Final Environmental Assessment
Nome Airport Runway Safety Area Improvements

Appendix Volume I of II
Appendices A - C

64.51° North Latitude and 165.44° West Longitude
Sections 21-23 and 26-28, T011S, R034W, Kateel River Meridian

October 2012
State Project Number: 61413

Prepared for:

United States Department of Transportation
Federal Aviation Administration
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On behalf of the sponsor:

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Appendix A – Snake River Relocation Concept Design Report

The following report describes alternatives for relocating the Snake River that were considered but ultimately dismissed from further evaluation.

NOME AIRPORT RSA EXPANSION

SNAKE RIVER RELOCATION

CONCEPT DESIGN REPORT

Nome, Alaska

May 2011

Prepared for:
Alaska Department of Transportation and Public Facilities
Northern Region

Prepared by:

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EXECUTIVE SUMMARY

Concept designs for relocation of the Snake River adjacent to the Nome Airport have been developed in support of a project proposed by the Alaska Department of Transportation and Public Facilities (DOT&PF) and the Federal Aviation Administration (FAA) to improve safety at the airport. The purpose of the proposed safety improvement project is to bring the Nome airport's runway safety areas (RSAs) into compliance with FAA design standards.

The Nome Airport has two runways – a main runway oriented approximately east-west, and a crosswind runway oriented northeast to southwest. The Snake River flows in an easterly direction along the western and southern margins of the Nome Airport. The river flows adjacent to the western end of the main runway and the southern end of the crosswind runway, and therefore presents a barrier to the construction of safety areas for the two runways.

The DOT&PF was considering a number of alternatives for addressing the RSA deficiencies at the Nome Airport when the Snake River relocation project began in 2009. Four alternatives for addressing RSA deficiencies on the main runway and four alternatives for addressing RSA deficiencies on the crosswind runway were presented in the July 2009 *Draft Practicability Study - Nome Airport Runway Safety Area*. The draft practicability study's recommended alternatives for the main and crosswind runways include relocating the Snake River to accommodate safety area construction.

Two Snake River Relocation options were developed by USKH in 2009 and presented in the December 2009 *Draft Snake River Relocation Concept Design Report*. The relocation concepts presented in the draft report accommodated maximum future airport expansion. The two relocation design concepts included the Lower River Reconnection Option and the New River Mouth Option. The Lower River Reconnection option would have been routed south beyond the projected western end of the maximum future expansion of the main runway, before turning east to rejoin the existing river channel briefly upstream of the crosswind runway. The new river channel would then have been routed to the south around the end of the extended crosswind runway embankment and then reconnected with the existing channel downstream and to the east of the expanded crosswind runway. The New River Mouth Option would have diverged from the existing river at the same location as the Lower River Reconnection Option, but instead of rejoining the existing channel it would be rerouted to the south to empty into Norton Sound at a new river mouth.

The need to accommodate maximum future airport expansion resulted in relocation designs that were extremely costly. The estimated cost of the Lower River Reconnection Option was approximately $77,000,000, while that of the New River Mouth Option was approximately $70,000,000. These costs were well beyond the FAA funding limits for RSA improvements at the Nome Airport, which are currently $25,000,000 for the main runway and $25,000,000 for the crosswind runway.

To address this, USKH provided the DOT&PF with three additional river relocations options – one that would allow construction of a 1,000-foot long and 500-foot wide safety area off the west end of the main runway (Option 3); a second option that would not only accommodate the safety area expansion but would also allow the future construction of a 1,775-foot long embankment extension of the main runway (Option 3 – Revised); and a third option that would accommodate the 1,775-foot long embankment extension of the main runway and a 275-foot threshold shift to the west (Option 4). This last option, allowing a future runway expansion and threshold shift, is essentially a much abbreviated and scaled back version of the previously developed Lower River Reconnection Option, and is called the Reduced Reconnection Option in this report.

One of the most important design features of the Reduced Reconnection Option is that it would maintain hydraulic connectivity with the lower Snake River. This connectivity would assure that existing flow conditions are maintained in the Snake River estuary and the Nome Harbor, and that the river's use as a transportation corridor would not be disrupted.

The alignment of the Reduced Reconnection Option would take off to the south from the existing Snake River and skirt the end of the proposed RSA expansion, a 275-foot threshold shift to the west, and the limits of a possible future 1,775-foot embankment extension of the main runway. This segment would generally parallel the proposed expanded runway embankment and tie back into the existing Snake River near the existing west end of the main runway.

The width of the new river valley would vary according to the elevation of the terrain through which the alignment passes. In lower elevations areas, the new valley would be wider, but it would narrow where ground surface elevations and excavation depths are greater. A floodplain that varies in width from 174-300 feet would be provided in the bottom of the new valley. The 150-foot wide and 7.5-foot deep channel of the relocated Snake River would meander gently within the floodplain. The length of this relocated valley segment would be approximately 4,600 feet, while the length of the meandering channel within the segment would be approximately 4,675 feet.

New valley excavation typical sections vary depending on whether or not the excavation occurs in previously mined areas. At this stage in the concept design process, approximately 2,660 feet of the proposed alignment would pass through previously mined areas. In areas that have not been previously mined, new valley side slopes would be cut at 3:1 (horizontal to vertical) while the new valley side slopes would be cut at 2.5:1 in previously mined areas. It is anticipated that excavation will be performed by conventional means (e.g., excavators, dozers, loaders, etc.) in previously mined areas and on the floodplain where permafrost is not expected to be present. A combination of conventional means and drilling and blasting is anticipated to be used in areas underlain by permafrost. In those areas, it is anticipated that the upper 10 feet of material can be excavated by conventional means, and that drilling and blasting would be required below that depth. Placement of a growth medium and reseeding will be required in addition to the placement of salvaged tundra mat where possible.

Excavation quantities would be approximately 1.6 million cubic yards, which comprises a significant portion of the estimated river relocation cost of $27.5 million.

Sedimentation occurring within the channel during the first few years after construction would result in temporary impacts to riverine and estuarine habitat downstream of the relocated portion of the stream. Juvenile salmonids would be the organisms most affected by these temporary impacts.

Wetland impacts would include the loss of approximately 26.5 acres of wetlands through direct excavation and fill for the new river valley, and the loss of approximately 47.7 acres of disturbed wetlands resulting from the disposal of unusable excavation on previously mined lands south of the airport.

Potentially hazardous waste and contaminated soils and groundwater would likely be encountered where the relocated river valley alignment passes through identified areas of environmental concern, which include abandoned barrels of a tar-like substance, metals contaminated soils and groundwater, and Alaska Department of Environmental Conservation (ADEC) Contaminated sites. Closure of ADEC Contaminated sites and proper removal and disposal of contaminated soil and groundwater would be required during the course of excavation, which could significantly increase project costs. Disposal of contaminated soils would occur within an ADEC permitted monofill. Disposal of contaminated groundwater would require an ADEC Excavation Dewatering permit with a mixing zone, which would also increase project costs.

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ACRONYMS

ADEC .... Alaska Department of Environmental Conservation
ADF&G .... Alaska Department of Fish and Game
ALP .... Airport Layout Plan
AOC .... Area of Concern
BLM .... Bureau of Land Management
cfs .... Cubic Feet per Second
CRREL .... Cold Regions Research and Engineering Laboratory
DNR .... Alaska Department of Natural Resources'
DOT&PF .... Alaska Department of Transportation and Public Facilities – Northern Region
EA .... Environmental Assessment
EDDA .... Environmental Due Diligence Audit
ESA .... Environmental Site Assessment
FAA .... Federal Aviation Administration
HEC-RAS .... Hydrologic Engineering Center River Analysis System
MATF .... Multi Agency Task Force
MLLW .... Mean Lower Low Water
mm .... millimeter
NEPA .... National Environmental Policy Act
NMFS .... National Marine Fisheries Service
NOAA .... National Oceanic and Atmospheric Administration
PDC .... PDC, Inc.
ppt .... parts per thousand
RM .... River Mile
RSA .... Runway Safety Area
RTK .... Real Time Kinematic
TAH .... Total Aromatic Hydrocarbons
TAqH .... Total Aqueous Hydrocarbons
UAF .... University Alaska Fairbanks
USACE .... United States Army Corps of Engineers
USFWS .... United States Fish and Wildlife Service
USGS .... United States Geological Survey
USKH .... USKH, Inc.

1 INTRODUCTION

1.1 RSA Expansion and Snake River Relocation Project Purpose and Need, and Overview

USKH Inc. (USKH) has been contracted by the Alaska Department of Transportation and Public Facilities – Northern Region (DOT&PF) to develop concept designs for relocation of the Snake River adjacent to the Nome Airport. The Snake River flows in an easterly direction along the western and southern margins of the Nome Airport. The river flows adjacent to the western end of the main runway and the southern end of the crosswind runway (see Figures 1 and 2), and therefore presents a barrier to the construction of safety areas for the two runways. River relocation concept designs have been developed in support of a project proposed by the DOT&PF and the Federal Aviation Administration (FAA) to improve safety at the airport. This would be at least the fourth known relocation of the Snake River. The Nome Airport is located approximately one mile northwest of the City of Nome, which is located on the south coast of the Seward Peninsula along the Bering Sea, facing Norton Sound.

The purpose of the proposed safety improvement project is to bring the Nome Airport's runway safety areas (RSAs) into compliance with FAA design standards. The runway safety area is a cleared area surrounding the runway to help reduce the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway. The Nome Airport has two runways – a main runway (Runway 10-28) oriented approximately east-west, and a crosswind runway (Runway 3-21) oriented northeast to southwest. Both runways lack safety areas beyond their thresholds. Several options for expanding RSAs in Nome have been considered as part of a Nome Airport Runway Safety Area Practicability Study. DOT&PF and FAA are currently evaluating one build alternative that would provide the most effective solution for achieving full safety area compliance.

Runway 10-28, the main runway at the Nome Airport, is 6,009 feet long. The current Airport Layout Plan (ALP) shows that there is no safety area beyond either threshold and that the width of the existing RSA is 300 feet. A standard length RSA would be provided by constructing a 1,000-foot full-width embankment off the west end of the runway and by grading and extending the existing cleared area off the east end of the runway to 1,000 feet beyond the threshold. The RSA beyond the eastern threshold would be constructed to the width practicable without impacting adjacent development northwest of the Nome Harbor. Existing cleared area along the north and south sides of the runway would be graded to create a 500-foot wide RSA along the entire paved runway with only minor deficiencies on the southwest end. The Proposed Action would also require acquisition of land and relocation of the Snake River for the west end RSA expansion. In accordance with FAA design standards, this alternative would provide a 1,000-foot long RSA on each end of the runway.

Runway 3-21, the crosswind runway at the Nome Airport, does not have an RSA beyond either threshold, leaving a large RSA length deficiency. The existing 300 foot width of the lateral safety area for this runway does not meet FAA standards. To improve these deficiencies, the RSA would be widened to the required 500 feet, except on the south end of the runway where it would follow the existing embankment to avoid additional impacts to the Snake River. Runway 3-21 thresholds would be shifted 600 feet to the north, providing a 600-foot non-standard RSA for Runway 3 operations. The safety area on the north end would then be extended beyond the new Runway 21 threshold by 1,000 feet. In addition to providing space for RSA, shifting the runway thresholds 600 feet would also correct a current FAA Flight Standards deficiency by eliminating airspace obstructions and would ensure that night time approach procedures for Runway 3 would continue. To maintain current navigational aid landing procedures, landing operations from the north would use a displaced threshold at the existing location of the Runway 21 threshold. The new embankment would require the existing access road to the northwest of the runway to be relocated.

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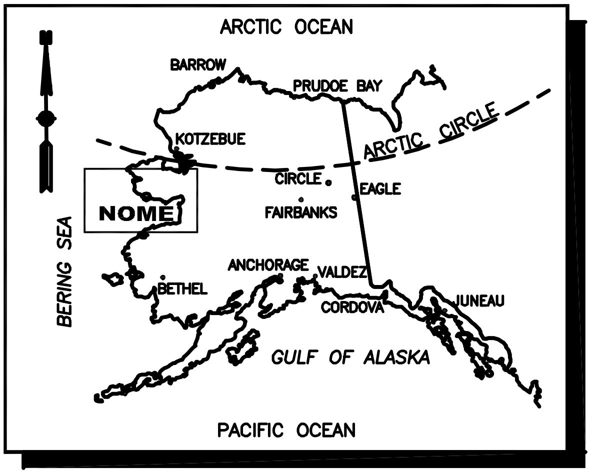
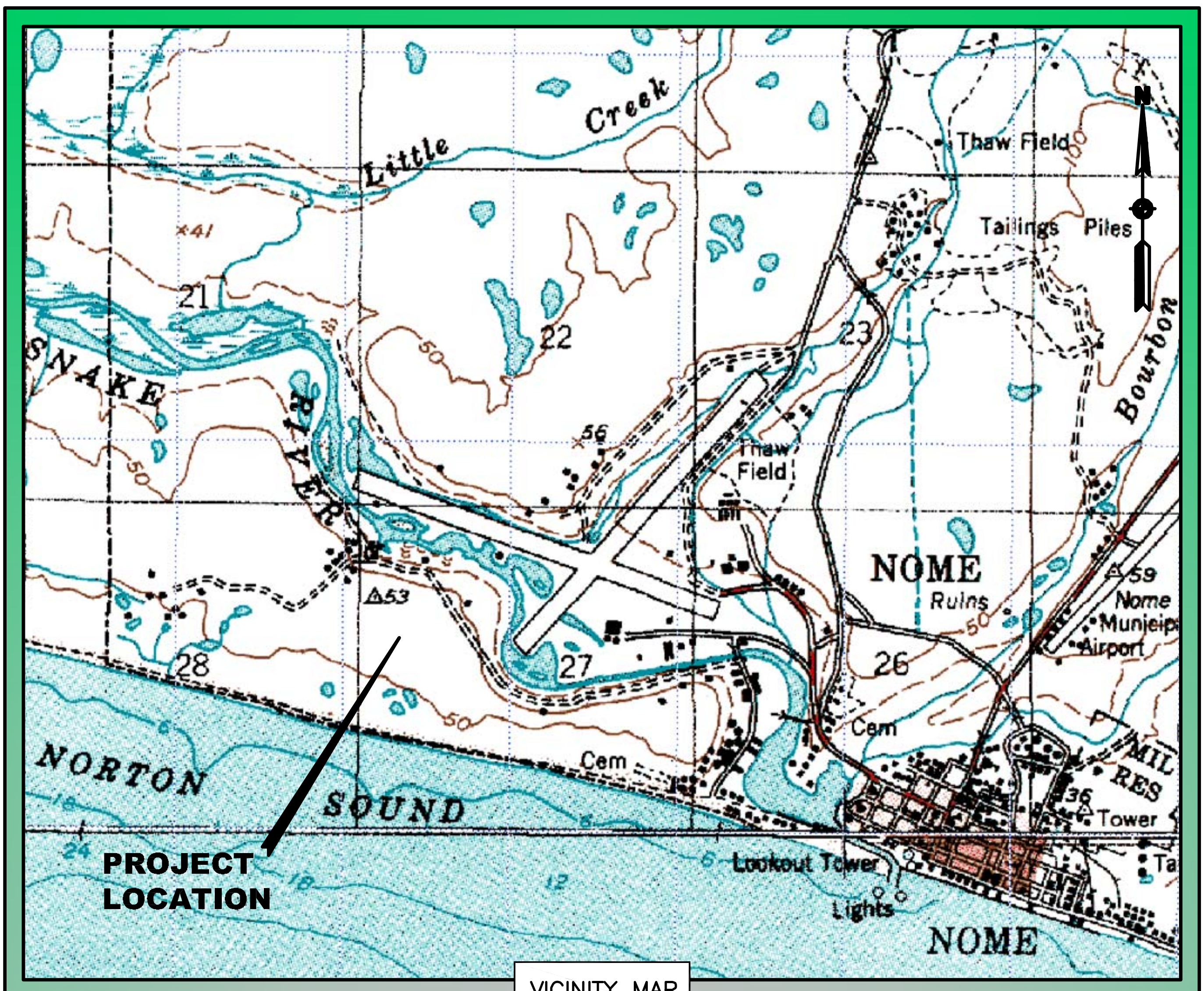


LOCATION MAP
NO SCALE

NOME AIRPORT, NOME, ALASKA
T. 11 S., R. 34 W.,
SEC. 21, 22, 23, 26, 27, 28
KATEEL RIVER MERIDIAN
Map Compiled with USGS Quads
AK NOME C-2; AK NOME C-1; and AK NOME B-1



VICINITY MAP

0 1/4 1/2 1 MILE
GRAPHIC SCALE (APPROX.)

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NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION

LOCATION & VICINITY MAPS

MAR. 2011

FIGURE
1

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NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION

EXISTING CONDITIONS

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FIGURE
2

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1.2 Snake River Relocation Project Overview and Timeline

The Snake River Relocation project started in August 2009. It was understood from the outset that the relocation of the river would be a large scale undertaking with significant economic and environmental costs. The DOT&PF instructed USKH to consider maximum future airport expansion in developing the relocation concept designs. This would assure that the river would not need to be relocated a second time to accommodate future improvements, and would help to minimize environmental and economic impacts. The specific future airport improvements to be considered under initial river relocation concept design efforts included expansion of the main runway to a length of 10,000 feet, with a full 500-foot wide safety area extending 1,000 feet beyond each threshold; construction of a parallel taxiway along the south side of the fully expanded main runway, adequate to accommodate any anticipated size of aircraft; and expansion of the crosswind runway's safety areas to a full 500-foot width, with 1,000 feet beyond each threshold.

Shortly after project startup, two Snake River relocation options were developed that would accommodate these projected airport improvements. Both options would have diverged from the existing river valley and channel at approximately River Mile (RM) 3.7 (river miles are measured as the distance upstream from a starting point at the existing river mouth; see Figure 2). The Lower River Reconnection Option would have been routed to the south beyond the projected western end of the maximum expansion of the main runway. The alignment would have then turned to the east, paralleling the future parallel taxiway until briefly rejoining the existing channel of the Snake River near the intersection of the main and crosswind runways. The alignment would then have left the existing river channel, and gone south and east around the projected end of the maximum expansion of the crosswind runway, been routed through a mining pit pond, and then rejoined the existing channel of the Snake River a short distance downstream of the expanded crosswind runway.

The route of the second relocation option, called the New River Mouth Option, would have followed the same alignment as the Lower River Reconnection Option for a distance of approximately 1,500 feet to stay beyond the projected western end of the maximum expansion of the main runway. However, rather than turning east like the Lower River Reconnection Option, the New River Mouth Option would have been routed generally to the south to empty into Norton Sound at a new river mouth located approximately 13,000 feet west of the existing river mouth.

The need to accommodate maximum future airport expansion resulted in relocation designs that were extremely costly. The estimated cost of the Lower River Reconnection Option was approximately $77,000,000, while that of the New River Mouth Option was approximately $70,000,000. These costs were well beyond the FAA funding limits for RSA improvements at the Nome Airport, which are currently $25,000,000 for the main runway and $25,000,000 for the crosswind runway.

To address this, USKH provided the DOT&PF with three additional river relocations options – one that would allow construction of a 1,000-foot long and 500-foot wide safety area off the west end of the main runway (Option 3); a second option that would not only accommodate the safety area expansion but would also allow the future construction of a 1,775-foot long embankment extension of the main runway (Option 3 – Revised); and a third option that would accommodate the 1,775-foot long embankment extension of the main runway and a 275-foot threshold shift to the west (Option 4). This last option, allowing a future runway expansion and threshold shift, is essentially a much abbreviated and scaled back version of the previously developed Lower River Reconnection Option, and is called the Reduced Reconnection Option.

The DOT&PF and FAA are no longer considering the Lower River Reconnection and New River Mouth relocation options that were the subject of the December 2009 Draft Concept Design Report. The river relocation option that is being considered as part of the Proposed Action for addressing RSA deficiencies at the Nome Airport is the Reduced Reconnection Option. This option allows the airport's RSA deficiencies to be addressed within FAA funding limits, while still allowing for the possibility of a future 1,775-foot embankment extension of the main runway (which is not part of the RSA improvements project), and a 275-foot threshold shift. The proposed future RSA expansions of the main and crosswind runways, the extent of the embankment associated with a possible future 1,775-foot main runway embankment extension and threshold shift are shown in Figure 3.

1.3 River Relocation Concept Design Overview

To produce the river relocation concept designs, USKH has enlisted the support of technical experts, including stream geomorphology subconsultant Confluence Environmental Company, Inc. (CEC; formerly Cherry Creek Environmental); geotechnical subconsultant Shannon & Wilson, Inc. (Shannon & Wilson); marine and estuarine biological subconsultant Pentec Environmental (Pentec); and coastal engineering subconsultant Coastline Engineering.

Work performed in support of the river relocation concept designs included site visits by team members; topographic field surveys; formation of a multi-agency task force (MATF) and conducting two MATF meetings; hydrologic and hydraulic analyses; the development of preliminary designs and rough order of magnitude cost estimates; and preliminary analyses of environmental impacts. Associated public involvement and environmental documentation work performed in support of the project included participation in two Nome Airport Master Plan Update Public Meetings, and Environmental Assessment (EA) scoping efforts for the Nome Airport RSA Expansion project.

1.3.1 Nome Airport Master Plan Update Public Meetings

The first public open house meeting, covering both the Nome Airport Master Plan Update project and the Nome Airport Runway Safety Area Expansion project, was held at Old St. Joseph's Church in Nome on September 17, 2009. DOT&PF representatives in attendance included Cindie Little, P.E., Aviation Design Group Chief; R.J. Stumpf, P.E., Project Manager; Ivet Hall, Project Engineer; and Ethan Birkholz, Transportation Planning Chief. Brooks and Associates, the public involvement lead for the Nome Airport Master Plan Update project, was represented by Anne Brooks. Two project presentations were made - one at 4:30 p.m. and one at 6:30 p.m. The Master Plan project was introduced and discussed by Royce Conlon of PDC, Inc. (PDC). Patrick Cotter of PDC was also in attendance. The RSA Expansion and Snake River Relocation project was presented by USKH representatives Hans Arnett, hydrologist and project lead, and Sara Lindberg, environmental analyst, wetlands specialist, and environmental lead, with USKH fisheries biologist Cindy Anderson also in attendance. After the presentations, public comments were solicited and questions were answered in a group format. As time permitted, DOT&PF and project representatives discussed the projects and answered questions individually. Minutes from the first public meeting are attached in Appendix A.

The second public open house meeting also covered both the Nome Airport Master Plan project and the Runway Safety Area Expansion project, and was again held at Old St. Joseph's Church. The meeting was held on June 2, 2010. DOT&PF representatives in attendance were RJ Stumpf, Janet Brown, Jeff Roach, and Ivet Hall. The FAA was represented by Pat Oien, Matt Freeman, and Bruce Greenwood. USKH was represented by Sara Lindberg, Hans Arnett, and Cindy Anderson. Royce Conlon and Patrick Cotter represented PDC Engineers, and Anne Brooks represented Brooks & Associates. Project presentations were made at 5:30 p.m.

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NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION

FUTURE
AIRPORT EXPANSION

MAR. 2011

FIGURE
3

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USKH Hydrologist Hans Arnett presented an overview of the Snake River Relocation portion of the Runway Safety Area Expansion project, and USKH Environmental Analyst Cindy Anderson continued with an overview of the National Environmental Policy Act (NEPA) process. After the presentations, public comments were solicited and questions were answered in a group format. Minutes from the second public meeting are attached in Appendix A.

1.3.2 Site Visits

Four site visits were performed for the project in 2009. The first site visit occurred during the period of September 18-20, 2009. Attendees included USKH representatives Hans Arnett, Mary O'Hara (water resources engineer; on site on September 18 only), Mary Jo Monahan (environmental analyst and hazardous waste specialist), and Sara Lindberg. Also in attendance were CEC representative Shane Cherry (stream geomorphologist), and Pentec representative Jon Houghton (marine and aquatic biologist).

The team split into two groups, with the first group consisting of Hans Arnett, Mary O'Hara, Shane Cherry, and Jon Houghton. This group secured a boat and boat pilot to make a reconnaissance of the Snake River; walked the approximate alignments of both the New River Mouth Option and the Reconnection Option; identified cross sections of the study reach of the Snake River for the purpose of hydraulic modeling; and made detailed observations of aquatic habitats present within the Snake River. Group two, comprised of Sara Lindberg and Mary Jo Monahan, completed a visual reconnaissance of the area by identifying areas of concern or areas with specific permitting needs. Their reconnaissance included areas potentially impacted by both Snake River relocation alternatives, as well as areas north and south of the crosswind runway where runway safety expansion is proposed.

A second and third site visit was performed by coastal engineer Doug Jones of Coastline Engineering, who completed an independent site visit on August 23-24, 2009, and returned September 23-24, 2009 to collect additional field information. Beach and sediment samples were collected for analysis on August 23-24, 2009. During this time, beach profiles from the causeway near the existing Snake River mouth to 2 miles west were surveyed. Upon return to Nome for the second site visit on September 23-24, 2009, more beach profiles on the east and west side (relative to the causeway) were also surveyed. Observations continued further west to verify that this area was similar to the beach previously surveyed. After meeting with the Port of Nome Harbormaster, Joy Baker, discussions ensued regarding the two main options to relocate the Snake River. Joy provided Doug with contact information for groups and individuals that have relevant information regarding the amount of beach material that has been sold from the accumulated sediments of the west side of the causeway.

On October 13-14, 2009, Shannon & Wilson geological engineers Frank Wuttig and Matt Billings performed the fourth site visit of the project - a geotechnical reconnaissance of the project site. The reconnaissance consisted of walking the majority of the proposed routes; observing terrain features; hand-probing for permafrost; observing the surface for indications of permafrost and thaw instability; observing the stability of existing cut and fill slopes; interviewing Nikolai Ivanoff, a NovaGold Resources Inc. (NovaGold) representative; reviewing exploratory boring logs in the NovaGold offices; and observing the stability of other earthwork structures in the Nome area.

The *Final Snake River Relocation Site Visit Memo* that documents observations and recommendations resulting from the four site visits is attached in Appendix B.

Two field investigations were conducted in 2010. Shannon & Wilson performed geotechnical and environmental field investigations in the spring and summer along two variations of the Reduced Reconnection Option alignment (one alignment that would accommodate the 1,775-foot runway embankment extension and one that would not). An exploratory drilling program was conducted to characterize geotechnical conditions along the proposed alignments and supplement information from research conducted previously, which had provided the basis for the conceptual design of cut slopes, and erosion and sediment control. Information from the 2010 exploration program will provide the basis for more detailed geotechnical design studies for the project, which had not yet been completed prior to the completion of the Snake River Relocation Concept Design Memo or its supplementary appendix. The two alignment options were explored with a total of 32 borings.

The explorations characterized the depth to bedrock, distribution of permafrost; thickness of surficial fine-grained and organic soils; character of the underlying tills, marine, and estuarine deposits; dredge tailings; groundwater conditions; salinity; permafrost temperature; and relative density of thawed soils.

The fieldwork was conducted in two phases. The first 20 borings were drilled in May 2010, in undisturbed ground between the take-off points of the two alignments and the boundary of previously mined areas. The remaining borings were completed in the previously mined areas during the period of July 16-31. Some of the borings were completed as monitoring wells to allow for water-quality sampling in the environmental assessment of the site.

On July 18-30, 2010, Shannon & Wilson’s environmental engineer Julie Keener performed the environmental investigation. Several areas of concern (AOCs) and potential environmental issues related to past activities had been identified within the project area in previous studies, and during the development of the work plan for the environmental investigation. To investigate the environmental concerns, soil samples were collected from the exploratory borings; monitoring wells were installed and groundwater samples and surface water samples from the Snake River were collected; surface soils were sampled; soil samples were collected from test pits; and waste in various drums at the site was characterized to determine treatment/disposal options.

1.3.3 Topographic Surveys and Preliminary Land Ownership Research

The control and topographic survey was performed by USKH October 6-11, 2009. The field crew consisted of Marshall Hetlet, P.L.S., Jon Essex, and Levi Blackwolf. Thirty-two river cross-sections were surveyed using Real Time Kinematic (RTK) techniques. Three bathymetric lines were also surveyed in a pond along the Reconnection Option alignment. High winds and storm conditions prohibited the field crew from collecting any additional lines in the pond. Six culvert outfalls along the north side of the Snake River were also located and surveyed as part of the field survey task.

The coordinate system for the completed survey is a modified Alaska State Plane Coordinate System, Zone 8 – (Scaled to Ground), scaled at point 551 (2 BAD-Primary Airport Control Station) using the Combined Scale Factor (Grid to Ground) of 1.00009517906. Reference Ellipsoid is NAD83 (NSRS2007). The vertical datum is NAVD88 in U.S. Survey Feet holding "2 BAD" as 14.93 feet.

A preliminary investigation of land ownership in the project area was conducted using several sources of information. The City of Nome provided an AutoCAD drawing depicting most of the mineral surveys lying along the Snake River, west of the Nome Harbor, and the area between the river and Norton Sound. This drawing was used as a starting point for a preliminary land ownership map. The orientation of the drawing was moved and rotated to agree approximately with the DOT&PF horizontal datum of the Nome Airport. Parcel boundaries within the drawing were then revised and updated based on online research from the Alaska Department of Natural Resources’ (DNR’s) Recorder’s Office, the DNR’s Alaska Land Records website, and Bureau of Land

Management (BLM) records. From the DNR and BLM records, it was possible to view and print copies of the Master Title Reports (both State and Federal), BLM rectangular surveys, and Mineral Surveys, all of which were used to edit the preliminary land ownership research drawing.

The ownership information is based on research of the DNR Recorder's Office and Alyeska Title Guaranty. Mineral Survey numbers were used to search the Recorder's records for documents indicating ownership. The title company provided a Limited Liability Report on four parcels which show the ownerships of those parcels. The ownership of the other properties will eventually need to be verified by a title company once a preferred river relocation option is selected. The results of the preliminary land ownership research efforts are shown in Figure 4.

1.3.4 Multi-Agency Task Force Meetings

A multi-agency task force (MATF) composed of staff representatives from key resources agencies was formed in order to solicit and document their preliminary concerns, address critical issues, and find a path forward to develop concept designs for the Snake River that are both feasible and permittable. The first MATF meeting was held in Nome on October 30, 2009. The meeting was designed to introduce the group to the two Snake River relocation options, answer their questions about the proposed work, and gather comments from agency members regarding the two Snake River relocation options. The meeting participants arrived at the airport at approximately 12:30 p.m. and were transported by van to the meeting place at the DOT&PF facility at the Nome Airport.

A presentation of the two proposed relocation options and their potential impacts was provided by the project team. Following the presentation, the MATF proceeded into the field to look at locations along proposed alignments, and then back to the meeting room for a post-site visit discussion and to identify next steps. Attendees included:

- DOT&PF representatives Cindie Little, P.E.; R.J. Stumpf, P.E.; Ivet Hall; Bob Madden, Nome Airport Manager; and Larry Smithhisler, Nome Maintenance and Operations Superintendent;
- FAA representative Bruce Greenwood, Environmental Manager;
- Alaska Department of Fish and Game (ADF&G) representatives Robert (Mac) McLean, Regional Supervisor, Fairbanks Office (via telephone) and Charles Lean, Fisheries Biologist (on behalf of ADF&G);
- Alaska Department of Environmental Conservation (ADEC) representative Tamara Cardona-Marek, PhD, Northern Region Project Manager;
- US Army Corps of Engineers (USACE) representative Don Kuhle, Regulatory Specialist;
- US Fish and Wildlife Service (USFWS) representative Bob Henszey; Habitat Conservation Planning;
- National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) representative Amy Cox; and
- USKH design team representatives Hans Arnett, Sara Lindberg, Cindy Anderson, Mary Jo Monahan, Shane Cherry, Doug Jones, and Jon Houghton.

The *Final October 30, 2009 Multi-Agency Task Force Meeting Summary*, which includes formal comments from MATF member agencies, is attached in Appendix C. Information provided and concerns expressed by MATF members during the on-site meeting and in their formal comments attached to the meeting summary have been taken into account during Snake River relocation concept design efforts.

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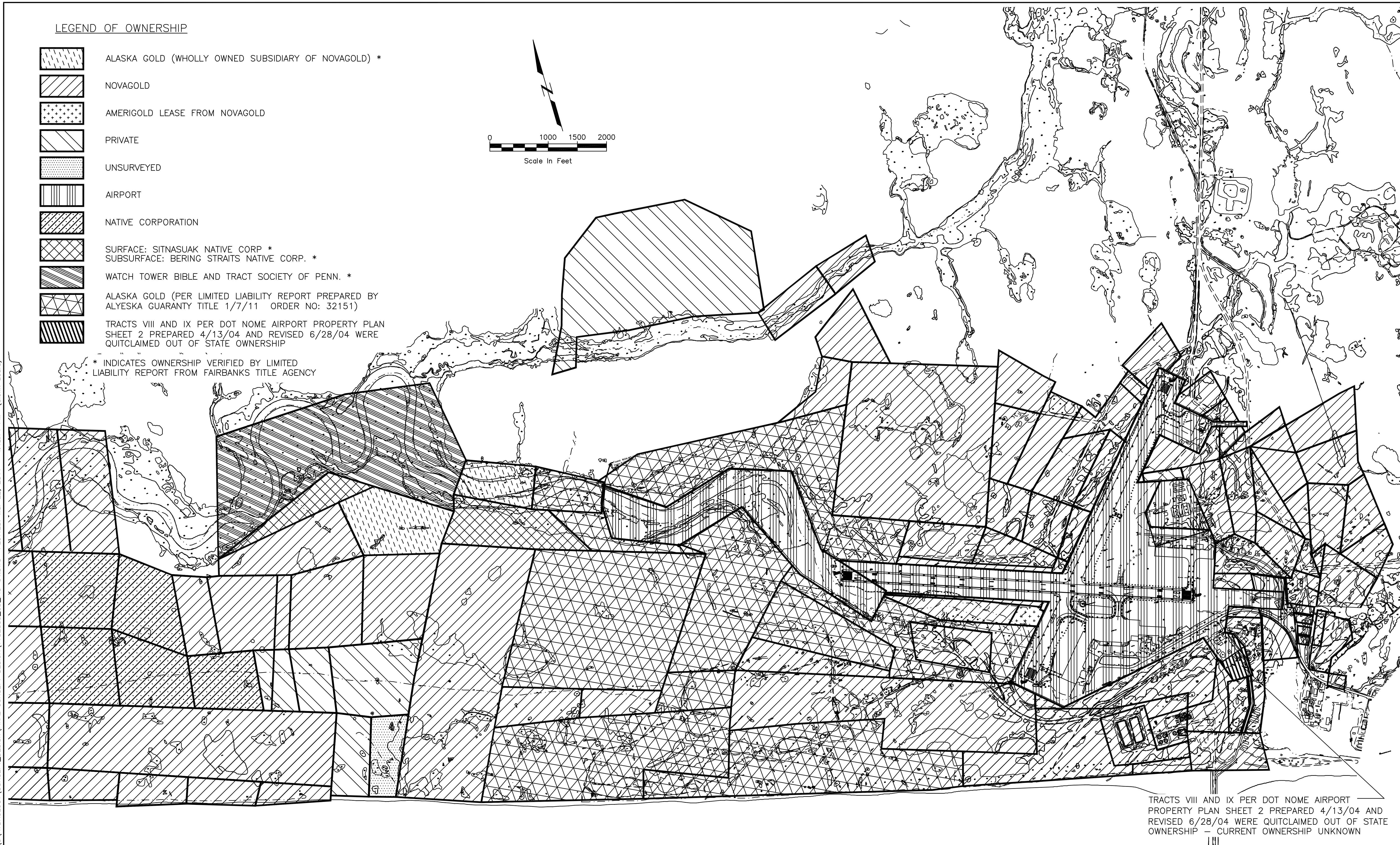

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NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION

PRELIMINARY LAND OWNERSHIP RESEARCH

MAR. 2011

FIGURE 4

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A second MATF meeting was held in Fairbanks, Alaska on November 17, 2010. Video and telephone conference opportunities were provided for members unable to attend in person. The meeting was designed to update agency members regarding the two dismissed Snake River relocation options and to introduce and gather comments regarding a new proposed relocation option.

A brief presentation of current conditions in the project area and of the two dismissed relocation options was provided by the project team, followed by a presentation on the new proposed relocation option. After the presentation, the MATF members were invited to share questions and concerns regarding the proposed relocation option.

Attendees included:

- DOT&PF representatives R.J. Stumpf, Ivet Hall, Bob Madden, and Larry Smithhisler;
- FAA representative Bruce Greenwood;
- ADF&G representative Robert (Mac) McLean
- Nome Port Commission representative Charles Lean;
- ADEC representative Tamara Cardona-Marek;
- USACE representative Don Kuhle;
- USFWS representative Bob Henszey;
- NMFS representatives Amy Cox and Eric Rothwell; and
- USKH design team representatives Hans Arnett, Sara Lindberg, Shane Cherry, Linda Smith, Daniel De Bord, Frank Wuttig, Julie Kenner, and Jon Houghton.

The *November 17, 2010 Second Multi-Agency Task Force Meeting Summary*, which includes formal comments from MATF member agencies, is attached in Appendix C. Information provided and concerns expressed by MATF members during this second meeting and in submitted formal comments in response to the meeting summary have been taken into account during subsequent Snake River relocation concept design efforts.

1.3.5 Nome Airport RSA Expansion Environmental Document, Agency Scoping

The scoping phase of the proposed project is complete. Public input was solicited during two meetings (October 20, 2009 and November 17, 2010) and a scoping letter was sent to federal, state, and local agencies and other interested parties in December 2010. Comments received were considered during subsequent project design revisions and will be included in the Draft Environmental Assessment (DEA) which is currently being prepared. Informal consultation with USFWS to comply with Section 7 of the Endangered Species Act and initiation of consultation with the State Historic Preservation Office, local and regional tribal governments and other interested parties in accordance with Section 106 of the National Historic Preservation Act is currently in progress. Preparation of the Environmental Document will be completed in compliance with NEPA and FAA Orders 1050.1E and 5050.4B.

1.4 Draft River Relocation Concept Design Report Organization

The Snake River Relocation Concept Design Report is organized into five sections. This introductory section is followed by a discussion in Section 2 of the design objectives and approach. Section 3 presents discussions of opportunities and constraints in both the natural and built environments in the project area. Design elements are described in detail in Section 4, and Section 5 presents a detailed discussion of the design and environmental impacts of the Reduced Reconnection Option.

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2 DESIGN OBJECTIVES AND APPROACH

2.1 Design Objectives

The recommended alternatives for RSA expansion presented in the October 2010 *Practicability Study - Nome Airport Runway Safety Area* require relocation of the Snake River in order to achieve project goals. Effective development of river relocation concept designs require clearly articulated design objectives. The following four design objectives take into account the purpose and desired outcomes for the Snake River Relocation that have been specified by the DOT&PF, and incorporate feedback from early coordination with regulatory agencies on the MATF:

- Relocate the Snake River to accommodate future expansion of the Nome Airport as identified in the Nome Airport Master Plan.
- Ensure hydraulic and geomorphic function of the relocated river channel including peak flows, sediment transport, ice transport, and geomorphic processes that form and maintain habitat.
- Provide an acceptable achievable level of ecological function within the new river channel.
- Manage costs to meet DOT&PF and FAA funding limitations.

Relocation of the Snake River would be a large scale undertaking with significant economic and environmental costs. Therefore, the evaluation of river relocation alternatives accounts for future airport expansion beyond the proposed RSA improvements.

The relocated river channel must provide adequate hydraulic capacity to convey the full range of anticipated river flows as well as the sediment load delivered from upstream. The relocated channel must convey water, sediment, and ice in a manner that does not impede the adjacent land use or damage infrastructure. At the same time, the habitat-forming geomorphic processes that operate within the channel must be maintained.

Ecological functions within the relocated river channel will be provided by habitat features created when the new channel is initially configured. Specific features that could be constructed to provide physical instream habitat include irregular river banks, channel bars, pools, and variations in channel width. These features will be supported by maintaining geomorphic processes that form and maintain habitat, which were identified during initial reconnaissance site visits.

Project cost affects project feasibility. Several elements of the design directly affect project cost, with the volume of excavation being the largest cost component. In order to be economically feasible, river relocation concept designs must balance project costs versus hydraulic and ecological functions, and environmental impacts.

2.2 Design Approach

As noted previously, the approach to design begins with clearly articulated design objectives. A clear target provides a foundation for the entire design process. Building on this foundation, the proposed design approach began with a characterization of existing conditions to define a comprehensive set of opportunities and constraints. These factors were accounted for in the development of conceptual design alternatives for river relocation. The design approach used observations of the existing river to form a template that guided the design of the new river channel. A thorough analysis of hydraulics, geomorphic process, and ecology was conducted with respect to each conceptual design alternative to ensure that design options met the defined objectives.

The first objective for the Snake River relocation is to accommodate future airport expansion. Therefore, it was essential to determine and document the extent of anticipated airport expansion: the proposed future RSA expansions of the main and crosswind runways, a possible future 1,775-foot main runway embankment extension, and a 275-foot main runway threshold shift (see Figure 3).The future airport configuration dictates the extent of river relocation required and constrains the areas available for possible river alignment options. In addition to this constraint, there are other factors that constrain the conceptual design options, including project cost, maintaining existing infrastructure, and regulatory requirements to avoid and minimize environmental impacts. A comprehensive set of design constraints was developed and characterized in order to develop viable conceptual design alternatives. In parallel, the design team reviewed existing conditions in the vicinity of the airport to identify design opportunities in order to more effectively meet the design objectives. Design constraints and opportunities are discussed in detail in Section 3.

The river relocation is one portion of the larger Nome Airport RSA Expansion project, which is subject to FAA funding limitations for practicable RSA improvements. Keeping construction costs down in order to assure economic feasibility has been one of the major driving forces in the design approach to meet the objective of accommodating future airport expansion.

Common practice in river restoration uses a natural river channel as a “reference reach” to establish a design template to guide design of a new river channel (e.g., Rosgen 1997; Miller and Skidmore 2003). This approach has demonstrated success in providing for both hydrologic performance and habitat performance. In the case of the Snake River, an ideal reference reach for full channel restoration is a portion of the broadly meandering channel located upstream of the point where the channel was historically realigned. This reference reach would present the optimal width and depth of a new channel, as well as the extent of the natural floodplain and river valley surrounding the channel. However, if this reference reach is applied, the excavation footprint and the volume of excavation required to produce this channel, floodplain, and valley configuration, would be substantially larger than narrower and straighter excavation options. There is not adequate area to construct a channel, floodplain, and valley with this configuration on the alignment of the Reduced Reconnection Option without impacting existing infrastructure and developed property.

The historically realigned reach of the river upstream of the end of the crosswind runway is more constrained than the broadly-meandering reach further upstream. Even so, this reach exhibits a somewhat dampened meandering pattern, and the river banks and habitat features approach the form of those same features observed in the natural reach upstream. The confined reach located downstream of the crosswind runway and immediately south of the airport terminal is straight and featureless. Combining these observations suggests that habitat conditions and geomorphic function can be supported in a relocated channel that is more constrained than the natural example. However, constraining the river to a straight and narrow channel with no floodplain would likely produce a featureless channel that provides little habitat value.

The proposed design approach identifies reference reach information from both the natural, broadly-meandering reach upstream and the historically relocated reach located upstream of the crosswind runway. This approach influenced the decision to manage costs by minimizing the excavation while providing a basis for establishing the size of a channel and floodplain sufficient for supporting ecological and hydrologic function.

Each conceptual design alternative was developed specifically to meet the design objectives while complying to the fullest extent possible with the design constraints and making use of design opportunities. In addition, each relocation option was subjected to hydraulic and sediment transport analysis to determine channel stability, flow and flood hydraulics, and sediment deposition patterns. These analyses influenced the evaluation of channel forming and habitat forming processes that could be anticipated in the new river channel and its associated floodplain.

Hydrology for the Snake River basin was evaluated for the design of the replacement bridge over the Snake River and presented in the *Final Hydraulics and Hydrology Report – Snake River Bridge Replacement Project, Nome Alaska* (USKH 2009). The previous hydrologic analysis results were used and modified as necessary to develop design flows for the Snake River Relocation conceptual design. Design flows range from low flow conditions up to a 100-year recurrence interval flood flow. The Hydrologic Engineering Center River Analysis System (HEC-RAS) water surface profile model was used to predict hydraulic characteristics of the river over the anticipated range of flows. HEC-RAS model scenarios were developed for the existing conditions of the river channel as well as for each of the river relocation alternatives.

Sediment dynamics were evaluated for existing conditions and each river relocation alternative using hydraulic output from the HEC-RAS modeling effort. Specifically, the model provides the flow velocity, water surface elevation, slope, and boundary shear stress for each cross section. These parameters were used to assess sediment transport properties, including transport capacity and competence. Transport capacity is a rate defined as the amount of sediment that can be moved past a point in the river per unit time. Transport capacity can be presented as either a mass per unit time or a volume per unit time. Competence is a sediment transport characteristic defined as the largest sediment size that can be mobilized and transported by a particular hydraulic condition. This is a size threshold parameter that varies with the channel configuration and with flow volume. The HEC-RAS results allow evaluation of these sediment transport characteristics at each cross section. Spatial variability in competence and transport capacity identified zones of potential scour and zones of potential deposition. The analytical results were compared to aerial photographs and field observations of the existing channel to inform predictions about sediment dynamics in each of the river relocation alternatives.

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3 DESIGN OPPORTUNITIES AND CONSTRAINTS

Nome's climate, geography, geology, culture, economy, and history provide a unique set of design opportunities and constraints that must be taken into account in the design of Snake River relocation options. The following section presents discussions of both the natural and built environments in Nome, and provides the context for the discussion of specific river relocation design elements presented in Section 4. The design opportunities and constraints discussions presented in Section 3 have borrowed heavily from observations presented in the *Final Snake River Relocation Site Visit Memo* (see Appendix B) and detailed discussions presented in Shannon & Wilson's 2011 *Geotechnical Studies, Snake River Relocation Project, Nome, Alaska*.

3.1 Natural Environment

Key features of the natural environment of Nome that affect the design of river relocation options include the community's Arctic setting along the Bering Sea coast; topography, geology, soils, and permafrost in the surrounding area; the hydrology of the Snake River basin; Snake River channel and floodplain morphology and hydraulics; fisheries; estuarine biology; wetland vegetation; and coastal processes.

3.1.1 Geotechnical Conditions

The information provided in Section 3.1.1 was developed from Shannon & Wilson's 2011 *Geotechnical Studies, Snake River Relocation Project, Nome, Alaska*. For more detailed discussions, the interested reader is referred to that document.

The Reduced Reconnection Option alignment traverses the northern portion of a prominent, broad east-west ridge rising to an elevation of 60 feet between the lower Snake River and the Bering Sea. The alignment crosses three basic types of terrain: the floodplain of the Snake River at the take-off and reconnection points; the tundra-covered morainal ridge; and an area of mine tailings from previous dredging operations. The floodplain area on the south bank of the Snake River is flat and poorly drained. Some areas have standing water and small ponds. This area is annually flooded during the spring thaw. The floodplain at the reconnection point appears to have been filled with mine tailings.

The un-mined area on the ridge is largely undisturbed terrain vegetated with tundra and dotted with scattered thaw lakes, swampy areas, and small drainages. The surface along this route is frequently hummocky and poorly drained, particularly on the upper portions of the ridge, where there appears to be more standing water. The hummocky areas are likely an indicator of solifluction, the slow downhill flow of soil caused by cryogenic processes.

The surface of the mined area consists of mostly uneven and irregular ground comprised of dredge tailings crossed by access roads, and what appear to be drained settling/tailings ponds. The characteristic fan-shaped pattern of coarse material left by dredging has been reworked or covered with fill in much of the area. The preponderance of surficial fill consists of silty, sandy gravel and sandy, gravelly silt with cobbles and occasional boulders.

The dredging process generally overturns and sorts the natural soil profile, with finer soils deposited near the bottom and coarser soils near the top. Dredging operations generally involve removing the near-surface silty and organic-rich layer, thawing the underlying soils down to bedrock using cold water and thaw points, followed by dredging. The entire section of thawed material is then dredged, washed, and processed, with the coarser material separated from the finer gold-bearing sands and gravels. The gold-bearing sands and gravels are run through a sluice box and, along with the silts, discharged into the dredge pond. The coarser material is stacked over the finer tailings in a characteristic fan-shaped pattern using a conveyor. Unmined remnants of natural ground may exist between dredge passes.

Exploratory borings (see Figure 5) on the floodplain of the Snake River at the take-off point encountered organics over interbedded, loose to medium-dense sandy silt, silty sand, sand, and gravelly sand overlying bedrock at an approximate elevation ranging from -6 feet to -33 feet relative to mean sea level (MSL). The soils were permafrost-free. Deeper bedrock appears to be associated with an ancient river channel and valley formed during a period of lower sea level. The groundwater table occurred at a depth below the ground surface (bgs) of about 5 feet at the time of drilling.

The 15 borings in the un-mined area on the ridge encountered permafrost from the ground surface down to the depths explored, except for one boring (10-10) located next to a thaw lake, that was thawed to the depth explored of 60.5 feet. A layer of peat was typically found from the ground surface down to depths ranging from 0.7 feet to 8.6 feet, averaging 3.2 feet bgs. Below the surficial peat, ice-rich silt occurred to depths ranging from 2.5 feet to 9.8 feet. The silt likely represents loess (windborne sediment) deposited across the coastal plain in the previous glacial period.

Below these surficial ice-rich silty and organic soils, a variety of interbedded materials were encountered, including sandy silt; silty sand; sand; gravelly sand; gravelly, sandy silt; and silty, sandy gravel, overlying bedrock. Bedrock was encountered in 14 of the 15 un-mined area borings at an approximate elevation ranging from -10 feet to -28 feet MSL. The overlying soils appear to be mixture of glacial till, glacial marine, and marine deposits. Scattered cobbles and small boulders were frequently encountered in what appeared to be glacial till consisting of gravelly, sandy silts and silty, sandy gravels.

The soils with more fines (including sandy silt, gravelly sandy silt, and silty sandy gravel) often contained visible ice. The cleaner, coarser-grained soils (including silty sand, sand, and gravelly sand) typically did not contain visible ice. Visible ice was typically greater in the upper 15 feet to 20 feet and decreased with depth. Segregated ice typically occurred in the form of lenses less than 1 inch thick. Massive ice in the form of ice wedges was not encountered. The moisture content of the permafrost was relatively high in the upper 10 feet to15 feet, and decreased with depth.

In the 10 borings advanced in the mined area, the soils typically consisted of a mixture of very loose to loose sand, gravelly sand, sandy gravel, gravelly sandy silt, sandy silt, and silty fine sand. The materials were thawed throughout the depths explored. Bedrock was encountered in three borings at approximate elevations ranging from -20 feet to -22.5 feet MSL. Groundwater occurred at depths ranging from 17 feet to 36 feet bgs (or approximate elevations of 11.1 to 20.3 feet MSL).

Thermistor-string measurements taken in July in three borings in the un-mined area showed frozen conditions from a depth of approximately 2 feet bgs to the base of the borings. Deeper permafrost temperatures ranged from 30 degrees Fahrenheit (°F) to 31 °F.

Porewater salinity in tested soil samples were all below 350 parts per million (ppm), indicating that soil porewater salinity at the site is generally low. For comparison purposes, the salinity of seawater is about two orders of magnitude higher at 35 parts per thousand (ppt). It does not appear soil salinity will be a design concern for the project.

0 600 900 1200

Scale In Feet

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GEOTECHNICAL SOIL BORINGS, MONITORING WELLS, AND OUTLYING SAMPLES

MAR. 2011

FIGURE
5

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3.1.2 Snake River Overview

Snake River Basin

The Snake River drains a mostly mountainous, 121-square mile basin on the southern Seward Peninsula (see Figure 6). The highest mountains in the basin rise to elevations of just under 3,000 feet. No glaciers are present in the basin. The majority of the basin is covered by low tundra vegetation. The basin has seen significant mining activity in the past, and mining on a reduced scale still continues today. Remnant diversion ditches, dredging excavations, and tailings piles are common within the basin.

The Snake River flows in a gently meandering pattern down a north-south trending valley until reaching the coastal lowlands. On the lowlands, the path of the river bends sharply to the southeast and the channel pattern becomes tightly meandering until it approaches the Nome Airport. The river flows southeasterly in a large, constructed channel to the south of the Nome airport, and then through the Nome port and industrial district to its river mouth along Norton Sound.

The lower Snake River has been relocated a number of times. The first relocation of the lower river occurred sometime in the 1930s to accommodate dredging associated with gold mining operations. The river was relocated again in 1942 as part of the wartime construction of the Nome airport by the USACE. Downstream of the airport, the lowermost portion of the river and the river mouth has been significantly rechanneled and relocated. Prior to 2005, the lowermost river flowed in a southeasterly direction through the dredged basin of the Nome small boat harbor before turning south and entering Norton Sound. Since the completion of construction of a new river mouth in 2005 by the USACE, the lowermost river now flows directly south to Norton Sound through a 3,100-foot long entrance channel that is protected by two breakwaters extending into the Bering Sea.

Basin Hydrology

The United States Geological Survey (USGS) operated a stream gage on the Snake River (USGS 15621000 *Snake River near Nome, Alaska*) for the period September 1, 1965 through September 30, 1991. The gage was located well upriver of the relocation project site, and had a drainage area of approximately 85.7 square miles. This is a significantly smaller drainage area than the 121.3-square-mile drainage area for the Snake River at its existing mouth, or the 108.4-square-mile drainage area at the point where the two relocation options would diverge from the existing channel. Due to the discrepancies in drainage area sizes, peak flood flow estimates were produced using methods outlined in the USGS publication *Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada,* WRI 03-4188 (Curran, Meyer, and Tasker, 2003), rather than applying adjusted data from the Snake River gage site to the existing river mouth and relocation diversion sites.

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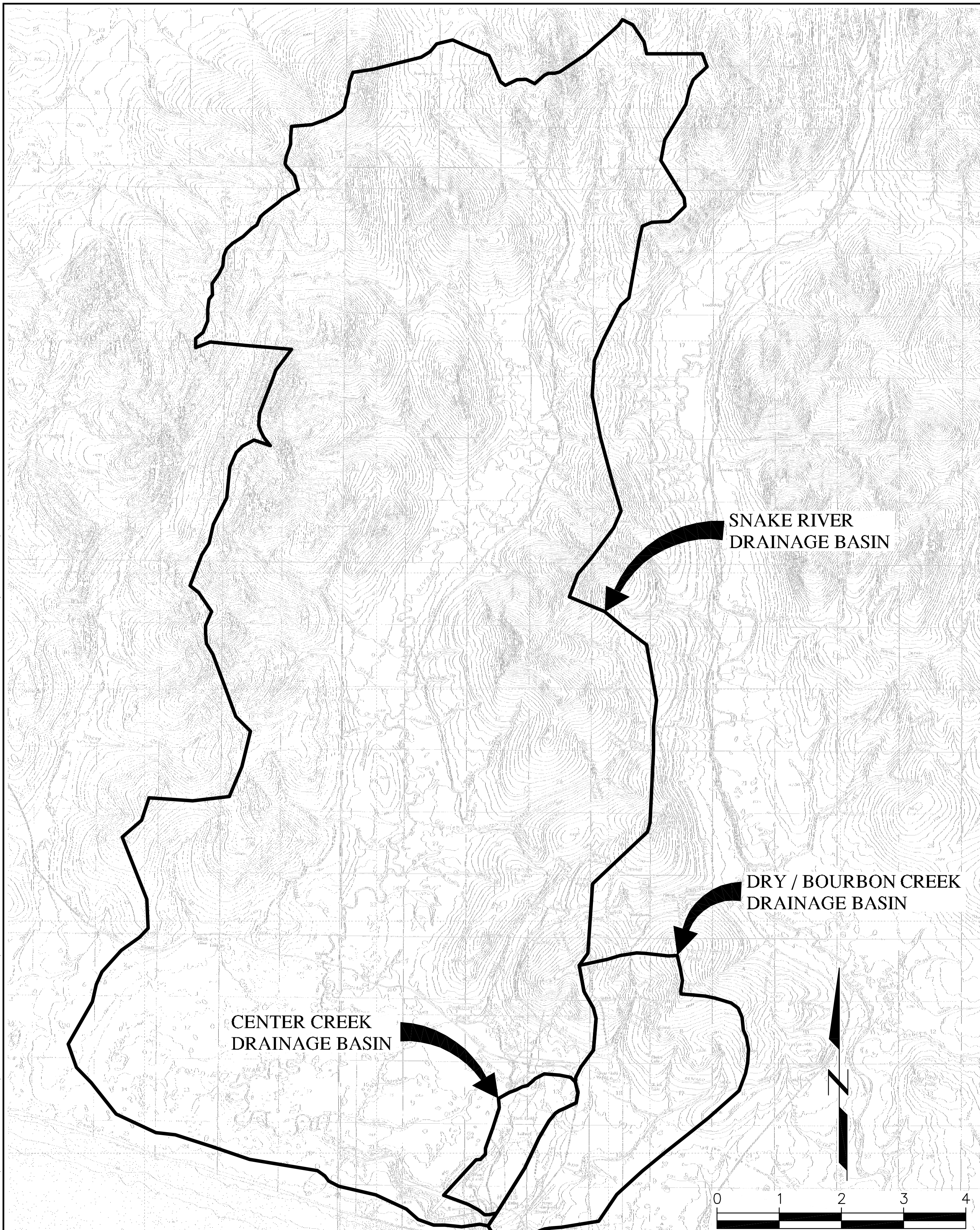

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MAP COMPILED FROM USGS
1:63,360 QUADS NOME B-1,
C-1, C-2, D-1, AND D-2

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SNAKE RIVER DRAINAGE
BASIN MAP

MAR. 2011

FIGURE
6

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Nome lies within Curran, Meyer, and Tasker's Region 7, for which the only applicable independent variable is the drainage area. The drainage areas for the Snake River at its existing mouth and the point where the two relocation options would diverge from the existing channel were adapted from a drainage area boundary developed for the Snake River Bridge Replacement project (USKH 2009). Table 1 presents a summary of peak flow estimates in cubic feet per second (cfs) for various recurrence intervals for the Snake River at its existing mouth. Table 2 presents a summary of peak flow estimates for various recurrence intervals for the Snake River in the vicinity of the take-off points for the river relocation options where they would diverge from the existing channel.

Table 1 - Snake River Peak Flow Summary at Existing River Mouth

Site	Basin Area (mi^2)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)	Q_{25} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)
Snake River at Existing Mouth	121.3	2,000	3,100	3,800	4,600	5,200	5,800

Table 2 - Snake River Peak Flow Summary in the Vicinity of the Relocation Option Take-off Points

Site	Basin Area (mi^2)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)	Q_{25} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)
Snake River at Relocation Diversion	108.4	1,800	2,800	3,400	4,200	4,700	5,300

Average flow conditions on the Snake River can be approximated with a mean annual flow value developed using methods outlined in the USGS publication *Estimation of Selected Flow and Water-Quality Characteristics of Alaska Streams, WRI-84-4247* (Park and Madison, 1985). For the Snake River at its existing mouth, the mean annual flow has been estimated to be approximately 135 cfs.

Flooding and Storm Surge

There is no documentation of rainfall runoff-induced flooding of the lower Snake River between the western end of the airport and the river mouth. This is because the relocated channel has a hydraulic capacity well in excess of flow rates associated with extremely low frequency peak flow events.

The principal flooding problem in Nome is due to coastal storm surges that generally occur during the fall. A storm surge consists of the water surface response to wind-induced surface shear stress and pressure fields. Storm-induced surges can produce short term increases in water levels to an elevation considerably above mean levels. During such events, Snake River flow conditions have no consequential effect on flood water surface elevations.

Nome is known to be subject to some of the highest storm surges on the Alaska coast. Part of the reason for this is due to the relatively shallow waters of Norton Sound and because of the open exposure of the southern side of the Seward Peninsula to the winds of the North Pacific and the Bering Sea. The shape of Norton Sound may also be a contributing factor to the height reached by storm surges.

The combination of storm surge flooding and storm-generated waves has caused significant damage to the Nome waterfront. A severe storm in 1913 destroyed numerous buildings. A 1945 storm also caused severe damage to waterfront structures. A 1946 storm created a surge that inundated many Nome streets, flooding buildings and property. Coastal erosion caused by the 1946 storm was so severe that several nearshore buildings were undermined and collapsed. Storms hitting the Nome coastline in November 1974 produced flood waters that were as much as 10 feet deep in some areas and 3 to 5 feet deep on Front Street, causing extensive damage to streets and structures. More recently, severe storms associated with high storm surges occurred in 1992, 1998, and each year from 2004 through 2007. The most severe of these recent storms occurred on September 23, 2005, and caused storm surge flooding heights to more than 10 feet.

River Ice, Ice Jams, and Spring Breakup

Ice thicknesses up to 4 feet occur on the lower Snake River annually. Ice impacts occurring during spring breakup have damaged the H-pile piers on the existing Snake River Bridge, necessitating the construction of ice breaking structures to protect the damaged piers.

Ice jams occurring during spring breakup on the lower Snake River are not uncommon, but rarely result in overbank flooding. A search of the USACE's Cold Regions Research and Engineering Laboratory (CRREL) Ice Jam Database produced records of only three ice jams in the project area. A 1985 report mentions an ice jam on the river, but does not give a specific location. A 1991 report notes several ice jams between the Teller Road bridge crossing and the airport (more than 5 river miles downstream from the bridge crossing), and notes overbank flooding, but does not make it clear whether that flooding occurred near the airport. A 2002 ice jam report notes floodwaters were present on parts of the airport's runways. However, a subsequent conversation with Jerry Steiger, the National Weather Service's Meteorologist-In-Charge at Nome, made it clear that, although overbank flooding did occur as a result of the 2002 ice jam flood, flooding did not extend as high as the runway surface. Furthermore, no ice jam flood event is known to have produced flooding of the runway surface.

The timing and character of spring breakup on the lower Snake River is determined in part by the timing and character of breakup of the shore ice in Norton Sound. In the past, breakup on the Snake River normally followed shortly behind breakup of the sea ice. However, the recent construction of the new river mouth, entrance channel, and second breakwater by the USACE may result in differences in the timing and character of breakup on the river. This is particularly likely if ice formed within the entrance channel between the two breakwaters is slower to breakup than the sea ice outside the breakwater system, resulting in a later average breakup date on the Snake River.

Tidal Influence

The lower Snake River is tidally influenced. This tidal influence probably extends some distance upstream of the airport and may affect the entire reach of interest in this concept design study. Table 3 presents tide datums and highest and lowest tide observations for Nome. The information presented in Table 3 is relative to the North American Vertical Datum of 1988 (NAVD88), which is the datum used for Nome Airport RSA Expansion project.

Table 3 - Tide Datums, and Highest and Lowest Tide Observations at Nome

Tide Datum or Observation	Elevation in feet
Highest Observed Water Level (10/06/1992) =	8.14
Mean Higher High Water (MHHW) =	1.03
Mean High Water (MHW) =	0.84
Mean Tide Level (MTL) =	0.32
Mean Sea Level (MSL) =	0.32
Mean Low Water (MLW) =	-0.20
Mean Lower Low Water (MLLW) =	-0.51
Lowest Observed Water Level (01/07/2001)	-6.31

Channel Gradient

The gradient of the channel of the lower Snake River is extremely low with less than 1 foot of vertical drop per mile. During normal flow periods, water movement is barely visible within the lower 2 miles of the river, and there are no visible riffles and pools. The gradient increases slightly upstream from approximately RM 4.0. In this reach the channel includes alternating pools and glides roughly synchronized with the alternating meander bends.

Channel Substrate

Substrate on the bed of the lower Snake River is dominated by sand and silt. Sand bars are present and are usually associated with meanders (inside point bars) or locations where the river width expands (mid-channel bars). Occasional small patches (less than 1 square yard) of pea gravel occur on the upstream edges of sand bars. The amount of small gravel on the river bed increases concurrently with the slight gradient change that occurs upstream of approximately RM 4.0. Angular rock, approximately 2-4 inches in diameter, occupies the river bed in two locations. The river bed in the reach located at the existing Snake River Bridge and upstream for approximately 1,000 feet includes angular rock. Similar rock was observed in the river bed at approximately RM 4.0 at the downstream end of the natural meandering channel. The characteristics of this angular rock match those of mine tailings.

Channel Morphology Zones and River Bank Forms

Channel cross-section and plan view morphology varies among four distinct channel morphology zones (see Figure 2). In the first zone within the harbor and immediately upstream to RM 0.6, the channel has been engineered and is maintained for navigation. The width and depth are significantly greater than observed in other zones (see Photo 1).

The second channel morphology zone is located upstream of the harbor and extends from RM 0.6 to the south end of the crosswind runway at RM 1.3. Within this zone, the channel is straight and narrow, especially along the southern perimeter of the airport. There is no floodplain, with the channel confined between the road embankment and a steep slope on the right (south) bank (see Photo 2).

The third channel morphology zone extends from the south end of the crosswind runway at RM 1.3 upstream to the downstream end of the broadly meandering channel at RM 4.0. This zone contains the take-off points for the proposed river relocation options. Within Zone 3, the channel is wider and includes sand bars and marsh areas along the channel edges (see Photo 3).

Channel Morphology Zone 4 extends upstream of Zone 3 and is characterized by broad, alternating meander bends and an extensive low elevation floodplain encompassing the entire width of the meander pattern. The landscape shows slightly elevated areas parallel and adjacent to the channel with distinct changes in vegetation (willows). These features are characteristic of natural levees that form over long periods as a result of sediment deposition during overbank flow events. As noted previously, alternating pools and glides coincide approximately with the alternating meanders in this zone. The channel cross-section follows textbook form with pools shifted to the outside of meander bends, sand bars located on the inside bank of meander bends, and approximately trapezoidal cross-sections in the straight reaches between bends (see Photo 4).

The banks of the Snake River show three characteristic forms. Within the most confined portion of the channel, located along the south perimeter of the airport, the river banks are composed of bare soil and angular rock that has the appearance of coarse gravel mine tailings (see Photo 2). Throughout the remainder of the channel within the project area, the banks are either low-elevation marsh areas (see Photo 5) or eroding cut banks vegetated by overhanging willows (see Photo 6). In the marsh areas, the bank transitions seamlessly from the channel, extending at a low gradient away from the channel. In each situation, the far edge bounding each marsh is formed by a slope. In some areas, the slope is the runway embankment.

In most areas, the edge of marsh is formed by the edge of the floodplain or a willow-vegetated slope formed at the edge of the high flow channel or a relict channel. Upstream of the confined portion of the channel, river banks are composed of sand and silt. Vegetation on the banks alternates between willows on higher banks (3-5 feet above the water surface) and marsh grasses on lower banks (0-1 feet above the water surface).

Channel Habitat Structure

Habitat structure in the channel of the Snake River is limited due to the absence of large woody debris. The largest observed trees anywhere near the channel were the willows, with maximum observed diameters of approximately 5 inches, and maximum heights of approximately 6 feet, with a shrub-like form. The primary pool-forming mechanism appears to be a hydraulic effect of meander bends. Larger pools alternate with shallower glides. Instream cover is limited to complex edge habitat provided by overhanging willow vegetation, and blocks of soil slumped into the channel along cut banks (see Photo 6). As blocks of river bank fall into the river, the willows and other plant roots hold the material together in the water, forming an irregular channel edge. It is not uncommon to see 2 or 3 blocks of sod that have progressively fallen into the channel at a single location, but at different times.

Photo 1 – Snake River Channel Morphology Zone 1 near river mouth. View facing south toward Norton Sound through the new river mouth and outer harbor breakwaters.

Photo 2 – Snake River Channel Morphology Zone 2 upstream of the Snake River Bridge. View facing west.

Photo 3 – Snake River Channel Morphology Zone 3 near the west end of the main runway. View facing north.

Photo 4 – Snake River Channel Morphology Zone 4 near RM 4.0. Note Meandering shape of channel, natural levee on the outside of the bend, and willows. View facing northeast.

Photo 5 – Marshy river bank along the Snake River near the main runway embankment. View facing northwest.

Photo 6 – Eroding cut bank along the Snake River upstream of the main runway. Note willows on top of bank and eroded blocks of tundra that have fallen into the river.

Channel Hydraulics

A HEC-RAS water surface profile model was produced to calculate existing hydraulic conditions on the Snake River, and for later modification to analyze the hydraulics of river relocation options. The existing conditions model was an expansion of the HEC-RAS model developed for the Snake River Bridge Replacement project (USKH 2009). The bridge replacement model was supplemented with cross-section data measured during the topographic field surveys. Channel and overbank Manning's "n" values were estimated based on the previous modeling efforts and observations made during the site visits. Cross-section locations for the existing conditions HEC-RAS model are shown in Figure 7.

The hydraulics of the Snake River channel are reflective of the channel characteristics described above. Velocities are low even during peak flow conditions. During 100-year flood conditions, calculated average channel velocities rarely exceed approximately 3 feet per second except in the narrow, straightened reach downstream of the crosswind runway where velocities as high as 7 feet per second have been calculated. HEC-RAS modeling output is attached in Appendix E.

Sediment Dynamics

Sediment dynamics in the Snake River have been analyzed to ensure that the river relocation alternatives are designed to account for the effects of channel configuration on sediment transport, river bed scour, and bank erosion. In this regard, the sediment dynamics analysis is an extension of the hydraulic analysis focused on assessing channel stability for the existing channel and each of the river relocation alternatives. In addition to affecting channel stability, sediment dynamics also drive the formation of instream habitat. In the case of the Snake River, large woody debris is essentially absent from the river system. Differential bank erosion, bar deposition, and river bed scour each contribute to the formation and maintenance of instream habitat features. Fundamentally, the river has an extremely low gradient, which sustains a low energy system with limited capacity to transport sediment, except at higher flows.

Two sediment transport characteristics were studied to evaluate sediment dynamics in the existing river channel. The first characteristic is sediment transport competence. The second characteristic is sediment transport capacity. In addition to characterizing existing conditions, these sediment transport metrics were used together as a screening tool in the design development to predict sediment transport and erosion processes at specific locations along the new river alignment alternatives.

In sediment transport analysis, "competence" is a technical term that describes the ability of a river to mobilize a particular size of sediment. Sediment transport competence is typically stated as a maximum grain size (e.g., the channel is competent to mobilize all sediment up to 10 millimeters [mm] in diameter). When a stream channel traverses a geomorphic transition and becomes flatter or less confined, the competence of the channel is reduced and may result in sediment deposition if the appropriate larger sediment sizes are presently in transport. Sediment transport competence relies on the Shields diagram to identify the critical shear stress associated with a particular size of sediment (Shields 1936, Vanoni 1975, Yalin 1977).

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SNAKE RIVER RELOCATION
EXISTING CONDITIONS HEC-RAS
MODEL CROSS SECTIONS

MAR. 2011

FIGURE
7

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Sediment transport capacity describes the rate of sediment transport, usually as a volume or mass of sediment per unit time (e.g., tons per year). Sediment transport capacity is determined by the hydraulic characteristics of the channel and the nature of the sediment supplied and transported by the river system. There are multiple empirically derived sediment transport equations, each with its limitations and optimal application. The Snake River transports primarily sand through a low gradient system. The Engelund-Hanson Function (Engelund and Hansen 1972) was selected as an appropriate sediment transport function for predicting sand transport in a low gradient system:

$$q_{s*} = (0.05/C_f)\ \tau_*^{2.5}$$

q_{s*} : dimensionless sediment transport rate

C_f : friction factor

τ_* : dimensionless shear stress

For the existing Snake River channel, sediment competence varies along the channel, depending on flow. The HEC-RAS model predicted hydraulic conditions for the river for each cross section included in the modeling effort. Shear stress predicted by the model was used to determine sediment transport competence using the Shields diagram. Figure 8 shows the variability of sediment transport competence by river station for four flow scenarios including the mean annual flow (135 cfs), 2-year flow (2,000 cfs), 50-year flow (5,200 cfs), and 100-year flow (5,800 cfs) corresponding to a -1.0 foot tide downstream boundary condition. Several notable observations illustrate sediment dynamics in the lower Snake River:

- For all flows up to the 100-year flow event modeled at 5,800 cfs, there is a section of the river ranging from Station 126+30 to 173+22 (stations are in feet above the existing river mouth [0+00]; refer to Figure 7) in which the competence consistently does not exceed 2 mm. This indicates that any sediment delivered from upstream coarser than 2 mm would be deposited within this mile-long reach of the river. This finding is consistent with direct field observations of the river bed.
- There are three localized small increases in sediment transport competence associated with localized channel constriction. These increases are located at Station 113+35, Station 180+62, and Station 254+02. At these three channel constrictions, the sediment competence increases by about a factor of three. These localized increases in transport competence are consistent with the formation of large deeper pools and a slight local increase in sediment size for the material retained on the river bed.
- The narrowest part of the river located between Station 28+29 and 61+40 constricts the flow and forms a backwater upstream. Within the narrow channel, flow is accelerated by the constriction and downstream expansion of channel conveyance capacity. This hydraulic effect locally increases the forces on the river bed and increases the competence of the channel to move gravel up to 2-3 inches in diameter. This is consistent with field observations of angular rock (presumably mine tailings) approximately this size on the river bed.

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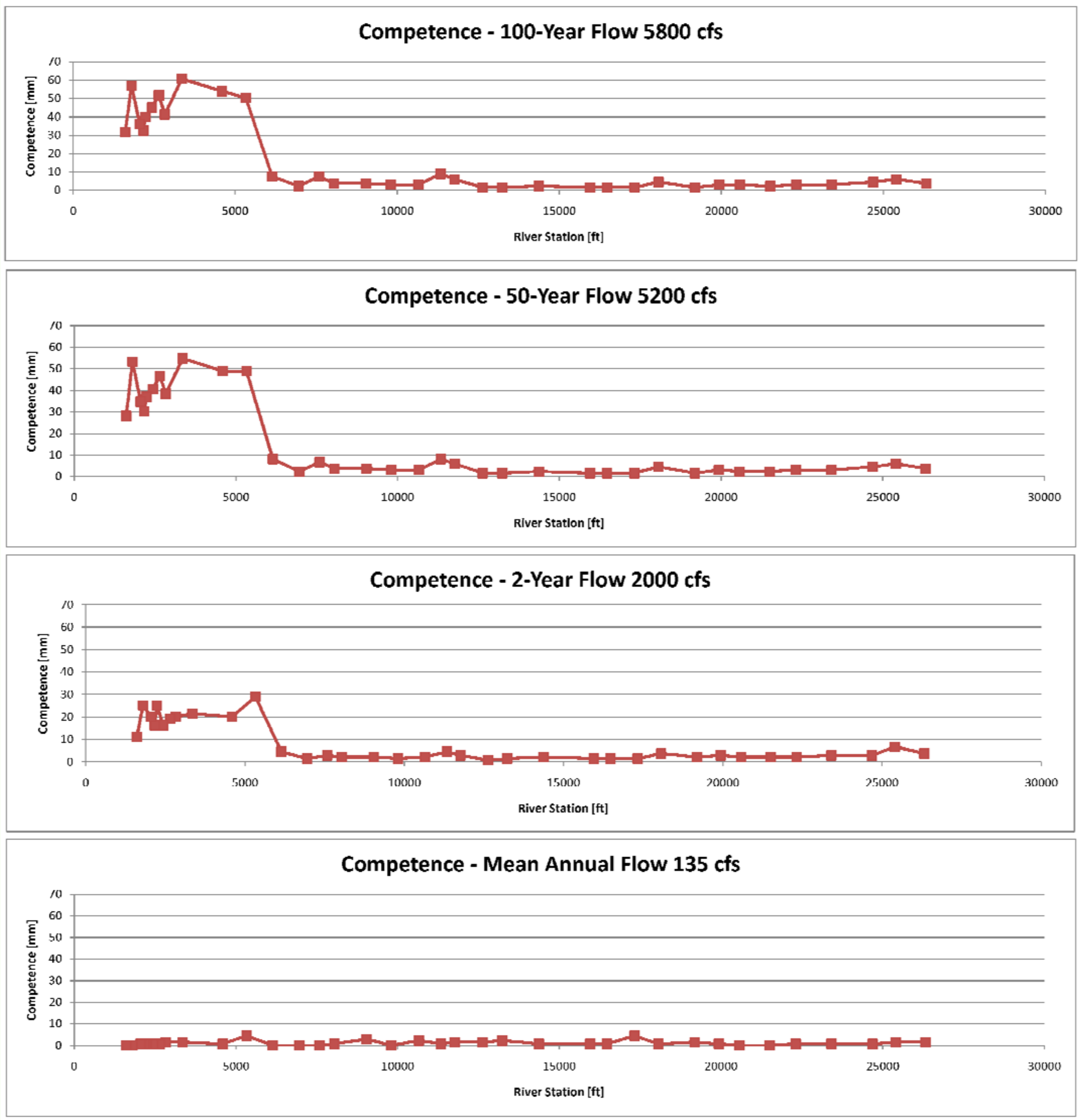

SNAKE RIVER - EXISTING CONDITIONS

USKH SHARED VISION. UNIFIED APPROACH.	NOME AIRPORT RSA EXPANSION SNAKE RIVER RELOCATION SNAKE RIVER SEDIMENT TRANSPORT COMPETENCE	MAR. 2011 FIGURE 8

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Sediment transport capacity is derived from the same localized shear stress values as sediment transport competence, and the results identify the same locations of interest. Sediment transport capacity is distinct from the actual sediment load. Even if the channel has the ability to transport a certain volume of sediment, it will only transport that amount of sediment if a supply of that material is available from the watershed upstream. As an analytical tool, sediment transport capacity analysis helps to identify channel zones that have the potential to deposit sediment or scour material from the river bed. Low transport capacity reaches effectively filter the sediment load delivered from upstream and reduce the amount and size of material conveyed downstream. Capacity also provides an assessment of the rate of change that can be expected in the more dynamic locations in the river.

The results of this analysis have several implications for design in terms of opportunities and constraints for the new Snake River channel:

- Channel constriction can be used strategically to produce localized hydraulic conditions that produce deeper pools.
- River bed erosion and scour may be effectively limited by use of modest sized gravel sediment (i.e., larger than 3 inches in diameter) within the existing river channel under existing flow conditions. This may provide an opportunity for beneficial reuse of clean mine tailings if used in conjunction with localized channel constrictions to produce pools and hydraulic diversity. It may also be used to ensure channel stability against bed scour and bank erosion.
- The HEC-RAS model results combined with the sediment transport analysis are consistent with the observed river bed sediment composition (i.e., sand with some pea-sized gravel). This indicates that the same analysis and approach can be used effectively to specify the river bed composition in the new channel alignments.

3.1.3 Snake River Fisheries Biology

The Snake River is a catalogued anadromous stream (stream number 333-10-11200) that provides habitat for all species of Pacific salmon - chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*), chum (*O. keta*), pink (*O. gorbuscha*), and coho (*O. kisutch*), as well as resident Dolly Varden (*Salvelinus malma*), Arctic grayling (*Thymallus arcticus*), and white fish (*Coregonus* spp.). The Snake River chum salmon are a designated Stock of Concern as defined in the Policy for the Management of Sustainable Salmon Fisheries (5 AAC 39.222). This stock has been listed as a management concern since 2000 due to the failure to meet escapement goals for several years.

The decline in chum salmon runs has likely been in response to several factors. The Snake River was heavily impacted by gold mining activities, which have historically played a significant role in damaging salmon spawning and rearing habitats, as well as impacting the returns of the different species of salmon. A few Snake River tributaries, such as Anvil Creek, are still actively mined today. Other activities such as road and railroad construction, and gravel mining within the river bed, have contributed to the loss of fish habitat (Norton Sound Comprehensive Salmon Plan 1996-2010). Additionally, western Alaska chum salmon share the same marine environment with chum salmon from Japanese hatcheries, and recent increases of Japanese hatchery chum salmon production have put more pressure on western Alaska chum salmon stocks.

A 2001 listing by the Alaska Board of Fisheries changed the status of the Snake River chum salmon stock to a Yield Concern since they are part of the contribution of stocks for the Nome Subdistrict for commercial and subsistence fishing. Several changes have been made to improve habitat and manage fishing to increase the production of the Snake River chum salmon stocks. As a result of this special status, recent studies have provided baseline data for chum salmon in western Alaska (Nemeth et al. 2006).

There is limited information regarding juvenile salmon in western Alaska. Historical studies have provided information on juvenile chum salmon size, diet, and movement from freshwater streams into estuary and nearshore marine waters. Nemeth et al. (2006) compared two nearby watersheds used by chum salmon in Norton Sound, and described fish habitat comparable to fish habitat for the Snake River chum populations.

As soon as ice is out in the spring, Snake River juvenile salmon migrate from the spawning areas above the project area, and begin occupying the lower reach of the river. Rue (1996) estimated that Norton Sound chum salmon fry emerge from the gravel in April or May, and enter Norton Sound in May and June.

Freshwater habitat quality and availability is critical to the success of spawning salmon and especially important in an area with declining or depressed chum salmon returns (Dunmall 2006). The Snake River has been highly altered over its lower mile and a half, which has had a significant effect on the availability and quality of habitat. This lower reach of the river provides migratory habitat for salmonids and summer habitat for resident species. Other species such as Saffron Cod (*Eleginus gracilis*), Bering Cisco (*Coregonus laurettae*), and Burbot (*Lota lota*) overwinter in the lower Snake River near the mouth in the harbor (Charles Lean, personal communication). The lower Snake River is an important transitional area for all species of salmon, but may be especially important for chum salmon which appear particularly sensitive to temperature changes (Beitinger and Bennett 2000).

The river is straightened and channelized along Seppala Drive and the airport for approximately one mile (RM 0.3 to 1.3). Riprap and coarse material (probably mine tailings) characterizes much of the left bank and a substantial portion of the right bank (see Photo 7). Riparian vegetation is largely lacking or limited to grasses and small herbs on the left bank, and limited in extent on the right bank, which has been disturbed by fill and industrial activities over the last century. This reach provides poor habitat for juvenile fish because of the lack of cover from predators, and is lacking in food sources. Without riparian vegetation and associated wetlands, there is no filtration of pollutants during storm events. While this is less of an impact for adult fish as they migrate to the spawning grounds above the project area, juvenile fish use the lower river habitat for several weeks, and could experience higher mortality from water quality issues.

The streambed in the lower mile and a half of the river appears to be a mix of silt-covered cobbles and artificial materials, including quarry spalls, riprap, and industrial debris. However, some areas of more natural sand bottom were also present. During the September 2009 site visit, migrating adult coho salmon were seen in this reach.

Upstream of the end of the crosswind runway (RM 1.4), the river banks begin to take on more natural characteristics, with a more natural floodplain and increasing riparian vegetation in the form of willows, sedges, and grasses. In several areas, the floodplain included connected or isolated sloughs with emergent *Carex*-dominated vegetation. In other areas, *Carex* dominated the vegetation on low benches and extended to, or into, the water's edge (see Photo 8). This riparian vegetation is important for migratory juveniles during the short span of time that they are outmigrating, protects juvenile salmon from predators, and provides transport of invertebrates as they are washed into the bed of the stream.

Photo 7 – Left bank of the Snake River downstream of the Snake River Bridge.

Photo 8 – *Carex*-dominated grassy bench on the inside of a meander bend.

Upstream of the airport, riparian vegetation, dominated by willows 5 to 6 feet tall, was thick on both sides of straight reaches. On the insides of bends, *Carex* and grass benches (see Photo 8) were common. On the outside of bends, steeper eroding cut banks with willow-dominated taller vegetation were typical. Even along straighter reaches, the willow and grass sod of the tundra was slumping into the channel margin (see Photo 6). However, the overall impression was one of slow change, perhaps as permafrost thaws along the bank of the river, rather than rapid erosion by river forces. These conditions continue for several miles upstream to the vicinity of a weir operated by the Norton Sound Economic Development Corporation (approximately RM 6), well above the point of the proposed diversion for the two relocation options (about RM 3.7). At the upper end of this reach, several small schools of adult salmon were seen during the September 2009 site visit – usually along the deeper pools on the outside of bends where stronger currents result in coarser sand and even small gravel that may be used for spawning. The first significant riffle habitats were also seen near and above the weir location, and where a large tributary entered from the west about 0.3 river miles below the weir.

3.1.4 Snake River Estuarine Biology

The Snake River currently flows into Norton Sound through the dredged basin of the Nome Harbor (see Figure 9). In recent times, the USACE has been responsible for maintenance of navigation depths in the harbor and for construction and maintenance of breakwaters. The present harbor configuration has the harbor entrance protected from seas by two long breakwaters that shelter an area termed the outer harbor. Each breakwater has a breach near shore that was included in the design to allow passage of small boats and along-shore migrating fish and marine life. A substantial area of fill at the approximate location of the natural Norton Sound shoreline further protects the inner harbor and provides some industrial land on either side of the new river mouth. On the inside of the western portion of this fill, a sand beach has been established by sand transported to the east along the beach and through the breach in the western breakwater. The storm berm behind this beach is littered with logs, primarily of Yukon River origin. The beach itself is quite clean (see Photo 9), and low boulders below the water line support limited amounts of annual algae (*Ulva intestinalis* and/or *U. prolifera)*.

Significant algal growths in shallow waters of Norton Sound are limited by winter ice. Marine organisms in the drift here included rockweed (*Fucus* sp.), and shells of two clams, *Tellina* sp., and razor clam (*Siliqua* sp.).

The inner portion of the harbor forms a rough “U” shape. The western arm of the “U” has a generally low gradient. In some places it appears to have almost natural shorelines, and carries the flow of the Snake River. The eastern arm of the “U”, into which Dry Creek flows in a constructed channel, has steep, constructed shorelines providing for industrial uses. The outer portions of the inner harbor along the base of the “U” also are heavily industrialized with steep riprap or vertical sheet pile occupying much of the shoreline (Photo 10). This area and the eastern portion of the harbor has recently been reconstructed to create more deepwater moorage and to change the mouth of the river to flow directly south into the outer harbor. Where beaches exist, along the western arm of the “U” and the northern portion of the base of the “U,” for example, they are often littered with industrial debris, including a major dump area in the southwest corner of the harbor (Photo 11).

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SNAKE RIVER RELOCATION

SNAKE RIVER ESTUARY AND NOME HARBOR

MAR. 2011

FIGURE 9

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Photo 9 – Sandy beach on inside of western breakwater (Outer Harbor).

Photo 10 – Sheet pile and riprap shorelines within the Inner Harbor.

Photo 11 – Western shore of Nome Harbor. View facing north.

The larger western lobe of the inner harbor has a relatively shallow beach on the eastern shore comprised of cobbles (Photo 12) that become increasingly fine toward the Snake River mouth. This area creates the primary launch in the city for small boats. Several starry flounder and one small cottid were seen near the shore in this area during the September 2009 site visit. On the opposite, western shore of the Snake River mouth (west arm of the "U") is a *Carex*-dominated brackish marsh (Photo 13) that is surrounded by low-gradient sand and mudflats. Very small fish seen here in September 2009 may have been ninespine stickleback. Farther south, this marsh and flat is truncated by encroaching fill, although another small patch of marsh was present just south of the metal dump area shown in Photo 11.

Nome Harbor and other estuaries along the north shoreline of Norton Sound (e.g., Nome River and Safety Sound) comprise an important habitat type for area biological resources. In addition to providing nursery areas for a number of marine species, including starry flounder and saffron cod (Nemeth et al. 2006), they provide a critical transition zone for anadromous fish between the fresh waters of their natal rivers and the saline waters of Norton Sound (Nemeth et al. 2006, Williams et al. 2009). Estuaries provide rich feeding areas for juvenile salmonids, allowing them to put on important growth before entering the marine environment (Simenstad et al. 1982). They may also provide shallow water refuge areas, allowing fish to evade certain predators (Heiser and Finn 1970). Finally, in estuaries, juvenile salmonids can select from a continuum of salinities between fresh and salt water to accommodate a gradual transition in their osmoregulatory adaptation to salt water (Beamer and Larson 2004).

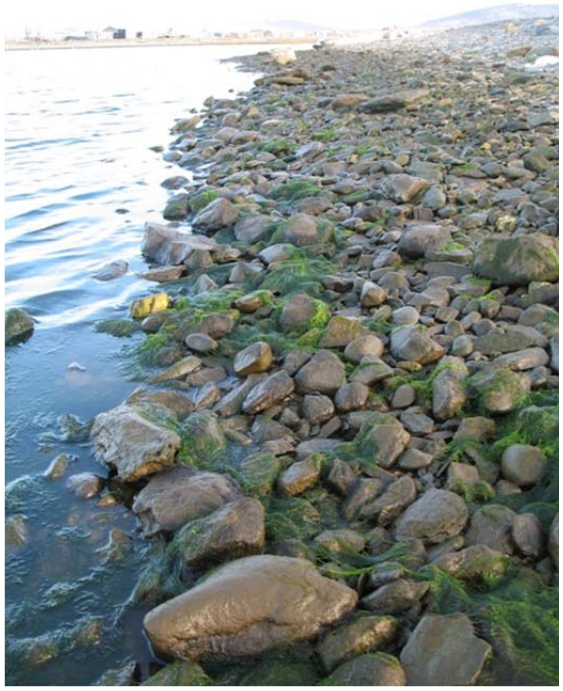


Photo 12 – Cobble beach in Nome Harbor near Snake River mouth.

Photo 13 – Marsh along the western shore of the lower Snake River near the river mouth. View facing south.

Nemeth et al. (2006) and Williams et al. (2009) surveyed Safety Sound and the Nome River estuary over a number of years and found that these waters provide all of these functions for at least juvenile chum and coho salmon, as well as for other species. Probable residence times for chum and coho last from several days to several weeks. During this time, fish are feeding actively on a mix of fresh water benthic insects, terrestrial insects, and marine benthos and plankton. Patterns of use vary greatly from year to year, and also with location in each estuary, but the importance of these habitats to Norton Sound anadromous fish is clearly great.

Nome Harbor, the present estuary of the Snake River and Dry Creek, provides some of these necessary ecological functions for anadromous fish spawning in both streams. However, the quality of those functions is diminished by changes that have resulted from a variety of alterations to the original estuary configuration, shoreline condition, depths, and water chemistry. No documentation has been found that any of these changes have been evaluated with scientific study in the harbor. The following characterization of the significance of these changes is based on our understanding of the impacts on estuarine habitat functions of similar changes in more southern estuaries.

Looking first at the role of the harbor as an area allowing a gradual transition from fresh to salt water, physical changes in the harbor may well have improved that function. Dredging and breakwater construction has increased the tidal prism of the inner harbor, providing for a greater intrusion of saltwater than would occur in the natural estuary. Nemeth et al. (2006) have shown that the Nome River estuary, which is very shallow, has very limited salt water influence and hence may not provide an ideal, gradual transition between fresh and salt water.

The Nome River estuary is probably a reasonable model for the pre-development Snake River estuary in that regard. Deepening of the Nome Harbor for navigation has allowed more saline water to come into the harbor and creates a vertical gradient with fresher water near the surface and more saline water in the deeper areas. Also, the creation of the outer harbor by breakwater construction allows the fresher water of the Snake River to extend beyond what was the pre-development river mouth at the present beach line, which also expands the area of the harbor where juvenile fish can select their preferred salinity from the gradients present.

While the changes in Nome Harbor bathymetry and extent likely improve the harbor's function in allowing gradual osmoregulatory adjustment by juvenile anadromous fish, other physical changes in the harbor clearly have degraded its quality as a feeding and rearing area for juvenile salmonids. Around the harbor perimeter, filling has eliminated a high percentage of productive shallow water habitat and associated vegetation, and also eliminated benthic production of aquatic and estuarine species that have been shown in the Nome River estuary and Safety Sound to be of high importance in juvenile salmonid diets. Steep riprap and vertical sheet pile bulkheads greatly reduce benthic production and degrade the nearshore migration corridor. In all likelihood, lack of benthic prey sources would limit the desirability of pelagic habitats along bulkheads to juvenile salmonids. Also, development around the Nome Harbor shorelines has eliminated most riparian vegetation that otherwise would contribute insects and leaf litter to the waters of the harbor. Insects and leaf litter contribute directly and indirectly, respectively, to the prey base available for juvenile salmonids (Brennan et al. 2004).

A final issue in the existing harbor is the possible presence of chemical contamination, including residues from mining and gold extraction; runoff from fuel storage and dumps of old machinery in the harbor watershed (see Photo 11); and ongoing discharges of fish and shellfish processing wastes into the harbor. While the degree of contamination and environmental degradation from these possible sources is unavailable, anecdotal reports suggest that levels could be biologically significant and could be impairing some biological functions.

3.1.5 Norton Sound Shoreline and Coastal Processes

The existing shoreline and shallow nearshore areas of Norton Sound west of the mouth of the Nome Harbor has been heavily affected by gold mining activities for many decades. Despite this, the beach may largely resemble the natural beach condition, except in recently disturbed areas. This is due to the fact that the beach is largely composed of a mix of sand, coarse gravel, and cobbles that, although they may be moved and sorted by a short-term quest for gold, ultimately are resorted by strong wave action into a relatively natural beach structure and gradient (Photo 14). The effects of several small mining operations using a gas-powered dredge and sluice box observed on the beach during the September 2009 site visit have likely already been obliterated by storm waves. More lasting effects of mining can be seen on upper beach and backshore areas where recent mining has impinged on the coastal bluffs or intermittent water courses draining adjacent uplands. Even these activities will eventually be erased by large storms, except for areas where there has been excavation into the bluff.

Photo 14 – Norton Sound beach to the west of Nome. View facing east.

An exception to the general condition of the mid- and lower beach described above is the gradual widening of the upper beach and backshore as the harbor breakwater is approached from the west. As a result of the predominantly easterly transport of sediments along this portion of the Norton Sound shoreline, a large fillet of sand and gravel has accumulated in front of the bluff, creating a very broad backshore (Figure 9). The backshore has accumulated large quantities of logs and has been colonized by squatters who have built a substantial number of camps and dwellings, some of which are quite extensive. Most have increased their space and elevation above the sea by cutting depressions back into the bluff behind the beach. A ramp from the west side of the harbor provides access for vehicular traffic to the beach. This fillet of sand has been built out to, and carries through, the breach in the west breakwater. The resulting sedimentation in the breach and outer harbor requires periodic dredging (Joy Baker, Port of Nome Harbormaster, personal communication).

3.1.6 Wetlands

The majority of the undisturbed land surrounding the Nome area is comprised of wetlands. All wetlands observed during a July 2009 wetland delineation were noted to be hydrologically connected to Norton Sound (ABR 2009). The wetlands within areas that would be impacted by the proposed river relocation options consist of a mix of wetland types, including marine, estuarine, riverine, flooded ponds, disturbed wetlands, palustrine emergent dominated, and palustrine shrub-scrub dominated. The following discussion describes the different wetland types in the project area. Figure 10 shows wetland locations and their association with the proposed project components.

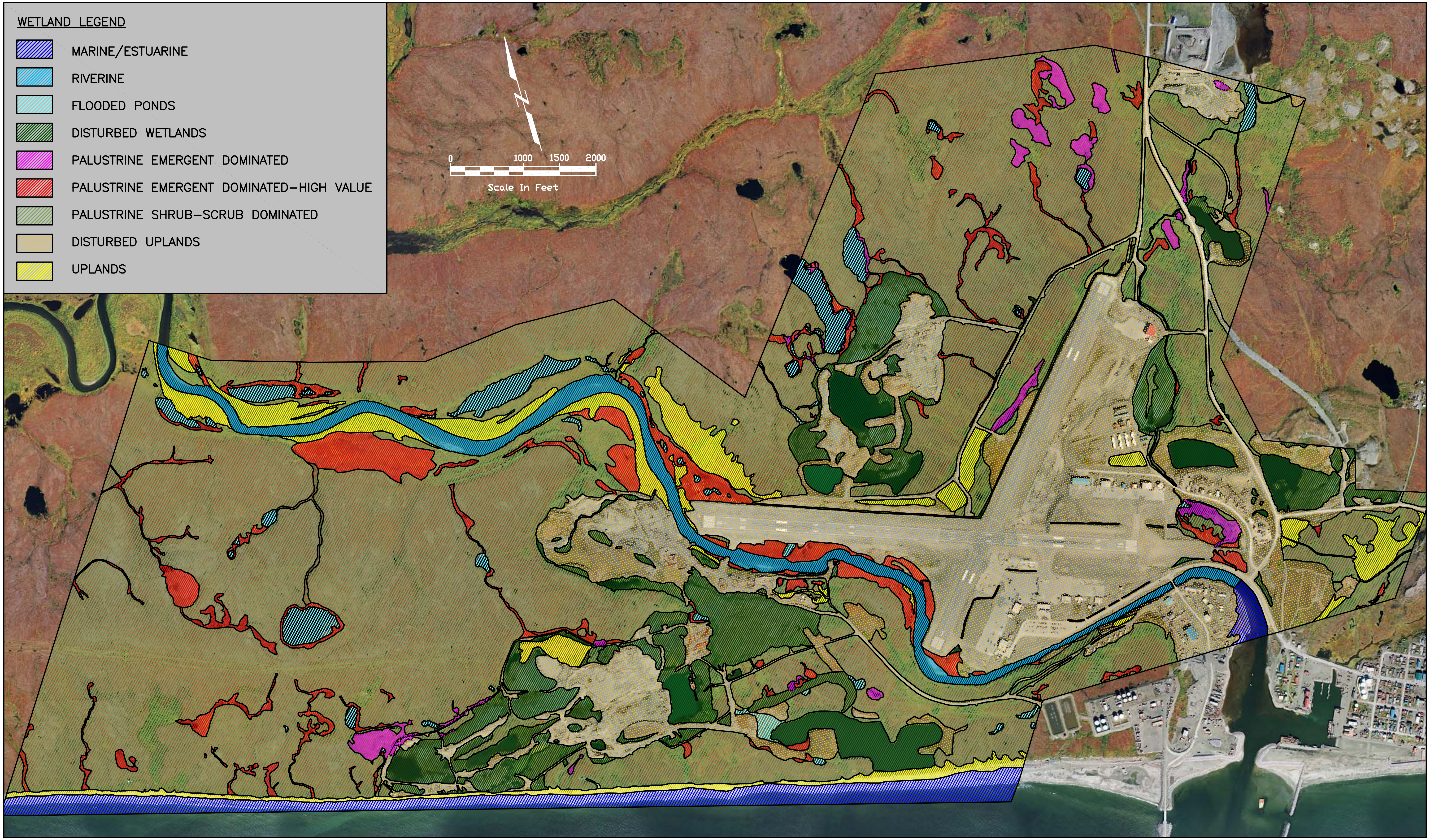
The undisturbed tundra southwest of the Nome airport consists of palustrine shrub-scrub and emergent dominated wetlands with a variety of vegetation communities. Dominant plants within these wetland types typically consist of willows (*Salix spp*.), bog birch (*Betula nana*), sedges (*Carex sp.*), and ericaceous shrubs such as blueberry (*Vacinnium uliginosum*) (ABR 2009). Flooded ponds are also common throughout this area. These waterbodies consist of shallow open water in depressions in the undisturbed tundra and along the Snake River. The flooded ponds are interspersed with intermittent streams that are considered permanently, semi-permanently, and seasonally flooded palustrine emergent dominated wetlands.

The Snake River borders the project area to the north and is considered a lower perennial riverine wetland within the boundaries of the river bed. The riparian zone surrounding the Snake River is also dominated by palustrine emergent and shrub-scrub communities with some upland shrub-dominated habitats as well. In addition to the palustrine and riverine wetlands along the Snake River and throughout the project area, marine and estuarine wetlands exist along the beach and within the Nome Harbor. One estuarine wetland was identified adjacent to the Snake River below the subtidal line at the north end of the Nome Harbor. This wetland class is a mosaic of wet sedges and prostrate shrub plant communities.

Much of the previously disturbed area within NovaGold property has since converted back to wetlands. These disturbed area wetlands consist of the same wetland types seen throughout the rest of the project area, but exist on areas that have been excavated in the past, and as a result have a less developed soil structure and a much lower functional capacity than undisturbed wetlands. Disturbed wetlands within the project area are restricted to areas associated with past dredge mining activities. Most of the disturbed wetlands are located on old dredge substrates found south of the Nome airport. Plant community composition in these areas typically includes early colonizing willows and grasses. Many excavated ponds occur throughout the previously mined areas as well. Some of the disturbed wetlands in this area consist of wet tailings associated with historic mining disturbances and are either barren or partially vegetated with colonizing species.

Uplands

Two distinct upland types are present in the project vicinity - uplands and disturbed uplands. Disturbed uplands make up the majority of uplands in the project area, and include areas of barren or partially vegetated fill associated with roads, ditches, or recent mining disturbances. Undisturbed uplands are rare within the project area and are comprised of tall, closed willow and dwarf shrub communities bordering the Snake River; low, open willow areas on raised bluffs above the floodplain; and vegetated surfaces that may have been disturbed in the past but have since established a well developed, shrub-dominated community.



USKH SHARED VISION. UNIFIED APPROACH.	NOME AIRPORT RSA EXPANSION SNAKE RIVER RELOCATION	MAR. 2011
	PROJECT AREA WETLANDS	FIGURE 10

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Wetland Functions and Values

Wetlands within the project area contribute many landscape functions that are necessary for wetland ecosystem maintenance, including but not limited to, flood flow regulation; sediment, nutrient, and toxicant removal; erosion control and shoreline protection; organic matter production; wildlife and fisheries habitat; and support of public needs, such as subsistence. The functions performed by wetlands and waters in the project area were qualitatively rated as low, moderate, or high, depending on the extent to which certain conditions are met and/or site characteristics are present (ABR 2009).

The majority of wetlands within the project area are classified with an overall rating of moderate to low functioning (ABR 2009). Moderate to low functioning wetlands can be important for a variety of wildlife species and provide higher watershed protection functions depending on where they are located within the landscape. For instance, although considered moderate to low functioning overall, the wetlands adjacent to the Snake River have a high functional capacity for support of fish and other wildlife. In addition, the seasonally flooded and semi-permanently flooded emergent wetlands throughout the project area have a high functional capacity when compared to other wetlands for sediment, nutrient, and toxicant removal, organic matter production, and flood flow regulation. These wetlands are located on the margins of tundra ponds, within old pond depressions, intermittent drainages, and along the abandoned floodplain areas of the Snake River. Figure 10 highlights some of these higher functioning wetlands within the project area.

The remaining wetlands within the project area are considered degraded to low functioning (ABR 2009). These wetlands are the smallest, most isolated, and least diverse wetlands, and have likely been degraded by human activities. These wetlands may also be readily restored and/or enhanced. Most of the degraded and low functioning wetlands exist within previously mined areas.

3.2 Built Environment

Key features of the built environment of Nome that affect the design of river relocation options include the existing and planned airport layout, land ownership, roads and transportation corridors, past and current mining activities in the area, Nome Harbor development, and potentially hazardous materials. The Snake River relocation project is being driven by the need to improve safety and address RSA deficiencies at the Nome Airport. Construction of the RSA improvements must be completed by 2015. However, as previously mentioned, the DOT&PF has instructed USKH to address future airport expansion in the development of river relocation options (refer to Section 1.2 and Figure 3). This future development is a controlling factor in determining the starting points, alignments, and ultimately the costs of the relocation options. Land ownership (see Section 1.3.3 and Figure 4) also affects the starting points and alignments of the relocation options, since relocation alignments need to avoid properties not owned by either the State or NovaGold, to the extent possible.

3.2.1 Transportation Corridors

The Snake River and Norton Sound shoreline are not only features of the natural environment, but also function as transportation corridors. The Snake River serves as a corridor for local residents participating in subsistence hunting and fishing, and recreational activities. Between breakup and freeze-up, transportation is by boat, and after a safe ice cover has formed in the winter, the river becomes a well used snowmachine corridor.

The Norton Sound shoreline is used by local residents as a travel corridor for subsistence hunting and fishing, and recreational activities, and also serves as an important access corridor for miners. Of particular importance is the use of the shoreline by the Gold Prospectors Association of America (GPAA) to access their Cripple River

Camp, located approximately 12 miles west of Nome. The GPAA's Cripple River property encompasses 2,300 acres. The camp has been built to resemble a frontier town, and is comprised of more than 50 buildings. The camp is used for recreational gold mining, and dozens of recreational gold miners occupy the camp for up to six weeks at a time during the summer. The GPAA accesses the camp via the Norton Sound shoreline between the end of May and the middle of August each year. All-terrain vehicles and large pickup trucks travel daily between Nome and the camp, with as many as 18 truck trips to and from Nome on weekends. The largest vehicles that travel between Nome and the camp include a Caterpillar D-6 bulldozer and a Foremost CF-100TT wheeled vehicle. The Foremost has a gross weight of 27,000 pounds, and is used to haul supplies to the camp from Nome on an almost daily basis during the early part of the season.

3.2.2 Infrastructure Development and Previous Mining Activities

Disturbance from mining and infrastructure development have had a profound effect on not only the Snake River, but also on the surrounding terrain through which river relocation options would be routed. Many of these disturbances, particularly those related to mining, have a direct impact on underlying soils and geologic conditions, which will in turn impact the size and configuration of excavations for the river relocation options.

Large portions of areas crossed by the Reduced Reconnection Option were mined with a dredge. This is important because dredging generally overturns and sorts the natural soil profile, with finer soils deposited near the bottom and coarser soils near the top. Dredging operations generally involve removing the near-surface silty and organic-rich layer, prethawing the underlying soils down to bedrock using cold water and thaw points, followed by dredging. The entire section of thawed material is then dredged, washed, and processed, with the coarser material separated from the finer gold-bearing sands and gravels. The gold-bearing sands and gravels are run through a sluice box and, along with the silts, discharged into the dredge pond. The coarser material is stacked over the finer tailings in a characteristic fan-shaped pattern using a conveyor. Unmined remnants of natural ground may exist between dredge passes.

Because of the importance that infrastructure development and previously disturbed areas have for the design of river relocation options, these areas were mapped using aerial photographs. This mapping effort is documented in a technical memorandum attached in Appendix F.

Recent development at the Nome Harbor has been extensive, with tens of millions of dollars being invested in a new breakwater, docks, a new Snake River mouth, shoreline protection, and other related harbor infrastructure. In addition, annual maintenance dredging is required to maintain safe navigation depths within the harbor and the lower Snake River.

Potentially Hazardous Materials and Areas of Concern

Contaminated soil and potential hazardous waste have been identified within four AOCs in the project area that may be impacted by the Reduced Reconnection Option. USKH and Shannon & Wilson completed Phase I and II Site Assessments during the fall of 2009 and summer of 2010.

