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# Technical Memorandum

**Date:** June 3, 2015

**To:** Keith Gordon, U.S. Army Corps of Engineers

**From:** Kristof Fabian, Ph.D., and Nancy Darigo, PG, CEG, AECOM

**Subject:** Evaluation of Proposed Donlin Gold Tailings Storage Facility Dam with Respect to Mount Polley Tailings Dam Breach

## 1.0 Introduction

The failure of the Imperial Metals Mount Polley tailings dam in British Columbia (BC) on August 4, 2014 has drawn much media attention and increased the level of concern about the Donlin Gold Tailings Storage Facility (TSF) dam with respect to design, construction, and operations issues. Following the Mount Polley incident, the BC government initiated a probe into the cause of the dam breach, engaging three of the most reputable civil/geotechnical engineers in the mining industry to serve as an Independent Expert Engineering Investigation and Review Panel (IEEIRP).

This memorandum has been prepared to:

- Compare current Alaska and BC dam safety regulations;
- Summarize the findings of the IEEIRP;
- Compare the proposed Donlin Gold TSF design to that of the Mount Polley dam;
- Inform the evaluation of geohazard/geotechnical and hydrologic effects in the Donlin Gold EIS; and
- Provide comparative context information for developing a potential dam failure spill scenario in the Donlin Gold EIS.

## 2.0 Comparison of Alaska and BC Dam Safety Regulations

The following is a comparison between the current dam safety programs of Alaska and BC. This comparison is not intended as a detailed legal evaluation, but rather as a comparison of how a practicing engineer would be affected by the two programs.

### 2.1 Alaska Dam Safety Program

The Alaska Department of Natural Resources (ADNR) issued its Alaska Dam Safety Program guidance in 2005 (ADNR 2005). It is a comprehensive program providing requirements and guidelines for the five stages of a dam's life (application, construction, operation, remediation, and closure). The regulations are very specific about the following:

- Hazard classification (Section 2);
- Design (Section 6) providing clear requirements and guidance on hydrology and hydraulics, stability, seismicity, seepage, and cold regions considerations;

- Construction (Section 7) with specific requirements for construction quality assurance/quality control plans;
- Operations and Maintenance (Section 8);
- Emergency Action Planning (Section 9);
- Inspections (Section 10) with specific requirements for extraordinary inspections after unique events, periodic safety inspections in accordance with hazard classification, and inspection checklists and guidance;
- Performance and Incident Reporting (Section 11);
- Remedial Investigations and Decision Making (Section 12); and
- Closure (Section 13).

## 2.2 Dam Safety in BC

In BC, there are several legislative, regulatory, and industry guidance documents affecting the design, construction, and operations of dams:

- The design, construction, and operation of dams on mine sites is covered by regulations and requirements under the BC Mines Act of 1996 and the *Health, Safety and Reclamation Code for Mines in British Columbia* (BC 2008). The code requires that major impoundments, water management facilities, and dams be designed in accordance with criteria provided in the Canadian Dam Association (2013) *Dam Safety Guidelines*;
- *Plan Submission Requirements for the Construction and Rehabilitation of Dams* (BC 2013b);
- *Water Act, British Columbia Dam Safety Regulation* (BC 2011c) aimed at the operation of dams;
- *Information Sheet, BC Dam Safety Regulation* (BC 2011a) which describes compliance reporting requirements;
- Professional practice guidelines by the Association of Professional Engineers and Geoscientists of BC (APEGBC 2013) for *Legislated Dam Safety Reviews in BC*, which replaced BC (2012) review guidelines;
- BC Water Management Branch (2011b) *Inspection & Maintenance of Dams, Dam Safety Guidelines*;
- *Developing an Operations, Maintenance and Surveillance Manual for Tailings and Water Management Facilities* (Mining Association of Canada 2011b);
- *A Guide to Management of Tailings Facilities* (Mining Association of Canada 2011a); and
- *BC Mining Dams – "At a Glance" Requirements* (BC 2014).

Most of the above guidelines connect back to basic principles and procedures presented in the Canadian Dam Association (2013) *Dam Safety Guidelines*. This document provides guidelines regarding dam safety management; operation, maintenance and surveillance; emergency preparedness; dam safety review; and analysis and assessment. In addition, Canadian Dam Association published a number of Technical Bulletins in 2007 to supplement the guidelines, entitled:

- *Inundation, Consequences, and Classification for Dam Safety;*
- *Surveillance of Dam Facilities;*
- *Flow Control Equipment for Dam Safety;*
- *Public Safety and Security Around Dams;*
- *Dam Safety Analysis and Assessment;*
- *Seismic Hazard Considerations for Dam Safety;*

- *Geotechnical Considerations for Dam Safety; and*
- *Structural Considerations for Dam Safety.*

## 2.3 Comparison between Alaska and BC Regulations

Points of comparison can be drawn between the Alaska and BC regulations regarding hazard classification and dam inspection.

### 2.3.1 Hazard Classification

Alaska has three categories of hazard classification that are used to identify the level of risk for certain aspects of dam design and operations (ADNR 2005, Table 2-1):

| | | |
|---|---|---|
| I | High | Probable loss of life |
| II | Significant | No loss of life, although significant danger to public health may exist; significant loss of property; loss or damage to anadromous fish stream |
| III | Low | Insignificant danger to human health, limited damage to property |

Canadian Dam Association (2007, 2013) and the BC Water Act (BC 2011c) have five classifications with respect to hazard:

| | |
|---|---|
| Extreme | Loss of life >100, major loss to environment, extremely high economic loss |
| Very High | Loss of life <100, significant loss to environment, very high economic loss |
| High | Loss of life <10, significant loss to environment, high economic loss |
| Significant | Low potential for loss of life, no significant loss to environment, low economic loss |
| Low | No loss of life, minimal loss to environment, minimal economic loss |

It is notable that the highest hazard classification under Alaska regulations applies to any potential for human casualties, while different thresholds of casualties differentiate the three highest classifications under BC regulations.

### 2.3.2 Reviews and Inspections

Reviews of preliminary and detailed design and construction packages are conducted by ADNR staff and experienced engineering consultants contracted by the State of Alaska. In some cases (e.g. Class I dams), ADNR may require that a Failure Modes Effects Analysis (FMEA) be conducted by a team of experienced engineers during the design phase as a risk assessment tool to identify potential design flaws and mitigation priorities (ADNR 2005, Cobb 2014). Typically mine owners also have a separate independent technical review panel. In the case of the Donlin Gold TSF dam, owner company Barrick Gold requires the use of an independent technical review team to review dam design.

Alaska requires the following schedule for formal detailed Periodic Safety Inspections to be performed by a qualified engineer in accordance with guidelines specified in Section 10 and Appendix A of the ADNR (2005) guidance:

| | |
|---|---|
| Class I and II | minimum of every 3 years |
| Class III | every 5 years |

In addition to Periodic Safety Inspections, construction, routine, and extraordinary inspections are required by ADNR. Routine inspections would be as specified in the operation and maintenance manual. An earthquake occurring during operations is an example of an event that would require an extraordinary inspection.

Design reviews in BC are typically conducted by the Engineer of Record based on BC, Canadian Dam Association, and Mining Association of Canada codes and guidelines described in Section 2.2. Regulators are limited by statute from taking on design responsibilities. The use of an Independent Tailings Review Board to provide third-party advice is increasingly becoming the standard of practice, but is not required for regulatory approval. BC currently hires an experienced engineering firm to review Independent Tailings Review Board findings. It is unknown if an Independent Tailings Review Board was used during the Mount Polley design phase, and current BC rules and practices regarding design reviews may not have been in place at the time of the initial Mount Polley dam design.

BC (2011c) has a complex inspection schedule (referred to as Schedule 2) to be performed by the dam owner. For mine tailings dams, the inspection schedule is set forth by requirements in BC (2014) that refer back to Canadian Dam Association (2007, 2013) requirements. Dam safety reviews must be performed for the various hazard classifications as follows:

| | |
|---|---|
| Extreme | every 5 years |
| Very High | every 5 years |
| High | every 7 years |
| Significant | every 10 years |
| Low | none, although the classification must be revised if downstream land-use changes |

The BC code also requires annual Dam Safety Inspections to be carried out for all dams at a mine site in accordance with BC Ministry of Energy and Mines guidelines (BC 2013a). Reports are required to be submitted by a qualified professional engineer registered with the APEGBC.

The Donlin Gold TSF will likely be Class I. It is unknown what the Mount Polley dam hazard class is. Regardless, based on a comparison of the above reviews and inspection schedules, a Class I or Class II dam under the Alaska Dam Safety Program would likely undergo a similar level of design review, but with more frequent formal inspections than a similar dam in BC.

### 2.3.3 Recent Regulatory Developments in BC

#### *2.3.3.1 Dam Safety Inspection Reviews*

In light of the Mount Polley tailings dam failure, the BC Chief Inspector of Mines issued orders to owners, agents, or managers responsible for tailings dams to review the safety of tailings impoundment structures at all mines in the province, and to establish where improvements may be required. The orders expedited the normal annual Dam Safety Inspection schedule from March 30, 2015 to December 1, 2014, and required completion of the following:

- Review of the Dam Safety Inspection by an independent qualified professional engineer who has not been previously associated with the dam;
- Review of the dam consequence classification;

- Update and testing of the Emergency Preparedness and Response Plan (EPRP);
- Completion of a dam break inundation study; and
- Summary of commitments for completing the recommended work along with a schedule for implementation.

The intent of the orders was to provide an overall picture of dam safety in BC, recognizing that they would provide information on a component of a much larger dam safety framework (Hatch, 2015).

#### *2.3.3.2 Environmental Reviews*

In addition to the expedited Dam Safety Inspection reviews, the BC Environmental Assessment Office recently took steps to ensure the safety of tailings management facilities at new mines. Following recommendations in the Mount Polley IEEIRP report, additional information requirements have been established for mines undergoing environmental assessments. Developed in collaboration between BC Ministry of Energy and Mines and the Ministry of Environment, the additional requirements apply to mines in all stages of environmental assessment, and have been outlined in writing for each company and posted on the Environmental Assessment Office's website.

Companies proposing to build mines with new tailings dams will need to show the following to support alternative selection:

- Options other than the selected option have been considered that address the potential for adverse effects on environmental, health, social, heritage, and economic values;
- Potential risks and implications of the selected option that have been considered, along with a technically and economically feasible plan to address them; and
- Clear and transparent rationale to support the selected option.

Companies will need to provide the following information:

- A description and assessment of alternative means of undertaking the proposed project with respect to options for tailings management that consider technology, siting, and water-balance management;
- A comparison of best practices and best-available technologies for tailings management;
- Options for managing water balance to enhance safety and reduce the risk of a tailings dam failure;
- A comparison of technically and economically viable engineering solutions to address site conditions; and
- A clear and transparent evaluation of the factors that supported the selection of the most-suitable option.

The BC Environmental Assessment Office will use the information to evaluate tailings management options and to determine whether plans and strategies presented by mining companies adequately address potential risks or implications. The review process also provides opportunities for Aboriginal groups, government agencies, and the public to provide input on the potential for environmental, economic, social, heritage, and health effects from a proposed project.

# 3.0 Evaluation of the Mount Polley Tailings Dam Breach

The review panel established by the BC government to evaluate the cause of the Mount Polley tailings dam failure presented their findings in *Report on Mount Polley Tailings Storage Facility Breach* dated January 30, 2015 (IEEIRP 2015). The following sections provide a summary of the panel findings, along with an independent evaluation of the root cause of the breach.

## 3.1 Panel Review Findings

Appendix A contains several figures, tables, and photos extracted from the IEEIRP (2015) report. Mount Polley Dam is a "ring dam", with man-made dam walls on three sides, and sloping terrain providing containment on the fourth side (Appendix A, Figure 3.1.1). The dam walls were constructed using the centerline method (Appendix A, Figure 4.1.1). In this construction method, a coarse material, usually a waste rock buttress, is built on the outer (downstream) side of the centerline, while tailings layers are built of on top of each raise on the inside (upstream) side. In between the tailings and the waste rock was a low permeability till layer, separated from the downstream waste rock by a series of filter layers to prevent migration of fine tailings and water and subsequent piping failure. The waste rock buttress was generally built with a 1.3:1 (horizontal to vertical) downstream slope. There were plans to flatten the slope in final closure to a 2:1 slope; however, the flattening had not happened yet at the time of failure.

On August 4, 2014 the eastern dam wall, called the Perimeter Dam, failed. This led to the release of large quantities of water and tailings impacting downstream land and waterways (Appendix A, Figures 5.1.1 and 5.1.2). The volume of tailings and water lost during the breach was on the order of 10% to 20% of the total capacity of the dam. The panel concluded that the primary cause of the breach was design oversight failing to identify the extent and material properties of a glaciolacustrine clay unit (Upper GLU) located about 26 feet below the surface under the footprint of the Perimeter Dam in the area of the breach. The panel conducted a site investigation, laboratory testing, and excessive slope stability and deformation analyses; compared the results to surface geometry of the failed dam remnants; and concluded that failure had occurred in the Upper GLU layer. Insufficient boring coverage during the pre-design site investigation lead to a poor understanding of the lateral extent of the Upper GLU and the overall complexity of the subsurface stratigraphy.

The designers considered that the Upper GLU would respond during loading largely as drained material because it is overconsolidated as a result of past glacial loading. However, the failure mode and the evaluation of oedometer tests indicate that it behaved in a normally consolidated manner, in which state undrained conditions usually govern stability. The panel concluded that the designers did not consider the undrained behavior of the Upper GLU and that the downstream slope of the dam at 1.3:1 was not suitable for the soil conditions.

The panel identified several contributing factors, including: the practice of year-to-year design and construction to stay just ahead of water volume; an optimistic interpretation of Canadian Dam Association recommendations for Factor of Safety; not installing sufficient monitoring instrumentation; and not constructing the downstream slope at a safer (2:1) slope. The panel concluded, however, that the dominant contribution to failure of the dam was its design, in that the designer(s) failed to recognize and properly evaluate the subsurface conditions and behavior of the Upper GLU. The report concludes that the design was "doomed to fail" once the load conditions associated with the Perimeter Dam exceeded the undrained strength of the Upper GLU.

In addition to identifying the cause of the failure, the panel provided recommendations for: the general improvement of tailings dam investigations and design; the use of Best Available Practices for existing TSFs and Best Available Technologies for new TSFs such as filtered, dried, compacted tailings; and increased oversight by Independent Tailings Review Boards.

### 3.2. Independent Evaluation of Root Cause

The IEEIRP (2015) report was reviewed in detail by an AECOM senior geotechnical engineer, with particular attention to the oedometer and selected cone penetrometer test results, as a check on the overconsolidated/normally consolidated conditions as the root cause of the Mount Polley breach. Figure 5.3.2 in Appendix A shows that the preconsolidation stress on the Upper GLU was about 500 kPa. Since the top elevation of the Upper GLU is about 922 meters (3,073 feet) and the crest of the Perimeter Dam about 967.4 meters (3,224 feet), the vertical pressure on the Upper GLU following construction was on the order of 900 kPa (assuming a 20 kN/m$^3$ (130 lb/ft$^3$) waste rock unit weight). As this is well beyond the preconsolidation stress, the Upper GLU likely behaved in a normally consolidated manner. Normally consolidated soils respond to vertical stress and shear in a contractant manner, which can lead to the build-up of excess pore-pressure, and thus undrained conditions. Direct simple shear tests (Appendix A, Table 5.3.1) indicate an undrained stress ratio of about 0.24, which is typical for normally consolidated clays.

A comparison of the IEEIRP slope stability analysis run using SLOPE/W (Appendix A, Figure 6.2.1) to the deformation analyses performed using PLAXIS (Appendix A, Figure 6.2.3) and the aerial photos of the breach (Appendix A, Figures 5.1.1 and 5.1.2) show excellent correlation, indicating an undrained (volume constant) failure mode.

Based on the evaluation of the oedometer and direct simple shear data, and the failure mode analyzed in SLOPE/W and PLAXIS together with field observations, AECOM concurs that the breach occurred in an area of the Perimeter Dam with a relatively thick layer of Upper GLU, which behaved as a normally consolidated material and failed in an undrained manner.

### 3.3 Conclusion

The IEEIRP (2015) report elaborates on a number of contributing factors to failure of the Mount Polley dam, including the history of the dam construction on a year-to-year basis, the high angle of repose (1.3H:1V slope [horizontal:vertical]) over the Upper GLU, proposing but never implementing plans to flatten the downstream slope, trying to achieve a Factor of Safety of 1.3 only, operational factors, and dam safety reviews not recognizing the undrained behavior of the underlying soils. Of these, however, the panel found that the overarching problem was the failure throughout to adopt an appropriate undrained strength interpretation for the glaciolacustrine silts and clays in the foundation.

## 4.0 Summary of the Proposed Donlin Gold TSF

The following is a brief summary of the proposed TSF dam located in Anaconda Creek Valley at the Donlin Gold mine site, based on the review of a design report by BGC (2011) and summary provided by SRK (2014). Prior to tailings dam construction, two temporary fresh water diversion dams would be constructed upstream of the tailings impoundment to divert fresh water into diversion channels around the tailings dam site in order to facilitate tailings dam and liner construction and limit the amount of surface water entering the TSF during construction and early operations. The North fresh water diversion dam would be 74 feet high and the South fresh water diversion dam would be 66 feet high. The

fresh water diversion dams would be removed in the third year of mine life as the TSF expands. Although temporary, these fresh water diversion dams would be sized to store the 100-year snowmelt and pass the 100-year peak instantaneous flow through their spillways.

The TSF would be constructed as a valley dam, where containment of tailings is provided by a man-made structure on one side only, and natural geologic materials would provide containment on all other sides. TSF dam construction would begin by clearing and stripping the foundation area soils and overburden to bedrock, thereby removing ice-rich and permafrost-containing materials. The purpose of this is to increase the strength and stability of the dam foundation by locating it directly on bedrock. The soil and overburden thickness requiring removal would be approximately 20 feet within the dam footprint, extending to 7 feet on the abutment valley side slopes.

The TSF dam would be constructed of the following materials, in sequence:

- Rockfill shell: The main body of the dam would consist of non-acid generating (NAG) greywacke rock with a particle size distribution of 0.8 to 39.4 inches placed and compacted in 5-foot lifts.
- Rockfill transition zone: A 20-foot thick transition zone would be constructed from non-acid generating rockfill placed and compacted in 3-foot lifts to separate the filter zones from the rockfill shell. The transition material will have a particle size distribution of 0.4 to 7.9 inches.
- Filter zones: Two 10-foot thick filter zones (one coarse and one fine) would be placed and compacted in 1-foot lifts. The fine filter zone would have a maximum particle size of 0.38 inch and the coarse filter zone would have a maximum particle size of 1.5 inches. The filter zone materials would be sized to prevent migration of tailings into the rockfill shell in the event that the liner is punctured. The filter thickness was selected to accommodate deformation under seismic loading.
- Liner Bedding: Three feet of liner bedding consisting of terrace gravels would be placed and compacted in 1-foot lifts on top of the filter zone.
- Liner: A 60-mil (0.06-inch) linear low density polyethylene geomembrane liner would be placed on top of the liner bedding materials. Linear low density polyethylene was selected over other liner materials for its cold-climate constructability, UV resistance, strength, puncture resistance, and strain tolerance. It is preferable to other geomembrane liners since it can sustain high levels of elongation and be handled and seamed in subfreezing temperatures. Linear low density polyethylene is commonly used for lining high-load mining facilities such as tailings impoundments.

The material used to construct the rockfill shell, transition zone, and filter zones would be obtained from rock quarried from the plant site and fuel farm site during mine construction and from the open pit during operations. The material would be non-acid generating and sized to meet specifications for shell, transition zone, and filter material. Liner bedding material would be obtained from terrace gravel borrow sources adjacent to Crooked Creek.

Downstream construction methods would be utilized to construct the tailings dam. The upstream face of the dam (inside the TSF) would be benched with slopes of 2H:1V to accommodate placement of the liner. The downstream slope would be constructed at 1.7H:1V based on results of static stability modeling, which yielded Factors of Safety of 1.5 to 1.7 (BGC 2011). The stability analysis considered the presence of weathered greywacke and siltstone/shale bedrock, as well as structural discontinuities such as joints, faults, and discreet volcanic ash layers.

The TSF dam would be constructed in stages. The first (starter) dam, constructed over a two-year period, would be 198 feet high in order to store the first year of tailings. After construction of the starter dam, the dam would be raised in the downstream direction in seven phases approximately every four years throughout the operating mine life. Thus, the TSF dam height would increase from the starter height to the final (ultimate) height of 471 feet at Year 25. The rate and size of the raises are designed so that the dam has sufficient height to store the amount of tailings produced over the period, operating pond volume, flood storage, and freeboard requirement. There would be 20-foot wide benches between each dam raise.

The construction of the TSF impoundment would begin with excavation of foundation soils to an average depth of 3 feet at the valley basin and 1.5 feet in mid-slope areas in order to remove the majority of organics and some ice-rich permafrost soils. A geotextile-wrapped rockfill underdrain, capable of handling baseflow through the Anaconda Creek Valley would be placed along the main creek bed and significant tributaries. Three feet of bedding material would be placed on top of the undrain system and cleared impoundment foundation, followed by placement of a 60-mil linear low density polyethylene geomembrane liner.

A TSF seepage recovery system consisting of a monitoring pond, diversion ditches, seepage recovery wells, and pump-back system would be constructed immediately downstream of the TSF dam. The seepage recovery system would capture underdrain water and incidental seepage through the TSF liner.

## 5.0 Evaluation and Comparison between Mount Polley and Donlin Gold Tailings Dams

A comparison of factors involved in the Mount Polley dam breach is summarized in Table 1 alongside comparable elements of the proposed Donlin Gold TSF dam. Unlike the Mount Polley dam, the Donlin Gold TSF dam is not a ring dam, and containment would be largely provided by natural topography and geologic formation. The TSF proposed design is inherently robust and the proposed slope angles are in line with, and perhaps even more conservative than, current industry practice. The proposed dam is fully lined, and has a robust filter zone scheme.

The dam would be built using a downstream construction method, which is inherently the safest dam construction method. It is more robust than centerline construction raises, which build upon tailings beneath the upstream half of the raise. Currently there are jurisdictions where centerline or upstream construction (i.e., dam raises partly or entirely built on tailings) is simply not allowed.

The proposed TSF construction would remove all soft, organic soil or soil that contains ice or permafrost. The dam would be built of waste rock, essentially "rock on rock." The bedrock beneath the proposed TSF footprint, including the weathered bedrock and discontinuities accounted for in the stability analysis, do not exhibit overconsolidated/normally consolidated behavior. There is no history of glaciation or presence of buried, laterally extensive clays at the Donlin Gold TSF site.

The Donlin Gold TSF and water balance modeling comply with Alaska dam safety requirements in terms of required factors of safety for slope stability and inflow design flood.

Tailings dams are dynamic systems, and their performance ultimately depends not only on design, but proper construction, construction quality control, operation, and appropriate inspections. SRK (2014) provides details regarding monitoring and inspections that would be conducted at the TSF dam during operations and closure.

Overall, the Donlin Gold TSF is being designed with relatively good subsurface conditions, planned subsurface foundation preparation, robust downstream construction, a low permeability upstream liner, with relatively low slope angles. These features suggest that the Donlin Gold TSF dam wall would likely perform in a more stable and safer manner than the Perimeter Dam wall at Mount Polley.

**Table 1: Summary Comparison of Mount Polley and Donlin Gold TSF Dams**

| Contributing Causes of Mount Polley Dam Breach | Mount Polley Perimeter Dam | Donlin Gold TSF Dam | Comments |
|---|---|---|---|
| **Foundation, Subsurface Geology** | Glacial deposits, including overconsolidated clay | Bedrock | No history of glaciation, buried clay deposits, or overconsolidated/normally consolidated behavior expected at Donlin TSF; overburden and permafrost to be removed. |
| **Pre-Design Site Investigation** | 6 borings in area of Perimeter Dam breach; other data points not deep enough or material not lab tested; wrong interpretation of clay data. | About 30 borings and continuous coreholes beneath and immediate vicinity of TSF footprint; rock weaknesses accounted for in stability analysis. | Insufficient investigation coverage at Mount Polley to recognize and test for Upper GLU; and faulty interpretation of material properties. |
| **Dam Layout** | Ring dam | Valley dam | Donlin TSF impoundment contained by ridges on 3 sides. Mount Polley dam man-made on 3 sides. |
| **Dam Construction** | Centerline, yearly raises | Downstream, raises every 4 years | Centerline construction partially founded on tailings. Multiple changes in Perimeter Dam due to limited time for mine and water planning. |
| **Slope Downstream Face** | 1.3H:1V | 1.7H:1V | Mount Polley is steeper. |
| **Target Factor of Safety** | 1.3 | 1.5 | Higher minimum target for Donlin Gold TSF. |
| **Dam Safety Reviews** | Design and dam safety reviews (≥ 5-year intervals) failed to recognize overconsolidated/ normally consolidated material issue. | Preliminary and subsequent Failure Mode Effects Analyses; owner-required independent technical review team; ADNR-required inspections (≤3-year intervals); proposed annual facility inspections. | Design reviews provided inadequate oversight at Mount Polley. |

## 6.0 References Cited

Alaska Department of Natural Resources (ADNR). 2005. *Guidelines for Cooperation with the Alaska Dam Safety Program*. Div. of Mining, Land, and water, Water Resources Section, Dam Safety and Construction Unit. June 30.

Association of Professional Engineers and Geoscientists of BC (APEGBC). 2013. *Legislated Dam Safety Reviews in BC.* APEGBC Professional Practice Guidelines, V2.0, 82 p.

BGC Engineering. 2011. *Tailings Storage Facility Design, Final Report.* Donlin Creek Gold Project, Feasibility Study Update II, prepared for Donlin Creek LLC 395 p., July 22.

British Columbia (BC). 2008. *Health, Safety and Reclamation Code for Mines in British Columbia*. Ministry of Energy, Mines and Petroleum Resources, Mining and Minerals Division.

BC. 2011a. *Information Sheet, BC Dam Safety Regulation Compliance Reporting.* Ministry of Forests, Lands and Natural Resource Operations.

BC. 2011b. *Inspection & Maintenance of Dams, Dam Safety Guidelines.* BC Water Management Branch, Dam Safety Section, Version 2 – March.

BC. 2011c. *Water Act, British Columbia Dam Safety Regulation.* Includes amendments up to B.C. Reg. 163/2011, November 30.

BC. 2012. *BC Dam Safety Review Guidelines.* BC Water Management Branch, Version 3, November.

BC. 2013a. *Guidelines for Annual Dam Safety Inspection Reports*. Ministry of Energy and Mines, updated August, 2 pp.

BC. 2013b. *Plan Submission Requirements for the Construction and Rehabilitation of Dams, BC Dam Safety Guidelines.* Ministry of Forests, Lands and Natural Resource Operations. Version 10 – May 13.

BC. 2014. *B.C. Mining Dams - "At a Glance" Requirements (v. January 2014).*

Canadian Dam Association. 2007. Technical Bulletins: *Inundation, Consequences, and Classification for Dam Safety; Surveillance of Dam Facilities; Flow Control Equipment for Dam Safety; Public Safety and Security Around Dams; Dam Safety Analysis and Assessment; Seismic Hazard Considerations for Dam Safety; Geotechnical Considerations for Dam Safety; and Structural Considerations for Dam Safety.*

Canadian Dam Association. 2013. *Dam Safety Guidelines 2007 (2013 Edition).*

Cobb, C. 2014. Presentation to Donlin Gold Cooperating Agency Meeting: *Alaska Dam Safety Program*. September 10.

Hatch Ltd. 2015. *Synthesis and Analysis of Submissions to the Chief Inspector's Orders for Project Management, Engagement and Geotechnical Review of Dam Safety Inspections in BC.* Report prepared for BC Ministry of Energy and Mines, H348238-000015-124-0001, January 29.
Independent Expert Evaluation and Investigation Review Panel (IEEIRP), Province of British Columbia. 2015. *Report on Mount Polley Tailings Storage Facility Breach*. 147 pp., January 30.

Mining Association of Canada. 2011a. *A Guide to Management of Tailings Facilities.* Second Edition.

Mining Association of Canada. 2011b. *Developing an Operations, Maintenance and Surveillance Manual for Tailings and Water Management Facilities.* Ottawa, Ontario.

SRK. 2014. *Tailings Dam Information for the Environmental Impact Statement, Memo, Donlin Gold Project, Alaska, USA*. 20 pp., July 31.

# Appendix A

## Selected Figures and Tables from the IEEIRP (2015) Report

FIGURE 2.1.1: TAILINGS STORAGE FACILITY PLAN

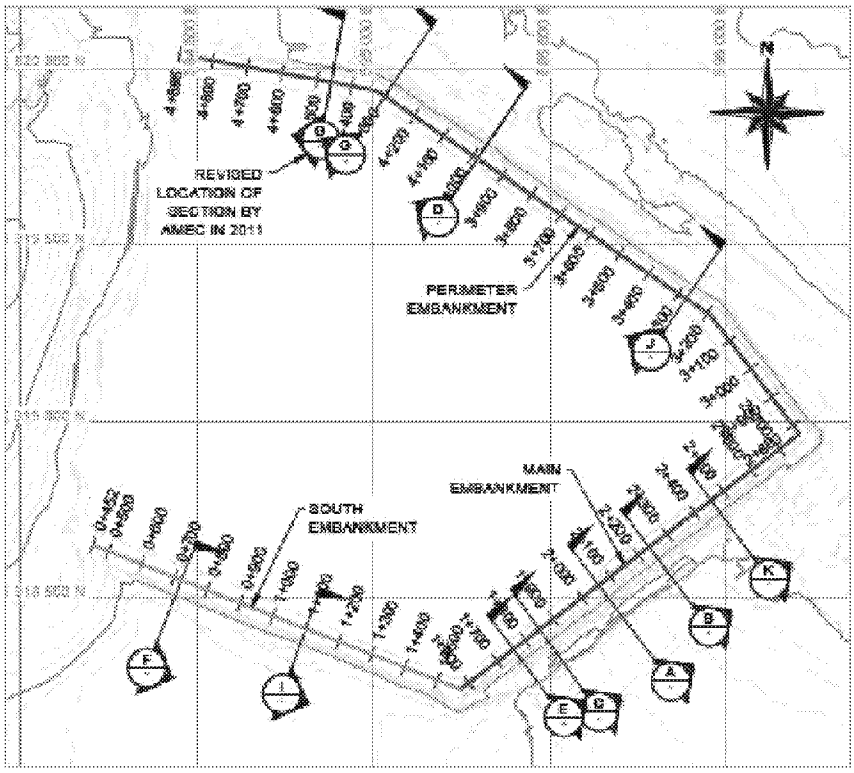



**Figure 4.1.1** shows a simplified cross-section of the dam. It is constructed of both earth and rockfill and would be classified as a zoned earth and rockfill dam. The specific zones are:

U Zone Upstream fill
C Zone Rockfill
S Zone Till core
F Zone Filter
T Zone Transition

FIGURE 4.1.1: SIMPLIFIED CROSS-SECTION OF THE MOUNT POLLEY DAM

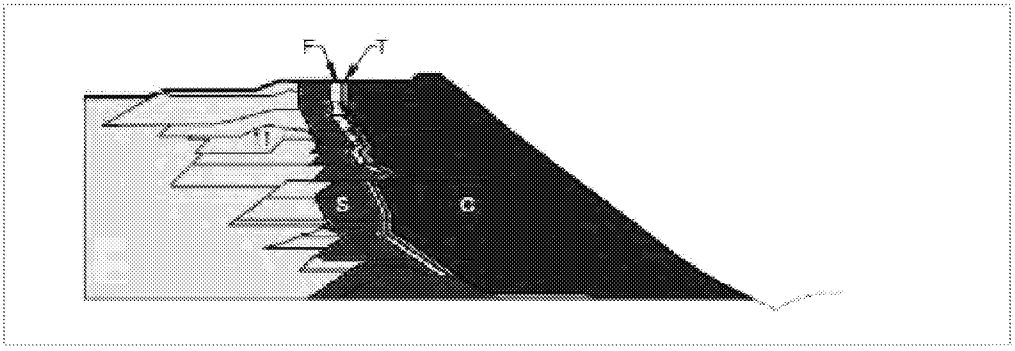


FIGURE 5.1.1: VIEW LOOKING UPSTREAM THROUGH THE BREACH (ARROW SHOWS DIRECTION OF OUTFLOW)

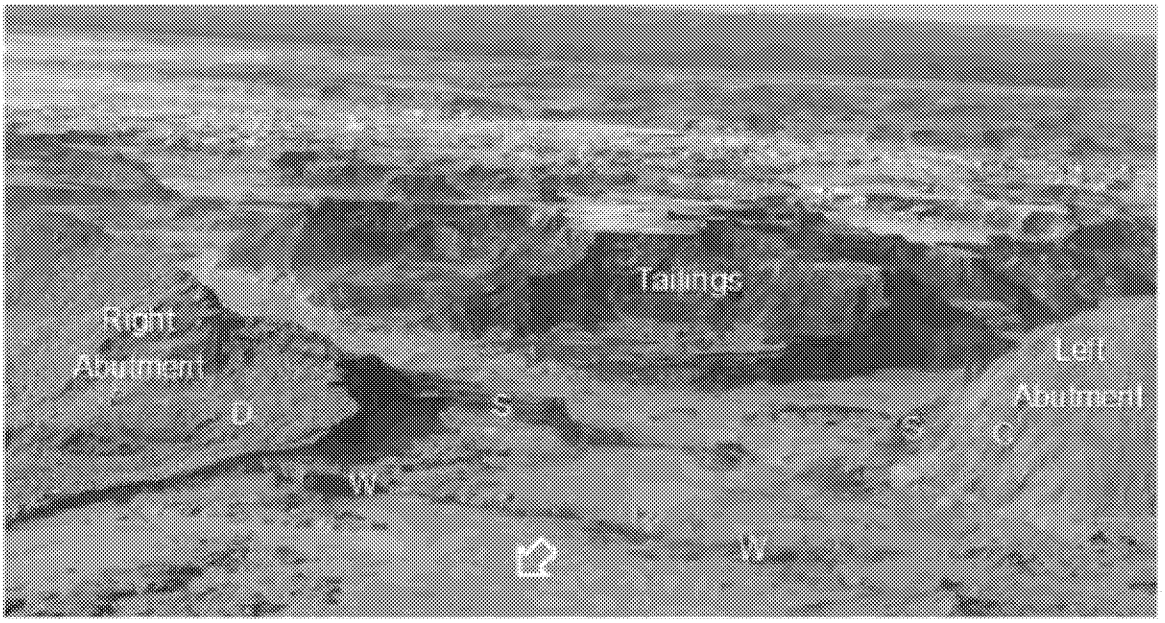



FIGURE 5.1.2: VIEW LOOKING DOWNSTREAM SHOWING UPSTREAM SIDE OF DAM AND REMAINING TAILINGS

TABLE 5.3.1: SUMMARY OF DIRECT SIMPLE SHEAR (DSS) TEST RESULTS

| SAMPLE | ELEVATION (m) | INFERRED PANEL SOIL UNIT | WATER CONTENT (%) | PLASTICITY INDEX | VERTICAL STRESS (kPa) | SHEAR BIAS | PEAK UNDRAINED STRENGTH RATIO |
|---|---|---|---|---|---|---|---|
| 14-106A Sa1C-T1 | | UPPER GLU | 43 | 31 | 600 | 0% | 0.22 |
| 14-106A Sa1C-T2 | 921.1 | UPPER GLU | 37 | 31 | 600 | 10% | 0.23 |
| 14-106A Sa1C-T3 | 921.1 | UPPER GLU | 38 | 31 | 600 | 20% | 0.26 |
| 14-106A Sa1C-T4 | 921.1 | UPPER GLU | 33 | 31 | 300 | 20% | 0.28 |
| 14-106C Sa1B-T1 | 921.2 | UPPER GLU | 44 | 33 | 600 | 30% | N/A |
| 14-106C Sa1B-T2 | 921.2 | UPPER GLU | 43 | 33 | 600 | 25% | 0.27 |
| 14-106C Sa1B-T3 | 921.2 | UPPER GLU | 39 | 33 | 600 | 10% | 0.21 |
| 14-106G SA2B-T1 | 920.9 | UPPER GLU | 44 | 21 | 600 | 10% | 0.21 |
| 14-106G SaB-T2 | 920.6 | UPPER GLU | 38 | 21 | 600 | 20% | 0.26 |
| 14-107 Sa6C-T1 | 921.5 | UPPER GLU | 44 | 23 | 300 | 10% | 0.27 |
| 14-107 Sa6C-T2 | 921.5 | UPPER GLU | 43 | 23 | 300 | 10% | 0.25 |
| 14-107A Sa1A-T1 | 920.9 | UPPER GLU | 43 | 34 | 600 | 0% | 0.21 |
| 14-107A Sa1A-T2 | 921.0 | UPPER GLU | 42 | 34 | 600 | 0% | 0.20 |
| 14-107A Sa7 | 916.3 | LOWER GLU | 26 | 15 | 600 | 0% | 0.30 |
| 14-109 Sa6B | 916.6 | LOWER GLU | 22 | 13 | 300 | 10% | 0.42 |
| 14-110 Sa6C | 916.3 | LOWER GLU | 21 | 15 | 300 | 10% | 0.27 |
| 14-113 Sa4B | 922.9 | UPPER TILL | 13 | 7 | 300 | 10% | 0.43 |

| | | |
|---|---|---|
| Average Peak Undrained Strength Ratio in Upper GLU | (no shear bias) | 0.21 |
| | (10% shear bias) | 0.23 |
| | (> = 20% shear bias) | 0.27 |
| | overall | 0.24 |

FIGURE 5.3.2: PRECONSOLIDATION STRESS EFFECT FOR BOTH TILL AND GLU

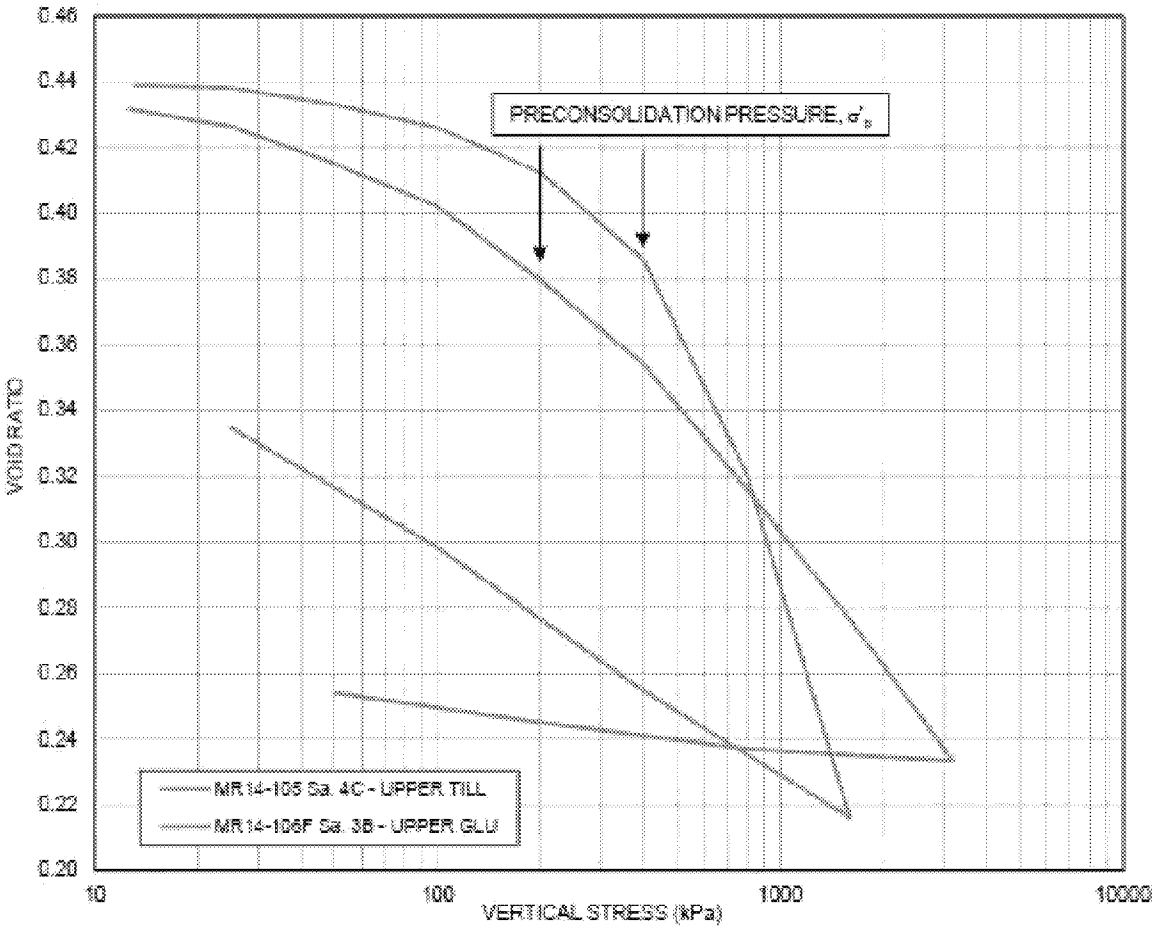


FIGURE 6.2.1: DETAILED SECTION USED FOR LIMIT EQUILIBRIUM ANALYSIS (HIGH WATER TABLE, UNDRAINED STRENGTH RATIO 0.27)

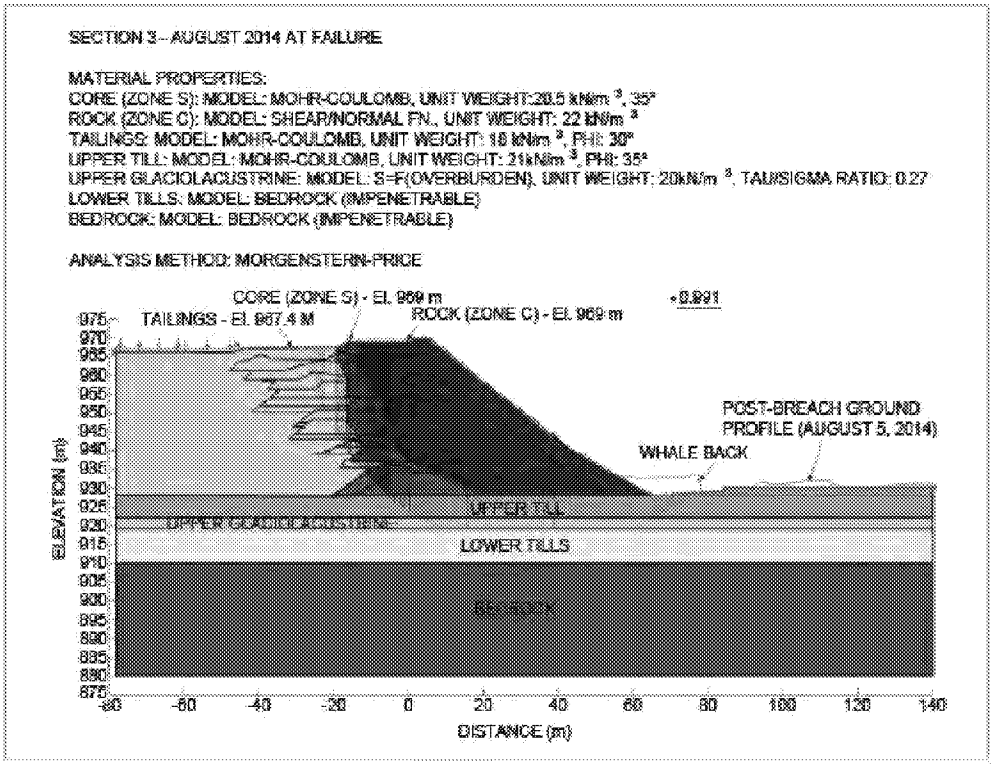
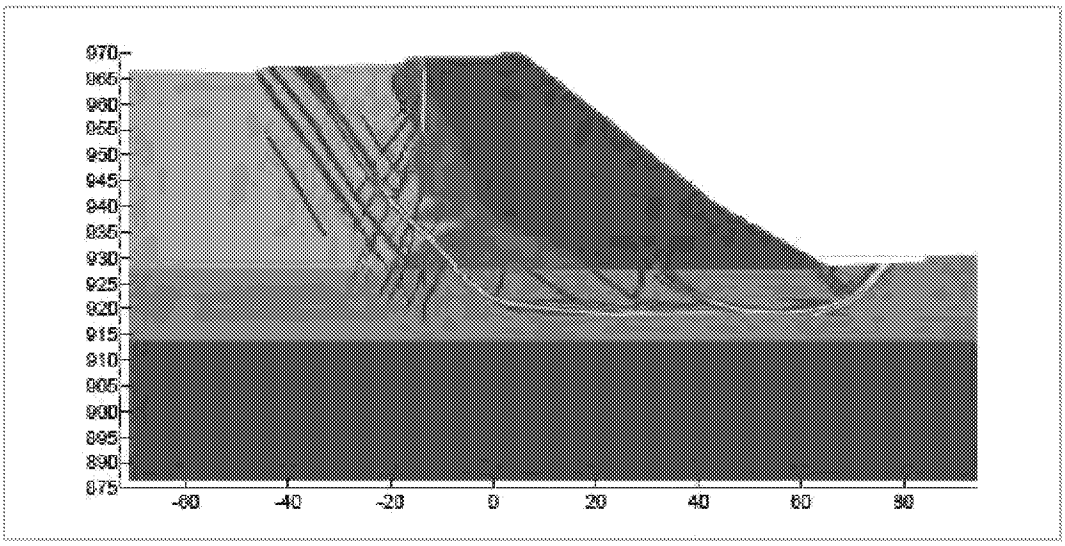



FIGURE 6.2.2: PLAXIS MODEL AT COLLAPSE (UNDRAINED STRENGTH RATIO 0.28)



Both the entry and exit of the failure surface in the foundation correspond closely with field observations summarized in **Figure C4.2.2** in Appendix C.

# Donlin Gold LLC

# Donlin Gold Project

# River Barge Fleet Design and Operation

# Project No: 173260
# 2 July 2013

**IMPORTANT NOTICE**

This report was prepared exclusively for Donlin Gold LLC by AMEC Americas Limited (AMEC). The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in AMEC's services and based on: I) information available at the time of preparation, ii) data supplied by outside sources and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by Donlin Gold LLC only, subject to the terms and conditions of its contract with AMEC. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

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## CONTENTS

1.0 INTRODUCTION ..... 1-1
2.0 FACTORS THAT INFLUENCED BARGE FLEET DESIGN AND OPERATING PLANS ..... 2-1
2.1 Mine Location and Regional Transport Infrastructure ..... 2-1
2.2 Donlin Creek Annual Resupply Logistics Plans ..... 2-2
2.3 General Design Considerations ..... 2-3
2.4 Kuskokwim River ..... 2-4
2.4.1 Ice and Navigation ..... 2-4
2.4.2 River Flows and Limiting Draft ..... 2-4
2.4.2.1 USGS Data at Crooked Creek ..... 2-4
2.4.2.2 Bathymetric Surveys ..... 2-7
2.4.2.3 Hydrometerological Studies ..... 2-7
2.4.2.4 ADF Readings and Limiting Draft ..... 2-8
2.5 River Barges ..... 2-8
2.5.1 Design and Construction ..... 2-8
2.5.2 Barge Operation ..... 2-9
2.5.3 Barge Load Planning System ..... 2-9
2.6 Strategic Inventories ..... 2-9
2.6.1 Bethel ..... 2-9
2.6.2 Mine Site ..... 2-9
2.7 Discrete Simulation Models ..... 2-9
3.0 RIVER BARGE FLEET DESIGN AND OPERATION ..... 3-1
3.1 General Cargo Fleet ..... 3-1
3.1.1 General Cargo River Barges ..... 3-1
3.1.2 General Cargo River Barge Fleet Operation ..... 3-2
3.2 Fuel Fleet ..... 3-3
3.2.1 Fuel River Barges ..... 3-3
3.2.2 Fuel River Barge Fleet Operation ..... 3-4
3.3 Extreme Years ..... 3-6
4.0 COMMUNICATIONS AND NAVIGATION ..... 4-1
4.1 Community Communications Strategy ..... 4-1
4.2 River Barge Communications and Navigation ..... 4-1

## TABLES

Table 2-1: Overall Historical Availability of Depth ..... 2-8
Table 3-1: General Cargo Barge Specifications ..... 3-1
Table 3-2: General Cargo Barge Tow – Draft and Load Capacity ..... 3-1
Table 3-3: River Barge Operating Parameters ..... 3-2
Table 3-4: River Barge Round-Trip Cycle Time ..... 3-2
Table 3-5: General Cargo – Simulation Results ..... 3-2
Table 3-6: General Cargoes – River Barge Fleet Operation ..... 3-3
Table 3-7: Fuel Barge Specifications ..... 3-3
Table 3-8: Fuel Barge Tow Capacity ..... 3-4
Table 3-9: River Barge Operating Parameters ..... 3-4
Table 3-10: River Barge Round-Trip Cycle Time ..... 3-4
Table 3-11: Fuel Supply Chain Model Simulation Results ..... 3-5

Table 3-12: Fuel River Barge Fleet Operation ..... 3-5

## FIGURES

Figure 2-1: Project Location Map ..... 2-1
Figure 2-2: General Cargo and Fuel Supply Chains ..... 2-2
Figure 2-3: Daily Flow of Kuskokwim River at Crooked Creek in Shipping Season ..... 2-5
Figure 2-4: Number of Days with ADF <45,000 cfs in Kuskokwim River in Shipping Season ..... 2-6
Figure 2-5: Correlation of ADF Recordings and Gauge Readings (based on USGS calibration data) ..... 2-6
Figure 3-1: Average ADF 1952 – 2006 and the ADF for 1997 ..... 3-7



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# 1.0 INTRODUCTION

When in production the Donlin Creek gold mine will consume approximately 115,000 st of general cargo and 42.3 USMgal of fuel each year. A key component of the mine's annual resupply logistics plan is the use of river barges to transport these supplies up the Kuskokwim River from Bethel to a terminal just downriver of Crooked Creek. This report provides background information on and describes development of the design and operating plan for the fleet of river barges that will operate on the Kuskokwim River.



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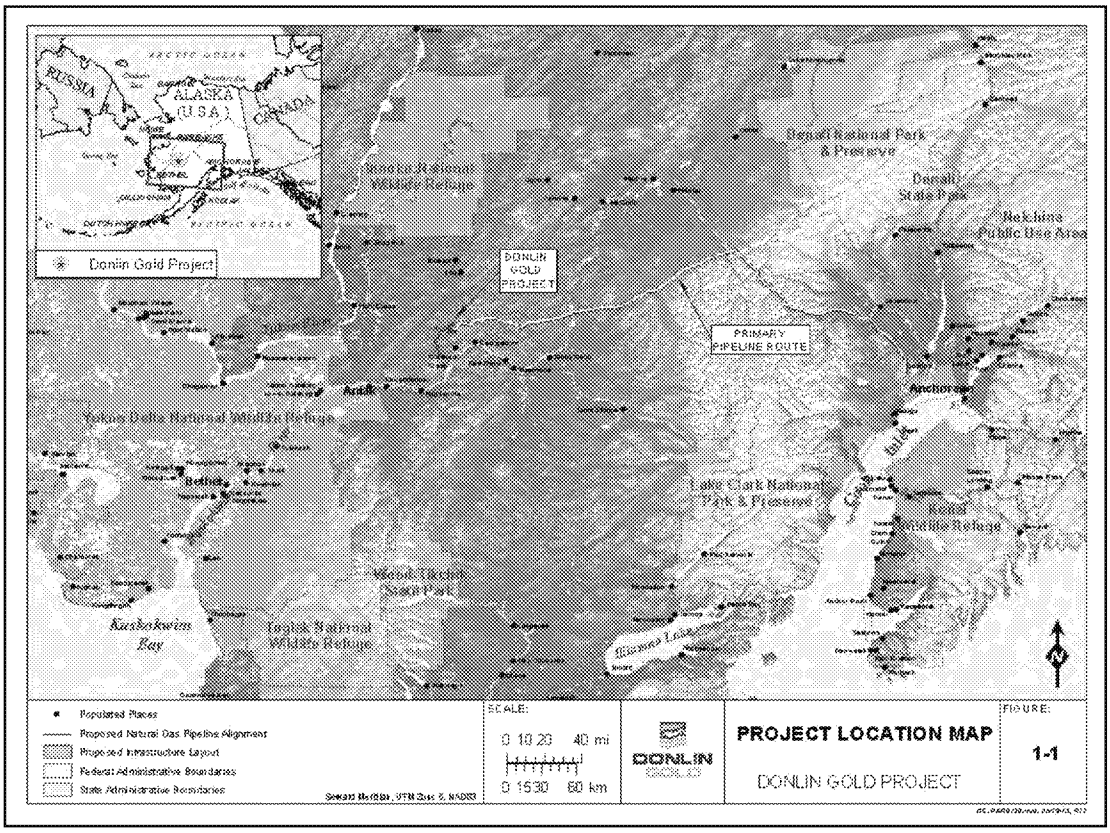
# 2.0 FACTORS THAT INFLUENCED BARGE FLEET DESIGN AND OPERATING PLANS

## 2.1 Mine Location and Regional Transport Infrastructure

The Donlin Gold Project is located in a remote region of south-western Alaska, approximately 145 miles northeast of Bethel, and 10 miles north of the village of Crooked Creek (Figure 2-1). With its limited road network the region's principal transportation artery is the Kuskokwim River. Fuel, supplies, and other cargoes loaded onto ocean-going barges in Seattle and elsewhere are delivered to Bethel, 73 nautical miles (nm) up from the mouth of the river where it empties into the Bering Sea. Bethel is the regional center and main port for the region. From Bethel, smaller river barges deliver supplies farther upstream. Because the river freezes over in winter, the shipping season is restricted to the ice-free period from approximately the beginning of June through the end of September each year. With no road planned between Bethel and the mine site, the project adopted this concept as the basis of its annual logistics resupply plan for general cargoes and fuel during construction and operations.

**Figure 2-1: Project Location Map**



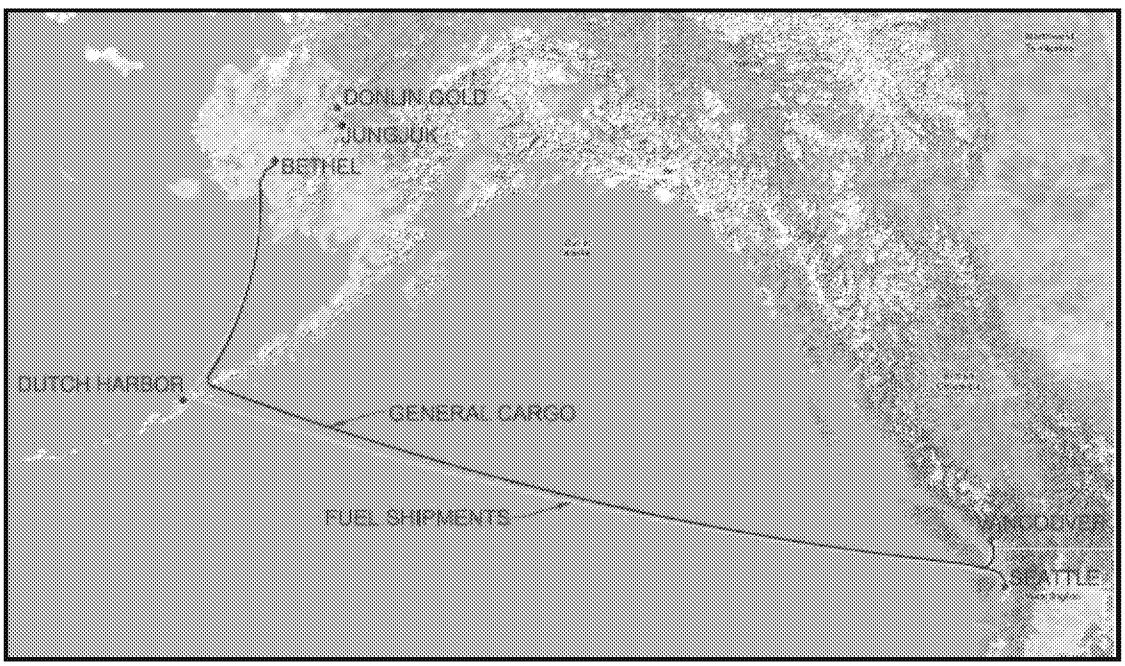
## 2.2 Donlin Creek Annual Resupply Logistics Plans

Donlin Mine developed two annual resupply logistics plans, one for 115,000 st of general cargoes, the other for 42.3 USMgal of fuel (Figure 2-2).

General cargoes sourced globally will be received in containers or as break-bulk (items too large or unsuitable for containers) at marine consolidation terminals in Seattle or Vancouver, where they will be loaded onto ocean barges for transport to Bethel. The first general cargo barge of each shipping season will leave the consolidation terminal(s) in early May to be in position off the mouth of the river when it clears of ice at the beginning of June. Ocean barges having a deadweight capacity of 12,000 st will take 32 days to make the round trip between the consolidation terminal and Bethel. A fleet of three ocean tugs and barges will be required to transport 115,000 st of general cargoes each season.

On arrival at Bethel the ocean barges will unload at a terminal to be constructed for the project. The terminal will have two general cargo berths, one for ocean barges and one for river barges, and a roll-on/roll-off berth. With an area of 16 acres, the terminal will have enough space to store up to 2,750 containers. General cargoes will be placed into temporary storage or transferred directly to river barges for transport 168 nm upriver to a new terminal to be constructed at Jungjuk, about 8 nm downstream of Crooked Creek.

**Figure 2-2: General Cargo and Fuel Supply Chains**




Jungjuk will have two river barge berths, a roll-on/roll-off berth, a fuel storage yard, and a container storage area with sufficient space to hold up to 1,000 containers. It will occupy an area of 21 acres. On arrival at Jungjuk, the cargoes will be loaded onto road transport



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for delivery to the mine site along a new access road. With an area of 21 acres, Jungjuk will be able to store up to 1,000 containers. At the mine site, the main storage area for general cargo will have space for up to 5,855 containers. Empty containers will be returned to the marine terminals in Seattle or Vancouver.

Fuel sourced from refineries in the Pacific Northwest will be delivered by 6.5 USMgal capacity double-hull ocean barges to Dutch Harbor, where it will be pumped ashore to storage tanks to await onward shipment to Bethel. The first fuel shipment should leave the refineries in early May. Dutch Harbor will have a total fuel storage capacity of around 13 USMgal, of which about 8 USMgal will be constructed for the project. Fuel will be transported from Dutch Harbor to Bethel by a double-hull 2.94 USMgal capacity ocean fuel barge.

On arrival at Bethel the barge will unload at the existing fuel terminal. The fuel will either be placed in storage or will be transferred to a double-hull river barge for transport upriver to Jungjuk.

The Bethel terminal currently has a total storage capacity of about 19 USMgal. Considering that the project will need a minimum storage capacity of 10 USMgal at Bethel, arrangements may be made with other terminal users to access the existing storage, or additional new tankage will need to be installed.

At Jungjuk, the fuel will be unloaded to a 2.6 USMgal capacity storage tank, and then loaded to road tanker for delivery to the mine site where the fuel tank farm will have a storage capacity of 37.5 USMgal, sufficient for about 10 months of fuel consumption during operations.

## 2.3 General Design Considerations

To reduce impacts on the Kuskokwim River and other users of the river, various approaches were used to reduce total river traffic and the potential for spills, including but not limited to:

- maximizing the cargo capacity of barges within the constraints of river navigability and safety to minimize the number of barge trips each shipping season
- adopting double-hull fuel barge designs for the fuel barge fleet
- designing a system that does not require river dredging
- building the port at Jungjuk to reduce the length of the overland road route and eliminate the need for a fuel pipeline from this port to the mine site
- using special ISO containers for the transport of cyanide
- implementing a communications strategy that keeps local communities informed of the schedules and current status of barge traffic



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- adopting current best practices for transport, handling, and storage of hazardous and dangerous goods
- adopting current best practices for transport, handling, and storage of fuel.

## 2.4 Kuskokwim River

### 2.4.1 Ice and Navigation

Ice conditions limit the extent of the barging season on the river. Ocean barges cannot enter the Kuskokwim River until shore-fast ice clears the main navigation channels at the mouth of river, usually around late May. A study by Triton Consultants Ltd., dated 2 January 2007, of satellite data of ice conditions at the mouth of the river concluded that the date of ice clearance has been as early as 1 May and as late as early June during the last ten years.

For the stretch of river between Bethel and Jungjuk, historical data on ice conditions and break-up indicate that river barges are usually able to move upstream of Bethel between 24 April and 1 June, and that the river begins to freeze up again in early October; dates that were confirmed as a reasonable basis for planning barge operations in discussions with local residents and barge operators.

Although the river upstream of Bethel is usually navigable in late September, the shipping window for river barges was reduced from 1 June–1 October to 1 June–9 September, or 110 days, as a precaution for planning purposes.

### 2.4.2 River Flows and Limiting Draft

#### 2.4.2.1 USGS Data at Crooked Creek

Local barge operators have reported the challenges of working on a river where river levels change constantly throughout the shipping season and recalled years such as 1997 when river levels were so low as to make it difficult to even move on the river for long periods of time. One method they use to estimate the depth of water in the river is to monitor the flow gauge readings at the USGS station at Crooked Creek where records of daily flows have been kept since 1952. When the river flow readings fall below 40,000 cfs, they know the river is not always navigable between Bethel and Crooked Creek because of the possibility of grounding in shallower sections of the river.

Figure 2-3 shows the long-term average daily flow (ADF) readings for each day between 1 June and 30 September recorded at Crooked Creek since 1952. As ice clears out and the spring freshet moves downstream in May; the river level usually rises until early June and then falls through late June and July, then rises again in mid-August before falling throughout September. Freeze-up generally starts in early October.



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As noted by barge operators, river levels in any particular year depend on local weather conditions, and they often do not follow this pattern. Flow data for 1964 and 1997, which are also plotted in Figure 2-3 show significant deviation from the average. In 1964, ADF peaked in June at about 392,000 cfs, or almost four times the level of 72,722 cfs in a typical year. In 1997, however, the ADF averaged only 41,250 cfs over the entire season.

The year-on-year variability in ADF is also illustrated in Figure 2-4, which shows the number of days each year from 1952 to 2009 that ADF was less than 45,000 cfs. ADF was less than 45,000 cfs for almost 100 days in 1997 and for 40 days or more in two other years, 1954 and 1974.

While ADF records have been kept continuously at Crooked Creek for 59 years, less information is available for the average daily gauge height. To extend the range of available gauge data the river flow and gauge measurements taken by USGS to calibrate the gauges at Crooked Creek were plotted as shown in Figure 2-5 and the trend line curve for these points estimated. The curve for the relationship between ADF and gauge calibration readings was then used to estimate the gauge reading, and the limiting depth of water available between Bethel and Jungjuk, for a given recorded ADF. It shows that for the critical water depth of 3.5 ft, the minimum depth of water for barge operation, the equivalent ADF is 37,000 cfs, which generally supports the information provided by local barge operators.

**Figure 2-3: Daily Flow of Kuskokwim River at Crooked Creek in Shipping Season**

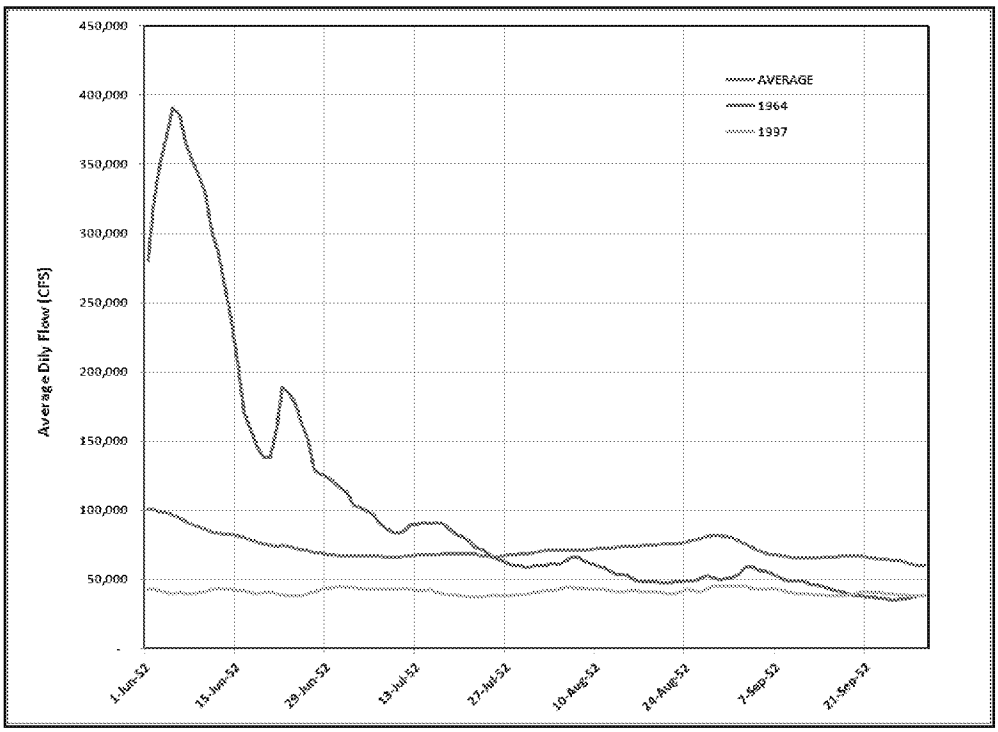




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**Figure 2-4: Number of Days with ADF <45,000 cfs in Kuskokwim River in Shipping Season**

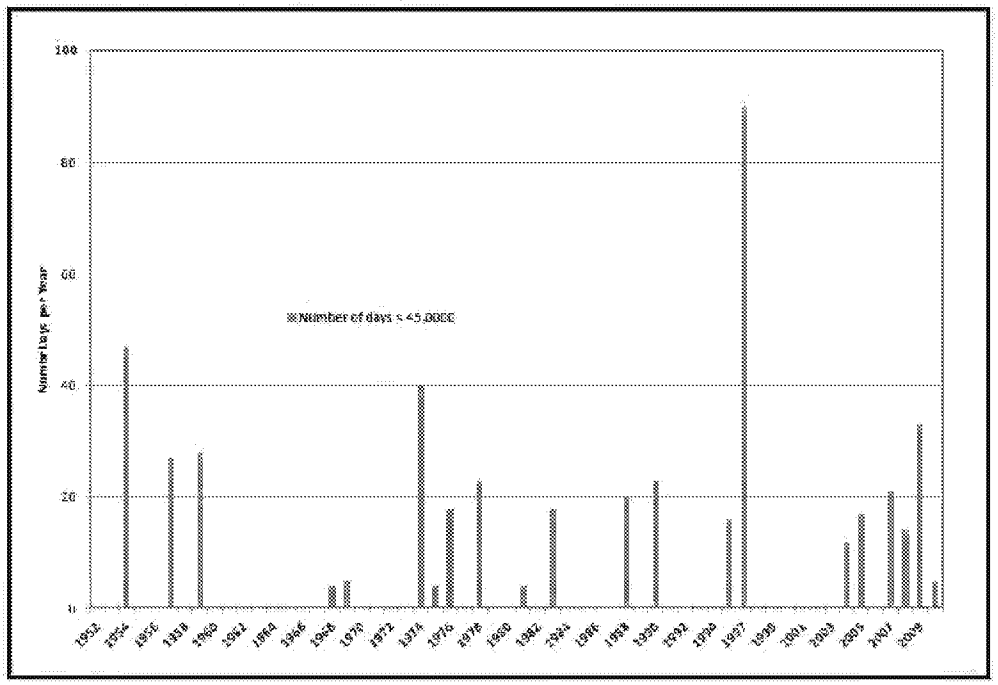
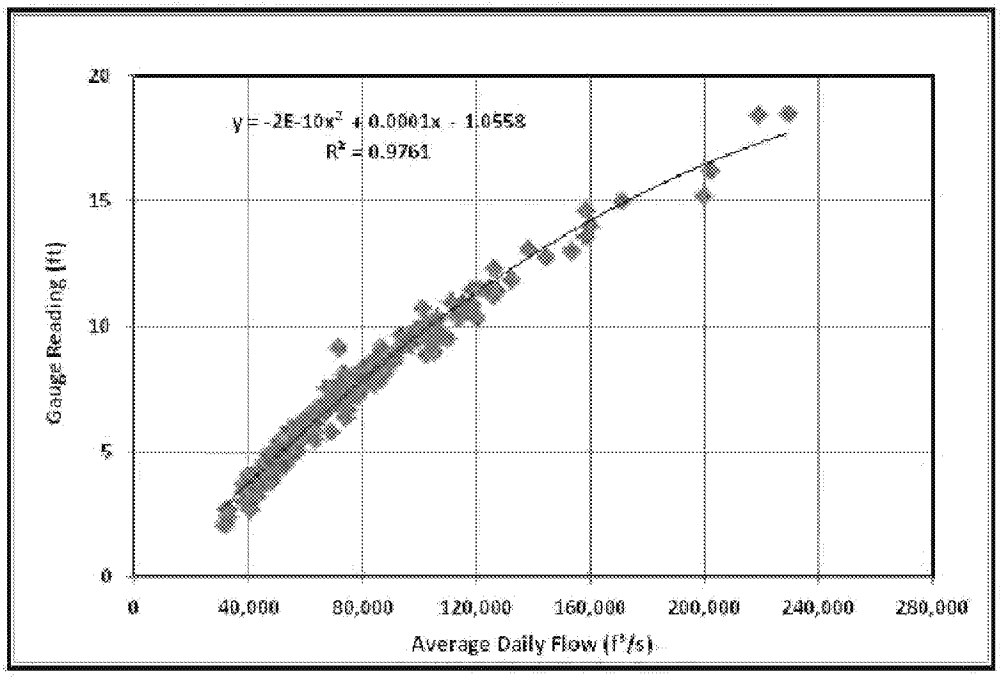



**Figure 2-5: Correlation of ADF Recordings and Gauge Readings (based on USGS calibration data)**



#### 2.4.2.2 Bathymetric Surveys

To verify local barge captains' claim that the ADF and gauge data could be used to estimate the limiting depth of water available in 2008 Donlin Gold LLC commissioned Terrasond to perform bathymetric surveys to investigate the shallows on the lower stretches of the Kuskokwim River around Nelson Island and near Aniak. These shallows were found not to be the ones limiting barge access for the project. Rather, according to local barge captains, shallower sections upstream of Aniak would tend to hamper access to the Jungjuk port.

To further investigate the relationship between the USGS river flow data and the available draft, Donlin Gold LLC commissioned Terrasond again in 2010 to perform bathymetric surveys of the Kuskokwim River between Aniak and Jungjuk. Between 9 and 18 September 2010, Terrasond surveyed seven sections for a total distance of about 26 km, or approximately 25% of the river length between these two locations. A total of 122 transects were surveyed at intervals of about 300 m.

The river was found to be at its shallowest at the site just upstream of the village of Aniak, where the available water depth within the navigation channel was measured at 8.4 ft when the ADF at Crooked Creek was 63,000 cfs. In all sections, the shipping channel was at least the width of two barges, and in many locations was much wider.

#### 2.4.2.3 Hydrometerological Studies

The river flow and gauge data from the USGS site at Crooked Creek and bathymetric survey data were then used as the primary inputs to a Hydrologic Engineering Centers River Analysis (HEC-RAS) model to estimate water depths and channel widths between Aniak and Jungjuk under different river flow conditions. HEC-RAS is a computer program developed by the U.S. Department of Defence, Army Corps of Engineers to model the hydraulics of water flow through natural rivers and other channels.

The primary objectives of the HEC-RAS modelling were as follows:

- calculate water levels at critical sections of the river above Aniak with respect to flow levels at Crooked Creek
- determine the cut-off flows for a 30 m wide barge at a critical section of the river.

The HEC-RAS model simulated the river flow using the water surface profiles and water levels at each transect surveyed between Aniak and Jungjuk. As part of the model calibration, ADF readings from the USGS site at Crooked Creek were used to estimate the peak high and low river flows. The model was run for ADF readings of between 13,418 cfs and 284,302 cfs.

Table 2-1 summarizes the results of the analysis of the available depth of water using the USGS river flow data from Crooked Creek site. It indicates a 97% probability of the depth

being 3.5 ft—the minimum depth of water for barge operation—or more, and an 88% probability of it being 4 ft or more within a 122-day window from 1 June to 1 October.

**Table 2-1: Overall Historical Availability of Depth**

| Depth (ft) | Availability (%) | Rationale |
|---|---|---|
| 3.5 | 97 | Minimum barge draft |
| 4.0 | 88 | Minimum barge draft + 6 inch clearance |
| 4.5 | 74 | Minimum barge draft + 1 ft clearance |
| 5.5 | 42 | Minimum barge draft + 2 ft clearance |

#### 2.4.2.4 ADF Readings and Limiting Draft

The analyses of the flow and gauge data, bathymetric survey, and the HEC-RAS model results support the use by local barge operators of the ADF and gauge readings from the USGS station at Crooked Creek to estimate the limiting draft available to barges operating between Bethel and Jungjuk. Specifically at flows below 40,000 cfs, the river may not always be navigable between Bethel and Crooked Creek because of the possibility of grounding in the shallow sections. Based on these conclusions, the river flow and gauge models were adopted as the basis for developing river fleet barge designs and operating plans.

