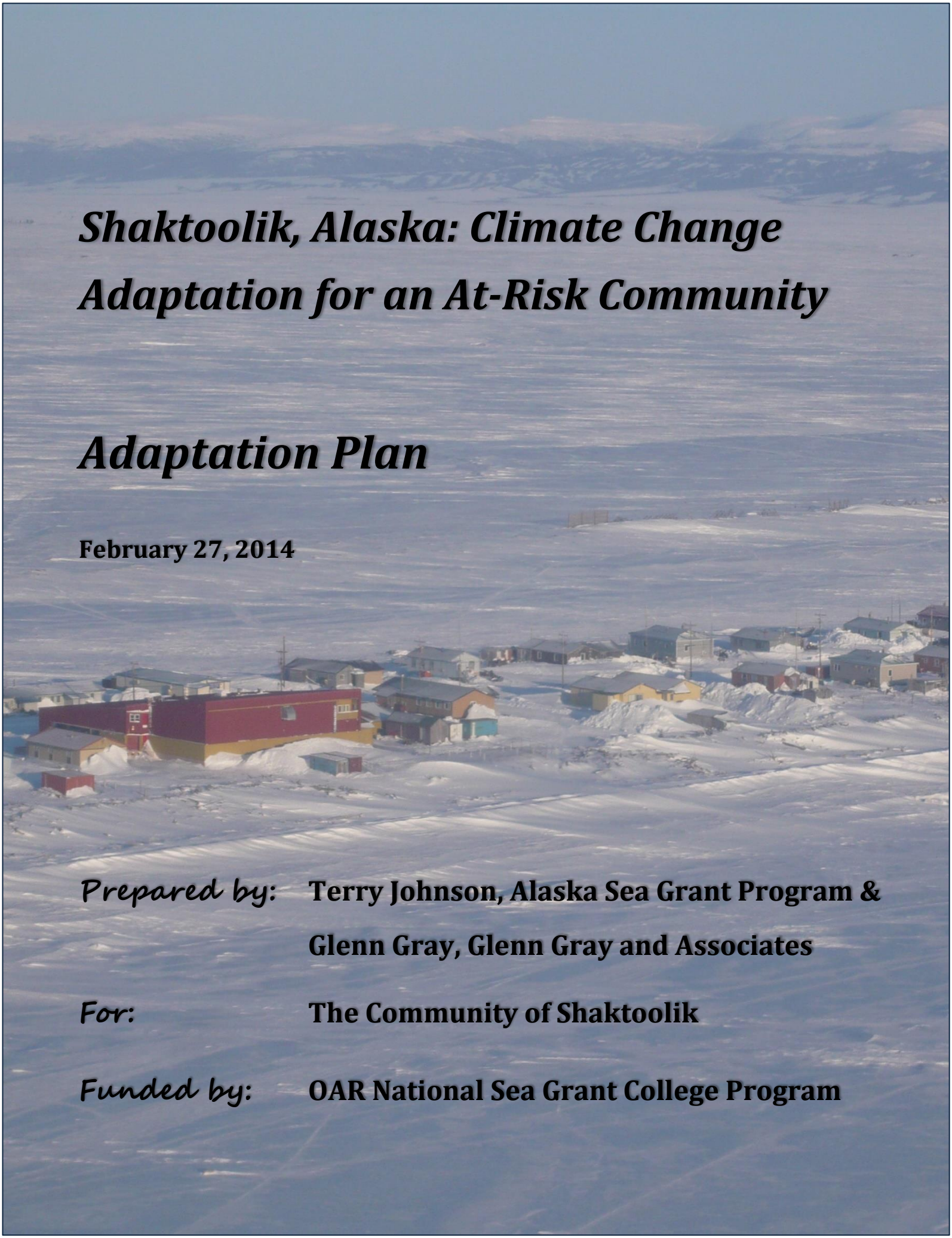

# *Shaktoolik, Alaska: Climate Change Adaptation for an At-Risk Community*

# *Adaptation Plan*

**February 27, 2014**


*Prepared by:* **Terry Johnson, Alaska Sea Grant Program &**
**Glenn Gray, Glenn Gray and Associates**


*For:* **The Community of Shaktoolik**


*Funded by:* **OAR National Sea Grant College Program**

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# Shaktoolik, Alaska: Climate Change Adaptation for an At-Risk Community

## Alaska Sea Grant Program

## *Adaptation Plan*


**Shaktoolik Planning Committee**

| | |
|---|---|
| Native Village of Shaktoolik: | Harvey Sookiayak, Sr. and Edgar Jackson, Sr. |
| City of Shaktoolik: | Mayor Eugene Asicksik and Agnes Takak |
| Shaktoolik Native Corporation: | Teresa Perry and George Sookiayak Sr. |

**Shaktoolik Project Coordinator**
Thomas Sagoonick, Native Village of Shaktoolik

**Native Village of Shaktoolik**
Axel Jackson, President
Harvey Sookiayak, Sr., Council Member
Edna Savetilik, Council Member
Agnes Takak, Council Member
Randall Takak, Council Member
Matilda Hardy, Council Member
Edgar Jackson, Sr., Council Member
Karlene Sagoonick, Administrator
Michael Sookiayak, Sr., Grant Writer

**City of Shaktoolik**
Eugene Asicksik, Mayor
Edgar Jackson, Sr., Vice Mayor
George Sookiayak, Council Member
Fred Sagoonick, Council Member
Axel Jackson, Council Member
Agnes Takak, Secretary
Edna Savetilik, Treasurer
Isabelle Jackson, City Clerk

**Shaktoolik Native Corporation**
Teresa Perry, President
Eugene Asicksik, Vice President
Carol Sookiayak, Secretary
Betty Jackson, Treasurer
Ellen Hunt, Board Member
George Sookiayak, Board Member
Fred Sagoonick, General Manager

**Sea Grant Team**
Terry Johnson, Alaska Sea Grant
Glenn Gray, Glenn Gray and Associates


**Project Website**: http://seagrant.uaf.edu/map/climate/shaktoolik/index.php

# Shaktoolik, Alaska: Climate Change Adaptation for an At-Risk Community

## Alaska Sea Grant Program

## *Climate Change Adaptation Plan*

**Abbreviations**

| | |
|---|---|
| ACCP | Alaska Community Coastal Protection Project |
| ANICA | Alaska Native Industries Cooperative Association, Inc. |
| ANTHC | Alaska Native Tribal Health Consortium |
| ATV | All-Terrain Vehicle |
| AVEC | Alaska Village Electric Cooperative |
| C | Celsius |
| CDQ | Community Development Quota |
| Corps | U.S. Army Corps of Engineers |
| DHS&EM | Alaska Division of Homeland Security and Emergency Management |
| DOT&PF | Alaska Department of Transportation and Public Facilities |
| DGGS | Division of Geological and Geophysical Services, Department of Natural Resources |
| EPA | Environmental Protection Agency |
| F | Fahrenheit |
| FEMA | Federal Emergency Management Agency |
| IGAP | Indian General Assistance Program |
| IRA | Indian Reorganization Act |
| IRR | Indian Reservation Roads Program |
| IRT | Innovative Readiness Training |
| kW | Kilowatt |
| LEO | Local Environmental Observer |
| NSEDC | Norton Sound Economic Development Corporation |
| MLLW | Mean lower low water |
| NOAA | National Oceanic and Atmospheric Administration |
| P.E. | Professional Engineer |
| SNAP | Scenarios Network for Alaska Planning |

# Shaktoolik, Alaska: Climate Change Adaptation for an At-Risk Community

## *Climate Change Adaptation Plan*

**Executive Summary**

This Adaptation Plan outlines next steps for the community of Shaktoolik as it responds to threats, primarily erosion and flooding, resulting from a changing climate. The Alaska Sea Grant project builds on previous planning efforts by the community, and it sets the stage for a project by the State of Alaska under the Alaska Community Coastal Protection Project.

Shaktoolik, a community of 250 people, is situated near the northern end of a sand spit bordered by the Tagoomenik River to the east and Norton Sound to the west. Residents moved to the current village site in 1975, located about a mile north of the former village, because of flooding and erosion concerns. Residents are descendants of Unalit (Yupik) and Malemiut (Iñupiat) people. They thrive on a mixed economy that includes traditional subsistence activities as well as earnings from commercial fishing and local jobs at the school, Tribe, City, and Shaktoolik Native Corporation.