Most of the potentially hazardous waste within the project area is in the form of numerous abandoned barrels of asphalt (AOCs 1and 2). AOCs 1-4 also encompass at least three locations where it appears that drums and other unidentified waste have been buried. The area directly east of AOC 1 shows evidence of recent track-hoe activity on the top of a mound of dirt, as well as evidence of buried 55-gallon drums within this mound of dirt. AOC 1 contains approximately 300 55-gallon drums containing asphalt residue. Six plastic containers filled with a petroleum-like substance are also present in this location. The location of the environmental investigation study area and AOCs are shown in Figure 11.

I:\1182800\DWGS\CIVIL\HYDROLOGY\CONCEPT_DESIGN\FINAL CONCEPT DESIGN\1182800_CD_FIG-11.DWG PLOTTED: Mar 22, 2011 - 5:43:39 PM (Glenn Sears)

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

USKH SHARED VISION. UNIFIED APPROACH.

NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION

ENVIRONMENTAL INVESTIGATION
STUDY AREA

MAR. 2011

FIGURE 11

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After the initial Phase I Site Investigations, additional characterization and testing of the AOCs was completed. Soil and groundwater samples were collected and visible surface contamination and solid waste was characterized. Soil contamination was found along the Reduced Reconnection Option, as well as the presence of naturally occurring metals above ADEC clean up levels.

AOC 1 - Any excavation activities through this location that have the potential to disturb existing containers and impacted soils would require characterization of the content of these containers and a potential investigation of any spills discovered beneath these containers. At a minimum, removal of containers and potentially impacted soils would be required, as well as investigation of any impacts to existing groundwater.

AOC 3 – Orange-colored sediment was observed at the toe of a slope adjacent to the Snake River. If excavation activities take place near this area, the source of this leachate may be exposed and should be characterized to rule out the presence of hazardous waste in order to prevent negative environmental impacts.

Potential buried waste in AOC-3 does not appear to have contaminated the seep flowing into the Snake River. The orange-colored slime in the seep is likely the result of naturally occurring bacteria that are reacting to the presence of iron and manganese in the water. Observations during excavation and field screening if stained soils are encountered are recommended.

AOC 1-4 - These areas encompass at least three locations where it appears that drums and other unidentified wastes have been buried. The Reduced Reconnection Option would require disturbance of soils in these areas. Further investigation will be required during construction to fully characterize potentially hazardous buried materials as needed. Buried waste will require characterization for contaminants and disposal in an ADEC-approved manner.

Asphalt - The asphalt found within AOCs 1-4 would not be considered a hazardous waste based on the analyzed toxicity characteristic leaching procedure (TCLP) criteria. The asphalt in AOC-1 and AOC-2 can be considered an unregulated waste and could be accepted for disposal by solid waste contractors such as Emerald, Inc. Other disposal options may include reuse as an asphalt product. The City of Nome landfill will not accept the asphalt for disposal. Analytical results of the soil near the surface of the AOC-1 asphalt and from the test pits at the asphalt's perimeter indicate the asphalt in AOC-1 and AOC-2 has affected the underlying soils, but has not contaminated it above cleanup levels (analytical results are presented in Shannon & Wilson's October 2010 *Environmental Studies Report, Snake River Relocation Project, Nome, Alaska*). Results indicate remediation of the soil is not warranted. Surface water on the asphalt has been contaminated by petroleum hydrocarbons and will require treatment prior to discharge.

Naturally Occurring Metals - Elevated concentrations of metals (arsenic, chromium, mercury, lead) are known to be present in soils within the Reduced Reconnection Option area (Phase II ESA, Nome Row Acquisition, 2004). Excavation of contaminated soils and movement of water by construction of a new river channel through previously undisturbed soils and sediments has the potential to mobilize these metals and negatively impact aquatic receptors.

The average arsenic concentration in soil samples was higher in the mined area (368 mg/kg) than in the unmined area (200 mg/kg). Toxicity characteristic leaching procedure (TCLP) testing indicated the arsenic is not leachable by TCLP. Additional sampling is underway to better understand the extent and types of metals contamination that exists within project area soils. Closure of the Nova Gold Barrel Dump (Site ID 400.38.029), an ADEC Contaminated Site within AOCs 1 and 2 and disposal of contaminated soils within an ADEC permitted monofill will be required to allow distribution of soil during construction.

Arsenic concentrations measured in groundwater were highly variable across the study area, and exceeded ADEC groundwater cleanup levels. Additional sampling is underway to obtain a more accurate determination of the type and extent of groundwater contamination in the project area. An ADEC Dewatering Permit and mixing zone will be required to treat and dispose of construction dewatering of groundwater during excavation of the new river valley.

Mercury detections within soil and groundwater were few and of low concentration in both mined and unmined areas, suggesting mining has not been a source of mercury contamination. Sampling activities detected mercury in the surface water of pond adjacent to Dredge No. 6 (Suspected Uncontrolled Hazardous Waste Site Investigation, 1986). Project activities will avoid disturbance of existing mining ponds to avoid disturbance of known mercury contaminated surface water.

4 DESIGN ELEMENTS

The design elements of the Snake River relocation options can be broken down into 5 general categories:

1. New river valley alignment and size;
2. New channel and floodplain geometry and hydraulic characteristics;
3. Stability of excavated slopes;
4. Disposal of unusable excavated material; and
5. Maintenance of vehicular access and transportation corridors.

4.1 New River Valley

The existing valley of the lower Snake River is separated from Norton Sound by a broad ridge that runs parallel to the coastline (see Figure 2). The elevation of the top of this ridge is approximately 55 feet in the project area. For the Reduced Reconnection Option, excavation for the new valley will approach the crest of this ridge. When the required depth of new channel construction is taken into account, maximum excavation depths approach 60 feet. Given the length and depth of required excavations for new valley construction, excavation quantities and the disposal of excavated material, which total approximately 1.6 million cubic yards for the Reduced Reconnection Option, become a controlling design element. If required excavation quantities are too high, the river relocation project may not be economically feasible. Minimizing the footprint of excavation also helps to reduce wetland impacts.

Limiting excavation quantities requires that new river valley alignments:

1. Are relatively straight;
2. Take advantage of terrain by following lower elevation areas to the greatest extent possible; and
3. Are as narrow as possible while still providing enough room to construct a new channel that has an acceptable and achievable level of ecologic, hydraulic, and geomorphic function.

The excavation limiting strategies listed above are counterbalanced by the requirement to accommodate maximum airport expansion, which to a large extent controls the required lengths of the new river valley alignments, and limits the ability to use terrain advantageously. Land ownership also plays a role in determining the alignments of the new river valleys, since the designs avoid properties not owned by either the State or NovaGold, to the extent possible to minimize the number of property owners impacted.

The following section describes the new channel and floodplain design elements within the context of the new river valley design constraints presented above.

4.2 New Channel and Floodplain

4.2.1 Channel Alignment

Channel alignment includes the path followed by the channel as well as the form of the channel as it appears in plan view. The ideal method for determining channel pattern uses the reference reach approach discussed previously in the design objectives.

The existing channel pattern of the Snake River upstream of RM 4.0 (see Figures 2 and 7) is characterized by broad sweeping meander bends on a wide floodplain that is approximately 10 times the width of the channel. If this part of the river were used as a reference reach, it would allow the design to provide the most complete and faithful reproduction of the natural river form. However, if fully employed, this approach would require an exceptionally large volume of excavation and impact to the landscape.

Consideration of ecological and geomorphic function suggests that some amount of floodplain along the channel provides essential habitat formation and hydraulic function. However, the floodplain would not have to be 10 times the channel width to support necessary ecological, hydraulic, and geomorphic functions.

This point is supported by considering Channel Morphology Zone 3 (see Figure 2). Between RM 1.3 and RM 4.0, the channel pattern shifts to a constrained meandering pattern on a floodplain that varies from 2 to 5 times the channel width. Within this reach, the two airport runways encroach on the floodplain and confine the river valley at two points to approximately the width of the channel. The narrower natural floodplain in this reach is visible in the field as well as on the aerial photo and topographic map (see Figures 2 and 7). The September 2009 site visit documented good habitat conditions within this reach supported by similar geomorphic processes observed in the less confined river upstream. Specific habitat-forming processes observed in this reach include:

- Edge habitat formed by erosion of river banks vegetated by willows, where clumps of river bank are gradually undercut by erosion and slump into the river.
- Pool formation by channel constriction.
- Although more constricted than the upstream reach, the middle reach of the river has sufficient floodplain to allow overbank flow during high flow events. Floodplain connectivity provides off-channel refuge areas during floods and provides hydraulic function by offering floodplain water storage and additional conveyance capacity.
- Sediment bars create hydraulic diversity and play a role in pool formation as noted previously. Over time, sediment bars may become vegetated and produce wetland communities within and adjacent to the river channel.

Downstream of this reach, from RM 1.3 to the approximate head of the harbor at RM 0.6 (Channel Morphology Zone 2), the river is narrowly confined with no floodplain between the airport and the slope south of the river. Within this reach, the river channel is narrower than it is upstream. The September 2009 site visit documented that this reach of the river lacks instream habitat structure and is rather featureless by comparison to other portions of the river. The HEC-RAS modeling shows that this constricted portion of the river experiences higher velocities and effectively backwaters the river for a few miles upstream.

As noted in the design objectives discussion, common practice in river restoration uses an undisturbed natural river channel as a reference reach to establish a design template to guide design of the new river channel. The design approach used in the current analysis to determine the channel alignment for each of the river relocation alternatives makes general use of information from Channel Morphology Zones 2-4. Within these three zones, the river channel width varies over a factor of two, and the floodplain width ranges from zero up to approximately 10 times the channel width.

For the relocated channel cross-section design, Channel Morphology Zone 3 was selected as providing the most suitable target for design, since this zone represents a relocated reach of the river that retains good hydraulic and geomorphic function, and has high quality instream habitat. Analyses of channel cross-section data in this zone show a range of top widths between 115 feet and 270 feet, and an average top width of 182 feet. Depths range from 4.5 feet to 12.5 feet, with an average depth of 8 feet. Stable stream bank side slopes in this zone are approximately 2 horizontal to 1 vertical. Using HEC-RAS modeling results that showed a computed bankfull flow of 1,900 cfs in this zone, a cross-section design was developed with a 150-foot top width, a depth of 7.5 feet, and side slopes of 2:1 (horizontal to vertical). Although narrower than the average cross-section width in Channel Morphology Zone 3, the design cross-section functions in a hydraulically similar manner to the other cross-sections. The narrower width helps to minimize excavation quantities and, for a given valley bottom width, allows for a larger floodplain than a wider cross-section would.

The proposed channel alignment for each relocation alternative includes at least a minimal floodplain along the entire alignment with the width minimized in locations of deepest excavation and larger widths provided where excavation is relatively shallow. The width of the valley bottom cut to accommodate the new river channel is set by the width of the floodplain. The floodplain width in the bottom of the valley cut allows for gentle meandering of the river channel. Including even a minimal floodplain will support the habitat forming process that provides irregular river banks through slow erosion into the floodplain. To further support this habitat formation process, the initial river construction will include building the river banks in an irregular pattern mimicking the form of the existing river channel.

The meander pattern of the channel within the relatively straight valley of each realignment option may be too gentle to support pool formation. During future, more detailed design efforts, the design will make use of localized channel constrictions to produce pools at roughly the same frequency as would be produced by the meander pattern observed upstream. As noted in the sediment dynamics discussion, channel constrictions may be stable within the river channel using gravel material approximately 3 inches in diameter and larger. Exact specifications for the material would be developed as future design efforts build on the current conceptual design.

In summary, the channel alignment for each of the river relocation alternatives results primarily from the constraints of landscape features, topography, excavation quantities, and future airport development. The reference reach approach is relaxed in the application of floodplain comparisons and focuses on replicating the natural river channel and instream features and functions.

4.2.2 Channel Gradient/Longitudinal Profile

Sediment dynamics are extremely sensitive to changes in channel slope. The existing Snake River gradient is extremely flat. The new channel gradient for river relocation alternatives is determined by the length of the new path of the river. The Reduced Reconnection Option maintains approximately the same channel length and gradient as the existing river channel.

4.2.3 Channel Bed Material

The existing river bed is composed almost entirely of sand with a few patches of pea-sized gravel and larger areas composed of angular rock presumably derived from mine tailings. During the September 2009 site visit, the team noted that upstream of the proposed channel modifications, the river bed composition becomes gradually coarser, including an increase in both the amount and size of gravel over several river miles. This observation is consistent with the increased competence and transport capacity predicted by the sediment transport analysis.

The Reduced Reconnection Option would maintain a similar longitudinal profile compared to the existing conditions. Therefore, the river bed material composition could remain the same as existing conditions, and be dominated by sand. If coarser gravel size material is encountered during excavation, at the proposed grade of the channel bed, the gravel material could be left in place and the river bed would remain stable.

4.2.4 Habitat Features

The lower Snake River system is devoid of large woody debris. Instream habitat features are limited to irregular river banks that create complex edge habitat and features such as meander bends and channel constrictions that form pools. Lateral and mid-channel sediment bars also create hydraulic diversity and can support formation of wetlands within and along the edges of the river channel.

River relocation alternatives would make use of the same set of design components to form habitat features. Design habitat features will include edge habitat formed by erosion of river banks vegetated by willows and pool formation by channel constriction.

4.2.5 Channel Erosion Prevention Measures

The low gradient of the channel in either river relocation option would maintain a low energy environment throughout the lower Snake River system over the range of flows at most locations. In the few locations that would experience higher flows, the potential for scour can be used as a beneficial effect to create pool habitat. HEC-RAS modeling results combined with the sediment transport analysis (see Appendix G) indicate that localized river bed erosion can be effectively prevented using relatively small diameter rock (e.g., 3-inch diameter gravel). Backwater effects from strategically located flow control channel constrictions could effectively prevent any significant erosion from occurring within several miles of the river.

River banks may erode during high flows, but this is an essential habitat forming process. River bank erosion in the natural river is self-limiting as the eroded sod clumps continue to hold together after they fall into the river and create a rough boundary. Bank erosion protection for the majority of the river bank will be native vegetation and rough boundary formed by gradual erosion of the floodplain. In localized sites of high velocity and shear stress predicted by the HEC-RAS model, additional bank stabilization measures may be employed including placement of medium gravel or erosion protection fabric along the river bank.

4.2.6 Floodplain Areas

Floodplain areas provide essential hydraulic and ecological functions in the existing Snake River system. These functions have been noted in previous discussions of channel alignment and habitat features. Critical functions provided by floodplain areas along the existing Snake River include edge habitat formed by erosion of river banks vegetated by willows, and overbank flooding during high flow events. Floodplain areas allow overbank flow during high flow events and reduce the energy of the flow within the river channel. Floodplain connectivity provides off-channel refuge areas during floods and provides hydraulic function by offering floodplain water storage and additional conveyance capacity.

As noted previously in the channel alignment discussion, the proposed channel alignment for each relocation alternative includes a narrow floodplain along the entire alignment. The floodplain width would be minimized in locations of deepest excavation and larger widths would be provided opportunistically where excavation is relatively shallow. The effort to minimize excavation as a means of controlling project costs leads to a minimal floodplain width along a portion of the alignment. Including even a minimal floodplain, however, will support the habitat forming process that provides irregular river banks through slow erosion into the floodplain.

For the Reduced Reconnection Option, the narrow floodplain has little effect on river hydraulics for most flow conditions. This is demonstrated by the HEC-RAS results predicting shear stress on the river bed. Essentially, the narrow section of the existing river between RM 1.3 to the approximate head of the harbor at RM 0.6 creates a backwater effect within the river for several miles upstream. The Reduced Reconnection Option preserves that feature of the existing channel. The new channel sections will be backwatered as long as they are constructed to have a larger flow capacity than the narrow reach of the river. In this condition, even a small floodplain will provide the essential habitat functions described previously.

For the constructed floodplains to function in the manner of the existing floodplains, the construction will need to make reasonable efforts to cultivate the appropriate willow-dominated plant community. It may be possible to salvage and replace plant material for this effort. If not, then alternative plant community restoration effort will need to be employed and temporary soil and bank stabilization measures (e.g., erosion mat or temporary erosion control seed mix) applied until the desired plant community is established.

4.3 Stability of Excavated Slopes

The information provided in Section 4.3 was developed from Shannon & Wilson's 2011 *Geotechnical Studies, Snake River Relocation Project, Nome, Alaska*. For more detail on the geotechnical studies for the project, the interested reader is referred to that document.

The project has numerous geotechnical challenges, including:

- The presence of thaw-unstable permafrost in the un-mined area and its impact on both the short- and long-term stability of valley slopes as they thaw;
- Instability of the natural tundra and permafrost along the top of the valley slopes;
- The extremely loose nature of mine tailings and the impact on long-term stability of the valley slopes;
- The presence of groundwater in the tailings on the order of 20 feet above the elevation of the planned channel and the impact on construction and slope stability, both during and after construction;
- The presence of deep taliks (thawed areas) in the permafrost in un-mined areas and the stability of valley slopes in the taliks, both during and after construction;
- Erosion of the new valley slopes in the permafrost and thawed mine tailings;
- Seepage from the active layer above permafrost cut slopes resulting in surface-icing problems aggravating slope instability; and
- Limited scour protection provided by *in situ* materials encountered in the channel excavation.

Given the relatively warm nature of permafrost in the Nome area, it is anticipated excavations will cause significant thermal degradation of surrounding permafrost. While relatively steep slopes may stand in frozen ground, they will become unstable as permafrost thaws. Perched groundwater seeping onto the cut slope from the active layer could have a destabilizing effect and may also result in potential surface-icing problems. Several techniques have been used to make cuts in thaw-unstable permafrost, including:

1. Cutting near-vertical slopes with a widened toe area and soil-retention structure to accommodate sloughing and allowing the slopes to heal naturally over time;
2. Buttressing steep cuts with a granular material;
3. Cutting moderate slopes covered with an insulated gravel layer to provide drainage and retard permafrost degradation; and
4. Cutting flat slopes without a protective covering where thawing of flatter slopes would result in more vertical settlement than lateral movement.

Given environmental and storm water pollution concerns, allowing the slopes to slough and heal naturally would not be an acceptable solution. Given the height of the planned cut, vertical slopes and buttressing or covering the slope with an insulated gravel layer would not be economically feasible. The most practical strategy for this project is to cut relatively flat slopes in the areas underlain by permafrost. Cuts in the frozen material would be sloped at 3 horizontal to 1 vertical to reduce instability.

All excavation and stabilization in permafrost would most likely need to be conducted in the winter during freezing temperatures. It would be difficult to accomplish the work during the summer months due to thaw-weakened soils. Some instability of the permafrost cut slopes in the first few years following construction is anticipated, as thawing rates are high and the potential for excess pore pressures at the thawing front exist, but it is expected the instability will decrease with time. It would therefore be desirable to allow the fresh cuts to stabilize for one or more thawing season before rerouting the river channel through the cut, although project timelines may not allow this. It has been noted that natural cryogenic solifluction processes may continue to cause the slow downhill creep of the near-surface active-layer soils after the overall slopes have stabilized. There are concerns that the ice-rich permafrost adjacent to the buttress at the top of the slope will be thermally disturbed by construction and begin to thaw, which could result in subsidence along the buttress, providing an area for surface water to collect and flow.

Slopes in mined areas would be cut at 2.5 horizontal to 1 vertical, and vegetated. The thaw-instability concerns associated with cuts in permafrost should not be present, although long-term creep from solifluction may occur in finer-grained, frost-susceptible soils. Field investigations have determined that there is a complex groundwater regime present in the mined areas. A groundwater table within the loose mine tailings on the order of 20 feet above the elevation of the channel presents both a construction and long-term stability challenge. Dewatering will likely be required during construction to achieve a stable excavation base and valley slopes. It is anticipated that the groundwater table will need to be lowered about 5 feet below the base of the excavation to achieve a stable base. Constraints on the dewatering system include the relatively fine nature and low permeability of the mine tailings, which will limit the spacing of well points, suction wells, deep well, or ejector systems, and relatively shallow bedrock below the base of the excavation, which will limit the potentiometric thickness available for design and construction of a dewatering system. Long-term stability of the valley slope may require slope drains to maintain the phreatic surface below the ground surface and increase stability.

In general, it will be desirable to prevent as much surface water as possible from flowing across cut slopes in order to reduce the potential for slope instability and surface-icing problems. Careful consideration will need to be given to a drainage plan and reducing the exposure of valley slopes to cross-drainage.

4.4 Disposal of Excavated Material

It is anticipated that some portion of the material excavated for new river valley, floodplain, and channel construction can be reused on the relocation project and for embankment fill on the expanded RSA construction. Given the volume of excavated material anticipated, however, more than one million cubic yards will need to be disposed of. Several options for disposal of excavated material exist in the Nome area, and costs for these options vary widely. Depending on the location of the disposal area, the excavated material may need to be temporarily stockpiled on site prior to hauling to the disposal site. It is likely that a combination of options will be desirable for disposal of unusable excavated material for this project. Several options for material disposal have been considered, including:

- Disposal within NovaGold property on previously disturbed ground;
- Placement of fill for beneficial purposes in the abandoned Snake River channel upstream of the expanded RSA on the west end of the main runway;
- Disposal on the slopes of the RSA and within the RSA embankment;
- Use as cover at the City landfill;
- Disposal in the mining pit pond;

- Ocean disposal within the existing disposal sites in Nome; and
- Ocean disposal within a new disposal site.

Two of these disposal options warrant detailed discussion – disposal on previously disturbed ground on NovaGold property adjacent to the relocation site, and placement of fill for beneficial purposes within the abandoned channel of the Snake River upstream of the western end of the main runway after RSA expansion construction is complete.

4.4.1 Disposal on Previously Disturbed NovaGold Property

The most feasible means to dispose of excavated material from river relocation option construction is to place the material on previously disturbed areas on NovaGold-owned property on the south side of the river. This area has been previously disturbed by mining operations and is comprised of disturbed wetlands and sparsely vegetated mine tailings. The area is adjacent to the location of proposed river relocation options, and would allow final disposal of excavated material in the course of a single handing operation. The proximity to the excavations and the ability to dispose of the material without multiple handling operations will minimize disposal costs, while placing the material on a previously disturbed site would minimize wetland impacts.

Based on the geotechnical findings for the project, approximately 1/3 of the excavation for the new valley and channel is expected to occur in frozen ground. The frozen portion of the excavated material is expected to consist of colluvium (ice-rich peat and silt) and frozen glacial till (mixture of silt, sand, and gravel) with up to 25% of the volume present as free water upon melting. Once excavated, ice within the frozen material will melt in the warmer months of the year. As the ice melts, the slope of the pile will flatten and meltwater will begin to discharge. The amount of meltwater discharged will depend on how excavated material is placed in the disposal area. Frozen material placed within the core of the disposal area is expected to be insulated by the overlying material, and remain frozen. However, frozen material exposed on the sides of the disposal pile will thaw during the warmer months. To address concerns about the discharge of meltwater, a containment and meltwater management system is proposed. The following paragraphs provide information on the considerations for the disposal of the unusable excavated material, including information on the disposal area, a containment berm system, meltwater management, and permitting.

The proposed disposal area is conveniently located near the area where excavation is anticipated to occur for river relocation options. The area slopes towards the southwest. Elevated levels of mercury have been documented within the Dredge Number 6 pond (see *Phase I Environmental Due Diligence Audit, Nome Airport Runway Safety Area Expansion*, USKH, December 2009). To minimize the potential for mercury contamination, a 100-foot buffer away from the pond would be established. The area available for disposal is approximately 65 acres. Initial earthwork volume estimates of the Reduced Reconnection Option indicate that approximately 1.6 million cubic yards of disposal volume is needed. To store this volume would require stacking the disposed material to an elevation of 100 feet, with a maximum fill depth of 75 feet. Height restrictions should not be a concern with the proposed disposal location as the maximum height of the disposed material is expected to be well below the height restriction determined by an airspace obstruction analysis performed for the future airport expansion.

As ice within the frozen portions of the disposed material melts, the potential for this material to mobilize will increase. To mitigate the potential of a slope failure, a berm is proposed to be constructed on three sides of the disposal area. On the fourth side, the higher grades of the existing ground will act as a berm. The initial berm design geometry is approximately 4,900 feet long and 10 feet high, with a 10-foot wide top width, and 2:1 side slopes. Along the inside of the berm, a ditch will collect meltwater and route it through the berm at various locations where culverts will be installed. The side slopes of the disposed material is anticipated to eventually stabilize and reach an angle of repose of 3:1 (horizontal to vertical), and will be stacked in a manner that will ensure that the stabilized toe is a minimum of 50 feet from the edge of the ditch at the base of the berm.

The meltwater management system for the proposed disposal area is a combination of ditches, culverts, and ponds to collect, convey, treat, and dispose of the meltwater into the Norton Sound. Based on the initial geotechnical findings for the project, the seasonal thaw depth of the disposed material is expected to be no more than eight feet, with the remainder of the material to remain frozen indefinitely. To provide a safe and cost-effective way to manage the meltwater, a passive meltwater management system is proposed that uses widely accepted storm water management strategies, although on a larger scale. Meltwater will be collected within the bermed disposal area and routed to various locations where culverts will be installed through the berm. The meltwater will then begin treatment in a gently sloping and vegetated bioswale. For additional treatment, the discharge will be routed into a series of interconnected bioswales and settling ponds that will have flow-regulated outlets to ensure residence times promote settling of fine-grained materials. Ultimate discharge from the final settling pond will be routed through a rock-lined channel across the beach and into Norton Sound. The rock-lined channel would be designed to allow continuous foot and vehicle traffic along the beach.

If passive meltwater management strategies are not sufficient to remove contaminated fine grained sediments from the meltwater runoff, an ADEC Excavation Dewatering Permit will be required for the meltwater discharge and will included design of a mixing zone in order to ensure meltwater runoff meets state ADEC water quality standards. The excavation dewatering permit has maximum effluent values for turbidity, total aromatic hydrocarbons (TAH), total aqueous hydrocarbons (TAqH), settleable solids, pH, and total iron.

4.4.2 Placement of Fill for Beneficial Purposes in the abandoned Snake River Channel

Once the river has been diverted and the RSA expansion has been completed, there will be an approximately 4,000-foot long segment of the dewatered Snake River channel that will still be hydraulically connected to the relocated river. This channel segment will be located between the diversion point of the relocated channel and the northern edge of the expanded RSA embankment on the western end of the main runway. Because of the hydraulic connection, this area will function as a backwater, or slough, during high water periods. This effect would likely result in standing water within the abandoned channel segment for extended periods of time, even when high water is not being diverted into it. This standing water could produce a wildlife hazard at the airport. In order to address this, the channel would be filled with excavated material from the unmined portions of excavation for the new river channel and valley after the river channel diversion is completed. The volume of this channel segment is 172,000 cubic yards. The feasibility of designing the fill placement to develop into an emergent wetland at some distance from the expanded RSA will be evaluated as part of the mitigation for project impacts. Flood waters would continue to occasionally spill into this former active floodplain, but would drain back into the diverted channel, and standing water would be minimized.

4.4.3 Maintenance of Access

Construction of the Reduced Reconnection Option is not expected to interrupt existing access routes.

5 CONCEPT DESIGN AND ENVIRONMENTAL IMPACTS

Since development of the Draft Snake River Relocation Concept Design Report in December 2009, the New River Mouth Option and Lower River Reconnection Option have been dropped from further consideration. The discussions of the concept designs and environmental impacts for those two options are provided in Appendix H. The following section describes the concept design and environmental impacts associated with the Reduced Reconnection Option.

One of the most important design features of the Reduced Reconnection Option is that it would maintain hydraulic connectivity with the lower Snake River. This connectivity would assure that existing flow conditions are maintained in the Snake River estuary and the Nome Harbor, and that the river's use as a transportation corridor would not be disrupted.

The alignment of the Reduced Reconnection Option would take off to the south from the existing Snake River and skirt the end of the proposed RSA expansion, a 275-foot threshold shift to the west, and the limits of a possible future 1,775-foot embankment extension of the main runway. This segment would generally parallel the proposed expanded runway embankment and tie back into the existing Snake River near the existing west end of the main runway.

The width of the new river valley would vary according to the elevation of the terrain through which the alignment passes. In lower elevations areas, the new valley would be wider, but it would narrow where ground surface elevations and excavation depths are greater. A floodplain that varies in width from 174-300 feet would be provided in the bottom of the new valley. The 150-foot wide and 7.5-foot deep channel of the relocated Snake River would meander gently within the floodplain. The length of this relocated valley segment would be approximately 4,600 feet, while the length of the meandering channel within the segment would be approximately 4,675 feet.

New valley excavation typical sections vary depending on whether or not the excavation occurs in previously mined areas. At this stage in the concept design process, approximately 2,660 feet of the proposed alignment would pass through previously mined areas. In areas that have not been previously mined, new valley side slopes would be cut at 3:1 (horizontal to vertical) while the new valley side slopes would be cut at 2.5:1 in previously mined areas. Placement of a growth medium and revegetation will be required in addition to the placement of salvaged tundra mat where possible.

The plan view and typical sections for the Reduced Reconnection Option are shown in Figures 12 and 13, respectively. Discussions of environmental changes and impacts related to the Reduced Reconnection Option are presented below.

5.1 BASIN HYDROLOGY CHANGES

The Reduced Reconnection Option does not change the drainage area of the Snake River, nor does it result in any significant disruption of existing drainage patterns. Consequently, there are no changes to basin hydrology related to this option.

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NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION

REDUCED RECONNECTION OPTION

MAR. 2011

FIGURE 12

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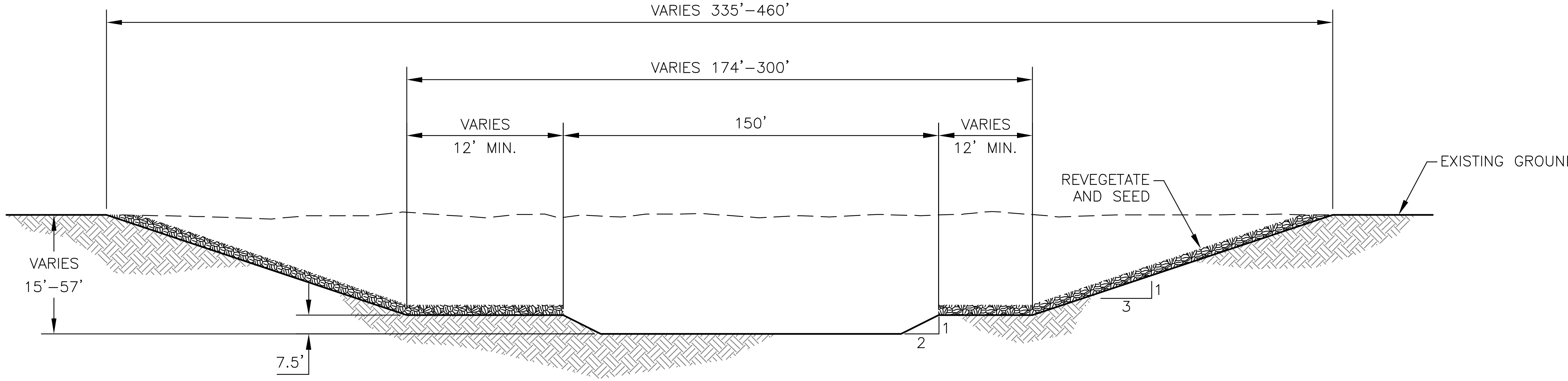
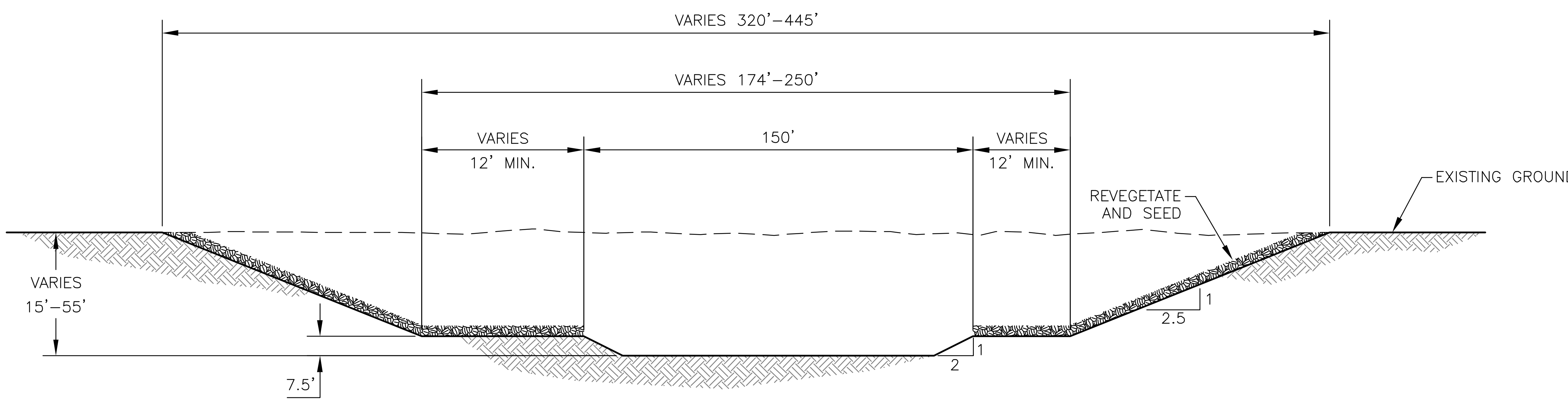


1/13 TYPICAL SECTION IN UNMINED AREAS



2/13 TYPICAL SECTION IN MINED AREAS

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NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION

REDUCED RECONNECTION OPTION TYPICAL SECTIONS

MAR. 2011

FIGURE 13

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5.2 HYDRAULIC CHARACTERISTICS OF THE RELOCATED CHANNEL

The Reduced Reconnection Option will result in a decrease of approximately 450 feet of channel over the existing Snake River channel length, which constitutes an extremely minor decrease in the total length of the Snake River. This decrease is not anticipated to change the hydraulic regime of the lower Snake River. Because the Reduced Reconnection Option closely mimics the hydraulics of the existing river, it would also have similar sediment transport characteristics.

5.3 FISH HABITAT IMPACTS

The Reduced Reconnection Option results in a decrease of approximately 450 feet of riverine habitat, a negative outcome of this option, which may slightly decrease the opportunity for juvenile fish to feed longer on their outmigration to Norton Sound. It is expected that providing additional instream and off-channel habitat structures in the constricted, featureless section of the existing channel downstream of the crosswind runway (Channel Morphology Zone 2; see Figure 2) would mitigate for this decrease in habitat. Similarly, channel habitat features would be incorporated in the new river channel. Constructed habitat may consist of pools, cutbank features, and the placement of tundra blocks along the edge of the channel to mimic tundra block sloughing, which provides more complex habitat.

During the new channel construction, there is potential for gravels to be exposed within the relocated channel. If so, the exposed gravels could provide new spawning habitat for resident and anadromous species. Pink salmon, which may have spawned in this area in the past, are known to be very opportunistic spawners, and commonly use new spawning gravels that appear after flood events. Newly exposed gravels within the relocated channel might be used as spawning habitat by pink salmon.

Initiation of flow through the new channel would result in a temporary increase in sediment loads for an unknown period of time. This effect would mainly impact juvenile fish, which are more susceptible to sediment loads than adults due to their size. Juvenile salmon have been shown to avoid areas of unacceptably high turbidities (Servizi 1988), although they may seek out areas of moderate turbidity (10 to 80 NTU), presumably as cover against predations (Cyrus and Blaber 1987s and 1987b). Feeding efficiency of juveniles is impaired by turbidities in excess of 70 NTU, well below sub-lethal stress levels (Bisson and Bilby 1982). Reduced preference by adult salmon homing to spawning areas has been demonstrated where turbidities exceed 30 NTU (20 milligram per liter [mg/L] suspended sediments). However, Chinook salmon exposed to 650 mg/L of suspended volcanic ash from a recent eruption were still able to find their natal water (Whitman et al. 1982). Based on these data, it is unlikely that the elevated turbidities and suspended sediment load generated by the proposed action would result in direct mortality of juvenile or adult salmonids that may be present, or deter adults from upstream migration. Prolonged (weeks or months) increases in sediment load, however, would likely reduce the abundance and availability of prey, as well as feeding efficiency of salmonids, within the lower channel and harbor. Under those circumstances, fish may migrate more quickly to marine waters to feed. As the system stabilizes over a period of one to a few years, the overall impact would be gradually reduced. Coordination with agencies is ongoing to develop design features and construction sequencing methods that would avoid and minimize impacts to fish habitat.

5.4 ESTUARINE HABITAT IMPACTS

The Reduced Reconnection Option would result in little change of the existing estuary configuration or function, except that there would likely be a substantial increase in sedimentation rates for the first few years as the new channel upstream becomes stabilized. As flow velocities decrease upon entering the estuary, some sediment would settle out. Sedimentation along the harbor shorelines, where it may fill interstices in riprap or cobbles, could increase productivity in those areas. Finer-grained material would support diatom and/or bacterial growth, forming the base of a food chain of microconsumers that would provide nutrients for deposit feeding invertebrates that would become prey for juvenile salmonids. On the other hand, existing areas that already support a productive food chain would likely experience reduced rates of productivity due to increased sedimentation. This in turn would reduce feeding opportunities for juvenile salmonids migrating to sea through the harbor. Wave action would re-suspend settled material, leading to its ultimate deposition in deepwater basins within the harbor, or transport out of the harbor with the net outward flow. Suspended material in the water column would also reduce the productivity of existing macro- and micro-vegetation in the harbor. In the limited marsh areas north of the harbor, sedimentation could slightly raise elevations over time, potentially altering the vegetation composition of the marshes.

During the period of temporarily increased sedimentation, salmon outmigrating from the Snake River could experience some loss of fitness resulting from somewhat poorer than normal conditions for feeding in the estuary. Returning adults should not be materially affected by the altered river channel and would be expected to pass through the harbor as they do under present conditions. Coordination with agencies is ongoing to develop design features and construction sequencing methods that would reduce sedimentation in the harbor and minimize impacts to estuarine habitats.

5.5 TRANSPORTATION CORRIDORS

The Reduced Reconnection Option would not cause any disruption to existing transportation corridors.

5.6 WETLAND IMPACTS

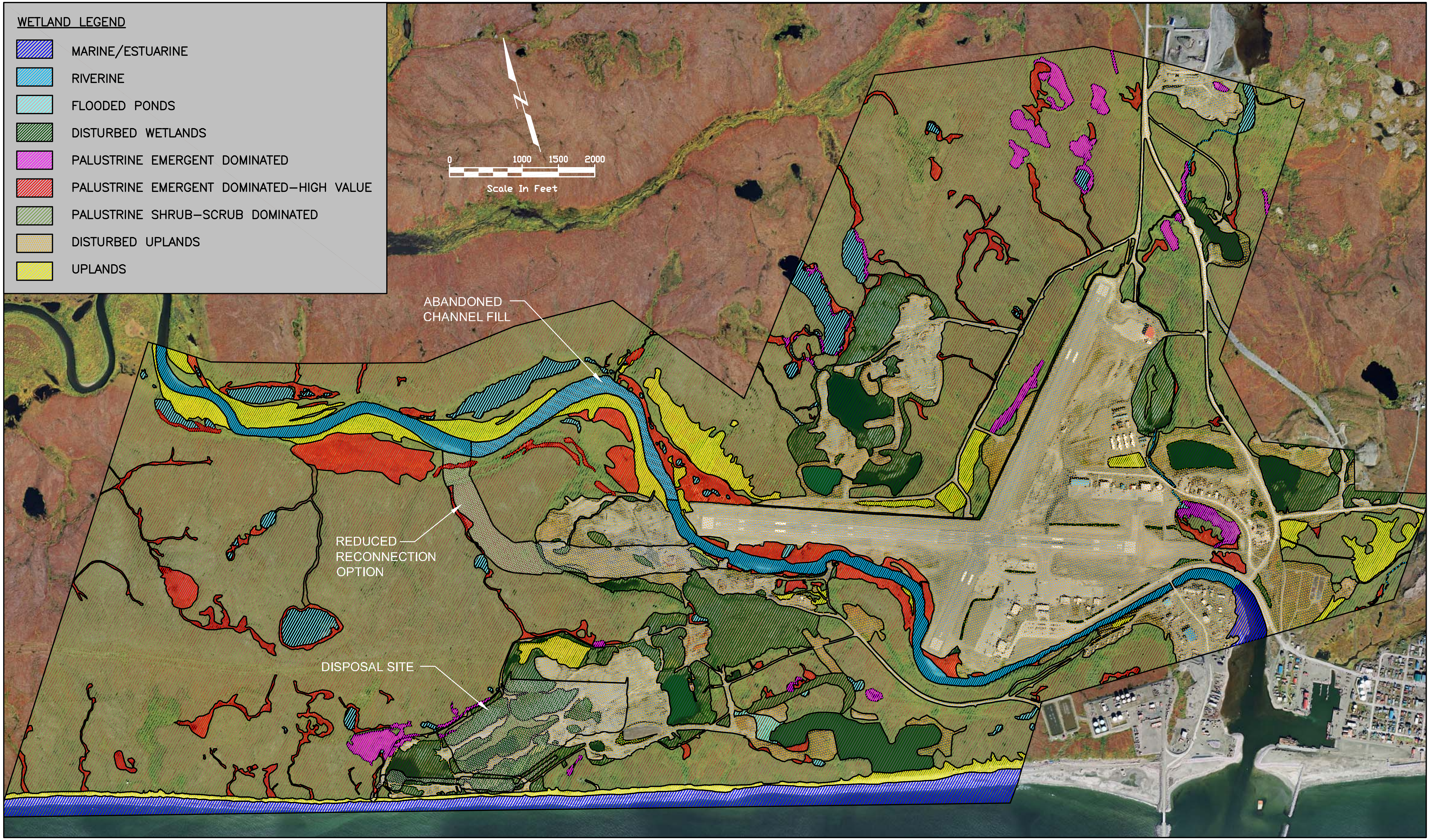
Construction of a new river valley and channel through the project area would impact wetlands in the following ways: direct loss of wetlands through excavation and fill, loss or change to wetland functional capacity from changes in hydrology, and wetland impacts (temporary or permanent) from stockpiling and disposal of excavated material.

5.6.1 Excavation and Fill

The Reduced Reconnection Option would result in the loss of approximately 26.5 acres of wetlands through direct excavation for the new river valley (see Figure 14). The majority of wetlands that would be impacted by these activities are palustrine shrub-scrub dominated and disturbed wetlands. Palustrine emergent dominated and other wetland types would also be impacted, but to a much lesser degree. After the new river valley is constructed, revegetation with tundra mat is anticipated to aid restoration of the new river channel and floodplain to palustrine emergent and riverine wetlands. The total area of wetlands that would be restored after construction of the new river valley and channel is complete is approximately 29.9acres.

5.6.2 Loss or Change in Wetland Functional Capacity

In addition to the direct impacts to wetlands from fill and excavation, the wetlands on either side of the new valley excavation may be converted to upland willow scrub and palustrine shrub-scrub dominated wetlands, similar to the margins of the existing Snake River valley. This change in wetland type and functional capacity would be caused by the change in local wetland hydrology. Wetland hydrology in the unmined areas of the project is driven by the presence of permafrost that acts as a restrictive barrier, ponding water at the surface and creating saturated conditions. After the new river valley is excavated, previously frozen soils along the



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USKH SHARED VISION. UNIFIED APPROACH.	NOME AIRPORT RSA EXPANSION SNAKE RIVER RELOCATION PROJECT AREA AND AFFECTED WETLANDS	MAR. 2011 FIGURE 14

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margins of the new river valley would begin to thaw and thus become well drained. The new soil conditions would likely allow a different plant community to develop along the valley margins to the limits of the disturbed permafrost. The resulting loss or change in wetland type and function along the new river valley may, in some areas, be considered a loss of wetlands. In other areas, the change in wetland functions would be of high value to the riparian system of the relocated river for fish and wildlife habitat.

Within the previously mined areas, wetland hydrology is not driven by the presence of permafrost or the presence of a high water table, but rather by local topography, ponded surface water, and seasonally frozen, fine-grained soils. Construction of a river valley in the previously mined area is not expected to change the hydrologic regime of the wetlands, or create a loss or change in functional capacity of the remaining wetlands.

As part of the Reduced Reconnection Option, approximately 24.0 acres of the existing Snake River channel would be abandoned. The majority of the abandoned channel north and west of the expanded RSA would be filled with excavated material generated during the new river valley construction in unmined areas. This material would consist of organics and silt, and would likely restore portions of the old river bed to palustrine emergent dominated wetlands. These restored wetland areas would not pond water or receive overflow from the river except for during very high water events. Near the expanded RSA, deeper fill would be placed to form upland conditions to ensure the abandoned channel does not form a bird attractant and produce a wildlife hazard. The disturbed and filled areas of the abandoned channel would be revegetated to stabilize soils against erosion.

5.6.3 Stockpiles and Disposal Areas

As the new valley is excavated, approximately 1.6 million cubic yards of excavated material would be placed in the permanent disposal site within the previously mined area south of the airport. This disposal would result in the placement of approximately 47.7 acres of fill in disturbed wetlands.

Table 4 on the following page identifies wetland losses through excavation and fill that would result from construction of the Reduced Reconnection Option.

Table 4 - Wetland Impacts from the Reduced Reconnection Option

Wetland Type	Impact Acres	Restored Acres
River Valley Construction		
Marine/Estuarine	0	0
Riverine	0	19.3
Flooded Ponds	0	0
Disturbed Wetlands	3.1	0
Palustrine Emergent dominated	1.2	10.6
Palustrine Shrub-Scrub dominated	22.2	0
Total	**26.5**	**29.9**
Abandoned Channel		
Riverine	24.0	**
Total	**24.0**	
Disposal Area		
Marine/Estuarine	0	0
Riverine	0	0
Flooded Ponds	0	0
Disturbed Wetlands	41.6	0
Palustrine Emergent dominated	0.1	0
Palustrine Shrub-Scrub dominated	6.0	0
Total	**47.7**	**0**
Total Wetlands Impacted	**98.2**	

**Acres of wetlands that would be restored within the abandoned channel is unknown at this time. Further design efforts will identify the portion of the abandoned channel that can be restored without creating a wildlife hazard adjacent to runway surfaces.

5.7 POTENTIALLY HAZARDOUS MATERIALS

Construction of the Reduced Reconnection Option would result in disturbance of areas known to contain contaminated soil and potentially hazardous waste. Disturbing soils near any of the identified areas of concern (AOCs) could mobilize contaminants through surface and groundwater, and/or release contaminants that may be present in soils and river sediments. ADEC Contaminated sites will be cleaned up and closed prior to construction. A dewatering and disposal plan will be developed prior to construction and coordinated with ADEC to ensure naturally occurring as well as anthropogenic sources of contamination are not introduced into the natural environment. Figure11 shows the locations of AOCs identified in the project area. The following outlines specific recommendations associated with potentially hazardous materials found in the project area.

- The asphalt within AOCs 1and 2 would not be considered a hazardous waste based on results of toxicity testing, and remediation of the surrounding soil is not warranted. Surface water on the asphalt has been contaminated by petroleum hydrocarbons and will require treatment prior to discharge. ADEC Contaminated sites associated with these AOCs will be cleaned up and closed prior to construction.

- Removal of metal drums and containers, and potentially impacted soils would be required. Any buried waste discovered during excavation should be characterized to rule out the presence of hazardous waste. Observations during excavation and field screening is recommended if stained soils are encountered, as well as fully characterizing potentially hazardous buried materials during construction.
- Arsenic and other metals concentrations measured in soil were highly variable across the study area, and exceeded the ADEC cleanup level. Additional sampling is underway to better understand the extent and types of metals contamination that exists within the project area. Closure of ADEC Contaminated Sites and disposal of contaminated soils within an ADEC permitted monofill will be required to allow distribution of soil during construction.
- Arsenic concentrations measured in groundwater were highly variable across the study area, and exceeded ADEC groundwater cleanup levels. Water encountered during excavation will be treated before it can be discharged into Norton Sound. A dewatering plan will be implemented during construction to ensure arsenic-rich sediments are not discharged into the natural environment during construction of the river valley. An ADEC Dewatering Permit and mixing zone will be required to treat and dispose of construction dewatering of groundwater during excavation of the new river valley.
- Mercury soil detections were few, of low concentration, present in both mined and unmined areas, and will not require remediation during construction.

5.8 Cost Estimates

A rough order of magnitude cost estimate has been produced for the construction of the Reduced Reconnection Option. A discussion of the assumptions and data sources used in preparing the cost estimate is presented below.

Construction Techniques

The cost estimate assumes that excavation will be performed by conventional means (e.g., excavators, dozers, loaders, etc.) in previously mined areas and on the floodplain where permafrost is not expected to be present. A combination of conventional means and drilling and blasting is anticipated to be used in areas underlain by permafrost. In those areas, it is anticipated that the upper 10 feet of material can be excavated by conventional means, and that drilling and blasting would be required below that depth.

Disposal of Excavated Materials

The cost estimate assumes that that the disposal area berm and meltwater management system will be constructed of of imported material prior to the start of excavation for the new river alignment. The cost estimate also assumes that approximately 172,000 cubic yards of material excavated from unmined areas will be temporarily stored within the permanent disposal area, and compartmentalized from the other excavated materials. The compartmentalized material would be placed as fill in the abandoned channel after the cross-over of flow into the new channel has been accomplished.

Historical Prices

To help identify costs for the estimate, USKH researched DOT&PF BidTabs Online, reviewed DOT&PF Compilation of Bids for several recent (2007-2009) Nome projects, and discussed methods of construction, schedule, and rough order of magnitude costs with a representative from the Anchorage Area Office of Kiewit Pacific Company during preparation of the draft concept design report in 2009. Additional contact was made with a representative of Quality Asphalt Paving in 2011 during the process of finalizing the report.

The rough order of magnitude cost estimate for the Reduced Reconnection Option is presented in Table 5.

Table 5 – Reduced Reconnection Option Rough Order of Magnitude Cost Estimate

	Reduced Reconnection Option
Construction Cost Subtotal	$19,190,000
Contingency (20%)	$3,838,000
Construction Engineering (15%)	$3,454,000
icap (4.25%)	$979,000
Total	**$27,461,000**

6 REFERENCES

ABR, Inc., December 2009.Snake River Fish Habitat Assessment, Nome Airport Master Plan Update, Nome, Alaska. Draft Report prepared for Alaska Department of Transportation and Public Facilities. Fairbanks, Alaska.

Alaska Department of Fish and Game, June 1996. Norton Sound/Bering Strait regional comprehensive salmon plan, 1996-2010. Norton Sound/Bering Strait Regional Planning Team, Alaska Department of Fish and Game, Juneau, Alaska 128 p.

Alaska Department of Transportation and Public Facilities, October 2010. Practicability Study - Nome Airport Runway Safety Area.

Appleton et al., July 1998. Navigation Improvements Final Interim Feasibility Report and Environmental Assessment, United States Army Corp of Engineers, Alaska District.

Beitinger, T.L., and W.A.Bennett, 2000. Quantification of the role of acclimation temperature in temperature tolerance of fishes. Environmental Biology of Fishes 58:277-288 p.

Bisson, P.A. and R.E. Bilby, 1982. Avoidance of Suspended Sediment by Juvenile Coho Salmon. North American Journal of Fisheries Management, 4:371 374.

Curran, Meyer, and Tasker, 2003. Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada. WRI 03-4188.

Cyrus, D.P. and S.J.M. Blaber, 1987a. The Influence of Turbidity on Juvenile Marine Fishes in Estuaries. Part 1: Field Studies at Lake St. Lucia on the Southeastern Coast of Africa. Journal of Experimental Marine Biology and Ecology, 109:53 70.

Cyrus, D.P. and S.J.M. Blaber, 1987b. The Influence of Turbidity on Juvenile Marine Fishes in Estuaries. Part 2: Laboratory Studies, Comparisons with Field Data and Conclusions. Journal of Experimental Marine Biology and Ecology, 109:71 91.

Dunmall, K.M. and T.J.Kroeker. 2006 Chum salmon spawning habitat on the Snake River: A feasibility study. Final report prepared for the Norton Sound Fishery Disaster Relief Fund by Kawerak, Inc., Nome, Alaska, 39p.

Engelund, F., and Hansen, E., 1972, A Monograph on Sediment Transport in Alluvial Streams: Copenhagen, Teknisk Forlag, 3rd ed., 62p.

Hasler, A.D., A.T. Scholz, and A.M. Horrall. 1978. Olfactory imprinting and homing in salmon. American Science 66: 347-355p.

Leopold, L. B. 1994. A View of the River. Harvard University Press. Cambridge, Massachusetts. 298p.

Merritt, M.F., and J.A. Raymond, 1983. Early life history of chum salmon in the Noatak River and Kotzebue Sound. Alaska Department of Fish and Game, FRED Report 1, Juneau, Alaska.

Miller, D. E. and P. B. Skidmore, 2003. A foundation for establishing a standard of practice for natural channel design. *In*: Montgomery, D. R., S. M. Bolton, D. B. Booth, and L. Wall (editors). Restoration of Puget Sound Rivers. University of Washington Press, Seattle, Washington.

Morris, William. 2003. Seasonal movements and habitat use of Arctic Grayling (Thymallus arcticus), B urbot(Lota Lota),and Broad Whitefish (Coregonus Nasus)within the Fish Creek drainage of the National Petroleum Reserve-Alaska, 2001-2002. Technical Report No. 03-02, Alaska Department of Natural Resources, Office of Habitat Management and Permitting, Fairbanks, Alaska, 67p.

Nemeth, M., B. Williams, B. Haley, and S. Kinneen, 2006. An ecological comparison of juvenile chum salmon from two watershed in Norton Sound, Alaska: migration, diet, estuarine habitat, and fish community assemblage.

Park and Madison, 1985.Estimation of Selected Flow and Water-Quality Characteristics of Alaska Streams, WRI-84-4247.

R&M Consultants Inc., 2004. Summary Report, Nome ROW Acquisition Phase II Environmental Site Assessment, AKSAS Project Number 61566.

Rosgen, D. L. 1994. A classification of natural rivers. Catena 22: 169-199p.

Rosgen, D. L. 1997. A geomorphological approach to restoration of incised rivers.

Rue, F. 1996. Norton Sound/Bering Strait regional comprehensive salmon plan 1996-2010. Alaska Department of Fish and Game, Juneau, Alaska.

Shields, A., 1936. Anwendung der Ähnlichkeitsmechanik auf die Geschiebebewegung: Berlin, Preussische Versuchanstalt für Wasserbau und Schiffbau, Mitteilungen, no. 26, 25p.

Shuler, S.W., R.B Nehring. 1994. Using the physical habitat simulation model to evaluate a stream habitat enhancement project. Rivers 4:175-193p.

Tryck, Nyman & Hayes et al., March 1986. Suspected Uncontrolled Hazardous Waste Site Inspections, State of Alaska, Alaska Gold Sites-AKDO38526620.

USKH Inc. (USKH), 2009. Final Hydraulics and Hydrology Report – Snake River Bridge Replacement Project, Nome Alaska.

USKH Inc. (USKH), November 2009. Nome Airport Phase I Environmental Due Diligence Audit.

Vanoni, V.A., ed., 1975. Sedimentation Engineering: American Society of Civil Engineers, Manuals and Reports on Engineering Practice, No. 54, 745p.

Yalin, M.S., 1977. Mechanics of Sediment Transport, 2nd Edition: Oxford, U.K., Pergamon, 298p.

Wang, S., E. J. Langendoen, and F. D. Shields, Jr. Proceedings of the conference on management of landscapes disturbed by channel incision.

Whitman, R.P., T.P. Quinn, and E.L. Brannon, 1982. Influence of Suspended Volcanic Ash on Homing Behavior of Adult Chinook Salmon. Transactions of the American Fisheries Society, 111:63 69.

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Appendix A

Nome Airport Master Plan Update Public Meetings Summaries

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NOME AIRPORT RUNWAY SAFETY AREA EXPANSION - PUBLIC OPEN HOUSE #1

September 17, 2009

4:00 P.M. – 8:00 P.M

Old Saint Joseph's Church, Nome, AK

Meeting Summary:

The first Public Open House meeting covered both the Nome Airport Master Plan project and the Runway Safety Area Expansion project. DOT&PF representatives in attendance were Cindie Little, Ethan Birkholz, RJ Stumpf, and Ivet Hall. Brooks and Associates was represented by Anne Brooks. Project presentations were made at 4:30pm and 6:30pm. The Master Plan project was introduced and discussed by Royce Conlon, of PDC. Patrick Cotter of PDC was also in attendance. The RSA Expansion project was presented by Hans Arnett and Sara Lindberg, with Cindy Anderson in attendance. After the presentations, questions were answered in a group format. As time permitted, DOT&PF and project representatives discussed the projects and answered questions individually. Meeting attendees are identified on the attached sign-in sheets.

Hans Arnett with USKH kicked off the Runway Safety Area Expansion portion of the meeting with the following comments:

- USKH has past experience with the successful relocation of fish streams to accommodate expansion of airports in Alaska. We have also successfully addressed environmental and regulatory issues associated fish stream relocation.
- One of our goals is to design a new river channel that looks and functions like a natural channel.
- One of the biggest issues facing the Nome Airport project and the relocation of the Snake River is the impact on the local population, since the river runs through town.
- An important part of the meeting this evening is to find out what concerns the residents of Nome have regarding the proposed river relocation options, and to gather special information from local residents that non-residents, like ourselves, do not have access to.
- The two proposed alignments have common starting points but vary considerably. The New River Mouth option is shorter and would presumably be less expensive, but access to the west near the mouth would be necessary, possibly meaning a bridge is needed. This option would reduce the flow at the existing mouth, but there would still be flow contributed by Center Creek and Dry Creek to the lower river. The second option involves a much longer route that reconnects to the lower river.
- Some of the issues associated with constructing a new mouth are known, including:
    - Need to provide access to the west for mining and other uses.
    - The location of a new mouth will change through time, unless special efforts are taken to stabilize it.
    - Effects on adjacent landowners, such as NovaGold.

  - Changes at the Port of Nome and the small boat harbor. Less water flow means less dilution of existing contamination. Breakup of the harbor might occur later.
  - What further issues do the people of Nome foresee?
- Some of these issues can be overcome by the second option, which reconnects to the lower river. However, this raises some different issues:
  - There may be more land ownership issues.
  - There is still a disruption of access, but to a lesser degree
  - Contaminated soils will be a much bigger issue in this option.
  - Because it is longer, this option is probably more expensive.
- Both options will require construction in permafrost.
- These two alignments are very preliminary and will change as design and study efforts proceed. It is very important that the thoughts and ideas of the public are taken into consideration, because that information will help the design to move forward.
- Please use the comment sheets to make any concerns known.
  - Will this affect your subsistence use of the area?
  - Will it affect your access to property or recreational areas?
  - Do you use the port? What issues are you concerned about?

Sara Lindberg with USKH continued with some of the following points:

- We want to talk to you about the Environmental Review Process for the Runway Safety Area Expansion Project.
- The end result of an Environmental Review is a decision document that analyzes the impacts of multiple alternatives.
- The goal of the process is to determine a preferred alternative for the expansion. The potential Snake River relocation is just one potential alternative, though we know that any expansion will likely require relocation of the river.
- We are currently early in the process in the information gathering stage. We will talk to various agencies and complete field studies regarding wetlands, fish habitats, contamination, subsistence issues, and so on.
- All of this is why these meetings and public input are so important. We get input from the locals about the resources of the area. You, the locals, are the experts. Please tell us what you think.

Questions regarding the Runway Safety Area Expansion included:

- Why is the expansion so large?
  - *Answer:* We do not want to have to move the Snake River again, so we are taking into account the longest probable runway and safety area expansion. The 10,000 foot runway is based for large aircraft use in the future, such as cargo planes. Smaller planes can also use this size of runway.
- What about building a bridge instead of relocating the river?
  - *Answer:* The cost of a runway bridge is prohibitive, and we do not yet know the costs for the river move.

- How about military involvement in the construction of the river relocation? C6? National Defense?
  - *Answer*: The military will be brought into the project for input.
- Why not expand the Crosswind runway to the north, instead?
  - *Answer:* There are hazardous waste sites which would cost too much money for the DOT to acquire the land and clean up.
- Why move the river instead of using an Engineered Material Arresting System (EMAS)?
  - *Answer:* With 600 feet of overrun required, the river would still need to be moved. Cordova is currently a test site to see how the EMAS will work. It is currently untested in the Arctic and expensive.
- How does the Nome runway length compare to Bethel and Kotzebue?
  - *Answer:* Each airport was looked at individually. Nome needs to look at the long term. The State of Alaska wants the airport to live and grow.
- How soon would construction start?
  - *Answer:* The river move and the environmental process is lengthy, perhaps as much as 2 years. The FAA has a goal of being built by 2015. It will take about 2 years to build and will go to bid by 2012. The rest of the master plan implementation will be from 0-5 years, 5-10 years, 10-20 years, and hopefully funded within the timeframe.
- The runway is 12 feet above sea level and one of the lowest in the nation. Within 25 years the runway will be inundated. What about relocation? What about floodproofing?
  - *Answer:* Relocation has been looked at. It's very expensive to relocate an airport. The river has been relocated before. After WWII the western end of the runway was moved, and the river was relocated.

General comments regarding the airport and Snake River relocation included:

- The DOT is talking about building a road to Nome. Has this been factored in as an alternative access method?
- The runway flooded two times in the last five years.
- Need to come flying in from the other way. Winter needs ILS on the other end.
- Get runway approaches away from the city. The way that it is now there are too many airspace obstructions. ILS is ¾ of a mile.
- The DOT put in a parallel runway in Bethel.
- Move runway upland. Build two parallel runways big enough for 737-400.
- Why not extend Crosswind to the north? Won't need to dredge, just to fill.
- How about a runway extension with fill and culverts?
- The runway is too low, down in a hole. What are we going to do about visibility, flooding, and getting to a higher altitude?
- There are issues with ILS.
- What about a parallel runway? Leave the airport alone and build a parallel runway up above the crosswind for the big jets.

- We would need parallel taxiways if the runway is that long.
- If the river is moved, the current turning basin in town would be a horrible eyesore and unsanitary.
- We just put $20 million into the port…why move the river away?
- We would need to keep water flowing through the harbor.
- The crab cannery would have to move the pipeline. The fish plant would be required to build a pipeline 2000 feet out. It would affect the business and fisheries in Nome.
- Moving river away will not eliminate the need for dredging—it will still need to be dredged.
- This would affect commercial fishing.
- Add the military to the agency contact list.
- Create recreational opportunities near dredge pond.
- All alternatives should be looked at.
- The harbor has raw sewage. If we abandon it, what will happen with contamination?
- If the mouth is re-routed, we need to re-route the port. There is raw sewage in port, and we'd need to fill in the port to prevent it from getting toxic.
- There are tanks at the port that leak, and the water flushes it out.
- The longer route may not be contaminated; ponds aren't red to show acid leech.
- Recreation is huge along that portion of the Snake River.
- Will it disturb the harbor?
- Will it dilute the harbor?
- Fish can't make an instant transfer from fresh to salt. There's no estuary. They need a zone where they can acclimate. Chums are the least able to make that transition.
- Lower option (on the map) is mostly already thawed ground.
- Changes in the port would lower property value.
- The river is the main winter trail out of town for mushers and snow machines.
- There is lots of boat use in the Snake River. If the mouth is changed, kids wouldn't be able to go to the harbor to fish.
- Can't take the harbor away! It's the fishing hole.
- Fog and flooding is already a problem with the airport.
- Walrus hunters use the port to launch their boats.
- The bluff has been eaten out by storms. If we go for the new mouth option, the road would have to be built away from the bluff.
- Include the Coast Guard in the contact list.

Written comments regarding the Runway Safety Area Expansion Included:

- What is the history of the Snake River before the runway?
- How many Nome frost heaves? What is/was the cause? Is it solved? [sic]
- Blowing snow conditions and flooding.
- Longer route has contamination issues if there is construction through dredged soils.

- If the Snake River is relocated, how does this affect land ownership?
- Permafrost issue is unknown. Never dealt with before.
- Why does runway airstrip need to be doubled?
- Coastal longshore transport at river mouth—what's the effect on land holders and transportation west of the mouth?
- Without the river push, is the ice movement going to be less?
- River may help reduce contamination in port by flushing it out.
- Cheaper should not be the deciding factor. If it is, then don't do anything.
- Will this mean less dredging?
- Saltwater intrusion into the Snake River stops at the Bering Air property.
- Use the river relocation to make ponds and new housing lots.
- Need a bridge for beach access.
- Map area marked for removal of land for sight distance.
- For lower river, 40 to 50 foot depth needed.
- Remove tundra from the lake and make it a 60 foot depth; use excavated land near dredge pond.
- The "sharpie" map looks at many options and not focused on one.
- Dredge pool on map is 80 feet deep.

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PUBLIC MEETING SIGN IN SHEET
September 17, 2009, 4-8:00 p.m.
Old Saint Joseph's Church, Nome, Alaska

What projects do you want to continue to receive updates and notices for? Check the box or boxes below	NAME (PLEASE PRINT)	MAILING ADDRESS/E-MAIL ADDRESS (to receive project notices, you MUST provide this information)	PHONE	This information is voluntary. *GENDER (M/F)	*RACE (W, AN, N, B, H, A, P, O)
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☒ Both	Anne Brooks	a.brooks@brooks-alaska.com	272-1877	F	W
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☒ Both	Charlie Weiss	Box 415 Nome, AK 99762	443-2108	m	w
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	[illegible]	Box 1716 Nome AK 99762	443-5508	F	
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Charlie Lean	Box 1716	443 5508	m	w
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Jay Wieler	Box 27 Nome	443-6329	M	AN
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Jim Dory	Box 333	443 6604	m	w
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both					

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☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☑ Both	Anthony C. Persaud	POB 1713 Nome, AK 99762 persous@nome.net	907 443-2364	M	W
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☑ Both	Tyler Rhodes	Po Box 610 Nome, AK 99762 tyler@nomenugget.com	443-5235		
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☑ Both	Laura Lawrence	Po Box 1573 Nome AK 99762 degnanl@hotmail.com	443-2399		
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Tim Smith	Box 747 Nome, AK 99762	443-5352	M	
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☑ Both	Sue Steinacher	PO Box 1609 Nome, AK 99762 suesteinacher@hotmail.com	443-7673	F	W
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☑ Both	John Handeland	PO Box 295 Nome, AK 99762 johnh@nome.net	443-6587	M	W
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☑ Both	Suzanne Greenly	Box 929 Nome sue.greenly@alaska.com	443-2423		

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☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☑ Both	Lloyd Ferrigo PO Box 1678 Nome Ak 99762		907 443-5322	M	W
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☑ Both	Robert W Madden	P.O Box 1048	907-443 2500	M	W
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Joanne Keith Corona del Mar, CA 92625			F	W
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Carl Emmons	783 Nome AK	443 2645		
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Joel Crats	PO 1351 Nome, AK	443-5946	M	An
☑ Nome Airport Master Plan Update ☑ Runway Safety Area Expansion ☐ Both	John Francis	po. 1847, Nome Ak kromnews@gmail.com	443 5221	M	W
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both					

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☑ Nome Airport Master Plan Update ☑ Runway Safety Area Expansion ☐ Both	Troy A. Walker	trex_eu103@yahoo.com			
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☒ Both	Denise Michels	mayor@ci.nome.ak.us	443-6600	F	AN
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☒ Both	Dane A. Robinson	Dane.Robinson@dns.gov	443-2143	M	O
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Ethan Birkhole	Ethan.Birkholz@alaska.gov	451-2381	M	O
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☒ Both	Scott Rauk	Box 666 Nome	443-2902	M	W
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Richley Abbott	PO Box 81 Nome	304 1665	M	W
☒ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Joy Baker	POB 281 Nome. Port of Nome	304-1905	F	W

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☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☒ Both	LAURA SAMUELSON	BOX 300, NOME VAPORTRAIL@GCI.NET	443-5597		
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	LARRY EGGART	Box 1641 Nome AK ldEggart@nome.net	4433056		
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	VICTOR L. OSER	P.O. Box 1924 NOME AK 99762 vic@nome.net	443-2102		
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Dan Bergstrom	333 Raspberry Rd Anchorage, AK 99518			
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both					
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both					
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both					

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☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☒ Both	Joel K. Alowa	Nome Eskimo Community POB 1090 Nome, AK 99762 joelalowa@gci.net	9074439129		
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☒ Both	Mike Quinn	Box 37 Nome mhq@gci.net	443-5926	M	
☐ Nome Airport Master Plan Update ☒ Runway Safety Area Expansion ☐ Both	DAVID BARRON	Box 1125 Nome AK 99762 Grumpy1224@hotmail.com		M	
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Mike WADE	P.O. Box 1623 Nome, AK 99762 Betsmike@nome.net	443-5470	M	
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☒ Both	Gary Samuelson	PO Box 300 Nome, AK. 99762	443-5597	M	
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both	Tony Gorn	Box 1488 Nome, AK 99762	443-7708	M	
☐ Nome Airport Master Plan Update ☐ Runway Safety Area Expansion ☐ Both					

Nome Airport Facts*

The average number of aircraft operations per day: 77. Breakdown of aircraft based on the field:

- Single engine planes: 51
- Multi-engine planes: 12
- Helicopters: 5
- Military aircraft: 3

* for 12-month period ending Nov. 1, 2008
Source: www.airnav.com

We need your input!

We want to hear your concerns, suggestions and ideas for updating the Nome Airport Master Plan and expanding the runway safety areas. Here are several ways to provide your input:

- *Come to the September 17, 2009, open house on this important project*
- *Send us your comments by telephone, mail, e-mail or fax (contact information below)*
- *Visit the web site **www.nomeairport.com** to complete our online survey or send us your comments.*

For more information or to comment on the Nome Airport Master Plan Update, contact:

Brooks & Associates
Anne Brooks, P.E., Public Involvement Specialist
301 W. Northern Lights Blvd, Suite 440
Anchorage, AK 99503
Toll-free telephone: 1-866-535-1877
E-mail: mycomments@brooks-alaska.com

The DOT&PF project manager for both projects is R.J. Stumpf, P.E., so the projects are well-coordinated.

Alaska Department of Transportation and Public Facilities
R.J. Stumpf, P.E., Project Manager
Telephone: 1-907-451-2285
E-mail: rj.stumpf@alaska.gov

Persons with hearing impairment can contact Relay Alaska at their Telephone Device for the Deaf (TDD/TTY) number, 800-770-8973 and they will assist in contacting the project team. We are able to offer, upon request, reasonable accommodations for special needs related to other disabilities.

www.nomeairport.com

Brooks & Associates
301 W. Northern Lights Blvd, Suite 440
Anchorage, AK 99503

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Permit #537

Nome Airport
Master Plan Update

You are invited to our Project Open House!
Thursday, September 17th

VICTOR L OLSEN
PO BOX 1924
NOME AK 99762-1924

HISTORY OF SNAKE RIVER BEFORE RUNWAY
HOW MANY NOME FROST HEAVE
HOW MUCH TO REROUTE SNAKE?
WHAT IS/WAS CAUSE
IS IT SOLVED?
SNOW CONDITIONS
BLOWING
FLOODING
NOME AIRPORT.COM

Nome Airport
Master Plan Update

Comment Sheet

Please review the following map of the Nome Airport. What can you tell us about your community and the greater Nome area that will help us to better plan improvements to the Nome Airport?

Q)

My comment is: Subsistance usage/flow of the river mouth for tomcod lincod, salmon, etc. Problems with dredge pond flow of river for land problems of subsistence. Had concerns of area availability of the wind turbine renewable energy placement for future electricity possibilities. Most of the river that I use is near the Terminal(s) for subsistence yet the amount of natural environment might be a problem for livestock. Port usage/waste would be wasted with New River option with future navigatable Artic Ocean use. So, concern, stay close to town with current, current historically used from Natives unknown 100+ years ago.

Provide the team an email address or telephone number if you want them to contact you about your comment:

Email: trex-ed03@yahoo.com

Telephone Number: 387-1496

More space is available on the back of this page. You may return this comment to the project at the meeting or fold and mail to the address on the other side of the page.

Comment continued...

Fold along dotted lines, tape edges and mail. Don't forget a stamp.

Thanks for providing comments on the Nome Airport Master Plan Update.

Place
stamp
here

Anne Brooks
Brooks & Associates
301 West Northern Lights Blvd,
Suite 440
Anchorage, AK 99503

Longer route - contamination issues cutting through dredged soils
land ownership

Bridge across the river
(Las Vegas option)

Nome Airport Runway Safety Area Expansion Project Comment Sheet

20 year forecast - 7500' @ both w/ 1,000 safety each end.

What can you tell us about the project area shown below that will help us study the issues and evaluate alternative options for the Nome Airport Runway Safety Area Expansion Project? *Feel free to draw on the map or write on the page margins or describe on the back of this form.*

600' overrun for larger

Without river push - ice movement less?
Less dredging.
River may help reduce contamination in port - flushing.

Cheaper should not be the deciding factor. If it's then don't do anything.

Permafrost issue unknown - never dealt with before

Sarah Liver environmental analysis done USKH in contract to DOT

Why does airstrip need to be doubled?

Cordova has EMAS system

Coastal longshore transport at new mouth - effect on land holders - transportation west

FBK 12,000' Based on future cargo

Comments

Please provide the team an email address or telephone number if you want them to contact you about your comment:

Email: ____________________

Telephone Number: ____________________

Thanks for providing comments on the Nome Airport RSA Expansion Project!

Fold along dotted lines and mail. Don't forget a stamp!

Place stamp here

Sara Lindberg
USKH Inc.
544 4th Avenue, Suite 102
Fairbanks, AK 99701-4714

Nome Airport Runway Safety Area Expansion Project Comment Sheet

What can you tell us about the project area shown below that will help us study the issues and evaluate alternative options for the Nome Airport Runway Safety Area Expansion Project? *Feel free to draw on the map or write on the page margins or describe on the back of this form.*

Comments

Richley Abbott
P.O. Box 81
Nome AK 99762

Please provide the team an email address or telephone number if you want them to contact you about your comment:

Email:

Telephone Number: 907 304-1665

Las Vegas 702 656-0360

Thanks for providing comments on the Nome Airport RSA Expansion Project!

Fold along dotted lines and mail. Don't forget a stamp!

Place stamp here

Sara Lindberg
USKH Inc.
544 4th Avenue, Suite 102
Fairbanks, AK 99701-4714

Nome Airport Runway Safety Area Expansion Project Comment Sheet

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Comments

Please provide the team an email address or telephone number if you want them to contact you about your comment:

Email: ______________________________

Telephone Number: ______________________________

Thanks for providing comments on the Nome Airport RSA Expansion Project!

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Place stamp here

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Fairbanks, AK 99701-4714

Nome Airport Runway Safety Area Expansion Project Comment Sheet

What can you tell us about the project area shown below that will help us study the issues and evaluate alternative options for the Nome Airport Runway Safety Area Expansion Project? *Feel free to draw on the map or write on the page margins or describe on the back of this form.*

Comments

John Hopkins – miner in
AK Gold Area

Nicoli – AK Gold – Home
has a #

Nova Gold bought AK Gold.

Please provide the team an email address or telephone number if you want them to contact you about your comment:

Email: ______________________________

Telephone Number: ______________________________

Thanks for providing comments on the Nome Airport RSA Expansion Project!

Fold along dotted lines and mail. Don't forget a stamp!

Place stamp here

Sara Lindberg
USKH Inc.
544 4th Avenue, Suite 102
Fairbanks, AK 99701-4714

Nome Airport Runway Safety Area Expansion Project Comment Sheet

What can you tell us about the project area shown below that will help us study the issues and evaluate alternative options for the Nome Airport Runway Safety Area Expansion Project? *Feel free to draw on the map or write on the page margins or describe on the back of this form.*

Estuary?

Salmon need to acclimatize to salt water

Bering air stops @ inversion saltwater

Crab Processing Plant gravel outfall

Loss of River current = relocation of outfall 2000 ft offshore

Comments

Charles Lean
Box 1716
Nome Ak

Please provide the team an email address or telephone number if you want them to contact you about your comment:

Email: Charlie@NSEDC.Com

Telephone Number: 907 443 2477

Thanks for providing comments on the Nome Airport RSA Expansion Project!

Fold along dotted lines and mail. Don't forget a stamp!

Place stamp here

Sara Lindberg
USKH Inc.
544 4th Avenue, Suite 102
Fairbanks, AK 99701-4714

NOME AIRPORT RUNWAY SAFETY AREA EXPANSION - PUBLIC OPEN HOUSE #2

June 2, 2010

5:00 P.M. – 7:00 P.M.

Old Saint Joseph's Church, Nome, AK

Meeting Summary:

The second Public Open House meeting covered both the Nome Airport Master Plan project and the Runway Safety Area Expansion project. DOT&PF representatives in attendance were RJ Stumpf, Janet Brown, Jeff Roach, and Ivet Hall. The FAA was represented by Pat Oien, Matt Freeman, and Bruce Greenwood. USKH Inc. was represented by Sara Lindberg, Hans Arnett, and Cindy Anderson. Royce Conlon and Patrick Cotter represented PDC Engineers, and Anne Brooks represented Brooks & Associates. Project presentations were made at 5:30 p.m.

RJ Stumpf, DOT&PF Project Manager, welcomed the public and thanked them for attending the second public meeting. He then introduced his staff, both project teams, and the FAA staff. He provided background on the importance of planning for the future and the current need to improve the Runway Safety Areas (RSA). He introduced PDC Project engineer Patrick Cotter for the first presentation on the Master Plan. The RSA Expansion project and potential Snake River Relocation Options were presented by Hans Arnett. Cindy Anderson of USKH spoke about the ongoing NEPA process for the project. Sara Lindberg of USKH was also in attendance. After the presentations, questions were answered in a group format. As time permitted, DOT&PF and project representatives discussed the projects and answered questions individually. Meeting attendees are identified on the attached sign-in sheets.

Hans Arnett, USKH Hydrologist, presented an overview of the Snake River Relocation portion of the Runway Safety Area Expansion project:

- In 1942, the airport was built on dredge tailings that date back to mining done in the 1930s. Because of the mining activities, the 1942 photo probably displays at least the second major relocation of the river.
- By 1950, the crosswind runway was extended to essentially its present location. The river was moved further south in a very narrow channel, and a lake present to the south of the southern end of the runway had been filled.
- In 1962, dredge mining was occurring in the river to the west of the airport, resulting in minor modifications to the Snake River channel.
- By 1986, the Snake River was in essentially the same configuration as it is today, with the exception of the river mouth. Dredge mining had moved up onto the hillside to the south and away from the river by that point. Also notable in the 1986 photography is that the westernmost of the two breakwaters that currently protect the port had been constructed.
- The last big change on the Snake River has been the construction of the new river mouth as part of the improvements at the port. Construction of the new mouth was completed in 2005.

- Last fall and early winter, two river relocation options were developed for achieving full safety area compliance. Both options were developed to accommodate:
  - Expansion of the main runway to 10,000 feet, with a full 500-foot wide safety area extending 1,000 feet beyond each threshold;
  - Construction of a parallel taxiway on the south side of the main runway, running the full length of the expanded runway; and
  - Expansion of the crosswind runway safety areas to a full 500-foot width, extending 1,000 feet beyond each threshold.
- The first relocation option was called the Lower River Reconnection option and the other was called the New River Mouth option.
- All of the river relocation options have some features in common:
  - All involve excavation to produce a new river valley and floodplain;
  - All require additional excavation to build a new channel in the bottom of the new valley; and
  - Large volumes of excavation are produced and need to be disposed of. Therefore, disposal of excavated material is an important feature of all the relocation options.
- **Lower River Reconnection Option**
  - The key feature of this option is that it maintains hydraulic connectivity with the lower river.
  - The new valley and channel takes off at approximately River Mile 3.7, cuts due south to skirt the end of the proposed 10,000-foot runway, and then the river would meander gently within a relatively straight new valley, to rejoin the existing river channel just upstream of the south end of the crosswind runway.
  - To accommodate the expansion of the safety area of the crosswind runway, a new valley and channel would be routed into the mining pit pond and back out the other side to rejoin the existing channel.
  - This option would be more than 15,000 feet long and would generate almost 6 million cubic yards of excavation.
    - Most of this excavation would be placed in a disposal area, which would be surrounded by a protective berm, and would have a series of settling ponds to collect sediment from melt water coming out of the thawing permafrost.
    - A portion of the excavated material would be placed in the dewatered segment of the channel.
- **New River Mouth Option**
  - The key feature of this option is that it has a significantly shorter channel that leads to a new river mouth and estuary along the Norton Sound coast, about 2 ½ miles west of the current mouth. The channel of this option is about 6,400 feet long, which is about 9,000 feet shorter than the Lower River Reconnection Option.
  - This option takes off at the same spot as the Lower River Reconnection option at approximately River Mile 3.7, and then snakes to the south, taking advantage of lower

  elevation terrain before cutting through the high point of the ridge and taking a bend to form a new estuary near the coast.
  - Having a new river mouth would disrupt normal access along the beach, so this option includes a bridge with access roads on either side to maintain access.
  - Excavated material would be placed in a disposal area and in the dewatered channel.
  - Less excavation is generated with this option - only 3.7 million cubic yards compared to 5.9 million for the Lower River Reconnection Option.
  - Even though the New River Mouth option is much shorter and has significantly less excavation, it is also much steeper which produces hydraulic concerns about channel stability. The cost estimate therefore includes hydraulic control structures and channel lining to prevent the new channel from head-cutting back up into the natural river.
  - Once costs are added for channel lining and hydraulic control structures, and for the 400-foot-long bridge and access roads, the costs of the two options start to get closer together.
- Before costs were known and while the concept designs were still being developed, both designs were presented to a Multi-Agency Task Force in October 2009.
  - The group was formed of the DOT&PF, FAA, USKH design and environmental teams, and agencies including the Department of Fish and Game, Department of Environmental Conservation, the U.S. Army Corps of Engineers, U.S. Fish and Wildlife, and the National Marine Fisheries Service.
- The goal of the group was to form a consensus on design that would create a feasible and permittable Snake River relocation option.
- After the presentation, the Task Force went on a field visit to the project site, and then comments and discussions were documented.
- After all of this, the two concept designs were completed, and it was discovered that the costs of the two alternatives were similar and very high at more than $70 million for each.
- These costs are well outside the FAA funding limits for RSA expansion.
  - Money from that particular FAA funding source can only be directed toward addressing RSA issues, and the first two alternatives that were developed addressed lengthening the main runway to 10,000 feet and construction of a parallel taxiway.
  - To address the FAA funding limitations, a third, lower-cost river relocation option was developed. This third option is called Option 3.
- **Option 3**:
  - Addresses full expansion of the main runway safety area 1,000 feet to the west beyond Threshold 10;
  - Full safety area expansion of 1,000 feet to the east beyond Threshold 28 with the last 600 feet narrowed; and
  - Allowance for a future 1,500-foot expansion of the main runway to achieve an eventual total runway length of 7,500 feet, which is the length that the Master Planning process has determined is needed in the next 20 years at the airport.

- Option 3 does not require relocation around the southern end of the crosswind runway to address RSA needs.
- Option 3 takes off from the existing river at approximately River Mile 3.2 (half a mile further downstream than the earlier two options) and is routed through a 5,500-foot long new valley to a reconnection point just downstream of the west end of the main runway.
- There is less excavation required with this option (about 1.6 million cubic yards) and consequently, the disposal area is much smaller.
- The cost estimate for Option 3 is roughly $27 million.
- Geotechnical studies are currently underway. Test holes have been drilled over the past several weeks. The results of these studies will help the DOT&PF to decide whether Option 3 or the No-Build alternative is the preferred alternative for RSA expansion.
- Hazardous Materials studies are also underway, with field work scheduled for this summer. These studies are necessary because the alignment of the relocation goes through some previously mined areas where there are a lot of discarded barrels with questionable substances in them. This is all being coordinated with ADEC.

Cindy Anderson, USKH Environmental Analyst, continued with the following points regarding the NEPA process:

- The DOT&PF's and FAA's goal is to provide the most effective solution for achieving full safety area compliance and provide opportunities for lower approach minimums and greater accessibility to the Nome Airport. This public meeting is being held to help make the public part of the process.
- The end result of the environmental process for this project will be a NEPA document that analyzes the impact to the human environment, including natural resources such as water, fish, wildlife, subsistence, access, land use, and others. The decision document will likely be an Environmental Assessment.
- The goal of the NEPA document is to identify a preferred alternative for improving safety areas at the Nome Airport that finds a balance between community needs, economics, and environmental impacts.
- Currently, the process is at the data gathering stage. The environmental review process began in 2009 with a public meeting, informal agency consultation to discuss the Snake River relocation (MATF), and data gathering, which is ongoing.
- To date, preliminary hydrology and wetland studies have been completed. Cultural surveys, geotechnical studies, and hazardous materials studies are ongoing.
- More data will be gathered to analyze the impacts of the proposed action. This process will continue through this year.
- This meeting is being held today to gather public input. There will be additional opportunities for comment when the draft NEPA document is published. Public input is an important part of the process.
- Once the environmental document has been completed, it will go to the FAA for review.
- The anticipated timeline for this project is to have the environmental document completed in early 2011 and construction completed by 2015.

- Public comments help to guide the process. Comments received to date have expressed concerns about contaminated soils, property access, construction in permafrost, reductions in freshwater flow to the harbor, impacts to property values, and others. All of these comments are helpful in the design of practicable alternatives and the development of useful investigations to examine impacts.

Questions regarding the Runway Safety Area Expansion and the River Relocation Options included:

- *What about putting a bridge over the river that the runway would go over? Was that analyzed and cost-estimated?*
  - *Answer:* The bridge option had been reviewed, and the costs to build a bridge are prohibitive.
- *Does the cost of the relocation also include the cost of rerouting roads?*
  - *Answer*: Yes, these costs will be included when the costs are developed.
- *If river relocation doesn't work, where would the mitigation funding come from?*
  - *Answer:* A monitoring plan would be funded within the project. The project would also include an adaptive management plan.
- *The west end of the runway is sinking. Is it caused by the river?*
  - *Answer:* No. It is caused by the fact that the runway was built on old, unstable placer mining spoils.
- *Why would you do something twice? Why not just do it right now?*
  - *Answer:* Part of the reason is funding, and part of it is the Congressional mandate. We may not be able to do a full 7,500-foot runway now, but we'll do as much as we can with $25 million per runway. If a full RSA cannot be completed, a non-standard RSA can be completed. The RSA is required for the Boeing 400 series aircraft operating in and out of Nome. It will be improved to the extent practicable by 2015, which is necessary for the airport to continue receiving jets.
- *Alaska Airlines does not feel [the RSA] is an issue for their planes.*
  - *Response:* The length of the RSA is not the only factor, but location is a safety issue, too.
- *How is $200 million divvied up? Who decides? Is it a STIP process, like for roads?*
  - *Answer:* Projects are nominated for improvements and put before a project evaluation board called the APEB (Aviation Project Evaluation Board). They allocate funding based on 16 criteria used to score the projects. Cost is only one of the criteria. Then the decision is put before the FAA. They use the list to allocate the FAA funding and any discretionary funding that becomes available. The FAA is open to what the public wants, but it still needs to be a reasonable alternative. The process is approved by the State of Alaska.
- *How do we get nomination forms?*
  - *Answer:* These forms are available from the DOT&PF web site. You may also make nominations by contacting the airport manger or area planner.
- *It seems like there are two separate issues here. One is the RSA expansion, which the FAA needs to complete. The other is the Master Plan Update. Doesn't the RSA drive the direction of the 20-*

year plan? It seems like you should move the East-West runway to the north and accommodate the needed runway safety area on the new runway.
  - *Answer:* While this is how it looks on the surface, the FAA's mandate is to complete RSA expansions by 2015. Thirty airports are finished so far, which is about half of the number that need RSA expansions. Money is available now for the RSA expansion, but not for runway relocation. The FAA works with DOT&PF to accommodate the RSA expansions to the best extent possible. Sometimes it is not possible to create a full RSA, but any improvement that makes the runway safer for the traveling public is the goal of the program.
- *What if the RSA is constructed as drawn? Would that drive the Master Plan process?*
  - *Answer:* The 20-year plan includes a much broader level of improvements. RSA improvements are mandated by Congress. What we are reviewing now are RSA projects to be completed within the next 5 years.
- *If you re-route the Snake River, wouldn't that eliminate some of the Master Plan projects?*
  - *Answer:* There would be some projects eliminated, yes. If we spend more money now, there would be additional benefits when you look 20 years into the future and beyond.

General comments regarding the Runway Safety Area expansion and potential Snake River relocation options included:

- Thanks for not moving the river.
- I'm concerned with the flow decrease, siltation, and the sloughing in of the sides of the valley.
- When we look at options including a new east-west runway, it puts it out of the market for RSA improvement grant money.
- The Master Plan should take place after the RSA project.
- RSA improvements are to the extent practicable. No-Build is a valid option.
- How much consideration is given to the size and growth of the city? For example, with the new hospital… it seems that the money spent on extending the runway could be spent on relocating the runway to the north, giving Nome area to expand. Look at Merrill Field in Anchorage—it has nowhere to go.
- People [project designers] don't live here, and don't realize that [residents] get stuck in Anchorage during airport construction.
- The smaller river relocation would not account for expansion beyond the 20-year mark.
- Don't put money into the existing runway. It's not a good investment. Spend the money going north.
- The west end of the runway gets torn up every five years. If you extend the runway over the river channel, you will continue to have problems with settlement and increase the cost of maintenance.
- Moving the river won't solve existing problems. We will continue to have problems with settling by constructing over [mined areas]. It would be better to move the runway north.

- The west end of the east-west runway continues to sink and would continue even if the Snake River is relocated.
- New floodplain laws will require the runways to go above the floodplain.
- The No-Build alternative has never been selected for an RSA expansion project in Alaska.
- We need to look at other considerations. We need to relocate.
- It seems like we should spend State and FAA money working towards a goal of moving the airport. Spend the money in the right direction.
- The current location has issues like sinking, fog, and obstructions. We should look at relocating.
- It sounds like the runway is unsafe and the directive to improve it within 5 years as long as it doesn't cost too much. The project seems to have an arbitrary spending cap. It's better to identify the best solution and go back to congress and get more money.
- Moving the runway north is the best solution.
- Making the runway longer doesn't necessarily make it better for Nome.
- The FAA's total fund for Alaska for 2008 was $200 million, total. Nome is one of 200 airports in Alaska. The money has to go a long way. But do we spend all the money in Nome and forget about other communities?

Written comments regarding the Runway Safety Area Expansion and the Snake River Relocation Options included:

- Plan looks good.
- This and the bottom one are better than your original ideas—less impact on the river, and us [referencing Shifted Primary, Shifted Crosswind, New GA and New Primary Shifted Crosswind, respectively]. Cons: Moves river. The river has been messed with enough - mouth moved a few years ago, channel by primary must have been modified in the past. This is still a living river—we fish and boat there. People camp upriver.
- [Referencing New Primary and Shifted Crosswind] Preferred. If you are going to skew the Primary a bit, why not the other way, starting near the present runway. Pros: Doesn't move river. Cons: New primary far from terminals.
- [Referencing Shifted Primary & Realigned Crosswind] Pros: Stays off road. Cons: Moves river.

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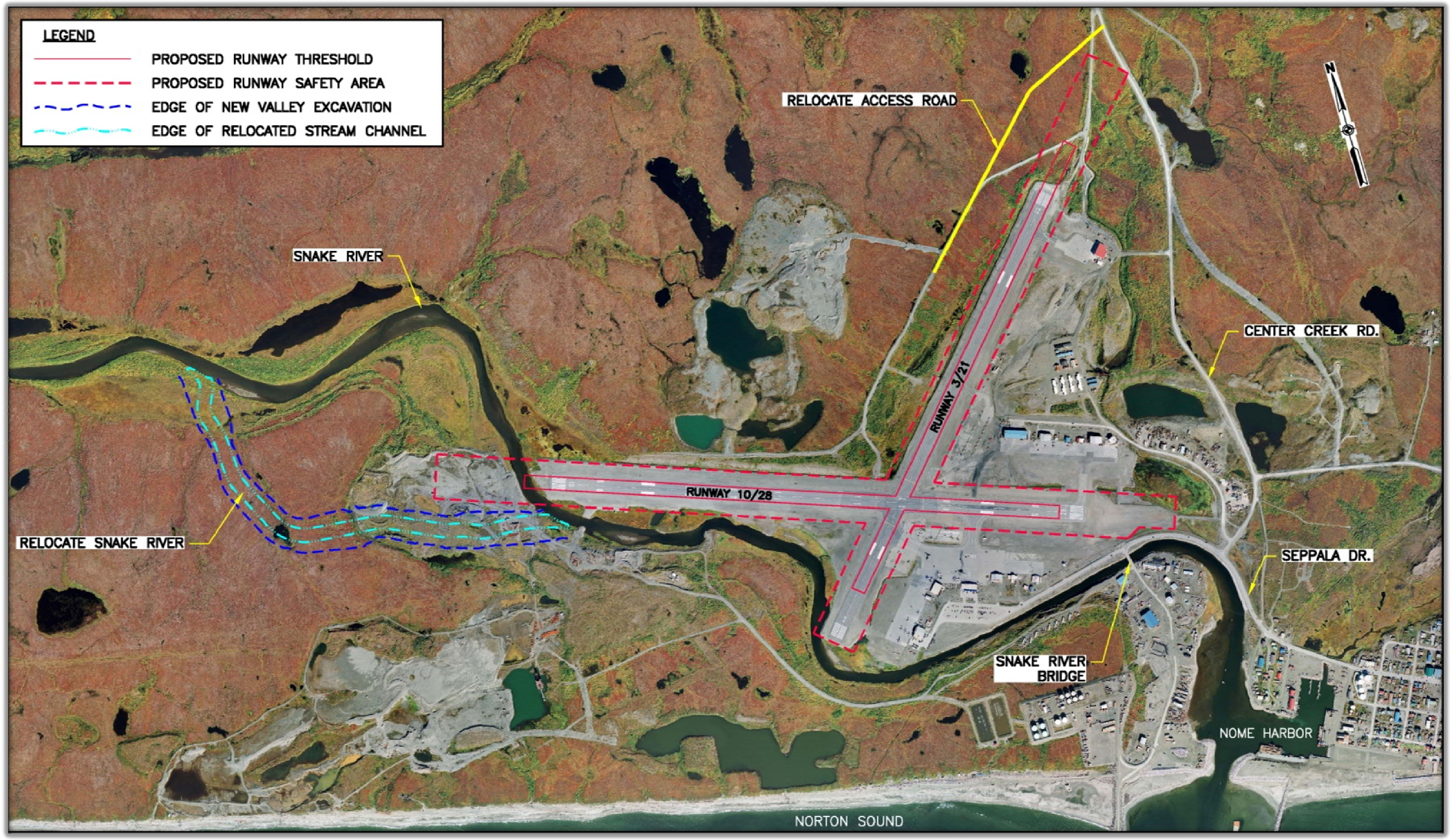
Nome Airport Runway Safety Area Expansion Project – Public Meeting Comment Sheet



Comments :

Please provide the team an email address or telephone number if you want them to contact you about your comment:

Name: ______________________ Email: ______________________ Telephone Number: ______________________

Appendix B

Final Snake River Relocation Site Visit Memo

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NOME HYDROLOGY STUDY

SNAKE RIVER RELOCATION

SITE VISIT MEMO

Nome, Alaska

December 2009

Prepared for:
Alaska Department of Transportation and Public Facilities
Northern Region

Prepared by:
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USKH WO# 1182800

TABLE OF CONTENTS

INTRODUCTION

The following memorandum documents observations and recommendations resulting from site visits performed in September and October 2009 in Nome, Alaska. The site visits were conducted in support of the Northern Region Hydrology Studies, Nome, Alaska - Snake River Relocation project for the Alaska Department of Transportation and Public Facilities, Northern Region (DOT&PF). The purpose of the site visits was to gather information supporting the development of options for the relocation of the Snake River to accommodate expansions of the existing runway safety areas at the Nome Airport.

The memorandum is organized into three primary sections. The first section provides an overview of the site visits, including the timing of the visits, participants, and the activities performed. The second section documents observations made in the field, and the third section presents a summary of key issues and recommendations regarding future design and analysis efforts on the project.

Two options are being considered for the Snake River relocation. One option relocates the Snake River within a new stream valley oriented roughly north-south to a new river mouth along the Norton Sound coast (the New River Mouth Option). The second option relocates the river to the south in an alignment that roughly parallels its existing course, and reconnects to the lower river downstream of the south end of the crosswind runway (the Lower River Reconnection Option). Both relocation options take off from the existing river upstream of the maximum projected expansion of the main runway and safety areas. The Lower River Reconnection Option is routed to the south of the longest practicable southward extension of the crosswind runway, which may require routing the relocated river through a mining pit currently filled with water (informally called the mining pit pond). The existing Nome Airport and Snake River, and the approximate alignments of the two relocation options, are shown on the attached aerial photo map (Figure 1) and topographic map (Figure 2).

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0 1000 1500 2000

Scale In Feet

USKH
SHARED VISION. UNIFIED APPROACH.

NOME AIRPORT
SNAKE RIVER RELOCATION
SITE VISIT MEMO
AERIAL PHOTO MAP

OCT. 2009

FIGURE
1

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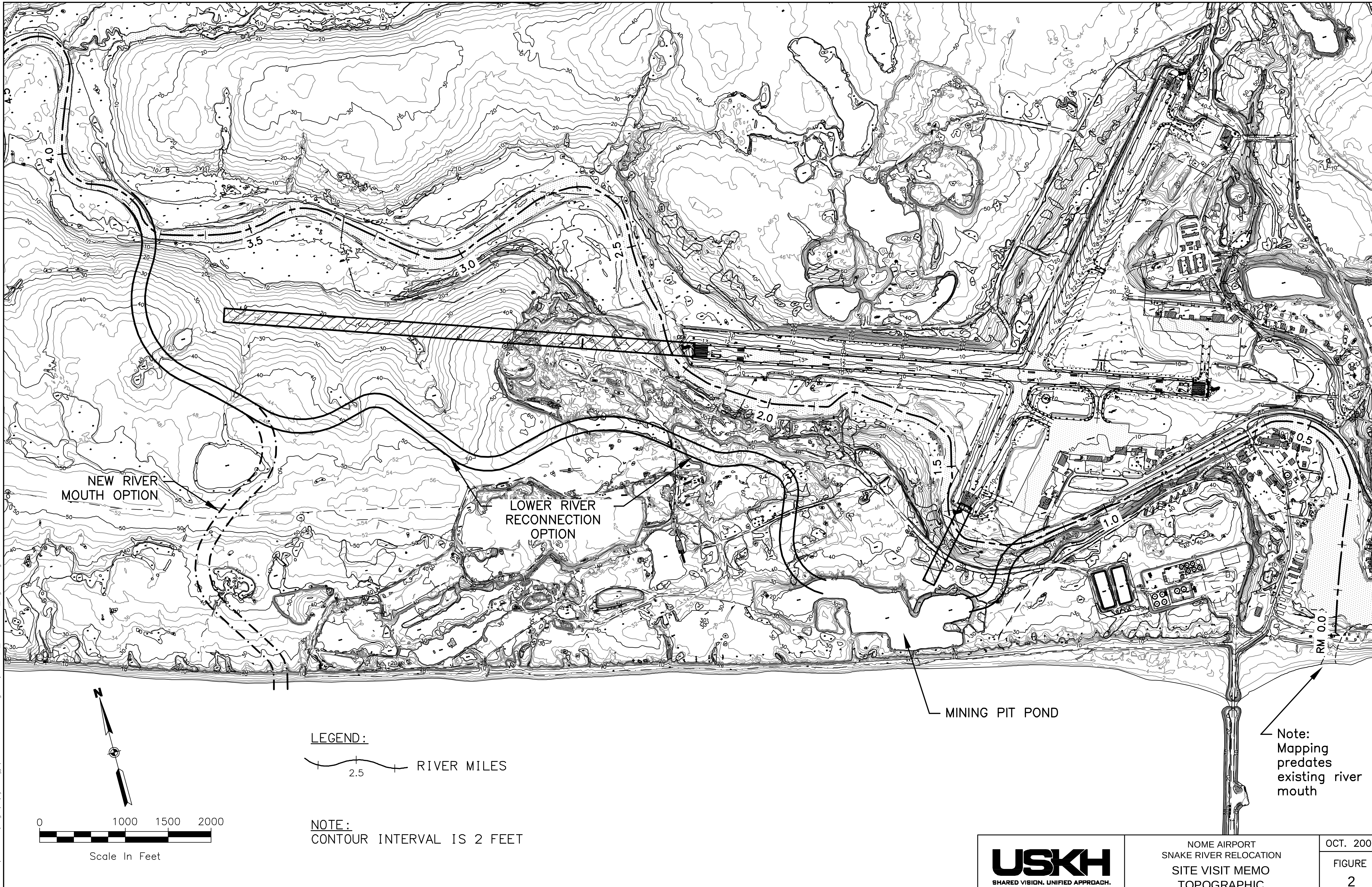

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1 SITE VISIT SCHEDULE, PARTICIPANTS, AND ACTIVITIES

Four site visits were performed for the project. The first site visit occurred during the period of September 18-20, 2009. Attendees included USKH Inc. (USKH) representatives Hans Arnett (hydrologist and project lead), Mary O'Hara (water resources engineer; on site on September 18 only), Mary Jo Monahan (environmental analyst and hazardous waste specialist), and Sara Lindberg (environmental analyst, wetlands specialist, and project environmental lead). Also in attendance were Cherry Creek Environmental representative Shane Cherry (stream geomorphologist), and Hart Crowser/Pentec Environmental representative Jon Houghton (marine and aquatic biologist).

The team, headed by USKH, participated in a brief meeting at the hotel to prioritize and plan the specific steps in the site reconnaissance. Following that meeting, two groups were formed. Group one included Hans Arnett, Mary O'Hara, Shane Cherry, and Jon Houghton. The first action of this group was to secure a boat and boat pilot to make a reconnaissance of the Snake River from the harbor up to approximately River Mile (RM) 6.0 (approximately 2 miles upstream of the proposed diversion point of the two river relocation options) at the site of a fish weir managed by the Norton Sound Economic Development Corporation (NSEDC). Si Larson, a Nome resident and biologist with the NSEDC, piloted the boat. On the return trip, Shane Cherry and Jon Houghton exited the boat at the proposed river relocation diversion point and walked the approximate alignment of the New River Mouth option to Norton Sound, and then walked along the shoreline back to Nome.

On Saturday, September 19, Shane Cherry and Hans Arnett traveled the length of the study reach of the Snake River, beginning at the harbor mouth and extending upstream of the proposed stream relocation diversion point. The purpose of this effort was to identify the location of channel cross-sections to be surveyed for use in hydraulic modeling and in measuring and characterizing cross-section and floodplain morphology. A hand-held Global Positioning System device was used to locate the right (with respect to an observer facing downstream) endpoint of each cross-section, and the approximate location and extent of each cross-section was marked on a field map to provide data and graphic illustration to the survey crew. Cross-sections were selected based on field observations and use of aerial photographs and maps in accordance with the following criteria:

- Identify and represent hydraulic control points including bridges, narrow channel locations, and other constrictions in channel flow capacity including mid-channel sediment bars, and roadway or runway embankments.
- Locate cross-sections to characterize notable transitions in channel shape (width, depth, and extent of floodplain).
- Identify and characterize changes in channel gradient that would affect flow capacity.
- Observe changes in hydraulic roughness in both the riverbed and floodplain, and locate cross-sections to represent those changes in roughness in the hydraulic model.
- Ensure that the collective set of channel cross-sections is adequate to represent the variability in geomorphic character of the river channel and floodplain present in the study area.

No physical measurements of the channel cross-section or slope were made. Instead, the quantitative data collected during the topographic survey (performed in October) will be relied upon during design. Further reconnaissance on foot was conducted upstream of the main runway end, which allowed for close observation of channel conditions. Additional observations of channel and floodplain features during the cross-section selection effort were made. After completing the cross-section selection effort, Hans Arnett and Shane Cherry walked the approximate alignment of the Lower River Reconnection option. During the course of the cross-section selection effort by Hans and Shane, Jon Houghton made detailed observations of aquatic habitats present along and within the Snake River from the river mouth (RM 0) to approximately RM 2.5, upstream of the western end of the main runway (river miles are shown in Figure 2). On Sunday, September 20, Hans Arnett, Shane Cherry, and Jon Houghton walked the perimeter of the mining pit pond located immediately south of the airport adjacent to the beach. The Lower River Reconnection option would potentially intersect this surface water feature, and the reconnaissance evaluated the condition of the soils that form the boundary between the pond and the beach.

While group one was performing the reconnaissance of the Snake River and the two relocation option alignments, group two, comprised of Sara Lindberg and Mary Jo Monahan, completed their own reconnaissance of the project area. Most of the site was walked by traversing the centerlines of the proposed river relocation alignments, as well as systematically walking areas in-between existing development to look for special areas of concern or areas with specific permitting needs. The site visit included a visual reconnaissance of areas potentially impacted by both Snake River relocation alternatives, as well as areas north and south of the crosswind runway where runway safety expansion is proposed. Areas were traversed by vehicle when accessible and by foot in roadless areas, particularly those areas south of the Snake River and west of the main runway.

A second and third site visit was performed by coastal engineer Doug Jones, of Coastline Engineering, who completed an independent site visit on August 23-24, 2009, and returned September 23-24, 2009 for further field information. Beach and sediment samples were collected for analysis on August 23-24, 2009. During this time, beach profiles from the causeway near the existing Snake River mouth to 2 miles west were surveyed. Upon return to Nome for the second site visit on September 23-24, 2009, more beach profiles on the east and west side, relative to the causeway, were also collected. Observations continued further west to verify that this area was similar to the beach previously surveyed. After meeting with the Port of Nome Harbormaster, Joy Baker, discussions ensued regarding the two main options to expand the runway safety areas. Joy provided Doug with contact information for groups and individuals that have relevant information regarding the amount of beach material that has been sold from the accumulated sediments of the west side of the causeway. This information will be used to calculate the sediment budget for the area.

On October 13-14, 2009, Shannon & Wilson geological engineers Frank Wuttig and Matt Billings performed the fourth site visit of the project - a geotechnical reconnaissance of the project site. The reconnaissance consisted of walking the majority of the proposed routes; observing terrain features; hand-probing for permafrost; observing the surface for indications of permafrost and thaw instability; observing the stability of existing cut and fill slopes; interviewing Nikolai Ivanoff, a NovaGold Resources

Resources Inc. (NovaGold) representative; reviewing exploratory boring logs in the NovaGold offices; and observing the stability of other earthwork structures in the Nome area.

