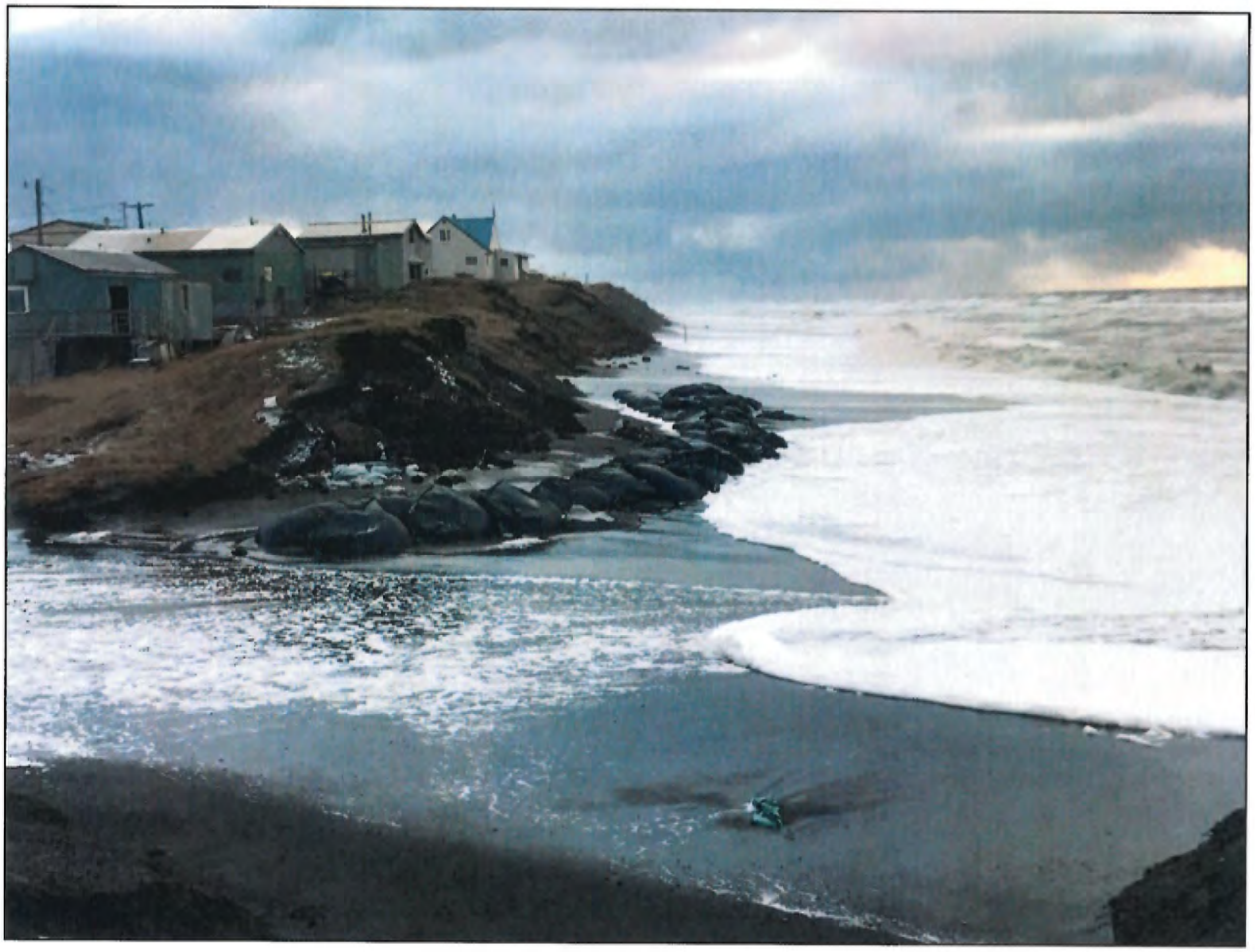
US Army Corps of Engineers
Alaska District

Feasibility Report

Barrow Alaska Coastal Erosion
Barrow, Alaska



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Prepared by
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EXECUTIVE SUMMARY

Barrow is the political and economic hub of the North Slope Borough (NSB), providing important services to the communities in Northern Alaska. This report examines the need for a coastal storm risk management project at Barrow, Alaska addressing coastal erosion and flooding to determine the feasibility of Federal participation in a potential project. This study utilizes Alaska Coastal Erosion Federal funds, which determined the study title.

Barrow experiences frequent and severe coastal storms, resulting in flooding and erosion that threaten public health and safety, the economy of the community, over $1 billion of critical infrastructure, access to subsistence areas, and cultural and historical resources. Reducing the risk of this threat to life-sustaining infrastructure is crucial to the preservation of the community. Barrow is in an arctic environment with approximately 300 days a year below freezing. The NSB currently engages in construction of temporary beach berms by bulldozing up beach material into a berm supplemented with borrow materials from upland areas. These ongoing activities and associated costs could be replaced by a permanent project.

This coastal storm risk management study evaluated a number of alternatives based on economic, engineering, environmental, and other factors. The Recommended Plan, Alternative H, would reduce the risk of storm damages to approximately 5 miles of coastline by using a combination of rock revetment at the bluff area, berm, and raising and revetting Stevenson Street. The coastline would be altered to some degree with the Recommended Plan. Sacrificial berms would no longer be necessary to reduce flooding and erosion risk to infrastructure and the community. There would be boat ramps and access points along the revetments to allow for boating and beach access for subsistence, recreational, and social activities. In addition, drainage points are being considered for Middle Salt Lagoon and Tasigarook Lagoon, which have existing outfalls. The U.S. Army Corps of Engineers (USACE) is working with the NSB, which is the non-Federal sponsor, and the community to collect feedback on optimal locations for these access points, boat ramps, and interior drainage points. The design would be finalized in subsequent phases of the project. The NFS supports the Recommended Plan.

This study is being conducted under Section 116 Authority, which affords this study the ability to select a plan based on other social effects (OSE), with selection supported by a Cost Effective/Incremental Cost Analysis (CE/ICA). This analysis resulted in community resilience units (CRUs) that were derived from community feedback, existing data, and existing knowledge. The output from this analysis determined that the Recommended Plan has the highest annual CRUs and is a best buy plan.

The NSB would be required to pay the non-Federal share of 35 percent of the costs assigned to the coastal storm risk management features of the study, as specified by the Section 116 Authority, as amended and as determined in accordance with 33 U.S.C. 2213(m). Based on October 2019 (FY20) price levels, the total project first cost is

$328.6M. The Recommended Plan would be cost shared 65 percent Federal ($213.6M) and 35 percent non-Federal ($110.5M). The NSB cost includes LERRs (Lands, Easements, Real Estate, and Rights-Of-Way) ($4.5M).

The benefit-cost analysis and calculation of the project benefit-cost ratio is based upon economic costs. The certified Total Project Cost Summary includes an Estimated Cost of $320.6M (FY20) which is consistent with the economic benefits evaluation. Adding the cost of operation and maintenance and interest during construction results in a total economic (NED) cost of $384M and an average annual NED cost of $14.2M (50 years, 2.750 percent). Comparing these costs to annual NED benefits of $8.3M results in Net Annual Benefits of negative $5.9M and a benefit-cost ratio of 0.58.

PERTINENT DATA

Recommended Plan: Alternative H

Alternative H: Barrow, Lagoon, Bluff, Browerville, South and Middle Salt and NARL											
Armored Revetment Coverage Area	Armor [cy]	B Rock [cy]	Core [cy]	Gravel [cy]	Filter Fabric [sy]	Excavation [cy]	Local Material [cy]	Maintenance Interval / Length	Maintenance Armor [cy]	Maintenance B Rock [cy]	Maintenance Core [cy]
Bluffs: Revetment	38,339	30,126	10,089	10,742	30,463	82,878	5,718	5 yrs / 2000 ft	21,323	16,755	5,611
Tasigarook Lagoon: Revetted Berm	32,694	30,887	7,404	7,895	23,469	71,530	NA	5 yrs / 2000 ft	22,548	21,302	5,106
Low Lying Areas: Raised Stevenson Street	140,262	126,971	43,963	47,396	135,634	398,864	120,943	5 yrs / 2000 ft	15,041	13,616	4,715

Community Resilience Units (CRUs) by	
Alternative	CRUs
No Action	0.00
A	10.50
B	16.63
C	22.75
D	36.49
E	42.62
F	48.74
G	48.75
H	54.87

Recommended Plan, Alternative H: Barrow, Lagoon, Bluff, Browerville, South and Middle Salt and Naval Arctic Research Laboratory (NARL)	
Item	Total ($1000)
Project Financial Costs (FY20)	
Certified Project First Cost	$328,630
Economic Costs (FY20)	
Annual Operations and Maintenance	$1,729
Total NED Cost (50 years, 2.750 percent)	$384,278
Total NED Benefits (50 years, 2.750 percent)	$223,024
Average Annual Cost	$14,234
Average Annual Benefits	$8,261
Average Net Annual Benefits	($5,973)
Benefit to Cost Ratio	0.58

LIST OF ACRONYMS AND ABBREVIATIONS

ADCP	Acoustic Doppler Current Profiler
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADM	Agency Decision Milestone
AHRS	Alaska Heritage Resources Survey
AMM	Alternatives Milestone Meeting
ANCSA	Alaska Native Claims Settlement Act
APE	Area of Potential Effect
BCR	Benefit to Cost Ratio
BUECI	Barrow Utilities and Electric Cooperative, Inc.
CE/ICA	Cost Effective/Incremental Cost Analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COL	Colonel
CRA	Cultural Resource Acres OR Areas at Risk
CRU	Community Resilience Unit
CY	Cubic Yards
CYF	Cubic Yards Contaminated Fill
DDD	Direct Dollar Damage
EA	Environmental Assessment
EAD	Expected OR Estimated Annual Damage
EF	Eligibility Factor
EQ	Environmental Quality
ER	Engineer Regulation
FCSA	Feasibility Cost Sharing Agreement
FONSI	Finding of No Significant Impact
FR/EA	Feasibility Report and Environmental Assessment
ft	Feet/Foot
FTE	Full Time Equivalent Jobs Impact
FWOP	Future without-Project
FWP	Future with-Project
H&H	Hydraulics and Hydrology
IDC	Interest During Construction
IWR	Institute for Water Resources
LERR	Lands, Easements, Real Estate, and Rights-Of-Way
LiDAR	Light Detection and Ranging
M	Million
MLLW	Mean Lower Low Water
MSC	Major Subordinate Command
N/A	Not Applicable

NARL	Navy Arctic Research Lab
NED	National Economic Development
NEPA	National Environmental Policy Act
NFS	Non-Federal Sponsor
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSB	North Slope Borough
NWS	National Weather Service
O&M	Operations and Maintenance
OSE	Other Social Effects
PDH	Person-Days High Risk Job Activity
PDU	Person-Days without Critical Utilities
PED	Preconstruction Engineering and Design
PPA	Project Partnership Agreement
R	Republican
RED	Regional Economic Development
SHPO	State Historic Preservation Officer
TEK	Traditional Ecological Knowledge
TSP	Tentatively Selected Plan
U.S.	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service

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1. INTRODUCTION

1.1 Project & Study Authority

This General Investigations study was conducted under authority granted by Section 116 of the Energy and Water Development and Related Agencies Appropriations Act of 2010 (P.L. 111-85), as amended (see Appendix A):

The Secretary of the Army is authorized to carry out structural and non-structural projects for storm damage prevention and reduction, coastal erosion, and ice and glacial damage in Alaska, including relocation of affected communities and construction of replacement facilities: Provided, That the non-Federal share of any project carried out pursuant to this section shall be no more than 35 percent of the total cost of the project and shall be subject to the ability of the non-Federal interest to pay, as determined in accordance with 33 U.S.C. 2213(m).

The implementation guidance for studies and projects under the Section 116 Authority notes that:

> *Each decision document will present the National Economic Development (NED) analysis for all viable alternative and identify the NED Plan when alternatives exist with net positive NED benefits. If there is no NED Plan and/or the selection of a plan other than the NED Plan is based in part or whole on non-monetary units (Environmental Quality and/or Other Social Effects), then the selection will be supported by a cost effectiveness/incremental cost analysis consistent with established evaluation procedures (Memorandum for Commander, Pacific Ocean Division, 10 May 2012).*

The guidance also notes that,

"The feasibility study will conform with the process for projects authorized without a report as discussed in ER 1105-2-100 (Appendix H) including the preparation of a Director's Report."

Upon signature of the Director's Report, the study is authorized to immediately move into Preconstruction, Engineering and Design (PED), and construction.

1.2 Scope of Study

Engineer Regulation (ER) 1105-2-100, "Planning Guidance Notebook" defines the contents of feasibility reports for coastal storm risk management. This Feasibility Report documents the studies and coordination conducted to determine whether the Federal Government should participate in coastal storm risk management at Barrow. Studies of potential coastal storm risk management consider a wide range of alternatives and the environmental consequences of those alternatives, but focused mainly on actions that would reduce erosion and flooding. Reducing the risk of erosion and flooding caused by storm events at Barrow is important for not only the community itself, but for surrounding communities because Barrow is a regional hub for all of the North Slope of Alaska. Coastal storm risk management is a high priority mission for the United States (U.S.) Army Corps of Engineers (USACE), and reducing the risk of erosion and flooding during storm events for the community of Barrow would generate sufficient benefits to allow the USACE to recommend a project under Section 116 of the Energy and Water Development and Related Agencies Appropriations Act of 2010 (P.L. 111-85), as amended.

1.3 Project Location

The community of Barrow, currently recognized as the City of Utqiaġvik, is located on the Chukchi Sea (Figure 1), approximately 750 miles north of Anchorage, Alaska. The State of Alaska officially renamed the community of Barrow to Utqiaġvik on 1 December 2016. However, for the purpose of this study, the former name of Barrow will generally be used as a practical matter to keep the name consistent with the previous study and the current Feasibility Cost Sharing Agreement (FCSA). Barrow is the northernmost community in the U.S. and the administrative, economic, social, and cultural center for the NSB. Barrow's municipal limits include several "neighborhood" areas, namely Barrow and Browerville, as well as the Naval Arctic Research Laboratory (NARL), which are located in the study area.

Figure 1. North Slope Borough, Project Vicinity Map. (Appendix I)

The study area (Figure 2) for this project, as defined during the charette on 12 September 2017, is approximately 5 miles of coastline heading North from the bluff area in front of the Wiley-Post Will Rogers Airport runway to Dewline Road, just past NARL. Local features are depicted in Figure 3.

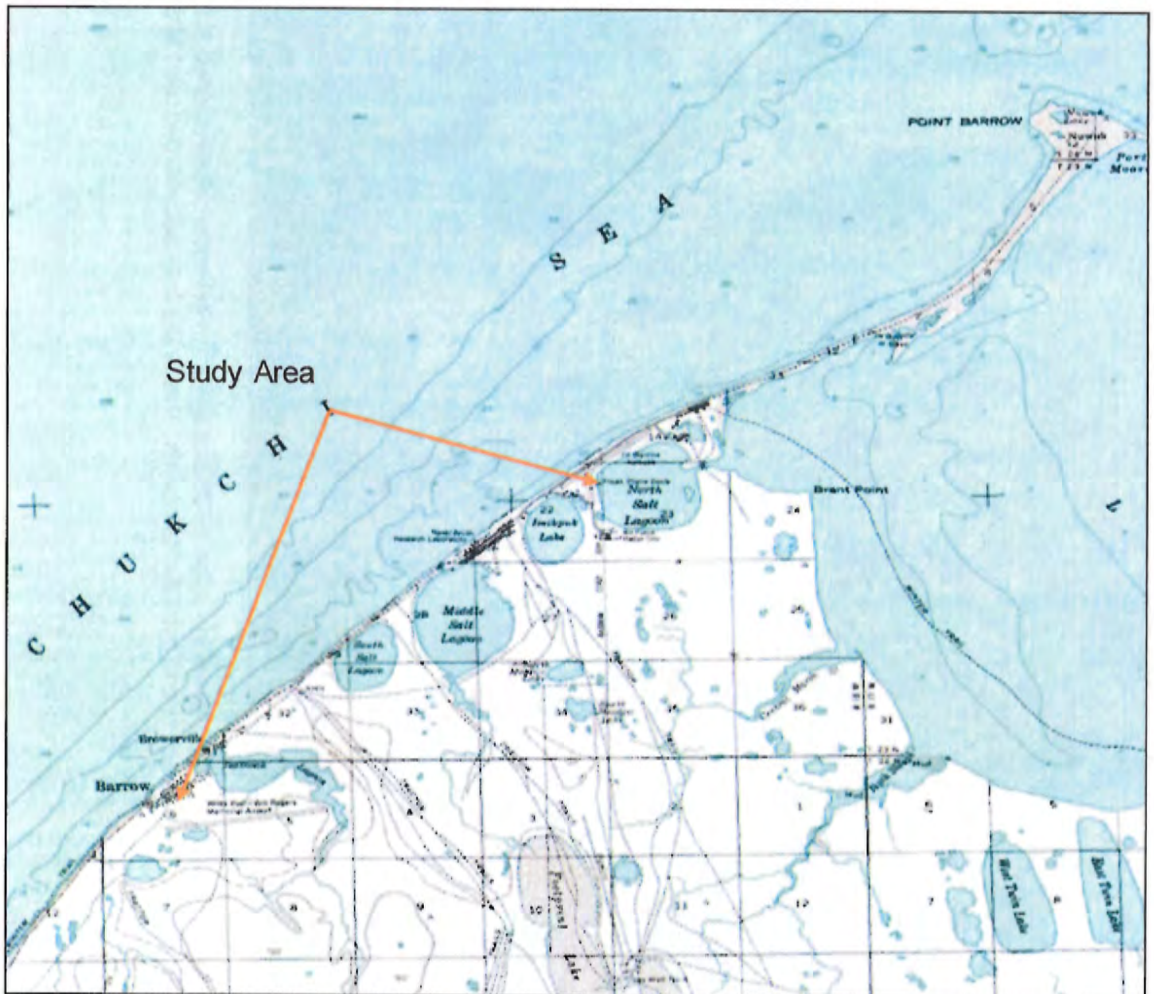

Figure 2. Study Area (Approximate, not Drawn to Scale).

Figure 3. Local Features (Approximate Location, not Drawn to Scale).
Pictures from left to right: Utqiaġvik Historical Site, September 2017 storm erosion, inside of Utilidor system, Stevenson Street closed at NARL
*Note: The red line is where Stevenson Street meets the coast and tracks north past the fish camp. This is the only access road past Middle Salt Lagoon.

1.4 Congressional District

The study area is in the Alaska Congressional District, which has the following Congressional delegation:

Senator Lisa Murkowski (R);
Senator Dan Sullivan (R);
Representative Don Young (R).

1.5 Study Participants/Coordination

The USACE Alaska District was primarily responsible for conducting studies for coastal storm risk management at Barrow. The studies that provide the basis for this report were conducted with the assistance of many individuals and agencies, including the North Slope Borough (NSB), the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), the U.S. Coast Guard (USCG), the State Department of Fish and Game (ADFG), the State of Alaska Department of Environmental Conservation (ADEC), Engineer Research and Development Center- Coastal and Hydraulics Laboratory (ERDC-CHL), and many interested members of the public who contributed information and constructive criticism to improve the quality of this report.

1.6 Non-Federal Sponsor

The NSB is the non-Federal sponsor (NFS) and has stated their intention to cost-share in Federally-constructed coastal storm risk management measures. This partnership of Federal and non-Federal interests in coastal storm risk management helps ensure that a constructed project would effectively serve both local and national needs. The Feasibility Cost Share Agreement (FCSA) for this study was signed on 12 July 2017. This agreement creates a Federal and non-Federal partnership with the objective to effectively serve both local and national interests. The feasibility phase is conducted at a 50/50 cost share.

1.7 Related Reports and Studies

There are no current USACE Civil Works projects in the Barrow area. However, the USACE has conducted a number of studies considering water resources needs of northern Alaska, including Barrow. A major state-wide watershed-by-watershed study was conducted from 1947 to 1962 and produced 10 interim reports, including one for northern and western Alaska. Other USACE studies covering Barrow include studies of beach erosion in 1969, 1991 (under authority of Section 103 of the 1962 River and Harbor Act), and in 1999 (under Section 14 of the 1946 Flood Control Act) as well as studies of small boat harbors in 1979 and 1993 (under Section 107 of the 1960 River and Harbor Act) (Appendix I). In June 2001, the USACE conducted a Section 905 (b) (Water Resources Development Act 86) Analysis entitled "Barrow, Alaska, Storm Damage Reduction, Flood Reduction, and Navigation Channel" (USACE 2001). The analysis recommended a further study to determine the feasibility of providing storm damage reduction, flood reduction, and navigation improvements.

A feasibility study with the NSB was initiated in 2003 and completed in 2010. The final deliverable was a Technical Report entitled "Barrow, Alaska Coastal Storm Damage Reduction Technical Report," dated July 2010 (Appendix I). Information from the Technical Report is relied upon heavily in this document and the Environmental Assessment; it is incorporated herein by reference. This report considered five basic alternatives with variations based on scale: rock revetments, beach nourishment, joining the National Flood Insurance Program, elevating/relocating buildings, and lagoon filling. At that time, analyses indicated that there was no economically justified Federal interest and the project was terminated.

The NSB and others have prepared a number of reports over the last couple of decades that directly or indirectly address the storm damage problems Barrow faces. In recent years, a number of Barrow stakeholders have been actively involved in planning, designing, and/or constructing new facilities. One characteristic common to the facilities being replaced or upgraded is their close proximity to the shoreline and their potential to suffer significant damages during future extreme storm events. Local entities have taken the erosion and flooding threat seriously and have generally employed the non-structural choice of retreat and relocation farther from danger for their vulnerable facilities.

Facilities relocated during reconstruction (prior to 2010) include the wastewater treatment plant, the hospital replacement, the Barrow Global Climate Change Research Facility, the new Barrow Arctic Science Consortium access road, and the dam renovation. These relocations were intended to minimize impacts from future erosion and flood damages. Even though these projects reduced possible NED benefits for a new USACE project, the local community chose to move what they could out of harm's way before damages could occur. Portions of existing commercial, residential, and public land and structures still remain susceptible to erosion and flooding from extreme storm events. The current study provides an opportunity to address the storm damage problems that threaten the long-term economic, social, and environmental well-being of Barrow and the NSB.

2. PLANNING CRITERIA, PURPOSE AND NEED FOR PROPOSED ACTION

2.1 Purpose & Need

The NSB has been facing storm damage and erosion problems for decades. Traditionally, foundation materials for local infrastructure would be obtained from the beach or a gravel pit area, updrift (southwest) a mile from Barrow. The reduction of natural beach nourishment material, coupled with frequent storms and decreased ice cover, has left the coastline vulnerable to flooding and erosion. The NSB currently engages in construction of temporary and sacrificial beach berms, by bulldozing up beach sand into a berm supplemented with borrow materials from upland areas. These ongoing activities and associated costs could be replaced by a permanent project.

The problem statement is:
Barrow experiences frequent and severe coastal storms, resulting in flooding and

erosion that threaten public health and safety, the economy of the community, over $1 billion of critical infrastructure, access to subsistence areas, and cultural and historical resources.

2.2 Objectives

2.2.1 National Objectives

The Federal objective of water and land resources planning is to contribute to NED in a manner consistent with protecting the nation's environment. NED benefits increase the net value of goods and services provided to the economy of the nation as a whole. In general, only benefits contributing to NED may be claimed for Federal economic justification of a project. However, Section 116 Implementation Guidance allows for selection of a plan based in part or whole on non-monetary units supported by a Cost Effectiveness/Incremental Cost Analysis (CE/ICA) if no NED plan is identified. Section 1.1 provides the implementation guidance for studies and projects under the Section 116 Authority.