## 2.5 River Barges

### 2.5.1 Design and Construction

River barge designs and operating parameters were developed in conjunction with major barging companies that own and operate barge fleets on the Kuskokwim River, and that provided detailed proposals to design, supply, and operate the river barge fleets. Barge operators proposed the concept of assembling four barges into a tow. This concept was preferred to that of single tug and barge system because it is easier to navigate on rivers. Its other advantage is that it allows barges to be uncoupled from the tow during periods of extremely low water to transit channels that are too narrow to accommodate the four-barge tow.

The river barges will be designed and constructed in accordance with the requirements of applicable State, Federal, and International legislation and regulations, including those of the, American Bureau for Shipping, and International Maritime Organization. Even though current regulations allow the use of single-hull fuel barges on the Kuskokwim River, a double-hull fuel barge design was selected for the project.

### 2.5.2 Barge Operation

During the shipping season, the barge fleet and terminals will operate 24 h/d, 7d/wk. Operation of the river barge fleet will be accordance with the applicable State, Federal, and International statues and regulations, the U.S. Coast Guard, and the relevant environmental protection agencies. Barge operators will be certified to International Standards Organization (ISO) service standards. Fleet crew sizes and rotation schedules will be in accordance with U.S. Coast Guard regulations.

### 2.5.3 Barge Load Planning System

The barge-loading plan for each trip will be based on expected river conditions and a forecast of the minimum available draft on the river for the duration of the trip between Bethel and Jungjuk. Because river levels vary from day to day, this will require real-time data on river conditions and the capability to predict river levels so that barges are loaded to maximum capacity, yet provide an adequate margin of safety against grounding. This capability will be provided by an automated load planning system that constantly monitors river conditions to provide load planners with the information they need to load barges so that they operate efficiently and safely.

## 2.6 Strategic Inventories

### 2.6.1 Bethel

The first ocean barge of each year will be scheduled to arrive at Bethel on 1 June, with others following almost immediately thereafter. To avoid delays in moving the material upriver, and to take advantage of the higher river levels expected in early June, up to 2,750 container loads of general cargoes and 4 USMgal of fuel will be brought to Bethel in September of the previous year and stored there over the winter months. This will allow the river barge operation to start as soon as the river upstream of Bethel has cleared of ice, or up to two weeks before the ice clears at the mouth of the Kuskokwim River.

### 2.6.2 Mine Site

Inventory storage capacity at the mine site for general cargoes and fuel will be equivalent to 10 months of mine consumption.

## 2.7 Discrete Simulation Models

Discrete simulation models were used to evaluate alternative barge fleet designs and their operation and to analyze the potential impacts of available water draft and other variables subject to uncertainty on system performance. The models simulated the operations of ocean and river barge fleets and transhipment terminals and measured key



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indicators of system performance such as annual volume actually shipped and inventory levels at transhipment points.

The primary objectives of the simulation model exercise were to determine:

- optimal number of tug and barges needed to satisfy demand for the transport of general cargoes and fuel
- maximum inventory capacities needed at transfer terminals to effectively de-couple inbound and outbound transport systems and optimize system performance
- probability that the supply chain would fail to transport the specified volumes of cargoes in any particular year.

Operation of the supply chain system was made conditional on uncertainty in the following key input variables:

- ocean barge arrivals
- shipping season on river
- available draft on river, which itself is conditional on flow data drawn from flow gauge readings at Crooked Creek
- year-to-year uncertainty in the demand for general cargo and fuel.

Two key aspects of the simulation model were the way in which it estimated the maximum allowable barge capacity for each trip and the model's implementation.

The model uses the ADF gauge data at Crooked Creek for the period 1952 to 2010 to estimate barge capacity. At the beginning of each run, the model randomly selects a year between 1952 and 2010 using a uniform distribution, and then uses the selected year's data for the river as the basis for estimating the available draft on the river. Before loading a barge, the model checks the date and minimum ADF reading at Crooked Creek between the barge leaving Bethel and it arriving at Jungjuk. The model then converts the minimum ADF readings to available draft and equivalent barge load using look-up tables.

The simulation models were run multiple times, varying the size of the ocean barge fleet between three and four units and river barge fleets between two and six tows. This process was repeated each year for 23 years and then started over. In the base runs, the length of the simulation was for 230 years so that the mine plan would be repeated 10 times. This provided enough data for a statistical analysis of the barge fleet and terminal operations.



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# 3.0 RIVER BARGE FLEET DESIGN AND OPERATION

## 3.1 General Cargo Fleet

### 3.1.1 General Cargo River Barges

The specifications for general cargo river barges are provided in Table 3-1. At a maximum operating draft of 7 ft a tow of four general cargos barges will have a capacity of 3,477 st (Table 3-2).

**Table 3-1: General Cargo Barge Specifications**

| Description | Unit | Value |
|---|---|---|
| Length | ft | 150 |
| Beam | ft | 44 |
| Depth | ft | 8 |
| Unloaded draft | ft | 1.5 |
| Minimum underkeel clearance | ft | 0.5 |
| Minimum operating draft | ft | 3 |
| Maximum operating draft | ft | 7.5 |
| Maximum net capacity | st | 942 |
| Maximum hull speed | knots | 15 |

**Table 3-2: General Cargo Barge Tow – Draft and Load Capacity**

| Draft (ft) | Load Capacity (st) |
|---|---|
| 1 | - |
| 2 | 580 |
| 3 | 1,160 |
| 4 | 1,740 |
| 5 | 2,318 |
| 6 | 2,898 |
| 7 | 3,477 |

The fleet will also include a 200 ft x 60 ft x 12 ft flat deck barge to carry break-bulk and other cargo too heavy to be placed on the deck of the regular barges, which are designed to primarily handle containers. Tugs will be triple-screw 2,000 hp with a minimum draft of 3 ft.

### 3.1.2 General Cargo River Barge Fleet Operation

Based on the operating assumptions listed in Table 3-3, general cargo river barges would have round-trip cycle times between Bethel and Jungjuk of 81 hours (Table 3-4).

As shown in Table 3-5, the discrete simulation analysis of the general cargo barge fleet concluded that the optimal barge fleet would be two tows and that this fleet would successfully deliver the specified volumes to the mine site 227 times out of 230, a success rate of about 99%. Its results also indicate that Bethel will need to have a storage capacity of about 30,000 st at the peak of the shipping season and that peak storage requirements at the mine will be about 120,000 st.

**Table 3-3: River Barge Operating Parameters**

| Item | Unit | General Cargo |
|---|---|---|
| Average barge turnaround time at Bethel | h | 12 |
| Average speed of loaded barge travelling upstream | knot | 4 |
| Distance from Bethel to Jungjuk | nm | 168 |
| Travel time loaded barge from Bethel to Jungjuk | h | 42 |
| Average speed downstream of barge loaded with empty containers | knots | 10 |
| Travel time from Jungjuk to Bethel | h | 17 |
| Average barge turnaround time at Jungjuk | h | 10 |

**Table 3-4: River Barge Round-Trip Cycle Time**

| Travel Route | Unit | General Cargo |
|---|---|---|
| Time to unload and load barge at Bethel | h | 12 |
| Travel time to Jungjuk | h | 42 |
| Time to unload and load barge at Jungjuk | h | 10 |
| Travel time from Jungjuk to Bethel | h | 17 |
| **Total Round-Trip Travel Time** | **h** | **81** |

**Table 3-5: General Cargo – Simulation Results**

| Description | Unit | Value |
|---|---|---|
| Number of general cargo tows | # | 2 |
| Run length | year | 230 |
| Success | % | 99 |
| Missed years | # | 3 |
| Maximum shortfall | st | 37,400 |
| Peak transhipment inventory | st | 30,000 |
| Peak inventory at mine site | st | 120,000 |

With an average round-trip cycle time of 81 hours each tow will make 32 round trips during the 110-day shipping season. If each tow loads an average of 1,883 st per trip, equivalent to a draft of 4.25 ft, a fleet of two tows will have the enough capacity to transport approximately 120,496 st of general cargoes each shipping season (Table 3-6), which is about 4,995 st, or 5%, more than the target volume of 115,000 st.

**Table 3-6: General Cargoes – River Barge Fleet Operation**

| Description | Unit | Value |
|---|---|---|
| Number of operating days each season | d | 110 |
| Number of operating hours each day | h | 24 |
| Number of operating hours each season | h | 2,640 |
| Annual volume of general cargo | s | 115,000 |
| Round-trip cycle time | h | 81 |
| Number of round-trips per tow each season | trip | 32 |
| Average load capacity per tow per trip | st | 1,883 |
| Seasonal load capacity of each tow | st | 60,248 |
| Number of tows in fleet | tow | 2 |
| Fleet capacity per season | st | 120,496 |
| **Total number of tow trips each season** | **trip** | **64** |
| **Average number of tow trips each day** | **trips/day** | **0.58** |

## 3.2 Fuel Fleet

### 3.2.1 Fuel River Barges

The specifications for the fuel barges are shown in Table 3-7. At a maximum operating draft of 7 ft a tow of four fuel barges will have capacity of 1.29 USMgal (Table 3-8).

Tugs will be triple-screw 1,450 hp with a minimum draft of 3.0 ft.

**Table 3-7: Fuel Barge Specifications**

| Description | Unit | Value |
|---|---|---|
| Length | ft | 165 |
| Beam | ft | 44 |
| Depth | ft | 9 |
| Unloaded draft | ft | 1.41 |
| Minimum underkeel clearance | ft | 0.5 |
| Minimum operating draft | ft | 3 |
| Maximum loaded draft | ft | 7.5 |
| Maximum capacity | USgal | 336,150 |
| Operating capacity/maximum capacity | % | 95 |



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**Table 3-8: Fuel Barge Tow Capacity**

| Draft (ft) | Capacity (USgal) |
|---|---|
| 1 | - |
| 2 | 214,329 |
| 3 | 428,658 |
| 4 | 642,987 |
| 5 | 857,316 |
| 6 | 1,071,645 |
| 7 | 1,285,974 |

### 3.2.2 Fuel River Barge Fleet Operation

Based on the operating assumptions listed in Table 3-9, fuel river barges will have round-trip cycle times between Bethel and Jungjuk of 81 hours (Table 3-10).

**Table 3-9: River Barge Operating Parameters**

| Item | Unit | Fuel |
|---|---|---|
| Average barge turnaround time at Bethel | h | 8 |
| Average speed of loaded barge traveling upstream | knot | 3.5 |
| Distance from Bethel to Jungjuk | nm | 168 |
| Travel time loaded barge from Bethel to Jungjuk | h | 48 |
| Average speed downstream of barge empty | knots | 10 |
| Travel time from Jungjuk to Bethel | h | 17 |
| Average barge turnaround time at Jungjuk | h | 8 |

**Table 3-10: River Barge Round-Trip Cycle Time**

| Travel Route | Unit | Fuel |
|---|---|---|
| Time to unload and load barge at Bethel | h | 8 |
| Travel time to Jungjuk | h | 48 |
| Time to unload and load barge at Jungjuk | h | 8 |
| Travel time from Jungjuk to Bethel | h | 17 |
| **Total Round-Trip Travel Time** | **h** | **81** |

The principal conclusions of the simulation model of the fuel resupply system (Table 3-11) were that the optimal fuel fleet would be two tows and that this fleet would successfully deliver the specified annual volumes of fuel to the mine site 223 times out of 230, a



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success rate of almost 97%. It also showed that storage requirements at Dutch Harbor and Bethel will be about 13 USMgal and 10 USMgal, respectively. The peak inventory at the mine site would be 38.5 USMgal.

With an average round-trip cycle time of 81 hours, each tow will make about 29 round-trips during the 110-day shipping season. If each tow loads an average of 691,000 USgal of fuel per trip, equivalent to draft of 4.25 ft, a fleet of two tows will have the enough capacity to transport up to 45.6 USMgal of fuel between Bethel and Jungjuk each shipping season (Table 3-12), or about 3.3 USMgal, or 8%, more than the specified target volume of 42.3 USMgal.

**Table 3-11: Fuel Supply Chain Model Simulation Results**

| Description | Unit | Value |
|---|---|---|
| Optimal number of river tows | # | 2 |
| Run length | year | 230 |
| Success | % | 97 |
| Maximum shortfall | USMgal | 11.1 |
| Dutch Harbor fuel storage capacity | USMgal | 13 |
| Bethel fuel storage capacity | USMgal | 10 |
| Mine site fuel storage capacity | USMgal | 45 |

**Table 3-12: Fuel River Barge Fleet Operation**

| Description | Unit | Value |
|---|---|---|
| Number of operating days each season | d | 110 |
| Number of operating hours each day | h | 24 |
| Number of operating hours each season | h | 2,640 |
| Round-trip cycle time of tow | h | 81 |
| Number of round-trips per tow each season | trip | 33 |
| Average load per tow | USMgal | 0.691 |
| Seasonal capacity per tow | USMgal | 22.8 |
| Number of tows in service | # | 2 |
| Fleet seasonal capacity | USMgal | 45.6 |
| **Total number of trips each season** | **trip** | **58** |
| Average number of trips each day | trips/day | 0.53 |



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## 3.3 Extreme Years

By its very nature the Kuskokwim River is subject to constant change: river flows, water depths, currents, navigation channel locations, and their profiles are always in a state of flux. As such, the possibility of river levels that result in barges being unable to reach Jungjuk because of shallow-water conditions at some times during the life of the mine must be considered. In an extreme year, the volume of general cargo and fuel that could be delivered to site with the existing fleet could be insufficient to supply the mine through to the start of the next barging season.

One such extreme year would have been 1997 when the ADF between 1 June and 20 September averaged only 41,250 cfs (Figure 3-1). The primary impacts of an extreme low water year such as that experienced in 1997 would be twofold: a) over the shipping season it would limit barge operating draft to an average of only 3.5 ft, and b) it would shorten the shipping season by 5 days, from 110 days to 105 days, operating restrictions that would reduce the nominal capacity of the barge fleets by about 27% and result in a potential shortfall in deliveries of 25,000 t of general cargoes and 9 USMgal of fuel. One way to compensate for this reduction in fleet capacity would be to add a third barge to the general cargo and fuel fleets to increase their nominal capacities in a low-water year like 1997 to 135,000 st and 49.9 USMgal, respectively. Alternatively, these shortfalls could be overcome by extending the shipping season later into September, which would have been possible in 1997, and drawing down on the strategic inventories at Bethel and the mine site.

Other contingency plans available to the mine in the event of prolonged periods of low water on the river include one or more of the following options:

- procure additional spare barges that could be brought into service when needed
- charter inadditional tug and barge sets
- break down the four tows into smaller units that could navigate the narrower sections of the river more easily
- increase strategic inventories in Bethel or at the forward deployment locations to be ready when water levels rise
- re-optimize the mine plan to defer material to later years, reducing fuel and consumable demands
- operate the mill from existing stockpiles or reduce plant throughput so as to conserve inventories.



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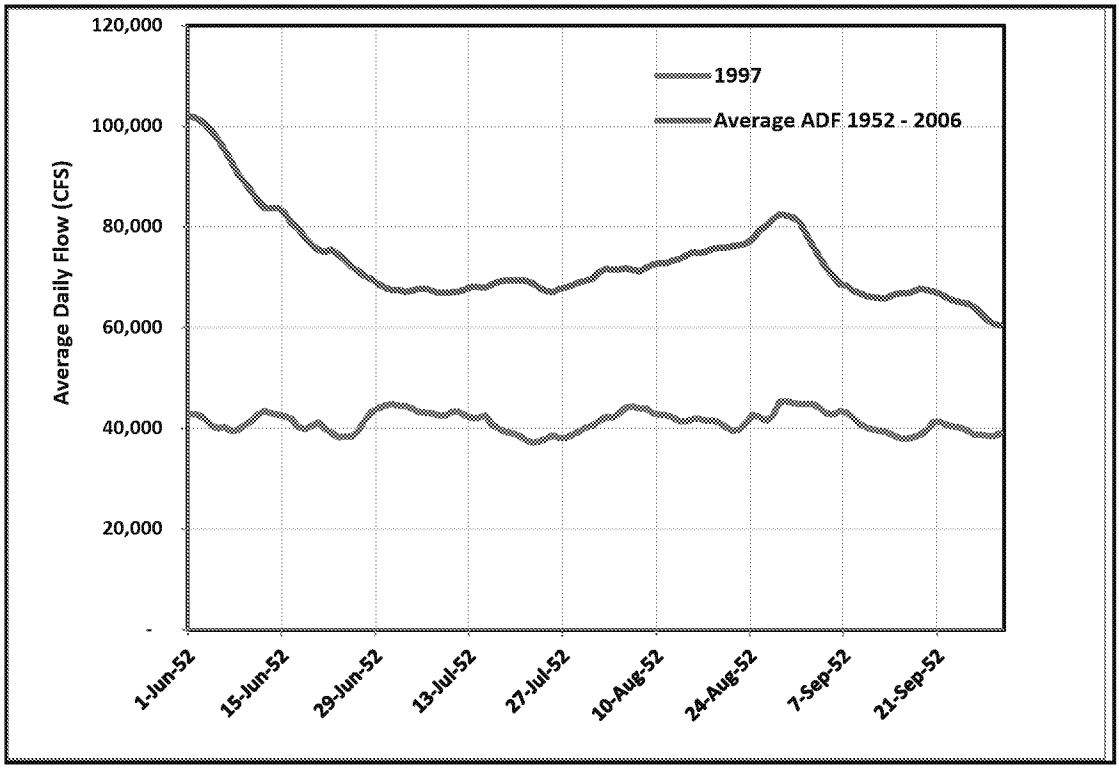
**Figure 3-1: Average ADF 1952 – 2006 and the ADF for 1997**



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# 4.0 COMMUNICATIONS AND NAVIGATION

## 4.1 Community Communications Strategy

From mid-May to the end of September, the barges and the terminals and facilities that serve them will operate 24 h/d, 7 d/wk. It will therefore be essential to maintain continuous dialogue with the local communities about the operations. Following are examples of communication and navigation initiatives that could be taken to share information with the local communities and others who live and work on the Kuskokwim River:

- establish mechanisms for dialogue and discussion between operators and local communities to address issues arising from the barging operations
- employ local representatives at communities along the river to represent the project and keep communities informed of what is happening on the river and how it might affect them
- employ a wide range of devices for communicating barging activities on the river, including notice boards, local radio, local television, access to vessels' radio channels, newsletters, and the Internet. The International Maritime Organization has requested that all member countries keep information such as vessel position, speed, and heading off the Internet and other broad-based communication systems for security reasons.
- where possible, locate facilities and barge routes away from areas where there is likely to be conflict
- incorporate net location survey data into the electronic river charts to help mitigate incidents of damaged nets
- make paper charts for the river available to all residents.

## 4.2 River Barge Communications and Navigation

Before the river transport system is implemented, the river will be surveyed and an electronic navigation chart will be developed. In addition, sections of the river where navigation is difficult and tight will be buoyed annually. A series of ranges (for navigation both upriver and downriver) can also be constructed. These ranges, providing "line-of-sight" navigation, are the most accurate of the non-electronic aids. They could be equipped with directional lighting powered by a small solar panel.

To ensure a safe and secure marine system on the river, each tug will be equipped with modern communication and navigation equipment. Standard equipment could include:

- an Automatic Identification System, which is an integrated marine chart and radar display system based on satellite (Inmarsat) and radio technology. This system



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places the location of the vessel on the electronic chart and radar screen and provides the location, identification, speed, and heading of all other similarly equipped vessels within radio range on the same chart and radar screen.

- an Inmarsat-based telephony and data service capable of providing traditional voice calls and real-time high-speed data (fax and/or email)
- a global Maritime Distress Safety System, which ensures rapid notification to shore-based rescue and communication authorities, as well as to all ships in the area, in the event of an emergency
- High Frequency Single Sideband and Very High Frequency communications systems retained as back-up safety systems.

Each tug-and-barge set will be equipped with a tracking transmitter to provide the traffic manager and terminal managers with the location of any vessel and its position in relation to the other fleet vessels, at all times.



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# GUIDELINES ON TAILINGS DAMS

## PLANNING, DESIGN, CONSTRUCTION, OPERATION AND CLOSURE

**MAY 2012**

ANCOLD

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Ex. 4 CBI - Copyright



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Preserving America's Heritage

# SECTION 106 AND THE U.N. DECLARATION ON THE RIGHTS OF INDIGENOUS PEOPLES: GENERAL INFORMATION AND GUIDANCE

The Advisory Council on Historic Preservation (ACHP) adopted a plan to support the U.N. Declaration on the Rights of Indigenous Peoples (Declaration) on March 1, 2013. In the plan, the ACHP commits to raising awareness about the Declaration in the historic preservation community and incorporating the principles and aspirations of the Declaration into ACHP initiatives and programs. As part of the effort to raise awareness, the ACHP also committed to developing guidance on the intersection of the process under Section 106 of the National Historic Preservation Act (Section 106) and the Declaration.

This document presents general information about the Declaration and the Section 106 process to give federal agencies, Indian tribes, Native Hawaiian organizations (NHOs), and other interested parties ways in which the two can be integrated in order to enhance the protection of historic properties.

In recognition that the Declaration is an international instrument written to be relevant to many nations and indigenous peoples, the ACHP has liberally interpreted the language and intention of the articles in the Declaration. It could be argued that there are other relevant articles and that the Declaration generally supports the purposes of the National Historic Preservation Act and the Section 106 process. In fact, the 17 of the 46 articles in the Declaration deal with indigenous culture and how to protect and promote it. These articles address issues such as language preservation, education in indigenous languages, and so on, all important but not within the sphere of Section 106. Therefore, the ACHP has identified nine articles that fairly closely intersect with the mission and work of the ACHP and with the Section 106 review process. They are Articles 8, 11, 12, 15, 16, 18, 25, 31, and 38 (see attached).

## U.N. Declaration on the Rights of Indigenous Peoples

The U.N. General Assembly adopted the Declaration in 2007 with four member states of the U.N., the United States, Canada, New Zealand, and Australia, initially opposed to it. These states have since reversed their positions.

"The Declaration is a comprehensive statement addressing the human rights of indigenous peoples. It was drafted and formally debated for over twenty years prior to being adopted by the General Assembly on 13 September 2007. The document emphasizes the rights of indigenous peoples to live in dignity, to maintain and strengthen their own institutions, cultures and traditions and to pursue their self-determined development, in keeping with their own needs and aspirations."[1]

"The Declaration establishes a universal framework of minimum standards for the survival, dignity, well-being and rights of the world's indigenous peoples. The Declaration addresses both individual and collective rights; cultural rights and identity; rights to education, health, employment, language, and others. It outlaws discrimination against indigenous peoples and promotes their full and effective participation in all matters that concern them. It also ensures their right to remain distinct and to pursue

[1] United Nations Permanent Forum on Indigenous Issues. "Frequently Asked Questions - Declaration on the Rights of Indigenous Peoples." Available at: http://www.un.org/esa/socdev/unpfii/documents/FAQsindigenousdeclaration.pdf.

their own priorities in economic, social and cultural development. The Declaration explicitly encourages harmonious and cooperative relations between States and indigenous peoples."[2]

For more information about the Declaration, go to http://www.un.org/en/events/indigenousday/pdf/FAQsindigenousdeclaration_FINAL.pdf.

**U.S. Position on the Declaration**

In 2010, at the second White House Tribal Nations Conference, President Obama announced that the United States supports the Declaration, thereby reversing the initial opposition of the U.S. In making the announcement, the President said that "what matters far more than words-what matters far more than any resolution or declaration-are actions to match those words."

The position of the United States is that the Declaration, "while not legally binding or a statement of current international law—has both moral and political force. It expresses both the aspirations of indigenous peoples around the world and those of States in seeking to improve their relations with indigenous peoples. Most importantly, it expresses aspirations of the United States, aspirations that this country seeks to achieve within the structure of the U.S. Constitution, laws, and international obligations, while also seeking, where appropriate, to improve our laws and policies."[3]

In its response to President Obama's announcement of U.S. support for the Declaration, the National Congress of American Indians (NCAI) issued a statement about the Declaration:

> "The importance of the Declaration to American Indian and Alaska Native tribes is significant. While not legally binding in and of itself, it nevertheless performs the invaluable functions of gathering together in one document the basic rights of indigenous peoples, educating the public, and providing clear direction for those nation states endorsing the Declaration. The Declaration has considerable moral and political force and Indian nations will not hesitate to use the Declaration as the standard by which to measure the actions of the federal government."

**The Section 106 Process**

Section 106 of the National Historic Preservation Act (NHPA) requires federal agencies to consider the effects on historic properties of any project they carry out or which receives federal financial assistance, permits, or approvals (undertakings), and provide the ACHP an opportunity to comment on these projects prior to making a final decision. Agencies must meet their Section 106 responsibilities through a process set forth in regulations issued by the ACHP. These regulations are published in the Code of Federal Regulations at 36 CFR Part 800, "Protection of Historic Properties," and can be found on the ACHP's Web site, www.achp.gov/regs.html.

Both the NHPA and the Section 106 regulations require that federal agencies, in carrying out their Section 106 responsibilities, consult with any Indian tribe or NHO that attaches traditional religious and cultural significance to historic properties that may be affected by an undertaking. The regulations provide general directions regarding tribal and Native Hawaiian consultation at Section 800.2(c)(2) as well as very specific steps to be taken throughout the process. The ACHP has issued extensive guidance regarding such consultation, all of which can be found at www.achp.gov/nap.

The Section 106 consultation requirements are very important because they afford Indian tribes and NHOs an opportunity to influence federal decision making when undertakings may affect historic properties of religious and cultural significance to them. These places are often referred to as sacred sites or sacred places. The Section 106 regulations also require federal agencies to acknowledge the special

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[2] http://www.ohchr.org/EN/Issues/IPeoples/Pages/Declaration.aspx

[3] In 2010, the State Department released, "Announcement of U.S. Support for the United Nations Declaration on the Rights of Indigenous Peoples." To read the full statement, go to http://www.achp.gov/docs/US%20Support%20for%20Declaration%2012-10.pdf.

expertise that Indian tribes and NHOs possess regarding the significance of such places. Further, the regulations support tribal sovereignty in that for an undertaking on tribal land or that affects historic properties on tribal land, an agreement resolving adverse effects to historic properties must have that Indian tribe's signature in order to go into effect. Absent such agreement, the federal agency can only conclude the Section 106 process through ACHP comment, whereby the ACHP membership provides its views to the head of that federal agency or department.

**How the Declaration and the Section 106 Process Intersect**

Since the Declaration expresses the rights of indigenous peoples to maintain and protect all aspects of their cultures, there is an obvious relationship to the aims of the NHPA and Section 106. There are also articles that tangentially relate to Section 106. For example, in 2013, the ACHP issued guidance regarding the intersection of Article 18 and the consultation requirements of Section 106.

Some of the rights related to culture and heritage expressed in the Declaration include the right:

- To practice and revitalize cultural traditions and customs
- To maintain, protect and develop the past, present and future manifestations of cultures such as archaeological and historical sites, artefacts, designs, ceremonies, technologies and visual and performing arts and literature
- To manifest, practice, develop and teach spiritual and religious traditions, customs and ceremonies
- To maintain, protect, and have access in privacy to religious and cultural sites
- To the use and control of ceremonial objects
- To the repatriation of human remains
- To maintain and strengthen distinctive spiritual relationships with traditionally owned or other occupied and used lands, territories, waters and coastal seas and other resources and to uphold responsibilities to future generations in this regard
- To maintain, control, protect and develop cultural heritage, traditional knowledge and traditional cultural expressions
- To maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions

Other indigenous rights in the Declaration related, in general, to Section 106 include the right to participate in decision making, the right to not be subjected to the destruction of culture, and the right to reflection of indigenous cultural diversity in State-run media.

**Working with the Declaration: Advice for Federal Agencies**

While the Declaration is not legally binding, and thus compliance with its terms is not required, federal agencies can look to the Declaration for policy guidance in general and specifically in carrying out their Section 106 responsibilities. Because the Declaration was developed with input from indigenous peoples around the world, it stands as a guide to what is important to indigenous peoples, above and beyond basic human rights. The ACHP suggests that federal agencies:

- Become familiar with the history of the Declaration and related work at the U.N. and in the U.S. For example, in 2012 Special Rapporteur James Anaya issued a report on the indigenous peoples in the U.S. Additionally, the U.N. held the World Conference on Indigenous Peoples in 2014 and adopted an outcome document or resolution with additional guidance for member states.
- Develop a working knowledge of the Declaration and its articles.
- Know the U.S. position on the Declaration.
- Consider the Declaration to be a policy reference both in the Section 106 process and beyond. In its 2008 policy on its relationship with NHOs, the ACHP clarified that the NHPA and the ACHP's regulations "set the minimum standards for federal agency interactions with its preservation partners." This clarification applies to all preservation partners, not simply NHOs. Therefore, unless a federal agency has binding limitations on what, when, where and how it

consults with Indian tribes and NHOs, it can always make improvements to its consultation practices and policies and the Declaration can help.

- Review agency policies regarding Indian tribes and NHOs and consider updating them to reflect Declaration principles.
- Understand that as indigenous peoples of the U.S. become more familiar with the Declaration, federal agencies may be pressed to recognize, support, and implement the Declaration in carrying out projects and programs.

**Working with the Declaration: Advice for Indian Tribes and Native Hawaiian Organizations**

- Become familiar with the Declaration and related work at the U.N. and in the U.S (see above). This information can provide ideas to bring forth in Section 106 and other consultations with federal agencies.
- Understand the current U.S. position on the Declaration and remind federal agencies of such when in consultation.
- Urge succeeding Administrations to continue, and strengthen, the current position on the Declaration.
- Review federal agency policies for consistency with Declaration principles and discuss the results of your review with agencies.
- While the Declaration is primarily directed toward U.N. member states, i.e. nations, share the Declaration with state and local officials to help them understand indigenous issues and the fact that these are global issues.
- Reference specific relevant Declaration articles in consultations and correspondence with federal officials.
- Ask if federal officials are familiar with the Declaration. Refer them to online resources including the ACHP's website.

**Articles of the U.N. Declaration on the Rights of Indigenous Peoples Relevant to the Section 106 Review Process**

Of the 46 articles of the Declaration on the Rights of Indigenous Peoples, the following are, in some way, related to the consultation rights afforded to Indian tribes and Native Hawaiian organizations in the Section 106 process, or the overall work of the ACHP. Some of these articles include provisions that are not relevant to historic preservation or the Section 106 process. Therefore, only the relevant provisions of each article are included rather than the entire article. To read the entire Declaration, go to http://www.achp.gov/docs/UN%20Declaration%20on%20the%20rights%20of%20indigenous%20peoples.pdf.

**Article 8**
1. Indigenous peoples and individuals have the right not to be subjected to forced assimilation or destruction of their culture.

2. States shall provide effective mechanisms for prevention of, and redress for:
   a. Any action which has the aim or effect of depriving them of their integrity as distinct peoples, or of their cultural values or ethnic identities

**Article 11**
1. Indigenous peoples have the right to practice and revitalize their cultural traditions and customs. This includes the right to maintain, protect and develop the past, present and future manifestations of their cultures, such as archaeological and historical sites, artefacts, designs, ceremonies, technologies and visual and performing arts and literature.

**Article 12**
1. Indigenous peoples have the right to manifest, practice, develop and teach their spiritual and religious traditions, customs and ceremonies, the right to maintain, protect, and have access in privacy to their religious and cultural sites; the right to the use and control of their ceremonial objects; and the right to the repatriation of their human remains.

**Article 15**
1. Indigenous peoples have the right to the dignity and diversity of their cultures, traditions, histories and aspirations which shall be appropriately reflected in education and public information.

**Article 16**
2. States shall take effective measures to ensure that State-owned media duly reflect indigenous cultural diversity.

**Article 18**
Indigenous peoples have the right to participate in decision-making in matters which would affect their rights, through representatives chosen by themselves in accordance with their own procedures, as well as to maintain and develop their own indigenous decision-making instructions.

**Article 25**
Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or other occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard.

**Article 31**
1. Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences,

technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts. They also have the right to maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions.

2. In conjunction with indigenous peoples, States shall take effect measures to recognize and protect the exercise of these rights.

**Article 38**
States, in consultation and cooperation with indigenous peoples, shall take the appropriate measures, including legislative measures, to achieve the ends of this Declaration.

# UML-led Team Finds Source of Arctic Mercury

**PROF. OBRIST'S RESEARCH RESULTS PUBLISHED IN 'NATURE'**

Prof. Daniel Obrist digs pits to measure tundra soil mercury concentrations and auxiliary soil chemistry on the Alaska North Slope.

07/13/2017

*By Edwin L. Aguirre*

Large quantities of mercury (https://www.epa.gov/mercury) are ending up in the Arctic, threatening the environment and the health and well-being of northern wildlife and people, according to new research led by Prof. Daniel Obrist (uml.edu/sciences/kcs-advisory-board/obrist-daniel.aspx), chairman of the Department of Environmental, Earth and Atmospheric Sciences (uml.edu/sciences/eeas/).

In a study published this month in the journal Nature

Tweet (https://twitter.com/intent/tweet?hashtags=umasslowell&url=https://www.uml.edu/news/stories/2017/obrist-mercury-pollution.aspx)

Share (https://www.facebook.com/sharer/sharer.php?u=https://www.uml.edu/news/stories/2017/obrist-mercury-pollution.aspx)

Email

(http://www.nature.com/nature/journal/v547/n7662/full/nature22997.html), Obrist's team found that the absorption of mercury from the atmosphere by the tundra is shown to drive high loads of mercury in Arctic tundra soils. Tundras are vast, treeless regions where the soils are permanently frozen, or "permafrost." Mercury runoff from tundra soil then supplies 65 to 85 tons of the toxic heavy metal to Arctic lakes, rivers and the Arctic Ocean each year.

"This mercury from the tundra soil explains half to two-thirds of the total mercury input to the Arctic Ocean," says Obrist.

Obrist recently led an international group — including researchers from UMass Lowell, the Desert Research Institute in Reno, Nev., Paris-Sorbonne University and the University of Toulouse in France, the University of Colorado and the Gas Technology Institute in Des Plaines, Ill. — to conduct a long-term study of the origin of mercury pollution in the Arctic tundra. The investigation was supported by the U.S. National Science Foundation.



ED_013708_00001218-00133

"This is the most comprehensive study ever done on mercury deposition," notes Obrist.

**A Highly Neurotoxic Pollutant**

Mercury is one of the most harmful pollutants threatening fish, birds and mammals worldwide. Hundreds of tons of it are released into the atmosphere each year by power plants through the burning of coal, as well as through mining activities and other industrial processes, and are distributed throughout the world. Airborne mercury eventually falls back to the ground, accumulating in soils, rivers, lakes and oceans.

A first global treaty, the Minamata Convention (http://www.mercuryconvention.org/) that aims to protect human health and the environment from the adverse effects of mercury, was adopted in 2013. It has been signed by 128 member countries — including the U.S. — and will take effect in August of this year.

Mercury is released into the atmosphere by power plants through the burning of coal, as well as through mining activities and other industrial processes.

"Mercury is a neurotoxic pollutant that has led to high exposure levels in northern wildlife, such as beluga whales, polar bears, seals, fish, eagles and other seabirds," says Obrist. "It also affects human populations, particularly the Inuit, which rely on traditional hunting and fishing."

Exposure to high levels of mercury over long periods can lead to neurological and cardiovascular problems. Infants and young children can suffer from developmental disorders, reduced memory performance and increased risk of attention problems.

During Arctic winter, a display of the aurora borealis, or

Mercury exists in several forms, including methylmercury and other organic compounds, elemental (metallic) mercury and inorganic mercury compounds.

"We determined the dominant source of mercury in the Arctic tundra to be the gaseous form of elemental mercury that is being transported in the atmosphere," says Obrist. "During a span of two years, we developed a complete accounting of all atmospheric mercury inputs and an inventory of soil mercury deposits at our



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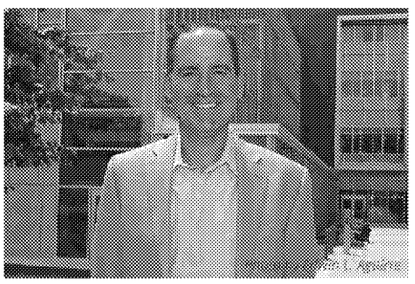
Northern Lights, occurs over the researchers' Toolik Field Station, which is on an inland tundra in northern Alaska north of the Brooks Range.

observation site, which is in an inland tundra in northern Alaska north of the Brooks Range. We used a unique combination of different techniques that allowed us to make precise measurements for two full years, including through the Arctic winter."

The scientists found that 70 percent of atmospheric mercury deposition is driven by the gaseous elemental form, whose deposition is normally not measured and travels the farthest distances in the atmosphere so it easily reaches the Arctic. In contrast, deposition via rain and snow, which generally is the focus in most studies, is very small over the northern Arctic tundra — approximately 2 percent of the total mercury deposition.



In addition to mercury, Obrist's other research interests include trace metals and persistent organic pollutants as well as greenhouse gases (carbon dioxide and methane).

How does gaseous elemental mercury end up in the tundra soil?

"It's a process similar to the uptake of carbon dioxide by plants. In this case, the mercury gas is absorbed by tundra plants and then transferred to the soil when the plants shed leaves or die off," explains Obrist. As a result, the Arctic tundra becomes a significant deposit for mercury emitted from industrialized, more southern regions of the world.

"We calculate that large amounts of mercury are trapped in tundra soils, possibly up to a third to one-half of the world's total soil mercury deposits. These deposits may be critically threatened by an unprecedented Arctic climate warming that could destabilize Arctic soils and possibly lead to more mercury being released into streams, rivers, lakes and the Arctic Ocean. This would further harm the welfare of Arctic wildlife and people," adds Obrist.

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Map & Directions (uml.edu/maps)

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*Attorneys for Defendants*

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE DISTRICT OF ALASKA**

| | |
|---|---|
| ALATNA VILLAGE COUNCIL, *et al.*,<br><br>Plaintiffs,<br><br>v.<br><br>THOMAS HEINLEIN, in his official capacity as United States Bureau of Land Management Alaska State Director, *et al.*,<br><br>Defendants,<br><br>and<br><br>AMBLER METALS, LLC, *et al.*,<br><br>Intervenor-Defendants. | Case No. 3:20-cv-00253-SLG |

**DECLARATION OF DEPUTY SECRETARY OF THE DEPARTMENT OF THE INTERIOR**

1. My name is Tommy P. Beaudreau and I am the Deputy Secretary of the Department of the Interior (Department). I was confirmed by the Senate for this position on June 17, 2021. As the Deputy Secretary, I am the Chief Operating Officer for the Department. I assist the Secretary of the Interior in supervising and administering all operations and activities of the Department, including those of the Bureau of Land Management (BLM) and National Park Service (NPS). The Department's mission is to protect and manage the Nation's natural resources and cultural heritage; provide scientific and other information about those resources; and honor its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

2. On behalf of the Department, I have reviewed the records underlying the following decisions challenged in the above-captioned matter: (1) the July 23, 2020 decision approving issuance of a Federal Land Policy and Management Act (FLPMA) Title V right-of-way (ROW) to the Alaska Industrial Development and Export Authority (AIDEA) for an industrial access gravel road across BLM-managed lands in northwest Alaska; (2) the associated BLM ROW permit; (3) the July 23, 2020 decision approving issuance of an Alaska National Interest Lands Conservation Act (ANILCA)-authorized ROW to AIDEA for an industrial access gravel road (Ambler Road) across Gates of the Arctic National Preserve; and (4) the associated NPS ROW permit. The records underlying these challenged decisions include the Alaska National Interest Lands Conservation Act (ANILCA) Section 810 Evaluation, National Historic Preservation Act (NHPA) Programmatic Agreement, environmental impact statement, decision records, and related materials.

3. The Department has identified substantial concerns regarding (1) the analysis of impacts to subsistence uses under ANILCA Section 810 and (2) the adequacy of government-to-government consultation with Tribes and related consideration of impacts under the NHPA to properties of traditional religious and cultural importance to federally recognized Tribes.

4. The BLM and NPS jointly engaged in the ANILCA Section 810 process, with the BLM serving as the primary author of the Section 810 Evaluation. I am aware that the challenged decisions rely upon the Section 810 Evaluation.

5. There are deficiencies in the analysis of impacts to subsistence use contained in the Section 810 Evaluation. The Section 810 Evaluation did not sufficiently analyze the extent or necessity of Ambler Road-related significant impacts to subsistence uses. These procedural deficiencies, in concert with broader trends impacting critical subsistence resources, necessitate remand of the decisions for a renewed Section 810 Evaluation and determination.

6. In particular, the Section 810 Evaluation: (1) lacks sufficient discussion of impacts on caribou forage vegetation and the resultant adverse impacts on subsistence; and (2) lacks sufficient discussion of water impacts that would occur in connection with construction and operation of the Ambler Road, including the dewatering of streams and groundwater as part of mining operations, and the impacts of such activities on salmon, sheefish, and other fish species; spawning areas, and other aquatic habitat; and related subsistence uses. These deficiencies are compounded by new information, not considered in the decisions, indicating significant declines in salmon and caribou populations critical to subsistence communities.

7. The BLM and NPS jointly engaged in the NHPA Section 106 process, with the BLM serving as the designated lead agency consistent with 36 C.F.R. § 800.2(a)(2). The BLM led development of a programmatic agreement as an alternative process for implementing

Section 106 in a phased approach under 36 C.F.R. § 800.14(b)(3). I am aware that the challenged decisions rely upon the programmatic agreement.

8. The programmatic agreement is deficient because the BLM did not engage in adequate consultation with Tribes prior to executing it. The administrative record shows that the priority of achieving a programmatic agreement within the timeframe established by the Department constrained the options for Tribal consultation, and that Tribes were afforded only a secondary role in the ultimate adoption of the programmatic agreement. Such limited consultation with Tribes is a deficiency necessitating remand of the decisions for a renewed Section 106 process, to include revisiting whether Tribes should be included as invited signatories to a programmatic agreement.

9. To ensure compliance with ANILCA and the NHPA and applicable Executive and Secretarial Orders and Departmental policies regarding Tribal consultation—including Executive Order 13175, Secretary's Order 3403, and the January 26, 2021 Presidential Memorandum: Tribal Consultations and Strengthening Nation-to-Nation Relationships—the Department has determined to undertake additional analysis and consultation under ANILCA Section 810 and NHPA Section 106.

10. In addition to correcting ANILCA Section 810 and NHPA Section 106 deficiencies, the Department also intends to supplement the applicable environmental impact statement to more thoroughly assess the impacts and resources identified as areas of concern in this litigation.

11. The review process will entail reinitiating the NHPA Section 106 process, including meaningful and thorough consultation with Tribes; reinitiating analysis of impacts to subsistence uses under ANILCA Section 810, including publishing a draft and final 810

evaluation; and publishing a draft and final supplemental environmental impact statement. The Department is committed to undertaking the necessary consultation, analysis, and supplementation in a timely manner.

12. While this review process is ongoing, the Department intends to suspend the ROW permits based on the deficiencies noted in the preceding paragraphs in order to preserve the environmental status quo. Any such suspensions will be issued after completing internal review and coordination by the BLM, NPS, and the Solicitor's Office.

13. Pursuant to 28 U.S.C. § 1746, I certify under penalty of perjury that the foregoing is true and correct.

Executed this 22nd day of February 2022, in Washington, D.C.

Tommy P. Beaudreau
Deputy Secretary
Department of the Interior

TODD KIM
Assistant Attorney General
United States Department of Justice
Environment and Natural Resources Division

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| ALATNA VILLAGE COUNCIL, *et al.*,<br><br>Plaintiffs,<br>v.<br><br>THOMAS HEINLEIN, in his official capacity as Acting BLM Alaska State Director, *et al.*,<br><br>Defendants,<br>and<br><br>AMBLER METALS, LLC, *et al.*,<br><br>Intervenor-Defendants. | Case No. 3:20-cv-00253-SLG |

**DEFENDANTS' MOTION FOR VOLUNTARY REMAND**

## INTRODUCTION

In 2015, the Alaska Industrial Development and Export Authority (AIDEA) submitted an application to federal land managers seeking to obtain a right-of-way, and begin construction of the Ambler Road. Defendants reviewed the application and sought public input in accordance with various statutes and regulations. In July 2020, the agencies concluded their reviews and issued final decisions, approving AIDEA's application subject to numerous terms and conditions and issuing rights-of-way on January 5, 2021.

Plaintiffs Alatna Village Council, et al. (AVC), with plaintiffs in the related case *Northern Alaska Environmental Center v. Haaland*, No. 20-cv-00187-SLG (NAEC), contend that Defendants violated a host of laws in evaluating the application. Defendants now recognize that it is appropriate to revisit the challenged decisions. Additional scrutiny in defending the fully briefed merits of Plaintiffs' claims has illuminated legal flaws that Defendants intend to reconsider through a further administrative process.

In particular, Defendants' analysis of impacts to subsistence uses under the Alaska National Interest Lands Conservation Act (ANILCA), and their consideration of impacts under the National Historic Preservation Act (NHPA) to properties of traditional religious and cultural importance to federally recognized tribes, was deficient. In addition, Defendants intend to supplement the analysis under National Environmental Policy Act (NEPA). Defendants therefore move for an order remanding the challenged decisions to

the agencies for reconsideration.[1] The Department will determine, based on the totality of the administrative record as supplemented by the additional analysis and consultation described below, whether to affirm, amend, or terminate the right-of-way permits.

## LEGAL BACKGROUND

Plaintiffs' claims under various statutes all proceed under the Administrative Procedure Act's (APA) waiver of sovereign immunity and standard of review.

### I. Alaska National Interest Lands Conservation Act

ANILCA reflects legislative policy and compromise of unique complexity and physical magnitude, commensurate with Alaska itself. *See* Alaska National Interest Lands Conservation Act, Pub. L. No. 96-487, 94 Stat. 2371, 2371-2551 (1980). In broad terms, "ANILCA sought to 'balance' two goals," of protecting "'the national interest in the scenic, natural, cultural and environmental values on the public lands in Alaska[,]'" while "'provid[ing] adequate opportunity for satisfaction of the economic and social needs of the State of Alaska and its people.'" *Sturgeon v. Frost*, 139 S. Ct. 1066, 1075 (2019) (quoting 16 U.S.C. § 3101(d)). In Title II, ANILCA made substantial additions to the National Park System, some of which were further included by Title VI and Title VII in the National Wild and Scenic Rivers System and National Wilderness Preservation

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1 Plaintiffs request that numerous elements of "Defendants' decision-making" be vacated. *See* Pls.' Opening Br. at 88, ECF No. 99. Vacatur is not appropriate here, because the Department intends to suspend further activity under the Project pending remand. *See* Decl. of Tommy Beaudreau ¶ 12, attached as Exhibit 1. The Army Corps of Engineers issued the Clean Water Act Section 404 permit. It will consider what action is needed with respect to the Section 404 permit in light of the Court's ruling on this motion and will follow the process outlined in its regulations at 33 C.F.R. § 325.7.

System, respectively. In Title VIII Congress sought "to preserve Alaska's natural resources, historic sites, and ecosystems, while also providing the continued opportunity for rural residents to engage in a subsistence way of life." *Dep't of Fish & Game v. Fed. Subsistence Bd.*, No. 3:20-cv-00195-SLG, 2020 WL 5625897, at *5 (D. Alaska Sept. 18, 2020) (citing *Alaska v. Fed. Subsistence Bd.*, 544 F.3d 1089, 1091 (9th Cir. 2008)).

## II. National Historic Preservation Act

The NHPA "is a 'stop, look, and listen' provision that requires each federal agency to consider the effects of its programs," but does not require that the agency reach particular outcomes. *Muckleshoot Indian Tribe v. U.S. Forest Serv.*, 177 F.3d 800, 805 (9th Cir. 1999); *see also* 54 U.S.C. § 306108 (formerly 16 U.S.C. § 470f (2013)). Nevertheless, the information gathered in the NHPA process helps to inform agency decision-making.

NHPA Section 106 requires federal agencies to "take into account the effect of [an] undertaking on any historic property." 54 U.S.C. § 306108. Regulations promulgated by the Advisory Council on Historic Preservation (ACHP) set forth procedures for implementing the NHPA. 36 C.F.R. pt. 800. The regulations direct agencies to determine whether a project qualifies as an "undertaking" and is a "type of activity that has the potential to cause effects on historic properties." *Id.* § 800.3(a).[2] If

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2 The regulations define historic properties as "any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places maintained by the Secretary of the Interior" and includes "properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization that meet the National Register criteria." 36 C.F.R. §

an undertaking is the type of activity with the potential to cause effects on historic properties, then the agency must consult with the State Historic Preservation Officer (SHPO) and, if appropriate, other consulting parties, including "[d]etermin[ing] and document[ing] the area of potential effects." 36 C.F.R. § 800.4(a)(1); *see also id.* § 800.16(d).[3] The agency also must "consult with any Indian tribe or Native Hawaiian organization that attaches religious and cultural significance to historic properties that may be affected by an undertaking," *id.* § 800.2(c)(2)(ii), and must provide such tribes or organizations a reasonable opportunity to identify historic properties and provide input regarding potential adverse effects on such properties. *Id.* § 800.2(c)(2)(ii)(A).

An agency must "make a reasonable and good faith effort" to identify historic properties within the APE. *Id.* § 800.4(b)(1); *see also Summit Lake Paiute Tribe of Nev. v. U.S. Bureau of Land Mgmt.*, 496 F. App'x. 712 (9th Cir. 2012). If the agency finds that historic properties may be affected, it must further engage with all consulting parties, including Indian tribes. 36 C.F.R. § 800.4(d)(2). The agency then applies the regulatory criteria to determine if there is an adverse effect, *id.* § 800.5(a), and if so, engages in further consultation regarding the resolution of any such adverse effects, *id.* § 800.6. In certain circumstances, an agency may negotiate a programmatic agreement (PA) with the SHPO and the ACHP, if it chooses to participate, to comply with section 106 while

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800.16(*l*)(1).

3 The regulations define an area of potential effects (APE) to mean "the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist." 36 C.F.R. § 800.16(d).

deferring identification of historic properties, assessment of effect on such properties, and effort to resolve adverse effects. *Id.* § 800.14(b).

## FACTUAL BACKGROUND

The Brooks Range contains rugged mountains and glaciated valleys draped by tundra and free-flowing rivers, supporting a diversity of fish and wildlife. Indigenous peoples have long inhabited the area, and it is valued by other Alaska residents and visitors. ANILCA contemplates a surface transportation corridor through the Gates of the Arctic National Preserve, to connect the Dalton Highway and the Ambler Mining District.[4] AIDEA's application for right-of-way approval and road construction triggered Defendants' duty to address ANILCA and numerous other laws and regulations.

### I. The Ambler Road Project

AIDEA initially submitted an application package on November 23, 2015, seeking approvals from the U.S. Bureau of Land Management (BLM), National Park Service (NPS), U.S. Army Corps of Engineers (Corps), and United States Coast Guard (USCG). *See* BLM_0000001-30.[5] AIDEA is an Alaska public corporation created in 1967 "to increase job opportunities and encourage the economic growth of the state, and specifically to support development of natural resources." BLM_0000024. AIDEA applied to build a "controlled-access industrial access road" limited to mining or

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4 *See* ANILCA Section 201(4) (16 U.S.C. § 410hh(4)).

5 The complete November 23 application package is contained in the administrative record at NPS_0050198-52206.

commercial uses with an expected 50 year lifespan consisting of "a new 211-mile-long gravel surfaced roadway along the southern flanks of the Brooks Range, extending west from the Dalton Highway near milepost (MP) 161 to the south bank of the Ambler River[.]" BLM_0000003. AIDEA sought authorization of a right-of-way to facilitate route analysis and assessment, followed by phased construction starting with a seasonal, single-lane gravel road approximately sixteen feet wide, then a year-round single-lane gravel road approximately twenty feet wide. BLM_0000007-8. If justified by ensuing exploration and initial mining activity, a third phase would upgrade the road to a two lane, all-season gravel surfaced roadway approximately thirty-two feet wide. BLM_0000008.

The agencies reviewed the application materials for the Ambler Road Project (Project), which involve a unique procedural interplay between ANILCA, other environmental laws, and the diverse land ownership pattern along the proposed road corridor.[6] Upon initial review, the agencies informed AIDEA that certain necessary information was missing and the application was incomplete. *See* BLM_0000043-46 (BLM letter dated January 21, 2016). AIDEA submitted a revised application on June 30, 2016. *See* NPS_0000155-60.[7] The agencies then determined that the application was complete. *See* NPS_0002865-66.

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6 "The road would cross State lands (61%), federal lands managed by BLM (12%) and the National Park Service (NPS) (12%), and lands owned by two Alaska Native Corporations (15%)." BLM_0006660.

7 The complete June 30 application package is contained in the administrative record at NPS_0000179-2859.

On February 28, 2017, BLM published a Notice of Intent to prepare an Environmental Impact Statement (EIS) in the Federal Register pursuant to the National Environmental Policy Act (NEPA).[8] *See* BLM_0000501-03 (82 Fed. Reg. 12,119 (Feb. 28, 2017)). After receiving oral testimony in more than a dozen Alaska communities and a total of 7,225 written scoping communications, *see* BLM_0006671-73, BLM released a Draft EIS in August, 2019. *See* BLM_0008037-38 (84 Fed. Reg. 45,799 (Aug. 30, 2019)); *see also* BLM_0006981-8029 (Draft EIS). Following a public comment period during which it considered over 29,000 communications, BLM made modifications to the Draft EIS. BLM_0016699. On March 27, 2020, BLM published notice of the availability of the Final EIS. *Id.* (85 Fed. Reg. 17,353-54 (Mar. 27, 2020)); *see also* BLM_0015376-16694 (Final EIS). A Joint Record of Decision (JROD) by BLM and the Corps was executed on July 23, 2020. *See* BLM_0016710-17028; BLM_0016741-43 (signatures). The JROD constitutes the BLM's approval under NEPA, in accordance with the Federal Land Policy and Management Act and ANILCA, and the Corps' determination under Section 404 of the Clean Water Act and Section 10 of the Rivers and

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8 BLM was designated as the lead agency for preparing the EIS to comply with NEPA. *See* BLM_0006657. BLM also directed compliance with ANILCA Section 810 and NHPA Section 106. *Id.* The Corps and Coast Guard were cooperating agencies given the potential that they would make additional "authorization decisions . . . about the proposed road project that require compliance with NEPA." *Id.*; *see also* BLM_0006662-63; BLM_0007001 (detailing lead, cooperating, and participating agencies).

Harbors Act, to mutually select Alternative A and to authorize the Project. BLM_0016720.[9]

### II. ANILCA Section 810 Evaluation

BLM and NPS jointly engaged in the ANILCA Section 810 process, with BLM serving as the primary author. Concurrent with preparation of the EIS, the BLM held a two-day subsistence workshop with cooperating agencies, prepared a subsistence technical report and evaluation, and determined that the project may significantly restrict subsistence uses. *See* BLM_0067627-74. BLM and NPS then prepared a draft 810 Evaluation and held hearings on subsistence resources and activities in conjunction with public meetings on the Draft EIS. BLM_0007880. The final 810 Evaluation is an appendix to the BLM JROD. BLM_0016809-41. The NPS ROD considered this Evaluation in its selection of the route. NPS_0009719.

### III. NHPA Section 106 Consultation

BLM and NPS also jointly engaged in the NHPA Section 106 process, with BLM again serving as the designated lead agency consistent with 36 C.F.R. § 800.2(a)(2). BLM_0016733. The agencies developed a PA and Cultural Resource Management Plan (CRMP) as an alternative process for implementing Section 106 in a phased approach

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9 NPS followed a similar process in conducting the Environmental and Economic Analysis (EEA). *See* NPS_0002870; NPS_0003820-52 (scoping); NPS_0003875-981 (draft EEA). On August 4, 2020, NPS published notice of the availability of a Record of Decision (ROD) and Final EEA. *See* NPS_0009879 (85 Fed. Reg. 47,240 (Aug. 4, 2020)). The ROD selected the Northern Alignment of the right-of-way through the Preserve, along with various stipulations and mitigation measures. NPS_0009719; NPS_0009727-77.

under 36 C.F.R. § 800.14(b)(3). The ACHP elected to participate in the development of the PA due to the potential for "procedural problems" and "issues of concern to Indian tribes." BLM_0065632. Development of the PA and CRMP primarily took place in 2019 and included a series of meetings with interested parties and comment periods on draft versions of the PA and CRMP. BLM finalized the PA in April 2020, and it was signed by BLM, the SHPO, ACHP, other invited signatories, and concurring parties, but not by any tribes, on April 27, 2020. BLM_0016933-7013.

## LEGAL STANDARD

Courts recognize the propriety of voluntarily remanding a challenged agency action without judicial consideration of the merits. "A federal agency may request remand in order to reconsider its initial action." *Cal. Cmtys. Against Toxics v. U.S. Env't Prot. Agency*, 688 F.3d 989, 992 (9th Cir. 2012) (citing *SKF USA Inc. v. United States,* 254 F.3d 1022, 1029 (Fed. Cir. 2001)). "Voluntary remand is consistent with the principle that '[a]dministrative agencies have an inherent authority to reconsider their own decisions, since the power to decide in the first instance carries with it the power to reconsider.'" *Nat. Res. Def. Council, Inc. v. U.S. Dep't of Interior*, 275 F. Supp. 2d 1136, 1141 (C.D. Cal. 2002) (quoting *Trujillo v. Gen. Elec. Co.,* 621 F.2d 1084, 1086 (10th Cir. 1980)); *see also Lute v. Singer Co.,* 678 F.2d 844, 846 (9th Cir. 1982).

In determining whether to grant a voluntary remand, courts within the Ninth Circuit have looked to the Federal Circuit's decision in *SKF USA* for guidance. *See, e.g.*, *Cal. Cmtys. Against Toxics*, 688 F.3d at 992; *N. Coast Rivers All. v. U.S. Dep't of the Interior*, No. 1:16-cv-307-LJO-MJS, 2016 WL 8673038, at *3 (E.D. Cal. Dec. 16, 2016).

In *SKF USA*, the court indicated that, in response to a challenge to agency action, "the agency may request a remand, without confessing error, to reconsider its previous position" or "the agency may request a remand because it believes that its original decision was incorrect on the merits and it wishes to change the result." *N. Coast Rivers All.*, 2016 WL 8673038, at *3 (quoting *SKF USA*, 254 F.3d at 1027-28). "Generally, courts only refuse voluntarily requested remand when the agency's request is frivolous or made in bad faith." *Cal. Cmtys. Against Toxics*, 688 F.3d at 992; *see also Rusty Coal Blackwater v. Sec. of the Interior*, No. 3:14-cv-244-LRH-VPC, 2015 WL 506475, at *2 (D. Nev. Feb. 5, 2015).

If a court grants a voluntary remand, it should then decide whether the agency's action should be vacated during the remand. "Whether agency action should be vacated depends on how serious the agency's errors are 'and the disruptive consequences of an interim change that may itself be changed.'" *Cal. Cmtys. Against Toxics*, 688 F.3d at 992 (quoting *Allied–Signal, Inc. v. U.S. Nuclear Regulatory Comm'n,* 988 F.2d 146, 150-51 (D.C. Cir. 1993) (internal quotation marks omitted)).

## ARGUMENT

BLM has identified deficiencies with the ANILCA Section 810 and NHPA analyses underlying the challenged decisions. *See* Beaudreau Decl. ¶¶ 5-6, 8. Defendants request that the Court remand the decisions to the agencies to allow for reconsideration through the administrative process. *Id.* ¶¶ 9-11. Because the Department of the Interior intends to suspend further activity during remand, it is not appropriate to vacate any of Defendants' challenged decisions. *See id.* ¶ 12.

## I. The Court Should Remand the Decisions to the Agencies

Remand is appropriate here because Defendants have identified concerns with the challenged decisions and are now committed to reconsidering those decisions through their own administrative process. A remand is "generally required" if "intervening events outside of the agency's control" "affect the validity of the agency action." *SKF USA*, 254 F.3d at 1028. But "even if there are no intervening events, the agency may request a remand (without confessing error) in order to reconsider its previous position." *Id.* at 1029. Courts "generally grant an agency's motion to remand so long as 'the agency intends to take further action with respect to the original agency decision on review.'" *Util. Solid Waste Activities Grp. v. Env't Prot. Agency*, 901 F.3d 414, 436 (D.C. Cir. 2018) (citation omitted); *see also Ethyl Corp. v. Browner*, 989 F.2d 522, 524 (D.C. Cir. 1993). An agency need not confess error to seek and receive a voluntary remand. *See, e.g., SKF USA*, 254 F.3d at 1029; *Ethyl Corp.*, 989 F.2d at 524; *Citizens Against Pellissippi Parkway Extension, Inc. v. Mineta*, 375 F.3d 412, 417 (6th Cir. 2004). Rather, remand is appropriate if an agency has identified "a substantial and legitimate" concern regarding the challenged decision. *See SKF USA*, 254 F.3d at 1029; *Cal. Cmtys. Against Toxics*, 688 F.3d at 992. Remanding where an agency has identified such a concern allows agencies "to cure their own mistakes" consistent with their inherent authority to reconsider, and conserves judicial resources. *Ethyl Corp.*, 989 F.2d at 524.

### A. ANILCA Section 810

The Project would traverse hundreds of miles of relatively undisturbed habitats and numerous waterways along the southern edge of the Brooks Range, and thus

presented substantial challenges in evaluating potential impacts to subsistence uses under ANILCA. Despite the agencies' efforts, certain aspects of the challenged decisions require remand and further analysis.

ANILCA Title VIII advances a policy that "the utilization of the public lands in Alaska is to cause the least adverse impact possible on rural residents who depend upon subsistence uses of the resources of such lands[.]" 16 U.S.C. § 3112(1). ANILCA Section 810:

> imposes procedural requirements upon federal decisionmakers; pursuant to its terms, an agency proposing an action resulting in the "use, occupancy, or disposition of public lands" must evaluate that action's effects on "subsistence uses and needs," the availability of other lands for the same purpose, and "other alternatives" that would reduce the impacts to subsistence uses.

*Se. Alaska Conservation Council v. United States Forest Serv.*, 443 F. Supp. 3d 995, 1015 (D. Alaska 2020) (quoting 16 U.S.C. § 3120(a)) (*Se. Alaska I*). The agency must first determine whether "the action 'would significantly restrict subsistence uses[.]'" *Id.* This determination is what Plaintiffs refer to as "Tier 1" of the 810 process. *See, e.g.*, Second. Am. Compl. ¶ 141, ECF No. 46. If the agency determines that the action would or may significantly restrict subsistence uses, then the agency must:

> provide notice to the affected communities, hold public hearings, and make three findings: "[T]hat (A) such a significant restriction of subsistence uses is necessary, consistent with sound management principles for the utilization of the public lands, (B) the proposed activity will involve the minimal amount of public lands necessary to accomplish the purposes of such use, occupancy, or other disposition, and (C) reasonable steps will be taken to minimize adverse impacts upon subsistence uses and resources resulting from such action."

*Se. Alaska I*, 443 F. Supp. 3d at 1015 (quoting 16 U.S.C. § 3120(a)(1)-(3)); *see also*

*Kunaknana v. Clark*, 742 F.2d 1145, 1151 (9th Cir. 1984). These hearings and findings comprise what Plaintiffs refer to as "Tier 2" of the 810 process. *See, e.g.*, Second Am. Compl. ¶¶ 142-143. These determinations are presented in the ANILCA Section 810 Final Evaluation, Appendix E to the JROD. BLM_0016809-40. The Subsistence Technical Report informed this analysis and is Appendix L to the Final EIS. BLM_0016188-411.

The agencies' analyses are deficient in several respects and therefore did not comply with ANILCA Section 810. First, they lack sufficient discussion of impacts on caribou forage vegetation and the resultant adverse impacts on subsistence. The EIS acknowledges that the Project and reasonably foreseeable future actions are expected to result in *widespread, long-term* adverse effects on vegetation, including adverse impacts on lichen and other vegetation that serve as important forage for caribou, BLM_0015535-36; BLM_0015921-23. But the Tier 1 evaluation itself failed to meaningfully discuss these impacts on vegetation, or the consequences for caribou foraging, caribou abundance, caribou availability for subsistence harvesting, or any other vegetation-related impacts on caribou and subsistence. The caribou section of the Tier 1 evaluation states that road construction and operation could affect caribou abundance through "loss . . . of habitat," BLM_0016817, and the vegetation section focuses on subsistence harvesting of vegetation, such as berries, wild plants, and wood. BLM_0016822-23. The Tier 1 evaluation also cross-references the subsistence section of the EIS, BLM_0016815, which makes references to "dust deposition" and "habitat fragmentation," BLM_0015584-87, but fails to address the subsistence impacts resulting from the damage

to and destruction of vegetation, including caribou forage habitat, that is expected across the region. *See generally* BLM_0015578-99; *see also* BLM_0016832-33. Despite the importance of this issue, the Subsistence Technical Report devotes only one sentence to this subject, BLM_0016373, and addresses other Project-related factors that could damage or destroy caribou forage vegetation, BLM_0016188-0016411. The Report also fails to address the potential impacts on subsistence resulting from the harm to caribou forage vegetation.[10]

Second, the analyses lack meaningful discussion of Project-related water impacts that would occur in connection with construction and operation of the Road, including the dewatering of streams and groundwater as part of mining operations, and the impacts of such activities on salmon, sheefish, and other fish species; spawning areas, and other aquatic habitat; and related subsistence uses. Construction of ice roads to be used for winter construction of the Ambler Road would require an estimated "1 million gallons of water for each mile of a 25-foot-wide ice road," and ice pads would require about "250,000 gallons . . . per acre." BLM_0015469; *see also* BLM_0015498. The EIS qualitatively described the types of impacts that water withdrawals can have on fish, streams, lakes, and wetlands, BLM_0015471, 0015497-98, but the only discussion of mine-related dewatering in the Tier 1 evaluation concerns its effect on vegetation. BLM_0016833. Neither the Tier 1 evaluation nor the Subsistence Technical Report contains any mention of dewatering's potentially significant impacts on fish, spawning

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10 These discussions fall short of BLM's own 810 guidance to "distill and summarize" the information in the EIS. *See* BLM_0042689-10.

areas, and subsistence, even though fish provide interior Alaska's greatest quantity of subsistence resources. BLM_0016833.

These deficiencies are compounded by new information not considered in the decisions suggesting declines in salmon and caribou populations critical to subsistence communities. Many subsistence communities within the Project area rely upon salmon runs within the Yukon River system. *See* BLM_0016264-68 (describing use in Koyukuk River region including to its confluence with the Yukon River); BLM_0016322-25 (Yukon River region). Yukon River salmon runs plunged in 2021 to historic lows.[11] Additionally, the Western Arctic Caribou Herd Working Group recently reported a decline in the Herd's population estimate from 244,000 to 188,000 over the last two years, "hitting a population level that justifies new hunting restrictions." *See* https://www.arctictoday.com/a-huge-alaska-caribou-herds-population-is-again-in-decline/ (last visited Feb. 21, 2022). Many subsistence communities are critically dependent on chum salmon and caribou harvest and consumption. *See* BLM_0016292 (estimating chum salmon constitute 44 and 48 percent of Alatna and Allakaket total subsistence

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11 The 2021 summer chum salmon count was approximately 153,497, not only "well below the historical median from years with late run timing of 1.6 million fish" but "the lowest in all the years of project operations (1995–2021)" and "well below the previous lowest counts of 442,546 and 448,665 in 2001 and 2000 respectively." *See* https://www.adfg.alaska.gov/static/applications/dcfnewsrelease/1344517999.pdf at 4 (last visited Feb. 21, 2022). Similarly, the 2021 "fall chum and coho salmon returns to the Yukon River were the lowest on record for a second consecutive year." *See* https://www.adfg.alaska.gov/static/applications/dcfnewsrelease/1350592856.pdf at 6 (last visited Feb. 21, 2022). These "low fall chum and coho salmon runs, on top of poor summer season salmon returns, led to extreme hardships for subsistence fishermen relying on these critical resources along the Yukon River." *Id.* at 3.

harvest, respectively, and caribou constitute 86.2 percent of Anaktuvuk Pass subsistence harvest); BLM_0016293 (estimating chum salmon constitute 51.4 and 56.8 percent of Hughes and Huslia total subsistence harvest, respectively); BLM_0016316 (Tanana River region communities); BLM_0016340 (Yukon River communities). The 810 Evaluation could not have considered this information because it postdates the challenged RODs, but deteriorating conditions now warrant thorough reconsideration. Instead, the 810 Evaluation only cursorily acknowledges that communities that rely on fish upstream and downstream of the Project corridor "could experience impacts on fish availability if larger impacts to fish movement or health occur," and that "[a]n impact of this scale would be quite significant." BLM_0016821-22.

The Section 810 analysis did not sufficiently analyze the extent or necessity of Project-related significant impacts to subsistence uses. These procedural deficiencies, in concert with broader trends impacting critical subsistence resources, necessitate remand of the decisions for a renewed Section 810 evaluation and determination.

B. NHPA

Shortcomings in the NHPA Section 106 compliance efforts further necessitate a remand of the decisions to allow a more robust process to precede any future decisions.

The ACHP regulations allow agencies to develop and rely on a PA for "certain complex project situations" such as when "effects on historic properties cannot be fully determined prior to approval of an undertaking." 36 C.F.R. § 800.14(b)(1)(ii). However, entering into a PA does not relieve the agencies from their obligation to conduct appropriate consultation, including with tribes, in development of a PA. *See id.*

§ 800.14(f). Consultation must be meaningful, and may trigger an agency responsibility "to engage in further investigations" to evaluate possible impacts to historic properties. *Pueblo of Sandia v. United States*, 50 F.3d 856, 860 (10th Cir. 1995); *see also Quechan Tribe of Fort Yuma Indian Rsrv. v. U.S. Dep't of Interior*, 755 F. Supp. 2d 1104, 1118-19 (S.D. Cal. 2010) (expressing concern where tribal "requests for information and meetings were frequently rebuffed or responses were extremely delayed as BLM-imposed deadlines loomed or passed").

BLM invited potentially interested parties to Section 106 consultation as early as April 2017. *See e.g.* BLM_0050902.[12] In March 2019 the process focused on utilizing a PA to comply with Section 106, and BLM extended a written invitation to 15 tribes to participate in PA development. *See e.g.* BLM_0065617. From that point, BLM limited its correspondence to those tribes who affirmatively indicated interest. Ultimately, the early drafts of the PA and associated CRMP were drafted by BLM and circulated to required signatories and invited signatories,[13] but not tribes. *See* BLM_0066019 at 5:03-6:17 (indicating this approach was adopted to maximize efficiency). During development

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12 A total of 108 parties were invited to participate as "consulting parties"' in the Section 106 process, including 52 potentially affected tribes, 23 Alaska Native Corporations, five tribal organizations, and 28 other entities representing state and federal agencies, municipal governments, landowners, and non-profit organizations. BLM_0017010-12. Of these, 35 entities indicated they wished to participate, including 14 tribes (BLM subsequently referred to these 35 entities as the "consulting parties"). *Id.*

13 Invited signatories were AIDEA, Alaska Department of Natural Resources, the Corps and NPS. *See* BLM_0016964-70. Only these parties have the authority to amend, alter or terminate the agreement. The way this PA was written, Tribes have no authority to require any such changes.

of the PA, BLM participated in government-to-government meetings with some tribes[14] where the Section 106 process was discussed. *See e.g.* BLM_0081447-48; BLM_0081550-52. Several tribes, including Plaintiffs, provided information about specific areas of importance, including a report intended to document a traditional cultural property (TCP). *See* BLM_0063238; BLM_0081448; BLM_0087902. Insofar as BLM responded, there was only limited correspondence between BLM's Section 106 lead and tribal representatives regarding this TCP. *See* BLM_0063188-90; BLM_0055054-55; BLM_0066122-24; BLM_0063233-34. The record does not demonstrate that BLM provided substantive responses to individual tribes, followed up with tribes following government-to-government consultations, or explained to individual tribes how the information and concerns they shared were taken into account. While BLM stated during Section 106 meetings and in general correspondence that it was willing to meet with any requesting tribe, few government-to-government consultations took place prior to execution of the PA.[15]

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14 These meetings address "responsibilities that arise from the unique legal relationship between the Federal Government and Indian tribal governments." Exec. Order 13175, Consultation and Coordination with Indian Tribal Governments, Sec. 3(a), 65 Fed. Reg. 67,249, 67,250 (Nov. 9, 2000).

15 Plaintiffs' NHPA argument contends the APE, extending one mile on either side of the Road's proposed route, is "unreasonably narrow" and "far too small for any meaningful consideration of potential effects on landscape-level historic properties." *See* Pls.' Opening Br. 68-70, ECF No. 99. Configuring a particular APE "requires a high level of agency expertise, and as such, the agency's determination is due a substantial amount of discretion." *Valley Cmty. Pres. Comm'n v. Mineta*, 373 F.3d 1078, 1091 (10th Cir. 2004). Defendants acknowledge that formulating the APE was an important step toward Section 106 compliance, and that opportunities for tribal input during that process were limited. On remand, as part of renewed consultation efforts, Defendants would

The Department's priority of achieving a PA within the Project's shortened timeframe constrained the options for tribal consultation. The tribes were afforded only a secondary role in the ultimate adoption of the PA. Because Defendants have now determined that, in the specific circumstances presented by this case, these efforts are deficient and did not comply with the NHPA, Defendants seek a remand of the decisions to revisit their consultation obligations vis-à-vis tribal sovereigns affected by the Project. This will include revisiting whether Tribes should be included as invited signatories to that Agreement. Beaudreau Decl. ¶ 8.