2 OVERVIEW OF FIELD OBSERVATIONS AND EXISTING CONDITIONS

The following sections present the results of observations made during the four site visits. The section is organized into observations made for the individual disciplines involved in site visits, specifically, geology; hydrology and stream geomorphology; marine and aquatic biology; wetlands; hazardous waste; and coastal engineering.

2.1 Geology

The Nome area lies on a coastal plain rising from sea level to rolling hills north of town. The plain is underlain by a sequence of marine and glacial sediments resulting from several glaciations and marine transgressions. In the project area, till is underlain by a thin, discontinuous layer of marine sediments consisting of sand, gravelly sand, and clay resting on an undulating schist bedrock surface. Overlying these sediments are till deposits formed as valley glaciers flowed down the Nome and Snake Rivers, coalescing and spreading out as piedmont glaciers on the coastal plain. The broad ridge separating the lower Snake River from the Bering Sea in the project area is a morainal ridge. The coastal side of the morainal ridge is overlain by marine sediments, consisting of 10 to 25 feet of well-sorted sand and gravel, to an elevation of approximately 40 feet. The equivalent marine deposits on the Snake River side of the ridge consist of finer-grained estuarine sediments.

During the last glacial age, ice was confined to the upper Nome and Snake River valleys, and did not reach the coastal plain. Outwash filled a buried gorge beneath the Snake River and incised tens of feet into the underlying schist bedrock. A thin layer of loess was deposited across the coastal plain, and intense frost-action resulted in a reworking of the loess and movement of colluvium, masking the original glacial relief. The reworked loess and colluvium is typically thinner on ridges, thickening to 5-foot to 10-foot thick deposits in swales and gullies. Fibrous peat, ranging in thickness from 1 foot to 10 feet, may underlie swales, drained lake basins, and poorly drained areas.

Nome is in a subarctic zone, where the coastal plain is underlain by near-continuous permafrost. Permafrost is defined as ground with a temperature below 32°F for two or more years. Permafrost along the coast of Norton Sound is naturally relatively warm, degrading if the thermal regime is adversely impacted by modifications to the ground surface. The thickness of the active layer (the near-surface ground that undergoes an annual freeze-thaw cycle) is largely dependent upon soil type, ground cover, and snow depth. Frost-penetration beneath areas kept clear of snow may exceed 10 feet. Frost-penetration in areas covered by organic material or snow is typically 3 feet to 5 feet or less.

Probing and the exploratory logs provided by NovaGold indicate undisturbed areas are typically underlain by shallow permafrost 2.5 feet to 3 feet deep. It is probable that permafrost is degrading and deeper in areas where the natural surface has been significantly modified or altered. Mined areas should generally be free of shallow permafrost.

Based on conversations with NovaGold representatives and a review of their logs, 2 feet to 3 feet of highly organic material is anticipated at the surface, underlain by highly thaw-unstable, organic silt containing occasional rock fragments to depths averaging near 12 feet (depths expected to vary), representing the reworked loess, colluvium, and peat described above.

Below these surficial organic soils, soils are primarily tills composed of a variable mix of gravel, sand, and silt with some clay, with thinner layers of marine sands and gravels anticipated. The fines content in the tills will likely be high enough to control behavior. Ice-content of these materials is difficult to discern from the logs. NovaGold indicated these sediments are lower in ice content than the overlying organic soils. Based on experience elsewhere in the Nome area, ice-content typically decreases below the surficial layer of silt and organic material, which can be up to 20 feet thick.

The cut for the new river valley and channel is not expected to extend into the schist bedrock underlying the glacial tills and marine deposits.

It is anticipated that groundwater will be perched on top of permafrost in areas of shallow permafrost. In mined areas, a groundwater table above sea level is expected, as evidenced by water levels in flooded pits and dredge ponds at the site.

Both proposed relocation routes traverse a prominent, broad east-west ridge between the lower Snake River and the Bering Sea. The more direct New River Mouth Option and a portion of the Lower River Reconnection Option both cross largely undisturbed terrain vegetated with tundra, dotted with scattered thaw lakes and swampy areas. The surface along this route, predominantly sloping areas, is covered by hummocky and poorly drained areas. The hummocky areas are likely an indicator of solifluction, the slow downhill flow of soil caused by cryogenic processes.

Probing of the active layer in the undisturbed terrain indicated generally shallow permafrost with an active layer on the order of 2.5 feet thick. The performance of field work in the late fall assured that probed depths would provide a good characterization of the maximum thickness of the active layer. In swampy areas with significant standing water, occasionally permafrost was not encountered within the 4-foot probed depth. A winter trail, approximately 12 feet wide, along the crest of the ridge was also thawed deeper than the 4-foot-long probe. The ground surface across the trail has settled approximately 2 feet. Permafrost beneath narrower four-wheeler trails crossing the tundra was typically only slightly deeper than beneath the undisturbed tundra surface.

A large portion of the Lower River Reconnection Option crosses areas that were typically mined with a dredge. It is assumed that dredging operations generally included removing a near-surface silty and organic-rich layer, and then pre-thawing the underlying soils down to bedrock using cold water and thaw points, followed by dredging. The entire section of thawed material was then mined and processed, with the coarser material separated from the finer gold-bearing sands and gravels. The gold-bearing sands and gravel were run through a sluice box and discharged into the dredge pond. The coarser material was stacked over the finer sands and gravel tailings in a characteristic fan-shaped pattern using a conveyor.

The surface of the mined areas across the project are generally covered with a variety of fill materials, access roads, and what appear to be drained settling/tailings ponds. The characteristic fan-shaped pattern of coarse material left by dredging has been reworked or covered with fill in much of the area.

The preponderance of surficial fill consists of sandy, gravelly silt to silty, sandy gravel with cobbles and occasional boulders with fairly steep angles of repose. A stockpile of oversized material consisting of cobbles and boulders was also observed. A vegetated backslope cut into natural soils along one edge of a settling/tailings pond had a slope of approximately 33 degrees.

A portion of the Lower River Reconnection Option may connect to a large irregular flooded pit (informally referred to as the mining pit pond; see Figures 1 and 2), excavated in a more recent mining venture. In 1996-97, this pit was excavated down to schist bedrock. Mining operations targeted a thin layer of gold-bearing marine deposits on top of bedrock. Excavated material above this layer was wasted. Excavation and mining was accomplished in the winter, and the ore was processed the following summer. Except for the near surface, which was ripped, excavation was accomplished by drilling and blasting due to the presence of permafrost. Presumably, the soils in the excavation were generally frozen except for a localized thawed zone near the coast, from which slow seepage occurred. The pit slopes were cut vertically.

Subsequent to mining, the pit filled with water and side slopes sloughed to their current configuration. Slopes of 36 degrees and steeper at one point along the edge of the pit were measured where the soils consisted of silt overlying marine sands. The pit slopes appear to be relatively stable, except along the southern edge of the pit near the coast.

Photo 1 – Southern edge of mining pit pond and strip of land separating the pond from Norton Sound. View facing east.

A portion of the southern edge of the pit is separated from the coast by a narrow strip of land approximately 50 feet wide covered with natural tundra. Tension cracks in the tundra occur across the width of the strip. Active sloughing along the pit side was observed. The depth to permafrost in the center of the strip was 2.5 feet to 3 feet, where probed, at the time of observation (see Photo 1).

Gravel roads across the project site and off-site commonly show evidence of thaw-instability. Depressions 2 feet to 3 feet deep occur in the road surface unless it is maintained. Settlement and ponded water were seen along embankment toes and the edges of fills placed over natural ground.

An off-site cut at the airport and access road was observed to assess stability. A 25-foot-high cut into natural soils, laid back on a 4-horizontal-to-1-vertical slope, occurs along the north side of the east-west runway, with an access road running along the top. Soils in the cut consist of 1 foot of slightly silty, fine to medium sand underlain by brown silt. Overall, the stability of the cut slope appears to be good. The slope surface undulates slightly, indicating past thaw-instability. Areas of small tension cracks suggest solifluction or settlement processes are active on the slope. Settlement and ponded water along the gravel access road above the slope indicate the presence of relatively thaw-unstable soils.

2.2 Hydrology and Stream Geomorphology

Channel Gradient

The gradient of the Snake River channel is extremely low with probably less than 1 ft of vertical drop per mile. Water movement was barely visible within the lower 2 miles of the river and there were no visible riffles and pools. Gradient increased slightly beginning at approximately RM 4.0 and upstream. In this reach the channel included alternating pools and glides roughly synchronized with the alternating meander bends. Current was strong enough to drift the boat within the glides.

Channel Substrate

Substrate observed on the river bed was dominated by sand and silt. Sand bars were present and usually associated with meanders (inside point bar) or locations where the river width expanded (mid-channel bars). Occasional small patches (less than 1 square yard) of pea gravel occurred on the upstream edges of sand bars. The amount of small gravel observed on the river bed increased concurrently with the slight gradient change observed upstream of approximately RM 4.0. Angular rock, approximately 2-4 inches in diameter, occupied the river bed in two locations. The river reach located at the existing bridge and upstream for approximately 1,000 feet included angular rock. Similar rock was observed in the riverbed at approximately RM 4.0 at the downstream end of the natural meandering channel. The characteristics of this angular rock match those of mine tailings.

Channel Morphology Zones and River Bank Forms

Channel cross-section and plan view morphology varies among four distinct zones (see Figure 1). In the first zone within the harbor and immediately upstream to RM 0.6, the channel has been engineered and is maintained for navigation. The width and depth are significantly greater than observed in other zones (see Photo 2).

Photo 2 – Snake River Channel Morphology Zone 1 near river mouth. View facing south toward Norton Sound through the new river mouth and outer harbor breakwaters.

The second channel geomorphology zone is located upstream of the harbor and extends from RM 0.6 to the south end of the crosswind runway at RM 1.3. Within this zone, the channel is straight and narrow, especially along the southern perimeter of the airport. There is no floodplain, with the channel confined between the road embankment and a steep slope on the right (south) bank (see Photo 3).

Photo 3 – Snake River Channel Morphology Zone 2 upstream of the Snake River Bridge. View facing west.

The third channel geomorphology zone extends from the south end of the crosswind runway at RM 1.3 upstream to the downstream end of the broadly meandering channel at RM 4.0. This point coincides with the approximate relocation diversion point for the two proposed river relocation options. Within Zone 3, the channel is wider and includes sand bars and marsh areas along the channel edges (see Photo 4).

Photo 4 – Snake River Channel Morphology Zone 3 near the west end of the main runway. View facing north.

Channel Morphology Zone 4 extends upstream of Zone 3 and is characterized by broad alternating

Photo 5 – Snake River Channel Morphology Zone 4 near RM 4. Note meandering shape of channel, natural levee on the outside of the bend, and willows. View facing northeast.

meander bends and an extensive low elevation floodplain encompassing the entire width of the meander pattern. The landscape shows slightly elevated areas parallel and adjacent to the channel with distinct changes in vegetation (willows). These features are characteristic of natural levees that form over long periods as a result of sediment deposition during overbank flow events. As noted previously, alternating pools and glides coincided approximately with the alternating meanders in this zone. The channel cross-section followed textbook form with pools shifted to the outside of meander bends, sand bars located on the inside bank of meander bends, and approximately trapezoidal cross-sections in the straight reaches between bends (see Photo 5).

River banks showed three characteristic forms. Within the most confined portion of the channel, located along the south perimeter of the airport, the river banks were composed of bare soil and angular rock that had the appearance of coarse gravel mine tailings (see Photo 3). Throughout the remainder of the observed channel, the banks were either low-elevation marsh areas (see Photo 6) or eroding cut banks vegetated by overhanging willows (see Photo 7). In the marsh areas, the bank transitioned seamlessly from the channel, extending at a low gradient away from the channel. In each situation, the far edge bounding each marsh was formed by a slope. In some areas, the slope was the runway embankment.

In most areas, the edge of marsh was formed by the edge of the floodplain or a willow-vegetated slope formed at the edge of the high flow channel or a relict channel. Upstream of the confined portion of the channel, river banks were composed of sand and silt. Vegetation on the banks alternated between willows on higher banks (3-5 ft above the water surface) and marsh grasses on lower banks (0-1 ft above the water surface).

Channel Habitat Structure

Habitat structure in the channel was limited due to the absence of woody debris in the channel. The largest observed trees anywhere near the channel were the willows, with maximum observed diameters of approximately 5 inches, and maximum heights of approximately 6 feet with a shrub-like form. The primary pool-forming mechanism appeared to be a hydraulic effect of meander bends. Larger pools alternate with shallower glides. In-stream cover was limited to complex edge habitat provided by overhanging willow vegetation, and blocks of soil slumped into the channel along cut

Photo 6 – Marshy river bank along the Snake River near the main runway embankment. View facing northwest.

Photo 7 – Eroding cut bank along the Snake River upstream of the main runway. Note willows on top of bank and eroded blocks of tundra that have fallen into the river.

banks (see Photo 7). As blocks of riverbank fall into the river, the willows and other plant roots hold the material together in the water, forming an irregular channel edge. There were numerous sightings of 2 or 3 blocks of sod that had progressively fallen into the channel at different times.

Tidal Influence

The influence of tides on channel morphology is manifested in subtle ways throughout the lower 3 miles of the river. Lunar and solar tides vary with an approximate vertical range up to 1.5 ft. Extreme tides are driven by storm surge and winds. Tide conditions coinciding with peak flows influence sediment deposition patterns and the frequency of overbank flow events.

Observations Made Along the Alignment of the New River Mouth Option

Photo 8 – Upland tundra slopes along the New River Mouth Option alignment. Snake River is in the distance. View facing northeast.

The landscape for the majority of the proposed New River Mouth alignment is open tundra with a small zone of willows along the channel bank and a cut slope at the head of the beach at the edge of Norton Sound. The most notable feature along the alignment was the elevation gain, comprising a long gentle slope from the edge of the existing channel (see Photo 8). According to the topographic map, the elevation difference between the peak land elevation and the river elevation is approximately 50 feet. There are two small ponds located along the proposed alignment that would likely be eliminated, since they would fall within the extent of the excavation for a new river valley and channel. The ponds were predominantly open water with fringes of wetland. It was observed that the beach along Norton Sound is rather consistent in its width and configuration. There were no apparent features in the immediate vicinity of the proposed new river mouth that could be used to distinguish a preferred site for establishing a new mouth.

The beach shows signs of frequent vehicle traffic and appears to be the primary travel route between Nome and points west located along the shore. An inactive and badly damaged powerline running parallel to the beach was observed, located on the short bluff above the beach (see Photo 1). This powerline provided power for the Alaska Gold (now NovaGold) dredge mining operation. Several of the poles have been broken off, and short sections of the wires are downed. No other signs of utilities were observed, but the presence of this utility suggests a need to verify the presence or absence of any other utilities that may conflict with the alignment.

While walking back on the beach, approximately 8 relatively small hydraulic dredge mining operations were observed off shore, in addition to two recreational miners working on the beach with sluice boxes.

Observations Made Along the Alignment of the Lower River Reconnection Option

Tundra formed the majority of land cover along the alignment of the Lower River Reconnection Option, but with a greater proportion of disturbed landscape compared to the New River Mouth Option. Disturbed areas included an accumulation of potentially hazardous material stored in metal drums (see hazardous waste discussion below). Topography along the alignment of this option is similar to that of the Lower River Reconnection Option. Much of the alignment would require excavation through 30 to 50 feet of soil to produce the appropriate riverbed elevation.

Extension of the crosswind runway to the south would require river relocation into a higher elevation area (approximately 50 feet in elevation). Excavation would reduce or eliminate the soil barrier between the river and the existing mining pit pond located south of the crosswind runway, requiring routing of the relocated river into the pond. Four overflow channels were observed that convey water from the mining pit pond over the top of the berm and to the beach. Water was trickling through one of these features at the time of observation. As noted previously, an inactive power line parallels the beach. This utility line follows a path on the top of the berm. The poles located on the berm are tilted toward the mining pit pond, possibly as a result of soil movement toward the pond (see Photo 1).

2.3 Marine and Aquatic Biology

Snake River Aquatic and Riparian Habitat

The Snake River has been highly altered over its lower mile and a half. The river is straightened and channelized along Seppala Drive and the airport for approximately 1 mile (RM 0.3 to 1.3). Riprap and coarse material (probably mining tailings) characterizes much of the left bank and a substantial portion of the right bank (see Photo 9). During the site visit, riparian vegetation was noted to be largely lacking or limited to grasses and small herbs on the left bank, and limited in extent on the right bank, which has been disturbed by fill and industrial activities over the last century. Where visible in this reach, the streambed appeared to be a mix of silt-covered cobbles and artificial materials, including quarry spalls from riprap and industrial debris. Some areas of more natural sand bottom were also present. Adult salmon were seen to be rolling in this reach on September 19, 2009.


Photo 9 - Left bank of Snake River downstream of Snake River Bridge.

Approximately 600 feet above the bridge on the right bank (approximately RM 1), and upstream of the end for the crosswind runway on the left bank (RM 1.4), the shorelines began to take on more natural characteristics with a more natural floodplain, increasing riparian vegetation in the form of willows, sedges, and grasses. In several areas, the floodplain included connected or isolated sloughs with emergent *Carex*-dominated vegetation. In other areas, *Carex* dominated the vegetation on low benches and extended to or into the water's edge. The bed in this reach was a uniform mix of coarse to fine sand, and silt with coarser materials where currents are stronger. Stream flow was laminar and the gradient was uniformly low. Arctic grayling were common in this reach and abundant in a large pool created by a former bridge or ford crossing of the river near the west end of main runway (RM 2.1).


Photo 10 – *Carex*-dominated grassy bench on the inside of a meander bend.

Above the west end of the main runway, the river is still subject to fluctuations in water level due to tides and storm surges in Norton Sound. Upstream of the airport, conditions described above for the right bank became characteristic of both banks, and riparian vegetation, dominated by willows 5 to 6 feet tall (see Photo 7), was thick on both sides of straight reaches. On the insides of bends, *Carex* and grass benches (see Photo 10) were common. On the outsides of bends, steeper eroding cut banks of the willow-dominated taller vegetation were typical.

Even along straighter reaches, the willow and grass sod of the tundra was slumping into the channel margin (see Photo 7). However, the overall impression was one of slow change, perhaps as permafrost thaws along the bank of the river, rather than rapid erosion by river forces.

These conditions continued for several miles upstream to the vicinity of a weir operated by the NSEDC (approximately RM 6), well past the point of the proposed diversion of the river to accommodate the airport runway and runway safety area (RSA) extension (about RM 3.8).

At the upper end of the observed reach, several small schools of adult salmon were seen – usually along the deeper slots on the outside of bends where stronger current flows result in coarser sand and even small gravel that may be used for spawning. The first significant riffle habitats were also seen near and above the weir location and the first significant tributary entered from the west about 0.3 RMs below the weir.

Not surprisingly, the stream has no large habitat-forming wood, but deeper water, root masses, and overhanging roots and stems of willows provide cover in the reach surveyed. Beavers have constructed houses of willow stems out into the river from the shoreline in at least two places.

At least one short-eared owl, a dozen or more mew gulls, and approximately a dozen probable greater scaup were seen on the river, and red foxes were scared from the river bank in two areas.

Si Larson, Nome resident and biologist with the NSEDC, noted that although the weir is typically pulled before the coho salmon migration runs are completed, there is an estimated run size of about 600 coho in the Snake River, along with a few Chinook salmon. Chum is the most important species in local fisheries, and run sizes have been lower in recent years. The NSEDC does not appear to have conducted any research on juvenile salmon in the system.

Photo 11 – Ponds within the Snake River floodplain upstream of the runway. View facing upstream and northwest.

Tundra Ponds

Several types of waterbodies considered to be tundra ponds were visited. As indicated above, there is a series of small- to medium-sized ponds within the broader Snake River floodplain above the airport (see Photo 11). Additional superficially similar ponds were also seen on higher terraces adjacent to the river. Although probably isolated from the river under most conditions, these types of ponds have obvious ecological value for nesting and resting waterfowl. During floods, these floodplain ponds likely contribute organic detritus to the lower Snake River, the harbor that occupies its mouth, and to Norton Sound. Because of the occasional connection to the river it is likely that the majority of such ponds support ninespine stickleback.

Photo 12 – Small upland tundra pond along the alignment of the New River Mouth Option.

On the relatively undisturbed higher tundra along the alignment of the New River Mouth Option, there are a number of small tundra ponds that appear to be wholly or mostly isolated from the Snake River. These ponds provide ecological functions similar to those of the floodplain ponds, except that they provide only limited, if any, organic detritus to the river. Most have areas of marsh around at least a portion of their perimeters with marshes dominated by *Carex* (see Photo 12), and in some areas, cotton grass. The sloping sides of the shallow glacial depressions within which the ponds lie typically have taller willow shrub vegetation, whereas the surrounding tundra is dominated by typical lower-growing vegetation. Wetter tundra is dominated by tussock grass and sphagnum moss, while drier areas have a mix of crowberry, cranberry, arctic birch, small willows, blueberries, and lichens.

A third pond type, lying primarily to the south and east of the Lower River Reconnection Option, is comprised of manmade ponds. The largest of these – the mining pit pond - lies just behind the shoreline of Norton Sound and measures approximately 2,300 feet long by 400 feet wide at its widest (see Figures 1 and 2). The pond appears to be quite steep-sided in most areas, although several species of submerged aquatic vegetation could be seen 1 to 5 feet below the water surface. Ninespine sticklebacks were abundant in shallow water along the shoreline, but other fish species may be present as well. A narrow (50- to 70-foot wide) berm of relatively undisturbed tundra separates the eastern half of this irregularly-shaped pond from draining to Norton Sound (see Photo 1). The water surface of the pond appears to be approximately 18 feet above the sea level.

Another large manmade pond lies to the west and at a slightly higher elevation than the mining pit pond. This pond was created for, and expanded by, Alaska Gold Company's (now NovaGold's) now-abandoned Dredge No. 6 (see Photo 13). This dredge was active until about 1995. The shorelines of this pond are much less vegetated than those of natural ponds or the mining pit pond. The dredge pond was initially filled with water pumped from the Snake River through 20-inch diameter steel pipe, remnants of which are still in place. Ninespine sticklebacks were likely introduced to the pond with this

Photo 13 – No. 6 dredge and dredge pond on NovaGold property.

inflow and are now abundant. Two other similarly sized dredge ponds to the south and west of the No. 6 dredge pond were not visited.

Nome Harbor Aquatic Habitat

The Snake River currently flows into Norton Sound through the dredged basin of the Nome Harbor. In recent times, the U.S. Army Corps of Engineers has been responsible for maintenance of navigation depths in the harbor and for construction and maintenance of breakwaters. The present harbor configuration has the harbor entrance protected from seas by two long breakwaters that shelter an area termed the “outer harbor” (see Figure 3). Each breakwater has a breach near shore that was included in the design to allow passage of small boats and along-shore migrating fish and marine life. A substantial area of fill at the approximate location of the natural Norton Sound shoreline further protects the inner harbor and provides some industrial land on either side of the new river mouth. On the inside of the western portion of this fill, a sand beach has been established by sand transported to the east along the beach and through the breach in the western breakwater. The storm berm behind this beach is littered with logs, primarily of the Yukon River origin. The beach itself is quite clean (see Photo 14), and low boulders below the water line support limited amounts of annual algae (*Ulva intestinalis* and/or *U. prolifera)*.

Photo 14 – Sandy beach on inside of western breakwater.

"Image © 2009 TerraMetrics, © 2008 Google Earth Pro - Acquired September, 2009"

0 800 1200 1600

Scale In Feet

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NOME AIRPORT
SNAKE RIVER RELOCATION
SITE VISIT MEMO
SNAKE RIVER MOUTH

OCT. 2009

FIGURE
3

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Significant algal growths in shallow waters of Norton Sound are limited by winter ice. Marine organisms in the drift here included rockweed (*Fucus* sp.) and shells of two clams - *Tellina* sp., and razor clam (*Siliqua* sp.).

The inner portion of the harbor forms a rough "U" shape. The western arm of the "U" has a generally low gradient. In some places it appears to have almost natural shorelines, and carries the flow of the Snake River. The eastern arm of the "U", into which Dry Creek flows in a constructed channel, has steep, constructed shorelines providing for industrial uses. The outer portions of the inner harbor along the base of the "U" also are heavily industrialized with steep riprap or vertical sheet pile occupying much of the shoreline. This area and the eastern portion of the harbor has recently been reconstructed to create more deepwater moorage and to change the mouth of the river to flow directly south into the outer harbor. Where beaches exist, along the western arm of the "U" and the northern portion of the base of the "U," for example (see Photo 15), they are often littered with industrial debris, including a major dump area in the southwest corner of the harbor.

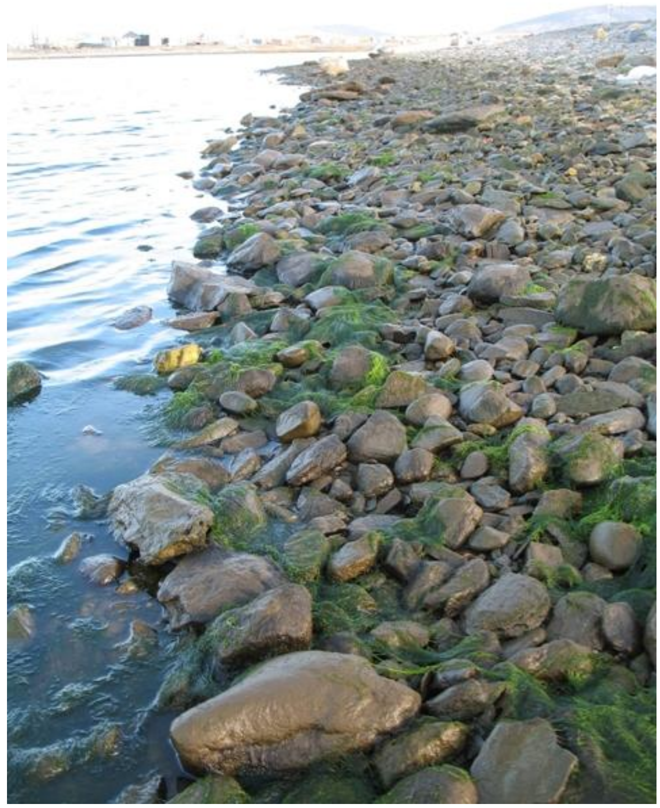

Photo 15 – Cobble beach in Nome Harbor near Snake River mouth.

Photo 16 – Marsh along the western shore of the lower Snake River near the river mouth. View facing south.

The larger western lobe of the inner harbor has a relatively shallow beach on the eastern shore comprised of cobbles that become increasingly fine toward the Snake River mouth. This area creates the primary launch in the city for small boats. Several starry flounder and one small cottid were seen near shore in this area. On the opposite, western shore of the Snake River mouth (west arm of the "U") is a *Carex*-dominated brackish marsh (see Photo 16) of that is surrounded by low-gradient sand and mudflats. Very small fish seen here may have been ninespine stickleback. Farther south, this marsh and flat is truncated by encroaching fill, although another small patch of marsh was present just south of the major metal dump area.

Norton Sound Shoreline

Photo 17 – Norton Sound beach to the west of Nome. View facing east.

The existing shoreline of Norton Sound west of the mouth of the Nome Harbor has been heavily affected by gold mining activities for many decades, yet may largely resemble the natural beach condition, except in recently disturbed areas. This is due to the fact that the beach is largely composed of a mix of sand, coarse gravel, and cobbles that, although they may be moved and sorted by a short-term quest for gold, ultimately are resorted by strong wave action into a relatively natural beach structure and gradient (see Photo 17). The effects of several one-man mining operations using a gas-powered dredge and sluice box which were underway during the site visit will likely be obliterated by the next storm. More lasting effects of mining were seen on upper beach and backshore areas where recent mining has impinged on the coastal bluffs or intermittent water courses draining the mine pit pond described above. Even these activities will be erased by large storms, except for areas where the there has been excavation into the bluff.

An exception to the general condition of the mid and lower beach described above is the gradual widening of the upper beach and backshore as the harbor breakwater is approached from the west. As a result of the predominantly easterly transport of sediments along this portion of Norton Sound shoreline, a large “fillet” of sand and gravel has accumulated in front of the bluff, creating a very broad backshore (see Figure 3). The backshore has been colonized by squatters who have built a substantial number of camps and dwellings, some of which are quite extensive. Most have increased their space and elevation above the sea by cutting depressions back into the bluff behind the beach. A ramp from the west side of the harbor provides access for vehicular traffic to the beach. This fillet of sand has been built out to and often through the breach in the west breakwater. The resulting sedimentation in the breach and outer harbor requires periodic dredging, according to Joy Baker, the Port of Nome Harbormaster. On these sand and gravel beaches outside the breakwater and to the west, observed drift animals included the clams seen inside the outer harbor (*Tellina* and *Siliqua*) along with *Hiatella* sp., unidentified sponges and hydroids, and egg masses of a moon snail (Naticidae). A wiry, branched red alga, probably *Ahnfeltia* sp., was by far the most common algal species on the beach.

2.4 Wetlands

Photo 18 – Typical project area wetland in an area disturbed by mining activity.

Project area wetlands consist of a mix of wetland types: palustrine emergent wet meadows dominated by sedges and grasses, and palustrine scrub shrub wetlands dominated by willow and bog blueberry. All vegetated wetland areas are dominated by a thick layer of lichen and moss. Several open water ponds are also dispersed throughout the site, those areas being bordered either by larger willow species or emergent sedges (see Photo 18). Soils in the project area are saturated to the surface, with permafrost likely forming the restrictive layer driving the soil saturation. Other hydrology indicators within the project area include the numerous ponds and small drainages that flow from the Snake River out to Norton Sound. A large portion of the project area is disturbed. These areas are primarily devoid of vegetation and have been filled. Any undisturbed ground or areas that have been allowed to revegetate between fill areas have since converted back to wetlands. These areas typically consist of ponded wetlands with wet sedge meadows and/or willow shrub scrub wetlands along the fringe (see Photo 19).

Photo 19 – Typical project area wetlands surrounding a pond in an undisturbed area near the alignment of the New River Mouth Option.

2.5 Hazardous Waste

Potentially hazardous waste was observed in five areas of concern (AOC) located across the Snake River south of the existing main runway (see Figure 1). Most of the potentially hazardous material was located in barrels and consisted of a tar-like substance (AOCs 1-4; see Photo 20). A tar-like substance was also noted on soil surface areas in a number of places within the AOCs.

Large mounds of dirt with evidence of buried drums and/or solid waste were observed, and in one case, orange liquid was observed leaching onto a wetland area that is hydraulically connected to the

Photo 20 – Barrels partially filled with tar-like material on hill above the Snake River. View facing north.

Photo 21 – Orange-colored seep from hillside above the Snake River.

Snake River (see Photo 21). In addition, due to dredge mining activities, the potential for soil and surface water contamination exists in other areas of the site. Stressed vegetation was noted in an area containing 55-gallon drums that were welded together (AOC 5). This area was also characterized by a large tailings pile that was completely void of any vegetation.

2.6 Coastal Engineering

During the two coastal engineering site visits, sediment samples were collected for later analysis, and beach profiles were surveyed from the causeway near the existing Snake River mouth (see Figure 2) to 2 miles west. Observations continued further west to verify that beaches in those westerly areas are similar to the beach previously surveyed. No active erosion was noted on the beach except for the berm line related to the last storm surge. For this beach, erosion will only occur during storms, unlike other beaches that are in a constant state of erosion.

A sediment budget will be calculated for material transported by longshore transport, based on information regarding the amount of beach material that has been mined and sold from the accumulated sediments of the west side of the causeway (see Figure 3). This information will be used in conjunction with estimates of the expected quantity of sediment transport in the Snake River in order to make the sediment budget calculation as accurate as possible. Preliminary observations indicate that the quantity of sediment transported by the Snake River is relatively small.

The NSEDC fish processing plant located near the mouth of the Snake River may be adversely affected by the construction of the New River Mouth Option, which would dramatically decrease the flow of water in the area of the existing river mouth. It may be that the processing plant will be required to extend their fish waste outfall a significant distance in order to provide adequate dilution due to the reduced flow at the mouth. The effect of flow reduction on this outfall will be investigated and included in the water quality model that will be run for the port and small boat harbor.

With respect to the evolution of the coastline and possible river mouth migration associated with the New River Mouth Option, the littoral transport will be modeled using the data collected on the two field trips combined with Nome wind data. Using this model, an estimate will be made of the rate of eastward migration of the new river mouth.

3 CONCLUSIONS AND RECOMMENDATIONS

3.1 Geotechnical Conclusions and Recommendations

The primary geotechnical concerns in constructing a new river valley and channel across the site are the presence of potentially thaw-unstable permafrost and perched groundwater. Both options are expected to cross thaw-unstable permafrost. Given the relatively warm nature of permafrost in the Nome area, it is anticipated that excavations will cause significant thermal degradation of the surrounding permafrost. While relatively steep slopes may stand in frozen ground, they will become unstable as the permafrost thaws. Perched groundwater seeping onto the cut slope will have a destabilizing effect and may also result in potential surface icing problems.

Several techniques have been used to make cuts in thaw unstable permafrost. These include:

1. Cutting near vertical slopes with a widened toe area and soil-retention structure to accommodate sloughing.
2. Buttressing steep cuts with a granular material.
3. Cutting moderate slopes covered with an insulated gravel layer to provide drainage and retard permafrost degradation.
4. Cutting flat slopes without a protective covering where thawing of flatter slopes would result in more vertical settlement than lateral movement.

The most appropriate strategy for this project would be to cut relatively steep slopes and buttress the highly thaw-unstable silts and organics soils near the surface, and then cut relatively flat slopes in the underlying tills and marine deposits. Conceptually, cuts in the underlying tills will be sloped in the range of 2.5-3.5 horizontal to 1 vertical, depending on ice content, to reduce instability. The overlying ice-rich soils should be cut nearly vertical and buttressed with granular material. The slope of the buttress should match the flattened slopes in the underlying materials. The slopes would be covered with a thick layer of organics saved from grubbing the site or turf recovered from the site. For conceptual planning purposes, it is suggested to assume the upper 12 feet will require buttressing.

Conceptually, all excavation and stabilization would be conducted in the winter during freezing temperatures. It would likely be difficult to accomplish the work during the summer months due to thaw-weakened soils.

Some instability of the cut slopes in the first few years following construction is anticipated, but it is expected that the instability will decrease with time. It may therefore be desirable to allow the fresh cuts to stabilize for one thawing season before rerouting the river channel through the cut. It has been noted that natural cryogenic solifluction processes may continue to cause the slow downhill creep of the near-surface active layer soils after the overall slopes have stabilized.

There are concerns that the ice-rich permafrost adjacent to the buttress at the top of the slope will be thermally disturbed by construction and begin to thaw, which could result in subsidence along the buttress, providing an area for surface water to collect and flow. In general, it will be desirable to prevent as much surface water as possible from flowing across the cut slopes to reduce the potential for slope instability and surface icing problems. Careful consideration should be given to a drainage plan. In general, it is suggested to route the new channels to reduce exposure to cross-drainage as much as possible.

Conceptually, slopes in mined areas would be cut no steeper than 2.5 horizontal to 1 vertical, and vegetated. The concerns associated with cuts in permafrost should not be present, although long term creep resulting from solifluction may occur in finer-grained, frost-susceptible soils. Again, careful consideration should be given to a drainage plan. In general, it is recommended to route the new channel through mined areas to reduce exposure to cross-drainage as much as possible.

The observed instability of the narrow strip of land between Norton Sound and the 1996-97 mining pit is a concern. Conceptually, the portion of the pit along the strip of the land should be filled with granular mine tailings to increase stability and provide greater separation between the new channel and the coast.

In general, new cut-slopes should be protected from erosion by the new river channel. The outside of bends in the relocated channel will require design measures to reduce or prevent erosion into the toes of the cut slopes.

3.2 Wetland Conclusions and Recommendations

Any work that takes place off of the existing disturbance within the NovaGold mining area will likely require a 404 wetlands permit. All project area wetlands observed are hydrologically connected to Norton Sound. All the wetlands in the Nome area appear to be typical of what was observed during the site reconnaissance.

Mitigation will be required for any disturbance or fill of wetlands within the project area.

3.3 Hazardous Waste Conclusions and Recommendations

Potentially hazardous waste has been identified in the project area in the form of numerous barrels of a tar-like substance and orange-colored leachate seeping from the hillside above the Snake River. There are also at least two locations where it appears that drums and other waste have been buried. Further investigation of these burial areas and the leachate is recommended to identify any associated human health and ecological hazards. Much of the identified potentially hazardous waste is concentrated adjacent to the area that will be occupied by the main runway safety area expansion and the Lower River Reconnection Option. Excavation activities for river relocation would likely be conducted in these AOCs and have the potential to cause a release of substances that could negatively impact the surrounding ecosystem and construction workers. Removal of the waste to repositories before excavation and construction activities for the river relocation could mitigate the risks to the ecosystem and construction workers.

3.4 Hydrologic and Engineering Conclusions and Recommendations

River Relocation Alignment Options

The two river relocation options can be distinguished from one another by a few key factors that will drive the feasibility and cost comparisons. One of the most significant costs will be excavation and disposal of soil to establish a new river valley and channel. The two alignment options traverse similar topography ranging up to approximately 50 ft in elevation, however, the length of the Lower River Reconnection Option is approximately twice the length of the New River Mouth Option. This length difference would translate to a large difference in excavation quantity and associated cost. Offsetting this difference to some degree would be the cost incurred to maintain the transportation corridor along the beach if it is interrupted by a new river mouth.

The Lower River Reconnection Option appears to encounter more hazardous materials than the New River Mouth Option. This factor could further increase the difference in cost between the two options.

If recoverable gold is present within either alignment in notable quantities, it may be a means of offsetting the cost of the large excavation necessary to establish a new river channel. The feasibility of gold recovery and associated cost and schedule implications will vary depending on the nature of the transaction with the current property owner.

Reconfiguring the Lower River Reconnection Option to minimize excavation is currently recommended. This can be accomplished by pushing the new alignment as far north as possible without crowding the runway and preserving as much as possible of the existing river channel by reconnecting to the existing river channel near the western end of the main runway rather than cutting across higher ground as shown on attached Figures 1 and 2. A shorter diversion around the extended crosswind runway and into the mining pit pond would still be required. It is understood that the DOT&PF would like to construct a parallel taxiway on the south side of the main runway, which would preclude reconnecting to the existing river channel as described above. However, preliminary engineering analyses suggest that construction of a parallel taxiway on the south side of the main runway will increase the quantity of excavation for the Lower River Reconnection Option by at least 1.3 million cubic yards. This additional increase in excavation could result in the Lower River Reconnection Option becoming economically infeasible.

The conceptual plan presently shows the crosswind runway extended approximately 1,000 ft to the south over the existing Snake River channel. The Lower River Reconnection Option would require relocation of a portion of the Snake River to the south intersecting with the existing mining pit pond. The water surface elevation in the pond is much higher than the river water surface elevation would be, and much of the pond would be effectively drained as a result of routing the river channel through the pond. Geotechnical team members will need to evaluate the effect of this change on the stability of the interior side slopes of the pond. Additionally, the condition of the existing berm between the pond and the beach suggests that if it is not strengthened, it may fail over time and allow the river to form a new river mouth at that location. The likely technical challenges and costs associated with routing the Snake River through the existing mining pit pond suggest a need to evaluate the feasibility of extending the crosswind runway to the north. We recommend developing and comparing cost estimates for extending the crosswind runway either to the north or to the south.

Cost estimates will need to be developed for excavation and grading work, hazardous materials cleanup, and maintenance of the transportation route along the beach for the New River Mouth Option. It is also recommended to work with NovaGold to assess the possibility of encountering gold in the excavation that may be recovered to offset excavation cost.

Channel Design Approach

Common practice in river restoration uses a natural river channel as a “reference reach” to establish a design template to guide design of a new river channel. This approach has demonstrated success in providing for hydrologic performance as well as habitat performance. In the case of the Snake River, an ideal reference reach would be a portion of the broadly meandering channel located upstream of the point where the channel was historically realigned. This reference reach would show the appropriate width and depth of the new channel as well as the extent of the natural floodplain surrounding the channel. However, if this approach were applied, it would greatly increase the excavation footprint and the volume of excavation required to produce this channel configuration. There is adequate area to do this along the New River Mouth Option, although it may not be economically feasible. There is not adequate area to construct a channel and floodplain with this configuration on the alignment of the Lower River Reconnection Option without impacting existing infrastructure and developed property.

The historically realigned reach of the river upstream of the end of the crosswind runway is more constrained than the natural broadly-meandering reach further upstream. Even so, this reach exhibits a somewhat dampened meandering pattern, and the river banks and habitat features approach the form of those same features observed in the natural reach upstream. The confined reach located immediately south of the airport terminal is straight and rather featureless. Combining these observations suggests that habitat conditions and geomorphic function can be supported in a relocated channel that is more constrained than the natural example. However, constraining the river to a straight and narrow channel with no floodplain would likely produce a featureless channel that provides little habitat value.

It is recommended to identify reference reach information from both the natural broadly-meandering reach upstream and the historically relocated reach located upstream of the crosswind runway. This approach will inform the decision to manage costs by minimizing the excavation while providing a basis for establishing the size of a channel and floodplain sufficient for supporting ecological and hydrologic function.

Appendix C

Final October 30, 2009 Multi-Agency Task Force Meeting Summary
Final November 17, 2010 Multi-Agency Task Force Meeting Summary

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USKH
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Memorandum

Date:	12/17/2010	**W.O.#:**	1182800
To:	RJ Stumpf, P.E., DOT&PF	**cc:**	Ivet Hall, DOT&PF Ray Plummer, P.E., USKH Hans Arnett, USKH
From:	Sara Lindberg, USKH		
Subject:	November 17, 2010 Second Multi-Agency Task Force Meeting Summary		

The following is a summary of attendance, comments, and discussion from the November 17, 2010 Second Multi-Agency Task Force (MATF) Meeting regarding the Nome Airport Snake River Relocation Study. In addition to the summary, please find the following documents attached for reference:

1. Sign-In Sheet
2. Power Point Presentation
3. Comment Sheets
4. Comment Resolution Handout

Summary
Nome Airport Snake River Relocation Study
Second Multi-Agency Task Force Meeting

Date: November 17, 2010

Location: Conference Room, USKH Fairbanks office, video linked to USKH Anchorage office.

Meeting Summary:
The second multi-agency task force (MATF) meeting was designed to update agency members regarding the two previous potential Snake River relocation options, which are no longer being considered as part of the Nome Airport Runway Safety Area (RSA) Expansion project, and to gather comments regarding a newly proposed relocation option. The meeting began at 1:00 PM at the USKH Inc. (USKH) offices in Fairbanks, Alaska. For those who could not attend in-person, a video link was set up with USKH's Anchorage office, and other members participated via telephone from their respective locations.

A brief presentation of current conditions in the project area and of the two previously proposed relocation options was provided by the project team, followed by a presentation on the newly proposed relocation option. After the presentation, the floor was opened for any questions or concerns from MATF members. The following summary details the presentation and summarizes questions, comments, and concerns presented during the meeting.

Attendees:

Alaska Department of Transportation & Public Facilities (DOT&PF)
- R.J. Stumpf, P.E., Project Manager
- Ivet Hall, Project Engineer

- Bob Madden, Nome Airport Manager
- Larry Smithhisler, Nome Maintenance and Operations Superintendent

Federal Aviation Administration (FAA)
- Bruce Greenwood, Environmental Manager

Alaska Department of Fish and Game (ADF&G)
- Robert (Mac) McLean, Regional Supervisor, Fairbanks Office

Nome Port Commission
- Charles Lean, Fisheries Biologist

Alaska Department of Environmental Conservation (ADEC)
- Tamara Cardona-Marek, PhD, Northern Region Project Manager

U.S. Army Corps of Engineers (USACE)
- Don Kuhle, Regulatory Specialist

US Fish and Wildlife Service (USFWS)
- Bob Henszey; Habitat Conservation Planning

National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS)
- Amy Cox, Lieutenant
- Eric Rothwell, Hydrologist

USKH Design Team
- Hans Arnett, USKH, Hydrologist
- Sara Lindberg, USKH, Wetlands Specialist
- Shane Cherry, Confluence Environmental, Geomorphologist
- Linda Smith, Environmental Analyst
- Daniel De Bord, Environmental Analyst
- Jon Houghton, Pentec Environmental/Hart Crowser, Estuary Development and Marine Biology
- Frank Wuttig, Shannon & Wilson
- Julie Keener, Shannon & Wilson

Meeting attendees are also identified on the attached sign-in sheet.

Presentation:
Introduction: Sara Lindberg (Sara) introduced the purpose of the river relocation study, goals of the MATF meeting, and all attendees introduced themselves.
- The proposed Snake River Relocation is one of several alternatives being considered as part of the Nome Airport RSA Expansion project.
- The goal of the MATF meeting is to form a consensus on design features that will create a feasible Snake River relocation option.

Project Overview: R.J. Stumpf (R.J.)

- The definition of a Runway Safety Area (RSA) is a cleared and graded area surrounding the runway to help reduce the damage to planes in the event of an over- or under-shoot.
- The highest number of jet aircraft accidents occur during takeoff and landing, and fatalities and damage to aircraft can be greatly reduced with an RSA. Because of this, FAA has been issued a congressional mandate to provide RSAs at deficient airports.
- Since the first MATF meeting in 2009, DOT&PF has completed an RSA Expansion Practicability Study. This document looked at different alternatives for an RSA expansion and guided DOT&PF to a preferred option.
- A few of the alternatives explored in the practicability study were ultimately dismissed.
    - The first dismissed alternative was an Engineered Material Arresting System (EMAS). The cost was high, and a 600-foot main runway extension would still have to be provided.
    - The second dismissed alternative was implementing declared distances (where the airport owner declares available distances for takeoff, landing, etc). This was dismissed because it would require shortening the runway to create an RSA. Carriers were unhappy with this option, and there is a state statute which dictates that an RSA cannot be created by shortening runways.
    - Another option was a bridge, which was dismissed because of the incredibly high cost of building a suitable superstructure to the necessary length and height to still provide navigable access to the river.
    - There was also consideration of shifting thresholds on the crosswind runway, but by doing so would lose lighted approach systems.
- The alternative that DOT&PF is focusing on provides a full 500-foot wide safety area on the main runway, with 1,000 feet of RSA beyond each end. However, the last 600 feet of the eastern end of the runway embankment will be narrower to avoid further river relocation needs, etc.
- The same is true for the crosswind runway, with a narrowing at the end of runway 3. The threshold will be shifted 600 feet to the north, which will be a sub-standard RSA with 600 feet instead of 1000, but there will still be a 1000-foot RSA at the far end. A positive point about this alternative is that shifting the runway 3 threshold to the north, nighttime operations can still be maintained.
- The environmental documents are scheduled to be done by the summer of 2011, allowing the DOT&PF to start with right-of-way acquisition. Crosswind runway construction is anticipated to start in 2012, with main runway construction anticipated to startin 2013.

River Relocation Overview: Hans Arnett (Hans)

- As a refresher from the first MATF meeting, several aerial photographs were reviewed, touching on the following information:
- The airport was originally constructed in 1942 on dredge tailings from historical mining practices (from the 1930s and earlier) at the project site.
- A review of aerial photos spanning 1942 to 2009 show the Snake River has been relocated several times. The latest major relocation of the Snake River has been construction of a new river mouth in 2005, the closing off of the old river mouth to the east, and the construction of a second breakwater to protect the port. These previous relocations have played a major role in creating the lower Snake River as it exists today.

- The river has four distinct channel morphology zones. A morphology zone is a length of the river that has a distinct shape, channel pattern, and hydraulic characteristics.
- Channel Morphology Zone 1 is at the lowermost point of the river, stretching from the mouth about 0.6 miles upstream near the airport. This zone has a very wide and deep channel, because it's a constructed channel and is dredged and maintained for navigation. The riverbed and banks are silt, sand, and gravel, but there is also riprap, chunks of concrete, and metal debris. Some of the banks are made up of sheet pile bulkheads. There is a floodplain in places and some limited tidal flats.
- Upstream is Channel Morphology Zone 2, which from River Mile (RM) 0.6 upstream to about RM 1.3, near the southern end of the crosswind runway. Zone 2 is a straight, constructed reach that is narrow and does not have a floodplain for the most part. This Zone is important in terms of the hydraulics of the lower river, because it forms a choke point that controls the hydraulics upstream by causing backwater effects. The riverbed and banks in this zone are sand and gravel, with coarse material like riprap and possibly mine tailings present. There's essentially no riparian vegetation, and not much fish habitat.
- Channel Morphology Zone 3 stretches from near the end of the crosswind runway up to about RM 4. This section is important, because it has been relocated and modified several times in the past, yet has maintained the positive, high-value habitat characteristics that are seen further upstream in the natural, unmodified section of the river. Zone 3 has a sandy riverbed with a channel that varies in width and depth. It also has a broadly meandering channel pattern within a well-formed floodplain. There is a significant amount of riparian vegetation and stream banks are formed by either low marshy areas or eroding cutbanks with overhanging willows. There are sand bars and pools, which helps to create fish habitat. The important thing to note about Zone 3 is that it has instream fish habitat and habitat-forming processes and features that are similar to the natural section of the river upstream.
- In Channel Morphology Zone 4, which is upstream of mining and other activities that have affected the river channel, there is a mostly sand bed channel with a regular cross-section and a highly sinuous, meandering channel that flows within a very broad, low-elevation floodplain.
- It is common practice to use a "reference reach" when designing a new channel, with the intent of mimicking the form, geometry, and hydraulics of an undisturbed reach. However, it is impractical to use Zone 4 as a target because the wide floodplain and sinuous channel would require a very large amount of area – probably more than is available – and tens of millions of cubic yards of excavation, which would not be economically feasible. Therefore, based on the similar instream fish habitat and habitat-forming processes, it is proposed to use Zone 3 as a reference reach. There are no trees to form large woody debris in the river, so instream fish habitat basically falls under two types: Habitat along the base of irregularly shaped river banks with overhanging willows, where big blocks of tundra have fallen into the river along cutbanks, and in deeper pools formed by scour along the outside of meander bends, or within the channel downstream of flow constrictions.
- Previous relocation design efforts were created in order to meet four objectives: 1) to relocate the river to accommodate maximum future airport expansion in order to minimize environmental and economic impacts from possible multiple relocations; 2) ensure the new channel functioned properly from a hydraulic and geomorphologic standpoint, particularly relating to fish habitat; 3) ensure the new channel functioned properly from an ecological standpoint; and 4) design a channel within DOT&PF's and FAA's budget limitations.

- After field visits, hydraulic modeling, and data analysis, two relocation options were developed to accommodate maximum airport expansion with a future 10,000-foot long runway with a full 500-foot wide safety area that extends 1,000 feet beyond either threshold. In addition, maximum future airport expansion included a parallel taxiway running the full length on the south side of the 10,000-foot runway. Maximum future expansion of the crosswind runway would mean a full 500-foot wide safety area extending 1,000 feet beyond either threshold.
- The previous Lower River Reconnection option was designed to take off from the Snake River beyond the limits of the furthest possible main runway expansion, and rejoin the river just downstream of the crosswind runway. This approximately 2.5-mile long relocation option maintained the existing mouth of the river. However, once design efforts went into serious development, it became clear that valley excavation quantities were going to be extremely large, measuring in the millions of cubic yards. The estimated cost of this option was $77 million.
- The previous New River Mouth option was just over a mile in length—much shorter than the Lower River Reconnection Option, and took off from the same point on the Snake River as the Lower River Reconnection option. This option would have shut off most of the flow to the lower river and the Port of Nome, affecting water quality, water levels, and circulation. It also would have disrupted an important transportation corridor along the beach, meaning a bridge would have to be provided. The cost of this option was $70 million.
- Both of these options far exceeded the budgetary limits of the DOT&PF and FAA. USKH was asked to revise design efforts with a budgetary target of $16 million. As a result of the restricted budget, designing for maximum future airport expansion became impossible.
- Two new options were developed. One would accommodate a 1,000 foot extension of the RSA off the west end of the main runway and nothing further, and would cost approximately $16 million. The other option would also allow the construction of a 1,500 foot extension of the main runway at some point in the future, and cost approximately $20 million. This option is called the Reduced Reconnection Option. DOT&PF has completed the practicability study for the Nome Airport RSA Expansion project and is moving forward with the Reduced Reconnection Option. The future runway expansion is not part of the RSA project.
- The river can now be relocated to bring the airport's RSAs up to FAA standards, allow for future runway expansion, and still provide hydraulic, geomorphic, and ecological functions similar to the design target of Channel Morphology Zone 3 while being within the DOT&PF and FAA's funding limitations.
- The relocation design is at the concept level, and most of the efforts were performed a year ago. There is new information about geologic and geotechnical conditions, and potentially hazardous wastes that have not yet been incorporated. However, the design components are still essentially valid.
- The Reduced Reconnection Option takes off from the existing river near RM 3.2, gently meanders, and heads south into the hillside. Going into the hillside requires deep cuts with high excavation quantities, so the valley starts narrowing.
- To reduce excavation quantities, the relocation stays as low on the hillside as possible once around the end of possible future expansion areas. As the design approaches the existing river, the valley is widened again, allowing more meander and floodplain development before reconnecting to the existing river near RM 2.2.
- The alignment is about 5,500 feet long, which is about the same length as the amount of river being cut off.

- Soils in unmined areas are different than soils in mined areas with respect to composition, permafrost, groundwater, and other issues, so the new valley will have a different typical section depending on whether the segment in question has been mined or not.
- The current concept design passes through about 3,000 feet of unmined areas and about 2,500 feet of mined areas.
- There are concerns in unmined areas about permafrost and instabilities from thawing, so the cut slopes have been designed to be relatively flat at 3:1 (horizontal to vertical). Under the current concept design, a buttress will be provided along the top of the slope in these areas, where a 12-foot high bench is cut in the ice-rich peat soils, which will be replaced by materials that are not frost-susceptible. This concept will be re-evaluated later in the design process, and we may dispense with the buttress.
- In the mined areas there is no concern about permafrost, so the slopes are cut a little steeper at 2.5:1, and no buttress is included, since there are no ice-rich peat soils in these areas.
- Regardless of the type of soil, there is concern about stabilizing the cut slopes as quickly as possible, because of possible sediment shed into the river from valley slopes. This requires re-vegetation as soon as possible. An important resource available in unmined areas is the tundra mat. It is suggested to do everything possible to salvage this mat and reuse it in the form of tundra blocks to re-vegetate slopes. In the floodplain where there are many willows, it is probably possible to harvest coherent blocks with a strong root structure. Higher elevation areas with shrub-scrub type vegetation will be more difficult to harvest. Regardless of how much tundra mat is successfully used, there will need to be other means of re-vegetation used. The tundra mat can probably be most successfully re-used on the relatively flat floodplain areas. It can also be considered to stack blocks of tundra mat at the base of a valley slope to form a buttress to capture sediment and assure that it is deposited on the floodplain rather than in the river.
- The bottom of the new valley forms the new floodplain, into which the relocated channel will be cut.
- Channel Morphology Zone 3 was used as the design target, and a preliminary cross-section for the new channel is a rough trapezoid that is 150 wide at the top, 7.5 feet deep, with 2:1 side slopes. This channel is a bit smaller than the average for Zone 3 in terms of width, but the depth is similar to the Zone 3 average. Being slightly narrower helps to reduce excavation quantities and provide a bigger floodplain.
- Even with the slight size difference, the proposed channel behaves hydraulically like the existing channel in Zone 3. The gradient in the existing channel is very low, and it has a sandy stream bed with very little sediment transport. Average velocities in the channel during a 100-year flood event are approximately 3 feet per second, which is relatively placid. This is due to the backwater effects in the narrow, constricted section of the river downstream of the crosswind runway.
- Geotechnical information indicates that the new channel will be excavated within sandy soils, which is not a big concern from a stability standpoint, since the new channel will be hydraulically similar to the existing channel.
- Further into the design effort, the channel cross section will be varied a bit to make it behave more naturally. Pools are one of the two main types of instream habitat, and the new channel should form and maintain pools. Stream banks should also erode and deform to develop irregular banks.

- Construction will call for the disposal of approximately 1.6 million cubic yards of excavated material. Some can be reused in the RSA construction, though it is only a fraction of the total. There are two disposal options that seem to make good sense. Once the river is directed into the new channel, the old channel will become a large backwater area. A ponded waterbody like that is likely to attract wildlife, specifically birds, which could form a hazard to the airport. 200,000 cubic yards of excavated material can be put in the dewatered channel and re-vegetated to form an emergent wetland. The bulk of the excavation is proposed to be placed in previously mined and disturbed areas on property that is currently owned by NovaGold Resources, Inc. (NovaGold). This would allow for minimal handling of the material, which saves money, and also will limit the environmental impacts from the disposal because these areas have already been disturbed. Much of the excavated material will be frozen and the outer portion of the pile will thaw during the summer, so it is proposed to build a meltwater management system around it, with a 3,200-foot long, 15-foot high berm with bioswales and settling ponds to control sediment before the meltwater is discharged to the ocean. The pile of excavated material would be vegetated.

Geological/Geotechnical Information: Frank Wuttig (Frank)

- The Nome area has a relatively gently sloping coastal plain approximately 3 miles wide between Norton Sound and uplands and mountains to the north.
- The coastal plain is underlain by relatively shallow schist bedrock 60 to 80 feet deep. Overlying soils consist of a series of marine beach and glacial sediments capped by wind-blown silt and peat deposits.
- The study site is located on a broad east-west trending ridge that rises to an elevation of 60 feet, separating the Lower Snake River from Norton Sound. It represents a terminal moraine from previous glaciations.
- In this periglacial environment, permafrost developed, a wind-blown layer of silt was deposited across the landscape, and there was extensive peat formation.
- Solifluction—the slow downhill creep movement of the active soil layer—and other processes continue to modify the landscape.
- Patterned ground and ice wedges, generally common, are noticeably absent in the project area.
- The presence of gold and the resultant mining has also greatly changed the landscape.
- Permafrost in the Nome area has been measured to be up to 90-120 feet thick.
- Prior to mining, nearly continuous permafrost conditions prevailed in the project area, although taliks (thawed zones) may exist beneath streams and other water bodies.
- Seismicity on the Seward Peninsula is relatively diffuse, with a few scattered clusters of concentrated activity. The seismic hazard in the Nome area is relatively low compared to the interior and southern portions of the state.
- Although Nome is located on the Norton Sound coast, the maritime influence of the Sound is limited to the open water season from early June to mid-November. When Norton Sound freezes, the climate changes from a maritime to a colder continental climate. The mean annual temperature at the airport (from 1950 to present) is 26.4 degrees Fahrenheit (^{o}F).
- In general, Alaska has gone through cycles of cooler and warmer periods lasting decades. Warmer periods occurred prior to the mid-1940s and after 1977, with a cooler-than average period in between. Climate trends in Nome are consistent with state-wide observations. When

analyzing the trends by freezing and thawing seasons, most of the warming appears to be occurring during winter.

- Measured permafrost temperatures in Nome are typically near 30°F or warmer, depending on surface conditions. Given the relatively warm nature of the permafrost, small changes to the heat balance at the surface could alter the thermal regime towards long-term thawing of permafrost.
- The relocation crosses three general types of terrain: the floodplain of the Snake River at the take-off and reconnection points; the natural tundra-covered morainal ridge; and an area of mine tailings from previous dredging operations. The floodplain area on the south bank of the Snake River is flat-lying and poorly drained, with areas of standing water and small ponds.
- The unmined area on the ridge in is largely undisturbed, gently sloping terrain vegetated with tundra and low shrubs and dotted with scattered thaw lakes, swampy areas, and small drainages.
- The surface along the route is frequently hummocky and poorly drained, particularly on the upper portions of the ridge, where there appears to be more standing water. The hummocky terrain is an indicator of solifluction, the slow downhill flow of soil caused by cryogenic processes.
- The active layer was probed at the end of the thawing season during a visit in 2009, and it was discovered that permafrost generally covered unmined upland areas, with an average active layer thickness of 2.5 feet.
- The depth to permafrost beneath tundra trails was typically deeper, on the order of 4 feet.
- The soils beneath larger thaw lakes can be completely thawed within otherwise continuous permafrost.
- Mining was typically accomplished by dredging. Dredging operations generally involve removing the near-surface silty and organic-rich layer, and pre-thawing the underlying soils down to bedrock with cold water thaw points.
- The entire section of thawed material was then dredged, washed, and processed, with the coarser material separated from the finer gold-bearing sands and gravels. The gold-bearing sands and gravels were run through a sluice box and, along with the silts, discharged into a dredge pond.
- The coarser material was stacked over the finer tailings in a characteristic fan-shaped pattern using a conveyor. The dredging process generally overturned the natural soil profile, with finer soils deposited near the bottom and coarser soils near the top.
- The surface of the mined area in the project area is uneven and irregular, and is typically covered by coarse dredge tailings, mining debris, drum-storage areas, and roads.
- The characteristic fan-shaped pattern of coarse material typically left by dredging has been largely reworked. What appear to be either settlement ponds or small basins without a drainage outlet occur within the tailings along the margin with the unmined tundra.
- This past spring and summer, subsurface conditions were explored along two proposed alignment options, with a total of 32 borings spaced approximately 300 feet to 400 feet apart. The borings were extended 20 feet or more below the proposed new floodplain elevation or to bedrock. The boring depths ranged from 20 feet to 70 feet. Bedrock was encountered in 22 borings.
- Fieldwork was conducted in two phases. The first 20 borings on the tundra in the unmined areas were drilled in May while the active layer was still frozen to minimize disturbances of the

vegetative mat. The borings in the mined area were drilled in July. Thermistor strings were installed in three borings in the unmined area to measure ground temperatures. Soils samples collected from the borings were tested for moisture content, grain size distribution, salinity, shear strength, and plasticity.

- All five borings on the floodplain of the Snake River at the take-off were thawed. The soils consisted of interbedded, loose to medium dense alluvial silts, sands, and gravels overlying bedrock at an elevation of -6 to -33 feet below sea level.
- The groundwater table in the borings on the floodplain was shallow.
- All 15 borings in the unmined area on the ridge encountered permafrost from the ground surface down to the depths explored, except for Boring 10-10 next to a thaw lake, which was thawed to the depth explored of 60.5 feet.
- The soils in the unmined area typically consisted of a surficial layer of peat and silt up to 9 feet thick and averaging 3 feet thick, underlain by interbedded glacial tills, alluvial and marine silty sands, and sandy silts overlying bedrock.
- Ground ice typically occurred in the form of lenses less than 1 inch thick and was more concentrated in the upper 15 to 20 feet. Massive ice in the form of ice wedges was not encountered.
- Bedrock was encountered at depths ranging from 29 feet near the base of the ridge to 68 feet on top of the ridge (approximate elevation -10 feet to -28 feet below mean sea level.)
- The bedrock was highly weathered and typically became more competent with depth.
- In the mined area soils consistent with dredge tailings were encountered. The soils typically consisted of a mixture of very loose to loose sand, sandy silt, and sandy silt overlain by coarser, gravelly soils.
- The materials were thawed throughout the depths explored. Bedrock was encountered in three borings ranging from 53 feet to 58 feet bgs (or approximate elevation -20 to -23 feet).
- Groundwater occurred at depths ranging from 17 feet to 36 feet (or approximate elevations of +11 to +20 feet).
- A typical temperature profile in the unmined permafrost area shows natural permafrost temperatures are relatively warm, between 30°F and 31°F.
- Moisture contents in the permafrost are elevated in the upper 15 feet to 20 feet, which correlates with a greater abundance of visible ice.
- Salinity measurements on both thawed and frozen samples were all below 350 parts per million, which is about two orders of magnitude lower than typical seawater, which has a salinity of 35 parts per thousand. It appears that soil salinity will not be a design concern for the project.
- Frank expressed two geotechnical concerns: Slope stability and slope stabilization in thawing permafrost soils after construction, and slope stability and slope stabilization during excavation in mine tailings.
- Geotechnical conclusions from Shannon and Wilson (S&W) include the following: In their opinion, the permafrost encountered in explorations will tend to be self-stabilizing over a period of several thaw seasons. Extensive massive ice or wedge ice was not encountered. Ground ice occurs in lenses with limited extent. The soils are relatively free draining, and the soils between the segregated ice appear to be relatively thaw stable. Aggressive erosion protection and revegetation measures will be necessary to accelerate slope stabilization and

provide sediment control. Planned and designed dewatering will be necessary in the mine tailings and taliks within the permafrost to achieve a stable and dry excavation.

- There are several strategies that can be used to construct slopes in ice rich permafrost. You can make near-vertical slopes and allow the slopes to slough and heal naturally over time. However, this method is now out of favor due to the large amount of sediment production and environmental impacts. You can also buttress steep cuts with a granular material. You can cut moderate slopes and cover them with an insulated layer of granular material to provide drainage and retard permafrost degradation. Or, you cut very flat slopes with an aggressive erosion control and revegetation program so that thawing results in more vertical settlement than down-slope movement. This is the strategy that S&W believes is most practical and best-suits the project.
- Reducing or controlling surface runoff from above the cut slopes will be important to the stability of the slopes.
- Thermal simulations suggest that the active layer thickness on the cut slopes in permafrost areas will increase due to the thermal disturbance. Long-term slow degradation of permafrost beneath the slopes will occur, but is not expected to have a destabilizing effect on slope stability.
- It is recommended that slopes in permafrost areas be cut no steeper than 3:1 (horizontal to vertical)
- It is recommended that slopes in the mine tailings be cut no steeper than 2.5:1.
- Planned dewatering will be necessary in the mine tailings and the talik around Boring 10-10 within the permafrost to achieve a stable and dry excavation.

Wetlands Impacts: Sara Lindberg (Sara)

- The presentation map used was from an ABR delineation from the 2009 field season.
- Green shading within the unmined areas consisting of shrub-dominated wetlands with low shrubs like blueberry and low willows. Wetland hydrology is driven by permafrost, which acts as a restrictive layer. These types of wetlands are lower value than other wetlands in the project area due to the presence of permafrost and the lack of habitat diversity for wildlife.
- Along the bank of the river is riparian vegetation (marked in yellow), which is actually well-drained and delineated as uplands by ABR. Permafrost in these areas has melted, and the resulting well-drained soils have allowed taller shrub species to move in.
- Areas marked in red and light green on the map consist of palustrine-emergent sloughs in areas of remnant stream bed, or existing side channels within the river valley. Most of these areas are designated as high value wetlands for their ability to pond water, which provides wildlife habitat, nutrient and toxicant removal, and serves as a buffer for flood waters. These areas are not open water, but are at least temporarily flooded at some time during the growing season and contain dense vegetation.
- Dark green shading within the mined areas indicates disturbed wetlands. These areas are devoid of permafrost at the surface, and the driving wetland hydrology is primarily due to frozen soils from seasonal frost, as well as very fine-grained soils near the surface that allow for saturated conditions. Groundwater is also high in some of these areas, which can be a contributing factor to the saturated conditions.
- Approximately 27 acres of wetlands would be disturbed from excavation of the proposed new river valley. However, some of the area would be restored to wetlands after construction.

- Wetlands within the floodplain of the river valley would be converted to emergent wetlands areas, with scrub shrub wetlands located along the toe of the slope. Moving up the slope, the depth to permafrost will change and the soils will become well-drained. Taller willows and scrub vegetation is expected to grow and create riparian habitat similar to what borders the river now.
- Approximately 25 acres of the Snake River channel would be dewatered as a result of the relocation. It is proposed to restore this area to emergent wetlands by disposing of some of the excavation material in the old channel. This would be an addition of nearly 20 acres of higher-value emergent areas, similar to those marked by red on the map. Using these methods, we believe we can avoid the majority of permanent impacts to wetlands and could potentially create a trade-off with the creation of higher-value wetlands. The overall net loss of wetlands would consist of the side slopes of the excavated valley being converted to the upland scrub shrub vegetation similar to what is currently along the banks. This would actually increase the amount of riparian habitat for wildlife and birds.

Fish Habitat: Sara Lindberg

- The Snake River is home to all 5 species of salmon, with chum as the most abundant, followed by pinks and coho. Chum numbers have been low in recent years, and they have been designated a “run of concern” by Alaska Department of Fish and Game (ADF&G).
- River habitats vary along the river. Habitat in the lower river is very degraded and only really used as a migration corridor. The upper river provides a much better habitat for spawning and rearing.
- Potential impacts to fish resulting from the Reduced Reconnection Option center around juvenile fish, who are most likely to be affected by any sediment impacts and any change in availability of feeding areas during the spring outmigration.
- Timing and phasing of construction is important to consider because each species outmigrates at a different time in the spring.
- Since the first MATF meeting, there is now more information regarding sediment in the river. Sediment transport from the melting valley side slopes is now less of a concern. The biggest concern is the “first flush” of sediment that comes out of the new river channel with the reroute of water. It will be important to time the placement of the river in the new channel with a time that is not as important for juvenile fish. This will ensure that they can acclimate in the harbor without the added stress of sediment loads. We also need to consider how to phase the filling of the old channel in such a way as to prevent fish from being trapped in the old channel.

Potentially Hazardous Material and Areas of Concern (AOCs): Julie Keener (Julie)

- S&W looked at the study area northwest, north, and northeast of the airport for indications of environmental concern.
- There were 3 Areas of Concern (or AOCs) that were identified in 2009 and are inside the potential reroute area. These 3 AOCs were specifically studied in S&W’s 2010 environmental field investigation.
- The Alaska Department of Environmental Conservation (ADEC) considers AOC 1 and 2 to be a contaminated site because of the presence of asphalt/asphaltic material.

- The objectives of the environmental investigation were to determine the nature and extent of petroleum hydrocarbon-contaminated soil; concentrations of heavy metals (esp. arsenic [As], mercury [Hg]); groundwater quality; and the nature of solid waste.
- Subsurface and near-surface soil, surface and groundwater, and asphalt were all sampled.
- Laboratory analyses were typically gasoline-, diesel-, and residual-range organics, volatile organic compounds, polynuclear aromatic hydrocarbons, and metals.
- Emerald Alaska (Emerald) was contracted to characterize the wastes on site, and provide a cost estimate for treatment and disposal. Results were compared to ADEC soil and groundwater cleanup levels. All soil results exceeded ADEC soil cleanup level for arsenic (3.9 mg/kg). All groundwater results exceeded ADEC groundwater cleanup level for arsenic (10 µg/L). Only results that exceed ADEC cleanup levels are presented here.
- S&W analyzed 2 or 3 soil samples from most of the geotechnical borings in both the mined and unmined areas for arsenic and mercury. Even the lowest detected arsenic concentration exceeds the cleanup level. Testing was performed for Toxicity Characteristic Leaching Procedure (TCLP) metals. Test indicated that the metals are not leachable, which is one less thing to be worried about.
- The areas and estimated volumes of asphalt on the ground were measured, with the following results:
    - AOC-1 = 6,000 square feet (sf), volume = 250 cubic yards (cy), if 1 foot thick
    - AOC-2 = 1,250 sf, volume = 50 cy, if 1 foot thick
    - Emerald considers this an “unregulated” waste
- A sample of the asphalt itself was tested for TCLP metals, TCLP volatiles, and TCLP semivolatiles. There were no detections, indicating the asphalt does not leach these constituents and the asphalt would not be a hazardous waste by the TCLP characterization.
- A soil sample from immediately under the asphalt was tested, and it did not exceed cleanup levels.
- A total of 10 test pits were excavated around the asphalt areas and soil samples were submitted for analysis.
- While low levels of petroleum compounds were detected, the results did not exceed ADEC soil cleanup levels, indicating the asphalt has not impacted the underlying soil.
- The large stain in the area north of the airport had diesel- and residual-range organics above cleanup levels. About 3 cubic yards of soil is estimated to be contaminated.
- A small stain north of the runway had diesel range organics, benzene, 1, 2, and 4-trimethylbenzene, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene levels above soil cleanup levels. Its volume is estimated to be even smaller than the first stain. Emerald’s estimate includes costs for disposal of these soils.
- Water was tested in the Snake River, both upstream and downstream of the mined areas, for metals. Results were less than ADEC groundwater cleanup levels and arsenic concentrations were less than ADEC Water Quality Criteria.
- Surface water ponded on the two asphalt areas contained petroleum hydrocarbons above groundwater cleanup levels. This water can be treated by Emerald.
- Water from the orange-colored seep from AOC 3 was tested and found to have a pH near neutral, and did not exceed groundwater cleanup levels. The orange-colored slime is the result of naturally occurring bacteria reacting to the iron and manganese in the water.
- Wells 10-10, 10-22, 10-26, and 10-30 exhibited poor recharge due to the fine-grained soils.

- S&W was unable to sample well 10-26 due to its slow recharge rate. That is, not enough water would come back in the well to collect a sample.
- S&W was only able to collect enough water from 10-22 for metals analysis.
- In conclusion, the few locations of stained soil are primarily a concern due to petroleum. Emerald can accept these soils for treatment. The asphalt would not be considered a hazardous waste based on the analyzed TCLP criteria, and it is not contaminating the underlying soil. The asphalt can be accepted by Emerald. Another disposal option may be reuse. The City of Nome landfill will not accept the asphalt for disposal. The Residual Range Organics (RRO) in monitoring well 10-10 are not attributable to petroleum hydrocarbon contamination.
- S&W believes the elevated metals concentrations are associated with high turbidity in the groundwater samples. For that reason S&W recommend some follow-up work consisting of resampling certain wells for residual range organics and metals, including hexavalent chromium, in addition to reducing the sample turbidity to obtain more accurate results. S&W will take on these tasks in the spring.
- Project implications include: The stains will need to be treated if they are excavated. The asphalt will be need to be disposed appropriately either offsite or onsite in a monofill, or possibly be reused; and a dewatering plan will need to be prepared prior to construction with requirements for settling out the sediments.

Presentation Wrap-Up and Next Steps:
Following the presentation, Sara Lindberg reviewed the ongoing process and next steps for the project. The first step is so move forward with the NEPA process. There will be another public meeting this winter to present the formalized RSA improvement alternatives and solicit public feedback on the Reduced Reconnection Option design. Formal agency scoping will begin by the first week of December. As the EA moves forward, the alternatives analysis from the practicability study will be fine-tuned. Currently, the EA is scheduled to be complete by April 2011, and at such time we will apply for permits, anticipating the completion and advertisement of construction bid documents by 2013. Per FAA mandate, construction will be complete by 2015.

Before opening the floor to general discussion, Sara reviewed a comment resolution hand-out that summarized comments from the first MATF meeting and responded to each of the following:

- Alternatives analysis including cost
- Effects to existing harbor
- Opportunities to enhance harbor for fish habitat, wetlands, contamination removal
- Maintain old channel for snow machine traffic
- Snow dams/ice jams
- Creation of habitat features in the narrow floodplain
- Floodplain habitat creation for birds
- How to address erosion and slumping of banks in a narrow valley after construction?
- How will sediment transport occur in the new channel?
- How will we reduce the “first flush” of sediment in the channel after construction?
- How to maintain fish habitat during the first few years after construction when spring floods move a lot of sediment?

Responses to these items as well as general questions, comments, and discussions are summarized below.

Questions, Concerns and General Comments regarding the Snake River Reduced Reconnection Option:

Effects to the existing harbor:

- This was a concern primarily with the rejected New River Mouth Option. The current Reduced Reconnection Option will not affect the quantity of water reaching the harbor.

Preliminary sediment transport/impacts to fish/dewatering the channel:

- Jon Houghton (Jon) noted that there has been some work done on the Snake River. Fish do feed as they migrate through the estuaries. Nome Harbor has been very much altered from what it looked like naturally, but the current condition is no worse than it would have been in the past during peak mining periods. The transition from the old channel to the new channel needs to be considered very seriously. There are many options for minimizing the first pulse of sediment. Is it better to have one “big gusher” in the spring or during a flood event, or to transition fairly slowly so that the whole flow is not put into the new channel at once, but rather over a period of days and weeks? He further stated that there is need to consider how to close the old channel, he would presume that they would work from the bottom up so that the fish left in the isolated reach would be chased back into the river. And other fish species, such as grayling which also winter in the river, need to be considered.
  - *Charlie Lean (Charlie) replied that when the ground is frozen in the spring there is less chance of a blow-out. During the annual spring flood, there doesn’t seem to be bad siltation. In fact, there is worse siltation in the fall when the ground is thawed. He stated that putting water in the channel in the spring is probably the best scenario. The fish are very mobile and able to negotiate the channel, and salmon in particular will be able to run into the current. Other fish species are generally higher up in the spawning beds because that is where the food is. He believes that most fish have finished their migration by June 20, and that June 20 to July 15 is a fairly fish-free window of time. If the channel is transitioned then, there will be less effect on juvenile and adult fish.*
  - *Jon replied that the team is considering forming a smaller sub-group of fishery biologists/fish experts to work out the details and practicality of the transition.*
  - *Mac McLean (Mac) replied that he would strongly agree with the formation of such a group, because those activities will be part of the permitting process. He also noted that standard practice is actually to close off the upstream end of channels first, because as the water level drops, fish tend to be flushed out.*
  - *Jon agreed, but noted that the stream in this reach is so flat that the procedure may not work here.*

Reuse of material/creation of emergent wetlands:

- Bob Henszey (Bob) asked Hans during his presentation what the plans are to fill in the old channel for the purposes of creating good habitat. He wanted to ensure that it would be filled enough to create emergent wetland and not open water. If it is mandated that we cannot build a bird attractant, can some of the other wetlands be filled? Even emergent wetlands can attract birds large enough to take down planes.

Sediment transport in the new channel/ground thawing:

- Bob asked if dewatering in mined areas with a high water table would be just during construction or a long-term solution.
    - *Frank replied that dewatering is just planned during construction, with expectations that it would draw down naturally after completion.*
- Charlie asked if there was expected to be any material excavated that would be suitable for construction, and if so, are there plans for reuse?
    - *Hans replied that there is expected to be usable material from the mine tailings that can be used in RSA construction.*
- Charlie also asked about the stability of the river banks. He said that he understood about the slope ratios, but noted that this is material that has not seen sunlight in millennia, so there is no resistance to erosion. He suspects that there will be rapid erosion up to the base of the steeper slope, and expressed doubts that the banks could be stabilized as-is.
    - *Hans replied that hydraulically speaking, there is very little sediment transport in the existing channel. The new channel will be hydraulically similar to Zone 3. Some instability within the new channel is actually favorable, because it will result in some natural deformation and erosion of river banks, which is one of the habitat forming processes in the existing river. The top of the river banks will be revegetated with tundra blocks as soon as possible, but the inability of the river to transport sediment of any notable size should relieve some worries about bank stability.*
    - *Charlie pointed out that the narrow channel from the bridge upstream to Bering Air has gravel, not sand in the streambed.*
    - *Hans noted that the area Charlie referred to was Channel Morphology Zone 2, which forms a choke point in the lower river and controls the upstream hydraulics. This zone has a coarse bed and is different from any existing zone upstream, and is also hydraulically different from the proposed new channel. The new channel is wider and flatter, low velocities and sediment transport capabilities. The narrower area downstream in Zone 2 results in higher velocity flows and higher sediment transport capabilities.*
    - *Shane Cherry (Shane) noted that the important thing to remember and consider is water surface gradient, not the streambed gradient. With such a low water surface gradient in the new channel, the flow will not be able to move gravel, but should be able to move sand within the reach.*
    - *Charlie noted that the material in the unmined areas is a combination of sand, silt, and gravel, which appears to be very erodible.*
    - *Shane replied that if the channel were just excavated down and left as-is, there would be some erosion of sand and silt. He stated that he did not think there was a need for riprap to prevent the erosion, but that gravel or even coarser-grained sand would suffice. Part of the design process would be to figure out which method would be best. Once the channel is excavated, we would have to assess what kind of material it is, and if it would be worth it to over-excavate and backfill.*
- Sara asked if the coarse material that Shane was talking about would be put on the bottom of the stream bed, or on the sides, and also what kind of material is expected to be found during excavation.
    - *Frank replied that it would be a silty sand or glacial till. Glacial till would be sand that has not been sorted by water, and the silty sand would have already been water-sorted.*

- *Shane noted that if all the native material was encountered, there would be a lot of silty, erodible material, which would be subject to water sorting. It would make muddy, mucky water, so it would be unwise to just leave it as-is to filter out. If the tundra block idea does not work, then the design will have to assess how big the material needs to be to avoid erosion and armor the channel.*
- *Mac suggested a trade-off. The channel can be armored and it will not erode, but it will not vegetate, either. So it needs to be recognized that regardless of armoring there needs to be some mobilization for revegetation purposes.*
- *Shane made a final note that there are two sources of sediment transport in the new channel: from upstream and from side slopes. Everything from upstream will be well washed and sorted. Everything from the sides would be raw, so that is the category that deserves focus. The design will have to determine which methods of stabilization are appropriate.*
- *Jon noted that there needs to be a good monitoring and adaptive management plan in place so that if problems are noted in the summer, they can be taken care of in winter when there is better access to the area.*

- As permafrost melts, will that prolong the flush beyond what would normally be seen?
  - *Frank noted that there was talk of armoring the channel, but with the native materials that are present, the channel will eventually self-armor.*
  - *Shane noted that if a coarser material is used, it does not necessarily have to line the whole channel. For instance, just the edges or the outside of a bend might need it, but not the inside bend.*

Revegetation:

- Charlie noted that one of the reasons why there is relatively lush growth in the riparian corridor is because of the thawed aquifer along the corridor. However, the design will cut through permafrost with limited permeability. With the lack of permeability, the tall willows cannot grow, and it will end up being shrub-scrub type wetlands.
  - *Frank noted that in long-term morphology, he expects a thaw bulb around the channel that will grow over time. In the first year, the active layer may increase to something like 8 feet, and in the long term depth is expected to be on the order of 15-20 feet over a 20 year period.*
  - *Charlie brought attention to the cutbank at the dredge pond, which after 10 years is still grass, with no signs of tundra vegetation. If that is an example, revegetation will take decades, not years.*
  - *Sara replied that part of the design process is to take the tundra blocks or a native seed source that will encourage the willows and other vegetation to grow. An important question to ask is, were the mined areas ever revegetated with anything other than grass seed? That will need to be looked into.*
  - *Frank noted further that on the floodplain where it is flatter, there will be accelerated thaw because of the proximity of the river. Therefore, the thaw there will be much faster than on the valley wall cut slopes. The same type of difference can be seen now between the mine tailings and the upper slopes.*
  - *Charlie noted that he did believe that this option in general is far superior to the options suggested before.*

Hazardous materials and areas of concern:

- Tamara Cardona-Marek (Tamara) clarified that the surface water of the Snake River does not have dangerous levels of arsenic, but the ground water does. Therefore, will digging the channel create higher arsenic levels in the river by disturbing the soil?
    - *Julie noted that conducting further study of the area and the arsenic types and levels is a recommendation of S&W.*
    - *Bruce Greenwood (Bruce) asked that if the arsenic basically sloughs off the ground, and then affects the water, it would then affect the fish, so do people who eat the fish then have to be concerned?*
    - *Tamara noted that scenario would be a worst-case outcome. There are two different types of arsenic—3 and 5—and one is worse than the other. One is biodegradable, which means it can dissolve. It is also possible that it will be a very temporary effect that will be relieved in the first flush. Regardless, the Nome community will need to know the results of the study, even if nothing can be done about it.*
    - *Frank noted that there would be no chemical or pH change of the water, so there would not be any effective change to the mobility of the arsenic. In other words, we would not be changing any procedures that would make anything worse.*
    - *Bruce summarized the discussion by noting that maybe a detailed explanation of Frank's statement would be a good enough answer in the long run, but the whole arsenic situation needs to be analyzed further and addressed in the EA.*
- It is planned to resample the water in the Snake River when the flow is high during a storm or flood, and sediment levels in the water are elevated. The water will also be tested to identify if arsenic levels change during fish runs as compared to spring or fall flood periods when sediment levels are elevated. In addition, analyses will be made of which type of arsenic may be introduced into the river and in what levels.
- Amy Cox (Amy) asked if there was any land adjacent to the new river channel that was privately owned that may be a future source of contamination because of mining or other means of disturbance.
    - Sara noted that NovaGold owns the majority of the land through which the new channel will pass. They currently have no plans to mine the area in the future because it is not economically viable, but it is possible that those plans might change.

Opportunities to enhance harbor for fish habitat, wetlands, contamination removal:

- Hans asked Charlie if there were opportunities that he was aware of to enhance the port for juvenile salmon as a means of mitigating the relocation project.
    - *Charlie replied that on the inner lobe of the harbor near Dry and Virgin Creeks, there has been efforts at habitat enhancement for salmon. He noted that there is groundwater near a beaver dam in the Dry Creek basin, and if a pond were to be put in there it would create good wintering habitat for coho and grayling. However, the boat harbor itself is very heavily used and it would be difficult to find opportunities for mitigation there.*
    - *Jon noted that there are some things that can be done on the shoreline to make it more fish-friendly. The beach is heavily littered, which makes it hard for fish and wildlife in the area. Also, he was under the impression that there is a bridge that is being planned for the area. There is a small carex marsh bench there that produces some good fish food, so perhaps there is an opportunity to the road design to either expand it or protect it.*

- *Charlie noted that the "junky" areas of the beach were already being cleaned up, and there are some plans to make that area a boat harbor.*
- *Tamara noted that there are some big contaminated sites right next to the harbor, so any planned improvement or mitigation efforts in those areas will need additional investigation.*

Snow dams/ice jams:

- There were concerns expressed in the first MATF meeting as to whether the relocation options would be more prone to snow drifting, damming by collapsing snow drifts, and ice jams. Hans noted that it is anticipated that there will always be some amount of winter base flow coming down the river, which will tend to maintain a tunnel for the flow of water under snow drifts. This maintained flow passage way will reduce the likelihood of damming by collapsing snow drifts, which is an uncommon occurrence. The river currently experiences ice jams near the airport, usually in the area of the existing Snake River Bridge where the channel is narrow. These ice jam events are usually short-lived and have never resulted in overbank flooding according to National Weather Service personnel in Nome. The channel geometry of the Reduced Reconnection Option is not anticipated to increase the likelihood of ice jamming.

Maintaining old channel for snow machine traffic:

- The realigned channel will serve as a corridor for snow machine traffic.

Miscellaneous:

- Bob Henszey What's the minimum distance from the airport for wildlife bird habitat?
  - *(FAA) -5000 feet. The most important thing to the FAA is just to make sure that we are not making anything worse than it already is.*
- Eric Rothwell (Eric) asked what the estimated volume of excavated material proposed for the dewatered channel? And according to aerial photos, he noted that it looks like there is some drainage into the reach of the channel. Has there been any consideration about how much water is draining into that channel from the surrounding areas?
  - *Hans replied that there is about 190,000 cubic yards of fill needed for the dewatered reach. Regarding the contribution of water, the fill would have to be designed with a westerly drainage, opposite of the stream's current flow direction. There hasn't been a detailed analysis performed yet of runoff from the slopes that drain into the reach.*
- Eric asked if the "tundra block method" proposed for revegetation has ever been used before.
  - *Hans and Sara replied that it has not been used as far as USKH is aware, but we could do a sort of "test run" before relying on success.*

Written comments received to date:

USFWS (Bob Henszey):

- Need more info on existing bird strikes on the west side of the runway, what species and density of wildlife use the area now, and what they might use as new wetland habitat (i.e., will increase/decrease strike likelihood). Do sandhill cranes nest in area?
- Large, riparian willows and other larger shrubs elsewhere are scarce and high-value small bird habitat in this area.
- Consider stockpiling useable gravel/fill for future projects instead of wasting into wetlands or dredge ponds.

- Mitigation option: improve [Seppala Drive] culverts from Dry and Bourbon Creek into bay for fish passage and estuary habitat rehab.
- USACE will have to decide if created wetlands offset loss, including risk of creation failure and temporal delay between loss and created function replacement.
- Having remnant wetlands north of the runway, and constructing wetlands south of the runway may be a recipe for attracting birds to fly back and forth between the two (i.e., across the runway). This was not a problem before when the river crossed from one side to the other west of the runway. This may only be a problem for a few weeks each year at the start and end of the breeding season. The rest of the year the birds are either gone or sitting on nests.
- I like the current plan much better than last year's plan.

Nome Port Commission (Charlie Lean):

- I would like to start by saying that this proposal is a great improvement. Some of my comments may be easily addressed since I do not have a complete picture.
- I appreciate the significant shortening of the reroute both as a fish biologist and a Nome Port Commissioner. I like the way the excavation is sited on previously mined tailings, because this will reduce sedimentation and side hill slump.
- I was surprised that no provisions were made to utilize the excavated material for a dike across the riparian plain at the upstream end of the evacuated channel or for airport extension. That would reduce the need for an offsite disposal area and the associated runoff on the beach.
- My interpretation of the hydrology is somewhat different than that of the presentation. It was stated the stream velocity is governed by the river reach near the powerhouse. That is true to an extent, but I have noticed that since the equipment ford near the western end of the runway was built, nearly a ½ mile of river above that has lost its channel and sprawled. I think that will happen immediately above the project area if the new riparian zone is kept narrow. This will have the effect of driving the river upstream of this constriction to the old channels on the outside of the natural riparian plain. So in times of flood, the extended airport is likely to be flooded. There needs to be a dam or dike to contain a 50 year flood.
- I am not a soils scientist, but I have some time in road construction and fish observation. The natural riparian soils are not glacial till, except where the river is at the margin of the riparian zone. One will note these areas erode rapidly once they thaw. If they are denuded of vegetation, the thaw is accelerated and after about two weeks of exposure, the muck will suck your boot off if you are foolish enough to walk on it. I can take you on a tour of sunken vehicles in/on the tundra.
- Placing tundra blocks on the cut through the glacial till is not going to happen. Tundra blocks being placed on tailings is possible and could result in vegetation taking hold. I think that it would be overly dry and I suspect the vegetation would be short and not particularly valuable as wildlife habitat. Still, just plain tailings take decades to revegetate.
- The cuts through the glacial till will probably evolve into blueberry tundra over time. There is a good example of that on the western side of the northern runway.
- Should the river reach the base of the side slope, a major erosion event will occur. Look at the steepness of the slopes on the margins of the riparian corridor. Once thawed, this material is composed of finer material than the river gravels in the riparian soils and so it goes quickly.
- Riparian vegetation is affected by soil and the depth of permafrost. The tall felt leaf willow, which is the good stuff here, requires thawed ground like that of the natural riparian gravels.

Red willow is on permafrost, but the active layer is deep, often next to thawed ground. Moist tundra or blueberry tundra is on permafrost with only a couple feet of active layer.

- The reason the riparian gravel is thawed is that it is permeable. The more silt is present, the less permeable the soil. Lining the banks of the river cut with gravel will harden them to reduce erosion and allow overhanging willows to get a hold. These cuts through the glacial till need to vegetated as soon as possible with grass or sedge.
- The longer the raw ground is exposed the greater the risk of a slump, and the longer it will take for permafrost to take a hold again. In fact, a discussion of winter excavation should be considered. This would minimize permafrost loss and seed nets could be deployed before the workers got mired in the muck.
- Tailing excavation timing is less important. As I said in the teleconference, the water should be turned into the new channel in late June –early July.
- I make these suggestions to minimize sedimentation in the harbor which would prevent a navigational issue.
- In the end, this [project] will have minor impacts to outmigrant fry and resident fish, and will have less detrimental impacts than [the previous relocation options].

ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

Multi Agency Task Force Meeting

SIGN IN SHEET

PROJECT NAME: Nome Airport RSA Expansion Snake River Relocation Study **DATE: November 17, 2010**

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PROJECT NAME: Nome Airport RSA Expansion Snake River Relocation Study **DATE: November 17, 2010**

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PROJECT NAME: Nome Airport RSA Expansion Snake River Relocation Study **DATE: November 17, 2010**

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Nome Airport Snake River Relocation Study
Multi-Agency Task Force (MATF)

GOAL: To form a consensus on design features that will create a feasible Snake River relocation alternative.

2

Nome Airport RSA Expansion

3

MATF GOAL: To form a consensus on design features that will create a feasible Snake River relocation alternative.

What we'd like to hear about from you today:

- Is the design sufficient given the constraints?
- Are our proposed avoidance, minimization and mitigation measures sufficient?
- Data needs. Areas of further study or consideration.
- Permit requirements.

4

Snake River Relocation Concept Design Overview

- Previous relocations of the Snake River
- Previous concept design efforts
- Overview of current river relocation concept design

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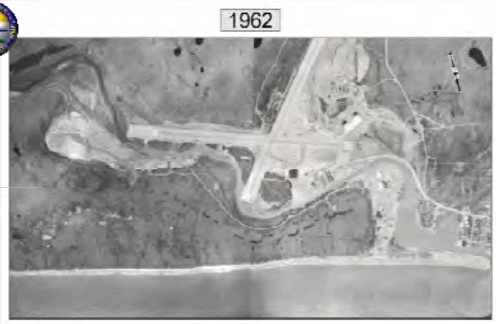

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Original Snake River Relocation Design Objectives

- Relocate the Snake River to accommodate maximum future expansion of the Nome Airport
- Ensure hydraulic and geomorphic function of the relocated river channel including peak flows, sediment transport, ice transport, and geomorphic processes that form and maintain habitat
- Provide an acceptable level of ecological function within the new river channel
- Manage costs to meet DOT&PF and FAA funding limitations

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Revised Snake River Relocation Design Objectives

- Relocate the Snake River to accommodate construction of a 1,000-foot long and 500-foot wide safety area off the west end of the main runway, and a possible future 1,500-foot long extension of the main runway
- Ensure hydraulic and geomorphic function of the relocated river channel including peak flows, sediment transport, ice transport, and geomorphic processes that form and maintain habitat
- Provide an acceptable level of ecological function within the new river channel
- Manage costs to meet DOT&PF and FAA funding limitations

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Reduced Reconnection Option

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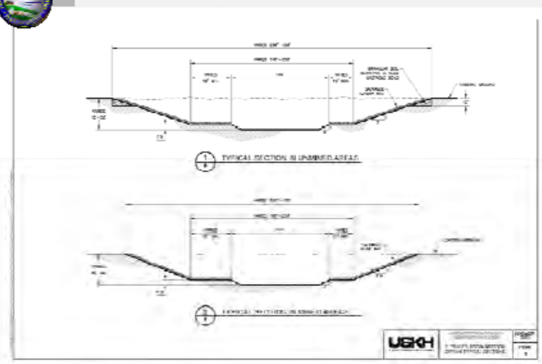

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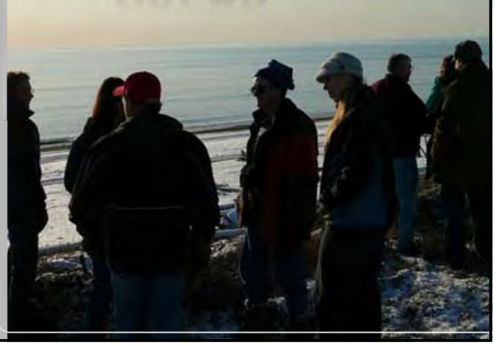

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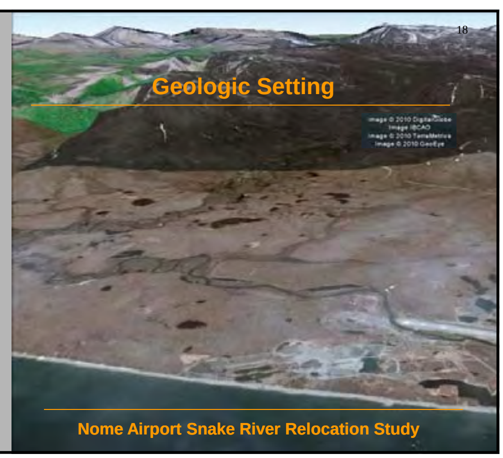

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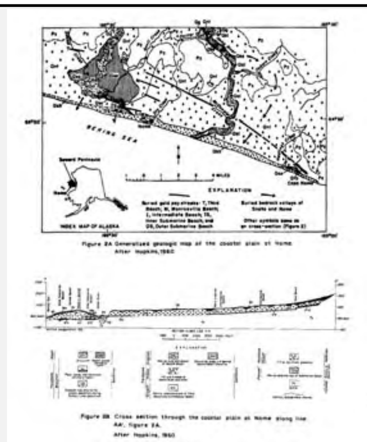

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Seismicity

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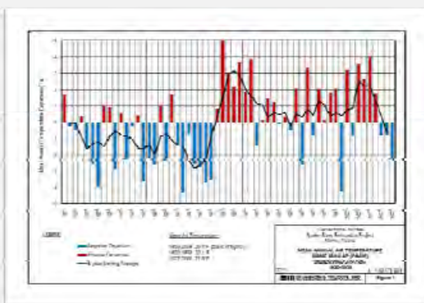
Climate



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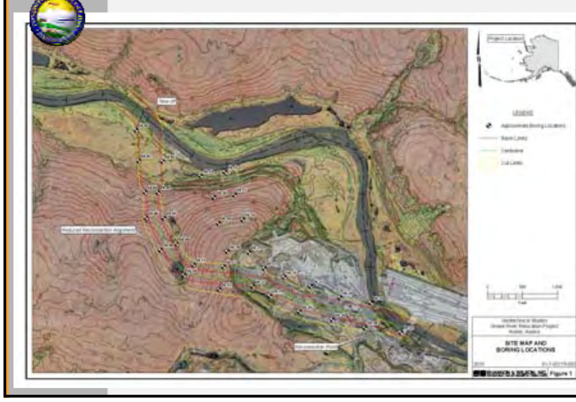
Terrain



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Unmined Area

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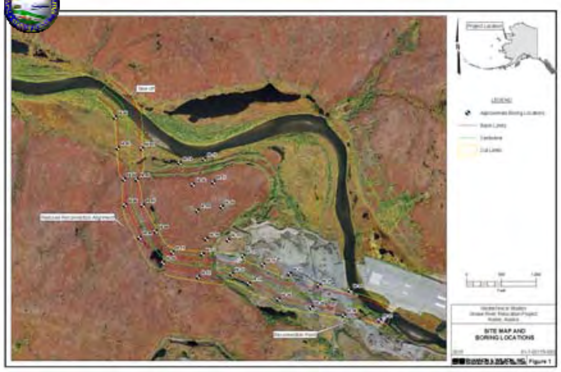
Mined Area

Exploration Plan

25

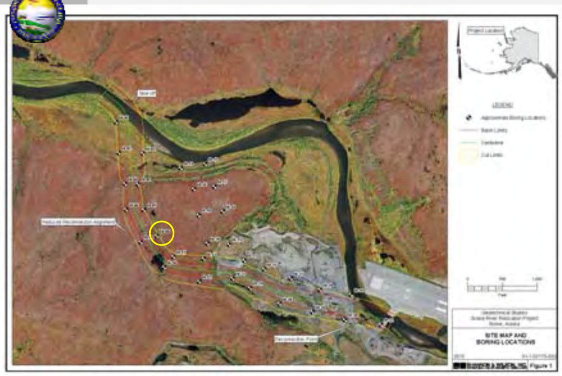


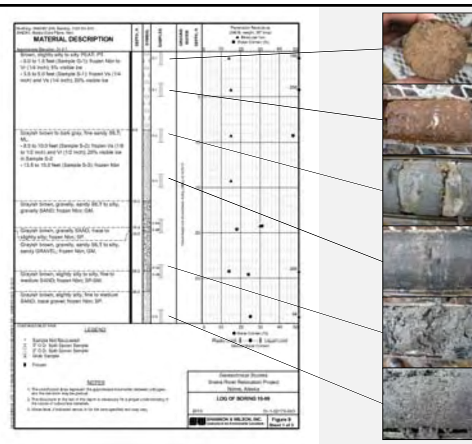
Field Explorations

26

Exploration Plan

27





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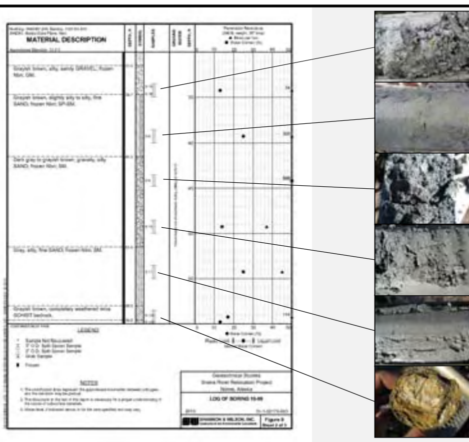

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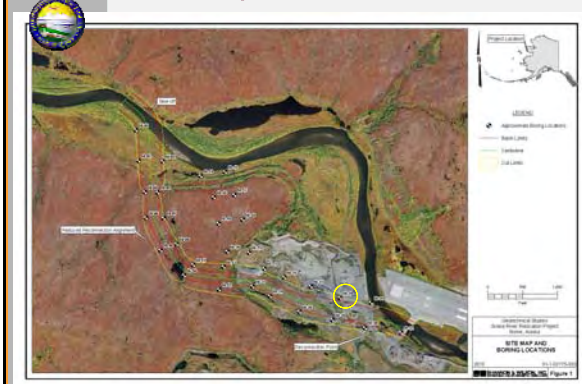
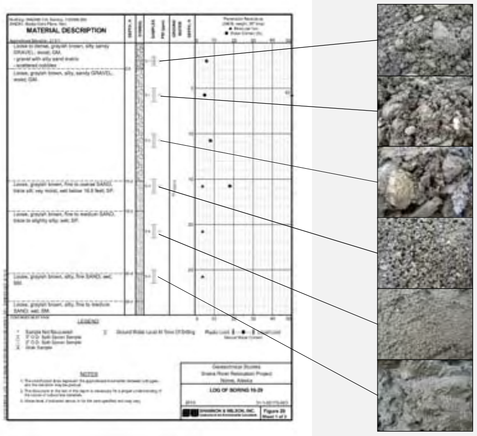
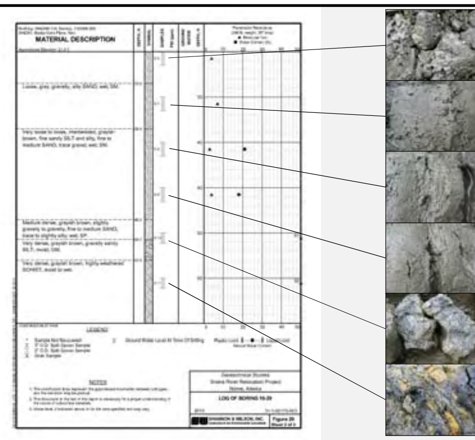
Exploration Plan

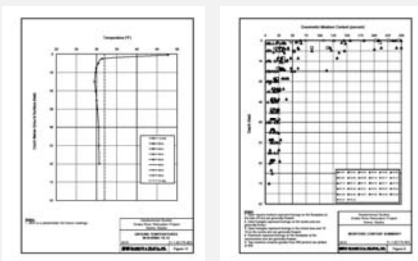
30







Field and Laboratory Data



Performance of Existing Embankments

Performance of Existing Slopes

Geotechnical Concerns

1. **Slope stability and slope stabilization in permafrost.**
2. **Slope stability and slope stabilization during excavation in mine tailings.**

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Conclusions

1. The permafrost encountered in our explorations will tend to be self-stabilizing over a period of several thaw seasons.
2. Aggressive erosion protection and revegetation measures will be necessary to accelerate slope stabilization and provide sediment control.
3. Planned and designed dewatering will be necessary in the mine tailings and taliks within the permafrost to achieve a stable and dry excavation.