2.2.2 Study Objectives

The planning goal is to formulate an effective and achievable measure or set of measures that will result in selecting an alternative plan that will meet the following study objectives:

- Reduce risk to life, health, and safety for the Barrow community over the 50-year period of analysis
- Reduce risk of damages in Barrow caused by flooding and shoreline erosion to residential and commercial structures and critical public infrastructure located within the 5 mile study area over the 50-year period of analysis
- Reduce or mitigate damage to tangible cultural heritage along the Barrow shoreline, specifically to reduce any further losses to the culturally significant Utqiaġvik Village Site over the 50-year period of analysis

2.3 Opportunities

Opportunities are statements about what will be realized or what will have the potential to be realized by meeting the main study objectives. The study opportunities that could be realized are:

- Maintain social and cultural values
- Maintain food security (subsistence resources)
- Ensure health and safety of smaller communities that rely on Barrow
- Preserve existing views of the Chukchi Sea
- Long-term economic growth and stability in Barrow
- Increase tourism and revenue
- Maintain access to Distant Early Warning Line and environmental research facilities
- Reduce risk to critical and future infrastructure

- Improve real estate situation
- National Flood Insurance Program eligibility
- Improve navigation access to community
- Reduce risk to recreational sites
- Reduce economic threat to NSB budget that impacts other communities
- Increased investment in infrastructure

2.4 Study Constraints

Constraints are statements about what should be avoided or what cannot be changed while meeting the study objectives. The study constraints are:

- Minimize adverse impacts to threatened and endangered species
- Minimize adverse impacts to cultural resources
- Maintain access for subsistence activities
- Minimize impacts to permafrost

2.5 National Evaluation Criteria

Alternative plans should be formulated to address the study objectives and adhere to study criteria. Federal Principles and Guidelines establish four criteria for evaluation of water resources projects. These criteria and their definitions are explained in Sections 2.5.1 through 2.5.4. In addition to those four, other screening criteria were used to evaluate alternative measures to include constructability, avoidance of constraints, completeness, first costs, and maintenance costs.

2.5.1 Acceptability

Acceptability is defined as "the viability and appropriateness of an alternative from the perspective of the Nation's general public and consistency with existing Federal laws, authorities, and public policies. It does not include local or regional preferences for particular solutions or political expediency."

2.5.2 Completeness

Completeness is defined as "the extent to which an alternative provides and accounts for all features, investments, and/or other actions necessary to realize the planned effects, including any necessary actions by others. It does not necessarily mean that alternative actions need to be large in scope or scale."

2.5.3 Effectiveness

Effectiveness is defined as "the extent to which an alternative alleviates the specified problems and achieves the specified opportunities."

2.5.4 Efficiency

Efficiency is defined as "the extent to which an alternative alleviates the specified problems and realizes the specified opportunities at the least cost."

2.6 Study Specific Evaluation Criteria

In addition to the previously stated criteria used for all potential USACE water resources development projects, some study specific criteria to be considered are avoiding or minimizing impacts to tangible cultural heritage, reducing impact to subsistence activities, and ensuring beach and road access is maintained within the community. An additional criteria is ensuring that alternatives are resilient in an environment that has permafrost, ivu events and varying wave action and inundation. Ivu is an Inupiat word for mounds of ice that pile up on land. Additional information on ivu events can be found in Section 3.2.1.1.

3. EXISTING CONDITIONS

Existing conditions within the study area are described in this section. Some existing resources are likely to be impacted, although most of the physical environment will not be impacted, including affects to the sea ice, climate change, and hydrology. Those resources that will be impacted are summarized in the subsections that follow, as background information to help inform the decision. The full inventory and analysis is included in the Environmental Assessment (EA) in Appendix B.

3.1 Historical Information

3.1.1 Storm Events

Historical data from storm surges and flooding events in Barrow are limited. According to traditional ecological knowledge (TEK), the biggest storm on record occurred in 1963. There is limited data regarding economic and physical damages from this storm. More recently, there have been three large storm events (2010, 2015, and 2017), and two of these storms were declared as states of emergency. Other notable storms are:

- September 1954: Water levels reached between +9 and +10 feet (ft) mean lower low water (MLLW), washing water over the beach and washing the community's helium tank nearly to Point Barrow.
- October 1954: Minor damage occurred with a maximum water level of +9.5 ft MLLW.
- October 1963: There is limited data available about this event, but local knowledge suggests storm water levels reached up to +14 ft MLLW. Flooding was more extensive in NARL than Barrow, with NARL being isolated for several days. A total of 32 homes were affected, 17 damaged and 15 destroyed, along with 3 small airplanes (NSB 2015).
- September 1968: A maximum water level of +5 ft MLLW eroded an average of 14 ft of bluff and caused $50,000 in damages (not adjusted for inflation). The road between Barrow and the city dump was severely eroded, and a bridge was damaged.
- September 1970: Minor damage occurred with an unknown water level.
- December 1977: Barrow's gas well runway partially flooded when 6 to 18 inches of water rose through a crack in the ice. Rising water also lifted the pack ice at

Barrow, and persistent winds drove it as much as 30 yards inland. A maximum water level of +3.5 ft MLLW was reached.

- September 1978: A maximum water level of +5 ft MLLW occurred causing between $5,000 and $50,000 (not adjusted for inflation) in damages to the road between NARL and Barrow.
- September 1986: There is limited data available about this event, but there were apparently two different storms during this month. The Leavitt House had to be moved and large sections of land were lost to erosion, along with archaeological remains.
- August 2000: This was the second most devastating storm in Barrow's recorded history, with heightened effects from the lack of sea ice. The NSB Disaster Coordinator reported $7.7M in damages (not adjusted for inflation). Most of this damage occurred to a beach nourishment dredge that was ripped from its anchors and washed ashore. The barge was grounded on the shoreline, damaging the bottom of the vessel beyond salvageable repair. The dredging operation was suspended after the storm due to the damages sustained and the operation's inability to produce gravel of sufficient quality for use on the beach. Additionally, 36 private homes and 4 NSB housing units sustained roof and siding damages. About 6 miles of road between the gravel pits and Birnick were damaged as well.
- October 2002: This storm caused more widespread flooding than the storm in August 2000 due to the dynamics of the sustained winds and heavy surf. Waves reached a peak of about +14 ft MLLW. Heavy equipment had to be used to build up the existing sea walls and reduce risk to the freshwater lagoon. Some roads were damaged and a power outage occurred.
- July 2003: There were two storm events during this month, both with minor damages. Some road damage occurred, but was limited as sand and gravel berms were reinforced to reduce flooding and erosion.
- November 2010: High storm surge flooded portions of the town.
- August 2015: A maximum water level of +5 ft MLLW was reached and caused $7M in damages (according to local knowledge). This storm was declared as a state of emergency and the Federal Emergency Management Agency (FEMA) helped with post emergency efforts.
- September 2017: Water level reached about +8 ft MLLW and caused $10M in damages (ADN 2017). This storm eroded approximately 3 miles of beach, washed away approximately 60 ft of guardrail, and destroyed approximately 6,000 ft of street surfaces. This storm was declared as a state of emergency and FEMA helped with post emergency efforts. Flooding persisted into October 2017.
- September 2018: Wind driven waves along the coastline resulted in the failure of HESCO Baskets along the bluffs in front of the Barrow Neighborhood and water overtopped the sacrificial berms resulting in flooding in residential areas.

3.1.2 Landfill Background

Since 1948, the U.S. Navy continuously maintained the Naval Arctic Research Laboratory (NARL) within Naval Petroleum Reserve No. 4. The associated landfill, known today as the "South Salt Lagoon Landfill" or "Old Navy Landfill," was used by both the Navy in support of NARL and the U.S. Air Force in support of the Distant Early Warning Line. The Navy filed a Notice of Intent to Relinquish NARL in 1981; the property was transferred to the Ukpeagvik Inupiat Corporation (UIC) in 1983. UIC conveyed the landfill to the NSB in 1986.

Because the landfill was not constructed nor operated as a State-approved sanitary landfill, the U.S. Environmental Protection Agency and the Alaska Department of Environmental Conservation (ADEC) required that the landfill be closed. As a result of the Navy and Air Force still using the landfill, the Navy received $2.5M from DoD as provided in the Fiscal Year 1999 appropriations bill to help in the cleanup work of the landfill to obtain its closure. The landfill was closed on 31 December 2006. ADEC acknowledged the landfill (which they call the "Barrow North Salt Lagoon Landfill") closure on 1 July 2007. The institutional controls (freezeback design with thermistor monitoring) in place at the landfill are maintained by the NSB Public Works Department.

3.2 Physical Setting

Barrow is located approximately 329 miles north of the Arctic Circle. The Chukchi Sea borders the City of Barrow to the northwest, and Point Barrow, the northernmost point in Alaska, is approximately 9.9 miles to the northeast. Ocean surface temperatures along the Chukchi Sea coast near Barrow have increased by about 2 percent over the period from 1982 to 2002, with a slight cooling near shore in January and February (Appendix I). High latitude coasts are susceptible to increases in global temperature through extended periods of ice thaw and reduced summer sea-ice extent, thereby creating greater wave exposure over a longer period of time. A warming climate affects the spring runoff and permafrost melting resulting in calving of large areas of bluff and further adding to the erosion problem.

3.2.1 Temperature and Precipitation

Barrow is in an arctic environment with continuous permafrost. Total average annual precipitation (rain and melted snow water) is light, averaging 4.5 inches. The average annual snowfall is 34 inches. Temperature extremes range from -55 to 79° Fahrenheit (F), with average summer temperatures ranging around 38°F. The daily minimum temperature is below freezing 300 days of the year. Prevailing winds are easterly and average 12 miles per hour. The Chukchi Sea is typically ice-free from mid-June through October, but shorefast ice has been decreasing over the last few years.

3.2.2 Air Quality

The North Slope Borough is listed as "attainment/unclassified" for National Ambient Air Quality Standards under the Clean Air Act. 83 FR 25776. Barrow has experienced limited industrial development, low population density, and strong meteorological influences allowing the community to maintain good to excellent air quality. No non-attainment areas exist in the region. Air pollution sources in the vicinity include automobiles, aircraft, fishing vessels, heavy machinery, incinerating solid wastes, electrical power generating facilities, and dusty or unpaved roads. Despite the presence of air pollution point sources, air quality is generally considered to be good because of the predominant winds that occur in the area year-round.

3.2.3 Tides

Barrow is in an area of semi-diurnal tides with two high waters and two low waters each lunar day. Tidal parameters at Barrow are similar to those predicted for Barrow Offshore (approximately 2.3 miles offshore of NARL). The tidal parameters in Table 1 were determined using the National Oceanic and Atmospheric Administration (NOAA) Tidal Benchmarks at Barrow Offshore (Station ID 9494935). The tidal datum was determined over a 1 year period from September 2008 to August 2009 based off of the 1983-2001 tidal epoch. The tidal determination was performed post storm surge modeling. Therefore, only an estimated mean higher high water (MHHW) of +0.5 ft MLLW was used in the analysis. The estimated tide was established based on engineering judgment and modeler's prior experience with ocean circulation modeling in the Arctic.

Table 1. Tidal Datum Elevations Relative to Mean Lower Low Water – Barrow Offshore.

Parameter	Elevation [ft]
Highest Observed Water Level	2.92
Mean Higher High Water (MHHW)	0.66
Mean Sea Level (MSL)	0.31
Mean Tide Level (MTL)	0.30
Mean Lower Low Water (MLLW)	0.00
Lowest Observed Water Level	-2.57

3.2.4 Wave Climate

The winds and site-specific oceanographic or geographical constraints determine the long-term wave climate along a coastal reach. In Barrow, the complexities increase because of its location and the ever-changing offshore ice coverage opening up the area for wind-wave development, or preventing it as the ice builds in the fall. Because of its location, Barrow remains relatively protected from growing wave conditions in the Beaufort Sea to the east, and swells south of Cape Lisburne in the Chukchi Sea. Barrow is unique and its wave climate is dictated by storms in the Arctic Ocean, limited in extent by the pack ice.

The nearshore wave climate is depth-limited controlled by the interaction of deep water waves with the seabed as they approach the shoreline. The wave energy transmitted to the coast is dependent upon the depth of water over the seabed. The total water level that limits the wave height includes storm surge, wave set-up, wave run-up, tide, and over time, relative sea level change (Appendix D, Section 10.4.1). There are no long-term tide gauge or offshore wave buoys for Barrow. The information used to develop the depth-limited wave conditions for this study include the following: Wave Information Study, deepwater wind and wave hindcast (Appendix D, Section 4.3) which was used as the offshore forcing for nearshore wave transformation (STWAVE) (Appendix D, Section 4.4), an ocean circulation model (ADCIRC) compared with 4 months of Acoustic Doppler Current Profiler (ADCP) data (Appendix D, Section 4.5), and wave run-up modeling performed with SBEACH (Appendix D, Section 9). The run-up on the beach was used to determine the total water level at the toe of alternative structures to determine the depth-limited wave height for the structures (Appendix D, Section 10.4).

3.2.5 Wind

The Alaska Climate Research Center at the Geophysical Institute, University of Alaska Fairbanks compiled wind data from 1971 to 2000 for Barrow. Barrow experiences an average wind speed of 10 mph Figure 4. The predominant wind direction is out of the east and north east with the majority of the wind coming out of the east northeast (Table 2). Barrow is typically ice free from August through October.

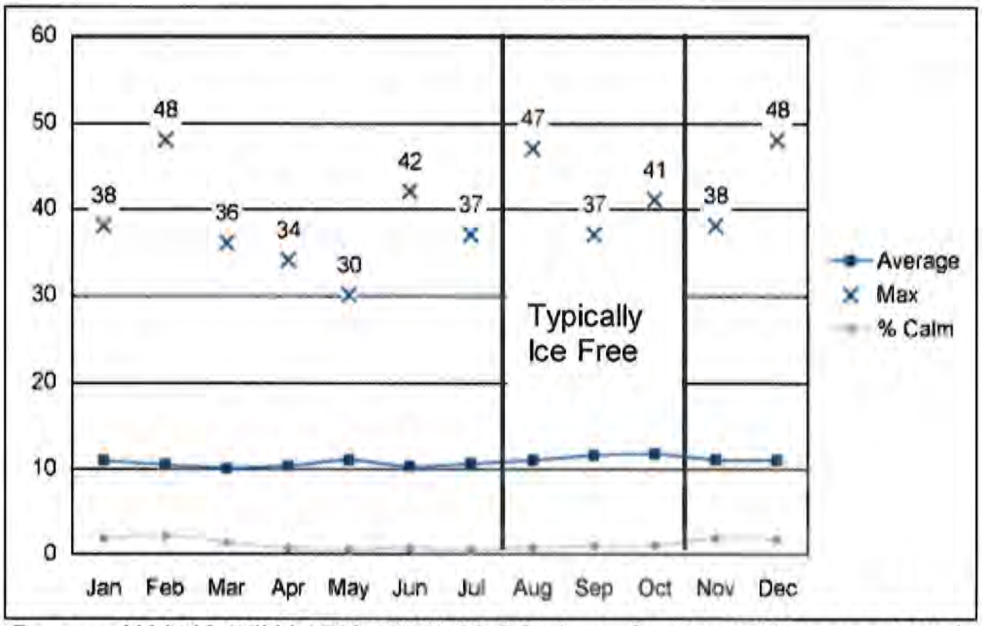

Figure 4. Barrow, AK (71° 17'N / 156° 46' W, 30.5 ft above Sea Level) Mean and Maximum Monthly Wind Speed (mph) and Percent Calm Observation.

Table 2. Monthly and Annual Wind Frequency Distribution (%) by Direction (1971 – 2000).

								Typically Ice Free					
Direction	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
N	2.8	4.1	3.9	3.4	2.4	4.8	4.9	4.6	3.8	4.0	3.0	2.6	3.7
NNE	2.9	3.0	5.4	4.1	2.6	4.7	4.4	3.7	3.0	3.2	2.7	2.8	3.5
NE	12.6	10.9	12.9	14.6	9.5	8.9	7.7	6.3	9.5	9.5	12.4	13.3	10.6
ENE	22.2	18.1	19.4	22.0	23.0	15.8	14.7	10.5	17.0	17.6	23.0	27.1	19.2
E	10.7	11.1	10.9	13.7	19.7	18.5	18.5	14.7	13.3	12.8	15.5	13.6	14.4
ESE	5.5	7.3	5.4	7.3	11.7	9.0	7.7	7.9	7.6	9.0	8.3	6.6	7.8
SE	3.7	4.1	3.2	3.4	4.8	3.7	2.9	3.7	4.8	6.8	5.2	3.5	4.2
SSE	3.0	2.6	2.5	2.8	3.0	2.9	2.2	2.9	4.1	5.6	4.4	2.4	3.2
S	3.4	3.5	2.7	3.2	2.8	2.1	2.1	3.0	4.3	6.3	4.7	2.9	3.4
SSW	4.7	4.7	4.0	3.2	2.5	1.5	2.1	3.4	3.9	4.7	4.4	3.5	3.5
SW	4.2	4.9	4.3	4.2	3.5	3.8	5.0	5.3	4.2	2.3	1.9	3.2	3.9
WSW	4.8	5.8	6.1	4.1	4.1	5.4	8.4	9.1	5.2	2.2	2.1	3.8	5.1
W	5.5	6.4	5.7	3.4	3.2	5.1	6.7	8.2	5.5	2.5	2.1	4.7	4.9
WNW	5.7	5.4	5.3	3.5	2.3	4.8	4.9	6.3	5.0	3.8	3.6	4.3	4.6
NW	5.0	4.5	4.1	3.5	2.4	4.2	3.8	5.9	4.7	5.2	3.3	3.2	4.2
NNW	3.5	3.8	4.3	3.4	2.4	4.7	3.9	4.5	4.0	4.7	3.6	2.6	3.8

3.2.1 Ice Conditions

Freeze up typically occurs in November, but the formation of stable shorefast ice may be delayed. In 2018, shorefast ice was not observed until January (ASIP 2018). Stability is achieved after one or more significant pack ice "shoves" deform causing the ice to ground.

Grounding can take place as late as January, or not at all. Thin ungrounded, maturing ice in the nearshore area is vulnerable. A strong offshore wind can tear away young ice all the way to the beach, leaving open water even when winter temperatures are low. In "cold years," the ice tends to stabilize by November, but recently ice has been (more) unstable, with episodes of shorefast ice breaking off at the beach as late as January or February. Once grounded and stabilized, the shorefast ice cover remains in place until the start of breakup in July. General ice features are illustrated in Figure 5.

Figure 5. Illustration of Nearshore Ice Processes.

3.2.1.1 Ivu Events

Point Barrow extends northward and is a major barrier to ice movement. As a result, the beaches near Barrow are subjected to the pushing action of ice more than most regions. Ivu events occur when the shorefast ice is pushed onto the beach and the leading edge digs into the beach and buckle up into piles of ice blocks as high as 30 ft. When this ice melts, it leaves a depression where it pushed into the beach, but any depression will be obliterated eventually by wave action. When the ice buckles, it may also push gravel ahead of it in a mound several feet in height. The North Slope Borough Hazard Mitigation Plan (HMP) describes the risk of an ivu event as rare and a credible probability with limited magnitude/severity (NSB, 2015). There are three recorded events with limited extent in the City of Barrow in the Borough's HMP.

Design for an infrequent ivu event was considered in the 2010 Technical Report (Appendix I). Upon consultation with the community and the Vertical Team, damaged associated with an ivu event was determined to be an acceptable risk that could be managed during routine community maintenance to the proposed structure. Damage from an ivu event was accounted for in the operations and maintenance cost (Section 7.6).

3.2.2 Sediments

3.2.2.1 Cross Shore Sediment Transport

Beach profile and shoreline data were obtained and a set of profile ranges were established, as shown in Figure 6. Profiles on most of these lines were obtained in 1987 and 2003. These profiles were the main ones used to analyze long-term shoreline change and as SBEACH input. Cross shore sediment transport mechanisms were evaluated using the SBEACH program and examining changes in cross shore profiles. Sediment samples were collected for input into the SBEACH model. The D_{50} sediment grain size analyzed for eleven beach samples ranged from 0.3 to 20 millimeters (mm) with an average D_{50} of 3 mm. Model runs with SBEACH indicate that the beach sediments at Barrow generally do not move in the cross shore direction. The threshold sediment size for movement to occur is 0.8 mm, which results in minor changes below the water level only.

Pair wise comparisons of the 1987 and 2003 profiles agree with SBEACH and show the profiles to be remarkably similar in shape and position. The average profile horizontal change of the zero elevation (shoreline) over this 15-year interval is 13.5 ft of accretion, with individual profiles ranging between -62 and +87 ft. Profile 22 is shown as an example in Figure 7, and a blowup of the active portion of this range line is shown in Figure 8.

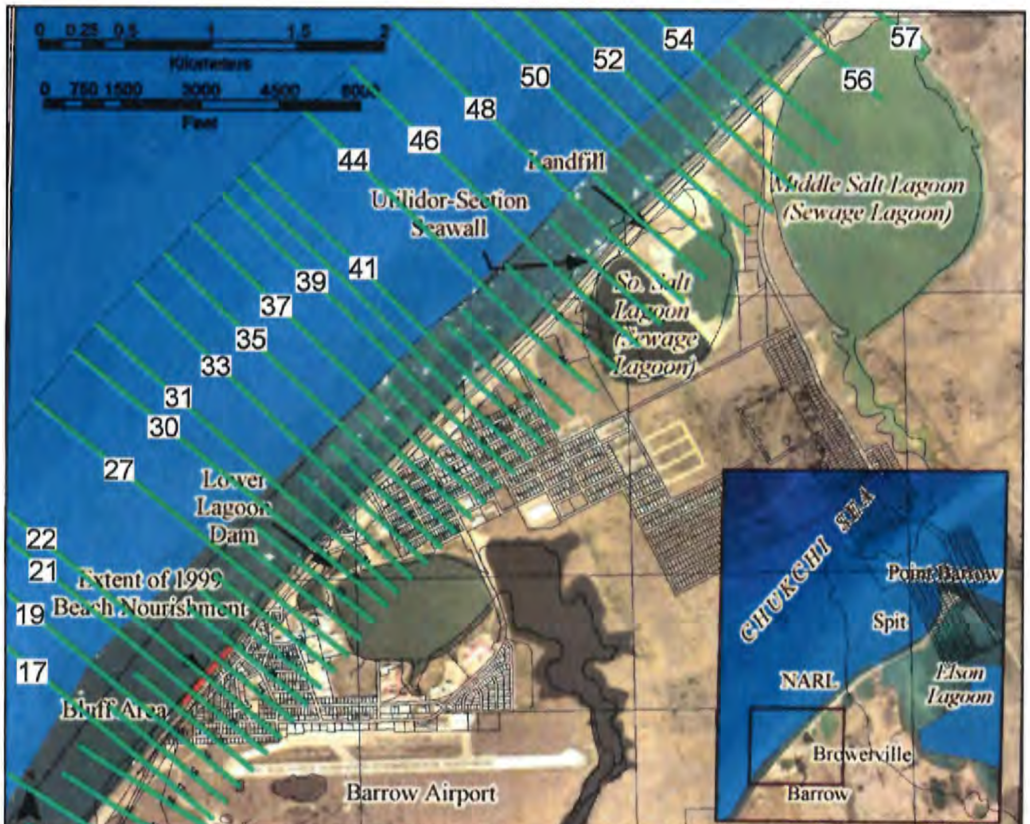

Figure 6. Transect Lines along the Coast.

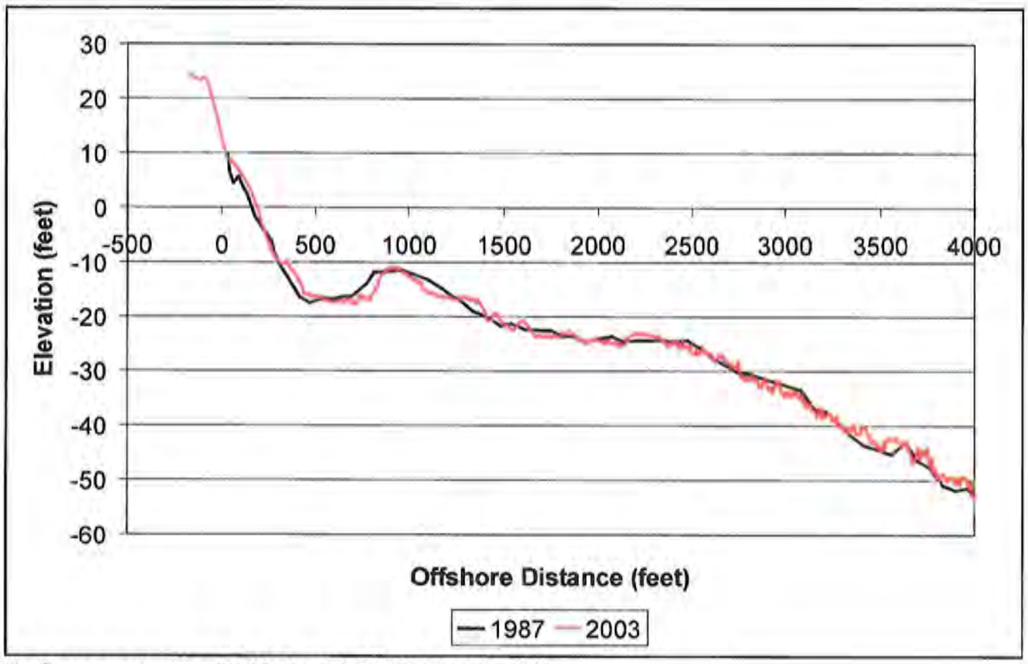

Figure 7. Comparison of 1987 and 2003 Profile-22.

