Kivalina Airport Relocation Feasibility Study

April 2024

Alternatives

NFAPT00742/3-02-0152-006-2022

Prepared for:

State of Alaska
Department of Transportation & Public Facilities, Northern Region
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Fairbanks, Alaska 99709

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EXECUTIVE SUMMARY

The Northern Region of the Alaska Department of Transportation and Public Facilities (DOT&PF) and the Federal Aviation Administration (FAA) is conducting an airport relocation feasibility study for the Kivalina Airport (KVL) in support of a larger community relocation plan. This is the Alternatives chapter.

A set of screening criteria are provided, which are used to create and evaluate a set of potential alternatives. The screening criteria include: Safety, Land Use, Environmental, Constructability, Materials, Utilities, and Cost. Public Involvement will also be incorporated through a public scoping process.

Five alternatives were developed and evaluated in addition to the No Action alternative. These include:

- Alternative 1 – Improve. This is maintaining the Airport in the current location while improving it to meet standards.

- Alternative 2 – Nearshore. This is shifting the airport onto the mainland, but in relatively close proximity to the current community of Kivalina. This runway was sited to avoid the lakes in the area. This alternative includes raising the surface elevation to +16 feet to avoid nearshore flooding.

- Alternative 3 – K-Hill (Farther). This is moving the airport to the vicinity of the relocated community at K-Hill. This alternative is located Southwest of K-Hill and is relatively more distant from K-Hill than Alternative 4. This provides space for the community to develop around K-Hill.

- Alternative 4 – K-Hill (Near). This is moving the airport near Alternative 3, but closer to K-Hill. This location takes advantage of some elevated terrain.

- Alternative 5 – N K-Hill. This is moving the Airport north of K-Hill.

Prior to engaging in public involvement, the two best alternatives are Alternative 1 “Improve” and Alternative 3 “K-Hill (Farther).”

- Alternative 1 “Improve” improves the existing infrastructure at its current location. This alternative becomes increasingly expensive to maintain and improve to meet the increasing threat from coastal flooding and erosion. In the long term, this alternative may be cost prohibitive. This alternative would be difficult to access for residents should they choose to relocate to K-Hill.

- Alternative 3 “K-Hill (Farther)” is the best alternative located near K-Hill. This is more expensive than Alternative 1 “Improve” initial construction cost, but it permanently removes the airport from the marine flooding, erosion, and storm surge threats and cost. This alternative is convenient for residents that move to K-Hill, but inconvenient for residents that stay at the current community.

This planning effort will use this information to engage in public scoping and gather stakeholder input on potential alternatives.

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LIST OF ACRONYMS

%	percent
ADEC	Alaska Department of Environmental Conservation
ATV	All-Terrain Vehicle
AWC	Anadromous Waters Catalog
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
CKNHL	Cape Krusenstern Archaeological District National Historic Landmark
DOT&PF	Department of Transportation and Public Facilities
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Program
ft	feet
K-Hill	Kisimigiuktuk Hill
KVL	Kivalina Airport
NAB	Northwest Arctic Borough
NRHP	National Register of Historic Places
Stantec	Stantec Consulting Services, Inc.
USDI- FWS	U.S. Department of the Interior Fish and Wildlife Service
USDI-NPS	U.S. Department of the Interior-National Park Service
USGS	U.S. Geological Survey

1 INTRODUCTION

The Northern Region of the Alaska Department of Transportation and Public Facilities (DOT&PF) and the Federal Aviation Administration (FAA) is conducting an airport relocation feasibility study for the Kivalina Airport (KVL) (Figures 1-1, 1-2, 1-3, and 1-4) in support of a larger community relocation plan.

The City of Kivalina is located on the southeast tip of a barrier island located between the Chukchi Sea (Arctic Ocean) and Kivalina Lagoon. Historically, the area was a seasonally used hunting camp. A school was constructed at the current site, which led to the transition from a seasonal establishment to the current permanent community. Due to severe storms and rising sea levels, Kivalina hopes to relocate to a site off the barrier island to higher ground near Kisimigiuktuk Hill (K-Hill). To accomplish the relocation, the community is actively developing a community relocation plan.

An evacuation road from the Kivalina barrier island, across the Kivalina Lagoon, was constructed in 2020 and now provides a safe means for the community to evacuate to K-Hill during storm surges. Additionally, the evacuation road connects the village with the new school site at K-Hill, opened in Fall 2023.

The issues with the current runway, identified in the inventory portion of the study, found:

1. Runway erosion.
2. Storm surge creating runway hazards.
3. Crosswinds on runway.
4. Runway incursions.
5. Too small of apron and/or apron congestion.
6. Trail use along the runway penetrating the Part 77 protected airspace.
7. Landfill at the end of the runway.

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City of Kivalina, Kotzebue Recording District
S21 T27N R26W, Kateel River Meridian

April 2024

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Figure 1-1:
Project Location and Vicinity Map

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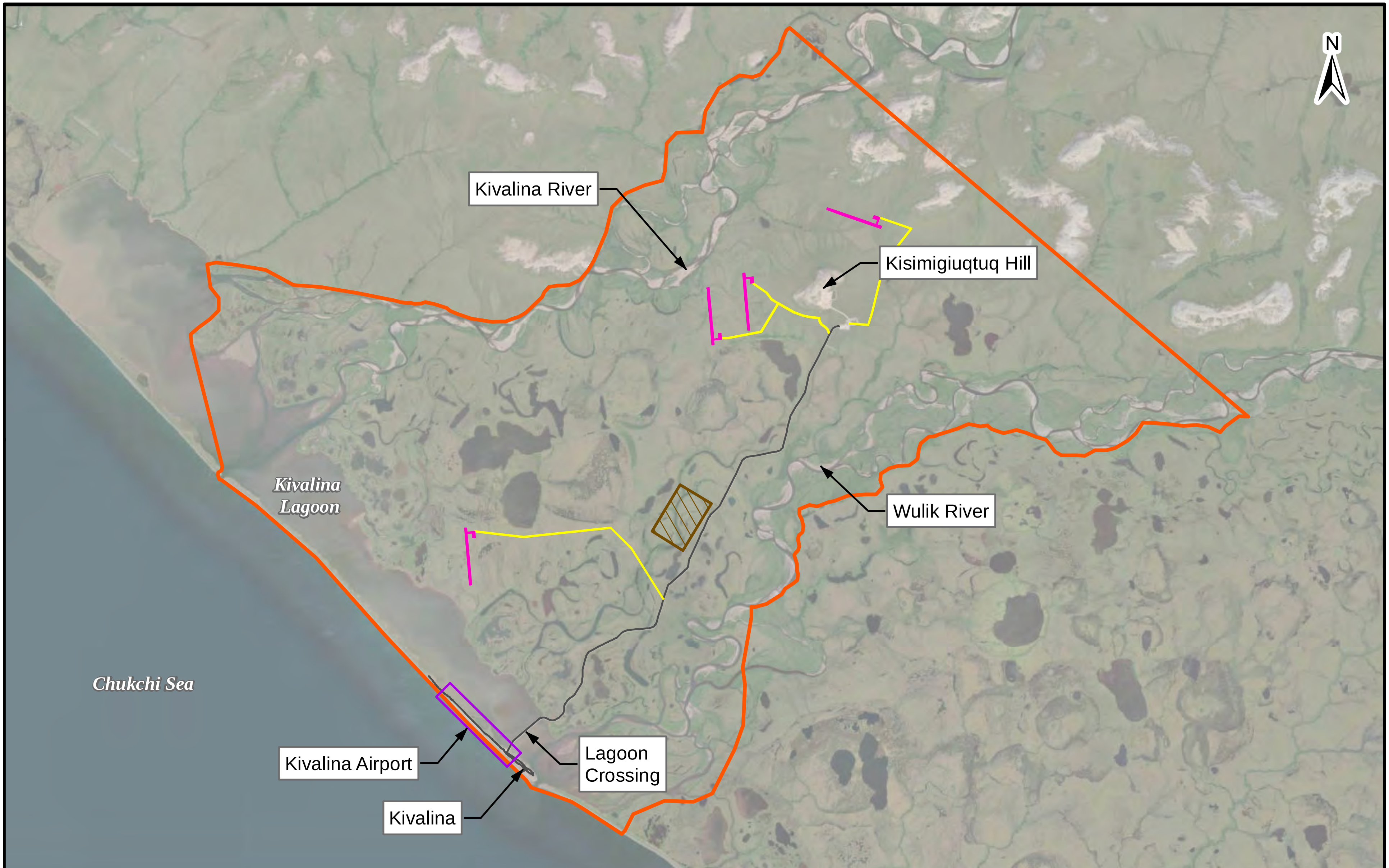

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Notes:
1. Coordinate System: NAD 1983 2011 StatePlane Alaska 8 FIPS 5008 Feet
2. Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Study Area Boundary
Airport Boundary
Proposed Landfill
Alternatives
Alternatives (roads)
Road

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Figure 1-2: Study Area

0 1,000 2,000 Feet

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Study Area Boundary
Airport Boundary
Road

Notes:
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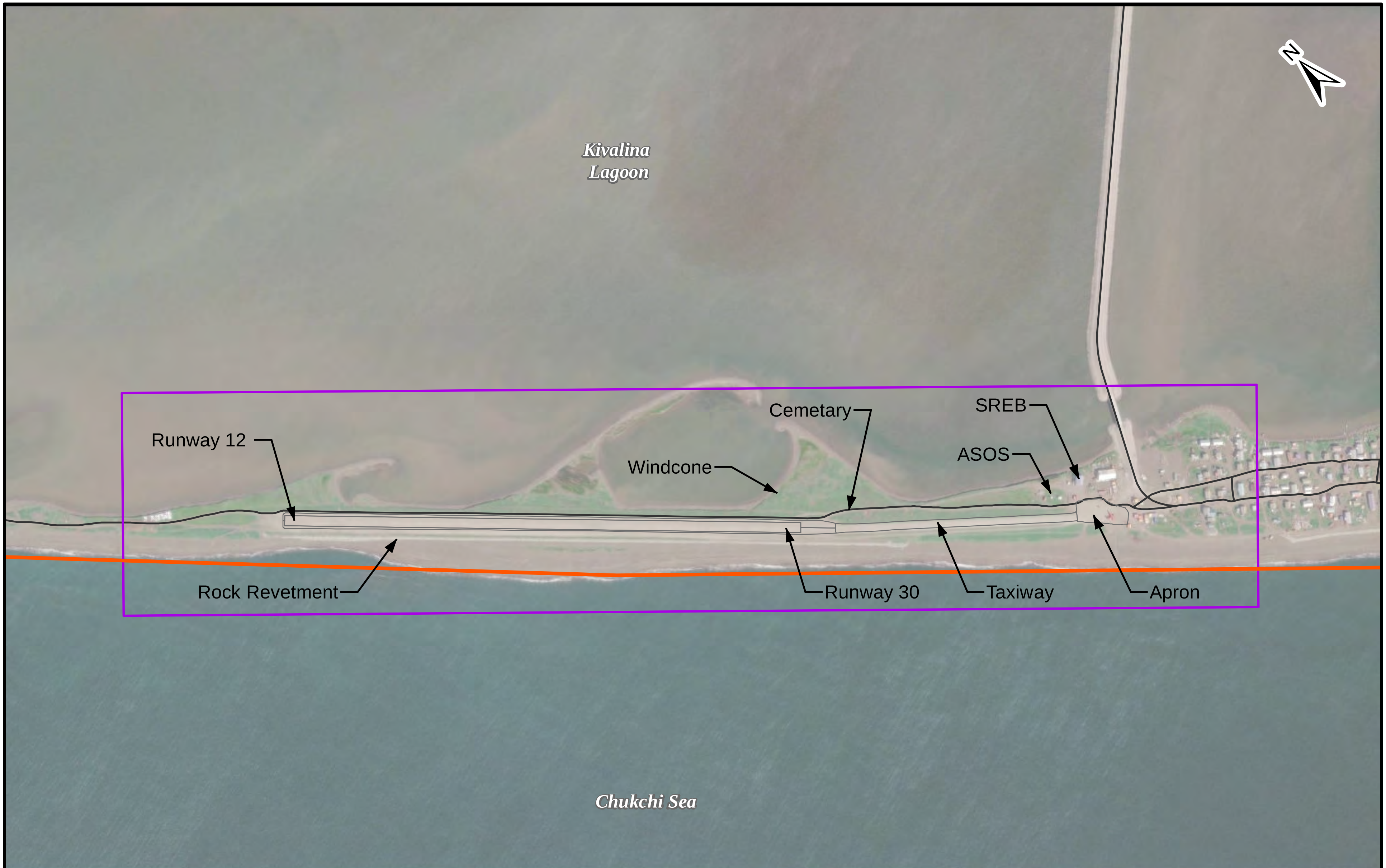
Figure 1-3: Kivalina



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Notes:
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Study Area Boundary
Airport Boundary
Road

SREB: Snow Removal Equipment Building;
ASOS: Automated Surface Observing System

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April 2024	Figure 1-4: Kivalina Airport (KVL)

2 EVALUATION CRITERIA

2.1 Safety and Airport Resiliency

2.1.1 Flooding and Erosion

Kivalina is not part of the Federal Emergency Management Agency (FEMA) floodplain mapping program, and Kivalina remains unmapped for flood potential (FEMA, 2023). However, the Kivalina Airport is routinely subjected to threats of shoreline erosion and infrastructure damage by wind driven waves during coastal storms. Coastal storms cause damage through two methods: localized flooding and high wave action depositing ice and debris on the runway.

Erosion is also a threat and, in 2018, the FAA funded DOT&PF to construct a Kivalina Airport erosion control project by installing a rock revetment to address threats to the runway (Brice, 2023).

Stantec Consulting Services, Inc. (Stantec) has completed a flood and coastal analysis, discussed more fully in Appendix 1. This analysis evaluated the revetment life, flooding, and erosion risk for the existing Kivalina Airport.

The report recommended alternatives to extend the life of the revetment and increase protection to the runway, including:

(1) Flood and Coastal Analysis: Alternative 1: Adding a layer of armor stone of the same class as the existing to the face of the revetment to increase the thickness of the revetment and thereby delay failure (exposure of the filter stone).

(2) Flood and Coastal Analysis: Alternative 2: Alternative (1) and raising the runway to minimize damage to the runway due to wave overtopping. Table 2-1 provides the required runway elevation, including a 1-foot freeboard, for the range of events and sea level projections considered in the study. (The existing runway has an elevation of 16 feet [NAVD88].)

Table 2-1 Required Runway Elevation Including a 1-foot Freeboard

Projection (yr)	Sea Level Rise (ft)	Required Runway Elevation for a Design Storm (ft, NAVD88)			
		10-yr	25-yr	50-yr	100-yr
2050	1.20	16	16	16	16
2060	1.89	16	16	16	16
2075	3.25	16	17	17.5	18
2100	6.32	19	20.5	21	21

Key: ft – feet; yr – year

(3) Flood and Coastal Analysis: No Action Alternative. The analyses conducted suggest that the size of the existing armor stone and overall design of the existing revetment are reasonable based on the storm conditions at Kivalina. The revetment would need to be actively maintained to prevent failure prior to 2060.

These alternatives all relate to the airport being improved and maintained in its current location.

2.1.2 Hydrologic and Hydraulic Review

AWR Engineering (2023 in Appendix 2) drafted a hydrologic and hydraulic review of the onshore area, including modeling the 1 percent (%) flood events for the Kivalina River. In 2017, Stantec modeled the 1% flood events for the Wulik River, and the potential flooding from ocean highwater events to the nearshore mainland (which flooded up to 8.5 feet). Taken together, these provide areas impacted by surface water flooding, which should be avoided in new airport site selection (Figure 2-1, Appendix 3).

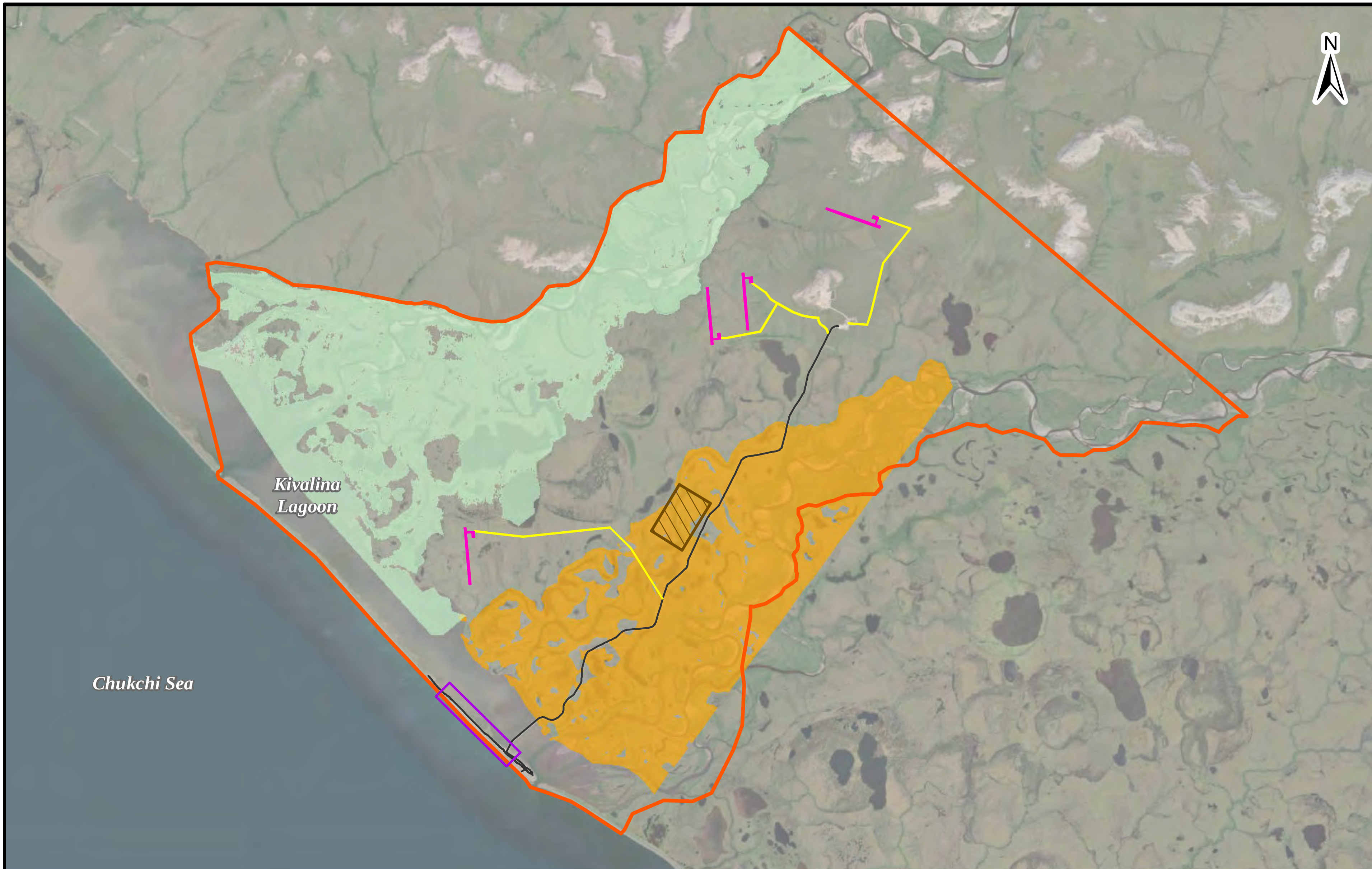
In addition, a number of smaller creeks and open water areas are evident on aerial photography which should also be avoided.

2.1.3 Fog and Low Visibility

Coastal fog impacts aviation operations in Kivalina, as it does over the rest of the coastal arctic. Local knowledge from multiple stakeholders has noted that the current Kivalina Airport is often subjected to coastal fog when more inland locations at K-Hill are not. Qualitative discussions indicate that the first few miles of coast are often the foggiest; but no local quantitative data is available to indicate how far inland the fog occurs. For this analysis, the first few miles of the coast are treated as having more fog as more inland locations.

2.1.4 Wind

Wind data collected at KVL from 2004 to 2013 indicate that the current runway provides 79.8% wind coverage for 10.5-knot crosswind, and 85.9% coverage for 13-knot crosswinds. For A-II (Small) aircraft, the allowable crosswind component is 13 knot winds. Winds are generally out of the southeast, but during strong winter storms, the winds are seen to come from the northeast.



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Notes:
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Study Area Boundary
Airport Boundary
Proposed Landfill
Alternatives
Alternatives (roads)
Road
Kivalina River 1% Annual Exceedance Probability (AEP) Floodplain
Wulik River 1% AEP Floodplain

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Figure 2-1: Hydrology

FAA standards require 95% wind coverage by runways for the required crosswind component. There is no orientation of a single runway that achieves 95% wind coverage for the wind data collected at the current airport. The best coverage for a single runway is 86.6% at an angle of 357 degrees.

For wind coverages less than 95%, development of a crosswind runway should be evaluated. When terrain does not allow and/or a crosswind runway is cost prohibitive, increasing the runway width to the next larger runway design category is acceptable. The greater runway width allows for better operational tolerance to crosswinds.

Severe storms also impact the runway. Wind pushed water can erode and flood the runway. Ice and rock debris can also be pushed up the shoreline and onto the runway. These can close the runway, particularly during bad weather events which require excavation.

Wind data on the mainland is also available from three other sources.

A wind study was published in a 2017 report, from wind measurements taken on top of K-Hill, to inform the potential for wind power (V3 Energy, 2017). This study found a mean annual wind speed of 7.94 meters/second (15.4 knots) at a height of 32 meters above K-Hill. The wind direction instruments were not calibrated; therefore, there is no wind direction data.

A 2014 wind analysis focused on the potential for wind energy at a mainland site along the coast, east the current village and east of the mouth of the Wulik River (V3 Energy and WH Pacific, 2014). Given its location, the data collected is of limited use to this project, but the study provides valuable situational awareness of the wind speed and direction.

A meteorological tower was installed near the new school at K-Hill during this Feasibility Study in Fall 2023. The tower is actively collecting wind direction and strength data. Until this data collection is complete, it is uncertain what the best alignment for a runway near K-Hill is.

2.1.5 Runway Incursions

Interviews with pilots documented their concern about runway incursions. The runway can be used as a ‘travel corridor’ for individuals – such as to the current solid waste facility. Airport alternatives that are set at a further distance from the community, and that do not serve as a transportation link to infrastructure, are less likely to be used for non-aviation activity.

2.2 Land Use

2.2.1 Land Ownership and Management

Land in the study area is primarily owned by NANA Regional Corporation (Figure 2-2). There are also Alaska Native Allotments and Bureau of Land Management lands distributed throughout the area. Alternatives were selected to avoid these locations, since land acquisition would be unlikely.

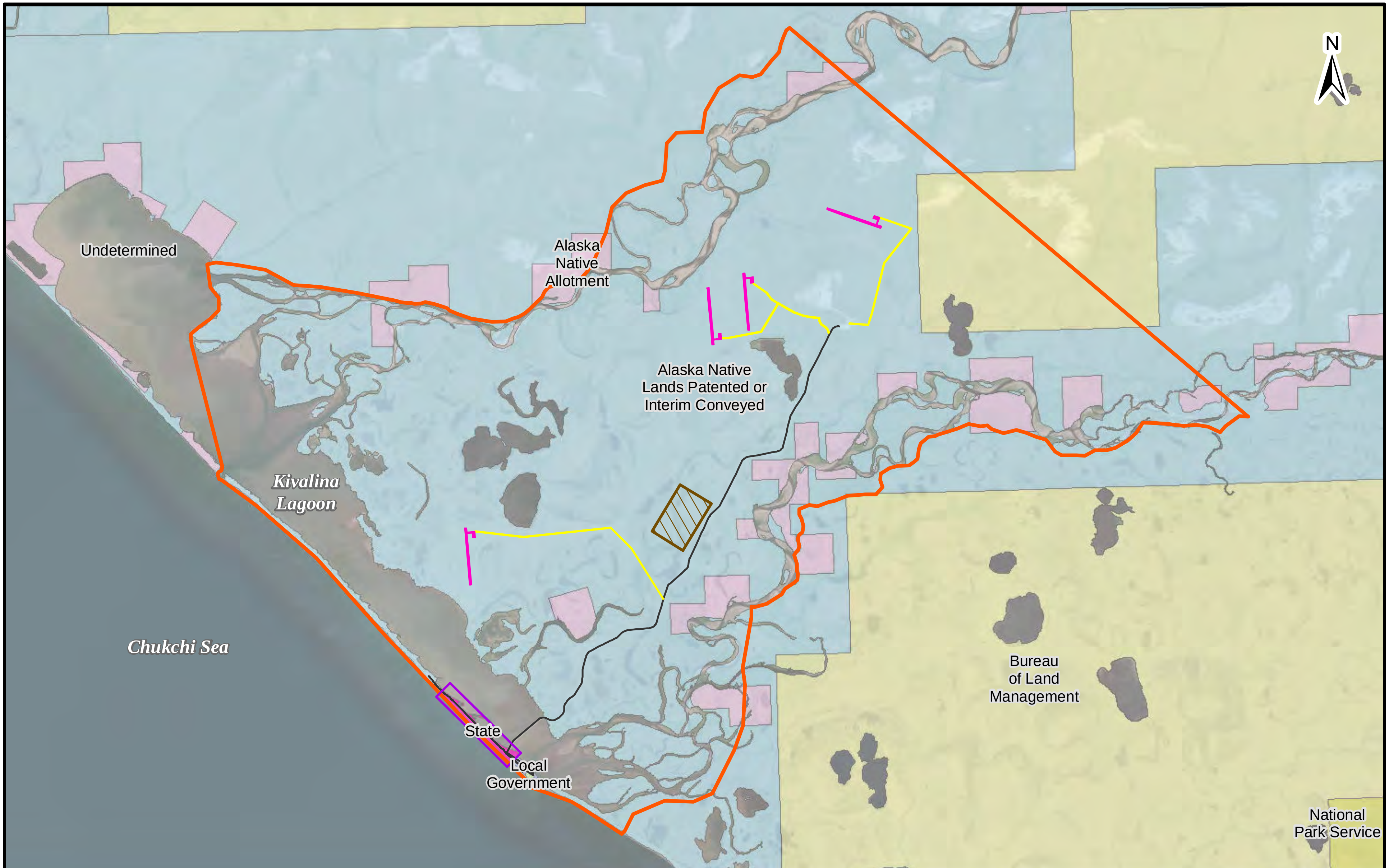
The local zoning is controlled by the Northwest Arctic Borough (NAB). The City of Kivalina lies within a Village Zoning District, and adjacent lands outside the City are designated as a Subsistence Conservation Zoning District for natural ecosystem conservation, subsistence resource access, and subsistence harvest, with high importance for subsistence resources and activities (NAB, 2011). Discussions with the NAB indicate that zoning will be modified to include the new road and site around K-Hill as part of the village zoning district. Discussions have also indicated that new airports would also be included in the rezoning effort.

2.2.2 Parks, Refuges and Recreational Areas (including Section 4f resources)

There are no parks or recreational lands near the existing Kivalina Airport. A community all-terrain vehicle (ATV) trail, which is not designated as a recreational resource, exists adjacent to the runway and is used to access the northern part of the island, including the landfill.