Nome Airport Snake River Relocation Study

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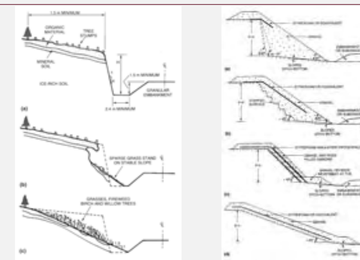
Conclusions



Nome Airport Snake River Relocation Study

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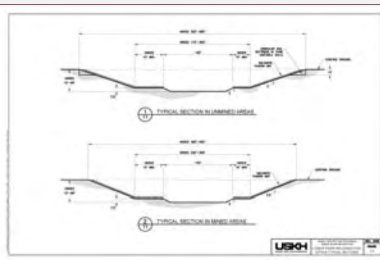
Conclusions



Nome Airport Snake River Relocation Study

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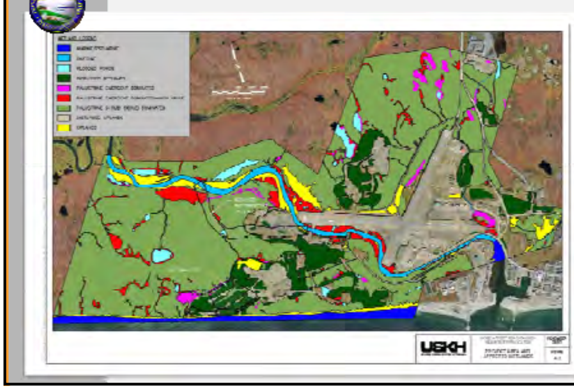
Wetland Overview



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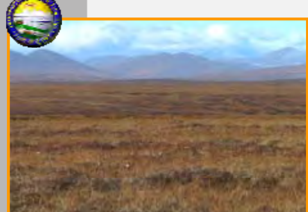
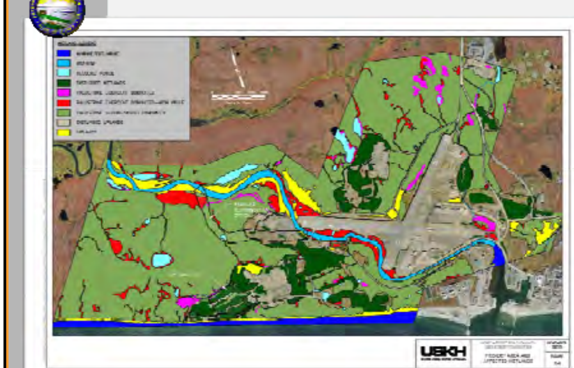
Wetlands in Unmined Areas



Wetland Types
- Emergent
- Scrub Shrub
- Ponded Wetlands

42

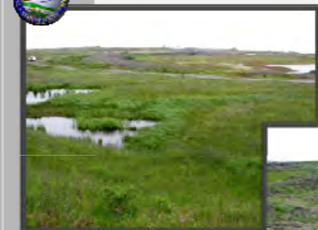
Wetland Overview



Wetland Within Mined Area

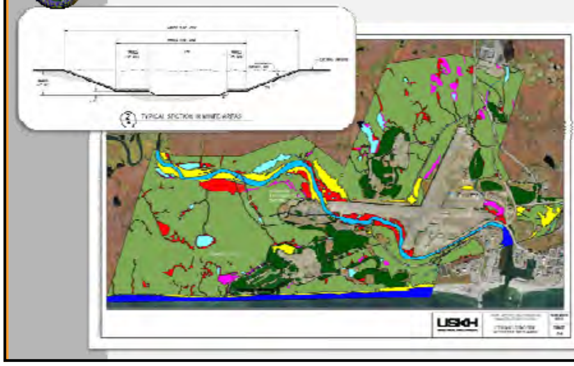
43

- Disturbed Wetlands



Impacts to Wetlands

44

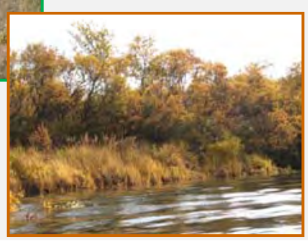


Fish Habitat

45

Lower Reach Habitat

Upper Reach Habitat



Impacts to Fish

46

- Sediment can be a concern to juvenile fish and their feeding areas
- Importance of timing windows and construction phasing

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Environmental Investigation

Nome Airport Snake River Relocation Study

Study Area and Areas of Concern

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Objectives

Determine:
- Nature and extent of petroleum-hydrocarbon contaminated soil
- Concentrations of heavy metals (esp. arsenic [As], mercury [Hg])
- Groundwater quality
- Nature of solid waste

50

Media Sampled

- Subsurface soil
- Near-surface soil
- Surface water
- Groundwater
- Asphalt

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Notes

- Results compared to ADEC soil and groundwater cleanup levels
- All soil results exceeded ADEC soil cleanup level for arsenic (3.9 mg/kg)
- All groundwater results exceeded ADEC groundwater cleanup level for arsenic (10 µg/L)
- Only exceedances presented here

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Subsurface Soil

From unmined area

	Range	Average
As (mg/kg)	8 – 1,100	200
Hg (mg/kg)	0.0472 – 0.0685	0.0578

From mined area

	Range	Average
As (mg/kg)	85 – 2,590	368
Hg (mg/kg)	0.0604 – 0.0938	0.0775

ADEC soil cleanup levels: 3.9 mg/kg As, 1.4 mg/kg Hg

Sample with highest As concentration
- Tested for TCLP metals; not detected

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Sample Locations

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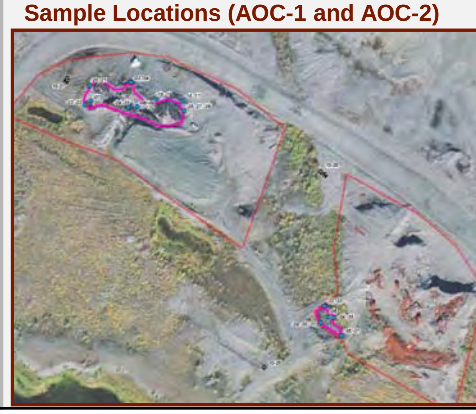
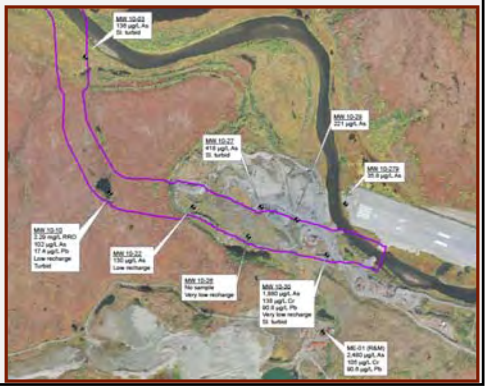
Sample Locations (AOC-1 and AOC-2)



55

Groundwater



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Conclusions

- Few locations of stained soil.
- Asphalt not contaminating underlying soil.
- Emerald can accept soil, water, and asphalt for treatment, disposal.
- RRO in well 10-10 not attributable to petroleum-hydrocarbon contamination.
- Elevated levels of metals in the groundwater are associated with high turbidity of the samples.

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Project Implications

- Soil stains will require treatment if excavated.
- The asphalt will need to be disposed properly (Offsite? Onsite monofill?) or possibly be reused.
- Preparation of a Dewatering Plan with stipulation for settling out metal-containing sediments prior to discharge to the Snake River. May require use of flocculent.

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COMMENT RESOLUTION

- ✓ Alternative analysis including cost
- ✓ ~~Effects to existing harbor~~
- ✓ ~~Opportunities to enhance harbor for fish habitat, wetlands, contamination removal~~
- ✓ Maintain old channel for snow machine traffic
- ✓ Snow dams/ice jams
- ✓ Creation of habitat features in the narrow floodplain
- ✓ Floodplain habitat creation for birds

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COMMENT RESOLUTION

- ✓ How to address erosion and slumping of banks in a narrow valley after construction
- ✓ How will sediment transport occur in the new channel?
- ✓ How will we reduce the "first flush" of sediment in the channel after construction?
- ✓ How to maintain fish habitat during the first few years after construction when spring floods move a lot of sediment?

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NEXT STEPS

- NEPA/environmental documentation process
- More advanced design efforts
- Formal Agency Scoping
- EA complete by April 2011
- Construction by 2015, anticipate bid in 2013


DISCUSSION
61
• Are the proposed minimization measures sufficient?
• Is this a permittible option?
• What else should we be considering?
• Additional design considerations, construction considerations?
• Additional information needs?
• Permit requirements?
• Mitigation requirements?

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ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

Multi Agency Task Force Meeting

Comment Sheet

PROJECT NAME: Nome Airport RSA Expansion Snake River Relocation Study

DATE: November 17, 2010

- Need more info on existing bird strikes on that (west) side of runway, what species and density of wildlife use area now + what might use new wetland habitat, ie, will increase/decrease strike likelyhood. Do sandhill cranes nest in area?
- Large, riparian willows and other larger shrubs elsewhere are scarse + high-value small bird habitat in this area
- Consider stockpiling usable gravel/fill for future projects instead of wasting into wetlands or dredge ponds
- Mitigation Option: improve culverts from Dry + Burbot Creek into Bay for fish passage + estuary habitat rehab (forgot road name)
- Corps will have to decide if created wetlands offset loss, including risk of creation failure and temporal delay between loss and created function replacement.

Name: Bob Henszey   Agency: FWS

ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

Multi Agency Task Force Meeting

Comment Sheet

PROJECT NAME: Nome Airport RSA Expansion Snake River Relocation Study

DATE: November 17, 2010

Relative to this project, the specific concern for the ADEC Solid Waste Program is ensuring that all regulated solid waste is properly disposed. This includes the asphalt-containing drums in AOC-1, other hazardous and non-hazardous solid wastes that may be encountered, and (possibly) the 1.6 million cubic yards of excavated soil generated by the project. As reported in the Technical Memorandum of November 12, 2010, the City of Nome has refused to accept the drums of asphalt at the city's landfill and those drums will be shipped to another permitted facility for proper disposal (if the asphalt cannot be used). Any other solid wastes found in the project area that are not accepted at the Nome landfill can also be properly managed by shipment to a facility that is permitted for the disposal of those items.

The biggest uncertainty for this project is the regulatory status of the excavated soil. Although excavated soil is generally not considered a solid waste, elevated metals concentrations (the Technical Memorandum mentions arsenic, chromium, lead, and mercury in soil) may necessitate that the excavated soil be regulated as a "polluted soil" when it is disposed. Under the solid waste regulations, soil is considered "polluted" if it contains a hazardous substance in excess of the applicable soil cleanup levels in Table B1 or Table B2 of 18 AAC 75.341. (The applicable cleanup levels will need to be established in coordination with the ADEC Contaminated Sites Program.) If the applicable levels are not exceeded, the soil is not polluted and is exempt from the regulations.

If the excavated soil qualifies as "polluted soil", then both of the selected disposal sites (the "Disposal Area" to the south of the project area and the dewatered river channel) will need to be permitted. However, the solid waste regulations allow soil that is polluted by naturally-occurring metals to be disposed without a permit if the soil is returned to the location from which it was excavated or is disposed in another area with equal or greater concentrations of the same metals. Thus, a disposal permit will not be needed for the proposed disposal areas if the background metals concentrations in those areas are equal to or higher than the metals concentrations in the excavated soil. Additional information is needed to document background soil conditions and to establish the regulatory status of the excavated soil.

Name: Doug Buteyn **Agency:** ADEC Solid Waste Program

The Technical Memorandum mentions the need for additional soil sampling to discern where the various metals are located. Any future soil sampling in the project area should be planned such that the results obtained will also allow separate characterization of the excavated soil and the proposed disposal areas with regard to metals. The sample results will then allow the Solid Waste Program to determine whether the excavated soil is "polluted" due to metals concentrations and, if so, determine whether the permit exemption mentioned above applies to the proposed disposal areas.

If a disposal permit is required for either or both of the disposal areas, the areas can be permitted separately under individual permits or, as applicable, permitted together under a single comprehensive permit. Either way, the Solid Waste Program will review the design and operating plan for either or both disposal areas as part of its review of the permit application(s). Please note that the melt water management system associated with the permanent disposal area will need to be reviewed by the ADEC Division of Water for compliance with water quality standards and discharge requirements.

Name: Doug Buteyn **Agency:** ADEC Solid Waste Program

Nome Airport RSA Expansion Snake River Relocation Study
Second Multi-Agency Task Force Meeting
November 17, 2010

Comment Resolution

- ✓ **Alternatives analysis including cost**

- ✓ **Effects to existing harbor**

- ✓ **Opportunities to enhance harbor for fish habitat, wetlands, contamination removal**

- ✓ **Maintain old channel for snow machine traffic**

- ✓ **Snow dams/ice jams**

- ✓ **Creation of habitat features in the narrow floodplain**

- ✓ **Floodplain habitat creation for birds**

- ✓ **How to address erosion and slumping of banks in a narrow valley after construction?**

- ✓ **How will sediment transport occur in the new channel?**

- ✓ **How will we reduce the "first flush" of sediment in the channel after construction?**

- ✓ **How to maintain fish habitat during the first few years after construction when spring floods move a lot of sediment?**

Appendix D

Initial Geotechnical Findings, Snake River Relocation Alternative for the Nome Runway Safety Area Expansion Project, Nome, Alaska

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SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
Alaska • California• Colorado •Florida • Missouri • Oregon • Washington

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Fairbanks, Alaska 99709-5326
(907) 458-3100 FAX: 479-5691
E-mail: sa@shanwil.com

Transmittal

To:	USKH, Inc.	Attn:	Mr. Hans Arnett
	2515 A Street	Date:	November 16, 2009
	Anchorage, Alaska 99503	Job #	31-1-02175-001
		Re:	Initial Geotechnical Findings, Snake River Relocation Alternative for the Nome Runway Safety Area Expansion Project, Nome, Alaska

The following items are enclosed:

Copies	Description
1	Report

These are transmitted:

X As requested
☐ For review and comment
☐ For your use
☐ For your action
☐ For your information
X For your files

Comments:

Copies to:

By: Frank Wuttig
Title: Associate

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

ALASKA
CALIFORNIA
COLORADO
FLORIDA
MISSOURI
OREGON
WASHINGTON

November 16, 2009

USKH, Inc.
2515 A Street
Anchorage, Alaska 99503

Attn: Mr. Hans Arnett

RE: INITIAL GEOTECHNICAL FINDINGS, SNAKE RIVER RELOCATION ALTERNATIVE FOR THE NOME RUNWAY SAFETY AREA EXPANSION PROJECT, NOME, ALASKA

We are pleased to present the results of our initial (Task 1) geotechnical findings for the Alaska Department of Transportation and Public Facilities (ADOT&PF)'s Snake River Relocation project, one alternative allowing for expansion of the Nome Runway Safety Area (RSA). In this alternative, the RSA for the east-west (main) runway is extended west across the current location of the river, requiring relocation of the lower Snake River channel. The purpose of this letter is to summarize our research and review of existing geotechnical information and our reconnaissance visit to Nome. In addition to our Task 1 services, we also prepared geotechnical concepts for channel geometry and discussed the geotechnical challenges for the project.

The letter report is organized into four primary sections: the first describes the project and extent of our research; the second discusses surface conditions and the results of our site reconnaissance; the third section presents anticipated subsurface conditions based on our research and site reconnaissance; and the fourth summarizes our concepts and a discussion of the geotechnical challenges of the project. We have not refined the future exploration plan, as we understand the alignments are likely to change.

PROJECT DESCRIPTION

Two alignment options are under consideration for the Snake River relocation. One option relocates the Snake River within a new stream valley oriented roughly north-south to a new river mouth along the Norton Sound coast (the New River Mouth Option); the second relocates the river to the south in an alignment that roughly parallels its existing course, and reconnects to the lower river downstream of the south end of the crosswind runway (the Lower River

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Reconnection Option). Both alignments take off from the existing river upstream of the maximum projected expansion of the main runway and safety areas. The Lower River Reconnection Option is south of the southward extension of the crosswind runway, which requires routing the river through a mining pit currently filled with water (informally called the mining pit pond). The existing Nome Airport and Snake River, and the approximate alignments of the two relocation options, are shown on the attached aerial photo map (Figure 1).

Research

We reviewed existing literature, available geotechnical information, aerial photographs, and information regarding past projects we have completed in the area, contained in our files. The majority of the available geotechnical information is from sites in the City of Nome, at the airport, and along streets and highways in the area, all of which are on the opposite bank of the Snake River Relocation project area. Exploratory work in the immediate project vicinity has been conducted primarily by mining companies exploring for gold; this information is not in the public domain. Our primary sources of information were:

- Alaska Climate Research Center Web site Temperature Data 1900-2007;
- Alaska Department of Transportation & Facilities (ADOT&PF), Technical Services Materials Section, Geotechnical Report – Investigation and Analysis of the Nome Runway Settlement Problems, Project No. R10184, Location/Design Study Appendix 1;
- DOWL Engineers, Final Subsurface Exploration For Foundation Recommendations, Norton Sound Regional Hospital, Nome, Alaska;
- Ferrians, O.J., Permafrost Map of Alaska;
- Hopkins, D., MacNeil, F., and Leopold, E., 1960, The coastal plain at Nome, Alaska – a Late Cenozoic type section for the Bering Strait Region from the 1960 International Geologic Conference;
- Jorgenson, T.; Yoshikawa, K.; Kanevsky, M.; and others, Permafrost Characteristics of Alaska;
- Quadra Engineering, Inc., Geotechnical Study, Water and Sewer Improvements, Phase 1;
- R&M Consultants, Inc., Geotechnical Investigation and Recommendations Report, Nome Airport Rehabilitation, Runway Settlement and Heave Evaluation, Nome, Alaska;
- Shannon & Wilson, Inc., 2008, Draft Geotechnical Study, UAF Northwest Campus Deferred Renewal, Nome, Alaska; and

- Shannon & Wilson, Inc., 2005, Geotechnical Study, Nome City Streets.
- In addition to the information in these studies, we reviewed information provided by NovaGold Resources Inc (NovaGold), including selected exploration logs and a database containing limited subsurface information.

Site Reconnaissance

Shannon & Wilson geological engineers Frank Wuttig and Matt Billings conducted a geotechnical reconnaissance of the project site October 13-14, 2009. Our reconnaissance consisted of:

- walking the majority of the proposed routes;
- observing terrain features;
- hand-probing for permafrost;
- observing the surface for indications of permafrost and thaw-instability;
- observing the stability of existing cut and fill slopes;
- interviewing Nikolai Ivanoff, a NovaGold representative;
- reviewing exploratory boring logs in NovaGold offices; and
- observing the stability of other earthwork structures in the Nome area.

SURFACE CONDITIONS

Both proposed relocation routes traverse a prominent, broad, east-west ridge between the lower Snake River and the Bering Sea. The New River Mouth crosses largely undisturbed terrain vegetated with tundra and dotted with scattered thaw lakes and swampy areas. The surface along this route is frequently hummocky and poorly drained. The hummocky areas are likely an indicator of solifluction, the slow downhill flow of soil caused by cryogenic processes. Photographs of surface conditions observed during our field reconnaissance (keyed to Figure 1) are in Appendix A.

A large portion of the Lower River Connection Option crosses areas that were typically mined with a dredge. The surface of the mined areas across the project are generally covered with a variety of fill materials, access roads, and what appear to be drained settling/tailings ponds. The characteristic fan-shaped pattern of coarse material left by dredging has been reworked or covered with fill in much of the area. The preponderance of surficial fill consists of sandy, gravelly silt to silty, sandy gravel with cobbles and occasional boulders; with fairly steep angles of repose. We also observed a stockpile of oversized material consisting of cobbles and boulders. A vegetated backslope cut into natural soils along one edge of a settling/tailings pond had a slope of approximately 33 degrees.

Dredging generally overturns and sorts the natural soil profile, with finer soils deposited near the bottom and coarser soils near the top. Dredging operations generally involve removing the near-surface silty and organic-rich layer, prethawing the underlying soils down to bedrock using cold water and thaw points, followed by dredging. The entire section of thawed material is then dredged, washed, and processed, with the coarser material separated from the finer gold-bearing sands and gravels. The gold-bearing sands and gravels are run through a sluice box and, along with the silts, discharged into the dredge pond. The coarser material is stacked over the finer tailings in a characteristic fan-shaped pattern using a conveyor. Unmined remnants of natural ground may exist between dredge passes.

A portion of the Lower River Connection Option crosses a large irregular water-filled mining pit, excavated in 1996-97. Mining operations targeted a thin layer of gold-bearing marine deposits on top of bedrock; excavated material above this layer was wasted. Excavation and mining was done in the winter; the ore was processed the following summer. Except for the near-surface, excavated by ripping with a dozer, excavation was accomplished by drilling and blasting due to the presence of permafrost. We understand the soils in the excavation were thawed near the coast, and slow water seepage has occurred. The excavation slopes were cut vertically where frozen.

Afterward, the excavation filled with water; side slopes sloughed to their current configuration. We measured slopes of 36 degrees and steeper at one point along the edge of the excavation, where the soils consisted of silt overlying marine sands. The slopes appear to be relatively stable, except along the southern edge near the coast.

A portion of the southern edge of the excavation is separated from the coast by a narrow strip of land approximately 50 feet wide covered with natural tundra. Tension cracks in the tundra occur across the width of the strip; we observed active sloughing along the excavation side. The depth to permafrost in the center of the strip was 2.5 feet to 3 feet, where probed, at the time of our observations.

Access roads across the project site and off-site along the runways at the airport show evidence of thaw-instability. Depressions 1 foot to 3 feet deep occur in the road surface where maintenance is infrequent. Thaw-settlement depressions (thermokarst) with ponded water were noted along the edges of road embankments or fills placed over natural ground. Paved Nome city streets, including the Seppala Drive, Bering Street, and the east end of Front Street, have significant settlement depressions.

We observed a cut and access road at the airport for stability. A 25-foot-high cut into natural soils, laid back on a 4-horizontal-to-1-vertical slope, exists along the north side of the main runway, with an access road along the top. Soils in the cut consist of approximately 1 foot of slightly silty, fine to medium sand underlain by brown silt. Overall, the cut slope currently appears stable. The slope surface undulates slightly, indicating past thaw-instability. Areas of small tension cracks suggest solifluction or settlement processes are active on the slope. Settlement and ponded water along the gravel access road above the slope indicate the presence of relatively thaw-unstable soils.

SUBSURFACE CONDITIONS

Geology

The Nome area lies on a coastal plain rising from sea level to rolling hills north of town. The plain is underlain by a sequence of marine and glacial sediments resulting from several glaciations and marine transgressions overlying a marine platform of schist bedrock. The coastal plain at Nome has been covered by glacial ice twice during glacial ages (Nebraskan or Kansan, and Illinoisan) preceding the last (Wisconsin) glacial age. During the last glacial age, ice did not reach Nome. Three marine stratigraphic units (Submarine Beach, Third/Intermediate Beach, and Second Beach) record three separate marine transgressions of the coastal plain, depositing near-shore marine sediments of sand and gravel, with some clay.

In the project area, Nebraskan- or Kansan-age till (Iron Creek glaciation) is underlain by a thin discontinuous layer of marine sediments consisting of sandy, gravelly sand and clay (Submarine Beach) resting on an undulating schist bedrock surface. The northern extent of Submarine Beach deposits ends at what appears to be a sea cliff cut into bedrock surface, based on a difference in the elevation of the bedrock surface on opposite sides of the of the main Runway at the airport. An expression of the sea cliff can be seen in bedrock elevations in NovaGold's data, plotted in Figure 2.

Till of the Iron Creek glaciation is in turn overlain by a discontinuous sheet of sand and gravel from the Third/Intermediate Beach. Overlying these sediments are Illinoisan-age (Nome River Glaciation) till deposits formed as valley glaciers flowed down the Nome and Snake Rivers, coalescing and spreading out as piedmont glaciers on the coastal plain. The broad ridge separating the lower Snake River from the Bering Sea in the project area is a morainal ridge from the Nome River glaciation. The coastal side of the morainal ridge is covered by marine sediments of Second Beach, consisting of 10 feet to 25 feet of well-sorted sand and gravel, to an elevation of approximately 40 feet. The equivalent marine deposits on the Snake River side of the ridge consist of finer-grained estuarine sediments.

During the last glacial age (Salmon Lake glaciation), ice was confined to the upper Nome and Snake River valleys, and did not reach the coastal plain. Outwash filled a buried gorge beneath the Snake River and incised tens of feet into the underlying schist bedrock. A thin layer of loess was deposited across the coastal plain, and intense frost-action resulted in a reworking of the loess and movement of colluvium, masking the original glacial relief of the preceding (Nome River) glaciation and covering the Second Beach deposits. The reworked loess and colluvium is typically thinner on ridges, thickening to 5-foot to 10-foot in swales and gullies. Fibrous peat, ranging in thickness from 1 foot to 10 feet, may underlie swales, drained lake basins, and poorly drained areas.

General Soil Conditions

Based on our review of existing geotechnical information in the Nome area, we anticipate the following general soil conditions along the two alignment options.

Windblown Silt, Peat, and Colluvium. We anticipate the surface to be underlain by ice-rich peat, peaty silt, and silt up to 20 feet thick. NovaGold's experience has been that these soils average about 12 feet in the project area. We expect moisture contents in the frozen peat of several hundred percent, and 30 percent to more than 100 percent in the organics and silt. Visible ice in both soil types may range from individual crystals to thick lenses. The percentage of ice by volume could average 30 percent to 40 percent and exceed 50 percent. The deposits are highly thaw-unstable, resulting in large differential ground settlements and thermokarsts, in addition to being extremely weak.

Till. Aside from some marine beach deposits, we anticipate the windblown silt, peat, and colluvium cover will be underlain primarily by glacial till. Based on our observation of mine tailings across the site, logs provided by NovaGold, and research of geotechnical studies, the underlying tills may consist of a mixture of silty sands and sandy silts that may be slightly gravelly to gravelly and contain highly variable amounts of cobbles and boulders. In general, we expect visible ice contents to be less than 10 percent and moisture contents less than 40 percent. Upon thawing, we anticipate moderate-strength loss, depending on the rate of thaw and moderate ground deformation due to thaw-instability.

Third Beach. These deposits may occur in the subsurface across the northern portion of the site within the till section. The deposits have been described as consisting of 5 feet to 10 feet of sand, gravel, silty sand, and sandy gravel. We expect these sediments to have low to moderate ice and moisture contents, and be slightly to moderately thaw-unstable. Due to their marine origin, elevated porewater salinity may be present.

Second Beach. These deposits underlie the surficial layer of windblown silt, peat, and colluvium across the southern portion of the project area; they have been described as consisting of poorly graded sand and gravel 10 feet to 25 feet thick. We expect these sediments to have low to moderate ice and moisture contents, and be slightly to moderately thaw-unstable. Due to their marine origin, elevated porewater salinity may be present.

Submarine Beach. Deposits of the Submarine Beach lie on an undulating bedrock surface or clay overlying bedrock. The marine sediments are described as typically consisting of sand and gravelly sand. We expect these sediments to have moderate ice and moisture contents and be slightly to moderately thaw-unstable. Due to their marine origin, elevated porewater salinity may be present. We do not expect the river relocation cut will extend down to these sediments.

Schist Bedrock. The bedrock in the area has generally been described as completely to highly weathered mica or graphitic schist. We expect ice contents in the schist to be low and the material relatively thaw-stable. Bedrock strength is expected to be highly variable in the thawed state. Based on exploratory information provided to us by NovaGold, described in the following section, we do not anticipate encountering bedrock in the cut for the river relocation.

Dredge Tailings As we indicated, dredging generally overturns and sorts the natural soil profile, with finer soils deposited beneath coarser soils. Silts are commonly found immediately overlying bedrock, followed by sands and then coarser tailings at the surface The fine-grained materials and sands were deposited in the dredge ponds in a very loose condition. Narrow, irregularly shaped areas of natural soils may be present between dredge passes. We anticipate dredge tailings will generally be thaw-stable; it is possible there are limited areas where the slightly thaw-unstable permafrost may have begun to regenerate.

Existing Site-Specific Explorations

The project area has been extensively explored with borings by various mining companies beginning in 1922 and ending in 1997. NovaGold provided us with selected drill logs and a data base containing information on depth to bedrock and frozen ground. The drilling was done for the purpose of gold exploration; therefore, the geotechnical information in the logs, in particular ice content, is often limited. The borings were typically drilled to bedrock. In Figure 2, we have presented approximate boring locations, depth to bedrock, and frozen ground conditions. Boring locations mined after drilling are also indicated on the figure.

Based on our conversation with NovaGold and a review of their logs, we anticipate 2 feet to 3 feet of highly organic material at the surface is underlain by highly thaw-unstable, organic silt containing occasional rock fragments to depths averaging near 12 feet (depths expected to vary), representing the reworked loess, colluvium, and peat described above.

Below these surficial organic soils, we anticipate primarily tills composed of a variable mix of gravel, sand, and silt with some clay, with thinner layers of marine sands and gravels. The fines content in the tills will likely be high enough to control behavior. Ice-content of these materials is difficult to discern from the logs. NovaGold indicated these sediments are lower in ice content than the overlying organic soils. Based on our experience elsewhere in the Nome area, ice-content typically decreases below the surficial layer of silt and organics, which can be up to 20 feet thick.

Bedrock elevations in NovaGold's data suggest bedrock in the project area is typically 20 feet to 45 feet below sea level, with a general trend of decreasing elevation from the north (Snake River) to the south (Norton Sound). As we described, the northern extent of the Submarine Beach deposits end at what appears to be a sea cliff cut into the bedrock surface, based on a difference in the elevation of the bedrock surface on opposite sides of the of the main runway at the airport. An expression of the sea cliff can be seen in bedrock elevations in NovaGold's data plotted in Figure 2.

Groundwater

We anticipate groundwater along the new stream valley will occur as supra-permafrost water perched on top of permafrost in the active layer and shallow taliks, in taliks extending through to the base of the permafrost, and as sub-permafrost water. We anticipate mine tailings will most likely be thawed, although permafrost may have been regenerated following mining, depending on the surface-heat balance, thermal characteristics of the soils, and groundwater movement. We suspect a deep talik extending to the base of the permafrost may occur in the 1996/97 mining pit. The water level in the pit was approximately 18 feet above sea level at the time of our field visit in October 2009.

In mined areas, we expect groundwater to be above sea level, as evidence by water levels in the flooded mining pit at the site. Groundwater in dredge tailings may be perched in the coarser materials overlying the finer silts and bedrock.

Zones within the permafrost that are not bonded due to elevated salinities and freezing point depression of the porewater may be encountered. At the airport isolated areas of significant salinity (up to18.8 ppt) were discovered in previous investigations. In general, however, salinities were in the range of 0 to 3 ppt. For reference, seawater salinity averages about 35 ppt.

We drilled seven exploratory borings for a geotechnical study on the UAF Northwest Campus, to depths ranging from 35 feet to 70 feet; we encountered salinities generally in the range of 1 to 4 ppt, with one exception of 8 ppt.

Permafrost

Nome is in a subarctic zone, where the coastal plain is underlain by discontinuous permafrost. Permafrost is defined as ground with a temperature below 32 ºF for two or more years.

Permafrost along the coast of Norton Sound is naturally relatively warm, degrading if the thermal regime is adversely impacted by modifications to the ground surface. The thickness of the active layer (the near-surface ground that undergoes an annual freeze-thaw cycle) is largely dependent upon soil type, ground cover, and snow depth. Frost-penetration beneath areas kept clear of snow may exceed 10 feet. Frost-penetration in areas covered by organic material or snow is typically 3 feet to 5 feet or less.

Permafrost in the Nome area has been measured to be up to 90 feet to 120 feet thick (Ferrians, 1965). In the UAF Nome Northwest Campus study, permafrost was encountered from depths of 5 feet to 12 feet deep down to depths between 40 feet to more than 51.5 feet.

We probed the active layer in the undisturbed terrain during our October 2009 site visit, at the end of the thawing season; results indicated generally shallow permafrost with an active layer on the order of 2.5 feet thick. In swampy areas with significant standing water, we occasionally did not encounter permafrost within the 4-foot probed depth. A winter trail, approximately 12 feet wide, along the crest of the east-west ridge across the project was also thawed deeper than our 4-foot-long probe. The ground surface across the trail has settled approximately 2 feet. Permafrost beneath narrower four-wheeler trails crossing the tundra was typically only slightly deeper than that beneath the undisturbed tundra surface.

Frozen ground information from existing mineral explorations, generally conducted prior to mining (Figure 2), suggests permafrost conditions prevail throughout the area with notable taliks. A large area at the airport on the north side of the river has thawed, as has a smaller area south of the Lower River Reconnection option within the project area. It appears mining may have been preferentially conducted to take advantage of these thawed conditions.

Along both the New River Mouth Option and Lower River Reconnection Option, the boring logs show generally frozen conditions existed at the time of exploration.

CLIMATE

Nome lies on the southern Seward Peninsula along the Norton Sound coast. Although coastal, the maritime influence of the open water of Norton Sound is typically greatest from early June to about the middle of November. Storms moving through this area during these months result in extended periods of cloudiness and rain, with nearly continuous cloud cover during July and August. Winds in the warmer months are relatively light, from the southwest.

When Norton Sound freezes in November, the climate changes considerably, from maritime to more of a continental climate. The majority of low-pressure systems track across the Bering Sea to the south of Nome, resulting in strong easterly winds which often bring blizzards, with winds later changing to northerly, reaching Nome across the colder frozen areas of northern Alaska. Winds higher than 70 mph have often been recorded. With the lack of forests, windblown snow is common.

Nome has a long historical climatological dataset beginning in 1900; however, data obtained before about 1949 are of poorer quality, and there are observations missing from the record. For the period of 1950 to 2008, the mean annual temperature measured at the airport is 26.4°F. The period prior to 1977 was cold, with a mean of 1.4 °F colder than the long-term mean; 1977 to 2008 was warmer, with a mean 1.2°F warmer than the long-term mean.

Temperatures generally remain well below freezing from the middle of November to the later part of April; January is usually the coldest month of the year with a mean temperature of -2°F. Temperatures usually begin to rise near the end of February, continuing to rise until they reach a maximum in July. During the summer months, the daily temperature range is very slight with highs typically around 55°F.

Precipitation reaches maximum during the late summer months, dropping to a minimum in April and May. Snow begins to fall in September, but usually does not accumulate until the first part of November. The snow cover decreases rapidly in April and May, and normally disappears by the middle of June. Snow depths in Nome have exceeded 70 inches. Most of the snowfall occurs November through January.

Climate Change

The topic of climate change is important to structures in permafrost areas. The earth's climate has changed in the past and will continue to change in the future. It is recognized that the earth has warmed on average approximately 1°F in the last century. In arctic marine regions, the warming was about 1.7°F. Global climate models through the end of the twenty-first century project a warming for the entire Arctic of 6°F to 12°F. The warming is expected to be greatest during the colder seasons.

Cycles of cooler and warmer periods lasting on the order of several decades are evident in temperature records across most of Alaska. Warmer periods occurred prior to the mid-1940s and after 1977. A cooler-than-average period occurred from the mid-1940s to 1976.

The temperature trends observed in Nome are consistent with statewide observations. The temperature departure from the long-term mean observed from 1950 to 2008 for Nome is shown in Figure 3. Prior to 1977, mean annual temperatures were typically below the long-term mean; after, they are generally above the long-term mean. The mean for the record from 1950 to 1976 is near 25°F; from 1976 to 2008 is near 27.6°F, an increase of 2.6 degrees. Analyzing the trends by freezing and thawing seasons, most of the change appears to be occurring during colder seasons (Figures 4 and 5). This is consistent with reports that most of the change has occurred in winter and spring, with the least amount of change in autumn.

Increased air temperatures may result in permafrost warming and increased active-layer thickness. Long-term permafrost degradation may also occur if the permafrost is close to freezing. Nome is in an area of discontinuous permafrost. Measured permafrost temperatures in Nome, below the depth at which seasonal frost occurs, are typically near 30°F or warmer depending on surface conditions. Given the relatively warm nature of the permafrost, small changes to the heat balance at the surface could alter the thermal regime toward long-term thawing of the underlying permafrost.

GEOTECHNICAL CONCERNS AND CONCLUSIONS

The primary geotechnical concern in relocating the Snake River across the site is the stability of cut slopes paralleling the new channel. The stability of cut slopes will be significantly affected by the presence of potentially thaw-unstable permafrost, surface water, and groundwater. We expect both alignment options will cross thaw-unstable permafrost. Given the relatively warm nature of permafrost in the Nome area, we anticipate excavations may cause significant thermal degradation of the surrounding permafrost. While relatively steep slopes may stand in frozen ground, they will become unstable as the permafrost thaws.

We expect excavation and construction of a new river valley will alter the surface-heat balance, resulting in warming permafrost and an increase in active-layer thickness beneath the valley side slopes, and possible long-term permafrost degradation. Factors such as vegetative cover, snow cover (including drifting), slope aspect, climate change, as well as other factors, could alter the thermal balance toward thawing. Given the uncertainties of climate warming and complex surface-heat balance, accurate prediction of permafrost thawing is difficult. In general, we assume long-term permafrost degradation could occur along portions of the new route, depending on local conditions.

We anticipate a talik will form around the new Snake River channel due to warmer surface conditions in the bed of the channel, convective heat transfer due to water flow, and exposure to brackish water. We expect the thaw bulb will likely extend to bedrock, which we expected may be on the order of 20 feet to 45 feet below sea level, based on NovaGold's information. Given permafrost in the Nome area is typically less than 90 feet to 120 feet deep, the talik beneath the channel may well extend to the base of the permafrost.

Construction in Frozen Areas

Based on our research of existing information, we anticipate the upper 12 feet to 30 feet of silt, peat, and colluvium will likely be ice-rich and highly thaw-unstable. In our opinion, the majority of the settlement distress and thermokarst development observed in the Nome area is likely due to this layer thawing.

Existing information suggests ice and moisture content in the underlying frozen till and marine deposits will be lower, although localized ice-rich zones could occur. While some ground settlement and deformation may occur as these soils thaw, we generally do not expect severe settlement, thermokarst formation, and slope instability. Channel-bottom stability will be more a function of scour than soil thaw-instability in the thaw bulb around the new river channel.

Several techniques have been used to make cuts in thaw unstable permafrost, including:

- cutting near vertical slopes with a widened toe area and soil-retention structure to accommodate sloughing;
- buttressing steep cuts with a granular material;

- cutting moderate slopes covered with an insulated gravel layer to provide drainage and retard permafrost degradation; or
- cutting flatter slopes without a protective covering.

Buttressing steep cuts for the full depth with granular materials or covering the entire slope with a granular blanket to provide drainage is not feasible given the size of the project. In our opinion, the most practical option would be to cut relatively flat slopes in the tills and marine deposits, and cut relatively steep slopes and buttress the highly thaw-unstable silts and organics soils at the surface. Conceptually, cuts in the tills will be sloped in the range of 2.5-3.5 horizontal to 1 vertical to reduce instability, depending on ice content. The overlying ice-rich soils would be cut nearly vertical and buttressed with granular material. The slope of the buttress should match the flatter slopes in the underlying materials. The slopes would be covered with a thick layer of organics saved from grubbing the site or intact turf recovered from the site. For conceptual planning purposes, we suggest assuming the upper 12 feet will require buttressing.

Conceptually, all excavation and stabilization would be conducted in the winter during freezing temperatures. In our opinion, it would be difficult to accomplish the work during the summer months due to thaw-weakened soils.

We anticipate some instability of the cut slopes in the first few years following construction, but expect the instability will decrease with time. It may therefore be desirable to allow the fresh cuts to partially stabilize for one thawing season or more before rerouting the river channel through the cut. We note that natural cryogenic solifluction processes may continue to cause the slow downhill creep of the near-surface active-layer soils after the overall slopes have stabilized.

We are concerned the ice-rich permafrost adjacent to the buttress at the top of the slope will be thermally disturbed by construction and begin to thaw, which could result in subsidence and thermokarst formation along the buttress, providing an area for surface water to collect and flow. In general, it will be desirable to prevent as much surface water as possible from flowing across the cut slopes, to reduce the potential for slope-instability and surface-icing problems. Careful consideration should be given to a drainage plan. In general, we suggest routing the relocate river to reduce exposure to as much cross-drainage as possible.

The observed instability of the narrow strip of land between the Bering Sea and the 1996-97 mining pit is a concern. Conceptually, the portion of the pit along the strip of the land should be filled with granular mine tailings to increase stability and provide greater separation between the new channel and the coast.

Construction in Thawed Areas

In thawed areas our primary concern is the stability of excavation slopes below the groundwater table, particularly in the loose saturated tailings. Excavation below the water table will have to be planned and construction dewatering, including dewatering wells, may be required to control seepage forces and provide cut-slope stability during construction. Conceptually, slopes in thawed areas would be cut no steeper than 2.5 horizontal to 1 vertical, and vegetated.

We anticipate some of the marine sediments may have elevated salinities and depressed porewater freezing points. We anticipate salinities will be significantly less than seawater. Zones with sufficient salinity to significantly reduce bonding of the soil particles by ice should be treated as thawed zones during construction. Excavation in saline areas will have to be planned and construction dewatering, including dewatering wells, may be required to control seepage forces and provide cut-slope stability during construction.

Icings

Aufeis, also called icings, are sheet-like masses of ice that form in winter in places where water seeps from the ground. Icings can develop where a side slope cut intersects a seep. They occur naturally in many small tributary valleys but can also be initiated by construction, due to inadequate drainage and/or by altering the seasonal frost depth. They can also develop in drainages where a road embankment causes an increase in the depth of seasonal frost blocking subsurface flow, forcing water to the surface, or when stream flow is restricted due to freezing. Icings may also develop as culverts become blocked with ice.

Groundwater seeping onto the cut slope may have a destabilizing effect, and may also result in potential surface-icing problems. We anticipate groundwater in deep natural taliks and taliks associated with mined areas may be drawn down to the level of the new river channel and may not be a primary source of icings on the valley slopes. We expect the primary source of icing may be water perched in the active layer on top of the permafrost or within shallow taliks that daylight into the valley. Cut slope icing problems could be mitigated with a system of subsurface drains.

In our opinion, construction of an extensive system of subsurface drains on the side slopes to control icing may not practical for this project, as impacts to infrastructure and neighboring properties is not a concern. In our opinion, the organic cover proposed for slopes will help reduce frost penetration and maintain drainage in the active layer, reducing icing problems. As mentioned previously, careful consideration should be given to a drainage plan, and we suggest selecting alignments that reduce exposure to cross-drainages as much as possible.

LIMITATIONS

The conclusions and concepts described in this report are based solely on our interpretation of conditions based upon the limited information available to Shannon & Wilson at the time the interpretations and conclusion are made. The concepts developed in this report are not to be used for final design or construction.

Subsurface explorations and testing may identify subsurface conditions significantly different than those interpreted in this report. The passage of time or intervening causes may change the actual conditions as well.

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We trust this information is sufficient for your needs at the present time. If you have any questions, please do not hesitate to call.

SHANNON & WILSON, INC.

Sincerely,

Frank Wuttig

Frank Wuttig
Geotechnical Engineer

Attachments:

Figure 1 - Project Location and Alignment Options
Figure 2 - NovaGold Boring Information
Figure 3 - Mean Annual Air Temperature
Figure 4 - Mean Annual Freezing Index
Figure 5 - Mean Annual Thawing Index
Appendix A - Site Photographs

REFERENCES

Alaska Climate Research Center, 2009, *Temperature data 1900-2007*: Available: http://climate.gi.alaska.edu/Climate/Location/Time Series/Data/omeTx.

Alaska Department of Transportation & Facilities, Technical Services Materials Section, 1986, *Geotechnical report – Investigation and analysis of the Nome Runway settlement problems, project no. R10184, location/design study Appendix 1*: Report prepared by ADOT&PF, Anchorage, Alaska, August, 54 p.

DOWL Engineers, 2008, *Final subsurface exploration for foundation recommendations, Norton Sound Regional Hospital, Nome, Alaska*: Report prepared by DOWL Engineers, Anchorage, Alaska, for Kumin Associates, Inc., Anchorage, Alaska, WOD59614, April, 66 p.

Ferrians, O.J., 1965. *Permafrost map of Alaska*, U.S. Geological Survey Misc. Geol. Inv. Map I-445, scale 1:2,500,000.

Hopkins, D., MacNeil, F., and Leopold, E., 1960, *The coastal plain at Nome, Alaska – a Late Cenozoic type section for the Bering Strait Region*: *in* Report of the Twenty-First Session Norden, Part IV, Proceedings of Section 4, Chronology and Climatology of the Quaternary, 1960, Proceedings: International Geologic Conference, p. 46-57.

Jorgenson, T.; Yoshikawa, K.; Kanevsky, M.; and others, 2008, *Permafrost characteristics of Alaska*, Institute of Northern Engineering, University of Alaska Fairbanks, Albers Alaska NAD83, scale 1:7,200,000.

Quadra Engineering, Inc., 1982, *Geotechnical study, water and sewer improvements, phase 1:* Report prepared by Quadra Engineering, Inc., Anchorage, Alaska, for City of Nome, Nome, Alaska, job no. 1-74, 120 p.

R&M Consultants, Inc., 2007, *Geotechnical investigation and recommendations report, Nome Airport rehabilitation, runway settlement and heave evaluation, Nome, Alaska*: Report prepared by R&M Consultants, Inc., Anchorage, Alaska, for Alaska Department of Transportation & Public Facilities, Fairbanks, Alaska, February.

Shannon & Wilson, Inc., 2008, *Draft geotechnical study, UAF Northwest Campus Deferred Renewal, Nome, Alaska*: Report prepared by Shannon & Wilson, Inc., Fairbanks, Alaska, for UAF Facilities Services Division of Design & Construction, Fairbanks, Alaska, December, 132 p.

Shannon & Wilson, Inc., 2005, *Geotechnical study, Nome City Streets, AKSAS project no. 62234*: Prepared by Shannon & Wilson, Inc., Fairbanks, Alaska, for ASCG Incorporated, Anchorage, Alaska, May, 153 p.

Shulski., M. and Wendler, G., 2007, *The climate of Alaska*, Snowy Owl Books, University of Alaska Press, 216 p.

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Project Location
Lower River Reconnection Option
New River Mouth Option
Mining Pit Pond
15
14
13
11, 12
16
10
17
9
8
7
5, 6
4
2,3
31
32
34
35
30
33
23
24
25, 26, 27
36, 37, 38
39
28, 29
18, 19
20
21
22
Legend:
Conceptual river realignments
10
Approximate photograph location and number*
Notes:
* referenced to Appendix A: Project Photographs
N
0
1,000
2,000
4,000
Feet
Approximate Scale
Initial Geotechnical Findings Report
Snake River Relocation Project
Nome, Alaska
PROJECT LOCATION AND
ALIGNMENT OPTIONS
2009
31-1-02175-001
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
Figure 1

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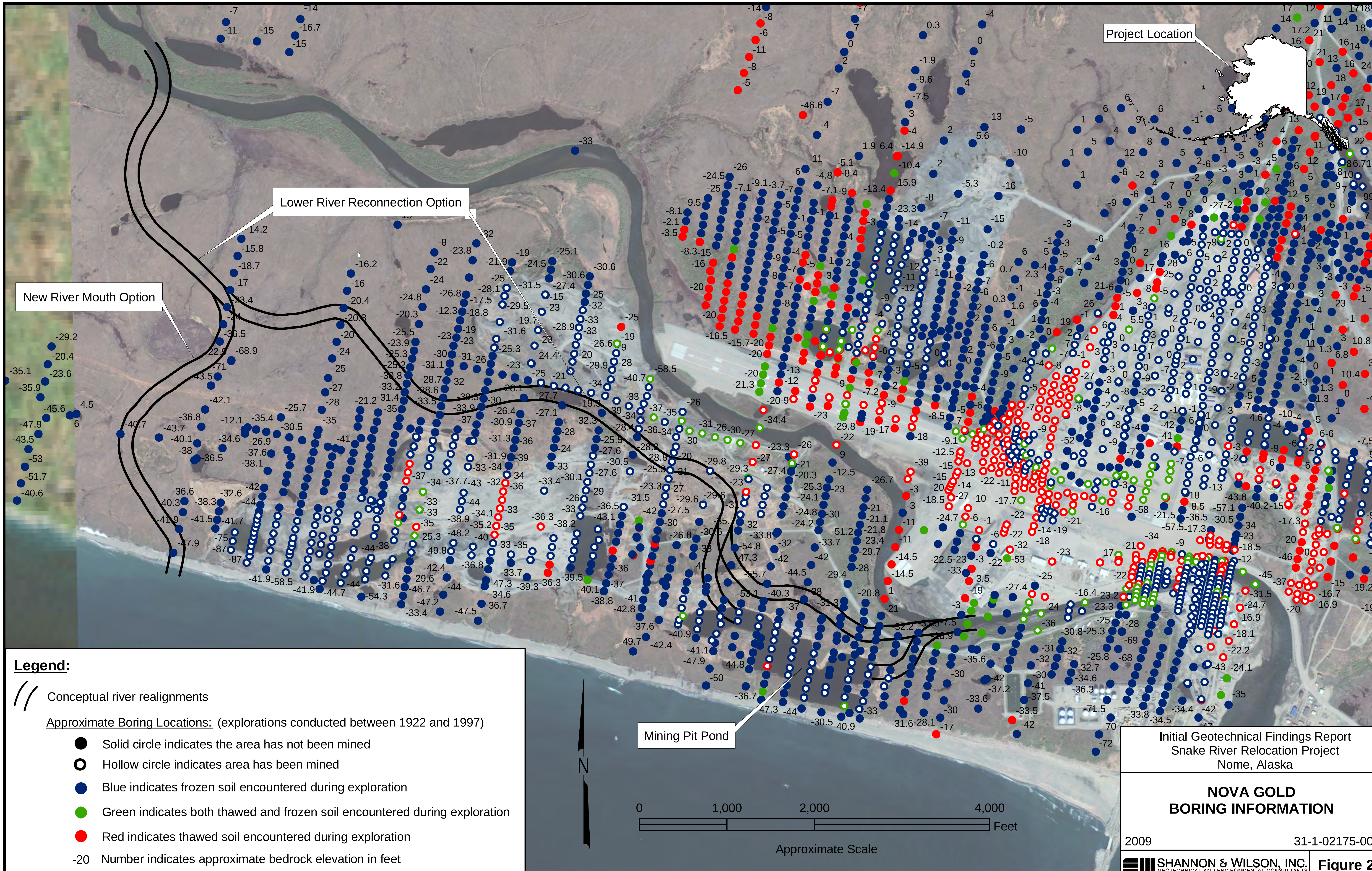

Project Location
Lower River Reconnection Option
New River Mouth Option
Mining Pit Pond
Legend:
Conceptual river realignments
Approximate Boring Locations: (explorations conducted between 1922 and 1997)
Solid circle indicates the area has not been mined
Hollow circle indicates area has been mined
Blue indicates frozen soil encountered during exploration
Green indicates both thawed and frozen soil encountered during exploration
Red indicates thawed soil encountered during exploration
-20 Number indicates approximate bedrock elevation in feet
N
0
1,000
2,000
4,000
Feet
Approximate Scale
Initial Geotechnical Findings Report
Snake River Relocation Project
Nome, Alaska
NOVA GOLD
BORING INFORMATION
2009
31-1-02175-001
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Figure 2

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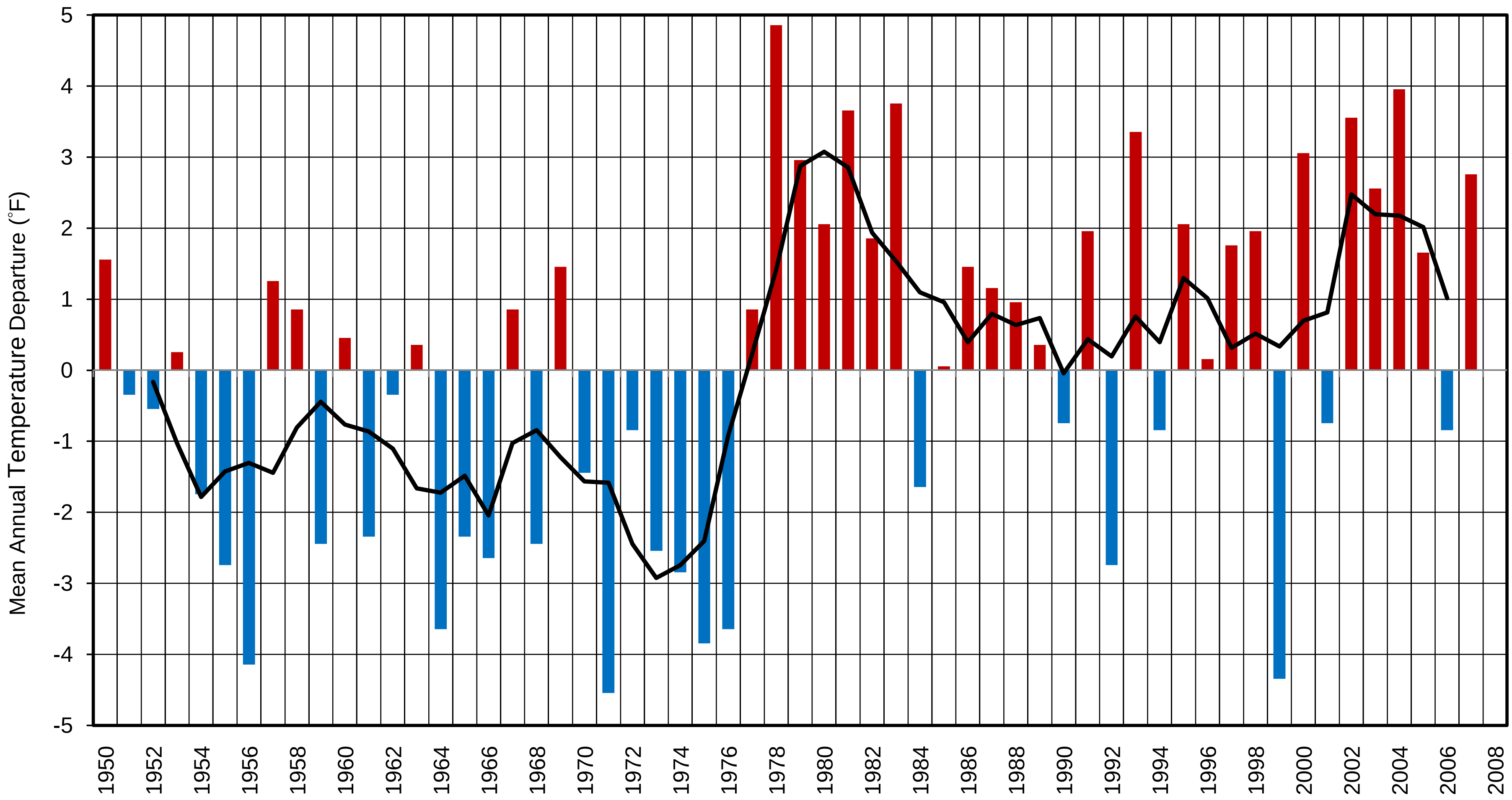

Legend:

- Negative Departure
- Positive Departure
- 5-year Moving Average

Mean Air Temperature:

1950-2008 26.4°F (basis of figure)
1950-1976 25.0°F
1977-2008 27.6°F

Initial Geotechnical Findings Report
Snake River Relocation Project
Nome, Alaska

MEAN ANNUAL AIR TEMPERATURE
NOME MUNICIPAL ARPT (PAOM)
OBSERVING STATION
1950-2008

2009 31-1-02175-001

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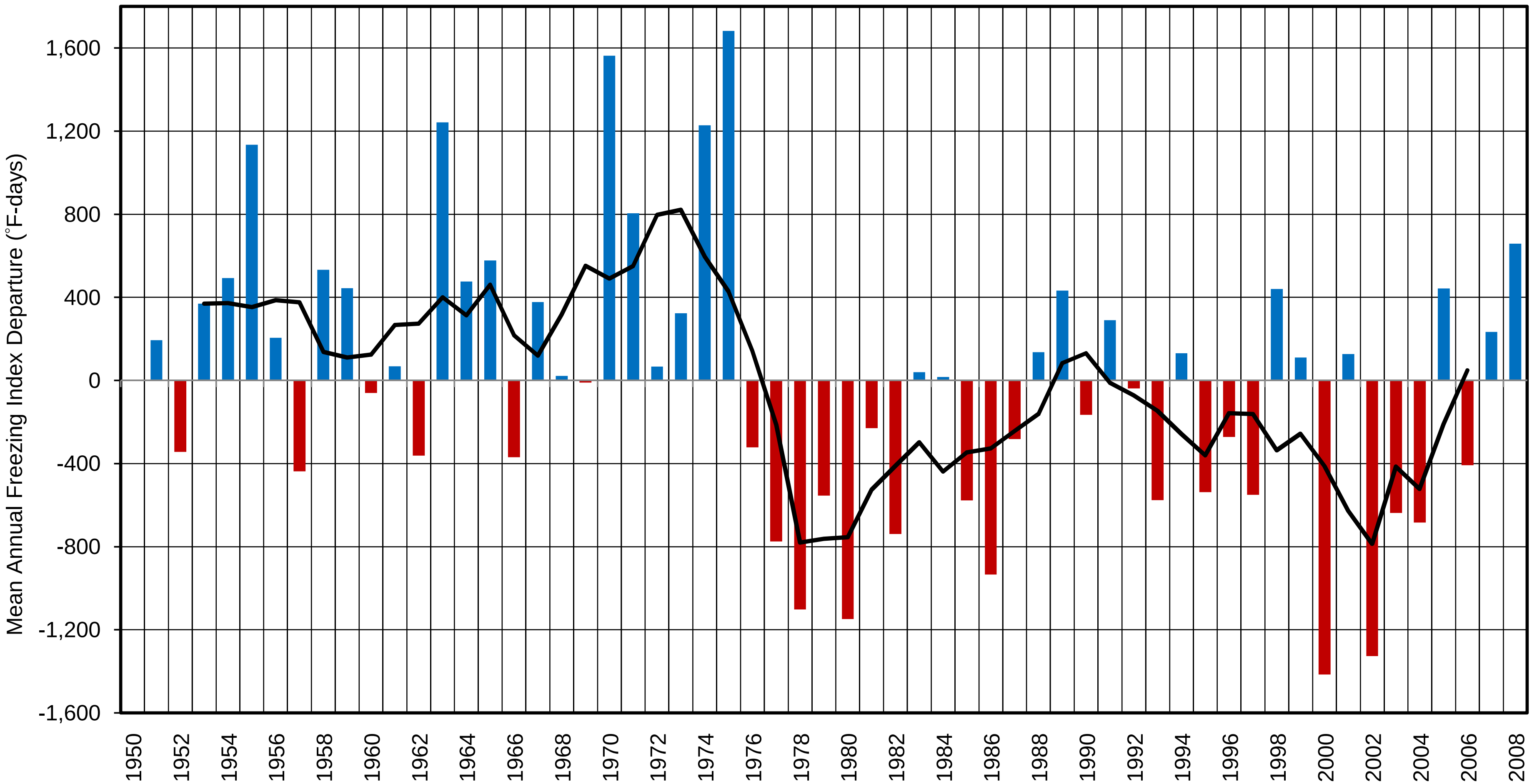
Figure 3



Legend:

Negative Departure
Positive Departure
5-year Moving Average

Mean Freezing Index (°F-days):

1950-2008 4,085°F-days (basis of figure)
1950-1976 4,465°F-days
1977-2008 3,776°F-days

Initial Geotechnical Findings Report
Snake River Relocation Project
Nome, Alaska

MEAN ANNUAL FREEZING INDEX
NOME MUNICIPAL ARPT (PAOM)
OBSERVING STATION
1950-2008

2009

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Figure 4

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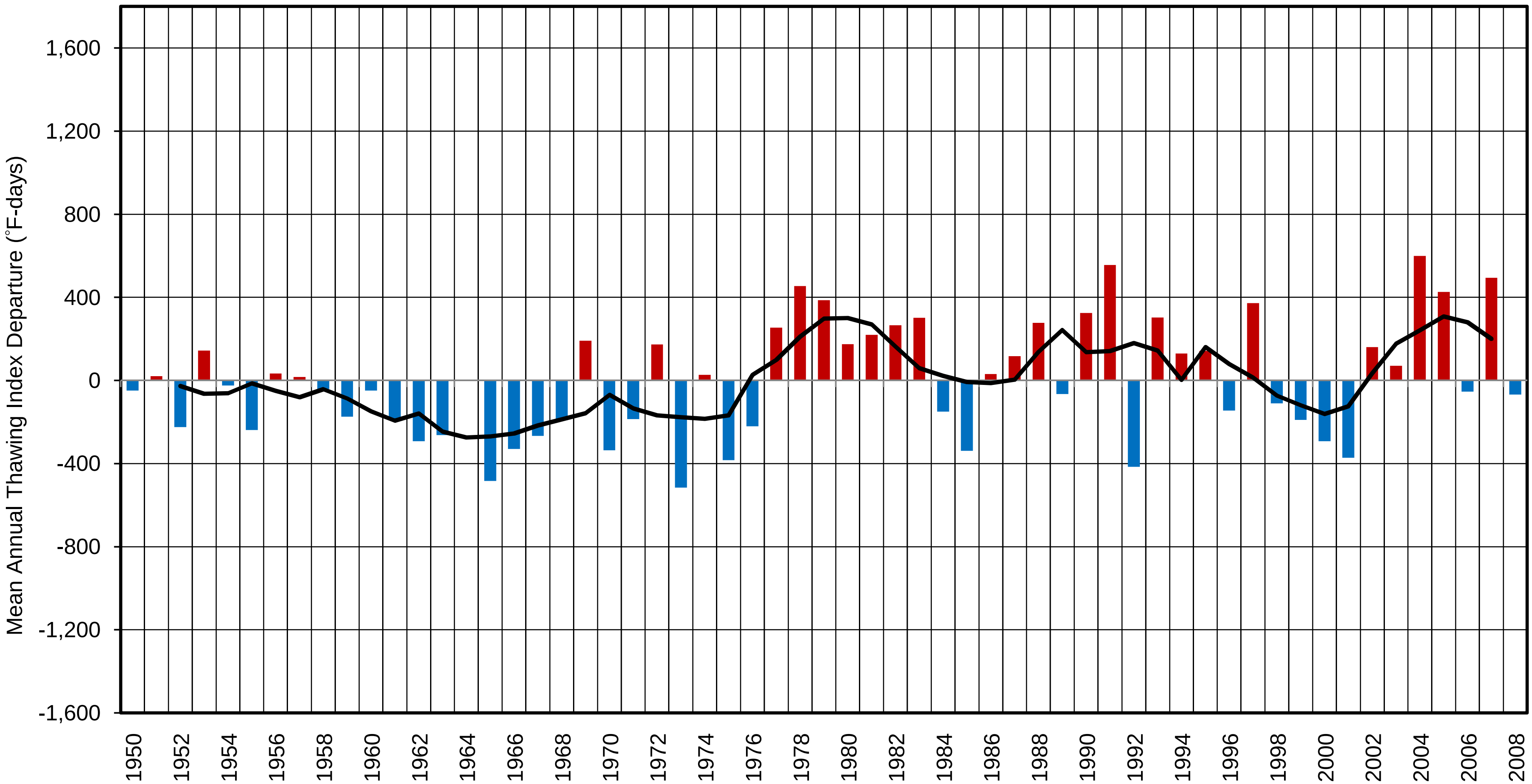

Legend:

- Negative Departure
- Positive Departure
- 5-year Moving Average

Mean Thawing Index (°F-days):

1950-2008 2,063°F-days (basis of figure)
1950-1976 1,921°F-days
1977-2008 2,184°F-days

Initial Geotechnical Findings Report
Snake River Relocation Project
Nome, Alaska

MEAN ANNUAL THAWING INDEX
NOME MUNICIPAL ARPT (PAOM)
OBSERVING STATION
1950-2008

2009

31-1-02175-001

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Figure 5

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APPENDIX A

SITE PHOTOGRAPHS

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Photo 1: Approximate 2H:1V slope in mining cut east of Nome.

Photo 2: Approximate 12-foot-high beach terrace.

Photo 3: Tension cracks at top edge of beach terrace.

Photo 4: Probing permafrost depth.

Photo 5: Hummocky, thermokarst terrain.

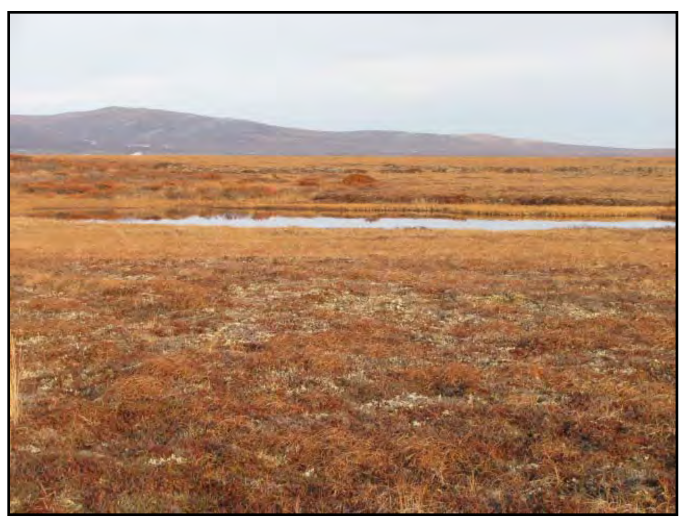

Photo 6: Thermokarst pond.

Photo 7: Possible scarp on Second Beach.

Photo 8: Ridge crest.

Photo 9: Thaw lake within thaw basin, near ridge crest.

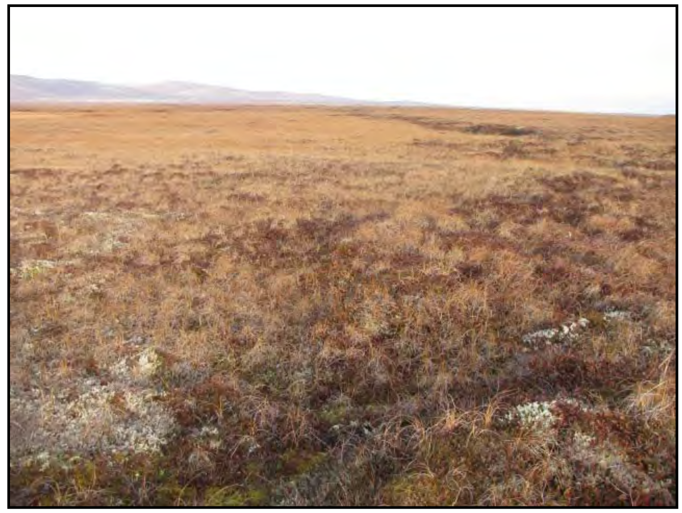

Photo 10: Hummocky ground near edge of thaw basin.

Photo 11: Thaw-lake drainage, draining toward Snake River.

Photo 12: Exposed soil in bank of thaw-lake drainage.

Photo 13: Thaw lake in small drainage.

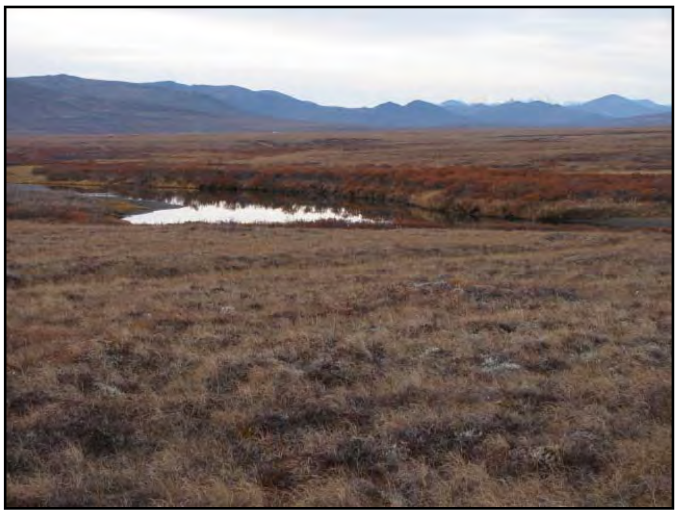

Photo 14: Hummocky ground, sloping toward Snake River.

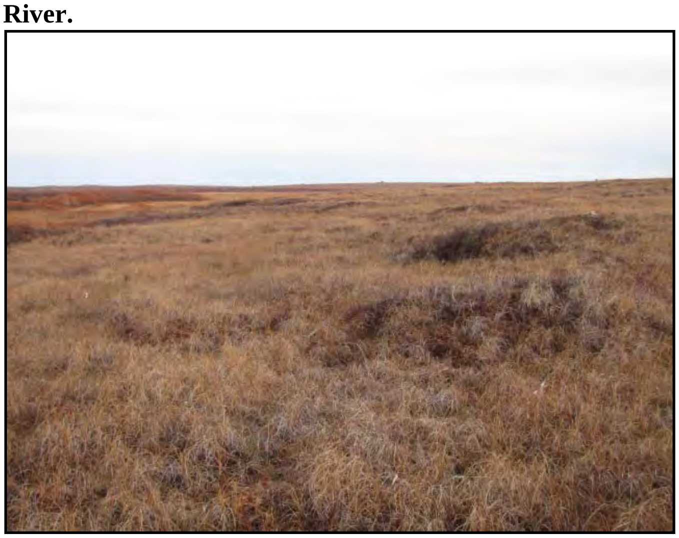

Photo 15: Solifluction lobes/surficial expression of changed substrate?

Photo 16: Slight thaw-settlement under ATV trail

Photo 17: Thaw settlement in winter trail along near ridge crest.

Photo 18: Cut slope along north side of Nome E/W runway.

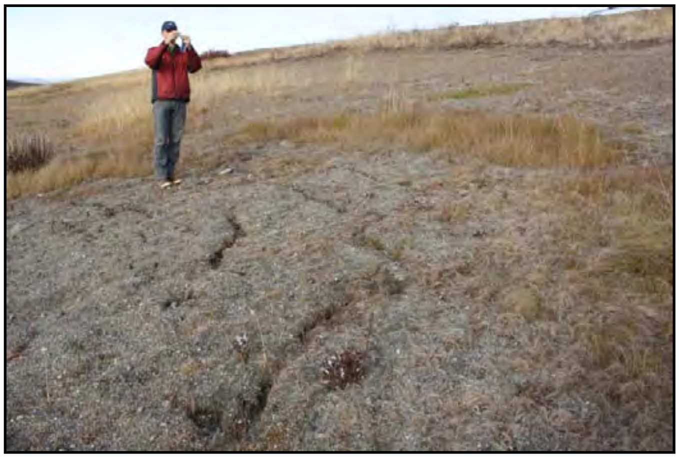

Photo 19: Tension cracks in cutslope along north side of Nome E/W runway..

Photo 20: Thaw-settlement depression in road surface along E/W runway.

Photo 21: Thaw settlement at toe of road embankment along N/S runway.

Photo 22: Slope of existing Snake River channel along Seppala Drive.

Photo 23: Thaw settlement/thermokarst terrain near dredge pond.

Photo 24: Revegetated, mined area.

Photo 25: Revegetated slopes of old mining pit.

Photo 26: Tension cracks in vegetated slope above mining pit.

Photo 27: Soils exposed in bank of mining pit.

Photo 28: Narrow strip of land between mining pit and Norton Sound.

Photo 29: Tension cracks between mining pit and Norton Sound.

Photo 30: Slope in dredge tailings.

Photo 31: Settling pond. Underlying soils are soft, fine-grained, and thawed to depth of probing (approx. 4 feet).

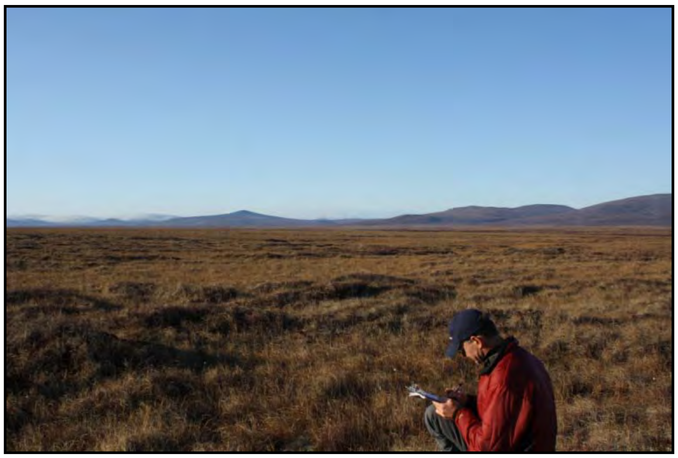

Photo 32: Hummocky, poorly drained terrain.

Photo 33: Typical stockpile of material, displaying possible cobble and boulder content of till.

Photo 34: Settlement pond; thawed, fine-grained soil to depth of probe (approximately 4 feet).

Photo 35: Broad area of fill/tailings, several feet thick.

Photo 36: Thaw settlement in access road.

Photo 37: Thaw settlement adjacent to access road.

Photo 38: Gentle, natural valley slope of Snake River (looking northwest).

Photo 39: Typical stockpile of material, displaying possible cobble and boulder content of till.

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Appendix E

HEC-RAS Modeling Output

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Snake River Existing Conditions
HEC-RAS Model
Results Summary

Tide Elevation of -1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
26325	135	-0.99	1.91	0.5	1.92	0.000232	1.00	134.95	100.32	0.15	1.34	0.02
25402	135	-1.57	1.74		1.75	0.000144	0.96	139.97	75.60	0.12	1.82	0.02
24681	135	-1.74	1.70		1.70	0.000032	0.57	238.84	94.69	0.06	2.51	0.01
23406	135	-1.50	1.61		1.62	0.000147	0.82	164.40	116.41	0.12	1.40	0.01
22313	135	-0.82	1.54		1.55	0.000040	0.52	261.92	141.95	0.07	1.84	0.00
21507	135	-3.58	1.52		1.52	0.000019	0.45	300.44	111.81	0.05	2.63	0.00
20572	135	-4.76	1.51		1.51	0.000008	0.35	389.21	110.56	0.03	3.45	0.00
19933	135	-2.38	1.50		1.50	0.000040	0.60	226.27	97.96	0.07	2.29	0.01
19190	135	0.01	1.42		1.43	0.000431	1.01	134.18	157.38	0.19	0.85	0.02
18062	135	-2.87	1.30		1.30	0.000031	0.57	238.05	90.93	0.06	2.58	0.01
17322	135	0.17	1.12		1.16	0.001912	1.67	80.92	136.02	0.38	0.59	0.07
16472	135	-1.71	0.88		0.89	0.000124	0.78	172.73	116.08	0.11	1.48	0.01
15949	135	-2.19	0.83		0.84	0.000078	0.67	200.19	117.90	0.09	1.69	0.01
14371	135	-1.25	0.66		0.67	0.000149	0.75	179.93	148.08	0.12	1.21	0.01
13231	135	-1.56	0.39		0.41	0.000396	1.06	127.57	130.53	0.19	0.98	0.02
12630	135	-2.21	0.24		0.25	0.000187	0.82	164.96	141.39	0.13	1.16	0.01
11764	135	-1.76	0.06		0.08	0.000207	0.93	145.03	110.65	0.14	1.31	0.02
11335	135	-4.00	0.04		0.04	0.000047	0.65	207.18	87.32	0.07	2.35	0.01
10653	135	-2.87	-0.05		-0.03	0.000299	1.16	116.23	83.19	0.17	1.39	0.03
9802	135	-6.58	-0.05		-0.05	0.000005	0.32	426.18	99.25	0.03	4.16	0.00
9038	135	-1.69	-0.09		-0.07	0.000597	1.20	112.47	129.68	0.23	0.87	0.03
8045	135	-4.48	-0.15		-0.15	0.000029	0.53	255.77	104.16	0.06	2.44	0.00
7584	135	-6.45	-0.16		-0.16	0.000009	0.37	362.28	99.39	0.03	3.55	0.00
6956	135	-5.09	-0.17		-0.17	0.000023	0.51	266.17	97.23	0.05	2.72	0.00
6140	135	-3.54	-0.19		-0.19	0.000029	0.46	295.09	114.87	0.05	2.56	0.00
5326	135	-3.42	-0.45		-0.41	0.000524	1.62	83.47	42.82	0.20	1.92	0.06
4588	135	-5.01	-0.60		-0.59	0.000055	0.74	182.92	55.77	0.07	3.20	0.01
3354	135	-3.90	-0.79		-0.78	0.000151	0.85	158.07	83.71	0.11	1.87	0.02
2829	135	-4.70	-0.89		-0.88	0.000155	0.89	151.80	77.02	0.11	1.96	0.02
2644	135	-4.60	-0.91		-0.91	0.000141	0.73	184.96	118.01	0.10	1.56	0.01
2431	135	-3.90	-0.94		-0.93	0.000085	0.61	222.22	127.61	0.08	1.74	0.01
2228	135	-4.10	-0.97		-0.96	0.000150	0.80	169.30	99.06	0.11	1.70	0.02
2165	135	-4.20	-0.97		-0.97	0.000067	0.56	240.13	130.12	0.07	1.84	0.01
2050	135	-4.80	-0.98		-0.97	0.000051	0.54	249.87	115.74	0.06	2.14	0.01
1799	135	-4.40	-0.99		-0.98	0.000048	0.49	273.93	140.69	0.06	1.94	0.01
1604	135	-4.90	-0.99		-0.99	0.000028	0.33	409.76	260.57	0.05	1.57	0.00
1397	135	-5.40	-1.00		-1.00	0.000018	0.29	469.06	262.78	0.04	1.78	0.00
226	135	-12.58	-1.00		-1.00	0.000000	0.01	11548.14	1171.51	0.00	9.81	0.00
0	135	-12.21	-1.00	-11.41	-1.00	0.000000	0.09	1574.89	185.73	0.01	8.33	0.00

Snake River Existing Conditions
HEC-RAS Model
Results Summary

Tide Elevation of +1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
26325	135	-0.99	2.01	0.5	2.03	0.000187	0.92	145.99	103.83	0.14	1.40	0.02
25402	135	-1.57	1.88		1.89	0.000118	0.90	150.67	78.09	0.11	1.89	0.01
24681	135	-1.74	1.84		1.85	0.000027	0.53	252.89	96.13	0.06	2.61	0.00
23406	135	-1.50	1.78		1.78	0.000111	0.73	183.96	124.35	0.11	1.47	0.01
22313	135	-0.82	1.72		1.73	0.000030	0.47	287.76	143.56	0.06	2.00	0.00
21507	135	-3.58	1.71		1.71	0.000016	0.42	321.44	114.93	0.04	2.74	0.00
20572	135	-4.76	1.70		1.70	0.000007	0.33	410.15	113.81	0.03	3.53	0.00
19933	135	-2.38	1.69		1.69	0.000032	0.55	245.03	100.68	0.06	2.41	0.00
19190	135	0.01	1.63		1.64	0.000220	0.80	169.63	170.92	0.14	0.99	0.01
18062	135	-2.87	1.55		1.56	0.000025	0.52	262.05	98.85	0.06	2.61	0.00
17322	135	0.17	1.47		1.49	0.000481	0.99	136.42	178.22	0.20	0.76	0.02
16472	135	-1.71	1.37		1.38	0.000058	0.57	237.59	145.38	0.08	1.62	0.01
15949	135	-2.19	1.35		1.35	0.000037	0.51	266.05	138.36	0.06	1.91	0.00
14371	135	-1.25	1.29		1.29	0.000041	0.48	279.51	169.16	0.07	1.65	0.00
13231	135	-1.56	1.23		1.23	0.000063	0.51	263.96	202.03	0.08	1.30	0.01
12630	135	-2.21	1.21		1.21	0.000026	0.43	315.97	161.43	0.05	1.95	0.00
11764	135	-1.76	1.18		1.19	0.000028	0.47	284.71	133.69	0.06	2.11	0.00
11335	135	-4.00	1.18		1.18	0.000014	0.43	311.39	95.81	0.04	3.21	0.00
10653	135	-2.87	1.16		1.16	0.000045	0.55	246.40	130.94	0.07	1.86	0.01
9802	135	-6.58	1.15		1.15	0.000003	0.24	551.88	111.02	0.02	4.82	0.00
9038	135	-1.69	1.15		1.15	0.000032	0.45	299.46	167.51	0.06	1.78	0.00
8045	135	-4.48	1.13		1.13	0.000008	0.34	402.09	123.47	0.03	3.22	0.00
7584	135	-6.45	1.13		1.13	0.000003	0.27	496.04	107.43	0.02	4.49	0.00
6956	135	-5.09	1.13		1.13	0.000007	0.34	396.11	102.53	0.03	3.81	0.00
6140	135	-3.54	1.12		1.12	0.000008	0.30	453.22	123.48	0.03	3.64	0.00
5326	135	-3.42	1.07		1.08	0.000090	0.84	161.27	59.27	0.09	2.68	0.02
4588	135	-5.01	1.05		1.05	0.000016	0.48	281.00	63.55	0.04	4.28	0.00
3354	135	-3.90	1.02		1.02	0.000017	0.42	321.31	95.74	0.04	3.31	0.00
2829	135	-4.70	1.01		1.01	0.000020	0.36	374.71	161.38	0.04	2.31	0.00
2644	135	-4.60	1.01		1.01	0.000010	0.31	432.83	136.44	0.03	3.14	0.00
2431	135	-3.90	1.01		1.01	0.000007	0.27	497.93	153.66	0.03	3.22	0.00
2228	135	-4.10	1.00		1.00	0.000014	0.30	453.80	191.38	0.03	2.36	0.00
2165	135	-4.20	1.00		1.00	0.000007	0.23	575.99	215.08	0.03	2.67	0.00
2050	135	-4.80	1.00		1.00	0.000008	0.24	564.22	224.07	0.03	2.50	0.00
1799	135	-4.40	1.00		1.00	0.000006	0.21	640.69	235.80	0.02	2.70	0.00
1604	135	-4.90	1.00		1.00	0.000002	0.14	975.51	313.78	0.01	3.10	0.00
1397	135	-5.40	1.00		1.00	0.000001	0.11	1258.91	459.38	0.01	2.74	0.00
226	135	-12.58	1.00		1.00	0.000000	0.01	13900.27	1180.83	0.00	11.71	0.00
0	135	-12.21	1.00	-11.41	1.00	0.000000	0.07	1970.54	209.92	0.00	9.22	0.00

Tide Elevation of -1.0, 2-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
26325	2000	-0.99	7.41	2.88	7.46	0.000152	2.02	1502.44	694.49	0.15	5.27	0.05
25402	2000	-1.57	7.16		7.27	0.000278	2.71	804.37	457.47	0.21	5.23	0.09
24681	2000	-1.74	7.07		7.13	0.000111	1.98	1521.64	491.05	0.14	6.52	0.04
23406	2000	-1.50	6.94		6.98	0.000110	1.83	1660.57	725.93	0.13	5.79	0.04
22313	2000	-0.82	6.84		6.88	0.000082	1.70	1644.57	654.30	0.12	6.52	0.03
21507	2000	-3.58	6.78		6.82	0.000067	1.55	2145.66	828.00	0.10	6.56	0.03
20572	2000	-4.76	6.72		6.75	0.000064	1.53	1820.93	629.42	0.10	6.65	0.03
19933	2000	-2.38	6.65		6.70	0.000107	1.94	1833.27	842.56	0.13	6.50	0.04
19190	2000	0.01	6.60		6.62	0.000084	1.45	2182.23	968.33	0.11	5.02	0.03
18062	2000	-2.87	6.44		6.50	0.000129	2.04	1155.88	415.64	0.14	6.08	0.05
17322	2000	0.17	6.39		6.42	0.000078	1.37	1795.92	825.82	0.11	4.84	0.02
16472	2000	-1.71	6.34		6.36	0.000059	1.33	2507.99	963.71	0.10	5.79	0.02
15949	2000	-2.19	6.30		6.33	0.000068	1.42	2297.62	897.31	0.10	5.74	0.02
14371	2000	-1.25	6.18		6.22	0.000074	1.50	1496.88	365.80	0.11	5.81	0.03
13231	2000	-1.56	6.12		6.14	0.000057	1.32	2012.36	773.75	0.10	5.82	0.02
12630	2000	-2.21	6.10		6.11	0.000034	1.07	3145.77	874.80	0.08	6.27	0.01
11764	2000	-1.76	5.98		6.04	0.000112	1.92	1113.79	240.30	0.14	6.12	0.04
11335	2000	-4.00	5.90		5.98	0.000163	2.27	882.18	146.04	0.16	5.95	0.06
10653	2000	-2.87	5.84		5.87	0.000075	1.47	1783.94	463.83	0.11	5.53	0.03
9802	2000	-6.58	5.78		5.81	0.000058	1.46	1599.31	366.72	0.10	6.70	0.02
9038	2000	-1.69	5.72		5.76	0.000088	1.63	1380.45	294.11	0.12	5.79	0.03
8045	2000	-4.48	5.64		5.67	0.000078	1.63	1609.76	415.67	0.11	6.34	0.03
7584	2000	-6.45	5.58		5.64	0.000083	1.96	1043.22	162.74	0.12	7.92	0.04
6956	2000	-5.09	5.54		5.56	0.000049	1.45	1968.55	489.54	0.09	7.52	0.02
6140	2000	-3.54	5.40		5.46	0.000133	1.97	1015.51	141.54	0.13	7.22	0.06
5326	2000	-3.42	4.66		5.00	0.001316	4.70	425.36	87.17	0.38	4.77	0.39
4588	2000	-5.01	3.99		4.24	0.000731	4.07	491.48	79.06	0.29	5.97	0.27
3354	2000	-3.90	2.72		2.98	0.001030	4.07	491.13	104.28	0.33	4.62	0.30
2829	2000	-4.70	2.00		2.21	0.001423	3.71	538.59	169.26	0.37	3.16	0.28
2644	2000	-4.60	1.76		1.98	0.001119	3.72	537.58	140.13	0.33	3.79	0.27
2431	2000	-3.90	1.56		1.75	0.000992	3.42	585.28	159.18	0.31	3.65	0.23
2228	2000	-4.10	1.16		1.42	0.002661	4.12	485.40	208.92	0.48	2.31	0.38
2165	2000	-4.20	1.10		1.28	0.001400	3.34	597.92	217.72	0.36	2.73	0.24
2050	2000	-4.80	0.87		1.08	0.001990	3.74	534.35	213.67	0.42	2.49	0.31
1799	2000	-4.40	0.14		0.45	0.003130	4.53	441.62	186.20	0.52	2.36	0.46
1604	2000	-4.90	-0.24		-0.07	0.001747	3.26	612.63	273.69	0.38	2.23	0.24
1397	2000	-5.40	-0.78		-0.56	0.003307	3.77	530.87	308.80	0.51	1.72	0.35
226	2000	-12.58	-0.97		-0.97	0.000001	0.17	11582.56	1171.65	0.01	9.84	0.00
0	2000	-12.21	-1.00	-9.49	-0.97	0.000046	1.27	1574.89	185.73	0.08	8.33	0.02

Snake River Existing Conditions
HEC-RAS Model
Results Summary

Tide Elevation of +1.0, 2-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
26325	2000	-0.99	7.41	2.88	7.47	0.000151	2.01	1506.13	694.87	0.15	5.28	0.05
25402	2000	-1.57	7.16		7.28	0.000277	2.71	807.27	461.75	0.21	5.23	0.09
24681	2000	-1.74	7.08		7.13	0.000110	1.98	1524.98	491.46	0.13	6.53	0.04
23406	2000	-1.50	6.94		6.99	0.000109	1.82	1666.05	727.09	0.13	5.80	0.04
22313	2000	-0.82	6.84		6.89	0.000081	1.70	1649.88	654.90	0.12	6.53	0.03
21507	2000	-3.58	6.79		6.82	0.000067	1.55	2152.65	829.18	0.10	6.57	0.03
20572	2000	-4.76	6.73		6.76	0.000064	1.53	1826.45	630.13	0.10	6.66	0.03
19933	2000	-2.38	6.66		6.71	0.000106	1.94	1841.15	842.81	0.13	6.51	0.04
19190	2000	0.01	6.61		6.63	0.000083	1.45	2191.75	969.73	0.11	5.03	0.03
18062	2000	-2.87	6.45		6.51	0.000128	2.04	1160.40	417.67	0.14	6.09	0.05
17322	2000	0.17	6.40		6.43	0.000077	1.36	1805.29	827.47	0.11	4.85	0.02
16472	2000	-1.71	6.35		6.37	0.000058	1.33	2519.45	964.50	0.10	5.80	0.02
15949	2000	-2.19	6.32		6.34	0.000067	1.42	2308.61	898.15	0.10	5.75	0.02
14371	2000	-1.25	6.20		6.23	0.000073	1.49	1501.72	366.28	0.11	5.82	0.03
13231	2000	-1.56	6.13		6.15	0.000056	1.31	2023.10	778.95	0.10	5.83	0.02
12630	2000	-2.21	6.11		6.12	0.000034	1.07	3158.06	875.64	0.07	6.28	0.01
11764	2000	-1.76	5.99		6.05	0.000112	1.91	1117.37	240.41	0.14	6.13	0.04
11335	2000	-4.00	5.92		6.00	0.000162	2.26	884.44	146.20	0.16	5.96	0.06
10653	2000	-2.87	5.85		5.88	0.000074	1.46	1791.46	463.97	0.11	5.55	0.03
9802	2000	-6.58	5.80		5.83	0.000058	1.46	1605.45	367.72	0.10	6.72	0.02
9038	2000	-1.69	5.74		5.77	0.000087	1.63	1385.55	294.29	0.12	5.81	0.03
8045	2000	-4.48	5.66		5.69	0.000077	1.63	1617.33	416.39	0.11	6.35	0.03
7584	2000	-6.45	5.59		5.65	0.000083	1.95	1046.24	164.30	0.12	7.93	0.04
6956	2000	-5.09	5.56		5.58	0.000048	1.44	1977.88	491.20	0.09	7.53	0.02
6140	2000	-3.54	5.42		5.48	0.000132	1.97	1018.37	141.72	0.13	7.23	0.06
5326	2000	-3.42	4.69		5.03	0.001292	4.67	428.00	87.34	0.37	4.79	0.39
4588	2000	-5.01	4.03		4.28	0.000716	4.04	494.96	79.25	0.28	6.00	0.27
3354	2000	-3.90	2.82		3.07	0.000966	3.99	501.63	104.78	0.32	4.70	0.28
2829	2000	-4.70	2.20		2.39	0.001176	3.49	572.32	170.65	0.34	3.33	0.24
2644	2000	-4.60	2.00		2.19	0.000925	3.50	571.20	141.29	0.31	3.99	0.23
2431	2000	-3.90	1.85		2.00	0.000792	3.17	630.45	161.88	0.28	3.87	0.19
2228	2000	-4.10	1.59		1.78	0.001672	3.45	580.28	230.37	0.38	2.50	0.26
2165	2000	-4.20	1.56		1.68	0.000893	2.86	698.75	229.44	0.29	3.03	0.17
2050	2000	-4.80	1.42		1.57	0.001120	3.02	661.53	236.74	0.32	2.78	0.19
1799	2000	-4.40	1.16		1.29	0.001043	2.95	678.03	238.34	0.31	2.82	0.18
1604	2000	-4.90	1.08		1.15	0.000412	2.00	1001.57	316.39	0.20	3.16	0.08
1397	2000	-5.40	1.03		1.06	0.000306	1.57	1270.99	459.89	0.17	2.76	0.05
226	2000	-12.58	1.02		1.02	0.000000	0.14	13922.15	1180.97	0.01	11.72	0.00
0	2000	-12.21	1.00	-9.49	1.02	0.000026	1.01	1970.54	209.92	0.06	9.22	0.01

Snake River Existing Conditions
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Results Summary

Tide Elevation of -1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
26325	5200	-0.99	11.12	4.73	11.17	0.000085	2.13	4152.30	714.37	0.12	8.88	0.05
25402	5200	-1.57	10.98		11.06	0.000146	2.81	3206.81	672.34	0.16	8.93	0.08
24681	5200	-1.74	10.91		10.97	0.000092	2.45	3564.21	535.61	0.13	10.25	0.06
23406	5200	-1.50	10.83		10.86	0.000062	1.93	4824.73	836.00	0.11	9.60	0.04
22313	5200	-0.82	10.75		10.80	0.000061	2.00	4747.16	928.68	0.11	10.31	0.04
21507	5200	-3.58	10.73		10.75	0.000044	1.69	6316.60	1255.19	0.09	10.32	0.03
20572	5200	-4.76	10.67		10.70	0.000053	1.88	4817.58	851.17	0.10	10.47	0.03
19933	5200	-2.38	10.64		10.67	0.000056	1.93	5423.28	966.22	0.10	10.39	0.04
19190	5200	0.01	10.61		10.63	0.000036	1.40	6698.81	1222.70	0.08	8.94	0.02
18062	5200	-2.87	10.49		10.56	0.000095	2.45	3969.78	1052.07	0.14	10.06	0.06
17322	5200	0.17	10.48		10.50	0.000037	1.40	6063.10	1157.39	0.08	8.90	0.02
16472	5200	-1.71	10.46		10.47	0.000031	1.38	6811.74	1111.42	0.08	9.86	0.02
15949	5200	-2.19	10.44		10.46	0.000036	1.47	6346.02	1050.43	0.08	9.73	0.02
14371	5200	-1.25	10.36		10.39	0.000045	1.67	5923.62	1507.92	0.09	9.98	0.03
13231	5200	-1.56	10.33		10.35	0.000034	1.46	5999.34	1002.48	0.08	10.01	0.02
12630	5200	-2.21	10.31		10.33	0.000024	1.27	7190.30	1001.35	0.07	10.46	0.02
11764	5200	-1.76	10.14		10.26	0.000120	2.79	2180.85	272.04	0.15	10.24	0.08
11335	5200	-4.00	10.02		10.19	0.000200	3.33	1628.38	241.48	0.19	9.10	0.11
10653	5200	-2.87	10.02		10.07	0.000060	1.87	3825.20	518.73	0.11	9.41	0.04
9802	5200	-6.58	9.96		10.02	0.000057	2.00	3878.48	663.59	0.11	10.80	0.04
9038	5200	-1.69	9.90		9.96	0.000077	2.19	3295.00	593.83	0.12	9.90	0.05
8045	5200	-4.48	9.83		9.89	0.000071	2.18	3581.00	533.26	0.12	10.44	0.05
7584	5200	-6.45	9.69		9.84	0.000134	3.15	1964.36	272.99	0.16	11.30	0.09
6956	5200	-5.09	9.71		9.74	0.000042	1.77	4396.50	680.58	0.09	11.50	0.03
6140	5200	-3.54	9.54		9.65	0.000154	2.84	2604.66	917.32	0.15	11.25	0.11
5326	5200	-3.42	8.42		9.08	0.001503	6.53	808.26	151.33	0.43	7.07	0.66
4588	5200	-5.01	7.36		8.05	0.001311	6.67	779.87	91.53	0.40	8.08	0.66
3354	5200	-3.90	5.19		5.92	0.001844	6.81	763.22	114.90	0.47	6.47	0.74
2829	5200	-4.70	4.32		4.79	0.001622	5.49	946.76	181.64	0.42	5.15	0.52
2644	5200	-4.60	3.87		4.45	0.001923	6.09	853.93	159.03	0.46	5.29	0.64
2431	5200	-3.90	3.54		4.04	0.001726	5.67	917.15	176.37	0.44	5.16	0.56
2228	5200	-4.10	3.20		3.62	0.002339	5.16	1008.14	281.18	0.48	3.56	0.52
2165	5200	-4.20	3.12		3.47	0.001801	4.72	1102.84	289.65	0.43	3.79	0.43
2050	5200	-4.80	2.84		3.21	0.002671	4.93	1053.98	347.57	0.50	3.02	0.50
1799	5200	-4.40	1.64		2.30	0.004856	6.51	799.11	271.86	0.67	2.92	0.88
1604	5200	-4.90	1.15		1.55	0.002626	5.09	1021.84	318.40	0.50	3.20	0.52
1397	5200	-5.40	0.01		0.64	0.008236	6.36	817.20	429.48	0.81	1.90	0.98
226	5200	-12.58	-0.80		-0.80	0.000004	0.44	11781.35	1172.42	0.02	10.00	0.00
0	5200	-12.21	-1.00	-7.69	-0.83	0.000309	3.30	1574.89	185.73	0.20	8.33	0.16

Snake River Existing Conditions
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Results Summary

Tide Elevation of +1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
26325	5200	-0.99	11.12	4.73	11.17	0.000085	2.13	4152.73	714.37	0.12	8.88	0.05
25402	5200	-1.57	10.98		11.06	0.000146	2.81	3207.25	672.35	0.16	8.93	0.08
24681	5200	-1.74	10.91		10.97	0.000092	2.45	3564.57	535.61	0.13	10.25	0.06
23406	5200	-1.50	10.83		10.87	0.000062	1.93	4825.32	836.01	0.11	9.60	0.04
22313	5200	-0.82	10.75		10.80	0.000061	2.00	4747.83	928.71	0.11	10.31	0.04
21507	5200	-3.58	10.73		10.75	0.000044	1.69	6317.52	1255.24	0.09	10.32	0.03
20572	5200	-4.76	10.67		10.71	0.000053	1.88	4818.22	851.20	0.10	10.48	0.03
19933	5200	-2.38	10.64		10.67	0.000056	1.93	5424.02	966.24	0.10	10.39	0.04
19190	5200	0.01	10.61		10.63	0.000036	1.40	6699.76	1222.73	0.08	8.94	0.02
18062	5200	-2.87	10.49		10.56	0.000095	2.45	3970.64	1052.10	0.14	10.06	0.06
17322	5200	0.17	10.48		10.51	0.000037	1.40	6064.06	1157.42	0.08	8.90	0.02
16472	5200	-1.71	10.46		10.48	0.000031	1.38	6812.67	1111.45	0.08	9.86	0.02
15949	5200	-2.19	10.44		10.46	0.000036	1.47	6346.91	1050.47	0.08	9.73	0.02
14371	5200	-1.25	10.36		10.40	0.000045	1.67	5924.94	1507.92	0.09	9.98	0.03
13231	5200	-1.56	10.33		10.35	0.000034	1.46	6000.24	1002.50	0.08	10.01	0.02
12630	5200	-2.21	10.32		10.33	0.000024	1.27	7191.20	1001.36	0.07	10.46	0.02
11764	5200	-1.76	10.15		10.26	0.000120	2.79	2181.10	272.05	0.15	10.24	0.08
11335	5200	-4.00	10.02		10.19	0.000200	3.33	1628.62	241.56	0.19	9.10	0.11
10653	5200	-2.87	10.02		10.07	0.000060	1.87	3825.72	518.74	0.11	9.41	0.04
9802	5200	-6.58	9.97		10.02	0.000057	2.00	3879.16	663.67	0.11	10.80	0.04
9038	5200	-1.69	9.90		9.97	0.000077	2.19	3295.62	593.88	0.12	9.91	0.05
8045	5200	-4.48	9.83		9.89	0.000071	2.18	3581.57	533.30	0.12	10.44	0.05
7584	5200	-6.45	9.69		9.84	0.000134	3.15	1964.66	273.04	0.16	11.30	0.09
6956	5200	-5.09	9.71		9.74	0.000042	1.77	4397.26	680.65	0.09	11.50	0.03
6140	5200	-3.54	9.54		9.65	0.000153	2.84	2605.79	917.63	0.15	11.25	0.11
5326	5200	-3.42	8.43		9.09	0.001502	6.53	808.55	151.47	0.43	7.07	0.66
4588	5200	-5.01	7.37		8.06	0.001310	6.67	780.13	91.54	0.40	8.09	0.66
3354	5200	-3.90	5.20		5.92	0.001836	6.80	764.26	114.94	0.46	6.47	0.74
2829	5200	-4.70	4.34		4.80	0.001605	5.47	949.95	181.72	0.42	5.17	0.52
2644	5200	-4.60	3.90		4.47	0.001897	6.06	857.66	159.15	0.46	5.31	0.63
2431	5200	-3.90	3.57		4.06	0.001697	5.64	922.42	176.62	0.43	5.18	0.55
2228	5200	-4.10	3.25		3.65	0.002253	5.10	1020.13	281.59	0.47	3.60	0.51
2165	5200	-4.20	3.17		3.50	0.001735	4.66	1116.29	290.29	0.42	3.83	0.41
2050	5200	-4.80	2.90		3.26	0.002557	4.83	1076.59	354.78	0.49	3.02	0.48
1799	5200	-4.40	1.86		2.43	0.004262	6.05	860.16	296.50	0.63	2.88	0.77
1604	5200	-4.90	1.49		1.82	0.001945	4.59	1132.84	328.97	0.44	3.43	0.42
1397	5200	-5.40	1.17		1.41	0.001757	3.89	1338.30	462.72	0.40	2.89	0.32
226	5200	-12.58	1.13		1.13	0.000002	0.37	14048.65	1181.77	0.02	11.82	0.00
0	5200	-12.21	1.00	-7.69	1.11	0.000172	2.64	1970.54	209.92	0.15	9.22	0.10

Snake River Existing Conditions
HEC-RAS Model
Results Summary

Tide Elevation of -1.0, 100-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
26325	5800	-0.99	11.67	5.06	11.72	0.000081	2.17	4546.83	714.37	0.12	9.42	0.05
25402	5800	-1.57	11.54		11.62	0.000137	2.83	3586.32	682.03	0.16	9.47	0.08
24681	5800	-1.74	11.47		11.53	0.000091	2.52	3864.35	535.61	0.13	10.79	0.06
23406	5800	-1.50	11.39		11.43	0.000060	1.96	5298.15	840.95	0.11	10.15	0.04
22313	5800	-0.82	11.32		11.36	0.000059	2.03	5280.88	951.04	0.11	10.85	0.04
21507	5800	-3.58	11.30		11.32	0.000041	1.70	7042.87	1293.08	0.09	10.86	0.03
20572	5800	-4.76	11.24		11.28	0.000052	1.92	5310.28	877.57	0.10	11.03	0.04
19933	5800	-2.38	11.21		11.24	0.000054	1.96	5981.33	985.57	0.10	10.95	0.04
19190	5800	0.01	11.19		11.21	0.000034	1.42	7407.21	1248.33	0.08	9.51	0.02
18062	5800	-2.87	11.07		11.14	0.000087	2.44	4590.17	1077.73	0.13	10.63	0.06
17322	5800	0.17	11.06		11.09	0.000035	1.42	6743.71	1180.28	0.08	9.48	0.02
16472	5800	-1.71	11.04		11.06	0.000030	1.42	7465.17	1128.22	0.08	10.43	0.02
15949	5800	-2.19	11.02		11.04	0.000034	1.50	6967.38	1077.97	0.08	10.31	0.02
14371	5800	-1.25	10.95		10.98	0.000040	1.65	6816.66	1512.16	0.09	10.57	0.03
13231	5800	-1.56	10.92		10.94	0.000032	1.49	6595.97	1011.93	0.08	10.60	0.02
12630	5800	-2.21	10.91		10.92	0.000024	1.31	7786.94	1014.91	0.07	11.05	0.02
11764	5800	-1.76	10.73		10.85	0.000123	2.93	2340.47	276.48	0.16	10.82	0.08
11335	5800	-4.00	10.60		10.78	0.000202	3.49	1780.62	287.66	0.20	9.67	0.12
10653	5800	-2.87	10.61		10.65	0.000060	1.94	4130.31	523.87	0.11	9.98	0.04
9802	5800	-6.58	10.55		10.60	0.000058	2.08	4275.51	692.24	0.11	11.37	0.04
9038	5800	-1.69	10.49		10.55	0.000076	2.26	3650.94	622.14	0.12	10.49	0.05
8045	5800	-4.48	10.42		10.48	0.000071	2.26	3898.85	552.96	0.12	11.02	0.05
7584	5800	-6.45	10.26		10.42	0.000139	3.31	2128.20	298.72	0.17	11.85	0.10
6956	5800	-5.09	10.29		10.32	0.000044	1.89	4808.75	767.42	0.09	12.06	0.03
6140	5800	-3.54	10.14		10.24	0.000137	2.78	3201.63	1040.29	0.14	11.84	0.10
5326	5800	-3.42	8.99		9.68	0.001478	6.69	902.10	174.24	0.43	7.43	0.69
4588	5800	-5.01	7.84		8.61	0.001394	7.04	824.13	93.28	0.42	8.37	0.73
3354	5800	-3.90	5.53		6.34	0.001970	7.23	802.39	116.03	0.48	6.72	0.83
2829	5800	-4.70	4.64		5.15	0.001675	5.77	1004.76	183.18	0.43	5.42	0.57
2644	5800	-4.60	4.15		4.80	0.002047	6.46	898.26	160.50	0.48	5.51	0.70
2431	5800	-3.90	3.80		4.36	0.001860	6.03	962.31	178.54	0.46	5.34	0.62
2228	5800	-4.10	3.46		3.91	0.002331	5.36	1081.49	283.66	0.48	3.79	0.55
2165	5800	-4.20	3.38		3.76	0.001823	4.92	1178.94	293.22	0.43	4.00	0.46
2050	5800	-4.80	3.11		3.51	0.002635	5.02	1154.79	367.06	0.50	3.13	0.52
1799	5800	-4.40	1.86		2.57	0.005289	6.73	861.33	296.95	0.70	2.88	0.95
1604	5800	-4.90	1.33		1.78	0.002783	5.37	1079.78	323.98	0.52	3.32	0.58
1397	5800	-5.40	0.13		0.82	0.008433	6.67	869.62	433.54	0.83	2.00	1.05
226	5800	-12.58	-0.75		-0.75	0.000005	0.49	11838.17	1172.65	0.03	10.05	0.00
0	5800	-12.21	-1.00	-7.41	-0.79	0.000384	3.68	1574.89	185.73	0.22	8.33	0.20

Tide Elevation of +1.0, 100-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
26325	5800	-0.99	11.67	5.06	11.72	0.000081	2.17	4547.02	714.37	0.12	9.42	0.05
25402	5800	-1.57	11.54		11.62	0.000137	2.83	3586.51	682.04	0.16	9.48	0.08
24681	5800	-1.74	11.47		11.53	0.000091	2.52	3864.50	535.61	0.13	10.79	0.06
23406	5800	-1.50	11.39		11.43	0.000060	1.96	5298.41	840.95	0.11	10.16	0.04
22313	5800	-0.82	11.32		11.36	0.000059	2.03	5281.18	951.06	0.11	10.85	0.04
21507	5800	-3.58	11.30		11.32	0.000041	1.70	7043.28	1293.11	0.09	10.86	0.03
20572	5800	-4.76	11.24		11.28	0.000052	1.92	5310.57	877.59	0.10	11.03	0.04
19933	5800	-2.38	11.21		11.24	0.000054	1.96	5981.66	985.58	0.10	10.95	0.04
19190	5800	0.01	11.19		11.21	0.000034	1.42	7407.62	1248.34	0.08	9.51	0.02
18062	5800	-2.87	11.07		11.14	0.000087	2.44	4590.55	1077.74	0.13	10.63	0.06
17322	5800	0.17	11.06		11.09	0.000034	1.42	6744.12	1180.30	0.08	9.48	0.02
16472	5800	-1.71	11.04		11.06	0.000030	1.42	7465.57	1128.23	0.08	10.43	0.02
15949	5800	-2.19	11.02		11.04	0.000034	1.50	6967.77	1077.98	0.08	10.31	0.02
14371	5800	-1.25	10.95		10.98	0.000040	1.65	6817.22	1512.16	0.09	10.57	0.03
13231	5800	-1.56	10.92		10.94	0.000032	1.49	6596.36	1011.94	0.08	10.60	0.02
12630	5800	-2.21	10.91		10.92	0.000024	1.31	7787.32	1014.92	0.07	11.05	0.02
11764	5800	-1.76	10.73		10.85	0.000123	2.93	2340.58	276.48	0.16	10.82	0.08
11335	5800	-4.00	10.60		10.78	0.000202	3.49	1780.74	287.70	0.20	9.67	0.12
10653	5800	-2.87	10.61		10.65	0.000060	1.94	4130.53	523.88	0.11	9.98	0.04
9802	5800	-6.58	10.55		10.60	0.000058	2.08	4275.80	692.26	0.11	11.37	0.04
9038	5800	-1.69	10.49		10.55	0.000076	2.26	3651.22	622.16	0.12	10.49	0.05
8045	5800	-4.48	10.42		10.48	0.000071	2.26	3899.10	552.98	0.12	11.02	0.05
7584	5800	-6.45	10.26		10.42	0.000139	3.31	2128.34	298.74	0.17	11.85	0.10
6956	5800	-5.09	10.29		10.32	0.000044	1.89	4809.11	767.54	0.09	12.06	0.03
6140	5800	-3.54	10.14		10.24	0.000137	2.78	3202.17	1040.32	0.14	11.84	0.10
5326	5800	-3.42	8.99		9.68	0.001478	6.69	902.24	174.25	0.43	7.43	0.69
4588	5800	-5.01	7.84		8.61	0.001394	7.04	824.25	93.28	0.42	8.37	0.73
3354	5800	-3.90	5.54		6.35	0.001967	7.22	802.88	116.04	0.48	6.73	0.83
2829	5800	-4.70	4.65		5.16	0.001668	5.76	1006.26	183.22	0.43	5.42	0.56
2644	5800	-4.60	4.16		4.81	0.002035	6.44	900.05	160.56	0.48	5.52	0.70
2431	5800	-3.90	3.81		4.37	0.001845	6.01	964.88	178.66	0.46	5.35	0.62
2228	5800	-4.10	3.48		3.92	0.002292	5.33	1087.28	283.86	0.48	3.80	0.54
2165	5800	-4.20	3.40		3.78	0.001793	4.89	1185.42	293.52	0.43	4.02	0.45
2050	5800	-4.80	3.15		3.53	0.002550	4.97	1166.64	367.36	0.49	3.16	0.50
1799	5800	-4.40	2.02		2.65	0.004783	6.38	909.35	315.43	0.66	2.86	0.86
1604	5800	-4.90	1.59		1.97	0.002229	4.98	1165.50	332.01	0.47	3.50	0.49
1397	5800	-5.40	1.21		1.50	0.002093	4.27	1356.82	463.49	0.44	2.92	0.38
226	5800	-12.58	1.16		1.16	0.000003	0.41	14084.86	1182.00	0.02	11.85	0.00
0	5800	-12.21	1.00	-7.41	1.13	0.000214	2.94	1970.54	209.92	0.17	9.22	0.12

