





Nelson Lagoon Hazard Impact Assessment

Prepared For:

Aleutians East Borough

3380 C Street, Suite 205

Anchorage, AK 99503

Prepared By:

HDR Alaska, Inc.

with

Shannon & Wilson

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Acronyms and Abbreviations

ABM	articulating block mat
ACS	American Community Survey
AEB	Aleutians East Borough
AFI	air freezing index
ATI	air thawing index
AVO	Alaska Volcano Observatory
DCRA	Division of Community and Regional Affairs
DHS&EM	Division of Homeland Security and Emergency Management
F	Fahrenheit
HDPE	high-density polyethylene
HIA	hazard impact assessment
MHHW	mean higher high water
MHW	mean high water
MLLW	mean lower low water
MLW	mean low water
MSL	mean sea level
NOAA	National Oceanic and Atmospheric Administration
PDO	Pacific Decadal Oscillation
RSLR	relative sea level rise
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WIS	Wave Information Studies

1. Introduction

The Aleutians East Borough (AEB) and the community of Nelson Lagoon recognize that erosion- and climate change-related hazards are a concern in Nelson Lagoon and that they need to take action to minimize the impacts on the community. In support of these efforts, the AEB has hired HDR Alaska and subconsultant Shannon & Wilson to perform a Hazard Impact Assessment (HIA) for Nelson Lagoon. The focus of this study is natural hazards, particularly those related to climate change such as erosion.

1.1. Public Involvement

To gain input into the plan, Laurie Cummings with HDR Alaska and Eric Anderson with Shannon & Wilson traveled to Nelson Lagoon to hold a community meeting where residents could share their concerns about climate change-related hazards. During their visit, they took sediment samples, visited previous erosion control measures, and observed various parts of the community. A second community meeting was held in September 2011 to discuss the results of the draft HIA. Copies of the public involvement materials are located in Appendix A.

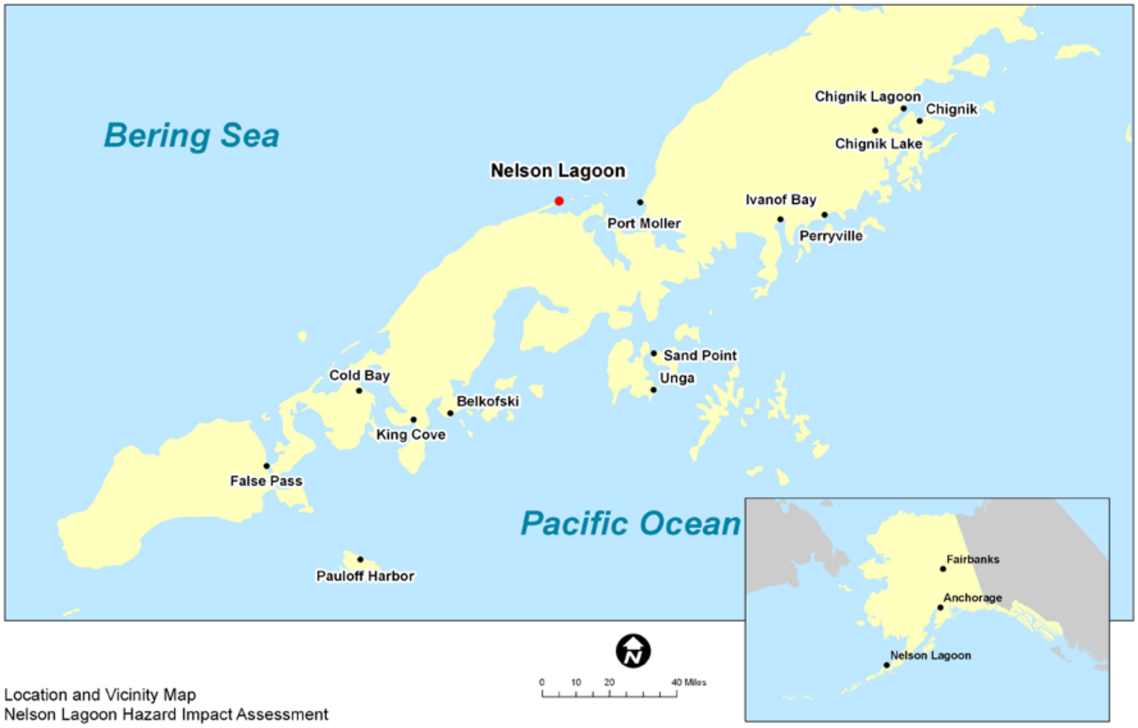
1.2. Community Description

Section 1 Community Description information is from the Division of Community and Regional Affairs (DCRA) Community Database online at http://www.commerce.state.ak.us/dca/commdb/CF_BLOCK.htm, and the AEB Multi-Hazard Mitigation Plan.

1.2.1 Location

Nelson Lagoon is on the northern coast of the Alaska Peninsula, approximately 580 miles southwest of Anchorage. The community of Nelson Lagoon is located at the end of a spit that extends between Nelson Lagoon to the south and the Bering Sea to the north (Figure 1). The width of the spit is approximately 1,900 feet near the community. The community of Nelson Lagoon is located on a series of vegetated sand dunes gradually increasing in size to the north to an elevation of approximately 20 to 30 feet.

Figure 1. Location Map



1.2.2 Culture

The culture is focused on commercial fishing and subsistence activities. There is a strong community pride and loyalty among the residents, with a desire to maintain their lifestyle with slow, monitored growth and development that can be managed by the residents.

1.2.3 Demographics

According to the 2010 Census, Nelson Lagoon[1] has a population of 52. This is down from 83 in the 2000 and 1990 Census. The majority (78%) of the population is all or part Alaska Native[2]. There are 32 housing units in the community, of which 22 are currently occupied. Of the 10 vacant units, nine are for seasonal, recreational, or occasional use. The average household size is 2.4.

1.2.4 Economy

Nelson Lagoon is situated in the midst of a rich and productive salmon fishery. In 2009, 23 residents held commercial fishing permits, primarily for salmon gillnet. In addition, some subsistence and trapping activity also occurs.

In 2009 (ADLWD 2009), local government was the main industry employing 42 percent of the area's workers. Workers are employed in industries including:

[1] Information is reported for the Nelson Lagoon Census Designated Place.
[2] The U.S. Census Bureau defines this category as American Indian and Alaska Native.

- Education and health services (19%)
- Trade, transportation, and utilities (10%)
- Professional and business services (10%)
- Financial activities (10%)
- Information (3%)
- Other (6%)

The 2005–2009 American Community Survey (ACS) estimated the per capita income for Nelson Lagoon as $27,596 and the median household income as $43,750. The ACS reports that 35 percent of individuals in Nelson Lagoon are considered to be living below the poverty level (U.S. Census Bureau 2009).

1.2.5 Transportation

Access to the community is generally via two transportation-related facilities:

- A State-owned 4,000-foot-long by 75-foot-wide gravel airstrip is available year-round and located approximately 1.3 miles east of the community. Scheduled air service is generally available three days a week via Cold Bay.
- A dock facility is located approximately one mile east of the community. This dock is approximately 250 feet long with several berthing areas and is large enough to receive commercial barges. There is also a boat loading ramp for smaller craft.

Within the community, transportation is generally via a road system constructed primarily of sand with small amounts of gravel or along the beaches. Motorcycles, four-wheelers, and pickups are the common modes of vehicular transport within the village.

1.2.6 Climate

The nearest weather station with data that is suitable for use in this study is Cold Bay (located approximately 83 miles to the southwest of Nelson Lagoon). We believe the Cold Bay conditions are similar enough to the conditions at Nelson Lagoon for the purpose of this analysis and are described in Section 2.1. The average monthly summer temperature is approximately 40 to 55°F. The monthly average winter temperature is on the order of 28° to 40°F. The average annual precipitation is approximately 44.5 inches per year, with snowfall on the order of 56 inches.

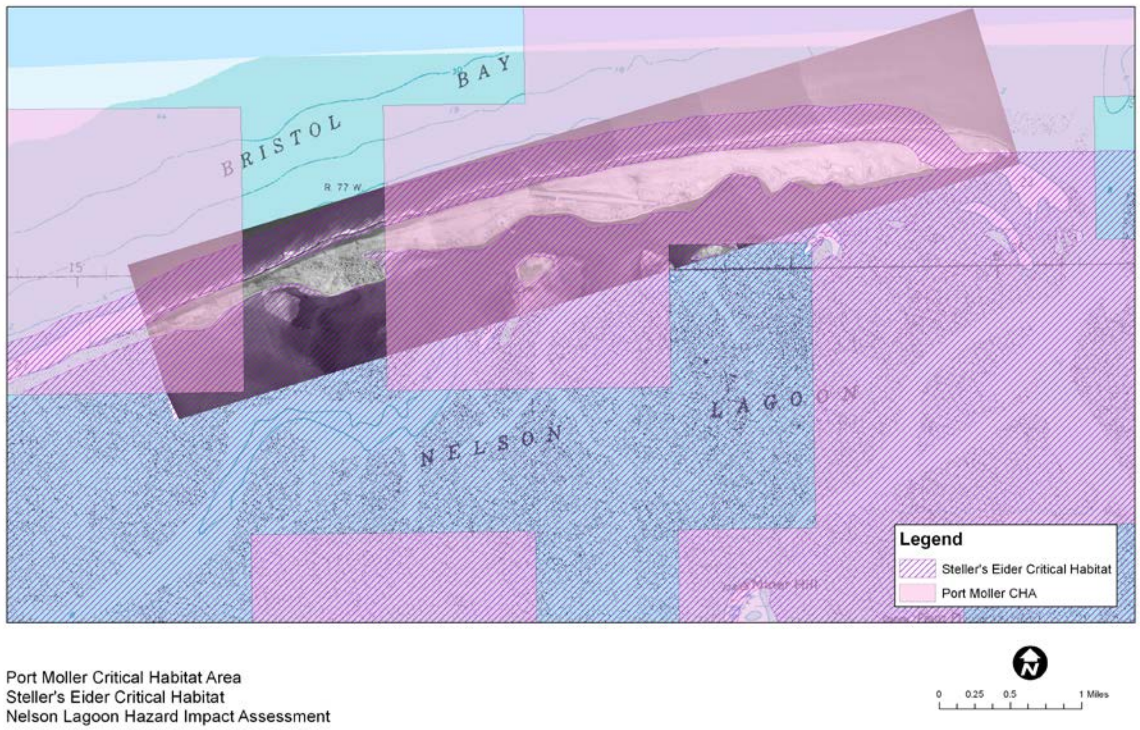
1.2.7 Other/Environmental

Lands around Nelson Lagoon (including the Nelson Lagoon airport) are part of the Port Moller Critical Habitat Area (Figure 2) and are subject to the *Bristol Bay Critical Habitat Areas Management Plan* (when finalized). The draft plan will “allow use, maintenance and/or improvements to existing airstrips on state and private lands within the critical habitat areas under terms and conditions of a Special Area Permit” (p. 30).

The draft plan has a shoreline alteration policy. The proposed policy is to not allow an alteration of the natural shoreline with a critical habitat area except when the alteration will provide an overwhelming public benefit and there is no feasible upland alternative, or “in the case where the proposed project is constructed entirely on privately owned land or tidelands for the purpose of private property protection. Shoreline alternation of public tidelands to protect private property will not be allowed.”

Nelson Lagoon is included in the area designated as Steller's eider critical habitat by the U.S. Fish and Wildlife Service (Figure 2).

Figure 2. Port Moller Critical Habitat Area and Steller's Eider Critical Habitat



1.2.8 Infrastructure

1.2.8.1 Water Infrastructure

According to the Source Area Assessment for Nelson Lagoon (ADEC 2004), the Nelson Lagoon water system is a Class A water system that obtains water from a lake located approximately 10 miles west of the community. The capacity of the intake and pump system is reported to be approximately 38 gallons per minute. The lake was found to have a high level of susceptibility to degradation based on factors such as climate, terrain, and intake location. This is not uncommon with surface water sources. The water system was given a vulnerability rating of low for the six contaminant categories, as the source area is in a remote location with limited access.

A four-inch-diameter high-density polyethylene (HDPE) pipe transfers water from the intake/pump to the community along the sand ridge near the north side of the beach. Initially, the pipe was located above ground, but two years after construction, the line was buried approximately two to four feet, but the location of the air valves and the pipe was not recorded or marked in the field, and thus the exact location of the line is generally unknown (CE2 2002).

During several erosional events, the pipe was exposed and damaged. Generally when it is exposed, it is repaired using local labor and equipment. However, during several events, more than one thousand feet of pipe had to be replaced due to damage.

Water is piped to the village and stored in a water tank. Currently, there are two tanks, but one has been damaged and is not in use. Water is chlorinated and pressurized in a small building next to the water tanks. From this point, it is fed into the water distribution system that includes 15 fire hydrants.

1.2.8.2 Wastewater Infrastructure

Most of the village community appears to be served with individual wastewater (septic) disposal systems. There was no identified central treatment or discharge location.

1.2.8.3 Electricity/Communication Infrastructure

The buildings in the community are served by power and telephone lines that appear to be a combination of above and below ground. The poles observed in the community appear to be generally in good condition and relatively vertical. Diesel generators are used to provide power to the community.

1.2.8.4 Solid Waste Disposal

Solid waste disposal for Nelson Lagoon consists generally of disposing of refuse in shallow trenches in an area approximately two-thirds of a mile west of Nelson Lagoon. The refuse in the trenches is burned to reduce volume. Items such as old propane tanks, vehicle parts, and heavier metal items are segregated and stored in the solid waste disposal area. Our review of state records indicated that the disposal area is not permitted by the Alaska Department of Environmental Conservation.

The waste disposal area is located approximately 9.5 miles from the local drinking water source and is not anticipated to present a direct potential health impact to the community.

1.2.8.5 Fuel Storage Area

The fuel farm is located near the dock facility, approximately one mile east of Nelson Lagoon. The relatively new fuel facility was constructed north of Airport Road and provides fuel storage for vehicles, power generation, and structures. The tanks are located within a bermed containment area. Additional smaller tanks are located near the power generator approximately 400 feet to the south. Buried fuel lines transfer product from the dock area to the fuel farm. Trucks and potentially other vehicles are utilized to deliver fuel oil to individual structures.

1.2.9 Structures

Most of the structures in the community appear to be constructed on at-grade timber foundations and on shallow post and pad foundations at the ground surface. The base of the structures is generally skirted with plywood for most of the structures in the community. Where visible, the structures have a crawl space of approximately 18 to 24 inches. In limited instances, the buildings may be founded on concrete footings. Due to the relatively high permeability of the sand, drainage problems around the structures were generally not observed. There is no indication of significant settlement occurring based on visual observations.

1.2.10 Roads

The community utilizes a combination of road systems in the interior portions of the community and the beaches for travel. The road surface is composed generally of medium to fine sand with low silt content. There is little in the way of fines (silt sized or smaller materials) to bind the sands together on the interior road surfaces and thus the roads are subject to pushing and rutting. In some areas, gravel has been added to the road surface to provide a driving surface. In beach areas, driving is generally performed on moist to wet areas or areas with gravel to reduce the pushing and rutting. No sidewalks or curbs were observed during our site visit.

2. Identification and Definition of Hazards

2.1. Climate Change

According to the State of Alaska's Alaska climate change strategy (State of Alaska 2011):

> "Climate change describes the variation in Earth's global and regional atmosphere over time. These changes are likely caused by a combination of natural processes and activities. The rise in the Earth's average surface temperature is known as global warming. Scientists attribute the accelerating rate of global warming to manmade greenhouse gas emissions.
>
> Global warming is currently impacting Alaska and will continue to impact it a number of ways. These impacts include melting polar ice, the retreat of glaciers, increasing storm intensity, wildfires, coastal flooding, droughts, crop failures, loss of habitat and threatened plant and animal species.
>
> Globally, 2005 was the warmest year on record (using records dating back to 1880) with a sustained period of warming in the arctic during 2000-2005[3]. Convincing evidence includes NASA satellite data that shows Arctic perennial sea ice decreasing by 9% per decade since 1979. Less ice means more open water-which means greater absorption of solar energy-which leads to increased warming in the ocean, and in turn accelerates more ice loss. This has led to a wide range of impacts in Alaska, including:
>
> - **melting glaciers, rising sea levels, and flooding of coastal communities.** Warming of oceans and melting of land-based ice increases the volume of ocean water. Loss of sea-ice cover changes habitat for arctic species and leaves coastal communities more exposed to larger waves generated by severe storms.
> - **thawing permafrost, increased storm severity,** and related infrastructure damage to roads, utility infrastructure, pipelines and buildings. Extremes in weather patterns, precipitation and rising sea levels will affect safe water sources in villages, and contributes to increased erosion along Alaska coasts and rivers and undermines Alaska boreal forests.
> - **loss of the subsistence way of life** as animal habitat and migration patterns shift and as hunting and fishing become more dangerous with changing sea and river ice. Warming streams and increased silt from melting glaciers affect fish habitat. Boreal forests advance northward and to higher elevations, displacing tundra. Invasive species compete with native vegetation. Humans, animals and plants may be exposed to new infectious diseases as habitat changes.
> - **forest fires and insect infestations** increasing in frequency and intensity. In the past decade, Alaska has witnessed a record loss of forests to fires and spruce bark beetles."