The first action of the Sea Grant project was establishment of the Planning Committee with members representing the City, Tribe and local Native Corporation. The project provided funding for a part-time local project coordinator. Sea Grant staff, the consultant and the local coordinator conducted meetings with experts, developed a suite of alternatives intended to afford the community protection against flooding and erosion, and prepared a detailed list of potential funding sources. In addition, the project included outreach to other Alaska coastal communities at risk to impacts from climate change.

Climate change will likely impact Shaktoolik in many ways, but this plan focuses on the two most compelling threats: flooding and erosion. While there is no scientific evidence that storms are getting fiercer and more frequent, it is well documented that winters are getting shorter, and temperatures are rising. The later freeze up of Norton Sound has delayed the buildup of shore ice each fall which historically has served as a buffer between the village and the November storms. This lack of shore ice makes the community more vulnerable to wave damage flooding and from storm surges. Fall storms have resulted in some damage during recent years, including erosion to the former village site and damage to utilities at the current village site, including several septic drainage fields. Wave runup has pushed potentially destructive driftwood to within a few feet of some buildings on the seaward side of the village. The storms that caused concern in recent years produced wave and storm surge heights well below that which is predicted to occur in the future.

The U.S. Army Corps of Engineers has modeled storms and wave heights for eastern Norton Sound, and it predicts that a 50-year storm would flood some buildings, and that a 100-year storm would flood the entire community with water heights between 2.9’ and 7.4’ above the finished floor

elevations of existing buildings. These estimates account for storm surge (temporary localized increase in sea level on both sides of the village) combined with wave runup and wave setup which would occur on the ocean side of the village. A vegetated berm built inland of the beach would absorb some of the wave energy and reduce flood levels.

An evacuation road has been evaluated as a measure to save lives in the event of catastrophic flooding, but is impractical for a number of reasons. The exit route that has been considered travels 13 miles down the narrow, low-lying spit to the nearest high ground, and any storm that flooded the village would also inundate the spit. The cost to build an evacuation road has been estimated at $12-60 million, and there are not enough vehicles in the village to evacuate everyone by road. Lastly, there are no buildings at the terminus of the route to shelter the community.

The former village site clearly is eroding, but it is uncertain whether the current village site is experiencing progressive erosion or episodic erosion followed by periods of accretion. While a comparison of aerial photos indicates movement inward of the beach berm in front of the community, this technique does not accurately predict beach erosion or accretion.

Some committee members acknowledge that the current site probably is untenable in the long term, but it may be decades before resources become available for relocation. Furthermore, people like where they live and don't want to move. Meanwhile, the threat from the sea renews annually with each fall storm season. Consequently the Planning Committee decided upon a "defend in place" approach which involves consideration of all options to allow residents to remain at the current site. Committee members recognize that new information someday may justify reconsideration of that decision. The Community adopted nine initiatives that focus on protection of human life, buildings and infrastructure. These measures, summarized below, were chosen because they are cost-effective and promote the use of local materials and labor.

1. **Vegetated Berm:** Construct a vegetated berm in front of the community.
2. **Storm Surge Mound:** Construct a mound to serve as a place of refuge during a storm.
3. **Multipurpose Building:** Construct a building for use as offices and a storm shelter.
4. **Tank Farms:** Explore options to replace and relocate the community's two tank farms.
5. **Background Papers:** Develop brief issue papers and funding proposals for each initiative.
6. **Hazard Plan:** Update the local hazard mitigation plan to reflect current priorities.
7. **Monitoring:** Continue community and agency monitoring of storm surges and erosion.
8. **Future Studies:** Pursue funding for new studies needed to implement the adaptation plan.
9. **Guidelines:** Develop local guidelines for future development to protect structures from storms.

The plan includes actions tables for each of these initiatives that can be updated to track progress and that can be amended to take advantage of changing conditions and new opportunities.

# Shaktoolik, Alaska: Climate Change Adaptation for an At-Risk Community

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# Shaktoolik, Alaska: Climate Change Adaptation for an At-Risk Community

## Alaska Sea Grant Program

## *Climate Change Adaptation Plan*

## 1 Introduction

Shaktoolik, a community located on the eastern edge of Norton Sound, faces increased risks of flooding and erosion. As a consequence of a warming climate, Norton Sound waters freeze up later in the fall than in the past, which means that sea ice no longer buffers the community from high seas and pounding waves from fall storms. While there are other current and potential impacts from climate change, this plan focuses on impacts from flooding and erosion, the most immediate climate-related threats to the community.

This Climate Change Adaptation Plan is the final product of a two-year project of the Alaska Sea Grant Program in collaboration with Glenn Gray and Associates and the community of Shaktoolik. In preparation for this project, the community established the Shaktoolik Planning Committee through a joint resolution approved by the City of Shaktoolik, the Native Village of Shaktoolik and the Shaktoolik Native Corporation. Participation by representatives of all three organizations ensured that the community spoke with one voice. The Committee operated informally, meetings were noticed and open to the community, and decisions were made by consensus. Members of the community who were not officially on the committee were welcome to share their thoughts at any time during committee meetings, and many community members participated.

Vicinity Map

The major sections of this plan include background about the community and this project, a description climate change impacts, a summary of initiatives to implement the plan, and conclusory remarks.

# 2 Background

This section provides background about the community and more detailed information about this project.

## 2.1 Community Background

With a 2010 population of 251, Shaktoolik is located on the eastern edge of Norton Sound 33 miles north of Unalakleet and 125 miles east of Nome. The community is situated on the northern end of a sand spit with Norton Sound to the west and the Tagoomenik River on the east. A beach ridge fronts the community on the side facing Norton Sound. The highest ground in the community is 24.7' above mean lower low water (MLLW) (U.S. Army Corps of Engineers 2011). The elevation drops to 14' above MLLW on the river side of the community (R.J. Kinney Associates 2008).[1] The homes and other buildings are located in two rows, one on either side of a single gravel road that runs through the village. The road extends north to the airport and several miles south past the former townsite.

Aerial view of Shaktoolik

The people of Shaktoolik are descendants of the Unalit and Malemiut people. The Unalit are Yupik Eskimos who occupied the area during the time of first western contact, and the Malemiut are Iñupiaq Eskimos who migrated to Norton Sound from the Kotzebue Sound area.

Shaktoolik faces erosive forces from both the Tagoomenik River and Norton Sound. The Tagoomenik and Shaktoolik rivers converge in a tidal lagoon two miles northwest of the community at the end of the sand spit. The entire community is located within the 100-year flood plain (U.S. Army Corps of Engineers 2011).

Shaktoolik is considered to have a subarctic climate with Norton Sound generally ice free between May and October and sometimes into late November. Typically, the temperature is between 47° and 62° F during summer months and between -4° and 11° F during the winter. Extreme temperatures vary between -50° and 87° F. The average annual precipitation is 14", including 43" of snowfall.

[1] MHHW is about four feet higher than MLLW.

Maps posted on the Alaska Department of Commerce, Community and Economic Development website depict buildings, utilities, subsistence use areas, and flood prone areas (State of Alaska 1980, and Kawerak 2004a, 2004b, 2004c, and 1996). Elevations on the 1980 and 2004 maps conflict, but a new topographic map completed by the U.S. Army Corps of Engineers in 2011 provides more accuracy based on a new tidal benchmark established by the National Oceanic and Atmospheric Administration (NOAA).

**Governance:** Shaktoolik has both a city government and a tribal government. The City of Shaktoolik incorporated as a 2nd class city in 1967 and is governed by a seven-member council with a strong mayor form of government. The mayor provides day-to-day management of city affairs with assistance from the city clerk. The City is in the process of selecting lands under authority of Section 14(C)(3) of the Alaska Native Claims Settlement Act.

The Native Village of Shaktoolik is a federally-recognized tribe organized under authority of the Indian Reorganization Act (IRA) that is governed by a seven-member council. The IRA has diverse powers, including authority for the protection of life, property, and the environment threatened by natural disasters (Kawerak 2007).

**Economy:** The local economy is primarily based on harvest of subsistence resources supplemented by commercial fishing and a limited number of conventional jobs provided by the City of Shaktoolik, the Native Village of Shaktoolik, the Shaktoolik Native Corporation, the Bering Strait School District, and the Shaktoolik Native Store. There were four active business licenses in Shaktoolik during February 2014, including the Shaktoolik Native Corporation, Shaktoolik Native Store, a building services business, and a bed and breakfast. The two grocery stores are operated by the Shaktoolik Native Corporation and the Alaska Native Industries Cooperative Association, Inc. (ANICA). In 2012, 82 people were employed in the community, the median household income was $29,219 and the mean household income was $47,846 (U.S. Census Bureau 2012).

