October 2001

Historical House Undercutting
Photo Courtesy of Tony Weyiouanna

City of Shishmaref, Alaska
Sarichef Island

Relocation Site Selection Feasibility Study
February 2016

March 2011

Completed by:
AECOM

Shishmaref Relocation Site Selection Feasibility Study

Shishmaref, Alaska
February, 2016

Submitted to:
City of Shishmaref
Post Office Box 83
Shishmaref, Alaska 99772

Submitted by:
AECOM Technical Services, Alaska
700 G Street, Suite 500
Anchorage, Alaska 99501

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Shishmaref Relocation Site Feasibility Study
Executive Summary

The City of Shishmaref is a coastal community that has been pursuing complete relocation since 1976. The community is located on Sarichef (*Kigiktaq*) Island, a barrier island in the Chukchi Sea, just north of the Bering Strait. Shishmaref Inlet lies between the Island and the mainland.

The island is repeatedly threatened by damaging storm surge, and structures have been damaged. The warmer sea water erodes their discontinuous permafrost, undercuts their protective embankment, and ultimately topples into the ocean during warmer weather. The resultant material is then redistributed down-current where their coastline is becoming shallower.

Many buildings and infrastructure are on relatively high terrain where they are temporarily protected by the 2005-2009 US Army Corps of Engineers (USACE). An Alaska Legislative grant passed through the Department of Community, Commerce, and Economic Development's (DCCED), Division of Community and Regional Affairs (DCRA), to the City of Shishmaref. (City officials decided to use these funds to build a slightly lower, longer revetment span in lieu of the USACE's revetment design which was taller and with larger sized armor rock. Additionally, Kawerak, Incorporated funded a 200' rip rap seawall (constructed along the west end of community funded through the BIA/IRR roads program costing approximately $2.2 million).

These coastal revetment projects combined costs were in excess of $27 million with a life expectancy of 15 years - to provide short-term protection.

The community still experiences direct damaging impacts to the unprotected portions of the Island from two storm types; severe wind driven storm surge waves and high tidal "quiet" wave surges. Both types have similar, devastating results. In combination with the Arctic's changing climate's sea level rise, warmer winter ocean temperatures, wind erosion, and late-forming protective sea ice, Shishmaref faces an uncertain future related to health, safety, and quality of life.

Community's Cultural Ocean Relationship

Shishmaref has been engaged in relocation, evacuation, and emergency preparedness planning for the past 40 years. Over this period, the Community has continued to make the best use of their long standing relationship with wildlife and marine natural resources, a relationship that necessitates their close proximity to the sea. These resources are essential to the cultural and economic well-being of Shishmaref.

There remain only two options for the community to maintain its culture, subsistence livelihood, and long-term survivability:

- Either complete community relocation, or
- Completely harden the remainder of Sarichef Island's coastline where infrastructure is threatened and in some places raise the terrain to protect existing infrastructure and provide new constructible land for expansion. These actions will need to be coordinated with DOT/PF airport design regulations to assure no infrastructure intrudes upon airfields flight path restrictions

Purpose of this Study

The Shishmaref Relocation Site Selection Feasibility Study directed AECOM (formerly URS Corporation) to work with the Shishmaref community to define resident's physical site criteria.

This would assist them with maintaining their social and economic lifestyle at a location that provides safety from severe coastal storm surge related damages from erosion, flooding, and other related hazard impacts. The project entailed collecting and reviewing pertinent historical studies, reports, and analyses. AECOM conducted community meetings and interviewing residents to discern their needs, priorities, and concerns that will form the basis of the project's relocation site selection criteria.

The potential sites for consideration will need to meet the majority of these selection criteria, which define how Shishmaref's culture will be compatible with, or differentiated from each identified future site's development potential and capacity to provide a long-term sustainable environment

Prior Studies, Reports and Investigations Analysis

In the course of this project, the AECOM Site Selection Feasibility Study team conducted historical document investigations and analyses from over 120 locational studies and reports to determine what has been studied and to what extent. These studies validate how their current conditions are deteriorating and their lifestyle longevity is threatened. In addition, this background information brought to light the fact that no geotechnical subsurface exploration had been accomplished past hand probe depth of approximately 8-10 feet from any of the previously identified potential relocation sites, and resulted in additional geotechnical drilling. The results of this drilling contributed to the analysis of constructability of the sites under consideration for community relocation.

Prior studies identified and evaluated multiple potential relocation sites, many of which have been deemed unacceptable. Along with the results of recent drilling, they all contained geotechnical analysis that eliminated some sites as non-constructible due to likely soil conditions.

How to Use this Report

This Shishmaref Relocation Site Selection Feasibility Study interprets these relevant data and presents AECOM's findings. They are intended to assist the community with deciding which of the site alternatives will best meet the community's long-term sustainability, cultural, and subsistence needs.

Pertinent information was prepared to present four alternative site descriptions. These include:

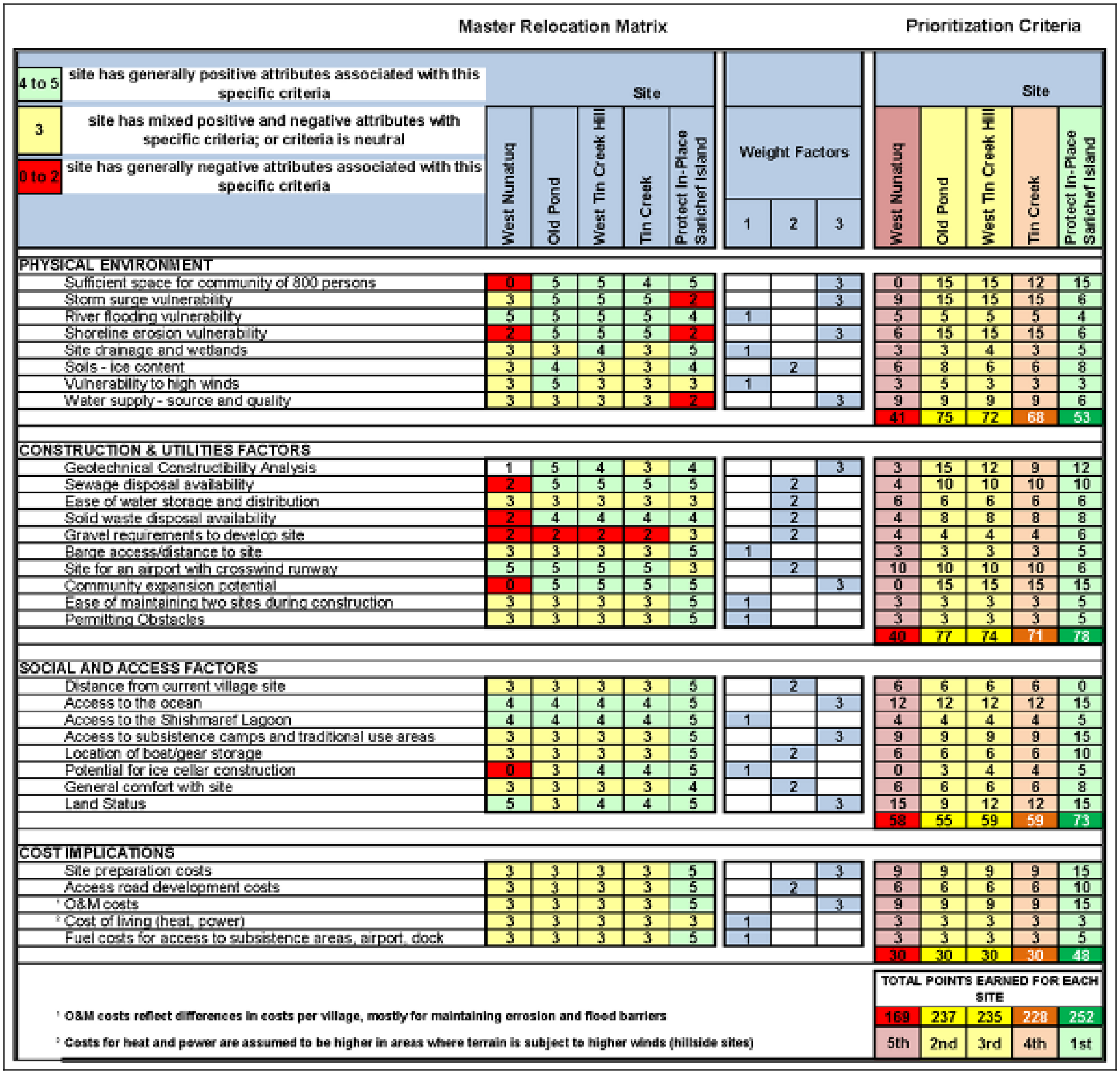
- Protect-In-Place on Sarichef Island,
- Old Pond,
- West Tin Creek Hills area, and
- Tin Creek

The following table provides a quick analysis of each site's strengths (advantages) and challenges to development as potentially providing long-term, sustainable environments for Shishmaref residents. The table compares the information side-by-side; easily summarizing our findings.

Note: A larger version of the Shishmaref Site Selectin Matrix is located in Section 4; Figure 4-1.

There are several considerations in reviewing this table:

- Potential relocation alternatives are compared using four factor categories – physical environment, construction and utility factors, social and community access factors, and cost implications. While each is scored, it should not be assumed that they are equally important.
- AECOM has used its judgment in providing the numeric values in the site comparisons;
  - the weighting factors for physical environment emphasizes the vulnerability and consequences of each factor,
  - construction/utilities factors ranks constructability and community expansion as most important
  - social and access factors ranks distance to the ocean, and subsistence and traditional use areas as most important
  - cost implication factors rank site preparation and operations/maintenance costs as most important
- There is little score difference between the three mainland sites because they have similar strengths and weaknesses.
- The Protect in Place options has the highest scores, primarily due to social/access factors and cost implications.



4 to 5	site has generally positive attributes associated with this specific criteria
3	site has mixed positive and negative attributes with specific criteria; or criteria is neutral
0 to 2	site has generally negative attributes associated with this specific criteria

Master Relocation Matrix									Prioritization Criteria				
	Site					Weight Factors			Site				
	West Nunatuq	Old Pond	West Tin Creek Hill	Tin Creek	Protect In-Place Sarichef Island	1	2	3	West Nunatuq	Old Pond	West Tin Creek Hill	Tin Creek	Protect In-Place Sarichef Island
PHYSICAL ENVIRONMENT													
Sufficient space for community of 800 persons	0	5	5	4	5			3	0	15	15	12	15
Storm surge vulnerability	3	5	5	5	2			3	9	15	15	15	6
River flooding vulnerability	5	5	5	5	4	1			5	5	5	5	4
Shoreline erosion vulnerability	2	5	5	5	2			3	6	15	15	15	6
Site drainage and wetlands	3	3	4	3	5	1			3	3	4	3	5
Soils - ice content	3	4	3	3	4		2		6	8	6	6	8
Vulnerability to high winds	3	5	3	3	3	1			3	5	3	3	3
Water supply - source and quality	3	3	3	3	2			3	9	9	9	9	6
									41	75	72	68	53
CONSTRUCTION & UTILITIES FACTORS													
Geotechnical Constructibility Analysis	1	5	4	3	4			3	3	15	12	9	12
Sewage disposal availability	2	5	5	5	5		2		4	10	10	10	10
Ease of water storage and distribution	3	3	3	3	3		2		6	6	6	6	6
Solid waste disposal availability	2	4	4	4	4		2		4	8	8	8	8
Gravel requirements to develop site	2	2	2	2	3		2		4	4	4	4	6
Barge access/distance to site	3	3	3	3	5	1			3	3	3	3	5
Site for an airport with crosswind runway	5	5	5	5	3		2		10	10	10	10	6
Community expansion potential	0	5	5	5	5			3	0	15	15	15	15
Ease of maintaining two sites during construction	3	3	3	3	5	1			3	3	3	3	5
Permitting Obstacles	3	3	3	3	5	1			3	3	3	3	5
									40	77	74	71	78
SOCIAL AND ACCESS FACTORS													
Distance from current village site	3	3	3	3	5		2		6	6	6	6	0
Access to the ocean	4	4	4	4	5			3	12	12	12	12	15
Access to the Shishmaref Lagoon	4	4	4	4	5	1			4	4	4	4	5
Access to subsistence camps and traditional use areas	3	3	3	3	5			3	9	9	9	9	15
Location of boat/gear storage	3	3	3	3	5		2		6	6	6	6	10
Potential for ice cellar construction	0	3	4	4	5	1			0	3	4	4	5
General comfort with site	3	3	3	3	4		2		6	6	6	6	8
Land Status	5	3	4	4	5			3	15	9	12	12	15
									58	55	59	59	73
COST IMPLICATIONS													
Site preparation costs	3	3	3	3	5			3	9	9	9	9	15
Access road development costs	3	3	3	3	5		2		6	6	6	6	10
[1] O&M costs	3	3	3	3	5			3	9	9	9	9	15
[2] Cost of living (heat, power)	3	3	3	3	3	1			3	3	3	3	3
Fuel costs for access to subsistence areas, airport, dock	3	3	3	3	5	1			3	3	3	3	5
									30	30	30	30	48
									TOTAL POINTS EARNED FOR EACH SITE				
									169	237	235	228	252
									5th	2nd	3rd	4th	1st

[1] O&M costs reflect differences in costs per village, mostly for maintaining errosion and flood barriers

[2] Costs for heat and power are assumed to be higher in areas where terrain is subject to higher winds (hillside sites)

It should be noted that at the outset of the project, there was no funding available to conduct underground soil analysis for any potential sites – only funding to review and compare existing data. However, during discussions with DOT/PF the agency disclosed their project had remaining funds that would be available to perform borehole drilling along the 2009 Ear Mountain Road alignment. The AECOM team worked with the City of Shishmaref's joint council to identify the three sites with the highest sustainable relocation potential along the Ear Mountain Road alignment. In early 2012 DOT/PF began their drilling activity's planning process. Weather and ice conditions challenges prevented drill until the early spring of 2015. While some subsurface ice was encountered, this subsurface drilling effort determined that all three mainland sites could provide a suitable location for community location, subject to site preparation and construction measures.

Executive Summary

This Shishmaref Site Selection Feasibility Study provides narrative descriptions of each alternative site; detailing their respective strengths and challenges. The accompanying appendices provide support documentation describing the community's past efforts to resolve their current infrastructure conditions as well as their ongoing search for relocation assistance.

The summary table, information presented in the body of the report, and appendices should be carefully reviewed by community members to consider the advantages and disadvantages associated with protect in place and relocation options before making any decisions. In particular, there are a number of factors that influence the ability to successfully follow-through on any of the options. These include:

- **The funding required for each option, who could provide the funds, and the likelihood and timing of obtaining founding** – a high cost option may result in a long time frame to obtain funding before relocation and be initiated and completed. The amount of required local match may also differ between options.
- **Other factors that specific options may be dependent on** – for example, several relocation options depend on construction of an Ear Mountain road and barge dock on the mainland side of Shishmaref Inlet. In order to provide year around access between a mainland relocation site and marine waters, construction of a causeway may be necessary.
- **It may be worth phasing relocation options** – by starting with protect in place, which is likely to be less expensive, funding can be obtained to protect existing facilities and see if full relocation will be necessary. It also allows time to
    1) Determine if the Ear Mountain road will be funded,
    2) Relocation or replacement of the existing community water collection basin. (Existing collection basin is insufficient and blocks many acres for development; there is potential for reviewing other water collection and purification alternatives such as desalinization.
    3) Study future expansion options at the existing community site, such as dredge and fill or placing specific facilities on Kigiqtam Iglua Island
- **It may be worth meeting with state and federal planning/funding partners before reaching a community decision** – if a key agency cannot support one of the relocations options, it is better to know before taking a community vote.

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Acronyms & Abbreviations List

AANHS	Alaska Area Native Health Service (*now ANTHC*)
ACCIMP	Alaska Climate Change Impact Mitigation Program
ACWF	Alaska Clean Water Fund
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
AECOM	AECOM, Consultant, or Contractor (formerly URS Corporation)
AIDEA	Alaska Industrial Development and Export Authority
ANA	Administration for Native Americans
ANCSA	Alaska Native Claims Settlement Act
ANILCA	Alaska National Interest Lands Conservation Act
ANTHC	Alaska Native Tribal Health Consortium
ATV	All-Terrain Vehicle
AVEC	Alaska Village Electric Cooperative, Inc.
BELA	Bering Land Bridge National Preserve
BIA	Bureau of Indian Affairs
bgs	Below Ground Surface
BTU	British Thermal Unit
CDBG	Community Development Block Grant
CFR	Code of Federal Regulations
CRREL	Cold Regions Research and Engineering Laboratory - US Army
CWA	Clean Water Act
DCCED	[Alaska] Department of Commerce Community, and Economic Development
DCRA	Division of Community and Regional Affairs
DEC	[Alaska] Department of Environmental Conservation
DOT/PF	[Alaska] Department of Transportation and Public Facilities
DHHS	US Department of Health and Human Services
DNR	Department of Natural Resources
DOI	Division of Insurance
EPA	Environmental Protection Agency
HUD	Department of Housing and Urban Development
ISA	Indian Set-Aside
MkWH	Million Kilowatt-hours
NPS	U.S. Department of Interior, National Park Service
NRCS	Natural Resources Conservation Service
NRMS	Northern Region Materials Section
ROW	Right-of-Way
SBA	Small Business Administration
SLC	Service Load Control
SWIM	Solid Waste Information Management System
TNH	Tryck Nyman Hayes, Inc.
UAA	University of Alaska Anchorage
UA/CED	University of Alaska Center for Economic Development
UAF	University of Alaska Fairbanks
URS	URS Corporation
US	United States

Acronyms & Abbreviations List

USACE	US Army Corps of Engineers, Alaska District
USDA	[U.S.] Department of Agriculture
USFWS	[U.S.] Fish and Wildlife Service
VSW	Village Safe Water

1 INTRODUCTION

The City of Shishmaref is a coastal community which is increasingly faced with impacts resulting from global climate change, including coastal flooding, erosion, and loss of houses and infrastructure. The City has been pursuing complete relocation with varying degrees of success since 1976.

Shishmaref is situated on the narrow Sarichef (*Kigiktaq*) Island, a barrier island in the Chukchi Sea, just north of the Bering Strait, with Shishmaref Inlet between the Island and the mainland. It is an incorporated 2nd Class City under state law, has an Alaska Native Claims Settlement Act (ANCSA) village corporation, and a federal recognized tribal government.

The barrier island consists mostly of sand, with a large permafrost layer fairly close to the surface throughout the community. Combined with the island's repeated exposure to severe multi-directional sea storms (sometimes changing direction during the same storm event), storm surge, and warmer sea water eroding the permafrost, there is considerable coastal cliff undercutting. Warm weather or the sheer weight of the overhanging bluff subsequently causes them to topple into the ocean. Once fallen, the sediment is absorbed and redistributed down-current away from the island center to the lagoon's north and south Inlet margins.

The majority of the buildings and infrastructure are on relatively high terrain or have been moved slightly inland (onto the old airport runway) to avoid loss along the eroding coast. Numerous structures, formerly situated along the coastline have been claimed by the sea. Many structures still remain and are still threatened with direct impact from quiet- high tidal surges, climate change induced sea level rise, seasonal storm surge, melting permafrost, severe wind erosion, warmer winter ocean temperatures, and late-forming protective sea ice, all of which have increased erosion rate impacts.

These impacts attack the tidal line by undercutting the 15 – 25 foot sandy dune embankment at the edge of the City's center. Storms recur at regular intervals when there is no shore-fast ice present and are considered the major causes of the permafrost laden sand "melting into the sea".

The Community has continued to shrink over the past 40 years with erosion eating away over 200 feet since 1969. A few storms have caused 25-30 foot erosion loses from a single storm. Past storm surges have engulfed nearly the entire low lying parts of the community along the old airport on the east, the west, and the south sides up to the power plant. From 2005 to 2009, in response to erosion and flooding threats to the community funding totaling approximately $27 million for:

- Kawerak, Incorporated constructed a 200' rip rap seawall along the west end of community funded through the BIA/IRR roads program at a cost of $2.2 million;
- The Alaska District US Army Corps of Engineers (USACE) constructed revetment in three phases to protect critical infrastructure from severe storm coastal erosion damages. Phase I was 625 ft., phase II was 700 ft., and phase III extended 230 ft. for a total of 1,515 ft. at a cost of $19,378,925; and
- The State Legislature provided a grant (approximately $5,450,000) through DCCED/ DCRA and ultimately to the City of Shishmaref to extend the USACE revetment project.

The Community's unique cultural, social, and economic relationship with wildlife and marine natural resources necessitates their close proximity to the sea. Therefore only two options remain to assure the community's culture, subsistence livelihood, and long-term survivability; either complete community relocation or completely harden the remainder of Sarichef Island's coastline to protect the airport, washeteria, and other at risk infrastructure.

Community relocation requires balancing a number of often competing objectives: maintaining subsistence access and traditional activities; selecting a site that will be safe over a long time period that is suitable for infrastructure development; selecting a relocation scenario that maximizes funding success and the communities ability to finance services on a long-term basis; and provide opportunities for economic development, with vastly improved quality of life such as running water and indoor plumbing.

Shishmaref has been engaged in relocation, evacuation, and emergency preparedness planning for some time. These efforts have included identifying and evaluating multiple potential relocation sites, many of which have proven unacceptable for various reasons such as having transitional permafrost and ice lenses, excessive wetlands, un-constructible soils, no water supply/distance from water resources, and extraordinary daily travel distances.

Unfortunately, none of the previously identified sites received borehole investigations due to limitation on site investigation funding sources. It is virtually impossible to determine constructability without "knowing" what lies beneath the surface. Borehole drilling provides significant geotechnical data on which decision makers can base sound judgment as to a site's expected capacity to support community development.

The AECOM Site Selection Feasibility Study team conducted document investigations and analyses as an essential requirement; vital to determining what has been studied and to what extent. This background information guided us throughout our site investigation process and provides validation for Shishmaref's options for long-term survivability and sustainability.

1.1 Purpose and Scope

The Shishmaref Relocation Site Selection Feasibility Study required AECOM (formerly URS Corporation) to work with the Shishmaref community to define resident's physical site criteria. This would assist them with maintaining their social and economic lifestyle at a location that provides safety from severe coastal storm surge related damages from erosion, flooding, and other related hazard impacts. The project entailed collecting and reviewing pertinent historical studies, reports, and analyses. AECOM conducted community meetings and interviewed residents to discern their needs, priorities, and concerns that will form the basis of the project's relocation site selection criteria.

The potential sites for consideration will need to meet the majority of these selection criteria, which define how Shishmaref culture will be compatible with, or differentiated from each identified future site's development potential and capacity to provide a long-term sustainable environment

AECOM was to continue the work outlined in the US Army Corps of Engineers (USACE) 2004, Shishmaref Partnership, Shishmaref Relocation and Collocation Study, Preliminary Cost Alternatives as well as the 2010 Bristol Environmental and Engineering's "Shishmaref Relocation Plan Update"; and other relevant investigations, namely to use established criteria to narrow the potential site list to at least three feasible alternatives that,

> *"… ensure[s] the safety and security of Shishmaref's citizens, with the ability to preserve the[ir] culture and integrity of the Community's subsistence lifestyle…" (Bristol 2010).*

This Shishmaref Relocation Site Selection Feasibility Study includes relevant findings from previously completed historical documents in order to provide pertinent information as to how a site may prove advantageous as a long-term, sustainable environment for Shishmaref residents.

(See Section 5, References and Appendix C, Technical Data Review Spreadsheet) Each of these alternative sites is located adjacent to the proposed Ear Mountain Road alignment on Shishmaref Inlet's coastal mainland.

The project analyzed these relocation sites to determine how they may fulfill the community's physical site requirements while also considering the community's socio and economic needs, potential future alternative energy requirements, and each sites potential development constructability.

1.2 Previous Studies, Reports, and Analyses

AECOM reviewed over 127 locational studies and reports conducted around the perimeter of Shishmaref Inlet associated with finding a viable relocation site. However, virtually none of them completed a detailed geotechnical, borehole supported grid search. Of these major reports the following provided the most comprehensive information relevant to this project:

- 2004 US Army Corps of Engineers (USACE) "Shishmaref Relocation and Collocation Study, Preliminary Cost Alternatives"
- 2004 Natural Resources Conservation Service (NRCS) "Identified Relocation Site Analysis"
- 2009 Alaska Department of Transportation and Public Facilities (DOT/PF) "Shishmaref Ear Mountain Road [Alignment] Reconnaissance Study"
- 2010 Bristol Environmental and Engineering's "Shishmaref Relocation Plan Update"
- 2015 DOT/PF Shishmaref potential community relocation site reconnaissance study for three identified sites adjacent to the Ear Mountain Road alignment

Other studies and reports were collected (Appendix C); many of which contained extensive geotechnical suppositions concerning non-constructability due to permafrost, ice rich soils, and undefined "massive ice" presence. However, these surveys relied heavily on hand probe testing which provides no defensible measureable soil data to support non-constructability decisions. In comparison, DOT/PF's 2015 relocation site borehole testing within a grid layout provided defensible geotechnical samples upon which agency decision makers can rely on when weighing relocation site viability.

1.3 Planning Objectives

AECOM identified four objectives that were central to completing a long-term usable site location feasibility study. They were to:

- Research and analyze existing data.
- Work with community members to address community socio-cultural needs.
- Determine whether sufficient geotechnical data existed to enable cooperative agencies consider long-term infrastructure investments at the newly selected relocation site.
- Develop the final document to enable the community to easily decide whether the potential sites' advantages out-weighed their relative disadvantage, and whether either of the feasible sites provided a better environment than their existing village location on Sarichef Island.

2 HISTORICAL RELOCATION SITE REVIEW

2.1 Review of Previous Documents

The Project Team analyzed several documents that identified Shishmaref's previously reviewed relocation sites, and had been deemed "unsuitable" using simple hand probing analysis. Among these were:

- Arctic
- East Nunatuq
- Tin Creek*
- West Nunatuq
- Igloot
- Old Pond*
- West Tin Creek Hills*

(* Deemed viable from borehole drilling operations)

Up until 2009, not all of these mainland sites had received equally extensive studies or natural resource analyses; only cursory or surficial surveys with minimal invasive geotechnical detail. Field investigations limited their subsurface "invasive" analysis to hand probe sampling which provided varied results and were further limited by frozen ground probe penetration. This process did not provide defined geotechnical analysis to adequately determine location constructability options.

Historical Relocation Site Review Considerations

Understanding prior relocation site consideration points provided guidance on where AECOM should focus research to determine viable yet sustainable relocation sites. This helped our team to pay particular attention to the most current studies spanning 2004 to present. For example, the 2004 USACE Shishmaref Relocation and Collocation Study provided a solid foundation for considering the community's future needs essential for developing a new community in close proximity to their current Sarichef Island home.

The Shishmaref City Council has stated that remaining on Sarichef Island is their first choice as it provides seasonal access to migrating sea mammals; the food resources form the foundation of their cultural dietary needs as well as providing individual income. However, Sarichef Island is proving very expensive to defend, requiring the community to continually search for funding to continue extending their rock revetment to sufficiently prevent continuous erosion damages. It therefore became essential to determine realistic site selection alternatives.

Most relocation site studies have determined that approximately 350 acres is needed for a typical 800 person community. This population size is used as a baseline for Shishmaref, even though the community size averages approximately 600 residents. The larger size will fulfill one of the community's desires – to be sufficiently sized to allow for community growth and expansion.

Mainland Ear Mountain Road Studies

The 2009 and 2015 DOT/PF investigations and subsequent reports were focused on determining the most viable route to Ear Mountain as a potential access road for developing a materials borrow source. If viable, these materials would provide much needed gravel for roads and other community construction surface requirements. The field crews were also tasked with determining whether Ear Mountain would have suitable soils as a future relocation site. Early assumptions were that the surrounding area provided a very suitable rock and gravel profile.

> *"Plans to relocate the village of Shishmaref have focused on the mainland south of the village. The closest source for rip rap, crushed aggregate and other rock products is Ear Mountain, located about 15 miles inland. A 6-mile-wide strip of the Bering Land Bridge National Preserve (BELA) lies between Ear Mountain and the proposed relocation site(s). An access road has been proposed from Ear Mountain to a new village site and coastal barge landing site.*
>
> *Northern Region Materials Section (NRMS) conducted a reconnaissance-level geotechical investigation for the Shishmaref Relocation Road project. The scope of work included exploration of two potential coastal material sites, a proposed access road between the coast and Ear Mountain, and a proposed village relocation site. We also collected surface rock samples and core drilled at Ear Mountain to characterize rock type and quality. This report presents data collected during three site visits: September 30 to October 1, 2007, April 3 to 21, 2008, and July19 to August 8, 2008…*
>
> ***Spring 2008***
>
> *The NRMS conducted drilling along a proposed access road to Ear Mt between April 3 and 21, 2008. The area was covered with 1 to 2 feet of snow. Access road test holes were drilled on approximately one-mile spacings. Addition test holes were located at two potential coastal material sites and a potential village relocation site. Test hole locations are shown on Figures 2, 3, and 4. Test hole numbers are 08-1020 to 08-1054" (DOT/PF 2009).*

Bristol Engineering's 2010 Shishmaref Relocation Report provided conflicting community desires as to which location sites should remain as needing more investigation:

> ***"Section 3.4 Current Site Selection***
>
> *…During a public meeting on December 12, 2007, the Community ratified Tin Creek as the preferred Shishmaref relocation site. No formal election was held. Although the Tin Creek site was ratified at that time, it is no longer considered the preferred relocation site. According to the March 18, 2010 Community meeting, which Bristol attended, the Tin Creek and West Tin Creek Hills sites were no longer considered viable options as relocation sites due to the abundance of ice-rich soils at both sites.* ***During the Community meeting held on March 30, 2010 which a Kawerak Transportation Planner attended, the Community indicated the desire for Tin Creek and West Tin Creek Hills to remain as potential relocation sites.****...*
>
> *A Community meeting held on June 3, 2010 indicated potential relocated sites included; West Nunatuq, Tin Creek, West Tin Creek Hills as well as a new potential site called Old Pond Site (See Figure 2), located west of the proposed Ear Mountain access road. West Nunatuq was listed by ADOT&PF as a potential barge landing site to access the potential Ear Mountain material source" (Bristol 2010).*

DOT/PF determined that the West Nunatuq site should not be considered viable because there is insufficient available land mass (size). It does not provide the minimum of 350 acres required to support all required city infrastructure and housing needs along with essential bulk fuel tank farm, barge landing, and materials staging and airport areas.

Therefore, the community stressed their desire to continue researching Old Pond, Tin Creek, and West Tin Creek Hills as these locations appeared to provide the most defensible locations from natural hazard impacts as well as close proximity to their hunting and harvesting areas – essential locations to assure their cultural heritage is not lost for future generations.

Old Pond's lower terrain with a slightly elevated surrounding embankment, formerly received limited consideration because it is a dry pond that collects snow melt run-off from the surrounding higher elevation terrain. Tin Creek and West Tin Creek Hills received recurring consideration because of adjacent water sources, vegetation, and overland access to cultural hunting grounds. All three of these sites received proximity geotechnical analysis during DOT/PF's 2009 initial and 2015 exploratory drilling efforts to determine the best route for the proposed Ear Mountain Road alignment and adjacent community constructability. The planning team determined that due to budget constraints, geotechnical drilling would be conducted within a 100 acre grid pattern. This would supply sufficient data to determine potential site viability.

2.2 Additional Geotechnical Investigation

After physically visiting all three sites, AECOM's project team member R&M Consultants, Inc. (R&M), journeyed to the mainland across Shishmaref Inlet to collect additional field data. Their non-intrusive hand probe findings were similar to prior NRCS project's analyses. R&M recommended seeking an agency willing to fund geotechnical analysis of the three selected sites as the only way to determine constructability and long-term viability. Borehole drilling would need to encompass a sufficiently sized area on which to build a community. It was determined that a 350-acre footprint is required for an 800-person community (residential commercial areas only) – the size of Shishmaref which would also allow for expansion as the community grew. Other infrastructure would be placed adjacent to the core community location.

Drilling became an essential requirement to fulfill project requirements in order to make sure that potential sites being evaluated were "constructible" for community relocation. However there was only one agency, DOT/PF, who expressed the possibility of assisting with geotechnical analysis for these locations. Mr. Ryan Anderson, Preconstruction Engineer, DOT/PF, Northern Region, explained that the Federal Highways Administration (FHWA) funded Ear Mountain Road Alignment Project may be able to fund drilling operations at the potential community sites as they were located in close proximity along the proposed Ear Mountain Road alignment. Community sites would need to be connected to the Ear Mountain Road to provide community access to essential facilities and services such as airport and barge landing facilities as well as a much needed small boat harbor.

DOT/PF staff sought, and received permission from FHWA program managers to conduct, exploratory drilling for the Old Pond, Tin Creek, and West Tin Creek Hills sites. DOT/PF finalized their drilling activity analysis in late August 2015 and is provided as Appendix F, Shishmaref Relocation Road, AK 115, Village Relocation Sites and Material Source Access Road, AKSAS 76779.

Their geotechnical drilling report's findings determined that all three sites have potential as Shishmaref's new village locations; providing long-term resiliency from future natural hazard impacts if they consider extreme cold climate construction practices.

- Old Pond
- Tin Creek
- West Tin Creek Hills

2.3 Requirements for Community Relocation Site

The AECOM project team strives to provide sufficient detailed information within the following sections to support each site's potential benefits as well as challenges. Information gleaned from geotechnical, wetland, and water resource focused studies completed by NRCS, DOT/PF, and DGGS will help the Shishmaref community understand each site's conditions, future potential, and their limitations for constructability.

The 2004 USACE Shishmaref Relocation and Collocation Study, provides the following description of Shishmaref's current and future physical needs:

"1.6 Physical Needs of Shishmaref Community

Based on the facilities, services, and structures that exist in the City of Shishmaref on Sarichef Island, and the current plans and expressed desires of the community for upgraded services, the following physical needs of the Shishmaref community were identified to which costs were applied:

- ***Defined Village Site.*** *The City of Shishmaref needs sufficient developable land area to provide for the existing land uses and private and public elements making up the community listed below. In addition, the community desires to have sufficient reserves of developable land to expand to as the community continues to grow and develop. The existing City comprises approximately 350 acres of land, including airfield, water source preserve, and those summer camps that are located on Sarichef Island.*
- ***Housing.*** *The community needs a sufficient number of homes to provide for the 589 residents making up the village. At present it is estimated that there are 153 occupied homes in the community, with an average household size of four.*
- ***Commercial and Industrial Buildings.*** *The existing community includes three commercial buildings and one industrial building (Native Store; Trading Post; Washeteria; and Tannery).*
- ***Public/Community Buildings.*** *The existing community contains the following public, community, and storage buildings: Health Clinic; School; City Hall/Post Office; Armory; Fire/Rescue Station and City Shop; Church; Library; Community Hall; Friendship Center; and 20 storage buildings.*
- ***Fresh Water Supply, Treatment Facility, and Distribution System.*** *The Shishmaref community needs an adequate, reliable, and safe supply of fresh water for the current population and expected future growth. Currently, the water supply, treatment, and distribution systems serving the community are inadequate, unsafe, and below regional standards. This will be further discussed in Section 2.3.*
- ***Sanitary Waste Collection, Treatment/Disposal System.*** *The community needs to have adequate systems and facilities to collect, treat, and dispose of sanitary wastes to promote and maintain a safe environment for its residents. Existing facilities and system for collection and treating/disposing of sanitary wastes are inadequate, below regional standards, and do not conform to applicable public health and safety regulations. This element will be further discussed in Section 2.3.*
- ***Solid Waste Collection System and Landfill.*** *Shishmaref needs to have an adequate system and facilities, which meet applicable health and safety standards and regulations, to collect and dispose of solid wastes generated in the community to support a safe environment for its residents. The existing landfill facility is below regional standards and does not conform to applicable public health and safety regulations. This will be further discussed in Section 2.3.*
- ***Electrical Generation Facility and Distribution System.*** *The Shishmaref community needs to have an adequate, reliable and sufficient source of electrical power; an essential ingredient of a safe and vibrant community. Currently, the Alaska Village Electric Cooperative (A VEC) provides adequate electricity to the community with three diesel generators and a network of overhead distribution lines.*
- ***Bulk Fuel Storage.*** *The community needs to have a sufficient and reliable supply of diesel and gasoline fuels for heating, power generation, vehicles, and equipment. Because of the remoteness of the community's location, having sufficient and safe bulk storage facilities (tank farms) are a must. The bulk storage facilities for the community include: Bering Straits Schools (54,200 gals); AVEC (122,200 gals); City (87,200 gal); Nayokpuk Trading Post (82,600 gal); Native Store (130,200 gal); U.S. Fish & Wildlife (3,100 gal); Lutheran Church (6,900 gal); National Guard (9,700 gal); and City Water Department (8,200 gal). However, the existing bulk storage tanks for the generating plant are in need of refurbishment or replacement, as are certain*

elements in the generating plant. These needs will be further discussed in Section 2.3.

- ***Roads.*** *The community needs a network of internal and service roads to connect the various elements comprising the city. The existing internal community roadways are narrow and covered with up to several inches of sand/silt, and contain no gravel. As a result, the frequent occurrences of wind-blown dust during summer, and muddy conditions during the spring thaw and following summer rainfalls are common problems. This is further discussed in Section 2.3.*
- ***Airfield.*** *An essential element of the city that helps ensure the safety and well being of the Shishmaref people is a properly functioning and serviceable airfield and associated facilities. The community is well served by a 5,000-foot by 70-foot paved runway and associated facilities, which were constructed and are maintained by the Alaska Department of Transportation and Public Facilities (AK DOT-PF).*
- ***Barge Landing Facility.*** *The continued existence and well-being of the community greatly depends on inflow of the hundreds of items and various materials required for daily living. Because of the remoteness and island setting of Shishmaref the majority of the items and materials essential to the community are brought in by barges during summer. Currently, there are adequate landing areas for supply barges to deliver goods along either of the channels on the west and east sides of the island, as well as the beach area just north of the Native Store (See the District's Hydrology and Hydraulics Appendix of the Shishmaref Erosion Protection, Relocation, and Collocation Study EIS for additional information).*
- ***Harbor and Boat Storage Facility.*** *Small boat usage is essential for transportation needs and to maintain the subsistence lifestyle of the Shishmaref community. The community has no designated harbor facilities, and fishing and other boats anchor offshore on the south side of Sarichef Island (on saltwater lagoon side), and boats are stored on shore (See the District's Hydrology and Hydraulics Appendix of the Shishmaref Erosion Protection, Relocation, and Collocation Study EIS for additional information).*
- ***Communication Facilities.*** *The satellite communication, Cable TV, and telephone facilities and services that the Shishmaref community is currently using provide an essential link between this remote location and the rest of the world.*
- ***Summer Camps.*** *The numerous shore-side privately-owned lots, located along the northern and southern perimeter of Sarichef Island, are used by members of the Shishmaref community for summer drying of subsistence foods; boat building, repair and maintenance; and a variety of other work activities" (USACE 2004).*

3 RELOCATION SITE ALTERNATIVES

Four alternatives were explored as listed within this Shishmaref Site Selection Feasibility Study. AECOM explored the benefits as well as potential challenges for each of the identified sites. Sarichef Island has a vast collection of historical information concerning their aging infrastructure, disaster impacts, and cultural and subsistence lifestyle needs.

The three mainland sites needed geotechnical exploration beyond ground probing to determine existing conditions for constructibility, access, and future land-uses to provide a basis for the community to make an educated decision as to which alternative; to either remain on Sarichef Island and Protect-in-Place (Alternative A) or to pursue the challenges of seeking agency support and funding to develop land at one of the three identified mainland alternative relocation sites (Alternatives B-D).

AECOM requested the City of Shishmaref provide the center points for each of their three identified relocation sites. AECOM then worked with R&M to identify and map each specific site's location to develop a borehole drilling grid pattern to enable DOT/PF to drill and analyze soil constructibility for each location. The following map depicts each site's location and their respective borehole pattern, as reviewed by the City of Shishmaref. These locations subsequently enabled locational analysis for each site; Alternatives B-D.

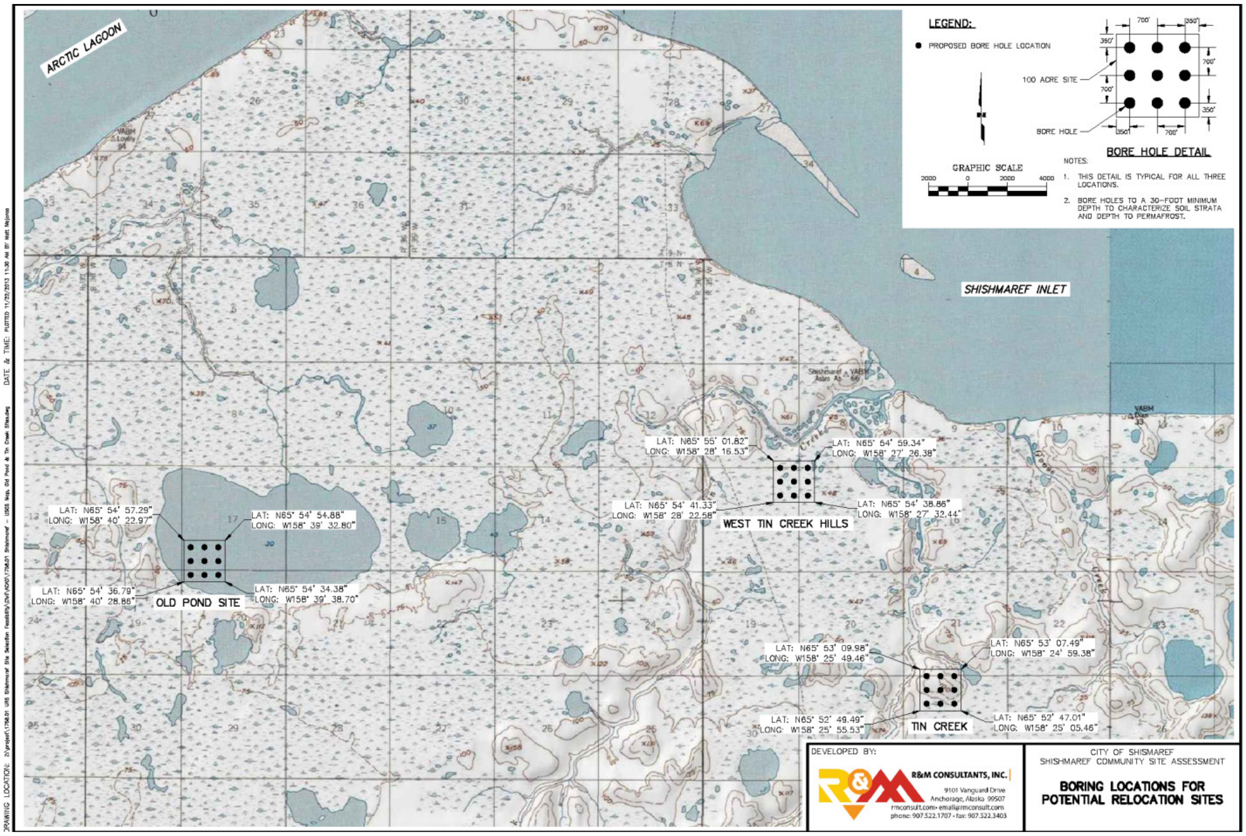


Figure 3-1 Alternatives B-D, Borehole Drilling Patterns (R&M 2012)

3.1 Alternative A: Protection In-Place

Remaining on Sarichef Island is likely the most beneficial as well as the most cost effective option, if it can be done in a manner that protects the community, allows for expansion, and is acceptable for agency investment in infrastructure.

Beneficial: The entire community relies heavily upon the sea, where essential sea mammals migrate close to Sarichef Island. Moving from this location would require hunters to traverse very dangerous, unstable ice conditions during the spring thaw and early winter freeze cycles; during the biennial marine mammal migrations. It would also involve more time and expense in pursuing marine subsistence activities.

Cost Effective: Much of the infrastructure is in-place although aging and needing repairs, upgrades or complete replacement. However, considerable investment from various agencies is occurring and proving successful at protecting the community from critical infrastructure and residential loss to persistent low intensity water flow, as well as severe wind driven erosive storm surge waves.

Several agency capital project programs have scheduled community improvement projects within the next few years, such as:

- Improving water quality and capacity by cleaning and upgrading the fresh water lagoon and water treatment system as well as cleaning the existing storage tank and installing a new one to expand their potable water storage capacity.
- Addressing underground pipe distribution (gas, water, sewage, etc.) lines.
- Rebuilding community roads; even paving those most frequently traveled.
- Expanding the school to improve capacity and upgrade existing facilities.
- Expanding the revetment to protect additional shoreline from persistent storm impacts.
- Re-asphalting the runway due to age and ongoing deterioration.

Current Location: The Alaska Division of Community and Regional Affairs (DCRA) website describes Shishmaref's location as:

> *"… located [at latitude 66.2557, longitude -166.0727] on Sarichef Island, in the Chukchi Sea, just north of the Bering Strait. Shishmaref is 5 miles from the mainland, 126 miles north of Nome, and 100 miles southwest of Kotzebue. The village is surrounded by the 2.6 million-acre Bering Land Bridge National Reserve. It is part of the Beringian National Heritage Park, endorsed by Presidents Bush and Gorbachev in 1990…" (DCRA 2015).*

Culture and History: The island's name originated from the Inuit language; the island was known as "Kigiktaq" with its present name as Sarichef Island. This location provided a safe harbor, ready access to migrating ocean resources and close proximity to mainland food sources which continues to provide food to residents who follow traditional Inupiaq boat building, fishing, and subsistence methods while teaching their children respect for their resources and culture. (DCRA 2015)

The current location has likely been used for thousands of years; as an established community, the village's history spans over 100 years:

- 1816 Lt. Otto Von Kotzebue named the Inlet "Shishmarev," after a member of his crew
- 1821 Excavations at "Keekiktuk" by archaeologists provided evidence of Inuit habitation from several centuries ago
- ~1900 The village became a supply center for gold mining activities to the south. The village was named after the Inlet
- 1901 A U.S. Post Office was established
- 1969 The city government was incorporated

- 1997 A severe storm eroded over 30 feet of the north shore, requiring 14 homes and the National Guard Armory to be relocated
- 2002 Five additional homes were relocated;
  Other storms have continued to erode the shoreline an average of three to five feet per year on the north shore
- 2002 Many believe residents voted to relocate the community in July but this involved a very limited number of residents (approximately 20) which is far below a majority vote (DCRA 2015)

Demographic Characteristics: The City of Shishmaref is a traditional Inupiat Village with a rich heritage of fishing with hunting land and marine mammals to provide a bountiful subsistence lifestyle.

The 2014 DCRA certified population survey recorded 607 residents, of which the median age was 22.5 indicating a relatively young population. The population of Shishmaref is expected to remain steady because over half of the population is between 20 and 54 years of age. The City is principally an Inupiat community with approximately 94.6 percent (%) of residents recognizing themselves as Alaska Native. The male to female population ratio is approximately 55% male and 45% female residents respectively. The 2010 census revealed that there are 141 households with the average household having approximately four individuals. Figure 3-2 and Table 3-1 illustrates the city's historic population trend. (DCRA 2015)

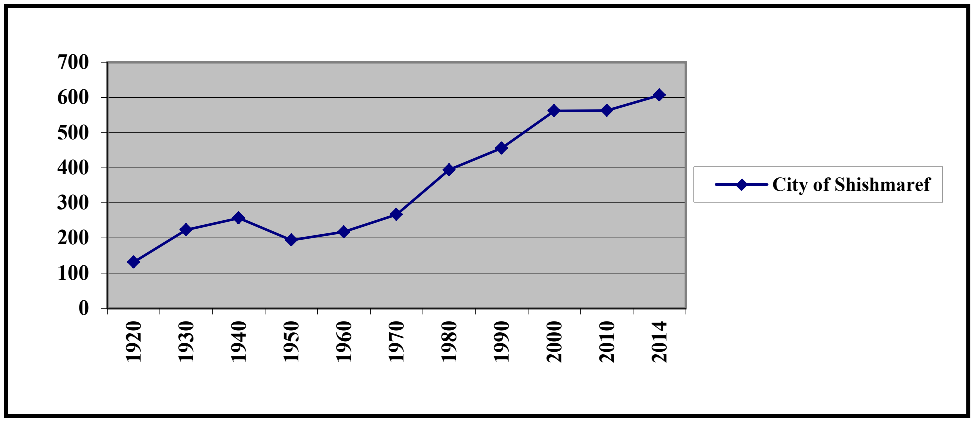


Figure 3-2 Shishmaref's Historical Population

Table 3-1 Historic Population Data for Shishmaref

Year	Actual	Increase/ Decrease	% Increase
1920	131	--	--
1930	223	92	70
1940	257	34	15
1950	194	(63)	-24.5
1960	217	23	11.8
1970	267	50	23
1980	394	127	47.5
1990	456	62	15.7
2000	562	106	23.2
2010	563	1	0.1

Table 3-1 Historic Population Data for Shishmaref

Year	Actual	Increase/ Decrease	% Increase
2014	607	44	0.93
2020	676	113	20
2030	811	135	20

(DCCED/DCRA 2011)

🟧 Key: Population Estimates for Growth Rates of Approximately 20 Percent

Economy: Shishmaref 's economy is primarily based on subsistence hunting and fishing; the local government (54.3%) is the principle industry, other general employment opportunities do exist within the community falling within leisure and hospitality (12.1%), education and health services (8.9%), and the "other" category (6.5%). The remaining named categories make up the raining 18.2%).

According to the 2014 U.S. Census estimated, the median household income is $36,750 with a per capita income of $10,651. Approximately 29.2% were reported to be living below the poverty level. There were approximately 367 workers aged 16 years or older in the work force, of which 176 were actively employed with approximately 29 (7.9%) unemployed. However, the unemployment rate included part-time and seasonal jobs, and practical unemployment or underemployment.

Critical Facilities: Rural Alaska communities rely heavily on their limited support infrastructure; therefore Shishmaref residents deem all facilities as critical for their basic survival. Table 5-2 lists Shishmaref's current critical facilities:

Table 3-2 Shishmaref Critical Facilities

Facility Category	Facility Name	Latitude DD	Longitude DD	Map Datum	Location/ Description
Government	City Hall/ Post Office	66.25581	-166.06794	NAD27	Located between water tank and Community Center
	National Guard Armory	66.25385	-166.076867	NAD27	Located southwest of Bilingual school near the airport
Emergency Response	Shishmaref City Ira Council Fire Station	66.25545	-166.06805	NAD27	First & Main Street
Education	Bilingual school	66.25699	-166.06975	NAD27	Located next to teachers housing
	Shishmaref High School	66.25641	-166.06977	NAD27	General delivery
	Shishmaref Elementary School	66.25678	-166.0697	NAD27	Located north of High School
Medical Care	Shishmaref Clinic	66.25556	-166.06722	NAD27	Across from City Office, adjacent to Community Center
Community	Community Center	66.25585	-166.06732	NAD27	Located between post office and tannery
	Nayokpuk Trading Post	66.25723	-166.06681	NAD27	Located southeast of Armory
	Shishmaref Native Store	66.25659	-166.07088	NAD27	Located west of high school
	Shishmaref Tannery	66.257967	-166.0595	NAD27	Located east of the washeteria
	Teachers Housing	66.2548	-166.075667	NAD27	Located next to Bilingual school and west of Airport Road

Table 3-2 Shishmaref Critical Facilities

Facility Category	Facility Name	Latitude DD	Longitude DD	Map Datum	Location/ Description
	American Lutheran Church	66.25698	-166.06337	NAD27	Located southeast of the Trading Post
	Cemetery	66.25715	-166.0615	NAD27	Located southwest of washeteria
Transportation	Shishmaref Airport	66.25029	-166.08678	NAD27	South end of Sarichef Island (5,000 x 70 ft. paved runway)
	Airport Storage and Maintenance Buildings	66.25363	-166.07809	NAD27	Located on the northwest side of paved runway
Utilities	Water Treatment Plant	66.25578	-166.06849	NAD27	Located south of high school and adjacent to water tank
	Washeteria	66.25801	-166.05862	NAD27	Located northeast end of town adjacent to large water storage tank
	City Catchment basin	66.25855	-166.04884	NAD27	North end of Sarichef Island, outside city area; north of housing area
	Washeteria Water tank	66.25807	-166.05811	NAD27	Located northeast end of town adjacent to washeteria
	Water Pump House	66.25855	-166.04884	NAD27	Located south of FAA towers east of town
	Water tank No.1	66.25582	-166.06831	NAD27	Located adjacent water treatment plant
	ANICA Fuel Tank Farm	66.25579	-166.07097	NAD27	Located adjacent to school tank farm
	AVEC Fuel Tank Farm No.1 (>500gal)	66.25564	-166.0699	NAD27	
	AVEC Fuel Tank Farm No.2 (>500gal)	66.25573	-166.06897	NAD27	
	City Fuel Tank Farm (>500gal)	66.25539	-166.07035	NAD27	Located south of AVEC Fuel Tank Farm
	School Fuel Tank Farm (>500gal)	66.25584	-166.07043	NAD27	Located south of high school and adjacent to ANICA Fuel Tank Farm
	AVEC Generator Building	66.25585	-166.06897	NAD27	Located north of AVEC tank farm No.2
	AVEC Building	66.25577	-166.06865	NAD27	
	Sewage Lagoon No. 1	66.25526	-166.06913	NAD27	Located to south of High School
	Sewage Lagoon No.2	66.25873	-166.05833	NAD27	Located north of the Washeteria
	Waste Water Treatment Facility	66.25801	-166.05862	NAD27	Located northeast end of town adjacent to large water tank
	Alascom Earth Station	66.25537	-166.0709	NAD27	Located west of City Fuel Tank Farm

(Shishmaref 2015)

Private Residences and Other Structures: According to DCRA 2014 certified population figures, there are 607 residents, 151 housing units, and 141 households with an average of four housing occupants. Table 3-3 lists other Shishmaref essential structures besides housing that supports community survival.

Table 3-3 Other Structures and Essential Facilities

Structure Type	Number	Use
Residential Housing	148	Housing
Teacher Housing	5	Housing
Church Housing	1	Housing
Drying Racks	~60	• Most families have drying racks to air cure their harvests • Essential subsistence structures
Boat Mooring and Storage	~75	• Anchored in Shishmaref Inlet on the east side of Sarichef Island (weather permitting) • Beached adjacent to the Inlet during winter freeze-up • Uses: Transportation and Subsistence
Cold Storage	~30	Consistent temperature storage – Subsistence
Other Storage	Undefined	Undefined

(DCRA 2015)

Land Ownership: The Shishmaref community has a long heritage, subsisting within the Shishmaref Inlet region (Figure 3-2) living from the land, harvesting sea and land mammals, berries and greens from the countryside, and fish from the ocean, rivers, and creeks. Historically, people moved in response to the season and resources, and ownership of land was not a consideration.

Land ownership and management significantly influences land availability for community relocation, access and easements that might be required. Formal land ownership in the Shishmaref region has been affected by Alaska Native Allotment Act of 1906, Statehood, the Alaska Native Claims Settlement Act of 1971 (ANCSA), and the Alaska National Interest Lands Conservation Act of 1980 (ANILCA). Prior to Statehood, the federal government owned all the land in the Territory of Alaska. The majority of that land at the time was under management of the Bureau of Land Management (BLM). Statehood provided an entitlement for transfer of federal land to state government. However, selection and transfer of lands to the State were affected by the subsequent passage of ANCSA and ANILCA.

ANCSA established regional and village Alaska Native corporations, and allowed those corporations to select land from the federal government. The Bering Strait Regional Corporation and the Shishmaref Native Corporation were established, allowing them to select subsurface and surface lands from the federal government. Native corporation lands generally include the barrier islands in the vicinity of Shishmaref, and coastal lands around Shishmaref Inlet. In addition, Section 14 (c)(3) of ANCSA allows the transfer of lands from village corporation to municipalities for community related needs.

Around that time, Alaska Natives were given the choice to become a shareholder in a Native corporation or complete applications for Native Allotments. Native allotments are considered trust lands under the direction of Bureau of Indian Affairs. Native Allotments within the city limits of Shishmaref and in the vicinity are primarily located on barrier islands, along the shoreline of Arctic Lagoon, and Shishmaref Inlet, and along rivers and creeks that feed into the Inlet.

The Bering land Bridge Land Bridge National Preserve was established in 1978 by a Presidential proclamation, just prior to the passage of ANILCA. ANILCA resulted in additional protections to specific and in national parks and preserves, wildlife refuges, wild and scenic rivers, national forests and other conservations areas. This included allowing subsistence and sport hunting in the Preserve.

Figure 3-3 displays the area's land ownership map with a color coded map key to define locational land management responsibility. The most important of which is BLM (yellow), and the Bering Land Bridge National Preserve (purple) areas that will require agency access permits. This includes access associated with planning for relocation, and access to rock and construction material sites on native corporation lands at Ear Mountain.

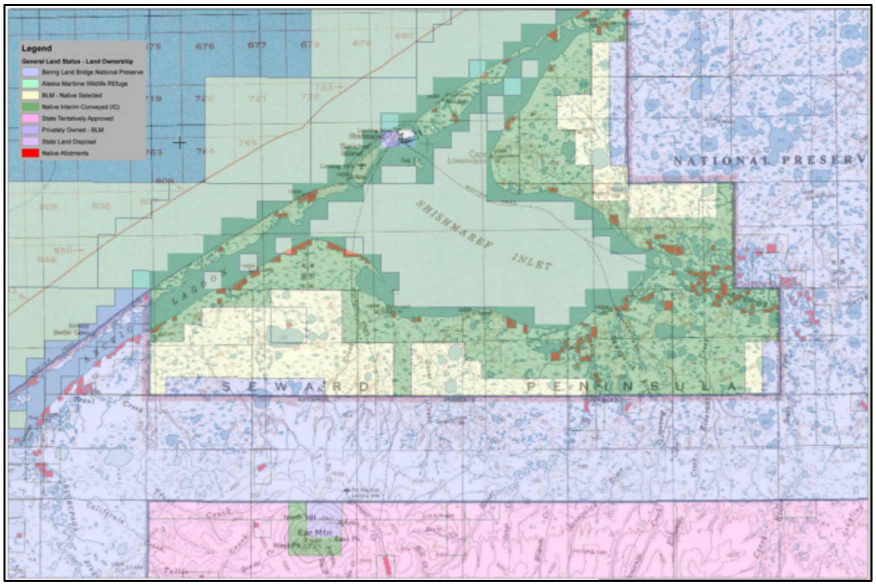


Figure 3-3 Area Land Ownership Map (DOT 2007)

3.1.1 Environment

3.1.1.1 Climate

The Division of Community and Regional Affairs community profile describes the area's climate:

> *"Shishmaref falls within the transitional climate zone, characterized by tundra interspersed with boreal forests, and weather patterns of long, cold winters and shorter, warm summers. The Chukchi Sea is frozen from mid-November through mid-June…*
>
> *… Summers can be foggy, with average temperatures ranging from 47 to 54 °F; winter temperatures average -12 to 2 °F. Average annual precipitation is about 8 inches, with 33 inches of snow" (DCRA 2011).*

3.1.1.2 Geology

It is essential to know what soil types exist and potential challenges that will need to be considered when investigating potential relocation sites. This is accomplished through scientific study known as "geotechnical investigations". These are studies using various processes such as digging a trench or drilling operations to collect soil samples. Drilling enables scientists and engineers to capture a core sample through borehole drilling. This is where soil cores are gathered by using hollow drills to capture undisturbed soil layers. A typical borehole "core" sample is depicted in Figure 3-4.

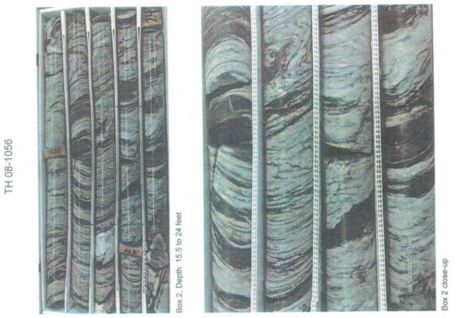


Figure 3-4 Typical Core from DOT/PF Borehole Drilling (DOT/PF 2015)

The Division of Geological and Geophysical Surveys (DGGS), Report of Investigations 96-7, Mason, 1996, Sheet 1; Geologic Map of Portions of the Shishmaref A-3, B-3, and Teller D-3 Quadrangles, Alaska depicts a broad view of the area’s geology. For example, Sarichef Island is comprised of:

Qmb Qbr

> *“MODERN BEACH DEPOSITS (Qmb) AND OLDER BEACH-RIDGE AND DUNE DEPOSITS (Qbr) – Fine to medium sand, thinly bedded. District organic beds in upper eolian facies that overlies older marine beach-ridge and overwash deposits (Qbr). Occupies barrier islands; not subdivided by age. Beach deposits at least several meters thick, possibly up to 20 m. Dunes up to 8 m high” (Mason 1996)*.

The remaining area is very diverse as displayed in Figure 3-5. This map provides too much detail for the purpose of the report and suggested reading for those agencies with interest in the area’s geology.

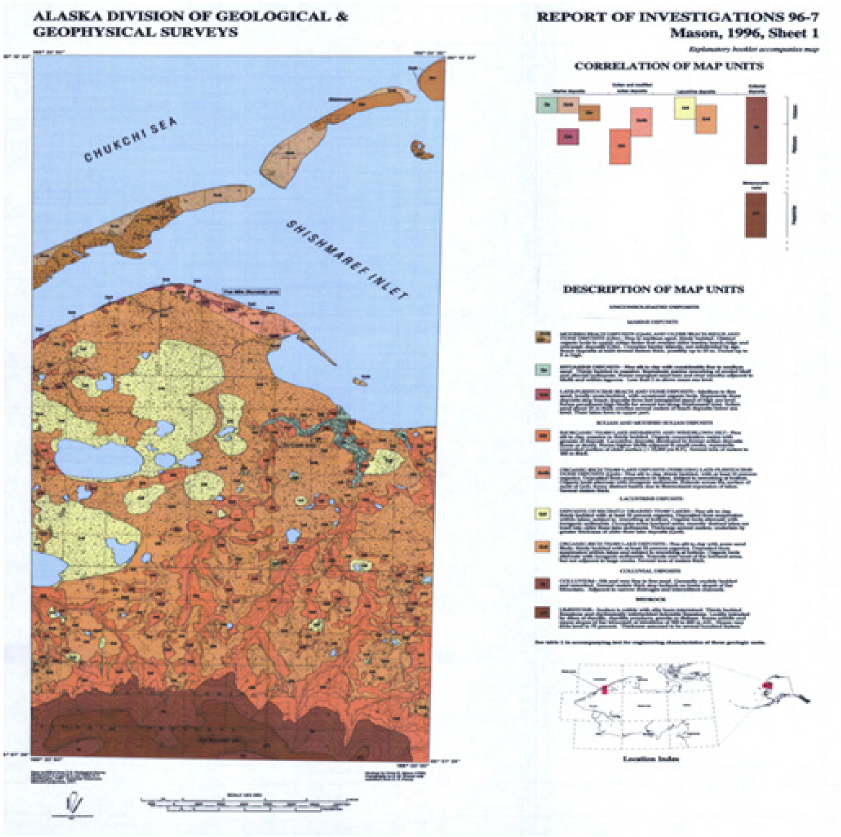


Figure 3-5 Report of Investigations 96-7, Mason, 1996, Sheet 1 (Mason 1996)

3.1.1.3 Ocean Storm Impacts

The 2013 DGGS “Preliminary Evaluation of Coastal Geomorphology and Geohazards on ‘Kigiqtam Iglua’” Island northeast of Shishmaref’s location on Sarichef Island provides a sea storm timeline chart spanning 60-years (Figure 3-6, next page). This greatly benefited our research as there is limited data for most rural locations.

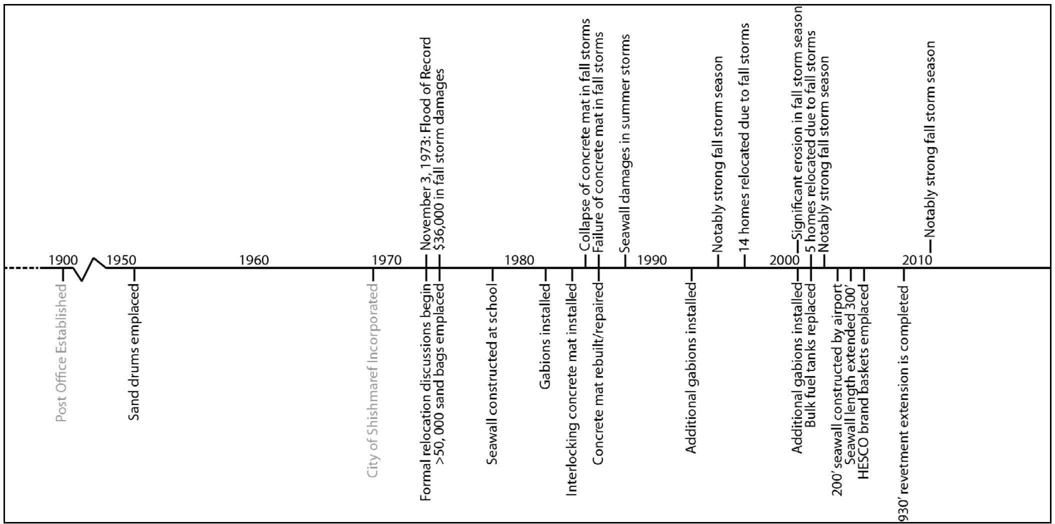


Figure 2. Timeline of the last 40 years showing significant storm events that affected Shishmaref above the line and notable coastal engineering events below the line.

Figure 3-6 Sea Storm Timeline (DGGS 2013)

The 2013 Kigiqtam Iglua investigation further described the coastal conditions in close proximity to Sarichef providing a sense of ocean water characteristics that has resulted in the community's current conditions:

> *"In 2009, DGGS received federal funding from the U.S. Minerals Management Service (now Bureau of Ocean Energy Management), through the Coastal Impact Assistance Program (CIAP), to establish a coastal community geohazards evaluation and geologic mapping program in support of local and regional planning. The DGGS CIAP program will document the geologic context and dominant coastal processes in at-risk Alaskan communities….*
>
> ***Regional Coastal Setting***
>
> *The Shishmaref coastal region is a micro-tidal (mean tidal range is 0.231 m; see fig. 3) barrier island system that trends at an azimuth of 60° along the southwest edge of Kotzebue Sound. The islands in this chain have an upper age limit of approximately 3,000 years (Mason and others, 1997b) and are undergoing long-term transgression in the vicinity of Shishmaref, as indicated by the exposure of basal peat beds on the foreshore and the presence of dynamically stable or erosional foredunes along most open-ocean shorelines. Mean grain size on the islands varies from fine sand on the shoreface to silt in the sheltered lagoons….*
>
> *Although micro-tidal, the shallow waters off the coast of the northern Seward Peninsula, coupled with the westward orientation of Kotzebue Sound, allow for the capture and amplification of extra-tropical cyclones that track easterly from both the Chukchi and Bering seas. Even during periods of storm system quiescence, atmospheric conditions have a strong influence on coastal water levels and often overwhelm trends in the astronomic tidal cycle. For example, the total water level during DGGS August 2012 field work was notably higher than the astronomical tidal range due to the presence of a mild low-pressure system. Wave setup also contributes to extreme water levels. Fetches of more than 1,000 km to the north–northwest are present during minimum sea ice extents, while fetches to the west across the Bering Strait are as little as 150 km. The highest documented winds on record in Shishmaref were 50 mph sustained, gusting to 61 mph from the northwest (295° azimuth), in September 1985 (FEMA, 2009).*
>
> *Net sediment transport, as indicated by the geomorphic offset of barrier island features, is toward the northeast and is primarily driven by geostrophic and tidal currents (Naidu and Gardner, 1988). During strong storm events, littoral transport typically reverses towards*

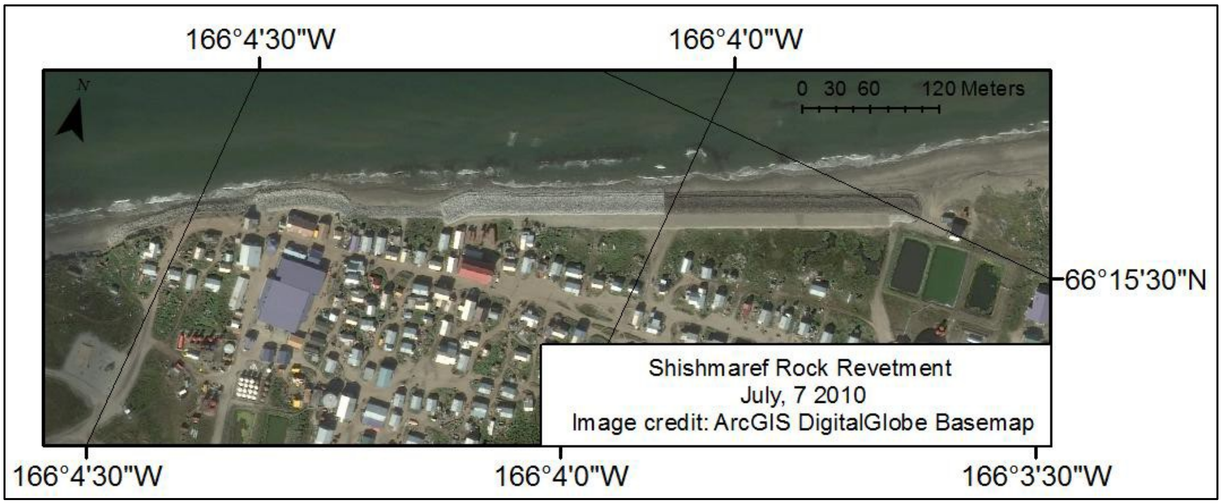
the southwest, driven by the prevailing high energy wind and wave directions (see fig. 4). The vast majority of sediment transport is limited to a 4–5 month annual open-ocean period from roughly June through October (Pilkey, 2003).