Shannon & Wilson evaluated the temperature trends from data collected in Cold Bay, the nearest identified weather station. Climate data recorded at the Cold Bay Airport were obtained from the Alaska State Climate Center for the period of record (approximately 1950 to 2011). The

[3] The National Oceanic and Atmospheric Administration (NOAA) reports that 2010 tied 2005 as the warmest year on record (NOAA, 2011a).

Cold Bay Airport was chosen due to its proximity to the site and the length of record. The Cold Bay Airport is a first order weather station[4].

From the mean daily temperatures, Shannon & Wilson calculated annual air freezing (AFI) and thawing indices (ATI). The AFI is calculated by identifying the number of days in a year where the mean daily temperature of below freezing (32°Fahrenheit (F)). For each day, the difference between the mean daily temperature is subtracted from 32°F. The resulting numbers are then summed to give the AFI for that year. The ATI is the opposite of the ATI as it looks at the days where the mean daily temperature is above freezing. Table 1 below summarizes the calculations.

Table 1. Air Freezing and Air Thawing Index Trends

Period of Record	Air Freezing Index (AFI)	Air Thawing Index (ATI)
1950–2010	Mean: 667 Trend: -1.8°F-days/yr	Mean: 2987 Trend: 6.5°F-days/yr
1950–1976	Mean: 759	Mean: 2801
1977–2008	Mean: 576	Mean: 3156

The 1950–2010 data, shows a trend where the annual AFI is decreasing (winters are getting warmer) by approximately 1.8°F-days per year[5] and the ATI is increasing (summers are getting warmer) by approximately 6.5°F-days per year during the complete period of record.

If the dataset is divided in two categories, pre-1977 and post-1977, significantly different results can be seen, including a potential interpretation that the winter and summer temperatures are cooling. However, the applicability of this interpretation is limited. The break in the data in 1977 corresponds to the start of the Pacific Decadal Oscillation (PDO). The PDO is a climate phenomenon, a long-lived El Nino like pattern of climatic variability, in the northern Pacific Ocean that is associated with changes in sea surface temperature, sea level, and wind patterns and temperatures. The PDO switches between a warm (or positive) phase and a cool (or negative) index phase. According to the University of Washington (2011), each PDO phase during the 20th century lasted for approximately 20 to 30 years. The PDO was in a cool phase from 1890 to 1925 and 1945 to 1977, with warm phases from 1925 to 1945 and 1977 to 2008. In 2008, NASA's Jet Propulsion Laboratory announced that the PDO had shifted to its cool stage (NASA 2008). The data used for the AFI and ATI analysis included data since 2008 which may impact the data trend. This does not mean that long-term warming is not occurring, but that the data available for this area are limited by the influence of the PDO and relatively short period of record relative to the PDO.

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[4] A first order weather station is maintained professionally by the National Weather Service or the Federal Aviation Administration. They report multiple weather variables such as temperature, wind speed, and humidity several times each day.

[5] An increase of 1.8°F-days per year means that days that have a mean temperature above freezing are, in general, 1.8°F warmer than the previous year.

2.2. Previous Soils Investigations

Nelson Lagoon is located within the physiographic province known as the Nushagak-Bristol Bay Lowland (Wahrhaftig 1965). This province is characterized by moraine and outwash-mantled lowland having local relief of 50 to 250 feet and rising from sea level to an altitude of 300 to 500 feet at its inner margins. There are no glaciers in this section, although it was glaciated during Pleistocene Glaciation. Permafrost is sporadic or absent in this province and is believed to not be present in the Nelson Lagoon area.

Shannon & Wilson (1993) conducted a subsurface soils investigation in support of the design of the dock facility on the southern shore of the Nelson Lagoon Peninsula near the location of the existing facility. Two borings were drilled as part of this investigation to depths of 42 and 38 feet below the mudline. In general, we observed black loose to very dense, fine-grained sand with thin layers of gravel in the borings. The density of the soils generally increased with depth. Permafrost was not identified.

CE2 Engineers (2002) identified that Nelson Lagoon lies on a spit in an extensive area of low-lying marshy coastline, tidal flats, and inlets and lagoons. The spit is generally composed of medium to fine black volcanic sand with "very occasional lenses of small particle-sized gravel." These sands are believed to be located on former beach ridges that have been partially stabilized by vegetation. CE2 Engineers states the sands are generally carried from west to east in the area. They also identify that a "tight silt layer" is evident at low tide beneath recently eroded areas.

2.3. Identification of Hazards in Nelson Lagoon

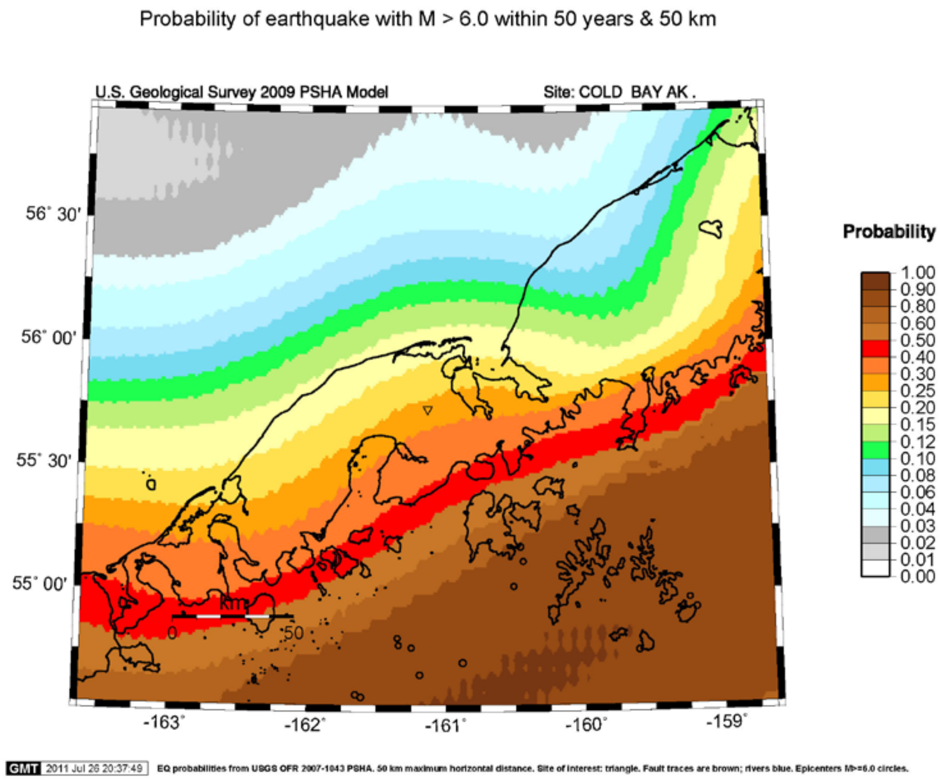
Based on the information in the AEB Hazard Mitigation plan, consultation with U.S. Geological Service (USGS), the Alaska Volcano Observatory (AVO), input from local residents, and documented past occurrences, Nelson Lagoon is at risk for the natural hazards of earthquake, volcano, tsunami, severe weather, wildfire, and erosion.

2.3.1 Earthquake

Alaska is one of the most seismically active regions in the world. According to the AEB Multi-Hazard Mitigation Plan, earthquakes are an area-wide hazard in Nelson Lagoon and any part of the community is at equal risk. Peter Haussler, with the USGS, indicated that Nelson Lagoon could potentially receive an earthquake in the low 7s on the Richter scale (Haussler 2011). There are no known active surface faults in the area, but Nelson Lagoon could be affected by the subduction of the Pacific Plate (Haussler 2011). According to the AEB Multi-Hazard Mitigation Plan, an earthquake in Nelson Lagoon has a high probability of occurrence within the next calendar year. Nelson Lagoon has a 60 percent probability of having an earthquake with a magnitude 5 or greater within 50 kilometers (Figure 3). According to the plan, an earthquake in Nelson Lagoon could be considered critical as it has the potential to cause injuries and/or illnesses that result in permanent disability, complete shutdown of critical facilities for at least two weeks, and more than 25 percent of property severely damaged.

The USGS has developed an earthquake mapping tool that calculates the probability of an earthquake of a particular size happening within a 50-kilometer radius (approximately 30 miles). According to the tool, there is approximately a 15 to 20 percent probability that an earthquake with a magnitude greater than 6 will occur within 50 kilometers of Nelson Lagoon over a 50-year period. The probability increases to 30 to 40 percent that an earthquake with a magnitude 6 or more will occur within a radius of 50 kilometers of Nelson Lagoon over a 100-year period.

Figure 3. Probability of Earthquake with Magnitude Greater than 5.0 within 50 Years and 50 Kilometers



According the USGS Interactive Deggregation website, the primary contributions for earthquakes for building design (a return period of approximately 2,475 years, according to the 2009 International Building Code) in the area are shallow random sources with a magnitude 5 to 7.3, 60-kilometer-deep seismicity not associated with a particular source, and the Aleutian Megathrust. The mean earthquake distance to the site is 60.4 kilometers away from Nelson Lagoon with a magnitude of 6.7.

Ground failure mechanisms are generally limited to densification of loose to medium dense sands, in part relating to liquefaction, and the potential for lateral spreading, both of which are associated with seismic events. Depending on the ground acceleration, clean sands may be particularly susceptible to densification or liquefaction as the result of a seismic event. During a seismic event, the shaking can result in an increase in the porewater pressure within saturated, loose to medium-dense, granular soils. This elevated pore water pressure results in a loss of shear strength in the soil. Liquefaction has been associated with major landslides, lateral movement of bridge supports, settling and tilting of structures, and failure of retaining structures during post-seismic analysis on many large earthquakes worldwide. The seismic load or demand placed on the soils required to cause liquefaction is a function of the intensity and duration of ground shaking. The duration of ground shaking is related to earthquake magnitude, and the intensity depends on magnitude, distance from the earthquake, and site response characteristics. Empirical evidence suggests that liquefaction is typically limited to soils above the 50-foot depth, with a relatively shallow groundwater table, and low relative density.

Given the generally lightly loaded footings anticipated with the one- and two-story timber-frame construction of most of the buildings and the seismicity of the area, we do not generally anticipate a punching type of failure for the footings. Settlement on the order of several inches or more may occur in areas where the groundwater table is close to the footing elevation and the underlying sands are loose.

Lateral spreading is the large-scale movement that occurs on gentle slopes when underlying soils exhibit fluid-like movement in saturated sediments, like what is anticipated to be present in the Nelson Lagoon area. It has been observed resulting from seismic events that have a moment magnitude greater than 6 (as a function of the distance to the source). The criterion for susceptibility of the soil to lateral spreading has been developed by Youd, Hansen, and Bartlett (2002). Post-seismic analysis has shown that sands similar to the sand at Nelson Lagoon are susceptible to this type of displacement and may potentially impact structures such as the city dock. The topography of the area should meet the requirements for proximity to a free-face slope or be on a gentle slope (between 0.1 and 6 percent). Given the depth to groundwater, we anticipate that if lateral spreading were to occur, it would be over larger areas and be a function of the overall slope of the ground below the waterline. For locations near a slope, the free-face ratio of slopes that have experienced lateral spreading has generally been observed to be less than 20 percent. The free-face ratio is defined as the height of the slope divided by the distance from the base of the free face to the point in question. Specific calculation of ground failure potential would require additional geotechnical exploration.

2.3.1.1 Earthquakes and Seismically Induced Ground Failure

Localized slope failures and some differential settlement may occur as the result of larger seismic events. The magnitude of these displacements would be a function of the relative density of the soils, which would be impacted by the depositional environmental, previous loading, and the impact of prior seismic events.

Climate change is not anticipated to significantly impact earthquakes or the behavior of soil as the result of a seismic event. If the sea water elevation increases significantly (on the order of feet), the elevated groundwater surface may cause a reduction of bearing capacity for structures and increase susceptibility to potential liquefaction and lateral spreading. We do not anticipate that this will occur over the next 20 years.

2.3.2 Volcano

According to the AEB Multi-Hazard Mitigation Plan, volcanoes are also considered an area-wide hazard in Nelson Lagoon, and any part of the community is at equal risk. According to the USGS, Nelson Lagoon would most likely be affected by the Emmons Lake Volcanic Center. Pavlof Volcano is the most active volcano in the volcanic center. Given the distance between Nelson Lagoon and the Emmons Lake Volcanic Center, Nelson Lagoon is more likely to experience a volcanic ash event rather than other activities associated with a volcanic event (such as a lahar, pyroclastic flow, or a lava flow) (Waythomas 2011). According to the AEB Multi-Hazard Mitigation Plan, a volcanic event in Nelson Lagoon has a high probability of occurrence within the next calendar year. According to Chris Waythomas with AVO, volcanic events that would impact Nelson Lagoon are uncommon. There is a seismic monitoring network in the area, so it is likely that Nelson Lagoon will receive prior warning about a volcanic event (Waythomas 2011).

2.3.3 Tsunami

According to the AEB Multi-Hazard Mitigation Plan, Nelson Lagoon faces a tsunami threat. The tsunami hazard has not been mapped, so the area that could be impacted by a tsunami is indeterminate at this time. According to the hazard mitigation plan, Nelson Lagoon has a low potential (meaning a possible runup to a 20-foot elevation and reaching up to 0.5 miles inland) for a distant source tsunami (a tsunami generated so far away that the earthquake that generated was not felt or only slightly felt).

Nelson Lagoon is also at risk for having a local tsunami hazard (a tsunami that is generated in nearby waters and could reach the community before a formal warning could be transmitted). These waves may arrive in less than one hour and have historically been the highest, up to 100 feet or more. The estimated possible height in Nelson Lagoon was not estimated.

Nelson Lagoon is currently ranked 48th out of 71 communities on the list of communities to have tsunami inundation mapping (AEIC 2011).

2.3.4 Severe Weather

According to the AEB Multi-Hazard Mitigation Plan, severe weather is considered an area-wide hazard in Nelson Lagoon and any part of the community is at equal risk. The plan considered there to be a moderate probability of a severe weather event, meaning it has up to a one in three year chance of occurring. According to the plan, a severe weather event in Nelson Lagoon could be considered limited as the event could cause injuries and/or illnesses that do not result in permanent disability, complete shutdown of critical facilities for more than one week, and more than 10 percent of property is severely damaged.

2.3.5 Wildfire

In general, a wildfire is a fire that burns uncontrolled in a natural setting such as a grassland or forest. During the May 2011 community meeting, residents indicated wildfires were a concern. The AEB Multi-Hazard Mitigation Plan indicates that wildfires are a low threat as soil conditions and rainfall volumes in the area make wildfire conditions unlikely (AEB 2009). Residents indicated that they were more concerned about a wildfire in the spring and fall as these tend to be the drier times of year. Residents also indicated that a wildfire was more likely to be the result of the burning of trash instead of a naturally occurring source (such as lightning). If parts of the community become drier, possibly due to climate change, a wildfire would be more likely to spread. Following proper burn practices at the landfill should minimize the potential for wildfires.