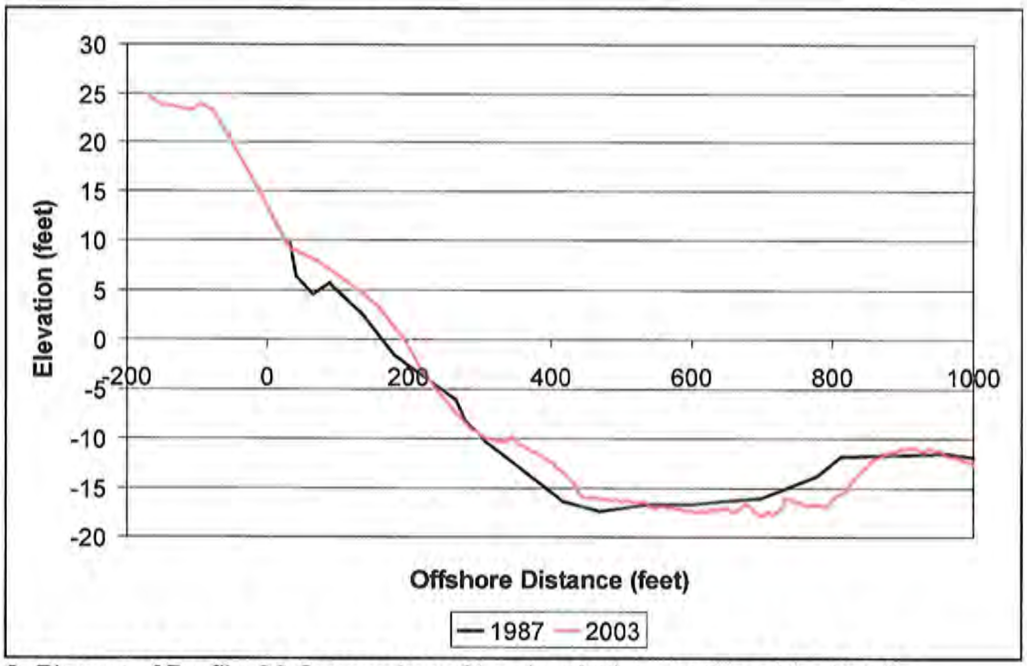

Figure 8. Blowup of Profile-22 Comparison Showing Active Portion of the Profile.

3.2.2.2 Longshore Sediment Transport

Longshore sediment transport at the site was evaluated using the formula of Soulsby, one of the few that is considered valid for the coarse beach material found at Barrow. Hindcast data from station 49 were used as model input. The Soulsby formula yielded an average annual gross transport rate of 9,800 cubic yards per year and an average annual net transport rate of 7,300 cubic yards per year to the northeast, towards Point Barrow. This estimate compares well with previous estimates made by researchers at the NARL of a net transport of 10,000 cubic yards per year.

Calculation of the longshore sediment transport rate using the CERC formula (USACE 2002) yielded much larger rates unless the value of the calibration coefficient, K, was reduced. Reducing the value by an order of magnitude to K=0.05 (all CERC formula calculations used significant wave heights) yielded results that compared very favorably with the Soulsby results, as shown in Figure 9 and Figure 10. Though this is a much smaller value of the CERC K coefficient that is normally used, it is appropriate, considering the grain sizes involved. For beach sediment median diameters in the range of 4 to 8 mm the most appropriate value for the CERC K term was 0.05.

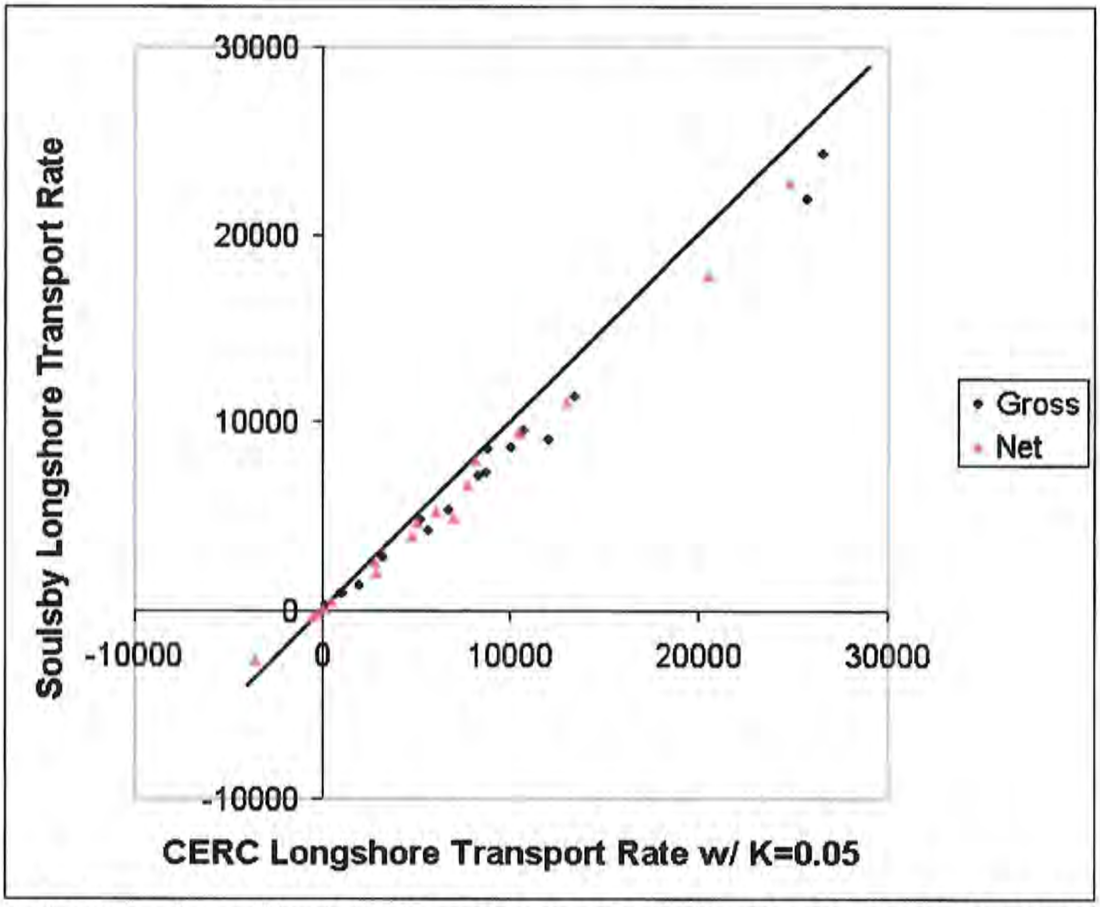

Figure 9. Comparison of Yearly Sediment Transport Rates (in yd^3/yr) between Soulsby and CERC Formulas.

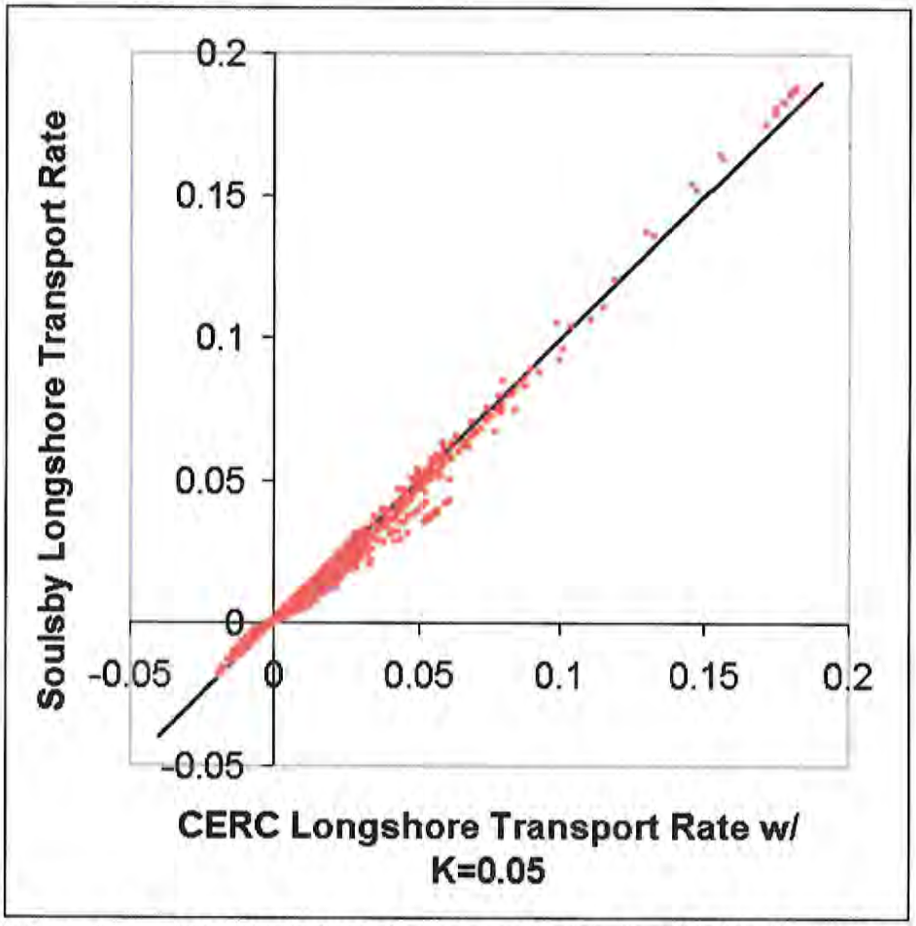

Figure 10. Comparison of Hourly Sediment Transport Rates (in yr^3/yr) between Soulsby and CERC Formulas.

3.3 Biological Setting

As noted in the EA (Appendix B), the biological resources near Barrow were described in the 2010 Coastal Storm Damage Technical Report (Attachment 1 to the EA). That inventory was for a previous study that considered a much wider range of alternatives, including significant development in the nearshore marine environment and developing new gravel sources on the tundra in Barrow. The information in Attachment 1 goes into great detail regarding Arctic flora and fauna to include terrestrial wildlife, marine mammals, essential fish habit, nearshore fish species, vegetation, and protected species.

Because this current study's reduced scope would predominantly impact the bluff, beach, and nearshore environments, this section discusses only those biological resources that are likely to be found within the proposed study footprint – tundra, birds, marine fish and invertebrates, and marine mammals. Any material that may be used to construct structures to reduce the risk of coastal erosion and flooding impacts would be from an existing quarry, likely in Nome, Alaska. It is possible that some gravel would come from an existing commercial quarry in Barrow.

3.3.1 Tundra

The predominant vegetation type in the Barrow study area is tundra formed over a permafrost layer. Coastal wetlands and moist tundra regions are particularly vulnerable to climatic variation and extreme events. Many of these areas are unstable and easily, or frequently, changed by erosion and flooding. Erosion has been observed along the north slope of Alaska in large part due to seasonal storm surges. This is seen specifically at the bluff area, with calving of large sections of the thawing permafrost. The bluff face terminates onto the beach and is within the wave-impact zone during storms and heavy wind events, causing active erosion during the summer and fall.

3.3.2 Birds

Many non-breeding seabirds occupy the marine waters of the Chukchi and Beaufort Seas offshore of Point Barrow during summer. Some species, including gulls and loons, nest on inland tundra ponds. Some common marine seabirds found near Barrow include black guillemots (*Cepphus grylle*), common (*Uria aalge*) and thick-billed murres (*Uria lomvial)*, horned puffins (*Fratercula corniculata*), and fulmars (*Fulmarus glacialis*). Habitat on and near point Barrow is used for foraging by post-breeding shorebirds and as resting and foraging habitat for some sea ducks.

Food resources for shorebirds provide an important source of energy after the energetic demands of the breeding season and in preparation for fall migration. Shorebirds include three species of plovers and numerous species of sandpipers. Plovers (common in the Point Barrow area include the golden (*Pluvialis dominica*), black-bellied (*Pluvialis squatarola*), and semipalmated plovers (*Charadrius semipalmatus*). Sandpipers (family Scolopacidae) include whimbrel, bar-tailed godwit, spotted sandpiper, long-billed dowitcher, ruddy turnstone, black turnstone, rock sandpiper, pectoral sandpiper, knot, dunlin, Baird's sandpiper, semipalmated sandpiper, and possibly the western sandpiper. Although not a shorebird, the Wilson's snipe (*Gallinago delicata)* is also a regular summer visitor to Point Barrow. Most all these species nest on the tundra of the National Petroleum Reserve, including Point Barrow, and non-breeders of many species might be present near study area.

3.3.2.1 Eiders

Both Steller's (*Polysticta stelleri*) and spectacled eiders (*Somateria fischeri*) can be found at nearshore leads in the sea ice in late May and early June. From June through early fall, both species can be found on the tundra near Barrow during pre-nesting (adult males and females), nesting, and rearing of their broods. Males and unsuccessful females may briefly be found in marine waters near Barrow after nesting is initiated (males) and if the nesting is unsuccessful. Males and females may be found in nearshore marine waters for a brief period early in the nesting season if they choose not to initiate a nest that season. In the early fall, both species may briefly be present in nearshore marine waters as they leave the tundra from either the Barrow area or pass through the area from more distant breeding grounds to the east.

3.3.3 Marine Fish and Invertebrates

Nearshore marine fish and invertebrates were sampled extensively near Barrow and along the Beaufort and Chukchi Sea coasts annually between 2004 and 2009 (Figure 11). These surveys took place for the previous 2010 study when several alternatives involved placing large amounts of fill in the water. The results suggested that nearshore fish and invertebrate species are highly variable along the coast. Data from these surveys are discussed in Appendix I.

Figure 11. Nearshore Fish Sampling.

3.3.4 Marine Mammals

All marine mammals are protected under the Marine Mammal Protection Act (MMPA) and some have additional protection under the Endangered Species Act (ESA). All of the species are discussed in the subsequent sections below.

3.3.4.1 Polar Bears

Polar bears (*Ursus maritimus*) were listed as *Threatened* under the ESA in 2008 by the USFWS due to loss of their sea ice habitat. Polar bear populations also are susceptible to other human-caused disturbances, such as offshore development, habitat alteration and human-caused mortality. These bears can be present in Barrow during every month of the year and can be found on the tundra, the beach, swimming near shore when pack ice is in the area, and on sea ice when present. Bears that are undetected by people or are moving through on either the beach or around the outskirts of town on the tundra are generally allowed to pass by unharmed. Polar bears present in town or those that are acting aggressively outside of town are often shot for safety reasons and used for subsistence. Polar bears are most common outside of Barrow, closer to the tip of the spit where bowhead whale bones and other carcasses from the subsistence harvests are deposited. This "bone pile" area is approximately 4.3 miles north of the northernmost extent of the footprint of the Recommended Plan.

3.3.4.2 Whales

Humpback whales (*Megaptera novaeangliae*) are very uncommon in in the Chukchi Sea, especially as far north as Barrow, although their range may be increasing. These whales are only rarely observed on summer aerial surveys in the Chukchi Sea. Like humpback whales, killer whales (*Orcinus orca)* are uncommon in the Chukchi Sea though they have been spotted during aerial surveys, vessel-based surveys, and by Native Alaskan seal hunters in the past few years.

Gray whales (*Eschrichtius robustus*) are occasional visitors to the Barrow area in summer and can often be found nearshore. USACE biologists encountered gray whales several times incidental to nearshore fishery studies near Barrow between 2003 and 2008.

Bowhead whales (*Balaena mysticetus*) are very unlikely in the study area during the summer as they are found far to the east and well into Canadian waters. Bowhead whales move back into the Barrow area in the fall where they are present for subsistence harvest by Barrow hunters, typically in October.

Beluga whales (*Delphinapterus leucas*) can be found near Barrow in winter and spring, but are generally far more abundant much farther north when the area near Barrow is sea ice free.

3.3.4.3 Harbor Porpoise

Harbor porpoises (*Phocoena phocoena*) are uncommon near Barrow. When encountered, they typically occur nearshore alone or in very small groups. If present in Barrow, they would most likely be encountered during the open water period.

3.3.4.4 Seals

The Arctic subspecies of ringed seals (*Pusa hispida*) is listed as *Threatened* under the ESA, primarily due to changes to their snow and ice habitat. Their presence near Barrow is strongly influenced by the presence of sea ice; they are abundant during late winter and spring and much less common in the area during the open water season when the area is sea ice free.

Bearded seals (*Erignathus barbatus*) are typically closely associated with sea ice and therefore are often found along leads or near the edge of the pack ice. As such, their presence in the Barrow area peaks during the spring and early summer when leads form and the pack ice retreats to the north and in the fall as sea ice forms nearshore and the pack ice forms.

Spotted seals (*Phoca largha*) are also closely associated with ice habitat, but are more likely than any other seal in the area to be encountered during the open water period in low numbers, on a very infrequent basis.

Ribbon seals (*Histriophoca fasciata*) are relatively solitary and are usually found much farther offshore than other ice seals. It is very unlikely that they would occur in the study area.

3.3.4.5 Walrus

Walrus (*Odobenus rosmarus*) are typically found far offshore from Barrow, near the ice edge. It would be very unlikely to encounter a walrus nearshore in Barrow during the open water period in later summer or fall.

3.3.4.6 Narwhal

Narwhals *(Monodon monoceros)* are very uncommon in Arctic waters off the coast of Alaska and it is extremely unlikely that they would be encountered near Barrow.

3.4 Recreational

The City of Barrow utilizes the beach and associated access points for recreational purposes. These include boating, walking along the beach, viewing the ocean, and holding social events. Because the coast is one of the most prominent features, and is directly tied to the cultures, access to the beach is very important to the community.

3.5 Social Economic Resources

Barrow has the largest population in the NSB and is the economic center of the region. Borough, state, and federal agencies are the largest employers in the city. Numerous businesses provide support services to oil field operations. Tourism and arts and crafts provide some cash income. Seven residents hold commercial fishing permits. Subsistence production is an important component of the local economy and social structure as many residents rely upon subsistence food sources. Whale, seal, polar bear, walrus, duck, caribou, grayling, and whitefish are harvested from the coast or nearby rivers and lakes for local subsistence.

Barrow is in the North Slope Census Area. Subsections 3.5.1 through 3.5.8 summarize social economic resource statistics for Barrow. Most of the information is based upon data from the U.S. Census and Alaska Department of Labor and Workforce Development's 2016 Population Overview.

3.5.1 Historical & Archeological Resources

Cultural resources in the Barrow area range from prehistoric subsurface sites to historic structures, from approximately 5,000 years ago to the Cold War. Barrow has at least 42 historical and prehistoric sites that have been recorded to the Alaska Heritage Resources Survey (AHRS) and are near or within the Area of Potential Effect (APE) discussed in Appendix B. Five additional sites are located near the study area. Significant sea level and environmental changes over the span of a millennia have altered the shoreline and continue to alter the landscape, likely hiding or erasing sites. The cultural resources that are located within the study area are identified in Figure 12.

Figure 12. Cultural Resource Sites in the Study Area.

3.5.2 Subsistence Production

In summer months, specific areas along the beach are used for subsistence access. Boats are launched using a portable mat on the beach and small boat trailers. There are approximately 50 boats utilized for subsistence actives ranging in size from 16 to 22 ft. During a spring whaling, after whales are harvested, the boats haul them onto the beach using any available beach area. The whales are then cut up for distribution within the community. Subsistence activities have typically been extremely adaptable to changes on the beach.

3.5.3 Life, Health, and Safety

Frigid flood waters during storms in the study area result in dangerous conditions. Additionally, the current practices of flood fighting during storms place equipment operators in extremely hazardous conditions (i.e. operating heavy equipment in increased wave conditions) in order to reduce risk to the community. The community faces risk of damage to personal property, including residential and non-residential structures and their contents. The high risk of flooding during storm events has negatively impacted the quality of life of local residents. In addition, erosion at the bluff (Reaches 1 and 2) results in loss of cultural resources from the Utqiaġvik Historical Site and threatens loss of infrastructure. Several private homes in addition to public infrastructure are threatened by increased slumping of permafrost due to wave-run up and permafrost thaw. Storm events increase wave run-up and undercutting of the already unstable bluff face.

3.5.4 Regional Emergency Services

As the political and economic hub of the NSB, Barrow provides important services to other communities in the borough. In February 2006, the emergency infrastructure systems in Barrow, which were identified as currently supporting operations in nearby villages, included search and rescue, law enforcement, fire support, health care, communication, and cargo delivery. While the nearby villages do have their own Search and Rescue building, police station, public works building, fire station, and village health clinic, they are equipped to handle only limited emergency needs. Four alternate communities (Anchorage, Fairbanks, Kotzebue, and Nome) were identified and analyzed as alternatives for providing emergency support services to NSB communities should Barrow be unable to provide such support.

3.5.5 Population

Barrow's population was steady over the period between 2010 and 2016, with a high of 4,548 in 2015, a low of 4,436 in 2012, and a 2016 population of 4,469. The population change in Barrow over the period 1880-2005 is shown in Figure 13. The most recent detailed demographic data for Barrow is from the U.S. Census American Community Survey program for 2016 (2016 Census). In 2016, 64 percent of the population was reported as Alaska Native alone or in combination with one or more races (7 percent). Of the remaining population, the largest racial groups were reported as white (12 percent) and Asian (12 percent).

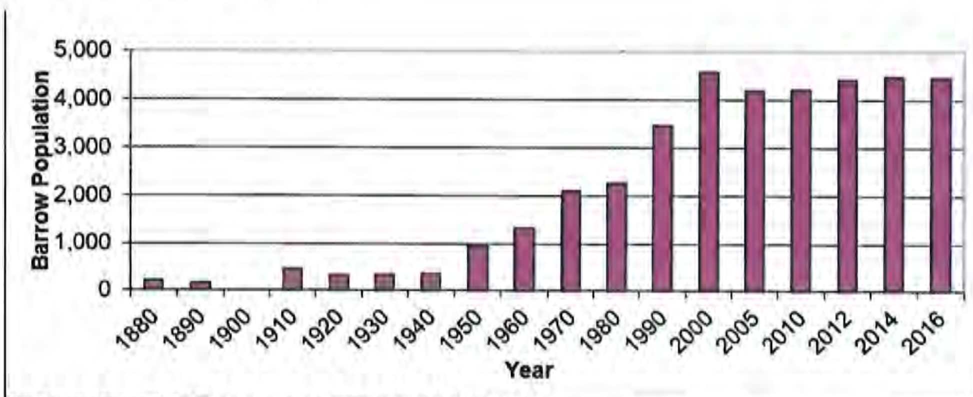

Figure 13. Population Change in Barrow 1880-2016.

The gender of Barrow's population in 2016 was approximately 52 percent male and 48 percent female. Approximately 39 percent of Barrow's population in 2016 was under the age of 20, with 45 percent between the ages of 20 and 54 and 16 percent over the age of 54. Barrow's median age was reported as 27.

Documented coastal flooding and erosion risk in the study area present a likelihood of numerous adverse consequences to the population of Barrow. Some of these consequences include the threat of inundation to the freshwater lagoon, Utilidor pump stations and washing out Stevenson Street, which is the only access to NARL and subsistence areas out to Point Barrow. These consequences are presented in Appendix C and key infrastructure is listed in Section 7.1.1.

3.5.6 Employment and Income

Of the Census-estimated 4,316 people living in Barrow in 2016, approximately 67 percent were considered as being in the potential work force (age 16 years and over), with 2,053 in the labor force (employed or seeking work) and 857 not in the labor force (not seeking work). Of the labor force, 59 percent were reported as employed and 11 percent reported as unemployed. The largest employer was government, accounting for 864 of the 1,722 jobs in 2016 (50 percent). The 2016 Census summarizes the employment statistics for Barrow (Table 3).

Table 3. Employment and Income.

Employment/Income Type	**#**	**%**
Total Potential Work Force (Age 16+):	2,910	
Unemployed (Seeking Work):	331	11.4%
Adults Not in Labor Force (Not Seeking Work):	857	29.5%
Total Employment:	1,722	59.2%
Breakdown of Employed Labor Force:		
Private Wage & Salary Workers:	818	48%
Self-Employed Workers (in own not incorporated business):	38	2%
Government Workers (City, Borough, State, Federal):	864	50%
Unpaid Family Workers:	2	0.10%

The industry category of education, health, and social services accounts for the most jobs, followed by Public Administration. Combined, these two industry categories account for approximately 43 percent of the jobs in Barrow.

Barrow's Per Capita Income was reported at $28,137 in the 2016 Census data (18 percent lower than the state average of $34,191).