The islands and Inlets around Shishmaref exhibit a mixed-energy signature manifested by a combination of well-developed or emergent ebb/flood-tidal deltas, broad tidal flats, and some recurved spit deposition. The occurrence of tide-dominated characteristics, despite the micro-tidal setting, along this portion of the barrier island system can be attributed to the large tidal prisms associated with the extensive and open lagoon system (Davis and Hayes, 1984). The average tidal prism is approximately 9.4 × 107 m3, split across just three Inlets (two major and one minor)....

Shoreline change

… A U.S. Army Corps of Engineers erosion report (USACE, 2006a) used similar techniques to quantify erosion rates on the ocean side of Shishmaref by using 1972, 1980, 1984, and 2003 imagery as well as measured rates in 2001–2003. The USACE report suggested annual retreat rates on the ocean side of the community of 0.8 to 2.7 m/ year. A direct comparison of these values to the rates presented for Kigiqtam Iglua suggests that the uninhabited island is undergoing less net retreat. The cause of this difference is not within the scope of this report—it may be due to human modification to the developed coast on Sarichef Island, differing wave energy, onshore geometry, or it may be an artifact of the high frequency of storms during the short time period over which the USACE erosion analysis was conducted" (DGGS 2013).

Northern Coast Revetment [Figure 3-7]



Shishmaref Rock Revetment
July, 7 2010
Image credit: ArcGIS DigitalGlobe Basemap

Figure 3-7 Aerial Image of Sarichef Island Rock Revetment (DGGS 2013)

3.1.2 Existing Infrastructure Conditions

Most of Shishmaref's infrastructure is protected from storm surge and flooding primarily due to USACE, DCCED/City of Shishmaref, and Kawerak Inc. revetment protection depicted in Figure 3-5 above. However as shown in the aerial photo the sewage lagoon is still vulnerable to these impacts as the revetment falls short of providing any protection.

Many agencies responsible for providing and supporting infrastructure have delayed addressing failing or aging facilities because the community has stated they desire to relocate. No agency has been willing to invest in large projects which "may" be replaced or relocated at some undetermined date during the relocation process.

No agency has been appointed to address community sustainability requirements to assure each threatened community receives statewide agency support to address basic health safety infrastructure repairs, updates, or complete replacement.

3.1.2.1 Potable Water Supply, Purification, and Storage

The community's water infrastructure is severely aging. The entire water treatment system needs improvement, water catchment basin has black organics over the entire liner with other water quality issues, the water storage tank is subsequently unable to keep treated water clean, and piping is damaged in a few locations.

The Alaska Department of Environmental Conservation's (DEC), Village Safe Water (VSW) section is striving to address these environmental conditions during 2016 and 2017. The following activities are scheduled for repairs and replacement of the following water facilities during 2016 – 2017:

- Clean and recondition existing water tank
- Repair, clean, and recondition water catchment basin

  > *"City Council stated the closed former landfill is becoming exposed north of the water catchment basin from increased wind erosion impacts. This could pose a potential problem for the catchment basin" (City 2016).*

- Repair and protect water piping from basin to water treatment facility
- Coordinate repairs and construction with transportation route improvements

The 1987 Shishmaref Water and Sewer Feasibility Study provides a valid representation of current, existing community challenges and subsequent current conditions. It states:

> *"…Snowmelt will continue to be the primary source of drinking water…It will be used only for human consumption and contact….*
>
> *The present snowmelt system is working satisfactorily, but two problems were identified…First, gas bubbles have formed beneath the existing linear and threaten the integrity of the lined system. The second problem is that trihalomethane levels in the drinking water measure above the State of Alaska Drinking Water Standards" (Site I.N.I. 1987)*

The 2013 Shishmaref Economic Development Plan (SLEDP) available through the online DCRA Community Plans Library, explains community water,

> ***"3.4.3 Water and Sewer***
>
> *…is derived from a catch basin on the East side of the island that collects rainwater and snowmelt. It is treated and stored in a tank for both community and washeteria use. In the winter, drinking water is also obtained from ice chopped from ponds on the mainland on both the East and West sides of the Inlet, five to seven miles from Sarichef Island. Other summer water sources include rainwater collected from the roofs, and hauling water from the Serpentine River.*
>
> *Only the school, clinic, washeteria, and teacher housing have complete piped water and sewer service. Some homes have internal flush/haul systems. But most residents self-haul water and there are City honey-bucket bins available around town. The water tank does not always maintain enough water for personal use and emergencies like fires. Residents must conserve water at certain times of the year" (DCRA 2013).*

3.1.2.2 Waste Disposal

Human Waste. The City's wastewater treatment system comprises a wastewater stabilization pond as well as a non-aerated wastewater lagoon. The washeteria is the central watering and haul point for the city. The City also provides water delivery service for those unable to haul water. There are two wastewater treatment certified staff.

The current eastern end of the rock revetment does not extend far enough to provide protection to the City's sewage lagoon. Ocean water rivulets extend from the open ocean towards the sewage lagoon perimeter. This perimeter is only about 20 yards from the the open Chukchi Sea.

Solid Waste. The City manages refuse collection and operates one of two very old landfills. There is no DEC landfill permit for the current Class III facility. The Class III landfill is located approximately 280 feet southeast of the Chukchi Sea continuously eroding embankment (sea storm surge, waves, and ice) and 1,900 feet southwest of the southern end of the runway. This location does not qualify for a permit as the landfill is too close to the active runway.

The 2013 SLEDP describes their landfill as an:

> ***"3.4.4 Landfill***
>
> *…EPA/SEP backhaul program (IGAP) that plays a major role in removing unwanted refuse from the area. Large trash items old [All Terrain Vehicles] ATVs and refrigerators get taken away by barge. Batteries and many other items containing toxic substances are also removed.*
>
> *The landfill has been reorganized into sections for larger items, recyclables, etc. There is a burn-box available for individuals to use at the landfill. Maintenance is challenging especially in the spring. The site is over-filled and needs expansion or a new site. IGAP had plans to put fencing around landfill but funding was lost.*
>
> *The landfill road currently serves as a seawall for the runway" (SLEDP 2013).*

Note: the landfill road is experiencing direct sea storm surge erosion and land loss. A 2015 storm has eroded the embankment taking out material as well as cross-cutting the road making the road unusable.

DEC, Solid Waste Program and Kawerak, Inc. conducted a CIAP, Waste Erosion Assessment and Review (WEAR) site visit on September 11t, 2012 and an additional inspection was conducted on September 11, 2014 that stated:

> *"Closed Landfill, 66.244553/-166.114609 (Closed) – This landfill was covered and closed in the 1990s when the new landfill was opened. This site was operated as a trench and fill in the sand. It contains primarily municipal waste. The current metals/salvage area is located on top of this site. This landfill is eroding when the south wind causes high wave action and during the increasingly frequent fall storms (DEC 2014).*

Storage. 18 AAC 60.010 states that a person may not accumulate solid waste in a manner that causes a litter violation under 18 AAC 64.015; the attraction or access of domestic animals, wildlife, or disease vectors; a health hazard; or polluted run-off water.

Transport. Per 18 AAC 60.015, a person who transports solid waste shall keep the waste contained during transport. Any solid waste spillage and associated waste residue shall be promptly picked up and disposed.

Shishmaref has a centralized, coordinated collection or control system in place. However, no record of waste taken to the landfill has been kept, and it is not known whether hazardous waste is separated from municipal solid waste.

3.1.2.3 Fuel Storage and Dispensing

> ***"3.4.6 Bulk Fuel/Alternative Energy***
>
> *The community has an AVEC grant to fund a waste-heat recovery project to heat the City Garage where water and sewer transport equipment are stored along with the fire truck…*
>
> *Citgo has provided diesel for heat over the past few years. But an energy/heat assistance program increase would need to be established at the State House level of government.*
>
> *Fuel costs:*
>
> - *$7/gallon*
> - *#2 diesel stove oil is almost*
>
>   *$7/gallon. The average home uses about 200 gallons/month in the winter – 55 gallons every 5-7 days. Homes were designed for warmer climates and built with inefficient boilers installed.*
> - *Propane is used for cooking fuel. Blazo "white fuel" is a clean-burning fuel for lanterns and cooking. It costs $42/gallon.*
>
> ***Fuel Tanks Currently in Use***
>
> *The [Alaska Energy Authority] AEA tank farm will be replaced in 2013. The City and Native Store tank farms will be consolidated into one in 2013. Old tanks that are unusable will be removed.*

OWNER	***CAPACITY (Gallons)***
City	*87,200*
General Store	*82,600*
Native Store	*130,200*
AVEC	*122,200*
School	*54,200*
Church	*6,900*
City/Washeteria	*8,200*

(SLEDP 2013)

Note: The AEA tank farm replacement has been delayed and is scheduled for replacement in FY 2016-2017.

3.1.3 Transportation System

Roads. The current road system is contained within the community of Shishmaref; roads are primarily sand, the only readily available road construction material. However, this material is highly mobile and susceptible to blowing wind, no matter the season. The only time-of-year that sand isn't blowing is during the winter when the snow packs down from ATV and snowmachine traffic giving the community a few months rest from wind driven sand impacts.

One problem noted on the Sarichef Island location is controlling four-wheeler speed. Excessive speed on sandy roads displaces essential aggravates the blowing dust problem. This directly creates health problems for the young and elderly. It will be essential to establish road use and guidelines to keep the new roads and streets in good shape as well as to minimize maintenance costs.

> ***"3.4.7 Existing Transportation Systems***
>
> *…4-wheelers and snowmachines are the most common vehicles used on land.*
>
> *There are only sand roads in the village. A small portion of the road to the runway is paved. A dirt/gravel road, which was built by the State of Alaska Department of Transportation, leads from the village to the dump and sewage lagoon…*

> *The roads to the landfill and airport have been improved and are faster and less bumpy to drive on but need to be protected from erosion. Storms can wash away 20' of land in a single hour and have been increasingly severe. The landfill road currently serves as a seawall for the airport. Kawerak Transportation Program (KTP) has detailed information concerning these issues…*
>
> *The City of Shishmaref is responsible for street lighting, wind-erosion, run-off, and dust control within town. Improvements are wanted in all areas. Drainage is not built into the current seawall design. Without street, speed, or stop signs the City cannot enforce its safety ordinances. Streetlights cost $10,000-$11,000 to purchase and install. Funding possibilities are being researched.*
>
> *Paving the road from the airport to the post office would make patient transport safer and easier. Currently, patients can get stuck in mud and bounced around with their IVs during transport…*
>
> *A taxi service or school bus would improve safety of students. Bears and wolves are threats and not always visible especially during winter darkness and snow storms" (SLEDP 2013).*

Air. The existing airstrip provides aircraft access to the community by small planes and some larger, prop-driven and smaller jet-powered passenger and cargo aircraft. In general, the airstrip mainly provides weather dependent access to the community and evacuation support in case of a medical emergency. Some cargo such as groceries and personal goods arrive by aircraft when barge access is not possible. All of the community's mail is brought in by air.

> ***"3.4.7 Existing Transportation Systems***
>
> *…Shishmaref's primary link to the rest of Alaska is by air. A state-owned 5,000' long by 70' wide paved runway is available for charter and freight services from Nome…*
>
> *An airline terminal would provide a safe place for passengers, especially medical patients, to be out of the harsh elements while awaiting flights. Merchandise also gets left in the cold on the runway.*
>
> *Airfare is too expensive for most residents to travel. Both the stores use by-pass mail for supply deliveries and there is no other choice. It is expensive even though it is subsidized and there is a 2000 pound minimum to use it" (SLEDP 2013)*

Note: the ocean's erosion impacts are slowly approaching west end of the airport runway. As stated previously, the landfill road traverses the land slightly north of the runway. This road has been lost and needs to be rebuilt. However, the only option is to redirect the road closer to the airport.

Water. The community relies heavily on their land vehicles and water vessels to accomplish everyday activities. For example the 2013 SLEDP states,

> ***"3.4.7 Existing Transportation Systems***
>
> *Most people use boats for trips to the mainland… [and subsistence hunting and fishing trips into the Chukchi Sea.]*
>
> *Shishmaref has an excellent natural boat harbor. Around 1900, it became a supply center for gold mining activities to the south…" (SLEDP 2013).*

Bulk goods and fuel are delivered by barge as weather permits. However, winter needs may dictate delivery by air – which is typically prohibitively expensive even when using drop shipping.

> *"Barge service is available from early July through September when the water is free of ice. Barge service is expensive; ½" plywood costs $78 per sheet to transport. Barges have to wait for weather to clear before they can land and only come to deliver fuel or*

> *when supplies are ordered for a major project. Receiving freight on a chartered plane is less expensive than by barge" (SLEDP 2013).*

Subsistence Resources. Important subsistence resources include bearded seals, walrus, fish, polar bear, rabbit, reindeer, moose, and community vegetation harvesting. As has previously been indicated, the current location of the community of Shishmaref is essential to pursue a wide range of subsistence activities, particularly those dependent on marine and coastal waters.

The 2013 SLEDP describes:

> ***"4.2 Employment and the Economy***
>
> *…The population is mostly Inupiaq. Subsistence foods, hunted and harvested locally, ensure that food is available all year. Seal oil is the most important and is eaten with all foods. Subsistence foods are the largest part of the local diet and eaten at every meal. Store-bought food is supplementary.*
>
> *The village location was settled because of the access to the ocean and the mainland for hunting and gathering. A large part of the Native diet consists of sea mammals. Residents rely on seal, fish, walrus, polar bear, rabbit, moose, caribou, reindeer, crab, berries, and a variety of greens. Reindeer herding has been challenging due to reindeer leaving with the migrating caribou herds.*
>
> *Carved and sewn crafts are made and traded for other necessities…*
>
> ***5.2 Vegetation***
>
> *Local residents harvest a variety berries and greens from the land.*
>
> ***5.4 Wildlife***
>
> *There are too many individual wildlife species around Shishmaref to list. Residents use seal, fish, walrus, polar bear, rabbit, moose, caribou, reindeer, and crab for food and materials to make tools, clothing, and other crafts. Those are just a few examples" (SLEDP 2013).*

3.1.4 Environmental Threats

The 2009 Shishmaref Hazard Mitigation Plan (HMP) explains the community's natural hazard threats and will not be duplicated within this document. Please refer to the HMP for additional natural hazard information.

Notable hazards defined by WHPacific (Table 3-4) within the HMP include:

Table 3-4 Shishmaref HMP Identified Hazards

Hazard	Yes/No	Decision to Profile Hazard
Flood	Yes	Designated as a hazard due to extensive history of flooding, and future vulnerability due to local topography.
Erosion	Yes	Designated as a hazard due to extensive history of erosion.
Earthquake	Yes	Designated as a hazard in State All-Hazard Risk Mitigation Plan.
Volcano	No	Shishmaref is not located near any active volcanoes.
Avalanche	No	Shishmaref's topography is not one likely to produce avalanches.
Tsunami	No	Designated as not a hazard in Alaska All-Hazard Risk Mitigation Plan.
Severe Weather	Yes	Designated as a hazard due to extensive history of previous severe weather events.

(WHP 2009)

3.1.5 Existing Site Improvements and Expansion Options

The Shishmaref Native Corporation has set aside land located adjacent to the most easterly housing area (located on the old air strip); extending toward the water catchment basin. The catchment basin has a designed protective buffer zone to assure no adverse impact to the community's water supply.

The most needed short-term items are to repair, upgrade or replace existing deteriorating infrastructure. Investment in improving existing infrastructure will also require expansion of existing shoreline protection.

Revetment Protection

The most essential long-term improvement would be to extend the shoreline revetment along the entire northern edge of Sarichef Island, and possibly the entire Island perimeter, with a solidly engineered revetment protected embankment. This would protect the majority of existing community infrastructure and encourage agencies to fund improvements and/or new infrastructure.

Sarichef Island's Water Catchment Basin Relocation or Removal

The community's current water catchment basin is sufficiently sized to serve the residents needs and has black organics over the entire liner with other water quality issues. With available land for expansion and growth at a premium, the catchment basin and setback around it take up a footprint roughly one--third the size of the developed portion of the community.

Sarichef Island's Southern Inlet Area Increase Elevation

The area between the new and old airport runways would greatly benefit from ground surface raising its elevation to enable community expansion within this typically wet location (Figure 3-8).

Redesign this open space to safely contain and control water run-off from this newly elevated area would control snow melt and rain run-off to avoid excess water collection, saturation, and excess ponding.

Ponding leads to water stagnation. It is vital to prevent water run-off because it could potentially cause contamination affecting fish and sea mammal resources in Shishmaref Inlet.

Figure 3-8 Southern Water Ponding Area

Potential Kigiqtam Iglua Island Expansion

Community expansion or relocating selected infrastructure to the island east of Sarichef (locally known as "Kigiqtam Iglua" meaning island to the east) could provide a viable long-term option.

This island is much broader than Sarichef Island, although without Sarichef's elevation. Like Sarichef, Kigiqtam Iglua is experiencing erosion and deposition, but possibly at a less intense rate. Nicole Kinsman, formerly of DGGS conducted a coastal hazards assessment in 2012. She states in her preliminary analysis of Kigiqtam Iglua, (Figure 3-9).

> *"the island is undergoing typical barrier island migration processes through erosion and accretion and, due to low relief, much of the area is vulnerable to episodic coastal flooding" (DGGS 2012)*

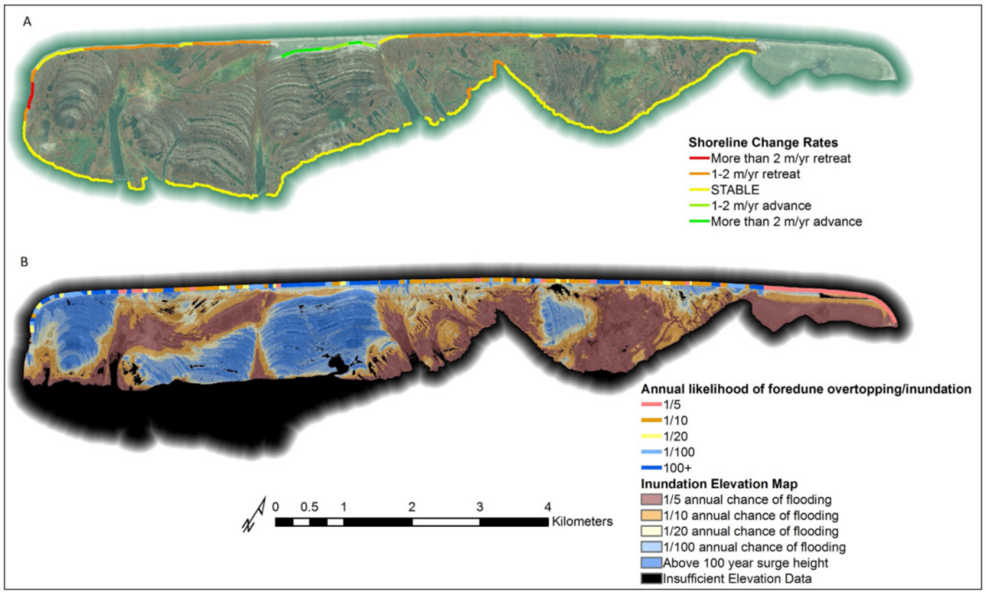


Figure 10. Preliminary coastal erosion and flooding vulnerability maps for Kigiqtam Iglua based on the best available data at time of publication. Map A illustrates shoreline change rates around the entire island based on changes in the position of the vegetation line since 1949. Map B is a colored elevation map in which the colors correspond to published surge heights for the Shishmaref region at varying recurrence intervals. Red areas are most susceptible to inundation and blue areas are least susceptible. The colored line along the open-ocean coast depicts the likelihood of the foredune ridge being overtopped by wave runup. A full description of the limitations of these early map products is described in the text. The basemap is a 2011 GeoEye satellite image.

Figure 3-9 Kigiqtam Iglua Island Coastal Change Study (DGGS 2013)

Kigiqtam Iglua possesses expansion capacity potential as indicated by the blue “higher elevation” areas on the lower 2012 DGGS photograph. These areas are above the 1 percent (%) chance of flood impact zone (100-year floodplain). However, considerable research and analysis is required before this location could be validated “safe” for long-term infrastructure expansion. It will be essential to perform borehole drilling similar to that used along the proposed Ear Mountain Road alignment to determine soil composition, constructability, and potential longevity.

Some of the potential activities that could be accomplished to make expandability and access a reality on Sarichef and Kigiqtam Iglua Islands include:

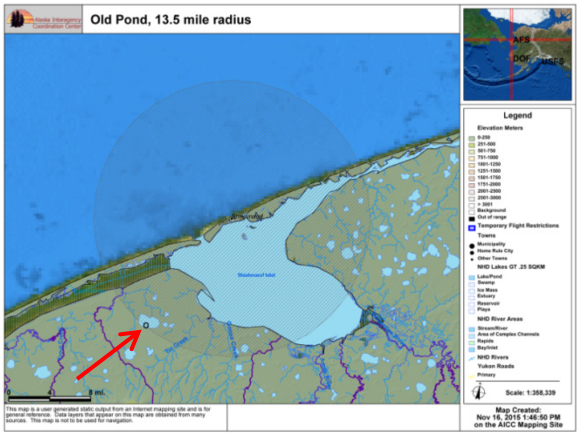
- Dredge for two-fold purpose: replenishment, boat launch, and deeper water boat harbor development. (The City Council stressed it is essential to determine sea-life impacts from dredging before this activity is considered for implementation)
- Construct causeway to Kigiqtam Iglua Island with water flow-through capability and embankment hardening to reduce high water flow erosive impacts
- Utilidor suspended beneath the causeway for water and/or waste water transport to respective sites on Kigiqtam Iglua Island
- Create boat moorage – safe harbor on the leeside of Sarichef at locations where dredging for land surface replenishment occurs
- Relocate or construct additional potable water containment area
- Relocate or construct new wastewater (sewage) lagoon

These activities could assure a long-term and sustainable environment if funding agencies completed detailed /coordinated geotechnical studies and drilling operations that would meet their combined funding and permitting requirements.

3.2 Alternative B: Old Pond

3.2.1 Location and Site Development

The Old Pond site, although known within the community, has received little attention until this project's inception and kick-off meeting. The City Council identified Old Pond as a site where they wanted more information. Therefore, AECOM asked their teaming partner R&M consultants, Inc. to conduct a field study in the Old Pond area seeking to identify the most likely relocation site; one that would provide long-term and sustainable future for the residents of Shishmaref.



The Old Pond site is currently situated on Bureau of Land Management (BLM) land pending Alaska Native Claims Settlement Act (ANCSA) conveyance. To the Shishmaref Native Corporation. The site lies approximately 13.5 miles from Shishmaref, 6.4 miles from the West Nunatuq barge landing site, and 6.5 from the Tin Creek entrance to Shishmaref Inlet.

3.2.2 Geology – Constructability Implications

R&M Consultants sampled soil along the embankment, within the north portion of Old Pond and the most southern area identified as the most likely relocation site. The field crew stated

> *"A hand driven probe with a sample barrel at the bottom… was used to measure the depth to which the ground was thawed, and to obtain soil samples.*

The first probe hole was obtained just north of the dry lake on the tundra bank and consisted of surface organics underlain with silt. The top of the bank is 6 to 7 feet above the lake bed. Frozen ground was encountered 1.5 feet below the surface.

The second probe hole was obtained in the north portion of the lake bed itself and consisted of a surface layer of organics underlain with approximately 3 feet of sandy silt. Frozen ground was encountered 3 feet below the surface. The unfrozen sandy silt was wet to moist.

The third borehole was obtained in the lake bed about 100 yards north of the south bank. Frozen ground was encountered 5 feet below the surface. Soil encountered consisted of sandy silt, wet to moist.

Water. The Old Pond area is fairly close to various ground water, springs, ponds, and small ground water lake sources. Further investigation is needed to determine water accessibility and sufficiency for this site

3.2.3 Access

The Old Pond site is located on the southern edge of Old Pond which is approximately 4 miles from Shishmaref Lagoon and 13.5 miles from Shishmaref and varies from 6.5 to 6.7 miles to the Inlet depending on which route is selected.

Airfield. DOT/PF started a wind and climate study to analyze Seward Peninsula climatic conditions in close proximity to the proposed relocation sites situated along the proposed Ear

Mountain Road. This study was to form the basis for designing a new-mainland sited airport with an associated Airport Master Plan.

Old Pond is in close proximity to the DOT/PF's southwestern air field option (Appendix B, Figure 5-4). The community's future Relocation Strategic Management Plan would need to ensure village residential and infrastructure siting would be coordinated and compatible with FAA regulatory criteria.

Barge Landing and Subsistence Boats. This location does not provide direct water access and would depend upon having a barge landing with boat harbor for barge delivery and subsistence equipment staging and protection. An access road to the community would need to be constructed.

It is recommended that a barge landing be constructed either along the West Nunatuq coastline or in close proximity to the Tin Creek outlet to Shishmaref Inlet. However, each of these locations will need to undergo analysis to determine needs and feasibility for retaining long-term use or sustainability from continual dredging. As indicated below and Figure 6 above, a causeway may be an essential alternative.

Old Pond would be approximately the same distance from either of the proposed West Nunatuq or Tin Creek barge landing areas.

Community Road. Old Pond would require internal community roads to serve the new community, with similar internal road requirements for Tin Creek and West Tin Creek Hills sites:

> ***"Internal Roads***
>
> *Internal road design will be specific to village configuration and layout. There is no way to estimate the amount of road needed other than to guess. The relative length of road is an indication of the length of other infrastructure, such as electric lines, sewer and water pipes and pedestrian walkways…*
>
> *West Tin Creek Hills could be configured with two circular main routes, an inner and outer loop, with radial connecting roads. This layout would require about four miles of road, and is shown conceptually in Figure 6" (NRCS 2004).*

All sites will also need road access to the barge landings, airport, and a materials source. This access road will be slightly longer than the West Tin Creek Hills site; about 6.4 miles long, directly northeast from the southeast edge of Old Pont to the West Nunatuq coast or approximately 6.7 miles to the Tin Creek outlet to Shishmaref Inlet.

3.2.4 Construction Considerations

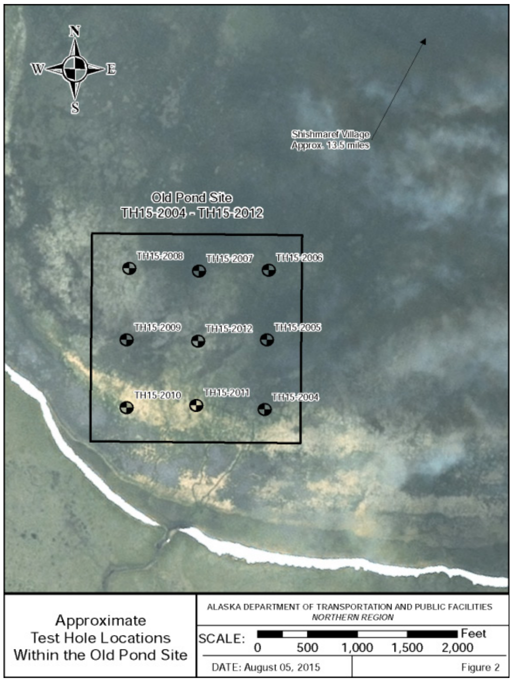
The 2011 R&M Consultants, Inc. Shishmaref Potential Relocation Sites Investigation reported that Old Pond area consists of:

> *"Standing water, generally one foot or less in depth, was present in most of the lower areas north of the lake. A local elder, Fred Goodhope, Jr., said the Old Pond site is a lake that is mostly dry and made of solid ground. This was confirmed by the site visit; there is a crescent of water along the north shore of the lake, but the majority of the lake to the south was solid ground. Primary vegetation observed consisted of cattails and "cotton" grass. The ground surface was moist, but generally firm.*
>
> *A hand driven probe with a sample barrel at the bottom … was used to measure the depth to which the ground was thawed, and to obtain soil samples. The first probe hole was obtained just north of the dry lake on the tundra bank and consisted of surface organics underlain with silt. The top of the bank is 6 to 7 feet above the lake bed. Frozen ground was encountered 1.5 feet below the surface. The second probe hole was*

> *obtained in the north portion of the lake bed itself and consisted of a surface layer of organics underlain with approximately 3 feet of sandy silt. Frozen ground was encountered 3 feet below the surface. The unfrozen sandy silt was wet to moist.* ***The third borehole was obtained in the lake bed about 100 yards north of the south bank. Frozen ground was encountered 5 feet below the surface. Soil encountered consisted of sandy silt, wet to moist****" (R&M 2011).*

The 2015 DOT/PF road alignment defined the following site specific information (edited for Old Pond site):

> ***"Expected Physical Site Conditions and Design Considerations***
>
> *Based upon this investigation and the general geology of the area, the following physical site conditions should be anticipated during construction:*
>
> - *Anticipate loose, wet, and liquefiable soils within the Old Pond Site and other thawed areas within the investigated area.*
> - *Anticipate encountering several feet of organic mat and organic rich soil within … relatively low-lying portions of the proposed material source alignment, and other areas of relatively low-topographic relief within the investigated area…*
> - *Anticipate thawed soils, and possibly a groundwater table in soils within and adjacent to drainages. The size of thaw bulb surrounding drainages, however, may be limited.*
> - *Anticipate possibility of encountering saline soils with a depressed thawing temperature.*
>
> *The major design consideration within the Old Pond Site is bearing capacity and settlement within relatively wet and loose silt soils. Depending upon construction practices and final village-site design, drainage of excessively wet soils and standing water may be necessary… Much of the soil encountered during this investigation may be frost-susceptible. Depending on location, design criteria, therefore, should be as such to mitigate settlement, thawing, and excessive frost heave"…*
>
> ***Subsurface Conditions within Old Pond Site***
>
> *Nine test holes, designated as TH15-2004 through TH15-2012, were drilled within the Old Pond Site. These test holes were spaced roughly evenly on an approximate 700-foot grid within the assigned extents of the site (see Figure 2). Drill depths of these test holes range between 19 feet and 31 feet bgs. The ground surface at these test holes was generally covered by approximately 12 inches to 18 inches of snow overlying approximately 6 inches to 12 inches of pond ice. Beneath the snow and ice cover, the test holes drilled within the Old Pond Site generally exhibited the following sequence of soils:*



Approximate Test Hole Locations Within the Old Pond Site

Figure 2

> - *2 feet to 5 feet of frozen, dark brown, organic-rich SILT and PEAT*
>   - *commonly containing visible ice*
> - *7 feet to 14.5 feet of grayish brown to brownish gray SILT*
>   - *frozen in portions lying above roughly 3.5 feet to 6 feet bgs*
>   - *slightly organic to organic with organic content decreasing with depth*
>   - *generally moist to wet*
> - *2 feet or more of thawed, brownish gray to gray SILT*
>   - *generally moist to wet*

> *A light gray SILT containing coarse Sand and fine Gravel was encountered at approximately 30 feet bgs within test hole TH15-2004. This soil, however, was not encountered within the other test holes within the Old Pond Site.*
>
> *In general, drill action and sample handling indicated that the thawed soils encountered within the Old Pond Site are moist to wet, loose and liquefiable (see Photos 6, 13, 26, 30 and 31). Laboratory analyses determined that moisture content of frozen soils ranged between approximately 74 percent and 98 percent and the moisture content of thawed soils ranged between approximately 17 percent and 51 percent. Table 5 summarizes soil moisture content within samples from the Old Pond Site.*
>
> ***Frozen Ground and Groundwater Table***
>
> *The test holes drilled within the Old Pond Site encountered roughly 3.5 feet to 6 feet of seasonal frost beneath the snow cover. Seasonal frost in excess of 6.5 feet may be anticipated if this site is kept clear of vegetation and snow cover - particularly near the end of relatively cold winters.*
>
> *Permafrost was encountered at approximately 30 feet bgs within test hole TH15-2004. In spite of our attempts, similar depths were not reached within the other test holes drilled within this site; likely resulting in the other test holes not encountering permafrost.*
>
> *A definitive groundwater table was not established while investigating the Old Pond Site. This was due to encountering excessively wet and loose soils and unstable test hole walls that prevented direct measurement. Presence of ponded ice, however, suggests the groundwater table is near or above the ground surface. The slight decrease in moisture content with depth may be a function of a slight increase of soil density with depth" (DOT/PF 2015).*

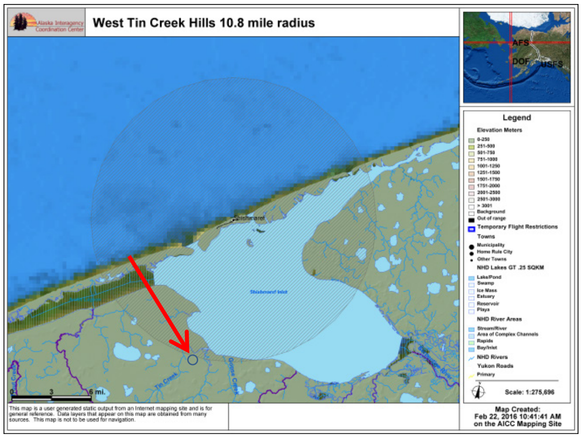
R&M Consulting provide the following constructability considerations for the Old Pond site upon receiving the 2015 DOT/PF site drilling report and laboratory analysis.

> *"The Old Pond Site is located on the mainland southwest of Sarichef Island (see Figure 1). USGS maps show the pond full of water, however during the site investigation, the majority of the lake to the south was observed to be solid ground with a crescent of water along the north shore. The site is accessed via a skiff by travelling southwest for approximately 13 miles from Shishmaref, up the Kuaruk (also known as little creek) for 2 miles, then walking cross country for 3 miles across low tundra-covered hills and shallow valleys, and finally walking another mile across the lake bed to the south shore of the lake.*
>
> *Barge access to the proposed access road to Old Pond is not currently viable and would require dredging. A large sand bar located just prior to the mainland impedes access near the mouth of the Kuaruk. The Old Pond Site is located approximately 6 road miles inland, making transport of existing infrastructure from Shishmaref challenging. Small boat access is available via the Kuaruk; however, the proposed site is still 4 miles inland and may not be large enough to support the community's existing number of boats. The Old Pond Site lacks a nearby source of fresh water and will likely require pumping water over great distances from a nearby water source that is not tidally influenced.*
>
> *Except for seasonal frost, this site appears to be underlain by unfrozen soils. However, one of the boreholes encountered permafrost at a depth of 30 feet. Most of the other eight holes were not drilled as deep, so there is potential that frozen soil is present at greater depths under more of the site. Based on the assumption that the site is generally thawed, and any permafrost at depths below 30 feet is generally thaw stable, the following general recommendations would apply to development of the Old Pond Site:*
>
> 1. *It is expected that the site will need to be filled to raise the grade above flood level. The weight of the fill material will result in settlement of the loose thawed soils. This settlement could be accelerated by surcharging with additional fill material which would be removed prior to site development.*

2. *A thermal analysis should be performed to determine if insulation should be placed under the embankment to reduce the frost penetration into the underlying frost susceptible soils.*
3. *The surcharging of building sites would allow the use of insulated shallow foundations typically used in seasonal frost areas free of permafrost.*
4. *The soils within the depth drilled are not suitable for support of pile foundations. Piles would only be practical if further investigation reveals the presence of dense or frozen soil at greater depth.*
5. *The surcharging of the fill embankment will allow the use of buried arctic insulated water and sewer carrier pipes" (R&M 2015).*

3.3 Alternative C: West Tin Creek Hills Area

3.3.1 Location and Site Description



The West Tin Creek Hills lowland site indicated by the "red" arrow is approximately 10.8 miles from present-day Shishmaref, 5.8 miles from the West Nunatuq barge landing, 1.13 miles from Tin Creek entrance into Shishmaref Inlet, and 2.14 miles from the Goose Creek entrance into Shishmaref Inlet respectively.

3.3.2 Geology – Constructability Implications

R & M Consulting Inc. site investigation theorized, that the West Tin Creek Hills geology was very similar to the Tin Creek Site with the following characteristics:

> *"that many, if not all the low hills in the lower portions of the Tin Creek drainage are underlain by massive ice. The surface of the low hills showed the same type of topography observed at West Nunatuq; the conclusion being that the hills in this area have thermally degrading polygonal ground on top of massive ice lens. The extensive presence of massive ice is noted in a number of the borings taken by DOT along the alignment for the proposed Ear Mountain materials source road. No probing was done at this site. (R&M 2011)*

R&M therefore determined from these observations to probe a location away from the West Tin Creek Hill site closer to West Tin Creek indicated by the red arrow. Their exploration, as well as the DOT/PF drilling activity, found this location as likely to be more constructible, as well as a potentially more sustainable site.

Water. The 2004 Site Comparison study describes the West Tin Creek Hills area's potable water availability as:

> ***"Water***
>
> *The West Tin Creek Hills site is not near any lakes large enough to support the required water flows. Direct removal from [the west finger of] Tin Creek, or groundwater development are the best water supply alternatives at this site" (NRCS 2004).*

3.3.3 Access

The West Tin Creek Hills area will need roads for airport, barge landing, and materials source access; it will also require development of roads within the community. The site is located approximately 10.8 miles from Shishmaref.

Airplane. As with the Tin Creek Site:

> *"Air travel will require a new runway. There are several lowland locations where an airport could be located. These locations are a similar distance from the village sites compared to the current airport location. One advantage of the new sites is room to build a crosswind runway. This is unfeasible at the present airstrip location" (NRCS 2004)*

West Tin Creek Hills area in close proximity to the DOT/PF's southwestern air field option (Appendix B, Figure 5-4). The community's future Relocation Strategic Management Plan would need to ensure village residential and infrastructure siting would be coordinated and compatible with FAA regulatory criteria.

Barge Landing and Subsistence Boats. Tin Creek channel is extremely sensitive to boat wake impacts which will cause subsequent embankment undercutting and block failure. The Tin Creek water flow is insufficient to move land failure embankment material downstream. This will eventually fill in the current river channel which in-turn will cause channel migration.

It is recommended that boat access to the new community site using the Tin Creek Channel should be very limited to prevent over taxing and ultimately damaging this waterway as this may be the community's main water resource.

It is also recommended that a barge landing be constructed either along the West Nunatuq coastline or in close proximity to the Tin Creek outlet to Shishmaref Inlet. However, each of these locations will need to undergo analysis to determine needs and feasibility for supporting long-term use or sustainability from continual dredging. As indicated below and Figure 6 above, a causeway may be an essential alternative.

> ***"Barge Access and Marina***
>
> *Both sites [Tin Creek and West Tin Creek Hills] will need a causeway into Shishmaref Inlet to reach deep enough water for barge access… At this time an estimated length for both sites is one to two miles" (NRCS 2004).*

The 2004 NRCS "Site Comparison of Tin Creek and West Tin Creek Hills…" study describes their analysis of the potential West Tin Creek Hills relocation site. However, it appears as though the identified location possessed extensive ice at various depths that was not substantiated because no borehole drilling was accomplished during the 2004 study.

> *"Both sites are on a similar geologic formation, and have similar soils. A 6 to 12 inch layer of vegetative mat is underlain by 10 to 16 inches of gray silt. This silt is underlain by permafrost composed of silt and a high amount of ice. Soil characteristics do not vary greatly on different slopes or different aspects" (NRCS 2004).*

The 2004 site comparison study did analyze a proposed barge landing and Shishmaref Inlet access needs. A road with a bridge would be require to cross Tin Creek continuing on to Shishmaref Inlet. The study indicated that a causeway would be needed extend into deep water due to the Inlets shallowness close to shore. Figure 6 depicts these recommendations; however the road would connect to the new community location slightly east of the NRCS study's proposed site marked with the small white dot (indicated for a lagoon at this site).

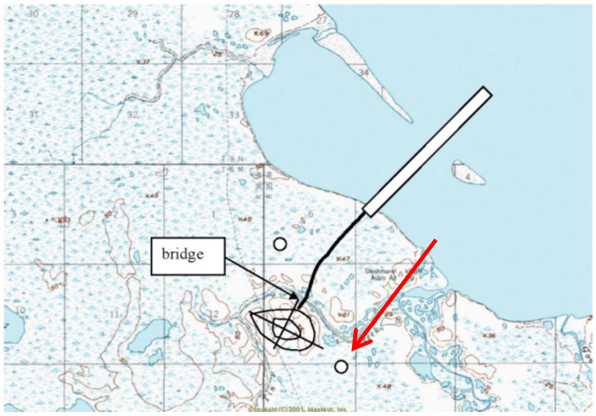


Figure 6 – Ocean (dark line) and internal road scheme (light line) at the [NRCS identified] West Tin Creek Hills site. The white box is a possible causeway for barge traffic and a small boat harbor. The white dots are potential lagoon locations" (NRCS 2004).

NOTE: *the lower white dot (red arrow) indicates the location of this Feasibility Study's West Tin Creek Hills area site. (See borehole layout figure below)*

Community Roads. Additionally, the new community would require internal roads to enable travel and access to needed facilities and residences. The 2004 NRCS Site Comparison study describes West Tin Creek Hills area's potential internal road requirements:

> ***"Internal Roads***
>
> *Internal road design will be specific to village configuration and layout. There is no way to estimate the amount of road needed other than to guess. The relative length of road is an indication of the length of other infrastructure, such as electric lines, sewer and water pipes and pedestrian walkways…*
>
> *West Tin Creek Hills could be configured with two circular main routes, an inner and outer loop, with radial connecting roads. This layout would require about four miles of road, barge landing, airport, and a gravel source and is shown conceptually in Figure 6" (NRCS 2004).*

NRCS further stated the West Tin Creek Hills area needed a road

> *"… about 1.3 miles long, and would go directly north from the village site. This alignment would require a bridge over Tin Creek. This road is anticipated to go across massive ice formations and wetlands and engineering would need to account for these conditions" (NRCS 2004).*

3.3.4 Construction Considerations

The 2004 Site Comparison Study provides analysis for infrastructure construction considerations:

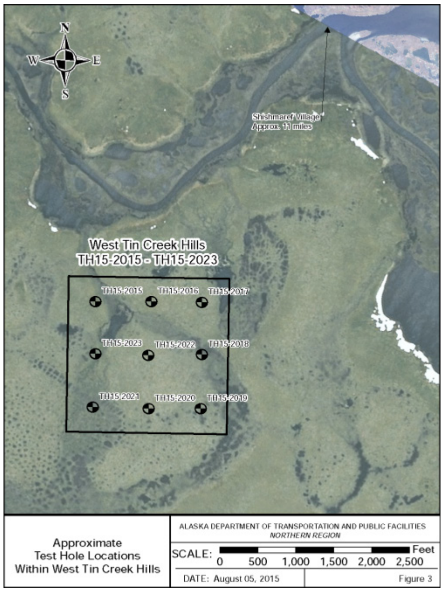
> ***"Sewer***
>
> *Because of the shallow depth to ice and amount of wetlands and groundwater, a lined primary treatment lagoon may be the best alternative. Sewage can be collected by means of a pump and haul system, or with central sewer pipes.*
>
> *If enough storage is provided at the lagoon, a secondary treatment through wetlands may be an effective discharge scheme in the summer.*
>
> *…The best location for a sewage lagoon at the West Tin Creek Hills site may be across Tin Creek to the Northwest. This site is shown [as "o"] in Figure 6" (NRCS 2004)*

The 2015 DOT/PF road alignment defined the following (edited for West Tin Creek Hills site):

“Expected Physical Site Conditions and Design Considerations

Based upon this investigation and the general geology of the area, the following physical site conditions should be anticipated during construction:

- *Anticipate encountering ice-rich frozen ground and thermokarst features such as thaw ponds.*
- *Anticipate encountering several feet of organic mat and organic rich soil within the West Tin Creek Hills Site, relatively low-lying portions of the proposed material source alignment, and other areas of relatively low-topographic relief within the investigated area…*
- *Anticipate thawed soils, and possibly a groundwater table in soils within and adjacent to drainages. The size of thaw bulb surrounding drainages, however, may be limited.*
- *Anticipate possibility of encountering saline soils with a depressed thawing temperature.*



…The West Tin Creek Hills Site exhibited ice-rich soils above roughly 11 feet bgs. These soils may become thaw-unstable if allowed to thaw. … Much of the soil encountered during this investigation may be frost-susceptible. Depending on location, design criteria, therefore, should be as such to mitigate settlement, thawing, and excessive frost heave.

… The pervasive, massive ice encountered in portions of both the proposed alignment and the Tin Creek Site will result in excessive settlement if allowed to thaw. Much of the soil encountered during this investigation may be frost-susceptible. Depending on location, design criteria, therefore, should be as such to mitigate settlement, thawing, and excessive frost heave….

Subsurface Conditions within the West Tin Creek Hills Site

Nine test holes, designated as TH15-2015 through TH15-2023, were drilled within the West Tin Creek Hills Site. These test holes were spaced roughly evenly on an approximate 700-foot grid within the assigned extents of the site (see Figure 3). Drill depths ranged between 10 feet and 23 feet [below ground surface] bgs, but commonly extended to roughly 15 feet to 19 feet bgs. The ground surface at these test holes was generally covered by approximately 12 inches to 18 inches of snow. Beneath the snow cover, the test holes drilled within this site generally exhibited the following sequence of soils:

- *1.5 feet to 5 feet of frozen organic cover, including Tundra Mat, PEAT and Organic SILT*
  - *generally ranging between 1.5 feet to 2 feet thick*
- *2 feet to 8 feet of frozen ice rich SILT*
  - *commonly organic rich, with organic content decreasing with depth*
- *Brown to gray, frozen SILT extending to depths explored*
  - *o ranging between frozen, well bonded with no excess ice (Nbn) to frozen, well bonded with excess ice (Nbe)*

Gray SILT containing interbedded layers of fine sandy SILT to silty fine SAND was encountered at approximately 16.5 feet bgs within test hole TH15-2023. This soil, however, was not encountered within the other test holes that extended to similar depths.

> *Moisture content amongst the soils collected within the West Tin Creek Hills Site varied between roughly 5 percent and 360 percent; with the highest values within ice-rich soils. Table 6 summarizes soil moisture content within samples from West Tin Creek Hills Site.*
>
> ***Frozen Ground and Groundwater Table***
>
> *The test holes drilled within the West Tin Creek Hills Site encountered pervasive frozen ground that extended to depths explored. The thickness of the active layer within this site was not determined due to the drilling taking place near the end of the freezing season – where maximum frost depths occur.*
>
> *Layers of massive ice were encountered in test holes TH15-2016, TH15-2017, TH15-2019 and TH15-2023. These ice layers were encountered between 1.5 feet and 6 feet bgs and ranged between 6-inches and 4-feet thick. Many of the test holes drilled within the West Tin Creek Hills Site encountered ice-rich soil within their upper 10 feet. Much of this soil contained approximately 25 percent or more ice by volume. Table 7 roughly illustrates the distribution and concentration of ground ice encountered within the West Tin Creek Hills Site.*
>
> *Groundwater was not encountered while drilling within the West Tin Creek Hills Site. Due to the relatively high moisture content of ice-rich soils and poor drainage conditions, local thawing may result in a perched water table" (DOT/PF 2015).*

R&M Consulting provide the following constructability considerations for the West Tin Creek Hills area site upon receiving the 2015 DOT/PF site drilling report and laboratory analysis.

> *"The West Tin Creek Hills Site is located on the mainland approximately 11 miles south of Sarichef Island (see Figure 1). To access the site by skiff, the route from Shishmaref consists of a wide 17 mile long arc to the east to avoid shallow water and reach the mouth of Tin Creek.*
>
> *Barge access to the proposed site currently is not viable without dredging, because of the long, shallow sand bar on the south side of the Shishmaref Inlet and a shallow channel that leads into Tin Creek. The West Tin Creek Hills Site is located approximately 1 mile from the mouth of Tin Creek making transport of existing infrastructure from Shishmaref challenging. Small boat access and parking is available at the mouth of Tin Creek but the area may not be large enough to support the community's existing number of boats. Fresh water is not readily available at the proposed site location and will require pumping from Tin Creek (a few miles upstream) because the creek is tidally influenced.*
>
> *This site is underlain by ice-rich permafrost. The development of the site will need measures to minimize the degradations of the permafrost, which would result in significant settlement. The following are general recommendations for development of the West Tin Creek Hills Site:*
>
> 1. *Road embankments and building pads will need to be insulated to minimize the thaw of the underlying ice-rich permafrost.*
> 2. *Buildings should either be on pile foundations and elevated off the ground, or constructed at-grade with passive ground cooling systems.*
> 3. *Boardwalks supported on pile foundations should be considered for pedestrian walk-ways.*
> 4. *Above ground arctic insulated water and sewer carrier pipes will be required to minimize the thaw of the underlying ice-rich permafrost" (R&M 2015).*

3.4 Alternative D: Tin Creek

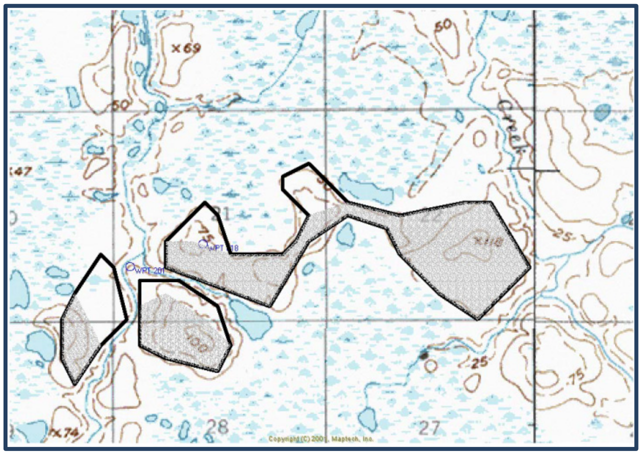
3.4.1 Location and Site Development

The Tin Creek site is approximately 10.2 miles from present-day Shishmaref; near the end of the east finger of Tin Creek (1.46 miles to the outlet into Shishmaref Inlet and 1.13 miles from Goose Creek's outlet into Shishmaref Inlet).

NRCS studies indicate that due to potential stream bank erosion from boat wakes and winter spring thaw cycles, boat access to the community via the creek should be avoided. Accessing barge landings, a new mainland airport, and boat moorage sites via the proposed Ear Mountain Road is recommended.

The 2004 NRCS "Site Comparison of Tin Creek and West Tin Creek Hills for Potential Emergency Evacuation and Permanent Relocation Site" study describes the potential Tin Creek relocation site as:

> *"Tin Creek site, and potentially developable areas, are shown in Figure 3. Overall, the Tin Creek site is very spread out, dissected by several low areas and drainage ways.*



> *Figure 3 – Tin Creek relocation site. Dark lines encompass usable area. Shaded areas indicate areas where residential housing would be suitable. Sections are in R35W K.R.M., T8N.*
>
> *The Tin Creek site has three developable areas. To the north and east is 186 acres shown by the dark line. Of this, 120 acres have the potential to be residential areas. To the south is an area of 102 acres that has 70 acres to develop into housing sites. Across the creek to the west is an area of 80 acres that has 40 acres suitable for housing sites. Overall, the site has 368 acres with 230 developable [acres]. At a housing density of 2 units per acre, this site could support a maximum of 460 structures. As a point of comparison, there are currently 160 structures in Shishmaref" (NRCS 2004).*

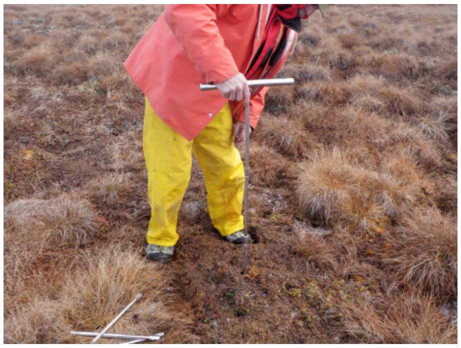
3.4.2 Geology – Constructability Implications

The study provides the following description for the Tin Creek site's geology:

> ***"Geology and Rock Materials***
>
> *In general, the area is developed in coastal deposits of interbedded marine and terrestrial sediments of clay, silt, lime, and sand. Ear Mountain and the foothills behind the Tin Creek site that form the catchment are developed in metasedimentary rocks with igneous*

> *intrusions. The predominant rock types observed were limestone and granite or granodiorite intrusions…*
>
> *The Tin Creek site is on the flatter, tidal influenced plain to the north of Ear Mountain. The tidal flat is developed in interbedded Quaternary (very recent) marine deposits (shallow sea floor) and terrestrial sediments (fluvial materials) deposited by Tin Creek and other surface streams draining into Shishmaref Inlet as well as eolian sediments (windblown) of sand, silt and volcanic ash. The predominant sediment material at the site is eolian and fluvial sand. The volcanic ash is a very minor constituent, derived predominantly from Devil Mountain northeast of Shishmaref Inlet…" (NRCS 2003).*

R & M Consulting Inc. site investigation described the Tin Creek Site as,



> *"… the higher of the two sites in the Tin Creek area; the topographic maps indicate the hill top is about 100 feet above sea level. Grass tussocks and low willow bushes are present on the higher mounds, with grasses prevailing in the surrounding lower swales. The same kind of hummocky topography was present on top of the hill as was observed at Nunatuq and West Tin Creek Hills. A single probe hole was obtained at the top of the hill, revealing approximately 3 inches of organics underlain by 1 foot of sandy silt. Frozen ground was encountered 1.25 feet below the surface" (R&M 2011).*

Water. The 2004 NRCS Site Comparison Study describes the Tin Creek site having water in fairly close proximity:

> ***"Water***
>
> *For a village of 800 people, a flow of approximately 125 gallons per minute can be used as a planning goal (Cold Region Utilities, 1996).*
>
> *Tin Creek has a small lake directly in the middle of the development, and has several other lakes surrounding the area. In general, lake water would be a good source of drinking water if the lake is kept isolated from surface runoff from the village, and is upgradient from any sewer works…*
>
> *Surface water may be available from the branch of Tin Creek that flows near the Tin Creek site. Investigation into the depth and persistence of winter freezing would be needed" (NRCS 2004).*

The NRCS 2003 Trip Report Shishmaref Relocation Study, Shishmaref AK, September 8-12, 2003, (NRCS 2003) provides a very descriptive analysis of various components of the Tin Creek site:

> ***"River Processes***
>
> *Observed creek banks adjacent to the Tin Creek site were steeply sloped to nearly vertical with very little associated woody vegetation. It appeared that lenses of compressed silt and bio-muck with higher shrink-swell potential are interlayered with more free-draining sandy soil layers. When exposed in the stream banks this material swells or "heaves" either with saturation or freeze-thaw activity. Cracks develop paralleling the stream flow, and wedges of bank material eventually fail into the creek. These wedges look like "clumps" of bank "eroding" into the creek. Cracks and subsidence associated with "blocks" of bank material along the creek were noted. The unstable bank areas did not coincide with outside curves in meanders, but instead were located along all sections of the river, on inside bends, outside bends and in crossovers and straight sections. The clumps remain along the bank areas for long periods of time. The creek does not exhibit sufficient energy to break down and remove or transport the materials*

effectively. Storm surges associated with fall and winter winds off the Chukchi Sea and Shishmaref Inlet destroy and transport some of the materials. Remnant wedges were observed occasionally along the Creek. There is only slight overall bank erosion occurring as well as little sediment transport activity. The bank soil materials appear to be active, but cumulative effects of present usage of the area do not appear to be severe.

Groundwater

Deeper groundwater recharge is mainly from rain and snowmelt water in the upper watershed (Ear Mountain). Deep groundwater may contribute to springs and small creeks and ponds observed throughout the study area as the groundwater flows intersect geologic contacts and fault zones associated with Ear Mountain and the surrounding area south of the study location.

There is little evidence of surface water flow or developed drainage paths (streams) off the majority of the upper hillslope area of Ear Mountain. Most of the precipitation probably infiltrates directly into the fractured bedrock on the hillslopes or is stored in the soil-vegetation mat. Soils are very shallow to bedrock or permafrost.

The entire area is underlain by permafrost, and there is surface evidence of some impacts to groundwater from long-term changes in the permafrost. The Tin Creek site and surrounding area includes thaw lakes, small areas of thermokarst, and extensive ice-wedge polygons.

Tin Creek is a perennial stream that derives much of its flow from groundwater, either from drainage of "pothole" or thaw lakes, or shallow groundwater perched on the permafrost and discharged into the creek.

Surface recharge is associated with "Tundra" soils and vegetation that act as a "sponge" to hold dramatic volumes of water in shallow aquifers perched above the permafrost as snows melt and spring rain collects on the surface. Later in the summer and fall, water is released slowly from the "sponge".

As is evidenced by the color and flavor of the water in the thaw lakes and in Tin Creek, the shallow groundwater in the area is very high in tannins and possibly other organic acids.

[From the] ***Conclusions and Recommendations*** *[section …]*

Channel Stability

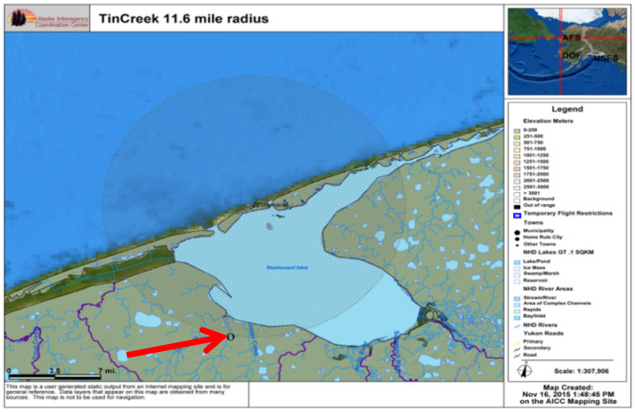
The slight river bank erosion that is presently occurring does not appear to be primarily a fluvial process (not the result of river flow). It appears that heaving of exposed compressed silty clayey or mucky soil in the river banks is the dominant physical process resulting in bank instability. The river does not appear to exhibit sufficient energy to break down and remove or transport the materials effectively. The bank soil materials are highly active, but the cumulative effects do not appear to be severe. The shrink-swell and soil heaving activity may be re-occurring seasonally in the same wedges rather than involving large volumes of "new" material each season. Management and treatment alternatives should focus on minimizing soil surface exposure. Since the process does not appear to be related to stream energy, management or use of Tin Creek, and channel treatments that alter the flow energy or transport capacity may result in significant impacts to channel stability.

Increased boat traffic and impacts of boat wake wave energy should be considered when planning the village relocation. Increased wave action may result in increased instability of the bank materials, increased wedge failure and sedimentation in Tin Creek. Without the stream flow energy to transport this material, Tin Creek may become overwide, and too shallow to support continued boat traffic. Vegetation alone will probably not be very effective. Treatment should address stabilizing the soil materials as a whole – keeping

> *"blocks" of material in-place. Treatment should address the "heaving" nature of the materials and boat wake impacts, not fluvial (river) processes.*
>
> ***Ground Water***
>
> ***Drinking Water Source***
>
> *The[re] appears to be ample shallow groundwater available at or adjacent to the Tin Creek site. The presence of tannins and possibly other organic acids and constituents will require testing and treatment of groundwater if used as a drinking or municipal water source…*
>
> *[From the]* ***Conclusions and Recommendations*** *[section …]*
>
> *Wet areas in and adjacent to the village site are associated with disruption of shallow groundwater, permafrost, and surface flow. Construction of roads and walkways, and building pads involving fill and leveling of soil materials can create small, localized "dams", changing shallow groundwater flowpaths and resulting in wet, boggy, and ponded water areas. These wet areas become nuisance zones for travel, land use and management.*
>
> *Construction and development plans at the new village site should consider these possible groundwater impacts and minimize the effects. New construction should include practices and considerations to minimize the effects. Leveling and filling for construction of building pads, roadways and walkways should not be completed without providing drainage for shallow groundwater and surface water from the slope toward the creek.*
>
> *Development plans and construction should also be planned to minimize impacts on the permafrost. Any thawing or disturbance to the permafrost in the area will result in increased problems with soil instability and disruption of shallow groundwater and will greatly accelerate the effects discussed above. Buildings should be constructed using elevated and insulated techniques and the soil and vegetated surface should be left undisturbed as much as possible" (NRCS 2003)*

Access

The area would be accessible by airplane, barge or boats. All-terrain vehicles (ATV) and small trucks would be used to transport people and goods along the proposed Ear Mountain Access Road corridor. The site is located approximately 11.6 miles from Shishmaref.



Airplane. The 2004 NRCS Site Comparison Study describes the Tin Creek site's airport access as:

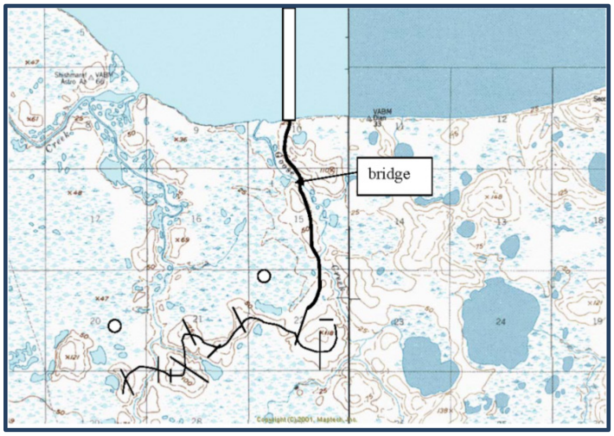
> *"Air travel will require a new runway. There are several lowland locations where an airport could be located. These locations are a similar distance from the village sites compared to the current airport location. One advantage of the new sites is room to build a crosswind runway. This is unfeasible at the present airstrip location" (NRCS 2004)*

The Tin Creek site is in close proximity to the DOT/PF's southeastern air field option (Appendix A, Figure A-3). The community's future Relocation Strategic Management Plan would need to ensure village residential and infrastructure siting would be coordinated and compatible with FAA regulatory criteria.

Barge Landing and Subsistence Boats. The 2003 NRCS site assessment describes the Tin Creek channels as potentially sensitive to boat wake impacts. The current low water flow rate is too slow to transport eroded embankment sediment. This condition could potentially "widen the channel and increase sediment depth making boat access a challenge or require constant dredging to keep the channel open. The writer's recommendation was to protect the embankment to prevent these weather and boat wake erosive force impacts:

> *"Increased boat traffic and impacts of boat wake wave energy should be considered when planning the village relocation. Increased wave action may result in increased instability of the bank materials, increased wedge failure and sedimentation in Tin Creek. Without the stream flow energy to transport this material, Tin Creek may become overwide, and too shallow to support continued boat traffic. Vegetation alone will probably not be very effective. Treatment should address stabilizing the soil materials as a whole – keeping "blocks" of material in-place. Treatment should address the "heaving" nature of the materials and boat wake impacts, not fluvial (river) processes" (NRCS 2003).*

The 2004 NRCS study identified three potential barge landing sites within Shishmaref Inlet: West Nunatuq, Tin Creek near its outflow into Shishmaref Inlet, and from an access route along Goose Creek located to the east of the Tin Creek site (Figure 5).



> *"Figure 5 – Ocean (dark line) and internal road scheme (light lines) at Tin Creek Site.*
>
> *The white box is a possible causeway for barge traffic and a small boat harbor. The white dots are potential lagoon locations…*
>
> ***Barge Access and Marina***
>
> *Both sites [Tin Creek and West Tin Creek Hills] will need a causeway into Shishmaref Inlet to reach deep enough water for barge access… At this time an estimated length for both sites is one to two miles" (NRCS 2004).*

It is recommended that a barge landing be constructed either along the West Nunatuq coastline or in close proximity to the Tin Creek outlet to Shishmaref Inlet. However, each of these locations will need to undergo analysis to determine needs and feasibility for supporting long-term use or sustainability from continual dredging. As indicated, a causeway may be an essential alternative.

Local boat access to the Tin Creek site would be through Shishmaref Inlet to the barge landing then using land transportation - from along the proposed Ear Mountain Access Road to the Tin Creek site.

Community Roads. Additionally, the new community would require roads that traverse the new community. The 2004 NRCS Site Comparison study describes Tin Creek's potential internal road requirements:

"Internal Roads

Internal road design will be specific to village configuration and layout. There is no way to estimate the amount of road needed other than to guess. The relative length of road is an indication of the length of other infrastructure, such as electric lines, sewer and water pipes and pedestrian walkways.

Tin Creek would need trunk and spur roads due to its spread out nature. These roads would total about 6 miles and include two bridges to reach all of the developable areas" (NRCS 2004).

3.4.3 Construction Considerations

The 2004 Site Comparison Study provides analysis for infrastructure construction considerations:

"Sewer

Because of the shallow depth to ice and amount of wetlands and groundwater, a lined primary treatment lagoon may be the best alternative. Sewage can be collected by means of a pump and haul system, or with central sewer pipes.

If enough storage is provided at the lagoon, a secondary treatment through wetlands may be an effective discharge scheme in the summer.

The Tin Creek site has a potential lagoon location in Section 22. This is shown [as "o"] in Figure 5 [above]" (DOT/PF 2009).

The 2015 DOT/PF road alignment defined the following (edited for Tin Creek site):

"Expected Physical Site Conditions and Design Considerations

Based upon this investigation and the general geology of the area, the following physical site conditions should be anticipated during construction:

- *Anticipate encountering ice-rich frozen ground and thermokarst features such as thaw ponds.*
- *Anticipate encountering several feet of organic mat and organic rich soil within … relatively low-lying portions of the proposed material source alignment, and other areas of relatively low-topographic relief within the investigated area*
- *Anticipate encountering thick layers of massive ice within large portions of the Tin Creek Site and portions of the proposed material source alignment of relatively high topographic relief*
- *Anticipate thawed soils, and possibly a groundwater table in soils within and adjacent to drainages. The size of thaw bulb surrounding drainages, however, may be limited.*
- *Anticipate possibility of encountering saline soils with a depressed thawing temperature.*

… The pervasive, massive ice encountered in portions of both the proposed alignment and the Tin Creek Site will result in excessive settlement if allowed to thaw. Much of the soil encountered during this investigation may be frost-susceptible. Depending on location, design criteria, therefore, should be as such to mitigate settlement, thawing, and excessive frost heave….

Subsurface Conditions within the West Tin Creek Hills Site

The Tin Creek Site is largely situated on a hill that extends from roughly 50 feet to 100 feet above sea level. This hill is believed to be an ice-rich cryogenic landform termed a

yedoma. Nine test holes, designated TH15-2030 through TH15-2038, were drilled on an approximate 700-foot spacing within the Tin Creek Site (see Figure 4). Seven of these test holes were drilled on the hill while two of these test holes (TH15-2037 and TH15-2038) were drilled on a valley floor near the base of the hill. Drill depths of these test holes extended between 19 feet and 31 feet bgs. Approximately 1.5 feet to 2 feet of snow covered the test hole locations within this site. The subsurface conditions encountered within test holes located on the hill and on the valley floor were notably different and are described separately.

In general, beneath the snow cover, the test holes drilled on the hill (TH15-2030 through TH15-2036) exhibited the following sequence of conditions:

- *6 inches to 2 feet of frozen Tundra Mat and PEAT*
- *0 feet (TH15-2030, TH15-2032 and TH15-2033) to 2.5 feet of frozen, dark brown, organic-rich SILT*
    - *commonly containing approximately 25 percent to 50 percent ice content by volume*
- *Massive ICE, commonly extending to depths explored (see Photos 101 and 109)*
    - *generally clear to translucent*
    - *occasionally containing trace amounts of tan, brown or gray silt*

Test holes TH15-2034 and TH15-2035 encountered gray SILT beneath massive ice between roughly 25.5 feet and 28.5 feet [below ground surface] bgs. This silt ranged between frozen, well bonded (Nbn) to containing roughly 25 percent to 75 percent ice by volume. In addition, test hole TH15-2034 encountered an approximate 4-foot thick layer of ice-rich silt at approximately 10 feet bgs. This layer of ice-rich silt contained approximately 60 percent to 70 percent ice by volume.

In general, beneath the snow cover, the test holes drilled on the valley floor (TH15-2037 and TH15-2038) exhibited the following sequence of soil:

- *Approximately 6 inches of frozen Tundra Mat*
- *1 foot to 2.5 feet of frozen, dark brown organic-rich silt*
    - *generally containing approximately 35 percent to 45 percent ice by volume*
- *14.5 feet or more of tan, brown and gray, frozen SILT*
    - *this layer in each test hole contained an approximate 4-foot to 5.5-foot thick layer of massive ICE with gray SILT*

Silt containing trace amounts of fine sand was encountered at approximately 10.5 feet bgs in test hole TH15-2037. This soil was not encountered in test hole TH15-2038.

Frozen Ground and Groundwater Table

The test holes drilled within the Tin Creek Site encountered pervasive frozen ground that extended to depths explored. A thawed active layer was not encountered due to the drilling taking place near the end of the freezing season – where maximum frost depths occur. An accurate determination of the active layer thickness within this site, therefore, cannot be determined from this investigation. In many of the test holes, the presence of massive ice within several feet of the base of overlying tundra mat, however, suggests the active layer does not extend more than 2 feet to 3 feet bgs.

Pervasive massive ice was encountered in test holes TH15-2030 through TH15-2036. These layers of ice ranged between 8-feet and 11-feet thick in test hole TH15-2034, 25.5-feet thick in test hole TH15-2035, and extended to depths explored in test holes TH15-2030 through TH15-2033 and TH15-2036. Massive ice was less predominant in test holes TH15-2037 and TH15-2038; which were located in the valley bottom. These test holes, however, exhibited between 4 feet and 5.5 feet of massive ice. Table 8 roughly illustrates the distribution and concentration of ground ice encountered within the Tin Creek Site.

> *Groundwater was not encountered while drilling within the Tin Creek Site. Due to the relatively high moisture content of ice-rich soils and poor drainage conditions, local thawing may result in a perched water table" (DOT/PF 2015).*

R&M Consulting provide the following constructability considerations for the Tin Creek site upon receiving the 2015 DOT/PF site drilling report and laboratory analysis.