A community cemetery, a Section 4f resource, exists adjacent to and approximately mid-way between runway thresholds.

The nearest federal conservation unit to Kivalina is the Cape Krusenstern National Monument managed by the U.S. Department of the Interior-National Park Service (USDI-NPS, Figure 2-2). Its northwestern-most border is located approximately 9 miles from Kivalina across Kivalina Lagoon and the Wulik River (USDI-NPS, 2023b). Approximately 16 miles north of Kivalina, several discrete units of the U. S. Department of the Interior Fish and Wildlife Service (USDI- FWS) Alaska Maritime National Wildlife Refuge are located on the Chukchi Sea coastline (USDI-FWS, 2023). Both of these federal conservation units lie well outside the area of consideration for potential airport relocation alternatives.



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Study Area Boundary
Airport Boundary
Proposed Landfill
Alternatives
Alternatives (roads)
Road

Land Status
Alaska Native Allotment
Alaska Native Lands
Army
Bureau of Land Management
State
National Park Service
Local Government
Private

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Figure 2-2: Land Ownership

2.2.3 Subsistence

Kivalina lies on a barrier island with no road access, relying on supplies delivered by air and seasonal barge services. Subsistence activities are integral to Kivalina residents' lives. Kivalina residents use ATVs, snow machines, and boats to access subsistence use areas. A 2007 subsistence survey conducted by the Alaska Department of Fish and Game (Magdanz et al., 2010) reported every household used subsistence food. This study also provides Geographic Information System information for the mapping of subsistence use areas.

Subsistence use areas are important to incorporate into infrastructure planning. Of note to airport alternatives analysis are the mapped subsistence use areas (Magdanz et al., 2010):

- Large terrestrial game (primarily caribou [Figure 2-3]) are harvested wherever found in the Kivalina and Wulik River drainages. Moose harvest areas are focused along the Kivalina and Wulik Rivers.

- Upland birds are harvested primarily along the Wulik River, but also along the other rivers (Figure 2-3).

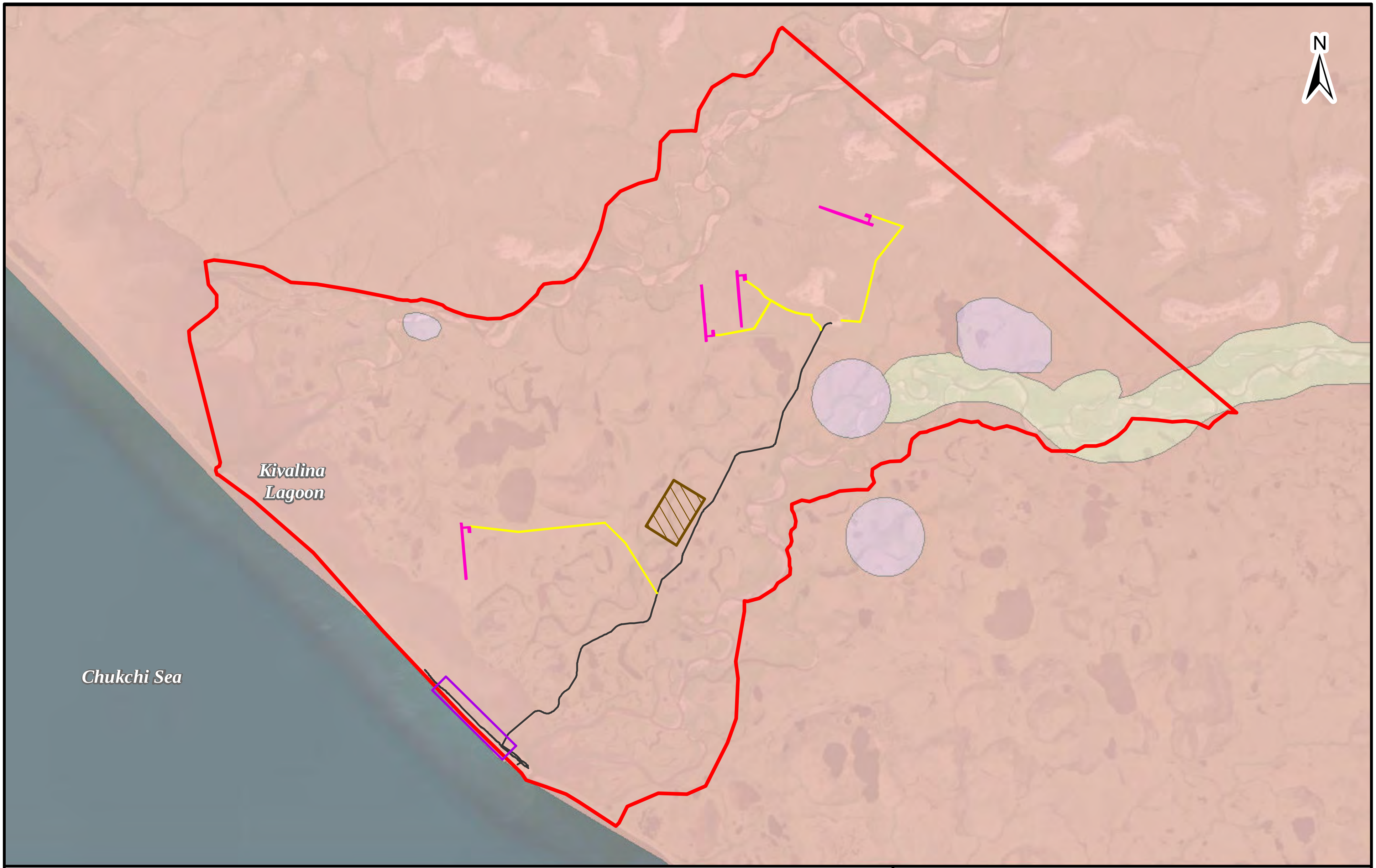
- Waterfowl are harvested primarily onshore, along the Kivalina and Wulik River corridors, which historically have provided access for hunters of these species (Figure 2-4).

- Marine mammals are harvested along the Chukchi Sea coast in spring and summer, and offshore from the Kivalina barrier islands in the fall (Figure 2-5).

- Furbearers are used throughout the area of analysis (Figure 2-6). Wolves are harvested east of the Wulik River, and beavers are harvest near the upstream portion of the Wulik River mouth.

- The river systems are the center of harvest for salmon (Figure 2-7) and non-salmon fish (Figure 2-8).

- Plants (including berries, and woody and herbaceous vegetation) are harvested throughout the area. Plants are particularly utilized near the accessible shorelines and rivers, which have easier access than inland locations (Figure 2-9).



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3. Magdanz et al. 2010 (GIS from ADF&G)

Study Area Boundary
Airport Boundary
Proposed Landfill
Alternatives
Alternatives (roads)
Road
Caribou
Ptarmigan
Moose

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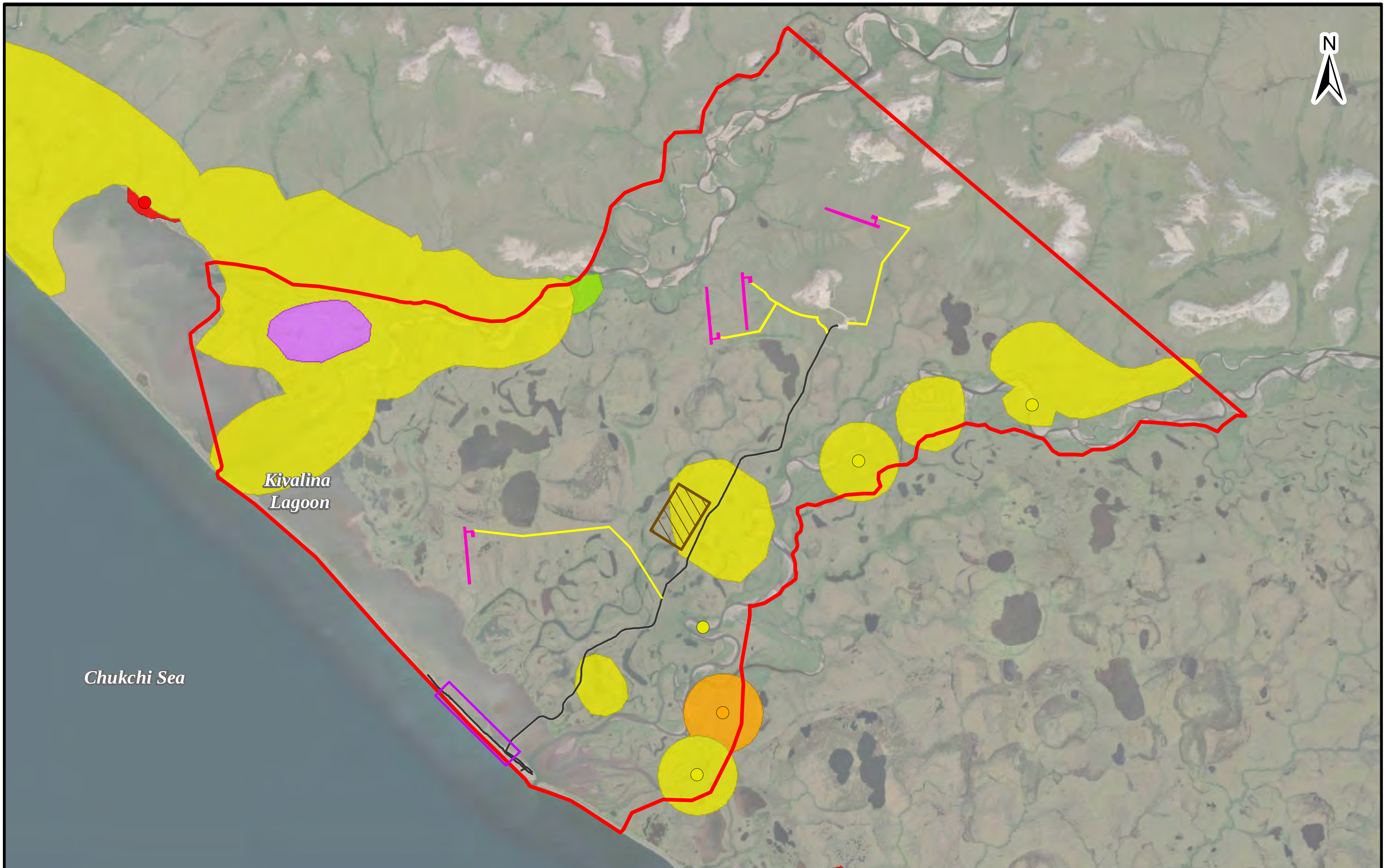
Figure 2-3: Use Areas for: Upland Birds, Moose, Caribou



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Study Area Boundary
Airport Boundary
Alternatives
Alternatives (roads)
Proposed Landfill
Road

Brant
Tundra Swan
Waterfowl

Brant
Canada Goose
Tundra Swan
Waterfowl
White-Fronted Goose

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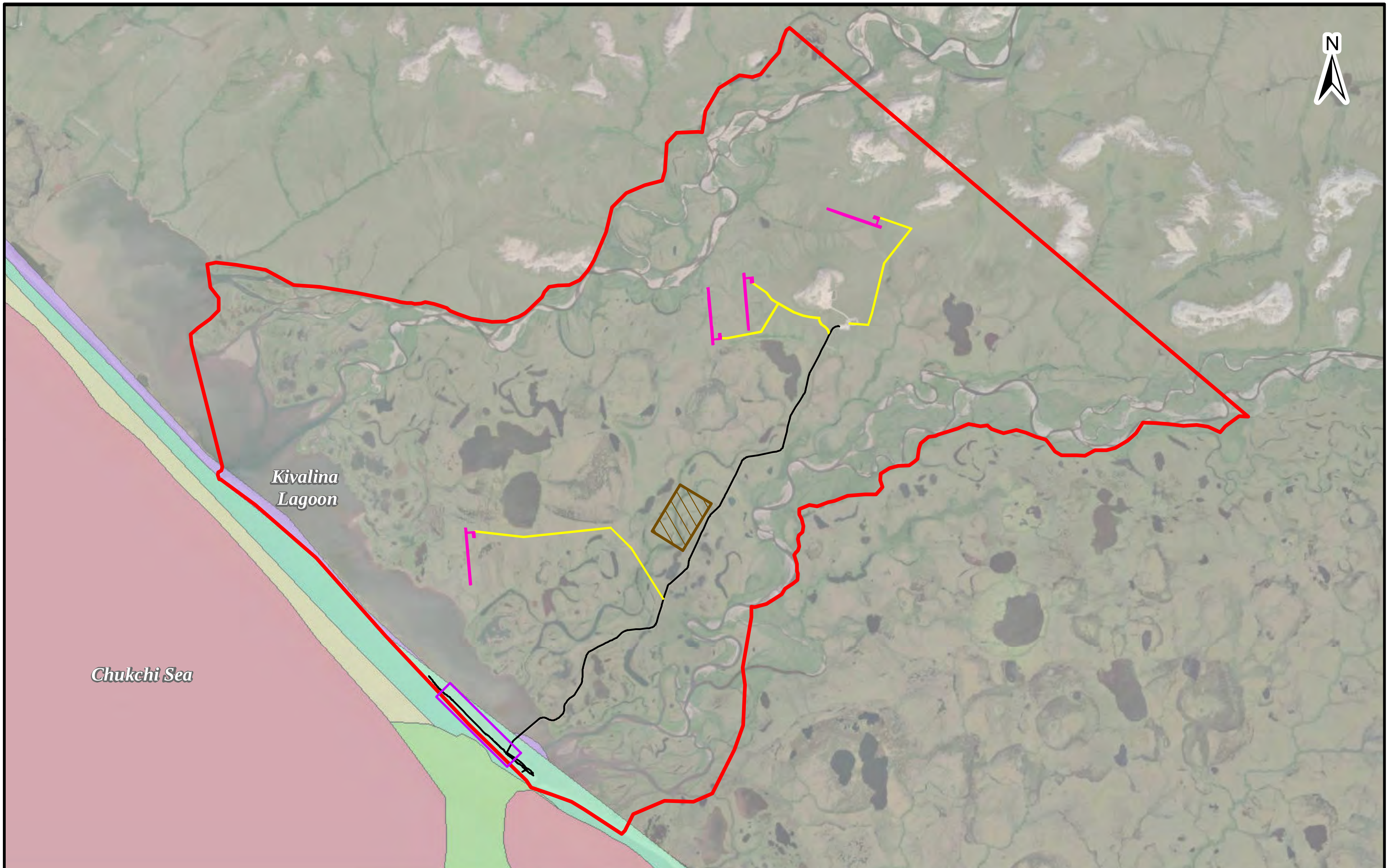
Figure 2-4: Use Areas for: Waterfowl



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Study Area Boundary
Airport Boundary
Alternatives
Alternatives (roads)
Proposed Landfill
Road
Bearded Seal
Beluga
Bowhead
Ribbon Seal
Ringed Seal
Walrus

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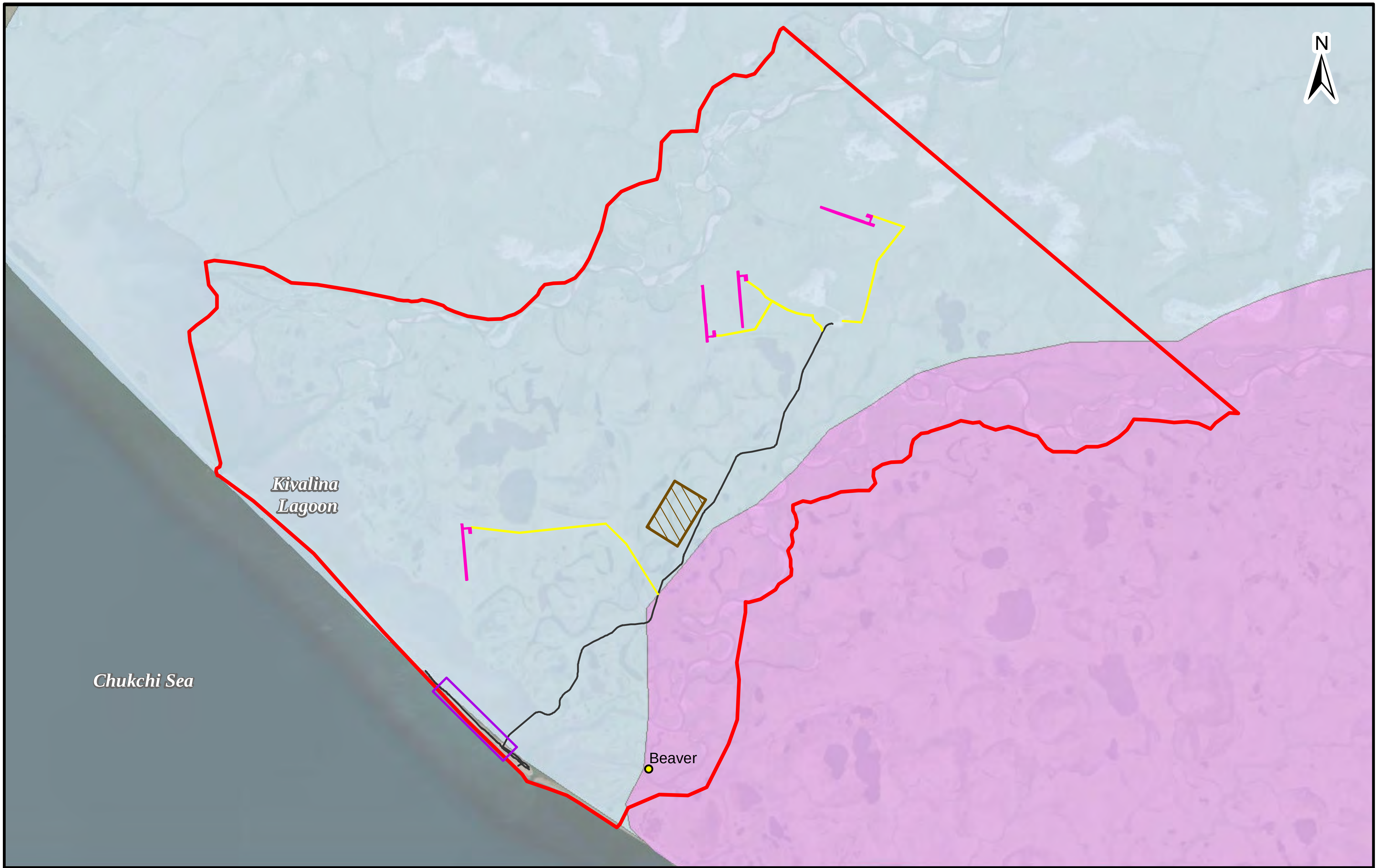
Figure 2-5: Use Areas for: Marine Mammals



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Study Area Boundary
Airport Boundary
Proposed Landfill
Alternatives
Alternatives (roads)
Road
Beaver
Furbearers
Wolf
Beaver

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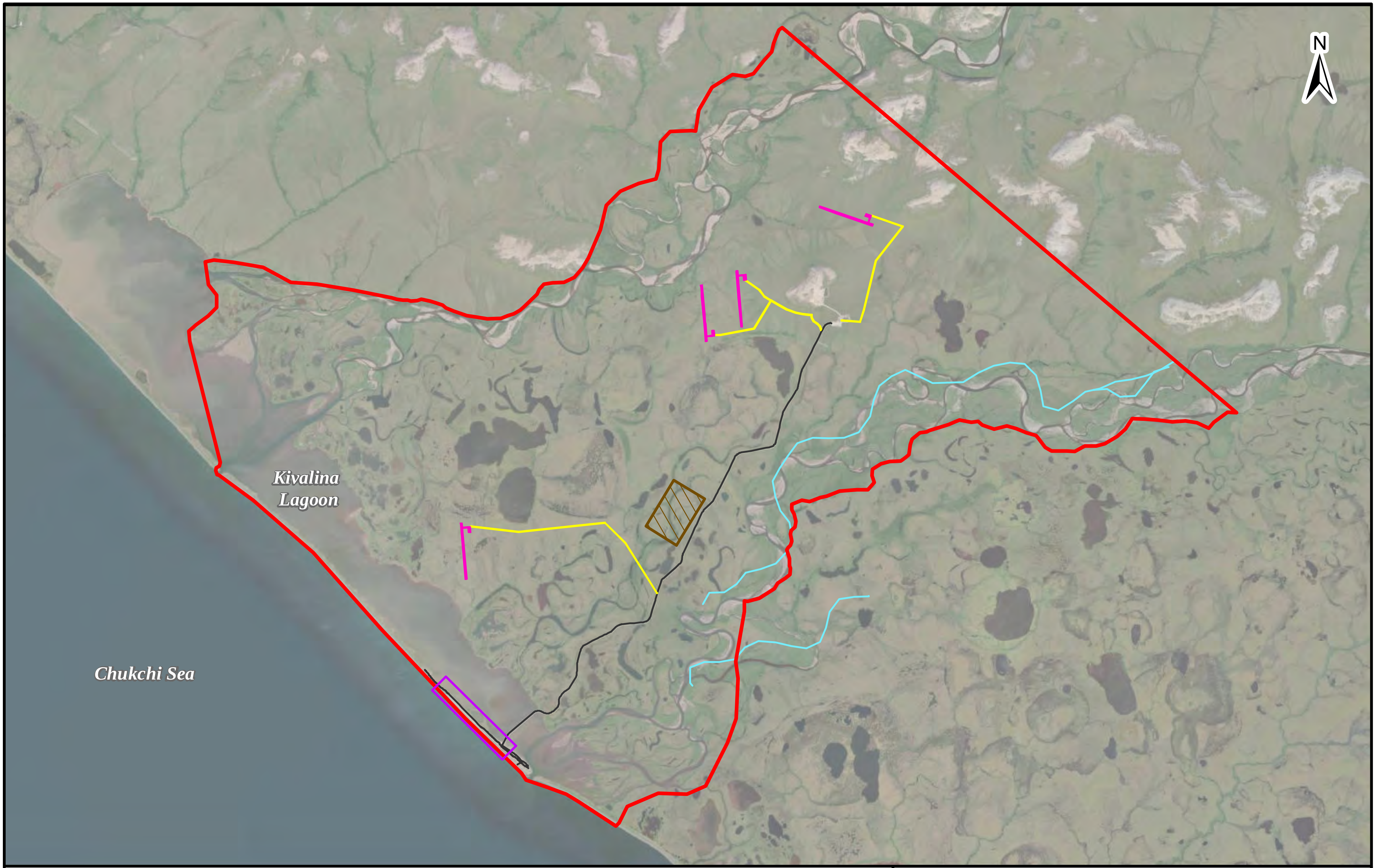
Figure 2-6: Use Areas for: Furbearers



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3. Magdanz et al. 2010 (GIS from ADF&G)

- Study Area Boundary
- Airport Boundary
- Alternatives
- Alternatives (roads)
- Landfill Alternative
- Road
- Salmon

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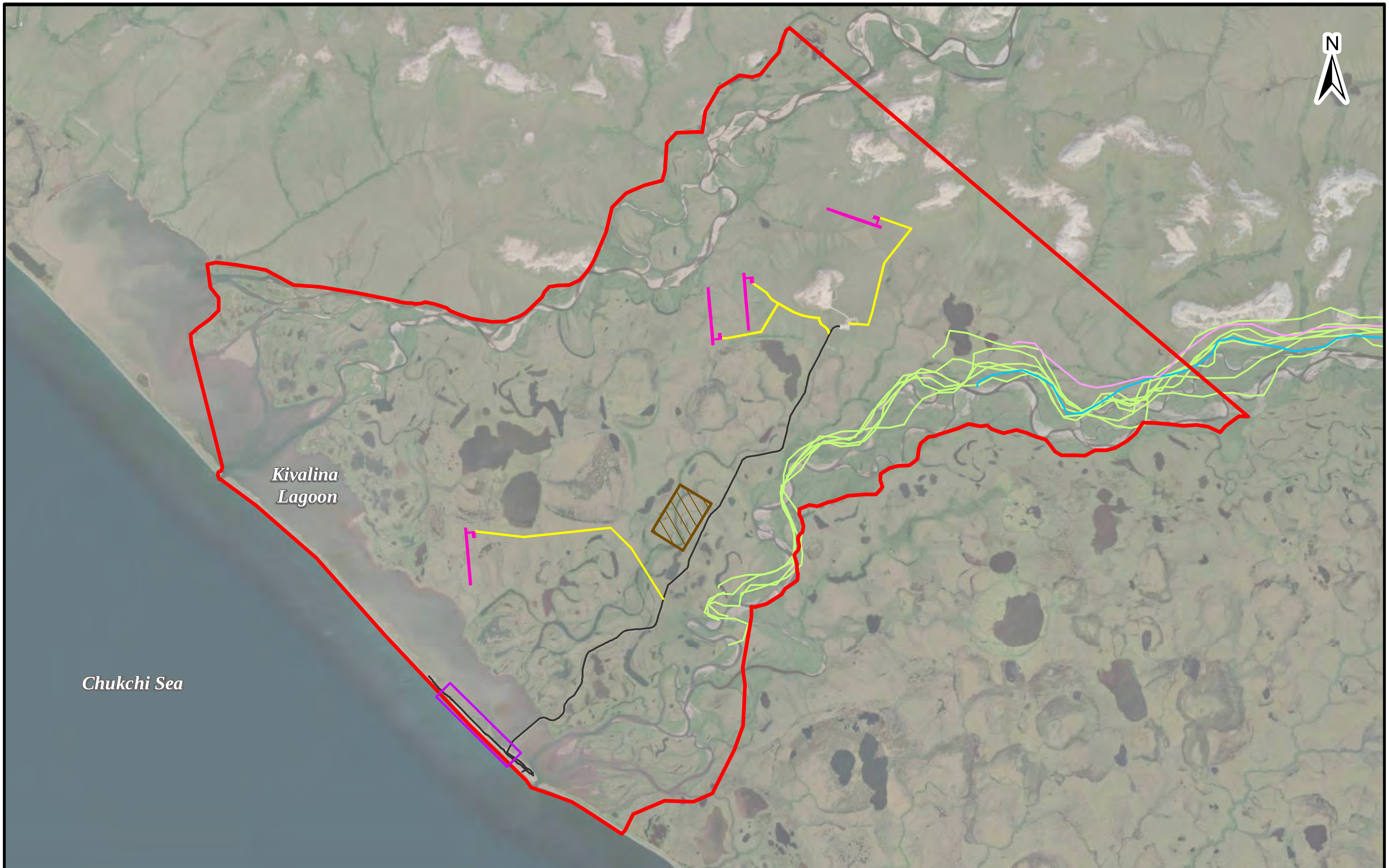
Figure 2-7: Use Areas for: Salmon



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3. Magdanz et al. 2010 (GIS from ADF&G)

Study Area Boundary
Airport Boundary
Alternatives
Alternatives (roads)
Proposed Landfill
Road
Arctic Grayling
Trout
Whitefish

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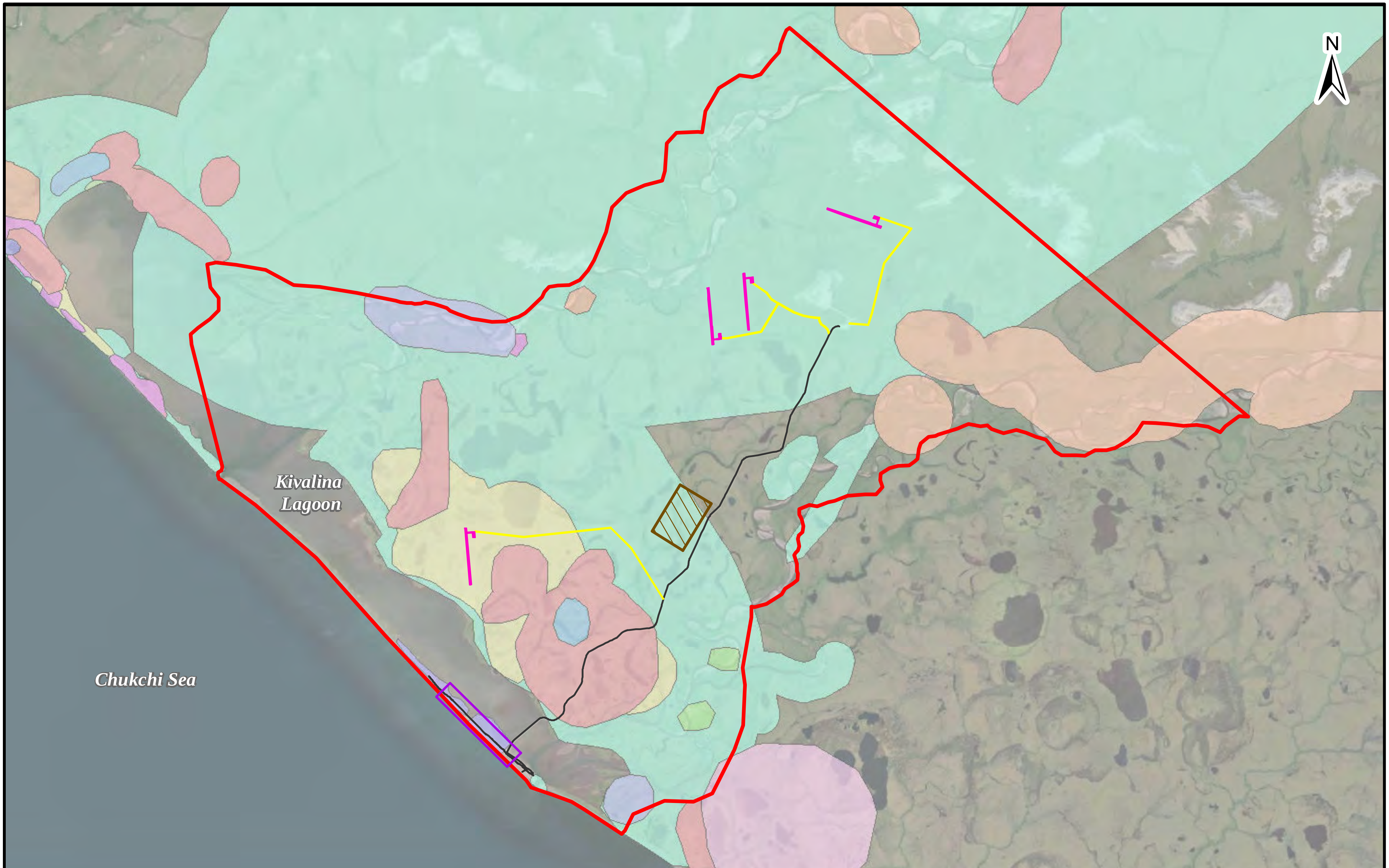
Figure 2-8: Use Areas for: Non-Salmon Fish



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Study Area Boundary
Airport Boundary
Proposed Landfill
Alternatives
Alternatives (roads)
Road
Berries and Plants
Blackberry
Blueberry
Crowberry
Plants
Salmonberry
Sourdock
Wild Celery
Wild Onion
Wild Potato
Wormwood

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Figure 2-9: Use Areas for: Berries/Plants

A project by the NAB (Satterthwaite-Phillips et al., 2016) also mapped subsistence harvest areas, but locations of high enough resolution to inform alternative analysis are not available. In addition, older, historic, subsistence use area mapping is available in Braund (2009) but was not used in this effort due to the newer Magdanz et al. (2010) data being available.