Fishing boats in the lagoon

Shaktoolik residents participate in commercial fisheries for salmon, herring and king crab. Commercial fishing provides the main source of cash income for the village in addition to government assistance programs. In the early 1960s, a local market for salmon was created when fish buyers came to the village, and in 1979, a

commercial herring fishery began. In February 2014, 54 residents had commercial fishing permits (Commercial Fishing Entry Commission 2014).

Shaktoolik participates in the Community Development Quota (CDQ) program through participation in the Norton Sound Economic Development Corporation (NSEDC). The intent of the CDQ program is to give a share of the Bering Sea fisheries to communities to generate sustainable fishery-related economies. NSEDC distributes a community benefit share to each of its member communities, and it administers a number of other programs that benefit the communities.

**Subsistence:** From a subsistence standpoint, the community is ideally located for easy access to Norton Sound and the Shaktoolik and Tagoomenik rivers. The river side of the community provides access to freshwater fish, upriver caribou and moose and a safe area for storing boats. Close proximity to Norton Sound provides convenient access to marine subsistence species. Residents harvest salmon, herring, crab, moose, beluga whale, caribou, seal, rabbit, geese, cranes, ducks, ptarmigan, berries, greens, and roots.

Salmon dries in a beachfront shelter

Subsistence provides Shaktoolik residents with food and wood for heating. In addition, subsistence is a way of life that provides cultural identity and a way to express traditional values of sharing. According to a subsistence researcher who lived in the community for a period of time, subsistence "links the harvester to heritage of countless generations of ancestors who harvested the same species, often in the same geographical location" (Thomas 1982, p. 290). Interviews conducted in 2010 revealed that most Shaktoolik residents have strong ties to the area, that is, both of their parents were from the community or its surrounding area (Glenn Gray and Associates 2010).

**Water:** The community obtains its water from the Tagoomenik River at two different sites. During the winter, it pumps water from the river adjacent to the community, and during the summer, water is obtained from an area a couple of miles south of the community known locally as "First Bend." The water is treated and then stored in an 848,000-gallon insulated tank. The City of Shaktoolik operates the water treatment facility and a washeteria. Sixty-one of the 66 estimated homes

Drinking water pump in the Tagoomenik River

are directly supplied with running water from the system, and about 75% of the homes have complete plumbing. The community is concerned that coastal erosion at First Bend will break through the sand spit and taint the water supply with salt water.

**Sewer:** Most homes in Shaktoolik are connected to septic systems that serve multiple households. Vertical perforated culverts serve as seepage pits. Septic sludge is disposed of at a designated site which does not meet Alaska Department of Environmental Conservation standards. High water from a November 2013 storm surge damaged several of the septic leach fields.

**Landfill:** An unpermitted dump site located close to the airport was relocated to a site just south of the village. Refuse is burned almost daily. The Native Village of Shaktoolik operates a program under the Environmental Protection Agency (EPA) Indian General Assistance Program (IGAP) that funds limited management of the dump site, including a backhaul program for lead-acid batteries, electronic waste and other hazardous materials. The November 2013 storm surge elevated waters close to the landfill.

**Power:** The Alaska Village Electric Cooperative (AVEC) provides electricity for the community using three diesel-powered generator sets of 207 kW, 175 kW, and 250 kW capacity (Alaska Village Electric Cooperative 2008). In 2012, the Alaska Energy Authority and AVEC constructed a $2.7 million wind generation system just north of the community to supplement the diesel-powered generators. The system includes two Northern Power 100 kW wind turbines.

**Bulk Fuel:** Two tank farms supply fuel for the community. The AVEC tank farm is located next to the power plant in the middle of the community. The second tank farm, located at the southern end of the community, is owned by the Shaktoolik Native Corporation, the Native Village of Shaktoolik and the Bering Straits School District. None of the tanks meet U.S. Coast Guard standards, and all need upgrading.[2] Both tank farms are potentially threatened by erosion and in need of relocation. Due to their condition, the tanks cannot be moved to a new location and will need to be replaced. A new location for the tank farm has not yet been selected.

AVEC Tank Farm

[2] The U.S. Coast Guard regulates facilities that receive fuel by barges.

**Airport:** The Alaska Department of Transportation and Public Facilities maintains a 4,000' by 75' gravel landing strip with regular service from Nome and Unalakleet. The airport is located north of the community towards the end of the sand spit. Partially located within the active beach zone, the apron at the south end of the airstrip periodically has been inundated during fall storms.

**Freight:** In addition to air freight, cargo is barged from Nome during the ice-free season. Barges land on the beach in locations near the school, the AVEC power plant and near the Shaktoolik Native Corporation tank farm.

**Housing:** According to the U.S. Census Bureau, there were 66 housing units in the community in 2010 with six of them vacant (U.S. Census Bureau 2010).

**Roads:** The City of Shaktoolik is responsible for road maintenance within the municipal boundaries, and the Alaska Department of Transportation and Public Facilities is responsible for maintaining the road to the airport (Rodney J. Kinney Associates 2007). The Shaktoolik IRA will be responsible for maintaining any future roads constructed under the Indian Reservation Roads (IRR) program.

## 2.2 Background on the Alaska Sea Grant Project

The Alaska Sea Grant Program initiated the current project in early 2012: *Climate Change Adaptation for an At-Risk Community, Shaktoolik, Alaska*. This project included a number of elements that provided information for completion of the final product, the Adaptation Plan.

- **Local Coordinator**: The project funded a part-time local coordinator, hired by the Native Village of Shaktoolik, to provide a single point of contact with the community.
- **Planning Committee Meetings:** The Planning Committee held six meetings during the two-year project. These meetings were open to the public and provided direction for the Sea Grant team. The Sea Grant team visited Shaktoolik in November 2012, July 2013, November 2013, and February 2014.
- **Community Meeting:** The draft Adaptation Plan was presented during the annual meeting of the Native Village of Shaktoolik, an event that attracts the entire community.

Shaktoolik youths enjoy a summer campfire

- **Expert Meetings:** The Sea Grant Project Team arranged meetings with experts in various disciplines, including coastal engineers with the Alaska Department of Transportation and Public Facilities and staff from the Army Corps of Engineers, University of Alaska, Alaska Department of Commerce, Community and Economic Development, Natural Resource Conservation Service, and Alaska Division of Homeland Security and Emergency Management. The meetings were held in person in Shaktoolik and by teleconference.
- **Field Trip:** In July 2013, an on-site investigation was conducted to evaluate evidence of erosion and potential measures to address flooding and erosion. A meeting with the Planning Team coincided with this visit.
- **Funding Sources:** The Sea Grant team developed a document that identified a comprehensive list of potential funding sources for use by Shaktoolik and other at-risk communities. This document is posted on the Sea Grant website.
- **Adaptation Measures:** The project also involved development of a list of potential adaptation measures the community could take to respond to threats of flooding and erosion. The Planning Committee used the Adaptation Measures document and other information to choose the initiatives and implementation actions included in the Adaptation Plan.
- **Outreach:** In addition to distribution of the final report, this project included outreach to the public during the 2013 and 2014 Alaska Forum on the Environment, an annual meeting involving rural tribal representatives, agency staff and scientists. The 2013 session involved a panel discussion with representatives from Shaktoolik and other at-risk communities, including Newtok, Shishmaref and Kivalina. The February 2014 forum involved a panel discussion on the Shaktoolik Sea Grant project. Also, project documents were posted on the Alaska Sea Grant website for use by Alaska at-risk communities and other interested parties. A total of about 70 people attended the two FOE sessions, most of them from rural Alaska communities.

**2013 Alaska Forum on the Environment. Terry Johnson, Sea Grant; Matilda Hardy, Shaktoolik; Mayor Stanley Tocktoo, Shishmaref; Millie Hawley, Kivalina. (Ruth Carter)**

- **Website:** Project documents may be viewed at: http://seagrant.uaf.edu/map/climate/shaktoolik/index.php

## 2.3 Context for the Adaptation Plan

This section provides a brief summary of how past and future initiatives relate to the Alaska Sea Grant Project.

### 2.3.1 Previous Projects

This section provides an overview of previous projects that in some way address the risks of flooding and erosion.