2.3.6 Erosion

Erosion is the primary natural hazard currently being experienced in Nelson Lagoon. According to the AEB Multi-Hazard Mitigation Plan, erosion is a critical hazard in Nelson Lagoon, meaning it could result in injuries and/or illnesses that result in permanent disability, the complete shutdown of critical facilities for at least two weeks, and that more than 25 percent of property is severely damaged. The plan lists Nelson Lagoon as having a moderate probability of an erosion event, meaning an event has up to a one in three year chance of occurring.

Figure 4. Ice along Shoreline in 1997

Figure 5. Ice along Shoreline in 1995

Erosion is currently impacting residential and storage buildings and threatens the stability of the supply line that provides water for use and fire protection for the community. Approximately a half dozen structures located in the southeast portion of the village are in danger from erosion along the shoreline. This erosion has resulted in removal of material near several residences. Local attempts to construct timber walls, gabion baskets, and other protection measures have not been successful.

According to the U.S. Army Corps of Engineers (USACE) Erosion Study, the erosion problems in Nelson Lagoon include coastline erosion on the Bering Sea and Nelson Lagoon side of the spit, and river erosion from the Nelson and Sapsuk rivers. Erosion is occurring on both sides of the spit where Nelson Lagoon is located. To the north, storms are reported to erode the dunes that run the length of the spit. In general, we observed the sand comprising the dunes to be approximately 25 to 35 feet above the elevation of the Bering Sea. In places, there is no vegetation and the sand slope is exposed. CE2 Engineers (2002) identified that erosion was more prevalent on the Bering Sea side of the spit (eight to 10 feet per year) compared to the lagoon side (two to five feet per year). This is contrary to the statements of the residents, which identify the south side as eroding at a higher rate.

In conversations with Mr. Mark McNeley (resident of Nelson Lagoon), who supports the environmental systems in the community, one of the major changes in the community over the past 20 to 40 years has been the severe reduction in the “ice bench” that historically formed during the winter on the north beach. He stated that during the 70s there used to be large ice benches, possibly on the order of 15 feet tall, which were formed from the ocean spray freezing during the winter. These ice benches provided some protection to the sand dunes on the north side of the island against the early spring storms. However, in recent years, these benches have been on the order of two feet tall and provided little protection against the spring storms. This comment was also made when the USACE researched the Erosion Information Paper for Nelson Lagoon (2007).

Mr. McNeley also stated that there have been several instances where the spit has been overtopped during storm events to the west of the community. This is consistent with information prepared by CE2 Engineers (2002), which stated that there was evidence the spit was overtopped by waves 1.2 miles east of Coast Lake in 1983 photography and 2.4 miles south of the village in 2001 aerial photography. CE2 also states that the spit is narrowing at a rate of 10 to 15 feet per year. However, according to Mr. McNeley, to date the spit has generally filled back in after the overtopping.

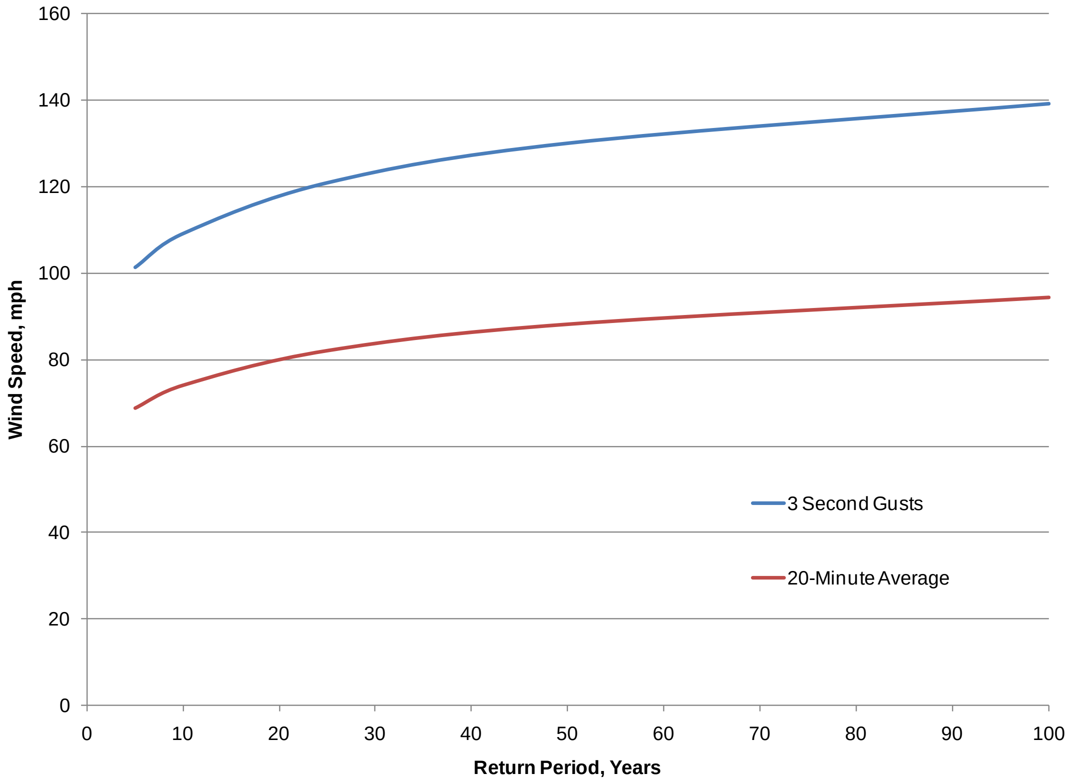
Buildings are generally located closer to the coastline of the southern part of the village relative to the northern coast. The southern beach generally 20 to 60 feet wide and consists of gray, gravelly sand with cobbles, depending on tides. The top of the vegetated surface is approximately 10 feet above sea level at the time of our observations. Community members indicated that during large storm events, the vegetated area may be overtopped.

A growing concern for areas in Alaska like Nelson Lagoon is the increasing coastal hazards posed by climate change. These changes may not directly cause erosion, but they can exacerbate or intensify natural coastal processes. For instance, winter ice and ground freezing help protect the shoreline from waves. If the duration of winter ice and ground freezing is steadily decreasing, a longer time period exists for waves to potentially erode the shoreline. In addition, changes in eustatic (global) sea-level rise and local effects from tectonic creep/shifting can alter normal water surface elevation, also contributing to shoreline retreat. Given its location on a spit, Nelson Lagoon is likely facing an on-going erosion problem which is being worsened by climate change.

2.3.6.1 Wind

At Nelson Lagoon, wind-generated waves are likely a primary cause of coastal sediment transport and erosion. Therefore, characterizing wind is an important part of understanding the hazard posed by erosion. Extreme wind statistics for coastal areas within the United States are available from ASCE (2002). For the Nelson Lagoon region, wind speed is plotted as a function of return period in Figure 6. Both 20-minute average and three-second gust wind speeds are shown in Figure 6 for comparison. The 20-minute average duration wind speeds of 74 mph and 94 mph, which represent approximate 10-year and 100-year return periods, respectively, were applied for the Nelson Lagoon (water body) wave analysis presented in Section 2.3.6.4.

Figure 6. Extreme Wind Speed Based on Return Period (ASCE 2002)



The nearest location having readily available wind data is Port Moller (NOAA 2011b), which is approximately 20 miles east of Nelson Lagoon (Figure 1). Wind data from this location are available only from 2010 to the present, not a long enough record to yield a confident representation of long-term wind statistics. Figure 7 shows a wind rose developed from the Port Moller data for January to December 2010. Wind roses provide a graphic means of describing the intensity and direction of wind. The wind speed shown in Figure 7 represents the 20-minute average.

From Figure 7, it can be seen that the majority of the wind in 2010 came from the north and southeast and the majority of the fastest winds came from the southeast. As mentioned earlier, because this wind record is relatively short, it may not provide an accurate portrayal of the typical wind climate. To supplement the Port Moller data, winds were obtained from the USACE Wave Information Studies (WIS) Hindcast Data (Tracy 2004). Note that hindcast data are calculated, not measured. As a substitute for actual measurements from data collection stations, hindcast data are modeled based on historical regional meteorological records.

Figure 8 shows a wind rose from USACE WIS Station 82289 for 1985 to 2009; this station is approximately 20 miles north of Nelson Lagoon. The WIS wind rose shows greater occurrence of winds from the east and west than reported for the Port Moller Gauge. However, it can be seen that the predominant winds are from the northwest and southeast, similar to the Port Moller data.

Figure 7. Wind Rose for Port Moller (Jan 2010 to Dec 2010) (NOAA 2011b)

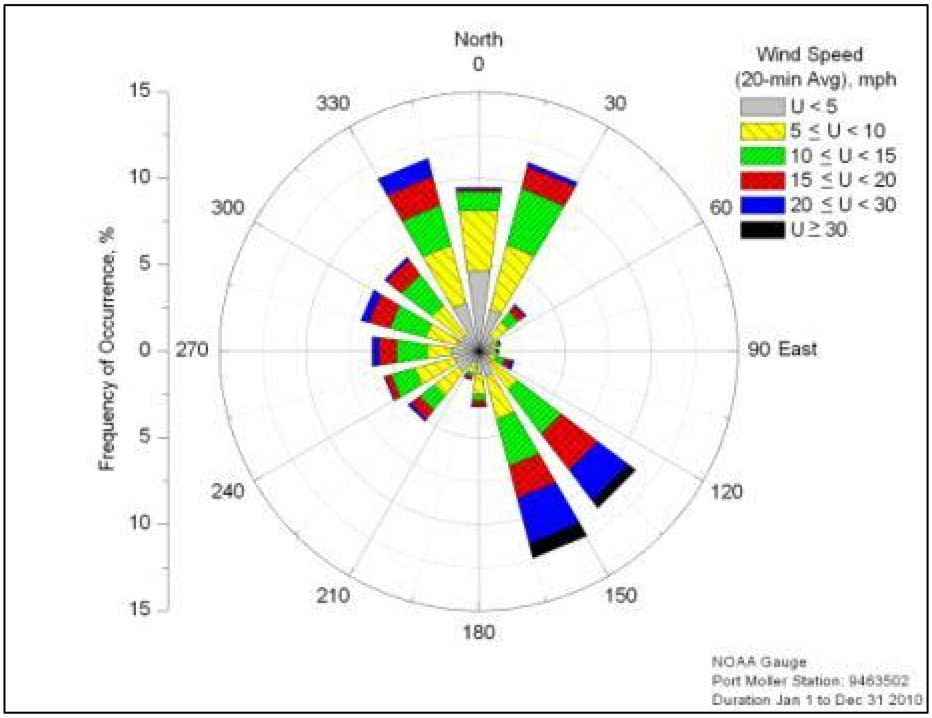
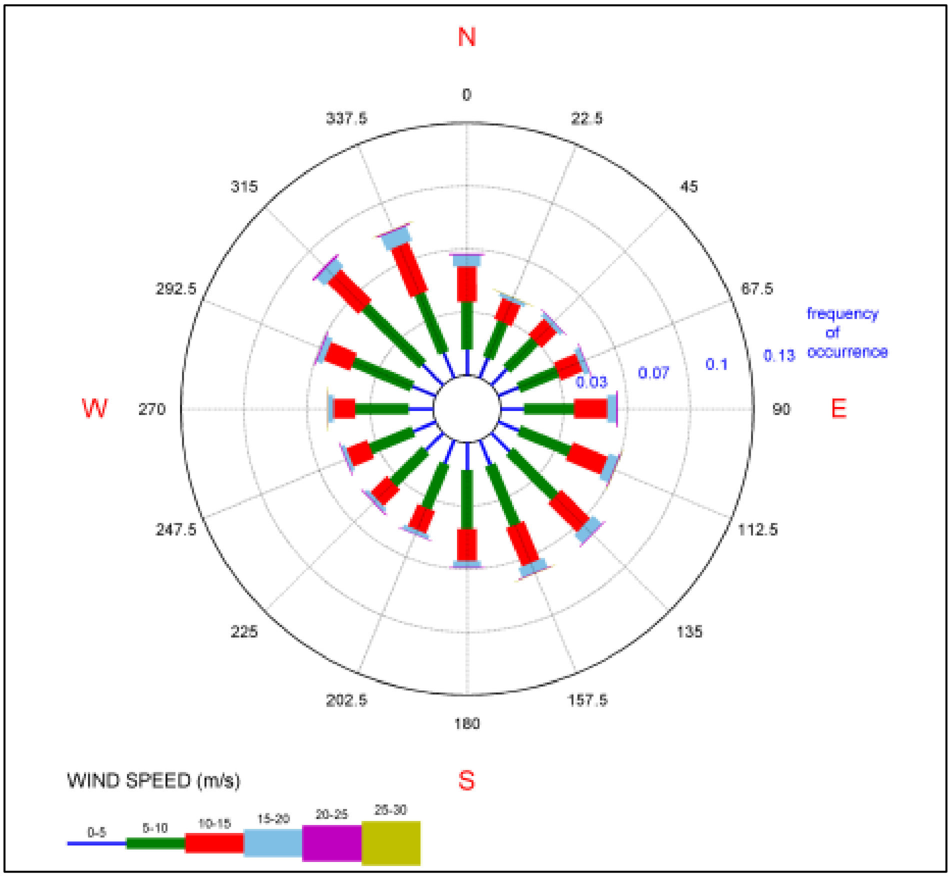


Figure 8. Wind Rose for WIS Station 82289 (Tracy 2004)



2.3.6.2 Water Level

The National Oceanic and Atmospheric Administration (NOAA) station at Port Moller provides tide data from 2007 to present. Table 2 shows the tidal datums relative to Mean Lower Low Water (MLLW) at Port Moller (NOAA 2011b). The greater diurnal tide range[6] is approximately 10.5 feet. Figure 9 plots water level at Port Moller as a percent of time exceeded with the tidal datums superimposed as vertical lines.

Table 2. Tidal Datums at Port Moller

Tidal Datum	Elevation with respect to MLLW, FT
Mean Higher High Water (MHHW)	10.5
Mean High Water (MHW)	9.7
Mean Sea Level (MSL)	5.9
Mean Low Water (MLW)	2.2
Mean Lower Low Water (MLLW)	0.0

[6] Greater diurnal tide range is defined as the difference in the Mean Highest High Water (MHHW) and Mean Lowest Low Water (MLLW) tidal datums.