2.3 Environmental

2.3.1 Noise

Aircraft approach and depart directly over the community of Kivalina. This subjects the community to increased airplane noise. Moving the airport away from the current location would decrease noise impacts to the community.

In many rural Alaskan communities, aircraft noise is not seen as a negative impact, but a welcome reminder of the connection to the larger hub communities and infrastructure.

2.3.2 Water Resources

Water resources include the Kivalina Lagoon, the Wulik River, the Kivalina River, and the Chukchi Sea and are discussed below.

Kivalina Lagoon. Kivalina Lagoon is a shallow body of water approximately 10 miles long that ranges in width from 3,000 feet (ft) near the mouth of the Wulik River to 8,000 ft north of the Kivalina River. The lagoon is fed by the Kivalina River at its northern end, and the Wulik River at the southern end, and also by tidal flows from the Chukchi Sea. Tidal flow is through two inlets that define the Kivalina island: Singuak entrance, on the southeastern side of the community of Kivalina, and Kivalik Inlet, approximately 5.5 miles to the northwest. The Kivalik and Singauk Inlets handle the majority of tidal and river ebb flows. Large areas of the lagoon, especially on the northeastern side, are only 1 to 3 ft deep, although deeper sections and channels, as deep as 10.4 ft, were measured (USACE, 2016). The lagoon's northeast shoreline is dominated by the deltas of the Kivalina and Wulik Rivers, and sediment transport along the Chukchi Sea occasionally blocks the Singauk or Kivalik Inlets. This blockage elevates the water level in the lagoon until it passes over the opening and a new channel is formed as the flow head cuts through the sand deposits (USACE, 2016).

In 2021, DOT&PF completed construction of the Kivalina Evacuation and School Site Access Road Project (ADOT&PF, 2023a). One component of the project constructed a lagoon-crossing causeway between the Kivalina barrier island and the mainland east of Kivalina Lagoon. The lagoon crossing has enabled Kivalina residents to drive highway and other vehicles to the mainland year-round to access the site of a new community school, as well as subsistence resource areas that had traditionally only been accessible by boat during summer months or snowmachine or dog sleds during winter months.

Wulik River. The Wulik River is approximately 80 miles long and originates in the De Long Mountains. It has an annual average discharge of 1,603 cubic feet per second (cfs); with large seasonal variation in surface water flow ranging from a monthly average discharge of 136 cfs in November to 3,175 cfs in June (USEPA, 2009). Based on flow data from a U.S. Geological Survey (USGS) streamflow gauge, the 100-year flow event was calculated to be 55,000 cfs (USACE, 2016).

The Wulik River estuary (confluence of the Wulik River with the Kivalina Lagoon) is located immediately east of Kivalina. The estuary is characterized by a series of small, low gradient tributary channels across the Wulik River floodplain.

Kivalina River. The Kivalina River is approximately 60 miles long and originates in the De Long Mountains. It is neither gauged, nor has any hydrologic analysis been performed to estimate peak flows. However, previous studies in the area (USACE, 2016) assumed that this river follows the same general flow pattern as the Wulik River. Based on area ratio and similarities to the Wulik River in its watershed and river slope, the U.S. Army Corps of Engineers (USACE) estimates that the Kivalina River could produce approximately 75% of the discharge of the Wulik River, resulting in an estimated 100-year flow of 41,250 cfs (USACE, 2016).

2.3.2.1 Water Quality.

No water quality issues are anticipated to impact the selection of an airport alternative.

2.3.2.2 Wild & Scenic Rivers

There are no Wild and Scenic Rivers in the vicinity of Kivalina.

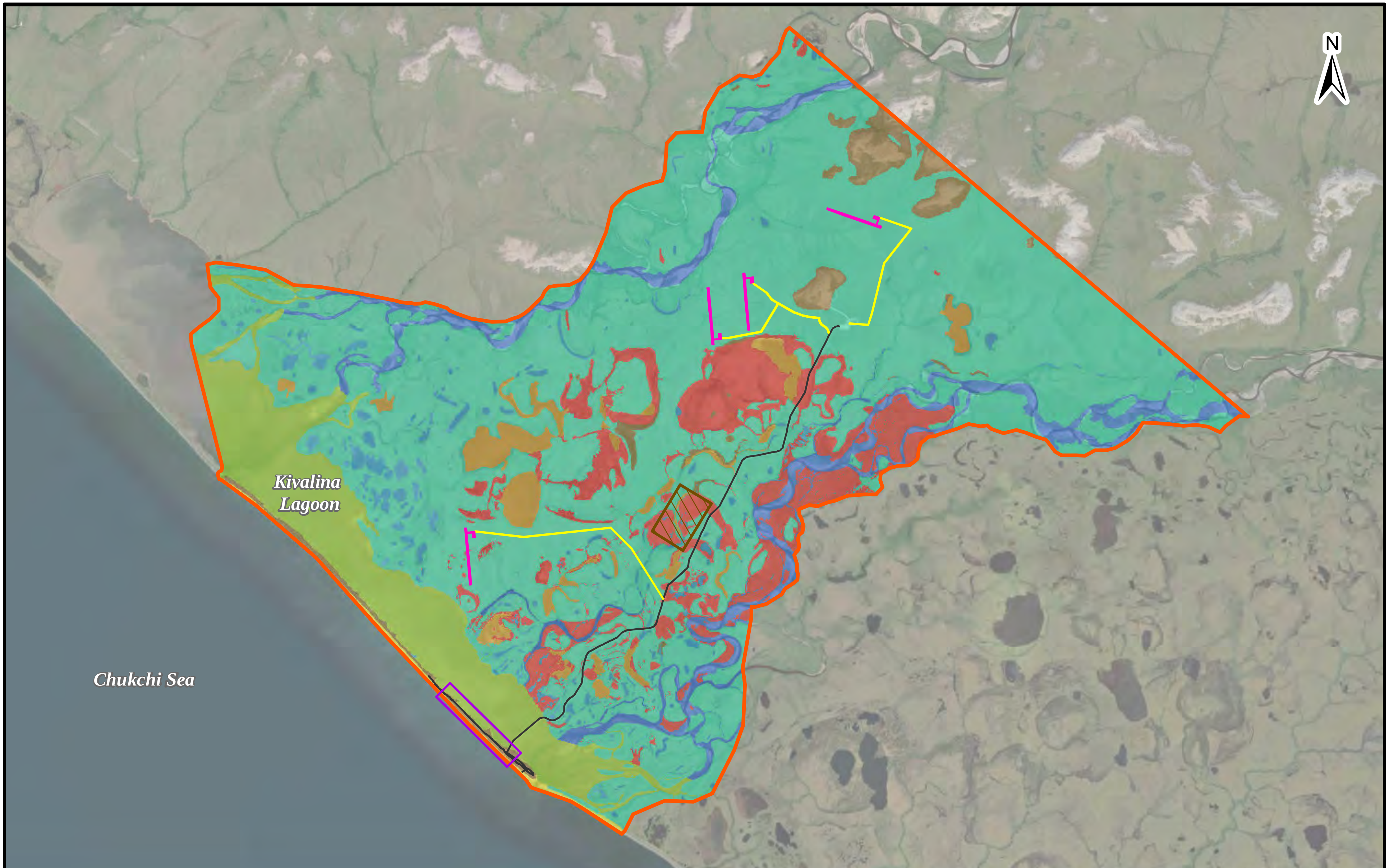
2.3.3 Wetlands

The Kivalina Airport is located on a barrier island between the Chukchi Sea and Kivalina Lagoon. The DOT&PF Kivalina Evacuation and School Site Access Road Project (ADOT&PF, 2023b) mapped the wetlands the area of analysis (Table 2-2, Figure 2-10). This effort updated previous National Wetland Inventory mapping. This wetland mapping was used to estimate the wetland impacts for proposed alternatives.

Table 2-2 Wetland Acreage

Habitat	Acres	% of Area of Analysis
Estuarine	3,821.98	10%
Lake	1,164.26	3%
Marine	182.82	0%
Palustrine (Wetland) Flooded	3,540.12	10%
Palustrine (Wetland) Saturated & Seasonally Flooded	23,894.01	65%
Pond	949.54	3%
Riverine	2,292.22	6%
Upland	1,071.48	3%
Total	36,916.43	100%

Key:
% – percent



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Notes:
1. Coordinate System: NAD 1983 2011 StatePlane Alaska 8 FIPS 5008 Feet
2. Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Study Area Boundary
Airport Boundary
Alternatives
Alternatives (roads)
Proposed Landfill
Road

Wetlands
Estuarine
Lake
Marine
Palustrine Flooded
Palustrine Saturated & Seasonally Flooded
Pond
Riverine
Upland

KIVALINA AIRPORT RELOCATION FEASIBILITY STUDY

STATE OF ALASKA
Department of Transportation and Public Facilities
2301 Peger Road Fairbanks, AK 99709

April 2024

Figure 2-10: Wetlands

2.3.4 Endangered Species Act

The area of analysis is within critical habitat for Endangered Species Act (ESA) listed threatened polar bears (*Ursus maritimus*). Polar bear critical habitat is along the coasts; and moving the airport inland would lessen the potential impact to polar bears (Figure 2-11).

The area of analysis also includes the potential range (but not within listed critical habitats) of ESA-listed threatened Spectacled eider (*Somaterial fischeri*) and threatened Steller's eider (*Polysticta stelleri*). The species have the potential to stage or nest anywhere along the region. The Kivalina lagoon is recognized as an important habitat for feeding, resting, and breeding of these species.

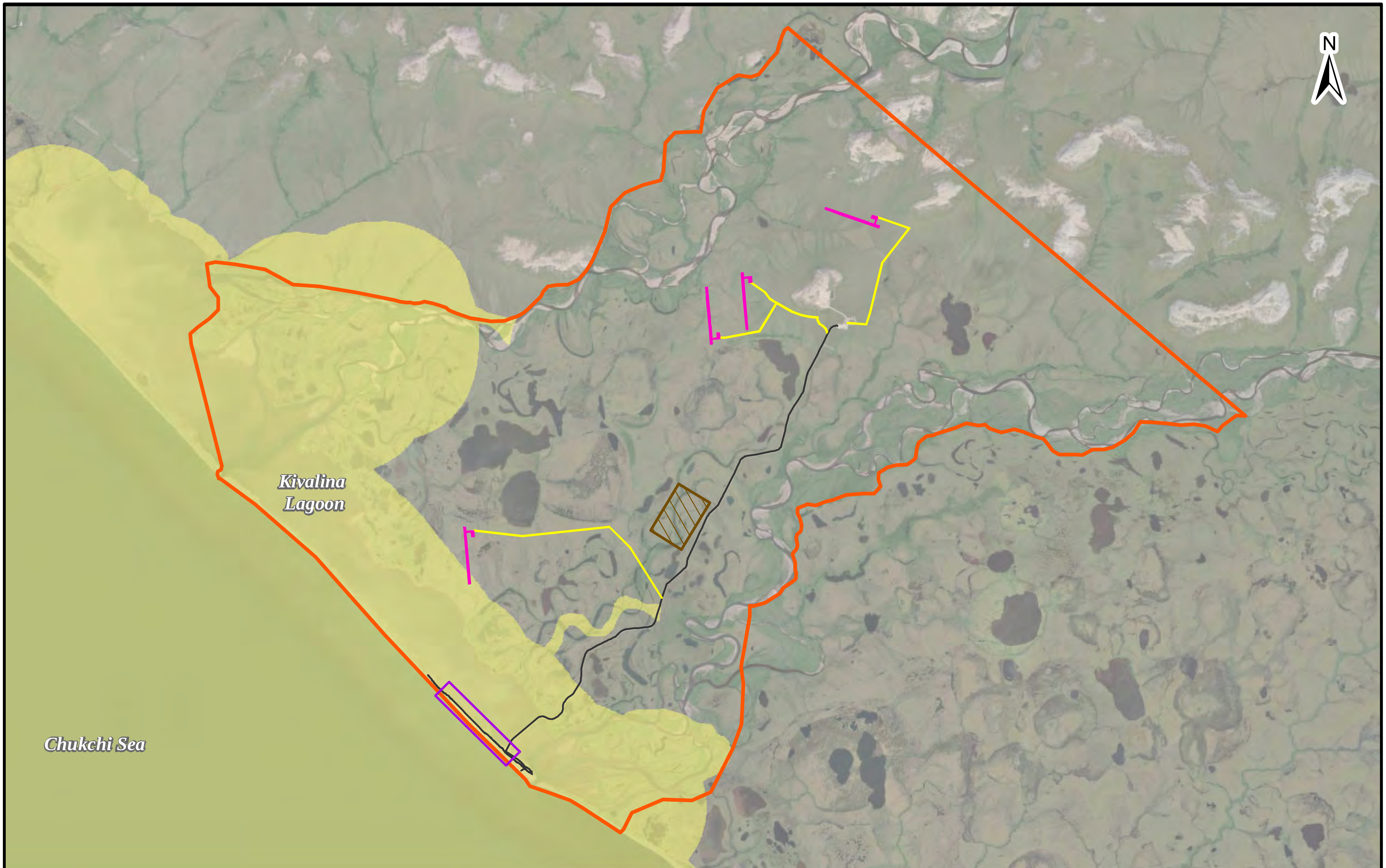
2.3.5 Terrestrial or Marine Wildlife

No reports are available of large terrestrial or marine wildlife regularly occurring on the currently developed portions of the Kivalina barrier island. Several seal species use portions of Kivalina Lagoon during the year for feeding on fish migrating to and from the Wulik and Kivalina Rivers. Seals and other marine mammals may also haul out to rest along the Chukchi Sea shoreline, though discussions with residents indicate the Kivalina Airport shoreline is not a regular haul out location for marine mammals.

Terrestrial wildlife (e.g., caribou, muskox, bears, moose, and wolves) have the potential to occur throughout the area.

2.3.6 Fish

The waters around Kivalina host a wide variety of fish species. The Chukchi Sea, Kivalina Lagoon, and the Wulik and Kivalina Rivers are all important habitats for marine, anadromous, and freshwater fishes. The Kivalina River (Anadromous Waters Catalog [AWC] Stream No. 331-00-10044) and the Wulik River (AWC Stream No. 331-00-10060) are both listed as important for the spawning, rearing, and migration of anadromous fish, including all five species of Pacific salmon and Dolly Varden, with the Wulik River additionally important for whitefishes (ADF&G, 2023a). The Kivalina Lagoon is documented to provide habitat for anadromous fish, Pacific salmon, and several demersal species, and is also listed in the AWC as Stream No. 331-00-10060-0010 (ADF&G, 2023a). As Kivalina Lagoon, the Wulik River, and the Kivalina River are listed watercourses in the AWC, they are considered Essential Fish Habitat (EFH) under the Federal Management Plan for Pacific Salmon in the Economic Exclusion Zone off the Coast of Alaska (NMFS, 2005).



0 1 2 Miles

1:110,000 (At original document size)

Notes:
1. Coordinate System: NAD 1983 2011 StatePlane Alaska 8 FIPS 5008 Feet
2. Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- Study Area Boundary
- Airport Boundary
- Proposed Landfill
- Alternatives
- Alternatives (roads)
- Road
- Polar Bear Critical Habitat

KIVALINA AIRPORT RELOCATION FEASIBILITY STUDY

STATE OF ALASKA
Department of Transportation and Public Facilities
2301 Peger Road Fairbanks, AK 99709

April 2024

Figure 2-11: Endangered Species Act

2.3.7 Birds

The area of analysis can host large numbers of a wide variety migratory bird species, particularly waterfowl and shorebirds, during the spring, summer, and fall migration periods. Many species of various ducks, geese, and loons, as well as sandhill cranes, are attracted to the Kivalina lagoon habitats and nearshore areas for feeding, resting, and breeding. These bird aggregations have the potential to create conditions for bird-strike flight hazards for aircraft operations at KVL.

2.3.8 Cultural Resources

The primary cultural resource overlying both the existing Airport and potential relocation sites on the mainland is the Cape Krusenstern Archaeological District National Historic Landmark (CKNHL). Properties designated as National Historic Landmarks are automatically listed in the National Register of Historic Places (NRHP) Code of Federal Regulations (CFR) 36.65.2. Archaeological investigations associated with construction of the Kivalina Evacuation and School Site Access Road were conducted in 2016 and 2017. These investigations did not result in identification of elements which contribute to continued understanding of Arctic prehistory and history within the CKNHL (ADOT&PF, 2023b).

On a more visible and local level, the Kivalina cemetery, a cataloged cultural resource area, is located adjacent to the existing runway. Additionally, as Kivalina Island has been occupied by Inupiat and other previous cultures for millennia, incidental discoveries of cultural resources occasionally occur in the vicinity of the existing airport, particularly during maintenance or repair construction work.

Regardless the proposed relocation alternative for a new Kivalina Airport, a dedicated cultural resource survey would be required to identify any previously unknown sites or resources.

2.3.9 Contaminated Sites

The Alaska Department of Environmental Conservation (ADEC) contaminated sites atlas reports a contaminated site in cleanup complete status adjacent to the existing Kivalina Airport: AKARNG Kivalina FSA (ADEC, 2023). No other hazardous materials are known that would influence airport alternative analysis.

2.3.10 Passenger Convenience

Passenger convenience is greatly increased for an airport located near the community. Kivalina is directly adjacent to the current Kivalina Airport. This proximity is important, because most residents arrive at

KVL by walking, or in open-air, off-road vehicles. There is no passenger shelter at the airport; during inclement weather, residents listen for the aircraft prior to travelling to KVL.

With the community relocation, passenger convenience is complicated. Some residents have expressed that they wish to move to K-Hill, and others have expressed they wish to remain at Kivalina's current location. For residents that move the K-Hill, an airport located near K-Hill would be more convenient than the current airport. For residents that remain at Kivalina, the current airport location will be more convenient.

Flights arrive at unexpected times, and residents at K-Hill or Kivalina would value the close proximity of the airport to be able to adapt to flight schedules.

KVL is also a center for a large quantity of freight and mail. These are unloaded onto the apron, often by local residents, who transport the freight and mail directly to their homes. A distant airport is less convenient to residents living distant from the airport.

2.4 Constructability

2.4.1 Geology

WSP USA Inc. (2023, in Appendix 4) drafted a map and review of the available geotechnical information in the study area (Table 2-3, Figure 2-12). This categorized the terrain into ranks of suitability, with 1 being the most suitable and 5 being not suitable.

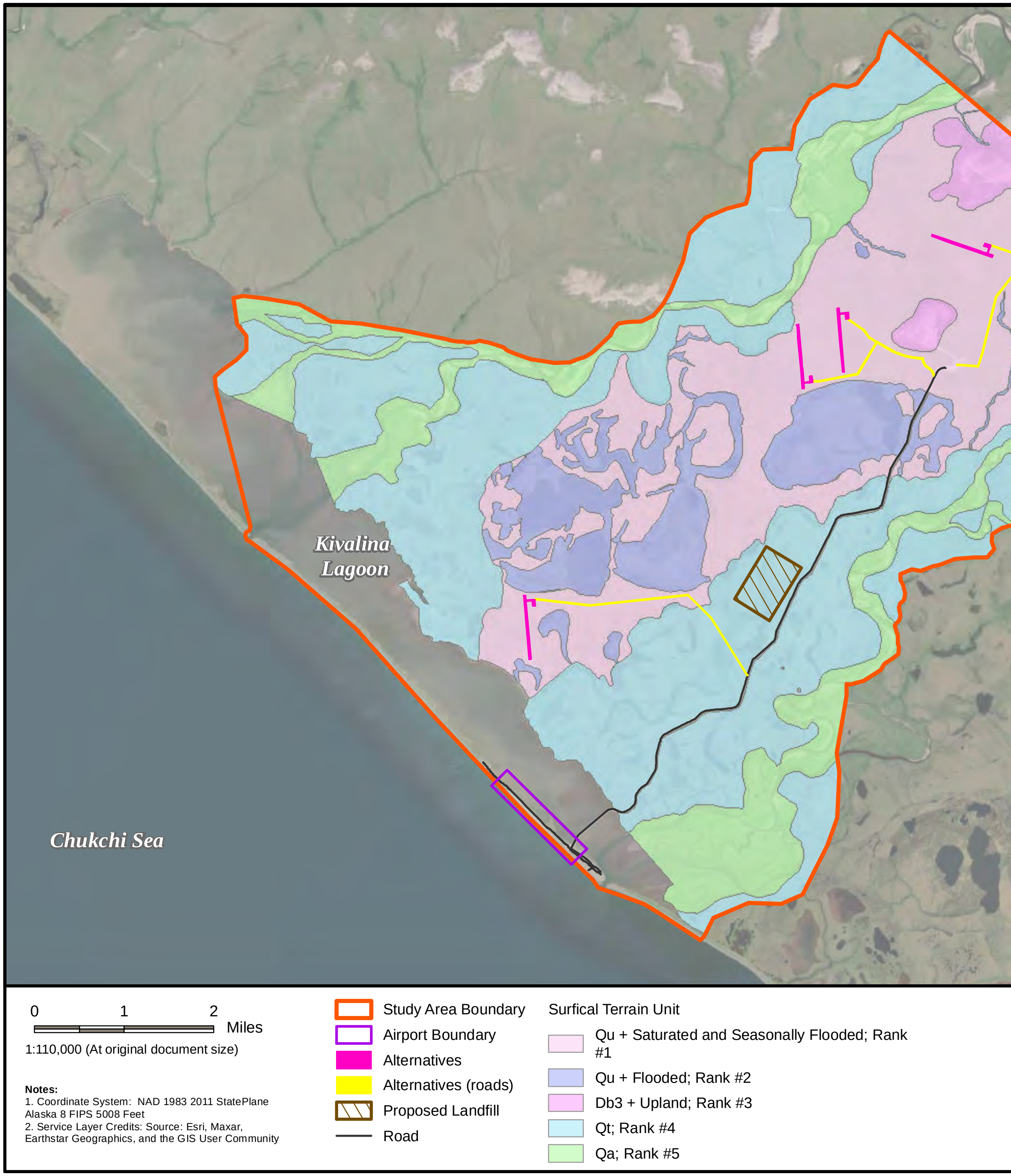
Table 2-3 Geotechnical Terrain

Terrain Unit Symbol	Terrain Unit Name	Description	Engineering Interpretations			
			Frost Heave Potential	Thaw Settlement Potential	Flood Potential	Rank
Qu + Saturated and Seasonally Flooded	(Quaternary) Undivided surficial deposits – saturated and seasonally flooded	Tundra and ice-rich material including lacustrine, alluvial, colluvial, and glacial deposits. Consists of clay, silt, sand, and gravel. Characterized as palustrine saturated and seasonally flooded.	High	High	Moderate	1
Qu + Flooded	(Quaternary) Undivided surficial deposits – flooded	Tundra and ice-rich material including lacustrine, alluvial, colluvial, and glacial deposits. Consists of clay, silt, sand, and gravel. Characterized as palustrine flooded.	High	High	High	2
Db3 + Upland	(Devonian) Exposed bedrock – upland	Light to dark gray massive to thick-bedded Devonian limestone and dolomite occurring in low rubble-covered hills. Vegetation, where present, consists of relatively drier soils and larger shrubs.	Low	Low	Low	3
Qt	(Quaternary) Terrace deposits	Inactive alluvial deposits. Consists of silt, sand, and gravel at or above high-water stage, and covered with stable vegetation.	Moderate	Moderate to High	High	4
Qa	(Quaternary) Alluvial deposits	Active stream and riverbeds and low terraces. Consists of sorted and layered sand, gravelly sand, and sandy gravel with some silty layers. Sparsely vegetated.	Low (high if surface cover)	Low	High	5

2.4.2 Constructability

KVL provides the only year-round access to other communities and emergency health care infrastructure and plays a vital role in the daily life of the residents of Kivalina. Closure of the airport due to construction prevents residents from being able to access emergency medical services and delivery of food and medical supplies.