Documented coastal flooding and erosion risk in the study area present a likelihood of numerous adverse consequences to the employment and income opportunities in Barrow. These consequences are presented in Appendix C.

3.5.7 Local Labor Resources

During the public comment period, comments were received regarding local labor uses on project construction and opportunities of the project to create jobs within the community of Barrow. USACE would include contract language regarding hiring of local residents where appropriate.

3.5.8 Infrastructure and Facilities

The Barrow Utilidor went into operation in 1984 and currently includes approximately 3.3 miles of corridors in Barrow and Browerville, containing 11 miles of water, sewer, and force mains, as well as electrical conduit and communications cable.
Coastal flooding in the Barrow neighborhoods of eastern Barrow and Browerville is expected to continue under future without project (FWOP) conditions. The Barrow Utilities and Electric Cooperative, Inc. (BUECI) provides Barrow with water, sewer, and electric service. The city's water source is the upper portion of Isatkoak Lagoon. The 2010 Technical Report provided estimates that the spillway will undergo damage when water surfaces in the area exceed +8 ft MLLW (Appendix I). Similarly, the Utilidor would undergo damage when water surfaces in the area exceed +10 ft MLLW. Erosion is expected to result in failure of the Utilidor at the west end of Agvik Street within 25 years.

Loss of utility services in Barrow would result in substantial risk to human health and safety due to the inability of residents to heat and power their homes and businesses in a geographic region with extreme climactic conditions. Additionally, current flood fighting and erosion response approaches necessitate placement of temporary risk reduction materials during storm conditions, including operation of heavy equipment in the surf. Impacts to infrastructure systems in Barrow extend the risk to human health and safety to other regional communities dependent upon Barrow for essential services and supplies.

3.5.9 Existing Construction Projects in Study Area

In September 2018, wind driven waves caused erosion that damaged a section of HESCO Baskets that were in place along a portion of the bluff in the Barrow Neighborhood. The NSB has requested the Federal Emergency Management Agency (FEMA) help to address the section of coastline where the HESCO baskets failed. As of 22 March 2019, FEMA has coordinated with the USACE and has verbally stated they will construct the repairs using the bluff design determined in this study (i.e rock revetment, Section 7.2). If FEMA constructs this design prior to the USACE, the USACE will be able to incorporate this structure into the larger 5-mile design seamlessly, while still capturing all of the benefits. If FEMA constructs a rock revetment in this area of the bluff per USACE design specifications and prior to USACE implementation, the proposed project cost and extent would be reduced. If FEMA does not construct a new project or repair the existing HESCO baskets, the recommended plan detailed in Section 7 of this FR would otherwise be unaffected and would have the same certified cost. If FEMA were to construct a revetment or other measure that is not up to USACE design standards, the recommended plan detailed in Section 7 would replace any existing structure, would otherwise be unaffected and would have the same certified cost. If any of the material from FEMA's structure could be used for the USACE proposed project, overall project cost would be reduced.

4. FUTURE WITHOUT-PROJECT CONDITIONS

The FWOP conditions mirror those conditions under the No Action Alternative. Coastal erosion and flooding risk results in adverse effects to terrestrial and nearshore environments, recreational, historical/archeological, economic, and social/cultural resources in the community of Barrow. The FWOP condition is the basis of evaluation against with-project conditions, and is described in the following subsections.

4.1 Environmental Condition

The FWOP condition would impact a larger area of tundra habitat over the long-term due to bluff erosion and wave run-up action than any of the action alternatives. Not implementing a risk reduction measure at the bluff would leave it susceptible to the natural elements causing harm from both erosion and saltwater exposure. Future changes in the sea ice and water temperature regime could lead to changes in species assemblages including a decrease or change in range of traditional Arctic species and the arrival of new species to the area near Barrow from the Bering Sea and more southerly portions of the Chukchi Sea. The extent and timescale for these potential changes are uncertain.

Unlike many other projects, the FWOP condition could lead to several negative impacts for marine mammals and birds. While this condition avoids all potential construction impacts associated with revetments, there are several potential implications of the FWOP condition. Coastal erosion and, to a greater extent, coastal flooding, typically leads to contamination and degradation of the marine environment. Erosion and flooding scatter everything from building materials to all types of personal property throughout the landscape leaving debris in the marine environment. This debris can impact birds and marine mammals by entanglement and ingestion. In addition to the debris, a more persistent potential problem involves spills of fuel and oil from a major erosion event or a flood. This issue concerns everything from large scale releases such as the gas station or large fuel tanks and the landfill, but also includes the potential for numerous small spills from fuel cans, four-wheelers, snow machines, home heating oil tanks, etc. These sorts of items are moved, toppled, and displaced during major erosion and flood events and can lead to long term pollution of nearshore marine habitats and the marine mammals and birds that rely on them. Because a large portion of the subsistence resources are locally harvested, the effects of debris and spills could have long term effects on subsistence, especially for protected species like seals and bowhead whales.

Though Middle Salt Lagoon is monitored to Alaska Department of Environmental Conservation (ADEC) Discharge Permit Limits and occasionally drained into the Chukchi Sea, it is done during specific times of the year to limit nearshore impacts. Also, South Salt Lagoon is not discharged into the Chukchi Sea and does not meet ADEC Discharge Permit Limits. During a storm event, flood waters could overtop Stevenson Street inundating the sewage lagoons. The resulting impacts to the community would be raw sewage contamination from the overflowing of the lagoons. Channelization of receding flood waters at the landfill site (known by ADEC as the "Barrow North Salt Lagoon Landfill"), could cause contaminants harmful to human health to be released into the nearshore environment and the communities water supply. Further impacts could potentially be realized through the contamination of the immediate nearshore environment by entering the marine food web. Should this occur, marine life would have the potential to be impacted locally which in turn could have a deleterious effect on subsistence resources. Information on the Middle Salt Lagoon Discharge can be found in Appendix D.

Beach in front of the sewage lagoons and landfill is low lying with little change in grade. The rate of erosion in front of these lagoons and the landfill is approximately -0.61 ft/yr (Appendix D). There is significant concern of overtopping of the road and flooding of the lagoons which would cause environmental damage to the nearshore environment. In addition, flooding impacts to the landfill could result in loss of topsoil including debris and contaminants being released into the marine environment and impacting life, health and safety when the flood waters recede after an event.

4.2 Relative Sea Level Change

The physical environment is a result of ongoing dynamic arctic coastal processes and a beach that is out of equilibrium due to beach mining activities (Appendix D, Section 8). These dynamic processes would not change in the FWOP condition. The FWOP condition would continue to have depth-limited waves eroding the bluffs and running up and flooding the low lying area. The relative sea level change trend (Appendix D, Section 6) indicated a sea level rise between 0.54 feet and 2.79 feet by year 2070 at Barrow. As relative sea level change (RSLC) is realized, the total water level at the coastline would increase and larger depth-limited waves would be able to attack the shoreline. Erosion and overtopping flooding area is non-linearly related to incident wave height; increasing wave height a little can produce a large increase in wave-driven erosion and wave overtopping.

4.3 Historical & Archeological Resources

In the FWOP condition, cultural resources and opportunities would be exposed to further damage from erosion and flooding, including the Utqiaġvik Historical Site in Barrow. Thawing permafrost in the Russian Arctic has led to the damage of several hundred buildings, many constructed after 1940 and designed for arctic conditions, as permafrost thawed and made the foundations unstable (Nelson *et al.* 2002).

4.4 Subsistence

Subsistence is extremely important to the community in Barrow. Sixty-four percent of the population is Alaskan Native (primarily Iñupiat Eskimo) and practice a subsistence lifestyle. Traditional marine mammal hunts and other subsistence practices are an active part of the culture. Opportunities to participate in subsistence activities are not expected to be limited or improved from without project conditions by any of the action alternatives evaluated. The relative effects on subsistence activities expected with each final alternative are described further below.

In a FWOP condition, future opportunities for subsistence participation are expected to remain in the study area. Although past storm events have damaged Stevenson Street and impeded eastward connectivity to Point Barrow, the NSB has proposed a new alternative connector road further inland that would act as secondary route to the subsistence fish camps at Elson Lagoon.

4.5 Recreation and Aesthetics

Recreational activities along the coast are very important to the community. In the FWOP condition, the use of the beach would remain the same in the short-term; however, due to increased erosion in the long-term, it would be limited or nonexistent. Housing, utilities, and roads would remain at risk along the coast, as flooding and erosion continues. Some activities would likely shift to other locations, including vessel access and social events. Aesthetics would not be affected by the FWOP conditions. There is currently a sacrificial berm blocking the view to the ocean at approximately +20 ft MLLW. This will likely remain as a flood control measure used by the NSB.

4.6 National Economic Damages

The NED benefits from the 2010 Technical Report were updated to FY20 price level and discount rate of 2.750 percent. These updated values were then compared to the cost of the alternative plans formulated for the current study. For the purpose of the economic analysis, estimated construction durations and operations and maintenance (O&M) estimates were also developed.

NED benefits are effects that increase the economic value of the National output of goods and services. Evaluation of NED effects are required by USACE planning regulations and all economic development projects require identification of the NED Plan as the alternative plan that maximizes net benefits (the difference in project costs and benefits). At Barrow, potential beneficial NED effects are possible by reduction of damages from flooding and erosion that would be expected to occur without a project. To expedite the study in response to the time-critical nature of the flood and erosion hazard in Barrow, the NED assessment was made using the best available existing information (coastal modeling results and economic damage estimates from the 2010 studies), with specific refinements as discussed in this section. It was the judgment of the PDT that the previous analysis was the best information available and reasonably representative of current conditions and appropriate for use in this study.

4.6.1 NED Analysis

NED categories in the 2010 study were divided between coastal storm damages and coastal erosion damages. Coastal storm damages included structures and contents, spillway and associated utilities, and Utilidor damages. Coastal erosion damages included land loss, structure condemnation, beach berm emergency erosion maintenance (including storm-fighting), Stevenson Road repairs, South and Middle Salt Lagoon failure, and Utilidor damages. The Without project NED damages by flooding and erosion are summarized in Table 4. As shown in the table, the Berm/Emergency Maintenance category is the largest category. Additionally, it shows that flood damages are under 3 percent of the total without project damages. That flood damages are a small proportion of total risk is important in determining the overall uncertainty in the estimate of potential benefits. If flood damages were a significant proportion of damages, there would be high uncertainty in the benefits achieved by a given alternative in the absence of updated risk-based flood modeling that estimates residual damages. However, since the main benefit driver is erosion, and residual risk of erosion is negligible with the project in place, there is much less uncertainty that an alternative will achieve estimated benefits. As such, the PDT determined that these updated values were suitable for use in the plan formulation process and for use in generating updated benefit-cost ratios for the alternatives and in sensitivity analyses (Appendix C).

Table 4. Updated Without Project Condition NED Summary.

Category	Type	Annual Damages ($1000)	%
Isatkoak Lagoon, (Water Supply and Utilities)	Flood	$184	2.2
Structures & Contents		$52	0.6
Utilidor (Critical Utilities)		$14	0.2
Subtotal		$250	2.99
Berm/Emergency Maintenance	Erosion	$7,449	89.2
Structures & Contents		$347	4.2
Utilidor (Critical Utilities)		$168	2.0
South and Middle Salt Lagoons (Sewage System & Old Navy Landfill)		$107	1.3
Land loss		$18	0.2
Bluff (Historic Native Village Site)		$14	0.2
Subtotal		$8,103	97.0
Total	-	$8,353	100 %

4.7 Summary Without-Project Conditions

In the Without-Project Condition, Barrow will continue to experience increased flooding during storm events and erosion of the bluff areas due to thawing permafrost and undercutting of the bluffs with wave action during open water periods. The NSB will continue to maintain sacrificial berms throughout the open water period which will continue to negatively impact housing development and other capital improvement projects. This housing shortage would increase out migration of Barrow residents reducing the population and impacting the economy. The NSB will continue to spend capital improvement money on flood fighting resulting in neglecting infrastructure updates across the community. In the next few decades, the community would likely see larger scale impacts to the Utilidor and airport runway through erosion, thus creating a burden on the economy and the surrounding communities that use barrow as a hub for goods and services.

An increased frequency of flooding and erosion would continue to erode the Utqiaġvik

Village Site and National Historic Registry of Places (NHRP) sites along the coastline resulting in the loss of tangible cultural heritage and removal of this information from the cultural record. Stevenson Street is the only access road to NARL, Dewline Road (radar facility), and the boat ramp north to Point Barrow. Further flooding along Stevenson Street could cut off inhabitants at NARL leaving them without access to critical life-saving services, such as the hospital, police support, fire department, grocery stores, fuel, and the airport. Loss of the road would also mean loss of access to other culturally and historically significant resources including being able to harvest whales, the hunting camps, and the "bone pile," which is important for drawing polar bears out of town.

The FWOP annual exceedance probability (AEP) for the South and Middle Salt Lagoons is approximately 20% (Economic Appendix Table 39). In the FWOP, there is risk of an environmental hazard when flood elevation reaches the crown of the road. Based on the 2010 H&H information, damage initiation between with and without project conditions is expected to be reduced from 21% to 0.15% AEP in Reach 5. It is not expected that new modeling would provide results showing significant changes in the level of protection that would change the decision. Crest elevation will be optimized in PED with this change in cost accounted for in the contingency. The free-flow can cause uncontrolled release of contamination into the nearshore and pose an ecological risk which may adversely affect subsistence resources via negative food web effects. For the landfill, as stated in the EA/FONSI, flooding poses persistent potential problems that involve spills of fuel and oil and leaching of contaminants and trash into the environment.

A full list of key infrastructure by reach can be found in Section 7.1.1. None of the infrastructure listed in Section 7.1.1 nor any additional infrastructure is currently being planned for relocation and no funds are currently being allocated to relocate structures within the study area. The NSB has decided that it is more cost effective to reduce the risk of flooding and erosion to critical infrastructure then to pursue relocation. Even if the NSB identified potential projects for structure relocation, the NSB has prioritized available funds into reducing risk to the coast by maintaining the temporary sacrificial berm since this in an immediate threat. The current USACE study is included in their prioritization list. If there is an immediate need for a relocation of any one structure due to future erosion/flooding impacts, then they would divert funds to those specific needs. Furthermore, material for relocations of structures in Barrow is limited since the gravel necessary to prepare the ground for a structure is being used in the temporary sacrificial berm.

5. FORMULATION & EVALUATION OF ALTERNATIVE PLANS

5.1 Plan Formulation Rationale

Plan formulation is the process of building alternative plans that meet planning objectives and avoid planning constraints. Alternatives are a set of one or more management measures functioning together to address the study objectives. A management measure is a feature or activity that can be implemented at a specific location to address one or more of the objectives. A feature is a "structural" element that requires construction or on-site assembly. An activity is defined as a "non-structural" action. These sections describe the measures and alternatives development and screening. Alternatives formulation occurred in three stages: initial array carried forward to the TSP Milestone, and final array iterations, which are described in Sections 5.4 to 5.7.

5.2 Plan Formulation Criteria

Measures were screened during the charette using the four national criteria and five study-specific criteria, discussed in Sections 2.5 and 2.6. Each measure was evaluated against the general metric of whether the design would address the major mechanisms causing the erosion and flooding (wave-run up, increased period during storm events, freeze-thaw cycles of permafrost). Wave run-up has been identified as the major driver for flood inundation during storm events and increased wave action undercutting the bluff, thus leading to erosion and calving, affecting the Utqiaġvik Historical Site.

5.3 Measures

A total of ten potential structural measures and nine non-structural measures were initially identified during the scoping meeting (charette). Of these measures, three structural and four non-nonstructural measures were identified to be carried forward for alternative development. One of the remaining non-structural measures, remediating contaminated sites, was later screened once additional information was obtained. Measures identified during the planning charette on 12-13 September 2017 included a combination of structural and non-structural solutions (Table 5). The "Screening Considerations" column explains why these measures were either screened from further consideration or carried forward and combined with other measures to develop the array of alternatives.

Table 5. Measures.

Measures	Retained	Description	Screening Considerations
Revetment	Yes	Structural	A revetment at the bluff would be an appropriate measure for stabilizing and reducing continued erosion and subsequent loss of cultural resources.
Seawall	No	Structural	Too many unknowns for arctic conditions which increase study costs. Sheetpile would increase/ accelerate beach erosion. High O&M costs.
Breakwater	No	Structural	Ivu events would result in high O&M costs and would not effectively alter erosion.
Berm (permanent, not sacrificial)	Yes	Structural	A permanent berm to replace the sacrificial berms could reduce wave run-up, causing erosion, inundation, and local gravel usage, which has put a strain on other capital improvement projects.
Beach nourishment (BN)	No	Structural	The community has unsuccessfully tried BN in the past. There is a high O&M for BN because there is no suitable material located in Barrow.
Join National Flood Insurance Program (NFIP)	Yes	Non-Structural	Joining the NFIP as a standalone measure was screened from consideration because it does not reduce the damages caused by erosion and flooding. However, per ER-1105-2-100, Appendix E, Exhibit E-1 (pg E-28), states, "Sponsors must comply with Federal flood insurance and floodplain management program requirements." All alternatives except the No Action will include Joining the NFIP along with other structural measures.
Raise Stevenson Street	Yes	Structural	The NSB currently maintains a sacrificial berm on the seaward side of Stevenson Street, which is a coastal road that runs from Tahak Street past NARL. It was discussed during the charette that building a permanent berm in place of the sacrificial berm may not reduce the overtopping of the road during a storm event. Raising the road and revetting the seaward side would be more effective at maintaining access during storm events.

Measures	Retained	Description	Screening Considerations
Ring wall (levee)	No	Structural	A levee is not necessary to reduce erosion. Storm induced flooding is due to wave run-up.
Fill in front of freshwater lagoon (elevating it)	No	Structural	Not effective as a standalone measure. Would not reduce risk from flooding.
Artificial Reef	No	Structural	Risk of impacting subsistence activities, including damage to vessels. Risk of ice damage.
Zoning	No	Non-Structural	Zoning as a standalone measure was screened from further consideration. The community currently has a housing shortage and limited resources to build new homes. This measure does not address erosion or flooding concerns for any of the major infrastructure that is unable to be moved away from the coastline.
Buyout Acquisition	Yes	Non-Structural	As a standalone option, buyout acquisition was not feasible due to the current housing shortage in the community. In addition, this measure alone would not address erosion at the bluff nor the wave run-up and inundation from storm events. The freshwater lagoon (sole water source), landfill, and sewage lagoons would continue to be threatened and are unable to be bought out and relocated. This measure was carried forward and combined with structural measures to form the final array of alternatives.
Recover cultural sites (excavate)	Yes	Non-Structural	Recover cultural sites as a standalone measure was screened from consideration because it does not reduce the risk of erosion and flooding to the community. This measure would be incorporated into any alternative that proposes a structural measure at the bluff, if applicable.
Groin Field	No	Structural	Little longshore sediment transport; risk of starving one area to supply another.
Remediate contaminated sites	No	Non-Structural	No contaminated sites were identified within the project footprint, so this measure was not included in any of the alternatives.

Measures	Retained	Description	Screening Considerations
Relocate at-risk structures	No	Non-Structural	Relocation as a standalone measure was screened from further consideration. Homes and businesses could be relocated, but there is too much major infrastructure along the coastline to make this a viable option as a standalone measure. Similar to the buyout discussion, the freshwater lagoon, Utilidor, and sewage lagoons would be unable to be relocated. These are naturally occurring features that the community utilizes. In addition, another landfill could be built away from the coastline, but the existing landfill could cause negative environmental impacts if left to the sea.
Elevate at-risk structures	No	Non-Structural	Since this is already practiced in the community, it was screened from the measures carried forward. Barrow currently elevates structures because of snow drifts and as a way to insulate homes in an arctic environment.
Emergency warning system and signage	No	Non-Structural	Since the community already has an effective warning system in place, this measure was screened from further consideration. Barrow has looked into emergency warning systems in the past, but due to strong wind and white-out conditions during weather events, the community opted for an electronic notification system which that for their community.

5.3.1 Structural Measures

Structural measures generally reduce erosion and flooding. Underwater reef and groin field were screened during the charette due to ineffectiveness and inefficiency. Further discussion with Hydrology & Hydraulics (H&H) after the charette determined that sheetpile would not be the most suitable material for this environment and would accelerate the erosion of the beach, which is a NSB concern. Therefore, as of April 2018, sheetpile was no longer considered. Additional concerns arose after the Tentatively Selected Plan (TSP) Milestone, regarding the double measures in front of Tasigarook Lagoon and retaining beach nourishment, which is not a cost-effective measure. After conferring with the Vertical Team, the PDT determined that it was appropriate to screen out two additional measures: filling in Tasigarook Lagoon and beach nourishment. After this screening took place in January 2019, the PDT retained three structural measures (revetment, berm, and raise and revet Stevenson Street). Please see Section 5.4 for a discussion on alternatives developed using these measures.

5.3.2 Non-Structural Measures

Non-structural measures would reduce the consequences of erosion, flooding, relocations, and buyouts associated with the project. Three non-structural measures (Table 5), were carried forward and combined with structural measures to form alternatives. Five non-structural measures discussed were assessed and screened from further consideration prior to alternative development. Explanations for why these measures were not carried through the plan formulation process and into alternative development is located in Table 5 above, under the "Screening Considerations" column.

Non-structural alternatives would be a viable short term solution to the long term problem. However, non-structural alternatives, such as relocations, zoning, and buyout acquisition, would not reduce the risk of coastal erosion and flooding in Barrow as standalone measures.

Erosion/flooding would still continue under the FWOP condition with the following impacts/risks:

- Impacting culturally sensitive areas - this project reduces the risk of +50 culturally significant areas being lost to erosion/flooding.
- Impacting subsistence lifestyle - no beach launching access means no access to whales or seals.
- Potentially inundating the only local freshwater source with saltwater.
- Potentially flooding the sewage lagoon and spreading effluent throughout the community and contaminating the freshwater source.
- Eroding the landfill - add marine debris into the ocean, Senator Sullivan supports the Save Our Seas act which helps remove marine debris.
- Washing away the only road to NARL, which includes a community of homes, the only tribal college in the Arctic, National Security Infrastructure, and an offloading area for barged goods and services.
- Flooding the Utilidor system – If you move houses and businesses, then you would have to also relocation part of the Utilidor system. This is a permanent system that would cost billions to relocation (according to the NSB).

Elevating structures in Barrow is a current practice due to snow drifts and constructing on permafrost (Table 5). The NSB has also invested in raising pump stations located along the coast for the Utilidor. Since this is an existing condition for private infrastructure and not a possibility for the critical infrastructure (Utilidor and freshwater lagoon), it was screened from further consideration.

Relocations take time to plan and execute. As an example, the community of Newtok voted to relocate in the 90s and is just moving its first set of residences in FY19. The NSB has the authority to relocate/buyout some structures, including homes, but not all of them. For those properties where they do not have the authority, the NSB would have to partner with the tribal entity to help facilitate those relocations. The NSB would need to vote on relocations, and the risk is that there may not be enough viable land within the 50-year erosion line to facilitate this. Relocation of structures would also require creating/relocating additional Utilidor corridor to supply water and electricity to the structures. The NSB has invested millions of dollars into fortifying and raising existing pump stations and maintaining the temporary berm within the coastal zone, which would be wasted time and money if those structures were relocated. Furthermore, relocations would require gravel to pad the roads and structures. The gravel is currently being used to build the temporary sacrificial berm, and the sources are dwindling. Additional gravel would have to be barged in for either purpose.

Zoning was considered as a standalone measure; however, it does not address erosion or flooding concerns for any of the major infrastructure that is unable to be moved away from the coastline. It was subsequently screened out. Zoning is a component of the NFIP which was carried forward into all alternatives. During the charette, it was explained that in place of an early warning system (such as an alarm), which has been evaluated in the past, the community has a phone/email tree to notify through the chain of personnel in the event of a storm. This is more effective than a warning system because, in high winds, an alarm could be rendered useless.

Joining the National Flood Insurance Program (NFIP) has been carried forward under all alternatives, as it is stated in ER-1105-2-100, Appendix E, Exhibit E-1 (pg E-281), "Sponsors must comply with Federal flood insurance and floodplain management program requirements." The basis of this requirement is in Section 204 of WRDA 1988:

> COMPLIANCE WITH FLOOD PLAIN MANAGEMENT AND INSURANCE PROGRAMS; Before construction of any project for local flood protection or any project for hurricane or storm damage reduction, the non-Federal interests shall agree to participate in and comply with Applicable Federal flood plain management and flood insurance programs.