## II. The Court Should Remand the Challenged Decisions Without Vacatur

The underlying decisions need not be vacated while the agencies determine how to proceed on remand. "Whether agency action should be vacated depends on how serious the agency's errors are 'and the disruptive consequences of an interim change that may itself be changed.'" *Cal. Cmtys. Against Toxics*, 688 F.3d at 992 (citation omitted); *see also Se. Alaska Conservation Council v. United States Forest Serv.*, 468 F. Supp. 3d 1148, 1151-52 (D. Alaska 2020). The Court has broad discretion in fashioning a remedy, and "when equity demands, [agency action] can be left in place while the agency follows the necessary procedures" to revise its action. *Idaho Farm Bureau Fed'n v. Babbitt*, 58 F.3d 1392, 1405 (9th Cir. 1995). In deciding whether to leave a decision in place, a court should also consider "the extent to which either vacating or leaving the decision in place

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reconsider the appropriate scope of the APE, including in the context of the Road's potential to impact landscape-scale properties that have been identified as having cultural significance to tribes.

would risk environmental harm." *Nat'l Family Farm Coal. v. U.S. Env't Prot. Agency*, 960 F.3d 1120, 1144-45 (9th Cir. 2020). Here, these factors weigh in favor of a remand without vacatur.

First, Defendants seek remand in lieu of a decision on the merits, and the Court should decline to "order vacatur . . . without an independent determination that [the challenged agency decisions were] not in accordance with the law." *Carpenters Indus. Council v. Salazar*, 734 F. Supp. 2d 126, 135 (D.D.C. 2010); *see also WildEarth Guardians v. Bernhardt*, No. CV 20-56 (RC), 2020 WL 6255291, at *1 (D.D.C. Oct. 23, 2020) ("The Court remands the decisions without vacatur because it has not reviewed the EAs, FONSIs, and DNAs underlying the leasing decisions – therefore, it has no basis to vacate the agency action."). Even if the Court could reach the merits and consider Plaintiffs' alleged deficiencies of the decisions as a matter of law for purposes of determining whether to vacate, doing so would undermine a principal rationale for remand: "preserv[ing] scarce judicial resources by allowing agencies 'to cure their own mistakes.'" *Carpenters Indus.*, 734 F. Supp. 2d at 132 (quoting *Ethyl Corp.*, 989 F.2d at 524). Here, the Department has committed to correcting ANILCA and NHPA deficiencies as well as supplementing its NEPA analysis. Beaudreau Decl. ¶ 10. It makes little sense for the Court to undertake an evaluation on the merits of decisions that the agency is currently revisiting.

Second, vacatur here would constitute a disruptive interim change that may itself be changed. *Cal. Cmtys. Against Toxics*, 688 F.3d at 992. Plaintiffs will not suffer prejudice, because Defendants intend to suspend the challenged rights-of-way, which will

defer any further project activity until remand and reconsideration are completed. Beaudreau Decl. ¶ 12. Plaintiffs will be able to fully participate in further administrative proceedings, and will retain any ability to renew their arguments, or raise new ones, when future decisions issue. AIDEA presumably submitted its application and tempered any expectations under the realization that any economic benefits from the Ambler Road Project depend on an uncertain and lengthy timeline. *See* BLM_0015882 (Reasonably Foreseeable Action timeline); BLM_0015899 (describing sequence of events involving business agreements, state approvals, financing, design, and contracting until at least 2023). While AIDEA must procure agency approval(s) at nearly every step of subsequent Project implementation, *see Hammond v. Norton*, 370 F. Supp. 2d 226, 259 (D.D.C. 2005) and BLM_0102472-79, it has expended funds and resources to date. Vacatur could prove to be unnecessarily disruptive if a suitable version of the Project is approved following remand. Defendants' approach reflects the most equitable balancing of the unique circumstances here.

Third, vacatur is not needed because the Department will reconsider the right-of-way permits based on the totality of the administrative record, including additional analysis and consultation to address the defects discussed herein. The Department may decide to affirm, amend or terminate the right-of-way permits.

Finally, vacatur is not needed to prevent possible environmental harm. Defendants recognize the challenged decisions represent the first steps toward construction of a new road through "a vast, wild region of superlative natural beauty[.]" S. Rep. No. 96-413 at 146, 1980 U.S.C.C.A.N. at 5089, 1979 WL 10337. But suspension

of the rights-of-way protects against any risk of environmental harm, and further activity will only resume upon Defendants' determination that a legally sufficient analysis of the Project has been completed.

## CONCLUSION

For the foregoing reasons, the Court should grant Defendants' motion and remand the challenged decisions to the agencies without vacatur.

Respectfully submitted this 22nd day of February, 2022.


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## CERTIFICATE OF COMPLIANCE

Pursuant to Local Civil Rule 7.4(a)(3), I hereby certify that this memorandum complies with the type-volume limitation of Local Civil Rule 7.4(a)(2), because this memorandum contains 5,671 words, excluding the parts exempted by Local Civil Rule 7.4(a)(4). This memorandum has been prepared in a proportionately spaced typeface, Times New Roman 13-point font, and I obtained the word count using Microsoft Word 2016 (16.0.5227.1000) MSO (16.0.5254.1001) 32-bit.

*/s/ Paul A. Turcke*
Paul A. Turcke

## CERTIFICATE OF SERVICE

I hereby certify that on February 22, 2022, a copy of the foregoing was served by electronic means on all counsel of record by the Court's CM/ECF system.

*/s/ Paul A. Turcke*
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# Advisory Announcement

***For Immediate Release:*** **November 4, 2021**
**Time: 4:00 p.m.**

**CONTACT: Nick Smith and Ben Gray**
**Kuskokwim Area Management Biologists**
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## Kuskokwim River Salmon Fishery Announcement #14

## 2021 Preliminary Kuskokwim Area Season Summary

This is an announcement from the Alaska Department of Fish and Game (department) for fishers in the Kuskokwim Area.

## Kuskokwim Area Management

Kuskokwim River salmon fisheries were managed according to the *Kuskokwim River Salmon Management Plan* (5 AAC 07.365). The Kuskokwim Bay salmon fisheries were managed according to the *Districts 4 and 5 Salmon Management Plan* (5 AAC 07.367).

## Kuskokwim River

### Preseason Forecast

The 2021 Kuskokwim River Chinook salmon forecast was for a range of 94,000–155,000 fish. The drainage-wide Chinook salmon escapement goal is 65,000–120,000 fish. If the run came back as projected, the drainage-wide and tributary escapement goals were expected to be achieved with a limited subsistence harvest. The 2021 season was managed in accordance with the *Kuskokwim River Salmon Management Plan* (5 AAC 07.365) with input from the Kuskokwim River Salmon Management Working Group (Working Group). It was the intent of the department to manage all Kuskokwim River salmon stocks in a conservative manner, consistent with the *Policy for the Management of Sustainable Salmon Fisheries* under 5 AAC 39.222, to meet escapement goals and the subsistence priority.

### Inseason Subsistence Management

Preseason management actions that were intended to achieve escapement goals included early season subsistence fishing closures, tributary closures, time and area restrictions, gillnet mesh size and length restrictions, and live-release requirements.

An early season gillnet subsistence fishing closure (i.e., "front-end closure") began on June 1, 2021, from the Yukon Delta National Wildlife Refuge (YDNWR) boundary at the mouth of the Kuskokwim River upriver to the Yukon Delta Refuge Boundary at Aniak; June 9 from the Yukon Delta boundary at Aniak up to the Holitna River mouth; and upstream of Holitna River mouth beginning June 11. With the closure came additional restrictions, including tributary closures and required live release of Chinook salmon captured in selective gears. During the front-end closure, there were three 16-hour set gillnet opportunities with 6-inch or less mesh to allow subsistence fishers time to harvest non-salmon species. These openings occurred on June 2, 5, and 9.

Between June 1 and July 22, a Federal Special Action (FSA) closed the Kuskokwim River gillnet fishery to non-Federally qualified users within the boundary of the YDNWR (Subsistence Sections 1–3). During the FSA, USFWS offered 6-inch setnet opportunities running concurrently to the 6-inch opportunities offered by the department on June 2, 5, and 9. Additionally, USFWS offered six 12-hour gillnet fishing periods on June 12, 15, 19 and July 2, 9, and 16 with 6-inch or less mesh, 25 fathoms in length above the Johnson River mouth and 50

fathoms in length below the Johnson River mouth. USFWS offered two 48-hour set gillnet fishing periods on July 10 and 17. On June 19, USFWS opened those waters between the Kalskag Bluffs to the YDNWR boundary at Aniak to subsistence fishing until further notice with 6-inch or less mesh, 25 fathoms in length gillnets. The department concurrently offered the same management actions within Subsistence Sections 1–3 with an additional opportunity provided on June 28, 2021. A 16-hour gillnet fishing period was provided on July 23 and a 50-hour setnet period was provided July 23–25 after the FSA was rescinded.

Chum salmon abundance was assessed to be extremely low based on Bethel Test Fishery catches, subsistence harvest reports, and Kuskokwim River Sonar passage, while sockeye salmon abundance was estimated to be average to above average. Given the poor chum salmon run, continued fishing restrictions and gillnet closures in July were needed for chum salmon protection. Beginning July 2, 2021, the release of chum salmon captured in fish wheels and beach seines was required throughout the Kuskokwim River drainage.

Beginning June 12, 2021, subsistence fishing with the subsistence king salmon permit was implemented in Subsistence Sections 4 and 5 (YDNWR boundary at Aniak upstream to the headwaters of the Kuskokwim River). On June 16, Section 5 (Holitna River mouth to headwaters) was opened to subsistence fishing until further notice with 6-inch or less mesh, 25 fathoms in length gillnets and all selective gear types. At that time, subsistence king permits were no longer required to subsistence fish in Subsistence Section 5. On June 19, Subsistence Section 4 (from the refuge boundary at Aniak to the Holitna River mouth) was opened to subsistence fishing until further notice with 6-inch or less mesh, 25 fathoms in length gillnets and subsistence king permits were no longer required to subsistence fish.

Most salmon fishing restrictions were lifted at the end of July. On July 31, after an average of 99–100% of the king salmon run, 99–100% of the sockeye salmon run, and 96–98% of the chum salmon run passed Bethel, the entire Kuskokwim River was opened to subsistence fishing with gillnets and most mainstem gear restrictions were rescinded. Tributary restrictions were rescinded August 31. The tributary restrictions were kept in place beyond the mainstem restrictions for the purpose of conservation while Chinook and chum salmon were on their spawning grounds.

Postseason subsistence harvest surveys are presently being conducted. An assessment of subsistence salmon harvest in 2021 will not be available until after postseason harvest surveys have been completed, data have been analyzed, and preliminary harvest estimates are produced. Final subsistence harvest estimates will be available in Spring 2022.

### 2021 District 1 Commercial Fishery

There were no commercial buyers or processors operating in the Kuskokwim River districts. Therefore, commercial fishing opportunities were limited to individuals registered with the department as catcher/sellers who had secured their own markets. A single catcher/seller applied for and received a commissioner's permit to harvest sockeye salmon with dipnet gear. This experimental fishery was intended to provide an opportunity to harvest abundant sockeye salmon while allowing live release of chum and Chinook salmon. Stipulations of the commissioner's permit required that all Chinook and chum salmon captured during dipnet fishing periods must be returned to the water unharmed. Between July 10–24, a total of ten 14-hour commercial dipnet periods were provided in District 1 of the Kuskokwim River. No fish were harvested during the dipnet fishing periods. A total of five commercial gillnet fishing periods (directed at coho salmon) were provided in District 1 of the Kuskokwim River between August 12–20 for a single catcher/seller. Due to the small number of participants in these gillnet fishing periods, salmon harvest was well below the historical average and State of Alaska confidentiality requirements prohibits release of the harvest data.

## Inseason Assessment Overview

In addition to recommendations and input from the Working Group, the department mainly utilized two lower Kuskokwim River assessment projects to inform inseason management decisions: the Bethel Test Fishery (BTF) and Kuskokwim River Sonar. The BTF provided information about salmon species catch-per-unit-effort (CPUE), species ratios, and run timing, while the sonar provided daily passage estimates for salmon and other species.

**Bethel Test Fishery**

BTF operated May 26–31 (early season) and June 1–August 24 (regular season). An hour after each posted high tide, a series of drifts were conducted to determine daily CPUE of salmon species. The area fished has not changed since its inception in 1984; however, gillnet mesh material changed beginning 2008. From the start of the early season to July 15, BTF used 8" and 5 3/8" mesh gillnets (each 50 fathoms in length) for assessment purposes. After July 15, only the 5 3/8" mesh gillnet was used because most of the Chinook salmon run had migrated upriver past the project site and the primary focus of assessment shifted to sockeye, chum, and coho salmon.

**Kuskokwim River Sonar**

The Kuskokwim River Sonar operated from June 1–August 26. The sonar provides timely information about the abundance of salmon and whitefish species as they migrate up the Kuskokwim River. The Kuskokwim River Sonar program operates a test fishery for species apportionment using a series of six gillnets (8 1/2", 7 1/2", 6 1/2", 5 1/4", 4", and 2 3/4" mesh). The sonar program generates daily species-specific passage estimates using species apportionment and sonar counts. The sonar does not provide total abundance or escapement estimates since some escapement occurs below the sonar and harvest occurs both downriver and upriver from the sonar.

**CPUE, Run Timing, and Passage Estimates**

**Chinook Salmon**

The cumulative Chinook salmon CPUE at the BTF was 532, which was similar to the 2008–2020 average of 568. The estimated midpoint of the Chinook salmon run was June 25 (3 days later than average).

The cumulative Chinook salmon passage estimate at the sonar was 102,552 fish (95% CI = 84,436–120,668 fish).

**Sockeye Salmon**

The cumulative sockeye salmon CPUE at the BTF was 1,694, which was slightly below the 2008–2020 average of 1,779. The estimated midpoint of the sockeye salmon run was July 6 (7 days later than average).

The cumulative sockeye salmon passage estimate at the sonar was 745,037 fish (95% CI = 696,236–793,838).

**Chum Salmon**

The cumulative chum salmon CPUE at the BTF was 327, which was the lowest on record and well below the 2008–2020 average of 5,980. The estimated midpoint of the chum salmon run was July 11 (6 days later than average).

The cumulative chum salmon passage estimate at the sonar was 25,689 fish (95% CI = 14,549–36,829).

**Coho Salmon**

Cumulative BTF CPUE and sonar passage estimates are incomplete because the coho salmon run was still progressing after BTF and Kuskokwim River Sonar ceased operations on August 24 and August 26, respectively. Escapements at weir projects provides a more complete picture of coho salmon run strength than the BTF or Kuskokwim River Sonar. That in mind, as of August 24, the cumulative CPUE for coho salmon at BTF was 1,696, which was below the 2008–2020 average of 3,289.

The cumulative coho salmon passage estimate at the sonar was 237,285 fish (95% CI = 209,317–265,253). This was the second year that the Kuskokwim River Sonar operated into late August. Prior year operations ended in late July.

**Whitefish**

Five species of whitefish were captured by the sonar's test fishery nets (least and Bering cisco, broad and humpback whitefish, and sheefish). The cumulative cisco (least and Bering) passage estimate at the Kuskokwim River Sonar was 823,091 fish (95% CI = 728,039–918,143). The cumulative broad whitefish passage estimate at the sonar was 22,859 fish (95% CI = 8,646–37,072). The cumulative humpback whitefish passage estimate at the sonar was 667,285 fish (95% CI 570,108–764,462). The cumulative sheefish passage estimate at the sonar was 20,731 fish (95% CI = 9,350–32,112).

## Salmon Escapement – Kuskokwim River Drainage

### Chinook Salmon

A run reconstruction model was used to estimate the preliminary total run and escapement for Chinook salmon in 2021. The preliminary Kuskokwim River total run estimate is 129,000 Chinook salmon (95% CI = 94,000–178,000) and an estimated 101,000 Chinook salmon (95% CI = 66,000–150,000) escaped Kuskokwim River fisheries, which met the drainage-wide Sustainable Escapement Goal (SEG) range of 65,000–120,000 fish. All weir-based escapement goals for Chinook salmon assessed in 2021 were met within the Kuskokwim River drainage (Table 1). The established SEG range of 4,800–8,800 fish at Kogrukluk River weir was met (6,969 fish), as was the SEG range of 1,800–3,300 fish at George River (2,920 fish). Aerial surveys were not conducted in 2021 due to weather and pilot availability (see Table 2 for historical data).

### Sockeye Salmon

Sockeye salmon escapement was mixed throughout the drainage with above average lake-type sockeye escapement and near average to slightly below average river-type sockeye salmon escapement (Table 3). The preliminary Kogrukluk River weir escapement of 13,534 sockeye salmon met the established SEG range of 4,400–17,000 fish. The Telaquana River weir observed the fifth highest escapement of sockeye salmon since the project was established in 2010 with a count of 123,958 fish (Table 3).

### Chum Salmon

Chum salmon escapement at all weir projects were the lowest on record (Table 4). The preliminary escapement count of 4,153 fish at the Kogrukluk River weir did not meet the established SEG range of 15,000–49,000 fish, and passage at all other weir projects was well below average.

### Coho Salmon

Coho salmon escapement was evaluated at two middle Kuskokwim River weirs in 2021. The George River weir coho salmon escapement of 31,491 fish was above the most recent 10-year average (2011–2020) of 22,462 fish (Table 5). At the Kogrukluk River weir, 14,373 coho salmon were counted, which met the SEG range of 13,000–28,000 fish (Table 5).

## Kuskokwim Bay

### District 4 (Quinhagak)

The 2021 District 4 commercial fishing season began on July 2 and ended on August 13. There were 24 commercial fishing periods (Table 6). The commercial fishing season was delayed from the normal start of June 15 to allow for Chinook salmon escapement. Additionally, for the first five periods (Table 6), area restrictions were enacted near the mouth of the Kanektok River to allow for Chinook salmon escapement.

Since 1987, an average of 223 permit holders (range 67–408) fished per year in District 4. Participation in 2021 was the second lowest on record (2020 was lowest) with a total of 74 individual permit holders making at least one recorded landing in the commercial fishery (Table 7). On average, 29 permit holders participated per period (range 1–54; Table 6).

A total of 2,468 Chinook, 78,462 sockeye, 13,012 coho, and 5,310 chum salmon were commercially harvested in District 4 (Table 7). Catch rates for sockeye salmon ranked second highest on record (2020 was highest) compared to available standardized catch rate data: 1981 to 2020. Sockeye salmon catch rates during the first five periods were highest on record since 1981. These catch rates remained above average for the following nine periods and then alternated between above-to-below average for the duration of the season. Chinook and chum salmon catch rates were mostly below average the entire season, while coho salmon catch rates were below average for all except one period (August 6). Sockeye salmon harvest was the eighth highest since 1960 and approximately 5,000 fish greater the most recent 10-year harvest average (2007–2020; *Note, 2007–2020 data used for most recent 10-year average comparisons because there was no fishery during 2016–2019*; Table 7). Chinook, chum, and coho salmon harvests were below the most recent 10-year averages (2007–2020). Chinook salmon harvest ranked third lowest since 1968, while chum salmon harvest was the lowest observed since 1967. Coho salmon harvest was the

lowest observed since 1999. A total of 29 pink salmon were purchased during 2021 in District 4; these were the first pink salmon purchased since 2005.

Chinook, sockeye, coho, chum, and pink salmon were purchased for $0.80, $0.60, $0.50, $0.15, and $0.05 per pound, respectively. Total exvessel value of the fishery was $357,273, approximately $482,000 below the most recent 10-year average (2007–2020; Table 7).

**District 4 Salmon Escapement**

An aerial survey was flown for the Kanektok River on July 25 (Table 8). Although within the standardized peak spawning abundance date range of July 17 to August 5, this survey was deemed early as both Chinook and sockeye salmon were not in full spawning colorations and fewer redds were noticeable than expected. Therefore, counts reported here are considered minimum estimates of spawning escapement. Additionally, intense wind and glare in Kagati Lake created poor visibility, meaning sockeye salmon were undoubtably missed. For this reason, the sockeye salmon survey was rated as poor. Although poor, 53,690 sockeye salmon were counted, which exceeded the aerial survey SEG range of 15,300–41,000 fish. The Chinook salmon survey was rated as fair because wind and glare was not as intense in the river reaches where they spawn. The Chinook salmon aerial survey SEG (range 3,900–12,000 fish) was achieved with a count of 4,115 fish.

**District 5 (Goodnews Bay)**

The 2021 District 5 commercial fishing season began on July 2 and ended on August 13. There were 32 commercial fishing periods (Table 9). The commercial fishing season was delayed from the normal start of June 15 to allow for Chinook salmon escapement.

The 2021 season saw the fewest permits fished in District 5 on record. Since 1980, an average of 61 permit holders (range 17–125) fished per year in District 5. During the 2021 season, a total of 13 individual permit holders made at least one recorded landing in the commercial fishery. On average, six permit holders participated per period (range 1–12; Table 9).

A total of 114 Chinook, 35,963 sockeye, 1,192 coho, and 535 chum salmon were commercially harvested in District 5 (Table 10). Catch rates for sockeye salmon during the 2021 season ranked highest on record compared to available standardized catch rate data from 1981–2020. Chinook, coho, and chum salmon catch rates were below their historical averages. Sockeye salmon harvest was the thirteenth highest since 1968 and approximately 4,000 fish greater the most recent 10-year harvest average (2007–2020; Table 10). Numbers of Chinook, coho, and chum salmon harvested were below the most recent 10-year averages (2007–2020). Chinook salmon harvests were the lowest on record since 1968, while chum and coho salmon harvests were the second lowest on record during the same period.

Chinook, sockeye, coho, and chum salmon were purchased for $0.80, $0.60, $0.50, and $0.15 per pound, respectively. Total exvessel value of the fishery was $136,186, which was approximately $198,000 below the most recent 10-year average (2007–2020; Table 10).

**District 5 Salmon Escapement**

The North Fork Goodnews River aerial survey was flown on July 24 and weather conditions were optimal, thus the survey was rated as good. Although flown within the standardized peak spawning abundance date range of July 17 to August 5, this survey was deemed early as both Chinook and sockeye salmon were not in full spawning colorations. Therefore, counts reported here are considered minimum estimates of spawning escapement. The Chinook salmon aerial SEG range of 640–3,300 fish was met with a count of 2,273 fish. The sockeye salmon SEG of 9,600–18,000 was exceeded with 95,020 fish counted (Table 11).

**For additional information concerning this advisory announcement**:
ADF&G: Nicholas Smith 907-267-2379 or Ben Gray 907-267-2303

Table 1.–Chinook salmon spawning weir escapement, Kuskokwim River drainage, Kuskokwim Management Area 2011–2021.

| | Chinook Salmon Escapement | | | | | |
|---|---|---|---|---|---|---|
| Year | Kwethluk | Salmon (Aniak) | George | Kogrukluk | Takotna | Salmon (Pitka) |
| 2011 | 4,056 | [a] | 1,605 | 6,926 | 149 | [a] |
| 2012 | [b] | [b] | 2,362 | [b] | 238 | [a] |
| 2013 | [b] | 711 | 1,267 | 1,919 | 104 | [a] |
| 2014 | 3,191 | 1,722 | 2,988 | 3,726 | [a] | [a] |
| 2015 | 8,163 | 2,401 | 2,301 | 8,333 | [a] | 7,156 |
| 2016 | [b] | [b] | 2,218 | 7,034 | [a] | 6,371 |
| 2017 | 7,207 | 2,611 | 3,669 | 7,787 | 318 | 8,298 |
| 2018 | [b] | 2,252 | 3,322 | 6,292 | 205 | 5,354 |
| 2019 | 8,505 | [a] | 3,828 | 10,301 | 554 | 4,823 |
| 2020 | [a] | 1,228 | 2,418 | 5,645 | 357 | 4,854 |
| 2021 [c] | [a] | 1,303 | 2,920 | 6,969 | 233 | 4,014 |
| SEG | 4,100–7,500 | | 1,800–3,300 | 4,800–8,800 | | |
| Average 2011–2020 | 6,224 | 1,747 | 2,627 | 6,493 | 270 | 5,839 |

[a] Weir did not operate.
[b] Historical run timing indicates that more than 40% of the run was missed; annual escapement was not determined.
[c] Preliminary numbers subject to change.

Table 2.–Chinook salmon spawning aerial survey index estimates, Kuskokwim River Drainage, Kuskokwim Management Area, 2011–2021.

| | Kuskokwim River[a] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lower | | Middle | | | | | | Upper | | | | |
| Year | Kwethluk | Kisaralik | Aniak | Kipchuk | Salmon (Aniak) | Holokuk | Oskawalik | Holitna | Gagarayah | Cheeneetnuk | Bear (Pitka) | Salmon (Pitka) | Upper Pitka Fork |
| 2011 | [b] | 534 | [b] | 116 | 79 | 20 | 26 | [b] | 96 | 249 | 145 | 767 | 85 |
| 2012 | [b] | 610 | [b] | 193 | 49 | 9 | 51 | [b] | 178 | 229 | [b] | 670 | [b] |
| 2013 | 1,165 | 597 | 754 | 261 | 154 | 29 | 38 | 670 | 74 | 138 | 64 | 475 | [b] |
| 2014 | [b] | 622 | 3,201 | 1,220 | 497 | 80 | 200 | 1,785 | 359 | 340 | [b] | 1,865 | [b] |
| 2015 | [b] | 709 | [b] | 917 | 810 | 77 | [b] | 662 | 19 | [b] | 1,381 | 2,016 | [b] |
| 2016 | [b] | 622 | 718 | 898 | [b] | 100 | 47 | 1,157 | 135 | 217 | 580 | 1,578 | [b] |
| 2017 | [b] | [b] | 1,781 | 889 | 423 | 140 | 136 | 676 | 453 | 660 | 492 | 687 | 234 |
| 2018 | [b] | 584 | 1,534 | 1,123 | 441 | 162 | [b] | 980 | 438 | 565 | 550 | 1,399 | 471 |
| 2019 | [b] | 1,063 | 3,160 | 1,344 | 950 | 719 | 638 | 1,377 | 760 | 1,345 | 542 | 1,918 | 330 |
| 2020 | 721 | 350 | 1,264 | 723 | 269 | 99 | 169 | 854 | [b] | 419 | 321 | 1,150 | 160 |
| 2021 | [b] | [b] | [b] | [b] | [b] | [b] | [b] | [b] | [b] | [b] | [b] | [b] | [b] |
| Escapement Goal Range: | | 400–1,200 | 1,200–2,300 | | 330–1,200 | | | | 300–830 | 340–1,300 | | 470–1,600 | |
| Average 2011–2020 | 943 | 632 | 1,773 | 768 | 408 | 144 | 163 | 1,020 | 279 | 462 | 509 | 1,253 | 256 |

[a] Estimates are from aerial surveys conducted during peak spawning periods under 'good' or 'fair' survey conditions.

[b] Survey was either not flown or did not meet acceptable survey criteria.

Table 3.–Sockeye salmon spawning weir escapement, Kuskokwim River drainage, Kuskokwim Management Area 2011–2021.

| Year | Sockeye Salmon Escapement | | | | |
|---|---|---|---|---|---|
| | Kwethluk | Salmon (Aniak) | George | Kogrukluk | Telaquana |
| 2011 | 1,541 | [a] | 43 | 8,079 | 35,099 |
| 2012 | [a] | 950 | 79 | [a] | 23,002 |
| 2013 | [a] | 966 | 150 | 7,793 | 28,058 |
| 2014 | 3,880 | 934 | 156 | 6,479 | 24,292 |
| 2015 | 8,998 | 1,504 | 159 | 6,647 | 95,570 |
| 2016 | 20,495 | 310 | 2,807 | 20,108 | 82,710 |
| 2017 | 28,806 | [a] | 912 | 24,696 | 145,281 |
| 2018 | [a] | 2,537 | 1,615 | 21,343 | 197,368 |
| 2019 | 42,212 | [a] | 3,973 | 32,116 | 198,485 |
| 2020 | [a] | 234 | 281 | 9,923 | 177,509 |
| 2021 [b] | [a] | 907 | 937 | 13,534 | 123,958 |
| SEG | | | | 4,400–17,000 | |
| Average 2011–2020 | 17,655 | 1,062 | 1,018 | 15,243 | 100,737 |

[a] Weir did not operate, or counts were incomplete.
[b] Preliminary numbers subject to change.

Table 4.–Chum salmon spawning weir escapement, Kuskokwim River drainage, Kuskokwim Management Area 2011–2021.

| Year | Chum Salmon Escapement | | | | |
|---|---|---|---|---|---|
| | Kwethluk | Salmon (Aniak) | George | Kogrukluk | Takotna |
| 2011 | 17,498 | [a] | 45,257 | 76,649 | 8,562 |
| 2012 | [a] | [a] | 33,277 | [a] | 6,039 |
| 2013 | [a] | 7,685 | 37,945 | 65,648 | 6,516 |
| 2014 | 17,942 | 2,777 | 17,183 | 30,697 | [a] |
| 2015 | 23,071 | 5,511 | 17,554 | 33,091 | [a] |
| 2016 | 22,914 | 1,691 | 19,469 | 45,234 | [a] |
| 2017 | 52,202 | 9,754 | 39,971 | 85,793 | 6,557 |
| 2018 | [a] | 18,770 | 48,915 | 52,937 | 6,007 |
| 2019 | 32,130 | [a] | 43,072 | 71,006 | 5,618 |
| 2020 | [a] | 1,995 | 8,943 | 19,032 | [a] |
| 2021 [b] | [a] | 537 | 1,371 | 4,153 | 151 [c] |
| SEG | | | | 15,000–49,000 | |
| Average 2011–2020 | 27,626 | 6,883 | 31,159 | 53,343 | 6,550 |

[a] Project did not operate, or counts were incomplete.
[b] Preliminary numbers subject to change.
[c] Observed escapement only. No estimate of missed passage included; therefore, the number presented is to be considered a minimum.

Table 5.–Coho salmon spawning weir escapement, Kuskokwim River drainage, Kuskokwim Management Area, 2011–2021.

| Year | Coho Salmon Escapement | | |
|---|---|---|---|
| | Kwethluk | George | Kogrukluk |
| 2011 | [a] | 31,900 | 21,950 |
| 2012 | 20,627 | 14,844 | 13,462 |
| 2013 | [a] | 14,823 | 23,800 |
| 2014 | 48,478 | 35,771 | 54,001 |
| 2015 | 32,124 | 35,790 | 32,900 |
| 2016 | 28,852 | [a] | [a] |
| 2017 | 55,722 | 25,338 | [a] |
| 2018 | [a] | 8,993 | 8,169 |
| 2019 | 34,561 | 13,277 | 16,470 |
| 2020 | [a] | 21,426 | 9,856[c] |
| 2021 [b] | [a] | 31,491 | 14,373 |
| SEG | >19,000 | | 13,000– 28,000 |
| Average 2011–2020 | 36,727 | 22,462 | 24,393 |

[a] Weir did not operate, or counts were incomplete.
[b] Preliminary numbers subject to change.
[c] Observed escapement only. No estimate of missed passage included; therefore, the number presented is to be considered a minimum.

Table 6.–Commercial harvest by period in the District 4, Kuskokwim Bay, 2021.

| Date | | Permits Fished | Hours Fished | Permit Hours | Chinook Catch | Chinook CPUE | Sockeye Catch | Sockeye CPUE | Coho Catch | Coho CPUE | Chum Catch | Chum CPUE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 2 | 37 | 12 | 444 | 479 | 1.1 | 9,448 | 21.3 | 0 | 0.0 | 150 | 0.3 |
| Jul | 4 | 35 | 12 | 420 | 297 | 0.7 | 9,788 | 23.3 | 0 | 0.0 | 117 | 0.3 |
| Jul | 6 | 31 | 12 | 372 | 244 | 0.7 | 8,104 | 21.8 | 0 | 0.0 | 99 | 0.3 |
| Jul | 8 | 36 | 12 | 432 | 192 | 0.4 | 8,609 | 19.9 | 0 | 0.0 | 260 | 0.6 |
| Jul | 10 | 54 | 12 | 648 | 311 | 0.5 | 10,009 | 15.4 | 0 | 0.0 | 474 | 0.7 |
| Jul | 13 | 45 | 12 | 540 | 245 | 0.5 | 6,980 | 12.9 | 0 | 0.0 | 465 | 0.9 |
| Jul | 15 | 52 | 12 | 624 | 177 | 0.3 | 6,686 | 10.7 | 0 | 0.0 | 450 | 0.7 |
| Jul | 17 | 51 | 12 | 612 | 150 | 0.2 | 4,562 | 7.5 | 0 | 0.0 | 501 | 0.8 |
| Jul | 19 | 29 | 12 | 348 | 61 | 0.2 | 2,997 | 8.6 | 0 | 0.0 | 330 | 0.9 |
| Jul | 21 | 35 | 12 | 420 | 131 | 0.3 | 3,808 | 9.1 | 0 | 0.0 | 661 | 1.6 |
| Jul | 23 | 33 | 12 | 396 | 79 | 0.2 | 2,326 | 5.9 | 7 | 0.0 | 524 | 1.3 |
| Jul | 25 | 12 | 12 | 144 | 18 | 0.1 | 1,316 | 9.1 | 17 | 0.1 | 327 | 2.3 |
| Jul | 27 | 7 | 12 | 84 | 8 | 0.1 | 468 | 5.6 | 42 | 0.5 | 91 | 1.1 |
| Jul | 29 [a] | 0 | 12 | 0 | 0 | - | 0 | - | 0 | - | 0 | - |
| Jul | 30 | 11 | 12 | 132 | 15 | 0.1 | 553 | 4.2 | 129 | 1.0 | 104 | 0.8 |
| Jul | 31 | 1 | 12 | 12 | 2 | 0.2 | 9 | 0.8 | 11 | 0.9 | 7 | 0.6 |
| Aug | 2 | 7 | 12 | 84 | 4 | 0.0 | 340 | 4.0 | 188 | 2.2 | 54 | 0.6 |
| Aug | 3 | 16 | 12 | 192 | 18 | 0.1 | 668 | 3.5 | 540 | 2.8 | 186 | 1.0 |
| Aug | 5 | 22 | 12 | 264 | 7 | 0.0 | 399 | 1.5 | 1,340 | 5.1 | 108 | 0.4 |
| Aug | 6 | 19 | 12 | 228 | 12 | 0.1 | 482 | 2.1 | 1,627 | 7.1 | 91 | 0.4 |
| Aug | 9 | 38 | 12 | 456 | 8 | 0.0 | 319 | 0.7 | 2,599 | 5.7 | 114 | 0.3 |
| Aug | 10 | 29 | 12 | 348 | 3 | 0.0 | 295 | 0.8 | 1,827 | 5.3 | 89 | 0.3 |
| Aug | 12 | 34 | 12 | 408 | 7 | 0.0 | 169 | 0.4 | 2,611 | 6.4 | 76 | 0.2 |
| Aug | 13 | 27 | 12 | 324 | 3 | 0.0 | 127 | 0.4 | 2,074 | 6.4 | 32 | 0.1 |

[a] No permit holders participated in this period.

Table 7.–Commercial salmon harvest District 4, Quinhagak, Kuskokwim Bay, 2007–2021.

| Year | Chinook | Sockeye | Coho | Chum | Pink | Value | Permits [a] |
|---|---|---|---|---|---|---|---|
| 2007 | 19,573 | 109,343 | 34,710 | 61,228 | 0 | $660,865 | 125 |
| 2008 | 13,812 | 69,743 | 94,257 | 57,033 | 0 | $750,731 | 146 |
| 2009 | 13,920 | 112,153 | 48,115 | 91,158 | 0 | $747,325 | 179 |
| 2010 | 14,230 | 138,362 | 13,690 | 106,610 | 0 | $1,655,321 | 241 |
| 2011 | 15,387 | 38,543 | 30,457 | 104,959 | 0 | $1,176,436 | 219 |
| 2012 | 6,675 | 37,688 | 31,214 | 61,140 | 0 | $824,435 | 179 |
| 2013 | 2,054 | 26,393 | 58,079 | 21,126 | 0 | $761,537 | 197 |
| 2014 | 2,265 | 58,879 | 52,317 | 14,563 | 0 | $858,638 | 194 |
| 2015 | 7,547 | 30,269 | 76,285 | 16,051 | 0 | $489,564 | 189 |
| 2020 | 4,345 | 113,849 | 29,374 | 6,531 | 0 | $468,074 | 67 |
| 2021 | 2,468 | 78,462 | 13,012 | 5,310 | 29 | $357,273 | 74 |
| Average 2007–2020 | 9,981 | 73,522 | 46,850 | 54,040 | 0 | $839,293 | 174 |

*Note:* No commercial fishery in Kuskokwim Area 2016 to 2019.

[a] Number of permits that made at least one delivery.

Table 8.–Kanektok River salmon spawning escapement estimates, 2011–2021.

| Year | Aerial Survey Escapement | |
|---|---|---|
| | Chinook | Sockeye |
| 2011 | [a] | [a] |
| 2012 | [a] | [a] |
| 2013 | 2,277 | 53,002 |
| 2014 | 1,840 | 136,400 |
| 2015 | 4,919 | 39,970 |
| 2016 | 5,631 | 80,160 |
| 2017 | [a] | [a] |
| 2018 | 4,246 | 326,200 |
| 2019 | 7,212 | 349,073 |
| 2020 | 4,405[b] | 52,886[b] |
| 2021 | 4,115 | 53,690[c] |
| SEG | 3,900–12,000 | 15,300–41,000 |
| Average 2011–2020 | 4,361 | 148,242 |

[a] Survey was either not flown or did not meet acceptable survey criteria.
[b] Survey was flown outside (August 13) of the standardized peak spawning abundance date range of July 17 to August 5. Therefore, counts are underestimates of spawning escapement.
[c] Survey was flown under poor weather conditions which hindered visibility in upper index regions. Therefore, counts are underestimates of spawning escapement.

Table 9.–Commercial harvest by period in the District 5, Kuskokwim Bay, 2021.

| Date | | Permits Fished | Hours Fished | Permit Hours | Chinook Catch | Chinook CPUE | Sockeye Catch | Sockeye CPUE | Coho Catch | Coho CPUE | Chum Catch | Chum CPUE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 2 | 6 | 12 | 72 | 32 | 0.4 | 1,883 | 26.2 | 0 | 0.0 | 26 | 0.4 |
| Jul | 4 | 7 | 12 | 84 | 8 | 0.1 | 2,554 | 30.4 | 0 | 0.0 | 33 | 0.4 |
| Jul | 5 | 3 | 12 | 36 | 0 | 0.0 | 924 | 25.7 | 0 | 0.0 | 17 | 0.5 |
| Jul | 6 | 5 | 12 | 60 | 2 | 0.0 | 1,471 | 24.5 | 0 | 0.0 | 23 | 0.4 |
| Jul | 7 | 7 | 12 | 84 | 2 | 0.0 | 2,478 | 29.5 | 0 | 0.0 | 6 | 0.1 |
| Jul | 8 | 6 | 12 | 72 | 3 | 0.0 | 851 | 11.8 | 0 | 0.0 | 8 | 0.1 |
| Jul | 9 | 7 | 12 | 84 | 1 | 0.0 | 2,847 | 33.9 | 0 | 0.0 | 42 | 0.5 |
| Jul | 10 | 12 | 12 | 144 | 0 | 0.0 | 1,818 | 12.6 | 0 | 0.0 | 3 | 0.0 |
| Jul | 14 | 8 | 12 | 96 | 3 | 0.0 | 663 | 6.9 | 0 | 0.0 | 0 | 0.0 |
| Jul | 15 | 10 | 12 | 120 | 3 | 0.0 | 1,607 | 13.4 | 0 | 0.0 | 9 | 0.1 |
| Jul | 16 | 8 | 12 | 96 | 5 | 0.1 | 1,628 | 17.0 | 0 | 0.0 | 32 | 0.3 |
| Jul | 19 | 9 | 12 | 108 | 6 | 0.1 | 2,172 | 20.1 | 0 | 0.0 | 42 | 0.4 |
| Jul | 20 | 7 | 12 | 84 | 5 | 0.1 | 1,461 | 17.4 | 0 | 0.0 | 31 | 0.4 |
| Jul | 21 | 7 | 12 | 84 | 2 | 0.0 | 1,471 | 17.5 | 0 | 0.0 | 45 | 0.5 |
| Jul | 22 | 6 | 12 | 72 | 4 | 0.1 | 1,062 | 14.8 | 0 | 0.0 | 23 | 0.3 |
| Jul | 23 | 8 | 12 | 96 | 15 | 0.2 | 2,441 | 25.4 | 0 | 0.0 | 59 | 0.6 |
| Jul | 25 | 7 | 12 | 84 | 5 | 0.1 | 1,404 | 16.7 | 5 | 0.1 | 30 | 0.4 |
| Jul | 26 | 7 | 12 | 84 | 3 | 0.0 | 897 | 10.7 | 8 | 0.1 | 26 | 0.3 |
| Jul | 27 | 1 | 12 | 12 | 0 | 0.0 | 72 | 6.0 | 0 | 0.0 | 3 | 0.3 |
| Jul | 28 | 1 | 12 | 12 | 0 | 0.0 | 176 | 14.7 | 0 | 0.0 | 9 | 0.8 |
| Jul | 29 [a] | 0 | 12 | 0 | 0 | - | 0 | - | 0 | - | 0 | - |
| Jul | 30 | 5 | 12 | 60 | 1 | 0.0 | 473 | 7.9 | 7 | 0.1 | 6 | 0.1 |
| Aug | 2 [a] | 0 | 12 | 0 | 0 | - | 0 | - | 0 | - | 0 | - |
| Aug | 3 | 4 | 12 | 48 | 3 | 0.1 | 683 | 14.2 | 46 | 1.0 | 6 | 0.1 |
| Aug | 4 | 3 | 12 | 36 | 2 | 0.1 | 688 | 19.1 | 16 | 0.4 | 8 | 0.2 |
| Aug | 5 | 4 | 12 | 48 | 2 | 0.0 | 286 | 6.0 | 9 | 0.2 | 0 | 0.0 |
| Aug | 6 | 4 | 12 | 48 | 0 | 0.0 | 722 | 15.0 | 112 | 2.3 | 7 | 0.1 |
| Aug | 9 | 6 | 12 | 72 | 2 | 0.0 | 692 | 9.6 | 164 | 2.3 | 20 | 0.3 |
| Aug | 10 | 5 | 12 | 60 | 2 | 0.0 | 919 | 15.3 | 151 | 2.5 | 9 | 0.2 |
| Aug | 11 | 5 | 12 | 60 | 2 | 0.0 | 659 | 11.0 | 274 | 4.6 | 7 | 0.1 |
| Aug | 12 | 5 | 12 | 60 | 0 | 0.0 | 545 | 9.1 | 236 | 3.9 | 5 | 0.1 |
| Aug | 13 | 5 | 12 | 60 | 1 | 0.0 | 416 | 6.9 | 164 | 2.7 | 0 | 0.0 |

[a] No permit holders participated in this period.

Table 10.–Commercial salmon harvests, District 5 Goodnews Bay, Kuskokwim Bay, 2007–2021.

| Year | Chinook | Sockeye | Coho | Chum | Value | Permits [a] |
|---|---|---|---|---|---|---|
| 2007 | 3,126 | 43,766 | 13,697 | 7,853 | $222,330 | 28 |
| 2008 | 1,281 | 27,237 | 22,547 | 10,408 | $198,070 | 25 |
| 2009 | 1,509 | 32,544 | 8,406 | 16,985 | $192,031 | 39 |
| 2010 | 1,759 | 41,074 | 4,900 | 26,914 | $470,661 | 48 |
| 2011 | 2,092 | 24,573 | 15,358 | 13,191 | $346,022 | 48 |
| 2012 | 1,536 | 50,647 | 25,515 | 24,487 | $617,765 | 58 |
| 2013 | 495 | 24,521 | 21,582 | 12,651 | $452,651 | 71 |
| 2014 | 205 | 20,515 | 52,158 | 3,403 | $584,654 | 61 |
| 2015 | 705 | 25,861 | 7,030 | 4,510 | $131,616 | 61 |
| 2020 | 442 | 28,859 | 10,928 | 3,037 | $128,196 | 17 |
| 2021 | 114 | 35,963 | 1,192 | 535 | $136,186 | 13 |
| Average 2007–2020 | 1,315 | 31,960 | 18,212 | 12,344 | $334,400 | 46 |

*Note:* No commercial fishery in Kuskokwim Area 2016 to 2019.
[a] Number of permits that made at least one delivery.

Table 11.–Salmon spawning escapement estimates, Goodnews River, Kuskokwim Bay, 2011–2021.

| Year | | Middle Fork Goodnews R. Weir Escapement | | | | North Fork Goodnews R. Aerial Escapement | |
|---|---|---|---|---|---|---|---|
| | | Chinook | Sockeye | Coho | Chum | Chinook | Sockeye |
| 2011 | | 2,045 | 19,643 | 24,668 | 19,974 | 853 | 14,140 |
| 2012 | | 524 | 29,531 | 11,371 | 9,065 | 378 | 16,710 |
| 2013 | | 1,187 | 23,545 | 1,189 | 27,682 | [a] | [a] |
| 2014 | [b] | 750 | 41,473 | 7,594 | 11,518 | 630 | [a] |
| 2015 | [b] | 1,494 | 57,809 | 15,084 | 11,517 | 991 | 38,390 |
| 2016 | [c] | 3,767 | 170,574 | | 41,815 | 1,120 | 90,060 |
| 2017 | [c] | 6,881 | 179,897 | | 54,799 | [a] | [a] |
| 2018 | [d] | | | | | [a] | [a] |
| 2019 | [c] | 6,421 | 167,105 | | 38,177 | 2,462 | 162,930 |
| 2020 | [d] | | | | | 1,098 | 55,110 |
| 2021 | [d] | | | | | 2,273 | 95,020 |
| SEG | | 1,500–2,900 | 18,000–40,000 | >12,000 | >12,000 | 640–3,300 | 9,600–18,000 |
| Average 2011–2020 | | 2,884 | 86,197 | 11,981 | 26,818 | 1,076 | 62,890 |

[a] Survey was either not flown or did not meet acceptable survey criteria.
[b] Weir operations ended Aug 31
[c] Weir operation ended July 31.
[d] Weir did not operate, or counts were incomplete.

-end-

*Community Spotlight:*

# HOMER AND NAPAKIAK, ALASKA

An aerial view of the Kuskokwim River, just up from Bethel, Alaska.

Credit: P.A. Lawrence, LLC. / Alamy Stock Photo

## Alaskan Communities Adapt to Dramatic Climate Change

*Each spring and fall, Napakiak City Council member and Alaska Native Walter Nelson watches the Kuskokwim River move closer to his town. A warming climate has altered the flow of Alaskan rivers, as ice melt speeds up and they are not frozen as long as they once were. Violent storms, also fueled by a warming climate, add to the changing characteristics of the Kuskokwim River as it flows by the tiny Alaskan village of Napakiak before emptying into the Bering Sea. Every year, a rising torrent chews out bigger swaths of riverbank, encroaching upon this small community of about 360 people, mostly of Inuit descent, driving the town into what experts call a "managed retreat."*

In 2019, strong spring storms took out the town boat landing, threatening the only school in town and forcing the community to move its city garage and fire station further away from the river. The town cemetery has already been flooded and relocated, Nelson says, and residents are now investing in metal caskets so they can be moved more easily in the future.

### FACT BOX

**Overview:** Alaska is facing some of the most imminent threats from climate change in the United States, with fast-rising temperatures, thawing permafrost and massive storms. The small Inuit village of Napakiak is under immediate threat of flooding from the rising Kuskokwim River, and community leaders are consulting with engineers and scientists to determine how and where to move. Homer, a fishing and tourist center of more than 5,000, adopted one of the state's first climate action plans and is continuing to try to adapt to a world with more dangerous storms and threatened fisheries.

**Location:** Homer and Napakiak, Alaska

**Community characteristics:** Small town and Inuit village

**Goals:** Reduce erosion, impacts from flooding and climate threats

**Response:** Develop managed retreat and climate mitigation and adaptation plans

**Project status:** Ongoing

**Key stakeholders:** Alaska Native Tribal Health Consortium, City of Homer, Denali Commission, Kachemak Coastal Estuarine Reserve, Napakiak City Council, Summit Consulting Services

**Key resources:** Alaska Native Tribal Health Consortium, Homer Climate Action Plan, Kachemak Coastal Estuarine Reserve



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"Every year we have to move some buildings," Nelson says. "The erosion rate is accelerating, and the funding is hard to get to do anything about it. But we can't just let the buildings fall into the river."

Located near Bethel in the western part of the state, Napakiak is one of hundreds of Alaskan Indigenous communities battling increasingly severe climate and weather conditions due to climate change. A 2009 U.S. Government Accountability Office report[1] estimated that more than 30 communities were facing "imminent threat" from flooding and erosion, and that number is growing as the climate warms. The Fourth National Climate Assessment's chapter on Alaska[2] warned that the effects of a changing climate will be particularly hard on Indigenous communities.

**Yukon Kuskokwim Delta National Wildlife Refuge in Alaska.**

Credit: P.A. Lawrence, LLC. / Alamy Stock Photo

"The impacts of climate change will likely affect all aspects of Alaska Native societies, from nutrition, infrastructure, economics, and health consequences to language, education, and the communities themselves," the federal report states.

But Napakiak is not sitting still. Its leaders are working with scientists and federal, state and Indigenous support groups to come up with plans to save the community. In the spring of 2019, an Alaska-based construction management and engineering firm, Summit Consulting Services, started working to rebuild the boat launch and barge landing in Napakiak, which are essential to the movement of freight and transportation. The company is also helping plan the town's managed retreat from the river. Their geotechnical investigation includes surveys to determine soil conditions in different locations. Based on the findings, the community will be able to make more informed decisions about its options for the future, says Summit president David Cramer.

*"Every year we have to move some buildings," Nelson says. "The erosion rate is accelerating, and the funding is hard to get to do anything about it. But we can't just let the buildings fall into the river."*

The challenges for Napakiak as well as many other communities in the Yukon Delta are hard to fathom, Cramer says, as erosion, permafrost thawing, sea level rise and inland river flooding are increasing threats to towns in the area. "We are seeing changes faster than anyone expected, and it's accelerating in ways no one projected... The consequences are huge. The whole region could be totally reconfigured by 2100."

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[1] U.S. Government Accountability Office (2009). Alaska Native Villages: Limited Progress Has Been Made on Relocating Villages Threatened by Flooding and Erosion. GAO-09-551. https://www.gao.gov/products/GAO-09-551.

[2] Markon, C. *et al.* (2018). Alaska. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R. *et al.* (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1185–1241. doi: 10.7930/NCA4.2018.CH26. https://nca2018.globalchange.gov/chapter/26/



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Cramer says that after years of planning, his construction company has the expertise to help address these challenges, although it would require a serious investment of money. Cramer says Summit's initial contract is for about $1 million, provided mainly through funding from the Denali Commission, an independent federal agency that provides economic support to rural Alaska. Unfortunately, the cost of moving the entire community of Napakiak to safer ground will cost perhaps 10-20 times that, he says. Where that money will come from is hard to know, especially in a state where oil revenues are declining and budgets are being squeezed.

Climate-related impacts in towns like Napakiak are becoming more dire with each passing storm, and local leaders know they can't wait for political winds to shift in their favor. Whether towns are on the coast or further inland, a warming climate presents growing threats to communities across the state. A 2018 report[3] from the Alaska Native Tribal Health Consortium, a nonprofit organization that works with tribal populations across the state, described the community's situation in blunt terms, calling for immediate action (see sidebar).

Napakiak community leaders like Walter Nelson have reached out to government and nonprofit organizations ranging from the U.S. Army Corps of Engineers to the Alaska Native Tribal Health Consortium, searching for help to deal with increasing threats to their way of life. In April 2019, Walter traveled to Wisconsin to attend the National Adaptation Forum, a national conference of professional and public climate adaptation experts, where he presented his community's story and search for a solution.

"We have seen from our own past experience that relying on other funding sources can be challenging, but we have been able to apply and have received limited funding for relocating buildings," Nelson said. "We are still facing upcoming, different challenges for our community without having a formal climate adaptation plan in place."

Nelson says the conference was an eye-opening experience for him, learning from community leaders around the country who are already working on a myriad of climate issues and plans. After listening to climate experts and talking to other community leaders, Nelson says it made him realize the massive challenges that lie ahead and become even more worried about his community's future. "We are so far remote and we haven't been paying attention to this problem...we are just beginning to wake up."

David Andrew, the tribal administrator for Napakiak, attended the adaptation forum as well. He has helped the community buy special trailers to move houses away from the river, including his mother's home. But he says at some point the town will have to move to safer ground, where the river and the thawing permafrost won't continue to threaten their homes. "People have lived in the area since the beginning of time," Andrew says. "The village used to be in a forest where we used to go hunting. Now the ice has thawed and we see dead salmon floating on the water because of the heat...it's scary to see."

**Alaska Native Tribal Health Consortium "Erosion in Napakiak" 2018 report**

"The magnitude and rapidity of erosion in Napakiak require immediate action and long- term planning. Studies done to-date have concluded that entire community of Napakiak will need to relocate to another site. Napakiak's immediate priority is to relocate and replace threatened infrastructure, and begin collecting data that will inform long-term planning. In some areas, the observed rate of erosion has been significantly faster than 25-50 ft. estimated by the US Army Corps of Engineers in 2009. According to the 2018 Napakiak Hazard Mitigation Plan, the community has lost up to 75 ft. of shoreline in one year...

It is likely that changes associated with a warming climate will cause erosion to accelerate. Examples of factors that may contribute to increased erosion include: the average annual temperature in Western Alaska is predicted to increase 7-13°F by 2100; heavy precipitation events are expected to increase, sea level is expected to rise, and permafrost is expected to degrade, etc. To best adapt to future conditions, Napakiak is seeking funding to conduct a climate risk assessment to estimate the future rate and extent of erosion."

[3] Neale, Max (2018). Alaska Native Tribal Health Consortium. Erosion in Napakiak, Alaska: May 10-11, 2018 Trip Report. https://www.commerce.alaska.gov/web/Portals/4/pub/RA/Max%20Neale%20Napakiak%20Trip%20Report.pdf.



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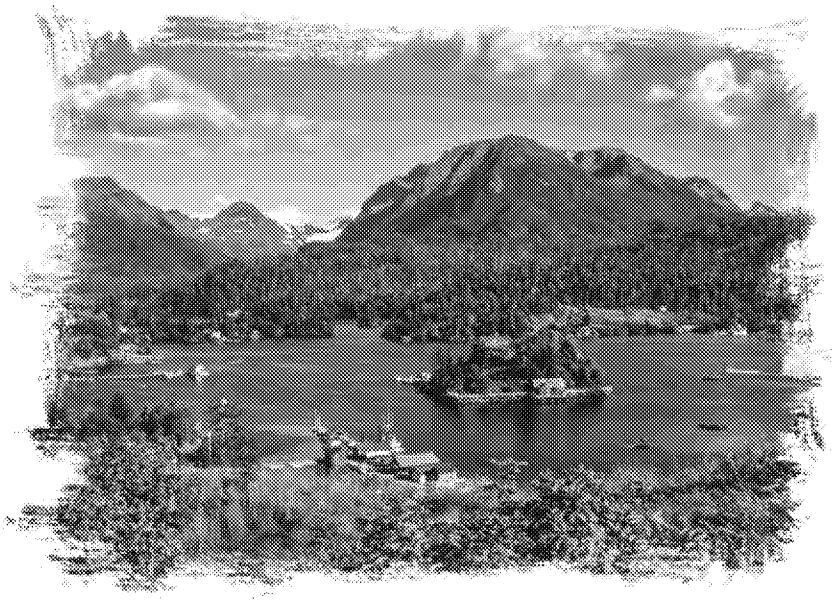
As Alaska's rural villages deal with increasingly dire impacts of a warming world, other cities and towns in Alaska have been preparing for climate change, too. Some already have specific plans in place. One of the first cities to tackle its changing climate was Homer, a fishing and tourist center of about 5,000 residents on the Kenai Peninsula by the Kachemak Bay. Homer created a climate action plan[4] after former mayor James Hornaday attended a national climate conference in 2006. Hornaday formed a global warming task force and got support from the city council for the plan. It includes energy management and efficiency programs, as well as public transportation, waste reduction and land use measures to cut greenhouse gas emissions in the town.



**Halibut Cove across Katchemak Bay from Homer, Alaska.**

Credit: Shutterstock.com

Finalized in 2007, Homer's climate plan was seen as visionary and forward-thinking: "If Homer's Climate Action Plan is used as intended, the community will see immediate local benefits and perhaps make a contribution to the global effort to combat climate change far beyond what most small towns have achieved," the climate report said.

But more than 10 years later, there is still much more work to do, especially in the area of adaptation. Increasing storms and coastal erosion are growing concerns for a town that lies near a spit of commercial land that juts out into the bay. A study published[5] by the University of Alberta examined Homer's climate plan in detail, stating that "...while Homer is experiencing a variety of climate change impacts, adaptation remains a low priority for city officials."

Some local officials are trying to change that. Donna Aderhold, a Homer city council member and wildlife biologist, is concerned about the low areas of town along the spit of land by the bay that includes many of the town's businesses. Although she is actively working on ways to increase local revenue for climate mitigation programs, she is aware that action is needed to address the effects of climate change already underway.

"From an adaptation standpoint, the Homer spit is highly vulnerable to storm surges and the city is currently in the early stages of working with the Alaska Department of Transportation and Public Facilities and the U.S. Army Corps of Engineers on erosion mitigation," Aderhold wrote in an email. "One thing leads to another and this

[4] City of Homer, Alaska (December 2007). Climate Action Plan: Reducing the Threat of Global Climate Change Through Government and Community Efforts. https://www.cityofhomer-ak.gov/sites/default/files/fileattachments/city_council/page/6722/climate_action_plan.pdf.

[5] S. Jeff Birchall & Nicole Bonnett (2019). Local-scale climate change stressors and policy response: the case of Homer, Alaska. Journal of Environmental Planning and Management, DOI: 10.1080/09640568.2018.1537975.



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could translate into comprehensive planning for the entire spit—which is important because our port and harbor are at the end of the spit and our summer economy is focused on the spit."

Aderhold admits climate adaptation for the city is "not on the front burner," but she is doing what she can to raise awareness. "Problems with wildlife populations are mounting in Alaska," she says. "We have warm water 'blobs'[6] in the Gulf of Alaska, more bird die-offs and gray whales are dying." The councilwoman is working with groups like the Kachemak Bay Coastal Estuarine Reserve, a conservation organization funded partly by the National Oceanic and Atmospheric Administration, that is hosting workshops and training programs to raise people's awareness of climate issues impacting the environment around them. Reserve officials believe climate change will become more of a priority as fisheries become more stressed and new threats arise from warming temperatures, such as shellfish poisoning and harmful algal blooms, which have increased in recent years.

"We are working with local fishermen to try to understand the impacts in their businesses," says Syverine Bentz, a coastal training coordinator with the Kachemak Bay Reserve. "We are trying to highlight the important issues and give people the planning tools they need...how we can preserve our natural lifestyles in the face of climate change when the resources may not be the same."

*"From an adaptation standpoint, the Homer spit is highly vulnerable to storm surges and the city is currently in the early stages of working with the Alaska Department of Transportation and Public Facilities and the U.S. Army Corps of Engineers on erosion mitigation..."*

[6] Cornwall, Warren (2019). Ocean heat waves like the Pacific's deadly 'Blob' could become the new normal. Science News (January 31, 2019). DOI: 10.1126/science.aaw8401. https://www.sciencemag.org/news/2019/01/ocean-heat-waves-pacific-s-deadly-blob-could-become-new-normal.

**Sunrise at Kachemak Bay, Homer Spit, Alaska.**

Credit: Shutterstock.com

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# AMAP Assessment 2021: Mercury in the Arctic

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# AMAP Assessment 2021:
# **Mercury in the Arctic**

AMAP

Arctic Monitoring and Assessment Programme (AMAP)
Tromsø, 2021

ED_013708_00001218-00189

# 3. Changes in Arctic mercury levels: emissions sources, pathways and accumulation

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# 4. Changes in Arctic mercury levels: processes affecting mercury transformations and biotic uptake

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*Continued on next page*

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WASTE GEO Technics

# Tailings Dam Failures: A Review of the Last One Hundred Years

*Shahid Azam*
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DONLIN GOLD PROJECT

# Analysis of Crooked Creek Stream Temperature

Draft
September 28, 2021

Project No.: 0011341

DRAFT

Prepared by BGC Engineering Inc. for:
**Donlin Gold LLC**

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# TABLE OF REVISIONS

| ISSUE | DATE | REV | REMARKS |
|---|---|---|---|
| DRAFT | September 28, 2021 | | Original issue for comment |
| | | | |
| | | | |
| | | | |
| | | | |

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**Food & Drink**

# For rural Alaskans, Pilot Bread is soul food

By Victoria Barber
Updated: December 2, 2017
Published: May 28, 2011

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**Victoria Barber**

Victoria Barber was formerly the features editor at the Anchorage Daily News.

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# DONLIN GOLD REPORTS EXCELLENT INITIAL 2022 DRILL PROGRAM RESULTS

## YIELDING ENCOURAGING ASSAYS WITH MORE HIGH-GRADE GOLD INTERCEPTS COUPLED WITH IMPORTANT GRADE CONTINUITY

**July 28, 2022 – Anchorage, AK** – Donlin Gold LLC ("Donlin Gold"), owned 50/50 by Barrick Gold Corporation ("Barrick") (TSX: ABX) (NYSE: GOLD) and NOVAGOLD RESOURCES INC. ("NOVAGOLD") (TSX, NYSE American: NG), is pleased to report the initial assay results for the 2022 drill program.

- The drill program is progressing ahead of schedule with 26,800 meters of the originally planned 34,000-meter drill program completed to date, and assay results received from approximately 9,870 meters of drilling. The results support the recent modelling concepts, and strategic mine planning work.
- The site crew (150 employees, contractors, and student interns), a majority of which are local hires representing 24 Yukon-Kuskokwim (Y-K) communities in Alaska, are working on a two-week rotation schedule and continue to advance project activities at a good pace.
- With the largest budget in more than a decade, the owners are advancing the Donlin Gold project up the value chain and are working toward a feasibility study decision, subject to Donlin Gold LLC Board approval.
- A workshop with Barrick and NOVAGOLD will take place in September at the Donlin Gold project in Alaska to review the work completed to date and lay the path forward.

**Statements by the Owners**

Barrick President and Chief Executive Mark Bristow said, "as expected, the drill program for 2022 continues to enhance our understanding of the ore bodies that make up the Donlin project. Also encouraging is that this year's drilling campaign is ahead of schedule and results so far support the most recent modelling concepts as we focus on moving the project toward a feasibility study decision. I look forward to the Donlin Gold workshop in Alaska in September to advance these efforts."

Greg Lang, NOVAGOLD's President and CEO, said, "The 2022 drill program has been extremely exciting, not to mention rewarding. With the latest set of assays, we continue to enjoy some of the best gold intercepts in the mining industry. The outstanding results reported today, such as the high-grade at ACMA and the deep exploration work, further substantiate Donlin Gold's potential, and the recent modelling concepts, in support of the strategic mine planning work and the engineering studies. We have significantly de-risked Donlin Gold over many years, taking it up the value chain so as to improve and enhance the value of the project for all our stakeholders. This progress is demonstrated through our commitment and dedication to building trust and transparency with our Alaska Native Corporation partners, Calista Corporation and The Kuskokwim Corporation, with whom we have created a model for responsible mining development."

Dan Graham, General Manager of Donlin Gold added, "Donlin Gold's top priorities continue to be the health and safety of our people following the best practices in environmental stewardship for the benefit of the people of Alaska. We could not be more pleased with the work of our 2022 Donlin Gold site crew. While exceeding productivity rates and running ahead of schedule, the overall morale of employees has been high



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and our safety record has remained strong. Moreover, we are most gratified to report that, during the program, the majority of our 150 employees and contractors were local hires from 24 Y-K communities in Alaska."

## Delivering Results

The prime focus of our activities this year is to undertake a 34,000-meter drill program with tight-spaced grid drilling as well as in-pit and ex-pit exploration; and to input the results from this drilling into the geologic modelling and interpretation work that is being used for updated resource models. In June, the Donlin Gold LLC Board approved an additional 43 drill holes and 8,380 meters to infill one of the 20-meter grids to 10-meter spacing. In addition to the engineering studies underway to support the mining schedules and life of mine business plans, this program will enable us to proceed with the preparation of an updated feasibility study, subject to a formal decision by the Donlin Gold LLC Board.

Following the excellent results of 2021, we are encouraged by the expanded drill program for 2022, with drilling also focused on upside prospects in the ACMA and Lewis pits where drilling so far has been limited. The new assays we received have thus far yielded some outstanding intercepts, with the five top intervals released today being:

- DC22-2040 intersected 52.27 m grading 14.63 g/t gold starting at 232.95 m drilled depth, including sub intervals of 13.94 m grading 33.95 g/t gold starting at 232.95 m drilled depth and 16.45 m grading 13.50 g/t gold starting at 257.18 m drilled depth;
- DC22-2040 intersected 18.65 m grading 10.78 g/t gold starting at 197.60 m drilled depth, including a sub interval of 7.68 m grading 19.69 g/t gold starting at 199.35 m drilled depth;
- DC22-2056 intersected 73.98 m grading 4.21 g/t gold starting at 99.82 m drilled depth, including a sub interval of 6.16 m grading 18.20 g/t gold starting at 109.12 m drilled depth;
- DC22-2063 intersected 12.10 m grading 22.15 g/t gold starting at 130.04 m drilled depth, including a sub interval of 5.43 m grading 47.17 g/t starting 135.48 m drilled depth; and
- DC22-2067 intersected 44.58 m grading 4.50 g/t gold starting at 464.06 m drilled depth, including sub intervals of 3.11 m grading 10.79 g/t gold starting at 464.06 m drilled depth and 6.35 m grading 10.26 g/t gold starting at 496.00 m drilled depth.

- Drill-hole collar locations and five of the top intervals are shown in Figure 1.
- Drill-hole orientations, depths and significant intervals are shown in Tables 1 and 2, respectively, in the Appendix at the end of this release.
- DC22-2063 interval is subparallel to a mineralized fault zone and mineralized dyke.
- DC22-2067 interval is subparallel to a mineralized fault zone.
- The team of 150 people at Donlin Gold are advancing drilling activities at a fine pace, with the drilling expected to wrap-up in the fall. The health and safety of our workforce is a priority. Donlin Gold has implemented strict safety protocols, while COVID-19 mitigation measures remain in place to ensure that the staff rotations in and out of the camp are conducted in both an efficient and safe manner.

## Donlin Gold 2022 Project Budget

The 2022 budget for Donlin Gold LLC (on a 100% basis) is set at $60 million, split equally between the two owners. The focus is to refresh geologic modelling and interpretation work for an updated resource model as well as engineering activities to inform an updated feasibility study decision. Approximately 34,000 meters of in-pit and below-pit drilling was planned under the original scope, in addition to fieldwork, for the Alaska Dam



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Safety Certifications, environmental studies, and external affairs efforts. An additional $4.8 million (100% basis) was approved by the Donlin Gold LLC Board for the additional 8,380 drill meter workplan.

The owners will continue to advance the Donlin Gold project as they have done for many years in a financially disciplined manner with a clear focus on a strong safety culture, engineering excellence, environmental stewardship, and active community engagement.

**About Donlin Gold**

The Donlin Gold project is located in Alaska, the second largest gold-producing state in the United States. With approximately 39 million ounces of gold grading 2.24 grams per tonne in the measured and indicated mineral resource categories (100 percent basis)[1], Donlin Gold hosts one of the largest and highest-grade undeveloped open-pit gold endowments in the world. The planned pits in which the existing resources are sited occupy only three kilometers of an eight-kilometer mineralized belt, which itself is located on less than 5% of Donlin Gold's land position. Current activities at Donlin Gold are focused on the drill program, optimization efforts, community outreach, and advancing the remaining State permitting actions.

Donlin Gold is a committed partner to the Alaska Native communities both surrounding the project and within the State as a whole. This commitment underpins our approach and is also reflected in the way in which the asset itself is structured. An important factor that distinguishes Donlin Gold from most other mining assets in Alaska is that the project is located on private land designated for mining activities under the 1971 Alaska Native Claims Settlement Act (ANCSA). Donlin Gold has entered into life-of-mine agreements with Calista, which owns the subsurface mineral rights and some surface land rights, and The Kuskokwim Corporation (TKC), a collection of 10 village corporations, which owns the majority of surface land rights. Donlin Gold is committed to providing employment opportunities, scholarships, and preferential contract considerations to Calista and TKC shareholders. The life-of-mine agreements include a revenue-sharing structure established in the context of the ANCSA, which resolved Alaska Native land claims and allotted some 44 million acres of land for use by Alaska Native Corporations. Additionally, our long-term commitment to economic development in the Y-K region is exemplified by Donlin Gold's support of TKC's initiative to launch energy and infrastructure projects in middle Kuskokwim villages. These partnerships, activities, and programs are illustrative of Donlin Gold's commitment to sustainable and responsible development of the project for the benefit of all stakeholders.

[1] Donlin Gold data as per the 2021 Technical Report and S-K 1300 Report (both as defined herein). Donlin Gold possesses Measured Resources of approximately 8 Mt grading 2.52 g/t and Indicated Resources of approximately 534 Mt grading 2.24 g/t, each on a 100% basis and inclusive of Mineral Reserves, of which approximately 4 Mt of Measured Resources and approximately 267 Mt of Indicated Resources inclusive of Reserves is attributable to NOVAGOLD through its 50% ownership interest in Donlin Gold LLC. Exclusive of Mineral Reserves, Donlin Gold possesses Measured Resources of approximately 1 Mt grading 2.23 g/t and Indicated Resources of approximately 69 Mt grading 2.44 g/t, of which approximately 0.5 Mt of Measured Resources and approximately 35 Mt of Indicated Resources exclusive of Mineral Reserves is attributable to NOVAGOLD. Donlin Gold possesses Proven Reserves of approximately 8 Mt grading 2.32 g/t and Probable Reserves of approximately 497 Mt grading 2.08 g/t, each on a 100% basis, of which approximately 4 Mt of Proven Reserves and approximately 249 Mt of Probable Reserves is attributable to NOVAGOLD. Mineral Reserves and Resources have been estimated in accordance with NI 43-101 and S-K 1300.