Consequently, air service must remain uninterrupted during construction. For alternatives located on, or adjacent to, the current runway, this may include partial runway closures, half-width runway operations, and reduced-length runway operations. The different elevations of partially-raised runways must be considered during design, as they may prevent safe runway operations (aircraft cannot land immediately adjacent to a large topographic change in the runway).



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April 2024	Figure 2-12: Geotechnical

2.4.3 Solid Waste Disposal Sites

The current community solid waste facility is located approximately 1,800 feet from the runway, directly in the path of approaching/departing aircraft. A new landfill is being constructed onshore, alongside the access road, halfway to K-Hill.

Airports are recommended to have 5,000 feet separation from a solid waste facility, to reduce flight hazards. For example, pilots report that the current landfill creates bird hazards at the current airstrip location. All onshore alternatives were selected to be greater than 5,000 feet from the proposed solid waste facility.

2.5 Materials

2.5.1 Material Source

Material source(s) are one of the primary cost drivers of construction. During the development of the evacuation road, K-Hill was confirmed as a suitable source of material. This is anticipated to be the material source for improvements.

2.6 Utilities

KVL requires power to operate the runway lights. The airport also utilizes local telecommunications to provide weather reporting and other information. Both of these utilities are based in Kivalina. The K-Hill school complex also has limited power, and telecommunications. The utilities at K-Hill are likely to require improvement to support an airport. These utilities may improve as the community expands at that location.

2.7 Cost Summary

A planning level cost estimate was developed to estimate the cost to build each alternative. The primary driver of cost is the cubic yards of material required to build the infrastructure. The quantity of material required is directly related to the topographic elevation changes that must be leveled to develop a suitable airport, access road, and similar infrastructure. The cost for each cubic yard of material is estimated from costs used to develop K-Hill for the construction of the evacuation road (Table 2-4).

Table 2-4 Cost Assumptions

Local Material	Cost
Unclassified Excavation	$15/cy
Borrow	$30/cy
Subbase	$60/cy
Crushed Aggregate Surface Course	$70/ton

Key:
cy – cubic yard

Access roads are assumed to be 24 feet top width, with 4 to 6 feet for ditches, for a total of an 80-foot-wide disturbance footprint.

Extensions of the existing revetment was estimated at $5,300 per linear foot, a cost estimate provided by DOT&PF from similar projects in rural Alaska.

A 25% design contingency was added for each estimate.

The estimates do not include 7% Indirect Cost Allocation Plan or 15% for Construction Engineering.

Land cost is unknown, but is estimated to cost $1,500/acre.

2.8 Public Opinion

Public opinion is an important element to infrastructure planning. Alternatives will be presented to the community, and input will be incorporated into the design.

3 ALTERNATIVES

Five alternatives were evaluated in addition to the No Action alternative (Figures 3-1, 3-2, 3-3). Typical cross-sections for the new alternative are listed in Figure 3-4.

Alternative 1 – Improve. This is maintaining the Airport in the current location while improving it to meet standards.

Alternative 2 – Nearshore. This is shifting the airport onto the mainland, but in relatively close proximity to the current community of Kivalina. This runway was sited to avoid the lakes in the area. This alternative includes raising the surface elevation to +16 feet to avoid nearshore flooding or high-water ocean flooding.

Alternative 3 – K-Hill (Farther). This is moving the airport to the vicinity of the relocated community at K-Hill. This alternative is located Southwest of K-Hill and is relatively more distant from K-Hill than Alternative 4. This provides space for the community to develop around K-Hill.

Alternative 4 – K-Hill (Near). This is moving the airport near Alternative 3, but closer to K-Hill. This location takes advantage of some elevated terrain.

Alternative 5 – N K-Hill. This is moving the Airport north of K-Hill.

Table 3-1 summarizes each alternative against the evaluation criteria. Costs are detailed in Appendix 5.

3.1 No Action

The No Action alternative is included as a comparison for the other alternatives.

The No Action alternative does not protect the taxiway and apron from storm surge, as the revetment will require maintenance.

The No Action alternative does not provide crosswind coverage.

0 1 2 Miles

1:110,000 (At original document size)

Notes:
1. Coordinate System: NAD 1983 2011 StatePlane Alaska 8 FIPS 5008 Feet
2. Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- Study Area Boundary
- Alternatives
- Alternatives (roads)
- Airport Boundary
- Proposed Landfill
- Planned Community at K-Hill
- Road

KIVALINA AIRPORT RELOCATION FEASIBILITY STUDY

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Figure 3-1: Alternatives

0 0.4 0.8 Miles

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Notes:
1. Coordinate System: NAD 1983 2011 StatePlane Alaska 8 FIPS 5008 Feet
2. Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- Study Area Boundary
- Airport Boundary
- Airport Boundary
- Alternatives
- Proposed Landfill
- Road

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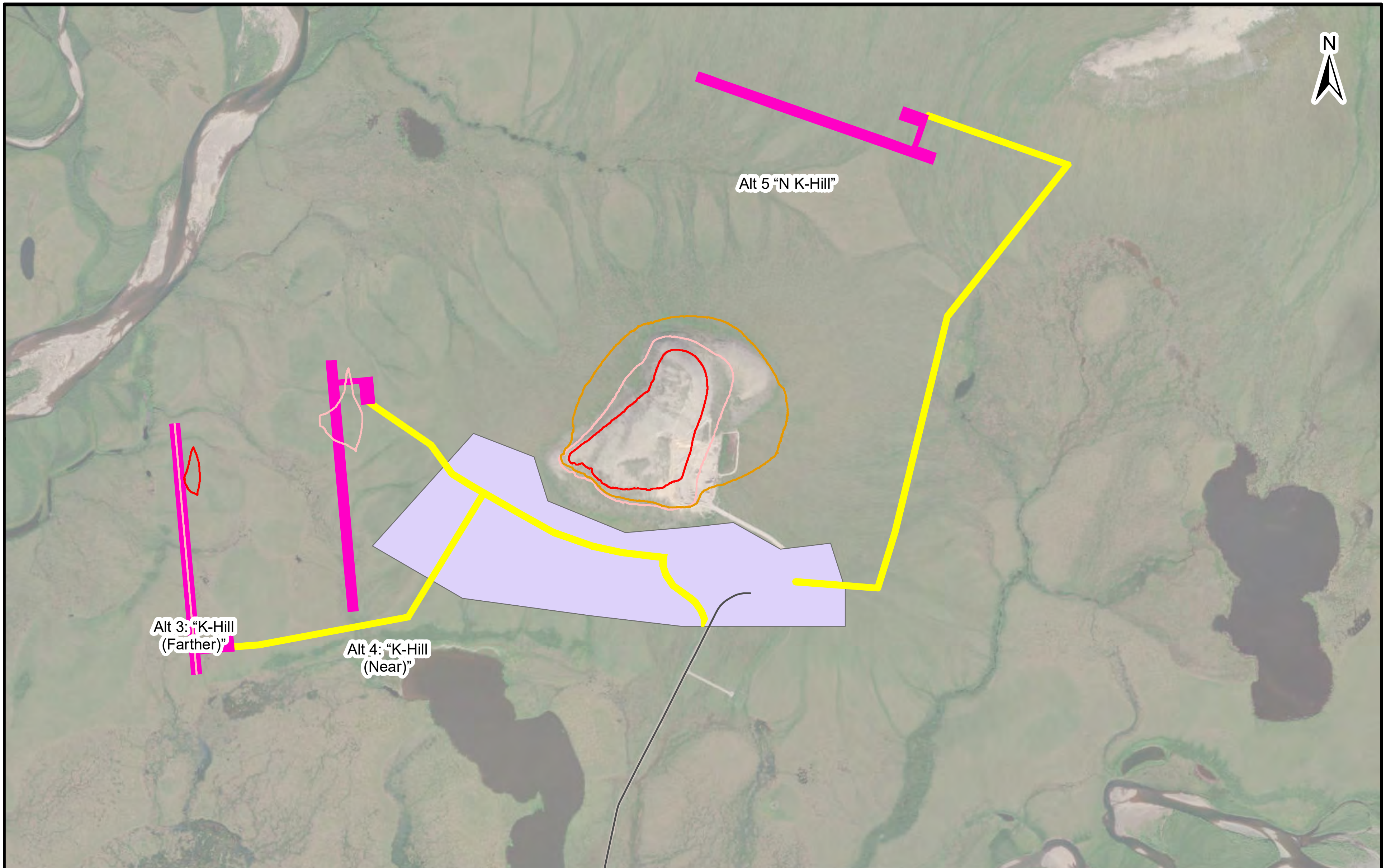
Figure 3-2: Nearshore Alternatives



0 0.2 0.4 Miles

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Notes:
1. Coordinate System: NAD 1983 2011 StatePlane Alaska 8 FIPS 5008 Feet
2. Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
3. Alternatives (roads) are aligned with communities

Study Area Boundary
Alternatives
Alternatives (roads)
Planned Community at K-Hill
Road

Pentrations to Part 77 Airspace
K-Hill (Near)
K-Hill (Far)
N K-Hill

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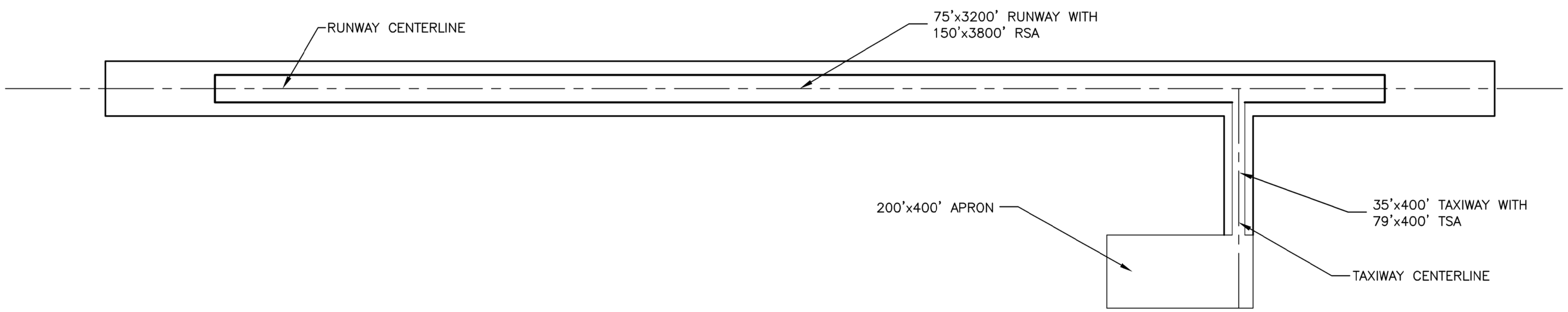
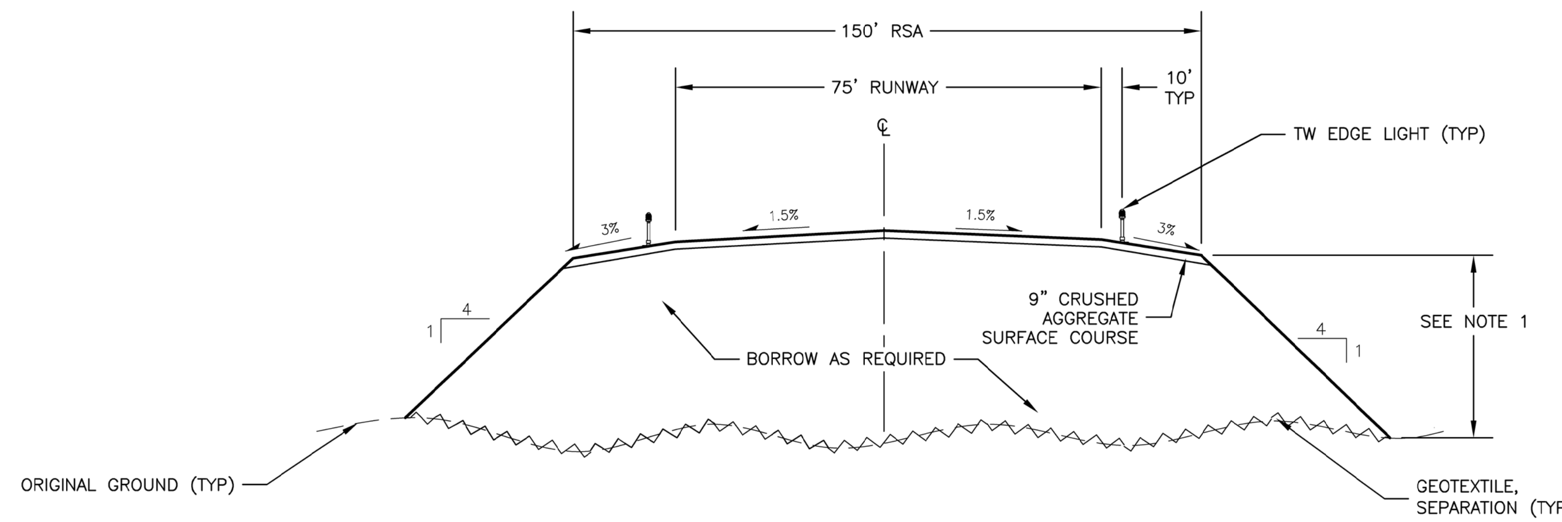
April 2024

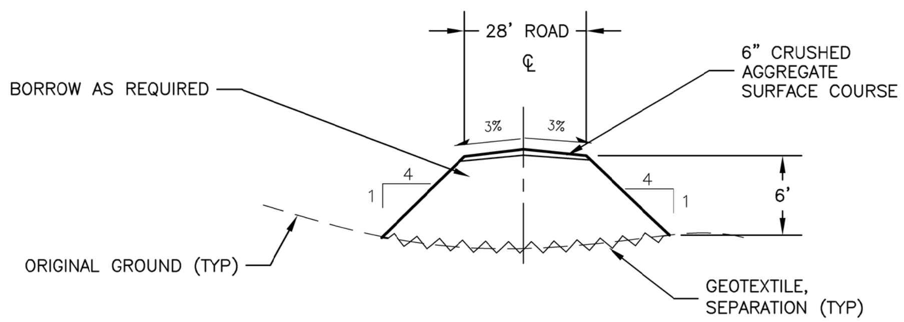
Figure 3-3: K-Hill Alternatives



1 KIVALINA AIRPORT ALTERNATIVES – AIRPORT PLAN

SCALE: NTS





2 RUNWAY SECTION

SCALE: NTS

NOTES:

1. 8' MIN. EMBANKMENT DEPTH FOR NEARSHORE ALTERNATIVE. 4' MIN EMBANKMENT DEPTH FOR OTHER, HIGHER ELEVATION ALTERNATIVES.

3 ROAD SECTION

SCALE: NTS

Figure 3-4; Alternative Typical

Table 3-1 Alternative Evaluation

Evaluation Factor	No Action	1: Improve	2: Nearshore	3: K-Hill (Farther)	4: K-Hill (Near)	5: N K-Hill
Safety and Airport Resiliency						
Storm Surge and Flood?	Partially Protected	Protected	Protected	Protected	Protected	Protected
Hydrology: In River Floodplain?	No	No	No	No	No	No
Fog and Low Visibility	Coastal (Worse)	Coastal (Worse)	Coastal (Worse)	Inland (Better)	Inland (Better)	Inland (Better)
Wind Coverage	85.9%	85.9%	85 – 86.6%	Unknown	Unknown	Unknown
Penetrations to Part 77 Airspace	Yes	Yes	No	Yes	Yes	Yes
Runway Incursion Risk	Higher	Higher	Lower	Lower	Higher	Lower
Land Status						
Land Ownership	DOT&PF	DOT&PF	NANA	NANA	NANA	NANA
Parks, Refuges and Recreational Areas	Cemetery	Cemetery	None	None	None	None
Likelihood of Acquisition	N/A	N/A	Uncertain	Uncertain	Uncertain	Uncertain
Subsistence Resources	Marine Mammals, Furbearers	Marine Mammals, Furbearers	Caribou, Furbearers, Berries/Plants	Caribou, Furbearers, Berries/Plants	Caribou, Furbearers, Berries/Plants	Caribou, Furbearers, Berries/Plants
Environmental						
Noise (Impacts to Residents)	Medium	Medium	Low	Low	Medium	Low
Water Resources	None	None	None	None	None	None
Wetland Fill	None	None	47.2 acres	34.6 acres	29.0 acres	38.3 acres
Endangered Species	Polar Bear Habitat	Polar Bear Habitat	Polar Bear Habitat	None	None	None
Terrestrial Mammals	Minimal	Minimal	Potential Habitat	Potential Habitat	Potential Habitat	Potential Habitat
Marine Mammals (excluding Polar Bear)	Haul out Habitat	Haul out Habitat	Minimal	None	None	None
Fish	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant
Birds	High	High	High	Lower	Lower	Lower
Cultural Resources	None	Potential (Cemetery)	Unknown	Unknown	Unknown	Unknown

Evaluation Factor	No Action	1: Improve	2: Nearshore	3: K-Hill (Farther)	4: K-Hill (Near)	5: N K-Hill
Contaminated Sites	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant
Passenger Convenience to Kivalina	High	High	Medium	Low	Low	Low
Passenger Convenience to K-Hill	Low	Low	Low	High	High	Medium
Distance to Kivalina (Travel)	0 miles	0 miles	6 miles	7.5 miles	7 miles	9 miles
Distance to K-Hill (Travel)	7 miles	7 miles	7 miles	0.5 miles	.25 miles	2 miles
Constructability						
Geology	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible
Constructability	Feasible	Challenge	Feasible	Feasible	Feasible	Feasible
Distance to old Solid Waste	3,560 feet	3,560 feet	3,260 feet	>30,000 feet	>30,000 feet	>30,000 feet
Distance to new Solid Waste	17,000 feet	17,000 feet	12,000 feet	9,500 feet	11,000 feet	20,000 feet
Materials						
Material Source Distance (Local)	N/A	7 miles	7 miles	1.5 miles	1 mile	1 mile
Cost	$0	$3,257,722	$16,522,992	$14,560,031	$12,533,732	$15,652,735
Utilities						
Utilities (Cost)	$0	$0	$600,000	$500,000	$500,000	$900,000
Cost Summary						
Land Acquisition	$0	$0	$70,800	$51,900	$43,500	$57,450
Materials	$0	$3,257,722	$16,522,992	$14,560,031	$12,533,732	$15,652,735
Utilities	$0	$0	$600,000	$500,000	$500,000	$900,000
Erosion Protection	$0	$5,300,000	$0	$0	$0	$0
Construction	$0	$9,044,639	$23,866,190	$16,990,464	$16,473,797	$17,684,121
Construction Cost	**$0**	**$17,602,361**	**$ 41,059,982**	**$ 32,102,395**	**$ 29,551,029**	**$ 34,294,306**
Erosion Maintenance	$0	$9,275,000	$0	$0	$0	$0
Total Cost	**$0**	**$26,877,361**	**$ 41,059,982**	**$ 32,102,395**	**$ 29,551,029**	**$ 34,294,306**
Public Opinion	TBD	TBD	TBD	TBD	TBD	TBD

Key:
% – percent
cy – cubic yard
DOT&PF – Alaska Department of Transportation and Public Facilities
TBD – to be provided
N/A – not applicable

3.2 Alternative 1 "Improve"

Alternative 1 "Improve" is to improve the current runway to meet FAA standards. These improvements include:

- Runway widened to 100' and Runway Safety Area to 150' to assist with crosswind coverage
- New crushed aggregate surface for runway, taxiway and apron
- New airport lighting
- 1,000' of new revetment for taxiway and apron
- Reconstruction of snow removal equipment building

The current Kivalina Community Relocation Plan's vision is to maintain infrastructure at both Kivalina and K-Hill. This is primarily driven by the continued required barge delivery of supplies and fuel at Kivalina. Some community infrastructure, such as fuel tank storage and power generation, is anticipated to stay at Kivalina, even after the entire relocation effort is completed. Some residents have also indicated a desire to stay at Kivalina.

3.2.1 Safety and Airport Resiliency

The airport would remain on the sand spit that hosts the current community of Kivalina. Flooding and erosion is being designed to be +16 feet; which is modeled to withstand a 100-year storm to a design life of 2060. Storms, flooding, or erosion after 2060 (or greater than modeled conditions), would still threaten the airport.

The existing runway rock revetment will need continual maintenance to prevent erosion. Maintenance cost is difficult to estimate and was assumed to equal 500 feet of new revetment ($5,300/foot) every 10 years for 35 years.

A new rock revetment will be required to protect the taxiway and apron ($1,000 feet).

Coastal fog and low visibility has a larger impact on the coast than for the inland locations.

Wind coverage is 85.9%, and FAA standards require 95% wind coverage. Creation of a crosswind runway is not practical given the location of the current airport. Increasing the runway width to the next larger runway design category is included in this design.

Runway incursions are high for this alternative. The community and current solid waste facility are located on opposite ends of the runway, which encourages use in this area. Subsistence users also travel the route to harvest resources.

The taxiway is in a non-standard orientation and width. Re-construction in a non-standard orientation would be required because it is cost prohibitive to relocate the taxiway.

The Snow Removal Equipment Building was built in 1994. Given the age of the structure, it will need to be part of the next airport reconstruction.

3.2.2 Land Use

The land is owned by DOT&PF.

The airport is directly adjacent to the cemetery. The cemetery is a cultural resource. While it has not been individually listed as an eligible property, the Cape Krusenstern Archaeological District covers the area and is a National Historic Landmark. As a result, the cemetery is likely a 4(f) property. A cultural resource study should be completed to ensure viability of this option. Initial reconnaissance estimates that the widening of the runway may avoid the cemetery, but improvements to the taxiway may not.

Subsistence resources used in the area include marine mammals and furbearers.

3.2.3 Environmental

This alternative has the following environmental obstacles:

- Noise impacts to local residents from aviation operations.
- The area is mapped as polar bear critical habitat. Improvements require permitting through the U.S. Fish and Wildlife Service. The Kivalina Lagoon is also recognized as high-quality habitat for threatened Spectacled eider and threatened Steller’s eider.

- The Kivalina Lagoon is a congregation area for birds. Infrastructure development and aviation operations could disturb birds. Additionally, bird hazards to aviation operations are elevated due to the high-quality habitat at the lagoon and close proximity of the current solid waste facility.
- Marine mammal haulout habitat along the ocean and lagoon shorelines.

Environmental benefits include:

- Reduced total footprint of disturbance.

Passenger convenience is high for residents living at Kivalina, and low for those at K-Hill.

3.2.4 Constructability

Constructability is a challenge for this alternative. Air service to the community cannot be shut down for extended periods of time since the airport is the community's connection to medical facilities and other essential services. More detailed design is required to evaluate feasible construction methods. Some alternatives include:

- Use of the long taxiway as a temporary runway.
- Long, gradual fills: Fills could happen at night over the entire length of the runway, and have compaction and grading completed well enough to allow aircraft operations to occur during the day.
- Shut down the runway: The contractor could have set periods of time to close the airport and do sequential lifts of the runway. These can be alternated with periods of the airport being open, during which the contractor can create the material needed for the next lift.

The alternative is also less than 5,000 feet from the existing solid waste facility. Pilots have complained about the existing solid waste site hosting avian hazards to flight. The facility is expected to be closed in the future, but the timeline for the closure is unknown.

The alternative is greater than 5,000 feet from the new proposed solid waste facility.

3.2.5 Materials

Materials would need to be hauled from K-Hill.

3.2.6 Utilities

Utilities would not need to be constructed for the airport.

3.2.7 Cost

The cost is estimated to be $17,602,361 in construction. Maintenance cost for the erosion control features is difficult to estimate but was assumed to be an additional $9,275,000; for a total facility cost of $26,877,361. This cost is the lowest construction cost, but the potential cost requirements to maintain the erosion protection increases the total facility costs.

3.3 Alternative 2 “Nearshore”

Alternative 2 “Nearshore” is in relatively close proximity to the current community of Kivalina but removed off of the sand spit island. It was sited to avoid local area lakes and ponds, while providing the best wind coverage for a single runway.

Alternatives 2, 3, 4, and 5 all share the same airport design, including:

- 3200' x 75' Runway, due to lack of crosswind coverage by a single runway in any configuration
- 3800' x 150' Runway Safety Area
- 400' long Taxiway
- 200' x 400' Apron
- Single Bay Snow Removal Equipment Building
- Runway and Taxiway Lighting
- Lighted Wind Cone
- Access Road to Existing Evacuation Road

3.3.1 Safety and Airport Resiliency

Flooding and erosion would be less of a concern at this alternative than the current airport. The airport would be built high enough to avoid floods.

Coastal fog and low visibility is likely a greater hazard for this alternative than the inland alternatives.

Wind data collected at the currently Kivalina airport is assumed to be applicable to this alternative. No single runway orientation can achieve 95% wind coverage; and the current alignment is expected to achieve between 85-86.6% wind coverage.

Runway incursions would likely be lower for this alternative. The runway would not be located near attractions or infrastructure that residents would visit regularly.

There are no identified penetration to Part 77 surfaces for this alternative.

3.3.2 Land Use

Land is owned by NANA and would require purchase.

There are no impacts to parks or recreational areas.

Subsistence resources used in the area include caribou, furbearers, and berries/plants.

3.3.3 Environmental

This alternative has the following environmental obstacles:

- The area is mapped as polar bear critical habitat. This would require permitting through the U.S. Fish and Wildlife Service.
- The Kivalina Lagoon is a congregation area for birds (including threatened Spectacled eider and threatened Steller's eider). Infrastructure development and aviation operations could disturb birds. Additionally, bird hazards to aviation operations are elevated due to the high-quality habitat at the lagoon and relatively close proximity of the current solid waste facility.

Environmental benefits include:

- Minimal impacts of aviation noise on residents.
- Avoidance of marine mammal habitat.

Other environmental considerations include cultural resources, which are unknown without additional field studies.

Passenger convenience is medium for residents living at Kivalina, and low for those at K-Hill.

3.3.4 Constructability

The geology and constructability is feasible for the project. All of the onshore alternatives have similar geotechnical considerations.

The alternative is less than 5,000 feet from the existing solid waste facility. Pilots have complained about the existing solid waste site hosting avian hazards to flight. The facility is expected to be closed in the future, but the timeline for the closure is unknown

All alternatives were selected to be greater than 5,000 feet from the new proposed solid waste facility.

3.3.5 Materials

Materials would need to be hauled from K-Hill

3.3.6 Utilities

Utilities would need to be constructed for the airport. Overhead powerlines run along the evacuation road and could likely be extended to the airport.

3.3.7 Cost

The cost is estimated to be $41,059,982. This estimate is high due to the relatively long access road, requiring a high quantity of materials. The cost to purchase the land is unknown.