Figure 9. Water Level Exceedance at Port Moller

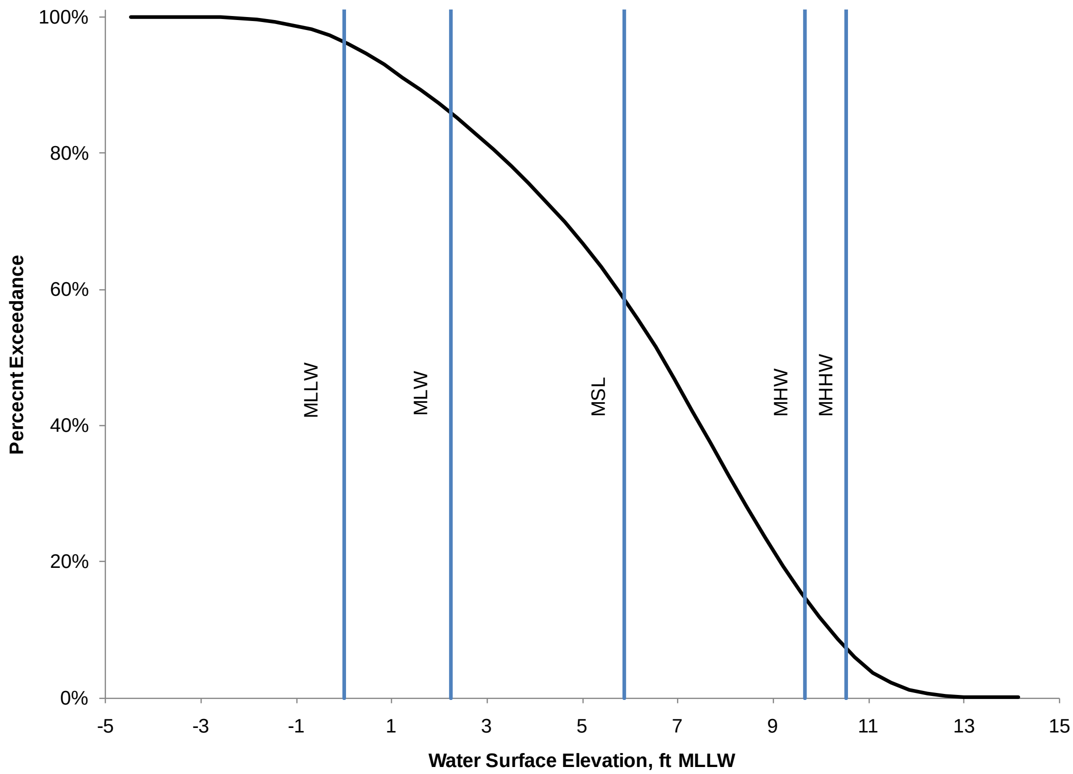
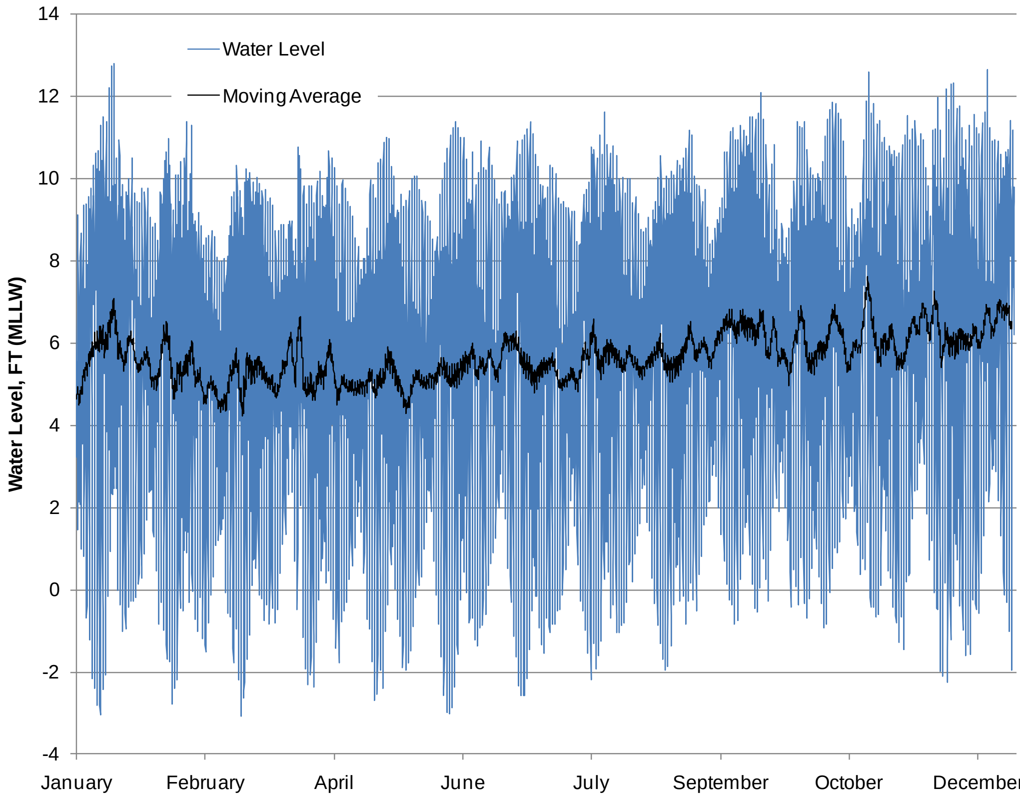


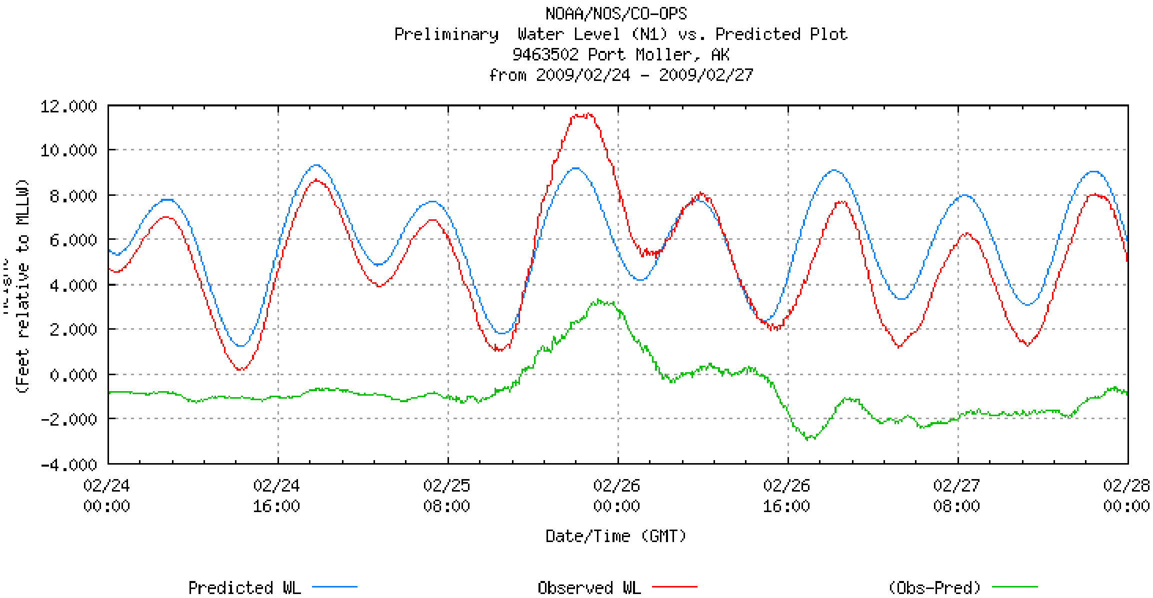
Figure 10 shows a time series of the water levels recorded at Port Moller from January 2009 to December 2009, the latest full year of continuous data. The solid black line indicates the computed averaged trend of the data.

Figure 10. Water Level Recorded During 2009 at Port Moller



Extreme water level (surge) information is limited for the area and will be needed for further analyses. Water level of a severe storm in that occurred in February 2009, ranked No. 9 in based wave height (refer to Section 2.3.6.3), was reviewed at Port Moller to get an indication of potential surge level. Figure 11 shows predicted water level, measured water level, and difference between predicted and measured water levels during the storm. From Figure 11, it can be seen that surge elevation reached approximately three feet.

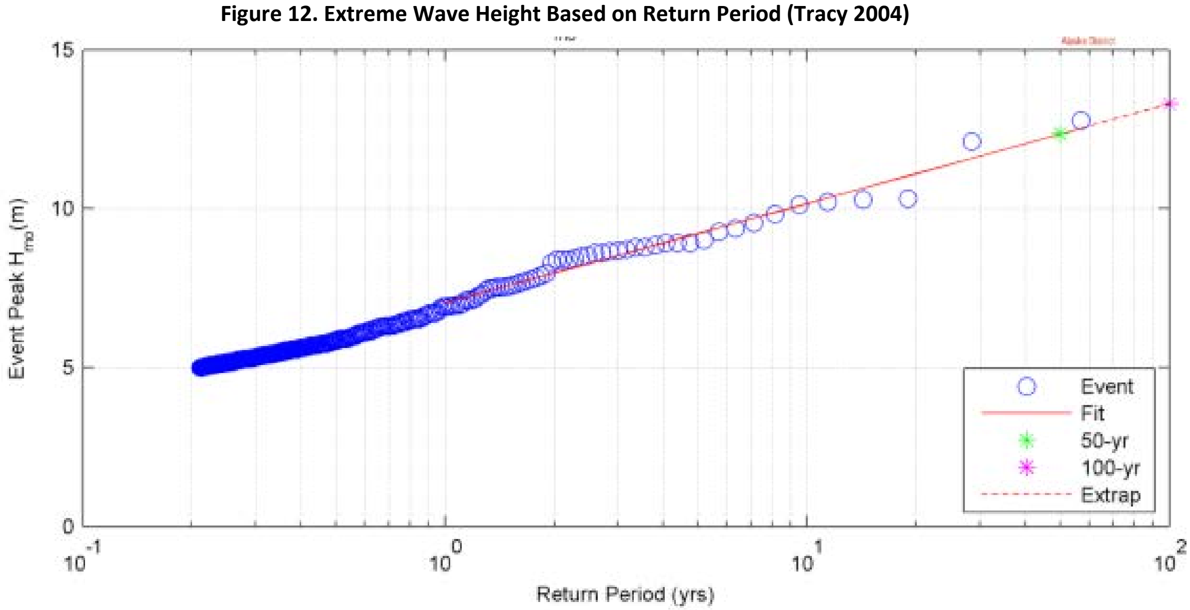
Figure 11. Water Level at Port Moller 2/2009 (NOAA 2011b)



2.3.6.3 Waves in the Bering Sea

WIS hindcast data were applied to characterize the offshore wave climate in the Bering Sea within the vicinity of Nelson Lagoon. Figure 12 shows extreme wave heights plotted against return period[7] based on data from 1954–2009. Based on the best fit line, the 10-year return period and 100-year return period significant wave heights are approximately 33 feet and 44 feet, respectively. The 10 storms having the largest waves are listed in Table 3.

Figure 12. Extreme Wave Height Based on Return Period (Tracy 2004)



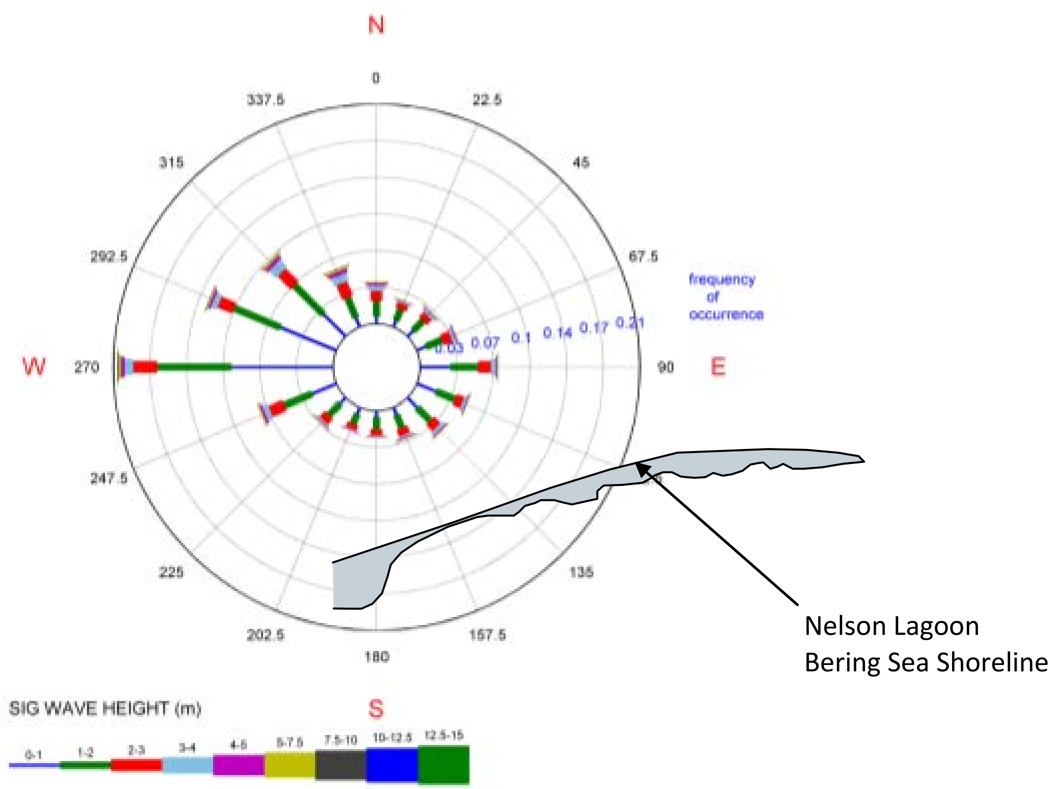
[7] Return period indicates the probability of an event occurring in a given year. For example a 100-year return period indicates there is a one percent (or 1/100) chance of that event occurring in a single year. A 100-year return period does **NOT** mean an event occurs only once every 100 years.

Table 3. Ten Largest Wave Events Based on Peak H_{mo} (Tracy 2004)

Event	Date	Spectral Significant Wave Height, H_{mo} (ft)	Peak Wave Period, Tp (sec)
1	11/26/1990	41.9	16.4
2	10/03/1955	39.7	16.4
3	11/27/1997	33.8	13.5
4	10/18/2005	33.7	14.9
5	11/27/1985	33.5	18.0
6	11/16/1979	33.2	14.9
7	12/03/2003	32.2	12.3
8	11/14/2000	31.3	19.8
9	02/25/2009	30.7	16.4
10	11/05/1996	30.4	16.4

Figure 13 shows a wave rose based on the WIS data from 1985 to 2009. The wave rose, similar to the wind rose, is a graphical means of describing the intensity and direction of waves. For reference, the shoreline of Nelson Lagoon is superimposed on the wave rose. From the figure, it can be seen that the largest and most frequent waves are from the west and northwest, likely influencing long-term sediment transport and associated geomorphic evolution of the barrier spit that separates Nelson Lagoon from the Bering Sea (refer to Section 2.3.6.10).

Figure 13. Wave Rose for WIS Station 82289 (Tracy 2004)



2.3.6.4 Waves in Nelson Lagoon

The offshore wave data shown in Figure 13 are not representative of waves within Nelson Lagoon due to confined geometry and shallower water within the lagoon. To calculate waves within Nelson Lagoon based on wind, there are several important factors to consider. The size of waves generated by local winds is a function of wind speed and duration, wind direction, water depth, and the distance across water that the wind blows (fetch). To conceptually quantify potential wave conditions within Nelson Lagoon, the available wind data were coupled with representative basin geometry of Nelson Lagoon as measured from existing nautical charts and aerial photography. An analytical method for wind wave growth and prediction was then applied, resulting in cursory estimates of 10-year return period and 100-year return period wave heights. Preliminary-level one-dimensional wave prediction techniques developed by the USACE were applied (USACE 2002).

The bathymetry for Nelson Lagoon was inferred from NOAA Navigation Chart 16363, which provides soundings only at the entrance channels into Nelson Lagoon; the remainder of the lagoon is indicated as mud/sand flats. For the purpose of the analysis, the lagoon bottom where there were no soundings was assumed to be at an elevation of 0 MLLW. Table 4 shows the results of the wave analysis.

Table 4. Results of Nelson Lagoon Wave Analysis

Return Period	Water Level, ft (MLLW)	Approximate H_{mo} (ft)	Approximate Tp (sec)
10 Year	10.5	4.2	3.7
	9.7	4.0	3.7
	5.9	3.0	3.4
	2.2	1.5	2.9
100 Year	10.5	5.1	4.1
	9.7	4.9	4.0
	5.9	3.5	3.8
	2.2	1.7	3.2

From the table it can be seen that, conceptually, a five-foot wave could occur within Nelson Lagoon during a 100-year return period event. This is likely a conservative estimate due to the lack of bathymetric data and the relatively simple wave calculation methodology applied. From the table it can also be seen that the tide level has a strong influence on wave height. As the tide rises, much larger waves are able to form.

2.3.6.5 Sediment Characteristics

During a May 2011 site visit, Shannon & Wilson, Inc. performed a cursory sediment analysis by collecting grab samples from various locations along the shoreline at Nelson Lagoon to characterize the type of sediments that exist at the site. Characterization of the sediments along the shorelines is important for assessing plausibility of potential shoreline protection methods as well as better understanding of the erosion processes. Table 5 shows the results of a draft grain size classification performed by Shannon & Wilson, Inc.