#### 2.3.1.1 Shaktoolik Planning Project

Between 2010 and 2012, Glenn Gray and Associates, in association with Kawerak Inc. and McKnight and Associates, worked with the community to complete the Shaktoolik Planning Project. The project involved an assessment of the risks of natural hazards to the community. It also involved a door-to-door survey of the residents, a Situation Assessment, and a final report that summarized recommendations by community leaders. Detailed information about the community and risks from natural hazards may be found in the Situation Assessment. In addition, the report included a vulnerability assessment.

#### 2.3.1.2 Hazard Mapping Project

The Alaska Division of Geological and Geophysical Surveys (DGGS) hazard mapping project involved field investigations in 2011 to assess natural hazards facing the community. The project involved collection of extensive baseline data about local geology, coastal and ocean processes and historic storms in and around the community. The DGGS team established beach profiles in front of the current community and the former site. The final product will be a map depicting the natural hazards. The investigators returned to Shaktoolik after the November 2011 storm to investigate storm damage and to complete new beach profiles (Kinsman and DeRaps 2012).

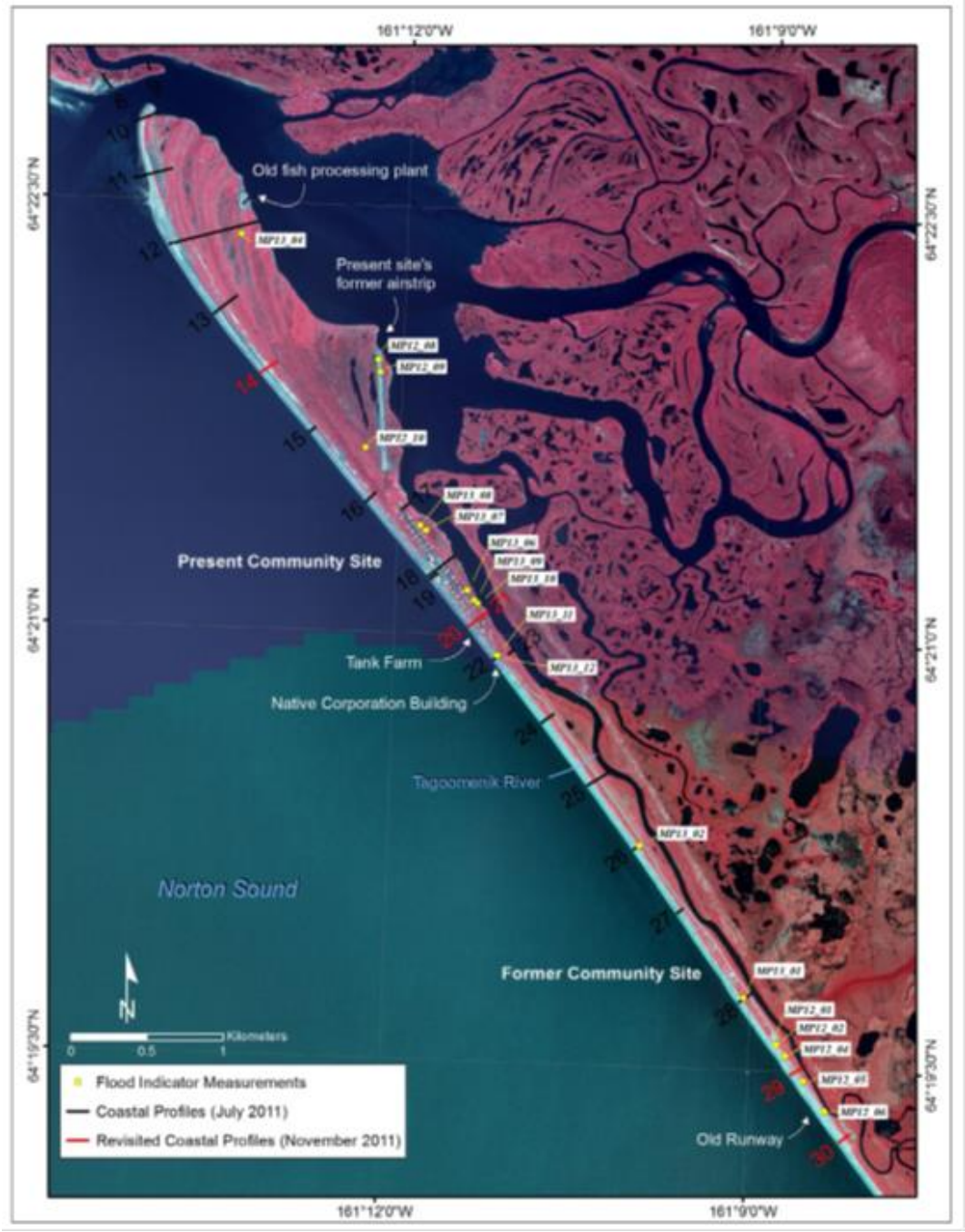
#### 2.3.1.3 Shaktoolik Flooding Analysis

The U.S. Army Corps of Engineers completed a study in 2011 of flooding risks to the community from Norton Sound and the Tagoomenik River. The study involved measurement of the offshore bathymetry, completion of beach profiles, development of a map referencing elevations to mean lower low water, and development of a model to predict flooding events. The model used historic wind, wave, and storm surge water level data. Results of the study are discussed in Section 3.1.

#### 2.3.1.4 Other Climate-Related Planning Efforts

A number of other planning efforts that relate to climate change impacts to Shaktoolik are summarized in the following bullets.

- **Local Hazard Multi-Hazard Mitigation Plan:** This plan identifies local hazards facing the community (WHPacific 2009). One of the recommendations in the adaptation plan is to update the hazard plan to include new information about flooding and erosion and to update the goals in the plan.




Map indicating beach profiles completed by DGGS (DeRaps and Kinsman 2011).

- **Emergency Plans:** Three plans completed in 2010 address community responses to emergencies, including storm-related events: *Emergency Operations Plan, Evacuation Plan*, and *Continuity of Operations Plan* (Ecology and Environment 2010a, 2010b and 2010c).
- **Multi-Purpose Building:** A 2012 feasibility study analyzed costs and options for a multi-purpose building that could also serve as an emergency shelter during a storm (USKH 2012).

- **Economic Development Plan:** Kawerak, Inc., the regional tribal organization, periodically updates the community's local economic development plan (Kawerak 2007). These plans identify local priorities, including those related to threats of natural hazards. Kawerak was developing an update to this plan in early 2014.
- **Norton Bay Climate Adaptation and Action Plan:** Although this plan mentions Shaktoolik, it focusses on the watershed around Elim, another community in Norton Sound (Norton Bay Inter-Tribal Watershed Council 2012). It includes seven goals, ranging from obtaining more data to increasing funding opportunities.

### 2.3.2 Future Projects

#### 2.3.2.1 Alaska Community Coastal Protection Project

The Division of Community and Regional Affairs, within the Alaska Department of Commerce, Community and Economic Development, plans to implement the Adaptation Plan through the Alaska Community Coastal Protection (ACCP) Project after completion of the Sea Grant project. The ACCP Project includes separate efforts for Shaktoolik, Kivalina and Shishmaref. An interagency work group will be established for Shaktoolik to help guide the development of a strategic management plan. The project will fund a local coordinator to work with the community as well as travel to the interagency work group meetings. A consultant will be hired to assist with development of the strategic management plan.

#### 2.3.2.2 Demonstration Berm

The Alaska Department of Transportation and Public Facilities (DOT&PF) received funding for a pilot project to construct a demonstration berm using beach wild-rye grass (*Leymus mollis*). While this project will only involve a small portion of the beachfront, it will provide a means to estimate costs for restoring the entire berm in front of the community. It will also establish coastal engineering procedures and criteria for use and monitoring of a vegetated coastal berm.

June 2011 Sea Grant Project field trip participants investigate potential location of the demonstration berm.

#### 2.3.2.3 Storm Surge Monitoring

DOT&PF received a grant to establish storm surge monitors in up to eight Western Alaska locations, including Shaktoolik. Coastal engineers established a gauge in Shaktoolik in June 2013 and made arrangements for local monitoring.

# 3 Impacts of Climate Change for Shaktoolik

Northern Alaska communities, such as Shaktoolik, are experiencing increasing impacts from a changing climate. This section provides an overview of current and likely impacts to the community from climate change. It begins with a discussion of the two factors of greatest importance to the community – flooding and erosion. It continues with a brief discussion of other climate change factors that currently affect or are likely to affect the community in the future.