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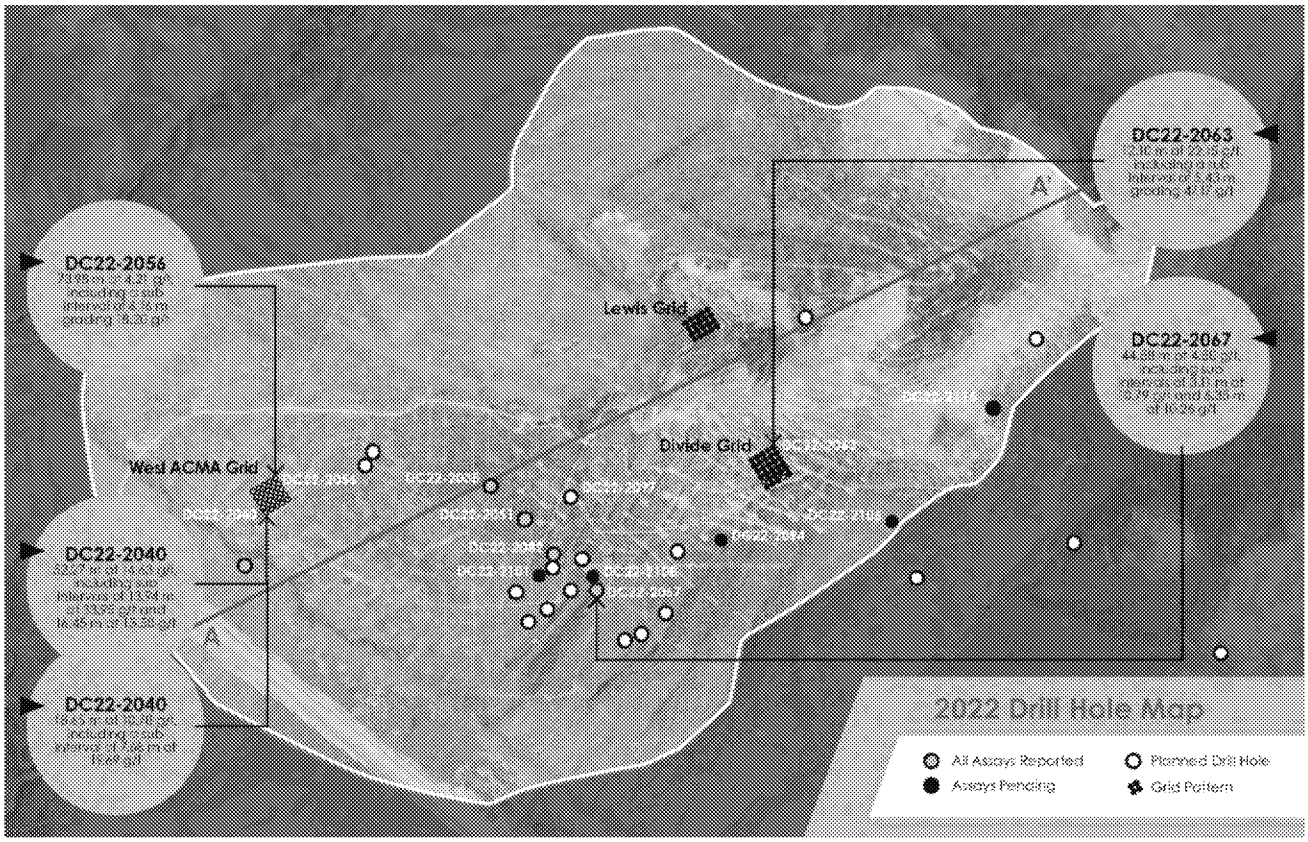
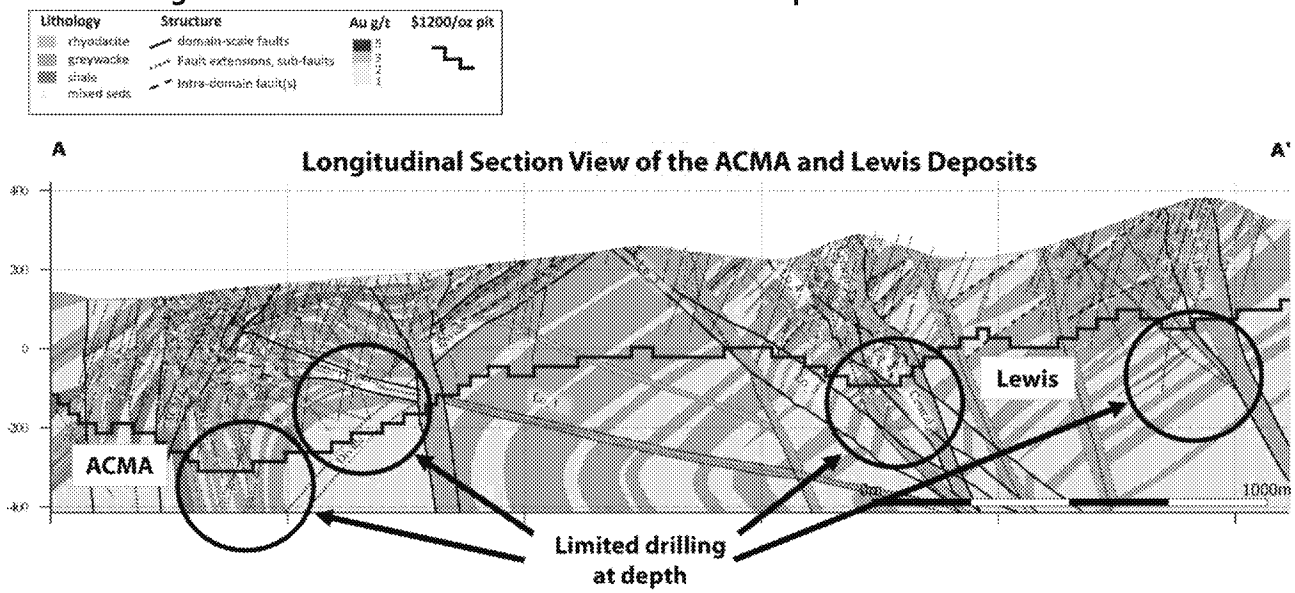
**FIGURE 1 Drill Hole Collar Locations**




Depicted grid system is based on NAD83 UTM zone 4N coordinates. Longitudinal Section View orientation below taken at A – A′ orientation depicted above.

**FIGURE 2 Longitudinal Section View of the ACMA and Lewis Deposits**




## QA/QC Procedures

The QA/QC procedures for the 2022 Donlin Gold project drill program and sampling protocol were developed and managed by Donlin Gold and overseen by Barrick and NOVAGOLD. The chain of custody from the drill site to the sample preparation facility was continuously monitored. All samples are HQ-diameter core. Approximately 94% core recovery has been achieved during the 2022 drill program. Core was logged, cut, and sampled at site by Donlin Gold employees. Samples were primarily collected on one- to two-meter lengths. Sampled half-core was crushed in Bureau Veritas' Juneau and Fairbanks, Alaska sample preparation facilities. Crushed samples were sent to Bureau Veritas' lab in Vancouver, British Columbia for pulverizing and gold assays and pulverized splits to an ALS Limited lab in Vancouver, British Columbia for multi-element analysis. Quality control samples were inserted (standards at 5% of primary samples, blanks at 5% of primary samples and duplicates at 2.5% of primary samples) into each batch of samples. The review of the quality control samples did not indicate any bias or error. Out of bounds quality control samples were handled with appropriate reruns and investigations. There are no known factors that would materially affect the accuracy or reliability of the drill program data referred to in this media release.

Downhole directional surveys were completed on all reported completed holes by Boart Longyear drill operators, and collar surveys were completed by Donlin Gold staff under the supervision of Professional Licensed Surveyors from Brice Engineering LLC.

Each of Bureau Veritas, ALS Limited, Boart Longyear, and Brice Engineering LLC are independent of Donlin Gold, Barrick, and NOVAGOLD.

## Scientific and Technical Information

In mid-2021, NOVAGOLD engaged Wood Canada Limited ("Wood") to update the Second Updated Feasibility Study on Donlin Gold completed in 2011 (the "2011 Technical Report"). This update resulted in a report titled "NI 43-101 Technical Report on the Donlin Gold Project, Alaska, USA" with an effective date of June 1, 2021 (the "2021 Technical Report"). In 2021, NOVAGOLD also engaged Wood to prepare a Donlin Gold technical report summary in accordance with *Subpart 229.1300 of Regulation S-K – Disclosure by Registrants Engaged in Mining Operations* ("S-K 1300") as of November 30, 2021. The resulting report is titled "S-K 1300 Technical Report Summary on the Donlin Gold Project, Alaska, USA" ("S-K 1300 Report"), current as of November 30, 2021. Wood incorporated 2020 costs and new gold price guidance to meet the NOVAGOLD's reporting



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requirements. The resultant 2021 Technical Report and S-K 1300 Report showed no material change to the previously reported mineral resources or mineral reserves.

NOVAGOLD is a registrant with the SEC and is reporting its Mineral Resources and Mineral Reserves in accordance with S-K 1300 as of November 30, 2021. While the S-K 1300 rules are similar to National Instrument 43-101 Standards of Disclosure for Mineral Projects ("NI 43-101") rules in Canada, they are not identical and therefore two reports have been produced for the Donlin Gold project.

Certain scientific and technical information contained herein with respect to the Donlin Gold project is derived from the 2021 Technical Report and the S-K 1300 Report. Henry Kim, P.Geo., Senior Resource Geologist, Wood Canada Limited; Mike Woloschuk, P.Eng., VP Global Business Development & Consulting, Wood Group USA, Inc.; and Kirk Hanson, MBA, P.E., Technical Director, Open Pit Mining, Wood Group USA, Inc. are the Qualified Persons responsible for the preparation of the 2021 Technical Report, and each is an independent Qualified Person as defined by National Instrument 43-101 ("NI 43-101"). Wood prepared the S-K 1300 Report.

Paul Chilson, P.E., who is the Manager of Mine Engineering for NOVAGOLD and a Qualified Person under NI 43-101, has approved and verified the scientific and technical information related to the 2021 and 2022 Donlin Gold project drill programs, the 2021 Technical Report and the S-K 1300 Report contained in this media release. To verify the information related to the drilling programs, he has visited the property in the past year; discussed logging, sampling, and sample shipping processes with responsible site staff; discussed and reviewed assay and QA/QC results with responsible personnel; and reviewed supporting documentation, including drill hole location and orientation and significant assay interval calculations.

Octavia Bath, P.Geo., who is a Barrick Mineral Resource Manager and a Qualified Person under NI 43-101 has reviewed and approved the assay results for the Donlin Gold project contained in this media release.

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**Cautionary Note Regarding Forward-Looking Statements**

*This media release includes certain "forward-looking information" and "forward-looking statements" (collectively "forward-looking statements") within the meaning of applicable securities legislation, including the United States Private Securities Litigation Reform Act of 1995. Forward-looking statements are frequently, but not always, identified by words such as "expects", "anticipates", "believes", "intends", "estimates", "potential", "possible", and similar expressions, or statements that events, conditions, or results "will", "may", "could", "would" or "should" occur or be achieved. Forward-looking statements are necessarily based on several opinions, estimates and assumptions that management of Barrick and NOVAGOLD considered appropriate and reasonable as of the date such statements are made, are subject to*



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*known and unknown risks, uncertainties, assumptions, and other factors that may cause the actual results, activity, performance, or achievements to be materially different from those expressed or implied by such forward-looking statements. All statements, other than statements of historical fact, included herein are forward-looking statements. These forward-looking statements include statements regarding assay results; the anticipated timing of a decision by the Board of Donlin Gold LLC to prepare a feasibility study update; anticipated benefits from recent drill programs including an improved geological model for Donlin Gold; the work program for the 2022 field season; the continuing priorities of Donlin Gold, including the health and safety of our people; ongoing support provided to key stakeholders including Native Corporation partners; the potential impact of the coronavirus global pandemic (COVID-19) on the development of Donlin Gold; the potential development and construction of Donlin Gold; the sufficiency of funds to continue to advance development of Donlin Gold; perceived merit of properties; mineral reserve and resource estimates; Donlin Gold's ability to secure the permits needed to construct and operate the Donlin Gold project in a timely manner, if at all; and legal challenges to Donlin Gold's existing permits. In addition, any statements that refer to expectations, intentions, projections or other characterizations of future events or circumstances are forward-looking statements. Forward-looking statements are not historical facts but instead represent the management expectations of Donlin Gold's, Barrick's and NOVAGOLD's estimates and projections regarding future events or circumstances on the date the statements are made.*

*Important factors that could cause actual results to differ materially from expectations include the need to obtain additional permits and governmental approvals; the timing and likelihood of securing permits; the need for additional financing to explore and develop properties and availability of financing in the debt and capital markets; the spread and impact of COVID-19; uncertainties involved in the interpretation of drill results and geological tests and the estimation of reserves and resources; exploitation and exploration successes; changes in national and local government legislation, taxation, controls or regulations and/or changes in the administration of laws, policies and practices, expropriation or nationalization of property and political or economic developments in the United States or Canada; the need for continued cooperation between Barrick and NOVAGOLD for the continued exploration, development and eventual construction of the Donlin Gold project; the need for cooperation of government agencies and native groups in the development and operation of properties; risks of construction and mining projects such as accidents, equipment breakdowns, bad weather, disease pandemics, non-compliance with environmental and permit requirements, unanticipated variation in geological structures, ore grades or recovery rates; unexpected cost increases, which could include significant increases in estimated capital and operating costs; fluctuations in metal prices and currency exchange rates; whether a positive construction decision will be made regarding Donlin Gold; and other risks and uncertainties disclosed in Barrick's most recent Form 40-F/Annual Information Form on file with the United States Securities and Exchange Commission (SEC) and Canadian provincial securities authorities, and NOVAGOLD's most recent reports on Forms 10-K and 10-Q, particularly the "Risk Factors" sections of those reports and other documents filed by Barrick and NOVAGOLD with applicable securities regulatory authorities from time to time. Copies of these filings may be obtained by visiting NOVAGOLD's website at www.novagold.com, Barrick's website at www.barrick.com, or the SEC's website at www.sec.gov, or at www.sedar.com. The forward-looking statements contained herein reflect the beliefs, opinions, and projections of Donlin Gold, NOVAGOLD, and Barrick on the date the statements are made. Donlin Gold, NOVAGOLD and Barrick assume no obligation to update the forward-looking statements of beliefs, opinions, projections, or other factors, should they change, except as required by law.*



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## APPENDIX

**TABLE 1**
**Drill Hole Orientations* and Depths**

| HOLE | Azimuth (°) | Inclination (°) | Depth (m) |
|---|---|---|---|
| DC22-2033 | 331 | 61 | 254.51 |
| DC22-2034 | 331 | 62 | 287.43 |
| DC22-2035 | 238 | 45 | 877.52 |
| DC22-2036 | 328 | 59 | 245.06 |
| DC22-2037 | 335 | 59 | 289.86 |
| DC22-2038 | 331 | 61 | 248.72 |
| DC22-2039 | 331 | 56 | 289.26 |
| DC22-2040 | 333 | 60 | 309.37 |
| DC22-2041 | 331 | 61 | 261.82 |
| DC22-2042 | 336 | 58 | 264.57 |
| DC22-2043 | 329 | 60 | 230.12 |
| DC22-2044 | 331 | 59 | 288.34 |
| DC22-2045 | 331 | 60 | 224.94 |
| DC22-2046 | 333 | 60 | 239.57 |
| DC22-2047 | 331 | 59 | 230.12 |
| DC22-2048 | 331 | 61 | 166.73 |
| DC22-2049 | 331 | 61 | 145.24 |
| DC22-2050 | 333 | 59 | 219.46 |
| DC22-2051 | 242 | 52 | 851.61 |
| DC22-2052 | 335 | 61 | 139.90 |
| DC22-2053 | 334 | 59 | 292.91 |
| DC22-2054 | 334 | 60 | 188.37 |
| DC22-2055 | 335 | 62 | 215.19 |
| DC22-2056 | 334 | 60 | 184.40 |
| DC22-2057 | 335 | 59 | 244.45 |
| DC22-2058 | 332 | 61 | 196.90 |
| DC22-2059 | 339 | 60 | 234.85 |
| DC22-2060 | 330 | 59 | 157.28 |
| DC22-2061 | 331 | 59 | 247.80 |
| DC22-2062 | 332 | 60 | 239.88 |
| DC22-2063 | 334 | 58 | 300.38 |
| DC22-2064 | 334 | 58 | 230.12 |
| DC22-2065 | 332 | 59 | 225.55 |
| DC22-2066 | 334 | 59 | 225.55 |
| DC22-2067 | 246 | 52 | 777.54 |
| DC22-2068 | 333 | 62 | 240.18 |
| DC22-2069 | 333 | 61 | 260.60 |
| DC22-2070 | 332 | 60 | 240.79 |
| DC22-2071 | 330 | 61 | 225.55 |
| DC22-2072 | 333 | 59 | 223.88 |



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| | | | |
|---|---|---|---|
| DC22-2073 | 330 | 61 | 233.17 |
| DC22-2074 | 332 | 61 | 240.03 |
| DC22-2075 | 330 | 59 | 233.78 |
| DC22-2076 | 333 | 60 | 227.99 |
| DC22-2077 | 330 | 61 | 211.68 |
| DC22-2078 | 333 | 59 | 230.12 |
| DC22-2079 | 334 | 61 | 235.00 |
| DC22-2080 | 332 | 58 | 256.34 |
| DC22-2081 | 332 | 59 | 239.88 |
| DC22-2082 | 245 | 54 | 789.43 |
| DC22-2083 | 328 | 64 | 220.07 |
| DC22-2084 | 335 | 62 | 209.09 |
| DC22-2085 | 334 | 57 | 249.94 |
| DC22-2086 | 334 | 58 | 210.31 |
| DC22-2087 | 332 | 56 | 220.37 |
| DC22-2088 | 334 | 59 | 219.46 |
| DC22-2089 | 332 | 59 | 243.84 |
| DC22-2090 | 330 | 58 | 220.07 |
| DC22-2091 | 334 | 60 | 260.30 |
| DC22-2092 | 333 | 59 | 225.55 |
| DC22-2093 | 334 | 59 | 235.00 |
| DC22-2094 | 327 | 63 | 915.10 |
| DC22-2095 | 335 | 58 | 199.95 |
| DC22-2096 | 332 | 60 | 275.84 |
| DC22-2097 | 256 | 70 | 483.11 |
| DC22-2098 | 337 | 58 | 199.95 |
| DC22-2099 | 333 | 58 | 227.38 |
| DC22-2100 | 334 | 57 | 216.56 |
| DC22-2101 | 311 | 64 | 522.43 |
| DC22-2102 | 331 | 60 | 227.08 |
| DC22-2103 | 330 | 61 | 291.08 |
| DC22-2104 | 330 | 60 | 239.57 |
| DC22-2105 | 336 | 59 | 275.84 |
| DC22-2106 | 324 | 62 | 920.95 |
| DC22-2107 | 334 | 60 | 265.18 |
| DC22-2108 | 294 | 67 | 557.78 |
| DC22-2109 | 334 | 62 | 303.28 |
| DC22-2110 | 331 | 61 | 289.56 |
| DC22-2111 | 332 | 61 | 245.36 |
| DC22-2113 | 334 | 63 | 259.99 |
| DC22-2114 | 334 | 61 | 256.95 |
| DC22-2115 | 334 | 60 | 311.05 |

* Note that azimuth and inclination values vary as each hole progresses. The stated values are hole averages, rounded to the nearest degree.

**TABLE 2**
**2021 Donlin Gold Significant Assay Intervals**

| Hole ID | Area | From (Meters) | To (Meters) | Length (Meters) | Au Grade (g/t) |
|---|---|---|---|---|---|
| DC22-2033 | ACMA | 33.04 | 36.50 | 3.46 | 1.24 |
| DC22-2033 | | 42.17 | 50.01 | 7.84 | 2.79 |
| DC22-2033 | | 105.65 | 126.32 | 20.67 | 2.76 |
| DC22-2033 | | 172.08 | 176.43 | 4.35 | 1.03 |
| DC22-2033 | | 185.79 | 189.64 | 3.85 | 1.87 |
| **DC22-2033** | | **TOTAL** | | **40.17** | **2.36** |
| DC22-2034 | ACMA | 44.35 | 48.16 | 3.81 | 1.78 |
| DC22-2034 | | 116.29 | 129.32 | 13.03 | 6.40 |
| *including* | | *121.31* | *127.97* | *6.66* | *10.51* |
| DC22-2034 | | 140.80 | 145.80 | 5.00 | 10.39 |
| DC22-2034 | | 208.38 | 220.88 | 12.50 | 2.18 |
| **DC22-2034** | | **TOTAL** | | **34.34** | **4.93** |
| DC22-2035 | ACMA | 433.53 | 440.95 | 7.42 | 6.30 |
| DC22-2035 | | 651.24 | 682.65 | 31.41 | 3.81 |
| DC22-2035 | | 751.88 | 756.10 | 4.22 | 8.15 |
| **DC22-2035** | | **TOTAL** | | **43.05** | **4.67** |
| DC22-2036 | ACMA | 137.33 | 144.48 | 7.15 | 3.39 |
| DC22-2036 | | 152.57 | 159.29 | 6.72 | 2.94 |
| **DC22-2036** | | **TOTAL** | | **13.87** | **3.17** |
| DC22-2037 | ACMA | 109.24 | 119.58 | 10.34 | 3.07 |
| **DC22-2037** | | **TOTAL** | | **10.34** | **3.07** |
| DC22-2038 | ACMA | 114.50 | 126.63 | 12.13 | 3.24 |
| DC22-2038 | | 185.16 | 190.15 | 4.99 | 4.90 |
| **DC22-2038** | | **TOTAL** | | **17.12** | **3.72** |
| DC22-2039 | ACMA | 122.46 | 126.13 | 3.67 | 3.46 |
| **DC22-2039** | | **TOTAL** | | **3.67** | **3.46** |
| DC22-2040 | ACMA | 97.26 | 105.21 | 7.95 | 2.77 |
| DC22-2040 | | 114.45 | 122.41 | 7.96 | 1.50 |
| DC22-2040 | | 139.25 | 154.84 | 15.59 | 3.64 |
| DC22-2040 | | 197.60 | 216.25 | 18.65 | 10.78 |
| *including* | | *199.35* | *207.03* | *7.68* | *19.69* |
| DC22-2040 | | 232.95 | 285.22 | 52.27 | 14.63 |
| *including* | | *232.95* | *246.89* | *13.94* | *33.95* |
| *including* | | *257.18* | *273.63* | *16.45* | *13.50* |
| **DC22-2040** | | **TOTAL** | | **102.42** | **10.31** |
| DC22-2041 | ACMA | 75.03 | 81.99 | 6.96 | 4.60 |
| DC22-2041 | | 86.43 | 101.36 | 14.93 | 1.82 |
| DC22-2041 | | 105.74 | 113.42 | 7.68 | 4.43 |



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| | | | | | |
|---|---|---|---|---|---|
| DC22-2041 | | 174.29 | 187.45 | 13.16 | 7.47 |
| **DC22-2041** | | **TOTAL** | | **42.73** | **4.48** |
| DC22-2042 | ACMA | 19.80 | 34.44 | 14.64 | 3.09 |
| DC22-2042 | | 95.10 | 102.28 | 7.18 | 3.71 |
| DC22-2042 | | 152.80 | 162.62 | 9.82 | 2.93 |
| DC22-2042 | | 168.21 | 187.81 | 19.60 | 4.06 |
| DC22-2042 | | 196.04 | 205.46 | 9.42 | 5.22 |
| **DC22-2042** | | **TOTAL** | | **60.66** | **3.78** |
| DC22-2043 | ACMA | 49.61 | 58.38 | 8.77 | 7.23 |
| DC22-2043 | | 144.97 | 168.48 | 23.51 | 6.20 |
| **DC22-2043** | | **TOTAL** | | **32.28** | **6.48** |
| DC22-2044 | ACMA | 26.21 | 30.14 | 3.93 | 2.78 |
| DC22-2044 | | 157.31 | 166.42 | 9.11 | 3.62 |
| DC22-2044 | | 171.95 | 176.69 | 4.74 | 4.55 |
| **DC22-2044** | | **TOTAL** | | **17.78** | **3.69** |
| DC22-2045 | ACMA | 12.53 | 18.23 | 5.70 | 3.95 |
| DC22-2045 | | 41.42 | 58.40 | 16.98 | 1.56 |
| DC22-2045 | | 63.84 | 73.05 | 9.21 | 2.40 |
| DC22-2045 | | 128.03 | 133.50 | 5.47 | 3.18 |
| DC22-2045 | | 138.75 | 146.20 | 7.45 | 1.74 |
| DC22-2045 | | 158.22 | 170.45 | 12.23 | 1.93 |
| DC22-2045 | | 205.38 | 213.77 | 8.39 | 1.92 |
| **DC22-2045** | | **TOTAL** | | **65.43** | **2.16** |
| DC22-2046 | ACMA | 24.38 | 32.42 | 8.04 | 5.25 |
| DC22-2046 | | 109.52 | 135.25 | 25.73 | 5.22 |
| DC22-2046 | | 176.88 | 194.04 | 17.16 | 3.48 |
| DC22-2046 | | 207.43 | 212.14 | 4.71 | 1.32 |
| DC22-2046 | | 220.58 | 223.77 | 3.19 | 1.02 |
| **DC22-2046** | | **TOTAL** | | **58.83** | **4.18** |
| DC22-2047 | ACMA | 37.19 | 47.66 | 10.47 | 2.37 |
| DC22-2047 | | 135.33 | 140.13 | 4.80 | 9.08 |
| *including* | | *136.37* | *140.13* | *3.76* | *11.06* |
| DC22-2047 | | 151.83 | 176.24 | 24.41 | 3.76 |
| **DC22-2047** | | **TOTAL** | | **39.68** | **4.04** |
| DC22-2048 | ACMA | 6.44 | 10.48 | 4.04 | 5.16 |
| DC22-2048 | | 23.77 | 30.48 | 6.71 | 7.43 |
| DC22-2048 | | 36.88 | 43.61 | 6.73 | 3.48 |
| DC22-2048 | | 94.64 | 106.83 | 12.19 | 3.11 |
| DC22-2048 | | 111.17 | 143.61 | 32.44 | 1.18 |
| **DC22-2048** | | **TOTAL** | | **62.11** | **2.74** |
| DC22-2049 | ACMA | 10.97 | 16.20 | 5.23 | 6.51 |
| DC22-2049 | | 95.70 | 112.44 | 16.74 | 2.76 |
| **DC22-2049** | | **TOTAL** | | **21.97** | **3.65** |
| DC22-2050 | ACMA | 38.40 | 42.93 | 4.53 | 1.22 |
| DC22-2050 | | 98.40 | 123.70 | 25.30 | 2.82 |
| DC22-2050 | | 137.98 | 162.88 | 24.90 | 2.74 |

| | | | | | |
|---|---|---|---|---|---|
| **DC22-2050** | | **TOTAL** | | **54.73** | **2.65** |
| DC22-2051 | ACMA | 69.70 | 80.01 | 10.31 | 1.27 |
| DC22-2051 | | 119.52 | 126.19 | 6.67 | 1.72 |
| DC22-2051 | | 343.75 | 356.05 | 12.30 | 3.24 |
| DC22-2051 | | 437.45 | 474.88 | 37.43 | 2.35 |
| DC22-2051 | | 533.86 | 565.30 | 31.44 | 4.63 |
| *including* | | *545.90* | *550.40* | *4.50* | *11.45* |
| DC22-2051 | | 693.27 | 708.65 | 15.38 | 6.81 |
| *including* | | *698.89* | *703.53* | *4.64* | *16.59* |
| DC22-2051 | | 746.67 | 767.93 | 21.26 | 3.74 |
| **DC22-2051** | | **TOTAL** | | **134.79** | **3.58** |
| DC22-2052 | ACMA | 6.36 | 17.07 | 10.71 | 2.43 |
| DC22-2052 | | 100.72 | 104.92 | 4.20 | 1.93 |
| **DC22-2052** | | **TOTAL** | | **14.91** | **2.29** |
| DC22-2053 | ACMA | 39.82 | 43.55 | 3.73 | 2.24 |
| DC22-2053 | | 50.55 | 59.82 | 9.27 | 2.09 |
| DC22-2053 | | 169.41 | 172.63 | 3.22 | 3.72 |
| DC22-2053 | | 286.82 | 290.15 | 3.33 | 2.57 |
| **DC22-2053** | | **TOTAL** | | **19.55** | **2.47** |
| DC22-2054 | ACMA | 10.05 | 13.42 | 3.37 | 3.44 |
| DC22-2054 | | 108.52 | 148.31 | 39.79 | 3.37 |
| DC22-2054 | | 152.89 | 179.89 | 27.00 | 2.70 |
| **DC22-2054** | | **TOTAL** | | **70.16** | **3.11** |
| DC22-2055 | ACMA | 12.19 | 35.77 | 23.58 | 2.36 |
| DC22-2055 | | 115.85 | 124.30 | 8.45 | 5.11 |
| DC22-2055 | | 131.99 | 152.88 | 20.89 | 4.12 |
| DC22-2055 | | 181.66 | 187.45 | 5.79 | 2.03 |
| **DC22-2055** | | **TOTAL** | | **58.71** | **3.35** |
| DC22-2056 | ACMA | 2.44 | 13.33 | 10.89 | 17.55 |
| *including* | | *7.01* | *11.13* | *4.12* | *44.11* |
| DC22-2056 | | 83.31 | 86.37 | 3.06 | 8.51 |
| DC22-2056 | | 99.82 | 173.80 | 73.98 | 4.21 |
| *including* | | *109.12* | *115.28* | *6.16* | *18.20* |
| **DC22-2056** | | **TOTAL** | | **87.93** | **6.02** |
| DC22-2057 | ACMA | 10.97 | 21.25 | 10.28 | 2.59 |
| DC22-2057 | | 40.56 | 48.17 | 7.61 | 1.97 |
| DC22-2057 | | 52.57 | 60.64 | 8.07 | 1.05 |
| DC22-2057 | | 118.89 | 123.88 | 4.99 | 2.23 |
| DC22-2057 | | 135.23 | 142.04 | 6.81 | 6.04 |
| DC22-2057 | | 147.74 | 160.25 | 12.51 | 3.91 |
| DC22-2057 | | 166.47 | 173.36 | 6.89 | 2.48 |
| DC22-2057 | | 186.43 | 194.98 | 8.55 | 4.04 |
| **DC22-2057** | | **TOTAL** | | **65.71** | **3.09** |
| DC22-2058 | ACMA | 5.18 | 14.02 | 8.84 | 2.81 |
| DC22-2058 | | 21.46 | 33.01 | 11.55 | 3.50 |
| DC22-2058 | | 112.19 | 118.57 | 6.38 | 3.84 |

| | | | | | |
|---|---|---|---|---|---|
| DC22-2058 | | 124.23 | 138.62 | 14.39 | 8.18 |
| *including* | | *130.24* | *136.99* | *6.75* | *15.15* |
| DC22-2058 | | 151.79 | 172.17 | 20.38 | 2.83 |
| **DC22-2058** | | **TOTAL** | | **61.54** | **4.31** |
| DC22-2059 | Divide | 57.65 | 76.04 | 18.39 | 3.64 |
| DC22-2059 | | 81.48 | 86.56 | 5.08 | 1.01 |
| DC22-2059 | | 95.38 | 109.70 | 14.32 | 2.75 |
| DC22-2059 | | 118.26 | 122.22 | 3.96 | 2.94 |
| **DC22-2059** | | **TOTAL** | | **41.75** | **2.95** |
| DC22-2060 | ACMA | 10.02 | 16.48 | 6.46 | 7.99 |
| DC22-2060 | | 116.69 | 121.75 | 5.06 | 2.26 |
| **DC22-2060** | | **TOTAL** | | **11.52** | **5.47** |
| DC22-2061 | Divide | 22.80 | 25.91 | 3.11 | 2.36 |
| DC22-2061 | | 32.72 | 41.90 | 9.18 | 2.10 |
| DC22-2061 | | 55.87 | 66.97 | 11.10 | 2.59 |
| DC22-2061 | | 73.76 | 81.30 | 7.54 | 1.80 |
| DC22-2061 | | 91.09 | 129.15 | 38.06 | 3.08 |
| DC22-2061 | | 172.94 | 176.31 | 3.37 | 2.49 |
| DC22-2061 | | 186.10 | 196.08 | 9.98 | 2.51 |
| **DC22-2061** | | **TOTAL** | | **82.34** | **2.67** |
| DC22-2062 | Divide | 54.25 | 87.49 | 33.24 | 1.02 |
| DC22-2062 | | 110.99 | 115.21 | 4.22 | 4.76 |
| DC22-2062 | | 126.31 | 132.65 | 6.34 | 9.68 |
| DC22-2062 | | 147.06 | 197.82 | 50.76 | 3.28 |
| **DC22-2062** | | **TOTAL** | | **94.56** | **2.98** |
| DC22-2063 | Divide | 9.14 | 15.75 | 6.61 | 1.32 |
| DC22-2063 | | 61.13 | 75.81 | 14.68 | 3.12 |
| DC22-2063 | | 130.04 | 142.14 | 12.10 | 22.15 |
| *including* | | *135.48* | *140.91* | *5.43* | *47.17* |
| **DC22-2063** | | **TOTAL** | | **33.39** | **9.66** |
| DC22-2067 | ACMA | 83.17 | 92.99 | 9.82 | 1.43 |
| DC22-2067 | | 123.01 | 130.91 | 7.90 | 2.41 |
| DC22-2067 | | 145.78 | 160.87 | 15.09 | 5.49 |
| DC22-2067 | | 251.68 | 260.64 | 8.96 | 1.05 |
| DC22-2067 | | 273.14 | 288.11 | 14.97 | 1.94 |
| DC22-2067 | | 416.80 | 434.50 | 17.70 | 4.26 |
| DC22-2067 | | 464.06 | 508.64 | 44.58 | 4.50 |
| *including* | | *464.06* | *467.17* | *3.11* | *10.79* |
| *including* | | *496.00* | *502.35* | *6.35* | *10.26* |
| DC22-2067 | | 582.22 | 592.53 | 10.31 | 2.82 |
| DC22-2067 | | 614.40 | 626.58 | 12.18 | 1.16 |
| DC22-2067 | | 644.08 | 652.25 | 8.17 | 1.79 |
| DC22-2067 | | 724.00 | 730.65 | 6.65 | 1.05 |
| **DC22-2067** | | **TOTAL** | | **156.33** | **3.17** |
| DC22-2082 | ACMA | 20.56 | 47.61 | 27.05 | 2.53 |
| DC22-2082 | | 60.07 | 68.99 | 8.92 | 2.26 |

| | | | | |
|---|---|---|---|---|
| DC22-2082 | 88.83 | 94.25 | 5.42 | 2.23 |
| DC22-2082 | 130.34 | 136.86 | 6.52 | 3.71 |
| DC22-2082 | 400.20 | 407.52 | 7.32 | 2.67 |
| DC22-2082 | 423.91 | 427.27 | 3.36 | 7.32 |
| DC22-2082 | 555.07 | 564.83 | 9.76 | 7.75 |
| DC22-2082 | 568.85 | 583.94 | 15.09 | 3.35 |
| DC22-2082 | 632.16 | 641.42 | 9.26 | 2.85 |
| DC22-2082 | 660.08 | 668.73 | 8.65 | 2.19 |
| DC22-2082 | 684.64 | 701.30 | 16.66 | 4.29 |
| DC22-2082 | 718.02 | 724.88 | 6.86 | 5.77 |
| **DC22-2082** | **TOTAL** | | **124.87** | **3.62** |

Significant intervals represent drilled intervals and not necessarily true thickness of mineralization. Mineralized intervals meet or exceed 3 meters in length above 1 g/t. A maximum of 4 meters of continuous dilution (< 1 g/t) is permitted. Assays from DC22-2033, DC-22-2034, DC22-2036 through DC22-2050, DC22-2052 through DC22-2058, and DC22-2060 represent holes from the 20-meter spaced West ACMA grid drilling and DC22-2059, DC22-2061 through DC22-2066, DC22-2068 through DC22-2081, DC22-2083 through DC22-2088, DC22-2090, DC22-2092, and DC22-2093 represent holes from the Divide 20-meter spaced grid drilling. DC22-2063 interval is subparallel to the mineralized fault zone and mineralized dyke. DC22-2067 interval is subparallel to a mineralized fault zone. Any drill intervals not depicted in this table did not meet the significant interval criteria. Assay data are not yet available from 122.79 m to 234.85 m in DC22-2059, 150.82 m to 300.38 m in DC22-2063, and all of holes DC22-2064 through DC22-2066, DC22-2068 through DC22-2081, and DC22-2083 through DC22-2115.



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THE STATE of ALASKA
GOVERNOR MICHAEL J. DUNLEAVY

Department of Environmental Conservation
DIVISION OF WATER
Director's Office
410 Willoughby Avenue
Juneau, Alaska 99811-1800
Main: 907.465.5180

May 13, 2022

Thomas S. Waldo
Earthjustice
325 Fourth Street
Juneau, AK 99801

RE: Donlin Gold Mine Certificate of Reasonable Assurance Remand Decision (3AN-21-06502CI)

Dear Mr. Waldo:

Consistent with the December 29, 2021 Order Granting Interlocutory Remand, find enclosed the Division's decision to affirm its April 5, 2019 decision to issue a 401 Certificate of Reasonable Assurance (POA-1995-120). After an exhaustive review by Division staff and a third-party expert, the Division asserts it has met the threshold of reasonable assurance for this project.

The Division acknowledges all models contain a degree of uncertainty. The objective of this remand was not to create more elaborate models, but to critically evaluate if the existing models provided by Donlin provided additional support for reasonable assurance of meeting water quality standards for mercury and temperature. After reviewing all of the provided expert opinion, the Division has even greater confidence of reasonable assurance noting that the mine will operate under a suite of permits, monitoring, sampling, and reporting requirements, engineering controls and adaptive management.

A person authorized under a provision of 18 AAC 15 may request an informal review of a contested decision by the Division Director in accordance with 18 AAC 15.185 and/or an adjudicatory hearing in accordance with 18 AAC 15.195 – 18 AAC 15.340. See DEC's "Appeal a DEC Decision" web page https://dec.alaska.gov/commish/review-guidance/ for access to the required forms and guidance on the appeal process. Please provide a courtesy copy of the adjudicatory hearing request in an electronic format to the parties required to be served under 18 AAC 15.200.

Sincerely,

Randy Bates
Director

Enclosed: The Division's Response to ONC Comments w/attachments

cc:

Jenn Currie, Department of Law
Kate Demarest, Department of Law
Erik Fjelstad, Perkins Coie LLP

# THE DIVISION'S RESPONSE TO ONC COMMENTS

## BACKGROUND

Donlin Gold LLC (Donlin) proposed to develop an open-pit, hard-rock gold mine in Southwest Alaska within the Crooked Creek watershed near the confluence of Crooked Creek and the Kuskokwim River. In July 2012, Donlin applied to the U.S. Army Corps of Engineers (Corps) for a permit under section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. The Corps determined that an Environmental Impact Statement (EIS) was necessary to inform the permit decision and issued a Draft EIS on November 25, 2015 for public notice and comment. The Corps issued the Final EIS (FEIS) on April 27, 2018.

On June 8, 2018, Donlin requested the Alaska Department of Environmental Conservation Division of Water (Division) consider issuing a Certificate of Reasonable Assurance (Certificate) required for the proposed 404 permit under Section 401 of the Clean Water Act. The Division issued notice of Donlin's materials on June 13, 2018 establishing a public comment period from June 13, 2018 to July 13, 2018. The Division issued a Certificate, Antidegradation Analysis, and a Response to Comments on August 10, 2018.

On August 13, 2018, the Corps and Bureau of Land Management (BLM) issued a joint Record of Decision and Permit Evaluation (ROD) along with a combined Clean Water Act Section 404 and Rivers and Harbors Act Section 10 permit.

On August 30, 2018, Orutsararmiut Native Council (ONC) submitted a request for informal review of the Certificate consistent with Title 18 Alaska Administrative Code, Chapter 15 (18 AAC 15). ONC amended this request on September 28, 2018. The Division Director



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issued a decision on the amended request to remand the permit to the Division for review. The Division revised its Response to Comments and reissued the Certificate on April 5, 2019.

On April 24, 2019, ONC submitted a second request for informal review raising issues substantially like those identified in its first request. The Division Director issued a decision on the second request on May 8, 2019 remanding the Certificate to the Division to address issues raised by ONC. The Division revised its Response to Comments and affirmed the previously issued Certificate on May 7, 2020.

On June 5, 2020, ONC submitted a request consistent with 18 AAC 15 for an adjudicatory hearing on behalf of several Alaska Native tribes and other organizations. The Department Commissioner referred the adjudicatory hearing request to the Office of Administrative Hearings. On July 31, 2020, the Administrative Law Judge held that all but one party, ONC, had not commented during the public comment period and therefore ONC was the only party with standing to appeal.[1] He also recommended the Commissioner grant an adjudicatory hearing on three issues: mercury, water temperature and existing uses. A hearing on the briefs occurred. On May 27, 2021, the Commissioner found that reasonable assurance existed that the proposed mine project would not result in exceedance of the Alaska Water Quality Standards and denied the ONC request to rescind the Certificate.

On June 28, 2021, ONC submitted Notice of Appeal to the Superior Court for the State of Alaska, Third Judicial District for the Commissioner's May 27, 2021 decision to uphold the

[1] In ONC's comments on the two Donlin reports, ONC purports to add new parties to this appeal. The Division will be opposing this addition in the event ONC requests an adjudicatory hearing.



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Certificate. On September 27, 2021, Donlin requested a temporary stay in briefing before the Court to allow Donlin to provide all parties additional information on two water quality standards at issue in ONC's appeal: mercury and water temperature limits. The Department filed a nonopposition to Donlin's request for stay on September 30, 2021. The Department received Donlin's reports on October 22, 2021 and ONC received the information on October 25, 2021. On November 19, 2021, the Department moved for an interlocutory remand back to the Division to evaluate whether, and to what extent, Donlin's technical submittals on mercury and water temperature affect the underlying certificate. On December 29, 2021, Superior Court Judge Easter granted the interlocutory remand and established procedures to apply on remand.

## PROCESS FOR REVIEW OF DONLIN REPORTS

The Division reviewed the Donlin reports on mercury and water temperature and were also briefed on the findings by the consultants who prepared each report. Due to the technical complexity and specificity of the reports, the Division sought third-party expert review and analysis of the Donlin reports. In January 2022, the Division secured a contract with Exponent, a multi-disciplinary engineering and consulting firm, to analyze the Donlin reports and provide comment on the assertions made in each report. The analysis of the Donlin reports *Expert Report of Mark W. Johns In the Matter of: Orutsararmiut Native Council v. Alaska Department of Environmental Conservation and Donlin Gold LLC* (Exponent 2022) is attached as Exhibit 1 and includes a curriculum vitae.

The supplemental information Donlin provided was in the form of two reports. The first was *Donlin Gold project: analysis of Crooked Creek stream temperature (draft)*, BCG Engineering Inc. (BGC 2021), Exhibit 2. The second report was *Draft Report: Donlin Gold*



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*Mine supplemental mercury modeling and mass balance analysis*, Ramboll US Consulting, Inc. (Ramboll 2021), Exhibit 3. Exponent conducted their review based largely on analysis of the two submitted reports, cited references, and publicly available documents. Analysis for Ramboll 2021 reached a point where Exponent required additional information. Twice during the analysis, the Division facilitated a meeting between Exponent, Donlin and Ramboll to fulfill Exponent's request for information.

BGC 2021 used updated water budgets published after the FEIS and stream flow and temperature data collected for the FEIS to develop a quantitative model of stream temperature using SSTEMP, a stream temperature model from the USGS. The model used average groundwater data and maximum annual surface water temperatures (from 2005) as the basis for the model. Results from the model showed that the stream temperatures are not expected to exceed the relevant water quality temperature standards for either egg/fry incubation and spawning or migration routes.

Dr. Mark Johns of Exponent independently evaluated the updated temperature model in BGC 2021. Results from his analysis are presented in Exponent 2022. Dr. Johns concluded that the model chosen in BGC 2021 was appropriate for the environmental data, that the use of 2005 temperature data represented a conservative case because it was the warmest year for which data were available, and that the quantitative evaluation conducted in BGC 2021 was reasonable.

Ramboll 2021 used updated operational information published after the FEIS, additional chemical data, and more refined assumptions about the transport and sources of mercury in the environment to model the potential impact of the proposed Donlin mine on local stream mercury concentrations (Ramboll 2021). The model used for the transport of mercury from the mine

emissions was CALPUFF, which was the same model previously used in the FEIS. However, from the additional analysis, Ramboll concluded that the majority of mercury in local streams is related to the erosion of naturally occurring geological materials, rather than atmospherically deposited mercury, and the new analysis determined that only a fraction of the project-related mercury would be transported to streams. The study concluded that the mass of mercury entering the Crooked Creek watershed would decrease as a result of the project due to runoff control in the vicinity of the mine, particularly in the American Creek watershed, which would be nearly entirely within the mine boundaries.

Dr. Mark Johns of Exponent independently evaluated the updated mercury analysis in Ramboll 2021. Results from his analysis are presented in Exponent 2022. Dr. Johns concluded that the approach used by Ramboll relied on appropriate sources and was reasonable but noted that a small fraction (0.3%) of the American Creek watershed would be subject to increased deposition that could lead to localized exceedances of the mercury aquatic water quality standard if flow remained in that creek. This small area was not explicitly addressed in the Ramboll 2021 supplemental mercury report.

The Division reviewed the remaining 0.3% of American Creek drainage concern with the applicant. After briefing the Exponent findings, Donlin had additional questions regarding the drainage and the non-zero potential for concentration based exceedances of mercury WQS. The Division facilitated a meeting between Exponent, Donlin, and Ramboll staff on February 23, 2022 to allow the two consulting firms to discuss their modeling approach and results for the drainage in question. A follow-up meeting occurred on March 31, 2022. During these meetings, Dr. Johns explained the concern his analysis discovered with a small portion of the American Creek drainage that would remain and not become incorporated into the pit or waste facility.

The area of the American Creek drainage remaining outside the mine footprint is adjacent to Crooked Creek and would be subject to runoff. The existing monitoring site for American Creek would be eliminated when the mine facilities are constructed. The Division engaged Donlin to address these concerns. Donlin submitted a proposed revision to the project Monitoring Plan on April 22, 2022, which addressed mercury monitoring for the remaining portion of the American Creek drainage. The proposed plan included the addition of a monitoring station which will endure the mine construction and operation and continue to inform the permit of mercury in any remaining portion of American Creek for potential impact to Crooked Creek. The Division approved and placed into effect the new Monitoring Plan on May 6, 2022. The revised plan established a requirement for Donlin to implement adaptive management strategies consistent with the permit requirement at section 2.7 of the project Waste Management Permit 2019DB0001, which is issued and in effect.

**ONC COMMENTS ON RAMBOL 2021 AND BGC 2021**

On March 29, 2022 ONC provided comments regarding the Donlin supplemental reports BGC 2021 and Ramboll 2021.[2] Exhibit 4. ONC provided a cover letter of comments with attachments. These comments assert that there is no reasonable assurance of compliance with water quality standards and recommended rescinding the Certificate.

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[2] After ONC submitted its comments on March 29, Donlin submitted responsive comments. Exhibit 5. Weeks later, and five days before this decision was due, ONC submitted responses to Donlin's responses to ONC's comments. Those comments by ONC submitted on May 9, 2022 (Exhibit 6) are not generally detailed in this response to comments due to a lack of time. The Division did, however, review comments submitted by Miller and Myers and found essentially no new substantive ONC comments that would change its decision to issue this Certification. The Division does, however, respond to a few of Miller's comments and the Chambers report, since this was a completely new expert report. Subsequently Donlin submitted a response to ONC's May 9, 2022 comments (Exhibit 7). Calista also submitted comments. Exhibit 8.



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ONC provided third-party expert review of Rambol 2021 and BGC 2021. For Mercury, ONC provided comment on Ramboll 2021 by Glenn C. Miller, Ph.D. Those comments were included as Exhibit 5, a memorandum prepared by Glenn C. Miller, Ph.D. Dr. Miller's memorandum provided a technical review of Ramboll's analysis of the potential for exceedances of the mercury water quality standards in Crooked Creek and nearby streams because of the proposed Project (Miller 2022). Dr. Miller concluded that the mercury estimates were unreasonably low because Ramboll 2021's analysis did not consider mercury-cyanide chemistry and because the emissions were much lower than those from the Goldstrike Mine in Nevada.

ONC also provided comment on BGC 2021 by Tom Myers, Ph.D. Those comments were included as Exhibit 6, a memorandum prepared by Tom Myers, Ph.D. Dr. Myers' memorandum provided a technical review of BGC's analysis of potential changes in Crooked Creek stream temperatures that may occur because of the proposed Project (Myers 2021). Myers concluded that the BGC analysis did not provide evidence indicating that "…the development of the Donlin Mine would not cause stream temperatures that would exceed standards."

## DIVISION'S GENERAL RESPONSE TO ONC COMMENTS ABOUT REASONABLE ASSURANCE AND MODELING

ONC asserts that at the end of consideration of all of the scientific information in the case, the Division lacks reasonable assurance to issue the certification. The Division has adopted water quality standards, which establish numeric and narrative standards for the state's surface waters, as required by the federal Clean Water Act.[3]. EPA regulations implementing the Clean

[3] *See* 33 USC § 1313(a); 18 AAC 70.020

Water Act also direct the state to develop and adopt a statewide antidegradation policy and identify methods for implementing this policy.[4] Section 401 of the Clean Water Act requires a state to certify that an applicant for a federal license or permit to discharge pollution into navigable waters will comply with state and federal water quality standards and any other appropriate requirements of state law, which become a condition of the license and are binding on the federal license.[5]

The Division's regulations implement the certification requirement under Section 401 of the Clean Water Act for all federally licensed or permitted activities.[6] The process for certification is set out at 18 AAC 15.130–18 AAC 15.180. The federal regulations applicable to this certification require that the state's certification include a "statement that there is reasonable assurance that the activity will be conducted in a manner which will not violate applicable water quality standards," 40 CFR § 121.2(a)(3) (1971), and a "statement of any conditions which the certifying agency deems necessary or desirable with respect to the discharge of the activity."[7]

In issuing its certification pursuant to section 401, the Division is not required to provide absolute certainty that permittees will never violate water quality standards.[8] Instead, the Division must conclude that it has "reasonable assurance" that the permitted activity will

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[4] 40 CFR § 131.12.
[5] 33 U.S.C. § 1341(d),
[6] 18 AAC 15.130(a); 18 AAC 15.180(a).
[7] 40 CFR § 121.2(a)(4) (1971).
[8] *Miners Advocacy Council v. State, Dep't of Envtl. Conservation*, 778 P.2d 1126, 1138 (Alaska 1989); *see also Port of Seattle v. Pollution Control Hearings Bd.*, 90 P.3d 659, 676 (Wash. 2004).



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comply with water quality standards.[9] The certification must address future events and the likelihood that those events will result in violations of water quality standards.[10]

The Division can base reasonable assurance of compliance with water quality standards on conditions that are stated in the section 401 certificate, including conditions that are included in the certificate as a result of the Division's review of the certificate in an administrative appeal.[11] The Division can also base reasonable assurance of compliance with water quality standards on Donlin's compliance with current and future permits governing its activity.[12] The Division can rely upon monitoring requirements and adaptive management measures in assessing reasonable assurance of compliance. [13]

Finally, the certification finds that there is reasonable assurance that the project will comply with state water quality standards. ONC argues that "will comply" means that there must be no projected exceedances of water quality standards using models and when the mine is operation, no exceedances whatsoever. This argument is contrary to the rule. EPA addressed the issue of "will comply" in the Federal Register. It stated that

> The Agency disagrees with the suggestion that using ''will comply'' will place an impossible standard on certifying authorities. The Agency does not intend or believe that the statutory language requires States to ensure that a project will maintain strict compliance, in every respect, throughout its entire existence. The inclusion of the statutory language ''will comply'' does not require certifying authorities to provide absolute certainty that applicants for a federal license or

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[9] *Miners Advocacy*, 778 P.2d at 1138.
[10] *Port of Seattle,* 90 P.3d at 676.
[11] *See, e.g., Port of Seattle*, 90 P.3d at 676 (board reviewing certification decision may add conditions to the certificate to achieve reasonable assurance); *Center for Environmental Law & Policy v. Washington Dep't of Ecology, Washington Pollution Control Hearings Board*, 2014 WL 2986620 at pp. 10-11.D
[12] *Port of Seattle*, 90 P.3d at 677-78.
[13] *Id.*



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> permit will never violate water quality requirements. Indeed, future compliance depends on many factors besides just facility design and operation, and it would not be reasonable for an authority to certify that no unknown future event could ever result in a violation of the certification. The use of the language comparable to ''will comply'' is not uncommon in [Clean Water Act] regulatory programs. For example, CWA section 402 contemplates that an NPDES permits may issue only upon a showing that discharge ''will meet'' various enumerated provisions. 33 U.S.C. 1342(a). This standard has not precluded States, Tribes, or the EPA from routinely issuing NPDES permits for a variety of discharges; nor has it resulted in NPDES permits that are impossible for permittees to comply with. The Agency concludes that use of the statutory language ''will comply'' in the final rule remains loyal to the words that Congress chose when it enacted section 401. The Agency has no theoretical or empirical basis to conclude that the language in the final rule will materially change the way in which certifying authorities, including the EPA, process certification requests, so long as certifying authorities act in good faith and in accordance with CWA section 401.[14]

With respect to modeling, ONC spends much of its comments on the Ramboll 2021 and BGC 2021 reports deriding the use of modeling. Because the Donlin mine has not yet been constructed, as happens with a large number of projects across the United States, modeling is how we predict what will happen in future years.

Reasonable assurance is predictive in nature.[15] Models are used in the Clean Water Act and the Clean Air Act, to name only two, in making predictive determinations.[16] "Any model is an abstraction from and simplification of the real world. Nevertheless, administrative agencies have undoubted power to use predictive models."[17] "Modeling is an approach that uses observed

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[14] 85 FR 42210, 42277 (2020).

[15] *Sierra Club v. State Water Control Board*, 898 F.3d 383, 397 (4th Cir. 2018).

[16] *American Farm Bureau Federation v. U.S. E.P.A.*, 948 F.Supp.2d 289, 298 and 339 (D.C. Pa 2013)(Reasonable assurance on load allocations that WQS would be met utilizing models is appropriate); *Montana Sulphur and Chemical Co. v. U.S.E.P.A.*, 666 F.3d 1174 (9th Cir.2012)("The EPA therefore did not act arbitrarily or capriciously by relying on predictive modeling…" to make a CAA decision)

[17] *Sierra Club v. Costle*, 657 F.2d 298, 332 (D.C. Cir. 1981); *Maryland Dept. of Env. v. Anacostia Riverkeeper*, 134 A.3d 892 (CA MD 2016); *Small Refiner Lead Phase-Down Task Force v. U.S.E.P.A.*, 705 F.2d 506, 536 (D.C. Cir. 1983).



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and simulated data to replicate what is occurring in the environment to make future predictions."[18] Courts routinely review 401 certifications that utilize modeling in order to predict the effects of a project on the environment.[19]

In Deep River Citizens' Coalition v. North Carolina Department of Environment and Natural Resources,[20] the Petitioner argued the Environmental Management Commission ("EMC") and trial court erred by determining the Randleman Dam and Reservoir project "would not violate certain water quality standards[,] specifically "water quality standards for chlorophyll *a*."[21] Petitioners contended the models used to predict the effects of the project on chlorophyll *a* were "flawed and unreliable."[22] Some models predicted chlorophyll levels within the applicable standard, other computer models predicted levels in excess.[23] The court in Deep River stated that when

> the Director of the Division of Water Quality issued the 401 Certification, he was aware of the potential for water quality standard violations and "specifically considered the existing Randleman Lake Water Supply Watershed Nutrient Management Strategy and the opportunity that the State would have to impose additional restrictions on nutrient sources in the event of actual or threatened water quality standard violations after the reservoir is constructed." We agree with respondents that "no one will know precisely whether or to what extent exceedances ... of the Standard will occur until construction of the dam and impoundment of the lake have been completed" but that mere "knowledge of the potential for exceedances ... of the chlorophyll *a* standard was not sufficient to preclude DENR from issuing the 401 Certification." The trial court therefore had before it substantial and competent evidence that, in the event water quality standards were actually threatened, the State could impose additional restrictions to avoid chlorophyll *a* violations. We conclude the trial court did not err in

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[18] *Maryland Dep't of Env't* ,134 A.3d 892, 903 (CA MD 2016).
[19] *Port of Seattle v. Pollution Control Hearings Board*, 90 P3d 659 (S.C. Wa. 2004).
[20] 598 S.E.2d 565 (CA N.C. 2004).
[21] *Id.* at 567.
[22] *Id.* at 569.
[23] *See id.*



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> concluding that DENR provided reasonable assurance that the State's water quality standards would not be violated by the proposed project.[24]

Subsequently, in Sound Rivers, Inc. v. N.C. Dep't of Env't Quality, Div. of Water Res.,[25] the court followed the same logic and stated that

> "no one will know precisely whether or to what extent violations of various water quality standards, including standards not addressed in this opinion, may occur until after discharge of wastewater begins." The ALJ and superior court determined that the Permit reasonably ensures compliance with water quality standards, but the Permit requires specific monitoring and reports, and if a violation does occur, DEQ can modify or revoke the Permit to prevent further violations of water quality standards. The reopener provision in no way allows DEQ 'to issue a permit expected to violate water quality standards' as Petitioner contends.[26]

In this case, models are required, since the mine has not been constructed yet. They are also appropriate for the predictive nature of reasonable assurance. As Port of Seattle noted about the use of modeling, "…safeguards exist because the Port must monitor actual flows and implement contingency measures accordingly."[27] Although models are used to predict the effect that Donlin will have on the environment, there are safeguards. Donlin will continue to monitor, as it has in the past years. This will provide real time data to determine if the predictive monitoring is representative of future events. In addition, there is a plan to address those situations where the predictive monitoring is straying from the conclusions reached, adaptive management.

**POINT BY POINT RESPONSE TO ONC COMMENTS ON RAMBOLL 2021 AND BGC 2021.**

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[24] *Id.* at 569 (brackets omitted).
[25] 845 S.E.2d 802, 842 (CA N.C. 2020)
[26] *Id.*
[27] *Port of Seattle*, 90 P3d at 679.



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## EARTHJUSTICE COVER LETTER COMMENTS

**Comment 1**: Pg. 2, ¶1, I. Introduction and Summary: "Both draft studies rely on models to estimate the impacts of the proposed mine decades in the future."

**The Division's Response**: Models are the tool we use to evaluate conditions prior to construction of the proposed mine site. The reports by BGC 2021 and Ramboll 2021 rely on data collected and vetted in the FEIS,[28] and data collected since the FEIS was issued under the water monitoring plan, as well as data or literature values gathered for the modeling in the above reports.

**Comment 2**: Pg. 2, ¶2, I. Introduction and Summary: "Both of Donlin's models predict outcomes almost exactly at the applicable standard. Given the large range of potential deviation from those outcomes, the models provide no basis to believe that compliance is any more likely than non-compliance."

**The Division's Response**: BGC prepared a quantitative analysis of Crooked Creek Stream temperature to evaluate potential stream temperature changes to Crooked Creek attributable to the proposed Donlin Gold Project (Project). The quantitative analysis provided the magnitude and frequency of potential temperature changes on a daily basis, where the qualitative analysis in the FEIS did not. BGC used data that included water temperature (every 30 minutes) and streamflow discharge for 2005 to 2009 and 2011 during the open water season (typically early June to late September).

[28] USACE. 2018. Donlin Gold project, final environmental impact statement. U.S. Army Corps of Engineers. JBER, AK. 3,299 pp.

Ramboll's mercury analysis used emissions estimates from the air permit (based on pilot studies) and literature values. They used these emissions as an input to an air transport model, CALPUFF, to determine potential project-related deposition to the surrounding area. Literature values were used to estimate the amount of this mercury that would enter streams. This was combined with the geological mercury present in the streams (calculated from data collected from local minerals and background aerial mercury deposition estimates) to estimate potential stream mercury loadings under project conditions. The comparison of potential exceedances with and without the project was the output. This isn't "almost exactly at the applicable standard." The term "almost exactly" is meaningless for this reasonable assurance analysis.

**Comment 3**: Pg. 2, ¶3, I. Introduction and Summary: "Thus, the Department must not treat them as risk-averse screening models."

**The Division's Response**: "Risk-averse screening models" does not appear to be a specific term here, although in other fields (economics) it is apparently used to indicate low uncertainty models. The implication is that there should be an uncertainty or safety factor added to the results, however uncertainty factors should not be required in this part of the analysis. Regardless, each time a "conservative" choice was made in the modeling would be an acknowledgement and incorporation of uncertainty. Each model selected the worst-case data available, annotated this selection, and standard modeling approaches returned results which were below water quality standards. There is no established threshold of anticipated water quality standard compliance. Compliance is not expressed in terms of probability or likeliness. The Division must make a determination of reasonable assurance.



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**Comment 4**: Pg. 2, ¶4, I. Introduction and Summary: "Neither of the draft reports attempts to quantify or characterize the degree of uncertainty associated with the projections."

**The Division's Response**: See Response to Comments 2 and 3.

**Comment 5**: Pg. 2, ¶5: I. Introduction and Summary: "…would be apparent even if one assumes they were well-designed and supported by ample data."

**The Division's Response**: As stated above, the stream temperature modeling is supported by a large database collected during the FEIS. Further, ONC's statement implies that no model could ever be used to satisfy the permit requirements. The mercury model incorporated results from a pilot study, more than a decade of water chemistry data, and hundreds of mineral/soil samples. As discussed above, it used a comprehensive air model that has been used by the USEPA.

**Comment 6**: Pg. 3, ¶1: I. Introduction and Summary: "…the likelihood of complying with both is lower still."

**The Division's Response**: This appears to be an either-or question. That is not how the regulatory environment works and implies that the Division is just hoping for the best. The assertion of reasonable assurance of water quality standards is not expressed as a probability or likelihood. Modeling data indicated compliance with water quality standards even using worst-case data to run the models.

**Comment 7**: Pg. 5, ¶4, Pg. 7, ¶2: Characterizing the temperature and mercury analyses as "so close to the standards…."

**The Division's Response**: This characterization is not appropriate. As a thought exercise, using Ramboll's approach, if you assume that they were off by 100% in their mercury deposition model, you would still end up with the same rate of exceedance of standards (i.e., only an increase in exceedances in American Creek, which will be removed). And BGC 2021 used the 2005 yearly results that were shown to be the highest measured and in the range of the climate change predictions as developed in the FEIS.

**Comment 8**: Pg. 6, ¶1 - 4: "The mine would be developed in a "mercury belt" with high concentrations of mercury occurring naturally in the environment" and "eliminating the principal conservative assumptions of the FEIS", etc.

**The Division's Response**: These comments try to both argue that you need to consider the background mercury and criticize Ramboll 2021 for taking into account the background mercury. This is internally inconsistent.

**Comment 9**: Pg. 6, ¶3: "Using conservative assumptions, the FEIS predicted a 40% increase in mercury concentrations."

**The Division's Response**: We are not reviewing the FEIS here. The Ramboll 2021 analysis was based on the Air Sciences 2021 report (Exhibit 9) and other newer analyses (i.e., SRK 2017 (Exhibit 10)) which do not seem to have been reviewed by the ONC's expert.

**Comment 10**: Pg. 11, ¶2: "It is potentially misleading for Ramboll to state that it was "conservative" to use the years of peak projected mercury emissions from the tailings disposal site and fugitive dust."

**The Division's Response**: See Response to Comment 34.



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**Comment 11**: Pg. 11, ¶2: "Both of Donlin's draft models make the elementary mistake of presenting each outcome as a single, highly precise number"

**The Division's Response**: See Response to Comment 34.

**Comment 12**: Pg. 15, ¶2: List of sources that the Ramboll report relies on.

**The Division's Response**: Many of these sources are not ones that have quantifiable error and error bars would be inappropriate.

**Comment 13**: Ramboll does not provide information on whether they did a sensitivity analysis.

**The Division's Response**: This does not mean that the Ramboll 2021 model results cannot be used. The lack of a sensitivity analysis does not negate the validity of the model to the extent of the predictive capability inherent in the utilized model. Nor does the lack of a sensitivity analysis contribute substantially to meeting the requirement of reasonable assurance.

**Comment 14**: Pg. 16-18, Section E: Discussion of Dr. Miller's comments on the mercury report. It suggests that mercury emissions are being underestimated in Ramboll 2021 modeling according to Miller.

**The Division's Response**: This is a summary of Dr. Miller's opinions on the mercury emissions estimates. Dr. Miller's analysis is unreliable, because he didn't review the relevant documents (Air Sciences 2021 and SRK 2017) which are the sources for the stack emissions and the cyanide information, respectively.

Dr. Miller relied heavily upon emission data from a mining facility in Nevada with which Dr. Miller appeared to have significant personal experience. There appears to be little analysis



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and comment on the relevant documents which succinctly address emissions and cyanide. Dr. Miller appears to have missed the mark substantially by only commenting in this report on the modeling results based on the data presented in the FEIS. Further, the Division adopts Donlin's response to this comment.

**Donlin's Response**: The estimated mercury emissions from the Donlin Gold tailings storage facility were not underestimated. The emissions are lower than the Twin Creeks emissions due to several relevant factors, including the ore mercury content at Donlin Gold that is more than an order of magnitude less than the Twin Creeks ore.

- Cyanide chemistry was considered in the mercury emission estimate for the tailings storage facility.
- The estimated mercury emissions for the Donlin Gold thermal units were not underestimated.
- An implausibly high mercury capture efficiency percentage was not assumed in the mercury emission estimates for the thermal units. In fact, the mercury emissions as a percentage of the total mercury in the feed ore at Donlin Gold are more conservative (i.e., lower) than the percentages for Twin Creeks and Goldstrike.
- The Donlin Gold thermal units do not process 30% more autoclave ore than Goldstrike; they process slightly less.
- The mercury emission estimates for the Donlin Gold thermal units did not rely solely on emission factors from the companies making the control equipment.



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The estimates were based on engineering process modeling, Nevada mercury control guidance, actual emissions data from equivalent units, and consideration of the site-specific conditions at the Donlin Gold facility.

- Donlin Gold is not predicted to be the second largest producer of byproduct mercury.

**Comment 15**: P. 17 "[T]he draft model significantly underestimates mercury emissions from the tailings pond, because it apparently fails to consider the cyanide in the tailings fluid." "If, as appears to be the case, the Ramboll report failed to take the cyanide into account, the estimates of mercury concentrations in the tailings pond may be off by orders of magnitude.'"

**The Division's Response:** See Response to Comment 26. Further, the Division adopts Donlin's response.

**Donlin's Response**: Regarding the Donlin Gold tailings liquid mercury content, as explained in Ramboll's responses to the Letter, there was no failure to consider cyanide chemistry. The differences between the estimated mercury emissions for the Twins Creeks and Donlin Gold tailings storage facilities are explained by other relevant considerations, such as: 1) the differences in mercury concentrations, and 2) the differences in environmental factors.

**Comment 16**: P. 17 "He [Dr. Miller] also compares the proposed Donlin project to the Twin Creek[s] tailings facility, which has measured mercury emissions of 63 kg/year, far greater than the 7.5 kg/year Ramboll predicts for Donlin. Miller concludes, 'Ultimately, the combination of a much higher mercury content in tailings from the Donlin Mine and the larger tailings surface area suggest that the mercury volatilization from the tailings is dramatically underestimated.'"

**The Division's Response**: The comparison of the Twin Creeks facility and Donlin appears to be inconsistent with the ore characteristics and climate of the Donlin mine and did not appear to be a suitable comparison. Further the Division adopts Donlin's response.

**Donlin's Response**: The Donlin Gold tailings mercury content is significantly lower than Twin Creeks tailings mercury content. Because mercury emissions are "positively correlated with material Hg concentrations" (Eckley et al 2011, p. 514), Donlin Gold is expected to have a lower mercury emission flux rate than Twin Creeks. Similarly, mercury flux is positively correlated with solar radiation (Eckley et al 2011, p. 518). The lower solar radiation in Alaska compared to Nevada will result in lower mercury flux at Donlin Gold. In addition, Alaska has lower temperatures and more snow and ice cover than Nevada. All these factors contribute to lower mercury flux and emissions at Donlin Gold. Even though the overall tailings surface area at Donlin Gold is larger, the reduced mercury flux at Donlin Gold results in lower mercury emissions than Twin Creeks.

As stated in the Donlin Gold mercury modeling report, "vapor mercury emissions (in the form of gaseous elemental mercury) from the proposed Donlin Gold Tailings Storage Facility (TSF) were estimated using methods similar to the studies for two active gold mines in Nevada … but using Donlin Gold-specific data and accounting for differences in solar radiation and geochemistry/mercury content between Donlin Gold and the Nevada mines." (Ramboll 2021, p. 3-12). Utilizing this methodology with site-specific data provides the best available estimation of mercury emissions from the Donlin Gold tailings storage facility.



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**Comment 17**: P. 17 "[T]he draft model also significantly underestimates mercury emissions from thermal sources at the mine by assuming an implausibly high 99.8% efficiency in capturing mercury"

**The Division's Response**: See Response to Comments 22-33. Further the Division adopts Donlin's response.

**Donlin's Response**: The capture efficiency cited in the Letter and Exhibit 5 of "greater than 99.8% efficiency" (Waldo, Thomas S. 2022, p. 17) (Miller, Glenn C. 2022, p. 6) appears to be derived from the mercury emissions of 15.9 kg (Miller, Glenn C. 2022, p. 6) divided by the total amount of mercury in the ore of 15.7 metric tons (Miller, Glenn C. 2022, p. 6).[29] Although, this is a useful metric for comparison to other mines, it is not representative of the capture efficiency or removal efficiency of the mercury control systems. For gold ore processing facilities that do not use roasters, the majority of mercury in the ore remains with the ore and is released to the tailings storage facility. Nonetheless, using Dr. Miller's metric of *overall mercury control efficiency* shows that the Donlin Gold *overall mercury control efficiency* is conservatively low, and the mercury air emissions are conservatively high.

**Comment 18**: P. 17 "While Goldstrike emits 60 pounds (27 kg) of mercury per year from the autoclaved ore based on actual measurements, the Ramboll draft mercury model predicts only 35 pounds (16 kg) from Donlin. Miller concludes that 'the Donlin Mine is likely to emit at least 60 lbs of mercury, and perhaps more, since 30% more ore is being subjected to the autoclave based process.'"

[29] 1 – (15.9 kg of air emissions) / (15.7 metric tons of mercury in the ore processed) = 99.8987%

**The Division's Response**: The Division found Dr. Miller's assertions inconsistent with the proposed equipment, projected emissions, and mass of ore processed and could not substantiate his assertion of 60 lbs of mercury emissions. Further the Division adopts Donlin's response.

**Donlin's Response**: The following points are important to consider:

- The Goldstrike thermal units (excluding the two roasters and three uncontrolled autoclaves, which do not have corresponding equipment at the Donlin Gold project) emit only 15.5 pounds (7 kg) (Miller, Glenn C. 2022, p. 51-52), not 60 pounds (27 kg) as asserted by Dr. Miller.
- The Donlin Gold autoclaves process slightly less ore (3.7 million tons) than the equivalent Goldstrike autoclaves (3.8 million tons) (Miller, Glenn C. 2022, p. 51), not 30% more.

**Comment 19**: P. 17 "Miller attributes the underestimate in part to the fact that the Ramboll draft model relies on emission factor estimates from the companies making the control equipment rather than on actual emissions from operating mines like Goldstrike."

**The Division's Response**: The Division did not find this assertion to be factual. Ramboll 2021 appeared to use several sources, including guidance from Nevada and emissions from Goldstrike Mine itself for model inputs. It appears Dr. Miller did not fully explore the cited references in the submitted information. Further the Division adopts Donlin's response.

**Donlin's Response**: The assertion that the Ramboll model relies on emission factor estimates from the companies making the control equipment, rather than on actual emissions from

operating mines like Goldstrike, is not correct. The Donlin Gold mercury emission estimates for the thermal units are based on the following information:

- The Hatch Ltd. engineering consulting company process modeling.
- The Nevada Mercury Control Program Permitting Guidance, General Industry NvMACT Determinations, which includes documented mercury emission rates for mercury control technologies (NDEP 2016).
- Three years of stack test data (actual emissions data) from the Goldstrike Autoclaves 4-6, Kiln, EW Cells, Retorts 1-4, and Furnaces East and West.
- The lower mercury content in the Donlin Gold ore of 1.27 ppm versus the Goldstrike ore of 24.6 ppm.

**Comment 20**: Pg. 18: Section F: Probability analysis for each of the models being appropriate.

**The Division's Response:** The Division could not determine any relevance of a probability analysis when the standard is reasonable assurance.

**Comment 21**: Pg. 19, ¶3: "these outcomes are so close to the standard"

**The Division's Response**: The Division could not locate a regulatory requirement for the threshold of predictive modeling results to meet the standard of reasonable assurance. Reasonable assurance is met if the project's projected discharge will comply with water quality standards, not whether it will come "close." The Division also asserts that the monitoring, sampling and reporting requirements contained in the permitting suite for the project properly informs the Division, permittee and the public of trends.

**The Division's Response to Comments: Miller Report, Exhibit 5**

**The Division's General Comments:**

As an expert for ONC, Dr. Miller reviewed the 2021 supplemental mercury analysis and provided comments on the analysis. On a general level, Miller asserted that Ramboll 2021 was intentionally biased and provided overly low estimates of mercury emissions ("an example of goal-modelling a contaminant release that is designed to meet some regulatory standard", "focused on predicting minimum mercury releases", the goal of the study was to show an unrealistically low mercury volatilization", pg. 1), but did not provide specific examples to illustrate this. He also implied that models are inherently unreliable and uncertain and should not be used to predict whether a project would result in environmental chemical concentrations likely to exceed environmental thresholds. Many of Miller's comments seem to be related to the reliance on numbers from the FEIS that he disagrees with. Those numbers were not actually used by Ramboll 2021, who relied on updated information for the new analysis (see below).

**Comment 22**: P. 1. Dr. Miller suggests that the Ramboll estimates of emissions are unreliable and should have been discussed more explicitly ("While the information presented in the Donlin supplemental report does not provide adequate information to understand where those data originated. . . ",).

**The Division's Response**: The Ramboll 2021 report does not include all of the relied upon information within the text of the document but provides citations to those data (see additional discussion below). Dr. Miller apparently did not read any of the cited references in the Ramboll

report which provide detail. In particular, these include the Air Sciences 2021 report and SRK 2017.

**Comment 23**: P. 8 The Ramboll Report does not use conservative values in its modeling, does not incorporate uncertainty, and ignores real-world conditions that would increase the risk of violations of the water quality standards. ("In reality, the amount if mercury that will be discharged to the atmosphere from the Donlin Mine is truly fraught with uncertainties.").

**The Division's Response**: The Ramboll 2021 relied on multiple empirical data sources, some of which were generated subsequent to the publication of the FEIS. These included mercury water concentrations, stream flow information, particulate mercury measurements, and pilot scale study tailings filtrate concentrations. In situations where there was a lack of data for modeling, the Ramboll Study used conservative assumptions to account for the inability to quantify uncertainty of values. Further the Division adopts Donlin's response.

**Donlin's Response**: The Ramboll Study adds to the data that was contained in the FEIS by incorporating new data and new studies not available when the FEIS was published, peer reviewed literature and other publicly available reports to more precisely mirror site conditions in order to more accurately estimate the potential mercury concentrations in the Crooked Creek watershed as a result of the Project.

There are a number of ways to account for uncertainty when modeling. In environmental risk assessment, conservative estimates can be used as a method of accounting for uncertainty because they present a high-end, rather than central tendency, estimate of outcomes. The



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Ramboll Study makes conservative assumptions to determine the effects on mercury in the streams.