Table 5. Grain Size Classification (Shannon & Wilson, Inc. 2011)

Sample	D_{50}, mm	Classification	Characteristic Location
S1 "Dunes"	0.25 mm	Fine Sand	Dunes and Bering Sea Shoreline
S3 "Breakwater"	1.00 mm	Medium Sand	Upper Nelson Lagoon Shoreline
S4 "Ripples"	0.35 mm	Fine Sand	Lower Nelson Lagoon Shoreline
S5 "SE Corner"	7.00 mm	Fine Gravel	Nelson Lagoon Shoreline near Timber Bulkhead

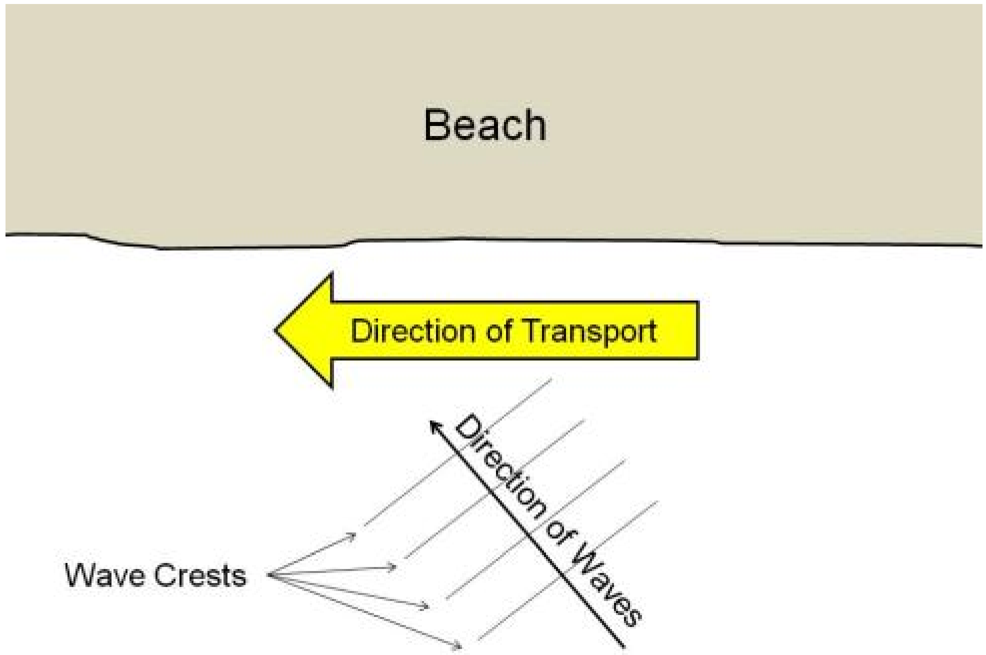
2.3.6.6 Potential Causes of Shoreline Retreat

Potential causes of shoreline retreat were investigated for both the seaside and bayside shorelines of Nelson Lagoon. The potential causes reviewed included: (1) wave-induced sediment transport, (2) current-induced sediment transport, and (3) relative sea-level rise. Due to the differing geometry of the two primary water bodies (i.e., Nelson Lagoon, Bering Sea) and shoreline orientation, the primary cause of sediment transport varies between the seaside and bayside shorelines.

Wave-Induced Sediment Transport

In general, sediment transport along a shoreline occurs by two primary processes: (1) longshore transport and (2) cross-shore transport. Longshore transport is the movement of sediment parallel to the shoreline. This process occurs primarily when waves approach the coast non-perpendicular to the shoreline. Because the height and direction of waves varies throughout the year, longshore transport rate and direction also vary throughout the year. One direction will commonly incur a larger transport over time, creating what is called "net longshore transport." Figure 14 illustrates longshore transport schematically.

Figure 14. Schematic of Longshore Sediment Transport Direction Based on Direction of Waves (Plan-View)



Cross-shore transport is the movement of sediment perpendicular to the shoreline. This sediment transport process is typically cyclic, especially on beaches open to large bodies of water such as the Bering Sea. Calmer summer waves often transport sand across the beach profile from deeper to shallower water, increasing beach width and creating larger sand bars. Winter storms often cause larger, more erosive waves that pull sand offshore, decreasing beach width. Although many natural beaches have a tendency to recover after storms, major storms can cause hundreds of feet of erosion in just a few days, much of which is permanent.

Current-Induced Sediment Transport

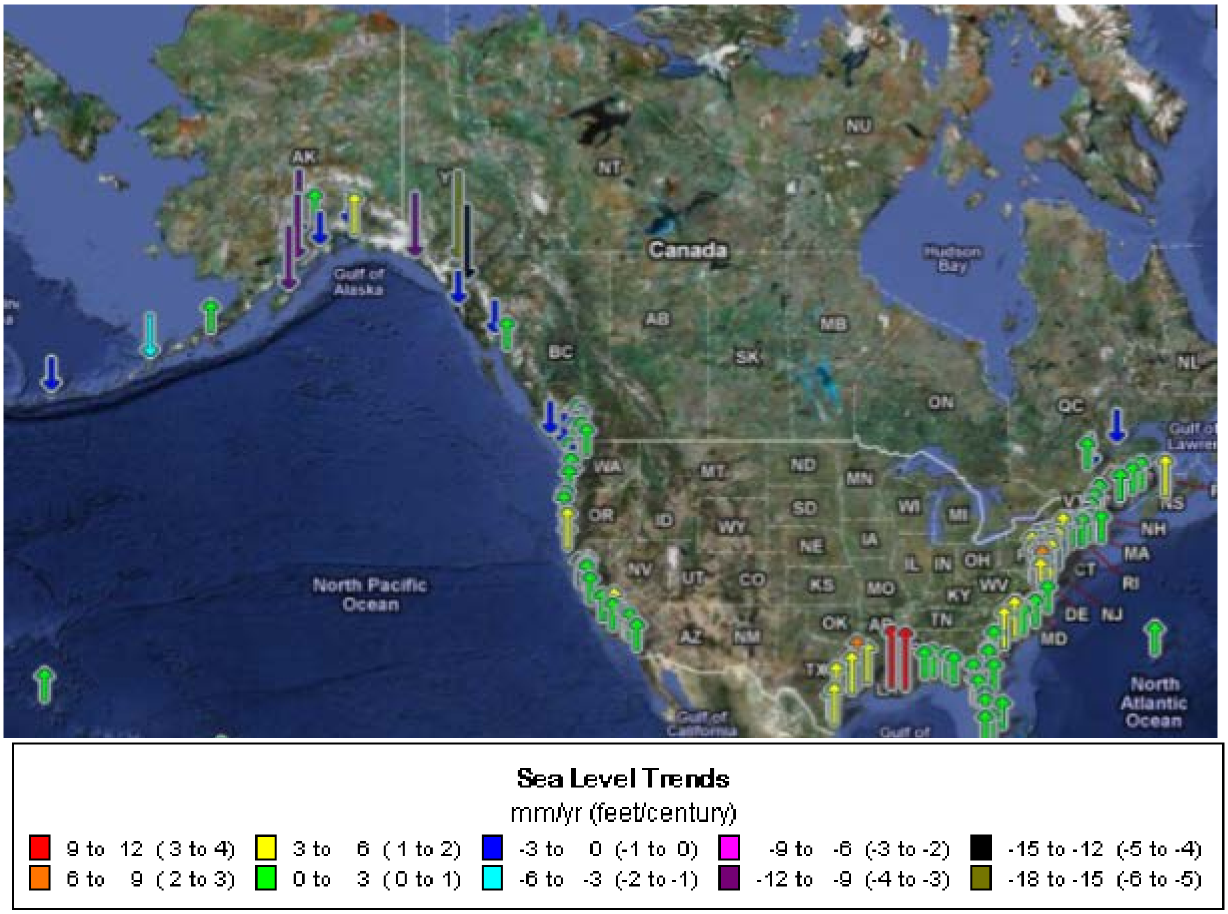
Sediment transport due to current is caused by fast-moving water such as at rivers and inlets or from large tidal swings. Currents can continually carve out banks and river/bay bottoms until a quasi-equilibrium between sediment size and current velocity is achieved. Decreasing currents can also act to deposit sediments.

Relative Sea Level Rise

Relative sea level rise (RSLR) is the combination of eustatic (global) sea level rise and local land subsidence (or in some cases, rise in land elevation). This local change in land elevation has a variety of causes, such as tectonic creep/shifting, groundwater reduction/increase, oil extraction, etc. NOAA calculates RSLR from tide gauges having long-term records. There are three gauges along the entire Aleutian Islands; these are at Adak Island, Unalaska, and Sand Point (Figure 15). The closest gauge is Sand Point, located approximately 50 miles from Nelson Lagoon on the Pacific Ocean side of the Aleutian Islands. The reported RSLR at Sand Point is 0.92 mm/yr, equivalent to 0.3 feet/century, based on sea level data from 1972 to 2006 (NOAA

2011b)[8]. Estimates of eustatic sea level rise range from 0.3 feet to more than 0.8 feet/century (NOAA 2001), leading to an assumption that there is negligible local land subsidence or even possible land rising at this location. This relatively small magnitude of long-term water level change is likely insignificant to shoreline retreat.

Figure 15. RSLR Reported by NOAA Tides and Currents (NOAA 2011b)

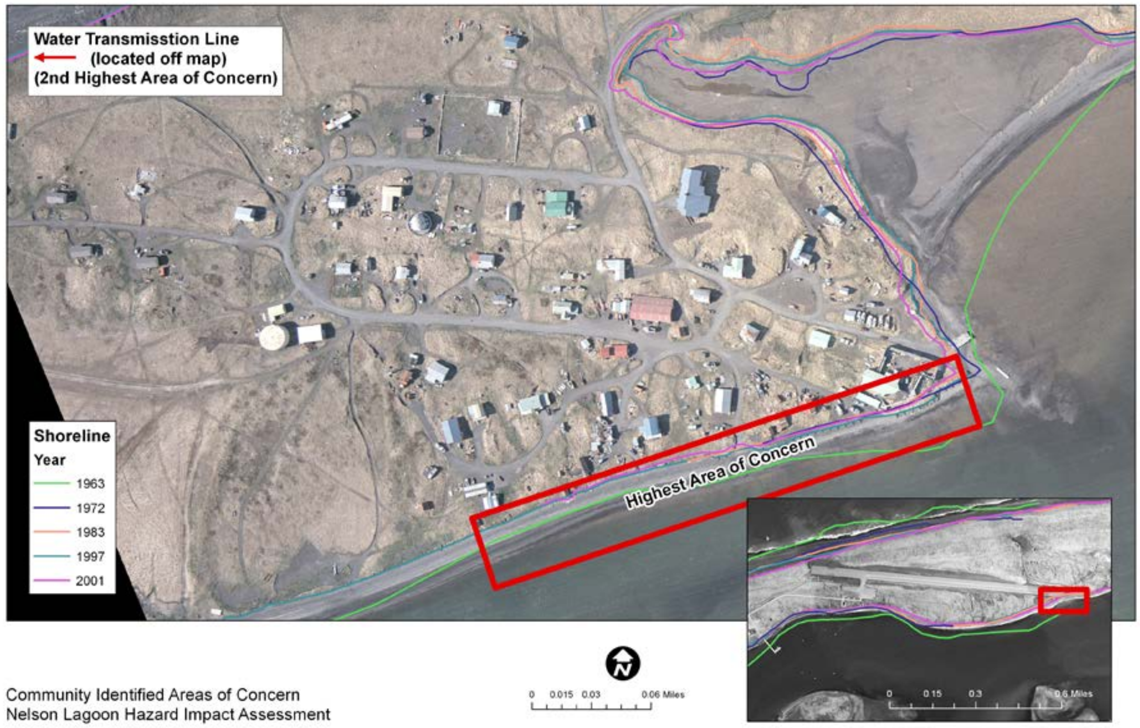


2.3.6.7 Community Identified Areas of Concern

During the first site visit, Laurie Cummings with HDR Alaska and Eric Anderson with Shannon & Wilson met with members of the community. They talked about areas of Nelson Lagoon that have been impacted by hazards over time. The areas of concern to community residents are shown on Figure 16.

[8] The 95% confidence interval at Sand Point reported by NOAA is +/- 1.32 mm/yr. Relative to other NOAA tide stations, the Sand Point station does not have a long duration, and longer durations provide better confidence.

Figure 16. Community-Identified Areas of Concern



2.3.6.8 Previous Erosion Control Measures

Previous measures have been taken to try to minimize further erosion damage. The previous measures are summarized below.

Wooden Seawall

A seawall is a structure built to prevent erosion and other damage from wave action and storm surge. A wooden seawall was built by the community in the early 1980s. Community residents indicate the wooden seawall was effective for many years but is no longer very effective. During the May 2011 community visit, this structure was observed to be in fair to very poor condition. In several locations, erosion had occurred to the point that the wall had been undermined and the soils behind the walls were being removed (Figure 17, Figure 18, and Figure 19).

Figure 17. Undermining and Removal of Material behind a Portion of the Timber Sea Wall in the Southeastern Portion of the Community

Figure 18. Damage to Wooden Seawall

Figure 19. Broken Section of Wooden Seawall

Community members also noted that the lateral supports placed on the outside portion of the wall that provide bracing were subject to damage from spring ice flows. Near the eastern edge of the timber sea wall, the earth behind the wall has been completely eroded (Figure 20).

Figure 20. Severe Erosion of Wooden Sea Wall on Eastern End of the Wall

In 1986, gabions (wire mesh cages containing rocks that are used to absorb some of the wave energy) were added to anchor the existing wood seawall (Figure 21 and Figure 22). This project cost approximately $60,000 and is reported to have had little success because of tides and high winds (USACE 2007). According to AEB, the rocks were undersized compared to the gabion mesh, resulting in the rocks eventually being washed away (U.S. Senate 2004).

Figure 21. Gabions

Figure 22. Gabions

Residents have attempted to utilize available materials to help stabilize the wall and protect it from erosion, including nets, plastic totes filled with cobbles and chunks of concrete, engine blocks, and metal debris. One homeowner has used rock-filled fish totes to help reinforce the wooden seawall and protect his property from further erosion (Figure 23).

Figure 23. Rock-Filled Fish Totes Used to Reinforce the Wooden Seawall

Geotube Containment Structure

In September 2005, a geotube containment structure, consisting of a sediment-filled sleeve of geotextile fabric, was installed near the city dock (Figure 24). According to the USACE (2007), the finished structure consists of approximately 300 linear feet of geotube that is five feet high with a 7.5 foot scour apron. The USACE reported that when they prepared their document, there had not been enough time to assess the structure's effectiveness. Based on a visual inspection during the May 2011 community visit, the tubes were observed to be in good condition. It was not possible to assess the impact of the geotubes when we made our observations, as we did not have a good basis of initial conditions for the erosion protection and the corresponding control area. However, it did appear that the vegetation extended one to three feet farther in the middle of the tube section relative to the ends, a possible indication the tubes were working. Community residents also indicated that the project has slowed erosion in the area. No quantifiable measurements were available to determine the effectiveness of this project.

Figure 24. Geotube Containment Structure

2.3.6.9 Erosion Rates

In Nelson Lagoon, the beach area historically tends to wash out in one area and then rebuild in another. The active erosion area along the Nelson Lagoon side of the spit is less than 100 feet from community structures, including housing and the runway. According to the USACE, major erosion events in the community have been constant for the last 20 years, resulting in an average of five feet per year of shoreline erosion (USACE 2007). Along the spit, erosion occurs at an approximate rate of one to two feet per year, per the USACE Erosion Information Paper; however, no specific measurements of extent were provided. In 2009, historical shoreline mapping was done by digitizing shorelines from the 1963 USGS quadrangle map and aerial photography from 1972, 1983, 1997, and 2001. Based on this historical shoreline mapping, erosion rates at various points along the shoreline were approximated. The results are shown in Figure 25.