The NSB is working with FEMA and has started the process of joining the NFIP. A coordination meeting was held in February 2019 to develop a path forward. The NSB will be part of the NFIP, or comparable plan, to meet USACE policy requirements prior to construction. A letter was received from the NSB on 29 May 2019, providing an update of the NSB's progress with FEMA in joining and implementing NFIP (Appendix H).

5.4 Initial Alternatives Development

All structural and non-structural measures were combined into common themes and developed into realistic alternatives that would meet the objectives of this study. Twelve alternatives, in addition to the future without project condition (No Action), were considered after the AMM and are described in Sections 5.4.1 through 5.4.13. Alternatives 5A through 5D included filling in Tasigarook Lagoon, which was considered in the 2010 Technical Report and resulted in the highest benefit to cost ratio (BCR) in that report. This measure was later screened out along with beach nourishment, as shown in Section 5.7, Final Array of Alternatives.

5.4.1 Alternative 1: No Action

The No Action Alternative would not take action to reduce or halt erosion and flooding along the coastline of Barrow, Alaska. The study objective would not be met, and no opportunities would be realized. Erosion would continue to take place, and flooding would occur during storm events. Public and private infrastructure, historical buildings, and cultural resources would continue to be lost as the ground beneath them eroded away.

5.4.2 Alternative 2A: Rock Revetment at Bluff and Berm in Front of Stevenson Street

This alternative would provide erosion risk reduction for the bluffs, starting in front of the airport, until the bluffs transition to low lying areas in front of Tasigarook Lagoon. This alternative would also include flood risk reduction for the low lying areas, starting in front of Tasigarook Lagoon, with a smooth transition from a rock revetment in front of the bluffs, to a revetted berm in front of Stevenson Street. The revetted berm would then continue in front of Stevenson Street until Stevenson Street intersects with Dewline Road on the far side of NARL. The revetted berm would run the remaining distance of the project area. This alternative would have a revetted berm height of +14.5 ft.

5.4.3 Alternative 2B: Rock Revetment at Bluff and Raise Stevenson Street

This alternative would provide the same level of reduced risk as Alternative 2A. The erosion risk reduction for the bluff would still extend from in front of the airport to in front of Tasigarook Lagoon. However, instead of constructing a revetted berm on the seaward side of Stevenson Street for the approximate 4 miles stretch, Stevenson Street would be raised to +14.5 ft, and the seaward side of the street would be revetted. This would allow people driving on the road to still have a view of the ocean and could decrease the quantity of armor rock.A revised description of Alternative 2, which was refined after the TSP Milestone is described in Section 5.6.1.

5.4.4 Alternative 3: Flood-Proofing and Beach Nourishment

Residences located within the flood projections for the 50-year period of analysis would be elevated or bought-out and relocated. Beach nourishment would take place and would have to be maintained throughout the 50-year period of analysis.

5.4.5 Alternative 4: Ice Berm

A facility would be constructed to produce large enough blocks of ice that would persist through the warmer seasons. Thermal off-gassing equipment would be installed along the whole stretch of the study area to assist with keeping the ice frozen and shoreline stabilized. The ice berm would work as the decreasing sea ice works in cutting down on wave action and working as a barrier between waves and the bluff.

5.4.6 Alternative 5A: Reduce Risk to Major Infrastructure

A revetted berm in front of the Tasigarook Lagoon would reduce the risk to the community's freshwater source, and it would be extended north-easterly to reduce risks at Pump Station #3 of the Utilidor. Infrastructure at greatest risk from flooding would get a flood risk reduction by raising or relocating lower elevation buildings and utilities. This would not reduce the risk to property stored outside on the ground, such as boats, snow machines, ATVs, cars, and/or trailers. The minimum elevation to raise the structures and utilities would consider the social, local, and economic issues associated with any action and be based on the flood exceedance probabilities and stage frequency flood plots that can be found in detail in Appendix D.

5.4.7 Alternative 5B. Barrow and Browerville Neighborhoods

Expanding on Alternative 5A, this alternative would include a rock revetment for the bluffs starting at the airport to Barrow. The revetted berm would be extended from Pump Station #3 north to the end of Browerville, near the intersection of Stevenson Street and Ahmoagak Avenue.

5.4.8 Alternative 5C: Barrow and Browerville Neighborhoods plus NARL

Expanding on Alternative 5B, this alternative would raise and revet Stevenson Street in front of NARL to reduce the risk of flooding and washing out the road in this low lying area.

5.4.9 Alternative 5D: Barrow and Browerville Neighborhoods Plus NARL and Landfill

Expanding on Alternative 5C, this alternative would reduce the risk of flooding impacts to the sewage lagoons and landfill, which would have negative environmental impacts by beach nourishing the length of shoreline between the revetted berm at the end of the Browerville neighborhood and where the road is raised near NARL. This would effectively create a continuous project to reduce risk to the community during the open water period and increasing storm events.

5.4.10 Alternative 6A: Combination Rock Revetment, Raise Stevenson Street, and Revetted Berm with Limited Beach Nourishment

This alternative includes erosion and flood risk reduction in front of the airport through the end of NARL with a secondary level of risk reduction added as beach nourishment. Various risk reduction measurements would be used for different stretches of the beach. The bluffs would be revetted; a revetted berm along with beach nourishment would be constructed in front of Tasigarook Lagoon and continue through the end of Browerville, and then Stevenson Street would be raised from the end of the berm through the end of NARL.

5.4.11 Alternative 6B: Combination Rock Revetment, Raise Stevenson Street, Revetted Berm, and Beach Nourishment:

Alternative 6B is similar to 6A in the type and length of coastal risk reduction measures.

However, instead of raising Stevenson Street in front of the sewage lagoon and landfill, these areas would only utilize beach nourishment for coastal risk reduction.

5.4.12 Alternative 6C: Beach Nourishment Only

This alternative only includes beach nourishment as a risk reduction measure. Beach nourishment would be placed along approximately 5 miles of coastline, from the airport through the end of NARL, where Stevenson Street intersects with Dewline Road. The beach nourishment could be gravel or coarse sand, depending on the method of fill design. The interval of re-nourishment would depend on the size of the material used for the initial nourishment.

5.4.13 Alternative 7: Series of Offshore Breakwaters and Beach Nourishment

A series of breakwaters would be constructed offshore to lessen wave action and reduce risk to the shoreline during storm events. Accompanied with beach nourishment, current residences and public infrastructure could be floodproofed in place with ring walls (risk reduction levees) placed around pump stations and the old Navy landfill. An advanced warning system would also be established to allow the public to prepare during severe storm events.

5.5 Alternatives Carried Forward to Tentatively Selected Plan Milestone

A description of each alternative that was carried forward to the TSP Milestone is depicted in Table 6. Alternatives 3, 4, and 7 were eliminated prior to the TSP Milestone. Alternative 3, floodproofing, buyout acquisition and beach nourishment did not address the risk of erosion and wave run-up during storm events. Flood-proofing structures would have reduced risk to public and private infrastructure, but would not have addressed the erosion at the bluff, loss of tangible cultural heritage and threat of saltwater inundation to the Utilidor and freshwater lagoon. Buyout acquisition was not feasible due to the housing shortage that currently persists in the community. In addition, this measure alone would not address erosion at the bluff nor the wave run-up and inundation from storm events.

The freshwater lagoon (sole water source), landfill, and sewage lagoons would continue to be threatened and are unable to be bought out and relocated. This measure was carried forward and combined with structural measures to form the final array of alternatives. Beach nourishment was screened as a measure due to the lack of suitable material in the community and the high cost of importing material. Because the primary causes of erosion is related to the reduction in sea ice and permafrost melting, Alternative 4 was not guaranteed for a 50-year period and was screened out. Alternative 7 would decrease wave action; however, it would not eliminate the risk of flooding and was subsequently screened out from further consideration.

Table 6. Alternatives Carried Forward to TSP Milestone.

Alternative	Description
Alternative 1 (No Action)	This alternative would be to take no action and leave the City of Barrow susceptible to the effects of storms.
Alternative 2A*	Rock Revetment at Bluff and Berm in Front of Stevenson Street
Alternative 2B*	Rock Revetment at Bluff and Raise Stevenson Street
Alternative 5A	Reduce Risk to Major Infrastructure
Alternative 5B	Barrow and Browerville Neighborhoods
Alternative 5C	Barrow and Browerville Neighborhoods Plus NARL
Alternative 5D	Barrow and Browerville Neighborhoods Plus NARL and old Navy Landfill
Alternative 6A	Combination Rock Revetment, Raise Stevenson Street, and Revetted Berm with Limited Beach Nourishment
Alternative 6B	Combination Rock Revetment, Raise Stevenson Street, Revetted Berm, and Beach Nourishment
Alternative 6C	Beach Nourishment Only

*See Section 5.6.1 for a revised description of the preferred alternative for the TSP Milestone, Alternative 2 Rock Revetment, Berm, and Raise Stevenson Street.

5.6 Original Alternatives Carried Forward as the Recommended Plan

Alternatives 2A and 2B are close in cost and have the same output for reducing the risk of flooding and erosion along the entire study area. It was determined, with Vertical Team alignment, that these two areas should be combined into one alternative as the Recommended Plan. The revision of Alternatives 2A and 2B into Alternative 2 is described in Section 5.6.1.

5.6.1 Alternative 2 Revised

Rock Revetment, Berm, and Raise Stevenson Street. This alternative would provide erosion risk reduction for the bluffs in front of Barrow starting in front of Wiley-Post Will Rogers airport and heading north until the bluffs start to decrease in height from +19 ft MLLW to +15 ft MLLW. A +14.5 ft MLLW berm would tie into the rock revetment and follow the shoreline north to where Tahak Street intersects Stevenson Street.

Stevenson Street would be raised to a height of +14.5 ft MLLW with the seaward side revetted starting at this intersection and heading north to Dewline Road, just past NARL. Existing beach access areas within the project footprint were identified during the public comment period, with community input. Alternative 2 would account for spring break-up, drainage, and public access. Joining the NFIP is a component of this alternative to meet the guidance cited in Section 5.3.2. The alternatives carried forward from the TSP Milestone are shown in Figure 14.

Figure 14. Initial Alternatives Carried Forward from the TSP Milestone.
*Note: Yellow numbered area is for reach reference.

5.7 Final Array of Alternatives

5.7.1 Screening and Revision of Alternatives before Agency Decision Milestone

As mentioned in Section 5.3, additional screening took place after the TSP Milestone. Due to the high cost and risk associated with beach nourishment, this measure was screened out. In addition, it was determined that filling in Tasigarook Lagoon was not an effective standalone measure, and it was screened from consideration because it was not necessary to double armor Tasigarook Lagoon because a berm is sufficient for reducing flooding in this area. A high cultural resource presence in the vicinity of this lagoon was also a concern and could incur high mitigation costs.

Screening out these measures left only Alternative 2 remaining. The PDT conducted a reach by reach analysis to determine which combinations of reaches and measures were cost-effective and which ones were best buys in the CE/ICA analysis explained in Section 6.6. Reaches are depicted in Figure 15 as a yellow bar numbered 1 through 6. At this stage, the numbering scheme was also modified to capture the reach by reach analysis. Alternatives will now be referred to as A through H, except for Alternative 1 (the No Action Alternative).

Due to the terrain and existing infrastructure, Reaches 1 and 2 are limited to the bluff revetment as a risk reduction measure. Similarly, Reach 3 is at sea level and does not contain a coastal road. Therefore, the only suitable measure would be the revetted berm. For Reaches 4-6, a cost analysis was conducted to determine if a revetted berm or raising and revetting Stevenson Street would be more affordable and cost-effective. Raising and revetting Stevenson Street is the least costly measure, and since both types of revetment provide the same level of risk reduction for flooding and erosion, raising and revetting the road was chosen as the preferred option. The reach by reach combination of the remaining measures (revetment, revetted berm, and raise Stevenson Street) is shown in Table 7 and Figure 15.

Table 7. Final Array of Alternatives.

Alternative	Description
No Action	
A	Barrow and Lagoon
B	Barrow, Lagoon, and Bluff
C	Barrow, Lagoon, Bluff, and Browerville
D	Barrow, Lagoon, and South and Middle Salt
E	Barrow, Lagoon, Bluff, and South and Middle Salt
F	Barrow, Lagoon, Bluff, Browerville, and South and Middle Salt
G	Barrow, Lagoon, Bluff, South and Middle Salt and NARL
H	Barrow, Lagoon, Bluff, Browerville, South and Middle Salt, and NARL

Figure 15. Final Array of Alternatives.
*Note: Yellow numbered area is for reach reference.

After the charette, the PDT decided that the fewest number of reaches to meet one objective of the study would be Reaches 2 and 3 (initial Alternative 5A explained in Section 5.4.6). This combination of reaches reduces the risk of inundation to the freshwater lagoon and Pump Stations #3 and #4 of the Utilidor, which are located on the coast. Because of this determination, the final array of alternatives, at a minimum, combined Reaches 2 and 3 (Barrow and Lagoon). In addition, joining the NFIP is a component of every alternative (A-H) to meet the guidance cited in Section 5.3.2.

5.7.2 Alternative A: Barrow and Lagoon

A rock revetment would be constructed against the natural bluff in the area labeled Barrow (Reach 2) in Figure 15. The lagoon (Reach 3) area would have a revetted berm constructed to reduce the risk of saltwater inundation to the community's freshwater source.

5.7.3 Alternative B. Barrow, Lagoon, and Bluff

Alternative B is Alternative A, with the addition of a rock revetment constructed against the natural bluff in the area labeled as bluff (Reach 1) in Figure 15.

5.7.4 Alternative C: Barrow, Lagoon, Bluff, and Browerville

Alternative C is Alternative B, with the addition of raising and revetting Stevenson Street in the area marked Browerville (Reach 4) in Figure 15 to reduce the risk of flooding to the neighborhood, which is a low lying area.

5.7.5 Alternative D: Barrow, Lagoon, and South and Middle Salt

Alternative D is Alternative A, with the addition of raising and revetting Stevenson Street in the area marked South and Middle Salt (Reach 5) in Figure 15 to reduce the risk of overtopping of the road and flooding to the landfill and sewage lagoons.

5.7.6 Alternative E: Barrow, Lagoon, Bluff, and South and Middle Salt

Alternative E is Alternative B, with the addition of raising and revetting Stevenson Street in the area marked South and Middle Salt (Reach 5) in Figure 15 to reduce the risk of overtopping of the road and flooding to the landfill and sewage lagoons.

5.7.7 Alternative F: Barrow, Lagoon, Bluff, Browerville, and South and Middle Salt

Alternative F is Alternative E, with the addition of raising and revetting Stevenson Street in the area marked Browerville (Reach 4) in Figure 15 to reduce the risk of flooding to the neighborhood, which is a low lying area.

5.7.8 Alternative G: Barrow, Lagoon, Bluff, South and Middle Salt, and NARL

Alternative G is Alternative E, with the addition of raising and revetting Stevenson Street in the area marked NARL (Reach 6) in Figure 15 to reduce the risk of flooding and over topping of the road during strong weather events.

5.7.9 Alternative H: Barrow, Lagoon, Bluff, Browerville, South and Middle Salt and NARL

Alternative H reduces the risk of flooding and erosion impacts to the entire 5-mile study area. A rock revetment would be constructed against the natural bluff in the areas marked bluff (Reach 1) and Barrow (Reach 2) in Figure 15. The lagoon (Reach 3) area would have a revetted berm constructed to reduce the risk of saltwater inundation to the community's freshwater source. The areas of Browerville (Reach 4), South and Middle Salt (Reach 5), and NARL (Reach 6) would have a raised and revetted Stevenson Street to reduce the risk of flooding and overtopping of the road during strong weather events.

6. COMPARISON AND SELECTION OF PLANS

6.1 With-Project Condition

The alternatives were designed to meet the planning objectives and criteria and were evaluated based on environmental, economic, and engineering considerations. This section summarizes the damages expected to occur under the various future with-project (FWP) scenarios. Continued erosion and flooding damages in all FWP scenarios are lower than in the FWOP condition (i.e., Alternative 1: No Action).

6.2 Biological Condition

6.2.1 Tundra

The No Action Alternative would impact a larger area of tundra habitat over the long-term, due to bluff erosion and wave run-up action, than any of the action alternatives. This alternative would not reduce risk at the bluff, leaving it susceptible to the natural elements and causing harm from both erosion and salt water exposure.

Alternative H encompasses the entire study area and includes an element of bluff revetment. The revetment along the bluff would stop future loss of tundra from future erosion and storm events. No significant impacts to tundra habitat would be anticipated. Alternatives A and D include a smaller area of bluff revetment in front of Barrow that Alternative H, leaving the bluff area with similar impacts as the No Action Alternative. Alternatives B, C, E, F, and G would have impacts similar to Alternative H because they each include the measure of armored bluff revetment extending along the same reaches. The revetment would not extend over the bluff, so there would be no effect to the tundra habitat on top of the bluff. The revetment would also reduce the risk of further erosion to the tundra area. None of the proposed staging areas would impact tundra, so no significant impacts would anticipated. Section 3 of the EA (Appendix B) discusses these impacts further.

6.2.2 Birds

The No Action Alternative has the potential to negatively impact a variety of bird species in both terrestrial, freshwater, and marine environments. While this alternative avoids all potential construction impacts associated with revetments, there are several potential implications of the No Action Alternative. Coastal erosion and, to a greater extent, coastal flooding, typically leads to contamination and degradation of the marine environment, leaving debris scattered across the tundra, in freshwater lakes (including drinking water sources), and into the marine environment. This debris can impact birds on land, freshwater, and marine waters. In addition to the debris, a more persistent potential problem involves spills of fuel and oil from a major erosion event or a flood. These sorts of items can lead to long term pollution of terrestrial, freshwater, and nearshore marine habitats and the bird species that rely on them.

The proposed project area for Alternatives A through H would not be used for nesting by any bird species. The area is eroded, filled annually, and receives a large amount of disturbance from vehicle and foot traffic. Several species of waterfowl and gulls would rest offshore, but this typically occurs farther north along the spit, especially near Point Barrow, which is outside the study area. The area of the spit adjacent to Elson Lagoon is heavily used as a crossing point for waterfowl migration to the west along the Beaufort Sea before turning south along the Chukchi Sea, and is well north of the study area. Other birds common in the study area include glaucous gulls and arctic terns, but these species already appear to tolerate the large amount of activity in the area and do not nest anywhere in the study area. Section 3of the EA (Appendix B) discusses these impacts further.

6.2.3 Marine Mammals

The No Action Alternative could lead to several negative impacts for marine mammals. Coastal erosion and, to a greater extent, coastal flooding, typically leads to contamination and degradation of the marine environment. Erosion and flooding scatter everything from building materials to all types of personal property throughout the landscape, leaving debris in the marine environment. This debris can impact birds and marine mammals by entanglement and ingestion. In addition to the debris, a more persistent potential problem involves spills of fuel and oil from a major erosion event or a flood. Since a large portion of the subsistence resources are locally harvested, the effects of debris and spills could have long term effects on subsistence, especially for protected species like seals and bowhead whales.

Alternative H would have no effect on polar bears. The project area is already degraded and disturbed due to active coastal erosion and the continual placement of sacrificial gravel to mitigate the effects of erosion from flooding during storm events. The footprint of this project and the proposed staging areas does not involve valuable habitat for polar bears or serve an important function, other than passage along the coastline. Polar bears would still be able to pass through the area during and after construction.

Alternative H would have no effect on whales (humpback, bowhead, orca, or gray) as there is no marine construction taking place and the barge traffic necessary to bring in construction materials would occur in an area where there is existing disturbance. This alternative would also have no effect on bowhead whales due to the very unlikely overlap between their distribution and the timing of material transport. Gray whales could be present in the area coincidental with barge traffic, albeit at low densities on an occasional basis, but tug boats in the project area are typically either holding the barge against the shoreline during unloading or travelling very slowing in a holding pattern offshore while waiting to offload. There is also no marine construction occurring as the project footprint is above the MHHW line. Most seal species and walrus would be out of the area during construction. Spotted seals could be encountered in small numbers on a very infrequent basis. There are no areas within the project footprint or several miles in either direction where seals and walrus would be expected to haul out of the water. Narwhal are extremely rare in Arctic waters in Alaska and would not be affected by this project.

Alternatives A through G would have the same effects as Alternative H, but would have a smaller footprint and therefore take a shorter period of time to construct and involve less material. These alternatives would have no effect on either species of eider, polar bears, bowhead or humpback whales. With the No Action Alternative, the entire coastline, would still continue to be susceptible to erosion and flooding and the risk of debris and pollutant contamination would remain a threat to all of the protected species discussed in this section. Section 3of the EA (Appendix B) discusses these impacts further.

6.2.4 Marine Fish and Invertebrates

The No Action Alternative could lead to several negative impacts for marine fish and invertebrates. While the No Action Alternative avoids all potential construction impacts associated with revetments, there are several potential implications of the No Action Alternative. Coastal erosion and, to a greater extent, coastal flooding, typically leads to contamination and degradation of the marine environment. Erosion and flooding scatter everything from building materials to all types of personal property throughout the landscape, leaving debris strewn across the tundra, in freshwater lakes (including drinking water sources), and into the marine environment. In addition to the debris, a more persistent potential problem involves spills of fuel and oil from a major erosion event or a flood. This issue concerns everything from large scale releases, such as the gas station or large fuel tanks and the landfill, to numerous small spills from fuel cans, four-wheelers, snow machines, home heating oil tanks, etc. These sorts of items are moved, toppled, and displaced during major erosion and flood events and can lead to long term pollution of terrestrial, freshwater, and nearshore marine habitats and the humans and wildlife species that rely on them. Since a large portion of the subsistence resources are locally harvested, the effects of debris and spills can have long term effects on subsistence.

Alternative H does not involve placing fill in the water, so there are no consequences anticipated for nearshore fish and invertebrates from this alternative. Essential Fish Habitat would not be impacted by the proposed project and is not considered further in this document. The proposed staging areas for construction materials are all located in disturbed areas on shore and would not impact marine fish or invertebrates.
While the effects of Alternative H pose no impacts to marine fish and invertebrates because the project area is out of the water, the sections of coastline not included under all of the other action alternatives would leave open the possibilities described under the No Action Alternative in terms of impacts to marine fish and invertebrates from debris and contamination from future coastal erosion and flooding. Section 3of the EA (Appendix B) discusses these impacts further.

6.3 Alternative Plan Costs

A summary of alternative costs is shown in Table 8. Alternative cost development details can be found in Appendix E.

Table 8. Alternative Costs (FY20).

Alt.	Description	Present Value Construction Cost ($1000)	Annual Operations & Maintenance ($1000)	Average Annual Cost ($1000)
NA	No Action	--	--	--
A	R2+R3	$65,498	$399	$2,844
B	R2+R3+R1	$95,067	$563	$4,129
C	R2+R3+R1+R4	$140,800	$824	$6,129
D	R2+R3+R5	$157,671	$929	$6,843
E	R2+R3+R5+R1	$187,240	$1,093	$8,148
F	R2+R3+R5+R1+R4	$232,973	$1,354	$10,172
G	R2+R3+R5+R1+R6	$252,316	$1,468	$11,018
H	R2+R3+R5+R1+R4+R6	$298,049	$1,729	$13,061

*Note: The order of the reaches is the order developed during the CE/ICA as the optimal order for construction. Interest During Construction (IDC) was estimated at 4 months of construction duration per reach (FY20 rate of 2.750 percent), and was added manually after running the CE/ICA.

6.4 With-Project Benefits

The NED benefits from the 2010 Technical Report were updated to FY20 price level and discount rate of 2.750 percent. This update to the 2010 NED analysis includes price level and discount rate updates of the estimated FWOP damages from that previous study. These updated values were then compared to the cost of the alternative plans formulated for the current study. The NED benefits for Alternatives A through H are summarized in Table 9.

Table 9. NED Benefits.

ID	Scenario	Ann. Cost ($1000)	Annual CRUs	NED Benefits ($1000)	Net NED Benefits ($1000)	BCR
NA	No Action	$0	0.00	$0	$0	-
A	R2+R3	$2,844	10.50	$3,431	$587	1.21
B	R2+R3+R1	$4,129	16.63	$4,391	$263	1.06
C	R2+R3+R1+R4	$6,129	22.57	$6,242	$113	1.02
D	R2+R3+R5	$6,843	36.49	$5,189	($1,653)	0.76
E	R2+R3+R5+R1	$8,148	42.62	$6,149	($1,998)	0.75
F	R2+R3+R5+R1+R4	$10,172	48.74	$7,999	($2,172)	0.79
G	R2+R3+R5+R1+R6	$11,018	48.75	$6,411	($4,606)	0.58
H	R2+R3+R5+R1+R4+R6	$13,061	54.87	$8,261	($4,800)	0.63

Alternative A has the highest net NED benefits of $587,000 resulting in a BCR of 1.21 and is therefore, the NED plan. This alternative would reduce risk of inundation to two pump stations (# 3 and 4) on the Utilidor and the risk of saltwater inundation to the freshwater lagoon. This alternative would not address erosion and would result in continued life safety risk of private infrastructure near the bluff edge due to the bluff succumbing to slumping as the permafrost is undercut by wave action. In addition, the objective of reducing loss of tangible cultural heritage, specifically at the Utqiagvik Historical Site, which is actively eroding out of the bluff would not be met. The community of Browerville, NARL, the sewage lagoons, and landfill would see continuous impacts of flooding as these areas would not be addressed under this alternative. Leaving Reaches 1 and 4-6 at risk jeopardizes the infrastructures for those areas and the life health and safety considerations as described in Section 7.1.1.