Examples of conservative assumptions applied in the Ramboll Study:

- The modeled emissions from the Donlin Gold mine pit in the Study are conservatively high because they do not account for the in-pit retention of dust particles which would lower the estimated mercury deposition of fugitive dust emissions from the Project.
- The modeled tailings pond mercury concentration is conservatively high (likely as much as seven times too high) because it does not account for Donlin Gold's plan to use mercury settling-enhanced reagents.
- The Project mercury mass balance omits some activities that would reduce mercury mass loading to streams, such as the retention of stream water at the Snow Gulch reservoir and the effect of groundwater extraction for pit dewatering outside areas with runoff management.
- The mercury concentration in the Wastewater Treatment Plant (WTP) effluent is set equal to the State of Alaska Water Quality Standard (WQS) of 12 ng/l to derive a conservatively high estimate of mercury mass loading at the WTP outfall on Crooked Creek. The mercury concentration is unlikely to be this high because the majority (~72%) of the water fed to the WTP will be groundwater which includes low levels of mercury. As described in the WRMP (SRK 2017), the WTP is designed to treat 95$^{th}$ percentile mercury concentrations in pit dewatering, Seepage



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Recovery Pond (SRS) and Contact Water Dam (CWD) source waters, and steady state concentrations from tailings storage facility reclaim (a minor source). Given the predicted flow rates from these sources during Project operation, and a 96% removal efficiency by reverse osmosis, the actual mercury concentration in WTP effluent is likely to be far lower than the WQS.

- Estimation of mercury loading from the WTP outfall to Crooked Creek makes use of projected flow rates presented in the WRMP (SRK 2017) under the most conservative water balance analysis scenario, i.e., above average precipitation case. In addition, although the WTP is only planned to operate seasonally (WRMP Section D-2), the Project mass balance estimates mercury mass loading from the WTP with the assumption that it would operate year-round. As shown in Table ES-3 in Ramboll (2021), even with these conservative assumptions, the predicted mercury mass loading from the WTP outfall is low relative to loading from background atmospheric and geogenic sources to areas downstream of the outfall.

- The geochemical fingerprinting analysis in the Study using site-specific data including new sampling data collected after the FEIS determined that the current background contribution of atmospheric mercury to soils, sediments, and suspended particulates was too small to be distinguished from the contribution of the background geologic sources. This supports the conclusion that Project atmospheric deposition impacts on water quality would be negligible. The baseline mercury mass balance (Table ES-2 in Ramboll (2021)) estimated a background atmospheric loading of 11% to 29% (depending on watershed) using a

combination of Crooked Creek watershed data and the peer reviewed literature. Although these estimated loadings were much higher than the (negligible) contribution identified from the geochemical fingerprinting analysis using site-specific data, the estimated loadings of 11% to 29% were included in the Study to be conservative.

When these conservative assumptions are incorporated in the modeling and analysis, the outcome is a conservative estimate that likely represents the upper bounds of potential effects from the Project. Therefore, the results presented are high-end characterizations (i.e., over-estimates) of effects. Adding uncertainty values around these results would overstate the upper limit of the potential effects; hence, the calculation of uncertainty measures such as confidence intervals would not be appropriate and is not necessary.

**Comment 24**: The model used in the Ramboll Study seeks "to eliminate the principal conservative assumptions of the FEIS" and focuses "on predicting minimum mercury releases and water concentrations."

**The Division's Response**: There are multiple refinements in the Ramboll 2021 report that explicitly build on additional information collected since the FEIS. This includes the incorporation of additional process information (e.g. Air Sciences 2021), additional environmental data (e.g., geogenic mercury) and more realistic assumptions about the behavior of atmospherically deposited mercury. The overly simplistic assumption that one hundred percent of atmospherically deposited mercury reaches the stream is scientifically unsupported, and was identified as an area for further work in the initial mercury modeling effort. This

refinement does not represent the removal of a conservative assumption. Further the Division adopts Donlin's response.

**Donlin's Response**: The FEIS assumed that the correlation between atmospheric mercury deposition and mercury concentration in surface water is linear in the vicinity of the Project but caveated this assumption by noting that "only a small fraction [of the mercury deposited from atmospheric sources] would be present as aqueous mercury in surface water." Additional study, data gathering, and analysis show that the FEIS assumption was very conservative and, in fact, that only a very small fraction of the atmospherically deposited mercury reaches surface waters. At the time of the FEIS, there was no empirical data at the time to quantify how much atmospheric mercury ultimately migrates to the surface water versus the input of geologic mercury. A new literature review indicated that there was significant retention and provided specific retention rates for this type of watershed. Additionally, an analysis from Arcadis (2020) showed that mercury in Crooked Creek is primarily associated with the suspended solid load and suspended iron in particular, suggesting geologic origin. Based on this information, new data were collected in 2021 to determine the geologic versus atmospheric contributions of mercury in Crooked Creek. These new results showed that mercury in Crooked Creek carried a strong geologic, rather than atmospheric, signature (Ramboll 2021, section 3.1.3), demonstrating that atmospheric mercury was strongly retained in the soils. This evidence informed the assessment of the contribution of geologic mercury to Crooked Creek and validated the high mercury retention value estimated from the literature review. This provided a compelling scientific basis for updating the FEIS assumption. Ignoring this new evidence to maintain a prior assumption, now properly understood to be overly conservative, would be poor scientific practice.



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**Comment 25**: Comparison to Nevada Mines Pg. 1, ¶3: Miller uses the Goldstrike Mine in Nevada as the appropriate comparison for the Donlin project, without giving relevant comparisons.

**The Division's Response**: Dr. Miller may have professional knowledge of the Goldstrike Mine in Nevada, but he does not draw a clear correlation between it and the proposed Donlin mine. The atmospheric differences between Nevada and Alaska are vast, and Alaska has numerous mining operations available for comparison. There are likely differences between emissions technologies in the nearly 50 years between the construction of the two mines.

**Comment 26**: ONC states that the Ramboll Study's "draft model significantly underestimates mercury emissions from the tailings pond, because it apparently fails to consider the cyanide in the tailings fluid."

**The Division's Response**: This is incorrect. Miller's conclusion is that the mercury concentration is unreasonably low because Ramboll 2021 did not use a number that considered cyanide, and he gives a very detailed discussion of cyanide chemistry. However, in SRK 2017 (cited in Ramboll 2021), there is a discussion of the recent pilot plant study that included optimization of the cyanide process to minimize mercury emissions. The numbers from this report were used to generate the leachate concentration that Ramboll 2021 used (which thus included cyanide). Miller apparently did not read this reference. As a result, the whole discussion on cyanide and the tailings pond is therefore irrelevant. Further the Division adopts Donlin's response.



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**Donlin's Response**: More specifically, cyanide is accounted for in estimating mercury concentration in the tailings leachate. Tailings filtrates were generated in pilot-scale studies of the actual Project process plant operations that included treatment with cyanide, and a mercury concentration of 0.0242 mg/L was measured (Donlin Creek, 2011). This measured concentration was further increased by a factor of 3 to account for recycling of the pond water, to obtain a final tailings pond concentration of 0.073 mg/L (SRK 2017). Therefore, mercury availability due to the presence of cyanide was accounted for in the Project tailings mercury emissions calculations.

The Donlin Gold tailings pond mercury emissions were reasonably estimated using best available data and robust methods as discussed in the Ramboll Study. Also important, increasing these emissions would not have a material impact on estimated Project water quality impacts because (i) they constitute a relatively small fraction of total Project emissions (5%, see Table 3.2-12 in Ramboll (2021)), (ii) they consist of gaseous elemental mercury which has negligible solubility in water, and (iii) the atmospheric loading contribution to creek mercury loading is very small compared to geogenic loading in this region as discussed in the Study.

The Study does not ignore the contribution to mercury "loss" (emissions) from dry tailings. It includes an assessment of mercury emissions from dry surfaces of tailings. In general, tailings mercury emissions are highly dependent on soil moisture (Eckley et al. 2011). So, the Study applies different correlations for wet and dry surfaces at the Project tailings storage facility recognizing that the moisture level affects the mercury emission flux.

The ONC comments attempt to compare measured mercury emissions from a tailings facility at a Nevada gold mine to the estimated tailings emissions for Donlin Gold. However, there are



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several differences between the Donlin Gold and Twin Creeks/Goldstrike mine sites which would cause lower tailings emissions at the Donlin Gold mine:

- Goldstrike is 130 metric tons per year, while Donlin is estimated at 15.7 metric tons per year. This is an order of magnitude difference, and the implied similarities in the first (tailings) section seem inappropriate. (Mark)
- The average mercury concentration in ore is significantly lower at Donlin Gold (1.27 parts per million (ppm)) than Twin Creeks (24 ppm[30]) and Goldstrike (24.6 ppm[1]).
- As noted by Eckley et al. (2011), lower solar radiation results in lower mercury emission fluxes. Solar radiation is typically lower at Donlin Gold than at Twin Creeks and Goldstrike. The effect of sunlight on emissions is accounted for in the Ramboll modeling using observations of solar radiation at the Donlin Gold site.
- The presence of ice cover during winter months (roughly half the year) at Donlin Gold reduces tailings emissions considerably.
- The tailings solution mercury concentration at Donlin Gold (0.073 mg/L) is approximately 15% that of Twin Creeks (0.496 mg/L; Eckley et al. 2010).

[30] The mercury concentrations for Twin Creeks and Goldstrike were obtained from the stack test reports used for 2020 annual emissions reporting, available from the Nevada Division of Environmental Protection.

**Comment 27**: P. 5 "The mercury present in the ore is quite high, and the byproduct mercury projected to be recovered is 34,600 lbs (15.7 metric tons)[31] and would make the Donlin Gold mine (if located in Nevada) the second largest producer of byproduct mercury in the state (and perhaps in the nation)".

**The Division's Response**: A large portion of Miller's discussion focuses on the Nevada Goldstrike mine, which has higher mercury emissions than are predicted for the Donlin project. In general, Dr. Miller uses this as evidence that the Donlin estimates are too low, but does not address the differences such as climate, mineralogy, or technology that may make the comparison inappropriate. More specifically, the operations at the Goldstrike and Donlin mines are not directly comparable due to process differences as described in SRK 2017. Miller does not appear to consider this document. Further the Division adopts Donlin's response.

**Donlin's Response**: The amount of mercury recovered cited above assumes that 100 percent of mercury in the ore will be recovered by Donlin Gold's mercury control systems. The actual fraction of mercury recovered depends on the gold ore processing method. Roasting facilities will recover the largest fraction because of the high ore roasting temperature. Autoclaving facilities will recover a much smaller fraction. For the Donlin Gold autoclaves, the mercury recovery will be further reduced because only a portion of the total ore mined (roughly 15%) is autoclaved and further processed for gold recovery.

[31] Correctly calculated, these numbers are: 1.62 mg/kg * 21,535,000 metric tons * 1,000 kg/metric ton = 34,900 kg (34.9 metric tons) (Miller, Glenn C. 2022, p. 6).

Twin Creeks recovered 2.7 to 16.5 tons (2.4 to 15.0 metric tons)[32] of mercury byproduct from processing roughly 4 million tons of autoclave ore (Miller, Glenn C. 2022, p. 22). At an ore mercury concentration of approximately 24 to 33 ppm, the total amount of mercury in the ore processed is 99 tons (90 metric tons) to 136 tons (123 metric tons). The mercury recovery in this example is 2% to 17% percent, well below 100%. Donlin Gold would be expected to recover less total mercury than Twin Creeks because of the lower ore mercury concentration.

In summary, the Project is not predicted to be the second largest producer of byproduct mercury because the Donlin Project does not utilize roasters to process its ore and the Donlin Gold ore contains low levels of mercury.

**Comment 28:** - Miller asserts that the "Ramboll draft model relies on emission factor estimates from the companies making the control equipment rather than on actual emissions from operating mines like Goldstrike."

**The Division's Response**: It appears that Miller did not review the correct documents to evaluate the thermal emissions. For example, on pg. 5, he points to a table from the FEIS and comments that the table does not match the mercury control efficiencies used in the Ramboll study. However, Ramboll 2021 did not use the FEIS numbers. Table 2-2-1 in the Ramboll study compares initial mercury analysis (left column) vs. Ramboll 2021 analysis (right column) and clearly shows the changes in data sources. This comment is therefore not relevant. Further the Division adopts Donlin's response.

[32] 15-year high and low

**Donlin's Response** – This is incorrect. In fact, the mercury emissions estimates for the autoclaves and carbon regeneration kiln at Donlin Gold used source test data from similar units at the Goldstrike Mine (while accounting for Project-specific stack flow data) and emissions estimates for the other units at Donlin Gold are based on the Nevada Mercury Control Program Permitting Guidance, General Industry NvMACT Determinations, which includes documented mercury emission rates for mercury control technologies (NDEP 2016) (NDEP 2016). Moreover, the modeled Project mercury speciation profiles are based on mercury speciation test data from the Goldstrike Mine. Additional details on the Project thermal emissions and reasons for differences in total emissions from the Nevada mines are provided in Air Sciences (2021, 2022).

**Comment 29**: Pg. 5, Table from FEIS: Miller comments that this table does not match the mercury control efficiency used in the Ramboll Study.

**The Division's Response**: See Response to Comments 17 and 22-33.

**Comment**: Pg. 6, ¶2: Miller compares the Goldstrike mine using FEIS data for comparison.

**The Division's Response**: These are not the updated numbers used in Ramboll 2021 therefore this discussion is not relevant.

**Comment 30**: Pg. 7, ¶1: Miller compares the autoclave process between Goldstrike and Donlin.

**The Division's Response**: The pilot studies discussed in SRK 2017 indicate a process optimization through pilot studies that suggest that the Goldstrike and Donlin mines are not directly comparable. It does not appear that Miller read this document.

**Comment 31**: Pg. 8, ¶1: "In reality, the amount of mercury that will be discharged to the atmosphere from the Donlin Mine is truly fraught with uncertainties."

**The Division's Response**: This appears to be Miller's main statement, and he summarizes his conclusions below it. Most of his comments are based on outdated information from the FEIS that was not used by Ramboll 2021 However, to address concerns about uncertainty, the Division recalculated potential WQS exceedances based on the assumption that Ramboll's modeled mercury deposition was too low by 100%. The number of predicted potential exceedances was unchanged.

**Comment 32**: Pg. 8, ¶8: "While this review did not focus on the processes that will deliver mercury to surface waters from soils, it is generally the case that higher concentrations of mercury in the surface soils will result in higher amounts of mercury delivered to the streams in an approximately linear fashion…Thus, twice as much mercury released from the mine will result in approximately twice as much mercury released to streams."

**The Division's Response**: This statement is technically true, but misleading. A doubling of the mercury emissions would double the amount of mine-related mercury reaching streams (based on the assumptions in Ramboll 2021) but this does not equate to a doubling of the in-stream concentrations, an important factor, because this ignores the geogenic background mercury, which would not be affected by mine-related deposition and is inconsistent with the relatively low fraction of atmospherically derived mercury in the streams as described by Ramboll 2021. Further the Division adopts Donlin's response.



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**Donlin's Response:** This is erroneous. In this response, we assume that "released from the mine" refers to mercury emissions to the atmosphere from mine-related activities. The concentration of mercury in water in the stream does depend on the overall amount of mercury in the soils surrounding the streams. However, the overall amount of mercury in those soils is not proportionally affected by changes in the atmospheric deposition resulting from any mine-related mercury emissions. The large amount of existing geologic mercury (as also noted in the ONC letter, page 6, "high concentrations of mercury occurring naturally in the environment") in the Crooked Creek area means that changes in the atmospheric deposition rate only slightly affect the total mercury in the surface soils. Moreover, there is significant retention in the soil (as also noted in the ONC letter Exhibit 5, page 8, "a good portion of the mercury is sorbed onto the surrounding soils"). Therefore, changes in the atmospheric deposition rate only minimally affect mercury concentrations in the streams. The net effect on stream water quality is negligible (and in some cases beneficial) as shown in the Study when considering Donlin Gold's runoff control measures (which reduce both geogenic and anthropogenic mercury loadings) under Project conditions.

**Comment 33**: Miller concludes with the assertion that because "it is generally the case that higher concentrations of mercury in the surface soils will result in higher amounts of mercury delivered to the streams," that "twice as much mercury released from the mine will result in approximately twice as much mercury released to streams."

**The Division's Response:** See Response to Comment 32. Further the Division adopts Donlin's response.

**Donlin's Response**: This is erroneous. In this response, we assume that "released from the mine" refers to mercury emissions to the atmosphere from mine-related activities. The concentration of mercury in water in the stream does depend on the overall amount of mercury in the soils surrounding the streams. However, the overall amount of mercury in those soils is not proportionally affected by changes in the atmospheric deposition resulting from any mine-related mercury emissions. The large amount of existing geologic mercury (as also noted in the ONC letter, page 6, "high concentrations of mercury occurring naturally in the environment") in the Crooked Creek area means that changes in the atmospheric deposition rate only slightly affect the total mercury in the surface soils. Moreover, there is significant retention in the soil (as also noted in the ONC letter Exhibit 5, page 8, "a good portion of the mercury is sorbed onto the surrounding soils"). Therefore, changes in the atmospheric deposition rate only minimally affect mercury concentrations in the streams. The net effect on stream water quality is negligible (and in some cases beneficial) as shown in the Study when considering Donlin Gold's runoff control measures (which reduce both geogenic and anthropogenic mercury loadings) under Project conditions.

**The Division's Response to Comments: Myers' Report, Exhibit 6**

**The Division's General Comments**

On page 1 of his report, Myers states that "[t]he Donlin Gold Project Final Environmental Impact Statement (FEIS) contained only qualitative discussion of stream temperatures" and that "BGC's analysis provided evidence that allowed BGC to conclude that stream temperatures would remain just below the permit requirement."

The FEIS contained the stream temperature data necessary to evaluate proposed project impacts on the stream." BGC 2021 prepared a quantitative analysis of Crooked Creek Stream temperature to evaluate potential stream temperature changes to Crooked Creek attributable to the proposed Project. The quantitative analysis provided the magnitude and frequency of potential temperature changes on a daily basis, where the qualitative analysis in the FEIS did not. BGC 2021 used data that include water temperature (every 30 minutes) and streamflow discharge for 2005 to 2009 and 2011 during the open water season (typically early June to late September). The data used in the FEIS analysis were presented in Appendix A of the 2021 report by BGC.

**Comment 34**: P. 2 "BGC (p 5) claims that the 2005 air temperature at Camp Station was 58.3°F which is almost 7 degrees warmer than the 51.4° average temperature for May through September at that station."'

**The Division's Response**: Table 3.26-7 of the FEIS shows the projected air temperature increases in Alaska under two climate scenarios. The anticipated air temperature increase for scenario B1 is 0 to 4°F and for Scenario A2 is 0 to 6°F. The 58.3°F air temperature was measured and is above the anticipated air temperature due to climate change models. During the 2005 season water temperatures in Crooked Creek were high as were water temperatures at American Creek and Anaconda Creek stations. This was a weather year high temperature event not related to modeled climate change. That is why 2005 is an appropriate year to model proposed mine temperature impacts. Results from the model showed that the stream temperatures are not expected to exceed the relevant water quality temperature standards for either egg/fry incubation and spawning or migration routes.

**Comment 35**: P. 2 "However, BGC presents no analysis as to the frequency that the low flows or high temperatures observed in summer 2005 have occurred so the predictive power of that knowledge is limited."

**The Division's Response**: See Response to Comment 34.

**Comment 36**: P. 2 "The model used to predict temperatures caused by the mine is a simple mixing model of flows with specified temperatures without any consideration of thermal effects between the points on the creeks, or nodes, at which temperatures are estimated."

**The Division's Response**: The model is populated by a large dataset that has been collected from nodes that are relatively closely spaced. The liner distance between American and Anaconda Creek confluences is less than 3 miles. The thermal effects between stream monitoring stations do not need to be estimated. The FEIS data was collected at locations that were closely spaced. In addition, BGC 2021 noted that "[t]he potential removal of riparian vegetation along Crooked Creek due to the proposed Project. This factor is not considered significant because there are no plans for the riparian zone of Crooked Creek to be disturbed, except for one bridge crossing." Myers assumed that this was an underestimate (Myers 2021, Exhibit 6, Page 3 of 18). The stream temperature measurements at a frequency of every 30 minutes eliminates the chance of underestimated temperatures and introducing solar radiation modeling error. In addition, because the stations are closely located the FEIS noted that the temperature and solar radiation are not likely to be notably different between the sites (FEIS, pg. 3.5-26 and 27. The FEIS, Section 3.5, pg. 3.5-133 April 2018 also noted that the "[d]esign and implementation of erosion control procedures and BMPs at each water body crossing would

minimize potential impacts to surface water flow and sediment load. Finally, see prior discussion on the use of modeling.

**Comment 37**: "Flow Assumptions" – "The first assumption is that stream flows will not be any lower than analyzed. The year 2005 had the lowest flows of the presented record but there is no indication as to the probability of those low flows being exceeded. If the background streamflow is lower than occurred in 2005, the mine would have more substantial effects on the stream temperatures than predicted by BGC."

**The Division's Response**: The Division agrees that model inputs based on observed and measured data provides a higher level of confidence than speculative inputs. The purpose of the BGC 2021 report was to use the actual stream temperature data collected every 30 minutes combined with the proposed mine dewatering plan to evaluate impacts on Crooked Creek. Their analysis showed that there were no predicted exceedances in stream temperature. Further the Division adopts Donlin's response.

**Donlin's Response**: BGC did not make assumptions about stream flow or temperatures. Instead, BGC used actual continuous stream flow and temperature data, measured over the summer months for 5 years. It is clearly recognized that BGC's analysis does not include all potential combinations of streamflow and stream temperature, given both the type of analysis conducted and the length of record available (2005, 2006, 2007, 2009 and 2011). However, it is not productive to replace the actual data with speculation about whether lower or higher levels might be observed. Actual data is a strong foundation for assessing likely future compliance with water quality standards. Moreover, Dr. Myers's comment assumes that there is a direct correlation between streamflow and stream temperatures. This assumption is not borne out by the

actual observations. For example, the 2005 data includes two days with identical streamflow at CCAC (53.3 cubic feet per second (cfs) on both July 23 and August 4). Despite identical streamflow on these two days, the stream temperatures were significantly different: 51.7°F on July 23 and 46.5°F on August 4. Because of these complexities, BGC's analysis focused on dates where corresponding streamflow and stream temperature data through the summer months in Crooked Creek, American Creek, and Anaconda Creek were available.

**Comment 38**: Streamflow as a Function of Watershed Area – "BGC assumed a linear flow to area relationship which means the stream gains flow as a function of area. While correct on a broad scale in the Donlin area, the reality is that the relationship varies with length and with the wetness in the watershed. During dry periods, most flow enters in select gaining reaches or at points of inflow. During storm runoff periods, for streams of this size and topography, there are probably discrete inflow points but they probably spread along the stream reach so the area relationship may be more accurate. BGC should have done a synoptic analysis on Crooked Creek to determine the actual relationship of flow with area during both wet and dry conditions."

**The Division's Response**: The Division can see the point Dr. Myers is trying to make, but when dry periods occur, a larger percentage of the remaining Crooked Creek flow will be derived from groundwater. During these periods, it is reasonable to expect Crooked Creek to reduce in temperature due to the average groundwater temperature of approximately 36° F. A synoptic analysis of the watershed is not appropriate given the number of variables to consider in the drainage. Climatic conditions in the region generate complex freeze, thaw, snow melt, and rainfall conditions. As ONC notes, the linear flow to area relationship which means the stream

gains flow as a function of area is correct on a broad scale. Further the Division adopts Donlin's response. Donlin's comment below evaluated the non-linear flow condition and shows minor impact on water temperature.

**Donlin's Response**: It is assumed that when referring to a synoptic study, Dr. Myers is describing coordinated, intensive sampling over a short time period (several days) during wet and dry periods where streamflow would be measured in Crooked Creek at a number of locations between American Creek and Anaconda Creek. A sensitivity analysis demonstrates that such additional streamflow data would not have a significant influence on the analysis. Therefore, even when accounting for a non-linear flow to watershed area relation, the impacts on stream temperature are relatively minor, with predicted stream temperatures in Crooked Creek remaining below the State of Alaska's water quality temperature standard of 55.4° F for egg/fry incubation in the years with available data.

**Comment 39**: P. 3 "The second assumption is there will be no thermal effects on the stream, meaning BGC ignored sources of heat that would add to stream temperatures … At the latitude of Donlin, longwave atmospheric radiation and conduction of heat from the atmosphere during warm days are likely to be the largest source of heating. Shortwave radiation, including direct sunlight onto the creek, reflects from surface water such that at lower than a 30-degree angle little heat would be absorbed. Reflected shortwave radiation however could hit the riparian vegetation thereby heating it thereby increasing long-wave radiation to the creek. At the low temperatures considered here, evaporation would remove only a small amount of heat. It seems likely that at least during warm weather periods with long days there would be a net gain of heat in the creek. Additionally, the stream meanders

substantially, as seen on BGC (2021) Figure 2-4; the meandering increases the surface area of the stream exposed to the factors listed above. By ignoring thermal effects, BGC ignored a substantial source of heat and has underestimated the temperature at the downstream end of the stream reach affected by the mine."

**The Division's Response**: The model is populated by a large dataset that has been collected from nodes that are relatively closely spaced. The linear distance between American and Anaconda Creek confluences is less than 3 miles. The thermal effects between stream monitoring stations do not need to be estimated. The FEIS data was collected at locations that were closely spaced. In addition, BGC 2021 noted that "[t]he potential removal of riparian vegetation along Crooked Creek due to the proposed Project. This factor is not considered significant because there are no plans for the riparian zone of Crooked Creek to be disturbed, except for one bridge crossing." Myers assumed that this was an underestimate (Myers 2021, Exhibit 6, Page 3 of 18). The stream temperature measurements at a frequency of every 30 minutes eliminates the chance of underestimated temperatures and introducing solar radiation modeling error. In addition, because the stations are closely located the FEIS noted that the temperature and solar radiation are not likely to be notably different between the sites (FEIS, pg. 3.5-26 and 27. The FEIS, Section 3.5, pg. 3.5-133 April 2018 also noted that the "[d]esign and implementation of erosion control procedures and BMPs at each water body crossing would minimize potential impacts to surface water flow and sediment load. Finally, see prior discussion on the use of modeling. Further the Division adopts Donlin's response.

**Donlin's Response**: The model is populated by a large dataset that has been collected from nodes that are relatively closely spaced. The liner distance between American and Anaconda

Creek confluences is less than 3 miles. The stream does meander significantly however, under the existing mine operations scenarios the riparian cover remains intact. Thermal impacts are measured as actual water temperature in the unimpacted stream. In addition, Myer's comment is overly simplistic in that the measured discharge and stream temperature implicitly accounts for the upstream radiation impacts on stream temperature. Therefore, thermal effects have not been accounted for as they would result in less conservative results. Furthermore, riparian and stream conditions on Crooked Creek would not be directly impacted by the proposed Project.

**Comment 40**: Effluent Discharge to the Stream – "The third unjustified assumption is that effluent temperatures would not be high enough to affect the stream. BGC provided no references to support the assumption. Effluent includes tailings decant water and runoff from waste rock and pit walls which could all be warmer than the stream temperatures during the summer due to radiation from the sun having warmed the source. There is also no discussion or evidence regarding heat that could be added to the water during treatment."

**The Division's Response**: BGC 2021 noted that 72% of the treated water would be from groundwater sources which has a measured temperature of approximately 36° F. The Division found no substantial argument that solar radiation would likely raise the volume of groundwater in the project area to over 55° F for which the model was conducted. Further the Division adopts Donlin's response.

**Donlin's Response**: The proposed water treatment includes a high-rate clarifier (HRC) and greensand filter, followed by reverse osmosis (RO). Neither of these treatment methods involve the addition of heat to the water. Therefore, the effluent temperature will generally be determined by the temperature of the water inputs fed through the water treatment plant (WTP).

To date, Donlin Gold has not modelled what the potential range of the treated effluent could be. However, for the September 28, 2021 report, we assumed a temperature of 55° F for the treated effluent. This temperature is a very conservative (i.e., high) assumption because:

- The proposed treatment methods do not involve the application of heat to the process.
- A majority of the predicted treatment volumes are modelled to be sourced from perimeter pit groundwater wells (29%), in-pit groundwater wells (19%), and the TSF Seepage Recovery System (SRS) (24%) (BGC, December 7, 2016). Together, these groundwater sources account for 72% of the modelled treatment volumes in July and August. As noted in BGC (September 28, 2011) groundwater has an average temperature of 35.6°F based on temperatures measured in the wells and vibrating wire piezometers installed in the immediate vicinity of the Donlin Project. Given that these three groundwater sources will be pumped directly to the WTP for treatment and will not be temporarily held in storage ponds, an assumed temperature of 55° F for the treated effluent is conservatively high.

**Comment 41**: P. 3 "BGC also ignored the potential that climate change would affect the thermal factors considered above. It could affect the stream in two ways. It could decrease flows during warm, dry periods and increase the air temperature and therefore the flux of heat from the air to the water. Both would increase the stream temperature. Because climate change would affect the stream temperatures regardless of the mine, it is necessary to consider it as part of any analysis of the impacts of the mine."

**The Division's Response**: Section 3.26.3 of the FEIS discusses climate change impacts to the proposed mine site extensively. Additionally, Dr. Myers assumes a static permitting process. The project's permits are renewed and reviewed on a recurring basis to incorporate new data from the previous permit cycle. The concept that an unexpected and unpredictable event 20 years in the future may cause exceedances discounts the adaptive permitting strategy which will account for changing conditions during each permit reissuance. Further the Division adopts Donlin's response.

**Donlin's Response**: The intent of BGC's analysis was to model potential increases in Crooked Creek stream temperature as a result of mining operations using available streamflow and stream temperature data. It is clearly recognized that BGC's analysis does not include all potential combinations of streamflow and stream temperature, including the potential impacts of climate change, given both the type of analysis being conducted and the length of record available.

The highest stream temperature measured at Crooked Creek during the 2005-2011 period was 51.7°F on July 23, 2005. Given the projected increases to air temperatures for northern climates in the coming century, it is possible that higher stream temperatures will occur in the future even if the Donlin Project does not proceed.

**Comment 42**: P. 4 "Uncertainty in the Predictions" - On Pages 4, 5, and 6 of his report, Myers states that BGC should have considered uncertainty for the following variables:

- Higher effluent temperatures
- Lower flow on Crooked Creek, which could make moderating temperatures on the effluent more difficult

- More cold water removed due to dewatering than the estimated 0.79 cfs.

**The Division's Response**: BGC 2021used a value of 2 cfs to conduct the modeling effort, which exceeds the maximum value expected of 1.66 cfs of removal from Crooked Creek. This decision appears to model for a circumstance which exceeds the maximum expected values and addresses some of the uncertainties inherent in predictive expected flows. Further the Division adopts Donlin's response.

**Donlin's Response**: The comment on higher effluent temperatures is addressed in Section 2.4. Effluent temperatures can be controlled by Donlin Gold and therefore represents a potential mitigation strategy. We assume the second bullet refers to issues already addressed in Sections 2.1 and 2.2. The final bullet refers to BGC's model assumption that the pit dewatering wells could remove 0.79 cfs from the hyporheic zone of Crooked Creek during operations, with the temperature of the captured water assumed to be at a typical groundwater temperature of 35.6°F.

It is first noted that in BGC's analysis of September 28, 2021, a loss in Crooked Creek water of 2 cfs was entered into the calculation, rather than the actual value of 0.79 cfs. At the same time, the model results did not account for the potential loss of groundwater flows in smaller tributaries adjacent to the open pit BGC, May 6, 2016). Total average groundwater loss from these tributaries is approximately 0.34 cfs over the life-of-mine. Combined with the Crooked Creek losses of 0.79 cfs, the average loss in groundwater inflows is then 1.13 cfs. Looking at the maximum annual values over the life-of-mine, which would occur in about Year 20 (Table 1 of BGC, May 6, 2016), this value of 1.13 cfs increases to 1.66 cfs, which is less than the 2 cfs used in the September 28, 2021 report. Therefore, this effectively results in another area of conservativeness in the calculations – using a number above the predicted maximum annual

value.

**Comment 43**: P. 5 "BGC does not account for potential uncertainties in the dewatering forecast. The dewatering forecast is based on groundwater modeling which has inherent uncertainties in the parameters used for analysis."

**The Division's Response**: This is an extension of the same comment regarding uncertainty. The Division acknowledges uncertainty exists, and the BGC 2021 report appears to address uncertainties by selecting model inputs which are conservative in nature. Modeling is the only reliable predictive tool at the Division's disposal to evaluate potential impact before the construction and operation of a proposed project. It is critical to keep in mind that the complex web of permits under which the mine will operate are not static in nature. The permits require monitoring and reporting and require the applicant to adapt their strategies if unanticipated results occur.

**Comment 44**: P. 2 "Conclusions - BGC (2021) does not provide evidence indicating that the development of the Donlin Mine would not cause stream temperatures that would exceed standards. In fact, there are so many assumptions necessary to keep the temperatures from exceeding the standards that it is likely that future stream temperatures will exceed the standards, especially as climate change increases the background temperatures that the mine will only increase with its effects."

**The Division's Response**: The Division again acknowledges uncertainties exist in all modeling efforts. In many instances where a discretionary decision was made regarding model inputs, BGC appeared to select conservative values. Dr. Myers provided no indication that there was no

possibility the project could meet WQS, only that the number of assumptions, be they logical and conservative or not, only makes it likely there will be temperature exceedances. He also appears to focus on the design of more elaborate models versus making an assertion if the presented model satisfies the threshold of reasonable assurance.

**The Division's Response to Comments: Limited Response to Dr. Miller's Supplemental Report**

**Comment 45**: Miller, May 8, pg 1: Tailings Mercury – Dr. Miller asserted in his May 8, 2022 memo that reliance on a single value estimating the mercury concentrations in the tailings impoundment was not reflective of his experience with Nevada mines.

**Division's Response**: Dr. Miller further refined his opinion on the relationship between mercury concentrations and Weak Acid Dissociable (WAD) cyanide concentrations in the gold extraction circulation water. The Division acknowledges this relationship. It is curious, however, there is criticism for using literature values in parts of the study, but then asserting the use data from mines in different parts of the country at other times. The Donlin ore composition, solar radiation, climate, and waste rock concentrations vary greatly from the Nevada mines Dr. Miller offers as a random, but perhaps not representative, sample. In addition, the Division adopts Donlin's response.

**Donlin's Response**: The Ramboll modeling and analysis provides reasonable science-based estimates using best available site-specific data, the peer-reviewed literature, and information from other existing mines as appropriate. Specifically, the analysis uses mercury concentration data from Donlin Gold ore, solar radiation, waste rock and water quality data at the Donlin Gold site, and mercury tailings concentration data from the Donlin Gold pilot processing study which

accounted for cyanide treatment. The temporal variability in emissions noted by Dr. Miller (e.g., variability due to sunlight and changes in cyanide/mercury concentrations) is on the timescale of days to months while the impact on creek concentrations is on the timescale of tens to hundreds of years due to retention in soils as discussed in the Ramboll (October 2021) report. Therefore, deposition resulting from a spike in emissions such as emission from tailings facility thaws would not immediately cause an increase in soil and creek concentrations; rather the latter are driven by longer-term average emissions. Moreover, to account for uncertainties in the data, the Ramboll study applied a series of conservative assumptions as discussed in the October 2021 report and in the April 2022 response to comments.

**Comment 46**: Miller, May 8, pg 4: Mercury Monitoring – Dr. Miller asserted the company should be required to monitor the concentrations of mercury in the tailings facility.

**Division's Response**: Mercury concentration monitoring at the tailings facility is a requirement of Section 2.5 of the Donlin Monitoring Plan (as revised and approved May 6, 2022), which is a required element of the Division's Waste Management Permit for Donlin. In addition, the Division adopts Donlin's response. The Division determined there is sufficient data available from the Monitoring Plan to inform the permit on potential mercury emissions from the tailings facility.

**Donlin's Response**: Quarterly monitoring of mercury concentrations at the tailings storage facility will be conducted by Donlin Gold per ADEC's waste management permit requirement and allow verification of the tailings concentration estimates. The Donlin Gold thermal facilities will be subject to mercury emissions testing as well as ongoing monitoring of mercury emission controls pursuant to EPA's National Emission Standards for Hazardous Air Pollutants: Gold

Mine Ore Processing and Production Area Source Category, 40 CFR 63.11640 - 11653. Furthermore, periodic monitoring of mercury concentrations at the tailings storage facility will be conducted by Donlin Gold per ADEC's waste management permit.

**The Division's Response to Comments: Limited Response to Dr. Myers' Supplemental Report**

**Comment 47**: Myers, May 9 (Memo dated April 29), pg 1: Dr. Myers asserted that "It is common in the scientific realm and a frequent regulatory requirement that low flow analysis be done of the 10-year return interval low flow. Having only a select five years of record, it is not possible to be analyzing a low flow that would be exceeded (flow less than that analyzed) at a ten-year or higher return interval."

**Division's Response**: The Division finds that using additional modeled inputs regarding the flows of Crooked Creek would insert additional uncertainties with little added benefit. The existing five-year period (2005, 2006, 2007, 2009, 2011) has measured values associated with measured flows. In addition, the Division adopts Donlin's response.

**Donlin's Response**: It is not clear what purpose that calculation would serve, as there would not be associated water temperatures with that estimate. He also re-iterates his position of potential thermal effects between model nodes due to reduced flows increasing the ratio of stream surface to flow area. The estimated reduction of flow in Crooked Creek due to activities in American Creek is minor relative to the total flow in Crooked Creek. A process-based stream temperature model could be employed to analyze the factors advocated by Dr. Myers. However, such a model would have much more uncertainty associated with the various required inputs than the use of actual data.



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**The Division's Response to Comments: Chambers Report**

Center for Science in Public Participation – David M. Chambers, dated May 5, 2022.

A series of new comments were introduced by ONC via an expert, Dr. David M. Chambers. Dr. Chambers was asked to comment on the applicability of some of the water treatment procedures proposed by BGC 2021 and provided comments in "Response to BGC Engineering—Temperature of Treated Effluent" (May 5, 2022). These comments are new comments, and focus on the idea that controlling temperature of the treated effluent will be difficult at the mine site and untested at any mine. According to Dr. Chambers, "historically for most mines, there hasn't been much emphasis on temperature control when managing water treatment plant operation. The emphasis is typically on the level of metals in the discharge." Dr. Chambers asserts that Donlin has not "conducted any studies to evaluate the feasibility of this proposal. BGC Engineering's mitigation proposals are all theoretical, and moving something from theory, to lab demonstrations, then into practical field applications has historically been problematic for the mining industry."

BGC 2021 used updated water budgets published after the FEIS and stream flow and temperature data collected for the FEIS to develop a quantitative model of stream temperature using SSTEMP, a stream temperature model from the USGS. The model used average groundwater data and maximum annual surface water temperatures (from 2005) as the basis for the model. Table 3.26-7 of the FEIS shows the projected air temperature increases in Alaska under two climate scenarios. The anticipated air temperature increase for scenario B1 MAAT Range is 0 to 4°F and for Scenario A2 MAAT range is 0 to 6°F. The 58.3°F air temperature was measured and is above the anticipated air temperature due to climate change models. During the

2005 season water temperatures in Crooked Creek were high as were water temperatures at American Creek and Anaconda Creek stations. This was a weather year high temperature event not related to modeled climate change. That is why 2005 is an appropriate year to model proposed mine temperature impacts. Results from the model showed that the stream temperatures are not expected to exceed the relevant water quality temperature standards for either egg/fry incubation and spawning or migration routes.

Dr. Mark Johns of Exponent independently evaluated the updated temperature model in BGC 2021. Results from his analysis were presented in Exponent 2022. Dr. Johns concluded the model chosen in BGC 2021 was appropriate for the environmental data, that the use of 2005 temperature data represented a conservative case because it was the warmest year for which data were available, and that the quantitative evaluation conducted in BGC 2021 was reasonable.

As Dr. Chambers mentions, in the project memorandum of April 14, 2022, BGC 2021 asserts that "Donlin Gold can control the temperature of the treated effluent by managing the quantity (i.e., flow) of the water sources that are fed to the WTP [Water Treatment Plant]." A range of measures such as using groundwater rather than surface water sources, cooling treated effluent, releasing impounded water from the Snow Gulch Dam, adding groundwater from new wells outside the mine area, and assessing options to reduce the loss of water from Crooked Creek's hyporheic zone due to the dewatering wells are a suite of options available to implement as an adaptive management approach in regards to temperature if necessary.

## CONCLUSION

After an unprecedentedly immersive review of the available data, predictive models and the additional information contained in the submitted Ramboll 2021, BGC 2021, Air Sciences and SRK 2017 supplemental reports, and third-party review by Exponent, the Division asserts that there is sufficient predictive modeling to support a determination of reasonable assurance of meeting water quality standards. The level of rigor applied to the evaluation and modeling of the proposed discharges to Waters of the United States provides the Division an even greater level of assurance that WQS will be attained. The Division is affirming its issuance of the Section 401 Certificate of Reasonable Assurance.

ONC's repeated assertions that models have uncertainties is generally acknowledged as axiom. The Division did not expect any predictive model used to have zero potential for error. In fact, its own third-party expert highlighted a previously unaccounted potential source of exceedances. This process highlights how permits should and do work. Once a potential for exceedance is known or observed, the permittee and the Division take appropriate management actions to mitigate, reduce or eliminate the discharge. By incorporating a concern the Division became aware of in the Monitoring Plan, greater assurance was attained with meeting WQS for mercury.

ONC seemed to assert that if at any time in the future unanticipated events were to happen, the models could not account for that and should not be relied upon for meeting the reasonable assurance criteria. In the presented models, real-world data was input into the models to develop predictive outcomes. In most cases, modelers selected "worst-case" real-world data. ONC suggests future conditions may not be the same as past conditions. But to suggest that even

the data input to the predictive models should itself be modeled for unknown future changes seems to be introducing more, not less, uncertainty.

ONC also sets an unattainable expectation for reasonable assurance without providing a regulatory basis. ONC asserts that reasonable assurance must include that the predictive models not only result in satisfying WQS, but they must satisfy them by an unspecified threshold, and satisfy them at all points in the future without any adaptive management or involvement from the Division. These absurd and ill-defined thresholds make nearly any project of moderate length unlikely to attain any assurance.

It is important to note that reasonable assurance establishes an expectation that a proposed project has reasonable and realistic likelihood that it can comply with water quality standards when operated under a suite of permits and monitoring plans. Simply imagining a multitude of scenarios, under which the permittee and Division take no action whatsoever, that exceed WQS does not remove reasonable assurance. The intent of reasonable assurance is to provide the Department and public that a federally permitted action, when properly permitted and operated within the confines of the permit conditions, has a reasonable expectation of meeting the permit requirements. It is not the intent of reasonable assurance to continuously and endlessly refine predictive modeling efforts, which will always include uncertainty. It is for this reason the Division strongly asserts it has more than met the threshold of reasonable assurance.

ONC asserted the models were not conservative in nature yet provided no insight for the regulatory basis for that requirement nor did they offer a definition of conservative models. The Division observed in cases where there was a range of data for model input, the models in Ramboll 2021 and BGC 2021 selected worst-case or higher end of the data spectrum data. While

the Division does not concur that a formal declaration of conservative modeling is a regulatory requirement to attain reasonable assurance, these actions alone appear to point to a modeling effort which is, at the very least, made broad assumptions and refrained from selecting data which led to bast-case results. Similarly where predictive values were necessary to model results, the BGC 2021 and Ramboll 2021 reports cited literature values which were cautious.

The BGC 2021 study conducted a quantitative analysis which provided the magnitude and frequency of potential temperature changes on a daily basis, in contrast to the qualitative analysis in the FEIS. The Ramboll 2021 analysis used emissions estimates from the air permit and literature values to conduct a quantitative analysis to estimate potential stream mercury loadings under project conditions. ONC asserts the Division should not consider these models as "risk-averse", but again, provides no regulatory basis for the Division to do so, or provide a definition. The implication from ONC appears to be that no model could ever be used to satisfy the requirement of reasonable assurance.

ONC asserts the Ramboll 2021 and BGC 2021 reports were hastily prepared in response to litigation. During the Division and third-party review of the Ramboll 2021, BGC 2021, Miller 2022, Myers 2022, and Chambers 2022 reports, the Division did not find this to be the case. In fact, in the Miller 2022 report, Dr. Miller asserts Ramboll 2021 failed to consider the effect of cyanide on mercury chemistry in the tailings pond. Ramboll 2021 did, however, include a detailed discussion of pilot studies that included optimization of the cyanide process to minimize mercury emissions. It appears the majority of concerns Dr. Miller stated were based on outdated information from the FEIS and not the most recent sources Ramboll 2021 cited. The Division

does not question the experience and credentials of Dr. Miller, but it does appear there was little time provided to Dr. Miller for review and comment on the Ramboll 2021 report.

The Division has completed its own review and an independent third-party review of the additional studies (BGC 2021 and Rambol 2021) Donlin submitted. Through third-party review the Division was made aware of a small potential for mercury exceedances in a very small portion of land remaining after the mine is constructed. Due to this review, the Division was able to engage Donlin and put in place mechanisms to obtain heretofore unreported data on water quality and improve the responsiveness of the reporting and adaptive management. The Division has greater confidence of reasonable assurance WQS will be met and affirms the decision to issue the Certificate.



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# ADAPT Y-K Delta
# Climate Adaptation Strategies for the Yukon-Kuskokwim (Y-K) Delta Region

Developed by the Adapt Y-K Delta Steering Committee

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# ADAPT Y-K Delta

## Climate Adaptation Strategies for the Yukon-Kuskokwim (Y-K) Delta Region

The Adapt Y-K Delta Adaptation Strategies report was prepared by a project staff team on behalf of the Adapt Y-K Delta Steering Committee and partner organizations. The Adapt Y-K Delta Steering Committee provided direction for the Adapt Y-K Delta Adaptation Strategies, with support from an Advisory Committee that provided content expertise as needed. Steering Committee, Advisory Committee and project staff members are listed by name and affiliation on the following pages and in Appendix 1.

The Adapt Y-K Delta Climate Adaptation Strategy was funded by the Western Alaska Landscape Conservation Cooperative with a grant from the U.S. Fish and Wildlife Service, as well as the Alaska Silver Jackets Partnership through funding provided by the U.S. Army Corps of Engineers, and Alaska Sea Grant. More information about the Adapt Y-K Delta Climate Adaptation Strategy is located on the Adapt Alaska website: www.adaptalaska.org. Please cite this report as follows:

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### With support from:

Association of Village Council Presidents

Alaska Native Tribal Health Consortium

Alaska Sea Grant

U.S. Fish and Wildlife Service

U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge

Alaska Silver Jackets Partnership, including:

- Alaska Department of Commerce, Community, and Economic Development, Division of Community and Regional Affairs, RiskMAP Program
- Alaska Department of Military and Veterans Affairs, Division of Homeland Security and Emergency Management, State Hazard Mitigation Officer
- Denali Commission
- National Oceanic and Atmospheric Administration, National Weather Service
- Western Alaska Landscape Conservation Cooperative
- U.S. Army Corps of Engineers



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# Foreword

The Yukon-Kuskokwim Delta (Y-K Delta) region has rich biological and cultural resources that have sustained our people, our fish and our wildlife for more than 10,000 years. The region, however, is changing fast and threatening these resources, our communities, our values and our livelihoods. Action is urgently needed to help the region's 56 tribes adapt to a new climate, new landscapes, new conservation and development challenges and opportunities.

This document was developed by a Steering Committee of local stakeholders in the Y-K Delta region to provide a systematic basis for action on our shared adaptation priorities. We are grateful to the Western Alaska Landscape Conservation Cooperative and the many Federal, State and local organizations, tribes and community members who contributed to the development of the Adapt Y-K Delta Climate Adaptation Strategies.

The heart of these strategies is a short list of modest, practical adaptation actions. These actions were identified through an ongoing dialogue with people in the region, as well as researchers and agencies whose missions include working with regional partners. Priorities were selected to be achievable in the near term and to set the stage for more ambitious actions to follow.

Development of the Adapt Y-K Delta Climate Adaptation Strategies was guided by approaches undertaken by indigenous communities globally and by our own 10,000 years of experience adapting to novel socio-political, ecological and technological challenges. We recognize that the Y-K Delta region is not isolated – we are connected with indigenous communities throughout the circumpolar Arctic, and with biological communities globally. We are, as a consequence, committed to sharing what we learn within the region and beyond as we adapt to a new global climate.

This Adapt Y-K Delta Climate Adaptation Strategies document marks the beginning of building regional climate change considerations into our local and regional decision-making, to proactively identify adaptation priorities and respond to current and to future changes and needs. Upon the completion of this document, climate adaptation considerations will be directly incorporated into future updates to the Yukon-Kuskokwim Region Comprehensive Economic Development Strategies (CEDS). Until then, the 2018-2023 CEDS document refers to this Adapt Y-K Delta Climate Adaptation Strategies document to provide guidance on regional priorities for climate change action. We encourage community members in the region, as well as agency representatives and experts to join these processes as we review, refine, develop, add to and test our adaptation strategies, learn from our efforts and share our lessons so that collectively we will sustain our ways of life, our environment and relationships and build greater resilience.

*Quyana*,

Adapt Y-K Delta Steering Committee



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# Contents

**ADAPT Y-K Delta** ..... **i**

Climate Adaptation Strategies for the Yukon-Kuskokwim (Y-K) Delta Region ..... i

Adapt Y-K Delta Steering Committee: ..... ii

Adapt Y-K Delta Staff: ..... iii

Adapt Y-K Delta Advisory Committee: ..... iii

**Foreword** ..... **v**

**Explanation of Agency Names and Abbreviations** ..... **x**

**Introduction** ..... **1**

**Yukon-Kuskokwim Delta Region Overview** ..... **2**

Project Area ..... 2

Biological and Physical Setting ..... 3

Socio-Cultural Setting ..... 4

Management Setting ..... 6

**Climate Change in the Yukon-Kuskokwim Delta Region** ..... **8**

Sea Level Rise, Storm Surge, and Coastal Responses in the Y-K Delta ..... 11

Putting It All Together ..... 13

**Adapt Y-K Delta Process** ..... **15**

**Our 2120 (100-year) Vision** ..... **18**

**Targets** ..... **19**

Impacts on Targets ..... 22



ED_013708_00001218-00343

**Strategic Opportunities for Action** ..... **24**
Strategic Opportunity 1: Subsistence Resources and Practices ..... 25
The Challenges and Opportunities ..... 25
Subsistence Resources and Practices Adaptation Actions ..... 26
Strategic Opportunity 2: Community Infrastructure Resilience ..... 31
The Challenges and Opportunities ..... 31
Community Infrastructure Adaptation Actions ..... 32
Strategic Opportunity 3: Trails and Transportation Safety ..... 41
The Challenges and Opportunities ..... 41
Trails and Transportation Adaptation Actions ..... 42
**Monitoring and Implementation** ..... **47**
Implementation Process ..... 47
Leadership and Implementation Actions ..... 47
**Adaptation Funding** ..... **49**
**Appendix 1: Participation in the Adapt Y-K Delta Process** ..... **50**
A. Steering Committee Members ..... 50
B. Adapt Y-K Delta Advisors, Staff and Facilitators ..... 51
**Appendix 2: Reference Materials** ..... **52**
**Appendix 3: Process to Identify Focus Areas** ..... **53**
Target Identification and Prioritization Criteria ..... 53
Situation Analysis ..... 53
**Appendix 4: Subsistence Action Plan Summary** ..... **55**
**Appendix 5: Infrastructure Action Plan Summary** ..... **58**
**Appendix 6: Trails and Transportation Action Plan Summary** ..... **61**



ED_013708_00001218-00344

ED_013708_00001218-00345

# Explanation of Agency Names and Abbreviations

| | |
|---|---|
| ABSI | Aleutian Bering Sea Islands |
| ADF&G | Alaska Department of Fish and Game |
| AFN | Alaska Federation of Natives |
| AHFC | Alaska Housing Finance Corporation |
| ANILCA | Alaska National Interest Lands Conservation Act |
| ANSEP | Alaska Native Science and Engineering Program |
| ANTHC | Alaska Native Tribal Health Consortium |
| AOOS | Alaska Ocean Observing System |
| APU | Alaska Pacific University |
| ATCEM | Alaska Tribal Conference on Environmental Management |
| AVCP | Association of Village Council Presidents |
| BIA | Bureau of Indian Affairs |
| BSFA | Bering Sea Fisherman's Association |
| DGGS | Division of Geological and Geographic Surveys |
| DNR | Alaska Department of Natural Resources |
| CCHRC | Cold Climate Housing Research Center |
| CVRF | Coastal Villages Region Fund |
| DCCED | Alaska Department of Commerce, Community, and Economic Development |
| DCRA | Division of Community and Regional Affairs |
| EPA | Environmental Protection Agency |



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| | |
|---|---|
| HCP | Healthy Country Planning |
| IGAP | Indian General Assistance Program |
| LCC | Landscape Conservation Cooperative |
| NRCS | Natural Resources Conservation Service |
| NWR | National Wildlife Refuge |
| ONC | Orutsararmiut Native Council |
| OS | Open Standards |
| OSM | Office of Subsistence Management[1] |
| OTIS | Ocean Technology Innovation Sprint |
| SNAP | Scenarios Development for Alaska and Arctic Planning |
| UAF | University of Alaska Fairbanks |
| USACE | United States Army Corps of Engineers |
| USDA | United States Department of Agriculture |
| USFWS | United States Fish and Wildlife Service |
| USGS | United States Geological Survey |

[1] The Office of Subsistence Management is within the U.S. Fish and Wildlife Service.



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# Climate Adaptation Strategies

These strategies are the first stage of an adaptive management process that is designed to help build the resilience of Y-K Delta resources and the people who depend on them.

## Vision 2120

Current and future generations enjoy healthy ecosystems that sustain our communities and our Indigenous way of life.

## Targets

Seven targets that must be healthy to achive this vision:

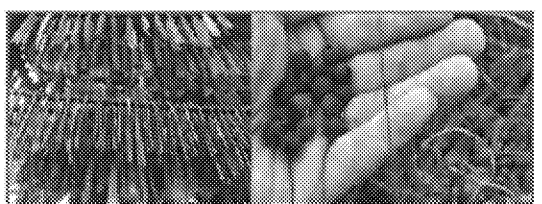
## Strategies for the Three Focus Areas

Priority was placed on a limited set of actions for each focus area that:

- can begin quickly;
- deal with what is important to our people now;
- complement what is already being done by others;
- can help make the targets healthier in the next five years.

### Community Infrastructure

- Provide communities with tools to collect data needed for funding requirements.
- Develop and share a simple adaptation planning template and process that identifies practical actions.
- Improve regional environmental data to support infrastructure investments and obtain funding.
- Develop and use infrastructure that is moveable, sustainable and affordable.



### Subsistence Resources Harvest Practices

- Explore new fish processing methods that meet our community needs and avoid waste.
- Share knowledge about new harvest practices among our communities.
- Refine current management practices related to fish and wildlife harvesting.
- Continue berry research and share the results with our communities.

### Trails and Transportation

- Improve understanding of existing trail use and trail-related impacts.
- Increase education on trail safety and trail-related impacts.
- Design and fund trail improvements.



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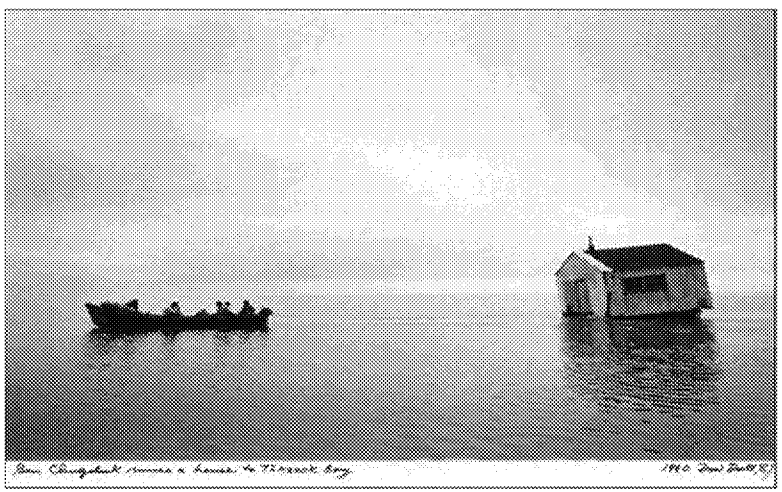
# Introduction

Climate change is affecting the Yukon-Kuskokwim Delta, from fish and wildlife habitats, to access to subsistence foods, to the stability of the ground under roads, runways and buildings to the reliability of winter ice used for travel. These changes are predicted to continue and intensify. The Adapt Y-K Delta Climate Adaptation Strategies are the first stage of an adaptive management process that is designed to help build the resilience of Y-K Delta resources and the people who depend on them. This document responds to these challenges and opportunities. The Adapt Y-K Delta Climate Adaptation Strategies were developed by a Steering Committee made up of a regionally representative group of tribal and community leaders, non-profit organizations, individuals, researchers and public resource managers, with advice from regionally based state and government agencies.

These strategies will be implemented by partners in the Adapt Y-K Delta process and through implementation of the Yukon-Kuskokwim Region Comprehensive Economic Development Strategies (CEDS). Progress will be reviewed periodically, and the strategies may be adjusted based on experience and determine whether additional strategies are necessary to achieve the vision.



*Left: Napakiak taking charge and moving the Multi-purpose Building, which was threatened by river erosion. Photo courtesy of Katrina Andrew, Napakiak.*
*Right: Creative adaption response strategies in Tooksook Bay, 1980. Photo by Reverend Don Doll, 1980, courtesy Michael J. Hoffman, AVCP.*



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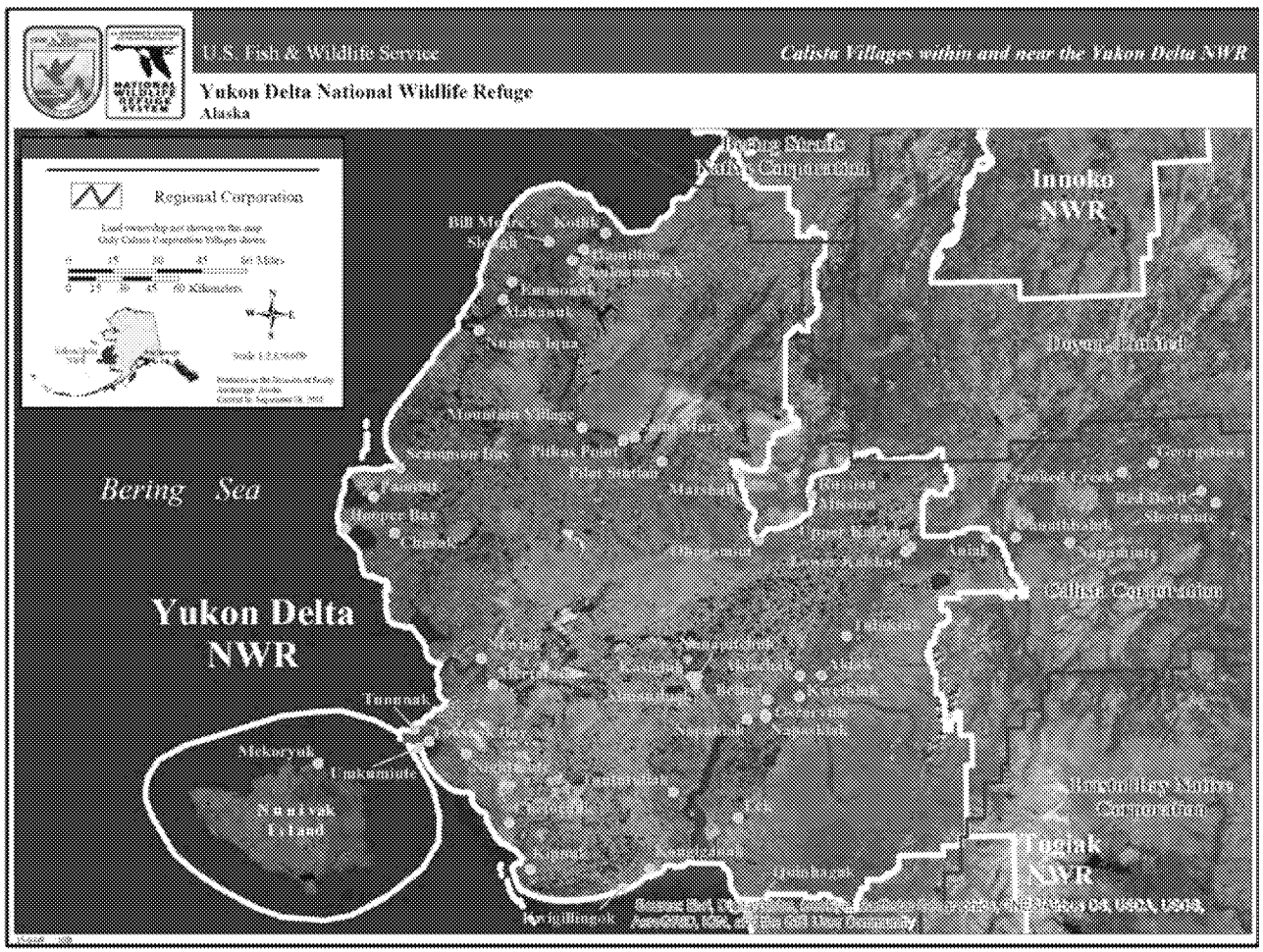
# Yukon-Kuskokwim Delta Region Overview

## Project Area

The area addressed in this plan is broadly defined as the Yukon-Kuskokwim delta region. This broadly, but not precisely corresponds to the boundaries of the Yukon Delta National Wildlife Refuge. Facts about this area include:

- 56 tribes
- Rich, enduring, adaptive cultural heritage
- Two of North America's largest rivers
- Productive, largely intact natural ecosystems

**Figure 1 Y-K Delta Region Villages and Landscapes**



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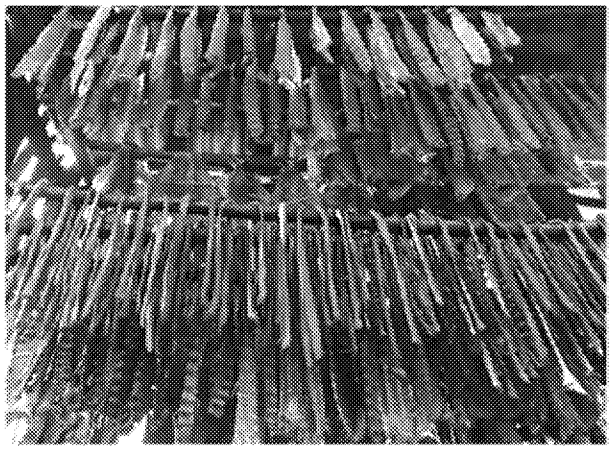
## Biological and Physical Setting



*Salmon drying. Photo courtesy of Nick Kameroff, Jr.*

The Yukon and Kuskokwim rivers are major drainages in Alaska. The Yukon River is the fifth largest by discharge volume in North America with a total watershed area of some 321,500 square miles. The Yukon begins its journey in Canada, from headwaters in the northern tip of British Columbia, flowing 1,980 miles to the Bering Sea and discharging an average of 227,000 cubic feet per second.

The Kuskokwim River is the ninth largest by discharge volume in the United States with a total watershed area of 48,000 square miles. The Kuskokwim begins on the north and west sides of the Alaska Range and flows south-westerly for 700 miles. The average discharge is 67,000 cubic feet per second.

As Figure 1 indicates, the Yukon and Kuskokwim rivers form one of the world's largest delta systems—even larger than the Mississippi Delta. Both rivers share a roughly parallel path to the coast through the lowlands of the Y-K Delta and play a major role shaping the Delta's wetland and tundra ecosystems.

The Yukon and Kuskokwim river systems provide important fisheries and waterfowl habitat and are major sources of subsistence resources for local communities. Both rivers are also major pathways for travel within the region, which has minimal surface transport infrastructure. There is increasing concern about the feasibility and safety of travel on rivers during winter, as river ice is increasingly thin and unstable. In recent years, Chinook salmon runs in both rivers have declined (Figure 2), prompting emergency closures and leading to conflict over allocation and access. And delays in arrival of fish until later wetter summer months has increased the challenges of preserving fish.



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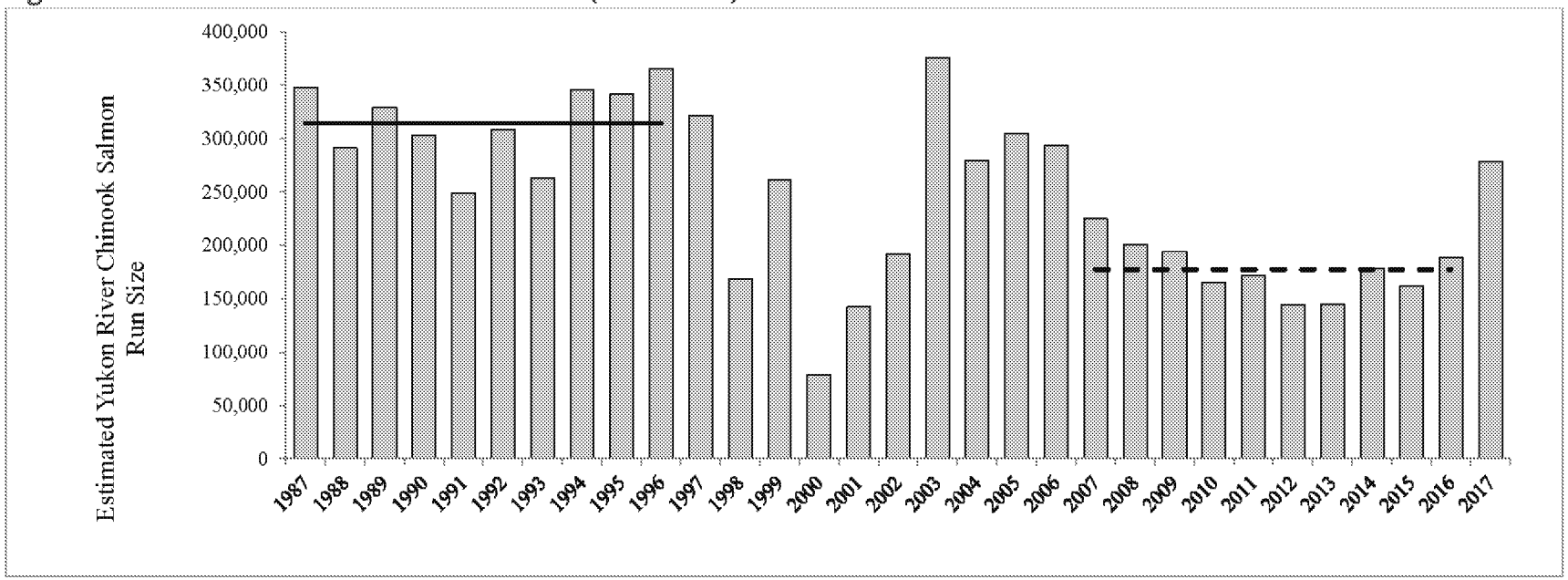
**Figure 2: Yukon River Chinook Salmon Runs (1987-2017)**




*Note: Total run size for 1987 through 1994 and 1996 is the Canadian origin run size doubled. Run size for 1995 and 1997 through 2017 is measured at Pilot Station sonar and includes escapement and harvest below the sonar. The solid black line is the 1987-1996 average run size. The dashed line is the recent 10-year average run size. Graph courtesy of the Alaska Department of Fish and Game (ADF&G). Please note that all information provided in this graph is preliminary and subject to change.*

# Socio-Cultural Setting

"Looking to the past, we see a better future." – *Adapt Y-K Delta Steering Committee Member*

The Yukon-Kuskokwim Delta has a deep and rich cultural history that predates European settlement of North America by 10,000 years. This 75,000 square-mile region is approximately the size of Oregon, with a population of more than 23,000 people living in 56 tribes unconnected by roads. According to the Yukon-Kuskokwim Health Corporation, Y-K Delta communities range in size from 25 to over 1,000 persons each. Bethel, the regional service and transportation center, has a population of nearly 7,000 and is only accessible by airplane, boat, four-wheelers and (in winter) snowmachines. Cars and trucks often use the frozen rivers as roads during winter.



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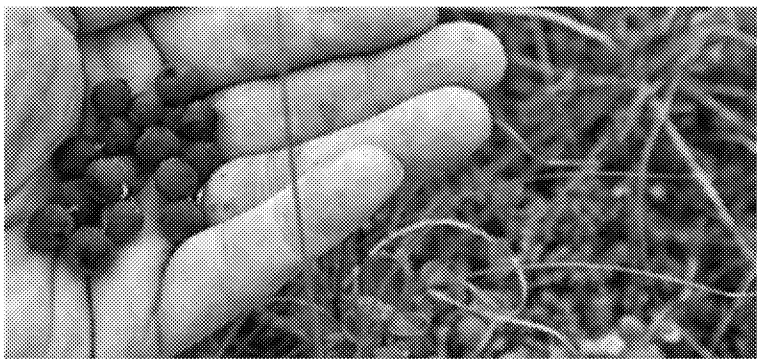
Traditionally, Yup'ik, Cup'ik and Cup'ig people have lived throughout the region, and Athabascans have resided along the Yukon River and Interior villages. The Yup'ik language is the first language of more than 14,000 men, women, and children in our area, making it the most widely spoken Alaska Native language today.

The land and waters of our area are rich in fish, mammals, birds, and plants that sustain Y-K Delta residents. The regional economy is mixed; residents use wages to pay for snowmachines, boats, motors, ammunition, and fuel, which are modern adaptations to traditional harvesting practices. Although prices are high, often making hunting and fishing difficult to afford, our region's residents remain committed to traditional harvesting activities and to sharing that return with loved ones.



*Left: High quality food in the neighborhood. Subsistence foods make up more than 50 percent of all food for most Y-K Delta families. Photo courtesy of Ian Dutton, Nautilus Impact Investing. Right: Scammon Bay community meeting – one of many Y-K Delta villages working together on priorities for economic development, cultural health, and climate change adaption. Photo courtesy of Chris Beck, Agnew Beck Consulting.*

"The most striking feature of the Nelson Island area is the fundamental dependence of its inhabitants on the products of the rivers and the sea, both traditionally and at present. Their way of life is inexorably bound up with the seasonal cycling of fish and game. Although communities have solidified in the last 30 years, to some extent obviating the need for the seasonal migrations, the places people have chosen to settle are precisely those which have in the past supplied, and continue to supply, ready access to subsistence resources." – *Ann Fienup-Riordan, Nelson Island Eskimo*



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# Management Setting

Historically, communities and subsistence practices established and moved as needed, sometimes incorporating regular campsites, especially in the winter. Those historical patterns of land use changed with the arrival of Russian colonists and the subsequent sale of Alaska to the United States.

Refuge lands were first set aside in the Y-K Delta region by President Theodore Roosevelt in 1909 as a preserve and breeding ground for native birds. In 1929, Nunivak Island was set aside as a refuge and breeding ground for wild birds, game, and furbearing animals. The Kuskokwim National Wildlife Range, established in 1960, was enlarged in 1961, and its name changed to the Clarence Rhode National Wildlife Range.

On December 2, 1980, with the enactment of the Alaska National Interest Lands Conservation Act (ANILCA) existing ranges and refuges were combined and enlarged to establish the Yukon Delta National Wildlife Refuge (NWR) which covers approximately 75 percent of the region. Subsequently under the Alaska Native Claims Settlement Act (ANCSA), the regional Native Corporation (Calista) and villages selected some 6.5 million acres for use and development. Figures 3 and 4 outline the relative extent of the Yukon Delta NWR and the complex configuration of refuge, village and other land uses within the region. Interwoven among this complex land tenure are the roles and responsibilities of federal, state, local and tribal governments as well as non-profit regional management, health and education organizations. Most prominent among these is the Association of Village Council Presidents (AVCP), which has served for 54 years (as of 2018), and which provides a diverse range of services at the regional scale from tribal justice to economic development.

