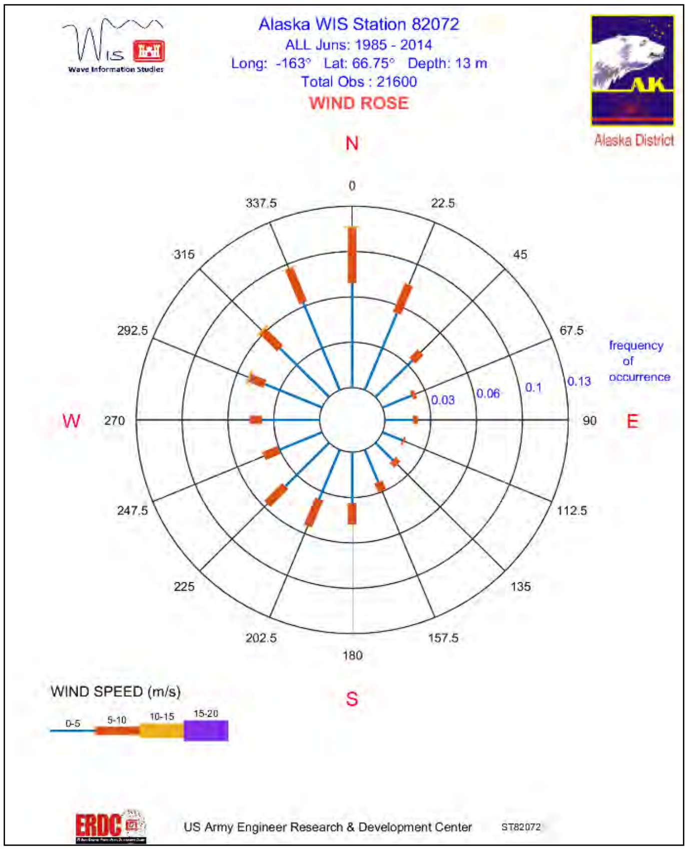


Figure 11. Wind Rose June 1985-2014

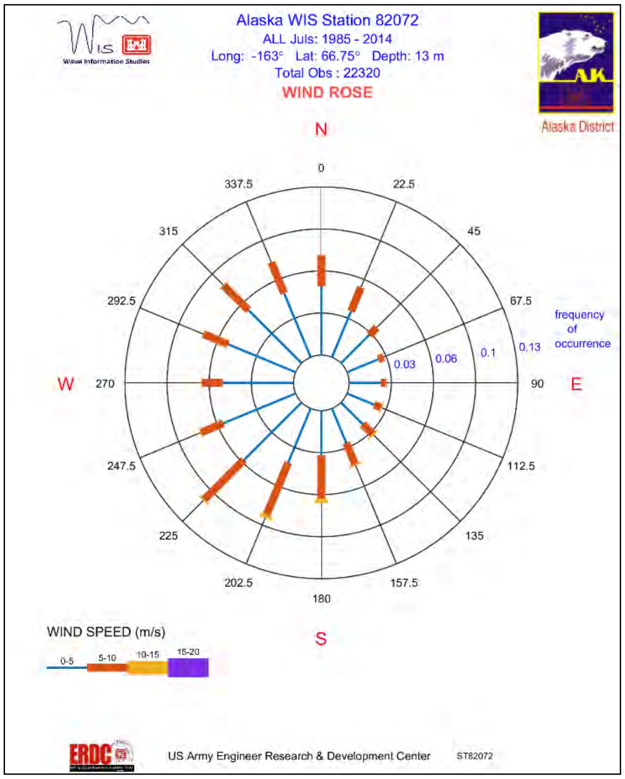


Figure 12. Wind Rose July 1985-2014

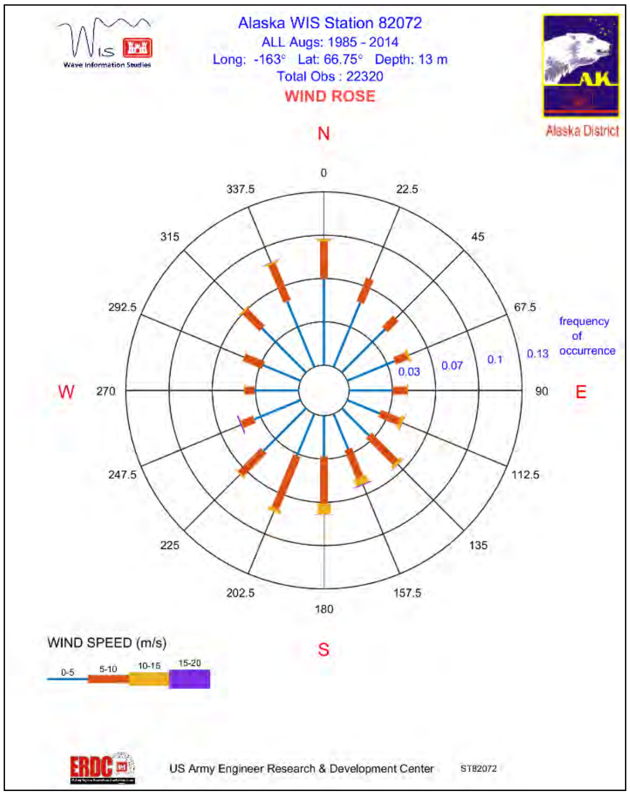


Figure 13. Wind Rose 1985 - 2014 August

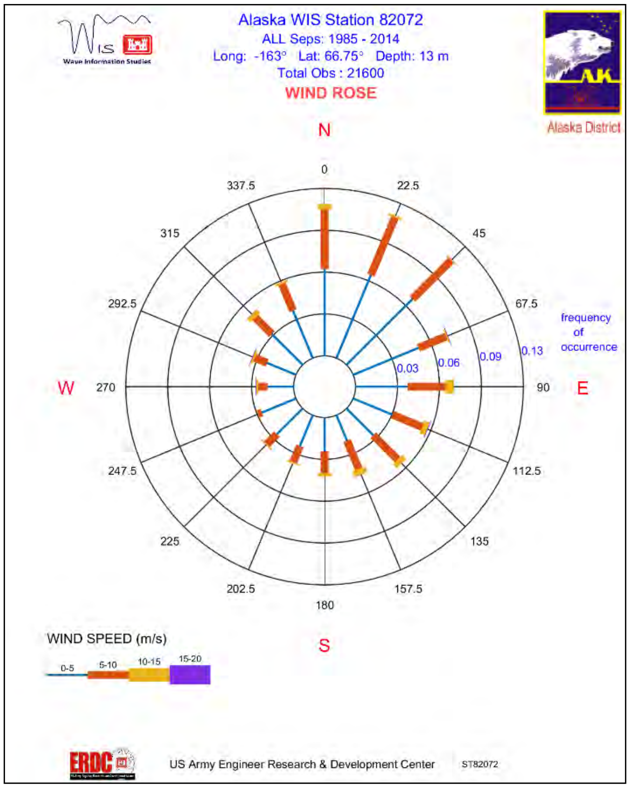


Figure 14. Wind Rose 1985 - 2014 September

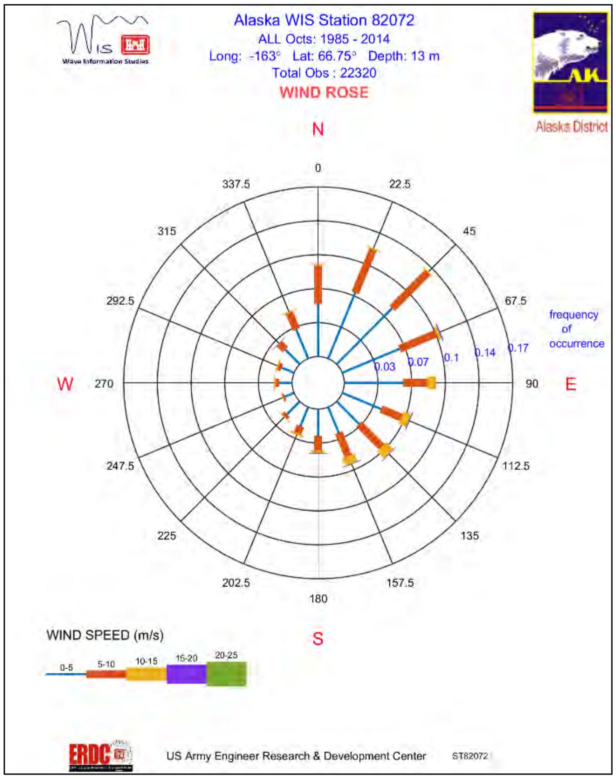


Figure 15. Wind Rose 1985 - 2014 October

4.0 GEOLOGY AND SOILS

The Baldwin Peninsula presents a gently rolling, sometimes flat topography, the surface of which is marked by polygonal ground thaw lakes. Broad morainal ridges rising up to 150 feet above the general surface form the topographic backbone of the peninsula. This rolling topography is typically bordered at the coast by bluffs 20 to 100 feet high. (Tetra Tech and Wright Forssen Associates, 1983)

The beach at the foot of the highest bluffs is usually less than 50 feet wide. The active erosion of the bluffs bordering the western edge of the peninsula is evidence of a retrograding shoreline. The lakes which dot the surface of the peninsula and the surrounding lowlands appear to be thaw lakes that have originated due to the thawing permafrost. These lakes are typically shallow and freeze to the bottom in winter although some larger, deeper lakes may be potential sources of water on a year-round basis. In general, the soils on Baldwin Peninsula are poorly drained. The active layer, which may thaw to a depth of about two feet during the summer is typically saturated. The combination of fine grained and organic soils, gentle to flat slopes, and permafrost at the base of a shallow active layer all contribute to poor drainage conditions. (Tetra Tech and Wright Forssen Associates, 1983)

Silt, organic silt, and peat are the predominant soil types at Cape Blossom. Brown organic silt and peat occur from the surface to depths typically between 10 and 20 feet. The thickness of these surficial soils, as exposed in the coastal bluffs range from less than 5 feet to greater than 20 feet. Massive ice is a common constituent of these soils. Gray silts, typically devoid of organics underlie the surficial soils. (Tetra Tech and Wright Forssen Associates, 1983)

Actively eroding slopes are common to the bluffs that border the coast. In places, the bluffs are completely bare of vegetation, quite steep and cut by steep walled gullies. Mud flows, debris slides, and block slumping are common along the front of the bluffs. (Tetra Tech and Wright Forssen Associates, 1983)

Bedrock does not outcrop on the Baldwin Peninsula. Bedrock was reported to have been intercepted at a depth of 82 feet in a hole drilled 1,000 feet west of the airport. (State of Alaska Department of Transportation & Public Facilities Northern RegionMaterial Section, 2009)

5.0 CIRCULATION AND WATER LEVELS

5.1 Circulation

Information on the circulation in Kotzebue Sound was available from a study of the Cape Thompson area in support of the Project Chariot Plowshare Program and studies on the flow of water through the Bering Straits.

Water from the Bering Sea flows predominantly north through the Bering Strait. North of the Bering Strait the sea broadens and there is a large embayment to the east leading to Kotzebue Sound. The north-flowing current that passes through the Bering Strait and enters the embayment decelerates, broadens, and turns eastward towards Kotzebue Sound tending to follow the bottom contours. (Coachman & Tripp, 1970) (Creager & McManus, 1966) (Flemming & Heggarty, 1966)

5.2 Water Level

Water level increase is typically a result of wave setup, storm surge, and tide. Water level decrease is typically a result of wave set-down, wind set-down, and tide. Relative sea level rise is a longer term change in water level and its effects on a project is an additional factor that needs to be considered.

5.2.1 Wave Setup/Set-down

Wave setup is the water level rise at the coast caused by breaking waves. Wave set-down is a water level decrease at the coast before the waves break. Any navigation project other than a barge landing on the shore is beyond the coastline affected by breaking waves, so the water level change due to the effects of wave set-up or set-down was not evaluated.

5.2.2 Surge/Wind Set-Down

Surge and wind set-down are caused by wind driven transport of seawater over relatively shallow and large unobstructed waters and are characterized by a change in water level beyond the normal tidal variations. Surge is an increase in water elevation and wind set-down is a decrease in the water elevation. Friction at the air-sea interface is increased when the air is colder than the water, which causes more wind-driven transport. Low pressure events can add to the increased water levels associated with surge, and high pressure events can reduce, even further, the water levels associated with wind set-down. Kotzebue Sound is relatively shallow and experiences wind and pressures that create surge and set-down conditions.

Surge

A study of water levels was performed by the CHL using CSTORM and CH3D. Table 3 and Table 4 show results of the Empirical Simulation Technique (EST) analysis used to generate stage –frequency relationships for Kotzebue and the top ten surge events used to develop the frequency of occurrence relationship.

Table 3. Stage Frequency Analysis for Kotzebue

Return Period [years]	Kotzebue Surge Level [ft MLLW]	Cape Blossom Surge Level [ft MTL]
5	4.0	4.1
10	5.1	5.6
50	8.1	8.7
100	9.6	10

Table 4. Top 10 surge events for Kotzebue and Cape Blossom

	Date	Kotzebue Maximum Water Level [ft MLLW]		Date	Cape Blossom Maximum Water Level [ft MTL]
1	Nov 1970	9.6		Nov 1970	9.2
2	Nov 1966	6.9		Nov 1966	6.9
3	Nov 1974	6.6		Aug 1962	6.6
4	Oct 1996	6.2		Nov 1974	6.2
5	Nov 2011	5.8		Oct 1996	5.9
6	Aug 1962	6.8		Nov 2011	5.6
7	Dec 2004	5.7		Dec 2004	5.6
8	Apr 2002	5.3		Nov 1965	5.2
9	Nov 1965	5.2		Apr 2002	4.9
10	Nov 1978	4.9		Sep 2005	4.3

Wind Set-Down

More important to channel navigation is the occurrence of wind set-down. Wind set-down events can affectability of a fully loaded barge to transit the channel and maintain a safe under-keel clearance. The ADCIRC model used for the Delong Mountain Terminal Navigation Study (Figure 16) predicted water surface elevations for a hypothetical season which included analysis of the occurrence of set-down events. The frequency of occurrence for water level set-down for the hypothetical year is shown in Figure 17. The information for the analysis was based on a limited data set and was dependent on the water surface differential that was imposed on the north and south boundaries of the ADCIRC model domain.

For the July through November season, set-down exceeded –4.9 feet less than 2 percent of the time; –3.3 feet about 3 percent of the time; and –1.6 feet 14 percent of the time. Typically, when set-down occurred, it was less than –1.2 feet (Figure 17 – note that departures (wind set-down) shown are in meters). The maximum set-down increased as the open water season moved into fall with a maximum value of –7.6 feet. For the purpose of this study, it was assumed that ships trying to deliver during set-down events will wait offshore until conditions permit channel transit.

Figure 16. Location of Delong Mountain Terminal and Cape Blossom

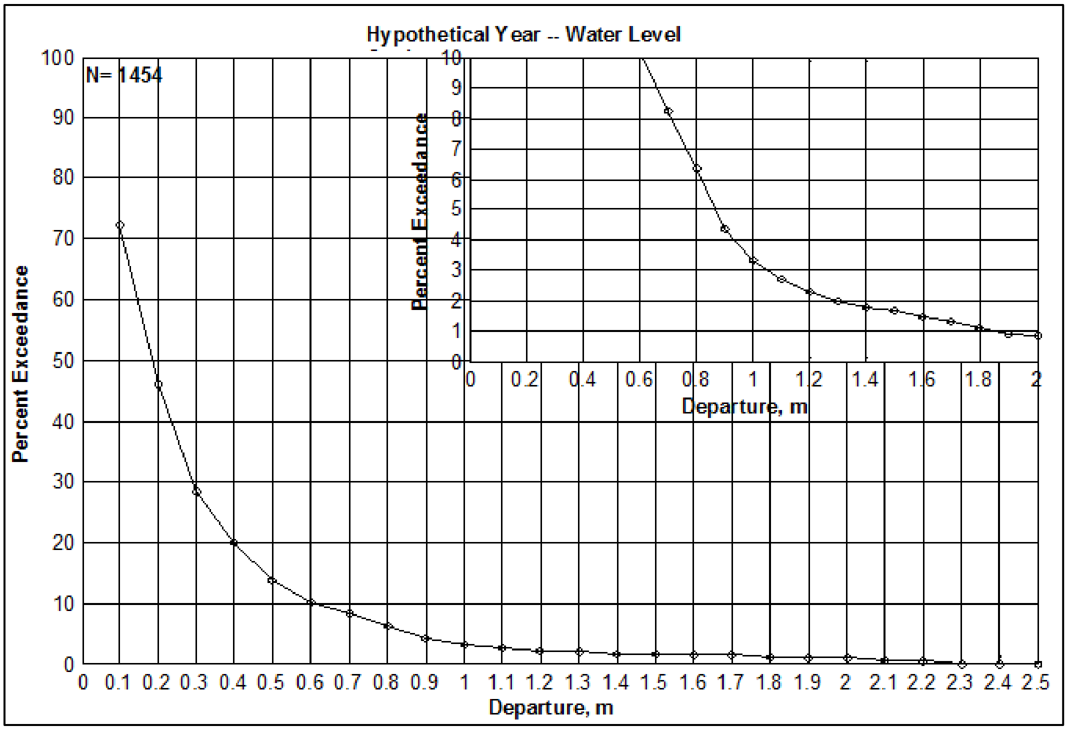


Figure 17. Frequency-of-occurrence for water level set-down hypothetical open-water season at the Delong Mountain Terminal. Note departure shown is in meters.

5.2.3 Relative Sea Level Change

Evidence suggests that the arctic environment is experiencing a warming trend. The magnitude, duration, and effect of a warming trend is not known; however, a shrinking polar ice pack could result in an extended open water season and an increase in frequency of the large storms that could impact a proposed navigation channel.

USACE requires that planning studies and engineering designs over the project life cycle, for both existing and proposed projects consider alternatives that are formulated and evaluated for the entire range of possible future rates of sea-level change (SLC), represented by three scenarios of “low,” “intermediate,” and “high” sea-level change. According to USACE guidance in ER 1100-2-8162 and ETL 1100-2-1, SLC “low” rate is the historic SLC. The “intermediate” and “high” rates are computed using the following:

Estimate the “intermediate” rate of local mean sea-level change using the modified NRC Curve I and the NRC equations. Add those to the local historic rate of vertical land movement.