Alternative B has positive net NED benefits of $263,000 and a BCR of 1.06. This alternative would provide the same level of risk reduction as Alternative A, with the addition of addressing erosion at the bluff in front of Barrow to reduce loss of tangible cultural heritage and threats to private infrastructure. This alternative would still leave the community of Browerville, NARL, the sewage lagoons, and landfill susceptible to flooding. Leaving Reaches 4-6 at risk jeopardizes the infrastructures for those areas and the life health and safety considerations as described in Section 7.1.1.

Alternative C has positive net benefits of $113,000 and a BCR of 1.02. This alternative would provide the same level of risk reduction as Alternative B, with the addition of reducing the risk of flooding to the community of Browerville. This alternative would still leave NARL, the sewage lagoons, and the landfill susceptible to flooding. Leaving Reaches 5-6 at risk jeopardizes the infrastructures for those areas and the life health and safety considerations as described in Section 7.1.1.

Although an NED Plan has been identified, the plan would not address all of the study objectives, resulting in areas of the community left vulnerable to erosion and flooding impacts, nor would it reduce risk to all of the areas described in Section 7.1.1. Based on the Section 116 authority, the other social effects account can be considered and a cost effectiveness, incremental cost analysis can be performed. This analysis was pursued and is explained in Section 6.6.

6.5 Sensitivity Analysis

6.5.1 Sensitivity Analysis for Environmental Component

The environmental variable for the landfill only falls under one reach, Reach 5 South and Middle Salt Lagoons. A sensitivity analysis was conducted to determine how to proceed with weighting of the CRU components. Unless the environmental input is significantly reduced to 5 percent or less, Reach 5 does not shift order to the highest incremental cost per unit, as shown in Figure 16 and Figure 17. Note that the total CRUs and Cost shown on the X and Y axes on the following figures were computed prior to the final refinement iteration of the CE/ICA and therefore do not match totals shown in Section 6.6. Minor changes resulted from the final refinement and were found not to have changed prior plan formulation steps, including this sensitivity analysis.

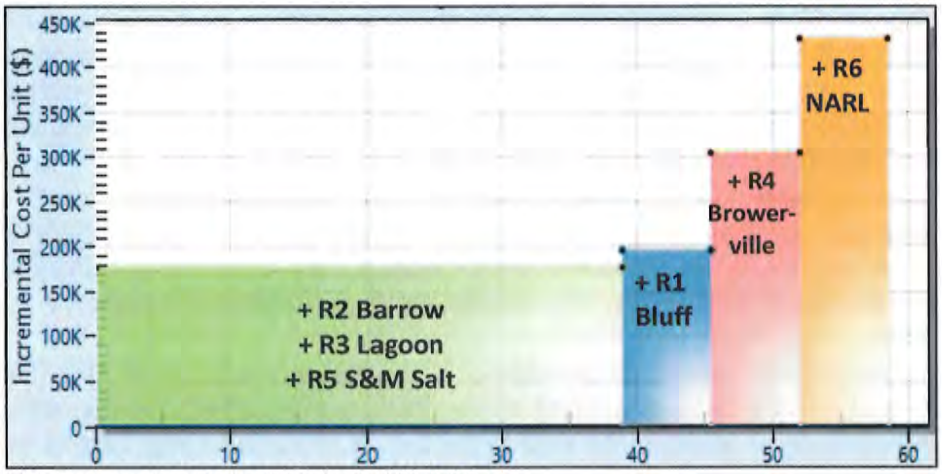

Figure 16. Environmental Output Equally Weighted.

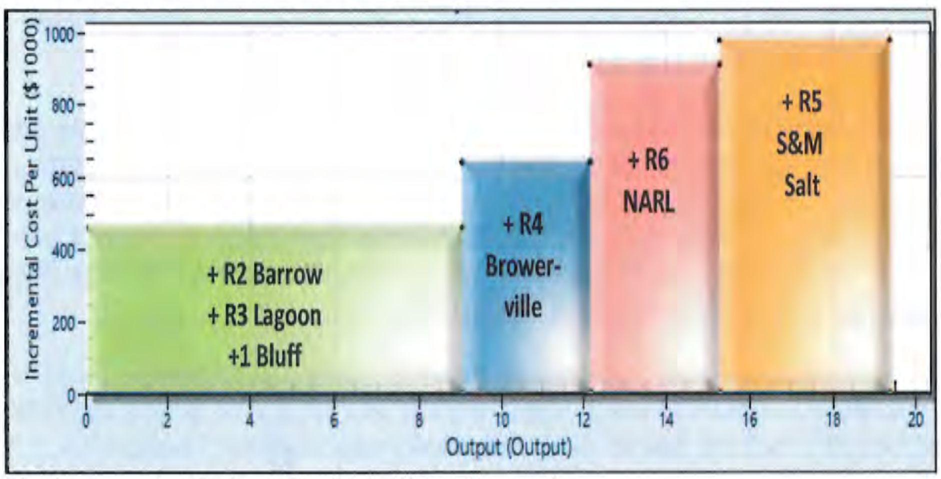

Figure 17. Environmental Output Reduced to 5 Percent.

6.5.2 Sensitivity Analysis for Design

The sensitivity analysis for design height considered two increased heights for the design. No lower heights were considered based upon the judgment of the PDT engineering component that the minimum height was already specified in the base design (Appendix I).

To evaluate the effects of height, the reach-by-reach analysis was repeated for the two additional height scenarios. The first scenario increased the height of the revetment by 1 foot, and the second scenario increased it by another 1.5 ft. In each scenario, the CRU output was recomputed based upon the CE/ICA framework. The computed CRUs and NED benefits for each design height are summarized in Table 10.

Table 10. Sensitivity for Design Height.

Scenario	Ann. Cost ($1000)	NED Benefits ($1000)	Net NED Benefits ($1000)	BCR	CRUs
Base	$13,039	$8,329	($4,710)	0.64	58.58
Base + 1 foot	$13,970	$8,339	($5,631)	0.60	59.28
Base + 2.5 feet	$15,437	$8,345	($7,092)	0.54	59.69

Note: Cost shown were computed prior to the final iteration of the CE/ICA. Differences in costs used in the sensitivity analysis and final iteration are marginal, vary consistently between alternatives, and were found to not affect plan prior formulation decisions related to this sensitivity analysis.

Additionally, with increased ice-free seasons, and increasing storm frequency, conditions are expected to worsen into the future. The PDT considered the effects of an increasingly long open-water (ice free) season and the analysis was approved for one-time use through the USACE's model certification process. The current open water season is approximately 92 days, from 15 July to 15 October. Once shorefast ice comes in, coastal storm risk is minimized until the ice recedes again in spring. Given ongoing changes in long-term climate patterns in the Arctic, researchers forecast growth in the duration of the open water (ice-free) season. Such growth would expose the community to damage from wind events for a longer period of the year. If the trend of increase in the annual duration of the open-water season continues, the likelihood of storms occurring during open water also increases. Data for the ice-free durations was based upon research by the University of Alaska Fairbanks (Johnson and Eicken 2016, See Appendix C). Based upon this research, three growth scenarios were evaluated:

- Low growth: growth of 1.1 days per year, for 25 years
- Medium growth: growth of 2.2 days per year, for 25 years
- High growth: growth of 2.2 days per year, for 50 years

For the purpose of the analysis, the low-growth scenario was chosen as an appropriate scenario to incorporate the risk associated with additional open water season, while remaining conservative regarding the representation of long-term changes in climate conditions.

6.5.3 Sensitivity Analysis Conclusions

The conclusion of the sensitivity analyses also showed that it was appropriate to proceed to final analysis with the equal weighting scheme for CRU components and that the lowest design height would be carried forward. The CE/ICA assessed all possible combinations of Reaches 1 through 6 with the caveat that the minimum plan to be considered is Reaches 2 and 3 because this is the smallest plan that meets at least one of the three study objectives. Therefore, all combinations presented in the next section include at a minimum, Reaches 2 and 3.

6.6 Cost Effective/Incremental Cost Analysis (CE/ICA)

6.6.1 Community Resilience

Risks to the Barrow community can be quantified in terms of local and regional economic impacts, risk to life and public health and safety, and risk of environmental contamination. As directed by Section 116 Implementation Guidance, when there is no NED Plan and/or the selection of a plan other than the NED Plan is based in part or whole on non-monetary units, the selection must be supported by a CE/ICA consistent with established evaluation procedures in ER 1105-2-100, Appendix E.

The PDT developed a framework for evaluating the effects of alternatives based upon the concept of community resilience. The proposed community resilience evaluation framework provides the data required for a CE/ICA to compare alternatives in terms of their contribution to improving community resilience at Barrow. Community resilience emphasizes the cooperation of a broad base of stakeholders and supporting partners. A resilience planning process helps a community define its greatest risks and supports decisions that decrease those risks and increase resilience.

To facilitate characterization of community resilience across projects and systems, a triple bottom line framework considered economic, social/cultural, and environmental components. This approach identified variables within each resilience component and identified key consequences that describe community resilience. The proposed framework evaluated the alternatives in terms of their reduction of adverse effects compared to the without-project condition.

A cross-walk between the nine identified consequence categories and the three resilience areas is explained in Table 11. As shown in the table, consequence categories may have more than one relevant unit of measure and may apply to more than one resilience area.

Table 11. Resilience Consequence Categories and the Triple Bottom Line.

<table>
<tr><th rowspan="2">Consequence Category</th><th colspan="3">Community Resilience</th></tr>
<tr><th>Economic</th><th>Social / Cultural</th><th>Environmental</th></tr>
<tr><td>1) Flooding of Structures & Contents</td><td rowspan="5">▪Direct Damages</td><td>-</td><td>-</td></tr>
<tr><td>2) Erosion Loss of Structures & Contents</td><td>-</td><td>-</td></tr>
<tr><td>3) Erosion Land Loss</td><td>-</td><td>-</td></tr>
<tr><td>4) Erosion of Bluff (Historic Village Site)</td><td>▪Cultural Resources Lost</td><td>-</td></tr>
<tr><td>5) Flood Damage to South and Middle Salt Lagoons (Sewage System & Old Navy Landfill)</td><td>-</td><td>▪Landfill Contaminants Released
▪Sewage Lagoon Contaminants Released</td></tr>
<tr><td>6) Flooding of Isatkoak Lagoon (Water Supply and Utilities)</td><td rowspan="3">▪Direct Damages
▪Job Opportunities Lost</td><td rowspan="3">▪ Utility / Water Supply Service Lost</td><td>-</td></tr>
<tr><td>7) Flooding of Utilidor (Loss of Service for Critical Utilities)</td><td>-</td></tr>
<tr><td>8) Erosion Damage to Utilidor (Loss of Service for Critical Utilities)</td><td>-</td></tr>
<tr><td>9) Flooding/Erosion Damage to Stevenson Street and Beach Berm, Emergency Maintenance and Capital Expenditures</td><td>▪Direct Damages</td><td>▪ Days Flood Fighters at Risk</td><td>-</td></tr>
</table>

This resilience-based framework for evaluating without-project conditions and the effects of alternatives is translated into a CE/ICA analysis by identifying a set of output variables that may serve as measurement tools for the types of consequences shown in Appendix C. Six such variables were identified for this framework, including:

6.6.1.1 Economic Resilience Variables

- *Direct Dollar Damage (DDD)*: This variable accounts for dollar damages and costs as a direct result of flood and/or erosion damage; such as structure and content losses, or storm response costs.

- *Full Time Equivalent Job Impacts (FTE)*: This variable accounts for the number of person days (full time equivalent) job opportunities lost due to estimated downtime of critical utility services due to coastal erosion and/or flooding.

6.6.1.2 Social/Cultural Resilience Variables

- *Cultural Resource Acres at Risk (CRA)*: This variable accounts for the known area of significant cultural resources associated with the original Utqiaġvik Village Site in the Barrow Neighborhood. Areas are quantified in terms of the total area at risk of loss to coastal erosion.

- *Person-days without Critical Utilities (PDU)*: This variable accounts for the threat to public health and safety associated with loss of critical life sustaining utility services in the harsh arctic environment of the study area. The variable is based upon the affected population and the expected duration of service interruption due to either saltwater inundation or damage to the water supply and utility infrastructure at Isatkoak Lagoon, Tasigrook Dam, or the Utilidor.

- *Person-days in High-Risk Flood Fighting Activity (PDH)*: This variable accounts for risk to human health and safety and is quantified in person-days of high-risk emergency maintenance flood fighting activity. During coastal storms the NSB frequently must perform emergency berm repair and shore protection during the storm, necessitating that machinery operators work during dangerous conditions; including operation of heavy equipment in the surf, seaward of the revetted berm.

6.6.1.3 Environmental Resilience Variables

- *Cubic Yards Contaminated Fill (CYF)*: This variable accounts for the damage to the environment surrounding the study area. It is based upon the estimated volume of potentially contaminated materials at risk of spill from flooding or erosion; including both the community sewage lagoons and known contaminated solid waste in the adjacent old Navy Landfill.

After estimating effects (risk reduction) in terms of each variable for each alternative, results can be presented at the triple bottom line level by combining the effectiveness scores across variables for each resilience area. For input into CE/ICA, a single derived variable termed CRU's was generated by combining effects across the three resilience areas (Economic, Social/Cultural, and Environmental) and their constituent output variables. Using estimated CRU's for each alternative, a CE/ICA model was run using the IWR Planning Suite software. The annual CRUs per the six established reaches explained previously are listed in Table 12.

Table 12. Annual CRU's by Reach.

Reach	Annual CRU's
1. Bluff	6.13
2. Barrow	5.70
3. Lagoon	4.80
4. Browerville	6.12
5. South and Middle Salt Lagoons	25.99
6. NARL	6.13

Section 6.6.2 discusses the CE/ICA conducted on the reaches to determine a best buy plan using these CRUs and the IWR Planning Suite.

6.6.2 Cost Effective and Best Buy Plans

The CE/ICA framework was applied to compute CRUs by reach to determine the cost effective and best buy plans. As noted previously, the PDT identified that the selected plan would need to include Reaches 2 and 3, at a minimum, to sufficiently address one of the three study objectives. As such, dependencies were specified in the CE/ICA model to require that Reaches 2 and 3 be included in all combinations of plans. The resultant plot of all possible combinations is presented in Figure 18. The incremental cost box plot for the best buy plans is presented in Figure 19. The incremental cost calculations for the best buy plans is presented in Table 13.

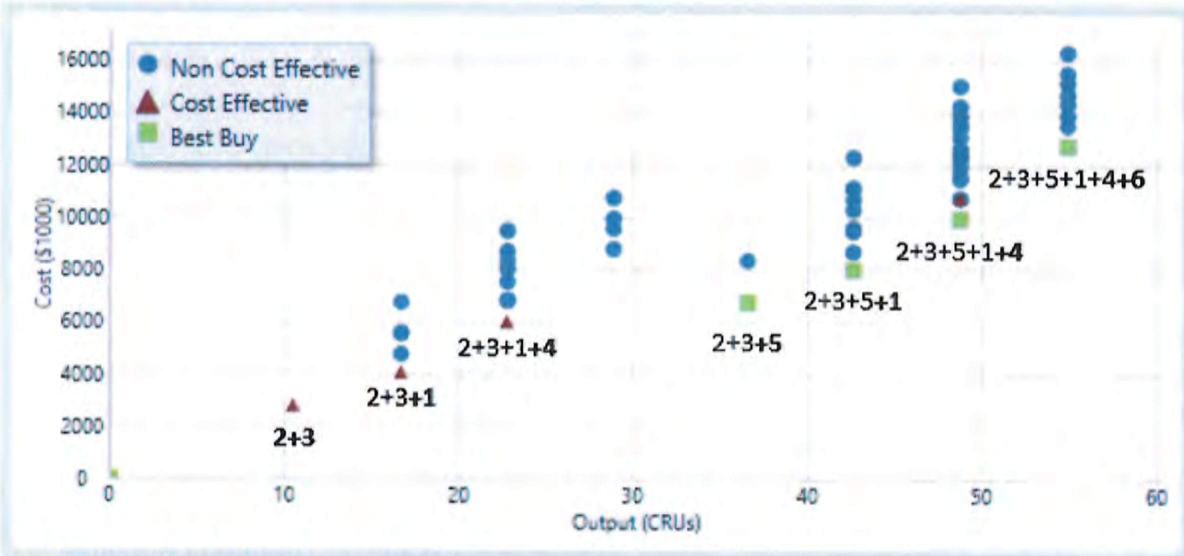

Figure 18. All Possible Plans by Reach.

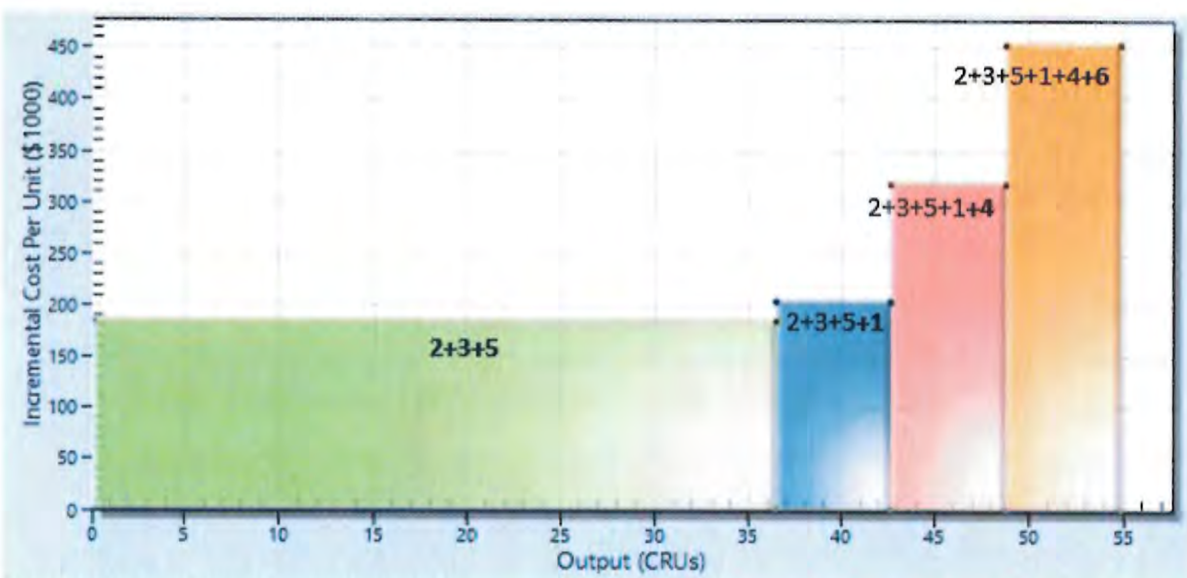

Figure 19. Best Buy Plans by Reach.

Table 13. Incremental Cost for Best Buy Plans by Reach.

Scenario	Annualized Cost ($1000)	CRU	Incremental Cost per Unit ($1000)
No Action	$0	0	$0
R2+R3+R5	$6,843	36.49	$188
R2+R3+R5+R1	$8,148	42.62	$213
R2+R3+R5+R1+R4	$10,172	48.74	$331
R2+R3+R5+R1+R4+R6	$13,061	54.87	$471
Note: IDC was added manually assuming 4 months of construction per included reach at the FY20 rate of 2.750 percent.			

Because the results indicated that some plans, which were cost effective, but not best buys may have positive net NED benefits, both the cost effective and best buy plans were carried forward. The cost effective and best buy plans are shown on a map in order to orient them to the study area (Figure 20).

As illustrated in Figure 19 and Table 13, Reach 5 is the first best buy addition after the required Reaches (2 and 3). This is attributable to the fact the in the CE/ICA framework for this project, only Reach 5 includes any environmental output, and as such, Reach 5 is the only reach where the environmental component of the triple bottom line framework is represented. Since each of these components is equally weighted within the framework, Reach 5 effectively accounts for about one third of the total possible CRUs. The sensitivity of the results to this weighting is explained in Section 6.5. The conclusion of that sensitivity analysis is that the equal weighting is appropriate.

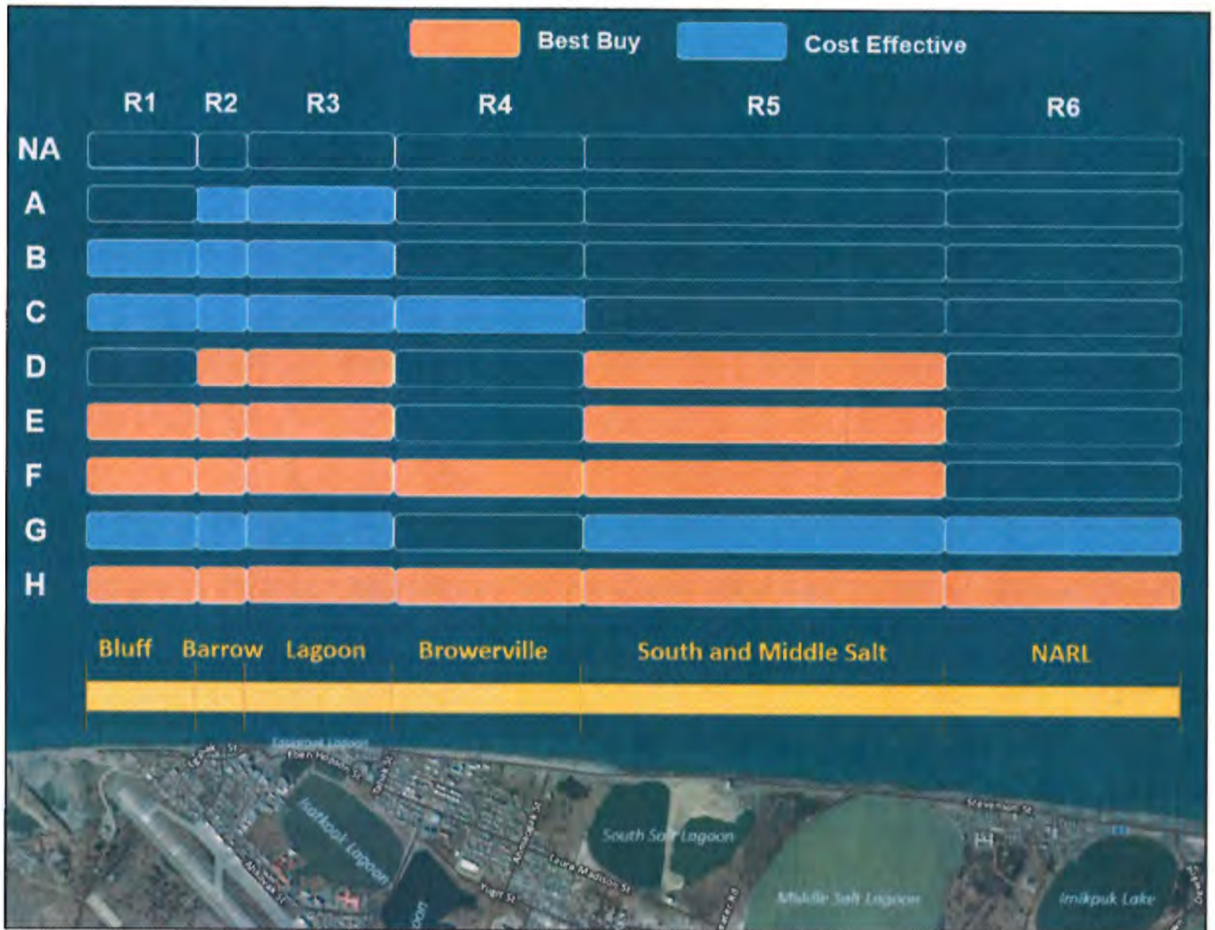

Figure 20. Cost Effective and Best Buy Plans Mapped by Reach.