**Figure 3: Land Status Within the Yukon Delta National Wildlife Refuge Boundary**

| Land Status within the Yukon Delta National Wildlife Refuge Boundary | |
|---|---|
| Village Corporation Conveyed | 5,213,141 |
| Region Corporation Conveyed | 8,623 |
| State of Alaska Conveyed | 62,729 |
| Native Allotment Conveyed | 338,853 |
| Other Private Conveyed | 5,629 |
| Other Federal Managed Land * | 56,171 |
| USFWS Managed Land ** | 17,263,027 |
| USFWS Manage Submerged land (around Nunivak Island) | 2,289,105 |
| * USFWS has secondary jurisdiction on Other Federal lands within the Refuge | |
| ** Selected lands are included in this number (ANILCA section 906(o)(2) | |
| Data used for these calculations is based on USFWS land ownership (current to June 2018) database (which is USFWS interpretation of BLM land records). Acreage calculations for conveyed land, is the legal acres on the conveyance document. Federal/USFWS land acreage uses GIS area calculations. | |

*Table courtesy of the U.S. Fish and Wildlife Service.*



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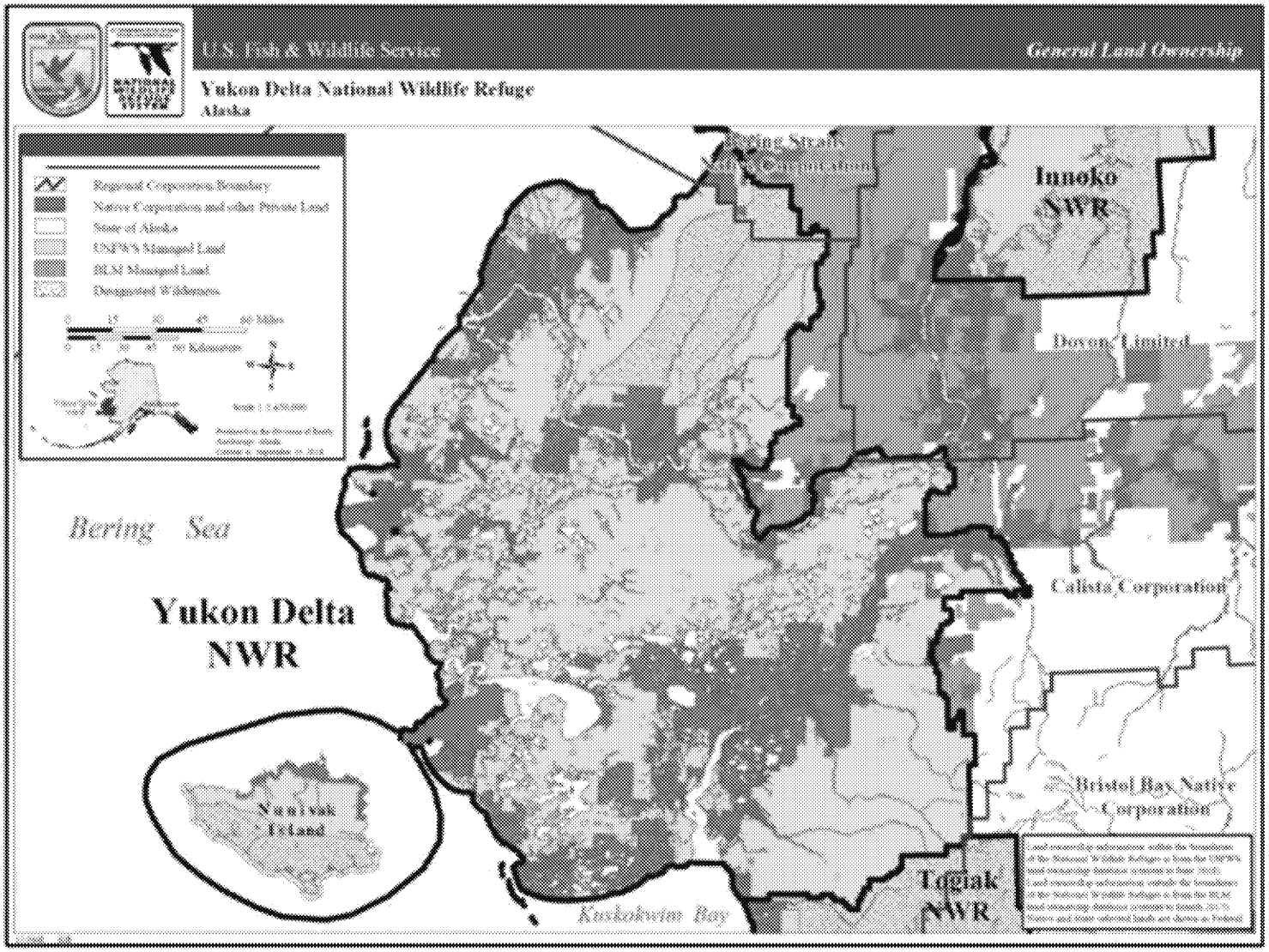
**Figure 4: Land Ownership in the Y-K Delta Region**




*Rivers are held by Native Village Corporations and Allottees. Much of the land between villages is held by the U.S. Fish and Wildlife Service. Map courtesy of the U.S. Fish and Wildlife Service.*



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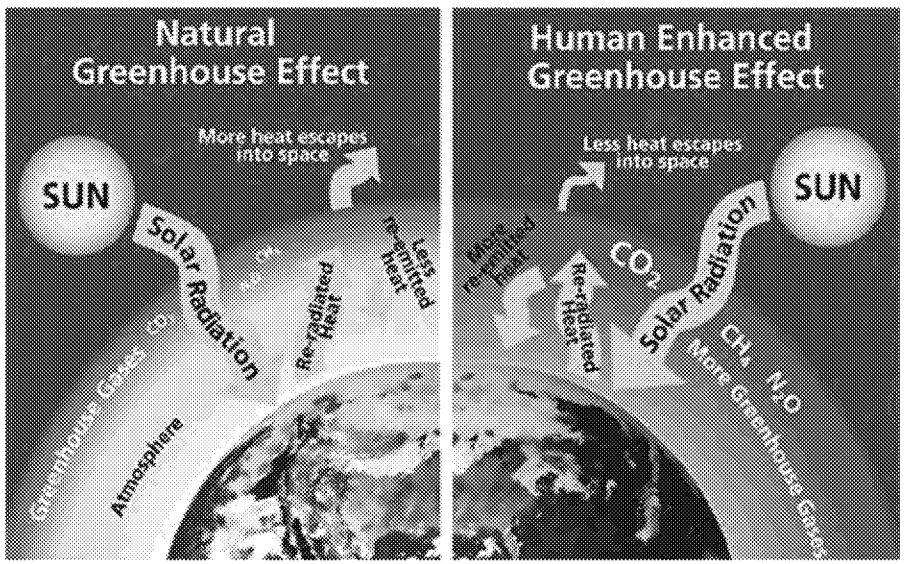
# Climate Change in the Yukon-Kuskokwim Delta Region

The steady increase in carbon dioxide and other greenhouse gases in the atmosphere is holding in heat and warming the planet. The Y-K Delta region is located in one of the world's fastest changing climate regions. According to the Fourth National Climate Assessment,[2] Alaska has warmed twice as fast as the rest of the nation. Presentations[3] to the Adapt Y-K Delta Steering Committee highlighted the major trends described on the following pages.

Four key messages for western Alaska

- Weather observations from 1970 to 2016 show that the Bethel area has already warmed over two and a half times faster (an increase of eight degrees Fahrenheit each century) than the global average (an increase of about three degrees Fahrenheit each century).
- By the 2050s, the average annual temperature in the Y-K Delta region is expected to increase by another seven to eight degrees Fahrenheit.
- Total yearly precipitation will likely increase about 10-15 percent, but less will come as snow.
- There is potential for higher variability: wet times will be wetter, dry times will be drier.




*In the same way a closed car warms up, increasing greenhouse gases in Earth's atmosphere hold heat, changing our world's climate. Image courtesy of http://climatechange.lta.org/get-started/learn/co2-methane-greenhouse-effect/.*

[2] http://nca2018.globalchange.gov/chapter/26/

[3] Presentation by Dr. Stephen Gray and Dr. Jeremy Littell from the Alaska Climate Adaptation Science Center and United States Geological Survey (USGS).



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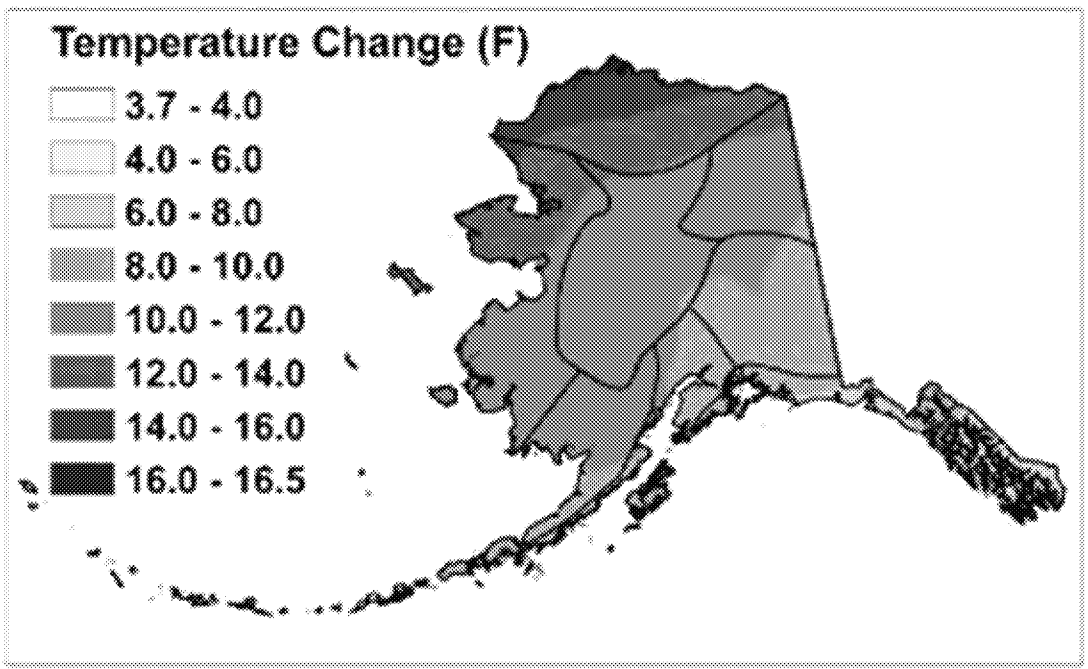
Figure 5 shows the dramatic changes in average temperatures projected in Alaska through the end of the century.[4] Alaska, like the rest of the Arctic, is warming much faster than other parts of the planet. The primary impacts of this warming in the Y-K Delta region include:

- Increased permafrost thaw.
- Less snow and ice cover, with a shorter season of snow and ice cover (Figure 6).[5]
- Increasing fire activity and potential vegetation change.
- There is potential for higher variability: wet times will very likely be wetter, dry times may be drier.
- Fewer extreme low temperatures and more hot days.

**Figure 5: 2070-2099 Projected Change in Annual Average Temperature Compared to 1970-1999**




*This figure was produced by the U.S. Geological Survey/Alaska Climate Adaptation Science Center. It represents an average of five climate models and higher emissions assumptions. This information is in turn based on climate models developed by the Scenarios Development for Alaska and Arctic Planning (SNAP) program at the University of Alaska Fairbanks. These are projections, not certainties, and incorporate judgements regarding the most likely future levels of greenhouse gas emissions and related global temperature increases (CMIP5, RCP 8.5).*

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SNAP

[4] Walsh, J. E., Bhatt, U. S., Littell, J. S., Leonawicz, M., Lindgren, M., Kurkowski, T. A., ... Rupp, T. S. (2018). Downscaling of climate model output for Alaskan stakeholders. Environmental Modelling & Software. http://www.sciencedirect.com/science/article/pii/S1364815217305662?via%3Dihub

[5] Littell, J.S.; McAfee, S.A.; Hayward, G.D. Alaska Snowpack Response to Climate Change: Statewide Snowfall Equivalent and Snowpack Water Scenarios. Water 2018, 10, 668. http://www.mdpi.com/2073-4441/10/5/668



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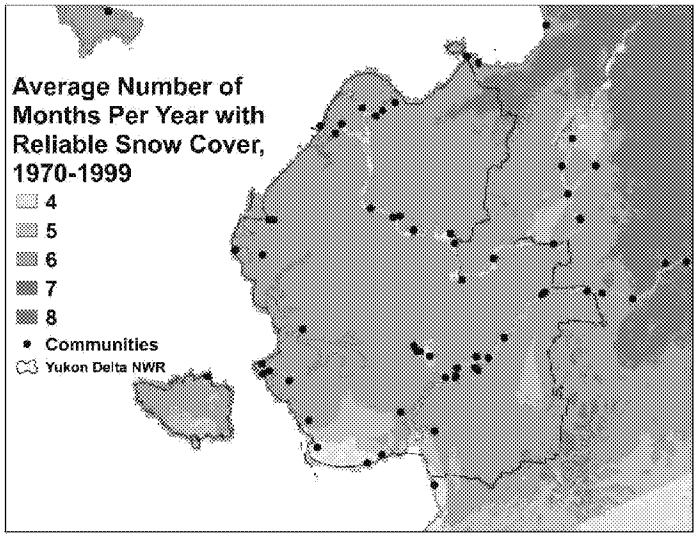


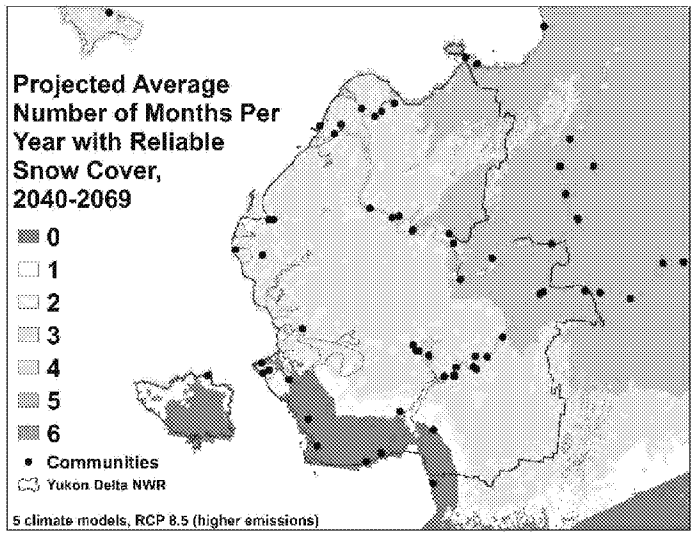


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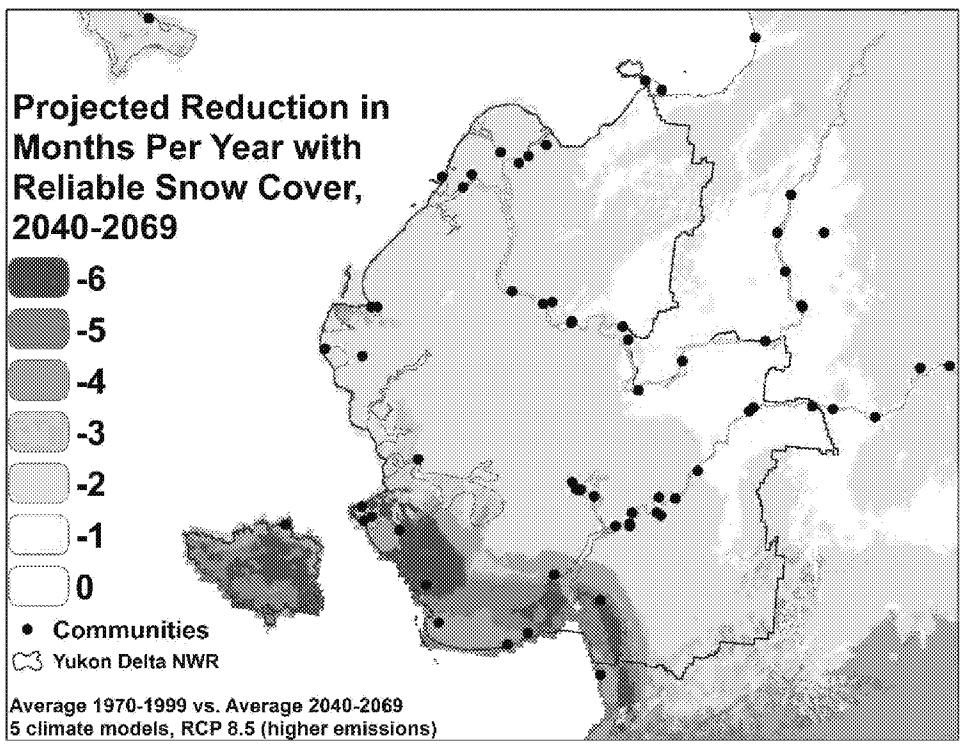


## Figure 6: Projected Changes in Snow Cover

*Top: These maps show the average number of months with reliable snow cover (more than 70% of precipitation as snow) for historical and future 30-year windows (Littell et al. 2018). Historical data use gridded weather observations. Future projections are averages from five climate models under higher greenhouse gas concentrations.*

*Left: Months with reliable snow cover decrease over most of the region, with precipitation in some areas near the coast becoming more rain than snow and having few months of reliable snow cover. This is because even historically, much of the precipitation fell closer to freezing than in colder areas.*

*These figures were produced by the U.S. Geological Survey/Alaska Climate Adaptation Science Center. This information is in turn based on climate models developed by the Scenarios Development for Alaska and Arctic Planning (SNAP) program at the University of Alaska Fairbanks. These are projections, not certainties, and incorporate judgements regarding the most likely future levels of greenhouse gas emissions and related global temperature increases.*



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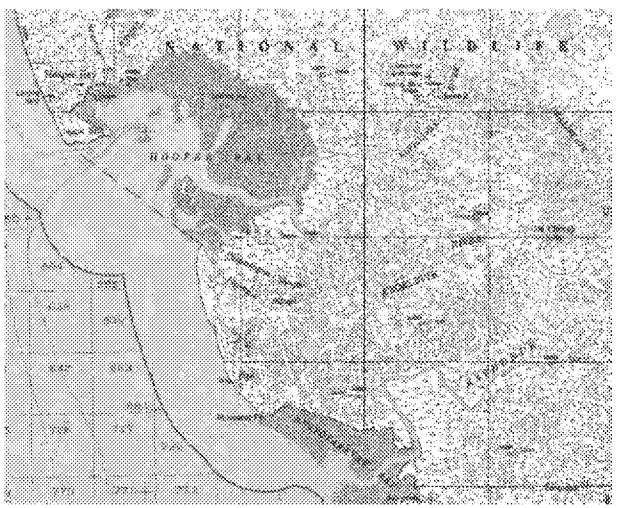
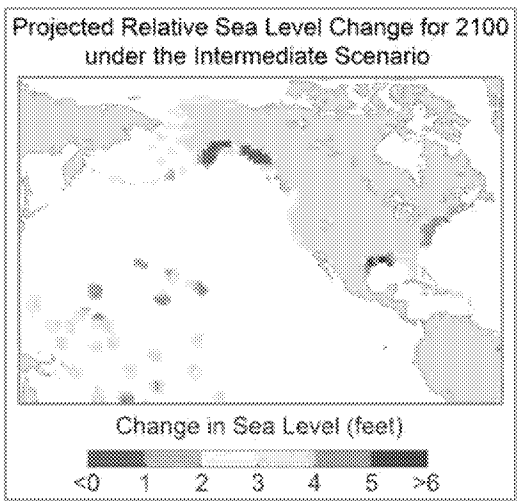
# Sea Level Rise, Storm Surge, and Coastal Responses in the Y-K Delta

Predicting the impacts of climate change is hard. Changes in one environmental category – for example, sea water temperatures – ripple through entire ecosystems, affecting everything from sea levels, to storm intensity, precipitation, sea ice, and the health of fish and wildlife. Greatly adding to this challenge is our lack of information about changing local conditions, and uncertainty about future levels of greenhouse gas emissions.

Despite these challenges, when there is a plausible basis for predicting change, and the potential impacts of change have big consequences, it is valuable to share what information is available. This is particularly true for sea level rise and related storm surge inundation in the YK Delta, where these changes are very likely to have major impacts. The following pages briefly summarize what is known, and not known on these critical topics. This is offered with a sense of humility about the limits of our understanding, but also with the resolve that we should not let complexity and uncertainty keep us from sharing this information and lead us into complacency.






*Left: The photo gives a view along the flight path between Bethel and Scammon Bay, looking west at a typical expanse of low-lying ground where water is as common as land. Center: The map is an extract from a USGS topographic map, showing similar terrain along the coast near Hooper Bay. Note that none of this land is more than 50 feet above sea level. Right: The map above shows projected relative sea level change in North America and the Pacific measured in feet. Note that change is not uniform, reflecting the complex mix of variables that control the amount of increase in any given location. Source: Sweet et al, 2017.*



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### What We Know

**Topography and soils in the Y-K Delta make the region particularly vulnerable to inundation.**

- Coastlines, estuaries, lagoons, river outlets provide valuable habitats for birds, fish and wildlife. Subsistence activities and many communities concentrate in these areas.
- Much of the region, including these highly productive areas, is only slightly above sea level.

**Permafrost is thawing.**

- Rising temperatures and the shift from snow to rainfall is thawing permafrost, which makes the land more vulnerable to erosion.

**Shorefast sea ice is declining, and storm intensity seems to be increasing.**

- Rising water and air temperatures are reducing the extent and duration of shorefast ice. Without the protection of shorefast sea ice, storms, particularly in the fall, direct stronger waves and wind onto coastlines. Together, these two phenomena increase the potential for erosion and inundation.

**Sea levels have risen and will continue to rise.**

- Sea levels have increased globally by seven inches since 1900.[6] Mid-level projections result in 1.1 feet of global sea level rise by the 2050s and 3.3 feet by the 2100s; with 5.9 feet of additional rise by 2150 and 9.2 feet by 2200.[7]

### What We Know We Don't Know

Predicting the magnitude and pace of change on the sea level rise is hard everywhere, and much more so on the west coast of Alaska.

**We have weak information on existing ocean levels and coastal topography.**

- Data in the YK Delta used for inundation mapping "is referenced to a USGS vertical reference frame from 1929, based on historic sea levels, and with no established conversion to modern reference frames."[8]

**We have minimal ocean observation equipment collecting data.**

- Thousands of tidal gauges line the Lower 48 coasts. These give precise information on sea levels, sea temperatures and other related data. There are no tidal gages on Alaska's west coast between the Alaska Peninsula and Unalakleet on Norton Sound.[9]

**Profound uncertainty about the specific local rate and magnitude of sea level rise, globally and in Alaska.**

- Uncertainty about future global greenhouse gas emissions, which increase temperatures, and in turn, drive sea level rise.
- The complex dynamics of local sea level change: the ocean does not rise equally all over the earth (like in a bathtub), but instead is affected by local temperatures and surface elevation changes.
- Uncertainty about game-changing factors like the potential melting of the Greenland and Antarctic ice sheets. Recent information suggests that melting could accelerate in those locations, adding significantly more water to the Earth's oceans.

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[6] Sweet et al. 2017.

[7] Sweet et al. 2018.

[8] Climate Central: http://ss2.climatecentral.org/#meth

[9] http://tidesandcurrents.noaa.gov/map/index.html?type=active&region=Alaska



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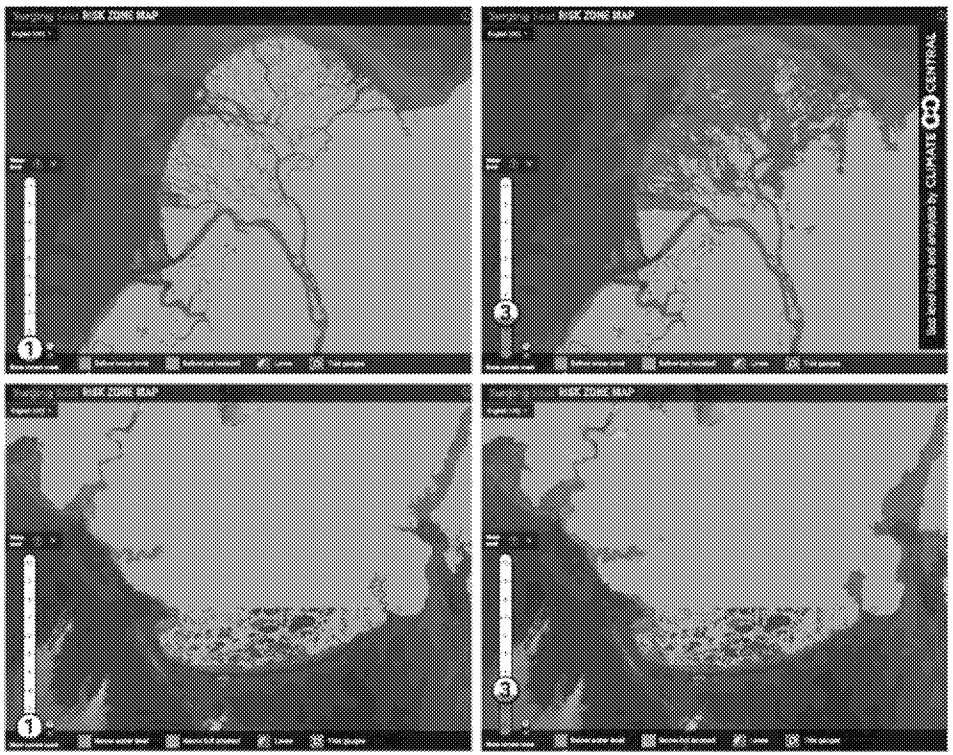
# Putting It All Together

It is not possible to describe with certainty the extent of future Y-K Delta coastal inundation due to sea level rise. While the extent of inundation cannot be predicted, all indicators say that in the next 50, 100 or 200 years, it is very likely that substantial portions of the Y-K Delta region (including many coastal communities) will be inundated by rising seas. The impact of rising seas will be complicated by the growing risks of significant inundation from temporary storm surges.

**Figure 7. Projected Inundation for the Y-K Delta at Two Levels**



*The mapping tool used to create these images relies on historical reference and 60-meter horizontal resolution USGS digital elevation models. Images courtesy of Climate Central: http://sealevel.climatecentral.org*

Figure 7. shows projected relative levels of inundation for the Yukon Delta (top row) and the Southern Y-K Delta (bottom row) for one and three feet of static sea level rise relative to historical elevation.

Low risk of inundation from sea level rise alone does not necessarily mean low probability or low consequence climate impacts. These maps do not add the significant, related secondary impacts of sea level rise. Risks and consequences of these secondary impacts, such as storm surge flooding, erosion, and (where permafrost is present) permafrost degradation, are particularly severe in the Y-K Delta region.

The Climate Science Special Report (CSSR) of the Fourth National Climate Assessment notes that there is an extensive array of scientific work to support the statement that, "The extent and depth of minor-to-major coastal flooding during high-water events will continue to increase in the future as local relative sea level rises."[10]

[10] USGCRP, 2017: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp. Chapter 12: http://science2017.globalchange.gov/chapter/12/



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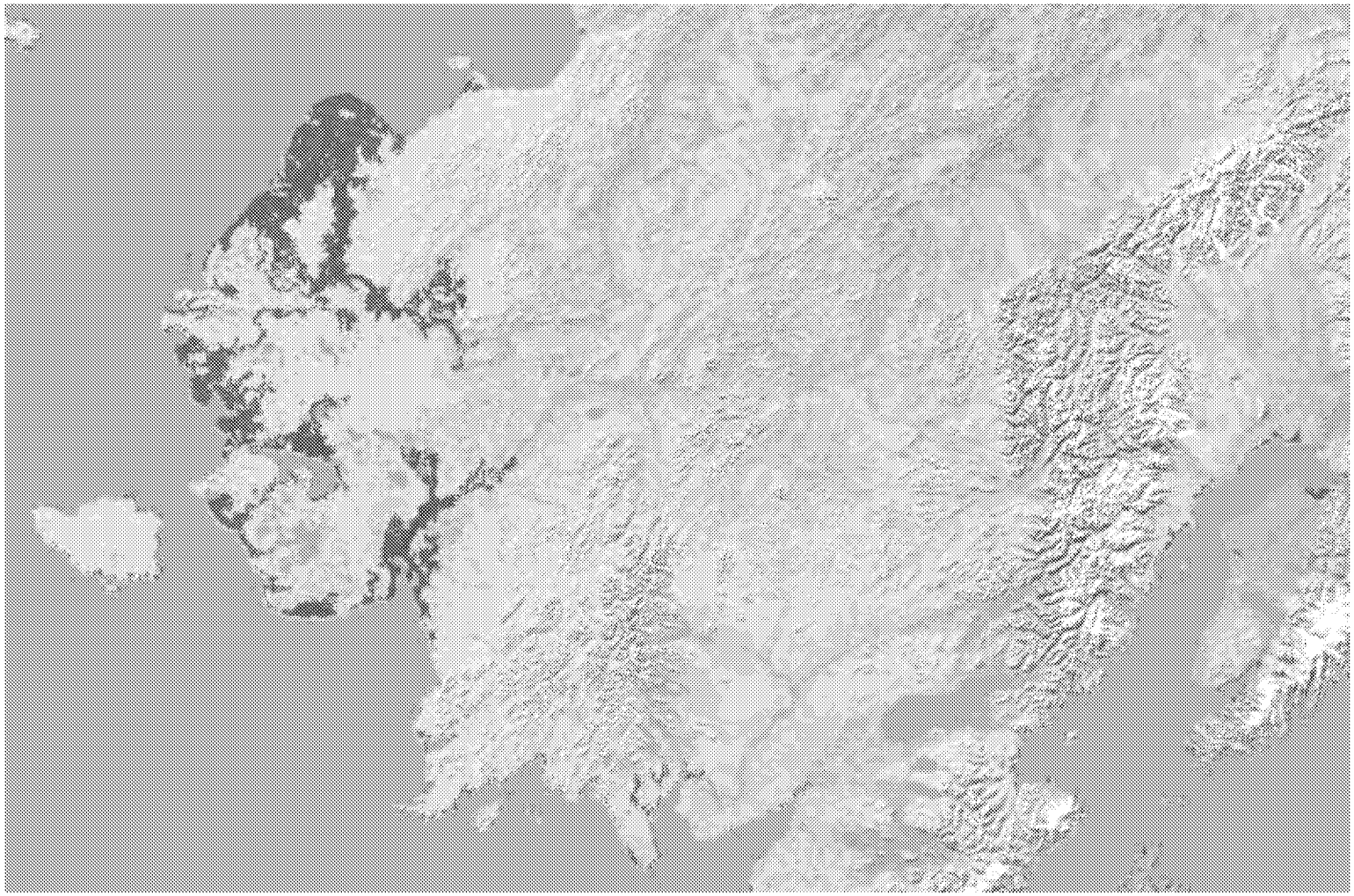
**Figure 8. Projected Sea Level Inundation with 2-meter (6.5-foot) Sea Level Rise**



The maps on the previous page show projected areas of inundation with sea level rise of 1 foot and 3 feet; this map shows projected inundation with a rise of two meters (about 6.5 feet). This sobering image has all the uncertainties outlined on the previous pages, including lack of solid information on current sea levels, existing topography, rate of permafrost thaw, and future greenhouse gas emissions. Despite these issues, the map provides useful illustration of the magnitude of impacts that could come with sea level rise currently projected to occur in the next 200 years. *Source:* *http://www.cresis.ku.edu/sites/default/files/Research/Maps/Alaska/PDF/alaska_2m.pdf*



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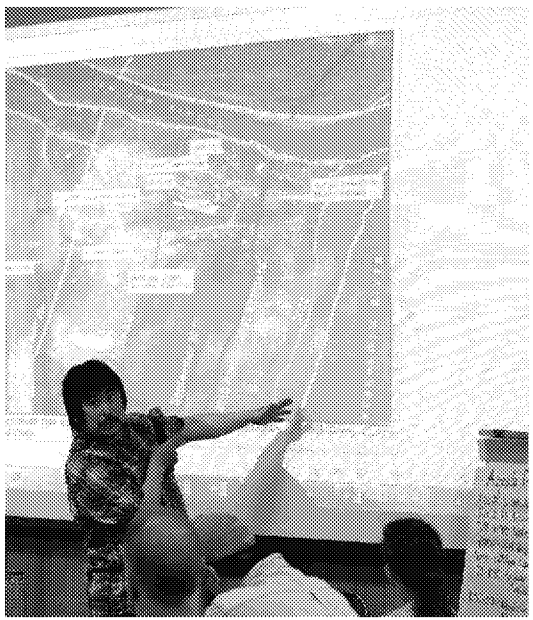
# Adapt Y-K Delta Process



*David Andrew, Native Village of Napakiak at the Steering Committee meeting August 2018. Photo courtesy of Ian Dutton, Nautilus Impact Investing.*

"It's too heavy for one person to lift something. You need other people to lift. We can't do the work as one person; we have to work together to get this thing done."

*– James Charles, Adapt Y-K Delta Steering Committee Member*

In 2015-16 the Western Alaska and Aleutian Bering Sea Islands (ABSI) Landscape Conservation Cooperatives (LCCs) facilitated a series of four regional dialogues on climate change in northern and western Alaska.[11] Those dialogues recognized that a more concerted local and regional adaptation effort is needed in the Y-K Delta. The increasing severity and scale of climate changes and increasing calls for action prompted this effort to get started in the Y-K Delta.

The Adapt Y-K Delta process began in 2017 under the auspices of the Western Alaska LCC. The Western Alaska LCC Steering Committee represents Federal, State and Alaska Native stakeholders who have a vested interest in the development of applied science products related to climate change in Western Alaska. The Western Alaska LCC Steering Committee recognized the need for an action-oriented regional climate adaptation process. They enlisted participation from other local, regional and statewide organizations with support from Alaska-based consultants Agnew Beck Consulting, Nautilus Impact Investing, Alaska Sea Grant and the Alaska Silver Jackets Partnership.[12] Further details of Adapt Y-K Delta Steering Committee members and advisors are listed in Appendix 1. The timeline and trajectory of the project is outlined in Figure 9.

[11] Report and products available at http://adaptalaska.org/

[12] Alaska Silver Jackets is a partnership of Federal and State agencies that promote and develop solutions for natural hazards risk reduction and management. For more details see: http://silverjackets.nfrmp.us/State-Teams/Alaska



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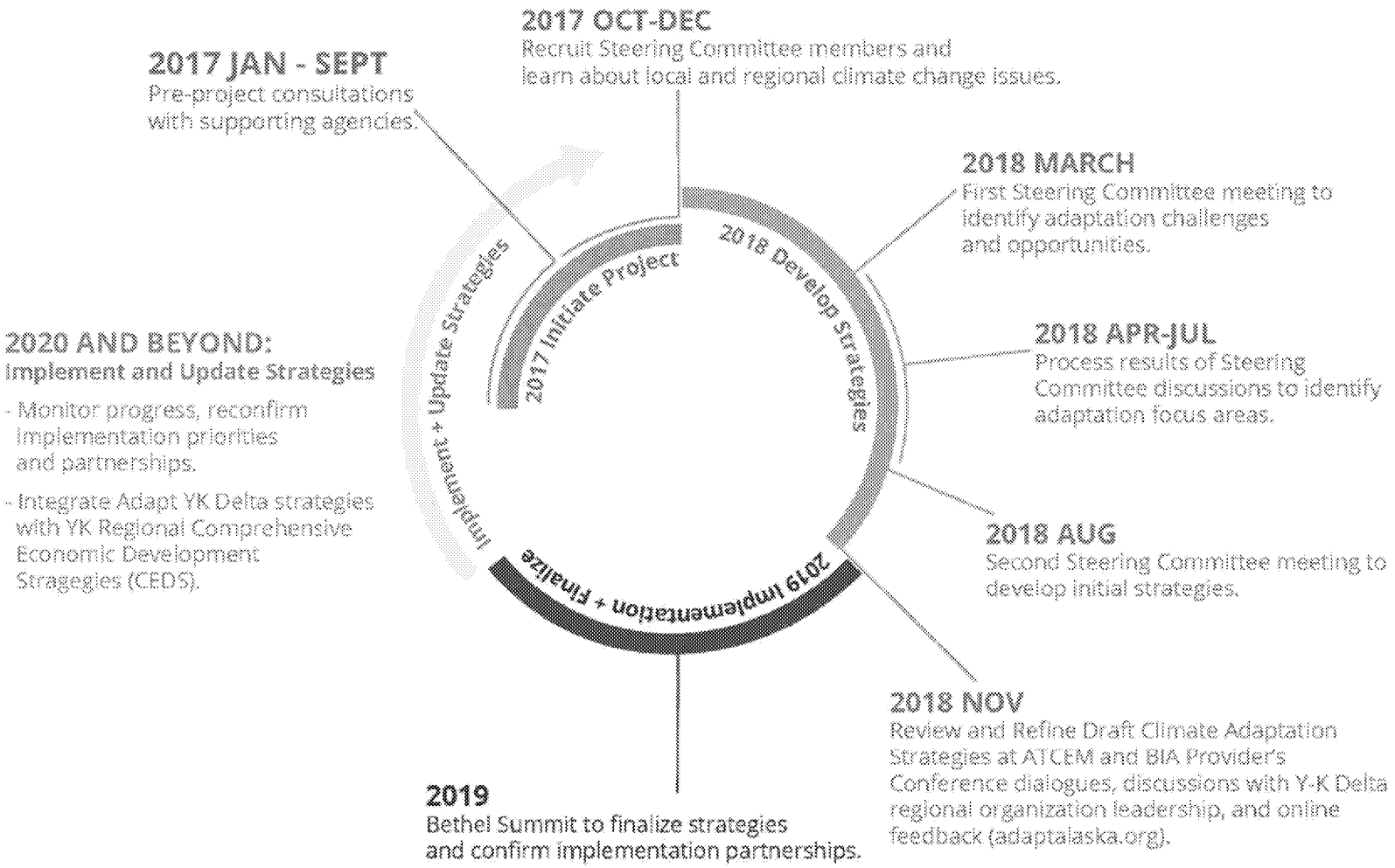
**Figure 9: Adapt Y-K Delta Project Timeline**



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Adapt Y-K Delta Steering Committee meetings and activities undertaken between meetings were guided by a process known as Open Standards/Healthy Country Planning. The Open Standards (OS)[13] process is an adaptive management cycle in which participants systematically plan, implement and monitor adaptation options to learn what works (or not) and why. The OS process has been refined by indigenous communities globally to better incorporate social and cultural concerns; that process is known as Healthy Country Planning (HCP).[14] The Adapt Y-K Delta process blended elements of both HCP and OS methods with local participatory planning approaches.

The two key elements that have defined the Adapt Y-K Delta process have been:

1) *A focus on bringing together stakeholders from through the Y-K Delta with experts and agencies from across the state.* In such a complex region, there is a need for collaboration at many levels. The Adapt Y-K Delta process actively seeks to engage experts from diverse backgrounds with local experts in a collaborative dialogue to tackle the many issues and opportunities associated with climate change.
2) *A commitment to action.* The Adapt Y-K Delta process prioritizes actions that promote short-term community adaptation and build longer-term community resilience.

Over time, it is expected that the vision, targets, threats, opportunities and strategies identified so far may need to be adjusted in the light of new information, and after the implementing initial adaptation strategies. That is the essence of adaptive management.

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[13] More about the Opens Standards process: http://cmp-openstandards.org/

[14] The model HCP that most informed this process was the plan developed by the Wunambal Gaambera aboriginal people in northern Australia: http://www.wunambalgaambera.org.au/healthy-country-plan.htm



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# Our 2120 (100-year) Vision

## Current and future generations enjoy healthy ecosystems that sustain our communities and our indigenous way of life.

"We can't keep expecting others to solve our problems. Communities have to solve problems on their own." – *Adapt Y-K Delta Steering Committee Member*

*Photos from Adapt Y-K Delta Steering Committee meetings. Top left: Patrick Sampson, Orutsararmiut Native Council; Nick Kameroff Jr., Kuskokwim River Inter-Tribal Fish Commission; Dr. Stephen Gray, U.S. Geological Survey. Top middle: Mellisa Heflin, Bering Sea Elders Group. Top right: Adapt Y-K Delta Steering Committee meeting discussion August 2018. Bottom left: Fred Phillips, Bering Sea Elders Group. Bottom middle: Aaron Moses, U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge. Bottom right: Adapt Y-K Delta Steering Committee meeting discussion March 2018. Photos courtesy of Ian Dutton, Nautilus Impact Investing.*



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# Targets

"Villages need jobs, or young people will keep moving away." – *Adapt Y-K Delta Steering Committee Member*

The Steering Committee identified seven major targets that together are key to the achievement of the Adapt Y-K Delta vision. These seven targets were selected after a comprehensive Steering Committee discussion of those natural and cultural elements of the Y-K Delta region that are most directly linked to the vision. It was noted that additional targets may become important over time, but these initial seven were the most critical to focus on over the next five years.

In establishing a current rating baseline of health for each of the targets, Steering Committee members used the traffic light rating below. The rating was challenging for some targets because of the high level of variability within the region and lack of clear data on the indicators of target health. However, the Steering Committee recognized that even with those limitations, this approach provides a basis for collective assessment of target health. In the OS/HCP process, targets with a health rating of fair or poor are key candidates for immediate action.

| | |
|---|---|
| **Very Good** | The key part of the target is very healthy and does not need too much work to be done to keep it very healthy. |
| **Good** | The key part of the target is healthy and may need some work to be done to keep it healthy or to make it very healthy. |
| **Fair** | The key part of the target is not healthy and needs work to be done to make it healthy again. If no work is done it will get worse. |
| **Poor** | The key part is unhealthy, and if no work is done soon to make it better, it may never be healthy again. |

| Target | Summary of Scope/Importance and Indicators | Current Health |
|---|---|---|
| **Intact Terrestrial Habitat** | Terrestrial habitat encompasses the mosaic of vegetation and wetland types that characterize the Y-K Delta region. From tundra to seasonally inundated wetlands, these habitat types provide a diverse range of subsistence foods and food for mammals and birds, which are also subsistence food resources.<br>**Indicators**:<br># area of tundra/lichen<br># area altered by trails, roads, development<br># area affected by fire annually<br># percent change in land and water cover by year | **Fair** |



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| Target | Summary of Scope/Importance and Indicators | Current Health |
|---|---|---|
| **Large Mammals** | The Y-K Delta supports large herds of caribou and increasing numbers of moose as shrub coverage increases. Less abundant but increasing are large animals such as musk ox. These mammals are key to food security in the Y-K Delta region, but changes in range and abundance are an increasing cause for concern as well. For example, as caribou migration changes, there are often greater costs associated with hunting.<br>**Indicators**:<br># caribou harvested<br># range of caribou<br># moose habitat area | **Fair** |
| **Migratory Birds** | The Y-K Delta supports one of the largest aggregations of waterbirds in the world. Over one million ducks, half a million geese, and 100,000 swans breed here. All minima cackling geese breed exclusively on the Y-K Delta, along with the vast majority of Pacific greater white-fronted geese, emperor geese, and black brant. In addition, nearly 50,000 loons and 30,000 cranes return to the Y-K Delta each spring to nest. Moreover, the Y-K Delta represents one of just three breeding locations in the world for spectacled eiders, a species currently listed under the Endangered Species Act. Millions of shorebirds use the refuge for breeding and staging. In fact, the Y-K Delta is one of the most important shorebird nesting areas in the country, and the vast intertidal zone is one of the most important wetlands for post-breeding shorebirds on the west coast of North America. Nearly the entire populations of several shorebird taxa, including bar-tailed godwit, bristle-thighed curlew and red knot, rely on the Y-K Delta at some point during their annual cycle. The Y-K Delta meets all criteria for the Ramsar Convention on Wetlands of International Importance and has been identified a site within the East Asian-Australasian Flyway Network and the Western Hemisphere Shorebird Reserve Network.<br>**Indicators**:<br># extent of permafrost # abundance of key species for subsistence | **Good** |
| **Healthy Marine Ecosystems** | The nearshore waters of the Y-K Delta have rich populations of marine mammals, such as seals and walrus, and are closely connected with the highly productive waters of the Bering Sea, where seasonal upwelling generates highly productive feeding grounds for marine mammals, seabirds and fish.<br>**Indicators**:<br># fish and sea mammals # sea ice # ocean acidification | **Fair** |
| **Salmon** | Both the Yukon and Kuskokwim rivers support runs of all five salmon species in Alaska. Those salmon runs have formed a major part of the subsistence diet of local communities and are also sustain important commercial and sport fishing industries. Concerns about fish availability and run timing are increasing as later runs result in more meat waste.<br>**Indicators**:<br># size and timing of total harvest | **Fair** |



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| Target | Summary of Scope/Importance and Indicators | Current Health |
|---|---|---|
| **Traditional Knowledge and Relationships** | Traditional knowledge is critical to community health and resilience. The ability of traditional knowledge to be shared within the community in traditional ways involving multi-generational networks has been diminished in the past century as a result of external interventions and restrictions, including limitations on the practice of native languages and arts. While there has been some revival of language training and use in the lower Y-K Delta, as Elders pass, there is increasing loss of local traditional knowledge, including subsistence practices.<br>**Indicators**:<br># Youth who speak local language # Length of time of fish camp use<br># Dried fish per household # Youth learning roles<br># Times law enforcement officers are called to household incidents | **Poor** |
| **Community Infrastructure** | Y-K Delta households and communities rely on a range of infrastructure to support economic, social and cultural activities. From buildings to airports, to sewage and drinking water supplies, to hospitals, cemeteries and schools, to trails and walkways, there is a vast array of infrastructure types that are vulnerable to climate change impacts, especially those related to permafrost degradation and reductions in sea ice.<br>**Indicators**:<br># Increased coastal and riverine erosion rates<br># Relocation and rebuilding of critical infrastructure<br># Increased maintenance costs | **Poor** |

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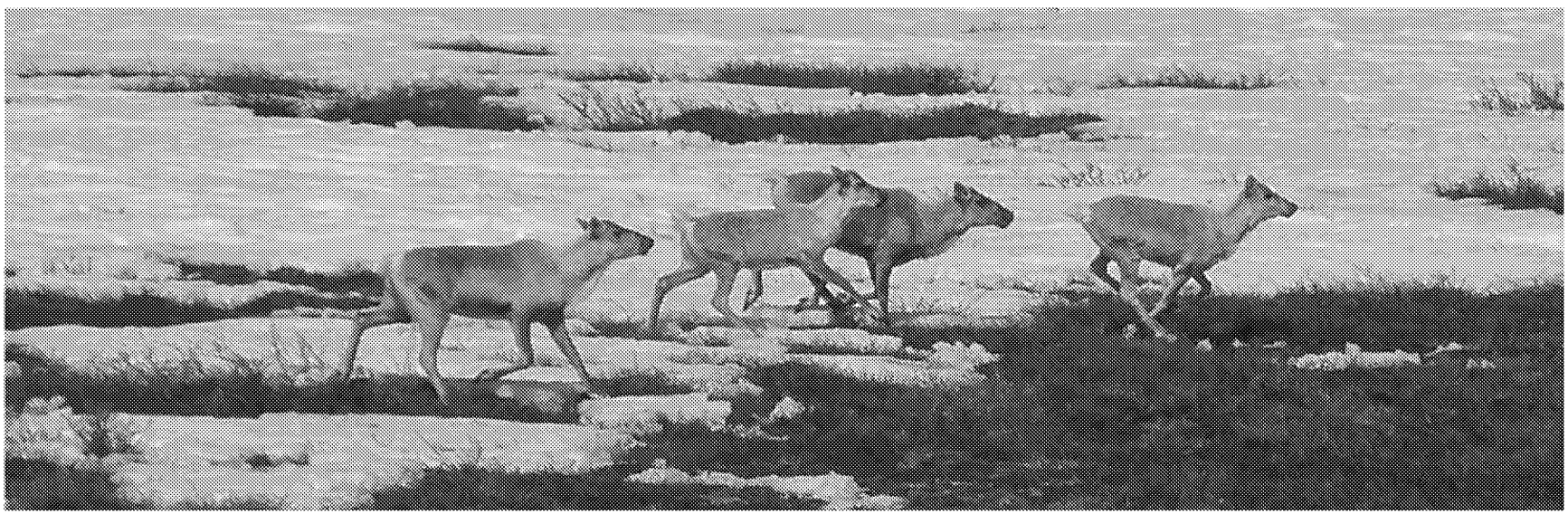
# Impacts on Targets

"Land has been eroding for an eternity – it's a delta!" – *Adapt Y-K Delta Steering Committee Member*

The health of all seven targets is affected by a range of processes and phenomena, many of which are related to global climate change. The table on the following page summarizes the intensity and scope of the various types of threats identified by Steering Committee members. The rating was very challenging for many targets because of the high level of variability within the region, the lack of clear data on the indicators of target health, and the complexity of impacts. For example, sometimes a change brings both positive and negative change.

Threats are classified as: very high (red) to high (orange) to medium (yellow) to low (green) or non-relevant (white). Under the OS/HCP process, threats that pose a very high or high threat to targets are typically a focus for immediate action. As may be expected, the overall and more impacts of climate change stand out as the major threat to the condition of Adapt Y-K Delta targets.



*Climate change is affecting every dimension of life in the Y-K Delta. Vegetation and precipitation patterns are changing, altering growing seasons and the pattern and availability of subsistence foods. An apparently positive change is area's growing moose population.*



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| Threats ↓ / Targets → | Intact Terrestrial Habitat | Large Mammals | Migratory Birds | Healthy Marine Ecosystems | Salmon | Traditional Knowledge and Relationships | Community Infrastructure |
|---|---|---|---|---|---|---|---|
| ATV and snowmachine use | HIGH | HIGH | HIGH | | MEDIUM | | HIGH |
| Noise Impacts on Wildlife | | VERY HIGH | VERY HIGH | | LOW | | |
| Trash | MEDIUM | LOW | MEDIUM | HIGH | MEDIUM | MEDIUM | MEDIUM |
| Mining | VERY HIGH | HIGH | HIGH | HIGH | HIGH | HIGH | LOW |
| Bycatch | | | HIGH | | VERY HIGH | | |
| Illegal Hunting | | HIGH | HIGH | | | MEDIUM | |
| Trawling | | | MEDIUM | VERY HIGH | HIGH | MEDIUM | |
| Illegal Fishing | | | LOW | MEDIUM | HIGH | MEDIUM | |
| Loss of Traditional Knowledge | MEDIUM | HIGH | HIGH | HIGH | HIGH | HIGH | MEDIUM |
| Western Science and Processes Dominate | MEDIUM | HIGH | HIGH | HIGH | HIGH | VERY HIGH | LOW |
| Lack of Access to Work Opportunities | | MEDIUM | MEDIUM | | MEDIUM | HIGH | HIGH |
| Loss of Subsistence Economies/Skills | | MEDIUM | MEDIUM | LOW | MEDIUM | VERY HIGH | MEDIUM |
| Climate Change Effects Overall[15] | HIGH | HIGH[16] | VERY HIGH | HIGH | HIGH | HIGH | VERY HIGH |
| • Permafrost Thaw | VERY HIGH | HIGH | VERY HIGH | | HIGH | HIGH | VERY HIGH |
| • Erosion | HIGH | MEDIUM | VERY HIGH | MEDIUM | HIGH | HIGH | VERY HIGH |
| • Loss of Sea ice | VERY HIGH | LOW | HIGH | VERY HIGH | MEDIUM | VERY HIGH | VERY HIGH |
| • Increased Rainfall | HIGH | MEDIUM | VERY HIGH | HIGH | VERY HIGH | HIGH | VERY HIGH |
| • Increased Flooding | VERY HIGH | MEDIUM | VERY HIGH | HIGH | VERY HIGH | HIGH | VERY HIGH |
| • Increased Fire | VERY HIGH | HIGH | HIGH | | MEDIUM | HIGH | HIGH |
| • More Extreme Weather | HIGH | VERY HIGH | VERY HIGH | HIGH | MEDIUM | HIGH | VERY HIGH |
| • Ocean Acidification | | | LOW | MEDIUM | MEDIUM | | |

[15] This rating for overall climate change effects is a composite of the ratings for individual climate impacts, which are summarized in the specific threats listed below that rating.

[16] Note that the rating is moderated by positive impacts on moose and negative impacts on caribou.



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# Strategic Opportunities for Action

"We have to be proactive, not only reactive." – *Adapt Y-K Delta Steering Committee Member*

After assessing the key targets that must be healthy for the Adapt Y-K Delta vision to be attained, the Steering Committee evaluated the threats and opportunities that affect the health of the targets. The Steering Committee then identified the sources of those threats and opportunities, and developed a situation analysis to assess options for adaptation response. The situation analysis is presented in Appendix 3.

That analysis, and conversations with Steering Committee members and advisors, revealed three near-term focus areas for potential action: (1) subsistence, (2) community infrastructure and (3) trails and transportation. Other strategic opportunities, such as responses to the possible effects of mining, were also discussed. The group chose to prioritize a limited set actions that met the following criteria:

a) the strategy/action can begin quickly;
b) the strategy/action addresses targets of immediate community concern;
c) the strategy/action does not duplicate work already in progress; and
d) the strategy/action has the potential to improve target conditions within the next five years.

**Seven Targets**

- Intact Terrestrial Ecosystems
- Large Mammals
- Migratory Birds
- Healthy Marine Ecosystems
- Salmon
- Traditional Knowledge and Relationships
- Community Infrastructure

**Criteria**

**Strategies/Actions in Three Focus Areas**

- Subsistence Resources Harvest Practices
- Community Infrastructure
- Trails and Transportation

The goal of the action matrices that follow is to translate good ideas into tangible action. Each matrix includes a column labeled "who"; that is, "Who are the entities most likely able to carry out the priority action?" It is expected that every five years, these strategies will be refined and new strategies added.



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# Strategic Opportunity 1: Subsistence Resources and Practices

"Hindu is a way of life and so is Alaska Native's relationship with the land, natural environment and all that is in it." – *William Naneng, Adapt Y-K Delta Steering Committee Member*

## The Challenges and Opportunities

Changing climate affects many aspects of subsistence resources and harvest practices, as is indicated in the situation analysis. Climate-related changes have become more variable and impactful on subsistence-dependent households and communities over the past 10-20 years. These changes are inter-related and include:

a) *changes in the physical environment*, e.g., changes in precipitation and snowfall patterns, longer periods of rainfall during harvest periods, warmer weather during meat processing periods, etc.;
b) *changes in the biological environment* (many of which are responses to physical changes), such as increased moose abundance as tundra converts to shrub cover, the changing distribution of berries as tundra structure evolves, changes in fish run timing and abundance (especially in the early season), etc.; and
c) *changes in the social environment*, including loss of skills to process fish and meat due to other work commitments of harvesters, loss of knowledge about traditional harvest practices, need to process large volumes of fish in a short period due to limited opening periods, etc.

In sum, these changes affect the availability of subsistence resources and require new ways of harvesting and processing fish and meat. They also require a deeper investment in research at the local scale to better understand the nature and trends of change and response options, as well as community education and outreach to ensure that Y-K Delta households are equipped to adjust their harvesting practices.

Note that in the following tables, priorities are based on the following color coding:

| Key to Strategic Action Priorities | |
|---|---|
| **Very High Priority** | A critical action within the context of these adaptation strategies; put forward as highest funding priority. |
| **High Priority** | Makes a substantial contribution to these adaptation strategies; lower priority for funding than Very High Priorities. |
| **Medium Priority** | Moderately important to these adaptation strategies; fund as resources permit. |



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## Subsistence Resources and Practices Adaptation Actions

| Objective | Action | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| **Strategic Action S1: Further assess the effectiveness of trial fish preservation methods. Explore new options to ensure fish processing meets community needs and avoids waste.** | | | | |
| **S1A.** Document the effectiveness of the 2018 Fish Preservation Pilot Project. | **S1A1.** Evaluate the pilot project: conduct interviews/surveys of participants and use these to:<br>(a) refine methods of fish and meat protection, and<br>(b) develop education materials. | **Very High Priority**<br>**2019**<br>**$** | U.S. Fish and Wildlife Service, Orutsararmiut Native Council | Creates a dialogue to determine best practices, then documents best practices (video, audio or in person). |
| **S1B.** Continue Fish Preservation Projects with a 2019 Fish Preservation Project. | **S1B1.** Hold a student competition. Identify alternative preservation techniques and innovations at household and community levels by running an innovation sprint or similar competition (possibly linked with Bering Sea Fishermen's Association Ocean Cluster Initiative[17]). | **High Priority**<br>**2020**<br>**$$** | Alaska Native Science and Engineering Program, Elders, Schools, Bering Sea Fishermen's Association, OTIS program[18] | Local youth (middle school, high school or summer bridge students) develop new ideas for fish preservation. OTIS competition format encourages fast innovation and has a high profile among funders. |

[17] Bering Sea Fishermen's Association OTIS (Ocean Technology Innovation Sprint) is an elite program based on the Google Ventures Sprint process that engages designers, engineers, marketers, finance and startup enthusiasts, who form interdisciplinary teams to solve challenges for Alaska's blue economy, the sustainable and impactful development of our vast ocean resources. No experience is needed to participate: www.otis.blue

Ocean Tuesday (www.oceantuesday.com) is a statewide community committed to advancing Alaska's blue economy. Ocean Tuesday brings people together throughout Alaska and the world to talk about innovation and entrepreneurship in the maritime-related 'blue' economy.

[18] Ibid.



ED_013708_00001218-00374

| Objective | Action | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| **S1C.** Increase access to community-based resources to support food preservation activities. | **S1C1.** Create a lending program for canning supplies and/or a community kitchen and smokehouse open to community members. Designate community kitchen(s) for canning that can be used by all members of the community. Create a donate-back program for Elders. | **High Priority**<br>**2019**<br>**$** | Non-Governmental Organizations, environmental or health programs in local community village governments, organizations, and universities.[19] | Provide an opportunity to preserve fish during a rainy season. Provides an opportunity to have preserved fish for community use such as elders' lunches, etc. |
| **Strategic Action S2: Promote increased knowledge-sharing among Y-K Delta communities for community resilience.** | | | | |
| **S2A.** Share ideas, traditional knowledge and new strategies by engaging youth with Elders in dialogues and learning activities. | **S2A1.** Create learning labs and encourage youth to get involved. | **High Priority**<br>**2019-2023**<br>**$** | Hooper Bay Charter School (developing this type of curricula), Alaska Native Science and Engineering Program, Alaska Pacific University, Y-K Delta School Districts | Communities regain and preserve knowledge, food security, mental health and wellness. Youth engagement with Elders in developing community resilience is encouraged. |
| | **S2A2.** Youth hunts before school starts.<br>**2A3.** Educational special use permits for harvest for fish camps, school, and | **Medium Priority**<br>**2020** | Alaska Department of Fish & Game, Y-K Delta Schools, possibly U.S. Fish and Wildlife | Students will be engaged in culturally relevant place-based science and participate in an activity that is important for cultural continuity. |

[19] University Cooperative Extension has information on community food preservation. Possibly AVCP or E3 can work with regional village corporations to help identify and coordinate on funding opportunities for priority community projects.



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| Objective | Action | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| | place-based science. | $ | Service[20] | |
| **S2B.** Systematically engage and document Elders' knowledge. | **S2B1.** Encourage researchers to document fish, wildlife and seabird harvesting and processing practices through interviews with Elders. | **High Priority**<br>**2019-2023**<br>**$** | First Alaskans Institute Summer interns, University of Alaska Fairbanks student researchers | Recorded interviews with Elders contribute to both historical archives and contemporary education materials. |
| **S2C.** Produce educational materials that can be easily accessed by community members. | **S2C1.** Create booklets and/or video series for multiple audiences.<br>**S2C2.** Expand the use of social media to engage community members and ensure knowledge is available in a timely and consistent manner (possibly with a dedicated Facebook membership page on subsistence processing methods). | **Medium Priority**<br>**2020-2023**<br>**$** | First Alaskans Institute Summer intern programs, Association of Village Council Presidents Interns, Alaska Sea Grant education materials | Publications and video series link to social media to make information about processing methods widely available throughout the Y-K Delta (and possibly statewide via the Alaska Sea Grant network). |
| **Strategic Action S3: Refine current management processes related to fish and wildlife harvesting practices. Better incorporate local knowledge, local concerns, and ensure that local stakeholders have a better understanding of seasonal plans and policies.** | | | | |
| **S3A.** Increase local pre-season engagement in | **S3A1.** "Kuskokwim Annual Pre-season Fish Gathering." Convene an annual pre-season meeting of Kuskokwim | **Very High Priority** | Association of Village Council Presidents, Kuskokwim River Inter- | Agencies receive increased public input into their decision-making process. Individuals and fishermen better understand others' |

[20] Note: USFWS supports science and educational camps already. On the Kuskokwim River, Federal lands are far enough from Bethel that logistics become daunting for these activities. Science camps are typically set up on private land, which does not require a State or Federal permit.



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| Objective | Action | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| fisheries policy ("safe space gathering"). | stakeholders and agencies, facilitated in Bethel by an outside facilitator, to inform agencies of local concerns and to share agency information and resources.<br><br>**S3A2.** Board of Fisheries and/or Federal Subsistence Board class led by the Tribal Wildlife Program at UAF. Plan for when the Board cycle has a meeting in Bethel or area community. | 2019<br><br>$$ | Tribal Fisheries Commission, Orutsararmiut Native Council, Alaska Department of Fish & Game, U.S. Fish and Wildlife Service.[21]<br>*Funding:* Calista, Office of Subsistence Management, Coastal Villages Region Fund, Bering Sea Fisherman's Association, Kuskokwim Corp., MTNT, Ltd. | concerns as well as agency thinking, and can provide input to the Board of Fish, Resource Advisory Councils, etc. |
| **S3B.** Build capacity for individual stakeholders to increase local involvement and employment in management and regulation. | **S3B1.** Create a coordinated post-secondary educational program for rural Alaskans interested in employment or community leadership in fish management. Dedicate funding among participating universities and agencies to develop curricula and fund student grants/scholarships. | Very High Priority<br><br>Long term<br><br>$$$$ | Alaska Department of Fish & Game, US Fish and Wildlife Service, Alaska Sea Grant, University of Alaska Fairbanks, Alaska Native Science and Engineering Program | Graduates are qualified for open positions in resource management and regulation. Communities, stakeholders and leaders are more knowledgeable. |

[21] The University may offer trainings about when and how agency processes work. Area committee meetings that inform Board of Fish/Board of Game meetings could be used to educate attendees about relevant processes.



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| Objective | Action | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| **S3C.** Share better information on changes to seasonality. | **S3C1.** Conduct more outreach on changes in fish run timing: When will fishing occur? Will these changes push fishing to the rainy season?<br>**S3C2.** Share better information on seasonal weather changes so people can adjust preservation methods (e.g., if rain is expected people can smoke and can more fish; when it is sunny, people can dry fish outside). | **High Priority**<br>**2019**<br>**$** | Coordination among local regulatory group(s), University of Alaska, Alaska Department of Fish & Game, others. [22] | Residents are better prepared for subsistence harvest and preservation. |
| **Strategic Action S4: Continue berry research projects and share results with Y-K Delta communities.** | | | | |
| **S4A.** Continue research currently underway by the USGS to better understand berry patch dynamics on the Y-K Delta. | **S4A1.** Continue to support berry research and modeling.<br>**S4A2.** Undertake outreach to local communities about the results of berry modeling and engage them in monitoring activities. | **Very High Priority**<br>**2018-2023**<br>**$$$** | U.S. Forest Service, Western Alaska Landscape Conservation Cooperative | Stakeholders have a better understanding of climate change impacts on berries and can begin to develop adaptation strategies for harvesting. |
| **S4B.** Look into alternative berry production methods as backup. | **S4B1.** Assisted migration of berry species. Transplant wild berry species where new environmental conditions will allow them to grow. | **Medium Priority**<br>**2019 and beyond**<br>**$** | Possibly U.S. Department of Agriculture, U.S. Forest Service | Berry species will continue to be available. |

[22] Intertribal fish commissions are the best sources for pre-season subsistence harvest openings. Alaska Ocean Observing System forecasts runs. U.S. Geological Survey and/or NOAA National Weather Service may be able to provide information on seasonal weather.



ED_013708_00001218-00378

# Strategic Opportunity 2: Community Infrastructure Resilience

"Developing partners is important because there are so many issues. IGAP (Indian General Assistance Program) and Brownfields programs are good examples. We need to share successes of communities with each other, such as grant proposals. Look for similar communities. We don't have to reinvent solutions!" – *Janessa Esquible, Orutsararmiut Native Council*

"We don't need to just spring back in the face of climate change challenges; we need to spring forward!" – *Adapt Y-K Delta Steering Committee Member*

## The Challenges and Opportunities

Community infrastructure, from the village to the household scale, are vulnerable to disruption and potentially failure and loss as climate change impacts accelerate in the Y-K Delta region. As with subsistence resources, impacts are driven by multiple causes and are often cumulative in effect. For example, a coastal building that may be failing due to permafrost thaw may also be vulnerable to erosion as sea ice cover is lost and winter storms accelerate coastal erosion. Of equal concern is the lack of a comprehensive infrastructure response strategy and funding pool.

*Y-K Delta communities rely on rivers and barge infrastructure to receive and distribute goods throughout the region. Low water, streambank erosion and flooding are combining to make movement of freight by barge and maintenance of barge landing port infrastructure increasingly costly and unreliable. Photo courtesy of Ian Dutton, PhD.*

Increasing funding for all aspects of climate change response is the single most effective means to support Alaska's communities in addressing the unavoidable impacts of climate change. Neither a comprehensive analysis of all costs associated with climate change in Alaska nor a comprehensive analysis of the benefits of proactive adaptation exist. However, two recent studies provide some indication of the costs. Melvin et al. (2016) estimated climate-related damages to Alaska's infrastructure would cost $5.5 billion between 2015 and 2099.[23] Their estimate did not include most infrastructure in rural Alaska; the actual cost is likely

[23] Melvin et al. (2016.) Climate Change Damages to Alaska Public Infrastructure and the Economics of Proactive Adaptation. Proceedings of the National Academy of Sciences.



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to be significantly higher than $5.5 billion. In 2018, the University of Alaska's Institute for Social and Economic Research (ISER) estimated that it will cost $50 million to $100 million per year for Alaska communities to protect and move infrastructure in response to environmental threats.[24] In the ISER study, "protect" refers to building structural solutions to environmental hazards (e.g., a sea wall to mitigate flooding), and "move" refers to migrating community infrastructure from hazard-prone areas to safe locations adjacent to or distant from existing sites.

At the same time, it is also clear that infrastructure technologies widely used in remote Alaskan villages have often proven to be difficult to maintain and afford. While systems like water and sewer delivery bring huge benefits, many communities have struggled to sustain these systems within locally available resources. Reliance on diesel and fuel oil likewise continues to be extraordinarily costly. With these realities in mind, people in the region are hoping the incentives of climate change might lead to a shift to new, more sustainable forms of community infrastructure, and creative, more self-sufficient, adaptation strategies.

## Community Infrastructure Adaptation Actions

| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| **Strategic Action I1: Expand the capacity of Y-K communities to anticipate and respond to climate change-related hazards.** | | | | |
| **I1A.** Measure and document the rate of erosion, storm flooding, sea level, and permafrost thaw in a manner that meets the technical requirements of funding agencies.<br><br>The following website | **I1A1.** Work with Alaska DNR DGGS to train community members in standardized monitoring protocols.<br><br>**I1A2.** Conduct monitoring in collaboration with State, so the information is shared and used.<br><br>**I1A3.** Set up a community managed system (e.g., through EPA IGAP program) to oversee the monitoring work. Monitoring activities can be | Very High Priority<br><br>Near term | Alaska Division of Geological & Geophysical Surveys, Environmental Protection Agency Indian General Assistance Program, community volunteers, students, Alaska Silver Jackets Partnership, U.S. | Credible environmental change data serves as a reference for planning and a basis for obtaining funding.<br><br>*Note about I1A2.* Getting the full value from monitoring requires following state and national standards and requirements for resource distribution. |

[24] Bergman, M and Schmidt, J. (2018). Economic Effects of Climate Change in Alaska. Institute for Social and Economic Research, University of Alaska Anchorage.



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| highlights the environmental data that are needed: http://dggs.alaska.gov/pubs/id/30096 | done by IGAP staff, community volunteers, and/or students. | $$ | Army Corps of Engineers Planning Assistance to States and Tribes[25], Research Institutions,[26] Alaska RiskMAP (Alaska DCCED-DCRA and FEMA) | |
| **I1B.** Increase community capacity to develop climate adaptation plans, as an internal guide for community action and as required for out-of-region funding and support. | **I1B1.** Develop a simple community climate change planning guide, for both the process and product. Include a practical, readily transferable methodology for community climate adaptation plans. | **High Priority**<br>**ASAP**<br>**$** | Alaska Native Tribal Health Consortium, Natural Resources Conservation Service, Alaska DCCED-DCRA, Alaska Silver Jackets Partnership, Alaska Sea Grant, consultants, U.S. Army Corps of Engineers Planning Assistance to States and Tribes | All at-risk communities can more quickly and easily assess local risks, develop and implement the climate adaptation plans that support action and investment.<br><br>Alaska communities and partners are better organized to access the substantial resources available to help with all dimensions of climate change adaptation. |
| | **I1B2.** Apply and refine the guide in several locations. Produce and share | **High Priority** | Alaska Native Tribal Health Consortium, | |

[25] Tribal Partnership Program: http://www.spa.usace.army.mil/Missions/Civil-Works/Tribal-Program/TPP-Section-203/

Planning Assistance to States: http://www.nae.usace.army.mil/Missions/Public-Services/Planning-Assistance-to-States/

[26] For example: The Arctic Coastal Risk Network is estimating the cost of flood exposure in the YK Delta region. Woods Hole is researching permafrost changes. The Yukon Inter-Tribal Watershed Council has collected permafrost data through their community-based science programs. University of Alaska Fairbanks is doing permafrost research. University of Alaska Anchorage and Hooper Bay have been researching erosion, permafrost changes, and their effects on wildlife and wildlife habitat. The National Oceanic and Atmospheric Administration (NOAA) National Weather Service is researching the effects of permafrost change and coastal mapping. Researchers are also testing methane leaks in the region.



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| | examples; continue with other communities. Aim for plans that cost approximately $25,000 to produce. | **Near term**<br>**$$** | Natural Resources Conservation Service, Alaska DCCED-DCRA,<br>Alaska Silver Jackets Partnership, Alaska Sea Grant, tribes, cities, village corporations, consultants | All at-risk communities can more quickly and easily assess local risks, develop and implement the climate adaptation plans that support action and investment.<br>Alaska communities and partners are better organized to access the substantial resources available to help with all dimensions of climate change adaptation. |
| | **I1B3.** Provide supporting resources, such as small grants, for individual communities to complete climate change risk assessments and adaptation plan.<br>**I1B4.** Set up in-region teams to help communities develop locally based plans.<br>**I1B5.** Train people in the region to help communities to complete plans. | **Medium Priority**<br>**Near term**<br>**$$** | Association of Village Council Presidents, U.S. Fish and Wildlife Service, regional partners, Alaska Native Tribal Health Consortium, Bureau of Indian Affairs | |
| | **I1B6.** Provide technical assistance staff to communities for planning, funding and implementation support (a non-tactical solution in the spirit of the EPA IGAP program). | **Medium Priority**<br>**Longer term**<br>**$$$** | Adapt Y-K Delta Steering Committee, regional leaders | |
| **Strategic Action I2: Regional/Statewide Collaborative Action** | | | | |
| **I2A.** Increase out-of-region funding to implement climate | **I2A1.** Create a regional grant application collaborative to leverage community funds to secure matching | **Medium Priority** | Association of Village Council Presidents, Alaska Native Tribal | Communities can access larger funding pools for climate adaptation activities. |



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| adaptation actions and address policy barriers to adaptation. | funds from outside funders. Alternatively, increase Alaska Native Tribal Health Consortium grant application staff dedicated to securing funding for climate adaptation efforts. | **Near term**<br>**$$** | Health Consortium,<br>tribes, cities, village corporations | |
| **I2B.** Increase sharing of solutions and resources; increase political clout. | **I2B1.** Create a new organization of rural Alaska communities facing major climate change issues. Associate it with State-sponsored climate change initiatives. | **Very High Priority**<br>**Near term**<br>**$$** | State of Alaska,<br>regional non-profits.<br>The Alaska Native Tribal Health Consortium could provide advice. The group could be convened as part of Alaska Federation of Natives (AFN) or a collaboration of regional non-profits. The Adapt Alaska website can provide an online platform for information exchange. | Rural Alaska communities facing major climate change issues can more frequently and effectively exchange tools, solutions, and practices for resilience with each other and with agencies/resource providers. |
| **I2C.** Support in-region economic development. | **I2C1.** Endorse findings of the recently completed Y-K Community Economic Development Strategies (CEDS) plan.<br>**I2C2.** Support a range of well-planned, locally beneficial economic development projects. | **Very High Priority**<br>**Mid term**<br>**$** | Association of Village Council Presidents, Calista, Alaska DCCED-DCRA, Federal agencies, business community. | Individuals and communities have greater resources and autonomy to carry out climate adaptation actions. |



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| **Strategic Action I3: Next Generation of Adaptive Infrastructure** | | | | |
| **I3A.** Develop and use more adaptive solutions to water, wastewater, energy and other infrastructure needs. (Spring Forward!) [27] | **I3A1.** Compile and apply lessons from cold climate communities in infrastructure and building construction, including solutions for thawing permafrost and the need for movable infrastructure. Include information about whether solutions can be insured, meet funder or regulatory requirements for performance and safety, etc.<br><br>**I3A2.** Actively support the State of Alaska Water and Sewer Challenge and the continued application of adaptive water and waste-water technology in Y-K Delta communities. Consider similar contest(s) for solutions like arctic tiny homes. | **Very High Priority**<br><br>**On-going**<br><br>**Varies** | Alaska DCCED-DCRA,<br><br>Alaska Silver Jackets Partnership, Federal Emergency Management Agency,<br><br>Village Safe Water, Alaska Native Tribal Health Consortium,<br><br>Cold Climate Housing Research Center,<br><br>Harvard student research partnership,<br><br>Engineering schools can give continuing education credits for *pro bono* work. | Embracing new technologies may provide the opportunity to replace outdated infrastructure (that often requires expensive maintenance beyond what local communities can afford and that fixes communities to locations that may need to change) with more effective and adaptive solutions. |
| **I3B.** Increase local capacity to invest in and maintain emerging technologies, such as wind generation. | **I3B1.** Set up training programs that provide on-the-job experience. | **Medium Priority**<br><br>**Mid Term**<br><br>**$$** | Schools, Yuut Elitnaurviat | Residents have access to new jobs and increased income.<br><br>Better maintenance increases the reliability of wind generation systems and other emerging technologies. |

[27] The University of Alaska Fairbanks (UAF) Engineering School is updating State of Alaska building design standards to account for climate change.