> *"The Tin Creek Site is located on the mainland approximately 13-1/2 miles south of Sarichef Island... To access the site by skiff, the route from Shishmaref consists of a wide 17 mile long arc to the east to avoid shallow water and reach the mouth of Tin Creek. Then you must travel an additional 2-1/2 miles upstream on the east fork of Tin Creek to reach the proposed site. The east fork is considerably narrower at the Tin Creek Site than the west fork at the West Tin Creek Hills Site. Topographic maps indicate the hill top is about 100 feet above sea level. Grass tussocks and low willow bushes are present on the higher mounds, with grasses prevailing in the surrounding lower swales.*
>
> *Access to the Tin Creek Site is identical to the West Tin Creek Hills Site except that it is approximately 2 miles further inland making it even more difficult and expensive to transport existing infrastructure from Shishmaref to the proposed site.*
>
> *This site is underlain almost entirely by massive ice to depths of at least 30 feet. In theory this site could be developed in a similar manner as the West Tin Creek Hills Site. However, the extent of massive ice underlying the site would greatly increase the risk of settlements resulting from permafrost degradation" (R&M 2015).*

4 NEXT STEPS AND CONCLUSION

4.1 Next Steps

4.1.1 Review This Information

The community should review this document to decide whether potential relocation sites have been sufficiently examined. Then use this report as a basis to ask questions and suggest improvements with HDR for inclusion within the Shishmaref Relocation Strategic Management Plan development project.

If the City Council can agree on the assessment presented in this document, they then should meet with the community to discuss how the community's long-term needs can be best fulfilled by each of the three relocation sites.

4.1.2 Community Vote

Once this process is complete, the entire community will need to participate in a public vote to determine whether to Protect-In-Place for perpetuity or to relocate to one of the identified relocation sites.

- Protect-In-Place
- Old Pond
- West Tin Creek Hills
- Tin Creek

Note: The community is encouraged to provide as much public discussion as possible. These discussions should include:

- A public meeting where the majority of the community and stakeholder agencies attends
- Consider a presentation to high school grade students as a "social science activity" with subsequent "straw ballot" vote as the outcome will impact all residents
- Hold a Shishmaref Interagency Planning Committee meeting to discuss whether stakeholder agencies would support community relocation in-light of their investment to implement communitywide infrastructure improvements.

4.1.3 What Comes Next?

The community's concurrent Relocation Strategic Management Plan development project (HDR) will outline various infrastructure needs. For example these will include ensuring village residential and infrastructure siting would be coordinated and compatible with specific responsible agency regulatory criteria or requirements.

R&M Consulting, Inc.'s relocation site analysis memorandum provided some insight into future relocation needs. These may be developed in stages or as temporary "pioneer" infrastructure to meet immediate relocation/development needs.

> *"Community Relocation Requirements*
>
> *Relocating Shishmaref will be costly and require an extensive amount of work over multiple years to move existing homes, businesses, public buildings (school, post office, etc.), water and sewer infrastructure (water storage tanks, piping, etc.), solid waste landfill, sewage lagoon, fuel tanks, power and lighting infrastructure, airport and runway,*

roads, equipment, vehicles, boats and docks, and barge landing. Existing infrastructure must be disassembled, loaded, and barged across the Shishmaref Inlet to one of the selected sites. Refer to community maps showing Shishmaref's existing infrastructure and layout.

Prior to relocating to the selected site, a new barge landing, access road, and earthen pad must be constructed to accommodate relocated and or new infrastructure. The following facilities will need to be located, developed, and made accessible prior to relocating any homes, businesses, and public facilities:

1. *Fresh water source, transmission main, water treatment plant, and storage tanks*
2. *Sewage lagoon & transmission main*
3. *Solid waste landfill*
4. *Barge landing & small boat docks*
5. *Haul roads & access road*

(R&M 2015)

Note: Appendix A provides a brief summary of recognized future relocation site selection needs. HDR will address Shishmaref specific community relocation needs within their Strategic Management Planning project.

4.2 Conclusions

This document describes the methods and results from a team of technical specialists examining the four options for protect in place and potential community relocation throughout the duration of this project (Table 4-1).

The findings are based on review of prior studies and reports, field assessments, geotechnical borehole soils analysis, and best professional judgment. The community should closely examine the assumptions and findings of the team and compare the findings with local community member's knowledge.

Once an option and site selection is placed before the community for a vote and finalized; all potential supporting or funding agencies will need to form a "Shishmaref Working Group" to coordinate future research and tasks essential for ensuring Shishmaref becomes a truly sustainable community. The Working Group should include, at a minimum:

- DCCED/DCRA: Responsible for community and government guidance/assistance programs
- USACE: Coastal erosion protection, barge landing, small boat harbor, causeway, and revetment
- DOT/PF: road and runway
- DEC/Village Safe Water and ANTHC: water and wastewater infrastructure such as tanks, utilidors, and associated piping
- AEA: bulk fuel and alternative energy infrastructure improvements
- Cold Climate Housing Research Center: cold climate construction
- Denali Commission: federal and state project management and funding coordination
- Bureau of Indian Affairs (BIA): Tribal transportation and infrastructure support

The community's decision to remain in place or relocate will also provide direction to HDR on how best to focus their Strategic Management Planning project. These considerations would greatly assist Shishmaref community members with identifying and consolidating future needs, prioritized actions, and agency permitting in order to support long-term community development efforts.

Shishmaref Site Comparison Matrix

Master Relocation Matrix | **Prioritization Criteria**

4 to 5	site has generally positive attributes associated with this specific criteria
3	site has mixed positive and negative attributes with specific criteria; or criteria is neutral
0 to 2	site has generally negative attributes associated with this specific criteria

	Site					Weight Factors			Site				
	West Nunatuq	Old Pond	West Tin Creek Hill	Tin Creek	Protect In-Place Sarichef Island	1	2	3	West Nunatuq	Old Pond	West Tin Creek Hill	Tin Creek	Protect In-Place Sarichef Island
PHYSICAL ENVIRONMENT													
Sufficient space for community of 800 persons	0	5	5	4	5			3	0	15	15	12	15
Storm surge vulnerability	3	5	5	5	2			3	9	15	15	15	6
River flooding vulnerability	5	5	5	5	4	1			5	5	5	5	4
Shoreline erosion vulnerability	2	5	5	5	2			3	6	15	15	15	6
Site drainage and wetlands	3	3	4	3	5	1			3	3	4	3	5
Soils - ice content	3	4	3	3	4		2		6	8	6	6	8
Vulnerability to high winds	3	5	3	3	3	1			3	5	3	3	3
Water supply - source and quality	3	3	3	3	2			3	9	9	9	9	6
									41	75	72	68	53
CONSTRUCTION & UTILITIES FACTORS													
Geotechnical Constructibility Analysis	1	5	4	3	4			3	3	15	12	9	12
Sewage disposal availability	2	5	5	5	5		2		4	10	10	10	10
Ease of water storage and distribution	3	3	3	3	3		2		6	6	6	6	6
Solid waste disposal availability	2	4	4	4	4		2		4	8	8	8	8
Gravel requirements to develop site	2	2	2	2	3		2		4	4	4	4	6
Barge access/distance to site	3	3	3	3	5	1			3	3	3	3	5
Site for an airport with crosswind runway	5	5	5	5	3		2		10	10	10	10	6
Community expansion potential	0	5	5	5	5			3	0	15	15	15	15
Ease of maintaining two sites during construction	3	3	3	3	5	1			3	3	3	3	5
Permitting Obstacles	3	3	3	3	5	1			3	3	3	3	5
									40	77	74	71	78
SOCIAL AND ACCESS FACTORS													
Distance from current village site	3	3	3	3	5		2		6	6	6	6	0
Access to the ocean	4	4	4	4	5			3	12	12	12	12	15
Access to the Shishmaref Lagoon	4	4	4	4	5	1			4	4	4	4	5
Access to subsistence camps and traditional use areas	3	3	3	3	5			3	9	9	9	9	15
Location of boat/gear storage	3	3	3	3	5		2		6	6	6	6	10
Potential for ice cellar construction	0	3	4	4	5	1			0	3	4	4	5
General comfort with site	3	3	3	3	4		2		6	6	6	6	8
Land Status	5	3	4	4	5			3	15	9	12	12	15
									58	55	59	59	73
COST IMPLICATIONS													
Site preparation costs	3	3	3	3	5			3	9	9	9	9	15
Access road development costs	3	3	3	3	5		2		6	6	6	6	10
[1] O&M costs	3	3	3	3	5			3	9	9	9	9	15
[2] Cost of living (heat, power)	3	3	3	3	3	1			3	3	3	3	3
Fuel costs for access to subsistence areas, airport, dock	3	3	3	3	5	1			3	3	3	3	5
									30	30	30	30	48
									TOTAL POINTS EARNED FOR EACH SITE				
									169	237	235	228	252
									5th	2nd	3rd	4th	1st

[1] **O&M costs reflect differences in costs per village, mostly for maintaining errosion and flood barriers**

[2] **Costs for heat and power are assumed to be higher in areas where terrain is subject to higher winds (hillside sites)**

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APPENDIX A

RELOCATION SITE SELECTION NEEDS CRITERIA

FUTURE SITE SELECTION NEEDS

Land Ownership

Determining land ownership is essential to acquire, build critical facilities such as airfields, and enable access to all potential relocation sites. The following provides a general description of each land type and Figure 4-3 provides a depiction of relevant locational ownership.

Land Ownership Characteristics

In the general vicinity of Shishmaref Inlet and Sarichef Island, land ownership is a combination of native, state, and federal lands

Federal lands. A few agencies manage lands on the mainland. The two most likely to impact any relocation project is the National Park Service (NPS) and the Bureau of Land Management (BLM).

- The NPS administers the Bering Heritage Land Bridge National Preserve (BHLBNP), which is located approximately 15 miles south of the community of Shishmaref. And is outlined in green in Figure 4-3. The BHLBNP is approximately six miles wide and runs east west along township boundaries across the entire project study area. DOT&PF has had preliminary discussions regarding road access in this area. The NPS issued a permit for geotechnical drilling activities for their Ear Mountain Road Alignment Drilling activities within the NPS's boundaries. However, should the Ear Mountain site be developed as a material source, either for the Sarichef Island Protect-in-Place option or to support a new community relocation site, a permanent road easement would be required through the BHLBNP for an access road. This could require congressional action.
- BLM owns the lands between Shishmaref Inlet, native owned allotment parcels, and the Old Pond Site. This site has been selected by the Shishmaref Native corporation under ANCSA but has yet to be finalized and conveyed.

State Lands. These lands show the Bureau of Land Management's (BLM) land ownership, management, and use responsibility or authority. Boundaries can be found on most any current land ownership map. Unconveyed lands will still show as BLM owned until conveyance is complete.

Native Corporation Lands. Both the Bering Strait Native Corporation and the Shishmaref Native Corporation have selected or own lands in various land ownership conveyance stages; conveyed, interim conveyed, or selected. These parcels are located throughout the area not owned by federal or state governments. Once conveyed, the Native Corporations could elect to make lands available for community use.

Native Allotments. The majority of the Native Allotments are located along the coast, rivers, or creeks and are indicated with orange borders. Community residents stated these lands typically provide subsistence benefits for each family enabling them uninterrupted access to their favorite harvesting sites. In addition to requiring approval of the allottee(s), any use of Native Allotments associated with community relocation would require approval of the Bureau of Indian Affairs.

Land Ownership at Potential Relocation Sites

Figure 4-3 displays potential relocation sites with a "red" star. These sites have undergone at least preliminary study to determine whether they would provide a viable, constructible location for which the Shishmaref community could call home; one that is long-term, sustainable, and resilient from future disaster impacts.

Those with a red “X” were discounted during previous study activities and are not included within this feasibility study. Among the reasons for excluding them was because

- They have not received in-depth or intrusive (digging or drilling analytical or exploratory) geotechnical drilling to fully determine whether they would be satisfactory relocation sites. Or
- They were not in close proximity to the proposed Ear Mountain Road Alignment.

Figure A-1 shows Shishmaref’s historical site assessment locations. The red stars designate sites addressed within this feasibility study.

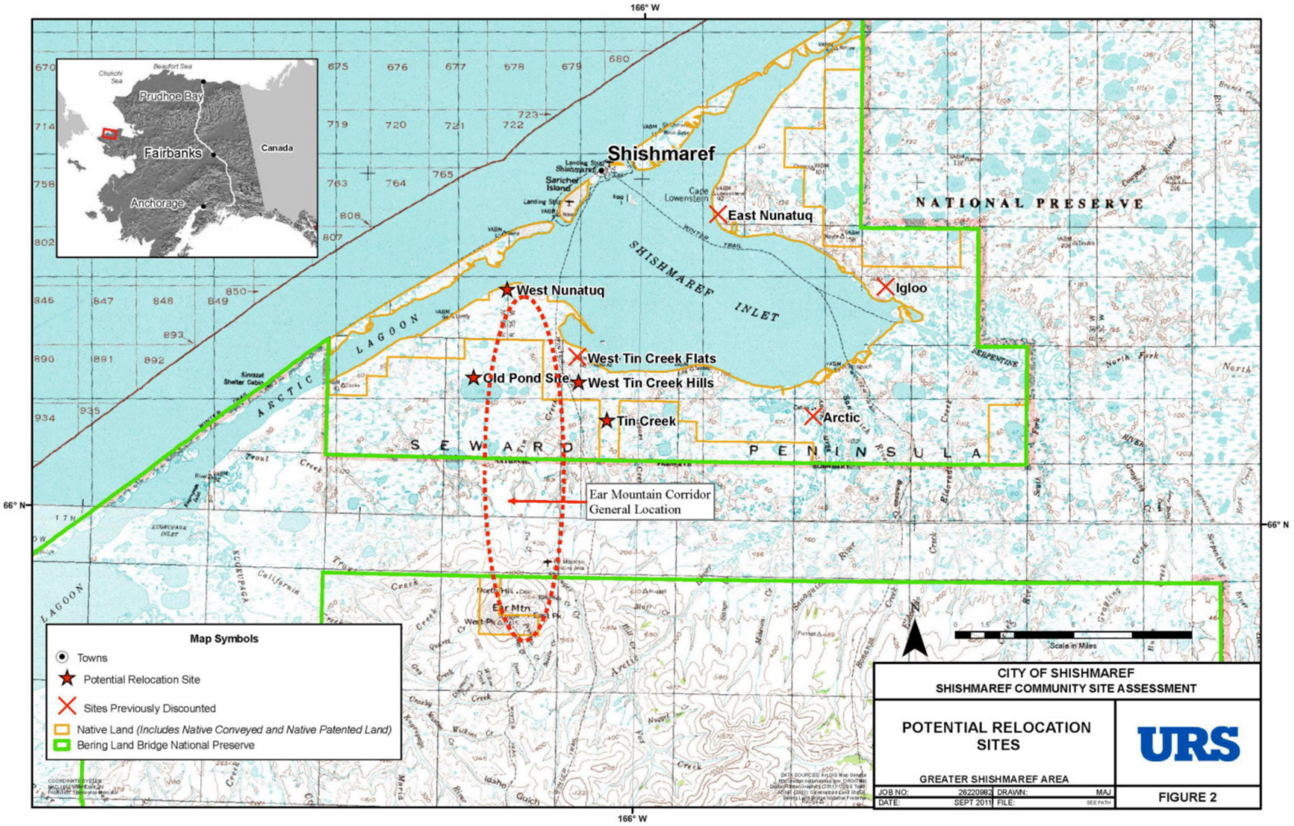


Figure A-1 Shishmaref Identified Relocation Sites with Land Ownership

Community Access

Each of the potential relocation sites should be accessible by aircraft, boats, and roads to barge landings and airfields. Aircraft provide a year around connection to the outside world. Shishmaref receive day air services for passengers and freight, connecting the community with the transportation hub at Nome. Community relocation would require construction of a new airport, and availability of suitable land for airport construction is a potential relocation site consideration.

Boat travel is the primary transportation mode used by community residents, considering the Chukchi Sea, Shishmaref Inlet, and Tin Creek provide either direct or indirect access to essential subsistence sea and land mammal hunting and vegetation harvesting grounds. During the open water season ocean going barges deliver goods and fuel to the community. Access to a suitable location to launch and store local boats, and to a suitable barge landing site, is a potential relocation site consideration.

Roads are important for vehicle access with a community and to critical infrastructure such as airports, barge landings, landfills, and water/waste water facilities. While roads are not typically a critical factor in a potential relocation site consideration, site conditions do influence constructability and cost of village relocation.

Community Roads and Streets

Road distances to the community from barge landing sites and airports will vary, but the general structural cross section will remain relatively the same for all sites, since all sites have similar soil conditions. We anticipate a typical road section with two 8 ft. wide lanes flanked by 2 ft. shoulders. The road section would be at least 5 ft. deep and side slopes graded out at a 2:1 ratio. This typical road section will allow four-wheelers to pass each other as well as pick-up trucks using the road, and would be conservative enough to keep costs under control.

Layout. The relocated community layout would be developed, alternatives reviewed, and final layout selected during the Shishmaref Strategic Management Plan's development. Recommended features should include a grid type road system within the community. Oriented properly, this type of system is easy to navigate, maintain and would provide a reduced exposure to snow drifting.

Community streets and road primary use is to support foot, four-wheeler, and snowmachine traffic. Some machinery movement would be required for essential access and maintenance. There are likely to be pick-up trucks in the community, but traffic speeds should be very low and circulation should not be a problem.

Size and Design. Community streets and roads would be gravel; sized for low-speed traffic that consists primarily of four-wheelers. Allowances for pick-up trucks and some maintenance equipment will have to be considered. We anticipate a typical road section with two 8 ft. wide lanes flanked by 2 ft. shoulders with adjacent open space utility easements.

The potential layout plan could feature a 60 ft. wide right-of-way (ROW) to facilitate utility installation and future expansion. Lane widths of 8ft. each side should be sufficient to allow a road grader and four-wheeler to pass each other. A 22 ft. ROW would remain from edge of lane to property line. This space would allow property owners sufficient space for storage.

No paved roads are planned at this time. Road designs would be based on geotechnical recommendations. The actual roadway structural gravel section design would` depend on the site selected. For sites where the subgrade is composed of silts and clays, a geotextile separation fabric can be used to provide separation and added support to the road prism.

The road section would potentially be at least 6 ft. deep with the top 6 inches being a crushed surface course to facilitate maintenance and sides slopes conservatively graded at a 2:1 ratio. The roads would be crowned at 2-3% to drain to each shoulder; run-off would be carried in roadside ditches to low points where High Density Polyethylene (HDPE) culverts would be installed to transport the water to main drainage channels, and ultimately off site.

The community has requested fire hydrants to facilitate firefighting. Location and number of hydrants would have to be coordinated to provide the best coverage at the most economical cost. Hydrant locations should be denser in the community and commercial areas where property loss can be potentially greater; and adequate in the residential areas to provide acceptable firefighting capability with the lower discharge rates associated with smaller-single family structures.

The hydrants can be located along the road or street ROWs, and should have a 'clear zone' staked around them to preclude private structure placement that can prevent access during a fire emergency.

Gravel roads and street design and construction may facilitate installing buried utilities in the ROWs or utilidors as deemed most appropriate, subject to environmental conditions.

Ancillary Barge and Airport Staging Areas and Access

In addition to roads with the community, road access will need to be developed to critical community infrastructure located outside the community center. This includes the barge landing, airport, landfill and potentially water/waste water facilities. Road design and construction would be similarly to that discussed under community roads. Road maintenance and snow clearing may be a requirement for some of these facilities. In addition, construction of additional gravel working and storage surfaces might be needed in the vicinity of the airport and barge landing to facilitate transfer of passengers and goods, and some degree of storage.

It is feasible to have a single barge landing, gravel pad staging area, and small boat harbor located along or adjacent to the West Nunatuq bluffs to serve all three potential relocation sites (Old Pond, West Tin Creek Hills, and Tin Creek). This location is in close proximity to the Shishmaref Inlet and not too distant from either potential DOT/PF identified airport sites.

Staging Area. The barge landing staging area would serve a dual purpose as a haul-out and dry storage area for boats and goods staging while awaiting community delivery. A small boat harbor would need to be adjacent to this area to maximize access to the staging and haul out area. In many cases, these elements will be adjacent to each other for convenience.

All-terrain vehicle (ATVs) small trucks, limited heavy equipment, and snowmachines are the most likely community vehicles needing access to this area for goods transport.

Depending on airport siting it may be feasible to collocate the airport adjacent to the staging area.

Ocean and Inlet Connection. Nicole Kinsman et al, DGGS, completed a preliminary bathymetric study during 2014. The Figure A-2 displays field study bathymetric tracks and the study delineates depths along those tracks. The image depicts shallow water depths throughout the Inlet.

Figure A-2 **Shishmaref Inlet Bathymetric Survey** (DGGS 2014)

The Inlet currently provides the best barge landing access at the southern end, at West Nunatuq. Moving northward toward Tin Creek, the water depth diminishes, and barge access could be dramatically restricted at various seasonal tide depths. Therefore, channel dredging may have to be considered along with causeway construction as part of an ongoing maintenance plan for any shallow water access.

Water Routes

The community has a traditional, long-standing coastal culture which depends on close proximity to the ocean, Inlet, rivers, streams, and creeks for a large part of their subsistence income and survival. Water access from the Inlet will allow access to the creeks and subsistence areas to the northeast and the ocean to the north. All potential sites will need an access route from the central community site to the Inlet for boat moorage and subsequent land, marine, and other water dependent subsistence environments.

Chukchi Sea. Shishmaref residents will require access to the Chukchi Sea for hunting sea mammals and fishing. Subsistence hunting, fishing, and gathering boats are currently anchored in Shishmaref Inlet on the east side of Sarichef Island. The Inlet provides sheltered mooring for the small craft the community uses to access hunting and gathering areas.

Any new community will require protected moorage and land storage for the community's boats. The location of moorage/storage will depend on the site selected.

Barge Access. Construction of a barge landing in the Inlet provides protected waters for safer mooring and an easier load and unload process for any of the potential new community relocation sites. However, there is no beach area along the Inlet with barge landing potential. A barge landing will need to be developed with sufficient clearance depths even for shallow draft barges.

The south end of Sarichef Island provides fair water depth needed to traverse Shishmaref Inlet. However, dredging may be required at near shore locations to enable barge and boat access to the mainland area. Low tide access is site dependent and potentially problematic. Mainland barge access and landing locations may require a dredged channel and potentially a causeway; depending where residents and agencies determine where the most appropriate barge landing and boat harbor sites will be located.

Shishmaref Inlet. It is important that access to the Inlet be available for subsistence activities. The current site has excellent Inlet access along the south side of the village for personal boats. The new site needs to allow as many residents as possible to have individual moorage space within a protected boat harbor.

Existing Inlet access for the selected site may not be acceptable in its natural condition. Constructing an armored gravel boat staging area for loading or unloading boats, hauling out for storage or repairs is critical for hunters and fishermen safety.

Rivers/Creeks. The south side of the Inlet provides creek access to Lone Butte Creek and Serpentine Hot Springs at the north end; and Tin Creek at the south end, and various small tidally influenced creeks throughout the Inlet. It is vitally important to facilitate Inlet access from a new community site, which may require building an access road.

From New Village Site. Access from the new community site to various destinations must also consider routes to boat moorages, subsistence resources, beaches, and trails. The exact access configurations shall depend on the location of the new site. Individual site conditions associated with topography, distance, and ground type will affect what design criteria and methodologies are employed.

Goods and Supplies Transport. The community will have two main methods of obtaining bulk goods and supplies: barge access from the ocean and from the airport. Both will require construction of an access road to the community. Each are conditional. Rough, shallow, or frozen water limits barge access. Severe storms, wind, and fog impact airplane access.

A barge landing is very simple, providing secure mooring points to vessels. A staging area and road access into the village to distribute goods must be constructed and maintained. The staging area should be at the immediate barge landing site sufficiently sized to allow temporary goods storage from barge unloading and vehicle loading for community transport. This will allow the barge to maintain a short turn-around time, and the community to ferry goods into the village at their own pace.

It is estimated the staging area would be approximately one to two acre(s) in size, to allow stacking barge delivered goods for easy community access, loading, and transport.

Airport Locations

It is problematic to locate an airstrip adjacent to the new village due to FAA regulatory requirements for landfill and community infrastructure separation stipulations. However, an airfield location should be easily accessible by foot, four-wheeler, snowmachine or small truck.

Bristol Environmental & Engineering Services Corporation (BEESC) states within their 2011 Shishmaref Relocation Plan Update that a prescribed 5,000 ft. runway length will accommodate emergency military aircraft (C-130 Hercules weighing 130,000 lbs.) landings.

The 2004 DOT/PF Airport Expansion and Relocation Study depicted location site specific investigation areas, in close proximity to each of the three candidate village sites, with potential alignments. The study stressed that these were preliminary considerations requiring further study to finalize airstrip placement, constructability, geotechnical, and wind data on which to base final location and directional layout designs.

The July 2009 DOT/PF Ear Mountain Road Reconnaissance Study described that in,

> *"…April 2009, GeoWatershed set up data collection instruments to perform a wind study near two potential future airport sites. Real-time data is now available from the monitoring stations at www.shishmaref-climate.org. Data collected includes wind speed and direction, air temperature and humidity, wind chill, and dew point, surface and subsurface soil temperature, rain and snowfall measurements, and images of local weather conditions.*
>
> *In August 2009 DOT&PF is performing a design reconnaissance study to evaluate summertime conditions for the potential alignments, including grades, potential drainage crossings, vegetation, geologic hazards, and wetland and wildlife concerns. Personnel from the National Park Service and DOT&PF's Environmental Department will be present to perform wetland delineation along potential routes and to address wildlife and park usage concerns" (DOT/PF 2009).*

This data collection effort enabled DOT/PF to further refine potential airport locations based on collected data within close proximity to all three identified relocation sites (Old Pond, West Tin Creek Hills, and Tin Creek) as depicted in Figure A-3.

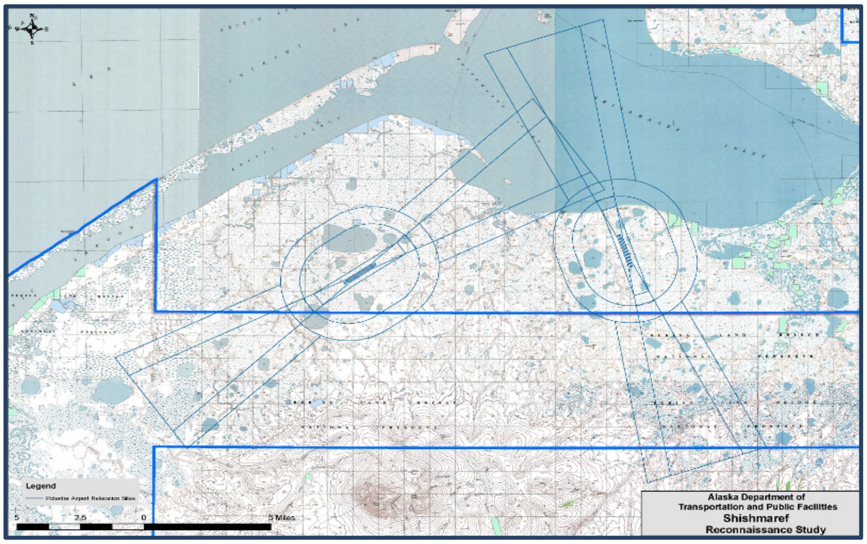


Figure A-3 **Mainland Airport Options** (DOT/PF 2009)

Subsistence Activity Considerations

The community must have year round access to subsistence use areas, in summer by foot, boat, or ATV, as well as in winter by snowshoe or snowmachine (Table A-1).

Table A-1 **Subsistence Activities**

Hunting	Gathering	Access
• Sea Mammals	• Vegetation	• Chukchi Sea
• Land Mammals	• Greens	• Shishmaref Lagoon
• Fishing	• Berries	• Essential Creeks

COMMUNITY DEVELOPMENT

Gravel Site Pads

All sites, with the exception of the “Shishmaref Protection In-Place” option, will require gravel pad placement to serve as the stable foundation for construction of the new village infrastructure. Gravel pad construction is one of the major community location costs. Gravel pad depths will vary between sites, depending on the geotechnical characteristics of the site. Gravel applied to the current Sarichef site is for raising the elevation of the south (lagoon) side of the existing site, and is not associated with maintaining soil thermal regime at the three eligible mainland relocation sites.

Suitable gravel pad construction borrow material has been identified in Nome and Kotzebue as well as at Ear Mountain approximately 25 miles from the City’s current location at the terminus of the proposed Ear Mountain Road alignment.

Most of the sites – Old Pond, West Tin Creek, and Tin Creek – have very similar existing geotechnical conditions.

Those sites exhibiting soil characteristics that indicate poor foundation material for the development of a new village, wet, silt/clay, ice rich soils will need a deeper gravel section to separate (insulate) the development of the village infrastructure from the existing soil conditions. The existing Shishmaref town site does not share the geotechnical characteristics of any of the recently explored sites, primarily with regard to the presence of ice rich soils.

The sites that have better support soils over a portion of their area, dry, gravelly, stable soils can be developed with a gravel pad of less depth over those with more fragile ice rich soils, reducing the total cost of the project.

It is important to note that the cost of gravel needed to create a new village site pad has been controversial since 1972. Current estimated gravel costs for a 12 ft. high pad is in the area of $85 million to $200 million. The cost spread is “material source” site location dependent – how far does it need to be shipped.

Crucial to the gravel cost controversy is Graph 1 of the September, 2002 letter from Bob Sanders of the USACE regarding gravel requirements and problems (Sanders, 2002). This graph points out that ground insulation placed below the gravel can reduce the thickness of the pad by over ½. Mr. Sanders shows in this graph that 8” of high density closed-cell foam insulation can reduce the thickness of gravel from almost 14 ft to just over 6 ft.

At an estimated placed cost of $35/cubic yard, 8 ft of gravel over a 100 acre site costs a little over $45.1 million, while 8” of closed cell foam insulation alone covering the same area costs about $21.8 million at $5/square foot. Replacing gravel with foam insulation represents a savings of around $23.6 million in gravel pad costs. This is a significant relocation in cost savings and should be seriously considered during gravel pad design.

The 2010 and more recent 2015 DOT/PF Ear Mountain Road and road alignment site drilling operations for West Nunatuq (2010), Tin Creek, West Tim Creek, and Old Pond (2015) provide sufficient geotechnical data to provide existing soils and thermal regime to sufficiently determine approximate foam insulation and gravel requirements to maintain the existing thermal regime and support a new village.

These sites are not immediately adjacent to the Chukchi Sea or Shishmaref Inlet; they will not require elevation above flood level and will benefit from cost savings such as not requiring erosion protection actions such as armor rock or sheet pilings to protect their perimeter.

However, it will be essential to protect the existing thermal regime due to existing ice deposits like ice lenses, etc. that are extremely large; in excess of thirty meters thick in some places. This creates a new long-term impact dilemma. Either protect it now by placing sufficiently deep gravel or face the consequences to building, roads, and other infrastructure when, not if, the ice formations melt.

Community Water Requirements

Potable Water Supply. The 1987 Shishmaref Water and Sewer Feasibility Study best describes future relocation site requirements:

> *“…Snowmelt will [likely] continue to be the primary source of drinking water…It will be used only for human consumption and contact….*
>
> *The present snowmelt system is working satisfactorily, but two problems were identified…First, gas bubbles have formed beneath the existing linear and threaten the integrity of the lined system. The second problem is that trihalomethane levels in the drinking water measure above the State of Alaska Drinking Water Standards” (DCRA 2015).*

Potable Water requirement. The average daily water demand for a fully piped community water system for a population of 700 is estimated at 10,000 to 50,000 per day.

Sewer System Requirements. The community requires 33,145 gallons per day for vacuum sewer system and 53,730 gallons per day for gravity sewer system.

Fire flow. Should be rated at 1,000 gpm for a sixty minute period, or 60,000 gallons of storage. At a rate of 1000 gallons per minute for fire flow, and adding seven days of average daily demand.

Water Storage. Regardless of the potential project site, new community water storage is needed with a community piped distribution system. Storage helps alleviate water shortages and provides for better fire protection by supplying a large quantity of water quickly.

A bolted steel tank insulated and heated in the winter to protect the water from freezing is needed. The water tank should be sized for DEC recommended water demand, and with extra storage for fire flow.

Water Distribution

Unlike most communities in Alaska, the City is currently restricted to hauling potable water. This is due to the poor condition of their community water catchment basin and low capacity and aging water storage tank. Many residents cannot drink or wash with their existing water capture and storage system due to ongoing water quality problems. Community members travel across Shishmaref Inlet to access potable water source streams and creeks. They cut ice blocks during the winter and use containers during the summer to easily transport back to the community to store until needed to supplement their daily water needs.

The community desires to have a piped water system, which coupled with improved storage capacity would allow Shishmaref to become a more modern – healthy community.

- **Piped System.** A communitywide distribution system provides the highest user service level which and was previously chosen by the community. A piped water system provides consumers water on demand (whenever it is needed), without the necessity of hauling water to fill holding tanks. It allows community water treatment monitoring to assure safety and quality control. This control decreases contamination by eliminating repetitive handling outside of the confined water delivery system.

  A piped distribution system can be developed using either a “pit orifice” or “circulation” systems.

  A pit orifice system supplies each office, home, and business with individual water service lines that utilize pit orifices to circulate the water. In order for the pit orifice to work properly the service line cannot be over 60 feet in length and the velocity in the main line must be at or above two feet per second (2 ft/sec).

  The circulation system incorporates two taps and two lines, an entry line and a return line. Services are connected to the main line through a brass plug valve called a corporation stop. The corporation stops are the pit orifice type. The Inlet pit orifice is pointed into the flow and the outlet pit orifice is pointed away from the flow. The service line loops into and out of the house. Small circulation pumps can be installed in the home to circulate the water if the head loss is too great for pit orifices, but would require electricity to operate and need to be maintained. The service lines are usually installed with heat tape to provide thaw recovery should circulation stop and the lines freeze. The optional meter would be attached to a tee on the top of the loop.

- **Piping Alternatives.** Pipes located within an arctic environments use either buried arctic pipe or above ground utilidors (an aboveground insulated containment structure used for general utility service protection from harsh or damaging conditions, extensively in arctic locations).
  - ***Arctic pipe*** is composed of an inside pipe called a carrier, several inches of high density polyurethane or polystyrene insulation that protects the carrier and an

outside protective layer. The carrier is usually made of PVC or HDPE. The outside layer is usually made of polyvinyl chloride butyl rubber (for underground installations) and 16 gauge corrugated steel or aluminum (for above ground installations). Water/sewer lines lay inside the carrier.

  - ***Utilidors*** are used in arctic locations to house and protect water distribution and sewer collection systems. The utilidor provides access for maintenance to piping, valves, and fire hydrants. Utilidors are more expensive to install and maintain than arctic pipe. They are commonly used in wetland areas and constructed above ground. They are also used in close proximity of multiple pipes. The three types of utilidors are concrete, wood, and arctic pipe. Service lines are housed inside the utilidor. Table A-2 introduces typical cost considerations for each utilidor type.

Table A-2 Utilidor Cost Considerations

Category	Arctic Pipe	Concrete Utilidor	Wood Utilidor	Arctic Pipe Utilidor
Cost	Low	High	High	Medium
Ground Placement	Above or below	Below	Above or below	Above or below
Materials	DCIP, PVC or HDPE carrier and 16 gauge corrugated steel coating.	concrete	(1) plywood with inside insulation (2) laminated planks with outside insulation	DCIP, PVC or HDPE carrier and 16 gauge corrugated steel coating.
Insulation	high density polyurethane or polystyrene	no	high density polyurethane or polystyrene	high density polyurethane or polystyrene

Arctic pipe and utilidors can be routed to best fit community needs. The first option would be to place the main lines (mains) in the road right-of-ways (ROWs). This greatly reduces easement requirements and also places the pipe in easy-to-reach locations for access and maintenance. ROW mains are most common. The other option is the extended main which installs the mains as close as possible to the house to be served to minimize the length of the service line. A ROW or easement agreement would be needed for this option. It increases the length of mainlines, and places the mains at risk during fire events.

- **Pipe Types.** There are three types of pipe suggested for use in the utilidors: Ductile Cast Iron pipe (DCIP), Polyvinyl Chloride pipe (PVC), and High Density Polyethylene pipe (HDPE). These types are suggested due to their proven ability for use in the arctic. Description of each is listed as follows (Table A-3).

Table A-3 Utilidor Pipe Considerations

Category	DCIP	PVC	HDPE
Material	Molten cast iron and magnesium	Unplasticized polyvinyl chloride	Polyethylene
Size	Diameter 3"to 54" Length 18' and 20' * C-Factor1 140	Diameter Schedule – 1/8" to 24" Pressure – 1.5" to 12" Class – 4" to 12" Length 20' * C-Factor1 150	Diameter 3/4"to 16" Length 500' (3/4" to 1.5" dia.) 350' (2" dia.) 20' and 40' (3" to 16" dia.) Pressure Rating: 65 to 220 psi (160 psi typical)
Pros	High strength, high impact internally and externally, good beam strength, resists corrosion	Lightweight, easy to install, corrosion free	Suited for extreme temperatures, lightweight, corrosion free

** C-Factor1 – The C-Factor is a representation of the hydraulic roughness of the pipe. The factor is used in the Hazen and Williams equation for determining head loss; the larger the number the smoother the pipe is hydraulically.*

- **Below-ground versus Above-ground systems.** Water distribution affects both the water and sewer systems. Distribution systems to serve Shishmaref can be constructed with above or below ground piping (Table A-4). Below ground piping is recommended only if the soil consists of thaw stable permafrost. Advantages and disadvantages of above and below ground piping are listed in the following tables.

Table A-4 Below or Above Ground Alternatives

Piping System	Pros (Advantages)	Cons (Disadvantages)
Below ground	Road and sidewalk crossings are not blocked and the pipes do not segregate the community.	The soil surrounding the pipes must be thaw stable or kept frozen.
	Heat loss experienced is approximately one third that of above ground pipes in similar climates.	Locating and repairing leaks can be difficult and costly.
	Aesthetics are improved.	Winter access difficult
Above ground	Less expensive to install and maintain since no excavation is required.	Communities tend to be segregated, and access is hindered or restricted to certain locations.
	Leaks are easier to detect, locate, and repair.	Subject to physical damage because they are exposed, particularly when they are installed near roads.

WASTEWATER

Collection and Disposal

The current waste water treatment is deemed an unhealthy environment by all residents. Community members and visitors are exposed to handling wastewater from nearly 95 percent of the community's housing, offices, and businesses when handling or collecting "honey buckets" that are subsequently hauled and dumped into ATV-towed collection containers for delivery to the community's wastewater stabilization pond systems (sewage lagoons). The community desires to have a modern piped wastewater system in their potential relocation community location, either placed underground or within a utilidor.

Treatment

Wastewater stabilization ponds (WWSPs) are also known as wastewater or sewage lagoons without aeration are the only means of secondary wastewater treatment available to rural communities.

The EPA 509/04 guideline states:

> *"Wastewater storage and evaporation lagoons are generally used to retain wastewater for treatment before reuse or disposal via evaporation or discharge.*
>
> *Wastewater may contain a range of pollutants, and such lagoons should be lined on the bottom and sides with compacted clay and/or a synthetic membrane of sufficiently low permeability to minimize environmental harm arising from the escape of pollutants by seepage" (EPA 2015).*

The 2004 NRCS site comparison studies indicate that the West Tin Creek and Tin Creek sites each have at least two potential sewage lagoon sites within close proximity of the communities. There is also sufficient space around Old Pond site for placing a sewage lagoon. The 2004 NRCS study states:

> *"Because of the shallow depth to ice and amount of wetlands and groundwater, a lined primary treatment lagoon may be the best alternative. Sewage can be collected by means of a pump and haul system, or with central sewer pipes.*
>
> *If enough storage is provided at the [sewage] lagoon, a secondary treatment through wetlands may be an effective discharge scheme in the summer" (NRCS 2004).*

This would be a viable option as all three identified sites are located adjacent to wetlands. This treatment scheme would need a refined hydraulics and hydrology study to determine long-term viability.

However, Sarichef Island already has a viable and manageable sewage lagoon. It only needs protection from potential sea storm impacts.

Solid Waste

The existing two landfills are threatened by storm surge erosion due to their close proximity to the ocean. The old landfill Class III was closed in 1990. However, it is at the high tide line and experiencing erosion damage.

The current landfill is located 280 feet from the Chukchi Sea and 1,900 feet southwest of the southern end of the runway. (DEC 2015)

The landfill access road has

experienced severe sea storm damages in 2014 when it was cut through. Additionally, both landfills are too close to the airport violating FAA infrastructure proximity regulations.

If the community decides to Protect-In-Place, they will need to officially decommission the two existing landfills and determine a more regulatory compliant landfill site away from the airport and to avoid potentially impacting other infrastructure.

A relocation site landfill would need to be sited and designed in accordance with in accordance with (IAW) governing regulations as an unlined Class III municipal solid waste landfill. Although this landfill will not be designed specifically as a permafrost landfill, an aboveground design with insulating cover and side berms is recommended as the design will minimize disturbing underlying permafrost.

Landfill siting considerations include: conducting an adequate soils investigation; locating the landfill in a stable, well-drained area and out of a floodplain; maintaining a minimum separation distance from groundwater and surface water according to Alaska Department of Environmental Conservation (DEC) standards; maintaining a regulated “minimum” distance from the airport; avoiding or minimizing wildlife attraction and associated hazards; and ensuring an accessible location of the landfill to community residents by road and to a docking area if hazardous materials are backhauled or shipped out. Also during the design process, hazardous material containment, septic sludge, and recycling programs need to be considered.

Hazardous containment includes the storage and disposal of batteries, used oil, other household hazardous waste, and their storage containers. Location of a sludge disposal pit should also be evaluated. Table A-5 provides more detail on the regulatory municipal Class III siting requirements.

Table A-5 Class II Landfill Siting Requirements

Requirement	Activity
16 USC 1531-1544 Endangered Species Act, Section 7	Listed (threatened or endangered) species may be identified near the proposed location of the new landfill. If so, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) must be consulted regarding any proposed action that may affect habitat for listed species.
16 USC 431, 70, and 25 USC 3001-3013 National Historic Preservation Act and Alaska Statute 41.35, 11 AAC 16 Alaska Historic Preservation Act	Once the location for the new landfill has been identified, the owner must document that the location is not listed with the Alaska Department of Natural Resources (DNR) as a historic and cultural resource.
15 Code of Federal Regulation (CFR) 930 6 AAC 80 and 85 Alaska Coastal Management Program (ACMP)	The DGC is the lead State Agency for certifying the ACMP consistency review if permits from more than one state or federal agency are required. This coastal management program has statewide planning goals, local comprehensive plans, and land use regulations for coastal jurisdictions.
18 AAC 60.210(c)	The landfill must be built on stable soils. If DEC finds that soil stability problems are likely at a Class III landfill, the owner shall submit information from three or more soil borings extending to groundwater, bedrock, permafrost, or at least 50 feet below the site base grade, that include, if applicable, the location and surface elevation, corrected to mean lower low water or to United States Geological Survey datum, of each borehole; a description of each major soil layer encountered during the boring, classified

Table A-5 Class II Landfill Siting Requirements

Requirement	Activity
	according to the Unified Soil Classification System; the hydraulic conductivity of each major soil layer based on available information, in-field testing, or laboratory determinations; a description of thermal regime and thaw stability, and an estimate of the percentage of ice content; the depth to groundwater during drilling, static water level after drilling, and an estimate of the seasonal high groundwater table; and an appropriate description of the estimated direction, gradient, and velocity of groundwater flow.
18 AAC 60.217	A new unlined landfill may not be located on a surface that is within 10 feet of the highest measured level of an aquifer of resource value unless the landfill is constructed two feet or more above the natural ground surface.
18 AAC 60.305	If the proposed site of the new landfill is located within 10,000 feet of an airport runway end used by turbojet aircraft, or within 5,000 feet of an airport runway end used by only piston-type aircraft, the owner shall demonstrate that the landfill is designed and operated so that it does not pose a bird hazard to aircraft. If the owner proposes to site a new landfill within a five-mile radius of an airport runway end used by turbojet or piston-type aircraft, the owner must notify the affected airport and the FAA at the time the permit application is submitted to DEC.
18 AAC 60.310	If the new landfill is proposed to be located in a 100-year floodplain, the owner shall demonstrate that the landfill will not restrict the flow of the 100-year flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste that would pose a hazard to public health or the environment.
18 AAC 60.315	A new landfill may not be located in wetlands, unless the owner demonstrates that to the extent required by or under 33 USC 1344 (Clean Water Act (CWA), sec. 404), as amended through 6 December 1995, there is no practical alternative landfill site available except other wetlands; construction and operation of the landfill will not cause or contribute to a violation of an applicable water quality standard under 18 AAC 70, violate an applicable toxic effluent standard or prohibition set out in, or established under, 33 USC 1317 CWA, sec. 307), as amended through 6 December 1995, jeopardize the continued existence of an endangered or threatened species or result in the destruction or adverse modification of a critical habitat protected under 16 USC 1531 – 1544 (Endangered Species Act of 1973), as amended through 6 December 1995, and violate a requirement of 33 USC 1401 – 1445 (Marine Protection, Research, and Sanctuaries Act of 1972), as amended through 6 December 1995, for the protection of a marine sanctuary. The landfill shall not cause or contribute to significant degradation of wetlands; the owner shall demonstrate the integrity of the landfill and its ability to protect ecological resources by addressing: erosion, stability, and migration potential of native wetland soil, muds, and deposits used to support the landfill and dredge and fill materials used to support the landfill; the volume and chemical nature of the waste managed in the landfill; effects on fish, wildlife, and

Table A-5 Class II Landfill Siting Requirements

Requirement	Activity
	other aquatic resources and their habitat from release of the solid waste; potential effects of catastrophic release of waste to the wetland and the resulting impacts on the environment; and any additional factors necessary to demonstrate that ecological resources in the wetland are sufficiently protected to the extent required under 33 USC 1344 (Clean Water Act, sec. 404), as amended through 6 December 1995, or applicable state wetlands laws, steps have been taken to achieve no net loss of wetlands, as defined by acreage and function, by first avoiding impacts to wetlands to the maximum extent practical, then minimizing unavoidable impacts to the maximum extent practical, and finally offsetting remaining unavoidable wetland impacts through all appropriate and practical compensatory mitigation actions such as restoration of existing degraded wetlands or creation of manmade wetlands; and sufficient information is available to fully support the demonstrations required under this section. A Corps of Engineers permit will be needed to build a landfill in a wetland.
18 AAC 60.320(b)	If the proposed landfill location is located in an unstable area, the owner shall demonstrate that engineering measures have been incorporated into the landfill design to ensure that the integrity of the structural components of the landfill will not be disrupted. The owner shall consider, at a minimum, the following factors to determine whether an area is unstable: known on-site or local soil conditions that more likely than not will result in differential settling or ground failure static conditions during an earthquake; known on-site or local geologic or geomorphologic features that pose a potential risk to the integrity of containment structures; and known on-site or local human-made surface and subsurface features or events.

Trash Collection

There needs to be a community trash/haul plan developed to ensure that collected items are properly disposed of according to hazard classifications and trash management priorities. All hazardous materials such as batteries and household appliances are properly handled to reduce or prevent chemical exposure and area soils and ground water contamination.

Landfill Management

The community should continue current landfill management practices as described in their 2013 – 2018 Shishmaref Local Economic Development Plan:

> *"3.4.4 Landfill*
>
> *Shishmaref IRA runs an EPA/SEP backhaul program (IGAP) that plays a major role in removing unwanted refuse from the area. Large trash items old ATVs and refrigerators get taken away by barge. Batteries and many other items containing toxic substances are also removed.*
>
> *The landfill has been reorganized into sections for larger items, recyclables, etc. There is a burn-box available for individuals to use at the landfill. Maintenance is challenging especially in the spring. The site is over-filled and needs expansion or a new site. IGAP had plans to put fencing around landfill but funding was lost" (LEDP 2013)*

COMMUNITY FUEL

Delivery and Transfer

Separate marine headers should be installed at the barge landing or docking point (site dependent location) for offloading #1 fuel oil and gasoline for transfer to the Bulk Fuel Storage (BFS) facility. Camlock caps are essential for barge marine header connections. Lockable block valves, check valves, and basket strainers with bolted covers and threaded bottom connections should be installed at the headers. A covered containment drip pan is required for containing minor spills and leaks.

Separate above- or below-ground fill pipelines should be constructed to transport #1 fuel oil and gasoline from the marine header site to the BFS facility. Pipeline size and routing is site dependent; for pipelines longer than 2 miles, an additional booster pump station may be required to ensure adequate flow rates.

Underground pipelines should be installed with coated pipe and anodes for corrosion protection at pipeline roadway crossings. The fill pipelines will be connected to tank headers for each fuel type at individual bulk storage tanks. The tanks will be individually equipped with automatic mechanical overfill valves. Additionally, trained personnel will watch a tank's clock faced level gauge and listen for an air operated whistle vent at 85% full to protect against overfilling the bulk storage tanks during filling operations.

Propane bottles (100 pound [lb.] size) should be offloaded from the supply barge at the header site and transported by vehicle to the BFS facility.

Storage

The Alaska DEC provide the following information concerning Shishmaref's current Sarichef Island location. They currently have bulk fuel storage to accommodate the City, residential, commercial, and industrial needs as indicated below:

- The Alaska Village Electric Cooperative owns a tank farm located on the west end of the village between the School and the sewage lagoon. One cell contains 16 tanks; a second cell has four tanks. Total volume: 176,000 gallons of diesel fuel.
- The City's tank farm is located adjacent to the community water tank, approximately 460 feet from Chukchi Sea. The five fuel tanks contain approximately 91,000 gallons of undefined fuel.
- Shishmaref IRA Tank Farm. This site includes three horizontal and three vertical tanks on the east side of town next to the community water tank. The 17 diesel fuel and gas tanks total 140,000 gallons. No available data to determine how many of each fuel type.
- Shishmaref Lone Tank (School Fuel Tank). This tank is located in close proximity of the high school. This tank contains approximately 20,000 gallons of diesel fuel.

The City of Shishmaref is scheduled to have their bulk fuel tank farm upgraded during 2016-2017. The Alaska Energy Authority (AEA) has placed an "Invitation To Bid" for bulk fuel tanks for the City of Shishmaref. The following excerpt describes their project requirements along with applicable tank and containment area shop drawings. The excerpt reads:

BULK FUEL TANK TECHNICAL SPECIFICATION
REG-2013-095

Shishmaref Bulk Fuel Upgrade Project

1.0 GENERAL

1.1 Scope

A. This specification is intended to identify specific tank details to be incorporated in new shop-fabricated, horizontal bulk fuel tanks. Definitions for terms used in this specification are in accordance with those listed in UL 142. The successful Bidder shall provide the following:

1. Five (5) twenty-nine thousand (29,000) gallon nominal volume, single wall, horizontal, skid mounted, above ground storage tanks. Provide three (3) tanks for diesel and two (2) tanks for gasoline service. Maximum outer tank dimensions shall be 12 feet in diameter by 34.5 feet in length (see Drawing T1.01 - T1.03). All (5) tanks shall have the same outer dimensions.

2. One (1) five thousand (5,000) gallon nominal volume, single wall, horizontal, dual product, skid mounted, above ground dispensing tank for diesel and gasoline service. Maximum outer tank dimensions shall be 7 feet in diameter by 18 feet in length (see Drawings T2.01- T2.03).

B. All tanks shall be constructed in accordance with this specification and the attached Drawings, and shall be furnished with the fittings and appurtenances specified herein.

C. The tanks shall, at a minimum, meet the requirements of the most current edition of Underwriters Laboratories Inc. (UL) Standard for Safety UL 142, "Steel Aboveground Tanks for Combustible Liquids." All tanks must be UL listed and labeled" (AEA 2015).

The community needs a single, consolidated BFS facility that should consist of multiple single-walled steel storage tanks that will store #1 fuel oil and gasoline separately. A commonly used and economical individual tank size for storing #1 fuel oil and gasoline in remote Bush communities is 29,000 gallons.

The BFS facility should be partitioned into individually secured areas to accommodate individual facility owners and users access.

Distribution

All common fuel type tanks should be connected through isolation valves to the fuel fill and issue system header and pipelines as required by regulatory criteria:

> * **Note:** Bulk fuel storage and distribution requirements for local emergency power generation equipment is not addressed at this time.

Individually owned and operated dual fuel dispensing stations should be located near the BFS facility for local dispensing of either #1 fuel oil or gasoline. The dispensing stations will be equipped with arctic hose and dispenser nozzles with automatic shutoff. Flow will be between 6 and 12 gallons per minute. These metering dispensers will be similar to those found at most gasoline stations on the highway system. Each individual dispensing station will be separately fenced, gated, and securely locked, and covered with a roof for weather protection.

In the event that a fuel truck delivery system is provided for the village, a high volume pump or metering station will be provided for filling the delivery truck. All dispensed fuel will be pumped from transfer tanks associated with a particular owner and dispensing station. The transfer tanks will be filled from an owner's large storage tanks. In the case an owner's storage tanks have a 10,000 gallon capacity or smaller; a separate transfer tank will not be required. Transfer tank sizes are listed in Table 5-6.

A spill response building containing spill containment devices and cleanup kits should be stored near the BFS facility.

Individual double-wall intermediate building storage tanks should be provided for larger buildings or groups of buildings such as the school, Washeteria, community center and/or City of Shishmaref office building(s). Small buildings and private residences should have small individual storage tanks and should be filled manually via private vehicle transportation of fuel from a dispensing station located at the BFS facility.

The intermediate building storage tanks should be required to have three levels of overfill protection:

1) Personnel should continuously monitor the level in the tank during filling operations. The tank should be provided with a level gauge, a whistle vent, and an amber panel light to indicate when the tank is nearly full.
2) Secondary overfill protection is provided via a float activated overfill high level protection valve with level switch and alarm that should stop fuel flow when the tank reaches a predetermined level above full.
3) Thirdly, a mechanical-float actuated fill shut-off valve provides high-high level overfill protection.

ENERGY

Power Generation

For a new community of 800 persons living in new and existing-relocated housing with plumbing it is estimated that the electrical need should be 2.0 Million Kilowatt Hours (MkWH) per year. This estimate anticipates the additional appliance usage and lighting also includes power usage for private buildings, community buildings, commercial buildings, school buildings, churches, the consolidated BFS facility and the AVEC station power.

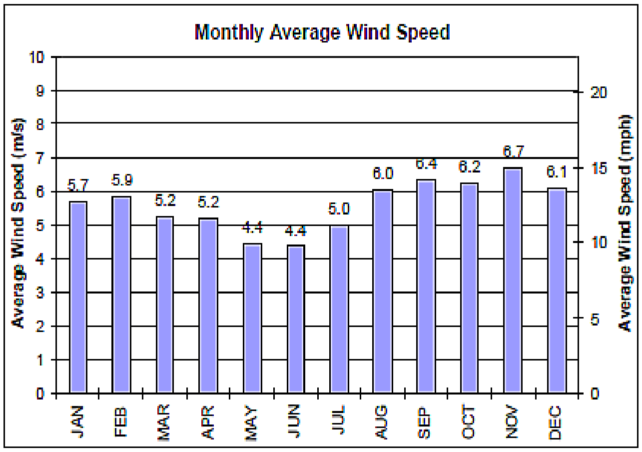
AVEC is the electrical supplier for the community; it is anticipated that they would also supply energy at the new site. A new power generation facility should include fully automatic control panels, individual cooling systems, support enclosures for hot and cold storage, lube oil storage, and living quarters. The facility would likely be modular construction elevated on piles above grade to reduce snowdrift problems.

An integral part of the AVEC generation facility would include a consolidated Bulk Fuel Storage (BFS) facility or tank farm. The BFS should be located adjacent to the AVEC power generation facility. A preliminary BFS facility layout can be found in the mechanical portion of this document. There would be separate containment areas within the BFS for AVEC, City of Shishmaref, Native Village, Bering Strait School District (BSSD), Nayokpuk store, Native Store, National Guard Amory, and DOT/PF fuel tanks. Separate electrical distribution, lighting and fuel dispensers should be included for the separate BFS areas. Operations building(s) may also be provided near the fuel dispensers for conducting day to day fueling operations. Further discussion of the electrical systems in the BFS is included under the distribution section below.

Renewable Energy

Wind. According to a 2009 AVEC fuel usage study, Shishmaref consumes an average of approximate 114,066 gallons of fuel oil for energy production. They could greatly benefit from using renewable energy as an AEA wind study supported installing wind turbines with a current location Wind Class rating of 4.

AVEC has had great success in Western-remote Alaska using wind generation to supplement fossil fuel power generation. The potential difficulty of transporting fuel to some of the identified relocation sites makes wind generation attractive and possibly essential. It is not known which site location should be most suitable to make wind generation feasible, however the better sites are likely to be the Tin Creek or West Tin Creek Hills area sites due to their elevated terrain. The installation of three or four wind generation turbines should be anticipated.



Though most turbines may be connected directly to the power grid, AVEC has employed a means of utilizing turbine power off of the main power grid by connection to an electric boiler. This allows integration to a heat recovery system to facilitate using off-peak surplus turbine power. Further discussion of the heat recovery system is included under the heat recovery section below.

Power Distribution

Community Electrical Distribution. Depending upon site selection; primary electrical distribution will be either overhead or underground. Those sites where substantial well drained fill is required are best suited for underground utilities. Those sites where more in situ soils exist and potential permafrost problems are more likely, are best suited for overhead utilities. Pad–mounted or pole-mounted transformers will convert 3-phase primary voltage to secondary 3-phase and single phase low voltage (208/120 volts 3-phase or 240/120 volts single phase) for building electrical services. All services will meet AVEC service standards. The service sizes for typical private homes will be 100 or 200 Amp, 240/120 volts single phase and 200 Amp or greater 208/120 volts 3-phase for community, commercial, and school buildings and churches. All electrical services will be metered, with demand type metering employed for commercial and larger community buildings.

Pole-mounted light fixtures will installed during the 2016 construction period. High pressure sodium (HPS) fixtures with cutoff optics at 100 or 250 watt sizes would likely be used as these are usually readily available, offer fair efficiency performance and are a typical AVEC standard. All street lighting would be metered for billing to the appropriate entity(ies). However, the light fixture types have not been discussed at this time.

Bulk Fuel Storage (BFS) Electrical Requirements. Electrical service to the BFS site would be provided to the site from the AVEC operations building. A transformer will serve multiple separate 240/120-volt single-phase 100 Amp services. The services would include a meter base and exterior disconnect and installed per AVEC service standard 93-23. Electrical power to all devices in the BFS site would use load centers via fuel control panels. Devices in the BFS bulk fuel area include lighting, pumps, and controls. A fuel control panel for each entity would be provided. Fuel control panels and load centers would likely be installed inside of an operations building near the fuel dispensers. Branch circuits would be provided for building lighting, receptacles, and fuel control panels; devices, and ventilation. Rough service fluorescent light fixtures with cold weather ballasts will provide for interior lighting.

Fuel control panels at the BFS will control site lighting, gasoline and fuel oil dispensing, transfer pumps, and solenoid valves. The panels will monitor tank level switches, transfer pump discharge pressure, and emergency shutdown switches. The panels will provide pump operation and tank level visual status indication. Transfer pump operation will be controlled from the fuel control panel but determined by tank level and pressure switches' status. Electrical and mechanical interlocks will prevent dispensing tank overfilling. Dispensing pump operation will also be controlled from the fuel control panel. A warning horn and flashing strobe for each entity should be located on the outside of the operations building to be activated when the fuel in the tank reaches the critical high-level point. Emergency shutdown will occur when any emergency shutdown pushbutton is depressed. Emergency shutdown will disconnect power for all field devices upon activation.

Intermediate Tank Monitoring. In addition to the fuel control panels in the BFS intermediate tank monitor panels should be located at the school buildings adjacent to the intermediate tanks. The tank monitor panels would monitor tank level switches and control the solenoid valve (if provided) for tank fill. The panels would also provide a means for emergency shutdown. Electrical and mechanical interlocks should be provided to prevent intermediate tanks' overfilling. 120-volt single-phase power for the tank monitoring panels should be fed from the nearest branch panel in adjacent school buildings.

Heat Recovery

The AVEC generators may include a heat recovery system to redistribute heat to other essential infrastructure such as community building hydronic and/or domestic water heating systems or as added heat for freeze protection in the community's potable water or fire hydrant distribution systems. As previously mentioned heat recovered from an electric boiler may be used to recover surplus wind-generated power. The heat recovery module should be located near the AVEC facility and within 1,000 feet of the customer connections to reduce heat transfer losses.

A metered electrical service to the heat recovery module should be provided via a 240/120-volt single-phase 100 Amp service. The service would include a meter base and exterior disconnect and should be installed per AVEC service standard 93-23. Additionally one metered 480-volt three-phase service for the electric boiler and one 480-volt three-phase feeder for the AVEC node pump and its controls should also be provided. Connection to the services and feeder will be from an AVEC generator/control module and will be coordinated with AVEC.

A main heat recovery control panel provides control for building lighting, receptacles, and the AVEC node heat recovery pump. The panel monitors system temperatures and drives the main circulation pump(s) at variable speed proportionally to the electric boiler power. Secondary customer pumps are metered separately and driven via a winter/summer control scheme. Control panels provide visual pump operation status; main pump speed, and variable frequency drive fault status.

An electric boiler should be provided to produce hot water from the surplus wind generated electrical power. A control panel for the boiler s load Center (SLC) should also be provided. The boiler control panel will allow accurate electric boilers heat output control. The boiler control panel can be monitored remotely to obtain energy consumption data.

Energy British Thermal Units (BTU) meters need to be installed in the heat recovery module as well as the school. BTU meter data, boiler control data, and the heat recovery module's electrical metering data will be used to accurately quantify the energy being consumed, recovered, and transferred to customer site(s).

SPACE HEATING

Public Facilities

Larger buildings and public facilities could potentially be heated with a hydronic heating system utilizing #1 fuel oil fired water boilers. Individual buildings could potentially be provided with an exterior double walled intermediate building storage tank and a small double wall interior day tank (approximately 50 to 100 gallons) where a small quantity of fuel is stored for a short period of time before being fed to the boiler. The small interior day tank could be equipped with a level sensor which could automatically transfer fuel from the exterior storage tank as required to keep itself full. Level sensors detect an abnormally high level of fuel in the day tank and disable the transfer pump to avoid overfilling. The day tanks could also be equipped with overflow piping which directs fuel back to the exterior storage tank. A sensor in the secondary tank detects primary tank rupture or leakage.

Private Residences

Private residences could be heated with either a hydronic system utilizing #1 fuel oil fired water boilers or an oil fired hot air furnace system. Individual residences will be provided with small exterior storage tanks that are filled manually by hauling fuel from the BFS facility' dispensing station.

COMMUNICATIONS

Satellite

Shishmaref residents and offices need satellite internet which is significantly faster than standard Alaska dial-up Internet access. The community currently has satellite access from the Bering Strait School District's Shishmaref PK-12 facility.

A communitywide accessible satellite infrastructure would provide increased speed enabling options for using individual broadband routers to share satellite's high speed Internet connections for multiple computers in homes or offices. Accessing the Internet to download computer updates or large files would be reduced from hours with dial up to minutes via satellite communication. This would greatly improve efficiency as well as bring the community closer to readily available information and emergency assistance as their needs dictate.

Fiber Optic

Within Community. Various materials are available to support communications cabling system needs. Copper could be routed from Shishmaref via Alascom Earth Station to all locations in the community. A minimum total of 2500 pair copper may be anticipated for serving the community.

A single mode optical fiber communications cabling system could also meet identified system requirements. Fiber will be routed from Alascom Earth Station to Shishmaref's school, businesses, and larger community buildings and the higher performance and speed of a fiber connection to these buildings is especially critical for applications such as distance learning programming. A minimum total of 200 strand single mode fiber should be anticipated for serving the community.

A cable television distribution system requiring coaxial cabling with necessary distribution components could be routed from Alascom Earth Station1 to all locations in the community. Optical fiber cabling may also be used instead of, or in additional to, coaxial cabling for video signal transmissions.

As with the electrical distribution, communications distribution with be either overhead or underground (direct burial), depending upon community site selection.

APPENDIX B

WEYIOUANNA CONGRESSIONAL TESTIMONY, OCTOBER 11, 2007

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TESTIMONY OF
THE SHISHMAREF EROSION AND RELOCATION COALITION
BEFORE THE COMMITTEE ON
Homeland Security and Governmental Affairs
Sub Committee on Disaster Recovery
OF THE UNITED STATES SENATE

October 11, 2007

HEARING ON

"The State and Federal Response to Storm Damage and Erosion in Alaska's Coastal Villages"

Presented by Tony A. Weyiouanna Sr.
Kawerak Transportation Planner and Technical Staff Assistant to the Shishmaref Erosion and Relocation Coalition
P.O. Box 72100
Shishmaref, Alaska 99772
(907) 649-2289, Fax (907) 649-4461

The Shishmaref Erosion and Relocation Coalition would like to thank you for this opportunity to testify before you today. I am Tony A. Weyiouanna Sr. - Transportation Planner for Kawerak, Inc. providing staff assistance to the Coalition and a member of the Relocation Coalition. The Shishmaref Erosion and Relocation Coalition, made up of the governing bodies of the Native Village of Shishmaref (the federally recognized tribe), City of Shishmaref, and the Shishmaref Native Corporation. I have provided for you today a packet of additional information, photos and a video file of storm footage of the November 2003 storm in Shishmaref available for downloading at the Coalition's web site at http://www.shishmarefrelocation.com/index.html.

We value the working relationship that we have developed with Congressional and State Representatives, agencies and different non-profit organizations and look forward to the continued progress of relocating our community with your continued support. We understand that the complete relocation of our community to the mainland can take another 5-10 years if funding is appropriated.

Alaska Coastal Erosion and authorized under Section 117 of Division C, Public Law 108-447. This allows 100% Federal funding for the most cost effective solution that satisfies the requirements of the law, providing funds are available. Section 117 states, "Notwithstanding any other provision of law, the Secretary of the Army is authorized to carry out, at full Federal expense, structural and non-structural projects for storm damage prevention and reduction, coastal erosion, and ice and glacial damage in Alaska, including relocation of affected communities and construction of replacement facilities."

I plan to address three main points that are important to the community of Shishmaref. They are: (I.) relocation of the community to the mainland; (II.) projects completed to date and effectiveness; and (III.) recommended projects to help move the relocation project forward.

I. The Shishmaref Erosion and Relocation Coalition honorably request your assistance in both funding and technical support from the State and federal government for the expedited relocation and beach front protection of our community.

We also are asking the State of Alaska to assist our community in this project and will work with the State representatives to find ways to fund the relocation project for Shishmaref. We respectfully request that the State of Alaska and Congress authorize and appropriate funds for the near term protection of our existing community while we prepare for a move and for relocation to a new site at Tin Creek under a pilot joint Federal-State-local coordinated project.

II. We have completed the following projects regarding flooding and erosion, and the relocation project since 2001:

1. 2001 Formation of the Erosion and Relocation Coalition consisting of the City Council of Shishmaref, IRA council and of the Board of directors of Shishmaref Native Corporation to work on a solution to the ongoing beach erosion and to represent the community in all activities associated with the relocation to the mainland. This Coalition group is still being used today and has been beneficial to the project for the community.
2. 2001 Kawerak funded the Nayokpuk Stores' beach front protection project- 101' gabion project. $36,000.00, Project protected thee tanks until they were replaced by Alaska Village Electric Cooperative (AVEC) through funding from the Denali Commission.
3. 2001 USDA-NRCS started evaluation of 11 potential relocation sites identified by the Coalition. Project completed, two sites recommended by NRCS for relocation site consideration, Tin Creek and West Tin Creek, Tin Creek site ultimately selected on December 12, 2006 as the relocation site for the community.
4. 2001 A storm prompted Governor Tony Knowles to appropriate $110,000 to complete placing sand-filled gabions along the worst hit shoreline. Single-line gabions constructed- approximately 1200' feet of temporary protection. Held for only one storm.
5. 2002 Shishmaref completed Strategic relocation plan. State mitigation funds provided- $50,000.00. Kawerak Transportation also provided assistance. Plan still being used and in place; updating of plan to be made by the Coalition.
6. 2002 On July 10th Shishmaref voted to relocate to the mainland by a City of Shishmaref sponsored vote July 19, 2002, realizing that the relocation could take 15 to 20 years to accomplish. The Coalition is currently working towards relocation as decided by the vote based on community consensus.
7. 2002 October- Senator Stevens calls for GAO study of villages experiencing flooding and erosion. Delegation from Shishmaref testified at the hearing in Anchorage-June 2004. The Coalition requested that Shishmaref be a community involved with the study and provided information to the GAO. We were happy that we were able to assist in this project.
8. 2002 AVEC/Denali Commission constructed replacement bulk fuel tanks for the Nayokpuk General store. The rest of the community bulk fuel tanks also need replacement.
9. 2002 USDA-NRCS recommended 5 potential sites for further studies.
10. 2003 USDA-NRCS Reconnaissance Study done" Shishmaref Site Analysis for Potential Emergency and Evacuation and Relocation sites. NRCS recommends, based on the team's evaluation that Shishmaref relocate to the Southwest site, West Nanatuq, with Igloot being the second choice of the team.
11. 2003 GAO report to Congress completed December 2003. The GAO confirms that Alaskan villages are encountering flooding and erosion and 186 villages are affected by this. Shishmaref was identified as one of the top four communities most affected by flooding and erosion that need to be relocated to a safe place away from flooding and erosion. 18 of our 20 villages in the Bering Straits Region are being affected by flooding and erosion.
12. 2004 Army Corps of Engineers Partnership Program Project funded $1m for a Cost of Alternatives for the relocation of Shishmaref. This study includes the Cultural impacts and subsistence use by the residents of Shishmaref. Study completed. Options for the community include relocating to a nearby location on the mainland at a cost of $180m, staying in place- $110m, Collocating to Nome-$93m and collocating to Kotzebue-$141m. Of the four alternatives identified by the Army Corps of Engineers, the community stands

by its' decision to relocate to Tin Creek nearby the existing site of Shishmaref to keep its' unique, 4000 year old Traditional lifestyle intact.