6.6.3 CE/ICA Conclusions

Of the four best buy plans, Alternatives D, E, F, and H, the PDT determined that the plan that meets all of the study objectives and provides the greatest reduction of risk to the community from flooding and erosion impacts is Alternative H. A full explanation of the Recommended Plan components and justification can be found in the Section 7.

6.7 Priority by Reach Implementation

If funding is not available in full, the PDT recommends considering both the best buy plan order in the CE/ICA and the H&H perspective of constructing a solid structure instead of discontinuous parts. This would result in Reaches 2 and 3 being constructed first, followed by Reaches 1, 4, 5, and 6 (in that order), to build off of the original structure and reduce risk of creating weak points in the final 5-mile structure. It was suggested that Reach 1 be the second piece constructed if full funding is not available due to the unstable conditions of the permafrost, risk to private residences, and continuing loss of tangible cultural heritage. Section 7.1.1 depicts the key infrastructure in each reach.

6.8 Summary of Accounts and Plan Comparison

6.8.1 National Economic Development

Section 6.4 shows the net NED benefits for each alternative. Alternative A (Reach 2 and 3) has the highest NED benefits of $587,000 and BCR of 1.21. However, the Section 116 authority affords this study the ability to look at Other Social Effects (OSE). As explained in Section 6.6, the CE/ICA resulted in four best buy plans. One of the best buy plans, Alternative H, was determined to be the Recommended Plan in order to reduce the risk of erosion and flooding impacts to the entire community. Section 7.1.1 describes the key infrastructure in each reach and the level of risk reduction the community would gain from constructing the Recommended Plan, Alternative H.

6.8.2 Regional Economic Development

Economic benefits that accrue to the region, but not necessarily the nation, include increased income and employment associated with the construction of a project at the bluff. Additionally, commercial businesses subject to erosion are expected to experience income/revenue losses. If erosion continues at the current rate, commercial activities will be disrupted as business owners and operators will eventually have to relocate their business or shut down completely. As a result, these businesses will experience a loss in income and the city/borough government will experience the loss of tax revenue.

Regarding construction spending, further analysis of regional economic benefits is detailed in the Appendix C and RED Addendum. The Regional Economic Development (RED) analysis includes the use of the regional economic impact modeling tool RECONS (Regional ECONomic System) to provide estimates of regional and national job creation, retention, and other economic measures such as sales, or value added.

6.8.3 Environmental Quality

Environmental Quality displays the non-monetary effects of the alternatives on natural and cultural resources and is described more fully in Sections 3.3 and 3.5 of this report. One of the major opportunities or enhancements that could be realized as a result of the proposed project is the restoration of degraded environmental functions and values in the project area, including establishment of an ecologically stable and functional streambank. Following Section 116 Implementation Guidance, which allows for selection of a plan based in part or whole on non-monetary units in the Environmental Quality (EQ) and/or Other Social Effects (OSE) accounts, a rugosity index was proposed to evaluate the non-monetary effects of alternatives on ecological resources. As a measure of complexity, rugosity is presumed to be an indicator of the amount of habitat available for colonization by benthic organisms (those attached to the seafloor), and shelter and foraging area for mobile organisms. The rugosity index was initially proposed as a CE/ICA metric; however, it did not meet the needs of the study, as habitat complexity was similar among alternatives so the index did not distinguish benefits. As such, a CE/ICA was conducted based on non-monetary units for the OSE account.

A sensitivity analysis was conducted to determine the environmental weighting component for the sewage lagoons and landfill (Section 6.5). It was determined from this sensitivity analysis that the environmental component would be equally weighted. If the landfill and sewage lagoons were inundated or eroded out during a storm event, environmental contaminants would be released into the marine environmental, affecting nearshore habitat and the community's subsistence lifestyle.

6.8.4 Other Social Effects

The OSE of each alternative are generally positive and beneficial, with the exception being the No Action Alternative.

6.8.5 Four Accounts Evaluation Summary

The CRU outputs from the CE/ICA are a combination of the NED, RED, OSE, and EQ variables that were identified in the framework; therefore, a narrative description for the RED, OSE, and EQ columns has been provided to summarize these accounts instead of breaking apart the CRU variables. The descriptions under RED, EQ, and OSE are consistent with the CE/ICA evaluation in terms of which variables were applied in which reaches, and the account that those variables would roll up to. For example, our RED variable was FTE, and evaluated employment impact based upon loss of utilities in Reaches 2 and 3. So alternatives that reduce risk in Reaches 2 and 3 would eliminate all of the RED impact that was considered in the CE/ICA. Based on the analysis of the four accounts, a summary of the four accounts for all alternatives can be found in Table 14.

Table 14. Four Accounts Evaluation Summary.

Alternatives	Net Annual NED Benefits ($1000) (B/C Ratio)	Average Annual Cost	EQ	RED	OSE
A	$587 (1.21)	$2,844	No benefit in terms of reduction in environmental contamination risk since risk of flooding the landfill and sewage lagoons is not reduced in Reach 5.	All alternatives reduce risk to critical utilities in Reaches 2 and 3. Avoiding loss of critical utilities would minimize risk of regional economic impact due to utility system downtime. Positive employment and income effects associated with project construction would increase in proportion to project cost.	All alternatives except A and D would reduce risks to cultural resources on the Bluff. All alternatives reduce risk to Reaches 2 and 3, minimizing life safety risk associated with critical utility loss and downtime. Alternatives would reduce life safety risk associated with active berm maintenance during storms in proportion to project length
B	$263 (1.06)	$4,129			
C	$113 (1.02)	$6,129			
D	($1,653) (0.76)	$6,843	By reducing the risk of flooding in Reach 5, the risk of environmental contamination from the landfill or sewage lagoons into the marine environmental is eliminated.		
E	($1,998) (0.75)	$8,148			
F	($2,172) (0.79)	$10,172			
G	($4,606) (0.58)	$11,018			
H	($4,800) (0.63)	$13,061			

7. RECOMMENDED PLAN AND FUTURE WITH PROJECT IMPACTS

7.1 Description of Recommended Plan, Alternative H

Alternative H reduces flooding and erosion impacts to the entire five mile study area. A rock revetment would be constructed against the natural bluff in the areas marked Bluff and Barrow in Figure 15. The Lagoon area would have a revetted berm constructed to reduce the risk of saltwater inundation to the community's freshwater source. The areas of Browerville, South and Middle Salt, and NARL would have a raised and revetted Stevenson Street to reduce the risk of flooding and over topping of the road during strong weather events. Key infrastructure for Reaches 1-6 is listed in Section 7.1.1.

7.1.1 Key Infrastructure by Reach

Reach 1, Bluff:

- Utqiaġvik Village Site (NRHP Eligible)
    - Actively eroding onto the beach and washing away tangible cultural heritage
- 9 properties with 6 homes at risk of eroding off of the bluff
    - One house is 7 ft from the edge
- Projected that the corner of the airport could be threatened by erosion in the next 25 years

Reach 2, Barrow:

- Utilidor infrastructure along the coast including Pump Station 3
- HESCO basket wall failed in Fall 2018 – no longer supports a section of the bluff
    - Threatening an apartment building, many public facilities, and culturally signification site BAR-002
- Several residences currently using supersacs to reduce risks from flooding and erosion
- North end of this reach has seen major flooding and road overtopping during the August 2015 and 2017 storms

Reach 3, Lagoon:

- Freshwater lagoon
    - Only local freshwater source for the community
- Utilidor infrastructure including Pump Station 4
    - Water
    - Sewage
    - Fiber optic cables
    - Electricity
    - Essential for a community ~300 days/yr of below freezing temperatures
- Two important dam systems that regulate water level
    - Important culvert for draining Lower Isatkoak Lagoon during spring break up
- Several historic properties
- Burial sites located on South side of Tasigarook Lagoon
- Building on the National Register of Historic places on the north side of Tasigarook Lagoon

Reach 4, Browerville:

- Stevenson Street
    - Main access road north (to NARL)
- Barrow Utilities and Electric Cooperative Inc. (BUECI)
    - About $90M in buildings and utility infrastructure just landward of Stevenson Street
- Only gas station in Barrow is near the coast
- Several private residences and public facilities at risk of flooding
- Cultural site located on the southern portion of Browerville
    - Subject to flooding during storm events

<u>Reach 5, South and Middle Salt</u>:

- Landfill
    - Previously used by the Navy until the 1980s, was capped and fenced to finalize closing procedures before it was permanently passed to the NSB
    - Still occasionally used and recapped
    - Contaminants from landfill could be released into the nearshore environment threatening fish, marine mammals, and subsistence lifestyle
- Sewage lagoons (South and Middle Salt Lagoons) monitored per EPA standards and occasionally drained to Chukchi
    - Sea when below all thresholds for bacteria etc.
    - Flooding of these lagoons could increase risk to health and safety in the community

<u>Reach 6, NARL</u>:

- Stevenson St.
    - Only access to NARL, and beyond
- Duck Camp
    - Significant subsistence use area
- Boat ramp
    - Alternative vessel access – approximately a 17 mile journey to the open ocean for hunting
- Point Barrow and Nuvuk
    - Significant archaeological sites past NARL
- Bone yard
    - Dump whale, marine mammal, caribou, etc. bones to minimize polar bears in town
- Community of people that live at NARL
- Houses only Tribal College in the state of Alaska
- Important barge access for goods/fuel
- Contributes to commerce
- Utility corridor for area
- Radar at Dewline Road

- Reduce risk to National Security installation

The impacts to Reaches 1 and 2 are mainly caused by erosion. With a revetment in place, the loss of cultural resources in Reach 1 and 2 would be reduced at the Utqiaġvik Historical Site. Based upon the 2010 Technical Report, the project would reduce the AEP of flood water overtopping the berm and initiating damages to structures in Barrow from 5.5% to 1.1%, an approximate change from the 18-year to the 91-year recurrence interval. For critical utilities in Barrow, which are at a marginally higher elevation than structures, the project would reduce the AEP of flood-initiated damages from 2.6% to 1.1%, an approximate change from the 38-year to the 91-year recurrence interval.

In Reach 3, the Lagoon itself, has a temporary berm of super sacs on the seaward side to reduce wave run-up. Implementation of a permanent project would eliminate the need for super sacs and the subsequent emergency response costs to repair a temporary berm. In addition, pump stations 3 and 4 of the Utilidor are located in this reach and are affected by flooding and erosion. The NSB has raised these pump stations to reduce flooding probability, however erosion of the sides of these structures is still likely. Additionally, the corner of the Utilidor closest to the shoreline, as estimated by the community, could be eroded out within the next 25 years in the absence of a permanent structure. There are additional pump stations located near the coast and a permanent project would reduce the need to raise these stations in the future by minimizing the risk of flooding and erosion. Based upon the 2010 Technical Report, the project would reduce the AEP of flood water overtopping the berm from 3.1% to 1.3%, an approximate change from the 32-year to the 79-year recurrence interval.

The impacts to Reaches 4-6 are primarily flooding due to the nature of the coastline with low lying land. Some erosion of the beach, as fine material is carried away when the water recedes along with erosion of the sacrificial berms and Stevenson Street which is continually maintained by the NSB also takes place. Implementation of a project would reduce the need for the sacrificial berm and the continued maintenance of Stevenson Street in order to maintain access.

Reach 4 which contains the community of Browerville, the BUECI buildings and the only gas station in Barrow is affected by flooding due to wave run-up. If any portion of Stevenson Street in this reach or Reaches 5 and 6 is over-topped and rendered impassable, the community at NARL would be stranded without fuel, groceries and access to police and hospital services, and other necessities.

Implementation of a permanent project in this area would ensure that the community's fuel source and main utility buildings would be able to continue to operate without the NSB incurring costs to protect them with a temporary solution, especially in an area that has approximately 300 days below freezing per year. Based upon the 2010 Technical Report, the project would reduce the AEP of flood water overtopping the berm from 5.5% to 1.2%, an approximate change from the 18-year to the 85-year recurrence interval.

Reach 5 contains a large portion of Stevenson and includes the landfill and the sewage lagoons. Increased wave-run up during storm events could increase water levels in the lagoons and release harmful contaminants as the water recedes. The release of debris and contaminated soils from the landfill could have similar negative impacts to the nearshore environment and persist in the food chain negatively impacting marine mammals which is an important subsistence food for the local economy. Implementation of a permanent project would reduce the risk of debris and contaminated soils being released into the nearshore environment and flooding into people's homes causing life safety risk. In addition, a permanent structure would eliminate the need for a temporary berm and the risk to life safety with having operators actively flood fighting during storm events. The risk of incurring mitigation costs with release of contaminates into the nearshore environment would also be reduces. Based upon the 2010 Technical Report, the project would reduce the AEP of flood water overtopping the berm from 21% to 0.15%, an approximate change from the 5-year to the 650-year recurrence interval.

The impacts to Reach 6 are similar to Reaches 4 and 5 with wave run-up causing flooding and overtopping of Stevenson Street. Stevenson Street is the only access road to NARL and beyond it to several pieces of infrastructure including the culturally significant duck camp, the whale bone dump site, and and the alternate boat launch site. During major storm events, shutdown of Stevenson Street due to flooding causes a life safety issue at NARL since the residents would have no way of accessing fuel, groceries, and medical services.

Maintaining this access road and reducing the flood risk at NARL is crucial to the community since it also houses the State's only Tribal College, the Dewline facility, and the barge landing site for bringing goods and services to the Barrow and surrounding communities that rely on Barrow. Implementation of a permanent structure would reduce the risk of losing access along Stevenson Street and the need for continued maintenance of a temporary structure. Based upon the 2010 Technical Report and the transect nearest the NARL reach, the project would reduce the AEP of flood water overtopping the berm from 14.7% to 0.03%, an approximate change from the 7-year to the 3,000-year recurrence interval. Note that the 2010 Technical Report did not extend all the way to NARL, resulting in additional uncertainty in this estimate, though effects would be at least commensurate with other reaches in the study.

All 6 Reaches discussed above have critical elements where risk needs to be reduced in order to ensure that the life health and safety of the community does not continue to be negatively impacted in the future. Storms like the ones seen in August 2015 and September 2017, which resulted in disaster declarations, will only become increasingly more common for this arctic community at the top of the world.

Implementation of a permanent project would reduce the need for the NSB to spend approximately $8.3M in emergency response costs annually. It would also eliminate the need for a temporary berm and super sacs which has caused a dire situation for infrastructure and road repairs, and adds marine debris into the ecologically sensitive Chukchi and Beaufort Seas as storms erode and destroy the temporary berm. Currently, the NSB has been using almost all of the local gravel for constructing and maintaining the temporary berm along the coastline. This has resulted in a housing and infrastructure shortage since no gravel is available to build foundations. In addition, road repairs and other capital improvement projects have been delayed since the community is using all of the available material to ensure critical infrastructure is protected during the open water period. Reducing the risk of erosion and flooding along all reaches with a permanent structure will also help preserve over 50 culturally significant sites along project area. The calculations by reach for AEP can be found in Table 15.

Table 15. AEP by Reach

Reach	Barrow (Structures)[1]	Barrow (Pump Station)	Lagoon	Browerville	South & Middle Salt	NARL
Transect	25	25	31	32	49	51
Without Project						
Dmg. initiation (ft)[2]	11.42	12.85	12.00	11.16	8.70	8.29
AEP (%)	5.520%	2.615%	3.1%	5.549%	21.029%	14.728%
RI (years)	18	38	32	18	5	7
With Project						
Project Height (ft)	14.50	14.50	14.50	14.50	14.50	14.50
AEP (%)	1.100%	1.100%	1.3%	1.173%	0.154%	0.029%
RI (years)	91	91	79	85	649	3,449

1) Two calculations are included for Barrow reach to separately consider the trigger elevation for structures and for Pump Station #4.

2) Reflects adjustment of top of bank as follows.

Barrow (structures): berm/bank height plus 1.875 feet to adjust for typical foundation height above ground

Barrow (pump station): berm/bank height at transect plus 3.3 feet to reflect current elevation of pump station entrance

Lagoon: Previous studies identified 12 feet as trigger elevation for utility infrastructure at this location

Browerville (structures): berm/bank height plus 1.875 feet to adjust for typical foundation height above ground

South & Middle Salt: reflects berm/bank crest at transect corresponding to the landfill.

NARL: reflects top of bank/berm at transect 51, the closest available transect to NARL from 2010 Technical Report

7.2 Plan Components

Revetment. The revetment along the bluff area would consist of two layers of 2.7 ton armor rock on the structure slope and two layers of B rock (Figure 21). The B rock, core, and gravel filter layers would be buried to be approximately one armor rock thickness (3.5 feet) below the existing beach elevation. The crest height is set at 19 ft, which is 0.5 ft higher than the 50-year run-up. The bluffs would not be excavated to provide a uniform slope on which to build, rather they would be dressed with local fill material to achieve a uniform slope. The bluffs are archaeologically rich, so no excavation would be permitted on the bluff face.

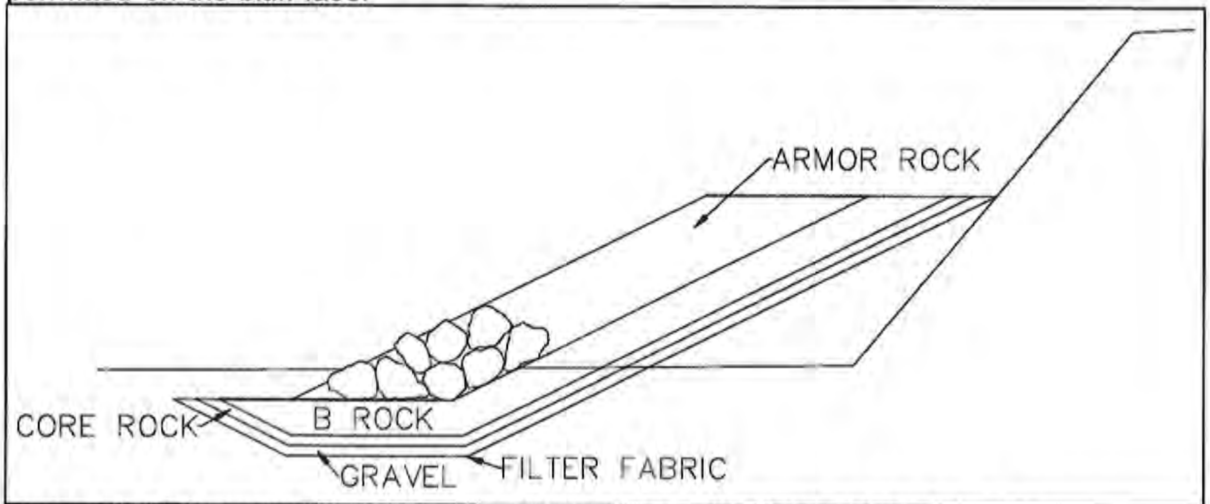

Figure 21. Bluff Erosion Risk Reduction with Armor Sized for Wave Risk Reduction.

Revetted Berm Structure. Coastal flooding at Barrow is the result of the combination of tide, surge, wave set up, and wave run-up, with wave run-up being the water level increase that results in flooding. The coastal flood risk reduction revetted berm is designed to address flooding by reducing the wave run-up energy.

Wave run-up elevations associated with a porous structure were calculated and are described in Appendix D. The crest height is set at 14.5 ft, which is 0.5 ft higher than the 100-year run-up and 2 ft higher than the 50-year run-up (Figure 22) and was chosen to increase the resilience of the flood risk reduction alterative in the low lying areas. The filtering B layer, core, gravel, and fabric would be buried so the top would be approximately 3.5 ft below the natural beach line for ice survivability. The structure would consist of two layers of 2.7 ton rocks with a 2 horizontal on 1 vertical seaward slope and 1.5 horizontal on 1 vertical landward slope. The reduced size of the structure would likely result in increased maintenance due to ivu events but the reduced size would make the maintenance of the structure easier to perform and a stockpile of replacement rock would be kept at Barrow for maintenance activities. The B rock would be a double layer placed on a 1 ft layer of core, 1 ft layer a gravel, and an underlayment of filter fabric.

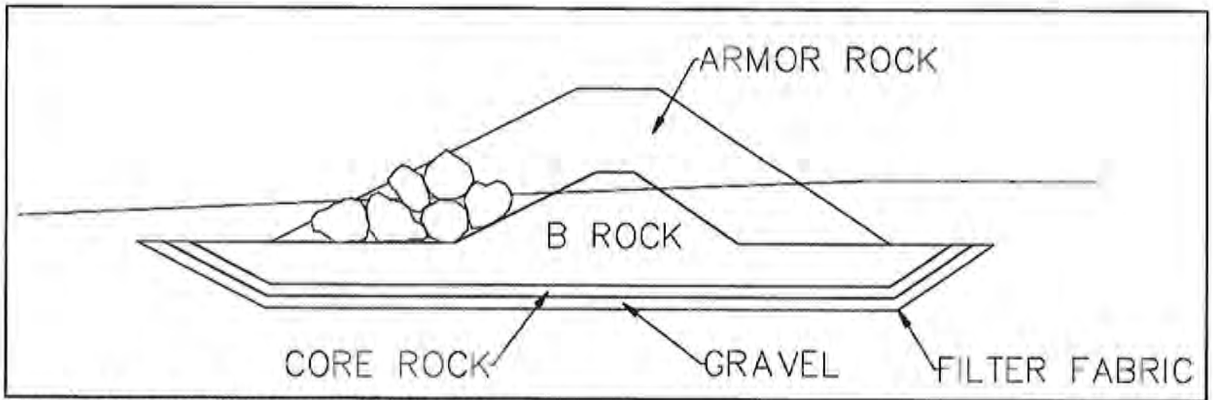

Figure 22. Revetted Berm Sized for Waves

Raise Stevenson Street. As an alternative to a revetted berm, Stevenson Street can be raised and revetted. Raising Stevenson Street, as opposed to a revetted berm, would decrease the quantity of armor rock required while maintaining a view of the ocean from the street. Stevenson Street would be raised to the elevation of the revetted berm with fill material to ensure a 100-year level of risk reduction. The seaward slope of the street would be revetted with two layers of 2.7 ton armor stone and two layers of B stone (Figure 23). The B rock, core, and gravel filter layers would be buried so the top would be 3.5 ft below the existing beach elevation.

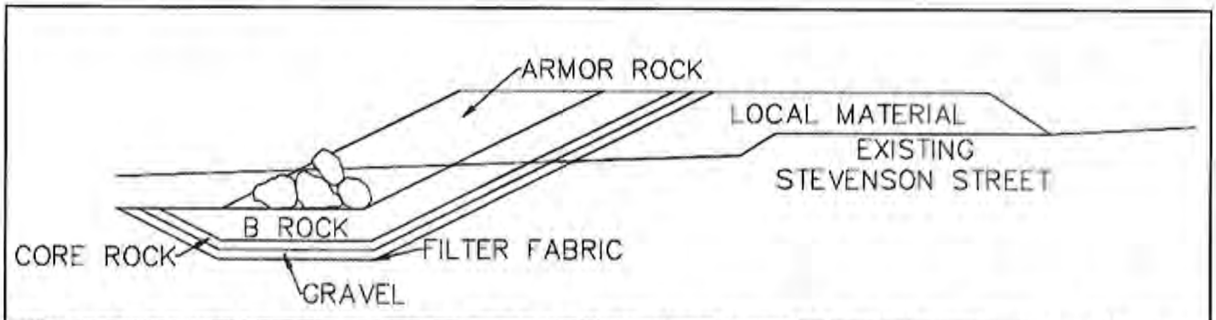

Figure 23. Stevenson Street Raised to +14.5 ft with Revetted Seaward Slope Sized for Waves.

7.3 Construction Methodology

Typical construction practices would be used to transport and place materials for the revetment, raising the road, and placing a berm in front of the road. The rock and gravel for the project would likely come from Nome, Alaska by barge (see Appendix F). It is assumed that construction access would be by water, with the barge off-loading materials onto the beach. Construction would most likely occur during the summer months of June through September due to freezing temperatures and low light availability impacting the ability to construct during the other months of the year. Staging of equipment and materials could take place outside of the summer season. A Section 106 Coordination letter with the State Historic Preservation Officer (SHPO) was received on 24 January 2019. Environmental compliance coordination has been completed with concurrence letters received from USFWS and NMFS on 19 October 2018 and 5 November 2018, respectively. In addition, all necessary real estate coordination and acquisition of lands and property would be complete before construction can start.

7.4 Financial Analysis

7.4.1 Ability to Pay

The ability to pay analysis for the Barrow Alaska Coastal Erosion Feasibility Study assesses the ability of the NSB to cost-share construction expenditures as required (generally it does not include operations, maintenance, and rehabilitation). This analysis is required by the Section 116 Guidance authorizing this project. The procedures aim to reduce non-Federal cost-share to the extent possible, and involve several steps.