## 3.1 Risks of Flooding and Erosion

The major climate change-related threats to the sand spit where Shaktoolik is located include coastal and riverine erosion and partial flooding or complete inundation. While storms may not be getting stronger than in the past, the later freeze-up subjects the community to increased risks of flooding and erosion. Without the protective cover of ice, waves and storm surges from fall storms damage the community.

Storm comparison at Shaktoolik Native Corporation Building (Photo: Gloria Andrew)

Threats include a potential for both loss of property and human life. The lack of site-specific data, complicated by different assumptions applied during various investigations, has resulted in differing opinions about the degree of flooding and erosion risks facing the community. While more clarity will likely be achieved as additional information is collected during future monitoring and studies, the community has decided to begin taking action based on the best available information.

### 3.1.1 Flooding Threats

The 2011 Shaktoolik Coastal Flooding Analysis prepared by the U.S. Army Corps of Engineers (Corps) includes estimates of the probability of future flood events with different recurrence periods.[3] For example, it predicts that a 50-year storm would inundate the community 1-3', while a 100-year storm would overtop the community 4.6'.[4] With the addition of waves, buildings in the community would be flooded between 2.9' and 7.4' above the finished floor elevations, depending on the

[3] Recurrence periods refer to estimates of the probability a flood will occur during a specific time period. For instance, a flood with a 100-year periodicity has a 1% chance of occurring in any given year.
[4] These figures include storm surge levels and wave setup. They do not include wave runup which occurs when waves rush up a beach.

elevation of the building. Construction of a vegetated berm or other structures along the beach would absorb some of the wave energy and reduce wave runup.

An extreme storm without adequate prior warning could lead to loss of life because currently there is no safe refuge in the community. Furthermore, it may not be safe to evacuate by aircraft or by vehicles along the coast during a storm, and there is no facility at higher ground to accept and shelter evacuees. A flood would damage electrical and communications systems, septic systems, and oil tanks. A major storm could cause contamination from septic systems, the oil tank farms and the landfill. In addition, a storm could do additional damage to buildings from battering driftwood and other debris.

While the 2011 flooding analysis is the most comprehensive investigation into flooding risks for Shaktoolik, it was not intended to be used by the community for major decisions. The Corps prepared the report for the Western Federal Lands Highways Division of the U.S. Department of Transportation, another federal agency. The study was requested by Kawerak, Inc., the regional tribal organization, for the purpose of a federal agency determination regarding transportation infrastructure funding.[5]

As more site-specific information becomes available, it may be useful to update the 2011 flooding analysis. As noted in the analysis, actual storm surge measurements at the community may change the flood levels predicted by the models. Possible considerations for additional investigation include amendments to the model to use actual particle size of beach materials[6] and consideration of how beach logs or an elevated berm could reduce wave damage by absorbing energy. In addition, it may be useful to incorporate data from the additional beach profiles completed by the Alaska Division of Geological and Geophysical Surveys as well as the different wave runup heights observed at the former and current village sites.[7]

The community has considered pursuing all options that would allow it to remain at the current site. Community leaders recognize that new information may justify reconsideration of that decision in the future.

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[5] Since the *Shaktoolik Coastal Flooding Analysis* was prepared by one federal agency for use by another federal agency, it does not require an engineer's endorsement as required by the State of Alaska. While the authors for the main part of the report are not indicated, the appendix includes an undated draft report by Chapman et al. titled *Storm-Induced Water Level Prediction Study for Shaktoolik Alaska*.

[6] The wave runup model used a particle size of 1 mm while the materials in front of community are actually made up of mostly coarse gravel between 15-20 mm.

[7] The model appears to use the same assumption for wave runup at the current village site as at the former village site. An investigation following a significant storm event in November 2011 storm, however, found that runup observed at the former village site was nearly seven feet higher than at the current village site (Kinsman and DeRaps 2012). This difference is likely attributable to differences in the nearshore water depths at the two sites.

### 3.1.2 Erosion Threats

The community faces two types of erosion threats: Erosion along the coast of Norton Sound and erosion along the Tagoomenik River. Each of these threats is briefly described below.

#### 3.1.2.1 Coastal Erosion

In the mid-1970s, the community moved from its former location about a mile south of the current village site due to concerns about erosion. Elders in the community recommended the current site because they believed it was a safer location. While fall storms have caused some erosion at the current village site, technical experts hold conflicting views on whether this area is subject to long-term erosion or if the area is relatively stable (this is, accretion of beach sediments during the summer offsets erosion from episodic storms in the fall). The remainder of this section summarizes a study that compared aerial photographs as well as recent observations at the community by coastal engineers.

A 2009 Community Erosion Assessment completed by the Corps compared the movement of vegetation line (beach berm) using three sets of aerial photos spanning a 24-year period.[8] This report estimated the erosion rate for three reaches near the community.

- Reach 1: The 9,600-foot section of the beach that fronts community - two feet per year.
- Reach 2: The 3,900-foot portion of coastline south of Reach 1 - one foot per year.
- Reach 3: The 4,700-foot portion of coastline south of Reach 2 - three feet per year.

Bank erosion at the former village site

An update to the 2009 study increased the erosion rate for Reach 2 to 1.5 feet per year (U.S. Army Corps of Engineers 2011).[9] The 2011 report acknowledges, however, that "determining erosion rates based solely on a vegetation line from aerial photography does not accurately predict beach erosion or accretion" (p. 31).

[8] The aerial photographs were taken in 1980, 1994 and 2004.
[9] The report does not indicate how the 2009 maps were updated or why the estimate for Reach 2 was changed.

During a July 2013 site visit, State of Alaska coastal engineers Harvey Smith, P.E. and Ruth Carter, P.E. reported that it appeared the area in front of the current site is stable while the old village site is eroding (Alaska Sea Grant 2013).[10] Given this information and the qualification in the 2011 Corps report, multi-year monitoring should be conducted to verify whether or not the area in front of the community is eroding. Monitoring and field-based data collection efforts, such as those of the Alaska Division of Geological and Geophysical Surveys (DGGS), will likely lead to more accurate erosion assessments. The DGGS investigations and the 2011 Corps study involved completion of a number of beach profiles which will provide an accurate baseline from which to measure future volumetric changes to the shoreline.

#### 3.1.2.2 Riverine Erosion

Some residents of Shaktoolik have expressed concern about erosion from the Tagoomenik River that could contribute to a breach in the barrier spit upon which the community is located. During a July 2013 site visit to the community, coastal engineers Harvey Smith P.E., and Ruth Carter P.E. evaluated the river at the narrowest part of the spit near the former community site and determined that there was no immediate threat from riverine erosion. There was some evidence of thermal erosion (slumping of the riverbank), however, due to thawing permafrost. While some erosion often occurs along the outside bank of a river, the Tagoomenik is a slow moving river with a low risk for significant erosion in the near future.

Slumping bank of Tagoomenik River

The potential for ocean beach erosion to cut through to the river at First Bend is an additional concern. Coastal engineers Harvey Smith, P.E. and Ruth Carter, P.E., estimated that the threat from a breach through the spit from the ocean side likewise is not imminent and that it would likely be at least 10 years before the beach on Norton Sound would erode through to the river. Water from Norton Sound, however, has overtopped the spit at this site, and during the November 2013 storm, residents reported increased erosion of the ocean beach adjacent to the First Bend area.

## 3.2 Other Risks from a Changing Climate

In addition to flooding and erosion, other climate-related impacts are currently impacting Shaktoolik residents, and greater impacts will likely occur in the future. Using information from the

[10] Beaches in the region typically lose material during fall storms and are gradually replenished during the summer months. The eroding bluffs about 15 miles south of the village provide a constant source of sediment due to the longshore currents which generally flow north.

community and other areas of Alaska, this section summarizes current and potential future impacts to Shaktoolik from a warming climate.

Alaska temperatures have increased at twice the rate as the rest of the country, and climate change models indicate there will be both a rise in temperature and precipitation for Alaska through the end of the century (SNAP 2010).[11] Since the 1950s, average temperatures rose 4° F, and they are projected to rise 1.5-5° F by 2030 and by 5-18° F by 2100 (Parson et al. 2009). Precipitation is expected to increase 20-25% in north and northwest Alaska by the end of the century.

Other climate-related impacts that currently impact or could potentially impact Shaktoolik in the future are summarized in the bullets below.