Estimate the “high” rate of local mean sea-level change using the modified NRC Curve III and NRC equations. Add those to the local rate of vertical land movement. This “high” rate exceeds the upper bounds of IPCC estimates from both 2001 and 2007 to accommodate the potential rapid loss of ice from Antarctica and Greenland.

NRC Equations

The 1987 NRC described these three scenarios using the following equation:

$E(t) = 0.0012t + bt^2$

In which t represents years, starting in 1986, b is a constant, and $E(t)$ is the eustatic sea-level change, in meters, as a function of t. The NRC committee recommended, "projections be updated approximately every decade to incorporate additional data." At the time the NRC report was prepared, the estimate of global mean sea-level change (GMSL) was approximately 1.2 mm/year. Using the current estimate of 1.7 mm/year for GMSL change, as presented by the IPCC (IPCC 2007), results in this equation being modified to be:

$E(t) = 0.0017t + bt^2$

The three scenarios proposed by the NRC result in global eustatic sea-level rise values, by the year 2100, of 0.5 meters, 1.0 meters, and 1.5 meters. Adjusting the equation to include the historic GMSL change rate of 1.7 mm/year and the start date of 1992 (which corresponds to the midpoint of the current National Tidal Datum Epoch of 1983-2001), results in updated values for the variable b being equal to 2.71E-5 for modified NRC Curve I, 7.00E-5 for modified NRC Curve II, and 1.13E-4 for modified NRC Curve III. The three GMSL rise scenarios are depicted in Figure 18.

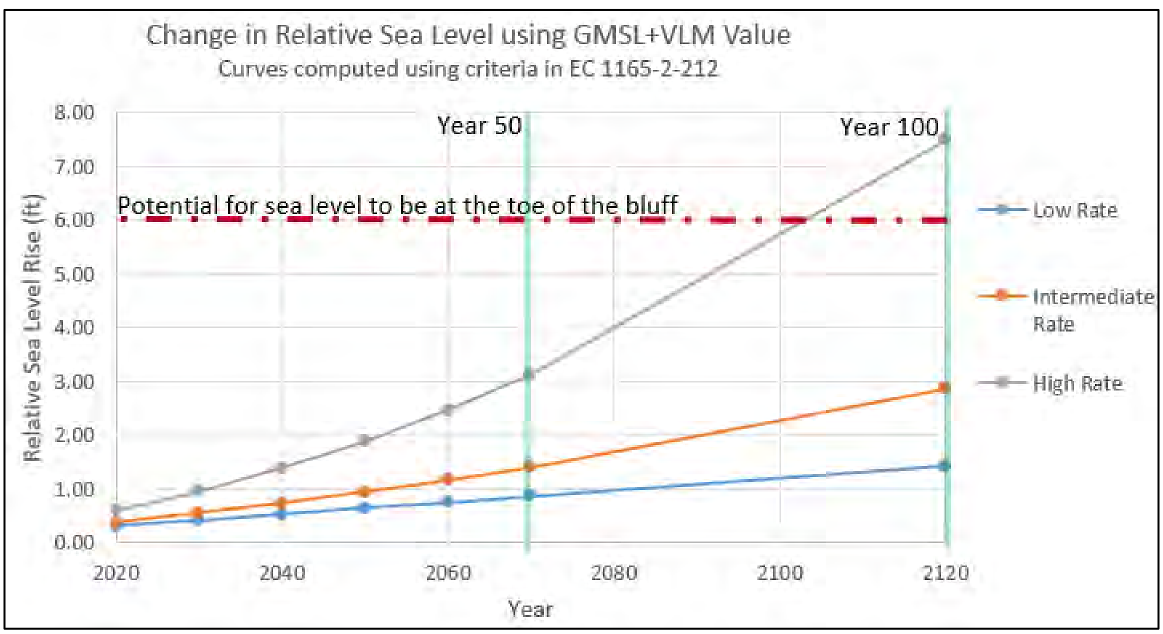


Figure 18. Scenarios for GMSL Rise (based on updates to NRC 1987 equation) Assumes project implementation in 2020.

Manipulating the equation to account for the fact that it was developed for eustatic sea level rise starting in 1992, while projects will actually be constructed at some date after 1992, results in the following equation:

$E(t_2) - E(t_1) = 0.0017(t_2 - t_1) + b(t_2^2 - t_1^2)$

Where t_1 is the time between the project's construction date and 1992 and t_2 is the time between a future date at which one wants an estimate for sea-level change and 1992 (or $t_2 = t_1$ + number of years after construction).

The USACE SLC scenarios were developed using the guidance in ER 1100-2-8162 and ETL 1100-2-1. Assuming *a* eustatic SLC rate of 1.7 mm/year and start date of 1992 (mid-year of the NOAA National Tidal Datum Epoch (NTDE) of 1983-2001), the updated values for the variable *b* in the 1987 NRC report are equal to 2.71E-5 for the modified NRC Curve I (USACE Intermediate Scenario), and 1.13E-4 for modified NRC Curve III (USACE High Rate Scenario). The USACE Low Rate Scenario extrapolates the historic rate of sea level change.

There is no sea level trend data for Kotzebue or the area around Kotzebue. The Permanent Service for Mean Sea Level (PSMSL) has sea level trends published for Providenia, Russia, which is the closest station to Kotzebue with a long term record. The record length for Providenia is 32 years which is less than the recommended two tidal epoch duration of about 40 years, but it is the longest record near Kotzebue. The published sea level trend for Providenia is +0.1299 inches/year. This value was used with the equations in ER 1100-2-8162 to determine the possible relative sea level change (RSLC) at the end of the project life.

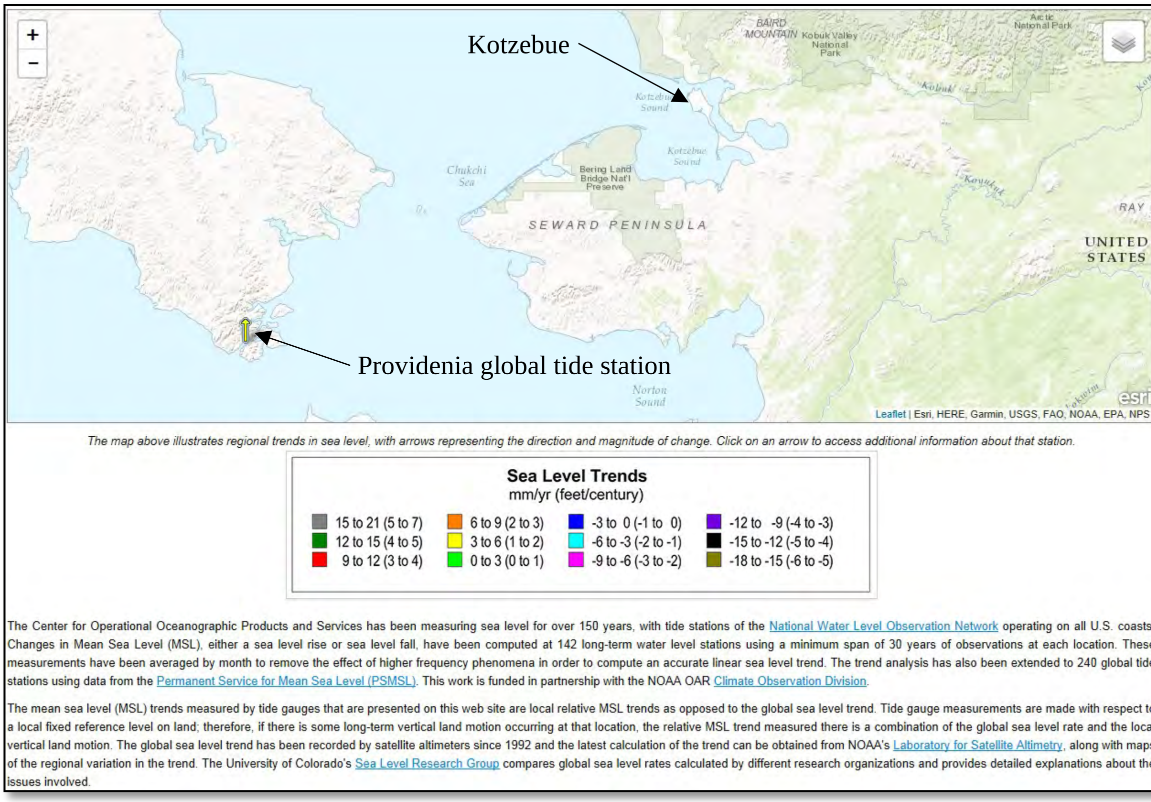


Figure 19. Location of Providenia, Russia

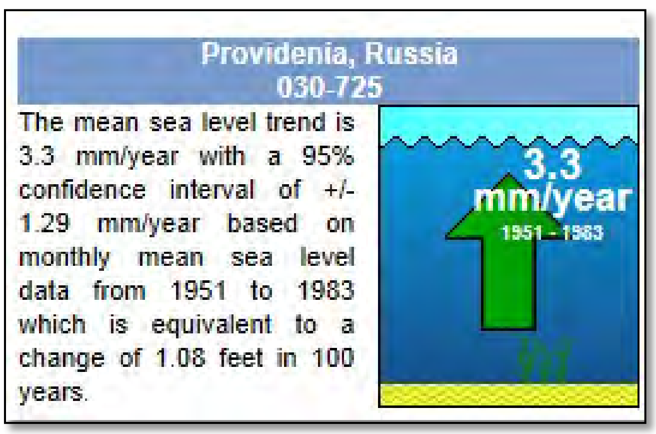


Figure 20. Relative sea level trend in Providenia, Russia

In addition to looking at the RSLC based on Providenia, Russia, the RSLC was evaluated using the GMSL change (1.7 mm/year or 0.0669 inches/year) and the vertical land movement (VLM) at Kotzebue as measured by the Jet Propulsion Laboratory (JPL), California Institute of Technology under contract with the National Aeronautics and Space Administration (NASA) (Figure 21). The VLM reported by JPL is -0.0659 inches/year (Figure 22). This was subtracted from the GMSL change and resulted in an RSLC of 0.133 inches/year (rising sea level).

Figure 21. Location of JPL's vertical land movement data site at Kotzebue

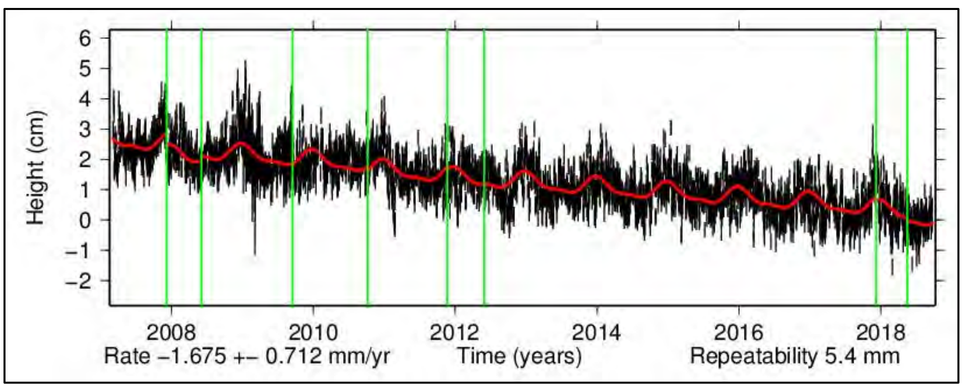


Figure 22. Vertical land movement data for Kotzebue

For a fifty-year project life (assumed starting in 2020), a project in the Kotzebue area could see relative sea level rise as much as 2.52 feet (Table 5), and as much as 6.89 feet for a 100-year planning horizon. A navigation channel will not be adversely affected by relative sea level rise. Maintenance dredging depth requirements could be re-evaluated in the event that the relative sea level rises to a level where the under-keel clearance is greater than needed for the function of the facility.

While relative sea level rise may not adversely affect the dredged channel, it is an important consideration for the shore side facilities and the structures built to connect to the channel. The local sponsor will need to consider the effects of relative sea level change during design to ensure that the shore side structures remain functional in the future. Because the sea level change will be gradual, the sponsor will be able to use adaptive measures to ensure the functionality of many of the project structures; however, the fixed elevation land side features would be more difficult to adapt. The land side features could benefit from early site planning to account for the changing relative sea level.

The earliest predicted action at the site due to sea level rise will occur when the sea level rises to the elevation of the shoreline bluff toe. A survey of the shore at the Cape Blossom area is not available, so an estimation of the bluff toe elevation was made by evaluating pictures from a site visit. Assuming the water level during the site visit was at 0 +/- 1-foot MLLW, it is estimated that the bluff toe is approximately +6 feet MLLW. This rise in sea level is noted in Figure 18 along with the low, intermediate, and high rate of sea level change. Six feet of sea level rise will have the potential to impact the toe of the bluff approximately at the year 2100 if the high level of sea level rise is realized.

Table 5. Relative sea level rise prediction for a 50-year project life

	Low		Intermediate	High
Using Providenia Russia Mean Relative sea Level Trend	0.54 feet		1.01 feet	2.51 feet
Using GMSL and VLM at Kotzebue	0.55 feet		1.02 feet	2.52 feet

6.0 EXTREME AND AVERAGE WAVE CLIMATE

The CHL performed a deep-water wave hindcast for the west coast of Alaska. The hindcast was driven by the wind data described in Section 3.4 Wind and was coupled with weekly ice field data to quantify the open water capable of wind-wave growth. The west coast hindcast includes 469 special output locations. Three of the special output locations (shown in Figure 23) are at the entrance to Kotzebue Sound. These locations provide percent occurrence statistics (wave height, period, and direction) and extreme storm analysis.

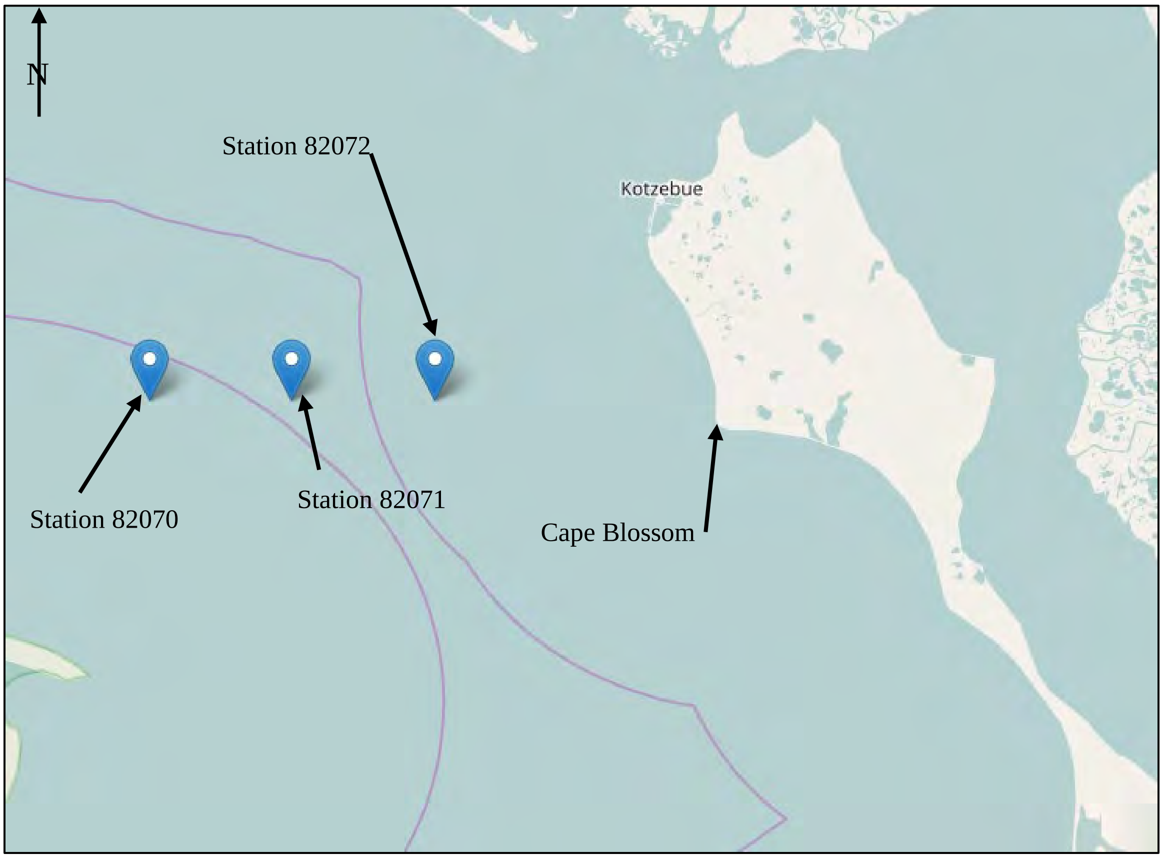
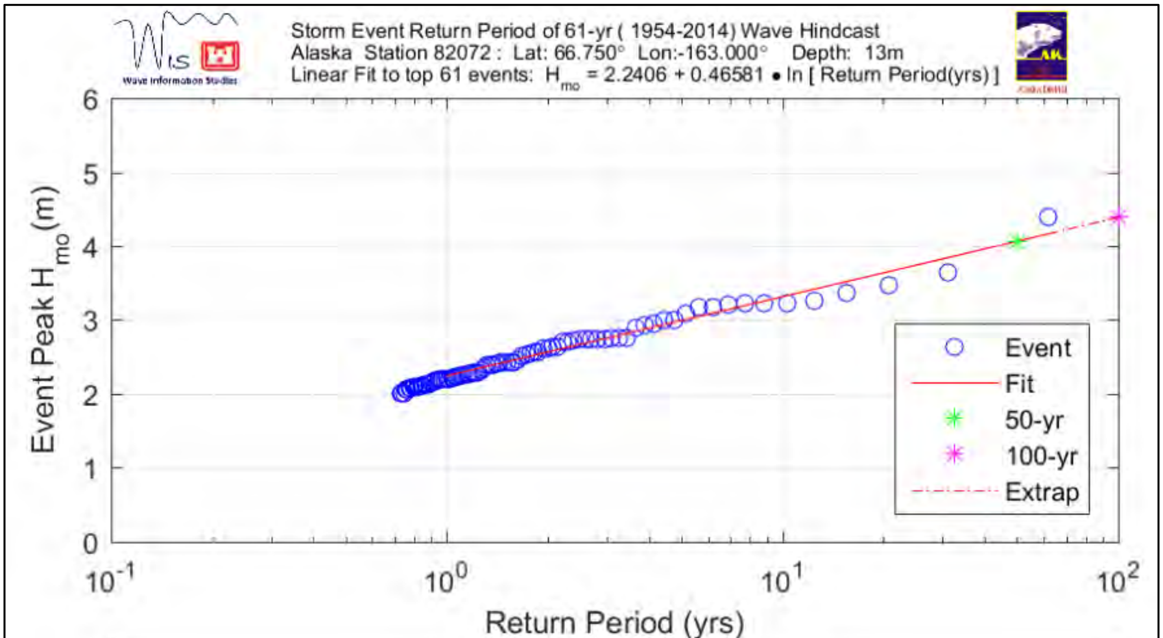


Figure 23. Wind and deep-water wave special output locations.