Lower River Reconnection Option
HEC-RAS Model
Results Summary

Tide Elevation of -1.0, Mean Annual Flow

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
27973	135	-0.99	1.70	0.5	1.72	0.000363	1.18	114.77	93.57	0.19	0.03
27050	135	-1.57	1.43		1.45	0.000231	1.15	117.69	70.11	0.16	0.02
26329	135	-1.74	1.36		1.36	0.000049	0.65	207.33	90.96	0.08	0.01
25054	135	-1.50	1.21		1.23	0.000332	1.12	120.77	99.34	0.18	0.03
23961	135	-0.82	0.99		0.99	0.000123	0.73	184.45	136.68	0.11	0.01
23155	135	-3.58	0.93		0.94	0.000035	0.57	238.20	99.92	0.06	0.01
22220	135	-4.76	0.92		0.92	0.000012	0.41	326.94	100.34	0.04	0.00
21801	135	-0.72	0.90		0.91	0.000087	0.68	198.50	125.41	0.10	0.01
20969	135	-0.80	0.83		0.84	0.000083	0.67	201.44	126.54	0.09	0.01
20364	135	-0.86	0.78		0.79	0.000082	0.67	202.65	126.53	0.09	0.01
19550	135	-0.94	0.72		0.73	0.000079	0.66	204.61	126.64	0.09	0.01
18742	135	-1.02	0.66		0.66	0.000076	0.65	207.61	127.17	0.09	0.01
17932	135	-1.10	0.60		0.60	0.000074	0.64	209.36	126.79	0.09	0.01
17124	135	-1.18	0.54		0.55	0.000071	0.64	211.90	126.72	0.09	0.01
16261	135	-1.26	0.48		0.49	0.000068	0.63	214.79	126.95	0.09	0.01
15461	135	-1.34	0.43		0.43	0.000064	0.62	218.26	127.03	0.08	0.01
14632	135	-1.42	0.38		0.38	0.000061	0.61	221.97	127.18	0.08	0.01
13828	135	-1.50	0.33		0.33	0.000057	0.60	226.18	127.32	0.08	0.01
12934	135	-1.58	0.28		0.29	0.000054	0.59	230.10	127.44	0.08	0.01
12107	135	-1.66	0.24		0.24	0.000051	0.58	234.66	127.51	0.07	0.01
11259	135	-1.74	0.20		0.20	0.000048	0.56	239.41	127.58	0.07	0.01
10466	135	-4.48	0.17		0.18	0.000020	0.46	290.55	108.97	0.05	0.00
9922	135	-1.53	0.15		0.16	0.000076	0.65	207.26	126.72	0.09	0.01
9122	135	-1.67	0.09		0.10	0.000065	0.62	217.97	127.04	0.08	0.01
8236	135	-1.67	0.03		0.04	0.000073	0.64	210.27	126.80	0.09	0.01
7013	135	-1.70	-0.06		-0.06	0.000083	0.67	201.93	126.55	0.09	0.01
6140	135	-3.54	-0.12		-0.12	0.000031	0.45	303.20	115.53	0.05	0.00
5326	135	-3.42	-0.39		-0.35	0.000559	1.57	86.15	43.50	0.20	0.07
4588	135	-5.01	-0.55		-0.54	0.000061	0.73	185.54	55.99	0.07	0.01
3354	135	-3.90	-0.76		-0.75	0.000168	0.84	160.43	83.94	0.11	0.02
2829	135	-4.70	-0.87		-0.86	0.000176	0.88	153.08	77.38	0.11	0.02
2644	135	-4.60	-0.90		-0.89	0.000159	0.72	186.48	118.17	0.10	0.02
2431	135	-3.90	-0.93		-0.92	0.000097	0.60	223.47	127.76	0.08	0.01
2228	135	-4.10	-0.96		-0.95	0.000173	0.79	169.87	99.48	0.11	0.02
2165	135	-4.20	-0.97	-3.19	-0.96	0.000077	0.56	240.76	130.31	0.07	0.01
2107.5	Bridge										
2050	135	-4.80	-0.97	-3.65	-0.97	0.000058	0.54	250.35	115.87	0.06	0.01
1799	135	-4.40	-0.99		-0.98	0.000056	0.49	274.24	140.71	0.06	0.01
1604	135	-4.90	-0.99		-0.99	0.000033	0.33	410.03	260.60	0.05	0.00
1397	135	-5.40	-1.00		-1.00	0.000021	0.29	469.14	262.83	0.04	0.00
226	135	-12.58	-1.00		-1.00	0.000000	0.01	11548.14	1171.51	0.00	0.00
0	135	-12.21	-1.00	-11.41	-1.00	0.000000	0.09	1574.89	185.73	0.01	0.00

Lower River Reconnection Option
HEC-RAS Model
Results Summary

Tide Elevation of +1.0, Mean Annual Flow

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
27973	135	-0.99	1.87	0.5	1.89	0.000250	1.03	131.38	99.16	0.16	0.02
27050	135	-1.57	1.69		1.71	0.000154	0.99	136.34	74.73	0.13	0.02
26329	135	-1.74	1.64		1.64	0.000034	0.58	233.60	94.08	0.06	0.01
25054	135	-1.50	1.55		1.57	0.000165	0.86	157.52	113.88	0.13	0.01
23961	135	-0.82	1.46		1.47	0.000046	0.54	250.74	141.20	0.07	0.01
23155	135	-3.58	1.44		1.44	0.000021	0.46	291.23	110.20	0.05	0.00
22220	135	-4.76	1.43		1.43	0.000008	0.35	380.30	109.15	0.03	0.00
21801	135	-0.72	1.42		1.43	0.000034	0.51	263.82	127.46	0.06	0.00
20969	135	-0.80	1.39		1.40	0.000031	0.49	272.94	128.78	0.06	0.00
20364	135	-0.86	1.38		1.38	0.000029	0.49	278.22	128.90	0.06	0.00
19550	135	-0.94	1.35		1.36	0.000027	0.47	285.74	129.17	0.06	0.00
18742	135	-1.02	1.33		1.34	0.000024	0.46	294.50	129.88	0.05	0.00
17932	135	-1.10	1.31		1.32	0.000023	0.45	301.34	129.66	0.05	0.00
17124	135	-1.18	1.30		1.30	0.000021	0.44	309.07	129.75	0.05	0.00
16261	135	-1.26	1.28		1.28	0.000019	0.43	317.62	130.15	0.05	0.00
15461	135	-1.34	1.27		1.27	0.000018	0.41	326.08	130.38	0.05	0.00
14632	135	-1.42	1.25		1.25	0.000016	0.40	334.82	130.69	0.04	0.00
13828	135	-1.50	1.24		1.24	0.000015	0.39	343.68	130.96	0.04	0.00
12934	135	-1.58	1.23		1.23	0.000014	0.38	352.51	131.23	0.04	0.00
12107	135	-1.66	1.22		1.22	0.000013	0.37	361.40	131.43	0.04	0.00
11259	135	-1.74	1.21		1.21	0.000012	0.36	370.34	131.62	0.04	0.00
10466	135	-4.48	1.20		1.20	0.000008	0.33	410.18	124.88	0.03	0.00
9922	135	-1.53	1.19		1.19	0.000015	0.40	341.42	130.89	0.04	0.00
9122	135	-1.67	1.18		1.18	0.000013	0.38	358.30	131.37	0.04	0.00
8236	135	-1.67	1.17		1.17	0.000013	0.38	356.78	131.33	0.04	0.00
7013	135	-1.70	1.15		1.16	0.000013	0.38	358.68	131.41	0.04	0.00
6140	135	-3.54	1.14		1.14	0.000009	0.30	455.38	123.53	0.03	0.00
5326	135	-3.42	1.09		1.10	0.000103	0.83	162.00	59.40	0.09	0.02
4588	135	-5.01	1.06		1.06	0.000018	0.48	281.49	63.59	0.04	0.00
3354	135	-3.90	1.02		1.03	0.000020	0.42	321.63	95.76	0.04	0.00
2829	135	-4.70	1.01		1.01	0.000024	0.36	374.97	161.41	0.04	0.00
2644	135	-4.60	1.01		1.01	0.000012	0.31	433.00	136.45	0.03	0.00
2431	135	-3.90	1.01		1.01	0.000009	0.27	498.08	153.67	0.03	0.00
2228	135	-4.10	1.00		1.01	0.000016	0.30	453.92	191.47	0.03	0.00
2165	135	-4.20	1.00	-3.19	1.00	0.000008	0.23	576.10	215.10	0.03	0.00
2107.5	Bridge										
2050	135	-4.80	1.00	-3.65	1.00	0.000009	0.24	564.32	224.08	0.03	0.00
1799	135	-4.40	1.00		1.00	0.000007	0.21	640.73	235.81	0.02	0.00
1604	135	-4.90	1.00		1.00	0.000002	0.14	975.53	313.78	0.01	0.00
1397	135	-5.40	1.00		1.00	0.000002	0.11	1258.92	459.38	0.01	0.00
226	135	-12.58	1.00		1.00	0.000000	0.01	13900.28	1180.83	0.00	0.00
0	135	-12.21	1.00	-11.41	1.00	0.000000	0.07	1970.54	209.92	0.00	0.00

Tide Elevation of -1.0, 2-Year Flow

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
27973	2000	-0.99	8.05	2.86	8.07	0.000094	1.14	1962.02	714.37	0.11	0.02
27050	2000	-1.57	7.88		7.96	0.000163	2.26	1210.04	614.22	0.16	0.06
26329	2000	-1.74	7.83		7.87	0.000068	1.66	1918.03	535.61	0.11	0.03
25054	2000	-1.50	7.76		7.79	0.000058	1.45	2301.43	804.60	0.10	0.02
23961	2000	-0.82	7.70		7.73	0.000046	1.39	2236.16	703.47	0.09	0.02
23155	2000	-3.58	7.67		7.69	0.000036	1.23	2927.50	930.15	0.08	0.02
22220	2000	-4.76	7.64		7.66	0.000036	1.25	2451.13	714.51	0.08	0.02
21801	2000	-0.72	7.59		7.63	0.000139	1.59	1255.71	313.65	0.14	0.03
20969	2000	-0.80	7.48		7.53	0.000105	1.70	1179.92	216.03	0.13	0.04
20364	2000	-0.86	7.42		7.47	0.000102	1.70	1173.27	208.55	0.13	0.04
19550	2000	-0.94	7.34		7.38	0.000102	1.71	1172.26	207.71	0.13	0.04
18742	2000	-1.02	7.25		7.29	0.000119	1.65	1210.84	254.72	0.13	0.03
17932	2000	-1.10	7.15		7.20	0.000124	1.66	1206.51	260.14	0.14	0.04
17124	2000	-1.18	7.05		7.09	0.000127	1.66	1201.36	262.45	0.14	0.04
16261	2000	-1.26	6.95		7.00	0.000090	1.76	1135.18	174.28	0.12	0.04
15461	2000	-1.34	6.88		6.93	0.000090	1.76	1137.14	175.40	0.12	0.04
14632	2000	-1.42	6.80		6.84	0.000126	1.67	1195.21	256.90	0.14	0.04
13828	2000	-1.50	6.69		6.73	0.000149	1.63	1226.21	312.26	0.15	0.04
12934	2000	-1.58	6.55		6.59	0.000156	1.66	1207.26	310.64	0.15	0.04
12107	2000	-1.66	6.42		6.46	0.000153	1.70	1177.38	286.88	0.15	0.04
11259	2000	-1.74	6.29		6.34	0.000143	1.75	1145.59	254.33	0.14	0.04
10466	2000	-4.48	6.24		6.27	0.000055	1.45	1865.70	435.00	0.10	0.02
9922	2000	-1.53	6.17		6.22	0.000115	1.91	1045.80	171.18	0.14	0.04
9122	2000	-1.67	6.07		6.13	0.000113	1.90	1053.53	171.35	0.13	0.04
8236	2000	-1.67	5.97		6.03	0.000119	1.93	1035.65	170.72	0.14	0.04
7013	2000	-1.70	5.82		5.88	0.000126	1.97	1015.55	170.11	0.14	0.05
6140	2000	-3.54	5.62		5.68	0.000140	1.91	1047.75	147.87	0.12	0.07
5326	2000	-3.42	4.90		5.21	0.001324	4.48	446.85	88.58	0.35	0.41
4588	2000	-5.01	4.20		4.44	0.000770	3.93	508.47	80.00	0.27	0.29
3354	2000	-3.90	2.88		3.12	0.001077	3.93	508.35	105.10	0.32	0.32
2829	2000	-4.70	2.15		2.35	0.001422	3.54	564.76	170.34	0.34	0.29
2644	2000	-4.60	1.91		2.11	0.001154	3.58	558.12	140.85	0.32	0.28
2431	2000	-3.90	1.70		1.87	0.001030	3.29	607.11	160.51	0.30	0.24
2228	2000	-4.10	1.32		1.55	0.002618	3.85	518.92	218.21	0.44	0.39
2165	2000	-4.20	1.25	-0.85	1.41	0.001394	3.17	630.21	221.54	0.33	0.25
2107.5	Bridge										
2050	2000	-4.80	1.04	-1.04	1.23	0.001961	3.49	573.09	225.25	0.39	0.31
1799	2000	-4.40	0.27		0.55	0.003862	4.24	471.46	229.88	0.52	0.49
1604	2000	-4.90	-0.15		0.00	0.001808	3.15	635.74	275.62	0.37	0.26
1397	2000	-5.40	-0.73		-0.52	0.003738	3.66	546.98	326.47	0.50	0.39
226	2000	-12.58	-0.97		-0.97	0.000001	0.17	11583.03	1171.65	0.01	0.00
0	2000	-12.21	-1.00	-9.49	-0.97	0.000053	1.27	1574.89	185.73	0.08	0.03

Tide Elevation of +1.0, 2-Year Flow

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
27973	2000	-0.99	8.06	2.86	8.08	0.000094	1.14	1964.65	714.37	0.11	0.02
27050	2000	-1.57	7.89		7.96	0.000162	2.26	1212.65	614.81	0.16	0.06
26329	2000	-1.74	7.84		7.87	0.000067	1.66	1920.39	535.61	0.11	0.03
25054	2000	-1.50	7.76		7.79	0.000058	1.45	2305.17	804.70	0.10	0.02
23961	2000	-0.82	7.71		7.73	0.000046	1.39	2239.55	703.60	0.09	0.02
23155	2000	-3.58	7.68		7.69	0.000036	1.23	2932.09	930.70	0.08	0.02
22220	2000	-4.76	7.64		7.66	0.000036	1.25	2454.72	714.69	0.08	0.02
21801	2000	-0.72	7.59		7.63	0.000138	1.59	1257.33	313.68	0.14	0.03
20969	2000	-0.80	7.49		7.53	0.000104	1.69	1181.12	216.06	0.13	0.04
20364	2000	-0.86	7.43		7.47	0.000102	1.70	1174.47	208.59	0.13	0.04
19550	2000	-0.94	7.34		7.39	0.000101	1.70	1173.51	207.75	0.13	0.04
18742	2000	-1.02	7.26		7.30	0.000119	1.65	1212.46	254.75	0.13	0.03
17932	2000	-1.10	7.16		7.20	0.000123	1.66	1208.28	260.18	0.14	0.04
17124	2000	-1.18	7.06		7.10	0.000127	1.66	1203.27	262.50	0.14	0.04
16261	2000	-1.26	6.96		7.01	0.000090	1.76	1136.51	174.33	0.12	0.04
15461	2000	-1.34	6.89		6.94	0.000090	1.76	1138.53	175.44	0.12	0.04
14632	2000	-1.42	6.81		6.85	0.000125	1.67	1197.35	256.95	0.14	0.04
13828	2000	-1.50	6.70		6.74	0.000148	1.63	1229.05	312.31	0.14	0.04
12934	2000	-1.58	6.56		6.60	0.000155	1.65	1210.43	310.69	0.15	0.04
12107	2000	-1.66	6.43		6.48	0.000152	1.69	1180.64	286.94	0.15	0.04
11259	2000	-1.74	6.30		6.35	0.000142	1.74	1148.76	254.40	0.14	0.04
10466	2000	-4.48	6.25		6.28	0.000054	1.44	1871.33	435.37	0.10	0.02
9922	2000	-1.53	6.18		6.24	0.000115	1.91	1048.08	171.26	0.14	0.04
9122	2000	-1.67	6.09		6.14	0.000112	1.89	1055.92	171.43	0.13	0.04
8236	2000	-1.67	5.98		6.04	0.000118	1.93	1038.16	170.81	0.14	0.04
7013	2000	-1.70	5.83		5.89	0.000125	1.96	1018.26	170.20	0.14	0.05
6140	2000	-3.54	5.64		5.70	0.000139	1.91	1050.36	148.41	0.12	0.06
5326	2000	-3.42	4.93		5.24	0.001305	4.45	449.13	88.73	0.35	0.40
4588	2000	-5.01	4.24		4.47	0.000757	3.91	511.48	80.15	0.27	0.29
3354	2000	-3.90	2.97		3.20	0.001021	3.87	517.40	105.54	0.31	0.31
2829	2000	-4.70	2.32		2.50	0.001218	3.37	593.27	171.51	0.32	0.26
2644	2000	-4.60	2.11		2.29	0.000987	3.41	586.59	141.77	0.30	0.25
2431	2000	-3.90	1.94		2.09	0.000854	3.10	645.65	162.68	0.27	0.21
2228	2000	-4.10	1.67		1.85	0.001776	3.34	599.57	234.06	0.37	0.28
2165	2000	-4.20	1.63	-0.85	1.75	0.000967	2.79	715.68	231.35	0.28	0.19
2107.5	Bridge										
2050	2000	-4.80	1.49	-1.04	1.63	0.001216	2.95	676.93	238.68	0.31	0.21
1799	2000	-4.40	1.19		1.33	0.001165	2.91	686.41	238.91	0.30	0.21
1604	2000	-4.90	1.10		1.16	0.000470	1.99	1006.90	316.92	0.20	0.09
1397	2000	-5.40	1.03		1.07	0.000353	1.57	1273.63	460.00	0.17	0.06
226	2000	-12.58	1.02		1.02	0.000000	0.14	13922.41	1180.97	0.01	0.00
0	2000	-12.21	1.00	-9.49	1.02	0.000030	1.01	1970.54	209.92	0.06	0.02

Lower River Reconnection Option
HEC-RAS Model
Results Summary

Tide Elevation of -1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)
27973	5200	-0.99	12.13	4.74	12.15	0.000037	1.22	4873.72	714.37	0.08	0.02
27050	5200	-1.57	12.04		12.10	0.000086	2.33	3934.80	690.81	0.13	0.05
26329	5200	-1.74	12.00		12.04	0.000060	2.10	4148.83	535.61	0.11	0.04
25054	5200	-1.50	11.95		11.98	0.000038	1.61	5769.72	845.84	0.09	0.03
23961	5200	-0.82	11.91		11.94	0.000037	1.66	5845.69	974.15	0.09	0.03
23155	5200	-3.58	11.89		11.91	0.000025	1.38	7826.44	1332.76	0.07	0.02
22220	5200	-4.76	11.86		11.88	0.000032	1.58	5862.39	906.25	0.08	0.02
21801	5200	-0.72	11.80		11.86	0.000089	1.98	2629.89	339.78	0.13	0.04
20969	5200	-0.80	11.68		11.77	0.000114	2.43	2141.43	242.45	0.14	0.06
20364	5200	-0.86	11.60		11.70	0.000116	2.48	2099.39	234.17	0.15	0.06
19550	5200	-0.94	11.51		11.61	0.000117	2.49	2091.69	233.14	0.15	0.06
18742	5200	-1.02	11.43		11.51	0.000104	2.23	2328.61	279.85	0.14	0.05
17932	5200	-1.10	11.35		11.43	0.000103	2.21	2352.71	285.92	0.14	0.05
17124	5200	-1.18	11.27		11.34	0.000103	2.20	2363.35	288.61	0.14	0.05
16261	5200	-1.26	11.13		11.24	0.000128	2.72	1914.71	199.35	0.15	0.07
15461	5200	-1.34	11.02		11.14	0.000129	2.72	1914.95	200.18	0.15	0.07
14632	5200	-1.42	10.95		11.03	0.000107	2.25	2310.58	280.03	0.14	0.05
13828	5200	-1.50	10.88		10.95	0.000093	2.01	2581.13	333.84	0.13	0.04
12934	5200	-1.58	10.80		10.86	0.000093	2.02	2573.17	332.36	0.13	0.04
12107	5200	-1.66	10.71		10.78	0.000099	2.12	2455.17	308.44	0.13	0.05
11259	5200	-1.74	10.61		10.69	0.000107	2.26	2298.19	276.45	0.14	0.05
10466	5200	-4.48	10.58		10.63	0.000054	1.99	3988.35	558.39	0.10	0.04
9922	5200	-1.53	10.45		10.57	0.000145	2.84	1834.12	197.02	0.16	0.08
9122	5200	-1.67	10.33		10.46	0.000144	2.83	1837.42	196.92	0.16	0.08
8236	5200	-1.67	10.20		10.32	0.000151	2.87	1810.94	196.12	0.17	0.08
7013	5200	-1.70	10.00		10.14	0.000159	2.92	1780.11	195.27	0.17	0.09
6140	5200	-3.54	9.85		9.94	0.000147	2.63	2904.53	995.22	0.13	0.11
5326	5200	-3.42	8.79		9.38	0.001503	6.18	867.07	169.70	0.40	0.68
4588	5200	-5.01	7.67		8.32	0.001372	6.43	808.59	92.67	0.38	0.71
3354	5200	-3.90	5.43		6.10	0.001927	6.58	790.12	115.78	0.44	0.80
2829	5200	-4.70	4.50		4.94	0.001688	5.31	980.15	182.53	0.40	0.56
2644	5200	-4.60	4.05		4.59	0.002022	5.90	881.51	159.94	0.44	0.69
2431	5200	-3.90	3.68		4.16	0.001845	5.52	942.49	177.59	0.42	0.61
2228	5200	-4.10	3.32		3.71	0.002445	4.99	1041.83	282.32	0.46	0.56
2165	5200	-4.20	3.23	0.94	3.55	0.001917	4.59	1133.95	291.12	0.41	0.46
2107.5	Bridge										
2050	5200	-4.80	2.90	1.05	3.27	0.002434	4.92	1057.57	354.29	0.46	0.55
1799	5200	-4.40	1.80		2.39	0.005133	6.17	842.64	289.64	0.64	0.93
1604	5200	-4.90	1.24		1.62	0.002807	4.95	1050.90	321.23	0.48	0.57
1397	5200	-5.40	0.11		0.68	0.008156	6.05	859.46	432.75	0.76	1.01
226	5200	-12.58	-0.80		-0.80	0.000005	0.44	11784.39	1172.44	0.02	0.00
0	5200	-12.21	-1.00	-7.69	-0.83	0.000358	3.30	1574.89	185.73	0.20	0.19

Tide Elevation of +1.0, 50-Year Flow

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
27973	5200	-0.99	12.13	4.74	12.15	0.000037	1.22	4874.08	714.37	0.08	0.02
27050	5200	-1.57	12.04		12.10	0.000086	2.33	3935.16	690.82	0.13	0.05
26329	5200	-1.74	12.00		12.04	0.000060	2.10	4149.11	535.61	0.11	0.04
25054	5200	-1.50	11.95		11.98	0.000038	1.61	5770.18	845.85	0.09	0.03
23961	5200	-0.82	11.91		11.94	0.000037	1.66	5846.22	974.18	0.09	0.03
23155	5200	-3.58	11.89		11.91	0.000025	1.38	7827.18	1332.80	0.07	0.02
22220	5200	-4.76	11.86		11.88	0.000032	1.58	5862.90	906.27	0.08	0.02
21801	5200	-0.72	11.80		11.86	0.000089	1.98	2630.08	339.78	0.13	0.04
20969	5200	-0.80	11.68		11.77	0.000114	2.43	2141.57	242.45	0.14	0.06
20364	5200	-0.86	11.61		11.70	0.000116	2.48	2099.54	234.17	0.15	0.06
19550	5200	-0.94	11.51		11.61	0.000117	2.49	2091.84	233.15	0.15	0.06
18742	5200	-1.02	11.43		11.51	0.000104	2.23	2328.79	279.86	0.14	0.05
17932	5200	-1.10	11.35		11.43	0.000103	2.21	2352.90	285.93	0.14	0.05
17124	5200	-1.18	11.27		11.34	0.000103	2.20	2363.55	288.61	0.14	0.05
16261	5200	-1.26	11.13		11.24	0.000128	2.72	1914.85	199.35	0.15	0.07
15461	5200	-1.34	11.02		11.14	0.000129	2.72	1915.10	200.19	0.15	0.07
14632	5200	-1.42	10.95		11.03	0.000107	2.25	2310.80	280.04	0.14	0.05
13828	5200	-1.50	10.88		10.95	0.000093	2.01	2581.39	333.85	0.13	0.04
12934	5200	-1.58	10.80		10.86	0.000093	2.02	2573.44	332.37	0.13	0.04
12107	5200	-1.66	10.71		10.78	0.000099	2.12	2455.43	308.44	0.13	0.05
11259	5200	-1.74	10.62		10.69	0.000107	2.26	2298.43	276.45	0.14	0.05
10466	5200	-4.48	10.58		10.63	0.000054	1.99	3988.85	558.42	0.10	0.04
9922	5200	-1.53	10.45		10.57	0.000145	2.83	1834.30	197.02	0.16	0.08
9122	5200	-1.67	10.33		10.46	0.000144	2.83	1837.61	196.93	0.16	0.08
8236	5200	-1.67	10.20		10.33	0.000151	2.87	1811.14	196.12	0.17	0.08
7013	5200	-1.70	10.00		10.14	0.000159	2.92	1780.32	195.28	0.17	0.09
6140	5200	-3.54	9.85		9.94	0.000147	2.63	2905.71	995.51	0.13	0.11
5326	5200	-3.42	8.79		9.38	0.001502	6.18	867.37	169.78	0.40	0.68
4588	5200	-5.01	7.68		8.32	0.001371	6.43	808.84	92.68	0.38	0.71
3354	5200	-3.90	5.44		6.11	0.001919	6.57	791.09	115.80	0.44	0.80
2829	5200	-4.70	4.52		4.95	0.001672	5.29	983.11	182.61	0.40	0.56
2644	5200	-4.60	4.07		4.61	0.001998	5.88	884.96	160.06	0.44	0.68
2431	5200	-3.90	3.71		4.18	0.001817	5.49	947.42	177.83	0.42	0.60
2228	5200	-4.10	3.36		3.74	0.002364	4.94	1053.01	282.70	0.45	0.55
2165	5200	-4.20	3.27	0.94	3.59	0.001852	4.54	1146.61	291.71	0.40	0.45
2107.5	Bridge										
2050	5200	-4.80	2.95	1.05	3.32	0.002309	4.84	1074.64	360.83	0.44	0.53
1799	5200	-4.40	2.00		2.51	0.004509	5.76	903.10	312.66	0.60	0.81
1604	5200	-4.90	1.57		1.88	0.002111	4.49	1159.17	331.42	0.42	0.46
1397	5200	-5.40	1.21		1.44	0.001962	3.84	1354.34	463.39	0.40	0.36
226	5200	-12.58	1.13		1.13	0.000003	0.37	14050.36	1181.78	0.02	0.00
0	5200	-12.21	1.00	-7.69	1.11	0.000200	2.64	1970.54	209.92	0.15	0.12

Tide Elevation of -1.0, 100-Year Flow

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
27973	5800	-0.99	12.74	5.62	12.76	0.000035	1.25	5306.83	714.37	0.08	0.02
27050	5800	-1.57	12.65		12.71	0.000082	2.35	4359.65	701.37	0.13	0.05
26329	5800	-1.74	12.61		12.65	0.000060	2.17	4475.55	535.61	0.11	0.04
25054	5800	-1.50	12.56		12.59	0.000037	1.65	6289.06	851.21	0.09	0.03
23961	5800	-0.82	12.52		12.55	0.000036	1.69	6450.82	998.32	0.08	0.03
23155	5800	-3.58	12.51		12.52	0.000025	1.40	8658.22	1373.62	0.07	0.02
22220	5800	-4.76	12.47		12.50	0.000032	1.63	6427.74	934.70	0.08	0.02
21801	5800	-0.72	12.41		12.47	0.000087	2.04	2838.62	343.57	0.13	0.04
20969	5800	-0.80	12.29		12.38	0.000116	2.53	2289.72	246.27	0.15	0.07
20364	5800	-0.86	12.21		12.31	0.000119	2.59	2242.17	237.87	0.15	0.07
19550	5800	-0.94	12.11		12.22	0.000119	2.60	2233.34	236.82	0.15	0.07
18742	5800	-1.02	12.04		12.12	0.000104	2.32	2498.61	283.48	0.14	0.06
17932	5800	-1.10	11.95		12.04	0.000103	2.30	2526.45	289.63	0.14	0.06
17124	5800	-1.18	11.87		11.95	0.000103	2.28	2538.80	292.35	0.14	0.05
16261	5800	-1.26	11.72		11.85	0.000133	2.85	2034.55	202.93	0.16	0.08
15461	5800	-1.34	11.61		11.74	0.000134	2.85	2034.42	203.72	0.16	0.08
14632	5800	-1.42	11.54		11.63	0.000107	2.34	2477.69	283.33	0.14	0.06
13828	5800	-1.50	11.48		11.55	0.000091	2.09	2780.75	336.91	0.13	0.05
12934	5800	-1.58	11.40		11.46	0.000092	2.09	2772.37	335.41	0.13	0.05
12107	5800	-1.66	11.31		11.38	0.000098	2.20	2640.17	311.44	0.13	0.05
11259	5800	-1.74	11.21		11.30	0.000107	2.35	2463.48	278.25	0.14	0.06
10466	5800	-4.48	11.18		11.23	0.000055	2.07	4328.23	578.51	0.11	0.04
9922	5800	-1.53	11.03		11.17	0.000151	2.97	1950.77	200.56	0.17	0.09
9122	5800	-1.67	10.91		11.05	0.000150	2.97	1953.09	200.42	0.17	0.09
8236	5800	-1.67	10.77		10.91	0.000157	3.01	1925.03	199.58	0.17	0.09
7013	5800	-1.70	10.57		10.72	0.000165	3.07	1892.12	198.69	0.18	0.10
6140	5800	-3.54	10.45		10.53	0.000127	2.53	3530.01	1057.81	0.13	0.10
5326	5800	-3.42	9.37		9.98	0.001439	6.31	968.61	175.90	0.39	0.70
4588	5800	-5.01	8.17		8.88	0.001458	6.79	854.72	94.46	0.40	0.78
3354	5800	-3.90	5.78		6.54	0.002051	6.98	830.93	116.60	0.46	0.89
2829	5800	-4.70	4.83		5.31	0.001743	5.58	1040.24	184.12	0.41	0.61
2644	5800	-4.60	4.34		4.94	0.002149	6.25	927.98	161.47	0.46	0.76
2431	5800	-3.90	3.95		4.48	0.001984	5.86	989.83	179.85	0.44	0.68
2228	5800	-4.10	3.59		4.01	0.002435	5.19	1117.90	284.89	0.46	0.59
2165	5800	-4.20	3.50	1.17	3.85	0.001938	4.78	1212.92	294.79	0.42	0.50
2107.5	Bridge										
2050	5800	-4.80	3.15	1.26	3.56	0.002418	5.12	1132.28	367.40	0.46	0.58
1799	5800	-4.40	2.03		2.66	0.005515	6.36	912.54	316.84	0.66	0.99
1604	5800	-4.90	1.42		1.85	0.002975	5.22	1110.37	326.87	0.50	0.63
1397	5800	-5.40	0.23		0.86	0.008355	6.34	914.60	436.99	0.77	1.09
226	5800	-12.58	-0.75		-0.75	0.000006	0.49	11841.91	1172.66	0.03	0.00
0	5800	-12.21	-1.00	-7.41	-0.79	0.000445	3.68	1574.89	185.73	0.22	0.23

Lower River Reconnection Option
HEC-RAS Model
Results Summary

Tide Elevation of +1.0, 100-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)
27973	5800	-0.99	12.74	5.62	12.76	0.000035	1.25	5307.04	714.37	0.08	0.02
27050	5800	-1.57	12.65		12.71	0.000082	2.35	4359.86	701.38	0.13	0.05
26329	5800	-1.74	12.61		12.66	0.000060	2.17	4475.71	535.61	0.11	0.04
25054	5800	-1.50	12.56		12.59	0.000037	1.65	6289.33	851.21	0.09	0.03
23961	5800	-0.82	12.52		12.55	0.000036	1.69	6451.14	998.33	0.08	0.03
23155	5800	-3.58	12.51		12.52	0.000024	1.40	8658.66	1373.64	0.07	0.02
22220	5800	-4.76	12.47		12.50	0.000032	1.63	6428.05	934.72	0.08	0.02
21801	5800	-0.72	12.41		12.47	0.000087	2.04	2838.73	343.57	0.13	0.04
20969	5800	-0.80	12.29		12.39	0.000116	2.53	2289.80	246.28	0.15	0.07
20364	5800	-0.86	12.21		12.31	0.000119	2.59	2242.25	237.87	0.15	0.07
19550	5800	-0.94	12.11		12.22	0.000119	2.60	2233.43	236.82	0.15	0.07
18742	5800	-1.02	12.04		12.12	0.000104	2.32	2498.72	283.48	0.14	0.06
17932	5800	-1.10	11.95		12.04	0.000103	2.30	2526.56	289.63	0.14	0.06
17124	5800	-1.18	11.87		11.95	0.000103	2.28	2538.91	292.36	0.14	0.05
16261	5800	-1.26	11.72		11.85	0.000133	2.85	2034.64	202.93	0.16	0.08
15461	5800	-1.34	11.62		11.74	0.000134	2.85	2034.51	203.72	0.16	0.08
14632	5800	-1.42	11.55		11.63	0.000107	2.34	2477.81	283.34	0.14	0.06
13828	5800	-1.50	11.48		11.55	0.000091	2.09	2780.90	336.91	0.13	0.05
12934	5800	-1.58	11.40		11.46	0.000092	2.09	2772.52	335.42	0.13	0.05
12107	5800	-1.66	11.31		11.38	0.000098	2.20	2640.32	311.44	0.13	0.05
11259	5800	-1.74	11.21		11.30	0.000107	2.35	2463.62	278.25	0.14	0.06
10466	5800	-4.48	11.18		11.23	0.000055	2.07	4328.52	578.53	0.11	0.04
9922	5800	-1.53	11.03		11.17	0.000151	2.97	1950.88	200.56	0.17	0.09
9122	5800	-1.67	10.91		11.05	0.000150	2.97	1953.20	200.43	0.17	0.09
8236	5800	-1.67	10.77		10.92	0.000157	3.01	1925.14	199.58	0.17	0.09
7013	5800	-1.70	10.57		10.72	0.000165	3.07	1892.24	198.70	0.18	0.10
6140	5800	-3.54	10.45		10.53	0.000127	2.53	3530.72	1057.84	0.13	0.10
5326	5800	-3.42	9.37		9.98	0.001438	6.30	968.79	175.91	0.39	0.70
4588	5800	-5.01	8.17		8.88	0.001458	6.78	854.87	94.47	0.40	0.78
3354	5800	-3.90	5.78		6.54	0.002046	6.98	831.53	116.62	0.46	0.88
2829	5800	-4.70	4.84		5.32	0.001734	5.57	1042.09	184.17	0.41	0.60
2644	5800	-4.60	4.35		4.95	0.002133	6.24	930.17	161.55	0.46	0.76
2431	5800	-3.90	3.97		4.50	0.001965	5.84	993.01	180.00	0.44	0.67
2228	5800	-4.10	3.62		4.03	0.002386	5.16	1125.05	285.13	0.46	0.58
2165	5800	-4.20	3.53	1.17	3.88	0.001899	4.75	1221.00	295.17	0.41	0.49
2107.5	Bridge										
2050	5800	-4.80	3.19	1.26	3.59	0.002344	5.07	1143.05	367.74	0.45	0.57
1799	5800	-4.40	2.18		2.74	0.004946	6.04	960.69	332.09	0.63	0.89
1604	5800	-4.90	1.68		2.05	0.002399	4.85	1195.90	334.81	0.45	0.53
1397	5800	-5.40	1.25		1.53	0.002321	4.21	1376.21	464.30	0.43	0.43
226	5800	-12.58	1.16		1.16	0.000003	0.41	14086.98	1182.02	0.02	0
0	5800	-12.21	1	-7.41	1.13	0.000249	2.94	1970.54	209.92	0.17	0.14

New River Mouth Option
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Tide Elevation of -1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)
12167	125	-0.99	3.02	0.45	3.02	0.000028	0.48	261.26	119.94	0.06	0.00
11244	125	-1.57	2.99		3.00	0.000025	0.51	247.51	94.10	0.05	0.00
10523	125	-1.74	2.99		2.99	0.000007	0.34	367.69	103.48	0.03	0.00
9248	125	-1.50	2.97		2.97	0.000014	0.36	342.66	136.40	0.04	0.00
8155	125	-0.82	2.96		2.97	0.000005	0.27	470.18	149.96	0.03	0.00
7349	125	-3.58	2.96		2.96	0.000005	0.26	478.32	134.23	0.02	0.00
6414	125	-4.76	2.96		2.96	0.000003	0.22	568.96	138.08	0.02	0.00
5925	125	2.18	2.92		2.95	0.001362	1.39	89.99	122.96	0.29	0.06
5375	125	1.29	2.04		2.08	0.001865	1.64	76.31	103.01	0.34	0.09
4675	125	0.15	1.01		1.04	0.001198	1.43	87.30	103.42	0.27	0.06
3875	125	-1.16	-0.53		-0.47	0.003385	1.96	63.68	102.52	0.44	0.13
3175	125	-2.30	-0.93		-0.92	0.000252	0.89	140.60	105.47	0.14	0.02
2425	125	-3.54	-0.98		-0.97	0.000031	0.47	266.94	108.11	0.05	0.00
1725	125	-4.70	-0.99		-0.99	0.000009	0.32	394.69	112.81	0.03	0.00
1125	125	-5.67	-0.99		-0.99	0.000004	0.25	509.53	117.75	0.02	0.00
925	125	-5.81	-0.99		-0.99	0.000003	0.20	624.77	139.27	0.02	0.00
525	125	-9.00	-0.99		-0.99	0.000007	0.26	473.20	149.10	0.03	0.00
350	125	-9.00	-0.99		-0.99	0.000011	0.26	473.18	200.61	0.03	0.00
275	125	-9.00	-1.00		-1.00	0.000014	0.26	472.39	253.34	0.03	0.00
0	125	-9.00	-1.00	-8.37	-1.00	0.000003	0.26	472.00	75.00	0.02	0.00

New River Mouth Option
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Results Summary

Tide Elevation of +1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)
12167	125	-0.99	3.03	0.45	3.03	0.000028	0.48	262.57	120.01	0.06	0.00
11244	125	-1.57	3.00		3.01	0.000025	0.50	248.57	94.21	0.05	0.00
10523	125	-1.74	3.00		3.00	0.000007	0.34	368.86	103.56	0.03	0.00
9248	125	-1.50	2.98		2.99	0.000013	0.36	344.22	136.48	0.04	0.00
8155	125	-0.82	2.98		2.98	0.000005	0.26	471.92	150.01	0.03	0.00
7349	125	-3.58	2.97		2.97	0.000004	0.26	479.88	134.39	0.02	0.00
6414	125	-4.76	2.97		2.97	0.000003	0.22	570.58	138.29	0.02	0.00
5925	125	2.18	2.93		2.96	0.001286	1.37	91.57	123.01	0.28	0.06
5375	125	1.29	1.99		2.04	0.002290	1.74	71.70	102.83	0.37	0.10
4675	125	0.15	1.12		1.14	0.000815	1.27	98.19	103.84	0.23	0.05
3875	125	-1.16	1.02		1.03	0.000053	0.55	227.73	108.73	0.07	0.01
3175	125	-2.30	1.01		1.01	0.000013	0.35	352.96	113.24	0.04	0.00
2425	125	-3.54	1.00		1.01	0.000005	0.26	487.45	114.40	0.02	0.00
1725	125	-4.70	1.00		1.00	0.000002	0.20	625.96	119.68	0.02	0.00
1125	125	-5.67	1.00		1.00	0.000001	0.17	751.57	125.30	0.01	0.00
925	125	-5.81	1.00		1.00	0.000001	0.14	910.13	147.23	0.01	0.00
525	125	-9.00	1.00		1.00	0.000001	0.16	778.31	157.07	0.01	0.00
350	125	-9.00	1.00		1.00	0.000001	0.14	881.34	208.59	0.01	0.00
275	125	-9.00	1.00		1.00	0.000001	0.13	986.75	261.33	0.01	0.00
0	125	-9.00	1.00	-8.37	1.00	0.000001	0.12	1014.82	275.41	0.01	0.00

Tide Elevation of -1.0, 2-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)
12167	1800	-0.99	7.01	2.74	7.07	0.000172	2.06	1232.47	637.55	0.16	0.05
11244	1800	-1.57	6.75		6.86	0.000297	2.66	679.87	170.57	0.21	0.09
10523	1800	-1.74	6.66		6.71	0.000119	1.98	1322.8	465.53	0.14	0.05
9248	1800	-1.5	6.5		6.55	0.000125	1.86	1362.67	649.04	0.14	0.04
8155	1800	-0.82	6.39		6.44	0.000089	1.7	1368.06	590.6	0.12	0.03
7349	1800	-3.58	6.33		6.37	0.000075	1.57	1787.43	765.18	0.11	0.03
6414	1800	-4.76	6.27		6.3	0.00007	1.53	1543.07	592.99	0.11	0.03
5925	1800	2.18	5.98		6.19	0.001186	3.71	484.8	135.2	0.35	0.26
5375	1800	1.29	5.14		5.43	0.001618	4.34	414.94	115.41	0.4	0.36
4675	1800	0.15	4.01		4.3	0.001614	4.33	415.27	115.41	0.4	0.36
3875	1800	-1.16	2.76		3.04	0.001527	4.26	422.59	115.68	0.39	0.34
3175	1800	-2.3	1.78		2.04	0.001333	4.08	441.33	116.32	0.37	0.31
2425	1800	-3.54	0.96		1.17	0.000977	3.73	482.06	114.25	0.32	0.25
1725	1800	-4.7	0.46		0.62	0.000611	3.2	561.93	117.82	0.26	0.18
1125	1800	-5.67	0.2		0.32	0.00039	2.76	652.68	122.27	0.21	0.13
925	1800	-5.81	0.17		0.25	0.000257	2.28	788.53	143.89	0.17	0.09
525	1800	-9	-0.03		0.1	0.000633	2.91	618.34	152.95	0.26	0.16
350	1800	-9	-0.21		-0.08	0.000856	2.85	631.72	203.75	0.29	0.16
275	1800	-9	-0.66		-0.5	0.001734	3.23	557.73	254.68	0.38	0.23
0	1800	-9	-1	-5.44	-0.77	0.00062	3.81	472	75	0.27	0.23

New River Mouth Option
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Tide Elevation of +1.0, 2-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)
12167	1800	-0.99	7.39	2.74	7.43	0.000125	1.82	1489.47	693.18	0.14	0.04
11244	1800	-1.57	7.19		7.28	0.00022	2.42	818.91	478.62	0.18	0.07
10523	1800	-1.74	7.13		7.17	0.000086	1.76	1549.35	494.5	0.12	0.04
9248	1800	-1.5	7.03		7.06	0.000083	1.6	1725.57	739.55	0.12	0.03
8155	1800	-0.82	6.95		6.98	0.000061	1.49	1719.52	662.71	0.1	0.03
7349	1800	-3.58	6.91		6.93	0.00005	1.35	2252.27	845.75	0.09	0.02
6414	1800	-4.76	6.86		6.89	0.000048	1.34	1912.85	653.77	0.09	0.02
5925	1800	2.18	6.72		6.82	0.001292	2.47	730.09	404.74	0.32	0.14
5375	1800	1.29	5.92		6.04	0.001541	2.82	637.83	329.09	0.36	0.19
4675	1800	0.15	4.88		5.01	0.001413	2.84	634.35	303.92	0.35	0.18
3875	1800	-1.16	3.26		3.48	0.002685	3.72	484.44	250.37	0.47	0.32
3175	1800	-2.3	2.24		2.45	0.000927	3.63	495.45	118.17	0.31	0.24
2425	1800	-3.54	1.74		1.89	0.00057	3.14	572.4	116.74	0.25	0.17
1725	1800	-4.7	1.47		1.58	0.000334	2.64	682.42	121.3	0.2	0.11
1125	1800	-5.67	1.33		1.41	0.000214	2.27	793.18	126.55	0.16	0.08
925	1800	-5.81	1.32		1.37	0.000141	1.88	956.5	148.48	0.13	0.06
525	1800	-9	1.21		1.28	0.000269	2.22	810.8	157.9	0.17	0.08
350	1800	-9	1.15		1.21	0.00026	1.97	913.06	209.2	0.17	0.07
275	1800	-9	1.07		1.12	0.000253	1.79	1005.02	261.61	0.16	0.06
0	1800	-9	1	-5.44	1.05	0.000262	1.77	1014.82	275.41	0.16	0.06

New River Mouth Option
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Results Summary

Tide Elevation of -1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)
12167	4700	-0.99	9.57	4.47	9.65	0.000163	2.62	3045.58	714.37	0.17	0.08
11244	4700	-1.57	9.26		9.43	0.000332	3.69	2076.93	642.61	0.24	0.15
10523	4700	-1.74	9.14		9.24	0.000174	2.97	2618.01	535.61	0.18	0.09
9248	4700	-1.50	8.96		9.03	0.000141	2.52	3278.45	819.64	0.16	0.07
8155	4700	-0.82	8.80		8.88	0.000135	2.59	3044.12	786.28	0.15	0.07
7349	4700	-3.58	8.72		8.78	0.000105	2.29	3972.34	1062.40	0.14	0.05
6414	4700	-4.76	8.60		8.67	0.000116	2.41	3157.28	755.42	0.14	0.06
5925	4700	2.18	8.36		8.53	0.001044	3.35	1404.25	419.04	0.32	0.22
5375	4700	1.29	7.67		7.90	0.001247	3.83	1226.57	340.80	0.36	0.28
4675	4700	0.15	6.88		7.10	0.001055	3.75	1251.83	315.94	0.33	0.26
3875	4700	-1.16	6.06		6.29	0.000956	3.90	1206.45	267.01	0.32	0.27
3175	4700	-2.30	5.24		5.58	0.001061	4.63	1014.52	186.09	0.35	0.36
2425	4700	-3.54	4.27		4.67	0.001363	5.11	920.57	174.87	0.39	0.44
1725	4700	-4.70	3.38		3.76	0.001218	4.94	950.69	174.20	0.37	0.41
1125	4700	-5.67	2.75		3.09	0.001009	4.67	1005.86	174.33	0.34	0.36
925	4700	-5.81	2.65		2.89	0.000706	3.86	1216.67	215.87	0.29	0.24
525	4700	-9.00	2.24		2.52	0.001800	4.22	1113.71	350.16	0.42	0.35
350	4700	-9.00	1.74		2.04	0.001997	4.40	1068.87	341.46	0.44	0.38
275	4700	-9.00	1.03	-2.54	1.38	0.001782	4.72	995.23	261.46	0.43	0.42
0	4700	-9.00	-1.00	-2.54	0.54	0.004226	9.96	472.00	75.00	0.70	1.58

Tide Elevation of +1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)
12167	4700	-0.99	9.57	4.47	9.65	0.000163	2.62	3046.01	714.37	0.17	0.08
11244	4700	-1.57	9.26		9.43	0.000332	3.69	2077.41	642.63	0.24	0.15
10523	4700	-1.74	9.14		9.24	0.000174	2.97	2618.43	535.61	0.18	0.09
9248	4700	-1.50	8.96		9.03	0.000141	2.52	3279.18	819.65	0.16	0.07
8155	4700	-0.82	8.80		8.88	0.000135	2.59	3044.88	786.37	0.15	0.07
7349	4700	-3.58	8.72		8.78	0.000105	2.29	3973.44	1062.52	0.14	0.05
6414	4700	-4.76	8.60		8.67	0.000116	2.41	3158.10	755.47	0.14	0.06
5925	4700	2.18	8.36		8.53	0.001043	3.35	1404.79	419.05	0.32	0.22
5375	4700	1.29	7.68		7.90	0.001244	3.83	1227.47	340.82	0.36	0.28
4675	4700	0.15	6.88		7.10	0.001050	3.75	1253.62	315.97	0.33	0.26
3875	4700	-1.16	6.07		6.30	0.000949	3.89	1209.49	267.08	0.32	0.27
3175	4700	-2.30	5.26		5.59	0.001049	4.62	1018.12	186.20	0.35	0.35
2425	4700	-3.54	4.30		4.70	0.001334	5.07	927.08	175.09	0.39	0.43
1725	4700	-4.70	3.45		3.82	0.001174	4.88	962.15	174.60	0.37	0.39
1125	4700	-5.67	2.84		3.17	0.000959	4.60	1022.56	174.91	0.34	0.34
925	4700	-5.81	2.76		2.98	0.000668	3.79	1238.80	216.61	0.28	0.23
525	4700	-9.00	2.38		2.63	0.001577	4.05	1161.26	352.01	0.39	0.32
350	4700	-9.00	1.98		2.24	0.001576	4.09	1149.52	342.88	0.39	0.33
275	4700	-9.00	1.47		1.75	0.001253	4.24	1109.47	263.20	0.36	0.32
0	4700	-9.00	1.00	-2.54	1.33	0.001788	4.63	1014.82	275.41	0.43	0.40

Tide Elevation of -1.0, 100-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)
12167	5300	-0.99	9.94	4.78	10.01	0.000167	2.73	3305.39	714.37	0.17	0.08
11244	5300	-1.57	9.62		9.79	0.000334	3.82	2308.86	648.82	0.24	0.16
10523	5300	-1.74	9.49		9.60	0.000184	3.14	2805.84	535.61	0.18	0.10
9248	5300	-1.50	9.31		9.38	0.000146	2.63	3562.26	822.67	0.16	0.07
8155	5300	-0.82	9.13		9.22	0.000143	2.74	3313.10	817.69	0.16	0.08
7349	5300	-3.58	9.05		9.11	0.000110	2.40	4332.21	1100.02	0.14	0.06
6414	5300	-4.76	8.92		9.00	0.000124	2.56	3403.49	770.37	0.15	0.07
5925	5300	2.18	8.67		8.86	0.000993	3.45	1536.12	421.78	0.32	0.22
5375	5300	1.29	8.02		8.26	0.001181	3.94	1343.73	343.09	0.35	0.29
4675	5300	0.15	7.27		7.50	0.000990	3.85	1375.51	318.29	0.33	0.26
3875	5300	-1.16	6.49		6.74	0.000907	4.01	1322.67	269.59	0.32	0.27
3175	5300	-2.30	5.68		6.04	0.001064	4.84	1095.70	188.65	0.35	0.38
2425	5300	-3.54	4.69		5.13	0.001362	5.32	995.79	177.47	0.40	0.47
1725	5300	-4.70	3.80		4.22	0.001230	5.17	1024.81	176.78	0.38	0.43
1125	5300	-5.67	3.15		3.53	0.001040	4.92	1077.48	176.80	0.35	0.39
925	5300	-5.81	3.07		3.32	0.000722	4.06	1306.34	218.85	0.29	0.26
525	5300	-9.00	2.66		2.94	0.001545	4.20	1261.24	355.86	0.39	0.34
350	5300	-9.00	2.27		2.55	0.001525	4.24	1250.36	344.65	0.39	0.34
275	5300	-9.00	1.63	-2.05	1.95	0.001923	4.57	1160.54	340.55	0.44	0.40
0	5300	-9.00	-1.00	-2.05	0.96	0.005373	11.23	472.00	75.00	0.79	2.01

Tide Elevation of +1.0, 100-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)
12167	5300	-0.99	9.94	4.78	10.01	0.000167	2.73	3305.48	714.37	0.17	0.08
11244	5300	-1.57	9.62		9.79	0.000334	3.82	2308.95	648.83	0.24	0.16
10523	5300	-1.74	9.49		9.60	0.000184	3.14	2805.93	535.61	0.18	0.10
9248	5300	-1.50	9.31		9.38	0.000146	2.63	3562.40	822.67	0.16	0.07
8155	5300	-0.82	9.13		9.22	0.000143	2.74	3313.25	817.71	0.16	0.08
7349	5300	-3.58	9.05		9.11	0.000110	2.40	4332.43	1100.04	0.14	0.06
6414	5300	-4.76	8.92		9.00	0.000124	2.56	3403.66	770.38	0.15	0.07
5925	5300	2.18	8.67		8.86	0.000993	3.45	1536.23	421.78	0.32	0.22
5375	5300	1.29	8.02		8.26	0.001180	3.94	1343.89	343.09	0.35	0.29
4675	5300	0.15	7.27		7.50	0.000989	3.85	1375.80	318.30	0.33	0.26
3875	5300	-1.16	6.49		6.74	0.000906	4.01	1323.10	269.60	0.32	0.27
3175	5300	-2.30	5.68		6.04	0.001062	4.83	1096.20	188.67	0.35	0.38
2425	5300	-3.54	4.70		5.14	0.001358	5.32	996.66	177.50	0.40	0.46
1725	5300	-4.70	3.81		4.23	0.001225	5.16	1026.31	176.83	0.38	0.43
1125	5300	-5.67	3.17		3.54	0.001034	4.91	1079.65	176.87	0.35	0.38
925	5300	-5.81	3.08		3.33	0.000717	4.05	1309.20	218.95	0.29	0.26
525	5300	-9.00	2.68		2.95	0.001522	4.18	1267.37	356.10	0.39	0.33
350	5300	-9.00	2.30		2.57	0.001490	4.21	1259.30	344.80	0.39	0.33
275	5300	-9.00	1.68		1.99	0.001827	4.50	1178.94	340.88	0.43	0.39
0	5300	-9.00	1.00	-2.05	1.42	0.002274	5.22	1014.82	275.41	0.48	0.51

Tide Elevation of -1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^{2})	Shear Chan (lb/sq ft)
25624	135	-0.99	1.82	0.50	1.83	0.000280	1.07	126.04	97.39	0.17	1.29	0.02
24701	135	-1.57	1.62		1.63	0.000173	1.03	130.71	73.37	0.14	1.75	0.02
23980	135	-1.74	1.56		1.56	0.000038	0.60	225.97	93.19	0.07	2.41	0.01
22705	135	-1.50	1.46		1.47	0.000199	0.92	146.67	109.79	0.14	1.33	0.02
21612	135	-0.82	1.36		1.36	0.000056	0.57	235.90	140.20	0.08	1.68	0.01
20806	135	-3.58	1.33		1.33	0.000023	0.48	279.53	108.01	0.05	2.54	0.00
19871	135	-4.76	1.32		1.32	0.000009	0.37	368.31	107.24	0.03	3.36	0.00
19232	135	-2.38	1.30		1.31	0.000052	0.65	207.47	95.16	0.08	2.16	0.01
18489	135	0.01	1.18		1.20	0.001024	1.37	98.50	139.05	0.29	0.71	0.05
17361	135	-2.87	1.07		1.07	0.000039	0.62	217.60	86.79	0.07	2.47	0.01
16613	135	0.17	0.75	0.75	0.95	0.015561	3.53	38.21	100.62	1.01	0.38	0.37
16129	135	-0.73	0.57	-0.39	0.58	0.000179	0.85	159.57	125.20	0.13	1.27	0.01
15729	135	-0.81	0.50		0.51	0.000174	0.84	160.80	125.25	0.13	1.28	0.01
14929	135	-0.99	0.37		0.38	0.000154	0.81	167.03	125.44	0.12	1.32	0.01
14429	135	-1.09	0.30		0.31	0.000144	0.79	170.34	125.55	0.12	1.35	0.01
13829	135	-1.21	0.22		0.23	0.000132	0.77	175.20	125.71	0.12	1.39	0.01
13279	135	-1.33	0.15		0.16	0.000117	0.74	181.79	125.91	0.11	1.44	0.01
12630	135	-1.47	0.08		0.09	0.000101	0.71	190.00	126.17	0.10	1.50	0.01
11930	135	-1.61	0.01		0.02	0.000085	0.67	200.20	126.49	0.09	1.57	0.01
11335	135	-4.00	-0.02		-0.02	0.000050	0.67	201.93	86.89	0.08	2.30	0.01
10653	135	-2.87	-0.12		-0.10	0.000337	1.22	110.53	80.39	0.18	1.37	0.03
9802	135	-6.58	-0.12		-0.12	0.000005	0.32	419.37	98.86	0.03	4.11	0.00
9038	135	-1.69	-0.16		-0.14	0.000790	1.31	102.89	127.96	0.26	0.80	0.04
8045	135	-4.48	-0.24		-0.23	0.000032	0.55	247.25	102.95	0.06	2.38	0.00
7584	135	-6.45	-0.24		-0.24	0.000009	0.38	354.13	98.54	0.04	3.50	0.00
6956	135	-5.09	-0.25		-0.25	0.000025	0.52	258.19	96.19	0.06	2.66	0.00
6140	135	-3.54	-0.28		-0.27	0.000032	0.47	285.65	114.11	0.05	2.49	0.00
5326	135	-3.42	-0.56		-0.51	0.000607	1.71	78.98	41.66	0.22	1.87	0.07
4588	135	-5.01	-0.63		-0.62	0.000057	0.75	181.10	55.62	0.07	3.18	0.01
3354	135	-3.90	-0.81		-0.80	0.000156	0.86	156.60	83.58	0.11	1.86	0.02
2829	135	-4.70	-0.89		-0.88	0.000155	0.89	151.70	76.99	0.11	1.96	0.02
2644	135	-4.60	-0.92		-0.91	0.000141	0.73	184.81	118.00	0.10	1.56	0.01
2431	135	-3.90	-0.94		-0.93	0.000085	0.61	222.05	127.59	0.08	1.73	0.01
2228	135	-4.10	-0.97		-0.96	0.000150	0.80	169.30	99.06	0.11	1.70	0.02
2165	135	-4.20	-0.97		-0.97	0.000067	0.56	240.13	130.12	0.07	1.84	0.01
2050	135	-4.80	-0.98		-0.97	0.000051	0.54	249.87	115.74	0.06	2.14	0.01
1799	135	-4.40	-0.99		-0.98	0.000048	0.49	273.93	140.69	0.06	1.94	0.01
1604	135	-4.90	-0.99		-0.99	0.000028	0.33	409.76	260.57	0.05	1.57	0.00
1397	135	-5.40	-1.00		-1.00	0.000018	0.29	469.06	262.78	0.04	1.78	0.00
226	135	-12.58	-1.00		-1.00	0.000000	0.01	11548.14	1171.51	0.00	9.81	0.00
0	135	-12.21	-1.00	-11.41	-1.00	0.000000	0.09	1574.89	185.73	0.01	8.33	0.00

Tide Elevation of +1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
25624	135	-0.99	1.93	0.50	1.95	0.000220	0.98	137.68	101.20	0.15	1.36	0.02
24701	135	-1.57	1.78		1.79	0.000136	0.95	142.69	76.24	0.12	1.87	0.02
23980	135	-1.74	1.73		1.74	0.000031	0.56	242.21	95.08	0.06	2.55	0.00
22705	135	-1.50	1.65		1.66	0.000137	0.80	169.05	118.08	0.12	1.43	0.01
21612	135	-0.82	1.59		1.59	0.000037	0.50	268.29	142.38	0.06	1.88	0.00
20806	135	-3.58	1.57		1.57	0.000018	0.44	305.60	112.59	0.05	2.71	0.00
19871	135	-4.76	1.56		1.56	0.000008	0.34	394.35	111.36	0.03	3.54	0.00
19232	135	-2.38	1.54		1.55	0.000038	0.58	230.89	98.64	0.07	2.34	0.01
18489	135	0.01	1.47		1.48	0.000362	0.95	142.82	161.38	0.18	0.88	0.02
17361	135	-2.87	1.40		1.40	0.000028	0.55	247.28	93.48	0.06	2.65	0.00
16613	135	0.17	1.32		1.34	0.000853	1.23	109.86	159.42	0.26	0.69	0.04
16129	135	-0.73	1.28		1.28	0.000042	0.54	248.77	128.02	0.07	1.94	0.01
15729	135	-0.81	1.26		1.26	0.000038	0.53	257.01	128.28	0.07	2.00	0.00
14929	135	-0.99	1.23		1.24	0.000030	0.49	276.76	128.89	0.06	2.15	0.00
14429	135	-1.09	1.22		1.22	0.000026	0.47	287.90	129.24	0.06	2.23	0.00
13829	135	-1.21	1.21		1.21	0.000023	0.45	301.58	129.67	0.05	2.33	0.00
13279	135	-1.33	1.19		1.20	0.000019	0.43	315.69	130.10	0.05	2.43	0.00
12630	135	-1.47	1.18		1.19	0.000017	0.41	331.79	130.59	0.04	2.54	0.00
11930	135	-1.61	1.17		1.17	0.000014	0.39	349.40	131.12	0.04	2.66	0.00
11335	135	-4.00	1.16		1.17	0.000014	0.44	310.24	95.72	0.04	3.24	0.00
10653	135	-2.87	1.14		1.15	0.000046	0.55	244.80	130.55	0.07	1.88	0.01
9802	135	-6.58	1.14		1.14	0.000003	0.25	550.52	110.87	0.02	4.97	0.00
9038	135	-1.69	1.13		1.14	0.000033	0.45	297.40	167.20	0.06	1.78	0.00
8045	135	-4.48	1.12		1.12	0.000008	0.34	400.54	123.27	0.03	3.25	0.00
7584	135	-6.45	1.12		1.12	0.000003	0.27	494.68	107.38	0.02	4.61	0.00
6956	135	-5.09	1.11		1.12	0.000007	0.34	394.83	102.48	0.03	3.85	0.00
6140	135	-3.54	1.11		1.11	0.000008	0.30	451.76	123.44	0.03	3.66	0.00
5326	135	-3.42	1.06		1.07	0.000091	0.84	160.62	59.15	0.09	2.72	0.02
4588	135	-5.01	1.04		1.05	0.000016	0.48	280.81	63.54	0.04	4.42	0.00
3354	135	-3.90	1.02		1.02	0.000017	0.42	321.18	95.73	0.04	3.35	0.00
2829	135	-4.70	1.01		1.01	0.000020	0.36	374.70	161.38	0.04	2.32	0.00
2644	135	-4.60	1.01		1.01	0.000010	0.31	432.83	136.44	0.03	3.17	0.00
2431	135	-3.90	1.01		1.01	0.000007	0.27	497.93	153.66	0.03	3.24	0.00
2228	135	-4.10	1.00		1.00	0.000014	0.30	453.80	191.38	0.03	2.37	0.00
2165	135	-4.20	1.00		1.00	0.000007	0.23	575.99	215.08	0.03	2.68	0.00
2050	135	-4.80	1.00		1.00	0.000008	0.24	564.22	224.07	0.03	2.52	0.00
1799	135	-4.40	1.00		1.00	0.000006	0.21	640.69	235.80	0.02	2.72	0.00
1604	135	-4.90	1.00		1.00	0.000002	0.14	975.51	313.78	0.01	3.11	0.00
1397	135	-5.40	1.00		1.00	0.000001	0.11	1258.91	459.38	0.01	2.74	0.00
226	135	-12.58	1.00		1.00	0.000000	0.01	13900.27	1180.83	0.00	11.77	0.00
0	135	-12.21	1.00	-11.41	1.00	0.000000	0.07	1970.54	209.92	0.00	9.39	0.00

Tide Elevation of -1.0, 2-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
25624	2000	-0.99	7.53	2.88	7.58	0.000136	1.94	1589.97	703.31	0.15	5.39	0.05
24701	2000	-1.57	7.31		7.41	0.000250	2.62	878.81	533.62	0.20	5.37	0.08
23980	2000	-1.74	7.23		7.28	0.000100	1.91	1598.53	500.57	0.13	6.66	0.04
22705	2000	-1.50	7.11		7.15	0.000096	1.74	1787.15	752.23	0.12	5.96	0.04
21612	2000	-0.82	7.02		7.06	0.000072	1.63	1765.70	667.83	0.11	6.70	0.03
20806	2000	-3.58	6.97		7.00	0.000058	1.47	2305.47	852.70	0.10	6.74	0.02
19871	2000	-4.76	6.92		6.95	0.000057	1.47	1947.91	664.58	0.10	6.83	0.02
19232	2000	-2.38	6.86		6.90	0.000089	1.82	2009.60	848.15	0.12	6.71	0.04
18489	2000	0.01	6.82		6.84	0.000070	1.35	2397.46	1005.08	0.10	5.20	0.02
17361	2000	-2.87	6.68		6.74	0.000111	1.95	1260.20	439.48	0.14	6.32	0.04
16613	2000	0.17	6.64		6.67	0.000062	1.32	2006.73	862.18	0.10	5.46	0.02
16129	2000	-0.73	6.56		6.62	0.000119	2.04	980.84	149.14	0.14	6.43	0.05
15729	2000	-0.81	6.51		6.58	0.000117	2.03	985.85	149.30	0.14	6.45	0.05
14929	2000	-0.99	6.42		6.48	0.000113	2.00	999.05	149.61	0.14	6.52	0.05
14429	2000	-1.09	6.37		6.43	0.000110	1.99	1005.88	149.82	0.14	6.56	0.05
13829	2000	-1.21	6.30		6.36	0.000108	1.97	1014.22	150.05	0.13	6.60	0.04
13279	2000	-1.33	6.23		6.29	0.000167	1.96	1022.73	215.04	0.16	4.68	0.05
12630	2000	-1.47	6.11		6.17	0.000202	1.95	1026.82	250.20	0.17	4.05	0.05
11930	2000	-1.61	5.97		6.03	0.000201	1.95	1027.34	250.21	0.17	4.05	0.05
11335	2000	-4.00	5.84		5.92	0.000168	2.29	872.53	145.33	0.16	5.92	0.06
10653	2000	-2.87	5.77		5.80	0.000079	1.49	1751.60	463.24	0.11	5.47	0.03
9802	2000	-6.58	5.71		5.74	0.000060	1.48	1573.03	362.41	0.10	6.63	0.03
9038	2000	-1.69	5.64		5.68	0.000092	1.65	1358.50	293.30	0.12	5.73	0.03
8045	2000	-4.48	5.56		5.60	0.000081	1.66	1577.20	412.56	0.12	6.28	0.03
7584	2000	-6.45	5.50		5.56	0.000086	1.98	1030.38	155.92	0.12	7.85	0.04
6956	2000	-5.09	5.48		5.51	0.000051	1.47	1939.79	484.40	0.09	7.47	0.02
6140	2000	-3.54	5.35		5.41	0.000137	1.99	1007.66	141.13	0.13	7.17	0.06
5326	2000	-3.42	4.59		4.94	0.001372	4.77	419.20	86.76	0.38	4.73	0.41
4588	2000	-5.01	3.92		4.18	0.000755	4.12	485.99	78.75	0.29	5.93	0.28
3354	2000	-3.90	2.61		2.88	0.001102	4.16	480.26	103.75	0.34	4.55	0.31
2829	2000	-4.70	2.00		2.21	0.001425	3.71	538.37	169.25	0.37	3.16	0.28
2644	2000	-4.60	1.76		1.98	0.001121	3.72	537.36	140.13	0.33	3.79	0.27
2431	2000	-3.90	1.56		1.74	0.000994	3.42	584.95	159.16	0.31	3.65	0.23
2228	2000	-4.10	1.16		1.42	0.002661	4.12	485.40	208.92	0.48	2.31	0.38
2165	2000	-4.20	1.10		1.28	0.001400	3.34	597.92	217.72	0.36	2.73	0.24
2050	2000	-4.80	0.87		1.08	0.001990	3.74	534.35	213.67	0.42	2.49	0.31
1799	2000	-4.40	0.14		0.45	0.003130	4.53	441.62	186.21	0.52	2.36	0.46
1604	2000	-4.90	-0.24		-0.07	0.001747	3.26	612.63	273.69	0.38	2.23	0.24
1397	2000	-5.40	-0.78		-0.56	0.003307	3.77	530.88	308.81	0.51	1.72	0.35
226	2000	-12.58	-0.97		-0.97	0.000001	0.17	11582.62	1171.65	0.01	9.84	0.00
0	2000	-12.21	-1.00	-9.49	-0.97	0.000046	1.27	1574.89	185.73	0.08	8.33	0.02

Tide Elevation of +1.0, 2-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
25624	2000	-0.99	7.55	2.88	7.60	0.000134	1.93	1603.60	704.67	0.14	5.54	0.05
24701	2000	-1.57	7.33		7.43	0.000246	2.61	891.01	536.80	0.19	5.56	0.08
23980	2000	-1.74	7.25		7.30	0.000098	1.90	1610.69	502.05	0.13	6.85	0.04
22705	2000	-1.50	7.13		7.17	0.000094	1.73	1807.19	756.31	0.12	6.11	0.04
21612	2000	-0.82	7.05		7.08	0.000071	1.62	1784.61	669.92	0.11	6.97	0.03
20806	2000	-3.58	7.00		7.03	0.000057	1.46	2330.45	855.95	0.10	7.11	0.02
19871	2000	-4.76	6.95		6.98	0.000056	1.46	1968.07	670.73	0.10	7.02	0.02
19232	2000	-2.38	6.89		6.93	0.000087	1.80	2036.58	849.00	0.12	6.91	0.04
18489	2000	0.01	6.85		6.87	0.000068	1.34	2430.80	1010.30	0.10	5.28	0.02
17361	2000	-2.87	6.72		6.77	0.000109	1.93	1276.08	441.94	0.13	6.46	0.04
16613	2000	0.17	6.68		6.70	0.000060	1.31	2039.01	867.61	0.10	5.52	0.02
16129	2000	-0.73	6.60		6.66	0.000117	2.03	986.58	149.30	0.14	6.61	0.05
15729	2000	-0.81	6.55		6.61	0.000115	2.02	991.74	149.45	0.14	6.64	0.05
14929	2000	-0.99	6.46		6.52	0.000110	1.99	1005.20	149.78	0.14	6.71	0.05
14429	2000	-1.09	6.41		6.47	0.000108	1.98	1012.19	149.99	0.13	6.75	0.04
13829	2000	-1.21	6.33		6.39	0.000159	1.96	1019.18	205.17	0.16	4.97	0.05
13279	2000	-1.33	6.24		6.30	0.000166	1.95	1025.45	215.12	0.16	4.77	0.05
12630	2000	-1.47	6.12		6.18	0.000199	1.94	1030.28	250.29	0.17	4.12	0.05
11930	2000	-1.61	5.99		6.04	0.000199	1.94	1031.21	250.30	0.17	4.12	0.05
11335	2000	-4.00	5.85		5.93	0.000167	2.29	874.93	145.51	0.16	6.01	0.06
10653	2000	-2.87	5.79		5.82	0.000078	1.49	1759.68	463.39	0.11	5.60	0.03
9802	2000	-6.58	5.73		5.76	0.000060	1.48	1579.58	363.49	0.10	6.79	0.02
9038	2000	-1.69	5.66		5.70	0.000091	1.65	1363.99	293.50	0.12	5.77	0.03
8045	2000	-4.48	5.58		5.62	0.000081	1.65	1585.33	413.34	0.12	6.37	0.03
7584	2000	-6.45	5.52		5.58	0.000085	1.97	1033.52	157.61	0.12	8.15	0.04
6956	2000	-5.09	5.50		5.53	0.000050	1.46	1949.71	486.18	0.09	7.68	0.02
6140	2000	-3.54	5.37		5.43	0.000135	1.98	1010.70	141.29	0.13	7.36	0.06
5326	2000	-3.42	4.62		4.97	0.001346	4.74	422.04	86.95	0.38	4.85	0.40
4588	2000	-5.01	3.96		4.22	0.000738	4.08	489.72	78.96	0.29	6.20	0.27
3354	2000	-3.90	2.73		2.98	0.001025	4.07	491.85	104.31	0.33	4.72	0.30
2829	2000	-4.70	2.20		2.39	0.001177	3.50	572.20	170.65	0.34	3.35	0.24
2644	2000	-4.60	2.00		2.19	0.000926	3.50	571.08	141.29	0.31	4.04	0.23
2431	2000	-3.90	1.84		2.00	0.000793	3.17	630.29	161.87	0.28	3.89	0.19
2228	2000	-4.10	1.59		1.78	0.001672	3.45	580.28	230.37	0.38	2.52	0.26
2165	2000	-4.20	1.56		1.68	0.000893	2.86	698.75	229.44	0.29	3.05	0.17
2050	2000	-4.80	1.42		1.57	0.001120	3.02	661.53	236.74	0.32	2.79	0.19
1799	2000	-4.40	1.16		1.29	0.001043	2.95	678.03	238.34	0.31	2.84	0.18
1604	2000	-4.90	1.08		1.15	0.000412	2.00	1001.57	316.39	0.20	3.17	0.08
1397	2000	-5.40	1.03		1.06	0.000306	1.57	1271.00	459.89	0.17	2.76	0.05
226	2000	-12.58	1.02		1.02	0.000000	0.14	13922.17	1180.97	0.01	11.79	0.00
0	2000	-12.21	1.00	-9.49	1.02	0.000026	1.01	1970.54	209.92	0.06	9.39	0.01

Tide Elevation of -1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
25624	5200	-0.99	11.44	4.73	11.48	0.000073	2.02	4376.92	714.37	0.12	9.19	0.04
24701	5200	-1.57	11.31		11.39	0.000123	2.64	3434.27	678.16	0.15	9.26	0.07
23980	5200	-1.74	11.25		11.31	0.000080	2.33	3749.17	535.61	0.12	10.58	0.05
22705	5200	-1.50	11.19		11.22	0.000053	1.82	5124.45	839.14	0.10	9.95	0.03
21612	5200	-0.82	11.12		11.16	0.000052	1.88	5093.12	943.24	0.10	10.66	0.03
20806	5200	-3.58	11.10		11.12	0.000036	1.58	6791.73	1280.11	0.08	10.67	0.02
19871	5200	-4.76	11.05		11.08	0.000045	1.77	5146.92	868.91	0.09	10.85	0.03
19232	5200	-2.38	11.03		11.05	0.000047	1.81	5800.80	979.35	0.10	10.77	0.03
18489	5200	0.01	11.01		11.02	0.000030	1.31	7181.94	1240.24	0.08	9.33	0.02
17361	5200	-2.87	10.91		10.97	0.000076	2.25	4414.02	1070.51	0.12	10.47	0.05
16613	5200	0.17	10.90		10.92	0.000031	1.36	6551.82	1173.87	0.08	9.69	0.02
16129	5200	-0.73	10.81		10.89	0.000135	2.27	2293.37	329.67	0.15	6.86	0.06
15729	5200	-0.81	10.75		10.83	0.000134	2.26	2301.61	330.35	0.15	6.87	0.06
14929	5200	-0.99	10.59		10.71	0.000161	2.82	1845.38	217.02	0.17	8.32	0.08
14429	5200	-1.09	10.50		10.63	0.000164	2.94	1771.59	198.22	0.17	8.72	0.09
13829	5200	-1.21	10.41		10.53	0.000156	2.73	1906.95	229.74	0.17	8.13	0.08
13279	5200	-1.33	10.33		10.44	0.000152	2.66	1956.90	240.27	0.16	7.98	0.08
12630	5200	-1.47	10.25		10.34	0.000140	2.46	2113.75	275.09	0.16	7.55	0.07
11930	5200	-1.61	10.15		10.25	0.000137	2.45	2126.77	275.45	0.16	7.59	0.07
11335	5200	-4.00	9.96		10.14	0.000205	3.36	1614.91	236.96	0.20	9.05	0.12
10653	5200	-2.87	9.97		10.01	0.000062	1.89	3795.47	518.22	0.11	9.35	0.04
9802	5200	-6.58	9.91		9.96	0.000059	2.01	3839.74	659.17	0.11	10.74	0.04
9038	5200	-1.69	9.84		9.91	0.000079	2.20	3259.38	590.92	0.12	9.84	0.05
8045	5200	-4.48	9.77		9.83	0.000073	2.19	3548.13	531.18	0.12	10.38	0.05
7584	5200	-6.45	9.63		9.77	0.000137	3.17	1947.18	270.15	0.16	11.24	0.10
6956	5200	-5.09	9.67		9.70	0.000042	1.78	4369.86	678.25	0.09	11.46	0.03
6140	5200	-3.54	9.50		9.61	0.000157	2.87	2569.37	907.71	0.15	11.21	0.11
5326	5200	-3.42	8.39		9.05	0.001527	6.57	802.42	148.50	0.43	7.05	0.67
4588	5200	-5.01	7.29		8.00	0.001342	6.72	773.52	91.28	0.41	8.04	0.67
3354	5200	-3.90	5.06		5.81	0.001963	6.96	747.40	114.36	0.48	6.37	0.78
2829	5200	-4.70	4.32		4.79	0.001621	5.49	947.05	181.64	0.42	5.15	0.52
2644	5200	-4.60	3.88		4.45	0.001921	6.09	854.27	159.04	0.46	5.29	0.63
2431	5200	-3.90	3.54		4.04	0.001723	5.67	917.64	176.39	0.44	5.16	0.56
2228	5200	-4.10	3.20		3.62	0.002339	5.16	1008.14	281.18	0.48	3.56	0.52
2165	5200	-4.20	3.12		3.47	0.001801	4.72	1102.84	289.65	0.43	3.79	0.43
2050	5200	-4.80	2.84		3.21	0.002671	4.93	1053.98	347.57	0.50	3.02	0.50
1799	5200	-4.40	1.64		2.30	0.004856	6.51	799.11	271.86	0.67	2.92	0.88
1604	5200	-4.90	1.15		1.55	0.002626	5.09	1021.83	318.40	0.50	3.20	0.52
1397	5200	-5.40	0.01		0.64	0.008235	6.36	817.21	429.48	0.81	1.90	0.98
226	5200	-12.58	-0.80		-0.80	0.000004	0.44	11781.69	1172.43	0.02	10.00	0.00
0	5200	-12.21	-1.00	-7.70	-0.83	0.000309	3.30	1574.89	185.73	0.20	8.33	0.16

Tide Elevation of +1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
25624	5200	-0.99	11.44	4.73	11.48	0.000073	2.02	4377.31	714.37	0.12	9.41	0.04
24701	5200	-1.57	11.31		11.39	0.000123	2.64	3434.67	678.17	0.15	9.54	0.07
23980	5200	-1.74	11.25		11.31	0.000080	2.33	3749.50	535.61	0.12	10.85	0.05
22705	5200	-1.50	11.19		11.22	0.000053	1.82	5124.97	839.14	0.10	10.16	0.03
21612	5200	-0.82	11.12		11.16	0.000052	1.88	5093.73	943.26	0.10	11.04	0.03
20806	5200	-3.58	11.10		11.12	0.000036	1.58	6792.56	1280.15	0.08	11.20	0.02
19871	5200	-4.76	11.05		11.08	0.000045	1.77	5147.49	868.94	0.09	11.12	0.03
19232	5200	-2.38	11.03		11.05	0.000047	1.81	5801.46	979.37	0.10	11.04	0.03
18489	5200	0.01	11.01		11.02	0.000030	1.31	7182.78	1240.27	0.08	9.42	0.02
17361	5200	-2.87	10.91		10.97	0.000076	2.25	4414.78	1070.54	0.12	10.66	0.05
16613	5200	0.17	10.90		10.92	0.000031	1.36	6552.65	1173.90	0.08	9.74	0.02
16129	5200	-0.73	10.81		10.89	0.000135	2.27	2293.61	329.67	0.15	6.96	0.06
15729	5200	-0.81	10.76		10.83	0.000134	2.26	2301.86	330.36	0.15	6.97	0.06
14929	5200	-0.99	10.59		10.71	0.000161	2.82	1845.55	217.03	0.17	8.50	0.08
14429	5200	-1.09	10.50		10.63	0.000164	2.93	1771.76	198.22	0.17	8.94	0.09
13829	5200	-1.21	10.41		10.53	0.000156	2.73	1907.14	229.75	0.17	8.30	0.08
13279	5200	-1.33	10.33		10.44	0.000152	2.66	1957.11	240.28	0.16	8.15	0.08
12630	5200	-1.47	10.25		10.34	0.000140	2.46	2114.00	275.09	0.16	7.68	0.07
11930	5200	-1.61	10.15		10.25	0.000137	2.44	2127.03	275.46	0.16	7.72	0.07
11335	5200	-4.00	9.97		10.14	0.000205	3.36	1615.14	237.04	0.20	9.18	0.12
10653	5200	-2.87	9.97		10.01	0.000062	1.88	3795.99	518.23	0.11	9.58	0.04
9802	5200	-6.58	9.91		9.96	0.000059	2.01	3840.42	659.25	0.11	10.97	0.04
9038	5200	-1.69	9.84		9.91	0.000079	2.20	3260.01	590.97	0.12	9.90	0.05
8045	5200	-4.48	9.77		9.83	0.000073	2.19	3548.71	531.22	0.12	10.51	0.05
7584	5200	-6.45	9.63		9.78	0.000136	3.17	1947.48	270.20	0.16	11.68	0.10
6956	5200	-5.09	9.67		9.70	0.000042	1.78	4370.63	678.31	0.09	11.78	0.03
6140	5200	-3.54	9.50		9.61	0.000157	2.87	2570.50	908.02	0.15	11.49	0.11
5326	5200	-3.42	8.39		9.06	0.001526	6.56	802.70	148.64	0.43	7.27	0.67
4588	5200	-5.01	7.30		8.00	0.001340	6.72	773.79	91.29	0.41	8.48	0.67
3354	5200	-3.90	5.07		5.82	0.001954	6.95	748.52	114.40	0.48	6.54	0.78
2829	5200	-4.70	4.34		4.80	0.001604	5.47	950.23	181.73	0.42	5.23	0.52
2644	5200	-4.60	3.90		4.47	0.001895	6.06	857.99	159.16	0.46	5.39	0.63
2431	5200	-3.90	3.57		4.07	0.001694	5.63	922.88	176.64	0.43	5.22	0.55
2228	5200	-4.10	3.25		3.65	0.002253	5.10	1020.14	281.59	0.47	3.62	0.51
2165	5200	-4.20	3.17		3.50	0.001735	4.66	1116.30	290.29	0.42	3.85	0.41
2050	5200	-4.80	2.90		3.26	0.002557	4.83	1076.60	354.78	0.49	3.03	0.48
1799	5200	-4.40	1.86		2.43	0.004262	6.05	860.18	296.50	0.63	2.90	0.77
1604	5200	-4.90	1.49		1.82	0.001945	4.59	1132.87	328.98	0.44	3.44	0.42
1397	5200	-5.40	1.17		1.41	0.001757	3.89	1338.36	462.72	0.40	2.89	0.32
226	5200	-12.58	1.13		1.13	0.000002	0.37	14048.82	1181.77	0.02	11.89	0.00
0	5200	-12.21	1.00	-7.70	1.11	0.000172	2.64	1970.54	209.92	0.15	9.39	0.10

Tide Elevation of -1.0, 100-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
25624	5800	-0.99	12.00	5.06	12.05	0.000070	2.06	4783.75	714.37	0.11	9.74	0.04
24701	5800	-1.57	11.89		11.96	0.000116	2.66	3827.70	688.13	0.15	9.82	0.07
23980	5800	-1.74	11.83		11.89	0.000079	2.40	4057.92	535.61	0.13	11.14	0.06
22705	5800	-1.50	11.77		11.80	0.000051	1.85	5612.49	844.21	0.10	10.52	0.03
21612	5800	-0.82	11.71		11.74	0.000050	1.91	5649.14	966.17	0.10	11.23	0.03
20806	5800	-3.58	11.68		11.71	0.000035	1.60	7550.75	1318.94	0.08	11.23	0.02
19871	5800	-4.76	11.63		11.67	0.000044	1.82	5662.18	895.96	0.09	11.42	0.03
19232	5800	-2.38	11.61		11.64	0.000045	1.84	6379.81	999.16	0.09	11.34	0.03
18489	5800	0.01	11.59		11.61	0.000029	1.34	7916.95	1266.45	0.07	9.91	0.02
17361	5800	-2.87	11.50		11.56	0.000070	2.25	5056.78	1096.64	0.12	11.05	0.05
16613	5800	0.17	11.49		11.51	0.000029	1.38	7254.52	1197.18	0.08	10.28	0.02
16129	5800	-0.73	11.40		11.48	0.000130	2.33	2488.64	333.30	0.15	7.36	0.06
15729	5800	-0.81	11.35		11.43	0.000129	2.32	2498.00	334.04	0.15	7.37	0.06
14929	5800	-0.99	11.17		11.31	0.000164	2.94	1973.52	220.59	0.17	8.75	0.09
14429	5800	-1.09	11.08		11.22	0.000169	3.07	1887.89	201.71	0.18	9.13	0.10
13829	5800	-1.21	10.99		11.12	0.000158	2.84	2041.59	233.24	0.17	8.57	0.08
13279	5800	-1.33	10.91		11.03	0.000153	2.77	2097.63	243.85	0.17	8.43	0.08
12630	5800	-1.47	10.83		10.93	0.000139	2.55	2275.14	278.59	0.16	8.02	0.07
11930	5800	-1.61	10.74		10.84	0.000136	2.53	2288.63	278.98	0.16	8.06	0.07
11335	5800	-4.00	10.54		10.73	0.000207	3.51	1764.20	283.05	0.20	9.61	0.12
10653	5800	-2.87	10.55		10.60	0.000061	1.96	4099.80	523.36	0.11	9.92	0.04
9802	5800	-6.58	10.49		10.55	0.000059	2.09	4234.35	689.43	0.11	11.32	0.04
9038	5800	-1.69	10.43		10.49	0.000078	2.27	3613.07	619.18	0.12	10.43	0.05
8045	5800	-4.48	10.35		10.42	0.000073	2.28	3864.30	550.86	0.12	10.96	0.05
7584	5800	-6.45	10.20		10.36	0.000142	3.33	2109.15	295.84	0.17	11.79	0.10
6956	5800	-5.09	10.24		10.28	0.000045	1.89	4777.24	757.41	0.09	12.02	0.03
6140	5800	-3.54	10.10		10.20	0.000140	2.81	3158.45	1037.96	0.14	11.80	0.10
5326	5800	-3.42	8.95		9.64	0.001509	6.74	894.20	174.05	0.43	7.39	0.70
4588	5800	-5.01	7.77		8.55	0.001426	7.09	817.66	93.02	0.42	8.33	0.74
3354	5800	-3.90	5.39		6.24	0.002102	7.38	785.72	115.68	0.50	6.61	0.87
2829	5800	-4.70	4.64		5.16	0.001675	5.77	1004.91	183.19	0.43	5.42	0.57
2644	5800	-4.60	4.15		4.80	0.002046	6.46	898.44	160.50	0.48	5.52	0.70
2431	5800	-3.90	3.80		4.36	0.001859	6.03	962.58	178.55	0.46	5.34	0.62
2228	5800	-4.10	3.46		3.91	0.002331	5.36	1081.49	283.66	0.48	3.79	0.55
2165	5800	-4.20	3.38		3.76	0.001823	4.92	1178.94	293.22	0.43	4.00	0.46
2050	5800	-4.80	3.11		3.51	0.002635	5.02	1154.79	367.06	0.50	3.13	0.52
1799	5800	-4.40	1.86		2.57	0.005289	6.73	861.33	296.95	0.70	2.88	0.95
1604	5800	-4.90	1.33		1.78	0.002783	5.37	1079.77	323.98	0.52	3.32	0.58
1397	5800	-5.40	0.13		0.82	0.008433	6.67	869.63	433.54	0.83	2.00	1.05
226	5800	-12.58	-0.75		-0.75	0.000005	0.49	11838.58	1172.65	0.03	10.05	0.00
0	5800	-12.21	-1.00	-7.41	-0.79	0.000384	3.68	1574.89	185.73	0.22	8.33	0.20

Tide Elevation of +1.0, 100-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)
25624	5800	-0.99	12.01	5.06	12.05	0.000070	2.06	4783.92	714.37	0.11	9.98	0.04
24701	5800	-1.57	11.89		11.96	0.000116	2.66	3827.87	688.13	0.15	10.12	0.07
23980	5800	-1.74	11.83		11.89	0.000079	2.40	4058.06	535.61	0.13	11.43	0.06
22705	5800	-1.50	11.77		11.80	0.000051	1.85	5612.72	844.22	0.10	10.74	0.03
21612	5800	-0.82	11.71		11.74	0.000050	1.91	5649.40	966.19	0.10	11.62	0.03
20806	5800	-3.58	11.68		11.71	0.000035	1.60	7551.12	1318.96	0.08	11.79	0.02
19871	5800	-4.76	11.63		11.67	0.000044	1.82	5662.43	895.97	0.09	11.70	0.03
19232	5800	-2.38	11.61		11.64	0.000045	1.84	6380.09	999.17	0.09	11.62	0.03
18489	5800	0.01	11.59		11.61	0.000029	1.34	7917.31	1266.47	0.07	10.00	0.02
17361	5800	-2.87	11.50		11.56	0.000070	2.25	5057.11	1096.65	0.12	11.25	0.05
16613	5800	0.17	11.49		11.51	0.000029	1.38	7254.88	1197.19	0.08	10.34	0.02
16129	5800	-0.73	11.40		11.48	0.000130	2.33	2488.74	333.30	0.15	7.47	0.06
15729	5800	-0.81	11.35		11.43	0.000129	2.32	2498.11	334.05	0.15	7.48	0.06
14929	5800	-0.99	11.18		11.31	0.000164	2.94	1973.59	220.59	0.17	8.95	0.09
14429	5800	-1.09	11.08		11.22	0.000169	3.07	1887.96	201.71	0.18	9.36	0.10
13829	5800	-1.21	10.99		11.12	0.000158	2.84	2041.67	233.24	0.17	8.75	0.08
13279	5800	-1.33	10.91		11.03	0.000153	2.76	2097.72	243.85	0.17	8.60	0.08
12630	5800	-1.47	10.83		10.93	0.000139	2.55	2275.24	278.59	0.16	8.17	0.07
11930	5800	-1.61	10.74		10.84	0.000136	2.53	2288.74	278.98	0.16	8.20	0.07
11335	5800	-4.00	10.54		10.73	0.000207	3.51	1764.32	283.08	0.20	9.76	0.12
10653	5800	-2.87	10.55		10.60	0.000061	1.96	4100.02	523.36	0.11	10.16	0.04
9802	5800	-6.58	10.49		10.55	0.000059	2.09	4234.65	689.45	0.11	11.55	0.04
9038	5800	-1.69	10.43		10.49	0.000078	2.27	3613.34	619.21	0.12	10.48	0.05
8045	5800	-4.48	10.36		10.42	0.000073	2.28	3864.55	550.87	0.12	11.09	0.05
7584	5800	-6.45	10.20		10.36	0.000142	3.33	2109.29	295.86	0.17	12.25	0.10
6956	5800	-5.09	10.25		10.28	0.000045	1.89	4777.59	757.53	0.09	12.36	0.03
6140	5800	-3.54	10.10		10.20	0.000140	2.81	3158.98	1037.99	0.14	12.09	0.10
5326	5800	-3.42	8.95		9.65	0.001509	6.74	894.34	174.05	0.43	7.63	0.70
4588	5800	-5.01	7.77		8.55	0.001425	7.09	817.78	93.03	0.42	8.79	0.74
3354	5800	-3.90	5.39		6.24	0.002098	7.38	786.24	115.69	0.50	6.80	0.87
2829	5800	-4.70	4.65		5.16	0.001667	5.76	1006.41	183.23	0.43	5.49	0.56
2644	5800	-4.60	4.16		4.81	0.002034	6.44	900.22	160.56	0.48	5.61	0.70
2431	5800	-3.90	3.81		4.37	0.001844	6.01	965.13	178.67	0.46	5.40	0.62
2228	5800	-4.10	3.48		3.92	0.002292	5.33	1087.28	283.86	0.48	3.83	0.54
2165	5800	-4.20	3.40		3.78	0.001793	4.89	1185.43	293.52	0.43	4.04	0.45
2050	5800	-4.80	3.15		3.53	0.002550	4.97	1166.65	367.36	0.49	3.18	0.50
1799	5800	-4.40	2.02		2.65	0.004783	6.38	909.37	315.44	0.66	2.88	0.86
1604	5800	-4.90	1.59		1.97	0.002228	4.98	1165.53	332.01	0.47	3.51	0.49
1397	5800	-5.40	1.21		1.50	0.002093	4.27	1356.89	463.50	0.44	2.93	0.38
226	5800	-12.58	1.16		1.16	0.000003	0.41	14085.07	1182.01	0.02	11.92	0.00
0	5800	-12.21	1.00	-7.41	1.13	0.000214	2.94	1970.54	209.92	0.17	9.39	0.12

Appendix F

Mapping of Areas of Development and Disturbance at the Nome Airport

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USKH
SHARED VISION. UNIFIED APPROACH.

Technical Memorandum

Date:	October 21, 2009	**W.O.#:**	1182800
To:	Hans Arnett	**cc:**	Zane Shanklin, Earl Korynta, Raymond Plummer, Evan Griffith, Sara Lindberg, Shane Cherry, Frank Wuttig
From:	Kim Elliott		
Project:	DOT(NR) Nome Hydrology Study		
Subject:	Mapping of Areas of Development and Disturbance at the Nome Airport		

The Snake River is located in the Cape Nome gold mining district and has been mined for gold since 1899. Placer mining along and within the Snake River has created a large amount of disturbed areas in the vicinity of the Nome Airport. Also, development of the airport and infrastructure in the area has affected the landscape within the project area. It is important to define these areas of development and disturbance since they will have a direct impact on underlying soils and geologic conditions, which will in turn impact the size and configuration of excavations for the river relocation options.

Historical aerial photography provided by the Alaska Department of Transportation and Public Facilities (DOT&PF) was used to determine the extent and timing of development and disturbance near the airport. The dates of aerial photographs provided by the DOT&PF include: 1941, 1942, 1944, 1950, 1951, 1960, 1962, 1963, 1967, 1969, 1970, 1971, 1973, 1986, 1992, 1998, 1999, and 2003.

Historical aerial photos dated as early as 1941 were analyzed to determine areas of disturbance from placer mining, and to document the relocation of the Snake River, and the former presence of a large lake to the south of the airport. Boundaries of these areas were marked on the aerial photographs and the boundaries were digitized onto a 2009 aerial photograph. Changes to the landscape resulting from placer mining and the development of both the Nome Airport and the City of Nome complicated the process of locating the boundaries of developed and disturbed areas on the 2009 aerial photograph. The digitized boundaries should be considered to be approximations. Although all of the photographs from DOT&PF were analyzed, development and disturbance boundaries were determined to be relevant only from the following dates: 1941, 1950, 1960, 1962, 1967, 1986, 1998, 1999, and 2003.

Areas of disturbance or development are categorized by the first year that the disturbance or development is visible in the aerial photos, allowing the establishment of a timeline of disturbance. Some of the major changes observed from the aerial photographs include the extension of the crosswind runway, the relocation of the Snake River, the relocation of the Snake River mouth, and the development of lakes associated with excavation on the north side of the main runway. The extension of the crosswind runway to its current southern extent occurred sometime between 1942 and 1950. This construction also included filling in an existing lake to the south of the end of the crosswind runway and the relocation of the Snake River. The development of another lake (informally termed the mining pit pond) further south of the existing crosswind runway occurred between 1986 and 1998. The lakes that are located north of the main runway were developed between 1998 and 1999. A new mouth of the Snake River was established west of the original mouth in 2005.

The 2009 aerial photograph map showing areas of development and disturbance is attached as Figure 1. Scanned copies of the individual aerial photographs used to develop the line work shown on the map are also attached.