- **Permafrost:** Warming temperatures are showing effects through thawing permafrost along the coastline and rivers around Shaktoolik. Residents report increasing difficulties in navigating local rivers a result of sedimentation from thawing riverbanks. Romanovsky et al. (2010) found that permafrost warming that began 20-30 years ago is continuing and that colder soils are warming at higher rates than permafrost soils closer to the thawing point (i.e., 0° C). Over the next 100 years, up to 30 feet of discontinuous permafrost depth is expected to thaw (Parson et al. 2009).
- **Weather:** Shaktoolik residents report more rainy periods, more unpredictable weather, and shorter winters (Ignatowski and Rosales 2013),
- **Drying Tundra:** Despite an increase in precipitation, soils are expected to become drier, especially during the growing season. Increased air temperatures will result in more evaporation, and an increase in the number of shrubs will result in more transpiration which will lead to drier tundra (O'Brien and Loya 2009, Parson et al. 2009, SNAP 2010).
- **Lakes:** Declining lakes in Alaska due to greater evaporation and thawing permafrost (U.S. Global Change Research Program 2009). Shaktoolik residents have witnessed the draining of several large lakes near the community.[12]
- **Wildfires:** As tundra soils dry, they are more vulnerable to fires. An increase in wildfires has been attributed to climate change in Alaska (Parson et al. 2009). Alaska wildfires are expected to double by the middle of the century and triple by the end of the century. Due to its location on the spit Shaktoolik is unlikely to suffer direct damage from tundra fires, but important subsistence harvesting areas could be affected.
- **Sea Level Rise:** Sea level rise is a long-term concern for Shaktoolik because of the community's low elevation, although so far it has not been documented in the region. It

[11] The models show monthly predictions for the following time periods 2001-2010, 2031-2040, 2061-2070, and 2091-2100. These predictions are displayed on a monthly basis using scenarios for low, medium and high greenhouse gas emissions.

[12] During the door-to-door survey for this project, five residents mentioned lakes close to the village have been draining, and they thought the cause was thawing permafrost. The residents did not indicate the name of the lakes.

occurs from an increase of fresh water into the ocean from melting sea ice and glaciers and from thermal expansion of seawater from warming temperatures. During the past 50 years, the sea has risen 8" or more in some areas of the U.S. coast (NOAA 2010), and it is projected to rise between 0.18-0.59 meters (7.08"-23.2" or 0.6' to 1.9') by the end of the century (Intergovernmental Panel on Climate Change 2007).

- **Ocean Acidification:** Ocean acidification is a growing concern in Alaska, especially since it is occurring more rapidly in Arctic waters than in other areas (University of Alaska 2009). It results from increasing concentrations of carbon dioxide in the atmosphere that are absorbed by the ocean. Acidification affects the ability of some animals to make shells and skeletons, including mollusks and krill.[13] Acidification may also indirectly affect fish and marine mammals through a reduced availability of some food sources. Acidification has been detected in the Bering Sea, but to date no biological effects have been reported in Norton Sound. However, king crab, a commercial fishery species targeted by some Shaktoolik resident, is one of the species considered to be vulnerable to the effects of acidification.

Shaktoolik Elder Hannah Takak displays a wolverine skin

- **Changing Plant and Animal Communities:** Models developed by scientists predict drastic changes in the major biomes (plant and animal communities) in Alaska (Murphy et al. 2010). About 60% of Alaska's biomes are expected to change by the end of the century, and the western tundra biome is expected to decrease by 54% to be replaced by shrubs. The Western Alaska tundra community is the most vulnerable and least resistant to climate change. While some northern areas have not shown much change, sudden shifts in vegetation type are expected in the future once tipping points are reached (Doak and Morris 2010).
- **Fisheries:** Warming sea temperatures in the Bering Sea between 2000 and 2005 resulted in lower numbers of some fish species that require sea ice (Overland 2010). Unusually cold ocean conditions since 2005, however, have resulted in an increase in Arctic cod and a decrease is pollock. Recent ocean temperature trends in the Bering Sea may be the result of natural variability, but by 2020 a trend of prolonged warm temperatures is expected (Overland 2010).

[13] For example, a 10% decrease in the population of pteropods (food for pink salmon) could result in a 20% decrease in body weight of adult pink salmon (ScienceDaily 2009). As a result of ocean acidification and an increase of melt water in the Canada Basin, calcifying organisms have experienced corrosion (Proshutinsky et al. 2010).

- **Marine Mammals:** A warming climate has implications for marine mammals that are dependent on sea ice, including bowhead and beluga whales, ringed and bearded seals, walrus, and polar bears. These mammals are at the top of the food chain so changes to them can be important indicators of climate change (Simpkins 2010). Behavioral changes have been observed for both polar bears and walrus.
- **Birds:** Over half of the world's shorebirds and 80% of its geese breed in Arctic and Subarctic regions (Gill 2010). Although several Arctic geese populations have declined, overall geese populations have increased and extended their range since the 1970s (Loonen et al. 2010). This situation has resulted in impacts to tundra vegetation and a greater supply of eggs for predators.
- **Invasive and Non-native Species:** Later freeze up, earlier break up and warming air and water temperatures may be contributing to sightings of new species and changes to the numbers and distribution of native species. Combined with other changes, climate change may increase the vulnerability of native species to impacts from invasive species (NOAA 2010). Changing conditions may be more favorable to new species that compete with native species.
- **Health and Safety:** Climate change may result in risks to human health. A decrease in use of subsistence foods from climate change-related impacts could lead to health problems including an increase in hunger, malnutrition and disease (ANTHC 2010). Displacement of subsistence resources may result in the need to travel further thereby increasing risks of accidents. Increased intensity of storms would increase risks to commercial fishermen and subsistence users. Climate change can also impact drinking water and septic systems through flooding and erosion with a potential for increased risk of infectious disease.

Old village site

Many of the factors discussed above have implications for subsistence. Warmer temperatures pose safety issues for ice-based subsistence. River travel by boat has also been affected due to sedimentation of the Shaktoolik and Tagoomenik rivers because of thawing permafrost of the river banks. Shaktoolik residents report some changes in marine mammal and fish migration routes, times and duration as well as new animal and insect species (Ignatowski and Rosales 2013).

# 4 Initiatives for Implementing the Adaptation Plan

The Shaktoolik Planning Committee met on December 17, 2013 and approved nine major initiatives for inclusion in this adaptation plan. These initiatives were developed by the Alaska Sea Grant team in close cooperation with the Shaktoolik Planning Committee and the local Sea Grant Coordinator.

**Nine Major Initiatives**

1. **Vegetated Berm:** Construct a berm in front of the community to deflect wave energy and reduce overtopping.
2. **Storm Surge Mound:** Construct a mound above the 500-year flood level to serve as a place of refuge during a storm.
3. **Multipurpose Building:** Seek funding to construct a building to house community offices and the community during a large storm.
4. **Tank Farms:** Explore options to replace the community's two tank farms in a location away from the beach
5. **Background Papers and Funding Proposals:** Develop issue papers for the initiatives for submittal to funding organizations.
6. **Hazard Plan:** Update the local hazard mitigation plan to reflect current priorities.
7. **Monitoring:** Initiate a community-based monitoring system and encourage agencies to continue hazard monitoring.
8. **Future Studies:** Pursue funding for new studies that will be needed to implement the adaptation plan.
9. **Guidelines:** Develop local guidelines for development to protect structures from storms.

By its very nature, the Adaptation Plan requires an adaptive approach to respond to new information and unexpected opportunities. The Planning Committee will reevaluate these initiatives periodically and revise the plan as needed.

This report on adaptation measures implements the "stay and defend" approach by evaluating options that will allow the community to remain at its current location. The following principles were used to develop the initiatives, strategies and actions.

- The most important concern is to protect lives during a catastrophic flood event.
- Low-cost approaches that involve local resources and labor will be given priority.
- Opportunities to partner with agencies and organizations will be encouraged.
- A reasonable likelihood exists that the measure can be funded.
- Monitoring impacts from future storms, including flood levels and erosion, will provide important information for future planning efforts.

The remainder of this chapter begins with a summary of the principles used to develop the Adaptation Plan followed by a detailed list of strategies that can be used to implement the plan.