Figure 25. Approximate Erosion Rates

2.3.6.10 Shoreline Erosion (Bering Sea)

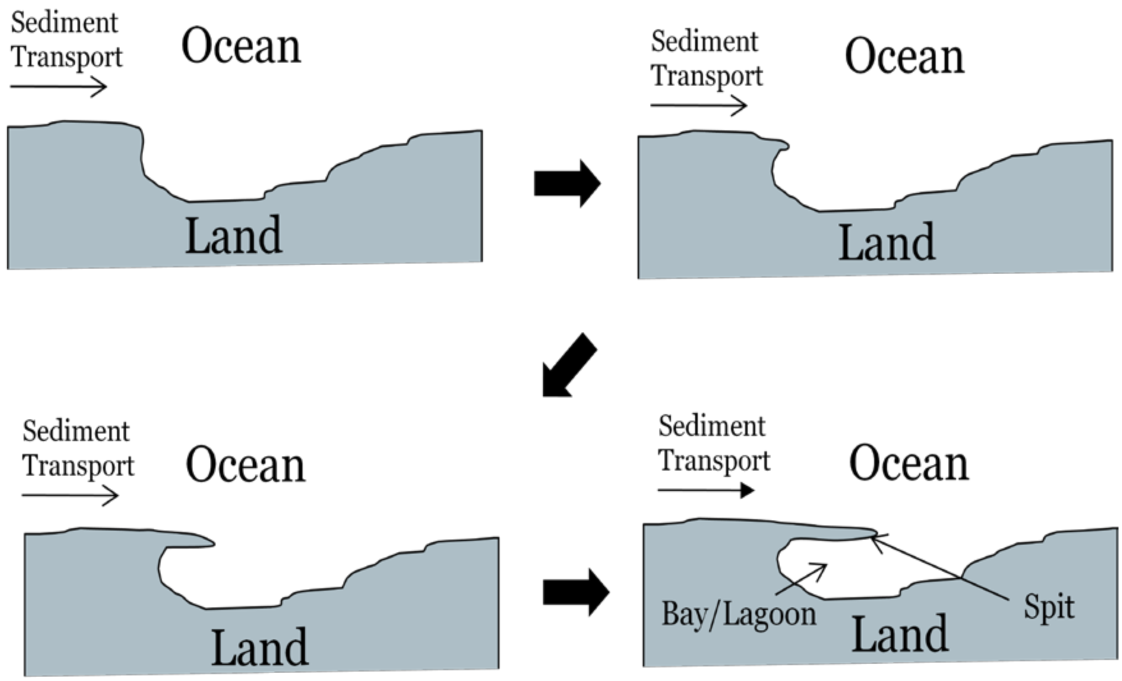
Based on a previous analysis of shoreline change by HDR (2010a), seaside erosion rates in the vicinity of the Nelson Lagoon airport range from five feet/year to as much as 33 feet/year. For this previous analysis, the time interval over which shoreline changes were measured varied from four to 14 years. These erosion rates may not reflect the magnitude of episodic erosion that occurs during storms because beaches often recover within a few years (refer to Section 2.3.6.6). Table 6 shows maximum erosion rates calculated for the time periods considered by HDR (2010a). Locations of maximum shoreline erosion vary for different time periods. As a comparison, USACE (2007) reported an average erosion rate of five feet/year and stated that the frequency of major erosion events has been relatively constant for the past 20 years.

Table 6. Bering Sea Shoreline Erosion Rates (HDR 2010a)

Time Period	Maximum Shoreline Retreat	Maximum Erosion Rate
1963–1972	300 ft	33 ft/yr
1972/1983	100 ft	9 ft/yr
1983–1997	80 ft	5 ft/yr
1997–2001	100 ft	25 ft/yr
Average (1963–2001)	500 ft	13 ft/yr

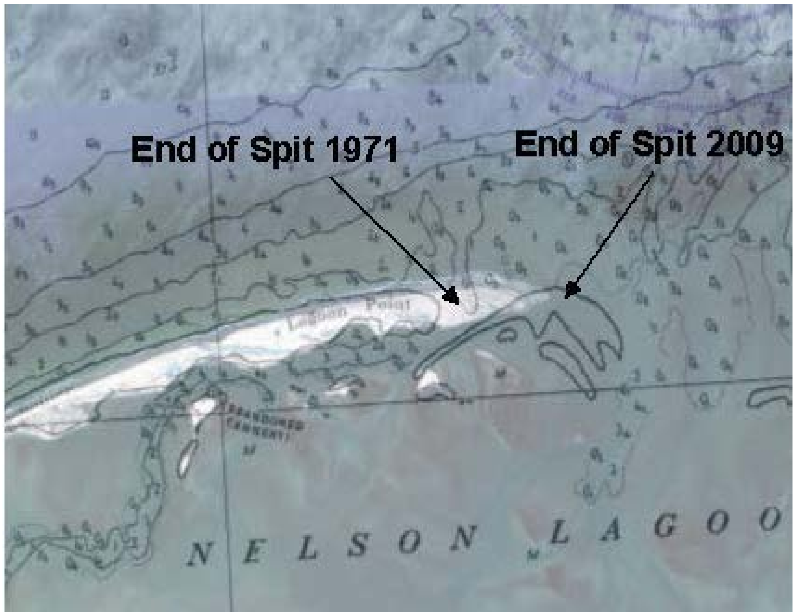
Shoreline retreat along the Bering Sea side of Nelson Lagoon appears to be caused primarily by wave-induced sediment transport. From aerial photography, the village of Nelson Lagoon is located on what appears to be a geomorphic feature commonly referred to as a “spit,” which is formed over a long period time (decades to centuries) by prevailing longshore sediment transport. Figure 26 schematically illustrates spit formation.

Figure 26. Schematic of Spit Forming over Time



The direction of spit growth is consistent with the predominant offshore wave direction as shown in Figure 13 and Figure 14. Given enough time and updrift sediment supply, spits can continue to grow and may eventually evolve into larger land features such as barrier peninsulas or islands. When comparing a 1971 T-Sheet and recent aerial photography, it appears the Nelson Lagoon spit is lengthening at a rate of approximately 140 feet/year (Figure 27). According to anecdotal data presented by Cordova et al. (2010), the spit has grown 1.5 miles in the past 50 years, equating to 160 feet/year. It should be noted that if the supply of sediment is no longer available or is reduced, the spit can dwindle in size, growing longer and thinner until it is completely breached and broken up by waves. USACE (2007) reported the spit is "…getting longer and narrower as erosion advances on both sides." Depletion of updrift sediment supply at Nelson Lagoon could potentially be catastrophic in the long term. A detailed assessment of updrift sediment supply and overall sediment budget will be important for prediction of future morphology of the spit.

Figure 27. 1971 T-Sheet Overlaid on a 2009 Aerial Photograph (Notice approximate 1 mile extension of spit - ~140 ft/year)



Cross-shore (onshore and offshore) transport of sand is an additional contributor to shoreline change. As discussed in Section 2.3.6.6, onshore and offshore transport are typically relatively balanced except during major storms. Evidence of erosion caused by cross-shore transport is shown in Figure 28, a photograph taken on May 23, 2011, along the Bering Sea shoreline of Nelson Lagoon. Along the back beach, note the approximate three- to five-foot-high scarp. This feature is probably sustained by large waves during high tides or storms. Cordova et al. (2010) and others have reported significant erosion of the seaside shoreline of Nelson Lagoon due to intense storms, often occurring during the fall. An 11-mile-long water transmission line runs from the mainland out to the community and has been damaged multiple times by erosion along the seaside shoreline (Figure 29). In at least one instance, a breach of the shoreline was reported but has since recovered (Cordova et al. 2010).

Figure 28. Bering Sea Shoreline (Facing Landward)

Figure 29. Bering Sea Shoreline Erosion (HDR 2010b; Notice exposed water transmission pipe)

2.3.6.11 Shoreline Erosion (Nelson Lagoon)

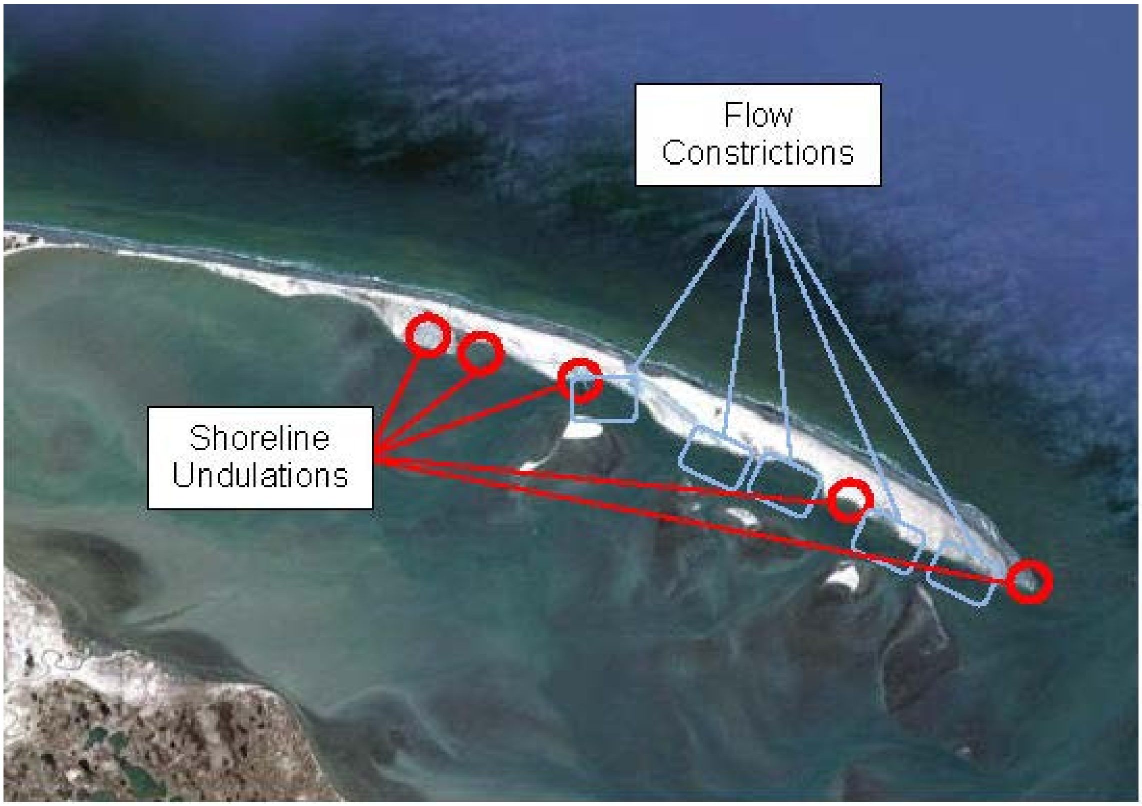
Using the same shoreline position analysis discussed in Section 2.3.6.10, bayside erosion rates in the vicinity of the Nelson Lagoon airport range from less than 1 foot/year to as much as 33 feet/year. Table 7 shows maximum erosion rates based on years shoreline position was reported. Location of maximum shoreline retreat varies between time periods.

Table 7. Nelson Lagoon Shoreline Erosion Rates (HDR Alaska 2010a)

Time Period	Maximum Shoreline Retreat	Maximum Erosion Rate
1963–1972	300 ft	33 ft/yr
1972–1983	30 ft	3 ft/yr
1983–1997	10 ft	<1 ft/yr
1997–2001	100 ft	11 ft/yr
(Average) 1963–2001	320 ft	8 ft/yr

In addition to waves, tidal currents were considered a mechanism for erosion along the bay shoreline of Nelson Lagoon. Various geometries of a bay, such as sharp undulations in the shoreline, abrupt changes in water depth, and focusing or narrowing of the water body, can constrict and/or amplify tidal currents. Figure 30 shows potential areas where this might occur in Nelson Lagoon. Changes in water depth were not evaluated due to lack of bathymetry for this area. More detailed hydrodynamic analysis within Nelson Lagoon would help identify areas of increased tidal current and potential erosion hotspots.

Figure 30. Potential Areas of Amplified Tidal Currents



As discussed in Section 2.3.6.4, there is limited available bathymetry in Nelson Lagoon. However, assuming that during a high tide Nelson Lagoon has a depth of 10 feet, significant wave heights of up to five feet could occur during a 100-year return period storm. Wind roses shown in Figure 7 and Figure 8 show that a higher frequency of winds occurs from the south to southeast, further suggesting waves could be a significant factor in erosion of the bayside shoreline. A more detailed two-dimensional wave analysis incorporating the geometry of Nelson Lagoon would help to better identify the potential impacts of erosion hazards along the bayside shoreline.

In addition to erosion caused by natural coastal processes, man-made events have also contributed to some erosion of the bayside shoreline. It was reported in Cordova et al. (2010) that gravel was removed on the bayside for construction of the airport. Removal of the gravel was perceived to have exacerbated erosion, resulting in the community constructing a timber bulkhead and passing a resolution prohibiting future removal of gravel from the spit.

2.4. Critical Facilities

Critical facilities are sites, structures, and infrastructure that are essential to the well-being of the community served by these systems. There is no universal definition of a critical facility, as facilities and their importance can vary in different communities. The AEB Hazard Mitigation Plan identified the critical facilities in Nelson Lagoon and their vulnerability to identified natural hazards. This information was used as a starting point and was updated based on information provided by the community. The results are shown in Figure 31 and Table 8.

Figure 31. Critical Facilities

Table 8 lists structures and their vulnerability to identified natural hazards and whether—based on its location—each asset has a low, moderate, or high vulnerability to specific natural hazards. If it is not identified as a hazard in the jurisdiction the column is marked with an N/A. The Alaska Division of Homeland Security and Emergency Management (DHS&EM) directed that until inundation maps are competed, the tsunami areas not be designated on hazard asset matrices (AEB, 2009).

Table 8. Nelson Lagoon Hazard Asset Matrix

Infrastructure/Structure	Earthquake	Volcano	Tsunami	Severe Weather	Wildfire	Erosion
1. Community Center	H	H	Not mapped	M	Not mapped	M
2. COHO Commercial Store	H	H		M		N/A
3. Community Clinic	H	H		M		N/A
4. Water Treatment Plant	H	H		M		N/A
5. Water Tower	H	H		M		N/A
6. Community Storage Building	H	H		M		N/A
7. Aleutians East Borough Teacher Living Quarters	H	H		M		N/A
8. Private Shop	H	H		M		N/A
9. Tide's Inn	H	H		M		M

Infrastructure/Structure	Earthquake	Volcano	Tsunami	Severe Weather	Wildfire	Erosion
10. USPS/VPSO Office	H	H		M		N/A
11. Private Shop	H	H		M		N/A
12. Bering Inn	H	H		M		N/A
13. Aleutians East Borough School District School Building	H	H		M		M
14. Public Dock/Boat Ramp	H	H		M		M
15. Fuel Tanks	H	H		M		
16. Nelson Lagoon Storage Company	H	H	Not mapped	M	Not mapped	
17. Nelson Lagoon Airport	H	H		M		M
18. Nelson Lagoon Electrical	H	H		M		M
19. Seafood Processing Plant	H	H		M		

Source: AEB Hazard Mitigation Plan and HDR

A tsunami inundation map has not been completed for Nelson Lagoon. The identification of critical facilities that are vulnerable to tsunamis should be done after this mapping has been completed.

While not identified as a critical facility in the AEB Multi-Hazard Mitigation Plan, the community water transmission line is important as it connects the community's water source with the water tank. Several times, the pipe has been damaged as a result of erosion and loss of support. If the pipe is damaged for a significant period of time such that it cannot transfer water, the village drinking water supply and fire protection capability could be in jeopardy. A sustained breach between Nelson Lagoon and the Bering Sea may result in a catastrophic failure of the line. If there is an increase in the frequency or magnitude of storm events, coupled with the reported decrease of the "ice wedge" that may have protected the dunes on the north side of the spit, there could be a significant increase in the maintenance required to maintain the line. These additional costs could place a financial burden on the community. The water source lake is located approximately 1,600 feet south of the Bering Sea beach (CE2 2002) and is not immediately susceptible to the impact of erosion.

3. Goals and Objectives

According to the Nelson Lagoon Strategic Economic and Community Development Plan, the community's vision is "to be a beautiful, clean, and stable community that grows and develops slowly, with a strong emphasis on community pride, a subsistence lifestyle, protection of natural resources, and diversification and strengthening of the commercial fishing industry."

In support of this vision, based on input from community residents and the community's strategic plan, the community's goal is to minimize the impact of erosion on the community. Minimizing the impacts includes:

- Protect existing development (buildings, waterline, etc.) from being damaged by erosion
- Prevent future development from being impacted by erosion

4. Alternatives Analysis & Recommendations

Communities facing a severe erosion threat have four general options available: do nothing, relocation, migration, and protect in place.

- **Do nothing** means taking no action to address erosion or other climate change-related hazards. Doing nothing involves the loss of land and will result in the loss of homes and other structures in the community. Doing nothing is not a practical solution to the erosion problem in Nelson Lagoon.
- **Relocation** involves moving the entire community to a new site that is not vulnerable to erosion or other climate change-related hazards. Because relocation requires the acquisition of a new community site and rebuilding the community infrastructure, it is a very expensive and time-consuming way to address erosion concerns. In general, relocation is considered only as a last resort after it has been determined that other methods of dealing with the erosion issue would not be effective or would be more expensive than relocating the community.
- **Migration** involves shifting the community away from erosion-prone areas. In order to migrate, a community needs suitable land nearby. Migration can be a slow process. In Nelson Lagoon, community residents indicate the surrounding area is unsuitable for development. Migration may be done on a small scale because erosion-control measures may be too late to save some structures.
- **Protect in place** is the use of shoreline protection measures and other erosion controls to prevent/minimize erosion. At this time, protecting in place appears to be the most appropriate solution to the erosion issue in Nelson Lagoon.