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USKH
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NOME AIRPORT
SNAKE RIVER RELOCATION
W.O. 1182800

MAP OF AREAS OF DEVELOPMENT AND DISTURBANCE

DATE
MAR. 2011

FIGURE
1

Drawing Name: J:\1182800\Dwgs\C\Hydrology\Disturbed Areas Memo figures\1182800-Fig1.dwg PLOTTED: Mar 23, 2011 - 1:22pm

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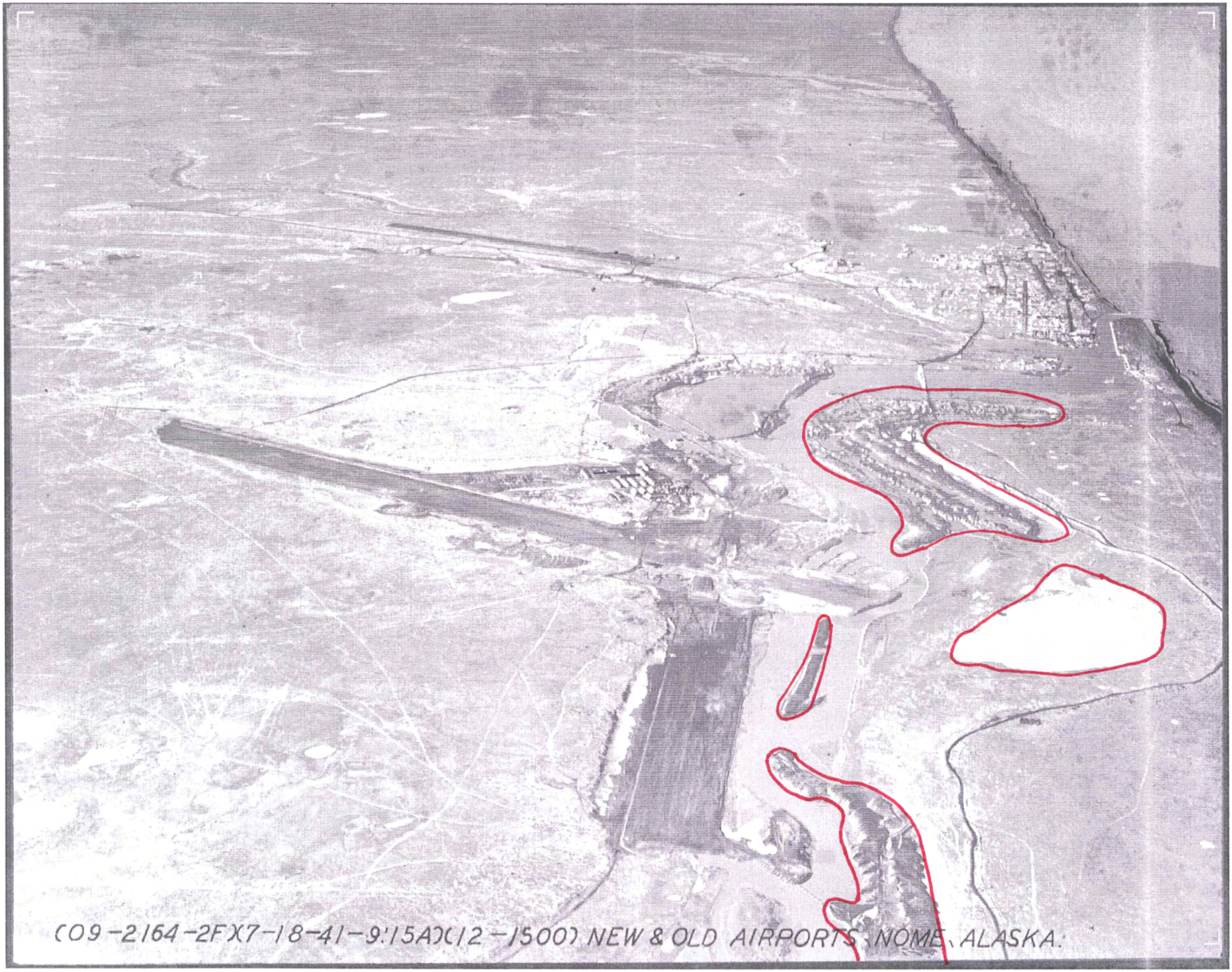
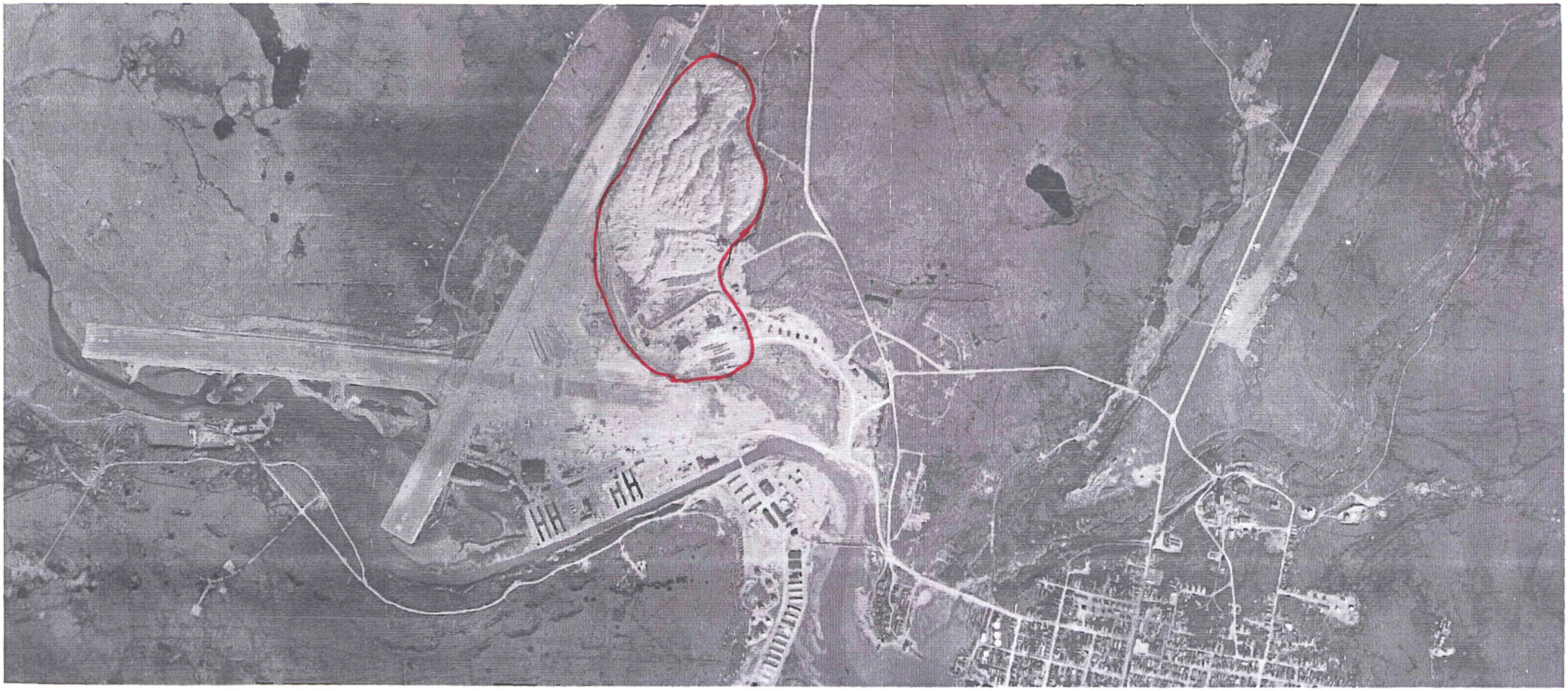


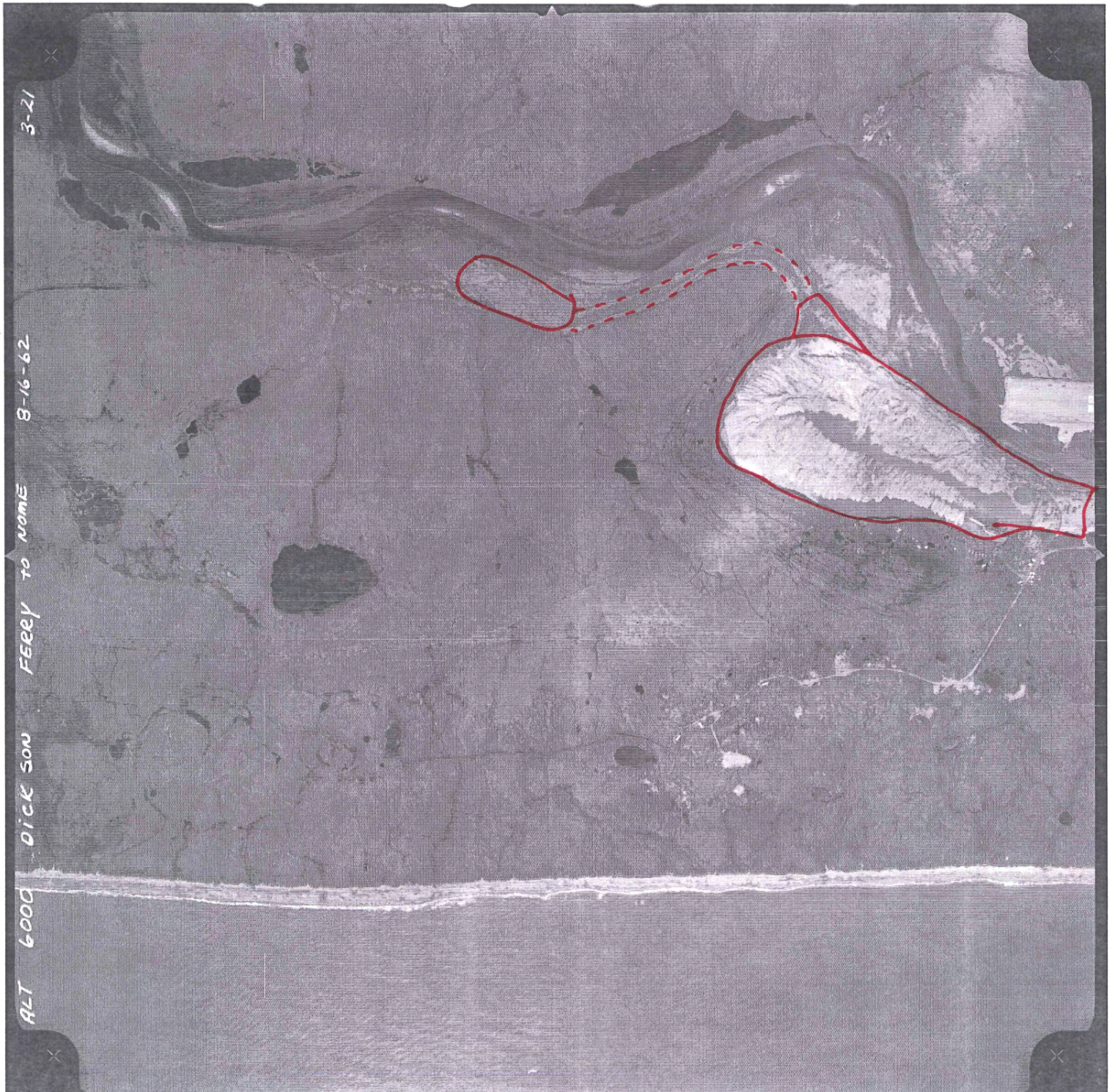
NOME 5

NOME - 1950 - photo 003

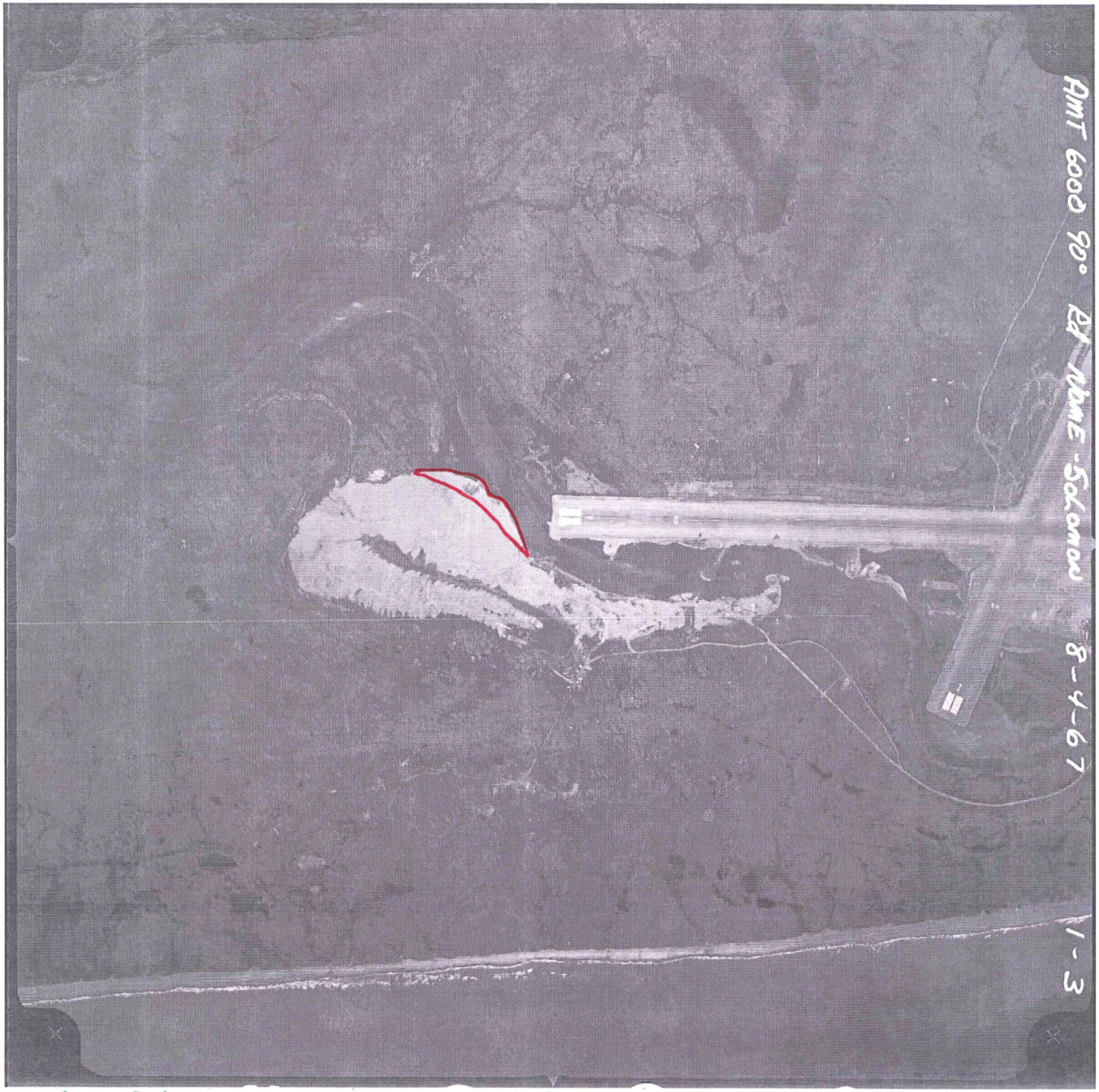
NOME 4/11/60



NOME - 1960 - April 11 - 1 aerial B&W print



NOME -1962 - Aug 16 - FL 3, photos 17,18,20,21



NOME_to_SOLOMON_1967_Aug4_FL1_photos_1 thru 3

NOME_1986_JUNE_30_NOME COUNCIL Rd_photo 1-25 Pg 2 of 24

NOME_1998_JUNE_17_NOME COUNCIL Rd_FL_1-photos_1thru5

Pg 4 of 5

Nome_1999_9_29

Pg 2 of 2

Nome_2003_Aug 6_Cape Nome_FL1_photos_1 thru 24

Pg 3 of 24

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Appendix G

Nome Airport Snake River Relocation Existing Conditions Hydraulic and Sediment Transport Results

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Nome Airport
Snake River Relocation
Existing Conditions Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam:	dsi [mm] =	0.1
	dsi [ft] =	0.000328

Tide Elevation of -1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
26325	135	-0.99	1.91	1.92	0.000232	1.00	1.34	0.02	1.48	0.014	1.893
25402	135	-1.57	1.74	1.75	0.000144	0.96	1.82	0.02	1.48	0.008	1.036
24681	135	-1.74	1.70	1.70	0.000032	0.57	2.51	0.01	0.74	0.001	0.076
23406	135	-1.50	1.61	1.62	0.000147	0.82	1.40	0.01	0.74	0.006	0.800
22313	135	-0.82	1.54	1.55	0.000040	0.52	1.84	0.00	0.00	0.001	0.083
21507	135	-3.58	1.52	1.52	0.000019	0.45	2.63	0.00	0.00	0.000	0.028
20572	135	-4.76	1.51	1.51	0.000008	0.35	3.45	0.00	0.00	0.000	0.007
19933	135	-2.38	1.50	1.50	0.000040	0.60	2.29	0.01	0.74	0.001	0.106
19190	135	0.01	1.42	1.43	0.000431	1.01	0.85	0.02	1.48	0.029	3.856
18062	135	-2.87	1.30	1.30	0.000031	0.57	2.58	0.01	0.74	0.001	0.073
17322	135	0.17	1.12	1.16	0.001912	1.67	0.59	0.07	5.18	0.372	49.634
16472	135	-1.71	0.88	0.89	0.000124	0.78	1.48	0.01	0.74	0.005	0.606
15949	135	-2.19	0.83	0.84	0.000078	0.67	1.69	0.01	0.74	0.002	0.278
14371	135	-1.25	0.66	0.67	0.000149	0.75	1.21	0.01	0.74	0.005	0.694
13231	135	-1.56	0.39	0.41	0.000396	1.06	0.98	0.02	1.48	0.029	3.827
12630	135	-2.21	0.24	0.25	0.000187	0.82	1.16	0.01	0.74	0.008	1.045
11764	135	-1.76	0.06	0.08	0.000207	0.93	1.31	0.02	1.48	0.011	1.467
11335	135	-4.00	0.04	0.04	0.000047	0.65	2.35	0.01	0.74	0.001	0.149
10653	135	-2.87	-0.05	-0.03	0.000299	1.16	1.39	0.03	2.22	0.025	3.273
9802	135	-6.58	-0.05	-0.05	0.000005	0.32	4.16	0.00	0.00	0.000	0.003
9038	135	-1.69	-0.09	-0.07	0.000597	1.20	0.87	0.03	2.22	0.057	7.556
8045	135	-4.48	-0.15	-0.15	0.000029	0.53	2.44	0.00	0.00	0.000	0.060
7584	135	-6.45	-0.16	-0.16	0.000009	0.37	3.55	0.00	0.00	0.000	0.009
6956	135	-5.09	-0.17	-0.17	0.000023	0.51	2.72	0.00	0.00	0.000	0.043
6140	135	-3.54	-0.19	-0.19	0.000029	0.46	2.56	0.00	0.00	0.000	0.053
5326	135	-3.42	-0.45	-0.41	0.000524	1.62	1.92	0.06	4.44	0.093	12.462
4588	135	-5.01	-0.60	-0.59	0.000055	0.74	3.20	0.01	0.74	0.002	0.250
3354	135	-3.90	-0.79	-0.78	0.000151	0.85	1.87	0.02	1.48	0.007	0.998
2829	135	-4.70	-0.89	-0.88	0.000155	0.89	1.96	0.02	1.48	0.008	1.113
2644	135	-4.60	-0.91	-0.91	0.000141	0.73	1.56	0.01	0.74	0.005	0.707
2431	135	-3.90	-0.94	-0.93	0.000085	0.61	1.74	0.01	0.74	0.002	0.292
2228	135	-4.10	-0.97	-0.96	0.000150	0.80	1.70	0.02	1.48	0.007	0.887
2165	135	-4.20	-0.97	-0.97	0.000067	0.56	1.84	0.01	0.74	0.001	0.193
2050	135	-4.80	-0.98	-0.97	0.000051	0.54	2.14	0.01	0.74	0.001	0.133
1799	135	-4.40	-0.99	-0.98	0.000048	0.49	1.94	0.01	0.74	0.001	0.105
1604	135	-4.90	-0.99	-0.99	0.000028	0.33	1.57	0.00	0.00	0.000	0.028
1397	135	-5.40	-1.00	-1.00	0.000018	0.29	1.78	0.00	0.00	0.000	0.014
226	135	-12.58	-1.00	-1.00	0.000000	0.01	9.81	0.00	0.00	0.000	0.000
0	135	-12.21	-1.00	-1.00	0.000000	0.09	8.33	0.00	0.00	0.000	0.000
								Reach Minimums:	0.00	0.00	0.00
								Upper Reach Average:	0.95	0.02	3.07

Nome Airport
Snake River Relocation
Existing Conditions Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

						Tide Elevation of -1.0, 2-Year Flow					
River Sta	**Q Total (cfs)**	**Min Ch El (ft)**	**W.S. Elev (ft)**	**E.G. Elev (ft)**	**E.G. Slope (ft/ft)**	**Vel Chnl (ft/s)**	**Ch. Hydraulic R. (ft^2)**	**Shear Chan (lb/sq ft)**	**Competence (mm)**	**Capacity (cfs)**	**Capacity (cy/hr)**
26325	2000	-0.99	7.41	7.46	0.000152	2.02	5.27	0.05	3.70	0.447	59.584
25402	2000	-1.57	7.16	7.27	0.000278	2.71	5.23	0.09	6.66	1.477	196.966
24681	2000	-1.74	7.07	7.13	0.000111	1.98	6.52	0.04	2.96	0.304	40.539
23406	2000	-1.50	6.94	6.98	0.000110	1.83	5.79	0.04	2.96	0.261	34.832
22313	2000	-0.82	6.84	6.88	0.000082	1.70	6.52	0.03	2.22	0.166	22.100
21507	2000	-3.58	6.78	6.82	0.000067	1.55	6.56	0.03	2.22	0.112	14.928
20572	2000	-4.76	6.72	6.75	0.000064	1.53	6.65	0.03	2.22	0.104	13.851
19933	2000	-2.38	6.65	6.70	0.000107	1.94	6.50	0.04	2.96	0.282	37.535
19190	2000	0.01	6.60	6.62	0.000084	1.45	5.02	0.03	2.22	0.129	17.149
18062	2000	-2.87	6.44	6.50	0.000129	2.04	6.08	0.05	3.70	0.379	50.532
17322	2000	0.17	6.39	6.42	0.000078	1.37	4.84	0.02	1.48	0.107	14.236
16472	2000	-1.71	6.34	6.36	0.000059	1.33	5.79	0.02	1.48	0.075	9.944
15949	2000	-2.19	6.30	6.33	0.000068	1.42	5.74	0.02	1.48	0.098	13.080
14371	2000	-1.25	6.18	6.22	0.000074	1.50	5.81	0.03	2.22	0.118	15.781
13231	2000	-1.56	6.12	6.14	0.000057	1.32	5.82	0.02	1.48	0.070	9.396
12630	2000	-2.21	6.10	6.11	0.000034	1.07	6.27	0.01	0.74	0.027	3.642
11764	2000	-1.76	5.98	6.04	0.000112	1.92	6.12	0.04	2.96	0.290	38.602
11335	2000	-4.00	5.90	5.98	0.000163	2.27	5.95	0.06	4.44	0.593	79.008
10653	2000	-2.87	5.84	5.87	0.000075	1.47	5.53	0.03	2.22	0.115	15.395
9802	2000	-6.58	5.78	5.81	0.000058	1.46	6.70	0.02	1.48	0.086	11.446
9038	2000	-1.69	5.72	5.76	0.000088	1.63	5.79	0.03	2.22	0.167	22.200
8045	2000	-4.48	5.64	5.67	0.000078	1.63	6.34	0.03	2.22	0.145	19.386
7584	2000	-6.45	5.58	5.64	0.000083	1.96	7.92	0.04	2.96	0.214	28.598
6956	2000	-5.09	5.54	5.56	0.000049	1.45	7.52	0.02	1.48	0.070	9.351
6140	2000	-3.54	5.40	5.46	0.000133	1.97	7.22	0.06	4.44	0.418	55.669
5326	2000	-3.42	4.66	5.00	0.001316	4.70	4.77	0.39	28.86	25.200	3360.044
4588	2000	-5.01	3.99	4.24	0.000731	4.07	5.97	0.27	19.98	10.107	1347.602
3354	2000	-3.90	2.72	2.98	0.001030	4.07	4.62	0.30	22.20	14.871	1982.784
2829	2000	-4.70	2.00	2.21	0.001423	3.71	3.16	0.28	20.72	18.205	2427.330
2644	2000	-4.60	1.76	1.98	0.001119	3.72	3.79	0.27	19.98	13.940	1858.711
2431	2000	-3.90	1.56	1.75	0.000992	3.42	3.65	0.23	17.02	10.498	1399.730
2228	2000	-4.10	1.16	1.42	0.002661	4.12	2.31	0.38	28.12	44.201	5893.518
2165	2000	-4.20	1.10	1.28	0.001400	3.34	2.73	0.24	17.76	14.866	1982.093
2050	2000	-4.80	0.87	1.08	0.001990	3.74	2.49	0.31	22.94	26.941	3592.154
1799	2000	-4.40	0.14	0.45	0.003130	4.53	2.36	0.46	34.04	62.667	8355.545
1604	2000	-4.90	-0.24	-0.07	0.001747	3.26	2.23	0.24	17.76	18.280	2437.325
1397	2000	-5.40	-0.78	-0.56	0.003307	3.77	1.72	0.35	25.90	48.353	6447.049
226	2000	-12.58	-0.97	-0.97	0.000001	0.17	9.84	0.00	0.00	0.000	0.004
0	2000	-12.21	-1.00	-0.97	0.000046	1.27	8.33	0.02	1.48	0.059	7.841

Reach Minimums:	0.74	0.03	3.64
Upper Reach Average:	2.61	0.25	33.35

Nome Airport
Snake River Relocation
Existing Conditions Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of -1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
26325	5200	-0.99	11.12	11.17	0.000085	2.13	8.88	0.05	3.70	0.665	88.673
25402	5200	-1.57	10.98	11.06	0.000146	2.81	8.93	0.08	5.92	1.981	264.082
24681	5200	-1.74	10.91	10.97	0.000092	2.45	10.25	0.06	4.44	0.925	123.392
23406	5200	-1.50	10.83	10.86	0.000062	1.93	9.60	0.04	2.96	0.390	52.042
22313	5200	-0.82	10.75	10.80	0.000061	2.00	10.31	0.04	2.96	0.409	54.542
21507	5200	-3.58	10.73	10.75	0.000044	1.69	10.32	0.03	2.22	0.212	28.248
20572	5200	-4.76	10.67	10.70	0.000053	1.88	10.47	0.03	2.22	0.314	41.843
19933	5200	-2.38	10.64	10.67	0.000056	1.93	10.39	0.04	2.96	0.349	46.476
19190	5200	0.01	10.61	10.63	0.000036	1.40	8.94	0.02	1.48	0.121	16.119
18062	5200	-2.87	10.49	10.56	0.000095	2.45	10.06	0.06	4.44	0.962	128.271
17322	5200	0.17	10.48	10.50	0.000037	1.40	8.90	0.02	1.48	0.126	16.757
16472	5200	-1.71	10.46	10.47	0.000031	1.38	9.86	0.02	1.48	0.100	13.333
15949	5200	-2.19	10.44	10.46	0.000036	1.47	9.73	0.02	1.48	0.132	17.657
14371	5200	-1.25	10.36	10.39	0.000045	1.67	9.98	0.03	2.22	0.213	28.391
13231	5200	-1.56	10.33	10.35	0.000034	1.46	10.01	0.02	1.48	0.122	16.325
12630	5200	-2.21	10.31	10.33	0.000024	1.27	10.46	0.02	1.48	0.065	8.609
11764	5200	-1.76	10.14	10.26	0.000120	2.79	10.24	0.08	5.92	1.569	209.220
11335	5200	-4.00	10.02	10.19	0.000200	3.33	9.10	0.11	8.14	3.799	506.509
10653	5200	-2.87	10.02	10.07	0.000060	1.87	9.41	0.04	2.96	0.356	47.527
9802	5200	-6.58	9.96	10.02	0.000057	2.00	10.80	0.04	2.96	0.378	50.423
9038	5200	-1.69	9.90	9.96	0.000077	2.19	9.90	0.05	3.70	0.622	82.999
8045	5200	-4.48	9.83	9.89	0.000071	2.18	10.44	0.05	3.70	0.563	75.123
7584	5200	-6.45	9.69	9.84	0.000134	3.15	11.30	0.09	6.66	2.196	292.809
6956	5200	-5.09	9.71	9.74	0.000042	1.77	11.50	0.03	2.22	0.218	29.126
6140	5200	-3.54	9.54	9.65	0.000154	2.84	11.25	0.11	8.14	2.434	324.529
5326	5200	-3.42	8.42	9.08	0.001503	6.53	7.07	0.66	48.85	135.270	18035.940
4588	5200	-5.01	7.36	8.05	0.001311	6.67	8.08	0.66	48.85	120.330	16044.012
3354	5200	-3.90	5.19	5.92	0.001844	6.81	6.47	0.74	54.77	183.392	24452.207
2829	5200	-4.70	4.32	4.79	0.001622	5.49	5.15	0.52	38.48	108.816	14508.739
2644	5200	-4.60	3.87	4.45	0.001923	6.09	5.29	0.64	47.37	157.926	21056.757
2431	5200	-3.90	3.54	4.04	0.001726	5.67	5.16	0.56	41.45	123.483	16464.423
2228	5200	-4.10	3.20	3.62	0.002339	5.16	3.56	0.52	38.48	147.251	19633.488
2165	5200	-4.20	3.12	3.47	0.001801	4.72	3.79	0.43	31.82	93.901	12520.152
2050	5200	-4.80	2.84	3.21	0.002671	4.93	3.02	0.50	37.00	158.125	21083.303
1799	5200	-4.40	1.64	2.30	0.004856	6.51	2.92	0.88	65.13	503.303	67107.006
1604	5200	-4.90	1.15	1.55	0.002626	5.09	3.20	0.52	38.48	163.822	21843.000
1397	5200	-5.40	0.01	0.64	0.008236	6.36	1.90	0.98	72.53	876.087	116811.568
226	5200	-12.58	-0.80	-0.80	0.000004	0.44	10.00	0.00	0.00	0.001	0.198
0	5200	-12.21	-1.00	-0.83	0.000309	3.30	8.33	0.16	11.84	6.917	922.256

	Reach Minimums:	1.48	0.06	8.61
	Upper Reach Average:	3.49	0.77	102.52

Nome Airport
Snake River Relocation
Existing Conditions Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam:	dsi [mm] =	0.1
	dsi [ft] =	0.000328

Tide Elevation of -1.0, 100-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
26325	5800	-0.99	11.67	11.72	0.000081	2.17	9.42	0.05	3.70	0.724	96.542
25402	5800	-1.57	11.54	11.62	0.000137	2.83	9.47	0.08	5.92	2.083	277.680
24681	5800	-1.74	11.47	11.53	0.000091	2.52	10.79	0.06	4.44	1.072	142.881
23406	5800	-1.50	11.39	11.43	0.000060	1.96	10.15	0.04	2.96	0.433	57.706
22313	5800	-0.82	11.32	11.36	0.000059	2.03	10.85	0.04	2.96	0.452	60.255
21507	5800	-3.58	11.30	11.32	0.000041	1.70	10.86	0.03	2.22	0.219	29.244
20572	5800	-4.76	11.24	11.28	0.000052	1.92	11.03	0.04	2.96	0.357	47.544
19933	5800	-2.38	11.21	11.24	0.000054	1.96	10.95	0.04	2.96	0.384	51.175
19190	5800	0.01	11.19	11.21	0.000034	1.42	9.51	0.02	1.48	0.129	17.262
18062	5800	-2.87	11.07	11.14	0.000087	2.44	10.63	0.06	4.44	0.963	128.362
17322	5800	0.17	11.06	11.09	0.000035	1.42	9.48	0.02	1.48	0.135	18.001
16472	5800	-1.71	11.04	11.06	0.000030	1.42	10.43	0.02	1.48	0.112	14.984
15949	5800	-2.19	11.02	11.04	0.000034	1.50	10.31	0.02	1.48	0.142	18.986
14371	5800	-1.25	10.95	10.98	0.000040	1.65	10.57	0.03	2.22	0.202	26.984
13231	5800	-1.56	10.92	10.94	0.000032	1.49	10.60	0.02	1.48	0.131	17.461
12630	5800	-2.21	10.91	10.92	0.000024	1.31	11.05	0.02	1.48	0.076	10.181
11764	5800	-1.76	10.73	10.85	0.000123	2.93	10.82	0.08	5.92	1.961	261.421
11335	5800	-4.00	10.60	10.78	0.000202	3.49	9.67	0.12	8.88	4.647	619.538
10653	5800	-2.87	10.61	10.65	0.000060	1.94	9.98	0.04	2.96	0.425	56.636
9802	5800	-6.58	10.55	10.60	0.000058	2.08	11.37	0.04	2.96	0.462	61.601
9038	5800	-1.69	10.49	10.55	0.000076	2.26	10.49	0.05	3.70	0.723	96.431
8045	5800	-4.48	10.42	10.48	0.000071	2.26	11.02	0.05	3.70	0.669	89.246
7584	5800	-6.45	10.26	10.42	0.000139	3.31	11.85	0.10	7.40	2.785	371.288
6956	5800	-5.09	10.29	10.32	0.000044	1.89	12.06	0.03	2.22	0.286	38.090
6140	5800	-3.54	10.14	10.24	0.000137	2.78	11.84	0.10	7.40	2.288	305.003
5326	5800	-3.42	8.99	9.68	0.001478	6.69	7.43	0.69	51.07	154.524	20603.180
4588	5800	-5.01	7.84	8.61	0.001394	7.04	8.37	0.73	54.03	158.086	21078.108
3354	5800	-3.90	5.53	6.34	0.001970	7.23	6.72	0.83	61.43	244.391	32585.497
2829	5800	-4.70	4.64	5.15	0.001675	5.77	5.42	0.57	42.19	137.329	18310.481
2644	5800	-4.60	4.15	4.80	0.002047	6.46	5.51	0.70	51.81	209.435	27924.613
2431	5800	-3.90	3.80	4.36	0.001860	6.03	5.34	0.62	45.89	166.694	22225.904
2228	5800	-4.10	3.46	3.91	0.002331	5.36	3.79	0.55	40.71	175.130	23350.699
2165	5800	-4.20	3.38	3.76	0.001823	4.92	4.00	0.46	34.04	114.219	15229.203
2050	5800	-4.80	3.11	3.51	0.002635	5.02	3.13	0.52	38.48	179.147	23886.301
1799	5800	-4.40	1.86	2.57	0.005289	6.73	2.88	0.95	70.31	655.141	87352.178
1604	5800	-4.90	1.33	1.78	0.002783	5.37	3.32	0.58	42.93	214.228	28563.750
1397	5800	-5.40	0.13	0.82	0.008433	6.67	2.00	1.05	77.71	1089.375	145249.974
226	5800	-12.58	-0.75	-0.75	0.000005	0.49	10.05	0.00	0.00	0.003	0.345
0	5800	-12.21	-1.00	-0.79	0.000384	3.68	8.33	0.20	14.80	11.919	1589.166

Reach Minimums:	1.48	0.08	10.18
Upper Reach Average:	3.55	0.87	116.58

Nome Airport
Snake River Relocation
Existing Conditions Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam:	dsi [mm] =	0.1
	dsi [ft] =	0.000328

Tide Elevation of +1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
26325	135	-0.99	2.01	2.03	0.000187	0.92	1.40	0.02	1.48	0.010	1.288
25402	135	-1.57	1.88	1.89	0.000118	0.90	1.89	0.01	0.74	0.006	0.734
24681	135	-1.74	1.84	1.85	0.000027	0.53	2.61	0.00	0.00	0.000	0.056
23406	135	-1.50	1.78	1.78	0.000111	0.73	1.47	0.01	0.74	0.004	0.479
22313	135	-0.82	1.72	1.73	0.000030	0.47	2.00	0.00	0.00	0.000	0.051
21507	135	-3.58	1.71	1.71	0.000016	0.42	2.74	0.00	0.00	0.000	0.021
20572	135	-4.76	1.70	1.70	0.000007	0.33	3.53	0.00	0.00	0.000	0.005
19933	135	-2.38	1.69	1.69	0.000032	0.55	2.41	0.00	0.00	0.001	0.072
19190	135	0.01	1.63	1.64	0.000220	0.80	0.99	0.01	0.74	0.009	1.202
18062	135	-2.87	1.55	1.56	0.000025	0.52	2.61	0.00	0.00	0.000	0.049
17322	135	0.17	1.47	1.49	0.000481	0.99	0.76	0.02	1.48	0.032	4.214
16472	135	-1.71	1.37	1.38	0.000058	0.57	1.62	0.01	0.74	0.001	0.148
15949	135	-2.19	1.35	1.35	0.000037	0.51	1.91	0.00	0.00	0.001	0.073
14371	135	-1.25	1.29	1.29	0.000041	0.48	1.65	0.00	0.00	0.001	0.075
13231	135	-1.56	1.23	1.23	0.000063	0.51	1.30	0.01	0.74	0.001	0.135
12630	135	-2.21	1.21	1.21	0.000026	0.43	1.95	0.00	0.00	0.000	0.037
11764	135	-1.76	1.18	1.19	0.000028	0.47	2.11	0.00	0.00	0.000	0.047
11335	135	-4.00	1.18	1.18	0.000014	0.43	3.21	0.00	0.00	0.000	0.019
10653	135	-2.87	1.16	1.16	0.000045	0.55	1.86	0.01	0.74	0.001	0.105
9802	135	-6.58	1.15	1.15	0.000003	0.24	4.82	0.00	0.00	0.000	0.001
9038	135	-1.69	1.15	1.15	0.000032	0.45	1.78	0.00	0.00	0.000	0.050
8045	135	-4.48	1.13	1.13	0.000008	0.34	3.22	0.00	0.00	0.000	0.006
7584	135	-6.45	1.13	1.13	0.000003	0.27	4.49	0.00	0.00	0.000	0.001
6956	135	-5.09	1.13	1.13	0.000007	0.34	3.81	0.00	0.00	0.000	0.006
6140	135	-3.54	1.12	1.12	0.000008	0.30	3.64	0.00	0.00	0.000	0.006
5326	135	-3.42	1.07	1.08	0.000090	0.84	2.68	0.02	1.48	0.004	0.543
4588	135	-5.01	1.05	1.05	0.000016	0.48	4.28	0.00	0.00	0.000	0.029
3354	135	-3.90	1.02	1.02	0.000017	0.42	3.31	0.00	0.00	0.000	0.025
2829	135	-4.70	1.01	1.01	0.000020	0.36	2.31	0.00	0.00	0.000	0.023
2644	135	-4.60	1.01	1.01	0.000010	0.31	3.14	0.00	0.00	0.000	0.008
2431	135	-3.90	1.01	1.01	0.000007	0.27	3.22	0.00	0.00	0.000	0.004
2228	135	-4.10	1.00	1.00	0.000014	0.30	2.36	0.00	0.00	0.000	0.011
2165	135	-4.20	1.00	1.00	0.000007	0.23	2.67	0.00	0.00	0.000	0.003
2050	135	-4.80	1.00	1.00	0.000008	0.24	2.50	0.00	0.00	0.000	0.004
1799	135	-4.40	1.00	1.00	0.000006	0.21	2.70	0.00	0.00	0.000	0.002
1604	135	-4.90	1.00	1.00	0.000002	0.14	3.10	0.00	0.00	0.000	0.000
1397	135	-5.40	1.00	1.00	0.000001	0.11	2.74	0.00	0.00	0.000	0.000
226	135	-12.58	1.00	1.00	0.000000	0.01	11.71	0.00	0.00	0.000	0.000
0	135	-12.21	1.00	1.00	0.000000	0.07	9.22	0.00	0.00	0.000	0.000
								Reach Minimums:	0.00	0.00	0.00
								Upper Reach Average:	0.30	0.00	0.36

Nome Airport
Snake River Relocation
Existing Conditions Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of +1.0, 2-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
26325	2000	-0.99	7.41	7.47	0.000151	2.01	5.28	0.05	3.70	0.441	58.760
25402	2000	-1.57	7.16	7.28	0.000277	2.71	5.23	0.09	6.66	1.469	195.904
24681	2000	-1.74	7.08	7.13	0.000110	1.98	6.53	0.04	2.96	0.300	40.023
23406	2000	-1.50	6.94	6.99	0.000109	1.82	5.80	0.04	2.96	0.257	34.200
22313	2000	-0.82	6.84	6.89	0.000081	1.70	6.53	0.03	2.22	0.163	21.714
21507	2000	-3.58	6.79	6.82	0.000067	1.55	6.57	0.03	2.22	0.112	14.939
20572	2000	-4.76	6.73	6.76	0.000064	1.53	6.66	0.03	2.22	0.104	13.861
19933	2000	-2.38	6.66	6.71	0.000106	1.94	6.51	0.04	2.96	0.278	37.039
19190	2000	0.01	6.61	6.63	0.000083	1.45	5.03	0.03	2.22	0.126	16.861
18062	2000	-2.87	6.45	6.51	0.000128	2.04	6.09	0.05	3.70	0.375	49.987
17322	2000	0.17	6.40	6.43	0.000077	1.36	4.85	0.02	1.48	0.104	13.876
16472	2000	-1.71	6.35	6.37	0.000058	1.33	5.80	0.02	1.48	0.073	9.701
15949	2000	-2.19	6.32	6.34	0.000067	1.42	5.75	0.02	1.48	0.096	12.804
14371	2000	-1.25	6.20	6.23	0.000073	1.49	5.82	0.03	2.22	0.115	15.372
13231	2000	-1.56	6.13	6.15	0.000056	1.31	5.83	0.02	1.48	0.068	9.088
12630	2000	-2.21	6.11	6.12	0.000034	1.07	6.28	0.01	0.74	0.027	3.645
11764	2000	-1.76	5.99	6.05	0.000112	1.91	6.13	0.04	2.96	0.288	38.432
11335	2000	-4.00	5.92	6.00	0.000162	2.26	5.96	0.06	4.44	0.585	78.002
10653	2000	-2.87	5.85	5.88	0.000074	1.46	5.55	0.03	2.22	0.113	15.012
9802	2000	-6.58	5.80	5.83	0.000058	1.46	6.72	0.02	1.48	0.086	11.463
9038	2000	-1.69	5.74	5.77	0.000087	1.63	5.81	0.03	2.22	0.164	21.860
8045	2000	-4.48	5.66	5.69	0.000077	1.63	6.35	0.03	2.22	0.143	19.029
7584	2000	-6.45	5.59	5.65	0.000083	1.95	7.93	0.04	2.96	0.214	28.470
6956	2000	-5.09	5.56	5.58	0.000048	1.44	7.53	0.02	1.48	0.068	9.010
6140	2000	-3.54	5.42	5.48	0.000132	1.97	7.23	0.06	4.44	0.413	55.081
5326	2000	-3.42	4.69	5.03	0.001292	4.67	4.79	0.39	28.86	24.409	3254.487
4588	2000	-5.01	4.03	4.28	0.000716	4.04	6.00	0.27	19.98	9.750	1299.962
3354	2000	-3.90	2.82	3.07	0.000966	3.99	4.70	0.28	20.72	13.355	1780.703
2829	2000	-4.70	2.20	2.39	0.001176	3.49	3.33	0.24	17.76	13.208	1761.013
2644	2000	-4.60	2.00	2.19	0.000925	3.50	3.99	0.23	17.02	10.114	1348.563
2431	2000	-3.90	1.85	2.00	0.000792	3.17	3.87	0.19	14.06	7.148	953.030
2228	2000	-4.10	1.59	1.78	0.001672	3.45	2.50	0.26	19.24	19.178	2557.099
2165	2000	-4.20	1.56	1.68	0.000893	2.86	3.03	0.17	12.58	6.832	910.896
2050	2000	-4.80	1.42	1.57	0.001120	3.02	2.78	0.19	14.06	9.706	1294.078
1799	2000	-4.40	1.16	1.29	0.001043	2.95	2.82	0.18	13.32	8.581	1144.135
1604	2000	-4.90	1.08	1.15	0.000412	2.00	3.16	0.08	5.92	1.529	203.856
1397	2000	-5.40	1.03	1.06	0.000306	1.57	2.76	0.05	3.70	0.718	95.728
226	2000	-12.58	1.02	1.02	0.000000	0.14	11.72	0.00	0.00	0.000	0.000
0	2000	-12.21	1.00	1.02	0.000026	1.01	9.22	0.01	0.74	0.021	2.788

Reach Minimums:	0.74	0.03	3.64
Upper Reach Average:	2.61	0.25	32.97

Nome Airport
Snake River Relocation
Existing Conditions Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam:	dsi [mm] =	0.1
	dsi [ft] =	0.000328

Tide Elevation of +1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
26325	5200	-0.99	11.12	11.17	0.000085	2.13	8.88	0.05	3.70	0.665	88.673
25402	5200	-1.57	10.98	11.06	0.000146	2.81	8.93	0.08	5.92	1.981	264.082
24681	5200	-1.74	10.91	10.97	0.000092	2.45	10.25	0.06	4.44	0.925	123.392
23406	5200	-1.50	10.83	10.87	0.000062	1.93	9.60	0.04	2.96	0.390	52.042
22313	5200	-0.82	10.75	10.80	0.000061	2.00	10.31	0.04	2.96	0.409	54.542
21507	5200	-3.58	10.73	10.75	0.000044	1.69	10.32	0.03	2.22	0.212	28.248
20572	5200	-4.76	10.67	10.71	0.000053	1.88	10.48	0.03	2.22	0.314	41.863
19933	5200	-2.38	10.64	10.67	0.000056	1.93	10.39	0.04	2.96	0.349	46.476
19190	5200	0.01	10.61	10.63	0.000036	1.40	8.94	0.02	1.48	0.121	16.119
18062	5200	-2.87	10.49	10.56	0.000095	2.45	10.06	0.06	4.44	0.962	128.271
17322	5200	0.17	10.48	10.51	0.000037	1.40	8.90	0.02	1.48	0.126	16.757
16472	5200	-1.71	10.46	10.48	0.000031	1.38	9.86	0.02	1.48	0.100	13.333
15949	5200	-2.19	10.44	10.46	0.000036	1.47	9.73	0.02	1.48	0.132	17.657
14371	5200	-1.25	10.36	10.40	0.000045	1.67	9.98	0.03	2.22	0.213	28.391
13231	5200	-1.56	10.33	10.35	0.000034	1.46	10.01	0.02	1.48	0.122	16.325
12630	5200	-2.21	10.32	10.33	0.000024	1.27	10.46	0.02	1.48	0.065	8.609
11764	5200	-1.76	10.15	10.26	0.000120	2.79	10.24	0.08	5.92	1.569	209.220
11335	5200	-4.00	10.02	10.19	0.000200	3.33	9.10	0.11	8.14	3.799	506.509
10653	5200	-2.87	10.02	10.07	0.000060	1.87	9.41	0.04	2.96	0.356	47.527
9802	5200	-6.58	9.97	10.02	0.000057	2.00	10.80	0.04	2.96	0.378	50.423
9038	5200	-1.69	9.90	9.97	0.000077	2.19	9.91	0.05	3.70	0.623	83.041
8045	5200	-4.48	9.83	9.89	0.000071	2.18	10.44	0.05	3.70	0.563	75.123
7584	5200	-6.45	9.69	9.84	0.000134	3.15	11.30	0.09	6.66	2.196	292.809
6956	5200	-5.09	9.71	9.74	0.000042	1.77	11.50	0.03	2.22	0.218	29.126
6140	5200	-3.54	9.54	9.65	0.000153	2.84	11.25	0.11	8.14	2.410	321.373
5326	5200	-3.42	8.43	9.09	0.001502	6.53	7.07	0.66	48.85	135.135	18017.943
4588	5200	-5.01	7.37	8.06	0.001310	6.67	8.09	0.66	48.85	120.267	16035.572
3354	5200	-3.90	5.20	5.92	0.001836	6.80	6.47	0.74	54.77	181.932	24257.581
2829	5200	-4.70	4.34	4.80	0.001605	5.47	5.17	0.52	38.48	106.926	14256.817
2644	5200	-4.60	3.90	4.47	0.001897	6.06	5.31	0.63	46.63	154.262	20568.296
2431	5200	-3.90	3.57	4.06	0.001697	5.64	5.18	0.55	40.71	119.979	15997.207
2228	5200	-4.10	3.25	3.65	0.002253	5.10	3.60	0.51	37.74	138.357	18447.633
2165	5200	-4.20	3.17	3.50	0.001735	4.66	3.83	0.41	30.34	88.120	11749.299
2050	5200	-4.80	2.90	3.26	0.002557	4.83	3.02	0.48	35.52	145.106	19347.467
1799	5200	-4.40	1.86	2.43	0.004262	6.05	2.88	0.77	56.99	381.953	50927.132
1604	5200	-4.90	1.49	1.82	0.001945	4.59	3.43	0.42	31.08	97.494	12999.199
1397	5200	-5.40	1.17	1.41	0.001757	3.89	2.89	0.32	23.68	65.117	8682.276
226	5200	-12.58	1.13	1.13	0.000002	0.37	11.82	0.00	0.00	0.000	0.064
0	5200	-12.21	1.00	1.11	0.000172	2.64	9.22	0.10	7.40	2.418	322.359

Reach Minimums:	1.48	0.06	8.61
Upper Reach Average:	3.49	0.77	102.40

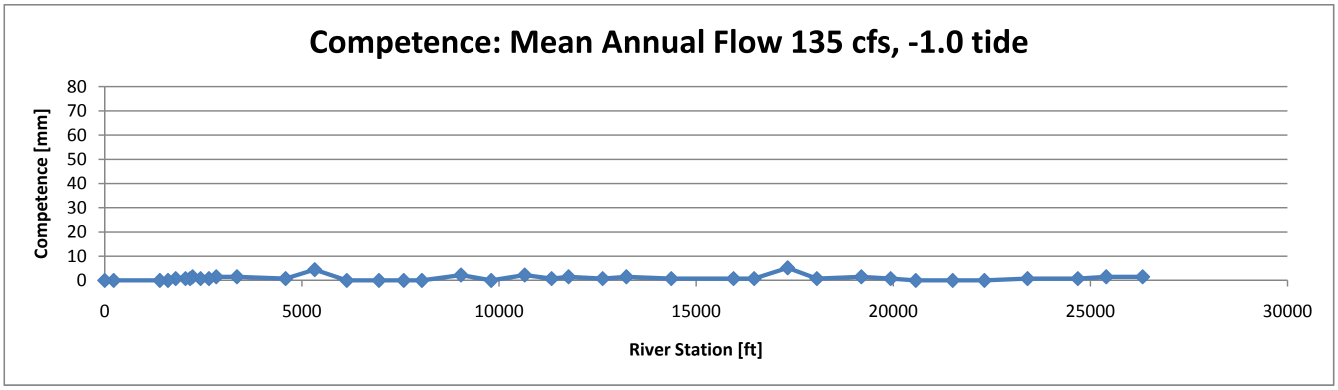
Nome Airport
Snake River Relocation
Existing Conditions Hydraulic and Sediment Transport Results
12/14/2009

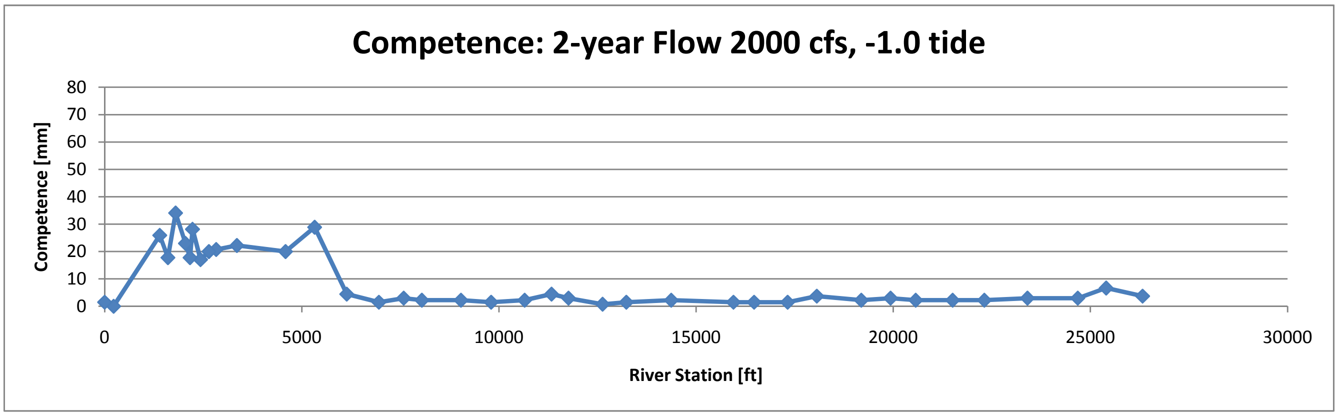
Sediment Diam:	dsi [mm] =	0.1
	dsi [ft] =	0.000328

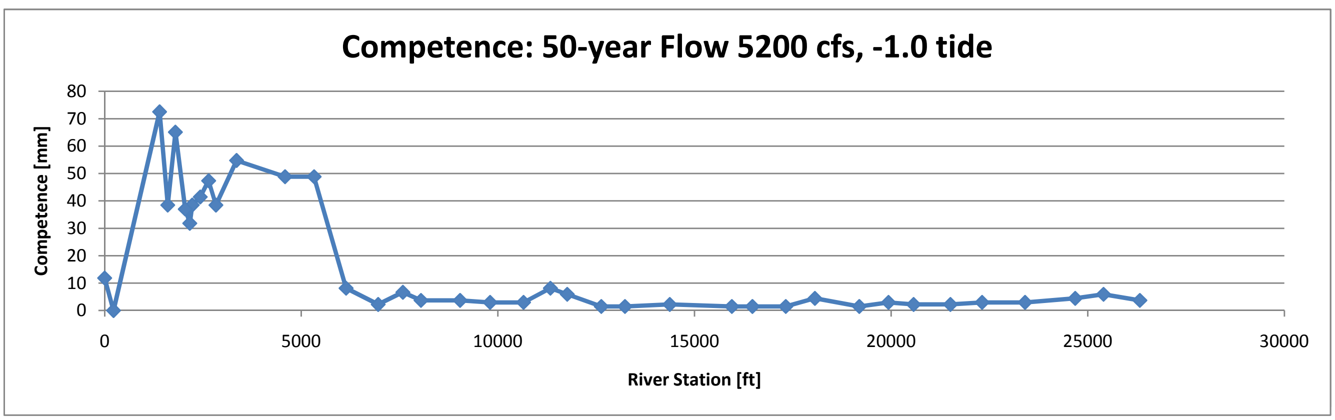
Tide Elevation of +1.0, 100-Year Flow

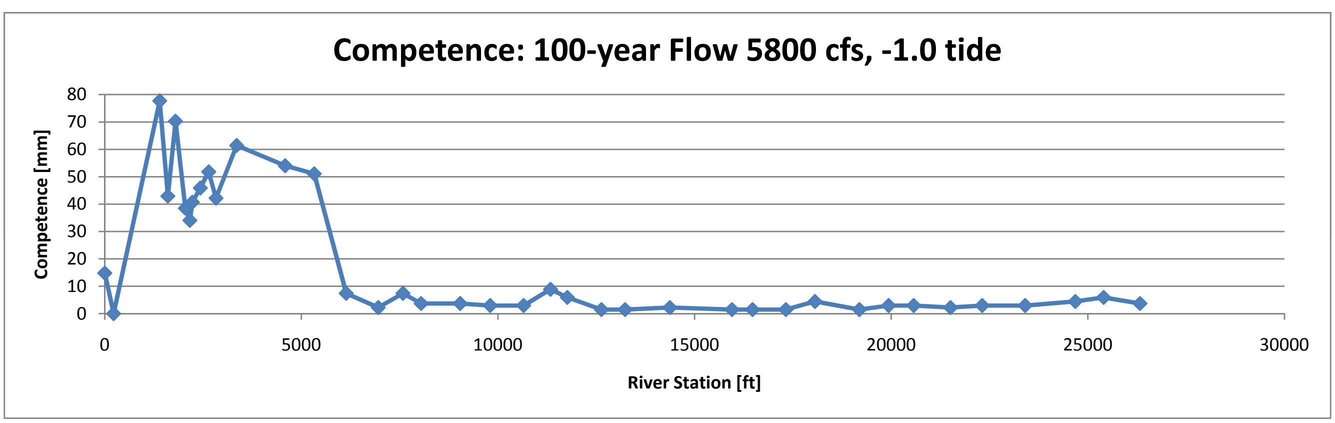
River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydraulic R. (ft^2)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
26325	5800	-0.99	11.67	11.72	0.000081	2.17	9.42	0.05	3.70	0.724	96.542
25402	5800	-1.57	11.54	11.62	0.000137	2.83	9.48	0.08	5.92	2.084	277.826
24681	5800	-1.74	11.47	11.53	0.000091	2.52	10.79	0.06	4.44	1.072	142.881
23406	5800	-1.50	11.39	11.43	0.000060	1.96	10.16	0.04	2.96	0.433	57.734
22313	5800	-0.82	11.32	11.36	0.000059	2.03	10.85	0.04	2.96	0.452	60.255
21507	5800	-3.58	11.30	11.32	0.000041	1.70	10.86	0.03	2.22	0.219	29.244
20572	5800	-4.76	11.24	11.28	0.000052	1.92	11.03	0.04	2.96	0.357	47.544
19933	5800	-2.38	11.21	11.24	0.000054	1.96	10.95	0.04	2.96	0.384	51.175
19190	5800	0.01	11.19	11.21	0.000034	1.42	9.51	0.02	1.48	0.129	17.262
18062	5800	-2.87	11.07	11.14	0.000087	2.44	10.63	0.06	4.44	0.963	128.362
17322	5800	0.17	11.06	11.09	0.000034	1.42	9.48	0.02	1.48	0.129	17.235
16472	5800	-1.71	11.04	11.06	0.000030	1.42	10.43	0.02	1.48	0.112	14.984
15949	5800	-2.19	11.02	11.04	0.000034	1.50	10.31	0.02	1.48	0.142	18.986
14371	5800	-1.25	10.95	10.98	0.000040	1.65	10.57	0.03	2.22	0.202	26.984
13231	5800	-1.56	10.92	10.94	0.000032	1.49	10.60	0.02	1.48	0.131	17.461
12630	5800	-2.21	10.91	10.92	0.000024	1.31	11.05	0.02	1.48	0.076	10.181
11764	5800	-1.76	10.73	10.85	0.000123	2.93	10.82	0.08	5.92	1.961	261.421
11335	5800	-4.00	10.60	10.78	0.000202	3.49	9.67	0.12	8.88	4.647	619.538
10653	5800	-2.87	10.61	10.65	0.000060	1.94	9.98	0.04	2.96	0.425	56.636
9802	5800	-6.58	10.55	10.60	0.000058	2.08	11.37	0.04	2.96	0.462	61.601
9038	5800	-1.69	10.49	10.55	0.000076	2.26	10.49	0.05	3.70	0.723	96.431
8045	5800	-4.48	10.42	10.48	0.000071	2.26	11.02	0.05	3.70	0.669	89.246
7584	5800	-6.45	10.26	10.42	0.000139	3.31	11.85	0.10	7.40	2.785	371.288
6956	5800	-5.09	10.29	10.32	0.000044	1.89	12.06	0.03	2.22	0.286	38.090
6140	5800	-3.54	10.14	10.24	0.000137	2.78	11.84	0.10	7.40	2.288	305.003
5326	5800	-3.42	8.99	9.68	0.001478	6.69	7.43	0.69	51.07	154.524	20603.180
4588	5800	-5.01	7.84	8.61	0.001394	7.04	8.37	0.73	54.03	158.086	21078.108
3354	5800	-3.90	5.54	6.35	0.001967	7.22	6.73	0.83	61.43	243.677	32490.272
2829	5800	-4.70	4.65	5.16	0.001668	5.76	5.42	0.56	41.45	136.232	18164.284
2644	5800	-4.60	4.16	4.81	0.002035	6.44	5.52	0.70	51.81	207.141	27618.756
2431	5800	-3.90	3.81	4.37	0.001845	6.01	5.35	0.62	45.89	164.289	21905.239
2228	5800	-4.10	3.48	3.92	0.002292	5.33	3.80	0.54	39.97	170.022	22669.556
2165	5800	-4.20	3.40	3.78	0.001793	4.89	4.02	0.45	33.30	111.008	14801.114
2050	5800	-4.80	3.15	3.53	0.002550	4.97	3.16	0.50	37.00	169.658	22621.025
1799	5800	-4.40	2.02	2.65	0.004783	6.38	2.86	0.86	63.65	532.252	70966.984
1604	5800	-4.90	1.59	1.97	0.002229	4.98	3.50	0.49	36.26	146.215	19495.328
1397	5800	-5.40	1.21	1.50	0.002093	4.27	2.92	0.38	28.12	104.193	13892.334
226	5800	-12.58	1.16	1.16	0.000003	0.41	11.85	0.00	0.00	0.001	0.146
0	5800	-12.21	1.00	1.13	0.000214	2.94	9.22	0.12	8.88	4.168	555.694
								Reach Minimums:	1.48	0.08	10.18
								Upper Reach Average:	3.55	0.87	116.56

Snake River - Existing Conditions

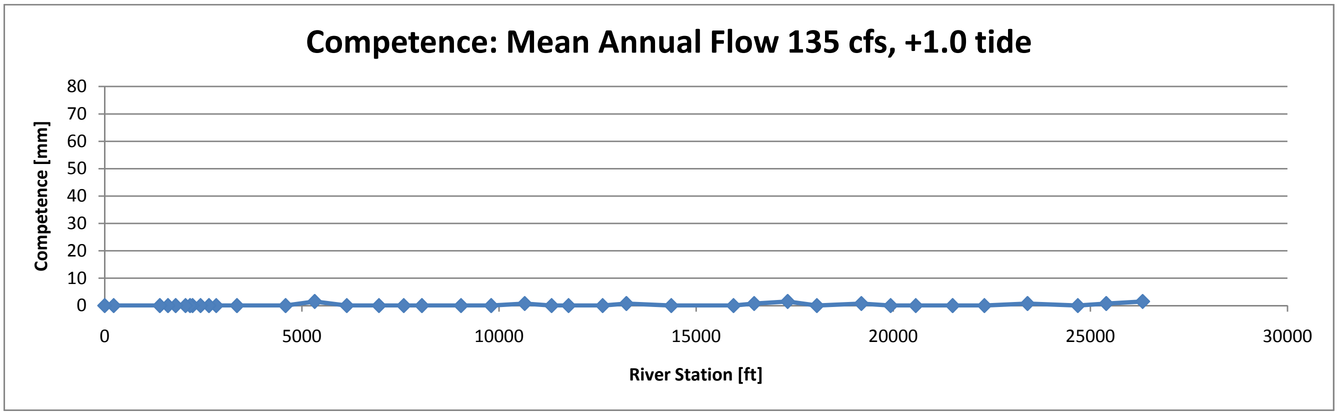


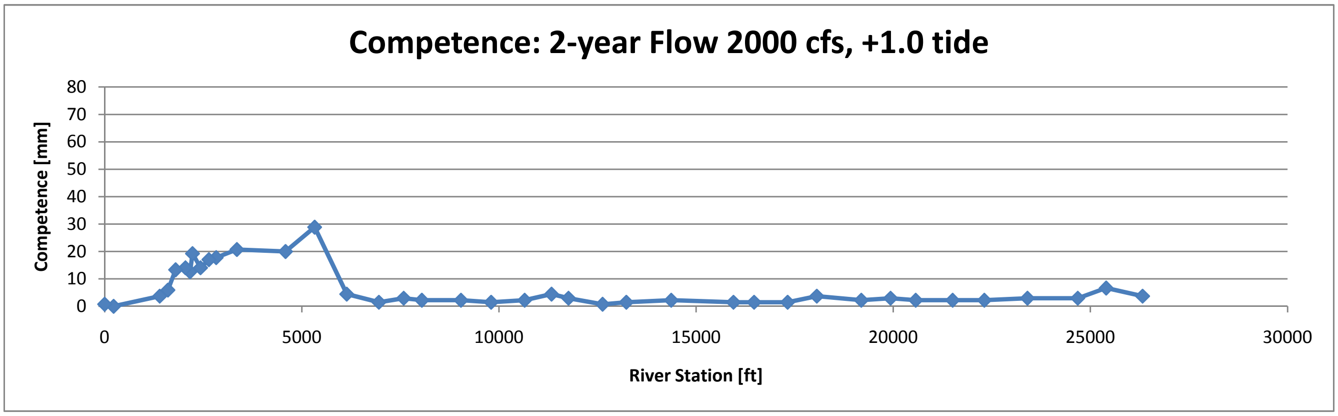


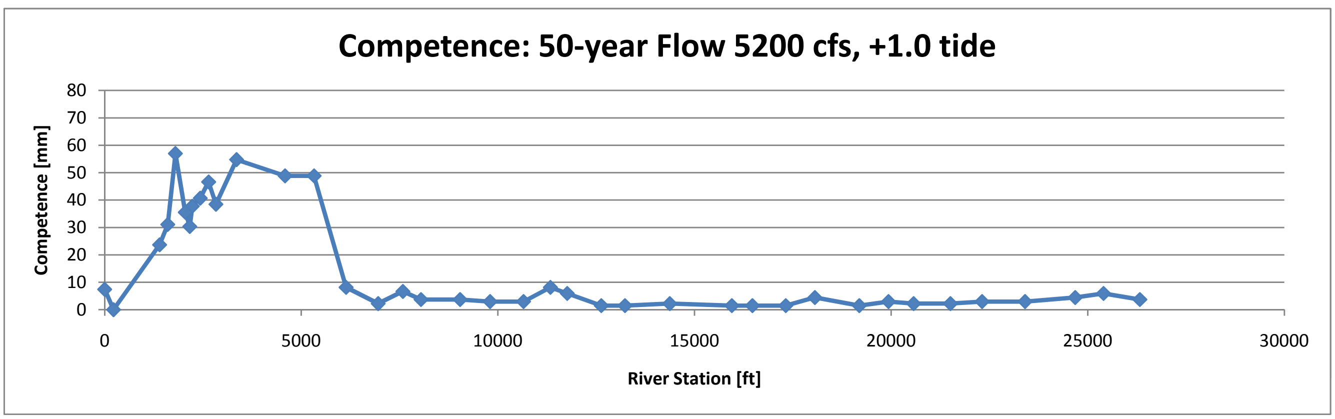


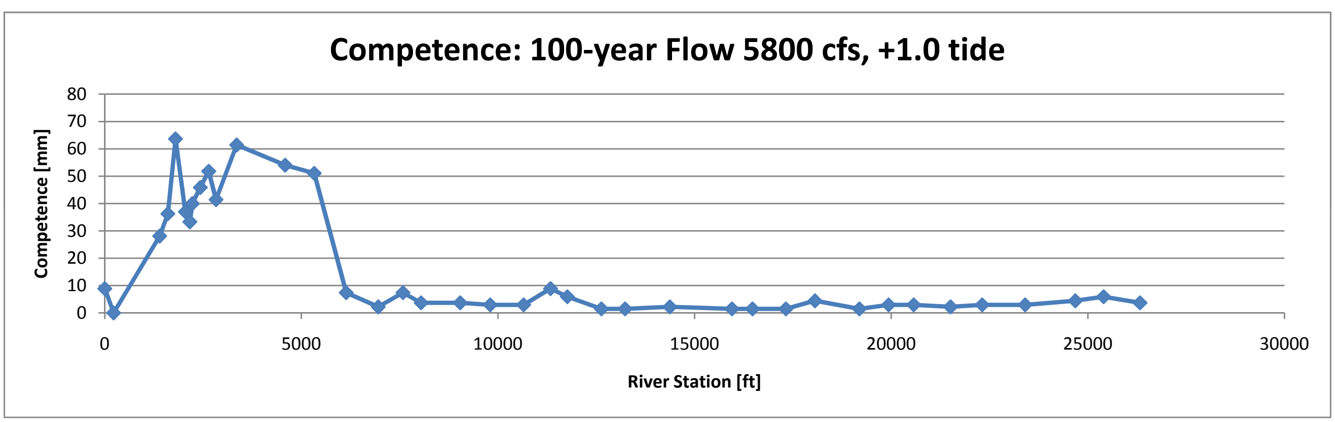


Snake River - Existing Conditions

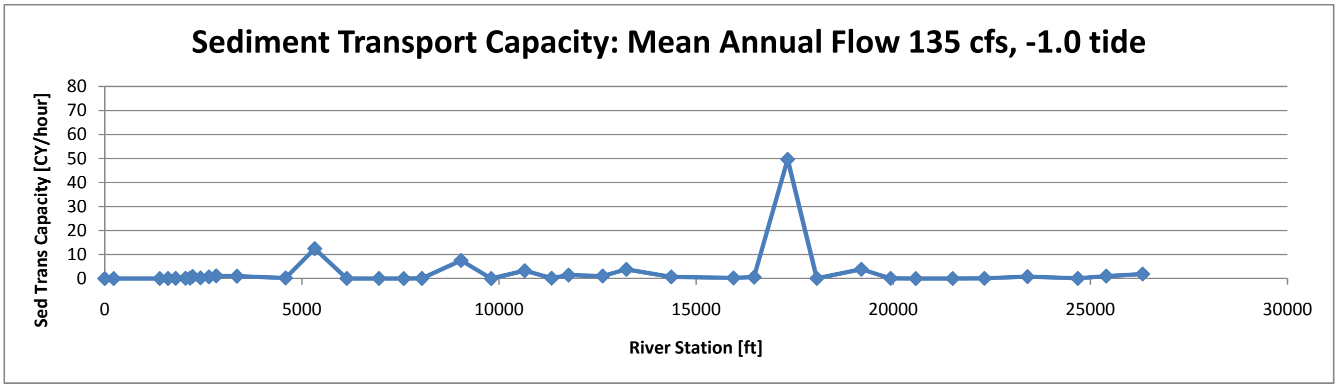


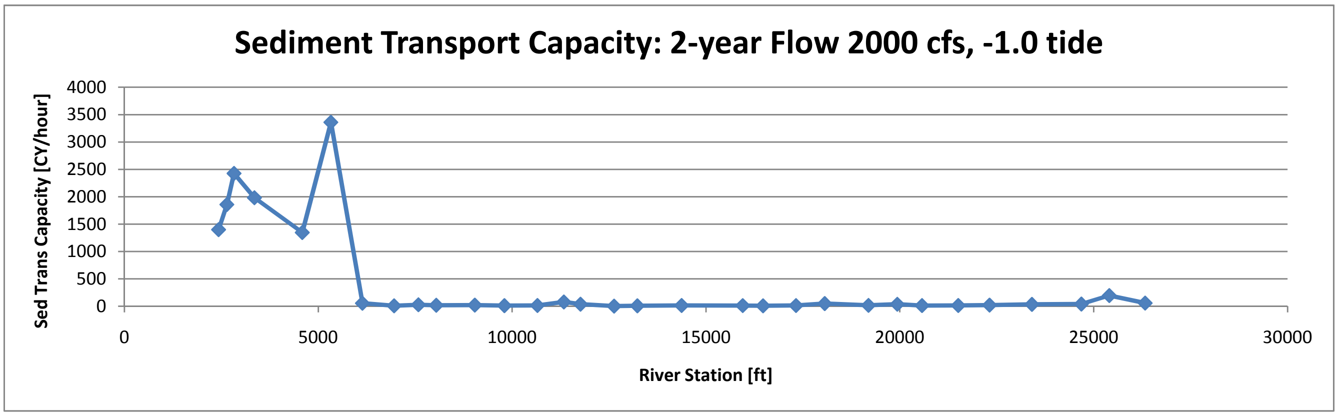


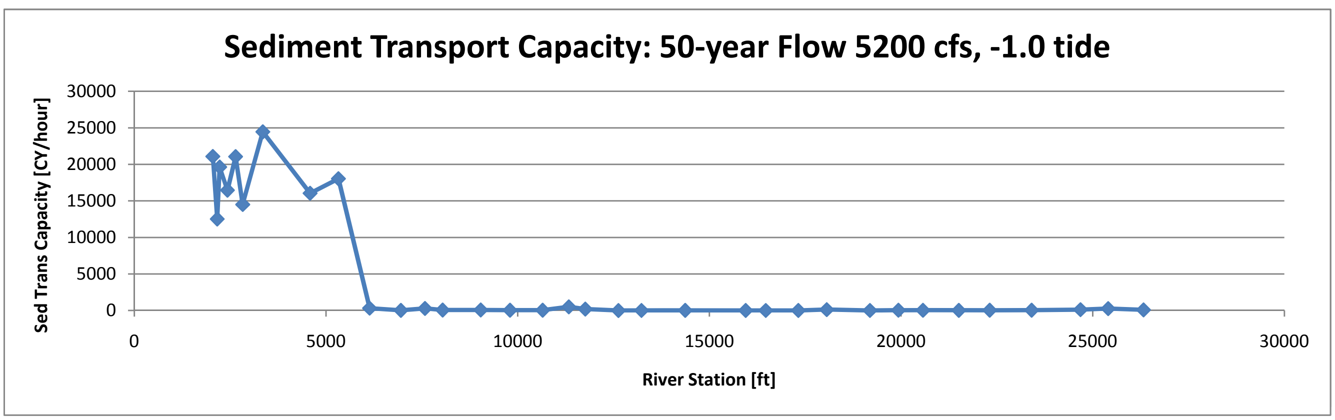


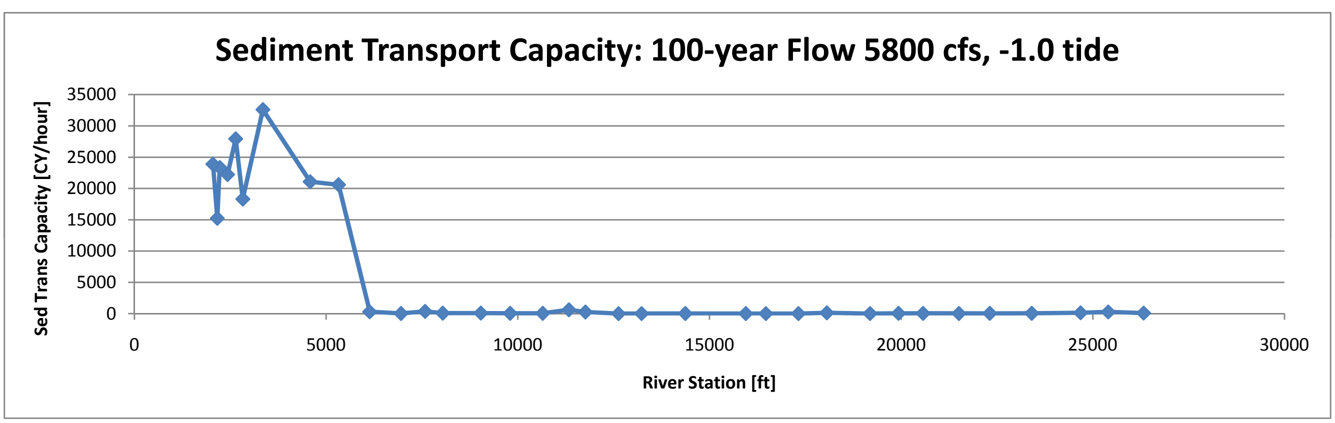


Snake River - Existing Conditions

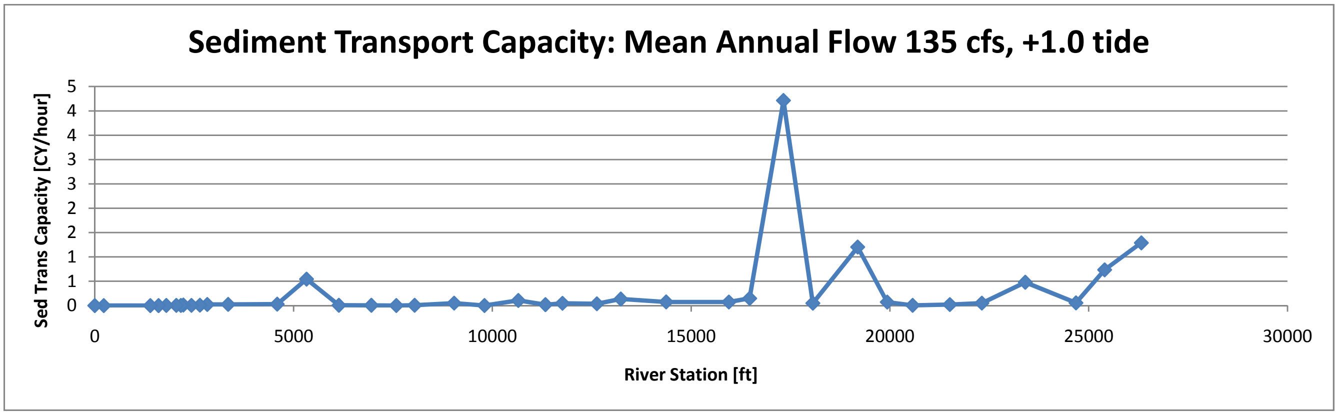


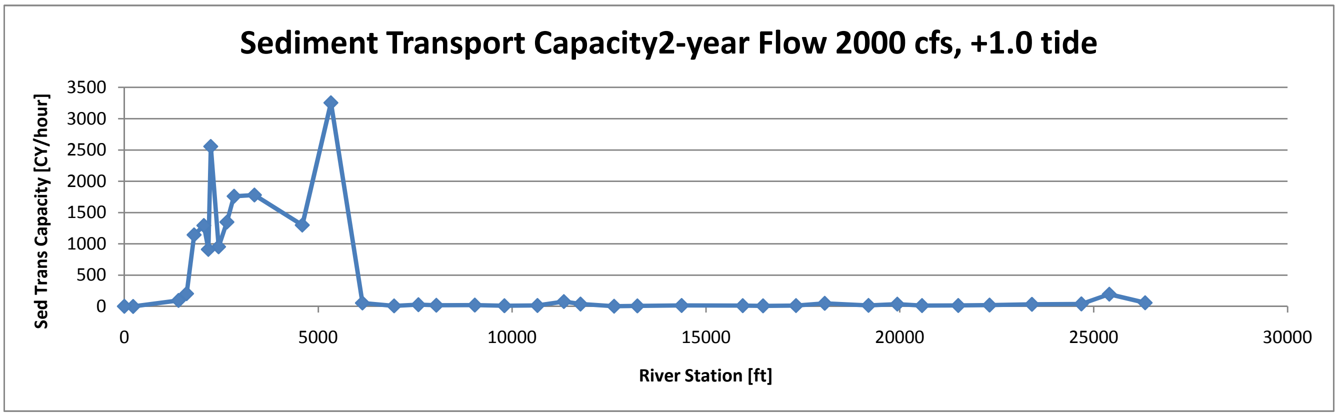


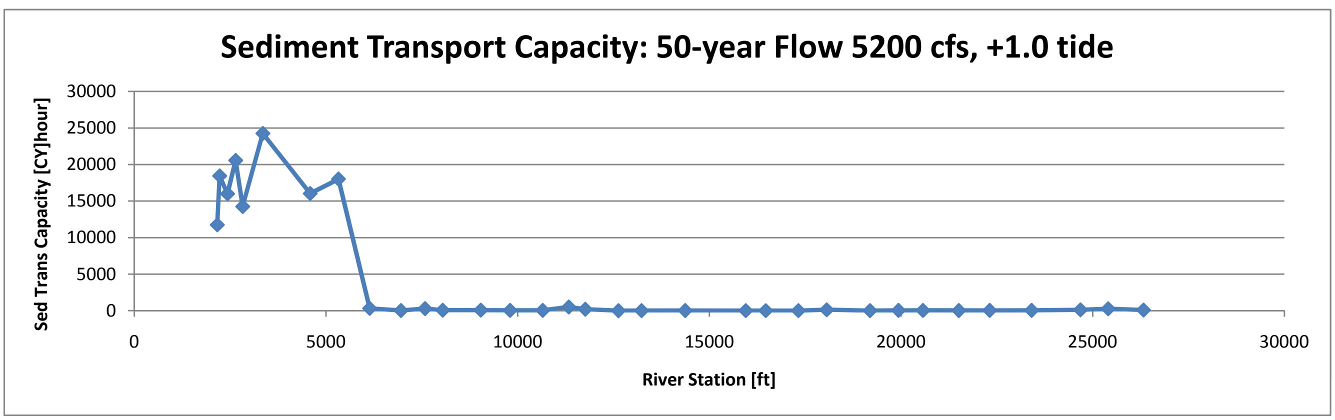


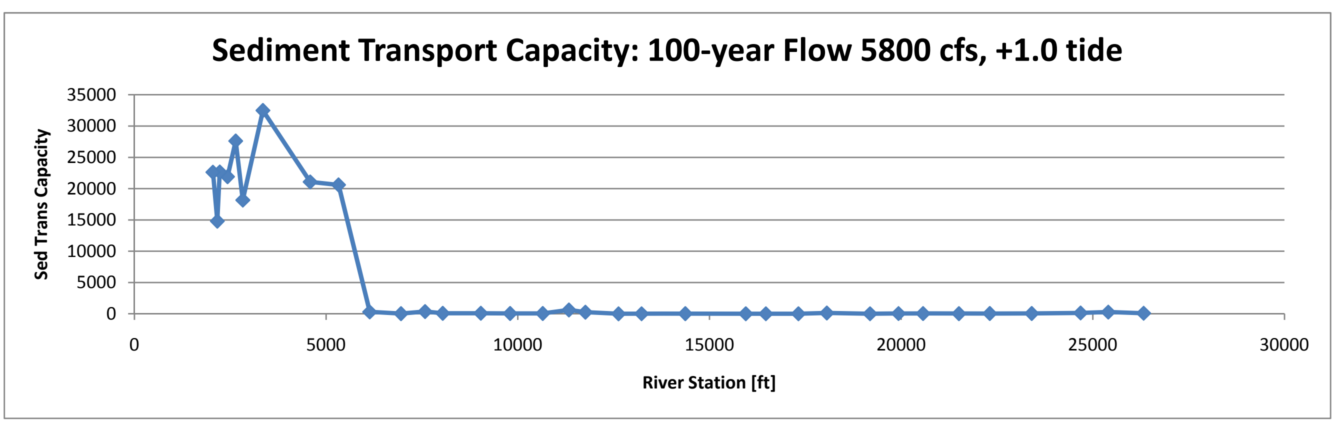


Snake River - Existing Conditions









Nome Airport
Snake River Relocation
Downstream Reconnection Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of -1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Depth Ave (ft_	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
27973	135	-0.99	1.70	1.72	0.000363	1.18	1.23	0.03	2.22	0.031	4.183
27050	135	-1.57	1.43	1.45	0.000231	1.15	1.68	0.02	1.48	0.018	2.421
26329	135	-1.74	1.36	1.36	0.000049	0.65	2.28	0.01	0.74	0.001	0.156
25054	135	-1.50	1.21	1.23	0.000332	1.12	1.22	0.03	2.22	0.026	3.458
23961	135	-0.82	0.99	0.99	0.000123	0.73	1.35	0.01	0.74	0.004	0.535
23155	135	-3.58	0.93	0.94	0.000035	0.57	2.38	0.01	0.74	0.001	0.084
22220	135	-4.76	0.92	0.92	0.000012	0.41	3.26	0.00	0.00	0.000	0.014
21801	135	-0.72	0.91	0.91	0.000087	0.68	1.58	0.01	0.74	0.002	0.321
20969	135	-0.80	0.83	0.84	0.000083	0.67	1.59	0.01	0.74	0.002	0.296
20364	135	-0.86	0.78	0.79	0.000082	0.67	1.60	0.01	0.74	0.002	0.291
19550	135	-0.94	0.72	0.73	0.000079	0.66	1.62	0.01	0.74	0.002	0.273
18742	135	-1.02	0.66	0.66	0.000076	0.65	1.63	0.01	0.74	0.002	0.255
17932	135	-1.10	0.60	0.60	0.000073	0.64	1.65	0.01	0.74	0.002	0.237
17124	135	-1.18	0.54	0.55	0.000071	0.64	1.67	0.01	0.74	0.002	0.229
16261	135	-1.26	0.48	0.49	0.000068	0.63	1.69	0.01	0.74	0.002	0.213
15461	135	-1.34	0.43	0.43	0.000064	0.62	1.72	0.01	0.74	0.001	0.193
14632	135	-1.42	0.38	0.38	0.000061	0.61	1.75	0.01	0.74	0.001	0.178
13828	135	-1.50	0.33	0.34	0.000057	0.60	1.78	0.01	0.74	0.001	0.159
12934	135	-1.58	0.28	0.29	0.000054	0.59	1.81	0.01	0.74	0.001	0.146
12107	135	-1.66	0.24	0.24	0.000051	0.57	1.84	0.01	0.74	0.001	0.130
11259	135	-1.74	0.20	0.20	0.000047	0.56	1.88	0.01	0.74	0.001	0.114
10466	135	-4.48	0.17	0.18	0.000020	0.46	2.67	0.00	0.00	0.000	0.031
9922	135	-1.53	0.15	0.16	0.000076	0.65	1.64	0.01	0.74	0.002	0.255
9122	135	-1.67	0.10	0.10	0.000064	0.62	1.72	0.01	0.74	0.001	0.193
8236	135	-1.67	0.04	0.04	0.000072	0.64	1.66	0.01	0.74	0.002	0.233
7013	135	-1.70	-0.06	-0.05	0.000082	0.67	1.60	0.01	0.74	0.002	0.291
6140	135	-3.54	-0.12	-0.12	0.000030	0.44	2.63	0.00	0.00	0.000	0.054
5326	135	-3.42	-0.38	-0.34	0.000555	1.56	1.98	0.07	5.18	0.100	13.293
4588	135	-5.01	-0.54	-0.54	0.000061	0.73	3.32	0.01	0.74	0.002	0.293
3354	135	-3.90	-0.76	-0.74	0.000165	0.84	1.92	0.02	1.48	0.009	1.141
2829	135	-4.70	-0.86	-0.85	0.000173	0.88	1.98	0.02	1.48	0.010	1.305
2644	135	-4.60	-0.89	-0.88	0.000156	0.72	1.59	0.02	1.48	0.006	0.818
2431	135	-3.90	-0.92	-0.91	0.000095	0.60	1.76	0.01	0.74	0.003	0.341
2228	135	-4.10	-0.95	-0.94	0.000171	0.79	1.70	0.02	1.48	0.008	1.068
2165	135	-4.20	-0.95	-0.95	0.000076	0.56	1.85	0.01	0.74	0.002	0.234
2050	135	-4.80	-0.96	-0.96	0.000058	0.54	2.16	0.01	0.74	0.001	0.162
1799	135	-4.40	-0.98	-0.97	0.000055	0.49	1.96	0.01	0.74	0.001	0.129
1604	135	-4.90	-0.98	-0.98	0.000032	0.33	1.58	0.00	0.00	0.000	0.035
1397	135	-5.40	-0.99	-0.99	0.000021	0.29	1.78	0.00	0.00	0.000	0.017
984	135	-4.23	-1.00	-1.00	0.000029	0.28	1.39	0.00	0.00	0.000	0.024
226	135	-12.58	-1.00	-1.00	0.000000	0.01	9.86	0.00	0.00	0.000	0.000
0	135	-12.21	-1.00	-1.00	0.000000	0.09	8.48	0.00	0.00	0.000	0.000
								Reach Minimums:	0.00	0.00	0.00
								Reach Average:	0.86	0.01	0.80

Nome Airport
Snake River Relocation
Downstream Reconnection Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of -1.0, 2-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Depth Ave (ft_	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
27973	2000	-0.99	8.06	8.07	0.000094	1.14	2.75	0.02	1.48	0.089	11.807
27050	2000	-1.57	7.88	7.96	0.000163	2.26	1.97	0.06	4.44	0.339	45.267
26329	2000	-1.74	7.83	7.87	0.000068	1.66	3.58	0.03	2.22	0.091	12.079
25054	2000	-1.50	7.76	7.79	0.000058	1.45	2.86	0.02	1.48	0.056	7.428
23961	2000	-0.82	7.70	7.73	0.000046	1.39	3.18	0.02	1.48	0.040	5.302
23155	2000	-3.58	7.67	7.69	0.000036	1.23	3.15	0.02	1.48	0.024	3.232
22220	2000	-4.76	7.64	7.66	0.000036	1.25	3.43	0.02	1.48	0.026	3.429
21801	2000	-0.72	7.59	7.63	0.000139	1.59	4.00	0.03	2.22	0.268	35.751
20969	2000	-0.80	7.48	7.53	0.000105	1.69	5.46	0.04	2.96	0.219	29.140
20364	2000	-0.86	7.42	7.47	0.000102	1.70	5.63	0.04	2.96	0.214	28.482
19550	2000	-0.94	7.34	7.38	0.000102	1.71	5.64	0.04	2.96	0.215	28.696
18742	2000	-1.02	7.25	7.29	0.000119	1.65	4.75	0.03	2.22	0.240	32.024
17932	2000	-1.10	7.15	7.20	0.000124	1.66	4.64	0.04	2.96	0.254	33.850
17124	2000	-1.18	7.05	7.09	0.000127	1.66	4.58	0.04	2.96	0.261	34.856
16261	2000	-1.26	6.95	7.00	0.000090	1.76	6.51	0.04	2.96	0.197	26.298
15461	2000	-1.34	6.88	6.93	0.000090	1.76	6.48	0.04	2.96	0.197	26.237
14632	2000	-1.42	6.80	6.84	0.000126	1.67	4.65	0.04	2.96	0.262	34.936
13828	2000	-1.50	6.69	6.73	0.000149	1.63	3.93	0.04	2.96	0.302	40.288
12934	2000	-1.58	6.55	6.59	0.000156	1.66	3.89	0.04	2.96	0.328	43.728
12107	2000	-1.66	6.42	6.47	0.000153	1.70	4.11	0.04	2.96	0.335	44.699
11259	2000	-1.74	6.29	6.34	0.000143	1.74	4.51	0.04	2.96	0.325	43.308
10466	2000	-4.48	6.24	6.27	0.000055	1.45	4.29	0.02	1.48	0.063	8.400
9922	2000	-1.53	6.17	6.22	0.000115	1.91	6.11	0.04	2.96	0.299	39.926
9122	2000	-1.67	6.08	6.13	0.000113	1.90	6.15	0.04	2.96	0.291	38.809
8236	2000	-1.67	5.97	6.03	0.000119	1.93	6.07	0.04	2.96	0.317	42.317
7013	2000	-1.70	5.82	5.88	0.000126	1.97	5.97	0.05	3.70	0.350	46.687
6140	2000	-3.54	5.63	5.68	0.000140	1.91	7.08	0.06	4.44	0.433	57.739
5326	2000	-3.42	4.91	5.22	0.001321	4.47	5.05	0.41	30.34	24.795	3305.976
4588	2000	-5.01	4.21	4.45	0.000767	3.93	6.36	0.29	21.46	10.826	1443.518
3354	2000	-3.90	2.90	3.14	0.001067	3.92	4.85	0.32	23.68	15.470	2062.710
2829	2000	-4.70	2.18	2.37	0.001381	3.51	3.34	0.29	21.46	16.935	2257.958
2644	2000	-4.60	1.95	2.14	0.001120	3.55	4.00	0.28	20.72	13.677	1823.656
2431	2000	-3.90	1.75	1.91	0.000993	3.25	3.82	0.24	17.76	10.218	1362.394
2228	2000	-4.10	1.39	1.61	0.002409	3.74	2.42	0.36	26.64	35.349	4713.164
2165	2000	-4.20	1.33	1.48	0.001287	3.09	2.90	0.23	17.02	12.488	1665.133
2050	2000	-4.80	1.14	1.32	0.001756	3.36	2.61	0.28	20.72	20.538	2738.360
1799	2000	-4.40	0.59	0.80	0.002409	3.67	2.35	0.35	25.90	34.230	4564.064
1604	2000	-4.90	0.36	0.46	0.000986	2.56	2.67	0.16	11.84	6.660	887.975
1397	2000	-5.40	0.16	0.24	0.001115	2.27	2.03	0.14	10.36	6.191	825.446
984	2000	-4.23	-0.88	-0.65	0.005244	3.87	1.41	0.46	34.04	89.769	11969.218
226	2000	-12.58	-0.97	-0.97	0.000001	0.17	9.89	0.00	0.00	0.000	0.004
0	2000	-12.21	-1.00	-0.97	0.000053	1.27	8.48	0.03	2.22	0.073	9.784
								Reach Minimums:	0.00	0.00	0.00
								Reach Average:	8.49	7.22	962.72

Nome Airport
Snake River Relocation
Downstream Reconnection Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam:	dsi [mm] =	0.1
	dsi [ft] =	0.000328

Tide Elevation of -1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Depth Ave (ft_	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
27973	5200	-0.99	12.13	12.15	0.000037	1.22	6.82	0.02	1.48	0.096	12.786
27050	5200	-1.57	12.04	12.10	0.000086	2.33	5.70	0.05	3.70	0.593	79.066
26329	5200	-1.74	12.00	12.04	0.000060	2.10	7.75	0.04	2.96	0.363	48.427
25054	5200	-1.50	11.95	11.98	0.000038	1.61	6.82	0.03	2.22	0.132	17.561
23961	5200	-0.82	11.91	11.94	0.000037	1.66	6.00	0.03	2.22	0.122	16.316
23155	5200	-3.58	11.89	11.91	0.000025	1.38	5.87	0.02	1.48	0.056	7.452
22220	5200	-4.76	11.86	11.88	0.000032	1.58	6.47	0.02	1.48	0.097	12.969
21801	5200	-0.72	11.80	11.86	0.000089	1.98	7.74	0.04	2.96	0.618	82.457
20969	5200	-0.80	11.68	11.77	0.000114	2.43	8.83	0.06	4.44	1.175	156.711
20364	5200	-0.86	11.61	11.70	0.000116	2.48	8.97	0.06	4.44	1.240	165.395
19550	5200	-0.94	11.51	11.61	0.000117	2.49	8.97	0.06	4.44	1.262	168.273
18742	5200	-1.02	11.43	11.51	0.000104	2.23	8.32	0.05	3.70	0.912	121.630
17932	5200	-1.10	11.35	11.43	0.000103	2.21	8.23	0.05	3.70	0.886	118.144
17124	5200	-1.18	11.27	11.34	0.000103	2.20	8.19	0.05	3.70	0.880	117.327
16261	5200	-1.26	11.13	11.24	0.000128	2.72	9.61	0.07	5.18	1.632	217.632
15461	5200	-1.34	11.02	11.14	0.000129	2.72	9.57	0.07	5.18	1.648	219.744
14632	5200	-1.42	10.95	11.03	0.000107	2.25	8.25	0.05	3.70	0.956	127.533
13828	5200	-1.50	10.88	10.95	0.000093	2.01	7.73	0.04	2.96	0.670	89.365
12934	5200	-1.58	10.80	10.86	0.000093	2.02	7.74	0.04	2.96	0.674	89.870
12107	5200	-1.66	10.71	10.78	0.000099	2.12	7.96	0.05	3.70	0.788	105.040
11259	5200	-1.74	10.62	10.70	0.000107	2.26	8.31	0.05	3.70	0.964	128.584
10466	5200	-4.48	10.58	10.63	0.000054	1.99	7.14	0.04	2.96	0.282	37.625
9922	5200	-1.53	10.45	10.57	0.000145	2.83	9.31	0.08	5.92	2.016	268.783
9122	5200	-1.67	10.33	10.46	0.000144	2.83	9.33	0.08	5.92	1.997	266.315
8236	5200	-1.67	10.20	10.33	0.000151	2.87	9.24	0.08	5.92	2.164	288.501
7013	5200	-1.70	10.00	10.14	0.000159	2.92	9.12	0.09	6.66	2.364	315.134
6140	5200	-3.54	9.85	9.94	0.000146	2.63	2.92	0.11	8.14	1.060	141.313
5326	5200	-3.42	8.79	9.38	0.001501	6.18	5.11	0.68	50.33	108.602	14480.272
4588	5200	-5.01	7.68	8.32	0.001370	6.43	8.73	0.71	52.55	128.800	17173.384
3354	5200	-3.90	5.44	6.11	0.001914	6.57	6.84	0.79	58.47	192.324	25643.167
2829	5200	-4.70	4.53	4.96	0.001660	5.28	5.39	0.55	40.71	110.887	14784.945
2644	5200	-4.60	4.09	4.62	0.001981	5.86	5.54	0.68	50.33	162.628	21683.710
2431	5200	-3.90	3.73	4.20	0.001796	5.47	5.34	0.59	43.67	128.667	17155.545
2228	5200	-4.10	3.39	3.76	0.002308	4.90	3.75	0.54	39.97	140.666	18755.429
2165	5200	-4.20	3.30	3.62	0.001808	4.50	3.96	0.44	32.56	91.999	12266.486
2050	5200	-4.80	2.99	3.35	0.002226	4.79	2.97	0.51	37.74	115.985	15464.699
1799	5200	-4.40	2.12	2.59	0.004199	5.53	2.87	0.75	55.51	340.738	45431.694
1604	5200	-4.90	1.73	2.02	0.001848	4.28	3.61	0.42	31.08	86.343	11512.366
1397	5200	-5.40	1.45	1.64	0.001524	3.54	3.13	0.30	22.20	49.853	6647.058
984	5200	-4.23	-0.29	0.38	0.012982	6.60	1.59	1.29	95.47	1647.302	219640.303
226	5200	-12.58	-0.80	-0.80	0.000005	0.44	10.05	0.00	0.00	0.002	0.278
0	5200	-12.21	-1.00	-0.83	0.000358	3.30	8.48	0.19	14.06	8.703	1160.379

Reach Minimums:	0.00	0.00	0.28
Reach Average:	17.39	79.50	10600.47

Nome Airport
Snake River Relocation
Downstream Reconnection Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of -1.0, 100-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Depth Ave (ft_	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
27973	5800	-0.99	12.74	12.76	0.000035	1.25	7.43	0.02	1.48	0.105	14.028
27050	5800	-1.57	12.65	12.71	0.000082	2.35	6.22	0.05	3.70	0.649	86.509
26329	5800	-1.74	12.61	12.66	0.000060	2.17	8.36	0.04	2.96	0.435	57.970
25054	5800	-1.50	12.56	12.59	0.000037	1.65	7.39	0.03	2.22	0.151	20.072
23961	5800	-0.82	12.52	12.55	0.000036	1.69	6.46	0.03	2.22	0.138	18.452
23155	5800	-3.58	12.51	12.52	0.000024	1.40	6.30	0.02	1.48	0.062	8.218
22220	5800	-4.76	12.47	12.50	0.000032	1.63	6.88	0.02	1.48	0.115	15.386
21801	5800	-0.72	12.41	12.47	0.000087	2.04	8.26	0.04	2.96	0.710	94.619
20969	5800	-0.80	12.29	12.39	0.000116	2.53	9.30	0.07	5.18	1.437	191.648
20364	5800	-0.86	12.21	12.31	0.000119	2.59	9.43	0.07	5.18	1.539	205.256
19550	5800	-0.94	12.11	12.22	0.000119	2.60	9.43	0.07	5.18	1.546	206.102
18742	5800	-1.02	12.04	12.12	0.000104	2.32	8.81	0.06	4.44	1.089	145.261
17932	5800	-1.10	11.96	12.04	0.000103	2.30	8.72	0.06	4.44	1.059	141.202
17124	5800	-1.18	11.87	11.95	0.000103	2.28	8.68	0.05	3.70	1.047	139.659
16261	5800	-1.26	11.72	11.85	0.000133	2.85	10.03	0.08	5.92	2.064	275.236
15461	5800	-1.34	11.62	11.74	0.000134	2.85	9.99	0.08	5.92	2.083	277.790
14632	5800	-1.42	11.55	11.63	0.000107	2.34	8.75	0.06	4.44	1.142	152.295
13828	5800	-1.50	11.48	11.55	0.000091	2.09	8.25	0.05	3.70	0.777	103.648
12934	5800	-1.58	11.40	11.46	0.000092	2.09	8.27	0.05	3.70	0.791	105.436
12107	5800	-1.66	11.31	11.39	0.000098	2.20	8.48	0.05	3.70	0.927	123.572
11259	5800	-1.74	11.21	11.30	0.000107	2.35	8.85	0.06	4.44	1.154	153.897
10466	5800	-4.48	11.18	11.23	0.000055	2.07	7.48	0.04	2.96	0.344	45.923
9922	5800	-1.53	11.04	11.17	0.000151	2.97	9.73	0.09	6.66	2.563	341.767
9122	5800	-1.67	10.92	11.05	0.000150	2.97	9.75	0.09	6.66	2.540	338.690
8236	5800	-1.67	10.77	10.92	0.000157	3.01	9.65	0.09	6.66	2.743	365.674
7013	5800	-1.70	10.57	10.72	0.000165	3.06	9.52	0.10	7.40	2.985	397.974
6140	5800	-3.54	10.45	10.53	0.000127	2.53	3.34	0.10	7.40	0.987	131.550
5326	5800	-3.42	9.37	9.98	0.001438	6.30	5.51	0.70	51.81	120.243	16032.365
4588	5800	-5.01	8.17	8.89	0.001457	6.78	9.05	0.78	57.73	169.172	22556.274
3354	5800	-3.90	5.79	6.54	0.002041	6.97	7.14	0.88	65.13	256.023	34136.463
2829	5800	-4.70	4.85	5.33	0.001723	5.55	5.67	0.60	44.41	140.930	18790.610
2644	5800	-4.60	4.37	4.97	0.002115	6.22	5.77	0.75	55.51	216.735	28898.016
2431	5800	-3.90	3.99	4.51	0.001943	5.82	5.53	0.67	49.59	174.829	23310.539
2228	5800	-4.10	3.64	4.05	0.002333	5.12	3.97	0.57	42.19	171.445	22859.393
2165	5800	-4.20	3.56	3.90	0.001855	4.71	4.16	0.48	35.52	114.481	15264.164
2050	5800	-4.80	3.23	3.62	0.002265	5.02	3.14	0.55	40.71	142.949	19059.930
1799	5800	-4.40	2.34	2.84	0.004310	5.72	2.96	0.79	58.47	414.942	55325.597
1604	5800	-4.90	1.93	2.25	0.001974	4.53	3.73	0.46	34.04	114.505	15267.377
1397	5800	-5.40	1.63	1.85	0.001589	3.73	3.28	0.32	23.68	63.839	8511.856
984	5800	-4.23	-0.19	0.55	0.013115	6.89	1.69	1.38	102.13	2003.656	267154.088
226	5800	-12.58	-0.75	-0.75	0.000006	0.49	10.10	0.00	0.00	0.003	0.455
0	5800	-12.21	-1.00	-0.79	0.000445	3.68	8.48	0.23	17.02	15.002	2000.203
								Reach Minimums:	0.00	0.00	0.46
								Reach Average:	18.91	98.81	13174.41

Nome Airport
Snake River Relocation
Downstream Reconnection Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of +1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Depth Ave (ft_	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
27973	135	-0.99	1.87	1.89	0.000250	1.03	1.33	0.02	1.48	0.016	2.169
27050	135	-1.57	1.69	1.71	0.000154	0.99	1.82	0.02	1.48	0.009	1.183
26329	135	-1.74	1.64	1.65	0.000034	0.58	2.48	0.01	0.74	0.001	0.084
25054	135	-1.50	1.55	1.57	0.000165	0.86	1.38	0.01	0.74	0.007	0.992
23961	135	-0.82	1.46	1.47	0.000046	0.54	1.78	0.01	0.74	0.001	0.104
23155	135	-3.58	1.44	1.44	0.000021	0.46	2.64	0.00	0.00	0.000	0.033
22220	135	-4.76	1.43	1.43	0.000008	0.35	3.48	0.00	0.00	0.000	0.007
21801	135	-0.72	1.42	1.43	0.000034	0.51	2.07	0.00	0.00	0.001	0.067
20969	135	-0.80	1.39	1.40	0.000031	0.49	2.12	0.00	0.00	0.000	0.057
20364	135	-0.86	1.38	1.38	0.000029	0.49	2.16	0.00	0.00	0.000	0.052
19550	135	-0.94	1.35	1.36	0.000027	0.47	2.21	0.00	0.00	0.000	0.045
18742	135	-1.02	1.33	1.34	0.000024	0.46	2.27	0.00	0.00	0.000	0.038
17932	135	-1.10	1.31	1.32	0.000023	0.45	2.32	0.00	0.00	0.000	0.035
17124	135	-1.18	1.30	1.30	0.000021	0.44	2.38	0.00	0.00	0.000	0.030
16261	135	-1.26	1.28	1.28	0.000019	0.42	2.44	0.00	0.00	0.000	0.025
15461	135	-1.34	1.27	1.27	0.000018	0.41	2.50	0.00	0.00	0.000	0.023
14632	135	-1.42	1.25	1.25	0.000016	0.40	2.56	0.00	0.00	0.000	0.019
13828	135	-1.50	1.24	1.24	0.000015	0.39	2.62	0.00	0.00	0.000	0.017
12934	135	-1.58	1.23	1.23	0.000014	0.38	2.69	0.00	0.00	0.000	0.015
12107	135	-1.66	1.22	1.22	0.000013	0.37	2.75	0.00	0.00	0.000	0.013
11259	135	-1.74	1.21	1.21	0.000012	0.36	2.81	0.00	0.00	0.000	0.012
10466	135	-4.48	1.20	1.20	0.000008	0.33	3.28	0.00	0.00	0.000	0.006
9922	135	-1.53	1.19	1.19	0.000015	0.40	2.61	0.00	0.00	0.000	0.017
9122	135	-1.67	1.18	1.18	0.000013	0.38	2.73	0.00	0.00	0.000	0.014
8236	135	-1.67	1.17	1.17	0.000013	0.38	2.72	0.00	0.00	0.000	0.014
7013	135	-1.70	1.15	1.16	0.000013	0.38	2.73	0.00	0.00	0.000	0.014
6140	135	-3.54	1.14	1.14	0.000009	0.30	3.69	0.00	0.00	0.000	0.007
5326	135	-3.42	1.09	1.10	0.000103	0.83	2.73	0.02	1.48	0.005	0.663
4588	135	-5.01	1.06	1.06	0.000018	0.48	4.43	0.00	0.00	0.000	0.036
3354	135	-3.90	1.02	1.03	0.000020	0.42	3.36	0.00	0.00	0.000	0.032
2829	135	-4.70	1.01	1.01	0.000024	0.36	2.32	0.00	0.00	0.000	0.030
2644	135	-4.60	1.01	1.01	0.000012	0.31	3.17	0.00	0.00	0.000	0.011
2431	135	-3.90	1.01	1.01	0.000009	0.27	3.24	0.00	0.00	0.000	0.006
2228	135	-4.10	1.00	1.01	0.000016	0.30	2.37	0.00	0.00	0.000	0.014
2165	135	-4.20	1.00	1.01	0.000008	0.23	2.68	0.00	0.00	0.000	0.004
2050	135	-4.80	1.00	1.00	0.000009	0.24	2.52	0.00	0.00	0.000	0.005
1799	135	-4.40	1.00	1.00	0.000007	0.21	2.72	0.00	0.00	0.000	0.003
1604	135	-4.90	1.00	1.00	0.000002	0.14	3.11	0.00	0.00	0.000	0.000
1397	135	-5.40	1.00	1.00	0.000002	0.11	2.74	0.00	0.00	0.000	0.000
984	135	-4.23	1.00	1.00	0.000001	0.09	2.66	0.00	0.00	0.000	0.000
226	135	-12.58	1.00	1.00	0.000000	0.01	11.77	0.00	0.00	0.000	0.000
0	135	-12.21	1.00	1.00	0.000000	0.07	9.39	0.00	0.00	0.000	0.000
								Reach Minimums:	0.00	0.00	0.00
								Reach Average:	0.16	0.00	0.14

Nome Airport
Snake River Relocation
Downstream Reconnection Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of +1.0, 2-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Depth Ave (ft_	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
27973	2000	-0.99	8.06	8.08	0.000094	1.14	2.75	0.02	1.48	0.089	11.815
27050	2000	-1.57	7.89	7.96	0.000162	2.26	1.97	0.06	4.44	0.337	44.878
26329	2000	-1.74	7.84	7.87	0.000067	1.66	3.59	0.03	2.22	0.089	11.821
25054	2000	-1.50	7.77	7.79	0.000058	1.45	2.87	0.02	1.48	0.056	7.434
23961	2000	-0.82	7.71	7.73	0.000046	1.39	3.18	0.02	1.48	0.040	5.306
23155	2000	-3.58	7.68	7.70	0.000036	1.23	3.15	0.02	1.48	0.024	3.234
22220	2000	-4.76	7.64	7.66	0.000036	1.25	3.44	0.02	1.48	0.026	3.431
21801	2000	-0.72	7.60	7.64	0.000138	1.59	4.01	0.03	2.22	0.265	35.388
20969	2000	-0.80	7.49	7.54	0.000104	1.69	5.47	0.03	2.22	0.216	28.737
20364	2000	-0.86	7.43	7.47	0.000101	1.70	5.63	0.04	2.96	0.211	28.077
19550	2000	-0.94	7.35	7.39	0.000101	1.70	5.65	0.04	2.96	0.211	28.122
18742	2000	-1.02	7.26	7.30	0.000119	1.65	4.76	0.03	2.22	0.240	32.043
17932	2000	-1.10	7.16	7.20	0.000123	1.65	4.65	0.04	2.96	0.249	33.262
17124	2000	-1.18	7.06	7.10	0.000127	1.66	4.59	0.04	2.96	0.262	34.882
16261	2000	-1.26	6.96	7.01	0.000090	1.76	6.52	0.04	2.96	0.197	26.310
15461	2000	-1.34	6.89	6.94	0.000090	1.76	6.49	0.04	2.96	0.197	26.250
14632	2000	-1.42	6.81	6.85	0.000125	1.67	4.66	0.04	2.96	0.259	34.550
13828	2000	-1.50	6.70	6.74	0.000148	1.63	3.94	0.04	2.96	0.299	39.928
12934	2000	-1.58	6.56	6.60	0.000155	1.65	3.90	0.04	2.96	0.323	43.102
12107	2000	-1.66	6.43	6.48	0.000151	1.69	4.12	0.04	2.96	0.327	43.625
11259	2000	-1.74	6.31	6.35	0.000142	1.74	4.52	0.04	2.96	0.322	42.909
10466	2000	-4.48	6.25	6.28	0.000054	1.44	4.30	0.02	1.48	0.061	8.125
9922	2000	-1.53	6.18	6.24	0.000114	1.91	6.12	0.04	2.96	0.296	39.440
9122	2000	-1.67	6.09	6.15	0.000112	1.89	6.16	0.04	2.96	0.286	38.128
8236	2000	-1.67	5.99	6.05	0.000118	1.93	6.08	0.04	2.96	0.314	41.826
7013	2000	-1.70	5.84	5.90	0.000125	1.96	5.99	0.05	3.70	0.345	45.948
6140	2000	-3.54	5.65	5.70	0.000139	1.91	7.08	0.06	4.44	0.428	57.088
5326	2000	-3.42	4.93	5.24	0.001301	4.45	5.07	0.40	29.60	24.168	3222.438
4588	2000	-5.01	4.24	4.48	0.000754	3.91	6.39	0.29	21.46	10.521	1402.756
3354	2000	-3.90	2.99	3.22	0.001011	3.85	4.92	0.30	22.20	14.110	1881.384
2829	2000	-4.70	2.35	2.52	0.001185	3.34	3.49	0.26	19.24	13.080	1744.064
2644	2000	-4.60	2.15	2.33	0.000963	3.38	4.16	0.25	18.50	10.596	1412.760
2431	2000	-3.90	1.98	2.13	0.000828	3.07	4.00	0.21	15.54	7.525	1003.278
2228	2000	-4.10	1.73	1.90	0.001674	3.26	2.59	0.27	19.98	18.481	2464.105
2165	2000	-4.20	1.69	1.80	0.000916	2.74	3.13	0.18	13.32	6.913	921.708
2050	2000	-4.80	1.56	1.69	0.001138	2.89	2.88	0.20	14.80	9.680	1290.708
1799	2000	-4.40	1.28	1.41	0.001057	2.82	2.95	0.19	14.06	8.555	1140.603
1604	2000	-4.90	1.20	1.26	0.000429	1.92	3.25	0.09	6.66	1.581	210.763
1397	2000	-5.40	1.14	1.18	0.000312	1.51	2.87	0.06	4.44	0.724	96.583
984	2000	-4.23	1.02	1.05	0.000275	1.35	2.67	0.05	3.70	0.517	68.986
226	2000	-12.58	1.02	1.02	0.000000	0.14	11.79	0.00	0.00	0.000	0.000
0	2000	-12.21	1.00	1.02	0.000030	1.01	9.39	0.02	1.48	0.026	3.486
								Reach Minimums:	0.00	0.00	0.00
								Reach Average:	6.59	3.15	420.46

Nome Airport
Snake River Relocation
Downstream Reconnection Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of +1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Depth Ave (ft_	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
27973	5200	-0.99	12.13	12.15	0.000037	1.22	6.82	0.02	1.48	0.096	12.787
27050	5200	-1.57	12.04	12.10	0.000086	2.33	5.70	0.05	3.70	0.593	79.069
26329	5200	-1.74	12.00	12.04	0.000060	2.10	7.75	0.04	2.96	0.363	48.429
25054	5200	-1.50	11.95	11.98	0.000038	1.61	6.82	0.03	2.22	0.132	17.561
23961	5200	-0.82	11.91	11.94	0.000037	1.66	6.00	0.03	2.22	0.122	16.317
23155	5200	-3.58	11.89	11.91	0.000025	1.38	5.87	0.02	1.48	0.056	7.453
22220	5200	-4.76	11.86	11.88	0.000032	1.58	6.47	0.02	1.48	0.097	12.969
21801	5200	-0.72	11.80	11.86	0.000089	1.98	7.74	0.04	2.96	0.618	82.458
20969	5200	-0.80	11.68	11.77	0.000114	2.43	8.83	0.06	4.44	1.175	156.716
20364	5200	-0.86	11.61	11.70	0.000116	2.48	8.97	0.06	4.44	1.240	165.397
19550	5200	-0.94	11.51	11.61	0.000117	2.49	8.97	0.06	4.44	1.262	168.279
18742	5200	-1.02	11.43	11.51	0.000104	2.23	8.32	0.05	3.70	0.912	121.634
17932	5200	-1.10	11.35	11.43	0.000103	2.21	8.23	0.05	3.70	0.886	118.148
17124	5200	-1.18	11.27	11.34	0.000103	2.20	8.19	0.05	3.70	0.880	117.330
16261	5200	-1.26	11.13	11.24	0.000128	2.72	9.61	0.07	5.18	1.632	217.640
15461	5200	-1.34	11.03	11.14	0.000129	2.71	9.57	0.07	5.18	1.642	218.945
14632	5200	-1.42	10.95	11.03	0.000107	2.25	8.25	0.05	3.70	0.957	127.539
13828	5200	-1.50	10.88	10.95	0.000093	2.01	7.73	0.04	2.96	0.670	89.368
12934	5200	-1.58	10.80	10.86	0.000093	2.02	7.74	0.04	2.96	0.674	89.875
12107	5200	-1.66	10.71	10.78	0.000099	2.12	7.96	0.05	3.70	0.788	105.046
11259	5200	-1.74	10.62	10.70	0.000107	2.26	8.32	0.05	3.70	0.964	128.588
10466	5200	-4.48	10.58	10.63	0.000054	1.99	7.14	0.04	2.96	0.282	37.626
9922	5200	-1.53	10.45	10.57	0.000145	2.83	9.31	0.08	5.92	2.016	268.796
9122	5200	-1.67	10.33	10.46	0.000144	2.83	9.33	0.08	5.92	1.997	266.322
8236	5200	-1.67	10.20	10.33	0.000151	2.87	9.24	0.08	5.92	2.164	288.516
7013	5200	-1.70	10.01	10.14	0.000158	2.92	9.12	0.09	6.66	2.341	312.176
6140	5200	-3.54	9.85	9.94	0.000146	2.63	2.92	0.11	8.14	1.060	141.321
5326	5200	-3.42	8.79	9.38	0.001500	6.18	5.11	0.68	50.33	108.487	14464.898
4588	5200	-5.01	7.68	8.32	0.001369	6.43	8.73	0.71	52.55	128.672	17156.309
3354	5200	-3.90	5.45	6.12	0.001907	6.56	6.84	0.79	58.47	191.086	25478.136
2829	5200	-4.70	4.55	4.98	0.001645	5.26	5.41	0.55	40.71	109.112	14548.260
2644	5200	-4.60	4.11	4.64	0.001958	5.84	5.56	0.67	49.59	159.502	21266.953
2431	5200	-3.90	3.76	4.22	0.001770	5.44	5.36	0.59	43.67	125.425	16723.353
2228	5200	-4.10	3.43	3.79	0.002237	4.85	3.78	0.52	38.48	133.425	17790.005
2165	5200	-4.20	3.34	3.65	0.001752	4.45	3.99	0.43	31.82	87.142	11618.898
2050	5200	-4.80	3.05	3.39	0.002125	4.72	3.01	0.50	37.00	107.205	14293.978
1799	5200	-4.40	2.27	2.70	0.003669	5.24	2.93	0.67	49.59	266.477	35530.273
1604	5200	-4.90	1.95	2.20	0.001562	4.04	3.75	0.36	26.64	64.553	8607.083
1397	5200	-5.40	1.73	1.90	0.001165	3.25	3.36	0.24	17.76	31.676	4223.423
984	5200	-4.23	1.13	1.31	0.001637	3.38	2.76	0.28	20.72	49.717	6628.882
226	5200	-12.58	1.13	1.13	0.000003	0.37	11.89	0.00	0.00	0.001	0.118
0	5200	-12.21	1.00	1.11	0.000200	2.64	9.39	0.12	8.88	3.059	407.842
								Reach Minimums:	0.00	0.00	0.12
								Reach Average:	15.05	37.88	5051.30