## 4.1 Initiatives

*At the June 2013 Shaktoolik Planning Committee, residents expressed a need to take action. They said there have been enough studies and enough talk.*

Today's funding situation, backed by Alaska's checkered history of implementing shoreline and flood protection projects, will require careful planning by Shaktoolik. Budget reductions by state and federal governments provide a challenge to the many rural communities that compete for funding. In addition, some funding programs require a positive benefit cost ratio (i.e., the estimated value of benefits must outweigh the costs of construction). Due in part to failure of some previous efforts, such as shoreline protection structures in Kivalina and Shishmaref, it will be important that options selected by Shaktoolik have a high likelihood of success.

For the near term, the community has decided to pursue a "stay and defend" approach. Rather than plan to relocate the community, village leaders have decided to pursue all practical options that will allow residents to remain at the current location for as long as possible. This approach appears to be a reasonable way forward given the information currently available to the community. Substantial investments in the infrastructure at the current community site will be necessary whether or not Shaktoolik eventually decides to relocate. Should the community change its current plan, it would take many years to fund and implement a move. The recommendations in this report represent low-cost options selected to prevent loss of life and avoid or minimize structural damage in the event that a severe storm occurs prior to any future relocation.

While it may be tempting to wait for results of monitoring and further studies, it is important that the community move forward with a plan of action. Such a plan of action would take years to implement, and each year brings a new threat of a major storm. Results of monitoring and further studies can be used to refine the plan in the future. The Sea Grant project concludes in February 2014, and the State of Alaska will begin implementation of the Adaptation Plan under a grant managed by the Division of Community and Regional Affairs, Alaska Department of Commerce, Community and Economic Development.

### 4.1.1 Vegetated Berm

**Initiative:** Finalize plans to construct the demonstration berm proposed by DOT&PF engineers and quantify construction costs for extending the berm. Community leaders would like to see a berm constructed along the entire ocean side of the community, and they believe the demonstration berm provides a first step to develop a methodology and quantify costs. On advice of the engineers, a driftwood-retention fence could be installed in conjunction with or separate from the demonstration berm. As well, driftwood logs could be anchored together by cable to provide stability. The community should secure funding to obtain a dump truck as soon as possible since this project cannot proceed without this equipment. Indications are that a properly constructed berm could prevent damage and flooding from all but the most severe anticipated storms.

| Table 1: Construct a Vegetative Berm in front of the Community | | |
|---|---|---|
| **Strategy** | **Actions** | **Partners** |
| 1. **Demonstration Berm** | a. Work with DOT&PF to work out logistics and establish a schedule for construction of the demonstration berm. Determine how much funding is available for local workers to construct the demonstration berm. | Local Coordinator, DOT&PF |
| | b. Obtain permission from landowner to use materials from the north end of the sand spit for construction of the demonstration berm. | |
| | c. Confirm that no permits are needed to remove materials and construct the berm. If permits are needed, submit permit applications. | |
| | d. Obtain beach grass from the Alaska Plant Materials Center or from local sources. | |
| | e. Recruit local workers. | |
| | f. Work with local teachers to explore opportunities for student participation in planting vegetation on the berm. | |
| 2. **Dump Truck** | a. Purchase or rent a dump truck.[14] | |
| | b. Secure funding to ship dump truck. | |
| 3. **Berm Extension** | a. Using information gained from demonstration berm project, estimate costs for completion of a berm in front of the entire community. | |
| | b. Work with DCCED to develop a proposal for assistance from the Innovative Readiness Training (IRT) Program to extend the berm in front of the entire community. | |
| | c. Consider requesting an Army Corps of Engineers feasibility study for coastal protection that would include consideration of a vegetated berm. | |
| | d. Obtain permission from landowner to use materials from the north end of the sand spit for construction of the demonstration berm. | |
| | e. Determine if any permits are needed to remove materials and construct the berm. | |

[14] A purchased dump truck could also be used to haul refuse to the landfill.

### 4.1.2 Storm Surge Mound

**Initiative:** Construct a storm surge mound. This is a concept widely applied in Japan for evacuation from tsunamis, and it is currently being developed in other countries. The Federal Emergency Management Agency (FEMA) recognizes vertical evacuation refuges, including mounds, as suitable response to tsunami threats (FEMA 2008).[15] In some ways, a storm surge behaves like a tsunami, in slow motion, and such a structure would provide refuge from the most extreme storm surge as well as the less likely threat of a tsunami. Construction of a mound above the estimated 500-year flood levels would provide a relatively low-cost option to protect against loss of life in the case of the most severe storm that could be expected. Such a mound would likely be less than 10-15 feet above ground level. If a large storm was to occur with short notice, evacuation from the current village to higher ground in the Foothills more than a dozen miles away would not be possible, but the entire population could find safety on the mound from rising sea waters in less than an hour. The mound could be constructed with local materials and employ local residents. The community has a suitable front end loader and needs only a dump truck and landowner permission to start this project (i.e., excavation and placement of fill).

| **Table 2: Construct a Storm Surge Mound** | | |
|---|---|---|
| **Strategy** | **Actions** | **Partners** |
| 1. **Find a Location** | a. Investigate alternatives for location of the mound (e.g., the area at the northern edge of the community). Map setback from airport required by ADOT&PF. | |
| | b. Confirm site, ownership and costs, if any, for extracting gravel. | |
| | c. Work with the landowner to determine who will own the property where the mound is located. Some federal programs require that either the City or IRA to own the land in order to receive funding. | |

[15] The 2008 FEMA publication, *Guidelines for Design of Structures for Vertical Evacuation from Tsunam*is, includes structural design criteria.

| | | |
|---|---|---|
| 3. **Complete Study** | a. Contact university engineering programs to solicit assistance in completing a feasibility study (e.g., through a class project or thesis). The study should indicate how high the mound must be, how much fill is needed, whether armoring is needed on the ocean side, and estimated construction costs. | |
| 4. **Secure Funding** | a. Investigate the feasibility of sharing construction costs with other projects (e.g., the mound could be used for the multipurpose building, a new clinic, or a new tank farm). | |
| | b. Determine if the mound could be built in conjunction with a possible IRT project for the vegetated berm (military training program). | |
| | c. Meet with Alaska legislative and congressional delegations or staff to explore funding options. | |
| 5. **Construct Mound** | a. Construct mound using local labor, materials and equipment. | |
| 6. **Shelter** | a. Pursue funding options for either a permanent or temporary shelter to house community members during a severe storm. Alternatives for a permanent shelter include structures that could also be used as a multi-purpose building, clinic, or heavy equipment storage shed. Temporary, moveable structures could be used until funding for a permanent building is secured. | |

### 4.1.3 Multipurpose Building

**Initiative:** Continue to pursue funding for a multipurpose building. The building would have several benefits for the community, one of which would be safe and comfortable shelter during a temporary stay during a storm. This structure could be constructed on the storm surge evacuation mound.

| **Table 3: Construct a Multipurpose Building** | | |
|---|---|---|
| **Strategy** | **Actions** | **Partners** |
| 1. **Reconsider Site** | a. Consider options for siting building on the storm surge mound. | |
| 2. **Reduce Costs** | a. Get engineering advice for ways to reduce the | |

| | | |
|---|---|---|
| | estimated $10 million cost for the facility. For instance, costs may be reduced by constructing the building on the storm surge mound which would be above the 100-year flood. | |
| 3. **Obtain Funding** | a. Continue to seek funding for construction of building. | |

### 4.1.4 Funding Proposals and Communication

**Initiative:** Develop proposals for review by funding agencies for the projects selected by the Planning Committee. The list of potential funding opportunities prepared as part of the Sea Grant Project summarizes funding opportunities.

| **Table 4: Complete Proposals for Each Initiative and Expand Communication Efforts** | | |
|---|---|---|
| **Strategy** | **Actions** | **Partners** |
| 1. **Written Proposals** | a. Develop one-page summaries for each initiative for submittal to funding agencies and organizations. | |
| | b. Prioritize initiatives. Decide which priorities can be pursued concurrently and which ones should be pursued at a later date. | |
| | c. As opportunities arise, develop full proposals for submittal to specific agencies or organizations tailored to their requirements. | |
| 2. **Communication** | a. Once one-page summaries are developed, schedule meetings with Alaska's Congressional delegation and legislators from 39-T (in 2014, Senator Olson and Representative Foster). | |
| | b. Compile a distribution list to potential funders and other stakeholders and distribute periodic updates (e.g., quarterly newsletter with information about status of initiatives and damage from storms). | |
| | c. Develop a website for the community that includes information about efforts to address risk of natural hazards and funding needs. | |
| | d. Distribute news releases to highlight accomplishments regarding initiatives. | |