6.1 Extreme Storms

Selected severe historic storms dating back to 1954 were included in the hindcast to provide higher confidence in the extreme wave estimates (those representing 50-year return-period events). The largest wave of record in the extremal wave analysis for save point 82072 (Figure 23) occurred in August 1962. The peak significant deep-water wave height was 14.4 feet with a 10.18-second period. A plot of the deep-water significant wave height and the return period for 82072 is shown in Figure 24 and significant wave heights for the top 10 storms from 1954 to 2009 are shown below the plot along with their ranking.



Top 10 events based on Peak H_{mo}

Event	Date/Time(UTC)	H_{mo}	T_p	θ_{mean}	Event	Date/Time(UTC)	H_{mo}	T_p	θ_{mean}
1	1962/08/30 21:00	4.39	10.18	287.0	6	1973/10/02 19:00	3.23	11.12	308.0
2	1997/10/04 01:00	3.65	7.43	271.0	7	1960/09/26 20:00	3.23	7.01	183.0
3	1996/11/09 13:00	3.46	7.09	144.0	8	1990/08/27 07:00	3.22	7.55	253.0
4	1990/11/05 07:00	3.37	7.90	264.0	9	2011/11/09 13:00	3.20	6.90	125.0
5	1992/10/06 13:00	3.26	7.15	159.0	10	1993/11/17 07:00	3.18	11.63	293.0

An event is defined as any period when H_{mo} > 2.00m θ_{mean} is direction that waves are arriving from

US Army Engineer Research & Development Center ST82072

Figure 24. Deep-water wave height return period for save point nearest the project site.

6.2 Average Deep-Water Wave Climate

The average deep-water wave climate in the analysis area is dominated by waves from the north-west as shown in wave roses shown in Figure 25 to Figure 30. The wave rose for all months (Figure 25) shows the same north-west tendency as the wave roses for June through October (Figure 26 through Figure 30). Wave heights between 0 to 3.25 feet dominate the wave climate from June through October. Wave heights of 3.3 feet and greater occur less than 10% of the time. Table 6 illustrates the percentage of occurrence of waves during the open water season.

While the deep-water wave climate at the entrance to Kotzebue Sound is dominated by waves from the northwest, the record of the top ten storms indicates that significant waves from the southeast are also possible.