13. 2004 Army Corps of Engineers completed a Design Analysis for emergency shelters on the mainland for Shishmaref. The Coalition has requested for funding from Congress to construct these emergency shelters at the relocation site.
14. 2004 five sites researched by USDA-NRCS narrowed down to two sites- Tin Creek and West Tin Creek. Tin Creek site being the better of the two based on space availability and potential for having more options for infrastructure development.
15. 200' Kawerak rip rap seawall constructed along the west end of town funded through the BIA/IRR roads program at a cost of $2.2m.
16. 2005 Further construction of rip rap seawall by the City and the Army Corps of Engineers of Engineers. Legislative funding $2.45m and the federal funding $1.5m through the Army Corps of Engineers of Engineers Section 14 program.
17. USDA-NRCS completed depth sounding of port and gravel fill needs for Tin Creek. Report given to Coalition January 2006. Report is preliminary and needs further assessment.
18. 2005 Funding received by the Army Corps of Engineers of Engineers for the full design of beach front protection to be completed by the end of the year.
19. 2005 Funding received in the Transportation bill to start construction of the relocation road. - $4.25mm appropriated by Congress in SAFETEA-LU and $500,000.00 match requirement obtained through the State Legislature. The Reconnaissance study is to be started in the late fall 2007 by ADOT and Kawerak Inc., with an estimated $1.5m to be left over for construction. Once project construction starts, Kawerak, Inc. will consider partnering with ADOT to help with project funding.
20. 2006 Army Corps of Engineers completed "Section 117 Shoreline Erosion Protection, Shishmaref, Alaska Technical Report, Environmental Assessment and Finding of no Significant Impact" - An examination of erosion issues in Shishmaref (not you have the " in the right place?0. This report states that 3,400' of beach needs protection; if the rest of the beach is not protected similar to the BSSD project, the rest of the community will be jeopardized by the flooding and erosion. Based on aerial comparisons of photos, we are losing 8.9' of shoreline per year. Since 2001 we have been taking measurements and based on these actual measurements we are losing an average of 22.6' of shoreline per year. No findings of negative impacts were found and the Army Corps of Engineers recommend that we move forward with the proposed project to construct additional rock seawall in Shishmaref. The FY 2008 Presidents Budget contains $1 million for the Tribal Partnership nationwide, and nothing for the Alaska Coastal Erosion work. At Shishmaref, there is 700 additional feet of revetment that is designed and is ready for construction at a cost of $7.5 million. This work can be incremented into a $5 million base amount with $2.5 million in options. The estimated cost to complete the authorized shore revetment is $25 million (includes the FY 08 capability)
21. 2006 Army Corps of Engineers completed the examination of Erosion issues of the following villages- Bethel, Dillingham, Kaktovik, Kivilina, Newtok, Shishmaref and Unalakleet, the report is entitled "Alaska Village Erosion Technical Assistance Program". This report highlights the Army Corps of Engineers assistance they have provided to these communities listed through their Tribal Partnership Program. In this report they mentioned that Shishmaref needs help in constructing more revetments to protect the community from flooding and erosion and that the Army Corps of Engineers is ready to provide assistance to our community.
22. 2006 Construction of the City of Shishmaref Housing and Urban Development (HUD) project constructing 297' of HESCO baskets funded by HUD ($500,000.00) and the City

of Shishmaref (300,000.00) - $800,000.00 project. Project served its purpose for a year and is currently being replaced with rip-rap by the Army Corps of Engineers project.

23. 2006 Public meeting in Shishmaref held. Coalition to have work sessions to consider the relocation sites for recommendation to the community for selection. Decision made by the community to ratify the Tin Creek location as the new relocation site during a public meeting on December 12, 2006.
24. 2007 $6,500,000.00 received by the Army Corps of Engineers for seawall construction for Shishmaref through the Army Corps of Engineers Section 117 program.
25. Started the Reconnaissance Study for the Gravel haul/ Relocation road. The new airport master plan development also is in process by ADOT. The wind study data collection for the new airport at Tin Creek is scheduled to get started this coming winter 2008. This project will gather two years of wind data to determine whether or not a cross wind runway is needed and the data collected can also be used to determine whether or not wind generation is feasible at the new site. The airport wind study is a part of the Airport Master Plan Development project for the new site of Shishmaref. The first community meeting was held here in Shishmaref on October 1, 2007 by ADOT and was the first step in the project.

III. Recommended projects to help move the relocation project forward:

1. That funding to the Shishmaref Erosion and Relocation Coalition for administrative capacity building, comprehensive relocation planning and technical assistance funding of our office here to ensure that the relocation of our community is completed in the most effective, efficient and suited for the traditional values of our community. We request funding in the amount of $950,818.00 for the first year funding and $1,100,000.00 per year until the relocation of our community is completed. Local coordination for the relocation project is essential; if we are to be successful. This is an extremely complicated venture and the people of Shishmaref need help planning for many more generations of our unique subsistence lifestyle. We have been established here for the past 4,000 years and have passed on our traditions and culture from generation to generation and are not about to give up our unique and inherent lifestyle that we continue to enjoy today.
2. Authorize and appropriate $30 million to the United States (Department of Transportation) as a project in the coming year’s Appropriations budget for the construction of a 21 mile long road from Tin Creek to Ear Mountain, a rock and gravel source. The SAFETEA-LU bill passed by Congress in 2005 provided seed funding in the amount of $4.25m for the start of the construction of this road, but is only enough to get the reconnaissance study done for the road. Funds are desperately needed for the complete construction of this project. Currently, the Alaska Department of Transportation has started the process of the reconnaissance study for the road and has targeted the fall of 2008 for completion of this study. Kawerak Inc. For the Native Village of Shishmaref, identified in the Long Range Transportation Plan to the Bureau of Indian Affairs Inventory of Roads Program (BIA-IRR) the need to construct this road and has been approved by the BIA-IRR program and is an eligible project to move to the construction phase once funding is provided to Kawerak, Inc.
3. Continued seawall funding to complete project, the Army Corps of Engineers has identified an additional $25m is needed to complete this project. The FY 2008 Presidents Budget contains $1 million for the Tribal Partnership nationwide, and nothing for the Alaska Coastal Erosion work. At Shishmaref, there is 700 additional feet of revetment that is designed and is ready for construction at a cost of $7.5 million. This work can be incremented into a $5 million base amount with $2.5 million in options. The estimated

cost to complete the authorized shore revetment is $25 million (includes the FY 08 capability

4. Authorize and appropriate $5 million for the construction of emergency evacuation shelters on the mainland for the community of Shishmaref. Once again, The Army Corps of Engineers has provided a Design Analysis for the emergency shelters and are aware that constructing these shelters is vital for the safety of our community. An alternative design for smaller modules, which can be used as family housing, is included in the attachment summary.
5. That Congress authorizes the National Park Service to dedicate a public roadway easement for an access corridor across the Bering Land Bridge to provide access to Ear Mountain (gravel source) to the community of Shishmaref without the requirement of a land exchange with our local Native Corporation.
6. The Native Village of Shishmaref council is the legal remnant of the Native traditional government who are organized and recognized as a tribal government under the Indian Reorganization Act of 1934. The Native Village of Shishmaref is organized as a public non-profit recognized by the federal government. With programs ranging from education to housing, and natural resource management to economic development, with the assistance of Kawerak, Inc. our regional non-profit, The Native Village of Shishmaref also seeks to improve the Region's social, economic, educational, cultural and political conditions.
7. In addition, Kawerak Inc. is the Regional non-profit established to serve the Native Villages in the Bering Straits region and has the capability to compact the federal programs under 638 compacting and is an authorized participant with P.L. 102-477 programs.
8. We recommend that consideration be given to identifying, tasking and funding an appropriate entity (e.g. Denali Commission or the Corps of Engineers) to take the federal lead to provide leadership and additional assistance to communities in Alaska needing relocation and flooding assistance.
9. Lastly, we would like to thank Governor Sarah Palin her leadership in setting up the Climate Change Sub-Cabinet. We hope that this will help the process in getting more assistance from the State of Alaska to communities like ours and others to get more constructive assistance in the future.

IV. Conclusion

In conclusion, we understand that other communities are faced with the similar problems as we are here in Shishmaref and also are working to relocate their communities. Shishmaref has tasked the Shishmaref Erosion and Relocation Coalition to advocate for funding and coordination of the erosion and relocation project by forming the Coalition in 2001 and to move forward by consensus of the community. Since then, we have worked for the best possible solution for the community of Shishmaref and express our community’s desire to move forward with the relocation project by presenting to you, our respected elected State and federal representatives our request for funding of the relocation project. We appreciate your support in working to reestablish Shishmaref to a site on the mainland safe from the dangers of being washed away and to exist as one people continuing to enjoy our unique subsistence lifestyle. We, as American people, deserve the attention and help of our fellow Americans.

Once again, I would like to thank you for giving me the opportunity to testify regarding our flooding, erosion and relocation projects in my home Shishmaref.

Available at: www.hsgac.senate.gov/download/weyiouanna-testimony

APPENDIX C

TECHNICAL DATA REVIEW SPREADSHEET

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The following table lists documents accessed and referenced as appropriate during while completing this project.

Author or Responsible Agency	Date	Title	URLs (as available)	Other Info (as available)
Adams, Corthal, Lee Consulting Engineers	1961	Shishmaref Airport Evaluation		State of Alaska Department of Public Works
DCCED/DCRA	2015	Shishmaref Community Overview	https://www.commerce.alaska.gov/dcra/DCRAExternal/community/Details/c075af9a-a51e-47bb-9dfb-60fd2513da0a	Alaska Community Database Detailed Community Information
DCCED/DCRA	1974	Background Information on the Shishmaref Relocation Effort		Division of Community Planning
DCCED/DCRA	2011	Alaska Climate Change Impact Mitigation Program	http://climatechange.alaska.gov/docs/afe11/ACCIMP_cox_feb11.pdf	Presentation by Sally Cox
DEC	2012	Northwest Arctic Subarea Contingency Plan: Sensitive Areas Section	https://dec.alaska.gov/spar/ppr/plans/scp_nw/NWA%20D-SensAreas%20(Jan%202012).pdf	Sensitive Areas Work Group; USCG Marinee Safety Office, Anchorage, USEPA Region X
ADFG	2002	Summaries of Division of Subsistence Research Projects in Northwest Alaska	http://library.alaska.gov/asp/edocs/2007/04/ocn133211742.pdf	Division of Subsistence
ADFG	2001	Brown Bear Annual Survey and Inventory Performance Report: Status of Alaska Brown Bears and Factors Influencing their Populations in Regions I, III, and V	https://data.doi.gov/dataset/brown-bear-annual-survey-and-inventory-performance-report	Submitted by Peter Bente
ADFG	2002	The Status of Alaska Muskoxen and Factors Influencing their Populations		Submitted by Peter Bente
ADFG	1990	The Harvest of Fish and Wildlife in Three Alaska Communities: Brevig Mission, Golovin, and Shishmaref	http://www.subsistence.adfg.state.ak.us/TechPap/tp188.pdf	Conger, A. O., Magdanz, J. Division of Subsistence
ADFG	1985	The Economics of Wild Resource Use in Shishmaref, Alaska	http://www.arlis.org/docs/vol1/A/13351954.pdf	Sandra S. Sobleman. Division of Subsistence
ADFG /DWC	2001	Caribou Management Report of Survey-Inventory Activities 1 July 1998-30 June 2000	https://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/mgt_rpts/mca01mt_western.pdf	C. Healy, editor. Project 3.0 Juneau, Alaska. Later editions available
ADFG /DWC	2002	Moose Management Report of Survey -Inventory Activities 1 July 1999-30 June 2001	https://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/mgt_rpts/mmo02_pt1_interior.pdf	C. Healy, editor. Project 1.0 Juneau, Alaska. Later editions available
ADFG /DWC	2002	Muskox Management Report of Survey -Inventory Activities. 1 July 2000-30 June 2001	http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/mgt_rpts/mu03mt.pdf	C. Healy, editor. Project 16.0 Juneau, Alaska. Later editions available
ADFG DWC	2003	Muskox Annual Survey and Inventory Federal Aid Performance Report		Grant and Segment Nr: W-27-5. Project Nr: 16.0
DMVA/DHS&EM	No Date	Fall Storm Community Plan		(Division of Emergency Services) State of Alaska Department of Military and Veterans Affairs
DMVA/DHS&EM	2004	Evacuation Plan for the Community of Shishmaref		
ADN	2013	Wet or Dry? Shishmaref Must Make a Choice	http://www.adn.com/article/20131019/wet-or-dry-shishmaref-must-make-choice	Article written by Kyle Hopkins
DNR	1992	Township and Range; Status Plat and Land Estate of Kateel River Meridian, Alaska		
DNR	1965	Township and Range; of Kateel River Meridian, Alaska		
DNR	1982	Township and Range; of Kateel River Meridian, Alaska		
DNR	1989	Township and Range; Mineral Estate Map and Water Estate Map of Kateel River Meridian, Alaska		
DNR	2006	Township and Range; Status of the Public Domain Land and Mineral Titles Map of Kateel River Meridian, Alaska		
DNR	2005	Bering Straits Coastal Resource Service Area Coastal Management Plan, Public Review Draft		
DNR	2010	Coastal Impact Assistance Program: Bering Straits Coastal Resource Service Area	http://dnr.alaska.gov/commis/CIAP/Fall2010/Leg/BSCRSA.pdf	Project awards
DNR/DGGS	No Date	Division of Geological and Geophysical Surveys (DGGS) Shishmaref Quadrangle: DGGS Publications	http://www.dggs.dnr.state.ak.us/pubs/quad/shishmaref	
DNR/DGGS	2015	Single-Beam Bathymetry Data Collected in Shallow-Wawter Areas near Gambell, Golovin, Hooper Bay, Savoonga, Shishmaref, and Wales, Alaska, 2012-2013	http://dggs.alaska.gov/pubs/id/29348	Nicole E.M. Kinsman.
DNR/DGGS	2014	Color-Indexed Elevation Maps for Flood-Vulnerable Coastal Communities in Western Alaska	http://dggs.alaska.gov/pubs/id/29129	Tschetter, T., N. Kinsman, A. Fish
DNR/DGGS	2013	Preliminary Evaluation of Coastal Geomorphology and Geohazards on 'Kigiqtam Iglua', an Island Northeast of Shishmaref, Alaska	http://www.dggs.alaska.gov/pubs/id/24955	Kinsman, N.E.M., DeRaps, M.R., and Smith, J.R.
DNR/DGGS	2010	Alaska Coastal Impact Assistance Program: December 2010 Amendment	http://dnr.alaska.gov/commis/CIAP/ciap.htm	
DNR/DGGS	2011	Coastal Geohazard Evaluation and Geologic Mapping for Coastal Communities: Multi-year Project Overview	https://www.anthc.org/chs/ces/climate/leo/upload/LEOwebinarNK4-21-15.pdf	
DNR/DGGS	1996	Geological and Anthropological Considerations in Relocating Shishmaref, Alaska	http://www.dggs.alaska.gov/pubs/id/2536	Mason, O. K.
ADNR/DGGS	2012	Summary of Fossil Fuel and Geothermal Resource Potential in the Bering Straits Energy Region	http://www.dggs.alaska.gov/pubs/id/24426	M. Simone, M. Wartes, and J. Clough
DOT/PF	1984	Shishmaref Airport As Builts Airport Relocation		Northern Region. A.I.P. No. 3-02-0404-01 Project No. D3732

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DOT/PF	1984	Shishmaref Airport Relocation Environmental Assessment		Federal Aviation Administration, Alaska Region
DOT/PF	1991	Shishmaref Airport Improvements: Snow Removal Equipment Storage Building; Environmental Assessment		Northern Region Design Group. A.I.P. No 3-02-0404-02 Project No. 65126
DOT/PF	1992	Construction Plans for Shishmaref Airport: Airport Improvements		Northern Region. A.I.P. No 3-02-0404-03 Project No. 65603
DOT/PF	1996	Shishmaref Airport Layout Plan		
DOT/PF	2003	Shishmaref Airport Layout Plan		Northern Region Deisgn Group
DOT/PF	2005	Shishmaref Airport Project Layout		Northern Region Design Group
DOT/PF	2009	Geotechnical Data Report: Shishmaref Relocation Road		Northern Region Design Group AKSAS: 76776
DOT/PF	2007	Shishmaref Relocation Road Sampling Preliminary Memorandum, AKSAS #76776		Northern Region Design Group AKSAS: 76776
DOT/PF	2015	Geotechnical Data Report: Shishmaref Relocation Road AK 115 Village Relocation Sites and Material Source Access Road		Northern Region Design Group, AKSAS: 76776
DOT/PF	2009	Preliminary Draft: Shishmaref Relocation Road Reconnaissance Study, State Project No. 76776		Northern Region Design Group. State Project No. 76776
DOT/PF	No Date	Vegetation Descriptions for Tin Creek Sites		
DOT/PF	1999	Shishmaref Airport; Geodedic Data		U.S. Army Topographic Engineering Center, Corpscon 5.11
DOT/PF	1994	Shishmaref Aerial Photographs		
DOT/PF	2001	Shishmaref Airport 2001 Pavement Condition Index Values		
DOT/PF	2015	Memorandum: Shishmaref Village Road AK 115; Village Relocation Sites & Material Source Access Road		Preliminary Data Report: 76776/002199. Northern Region Design and Engineering Services.
DOT/PF	2008	Memorandum: Shishmaref Relocation Road Preliminary Results from Geotechnical Investigation		
DOT/PF	1984	Engineering geology and soils report: Shishmaref Airport, E-W runway centerline and materials investigation, Project Number D37322, 1984.		Northern Region Design and Construction
DOT/PF	2004	Shishmaref Airport: Wetland Delineation and Wetland Functional Assessment, Vegetation Classification, Wildlife Habitat Evaluation		Prepared by DOWL Engineers. W.O. D58530E
AEA	2009	Alaska Energy: A First Step Toward Energy Independence. A Guide for Alaskan Communities to Utilize Local Energy Resources.	http://www.akenergyauthority.org/Content/Publications/AKEnergyJan2009.pdf	Prepared by the Alaska Energy Authority and the Alaska Center for Energy and Power
AEA	2011	Renewable Energy Atlas of Alaska: A Guide to Alaska's Clean, Local, and Inexhaustible Energy Resources	ftp://ftp.aidea.org/AEAPublications/2011_RenewableEnergyAtlasofAlaska.pdf	Renewable Energy Alaska Project (REAP)
AHFC	2015	Grants: Program Summaries	https://www.ahfc.us/pros/grants/	
Alaska Area Native Health Service, Environmental Health Branch	1979	Water, Wastewater and Solid Waste Haul System Feasibility Study for Shishmaref, Alaska		Hale, Lawrence C.
Alaska Climate Research Center	2014	Temperature Changes in Alaska	http://climate.gi.alaska.edu/ClimTrends/Change/TempChange.html	
Alaska State Geo-Spatial Data Clearinghouse	No Date	Most Environmentally Sensitive Areas in Arctic, Western, and Southwest Alaska	http://www.asgdc.state.ak.us/maps/cplans/base/mesa_vol1.pdf	
Aurora Consulting	No Date	Kawerak, Inc. – Shishmaref Relocation Planning	http://www.auroraconsulting.org/serv_community_plan_kawerek.html	
BEESC	2010	Shishmaref Relocation Plan Update Final		Shishmaref Erosion and Relocation Coalition, Karerak, Inc. Bristol Project No. 210029
BIA	1974	Correspondence between BIA and Community of Shishmaref		Shishmaref Native Corporation
BIA	1975	Correspondence between BIA and Community of Shishmaref		Shishmaref Native Corporation
BIA	1973	Meeting minutes: City Council, Village Council, Native Corporation		Shishmaref Native Corporation
BIA	1973	November 9th and 10th Storm Report		Shishmaref Native Corporation
BOEMRE	2010	Coastal Impact Assistance Program State Plan and Plan Amendment Guidelines	http://dnr.alaska.gov/commis/CIAP/CIAP_State_Plan_Guidelines_Aug.pdf	
BOM	1966	Tin-Lode Investigations, Cape Mountain Area, Seward Peninsula, Alaska	http://www.dggs.alaska.gov/webpubs/usbm/ri/text/ri6737.PDF	Mulligan, John J. Report of Investigations 6737
Bronen, Robin	2013	Climate-Induced Displacement of Alaska Native Communities	http://www.brookings.edu/~/media/research/files/papers/2013/1/30-arctic-alaska-bronen/30-climate-alaska-bronen-paper.pdf	Alaska Institute for Justice. University of Alaska, Fairbanks. Brookings-LSE Project on Internal Displacement
Conant, B., Mallek, E. J.	2006	Waterfowl Breeding Population Survey: Alaska-Yukon; May 16 to June 6, 2006	http://www.fws.gov/migratorybirds/NewReportsPublications/WPS/Reports06/AKYukonBPS2006.pdf	U.S. Fish and Wildlife Service, Juneau, Alaska
DOWL Engineers	1975	Shishmaref Erosion Protection, Alternatives Feasibility & Cost Study: A		Division of Community Planning, Department of

Author or Responsible Agency	Date	Title	URLs (as available)	Other Info (as available)
		Comprehensive Planning Assistance Project		Community and Regional Affairs, State of Alaska
DOWL Engineers	1978	Shishmaref Expansion and Relocation Study		
EPA	2006	Ionizing Radiation Fact Sheet Series: No. 2	http://www.rst2.edu/ties/radon/ramfordu/pdffiles/med3.pdf	
EPA	2006	Ionizing Radiation Fact Sheet Series: No. 1	http://www.agriculturedefensecoalition.org/sites/default/files/pdfs/5I_2004_Ionizing_Radiation_Fact_Sheet_EPA_2004.pdf	
EPA	2000	Radionuclides	http://www.epa.gov/ttn/atw/hlthef/radionuc.html	
Furbush, C. E.	1975	Soils Reports: Nunatak and Singeak Areas, Ikpek and Shishmaref Areas		
GAO	2003	Alaska Native Villages: Most are Affected by Flooding and Erosion, but Few Qualify for Federal Assistance	http://www.gao.gov/new.items/d04142.pdf	Report to Congressional Committees GAO-04-142
GAO	2009	Limited Progress Has Been Made on Relocating Villages Threatened by Flooding and Erosion	http://www.gao.gov/new.items/d09551.pdf	Report to Congressional Committees GAO-09-551
I.N.I Builders Inc.	1987	Shishmaref Water and Sewer Feasibility Study		
IAWG	2009	Recommendations to the Governor's Subcabinet on Climate Change	http://climatechange.alaska.gov/docs/iaw_finalrpt_12mar09.pdf	
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Karawek, Inc., Maniilaq Association, ADF&G	2004	Subsistence Wildlife Harvests in Five Northwest Alaska Communities, 2001-2003	http://library.state.ak.us/asp/edocs/2007/04/ocn123495361.pdf	Georgette, S., Persons, K., Shiedt, E., Tahbone, S.
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Kawerak, Inc.		Shishmaref Local Economic Development Plan 2013-2018	http://www.kawerak.org/ledps/shishmaref.pdf	
Kawerak, Inc.	2003	The Bering Strait Comprehensive Economic Development Strategy 2003-2008	http://www.kawerak.org/forms/csd/2013%20Comprehensive%20Economic%20Development%20Strategy.pdf	URL is link to updated version, 2013-2018
Kawerak, Inc.	2009	Bering Strait Regional Energy Report: Conditions - Needs - Priorities	http://www.kawerak.org/cpd.html	Compiled by: Regional Energy Specialist Walter Rose
Kawerak, Inc.	2012	Communities of the Bering Strait: Shishmaref	http://www.kawerak.org/communities/shishmaref.html	
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NPS	2010	Public meeting notes, November 8, 2010. Community of Shishmaref, regarding Serpentine Hot Springs Transportation Study		
NPS	2011	Personal Communication with URS re: Serpentine Hot Springs Transportation Study.		Pomerenke, Jeanette
NRCS	2002	Preliminary Natural Resources Assessment of Relocation and Emergency Evacuation Sites: Discussion Paper		United States Department of Agriculture
NRCS	2004	Site Comparison of Tin Creek and West Nunatuq for Permanent Relocation Sites		In cooperation with The Shishmaref Erosion and Relocation Coalition
NRCS	2004	Site Comparison of Tin Creek and West Tin Creek Hills for Potential Emergency Evacuation and Permanent Relocation Sites		In cooperation with The Shishmaref Erosion and Relocation Coalition
NRCS	2004	Shishmaref Site Analysis for Potential Emergency Evacuation and Permanent Relocation Sites	http://www.arlis.org/docs/vol1/B/525293949.pdf	In cooperation with The Shishmaref Erosion and Relocation Coalition
OIA	1939	Constitution and By-Laws of the Native Village of Shishmaref	https://www.loc.gov/law/help/american-indian-consts/PDF/40026121.pdf	Government Printing Office, Washington
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R&M Consultants, Inc.	2011	Shishmaref Potential Relocation Sites Field Investigation Report	https://www.commerce.alaska.gov/web/Portals/4/pub/Shishmaref_Potential_Relocation_Sites_Report_Final.pdf	
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SERC	2002	Shishmaref Relocation Strategic Plan	http://www.cakex.org/sites/default/files/strategic_plan_final_200211.pdf	(Shishmaref Erosion and Relocation Coalition)
SERC	2014	We are Worth Saving: One of Many Feathers	http://www.oneofmanyfeathers.com/we_are_worth_saving.html	
SERC	2007	Testimony of the Shishmaref Erosion and Relocation Coalition Before the Committee on Homeland Security and Governmental Affairs	http://www.gpo.gov/fdsys/pkg/CHRG-110shrg38848/html/CHRG-110shrg38848.htm	
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The Native Village of Shishmaref, The City of Shishmaref, and The Shishmaref Village Corporation	2001	Ref: Appropriations for the National Shoreline Erosion Control Demonstration Proposal for a project located in Shishmaref, Alaska		Letter to Senator Stevens
UAA-ISER	1998	Alaska Regional Profiles: Northwest Region	http://www.alaskool.org/resources/regional/nw_reg_pro/index.html	University of Alaska Anchorage, Institute of Social and Economic Research
United States Public Health Service, Environmental Health Branch	1980	Ponds as Potable Water Sources at Shishmaref, Alaska		Wheaton, Scott.
USACE	2004	Shishmaref Partnership: Shishmaref Relocation and Collocation Study, Preliminary Costs of Alternatives	http://www.cakex.org/sites/default/files/relocation_shishmaref.pdf	Tetra Tech, Inc.
USACE	2006	Section 117 Shoreline Erosion Protection, Shishmaref, Alaska	http://www.poa.usace.army.mil/Portals/34/docs/civilworks/archive/shish117tabe.pdf	Technical Report, Environmental Assessment and Finding of No Significant Impact
USACE	2009	Alaska Coastal Erosion, Shishmaref Alaska, Contract No. W911KB-07-C-0022		
USACE	2009	Shishmaref Beach Stabilization, Condition of Improvement	http://www.poa.usace.army.mil/Portals/34/docs/operations/EFC/2009ShishmarefBeachStabilization.pdf	
USACE	2010	Shishmaref Beach Stabilization, Condition of Improvement	http://www.poa.usace.army.mil/Portals/34/docs/operations/EFC/2010ShishmarefBeachStabilization.pdf	
USACE	2011	Flood Hazard Data: Shishmaref	http://206.174.16.211/floodplain_data/Shishmaref/Documents/shishmaref.pdf	
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USACE	2005	"We're always going back and forth" *Kigiqtaamiut* Subsistence Land Use and Occupancy For the Community of Shishmaref		Prepared by Josh Wisniewski, Alaska District
USACE	1990	Shishmaref, Alaska - Section 103 Preliminary Reconnaissance Report		Memorandum for Commander, North Pacific Division
USACE	2006	An Examination of Erosion Issues in the Communities of Bethel, Dillingham, Kaktovik, Kivalina, Newtok, Shishmaref, and Unalakleet.	http://www.housemajority.org/coms/cli/AVETA_Report.pdf	Alaska Village Erosion Technical Assistance Program
USDA/NRCS	2003	Trip Report Shishmaref Relocation Study, Shishmaref, AK, September 8-12, 2003		
USFWS	2007	Endangered, Threatened, Proposed, Candidate, and Delisted Species in Alaska, April, 2007	http://alaska.fws.gov/fisheries/endangered/pdf/consultation_guide/4_Species_List_April_2007.pdf	
USGS	1906	Progress of Investigations of Mineral Resources of Alaska in 1905	http://www.dggs.alaska.gov/webpubs/usgs/b/text/b0284.PDF	A. Brooks et al. Bulletin No. 284. Series A, Economic Geology, 72
USGS	1908	Mineral Resources of Alaska: Report on Progress of Investigations in 1907	http://www.dggs.alaska.gov/webpubs/usgs/b/text/b0345.PDF	A. Brooks et al. Bulletin No. 345.
USGS	1955	Radioactivity Investigations at Ear Mountain Seward Peninsula Alaska, 1945	http://pubs.usgs.gov/bul/1024c/report.pdf http://www.dggs.alaska.gov/webpubs/usgs/b/oversized/b1024cpt10.PDF http://www.dggs.alaska.gov/webpubs/usgs/b/oversized/b1024cpt11.PDF	Killeen, P. L., Ordway, R. J. Mineral Resources of Alaska, U.S. Atomic Energy Commission. Geological Survey Bulletin 1024-C. Has associated plates (2).
USGS	1998	Alaska Resource Data File: Teller Quadrangle	http://ardf.wr.usgs.gov/quads/html/Teller.html	Newer files available at http://ardf.wr.usgs.gov/ardf_data/1225.pdf
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Western Regional Air Partnership	2005	Alaska Aviation Emission Inventory. Appendix A: Annual Aircraft Activity by Facility and Borough. Appendix F: Detailed Emission Inventories by Facility and Borough.	http://www.wrapair.org/forums/ef/inventories/akai/Aviation_EI_Final_Report.pdf http://www.wrapair.org/forums/ef/inventories/akai/Aviation_EI_Appendix_A.pdf http://www.wrapair.org/forums/ef/inventories/akai/Aviation_EI_Appendix_F.pdf	Prepared by Sierra Research. Report No. SR2005-06-02
WH Pacific, Bechtol Planning and Development	2009	City of Shishmaref, Alaska: Local Hazard Mitigation Plan	https://www.commerce.alaska.gov/dcra/DCRARepoExt/RepoPubs/Plans/Shishmaref%20-%20Feb%202010.pdf	
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Author or Responsible Agency	Date	Title	URLs (as available)	Other Info (as available)
Agency Acronym List				

ADFG	Alaska Department of Fish and Game
ADN	Alaska Dispatch News
AEA	Alaska Energy Authority
AHFC	Alaska Housing Finance Corporation
BEESC	Bristol Environmental & Engineering Services Corporation
BIA	Bureau of Indian Affairs
BOEMRE	U. S. Department of the Interior; Bureau of Ocean Energy Management, Regulation and Enforcement (historic)
BOM	U. S. Department of the Interior; Bureau of Mines (historic)
CRSA	Coastal Resources Service Area
DCCED	Alaska Department of Commerce, Community, and Economic Development
DCRA	Division of Community and Regional Affairs
DGGS	Division of Geological & Geophysical Surveys
DHS&EM	Division of Homeland Security and Emergency Management
DMVA	Alaska Department of Military and Veterans Affairs
DOT/PF	Alaska Department of Transportation and Public Facilities
DOWL Engineers	Dickinson-Oswald-Walch-Lee Engineers (historic)
DWC	Division of Wildlife Conservation
GAO	U.S. General Accounting Office
IAWG	Immediate Action Workgroup
ISER	Institute of Social and Economic Research
NPS	National Park Service
NRCS	Natural Resources Conservation Service
OAI	US Department of Interior; Office of Indian Affairs
SERC	Shishmaref Erosion and Relocation Coalition
SOA	State of Alaska
UAA	University of Alaska, Anchorage
UAF	University of Alaska, Fairbanks
USACE	US Army Corps of Engineers
USDA	US Department of Agriculture
USDOI	US Department of Interior
USFWS	US Fish and Wildlife Service
USGS	US Department of the Interior, U. S. Geological Survey

APPENDIX D

POTENTIAL FUNDING RESOURCES

Many funding sources require matching or shared funding. For example, FEMA requires a 25% **non-federal funding source match** for many of their grants. The Regional Administrator has the opportunity to reduce that share amount to 10% for qualified “Impoverished Communities.” Impoverished community criteria is found in Code of Federal Regulations 44, Section (§)201.2. Definitions.

Potential grant applicants need to research the grant opportunities listed within this Appendix to determine their eligibility to apply for, and the process to, complete and qualify for available funding.

Potential applicants may be able to apply directly to the granting authority or apply under a governing entity. For example, a recognized Tribal government is able to apply directly to a federal agency. However, the tribe will be responsibility to provide or absorb the cost share as a requirement for receiving the grant.

However, tribal governments can apply through their State; the State may in-turn absorb their cost share. However, this is subject to ever changing budget initiatives and is therefore not a guaranteed policy. Available funding resources are becoming more scarce which causes match requirements to adapt to current needs.

Federal Funding Resources

The Federal government requires local governments to have a HMP in place to be eligible for mitigation funding opportunities through FEMA such as the Hazard Mitigation Assistance (HMA) Programs such as the Hazard Mitigation Grant Program (HMGP) and the Flood Mitigation Assistance (FMA) Program. The Hazard Mitigation Technical Assistance Programs (HMTP) available to local governments are also a valuable resource. FEMA may also provide temporary housing assistance through rental assistance, mobile homes, furniture rental, mortgage assistance, and emergency home repairs. The Disaster Preparedness Improvement Grant (DPIG) also promotes educational opportunities with respect to hazard awareness and mitigation.

- **FEMA**, through its **Emergency Management Institute (EMI)**, offers training in many aspects of emergency management, including hazard mitigation. FEMA has also developed a large number of documents that address implementing hazard mitigation at the local level. Five key resource documents are available from FEMA Publication Warehouse (1-800-480-2520) and are briefly described here:
    - How-to Guides. FEMA has developed a series of how-to guides to assist states, communities, and tribes in enhancing their hazard mitigation planning capabilities. The first four guides describe the four major phases of hazard mitigation planning. The last five how-to guides address special topics that arise in hazard mitigation planning such as conducting cost-benefit analysis and preparing multi-jurisdictional plans. The use of worksheets, checklists, and tables make these guides a practical source of guidance to address all stages of the hazard mitigation planning process. They also include special tips on meeting DMA 2000 requirements (http://www.fema.gov/hazard-mitigation-planning-resources#1).
    - Local Mitigation Planning Handbook, March 2013. This handbook explains the basic concepts of hazard mitigation and provides guidance to local governments on developing or updating hazard mitigation plans to meet the requirements of Title 44 Code of Federal Regulations (CFR) §201.6 for FEMA approval and eligibility to apply for FEMA Hazard Mitigation Assistance grant programs. (http://www.fema.gov/library/viewRecord.do?id=7209)
    - A Guide to Recovery Programs FEMA 229(4), September 2005. The programs described in this guide may all be of assistance during disaster incident recovery.

  Some are available only after a Presidential declaration of disaster, but others are available without a declaration. Please see the individual program descriptions for details. (http://www.fema.gov/txt/rebuild/ltrc/recoveryprograms229.txt)
  - The Emergency Management Guide for Business and Industry. FEMA 141, October 1993. This guide provides a step-by-step approach to emergency management planning, response, and recovery. It also details a planning process that businesses can follow to better prepare for a wide range of hazards and emergency events. This effort can enhance a business's ability to recover from financial losses, loss of market share, damages to equipment, and product or business interruptions. This guide could be of great assistance to a community's industries and businesses located in hazard prone areas. (https://www.fema.gov/media-library/assets/documents/3412)
  - The 2015 Hazard Mitigation Assistance (HMA) Guidance and Addendum, February 27 and March 3, 2015 respectively. Part I of the Hazard Mitigation Assistance (HMA) Guidance introduces the three HMA programs, identifies roles and responsibilities, and outlines the organization of the document. This guidance applies to Hazard Mitigation Grant Program (HMGP) disasters declared on or after the date of publication unless indicated otherwise. This guidance is also applicable to the Pre-Disaster Mitigation (PDM) and Flood Mitigation Assistance (FMA) Programs; the application cycles are announced via http://www.grants.gov/. The guidance in this document is subject to change based on new laws or regulations enacted after publication.
- FEMA, http://www.fema.gov - includes links to information, resources, and grants that communities can use in planning and implementing community resilience and sustainability measures.
- FEMA also administers emergency management grants (http://www.fema.gov/help/site.shtm) and various firefighter grant programs (http://www.firegrantsupport.com/) such as
  - Emergency Management Performance Grant (EMPG). This is a pass through grant. The amount is determined by the State. The grant is intended to support critical assistance to sustain and enhance State and local emergency management capabilities at the State and local levels for all-hazard mitigation, preparedness, response, and recovery including coordination of inter-governmental (Federal, State, regional, local, and tribal) resources, joint operations, and mutual aid compacts state-to-state and nationwide. Sub-recipients must be compliant with National Incident Management System (NIMS) implementation as a condition for receiving funds. Requires 50% match. (https://www.fema.gov/fiscal-year-2015-emergency-management-performance-grant-program)
  - National Earthquake Hazards Reduction Program (NEHRP). The National Earthquake Hazards Reduction Program (NEHRP) seeks to mitigate earthquake losses in the United States through both basic and directed research and implementation activities in the fields of earthquake science and engineering. (https://www.fema.gov/national-earthquake-hazards-reduction-program)
    - The NEHRP is the Federal Government's coordinated approach to addressing earthquake risks. Congress established the program in 1977 (Public Law 95-124) as a long-term, nationwide program to reduce the risks to life and property in the United States resulting from earthquakes. The NEHRP is managed as a collaborative effort among FEMA, the National Institute of Standards and Technology, the National Science Foundation, the United States Geological Survey, and the Department of Interior.
    - The four goals of the NEHRP are to:

        - Develop effective practices and policies for earthquake loss-reduction and accelerate their implementation.
        - Improve techniques to reduce seismic vulnerability of facilities and systems.
        - Improve seismic hazards identification and risk-assessment methods and their use.
        - Improve the understanding of earthquakes and their effects.
      - NEHRPDHSnformation may be found at: http://www.fema.gov/plan/prevent/earthquake/nehrp.shtm, and http://www.ehow.com/info_7968511_disaster-research-grant-funding.html
  - Assistance to Fire Fighters Grant (AFG), Fire Prevention and Safety (FP&S), Staffing for Adequate Fire and Emergency Response Grants (SAFER), and Assistance to Firefighters Station Construction Grant programs. Information can be found at: (http://forestry.alaska.gov/fire/vfa.htm).
- **US Department of Homeland Security (DHS)** provides the following grants:
  - Homeland Security Grant Program (HSGP), State Homeland Security Program (SHSP) grants are 80% pass through grants. SHSP supports implementing the State Homeland Security Strategies to address identified planning, organization, equipment, training, and exercise needs for acts of terrorism and other catastrophic events. In addition, SHSP supports implementing the National Preparedness Guidelines, the NIMS, and the National Response Framework (NRF). Must ensure at least 25% of funds are dedicated towards law enforcement terrorism prevention-oriented activities. (https://www.dhs.gov/homeland-security-grant-program-hsgp)
  - Citizen Corps Program (CCP). The Citizen Corps mission is to bring community and government leaders together to coordinate involving community members in emergency preparedness, planning, mitigation, response, and recovery activities. (http://www.dhs.gov/citizen-corps)
  - Emergency Operations Center (EOC) Guidance. This program is intended to improve emergency management and preparedness capabilities by supporting flexible, sustainable, secure, strategically located, and fully interoperable Emergency Operations Centers (EOCs) with a focus on addressing identified deficiencies and needs. Fully capable emergency operations facilities at the State and local levels are an essential element of a comprehensive national emergency management system and are necessary to ensure continuity of operations and continuity of government in major disasters or emergencies caused by any hazard. Requires 25% match. (https://www.fema.gov/media-library/assets/documents/20622)
  - Emergency Alert System (EAS). Resilient public alert and warning tools are essential to save lives and protect property during times of national, state, regional, and local emergencies. The Emergency Alert System (EAS) is used by alerting authorities to send warnings via broadcast, cable, satellite, and wireline communications pathways. Emergency Alert System participants, which consist of broadcast, cable, satellite, and wireline providers, are the stewards of this important public service in close partnership with alerting officials at all levels of government. The EAS is also used when all other means of alerting the public are unavailable, providing an added layer of resiliency to the suite of available emergency communication tools. The EAS is in a constant state of improvement to ensure seamless integration of CAP-based and emerging technologies. (https://www.fema.gov/emergency-alert-system)
- Department of Commerce's grant programs include:
  - National Oceanic and Atmospheric Administration (NOAA), provides funds to the State of Alaska due to Alaska's high threat for tsunami. The allocation supports the promotion of local, regional, and state level tsunami mitigation and preparedness; installation of warning communications systems; installation of warning

    communications systems; installation of tsunami signage; promotion of the Tsunami Ready Program in Alaska; development of inundation models; and delivery of inundation maps and decision-support tools to communities in Alaska. (http://www.tsunami.noaa.gov/warning_system_works.html)
  - Remote Community Alert Systems (RCASP) grant for outdoor alerting technologies in remote communities effectively underserved by commercial mobile service for the purpose of enabling residents of those communities to receive emergency messages. (http://www.federalgrants.com/Remote-Community-Alert-Systems-Program-11966.html) This program is a contributing element of the Warning, Alert, and Response Network (WARN) Act.
  - Public Works and Development Facilities Program. This program provides assistance to help distressed communities attract new industry, encourage business expansion, diversify local economies, and generate long-term, private sector jobs. Among the types of projects funded are water and sewer facilities, primarily serving industry and commerce; access roads to industrial parks or sites; port improvements; business incubator facilities; technology infrastructure; sustainable development activities; export programs; brownfields redevelopment; aquaculture facilities; and other infrastructure projects. Specific activities may include demolition, renovation, and construction of public facilities; provision of water or sewer infrastructure; or the development of stormwater control mechanisms (e.g., a retention pond) as part of an industrial park or other eligible project. (http://cfpub.epa.gov/fedfund/program.cfm?prog_num=51)
- **Environmental Protection Agency (EPA)**. Under EPA's Clean Water State Revolving Fund (CWSRF) program, each state maintains a revolving loan fund to provide independent and permanent sources of low-cost financing for a wide range of water quality infrastructure projects, including: municipal wastewater treatment projects; non-point source projects; watershed protection or restoration projects; and estuary management projects. (http://yosemite.epa.gov/R10/ecocomm.nsf/6da048b9966d22518825662d00729a35/7b68c420b668ada5882569ab00720988!OpenDocument)
  - Indian Environmental General Assistance Program (IGAP). 1992, Congress passed the Indian Environmental General Assistance Program Act (42 U.S.C. 4368b) which authorizes EPA to provide General Assistance Program (GAP) grants to federally-recognized tribes and tribal consortia for planning, developing, and establishing environmental protection programs in Indian country, as well as for developing and implementing solid and hazardous waste programs on tribal lands.

    The goal of this program is to assist tribes in developing the capacity to manage their own environmental protection programs, and to develop and implement solid and hazardous waste programs in accordance with individual tribal needs and applicable federal laws and regulations. http://www.epa.gov/Indian/gap.htm

  - Wastewater in Tribal Communities. EPA provides funding to tribal communities for the planning, design and construction of wastewater infrastructure and for water pollution control through the following programs (some programs listed below also provide funding for drinking water infrastructure): http://water.epa.gov/type/watersheds/wastewater/Grants-and-Funding.cfm)
    - Alaska Native Village and Rural Communities Sanitation Grant Program – Provides grants to Alaska Native Villages and rural Alaskan communities for the construction of drinking water and wastewater treatment systems, improvements in existing systems, and for training and technical assistance in the operations and maintenance of these systems.

    - Clean Water Indian Set-Aside (ISA) Grant Program – Provides grants for wastewater infrastructure to Indian tribes and Alaska Native Villages.
    - Section 106 Tribal Pollution Grant Control Program – Provides grants to federally-recognized Indian tribes to assist in the development and implementation of water pollution control programs.
    - EPA's Tribal Portal has additional links to grants and funding resources.
    - Tribal Resource Directory for Drinking Water and Wastewater Treatment – A searchable catalog of over thirty federal and non-federal programs that offer funding and technical support for tribal drinking water and wastewater systems, many of which are also available to non-tribal entities.
- **US Department of Agriculture (USDA)**. Provides diverse funding opportunities; providing a wide benefit range. Their grants and loans website provides a brief programmatic overview with links to specific programs and services. (http://www.rd.usda.gov/programs-services)
  - Farm Service Agency: Emergency Conservation Program, Non-Insured Assistance, Emergency Forest Restoration Program, Emergency Watershed Protection, Rural Housing Service, Rural Utilities Service, and Rural Business and Cooperative Service. (http://www.fsa.usda.gov/FSA/stateoffapp?mystate=ak&area=home&subject=landing&topic=landing)
  - Natural Resources Conservation Service (NRCS) has several funding sources to fulfill mitigation needs. (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/alphabetical/)
    - Conservation Technical Assistance Program (CTA) is voluntary program available to any group or individual interested in conserving their natural resources and sustaining agricultural production. The program assists land users with addressing opportunities, concerns, and problems related to using their natural resources enabling them to make sound natural resource management decisions on private, tribal, and other non-federal lands. (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/technical/)
    - Conservation Innovation Grants (CIG) is a voluntary program intended to stimulate developing and adopting innovative conservation approaches and technologies while leveraging Federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under CIG, Environmental Quality Incentives Program funds are used to award competitive grants to non-Federal governmental or nongovernmental organizations, Tribes, or individuals.

      CIG enables NRCS to work with other public and private entities to accelerate technology transfer and adoption of promising technologies and approaches to address some of the Nation's most pressing natural resource concerns. CIG will benefit agricultural producers by providing more options for environmental enhancement and compliance with Federal, State, and local regulations. (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/cig/)

    - The Environmental Quality Incentives Program (EQIP) is a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of ten years in length. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and for opportunities to improve soil, water, plant, animal, air and related resources on agricultural land and non-industrial private forestland. In addition, a purpose of EQIP is to help producers meet

    - Federal, State, Tribal and local environmental regulations. (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/eqip/?cid=stelprdb1242633)
    - The Emergency Watershed Protection Program (EWP) is designed is to undertake emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other natural occurrence is causing or has caused a sudden impairment of the watershed. (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/)
    - Watershed Surveys and Planning. NRCS watershed activities in Alaska are voluntary efforts requested through conservation districts and units of government and/or tribes. The purpose of the program is to assist Federal, State, and local agencies and tribal governments to protect watersheds from damage caused by erosion, floodwater, and sediment and to conserve and develop water and land resources. Resource concerns addressed by the program include water quality, opportunities for water conservation, wetland and water storage capacity, agricultural drought problems, rural development, municipal and industrial water needs, upstream flood damages, and water needs for fish, wildlife, and forest-based industries. (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wsp/)
- **US Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy, Weatherization Assistance Program.** This program minimizes the adverse effects of high energy costs on low-income, elderly, and handicapped citizens through client education activities and weatherization services such as an all-around safety check of major energy systems, including heating system modifications and insulation checks. (http://www1.eere.energy.gov/wip/wap.html)
  - The Tribal Energy Program offers financial and technical assistance to Indian tribes to help them create sustainable renewable energy installations on their lands. This program promotes tribal energy self-sufficiency and fosters employment and economic development on America's tribal lands. (http://energy.gov/eere/wipo/tribal-energy-program)
- **US Department of Health and Human Services (DHHS), Administration of Children & Families, Administration for Native Americans (ANA)**. The ANA awards funds through grants to American Indians, Native Americans, Native Alaskans, Native Hawaiians, and Pacific Islanders. These grants are awarded to individual organizations that successfully apply for discretionary funds. ANA publishes in the Federal Register an announcement of funds available, the primary areas of focus, review criteria, and application information. (http://www.acf.hhs.gov/grants/open/foa/)
- **Department of Housing and Urban Development (HUD)** provides a variety of disaster resources. They also partner with Federal and state agencies to help implement disaster recovery assistance. Under the *National Response Framework* the FEMA and the Small Business Administration (SBA) offer initial recovery assistance. (http://www.hud.gov/info/disasterresources_dev.cfm)
  - HUD, Office of Homes and Communities, Section 108 Loan Guarantee Programs. This program provides loan guarantees as security for Federal loans for acquisition, rehabilitation, relocation, clearance, site preparation, special economic development activities, and construction of certain public facilities and housing. (http://www.hud.gov/offices/cpd/communitydevelopment/programs/108/index.cfm)

- HUD, Office of Homes and Communities, Section 184 Indian Home Loan Guarantee Programs (IHLGP). The Section 184 Indian Home Loan Guarantee Program is a home mortgage specifically designed for American Indian and Alaska Native families, Alaska Villages, Tribes, or Tribally Designated Housing Entities. Section 184 loans can be used, both on and off native lands, for new construction, rehabilitation, purchase of an existing home, or refinance.
- Because of the unique status of Indian lands being held in Trust, Native American homeownership has historically been an underserved market. Working with an expanding network of private sector and tribal partners, the Section 184 Program endeavors to increase access to capital for Native Americans and provide private funding opportunities for tribal housing agencies with the Section 184 Program. (http://www.hud.gov/offices/pih/ih/homeownership/184/)
- Indian Housing Block Grant / Native American Housing Assistance and Self Determination Act (IHBG/NAHASDA) administration, operating & construction funds. The act is separated into seven sections:

  The Indian Housing Block Grant Program (IHBG) is a formula grant that provides a range of affordable housing activities on Indian reservations and Indian areas. The block grant approach to housing for Native Americans was enabled by the Native American Housing Assistance and Self Determination Act of 1996 (NAHASDA).

  Eligible IHBG recipients are Federally recognized Indian tribes or their tribally designated housing entity (TDHE), and a limited number of state recognized tribes who were funded under the Indian Housing Program authorized by the United States Housing Act of 1937 (USHA). With the enactment of NAHASDA, Indian tribes are no longer eligible for assistance under the USHA.

  An eligible recipient must submit to HUD an Indian Housing Plan (IHP) each year to receive funding. At the end of each year, recipients must submit to HUD an Annual Performance Report (APR) reporting on their progress in meeting the goals and objectives included in their IHPs.

  Eligible activities include housing development, assistance to housing developed under the Indian Housing Program, housing services to eligible families and individuals, crime prevention and safety, and model activities that provide creative approaches to solving affordable housing problems. (http://portal.hud.gov/hudportal/HUD?src=/program_offices/public_indian_housing/ih/grants/ihbg)

- Community Development Block Grants (CDBG) provides grant assistance and technical assistance to aid communities in planning activities that address issues detrimental to the health and safety of local residents, such as housing rehabilitation, public services, community facilities, and infrastructure improvements that would primarily benefit low-and moderate-income. persons (http://www.hud.gov/offices/cpd/communitydevelopment/programs/)
- National Disaster Resilience (NDR) grant is a HUD/CDBG. The grant opportunity is called the Community Block Development Grant-National Disaster Resilience (CDBG-NDR). HUD sponsors the National Disaster Resilience Competition (NDRC) to help eligible communities impacted by federally declared disasters in 2011, 2012 and 2013 become more resilient. The NDRC is a two-phase process that will competitively award nearly $1 billion in HUD Disaster Recovery funds to the most impacted, distressed and needy eligible communities. The grant opportunity is called the Community Block Development Grant-National Disaster Resilience (CDBG-

  NDR). The State of Alaska is one of many applicants nationwide eligible to apply on behalf of its impacted communities. (https://www.hudexchange.info/course-content/ndrc-nofa-phase-1-factors/NDRC-NOFA-Phase-1-Factors-Slides-2014-11-03.pdf)
  - HUD/Indian Community Development Block Grants (ICDBG) provide grant assistance and technical assistance to aid communities or Indian tribes in planning activities that address issues detrimental to the health and safety of local residents, such as housing rehabilitation, public services, community facilities, and infrastructure improvements that would primarily benefit low-and moderate-income. persons (http://portal.hud.gov/hudportal/HUD?src=/program_offices/public_indian_housing/ih/grants/icdbg)
- **US Department of Labor (DOL)**, Employment and Training Administration, Disaster Unemployment Assistance (DUA). Provides weekly unemployment subsistence grants for those who become unemployed because of a major disaster or emergency. Applicants must have exhausted all benefits for which they would normally be eligible. (http://www.workforcesecurity.doleta.gov/unemploy/disaster.asp)
  - The Workforce Investment Act contains provisions aimed at supporting employment and training activities for Indian, Alaska Native, and Native Hawaiian individuals. The Department of Labor's Indian and Native American Programs (INAP) funds grant programs that provide training opportunities at the local level for this target population. (http://www.dol.gov/dol/topic/training/indianprograms.htm)
- **US Department of Transportation (DOT)**, Hazardous Materials Emergency Preparedness (HMEP) Grant. The Hazardous Materials Transportation Safety and Security Reauthorization Act of 2005 authorizes the U.S. DOT to provide assistance to public sector employees through training and planning grants to States, Territories, and Native American tribes for emergency response. The purpose of this grant program is to increase State, Territorial, Tribal, and local effectiveness in safely and efficiently handling hazardous materials accidents and incidents, enhance implementation of the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA), and encourage a comprehensive approach to emergency training and planning by incorporating the unique challenges of responses to transportation situations. (http://www.phmsa.dot.gov/hazmat/grants)
- Federal Financial Institutions. Member banks of Federal Deposit Insurance Corporation, Financial Reporting Standards or Federal Home Loan Bank Board may be permitted to waive early withdrawal penalties for Certificates of Deposit and Individual Retirement Accounts.
- **Internal Revenue Service (IRS),** Disaster Tax Relief. Provides extensions to current year's tax return, allows deductions for disaster losses, and allows amendment of previous year’s tax returns (http://www.irs.gov/Businesses/Small-Businesses-%26-Self-Employed/Disaster-Assistance-and-Emergency-Relief-for-Individuals-and-Businesses-1).
- **Small Business Administration (SBA)** Disaster Assistance Loans and Grants program provides information concerning disaster assistance, preparedness, planning, cleanup, and recovery planning. (https://www.sba.gov/category/navigation-structure/loans-grants)

  May provide low-interest disaster loans to individuals and businesses that have suffered a loss due to a disaster. (https://www.sba.gov/category/navigation-structure/loans-grants/small-business-loans/disaster-loans). Requests for SBA loan assistance should be submitted to DHS&EM.

- **US Army Corps of Engineers (USACE)** Alaska District's Civil Works Branch studies potential water resource projects in Alaska. These studies analyze and solve water resource issues of concern to the local communities. These issues may involve navigational improvements, flood control or ecosystem restoration. The agency also tracks flood hazard data for over 300 Alaskan communities on floodplains or the sea coast. These data help local communities assess the risk of floods to their communities and prepare for potential future floods. The USACE is a member and co-chair of the Alaska Climate Change Sub-Cabinet.
    - Civil Works and Planning (http://www.poa.usace.army.mil/Missions/CivilWorksandPlanning.aspx)
    - Environmental Resources Section (http://www.poa.usace.army.mil/About/Offices/Engineering/EnvironmentalResources.aspx)
    - USACE Alaska District Grants (http://search.usa.gov/search?affiliate=alaska_district&query=grants)
- The **Grants.gov** program management office was established, in 2002, as a part of the President's Management Agenda. Managed by the Department of Health and Human Services, Grants.gov is an E-Government initiative operating under the governance of the Office of Management and Budget.

  Under the President's Management Agenda, the office was chartered to deliver a system that provides a centralized location for grant seekers to find and apply for federal funding opportunities. Today, the Grants.gov system houses information on over 1,000 grant programs and vets grant applications for 26 federal grant-making agencies.

State Funding Resources

- **Department of Military and Veterans Affairs (DMVA)**: Provides damage appraisals and settlements for VA-insured homes, and assists with filing of survivor benefits. (http://veterans.alaska.gov/links.htm)
    - **DHS&EM** within DMVA is responsible for improving hazard mitigation technical assistance for local governments for the State of Alaska. Providing hazard mitigation training, current hazard information and communication facilitation with other agencies will enhance local hazard mitigation efforts. DHS&EM administers FEMA mitigation grants to mitigate future disaster damages such as those that may affect infrastructure including elevating, relocating, or acquiring hazard-prone properties. (http://ready.alaska.gov/plans/mitigation.htm)

      DHS&EM also provides mitigation funding resources for mitigation planning on their Web site at http://ready.alaska.gov/grants.
- **Division of Health and Social Services (DHSS)**: On this site you will find information intended to assist all who are interested in DHSS grants and services they support. (http://dhss.alaska.gov/fms/grants/Pages/grants.aspx and http://dhss.alaska.gov/fms/Documents/FY15GrantBook.pdf)
- **Division of Health and Social Services (DSS)**: Provides special outreach services for seniors, including food, shelter and clothing. (http://dhss.alaska.gov/dsds/Pages/hcb/hcb.aspx)
- **Division of Insurance (DOI)**: Provides assistance in obtaining copies of policies and provides information regarding filing claims. (http://commerce.state.ak.us/dnn/ins/Consumers/AlaskaConsumerGuide.aspx)

- Department of Commerce, Community and Economic Development (DCCED) mission To Promote A Healthy Economy, Strong Communities, and Protect Consumers in Alaska.
    - **Division of Community and Regional Affairs (DCRA)** administers the HUD/CDBG, FMA Program, and the Climate Change Sub-Cabinet's Interagency Working Group's program funds and administers various flood and erosion mitigation projects, including the elevation, relocation, or acquisition of flood-prone homes and businesses throughout the State. This division also administers programs for State's" distressed" and "targeted" communities. (http://www.commerce.state.ak.us/dca/)
        - DCRA Planning and Land Management staff provide Alaska Climate Change Impact Mitigation Program (ACCIMP) funding to Alaskan communities that meet one or more of the following criteria related to flooding, erosion, melting permafrost, or other climate change-related phenomena: Life/safety risk during storm/flood events; loss of critical infrastructure; public health threats; and loss of 10% of residential dwellings. (http://commerce.state.ak.us/dnn/dcra/PlanningLandManagement/ACCIMP.aspx)
        - The Hazard Impact Assessment is the first step in the ACCIMP process. The HIA identifies and defines the climate change-related hazards in the community, establishes current and predicted impacts, and provides recommendations to the community on alternatives to mitigate the impact. (http://commerce.alaska.gov/dca/planning/accimp/hazard_impact.html)
- **Department of Environmental Conservation (DEC)**. DEC's primary roles and responsibilities concerning hazards mitigation are ensuring safe food and safe water, and pollution prevention and pollution response. DEC ensures water treatment plants, landfills, and bulk fuel storage tank farms are safely constructed and operated in communities. Agency and facility response plans include hazards identification and pollution prevention and response strategies. (http://dec.alaska.gov/)
    - The Division of Water's, Village Safe Water (VSW) Program works with rural communities to develop sustainable sanitation facilities. Communities apply each year to VSW for grants for sanitation projects. Federal and state funding for this program is administered and managed by the VSW program. VSW provides technical and financial support to Alaska's smallest communities to design and construct water and wastewater systems. In some cases, funding is awarded by VSW through the Alaska Native Tribal Health Consortium (ANTHC), who in turn assist communities in design and construct of sanitation projects.
    - Municipal Grants and Loans (MGL) Program. The Department of Environmental Conservation / Division of Water administer the Alaska Clean Water Fund (ACWF) and the Alaska Drinking Water Fund (ADWF). The division is fiscally responsible to the Environmental Protection Agency (EPA) to administer the loan funds as the EPA provides capitalization grants to the division for each of the loan funds. In addition, it is prudent upon the division to administer the funds in a manner that ensures their continued viability. (http://dec.alaska.gov/water/MuniGrantsLoans/loanoverview.html
    - Alaska's Clean Water State Revolving Fund (CWSRF) program, maintains a revolving loan fund to provide independent and permanent sources of low-cost financing for a wide range of water quality infrastructure projects, including: municipal wastewater treatment projects; non-point source projects; watershed protection or restoration projects; and estuary management, [and stormwater management] projects. (http://yosemite.epa.gov/R10/ecocomm.nsf/6da048b9966d22518825662d00729a35/7b68c420b668ada5882569ab00720988!OpenDocument)

    - Alaska's Revolving Loan Fund Program, prescribed by Title VI of the Clean Water Act as amended by the Water Quality Act of 1987, Public Law 100-4. DEC will use the ACWF account to administer the loan fund. This Agreement will continue from year-to-year and will be incorporated by reference into the annual capitalization grant agreement between EPA and the DEC. DEC will use a fiscal year of July 1 to June 30 for reporting purposes. (http://www.epa.gov/region10/pdf/water/srf/cwsrf_alaska_operating_agreement.pdf)

- **Department of Transportation and Public Facilities (DOT/PF)** personnel provide technical assistance to the various emergency management programs, to include mitigation. This assistance is addressed in the DHS&EM-DOT/PF Memorandum of Agreement and includes but is not limited to: environmental reviews, archaeological surveys, and historic preservation reviews.
  - DOT/PF and DHS&EM coordinate buy-out projects to ensure that there are no potential right-of-way conflicts with future use of land for bridge and highway projects, and collaborate on earthquake mitigation.
  - Additionally, DOT/PF provides the safe, efficient, economical, and effective State highway, harbor, and airport operation. DOT/PF uses it's Planning, Design and Engineering, Maintenance and Operations, and Intelligent Transportation Systems resources to identify hazards, plan and initiate mitigation activities to meet the transportation needs of Alaskans, and make Alaska a better place to live and work. DOT/PF budgets for temporary bridge replacements and materials necessary to make the multi-modal transportation system operational following natural disaster events.
- **Department of Natural Resources (DNR)** administers various projects designed to reduce stream bank erosion, reduce localized flooding, improve drainage, and improve discharge water quality through the stormwater grant program funds. Within DNR,
  - The **Division of Geological and Geophysical Survey (DGGS**) is responsible Alaska's mineral, land, and water resources use, development, and earthquake mitigation collaboration.

    Their geologists and support staff are leaders in researching Alaska's geology and implementing technological tools to most efficiently collect, interpret, publish, archive, and disseminate information to the public. (http://dggs.alaska.gov/pubs/advanced-search)

  - The **Division of Forestry (DOF)** participates in a statewide wildfire control program in cooperation with the forest industry, rural fire departments and other agencies. Prescribed burning may increase the risks of fire hazards; however, prescribed burning reduces the availability of fire fuels and therefore the potential for future, more serious fires. (http://forestry.alaska.gov/pdfs/08FireSuppressionMediaGuide.pdf)

    DOF also manages various wildland fire programs, activities, and grant programs such as the FireWise Program (http://forestry.alaska.gov/fire/firewise.htm), Community Forestry Program (CFP) (http://forestry.alaska.gov/community/), Assistance to Fire Fighters Grant (AFG), Fire Prevention and Safety (FP&S), Staffing for Adequate Fire and Emergency Response Grants (SAFER), and Volunteer Fire Assistance and Rural Fire Assistance Grant (VFA-RFA) programs (http://forestry.alaska.gov/fire/vfarfa.htm). Information can be found at http://forestry.alaska.gov/fire/current.htm.

  - The Alaska Interagency Coordination Center (AICC) is the Geographic Area Coordination Center for Alaska. AICC serves as the focal point for initial attack resource coordination, logistics support, and predictive services for all state and federal agencies involved in wildland fire management and suppression in Alaska.
    - Fire management planning, preparedness, suppression operations, prescribed burning, and related activities are coordinated on an interagency basis. DOF has cooperative agreements with the Departments of Agriculture and Interior, and numerous local government and volunteer fire departments to respond to wildland fires, reduce duplication of efforts, and share resources.
    - In 1984 the State of Alaska adopted the National Interagency Incident Management System Incident Command System concept for managing fire suppression. The Incident Command System (ICS) guiding principles are followed in all wildland fire management operations. All State of Alaska Departments adopted ICS in 1996 through the Governor's administrative order.

Other Funding Resources

The following provide focused access to valuable planning resources for communities interested in sustainable development activities.

- **Rural Alaska Community Action Program Inc. (RurAL CAP)** In the nearly 50 years since it began, it is difficult to imagine any aspect of rural Alaskan lives which has not been touched in some way by the people and programs of RurAL CAP. From Head Start, parent education, adult basic education, and elder-youth programs, to Native land claims and subsistence rights, energy and weatherization programs, and alcohol and substance abuse prevention, RurAL CAP has left a lasting mark on the history and development of Alaska and its rural Peoples. (http://ruralcap.com/?page_id=334)
  - Weatherization Assistance Program assists low to moderate income households in weatherization needs. The program is available to homeowners as well as renters and includes; single family homes, cabins, mobile homes, condominiums and multifamily dwellings. (http://ruralcap.com/?page_id=794)
  - Solid Waste Management. RurAL CAP continues to host an expert solid waste liaison, Ted Jacobson, through funding provided by the Environmental Protection Agency (EPA) and Senior Services America, Inc. The liaison provides solid waste management technical assistance to rural communities through training, site visits, hands-on demonstrations, and remote contact. Resources are provided for dump management activities, collaborating with funders for funding and technical assistance on solid waste management, recycling, and backhaul. (http://ruralcap.com/?page_id=198
- **American Planning Association (APA)**, http://www.planning.org - a non-profit professional association that serves as a resource for planners, elected officials, and citizens concerned with planning and growth initiatives.
- **Institute for Business and Home Safety (IBHS)**, an initiative of the insurance industry to reduce deaths, injuries, property damage, economic losses, and human suffering caused by natural disasters. (http://www.disastersafety.org/)
- **American Red Cross (ARC).** Provides for the critical needs of individuals such as food, clothing, shelter, and supplemental medical needs. Provides recovery needs such as furniture, home repair, home purchasing, essential tools, and some bill payment may be provided. (http://www.redcross.org/find-help)
- **Catalog of Federal Domestic Assistance (DFDA) Crisis Counseling Program (CCP).** Provides grants to State and Borough Mental Health Departments, which in turn provide training for screening, diagnosing and counseling techniques. Also provides

funds for counseling, outreach, and consultation for those affected by disaster. (http://dialoguemakers.org/Resourses4states+Nonprofits.htm)

- **Denali Commission.** Introduced by Congress in 1998, the Denali Commission is an independent federal agency designed to provide critical utilities, infrastructure, and economic support throughout Alaska. With the creation of the Denali Commission, Congress acknowledged the need for increased inter-agency cooperation and focus on Alaska's remote communities. Since its first meeting in April 1999, the Commission is credited with providing numerous cost-shared infrastructure projects across the State that exemplifies effective and efficient partnership between federal and state agencies, and the private sector. (http://www.denali.gov/grants)
  - The Energy Program primarily funds design and construction of replacement bulk fuel storage facilities, upgrades to community power generation and distribution systems, alternative-renewable energy projects, and some energy cost reduction projects. The Commission works with the Alaska Energy Authority (AEA), Alaska Village Electric Cooperative (AVEC), Alaska Power and Telephone and other partners to meet rural communities' fuel storage and power generation needs.
  - The goal of the solid waste program at the Denali Commission is to provide funding to address deficiencies in solid waste disposal sites which threaten to contaminate rural drinking water supplies.
- **Lindbergh Foundation Grants.** Each year, The Charles A. and Anne Morrow Lindbergh Foundation provides grants of up to $10,580 (a symbolic amount representing the cost of the Spirit of St. Louis) to men and women whose individual initiative and work in a wide spectrum of disciplines furthers the Lindberghs' vision of a balance between the advance of technology and the preservation of the natural/human environment. (http://www.thelindberghfoundation.org/awards)
- **Rasmuson Foundation Grants.** The Rasmuson foundation invests both in individuals and well-managed 501(c)(3) organizations dedicated to improving the quality of life for Alaskans.
  - Rasmuson Foundation awards grants both to organizations serving Alaskans through a base of operations in Alaska, and to individuals for projects, fellowships and sabbaticals. To be considered for a grant award, grant seekers must meet specific criteria and complete and submit the required application according to the specific guidelines of each program. (http://www.rasmuson.org/index.php?switch=viewpage&pageid=5)
    - Tier 1 Awards: Grants of up to $25,000 for capital projects, technology updates, capacity building, program expansion, and creative works.
    - Tier 2 Awards: Grants over $25,000 for projects of demonstrable strategic importance or innovative nature.
    - Pre-Development Program: Guidance and technical resources for planning new, sustainable capital projects.