### 4.1.5 Local Mitigation Hazard Plan

**Initiative:** Update the 2009 Local Multi-Hazard Mitigation Plan to incorporate information from the 2010 Shaktoolik Situation Assessment and the 2011 Shaktoolik Coastal Flooding Analysis. FEMA and the Alaska Division of Homeland Security and Emergency Services require that the plan be updated by February 16, 2016 in order to receive funding. Since funding must relate to the goals of the plan, the revised plan should align with the recommendations of the Planning Committee.

| **Table 5: Local Hazard Mitigation Plan** | | |
|---|---|---|
| **Strategy** | **Actions** | **Partners** |
| 1. **Contact DHS&EM** | a. Contact the Alaska Division of Homeland Security and Emergency Management (DHS&EM) to discuss revision to the 2009 Local Hazard Mitigation Plan (Scott Nelsen at 907-428-7010). | |
| 2. **Revise Plan** | a. Decide who within the community will update the plan.[16] Update the plan to include new information about flooding and erosion hazards. Amend the plan goals to incorporate relevant initiatives from the Adaptation Plan. | Tribe and City |
| 3. **Obtain Approval** | a. Submit plan to DHS&EM for approval. | |

### 4.1.6 Tank Farms

**Initiative:** Work with tank farm owners and potential funders to finance relocation of the two major tank farms further from the coastline, possibly on the storm surge evacuation mound.

| **Table 6: Construct New Tank Farm further from the Coast** | | |
|---|---|---|
| **Strategy** | **Actions** | **Partners** |
| 1. **Schedule Meeting** | a. Schedule a meeting with tank owners, Alaska Department of Environment Conservation (ADEC) and the Coast Guard (USCG) to explore options for a coordinated approach to relocate the tank farms.[17] | City, Corporation, School District, AVEC, ADEC and USCG. |
| 2. **Explore Options** | a. Complete an evaluation of potential sites for a new tank farm. | |
| 3. **Develop Plan** | a. Develop a written plan for moving the tank farms that specifies commitments of current tank owners. Consider development of a joint resolution of tank owners supporting plan. | |

[16] Grants are not available from the DHS&EM to update hazard mitigation plans, so this update will need to be done in house.

[17] The Coast Guard and ADEC have regulatory authority over tank farms.

### 4.2.7 Monitoring

**Initiative:** The following recommendations for monitoring include both community-based monitoring and efforts that would need to be completed by outside experts. The community monitoring programs could be implemented as part of the IRA's participation in the Local Environmental Observer (LEO) program or by city staff.

a. **Storm surge levels:** Monitor water levels during storms. As a result of efforts by NOAA in 2010, Shaktoolik now has a benchmark to reference mean lower low water. The DOT&PF installed a storm gauge in June 2013 and is considering implementing a grant it received for local monitoring of storm surges.

b. **Beach Erosion:** Seek funding for continued erosion monitoring of the beach in front of the community, including monitoring to determine if areas eroded during the November 2013 are replenished with new material. As mentioned earlier in this report, it is not certain whether the area in front of the current village site is experiencing long-term net erosion or is relatively stable (i.e., summer accretion replaces material lost during fall storms). The DGGS and Corps completed beach profiles which provide a baseline for future measurements.

c. **Driftwood Line:** Implement a community-based monitoring program of the driftwood line at the current village site. This effort would involve measurements from a fixed point (e.g., corner of school) to the driftwood line. This measurement should be taken after each large storm and be accompanied by photographs taken from the same viewpoint.

d. **Erosion at First Bend:** Implement a community-based monitoring program at the old village site near First Bend.[18] This program would involve installation of a stable marker, such as a rebar driven into the ground, for measuring distance from this point to the river bank and the eroding beach berm. Photographs should be taken at least once a year, and a camera could be set up to take time-lapse photography.

**Table 7: Implement Community-Based and Agency Monitoring**

| Strategy | Actions | Partners |
|---|---|---|
| 1. **Community Action** | a. Develop a draft plan for community-based monitoring of beach and riverine erosion and storm surges. Consider possibility of establishing an ongoing class project to train and involve students in monitoring. | |
| | b. Contact potential collaborators and funders. | IRA IGAP program, ANTHC LEO Program ADOT&PF, and school. |
| | c. Begin implementing the plan, including establishment of benchmarks to measure erosion | |

[18] Training may be available through the Alaska Coastal Observers Network: http://www.akcoastalcorps.org/home.

| | | |
|---|---|---|
| | at First Bend and driftwood line in front of community. Continue to take photographs before and after storms from the same vantage point to track erosion and movement of driftwood in front of the community. Keep photos cataloged in a file for future use. | |
| 2. **Agency Efforts** | a. Establish regular communication with agencies that have done studies or monitoring in the community. | City, tribe, ADOT&PF, DGGS, and Corps. |
| | b. Explore options with agencies to coordinate future monitoring of storm surges and erosion. | |

### 4.1.8 Future Studies

**Initiative:** Pursue funding for new studies needed to implement the adaptation plan. Some potential information needs are outlined in the following bullets.

- Incorporate new information into the flooding models.[19]
- Complete new beach profiles at the same locations as the previous profiles to quantify how much material has been eroded or accreted.
- Seek funds to complete a study on potential drinking water sources needs to plan for options if erosion causes a break in the sand spit at First Bend.
- If the community chooses to pursue high-cost erosion or flood control projects, feasibility studies that examine several alternatives may be required.

It is recommended that future studies and projects include involvement of coastal engineers in the design of erosion and flood protection projects. Coastal engineers have extensive training in coastal processes and have experience in appropriate responses to respond to flooding and erosion. Also, the community may wish to encourage accountability by requesting that future studies identify the authors and that engineering-related documents include an engineering stamp.[20]

| **Table 8: Conduct Studies Needed to Implement Adaptation Plan** | | |
|---|---|---|
| **Strategy** | **Actions** | **Partners** |
| 1. **Prioritize Needs** | a. Determine what studies need to be done to complete initiatives. Prioritize studies and work with state and federal agencies to fund them. | |

[19] For example, information from the beach profiles from the 2011 DGGS study could be added to the flooding models as well as other data collected since the 2011 flooding analysis, including storm surge measurements from the equipment installed in June 2011.

[20] An engineering stamp certifies that a qualified engineer vouches for the accuracy and appropriateness of the documents. State of Alaska Administrative Order No. 175 requires that state-funded erosion control project include stamped drawings and design by a registered engineer in Alaska (Office of the Governor 1998). Federal requirements, however, may be different.

| | | |
|---|---|---|
| 2. **Feasibility Study** | a. Work with Kawerak to determine if a request should be submitted to the Corps for an assessment of the alternatives for flood and erosion protection. If so, develop parameters to guide the study. | |

### 4.1.9 Guidelines

**Initiative:** Develop local guidelines or ordinances to reduce damage from storms. The following bullets provide some examples of potential measures that could be adopted as an ordinance or guideline.

- Establish setbacks from the beach for buildings constructed in the future.
- Prohibit excavation of materials from the beach.
- Designate specific points for ATV crossings over the berm to the beach.
- Establish structural guidance for new buildings (e.g., raised on pilings above the 100-year storm water level).

| **Table 9: Develop Local Guidelines for Development** | | |
|---|---|---|
| **Strategy** | **Actions** | **Partners** |
| 1. **Investigate Options** | a. Investigate what Alaska communities have implemented local requirements or guidelines for protection from flooding and erosion. | |
| 2. **Approach** | a. Decide whether the community wishes to enact a local ordinance that can be enforced or whether it should simply establish guidelines. | |
| 3. **Implementation** | a. Develop an implementation plan that includes a public education component (e.g., public meeting or a brochure). | |

# 5. Implementation

This Adaptation Plan was developed with the assumption that the community's Planning Committee will continue to oversee efforts to address impacts from climate change. This plan provides a starting point for future work under the Alaska Community Coastal Protection Project (ACCP). The Alaska Division of Community and Regional Affairs will oversee the ACCP project for community with assistance from a local coordinator, a consultant and an interagency committee.

The initiatives, strategies and actions in this Adaptation Plan have been developed in a table format that can be updated as needed to track results and to add new opportunities and priorities. The tables include a column that indicates the agencies and organizations that will implement the various actions. This column has not been completed for most actions. Instead, the local coordinator and Planning Committee will determine who will do what as they implement this plan.

**Most of the driftwood in this June 2013 photograph washed away during the November 2013 storm.**

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