Nome Airport
Snake River Relocation
Downstream Reconnection Alternative Hydraulic and Sediment Transport Results
12/14/2009

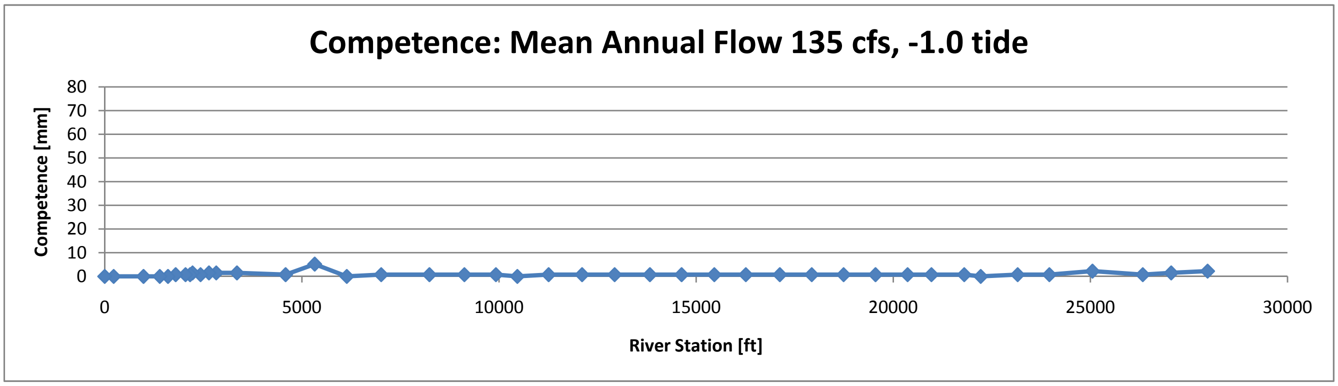
Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

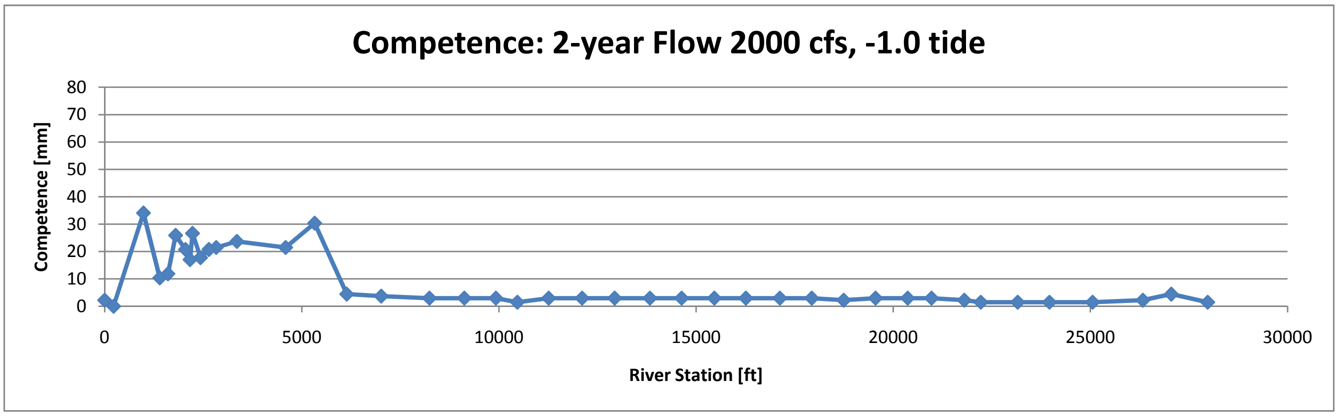
Tide Elevation of +1.0, 100-Year Flow

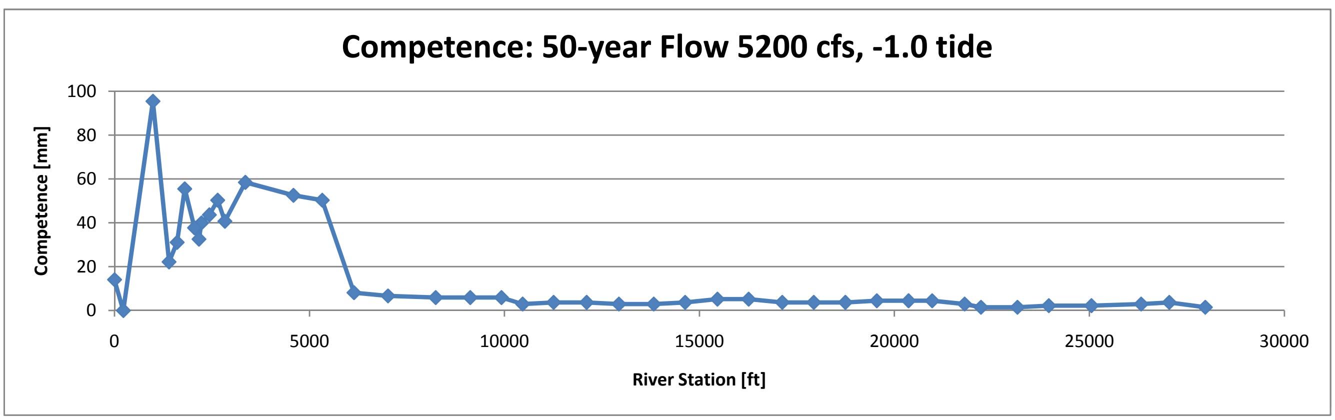
River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Depth Ave (ft_	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
27973	5800	-0.99	12.74	12.76	0.000035	1.25	7.43	0.02	1.48	0.105	14.028
27050	5800	-1.57	12.65	12.71	0.000082	2.35	6.22	0.05	3.70	0.649	86.512
26329	5800	-1.74	12.61	12.66	0.000060	2.17	8.36	0.04	2.96	0.435	57.972
25054	5800	-1.50	12.57	12.59	0.000037	1.65	7.39	0.03	2.22	0.151	20.072
23961	5800	-0.82	12.52	12.55	0.000036	1.69	6.46	0.03	2.22	0.138	18.452
23155	5800	-3.58	12.51	12.52	0.000024	1.40	6.30	0.02	1.48	0.062	8.218
22220	5800	-4.76	12.47	12.50	0.000032	1.63	6.88	0.02	1.48	0.115	15.386
21801	5800	-0.72	12.41	12.47	0.000087	2.04	8.26	0.04	2.96	0.710	94.620
20969	5800	-0.80	12.29	12.39	0.000116	2.53	9.30	0.07	5.18	1.437	191.654
20364	5800	-0.86	12.21	12.31	0.000118	2.59	9.43	0.07	5.18	1.520	202.680
19550	5800	-0.94	12.11	12.22	0.000119	2.60	9.43	0.07	5.18	1.546	206.104
18742	5800	-1.02	12.04	12.12	0.000104	2.32	8.82	0.06	4.44	1.089	145.263
17932	5800	-1.10	11.96	12.04	0.000103	2.30	8.72	0.06	4.44	1.059	141.205
17124	5800	-1.18	11.87	11.95	0.000103	2.28	8.69	0.05	3.70	1.047	139.665
16261	5800	-1.26	11.72	11.85	0.000133	2.85	10.03	0.08	5.92	2.064	275.239
15461	5800	-1.34	11.62	11.74	0.000134	2.85	9.99	0.08	5.92	2.084	277.801
14632	5800	-1.42	11.55	11.63	0.000107	2.34	8.75	0.06	4.44	1.142	152.302
13828	5800	-1.50	11.48	11.55	0.000091	2.09	8.26	0.05	3.70	0.777	103.651
12934	5800	-1.58	11.40	11.47	0.000092	2.09	8.27	0.05	3.70	0.791	105.441
12107	5800	-1.66	11.31	11.39	0.000098	2.20	8.48	0.05	3.70	0.927	123.576
11259	5800	-1.74	11.21	11.30	0.000107	2.35	8.86	0.06	4.44	1.154	153.901
10466	5800	-4.48	11.18	11.23	0.000055	2.07	7.48	0.04	2.96	0.344	45.925
9922	5800	-1.53	11.04	11.17	0.000151	2.97	9.73	0.09	6.66	2.563	341.774
9122	5800	-1.67	10.92	11.05	0.000150	2.97	9.75	0.09	6.66	2.540	338.697
8236	5800	-1.67	10.78	10.92	0.000157	3.01	9.65	0.09	6.66	2.743	365.692
7013	5800	-1.70	10.57	10.72	0.000165	3.06	9.52	0.10	7.40	2.985	397.986
6140	5800	-3.54	10.46	10.53	0.000127	2.53	3.34	0.10	7.40	0.987	131.568
5326	5800	-3.42	9.38	9.98	0.001436	6.30	5.51	0.69	51.07	120.008	16001.033
4588	5800	-5.01	8.17	8.89	0.001456	6.78	9.05	0.78	57.73	169.014	22535.157
3354	5800	-3.90	5.80	6.55	0.002033	6.96	7.14	0.88	65.13	254.287	33904.916
2829	5800	-4.70	4.87	5.34	0.001707	5.54	5.68	0.60	44.41	138.894	18519.243
2644	5800	-4.60	4.39	4.98	0.002091	6.19	5.79	0.74	54.77	212.359	28314.516
2431	5800	-3.90	4.02	4.54	0.001914	5.79	5.55	0.66	48.85	170.376	22716.856
2228	5800	-4.10	3.68	4.08	0.002260	5.07	4.01	0.56	41.45	162.571	21676.130
2165	5800	-4.20	3.60	3.94	0.001797	4.67	4.20	0.47	34.78	108.682	14490.956
2050	5800	-4.80	3.29	3.67	0.002161	4.95	3.18	0.54	39.97	132.208	17627.731
1799	5800	-4.40	2.47	2.93	0.004058	5.47	2.89	0.73	54.03	358.599	47813.245
1604	5800	-4.90	2.10	2.39	0.001738	4.33	3.84	0.42	31.08	91.643	12219.022
1397	5800	-5.40	1.86	2.05	0.001291	3.49	3.46	0.28	20.72	44.916	5988.826
984	5800	-4.23	1.16	1.38	0.001967	3.72	2.78	0.34	25.16	80.747	10766.283
226	5800	-12.58	1.16	1.16	0.000003	0.41	11.92	0	0.00	0.001	0.146
0	5800	-12.21	1	1.13	0.000249	2.94	9.39	0.14	10.36	5.278	703.743

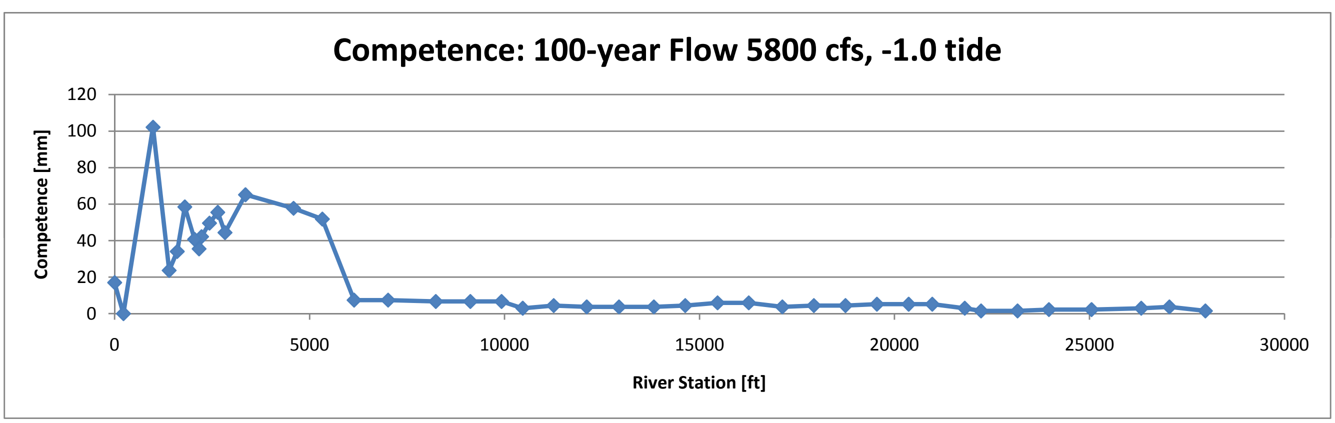
Reach Minimums:	0.00	0.00	0.15
Reach Average:	16.56	49.54	6605.55

Snake River - Downstream Reconnection Option

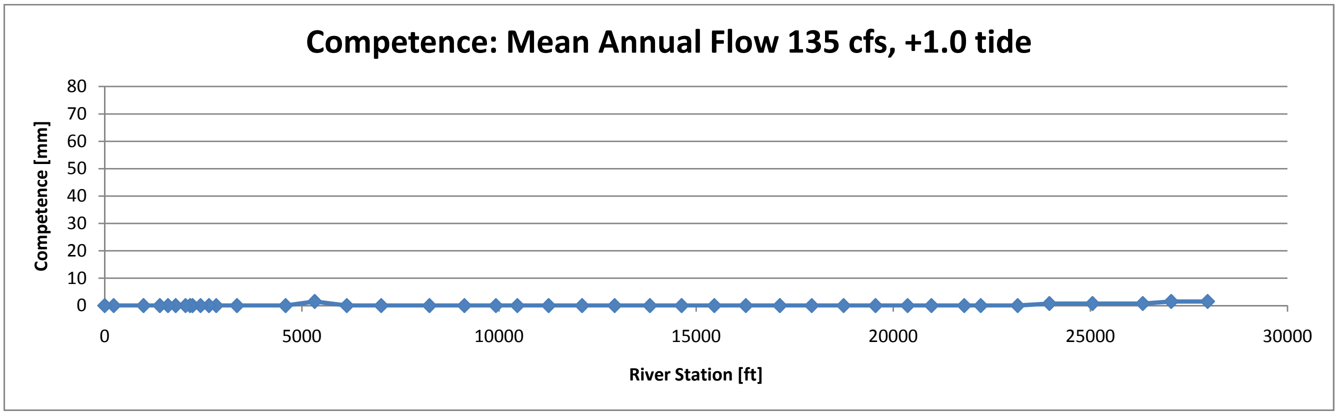


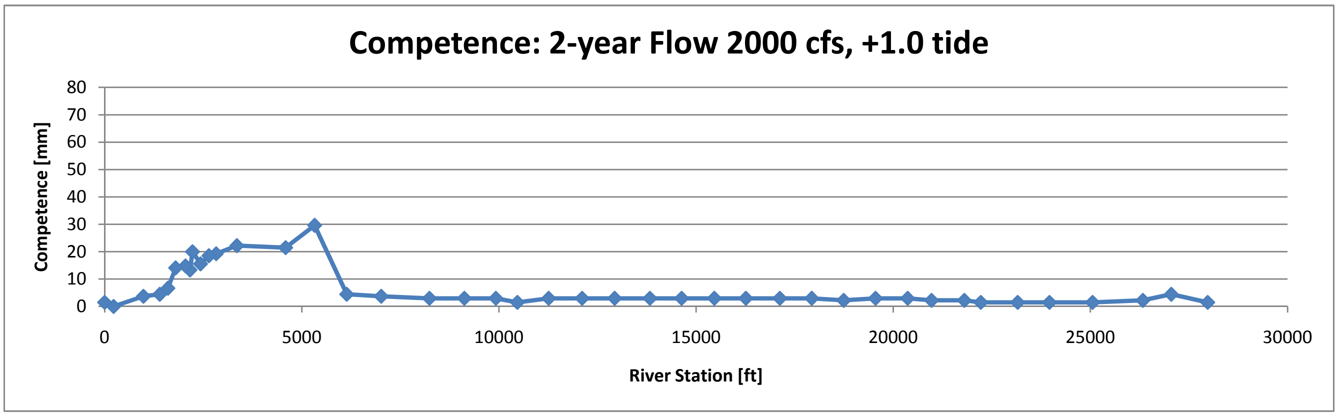


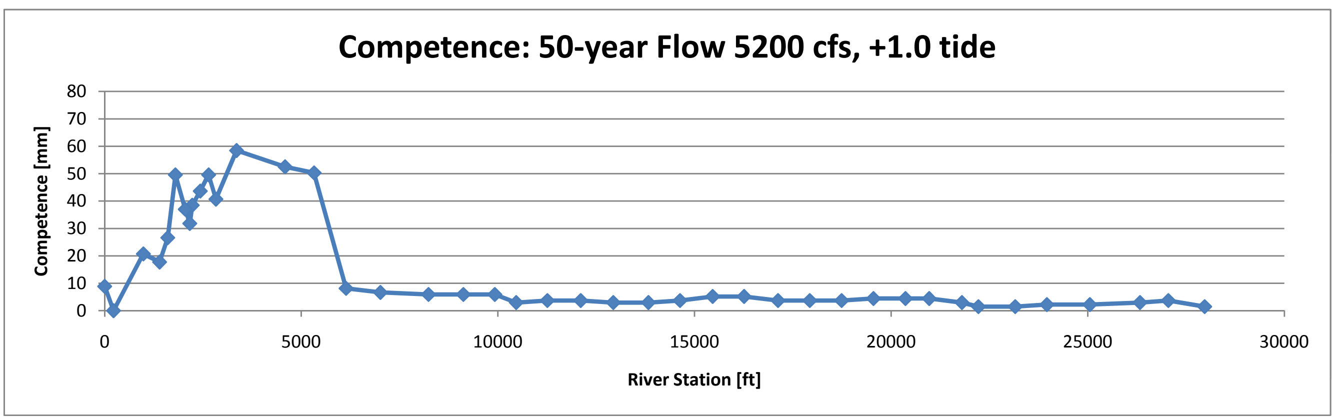


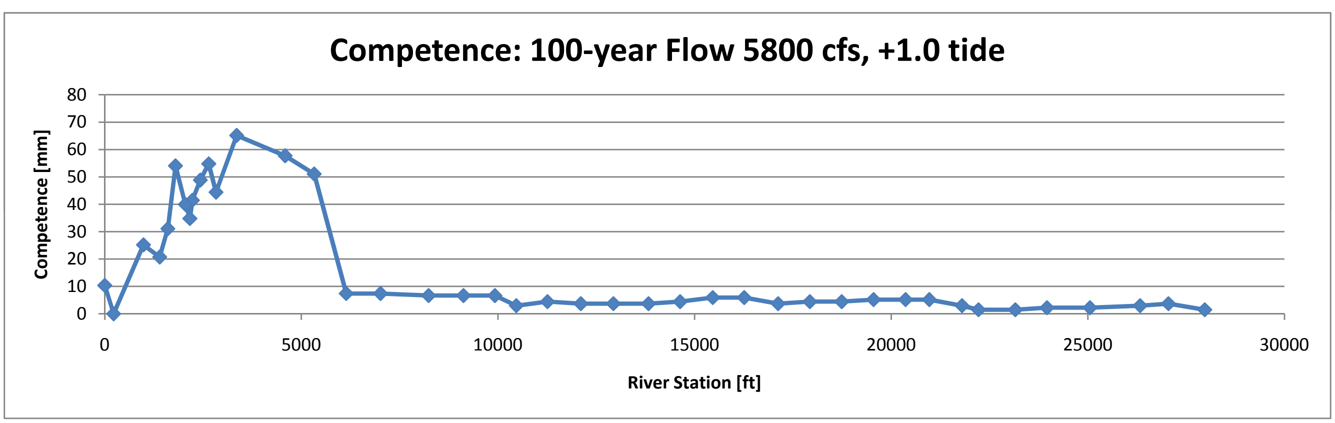


Snake River - Downstream Reconnection Option

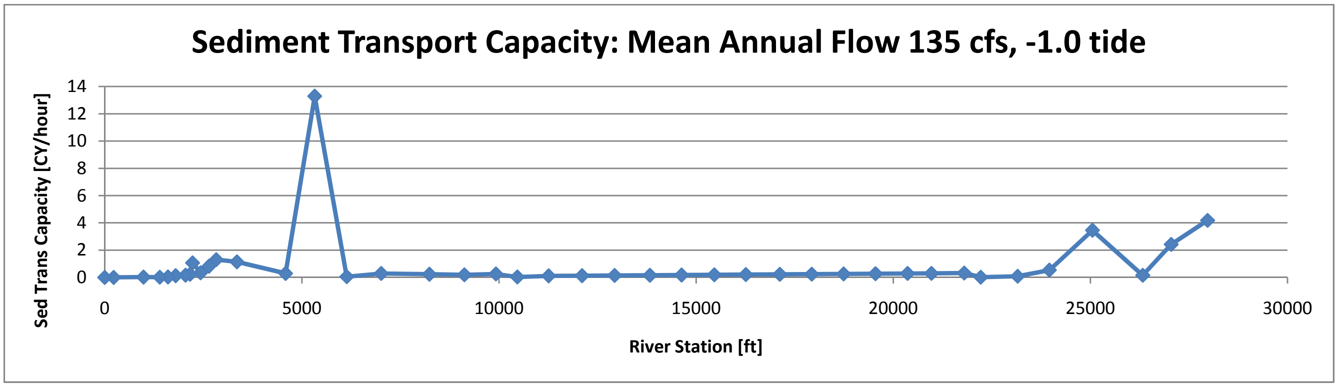


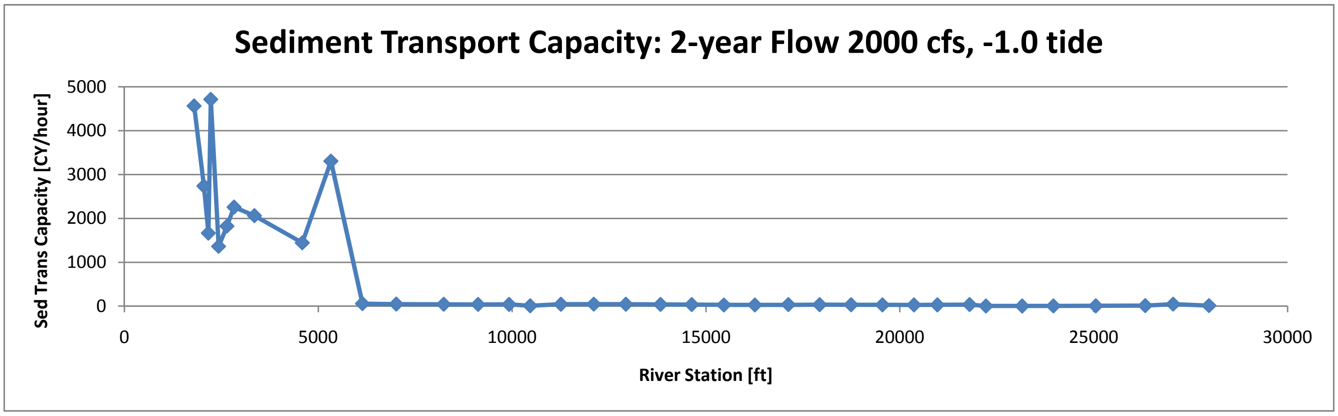


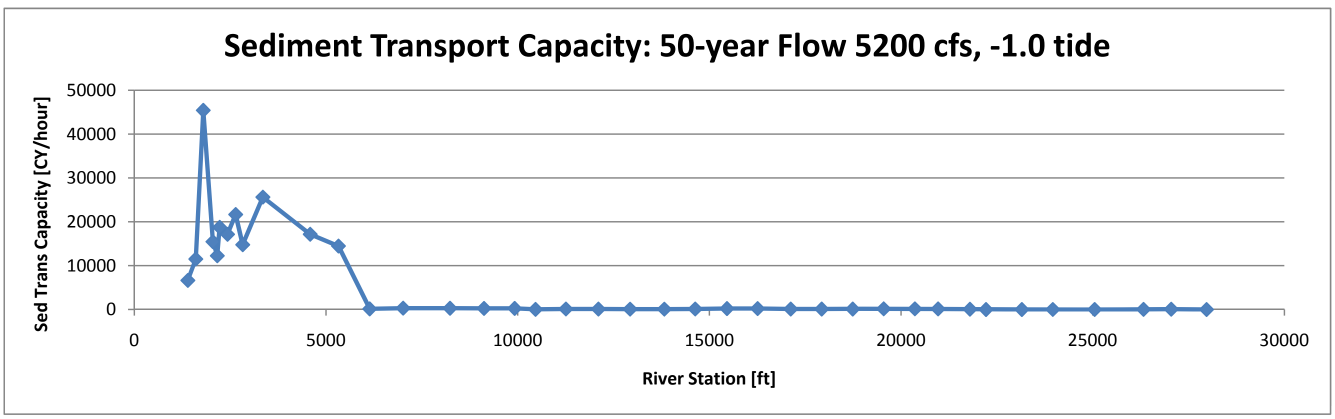


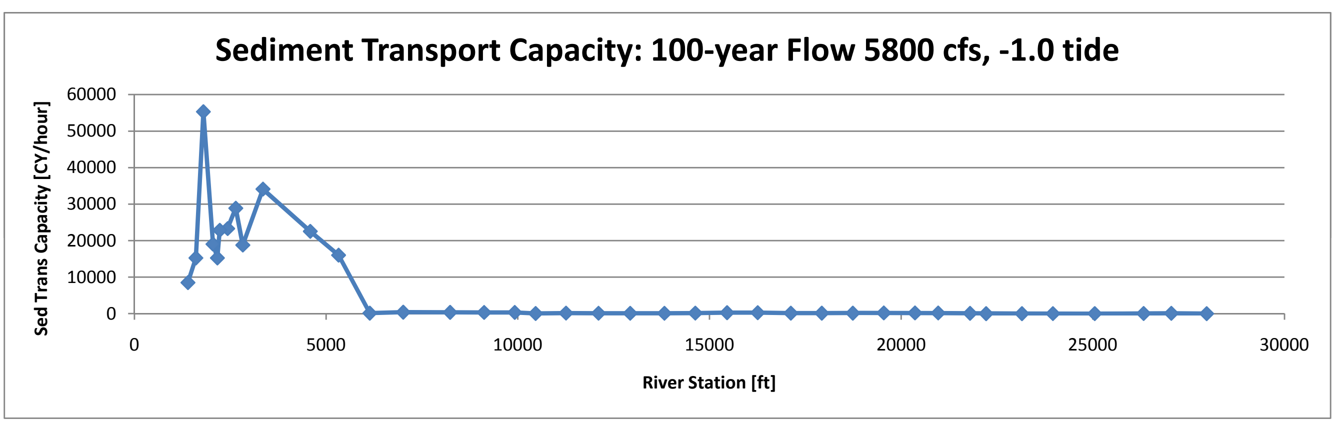


Snake River - Downstream Reconnection Option

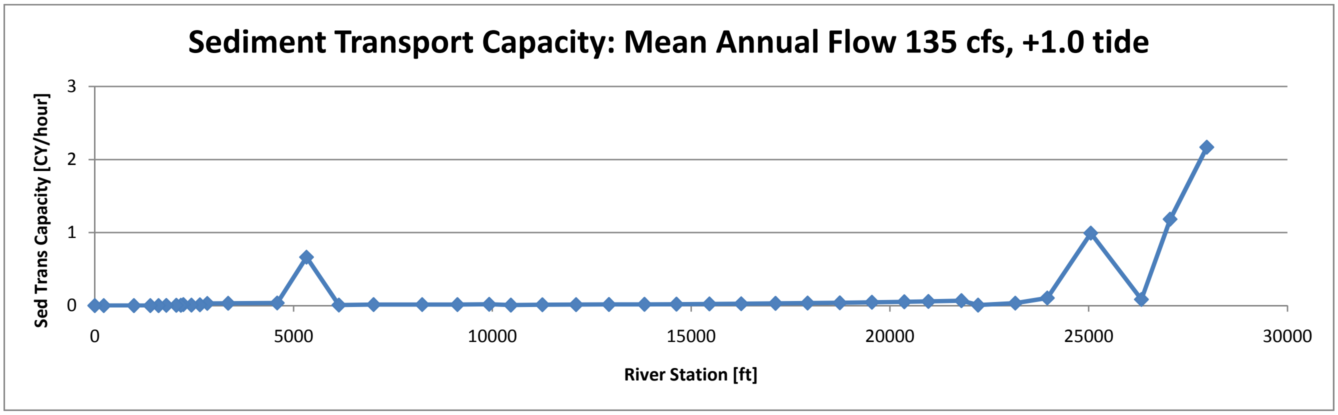


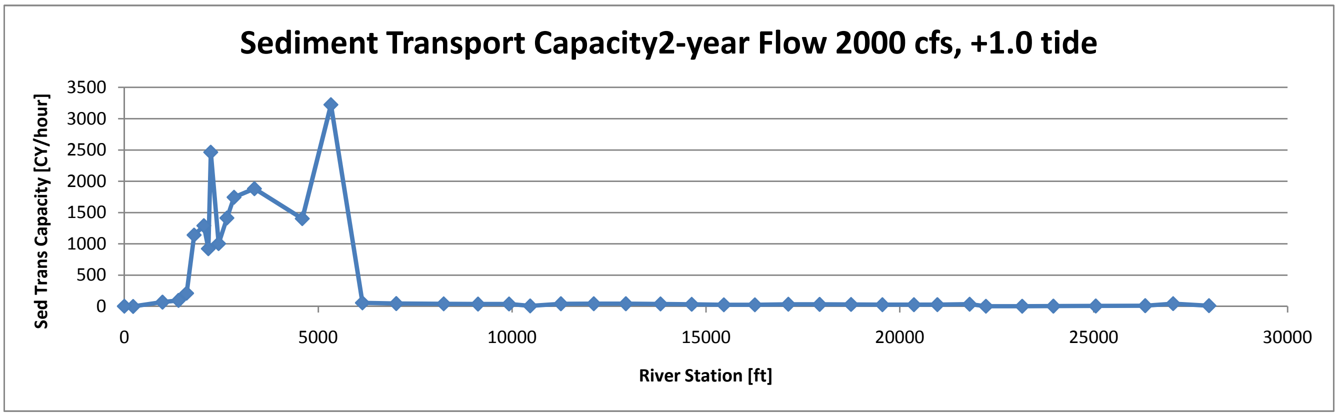


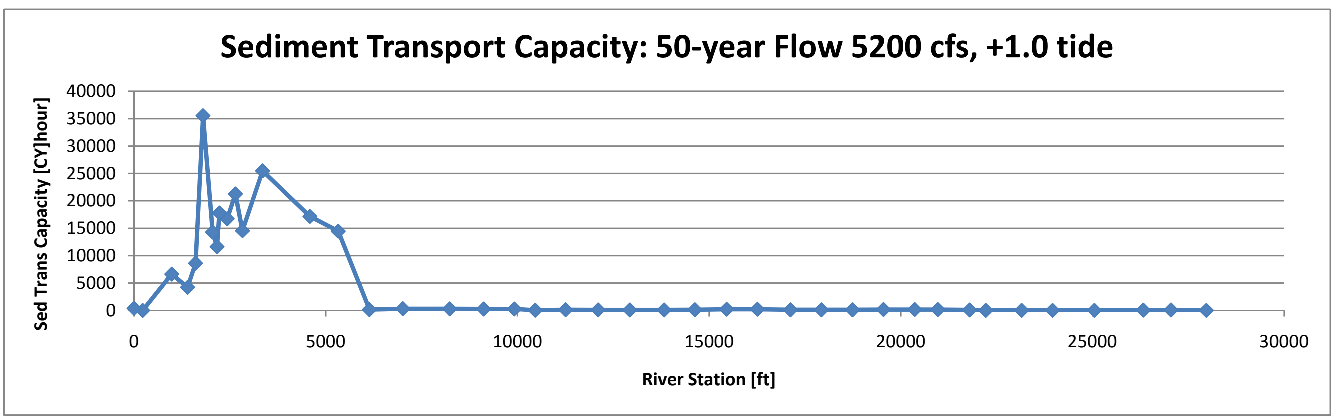


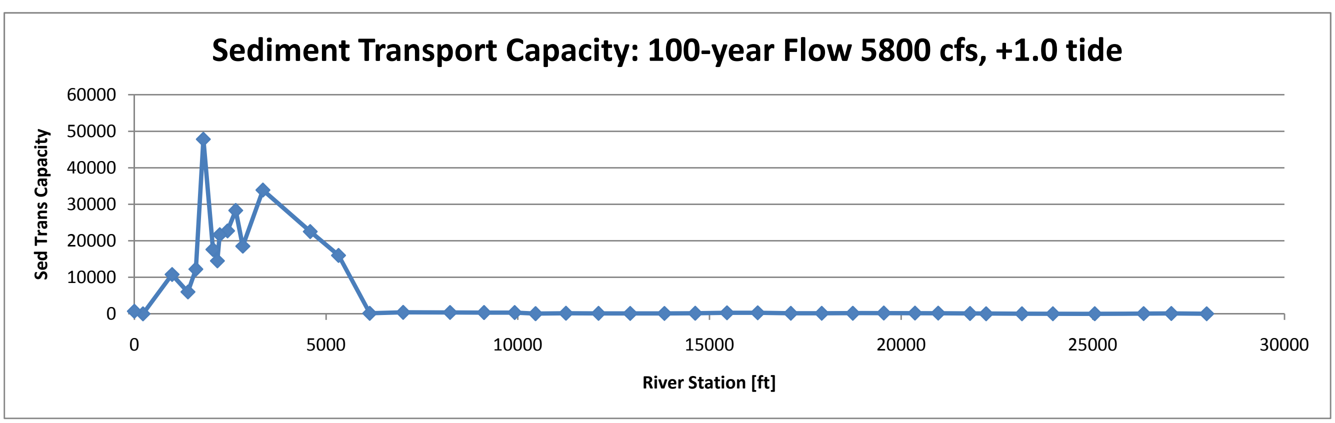


Snake River - Downstream Reconnection Option









Nome Airport
Snake River Relocation
New River Mouth Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of -1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydr Rad. (ft)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
12167	125	-0.99	3.02	3.02	0.000028	0.48	2.16	0.00	0.00	0.000	0.045
11244	125	-1.57	2.99	3.00	0.000025	0.51	2.55	0.00	0.00	0.000	0.044
10523	125	-1.74	2.99	2.99	0.000007	0.34	3.52	0.00	0.00	0.000	0.005
9248	125	-1.50	2.97	2.97	0.000014	0.36	2.48	0.00	0.00	0.000	0.013
8155	125	-0.82	2.96	2.97	0.000005	0.27	3.07	0.00	0.00	0.000	0.002
7349	125	-3.58	2.96	2.96	0.000005	0.26	3.43	0.00	0.00	0.000	0.002
6414	125	-4.76	2.96	2.96	0.000003	0.22	4.04	0.00	0.00	0.000	0.001
5925	125	2.18	2.92	2.95	0.001362	1.39	0.73	0.06	4.44	0.192	25.581
5375	125	1.29	2.04	2.08	0.001865	1.64	0.74	0.09	6.66	0.365	48.692
4675	125	0.15	1.01	1.04	0.001198	1.43	0.84	0.06	4.44	0.175	23.289
3875	125	-1.16	-0.53	-0.47	0.003385	1.96	0.62	0.13	9.62	0.977	130.249
3175	125	-2.30	-0.93	-0.92	0.000252	0.89	1.32	0.02	1.48	0.013	1.753
2425	125	-3.54	-0.98	-0.97	0.000031	0.47	2.44	0.00	0.00	0.000	0.054
1725	125	-4.70	-0.99	-0.99	0.000009	0.32	3.44	0.00	0.00	0.000	0.007
1125	125	-5.67	-0.99	-0.99	0.000004	0.25	4.24	0.00	0.00	0.000	0.002
925	125	-5.81	-0.99	-0.99	0.000003	0.20	4.41	0.00	0.00	0.000	0.001
525	125	-9.00	-0.99	-0.99	0.000007	0.26	3.10	0.00	0.00	0.000	0.004
350	125	-9.00	-0.99	-0.99	0.000011	0.26	2.32	0.00	0.00	0.000	0.006
275	125	-9.00	-1.00	-1.00	0.000014	0.26	1.84	0.00	0.00	0.000	0.008
0	125	-9.00	-1.00	-1.00	0.000003	0.26	5.99	0.00	0.00	0.000	0.001
								Reach Minimums:	0.00	0.00	0.00
								Reach Average:	1.33	0.09	11.49

Tide Elevation of -1.0, 5-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydr Rad. (ft)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
12167	2800	-0.99	8.26	8.32	0.000145	2.17	6.09	0.06	4.44	0.673	89.754
11244	2800	-1.57	7.99	8.13	0.000294	3.07	6.03	0.11	8.14	2.736	364.796
10523	2800	-1.74	7.91	7.97	0.000126	2.29	7.32	0.06	4.44	0.631	84.116
9248	2800	-1.50	7.76	7.81	0.000114	2.03	6.60	0.05	3.70	0.457	60.934
8155	2800	-0.82	7.65	7.70	0.000094	1.97	7.31	0.04	2.96	0.349	46.596
7349	2800	-3.58	7.59	7.63	0.000075	1.76	7.33	0.03	2.22	0.223	29.709
6414	2800	-4.76	7.51	7.56	0.000077	1.80	7.40	0.04	2.96	0.238	31.758
5925	2800	2.18	7.33	7.45	0.001210	2.87	2.37	0.18	13.32	13.388	1785.115
5375	2800	1.29	6.55	6.72	0.001468	3.30	2.53	0.23	17.02	21.255	2833.971
4675	2800	0.15	5.54	5.72	0.001392	3.35	2.69	0.23	17.02	20.543	2739.125
3875	2800	-1.16	4.33	4.54	0.001542	3.72	2.91	0.28	20.72	27.664	3688.486
3175	2800	-2.30	3.10	3.41	0.001676	4.45	3.58	0.37	27.38	41.592	5545.550
2425	2800	-3.54	2.05	2.38	0.001135	4.60	5.04	0.36	26.64	28.429	3790.522
1725	2800	-4.70	1.42	1.69	0.000832	4.14	5.44	0.28	20.72	16.683	2224.421
1125	2800	-5.67	1.04	1.25	0.000601	3.70	5.87	0.22	16.28	9.509	1267.840
925	2800	-5.81	0.99	1.13	0.000401	3.08	6.04	0.15	11.10	4.376	583.469
525	2800	-9.00	0.65	0.88	0.000931	3.87	4.51	0.26	19.24	16.808	2241.072
350	2800	-9.00		0.62	0.001147	3.69	3.60	0.26	19.24	19.580	2610.687
275	2800	-9.00		0.07	0.002217	4.13	2.60	0.36	26.64	50.047	6672.943
0	2800	-9.00	-4.29	-0.45	0.001500	5.93	5.99	0.56	41.45	60.701	8093.514
								Reach Minimums:	2.22	0.22	29.71
								Reach Average:	15.28	16.79	2239.22

Nome Airport
Snake River Relocation
New River Mouth Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of -1.0, 50-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydr Rad. (ft)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
12167	4700	-0.99	9.57	9.65	0.000163	2.62	7.37	0.08	5.92	1.789	238.500
11244	4700	-1.57	9.26	9.43	0.000332	3.69	7.26	0.15	11.10	7.268	969.111
10523	4700	-1.74	9.14	9.24	0.000174	2.97	8.52	0.09	6.66	2.405	320.606
9248	4700	-1.50	8.96	9.03	0.000141	2.52	7.77	0.07	5.18	1.421	189.501
8155	4700	-0.82	8.80	8.88	0.000135	2.59	8.42	0.07	5.18	1.425	189.945
7349	4700	-3.58	8.72	8.78	0.000105	2.29	8.41	0.05	3.70	0.863	115.130
6414	4700	-4.76	8.60	8.67	0.000116	2.41	8.46	0.06	4.44	1.058	141.111
5925	4700	2.18	8.36	8.53	0.001044	3.35	3.33	0.22	16.28	24.920	3322.688
5375	4700	1.29	7.67	7.90	0.001247	3.83	3.57	0.28	20.72	38.509	5134.575
4675	4700	0.15	6.88	7.10	0.001055	3.75	3.93	0.26	19.24	30.785	4104.669
3875	4700	-1.16	6.06	6.29	0.000956	3.90	4.47	0.27	19.98	29.454	3927.147
3175	4700	-2.30	5.24	5.58	0.001061	4.63	5.36	0.36	26.64	44.768	5969.094
2425	4700	-3.54	4.27	4.67	0.001363	5.11	5.14	0.44	32.56	70.450	9393.300
1725	4700	-4.70	3.38	3.76	0.001218	4.94	5.33	0.41	30.34	58.586	7811.482
1125	4700	-5.67	2.75	3.09	0.001009	4.67	5.64	0.36	26.64	42.956	5727.500
925	4700	-5.81	2.65	2.89	0.000706	3.86	5.54	0.24	17.76	20.596	2746.131
525	4700	-9.00	2.24	2.52	0.001800	4.22	3.13	0.35	25.90	68.901	9186.822
350	4700	-9.00	1.74	2.04	0.001997	4.40	3.08	0.38	28.12	83.278	11103.684
275	4700	-9.00	1.03	1.38	0.001782	4.72	3.74	0.42	31.08	82.980	11063.978
0	4700	-9.00	-1.00	0.54	0.004226	9.96	5.99	1.58	116.93	809.283	107904.345
								Reach Minimums:	3.70	0.86	115.13
								Reach Average:	22.72	71.08	9477.97

Tide Elevation of -1.0, 100-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydr Rad. (ft)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
12167	5300	-0.99	9.94	10.01	0.000167	2.73	7.72	0.08	5.92	2.231	297.438
11244	5300	-1.57	9.62	9.79	0.000334	3.82	7.61	0.16	11.84	8.766	1168.760
10523	5300	-1.74	9.49	9.60	0.000184	3.14	8.87	0.10	7.40	3.181	424.100
9248	5300	-1.50	9.31	9.38	0.000146	2.63	8.11	0.07	5.18	1.801	240.074
8155	5300	-0.82	9.13	9.22	0.000143	2.74	8.74	0.08	5.92	1.888	251.687
7349	5300	-3.58	9.05	9.11	0.000110	2.40	8.72	0.06	4.44	1.114	148.562
6414	5300	-4.76	8.92	9.00	0.000124	2.56	8.77	0.07	5.18	1.427	190.205
5925	5300	2.18	8.67	8.86	0.000993	3.45	3.62	0.22	16.28	27.990	3732.048
5375	5300	1.29	8.02	8.26	0.001181	3.94	3.89	0.29	21.46	42.979	5730.544
4675	5300	0.15	7.27	7.50	0.000990	3.85	4.28	0.26	19.24	33.810	4508.015
3875	5300	-1.16	6.49	6.74	0.000907	4.01	4.85	0.27	19.98	32.873	4383.047
3175	5300	-2.30	5.68	6.04	0.001064	4.84	5.71	0.38	28.12	54.700	7293.329
2425	5300	-3.54	4.69	5.13	0.001362	5.32	5.47	0.47	34.78	85.228	11363.730
1725	5300	-4.70	3.80	4.22	0.001230	5.17	5.66	0.43	31.82	72.305	9640.651
1125	5300	-5.67	3.15	3.53	0.001040	4.92	5.95	0.39	28.86	54.851	7313.471
925	5300	-5.81	3.07	3.32	0.000722	4.06	5.86	0.26	19.24	25.983	3464.420
525	5300	-9.00	2.66	2.94	0.001545	4.20	3.49	0.34	25.16	64.933	8657.743
350	5300	-9.00	2.27	2.55	0.001525	4.24	3.57	0.34	25.16	65.015	8668.714
275	5300	-9.00	1.63	1.95	0.001923	4.57	3.36	0.40	29.60	96.264	12835.262
0	5300	-9.00	-1.00	0.96	0.005373	11.23	5.99	2.01	148.76	1475.128	196683.707
								Reach Minimums:	4.44	1.11	148.56
								Reach Average:	24.72	107.62	14349.78

Nome Airport
Snake River Relocation
New River Mouth Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

Tide Elevation of +1.0, Mean Annual Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydr Rad. (ft)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
12167	125	-0.99	3.03	3.03	0.000028	0.48	2.17	0.00	0.00	0.000	0.045
11244	125	-1.57	3.00	3.01	0.000025	0.50	2.56	0.00	0.00	0.000	0.043
10523	125	-1.74	3.00	3.00	0.000007	0.34	3.53	0.00	0.00	0.000	0.005
9248	125	-1.50	2.98	2.99	0.000013	0.36	2.49	0.00	0.00	0.000	0.011
8155	125	-0.82	2.98	2.98	0.000005	0.26	3.08	0.00	0.00	0.000	0.002
7349	125	-3.58	2.97	2.97	0.000004	0.26	3.44	0.00	0.00	0.000	0.002
6414	125	-4.76	2.97	2.97	0.000003	0.22	4.04	0.00	0.00	0.000	0.001
5925	125	2.18	2.93	2.96	0.001286	1.37	0.74	0.06	4.44	0.175	23.291
5375	125	1.29	1.99	2.04	0.002290	1.74	0.70	0.10	7.40	0.513	68.365
4675	125	0.15	1.12	1.14	0.000815	1.27	0.94	0.05	3.70	0.092	12.277
3875	125	-1.16	1.02	1.03	0.000053	0.55	2.07	0.01	0.74	0.001	0.131
3175	125	-2.30	1.01	1.01	0.000013	0.35	3.07	0.00	0.00	0.000	0.012
2425	125	-3.54	1.00	1.01	0.000005	0.26	4.17	0.00	0.00	0.000	0.003
1725	125	-4.70	1.00	1.00	0.000002	0.20	5.10	0.00	0.00	0.000	0.001
1125	125	-5.67	1.00	1.00	0.000001	0.17	5.84	0.00	0.00	0.000	0.000
925	125	-5.81	1.00	1.00	0.000001	0.14	6.05	0.00	0.00	0.000	0.000
525	125	-9.00	1.00	1.00	0.000001	0.16	4.81	0.00	0.00	0.000	0.000
350	125	-9.00	1.00	1.00	0.000001	0.14	4.13	0.00	0.00	0.000	0.000
275	125	-9.00	1.00	1.00	0.000001	0.13	3.71	0.00	0.00	0.000	0.000
0	125	-9	1	1	0.000001	0.12	3.62	0	0.00	0.000	0.000
								Reach Minimums:	0.00	0.00	0.00
								Reach Average:	0.81	0.04	5.21

Tide Elevation of +1.0, 5-Year Flow

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydr Rad. (ft)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
12167	2800	-0.99	8.26	8.32	0.000145	2.17	6.09	0.06	4.44	0.673	89.754
11244	2800	-1.57	7.99	8.13	0.000294	3.07	6.03	0.11	8.14	2.736	364.796
10523	2800	-1.74	7.91	7.97	0.000126	2.29	7.32	0.06	4.44	0.631	84.116
9248	2800	-1.50	7.76	7.81	0.000114	2.03	6.60	0.05	3.70	0.457	60.934
8155	2800	-0.82	7.65	7.70	0.000094	1.97	7.31	0.04	2.96	0.349	46.596
7349	2800	-3.58	7.59	7.63	0.000075	1.76	7.33	0.03	2.22	0.223	29.709
6414	2800	-4.76	7.52	7.56	0.000077	1.80	7.40	0.04	2.96	0.238	31.758
5925	2800	2.18	7.33	7.45	0.001209	2.87	2.37	0.18	13.32	13.372	1782.903
5375	2800	1.29	6.55	6.72	0.001466	3.30	2.53	0.23	17.02	21.211	2828.181
4675	2800	0.15	5.55	5.72	0.001379	3.34	2.70	0.23	17.02	20.233	2697.782
3875	2800	-1.16	4.38	4.59	0.001450	3.65	2.96	0.27	19.98	24.962	3328.303
3175	2800	-2.30	3.31	3.58	0.001403	4.20	3.76	0.33	24.42	30.812	4108.297
2425	2800	-3.54	2.48	2.76	0.000886	4.24	5.38	0.30	22.20	18.672	2489.658
1725	2800	-4.70	2.01	2.23	0.000607	3.74	5.91	0.22	16.28	9.789	1305.210
1125	2800	-5.67	1.74	1.91	0.000426	3.31	6.42	0.17	12.58	5.309	707.851
925	2800	-5.81	1.70	1.82	0.000408	2.76	5.05	0.13	9.62	3.680	490.656
525	2800	-9.00	1.46	1.63	0.000557	3.29	5.20	0.18	13.32	7.100	946.700
350	2800	-9.00	1.35	1.48	0.000547	2.93	4.44	0.15	11.10	5.686	758.180
275	2800	-9.00	1.17	1.28	0.000565	2.72	3.86	0.14	10.36	5.167	688.918
0	2800	-9	1	1.12	0.000635	2.76	3.62	0.14	10.36	6.049	806.596
								Reach Minimums:	2.22	0.22	29.71
								Reach Average:	11.32	8.87	1182.34

Nome Airport
Snake River Relocation
New River Mouth Alternative Hydraulic and Sediment Transport Results
12/14/2009

Sediment Diam: dsi [mm] = 0.1
dsi [ft] = 0.000328

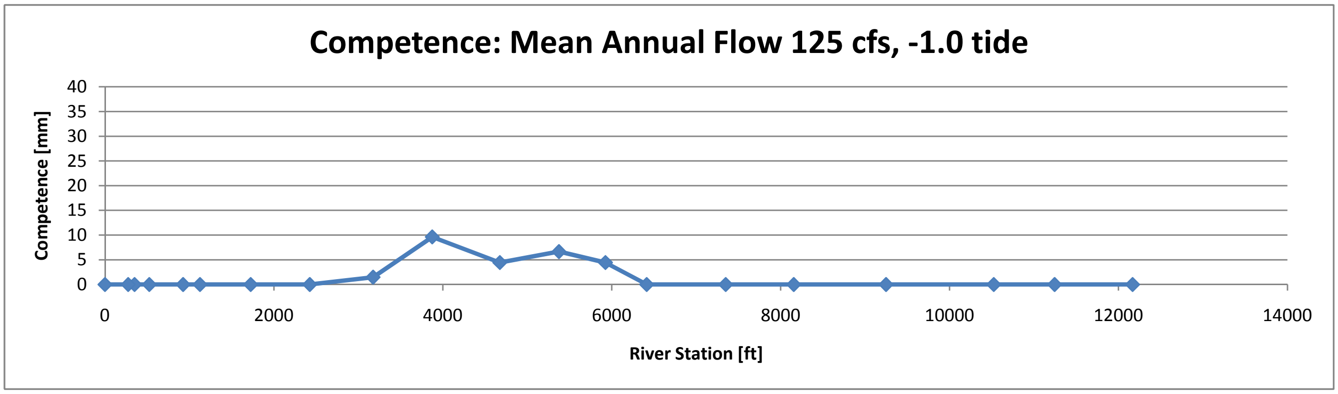
Tide Elevation of +1.0, 50-Year Flow

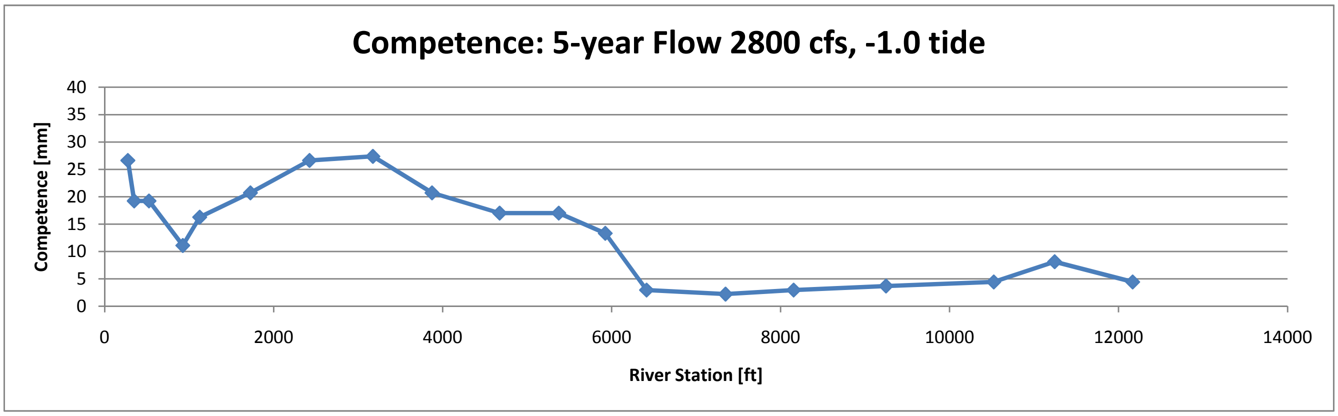
River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydr Rad. (ft)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
12167	4700	-0.99	9.57	9.65	0.000163	2.62	7.37	0.08	5.92	1.789	238.500
11244	4700	-1.57	9.26	9.43	0.000332	3.69	7.26	0.15	11.10	7.268	969.111
10523	4700	-1.74	9.14	9.24	0.000174	2.97	8.52	0.09	6.66	2.405	320.606
9248	4700	-1.50	8.96	9.03	0.000141	2.52	7.77	0.07	5.18	1.421	189.501
8155	4700	-0.82	8.80	8.88	0.000135	2.59	8.42	0.07	5.18	1.425	189.945
7349	4700	-3.58	8.72	8.78	0.000105	2.29	8.41	0.05	3.70	0.863	115.130
6414	4700	-4.76	8.60	8.67	0.000116	2.41	8.46	0.06	4.44	1.058	141.111
5925	4700	2.18	8.36	8.53	0.001043	3.35	3.33	0.22	16.28	24.884	3317.916
5375	4700	1.29	7.68	7.90	0.001244	3.83	3.57	0.28	20.72	38.370	5116.057
4675	4700	0.15	6.88	7.10	0.001050	3.75	3.93	0.26	19.24	30.566	4075.524
3875	4700	-1.16	6.07	6.30	0.000949	3.89	4.48	0.27	19.98	29.088	3878.465
3175	4700	-2.30	5.26	5.59	0.001049	4.62	5.38	0.35	25.90	43.998	5866.354
2425	4700	-3.54	4.30	4.70	0.001334	5.07	5.17	0.43	31.82	67.877	9050.215
1725	4700	-4.70	3.45	3.82	0.001174	4.88	5.38	0.39	28.86	55.023	7336.435
1125	4700	-5.67	2.84	3.17	0.000959	4.60	5.71	0.34	25.16	39.449	5259.879
925	4700	-5.81	2.76	2.98	0.000668	3.79	5.62	0.23	17.02	18.746	2499.447
525	4700	-9.00	2.38	2.63	0.001577	4.05	3.25	0.32	23.68	55.256	7367.433
350	4700	-9.00	1.98	2.24	0.001576	4.09	3.30	0.33	24.42	56.176	7490.081
275	4700	-9.00	1.47	1.75	0.001253	4.24	4.14	0.32	23.68	46.241	6165.447
0	4700	-9	1	1.33	0.001788	4.63	3.62	0.4	29.60	80.486	10731.452
								Reach Minimums:	3.70	0.86	115.13
								Reach Average:	17.43	30.12	4015.93

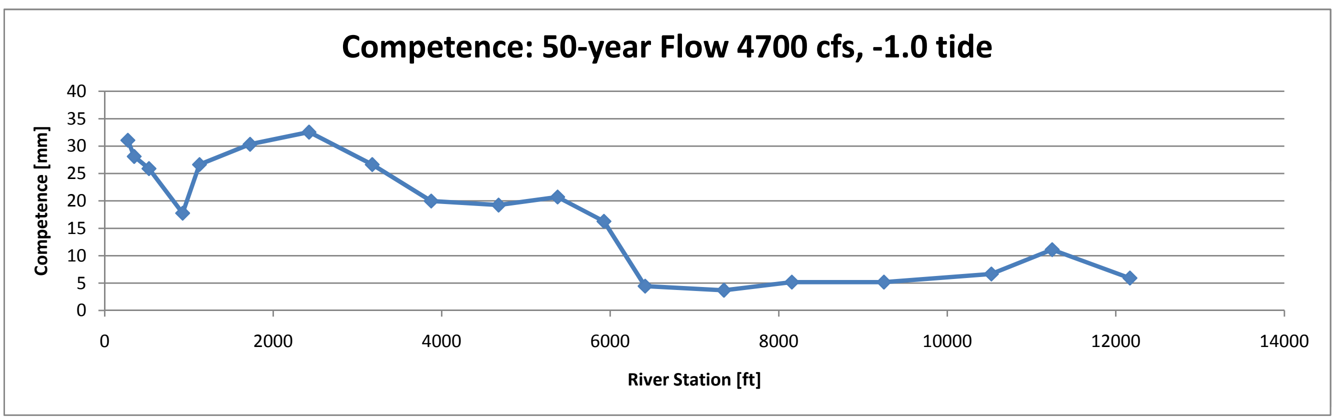
Tide Elevation of +1.0, 100-Year Flow

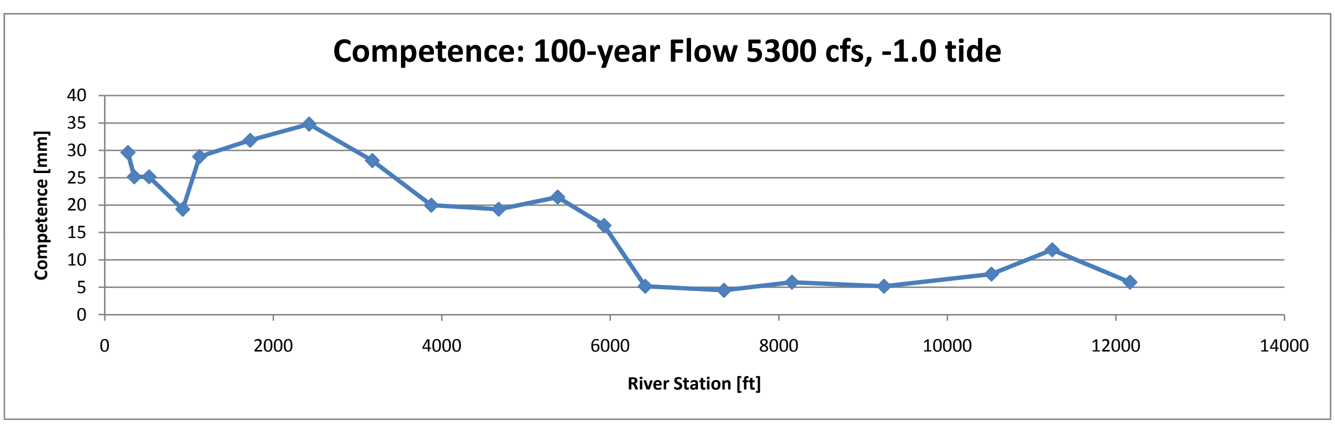
River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Ch. Hydr Rad. (ft)	Shear Chan (lb/sq ft)	Competence (mm)	Capacity (cfs)	Capacity (cy/hr)
12167	5300	-0.99	9.94	10.01	0.000167	2.73	7.72	0.08	5.92	2.231	297.438
11244	5300	-1.57	9.62	9.79	0.000334	3.82	7.61	0.16	11.84	8.766	1168.760
10523	5300	-1.74	9.49	9.60	0.000184	3.14	8.87	0.10	7.40	3.181	424.100
9248	5300	-1.50	9.31	9.38	0.000146	2.63	8.11	0.07	5.18	1.801	240.074
8155	5300	-0.82	9.13	9.22	0.000143	2.74	8.74	0.08	5.92	1.888	251.687
7349	5300	-3.58	9.05	9.11	0.000110	2.40	8.72	0.06	4.44	1.114	148.562
6414	5300	-4.76	8.92	9.00	0.000124	2.56	8.77	0.07	5.18	1.427	190.205
5925	5300	2.18	8.67	8.86	0.000993	3.45	3.62	0.22	16.28	27.990	3732.048
5375	5300	1.29	8.02	8.26	0.001180	3.94	3.89	0.29	21.46	42.925	5723.267
4675	5300	0.15	7.27	7.50	0.000989	3.85	4.28	0.26	19.24	33.759	4501.187
3875	5300	-1.16	6.49	6.74	0.000906	4.01	4.85	0.27	19.98	32.819	4375.800
3175	5300	-2.30	5.68	6.04	0.001062	4.83	5.71	0.38	28.12	54.433	7257.749
2425	5300	-3.54	4.70	5.14	0.001358	5.32	5.48	0.46	34.04	84.930	11324.043
1725	5300	-4.70	3.81	4.23	0.001225	5.16	5.67	0.43	31.82	71.789	9571.838
1125	5300	-5.67	3.17	3.54	0.001034	4.91	5.96	0.38	28.12	54.312	7241.614
925	5300	-5.81	3.08	3.33	0.000717	4.05	5.87	0.26	19.24	25.672	3422.967
525	5300	-9.00	2.68	2.95	0.001522	4.18	3.51	0.33	24.42	63.367	8448.931
350	5300	-9.00	2.30	2.57	0.001490	4.21	3.60	0.33	24.42	62.607	8347.621
275	5300	-9.00	1.68	1.99	0.001827	4.50	3.41	0.39	28.86	88.432	11790.914
0	5300	-9	1	1.42	0.002274	5.22	3.62	0.51	37.74	146.765	19568.631
								Reach Minimums:	4.44	1.11	148.56
								Reach Average:	18.98	40.51	5401.37

Snake River - New River Mouth Option

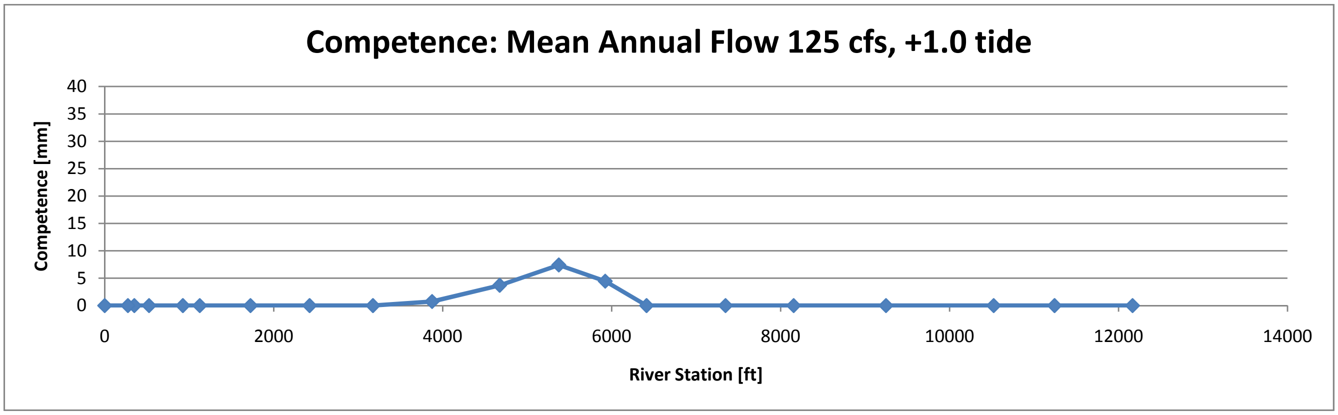


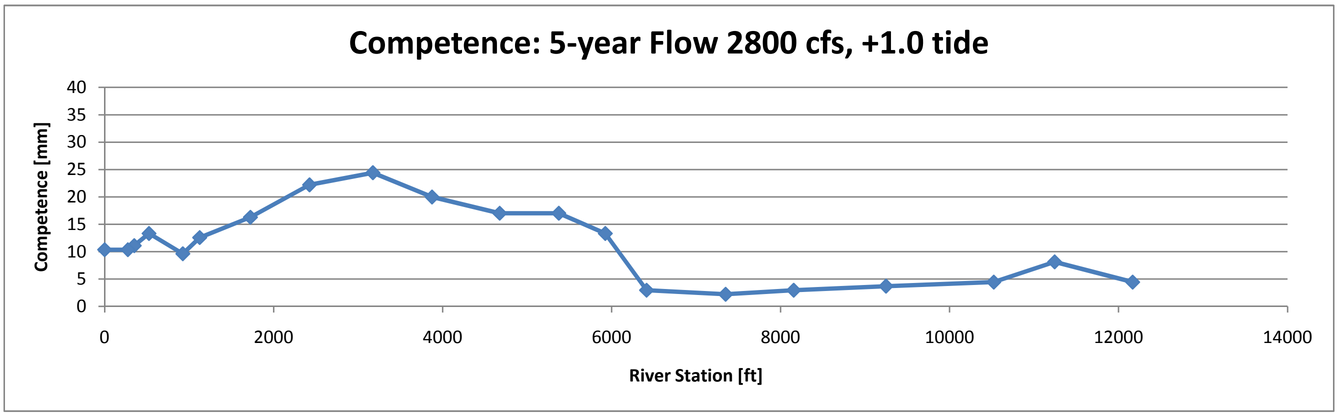


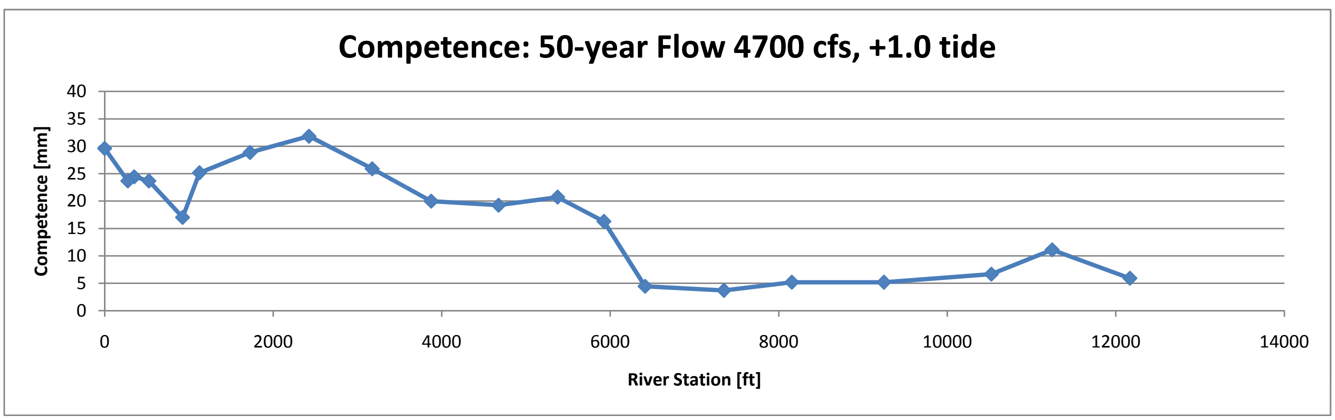


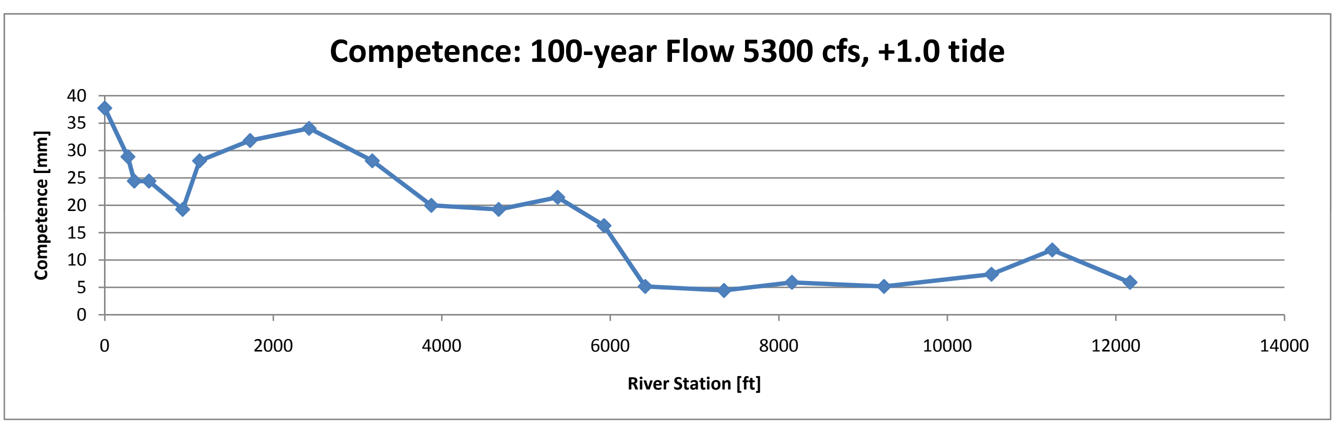


Snake River - New River Mouth Option

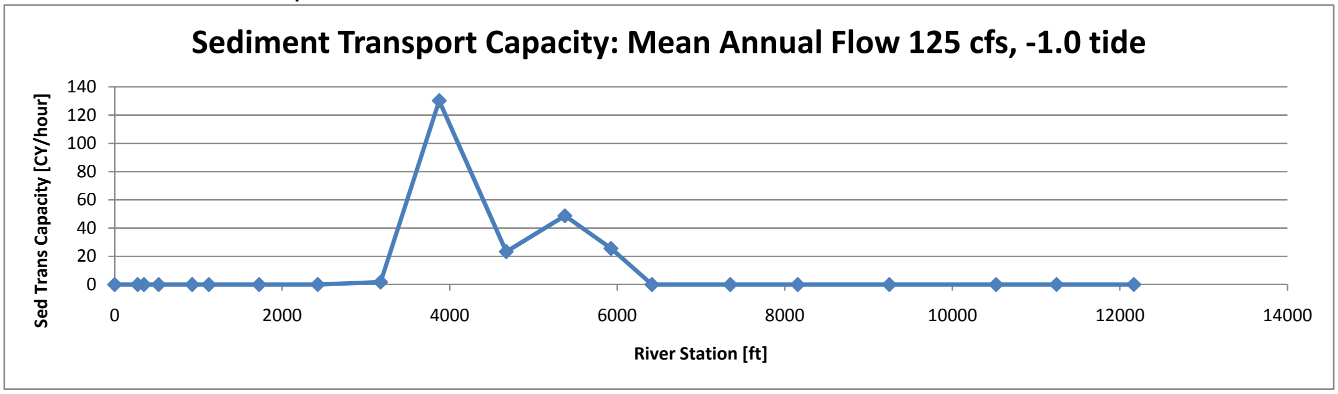


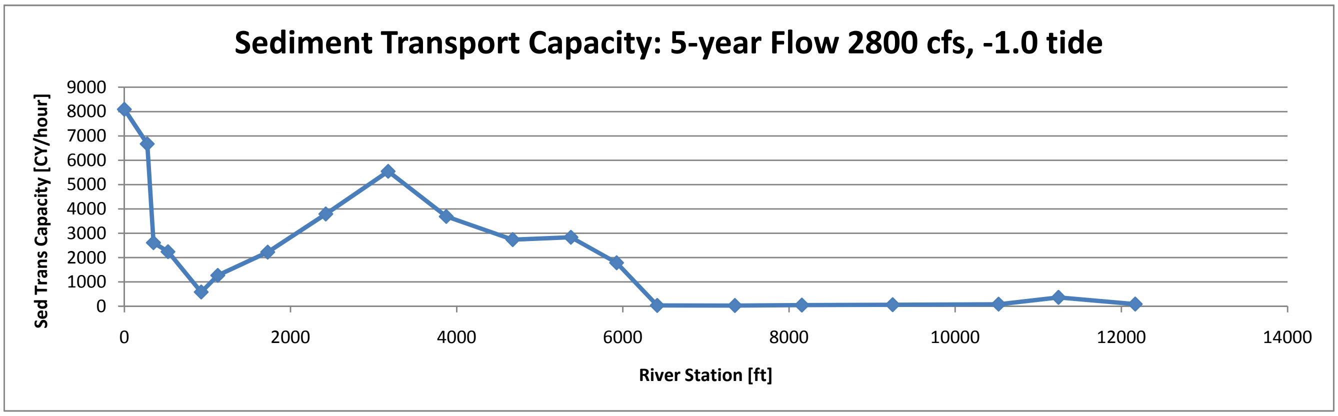


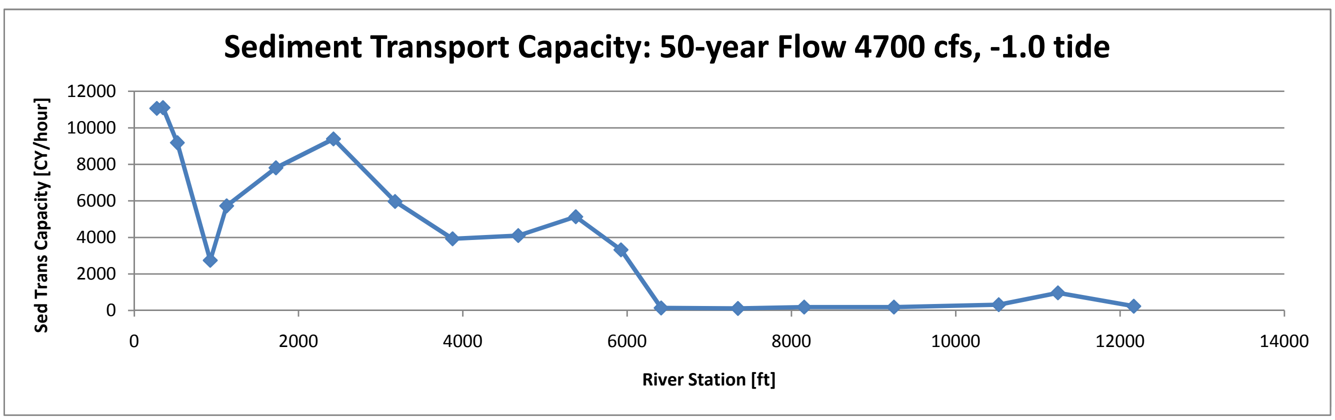


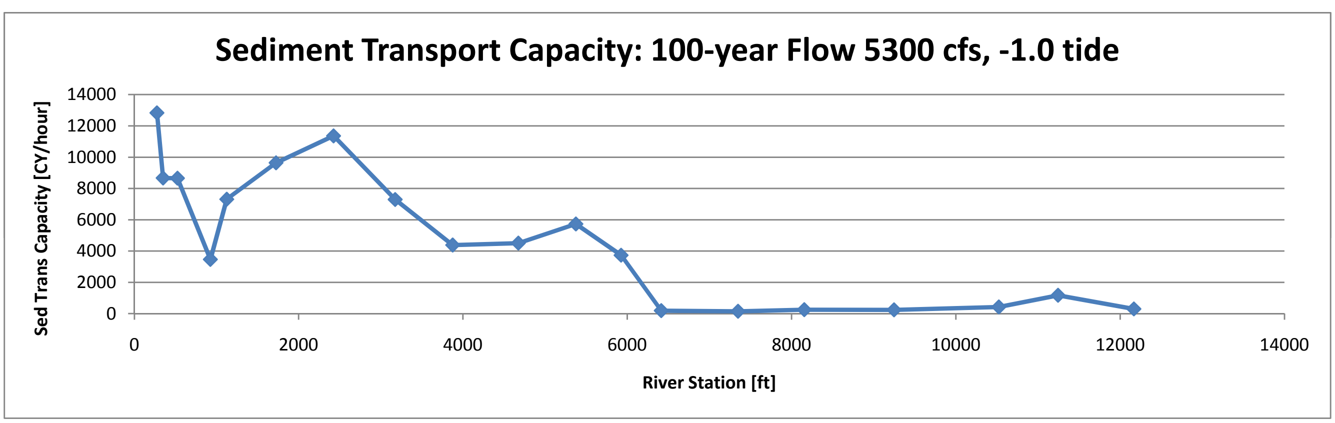


Snake River - New River Mouth Option

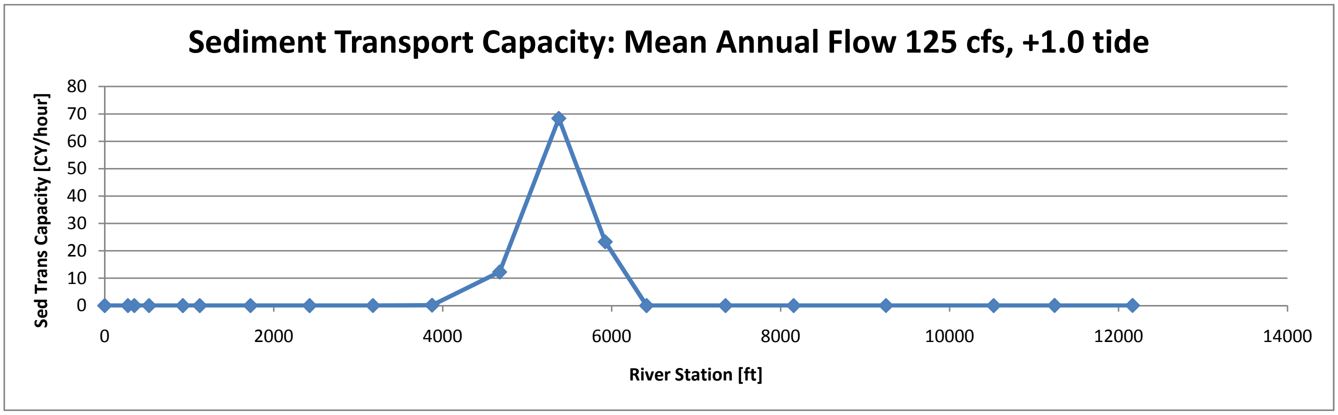


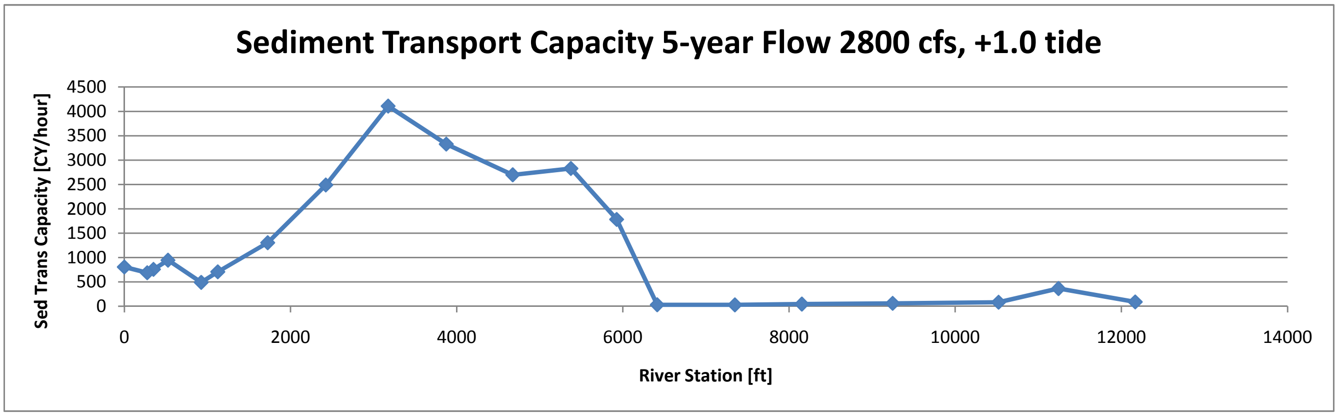


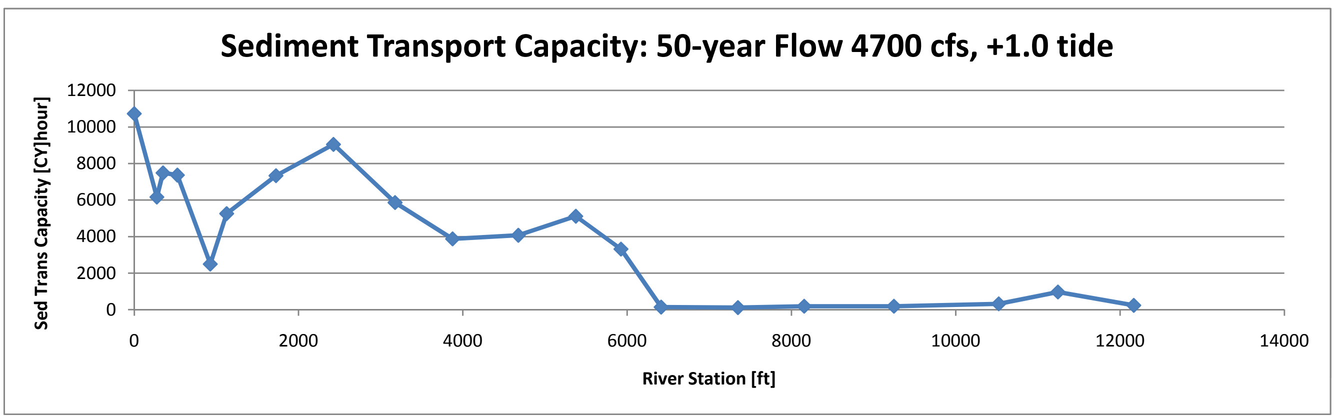


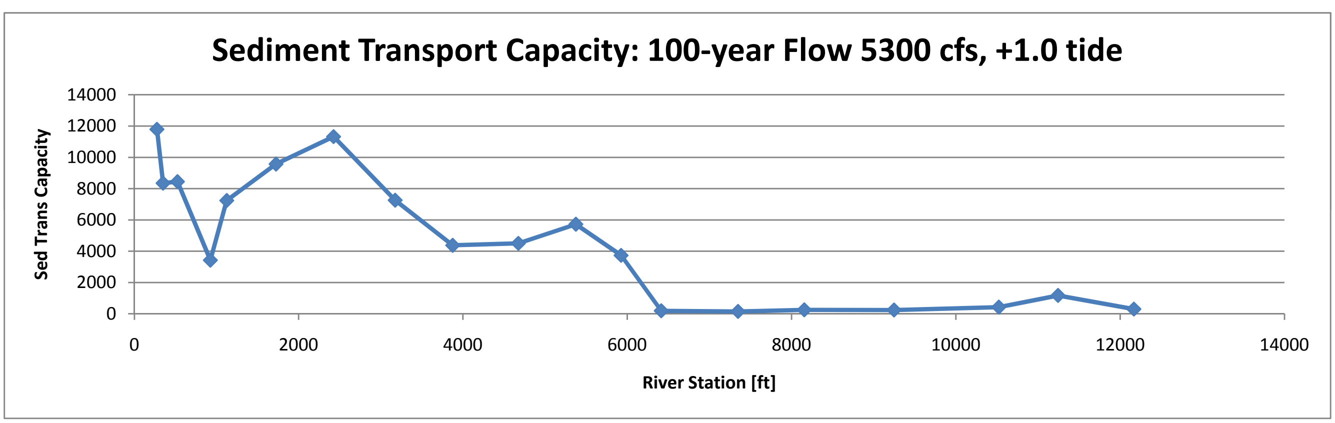


Snake River - New River Mouth Option









Appendix H

New River Mouth and Lower River Reconnection Design and Environmental Impacts Discussions

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CONCEPT DESIGNS

Two Snake River relocation concepts designs were developed for the December 2009 *Draft Snake River Concept Design Report*. The concept designs both accommodate maximum future expansion at the Nome Airport. The following section provides detailed discussions of the two designs, and summaries of their environmental impacts.

1 LOWER RIVER RECONNECTION OPTION

The most important design feature of the Lower River Reconnection Option (Reconnection Option) is that it would maintain hydraulic connectivity with the lower Snake River. This connectivity would assure that existing flow conditions are maintained in the Snake River estuary and the Nome Harbor, and that the river's use as a transportation corridor would not be disrupted.

The alignment of the Reconnection Option is broken into three segments – A, B, and C. The first segment (Segment A) would take off to the south from the existing Snake River and skirt the end of the proposed 10,000-foot runway expansion. This segment would generally parallel the proposed expanded runway and tie back into the existing Snake River near the south end of the crosswind runway. The second segment (Segment B) of the relocated river alignment would connect the existing river channel on the west side of the crosswind runway with the 1996/97 mining pit pond to the south, while skirting the western margin of proposed crosswind runway RSA expansion. The third segment (Segment C) of the alignment would exit the pond, skirt the east side of the proposed crosswind runway RSA expansion, and reconnect to the existing Snake River on the east side of the crosswind runway.

The location of the take-off point of Segment A is constrained by the end of the proposed expanded runway, and occurs on Native-owned land (the surface is owned by the Sitnasuak Native Corporation and the subsurface is owned by the Bering Straits Native Corporation). After skirting the proposed expanded runway, the alignment of the new river valley would curve sharply to the east and follow the edge of the proposed parallel taxiway until reconnecting to the existing river near the southern end of the crosswind runway. The alignment of this segment of the new river valley has been designed so that the northern edge of the new valley excavation would stay within approximately 30 feet of the embankment and excavation limits of the proposed parallel taxiway. This would allow the alignment to stay in lower elevation terrain, which would significantly reduce excavation quantities.

The width of the new river valley in Segment A would vary according to the elevation of the terrain through which the alignment passes. In lower elevations areas, the new valley would be wider, but it would narrow where ground surface elevations and excavation depths are greater. A floodplain that varies in width from 170-300 feet would be provided in the bottom of Segment A of the Reconnection Option alignment. The 150-foot wide and 7.5-foot deep channel of the relocated Snake River would meander gently within the floodplain. The length of this relocated valley segment would be 10,840 feet, while the length of the meandering channel within the segment would be 11,210 feet.

Segment B of the Reconnection Option alignment would take off to the south from the existing channel, skirt the western edge of the excavation and embankment limits of the expanded crosswind runway RSA, and enter the mining pit pond. The alignment of this segment forms a gentle bend, and 10 feet of floodplain would be provided on either side of the channel within the new valley segment. The length of the new valley and relocated channel are essentially the same in this segment, totaling 1,640 feet.

Segment C of the Reconnection Option alignment would exit the mining pit pond, skirt the east edge of the excavation and embankment limits of the expanded crosswind runway RSA, and reconnect to the existing Snake River immediately downstream of the crosswind runway. Like Segment B, 10 feet of floodplain would be provided on either side of the relocated channel. The length of the new valley and relocated channel are essentially the same in this segment, totaling 750 feet.

The total length of the relocated channel within the Reconnection Option is 15,400 feet, which includes the channel lengths within the three new valley segments, an approximately 550-foot long section of the existing channel, and a 1,250-foot long flow path within the mining pit pond.

The observed instability of the narrow strip of land between Norton Sound and the southern edge of the mining pit pond is a concern. If this strip of land were to become breached due to coastal erosion on its south side, river erosion on its north side, or some combination of the two, the flow of the river could be diverted to a new mouth at this location. To assure that this does not occur, the strip of land would be buttressed by building a berm of granular material along the southern end of the pond. The buttress would increase the total top width in this area from its existing dimension of approximately 50 feet to a new dimension of 200 feet. Some relatively minor excavation is expected to be required on the north end of the mining pit to provide adequate room for river flow between that portion of the pit and the buttress constructed on the south side. Most of the water in the pond would need to be drained before this excavation, the construction of the two relocated river segments, and the construction of the mining pit buttress could be accomplished. Limited bathymetric survey data suggest that the volume of the pond is more than 100 million gallons.

Because the crosswind runway RSA expansion and river relocation into the mining pit pond would disrupt NovaGold’s road access to the western portion of their property, a new 4,600-foot long segment of access road would be constructed to the south of the mining pit. The road would be 24-feet wide with 5-foot wide shoulders, and would be surfaced with gravel.

New valley excavation typical sections vary depending on whether or not the excavation occurs in previously mined areas. Approximately 3,400 feet of the Segment A alignment would pass through previously mined areas. Segments B and C would both be constructed in areas that have not been previously mined.

In areas that have not been previously mined, new valley side slopes would be cut at 3:1 (horizontal to vertical), and a 12-foot high bench would be cut into the ice-rich, thaw-unstable soils at the top of the excavated slope. The back slope of this bench would be vertical or nearly vertical, and the excavated bench would be replaced with granular soils to buttress the thaw-unstable soils. To the extent possible, tundra mat salvaged from clearing and grubbing for the excavation would be reused on side slopes and the floodplain to help stabilize excavated surfaces. In previously mined areas, new valley side slopes would be cut at 2.5:1 and buttressing with granular material at the top of excavated slopes would not be required. Salvaged tundra mat would be used to stabilize excavated slopes and floodplain surfaces, to the extent possible, in previously mined areas as well.

Excavation quantities for the Reconnection Option are estimated to be 5,870,000 cubic yards. A portion of that material is anticipated to be usable for RSA expansion fill, buttressing of the mining pit pond, buttressing of thaw-unstable soils at the top of excavated slopes, and the NovaGold access road. The remaining unusable excavated material would be disposed of in an area surrounded by a meltwater containment berm system located to the south of the airport. The meltwater containment berm would also be constructed from material excavated during new valley and channel construction. After completion of the diversion of the river into the new channel, a portion of the disposed material would be used to fill in the dewatered portion of the Snake River channel located between the diversion point of the relocated channel and the northern edge of the expanded RSA embankment on the western end of the main runway. This disposal would reduce the risk of wildlife hazards caused by standing water near the airport, and would convert the existing riverine wetlands to emergent wetlands.

The alignment of the Reconnection Option differs significantly from the general alignment developed during contract scoping for the relocation project, and presented in earlier project submittals. The earlier alignment, developed prior to project startup and without the benefit of contour information or engineering analyses, traversed the highest elevation portion of the ridge to the south of the airport, which would have resulted in much higher excavation quantities than the current alignment.

The plan view and typical sections for the Reconnection Option are shown in Figures H-1 and H-2, respectively. Discussions of environmental changes and impacts related to the Reconnection Option are presented below.

1.1 Basin Hydrology Changes

The Reconnection Option does not change the drainage area of the Snake River, nor does it result in any significant disruption of existing drainage patterns. Consequently, there are no changes to basin hydrology related to this option.

1.2 Hydraulic Characteristics of the Relocated Channel

The Reconnection Option will result in an increase of 1,650 feet of channel over the existing Snake River channel length, which constitutes a minor increase in the total length of the Snake River.

HEC-RAS water surface profile modeling was performed to aid in the design of the relocated channel. Modeling results show that the hydraulics of the relocated channel closely mimic those of Channel Morphology Zone 3, the reach that was used as a design target for the relocated channel. For the flow range including the mean annual, 2-year, 50-year, and 100-year flows, within the constructed channel, floodplain depths range from 0.0 to 6.0 feet; channel velocities range from 0.3 to 3.1 feet per second; shear stress values range from 0.0 to 0.1 pounds per square foot; and the slope of the energy grade line varies from 0.000008 to 0.0001 feet per foot (HEC-RAS cross-section locations are shown in Figure H-3; HEC-RAS modeling output is provided in Appendix E).

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NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION

LOWER RIVER RECONNECTION OPTION - PLAN

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FIGURE H-1

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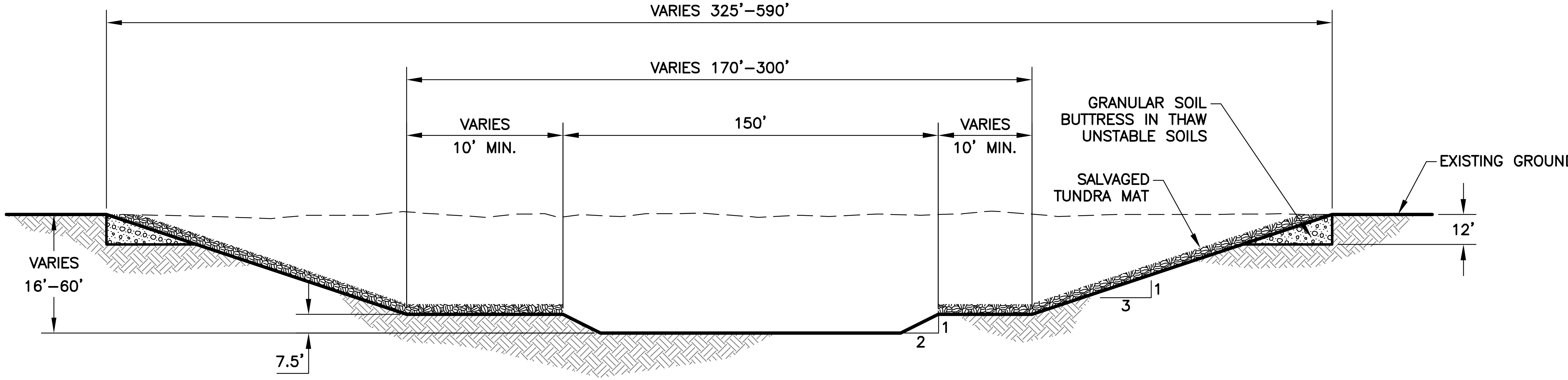
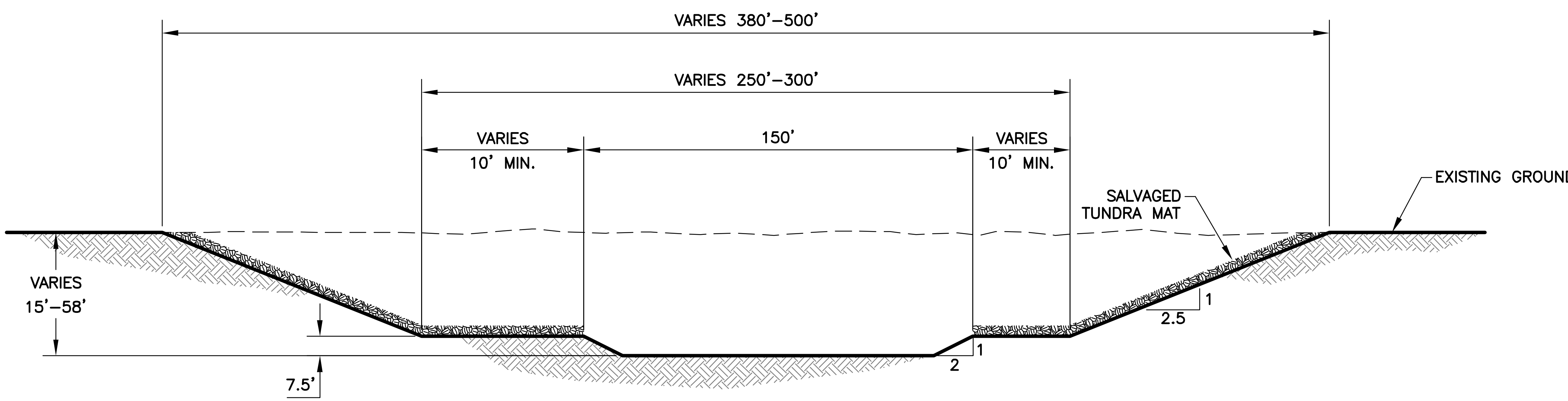


1 H–2 TYPICAL SECTION IN UNMINED AREAS



2 H–2 TYPICAL SECTION IN MINED AREAS

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NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION
LOWER RIVER RECONNECTION
OPTION TYPICAL SECTIONS

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FIGURE
H-2

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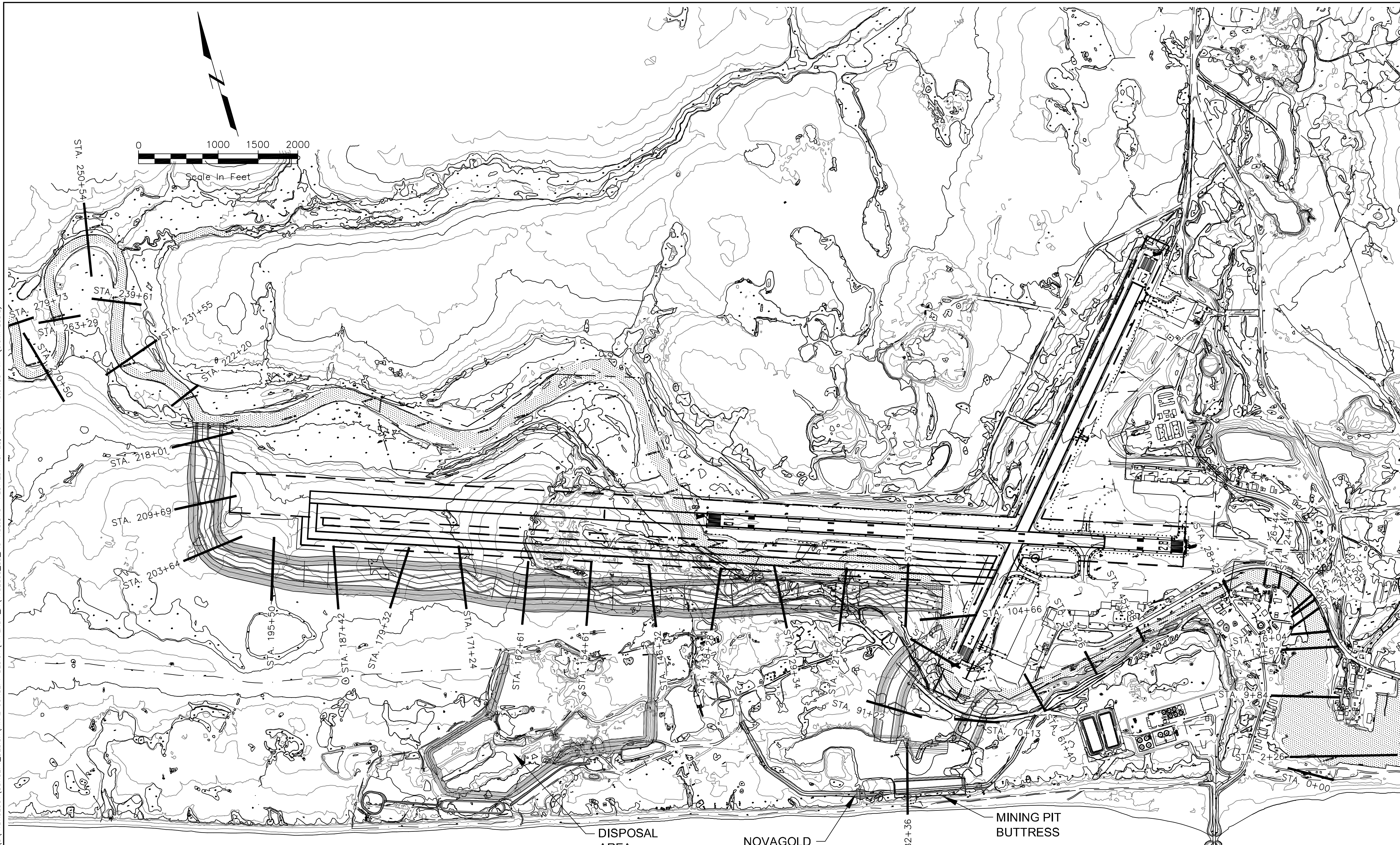

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NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION

LOWER RIVER RECONNECTION
HEC-RAS MODEL X-SECTIONS

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FIGURE
H-3

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Because the Reconnection Option closely mimics the hydraulics of the existing river, it would also have similar sediment transport characteristics (see Section 4.2.3 and Appendix G).

1.3 Existing Snake River Estuary Hydrologic Changes

The Reconnection Option would maintain the existing hydrologic conditions within the existing Snake River estuary.

1.4 Fish Habitat Impacts

The Reconnection Option results in an increase of approximately 1,650 feet of riverine habitat, which may increase the opportunity for juvenile fish to feed longer on their outmigration to Norton Sound. As previously noted, the lower Snake River provides juvenile salmon the opportunity to feed and grow before they enter the marine environment. An increase in the length of this lower river habitat would be a positive outcome of this option. Since chum salmon spend more time in this habitat feeding, the expectation would be that there would be an increase in size and a resulting increase in viability.

During the new channel construction, it could be that gravels will be exposed within the relocated channel. If so, these exposed gravels could provide new spawning habitat for resident and anadromous species. Pink salmon, which may have spawned in this area in the past, are known to be very opportunistic spawners, and commonly use new spawning gravels that appear after flood events. Newly exposed gravels within the relocated channel might be used as spawning habitat by pink salmon.

The new channel would result in a temporary increase in sediment loads for an unknown period of time. If the system were stabilized in 1-2 years, the impact would be insignificant. When the water quality is impaired, fish will migrate to marine waters to feed. This would impact juvenile fish, and could result in high mortality. Because of their size, they are more susceptible to sediment loads than adults that are migrating beyond the project area to their spawning beds.

While the Reconnection Option results in the lower river remaining unchanged, there is an opportunity to provide additional instream habitat structures. For example, the mining pit pond could provide rearing and feeding opportunities to all fish species, and could therefore be used to mitigate the temporary impacts to the fish resources.

1.5 Estuarine Habitat Impacts

Under the Reconnection Option, there would be little change in the existing estuary configuration or function, except that there would likely be a substantial increase in sedimentation rates for the first few years as the new channel upstream became stabilized. The channel would pass through the mining pit pond off the south end of the crosswind runway, which would function as a sediment trap. It is expected that this pond would be effective at removing most of the coarser sediment that might be introduced from the newly constructed channel upstream.

Only a relatively small amount of finer suspended material would be carried through the pond into the remaining river reach extending through the existing channel to the estuary. As flow velocities decrease in the estuary, some of these fines would settle out. Sedimentation along the harbor shorelines, where it filled interstices in riprap or cobbles, might increase productivity in those areas. The finer-grained material would support diatom and/or bacterial growth, and form the base of a food chain of microconsumers, leading to deposit feeding invertebrates that could become prey for juvenile salmonids. On the other hand, in existing areas that already support that food chain, excessive sedimentation would reduce existing rates of productivity. Wave action would re-suspend settled material, leading to its ultimate deposition in deepwater basins within the harbor, or transport out of the harbor with the net outward flow. Suspended material in the water column would also reduce the productivity of existing macro- and micro-vegetation in the harbor. In the limited marsh areas around the harbor, sedimentation could raise elevations slightly over time, potentially altering the vegetation composition of the marshes.

During the period of temporarily increased sedimentation, salmon outmigrating from the Snake River could experience some loss of fitness as they migrate out through the existing harbor and find somewhat poorer than normal conditions for feeding during their stay in the estuary. Returning adults should not be materially affected by the altered river channel and would be expected to pass through the harbor as they do under present conditions.

1.6 Transportation Corridors

The only effect on transportation corridors resulting from construction of the Reconnection Option would be the disruption of NovaGold's access to their property to the west of the mining pit pond after the river has been relocated through the pond. The construction of a new access road that is routed to the south of the mining pit pond would effectively mitigate the disruption of NovaGold's access.

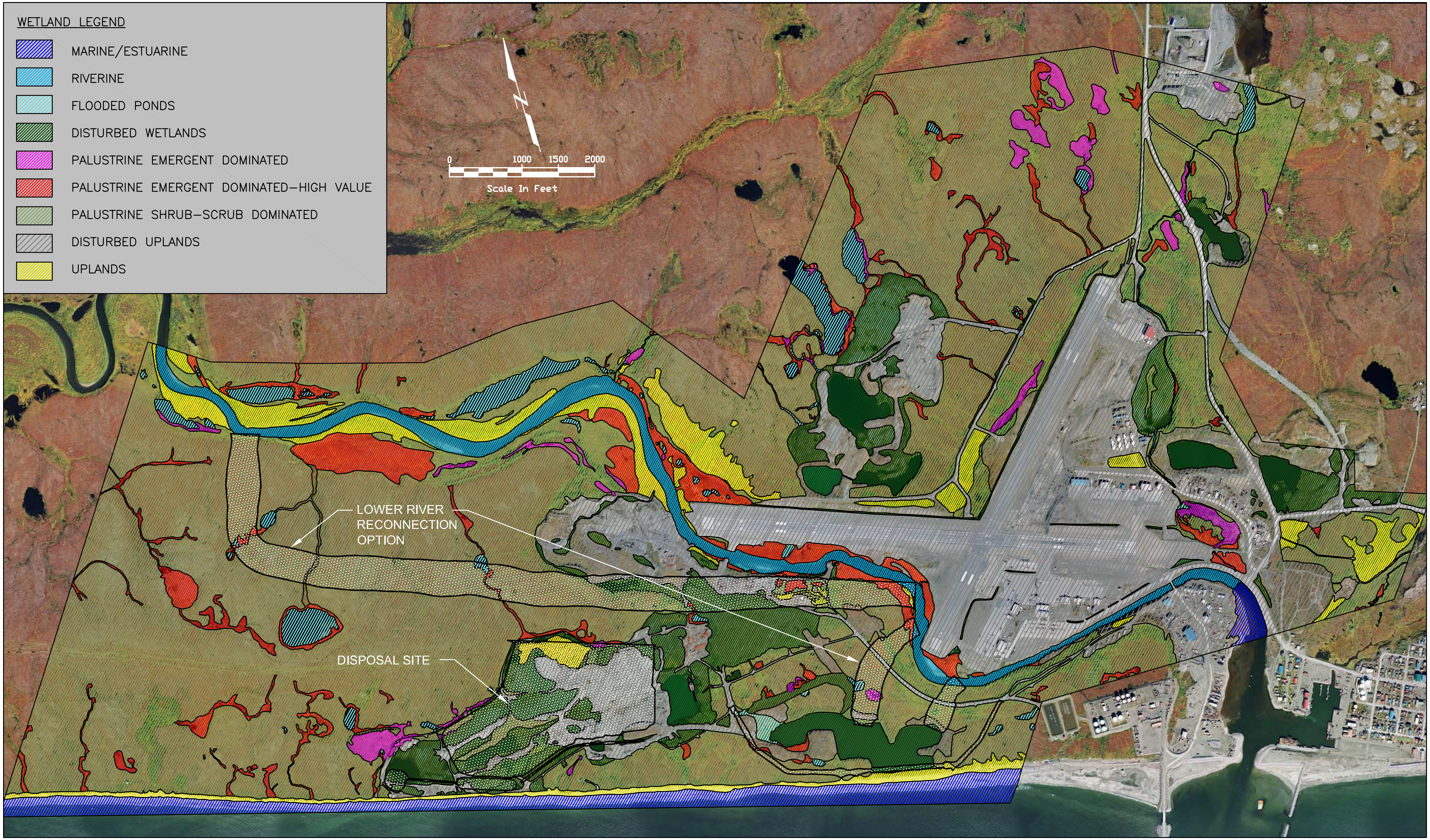
1.7 Wetland Impacts

Construction of a new river valley and channel through the project area would impact wetlands in the following ways: direct loss of wetlands through excavation and fill, loss or change to wetland functional capacity from changes in hydrology, and wetland impacts (temporary or permanent) from stockpiling and disposal of excavated material.