3.4 Alternative 3 “K-Hill (Farther)”

Alternative 3 “K-Hill (Farther)” provides space for the community to develop around K-Hill and would provide separation of activities from the community and the airport. This location is slightly lower in elevation than Alternative 4 “K-Hill (Nearer)” and likely has slightly worse geotechnical conditions. It also provides almost direct access to the Kivalina River, which has the disadvantage of attracting non-aviation users.

3.4.1 Safety and Airport Resiliency

Coastal flooding and erosion would not be a concern at this alternative. The airport would be built outside of the Kivalina River floodplains.

Fog is less of a concern on the inland alternatives.

Wind coverage is less certain and is pending data from the wind tower.

Runway incursions are expected to be lower for this option because the runway does not lead to any desirable location.

Identified penetrations to Part 77 surfaces include K-Hill and an area directly adjacent to the airport.

3.4.2 Land Use

Land is owned by NANA and would require purchase.

There are no impacts to parks or recreational areas.

Subsistence resources used in the area include caribou, furbearers, and berries/plants.

3.4.3 Environmental

This alternative has the following environmental obstacles:

- The potential impacts to wildlife habitat for all the alternatives near K-Hill is moderate. Historically these areas were more isolated from human access. As K-Hill is developed, wildlife presence in the area is likely to change.

Environmental benefits include:

- No impacts to threatened and endangered species critical habitat.
- Avoidance of marine mammal habitat.
- The impacts to bird habitat is lower than the coastal alternatives, as is the potential bird hazards to aviation.

Other environmental considerations include cultural resources, which are unknown without additional field studies.

Passenger convenience is low for residents living at Kivalina, and high for those at K-Hill.

3.4.4 Constructability

The geology and constructability is feasible for the project.

The alternative is greater than 5,000 feet from the existing and proposed solid waste facility.

3.4.5 Materials

Materials would only need to be hauled from K-Hill.

3.4.6 Utilities

Utilities would need to be constructed for the airport from the developing K-Hill community.

3.4.7 Cost

The cost is estimated to be $32,102,395. This cost is moderate, because it takes advantage of the existing K-Hill infrastructure, but still requires a new runway and access road. The cost to purchase the land is unknown.

3.5 Alternative 4 “K-Hill (Near)”

Alternative 4 “K-Hill (Near)” takes advantage of elevated terrain, potentially with better geology and fewer wetlands. The disadvantage of putting the airport so close to the community is the potential restrictions on growth of the community, and the increased potential for runway incursions.

3.5.1 Safety and Airport Resiliency

Flooding and erosion would not be a concern at this alternative. The airport would be built outside of the floodplains.

Fog is less of a concern on the inland alternatives.

Wind coverage is less certain and is pending data from the wind tower. The ability to rotate the runway to meet local wind conditions is lower for this alternative, because of the topography and proximity to the community.

Runway incursions may be elevated for this alternative due to the close proximity to the planned community at K-Hill. This might encourage incidental use. In contrast, the runway does have the advantage of not leading to any particular resources (like the Kivalina River).

Identified penetrations to Part 77 surfaces include K-Hill and an area directly adjacent to the airport. K-Hill poses the largest penetration to the protected airspace, because of its close proximity.

3.5.2 Land Use

Land is owned by NANA and would require purchase.

There are no impacts to parks or recreational areas.

Subsistence resources used in the area include caribou, furbearers, and berries/plants.

3.5.3 Environmental

This alternative has the following environmental obstacles:

- The potential impacts to wildlife habitat for all the alternatives near K-Hill is moderate. Historically these areas were more isolated from human access. As K-Hill is developed, wildlife presence in the area is likely to change.

Environmental benefits include:

- No impacts to threatened and endangered species critical habitat.
- Avoidance of marine mammal habitat.
- The impacts to bird habitat is lower than the coastal alternatives, as is the potential bird hazards to aviation.

Other environmental considerations include cultural resources, which are unknown without additional field studies.

Passenger convenience is low for residents living at Kivalina, and high for those at K-Hill.

3.5.4 Constructability

The geology and constructability is feasible for the project.

The alternative is greater than 5,000 feet from the existing and proposed solid waste facility.

3.5.5 Materials

Materials would only need to be hauled from K-Hill

3.5.6 Utilities

Utilities would need to be constructed for the airport from the developing K-Hill community.

3.5.7 Cost

The cost is estimated to be $29,551,029. This cost is similar to Alternative 3, but slightly less, because it is closer to the existing K-Hill infrastructure. The cost to purchase the land is unknown.

3.6 Alternative 5 "N K-Hill"

Alternative 5 "N K-Hill" was selected to explore the option of moving the airport north of K-Hill. The topography of the surrounding foothills is a challenge and restricts the orientation of the runway. The advantage of this site is that it would not constrain community development.

3.6.1 Safety and Airport Resiliency

Flooding and erosion would not be a concern at this alternative. The airport would be built outside of the floodplains.

Fog is less of a concern on the inland alternatives.

Wind coverage is less certain and is pending data from the wind tower.

Runway incursions would likely be lower for this alternative. The airport would be located distant from residences and would not lead to a particularly desirable resource.

Identified penetrations to Part 77 surfaces include K-Hill.

3.6.2 Land Use

Land is owned by NANA and would require purchase.

There are no impacts to parks or recreational areas.

Subsistence resources used in the area include caribou, furbearers, and berries/plants.

3.6.3 Environmental

This alternative has the following environmental obstacles:

- The potential impacts to wildlife habitat for all the alternatives near K-Hill is moderate. Historically these areas were more isolated from human access. As K-Hill is developed, wildlife presence in the area is likely to change.

Environmental benefits include:

- No impacts to threatened and endangered species critical habitat.
- Avoidance of marine mammal habitat.
- The impacts to bird habitat is lower than the coastal alternatives, as is the potential bird hazards to aviation.

Other environmental considerations include cultural resources, which are unknown without additional field studies.

Passenger convenience is low for residents living at Kivalina, and medium for those at K-Hill.

3.6.4 Constructability

The geology and constructability is feasible for the project.

The alternative is greater than 5,000 feet from the existing and proposed solid waste facility.

3.6.5 Materials

Materials would need to be hauled from K-Hill.

3.6.6 Utilities

Utilities would need to be constructed for the airport from the developing K-Hill community.

3.6.7 Cost

The cost is estimated to be $34,294,306. This cost is high due to the long access road required to connect to the existing K-Hill infrastructure. The cost to purchase the land is unknown.

4 RECOMMENDATIONS

Prior to engaging in public involvement, the two best alternatives are Alternative 1 “Improve” and Alternative 3 “K-Hill (Farther).”

- Alternative 1 “Improve” improves the existing infrastructure at its current location. This alternative becomes increasingly expensive to maintain and improve to meet the increasing threat from coastal flooding and erosion. In the long term, this alternative may be cost prohibitive. This alternative would be difficult to access for residents should they choose to relocate to K-Hill.

- Alternative 3 “K-Hill (Farther)” is the best alternative located near K-Hill. This is more expensive than Alternative 1 “Improve” initial construction cost, but it permanently removes the airport from the marine flooding, erosion, and storm surge threats and cost. This alternative is convenient for residents that move to K-Hill, but inconvenient for residents that stay at the current community.

Public engagement with Kivalina will help determine a preferred alternative.

These alternatives are less beneficial:

- The No Action is not recommended, because it does not meet the purpose and need of the airport. The airport does not meet crosswind coverage requirements and has non-standard conditions. Maintenance of the revetment is required to protect the runway.

- Alternative 2 “Nearshore” is not recommended due to cost, and relatively larger environmental impacts.

- Alternative 4 “K-Hill (Near)” is not recommended due to safety considerations. Separating the runway from the community will likely result in fewer runway incursions, and fewer aviation impacts to the community.

- Alternative 5 “N K-Hill” is not recommended due to cost, and relatively larger environmental impacts.

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APPENDIX 1: KIVALINA AIRSTRIP REVETMENT LIFE AND ALTERNATIVE ANALYSIS

APPENDIX 2: HYDROLOGIC AND HYDRAULIC REVIEW FOR THE KIVALINA AIRPORT RELOCATION FEASIBILITY STUDY

Water Resources
Engineering | Analysis | Design

Memorandum

To: Ryan Cooper and Andrew Niemiec, PE | Stantec Consulting Services, Inc.

From: Janie Dusel, PE and Lori Morrison, PE

Date: June 20, 2023

Re: Hydrologic and Hydraulic Review for the Kivalina Airport Relocation Feasibility Study (DRAFT)

The purpose of this memorandum is to summarize the hydrologic and hydraulic (H&H) review completed by AWR Engineering (AWR) for Stantec Consulting Services (Stantec) in support of the Kivalina Airport Relocation Feasibility Study.

1. Background

Kivalina is located on a barrier island in Northwest Alaska, between the Arctic Ocean and the Kivalina Lagoon. Due to increased frequency of storms and rising sea levels, the community of Kivalina is considering relocation to the adjacent mainland. As a part of the relocation plan, Stantec is working with the Alaska Department of Transportation and Public Facilities (DOT&PF) to complete a feasibility study that identifies and considers potential new sites for the Kivalina airport.

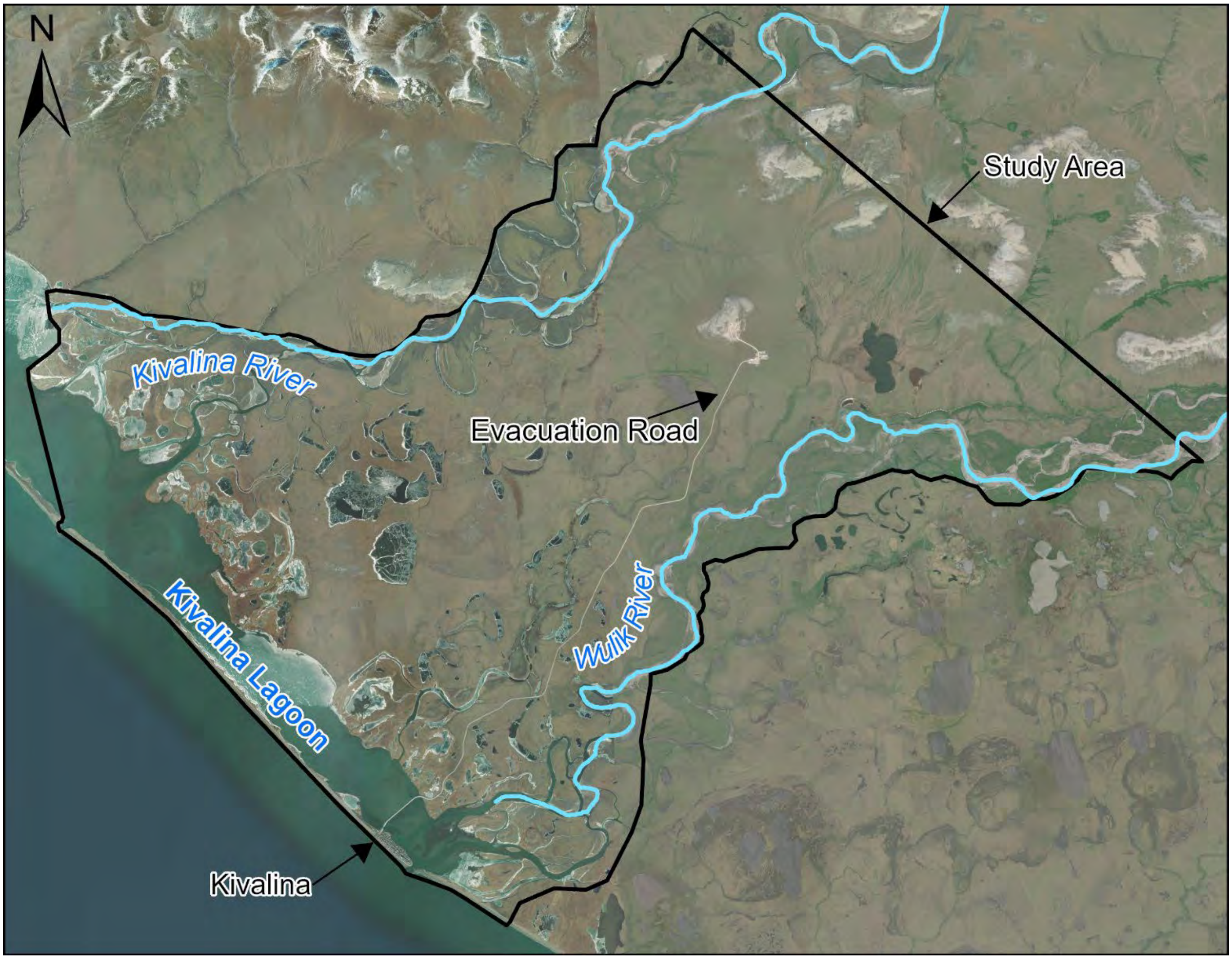
As a part of the feasibility study for a new airport site, AWR is assisting Stantec with review and summarization of relevant H&H information to help inform the alternative analyses. AWR's data review excludes review of coastal impacts, as this is being reviewed by other members of the project team.

2. Study Area Description

The project study area was provided by Stantec and is shown in Figure 1. Potential sites for relocating the airport are understood to be limited to the area shown. The project area is generally bounded by the Wulik River on the south, the Kivalina River on the north, and the Kivalina Lagoon on the west. As shown in Figure 1, a new evacuation road was recently constructed that connects Kivalina to the mainland. Access to a new airport site would be from this existing road.

The floodplains associated with the Wulik and Kivalina Rivers are expected to be the primary cause of surface water flooding within the project area. Understanding the location of these floodplains is important for identifying suitable locations for the proposed new airport. As such, this data analysis primarily focused on identifying information related to flooding along these rivers.

Figure 1: Project Study Area



3. Review of Existing Information

Stantec provided several documents with H&H information for the study area. A summary of the information is provided in Table 1.

Table 1: Data Provided by Stantec

Data from Stantec	Summary
1. Aerial Imagery of the Mouth of the Wulik River 1952-2016	Aerial imagery showing the dynamic nature of the Wulik River as it flows into the Kivalina Lagoon, just north of Kivalina.
2. Kivalina Causeway Geotechnical Report, Kivalina, Alaska 2015	Report prepared by Golder Associates for the US Army Corps of Engineers to detail the subsurface exploration that was done in support of the Kivalina Evacuation Road Project.
3. Kivalina LiDAR and Photos Technical Data Report 2016	Report prepared by Quantum Spatial for McClintock Land Associates. This report accompanied the LiDAR and imagery that was taken in support of the Kivalina Evacuation Road Project.
4. Kivalina Evacuation Road & School Site Access Road – Location Hydraulic Study for the Wulik River 2017	Report prepared by Stantec for the Alaska Department of Transportation & Public Facilities. The evacuation road was built within the floodplain of the Wulik River. The lower portion of the Wulik River was modeled and impacts to the road were discussed. Stantec provided associated GIS files including delineations of the 100-year floodplain of the Wulik River within the current project area.
5. Floodplain Mapping of the Wulik River, Kivalina-Alaska 2017	Memorandum describing the model development and results for the floodplain mapping of the Wulik River.
6. Kivalina Lagoon Crossing Design Water Levels and Sedimentation Characteristics 2017	Memorandum discussing the development of a design water level in the Kivalina Lagoon for the Kivalina Evacuation Road Project. The effect of sedimentation in the lagoon is also discussed.
7. Hydrodynamic Modeling Results in Support of Kivalina Lagoon Crossing Design 2019	Report prepared by Stantec for the Alaska Department of Transportation & Public Facilities in support of the Kivalina Evacuation Road Project. The report details the hydrodynamic study completed by Stantec, including the development and results of modeling the Kivalina Lagoon, the effects of adding the evacuation road project, and the hydrodynamic effects of the 100-year ocean storm surge and the 100-year flow events on the Kivalina River and the Wulik River.

Items 4 and 5 in Table 1 provided information for mapping the Wulik River floodplain. Further discussion of the Wulik River floodplain delineation is provided in Section 4.

AWR was not able to find existing floodplain delineation or mapping for the Kivalina River. The only existing information regarding flooding on the Kivalina River was found in Item 7 from Table 1, which noted that the downstream portion of the Kivalina River was modeled to determine the effects that the 1% annual exceedance probability (AEP) event would have on the Kivalina Lagoon. This information was not sufficient to delineate the floodplain within the study area. Because delineation and mapping of the floodplain on the Kivalina River is a key piece of information for airport relocation feasibility, AWR completed further analysis of the river. Details are provided in Section 5.

4. Wulik River Flooding

As described in Items 4 and 5 from Table 1, Stantec modeled the 1% AEP flood extents of the Wulik River using the MIKE 21 hydrodynamic modeling software package. The 2016 Kivalina LiDAR was used for the terrain in the model. Multiple river bottom elevation scenarios were modeled. In one scenario, the bottom of the river channel was assumed to be at the LiDAR elevation. In a second scenario, the river channel was assumed to be 10 feet below the LiDAR elevation. For this data review and analysis, AWR is presenting the delineated Wulik River floodplain assuming the channel bottom was at the LiDAR elevation, as this would provide a more conservative result.

5. Kivalina River Flooding and Floodplain Analysis

AWR completed a baseline H&H analysis to delineate the 1% AEP flood extents of the Kivalina River. An approximate floodplain for the Kivalina River was established within the project area. This section discusses the data and methods used for this analysis.

Data Used. Key information and data used to support the H&H analyses are summarized below.

- <u>Wulik River Hydraulic Study</u>. Information and results from Items 4 and 5 in Table 1 were used to inform modeling assumptions.

- <u>Stream Gage Data.</u> Stream gage data for the Wulik River gage USGS 15747000 WULIK R BL TUTAK C NR KIVALINA AK was obtained from the United States Geological Survey (USGS) National Water Information System Web Interface.

- <u>Kivalina River Watershed.</u> The Kivalina River watershed was obtained from the USGS HUC-10 Watershed Boundary Dataset.

- <u>Topographic Information.</u> Two sources of LiDAR were used to support this analysis.

  <u>(1)</u> In the area around the Kivalina Evacuation Road Project, the 2016 LiDAR (Item 3 from Table 1) was used for the terrain of the model. The contour lines provided by Stantec were converted to a raster dataset using GIS processing.

  <u>(2)</u> Outside of the extents of the 2016 LiDAR, topographic information was obtained from the Alaska Division of Geological and Geophysical Surveys 2012 Interferometric Synthetic Aperture Radar (IFSAR) dataset. This raster has a resolution of five meters.

Hydrology. The Kivalina River is not gaged in the project vicinity. The 1% AEP flow for the Kivalina River was computed using a basin correlation to the nearby gaged Wulik River. A flood frequency analysis on the nearby Wulik River gage was first completed using the USGS program PeakFQ, which utilizes the methodology outlined in the USGS publication

Guidelines for Determining Flood Flow Frequency Bulletin 17C. Details regarding the flood frequency analysis are provided in Attachment 2.

The drainage area of the Kivalina River basin was then computed using GIS processing based on the USGS HUC-10 Watershed Boundary Dataset. The drainage area was determined to be 681 square miles. The USGS reports a drainage area of 705 square miles for the nearby Wulik River, to the location of the Wulik River gage. To determine a 1% AEP flow for the Kivalina River, the ratio of the Kivalina River drainage area to the Wulik River gage drainage area was multiplied by the Wulik River 1% AEP flow from the flood frequency analysis. This resulted in a peak flow of 42,055 cfs for the Kivalina River.

Hydraulics. AWR's hydraulic evaluation of the Kivalina River was completed using the SRH-2D program within the SMS 13.1 platform. Modeling details and assumptions are discussed below.

<u>Model Extents and Boundary Conditions.</u> The upstream boundary of the hydraulic model was selected as a location upstream of the study area boundary. The upstream boundary condition was defined as a hydrograph with a constant inflow of 42,055 cfs (the 1% AEP flow). The boundary condition was defined as a constant inflow rather than a varying hydrograph to give a more conservative solution.

The downstream boundary was selected as the Kivalina Lagoon. The downstream boundary condition was set at a constant water surface elevation of 4.5 feet. This value was obtained from the Wulik River model which is described in Section 4 of this memorandum.

<u>Topography.</u> The model topography consisted primarily of the 2012 IFSAR data, but the 2016 LiDAR was used where it was available. Channel stamping, or assuming the channel bottom was deeper than the LiDAR surface, was not completed.

<u>Manning's n.</u> The Manning's n values for the stream channel and the overbank flow areas were set to 0.02 and 0.1, respectively. These were the same roughness values used in the Wulik River model, and were expected to be appropriate for the Kivalina River model as well based on review of aerial imagery.

<u>Model Simulation Settings.</u> The model was run using the full momentum equations with a computational time step of two seconds. The model was run until the results stabilized, meaning that the solution was no longer changing with time. This required a computational run time of 24 hours.

<u>Results.</u> The results are presented visually in Attachment 1. Generally, results show that the Kivalina River floodplain resulting from the 1% AEP event encompasses the northern and western portions of the study area.

<u>Limitations.</u> This H&H analysis provides a watershed-scale approximation of the Kivalina River floodplain. It is not intended to represent exact flooding limits at any specific location. Additionally, the provided floodplain accuracy is limited by the accuracy of the available LiDAR.

6. Recommendations

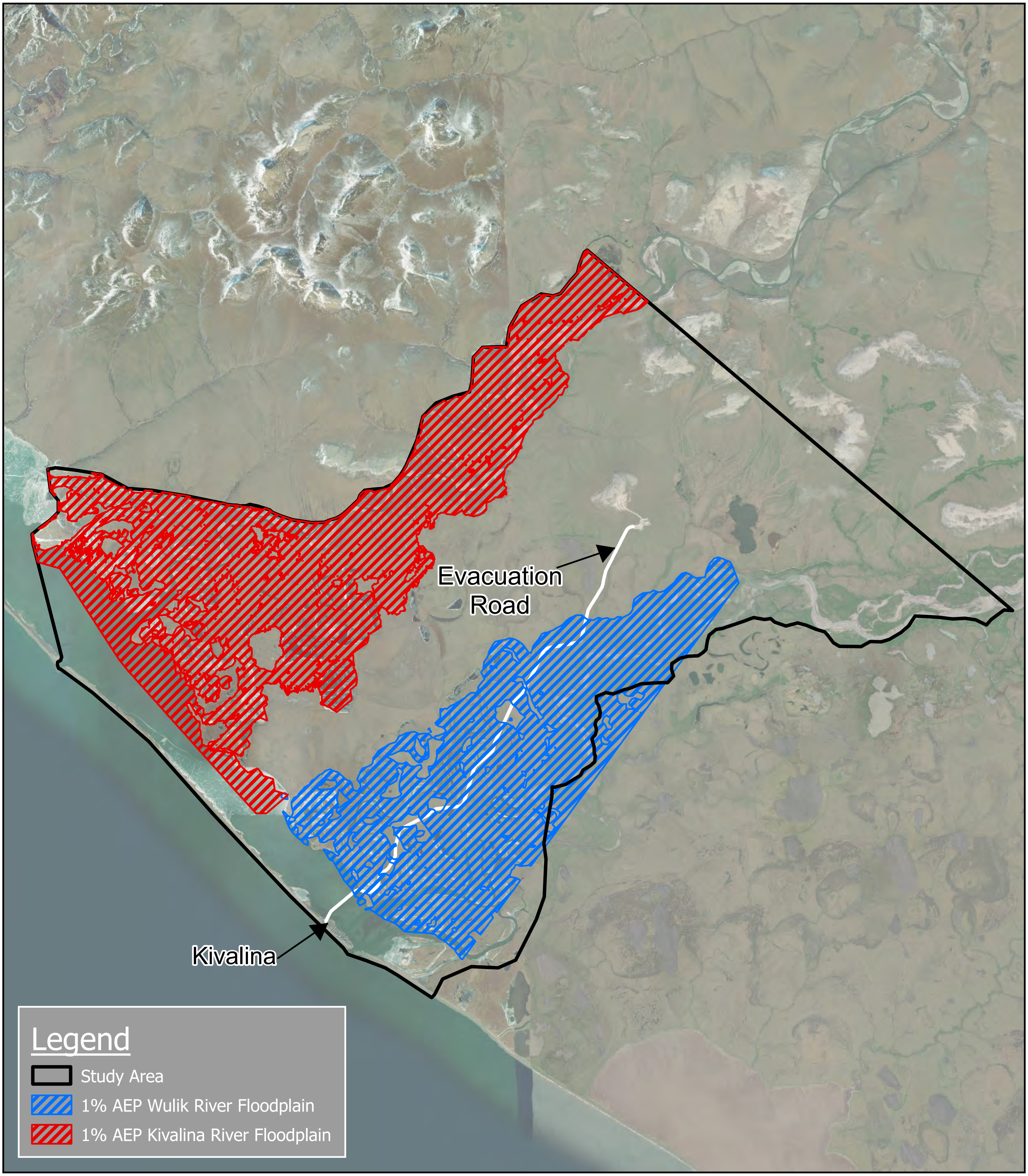
Based on review of available information and completion of the H&H analysis described in this document, areas expected to be impacted by surface water flooding in the project study area are shown in Attachment 1. AWR recommends the proposed new airport site be selected outside of these flood limits.

Additionally, there are a number of smaller creeks and areas of open water that do not lie within the delineated floodplains. AWR also recommends avoiding close proximity to these creeks and open water areas when selecting a new airport site.