      The Foundation trustees believe successful organizations can sustain their basic operations through other means of support and prefer to assist organizations with specific needs, focusing on requests which allow the organizations to become more efficient and effective. The trustees look favorably on organizations which demonstrate broad community support, superior fiscal management and matching project support. (http://www.rasmuson.org/index.php)

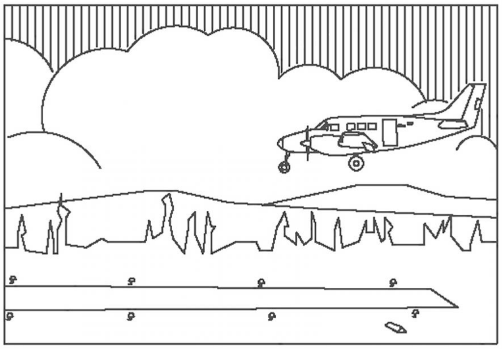
APPENDIX E

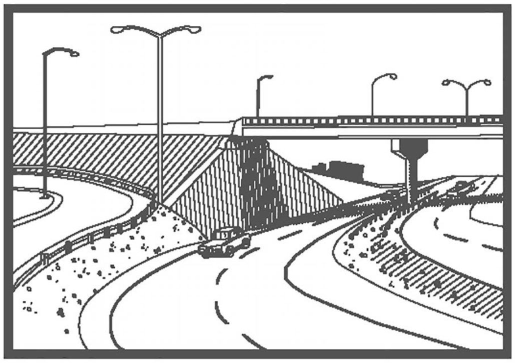
SHISHMAREF RELOCATION ROAD AK 115 VILLAGE RELOCATION SITES AND MATERIAL SOURCE ACCESS ROAD; AKSAS 76779

GEOTECHNICAL INVESTIGATION REPORT

SHISHMAREF RELOCATION ROAD AK 115 VILLAGE RELOCATION SITES AND MATERIAL SOURCE ACCESS ROAD

AKSAS 76779





STATE OF ALASKA

Department of Transportation
and Public Facilities

NORTHERN REGION

AUGUST 2015

GEOTECHNICAL INVESTIGATION REPORT
SHISHMAREF RELOCATION ROAD AK 115 VILLAGE RELOCATION SITES & MATERIAL SOURCE ACCESS ROAD:
76779/002199
AUGUST 2015

PREPARED BY:

MATT BILLINGS
Engineering Geologist

REVIEWED BY:

KEVIN MAXWELL
Regional Geologist

APPROVED BY:

STATE OF ALASKA
49TH
8-5-15
JEFFREY L. CURREY
CE 10813
REGISTERED PROFESSIONAL ENGINEER

JEFF CURREY, P.E.
Materials Engineer

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Introduction

The Alaska Department of Transportation and Public Facilities (ADOT&PF) is investigating a proposed access road that would lead to a potential material source on Ear Mountain, near Shishmaref, Alaska. ADOT&PF is also investigating three proposed relocation sites for the village of Shishmaref. The proposed alignment stretches approximately 17.5 miles from the tidewater of Shishmaref Inlet to the potential material source on Ear Mountain. This site, intended to supply construction material for this and other projects in the area, was identified in a previous 2009 ADOT&PF geotechnical investigation. The proposed village relocation sites, known as the Old Pond Site, West Tin Creek Hills, and Tin Creek were identified by R&M Consultants, Inc. Each site covers an approximate 100-acre area, and measures approximately 2,100 feet in each dimension. The approximate location and extent of the investigated portion of the proposed Ear Mountain material site access road, as well as the three proposed village relocation sites are shown in Figure 1.

Northern Region Material Section (NRMS) personnel recently conducted geotechnical drilling along a portion of the proposed material site access road, as well as within each of the three proposed village relocation sites. The purpose of this investigation was to provide reconnaissance-level information of the subsurface conditions underlying the three village relocation sites and the possible material source access road. This information is intended to aid designers in the selection and design of both a possible material source access road and a possible village relocation site.

This report documents physical site conditions and subsurface geotechnical conditions. This report also provides interpretation of anticipated site conditions, as well as design considerations for the project.

Summary

Thirty-five solid-stem test holes were drilled and 90 soil samples were collected during this investigation. Drilling was conducted on the snow surface and drill depths ranged between 10 feet and 35 feet below snow surface (bss).

In general, either massive ice or ice-rich silt was encountered where frozen, and wet, loose silt was encountered where thawed. The majority of the thawed, loose soil was encountered within the Old Pond Site, while the majority of massive ice was encountered within the hill-top and hill-slope portions of the Tin Creek Site and proposed material source access road. The massive ice encountered within areas of relatively high topographic relief is believed to be that of a cryogenic landform termed a yedoma. The West Tin Creek Hills Site generally exhibited several feet of peat and organic-rich silt overlying perennially frozen silt with varying concentration of visible ice. Where discernable, seasonal frost extended between 3.5 feet and 9 feet below ground surface (bgs) and commonly extended on the order of 4 feet bgs.

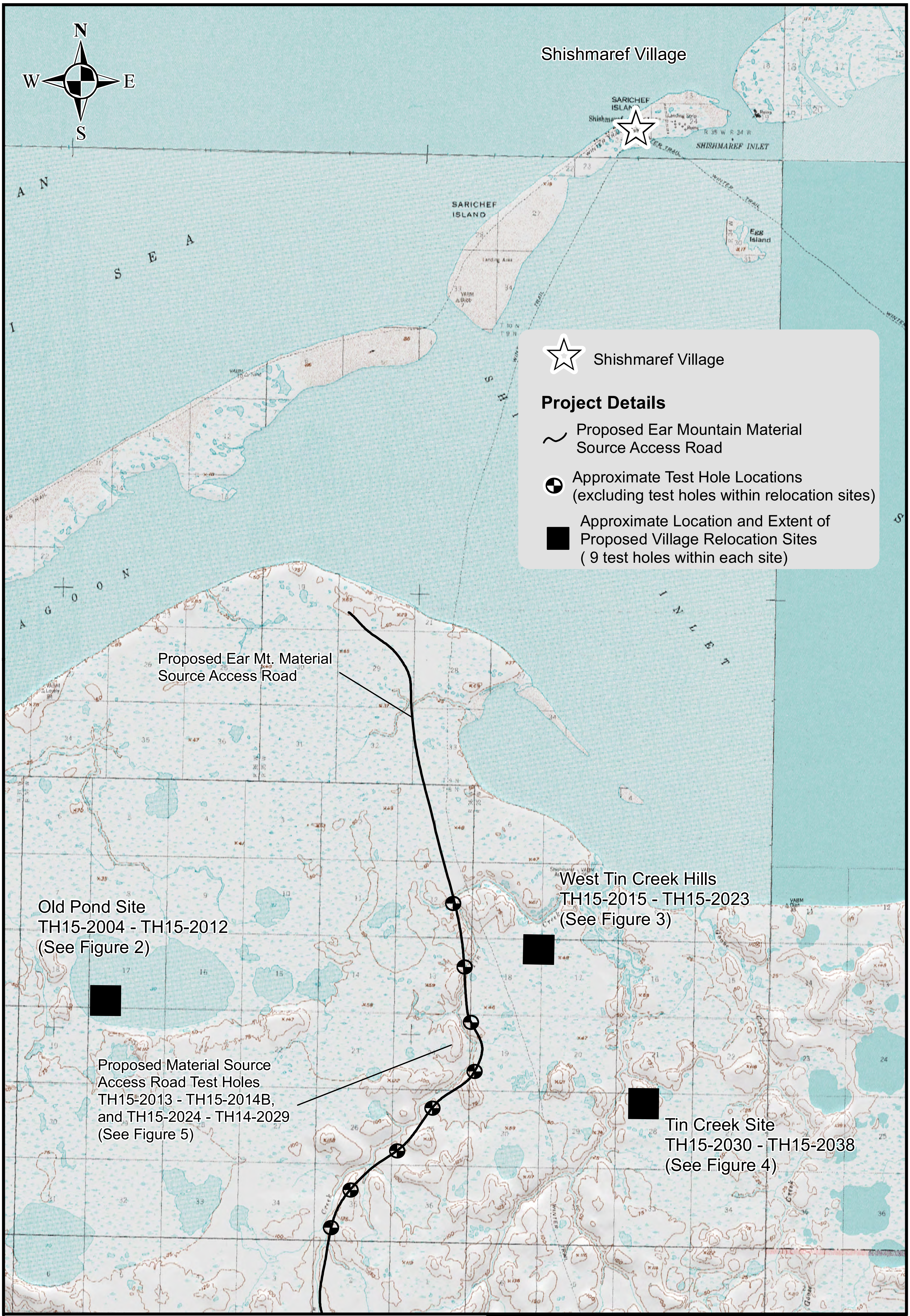


Figure 1

Approximate Test Hole Locations, Extent of Proposed Material Source Access Road, and Village Relocation Sites

ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
NORTHERN REGION

Miles
0 0.5 1 2 3 4 5

DATE: August 05, 2015

SHEET: 1 of 1

Basic design considerations include thaw stability of frozen soil, bearing capacity and consolidation of loose and thawed soil, and frost susceptibility. In general, frozen soils appear thaw-unstable, with a decrease in thaw stability associated with an increase in ice content. In addition, thawed soils (particularly within the Old Pond Site) appear loose and likely have a low bearing capacity. The soil within the investigated area may be frost-susceptible.

Physical Setting

Location and Geologic Setting

Shishmaref is located on Sarichef Island, which lies approximately 530 miles west-northwest of Fairbanks, Alaska. Sarichef Island lies north of the Arctic Circle and is one of the many off-shore barrier islands that border the northwest shoreline of the Seward Peninsula.

The investigated area is located on the mainland of the Seward Peninsula, approximately 11 miles to 15 miles from the village of Shishmaref across Shishmaref Inlet. This area lies within an arctic coastal plain that is underlain by permafrost and is characterized by polygonal ground patterns, thaw ponds, small drainages, pingos and yedoma. Yedoma are perennially frozen, ice-rich hills believed to have resulted from the syngenetic development of permafrost, ice-wedges, and deposition of wind-blown silt (loess) during the late Pleistocene – resulting in topographic features consisting largely of ice and organic-rich silt. Muskeg tundra consisting of moss and lichen covers the area, while sedges, grasses and shrubby willows are largely confined to areas near water bodies and drainages, and alder thickets are largely confined to hill-slopes. Subsurface soil in this region generally consists of ice-rich peat over ice-rich silt over sandy silt to silty fine sand.

Climate

Shishmaref lies within the Transitional Climate Zone of Alaska. Due to proximity with the Arctic Ocean, the region’s climate has a marine influence in the summer months, when the ice pack goes out. During the winter months, however, this region’s climate is more continental, resulting in relatively cold and dry winters. Shishmaref weather data is limited; therefore, weather data for nearby Wales (approximately 73 miles southwest) and nearby Kotzebue (approximately 105 miles northeast) were used for our analysis. The average monthly temperatures for both Wales and Kotzebue, made available through the Western Regional Climate Data Center (WRCC), are summarized in Table 1.

The freezing and thawing indices for both Wales and Kotzebue were calculated using the 1981 through 2010, 30-year daily average temperatures made available through the WRCC website (http://www.wrcc.dri.edu). Design freezing and thawing indices for these communities were calculated from the three coldest winters and three warmest summers observed from available data. The freezing and thawing indices, as well as the design freezing and thawing indices calculated for these two communities are illustrated in Table 2. These values should be used with

Table 1: Average monthly temperatures for both Wales, and Kotzebue, Alaska

Average Monthly Temperatures of Wales, Alaska (recorded between 10/10/1925 and 08/31/1995)												
Months	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Average Max. Temperature (°F)	8.4	2.8	5.8	16.4	32.1	43.3	51.0	50.7	43.8	32.7	22.3	10.1
Average Min. Temperature (°F)	-5.9	-10.6	-8.3	3.5	22.9	33.3	41.7	42.4	36.4	24.7	11.0	-2.7
Ave. Daily Temperature (°F)	1.3	-3.9	-1.3	10.0	27.5	38.3	46.4	46.6	40.1	28.7	16.7	3.7
Average Monthly Temperatures of Kotzebue, Alaska (recorded between 09/12/1897 and 01/20/2015)												
Average Max. Temperature (°F)	3.8	4.2	8.4	21.4	38.0	50.7	59.2	56.5	46.9	28.2	14.0	5.5
Average Min. Temperature (°F)	-9.5	-10.2	-7.9	4.3	25.1	38.8	48.8	47.1	37.3	19.0	3.4	-7.3
Ave. Daily Temperature (°F)	-2.9	-3.0	0.3	12.9	31.6	44.8	54.0	51.8	42.1	23.6	8.7	-0.9
Data acquired from the Western Regional Climate Data Center (http://www.wrcc.dri.edu)												

discretion due to the distance between Shishmaref and the communities of Wales and Kotzebue. Furthermore, the design freezing and thawing indices were determined from monthly average temperatures and therefore may be subject to error.

Seismicity

Shishmaref is located within a region of relatively low seismicity. Currently, there are no seismically active faults mapped in the area, and there have been no major earthquakes recorded in the Alaska Earthquake Information Center's database (www.aeic.alaska.edu). According to the United States Geological Survey, the 50-year probability of the Shishmaref Area to experience a seismically induced Peak Ground Acceleration (PGA) in excess of 7.2 percent and 10.4 percent the earth's gravitational force (g) is 10 percent and 5 percent, respectively (www.earthquake.usgs.gov).

Table 2: Freezing and thawing indices for nearby Wales and Kotzebue

Indices	**Location**	
	Wales	**Kotzebue**
Freezing Index	5098 °F-days 1)	5385 °F-days 1)
Thawing Index	1363 °F-days 1)	2058 °F-days 1)
Design Freezing Index	6399 °F-days 2)	6715 °F-days 4)
Design Thawing Index	1689 °F-days 3)	2566 °F-days 5)

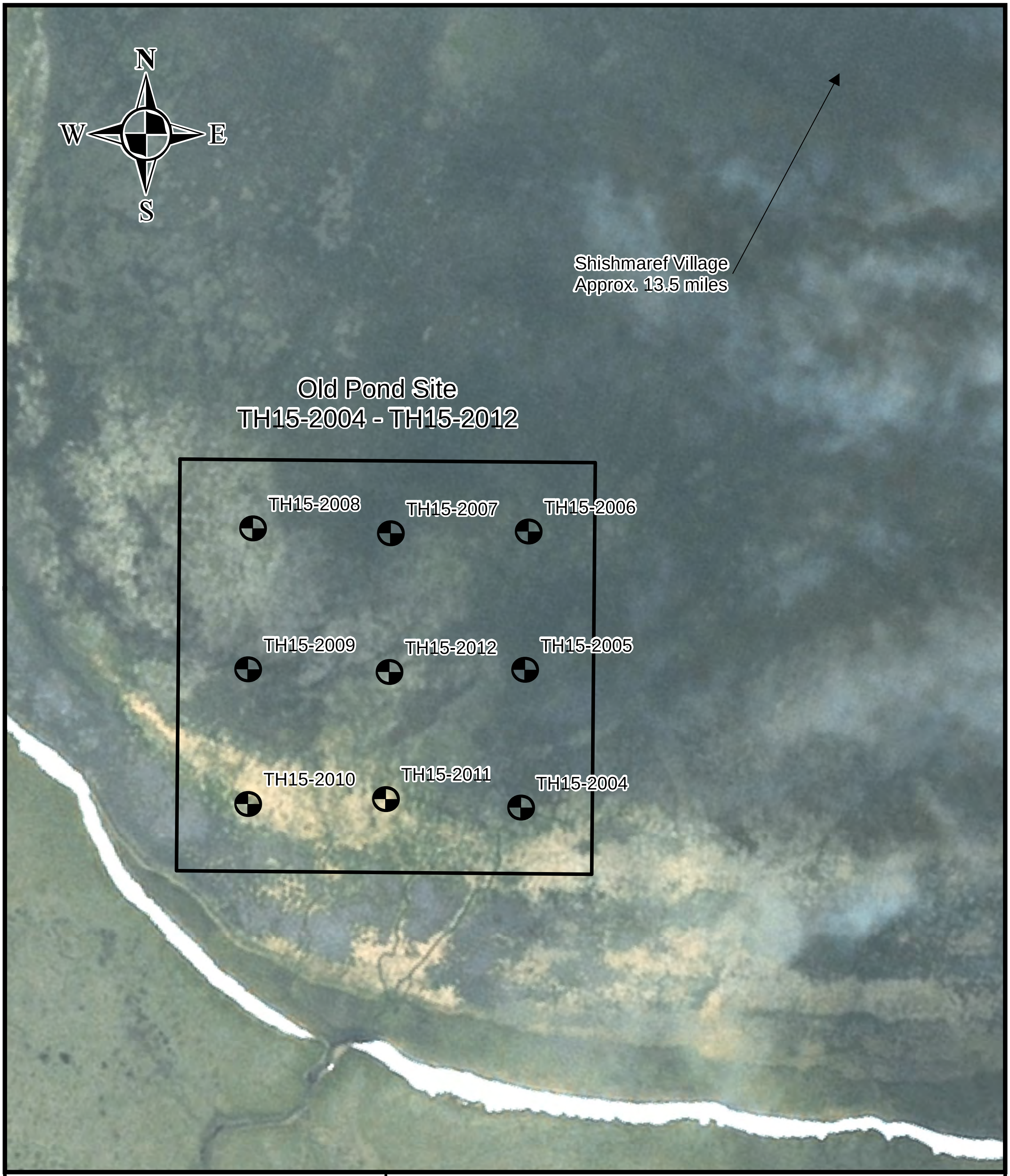
Notes:

1) Calculated from 1981 through 2010 daily average temperatures
2) Average of freezing indices calculated from monthly average temperatures within three coldest winters between 1962 and 1994. Due to incomplete data, calculations excluded average monthly temperatures from 1970, 1978, and 1979.
3) Average of thawing indices calculated from monthly average temperatures within three warmest summers between 1962 and 1994. Due to incomplete data, calculations excluded average monthly temperatures from 1970, 1978, and 1979.
4) Average of the freezing index calculated from monthly average temperatures within three coldest winters between 1985 and 2014.
5) Average of the thawing index calculated from monthly average temperatures within three warmest summers between 1985 and 2014.

Field Investigation and Laboratory Methods

The exploratory drilling was conducted between March 31 and April 12 2014, by NRMS personnel S. Parker, G. Nelson, and engineering geologist M. Billings. The drill rig was pulled behind a snowmobile to each test hole location while situated on two polyethylene sleds (see Photos 1 and 117). The investigation involved drilling 35 test holes, ranging between 10 and 35 feet deep, with a track-mounted B-24 drill rig equipped with 4-inch diameter solid stem augers. Nine test holes were drilled within each of the three proposed village relocation sites, while eight test holes were drilled along the proposed material source access road. Figures 2 through 5 illustrate the approximate location of each of the three proposed village relocation sites, the investigated portion of the proposed material source access road, and our test holes. Table 3 summarizes the drilling effort for this investigation.

During the drilling, 90 soil samples, designated 15-8000 through 15-8089 were collected from auger cuttings. Upon completion of drilling, these samples were transported to the NRMS laboratory for testing. Laboratory testing for these samples included particle size distribution and Atterberg Limits analyses, determination of both moisture and organic contents, and soil salinity. Table 4 summarizes our assigned laboratory testing for this project.



Approximate Test Hole Locations Within the Old Pond Site

ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
NORTHERN REGION

SCALE: 0 500 1,000 1,500 2,000 Feet

DATE: August 05, 2015

Figure 2

**Approximate
Test Hole Locations
Within West Tin Creek Hills**

ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
NORTHERN REGION

SCALE: 0 500 1,000 1,500 2,000 2,500 Feet

DATE: August 05, 2015

Figure 3

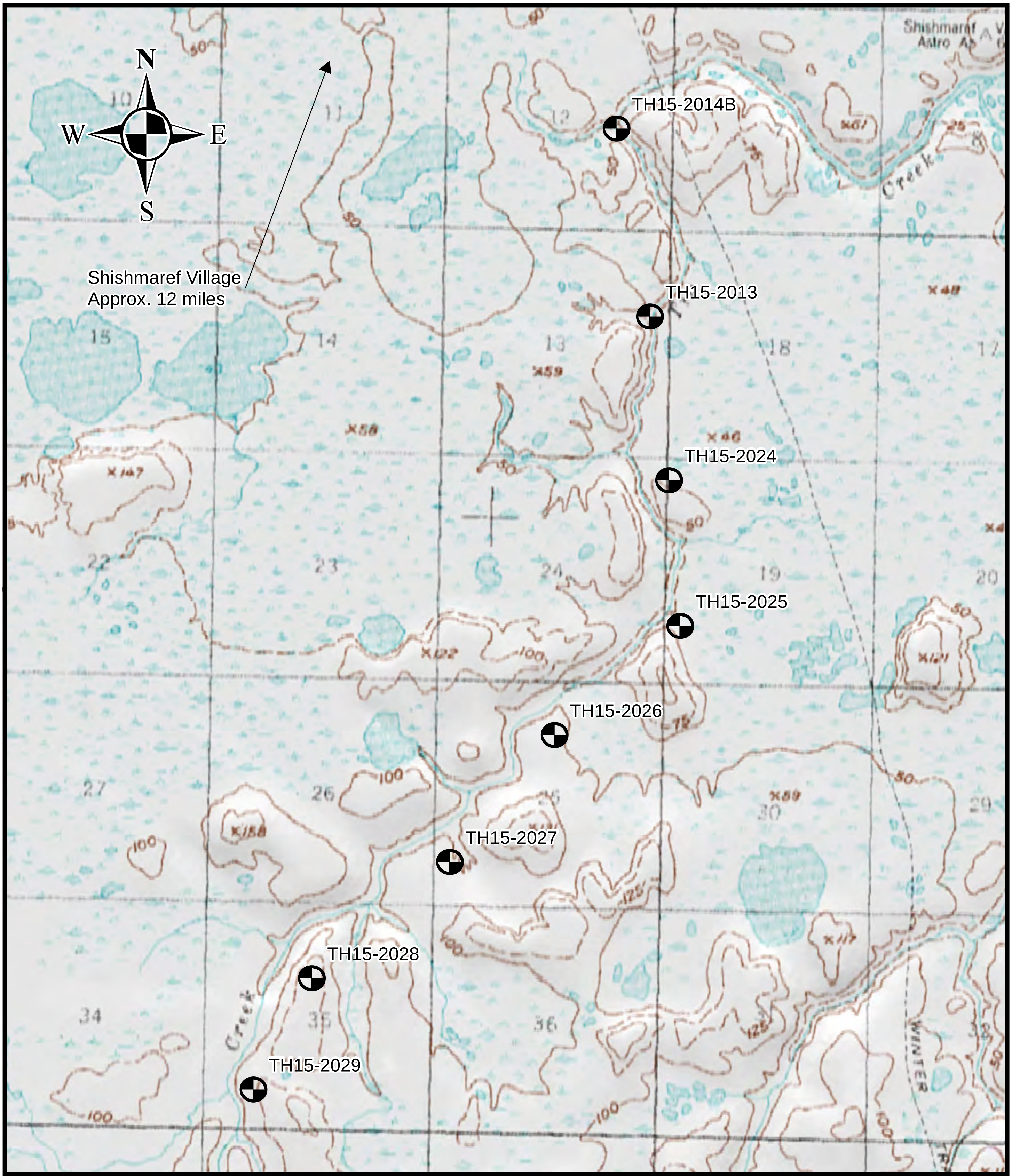
Approximate Test Hole Locations Within the Tin Creek Site

ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
NORTHERN REGION

SCALE: 0 500 1,000 1,500 2,000 2,500 Feet

DATE: August 05, 2015

Figure 4



ApproximateTest Hole Locations along the Proposed Material Source Access Road

ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
NORTHERN REGION

SCALE: 0 2,500 5,000 7,500 10,000 Feet

DATE: August 05, 2015

Figure 5

Table 3: Summary of drilling effort for each investigated area.

Investigated Area	Total Drilling Effort		
	Test Holes	Range of Depths (ft.)	Count
Old Pond Site	TH15-2004 through TH15-2012	19 - 31	9
West Tin Creek Hills Site	TH15-2015 through TH15-2023	10 - 23	9
Tin Creek Site	TH15-2030 through TH15-2038	19 - 31	9
Proposed Material Source Access Road	TH15-2013, TH15-2014B, and TH15-2024 through TH15-2029	18.5 - 35	8
			Total: 35

Table 4: Number of laboratory tests conducted and the standard specifications practiced.

LABORATORY TEST		STANDARD SPECIFICATION(S)		Number of Tests Conducted
		Description	Standard	
Classification (USCS) ASTM D2487	**Particle Size Distribution**	Sieve Analysis of Fine and Coarse Aggregates	AASHTO T27/T11	45
	Atterberg Limits	Standard Method of Test for Determining the Liquid Limit of Soils	AASHTO T89 ASTM D4318	
		Standard Method of Test for Determining the Plastic Limit of Soils	AASHTO T90 ASTM D4318	
Moisture Content		Standard Method of Test for Total Evaporable Moisture Content of Aggregate by Drying/ Standard Method of Test for Laboratory Determination of Moisture Content of Soils	AASHTO T255/T265 ASTM C566/D2216	85
Organic Content		Organic Content of Soils	ATM 203	43
Salinity Analysis		Salinity Content of Soil	Shannon & Wilson, Inc. YSI 30 Salinity Reading	12

Subsurface Conditions within Old Pond Site

Nine test holes, designated as TH15-2004 through TH15-2012, were drilled within the Old Pond Site. These test holes were spaced roughly evenly on an approximate 700-foot grid within the assigned extents of the site (see Figure 2). Drill depths of these test holes range between 19 feet and 31 feet bss. The ground surface at these test holes was generally covered by approximately 12 inches to 18 inches of snow overlying approximately 6 inches to 12 inches of pond ice. Beneath the snow and ice cover, the test holes drilled within the Old Pond Site generally exhibited the following sequence of soils:

- 2 feet to 5 feet of frozen, dark brown, organic-rich SILT and PEAT
    - commonly containing visible ice
- 7 feet to 14.5 feet of grayish brown to brownish gray SILT
    - frozen in portions lying above roughly 3.5 feet to 6 feet bgs
    - slightly organic to organic with organic content decreasing with depth
    - generally moist to wet
- 2 feet or more of thawed, brownish gray to gray SILT
    - generally moist to wet

A light gray SILT containing coarse Sand and fine Gravel was encountered at approximately 30 feet bgs within test hole TH15-2004. This soil, however, was not encountered within the other test holes within the Old Pond Site.

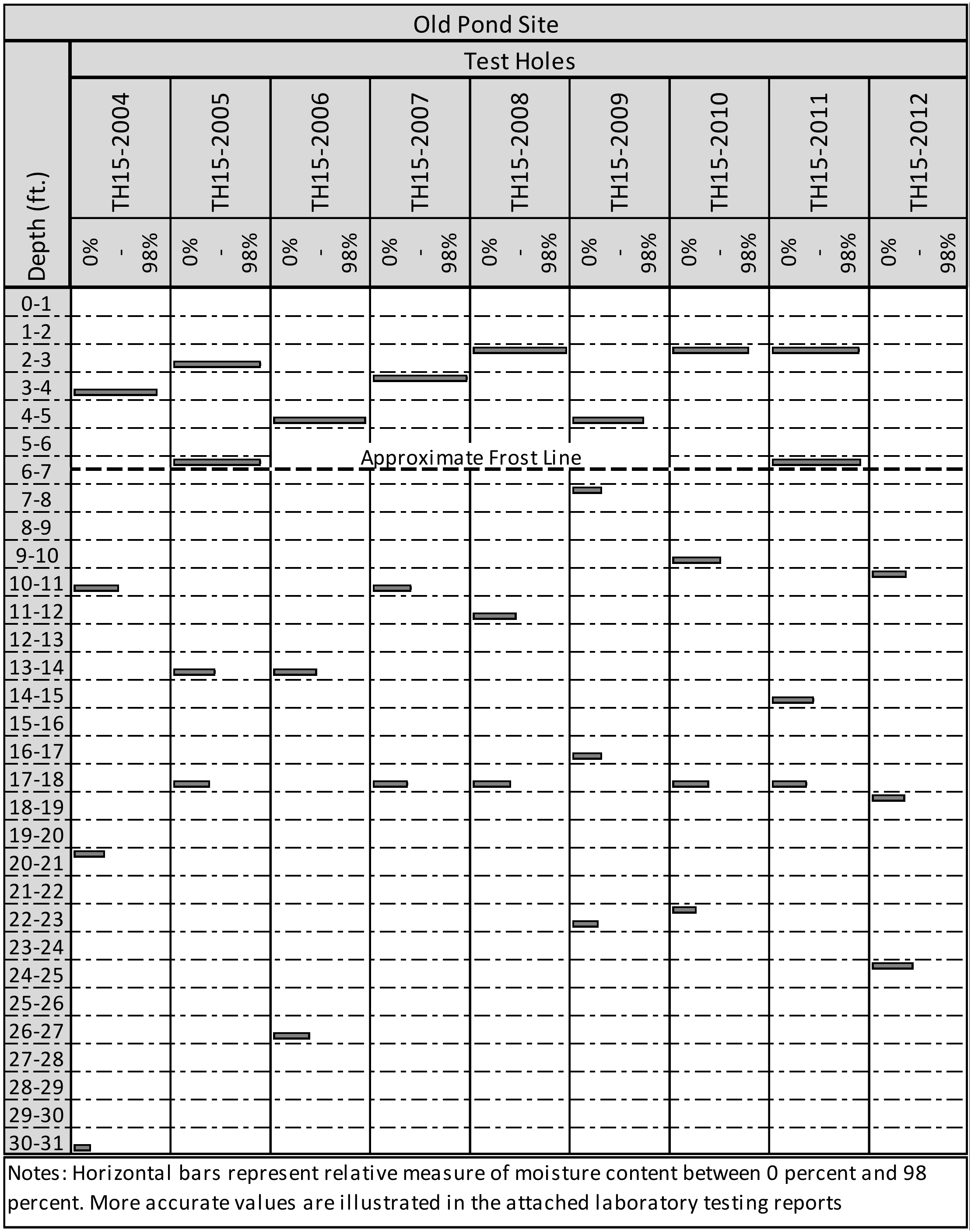
In general, drill action and sample handling indicated that the thawed soils encountered within the Old Pond Site are moist to wet, loose and liquefiable (see Photos 6, 13, 26, 30 and 31). Laboratory analyses determined that moisture content of frozen soils ranged between approximately 74 percent and 98 percent and the moisture content of thawed soils ranged between approximately 17 percent and 51 percent. Table 5 summarizes soil moisture content within samples from the Old Pond Site.

Frozen Ground and Groundwater Table

The test holes drilled within the Old Pond Site encountered roughly 3.5 feet to 6 feet of seasonal frost beneath the snow cover. Seasonal frost in excess of 6.5 feet may be anticipated if this site is kept clear of vegetation and snow cover - particularly near the end of relatively cold winters. Permafrost was encountered at approximately 30 feet bgs within test hole TH15-2004. In spite of our attempts, similar depths were not reached within the other test holes drilled within this site; likely resulting in the other test holes not encountering permafrost.

A definitive groundwater table was not established while investigating the Old Pond Site. This was due to encountering excessively wet and loose soils and unstable test hole walls that prevented direct measurement. Presence of ponded ice, however, suggests the groundwater table is near or above the ground surface. The slight decrease in moisture content with depth may be a function of a slight increase of soil density with depth.

Table 5: Summary of soil moisture content within the Old Pond Site



Notes: Horizontal bars represent relative measure of moisture content between 0 percent and 98 percent. More accurate values are illustrated in the attached laboratory testing reports

Subsurface Conditions within the West Tin Creek Hills Site

Nine test holes, designated as TH15-2015 through TH15-2023, were drilled within the West Tin Creek Hills Site. These test holes were spaced roughly evenly on an approximate 700-foot grid within the assigned extents of the site (see Figure 3). Drill depths ranged between 10 feet and 23 feet bss, but commonly extended to roughly 15 feet to 19 feet bss. The ground surface at these test holes was generally covered by approximately 12 inches to 18 inches of snow. Beneath the snow cover, the test holes drilled within this site generally exhibited the following sequence of soils:

- 1.5 feet to 5 feet of frozen organic cover, including Tundra Mat, PEAT and Organic SILT
    - generally ranging between 1.5 feet to 2 feet thick
- 2 feet to 8 feet of frozen ice rich SILT
    - commonly organic rich, with organic content decreasing with depth
- Brown to gray, frozen SILT extending to depths explored
    - ranging between frozen, well bonded with no excess ice (Nbn) to frozen, well bonded with excess ice (Nbe)

Gray SILT containing interbedded layers of fine sandy SILT to silty fine SAND was encountered at approximately 16.5 feet bgs within test hole TH15-2023. This soil, however, was not encountered within the other test holes that extended to similar depths.

Moisture content amongst the soils collected within the West Tin Creek Hills Site varied between roughly 5 percent and 360 percent; with the highest values within ice-rich soils. Table 6 summarizes soil moisture content within samples from West Tin Creek Hills Site.

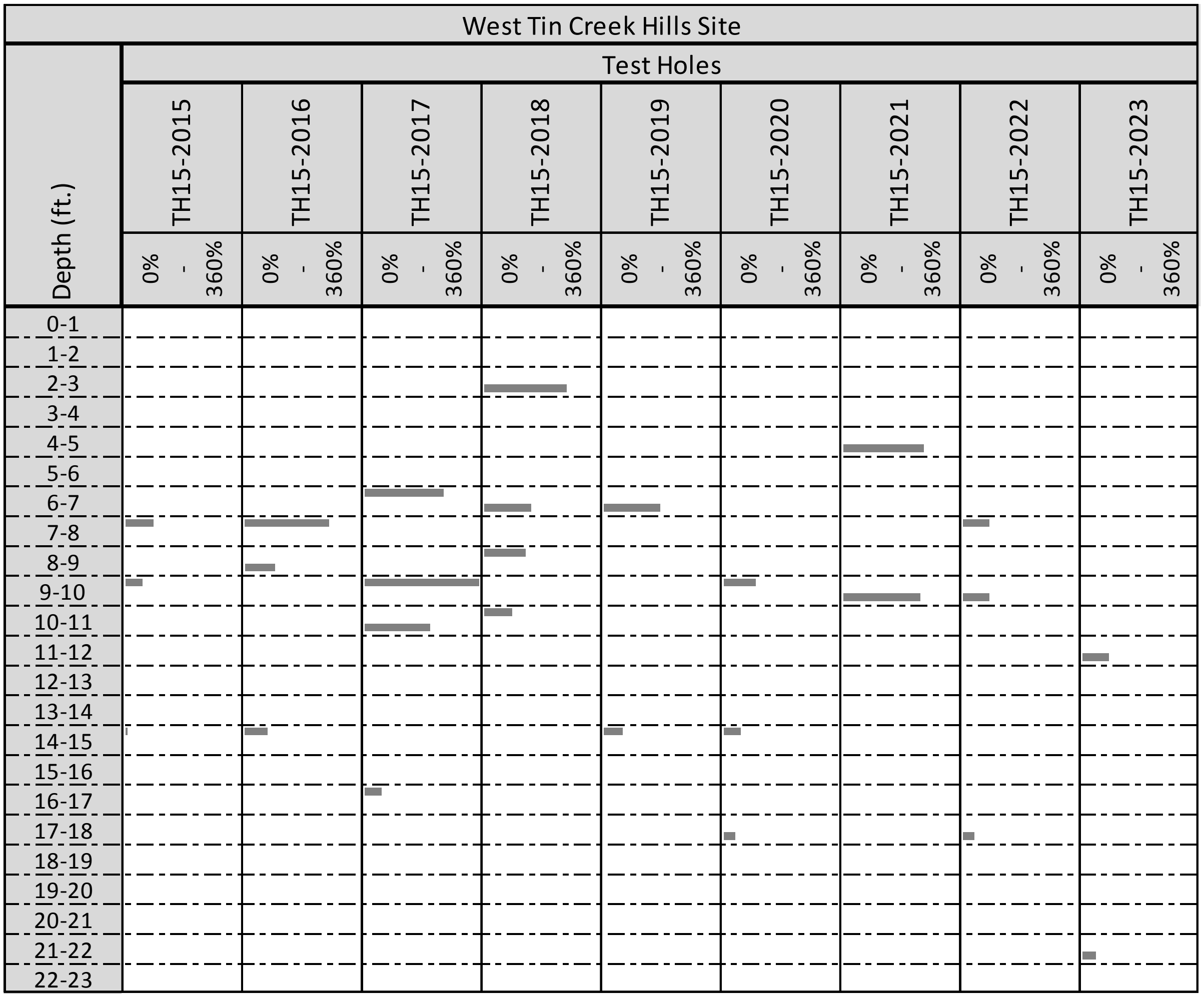
Frozen Ground and Groundwater Table

The test holes drilled within the West Tin Creek Hills Site encountered pervasive frozen ground that extended to depths explored. The thickness of the active layer within this site was not determined due to the drilling taking place near the end of the freezing season – where maximum frost depths occur.

Layers of massive ice were encountered in test holes TH15-2016, TH15-2017, TH15-2019 and TH15-2023. These ice layers were encountered between 1.5 feet and 6 feet bgs and ranged between 6-inches and 4-feet thick. Many of the test holes drilled within the West Tin Creek Hills Site encountered ice-rich soil within their upper 10 feet. Much of this soil contained approximately 25 percent or more ice by volume. Table 7 roughly illustrates the distribution and concentration of ground ice encountered within the West Tin Creek Hills Site.

Groundwater was not encountered while drilling within the West Tin Creek Hills Site. Due to the relatively high moisture content of ice-rich soils and poor drainage conditions, local thawing may result in a perched water table.

Table 6 Summary of soil moisture content within the West Tin Creek Hills Site



Notes: Horizontal bars represent relative measure of moisture content between 0 percent and 360 percent. More accurate values are illustrated in the attached laboratory testing reports

Subsurface Conditions within the Tin Creek Site

The Tin Creek Site is largely situated on a hill that extends from roughly 50 feet to 100 feet above sea level. This hill is believed to be an ice-rich cryogenic landform termed a yedoma. Nine test holes, designated TH15-2030 through TH15-2038, were drilled on an approximate 700-foot spacing within the Tin Creek Site (see Figure 4). Seven of these test holes were drilled on the hill while two of these test holes (TH15-2037 and TH15-2038) were drilled on a valley floor near the base of the hill. Drill depths of these test holes extended between 19 feet and 31 feet bss. Approximately 1.5 feet to 2 feet of snow covered the test hole locations within this site. The subsurface conditions encountered within test holes located on the hill and on the valley floor were notably different and are described separately.

Table 7: Estimated ice content of soil encountered within the West Tin Creek Hills Site.

West Tin Creek Hills Site									
Depth (feet)	**Test Holes**								
	TH15-2015	**TH15-2016**	**TH15-2017**	**TH15-2018**	**TH15-2019**	**TH15-2020**	**TH15-2021**	**TH15-2022**	**TH15-2023**
	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%
0 - 1	SNOW	SNOW	SNOW	SNOW	SNOW	SNOW	SNOW	SNOW	SNOW
1 - 2		ORG	ORG	ORG	ORG			ORG	
2 - 3	ORG					ORG	ORG		ORG
3 - 4	▨▨▨▨		▨▨▨▨	▨	▨▨		▨▨		▨▨▨▨
4 - 5	▨▨▨		▨▨▨	▨	▨▨▨▨	▨▨▨	▨▨	▨▨	▨▨▨▨
5 - 6	▨▨▨			▨	▨▨	▨▨▨	▨▨	▨▨	▨▨▨▨
6 - 7	▨▨	▨▨▨▨		▨	▨▨▨▨	▨▨▨	▨	▨▨	▨▨▨▨
7 - 8	▨▨	▨			▨▨	▨▨▨		▨	▨▨
8 - 9	▨		▨▨▨			▨▨		▨	▨▨
9 - 10	▨		▨▨▨			▨▨			▨▨
10 - 11			▨▨▨			▨▨			▨▨
11 - 12			▨▨▨						▨
12 - 13									▨
13 -									

Note:

- SNOW AND ORG approximately account for footage of snow and tundra cover, respectively.
- Depth resolution is illustrated in 1-foot intervals and may vary up to 6 inches or more from that observed and recorded in field.
- Ice contents are illustrated in 25-percent intervals and may differ from those observed in field. More accurate estimates are illustrated on individual test hole logs.

In general, beneath the snow cover, the test holes drilled on the hill (TH15-2030 through TH15-2036) exhibited the following sequence of conditions:

- 6 inches to 2 feet of frozen Tundra Mat and PEAT
- 0 feet (TH15-2030, TH15-2032 and TH15-2033) to 2.5 feet of frozen, dark brown, organic-rich SILT
  - commonly containing approximately 25 percent to 50 percent ice content by volume
- Massive ICE, commonly extending to depths explored (see Photos 101 and 109)

    - generally clear to translucent
    - occasionally containing trace amounts of tan, brown or gray silt

Test holes TH15-2034 and TH15-2035 encountered gray SILT beneath massive ice between roughly 25.5 feet and 28.5 feet bgs. This silt ranged between frozen, well bonded (Nbn) to containing roughly 25 percent to 75 percent ice by volume. In addition, test hole TH15-2034 encountered an approximate 4-foot thick layer of ice-rich silt at approximately 10 feet bgs. This layer of ice-rich silt contained approximately 60 percent to 70 percent ice by volume.

In general, beneath the snow cover, the test holes drilled on the valley floor (TH15-2037 and TH15-2038) exhibited the following sequence of soil:

- Approximately 6 inches of frozen Tundra Mat
- 1 foot to 2.5 feet of frozen, dark brown organic-rich silt
    - generally containing approximately 35 percent to 45 percent ice by volume
- 14.5 feet or more of tan, brown and gray, frozen SILT
    - this layer in each test hole contained an approximate 4-foot to 5.5-foot thick layer of massive ICE with gray SILT

Silt containing trace amounts of fine sand was encountered at approximately 10.5 feet bgs in test hole TH15-2037. This soil was not encountered in test hole TH15-2038.

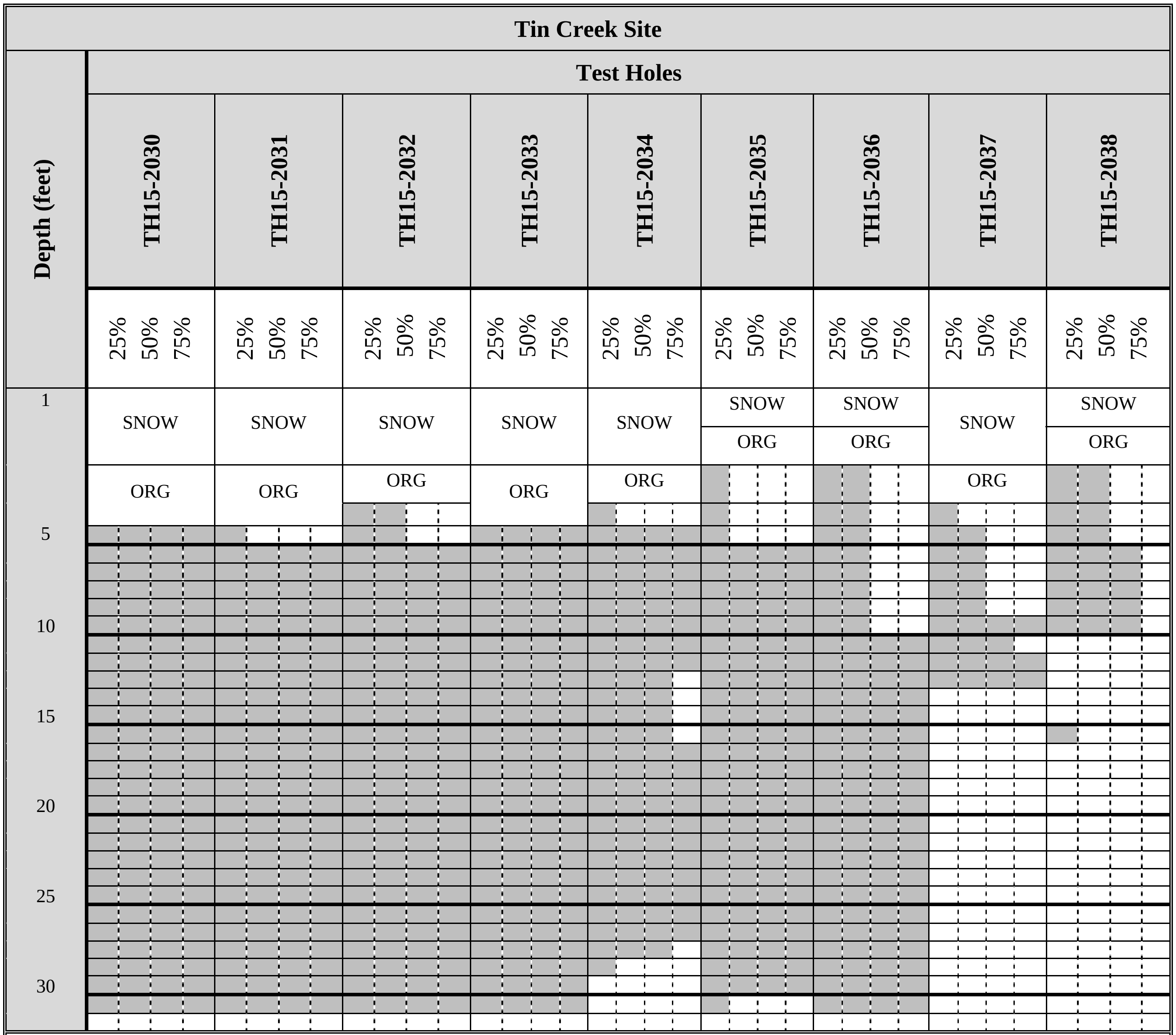
Frozen Ground and Groundwater Table

The test holes drilled within the Tin Creek Site encountered pervasive frozen ground that extended to depths explored. A thawed active layer was not encountered due to the drilling taking place near the end of the freezing season – where maximum frost depths occur. An accurate determination of the active layer thickness within this site, therefore, cannot be determined from this investigation. In many of the test holes, the presence of massive ice within several feet of the base of overlying tundra mat, however, suggests the active layer does not extend more than 2 feet to 3 feet bgs.

Pervasive massive ice was encountered in test holes TH15-2030 through TH15-2036. These layers of ice ranged between 8-feet and 11-feet thick in test hole TH15-2034, 25.5-feet thick in test hole TH15-2035, and extended to depths explored in test holes TH15-2030 through TH15-2033 and TH15-2036. Massive ice was less predominant in test holes TH15-2037 and TH15-2038; which were located in the valley bottom. These test holes, however, exhibited between 4 feet and 5.5 feet of massive ice. Table 8 roughly illustrates the distribution and concentration of ground ice encountered within the Tin Creek Site.

Groundwater was not encountered while drilling within the Tin Creek Site. Due to the relatively high moisture content of ice-rich soils and poor drainage conditions, local thawing may result in a perched water table.

Table 8: Estimated ice content of soil encountered within the Tin Creek Site.



Note:

- SNOW AND ORG approximately account for footage of snow and tundra cover, respectively.
- Depth resolution is illustrated in 1-foot intervals and may vary up to 6 inches or more from that observed and recorded in field.
- Ice contents are illustrated in 25-percent intervals and may differ from those observed in field. More accurate estimates are illustrated on individual test hole logs.

Subsurface Conditions along the Proposed Material Source Access Road

Eight test holes designated as TH15-2013, TH15-2014B and TH15-2024 through TH15-2029 were drilled while investigating a portion of the proposed material source access road. Test hole TH15-2014A encountered water beneath a layer of ice. This test hole, therefore, was moved approximately 15-feet and re-designated as test hole TH14-2014B. These eight test holes were spaced roughly evenly along the investigated portion of the alignment at an approximate ¾-mile spacing (see Figures 1 and 5). Drill depths commonly extended to roughly 19 feet bss, but ranged between 10 feet and 35 feet bss. Two of the eight test holes (TH15-2013 and TH15-2014B) were drilled within close proximity to Tin Creek. Three of the eight test holes (TH15-2024, TH15-2027, and TH15-2029) were drilled in relatively flat-lying areas of low topographic relief. The remaining three test holes (TH15-2025, TH15-2026 and TH15-2028) were drilled on either a raised plateau or a hill. Approximately 1 foot to 1.5 feet of snow covered the test hole locations along the alignment. The subsurface conditions encountered within test holes located near the creek, in relatively flat, low-lying areas, and in areas of relatively high topographic relief were notably different and are described separately.

In general, beneath the snow cover, the two test holes drilled within close proximity to Tin Creek (TH15-2013 and TH15-2014B) exhibited the following sequence of soils:

- 1.5 feet to 5 feet of frozen Tundra Mat
    - containing approximately 25 percent to 40 percent ice by volume
- approximately 2 feet of frozen, light brown to dark brown, organic-rich SILT
    - ranging between friable (Nf), well bonded (Nbn to Nbe) to containing approximately 25 percent ice by volume
- 6 feet to 14 feet or more of thawed, dark grey to black SILT
    - generally moist below roughly 3 feet to 9 feet bgs
    - slightly organic to highly organic; possibly consisting of silt-sized organics
- 0 feet (TH15-2014B) to 5 feet or more of thawed, gray SILT
    - moist to wet; wet below approximately 16 feet bgs

In general, beneath the snow cover, the three test holes drilled within low-lying areas of low topographic relief (TH15-2024, TH15-2027, and TH15-2029) exhibited the following sequence of soils:

- 0.5 feet to 3 feet of frozen Tundra Mat
- 3 feet to 3.5 feet of frozen, light tannish brown to dark brown, organic-rich SILT and dark brown Organic SILT to PEAT
    - ranging between well-bonded with excess ice (Nbe) to containing approximately 35 percent to 50 percent ice by volume
- Tan, brown and gray, frozen silt extending to depths explored (17 feet to 18 feet bgs)
    - containing occasional 6-inch to 1-foot thick layers of massive ICE

In general, beneath the snow cover, the three test holes drilled on a hill or other areas of relatively high topographic relief (TH15-2025, TH15-2026, and TH15-2028) exhibited the following sequence of conditions:

- 6 inches to 3.5 feet of frozen Tundra Mat and PEAT
- 0 feet (TH15-2025) to 3.5 feet of frozen, dark brown, organic-rich SILT
    - generally containing between 15 percent to 30 percent ice by volume
- 5 feet to 29 feet or more of massive ICE (see Photo 87)
    - generally clear to translucent
    - occasionally containing trace amounts of tan, brown or gray SILT
- 0 feet to 9 feet or more (TH15-2025) of frozen, dark brown to grayish brown SILT
    - slightly organic to organic
    - generally containing 15 percent to 30 percent ice by volume

Approximately 9 feet of SILT was encountered at roughly 8.5 feet bgs in test hole TH15-2025. This silt layer is overlain by an approximate 5-foot thick layer of massive ICE. Both test holes TH15-2026 and TH15-2028 terminated within massive ice at depths of approximately 33.5 feet and 28 feet bgs, respectively.

Frozen Ground and Groundwater Table

Test holes TH15-2013 and TH15-2014B encountered approximately 5.5 feet and 10 feet of seasonal frost. Permafrost was not encountered in these test holes.

Test holes TH15-2024 through TH15-2029 encountered frozen ground that extended to depths explored. Amongst these test holes, a thawed active layer was not encountered due to the drilling taking place near the end of the freezing season – where maximum frost depths occur. An accurate determination of the active layer thickness within these test holes, therefore, cannot be determined from this investigation. The presence of the top of massive ice between roughly 3.5 feet and 4 feet bgs, however, suggests the active layer extends to or above these depths.

Relatively thin layers of massive ice were encountered in test holes TH15-2024 and TH15-2025, respectively. Test holes TH15-2026 and TH15-2028 encountered massive ice that extended from approximately 3 feet to 4 feet bgs to depths explored. Table 9 roughly illustrates the distribution and concentration of ground ice encountered along the investigated portion of the proposed material source access road.

Surface water was encountered in test hole TH15-2014A. This test hole, therefore was moved and re-designated as TH15-2014B. Groundwater was not definitively encountered while investigating the proposed material source access road. This was due to either pervasive frozen ground within the test hole, or the instability of thawed test hole walls preventing direct measurement. A groundwater table may be anticipated within thawed soil near relatively large drainages. Furthermore, the elevation of the groundwater table may be anticipated to be near, and fluctuate with, that of the creek.

Table 9: Estimated ice content encountered along the Proposed Material Source Access Road.

Proposed Material Site Access Road								
	Test Holes							
Depth (feet)	TH15-2013	TH15-2014B	TH15-2024	TH15-2025	TH15-2026	TH15-2027	TH15-2028	TH15-2029
	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%	25% 50% 75%
1	SNOW	SNOW	SNOW	SNOW	SNOW	SNOW	SNOW	SNOW
	ORG	ORG	ORG		ORG		ORG	ORG
			▨▨	ORG	▨	ORG	▨▨	▨▨
			▨▨		▨		▨	▨▨
5			▨▨		▨		▨	▨▨
			▨▨▨▨	▨▨▨▨	▨▨▨▨	▨	▨▨▨▨	▨▨▨
	▨		▨▨▨▨	▨▨▨▨	▨▨▨▨	▨	▨▨▨▨	▨▨▨
	▨		▨▨▨▨	▨▨▨▨	▨▨▨▨	▨	▨▨▨▨	▨▨▨
			▨	▨▨▨▨	▨▨▨▨	▨▨▨▨	▨▨▨▨	
10				▨▨▨▨	▨▨▨▨		▨▨▨▨	
				▨	▨▨▨▨	▨▨▨▨	▨▨▨▨	▨
				▨	▨▨▨▨		▨▨▨▨	▨
				▨	▨▨▨▨		▨▨▨▨	▨
				▨	▨▨▨▨	▨	▨▨▨▨	
15				▨	▨▨▨▨	▨	▨▨▨▨	
				▨	▨▨▨▨	▨	▨▨▨▨	
					▨▨▨▨		▨▨▨▨	
					▨▨▨▨		▨▨▨▨	
				▨	▨▨▨▨		▨▨▨▨	
20					▨▨▨▨		▨▨▨▨	
					▨▨▨▨		▨▨▨▨	
					▨▨▨▨		▨▨▨▨	
					▨▨▨▨		▨▨▨▨	
					▨▨▨▨		▨▨▨▨	
25					▨▨▨▨		▨▨▨▨	
					▨▨▨▨		▨▨▨▨	
					▨▨▨▨		▨▨▨▨	
					▨▨▨▨		▨▨▨▨	
					▨▨▨▨		▨▨▨▨	
30					▨▨▨▨			
					▨▨▨▨			
					▨▨▨▨			
					▨▨▨▨			
					▨▨▨▨			
35					▨▨▨▨			

Note:

- SNOW AND ORG approximately account for footage of snow and tundra cover, respectively.
- Depth resolution is illustrated in 1-foot intervals and may vary up to 6 inches or more from that observed and recorded in field.
- Ice contents are illustrated in 25-percent intervals and may differ from those observed in field. More accurate estimates are illustrated on individual test hole logs.

Laboratory Results

Ninety soil samples, designated 15-8000 through 15-8089 were collected during this investigation. Amongst these samples, 32 (15-8000 through 15-8031) were collected while drilling the Old Pond Site, 27 (15-8039 through 15-8065) were collected while drilling the West Tin Creek Hills Site, 10 (15-8080 through 15-8089) were collected while drilling the Tin Creek Site, and 21 (15-8032 through 15-8038 and 15-8066 through 15-8077) were collected while drilling the proposed material source alignment. Laboratory testing for these samples included particle size distribution and Atterberg Limits analyses, determination of both moisture and organic contents, and soil salinity. Tables 10 through 13 illustrate the results of our laboratory testing. Our laboratory results are also listed in Appendix B attached.

The results of the laboratory testing indicate that the soils encountered during this investigation consist largely of non-plastic silt. These silts contained relatively high moisture content, particularly within the ice-rich zones. The organic content of soils encountered within the West Tin Creek Hills Site and along the alignment generally ranged between 20 percent and 60 percent in the upper 5 feet. The organic content of soils encountered in the Old Pond Site and the Tin Creek Site generally ranged between 10 and 25 percent in the upper 5 feet. Salinity ranged between 0.1 parts per thousand (ppt) and 37.6 ppt amongst the soils tested. Highest salinity values (21.6 ppt and 37.6 ppt) were measured in samples 15-8035 and 15-8038, which were collected in test holes TH15-2013, and TH15-2014B, respectively.

Table 10: Summary of laboratory results from Old Pond Site.

Borehole	Sample	Sample Depth Interval (feet)	USCS Soil Class	Minus #200 (%)	Atterberg Limits (LL, PL)	Natural Moisture (%)	Organic Content (%)	Salinity (ppt)
TH15-2004	15-8000	2.5 - 5	---	---	---	87.3	18.4	---
	15-8001	9.5 - 12	ML	94	NV, NP	47.5	8.3	---
	15-8002	20 - 21	---	---	---	32.1	3.8	3.0
	15-8003	31 - 31.5	---	---	---	17.2	---	---
TH15-2005	15-8004	2 - 3.5	ML	97.8	NV, NP	91.3	12.9	---
	15-8005	5 - 6.5	---	---	---	90.3	16.2	---
	15-8006	13 - 15	---	---		43.2	---	---
	15-8007	17 - 19	ML	97.6	NV, NP	38.8	---	---
TH15-2006	15-8008	4 - 5.5	---	---	---	96.6	---	---
	15-8009	13 - 15	ML	97.5	NV, NP	45.1	9.1	---
	15-8010	26 - 28	ML	92.5	NV, NP	37.1		1.3
TH15-2007	15-8011	2.5 - 4	ML	99.9	NV, NP	97.7	13.6	---
	15-8012	10 - 12	---	---	---	39.6	---	---
	15-8013	17 - 19	ML	98.1	NV, NP	35.6	---	1.4
TH15-2008	15-8014	2 - 3	---	---	---	97.3	12.4	---
	15-8015	11 - 13	ML	98.0	NV, NP	44.6	9.6	---
	15-8016	17 - 19	---	---	---	40.6	---	---

Table 10 Continued: Summary of laboratory results from Old Pond Site.

Borehole	Sample	Sample Depth Interval (feet)	USCS Soil Class	Minus #200 (%)	Atterberg Limits (LL, PL)	Natural Moisture (%)	Organic Content (%)	Salinity (ppt)
TH15-2009	15-8017	4 - 6	---	---	---	74.4	13.1	---
	15-8018	7 - 8	ML	92.7	NV, NP	31.2	---	---
	15-8019	16 - 18	---	---	---	30.4	---	---
	15-8020	21 - 22.5	ML	78.3	NV, NP	28	2.4	1.2
TH15-2010	15-8021	2 - 3	---	---	NV, NP	80.5	8.5	---
	15-8022	9 - 11	ML	99.0	NV, NP	50.6	---	---
	15-8023	17 - 19	ML	76.7	NV, NP	37.2	5.7	---
	15-8024	21.5 - 23	---	---	---	25.7	---	1.4
TH15-2011	15-8025	2 - 3	ML	66.9	NV, NP	90.9	8.8	---
	15-8026	6 - 7	---	---	---	91.4	14.7	---
	15-8027	14 - 15.5	---	---	---	44.2	---	---
	15-8028	17.5 - 19	ML	89.1	NV, NP	36.1	---	---
TH15-2012	15-8029	10 - 11.5	ML	93.5	NV, NP	35.7	5.7	---
	15-8030	18 - 19	---	---	---	34.2	5.1	---
	15-8031	24 - 25	ML	95.1	NV, NP	42.6	---	0.7

Table 11: Summary of laboratory results from West Tin Creek Hills Site.

Borehole	Sample	Sample Depth Interval (feet)	USCS Soil Class	Minus #200 (%)	Atterberg Limits (LL, PL)	Natural Moisture (%)	Organic Content (%)	Salinity (ppt)
TH15-2015	15-8039	7 - 8	ML	93.8	NV, NP	88.6	---	---
	15-8040	9 - 10	---	---	---	55.8	---	---
	15-8041	14 - 15	ML	94.1	NV, NP	5.1	---	7.6
TH15-2016	15-8042	5 - 6	---	---	---	---	39.8	---
	15-8043	7 - 8	ML	97.6	NV, NP	267.5	14.5	---
	15-8044	8.5 - 9.5	---	---	---	95.5	---	---
	15-8045	14 - 15	---	---	---	73.1	---	---
TH15-2017	15-8046	5.5 - 7	---	---	---	248.7	12.1	---
	15-8047	9 - 10	---	---	---	359.7	---	---
	15-8048	10.5 - 11.5	---	---	---	204.9	---	---
	15-8049	16 - 17	ML	95.3	NV, NP	50.5	5.0	---
TH15-2018	15-8050	2.5 - 3	ML	61.9	NV, NP	260.0	57.7	---
	15-8051	6.5 - 7.5	---	---	---	146.8	11.8	---
	15-8052	8 - 9	ML	81.9	NV, NP	126.8	---	---
	15-8053	10 - 11	ML	95.5	NV, NP	90.7	---	---
TH15-2019	15-8054	6.5 - 7.5	---	---	---	177.7	---	---
	15-8055	14 - 15	ML	95.4	NV, NP	58.8	---	---

Table 11 Continued: Summary of laboratory results from West Tin Creek Hills Site.

Borehole	Sample	Sample Depth Interval (feet)	USCS Soil Class	Minus #200 (%)	Atterberg Limits (LL, PL)	Natural Moisture (%)	Organic Content (%)	Salinity (ppt)
TH15-2020	15-8056	9 - 10	ML	95.8	NV, NP	97.8	8.8	---
	15-8057	14 - 15	---	---	---	53.5	---	---
	15-8058	17.5 - 18.5	---	---	---	36.9	---	---
TH15-2021	15-8059	4.5 - 5.5	ML	87.2	NV, NP	254.4	27.9	---
	15-8060	9.5 - 10	---	---	---	240.5	---	---
TH15-2022	15-8061	7 - 8	ML	89.4	NV, NP	80.4	9.6	---
	15-8062	9 - 11	ML	98.6	NV, NP	81.4	8.9	---
	15-8063	17.5 - 18.5	---	---	---	37.5	---	---
TH15-2023	15-8064	11 - 12	ML	96.1	NV, NP	80.5	8.4	---
	15-8065	21.5 - 22.5	ML	89.2	NV, NP	39.7	---	10.9

Table 12: Summary of laboratory results from the Tin Creek Site.

Borehole	Sample	Sample Depth Interval (feet)	USCS Soil Class	Minus #200 (%)	Atterberg Limits (LL, PL)	Natural Moisture (%)	Organic Content (%)	Salinity (ppt)
TH15-2031	15-8080	2.5 - 3.5	---	---	---	---	24.2	---
TH15-2032	15-8081	3 - 4	---	---	---	---	22.4	---
TH15-2034	15-8082	2.5 - 3.5	ML	96.6	NV, NP	58.8	10.3	---
	15-8083	13 - 14	---	---	---	143.0	---	---
	15-8084	30 - 31	ML	84.5	NV, NP	90.8	---	0.5
TH15-2036	15-8085	2.5 - 3.5	---	---	---	167.0	23.1	---
	15-8086	6 - 7	ML	97.3	NV, NP	125.7	---	---
TH15-2037	15-8087	14 - 15	ML	95.5	NV, NP	46.1	---	---
TH15-2038	15-8088	13.5 - 15	ML	97.9	NV, NP	43.8	5.5	---
	15-8089	17.5 - 18.5	---	---	---	37.1	---	---

Table 13: Summary of laboratory results from the Proposed Material Source Access Road.

Borehole	Sample	Sample Depth Interval (feet)	USCS Soil Class	Minus #200 (%)	Atterberg Limits (LL, PL)	Natural Moisture (%)	Organic Content (%)	Salinity (ppt)
TH15-2013	15-8032	1.5 - 2.5	---	---	---	---	59.9	---
	15-8033	6 - 7	---	---	---	151.9	23.1	---
	15-8034	8 - 9	ML	95.6	NV, NP	44.9	7.1	---
	15-8035	18 - 19	SM	28.9	NV, NP	20	---	21.6
TH15-2014B	15-8036	3 - 4	---	---	---	82.0	16.5	---
	15-8037	10 - 11.5	ML	96.8	NV, NP	46.5	11.9	---
	15-8038	14 - 15	ML	86.2	NV, NP	36.5	---	37.6

Table 13 Continued: Summary of laboratory results from the Proposed Material Source Access Road.

Borehole	Sample	Sample Depth Interval (feet)	USCS Soil Class	Minus #200 (%)	Atterberg Limits (LL, PL)	Natural Moisture (%)	Organic Content (%)	Salinity (ppt)
TH15-2024	15-8066	2.5 - 3.5	---	---	---	165.4	36.9	---
	15-8067	8.5 - 10	ML	96.7	NV, NP	77.4	---	---
	15-8068	14 - 15	---	---	---	44.7	---	---
	15-8069	17.5 - 18.5	ML	80	NV, NP	32.0	---	---
TH15-2025	15-8070	10 - 11	---	---	---	215.4	10.0	---
	15-8071	12 - 13	ML	99.7	NV, NP	177.0	---	---
	15-8072	18 - 19	---	---	---	203.2	11.8	---
TH15-2027	15-8073	2 - 3	---	---	---	---	25.4	---
	15-8074	5.5 - 6.5	---	---	---	308.7	33.0	---
	15-8075	10.5 - 11	ML	98.8	NV, NP	217.6	---	---
	15-8076	13.5 - 14.5	---	---	---	163.0	---	---
TH15-2028	15-8079	3 - 4	ML	95.9	NV, NP	86.5	15.3	---
	15-8078	28 - 29	---	---	---	152.4	---	---
TH15-2029	15-8077	13.5 - 14.5	ML	99.6	NV, NP	131.9	---	0.1

Expected Physical Site Conditions and Design Considerations

Based upon this investigation and the general geology of the area, the following physical site conditions should be anticipated during construction:

- Anticipate encountering ice-rich frozen ground and thermokarst features such as thaw ponds.

- Anticipate loose, wet, and liquefiable soils within the Old Pond Site and other thawed areas within the investigated area.

- Anticipate encountering several feet of organic mat and organic rich soil within the West Tin Creek Hills Site, relatively low-lying portions of the proposed material source alignment, and other areas of relatively low-topographic relief within the investigated area

- Anticipate encountering thick layers of massive ice within large portions of the Tin Creek Site and portions of the proposed material source alignment of relatively high topographic relief

Anticipate thawed soils, and possibly a groundwater table in soils within and adjacent to drainages. The size of thaw bulb surrounding drainages, however, may be limited.

- Anticipate possibility of encountering saline soils with a depressed thawing temperature.

The major design consideration within the Old Pond Site is bearing capacity and settlement within relatively wet and loose silt soils. Depending upon construction practices and final village-site design, drainage of excessively wet soils and standing water may be necessary. The West Tin Creek Hills Site exhibited ice-rich soils above roughly 11 feet bgs. These soils may become thaw-unstable if allowed to thaw. The pervasive, massive ice encountered in portions of both the proposed alignment and the Tin Creek Site will result in excessive settlement if allowed to thaw. Much of the soil encountered during this investigation may be frost-susceptible. Depending on location, design criteria, therefore, should be as such to mitigate settlement, thawing, and excessive frost heave.