Erosion is a complex problem and more data than is currently available is needed to fully understand the causes of erosion in Nelson Lagoon. Solutions to erosion problems need to be based on accurate and complete information or else the erosion problem could be made worse or just moved to a different location. Based on existing information, several additional studies and actions are recommended to reduce the potential effects of erosion in Nelson Lagoon. These studies and actions are summarized in Table 9. Each project is described in more detail below.

Table 9. Summary of Recommendations

Project	Hazard(s) Addressed	Estimated Cost	Possible Resources	Estimated Timeframe
Monitoring Program	Erosion	0 to $60,000 annually depending on program	AEB, Native Village of Nelson Lagoon	Ongoing
Coordination with ADF&G and USFWS	Erosion	Under $10,000	AEB, Native Village of Nelson Lagoon	Ongoing

Project	Hazard(s) Addressed	Estimated Cost	Possible Resources	Estimated Timeframe
Updated Mapping & Shoreline Analysis	Erosion	$50,000 - $100,000	USACE, DCCED, Coastal Impact Assistance Fund (CIAP)	1–2 years
Nelson Lagoon Erosion Study	Erosion	$150,000–$300,000	AEB, USACE, DCCED, CIAP	1–3 years
Community land use plan	Multiple	Less than $50,000	Native Village of Nelson Lagoon, AEB, DCCED	1–5 years
Establish setback requirement	Erosion	Under $10,000	AEB, DCCED	1–5 years (depending on erosion study)
Water Line Alternative Analysis	Erosion	Between $25,000 and $50,000	AEB, Village Safe Water, DCCED	1–2 years (depending on erosion study)
Shoreline Protection	Erosion	Depends on type of shoreline protection	AEB, USACE	Depends on type of shoreline protection

4.1. Monitoring Program

Having accurate information is essential to addressing the erosion issue in Nelson Lagoon. Having a shoreline monitoring program to help identify erosion rates would provide valuable information about where and when erosion is occurring so erosion protection activities can be prioritized appropriately. Shoreline monitoring could be performed in a variety of ways. A typical beach monitoring program consists of survey transects and aerial photography occurring annually and/or post-storm, which, for a community the size of Nelson Lagoon, could range from $30,000 to $60,000 per survey. If this level of monitoring is not cost-feasible, a lower cost monitoring program could be developed in which the individuals from the community perform most of the data collection. For example, a surveyor could install grade markers (such as with timber posts) along transects for periodic readings of the ground elevation by a local resident. These markers would need to be able to withstand the strong wave/current forces so they last several years.

4.2. Coordination

As the Nelson Lagoon area is part of the Port Moller Critical Habitat Area and the area identified as critical habitat for Steller's eiders, coordinate with ADF&G and USFWS is important. These areas have special regulations/protections designed to protect habitat that may have an impact on the development of shoreline protection measures. Early coordination with these agencies to ensure they understand the erosion problem in Nelson Lagoon and to address their concerns as potential solutions are implemented will be valuable.

4.3. Updated Mapping & Shoreline Analysis

The most recent aerial photography was taken in 2001, making it approximately 10 years old. New aerial photography should be obtained to see what changes have occurred in the shoreline over the past decade. The new imagery should extend to the water source as better information about this area is needed to help identify solutions to the water transmission line problem.

New aerial photography, as well as the 1972, 1983, 1997, and 2001 photos, should be ortho-rectified[9]. The shoreline analysis should be redone based on the ortho-rectified images to improve the accuracy of the analysis.

4.4. Nelson Lagoon Erosion Study

Coastal erosion is a complex process. Additional data collection and analyses are needed to develop a comprehensive understanding about the underlying causes of erosion and to identify solutions to adequately address the issue. Without sufficient information about the erosion process for the area, erosion mitigation issues could simply relocate the problem to another part of the community. Specific data collection and analyses that should be done as part of a more detailed study include:

- Establish project goals
  - Prioritization of shoreline reaches
  - Establish design criteria (such as protection against certain storm intensity, desired lifespan, need for environmental synergy, etc.) for shoreline protection solutions
  - Identify potential funding sources
  - Establish short-term and long-term financial budgets
- Collect bathymetric data within Nelson Lagoon
- Collect shoreline survey transects of Bering Sea and Nelson Lagoon shoreline
- Collect additional geotechnical information including sediment samples and borings
- Perform wave and surge numerical modeling analysis of Bering Sea shoreline
- Perform sediment budget/management plan analysis
- Perform wave and hydrodynamic numerical modeling analysis of Nelson Lagoon
- Establish and implement a shoreline monitoring program

4.5. Community Land Use Plan

In Nelson Lagoon, much of the development is located along the shoreline of the lagoon. This is the area of greatest concern to the community. While some facilities and land uses, such as the community dock, are dependent on being near the water, others could be located in another part of the community. Developing a land use that identifies areas away from the erosion-prone areas would help minimize the impact of erosion on new development in the community.

The areas that are best suited for development could be identified though a geotechnical survey of undeveloped land adjacent to the existing community. Developing land adjacent to existing

[9] Ortho-rectified means the photo has been adjusted to account for topographic relief, lens distortion, and camera tilt, giving an accurate representation of the Earth's surface.

development would be recommended so the new development can be connected to existing community infrastructure (water, electricity, etc.) at a lower cost. The area west of the existing community would be one potential area for future development.

As part of the plan, the community should consider establishing a minimum elevation for all new structures. Community residents indicated that some buildings were located below sea level. As a result, these buildings are vulnerable to flooding during storm surge events. Requiring buildings to be above the flood level will minimize damage from future storm events.

4.6. Setback Requirement

Nelson Lagoon should establish a setback requirement preventing new development from being built too close to the shoreline. All new buildings should be built behind the setback, reducing the need for erosion control structures and minimizing damage from erosion, because it limits structures from being built in erosion-prone areas. Setback requirements tend to help new development more than existing development.

A setback requirement would need to include provisions that prevent a “taking.” A “taking” is when the government takes private property for public use without compensation, either by the physical taking of the property or by restricting development in a way that leaves the property undevelopable. Potential ways to avoid a “taking” include having the local government purchase the property and allowing variances in cases where a property owner would be unable to develop their property.

The setback line can be measured from a variety of points, such as the first line of stable natural vegetation (also called the dune vegetation line) or the high tide line. The setback requirement would need to be adjusted if the shoreline continues to erode.

The setback distance should be set based on the erosion rate and consider the building type and expected lifetime of the structure. Larger, immobile buildings or those with longer life spans would require deeper setbacks than smaller buildings that could be moved. Basing the setback on the anticipated building lifetime assumes that by the time erosion approaches the building, the structure would be ready for replacement. The new building would then be built at a new setback.

The erosion setback requirement could be a temporary measure depending on the results of the erosion study. Structural protection measures may make this unnecessary.

4.7. Water Line Alternative Analysis

Erosion has impacted the community water transmission line on several occasions and is likely to do so again in the future. A long-term solution is needed. There are several different approaches that could be taken but finding the right solution requires additional information. Potential solutions include:

- Bury the waterline in its existing location. It would be buried to a depth sufficient to provide freeze and erosion protection.
- Realign the pipe further inland and bury it at a distance and depth from the eroded shoreline that will prevent exposure in the future.

- Realign the pipe on land away from the shoreline in a location that is unlikely to be eroded before the pipe would need replacing. The pipe would be insulated to protect it from freezing.
- Develop an alternative water source closer to the community that eliminates the need for a water transmission line in erosion-prone areas. For example, a desalination plant could be used.
- Develop a second water tank to provide sufficient water for community needs. The water line could then be left in place and repaired as needed.

A water line alternative analysis should be conducted to identify the most appropriate solution.

4.8. Shoreline Protection

Potential concepts for erosion mitigation along both the seaside and bayside shorelines of Nelson Lagoon were reviewed. Section 2.3.6.6 discussed potential causes of shoreline erosion. However, the exact causes and detailed rates of erosion have not yet been quantified. Without yet fully understanding the erosion problem, determination of appropriate solution(s) is somewhat speculative. Further engineering analysis of the erosion at Nelson Lagoon is needed before a more definitive alternatives analysis can be performed. The following discusses the previous shoreline protection methods implemented at Nelson Lagoon as well as possible cursory-level concepts for protection based on potential causes discussed in Section 2.3.6.6.

4.8.1 Bering Sea Shoreline

There are two general categories for shoreline protection: “hard” and “soft” methods. Hard methods, such as seawalls, revetments, breakwaters, groins, and bulkheads, are shoreline protection structures designed to be stable with relatively little movement. Soft solutions, such as beach nourishment and dynamic gravel berms, typically emulate the natural environment and are designed to have a “dynamic stability” that allows the individual elements to move within a specific footprint or template, often supplemented with periodic maintenance.

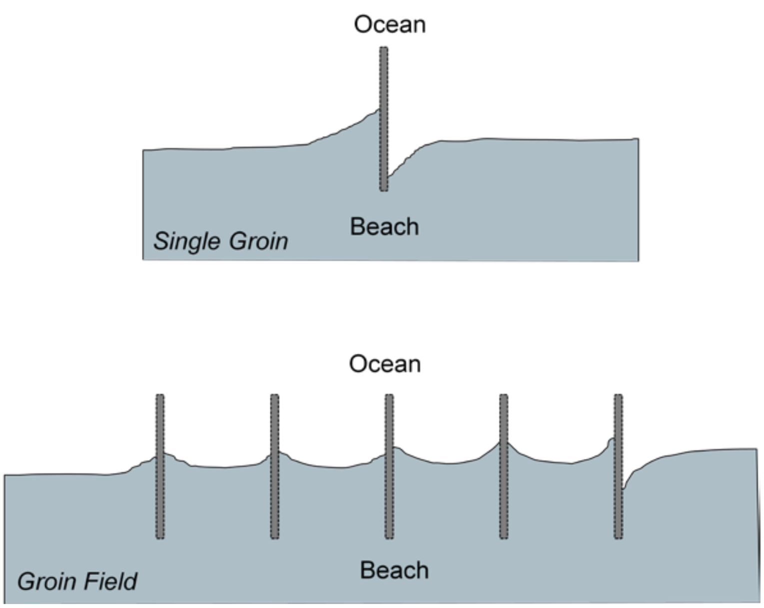
Hard methods typically have longer design lives but greater initial cost and can be more disruptive to the natural environment. There are dozens of hard methods that, properly designed and constructed, may be suitable along the Bering Sea shoreline depending on desired level of protection, longevity, cost, and other factors. Low-cost methods such as gabions, geotextile tubes, and sheetpile will likely be effective only as short-term or emergency solutions along the Bering Sea shoreline. Methods that involve placement of more permanent shore-parallel structures along the backbeach, such as seawalls and revetments, may be preferred if long-term storm protection to landward infrastructure is desired in lieu of maintaining a beach. Although discussion of a complete range of possible hard methods of shoreline protection is beyond the scope of this analysis, several concepts that appear to offer good potential are presented below.

As an alternative to hard methods, soft methods often have lower initial cost and are less disruptive to the natural environment; however, they often need to be repeated or managed to be effective over the long-term, increasing long-term cost. A soft shoreline protection concept is also discussed below.

4.8.1.1 Groins

Groins are structures that extend seaward from the beach perpendicular to the shoreline. Given the significant role that longshore sediment transport contributes to shoreline change along the Bering Sea shoreline, a groin system would potentially be effective in helping to retain sand along the beach. Groins can be constructed from a variety of materials including stone and/or sheetpiling. When multiple groins are built along a shoreline, they make up what is called a "groin field." Figure 32 shows a schematic of a single groin and groin field. The fundamental function of groins is to decrease the longshore transport of sand. If not properly designed, groins can accelerate erosion along the downdrift beach. Groins are not generally effective for reducing offshore transport. Groins along open-ocean beaches can be very expensive due to the large amount of stone or other material required.

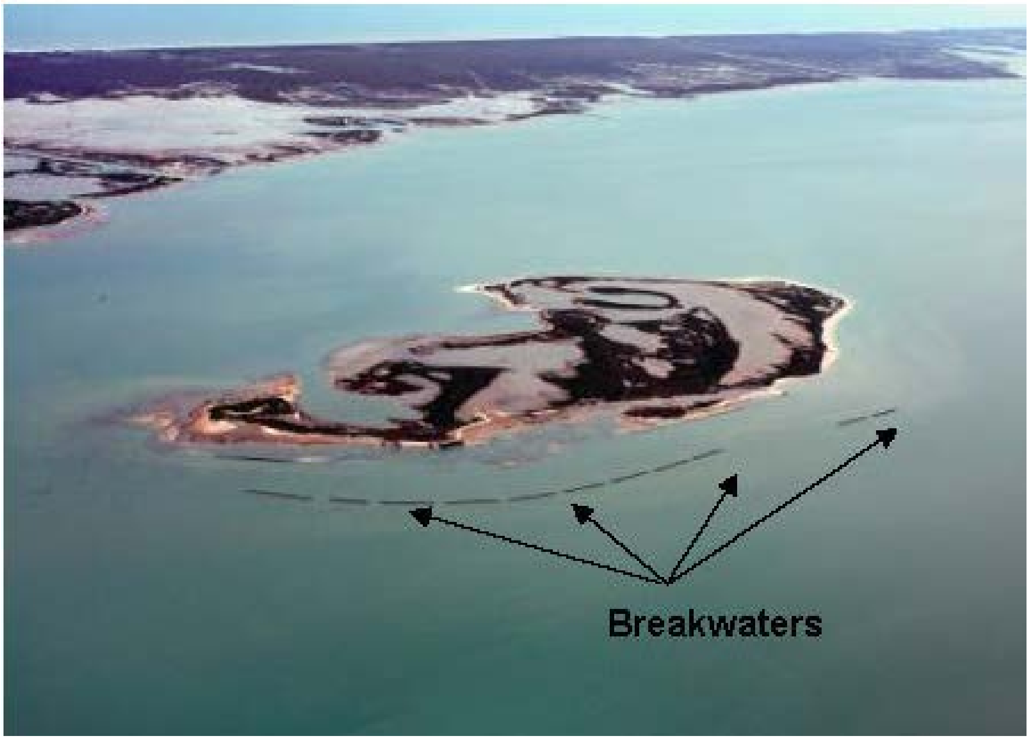
Figure 32. Schematic of a Single Groin and Groin Field



4.8.1.2 Segmented Breakwater

Segmented breakwaters are a common shoreline protection method that consists typically of segmented sections of quarrystone or precast concrete units placed parallel to and detached from the shoreline. The fundamental function of a breakwater is to break or dissipate the energy of incoming waves. This reduces both cross-shore and longshore sediment transport. Similar to groins, breakwaters can adversely impact downdrift areas if not properly designed. Figure 33 provides an example of a segmented breakwater. The distance offshore, cross-sectional geometry, and components of breakwaters can vary greatly depending on the specific site conditions and design goal of the structure. Similar to groins, breakwaters constructed in the open ocean can be very expensive due to the large quantity of material required.

Figure 33. Example of Segmented Breakwaters



4.8.1.3 Sand Back-Passing

Sand back-passing involves removing sand on the down-drift end of a section of beach and placing it back on the up-drift end, recycling it within the natural longshore transport system. This is not a one-time solution and would need to be done periodically, requiring a long-term commitment to beach monitoring and funding. The amount of sand relocated and how often this practice should be performed dictate the cost of this solution. Smaller amounts of sand could possibly be excavated with heavy construction equipment and truck hauled to the up-drift end. If large amounts of sand need to be relocated, a pipeline dredge may be more cost effective; however, mobilization of a pipeline dredge to such a remote area may not be feasible. Other than cost, many things need to be considered, including long-term impacts to regional morphology, potential impacts to down-drift areas (i.e., Port Moller), and the natural environment. Cost for back-passing can range greatly depending on the volume of material, frequency, and other factors. Developing a sediment budget and management plan would be a critical component.