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| **I 3C.** Reduce local contribution to greenhouse gas emissions. | **I3C1.** Expand use of wind and other alternative energy sources.<br><br>**I3C2.** Improve the energy efficiency of existing homes using techniques and technologies for cold climates.<br><br>**I3C3.** Reinstitute the Alaska Energy Efficient Homes program.<br><br>**I3C4.** Expand local capacity to take advantage of state energy programs. | **Medium Priority**<br><br>**On-going**<br><br>**$$$** | Alaska Energy Authority,<br><br>Nuvista Light and Electric Cooperative,<br><br>Local and regional partners, Alaska Housing Finance Corporation, U.S. Department of Housing and Urban Development (housing efficiency) | Residents enjoy lower energy bills from energy efficiency improvements. Residents have the option to switch to more affordable, renewable energy sources and to demonstrate a local commitment to reducing greenhouse gas emissions.<br><br>New technologies can be more affordable and create opportunities for new local jobs and businesses |
| **Strategic Action I4: Research/Research-Based Infrastructure Decisions** | | | | |
| **I4A.** Maximize the lasting value of infrastructure investments. Design infrastructure based on anticipated environmental change. Invest in | **I4A1.** Develop new protocols for decision-making about the location and form of costly community infrastructure, considering climate change impacts in addition to land ownership, availability of water, access, etc. | **Very High Priority**<br><br>**Near term** | U.S. Army Corps of Engineers, Alaska Native Tribal Health Consortium, Denali Commission, Alaska RiskMAP (Alaska DCCED-DCRA and | Infrastructure is less likely to be developed or installed where it is likely to be threatened by erosion, permafrost thaw or related climate change impacts. |



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| forms of infrastructure that are sustainable and affordable. | **14A2.** Develop better approaches to investing during transitional periods in locations where interim infrastructure solutions are needed for health and safety reasons, but where a community relocation is happening or likely to be needed (e.g., Newtok/Mertarvik). | $ (I4A1)<br>$$ -$$$ (14A2) | FEMA) | |
| **I4B.** Gather foundational baseline environmental data necessary for hazard risk assessments and advance both community-specific and region-wide risk | **I4B1.** Document the highest-priority data gaps.<br>**I4B2.** Partner with agencies and researchers to obtain funding for locally guided research by National Science Foundation, National Oceanic and Atmospheric Administration, Alaska Division of Geological & | Very High Priority<br>Near term and on-going | Research and land management agencies: Federal Emergency Management Agency, Alaska RiskMAP (Alaska DCCED-DCRA and FEMA), Alaska Ocean Observing System, Alaska Division of | Improved environmental data supports more useful and accurate information for local planning and investment decisions, sets the stage for more complex adaptation actions (i.e., moving villages), and increases understanding by funders, State and Federal leadership, and other decision-makers of the climate change realities Y-K |



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| assessments | Geophysical Surveys, Alaska Ocean Observing System, University of Alaska Fairbanks, and others.<br><br>**14B3.** Work with regional partners to incorporate local knowledge and monitoring into the process of setting research agendas and carrying out research. | $$ | Geological & Geophysical Surveys, Alaska Silver Jackets Partnership, U.S. Army Corps of Engineers Planning Assistance to States and Tribes,[28]<br><br>Local and regional leadership, State of Alaska leadership, Alaska Congressional delegation | Delta communities face. |
| **Strategic Action I5: Education and Training** | | | | |
| **I5A.** Engage and motivate youth in climate adaption actions. | **I5A1.** Set up school programs that support meaningful adaptation action and job training (e.g. monitoring, infrastructure maintenance training). | **Very High Priority**<br><br>**Near term**<br><br>**$$** | Y-K Delta School Districts, Yuut Elitnaurviat | School programs invest in future regional leaders and generate more resources to do work that needs doing. |
| **I5B.** Create a pool of funding to support specific local climate adaptation actions. | **I5B1.** Establish a climate adaptation endowment fund. Obtain seed funding, set up an investment board, secure non-profit status, and formalize | **Medium Priority**<br><br>**Mid term** | Calista, Association of Village Council Presidents, Yukon Kuskokwim Health | An endowment fund provides a sustainable, self-replenishing, locally controlled source of funding for climate adaptation actions. |

[28] Tribal Partnership Program: http://www.spa.usace.army.mil/Missions/Civil-Works/Tribal-Program/TPP-Section-203/

Planning Assistance to States: http://www.nae.usace.army.mil/Missions/Public-Services/Planning-Assistance-to-States/



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| | distribution criteria. | $$$ | Corporation and other regional non-profits | |
| **I5C.** Increase understanding of climate change challenges and opportunities, within and beyond the Y-K Delta region. | **I5C1.** Plan and implement a publicity program aimed at widely sharing the results of the Adapt Y-K Delta project (via radio, social media, conferences). | Very High Priority | Steering Committee, project partners | Expanded understanding of climate change challenges and opportunities increases support for adaptation actions. |
| | **I5C2.** Share Adapt Y-K Delta project results and continue to refine the project processes through the broader Adapt Alaska effort and associated website. Translate technical environmental data into a layperson-friendly form that informs local action. Translate important information into Yup'ik as possible. | Near term<br>$ | | |



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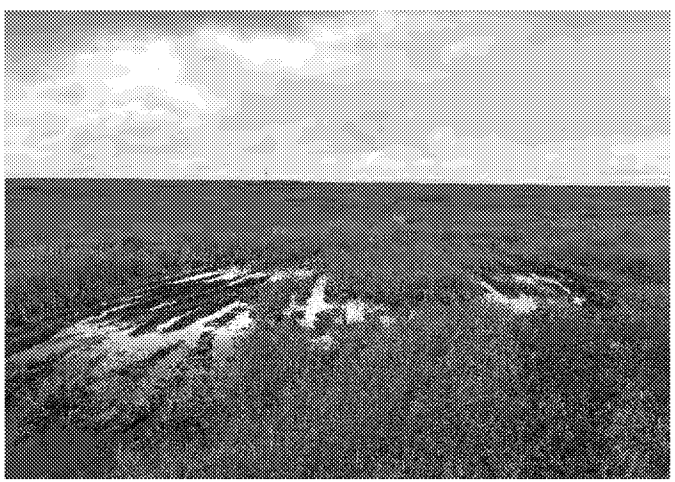
# Strategic Opportunity 3: Trails and Transportation Safety

"We must look to our past to see our future." – *Marvin Parent, Adapt Y-K Delta Steering Committee Member*

## The Challenges and Opportunities

In a region with very limited road infrastructure, trails are a vital artery for meeting the economic, social and cultural wellbeing of the 56 tribes spread through the Y-K Delta. Together with waterways and air transportation infrastructure, trails form a key part of the options to connect villages. With air transportation costs increasing, trails have become an even more important form of intra-regional transport. Some schools now use ATVs to transport student athletes to competition events in other villages. Residents of the Y-K Delta also rely on tundra habitat to access subsistence resources throughout the year. There is a growing concern about the impacts of increased use of all-terrain vehicles (ATVs) and snowmachines for travel and subsistence hunting and gathering practices on the tundra habitat. Lack of hardened trails, inadequate user knowledge, lack of ATV regulations, and limited safe travel alternatives contribute to the overall impact of increased ATV use on the Y-K Delta. However, as noted in the situation analysis, there are increasing concerns about (a) the adequacy of trails, (b) the safety of trails and (c) the impacts of trails on wetlands, tundra and salmon streams of the Y-K Delta.



*Challenges and progress on trails in Mekoryuk. Photos courtesy of Hazel Peterson, Native Village of Mekoryuk.*



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## Trails and Transportation Adaptation Actions

| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| **Strategic Action T1: Analyze how the existing Y-K Delta trail network is used, environmental impacts associated with the trail system, and how those impacts could be lessened or avoided.** | | | | |
| **T1A.** Conduct trail use and risk assessments of current Y-K Delta trails and transportation networks, including waterways and tundra trails. | **T1A1.** Map existing trails and trail use to better understand how people are using the trails and where trail improvements or new trails are needed.<br><br>Define trails within 1-2 mile-wide 'trail zones' to allow the exact path to flex with conditions to the most stable or durable areas at a given point in time. | Very High Priority<br><br>2019-2020<br><br>$$ | Association of Village Council Presidents Transportation Department, Search and Rescue, Ice Road Partners along the Kuskokwim, Orutsararmiut Native Council, National Park Service.[29] | A trail map serves as the baseline for an assessment of trail conditions, guides the development of new trails and priorities for trail improvements. |
| | **T1A2.** Interview trail users to better understand how they use trails and what their safety concerns are. | Very High Priority<br><br>Near term<br><br>$ | Association of Village Council Presidents Transportation Department, Search and Rescue | User-sourced information about trail safety issues, improvement priorities, and use informs risk and trail use assessments. Interviews can also inform trail managers about how to communicate most effectively with trail users, share educational information about trail safety and maintenance, and may generate innovate ideas for improving the Y-K Delta trail system. |
| | **T1A3.** Conduct a risk assessment using both historical accident data and updated hazard assessment methods. | **High Priority**<br><br>**Near term**<br><br>**$$** | United States Geological Survey | A system-level analysis of safety issues within the Y-K Delta trail network provides a basis for prioritizing safety improvements. |

[29] The people who do the marking for K-100 race would know the most consistently safe areas.



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| | **T1A4.** Research travel impacts on the land as well as the effectiveness of various strategies to mitigate, minimize, or avoid negative impacts (e.g., how long until birds return to exclusion zones). | **High Priority**<br>**2019-2023**<br>**$$$** | U.S. Fish and Wildlife Service (research funding), Western Alaska Landscape Conservation Cooperative, possibly Non-Governmental Organizations and/or universities working on trail networks | A better understanding of the environmental impacts of trails and trail use guides policies and priorities for trail maintenance, construction and improvement. |
| **Strategic Action T2: Develop education resources and programs that promote safe and responsible trail behavior to improve safety and reduce negative impacts on changing wildlife habitat important for subsistence.** | | | | |
| **T2A.** Provide education that promotes safe and responsible trail use. | **T2A1.** Create in-school trail safety education programs involving youth and Elders. | **Medium Priority**<br>**2019-2023**<br>**$** | Y-K School Districts (e.g., existing Lower Yukon School District Natural Helpers program) | The community has a better understanding of safe and responsible trail behaviors and looks out for each other. |
| | **T2A2.** Develop a social media platform (e.g., Facebook members page) that allows trail users to update each other on trail conditions, share safety reminders and possibly report safe travel. | **High Priority**<br>**2019-2023**<br>**$** | Trail users, possibly moderated by Association of Village Council Presidents | Increased communication helps people travel more safely and responsibly on trails throughout the Y-K Delta. |



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| | **T2A3.** Develop/identify and use an app to photograph problem areas and tag GIS coordinates. These data can be shared via social media for local use and feed into a database for analysis.<br>**T2A4.**Mount trail cameras and ice thickness sensors on snow machines to show where trails are used and how thick the underlying ice is. | **Medium Priority**<br>**2019 and beyond**<br>**Varies** | Association of Village Council Presidents Transportation, U.S. Fish and Wildlife Service, Alaska Native Tribal Health Consortium (developed LEO app), Search and Rescue | Better, more immediate access to trail safety information for residents and data that can help improve trail planning by the appropriate agencies. |
| | **T2A5.** Develop trail use etiquette[30] with Y-K Delta communities; share through social media and posters to support other education activities | **Very High Priority**<br>**2019**<br>**$$** | Association of Village Council Presidents, U.S. Fish and Wildlife Service | A code of behavior developed and agreed upon by local trail users improves safety and reduces negative trail impacts on changing natural environments and wildlife important for subsistence. |
| **T2B.** Explore options for adaptive technology that increases travel safety. | **T2B1.** Promote the development and use of adaptive technology for travel and transportation throughout the region, e.g.,<br>• Float coats (YKHC sells at cost)<br>• Airboat that can go on ice (Golovin | **Medium Priority**<br>**2019 and beyond** | Communities and individual residents<br>Regional organizations (e.g., Yukon Kuskokwim Health Corporation, Association of Village Council Presidents, | Travel safety is increased. New technology may create new businesses and jobs. People use their creativity to improve quality of life for all. |

[30] Could be built from the Tread Lightly and similar ATV safety and etiquette protocols: www.treadlightly.org/



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| | has one)<br>• Airboat/snow machine hybrid<br>• Floating device for snow machines (Canadians have these)<br>• ATVs with floats<br>• Helicopters (or other aircraft if airplanes cannot land)<br>• Drones and underwater cameras for search and rescue<br>• Device that is mounted on snow machines/ATVs to measure ice thickness | **Varies** | Alaska Native Tribal Health Consortium)<br>Universities (Alaska Pacific University, University of Alaska System), Alaska Native Science and Engineering Program<br>State of Alaska | |
| **Strategic Action T3: Establish a trail improvement strategy and fund to guide future trail development and maintenance priorities, and to ensure that there is regional capacity to respond quickly to trail system needs.** | | | | |
| **T3A.** Develop and use a trail improvement strategy to guide future improvements. | **T3A1.** Develop trail hardening and development strategies to guide trail upgrades. | **Very High Priority**<br>**2021-23** | Natural Resources Conservation Service, Consultants, Tourism industry, Calista | A regional trail strategy improves user safety and reduces the negative impacts of trail use on wildlife habitat, especially in areas where permafrost thaw and flooding |



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| | | $$ | Corporation, National Park Service[31] | increase. |
| | **T3A2.** Develop and use common regional trail marking standards for color coding, permanent markers. Consider planting trees as trail markers and wind breaks.<br><br>**T3A3.** Include signs along river trails (i.e., "To Bethel" or "To Stony River" with arrow) to help people navigate changing sloughs. | **High Priority**<br><br>**2019 and beyond**<br><br>**Varies** | Individual communities, Association of Village Council Presidents Transportation, U.S. Fish and Wildlife Service, Search and rescue.[32] | More people can travel safely on regional trails between communities, with confidence in where they are going.<br><br>More people can travel safely on rivers, with confidence in where they are going. |
| | **T3A4.** Create a trail improvement fund to support trail improvements and emergency repairs (e.g., bridges).<br><br>**T3A5.** Complete a trail funding feasibility assessment to guide future funding strategies and grant applications.<br><br>**T3A6.** Develop a triage system for trail improvements. | **High Priority**<br><br>**2020**<br><br>**$** | Private funders (e.g., Rasmuson Foundation, Alaska Community Foundation), Donlin Gold, Regional trail coordinating entity (e.g., Association of Village Council Presidents Transportation) | Stable, regionally administered funding is available for emergency repairs (e.g., bridges), planned trail improvements, and can be leveraged as a match for larger trail improvement projects.<br><br>Safety is maximized, as the most dangerous trails are improved first. |

[31] The National Park Service Rivers, Trails, and Conservation Assistance Program (RTCA) can be another technical assistance resource for communities interested in working on trail planning and implementation (http://www.nps.gov/orgs/1005/index.htm). Y-K Regional Contact (2019) is Michael Downs (michael_e_downs@nps.gov).

[32] Alaska Village Electric Cooperative and coastal villages that share electric interties already have reflective markers on poles used for energy transmission.



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# Monitoring and Implementation

## Implementation Process

The Adapt Y-K Delta Climate Adaptation Strategies document marks the beginning of building regional climate change considerations into our local and regional decision-making, to proactively identify adaptation priorities and respond to current and to future changes and needs. Upon the completion of this document, climate adaptation considerations will be directly incorporated into future updates to the Yukon-Kuskokwim Region Comprehensive Economic Development Strategies (CEDS). Until then, the 2018-2023 CEDS document refers to this Adapt Y-K Delta Climate Adaptation Strategies document to provide guidance on regional priorities for climate change action.

The CEDS process has been supported for several years by an established partnership of Yukon-Kuskokwim regional organizations and Federal funding through the Economic Development Administration. By incorporating these climate adaptation strategies into strategic regional economic development activities, monitoring and implementation of the Adapt YK Delta strategies will continue to be overseen by a committee comprised of representatives of Y-K Delta organizations and individuals with support from other Federal, State and local technical advisory agencies.

## Leadership and Implementation Actions

Discussions also revealed a set of actions related specifically to capacity-building, enhancing climate adaptation leadership and implementing the climate adaptation strategies.

| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| **LI1. Develop leadership and implementation capacity at all levels (individual, organizational, community, regional) to build capacity, find new solutions and create new job opportunities.** | | | | |
| **LI1A.** Increase the capacity of individual organizations to work | **LI1A1.** Identify and address barriers to compacting and capacity building at the community level to increase | Very High Priority | Individual communities with support from trusted | Communities build their own capacity to do more with existing resources as well as access new resources. |



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| Objective | Action(s) | Priority / Time / Cost | Who Can Help? | Outcome |
|---|---|---|---|---|
| together in partnership on projects. | effective partnerships among village corporation, city and tribe in individual communities.<br><br>**LI1A2**. Develop partnerships with regional, state and federal agencies. Work with state and federal agencies to eliminate policy barriers to adaptation actions.<br><br>**LI1A3**. Leverage existing funding as match for building more funds. | 2019 and beyond<br><br>Varies | networks.[33] | |
| **LI1B**. Increase local capacity to develop solutions in place. | **LI1B1**. Increase opportunities for students to learn through experiential learning labs that encourage innovation.<br><br>**LI1B2**. Increase participation in internship and/or mentorship programs with agencies such as Natural Resources Conservation Service, U.S. Fish and Wildlife Service.<br><br>**LI1B3**. Agreement between ANSEP and tribe to fund a student who comes back to their community to work on engineering projects. | Very High Priority<br><br>2019 and beyond<br><br>Varies | Schools, Alaska Pacific University, Tribes in partnership with the Alaska Native Science and Engineering Program (ANSEP), communities, partner agencies | Students learn to apply their creative problem-solving skills to finding solutions to local and regional concerns.<br><br>Local people gain experience and increase understanding of how to work with agencies more effectively.<br><br>More professional jobs are available in rural communities for residents. |

[33] For example, Tribes can use BIA Tribal Transportation Program funds for trails. Subsistence access trails may be able to access resources from USDA Natural Resources Conservation Service (NRCS), Alaska Department of Fish & Game.



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# Adaptation Funding

Funding for implementation of climate adaptation efforts is problematic globally. There are very few public or private funders who have the capacity or commitment to the types of long-term adaptive management envisaged by these strategies. Because of the *ad hoc* nature of climate response funding, it can therefore be challenging to secure formal commitments annually. This document is intended to be flexible to take advantage of funding opportunities as they emerge and to ensure that adaptation efforts align with community priorities. The strategy for funding the Adapt Y-K Delta Climate Adaptation Strategies is based on two principles:

1. The Steering Committee believes that it is incumbent on funders to not reinvent the wheel. As global, Federal, State and local programs evolve, and new opportunities emerge for funding of climate adaptation activities in the Y-K Delta, it is hoped that funders will use this document as a basis for priority setting and funding commitments. Committee members will highlight this document when advocating for immediate funding priorities.
2. The Steering Committee aspires to always take the longer view of climate change in the Y-K Delta to ensure that investments being made contribute to the overall vision of the Adapt Y-K Delta Climate Adaptation Strategies. At annual progress meetings and in developing the next five-year version of the document, the Steering Committee may revisit the vision, targets, assumptions, strategies and implementation process to ensure it reflects the view of the region and is achieving shared priorities.



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# Appendix 1: Participation in the Adapt Y-K Delta Process

## A. Steering Committee Members

- Ray Born — U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge; Western Alaska LCC Steering Committee
- James Charles — Tuntutuliak Elder
- Janessa Esquible — Orutsararmiut Native Council, Fisheries
- Jennine Jordan — Calista Native Corporation
- Mellisa Heflin — Bering Sea Elders Group
- Jennifer Hooper — Association of Village Council Presidents, Natural Resources Department; Western Alaska LCC Steering Committee
- Nicholas Kameroff — Aniak Traditional Council, Fisheries and Kuskokwim River Inter-Tribal Fisheries Commission
- Megan Leary — Kuskokwim Corporation
- Bernadette Lewis — Village of Cherfornak
- Sarah Mutter — Association of Village Council Presidents, Natural Resources Department
- William Naneng — Sea Lion Corporation, Hooper Bay
- Myron Naneng — Sea Lion Corporation, Hooper Bay
- Orville Huntington — Tanana Chiefs Conference Wildlife and Parks
- Marvin Parent — Marshall Traditional Council
- Mary Pete — University of Alaska Fairbanks, Kuskokwim Campus
- Hazel Peterson — Native Village of Mekoryuk
- Fred Phillip — Bering Sea Elders Group
- David Runfola — Alaska Department of Fish and Game, Subsistence Division
- Brittany Rutherford — Kuskokwim River Inter-Tribal Fisheries Commission
- Susan Taylor — Bethel Lions Club



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# B. Adapt Y-K Delta Advisors, Staff and Facilitators

### Advisors

- David Andrew — Native Village of Napakiak
- Donna Bach — U.S. Census Bureau, formerly Alaska Gasline Development Corporation
- Diana Biesanz — U.S. Fish and Wildlife Service
- Douglas Campbell — U.S. Fish and Wildlife Service
- Paul Clark — National Park Service
- Grace Edwards — U.S. Department of Agriculture, Natural Resources Conservation Service
- Stephen Gray — U.S. Geological Survey; Western Alaska LCC Steering Committee
- Ana Hoffman — Bethel Native Corporation
- Joanne Kuykendall — U.S. Department of Agriculture, Natural Resources Conservation Service
- Jeremy Littell — U.S. Geological Survey; Western Alaska LCC Steering Committee
- Ryan Maroney — U.S. Department of Agriculture, Natural Resources Conservation Service
- David Morton — U.S. Fish and Wildlife Service
- Aaron Moses — U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge
- Max Neale — Alaska Native Tribal Health Consortium
- Francis (Fran) Reich — National Older Workers Career Center
- Mike Riley — Bethel Search and Rescue
- Patrick Sampson — Orutsararmiut Native Council, Tribal Transportation
- Art Tovar — U.S. Fish and Wildlife Service
- Eva Patton — U.S. Fish and Wildlife Service

### Staff

- Davin Holen — Alaska Sea Grant
- Jeff Herzog, George Kalli, Amber Metallo, Lauren Oliver — U.S. Army Corps of Engineers; Alaska Silver Jackets Partnership
- Karen Murphy — formerly U.S. Fish and Wildlife Service; Western Alaska LCC staff
- Elizabeth Powers — U.S. Fish and Wildlife Service; Western Alaska LCC staff
- Sally Russell Cox — Alaska Department of Commerce, Community and Economic Development, Division of Community and Regional Affairs; Alaska Silver Jackets Partnership; Western Alaska LCC
- Charla Sterne — U.S. Fish and Wildlife Service; Western Alaska LCC
- Danielle Stickman — Western Alaska LCC

### Facilitators

- Chris Beck — Agnew Beck Consulting
- Ian Dutton — Nautilus Impact Investing
- Heather Stewart — Agnew Beck Consulting
- Sarah Warnock — Nautilus Impact Investing



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# Appendix 2: Reference Materials


Austin, B.J., T. Vigilante, S. Cowell, I.M. Dutton, D. Djanghara, S. Mangolomara, B. Puermora, A. Bundamurra and Z. Clement, 2017. Evaluating the Wunambal Gaambera Healthy Country Plan: Intercultural Governance of a Land and Sea Management Program in the Kimberley, Ecological Management and Restoration 18(2): 124-133. DOI:10.1111/emr.12257.

Fienup-Riordan, Ann. (1994). Boundaries and Passages: Rule and Ritual in Yup'ik Eskimo Oral Tradition. Norman, OK: University of Oklahoma Press

Littell, J.S.; McAfee, S.A.; Hayward, G.D. Alaska Snowpack Response to Climate Change: Statewide Snowfall Equivalent and Snowpack Water Scenarios. Water 2018, 10, 668.

Lyman K. Thorsteinson; Paul R. Becker; David A. Hale (1989). The Yukon Delta: a synthesis of information. National Oceanic and Atmospheric Administration

Markon, C., S. Gray, M. Berman, L. Eerkes-Medrano, T. Hennessy, H. Huntington, J. Littell, M. McCammon, R. Thoman, and S. Trainor, 2018: Alaska. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1185–1241. doi: 10.7930/NCA4.2018.CH26

Sweet, W.V., R. Horton, R.E. Kopp, A.N. LeGrande, and A. Romanou, 2017: Sea level rise. In: *Climate Science Special Report: Fourth National Climate Assessment, Volume I*[Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 333-363, doi: 10.7930/J0VM49F2. (Table 12.5, CCSR Chapter 12.)

U.S. Fish and Wildlife Service. Region 7 (1987). Yukon Delta National Wildlife Refuge: comprehensive conservation plan, environmental impact statement, wilderness review, and wild river plan: draft. U.S. Dept. of the Interior, Fish and Wildlife Service.

USAID (2016) Developing Situation Models in USAID Biodiversity Programming, USAID Biodiversity How to Guide 1: http://cmp-openstandards.org/wp-content/uploads/2016/10/USAID_SituationAnalysis_Guide1_2016.pdf

Walsh, J. E., Bhatt, U. S., Littell, J. S., Leonawicz, M., Lindgren, M., Kurkowski, T. A., ... Rupp, T. S. (2018). Downscaling of climate model output for Alaskan stakeholders. Environmental Modelling & Software. http://doi.org/10.1016/j.envsoft.2018.03.021

Wunambal Gaambera Aboriginal Corporation (2010). Wunambal Gaambera Healthy Country Plan – Looking after Wunambal Gaambera Country 2010 –2020.





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# Appendix 3: Process to Identify Focus Areas

## Target Identification and Prioritization Criteria

The Adapt Y-K Delta Steering Committee vision for the Y-K Delta region for next 100 years is that:" *Current and future generations enjoy healthy ecosystems that sustain our communities and our Indigenous way of life."* The Steering Committee then identified seven major targets that together are key to the achievement of the Adapt Y-K Delta vision:

- Intact Terrestrial Ecosystems
- Large Mammals
- Migratory Birds
- Healthy Marine Ecosystems
- Salmon
- Traditional Knowledge and Relationships
- Community Infrastructure

These seven targets were selected after a comprehensive Steering Committee discussion of those natural and cultural elements of the Y-K Delta region that are most directly linked to the vision. It was noted that additional targets may become important over time, but these initial seven were the most critical to focus on over the next five years.

After assessing the key targets that must be healthy for the Adapt Y-K Delta vision to be attained, the Steering Committee evaluated the threats and opportunities that must be addressed if the targets that are in poor condition are to be returned to a healthy condition, and targets in fair or good condition that are to be maintained at acceptable levels. Following these steps, the Steering Committee identified the sources of those threats and developed a situation analysis to assess challenges, opportunities and options for adaptation response.

## Situation Analysis

A situation analysis is a diagram that displays the findings from a context/problem analysis in a logical, causal fashion to convey the most important direct threats and drivers affecting focal interests. Further details of the use of conceptual models is provided by USAID (2016).



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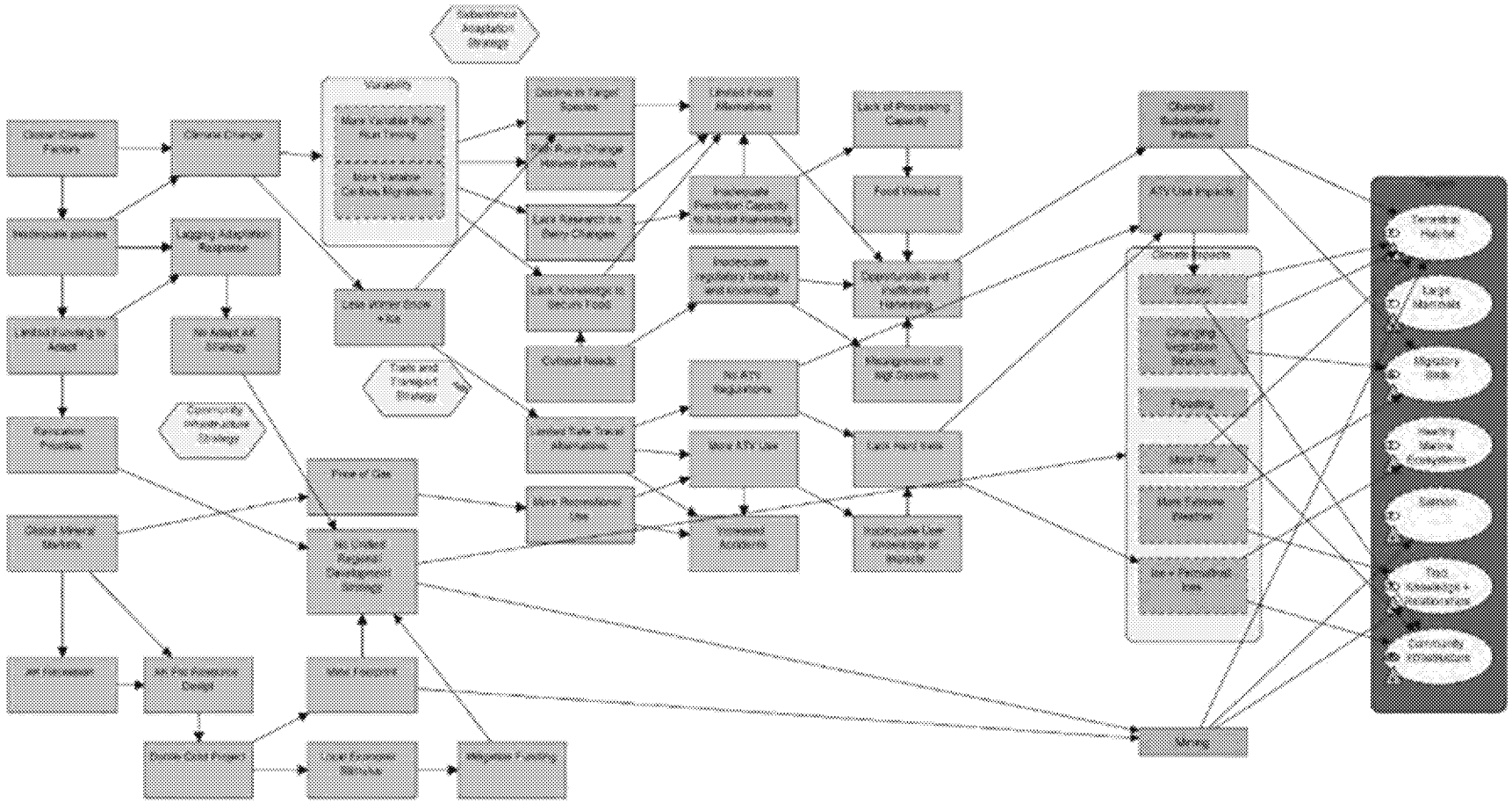
## Adapt Y-K Delta Situation Analysis



The analysis presented above was developed by the Steering Committee after selecting the key targets (green boxes) for the Adapt Y-K Delta Climate Adaptation Strategies and then identifying key threats (pink boxes) to those targets. After that, the Committee reviewed the trends and factors (orange boxes) that were "driving" those threats and began to group those drivers together to assess opportunities for action. In the diagram below, those opportunities for strategic action are shown in yellow. These opportunities for strategic action formed the framework for the second Steering Committee workshop. Like all conceptual models, it is important to revisit this analysis in future to see whether the threats and their drivers are changing, and if so, what new actions may be needed.



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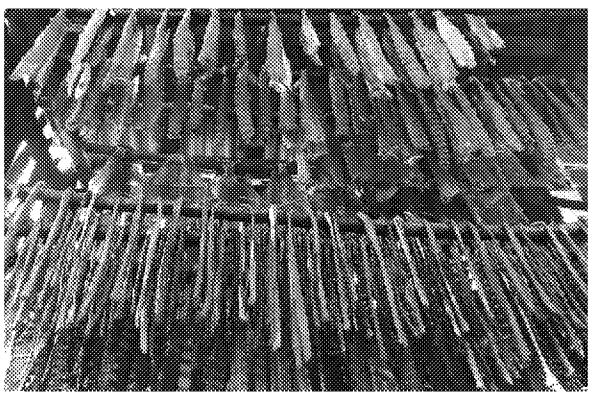
# Appendix 4: Subsistence Action Plan Summary

## Approach

Gather forward-looking information regarding anticipated environmental change in the Y-K Delta, from both local observations and scientific research. Use this information for short- and long-term assessments of subsistence challenges and opportunities, then to help set and implement community and regional adaptation actions, from fish preservation to longer term changes in subsistence access and practices.



*Kuskokwim fish rack (photo by Nick Kameroff, Jr.). Climate change impacts subsistence food harvest and preservation. For example, delays in the timing of fish runs, with more late-summer rainfall, creates challenges for preserving fish.*

**OBJECTIVE 1.** Increase knowledge about anticipated future environmental change by expanding and integrating scientific research with local observations and knowledge.

***Priority Actions:***

| | |
|---|---|
| **I1A** | Carry out environmental change research. Compile and share information on anticipated changes in temperatures, precipitation, sea level, storm frequency and intensity, erosion, permafrost thaw, and hydrology to create base data that can be used to anticipate changes in vegetation and habitats. |
| **I4B1, I4B3** | Identify and fill the highest-priority gaps in the data and information needed to anticipate environmental changes and their resulting impacts on subsistence. |



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| **OBJECTIVE 2.** Continue to develop, evaluate and refine fish preservation methods. | |
|---|---|
| ***Priority Actions:*** | |
| **S1A1** | Evaluate the results of the fish preservation pilot project. Use this information to consider improved options preserve fish, meet community needs and avoid waste. |
| **S1B1** | Hold a student competition to explore alternative preservation techniques and promote innovations at household and community levels. |
| **S1C1** | Create a lending program for canning supplies, kitchens and/or smokehouses open to community members. Create a donate-back program for Elders. |

| **OBJECTIVE 3.** Share traditions and new ideas for subsistence adaptation among Y-K Delta communities, and between Elders and youth. | |
|---|---|
| ***Priority Actions:*** | |
| **S2A1** | Increase opportunities for students to learn through experiential learning labs that encourage innovation. Get more youth involved in subsistence. |
| **S2A2–S2A3** | Plan for youth hunts before school starts. Provide educational special use permits for harvest for fish camps, school, and place-based science. |
| **S2B1** | Systematically engage and document Elders' knowledge by encouraging researchers to document fish, wildlife and seabird harvesting and processing practices; for example, through interviews with Elders. |
| **S2C1–S2C2** | Create subsistence booklets and/or video series for multiple audiences. Expand the use of social media to engage community members and ensure knowledge is available in a timely and consistent manner (possibly with a dedicated Facebook membership page on subsistence processing methods). |



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**OBJECTIVE 4.** Refine current management processes related to fish and wildlife harvesting practices. Better incorporate local knowledge, local concerns, and ensure that local stakeholders have more understanding of and more voice in setting seasonal harvest plans and policies.

***Priority Actions:***

| | |
|---|---|
| **S3A1** | "Kuskokwim Annual Pre-season Fish Gathering." Convene an annual pre-season meeting of Kuskokwim stakeholders and agencies, facilitated in Bethel by an outside facilitator, to inform agencies of local concerns and to share agency information and resources. |
| **S3A2** | Conduct a Board of Fisheries and/or Federal Subsistence Board class led by the Tribal Wildlife Program at UAF. Plan for when the Board cycle has a meeting in Bethel or area community. |
| **S3B1** | Build capacity for individual stakeholders to increase local involvement and employment in management and regulation. Create a coordinated post-secondary educational program for rural Alaskans interested in employment or community leadership in fish management. Dedicate funding among participating universities and agencies to develop curricula and fund scholarships. |
| **S3C1** | Share more synthesized forecast information on changes to seasonality that includes fish run timing, weather pattern shifts, etc. Conduct more outreach on changes in fish run timing help people anticipate when fishing will occur, and whether these changes will push fishing into the rainy season. |
| **S3C2** | Share better information on seasonal weather changes so people can adjust preservation methods. For example, if rain is expected, people can smoke and can more fish; when it is sunny, people can dry fish outside. |

**OBJECTIVE 5. Expand knowledge of changes in berries, and berry habitat important to Y-K Delta communities.**

***Priority Actions:***

| | |
|---|---|
| **S4A1** | Continue research currently underway by the USGS to better understand berry patch dynamics; share results with Y-K Delta communities. |
| **S4A2** | Undertake outreach to communities about the results of berry modeling and engage them in monitoring activities. |
| **S4B1** | Look into alternative berry production methods as backup. Consider assisted migration to help berry species re-establish in new locations. |



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# Appendix 5: Infrastructure Action Plan Summary

## Approach

**Base Information → Risk Assessment → Adaptation Plans → Adaptation Actions**

Gather forward-looking information regarding anticipated environmental change in the Y-K Delta, from both local observations and scientific research. Apply this information for short-term and long-term risk assessment; for example, through flood and erosion vulnerability mapping. Use risk assessments to plan and implement community and regional adaptation actions, from new approaches to water and wastewater, to energy efficient and even movable homes.

**OBJECTIVE 1.** Identify Y-K communities with the highest risk of infrastructure impacts from erosion, storm flooding, sea level rise and permafrost degradation.[34] Assemble sufficient information about anticipated climate change-driven environmental changes to make workable assessments about climate change risks in these locations. Aim to develop risk assessments in an initial subset of communities by December 2020.

***Priority Actions:***

| | |
|---|---|
| **I4B2** | Identify a representative sample of most threatened communities. Determine the level of information currently available to assess hazards in these threatened communities. |
| **I4B2** | Assemble representatives of in- and out-of-region entities with interest/capacity/funds to develop needed hazard assessment information; together set a shared strategy and standards for creating acceptable risk information in identified communities. |
| **I4B2 I1A1–I1A3** | Clarify and implement approaches to best blend local and out-of-region knowledge, including strategies to maximize use and value of locally based monitoring. |
| **I4B1, I4B3** | Identify highest priority data gaps and strategies to fill these information needs. |

[34] Preliminary Denali Commission evaluation of highest risk communities included Emmonak, Napakiak, Newtok, Kotlik, and Alakanuk. Other communities may face equal or greater risk of environmental change.



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**OBJECTIVE 2.** Using the environmental change and risk evaluation in Objective 1, produce and approve an initial set of adaptation plans by December 2021. The process to create and the outcomes of this initial round of adaptation plans can then be widely shared as templates with other at-risk communities in the YK Delta.

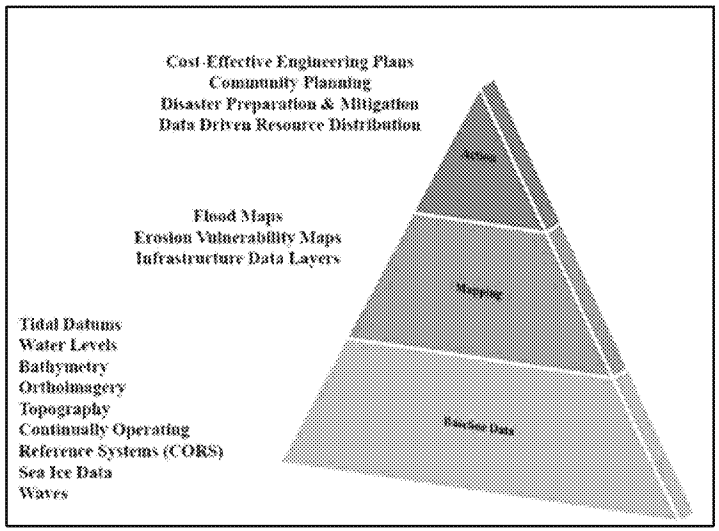
***Priority Actions:***

| | |
|---|---|
| **I1B1** | Develop or identify practical, affordable models for adaptation plans that build from local goals and knowledge but benefit from outside support and expertise. Explore new models for affordability, project management, grant management, local coordinator positions in communities, etc. |
| **I1B3–I1B6, I5A1** | Identify and secure funding and local, regional and out of region partners who together produce initial plans. |
| **I1B2** | Learn from the initial round of adaptation planning. Use the results as strategies and templates for other communities. |

**OBJECTIVE 3.** Integrate climate change adaptation work with the ongoing Comprehensive Economic Development Strategy process (CEDS).

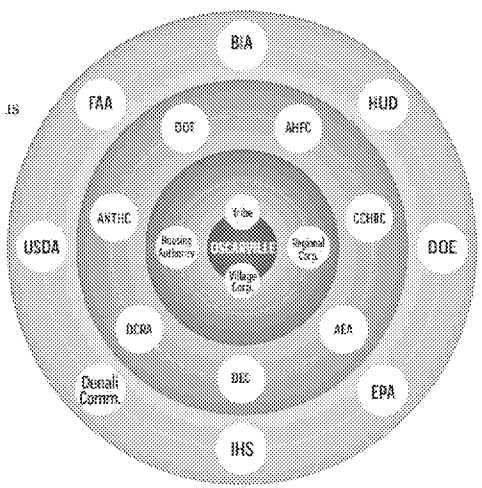
***Priority Actions:***

| | |
|---|---|
| **I2C1** | Develop and implement action plans to carry out the Y-K Regional Comprehensive Economic Development Strategies (CEDS)/Adapt YK Delta Adaptation Strategies, in coordination with regional partners. |
| **I2C2** | Support a range of well-planned, locally beneficial economic development projects that can increase resources available for climate change adaptions actions. |




*Above: Figure, by Jaci Overbeck, outlines the layered process needed for these practical, well-informed community infrastructure climate change adaptation strategies.*

*Below: A conceptual model for roles in adaptation planning from the Oscarville Adaptation Plan.*



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**OBJECTIVE 4.** Explore and share new approaches to buildings and infrastructure solutions – more affordable, sustainable and adaptable options for water, wastewater, power generation; including options for mobile community infrastructure. Promote energy conservation and reduction in emission of climate changing greenhouse gases.

***Priority Actions:***

| | |
|---|---|
| **I3A1–I3A2** | Apply lessons from cold climate communities in infrastructure and building construction, as well as results from the State of Alaska Water and Sewer Challenge. |
| **I3B1** | Set up training programs so residents can get jobs installing and maintaining emerging technologies, such as wind energy generation. |
| **I3C1–I3C2** | Expand use of wind and other alternative energy sources; improve energy efficiency. |
| **I4A1–I4A2** | In locations of greatest risk for environmental change, develop new protocols for decisions regarding installation and/or repairs to costly community infrastructure. |

*Other Actions:*

| | |
|---|---|
| **I3C3–I3C4** | Reinstitute the Alaska Energy Efficient Homes program. Expand local capacity to take advantage of state energy programs. |

**OBJECTIVE 5.** Increase access to and effectiveness of funding, from government, non-profits, businesses and other sources to support the development and implementation of community-driven climate change adaptation solutions.

***Priority Actions:***

| | |
|---|---|
| **LI1A** | Work with state and federal agencies to eliminate policy barriers to adaptation actions. |
| **I2A1** | Create a regional grant application collaborative to leverage community funds to secure matching funds from outside funders. Increase ANTHC grant application staff dedicated to securing funding for climate adaptation efforts. |
| **I5B1** | Investigate options for models like the Sustainable Southeast program, where non-profit foundations have provided funds for community-based adaptation planners. |
| **I5C1–I5C2** | Increase awareness at the state and national level about the magnitude and severity of climate change impacts in the Y-K Delta region. Link the campaign with the broader Adapt Alaska program. |

*Other Actions:*

| | |
|---|---|
| **I5B1** | Establish a regional and/or statewide climate adaptation endowment fund. |
| **I2A1** | Create a new statewide organization of rural Alaska communities facing major climate change issues. |



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# Appendix 6: Trails and Transportation Action Plan Summary

## Approach

Establish a baseline of information on existing trail use, condition, hazards and impacts, using surveys and in-person interviews, research, and projections of environmental change. Use this information to develop trail improvement, maintenance and development plans, with prioritized improvements. Develop and implement educational and informational strategies to promote safe and responsible trail use.

**OBJECTIVE 1.** Establish baseline knowledge of existing trail use patterns, condition and hazards, and impacts on habitats and associated resources. Incorporate information about anticipated climate-driven environmental change into hazard assessments.

***Priority Actions:***

| | |
|---|---|
| **T1A1** | Map existing trails and trail use to better understand how people are using the trails and where trail improvements or new trails are needed. |
| **T1A2** | Interview trial users to better understand how they use trails and what their safety concerns are. |
| **T1A3** | Conduct risk assessments using both historical accident data and updated hazard assessment methods. |
| **T1A4** | Research travel impacts on the land as well as the effectiveness of various strategies to mitigate, minimize, or avoid negative impacts (e.g., how long until birds return to exclusion zones). |



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| **OBJECTIVE 2.** Improve safety and reduce negative impacts on habitat by promoting safe and responsible trail behavior. | |
|---|---|
| ***Priority Actions:*** | |
| **T2A1** | Create in-school safety education programs involving youth and Elders. |
| **T2A2** | Develop a social media platform that allows trail users to update each other on trail conditions, share safety reminders and report safe travel. |
| **T2A3** | Develop and use an app to photograph problem areas; tag GIS coordinates and share on social media. |
| **T2A4** | Mount trail cameras and ice thickness sensors on snow machines to show where trails are used and how thick the underlying ice is. |
| **T2A5** | Develop trail use etiquette with Y-K Delta communities; share on social media, posters, other communication formats. |
| **T2B1** | Promote the development and use of adaptive technology for travel and transportation throughout the region. |

| **OBJECTIVE 3.** Establish a trail improvement strategy to guide future trail development and maintenance priorities. | |
|---|---|
| ***Priority Actions:*** | |
| **T3A1** | Develop trail hardening and development strategies to guide trail upgrades. |
| **T3A2** | Develop common regional trail marking standards for color coding and use of permanent markers. |
| **T3A3** | Install directional signage. |
| **T3A4** | Create a trail improvement fund to support trail improvements and emergency repairs. |
| **T3A5** | Complete a trail funding feasibility assessment to guide future funding strategies and grant applications. |
| **LI1A1** | Identify and address barriers to compacting and capacity building at the community level to increase effective partnerships. |
| **LI1B1** | Increase local capacity to develop solutions in place by increasing opportunities for students to learn through experiential learning labs, internships or mentorship programs with agencies and partnerships with ANSEP. |



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By Elwood Brehmer, Alaska Journal of Commerce
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*Elwood Brehmer can be reached at elwood.brehmer@alaskajournal.com.*

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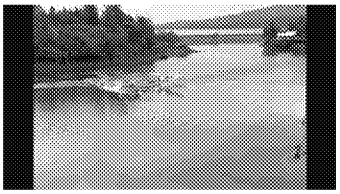

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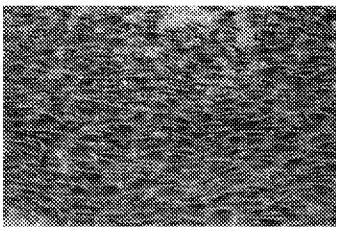

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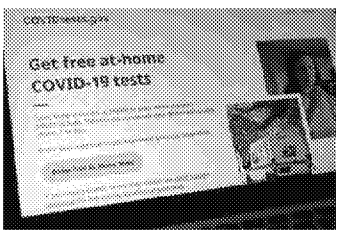


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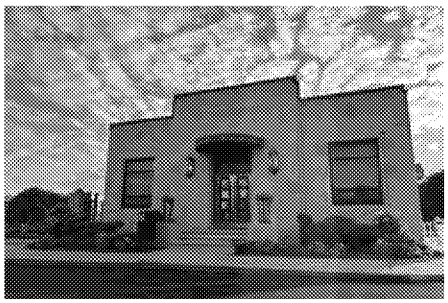

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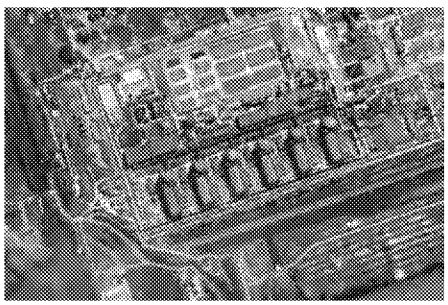

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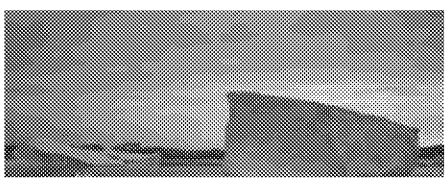

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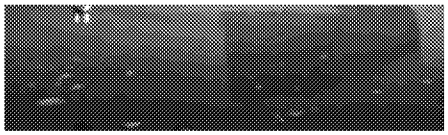

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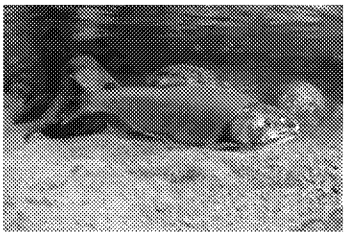

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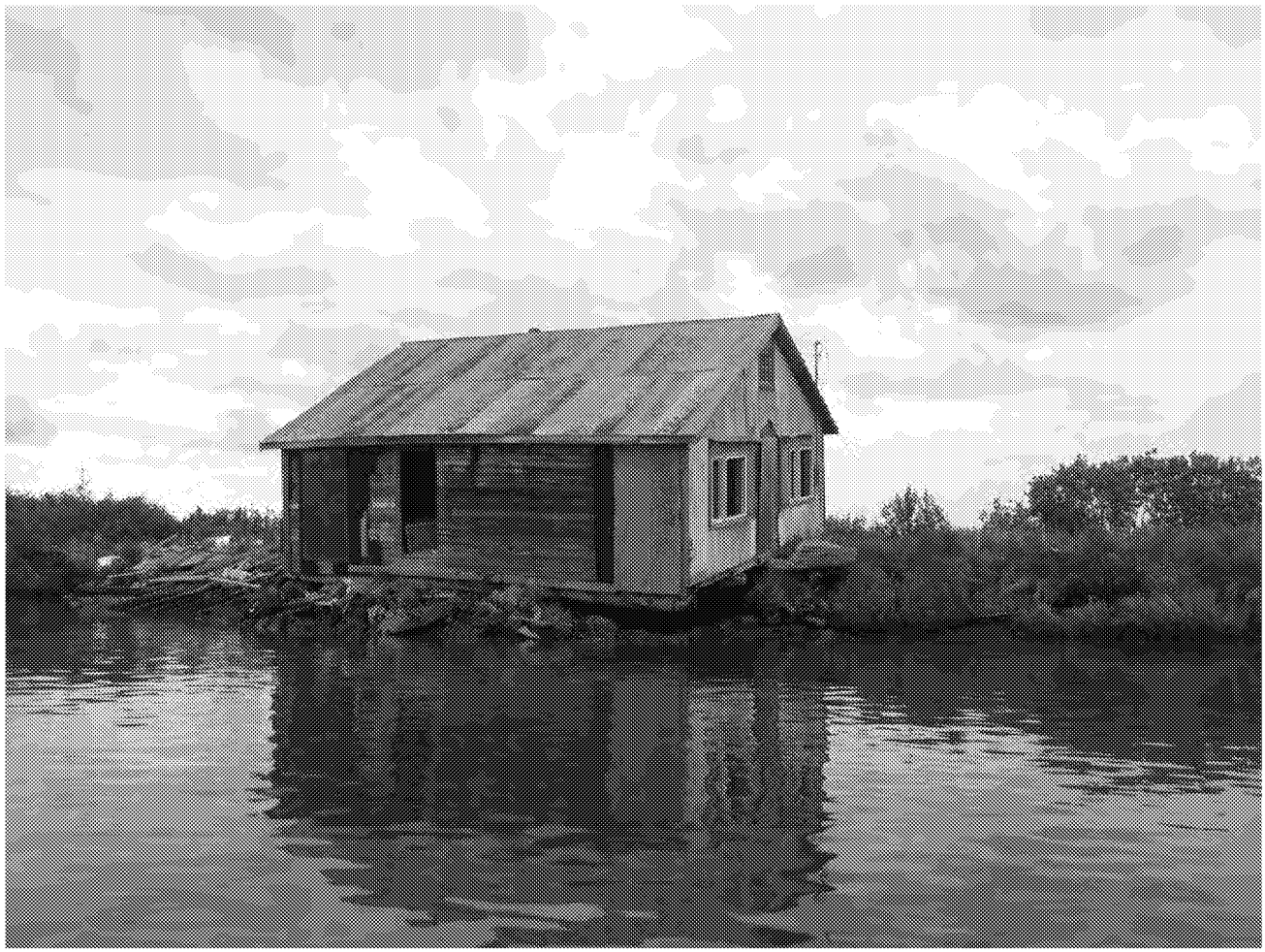
Report of Investigation 2021-3

# EROSION EXPOSURE ASSESSMENT OF INFRASTRUCTURE IN ALASKA COASTAL COMMUNITIES

Richard M. Buzard, Mark M. Turner, Katie Y. Miller, Donald C. Antrobus, and Jacquelyn R. Overbeck



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Richard M. Buzard, Mark M. Turner, Katie Y. Miller, Donald C. Antrobus, and Jacquelyn R. Overbeck

Report of Investigation 2021-3

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# Contents

Introduction ..... 1
Background ..... 3
Scope of This Report and Community-Specific Reports ..... 4
Methods ..... 5
- Shoreline Change Assessment ..... 5
- Suitable Shoreline Proxies for Erosion Forecasting ..... 6
- Shoreline Forecasts ..... 6
- Infrastructure Data and Erosion Exposure ..... 7
- Special Cases ..... 9

Discussion of Methods ..... 10
- Advantages and Limitations of Linear Regression Erosion Forecasts ..... 10
- Infrastructure and Replacement Cost ..... 14
- Subsistence and Cultural Sites ..... 14

Results ..... 14
Discussion of Results ..... 16
- Intended Use of Erosion Exposure Assessments ..... 17
- Consequences of Unclear and Exaggerated Erosion Forecast Language ..... 17
- Future Work ..... 18

Conclusion ..... 19
Acknowledgments ..... 19
References ..... 20
Appendix A ..... 24

# Figures

Figure 1. Aerial images comparing erosion in Napakiak from 1952 to 2019 ..... 2
Figure 2. Aerial images comparing erosion in Kotlik from the 1950s to present ..... 3
Figure 3. Location of erosion exposure assessments completed with this report ..... 4
Figure 4. Mean high water and vegetation shorelines in Hooper Bay show different erosion and accretion trends ..... 5
Figure 5. Diagram depicting linear erosion forecast method ..... 7
Figure 6. The history of the Alakanuk River is shown with the 1951 river footprint ..... 10
Figure 7. Diagram showing the unpredictable erosion of the Kanektok River in Quinhagak and the re-routing of the Twin Hills River from 1952 to 2016 ..... 11
Figure 8. Color infrared and aerial image showing the potential erosion impacts in Dillingham ..... 12
Figure 9. The shoreline history of Shishmaref shows erosion across the island and stability at the eastern revetment between 2004 and 2019 ..... 13
Figure 10. Examples of erosion forecast and erosion exposure map products ..... 15
Figure 11. Percent of total replacement cost of infrastructure forecast to be exposed to erosion by the 2070s for each of the 48 communities assessed ..... 16

# Tables

Table 1. Generic cost of infrastructure in rural Alaska communities determined by the Alaska Native Tribal Health Consortium ..... 8

# EROSION EXPOSURE ASSESSMENT OF INFRASTRUCTURE IN ALASKA COASTAL COMMUNITIES

Richard M. Buzard[1], Mark M. Turner[1], Katie Y. Miller[1], Donald C. Antrobus[2], and Jacquelyn R. Overbeck[1]

**Abstract**

Alaska communities located along coastlines and tidally influenced rivers are vulnerable to coastal erosion. These communities face decisions that require advance planning, such as implementing shore protection or moving infrastructure. To aid in erosion planning, we estimate erosion exposure for 48 communities from the Bering to the Beaufort seas. We conduct a shoreline change assessment, forecast 60 years of erosion, and estimate the replacement cost of infrastructure in the forecast area. Of 48 communities analyzed, 33 have infrastructure within the erosion forecast area. Fifteen communities comprise 90 percent of the total replacement cost. Eleven of these, and 80 percent of total estimated cost, are in the Yukon–Kuskokwim Delta. More than 40 percent of the estimated cost is forecast to occur by the late 2030s.

A summary of findings and map(s) of erosion forecast areas are provided for each community where an assessment could be performed. Erosion forecasts require a clearly identifiable shoreline that can be tracked through time in aerial imagery, as well as no major coastal protection structures in the forecast area. Erosion forecasts are not suitable for 12 communities, so we provide recommendations to address erosion concerns in those community assessment reports. The assessment conducted here is a tool for developing local hazard mitigation plans and strategies to address erosion. There are methodological limitations to linear shoreline change measurements, forecasts, and infrastructure replacement costs. Total costs are not reported in this summary due to these limitations. Users must incorporate expertise and local knowledge when interpreting results.

## INTRODUCTION

A critical component of risk management is identifying exposure—the situation of tangible assets in a hazard-prone area (Crichton, 1999; United Nations Office for Disaster Risk Reduction, www.undrr.org/terminology/exposure). In this assessment, we estimate the amount of infrastructure exposed to erosion in 48 Alaska communities from the Bering to the Beaufort seas. We conduct a shoreline change analysis, forecast 60 years of erosion, and estimate the replacement cost of infrastructure in the forecast area. The products can be incorporated into multi-hazard assessments such as community and statewide hazard mitigation plans and assessments (for example, University of Alaska Fairbanks [UAF] and others, 2019). The discussion section of this summary report explains the intended use and limitations of exposure assessments as an element of risk assessment.

Alaska's Bering, Chukchi, and Beaufort coasts are dotted with many rural communities that are vulnerable to erosion (UAF and others, 2019). Based on an analysis of shoreline positions from the 1950s to 2010s, at least 28 of these commu-

[1] Alaska Division of Geological & Geophysical Surveys, 3354 College Rd., Fairbanks, Alaska 99709-3707
[2] Alaska Native Tribal Health Consortium, 4000 Ambassador Drive, Anchorage, Alaska 99508

nities experience erosion rates greater than 3.3 feet per year (1 meter per year; Overbeck and others, 2020). Coastal erosion in this region is driven by wave and storm activity (U.S. Army Corps of Engineers [USACE], 2009a) and influenced by local geology, hydrology, permafrost thaw, flooding, reductions in sea ice, human activity, and many other factors (Farquharson and others, 2018; Jones and others, 2018; Overbeck and others, 2020). Rapid erosion rates have resulted in the relocation of entire villages, including Napakiak (see example in fig. 1), Meshik (now Port Heiden; Kinsman and others, 2014), and currently Newtok (Native Village of Newtok and others, 2015). Even communities with slow erosion rates face elevated exposure if infrastructure is near the coastline (UAF and others, 2019; Overbeck and others, 2020; fig. 2).

All communities in northern and western Alaska have increased the amount and value of infrastructure over the past 70 years: runways doubled in size to accommodate larger planes; bulk fuel tank farms, wastewater lagoons, and landfills have been installed and expanded; drinking water systems, larger schools, more homes, and new neighborhoods have been built (fig. 2). These additions improved community health and safety (U.S. Congress, 1994; U.S. Arctic Research Commission, 2015). However, in many places new infrastructure was placed near the coast—establishing a community footprint closer to shorelines. Communities are actively and continually addressing erosion by constructing and maintaining shoreline protection structures, moving individual buildings, and relocating to new sites.

Rural Alaska communities are uniquely vulnerable to hazards because most are disconnected from the road system, are only accessible by plane, require boat or barge access for supplies, and have an isolated grid for utilities and infrastructure. Critical infrastructure—"facilities that provide essential products and services to the general public"—are often singular (Alaska Division of

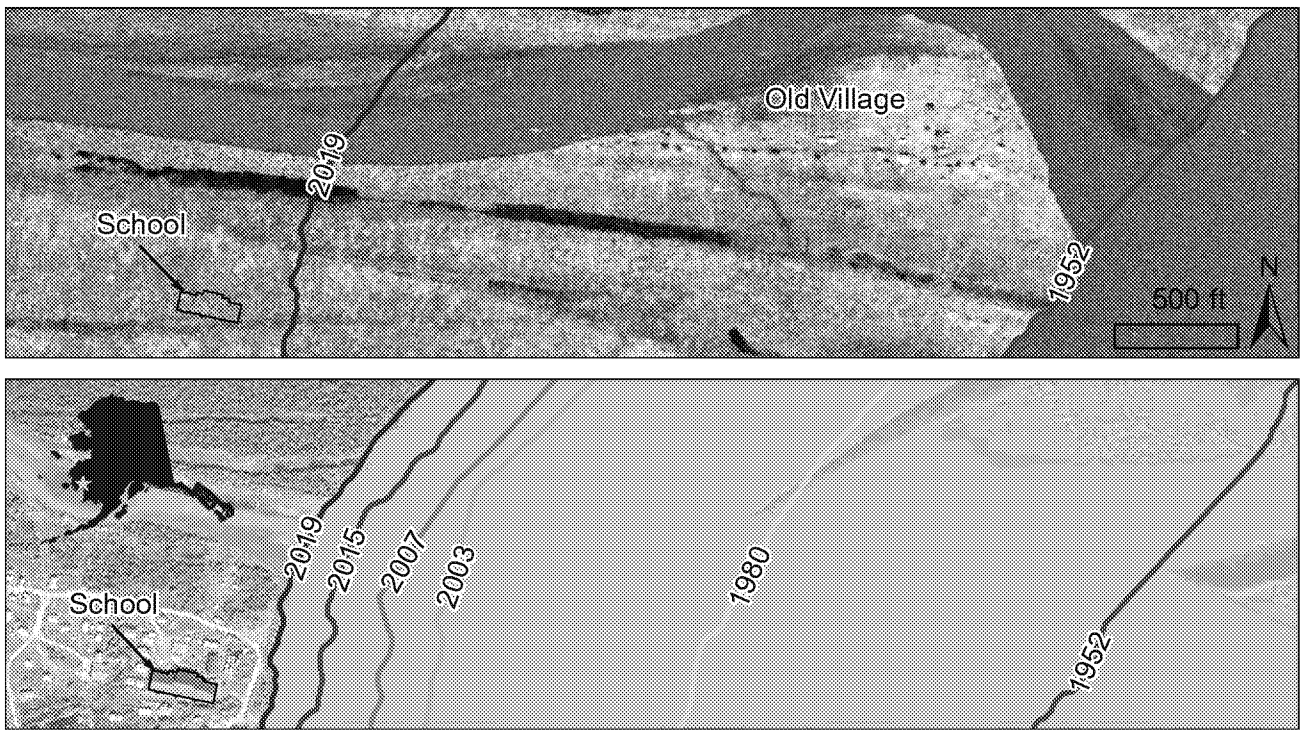



**Figure 1.** (Top) This aerial image from 1952 shows the former location of Napakiak (with the 2019 school and shoreline superimposed). The entire village has since relocated from the old site due to erosion. (Bottom) Erosion now threatens the current school and surrounding infrastructure. Erosion rates averaged 38 ft per year over 67 years, and the school is 200 ft from the 2019 shoreline (Overbeck and others, 2020).

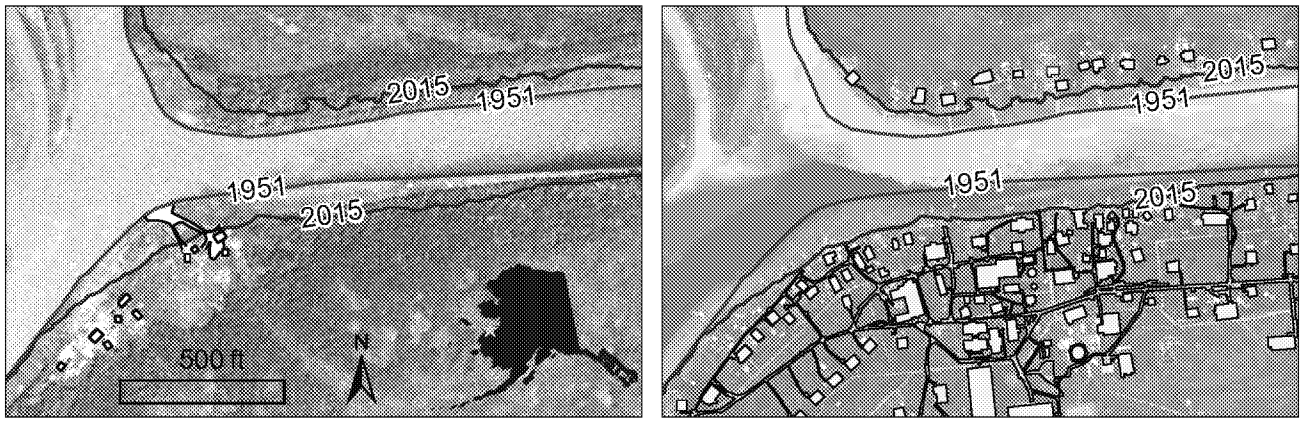



**Figure 2.** (Left) Kotlik was a small trading hub in the 1950s (Himes-Cornell and others, 2013). In 1959, the Bureau of Indian Affairs built a school in Kotlik, and neighboring communities moved there to attend. (Right) The community footprint rapidly expanded with housing, utility systems, boardwalks, and other infrastructure. Erosion is relatively slow, but pervasive, and undermines many coastal structures (Overbeck and others, 2020).

Homeland Security & Emergency Management [DHS&EM], 2018). These include the airport, barge landing, fuel storage, wastewater treatment, landfill, and washeteria (commonly the only source of treated drinking water and shower/laundry facilities). DHS&EM (2018) explains, "Due to many of Alaska's communities' remote rural location... most all facilities are deemed 'critical' to a community or agency's survival." Without backup options, the loss of any one facility can result in the loss of essential services to the entire community.

There is great need for erosion exposure assessments in rural Alaska communities. Local and statewide hazard assessments speculate erosion will soon impact subsistence sites, homes, and critical infrastructure (U.S. General Accounting Office [GAO], 2003; GAO, 2009; Immediate Action Workgroup [IAWG], 2009; USACE, 2009a; UAF and others, 2019). However, in the absence of quantitative analyses, hazard assessments often err on the side of bleak narratives (see examples in "Discussion" section). Yoder (2018) explains, "In Alaska, many residents have expressed concern and a feeling of depression related to the uncertainty of the scope and magnitude of potential climate change." This uncertain narrative also led to costly, rushed responses. Such is the case in Shishmaref where a series of shoreline stabilization efforts have been employed since the 1940s which ultimately failed, until the placement of boulder rock revetments in the 2000s (Mason and others, 2012), which still do not extend along the entire area at risk to erosion. Larsen and others (2008) estimate Alaska's infrastructure upkeep costs may rise by 10 to 12 percent by 2080 due to climate change, but informed adaptation strategies can significantly reduce costs. Quantitative erosion exposure assessments can aid Alaska communities with informed resilience planning and alleviate concerns over the unknown.

## BACKGROUND

The first systematic documentation of erosion in Alaska occurred when the Alaska Division of Community and Regional Affairs (DCRA, 1982) collected written surveys and interviews from communities and agencies. DCRA (1982) found that 169 of 213 Alaska Native villages experienced erosion and/or flooding, with the greatest impacts felt along coasts and tidally influenced rivers. GAO (2003) reached similar conclusions in an updated survey, which sparked the Baseline Erosion Assessment by USACE (2009a) (IAWG, 2009). The USACE assessment provided an unprecedented look into erosion across the state and recommended action based on level of threat from erosion using three categories: priority action, monitor conditions, and minimal erosion. The USACE (2009a) results have been used to imple-

ment federal shoreline protection and relocation projects. Ten years later, UAF and others (2019) investigated erosion risk, but for many communities the best existing erosion documentation was still the USACE (2009a) Baseline Erosion Assessment. Ultimately, there remains a need for quantitative data to adequately assess erosion exposure for Alaska communities. Overbeck and others (2020) computed linear shoreline change rates using aerial imagery from approximately the 1950s to the modern era (2015–18) for coastal communities. Our study builds upon this effort by estimating infrastructure exposure to future erosion.

## SCOPE OF THIS REPORT AND COMMUNITY-SPECIFIC REPORTS

This report discusses the methods used to assess exposure of infrastructure to erosion in Alaska communities. Results for each community are provided in a separate community report and map(s) where applicable (fig. 3). The products, listed below, are designed to aid in near- and long-term planning for erosion mitigation and adaptation:

1. Community report describing observed erosion, mitigation, forecast results, and special considerations.

**Figure 3.** Location of erosion exposure assessments completed with this report.

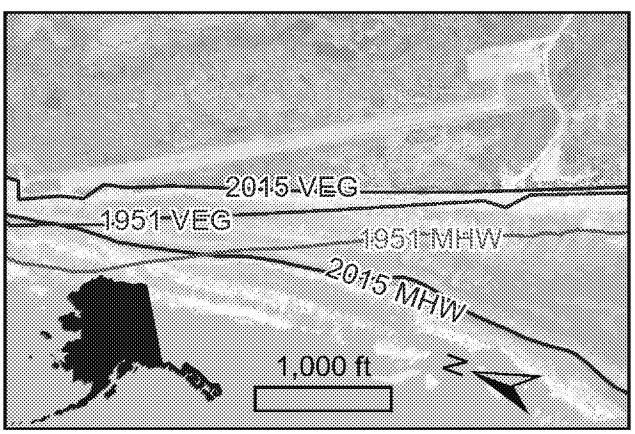
2. Erosion forecast map(s) showing the area of land exposed to erosion for 20-, 40-, and 60-year intervals along with model uncertainty.
3. Erosion exposure map(s) highlighting infrastructure exposed to erosion in 20, 40, and 60 years.

# METHODS

To assess erosion exposure of infrastructure, we conduct a shoreline change assessment, forecast 60 years of erosion continuing at the historical rate, and estimate the replacement cost of infrastructure in the forecast area.

## Shoreline Change Assessment

In coastal studies, the term "shoreline" can be defined by many features, such as the mean high water line (MHW), land-water interface (LWI), or vegetation line (Boak and Turner, 2005). Different types of shorelines can exhibit different patterns of erosion and accretion. Some shoreline types have greater relevance depending on the study focus. For this assessment, the relevant shoreline represents a discernible feature at which infrastructure cannot be developed seaward due to active coastal or riverine processes. This is most commonly the vegetation line, riverbank, or bluff top edge. While MHW and LWI generally parallel vegetation, their position and change rates are subject to greater uncertainty due to short- and long-term fluctuations in the tidal regime (Boak and Turner, 2005). Water lines can also represent cyclical beach change or an erosional regime altogether different from nearby vegetation lines at the boundary of developable land (Ruggiero and others, 2005; fig. 4). For these reasons, we forecast vegetation-based shorelines where possible.




Overbeck and others (2020) delineated or collected shoreline data for 48 Alaska communities. Sixty percent of the shorelines from Overbeck and others (2020) are vegetation lines, and the remaining are HWL or LWI. Where needed, we delineate shorelines using the vegetation line, riverbank, or bluff top edge using orthoimagery datasets and methods described by Overbeck and others (2020).

Calculating erosion rates requires at least two shorelines from different dates, but more shorelines at regular time steps can improve accuracy (Crowell and others, 2018). For this study, each site has at least three shorelines: one recent shoreline (2015 to 2019) and two or more historical shorelines (1950s, 1980s, 2000s), spanning over 60 years total. Multiple authors review new delineations and compare them to oblique imagery from the ShoreZone Partnership (www.shorezone.org) in order to identify delineation errors and find the best feature to trace. Shoreline delineation uncertainty is calculated as the root-sum-of-squares of the imagery orthorectification error, ground sampling distance, and digitizer error (see Overbeck and others [2020] for a full description).

Shoreline change rates are calculated using the Digital Shoreline Analysis System tool (DSAS; Himmelstoss and others, 2018). Virtual transects are cast perpendicular to the shoreline at 25-meter spacing. Along each transect, DSAS measures the position and distance between shorelines over time. Erosion rates are calculated using the weighted linear regression rate of change statistic and uncertainty at a 90 percent confidence interval when at least three shorelines are present (Himmelstoss and others, 2018).

**Figure 4.** Mean high water (MHW; blue) and vegetation (red) shorelines at Hooper Bay show different erosion and accretion trends. A sand lobe has migrated in front of the airport, showing a strong accretion signal; however, storm surge still reaches the vegetation line, causing erosion that threatens the runway. This example shows the importance of using the vegetation line to calculate the erosion trend fronting the Hooper Bay runway.

Shorelines are generally linear alongshore features, but at finer scales they are not always straight lines. Shorelines can fluctuate by several meters toward and away from the water, especially near a river outlet or beach access road where a vegetation line turns sharply inland. The DSAS transect method is sensitive to these fluctuations, which are outliers to the neighboring shoreline position. If a forecast is made from an outlier, the deviation propagates to create an unrealistic future shoreline (eroding or stabilizing at a rate vastly different from the nearest transects). We reduce the influence of outliers by generalizing shoreline change rates using a 3-transect moving window to compute the weighted mean erosion rate (WMER) and uncertainty (WMCI90), similar to Genz and others (2007). This practice also reduces uncertainty when neighboring transects have agreeing values (in other words, if three neighboring transects have the same erosion rate, it is more certain that the measured rate is the true rate). However, if the uncertainty was already small, the weighted uncertainty can approach 0.0 m per year, which is unrealistic. To avoid overconfident forecasts, a cutoff of 0.1 m per year is applied to the forecast uncertainty. With this cutoff, a 60-year erosion forecast will have at least a 6-meter uncertainty.

### Suitable Shoreline Proxies for Erosion Forecasting

Delineating the appropriate shoreline proxy is a critical aspect to shoreline change analyses. The term "proxy" is used because shorelines are interpreted from photo-identifiable features rather than measured directly (such as with GPS or on an elevation model), and this process introduces uncertainty. We find that the vegetation line (including bluff top edge or scarp) is the most suitable shoreline for measuring erosion of developable land—the landward-most features eroded by high water events are bluffs, scarps, and vegetation lines (Boak and Turner, 2005). These features are typically easier to interpret in aerial imagery than water line proxies like MHW or LWI. Challenges still arise, especially when dense vegetation obscures the top and toe of a bluff. We address this issue by using elevation models or oblique imagery to identify the correct vegetation line proxy. This validation technique is effective with recent, high-resolution, multiband orthoimagery, but less so for older, coarse, panchromatic orthoimagery. Fortunately for this effort, dense vegetation is uncommon in most assessed communities. A second accuracy limitation comes with the datasets themselves: poorly orthorectified imagery causes horizontal offsets and relief displacement (Crowell and others, 1991). This issue is most common for tall, steep cliffs orthorectified from few images. Historical orthomosaics were orthorectified using few images, but such geographic features are uncommon for communities in our assessment, so we assume this error is the same as the image horizontal uncertainty.