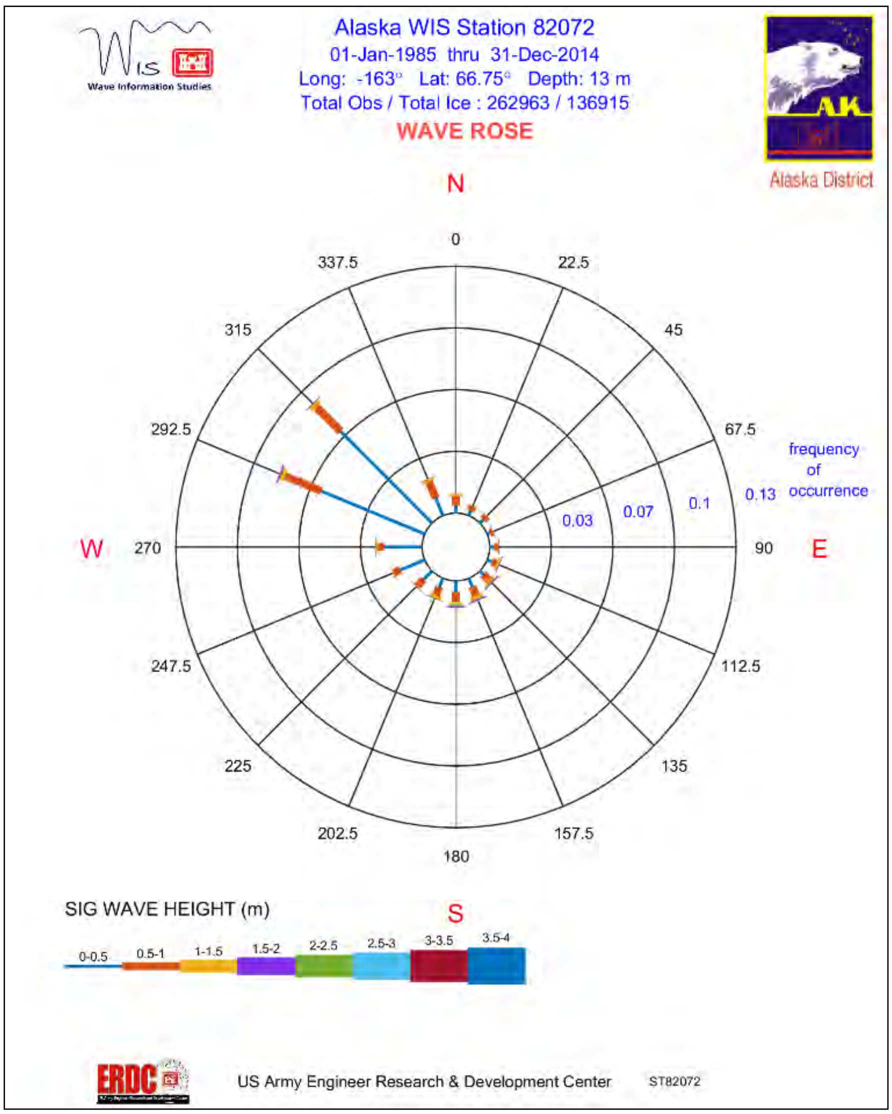


Figure 25. Wave rose for all hindcast years, January through December

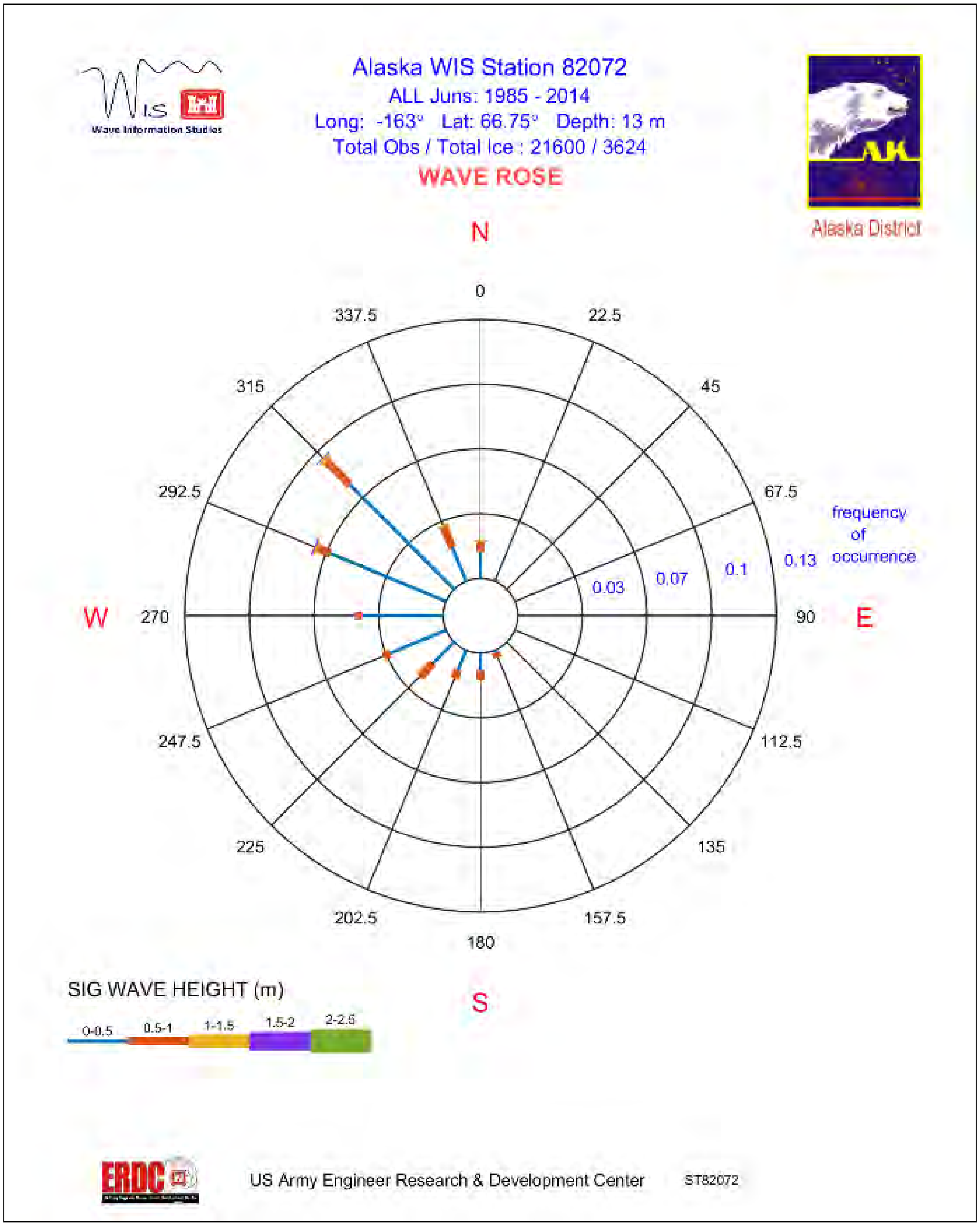


Figure 26. Wave rose for all hindcast years, June

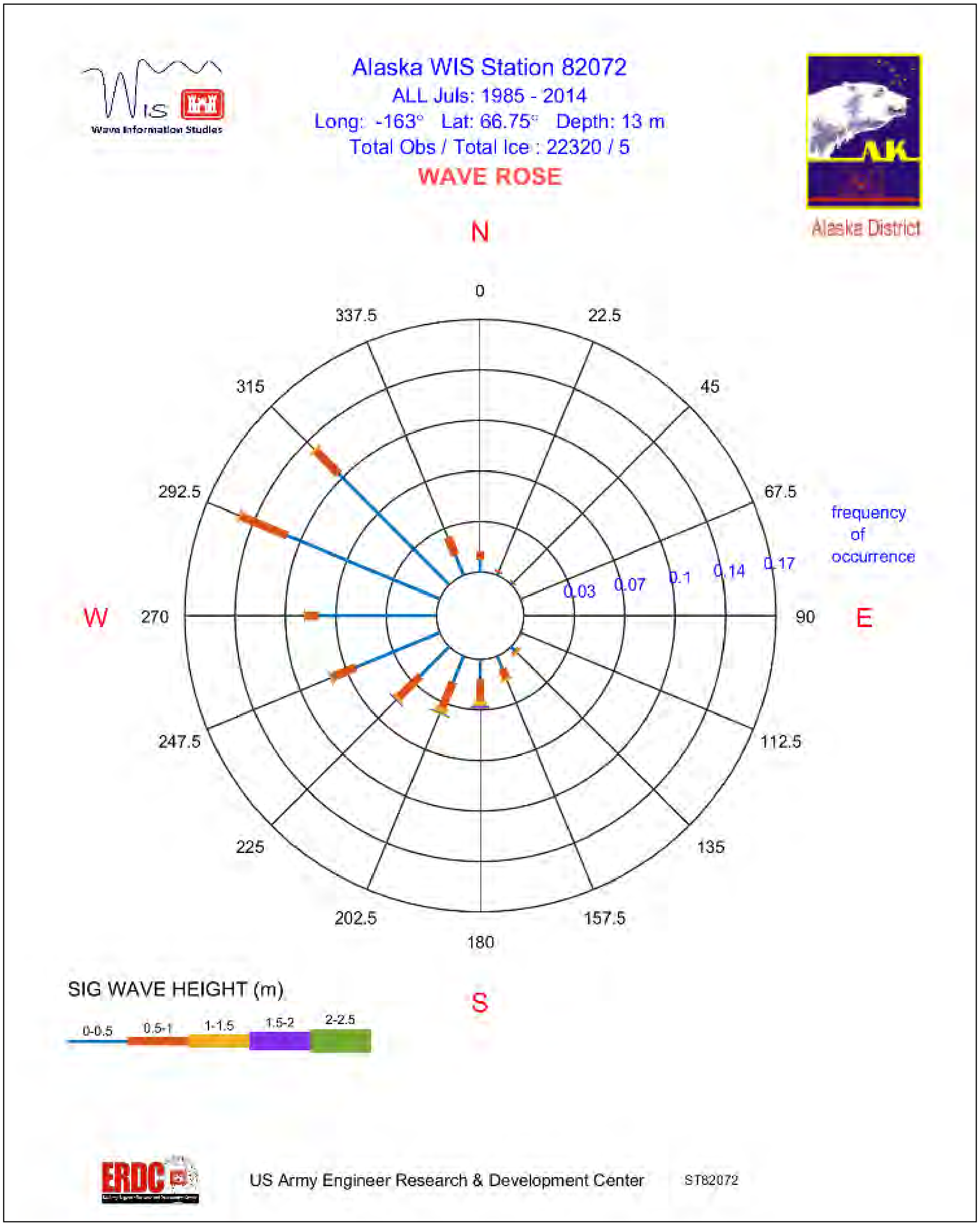


Figure 27. Wave rose for all hindcast years, July

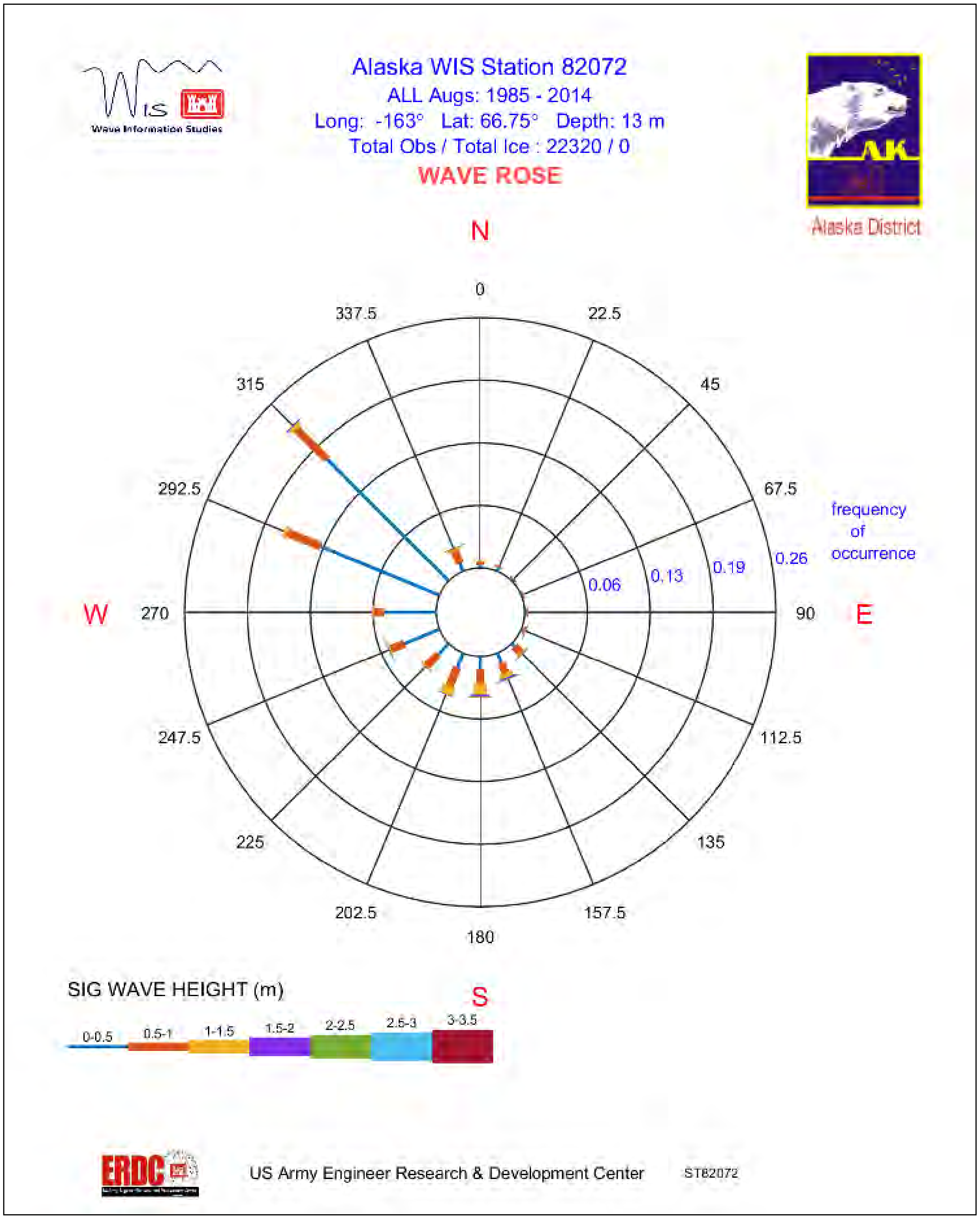


Figure 28. Wave rose for all hindcast years, August

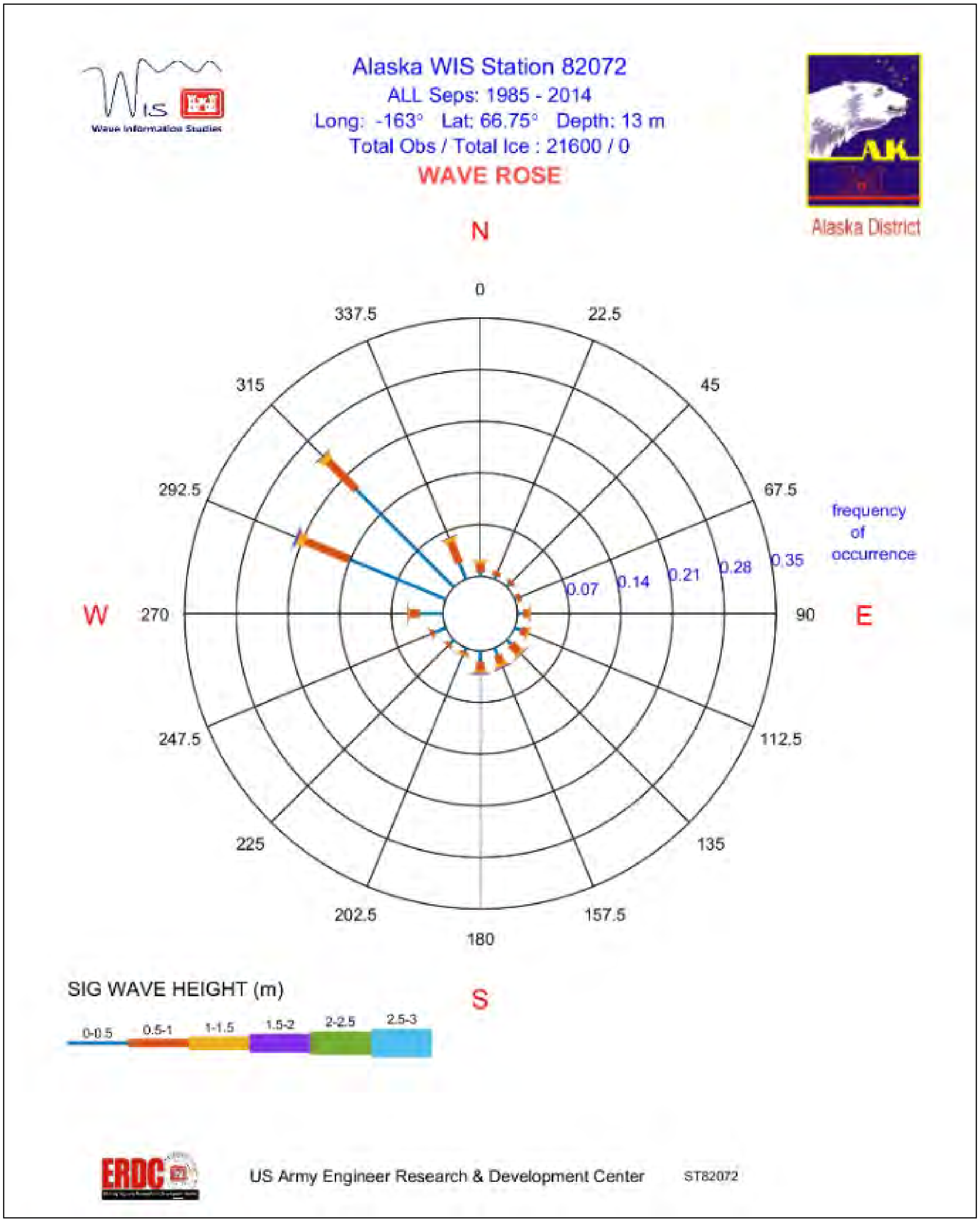


Figure 29. Wave rose for all hindcast years, September

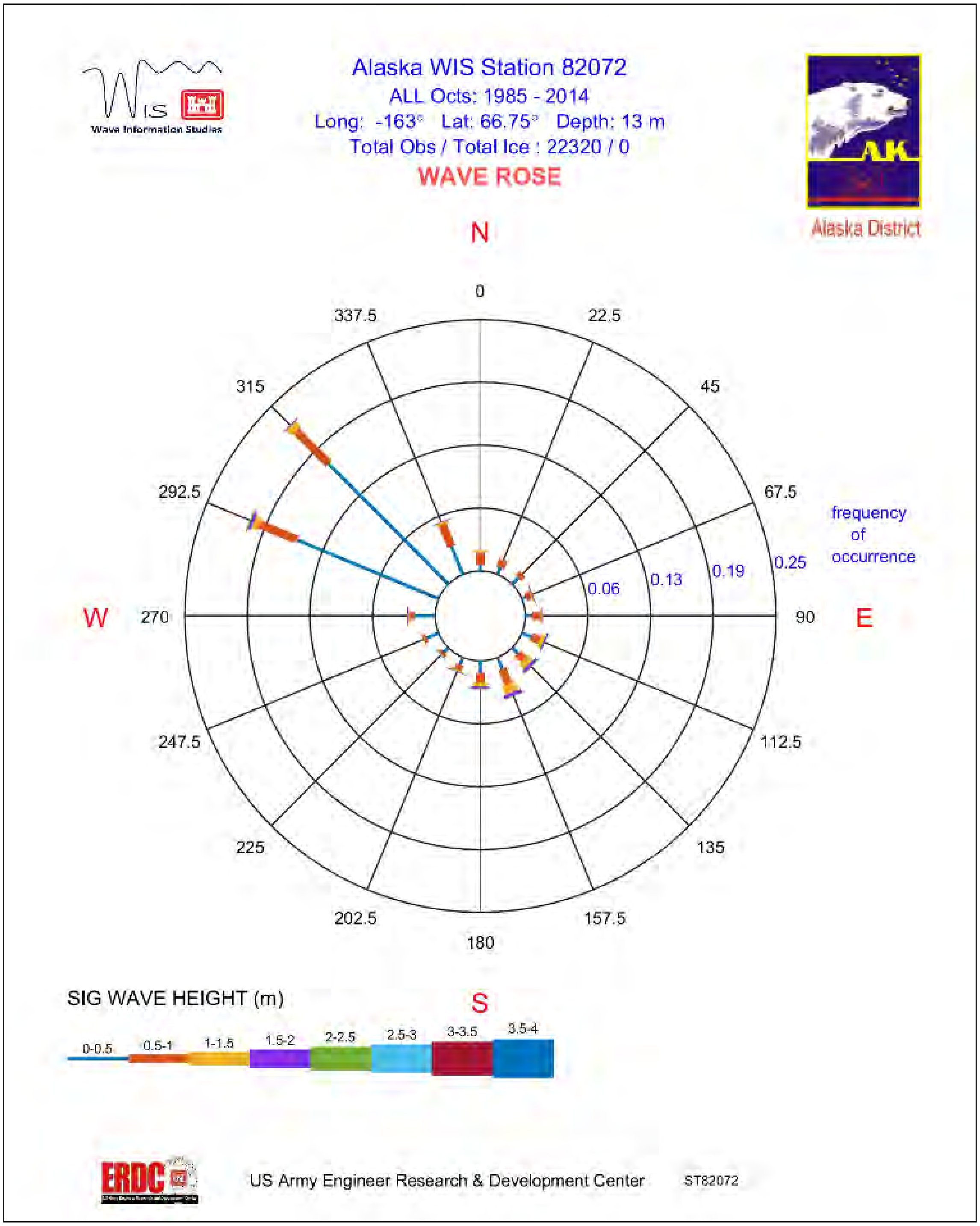


Figure 30. Wave rose for all hindcast years, October

Table 6. Percent of occurrence of wave heights for all directions (save point 82072)

Wave Height

	Calms 0-0.3 feet	0.3-1.6 feet	1.6-3.3 feet	3.3+ feet
June*	46.1	29.0	7.3	0.9
July	33.1	47.3	17.2	2.4
August	24.3	48.9	20.7	6.0
September	17.6	48.9	26.2	7.4
October	21.1	49.1	21.8	8.0
***includes periods of ice cover**				

7.0 SEDIMENT MOVEMENT

Any site that is chosen for navigation improvements will need further analysis will need to have an analysis of sediment transport to ensure that a channel dredged will stay open during the shipping season, and be maintainable.

The dredged channel location studied in the Navigation Improvement Study was found to stay open during the shipping season and require minimal maintenance. A similar study would need to be performed for any other location selected.

The beach east of Cape Blossom is primarily composed of sand and gravel. Behind the beach is a thick organic mat with exposed melting permafrost (Figure 31 and Figure 32).

Figure 31. Beach and organic mat in the area of the proposed navigation improvement.

Figure 32. Exposed permafrost in the organic mat.

8.0 EROSION

8.1 Original Erosion Analysis

The original Navigation Improvement Study at Cape Blossom focussed on the coast of a BLM parcel of land. To determine its suitability to support shore side facilities, an aerial photo analysis of erosion was performed. Orthorectified aerial photos from the years 1952, 1953, 1973, 1978 and 2013 were obtained. Addional aerial photos from 2012, 2014, 2018-May, and 2018-August were obtained from DigitalGlobe.

The DigitalGlobe photos were checked to ensure that they correlated well with the orthorectified photos. Once there was confidence that the photos were co-located, bluff lines were digitized for each of the photos. The accuracy of the digitizing effort varied with the resolution of the photos. Six transect lines were drawn across the shore of the BLM parcel to measure the shoreline difference at the same location between years (Figure 33) 1952 shoreline was the first year of the analysis.

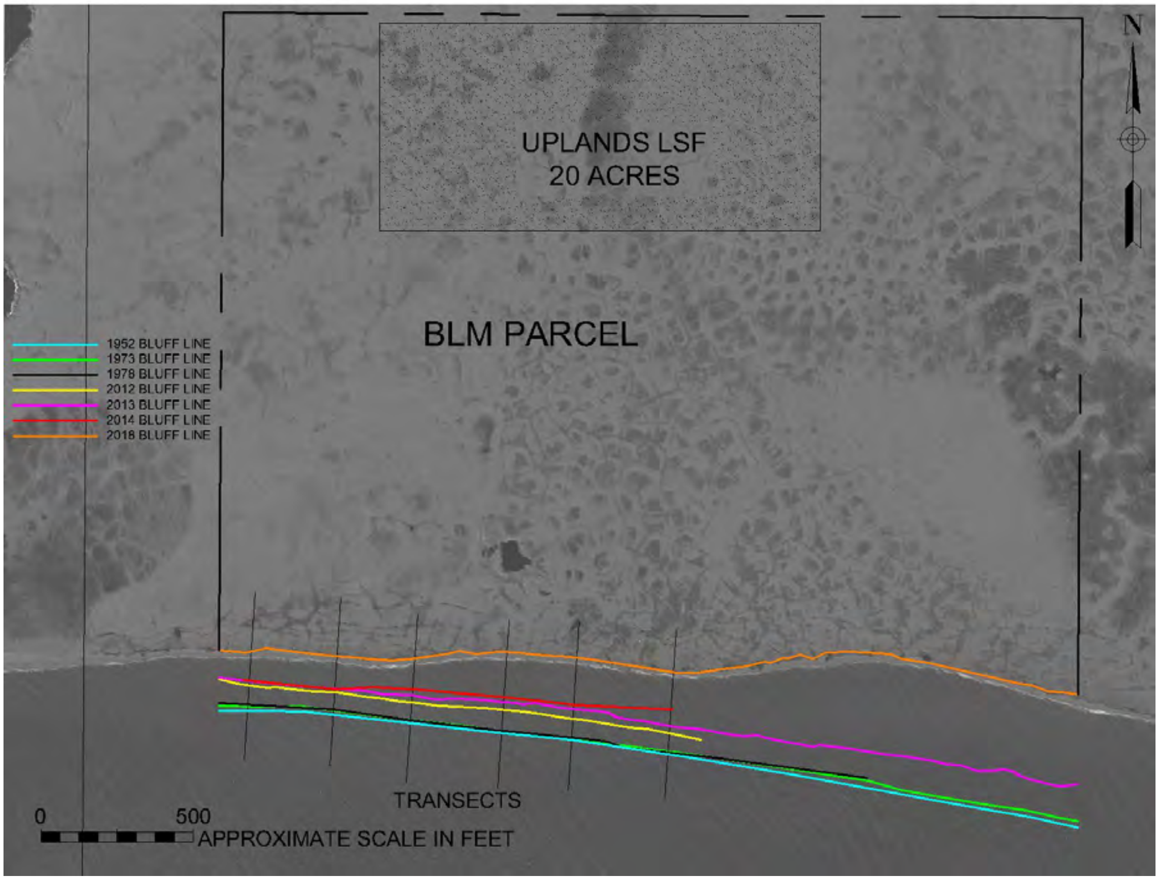


Figure 33 Shoreline change from previous year

The erosion rates between years were then calculated and are shown in Table 7.

Table 7 Shoreline change from previous year and erosion rates developed from aerial photo analysis

Year	Years between photos	Transect 1 [ft]	Transect 2 [ft]	Transect 3 [ft]	Transect 4 [ft]	Transect 5 [ft]	Transect 6 [ft]	Avg. change [ft]	Avg. rate [ft/yr]
1952	0	0	0	0	0	0	0	0	0
1973	21	14.8	17.2	8.7	3.2	1.3	10.5	9.3	0.4
1978	5	0	0	0	0	0	0	0	0
2012	34	62.7	56.5	58.7	70.6	62.0	65.5	62.7	1.8
2013	1	14.6	10.6	22.9	25.3	31.9	23.4	21.4	21.4
2014	1	2.8	0	19.8	16.3	14.1	53.6	17.7	17.7
2018	4	94.8	108.4	101.1	146.5	154.2	123.6	121.4	30.4

Note: A zero erosion rate was noted for the beginning years that had no previous year for comparison and years where there was no discernable bluff change noted during the aerial photo analysis.

The impacts of various erosion rates were evaluated by looking high, intermediate, and low erosion rates. The highest rate of erosion in the analysis was between the years 2014 through 2018. The intermediate rate was the average erosion rate for the years 2013 through 2018, and the low erosion rate was the average rate for the years 1973 through 2018 (Table 8). Table 9 and Figure 34 show the erosion that could be realized over a 50-year period using the low, intermediate, and high rate.

Table 8. Rates of erosion

Low [ft/yr]	Intermediate [ft/yr]	High [ft/yr]
12.0	23.5	30.4

Table 9. Projected erosion over a 50-year project life

Low [ft]	Intermediate [ft]	High [ft]
600	1160	1520

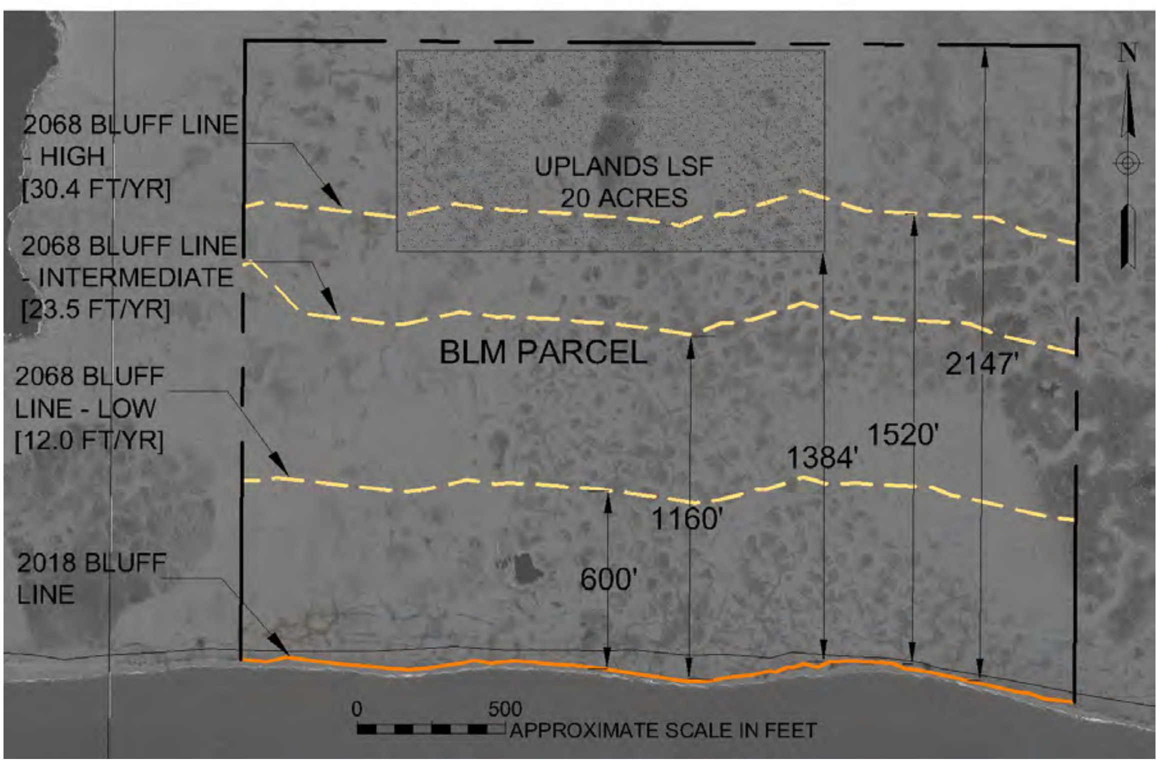


Figure 34. Projected 50-year erosion lines. Aerial photograph is August 2018 from DigitalGlobe.

Due to the high erosion rates, this analysis was expanded to look at erosion along the coast north and east of Cape Blossom to see if there was an location that was experiencing less erosion.

8.2 Expanded Erosion Analysis

In 2019, the United States Geological Survey (USGS) published a report that looked at the erosion rates from Icy Cape to Cape Prince of Wales (Gibbs, 2019) (Figure 35). This includes the Cape Blossom area. The report compared aerial photography from 1950s, 1980s, 2003, and 2010s (2015-2016) to develop long term and short term erosion rates. The maximum long term erosion was calculated using a linear regression for erosion measured using the photos from the 1950s through 2010s. East of Cape Blossom this rate was reported as 12.8 feet/year. The maximum short term erosion was calculated using the end point method for photos analyzed from 1980s and 2010s. This rate was reported as 18.4 feet/year.