4.8.2 Nelson Lagoon Shoreline

The most appropriate solutions for the bayside shoreline of Nelson Lagoon are contingent on understanding the mechanisms causing the erosion. As discussed in Section 2.3.6.11, the specific cause(s) of erosion and their relative contributions have not yet been analyzed in detail. Certain approaches may perform better depending on whether waves, ice, current, or a combination of the above is the major contributor. Also, the intensity of waves, currents, etc. is key in selecting an appropriate solution. Given the milder wave climate than along the Bering Sea shoreline, low-cost methods of shoreline protection are likely to be more feasible along the bayside shoreline. The following discusses general shoreline protection concepts commonly used in bay and riverine environments.

4.8.2.1 Revetment

A revetment is a sloped system that is situated directly on the shoreline and extends into the water. The cross-sectional geometry of a revetment varies depending on site conditions and level of protection required. There are several types of materials commonly used to construct revetments including quarrystone, articulating block mats (ABMs), gabion mattresses[10], and marine mattresses. Cost of revetments varies mostly due to size.

Quarrystone revetments, as shown in Figure 34, use stone having a specified gradation produced at a quarry. Stone size depends on stability required to withstand waves associated with storm events and/or tidal currents. Major storms, for instance, a 100-year event, require much larger stone than needed for waves generated by more frequent events and typical seasonal conditions.

ABMs are a series of precast concrete units placed along the shoreline that interlock and/or tie together (usually by cable) as shown in Figure 34. During construction, if the mattresses are not pre-assembled with cables prior to placement, they are individually placed by hand along the shoreline. If the units are pre-assembled, the mattresses are placed by a trackhoe or crane. ABMs have the ability to articulate, or flex, which helps the structure conform to shoreline contours that may change over time. Depending on the type of blocks used, vegetation is often able to grow around and on top of some open concrete units (if topsoil is laid). ABM revetments are generally not stable enough for long-term applications along open-ocean coastlines but have a good history of performance along bay shorelines.

Gabions and marine mattresses are prefabricated similar to ABMs and then lowered into place along the shoreline (Figure 34). Both are systems that encapsulate small crushed rock within "mattress" type structures. Gabions are a wire mesh mattress that can be made of variety of corrosion-resistant metals. Marine mattresses are made of HDPE geotextile grid and are comparable in strength to gabions. Because the stone is encapsulated, smaller stone may be used than compared to a quarrystone revetment for a similar storm event.

[10] Gabion mattress differs from gabions previously installed at Nelson Lagoon. Gabions previously installed where stacked single units. Gabion mattresses are more continuous, compartmentalized units placed along a slope.

Figure 34. Examples of Revetment Structures: Quarry-stone (upper left), ABM (upper right), marine mattress (lower left), and gabion (lower right) (courtesy of Maccaferri)

4.8.2.2 Beach Fill

Beach fill is a "soft" shoreline protection method that offsets erosion by placing sand material along the shoreline (Figure 35). Material can come from upland stockpiles, offshore borrow areas, and maintenance dredging of a navigation channel (which is probably not a viable source for Nelson Lagoon). Similar to back-passing discussed above, beach fill essentially involves replacing sediments previously lost from the shoreline and is therefore subject to the same erosion, requiring a commitment to periodic maintenance. However, depending on the source of the nourishment material, beach nourishment can be relatively inexpensive. Since the wave environment within Nelson Lagoon is significantly milder than within the Bering Sea, less sand would be needed than along the seaside.

Figure 35. Example of Beach Nourishment- Discharge of Dredge Pipe

4.8.2.3 Bulkhead

Bulkheads typically consist of pre-cast concrete panels or steel sheetpiles that are jetted/driven into place along the shoreline and tied together by a concrete cap and/or anchored. The area landward of the bulkhead is generally backfilled and sometimes covered with a walkway (Figure 36). As mentioned previously, a sheetpile bulkhead has already been implemented at Nelson Lagoon and is reported to be in relatively good condition after 15 years.

Figure 36. Example of Concrete Panel Bulkhead with Sidewalk

4.8.2.4 Geotextile Tube

Geotextile tubes are relatively low-cost shoreline protection structures fabricated from geotextile fabric and filled with *in situ* sandy sediments (Figure 37). The geotextile tubes can be placed near or along the shoreline (either on land or in water) in various configurations to help block waves. The typical lifespan of geotextile tubes is considerably less than more traditional quarrystone or concrete structures due to natural (ultraviolet degradation, tearing from floating debris, etc.) and human (vandalism, puncture by boat anchor or prop, etc.) impacts.

Figure 37. Example of Geotextile Tube

4.8.3 Non-Engineered Armoring

Since Nelson Lagoon is a small remote community, obtaining funds for multimillion dollar projects may not be feasible. There are several relatively low-cost methods of shoreline protection that have worked well in particular situations but for which there is very limited (or no) published design guidance. For these methods, detailed design calculations and lifespan projections may not be possible. However, non-engineered solutions are sometimes significantly less expensive to construct than engineered solutions. The tradeoff is the uncertain effectiveness of the project in terms of lifespan, impacts to the natural environment, unforeseen downdrift impacts, etc. The following is a list of "low-cost" methods for shoreline protection that have limited ability to be formally designed. More information on these concepts can be found in USACE (1981).

- Erosion control mat – biodegradable mat that allows native vegetation to take root. The vegetation then becomes the shoreline protection.
- Concrete bags – strategically stacked bags of concrete. When water inundates the concrete bag, the concrete hardens and becomes an armor unit. The effectiveness of this method is highly dependent upon installation methods.
- Timber bulkhead – this method has already been implemented at Nelson Lagoon. It is currently damaged but appears to have worked well for several years.
- Rubble riprap – mixture of heavy objects piled up such as broken concrete and rocks.
- Hogwire fence and stacked bags – stacked sand bags secured together with hogwire fence.

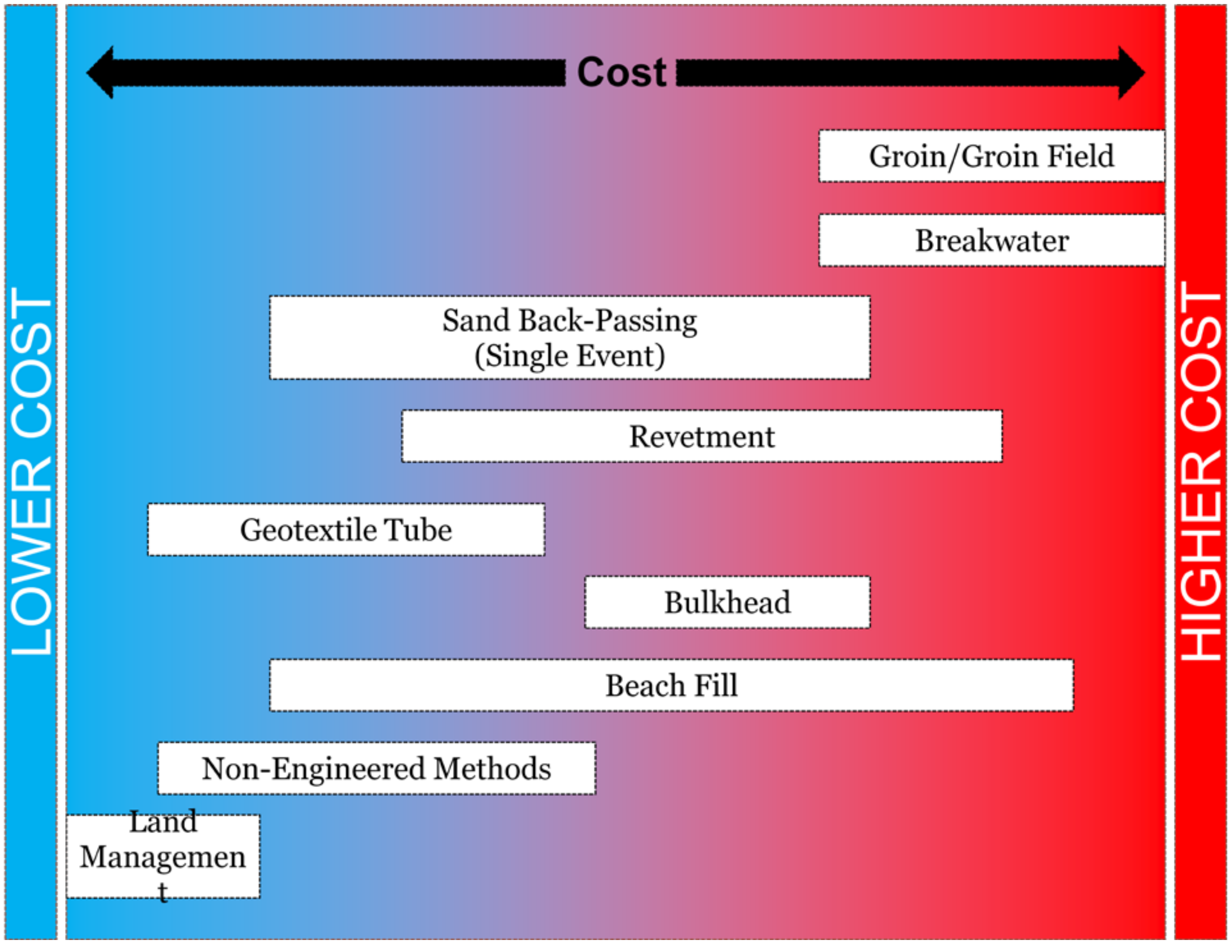
- Tire and post bulkhead – series of posts/bollards driven parallel to the shoreline with tires stacked on the post.
- Fuel or concrete barrel wall – barrels placed end to end, parallel to the shoreline, typically filled with sand or rubble.

It is beyond the scope of the current analysis to determine anticipated or probable costs of the shoreline protection methods discussed in Section 4.8 due to the limited data, uncertainty of hydrodynamic environment, and uncertainty in exact cause(s) of erosion. Some of the information required to develop meaningful cost projections includes:

- Bathymetric/Topographic data
- Detailed hydrodynamic (tide, current, surge, and waves) data
- Priority and length of shoreline protection
- Exact cause and extent of shoreline erosion
- Sediment budget (sources and sinks of sediment)
- Recent market value of materials
- Design criteria/expectations
- Geotechnical data and analyses
- Construction time windows
- Available construction plant/equipment
- Available construction materials
- Regulatory restrictions

It is understood, however, that general ideas of costs are desired by the community of Nelson Lagoon to help make further decisions on protecting their shorelines. Figure 38 shows conceptual relative costs to help compare the shoreline protection methods presented. Within the continental United States, “Higher Costs” can be on the order of $1,000 to $4,000 per linear foot of shoreline protection and “Lower Costs” can be on the order of $100 to $300 per linear foot of shoreline protection. USACE (1995) provides additional details on costs for representative shoreline protection projects.

Figure 38. Conceptual Relative Costs of Typical Shoreline Protection Methods



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Appendix A

Public Involvement

ONE COMPANY
Many Solutions℠

Memo

Subject:	Community Meeting #1 Meeting Notes
Client:	Aleutians East Borough
Project:	Nelson Lagoon HIA
Meeting Date: May 23, 2011	In Attendance: See sign in sheet
Notes by:	Laurie Cummings

The first community meeting about the Nelson Lagoon Hazard Impact Assessment (HIA) was held on May 23, 2011. The first meeting was to introduce the project to community residents and to obtain input about:

- natural hazards than can occur in Nelson Lagoon
- areas of concern including areas where residents have noticed erosion occurring
- location of critical facilities

Natural Hazards in Nelson Lagoon

In addition to erosion, extreme weather, earthquake, tsunami, and volcano hazards, community residents indentified brush fires as a potential hazard in the community. The potential for a brush fire is more associated with burning at the landfill instead of caused by lightning strikes or other natural causes. The fire potential is worse in the spring and fall. Justine noted that Nelson Lagoon has Code Red but the community does not have the ability to replace material used by the system.

Areas of Concern

Meeting attendees made the following comments regarding erosion in Nelson Lagoon:

- The area of greatest concern is the coastline on the lagoon side. Tommy John's house will be the first house to go.
- The breakwater was working but ice is causing problems
- Some parts of the community are below sea level
- The area in front of the Tides Inn has experienced more erosion since breakwater
- The beach is just sandy beach
- Lagoon coastline is eroding towards sea
- Don't keep studying the erosion – build something
- Maybe use harbor rock along the beach for armouring
- Erosion is now occurring under the breakwater
- Tides are bigger than they used to be (bigger tidal surge)
- Something is wrong with the 2001 shoreline used in the mapping

Critical Facilities

Justine clarified the location of the community center and confirmed the location of the water treatment plant. Justine also clarified the locations of the fuel tank farm, generator, and fish processing facility. In addition, the building shown as the community office is the VPSO office and the post office.

Hazard Impact Assessment – Nelson Lagoon

Public Meeting – Sign in Sheet

Name	Address/City/Zip	Phone	Email
Laura J. Johnson	P.O. 914 NLG. AK.	907-989-2218	
Tommy E. Johnson	NELSON LAGOON, AK.	" " "	
Justine Gundersen	PO BX 939 NLG 99571	907 9892205	JGUNDE1125@AOL.com
ZC2	Po Box 925 NLG 99571	907-989-4040	m.mcneley@hotmail.com

HDR ONE COMPANY *Many Solutions*℠

Memo

Subject: Community Meeting #2 Meeting Notes	
Client: Aleutians East Borough	
Project: Nelson Lagoon HIA	
Meeting Date: Sept 26, 2011	In Attendance: See sign in sheet
Notes by: Laurie Cummings	

The final community meeting about the Nelson Lagoon Hazard Impact Assessment (HIA) was held on September 26, 2011. This meeting was to discuss the recommendations of the HIA and to obtain feedback from the community.

The meeting began by reviewing the purpose of the HIA and what it is supposed to include. Then, the identified natural hazards (Erosion, Extreme Weather, Earthquake, Tsunami, Volcano, and Wildfire) were reviewed. There were no questions or additional information requested about the hazards.

Next, the updated map showing critical facilities in the community was presented. Community members reviewed the map and did not identify any additional changes.

A map showing historical erosion rates was also presented. Overall, the erosion rate appeared to be highest between 1963 and 1972. Mark McNeley commented that additional refinement of the shoreline data is likely to be needed in the future as the data shows changes in the shoreline in areas that are protected by the breakwater.

Lastly, the following HIA recommendations were discussed:

- Monitoring Program
- Coordination with ADF&G and USFWS
- Updated Mapping & Shoreline Analysis
- Nelson Lagoon Erosion Study
- Community Land Use Plan
- Establish Setback Requirement
- Water Line Alternative Analysis
- Shoreline Protection

In general, the recommendations were acceptable to community members but they were frustrated because erosion in Nelson Lagoon has been studied for many years and the community is ready to move past the studying stage. The community indicated that with some funding to buy materials, they would be able to implement some erosion mitigation measures.

In addition, some people expressed their concern about the ability to fund these projects. Several of the recommendations already have at least partial funding through a CIAP grant. Other projects may be able to be funded by the Community Planning Grant. Additional information about the Community Planning Grants was not available at the meeting and it was agreed that Laurie Cummings would find out additional information about the grant.

Meeting Follow Up

Upon completion of the HIA, Nelson Lagoon is eligible for a $150,000 Community Planning Grant from the Department of Commerce, Community and Economic Development. According to Sally Cox with DCCED, the funds for the grant have not been allocated yet and are subject to legislative approval in the Fiscal Year 2013 budget.

The projects that can be funded by the grant are fairly flexible but they need to come out of the HIA recommendations. The funds can be used to advance 1 or more of the recommendations from the HIA. The funds can be used to purchase supplies/construction materials if the project fits in with the recommendations. Nelson Lagoon and the Aleutian East Borough should coordinate with DCCED to identify the projects to be included in the grant when funding is available.

Hazard Impact Assessment – Nelson Lagoon

Public Meeting – Sign in Sheet

Name	Address/City/Zip	Phone	Email
Lydia Johnson	P.O. Box 920 Nelson Lagoon	989-2589	lesandbreez@yahoo.com
Nanette Johnson	PO Box 924 Nelson Lagoon	989-4045	x16XE
Paul Butch Gundersen	PO Box 902 NLG	989-2206	
[illegible] Nelson	Box 916 NLG	989-2265	~~0~~