## Shoreline Forecasts

We use the WMER and WMCI90 to forecast mean and maximum distances of future shorelines. The mean distance ($d_\mu$) is the WMER multiplied by the number of years into the future ($t_y$; equation 1). The maximum distance ($d_{max}$) accommodates the uncertainty in the shoreline forecast and is calculated by adding WMCI90 to WMER, then multiplying by 60 years (equation 2).

$$d_\mu = WMER \times t_y \quad (1)$$

$$d_{max} = (WMER + WCI90) \times t_{60} \quad (2)$$

$d_\mu$ = mean erosion distance

$d_{max}$ = maximum erosion distance

$t_y$ = number of years from most recent shoreline

The conceptual diagram in figure 5 illustrates the erosion exposure assessment method. Erosion rates, based on historical shoreline positions (transparent to modern shoreline), are forecast to continue at a linear pace for 20, 40, and 60 years from the most recent shoreline (black solid line). The uncertainty area (light blue) shows the maximum erosion distance forecast within a 90

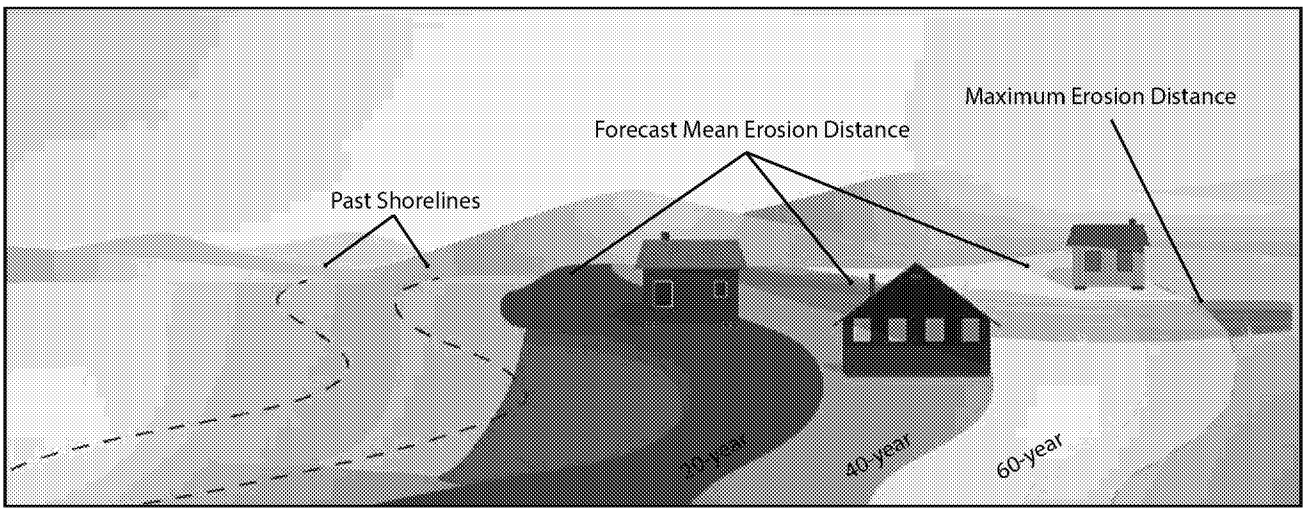



**Figure 5.** Diagram depicting linear erosion forecast method. Erosion of the shoreline is forecast to continue for 20, 40, and 60 years (purple, orange, and yellow, respectively). The light blue region represents the maximum forecast erosion in 60 years. In this example, the eroding shoreline is forecast to reach the red building within 20 years. The blue building is in the 40-year erosion interval. The yellow building is just beyond the 60-year erosion forecast but still within the 60-year erosion uncertainty range (light blue).

percent confidence interval. Erosion exposure for other infrastructure such as roads and water lines is analyzed by computing the length of exposed infrastructure per 20-year interval.

Defining the forecast timespan is an important consideration. These erosion forecasts are intended to inform infrastructure planning. Erosion setback policies in the United States and building design lives are often made with 50-year timelines. Linear regression is a common method for defining coastal setback zones and erosion hazard areas across coastal zone management sectors (Perello, 2019). Most shoreline data available for Alaska communities date back to the 1950s, approximately 60 years from the most recent shoreline data (2015–19). Crowell and others (1993) advise forecasts using 60 years of data not exceed 60 years into the future. With these considerations in mind, we forecast 60 years from the most recent shoreline (up to 6 years older than the publication date), so our products are relevant to the 50-year design and policy timeline for at least four years from the time of publication.

## Infrastructure Data and Erosion Exposure

Databases of infrastructure are not complete or available for the entire state of Alaska (Larsen and others, 2008). For some rural communities, infrastructure was originally drawn by DCRA (2021). We update the layers first by converting file formats from AutoCAD to ArcGIS, then by using recent imagery to delineate relevant changes to the community, such as new or removed infrastructure.

To estimate erosion exposure, we compare erosion forecast extents to infrastructure outlines. This reveals what and how much infrastructure could be exposed to erosion in the future. We associate infrastructure with a cost of replacement in order to give more weight to items that may be more expensive to address (such as valuing a school more than a single residence). Cost of replacement is one of many methods to estimate exposure and does not completely quantify risk (see "Discussion" section; Crowell and others, 1999; Burgess and others, 2000; Larsen and others, 2008).

**Table 1.** Generic cost of infrastructure in rural Alaska communities determined by the Alaska Native Tribal Health Consortium (ANTHC). Infrastructure listed include only those identified using community planning documents and aerial imagery. Units are linear foot (LF), square foot (SF), and lump sum (LS).

| Infrastructure | Unit | Unit Cost | Minimum Cost | Note |
|---|---|---|---|---|
| Boardwalk | LF | $75 | $75,000 | |
| Fuel Lines | LF | $60 | $50,000 | 2-inch schedule 40 steel pipeline |
| Gravel Road | LF | $400 | $200,000 | Based on average of $2.1 million per mile of road |
| Overhead Distribution Lines | LF | $200 | $50,000 | Average distance between poles of 100 LF |
| Water/Sewer Line | LF | $400 | $50,000 | |
| Community Hall | SF | $1,000 | $4,000,000 | Based on construction similar to the Mertarvik Evacuation Center (multi-purpose building) |
| Residential Housing | SF | $350 | $400,000 | New construction of 3- or 4-bedroom residence, indoor plumbing, post and pad gravel foundation |
| Unspecified Building | SF | $350 | $400,000 | Only if greater than 500 SF; maximum cost of $500,000 |
| Airport | LS | $40,000,000* | N/A | Based on $10,000,000 per 1,000 feet; will vary based on gravel price |
| Barge Landing | LS | $2,500,000* | N/A | Shallow draft landing with mooring points and small laydown area |
| Bulk Fuel Farm | LS | $4,500,000 | N/A | 140,000 gallon capacity |
| Church | LS | $500,000 | N/A | Large but simpler construction compared to residential home |
| City Office | LS | $500,000 | N/A | Approximately equivalent to residential housing |
| Clinic (medium size) | LS | $2,500,000 | N/A | |
| K–12 School | LS | $35,000,000 | N/A | |
| Landfill | LS | $1,000,000 | N/A | |
| Lift Station | LS | $1,000,000 | N/A | |
| Police and Jail | LS | $750,000 | N/A | |
| Power Plant | LS | $3,250,000 | N/A | 3-generator module, 250 kW capacity |
| Store | LS | $500,000 | N/A | |
| Teacher Housing | LS | $500,000 | N/A | Duplex construction |
| Tribal Office | LS | $500,000 | N/A | Approximately equivalent to residential housing |
| Wastewater Lagoon | LS | $6,000,000 | N/A | 3 acres |
| Water Storage Tank | LS | $1,500,000 | N/A | 200,000 gallon tank on gravel pad |

*Cost may be estimated using cost per SF or LF if appropriate.

Unit costs for replacement are assigned to each type of infrastructure (table 1). If available, we use reported infrastructure cost from community plans, such as local hazard mitigation plans. A consistent cost is applied to each community using generic estimates (table 1) developed using the professional judgment of Alaska Native Tribal Health Consortium (ANTHC) engineers, consultants, and partner agencies. Unit costs are approximate order of magnitude estimates intended to represent an average cost for infrastructure construction in rural Alaska. The costs developed by this method are based on average costs in northern and western Alaska and are similar to those found in community hazard mitigation plans (such as Nunam Iqua, Quinhagak, and Napakiak) available at www.commerce.alaska.gov. Assumptions used to determine costs are found in table 1. Uncertainty of each replacement cost is estimated to be ± 30 percent.

We do not make any adjustments or assumptions for regional variances, population scaling, cost-sharing, or adaptation options such as retreat, accommodation, decommissioning, environmental restoration, building shore protection, or modifying existing infrastructure. These cost estimates are a snapshot in time—we do not consider any changes in the cost of infrastructure over time or maintenance of existing infrastructure. These calculations are intended to give community decision makers the capacity to identify priority areas or facilities within a community that may require a response, mitigation action, or adaptation strategy. These calculations are not meant to serve as construction estimates or an economic assessment of risk.

The estimated cost to replace infrastructure depends on the type of infrastructure. If erosion can compromise the entire facility or feature, a lump sum (LS) cost is used. This is the case for buildings, fuel and water tanks, landfills, and wastewater lagoons. Larger residences generally cost more than smaller ones, so we estimate residential cost using square footage (SF). The cost to replace airport runways is computed using linear footage (LF) because they are sometimes repaired rather than abandoned. For example, if a gravel runway costs $40,000,000 and is 4,000 feet long, the runway cost is $10,000 per linear foot. A 60-year erosion forecast of 50 feet of runway will likely not cause an abandonment; instead, it will cost $500,000 to rebuild the eroded section (or replace it by building on the other end of the runway). Similarly, linear features such as roads, boardwalks, power lines, water utility corridors, and fuel lines may not require complete replacement if a small section is damaged by erosion, so cost is measured using the linear foot of the feature centerline.

Alternatively, erosion can compromise infrastructure to a greater extent even when only one section is at risk. For example, if a small section of water pipe is exposed, then the remaining structure may need rerouting. Given the labor and equipment costs to complete even a small project, a minimum cost associated with building or repairing infrastructure is applied to infrastructure with unit costs. Additionally, small buildings and residential housing may be replaced with modern structures that, in practice, are found to have a minimum cost of replacement regardless of the size of the original building. Generic unit and minimum costs are listed in table 1.

## Special Cases

We forecast erosion exposure for communities on tidally influenced rivers, but some river systems are too complex for linear forecasts. The forecast method is practicable for rivers that have exhibited near-linear changes over the study period (see Napakiak). Linear forecasts are less appropriate for rivers with erosion at sharp bends because they may experience avulsion and subsequent channel migration (Hooke, 2007; see Quinhagak). Forecasts in complex river systems require greater effort than the scope of this project (Lagasse and others, 2002), so we use alternative methods to communicate erosion exposure. The simplest method is to visualize river change with footprints of past rivers so decision-makers can see changes and make their own interpretations (fig. 6).

Many communities have characteristics that limit the ability to forecast erosion with the methods outlined in this report. Some have slow erosion rates, stable shorelines, or exhibit accretion trends, so the forecast shows no major changes. In these cases, we decide not to create a map but note findings in the community summary. For communities with erosion mitigation structures (such as a seawall), we do not forecast for the locations where protections exist. We cannot assume the effectiveness and longevity of the erosion control measures, so the 60-year uncertainty polygon is mapped as a "worst-case scenario" visual aid. Decision makers can use nearby forecasts, uncertainty, and historical shoreline positions to interpret the effectiveness of existing erosion control measures.

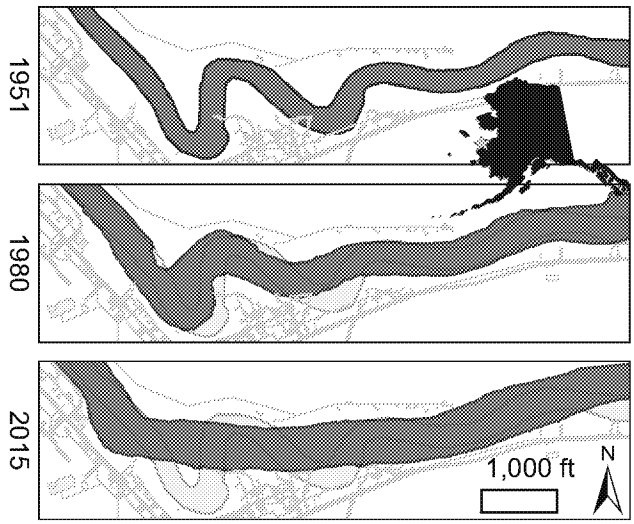



**Figure 6.** The history of the Alakanuk River (blue) is shown with the 1951 river footprint (gray area). The 2015 infrastructure (light gray lines) is shown in all panels. The river doubled in width and lost meanders over 64 years. Some infrastructure is built in abandoned river meanders. A traditional erosion forecast is not suitable, but the past river footprints communicate the dynamic history and susceptibility to change.

## DISCUSSION OF METHODS

### Advantages and Limitations of Linear Regression Erosion Forecasts

Linear regression analysis is the simplest method of forecasting; the results are easy to understand, as are the limitations (Crowell and others, 2018). However, linear forecasts are not appropriate for coastlines with highly episodic erosion drivers or complex multi-forcing factors (Douglas and Crowell, 2000). For example, rocky cliffs can experience extremely episodic erosion in the form of rockfalls (Hapke and Plant, 2010), and may be better represented by a hazard rating (Dunham and others, 2017). Mass wasting event cycles—which can be triggered by erosion undercutting a slope or by seismic activity—can take decades or centuries to repeat, requiring greater analysis to identify risk (Burns and Mickelson, 2016). Rivers can also undergo erosion in relatively unpredictable episodes and may require non-linear risk assessments (Lagasse and others, 2002; fig. 7). Gradual erosion can be forecast until a significant event, such as avulsion, changes the entire river morphology (Hooke, 2007). The event can be triggered by either gradual erosion or a sudden increase in discharge (due to rainfall, snowmelt, and/or flooding), so the exact timing is challenging to forecast (Turnipseed and others, 2021). There are many river communities in Alaska with erosion hazards where linear forecasts may not sufficiently identify risk (UAF and others, 2019). Beyond natural forcing, erosion can also be increased by anthropogenic activity such as boat wake, vehicles scouring sand on beaches and dunes, and vegetation and permafrost degradation from frequent traffic or construction. Similarly, erosion protection structures and beach nourishment may mitigate or offset the natural or induced erosion. Computed erosion rates represent the summation of all forcing factors, and linear forecasts imply those factors will continue at the same historical rate, so users should apply critical judgment and local knowledge to interpret results.

Expertise and local knowledge are instrumental in critically evaluating the results of linear erosion forecasts. For example, even if a coastline has experienced steady erosion, the rate can change significantly when erosion reaches different topography or lithology. This is occurring in Dillingham, where rapid and consistent erosion of a peat meadow is encroaching on the wastewater lagoon (fig. 8). The

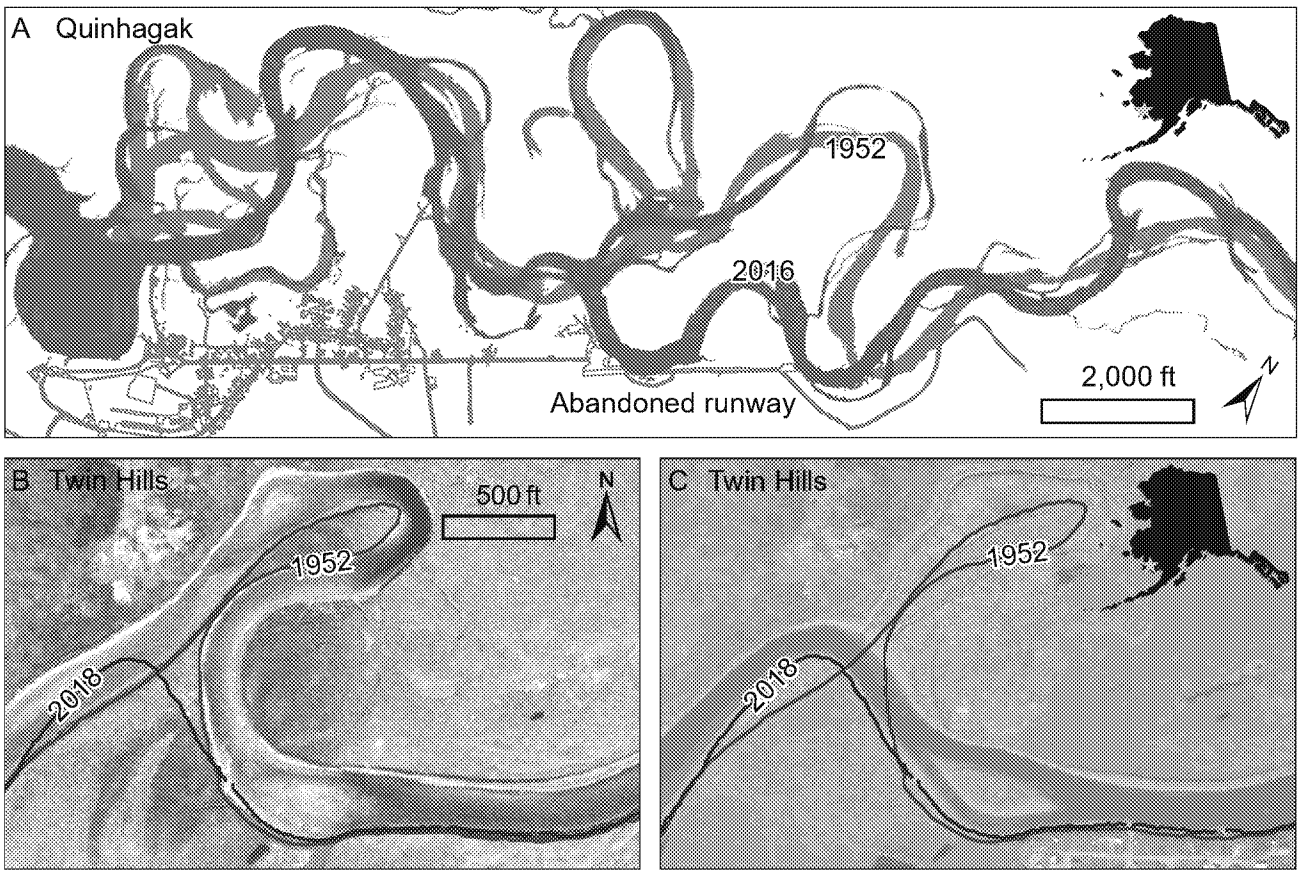



**Figure 7.** Examples of river shoreline change at the communities of Quinhagak and Twin Hills show how rivers can erode ununpredictably. **A.** The Kanektok River switched channels thousands of feet between 1952 (blue) and 2016 (red) and eroded the now-abandoned runway in Quinhagak. Linear regression could not have forecast this change. **B.** The Twin Hills River gradually eroded the thin strip of land in 1952 (blue). **C.** After breaking through this barrier, the river rerouted to its modern position (red). Although the river was significantly modified, shoreline change rates remained relatively stable near the community. These two examples demonstrate the drastic contrast between impacts that river change can cause, emphasizing the importance of using appropriate hazard assessment methods.

linear erosion forecast shows the shoreline will reach the lagoon around 2058. However, the peat meadow transitions into a vegetated hill covered with fill from the lagoon's construction. This change may significantly alter the rate of erosion, so a closer investigation (such as a geotechnical engineering study) would be appropriate to assess exposure. In communities with similar situations, the maps and reporting from this assessment can be used to demonstrate potential exposure and justify the need for in-depth hazard studies. This scenario is uncommon across the communities in this study and discussed when applicable in the community-specific reports.

The fundamental assumption of linear regression erosion forecasts is erosion rates will not accelerate or slow over time. Periods of greater or lesser erosion rates are expected but thought to remain within a confidence interval. This assumption is challenged by the expectation that coastal erosion will accelerate in response to longer ice-free water seasons, warmer temperatures, and many other climate-related factors changing in Alaska and the Arctic (Chapin and others, 2014). The mechanistic connection between these factors and erosion is generally understood, but the exact magnitude of acceleration is not well defined. For example, Jones and others (2018) measure erosion rates accelerating up to 2.5 times the historical rate on Alaska's north coast, but conclude there is no single driver or combination of drivers to completely explain the observed change.

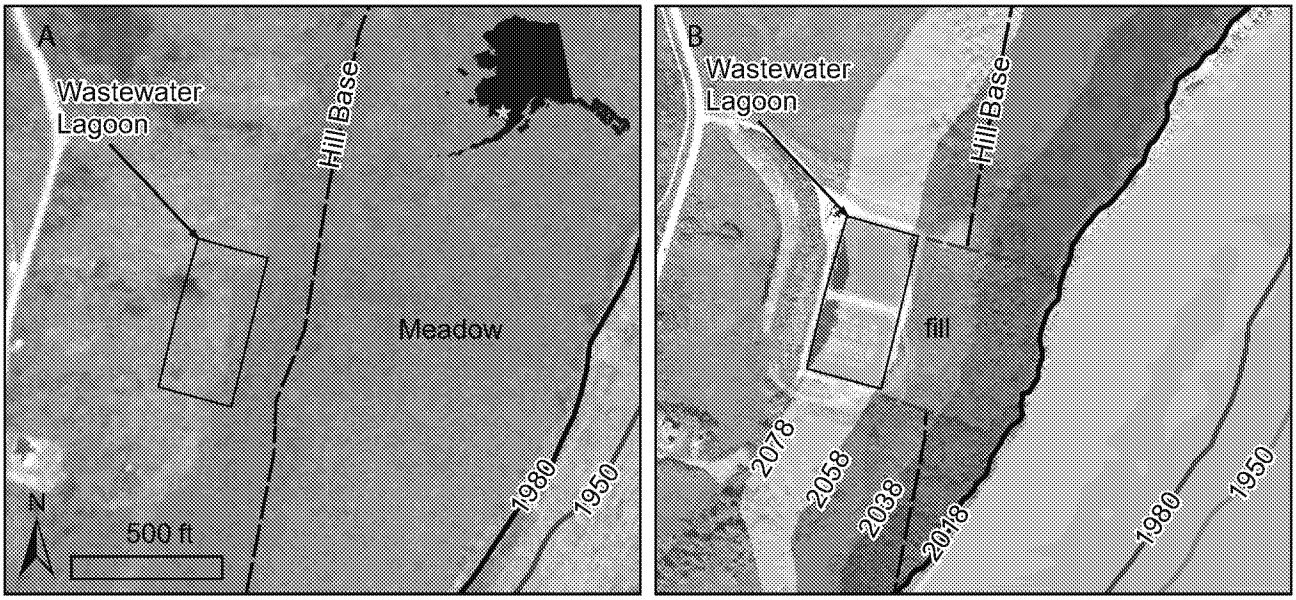



**Figure 8.** The Dillingham wastewater lagoon is an example of how linear shoreline forecasts may be inaccurate when there are changes in topography or lithology that likely change the erosion rate. (**A**) The 1980 color-infrared image shows the hill where the Dillingham wastewater lagoon is eventually built, and the broad meadow downslope toward the shoreline. (**B**) The wastewater lagoon is built into the hill, and fill from construction is deposited seaward. Erosion continues at a linear rate toward the hill's base and the fill area, suggesting an impact date near 2058; however, the fill area has a different lithology and vegetation cover that can significantly change erosion rates.

On Chukchi Sea coastlines, Farquharson and others (2018) observe increased dynamism (erosion and accretion) that may be a symptom of an increase in climate-driven forcing factors, but do not explicitly find accelerated shoreline erosion. Instead, a trend of increasing disturbance factors (such as storms during open water) do not allow coastal systems adequate time to equilibrate, possibly leading to a major shift in coastal geomorphology (Farquharson and others, 2018). These examples illustrate the complex combination of erosion drivers and coastal response that hinders attempts to introduce a simple acceleration variable into an otherwise linear forecast.

Irrgang and others (2019) explore whether shoreline datasets like those used in our study are adequate to detect and forecast acceleration or deceleration of erosion. In the most extreme example, their exponential model forecasts erosion rates increasing by more than three times, on average, as compared to the linear rate. Such increases are rare for coastlines that are already rapidly eroding. This may be due to a lack of increasing erosion drivers. For example, where thawing permafrost leads to increased erosion rates, the rates may stop increasing once the ground has thawed completely. In addition, once storm seasons are ice free and 100 percent of wave events are unimpeded, there can be no greater increase in this major forcing factor (sea ice loss) to further accelerate erosion rates. Regions of Alaska where these drivers have peaked may have already undergone their transition to faster or more dynamic erosion rates and will instead see constant or even decelerated rates, what Farquharson and others (2018) call a "new state of geomorphic equilibria." In such cases, a linear forecast based on historical or recent shoreline change is more appropriate than an acceleration model. The limited number of shoreline vector years in Alaska already inhibits complex forecast methods (Crowell and others, 1997; Douglas and Crowell, 2000; Genz and others, 2007). The discussed studies demonstrate how limitations of the current shoreline data and understanding of the role of climate-forcing parameters prohibit the ability to

forecast non-linear changes. While linear forecasts may underestimate erosion rates that are accelerating, they remain the most reliable method for widespread use (Crowell and others, 2018).

Parameterized and numerical models can incorporate accelerated erosion drivers in forecasts. For example, where sea level rise is the main driver of shoreline migration, the rising MHW datum can be mapped on an elevation model to forecast future shorelines (Crowell and others, 1997). However, sea level rise is difficult to estimate in Alaska due to limited water level and land level change data (Gorokhovich and Leiserowiz, 2012; Overbeck, 2018; DeGrandpre and Freymueller, 2019). Bull and others (2020) demonstrate the combination of environmental parameters required to model and possibly forecast permafrost erosion. Coastal permafrost erosion acceleration is primarily driven by the interaction between rising temperatures and reduced sea ice (Lantuit and others, 2013; Jones and others, 2018). A longer open water season allows increased thermal denudation and net wave energy, as well as more time for storm-driven waves to act on the coast (Overeem and others, 2011; Farquharson and others, 2018; Bogardus and others, 2020). Given that warming is projected to continue (Intergovernmental Panel on Climate Change, 2014; Thoman and Walsh, 2019), parameterized and numerical models can incorporate climate scenarios to forecast non-linear change. The necessary baseline data to accomplish this effort are largely absent for Alaska (Bull and others, 2020). Ultimately, advanced models will require the extensive collection of baseline data, such as relative sea level rise measurements, wave climatology data, a densified water level observation network, tidal-to-geodetic transformation tools (such as VDatum) to connect nearshore bathymetry to bare earth elevation models, permafrost and lithology characteristics, and climate models projecting environmental change. Erosion is a time-sensitive issue, and communities are already making decisions that will define their erosion response for the coming decades. Given these needs and constraints, a simple linear regression analysis remains an excellent first-order method to estimate erosion exposure across most communities in Alaska.

Linear regression analysis assumes erosion will continue at the same rate as it has been measured historically. For many sites, shore protection measures have been placed or constructed to mitigate or halt erosion. For example, rock revetments in Shishmaref reduced erosion rates, but erosion continues in the unprotected areas (fig. 9). We do

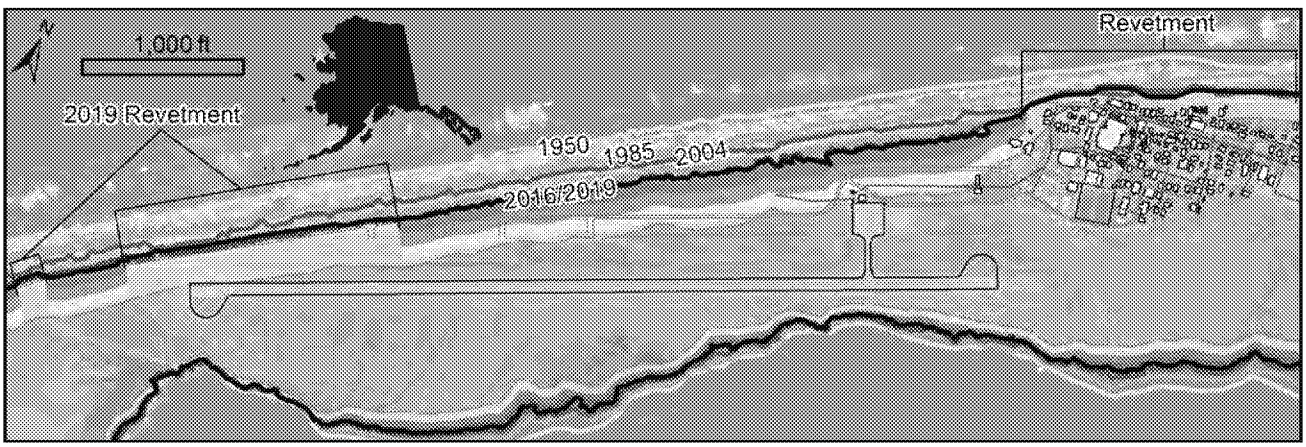



**Figure 9.** The shoreline history of Shishmaref (blue-scale lines) shows erosion across the island and stability at the eastern revetment between 2004 and 2019. The erosion forecast is only made where revetments do not exist, but the extent of the 60-year forecast uncertainty (light blue) is kept to approximate where erosion would occur based on past shoreline positions. Without the 2019 revetment, erosion is forecast to impact the runway. The revetment fronting the community protects almost all coastal infrastructure in this figure.

not display erosion forecasts along revetments or other shore protection structures; instead, we map the uncertainty boundary in order to communicate the possible magnitude of erosion based on past changes. The forecast does not account for edge effects around shoreline protection. As more coastal modifications are made, linear forecasts based on past shorelines alone become impossible. This is the case for Shaktoolik, where a community-wide berm is eroded and repaired frequently. These examples demonstrate the range of limitations caused by management of coastal sediment and placement of erosion control structures.

## Infrastructure and Replacement Cost

Infrastructure location and replacement cost are important aspects of exposure assessments because they help quantify the magnitude of exposure that erosion poses, but there are limitations in these datasets as well. Maintaining an accurate inventory of infrastructure is challenging, however updates to the infrastructure databases are based on the most recent aerial imagery, community planning documents, and fieldwork observations by DGGS. Communities are constantly changing—especially those with rapid erosion rates—so some infrastructure data may already be outdated. This was the case in Napakiak, where at least five structures were removed between 2015 and 2019 (the most recent aerial and satellite imagery we acquired, respectively; fig. 1). In addition, our method does not estimate the success, longevity, or upkeep costs of engineered solutions.

Infrastructure replacement cost is the cost of construction and does not include the total cost a project may entail or any cost adjustments over time. The infrastructure metadata lack critical details needed for an economic analysis of erosion exposure, including the useful life, age, and maintenance costs of infrastructure (Larsen and others, 2008). Replacement and demolition can also be an expensive process, especially for infrastructure with environmental contaminants, such as a fuel tank farm. Infrastructure construction and dismantling costs also increase if the community does not have the existing capacity to perform these projects (such as heavy equipment, tools, and personnel), or if projects need to be accomplished in phases over an extended period due to weather or funding availability. Access to resources like gravel or armor rock can substantially change the cost of projects due to shipping. Ultimately, the replacement costs estimated in this analysis are meant to provide enough information for community leaders to prioritize what infrastructure must be replaced and when; they do not reflect the total project cost.

## Subsistence and Cultural Sites

Most of the communities assessed have subsistence-based economies: fishing, hunting, and harvesting. Erosion can cause significant damage to fish camps, cut off access to hunting grounds, or destroy safe harbors and launch points for fishing vessels (Brady and Leichenko, 2020; Overbeck and others, 2020). The reduction or loss of critical subsistence activities can bring community-wide disruptions. Alaska's communities are also home to Indigenous people whose ancestors have lived along the coast for thousands of years at sites outside community footprints (Mason and others, 2012). These sites and landmarks are not consistently well-documented, although some have been found near eroding shorelines. Incorporating subsistence and cultural impacts is beyond the scope of what can be achieved by this assessment. Communities and organizations must leverage local knowledge along with scientific studies to evaluate erosion impacts to subsistence and cultural resources.

# RESULTS

Results of this assessment are documented in community-specific summary reports. Two types of map products provide a visual presentation of erosion forecasts near infrastructure (fig. 10). There may be more or fewer maps per location depending on the extent and severity of erosion.

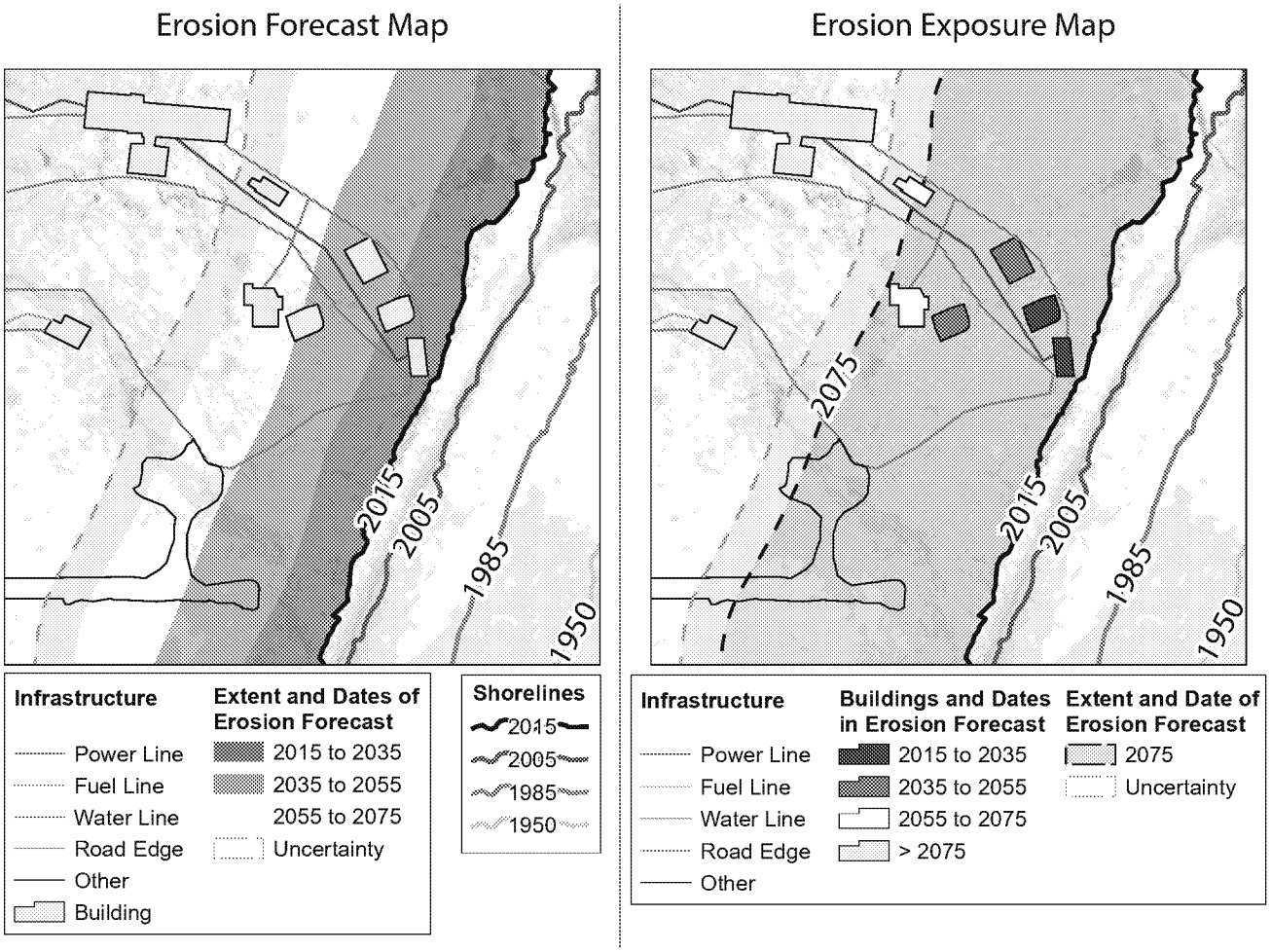



**Figure 10.** Examples of map products. Erosion Forecast Maps (left) show the extent of forecast erosion over time. Erosion Exposure Maps (right) show the total extent of erosion over 60 years and highlight infrastructure impacts per 20-year interval. Both maps show infrastructure categories, 60-year uncertainty, and historical shoreline positions.

The Erosion Forecast Map shows where future shorelines are forecast to be in 20-year intervals (fig. 10). The map displays the timing and extent of erosion relative to infrastructure locations. Exposure of undeveloped areas can also be determined. Past shorelines are included.

The Erosion Exposure Map shows which buildings are within the erosion forecast zone (fig. 10). We scale this map to focus on exposed buildings, which are colored by 20-year intervals. The 60-year extent of erosion is shown (darker blue), along with uncertainty (lighter blue) and past shorelines (pink scale).

Of the 48 communities assessed, 33 have infrastructure in areas forecast to erode by the 2070s. Of the remaining 15 communities, many experience erosion; however, we cannot forecast exposure due to the nature of erosion and recovery processes and/or local coastal management practices such as renourishment after coastal storms or stabilization of the coastline. Results are shown in figure 11 as a grouped percentage of the total replacement cost of all communities assessed, ordered by individual cost. Newtok and Napakiak comprise nearly 50 percent of the total cost. Thirteen more communities comprise another 40 percent (meaning their combined cost is nearly equal to Newtok and Napakiak combined). The 17 Yukon–Kuskokwim Delta communities assessed comprise 82 percent of the total cost. More than 40 percent of the estimated cost is forecast to occur

**Figure 11.** Percent of total replacement cost of infrastructure forecast to be exposed to erosion by the 2070s for each of the 48 communities assessed. The greatest costs are found on the Yukon–Kuskokwim Delta.

before 2040. Buildings comprise 69 percent of the total cost. Erosion is forecast to reach 4 wastewater lagoons, 7 airports, 10 barge landings, and 3 landfills. Appendix A lists infrastructure exposure per community. See community-specific reports for more information.

## DISCUSSION OF RESULTS

This assessment identifies infrastructure that could be exposed to erosion if historical shoreline retreat continues at its long-term rate and is not mitigated. The practice of forecasting, in general, has caveats stemming from data generation, analysis

methodology, and the presence of uncontrolled variables. Two of the greatest variables—climate change and coastal management practices—will reduce forecast accuracy, especially further into the future. This assessment provides a snapshot of erosion exposure based on known erosion trends. Continued monitoring of erosion rates and collection of new aerial imagery at 5- to 10-year intervals is critical to keep adequate accounting of erosion exposure.

## Intended Use of Erosion Exposure Assessments

This erosion exposure assessment identifies the location and replacement cost of infrastructure in areas forecast to erode by the 2070s. This provides one component to be included in a larger assessment of hazards, such as a local or regional multi-hazard assessment or mitigation plan. When assessing erosion risk for a particular community, one must also consider the magnitude of the hazard and vulnerability (Crichton, 1999). Because erosion results in the permanent loss of developable land, solutions tend to be limited to prevention or relocation: erosion hazards are reduced through mitigation, and exposure is reduced by relocating infrastructure out of the forecast erosion area. The vulnerability of the community to erosion is related to these concepts but also accounts for critical facilities, vulnerable populations, and broader economic or intangible impacts. For example, if erosion of the only power plant will cut off power for the entire community, they are likely more vulnerable than a place with several homes but no critical infrastructure in an erosion area. Residents who do not have the means to relocate are also more vulnerable. Additionally, erosion of the boat parking and launching area will disproportionately impact a subsistence fishing economy. These considerations must be made by the risk assessor, in addition to the exposure component.

Erosion forecasts are useful for defining timetables to address hazards and identify safe locations. In Newtok, erosion is rapid, and there is no significant shoreline protection. The community is relocating to the new site of Mertarvik, a challenging endeavor that has taken decades and is still not complete. During this lengthy transition period, critical infrastructure must be replaced to maintain vital utilities such as electricity, heat, and clean water. However, the community struggled to obtain funding for running water and wastewater infrastructure at Newtok due to the threat of erosion and inevitable relocation, resulting in health issues (Bronen and Chapin, 2013). Our erosion forecast shows that the wastewater lagoon, washeteria, health clinic, airport runway, school, and numerous homes and other structures may erode by 2035 (see Newtok). USACE (2008) forecasts similar impacts culminating by 2027. While the results are bleak, they also identify areas not exposed to erosion, giving the community more leverage to replace critical infrastructure by demonstrating safe areas and timelines.

## Consequences of Unclear and Exaggerated Erosion Forecast Language

Shishmaref, Kivalina, and many more Alaska communities are discussed in media as if they will experience the same erosion future as Newtok (Herrmann, 2017). Shishmaref has a history of rapid erosion and major impacts, but Mason and others (2012) find that many sources grossly embellish erosion impacts. The greatest exaggeration came in 1975 from an engineering firm that speculated up to half of the community eroding between 1976 and 1985. Based on projections from computed shoreline change by Mason and others (2012), the impact purported by the engineering firm could have occurred within 30 years, not 1 to 10 years. While the erosion exposure is significant, the exaggerated erosion forecast led to rushed mitigation strategies that largely failed (Mason and others, 2012). Shishmaref's current revetment is significantly more effective at halting erosion, and long-term erosion rates suggest most of the community may be safe for several decades (fig. 9). Although the realized erosion was far less than the

exaggerated forecast and mitigation has successfully halted erosion in front of the community, Shishmaref's vote to relocate barred the community from constructing running water and piped sewer infrastructure (Bronen and Chapin, 2013).

Kivalina's experience with erosion hazard response is similar to Shishmaref's, despite having a combination of erosion and accretion that nets into a stable shoreline (USACE, 2009b). Two major storms (2004 and 2005) caused an unprecedented 70 to 80 ft of erosion. Despite the known historical stability, USACE (2009b) assumes this erosion will continue annually, and claims, "...infrastructure costs in Kivalina total more than $105 million for the 20-year project horizon, although the community will become uninhabited long before complete loss occurs." The assumed accelerated erosion may stem from an outdated storm surge model that predicted the 2004 storm was a 1-year event and the entire community could be inundated by a 5-year event, even though no community-inundating storm has been observed in over 100 years (Glenn Gray and Associates, 2010). Like Shishmaref, Kivalina struggled to obtain funds for adequate sewer and water systems because any new infrastructure would purportedly be built in a floodplain, eroded, or abandoned after the community voted to relocate (ANTHC, 2011; Bronen and Chapin, 2013). Chapman and others (2009) published a storm surge model that estimates substantially lower flood levels, showing that even a 100-year storm would barely reach coastal infrastructure and certainly would not inundate the barrier island (Glenn Gray and Associates, 2010). While hindsight indicates the USACE (2009b) erosion forecast was inaccurate, there is probable reason to believe erosion will increase due to reduced sea ice during storm seasons (Fang and others, 2018; Farquharson and others, 2018). Fortunately, the rock revetment built in 2010 appears to have prevented further bluff erosion for that section of the spit, and the beach is accreting (Overbeck and others, 2020).

Shishmaref, Kivalina, and likely many other communities are in a gray area where erosion hazards are present and possibly increasing but magnitude of exposure is often exaggerated. For these two communities, hazards are mostly addressed through adequate mitigation, yet media and reports continue to echo the language predicting imminent community-wide destruction (Herrmann, 2017; Mason and others, 2012). These echoes disempower communities by ignoring their resilience efforts (Herrmann, 2017), and lead to serious damage to societal health, such as lack of access to safe water (Bronen and Chapin, 2013). These examples emphasize the importance of incorporating uncertainty, scientific judgment, and local observations when using erosion forecast maps.

## Future Work

This assessment is the first attempt to quantify erosion exposure for several Alaska communities. There are many limitations to the results, stemming from data availability, analysis methods, and evaluating impact through estimates of replacement cost. Future work should address these limitations. Updated infrastructure data layers are vital to reflect the current community layout. Given the prominent subsistence economy, erosion costs should be expanded to include subsistence-related resources and assets. Cultural sites were also not included in this analysis because no consistent database of their locations was available. Possible follow-on work could also examine more nuanced vulnerability factors that incorporate environmental, cultural, and socio-economic data. We recognize that shoreline erosion forecasts are not suitable for communities with primarily beach (not bluff) erosion or complex river systems, so a separate analysis method is needed to adequately assess erosion exposure. Finally, our assessment will become outdated as communities and the environment change. Many locations saw major infrastructure and shoreline change in the approximately 10 years between the USACE (2009a) assessment and our study. We suggest the methods of this study—improved to include more communities and assets—be repeated within 10 years. These assessments can be incorporated into

the 5-year hazard mitigation plan updates common to most communities.

## CONCLUSION

We forecast erosion based on a linear shoreline change in rural Alaska communities. Resulting products communicate erosion exposure: the timing and extent of erosion and how it relates to existing infrastructure. The community-specific erosion exposure assessments include maps and tables displaying the extent of the erosion forecast, historical shorelines, and existing infrastructure outlines to illustrate local erosion hotspots and the relative magnitude of impact based on estimated replacement costs of infrastructure. Communities can incorporate this assessment into local hazard mitigation plans and applications for funding, when advising new construction, or sharing their experiences. Linear erosion forecasts are not sufficient where there is significant coastal management through coastal protections or shoreline nourishment. We do not forecast erosion for these coastlines. Instead, we recommend regular re-mapping and monitoring of coastal elevations, as well as considering parameterized or numerical models. Erosion is a pervasive issue across Alaska, and continued warming and concomitant changes will only exacerbate the problem. Erosion forecast tools provide a baseline expectation of exposure, but there will always be limitations. Communities and other users must combine these tools with local knowledge and evidence to decide the best course of action.

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## REFERENCES


Alaska Division of Community & Regional Affairs (DCRA), 1982, A listing of Alaskan communities for documentation of erosion problems: Division of Community Planning, 18 p.

———2021, DCRA community profile maps: [website] found at: https://dcced.maps.arcgis.com/apps/webappviewer/index.html?id=18fdb060875740fdad22099ca779d637

Alaska Division of Homeland Security & Emergency Management (DHS&EM), 2018, State of Alaska hazard mitigation plan: DHS&EM, 753 p.

Alaska Native Tribal Health Consortium (ANTHC), 2011, Climate change in Kivalina, Alaska: ANTHC Center for Climate and Health, 66 p.

Boak, E.H., and Turner, I.L., 2005, Shoreline definition and detection—A review: Journal of Coastal Research, v. 21, no. 4, p. 688–703.

Bogardus, Reyce, Maio, C.V., Mason, O.K., Buzard, R.M., Mahoney, A.R., and de Wit, Cary, 2020, Mid-winter breakout of landfast sea ice and major storm leads to significant ice push event along Chukchi Sea coastline: Frontiers in Earth Science, v. 8, no. 344, 18 p. http://doi.org/10.3389/feart.2020.00344

Brady, M.B., and Leichenko, Robin, 2020, The impacts of coastal erosion on Alaska's North Slope communities—A co-production assessment of land use damages and risks: Polar Geography, v. 43, no. 4, p. 259–279.

Bronen, Robin, and Chapin, F.S., III, 2013, Adaptive governance and institutional strategies for climate-induced community relocations in Alaska: Proceedings of the National Academy of Sciences, v. 110, no. 23, p. 9,320–9,325.

Bull, D.L., Bristol, E.M., Brown, Eloise, Choens, R.C., Connolly, C.T., Flanary, Christopher, Frederick, J.M., Jones, B.M., Jones, C.A., Ward Jones, Melissa, Kasper, J.L., McClelland, J.W., Mota, Alejandro, and Tezaur, Irina, 2020, Arctic coastal erosion—Modeling and experimentation: SAND2020-10223, Sandia National Laboratories, NM, 229 p.

Burgess, Kevin, Samuels, Paul, Chatterton, John, Penning-Rowsell, E., and Deakin, Robert, 2000, Assessment of economic value of national assets at risk from flooding and coastal erosion, *in* Annual Conference of River and Coastal Engineering, University of Keele, 2000, MAFF, London, 10 p.

Burns, W.J., and Mickelson, K.A., 2016, Protocol for deep landslide susceptibility mapping: Oregon Department of Geology and Mineral Industries Special Paper 48, 66 p.

Chapin, F.S., III, Trainor, S.F., Cochran, P., Huntington, H., Markon, C., McCammon, M., McGuire, A.D., and Serreze, M., 2014, Ch. 22—Alaska, *in* Melillo, J.M., Richmond, T.C., and Yohe, G.W., eds., Climate change impacts in the United States—the third national climate assessment: U.S. Global Change Research Program, p. 514–536.

Chapman, R.S., Kim, S.-C., and Mark, D.J., 2009, Storm-induced water level prediction study for the western coast of Alaska: U.S. Army Corps of Engineers Coastal and Hydraulics Laboratory, 92 p.

City of Kivalina, 2015, City of Kivalina hazard mitigation plan—updated December 2015: The City of Kivalina Hazard Mitigation Planning Team, 275 p.

Crichton, David, 1999, The Risk Triangle, *in* Ingleton, J., ed., Natural Disaster Management: Leicester, England, Tudor Rose, p. 102–103.

Crowell, Mark, Douglas, B.C., and Leatherman, S.P., 1997, On forecasting future U.S. shoreline positions—A test of algorithms: Journal of Coastal Research, v. 13, no. 4, p. 1,245–1,255.

Crowell, Mark, Leatherman, S.P., and Douglas, B.C., 2018, Erosion—Historical analysis and forecasting, *in* Finkl, C.W., and Makowski, C., eds., Encyclopedia of Coastal Science: Springer International Publishing AG, p. 428–432.

Crowell, Mark, Leatherman, S.P., and Buckley, M.K., 1991, Historical shoreline change—Error analysis and mapping accuracy: Journal of Coastal Research, v. 7, no. 3, p. 839–852.

———1993, Shoreline change rate analysis—Long term versus short term data: Shore & Beach, v. 61, no. 2, p. 13–20.

Crowell, Mark, Leikin, H., and Buckley, M.K., 1999, Evaluation of coastal erosion hazards study: an overview: Journal of Coastal Research, special issue no. 28, p. 2–9.

Douglas, B.C., and Crowell, Mark, 2000, Long-term shoreline position prediction and error propagation: Journal of Coastal Research, v. 16, no. 1, p. 145–152.

DeGrandpre, K.G., and Freymueller, J.T., 2019, Vertical velocities, glacial isostatic adjustment, and earth structure of northern and western Alaska based on repeat GPS measurements: Journal of Geophysical Research—Solid Earth 124, 16 p. https://doi.org/10.1029/2018JB017163

Dunham, Lisa, Wartman, Joseph, Olsen, M.J., O'Banion, Matthew, and Cunningham, Keith, 2017, Rockfall activity index (RAI): A lidar-derived, morphology-based method for hazard assessment: Engineering Geology, v. 221, p. 184–192. https://doi.org/10.1016/j.enggeo.2017.03.009

Farquharson, L.M., Mann, D.H., Swanson, D.K., Jones, B.M., Buzard, R.M., and Jordan, J.W., 2018, Temporal and spatial variability in coastline response to declining sea-ice in northwest Alaska: Marine Geology 404, p. 71–83.

Fang, Zhanpei, Freeman, P.T., Field, C.B., and Mach, K.J., 2018, Reduced sea ice protection period increases storm exposure in Kivalina, Alaska: Arctic Science, v. 4, p. 525–537.

Genz, A.S., Fletcher, C.H., Dunn, R.A., Fazer, L.N., and Rooney, J.J., 2007, The predictive accuracy of shoreline change rate methods and alongshore beach variation on Maui, Hawaii: Journal of Coastal Research, v. 23, no. 1, p. 87–105.

Glenn Gray and Associates, 2010, Situation assessment—Kivalina consensus building project: Glenn Gray and Associates, 49 p.

Gorokhovich, Yuri, and Leiserowiz, Anthony, 2012, Historical and future coastal changes in northwest Alaska: Journal of Coastal Research, v. 28, no. 1A, p. 174–186. https://doi.org/10.2112/JCOASTRES-D-11-00031.1

Hapke, C.J., and Plant, N.G., 2010, Predicting coastal cliff erosion using a Bayesian probabilistic model: Marine Geology 278, p. 140–149. https://doi.org/10.1016/j.margeo.2010.10.001

Herrmann, Victoria, 2017, America's first climate change refugees—Victimization, distancing, and disempowerment in journalistic storytelling: Energy Research & Social Science, v. 31, p. 205–214.

Himes-Cornell, A., Hoelting, K., Maquire, C., Munger-Little, L., Lee, J., Fisk, J., Felthoven, R., Geller, C., and Little, P., 2013, Community profiles for North Pacific fisheries–Alaska: NOAA Technical Memorandum NMFS-AFSC-259, v. 12, 711 p.

Himmelstoss, E.A., Farris, A.S., Henderson, R.E., Kratzmann, M.G., Ergul, Ayhan, Zhang, Ouya, Zichichi, J.L., and Thieler, E.R., 2018, Digital shoreline analysis system (version 5.0): U.S. Geological Survey software release. https://code.usgs.gov/cch/dsas

Hooke, J.M., 2007, Complexity, self-organization and variation in behavior in meandering rivers: Geomorphology 91, p. 236–258.

Immediate Action Working Group (IAWG), 2009, Recommendations report to the governor's sub-cabinet on climate change: Immediate Action Working Group, 168 p. https://dec.alaska.gov/climate-change/

Intergovernmental Panel on Climate Change, 2014, Climate change 2014—Synthesis report: Contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change in Core Writing Team, Pachauri, R.K., and Meyer, L.A., eds., Intergovernmental Panel on Climate Change, Geneva, Switzerland, 151 p.

Irrgang, A.M., Lantuit, Hugues, Gordon, R.R., Piskor, Ashley, and Manson, G.K., 2019, Impacts of past and future coastal changes on the Yukon coast—Threats for cultural sites, infrastructure, and travel routes: Arctic Science 5, p. 107–126. http://doi.org/10.1139/as-2017-0041

Jones, B.M., Farquharson, L.M., Baughman, C.A., Buzard, R.M., Arp, C.D., Grosse, G., Bull, D., Guenther, F., Nitze, I., Urban, F., Kasper, J., Frederick, J.M., Thomas, M., Jones, C., Mota, A., Dallimore, S., Tweedle, C., Maio, C.V., Mann, D.H., Richmond, B., Gibbs, A.E., Xiao, M., Kanevskiy, M., and Romanovsky, V.E., 2018, A decade of remotely sensed observations highlight complex processes linked to coastal permafrost bluff erosion in the Arctic: Environmental Research Letters, v. 13, no. 11, 13 p.

Kinsman, N.E.M., and Gould, A.I., 2014, Contemporary shoreline retreat rates at Meshik in Port Heiden, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2014-4, 21 p. http://doi.org/10.14509/27321

Lagasse, P.F., Spitz, W.J., and Zevenbergen, L.W., 2002, A methodology for predicting channel migration NCHRP Project No. 42-16, *in* Chen, Hamn-Ching, Briaud, Jean-Louis (Hg.): First International Conference on Scour of Foundations, College Station, Texas, Nov. 17-20, 2002: Texas Transportation Institute, Publications Dept., p. 1,051–1,060.

Lantuit, Hugues, Overduin, P.P., and Wetterich, S., 2013, Recent progress regarding permafrost coasts: Permafrost and Periglacial Processes 24, p. 120–130. http://doi.org/10.1002/ppp.1777

Larsen, P.H., Goldsmith, S., Smith, O., Wilson, M.L., Strzepek, K., Chinowsky, P., and Saylor, B., 2008, Estimating future costs for Alaska public infrastructure at risk from climate change: Global Environmental Change, v. 18, no. 3, p. 442–457. http://doi.org/10.1016/j.gloenvcha.2008.03.005

Mason, O.K., Jordan, J.W., Lestak, L.R., and Manley, W.F., 2012, Narratives of shoreline erosion and protection at Shishmaref, Alaska—The anecdotal and the analytical, *in* Cooper, Andrew, and Pilkey, Orrin, eds., Pitfalls of shoreline stabilization: Springer, Dordrecht, p. 73–92.

Native Village of Newtok, AECOM+URS Corporation, and BP&D, 2015, Newtok Village tribal hazard mitigation plan update: Federal Emergency Management Agency, 82 p.

Overbeck, J.R., 2018, Alaska coastal mapping gaps & priorities: Alaska Division of Geological & Geophysical Surveys Information Circular 72. http://doi.org/10.14509/30096

Overbeck, J.R., Buzard, R.M., Turner, M.M., Miller, K.Y., and Glenn, R.J., 2020, Shoreline change at Alaska coastal communities: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2020-10, 29 p., 47 sheets. https://doi.org/10.14509/30552

Overeem, Irina, Anderson, R.S., Wobus, C.W., Clow, G.D., Urban, F.E., and Matell, Nora, 2011, Sea ice loss enhances wave action at the Arctic coast: Geophysical Research Letters, v. 38, L17503, 6 p. http://doi.org/10.1029/2011GL048681

Perello, Melanie, November 2019, Draft Great Lakes coastal erosion—Review of erosion estimates, mapping, and public policies and outreach across the Great Lakes: Minnesota Department of Natural Resources, Lake Superior Coastal Program, 48 p. http://ardc.org/wp-content/uploads/2020/01/20191105_ReportOnGreatLakesErosionEfforts.pdf

Ruggiero, Peter, Kaminsky, G.M., Gelfenbaum, Guy, and Voigt, Brian, 2005, Seasonal to interannual morphodynamics along a high-energy dissipative littoral cell: Journal of Coastal Research, v. 21, no. 3, p. 553–578. http://doi.org/10.2112/03-0029.1

Thoman, Rick, and Walsh, J.E., 2019, Alaska's changing environment—Documenting Alaska's physical and biological changes through observations, International Arctic Research Center, University of Alaska Fairbanks, 16 p.

Turnipseed, Christopher, Konsoer, Kory, Richards, Derek, and Willson, Clinton, 2021, Numerical modeling of two-dimensional hydrodynamics in a highly curving and actively evolving neck cutoff under different hydrologic conditions: Water Resources Research, v. 57, 14 p. https://doi.org/10.1029/2020WR027329

U.S. Arctic Research Commission, 2015, Alaskan water and sanitation retrospective 1970–2005: Alaska Rural Water and Sanitation Working Group, 26 p.

U.S. Congress, Office of Technology Assessment, 1994, An Alaskan challenge—Native village sanitation: OTA-ENV-591, Washington, D.C., U.S. Government Printing Office, 126 p.

U.S. General Accounting Office (GAO), 2003, Alaska Native villages: most are affected by flooding and erosion, but few qualify for federal assistance: U.S. General Accounting Office, GAO-04-142, 91 p.

———2009, Alaska Native villages: limited progress has been made on relocating villages threatened by flooding and erosion: U.S. Government Accountability Office, GAO-09-551, 53 p.

U.S. Army Corps of Engineers (USACE), 2008, Revised environmental assessment—Finding of no significant impact—Newtok evacuation center Mertarvik, Nelson Island, Alaska: U.S. Army Corps of Engineers Alaska District, 64 p.

———2009a, Alaska baseline erosion assessment—Study findings and technical report: U.S. Army Corps of Engineers Alaska District, 65 p.

———2009b, AVETA report summary—Kivalina, Alaska: U.S. Army Corps of Engineers Alaska District, 4 p.

University of Alaska Fairbanks (UAF) Institute of Northern Engineering, U.S. Army Corps of Engineers Alaska District, U.S. Army Corps of Engineers (USACE) Cold Regions Research and Engineering Laboratory, 2019, Statewide threat assessment—identification of threats from erosion, flooding, and thawing permafrost in remote Alaska communities: Report #INE 19.03, 99 p.

Yoder, Sarah, 2018, Assessment of the potential health impacts of climate change in Alaska: State of Alaska Epidemiology Bulletin, v. 20, 77 p.

# APPENDIX A

**Table A1.** Summary table of quantity of exposed infrastructure by forecast date range and community. Some items are measured in linear feet (LF) or square feet (SF).

| Community | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Other |
|---|---|---|---|---|---|---|---|
| **Newtok** | 2015 to 2035 | 2,007 LF Power Line<br>1,675 LF Water Line<br>6,155 LF Road & Boardwalk<br>38,850 SF Barge Landing<br>31 Buildings<br>1 Tank Facility<br>69,320 SF Wastewater Lagoon<br>220 LF Airport | 2035 to 2055 | 3,373 LF Power Line<br>1,854 LF Water Line<br>10,892 LF Road & Boardwalk<br>3,480 SF Barge Landing<br>44 Buildings<br>1 Tank Facility<br>730 LF Airport | 2055 to 2075 | 1,191 LF Power Line<br>254 LF Water Line<br>1,347 LF Road & Boardwalk<br>9 Buildings<br>1 Tank Facility<br>520 LF Airport | n/a |
| **Napakiak** | 2015 to 2035 | 983 LF Power Line<br>598 LF Water Line<br>2,091 LF Road<br>19 Buildings | 2035 to 2055 | 1,117 LF Power Line<br>288 LF Water Line<br>3,088 LF Road<br>25 Buildings<br>145,240 SF Landfill | 2055 to 2075 | 1,222 LF Power Line<br>2,377 LF Road Line<br>19 Buildings<br>1 Tank Facility | n/a |
| **Kotlik** | 2015 to 2035 | 892 LF Power Line<br>31 LF Water Line<br>242 LF Boardwalk<br>24 Buildings | 2035 to 2055 | 955 LF Power Line<br>44 LF Water Line<br>500 LF Boardwalk<br>26 Buildings | 2055 to 2075 | 430 LF Power Line<br>100 LF Water Line<br>480 LF Boardwalk<br>13 Buildings | n/a |
| **Alakanuk** | 2015 to 2035 | 40 LF Power Line<br>10 LF Water Line<br>530 LF Road<br>2 Buildings | 2035 to 2055 | 1,330 LF Power Line<br>280 LF Water Line<br>4,100 LF Road<br>4 Buildings | 2055 to 2075 | 1,689 LF Power Line<br>3 LF Fuel Line<br>780 LF Water Line<br>1,250 LF Road<br>13 Buildings | n/a |
| **Egegik** | 2018 to 2038 | 73 LF Power Line<br>1,545 LF Water Line<br>539 Road<br>10 Buildings | 2038 to 2058 | 505 LF Power Line<br>2,715 LF Water Line<br>763 Road<br>16 Buildings | 2058 to 2078 | 1,574 LF Power Line<br>4,257 LF Water Line<br>1,326 Road<br>8 Buildings | n/a |

| Community | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Other |
|---|---|---|---|---|---|---|---|
| **Kipnuk** | 2015 to 2035 | 333 LF Power Line<br>537 LF Fuel Line<br>741 LF Road & Boardwalk<br>38,850 SF Barge Landing<br>4 Buildings<br>2 Tank Facilities | 2035 to 2055 | 768 LF Power Line<br>340 LF Fuel Line<br>1,781 LF Road & Boardwalk<br>3,480 SF Barge Landing<br>9 Buildings<br>1 Tank Facility | 2055 to 2075 | 837 LF Power Line<br>210 LF Fuel Line<br>79 LF Water Line<br>1,928 LF Road & Boardwalk<br>17 Buildings | n/a |
| **Quinhagak** | 2016 To 2036 | None | 2036 to 2056 | None | 2056 to 2076 | 69,319 SF Wastewater Lagoon | **Floodplain**<br>32 Buildings<br>3,398 LF Power<br>1,123 LF Water<br>8,071 LF Road<br>1 City Dock |
| **Tuntutuliak** | 2015 to 2035 | 367 LF Power Line<br>74 LF Fuel Line<br>110 LF Water Line<br>622 LF Boardwalk<br>22,410 SF Barge Landing<br>25 Buildings | 2035 to 2055 | 400 LF Power Line<br>245 LF Fuel Line<br>331 LF Water Line<br>1,466 LF Boardwalk<br>23,256 SF Barge Landing<br>27 Buildings<br>1 Tank Facility | 2055 to 2075 | 505 LF Power Line<br>199 LF Fuel Line<br>362 LF Water Line<br>946 LF Boardwalk<br>145,237 SF Barge Landing<br>17 Buildings<br>13 LF Airport | n/a |
| **Dillingham** | 2018 to 2038 | 610 LF Water Line | 2038 to 2058 | 981 LF Water Line<br>2,006 SF Wastewater Lagoon<br>9 Buildings | 2058 to 2078 | 1,258 LF Water Line<br>97,854 SF Wastewater Lagoon<br>8 Buildings | n/a |
| **Emmonak** | 2015 to 2035 | 3,769 LF Power Line<br>37 LF Fuel Line<br>27 LF Water Line<br>4,279 LF Road<br>3 Buildings | 2035 to 2055 | 368 LF Power Line<br>37 LF Fuel Line<br>71 LF Water Line<br>2,225 LF Road<br>4 Buildings | 2055 to 2075 | 637 LF Power Line<br>37 LF Fuel Line<br>242 LF Water Line<br>1,026 LF Road<br>14 Buildings | n/a |

| Community | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Other |
|---|---|---|---|---|---|---|---|
| **Hooper Bay** | 2015 to 2035 | 9 LF Road | 2035 to 2055 | 209 LF Road<br>463 LF Airport | 2055 to 2075 | 7 LF Fuel Line<br>116 LF Road<br>505 LF Airport | n/a |
| **Shishmaref** | 2019 to 2039 | 7 LF Water Line<br>1,045 LF Road<br>3 Buildings | 2039 to 2059 | 522 LF Road<br>2 Buildings<br>18 SF Wastewater Lagoon | 2059 to 2079 | 249 LF Power Line<br>488 LF Road<br>2 Buildings<br>3,935 SF Wastewater Lagoon | n/a |
| **Kwigillingok** | 2015 to 2035 | 47 LF Power Line<br>1,109 LF Road & Boardwalk<br>18,388 SF Barge Landing<br>5 Buildings | 2035 to 2055 | 492 LF Power Line<br>62 LF Water Line<br>1,187 LF Road & Boardwalk<br>9 Buildings | 2055 to 2075 | 1,593 LF Power Line<br>385 LF Water Line<br>1,910 LF Road & Boardwalk<br>21 Buildings | **River Migration Hazard**<br>103 LF Power<br>459 LF Road & Boardwalk<br>3 Buildings |
| **Point Hope** | 2019 to 2039 | 282 LF Airport | 2039 to 2059 | 231 LF Airport | 2059 to 2079 | 191 LF Airport | n/a |
| **Chefornak** | 2015 to 2035 | 65 LF Fuel Line<br>7 LF Road & Boardwalk<br>5,969 SF Barge Landing<br>5 Buildings | 2035 to 2055 | 65 LF Fuel Line<br>7 LF Road & Boardwalk<br>6,680 SF Barge Landing<br>6 Buildings | 2055 to 2075 | 149 LF Fuel Line<br>7 LF Road & Boardwalk<br>6,410 SF Barge Landing<br>9 Buildings | n/a |
| **Kongiganak** | 2015 to 2035 | 158 LF Power Line<br>13 LF Road & Boardwalk<br>3,114 SF Barge Landing | 2035 to 2055 | 224 LF Power Line<br>333 LF Road & Boardwalk<br>2,977 SF Barge Landing | 2055 to 2075 | 180 LF Power Line<br>18 LF Fuel Line<br>79 LF Water Line<br>197 LF Road & Boardwalk<br>2,608 SF Barge Landing<br>1 Building<br>1 Tank Facility | n/a |

| Community | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Other |
|---|---|---|---|---|---|---|---|
| **Nunam Iqua** | 2019 to 2039 | 294 LF Power Line<br>63 LF Fuel Line<br>201 LF Water Line<br>270 LF Boardwalk<br>6 Buildings<br>853 SF Airport<br>13,750 SF Barge Landing | 2039 to 2059 | 471 LF Power Line<br>63 LF Fuel Line<br>321 LF Water Line<br>610 LF Boardwalk<br>5 Buildings<br>1,163 SF Airport<br>9,530 SF Barge Landing | 2059 to 2079 | 98 LF Power Line<br>96 LF Fuel Line<br>537 LF Water Line<br>849 LF Boardwalk<br>3 Buildings<br>1,564 SF Airport<br>4,760 SF Barge Landing | n/a |
| **Clark's Point** | 2018 to 2038 | 11 Buildings | 2038 to 2058 | 404 LF Water Line<br>13 LF Road<br>4 Buildings | 2058 to 2078 | 261 LF Water Line<br>14 LF Road<br>1 Building | n/a |
| **Ekuk** | 2018 to 2038 | 254 LF Power Line<br>13 Buildings | 2038 to 2058 | 336 LF Power Line<br>86 LF Airport<br>10 Buildings<br>1 Tank Facility | 2058 to 2078 | 180 LF Power Line<br>145 LF Airport<br>14 Buildings | n/a |
| **Pilot Point** | 2019 to 2039 | 1,859 LF Road | 2039 to 2059 | 682 LF Road<br>1 Bulkhead | 2059 to 2079 | 964 LF Road | n/a |
| **Stebbins** | 2015 to 2035 | 3 LF Road<br>7 Buildings | 2035 to 2055 | 3 LF Road<br>6 Buildings | 2055 to 2075 | 3 LF Road<br>5 Buildings | n/a |
| **Naknek** | 2018 to 2038 | 48 LF Road<br>2 Buildings | 2038 to 2058 | 3 LF Power Line<br>83 LF Road<br>3 Buildings | 2058 to 2078 | 94 LF Road<br>3 Buildings | n/a |
| **Port Heiden** | 2019 to 2039 | 482 LF Road<br>1 Barge Landing | 2039 to 2059 | 922 LF Road<br>1 Building | 2059 to 2079 | Not Assessed | n/a |

| Community | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Other |
|---|---|---|---|---|---|---|---|
| **Levelock** | 2018 to 2038 | 51 LF Boat Launch<br>3 Buildings | 2038 to 2058 | 48 LF Boat Launch<br>1 Building | 2058 to 2078 | 45 LF Power Line<br>31 LF Boat Launch | n/a |
| **Kaktovik** | 2019 to 2039 | 19 LF Water Line<br>220 LF Road | 2039 to 2059 | 17 LF Water Line<br>400 LF Road<br>1 Fuel Header | 2059 to 2079 | 17 LF Water Line<br>2,262 LF Road | n/a |
| **Wainwright** | 2019 to 2039 | 4 LF Water Line<br>13 LF Road | 2039 to 2059 | 24 LF Power Line<br>118 LF Water Line<br>60 LF Road | 2059 to 2079 | 66 LF Power Line<br>219 LF Water Line<br>238 LF Road<br>1 Building | n/a |
| **Scammon Bay** | 2015 to 2035 | 33 LF Road | 2035 to 2055 | 42 LF Road<br>26 LF Airport | 2055 to 2075 | 48 LF Road<br>25 LF Airport | n/a |
| **Eek** | 2015 to 2035 | 2 LF Water Line<br>9 LF Road<br>1 Building | 2035 to 2055 | 19 LF Road | 2055 to 2075 | 20 LF Road | n/a |
| **South Naknek** | 2018 to 2038 | 22 LF Road | 2038 to 2058 | 39 LF Road | 2058 to 2078 | 45 LF Road<br>1 Building | n/a |
| **Toksook Bay** | 2015 to 2035 | 18 LF Road | 2035 to 2055 | 13 LF Road<br>1 Building | 2055 to 2075 | 19 LF Road<br>4 Buildings | n/a |
| **Tununak** | 2015 to 2035 | 213 LF Road<br>1 Bridge | 2035 to 2055 | 26 LF Road | 2055 to 2075 | 66 LF Road | n/a |

| Community | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Date Range | Quantity of Exposed Infrastructure | Other |
|---|---|---|---|---|---|---|---|
| **Koyuk** | 2015 to 2035 | 13 LF Road | 2035 to 2055 | 21 LF Road | 2055 to 2075 | 20 LF Road | n/a |
| **Point Lay** | 2019 to 2039 | None | 2039 to 2059 | 79 LF Water Line | 2059 to 2079 | 88 LF Water Line | n/a |
| **Golovin** | No infrastructure exposed to erosion | | | | | | |
| **Goodnews Bay** | No infrastructure exposed to erosion | | | | | | |
| **St. Michael** | No infrastructure exposed to erosion | | | | | | |
| **Teller** | No infrastructure exposed to erosion | | | | | | |
| **Brevig Mission** | No significant erosion found with shoreline change method | | | | | | |
| **Elim** | No significant erosion found with shoreline change method | | | | | | |
| **Kivalina** | No significant erosion found with shoreline change method | | | | | | |
| **Togiak** | No significant erosion found with shoreline change method | | | | | | |
| **Twin Hills** | No significant erosion found with shoreline change method | | | | | | |
| **Deering** | Cannot assess erosion exposure with shoreline change method | | | | | | |
| **Kotzebue** | Cannot assess erosion exposure with shoreline change method | | | | | | |
| **Nome** | Cannot assess erosion exposure with shoreline change method | | | | | | |
| **Shaktoolik** | Cannot assess erosion exposure with shoreline change method | | | | | | |
| **Unalakleet** | Cannot assess erosion exposure with shoreline change method | | | | | | |
| **Wales** | Cannot assess erosion exposure with shoreline change method | | | | | | |