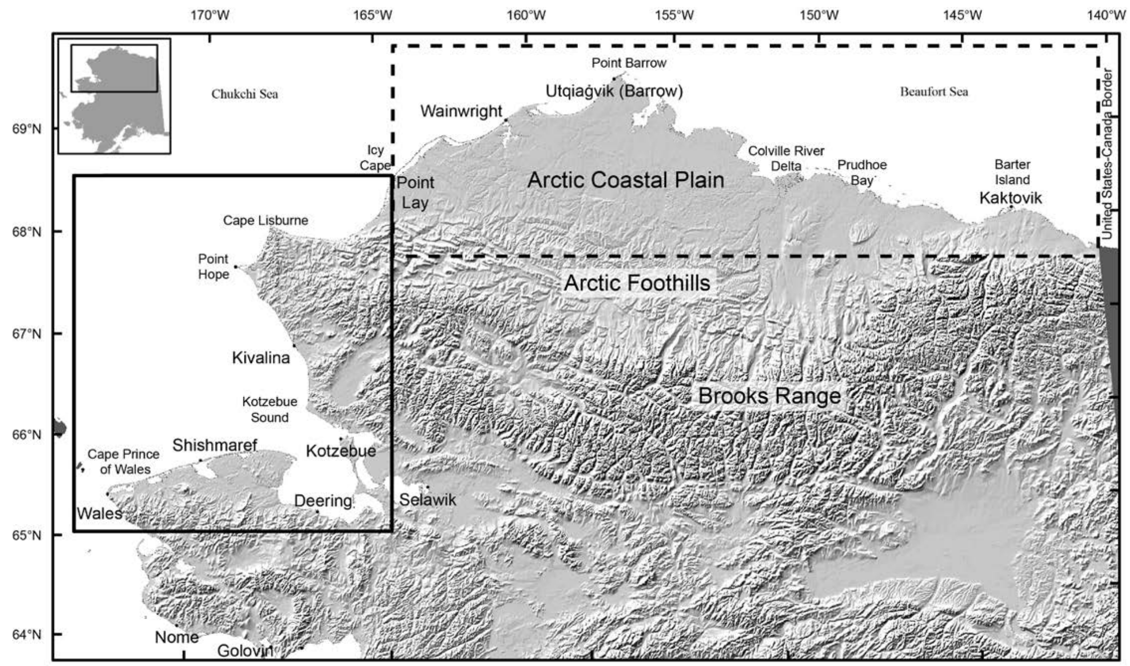


Figure 35 Location of USGS shoreline change analysis. Area bounded by solid black line.

The erosion rates evaluated for this analysis were developed in the same manner as the original USACE erosion analysis performed for the Navigation Improvements Study. Orthorectified aerial photos for the years 1952 (supplimented as necessary by 1953 photography) and 1978; and DigitalGlobe aerial photos for 2013, and 2020 were digitized to evaluate coastal erosion and determine if there was a more stable location for the shoreside facilities needed to support a navagation improvement project.

Since the erosion varied, the coast was broken into seven reaches with similar erosion rates, labeled EA-EG (Figure 36 and Figure 37). Six transect lines were drawn across the shore of each reach to measure the shoreline change between years.

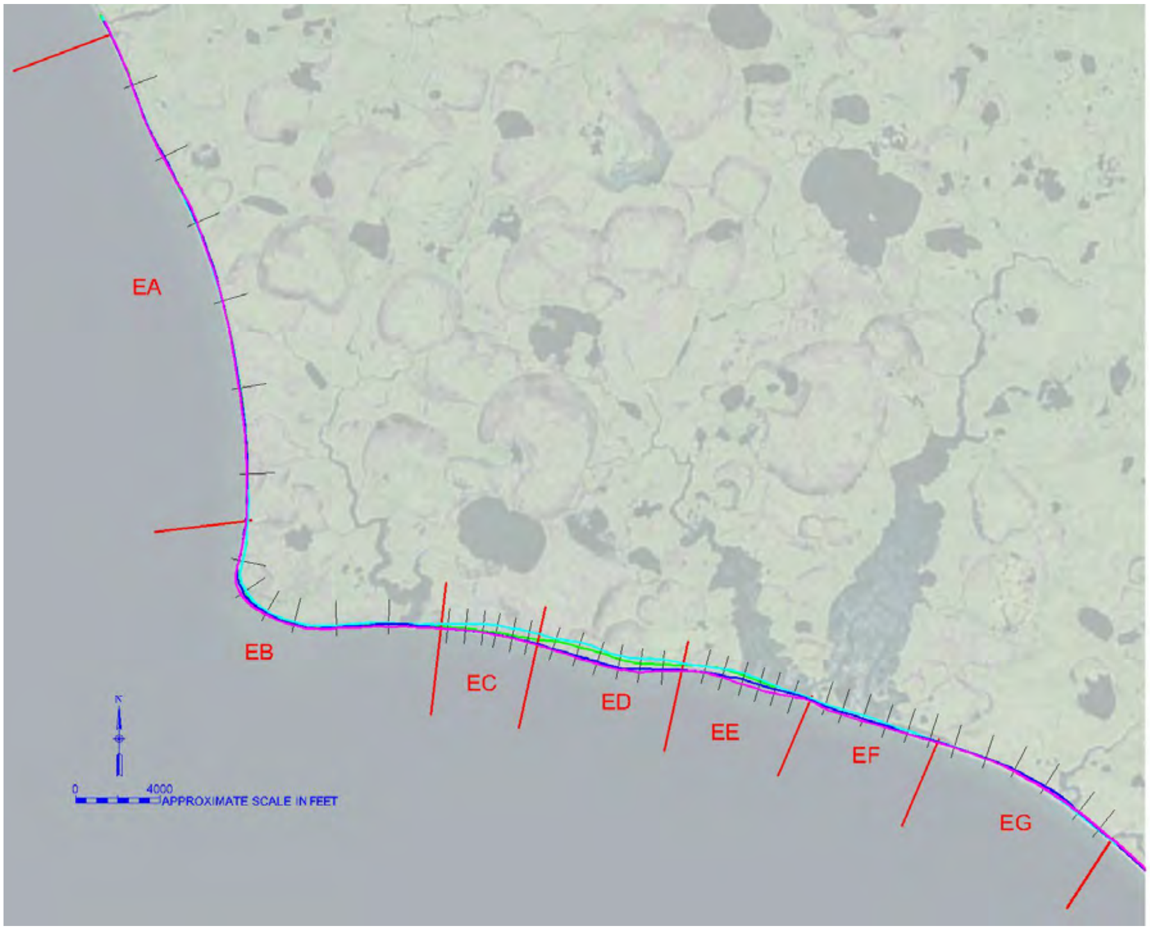


Figure 36 Shoreline reach breakout for erosion analysis. Magenta=1952; Blue=1978; Green=2013; Cyan=2020

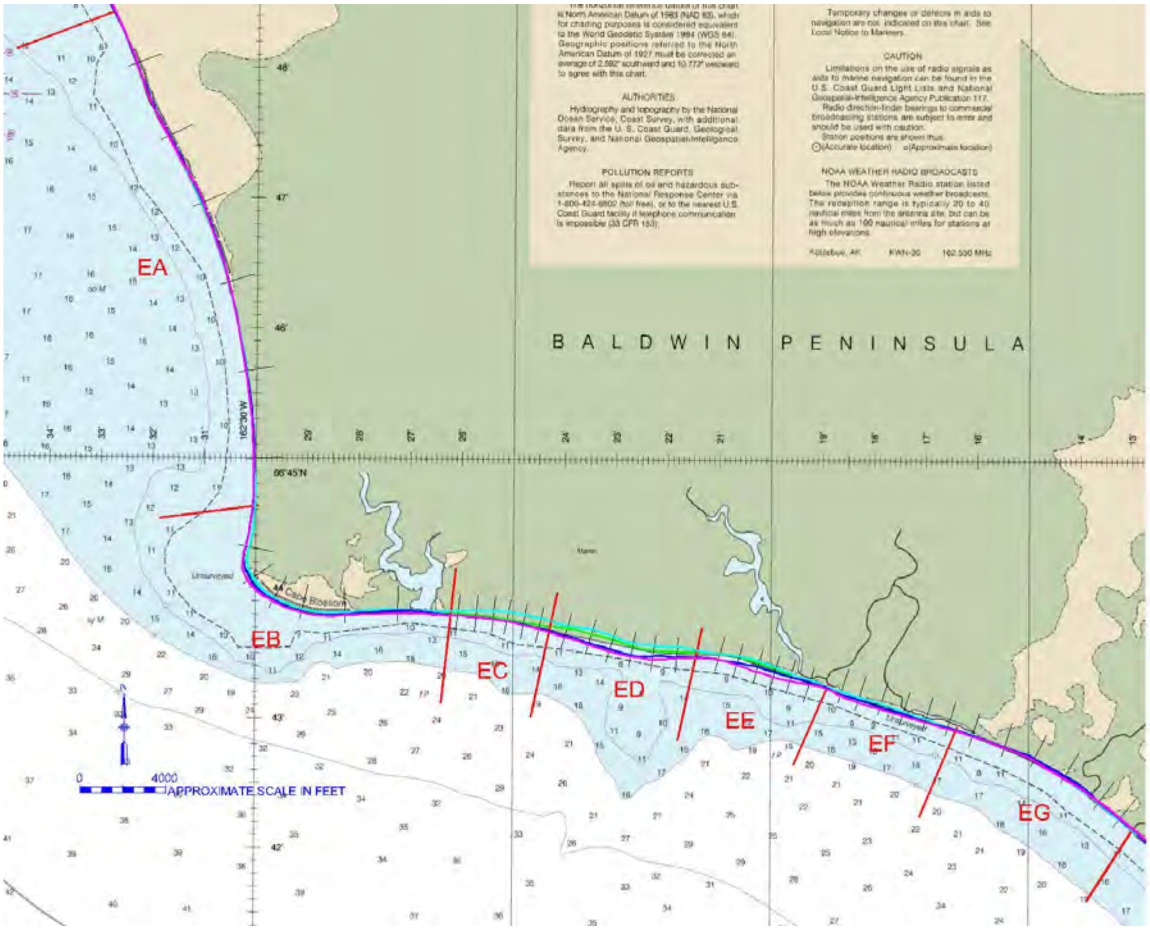


Figure 37 NOAA Chart 16161 with reach breakouts

Reach EA

Reach EA is located on the coast north of Cape Blossom. It is characterized by a vegetated bluff (Figure 38) that is fronted by a wide mud flat (Figure 37). The coast in this area appears to be protected by the wide mud flat as evidenced by the vegetated bluffs. Variations in the digitized shoreline analysis in this area were minimal and were assumed to be a product of the difference between aerial photography quality and not indicative of erosion. This reach of the coast is stable with no measurable erosion rate.

Figure 38 Reach EA - Coast north of Cape Blossom (ShoreZone, n.d.)

Table 10 Reach EA - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Year	Years between photos	Transect 1 [ft]	Transect 2 [ft]	Transect 3 [ft]	Transect 4 [ft]	Transect 5 [ft]	Transect 6 [ft]	Avg. change [ft]	Avg. rate [ft/yr]
1952	0	NM	NM	NM	NM	NM	NM	-	-
1978	26	NM	NM	NM	NM	NM	NM	-	-
2013	35	NM	NM	NM	NM	NM	NM	-	-
2020	7	NM	NM	NM	NM	NM	NM	-	-
NM = Not Measured									

Reach EB

Reach EB covers Cape Blossom and the coast that is immediately north and east of Cape Blossom. It is characterized by exposed bluffs to the north of Cape Blossom that give way to taller exposed bluffs at Cape Blossom. East of Cape Blossom, the bluffs reduce in height and are characterized by a mix of vegetated and exposed bluff faces (Figure 39 through Figure 41).

Figure 39 Reach EB - Coast north of Cape Blossom (ShoreZone, n.d.)

Figure 40 Reach EB - Cape Blossom (ShoreZone, n.d.)

Figure 41 Reach EB - Coast east of Cape Blossom (ShoreZone, n.d.)

The Reach EB shoreline erosion is shown in Table 11. The erosion that could be realized over a 50-year period using the average rate of erosion that occurred between 2013 and 2020 is 175 feet and is shown in Figure 42.

Table 11 Reach EB - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Year	Years between photos	Transect 1 [ft]	Transect 2 [ft]	Transect 3 [ft]	Transect 4 [ft]	Transect 5 [ft]	Transect 6 [ft]	Avg. change [ft]	Avg. rate [ft/yr]
1952	0	0	0	0	0	0	0	0	0
1978	26	3.9	134.8	64.6	48	48.6	130.3	71.7	2.8
2013	35	172.2	103.6	69.7	98.9	89.3	27.5	94.2	2.7
2020	7	0	47.9	22.4	48	5.1	23.6	24.5	3.5

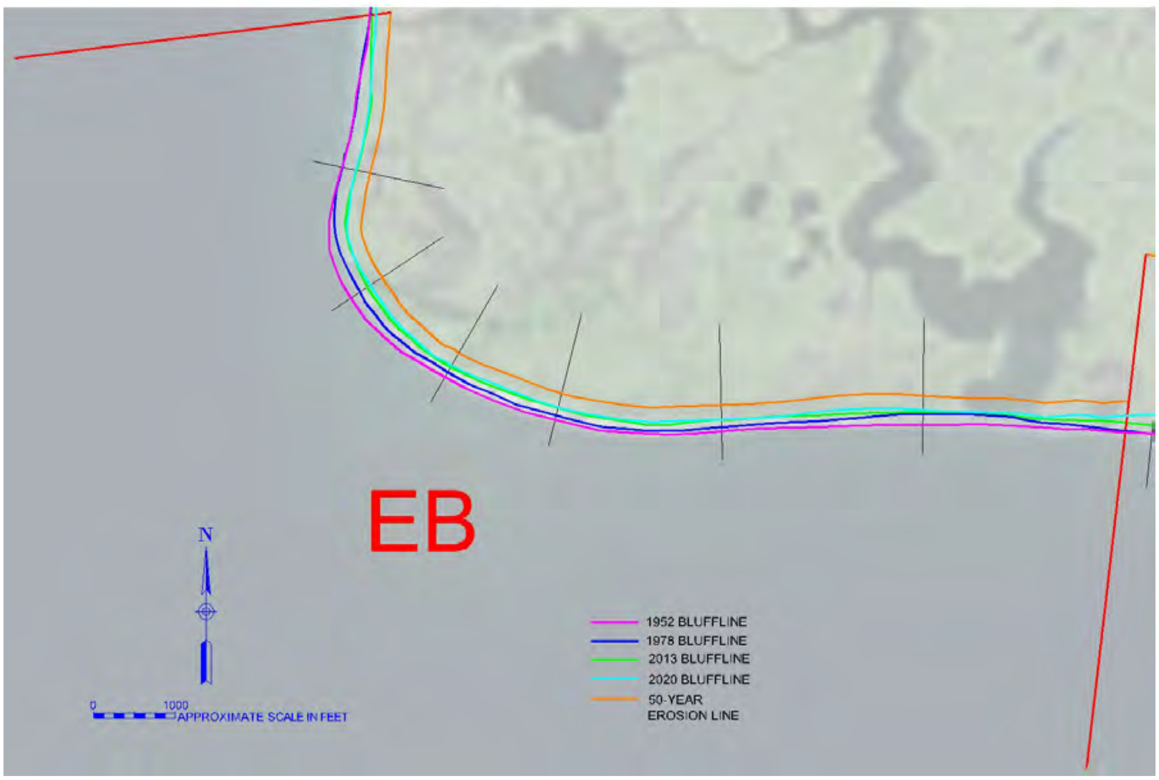


Figure 42 Reach EB with the projected 50-year erosion line. Magenta=1952; Blue=1978; Green=2013; Cyan=2020; Orange=Projected 50-year erosion line

Reach EC

Reach EC is characterized by bluffs of reduced height that are exposed and visibly eroding exposed (Figure 43 through Figure 45).

Figure 43 Reach EC - Bluffs are reduced in height and are visibly eroding (ShoreZone, n.d.)

Figure 44 Reach EC - Visibly eroding bluffs (ShoreZone, n.d.)

The Reach EC shoreline erosion is shown in Table 12. The erosion that could be realized over a 50-year period using the average rate of erosion that occurred between 2013 and 2020 is 1,951 feet and is shown in Figure 45.