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Appendix A. Test Hole Logs

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist M. BILLINGS
Field Crew S. Parker, G. Nelson

Project Shishmaref Relocation Road
Project Number AKSAS 76776
Material Site Old Pond
Equipment Type Mobile B-24
Weather -10 F, clear, breezy
Vegetation

Test Hole Number TH15-2004
Total Depth 31.5 feet
Dates Drilled 3/31/2015 - 3/31/2015
Station, Offset
Latitude, Longitude N66.0861°, W166.3076°
Elevation

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:
* Relative density was estimated from drill action and sample handling

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Graphic Log	SUBSURFACE MATERIAL
	0									Snow
	1									Pond ICE with lake grass
	2									
	3		AUGER	15-8000						Dark brown, organic-rich SILT; frozen Vx 15% - 20% ice
	4									
	5									
	6									
	7									
	8									
	9									
	10		AUGER	15-8001						
	11									Loose*, brownish gray SILT; moist to wet slightly organic
	12									
	13									
	14									
S-S Auger	15									
	16									
	17									
	18									
	19									
	20		AUGER	15-8002						
	21									
	22									
	23									
	24									Loose*, brownish gray to gray SILT; wet trace fine sand slightly organic
	25									
	26									
	27									
	28									
	29									
	30									
	31		AUGER	15-8003					BOH	Gray SILT with Gravel; frozen Nbn coarse sand and fine gravel particles

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist	M. BILLINGS	Project	Shishmaref Relocation Road
Field Crew	S. Parker, G. Nelson	Project Number	AKSAS 76776
		Material Site	Old Pond
		Equipment Type	Mobile B-24
		Weather	-5 F, clear, breezy
		Vegetation	

Test Hole Number	TH15-2005
Total Depth	19 feet
Dates Drilled	4/1/2015 - 4/1/2015
Station, Offset	
Latitude, Longitude	N66.0879º, W166.3076º
Elevation	

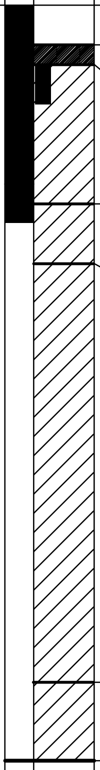
Ground Water Data

	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

* Relative density was estimated from drill action and sample handling

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data Method	Sample Data Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Graphic Log	SUBSURFACE MATERIAL
S-S Auger	0 – 1									Snow
	1 – 2									Pond ICE with lake grass
	2 – 5		AUGER	15-8004		2 – 3.5				Dark brown, organic-rich SILT; frozen Nbn to Vx 1.5 feet to 2.5 feet: Vx, 20% - 30% ice 2.5 feet to 5 feet: Nbn
	5 – 7		AUGER	15-8005		5 – 6.5				Dark brown organic SILT; frozen Nbn to Nbe to moist moist below 5.5 feet
	7 – 17		AUGER	15-8006		13 – 15				Loose*, grayish Brown SILT; moist to wet slightly organic wet below ~12 feet
	17 – 19		AUGER	15-8007		17 – 19				Loose*, brownish gray to gray SILT; wet
	19									BOH



Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Old Pond
Equipment Type: Mobile B-24
Weather: -5 F, clear, breezy
Vegetation:

Test Hole Number: TH15-2006
Total Depth: 29 feet
Dates Drilled: 4/1/2015 - 4/1/2015
Station, Offset:
Latitude, Longitude: N66.0898°, W166.3075°
Elevation:

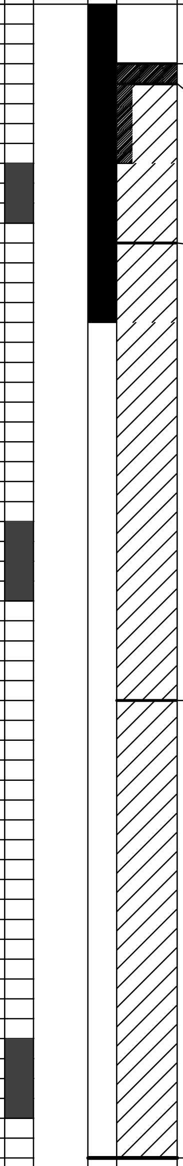
Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

* Relative density was estimated from drill action and sample handling

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Graphic Log
S-S Auger	4		AUGER	15-8008					
	13		AUGER	15-8009					
	26		AUGER	15-8010					



SUBSURFACE MATERIAL

Snow

Pond ICE with lake grass

Dark brown SILT; frozen Nbn, Nbe and Vx
1.5 feet to 4 feet: Vx, ~ 20% - 30% Ice
4 feet to 6 feet: Nbn to Nbe
slightly organic to highly organic, 1/16-inch to 1/8-inch organic inclusions

Loose*, brown to grayish brown SILT; frozen Nbn to moist
moist below 8 feet
6 feet to 8 feet: laminated layers of brown and gray silt
slightly organic to organic; organic content appears to decrease with depth

Loose*, brownish gray to gray SILT; wet

BOH

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Old Pond
Equipment Type: Mobile B-24
Weather: 0 F, cloudy, calm
Vegetation:

Test Hole Number: TH15-2007
Total Depth: 19 feet
Dates Drilled: 4/2/2015 - 4/2/2015
Station, Offset:
Latitude, Longitude: N66.0898°, W166.3123°
Elevation:

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

* Relative density was estimated from drill action and sample handling

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Subsurface Material
S-S Auger	0 – 1.5							Frozen	Snow
	1.5 – 2							Frozen	Pond ICE with lake grass
	2 – 6.5		AUGER	15-8011		2.5 – 4		Frozen	Dark brown SILT; frozen Nbn, Nbe, and Vx organic to highly organic 2 feet to 2.5 feet: Vx, ~ 20% - 30% ice 2.5 feet to 6.5 feet; Nbn to Nbe
	6.5 – 17		AUGER	15-8012		10 – 12			Loose*, grayish brown to brownish gray SILT; moist to wet
	17 – 19		AUGER	15-8013		17 – 19			Loose*, gray SILT; wet
	19								BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist	M. BILLINGS		
Field Crew	S. Parker, G. Nelson		
Project	Shishmaref Relocation Road	Test Hole Number	TH15-2008
Project Number	AKSAS 76776	Total Depth	20 feet
Material Site	Old Pond	Dates Drilled	4/2/2015 - 4/2/2015
Equipment Type	Mobile B-24	Station, Offset	
Weather	0 F, cloudy, calm	Latitude, Longitude	N66.0898°, W166.3169°
Vegetation		Elevation	

Ground Water Data

	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

* Relative density was estimated from drill action and sample handling

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Sample Data: Number	Sample Data: Blow Count	Sample Data: Sample Interval	Sample Data: Uncorrected N-Value	Frozen	Graphic Log	SUBSURFACE MATERIAL
S-S Auger	0							■		Snow
	1							■		Pond ICE with lake grass
	2		AUGER	15-8014		■		■		
	3							■		Dark brown, organic-rich SILT; frozen Vx ~20% ice
	4							■		
	5							■		
	6									Loose*, brown to grayish brown SILT; moist to wet organic 5.5 feet to 10 feet: moist moist to wet below 10 feet
	7									
	8									
	9									
	10									
	11		AUGER	15-8015		■				
	12					■				
	13									
	14									
	15									Loose*, brownish gray SILT; moist to wet
	16									
	17		AUGER	15-8016		■				
	18					■				
	19									
	20									BOH

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist M. BILLINGS
Field Crew S. Parker, G. Nelson

Project Shishmaref Relocation Road
Project Number AKSAS 76776
Material Site Old Pond
Equipment Type Mobile B-24
Weather 5 F, sunny, slight breeze
Vegetation

Test Hole Number TH15-2009
Total Depth 22.5 feet
Dates Drilled 4/2/2015 - 4/2/2015
Station, Offset
Latitude, Longitude N66.0878°, W166.3171°
Elevation

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

* Relative density was estimated from drill action and sample handling

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0 – 1.5							■	Snow
	1.5 – 2							■	Pond ICE with lake grass and organic silt
	2 – 7							■ (0 – 6)	Dark brown, organic-rich SILT; frozen Nbn to moist zones and inclusions of dark brown PEAT loose* and moist below 6 feet
	4 – 6		AUGER	15-8017		■			
	7 – 14								Loose*, grayish brown SILT; moist
	7 – 8		AUGER	15-8018		■			
	14 – 22.5								Loose*, gray SILT with Sand; moist to wet
	16 – 18		AUGER	15-8019		■			
	21 – 22.5		AUGER	15-8020		■			
	22.5								BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist	M. BILLINGS		
Field Crew	S. Parker, G. Nelson		
Project	Shishmaref Relocation Road	Test Hole Number	TH15-2010
Project Number	AKSAS 76776	Total Depth	23 feet
Material Site	Old Pond	Dates Drilled	4/2/2015 - 4/2/2015
Equipment Type	Mobile B-24	Station, Offset	
Weather	5 F, sunny, slight breeze	Latitude, Longitude	N66.0861°, W166.3169°
Vegetation		Elevation	

Ground Water Data

	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

* Relative density was estimated from drill action and sample handling

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0							Frozen 0–6	
	1								Snow
	2		AUGER	15-8021		2–3			Pond ICE with lake grass and organic silt
	3								
	4								Dark brown, organic-rich SILT; frozen Vx ~20% ice
	5								
	6								
	7								
	8								
	9		AUGER	15-8022		9–11			Dark brown SILT; frozen Nbn to moist slightly organic to organic; decreasing with depth 4 feet to 6 feet: Nbn loose* and moist below 6 feet
	10								
	11								
	12								
	13								
	14								
	15								
	16								
	17		AUGER	15-8023		17–19			
	18								
	19								Loose*, gray SILT with Sand; wet
	20								
	21								
	22		AUGER	15-8024		22–23			
	23								BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Old Pond
Equipment Type: Mobile B-24
Weather: -5 F, foggy, ~ 10mph wind
Vegetation:

Test Hole Number: TH15-2011
Total Depth: 19 feet
Dates Drilled: 4/3/2015 - 4/3/2015
Station, Offset:
Latitude, Longitude: N66.0861°, W166.3122°
Elevation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

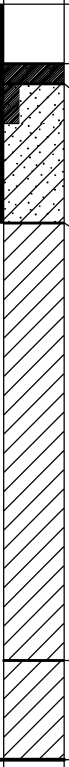
GENERAL COMMENTS:

* Relative density was estimated from drill action and sample handling

Drilling Method: S-S Auger

Sample Method	Number	Sample Interval (Feet)
AUGER	15-8025	2 - 3
AUGER	15-8026	6 - 7
AUGER	15-8027	14 - 15.5
AUGER	15-8028	18 - 19

Frozen: 0 - 5.5 feet



SUBSURFACE MATERIAL

Depth in (Feet)	Description
0 - 1.5	Snow
1.5 - 2.8	Pond ICE with lake grass and organic silt
2 - 5.5	Brown to dark brown Sandy SILT; frozen Nbn, Nbe and Vx organic 2 feet to 3 feet: Vx, ~ 30% ice 3 feet to 5.5 feet: Nbn to Nbe
5.5 - 16.5	Loose*, grayish brown to brown SILT; moist organic
16.5 - 19	Loose*, gray SILT; moist to wet
19	BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Old Pond
Equipment Type: Mobile B-24
Weather: -5 F, foggy, ~ 10mph wind
Vegetation:

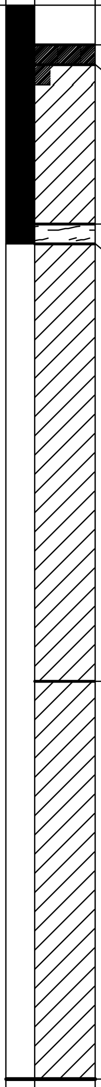
Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Test Hole Number: TH15-2012
Total Depth: 27 feet
Dates Drilled: 4/3/2015 - 4/3/2015
Station, Offset:
Latitude, Longitude: N66.0878°, W166.3122°
Elevation:

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

* Relative density was estimated from drill action and sample handling



Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	SUBSURFACE MATERIAL
S-S Auger	0							Snow
	1							Pond ICE with lake grass and organic silt
	3							Dark brown SILT; frozen Nbn to Vx organic to highly organic; organic content decreasing with depth 1.5 feet to 2 feet: Vx, ~ 20% - 30% ice 2 feet to 5.5 feet: Nbn
	6							Dark brown PEAT; frozen Nbn
	10		AUGER	15-8029		■		
	11					■		Loose*, grayish brown SILT; moist
	17							
	18		AUGER	15-8030		■		
	21							Loose*, gray SILT; moist to wet
	24		AUGER	15-8031		■		
	27							BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Alignment
Equipment Type: Mobile B-24
Weather: 0 F, partly cloudy, 5mph wind
Vegetation:

Test Hole Number: TH15-2013
Total Depth: 19 feet
Dates Drilled: 4/3/2015 - 4/3/2015
Station, Offset:
Latitude, Longitude: N66.0957°, W166.1452°
Elevation:

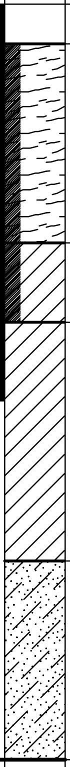
Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data

	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:
* Relative density was estimated from drill action and sample handling

Located mid-slope, near bottom of Tin Creek valley



Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	SUBSURFACE MATERIAL
S-S Auger	0							Snow
	1							Tannish orange and brown Tundra and Organic Mat; frozen Vx ~25% - 35% ice 4 feet to 6 feet: thin layers of ice
	2		AUGER	15-8032		■		
	6		AUGER	15-8033		■		Dark brown, organic-rich SILT; frozen Vx ~25% ice thin layers of ice
	8		AUGER	15-8034		■		Dark grey to black SILT; frozen Nbn to Nbe, moist below 10 feet organic; silt-sized organics loose* and moist below 10 feet
	14							Loose*, gray Silty SAND; moist to wet
	18		AUGER	15-8035		■		
	19							BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Alignment
Equipment Type: Mobile B-24
Weather: 0 F, clear, 10mph wind
Vegetation:

Test Hole Number: TH15-2014 A
Total Depth: 10 feet
Dates Drilled: 4/4/2015 - 4/4/2015
Station, Offset:
Latitude, Longitude: N66.1074°, W166.1502°
Elevation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

* Relative density was estimated from drill action and sample handling

Located within creek bed

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Graphic Log	SUBSURFACE MATERIAL
S-S Auger	0							■		
	1							■		Snow
	2							■	▨	
	3							■	▨	ICE
	4									
	5									
	6									Water
	7									
	8								▨	
	9								▨	Loose*, dark brown, organic-rich SILT; wet
	10									BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist M. BILLINGS
Field Crew S. Parker, G. Nelson

Project Shishmaref Relocation Road
Project Number AKSAS 76776
Material Site Alignment
Equipment Type Mobile B-24
Weather 0 F, clear, 10mph wind
Vegetation

Test Hole Number TH15-2014 B
Total Depth 19 feet
Dates Drilled 4/4/2015 - 4/4/2015
Station, Offset
Latitude, Longitude N66.1076°, W166.1511°
Elevation

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

* Relative density was estimated from drill action and sample handling

Located mid-slope above valley bottom

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen
S-S Auger	0–19							
	0–5.5							■
	3–4		AUGER	15-8036		■		
	10–11.5		AUGER	15-8037		■		
	14–15		AUGER	15-8038		■		

SUBSURFACE MATERIAL

0	Snow
1.5	Tan, brown and green Tundra Mat and grass; frozen Vx ~40% ice
3	Light brown, tan and gray mottled SILT; frozen Nf to Nbn highly organic; silt-sized organics; strong organic odor
5	Loose*, dark gray to black SILT; moist to wet slightly organic moisture content increased with depth strong sulfur and methane odor
19	BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist M. BILLINGS
Field Crew S. Parker, G. Nelson

Project Shishmaref Relocation Road
Project Number AKSAS 76776
Material Site West Tin Creek Hills
Equipment Type Mobile B-24
Weather 5 F, clear, 5mph wind
Vegetation

Test Hole Number TH15-2015
Total Depth 15 feet
Dates Drilled 4/4/2015 - 4/4/2015
Station, Offset
Latitude, Longitude N66.1011°, W166.1155°
Elevation

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Sample Data: Number	Sample Data: Blow Count	Sample Data: Sample Interval	Sample Data: Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0							■	Snow
	1							■	
	2							■	Brown and green Tundra and Organic Mat; frozen Vx ~ 30% - 40% ice
	3							■	Tan Silt; frozen Vx 3 feet to 4 feet: ~ 80% - 90% ice 4 feet to 6 feet: ~ 60% - 70% ice
	4							■	
	5							■	
	6							■	Brown, tan and gray mottled SILT; frozen Vx 6 feet to 8 feet: ~ 40% ice 8 feet to 10 feet: ~ 5% - 10% ice
	7		AUGER	15-8039		■		■	
	8							■	
	9		AUGER	15-8040		■		■	
	10							■	Grayish brown to brownish gray SILT; frozen Nbn
	11							■	
	12							■	
	13							■	
	14		AUGER	15-8041		■		■	
	15								BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

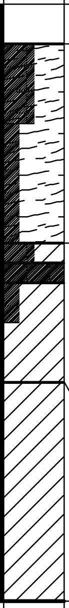
TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist	M. BILLINGS	Project	Shishmaref Relocation Road
Field Crew	S. Parker, G. Nelson	Project Number	AKSAS 76776
		Material Site	West Tin Creek Hills
		Equipment Type	Mobile B-24
		Weather	5-10 F, 10-15mph wind
		Vegetation	
		Test Hole Number	TH15-2016
		Total Depth	15 feet
		Dates Drilled	4/4/2015 - 4/4/2015
		Station, Offset	
		Latitude, Longitude	N66.1011°, W166.1105°
		Elevation	

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:



Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Sample Data: Number	Sample Data: Blow Count	Sample Data: Sample Interval	Sample Data: Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0							■	Snow
	1							■	Tan, brown and orange Tundra Mat, dark brown PEAT, and organic SILT; frozen Vx 1 foot to 3 feet: ~40% - 60% ice 3 feet to 4.5 feet: ~25% - 40% ice 4.5 feet to 6 feet: ~ 25% ice strong organic odor
	2							■	
	3							■	
	4							■	
	5		AUGER	15-8042		■		■	
	6							■	Dark brown SILT; frozen Nbn to Vx Organic to highly organic 6 feet to 6.5 feet: ~ 40% ice 6.5 feet to 7 feet: ICE 7 feet to 8 feet: ~ 25% - 30% ice 8 feet to 9.5 feet: Nbn strong organic odor
	7		AUGER	15-8043		■		■	
	8							■	
	9		AUGER	15-8044		■		■	
	10							■	Brownish gray SILT; frozen Nbn to Nbe
	11							■	
	12							■	
	13							■	
	14		AUGER	15-8045		■		■	
	15								BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: West Tin Creek Hills
Equipment Type: Mobile B-24
Weather: 15-20 F, cloudy, 15-20mph wind
Vegetation:

Test Hole Number: TH15-2017
Total Depth: 17 feet
Dates Drilled: 4/5/2015 - 4/5/2015
Station, Offset:
Latitude, Longitude: N66.1011º, W166.1061º
Elevation:

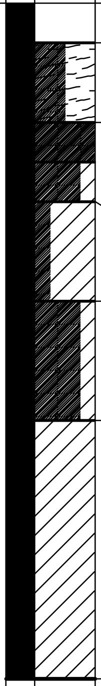
Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Uncorrected N-Value	SUBSURFACE MATERIAL
S-S Auger	0						Snow
	1						Tan, brown and green Tundra Mat; frozen Vx ~40% - 50% ice
	2						
	3						ICE and ICE with tan SILT 3 feet to 4 feet: ICE 4 feet to 5 feet: ~ 90% ice
	4						
	5						Dark brown SILT; frozen Vx slightly organic to organic ~25% - 30% ice
	6		AUGER	15-8046			
	7						
	8						Gray SILT; frozen Vx ~ 85% ice
	9		AUGER	15-8047			
	10						Brown SILT; frozen Nbn to Nbe slightly organic
	11		AUGER	15-8048			
	12						
	13						
	14						
	15						
	16		AUGER	15-8049			
	17						BOH

Sample Interval · Frozen · Graphic Log



Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist M. BILLINGS
Field Crew S. Parker, G. Nelson

Project Shishmaref Relocation Road
Project Number AKSAS 76776
Material Site West Tin Creek Hills
Equipment Type Mobile B-24
Weather 10-15 F, 10-15mph wind
Vegetation

Test Hole Number TH15-2018
Total Depth 15 feet
Dates Drilled 4/5/2015 - 4/5/2015
Station, Offset
Latitude, Longitude N66.0992°, W166.1059°
Elevation

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Graphic Log	SUBSURFACE MATERIAL
S-S Auger	0 - 1							■		Snow
	1 - 2.5							■		Tan, brown and green Tundra Mat; frozen Vx ~25% - 35% ice
	2.5 - 6.5		AUGER	15-8050		■		■		Tannish brown, Sandy, Silty PEAT: frozen Vx ~ 25% ice
	6.5 - 15		AUGER AUGER AUGER	15-8051 15-8052 15-8053		■		■		Grayish Brown to brownish gray SILT; frozen Nbn to Nbe 6.5 feet to 9.5 feet: organic 9.5 feet to 15 feet: slightly organic
	15									BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

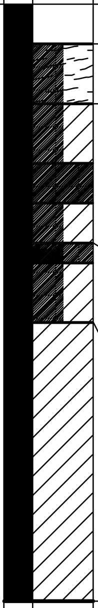
Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: West Tin Creek Hills
Equipment Type: Mobile B-24
Weather: 10 F, 20-25mph wind
Vegetation:

Test Hole Number: TH15-2019
Total Depth: 15 feet
Dates Drilled: 4/5/2015 - 4/5/2015
Station, Offset:
Latitude, Longitude: N66.0973º, W166.1059º
Elevation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:



Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Graphic Log	SUBSURFACE MATERIAL
S-S Auger	0									Snow
	1									brown, tan and green Tundra Mat; frozen Vx ~ 40% ice
	2.5									Brown to dark brown SILT; frozen Vx highly organic 2.5 feet to 4 feet: ~ 40% - 50% ice 4 feet to 5 feet: ICE 5 feet to 6 feet: ~35% - 45% ice
	6		AUGER	15-8054		■				Grayish brown SILT; frozen Vx slightly organic 6 feet to 6.5 feet: ~ 3-inch to 6-inch thick layer of ICE 6.5 feet to 8 feet: ~ 35% ice
	8									Brownish gray SILT; frozen Nbn
	14		AUGER	15-8055		■				
	15									BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

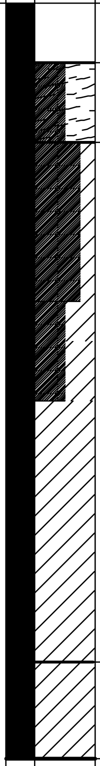
STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

		Project	Shishmaref Relocation Road	Test Hole Number	TH15-2020
		Project Number	AKSAS 76776	Total Depth	19 feet
Field Geologist	M. BILLINGS	Material Site	West Tin Creek Hills	Dates Drilled	4/8/2015 - 4/8/2015
Field Crew	S. Parker, G. Nelson	Equipment Type	Mobile B-24	Station, Offset	
		Weather	14 F, 10-15mph wind	Latitude, Longitude	N66.0973°, W166.1106°
		Vegetation		Elevation	

Ground Water Data

	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:



Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Sample Data: Number	Sample Data: Blow Count	Sample Data: Sample Interval	Sample Data: Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0							■	Snow
	1							■	
	2							■	Orange, brown, tan and green Tundra Mat, PEAT and organic SILT; frozen Vx ~ 40% ice
	3							■	
	4							■	Dark brown to brown SILT; frozen Nbn, Nbe to Vx slightly organic 3.5 feet to 7.5 feet: ~ 60% - 70% ice 7.5 feet to 8.5 feet: ~ 50% - 60% ice 8.5 feet to 10 feet: ~ 30% ice 10 feet to 16.5 feet: Nbn to Nbe organic content appears to decrease with depth
	5							■	
	6							■	
	7							■	
	8							■	
	9		AUGER	15-8056		■		■	
	10							■	
	11							■	
	12							■	
	13							■	
	14		AUGER	15-8057		■		■	
	15							■	
	16							■	
	17							■	Brownish gray SILT; frozen Nbn to Nbe
	18		AUGER	15-8058		■		■	
	19								BOH

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

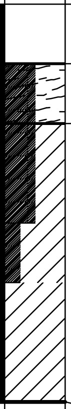
Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: West Tin Creek Hills
Equipment Type: Mobile B-24
Weather: 15 F, 5-15mph wind
Vegetation:

Test Hole Number: TH15-2021
Total Depth: 10 feet
Dates Drilled: 4/8/2015 - 4/8/2015
Station, Offset:
Latitude, Longitude: N66.0973º, W166.1155º
Elevation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:



Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data Method	Sample Data Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0							■	
	1							■	Snow
	2							■	Brown, tan, orange and green Tundra Mat; frozen Vx ~ 40% ice
	3							■	
	4							■	
	5		AUGER	15-8059		■		■	Dark brown, organic-rich SILT; frozen Nbn, Nbe, and Vx 3 feet to 5.5 feet: ~ 30% - 40% ice 5.5 feet to 7 feet; ~ 25% ice 7 feet to 10 feet: Nbn to Nbe organic content apears to decrease with depth
	6							■	
	7							■	
	8							■	
	9							■	
	10		AUGER	15-8060		■		■	BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: West Tin Creek Hills
Equipment Type: Mobile B-24
Weather: 10 F, partly cloudy, windy
Vegetation:

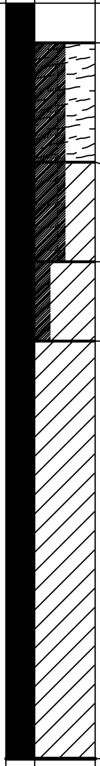
Test Hole Number: TH15-2022
Total Depth: 19 feet
Dates Drilled: 4/8/2015 - 4/8/2015
Station, Offset:
Latitude, Longitude: N66.0992º, W166.1096º
Elevation:

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0							■	Snow
	1							■	Dark brown, tan and orange Tundra Mat and Organic Silt; frozen Vx ~40% - 50% ice
	4							■	Dark brown SILT; frozen Vx highly organic ~ 50% ice
	6							■	Brown and gray mottled SILT; frozen Nbe to Vx slighly organic with a strong organic odor ~ 5% ice
	7		AUGER	15-8061		■		■	
	9		AUGER	15-8062		■		■	Gray SILT; frozen Nbn trace fine sand
	18		AUGER	15-8063		■		■	
	19								BOH

Graphic Log



Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: West Tin Creek Hills
Equipment Type: Mobile B-24
Weather: 10 F, snow, ~15mph wind
Vegetation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Test Hole Number: TH15-2023
Total Depth: 23 feet
Dates Drilled: 4/8/2015 - 4/8/2015
Station, Offset:
Latitude, Longitude: N66.0992°, W166.1154°
Elevation:

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Sample Data: Number	Sample Data: Blow Count	Sample Data: Sample Interval	Sample Data: Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0							■	
	1							■	Snow
	2							■	tan and brown Tundra Mat; frozen Vx
	3							■	~ 40% ice
	4							■	ICE with tannish brown Silt
	5							■	~ 85% - 95% ICE
	6							■	
	7							■	
	8							■	
	9							■	Dark brown SILT; frozen Vx
	10							■	organic
	11		AUGER	15-8064		■		■	7 feet to 11 feet: ~ 50% - 60% ice 11 feet to 13 feet: ~ 15% - 20% ice
	12							■	
	13							■	
	14							■	
	15							■	brownish gray SILT; frozen Nbn to Nbe
	16							■	
	17							■	
	18							■	
	19							■	
	20							■	Gray SILT wih interbedded layers of fine sandy SILT; frozen Nbn
	21							■	~ 2-inch to 6-inch thick layers of fine sany SILT
	22		AUGER	15-8065		■		■	
	23								BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Alignment
Equipment Type: Mobile B-24
Weather: 10 F, snow, slight breeze
Vegetation:

Test Hole Number: TH15-2024
Total Depth: 19 feet
Dates Drilled: 4/8/2015 - 4/8/2015
Station, Offset:
Latitude, Longitude: N66.0852º, W166.1418º
Elevation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Located near base of slop within low-lying area

Drilling Method: S-S Auger

Method	Number
AUGER	15-8066
AUGER	15-8067
AUGER	15-8068
AUGER	15-8069

SUBSURFACE MATERIAL

Snow

Brown, tan and green Tundra Mat; frozen Vx
~40% ice

Light, tannish brown SILT; frozen Vx
organic
~35% - 40% ice

ICE with tannish brown SILT and PEAT
~85% - 95% ICE

Tan, gray and brown SILT; frozen Vx and Nbn
7.5 feet to 8.5 feet: Vx, ~25% - 35% ice
8.5 feet to 16.5 feet: Nbn
12.5 feet to 13.5 feet: scattered ~2-inch thick layers of ice

Gray, SILT with Sand; frozen Nbn

BOH

Depth in (Feet): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Alignment
Equipment Type: Mobile B-24
Weather: 20-25 F, cloudy, slight breeze
Vegetation:

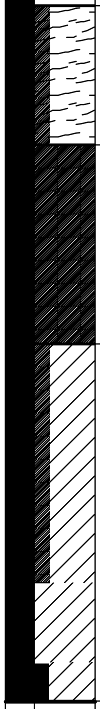
Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Test Hole Number: TH15-2025
Total Depth: 19 feet
Dates Drilled: 4/9/2015 - 4/9/2015
Station, Offset:
Latitude, Longitude: N66.0759°, W166.1396°
Elevation:

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Located near toe of slope on a raised plateau



Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Sample Data: Number	Sample Data: Blow Count	Sample Data: Sample Interval	Sample Data: Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL	
S-S Auger	0							■		0
	1							■	Snow	1
	2							■	Orange, tan, brown and green Tundra Mat and dark brown PEAT; frozen Vx 1.5 feet to 3 feet: Tundra Mat 3 feet to 5 feet: PEAT ~25% - 40% ice	2
	3							■		3
	4							■		4
	5							■		5
	6							■		6
	7							■	ICE with tan, gray and brown SILT ~75% - 95% ice ice content decreases with depth	7
	8							■		8
	9							■		9
	10		AUGER	15-8070		■		■		10
	11							■		11
	12		AUGER	15-8071		■		■		12
	13							■	Dark brown to grayish brown SILT; frozen Nbe to Vx slightly organic to organic 10 feet to 16 feet: Vx, ~15% - 30% ice 16 feet to 18 feet: Nbe 18 feet to 19 feet: Vx, ~20% - 25% ice	13
	14							■		14
	15							■		15
	16							■		16
	17							■		17
	18		AUGER	15-8072		■		■		18
	19								BOH	19

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist M. BILLINGS
Field Crew S. Parker, G. Nelson

Project Shishmaref Relocation Road
Project Number AKSAS 76776
Material Site Alignment
Equipment Type Mobile B-24
Weather 20-25 F, cloudy, slight breeze
Vegetation

Test Hole Number TH15-2026
Total Depth 35 feet
Dates Drilled 4/9/2015 - 4/9/2015
Station, Offset
Latitude, Longitude N66.0688°, W166.1591°
Elevation

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Located ~10 feet below top of hill

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Graphic Log	SUBSURFACE MATERIAL
S-S Auger	0 – 1.5									Snow
	1.5 – 2									Tan, brown and green Tundra Mat and grass; frozen Vx ~25% ice
	2 – 4.5									Dark brown organic SILT; frozen Vx scattered to numerous PEAT inclusions ~30% ice
	4.5 – 35									ICE with trace SILT ~ 95% - 100% ice
	35									BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Alignment
Equipment Type: Mobile B-24
Weather: 20 F, cloudy, slight breeze
Vegetation:

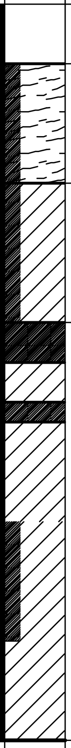
Test Hole Number: TH15-2027
Total Depth: 18.5 feet
Dates Drilled: 4/9/2015 - 4/9/2015
Station, Offset:
Latitude, Longitude: N66.0606°, W166.1751°
Elevation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Located on gentle slope of broad plateau



Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0								Snow
	1								
	2		AUGER	15-8073		■			Tan and brown Tundra Mat, dark brown PEAT and organic SILT; frozen Vx 1.5 feet to 2 feet: Tundra Mat 2 feet to 4.5 feet: PEAT ~30% ice
	3								
	4								
	5								
	6		AUGER	15-8074		■			Dark brown, organic SILT; frozen Nbe to Vx
	7								
	8								
	9								
	10								
	11		AUGER	15-8075		■			
	12								Brown to brownish gray SILT with 6-inch to 12-inch thick layers of ICE 9 feet to 10 feet and 10.5 feet to 13 feet: Nbn to Nbe 13 feet to 16 feet: Vx, ~10% ice 16 feet to 18.5 feet: Nbe
	13								
	14		AUGER	15-8076		■			
	15								
	16								
	17								
	18								BOH

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Alignment
Equipment Type: Mobile B-24
Weather: 20 F, cloudy, slight breeze
Vegetation:

Test Hole Number: TH15-2028
Total Depth: 29 feet
Dates Drilled: 4/9/2015 - 4/9/2015
Station, Offset:
Latitude, Longitude: N66.0531°, W166.1964°
Elevation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Located near top of hill

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Method	Sample Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen
S-S Auger	3 - 4		AUGER	15-8079		■		■
S-S Auger	28 - 29		AUGER	15-8078		■		■

SUBSURFACE MATERIAL

Depth (ft)	Description
0 - 1	Snow
1 - 1.5	Brown and green Tundra Mat with grass
1.5 - 5	Dark brown, organic-rich SILT; frozen Vx 1.5 feet to 3 feet: ~40% ice 3 feet to 5 feet: ~15% - 20% ice
5 - 24	ICE
24 - 29	ICE with brown and gray SILT ~ 95% Ice
29	BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Alignment
Equipment Type: Mobile B-24
Weather: 20 F, snow, cloudy, slight breeze
Vegetation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

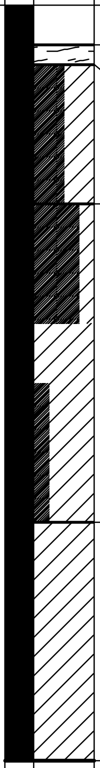
Test Hole Number: TH15-2029
Total Depth: 19 feet
Dates Drilled: 4/9/2015 - 4/9/2015
Station, Offset:
Latitude, Longitude: N66.0459°, W166.2052°
Elevation:

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Located within low-lying area above Tin Creek

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Graphic Log
S-S Auger	0 – 19		AUGER	15-8077		13.5 – 14.5		0 – 19	



SUBSURFACE MATERIAL

Snow

Brown Tundra Mat; frozen Vx

Dark brown Organic SILT to PEAT; frozen Vx
~40% - 50% ice

Dark brown SILT; frozen Nbe to Vx
5 feet to 8 feet: Vx, ~75% - 85% ice
8 feet to 9.5 feet: Nbe
9.5 feet to 13 feet: Vx, ~5% - 15% ice

Dark brown gray SILT; frozen Nbn to Nbe
slightly organic; strong organic odor

BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist	M. BILLINGS	Project	Shishmaref Relocation Road
Field Crew	S. Parker, G. Nelson	Project Number	AKSAS 76776
		Material Site	Tin Creek
		Equipment Type	Mobile B-24
		Weather	5-10 F, snow, foggy, cloudy, 20-25mph wind
		Vegetation	

Test Hole Number	TH15-2030
Total Depth	31 feet
Dates Drilled	4/10/2015 - 4/10/2015
Station, Offset	
Latitude, Longitude	N66.0723°, W166.0651°
Elevation	

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Graphic Log	SUBSURFACE MATERIAL
S-S Auger	0 - 2							■		Snow
	2 - 4							■		Dark brown Tundra Mat and PEAT with organic SILT; frozen Vx ~35% - 40% ice
	4 - 31							■		ICE
	31									BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

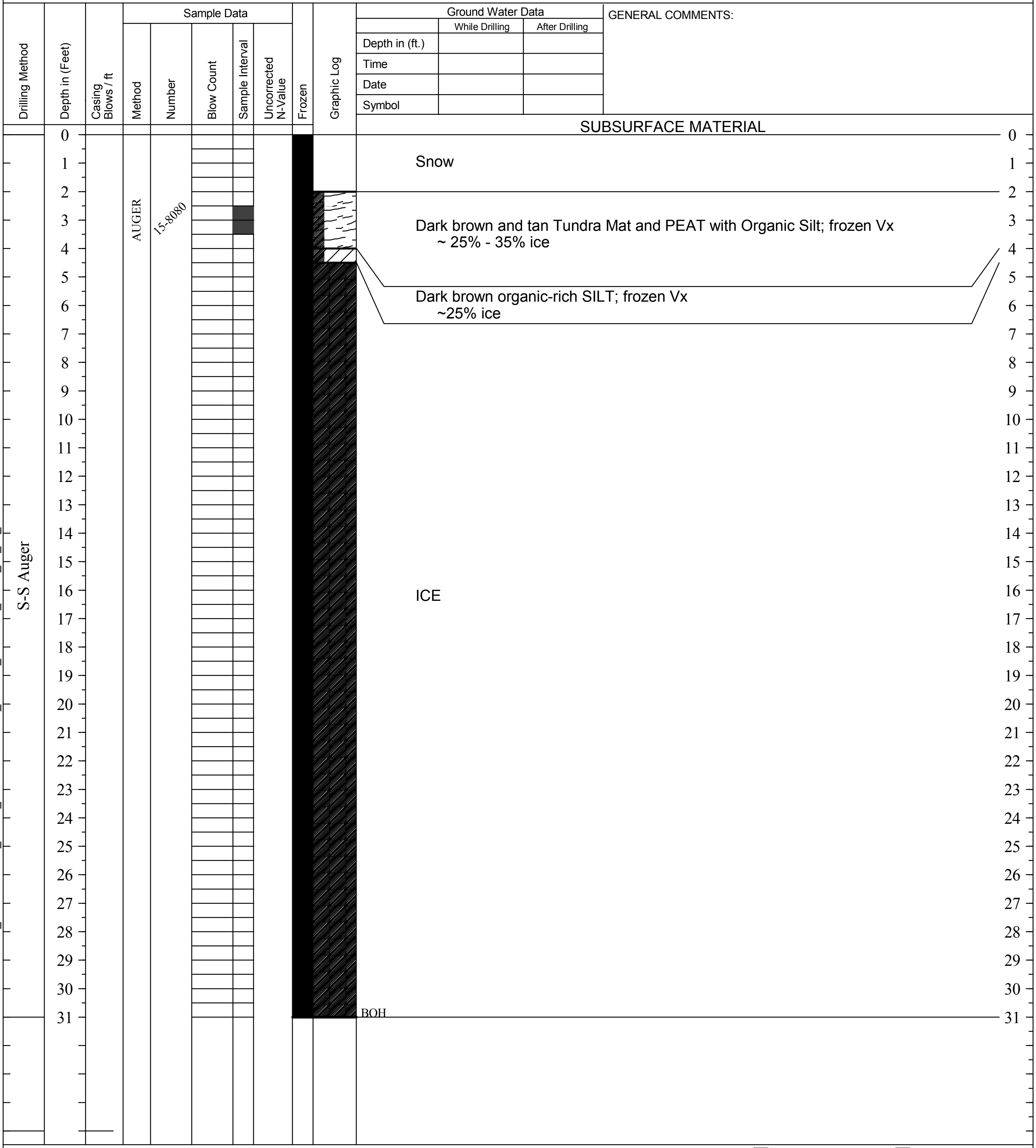
Project Shishmaref Relocation Road
Project Number AKSAS 76776
Material Site Tin Creek
Equipment Type Mobile B-24
Weather 5-10 F, cloudy, 20-25mph wind
Vegetation

Test Hole Number TH15-2031
Total Depth 31 feet
Dates Drilled 4/10/2015 - 4/10/2015
Station, Offset
Latitude, Longitude N66.0723°, W166.0603°
Elevation

Field Geologist M. BILLINGS
Field Crew S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:



SUBSURFACE MATERIAL

Snow

Dark brown and tan Tundra Mat and PEAT with Organic Silt; frozen Vx
~ 25% - 35% ice

Dark brown organic-rich SILT; frozen Vx
~25% ice

ICE

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist	M. BILLINGS	Project	Shishmaref Relocation Road
Field Crew	S. Parker, G. Nelson	Project Number	AKSAS 76776
		Material Site	Tin Creek
		Equipment Type	Mobile B-24
		Weather	5-10 F, cloudy, 20-25mph wind
		Vegetation	

Test Hole Number	TH15-2032
Total Depth	31 feet
Dates Drilled	4/10/2015 - 4/10/2015
Station, Offset	
Latitude, Longitude	N66.0721°, W166.0558°
Elevation	

Ground Water Data

	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method	Depth in (Feet)	Casing Blows / ft	Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0 - 2							■	Snow
S-S Auger	2 - 3		AUGER	15-8081				■	Dark brown Tundra Mat and PEAT with Organic SILT; frozen Vx ~35% - 40% ice
S-S Auger	3 - 4		AUGER	15-8081		■		■	Brown, organic-rich SILT; frozen Vx ~35% - 40% ice
S-S Auger	4 - 31							■	ICE
	31								BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project	Shishmaref Relocation Road	Test Hole Number	TH15-2033
Project Number	AKSAS 76776	Total Depth	31 feet
Material Site	Tin Creek	Dates Drilled	4/10/2015 - 4/10/2015
Equipment Type	Mobile B-24	Station, Offset	
Weather	5-10 F, blowing snow, 25mph wind	Latitude, Longitude	N66.0703°, W166.0556°
Vegetation		Elevation	

Field Geologist M. BILLINGS
Field Crew S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Sample Data: Method | Number | Blow Count | Sample Interval | Uncorrected N-Value

Drilling Method	Depth in (Feet)	Casing Blows / ft	Frozen	SUBSURFACE MATERIAL
S-S Auger	0 - 2		■	Snow
	2 - 4		■	Dark brown, tan and green Tundra Mat and PEAT with Organic SILT; frozen Vx ~35% ice
	4 - 31		■	ICE
	31			BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

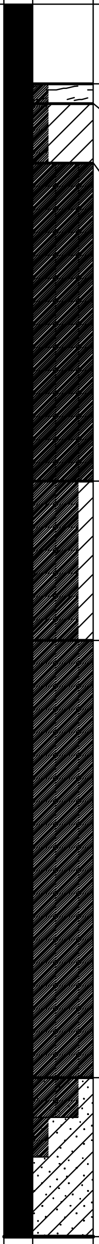
TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist	M. BILLINGS	Project	Shishmaref Relocation Road
Field Crew	S. Parker, G. Nelson	Project Number	AKSAS 76776
		Material Site	Tin Creek
		Equipment Type	Mobile B-24
		Weather	5 F, partly cloudy, slight breeze
		Vegetation	
		Test Hole Number	TH15-2034
		Total Depth	31 feet
		Dates Drilled	4/12/2015 - 4/12/2015
		Station, Offset	
		Latitude, Longitude	N66.0688°, W166.0557°
		Elevation	

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:



Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Sample Data: Number	Sample Data: Blow Count	Sample Data: Sample Interval	Sample Data: Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL	
	0									0
	1								Snow	1
	2								Brown Tundra Mat; frozen Vx ~40% ice	2
	3		AUGER	15-8082						3
	4								Dark brown organic-rich SILT; frozen Vx ~25%-35% ice numerous dark brown PEAT inclusions	4
	5									5
	6									6
	7									7
	8								ICE	8
	9									9
	10									10
	11									11
	12									12
	13		AUGER	15-8083					Gray SILT; frozen Vx trace fine Sand ~60% - 70% ice	13
	14									14
S-S Auger	15									15
	16									16
	17									17
	18									18
	19									19
	20									20
	21								ICE	21
	22									22
	23									23
	24									24
	25									25
	26									26
	27									27
	28								Gray SILT with Sand; frozen Vx 27 feet to 28 feet: ~60% - 70% ice 28 feet to 29 feet: ~15% - 25% ice 29 feet to 30 feet: ~5% - 10% ice 30 feet to 31 feet: Nbn	28
	29									29
	30		AUGER	15-8084						30
	31								BOH	31

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Tin Creek
Equipment Type: Mobile B-24
Weather: 5 F, partly cloudy, 5-10mph wind
Vegetation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Test Hole Number: TH15-2035
Total Depth: 31 feet
Dates Drilled: 4/12/2015 - 4/12/2015
Station, Offset:
Latitude, Longitude: N66.0702°, W166.0607°
Elevation:

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method: S-S Auger

Columns: Drilling Method | Depth in (Feet) | Casing Blows / ft | Sample Data: Method, Number, Blow Count, Sample Interval, Uncorrected N-Value | Frozen | Graphic Log

SUBSURFACE MATERIAL

Depth in (Feet)	Subsurface Material
0	Snow
1	
2	Dark brown and green Tundra Mat; frozen Vx ~30% ice
3	Dark brown organic-rich SILT; frozen Vx ~35% ice
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	ICE
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	Gray SILT; frozen Vx ~25% - 30% ice
31	BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist M. BILLINGS
Field Crew S. Parker, G. Nelson

Project Shishmaref Relocation Road
Project Number AKSAS 76776
Material Site Tin Creek
Equipment Type Mobile B-24
Weather 5 F, partly cloudy, 10-15mph wind
Vegetation

Test Hole Number TH15-2036
Total Depth 31 feet
Dates Drilled 4/12/2015 - 4/12/2015
Station, Offset
Latitude, Longitude N66.0704°, W166.0652°
Elevation

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method: S-S Auger

Sample Data

Method	Number	Sample Interval (Depth in Feet)
AUGER	15-8085	2.5 - 3.5
AUGER	15-8086	6 - 7

SUBSURFACE MATERIAL

Depth in (Feet)	Subsurface Material
0 - 1.5	Snow
1.5 - 2	Brown and green Tundra Mat with grass; frozen Vx ~40% ice
2 - 5	brown organic-rich SILT; frozen Vx ~40% - 50% ice
5 - 10	Gray SILT; frozen Vx ~55% - 65% ice
10 - 31	ICE
31	BOH

Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Project: Shishmaref Relocation Road
Project Number: AKSAS 76776
Material Site: Tin Creek
Equipment Type: Mobile B-24
Weather: 0 F, partly cloudy, slight breeze
Vegetation:

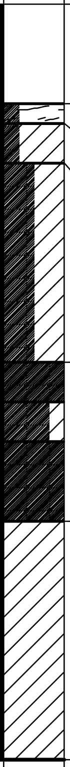
Test Hole Number: TH15-2037
Total Depth: 19 feet
Dates Drilled: 4/12/2015 - 4/12/2015
Station, Offset:
Latitude, Longitude: N66.0685°, W166.0606°
Elevation:

Field Geologist: M. BILLINGS
Field Crew: S. Parker, G. Nelson

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	Graphic Log	SUBSURFACE MATERIAL
S-S Auger	0 – 2							■		Snow
	2 – 3							■		Brown and green Tundra Mat; frozen Vx ~35% - 40% ice
	3 – 4							■		Brown organic-rich SILT; frozen Vx ~35% ice
	4 – 9							■		Tan and Gray SILT; frozen Vx ~60% - 70% ice
	9 – 13							■		ICE and ICE with gray SILT
	13 – 19		AUGER	15-8087		14 – 15		■		Brownish gray SILT; frozen Nbn to Nbe trace fine sand
	19								BOH	



Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

TEST HOLE LOG

STATE OF ALASKA DOT/PF
Northern Region Materials
Geology Section

Field Geologist M. BILLINGS
Field Crew S. Parker, G. Nelson

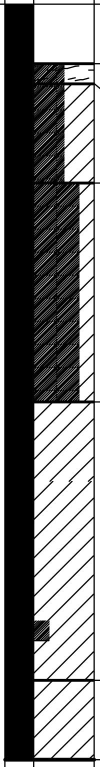
Project Shishmaref Relocation Road
Project Number AKSAS 76776
Material Site Tin Creek
Equipment Type Mobile B-24
Weather 0 F, partly cloudy, slight breeze
Vegetation

Test Hole Number TH15-2038
Total Depth 19 feet
Dates Drilled 4/12/2015 - 4/12/2015
Station, Offset
Latitude, Longitude N66.0683º, W166.0652º
Elevation

Ground Water Data	While Drilling	After Drilling
Depth in (ft.)		
Time		
Date		
Symbol		

GENERAL COMMENTS:

Drilling Method	Depth in (Feet)	Casing Blows / ft	Sample Data: Method	Number	Blow Count	Sample Interval	Uncorrected N-Value	Frozen	SUBSURFACE MATERIAL
S-S Auger	0								
	0 - 1.5							■	Snow
	1.5 - 2.8							■	Brown and green Tundra Mat; frozen Vx ~40% ice
	2.8 - 4.5							■	Dark brown, organic-rich SILT; frozen Vx ~40% - 45% ice
	4.5 - 10							■	ICE with gray SILT ~85% - 90% ICE
	10 - 17							■	Brown and gray mottled SILT; frozen Nbn slightly organic scattered 1/16-inch porganic inclusions and possible silt-sized organics
	14 - 15		AUGER	15-8088		■		■	
	17 - 19							■	Gray SILT; frozen Nbn
	18 - 18.5		AUGER	15-8089		■		■	
	19								BOH



Note: Unless otherwise noted, all samples are taken with 1-3/8-in. ID Standard Penetration Sampler driven with 140 lb. hammer with 30-in. drop. ☐ CME Auto Hammer ☐ Cathead Rope Method

NR AKDOT TEST HOLE LOG - USCS SHISH_RELOCATION_ROAD_PRELIM.GPJ NR_AKDOT_PRECON_USCS_06_28_07.GDT 5/9/15

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Appendix B. Laboratory Testing Reports

STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME:	Shishmaref Relocation Road
PROJECT NUMBER:	
AKSAS NUMBER:	76776
SAMPLED BY:	M. BILLINGS
MATERIAL SOURCE:	CENTERLINE

TEST HOLE NUMBER		TH15-2004	TH15-2004	TH15-2004	TH15-2004	TH15-2005	TH15-2005	TH15-2005
DEPTH (feet)		2.5-5.0	9.5-12.0	20.0-21.0	31.0-31.5	2.0-3.5	5.0-6.5	13.0-15.0
LATITUDE		N66.0861°	N66.0861°	N66.0861°	N66.0861°	N66.0879°	N66.0879°	N66.0879°
LONGITUDE		W166.3076°	W166.3076°	W166.3076°	W166.3076°	W166.3076°	W166.3076°	W166.3076°
LAB NUMBER		**15-8000**	**15-8001**	**15-8002**	**15-8003**	**15-8004**	**15-8005**	**15-8006**
DATE SAMPLED		31-Mar-15	31-Mar-15	31-Mar-15	31-Mar-15	1-Apr-15	1-Apr-15	1-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
Sand	**#8**							
	#10							
	#16		100					
	#30		99					
	#40		98			100		
	#50		98			99		
	#60		97			99		
	#80		97			99		
	#100		97			99		
Silt/Clay	**#200**		94.0			97.8		
Hydro	**0.02**							
	0.005							
	0.002							
	0.001							
LIQUID LIMIT			NV			NV		
PLASTIC INDEX			NP			NP		
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		87.3	47.5	32.1	17.2	91.3	90.3	43.2
ORGANICS		18.4	8.3	3.8		12.9	16.2	
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS		hi Org[1]	Org[1]	sl Org[1]		Org[1]	hi Org[1]	

GENERAL COMMENTS

Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7.

[1] Organic content determination is based on the results of the ATM T-6 test method.

(Soil descriptions shown in parentheses are based on field determinations.)

USCS Soil Description Abbreviations: WG = Well-graded; PG = Poorly-graded; E = Elastic; L = Lean; F = Fat

STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME: Shishmaref Relocation Road
PROJECT NUMBER:
AKSAS NUMBER: 76776
SAMPLED BY: M. BILLINGS
MATERIAL SOURCE: CENTERLINE

TEST HOLE NUMBER		TH15-2005	TH15-2006	TH15-2006	TH15-2006	TH15-2007	TH15-2007	TH15-2007
DEPTH (feet)		17.0-19.0	4.0-5.5	13.0-15.0	26.0-28.0	2.5-4.0	10.0-12.0	17.0-19.0
LATITUDE		N66.0879°	N66.0898°	N66.0898°	N66.0898°	N66.0898°	N66.0898°	N66.0898°
LONGITUDE		W166.3076°	W166.3075°	W166.3075°	W166.3075°	W166.3123°	W166.3123°	W166.3123°
LAB NUMBER		**15-8007**	**15-8008**	**15-8009**	**15-8010**	**15-8011**	**15-8012**	**15-8013**
DATE SAMPLED		1-Apr-15	1-Apr-15	1-Apr-15	1-Apr-15	2-Apr-15	2-Apr-15	2-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
	#8							
	#10							
	#16				100			
	#30				99			
Sand	**#40**				99			
	#50				99			
	#60	100		100	99			
	#80	99		99	98			
	#100	99		99	98			100
Silt/Clay	**#200**	97.6		97.5	92.5	99.9		98.1
	0.02				30.1			
Hydro	**0.005**				12.9			
	0.002				7.0			
	0.001							
LIQUID LIMIT		NV		NV	NV	NV		NV
PLASTIC INDEX		NP		NP	NP	NP		NP
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		38.8	96.6	45.1	37.1	97.7	39.6	35.6
ORGANICS				9.1		13.6		
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS				Org[1]		Org[1]		

GENERAL COMMENTS

Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7.

[1] Organic content determination is based on the results of the ATM T-6 test method.

(Soil descriptions shown in parentheses are based on field determinations.)

USCS Soil Description Abbreviations: WG = Well-graded; PG = Poorly-graded; E = Elastic; L = Lean; F = Fat

STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME: Shishmaref Relocation Road
PROJECT NUMBER:
AKSAS NUMBER: 76776
SAMPLED BY: M. BILLINGS
MATERIAL SOURCE: CENTERLINE

TEST HOLE NUMBER		TH15-2008	TH15-2008	TH15-2008	TH15-2009	TH15-2009	TH15-2009	TH15-2009
DEPTH (feet)		2.0-3.0	11.0-13.0	17.0-19.0	4.0-6.0	7.0-8.0	16.0-18.0	21.0-22.5
LATITUDE		N66.0898°	N66.0898°	N66.0898°	N66.0878°	N66.0878°	N66.0878°	N66.0878°
LONGITUDE		W166.3169°	W166.3169°	W166.3169°	W166.3171°	W166.3171°	W166.3171°	W166.3171°
LAB NUMBER		**15-8014**	**15-8015**	**15-8016**	**15-8017**	**15-8018**	**15-8019**	**15-8020**
DATE SAMPLED		2-Apr-15	2-Apr-15	2-Apr-15	2-Apr-15	2-Apr-15	2-Apr-15	2-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
	#8							
	#10							
	#16							
	#30							
Sand	**#40**					100		
	#50		100			99		
	#60		99			99		100
	#80		99			99		99
	#100		99			98		98
Silt/Clay	**#200**		98.0			92.7		78.3
	0.02							13.5
Hydro	**0.005**							8.9
	0.002							6.7
	0.001							
LIQUID LIMIT			NV			NV		NV
PLASTIC INDEX			NP			NP		NP
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		97.3	44.6	40.4	74.4	31.2	30.4	28.0
ORGANICS		12.4	9.6		13.1			2.4
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS		Org[1]	Org[1]		Org[1]			sl Org[1]

GENERAL COMMENTS

Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7.

[1] Organic content determination is based on the results of the ATM T-6 test method.

(Soil descriptions shown in parentheses are based on field determinations.)

USCS Soil Description Abbreviations: WG = Well-graded; PG = Poorly-graded; E = Elastic; L = Lean; F = Fat

STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME:	Shishmaref Relocation Road
PROJECT NUMBER:	
AKSAS NUMBER:	76776
SAMPLED BY:	M. BILLINGS
MATERIAL SOURCE:	CENTERLINE

TEST HOLE NUMBER		TH15-2010	TH15-2010	TH15-2010	TH15-2010	TH15-2011	TH15-2011	TH15-2011
DEPTH (feet)		2.0-3.0	9.0-11.0	17.0-19.0	21.5-23.0	2.0-3.0	6.0-7.0	14.0-15.5
LATITUDE		N66.0861°	N66.0861°	N66.0861°	N66.0861°	N66.0861°	N66.0861°	N66.0861°
LONGITUDE		W166.3169°	W166.3169°	W166.3169°	W166.3169°	W166.3122°	W166.3122°	W166.3122°
LAB NUMBER		**15-8021**	**15-8022**	**15-8023**	**15-8024**	**15-8025**	**15-8026**	**15-8027**
DATE SAMPLED		2-Apr-15	2-Apr-15	2-Apr-15	2-Apr-15	3-Apr-15	3-Apr-15	3-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
	#8							
	#10							
	#16					98		
	#30			100		92		
Sand	**#40**			99		88		
	#50			99		84		
	#60			99		82		
	#80			97		78		
	#100		100	94		77		
Silt/Clay	**#200**		99.0	76.7		66.9		
	0.02			27.4				
Hydro	**0.005**			14.9				
	0.002			9.7				
	0.001							
LIQUID LIMIT		NV	NV	NV		NV		
PLASTIC INDEX		NP	NP	NP		NP		
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		80.5	50.6	37.2	25.7	90.9	91.4	44.2
ORGANICS		8.5		5.7		8.8	14.7	
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS		Org[1]		Org[1]		Org[1]	Org[1]	

GENERAL COMMENTS

Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7.

[1] Organic content determination is based on the results of the ATM T-6 test method.

(Soil descriptions shown in parentheses are based on field determinations.)

USCS Soil Description Abbreviations: WG = Well-graded; PG = Poorly-graded; E = Elastic; L = Lean; F = Fat

STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME:	Shishmaref Relocation Road
PROJECT NUMBER:	
AKSAS NUMBER:	76776
SAMPLED BY:	M. BILLINGS
MATERIAL SOURCE:	CENTERLINE

TEST HOLE NUMBER		TH15-2011	TH15-2012	TH15-2012	TH15-2012	TH15-2013	TH15-2013	TH15-2013
DEPTH (feet)		17.5-19.0	10.0-11.5	18.0-19.0	24.0-25.0	1.5-2.5	6.0-7.0	8.0-9.0
LATITUDE		N66.0861°	N66.0878°	N66.0878°	N66.0878°	N66.0957°	N66.0957°	N66.0957°
LONGITUDE		W166.3122°	W166.3122°	W166.3122°	W166.3122°	W166.1452°	W166.1452°	W166.1452°
LAB NUMBER		**15-8028**	**15-8029**	**15-8030**	**15-8031**	**15-8032**	**15-8033**	**15-8034**
DATE SAMPLED		3-Apr-15	3-Apr-15	3-Apr-15	3-Apr-15	3-Apr-15	3-Apr-15	3-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
	#8							
	#10							
	#16		100					
	#30		99					
Sand	**#40**		98		100			
	#50		98		99			
	#60	100	98		99			100
	#80	99	97		99			99
	#100	99	97		99			99
Silt/Clay	**#200**	89.1	93.5		95.1			95.6
	0.02				29.3			
Hydro	**0.005**				13.0			
	0.002				7.8			
	0.001							
LIQUID LIMIT		NV	NV		NV			NV
PLASTIC INDEX		NP	NP		NP			NP
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		36.1	35.7	34.2	42.6		151.9	44.9
ORGANICS			5.7	5.1		59.9	23.1	7.1
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS			Org[1]	Org[1]		hi Org[1]	hi Org[1]	Org[1]
GENERAL COMMENTS		Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7. [1] Organic content determination is based on the results of the ATM T-6 test method. (Soil descriptions shown in parentheses are based on field determinations.) USCS Soil Description Abbreviations: WG = Well-graded; PG = Poorly-graded; E = Elastic; L = Lean; F = Fat						

STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME:	Shishmaref Relocation Road
PROJECT NUMBER:	
AKSAS NUMBER:	76776
SAMPLED BY:	M. BILLINGS
MATERIAL SOURCE:	CENTERLINE

TEST HOLE NUMBER		TH15-2013	TH15-2014	TH15-2014	TH15-2014	TH15-2015	TH15-2015	TH15-2015
DEPTH (feet)		18.0-19.0	3.0-4.0	10.0-11.5	14.0-15.0	7.0-8.0	9.0-10.0	14.0-15.0
LATITUDE		N66.0957°	N66.1076°	N66.1076°	N66.1076°	N66.1011°	N66.1011°	N66.1011°
LONGITUDE		W166.1452°	W166.1511°	W166.1511°	W166.1511°	W166.1155°	W166.1155°	W166.1155°
LAB NUMBER		**15-8035**	**15-8036**	**15-8037**	**15-8038**	**15-8039**	**15-8040**	**15-8041**
DATE SAMPLED		3-Apr-15	4-Apr-15	4-Apr-15	4-Apr-15	4-Apr-15	4-Apr-15	4-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4	99						
	#8	93						
	#10	91						
	#16	83			100			
	#30	78			99	100		
Sand	**#40**	76			99	99		
	#50	75		100	99	99		
	#60	73		99	99	99		
	#80	64		99	95	99		
	#100	57		99	93	98		100
Silt/Clay	**#200**	28.9		96.8	86.2	93.8		94.1
	0.02							
Hydro	**0.005**							
	0.002							
	0.001							
LIQUID LIMIT		NV		NV	NV	NV		NV
PLASTIC INDEX		NP		NP	NP	NP		NP
USCS CLASSIFICATION		SM						
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		20.0	82.0	46.5	36.5	88.6	55.8	5.1
ORGANICS			16.5	11.9				
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS			hi Org[1]	Org[1]				

GENERAL COMMENTS

Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7.

[1] Organic content determination is based on the results of the ATM T-6 test method.

(Soil descriptions shown in parentheses are based on field determinations.)

USCS Soil Description Abbreviations: WG = Well-graded; PG = Poorly-graded; E = Elastic; L = Lean; F = Fat

STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME: Shishmaref Relocation Road
PROJECT NUMBER:
AKSAS NUMBER: 76776
SAMPLED BY: M. BILLINGS
MATERIAL SOURCE: CENTERLINE

TEST HOLE NUMBER		TH15-2016	TH15-2016	TH15-2016	TH15-2016	TH15-2017	TH15-2017	TH15-2017
DEPTH (feet)		5.0-6.0	7.0-8.0	8.5-9.5	14.0-15.0	5.5-7.0	9.0-10.0	10.5-11.5
LATITUDE		N66.1011°	N66.1011°	N66.1011°	N66.1011°	N66.1011°	N66.1011°	N66.1011°
LONGITUDE		W166.1105°	W166.1105°	W166.1105°	W166.1105°	W166.1061°	W166.1061°	W166.1061°
LAB NUMBER		**15-8042**	**15-8043**	**15-8044**	**15-8045**	**15-8046**	**15-8047**	**15-8048**
DATE SAMPLED		4-Apr-15	4-Apr-15	4-Apr-15	4-Apr-15	5-Apr-15	5-Apr-15	5-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
	#8							
	#10							
	#16							
	#30							
Sand	**#40**							
	#50		100					
	#60		99					
	#80		99					
	#100		99					
Silt/Clay	**#200**		97.6					
	0.02		79.4					
Hydro	**0.005**		32.9					
	0.002		18.4					
	0.001							
LIQUID LIMIT			NV					
PLASTIC INDEX			NP					
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE			267.5	95.5	73.1	248.7	359.7	204.9
ORGANICS		39.8	14.5			12.1		
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS		hi Org[1]	Org[1]			Org[1]		

GENERAL COMMENTS

Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7.

[1] Organic content determination is based on the results of the ATM T-6 test method.

(Soil descriptions shown in parentheses are based on field determinations.)

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STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME: Shishmaref Relocation Road
PROJECT NUMBER:
AKSAS NUMBER: 76776
SAMPLED BY: M. BILLINGS
MATERIAL SOURCE: CENTERLINE

TEST HOLE NUMBER		TH15-2017	TH15-2018	TH15-2018	TH15-2018	TH15-2018	TH15-2019	TH15-2019
DEPTH (feet)		16.0-17.0	2.5-3.0	6.5-7.5	8.0-9.0	10.0-11.0	6.5-7.5	14.0-15.0
LATITUDE		N66.1011°	N66.0992°	N66.0992°	N66.0992°	N66.0992°	N66.0973°	N66.0973°
LONGITUDE		W166.1061°	W166.1059°	W166.1059°	W166.1059°	W166.1059°	W166.1059°	W166.1059°
LAB NUMBER		**15-8049**	**15-8050**	**15-8051**	**15-8052**	**15-8053**	**15-8054**	**15-8055**
DATE SAMPLED		5-Apr-15	5-Apr-15	5-Apr-15	5-Apr-15	5-Apr-15	5-Apr-15	5-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
	#8							
	#10							
	#16							
	#30				100			100
Sand	**#40**		91		99	100		99
	#50		85		98	99		99
	#60		83		98	99		98
	#80		77		96	99		98
	#100	100	73		94	99		97
Silt/Clay	**#200**	95.3	61.9		81.9	95.5		95.4
	0.02							
Hydro	**0.005**							
	0.002							
	0.001							
LIQUID LIMIT		NV	NV		NV	NV		NV
PLASTIC INDEX		NP	NP		NP	NP		NP
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		50.5	260.0	146.8	126.8	90.7	177.7	58.8
ORGANICS		5.0	57.7	11.8				
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS		Org[1]	hi Org[1]	Org[1]				

GENERAL COMMENTS

Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7.

[1] Organic content determination is based on the results of the ATM T-6 test method.

(Soil descriptions shown in parentheses are based on field determinations.)

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STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME:	Shishmaref Relocation Road
PROJECT NUMBER:	
AKSAS NUMBER:	76776
SAMPLED BY:	M. BILLINGS
MATERIAL SOURCE:	CENTERLINE

TEST HOLE NUMBER		TH15-2020	TH15-2020	TH15-2020	TH15-2021	TH15-2021	TH15-2022	TH15-2022
DEPTH (feet)		9.0-10.0	14.0-15.0	17.5-18.5	4.5-5.5	9.5-10.0	7.0-8.0	9.0-11.0
LATITUDE		N66.0973°	N66.0973°	N66.0973°	N66.0973°	N66.0973°	N66.0992°	N66.0992°
LONGITUDE		W166.1106°	W166.1106°	W166.1106°	W166.1155°	W166.1155°	W166.1096°	W166.1096°
LAB NUMBER		**15-8056**	**15-8057**	**15-8058**	**15-8059**	**15-8060**	**15-8061**	**15-8062**
DATE SAMPLED		8-Apr-15	8-Apr-15	8-Apr-15	8-Apr-15	8-Apr-15	8-Apr-15	8-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
	#8							
	#10							
	#16				100			
	#30				99		100	
Sand	**#40**				98		99	
	#50				97		99	
	#60				96		98	
	#80	100			94		97	
	#100	99			93		96	100
Silt/Clay	**#200**	95.8			87.2		89.4	98.6
	0.02							
Hydro	**0.005**							
	0.002							
	0.001							
LIQUID LIMIT		NV			NV		NV	NV
PLASTIC INDEX		NP			NP		NP	NP
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		97.8	53.5	36.9	254.4	240.5	80.4	81.4
ORGANICS		8.8			27.9		9.6	8.9
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS		Org[1]			hi Org[1]		Org[1]	Org[1]

GENERAL COMMENTS

Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7.

[1] Organic content determination is based on the results of the ATM T-6 test method.

(Soil descriptions shown in parentheses are based on field determinations.)

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STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME:	Shishmaref Relocation Road
PROJECT NUMBER:	
AKSAS NUMBER:	76776
SAMPLED BY:	M. BILLINGS
MATERIAL SOURCE:	CENTERLINE

TEST HOLE NUMBER		TH15-2022	TH15-2023	TH15-2023	TH15-2024	TH15-2024	TH15-2024	TH15-2024
DEPTH (feet)		17.5-18.5	11.0-12.0	21.5-22.5	2.5-3.5	8.5-10.0	14.0-15.0	17.5-18.5
LATITUDE		N66.0992°	N66.0992°	N66.0992°	N66.0852°	N66.0852°	N66.0852°	N66.0852°
LONGITUDE		W166.1096°	W166.1154°	W166.1154°	W166.1418°	W166.1418°	W166.1418°	W166.1418°
LAB NUMBER		**15-8063**	**15-8064**	**15-8065**	**15-8066**	**15-8067**	**15-8068**	**15-8069**
DATE SAMPLED		8-Apr-15	8-Apr-15	8-Apr-15	8-Apr-15	8-Apr-15	8-Apr-15	8-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
	#8							
	#10							
	#16							
	#30							
Sand	**#40**		100	100				
	#50		99	99				
	#60		99	99		100		100
	#80		99	99		99		99
	#100		99	98		99		97
Silt/Clay	**#200**		96.1	89.2		96.7		80.0
	0.02			25.4				
Hydro	**0.005**			12.8				
	0.002			8.3				
	0.001							
LIQUID LIMIT			NV	NV		NV		NV
PLASTIC INDEX			NP	NP		NP		NP
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		37.5	80.5	39.7	165.4	77.4	44.7	32.0
ORGANICS			8.4		36.9			
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS			Org[1]		hi Org[1]			
GENERAL COMMENTS		Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7. [1] Organic content determination is based on the results of the ATM T-6 test method. (Soil descriptions shown in parentheses are based on field determinations.) USCS Soil Description Abbreviations: WG = Well-graded; PG = Poorly-graded; E = Elastic; L = Lean; F = Fat						

STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME: Shishmaref Relocation Road
PROJECT NUMBER:
AKSAS NUMBER: 76776
SAMPLED BY: M. BILLINGS
MATERIAL SOURCE: CENTERLINE

TEST HOLE NUMBER		TH15-2025	TH15-2025	TH15-2025	TH15-2027	TH15-2027	TH15-2027	TH15-2027
DEPTH (feet)		10.0-11.0	12.0-13.0	18.0-19.0	2.0-3.0	5.5-6.5	10.5-11.0	13.5-14.5
LATITUDE		N66.0759°	N66.0759°	N66.0759°	N66.0606°	N66.0606°	N66.0606°	N66.0606°
LONGITUDE		W166.1396°	W166.1396°	W166.1396°	W166.1751°	W166.1751°	W166.1751°	W166.1751°
LAB NUMBER		**15-8070**	**15-8071**	**15-8072**	**15-8073**	**15-8074**	**15-8075**	**15-8076**
DATE SAMPLED		9-Apr-15	9-Apr-15	9-Apr-15	9-Apr-15	9-Apr-15	9-Apr-15	9-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
Sand	**#8**							
	#10							
	#16							
	#30							
	#40							
	#50							
	#60							
	#80							
	#100						100	
Silt/Clay	**#200**		99.7				98.8	
Hydro	**0.02**							
	0.005							
	0.002							
	0.001							
LIQUID LIMIT			NV				NV	
PLASTIC INDEX			NP				NP	
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		215.4	177.0	203.2		308.7	217.6	163.0
ORGANICS		10.0		11.8	25.4	33.0		
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS		Org[1]		Org[1]	hi Org[1]	hi Org[1]		

GENERAL COMMENTS

Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7.

[1] Organic content determination is based on the results of the ATM T-6 test method.

(Soil descriptions shown in parentheses are based on field determinations.)

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STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
LABORATORY TESTING REPORT

PROJECT NAME: Shishmaref Relocation Road
PROJECT NUMBER:
AKSAS NUMBER: 76776
SAMPLED BY: M. BILLINGS
MATERIAL SOURCE: CENTERLINE

TEST HOLE NUMBER		TH15-2029	TH15-2028	TH15-2028	TH15-2031	TH15-2032	TH15-2034	TH15-2034
DEPTH (feet)		13.5-14.5	28.0-29.0	3.0-4.0	2.5-3.5	3.0-4.0	2.5-3.5	13.0-14.0
LATITUDE		N66.0459°	N66.0531°	N66.0531°	N66.0723°	N66.0721°	N66.0688°	N66.0688°
LONGITUDE		W166.2052°	W166.1964°	W166.1964°	W166.0603°	W166.0558°	W166.0557°	W166.0557°
LAB NUMBER		**15-8077**	**15-8078**	**15-8079**	**15-8080**	**15-8081**	**15-8082**	**15-8083**
DATE SAMPLED		9-Apr-15	9-Apr-15	9-Apr-15	10-Apr-15	10-Apr-15	12-Apr-15	12-Apr-15
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
	#8							
	#10							
	#16							
	#30							
Sand	**#40**						100	
	#50						99	
	#60			100			99	
	#80			99			99	
	#100			99			98	
Silt/Clay	**#200**	99.6		95.9			96.6	
	0.02							
Hydro	**0.005**							
	0.002							
	0.001							
LIQUID LIMIT		NV		NV			NV	
PLASTIC INDEX		NP		NP			NP	
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		131.9	152.4	86.5			58.8	143.0
ORGANICS				15.3	24.2	22.4	10.3	
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS				hi Org[1]	hi Org[1]	hi Org[1]	Org[1]	

GENERAL COMMENTS

Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7.

[1] Organic content determination is based on the results of the ATM T-6 test method.

(Soil descriptions shown in parentheses are based on field determinations.)