Attachments:

1. Floodplain Limits in the Study Area
2. Flood Frequency Analysis Details

Attachment 1
Floodplain Limits in the Study Area



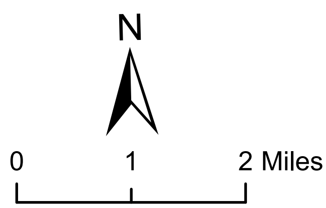
Map 01

Kivalina Airport Relocation Feasibility Study

Hydrology Review

Floodplain Limits in the Study Area

June 2023



Attachment 2
Flood Frequency Analysis Details

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1
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  Version 7.3         Annual peak flow frequency analysis      Run Date / Time
  10/25/2019                                                   06/05/2023 11:30

                       --- PROCESSING OPTIONS ---

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                    Input peaks format  = WATSTORE peak file

                    Input files used:
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                       specifications - C:\Users\LoriJones\Desktop\Wulik FFA\PKFQWPSF.TMP

                    Output file(s):
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  ***  User responsible for assessment and interpretation of the following analysis  ***

1


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  Version 7.3         Annual peak flow frequency analysis      Run Date / Time
  10/25/2019                                                   06/05/2023 11:30

             Station - 15747000  WULIK R BL TUTAK C NR KIVALINA AK


                   TABLE 1 - INPUT DATA SUMMARY

              Number of peaks in record           =       38
              Peaks not used in analysis          =        0
              Gaged peaks in analysis             =       38
              Historic peaks in analysis          =        0
              Beginning Year                      =     1985
              Ending Year                         =     2022
              Historical Period Length            =       38
              Skew option                         = STATION SKEW
              Regional skew                       =   --
                   Standard error                 =     --
                   Mean Square error              =     --
              Gage base discharge                 =      0.0
              User supplied high outlier threshold =   --
              User supplied PILF (LO) criterion    =   --
              Plotting position parameter         =     0.00
              Type of analysis                              EMA
              PILF (LO) Test Method                        MGBT
              Perceptible Ranges:
                  Start Year  End Year  Lower Bound  Upper Bound
                        1985      2022          0.0          INF    DEFAULT

              Interval Data                   =   None Specified


    TABLE 2 - DIAGNOSTIC MESSAGE AND PILF RESULTS


   *WCF107I-ACCEPTED GEN SKEW OUTSIDE MAP LIMITS.-999.000  -0.400   0.800
   *WCF151I-17B WEIGHTED SKEW REPLACED BY USER OPTION.  -312.411     0.060  -1
  **WCF233W-EXPECTED PROB OUT OF RANGE AT TAB PROB.   0.00000   0.00000
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
    EMA002W-CONFIDENCE INTERVALS ARE NOT EXACT IF HISTORIC PERIOD > 0


    MULTIPLE GRUBBS-BECK TEST RESULTS
    MULTIPLE GRUBBS-BECK PILF THRESHOLD     N/A
    NUMBER OF PILFS IDENTIFIED                0


                     Kendall's Tau Parameters

                                   MEDIAN   No. of
                     TAU    P-VALUE    SLOPE   PEAKS
               ---------------------------------------
```

GAGED PEAKS -0.071 0.538 -43.750 38

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.002
Version 7.3 Annual peak flow frequency analysis Run Date / Time
10/25/2019 06/05/2023 11:30

Station - 15747000 WULIK R BL TUTAK C NR KIVALINA AK

TABLE 3 - ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	LOGARITHMIC		
	MEAN	STANDARD DEVIATION	SKEW
EMA WITHOUT REG SKEW	4.2127	0.1798	0.060
EMA WITH REG SKEW	4.2127	0.1798	0.060

EMA ESTIMATE OF MSE OF SKEW WITHOUT REG SKEW 0.1377
EMA ESTIMATE OF MSE OF SKEW W/GAGED PEAKS ONLY (AT-SITE) 0.1377

TABLE 4 - ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	<- EMA ESTIMATE -> WITH REG SKEW	WITHOUT REG SKEW	<- FOR EMA ESTIMATE WITH REG SKEW -> LOG VARIANCE OF EST.	<-CONFIDENCE LIMITS-> 5.0% LOWER	95.0% UPPER
0.9950	5750.	5750.	0.0066	3587.0	7260.0
0.9900	6344.	6344.	0.0048	4253.0	7773.0
0.9500	8319.	8319.	0.0021	6531.0	9635.0
0.9000	9627.	9627.	0.0015	8018.0	10980.0
0.8000	11510.	11510.	0.0011	9988.0	13000.0
0.6667	13610.	13610.	0.0010	12000.0	15330.0
0.5000	16250.	16250.	0.0010	14400.0	18350.0
0.4292	17500.	17500.	0.0010	15520.0	19800.0
0.2000	23090.	23090.	0.0012	20380.0	26790.0
0.1000	27820.	27820.	0.0016	24260.0	33820.0
0.0400	33980.	33980.	0.0027	28910.0	45270.0
0.0200	38700.	38700.	0.0040	32150.0	55880.0
0.0100	43540.	43540.	0.0056	35170.0	68470.0
0.0050	48530.	48530.	0.0076	38030.0	83410.0
0.0020	55380.	55380.	0.0109	41590.0	107500.0

*Note: If Station Skew option is selected then EMA ESTIMATE WITH REG SKEW will display values for and be equal to EMA ESTIMATE WITHOUT REG SKEW.

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Version 7.3 Annual peak flow frequency analysis Run Date / Time
10/25/2019 06/05/2023 11:30

Station - 15747000 WULIK R BL TUTAK C NR KIVALINA AK

TABLE 5 - INPUT DATA LISTING

WATER YEAR	PEAK VALUE	PEAKFQ CODES	FLOW INTERVALS (WHERE LOWER BOUND NOT = UPPER BOUND) LOWER BOUND	UPPER BOUND	REMARKS
1985	15600.0				
1986	15000.0				
1987	9320.0				
1988	24400.0				
1989	26100.0				
1990	19600.0				
1991	13800.0				
1992	14700.0				
1993	18400.0				
1994	30700.0				
1995	12900.0				
1996	25800.0				
1997	8930.0				
1998	18200.0				
1999	11900.0				
2000	14200.0				

```
    2001    20400.0
    2002    18600.0
    2003    15900.0
    2004    18100.0
    2005    25400.0
    2006    16700.0
    2007     6330.0
    2008     7000.0
    2009    22700.0
    2010    13400.0
    2011    27700.0
    2012    50400.0
    2013    14500.0
    2014    15800.0
    2015    19600.0
    2016    14300.0
    2017     9820.0
    2018    14000.0
    2019    15300.0
    2020     9850.0
    2021    25100.0
    2022    14600.0

       Explanation of peak discharge qualification codes

      PeakFQ    NWIS
       CODE     CODE   DEFINITION

         D        3    Dam failure, non-recurrent flow anomaly
         G        8    Discharge greater than stated value
         X       3+8   Both of the above
         L        4    Discharge less than stated value
         K      6 OR C  Known effect of regulation or urbanization
         O        O    Opportunistic peak
         H        7    Historic peak

         -  Minus-flagged discharge -- Not used in computation
               -8888.0 -- No discharge value given
         -  Minus-flagged water year -- Historic peak used in computation


1

  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.004
  Version 7.3         Annual peak flow frequency analysis      Run Date / Time
  10/25/2019                                                    06/05/2023 11:30

           Station - 15747000  WULIK R BL TUTAK C NR KIVALINA AK


  TABLE 6 - EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

   WATER     RANKED      EMA      FLOW INTERVALS (WHERE LOWER BOUND NOT = UPPER BOUND)
    YEAR   DISCHARGE   ESTIMATE   LOWER BOUND  UPPER BOUND
    2012    50400.0     0.0256
    1994    30700.0     0.0512
    2011    27700.0     0.0769
    1989    26100.0     0.1025
    1996    25800.0     0.1282
    2005    25400.0     0.1538
    2021    25100.0     0.1794
    1988    24400.0     0.2051
    2009    22700.0     0.2307
    2001    20400.0     0.2564
    1990    19600.0     0.3077
    2015    19600.0     0.2820
    2002    18600.0     0.3333
    1993    18400.0     0.3590
    1998    18200.0     0.3846
    2004    18100.0     0.4102
    2006    16700.0     0.4359
    2003    15900.0     0.4615
    2014    15800.0     0.4872
    1985    15600.0     0.5128
    2019    15300.0     0.5385
    1986    15000.0     0.5641
    1992    14700.0     0.5898
    2022    14600.0     0.6154
    2013    14500.0     0.6410
    2016    14300.0     0.6667
```

2000	14200.0	0.6923
2018	14000.0	0.7180
1991	13800.0	0.7436
2010	13400.0	0.7693
1995	12900.0	0.7949
1999	11900.0	0.8206
2020	9850.0	0.8462
2017	9820.0	0.8718
1987	9320.0	0.8975
1997	8930.0	0.9231
2008	7000.0	0.9488
2007	6330.0	0.9744

1

```
Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.001.005
Version 7.3         Annual peak flow frequency analysis      Run Date / Time
10/25/2019                                                 06/05/2023 11:30

          Station - 15747000  WULIK R BL TUTAK C NR KIVALINA AK
```

TABLE 7 - EMA REPRESENTATION OF DATA

WATER	OBSERVED		EMA		USER-ENTERED PERCEPTIBLE RANGES		FINAL PERCEPTIBLE RANGES	
YEAR	Q_LOWER	Q_UPPER	Q_LOWER	Q_UPPER	LOWER	UPPER	LOWER	UPPER
1985	15600.0	15600.0	15600.0	15600.0	0.0	INF	0.0	INF
1986	15000.0	15000.0	15000.0	15000.0	0.0	INF	0.0	INF
1987	9320.0	9320.0	9320.0	9320.0	0.0	INF	0.0	INF
1988	24400.0	24400.0	24400.0	24400.0	0.0	INF	0.0	INF
1989	26100.0	26100.0	26100.0	26100.0	0.0	INF	0.0	INF
1990	19600.0	19600.0	19600.0	19600.0	0.0	INF	0.0	INF
1991	13800.0	13800.0	13800.0	13800.0	0.0	INF	0.0	INF
1992	14700.0	14700.0	14700.0	14700.0	0.0	INF	0.0	INF
1993	18400.0	18400.0	18400.0	18400.0	0.0	INF	0.0	INF
1994	30700.0	30700.0	30700.0	30700.0	0.0	INF	0.0	INF
1995	12900.0	12900.0	12900.0	12900.0	0.0	INF	0.0	INF
1996	25800.0	25800.0	25800.0	25800.0	0.0	INF	0.0	INF
1997	8930.0	8930.0	8930.0	8930.0	0.0	INF	0.0	INF
1998	18200.0	18200.0	18200.0	18200.0	0.0	INF	0.0	INF
1999	11900.0	11900.0	11900.0	11900.0	0.0	INF	0.0	INF
2000	14200.0	14200.0	14200.0	14200.0	0.0	INF	0.0	INF
2001	20400.0	20400.0	20400.0	20400.0	0.0	INF	0.0	INF
2002	18600.0	18600.0	18600.0	18600.0	0.0	INF	0.0	INF
2003	15900.0	15900.0	15900.0	15900.0	0.0	INF	0.0	INF
2004	18100.0	18100.0	18100.0	18100.0	0.0	INF	0.0	INF
2005	25400.0	25400.0	25400.0	25400.0	0.0	INF	0.0	INF
2006	16700.0	16700.0	16700.0	16700.0	0.0	INF	0.0	INF
2007	6330.0	6330.0	6330.0	6330.0	0.0	INF	0.0	INF
2008	7000.0	7000.0	7000.0	7000.0	0.0	INF	0.0	INF
2009	22700.0	22700.0	22700.0	22700.0	0.0	INF	0.0	INF
2010	13400.0	13400.0	13400.0	13400.0	0.0	INF	0.0	INF
2011	27700.0	27700.0	27700.0	27700.0	0.0	INF	0.0	INF
2012	50400.0	50400.0	50400.0	50400.0	0.0	INF	0.0	INF
2013	14500.0	14500.0	14500.0	14500.0	0.0	INF	0.0	INF
2014	15800.0	15800.0	15800.0	15800.0	0.0	INF	0.0	INF
2015	19600.0	19600.0	19600.0	19600.0	0.0	INF	0.0	INF
2016	14300.0	14300.0	14300.0	14300.0	0.0	INF	0.0	INF
2017	9820.0	9820.0	9820.0	9820.0	0.0	INF	0.0	INF
2018	14000.0	14000.0	14000.0	14000.0	0.0	INF	0.0	INF
2019	15300.0	15300.0	15300.0	15300.0	0.0	INF	0.0	INF
2020	9850.0	9850.0	9850.0	9850.0	0.0	INF	0.0	INF
2021	25100.0	25100.0	25100.0	25100.0	0.0	INF	0.0	INF
2022	14600.0	14600.0	14600.0	14600.0	0.0	INF	0.0	INF

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      38

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  15747000       USGS WULIK R BL TUTAK C NR KIVALIN
```

APPENDIX 3: FLOODPLAIN MAPPING OF THE WULIK RIVER, KIVALINA-ALASKA

To:	Andrew Niemiec	From:	Seifu Guangul
	Stantec, Anchorage, USA		Stantec, Winnipeg, Canada
File:	2047055101	Date:	November 30, 2017

Reference: Floodplain Mapping of the Wulik River, Kivalina-Alaska

This memo describes the data, assumption, method, analysis, and result for floodplain mapping of the Wulik River. The primary objective of this work is to delineate floodplain extent of the Wulik River for the 100-year flow under different topographical scenarios. Because there was no bathymetry data available to properly describe a stream cross-section of the Wulik River, a scenario based modelling approach was adopted, using topographic data obtained from LiDAR.

SCOPE OF WORK

The scope of work completed for this river floodplain mapping study includes the following:

- Review of available existing LiDAR data.
- Review of available existing 100-year flow event hydrograph for Wulik River.
- Estimate 100-year flood hydrography at the upstream boundary of the hydrodynamic model.
- Develop 2D Hydrodynamic model for the Wulik River.
- Delineate a 100-year river floodplain map for the Wulik River.
- Estimate the area of the project footprint that will potentially be affected by a 100-year flow event of the Wulik River.

MODEL ASSUMPTION

Several assumptions were made in completing the required work described in this memo:

1. *Upstream inflow boundary condition*: A 100-year inflow hydrograph was estimated based on a USGS site located further upstream of the model domain (USGS 15747000). The inflow hydrograph assumes this full flow at the model boundary and does not account for local flow for areas between the gauge site and the model domain (see Figure 2).

2. *River bathymetry data*: River geometry affects the amount excess water spilled-out by the river and hence the river floodplain extent. In the absence of river cross-section information, we ran two different hypothetical cross-sections scenarios (as detailed below).

3. *Roughness coefficients*: The velocity and depth of flood water also depends on the impediment or resistance the land surface and river channel offer against flow. Such resistance to flow depends on land-use/-cover of the land surface, surface roughness of the bed material, geometry of the channel and flow obstruction. In the absence of this information, the roughness coefficients used in this analysis don't explicitly consider these

factors. Roughness coefficients were therefore assumed based on aerial and site photos and published coefficient values.

Results presented in this memo should be taken considered in context of these assumptions.

MODEL SCENARIOS

Two scenarios were considered for the floodplain modeling:

Scenario I: assumes river channel bottom matches the LiDAR elevation. This assumption in conservative as it would result in a larger estimated floodplain compared to Scenario II.

Scenario II: assumes river channel bottom elevation is the LiDAR lowered by 10ft. Based on anecdotal observations, this assumption is considered to more accurately reflect the real river channel dimension than Scenario I.

HYDRODYNAMIC MODEL DEVELOPMENT

AVAILABLE DATA

LiDAR Data

A continuous surface layer was first created based on the available LiDAR data with 2 ft interval contours, and then a point cloud for the hydrodynamic model was generated.

Inflow Hydrograph

A 100-year flow of 55,000 cfs was applied to delineate the river floodplain. Based on flow hydrograph analysis of the Wulik River (at USGS station number 15747000), a unit peak hydrograph was created and then scaled for the 55,000 cfs (Figure 1). This inflow hydrograph constituted the upstream boundary condition of the model.

Lagoon Water Level Data

MHHW record from Red Dog Mine tide gauge is 3.5ft. To be conservative, we allowed for spatial variance between the gauge location and the study area, and assumed that the river flood could coincide with a higher than average high tide. As a result, we set the lagoon water level elevation, which is the downstream model boundary condition, at 4.5ft.

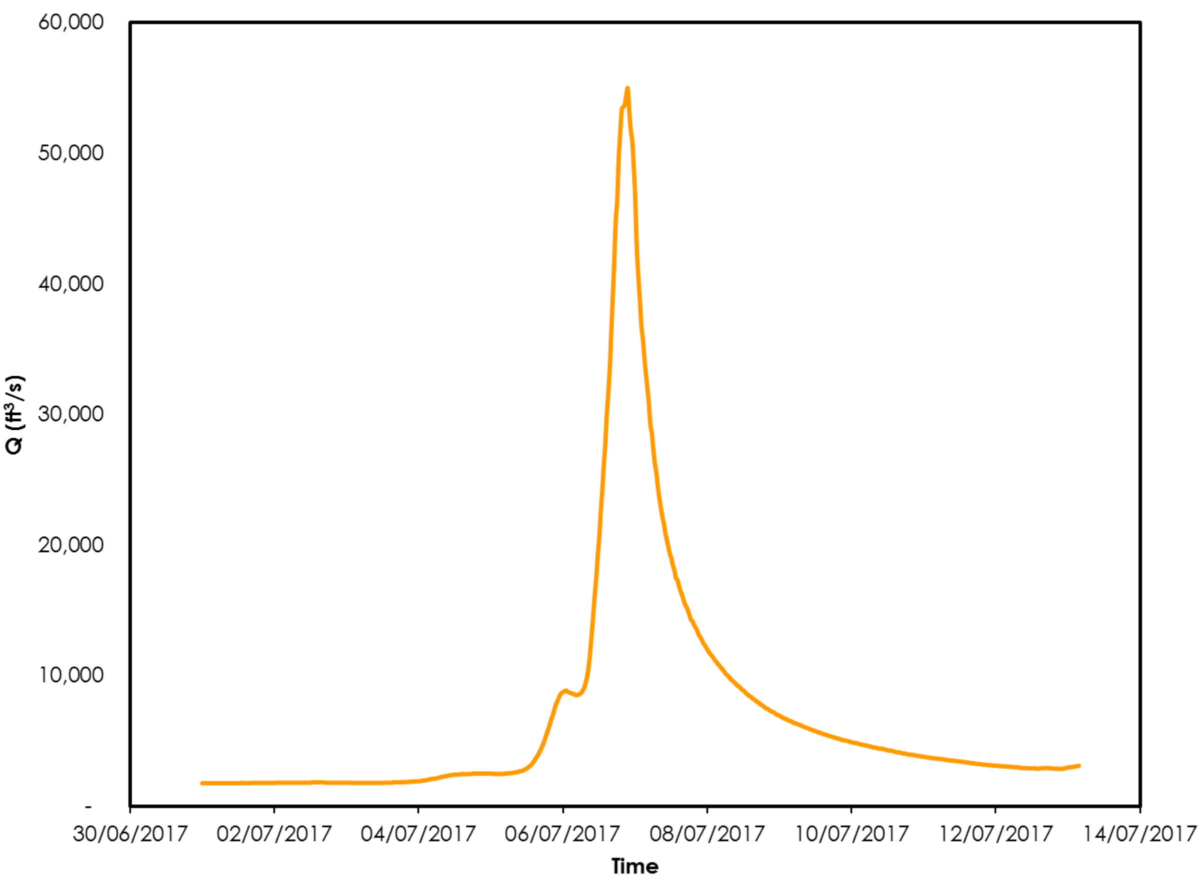


Figure 1: Input Inflow Hydrograph

MODEL SETUP

We used the MIKE 21 Hydrodynamic model to simulate the floodplain during a 100-year river flow event. The hydrodynamic model simulates unsteady flow considering density variations, bathymetry and external forcing in rivers, lakes, estuaries, and coastal areas. The modelling system is based on the numerical solution of 2-D incompressible Reynolds averaged Navier-Stokes equations subject to the assumptions of Boussinesq and of hydrostatic pressure. Thus, the model consists of continuity, momentum, temperature, salinity and density equations and it is closed by a turbulent closure scheme. The density does not depend on the pressure, but only on the temperature and salinity.

The model setup involves defining model domain, generating computational element meshes, and specifying model parameters and boundary conditions

Model Mesh Development

- Computational Model Domain

  The model domain was defined based on the available LiDAR data extent. The LiDAR grids were created within the model domain, based on the available LiDAR data (Figure 2).

- Computational Mesh

  The elevation scatter points were used to develop the river bathymetry and surface elevation for the overland flow computations. The computational mesh was derived after an iterative process of refining and smoothing the mesh density to ensure proper convergence and accuracy of the numerical solution over a full range of river flows.

  The generated mesh contains 38,594 triangular elements (Figure 3). The mesh arrangement was optimized to establish smooth boundaries. The resolution of the mesh, combined with the chosen time-step, governs the Courant number developed in the model set-up. The Courant number affects the numerical stability of the model. The resolution of the model in geographical space and time must be selected to maintain numerical stability. The mesh was optimized, based on the level of detail required and the amount of computational time necessary to run the model.

Reference: Floodplain Mapping of the Wulik River, Kivalina-Alaska

Legend

- Streamflow Gauging Station
- Stream
- LiDAR extent

0 2 4
Miles
1:250,000 (at original document size of 8.5x11)

Figure No.
2

Title
Location Map

Notes

1. Coordinate System: NAD 1983 StatePlane Alaska 8 FIPS 5008 Feet
2. Base features provided by State of Alaska Department of Transportation and Public Facilities
3. Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

Reference: Floodplain Mapping of the Wulik River, Kivalina-Alaska

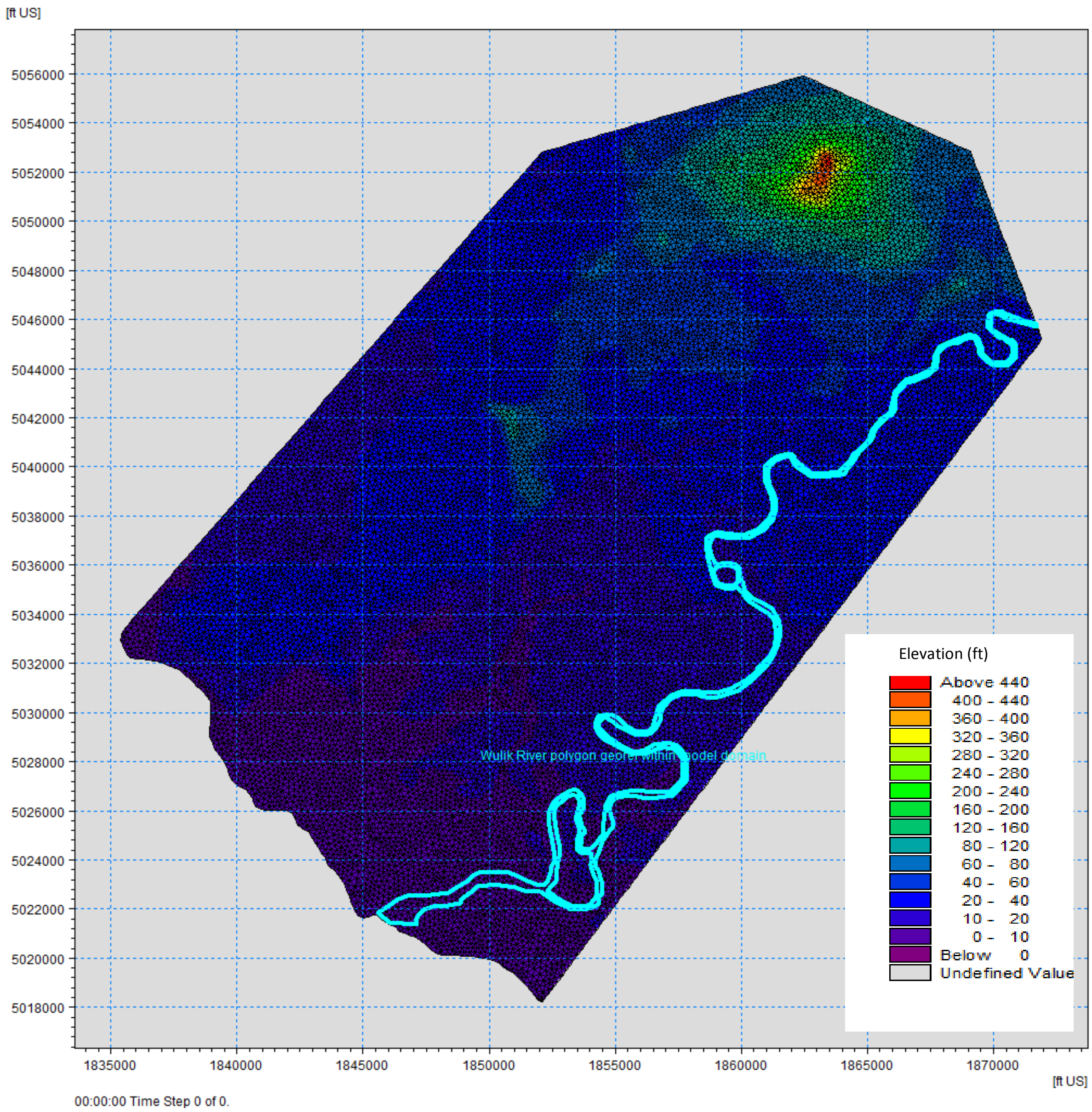


Figure 3: Computational Mesh

Boundary Conditions

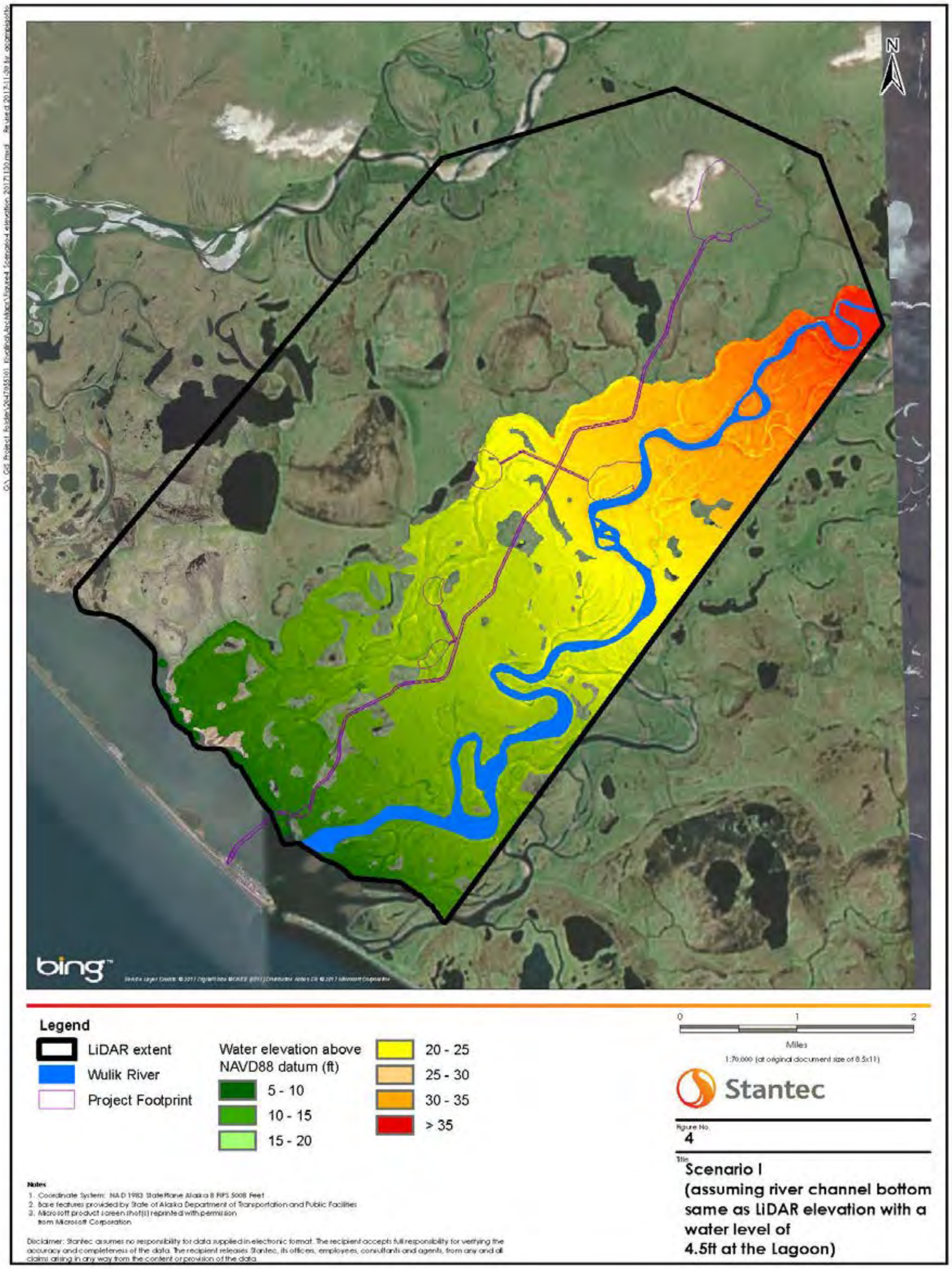
The following model boundaries were applied to the model domain setup:

- The upstream boundary condition was set the flow boundary condition. The 100-year flood inflow hydrograph (Figure 1) was used as the upstream boundary condition.
- The downstream river control boundary was set as a lagoon water level boundary condition. We used a lagoon water level of 4.5ft. The downstream boundary condition was considered as constant head boundary, but porous, where water in the floodplain could be lost to the lagoon if the floodplain water level exceeds that of the constant head boundary.
- Manning's roughness values of 0.1 for the overland part of the model domain and 0.02 for the main river were used.