Table 12 Reach EC - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Year	Years between photos	Transect 1 [ft]	Transect 2 [ft]	Transect 3 [ft]	Transect 4 [ft]	Transect 5 [ft]	Transect 6 [ft]	Avg. change [ft]	Avg. rate [ft/yr]
1952	0	0	0	0	0	0	0	0	0
1978	26	0	0	8.9	20.2	21.1	31.7	13.7	0.5
2013	35	99.8	96.1	80.9	86.6	99.8	156.6	103.3	3.0
2020	7	128.6	201.8	295	345.3	353.4	314.9	273.2	39

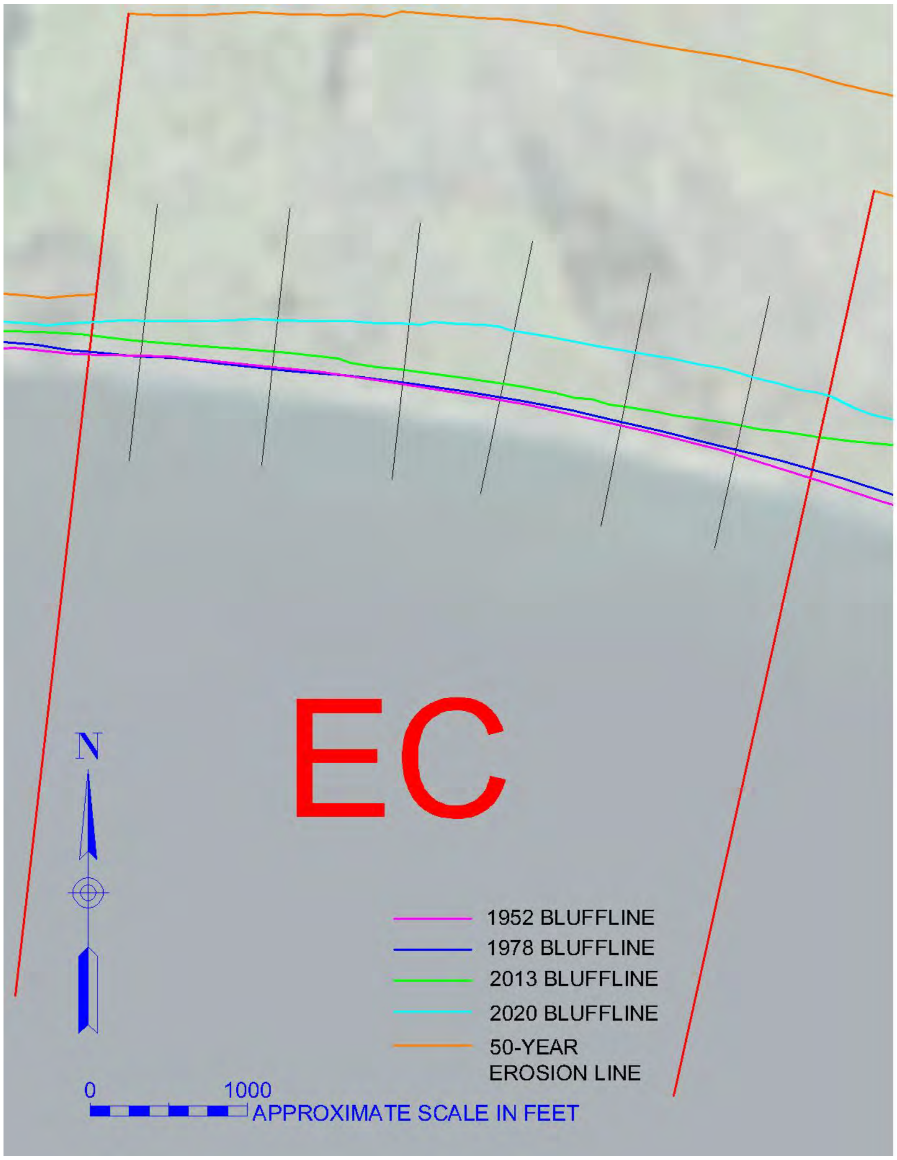


Figure 45 Reach EC with the projected 50-year erosion line. Magenta=1952; Blue=1978; Green=2013; Cyan=2020; Orange=Projected 50-year erosion line

Reach ED

Reach ED is characterized by exposed eroding bluffs with a widened area of shallow water in front of the bluff. Unlike Reach EA, where the mudflats appear to protect the bluff, the shallow water in Reach ED appears to focus wave activity. Reaches EC and ED have the fastest rate of erosion and focused wave activity is suspected to be part of the cause (Figure 46).

Figure 46 Reach ED Actively eroding bluff (ShoreZone, n.d.)

Reach ED erosion is shown in Table 13. The erosion that could be realized over a 50-year period using the average rate of erosion that occurred between 2013 and 2020 is 1,338 feet and is shown in Figure 47.

Table 13 Reach ED - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Year	Years between photos	Transect 1 [ft]	Transect 2 [ft]	Transect 3 [ft]	Transect 4 [ft]	Transect 5 [ft]	Transect 6 [ft]	Avg. change [ft]	Avg. rate [ft/yr]
1952	0	0	0	0	0	0	0	0	0
1978	26	63.3	86.4	104.5	65.4	166.8	74.4	93.5	3.6
2013	35	372.4	430.1	441.4	411.2	254.8	232.9	357.1	10.2
2020	7	118.1	219.3	155.5	172.2	224.2	234.4	187.3	26.8

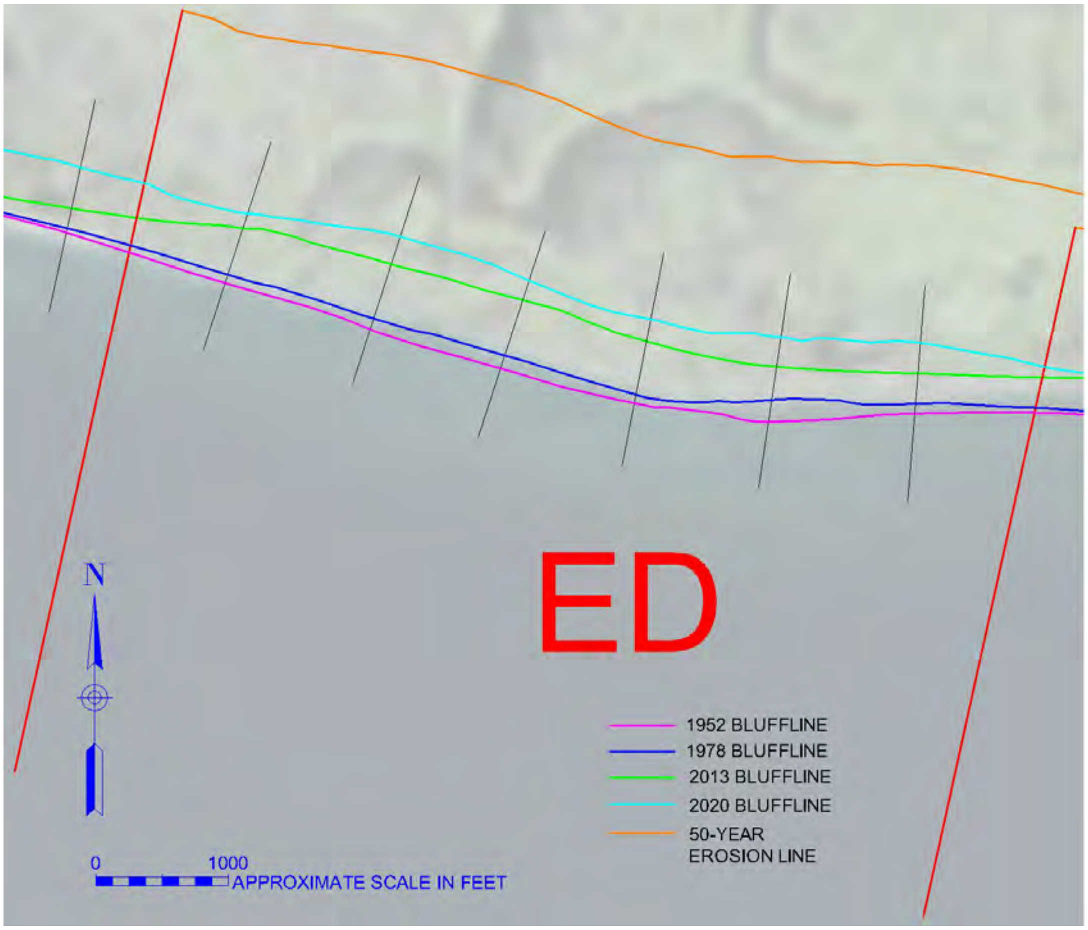


Figure 47 Reach ED with the projected 50-year erosion line. Magenta=1952; Blue=1978; Green=2013; Cyan=2020; Orange=Projected 50-year erosion line

Reach EE

Reach EE is characterized by a combination of low exposed bluffs and non-existent bluffs. This area fronts wetlands and lakes.

Figure 48 - Reach EE; low bluff and no bluff (ShoreZone, n.d.)

Figure 49 Reach EE - No bluffs; narrow beach backed by wetland (ShoreZone, n.d.)

Reach EE erosion is shown in Table 14. The erosion that could be realized over a 50-year period using the average rate of erosion that occurred between 2013 and 2020 is 1,079 feet and is shown in Figure 47.

Table 14 Reach EE - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Year	Years between photos	Transect 1 [ft]	Transect 2 [ft]	Transect 3 [ft]	Transect 4 [ft]	Transect 5 [ft]	Transect 6 [ft]	Avg. change [ft]	Avg. rate [ft/yr]
1952	0	0	0	0	0	0	0	0	0
1978	26	17.0	85.3	112.0	105.1	75.6	74.4	78.2	3.0
2013	35	278.7	286.6	173.0	151.4	98.4	N/A	197.6	5.6
2020	7	0	28.7	236.8	211.9	194.5	234.4	151.1	21.6

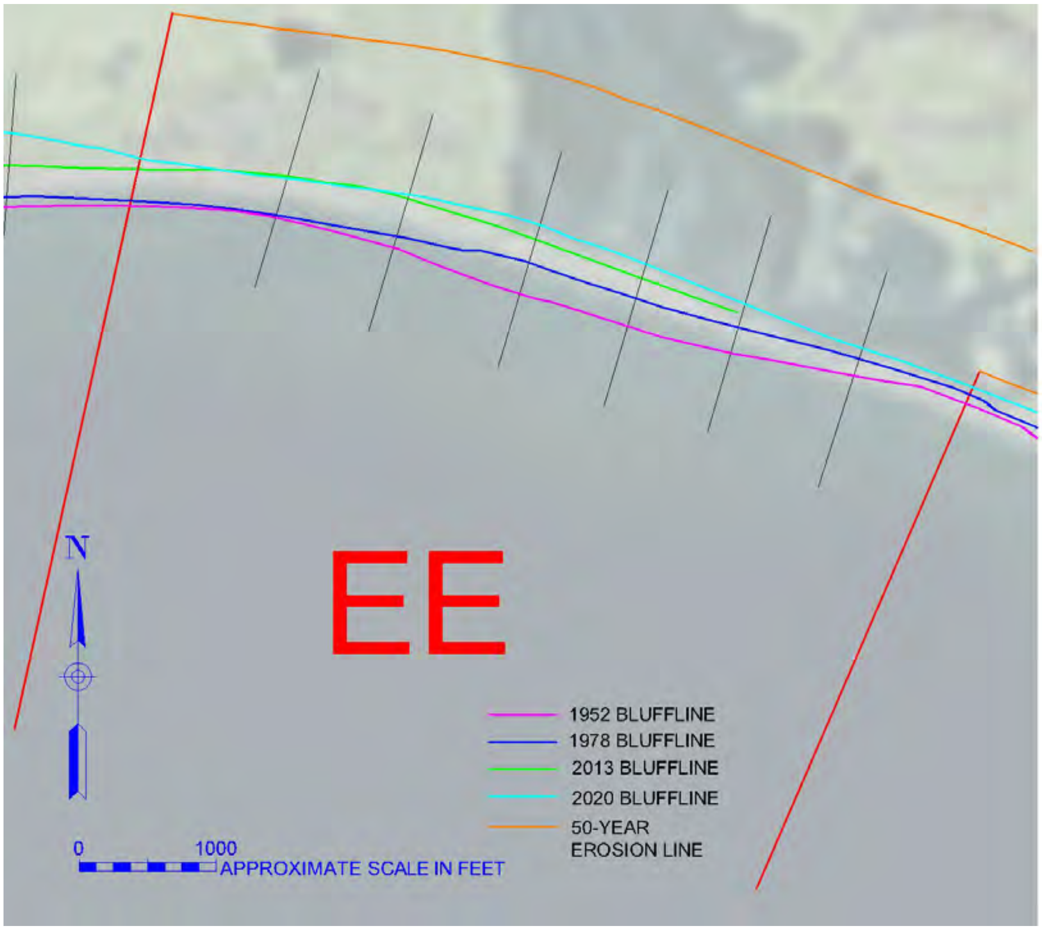


Figure 50 Reach EE with the projected 50-year erosion line. Magenta=1952; Blue=1978; Green=2013; Cyan=2020; Orange=Projected 50-year erosion line

Reach EF

Reach EF is characterized by narrow beaches with a few low exposed bluffs that fronts wetlands, lakes, and streams.

Figure 51 Reach EF; low berm and beach backed by wetland (ShoreZone, n.d.)

Figure 52 Reach EF; narrow beach backed by stream (ShoreZone, n.d.)

Reach EF erosion over the years of analysis is shown in Table 15. Aerial photography for 2013 was not available for this reach, so it was excluded from the analysis. The erosion that could be realized over a 50-year period using the average rate of erosion that occurred between 1978 and 2020 is 125 feet and is shown in Figure 53.

Table 15 Reach EF - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Year	Years between photos	Transect 1 [ft]	Transect 2 [ft]	Transect 3 [ft]	Transect 4 [ft]	Transect 5 [ft]	Transect 6 [ft]	Avg. change [ft]	Avg. rate [ft/yr]
1952	0	0	0	0	0	0	0	0	0
1978	26	102.9	120.6	105.7	80.7	22.3	44.2	79.4	3.1
2020	42	100.5	111.0	147.4	106.7	135.7	28.2	104.9	2.5

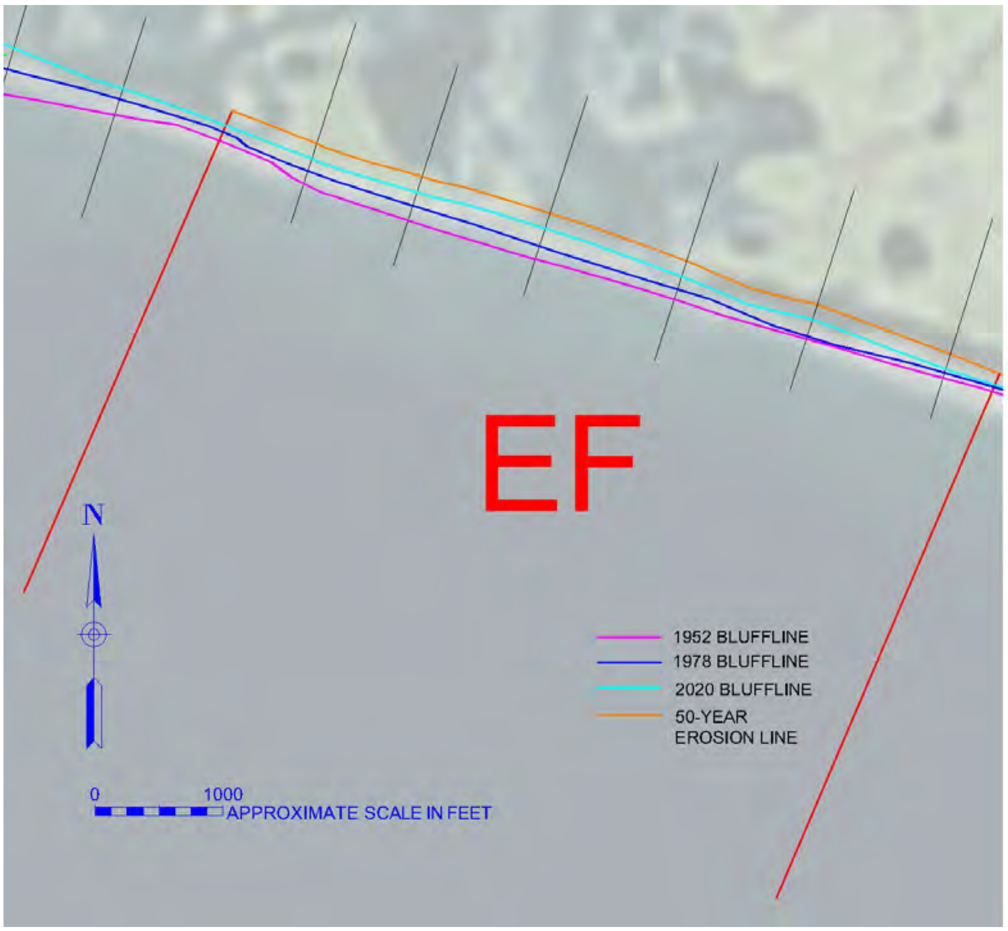


Figure 53 Reach EF with the projected 50-year erosion line. Magenta=1952; Blue=1978; Green=2013; Cyan=2020; Orange=Projected 50-year erosion line

Reach EG

Reach EG is characterized by low vegetated bluffs fronted by a wider beach. The low bluffs reduce in height until the coast is characterized by a wider, flat beach. This reach of the coast is stable with no measurable erosion rate.

Aerial photography for 2013 was not available for this reach, so it was excluded from the analysis. Variations in the digitized shoreline were minimal and were assumed to be a product of the difference between aerial photography quality and not indicative of erosion.

Figure 54 Reach EG; Low vegetated bluffs with wider beach (ShoreZone, n.d.)

Figure 55 Reach EG; Continuation of low bluffs and wider beach (ShoreZone, n.d.)

Figure 56 Reach EG; no bluffs, wider beach (ShoreZone, n.d.)

Table 16 Reach EG - Shoreline change from previous year and erosion rates developed from aerial photo analysis

Year	Years between photos	Transect 1 [ft]	Transect 2 [ft]	Transect 3 [ft]	Transect 4 [ft]	Transect 5 [ft]	Transect 6 [ft]	Avg. change [ft]	Avg. rate [ft/yr]
1952	0	NM	NM	NM	NM	NM	NM	-	-
1978	26	NM	NM	NM	NM	NM	NM	-	-
2020	42	NM	NM	NM	NM	NM	NM	-	-
NM = Not Measured									

9.0 NAVIGATION IMPROVEMENTS

The navigation improvement that was being evaluated in the Navigation Improvement Study was a dredged channel towards the shore that terminated at a dock connected to the shore by an elevated road.

It was assumed that the channel access would involve a road on cellular supports similar to the trestle supports at the Delong Mountain Terminal loading facility (Figure 57). This structure, also known as Red Dog Dock, is located south of Kivalina and has survived the arctic conditions.

Figure 57. Cellular support structure at the Delong Mountain Terminal

10.0 CHANNEL DESIGN

The purpose of dredging the channel is to provide access to an offloading facility located near the shore. The channel design followed the standards of Engineering Manual (EM) 1110-2-1613, "Hydraulic Design of Deep-Draft Navigation Projects," and was checked against PIANC guidance.

10.1 Design Vessel Criteria

The design vessel for this analysis is a barge that would bring in fuel and goods. In addition to the barge, the dimensions of a tug accompanying the barge are also included as the design vessel because its draft requires the use of the channel during transit. The tug dimensions are based on the tugs that are currently used to escort the barge. The dimensions of the design vessel and tug are shown in Table 17.