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STATE OF ALASKA DEPARTMENT OF TRANSPORTATION
NORTHERN REGION
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PROJECT NAME: Shishmaref Relocation Road
PROJECT NUMBER:
AKSAS NUMBER: 76776
SAMPLED BY: M. BILLINGS
MATERIAL SOURCE: CENTERLINE

TEST HOLE NUMBER		TH15-2034	TH15-2036	TH15-2036	TH15-2037	TH15-2038	TH15-2038	
DEPTH (feet)		30.0-31.0	2.5-3.5	6.0-7.0	14.0-15.0	13.5-15.0	17.5-18.5	
LATITUDE		N66.0688°	N66.0704°	N66.0704°	N66.0685°	N66.0683°	N66.0683°	
LONGITUDE		W166.0557°	W166.0652°	W166.0652°	W166.0606°	W166.0652°	W166.0652°	
LAB NUMBER		**15-8084**	**15-8085**	**15-8086**	**15-8087**	**15-8088**	**15-8089**	
DATE SAMPLED		12-Apr-15	12-Apr-15	12-Apr-15	12-Apr-15	12-Apr-15	12-Apr-15	
% Passing	**3"**							
	2"							
	1.5"							
Gravel	**1.0"**							
	0.75"							
	0.5"							
	0.375"							
	#4							
	#8							
	#10							
	#16							
	#30							
Sand	**#40**	100						
	#50	99						
	#60	99		100				
	#80	97		99				
	#100	95		99	100	100		
Silt/Clay	**#200**	84.5		97.3	95.5	97.9		
	0.02							
Hydro	**0.005**							
	0.002							
	0.001							
LIQUID LIMIT		NV		NV	NV	NV		
PLASTIC INDEX		NP		NP	NP	NP		
USCS CLASSIFICATION								
USCS SOIL DESCRIPTION								
NATURAL MOISTURE		90.8	167.0	125.7	46.1	43.8	37.1	
ORGANICS			23.1			5.5		
SP. GR. (FINE)								
SP. GR. (COARSE)								
MAX. DRY DENSITY								
OPTIMUM MOISTURE								
L.A. ABRASION								
DEGRAD. FACTOR								
SODIUM SULF. (CRSE)								
SODIUM SULF. (FINE)								
NORDIC ABRASION								
REMARKS			hi Org[1]			Org[1]		
GENERAL COMMENTS		Gradation is based on material passing the 3" sieve, according to Alaska Test Method T-7. [1] Organic content determination is based on the results of the ATM T-6 test method. (Soil descriptions shown in parentheses are based on field determinations.) USCS Soil Description Abbreviations: WG = Well-graded; PG = Poorly-graded; E = Elastic; L = Lean; F = Fat						

SALINITY CALCULATIONS

FILL IN ALL COLORED BOXES WITH YOUR TEST DATA. SAVE A COPY OF THIS FILE WITH YOUR DATA IN THE APPROPRIATE JOB/WORK ORDER FILE

PROJECT NO.	31-1-08907-001
START/END DATE	5/22/2015
WORK ORDER	4211
TEST METHOD	S&W (YSI 30 Salinity Reading)

PROJECT NAME/LOCATION	Shismaref Relocation Road AKSAS76776

BORING NO.	AKSAS76776					
SAMPLE IDENTIFICATION	15-8002	15-8010	15-8013	15-8020	15-8024	15-8031
MASS OF TARE (g)	0.0	0.0	0.0	0.0	0.0	0.0
MASS OF TARE AND WET SOIL (g)	73.7	137.1	135.6	128.0	125.7	142.6
MASS OF TARE AND DRY SOIL (1) (g)	55.7	100.0	100.0	100.0	100.0	100.0
MASS OF TARE AND DRY SOIL (2) (g)	55.7	100.0	100.0	100.0	100.0	100.0
MASS DRY SOIL (g)	**55.7**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
MASS OF WATER (g)	**17.9**	**37.1**	**35.6**	**28.0**	**25.7**	**42.6**
MOISTURE CONTENT (%)	**32.1%**	**37.1%**	**35.6%**	**28.0%**	**25.7%**	**42.6%**
VESSEL IDENTIFICATION	1	2	3	4	5	6
MASS OF WET SAMPLE (g)	73.7	137.1	135.6	128.0	125.7	142.6
MASS OF WATER ADDED TO WET SAMPLE (g)	182.1	162.9	164.4	172.0	174.3	157.4
DILUTION RATIO	**10.16**	**4.39**	**4.62**	**6.14**	**6.78**	**3.69**
YSI 30 SALINITY READING (ppt)	0.3	0.3	0.3	0.2	0.2	0.2
CALCULATED SALINITY (ppt)	**3.0**	**1.3**	**1.4**	**1.2**	**1.4**	**0.7**

BORING NO.	AKSAS76776					
SAMPLE IDENTIFICATION	15-8035	15-8038	15-8041	15-8065	15-8777	15-8084
MASS OF TARE (g)	0.0	0.0	0.0	0.0	0.0	0.0
MASS OF TARE AND WET SOIL (g)	120.0	136.5	105.1	126.9	231.9	190.8
MASS OF TARE AND DRY SOIL (1) (g)	100.0	100.0	100.0	100.0	100.0	100.0
MASS OF TARE AND DRY SOIL (2) (g)	100.0	100.0	100.0	100.0	100.0	100.0
MASS DRY SOIL (g)	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
MASS OF WATER (g)	**20.0**	**36.5**	**5.1**	**26.9**	**131.9**	**90.8**
MOISTURE CONTENT (%)	**20.0%**	**36.5%**	**5.1%**	**26.9%**	**131.9%**	**90.8%**
VESSEL IDENTIFICATION	7	8	9	10	11	12
MASS OF WET SAMPLE (g)	120.0	136.5	105.1	126.9	231.9	190.8
MASS OF WATER ADDED TO WET SAMPLE (g)	180.0	163.5	194.9	173.1	68.1	109.2
DILUTION RATIO	**9.00**	**4.48**	**38.22**	**6.43**	**0.52**	**1.20**
YSI 30 SALINITY READING (ppt)	2.4	8.4	0.2	1.7	0.2	0.4
CALCULATED SALINITY (ppt)	**21.6**	**37.6**	**7.6**	**10.9**	**0.1**	**0.5**

TO ACCOMPANY "SALINITY (Direct Reading) WORKSHEET.DOCX", VERSION 1, December 2010

DATA ENTRY BY	PMW
CHECKED BY	AMV

Appendix C. Project Photographs

Photo 1: Sled-Mounted Drill Rig

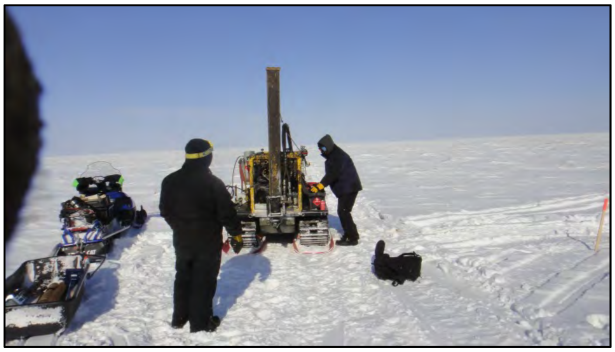


Photo 2: Test Hole TH15-2004

Photo 3: Sample 15-8000

Photo 4: Sample 15-8001

Photo 5: Sample 15-8002

Photo 6: Excessively wet, apparently liquefiable cuttings from TH15-2004

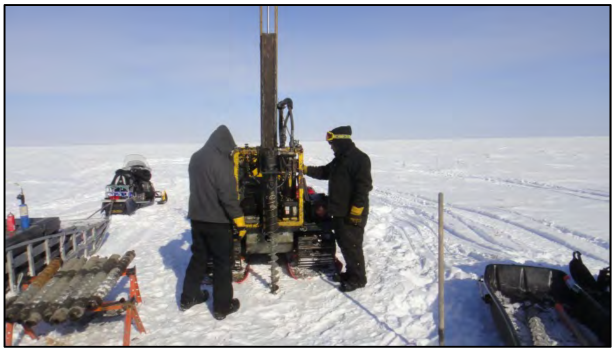


Photo 7: Test Hole TH15-2005

Photo 8: Sample 15-8004

Photo 9: Sample 15-8005

Photo 10: Sample 15-8006

Photo 11: Sample 15-8007

Photo 12: Sample 15-8008

Photo 13: Sample 15-8009

Photo 13: Sample 15-8010; wet and apparently liquefiable

Photo 14: Test Hole TH15-2007

Photo 15: Sample 15-8011

Photo 16: Sample 15-8012

Photo 17: Sample 15-8013

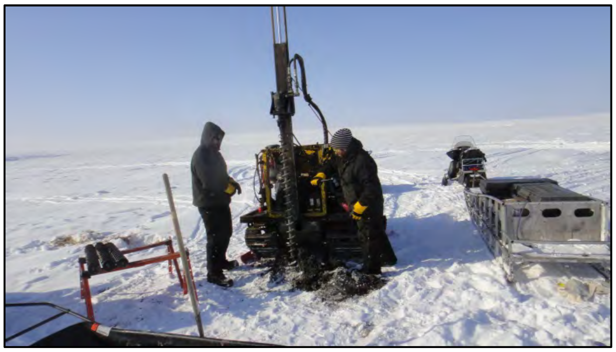


Photo 18: Test Hole TH15-2008

Photo 19: Sample 15-8014

Photo 20: Sample 15-8015

Photo 21: Sample 15-8016

Photo 22: Test Hole TH15-2009

Photo 23: Sample 15-8017

Photo 24: Sample 15-8018

Photo 25: Sample 15-8019

Photo 26: Sample 15-8020; wet and apparently liquefiable

Photo 27: Sample 15-8021

Photo 28: Sample 15-8022

Photo 29: Sample 15-8023

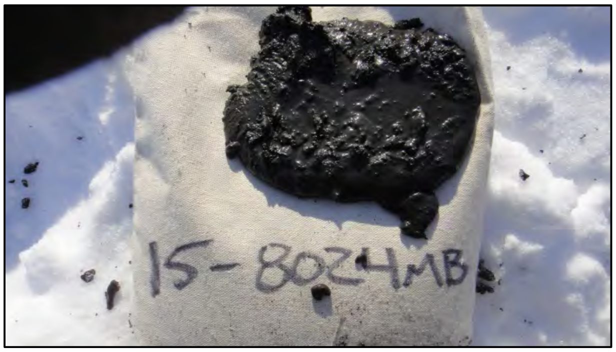


Photo 30: Sample 15-8024; wet and apparently liquefiable

Photo 31: Excessively wet, apparently liquefiable cuttings from TH15-2010

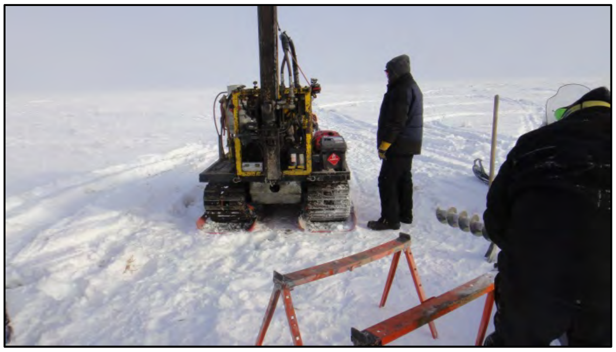


Photo 32: Test Hole TH15-2011

Photo 33: Sample 15-8025

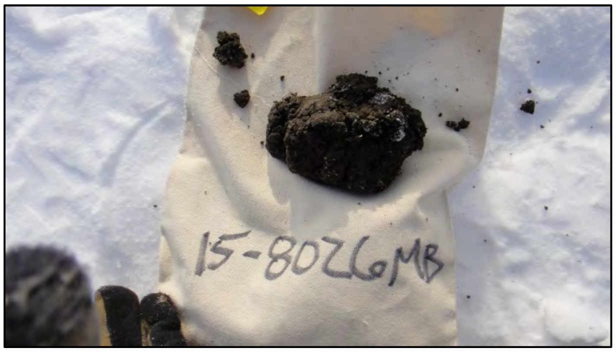


Photo 34: Sample 15-8026

Photo 35: Sample 15-8027

Photo 36: Sample 15-8028

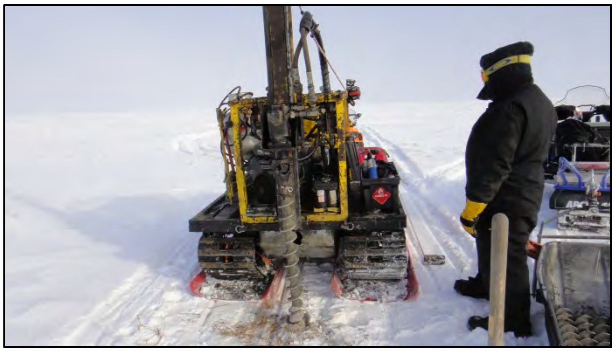


Photo 37: test Hole TH15-2012

Photo 38: Sample 15-8029

Photo 39: Sample 15-8030

Photo 40: Sample 15-8031

Photo 41: Test Hole TH15-2013

Photo 42: Sample 15-8032

Photo 43: Sample 15-8033

Photo 44: Sample 15-8034

Photo 45: Excessively wet, apparently liquefiable cuttings from TH15-2013

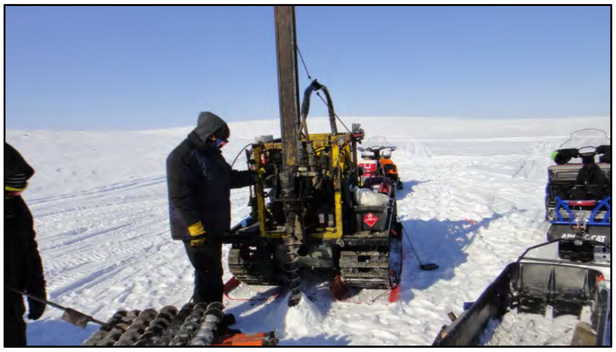


Photo 46: Test Hole TH15-2014B

Photo 47: Sample 15-8037

Photo 48: Sample 15-8038

Photo 49: Test Hole TH15-2015

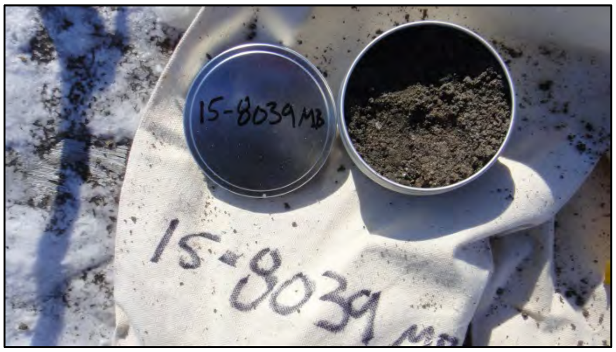


Photo 50: Sample 15-8039

Photo 51: Sample 15-8040

Photo 52: Sample 15-8041

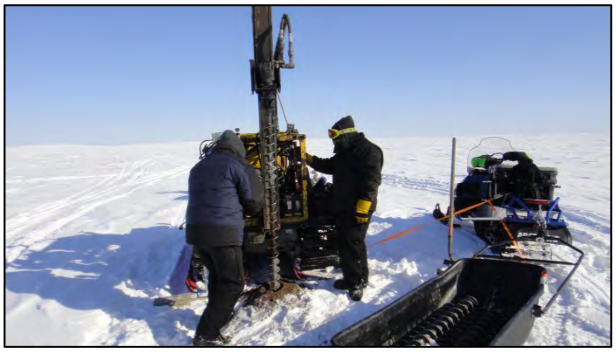


Photo 53: Test Hole TH15-2016

Photo 54: Sample 15-8042

Photo 55: Sample 15-8043

Photo 56: Sample 15-8044

Photo 57: Sample 15-8045

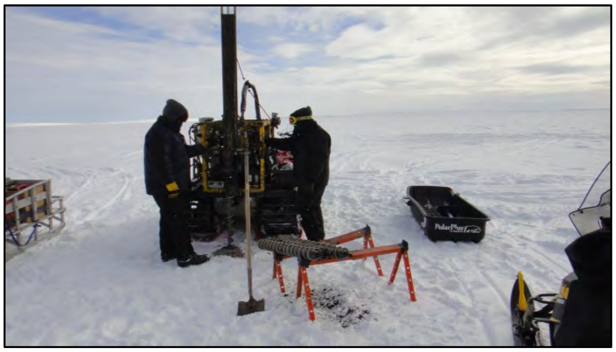


Photo 58: Test Hole TH15-2017

Photo 59: Sample 15-8046

Photo 60: Sample 15-8047

Photo 61: Sample 15-8048

Photo 62: Sample 15-8049

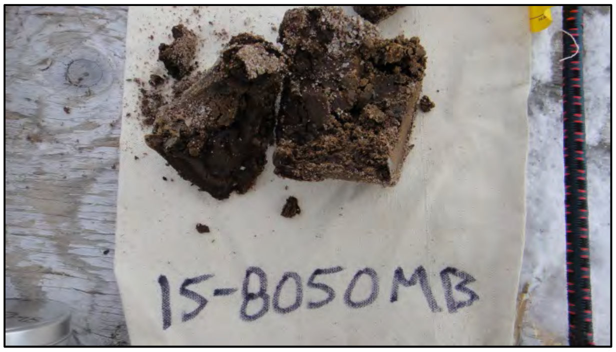


Photo 63: Sample 15-8050

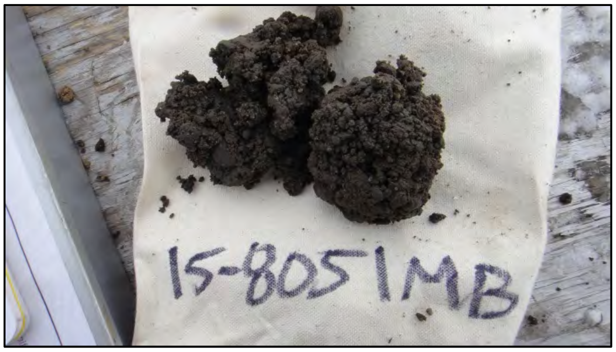


Photo 64: Sample 15-8051

Photo 65: Sample 15-8052

Photo 66: Sample 15-8053

Photo 67: Sample 15-8054

Pho to 68: Sample 15-8055

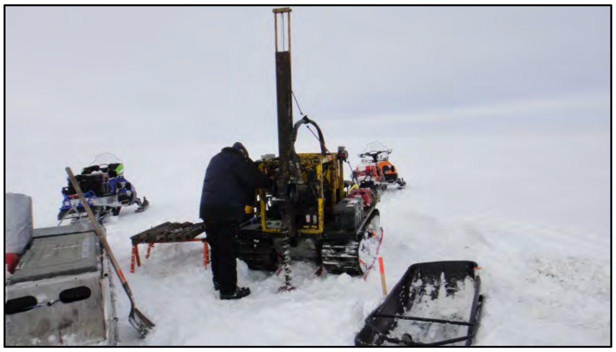


Photo 69: Test Hole TH15-2020

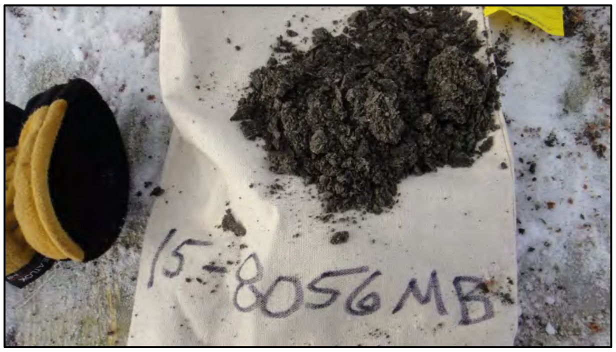


Photo 70: Sample 15-8056

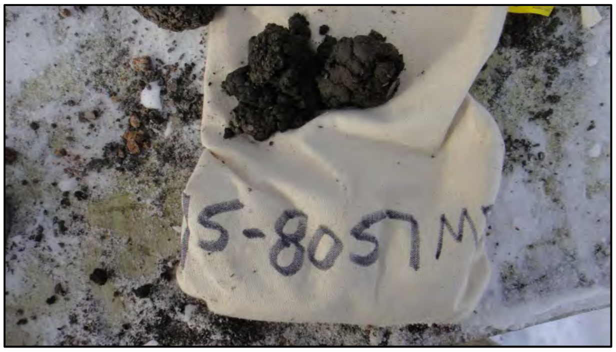


Photo 71: Sample 15-8057

Photo 72: Sample 15-8059

Photo 73: Sample 15-8061

Photo 74: Sample 15-8062

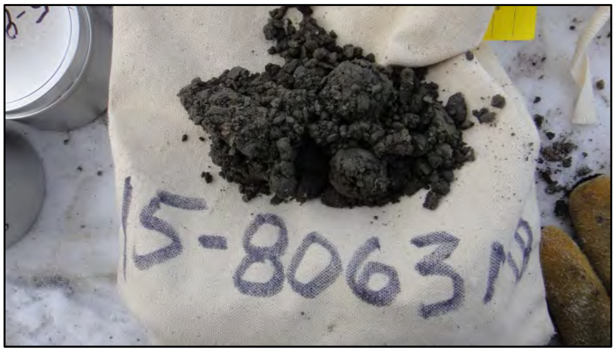


Photo 75: Sample 15-8063

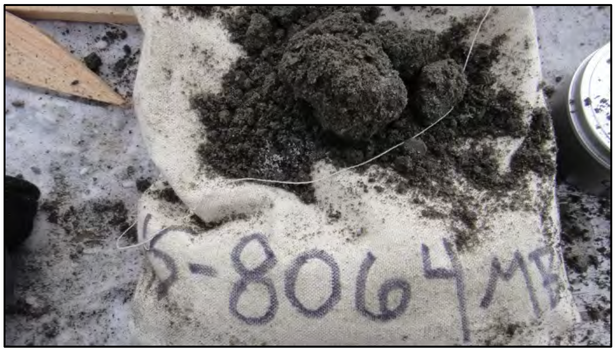


Photo 76: Sample 15-8064

Photo 77: Sample 15-8065

Photo 78: Sample 15-8066

Photo 79: Sample 15-8067

Photo 80: Sample 15-8068

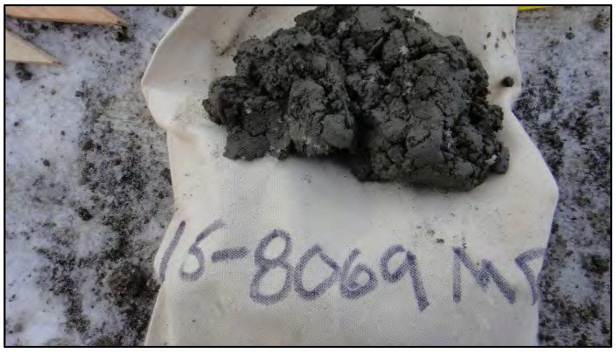


Photo 81: Sample 15-8069

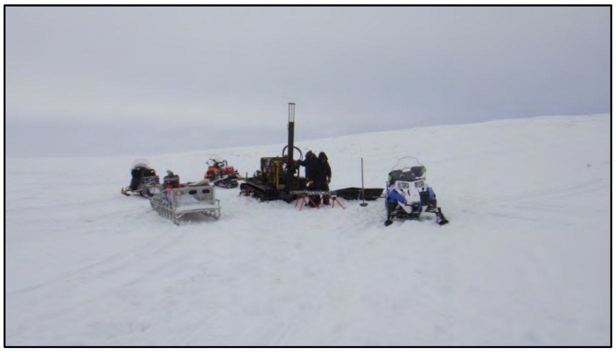


Photo 82: Test Hole TH15-2025

Photo 83: Sample 15-8070

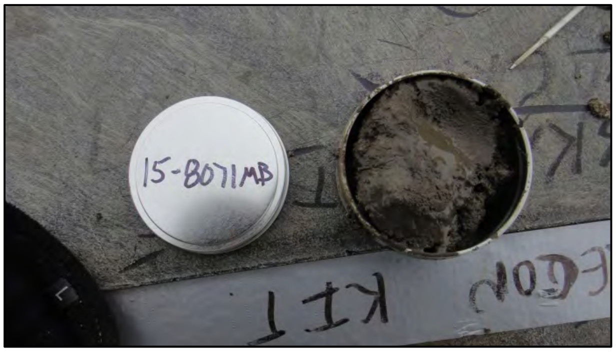


Photo 84: Sample 15-8071

Photo 85: Sample 15-8072

Photo 86: Test Hole TH15-2026

Photo 87: Ice cuttings from TH15-2026

Photo 88: Test Hole TH15-2027

Photo 89: Sample 15-8073

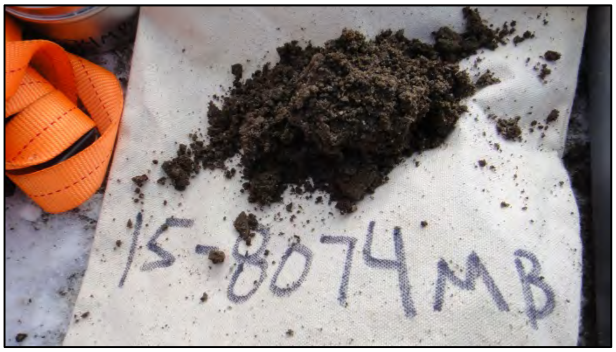


Photo 90: Sample 15-8074

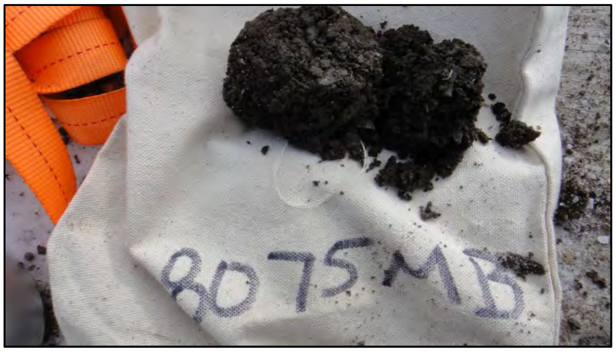


Photo 91: Sample 15-8075

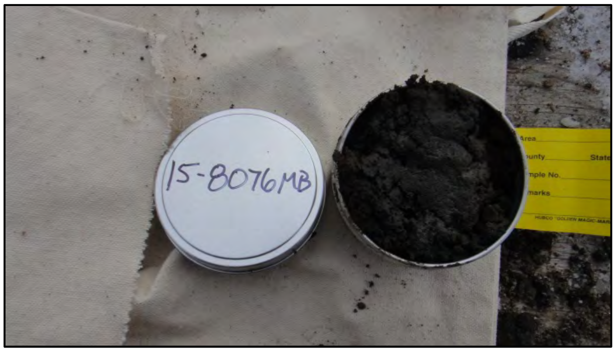


Photo 92: Sample 15-8076

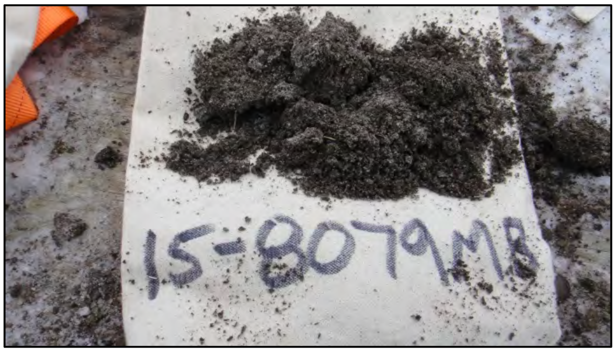


Photo 93: Sample 15-8079

Photo 94: Sample 15-8078

Photo 95: Ice cuttings from TH15-2028

Photo 96: Test Hole TH15-2029

Photo 97: Sample 15-8077

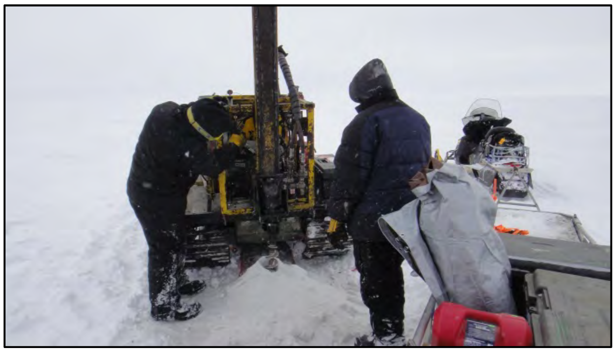


Photo 98: Ice cuttings from TH15-2030

Photo 99: Test Hole TH15-2031

Photo 100: Sample 15-8080

Photo 101: Ice cuttings from TH15-2031

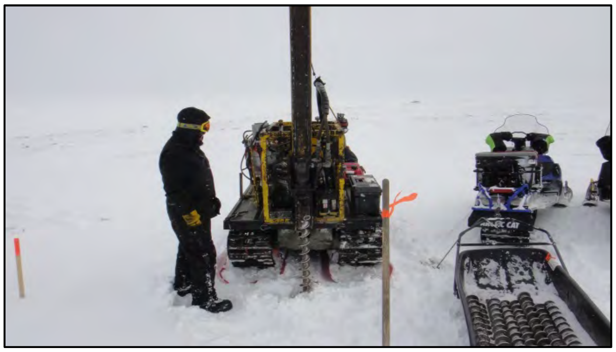


Photo 102: Test Hole TH15-2032

Photo 103: Sample 15-8081

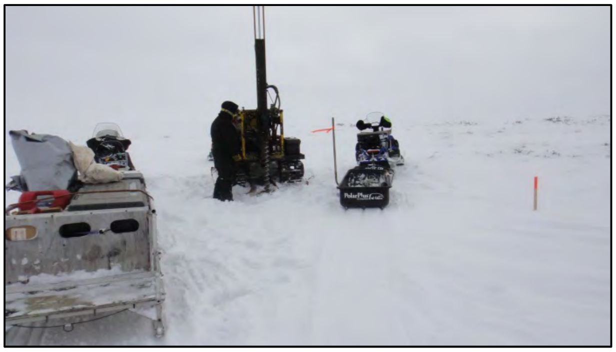


Photo 104: Test Hole TH15-2033

Photo 105: Test Hole TH15-2034

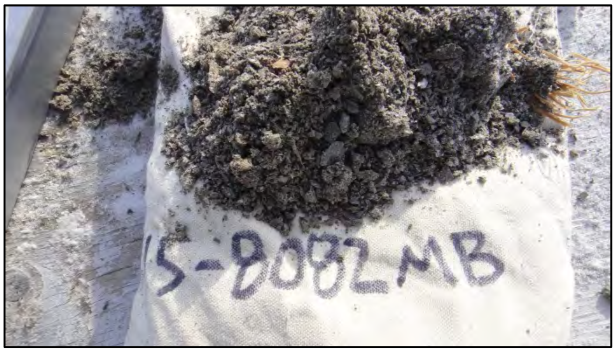


Photo 106: Sample 15-8082

Photo 107: Sample 15-8083

Photo 108: Sample 15-8084

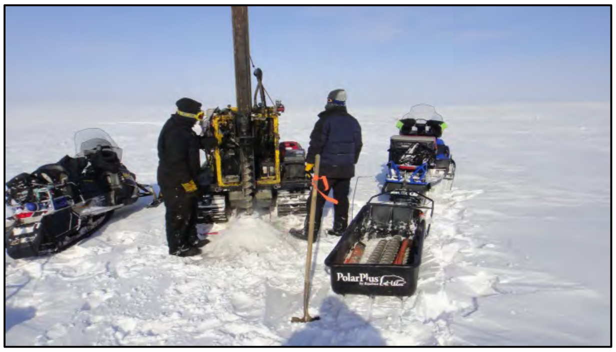


Photo 109: Test Hole TH15-2035; exhibiting ice cuttings

Photo 110: Sample 15-8085

Photo 111: Sample 15-8086

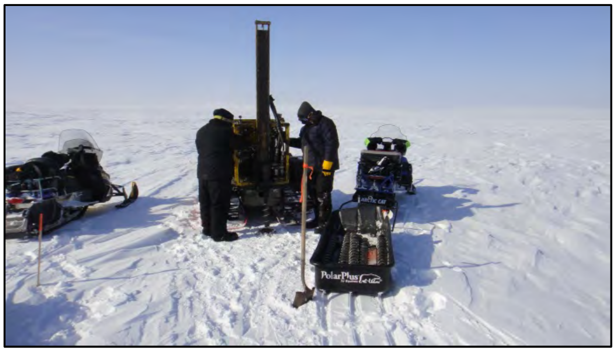


Photo 112: Test Hole TH15-2037

Photo 113: Sample 15-8087

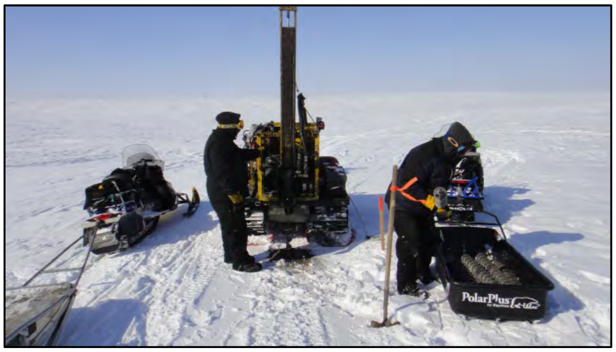


Photo 114: Test Hole TH15-2038

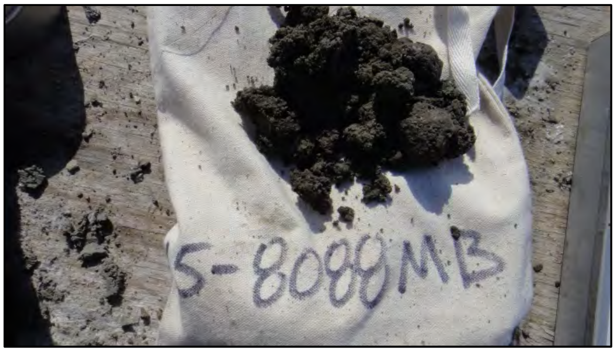


Photo 115: Sample 15-8088

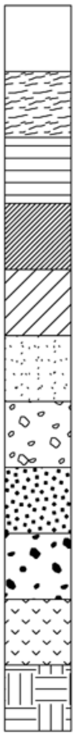
Photo 116: Sample 15-8089

Photo 117: Transporting Drill Rig back to Shishmaref

Appendix D. Soil Classification Guidelines

SYMBOLS AND DEFINITIONS

BASIC MATERIAL SYMBOLS



SOFT OR HARD BEDROCK BASED ON DRILLING RATE

NOTE

MAIN COMPONENT (UPPER CASE ... SOLID LINES)
MINOR COMPONENT (Title Case ... DASHED LINES OR SPARSER PATTERN)

USCS SIZE DEFINITIONS

BOULDERS (Boulders)	12"+
COBBLES (Cobbles)	3" TO 12"
GRAVEL	#4 TO 3"
ANGULAR FRAGMENTS	#10 +
SAND	#200 TO #4
SILT	#200 TO 0.005 mm
CLAY	MINUS 0.005 mm

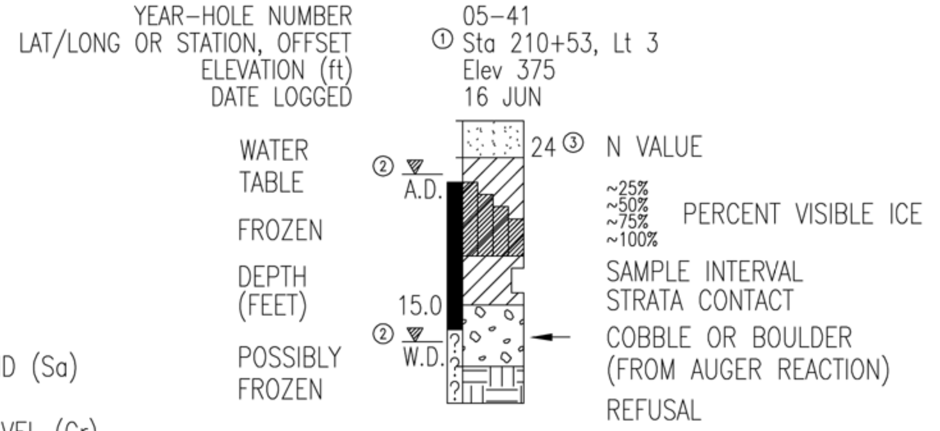
TEST RESULTS

_._%-200 = % PASSING #200 SIEVE
NM _._% = NATURAL MOISTURE
ORG _._% = ORGANIC CONTENT
SSc _ = SODIUM SULFATE LOSS(coarse)
SSf _ = SODIUM SULFATE LOSS(fine)
LA _ = LOS ANGELES ABRASION
DEG _ = DEGRADATION
LL _ = LIQUID LIMIT (NV = no value)
PI _ = PLASTIC INDEX (NP = non-plastic)

MISC.

Tr = TRACE
sl = SLIGHTLY
hi = HIGHLY
w/_ = WITH UNSPECIFIED AMOUNT
X'tls = CRYSTALS
TH = TEST HOLE
TT = TEST TRENCH
TP = TEST PIT

TYPICAL LOG

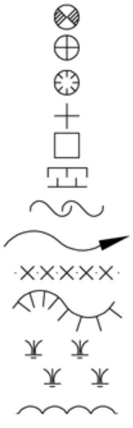


① Station value may also be on centerline e.g. Sta 210+53, CL or lat-long format e.g. N64.56789°, W145.67890°

② W.D.= WHILE DRILLING, A.D.= AFTER DRILLING

③ "N VALUE" INDICATES STANDARD PENETRATION TEST (1.4" I.D., 2.0" O.D. SAMPLER DRIVEN WITH 140 LB. HAMMER, 30" FREE FALL) AND IS SUM OF 2nd AND 3rd 6" OF PENETRATION.

PLAN VIEW SYMBOLS



SOIL DENSITY/CONSISTENCY DESCRIPTORS

NON-COHESIVE		COHESIVE	
RELATIVE DENSITY	BLOWS/FOOT (N) VALUE	CONSISTENCY	BLOWS/FOOT (N) VALUE
VERY LOOSE	< 4	VERY SOFT	< 2
LOOSE	5-10	SOFT	2-4
MEDIUM DENSE	11-30	FIRM	5-8
DENSE	31-50	STIFF	9-15
VERY DENSE	> 50	VERY STIFF	16-30
		HARD	> 30

COLOR

Bk = BLACK
Bl = BLUE
Bn = BROWN
Gn = GREEN
Gy = GRAY
Or = ORANGE
Rd = RED
Tn = TAN
Wh = WHITE
Yw = YELLOW

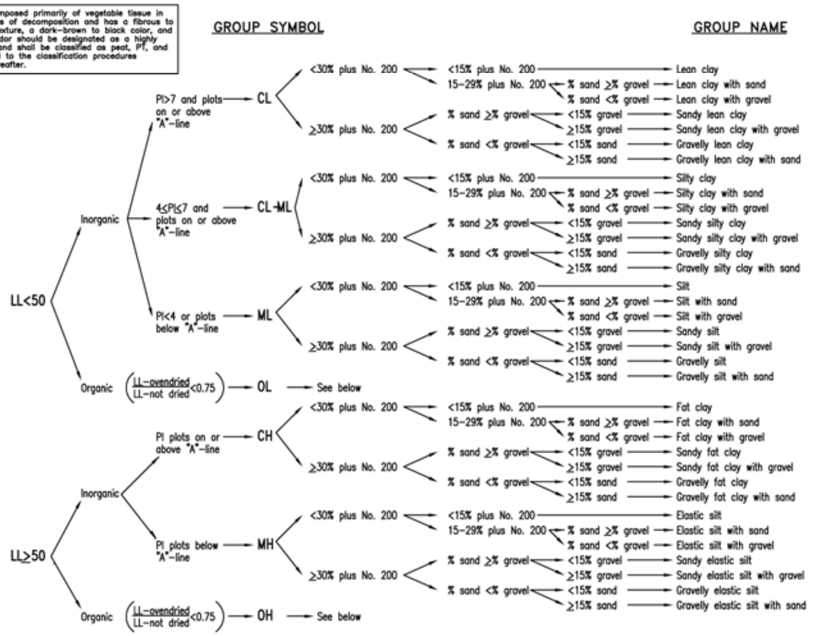
MOISTURE

dry = < OPTIMUM* DUSTY, DRY TO THE TOUCH
moist ~ OPTIMUM* DAMP, NO VISIBLE WATER
wet = > OPTIMUM* VISIBLE FREE WATER

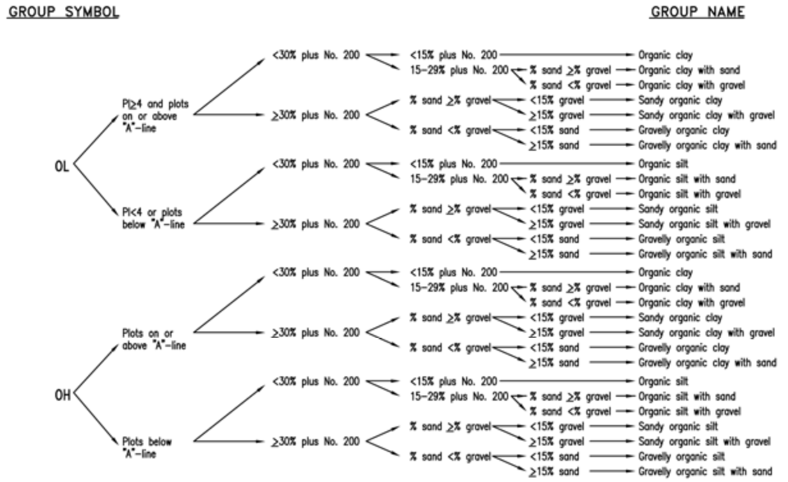
* OPTIMUM MOISTURE FOR MAXIMUM DENSITY

Classification of Soils for Engineering Purposes (Unified Soil Classification System)

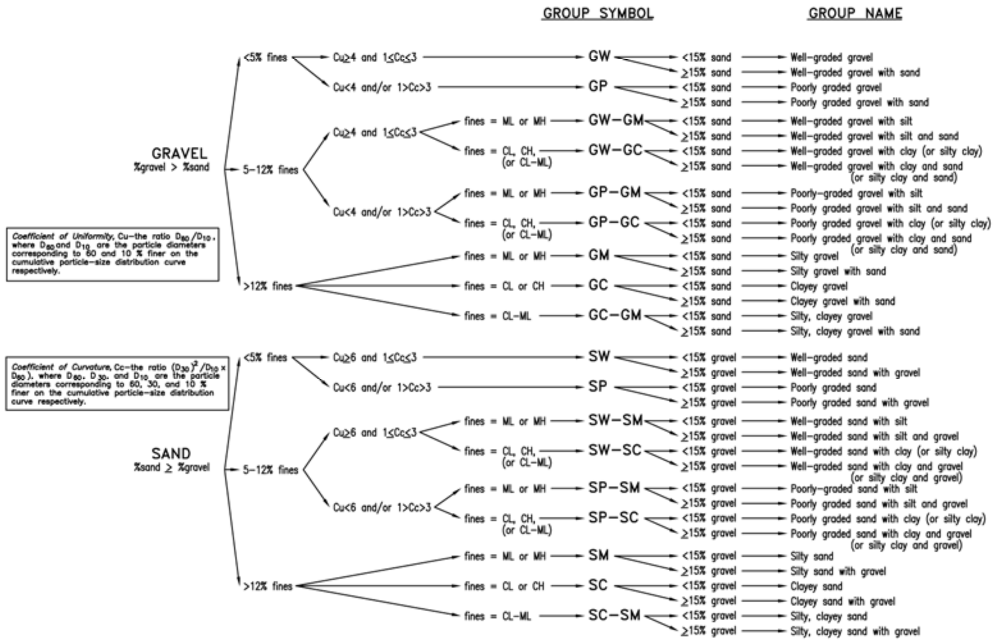
A sample composed primarily of vegetable tissue in various stages of decomposition and has a fibrous to amorphous texture, a dark-brown to black color, and an organic odor should be designated as a highly organic soil and shall be classified as peat, PT, and not subjected to the classification procedures described hereafter.



Flow Chart for Classifying Fine-Grained Soil (50% or More Passes No. 200 Sieve)



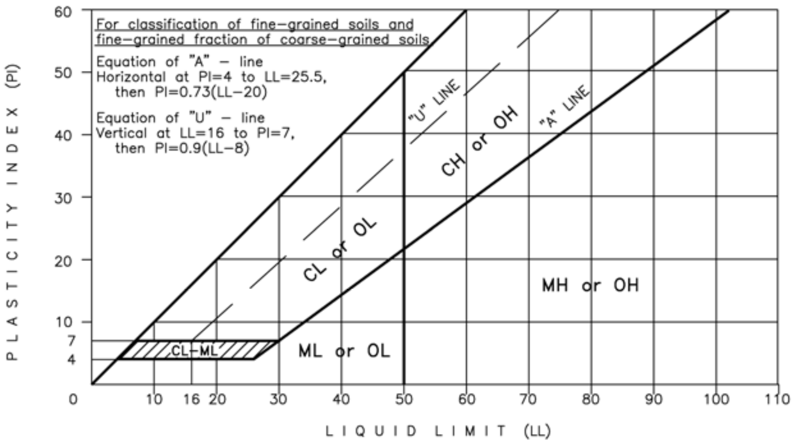
Flow Chart for Classifying Organic Fine-Grained Soil (50% or More Passes No. 200 Sieve)



Coefficient of Uniformity, Cu–the ratio D_{60}/D_{10}, where D_{60} and D_{10} are the particle diameters corresponding to 60 and 10 % finer on the cumulative particle-size distribution curve respectively.

Coefficient of Curvature, Cc–the ratio $(D_{30})^2/D_{10} \times D_{60}$), where D_{60}, D_{30}, and D_{10} are the particle diameters corresponding to 60, 30, and 10 % finer on the cumulative particle-size distribution curve respectively.

Flow Chart for Classifying Coarse-Grained Soil (More Than 50% Retained on No. 200 Sieve)



Plasticity Chart

DESCRIPTION AND CLASSIFICATION OF FROZEN SOILS

Part I
Description of Soil Phase (a)
(Independent of Frozen State)

	Major Group		Sub-Group				Guide for Construction on Soils Subject to Freezing and Thawing	
	Description (2)	Designation (3)	Description (4)	Designation (5)	Field Identification (6)	Pertinent Properties of Frozen Materials which may be measured by physical tests to supplement field identification. (7)	Thaw Characteristics (8)	Criteria (9)
Part II Description of Frozen Soil	Segregated ice is not visible by eye **(b)**	**N**	Poorly Bonded or Friable	**Nf**	Identify by visual examination. To determine presence of excess ice, use procedure under note **(c)** below and hand magnifying lens as necessary. For soils not fully saturated, estimate degree of ice saturation: Medium, Low. Note presence of crystals, or of ice coatings around larger particles.	In-Place Temperature Density and Void Ratio a) In Frozen State b) After Thawing in Place Water Content (Total H_2O, including ice) a) Average b) Distribution Strength a) Compressive b) Tensile c) Shear d) Adfreeze Elastic Properties Plastic Properties Thermal Properties Ice Crystal Structure (using optional instruments.) a) Orientation of Axes b) Crystal size c) Crystal shape d) Pattern of Arrangement	Usually Thaw-Stable	The potential intensity of ice segregation in a soil is dependent to a large degree on its void sizes and may be expressed as an empirical function of grain size as follows: Most inorganic soils containing 3 percent or more of grains finer than 0.02 mm in diameter by weight are frost-susceptible. Gravels, well-graded sands and silty sands, especially those approaching the theoretical maximum density curve, which contain 1.5 to 3 percent finer than 0.02 mm by weight without being frost-susceptible. However, their tendency to occur interbedded with other soils usually makes it impractical to consider them separately.
			No excess ice	**n**				
			Well Bonded	**Nb**				
			Excess ice	**e**				
	Segregated ice is visible by eye. (Ice 1 inch or less in thickness) **(b)**	**V**	Individual ice crystals or inclusions	**Vx**	For ice phase, record the following as applicable: Location Size Orientation Shape Thickness Spacing Pattern of arrangement Length Hardness } Structure } per part III Below Color } Estimate volume of visible segregated ice present as percent of total sample volume		Usually Thaw-Unstable	Soils classed as frost-susceptible under the above criteria are likely to develop significant ice segregation and frost heave if frozen at normal rates with free water readily available. Soils so frozen will fall into the thaw-unstable category. However, they ma also be classed as thaw-stable if frozen with insufficient water to permit ice segregation.
			Ice coatings on particles	**Vc**				
			Random or irregularly oriented ice formations	**Vr**				
			Stratified or distinctly oriented ice formations	**Vs**				Soils classed as non-frost-susceptible (*NFS) under the above criteria usually occur without significant ice segregation and are not exact and may be inadequate for some structure applications exceptions may also result from minor soil variations.
Part III Description of Substantial Ice Strata	Ice (Greater than 1 inch in thickness)	**Ice**	Ice with soil inclusions	**Ice + Soil Type**	Designate material as ICE **(d)** and use descriptive terms as follows, usually one item from each group, as applicable:			In permafrost areas, ice wedges, pockets, veins, or other ice bodies may be found whose mode of origin is different from that described above. Such ice may be the result of long-time surface expansion and contraction phenomena or may be glacial or other ice which has been buried under a protective earth cover.
			Ice without soil inclusions	**Ice**	(see below)	Same as Part II above, as applicable, with special emphasis on Ice Crystal Structure		

Hardness	Structure	Color	Admixtures
Hard	Clear	e.g.:	e.g.
Soft	Cloudy	Colorless	Contains
(mass,	Porous	Gray	Thin Silt
not individual	Candled	Blue	Inclusions
crystals)	Granular		
	Stratified		

DEFINITIONS:

Ice Coatings on Particles are discernible layers of ice found on or below the larger soil particles in a frozen soil mass. They are sometimes associated with hoarfrost crystals, which have grown into voids produced by the freezing action.

Ice Crystal is a very small individual ice particle visible in the face of a soil mass. Crystals may be present alone or in a combination with other ice formations.

Clear ice is transparent and contains only a moderate number of air bubbles.**(e)**

Cloudy Ice is translucent, but essentially sound and non-pervious.

Porous Ice contains numerous voids, usually interconnected and usually resulting from melting at air bubbles or along crystal interfaces from presence of salt or other materials in the water, or from the freezing of saturated snow. Though porous, the mass retains its structural unity.

Candled ice is ice which has rotted or otherwise formed into long columnar crystals, very loosely bonded together.

Granular Ice is composed of coarse, more or less equidimensional, ice crystals weakly bonded together.

Ice Lenses are lenticular ice formations in soil occurring essentially parallel to each other, generally normal to the direction of heat loss and commonly in repeated layers.

Ice Segregation is the growth of ice as distinct lenses, layers, veins and masses in soils, commonly but not always oriented normal to direction of heat loss.

Well-bonded signifies that the soil particles are strongly held together by the ice and that the frozen soil possesses relatively high resistance to chipping or breaking.

Poorly-bonded signifies that the soil particles are weakly held together by the ice and that the frozen soil consequently has poor resistance to chipping or breaking.

Friable denotes a condition in which material is easily broken up under light to moderate pressure.

Thaw-Stable frozen soils do not, on thawing, show loss of strength below normal, long-time thawed values nor produce detrimental settlement.

Thaw-Unstable frozen soils show on thawing, significant loss of strength below normal, long-time thawed values and/or significant settlement, as a direct result of the melting of the excess ice in the soil.

Modified from: Linell, K. A. and Kaplar, C. W., 1966, *Description and Classification of Frozen Soils,* Proc. International Conference on Permafrost (1963), Lafayette, IN, U.S. National Academy of Sciences, Publ. 1287, pp 481-487.

NOTES:

(a) When rock is encountered, standard rock classification terminology should be used.

(b) Frozen soils in the N group may on close examination indicate presence of ice within the voids of the material by crystalline reflections or by a sheen on fractured or trimmed surfaces. However, the impression to the unaided eye is that none of the frozen water occupies space in excess of the original voids in the soil. The opposite is true of frozen soils in the V group.

(c) When visual methods may be inadequate, a simple field test to aid evaluation of volume of excess ice can be made by placing some frozen soil in a small jar, allowing it to melt and observing the quantity of supernatant water as a percent of total volume.

(d) Where special forms of ice, such as hoarfrost, can be distinguished, more explicit description should be given.

(e) Observer should be careful to avoid being misled by surface scratches or frost coating on the ice.

APPENDIX F

SHISHMAREF RELOCATION PLAN UPDATE, FINAL

SHISHMAREF RELOCATION PLAN UPDATE

FINAL

Shishmaref, Alaska

Prepared For:

Shishmaref Erosion and Relocation Coalition
P.O. Box 72110
Shishmaref, Alaska 99772
and
Kawerak, Inc.
P.O. Box 948
Nome, Alaska 99762

Prepared By:

Bristol Environmental & Engineering
Services Corporation
111 West 16th Avenue, Third Floor
Anchorage, Alaska 99501
(907) 563-0013

June 2010

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ACRONYMS AND ABBREVIATIONS

AVEC	Alaska Village Electric Cooperative
Bristol	Bristol Environmental & Engineering Services Corporation
Coalition	Shishmaref Erosion and Relocation Coalition
Community	Community of Shishmaref
DOT&PF	Alaska Department of Transportation & Public Facilities
EO	Executive Order
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
NRCS	Natural Resources Conservation Service
USACE	U.S. Army Corps of Engineers

EXECUTIVE SUMMARY

The Community of Shishmaref (Community), a Native Alaskan Community located on Sarichef Island, is facing ongoing threats of seaward erosion, causing increasing safety hazards, security and physical integrity of Shishmaref. The Shishmaref Erosion and Relocation Coalition (Coalition) has determined that keeping the Community in the current location, with continued danger posed from excessively erosive storms, is unacceptable. Relocation of the Community to a new mainland site to ensure the safety and security of Shishmaref's citizens, with the ability to preserve the culture and integrity of the Community's subsistence lifestyle, has been determined to be the preferred option of the citizens through multiple Community meetings. The purpose of this report was to provide updates to the Coalition's Relocation Plan. The relocation update includes:

- Detailed summaries of previously evaluated relocation sites,
- Reviews of future evaluations and required studies for potential relocation sites,
- Reviews of future infrastructure development including,
  - Cost estimates for basic infrastructure and potential funding sources
  - Procedure recommendations
  - Schedule and implementation plan time line.

The most important focus of the update is to provide the Coalition and the Shishmaref community with the best recommendations for progression, in terms of relocation, no relocation and collocation options. This report does not recommend or identify a final Shishmaref relocation site. Additional studies and preliminary investigations are required.

Currently, the Shishmaref Erosion and Relocation Coalition has identified three potential relocation sites; West Nunatuq, Tin Creek, West Tin Creek Hills and Old Pond Site (See Figures 1 and 2). Due to the majority of community members being unfamiliar with the proposed relocation sites, summer photos of the proposed relocation sites will better acquaint the Shishmaref citizens with the proposed sites. It is the Community's preference that relocation sites not be located any further inland than the proposed Tin Creek site. The National Preserve is the final inland boundary for relocation sites (See Figure 2).

1.0 BACKGROUND

Shishmaref is located approximately 30 miles south of the Arctic Circle, and 50 miles northeast of the Bering Straits. The Community of Shishmaref (Community) is home to approximately 600 people, mostly consisting of Native Inupiaq Eskimos, and is situated on a barrier island approximately one-fourth-mile wide and approximately 3 miles long. The local economy is subsistence based, and supplemented by part-time wage earnings and local sales of arts and crafts. Although 600 people live in Shishmaref, a noticeable number of individuals have relocated to other parts of Alaska. This is due to the fact that the island can no longer expand services needed for increased development of new homes and related infrastructure. The lack of roads, high costs of fresh foods, inadequate fuel storage for home heating and transportation, and exorbitant cost of basic services, is a burden on the entire Community (Shishmaref Erosion and Relocation Coalition [Coalition], 2002).

The barrier island, where Shishmaref is located, is comprised primarily of fine sand deposits and permafrost that makes it extremely vulnerable to erosion from tidal high water, combined with intense wave action of the Chukchi Sea. During October 1997, a severe storm eroded over 30 feet of the north shore, requiring relocation of 14 homes and the National Guard Armory. Five additional homes were relocated in 2002. Other storms have continued to erode the shoreline, an average of 3 to 5 feet per year on the north shore. In July 2002, residents voted to relocate the community (Alaska Department of Commerce, Community, and Economic Development, 2009).

2.0 INTRODUCTION

Bristol Environmental & Engineering Services Corporation (Bristol) is under contract to Kawerak Inc., on behalf of the Shishmaref Erosion and Relocation Coalition, to update current plans that identify and evaluate potential relocation sites for the Community of Shishmaref and develop a baseline for future studies. The Relocation Plan Update will act as a guideline to assist the Community with an organized relocation, through the identification of relocation site characteristics, required evaluations and studies, essential infrastructure development and other basic community infrastructure needs, identification of salvageable and moveable infrastructure facilities, time line for infrastructure development, and potential resource identification (Appendices A, B & C).

The loss of land through erosive action and increasing risk to property and lives has caused a dangerous situation for the Community. The Community has determined that staying on the island to face the ever-present threat from ocean-based storms is unacceptable. The only viable solution is to relocate the Community off the island to a nearby mainland location, which is accessible to the sea, suitable for their subsistence lifestyle, and preserves the culture and integrity of the Community (Shishmaref Erosion and Relocation Coalition, 2002).

Information provided in this report was gathered from two on-site meetings with the Shishmaref Erosion and Relocation Coalition, community members, and agency representatives. Additional review and input was provided by DCCED-Division of Community & Regional Affairs.

2.1 RELOCATION

There are limited options for the Community regarding a future location. The City of Shishmaref needs sufficient developable land area to provide for the existing land uses involving both private and public elements. Additionally, the Community desires to have sufficient reserves of developable land to expand, grow, and develop. Suitable site access via barge, in addition to adequate access to water for subsistence purposes is a necessity. Of the proposed options presented, the preference of the citizen has continued to be relocation of the Community to a new mainland site, as opposed to collocation or no relocation.

The boundaries of possible relocation from the current village site needs to be determined. Based on public meetings that Bristol attended, providing adequate access to the water and subsistence areas was of great importance. A village consensus on an acceptable distance from water and subsistence areas was determined to be located no further inland than the preserve boundary (See Figure 2). Based on previous geo-technical studies and new information collected by ADOT, a suitable site, in terms of soil conditions, may be located in the proximity of Ear Mountain, located 10 miles from Shishmaref Inlet.

According to the *Shishmaref Site Analysis for Potential Emergency Evacuation and Permanent Relocation Sites*, by the Natural Resources Conservation Service (NRCS), relocation sites should be evaluated on the following parameters:

1. Site Layout
2. Development Potential
3. Natural Resources
4. Infrastructure
5. Human Factors

Bristol concurs with the NRCS criteria listed above. Continued and constant community input into the listed NRCS criteria is a vital. Further examination of the listed NRCA criteria continues below. In addition to the criteria determined by the NRCS, it is critical for the final relocation site to provide Community access to water, in order to maintain and preserve their subsistence based lifestyle. Also, proper subsurface geo-technical examination of all potential relocation sites will ensure development on quality soil, which will aid in keeping construction costs as low as possible.

2.1.1 Site Layout

Prior to determining and evaluating potential relocation sites, the overall relocation area required must be determined. Potential relocation sites must be able to adequately encompass the current Shishmaref town site, in addition to providing sufficient area to accommodate future infrastructure development.

2.1.2 Development Potential

The development potential of a proposed site is based upon the following:

- The measurement of the average slope of the proposed site. A moderately sloped site at 2-6% is preferred to a flat slope, or a steep slope.
- The soil quality will be evaluated through geotechnical studies. Coarse soil with a deeper permafrost level will be preferred to finer grained soils with a shallow depth to permafrost.
- The proposed sites will be evaluated for the proximity to sand, gravel, and rock material sources.

2.1.3 Natural Resources

The proposed relocation sites will be evaluated based upon natural resource advantages and disadvantages. The following natural resources will be examined based on proximity to the proposed sites:

- Fresh water sources will be examined and categorized by the following types: lakes, springs, rivers, and potential groundwater sources. Proposed sites with multiple natural resource possibilities will be preferred.
- Sites will be evaluated for erosion and flooding potential.
- The availability and proximity of subsistence gathering, and hunting and fishing areas will be discussed with input gathered from the Community.

2.1.4 Infrastructure

Potential infrastructure development at each proposed site will be evaluated for:

- Locations for a sewage lagoon, landfill, and a variety of access roads will be examined for each proposed site. Considerations for each site include: proximity to the fresh water supply, land slope, and distance to village site.
- Potential airport sites will be examined. Sites which are relatively flat, and could support a primary runway and a cross-wind runway of approximately 5,000 feet, will be preferred. Site proximity to the proposed village site will also be evaluated.
- Proposed sites will also be evaluated on potential for development of a small boat harbor and marina. Space, water depth, access from village site and cost estimate will be assessed for each site. The ability of each site to handle large barge traffic will be evaluated. Factors will include depth of approach channel, location of unlading facilities, and proximity to the town site. Most importantly, barge access to the final relocation site

is one of the most critical elements for the development and long term success of a relocation site.

2.1.5 Human Factors

The Community of Shishmaref has indicated, during two community meetings that Bristol attended, the need and desire of the Community to maintain their subsistence culture and way of life. To ensure the preservation of their subsistence culture, potential relocation sites must occur in relatively close proximity and access to water, along with adequate subsistence hunting and gathering areas.

Additionally, the Community of Shishmaref desires that final relocation site selection be based on a Community-wide election once the potential relocation sites have been narrowed.

Human factors discussed with the Community include the impact of development of each proposed site to Native allotments, and potential impact to cultural resource sites, as well as aspect and aesthetics.

2.2 NO RELOCATION

If the Community were to remain in its present location on Sarichef Island, discussion would be necessary regarding measures needed to maintain the current location. The following relevant information regarding the “No Relocation Alternative” would need to be addressed (U.S. Army Corps of Engineers [USACE], 2004).

- Erosion control measures to ensure ongoing safety and integrity of the Shishmaref Community and the costs associated with these measures and any physical Community needs of Shishmaref.
- A discussion of relevant existing conditions, constraints, assumptions, and any identified Community and agency plans.
- A compiled list of agencies that would typically provide funding and other assistance in meeting any Community needs.
- Infrastructure updates regarding the refurbishment of Community facilities.

3.0 IDENTIFICATION OF SITES

Many studies will be necessary in determining a site suitable for relocation. Once potential sites have been identified, they can be narrowed down to a list of two or three and the appropriate studies will need to be expanded to allow for more in-depth analysis of the possible relocation sites. Once a proposed site has been selected as the preferred relocation area, site studies can be focused into preliminary research and scoping to determine appropriate permit applications, which will be required under the National Environment Policy Act (NEPA Process).

Potential relocation sites will need to be examined through preliminary studies and research, and then screened to identify the following: soil quality to support infrastructure requirements; size minimums to address community growth; subsistence; and most importantly proper access by land, air and water. The potential sites will need to be further examined to determine required evaluations and studies, permitting, geotechnical studies, and hydrologic studies. Five or more years could potentially be required for the Community to complete the planning necessary; prepare designs; coordinate with the array of relevant local, state, and federal agencies; obtain necessary permits; establish a plan for funding through programs, grants, and other fiscal opportunities available. This time period would be followed by a five-year relocation period (USACE, 2004).

The scope of studies and research will be expanded to include, but not limited to, evaluation of the following:

3.1.1 Hydrology, Soils, and Geology

Preferred sites should be located in upland locations with adequate drainage and a deep soil horizon above permafrost comprised of coarse soils, which will assist in future development and growth of the Community. The Community must next expand upon the studies already performed through more detailed geotechnical and hydrological studies, which will better determine a proposed site’s ability to support the Community’s needs. Additionally, potential material sources must be identified which can be used for infrastructure construction. A suitable material source site has been identified at Ear Mountain in the *Shishmaref Relocation Road Reconnaissance Study*, through the Alaska Department of Transportation & Public Facilities (DOT&PF).

3.1.2 Fish and Wildlife

The Community is a traditional Inupiaq Eskimo village reliant upon subsistence lifestyle activities, which also support the local economy. The final relocation site will be evaluated to ensure that subsistence needs, such as hunting and gathering activities, will adequately support the needs of Shishmaref citizens. Current fish and wildlife habitats in proximity to proposed relocation sites will be examined and evaluated through agency databases, and consultation with the Alaska Department of Natural Resources and U.S. Fish and Wildlife Service to ensure that site development will not negatively impact fish and wildlife populations.

3.1.3 Wetlands

U.S. Fish and Wildlife Service's National Wetlands Inventory data, if available, will be consulted for verification of any mapped wetlands near or within any proposed relocation sites. If the proposed relocation area has not been previously mapped, possible wetland impacts to proposed relocation sites will be evaluated through on-site wetland analysis and fieldwork to complete a Wetland Delineation Report for submittal to the USACE for review and concurrence. A USACE Section 404 Permit Application will be submitted to the USACE along with proposed mitigation to any project imposed wetland impacts.

3.1.4 Floodplain and Flood Hazard

Federal Emergency Management Agency floodplain maps will be consulted, via desktop research, for proposed relocation sites for verification of whether the proposed site occurs near or within any mapped-designated floodplain areas. Flooding risks within the proposed project sites can most likely be attributed to tidal storm surges off the Bering Sea and Kotzebue Sound, which can cause destructive storm-induced erosion of coastal areas. Additionally, the USACE flood hazard maps, where available, will be reviewed to verify the location of any marked flood hazard zone boundaries. All proposed relocation sites were selected at adequate elevations to reduce the risk of flood hazards.

3.1.5 Water Source and Quality

The preferred relocation site will be evaluated for proximity to projected freshwater sources and the ability of the available sources to adequately supply the Community with potable water.

Potential negative effects and contamination to freshwater sources due to proposed site locations and projected infrastructure development will be evaluated and examined.

3.1.6 Cultural Resources

The State Historical Preservation Office will be consulted for review and approval of appropriate archaeological and historical research, in accordance with Section 106 of the National Historic Preservation Act. The Section 106 Review will determine if any archaeological, historical, or cultural properties will be impacted by any development that will occur through the relocation of the Shishmaref Community. On-site research will need to be performed by an archaeologist for any potential project impacts to any archaeological, historical, or cultural properties; in addition, a report will need to be submitted for review and concurrence by the State Historical Preservation Office.

3.1.7 Socioeconomics

Proposed relocation sites will be evaluated for potential adverse human health or environmental impacts to the minority or low-income populations within Shishmaref, through desktop research. Proposed relocation sites will be examined to ensure that the lifestyles, cultural values, attitudes, and expectations of the Community will be maintained, through collaboration with the Shishmaref citizens. The Shishmaref citizens will ultimately determine whether a relocation site is suitable to maintain the cultural values, lifestyle, and attitudes of the Community.

3.2 PREVIOUS STUDIES

Potential relocation sites were evaluated from a physiographic, infrastructure, natural resources, development, and social perspective by the NRCS. Potential relocation sites were assessed in terms of soil quality, and water and plant resources.

According to the 2005 *Shishmaref Site Analysis for Potential Emergency Evacuation and Permanent Relocation Sites* reconnaissance report, potential relocation sites were selected under the following basic criteria (NRCS, 2005):

- Greater than 50 feet above sea level in order to limit storm surge flooding.
- Flatter than 10% slope to facilitate development.

- Contiguous area of more than 100 acres that meets the first two criteria.

In addition to the criteria listed above, barge access and subsurface quality will be the initial criteria for potential site selection.

Six potential relocation sites were previously identified and evaluated by the Natural Resources Conservation Service, in cooperation with the Coalition (see Figure 1 and Appendix C), most of which were deemed infeasible for relocation.

Figure 1 NRCS-Identified Relocation Sites

3.3 PREVIOUS NRCS EVALUATED RELOCATION SITES

The following sites were previously identified and evaluated by the NRCS. Each of the sites was determined as unsuitable relocation sites at a public meeting on March 18, 2010, which Bristol attended (See Figure 2). The sites were eliminated primarily due to poor barge access potential, maintaining subsistence areas, or the presence of ice rich soils.

3.3.1 East Nunatuq

East Nunatuq is approximately 6.4 miles east by southeast of Shishmaref, with direct access to the Shishmaref Inlet. The proposed site has gently rolling hills with perennial streams and lakes in close proximity, and an average elevation of 75 feet above sea level. Soils are 6 to 12 inches of vegetative mat, followed by 12-16 inches of gray silt, then to ice at maximum thaw (NRCS, 2005).

The site was rated poor for overall layout potential, poor development and infrastructure potential, along with bluff erosion potential by the NRCS. The proposed site was determined to be infeasible as a relocation site for the Shishmaref Community.

3.3.2 Arctic

The Arctic site is accessed via boat, approximately two miles up the Arctic River. The site is located approximately 16.4 miles southeast of Shishmaref, and is bounded by the Sanaguich and Arctic rivers. The terrain is nearly flat to gently sloping. Underneath a foot of vegetative mat, soils are gray silt and 12 to 16 inches deep to permafrost. The harbor area is shallow and requires careful navigation to find the entrance to the Arctic River, which may not provide enough space for a potential small boat harbor. If the Shishmaref Inlet would be used for a harbor, an access road would be needed from the proposed town site (NRCS, 2005).

The proposed site is difficult to access, the proximity of a material source site and development potential is rated as poor. Therefore, the Arctic site was deemed infeasible as a potential relocation site for the Community of Shishmaref.

3.3.3 Igloot

The Igloot site is located approximately 15.9 miles from Shishmaref, near the Serpentine River, and offers fairly direct access to Shishmaref Inlet. The proposed site is in proximity to several fish camp cabins and archaeological sites. Igloot is surrounded by rolling terrain with moderate slopes. Compared to other sites, the soils are slightly deeper (approximately 24 inches). Coarser soils are exhibited, comprised of fine sands as compared to silt at other sites (NRCS, 2005).