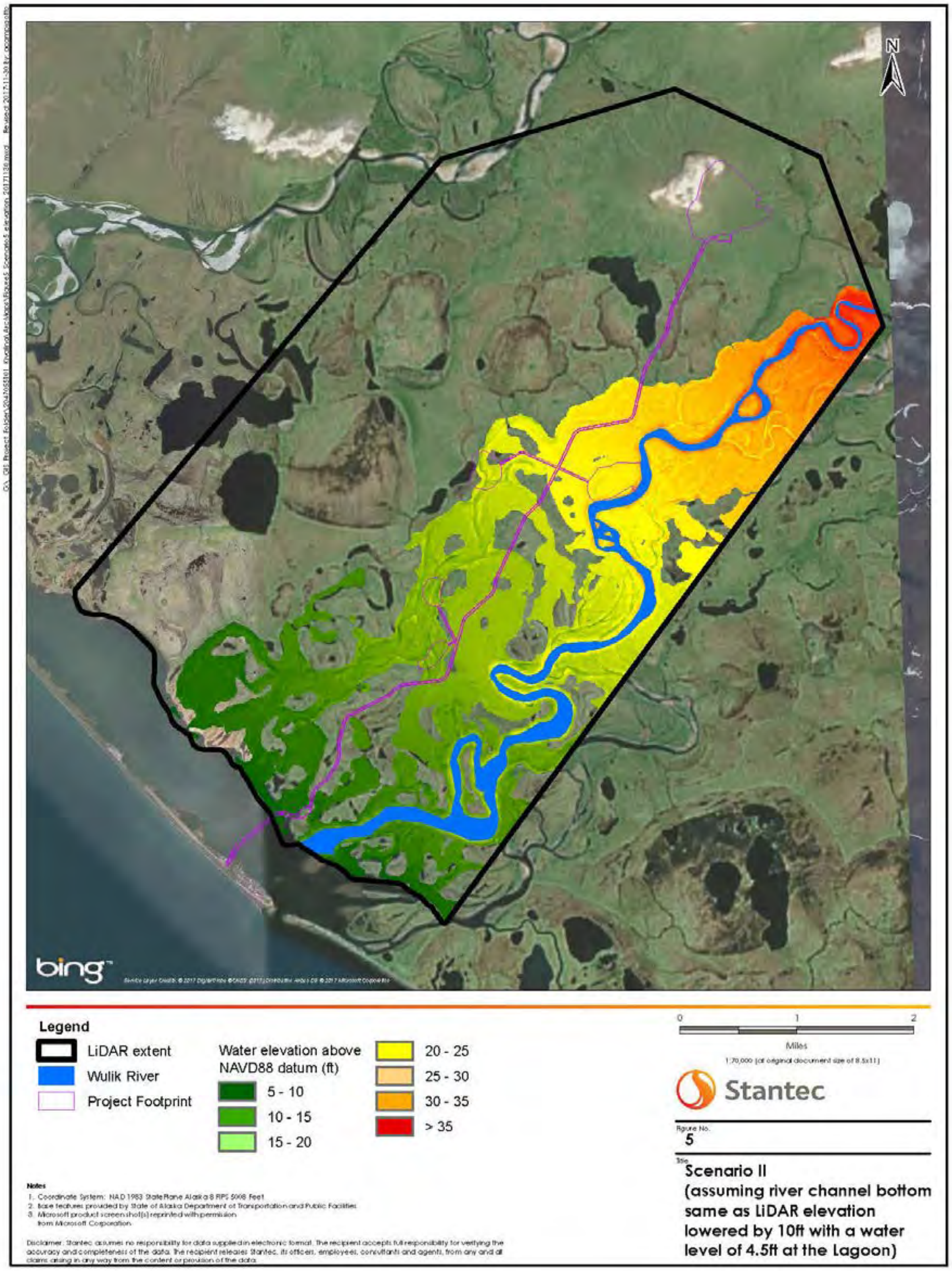
RESULTS

Floodplains for each of the river depths were mapped to estimate the maximum extent of a 100-year river flood event (Figures 4 and 5) and to estimate the area of project footprint that would be in the floodplain (Table 1). Results for Scenario I are considered conservative; the shallower river depth combined with a higher than MHHW lagoon water level, resulting in a larger estimated floodplain extent as compared to the more realistic Scenario II conditions. The maximum estimated floodplain extents, acreage of project footprint impacted, and resulting elevations of both scenarios, were similar, estimated between 196.6 and 226.4 acres of the project footprint occurring within the 100-year Wulik River floodplain; a 6.2% difference. Based on the available data and assumptions made herein, we consider these model results to be a reasonable prediction of maximum floodplain extent for the lower Wulik River inside the model domain.

Reference: Floodplain Mapping of the Wulik River, Kivalina-Alaska



Reference: Floodplain Mapping of the Wulik River, Kivalina-Alaska



Reference: Floodplain Mapping of the Wulik River, Kivalina-Alaska

Table 1: Project Footprint in the Model Domain affected

Scenario	Project Footprint within the Floodplain (sqft)	Project Footprint within the Floodplain (acres)	Percent Project Footprint within the Floodplain
Scenario I	9,859,697	226.4	47.2
Scenario II	8,562,745	196.6	41.0

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APPENDIX 4: KIVALINA AIRPORT RELOCATION – GEOTECHNICAL DATA REVIEW

October 4, 2023 | Project No. 31407010.000

Ryan Cooper, MS
Stantec Consulting Services Inc.
725 E. Fireweed Lane
Suite 200
Anchorage, AK 99503

KIVALINA AIRPORT RELOCATION – GEOTECHNICAL DATA REVIEW

Greetings Ryan:

WSP USA Inc. (WSP) is pleased to present this letter report to Stantec Consulting Services Inc. (Stantec) summarizing our background geotechnical data review in support of the Kivalina Airport Relocation Feasibility Study in Kivalina, Alaska. The intent of this data review was to collect and review existing and in-house geotechnical data to develop a generalized surficial terrain unit map of the project area that identifies suitable map units for future airport construction.

Our services were performed in general accordance with our proposal to Stantec dated June 5, 2023.

1.0 PROJECT UNDERSTANDING AND BACKGROUND

We understand that Stantec is the prime contractor in assisting the Alaska Department of Transportation and Public Facilities (ADOT&PF) with the Kivalina Airport Relocation Feasibility Study, with WSP supporting the geotechnical engineering aspects of this project.

The current Kivalina Airport (KVL) is located on a barrier island between the Chukchi Sea and the Kivalina Lagoon (Figure 1) that is actively eroding, and experiences impacts from periodic storm surges. ADOT&PF is currently evaluating the feasibility of an airport relocation to provide a reliable transportation link between Kivalina and Kotzebue. The area of interest for this scope of work encompasses the area between the Kivalina and Wulik River drainages, from the Kivalina Lagoon in the southwest to the area approximately two miles north of the new school and Kisimigiuktuk Hill (Figure 1). In developing target locations for the proposed airport relocation, we considered relatively flat-lying areas that would allow for an approximately one-mile-long runway in the north-northeast orientation.

2.0 SCOPE OF SERVICES

WSP's scope of work consisted of the following tasks:

- Conduct a kickoff meeting to discuss and outline project objectives

- Collect and review existing and in-house geotechnical data, including past field investigations and publicly available information
- Develop a generalized surficial terrain unit of the map to perform a qualitative review of available data
  - Identify and rank map units that are more suitable for a potential future airport
  - Provide generalized benefits and geotechnical risks related to the general areas
- Provide a letter report of our findings, including a summary of the applicable information for the project area and a summary of the findings from the data collection and review task

3.0 BACKGROUND

As described in Section 1, the area of interest for this scope of work encompasses the area between the Kivalina and Wulik River drainages, from the Kivalina Lagoon in the southwest to the area approximately two miles north of the new school and Kisimigiuktuk Hill (Figure 1). Generalized surficial units have been identified from existing and in-house data and ranked based on the assessed suitability of that unit to airport construction.

The sections below describe the regional and site setting based on our review of in-house geological and geotechnical data.

3.1 Regional Setting

Kivalina is located within the Arctic Foothills Physiographic Province, which is generally characterized by rolling hills and gentle slopes. The community of Kivalina and the current airport; however, are located on the southern end of Kivalina Island, a barrier island that separates Kivalina Lagoon on the east from the Chukchi Sea on the west. The Kivalina River and Wulik River both flow into Kivalina Lagoon, which in turn discharges into the open sea through the Kivalik Inlet and the Sinauk Entrance.

Bedrock is seldom exposed in the area except in isolated hills, especially those northwest of the Kivalina floodplain. These hills are topped with rock rubble and outcrops of limestone have been reported. Kisimgiuktuk Hill, located within the project area near the new school location, is rubble covered.

Although Pleistocene glaciation did not extend to the coast, it has had a major impact on the near surface geology and geomorphology in the Kivalina area. Sea level fluctuation has resulted in the accumulation of sandy beach deposits at various locations both offshore and inland from the present coastline. These deposits are similar in composition to present beach deposits, but in many cases, they have been partially or totally eroded away or buried by more recent fine-grained material. The drainage patterns of the Wulik and Kivalina Rivers have controlled much of the post-glacial deposition of local sediments. Glacial deposits near the headwaters of these drainages have been reworked by stream and river action and are the source of gravelly sand and sandy gravel deposits in the modern floodplains. Wind-blown silt and sand are often present as a near-surface veneer that, with surface vegetation, forms the present tundra cover. Along the eastern edge of Kivalina Lagoon, between the Kivalina and Wulik Rivers, a vegetation covered and tidally influenced zone extends as much as two miles inland.

The ground surface in the project area is located within a continuous permafrost zone (Jorgenson et al. 2008), and is characterized predominantly by ponds, lakes, fluvial landforms, and polygonal patterned ground. Permafrost ground temperatures vary with depth and are generally dependent on air temperature, snow depth, vegetation, presence of water bodies, and the presence of gravel embankments and other manmade structures.

Thawing of permafrost can occur in continuous permafrost zones in the vicinity of water bodies, and steep topography changes which allow for deep winter snow drifts, both typical scenarios along river beds, and as a result, thaw bulbs (talik) may develop.

Beneath one to two feet of seasonally thawed material, the mainland east of the lagoon is almost universally underlain by permafrost. Horizontally layered ice masses are common and near vertical ice wedges that have developed in soil contraction cracks often result in a surface feature known as polygonal ground. The segregated ice is generally confined to fine-grained, organic-rich surface material, but under some conditions ice wedges have penetrated into the underlying granular material.

3.2 Site Setting

Based on a review of aerial imagery and available LiDAR, the study area is characterized by hummocky terrain, ponds, lakes, and fluvial landforms. Polygonal ground is evident throughout the site, indicating the presence of wedge ice formations. Pingos are also evident throughout the study area, which is also indicative of the presence of ground ice and thaw settlement protentional.

Existing geological and geotechnical data collected in the area indicates the study area generally consists of three distinct soil horizons: 1) fine grained and organic deposits, 2) undifferentiated alluvial deposits, and 3) outwash deposits (Golder 2013, 2016). The fine grained and organic deposits generally consist of peat, organic silt, mineral silt, and/or clay, with an average moisture content of 171% (Golder 2016). The undifferentiated alluvial deposits generally consist of silty sand and poorly graded sand and gravel, with an average moisture content of 21% (Golder 2016). Outwash deposits generally consist of silty gravel and poorly graded gravel and sand, with an average moisture content of 12%. The depth of each of these soil horizons is highly variable across the study area. Mayfield et al. (1984) provide a surficial geology map of the area showing the project area largely consists of Quaternary terrace, lacustrine, alluvial, colluvial, and glacial deposits. Isolated occurrences of exposed bedrock present in the study area are mapped as massive limestone and dolomite of the Devonian period (419.2 million years before present [Ma], Mayfield et al. 1984)

In 2017 Stantec conducted a Wetland Delineation and Functions & Values Assessment that spans the project area. The results of that study indicate nearly the entire project area is underlain by waters and wetlands to varying degrees, with a small area of uplands, which are defined as being elevated from the surrounding wetlands and consisting of relatively drier soils. Wetlands range from palustrine saturated and seasonally flooded to palustrine flooded. According to Stantec (2017), palustrine saturated and seasonally flooded wetlands are saturated and seasonally flooded areas that are commonly found on slight inclines bordering lagoons and ponds, and commonly consist of increased ice wedge content. Palustrine flooded wetlands are the transition between permanently flooded and seasonally flooded/saturated, and generally contain river sloughs.

4.0 GENERALIZED SURFICIAL TERRAIN UNIT MAP

For this effort, we mapped terrain units based on existing geological and geotechnical data, aerial imagery, available LiDAR, and wetland classifications provided by Stantec (2017). The generalized surficial terrain unit map is provided as Figure 2. Table 1 below provides descriptions, characteristics, and geotechnical interpretations of factors affecting potential airport locations for the identified terrain units. We acknowledge that geotechnical behavior of soil may vary significantly due to variations in site-specific conditions but provide generalized engineering interpretations of anticipated soil behavior for each identified terrain unit. Considering these interpretations, we provided a relative ranking of the units on suitability for a potential future airport location, where one is most preferable and five is least preferable.

Table 1: Generalized Surficial Terrain Unit Descriptions

Terrain Unit Symbol	Terrain Unit Name	Description	Engineering Interpretations			
			Frost Heave Potential	Thaw Settlement Potential	Flood Potential	Rank
Qu + Saturated and Seasonally Flooded	(Quaternary) Undivided surficial deposits – saturated and seasonally flooded	Tundra and ice-rich material including lacustrine, alluvial, colluvial, and glacial deposits. Consists of clay, silt, sand, and gravel (Mayfield et al. 1984, Golder 2016). Characterized as palustrine saturated and seasonally flooded (Stantec 2017).	High	High	Moderate	1
Qu + Flooded	(Quaternary) Undivided surficial deposits – flooded	Tundra and ice-rich material including lacustrine, alluvial, colluvial, and glacial deposits. Consists of clay, silt, sand, and gravel (Mayfield et al. 1984, Golder 2016). Characterized as palustrine flooded (Stantec 2017).	High	High	High	2
Db3 + Upland	(Devonian) Exposed bedrock – upland	Light to dark gray massive to thick-bedded Devonian limestone and dolomite occurring in low rubble-covered hills (Mayfield et al. 1984). Vegetation, where present, consists of relatively drier soils and larger shrubs (Stantec 2017).	Low	Low	Low	3
Qt	(Quaternary) Terrace deposits	Inactive alluvial deposits. Consists of silt, sand, and gravel at or above high-water stage, and covered with stable vegetation (Mayfield et al. 1984).	Moderate	Moderate to High	High	4
Qa	(Quaternary) Alluvial deposits	Active stream and riverbeds and low terraces. Consists of sorted and layered sand, gravelly sand, and sandy gravel with some silty layers. Sparsely vegetated.	Low (high if surface cover)	Low	High	5

Note: These interpretations are based on the current understanding and anticipated conditions for each soil unit. Field verification will be necessary for refinement.

It is noted that the Db3 + Upland terrain unit ranks “Low” on the engineering interpretations, but overall it is ranked third. This is due to relatively drastic elevation changes in this area and anticipated shallow depth to bedrock that would require significant blasting during airport construction, and the location on a hill may present difficulties to airport operation. The Qt terrain unit also ranks relatively better in both frost heave and thaw settlement potential but is ranked fourth due to the anticipated presence of talik and high flood potential that would present challenges with airport construction and operation. Golder (2013) conducted hand probes and excavated test holes in the Qt unit near the new road and found unfrozen peat underlain by frozen silty sand, and generally described the area as very wet. There are many water bodies present in the Qt terrain unit that would require additional material for airport construction. Active alluvial deposits (Qa terrain unit) are ranked last due to very high flood potential.

The Qu + Saturated and Seasonally Flooded terrain unit was identified as the best candidate for proposed airport locations due to its consistent elevation and relatively lower likelihood for flood potential. It is noted that this unit does consist of polygonal patterned ground and pingos, which is indicative of ground ice, creating high potential for thaw settlement.

A ”Slope” layer is included in the surficial terrain unit map (Figure 2) indicating areas with approximately 5% grade or more. These areas are not recommended for airport construction regardless of the surficial terrain unit due to constructability. The relatively flat-lying area between the hills in the northwestern portion of the map is also not initially viewed as a preferred location for airport construction due to accessibility and anticipated snow drifting.

Four proposed airport locations are identified in Figure 2. In considering potential airport locations, we targeted the Qu + Saturated and Seasonally Flooded terrain units at least one mile long in the north-northeast direction. The proposed airport location descriptions include relative geotechnical benefits and risks and are discussed in further detail below.

Proposed Airport Location 1

Proposed Airport Location 1 is south of the Kivalina River and about one mile west of Kisimigiuktuk Hill. The subsurface conditions generally consist of an unfrozen organic peat mat, underlain by frozen organic silt and clay, underlain by frozen mineral silt (Golder 2013, 2016). These layers are likely underlain by alluvium and outwash deposits, and ultimately bedrock. The location is in an area of continuous permafrost with polygonal patterned ground evident in aerial imagery, indicating thaw settlement potential. Due to the proximity to Kisimigiuktuk Hill, however, bedrock may be relatively shallower than other proposed airport locations which may reduce overall thaw settlement. Stantec (2017) identifies this as palustrine saturated and seasonally flooded, indicating the area is likely wet which will require additional materials to construct the airport. The proximity to Kisimigiuktuk Hill gives this area a greater elevation change than other alternate locations which may require additional blasting.

Proposed Airport Location 2

This location is approximately 2.5 miles west of Kisimigiuktuk Hill and just south of the Kivalina River. The subsurface soils in this location likely consist of an unfrozen organic peat mat overlying frozen clay and silt, overlying alluvium deposits and outwash deposits (Golder 2013, 2016). There is continuous permafrost with polygonal patterned ground evident in aerial imagery, indicating the presence of ground ice and thaw settlement potential. The elevation increases in the south and east of this proposed alignment, which will require material removal during airport construction, but is otherwise fairly consistent throughout. This area is identified by Stantec (2017) as palustrine saturated and seasonally flooded, indicating the area is likely wet which will require additional materials to construct the airport.

Proposed Airport Location 3

This location is about five miles southwest of Kisimigiuktuk Hill and a half of a mile inland from the Kivalina Lagoon. The distance from the new school and evacuation building is greater at this location than the alternate proposed airport locations. The subsurface soils likely consist of an unfrozen organic peat mat, underlain by frozen clay and silt, alluvium deposits, and outwash deposits (Golder 2013, 2016). There is continuous permafrost throughout and polygonal patterned ground is evident in aerial imagery, indicating the presence of ground ice and thaw settlement potential. Two pingos are evident in LiDAR and aerial imagery approximately 500 and 1000 feet west of the proposed alignment, which should be avoided during construction. The elevation is consistent throughout this proposed location. This area is identified by Stantec (2017) as palustrine saturated and seasonally flooded, indicating the area is likely wet which will require additional materials to construct the airport.

Proposed Airport Location 4

Proposed Airport Location 4 is approximately three miles southwest of Kismigiuktuk Hill and south of the Kivalina River. The subsurface soils in this location likely consist of an unfrozen organic peat mat overlying frozen clay and silt, overlying alluvium deposits and outwash deposits (Golder 2013, 2016). There is continuous permafrost throughout and polygonal patterned ground is evident in aerial imagery, indicating the presence of ground ice and thaw settlement potential. Pingos are also apparent in LiDAR and aerial imagery within approximately 150 feet of the proposed alignment, which should be avoided during construction. The elevation is consistent throughout this proposed location. This area is identified by Stantec (2017) as palustrine saturated and seasonally flooded as well as palustrine flooded, indicating the area is likely wet which will require additional materials to construct the airport. The northern end of this proposed alignment is located near the Kivalina River, which may subject the location to flooding events.

5.0 DISCUSSION

We have developed a generalized surficial terrain unit map based on existing geotechnical and environmental data and have identified four proposed airport locations that should be investigated further. Based on our background review, the project area largely consists of ice-rich lacustrine, alluvial, colluvial, and glacial deposits, commonly consisting of organics, clay, silt, sand, and gravel. Polygonal patterned ground and the presence of pingos indicates ground ice formations are prevalent throughout the project area. Nearly the entire project area is underlain by waters and wetlands to varying degrees (Stantec 2017). The proposed potential airport locations have been chosen in the relatively less saturated and flooded wetland areas that are flat-lying and at least one mile long in the north-northeast direction. Additional explorations will be necessary to determine the geotechnical properties of the exact area chosen for the proposed new airport facility.

6.0 CLOSING

We appreciate the opportunity to work with you on this project. If you have any questions, please do not hesitate to reach out to John Thornley at 907-787-9370 or Jessica Feenstra at 907-202-8192.

WSP USA Inc.

Jessica P. Feenstra
Senior Geologist/Geophysicist

John D. Thornley, PhD, PE, BC.GE
Assistant Vice President

JPF/JDT/mlp

Attachments: Figure 1: Vicinity Map
Figure 2: Surficial Terrain Unit Map

7.0 REFERENCES

Golder (Golder Associates Inc.) 2016. Kivalina Evacuation Road Geotechnical Report, Kivalina, Alaska, submitted to Northwest Arctic Borough, submitted by Golder Associates Inc., Anchorage, AK, Project No. 1664429, geotechnical report, November 11, 2016.

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Last Edited By: agarrigus Date: 2023-08-04 Time:5:19:17 PM | Printed By: AGarrigus Date: 2023-10-04 Time:2:36:18 PM
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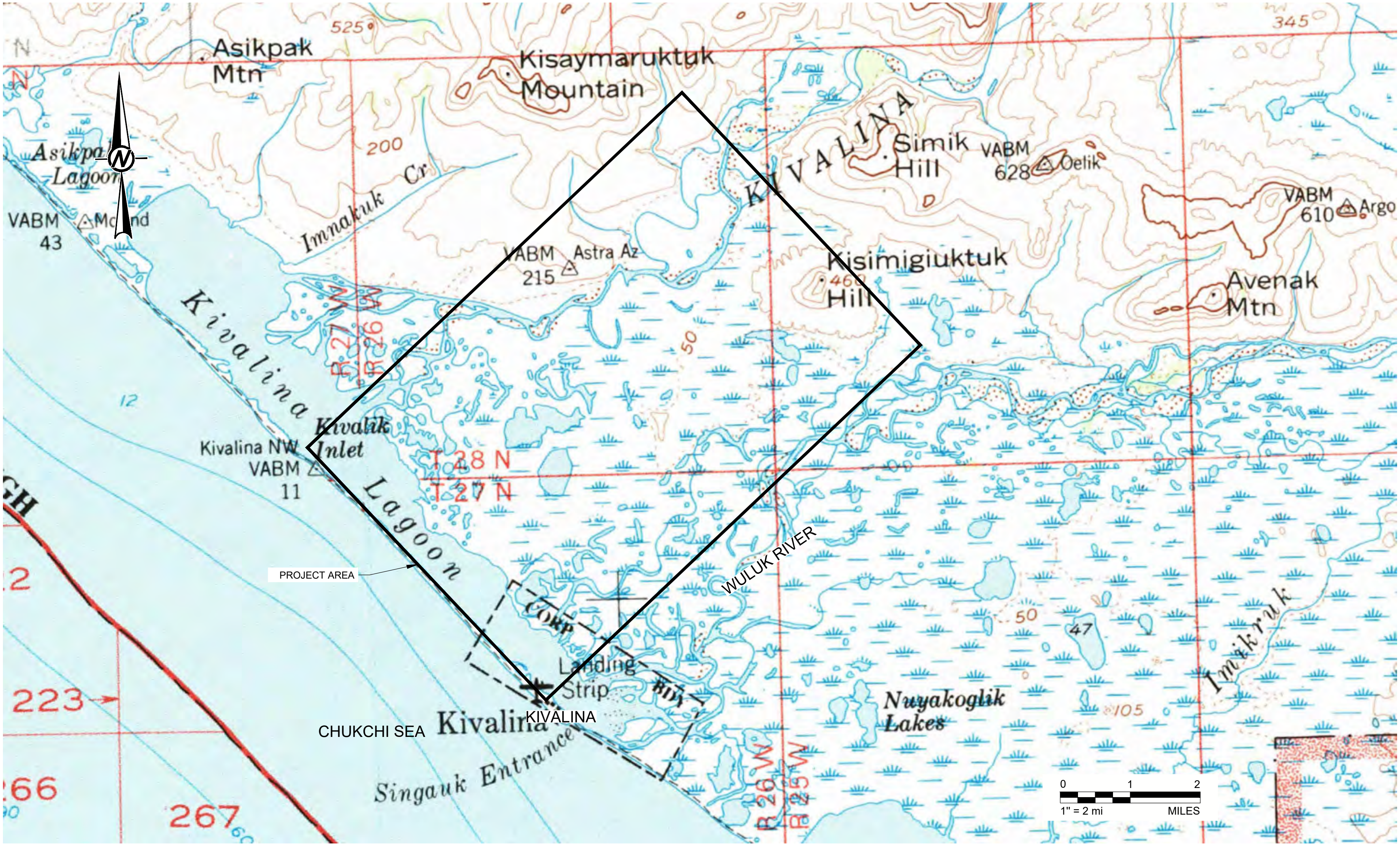

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REFERENCE
TOPOGRAPHIC MAPS WERE PRODUCED AND DISTRIBUTED BY USGS.

CLIENT
STANTEC CONSULTING SERVICES INC.