Table 17. Design Vessel Information

	Design Barge	**Design Tug**
Length Overall [feet]	380	126
Beam [feet]	96	34
Loaded Draft [feet]	20	17

10.2 Configuration and Use

The channel is a straight channel that maintains a constant width to accommodate the fully loaded barge until the -23 foot contour. At this contour, the channel widens to accommodate the underkeel clearance of the barge and tug towing alongside the barge. The channel continues straight with a constant width until it reaches the dock for unloading where it widens into a turning basin for the barge.

10.2.1 Channel Width

USACE guidance sets the channel width at 432 feet up to the -23 foot contour. This is based on one-way traffic, shallow cross-section, average aids to navigation, and currents up to 0.68 knots. These design criteria produce a beam multiplier of 4.5. At the -32 foot contour, the channel width was widened to provide navigation draft for a tug used to guide the ship. The width calculation was based on the same criteria with the exception that the shallow cross-section was now a trench cross-section. These criteria produced a beam multiplier of 4.0 and was applied with the combined beam of 96 feet (barge) and 34 feet (tug) resulting in a channel width of 520 feet.

The channel width was checked using the Permanent International Association of Navigation Congresses (PIANC) guidance. The PIANC width detailed in Table 18 shows the need for an approximate width of 546 feet which checks well with the channel width determined using USACE guidance.

Table 18. PIANC width factors

Condition	Site Description	Width Factor
Vessel Speed (knots)	slow (5-8)	0.0B
Prevailing Cross Wind (knots)	moderate 15-33	0.6B
Prevailing Cross Current (knots)	strong 1.5-2.0	0.3B
Prevailing Longitudinal Current (knots)	low ≤ 1.5	0.0B
Bean & stern quartering wave height (m)	Hs<1	0.0B
Aids to Navigation	moderate with infrequent poor visibility	0.4B
Bottom Surface	< 1.5T and smooth	0.1B
Depth of Waterway	<1.25T	0.2B
Cargo Hazard Level	Medium	0.0B
Additional Width for Bank Clearance (2x)	Sloping channel edges	0.3B
Basic Ship Maneuvering Lane	Poor Ship Maneuverability	1.8B
Sloping channel edges and shoals	slow (5-8 knots)	0.3B
B = 96 feet + 34 feet = 130	Total	4.2B
Width = 546 feet		

10.2.2 Turning Basin

The channel ends with a turning basin that is 570 feet which is 1.5 times the length of the barge. This allows the barge to be turned fully loaded which will allow for a quick departure from the dock once unloading is complete or in the event that weather conditions change and make it unsafe to remain at the dock.

10.2.3 Channel Depth

Vessels moving in a navigation channel must maintain clearance between their hulls and channel bottom. Navigational design parameters such as squat, safety clearance, vertical motion due to waves, and water density effects were analyzed to determine the required minimum under-keel clearance. Figure 58 illustrates vessel factors that determine the minimum channel depth.

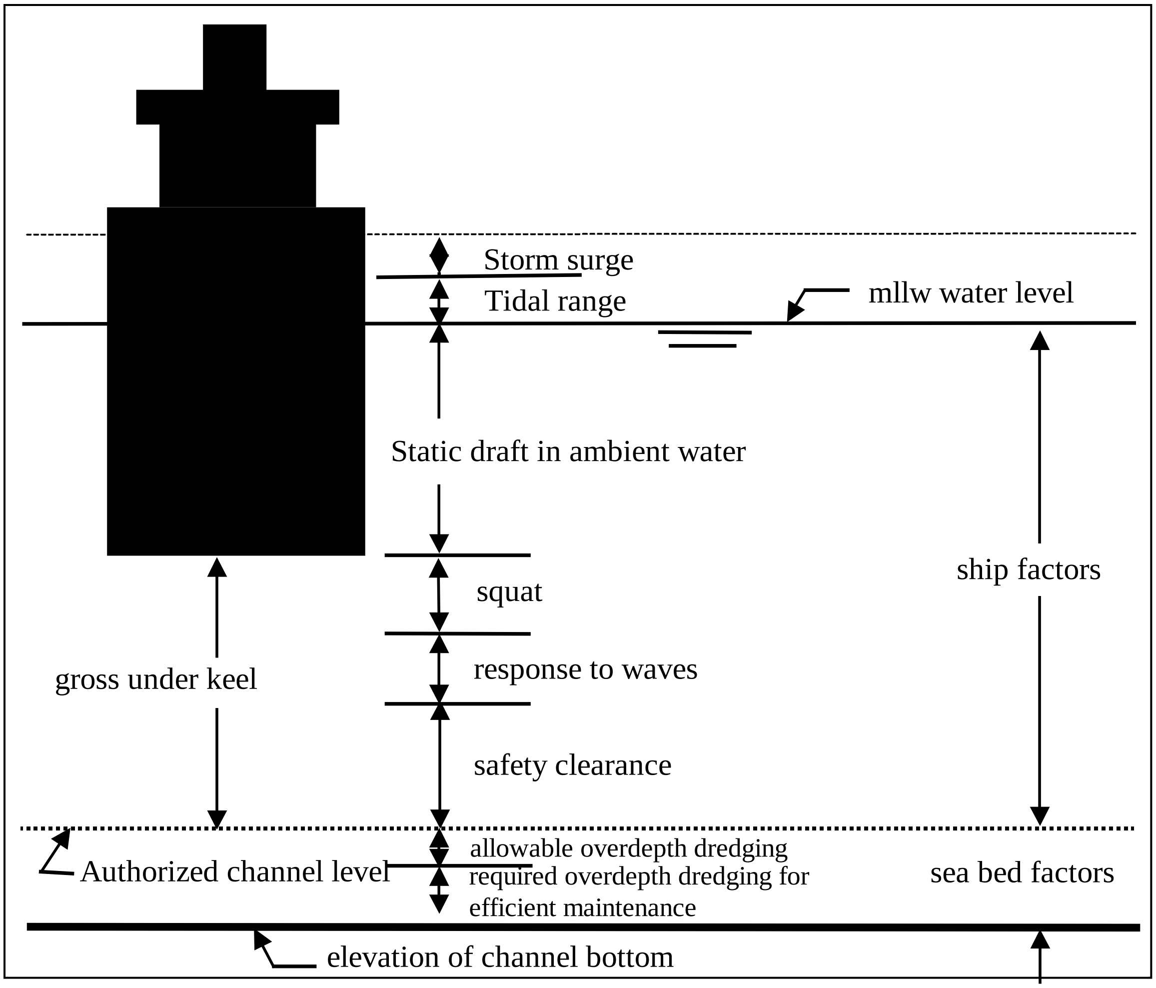


Figure 58. Vessel Factors that Determine Minimal Channel Depth

Draft. The fully loaded draft of the design barge is 20 feet (Table 19) and the loaded draft of the associated tug is 17 feet.

Squat. Squat is the lowering of the vessel in the water column due to the hydrodynamic pressure gradient created by the fluid velocity around and under the vessel hull when a vessel is underway. The vessel draft increases when sailing as the hydrostatic and kinetic energy is balanced. Squat varies with vessel speed, water depth beneath the keel, and the ratio of the vessel cross-section area to the cross-section area of the channel. Because the vessel is assumed to be moving at a very slow speed, squat was assumed to be 0.5 feet during channel transit.

Response to Waves. Values for vessel response to waves was obtained using EM 1110-2-1613 which cites a Columbia River ship motion study. Critical motions of a ship occur at the bow and stern and are most dependent on the wave height and encounter period, with wave height having the most influence on ship motion. The data collected during the

Columbia River study was used to develop a relationship to describe the ship motion assuming a Rayleigh distribution of motion. Assuming channel transit is limited to times when the wave height is 3 feet, the critical ship motion for transit of the channel is 3.5 feet.

Safety Clearance. USACE guidance suggests a minimum net under-keel clearance of 2 feet. The channel bottom is composed of silt, sand, and organics. Based on the description of the material a safety factor of 2 feet was used for this analysis.

Minimum Clearance. The total of squat, response to waves, and safety clearance for the channel provides a design depth of -26 feet MLLW (Table 19).

Set Down. By keeping the berthing area depth the same as the channel depth, set down events up to 4 feet during the shipping season can be tolerated by a ship at the dock and leave a 2-foot safety clearance.

Table 19. Channel depth factors

Channel Factor	Depth [ft]
Loaded draft	20
Squat	.5
Ships response to waves	3.5
Safety Clearance	2
Total	26

Dredging equipment and procedures cannot provide a smoothly excavated bottom at a precisely defined elevation. Two feet of allowable over depth dredging was added to the target depth of excavation to guarantee mariners a least-depth equivalent to the sum of ship factors.

10.3 Channel Length Analysis

Possible channel locations were examined along the coast north and east of Cape Blossom. The area covered is shown in Figure 59.

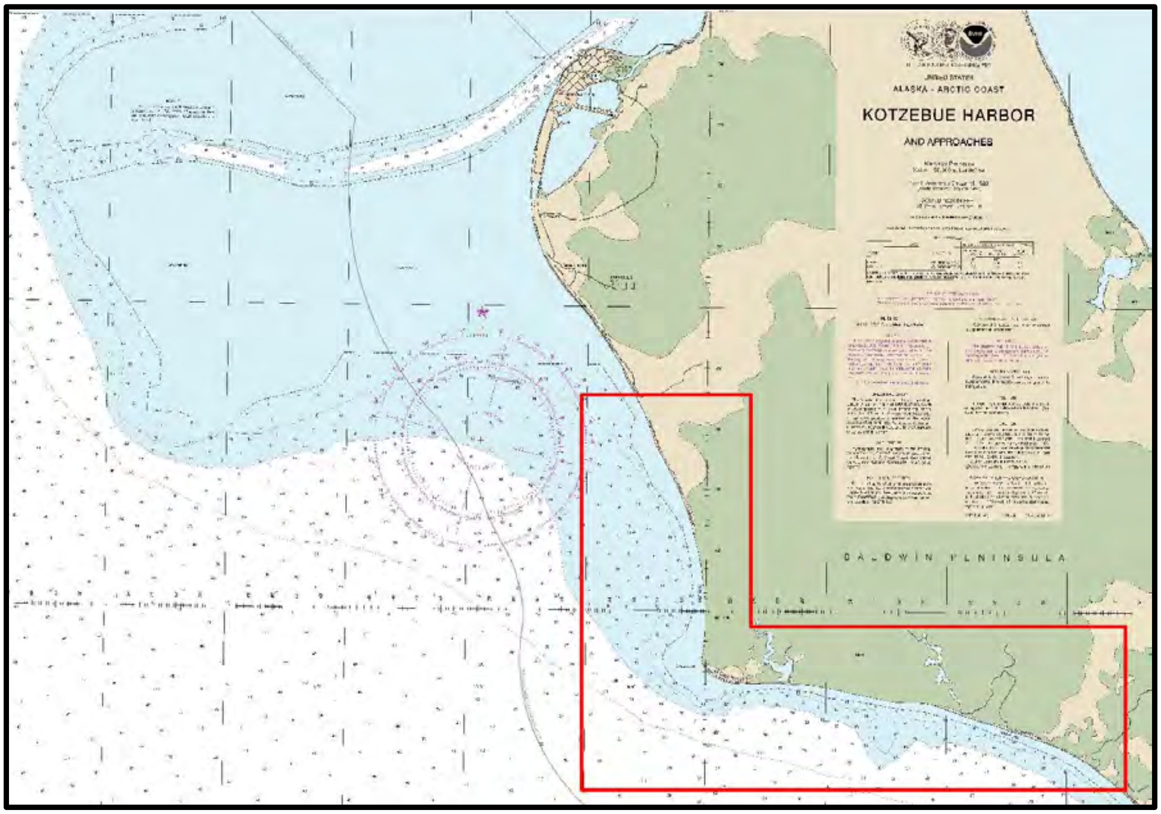


Figure 59 Area evaluated for channel location

10.3.1 Nearshore Channel End

To minimize channel infilling and impacts to the coastal processes, the nearshore end of the channel was located at the -12 foot contour.

Analysis of aerial photography of the shoreline from 1952 to 2018 performed during the Navigation Improvements Study indicates that the beach area is very active, filling areas that are cut (Figure 60 - Figure 64). This prohibits the dredge channel from being dredged all the way into the shore.

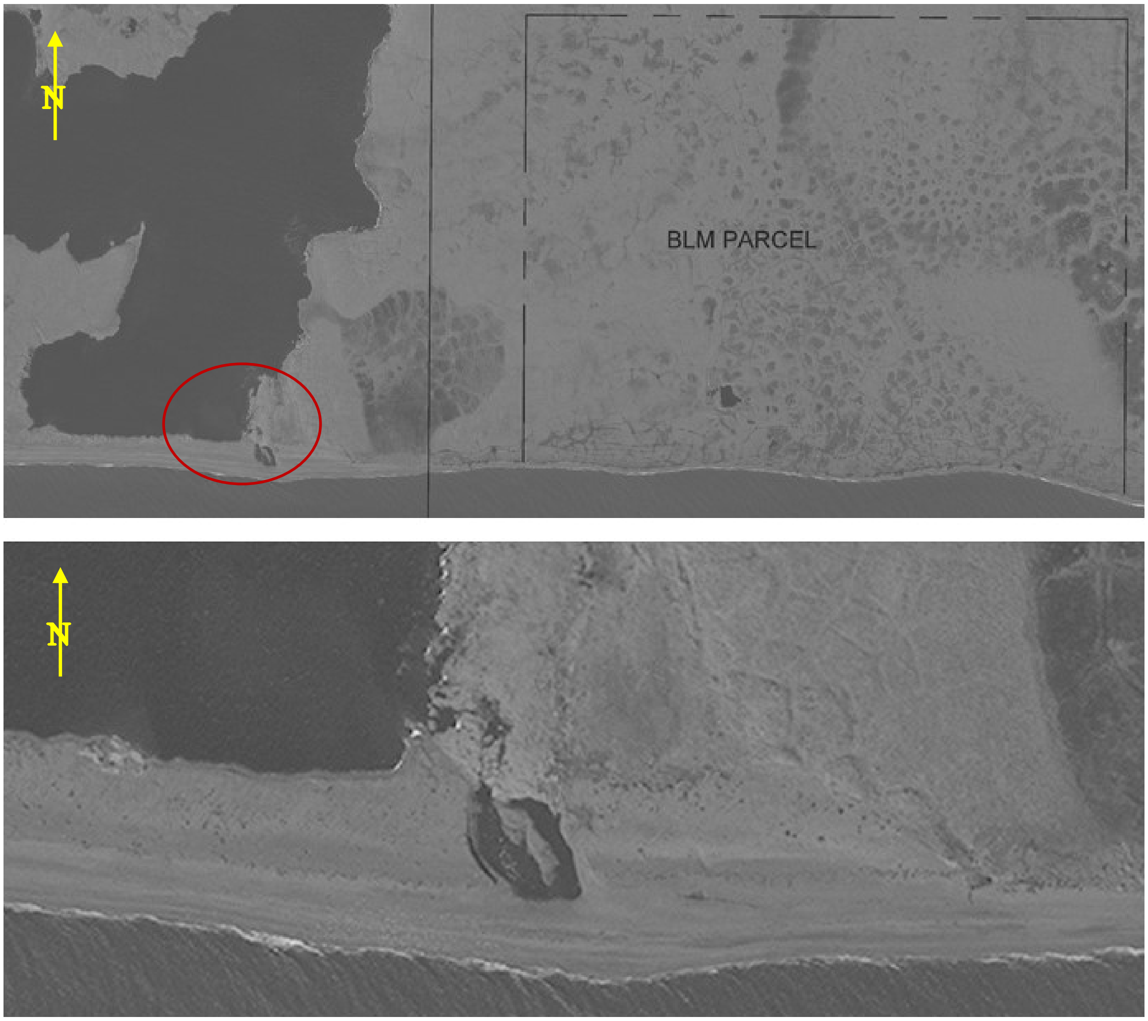


Figure 60. 2018 closed shoreline at the lagoon.

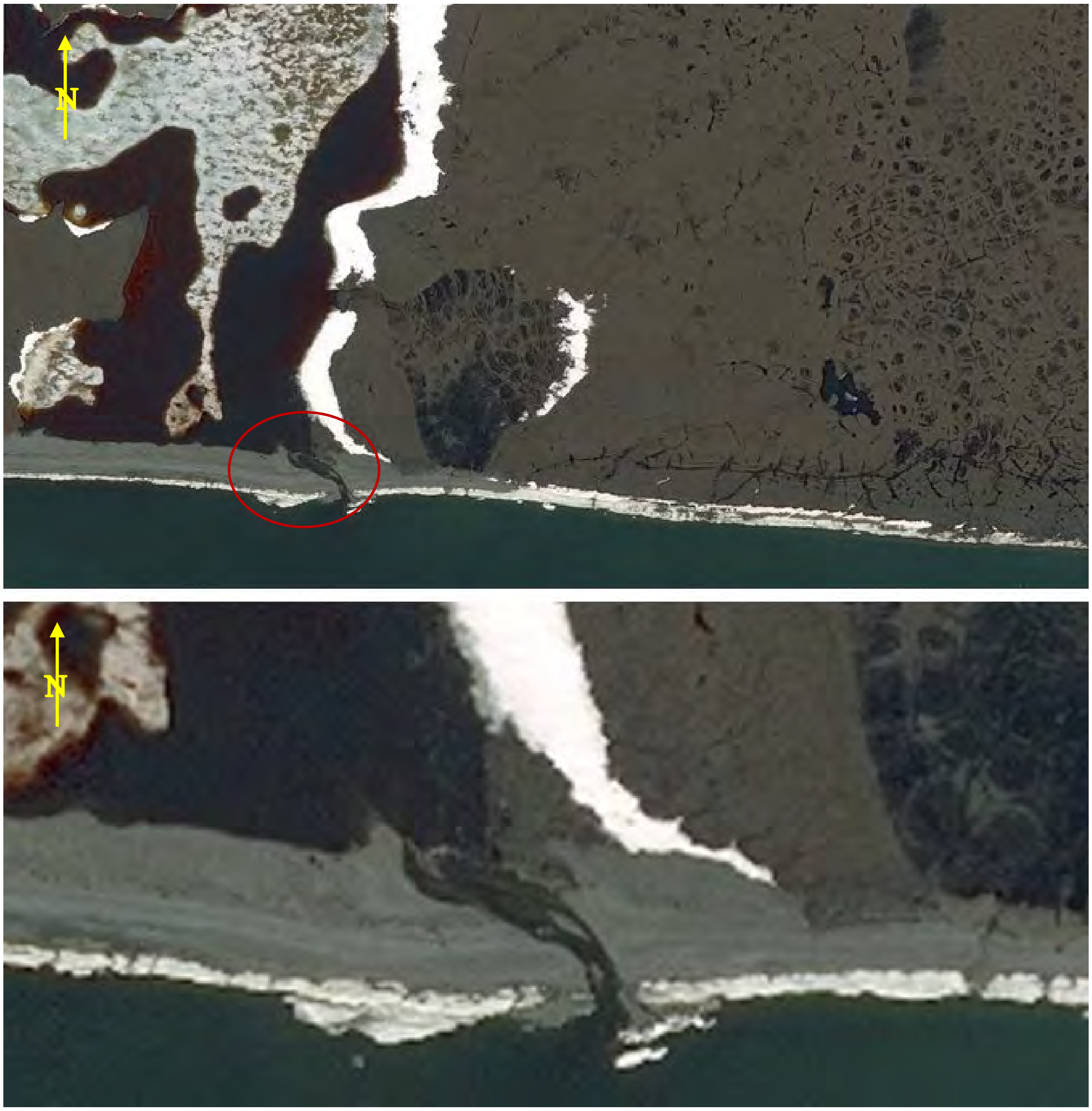


Figure 61. 2016 open shoreline at the lagoon.