The Igloot site was rated poor for potential material sources, infrastructure development potential, and erosion potential by the NRCS. Additionally, the Igloot site has major historical significance as a subsistence use area for the Community, which could be negatively impacted by development. Therefore, the proposed site was determined to be infeasible as a relocation option for the Shishmaref Community.

3.3.4 Tin Creek

The Tin Creek site is located approximately 11.6 miles from Shishmaref. The proposed site is long and narrow, and dissected by several drainages. The Tin Creek site is accessed via the south branch of Tin Creek, and is bounded on the east by Goose Creek. The construction of a 2-mile access road would be required to reach the Shishmaref Inlet, where a small boat harbor and barge access would be located. The site soils are 12 to 16 inches of gray silt down to permafrost, and is the closest of the proposed sites to the borrow source is located at Ear Mountain (NRCS, 2005).

According to DOT&PF, drilling indicated that multiple ice-rich hills exist in and around the Tin Creek site. The overall site location and potential layout is poor, as well as infrastructure development potential due to the abundance of ice-rich soils. The site was also deemed vulnerable to potential stream bank erosion.

3.3.5 West Tin Creek Hills

The West Tin Creek Hills site is located approximately 2 miles up the main stem of Tin Creek. The proposed site has flat to gently rolling terrain, with 12 to 16 inches of gray silt soil down to permafrost. The site is accessed via boat up the main stem of Tin Creek, and like the proposed Tin Creek site, would require the development of an access road to the Shishmaref Inlet, where a small boat harbor and barge landing would be located (NRCS, 2005).

The site was rated as fair for development potential by the NRCS, with stream bank erosion potential and poor infrastructure development potential. According to the DOT&PF, an abundance of ice-rich hills exist around the West Tin Creek Hills relocation site which will cause development costs to increase significantly.

3.3.6 West Tin Creek Flats

This proposed site is located adjacent to Shishmaref Inlet, on very flat terrain. The site soils are comprised of gray silt 8 to 12 inches to permafrost. West Tin Creek Flats would be easy to develop due to the flat topography, but site drainage remains a concern with indicators of massive ice formations on site, such as solifluction and polygons (NRCS, 2005).

Although West Tin Creek Flats rated high for potential layout by the NRCS, it consisted of poor soils, drainage, infrastructure development potential, and high erosion potential. The site is also vulnerable to flooding. The site was determined to be infeasible as a Shishmaref relocation site.

3.4 CURRENT SITE SELECTION

During a public meeting on December 12, 2007, the Community ratified Tin Creek as the preferred Shishmaref relocation site. No formal election was held. Although the Tin Creek site was ratified at that time, it is no longer considered the preferred relocation site. According to the March 18, 2010 Community meeting, which Bristol attended, the Tin Creek and West Tin Creek Hills sites were no longer considered viable options as relocation sites due to the abundance of ice-rich soils at both sites. During the Community meeting held on March 30, 2010 which a Kawerak Transportation Planner attended, the Community indicated the desire for Tin Creek and West Tin Creek Hills to remain as potential relocation sites. At both March meetings, many Community members mentioned the West Nunataq site as a possible relocation site (See Figure 2). A Community meeting held on June 3, 2010 indicated potential relocated sites included; West Nunatuq, Tin Creek, West Tin Creek Hills as well as a new potential site called Old Pond Site (See Figure 2), located west of the proposed Ear Mountain access road. West Nunatuq was listed by ADOT&PF as a potential barge landing site to access the potential Ear Mountain material source. No additional studies or information exists for West Nunataq. It is Bristol's recommendation that the potential relocation site search be expanded to included areas along the proposed Ear Mountain Road, which provide areas free of ice-rich soils (See Figure 2). Community members expressed that the relocation site must be located north of the National Preserve boundary.

The DOT&PF is currently preparing a reconnaissance study, evaluating Ear Mountain as a possible material source site for the future Shishmaref relocation site. Ear Mountain is located on the southwest side of Shishmaref Inlet, and could potentially provide convenient access to construction material for the West Nunataq site and other potential sites along the proposed access road. The study is also evaluating an access road to run from the Shishmaref Inlet to the proposed material source. With site access being a major factor in determining a possible relocation site, selection of a site in proximity to the Ear Mountain access road could be a major benefit to the Community (See Figure 2). According to the DOT&PF, the evaluation is based upon community input, topography, soil conditions, hydrology, snow and icing problems, development potential wetlands, and wildlife issues, along with many others.

According to the 2009 DOT&PF reconnaissance study, Ear Mountain, as a material source, has the potential to provide an estimated 100 million cubic yards of durable porphyritic granite, which is suitable material for Shishmaref community-based projects. The study also states that other potential material sources have proven unrealistic due to high volumes of ice and silt material. In addition to the potential material source, the study also evaluated two potential barge landing sites, which will require additional studies. Construction of an ice road to haul borrow material from an outside source was also examined. However, the exorbitant costs of preparing and mobilizing equipment for an ice road would ultimately be balanced out by the development of a local material source at Ear Mountain (DOT&PF, 2009).

In addition, the ADOT&PF report indicated the proposed Ear Mountain access road would facilitate safer and more efficient access to gathering, hunting and fishing use areas, and may also result in an increase of subsistence activities on potentially more accessible lands. Development of a relocation site in proximity to the proposed access road would provide the Shishmaref Community access to adequate subsistence use areas to maintain their subsistence lifestyle.

3.4.1 Collocation

In addition to the proposed relocation sites, possible collocation options have been acknowledged, although the citizens of Shishmaref have identified relocation to a new mainland site as the preferred option. The following collocation options exhibit the required capabilities and needed infrastructure to efficiently absorb the Community (USACE, 2004):

- Collocating to Nome
- Collocating to Kotzebue

Collocation to Nome offers the most cost effective alternative for the Community, according to the cost analysis study presented by the USACE.

3.5 NO RELOCATION

If the Community were to remain on Sharichef Island, and not relocate or collocate, the installation and periodic refurbishment of physical measures would be required to halt the seaward erosion which is threatening the safety and integrity of the Community. In addition, the following considerations would need to be evaluated according to the USACE's *Shishmaref relocation and collocation study*:

- Inventory of the condition and remaining life expectancy of existing infrastructure; homes; community, business, industrial, and other structures; as well as the constraints to and opportunities for further development or expansion.
- Determine the capital requirements necessary for meeting the physical needs of the Community, with focus on the timelines for replacing, refurbishing, and upgrading Community infrastructure and facilities in the foreseeable future.
- Develop infrastructure, such as fully plumbed community
- Determine and rank needs of the Community.

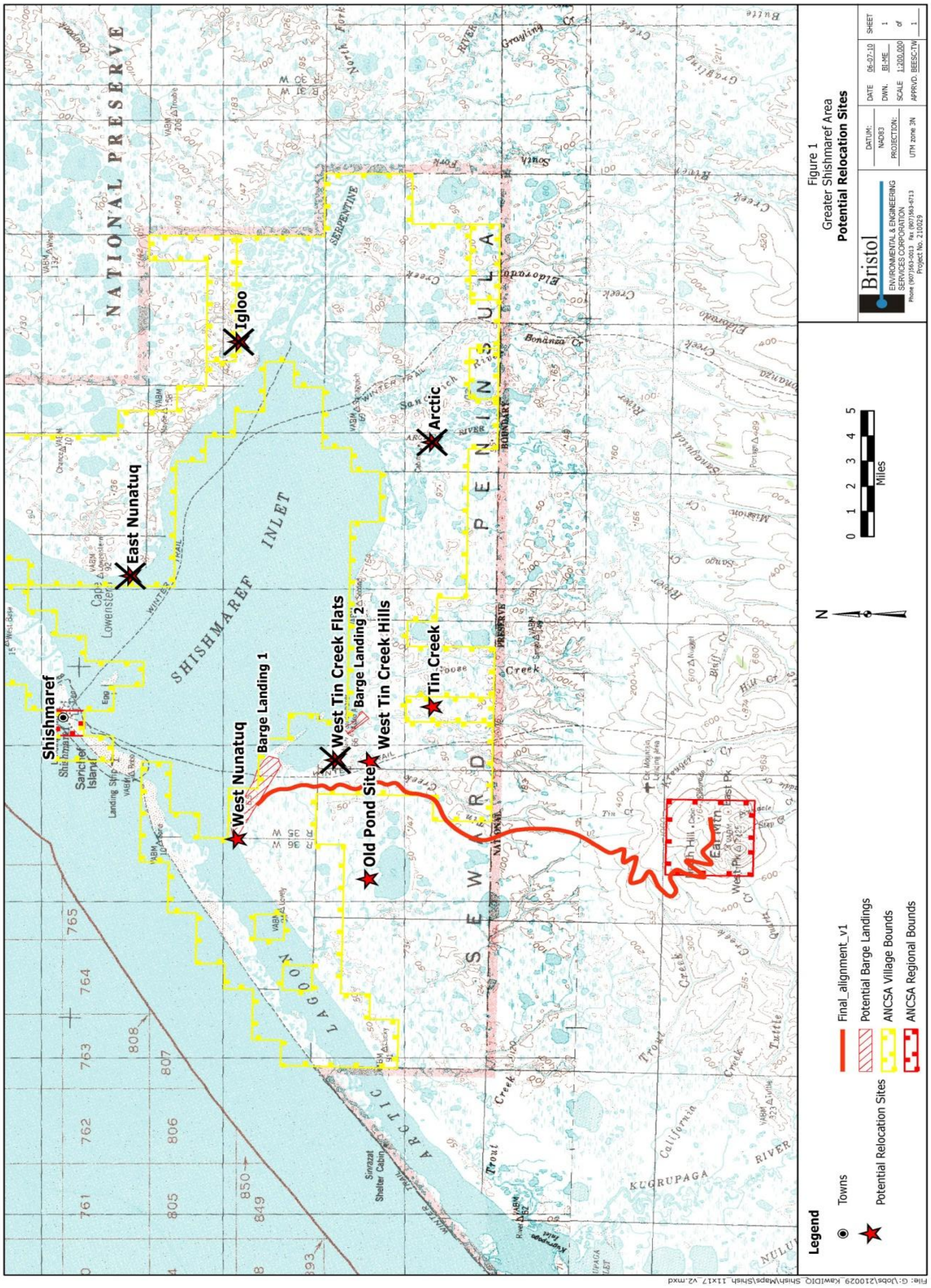

Figure 2: Potential Relocation Sites

4.0 INFRASTRUCTURE DEVELOPMENT

The Community must identify infrastructure development needed to improve the quality of life for citizens, whether through development of a new village site or through maintaining the current town site. To successfully relocate, basic infrastructure needs will need to be identified and prioritized before being expanded to encompass more detailed infrastructure projects. The Community will need to focus on the basic needs for development to create a solid base for future development; this will ensure the ability to customize the development of their site to best suit the needs of the Community.

4.1 RELOCATION

The most basic element for infrastructure development is satisfying the need of three criteria;

- Suitable barge access,
- Adequate water supply, and
- Sewage disposal.

Once these criteria have been met, the relocation process can begin and the new town site can be developed from that point forward. An engineering feasibility study would need to be performed that would cover each of these needs in detail. Prior to the engineering study, detailed survey and aerial mapping information must be obtained for the relocation site.

The following sections expand upon required studies for future site development. The expanded studies will commence upon completion of the three basic criteria mentioned above.

4.1.1 Water, Sewer, and Solid Waste Engineering Study

The following steps would occur for the water and sewer engineering study:

1. Review existing water and wastewater utilities to determine existing demands.
2. Identify potential drinking water sources. Identification and selection will be based on the following factors:
   a. Seasonal availability (winter versus summer).
   b. Locate surface water source that can be used/accessed in the winter.
   c. Water quality (testing will be required).

    d. Distance to proposed community site (for both winter and summer supplies).
    e. Surface water sources versus groundwater or surface influenced groundwaters.
    f. Need for catchment basin.
3. Provide a conceptual layout or design for proposed infrastructure for water treatment facility. Evaluations will include pump requirements, heat add, available waste heat (power plant). A pilot testing program should be assumed for treatment recommendations.
4. Provide a conceptual design for a proposed water distribution system. The following items should be considered:
    a. System type (buried circulating, above ground utilidor, etc.)
    b. System layout versus cost of freeze prevention requirements (heat add and pumping costs).
    c. Affect of disinfection by-products on proposed distribution system.
    d. Need for washeteria and/or central watering point.
    e. Ease of operation.
5. Identify storage requirements, including tank size, tank type, baffling requirements, heat add requirements, location, salvagability of existing water tanks.
6. Provide recommendations for wastewater collection (community collection system, individual or cluster on-site systems, etc.)
7. Wastewater treatment recommendations (lagoon, permitting requirements, discharge).
8. Provide preliminary cost estimates that will serve as the basis for funding and implementation.
9. Develop a phased construction plan that will fit into manageable blocks of funding.
10. Discuss utility management needs and required revenues for sustainable operations.
11. Water Quality Standards are set forth in 18 AAC 70
12. Wastewater disposal standards are set forth in 18 AAC 72.
13. Drinking water standards are set forth 18AAC 80.

4.1.2 Solid Waste Engineering Study (Landfill)

The following steps would occur for the solid waste engineering study:

1. Conduct a geotechnical investigation of potential landfill sites that will include:

    a. Subsurface soil conditions.
    b. Extent of permafrost or groundwater.
    c. Distance to surface water sources.
    d. Borrow material availability for berm construction and cover material.
2. Identify potential Class 3 landfill site in accordance with 18 AAC 60.
    a. Location must meet FAA airport separation distances and other requirements, such as wildlife hazard mitigation.
    b. Typically, the bottom of the cell shall be located a minimum of 10 feet from groundwater unless the landfill is constructed two feet or more above ground surface.
3. Determine current and future amount of generated solid waste.
4. Estimate parcel of land needed for landfill use (initial and future cells).
5. Prepare conceptual design of new cell, salvage area, access road, and burn box.
6. Affect of permafrost (freezeback design, burn box design and operation, etc).
7. Evaluate haul requirements (self haul, community haul from dumpsters, curbside pickup, etc).
8. Discuss utility management needs and required revenues for sustainable operations.

4.1.3 Energy Feasibility Study

The energy feasibility study would consist of evaluation the combination of using diesel and wind generation to provide electrical power. The following steps would occur for the energy feasibility study:

1. Determine fuel consumption (current and future)
2. Determine fuel storage needs (current and future)
3. Evaluate fuel delivery.
4. Select a fuel tank site so that tanks could be consolidated to reduce construction costs and streamline fuel delivery and handling
5. Site tanks above storm tide/flood level (Analyze flood data).
6. Site tanks that provide year round access.
7. Determine location of marine header.
8. Collect wind data to determine if wind generation is feasible.

9. Conduct pilot wind generation study.
10. Develop conceptual fuel tank farm and power plant design.
11. Develop preliminary cost estimate and phasing plan.

4.1.4 Transportation Feasibility Study

The transportation study would encompass travel by land, sea, and air. The study would evaluate barge landing/dock, airport, and roads both within and exterior to the community. The following areas would be covered under this study:

1) Develop airport master plan
    a. Prepare conceptual design and layout.
2) Develop Long Range Transportation Plan
    a. Identify short, medium, and long range plans
    b. Work with local and state agencies and planners.
3) Evaluate barge landing area and boat ramp
    a. Determine type of dock
        i. Open cell
        ii. Close face
        iii. Beach landing
    b. Collect water depth and tide data
    c. Determine size of vessel and mooring capacity
    d. Determine size of barging area
    e. Develop conceptual plan and cost estimate.
4) Collect geotechnical data

4.1.5 Facilities Development Study

In order to determine the amount of infrastructure development needed at the new site, a detailed inventory of the Community would need to occur in order to evaluate what existing infrastructure would be salvageable. The relocation of existing infrastructure will pose certain difficulties, because the existing location has to maintain operations while a new location is developed, essentially requiring the operation of two town sites simultaneously.

The list of salvageable, moveable infrastructure facilities will be generated in addition to the following facilities, identified by the Coalition (Shishmaref Erosion and Relocation Coalition, 2002):

- Alaska Village Electric Cooperative (AVEC) Power Plant and bulk tanks
- City buildings and bulk tanks
- Shishmaref Native Store, warehouses, and bulk fuel tanks
- Nayokpuk General Store, warehouses, and bulk tanks
- Clinic building
- Tannery Buildings (4)
- Shishmaref Lutheran Church/Parsonage building, and bulk tank
- City water tanks (2)
- National Guard facilities

A structural engineer will be required to assess the structural integrity of all buildings and determine if the structure is relocatable, or if the building can be demolished and the materials salvaged. Fuel tanks and water tanks shall be inspected by a qualified tank inspector and it must be determined if the tanks are usable and relocatable.

4.2 NO RELOCATION

According to the *Shishmaref Relocation and Collocation Study,* prepared by the USACE in 2004, a base for Community needs was established through the examination of existing facilities, services, structures, and current desires of Shishmaref for upgraded service. All existing and future infrastructure development must be evaluated and approved if Shishmaref were not to relocate. The following physical needs were identified within the report prepared by the USACE:

4.2.1 Defined Village Site

Currently, there is minimal land available on Sarichef Island for housing, infrastructure, and facility expansion and growth. The land use constraints will continue to increase due to the vulnerability to flooding and storm surges. These physical limitations have historically and will continue to make it difficult for the Community to expand and grow in the current location (USACE, 2004).

4.2.2 Housing

Currently, there are an estimated 153 occupied homes within the Community, with an average of four members per household. According to the *Shishmaref Relocation and Collocation Study*, housing in the community is repaired, renovated, expanded, and replaced, based on the financial ability of homeowners, labor, and availability of appropriate funding for qualifying homes, through Bering Straits Housing Authority, Housing and Urban Development, and other applicable housing programs.

4.2.3 Commercial and Industrial Buildings

The existing Community includes three commercial buildings and one industrial building, which includes: the Native store, trading post, washeteria, and tannery. All four buildings are in fair to good conditions. The Native store and washeteria are in fair condition, with an approximate 10-year life span remaining. According to the USACE the trading post has approximately 15 years of useful life remaining. The tannery is estimated to have at least 40 years of useful life remaining, as reported by the USACE (USACE, 2004).

4.2.4 Public/Community Buildings

The existing Community contains the following public, community, and storage buildings: Health Clinic; School: City Hall/Post Office; Armory; Fire/Rescue Station and City Shop; Church; Library; Community Hall; Friendship Center; and 20 storage buildings.

The Community Health Clinic is currently below regional health standards, and in need of upgrading and refurbishment. Possible upgrades have been placed on hold because of possible relocation. Additionally, the City Hall building is nearing the end of its life span, and considered to be a fire hazard by many. The Fire/Rescue Building, Church, and Community Hall are all nearing the end of useful service, and are considered to be unsafe by Community members (USACE, 2004).

4.2.5 Freshwater Supply, Treatment Facility, and Distribution System

The Community needs an adequate, reliable, and safe supply of freshwater for the current population and anticipated future growth. Currently, the Community's water supply, treatment, and distribution systems serving the Community are inadequate, unsafe, and below regional standards. Additionally, the water supply serving the existing Community is limited and does not provide for the current population.

Shishmaref's current water catchment area can collect up to 3 million gallons per year, but the storage facilities the Community has in place provides inadequate storage. The catchment facility pipes the water to supply and treatment facilities, which are outdated and do not meet either U.S. Environmental Protection Agency's (EPA's) Surface Water Treatment Rule, or EPA's Disinfection Byproducts Rule. If the Community elected not to relocate, it would be necessary to upgrade the catchment area, construct a new water treatment plant, and several new water storage tanks would be required (USACE, 2004).

4.2.6 Sanitary Waste Collection, Treatment/Disposal System

The Community needs to develop adequate systems and facilities to collect, treat, and dispose of sanitary waste to promote and maintain a safe environment for its residents. Existing facilities and system for collection and treating/disposing of sanitary wastes are inadequate, below regional standards, and do not conform to applicable public health and safety regulations.

Currently, the Community operates an unpermitted landfill/waste lagoon pit, which violates FAA regulations for being too close to an airfield. There are no plans for upgrades to the current landfill. If the Community were to remain in its present location, an approved and permitted landfill area would be required, but the land required for expansion is limited.

4.2.7 Solid Waste Collection System and Landfill

Shishmaref needs to have an adequate collection system and facilities, which meet applicable health and safety standards and regulations, to collect and dispose of solid wastes generated in the Community to support a safe environment for all residents. The existing landfill facility is below regional standards and does not conform to applicable public health and safety regulations.

4.2.8 Electrical Generation Facility and Distribution System

Currently, the AVEC provides adequate electricity to the Community, through the use of three diesel generators and a network of overhead distribution lines. An adequate, reliable, and sufficient source of electrical power needs to be maintained, which allows for a safe and vibrant Community.

4.2.9 Bulk Fuel Storage

A sufficient and reliable supply of diesel and gasoline fuels for heating, power generation, vehicles, and equipment, is essential because of the remote location of Shishmaref. Currently, a joint effort is underway to develop a new upgraded tank farm in Shishmaref.

4.2.10 Road Infrastructure

A quality network of internal and service roads to connect the various elements comprising a city is needed. The existing internal roadways are narrow and covered with up to several inches of sand/silt, and contain no gravel. Currently, the only gravel road in the Community is the 1.2-mile-long, single land road to the landfill.

4.2.11 Airfield

An essential element of Shishmaref that helps ensure the safety and well-being of all citizens is a properly functioning and serviceable air field and associated facilities. The current air field has an estimated 5-8 years of serviceable life remaining.

4.2.12 Barge Landing Facility

The continued well-being and existence of Shishmaref greatly depends on the constant inflow of the items and various materials required for daily living. An adequate landing area for supply barges to deliver goods to Shishmaref is essential.

4.2.13 Harbor and Boat Storage Facility

Small boat usage is essential for transportation needs, and to maintain the subsistence lifestyle of the Community.

4.2.14 Communication Facilities

The satellite communication, television, and telephone facilities and services, currently used by the Community, provide an essential link between its remote location and the rest of the world.

4.2.15 Summer Camps

The numerous shore-side privately-owned lots, located along the northern and southern perimeter of Sarichef Island, are used by members of the Community for summer drying of subsistence foods; boat building, repair, and maintenance; and a variety of other work activities.

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5.0 IDENTIFICATION OF RESOURCES

Funding and technical assistance resources will be essential for the Community in terms of community planning and infrastructure planning and development, including:

- Federal Agencies
- State Agencies
- Statewide Organizations
- Regional Organizations

For both the relocation and the no relocation options, a summary matrix of funding and technical assistance resources has been provided, which indicates the primary federal agencies, state agencies, statewide organizations, and regional organizations that could provide either funding or technical assistance by specific areas of interest, including:

- Air Fields
- Barge Landing Facility
- Bulk Fuel Storage
- Commercial and Industrial Buildings
- Community Planning
- Emergency - Disaster Planning
- Erosion Protection
- Health Facilities
- Housing
- Permitting
- Power Generation and Distribution
- Public Community Buildings
- Roads
- School Facilities
- Small Boat Harbor and Storage
- Solid Waste Collection & Disposal
- Teacher Housing
- Water and Wastewater

In general terms, sources of funding are indicated with a "$" and sources of technical assistance are indicated with an "x". However, many funding sources also will provide technical assistance and many technical assistance sources will have valuable information on current funding opportunities. Therefore, it will be important for the Shishmaref planning group to contact both potential funding and technical sources to learn about the most current assistance available.

Appendix A provides a narrative description for each agency/organization and includes contact information, general descriptions of the type of funding or technical assistance available, and areas of agency/organizational interest. (This section of the plan was prepared by Aurora Consulting)

5.1 RELOCATION

Prepared by Aurora Consulting.

AGENCY	AREAS OF INTEREST																		
	Airfields	Barge Landing Facility	Bulk Fuel Storage	Commercial & Industrial Buildings	Community Planning	Emergency - Disaster Planning	Erosion Protection	Health Facilities	Housing	Land Issues	Permitting	Power Generation & Distribution	Public Community Buildings	Roads	School Facilities	Small Boat Harbor and Storage	Solid Waste Collection & Disposal	Teacher Housing	Water & Wastewater
FEDERAL AGENCIES																			
BIA					$									$					
DC			$		$			$				$	$	$		$	$	$	$
NPS										x									
NRCS							x												
EDA				$	$											$			
EPA											x						$		$
FAA	x																		
FEMA						$													
FHWA														x					
F&WS											x								
HUD				$					$				$	$					
USACE		x					$									x			
USDA-RD									$				$				$		$
STATE AGENCIES																			
AEA			$									$							
AHFC									$										
DCCED					$		x												
DEC											x								$
DEED															x				
DHSEM						$													
DHSS								x											
DOT&PF	$	$												$		$			
DCOM					$		$				x								
OHA											x								
OPMP											x								
STATEWIDE ORGANIZATIONS																			
ANTHC																	$		$
AVEC			x									x							
RurAL CAP									x								x		
REGIONAL ORGANIZATIONS																			
BSSD															x			x	
BSRHA									x										
Kawerak	x	x			x	x			x					x		x			
NSHC								x											

BIA	U.S. Department of the Interior, Bureau of Indian Affairs
DC	Denali Commission
NRCS	U.S. Department of Agriculture/National Resources Conservation Service
EDA	U.S. Department of Commerce, Economic Development Administration
FAA	U.S. Department of Transportation/Federal Aviation Administration
FEMA	U.S. Department of Homeland Security/Federal Emergency Management Agency
FHWA	U.S. Department of Transportation/Federal Highway Administration
F&WS	U.S. Department of Interior/Fish and Wildlife Service
HUD	U.S. Department of Housing and Urban Development
USACE	U.S. Army Corps of Engineers
USDA-RD	U.S. Department of Agriculture/Rural Development
AEA	Alaska Energy Authority
AHFC	Alaska Housing Finance Corporation
DCCED	Alaska Department of Community, Commerce & Economic Development
DEED	Alaska Department of Education & Early Development
DHSEM	Alaska Department of Military & Veterans Affairs, Division of Homeland Security & Emergency Management
DHSS	Alaska Department of Health & Social Services
DOT&PF	Alaska Department of Transportation & Public Facilities
DCOM	Alaska Department of Natural Resources, Division of Coastal and Ocean Management
OHA	Alaska Department of Natural Resources, Office of History & Archeology
OPMP	Alaska Department of Natural Resources, Office of Project Management and Permitting
ANTHC	Alaska Native Tribal Health Consortium, Division of Environmental Health & Engineering
AVEC	Alaska Village Electric Corporation, Inc.
RurAL CAP	Alaska Rural Community Action Program
BSSD	Bering Strait School District
BSRHA	Bering Straits Regional Housing Authority
Kawerak	Kawerak, Inc.
NSHC	Norton Sound Health Corporation

5.2 NO RELOCATION

Prepared by Aurora Consulting.

AGENCY	AREAS OF INTEREST																	
	Airfields	Barge Landing Facility	Bulk Fuel Storage	Commercial & Industrial Buildings	Community Planning	Emergency - Disaster Planning	Erosion Protection	Health Facilities	Housing	Permitting	Power Generation & Distribution	Public Community Buildings	Roads	School Facilities	Small Boat Harbor and Storage	Solid Waste Collection & Disposal	Teacher Housing	Water & Wastewater
FEDERAL AGENCIES																		
BIA					$								$					
DC			$		$			$			$	$	$		$	$	$	$
NRCS							x											
EDA				$	$										$			
FAA	x																	
FEMA						$												
HUD				$					$			$	$					
USACE		x					$								x			
USDA-RD									$			$				$		$
STATE AGENCIES																		
DCCED					$		x											
DHSEM						$												
DOT&PF	$	$											$		$			
DCOM					$		$			x								
STATEWIDE ORGANIZATIONS																		
ANTHC																$		$
AVEC			x								x							
RurAL CAP									x							x		
REGIONAL ORGANIZATIONS																		
BSSD														x			x	
BSRHA									x									
Kawerak	x	x			x	x			x				x		x			
NSHC								x										

BIA	U.S. Department of the Interior, Bureau of Indian Affairs
DC	Denali Commission
NRCS	U.S. Department of Agriculture/National Resources Conservation Service
EDA	U.S. Department of Commerce, Economic Development Administration
FAA	U.S. Department of Transportation/Federal Aviation Administration
FEMA	U.S. Department of Homeland Security/Federal Emergency Management Agency
FHWA	U.S. Department of Transportation/Federal Highway Administration
HUD	U.S. Department of Housing and Urban Development
USACE	U.S. Army Corps of Engineers
USDA-RD	U.S. Department of Agriculture/Rural Development
DCCED	Alaska Department of Community, Commerce & Economic Development
DHSEM	Alaska Department of Military & Veterans Affairs, Division of Homeland Security & Emergency Management
DOT&PF	Alaska Department of Transportation & Public Facilities
DCOM	Alaska Department of Natural Resources, Division of Coastal and Ocean Management
ANTHC	Alaska Native Tribal Health Consortium, Division of Environmental Health & Engineering
AVEC	Alaska Village Electric Corporation, Inc.
RurAL CAP	Alaska Rural Community Action Program
BSSD	Bering Strait School District
BSRHA	Bering Straits Regional Housing Authority
Kawerak	Kawerak, Inc.
NSHC	Norton Sound Health Corporation

6.0 COST

Identification of preliminary costs associated with the relocation and no relocation alternatives were previously compiled by the USACE in 2004. Information was gathered to identify the basic needs of the Community, and the capital requirements associated with meeting the physical needs of the Community for both alternatives. It is Bristol's recommendation that new cost analysis studies be performed to re-evaluate costs prior to selecting a final relocation site. The information provided within the report is provided to help the Coalition determine the next step forward in deciding which alternative best suits the needs of the Community, from a preliminary costs perspective. According to the USACE, preliminary costs were compiled based on the following:

- The basic physical needs of the Community
- Development constraints and opportunities associated with each alternative
- Capital requirements associated with meeting the physical needs of the Community, identified by each alternative

The cost study performed by the USACE only addressed the physical needs of the Community, and did not address social, cultural, and economic needs (Shishmaref Relocation and Collocation Study, 2004). The USACE relocation cost alternative breaks down the first 5 years individually, then summarizes the costs associated with years 5+. The USACE no relocation cost alternative is divided into three time horizons: near term (1-5 years); intermediate term (5 to 15 years); and long-term (15+ years) (USACE, 2004).

According to the Newtok Planning Group, efficient cost-cutting measures would include incorporating local-labor on development/infrastructure projects, in addition to the use of pre-fabricated buildings to help alleviate design and construction costs.

6.1 RELOCATION

The preliminary costs and capital requirements associated with the relocation alternative are based on the physical needs of the Community (USACE, 2004). Agencies with capabilities of assisting with the capital requirements associated with this project can be found in Section 5.1 of this report. The total anticipated costs associated with relocation have been adjusted for inflation from the 2004 report by an increase of 3%. The adjustment brings the total anticipated cost for relocation to $214,118,055 over a projected 15+ year time frame.

The preliminary cost, capital requirements associated with relocation and the physical needs of Shishmaref are examined in Table 1. According to the USACE, the following assumptions were made in determining capital costs associated with the relocation alternative:

- The physical Shishmaref relocation would occur over a five-year period.
- Prior to the five-year relocation period, up to five years will be required for the completion of all necessary planning; site design; local, state and federal agency coordination; permitting; establishing real estate and securing easements; and establishing a plan for needed funding.
- The costs are associated with only the physical needs of the Community, which include the preliminary estimate for decommissioning, closure, and cleanup that might be required on Sarichef Island.

The anticipated relocation costs can be significantly lowered through the use of local labor, pre-fabricated buildings and developing on a site free of ice-rich soils.

Table 1 Capital Requirements and Preliminary Costs – Relocation

Near Term (Year 1)		
Physical Community Needs	**Capital Requirements**	**Preliminary Cost**
Erosion Protection Measures	Sarichef Island erosion protection - Capital cost	$3,356,480
Physical Area for Community	Real Estate	Unknown
Barge Landing Facility	Construct barge landing - Capital cost plus 1 years of maintenance	$3,695,920
Roads	Construct road system phase I (25%) and bridge	$7,000,000
Sanitary Waste Collection and Treatment	Construct sewage lagoon	$3,500,000
Solid Waste Collection and Disposal	Construct solid waste landfill	$3,700,000
Public/Community Buildings	Construct the community hall building as a multipurpose complex	$1,385,000
	Contingency (25%)	***$5,659,350***
	TOTAL COST (Year 1)	**$28,296,750**
Near Term (Year 2)		
Physical Community Needs	**Capital Requirements**	**Preliminary Cost**
Roads	Construct road system phase II (25%)	$5,500,000
Bulk Fuel Storage	Construct fuel tank farm	$2,126,000
Electric Utility	Construct power generation facilities phase I (50%)	$2,740,000
Water supply and treatment facilities	Develop water source and construct water treatment plant	$4,875,000
	Contingency (25%)	***$3,810,250***
	TOTAL COST (Year 2)	**$19,051,250**

Table 1 Capital Requirements and Preliminary Costs – Relocation (continued)

Near Term (Year 3)		
Physical Community Needs	**Capital Requirements**	**Preliminary Cost**
Roads	Construct road system phase III (25%)	$5,500,000
Electric Utility	Construct power generation facilities phase II (50%)	$2,740,000
Water supply and treatment facilities	Construct water storage tanks	$4,400,000
Homes and Personal Storage Buildings	Relocate/construct homes and storage phase I (20%)	$3,866,000
Commercial and Industrial Buildings	Construct Native Store, Trading Post and Washeteria	$4,725,000
Public/Community Buildings	Construct Health Clinic	$875,000
	Contingency (25%)	***$5,526,500***
	TOTAL COST (Year 3)	**$27,632,500**
Near Term (Year 4)		
Physical Community Needs	**Capital Requirements**	**Preliminary Cost**
Roads	Construct road system phase IV (25%)	$5,500,000
Homes and Personal Storage Buildings	Relocate/construct homes and storage phase II (60%)	$11,598,000
Public/Community Buildings	Construct City Hall/Post Office, Fire/Rescue Station and City Shop	$3,705,000
Communication Facilities	Construct communication facilities	$1,778,000
	Contingency (25%)	***$5,645,250***
	TOTAL COST (Year 4)	**$28,226,250**

Table 1 Capital Requirements and Preliminary Costs – Relocation (continued)

Near Term (Year 5)		
Physical Community Needs	**Capital Requirements**	**Preliminary Cost**
Homes and Personal Storage Buildings	Relocate/construct homes and storage phase III (20%)	$3,866,000
Commercial and Industrial Buildings	Construct Tannery	$275,000
Public/Community Buildings	Construct Church, Library, storage and Friendship Center and relocate Armory	$4,175,000
Sanitary Waste Collection and Treatment	Install indoor plumbing and flush and haul systems to unequipped homes	$7,900,000
	Contingency (25%)	***$4,054,000***
	TOTAL COST (Year 5)	**$20,270,000**
Beyond Year 5		
Physical Community Needs	**Capital Requirements**	**Preliminary Cost**
Air Field	Construct airport facilities	$25,000,000
Public/Community Buildings	Construct school and teacher housing	$15,855,000
Decommissioning and Closure	Decommissioning, closure, and cleanup activities	$3,820,000
	Contingency (25%)	***$11,168,750***
	TOTAL COST (Beyond Year 5)	**$55,843,750**
	TOTAL COST (Relocating to a New Mainland Site, 2004 Study)	**$179,320,500**
	TOTAL COST (+3% Per Year Inflation)	**$214,118,055**

(Shishmaref Relocation and Collocation Study, Preliminary Costs of Alternatives, 2004)

6.2 NO RELOCATION

The no relocation alternative is based on the premise that the seaward erosion that is threatening the safety and integrity of the Community can be stopped. Infrastructure development and facility refurbishment associated with the physical needs of the Community are included in the calculated capital requirements. Adjusted for 3% inflation, the projected preliminary costs total approximately $112,595,068 for the Community to remain in the current location. Potential agencies able to assist with the capital requirements associated with no relocation can be found in Section 5.2 of this report. Table 6 summarizes the anticipated preliminary costs calculated by the USACE.

Table 2 Capital Requirements and Preliminary Costs – No Relocation

Near Term (1-5 years)		
Physical Community Needs	**Capital Requirements**	**Preliminary Cost**
Erosion Protection Measures	Sarichef Island erosion protection - Capital cost	$4,234,480
Public/Community Buildings	Replace City Hall/Post Office, Fire/Rescue Station, and construct a new City Shop	$3,600,000
Water Supply and Treament Facilities	Upgrade water catchment area and water treatment plant	$15,000,000
Sanitary Waste Collection and Treatment	Upgrade remaining homes with indoor plumbing and flush-haul system	$8,830,000
Electric Utility	Construct new power plant and bulk fuel tank farm	$2,980,000
Bulk Fuel Storage	Construct new fuel tank farm	$2,126,000
	Contingency (25%)	***$9,192,620***
	TOTAL COST (1-5 years)	**$45,963,100**
Intermediate Term (5-15 years)		
Physical Community Needs	**Capital Requirements**	**Preliminary Cost**
Commercial and Industrial Buildings	Replace Native Store, Trading Post, and Washeteria	$4,620,000
Public/Community Buildings	Replace Health Clinic, Church, Community Hall and Friendship Center	$4,890,000
Water Supply and Treatment Facilities	Upgrade water storage system	$16,412,000
Sanitary Waste Collection and Treatment	Upgrade sewer lagoon system	$3,000,000
Roads	Upgrade landfill road	$2,400,000
Air Field	Repaving and Surface Rehabilitation	$2,500,000
	Contingency (25%)	***$8,455,500***
	TOTAL COST (5-15 years)	**$42,277,500**

Table 2 Capital Requirements and Preliminary Costs – No Relocation (continued)

Long Term (15+ years)		
Physical Community Needs	**Capital Requirements**	**Preliminary Cost**
Commercial and Industrial Buildings	Replace Tannery	$1,500,000
Public/Community Buildings	Replace School	$15,360,000
	Contingency (25%)	***$4,215,000***
	TOTAL COST (15+ years)	**$21,075,000**
	TOTAL COST (No Relocation, 2004 Study)	**$109,315,600**
	TOTAL COST (+3% Per Year Inflation)	**$130,528,543**
	Annual Erosion Protection O&M Cost (Not Included in Total Cost)	***$2,544,696***

(Shishmaref Relocation and Collocation Study, Preliminary Costs of Alternatives 2004)

(Intentionally Blank)

7.0 SCHEDULE AND IMPLEMENTATION PLAN

A schedule and implementation plan will be the first order of business upon deciding upon either a final relocation site or no relocation. The schedule and implementation plan will list the required development and put forth a time frame for completion. The relocation and no relocation time lines are addressed below. The USACE formulated a detailed time frame for completion with the costs associated with each developmental phase in the Shishmaref Relocation and Collocation Study.

A preliminary schedule and implementation plan for relocation and no relocation are listed below.

7.1 RELOCATION

The Shishmaref Relocation Plan Timeline, prepared by Bristol, has been separated into four time blocks - Critical Initiators, Years 1 - 5, Years 6 – 10, and Years 10+. See Shishmaref Relocation Planning Timeline in Appendix A.

7.1.1 Critical Initiators

Critical initiators include three functions that should be accomplished prior to embarking on relocation action planning, infrastructure development, and/or project funding. The three functions are:

- Form a planning team –The Shishmaref Erosion and Relocation Coalition, consisting of the City Council of Shishmaref, IRA Council and the Shishmaref Native Corporation Board of Directors, was formed in 2001.
- Commit to a firm relocation site - The community of Shishmaref should commit to a firm relocation site, with alternatives.
- Develop an initial site plan and community layout - An initial site plan and community layout should be developed that shows the relocation of the new community, as well as the community's vision for the layout of critical infrastructure, including roads, housing, community buildings, utilities, schools, local businesses, and other important infrastructure.

7.1.2 Years 1- 5

Relocation activities that should be accomplished during Years 1 - 5 include:

- Establish erosion control measures to ensure safety of the new relocation site
- Finalize the physical relocation area, begin establishing real estate
- Begin construction on the road system
- Development of sanitary and sold waste collection, disposal, storage and treatment facilities should begin
- Bulk fuel facilities, electrical utilities, and water supply and treatment facilities development
- Relocation and construction of personal, commercial, industrial, public and community buildings should begin.

7.1.3 Years 6-10

Relocation activities that should be accomplished during Years 6 – 10 include:

- The relocation and construction of buildings should progress to the 60% level.
- Continue construction and development of Community road system
- Begin development of communication facilities
- Begin indoor plumbing and sanitary waste collection

7.1.4 Years 10+

Relocation activities that should be accomplished during Years 10+ include:

- Begin the construction and development of airport facilities
- Continue development of community buildings – school, teacher housing
- Decommissioning and closure of old town site
- Finalize water distribution and piping throughout Community
- Finalize sewer collection and piping throughout Community

7.2 NO RELOCATION

If the Community decides not to relocate, a preliminary time line is as follows. The format is the same as the relocation time line, and has been separated into the same four time blocks - Critical Initiators, Years 1 - 5, Years 6 – 10, and Years 10+.

7.2.1 Critical Initiators

Critical initiators include three functions that should be accomplished prior to embarking on no relocation action planning, erosion control measures, infrastructure development, and/or facility repair funding. The three functions are:

- Form a planning team - The Shishmaref Erosion and Relocation Coalition, consisting of the City Council of Shishmaref, IRA Council and the Shishmaref Native Corporation Board of Directors, was formed in 2001.
- Develop an initial site plan and community layout - An initial site plan and community layout should be developed that shows the community's vision for the layout of critical infrastructure, including erosion control, roads, housing, community buildings, utilities, schools, local businesses, and other important infrastructure that need to be repaired, refurbished, or replaced within the Community. In addition, future development of the Shishmaref Community, were applicable, will need to be addressed to improve the quality of living within the existing Shishmaref Community.

7.2.2 Years 1- 5

Relocation activities that should be accomplished during Years 1 - 5 include:

- Establish erosion control measures to ensure safety of the Shishmaref Community
- Replace/Repair/Constructed public/community buildings
- Upgrade Community water supply and treatment facilities with new catchment area and treatment plant.

7.2.3 Years 6 -10

Relocation activities that should be accomplished during Years 6 – 10 include:

- Upgrade sanitary and solid waste collection and treatment facilities. Install indoor plumbing systems in all public/community/personal buildings.
- Improve road systems within Shishmaref
- Upgrade electric utilities through construction of new power plant and bulk fuel tank farm

7.2.4 Years 10+

Relocation activities that should be accomplished during Years 10+ include:

- Continue road upgrades throughout the Community
- Repave/surface rehabilitation of the current air field
- Replace/Upgrade Community/Industrial Buildings
- Maintenance of erosion control measures

8.0 REFERENCES

Alaska Department of Commerce, Community, and Economic Development, 2009. *Alaska Community Database website, Community Profiles Online: Shishmaref*, Website: http://www.commerce.state.ak.us/dca/commdb/CF_BLOCK.cfm. Accessed January 26, 2010.

Shishmaref Erosion and Relocation Coalition, 2002. *Shishmaref Relocation Strategic Plan, January, 2002*.

State of Alaska Department of Transportation & Public Facilities Northern Region, 2009. *Preliminary Draft: Shishmaref Relocation Road Reconnaissance Study. State Project No.*76776. July 2009.

Natural Resources Conservation Service, 2005. *Shishmaref Site Analysis for Potential Emergency Evacuation and Permanent Relocation Sites*. Completed in cooperation with the Shishmaref Erosion and Relocation Coalition.

U.S. Army Corps of Engineers, 2004. *Shishmaref Partnership: Shishmaref Relocation and Collocation Study. Shishmaref, Alaska*. Prepared by Tetra Tech, Inc., Seattle Washington.

APPENDIX A

FEDERAL AND STATE AGENCIES

Federal Agencies:

Denali Commission
U.S. Army Corps of Engineers (USACE)
U.S. Department of Agriculture/National Resources Conservation Service (NRCS)
U.S. Department of Agriculture/Rural Development (USDA-RD)
U.S. Department of Commerce, Economic Development Administration (EDA)
U.S. Department of Environmental Protection (EPA)
U.S. Department of Homeland Security/Federal Emergency Management Agency (FEMA)
U.S. Department of Housing and Urban Development (HUD)
U.S. Department of Interior/Fish and Wildlife Service (F&WS)
U.S. Department of the Interior, Bureau of Indian Affairs (BIA)
U.S. Department of the Interior, National Park Service (NPS)
U.S. Department of Transportation/Federal Aviation Administration (FAA)
U.S. Department of Transportation/Federal Highway Administration (FHWA)

<table>
<tr><td colspan="2">Denali Commission</td></tr>
<tr><td>Address/Contact

Denali Commission
510 L St. Ste 410
Peterson Tower
Anchorage, AK 99501

Joel Neimeyer, Federal Co-Chair
Phone: (907) 271-1426

Krag Johnsen, Chief Operating Officer
Tel: (907) 271-1413</td><td>Assistance

• Project funding
• Technical assistance</td></tr>
<tr><td colspan="2">Areas of Interest:
• Community Planning
• Community Power Generation & Distribution
• Bulk Fuel Storage
• Renewable and Alternative Energy
• Solid Waste Equipment & Facilities
• Health Facilities
• Roads and Boardwalks
• Regional Ports and Small Boat Harbors
• Teacher Housing</td></tr>
</table>

U.S. Army Corps of Engineers (USACE)

Address/Contact

US Army Corps of Engineers
PO Box 6898
Elmendorf AFB, AK 99506

Brenda Kerr
Phone: (907) 753-5537
Brenda.M.Kerr@poa.02.usace.army.mil

Bruce Sexauer, Study Manager
Alaska District
Phone: (907) 753-5619
Bruce.R.Sexauer@usace.army.mil

Assistance

- Continuing Authorities Program (CAP)
- Design and construct revetment
- Water quality testing
- Perform wildlife, archeological surveys
- Construction for erosion protection, flood damage reduction measures

Eligibility Requirements

- 35 percent of the total project costs.
- All lands, easements, rights of way, relocations, and dredged material placement areas (LERRD) necessary for construction of the project in cash a minimum of 5 percent of the total project costs for structural solutions.
- Formal assurance of local cooperation
- During the planning phase, the sponsor will be required to demonstrate financial capability to fulfill all items of local cooperation.

Areas of Interest:

- Erosion protection
- Small boat harbor and storage facility
- Barge landing facility

U.S. Department of Agriculture/National Resources Conservation Service (NRCS)

Address/Contact

Alaska State Office
USDA - Natural Resources Conservation Service
800 W. Evergreen Avenue, Suite 100
Palmer, AK 99645

State Conservationist: Robert N. Jones
Phone: (907) 761-7760
Fax: (907) 761-7790

Nome Field Office
240 Front Street, Room 107A
P.O. Box 1009
Nome, AK 99762-1009

Phone: (907) 443-6096
Fax: (907) 443-6098

Assistance

Conservation Technical Assistance Program:

- Provides technical assistance to communities to solve natural resource problems including reducing erosion, improving air and water quality, maintaining or restoring wetlands and habitat
- Provides information on watershed planning and flood control

Eligibility Requirements

- Individuals
- Indian Tribes
- Units of a State governments
- Non-governmental organizations

Areas of Interest:

- Erosion protection

U.S. Department of Agriculture/Rural Development (USDA-RD)

Address/Contact

USDA Rural Development, Alaska State Office
880 W. Evergreen, Suite 201
Palmer, AK 99645

Deborah Davis, Director Rural Housing Programs
Dean Steward, Director of Business Programs
Merlaine Kruse, Director of Cooperative Programs
Phone: (907) 761-7705
Fax: (907) 761-7783

Nome Field Office
P.O. Box 1569
Nome, Alaska 99762

Area Director
Phone: (907) 479-4362

Assistance

- Guarantee, loan and grant programs
  - Water and sewer systems
  - Housing
  - Health clinics
  - Emergency service facilities
  - Electric and telephone service.

- Economic development
  - Guarantee loans to businesses through qualified lenders.
- Renewable energy and energy efficiency projects
  - Wind
  - Geothermal,
  - Hydro
  - Biodiesel
- Technical assistance and information
  - Cooperative startups
  - Rural Economic Development Loan and Grant program

Areas of Interest:

- Public/Community buildings
- Water supply & treatment facilities
- Solid waste collection & disposal facilities
- Power generation & distribution
- Housing

U.S. Department of Commerce, Economic Development Administration (EDA)

Address/Contact

Seattle Regional Office
Jackson Federal Building, Room 1890
915 Second Avenue
Seattle, WA 98174-1001

A. Leonard Smith, Regional Director
Phone: (206) 220-7660
Fax: (206) 220-7669
lsmith7@eda.doc.gov

Alaska Office
510 ‘L’ Street, Suite 444
Anchorage, AK 99501

Bernhard Richert
Phone: (907) 271-2272
brichert@eda.doc.gov

Assistance

- Economic Adjustment Program builds erosion or flood-control structures in order to protect commercial village structures such as canneries.
- Economic development projects.
- Infrastructure development.

Eligibility Requirements

- City or other political subdivision of a State.
- Indian Tribe or a consortium of Indian Tribes.

Notes:

EDA Investments generally take the form of Grants to or Cooperative Agreements with Eligible Recipients.
Additional information at www.eda.gov

Areas of Interest:

- Community planning
- Commercial & industrial buildings
- Small boat harbor and storage

U.S. Environmental Protection Agency (EPA)

Address/Contact

U.S. Environmental Protection Agency
Alaska Operations Office
222 West 7th Ave, #19
Anchorage, AK 99513-5083

Marcia Combes, AOO Director
Phone: (907) 271-6555
Combes.Marcia@epa.gov

Assistance

- Tribal Project funding
- Technical assistance
- Planning
- Permitting/Compliance

Areas of Interest:

- Tribal Water and Solid Waste Projects
- Project Permitting
- Regulatory Compliance
- Climate Change Assessment

U.S. Department of Homeland Security/Federal Emergency Management Agency (FEMA)

Address/Contact

FEMA Regional Office
1501 4th Ave., Suite 1400
Seattle, WA 98101

Phone: (206) 438-2607
Fax: (206) 438-2699
Cell: 425.417.3159
mlujan@ostglobal.com

Mitigation Division Chief
Bothell WA

Debbie Key, Bob Cook
Phone: (425) 487-4717

Assistance

- Supplemental federal grant assistance for repair, replacement, restoration of disaster-damaged, publicly- owned facilities and facilities
- Pre-disaster mitigation (PDM) program to implement mitigation projects prior to a disaster event
- Makes flood insurance available

Eligibility Requirements

- State agency
- Tribal government
- Local government

Areas of Interest:

- Disaster planning

Notes:

Some programs are "direct assist" programs, not monetary awards. Availability of funds changes throughout the year and application periods differ by program. Refer to:
www.fema.gov/government/grant.index.shtm
www.fema.gov/government/mitigation.shtm
www.fema.gov/government/tribal/index.shtm

U.S. Department of Housing and Urban Development (HUD)

Address/Contact

HUD Office of Native American Programs
(ONAP)Anchorage Field Office
3000 C St. Ste 401
Anchorage, AK 99503

Wayne Mundy, Administrator
Office of Native American Programs
Phone: (907) 677-9860
wayne_mundy@hud.gov

David Vought, Native American Program Specialist
Phone: (907) 677-9862
david_vought@hud.gov

Bering Straits Housing Authority
PO 995
Nome, Alaska 99762

Robert Mocan, President & CEO
Phone: (907) 443-5256
bmocan@bsrha.org
Fax: (907) 443-8652

Assistance

- Indian Community Development Block Grants ($500,000 per community/year)
- Rural housing & Economic Development Grants ($25 million/nationwide/year)
- 1996 Native American Housing Assistance Self-Determination Act (NAHASDA) provides grants and technical assistance to Alaska Native Villages to develop affordable housing and to move homes threatened by flooding and erosion
- Imminent Threats Grants Program provides funding to alleviate or remove imminent threats to health or safety including threats posed by flooding or erosion

Eligibility Requirements

- Any Indian tribe, band, group, or nation(including Alaska Indians, Aleut, and Eskimos) or Alaska Native village which has established a relationship to the Federal government as defined in the program regulations;
- Tribal organizations may be eligible to apply.

Areas of Interest:

- Housing - rehabilitation, land acquisition to support new housing construction, and under limited circumstances, new housing construction.
- Community Facilities - infrastructure construction, e.g., roads, water and sewer facilities; and, single or multipurpose community buildings.
- Economic Development - wide variety of commercial, industrial, agricultural projects which may be recipient owned and operated or which may be owned and/or operated by a third party.

U.S. Department of Interior/ U.S. Fish and Wildlife Service (F&WS)

Address/Contact

Native American Liaison
1011 East Tudor Road
Anchorage, AK 99503-6199

Sue Detwiler
Phone: (907) 786-3868
Fax: (907) 786-3495

Anchorage Field Office
605 W 4th Ave. Room G-61
Anchorage, AK 99501

Greg Risdahl
Phone: (907) 271-2807
Greg_Risdahl@fws.gov

Assistance

- Surveys for wildlife presence

Areas of Interest:

- Wildlife issues, concerns.

U.S. Department of the Interior, Bureau of Indian Affairs (BIA)

Address/Contact

Alaska Regional Office
Bureau of Indian Affairs
PO Box 25520
709 West 9th St.
Juneau, AK 99802

Phone: (800) 645-8397
Fax: (907) 856-7252

Niles Cesar, Regional Director
Charles Bunch, Deputy Regional Director, Trust Services

Assistance

- Indian Reservations Roads (IRR) program

Eligibility Requirements

Indian Reservations Roads (IRR) projects are selected by Tribal governments and approved by the BIA and the Federal Highway Administration (FHWA). Each project must be listed in the Tribal Transportation Improvement Program (TIP), which is submitted by the BIA to the FHWA for approval and then forwarded to the respective State for inclusion in the Metropolitan Planning Organization (MPO) TIP and State Transportation Improvement Program (STIP). Approved IRR projects may be subject to metropolitan and statewide planning requirements and guidelines.

Areas of Interest:

- Roads
- Physical area for community

Notes:

Twelve regional offices with a Regional Director, Deputy Regional Director for Trust Services and Deputy Regional Director for Indian Services.

U.S. Department of the Interior, National Park Service (NPS)

Address/Contact

U.S. Department of the Interior
Alaska Regional Office
240 West 5th Avenue
Anchorage, AK 01

Sue Masica, Regional Director
(907) 644-3510

Jeannette Pomrenke, Park Superintendent
Bering Straits National Park
214 E Front St.
P.O. Box 220
Nome, AK 99672
Tel: (907) 443-2522

Assistance

- Land Issues
- Cultural Preservation

Areas of Interest:
- Land Issues
- Cultural Preservation

U.S. Department of Transportation/Federal Aviation Administration (FAA)

Address/Contact

FAA Anchorage
222 W 7th Ave.
PO Box 14
Anchorage, AK 99513

Robert Van Haastert
Phone: (907) 271-5863
Robert.van_haastert@faa.gov

John Lovett
Phone: (907) 271-5446
John.Lovett@faa.gov

Mark Mayo
Phone: (907) 269-0519

Assistance

- Airport planning through the Alaska Department of Transportation and Public Facilities (DOTP&F)
- Improve airport infrastructure

Eligibility Requirements
If awarded airport financial assistance, the Alaska Department of Transportation and Public Facilities (DOTP&F) would have to be involved in the airport planning.

Areas of Interest:

- Airfields

U.S. Department of Transportation/Federal Highway Administration (FHWA)

Address/Contact

FHWA Alaska Division
P.O. Box 21648
709 West 9th Street, Room 851
Juneau, AK 99802-1648

Phone: (907) 586-7418
Fax: (907)-586-7420

Assistance

- For study to construct road

Areas of Interest:

- Roads

State Agencies:

Alaska Department of Transportation and Public Facilities (DOT&PF)
Alaska Energy Authority (AEA)
Alaska Housing Finance Corporation (AHFC)
Alaska Department of Commerce, Community and Economic Development (DCCED)
Alaska Department of Education and Early Development (DEED)
Alaska Department of Military & Veterans Affairs, Division of Homeland Security & Emergency Management (DHSEM)
Alaska Department of Health and Social Services (DHSS)U.S. Department of Alaska Department of Natural Resources (DNR) Division of Coastal and Ocean Management (DCOM)
Alaska Department of Natural Resources Office of History and Archeology (OHA)
Alaska Department of Natural Resources Office of Project Management and Permitting (OPMP)

Alaska Department of Transportation and Public Facilities (DOT&PF)	
Address/Contact AKDOTP&F Northern Region Planning 2301 Peger Road Fairbanks, AK 99709 - 5316 Mail Stop 2550/(907) 451-2380 Alexa Greene Northern Area Planner Phone: (907) 451-2388	**Assistance** • Transportation infrastructure development • Village airstrip erosion protection • Work with USACE, community, DCCED to design and develop shoreline protection measures
Areas of Interest: • Roads • Airfield • Barge landing facility	

Alaska Energy Authority (AEA)

Address/Contact

Alaska Energy Authority
813 W Northern Lights Blvd.
Anchorage, AK 99503

Bruce Chertkow, Loan Officer
Phone: (907) 771-3037
bchertkow@aidea.org

Assistance

- Power Project Loan Fund
- Bulk Fuel Revolving Loan Fund

Eligibility Requirements

- Electric Utility, City or Village Council, Regional or Village Corporation

Areas of Interest:

- Project planning
- Power generation and distribution
- Bulk fuel storage

Alaska Housing Finance Corporation (AHFC)

Address/Contact

Alaska Housing Finance Corporation
4300 Boniface Parkway 99504
PO Box 101020
Anchorage, AK 99510-1020
(907) 338-6100
(800) 478- 2432
Fax: (90)-338-9218

Esther Combs, Supplemental Housing Development Grant Program Manager
Phone: (907)-330-8129
ecombs@ahfc.state.ak.us

Assistance

- program provides loans or grants to persons in imminent danger of losing their homes
- Community Development Block Grants (CDBG) can be used for community site planning, one-time basis, maximum $850,000

Eligibility Requirements

- Must be a recognized housing authority (BSRHA, AVCP), local government or non-profit organization.

Notes: *Elder housing program w/Denali Commission* – provides federal funds to plan, construct and rehabilitate housing in rural Alaska
Supplemental housing development grant program – provides funding to **regional housing authorities** to supplement housing projects approved under HUD's housing development programs. The funds can be used only for the cost of on-site water and sewer facilities, road construction to project sites, electrical distribution facilities and energy-efficient design features in the homes.

Areas of Interest:

- Housing

Alaska Department of Commerce, Community and Economic Development (DCCED)

Address/Contact

Division of Community & Regional Affairs
550 W 7th Ave. Ste 1770
Anchorage, AK 99501

Tara Jollie, Director
Phone: (907) 269-4580
Tara.Jollie@alaska.gov

Leroy Seppilu
Local Government Specialist, Nome Regional Office
Phone: (907) 443-5457
Leroy.Seppilu@alaska.gov

Assistance

- Community planning
- Local government assistance
- Hazard mitigation plans
- Floodplain management
- Community Development Block Grants
- Grants Database

Eligibility Requirements

- For floodplain management program must be identified as a community of significant risk where a phased and coordinated approach to project development is needed to ensure infrastructure and community-wide safety

Areas of Interest:

- Erosion protection and floodplain management
- Community Planning
- Local government assistance
- Community infrastructure development

Alaska Department of Education and Early Development (DEED)

Address/Contact

Department of Education and Early Development
801 West 10th Street, Ste 200
PO Box 110500
Juneau, AK 99811-0500
Phone: (907) 465-2800
Fax: (907) 465-4156

Phyllis Carlson, Director of Rural Education
Phone: (907) 465-2800
phyllis.carlson@alaska.gov

Assistance

- School facilities, planning and funding
- Teaching and learning support

Areas of Interest:

- School facilities
- Teaching

Alaska Department of Military & Veterans Affairs, Division of Homeland Security & Emergency Management (DHSEM)	
Address/Contact Division of Homeland Security & Emergency Management PO Box 5800 Fort Richardson, AK 99505 John Madden, Director Phone: (907) 428-7062 john.madden@alaska.gov	**Assistance** • develop emergency plan for emergency operations, community evacuation, hazard mitigation • helps communities recover from the effects of disasters and emergencies • provide information on grants
Areas of Interest: • Planning, Analysis & Mitigation • Emergency preparedness	

Alaska Department of Health and Social Services (DHSS)	
Address/Contact Department of Health and Social Services 350 Main Street, Room 404 PO Box 110601 Juneau, AK 99811-0601 Phone: (907) 465-3030 Fax: (907) 465-3068 Bill Hogan, Commissioner bill.hogan@alaska.gov	**Assistance** • Planning
Areas of Interest: • Health Care Services and Facilities • Public Health	

Alaska Department of Natural Resources (DNR) Division of Coastal and Ocean Management (DCOM)

Address/Contact

Division of Coastal and Ocean Management
302 Gold St. Ste 202
PO Box 111030
Juneau, AK 99811
MS 1030/JNU

Sylvia Kreel, Project Coordinator/CIAP
Phone: (907) 465- 3177
Fax: (907) 465-3075
Sylvia.Kreel@alaska.gov

David Gann, District Planning Specialist-DCOM
Phone: (907) 465-3529
David.Gann@alaska.gov

Assistance

- Alaska Coastal Management Program provides information on available grants, educational opportunities relating to coastal issues and management, policies
- U.S. Minerals Management Service - Coast Impact Assistant Program - Funding available for the purpose of conservation, protection, or restoration of coastal areas including wetlands; mitigation of damage to fish, wildlife, or natural resources; planning assistance and the administrative costs of complying with these objectives; implementation of a federally-approved marine, coastal, or comprehensive conservation management plan; and, mitigation of the impact of Outer Continental Shelf activities through funding of onshore infrastructure projects and public service needs.

Eligibility:

- Shishmaref is included in the Bering Straits coastal resource service area, which is part of the northwest coastal district.

Areas of Interest:

- Community/Waterfront Planning
- Site Inventory & Assessments

Alaska Department of Natural Resources Office of History and Archeology (OHA)

Address/Contact

Office of History & Archaeology
Division of Parks and Outdoor Recreation
550 W 7th Ave. Ste 1310
Anchorage, AK 99501

Dave McMahan, Deputy SHPO/State Archaeologist
Phone: (907) 269-8723
Fax: (907) 269-8908
e-mail: dave.mcmahan@alaska.gov

Assistance

- provides regulations, instructions on permits for investigations on state land
- information on historic preservations, cultural assessment
- work with federal and state agencies during the early stages of project planning to protect cultural resources

Areas of Interest:

- Historic/cultural preservation
- Permitting for investigations on state lands
- Review of federal, state and local undertakings that may affect historic properties

Alaska Department of Natural Resources Office of Project Management and Permitting (OPMP)

Address/Contact

Office of Project Management & Permitting
550 W 7th Ave Ste 1660
Anchorage, AK 99501

Ed Fogels, Director
Phone: (907) 269-8431

Assistance

- Review of large scale projects
- Interagency coordination

APPENDIX B

SHISHMAREF RELOCATION PLANNING TIMELINE

Critical Initiators:

- Form Planning Team
- Firm Commitment to Location
- Site Plan and Community Layout

Years 6 - 10:

- Relocate/Construction of buildings – Phase II (60%)
- Continue Road System construction
- Communication Facilities
- Indoor plumbing – Sanitary waste collection

Critical Initiators | **Years 1 - 5** | **Years 6 - 10** | **Years 10 +**

Years 1- 5:

- Erosion Protection Measures
- Finalize Physical Area
- Begin Road System
- Sanitary/Solid Waste Collection, Disposal and Treatment
- Bulk Fuel/Electrical Utilities/Water supply and treatment facilities
- Relocate/construct personal, commercial, industrial, public and community buildings – Phase I (20%)

Years 10+:

- Construct Airport Facilities
- Public/Community Buildings – School, Teachers Housing
- Decommissioning and Closure of old town site
- Water distribution/piping throughout Community
- Sewer collection/piping throughout Community

Shishmaref Relocation Planning Timeline

APPENDIX C

NRCS SITE EVALUATION RESULTS

NRCS Site Evaluation Results:

NCRS evaluated potential relocation sites based on five parameters, which include: site layout, development potential, natural resources, infrastructure, and social and cultural considerations. The site evaluations were performed by the NRCS, which ranked the proposed sites qualitatively. However, NRCS did not factor in, or account for, a review or opinion of the Shishmaref Community.

Table 1 Site Layout Data

Site	Area (acres)	Elevation (feet)	Contiguous Ground
East Nunatuq	520	75	Low
Arctic	340	100	Medium
Igloot	450	75	Medium
Tin Creek	390	50	Low
West Tin Creek Hills	160	50	Medium
West Tin Creek Flats	640	25	High

Note: (Shishmaref Site Analysis for Potential Emergency Evacuation and Permanent Relocation Sites, 2005)

West Tin Creek Flats had the largest potential development area, as well as the largest contiguous area of acceptable ground and best combination of shape, elevation and area. It also had the lowest elevation of all the proposed sites. West Tin Creek Flats was followed closely by Igloot and Arctic in the site layout rankings (See Table 1 above).

Table 2 Development Potential

				Material Sources		
Site	**Slope (percent)**	**Soils**	**Drainage**	**sand**	**gravel**	**rock**
East Nunatuq	6	Fair	Fair	Poor	Poor	Poor
Arctic	2	Fair	Fair	Poor	Poor	Poor
Igloot	4	Good	Good	Poor	Poor	Poor
Tin Creek	6	Fair	Fair	Fair	Fair	Fair
West Tin Creek Hills	4	Good	Fair	Fair	Fair	Fair
West Tin Creek Flats	1	Poor	Poor	Good	Fair	Fair

Note: (Shishmaref Site Analysis for Potential Emergency Evacuation and Permanent Relocation Sites, 2005)

According to the NRCS, the majority of the proposed relocation sites are located similar distances from building material sources. Proposed sites located on the southwest side of the Shishmaref Inlet are closer in proximity to Ear Mountain (a rock and gravel source), which gives those sites an advantage. Deep thawed layers were discovered at Igloot and West Tin Creek Hills; this provides better soil and depth for infrastructure development potential (see Table 2 above). Each site was soil probed to determine soil quality for the proposed area. The preferred relocation site will require further soil testing and evaluation, through detailed geotechnical investigations.

Table 3 Natural Resources Attributes

Site	Fresh Water*	Erosion
East Nunatuq	L	Low-Medium**
Arctic	S,L,G	Low-Medium**
Igloot	R,L,S,G	Low-Medium***
Tin Creek	R,L,S,G	Low-Medium***
West Tin Creek Hills	S,L,G	Low-Medium***
West Tin Creek Flats	S,L,G	Medium-High**

Notes: (Shishmaref Site Analysis for Potential Emergency Evacuation and Permanent Relocation Sites, 2005)

*S=Spring, L=Lake, R=River, G=Suspected Groundwater

**Bluff erosion potential
***Streambank erosion potential

Potential relocation sites were evaluated based on proximity to natural resources. None of the proposed sites are subject to flooding hazards, or to some degree, erosion, because initial site selection criteria were for sites located away from the ocean. Streambank erosion will be a concern at Igloot, Tin Creek, and West Tin Creek Hills, due to forecasted boat traffic on streams located in close proximity to the proposed town sites. Igloot and Tin Creek had the highest overall rating due to site proximity to potential freshwater sources. Site erosion potentials were evaluated through examining site proximity to streams, potential boat traffic, and flooding potential.

Table 4 Infrastructure Development Data

						Access Road	
Site	**Airport**	**Small Boat Harbor**	**Barge Access**	**Sewage Lagoon**	**Landfill**	**Local**	**Service**
East Nunatuq	Fair	Poor[1]	Poor	Fair	Fair	Fair	.75 mi
Arctic	Fair	Fair[2]	Poor[3]	Fair	Fair	Fair	2.5 mi[5]
Igloot	Poor	Poor[1]	Fair	Fair	Fair	Fair	1 mi
Tin Creek	Fair-Good	Fair[2]	Fair[4]	Poor	Fair	Fair	2 mi
West Tin Creek Hills	Fair	Fair[2]	Fair[4]	Poor	Fair	Fair	1.5 mi[5]
West Tin Creek Flats	Good	Fair-Good	Fair[4]	Poor	Poor	Poor	0 mi

Notes: (Shishmaref Site Analysis for Potential Emergency Evacuation and Permanent Relocation Sites, 2005)
[1] A constructed breakwater will be required.
[2] A constructed port and marina will be required.
[3] This site will need a long jetty and constant dredging.
[4] These ports are well sheltered. A jetty will be required.
[5] Bridges will be needed on the road to the harbor.
mi = mile

Proposed relocation site selection criteria, requiring a gentle terrain, created a good base for infrastructure development evaluation. All proposed relocation sites will require development of access roads throughout town to connect proposed development areas, such as the airport and marina. Additional infrastructure would include development of a landfill and a sewer lagoon. Table 4 shows how the NRCS evaluated the infrastructure potential of each proposed relocation site.

Table 5 Cultural and Social Considerations

Site	Cultural Sites	Native Allotments	Team Consensus
East Nunatuq	*	*	Low
Arctic	*	*	Medium
Igloot	*	*	Medium
Tin Creek	*	*	High
West Tin Creek Hills	*	*	High
West Tin Creek Flats	*	*	Low

Notes: (Shishmaref Site Analysis for Potential Emergency Evacuation and Permanent Relocation Sites, 2005)
*Not evaluated by NRCS

The social and cultural consideration for the proposed relocations sites was left to “gut feeling” by the NRCS (See Table 5 above). The social and cultural aspect was felt to be better left to the local Community for their evaluation.

The NRCS delivered a final consensus by equally weighing each of the categories listed above in order summarize which potential relocation sites would best serve the interests of the Community. The NRCS determined that the Igloot relocation site was the most desirable after weighing all attributes evenly. Igloot was followed closely by West Tin Creek Hills and Tin Creek (NRCS, 2005).