PROJECT
KIVALINA AIRPORT RELOCATION–GEOTECHNICAL DATA REVIEW
KIVALINA, ALASKA

CONSULTANT

YYYY-MM-DD	2023-10-04
DESIGNED	-
PREPARED	APG
REVIEWED	JPF
APPROVED	JDT

TITLE
VICINITY MAP

PROJECT NO.	CONTROL	REV.	FIGURE
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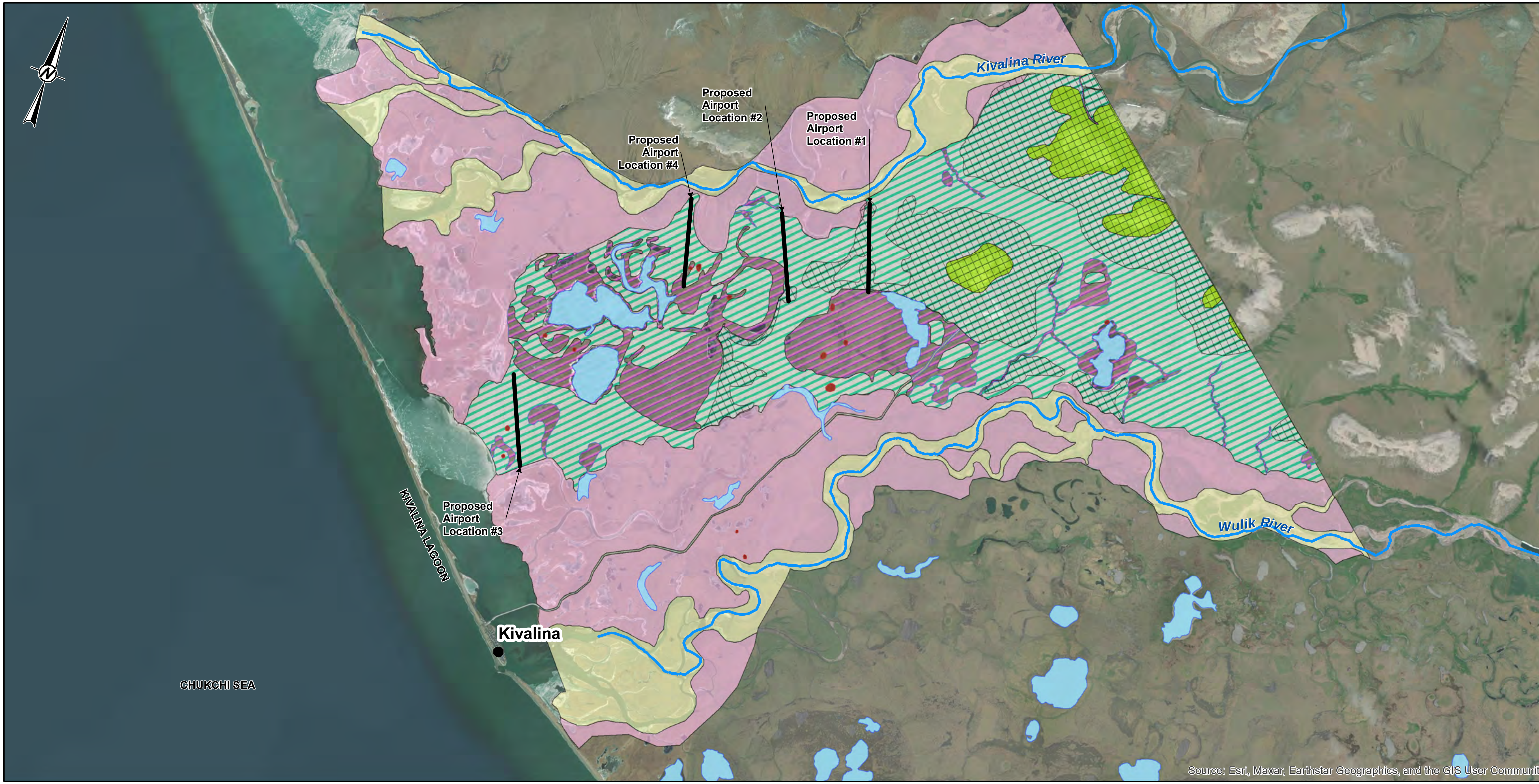

LEGEND

- Proposed Airport Relocation Lines
- Pingo
- Qu+Saturated and Seasonally Flooded
- Qu+Flooded
- Qa
- Db3+Upland
- Qt
- Steep Slopes
- Lakes
- River

REFERENCE(S)

1.ORTHOIMAGERY DATED 2021-10-08 WAS DISTRIBUTED AS WORLD IMAGERY LAYER FROM ARCGIS ONLINE. SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
2. HILLSHADE IMAGE DEVELOPED FROM BARE EARTH IFSAR ELEVATION DATA DISTRIBUTED BY STATE OF ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS (AKDGGS), FAIRBANKS, ALASKA USA.

CLIENT	STANTEC CONSULTING SERVICES INC.
PROJECT	KIVALINA AIRPORT RELOCATION–GEOTECHNICAL DATA REVIEW KIVALINA, ALASKA
CONSULTANT	wsp
YYYY-MM-DD	2023-10-02
DESIGNED	JPF
PREPARED	APG
REVIEWED	JPF
APPROVED	JDT
TITLE	SURFICIAL TERRAIN UNIT MAP
PROJECT NO.	31407010.000
CONTROL	
REV.	0
FIGURE	2

APPENDIX 5: KIVALINA AIRPORT RELOCATION – COST ESTIMATE

Engineer's Quantity Calculations

for

State of Alaska
Department of Transportation & Public Facilities
Northern Region

Construction Project:

Kivalina Airport Relocation

AIP No.

Project No.

Prepared by: Stantec

ARCHITECTURE · ENGINEERING · LAND SURVEYING · PLANNING

4/8/2024

Kivalina Airport Alternatives

Alternative	Construction Cost Estimate	Notes
Improve Existing Airport	$17,602,361	Widen RW to 100' and RSA to 150', New CASC (RW, TW, and Apron), New Airport Lighting, 1,000' of revetment repair, replace SREB
Relocate Nearshore**	$41,059,983	Includes additional 1' embankment for subsidence and a bridge over a slough
Relocate K-Hill Far**	$32,102,396	
Relocate K-Hill Near**	$29,551,030	
Relocate N of K-Hill**	$34,294,306	Includes additional 1' embankment for subsidence

** Relocation Alternatives include:
3200' x 75' Runway (ADG II)
3800' x 150' RSA (ADG II)
400' long TDG 2 Taxiway
200' x 400' Apron
Single Bay SREB
Runway and Taxiway Lighting
Lighted Windcone
PAPIs
Access Road to Existing Evacuation Road

Engineer's Estimate

Project Name: **Project Number:**

KIVALINA AIRPORT RELOCATION: Improve Existing Alt

Item No	Pay Item	Pay Unit	Quantity	Unit Price	Amount	
G-100a	MOBILIZATION AND DEMOBILIZATION	LUMP SUM	ALL REQUIRED	$1,200,000	$1,200,000	
G-115a	WORKER MEALS AND LODGING, OR PER DIEM	LUMP SUM	ALL REQUIRED	$200,000	$200,000	
G-130j	ENGINEERING COMMUNICATIONS	CONTINGENT SUM	ALL REQUIRED	$10,000	$10,000	
G-131a	ENGINEERING TRANSPORTATION (TRUCK)	EACH	2	$50,000	$100,000	
G-131b	ENGINEERING TRANSPORTATION (ATV)	EACH	1	$15,000	$15,000	
G-135a	CONSTRUCTION SURVEYING BY THE CONTRACTOR	LUMP SUM	ALL REQUIRED	$80,000	$80,000	
L-100a	AIRPORT LIGHTING	LUMP SUM	ALL REQUIRED	$1,500,000	$1,500,000	
P-152a	UNCLASSIFIED EXCAVATION	CUBIC YARD	1,944	$15	$29,167	
P-152i	BORROW	CUBIC YARD	23,333	$30	$700,000	
P-156a	EROSION, SEDIMENT AND POLLUTION CONTROL ADMINISTRATION	LUMP SUM	ALL REQUIRED	$15,000	$15,000	
P-156c	TEMPORARY EROSION, SEDIMENT AND POLLUTION CONTROL	LUMP SUM	ALL REQUIRED	$80,000	$80,000	
P-156d	TEMPORARY EROSION, SEDIMENT AND POLLUTION CONTROL ADDITIVES	CONTINGENT SUM	ALL REQUIRED	$25,000	$25,000	
P-156g	SWPPP MANAGER	LUMP SUM	ALL REQUIRED	$20,000	$20,000	
P-210c	CRUSHED AGGREGATE SURFACE COURSE	TON	36,539	$70	$2,557,722	
P-640b	SEGMENTED CIRCLE (PANEL-TYPE)	LUMP SUM	ALL REQUIRED	$0	$0	
P-167a	Dust Palliative	LUMP SUM	ALL REQUIRED	$250,000	$250,000	
P-XXX	EROSION PROTECTION	LINEAR FOOT	1000	$5,300	$5,300,000	
P-681a	GEOTEXTILE, SEPARATION	SQUARE YARD	0	$3	$0	
S-142p	EQUIPMENT STORAGE BUILDING	LUMP SUM	ALL REQUIRED	$2,000,000	$2,000,000	
S-1XXx	BRIDGE	LUMP SUM	ALL REQUIRED	$0	$0	
U-400a	TELEPHONE SYSTEM	LUMP SUM	ALL REQUIRED	$0	$0	
U-500b	ELECTRICAL LINE EXTENSION	LUMP SUM	ALL REQUIRED	$0	$0	
				Subtotal:	$14,081,889	
	DESIGN CONTINGENCY			25.00%	$3,520,472	$17,602,361
				Subtotal:	$17,602,361	
	EROSION PROTECT MAINTENANCE THROUGH YEAR 2060				$9,275,000	Assume 500'/10 years of reconstruction @$5300/ft over 35
				Total:	$26,877,361	

Engineer's Estimate

Project Name: **Project Number:**

KIVALINA AIRPORT RELOCATION: Relocate Nearshore

Item No	Pay Item	Pay Unit	Quantity	Unit Price	Amount
G-100a	MOBILIZATION AND DEMOBILIZATION	LUMP SUM	ALL REQUIRED	$3,000,000	$3,000,000
G-115a	WORKER MEALS AND LODGING, OR PER DIEM	LUMP SUM	ALL REQUIRED	$1,000,000	$1,000,000
G-130a	FIELD OFFICE	LUMP SUM	ALL REQUIRED	$60,000	$60,000
G-130b	FIELD LABORATORY	LUMP SUM	ALL REQUIRED	$30,000	$30,000
G-130g	NUCLEAR TESTING EQUIPMENT STORAGE SHED	EACH	1	$20,000	$20,000
G-130j	ENGINEERING COMMUNICATIONS	CONTINGENT SUM	ALL REQUIRED	$10,000	$10,000
G-131a	ENGINEERING TRANSPORTATION (TRUCK)	EACH	3	$50,000	$150,000
G-131b	ENGINEERING TRANSPORTATION (ATV)	EACH	1	$15,000	$15,000
G-135a	CONSTRUCTION SURVEYING BY THE CONTRACTOR	LUMP SUM	ALL REQUIRED	$400,000	$400,000
L-100a	AIRPORT LIGHTING	LUMP SUM	ALL REQUIRED	$1,500,000	$1,500,000
L-132aPAPI	INSTALL APPROACH LIGHTING AIDS, PAPI	LUMP SUM	ALL REQUIRED	$600,000	$600,000
P-152a	UNCLASSIFIED EXCAVATION	CUBIC YARD	0	$15	$0
P-152i	BORROW	CUBIC YARD	426,831	$30	$12,804,942
P-156a	EROSION, SEDIMENT AND POLLUTION CONTROL ADMINISTRATION	LUMP SUM	ALL REQUIRED	$50,000	$50,000
P-156c	TEMPORARY EROSION, SEDIMENT AND POLLUTION CONTROL	LUMP SUM	ALL REQUIRED	$300,000	$300,000
P-156d	TEMPORARY EROSION, SEDIMENT AND POLLUTION CONTROL ADDITIVES	CONTINGENT SUM	ALL REQUIRED	$200,000	$200,000
P-156g	SWPPP MANAGER	LUMP SUM	ALL REQUIRED	$150,000	$150,000
P-190a	INSULATION BOARD	SQUARE FOOT	0	$8	$0
P-210c	CRUSHED AGGREGATE SURFACE COURSE	TON	53,115	$70	$3,718,050
P-640b	SEGMENTED CIRCLE (PANEL-TYPE)	LUMP SUM	ALL REQUIRED	$50,000	$50,000
P-167a	Dust Palliative	LUMP SUM	ALL REQUIRED	$250,000	$250,000
P-XXX	EROSION PROTECTION	LUMP SUM	ALL REQUIRED	$0	$0

Item No	Pay Item	Pay Unit	Quantity	Unit Price	Amount
P-681a	GEOTEXTILE, SEPARATION	SQUARE YARD	234,999	$4	$939,995
S-142p	EQUIPMENT STORAGE BUILDING	LUMP SUM	ALL REQUIRED	$2,000,000	$2,000,000
S-1XXx	BRIDGE	LUMP SUM	ALL REQUIRED	$5,000,000	$5,000,000
U-400a	TELEPHONE SYSTEM	LUMP SUM	ALL REQUIRED	$200,000	$200,000
U-500b	ELECTRICAL LINE EXTENSION	LUMP SUM	ALL REQUIRED	$400,000	$400,000
				Subtotal:	$32,847,986
	DESIGN CONTINGENCY			25.00%	$8,211,997
				Subtotal:	$41,059,983

Engineer's Estimate

Project Name: **Project Number:**

KIVALINA AIRPORT RELOCATION: Relocate K-Hill Far

Item No	Pay Item	Pay Unit	Quantity	Unit Price	Amount
G-100a	MOBILIZATION AND DEMOBILIZATION	LUMP SUM	ALL REQUIRED	$3,000,000	$3,000,000
G-115a	WORKER MEALS AND LODGING, OR PER DIEM	LUMP SUM	ALL REQUIRED	$1,000,000	$1,000,000
G-130a	FIELD OFFICE	LUMP SUM	ALL REQUIRED	$60,000	$60,000
G-130b	FIELD LABORATORY	LUMP SUM	ALL REQUIRED	$30,000	$30,000
G-130g	NUCLEAR TESTING EQUIPMENT STORAGE SHED	EACH	1	$20,000	$20,000
G-130j	ENGINEERING COMMUNICATIONS	CONTINGENT SUM	ALL REQUIRED	$10,000	$10,000
G-131a	ENGINEERING TRANSPORTATION (TRUCK)	EACH	3	$50,000	$150,000
G-131b	ENGINEERING TRANSPORTATION (ATV)	EACH	1	$15,000	$15,000
G-135a	CONSTRUCTION SURVEYING BY THE CONTRACTOR	LUMP SUM	ALL REQUIRED	$400,000	$400,000
L-100a	AIRPORT LIGHTING	LUMP SUM	ALL REQUIRED	$1,500,000	$1,500,000
L-132aPAPI	INSTALL APPROACH LIGHTING AIDS, PAPI	LUMP SUM	ALL REQUIRED	$600,000	$600,000
P-152a	UNCLASSIFIED EXCAVATION	CUBIC YARD	0	$20	$0
P-152i	BORROW	CUBIC YARD	373,498	$30	$11,204,944
P-156a	EROSION, SEDIMENT AND POLLUTION CONTROL ADMINISTRATION	LUMP SUM	ALL REQUIRED	$50,000	$50,000
P-156c	TEMPORARY EROSION, SEDIMENT AND POLLUTION CONTROL	LUMP SUM	ALL REQUIRED	$300,000	$300,000
P-156d	TEMPORARY EROSION, SEDIMENT AND POLLUTION CONTROL ADDITIVES	CONTINGENT SUM	ALL REQUIRED	$200,000	$200,000
P-156g	SWPPP MANAGER	LUMP SUM	ALL REQUIRED	$150,000	$150,000
P-167a	Dust Palliative	LUMP SUM	ALL REQUIRED	$250,000	$250,000
P-210c	CRUSHED AGGREGATE SURFACE COURSE	TON	47,930	$70	$3,355,087
P-640b	SEGMENTED CIRCLE (PANEL-TYPE)	LUMP SUM	ALL REQUIRED	$50,000	$50,000
P-681a	GEOTEXTILE, SEPARATION	SQUARE YARD	209,221	$4	$836,886
S-142p	EQUIPMENT STORAGE BUILDING	LUMP SUM	ALL REQUIRED	$2,000,000	$2,000,000
S-1XXx	BRIDGE	LUMP SUM	ALL REQUIRED	$0	$0
U-400a	TELEPHONE SYSTEM	LUMP SUM	ALL REQUIRED	$150,000	$150,000
U-500b	ELECTRICAL LINE EXTENSION	LUMP SUM	ALL REQUIRED	$350,000	$350,000
				Subtotal:	$25,681,917
	DESIGN CONTINGENCY			25.00%	$6,420,479
				Subtotal:	$32,102,396

Engineer's Estimate

Project Name: **Project Number:**

KIVALINA AIRPORT RELOCATION: Relocate K-Hill Near

Item No	Pay Item	Pay Unit	Quantity	Unit Price	Amount
G-100a	MOBILIZATION AND DEMOBILIZATION	LUMP SUM	ALL REQUIRED	$3,000,000	$3,000,000
G-115a	WORKER MEALS AND LODGING, OR PER DIEM	LUMP SUM	ALL REQUIRED	$1,000,000	$1,000,000
G-130a	FIELD OFFICE	LUMP SUM	ALL REQUIRED	$60,000	$60,000
G-130b	FIELD LABORATORY	LUMP SUM	ALL REQUIRED	$30,000	$30,000
G-130g	NUCLEAR TESTING EQUIPMENT STORAGE SHED	EACH	1	$20,000	$20,000
G-130j	ENGINEERING COMMUNICATIONS	CONTINGENT SUM	ALL REQUIRED	$10,000	$10,000
G-131a	ENGINEERING TRANSPORTATION (TRUCK)	EACH	4	$50,000	$200,000
G-131b	ENGINEERING TRANSPORTATION (ATV)	EACH	1	$15,000	$15,000
G-135a	CONSTRUCTION SURVEYING BY THE CONTRACTOR	LUMP SUM	ALL REQUIRED	$500,000	$500,000
L-100a	AIRPORT LIGHTING	LUMP SUM	ALL REQUIRED	$1,500,000	$1,500,000
L-132aPAPI	INSTALL APPROACH LIGHTING AIDS, PAPI	LUMP SUM	ALL REQUIRED	$600,000	$600,000
P-152a	UNCLASSIFIED EXCAVATION	CUBIC YARD	0	$20	$0
P-152i	BORROW	CUBIC YARD	314,424	$30	$9,432,719
P-156a	EROSION, SEDIMENT AND POLLUTION CONTROL ADMINISTRATION	LUMP SUM	ALL REQUIRED	$50,000	$50,000
P-156c	TEMPORARY EROSION, SEDIMENT AND POLLUTION CONTROL	LUMP SUM	ALL REQUIRED	$300,000	$300,000
P-156d	TEMPORARY EROSION, SEDIMENT AND POLLUTION CONTROL ADDITIVES	CONTINGENT SUM	ALL REQUIRED	$200,000	$200,000
P-156g	SWPPP MANAGER	LUMP SUM	ALL REQUIRED	$150,000	$150,000
P-167a	Dust Palliative	LUMP SUM	ALL REQUIRED	$250,000	$250,000
P-210c	CRUSHED AGGREGATE SURFACE COURSE	TON	44,300	$70	$3,101,013
P-640b	SEGMENTED CIRCLE (PANEL-TYPE)	LUMP SUM	ALL REQUIRED	$50,000	$50,000
P-681a	GEOTEXTILE, SEPARATION	SQUARE YARD	168,023	$4	$672,092
S-142p	EQUIPMENT STORAGE BUILDING	LUMP SUM	ALL REQUIRED	$2,000,000	$2,000,000
S-1XXx	BRIDGE	LUMP SUM	ALL REQUIRED	$0	$0
U-400a	TELEPHONE SYSTEM	LUMP SUM	ALL REQUIRED	$150,000	$150,000
U-500b	ELECTRICAL LINE EXTENSION	LUMP SUM	ALL REQUIRED	$350,000	$350,000
				Subtotal:	$23,640,824
	DESIGN CONTINGENCY			25.00%	$5,910,206
				Subtotal:	$29,551,030

Engineer's Estimate

Project Name: KIVALINA AIRPORT RELOCATION: N of K-Hill

Project Number:

Item No	Pay Item	Pay Unit	Quantity	Unit Price	Amount
G-100a	MOBILIZATION AND DEMOBILIZATION	LUMP SUM	ALL REQUIRED	$3,000,000	$3,000,000
G-115a	WORKER MEALS AND LODGING, OR PER DIEM	LUMP SUM	ALL REQUIRED	$1,000,000	$1,000,000
G-130a	FIELD OFFICE	LUMP SUM	ALL REQUIRED	$60,000	$60,000
G-130b	FIELD LABORATORY	LUMP SUM	ALL REQUIRED	$30,000	$30,000
G-130g	NUCLEAR TESTING EQUIPMENT STORAGE SHED	EACH	1	$20,000	$20,000
G-130j	ENGINEERING COMMUNICATIONS	CONTINGENT SUM	ALL REQUIRED	$10,000	$10,000
G-131a	ENGINEERING TRANSPORTATION (TRUCK)	EACH	4	$50,000	$200,000
G-131b	ENGINEERING TRANSPORTATION (ATV)	EACH	1	$15,000	$15,000
G-135a	CONSTRUCTION SURVEYING BY THE CONTRACTOR	LUMP SUM	ALL REQUIRED	$500,000	$500,000
L-100a	AIRPORT LIGHTING	LUMP SUM	ALL REQUIRED	$1,500,000	$1,500,000
L-132aPAPI	INSTALL APPROACH LIGHTING AIDS, PAPI	LUMP SUM	ALL REQUIRED	$600,000	$600,000
P-152a	UNCLASSIFIED EXCAVATION	CUBIC YARD	0	$20	$0
P-152i	BORROW	CUBIC YARD	408,228	$30	$12,246,833
P-156a	EROSION, SEDIMENT AND POLLUTION CONTROL ADMINISTRATION	LUMP SUM	ALL REQUIRED	$50,000	$50,000
P-156c	TEMPORARY EROSION, SEDIMENT AND POLLUTION CONTROL	LUMP SUM	ALL REQUIRED	$300,000	$300,000
P-156d	TEMPORARY EROSION, SEDIMENT AND POLLUTION CONTROL ADDITIVES	CONTINGENT SUM	ALL REQUIRED	$200,000	$200,000
P-156g	SWPPP MANAGER	LUMP SUM	ALL REQUIRED	$150,000	$150,000
P-167a	Dust Palliative	LUMP SUM	ALL REQUIRED	$250,000	$250,000
P-210c	CRUSHED AGGREGATE SURFACE COURSE	TON	48,656	$70	$3,405,902
P-640b	SEGMENTED CIRCLE (PANEL-TYPE)	LUMP SUM	ALL REQUIRED	$50,000	$50,000
P-681a	GEOTEXTILE, SEPARATION	SQUARE YARD	236,928	$4	$947,710
S-142p	EQUIPMENT STORAGE BUILDING	LUMP SUM	ALL REQUIRED	$2,000,000	$2,000,000
S-1XXx	BRIDGE	LUMP SUM	ALL REQUIRED	$0	$0
U-400a	TELEPHONE SYSTEM	LUMP SUM	ALL REQUIRED	$350,000	$350,000
U-500b	ELECTRICAL LINE EXTENSION	LUMP SUM	ALL REQUIRED	$550,000	$550,000
				Subtotal:	$27,435,445
	DESIGN CONTINGENCY			25.00%	$6,858,861
				Subtotal:	$34,294,306

RELOCATE K-Hill Far (River Alt)

	Alternative	X section End Area (SF)	Length	Width	Depth	Area (SY)	Volume (CY)	Tons (x2)
Runway	Total Fill							
							241926.00	
							0	0
	CABC		3800	150	0.75		15833.33333	31666.67
	Borrow						226,093	
	Geotextile Fabric					109222		
APRON AND TW	Total Fill						38500	
	CABC-APRON		200	400	0.75		2222.222222	
	CABC-TW		330	79	0.75		724.1666667	
	Borrow						35554	
	Geotextile Fabric					15555		
Road	Total Fill	316	10000				117037.037	
	CABC		10000	28	0.5		5185.185185	
	Borrow						111851.8519	
	Geotextile Fabric		10000	76		84444		

						Area (SY)	Volume (CY)	Tons (x2)
Airport	Borrow						373,498	
	Subbase						0	
	CABC						23,965	47,930
	Geotextile Fabric					209,221		

RELOCATE Nearshore

	Alternative	X section End Area (SF)	Length	Width	Depth	Area (SY)	Volume (CY)	Tons (x2)	Note
Runway	Total Fill								Includes additional 1' of embankment for subsidence
							226000.00		
	CABC		3800	150	0.75		15833.33333		
	Borrow						226,000		
	Geotextile Fabric					90555			

Stantec

APRON & TW	Total Fill						36000	
	CABC-APRON		200	400	0.75		2222.222222	
	CABC-TW		330	79	0.75		724.1666667	
	Borrow						33053.61111	
	Geotextile Fabric					17777		

Road	Total Fill	316	15000				175555.5556	
	CABC		15000	28	0.5		7777.777778	
	Borrow						167777.7778	
	Geotextile Fabric		15000	76		126667		
	+BRIDGE							

						Area (SY)	Volume (CY)	Tons (x2)
Airport	Borrow						426,831	853,663
	CABC						26,558	53,115
	Geotextile Fabric					234,999		

RELOCATE K-Hill Near

	Alternative	X section End Area (SF)	Length	Width	Depth	Area (SY)	Volume (CY)	Tons (x2)
Runway	Total Fill							
							265500.00	
	CABC		3800	150	0.75		15833.33333	
	Borrow						249,667	
	Geotextile Fabric					98500		

APRON & TW	Total Fill						-5000	
	CABC-APRON		200	400	0.75		2222.222222	
	CABC-TW		330	79	0.75		724.1666667	
	Borrow						-7946.38889	
	Geotextile Fabric					14634		

Road	Total Fill	316	6500				76074.07407	
	CABC		6500	28	0.5		3370.37037	
	Borrow						72703.7037	
	Geotextile Fabric		6500	76		54889		

						Area (SY)	Volume (CY)	Tons (x2)
Airport	Borrow						314,424	628,848
	CABC						22,150	44,300
	Geotextile Fabric					168,023		

RELOCATE N of K-Hill (VALLEY ALT)

	Alternative	X section End Area (SF)	Length	Width	Depth	Area (SY)	Volume (CY)	Tons (x2)	Note
Runway	Total Fill								Includes additional 1' of embankment for subsidence
							266100.00		
	CABC		3800	150	0.75		15833.33333		
	Borrow						250,267		
	Geotextile Fabric					128130			

APRON and TW	Total Fill						41226	
	CABC-APRON		200	400	0.75		2222.222222	
	CABC-TW		330	79	0.75		724.1666667	

	Borrow						38279.61111	
	Geotextile Fabric					18442		

	Total Fill	316	10700				125229.6296	
Road	CABC		10700	28	0.5		5548.148148	
	Borrow						119681.4815	
	Geotextile Fabric		10700	76		90356		

						Area (SY)	**Volume (CY)**	**Tons (x2)**
Airport	Borrow						408,228	
	CABC						24,328	48,656
	Geotextile Fabric					236,928		
	Excavation						0	

EXISTING AIRPORT IMPROVEMENTS

RUNWAY	**Alternative**	**X section End Area (SF)**	**Length**	**Width**	**Depth**	**Area (SY)**	**Volume (CY)**	**Tons (x2)**	
	Total Fill					35000	23333.33333		Assume 2' Borrow for RSA widening
	Excavation					35000	1944.44		Assume 6" excavation prior to placing RSA borrow
	CABC - RW		3600	150	0.75		15000	30000	
	CABC - APRON		290	130	0.75		1047.222222		
	CABC - TW		1600	50	0.75		2,222		
	Borrow						0		
	Geotextile Fabric								

						Area (SY)	**Volume (CY)**	**Tons (x2)**
Airport	Borrow						23,333	
	CABC						18,269	36,539
	Geotextile Fabric							
	Excavation						1,944	