Figure 62. 2014 closed shoreline at the lagoon.

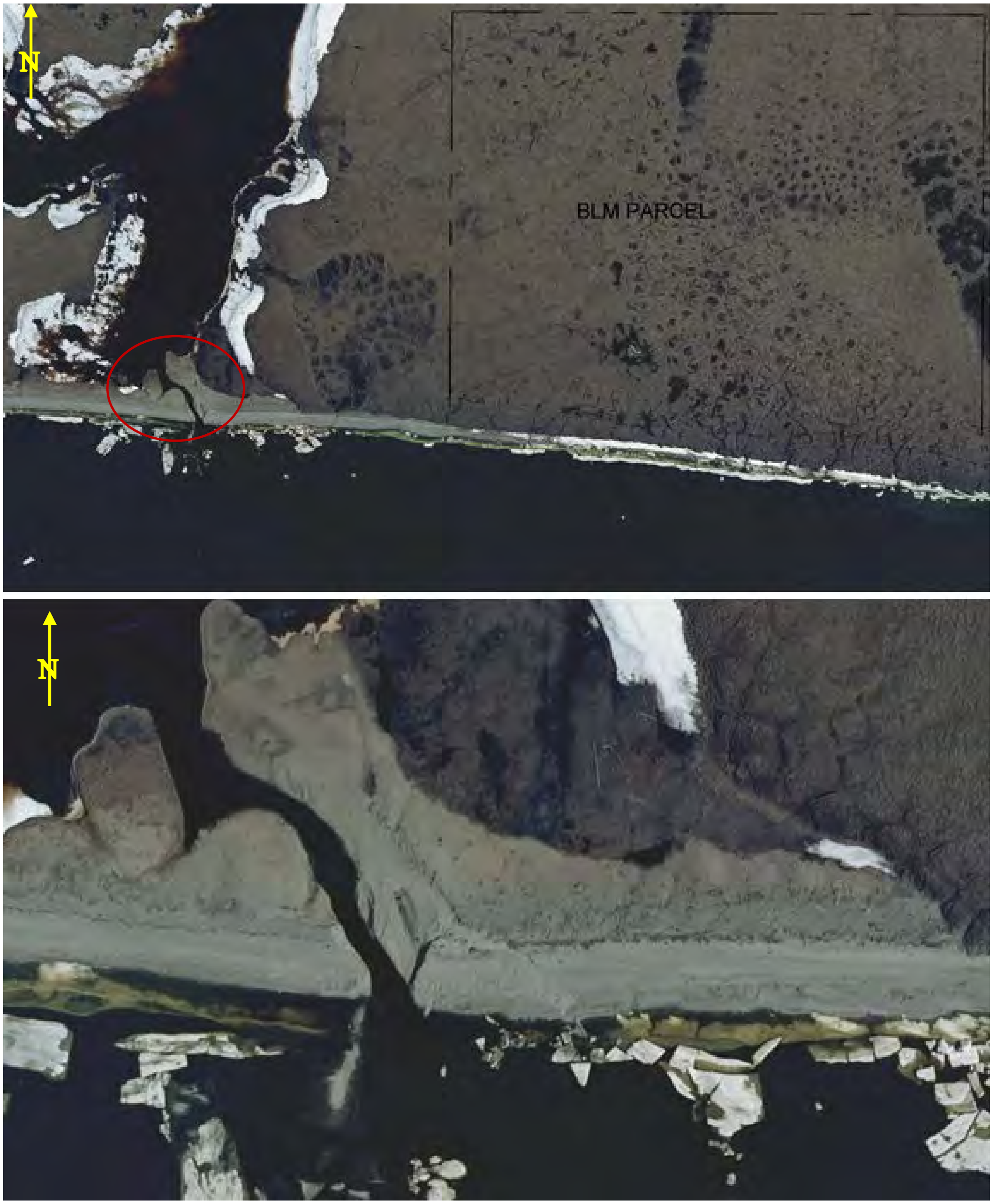


Figure 63. 2013 open shoreline at the lagoon.

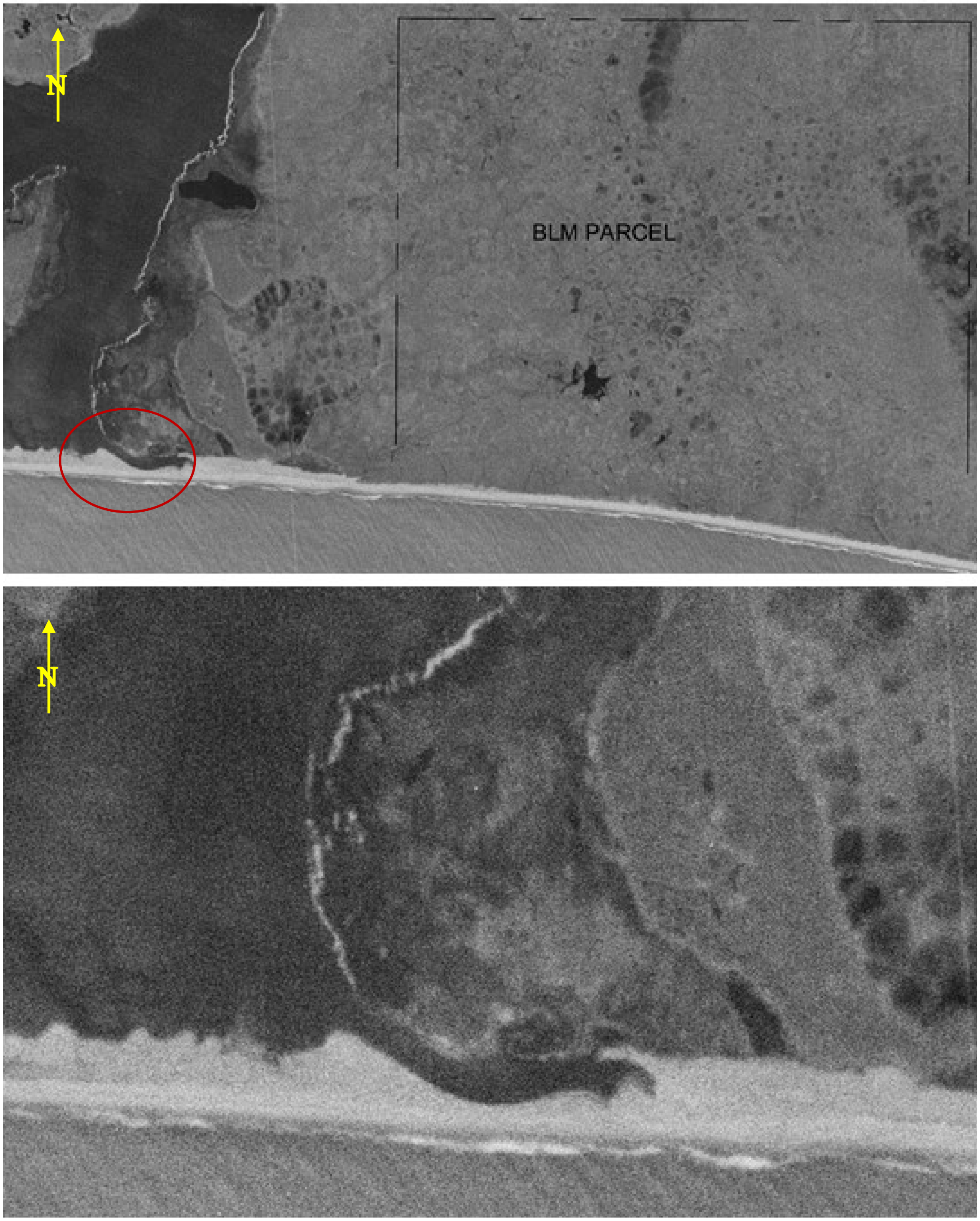


Figure 64. 1952 closed shoreline at the lagoon.

10.3.2 Channel Length

The channel length was determined by measuring the distance from offshore location where the bathymetry contour is equal to the required channel depth to the near shore contour where the channel dredging would end (-12 feet). A connection to the shore side facilities would begin at the nearshore end of the channel. An example of the channel from the Navigation Improvement Study is shown in Figure 65.

Channel lengths were evaluated for five locations along the coast using NOAA Chart 16161. A more detailed analysis of the channel using a bathymetric survey needs to be performed once a channel location is selected.

To evaluate potential channel locations the coast was split up into regions with similar bathymetry. This allowed one representative channel to be used to evaluate the length of the dredged channel and shore side facility connection. The channel reaches are shown in Figure 66 and the corresponding lengths are noted in Table 20.

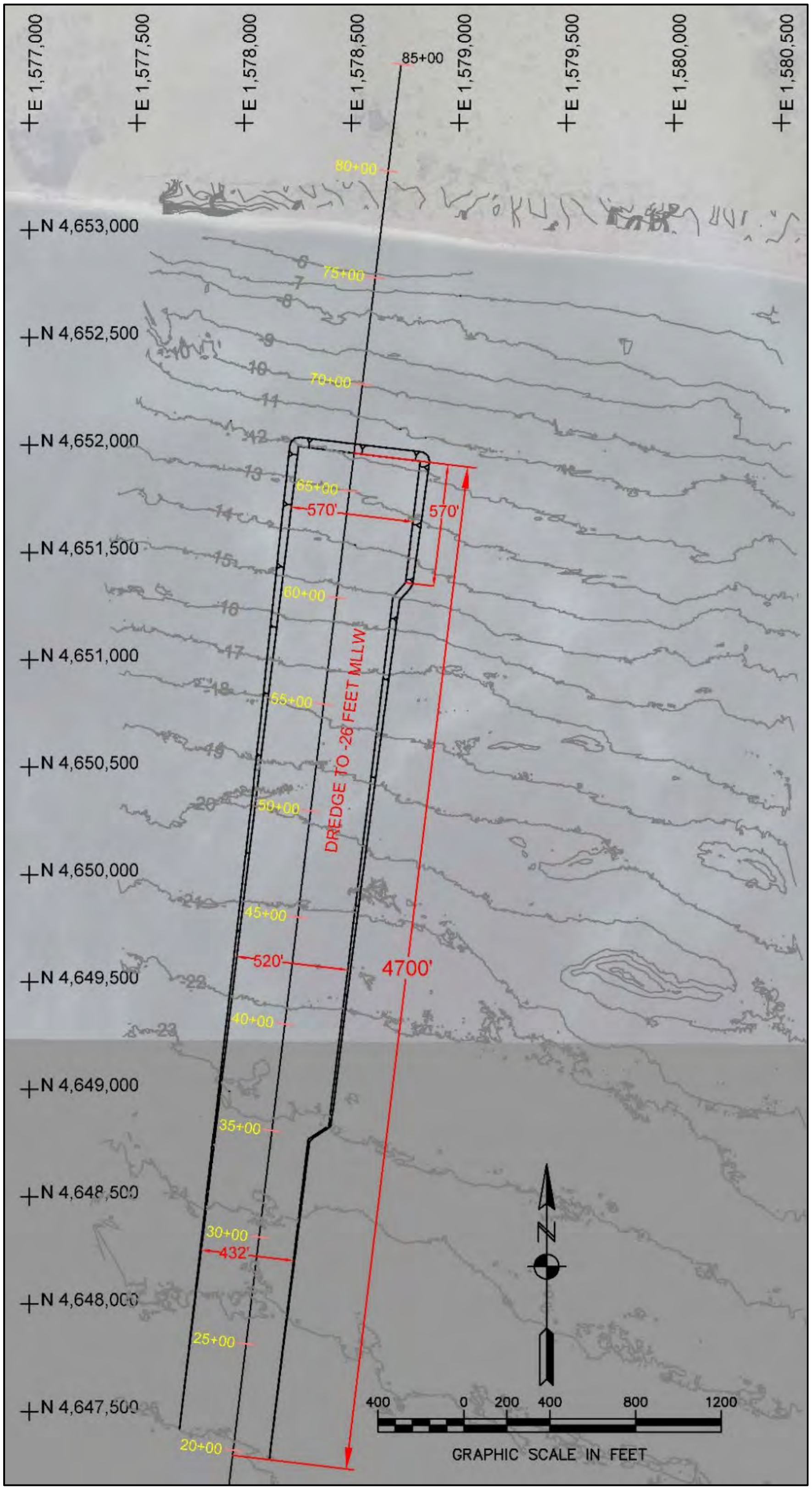


Figure 65 Example dredged channel at the Navigation Improvement Study location

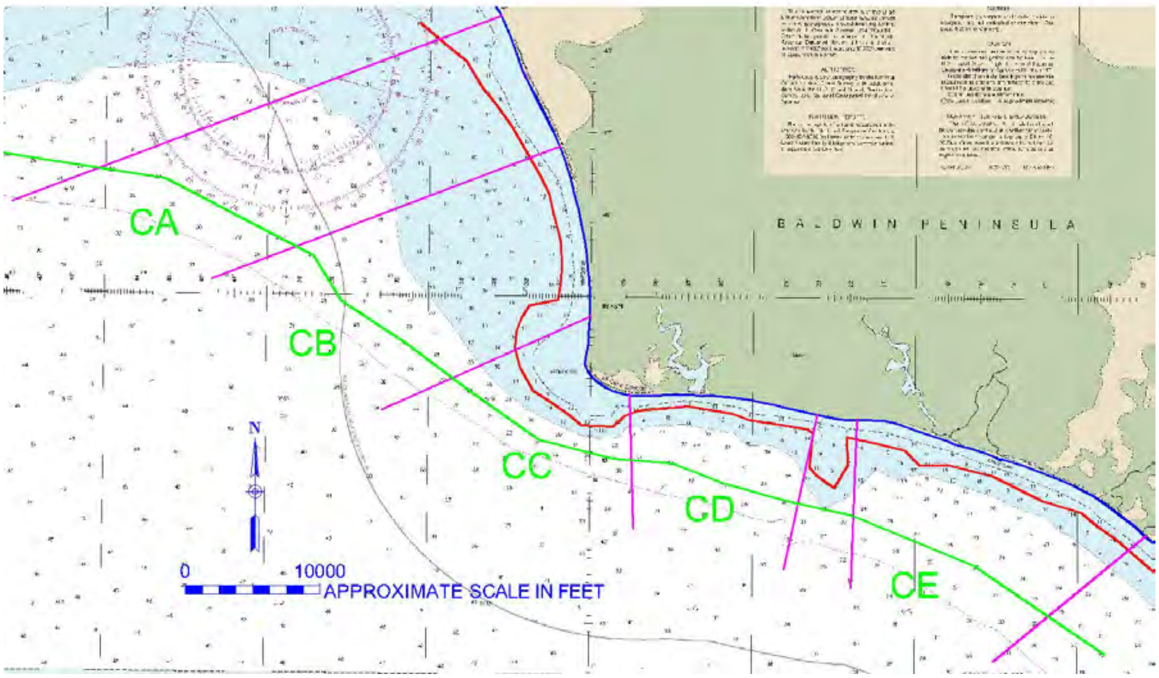


Figure 66 Reaches used for channel length analysis. Green = offshore dredge channel start; Red = nearshore channel end and shoreside connection structure begin; Blue = shoreline and shore side connection structure end. Reaches are bounded by magenta lines and are defined by green letter between magenta lines.

Table 20. Channel dredge length for reaches shown in Figure 66

Channel Reach	Near Shore Length [ft]	Channel Length [ft]
CA	2,884	21,110
CB	1,764	15,630
CC	3,295	2,862
CD	1,095	4,840
CE	1,630	6,609

11.0 SITE SELECTION CONSIDERATIONS

This analysis looked at the coast with regards to dredging a channel for access to an offloading facility. The length of the dredged channel and shore side facility connection was evaluated along with the rate of coastal erosion. This was not intended to be an in depth analysis for site selection; rather this analysis is intended to provide a tool to narrow the selection of possible coast locations.

Once the coast location has been determined, a more in depth look at the site, similar to the original navigation improvement study, needs to be performed. This would involve evaluation of:

- Sediment transport with regards to keeping the channel open.
- Maintenance dredging requirements (frequency and volume)
- Wind at the site
- Waves at the site
- Water currents
- Ice conditions at the site
- Constructability (dredge material)

Additional considerations for siting the project include:

- Road access to the site from Kotzebue
- Road maintenance requirements
- Real estate for the road corridor
- Real estate for the shoreside facilities (storage pad, fuel tanks, etc.)
- Topography
- Permafrost
- Cultural resources
- Biological resources

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