Per EGM 14-04, if the Eligibility Factor (EF) is one or more, the project is eligible for the full reduction in cost-share to the benefits based floor. If EF is zero or less, the project is not eligible for a reduction. For the Barrow Alaska Coastal Erosion Feasibility Study, EF is negative (-7.394) and therefore not eligible for a reduction in cost sharing.

7.5 Sponsor Capability

The NSB is willing and able to cost share their portion (35 percent) of the proposed project and provide LERRs, as explained in Section 7.8.

7.6 Operations & Maintenance

Initial estimates of operations and maintenance (O&M) for the Recommended Plan is $1.7M per year, based on a 50-year period of analysis. A stockpile of material would be supplied so the community can manage any O&M required for the project. O&M costs are a NFS responsibility.

The frequency and severity of ivu events is generally limited to photographs and personal accounts and has grown increasingly rarer, as stated previously, with the increase in the open water period. Statistics on the frequency of occurrence and associated ice strength, length of ice impact, and duration of ivu events has not been developed and currently there is not enough data to develop these statistics. Ivu events would be the primary reason for revetment maintenance. In the absence of statistical information, an assumption of occurrence of an ivu event every 5 years was chosen for determining O&M. A stockpile of rock would be maintained at Barrow to support maintenance assuming 2,000ft of damaged shoreline (Appendix D). Due to the extensive experience of the NSB Public Works Department in storm response and recovery and the current equipment that is maintained in the community it is anticipated that the community would perform all maintenance activities with the stockpiled material.

The project would need to be inspected for damage at least twice annually. One inspection would need to occur after the snow and ice melts and a second in the fall before freeze up. There would also need to be post storm inspections to check the condition of the structure toe and any displaced material. It is imperative that these inspections be performed in order have adequate time to repair damage before winter.

7.7 Integration of Environmental Operating Principles

Environmental operating principles have been integrated into the planning process wherever possible. Specific considerations are:

Foster sustainability as a way of life throughout the organization: This project seeks to reduce risk of flooding and erosion impacts on subsistence activities and the lifestyle of citizens in rural Alaska. Risk reduction of erosion and flooding due to wave run-up during storm events directly and positively impact the Barrow's social connectedness, identity, and resiliency.

Proactively consider environmental consequences of all USACE activities and act accordingly: Environmental and cultural consequences were considered throughout the planning process and every effort has been made to avoid, minimize, or mitigate all anticipated impacts. These actions included early and continuing coordination with the USFWS, the NMFS, ADFG, and SHPO to include an interagency site visit in September 2017. Mitigation for cultural resources would take place at the Utqiaġvik Village Site and implemented through a Memorandum of Agreement (MOA). In-lieu mitigation was costed at $630,000 (including contingency) and is included in the certified project first cost. The MOA was signed on 07 June 2019 and is included in Appendix B, Attachment 2.

Create mutually supporting economic and environmentally sustainable solutions: The Recommended Plan provides the maximum amount of benefits to the nation among the alternatives considered, as encapsulated by the NED analysis and CE/ICA including the OSE, EQ, and RED accounts. The alternative was formulated in a way that makes it lasting, requiring limited annual maintenance, and mitigates for cultural impacts.

Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments: A full environmental assessment was conducted as required by NEPA. In addition, the principles of avoidance, minimization, and mitigation were enacted to the extent possible. An MOA was conducted with coordination through the NSB, SHPO, tribal entities, and stakeholders to identify mitigation for cultural impacts within the project extent.

Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs: For this study, a systems approach was utilized to examine the interaction between terrestrial and nearshore effects to formulate the Recommended Plan in a way that would avoid or minimize these impacts. Formal consultation with NMFS and a review of previous environmental sampling information in Barrow from 2004-2009 was conducted to determine that the Recommended Plan would not result in adverse impacts for environmental due to the nature of the project and not conducting construction in water. The project footprint and staging areas have been previously used by the NSB.

Leverage scientific, economic and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner: USACE worked closely with other Federal and state agencies, including SHPO, to develop an understanding of available environmental and cultural resource knowledge, and how these resources could be impacted by the project. The NSB provided insight and documentation to quantify the other social effects. In addition, USACE utilized the results of numerous historical including the 2010 USACE Technical Report, to develop an understanding of the physical setting and how each structural alternative (i.e., Alternatives A-H) would meet the objective of reduce or mitigate damage to tangible cultural heritage along the Barrow shoreline, specifically the Utqiaġvik Village Site over the 50-year period of analysis.

Employ an open, transparent process that respects the views of individuals and groups interested in Corps activities: USACE has followed all guidelines for public involvement and made every effort to be responsive to stakeholder concerns. Multiple meetings with key stakeholders were held in Barrow to present the project and recommended plan in addition to two open public meetings to collect verbal and written comments from the community. These meetings rewarded this project with 362 public comments which were addressed throughout this document and appendices. The five main categories of public comments as discussed during the ADM can be found in Table 16. Additional comments were based on questions related to the presentation, project specific questions (i.e. project cost and timeline), how can the community assist in moving the project forward and personal accounts of historic storms and community impacts.

Table 16. Public Comment Categories.

Common Themes (# received)	Resolution
Safety considerations for road design as well as polar bear escape routes (70)	The design for raising Stevenson Street would address all necessary safety features and public access points to allow egress from the beach onto the road.
Need for beach and public access points; boat ramps (20)	Current public access points affected by the project will be relocated and maintained per USACE policy.
Property Acquisition (10)	A USACE Real Estate specialist is working with the NSB to determine impact to properties within the project footprint.
Local hires should be contracted and trained (6)	As prescribed in 252.222-7000, ". . . individuals who are residents of Alaska and who, in the case of any craft or trade, possess or would be able to acquire promptly the necessary skills to perform the contract" could be hired.
Will the height be big enough to withstand worsening storm events? (3)	Yes, additional H&H modeling will take place in PED to ensure adequate flood and erosion risk reduction.
Environmental Concern- Old landfill (2)	The project footprint is located on the seaward side of Stevenson Street and this area is consistently disturbed to rebuild the sacrificial berms. No additional environmental impacts are anticipated.

7.8 Real Estate Considerations

LERR necessary to implement the recommended plan are lands owned by the NSB, UIC, City of Barrow, private owners, and native allotees. Due to active erosion within the study area, the PDT decided to look at current (2018) vs. future (2025) real estate impacts to be conservative based on the proposed construction timeline. Accounting for the on-going erosion in the study area assisted the PDT to better represent the future real estate considerations needed for construction. For the 2018 LERR Requirements, 40 land owners and about 119.68 acres are anticipated to be impacted by construction of the Recommended Plan. For the 2025 LERR Requirements, 42 land owners and about 122.38 acres are anticipated to be impacted by construction of the Recommended Plan. Baseline cost estimates for LERR is $4.5M. A full assessment of real estate located in the project area can be found in Appendix G.

7.8.1 Project Staging Areas

Three staging and two barge offloading areas have been identified for the proposed project (Figure 24). Images of the tentative rock staging areas with barge landings are shown in Figure 25, Figure 26, and Figure 27. These areas are already used by the community and would be where the project rock and equipment are offloaded. Appendix F provides additional details on the barge offloading areas.

Figure 24. Staging Area and Barge Offloading Areas.

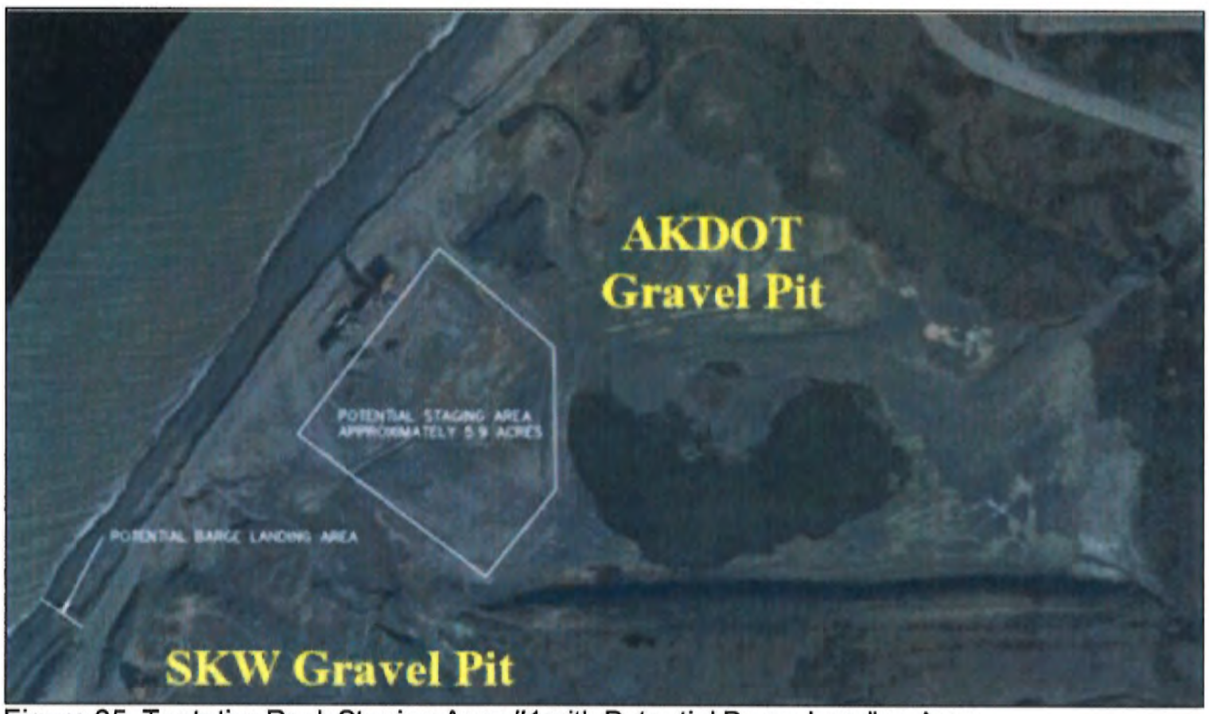

Figure 25. Tentative Rock Staging Area #1 with Potential Barge Landing Area.

Figure 26. Tentative Rock Staging Area #2 with Potential Barge Landing Area.

Figure 27. Tentative Rock Staging Area #3 with Potential Barge Landing Area.

7.8.2 Land Acquisition

Native restricted properties located in the project area can be found in Appendix G. Appendix G explains all of the laws governing native restricted properties, the allowance of eminent domain to condemn lands owned by Native Alaskans in Barrow is determined by the timing of the acquisition of the land and the law under which the land was acquired. The Allotment of Indian Lands provision of the Indians Code (31 Stat. 1084) provides for eminent domain under the laws of the State in which the land is located for allotments that were awarded under that provision. Identification of whether ANCSA applies to two properties is still outstanding.

If these two properties are ANCSA properties and cannot be acquired prior to construction, then the portion of the bluff in front of these lands would not be included in the final project design. There will be no risk reduction to bluff undercutting and erosion to these two properties and it will be up to the land owners to address the active erosion. A discontinuous revetment would create weak points to the bluff revetment up to the first beach access at the northeast end of Reach 1. The lack of a continuous revetment in Reach 1 may result in bluff failure and slumping events where a large section of the degraded permafrost breaks away, undermining the revetment. Although less rock would result in reduced construction costs, this could increase O&M costs. The remaining stretch of the project (Reaches 2 through 6) will not be affected.

The state land in Reach 1, adjacent to the airport runway, is where the project is anticipated to start. If the NSB is unable to acquire this land, there would be minimal negative impact to the project. Additionally, the length of Reach 1 would be reduced by not constructing on state land which would decrease the overall cost associated with rock and other revetment materials. This would however, have a negative impact to the community in the long term since continued erosion at the bluff threatens the corner of the runway. Active erosion would likely impact the airport runway in approximately 25 years, according to the NSB. If the airport runway is not included in the USACE project, it would be up to the land owner or other entity to address the active erosion in this area and subsequent threat to major infrastructure.

Four existing beach access areas (breaks in the sacrificial berm or natural coastline features) are currently used for public vessel launching, commercial goods offloading and public access for the community to gain access to the beach from the road. The intent of the Recommended Plan is to maintain these four beach access area in their current location. If the plans and specifications developed during PED require a change in the location of any or all of the beach access areas, then these beach access areas would be treated as relocations. There is currently no infrastructure in these four areas. These locations are both natural breaks in the coastline used for public access for recreation and subsistence activities and breaks in the sacrificial berm where the community places removable rubber mats to launch vessels and barge landing to offload goods. No land would need to be acquired if either the four beach access areas are maintained in their current location or relocated along the beach in Barrow. Land ownership can be found in Appendix G, Tables 1 and 3. The Baseline Cost Estimate on Acquisition of LERR can be found in Appendix G, Table 2. The below images show examples of existing beach access areas that plan to be maintained with implementation of a project. A break in the sacrificial berm used by the public to access the beach, similar to walking through a break in a sand dune, is shown in Figure 28. The same beach access area from different viewpoints is shown in Figure 29 and Figure 30.

Figure 28. Break in the sacrificial berm for public beach access in Barrow, Alaska.

Figure 29. Public beach access at natural break in the coastline between Reaches 1 and 2 (view from the ground).

Figure 30. Public beach access at natural break in the coastline between Reaches 1 and 2 (view from the air). The red arrow shows the viewpoint from Figure 29.

7.9 Environmental Impacts

7.9.1 Environmental Consequences of Resources

Biological resources include fish, wildlife, vegetation, Federal threatened and endangered species, and other protected species. Although historic development within and adjacent to the project area has modified the shoreline and the sediment regime, these actions occurred in a regulatory landscape that is different from today. While future development would likely have localized impacts on these resources, under the current regulatory regime these resources are unlikely to suffer significant losses. Any future Federal actions would require additional evaluation under NEPA at the time of their development. The consequences of the Recommended Plan are detailed in Section 6.2 of this report. Additional consequences discussion can be found in the EA (Appendix B).

7.9.2 Subsistence Consequences of Recommended Plan

The Recommended Plan would include access points along sections of the barriers to allow residents to have multiple entrances to the beach and water. These access points would also be used by the construction teams as the barriers are being constructed to safely move from either side for construction. The access points would be open to local subsistence hunters and whalers use of these access points to deploy their boats from. There would be no change to the subsistence lifestyle nor any known detriment to local wildlife.

7.10 Risk & Uncertainty

7.10.1 Economic Risks

With regard to uncertainty in the achievement of the benefits documented in this report, the key identified risk was the use and price level update of the 2010 Technical Report information as input to this current analysis, including:

- Use of the 2010 flood hydraulics information to support the CE/ICA (Appendix C), and
- Use of the previously estimated expected annual flood damages in Beach-fx (Appendix C).

This data was used because new coastal hydraulic analysis required for a new coastal flood damage analysis was not available at the time of this study. However, the risk of using this information was found to be minor because flood risk is not a driver of project benefits. Rather, it is the reduction of damages in the Berm/Emergency Maintenance and Capital Expenditures consequence category; both associated with coastal erosion, which drive the benefits. Because erosion damages identified in this analysis are expected to be eliminated by construction of a berm/revetment, 97 percent of the without project damages would be expected to be achieved even if the flood risk benefits were not included in the study entirely. As such, the PDT determined that such use of the 2010 Technical Report (updated to current price levels) was a tolerable risk given the need for timely delivery of a project at Barrow.

7.10.2 Study Risks

Due to the acceleration of the study timeline and available funding, risk informed decisions were made to move the updating or completion of some modelling, geophysical surveys, identifying of rock sources, and design optimization to the PED phase. Some analysis and data collection were necessary for determination of costs and quantities that were conducted during the study. The LiDAR data has been used to inform the design and material quantities; however, the storm reoccurrence interval will not be available prior to the release of this report. It will be used to inform further refinement of the study design during PED.

Due to timeline acceleration and the need to reduce the cost of the study, H&H modeling was not updated from the 2010 study before determining the Recommended Plan. Modeling to determine the effects of shorefast ice developing later in the season will be updated during PED and may affect the design, but would not affect the Recommended Plan.

Selection of a source of rock and gravel that is suitable, available, and cost-effective will be determined in PED. The current assumption is the rock would be sourced from Nome, Alaska (Appendix F) and this has been incorporated into the project cost detailed in Appendix E. If a rock/gravel source is identified and then the volumes or costs of those materials change significantly, there is a risk of having to find another source that would satisfy the needs of the project.

Upon further data gathering and review of Hazardous, Toxic, Radioactive, and Wastes (HTRW) databases, it was determined that there is no HTRW known in the proposed project area. If any contaminated soils are identified during construction, the NSB understands that it is their sole responsibility to properly dispose of these materials at 100 percent NFS cost. The four remaining risk items for the study are explained in Table 17.

Table 17. Risk and Uncertainty Summary.

Risk	Work to Date	Future Work	Timing
NFIP compliance or comparable plan	• Reviewed policy • Elevated to OC and HQ	• Work with NSB to be NFIP compliant prior to construction	PED
Relative Sea Level Change not accounted for in 2004 modeling	• Calculated RSLC estimates; QC'd by Climate Change CoP • Start ADCIRC runs	• Complete selected ADCIRC runs with 3 RSLC curve estimates for 2070 & 2100	PED
Rock/gravel source	• Eliminated some unsuitable local sources • Assume rock/gravel from Nome	• Locate suitable sources	PED
Land acquisition	• Consulted with NSB on eminent domain authority • Three properties (two native and one State) identified that may not fall under the eminent domain purview of the NSB	• NSB to coordinate with land owners to obtain permanent easements	PED

*Note: NFIP discussion is in Section 5.3.2.

7.10.3 Residual Risk

A risk informed decision made in feasibility was to use the available 2010 H&H data to conduct the feasibility level design. Additional modeling will be conducted in PED to refine the project design. There is the risk that a larger than designed for storm could overtop the structure which has been accounted for in O&M. The risk of an ivu event is low, but ice damage to the structure could still occur. O&M cost addresses ice damage and was explained in Section 7.6. Additional flooding may occur outside of the project area affecting cultural resources and existing gravel pits, which does not directly affect human safety, but are of high importance to the community.

7.11 Project Cost

Based on economic costs, analyses indicate that the Recommended Plan will have an average annual equivalent cost of $14.2M. Maximum annual benefits for the Recommended Plan are estimated at $8.3M. The MCACES estimate resulted in a total project first cost of $328.6M (01 October 2019 / FY20).

7.11.1 Cost Apportionment

The cost estimate for the Recommended Plan was completed in MCACES. The Recommended Plan cost estimate was refined based upon subsequent review comments of the MCACES estimate. Changes included modification of the contingent based on the completed cost and schedule risk analysis as well as refinement of markups applied within MCACES. It was determined that these changes would have affected alternatives on a relatively equal basis and would not have changed plan formulation or the Recommended Plan. The Recommended Plan will be cost shared 65 percent Federal and 35 percent non-Federal (Table 18). LERRs and O&M are 100 percent NFS costs.

Table 18. Project First Cost Breakdown.

Cost Item	Federal	Non-Federal	Total
Construction	$207,504,050	$107,278,950	$314,783,000
Preconstruction Engineering and Design	$5,686,200	$3,061,800	$8,748,000
Cultural Resources Mitigation	$419,250	$225,750	$645,000
LERRDs	$0	$4,454,000	$4,454,000
Total (65% Fed/35% Non-Fed)	$213,609,500	$115,020,500	$328,630,000

7.11.2 Schedule

The study schedule for the feasibility phase is shown in Table 19. This study has been accelerated to be completed within 27 months of signing the FCSA.

Table 19. Feasibility Study Schedule.

Milestone	Date
Feasibility Cost Sharing Agreement Executed (FCSA)	12-Jul-17
Alternatives Milestone Meeting (AMM)	16-Nov-17
Tentatively Selected Plan Milestone (TSP)	28-Jun-18
Agency Decision Milestone (ADM)	04-Feb-19
Major Subordinate Command (MSC) Transmittal of Final Report	14-Jun-19
Director's Report Signed	18-Oct-19

8. CONCLUSIONS & RECOMMENDATIONS

8.1 Views of the Sponsor

The NSB has expressed ongoing, enthusiastic support for the Recommended Plan and has their full portion of funding that would allow for a smooth transition into both the PED and construction phases of this project. A letter of intent and self-certification of financial capability were provided on 03 June 2019.

8.2 Conclusions

Investigations of physical conditions and economic needs show that federal participation in coastal storm risk management at Barrow, Alaska would benefit the community by reducing risk of erosion and flooding from wave-run up during the increasing open water period. The Recommended Plan, Alternative H, would reduce the risk of storm damages to approximately five miles of coastline using a combination of rock revetment at the bluff area, berm, and raising and revetting Stevenson Street. The coastline would be altered to some degree with the recommended plan. Sacrificial berms would no longer be necessary to reduce risk to infrastructure and the community. There would be boat ramps and access along the revetments to allow for boating and beach access for subsistence, recreational and social activities. In addition, drainage points are being considered for Middle Salt Lagoon and Tasigarook Lagoon which have existing outfalls. This study is being conducted under Section 116 Authority, which affords this study the ability to select a plan based on OSE, with selection supported by a CE/ICA. This analysis resulted in CRUs based on feedback from the community and existing knowledge. The output from this analysis determined that the Recommended Plan has the highest annual CRUs and is a best buy plan. Total project first cost is $328.6M (as of 01 October 2019). The Recommended Plan would be cost shared 65 percent Federal ($213.6M) and 35 percent non-Federal ($110.5M). The NFS cost includes LERRs ($4.5M).

The Recommended Plan would require short-term in-lieu mitigation to account for adverse impacts to the Utqiaġvik Historical Site, as explained in Appendix B. In-lieu mitigation was costed at $630,000 (including contingency) and is included in the certified project first cost. In the long term, the selected erosion and flooding rick reduction plan would improve the overall quality of the human environment, reducing risk to life, health and safety, and negative impacts to life sustaining infrastructure. The NSB has indicated its intent to act as the NFS and has proven it has the financial capability to do so.

8.3 Recommendations

I recommend that the selected plan, as a coastal storm risk management measure at Barrow, Alaska, be constructed generally in accordance with the selected plan herein, and with such modifications thereof as in the discretion of the Director of Civil Works may be advisable at an estimated total project cost of $328.6M (project cost as of 01 October 2019).

Recommendations for provision of Federal participation in the plan described in this report would require the NFS to enter into a written PPA, as required by Section 221 of Public Law 91-611, as amended, to provide local cooperation satisfactory to the Secretary of the Army. Such local cooperation shall provide, in part, the following draft items of local cooperation:

a. Provide during the periods of design and construction, a minimum of 35 percent of project costs assigned to coastal and storm damage risk reduction as further defined below:

(1) Provide, during design, 35 percent of design costs allocated to coastal and storm damage reduction in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

(2) Provide all lands, easements, rights-of-way, including suitable borrow areas, and perform or assure performance of all relocations, including utility relocations, as determined by the Federal government to be necessary for the initial construction, periodic nourishment or operation and maintenance of the project;

(3) Provide, during construction, any additional amounts necessary to make its total contribution equal to 35 percent of initial project costs assigned to coastal and storm damage reduction;

b. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;

c. Inform affected interests, at least yearly, of the extent of protection afforded by the flood risk management features; participate in and comply with applicable federal floodplain management and flood insurance programs; comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12); and publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the flood risk management features;

d. Operate, maintain, repair, replace, and rehabilitate the completed project, or function portion of the project, at no cost to the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and state laws and regulations and any specific directions prescribed by the Federal government;

e. For so long as the project remains authorized, ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based;

f. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms;

g. At least twice annually and after storm events, perform surveillance of the project to determine losses of material from the project design section and provide the results of such surveillance to the Federal government;

h. Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

i. Hold and save the United States free from all damages arising from the initial construction, periodic nourishment, operation, maintenance, repair, replacement, and rehabilitation of the project, except for damages due to the fault or negligence of the United States or its contractors;

j. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;

k. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the initial construction, periodic nourishment, operation and maintenance of the project;

l. Assume, as between the Federal government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way required for the initial construction, periodic nourishment, or operation and maintenance of the project;

m. Agree, as between the Federal government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and, to the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA;

n. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law 99-662, as amended, (33 U.S.C. 2211(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4601-4655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

p. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)); and

q. Not use funds from other Federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor's obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project;

The recommendations for implementation of coastal storm risk management measures at Barrow, Alaska reflect the policies governing formulation of individual projects and the information available at this time. They do not necessarily reflect the program and budgeting priorities inherent in the local and State programs or the formulation of a national civil works water resources program. Consequently, the recommendations may be changed at higher review levels of the executive branch outside Alaska before they are used to support funding.

PHILLIP J. BORDERS
COL, EN
Commanding

8 NOV 19
Date

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