Excavation and Fill

The Reconnection Option would result in the loss of approximately 117.7 acres of wetlands through direct excavation and fill for the new river valley, and construction of the NovaGold access road (see Figure H-4). The majority of wetlands that would be impacted by these activities are palustrine shrub-scrub dominated and disturbed wetlands. Palustrine emergent dominated and other wetland types would also be impacted, but to a much lesser degree (see Table H-1).

After the new river valley is constructed, it is anticipated that the new river channel and floodplain will be restored to palustrine emergent and riverine wetlands once the area is revegetated with tundra mat. The total area of wetlands that would be restored after construction of the new river valley and channel is complete is approximately 70.5 acres.



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NOME AIRPORT RSA EXPANSION
SNAKE RIVER RELOCATION

LOWER RIVER RECONNECTION AFFECTED WETLANDS

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FIGURE H-4

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Loss or Change in Wetland Functional Capacity

In addition to the direct impacts to wetlands from fill and excavation, the wetlands on either side of the new valley excavation may be converted to upland willow scrub and palustrine shrub-scrub dominated wetlands, similar to the margins of the existing Snake River valley. This change in wetland type and functional capacity would be caused by the change in local wetland hydrology from a new hydrologic regime in the area. After the new river valley is excavated, previously frozen soils along the margins of the new river valley would begin to thaw. These new soil conditions would likely allow a different plant community to develop along the valley margins to the extent where the soil becomes frozen again. The resulting loss or change in wetland type and function along the new river valley may, in some areas, be considered a loss of wetlands. In other areas, the change in wetland functions would be of high value to the riparian system of the relocated river for fish and wildlife habitat.

As part of the Reconnection Option, approximately 42.7 acres of the existing Snake River channel would be dewatered. Approximately 29.7 acres of the channel west of the main runway would be filled with unusable excavated material generated during valley construction. This material would consist of organics and silt, and would likely restore the old river bed to palustrine emergent dominated wetlands. These restored wetland areas would not pond water or receive overflow from the river except for during very high water events. The remaining section of dewatered channel would be seeded to stabilize the sediments for storm water management.

Stockpiles and Disposal Areas

As the new valley is excavated, approximately 5.9 million cubic yards of overburden and unusable excavation may need to be stockpiled prior to transport to the permanent disposal site. Depending on the disposal site selected for this option, additional temporary and/or permanent wetland impacts may occur if overburden is stockpiled within wetlands. The preferred disposal option for this project is to permanently dispose of 310,000 cubic yards of materials within the old river channel, and 5.3 million cubic yards of materials with the previously mined area south of the airport. This disposal option would result in approximately 45.9 acres of fill in disturbed wetlands.

Table H-1 identifies wetland losses through excavation and fill that would result from construction of the Reconnection Option.

Table H-1 - Wetland Impacts from the Reconnection Option

Wetland Type	Impact Acres	Restored Acres
River Valley Construction		
Marine/Estuarine	0.0	0
Riverine	1.4	46.8
Flooded Ponds	1.0	0
Disturbed Wetlands	18.5	0
Palustrine Emergent dominated	0.6	23.7
Palustrine Shrub-Scrub dominated	96.1	0
Total	**117.7**	**70.5**
Dewatered Channel		
Riverine	42.7	29.7
Total	**42.7**	**29.7**
Disposal Area		
Marine/Estuarine	0	0
Riverine	0	0
Flooded Ponds	0	0
Disturbed Wetlands	39.6	0
Palustrine Emergent dominated	0.5	0
Palustrine Shrub-Scrub dominated	5.8	0
Total	**45.9**	**0**
Total Wetlands Impacted	**206.3**	**100.2**

1.8 Potentially Hazardous Materials

Potentially hazardous waste has been identified in this project area in the form of numerous abandoned barrels of a tar-like substance (AOC 1-4, Figure H-1) and orange-colored leachate seeping from the hillside above the Snake River (northwest of AOC 3 on the banks of the Snake River). AOCs 1-4 also encompass at least three locations where it appears that drums and other unidentified waste have been buried. The area directly east of AOC 1 shows evidence of recent track-hoe activity on the top of a mound of dirt, as well as evidence of buried 55-gallon drums within this mound of dirt. AOC 1 contains approximately 300 55-gallon drums containing a tar/asphaltic-like substance. Numerous plastic containers filled with a petroleum-like substance are also present in this location. The contents of these containers have not been fully characterized. The soils and groundwater beneath these containers may be impacted by the contents of the containers due to the lack of secondary containment.

Figure H-1 shows the AOCs within the project area that could be affected by construction of the Reconnection Option. Disturbing soils near any of the identified AOCs could mobilize contaminants through surface and groundwater, and/or release contaminants that may be present in soils and river sediments.

Construction activities associated with the Reconnection Option could mobilize naturally occurring metals by exposing them to oxygen and potentially changing their oxidation states, causing potential negative impacts to aquatic receptors. The following outlines specific recommendations associated with AOCs within the project area:

AOC 1 - Any excavation activities through this location that have the potential to disturb existing containers and impacted soils would require characterization of the content of these containers and a potential investigation of any spills discovered beneath these containers. At a minimum, removal of containers and potentially impacted soils would be required, as well as investigation of any impacts to existing groundwater.

AOC 3 - Orange leachate was observed coming from the toe of a slope adjacent to the Snake River. If excavation activities take place near this area, any buried waste generating this leachate may be exposed and should be characterized to rule out the presence of hazardous waste in order to prevent negative environmental impacts.

AOC 1-4 - These areas encompass at least three locations where it appears that drums and other unidentified wastes have been buried. Should the Reconnection Option require disturbance of soils in these areas, further investigation will be required to fully characterize potentially hazardous buried materials.

Naturally Occurring Metals - Elevated concentrations of naturally occurring metals (arsenic, chromium) are known to be present within the Reconnection Option area (Phase II ESA, Nome Row Acquisition, 2004). Movement of water by construction of a new river channel through previously undisturbed soils and sediments has the potential to mobilize these metals and negatively impact aquatic receptors. Also, movement of water throughout previously dredged areas has the potential to mobilize mercury bound onto soil particles and impact aquatic receptors.

Dewatering Activities - Sampling activities detected mercury in the surface water of pond adjacent to Dredge No. 6 (Suspected Uncontrolled Hazardous Waste Site Investigation, 1986). If excavation activities requiring dewatering take place, an ADEC Excavation Dewatering General Permit will be needed for dewatering activities taking place within one mile of a contaminated site.

2 NEW RIVER MOUTH OPTION

The New River Mouth Option would relocate the Snake River along a significantly shorter alignment than the river currently follows. Under this option, the river would be routed to a new estuary and river mouth along the Norton Sound coast. The new mouth would be located approximately 2.5 miles west of the river's existing mouth. The alignment of the new valley would be approximately 6,400 feet long, and would take off to the south from the existing Snake River at the same location as the Reconnection Option. After skirting the end of the proposed 10,000-foot runway excavation and embankment limits, the alignment would sweep gently to the east to take advantage of lower elevation terrain and avoid privately-owned parcels. As the alignment approaches the top of the 55-foot high ridge, it would straighten for about 1,500 feet before gently bending back to the west to take advantage of lower elevation terrain as the alignment approaches the coast. About 1,000 feet from the coast, the alignment would bend sharply to the east and parallel the coast within a new estuary before bending back sharply to the south to enter Norton Sound through a new river mouth.

The presence of the new river mouth would disrupt the Norton Sound beach transportation corridor. To address this, a new bridge would be constructed upstream of the new estuary, with access road segments leading to the beach to the east and west. The new bridge would be constructed to provide 3 feet of freeboard between the

100-year storm surge elevation and the low chord of the bridge. The bridge would be approximately 300 feet long, and would be built in three 100-foot spans, with two instream piers. The bridge deck would be 40 feet wide and surfaced with gravel for ease of maintenance. Bridge girders would be standard 54-inch precast, pre-stressed, Bulb "T" girders. Bridge abutments would be supported with 18-inch diameter, concrete-filled steel pipe piles driven to bedrock. Instream piers would be 48-inch diameter, concrete-filled steel pipe piles driven to bedrock, and would be protected on the upstream side by ice-breaking structures.

The Norton Sound beach access road leading to the bridge would have a 24-foot wide gravel surface and 5-foot wide shoulders. Culverts would be provided at the location of prominent drainages. The total length of new access road construction would be 3,820 feet.

Coastal processes along this portion of the Norton Sound coast are expected to cause eastward migration of the new river mouth. The beach takeoff point of the eastern section of the access road to the bridge was selected based on a combination of estimates of river mouth migration, terrain, and engineering judgment. The processes involved in river mouth evolution and migration are detailed within the Coastline Engineering report titled *Coastal Engineering Issues of Relocating the Snake River* (see Appendix I).

The width of the new river valley would vary according to three factors. Over much of the alignment, the elevation of the terrain through which the alignment passes would govern the valley width. In general, the new valley would be widest in lower elevation areas in order to provide a wider floodplain, but would narrow where ground surface elevations and excavation depths are greater. As the alignment approaches the coast after passing through the crest of the ridge, the valley width would remain narrow in order to minimize the required length of the bridge crossing. Downstream of the bridge crossing, the valley would widen significantly to form the new estuary.

A floodplain that varies in width from 170-380 feet would be provided in the bottom of the new valley upstream of the estuary. A 130- to 150-foot wide channel, with depths ranging from 4 to approximately 8 feet, would meander gently within the floodplain. In the estuary, the valley width would be 340 feet. The estuary would provide a system of intertidal benches and an intertidal island, and an approximately 110-foot wide, 8-foot deep thalweg channel to provide a navigable corridor through the relatively shallow estuary reach. The upper portion of the intertidal benches and island would be expected to become colonized by marsh vegetation such as *Carex*.

The New River Mouth Option does not pass through terrain that has been previously mined. Therefore, excavation geometry and features would be the same as that described for unmined areas along the Reconnection Option. Specifically, new valley side slopes would be cut at 3:1 (horizontal to vertical); a 12-foot high bench would be cut into the top of the excavation and replaced with granular soils to buttress thaw-unstable soils; and, to the extent possible, tundra mat salvaged from clearing and grubbing for the excavation would be reused on side slopes and the floodplain to help stabilize excavated surfaces.

Because the sediment transport characteristics of the New River Mouth Option will allow the mobilization of gravel-sized material during high flow events, special provisions have been added to the design to prevent stream bed scour and head cutting in the relocated river channel. If left unchecked, it is possible that head cutting could proceed up the full length of the relocated channel and several miles up the native channel upstream of the relocation diversion point. To address this, a 1.5-foot thick layer of scour-resistant, coarse gravel channel lining will be provided between the take-off point of the new channel and the upstream end of the estuary. Additionally, hydraulic grade control structures will be provided every 500 feet along the length of the new valley between the take-off point and the upstream end of the estuary. The preliminary design of these grade control structures consists of a 30-foot wide, 3-foot thick blanket of DOT&PF Class I riprap placed below grade across the full width of the floodplain and channel.

Excavation quantities for the New River Mouth Option are estimated to be approximately 3,680,000 cubic yards. A portion of that material is anticipated to be usable for RSA expansion fill, buttressing of thaw-unstable soils at the top of excavated slopes, and the Norton Sound beach access road. The remaining unusable excavated material would be disposed of in the same manner as described for the Reconnection Option - in an area surrounded by a meltwater containment berm system located to the south of the airport, and in the dewatered portion of the Snake River channel upstream of the northern edge of the main runway’s expanded RSA embankment.

The total length of the relocated channel within the New River Mouth Option is 6,420 feet. The plan view and typical sections for the New River Mouth Option are shown in Figure H-5 and H-6, respectively.

2.1 Basin Hydrology Changes

The New River Mouth Option would reduce the drainage area of the Snake River from 121.3 square miles at its existing mouth to 108.4 square miles at the new river mouth, a difference of almost 13 square miles. This would have the effect of reducing the average flows at the existing river mouth and estuary from its current rate of 135 cfs to 13 cfs after the river has been relocated.

The New River Mouth Option would also disrupt existing drainage patterns near the airport. A 178-acre closed depression would be created within the dewatered river valley to the south of the main runway and west of the crosswind runway (see Figure H-5). This closed depression could result in a standing water feature that would constitute a wildlife hazard. Three options have been briefly evaluated to prevent water from pooling in this area. The first option would be to install a culvert in the current river channel below the expanded crosswind runway embankment, allowing drainage to flow under the runway and maintain the natural flow pattern. Another option would be to use porous material such as boulders or other large fill material to allow drainage to pass through the expanded embankment and follow the natural drainage pattern. A third option would be to maintain the depression, but fill the dewatered channel with excavated material in an irregular pattern that would create small, isolated pools instead of a large body of standing water.

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USKH SHARED VISION. UNIFIED APPROACH.	NOME AIRPORT RSA EXPANSION SNAKE RIVER RELOCATION NEW RIVER MOUTH OPTION - PLAN	MAR. 2011 FIGURE H-5

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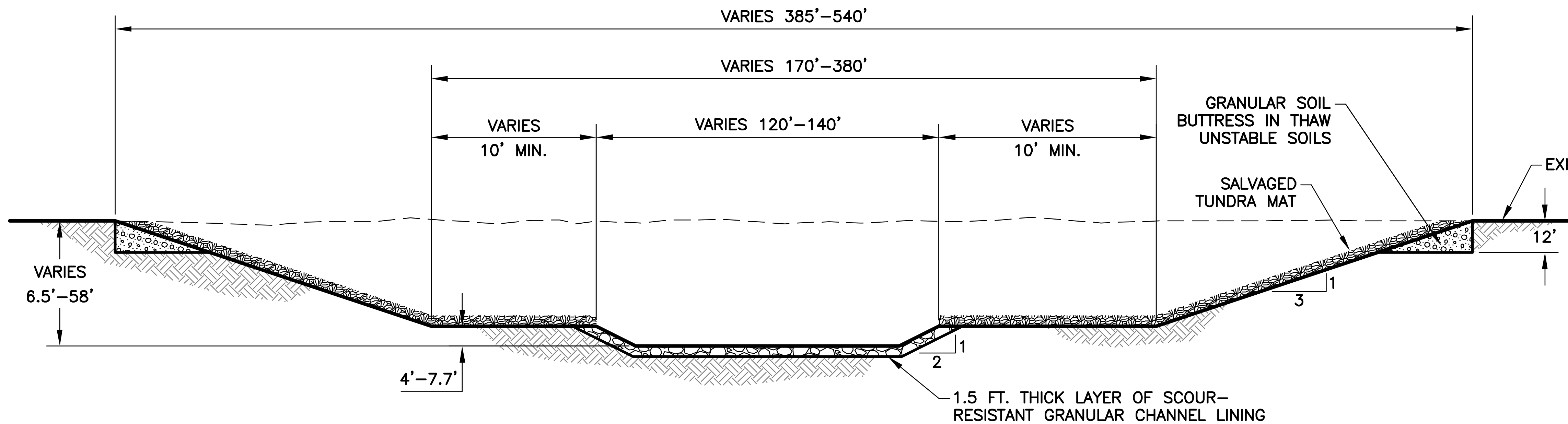
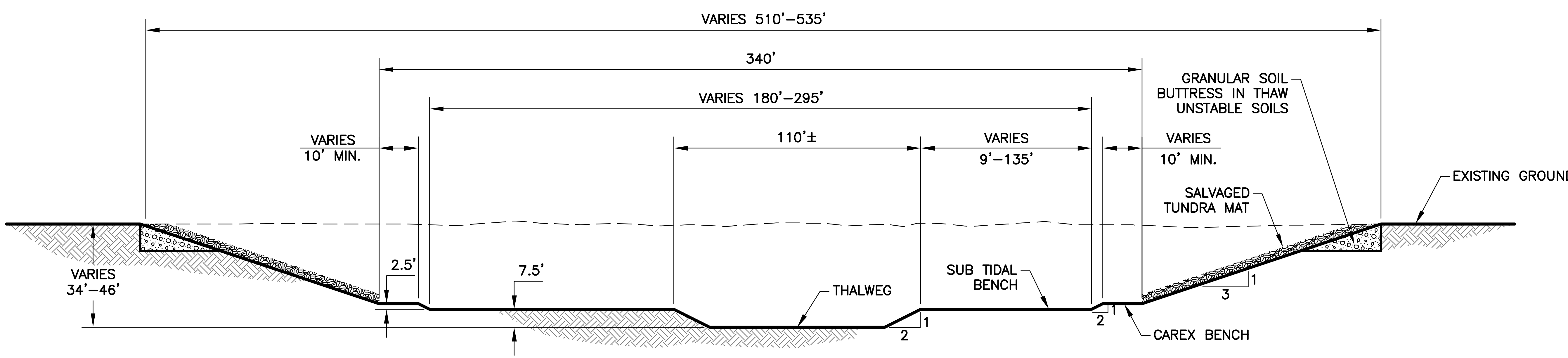


1 H–6 TYPICAL SECTION



2 H–6 TYPICAL ESTUARY SECTION

USKH SHARED VISION. UNIFIED APPROACH.	NOME AIRPORT RSA EXPANSION SNAKE RIVER RELOCATION NEW RIVER MOUTH OPTION TYPICAL SECTIONS	MAR. 2011 FIGURE H-6

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2.2 Hydraulic Characteristics of the Relocated Channel

The New River Mouth Option would result in a reduction of 14,160 feet of channel over the existing Snake River channel length, which constitutes a significant reduction in the total length of the Snake River. Because of this, the design of the New River Mouth Option presents a unique hydraulic challenge.

HEC-RAS water surface profile modeling was performed to aid in the design of the relocated channel (modeling results are presented in Appendix E; HEC-RAS cross-section locations are shown in Figure H-7). Modeling results show that the average slope of all flows modeled for this option are significantly greater than for equivalent flows in the existing channel. Consequently, the hydraulic characteristics of the channel in the New River Mouth Option are significantly different from those within Channel Morphology Zone 3, which was used as the design target for the relocated channel. It should be noted that for equal recurrence intervals, the flows within the channel for this option are slightly lower than those in the existing channel and the Reconnection Option due to the reduction in basin area.

With an increase in average profile slope, channel depths are reduced while velocity, shear stress, and the slope of the energy grade line increase. Because the hydraulic properties of the New River Mouth Option are significantly different from those of the reference reach, the sediment transport characteristics of the relocation option also differ significantly from those of the existing channel. The increased velocities and energy grade line slopes result in increased sediment transport capacities and competence, as discussed in Section 4.2.3 (see also Appendix G).

While these general hydraulic trends cannot be reversed, the impact of the relative changes in hydraulic characteristics has been reduced in three ways. First, the proposed channel cross-sectional geometry and profile have been optimized to reduce the potential for these impacts to be propagated upstream. Second, adjustments have been made to the channel geometry and profile to smooth the water surface profile to reduce localized peaks in the energy grade line. Finally, scour-resistant channel lining and hydraulic grade control structures have been incorporated within the design in order to protect against head cutting.

2.3 Existing Snake River Estuary Hydrologic Changes

A modeling effort was performed to analyze the changes in mixing and water quality in the Nome Harbor and the remaining estuary after construction of the New River Mouth option. The modeling involved introducing a hypothetical pollutant at the initiation of a model run, and following it through several tidal cycles, allowing the calculation of a mixing efficiency coefficient. Modeling was also performed to compare the mixing efficiency of the harbor and estuary prior to construction of the current river mouth. Modeling results suggest that the previous mixing efficiency of the harbor and estuary was decreased by at least half as a result of the relocation of the river mouth to its current location. More importantly, modeling suggests that the mixing efficiency of the harbor and remaining estuary would be further decreased to approximately half of current values if the New River Mouth Option were constructed. Detailed discussions of the modeling efforts are presented in Appendix I.

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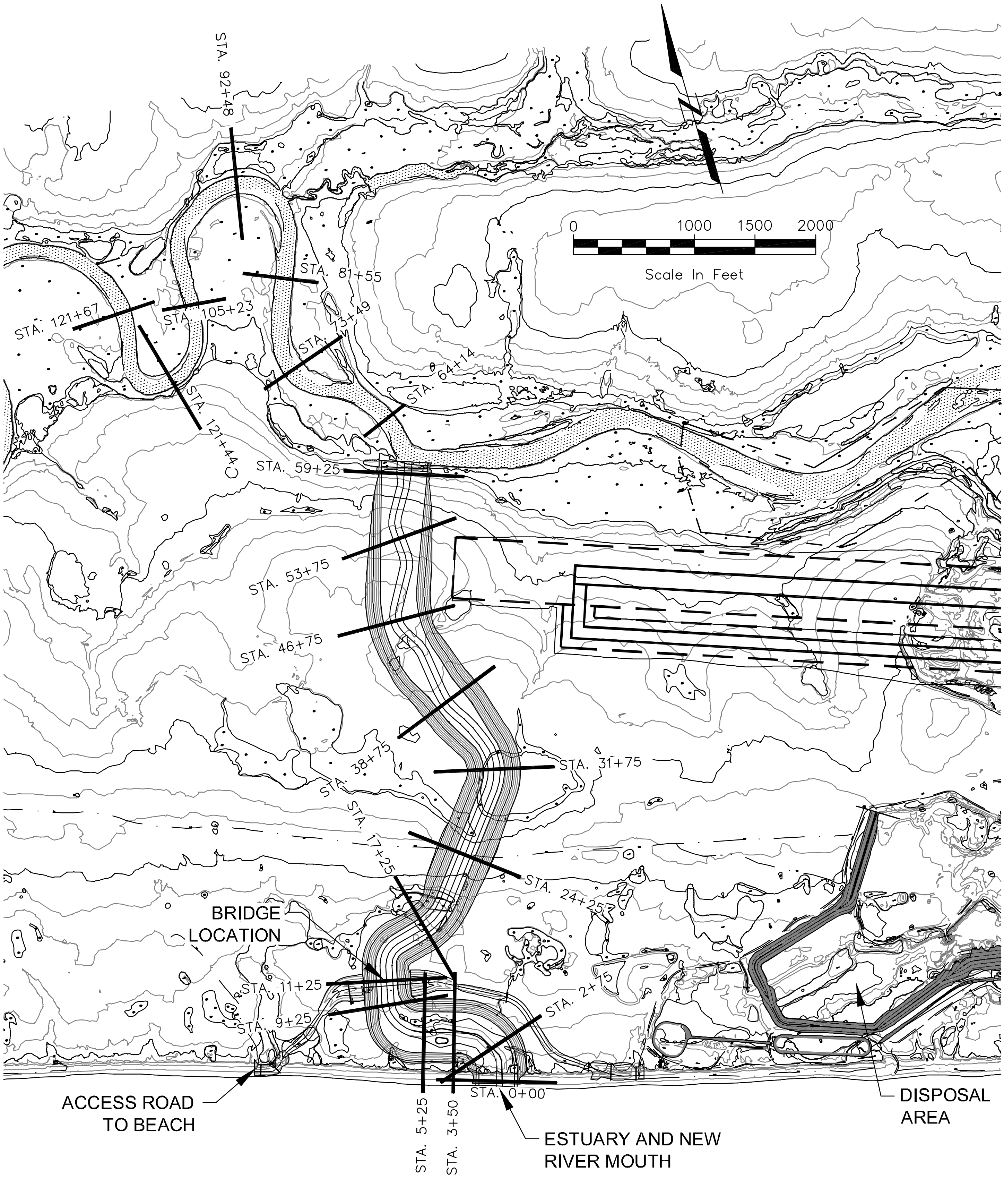

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USKH SHARED VISION. UNIFIED APPROACH.	NOME AIRPORT RSA EXPANSION SNAKE RIVER RELOCATION NEW RIVER MOUTH HEC-RAS MODEL X-SECTIONS	MAR. 2011 FIGURE H-7

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2.4 Fish Habitat Impacts

The proposed New River Mouth Option would decrease the amount of riverine habitat by 14,160 feet. The habitat that would be lost is the migratory corridor used by both adult and juvenile salmonids. The impacts to the adult migrating population would be undetectable. For juvenile salmon, it is difficult to predict the impact from this reduction in the length of habitat used for feeding and outmigration. The loss of habitat could decrease the amount of time juvenile fish have for feeding and osmoregulatory adaptation before entering the marine environment. This could cause a decrease in juvenile fitness and result in higher mortality to the fish population, with a resultant overall decrease in fish production. Since resident fish would also use this corridor, there would also be an impact to that population. Without a thorough inventory of the use of habitat within the existing migratory corridor, it is difficult to predict the impacts to the resident fish population within the new, shorter channel of the relocated river.

During the first few years after the new channel is constructed, there would be an increase of sediment from the excavation of the channel. This would be a temporary impact to juvenile fish populations, which are more vulnerable to sediment loads than adults. When juvenile fish are exposed to increased sediment, their gills can become overloaded, resulting in mortality.

The New River Mouth Option would change salinity in the migration corridor for the fish that return to Dry Creek. Fish entering the harbor to reach the Dry and Bourbon Creek drainages, and juvenile fish that would be outmigrating, may be impacted by the decrease in fresh water. Increased salinity could make it more difficult for juvenile fish to transition to the fresh water phase of their lifecycle, although it is unknown what specific effects the changes would have on the ability of salmonids to osmoregulate in the changed environment.

Adult salmon returning to the Snake River in the first 2 or 3 years after flow is first changed to the new river mouth may suffer a greater amount of straying than is normal for these populations, depending on how much of their imprinted homing instinct is based on river versus stream mouth/estuary cues. It is expected that the great majority of the Snake River returns would choose to enter the new stream mouth. Most of those that do not might be expected to spawn in Dry Creek, the Nome River, or perhaps streams in the Cripple River area. After the first few years, salmon that had outmigrated through the new river channel and estuary would have no problem finding and using the new river mouth and estuary to return to upriver spawning areas.

2.5 Estuarine Habitat Impacts

The new estuary would be designed to maximize its ecological function, especially for juvenile salmonids. Specifically, it would be designed, to the degree practicable, to provide a broad gradient of salinity, high biological productivity, and shallow water shoreline migration corridors. Marsh and riparian vegetation would be maximized. Shorelines would be allowed to colonize with vegetation natural to the elevations provided. It is expected that areas of *Carex*-dominated marsh and of riparian vegetation would be larger than those in the existing harbor and estuary. Thus, the new estuary would provide feeding opportunities for outmigrating juvenile salmonids that, after a period of one or more open water seasons, would be comparable to those in the existing Nome Harbor and estuary.

Estuarine rearing conditions encountered by the first and second year classes of outmigrating juvenile salmonids would likely not be as productive for potential prey as the existing estuary in Nome Harbor. After 2 to 3 years, however, it is expected that the newly constructed estuary would equal, and ultimately surpass the present river mouth in terms of quality of estuarine functions provided to juvenile salmonids, because of the absence of industrial activity and contamination, and the greater area of marsh and riparian vegetation surrounding the new estuary.

The reduction of flow to the harbor and remaining estuary after the relocation of the river would significantly alter the ecological functions of the harbor and estuary. Snake River runs of anadromous fish would no longer use the harbor area for transit to and from spawning/rearing areas in the upper river, although fish from Dry Creek would continue to do so. Use of the limited and somewhat degraded habitats in the harbor by juvenile salmonids would be reduced. However, in addition to the small Dry Creek runs, some fish outmigrating from the Snake and other rivers in Norton Sound could be expected to enter the harbor and, to the degree that conditions were found to be favorable, continue to feed and grow in the harbor for a time before moving out to Norton Sound. Recent work in Puget Sound has found a high use (and importance) of these non-natal estuaries by Chinook salmon and found a high survival value associated with that use (Beamer et al. 2003, 2006).

Increased salinity in the harbor would be likely to shift the nature of fish and invertebrate populations in the harbor from those characteristic of a brackish estuarine environment, to those better adapted to more saline conditions. Species more common offshore or in the outer harbor may become more common in the inner harbor. A potential risk to these fish is the unknown level of contaminants existing in the sediments in the harbor or entering the harbor from seeps, remaining tributaries, storm water, and industrial discharges. Lacking the dilution from the Snake River flow, some parts of the harbor might build up acutely or chronically unhealthy concentrations of some contaminants. Increased salinity in the harbor would also alter the nature of intertidal vegetation assemblages such as the *Carex* dominated marsh along the northwest shore of the harbor. While this area would likely remain a tidal marsh, it is unclear what species shifts might occur.

2.6 Transportation Corridors

Disruption of the Norton Sound Beach travel corridor by the construction of a new river mouth would be mitigated by the construction of a bridge across the relocated river, with an access road leading to and from the beach. New river mouth construction would also disrupt the use of the Snake River as a travel corridor. During the open water season, it would be necessary for river boats to go into Norton Sound and travel more than two miles along the coast to reach the new river mouth. During periods of inclement weather and rough seas in Norton Sound, it may not be possible for local residents to access the river unless they were to haul their boats on trailers up the beach to the new mouth, and launch their boats from the beach. In the winter, the Snake River is a commonly used corridor for snowmachines. Once expansion of the crosswind RSA is completed, the river would no longer serve as an unrestricted travel corridor. People traveling on snowmachines would have to cross NovaGold-owned lands to the south of the airport or travel up the Norton Sound coast to reach the river.

Recent changes in the configuration of the mouth of the Snake River appear to have produced a delay in the timing of breakup in the Nome Harbor. Under the current configuration, the river no longer flows through the harbor, which in the past had helped to push ice out of the harbor. It is expected that the reduction of flow near the harbor that would result from the relocation of the river under the New River Mouth Option would further delay the timing of breakup in the harbor. With little flow to push ice out of the harbor, ice would likely need to melt in place. This delay in breakup would reduce the period of open water use for the harbor.

2.7 Wetland Impacts

Construction of the New River Mouth Option would impact wetlands through direct losses associated with excavation and fill, loss or change to wetland functional capacity from changes in hydrology, and wetland impacts (temporary or permanent) from stockpiling and disposal of excavated material.

Excavation and Fill

The New River Mouth Option would result in the loss of approximately 74.8 acres of wetlands through direct excavation and fill for the new river valley, and construction/reconstruction of access roads and a bridge across the new river valley as shown on Figure H-8. The majority of wetlands that would be impacted by these activities are palustrine shrub-scrub dominated wetlands. Palustrine emergent, flooded ponds, and other wetland types would also be impacted, but to a much lesser degree (see Table H-2).

After the new river valley is constructed, it is anticipated that the new river channel and floodplain will be restored to palustrine emergent and riverine wetlands once the area is revegetated with tundra mat. In addition, construction of the new estuary would create high value estuarine wetland habitat. The total area of wetlands that would be restored after the river valley is complete is approximately 37.2 acres.

Loss or Change in Wetland Functional Capacity

As mentioned previously with regard to the Reconnection Option, changes in local wetland hydrology may cause the wetlands on either side of the new valley excavation to be converted to upland willow scrub and palustrine shrub-scrub dominated wetlands, similar to the margins of the existing Snake River valley. The resulting loss or change in wetland type and function along the new river valley may, in some areas, be considered a loss of wetlands. In other areas, the change in wetland functions would be of high value to the riparian system of the relocated river.

Another change to wetland functional capacity would occur as a change in the hydrology of intermittent streams and tundra ponds directly adjacent to the new river valley. The New River Mouth Option may dewater the tundra ponds and intermittent streams located adjacent to or across the proposed route for the new valley. The existing high value palustrine emergent marshes have a high functional capacity when compared to other wetlands for sediment, nutrient and toxicant removal, organic matter production, and flood flow regulation.

As part of the New River Mouth Option, approximately 48.8 acres of the existing Snake River channel would be dewatered. Approximately 30.0 acres of the channel west of the main runway would be filled with unusable excavated material generated during valley construction. This material would consist of organics and silt, and would likely restore the old river bed to palustrine emergent dominated wetlands. These restored wetland areas would not pond water or receive overflow from the river except during high water events. The remaining section of dewatered channel would be seeded to stabilize the sediments for storm water management.

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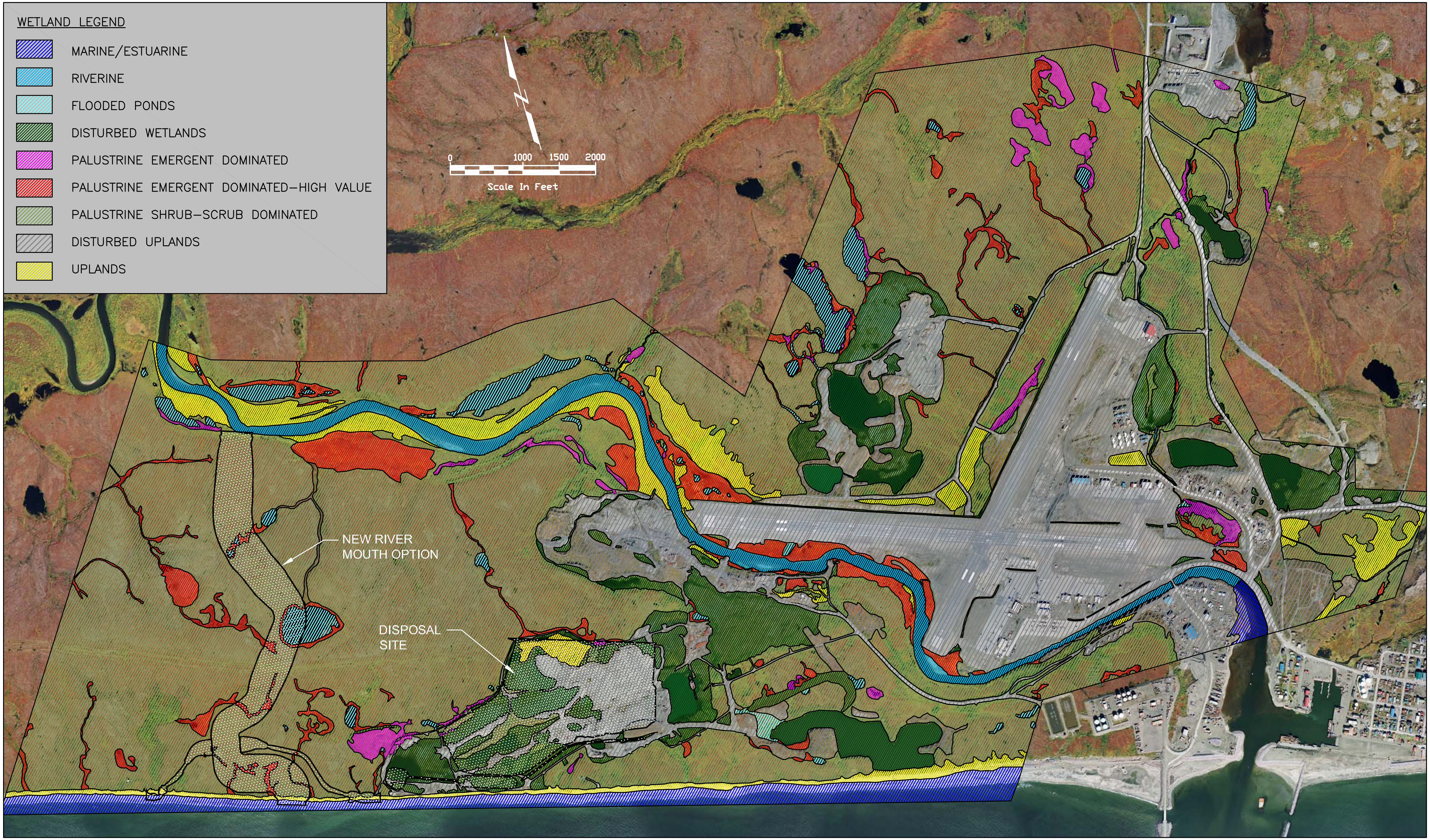

USKH SHARED VISION. UNIFIED APPROACH.	NOME AIRPORT RSA EXPANSION SNAKE RIVER RELOCATION NEW RIVER MOUTH AFFECTED WETLANDS	MAR. 2011 FIGURE H-8

I:\1182800\DWGS\C\HYDROLOGY\CONCEPT_DESIGN\FINAL CONCEPT DESIGN\APPENDIX_H\1182800_CD_FIG-H08.DWG PLOTTED: Mar 23, 2011 - 10:26:26 AM (Glenn Sears)

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Stockpiles and Disposal Areas

As the new valley is excavated, approximately 3.7 million cubic yards of overburden and unusable excavation may need to be stockpiled prior to transport to the permanent disposal site. Depending on the disposal site selected for this option, additional temporary and/or permanent wetland impacts may occur if overburden is stockpiled within wetlands. The preferred disposal option for this project is to permanently dispose of 310,000 cubic yards of materials within the old river channel, and 3.1 million cubic yards of materials within the previously mined area south of the airport. This disposal option would result in approximately 45.9 acres of fill in disturbed wetlands. Table H-2 identifies wetland losses through excavation and fill that would result from construction of the New River Mouth Option.

Table H-2 - Wetland Impacts from the New River Mouth Option

Wetland Type	Impact Acres	Restored Acres
River Valley Construction		
Marine/Estuarine	1.2	0*
Riverine	0.1	17.5
Flooded Ponds	3.5	0
Disturbed Wetlands	0	0
Palustrine Emergent dominated	4.7	19.7
Palustrine Shrub-Scrub dominated	65.4	0
Total	**74.8**	**37.2**
Dewatered Channel		
Riverine	48.8	30.0
Total	**48.8**	**30.0**
Disposal Area		
Marine/Estuarine	0	0
Riverine	0	0
Flooded Ponds	0	0
Disturbed Wetlands	39.6	0
Palustrine Emergent dominated	0.5	0
Palustrine Shrub-Scrub dominated	5.8	0
Total	**45.9**	**0**
Total Wetlands Impacted	**120.7**	**67.2**

*Some estuarine wetlands would be created near the mouth of the new river valley

2.8 Potentially Hazardous Materials

Contaminated Soils

Excavation activities related to construction of the New River Mouth option do not have the potential to impact any of the previously identified AOCs 1-4. Although elevated levels of naturally occurring metals such as arsenic and chromium have been identified in the Nome area (Phase II ESA, Nome Row Acquisition, 2004), no data have been found to indicate that this is the case for the New River Mouth Option. If elevated levels of naturally occurring metals were to be present within the newly constructed river channel, there might be the potential to mobilize bound metals and negatively impact aquatic receptors. Additional data regarding background metals concentrations and their oxidation states for the area affected would be required to understand the impacts of any elevated naturally-occurring metals concentration for the New River Mouth Option.

Construction of the New River Mouth Option would result in the reduction of flushing flow through the existing harbor. Initial studies conducted on the effect of existing Snake River flows on the water quality of the existing harbor reveal that the Snake River flow has a significant effect on water quality by increasing mixing efficiency. Although there is anecdotal information regarding contamination that is currently "capped" in the existing harbor mouth, no data regarding the types or concentrations of these contaminants have been found. However, elevated concentrations of arsenic, mercury, and PAHs have been identified in existing harbor mouth sediments (Nome Navigational Improvements Final Interim Feasibility and Environmental Assessment, USACE, July 1998), and lack of flushing flow to the harbor due to construction of the New River Mouth Option has the potential to reduce the dilution of these contaminants.

COST ESTIMATES

Rough order of magnitude cost estimates have been produced for the construction of the Reconnection Option and the New River Mouth Option. A discussion of the assumptions and data sources used in preparing the cost estimates is presented below.

Construction Techniques

The cost estimates for both options assume that the required excavation will be performed by conventional means (e.g., excavators, dozers, loaders, etc.) in the winter, and that drilling and blasting, or pre-thawing and dredging will not be necessary. If drilling and blasting were used, the unit cost per cubic yard of excavation would be expected to triple.

Due to the thaw-unstable nature of the in-situ soils to be excavated, the cost estimates for both options assume that excavation and stabilization construction will occur during the winter months when the ground is frozen. Construction will likely require two winter seasons to complete.

The Reconnection Option requires the mining pit pond to be dewatered. This dewatering would constitute a considerable effort and, therefore, the cost estimate for this option includes an item for dewatering. Dewatering will be required for both options for the new valley and channel excavation, but the dewatering item shown for the Reconnection Option is intended to cover and give consideration specific to the effort required to dewater over 100 million gallons of water from the mining pit pond. The method to accomplish this is still unknown, but ideas that have been considered include pumping and draining through a directionally-drilled pipe.

Disposal of Excavated Materials

Both options assume that the disposal storage berm will be constructed of approximately 257,000 cubic yards of material excavated for the new river alignment. Both options also assume that approximately 310,000 cubic yards of material excavated for the new river alignment can be displaced in the abandoned river channel once the river waters have been diverted to the new channel. Material excavated for the new valley and river alignment, and reused for the berm construction and to fill the old river channel, is categorized as Common Excavation.

Excavated material will otherwise be disposed of landside within the meltwater management berm system located within the project limits. It is assumed that no offshore disposal or landside disposal outside the limits of the project will be required. Material excavated and wasted is categorized as Unclassified Excavation.

Restore Vegetative Mat

This pay item, Restore Vegetative Mat, represents a combined method of stabilizing the side slopes of the new channel. The cost estimates (for both options) assume that a combined approach involving seeding, erosion-control mats, and salvaging of tundra will be used to stabilize the excavation side slopes and the new floodplain. Salvaging of tundra would involve stripping the existing vegetative mat from the new river alignment and placing the salvaged mats on the side slopes of the new river channel side slopes. Salvaging of tundra on this scale is unprecedented, however, similar techniques have been used on a much smaller scale on other DOT&PF projects in Kotzebue, King Cove, and Anchorage. Because this method is rather unconventional, available historical cost data is of limited use and is not expected to be representative for large quantities.

Historical Prices

To help identify costs for the estimate, USKH researched DOT&PF BidTabs Online, reviewed DOT&PF Compilation of Bids for several recent (2007-2009) Nome projects, and discussed methods of construction, schedule, and rough order of magnitude costs with a representative from the Anchorage Area Office of Kiewit Pacific Company. From these sources, reliable cost data was found for the more common, conventional pay items. However, the Restore Vegetative Mat item is the biggest unknown and the unit cost shown in the estimate is a best guess based on the historical costs for other, more conventional, means of stabilization and the assumption that the unit price would theoretically be lower due to the large quantity.

Special Provision Pay Items

The cost estimate for the New River Mouth Option includes the cost of construction of a bridge. The Reconnection Option includes the cost of a monofill for the disposal of drums that would be encountered during excavation. These two items are shown as special provision pay items with lump sum costs in the cost estimates. A discussion of the elements and assumptions of the bridge design is included with the detailed cost estimates provided in Appendix J.

Design Contingency and Construction Administration

The Snake River Relocation Options presented are conceptual. Quantities shown in the estimate are based only on conceptual, preliminary design efforts. Therefore, a 20% design contingency is shown as a single line item in the cost estimate for each option. In addition, a line item for Construction Administration was also included for 15% of the overall total cost.

The rough order of magnitude cost estimates for the two river relocation options are presented in Table H-3.

Table H-3 – Snake River Relocation Rough Order of Magnitude Cost Estimates

	Lower River Reconnection	New River Mouth
Construction Cost Subtotal	$55,880,000	$50,860,000
Contingency (20%)	$11,180,000	$10,170,000
Construction Administration	$10,060,000	$9,160,000
Total	**$77,120,000**	**$70,190,000**

Appendix I

Coastal Engineering Issues of Relocating the Snake River

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Coastal Engineering Issues of Relocating the Snake River

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December 15, 2009

Introduction

Several aspects involving relocation of the Snake River to a new location west of its present position have been addressed in this brief report. The first deals with constructing a bridge to span the new river location near its mouth. A method to attempt to estimate the rate of river migration of the new river mouth is also described. An estimate is also provided, using examples from other sites, to estimate the maximum migration distance for the new river location. Finally, the modeling effort to describe the differences in mixing and water quality in the harbor facilities that will remain after the river is relocated is then discussed. As an adjunct to that discussion, the modeling analysis of mixing conditions that existed in the boat harbor and lower river mouth prior to its relocation to its present position is described. In the conclusions' section some preventative and mitigation issues for the river mouth migration and to increase the mixing in the boat harbor and in, what is now, the lower river reach if the Snake River is relocated are also presented.

Bridge on the Relocated Snake River

Consideration is being given to locating the Snake River about two miles west of its present site. As I understand it, a beach-parallel reach would be designed in the river just before it crosses the beach. Its purpose is to provide an estuarine-like reach where young fish could acclimate to saline conditions before entering permanently into fully marine water. A bridge will be designed to cross the river somewhere above this designed reach. Care should be taken in determining how close to the beach bluff this dog-leg should be located and the long-term bluff erosion from the beach side should be considered. Two photographs (one from 1962 and another from 2009) were examined and no noticeable bluff erosion was suggested. An additional analysis using other photography should be completed before the design is finalized. The river's seaward bank should be located at least 200 feet north of the edge of the present bluff to allow for the current rate of erosion plus any probable accelerated erosion that could occur in the future. The bridge over the river could probably be safely located anywhere north of this beach-parallel section.

Possible River Mouth Migration

One of the concerns associated with locating the river to the west about two miles is how fast and how far could the river mouth migrate along the beach from the point where it originally crossed the beach. This is an issue that, to our knowledge, has never before been addressed analytically. It might be possible, however, to provide an upper limit to the rate of migration and then, based on experience and using analogies to other locations, to determine the likely length of the migrated section.

Before describing the procedure for estimating the possible migration rate, the physical process by which the river mouth could migrate will be described. This description will be a highly simplified and the actual process can be affected by several factors. Those include ice effects, the variability of sediment sizes that occur naturally along the beach, and the annual variability of storms, storm-surge levels, and river discharges and none of these is discussed further. The actual migration process would be expected to vary significantly from that discussed herein.

The process relies on the fact that breaking waves generate a longshore (littoral) current as they approach the shoreline obliquely. As the waves reach a certain depth relative to their height and wave length, they will break and much of their energy will be converted to force (actually to a force per unit area-often referred to as a wave thrust). This force will have both an onshore and a longshore component.

The longshore component is responsible for generating the littoral current. The onshore component is responsible for features like under-tows and rip currents. Both components can move sediments especially the sediments that are mobilized by the wave turbulence. The onshore component can move sediments perpendicular to the shoreline while the littoral current produces littoral transport parallel to the shoreline.

This discussion considers only the longshore component, but the onshore component can significantly alter the process of mouth migration. There is an assumed equilibrium between the sediments in suspension by the littoral current and the capacity of the current to carry sediment. Each particle is continually being deposited and re-eroded as it moves down the beach. If sufficient sediment loads are entering a certain portion of the beach and the wave conditions (and beach conditions) do not change within this section, no net erosion or deposition should occur.

Now consider the river being placed across the beach as in Figure 1. The major change created here is the water has deepened significantly due to the presence of the river. As the sediment-laden littoral current encounters the river, its longshore velocity decreases and it may be redirected offshore depending on the rate of flow in the river. Near the up-drift (relative to the littoral current) side of the river, the littoral current responds by depositing some of its sediment. As the littoral current moves further into the river, it and its sediments can be redirected offshore and be deposited when the water deepens and the river flow slows (Figure 2). This begins the development of offshore shoals that often are incorporated into a delta system.

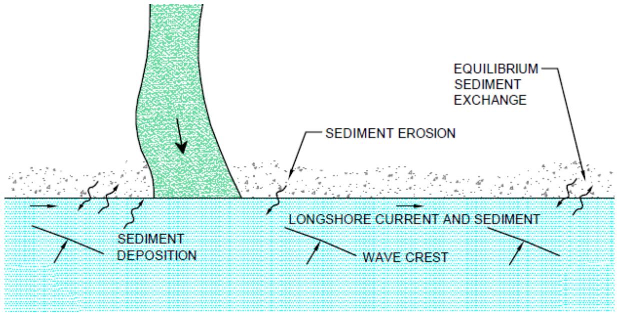

Figure 1. River's initial position across the beach.

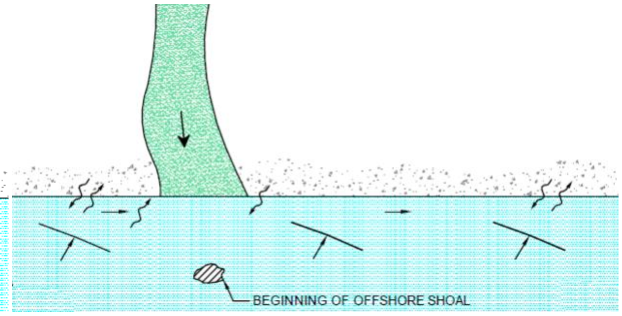

Figure 2. Erosion and deposition begin on opposite sides of the river.

On the downdrift side of the river, two additional responses begin to occur. First the littoral current begins to reform as the water shallows again and there is a slight increase in the river velocity on that side as deposition of the up-drift side has constricted the flow. Both will cause increased erosion of the material on this side resulting in the downdrift redirection of the river.

As this continues, a barrier bar forms on the up drift side of the river as the river mouth continues to move downdrift (Figure 3). Over time the barrier bar will continue to lengthen and this will cause an increased elevation of the river which will, in turn, eventually cause a breakout to occur somewhere up-drift (and upstream) of the river mouth (Figure 4). This results essentially in resetting the river mouth and starting the process over again.

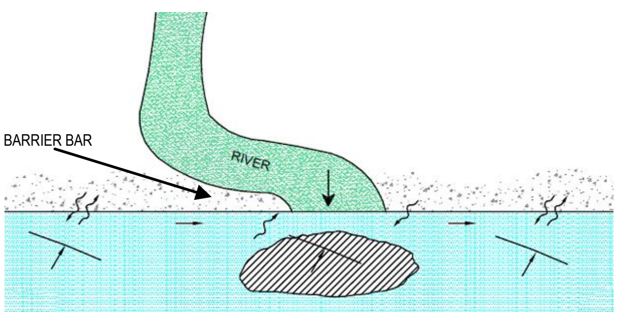

Figure 3 River continues to migrate and form barrier bar.

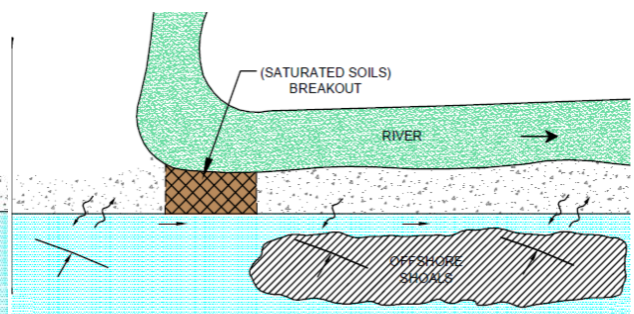

Figure 4. Migration has continued, breakout is likely.

Estimation of where and when these breakouts can occur could be improved with long-term observational data but are probably not predicable. Factors that can have a significant influence on these breakouts are the size of the sediments, the peak volume flow rates of the river and the frequency and height of storm surges.

The peak flows will increase the force exerted on the barrier bar from the river particularly where the river makes the initial bend to flow parallel to the shoreline. With regard to storms, a storm surge will essentially saturate the barrier bar material. This will severely reduce its strength and reduce the force necessary to create a breakout. In addition to the barrier's loss of strength, the storm surges are accompanied by waves that could completely remove the barrier bar anywhere along its length.

Some bars become vegetated that adds considerable strength to its soils, but this is more common in sheltered areas where the waves are less severe. This location is exposed to the full force of the North Pacific Ocean and the Bering Sea storms and its stability is probably tenuous at best. As described below (in the conclusions' section) it is suspected that a maximum river offset in this region could be about 2,000 feet based on what the offset on the Snake River appeared to be prior to its relocation in 2005.

The rate of migration depends on the net sediment transport and on the volume of the active beach. Active beach refers to that portion of the beach (above and below the waterline) that is in motion sometime throughout the year. Of course some years this may be greater than in other years.

It appears from examination of the other streams that enter Norton Sound in the vicinity of the proposed new mouth that this site probably has a net sediment transport to the east, but is less than the net eastward transport at the present river mouth. Some streams to the west of this site even appear to have a net transport to the west.

The rates of sediment transport (Q) can be estimated from the annual wave climate at the site, the sediment size, and the beach orientation. The process proposed herein to calculate the migration rates is the following. Adopting the usual convention in which the longshore sediment transport is positive to the right as an observer looks seaward and vice versa if $Q_+ > |Q_-|$, the entrance will tend to migrate to the left and to the right if $Q_+ < |Q_-|$. For the situation, "to the right" refers to the westward direction.

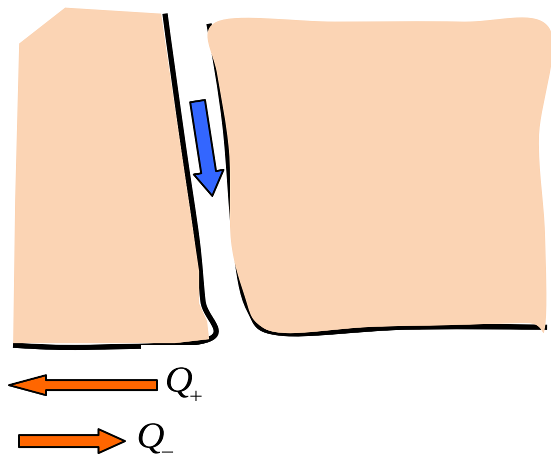

Figure 5. Definition sketch.

Considering the case, for example, in which $Q_+ > |Q_-|$, it may be possible to estimate an upper limit for the tendency to migrate. By estimating the height of the active profile, $h_* + B$ and width of the adjacent berm, W, respectively, two estimates of the rate of migration can be developed. The value, W, can be thought of as the distance from the base of the bluff to well offshore. The depth, B, is the total thickness of the beach from the bluff base to the low-water line and h⁎ represents the depth at the offshore extension of W as determined from the equilibrium profile.

The upper limit estimate is based on consideration of the total Q_+ transport contributing to the migration and results in

$$V_{Migration,Upper} = \frac{Q_+}{h_* + B\ \ W}$$

and the lower limit is

$$V_{Migration,Lower} = \frac{Q_+ + Q_-}{h_* + B\ \ W}$$

There are several variables that must be estimated or assumed to determine the sediment transport rate (Q). The equation that is used is

$$Q = 0.4 \frac{H_B^{2.5}\sqrt{g/\kappa}}{16(S-1)(1-p)} \sin 2(\beta - \alpha_B)$$

Where H_B is the wave height at breaking, β is the azimuth of the outward beach normal, α_B is the wave angle at breaking, S is the specific gravity of the sediments and p is the sediment porosity. Gravity (g) is 32.2 ft^2/s and the wave breaking ratio (κ) is 0.6.

To calculate the transport, 37 years of hourly wind data were first used to calculate H_B and α_B for each wind value. It appeared that the azimuth of the outward normal for the beach at this location was about 195°. The transports for this direction and several others are presented in Table 1.

Table 1. Transport rates for 37 years of wind data from Nome

Shore Normal Azimuth (Degrees)	Longshore Sediment Transport (1,000 cy/year)		
	Net Transport (Q)	Positive Transport (Q_+)	Negative Transport (Q_-)
195.0	+ 49.3	+ 83.3	- 33.9
185	- 279.2	+ 1.8	- 281.0
190	- 116.7	+ 20.5	- 137.2
200	+ 213.9	+ 214.7	- 0.9
205	+ 371.9	+ 371.9	0.0
193.5	- 0.5	+ 58.1	- 58.6

It appears that a null point (a point where the net transport is about zero) occurs when the beach azimuth is about 193.5 degrees. A positive net transport yields a transport direction to the west. To solve the equations for the transport rates, we have assumed an active beach width, W to be 400 feet. Based on the beach surveys and an assumed equilibrium beach profile, B and h_* together are taken as 21 feet. This yields an annual migration rate of about 6 feet to the west.

It was expected that the net transport would be to the east in line with what the transport is at the former river mouth and the current location of the breakwaters. Since the net transport was not to the east, as assumed it is suspected that there was a problem with the use of the archived wind data from the airport. These data were archived to the nearest 10°. That means that an error of 5° is possible. Since 195° is only 1.5° from an estimated null point, errors for this beach location can result in rather startling results. It has also been assumed that the directions and speeds for the airport are truly representative for the offshore region. No independent data are available to determine if that is true.

Work will continue on attempting to use this method to develop migration rates and while the physics of the approach seems correct, usable rates may have to wait for monitoring after the project is completed. The determination of a sediment budget, if that is possible, should also shed information about the possible migration rates.

Migration tendencies of river mouths appear to be strongest for generally weak river discharges such that the momentum of the out-flowing water would not tend to limit migration. If the river outflows were strong at periods that were shorter than or nearly the same as the time that is required for the bar to migrate past the river mouth, the tendency for the river mouth to migrate would be diminished. Such might be the case, for example, if the river had particularly high annual peak flows.

A bar across a river mouth will cause an elevated backwater curve during periods of high discharge, especially during the early phases of the increased discharge prior to the time that the discharge can flush the sediment forming the bar seaward. In some situations, this higher backwater curve can cause undesirable flooding. That should not be a problem here, however.

Water Quality Implications

A second question was to consider the effect of relocating Snake River on the water quality within the water bodies that will remain. These would probably include the lower 1,000 feet of the present river mouth, the boat harbor and the outer harbor created between the two breakwaters (Figure 6). Relocating the river would eliminate any assistance it provides to flush this area.

The lower river mouth represents the region that will undergo the largest physical change if the river is relocated to the west. Presently it directly receives the flow from the Snake River and is for the most part nearly entirely fresh water. Its fresh water then flows into the boat harbor and the outer harbor. Norton Sound water flows into the outer harbor from the open boundaries on its south end between the two breakwaters and through the gaps on each breakwater near the shore.

The flow in the Snake River is reported to have a mean annual discharge of 136 cubic feet per second (cfs) and this includes 11 cfs from the lower Snake River drainage. The boat harbor also receives a small amount of fresh water (annual rate of 10 cfs) from Dry Creek on its northern boundary. All of these boundaries represent sources that can refresh the water within the model domain.

Figure 6. Three areas of special concern within the entire domain.

To assess the current ability for the system to flush, a mixing efficiency coefficient was calculated for the entire domain and separately for the boat harbor as it is presently configured. Then the Snake River input (except for the lower Snake River input) was eliminated from the domain and the efficiency coefficients were recalculated and then the two conditions were compared.

The mixing efficiency coefficient (E) was first used by Nece[1] to investigate mixing in boat harbors using hydraulic physical models. It has been used many times since by this author and others including the investigation of over 140 hypothetical boat harbor configurations for the ADEC by Harvey Smith (the H. Norman Smith in the footnote reference) and Ruth Carter (both

[1] Nece, Ronald E., Eugene P. Richey, Joonpyo Rhee, and H. Norman Smith, 1979. Effects of Planform Geometry on Tidal Flushing and Mixing in Marinas, Tech Rept. No. 62, Charles W. Harris Hydraulics Laboratory, Dept. of C.E., UW, Dec. 1979, pp. 74

of ADOT&PF) and the present author (Doug Jones of Coastline Engineering). It was been found to be an effective tool for comparing design options with regard to the water quality impacts.

The coefficient E is defined as:

$$E = 1 - R$$

Where *R* is defined as the average, per cycle, retention coefficient and can be represented as:

$$R = \left(\frac{C_n}{C_o}\right)^{1/n}$$

Where C_o and C_n are the defined as the concentration of a dye initially and after n number of tides, respectively.

This has been adapted to computer modeling and simplified for more rapid analysis by assuming that initial concentration C_o is totally consisting of a contaminant (i.e. the concentration is 100 percent). For comparison, it is generally assumed that all the water that enters the domain is completely uncontaminated water. In fact, the case is that usually the incoming water may entrain some of the contaminant that flowed during the preceding ebb. To account for this entrainment, the size of the domain can be increased so that the area of interest becomes only a portion of the domain. That is not the case for this analysis.

The original study was able to determine that when the average value of efficiency coefficient exceeded about 0.3 (with other conditions on the overall distribution of E within the harbor) then mixing within the harbor was considered to be adequate. This value is equivalent to 30 percent of the volume being replaced on each tidal cycle. For the present case, the objective is not to design a harbor but only to compare mixing with and without the contribution of the Snake River inflow.

The model used to compute the mixing efficiency is the EFDC (**E**nvironmental **F**luid **D**ynamics **C**ode). It is a standard structured model that calculates the hydrodynamics and then uses this to calculate constituent discharge. The model is capable of both 2- and 3-dimensional analysis and was operated in the 3-dimensional mode for this analysis.

The modeling domain consists of 8,888 active cells. Each cell is a square with each side having a length of 26.25 feet (8 meters). The tide varies the depth within the domain causing some cells to go dry during ebb as the surface water elevation drops.

Using the model, the distribution of a hypothetical conservative substance from having an initial concentration of 100 percent is allowed to be diluted over four tidal cycles. At that time, its concentration is used to calculate the mixing efficiency coefficient (E) for each active cell within the domain. Figure 7 demonstrates initial concentration for both cases. Figure 8 shows the dilution after four tidal cycles when the river input is included (the present situation). Figure 9 presents the distribution after four tidal cycles without the river input (except for the lower Snake River input).

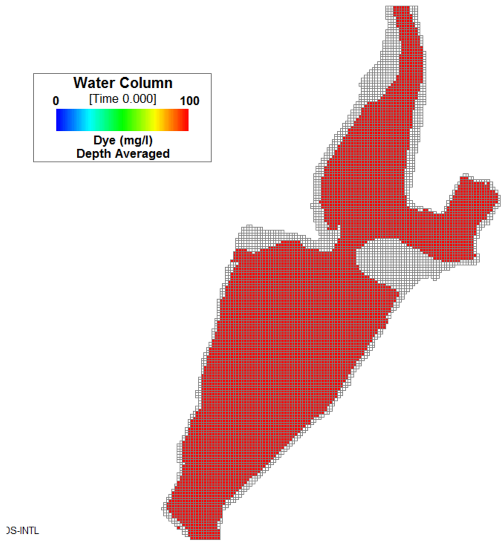

Figure 7. Initial concentration in the domain.

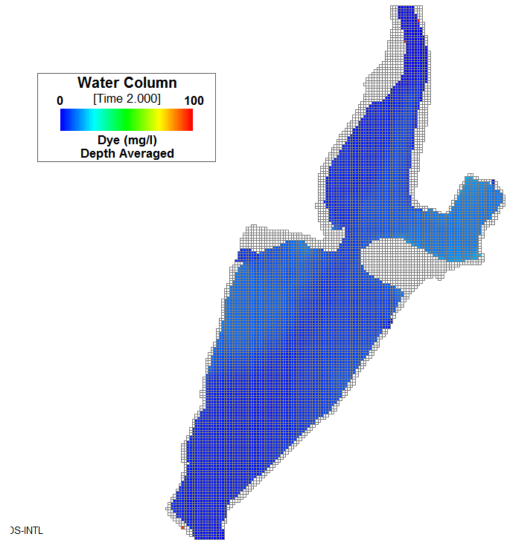

Figure 8. Concentration after 4 tidal cycles with the Snake River input considered.

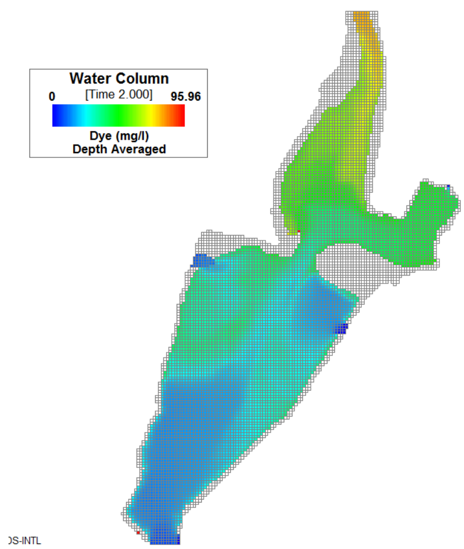

Figure 9. Concentration after 4 tidal cycles without the Snake River input considered.

From these, the E-values were calculated for four separate areas. These were:

- The entire domain-Region A
- The boat harbor and its entrance–Region B
- The entire region north of the inlet connecting the outer harbor with the remainder of the domain-Region C
- The outer harbor-Range D

These can be seen in Figure 6; however, they do not correspond exactly with the areas bounded by the red lines. Table 2 shows the E-values for the three areas with and without the Snake River input being considered.

Table 2. Mixing Efficiency Coefficients (E)

Region	With River Input	Without River Input
A	0.54	0.26
B	0.41	0.19
C	0.53	0.20
D	0.55	0.32

Even though the actual Snake River is not considered in the "Without River Input" column, the discharges from the lower Snake River and from Dry Creek (directly into the boat harbor) are considered in all cases as these should exist regardless of what changes are made to the river's location.

Table 2 suggests a significant difference between the two river input cases. The average E-value for the entire area is less than half that for the same area when the river input is considered (the present situation). Also it appears that compared to the "without river" case, the river increases the mixing efficiency by about of 100 percent.

An additional analysis was made to determine what the mixing was like in the boat harbor before the Snake River was relocated to its present location in 2005. Again using the same technique of introducing a hypothetical pollutant at the initiation of the model run and following it through several tidal cycles, we can calculate a mixing efficiency coefficient. Figure 10 shows the dilution of the pollutant after only one tidal cycle for both with and without the effects of the river taken into consideration.

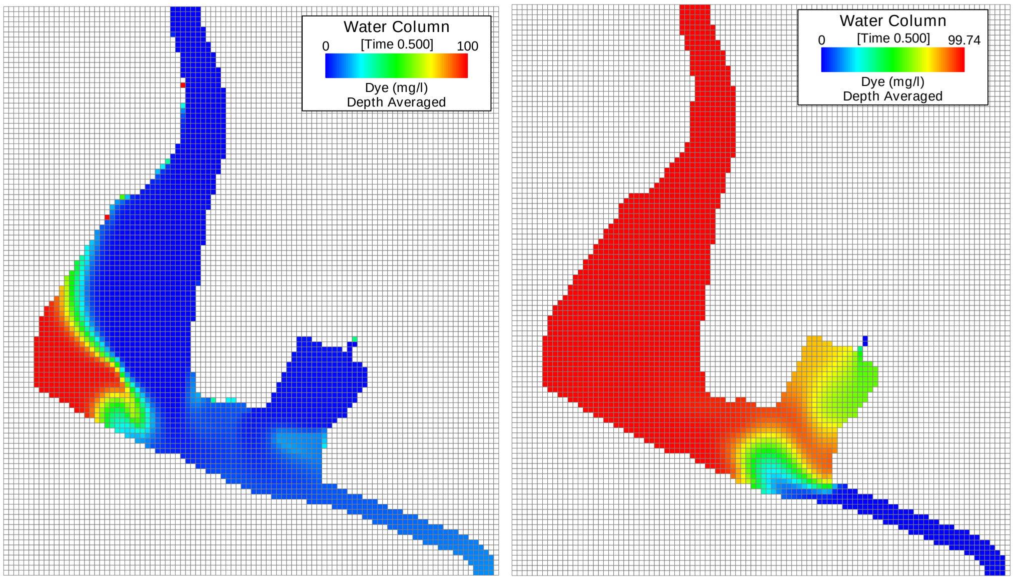

Figure 10. Concentration after 1 tidal cycle (left-with river influence; right-no river influence).

Analysis of the concentrations for this configuration indicates that the mixing was predominately due to the river as shown in the following table.

Table 3. Mixing Efficiency Coefficients for the former river location.

With River Input	Without River Input
0.91	0.26

The relocation of the river has degraded the flushing significantly. Mixing in the boat harbor now with the effects of the river included still indicate that it is mixed less than half of what it originally was before the 2005 relocation.

Conclusions

Water Quality

Snake River clearly has a significant effect on the water quality on the lower part of the river including the boat harbor and the outer harbor. It seems to more than double the mixing efficiency caused by tides and two smaller fresh water inputs. If the decision is made to relocate Snake River, then tidal mixing might be enhanced by changing the configuration of the entrance just north of the outer harbor and of the entrance into the boat harbor. By making both narrower is likely to create a “jetting” action that could enhance the circulation. That analysis was beyond the scope of this effort.

River Migration

The results of the sediment transport analyses have not been completed. Sufficient analysis has been done, however, to indicate that it is unlikely that a realistic migration rate for the river can be determined analytically. The wind direction data are likely not precise enough to obtain a reasonable estimate of the net sediment transport. This will be re-examined when the sediment budget is complete and perhaps a more realistic transport rate can be found.

The most reasonable way to estimate the maximum distance of migration is to consider a couple of examples. As was mentioned earlier, lower stream discharges correspond to longer migration distances. As examples, consider Starisky Creek near Anchor Point (Cook Inlet) and the Buskin River on Kodiak Island. Starisky Creek has a low discharge that is often so low that at points the discharge percolates into the beach, subsequently, leaving only spotty indications. However, when the flow is sufficient it can be clearly seen extending over 2.5 miles down the coast. There is evidence that breakouts have occurred at numerous places along its length and when those occur the river will reset from that location and then continue to migrate down the beach.

On the other hand, the Buskin River near the Kodiak Airport has roughly the same discharge (125 cfs) as the Snake River. It was relocated from south of its present position in 1939 to facilitate construction of the current airport. Since then the river mouth has migrated (perhaps continuously without a breakout) for a distance of about 1,500 feet. It appears that the Buskin's mouth migrates around its location, depending on storm direction and intensity, perhaps as much as 400 feet in either direction.

Another example is the current Snake River. Up until a few years ago, its mouth was located about 2,000 feet east of its present position. Its history before about a hundred years ago or so is unknown, but the previous position might be considered at its maximum migration extent. It is probably not unreasonable to assume that similarly 2,000 feet is a likely estimate to assign to the maximum excursion distance for the relocated river.

Mitigation

Possible Methods of Preventing Migration

Structuring a river mouth is an effective approach to reduce migration. Structures could be placed on the up-drift side, the downdrift side or both sides of the river mouth. A structure placed on the up-drift side would block transport to the downdrift beaches and would cause downdrift erosion. However, once bypassing of an up-drift structure commences, the migration tendency will reoccur.

If a structure of limited length is constructed on the downdrift side of an entrance, it will limit migration and cause sediment deposition on its up-drift side. These deposits will be flushed seaward during the stronger flows which will in turn be transported back into the downdrift littoral system by waves.

While not eliminating migration, it would probably not require too much effort to dredge a new mouth location if it is deemed to have migrated too far. A frequency of not less than about 20 years would certainly be doable. A dredge is at Nome to clear the sand that flows into the outer harbor through the fish passage breeches placed in the breakwaters. It wouldn't require much effort to reconfigure the river mouth while they were on site.

In summary of measures to prevent migration of a river mouth, structures can be effective but can also result in undesirable outcomes including downdrift erosion and increase in flood elevations. Although all combinations of structures should be considered, it appears that a single structure on the downdrift side of the river mouth has advantages in terms of effectiveness, cost and downdrift impacts.

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Appendix J

Cost Estimates

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Engineer's Estimate

State of Alaska - Department of Transportation and Public Facilities

Northern Region

Project Name: **Project Numbers:**

Nome Airport RSA Expansion Project
Snake River Relocation - Concept Design
Lower River Reconnection Option

Item No	Pay Item	Pay Unit	Quantity	Unit Price	Amount
D-701a	CM Pipe, 24-inch	Linear Foot	500	$200.00	$100,000.00
D-780a	De-Watering	Lump Sum	All Required	$250,000.00	$250,000.00
G-100a	Mobilization and Demobilization	Lump Sum	All Required	$5,000,000.00	$5,000,000.00
G-115a	Workers Meals and Lodging, or Per Diem	Lump Sum	All Required	$2,000,000.00	$2,000,000.00
G-130a	Field Office	Lump Sum	All Required	$100,000.00	$100,000.00
G-130b	Field Laboratory	Lump Sum	All Required	$75,000.00	$75,000.00
G-130g	Nuclear Testing Equipment Storage Shed	Each	1	$20,000.00	$20,000.00
G-131a	Engineering Transportation (Truck)	Each	4	$20,000.00	$80,000.00
G-135a	Construction Surveying By The Contractor	Lump Sum	All Required	$500,000.00	$500,000.00
P-152a	Unclassified Excavation	Cubic Yard	5,304,000	$5.00	$26,520,000.00
P-152aa	Common Excavation	Cubic Yard	567,000	$7.50	$4,252,500.00
P-154b	Subbase Course	Ton	107,000	$17.00	$1,819,000.00
P-154x	Granular Fill for Buttress	Ton	374,000	$20.00	$7,480,000.00
P-157a	Erosion, Sediment, and Pollution Control Administration	Lump Sum	All Required	$125,000.00	$125,000.00
P-157b	Temporary Erosion, Sediment, and Pollution Control	Lump Sum	All Required	$75,000.00	$75,000.00
P-157e	Erosion, Sediment, and Pollution Control Price Adjustment	Contingent Sum	All Required	$0.00	$0.00
P-157f	SWPPP Manager	Lump Sum	All Required	$100,000.00	$100,000.00
P-208c	Crushed Aggregate Surface Course	Ton	4,000	$45.00	$180,000.00
T-901a	Seeding	Acre	82	$10,000.00	$820,000.00
T-904x	Restore Vegetative Mat	Acre	84	$70,000.00	$5,880,000.00
S-146a	Monofill	Lump Sum	All Required	$500,000.00	$500,000.00
				Subtotal:	$55,876,500.00
	Design Contingency			20%	$11,175,300.00
				Subtotal:	$67,051,800.00
	Construction Administration			15%	$10,057,770.00
				Total:	$77,109,570.00

Engineer's Estimate

State of Alaska - Department of Transportation and Public Facilities

Northern Region

Project Name: **Project Numbers:**

Nome Airport RSA Expansion Project
Snake River Relocation - Concept Design
New River Mouth Option

Item No	Pay Item	Pay Unit	Quantity	Unit Price	Amount
D-701a	CM Pipe, 24-inch	Linear Foot	900	$200.00	$180,000.00
G-100a	Mobilization and Demobilization	Lump Sum	All Required	$5,000,000.00	$5,000,000.00
G-115a	Workers Meals and Lodging, or Per Diem	Lump Sum	All Required	$2,000,000.00	$2,000,000.00
G-130a	Field Office	Lump Sum	All Required	$100,000.00	$100,000.00
G-130b	Field Laboratory	Lump Sum	All Required	$75,000.00	$75,000.00
G-130g	Nuclear Testing Equipment Storage Shed	Each	1	$20,000.00	$20,000.00
G-131a	Engineering Transportation (Truck)	Each	4	$20,000.00	$80,000.00
G-135a	Construction Surveying By The Contractor	Lump Sum	All Required	$500,000.00	$500,000.00
G-710a	Highway Traffic Maintenance	Lump Sum	All Required	$250,000.00	$250,000.00
G-710c	Highway Traffic Control	Contingent Sum	All Required	$100,000.00	$100,000.00
P-152a	Unclassified Excavation	Cubic Yard	3,109,000	$5.00	$15,545,000.00
P-152j	Porous Backfill	Ton	65,000	$80.00	$5,200,000.00
P-152aa	Common Excavation	Cubic Yard	567,000	$7.50	$4,252,500.00
P-154b	Subbase Course	Ton	60,000	$17.00	$1,020,000.00
P-154x	Granular Fill for Buttress	Ton	201,000	$20.00	$4,020,000.00
P-157a	Erosion, Sediment, and Pollution Control Administration	Lump Sum	All Required	$125,000.00	$125,000.00
P-157b	Temporary Erosion, Sediment, and Pollution Control	Lump Sum	All Required	$75,000.00	$75,000.00
P-157e	Erosion, Sediment, and Pollution Control Price Adjustment	Contingent Sum	All Required	$0.00	$0.00
P-157f	SWPPP Manager	Lump Sum	All Required	$100,000.00	$100,000.00
P-180a	Riprap, Class I	Ton	12,400	$150.00	$1,860,000.00
P-208c	Crushed Aggregate Surface Course	Ton	3,000	$45.00	$135,000.00
T-901a	Seeding	Acre	82	$10,000.00	$820,000.00
T-904x	Restore Vegetative Mat	Acre	51	$70,000.00	$3,570,000.00
S-145a	Bridge	Lump Sum	All Required	$5,830,000.00	$5,830,000.00
				Subtotal:	$50,857,500.00
	Design Contingency			20%	$10,171,500.00
				Subtotal:	$61,029,000.00
	Construction Administration			15%	$9,154,350.00
				Total:	$70,183,350.00

Engineer's Estimate

State of Alaska - Department of Transportation and Public Facilities

Northern Region

Project Name: **Project Numbers:**

Nome Airport RSA Expansion Project
Snake River Relocation Concept Design
Reduced Reconnection Option (Option 4)

Item No	Pay Item	Pay Unit	Quantity	Unit Price	Amount
D-701a	CM Pipe, 24-inch	Linear Foot	1,400	$200.00	$280,000.00
D-780a	De-Watering	Lump Sum	All Required	$375,000.00	$375,000.00
G-100a	Mobilization and Demobilization	Lump Sum	All Required	$1,800,000.00	$1,800,000.00
G-115a	Workers Meals and Lodging, or Per Diem	Lump Sum	All Required	$575,000.00	$575,000.00
G-130a	Field Office	Lump Sum	All Required	$80,000.00	$80,000.00
G-130b	Field Laboratory	Lump Sum	All Required	$75,000.00	$75,000.00
G-130g	Nuclear Testing Equipment Storage Shed	Each	1	$20,000.00	$20,000.00
G-131a	Engineering Transportation (Truck)	Each	4	$30,000.00	$120,000.00
G-135a	Construction Surveying By The Contractor	Lump Sum	All Required	$200,000.00	$200,000.00
P-152a	Unclassified Excavation	Cubic Yard	1,580,000	$6.50	$10,270,000.00
	Fill in Old Channel	Cubic Yard	172,000	$7.50	$1,290,000.00
	Disposal Area Berm	Cubic Yard	84,000	$10.00	$840,000.00
	Channel Plug Material for Flow Cross-over	Cubic Yard	2,300	$30.00	$69,000.00
P-157a	Erosion, Sediment, and Pollution Control Administration	Lump Sum	All Required	$150,000.00	$150,000.00
P-157b	Temporary Erosion, Sediment, and Pollution Control	Lump Sum	All Required	$300,000.00	$300,000.00
P-157e	Erosion, Sediment, and Pollution Control Price Adjustment	Contingent Sum	All Required	$0.00	$0.00
P-157f	SWPPP Manager	Lump Sum	All Required	$100,000.00	$100,000.00
P-180a	Riprap, Class I	Ton	1,000	$150.00	$150,000.00
T-904x	Revegetation and Seeding New Valley and Floodplain	Acre	30	$50,000.00	$1,500,000.00
T-904x	Revegetation and Seeding Disposal Area Berm	Acre	10	$8,000.00	$80,000.00
T-904x	Re-vegetation and Seeding Disposal Area	Acre	34	$8,000.00	$272,000.00
T-904x	Revegetation and Seeding Fill in Old Channel	Acre	18	$8,000.00	$144,000.00
	Channel Habitat Features	Each	20	$10,000.00	$200,000.00
S-146a	Monofill for Areas of Concern	Lump Sum	All Required	$300,000.00	$300,000.00
				Subtotal:	**$19,190,000.00**
	Contingency			20%	$3,838,000.00
				Subtotal:	**$23,028,000.00**
	Construction Engineering			15%	$3,454,200.00
				Subtotal:	$26,482,200.00
	icap			4.25%	$978,690.00
				Total	$27,460,890.00

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BRIDGE DESIGN NARRATIVE

General conditions

The construction process envisioned for this project is to excavate the new river channel to some level slightly above the high tide mark. The bottom of this excavation would be fortified with compacted structural fill to create an access road from the beach to the bridge site. Drainage ditches would be created on each side of this new access road at the base of each cut slope to intercept surface runoff and seepage.

The bridge would be constructed over "dry" ground to aid concrete forming, staging, scaffolding and other construction related activities. Once the bridge is completed, excavation would resume, reducing the bottom of the channel to that of the new river channel.

The designer envisions that the general contractor would build a temporary dock facility at the mouth of the new river channel as a means of receiving equipment, materials, and bridge components. Part of the material being excavated could be placed between sheet pile walls driven into the beach and extending out into the bay, in order to create a dock structure. Dredging will likely also be required to provide adequate depth to float barges to this temporary structure.

Temporary project facilities are also anticipated for the bridge site. The bridge project office can be located in the river channel above or below the new bridge crossing. In addition, the project will likely require temporary enclosures for materials and equipment; both for warm storage and for maintenance purposes.

The estimate also includes monies for temporary heat and site lighting. The project is expected to extend beyond a single construction season. Late season construction will likely require heating portions of the structure as concrete cures, or as other operations deem it necessary. The short days of fall and winter will likely require that the contractor provide temporary site lighting as well. The rigors of this site will be a challenge for the construction crew(s).

Bridge construction details

The new channel for the proposed river relocation may be nearly 45 feet deep at the bridge crossing. Crossing at the top of the new channel would require a span of nearly 400 feet. The bottom of the proposed bridge is located at 17 feet above sea level, placing the structure about 3 feet above the maximum conceivable high water level. Placed at this elevation, the bridge span is approximately 300 feet. Details of the proposed bridge follow in the text below.

Bridge deck

The bridge deck was estimated to be 40 feet wide by 300 feet long. The 40 feet width is slightly wider than the proposed road section to simplify calculation for the purposes of this report, and also to ensure the estimate is slightly conservative. The deck is imagined to contain 12 inches of gravel fill over an 8 inch concrete deck. The gravel fill was chosen to eliminate the transitional difficulties that exist between a gravel road surface and the hard bridge deck. A gravel surface will not degenerate as a result of freeze/thaw cycles, and it is easily maintained with available equipment and personnel.

Guard Rail

The estimate includes a steel rail system on each side consisting of three horizontal tube rails spanning between "I" shaped steel posts (California Type CA-117). The open rail system was selected to allow wind scout to minimize snow accumulations on the bridge. The thought is that a solid concrete barrier would trap snow on the deck and lessen the distance between the top rail and the driving surface for winter traffic.

Girders

Standard 54-inch pre-cast, pre-stressed concrete bulb T girders were selected for this estimate. Twelve girders are proposed, four abreast on each of three 100-foot spans. As such, each girder would support a tributary width of 10 feet. The 100-foot girders were selected over fewer, longer (150-foot) girders to facilitate transporting and handling the girders on site.

Abutments

The bridge abutments are expected to be cast-in-place concrete pile caps over steel pipe piles which extend to bedrock. The pile cap is estimated as a rectangular structure 5 feet deep, 8 feet wide and 40 feet long. A 16-inch thick by 5-foot high concrete headwall will extend for the 40-foot width to encapsulate the ends of the girders. Wing walls are not anticipated, given the geometry of the bridge crossing.

Abutment piles

The structural piles under the bridge abutments are estimated to be 18-inch diameter pipe piles spaced 5 feet on center. The pipe piles will be driven open-ended to bedrock, then evacuated to approximately -5 feet mean sea level (msl), and filled with a heavily reinforced concrete structure. The reinforced concrete section will extend upward into the pile cap section.

Intermediate piers

Two intermediate in-channel piers are included in the estimate. The piers will support a pile cap approximately 8 feet wide, 8 feet high, and 40 feet long on four 48-inch diameter steel pipe piles driven to bedrock at an elevation of -45 feet. As with the 18-inch pipe piles, the 48-inch piles will be evacuated and filled with a reinforced concrete column section extending up into the pile cap. The bottom of the concrete fill is expected to be about -5 feet msl.

The in-stream piers include an “ice-breaking” structure on the upstream edge. This feature will include a sloped steel structure extending from about -5 feet msl to approximately +10 feet msl. It will serve to break the ice flowing downstream to relieve ice loads acting on the bridge pier piles.

Other types of structure

This narrative is not intended to limit the new bridge to the structure described. Structures other than the concrete bridge described in this narrative could be used to make this river crossing, provided those structures conform to the requirements of the American Association of State Highway and Transportation Officials (AASHTO) “Standard Specifications for Highway Bridges” and amended and adopted by the State of Alaska.

This narrative is only intended to describe one possible solution, and to determine an order of magnitude estimate of the construction cost for that structure, given the prevailing conditions at the project site.

Appendix B – Stockpile Area Options

The following evaluates alternatives for the location of the proposed stockpile site presented in the Draft Environmental Assessment. In the Final Environmental Assessment, in response to agency comments, the analysis was ultimately revised, and Stockpile Site 2 was selected as the Least Environmentally Damaging Practicable Alternative (LEDPA). See Appendix D for additional information.

Nome Airport Runway Safety Area (RSA) Improvements Stockpile Site Options Analysis

Safety improvements at the Nome Airport as identified in the Proposed Action would generate a large amount of excavated material which would require disposal. It is anticipated that construction of the crosswind runway embankment alone would result in approximately 280,000 cubic yards of excavated material. A large portion of this excavated material would not be used for this proposed project, however much of it is expected to be useable and should be stockpiled for reuse for maintenance activities or for future airport projects.

Therefore, a stockpile site is needed to provide storage for the excess excavation associated with the Proposed Action. The stockpile site needs to be large enough for the project and to be in a location compatible with the Airport Master Plan Update (AMP) and the Airport Layout Plan (ALP). Costs to haul material are expensive. Preferably, the stockpile site would be close to the area generating the most excavation to provide a short haul route, would require as little additional property acquisition as possible and would be contiguous to airport property so it could be utilized in the future for other purposes such as providing area for snow storage, equipment storage and staging, material storage, impound yard, or leasing for aviation purposes.

Minimizing the acquired ROW for the stockpile area is important. Four options for stockpile site locations (sites 1, 2, 2a and 3) were evaluated for project feasibility, airport needs and potential environmental impacts. Figure A shows the locations of the four stockpile site alternatives. Criteria considered in the selection of a preferred stockpile site are shown on the attached matrix and include the following factors:

- Amount of Right of Way (ROW) acreage required
- Impacts to wetlands
- Contaminated areas affected
- Impact to cultural resources
- Whether the site is compatible with the AMP and if the location would benefit the airport
- The distance of the haul route and how much it would cost to transport the material
- Would haul roads need to be constructed or improved?
- The estimated cost of wetland mitigation
- The total estimated cost range to develop and use the site
- Whether additional mining claim parcels would be required for ROW acquisition beyond what is needed for the airport improvement project
- Could ROW acquisition require additional time and potentially delay the project beyond 2015?

The following stockpile site options were considered but dismissed:

Stockpile Site 2

The location for Stockpile Site 2 was chosen for analysis because it is the closest area of uplands/previously disturbed land to the area of excavation. Stockpile Site 2 would be located west of the crosswind runway in an area previously used for mining activities. A short access road would link the site to Construction Road. It is likely that improvements would be needed for both a portion of Construction Road which is not being relocated as well as the short access road leading to the stockpile site. Part of Site 2 was used in the past for equipment storage and contains a small amount of known soil petroleum contamination that would require cleanup before stockpiling at this location. Although minor, the cleanup of contaminated soils may delay ROW acquisition and therefore the project beyond the 2015 completion deadline for RSA improvements. The site would be largely contained within the disturbed upland area of the mining development, and would impact about five acres of wetlands (not including improvements to the haul route). There are no future airport improvements for this location identified in the AMP. This site would be separated from the proposed airport property, connected by an access road, and therefore would not provide as many benefits to the airport as if it were contiguous to the airport. The longer haul distance and maintenance of the access road would make this site much less likely to be used by maintenance in the winter for snow storage. Future use of this site would have limited function. Combined cost consideration to develop this site ranges from $439,218 to $613,968. Due to the potential project schedule delay caused by contamination presence and lack of direct benefit to future airport use and operations, this alternative was dismissed from further consideration.

Stockpile Site 2a
The location for Stockpile Site 2a was chosen for analysis in order to provide benefits similar to Stockpile Site 2 while avoiding contaminated soil. Avoidance of contamination would increase the amount of wetland habitat impacted. Furthermore, this site would have the second highest ROW requirement at 25.9 acres. Similarly to Site 2, the land is not contiguous to the proposed airport property. Separation from existing airport property would not provide direct benefits to the airport by supplying a contiguous area to conduct airport operations. The longer haul distance and maintenance of the access road would make this site much less likely to be used by maintenance in the winter for snow storage. Combined cost consideration to develop the site ranges from $509,283 to $703,533. Four additional mining claim parcels would be required for ROW purchase in addition to the acreage required for the airport project improvements. Due to the amount of ROW required, greater wetland impact than sites 2 and 3, the projected cost to purchase in comparison to the other sites, and lack of direct benefit to future airport use and operations, this alternative was dismissed from further consideration.

Stockpile Site 3
The location of Stockpile Site 3 was chosen for analysis because it is a previously disturbed area near the river realignment excavation and it was originally evaluated during analysis of an earlier improvement alternative. The site would be located south of the Snake River, southwest of the existing airport property. The site would not be contiguous with proposed airport property and would provide the furthest haul route distance, which increase haul costs significantly. It is likely that improvements to the haul route would be needed for all gravel surface roads, from approximately the Snake River Bridge to the stockpile site. The site would be located on land disturbed from mining activities and would impact about 2 acres of wetland habitat. This site would require the most ROW at 34.1 acres. There are no future airport improvements for this location identified in the AMP. Separation and distance from the proposed airport property would not provide direct benefits to the airport by supplying a contiguous area to conduct airport operations. There would likely be no future use of this site by the airport. Combined cost consideration to develop the site is the highest of all sites considered and ranges from $1,427,117 to $1,682,867. Due to the large amount and projected high costs of ROW and lack of benefit for future airport operations and use, this alternative was dismissed from further consideration.

Preferred Stockpile Site Alternative- Stockpile Site 1

None of the considered sites ranked the highest in meeting the selection criteria described above. Therefore the advantages and disadvantages of each site were weighted with respect to this project as well as overall airport needs. Stockpile site 1 was selected as the preferred alternative.

The location for Stockpile Site 1 was chosen for analysis because it is close to the area of excavation, is compatible with the AMP and ALP, and would provide benefits to the airport due to its proximity. The site would be located northwest of the existing airport property and adjacent to the relocated Construction Road. The stockpile site and the relocated road would be constructed on open tundra. The eastern border of the site would be contiguous to the proposed airport property. The relocated Construction Road would provide access to the stockpile site; therefore no improvement to the haul route would be needed outside of the already planned improvements for this project. This site would require the lowest acreage of ROW acquisition at 16.6 acres and would impact the least amount of additional mining claims. Even though this site would impact the most wetlands, the site is situated to avoid high value wetlands, the majority of wetlands impacted being of low-to-moderate quality. The site does not affect any known contaminated areas. This site would be most convenient for future airport uses and would reduce costs for future airport projects as well as current and/or future maintenance activities. Stockpile Site 1 could benefit future projects by providing an adjacent location for equipment staging, waste disposal, material storage, impound yard, leasing for aviation purposes, revenue generation that would directly affect the airport. Combined cost estimates to develop the site range from $444,967 to $569,467, the lowest high-end cost estimate of all the options. For these reasons, Site 1 was selected as the preferred alternative stockpile site.

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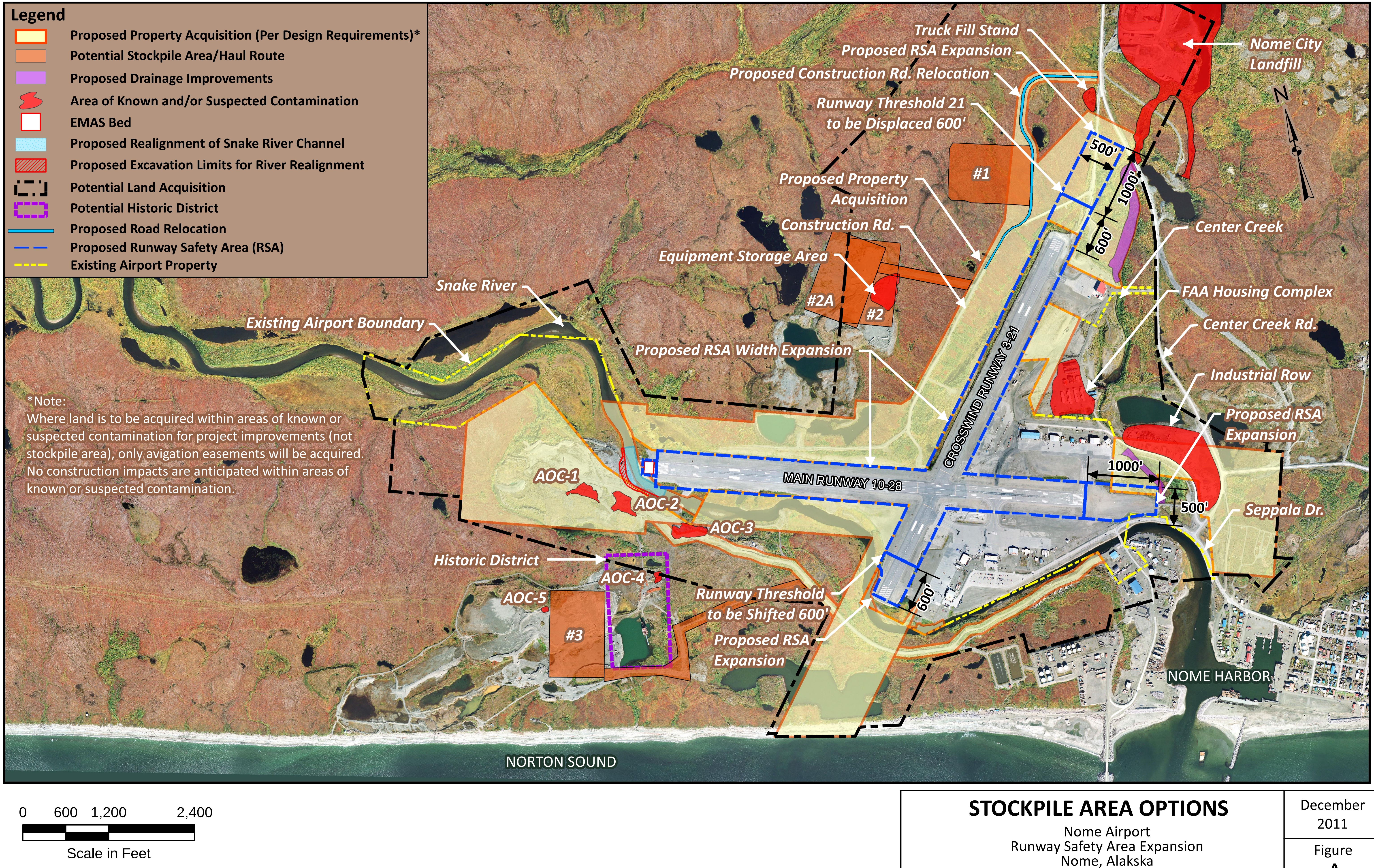

STOCKPILE AREA OPTIONS

Nome Airport
Runway Safety Area Expansion
Nome, Alaska
DOT&PF Project No. 61413

December 2011

Figure A

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Nome RSA Safety Improvements
Stockpile Area Options Matrix

Stockpile Location	Total ROW Required Including Haul Route (acres)	Wetland Impact* (approximate acreage)	Contamination Areas	Cultural Resources	Compatibility With Airport Master Plan/Land Contiguous With Existing Airport Property	Haul Distance (miles) **	Cost to Haul Material To Stockpile Area (gallons of diesel fuel required)***	Estimated Wetland Mitigation Cost†	ROW Take Considerations††		Property Acquisition May Delay The Project Beyond 2015
									Estimated Cost Range	Number Of Additional Mining Claim Acquisitions Required+	
Site 1	16.6	High Value: 1	No. There are no identified contaminated sites within the footprint of this potential stockpile area.	No. No cultural resources have been identified within the footprint of this potential stockpile area.	Yes. This potential stockpile area coincides with the potential location of the future general aviation (GA) apron that is identified in the Nome Airport Master Plan Update. The land would be contiguous with the proposed airport property and would benefit the airport by allowing use as snow storage, equipment storage, staging, materials storage and other beneficial uses directly affecting the airport.	0.5	$326,667 (2,333)	$76,800	$41,500 - $166,000	2	No.
		Low/Moderate: 20				**Anticipated Haul Route Improvements:** No	**Combined Cost:** $444,967 - $569,467				
Site 2	23.3	High Value: 0.01	Yes. There is minor soil staining present within this site, however estimated quantity of contaminated soil is low. It is anticipated that 3 cubic yards of petroleum contaminated soil will require clean up prior to stockpile area use.	No. No resources eligible for NRHP are located within this area.	No. There are no future airport improvements for this location identified in the Nome Airport Master Plan. Land is not contiguous to proposed airport property. Distance from existing airport does not allow for direct benefit to airport uses by providing a contiguous area to conduct airport operations. Future use of this site would be limited.	0.6	$364,000 (2,800)	$16,968	$58,250 - $233,000	3	Yes. Property Acquisition would be held up until cleanup of contamination is complete.
		Low/Moderate: 4.7				**Anticipated Haul Route Improvements:** Yes, 0.25 miles	**Combined Cost:** $439,218 - $613,968				
Site 2a	25.9	High Value: 0	No. There are no identified contaminated sites within the footprint of this potential stockpile area.	No. No resources eligible for NRHP are located within this area.	No. There are no future airport improvements for this location identified in the Nome Airport Master Plan. Land is not contiguous to proposed airport property. Distance from existing airport does not allow for direct benefit to airport uses by providing a contiguous area to conduct airport operations. Future use of this site by the airport would be limited.	0.7	$401,333 (3,276)	$43,200	$64,750 - $259,000	4	No.
		Low/Moderate: 12				**Anticipated Haul Route Improvements:** Yes, 0.3 miles	**Combined Cost:** $509,283 - $703,533				
Site 3	34.1	High Value: 0	No. There are no identified contaminated sites within the footprint of this potential stockpile area.	No. The Nome Historic Mining District is directly adjacent to the area, although no adverse effect to the historic district is anticipated.	No. There are no future airport improvements for this location identified in the Nome Airport Master Plan. Land is not contiguous to proposed airport property. Distance from existing airport does not allow for direct benefit to airport uses by providing a contiguous area to conduct airport operations. There would likely be no future use of this site by the airport.	3.2	$1,334,667 (14,933)	$7,200	$85,250 - $341,000	2	No.
		Low/Moderate: 2				**Anticipated Haul Route Improvements:** Yes, 1.75 miles	**Combined Cost:** $1,427,117 - $1,682,867				

Nome RSA Safety Improvements
Stockpile Area Options Matrix

* The amount of wetland impact for Site 1 is higher than the total ROW acquisition because the impact of constructing a longer realignment of Construction Road is included in the approximation. Although less ROW is necessary for the Site 1 alternative, the proposed Construction Road realignment (the road used to access Site 1) would need to be slightly longer for this option than if Site 1 were not developed. All other wetland impact amounts do not include impacts associated to haul route improvements.

** One way haul distance from the north crosswind runway excavation location to the stockpile area.

*** Cost estimate to haul material from the north crosswind runway excavation location to the stockpile area. Assumes 280,000 cy of excavation to be hauled. Round-trip distances were used in the calculation. Only the excavation for the crosswind runway was considered in the estimate since it is the project component with the greatest amount of estimated excavation. The relatively small amounts of estimated excavation for the river relocation and the ditching north of the main runway and east of the crosswind runway are comparable, so those quantities were considered to balance out and were not considered in the cost. Cost based on a cubic yard-per-mile amount as follows: Site 1: $1.17; Site 2: $1.08; Site 3: $1.02; Site 4: $0.74). Gallons of fuel required for haul of material took into consideration the equipment type and fuel economy, number of trips required, and haul distance.

†Assumes approximately $2,400 per acre wetland mitigation would be required. Assumes a 2:1 ratio of mitigation for high value wetland impacts and a 1.5:1 ratio of mitigation for moderate and low value wetland impacts.

†† Cost based on a range of $2,500 to $10,000 per acre land value.

+The number of additional mining claims required for acquisition increases the level of uncertainty of the ROW cost.

Appendix C – EFH Assessment

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Essential Fish Habitat Assessment
Nome Airport RSA Improvements Project
Nome, Alaska

Prepared for
Federal Aviation Administration

January 4, 2012
12613-05

Essential Fish Habitat Assessment
Nome Airport RSA Improvements Project
Nome, Alaska

Prepared for
Alaska Department of Transportation and Public Facilities
and
Federal Aviation Administration

January 4, 2012
12613-05

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ESSENTIAL FISH HABITAT ASSESSMENT
NOME AIRPORT RSA IMPROVEMENTS PROJECT
NOME, ALASKA

1.0 INTRODUCTION

The purpose of this document is to present the findings of the Essential Fish Habitat (EFH) assessment conducted for the proposed Nome Airport (Airport) runway safety areas (RSA) Expansion project, as required by the Magnuson-Stevens Fishery Conservation and Management Act, as amended. The objective of this EFH assessment is to describe how actions proposed for the Airport expansion may affect EFH designated by the National Marine Fisheries Service (NMFS) and the North Pacific Fisheries Management Council (NPFMC). According to the NPFMC, EFH within Norton Sound includes all estuarine and marine waters and substrates from the shoreline to the seaward limit of the Exclusive Economic Zone. The Snake River contains essential spawning and rearing habitat that is considered EFH for several species of anadromous salmon. Nome Harbor just downstream of the project area also supports marine fish and invertebrates for which EFH has been designated.

2.0 PROJECT DESCRIPTION

2.1 Project Location

The Nome Airport is located 2.5 miles northwest of the City of Nome, Alaska at 64.51055° North Latitude and 165.44452° West Longitude. The project area includes Sections 21–23 and 26–28, Township 11S, Range 34W, Kateel River Meridian, USGS Quad Nome C-1 (Figure 1). The project area, the area that could experience direct or indirect effects from Airport expansion alternatives, is defined as the lower Snake River, adjacent riparian and wetland habitat, tundra, and the estuary of Nome Harbor.

2.2 Project Description

The purpose of the proposed project is to improve the Nome Airport RSAs as required by a congressional mandate. An RSA is an area surrounding the runway that is cleared to enhance safety and reduce the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway. It also provides greater accessibility for fire-fighting and rescue equipment during such incidents. Congressional mandate (Public Law 109-115) requires all applicable airports to improve their RSAs in accordance with Federal Aviation Administration (FAA) safety standards by December 31, 2015. FAA design standards allow for a reduced RSA alternative if it is not practicable to construct a standard RSA at an existing airport. The FAA-approved, non-standard RSA improvement would comply with public law.

Both the main and crosswind runways (RW 10-28 and RW 3-21, respectively) at the Nome Airport are currently classified as Transport Airport Reference Code C-III runways and service commercial jets. FAA design standards for this airport classification identify that safety areas around these runway types should be 500 feet wide and should extend 1,000 feet beyond each runway end (threshold). However, the RSAs of both the main and crosswind runways at the Nome Airport do not meet FAA design standards.

The Proposed Action is shown on Figures 2 through 4 and includes the following elements with a potential to impact EFH:

- Improvement to both the main and crosswind runways to address RSA deficiencies;
- Realignment of the Snake River channel around the RSA expansion at the west end of the main runway;
- Drainage improvements constructed to the east of the crosswind runway and northeast of the main runway that would affect portions of Center Creek; and
- Development of a stockpile area for unused excavated material generated from various project components.

2.2.1 Proposed Action Details

2.2.1.1 Main Runway (10-28)

The main runway at Nome Airport, Runway 10-28, does not meet FAA safety area standards. The existing safety area is deficient in width, there is no safety area beyond threshold 10, and the graded area beyond threshold 28 is of deficient width and narrows to less than the runway width towards the east end. To comply with the congressional mandate to improve safety areas, existing cleared areas along the north and south sides of the runway would be graded to create a 500-foot-wide RSA along the entire paved runway, with only minor deficiencies in width on the southwest end. Additionally, threshold RSAs would be constructed at the east and west ends of the runway, respectively.

A 1,000-foot-long RSA would be built beyond the eastern end of the runway by grading and extending the existing cleared area to the width practicable without impacting Seppala Drive and the Snake River. This RSA would be deficient in width on the south side for 500 feet on the east end (Figure 2).

A new 200-foot-wide by 190-foot-long embankment off the western end of the runway would provide for a 170-foot-long RSA equipped with an EMAS. An EMAS is designed to stop an aircraft that overshoots a runway without causing structural damage to the aircraft. It consists of a bed of high-energy absorbing, cellular cement material that is designed to crush under the weight of aircraft and exert deceleration forces on the landing gear. To meet FAA design standards, the RSA should be widened to 500 feet along its entire length; however, if an RSA is equipped with EMAS, the width should correspond with the runway width plus enough area to slope the sides of the raised arrestor bed for emergency personnel access and safe passenger egress. A 150-foot-wide and 135-foot-long EMAS arrestor bed would be constructed on the paved RSA surface beyond the west threshold, with a set-back/lead-in ramp of 35 feet. The north and south edges of the EMAS bed would slope for 10 feet to allow access for emergency personnel and safe passenger egress from aircraft. The RSA would include a 20-foot-wide paved access off the west end of the arrestor bed, and a 15-foot-wide paved access on the north and south sides of the arrestor for maintenance and emergency vehicle access.

This alternative would result in the extension of the western embankment into the Snake River and would therefore require realignment of a segment of the river farther west to accommodate the extension (Figure 3 and 4). The river would be realigned between approximately river miles (RMs) 2.1 and 2.3 and routed around the RSA expansion area in a new 900-foot-long channel. A ditch on the north side of the main runway would be improved and water would continue to flow from the drainage to the Snake River as it does at present. The design of the realigned Snake River channel would be based on maintaining the cross-sectional area of the existing channel, in order to mimic the existing hydraulic regime of the river. Therefore, the realigned channel would have cross-sectional geometry, and flood flow and spring breakup ice flow conveyance characteristics similar to those of the existing river.

The maximum slope of the RSA embankment where it extends into the new river channel would be 2:1 (horizontal to vertical; Figure 4). The cut slope geometry on the outside of the bend across the river from the expanded RSA would be based on the existing cross-sectional geometry of the river, with a maximum slope of 3:1. Cut slopes above the ordinary high water line (OHW) would be revegetated with a seed mix appropriate for the region. The anticipated maximum depth of excavation for the proposed river realignment is approximately 25 feet. Construction dewatering would be required to manage groundwater within excavation limits. Approximately 25,000 cubic yards (cy) of excavated material would be generated from the river realignment. Usable material would be placed as fill on the new embankments of the main and crosswind runways. Unusable excavated material would be stockpiled in a DOT&PF stockpile area proposed as part of the project (see below). River realignment would provide for feasible RSA improvements to comply with the congressional mandate by the 2015 deadline.

The Proposed Action would require acquisition of land and realignment of the Snake River for the west end RSA expansion. The Proposed Action would avoid impacts to the adjacent Seppala Drive at the east end of RW 10-28, and allow preservation of the existing instrument approach procedures.

2.2.1.2 Crosswind Runway 3-21

Runway 3-21, the crosswind runway, does not meet FAA safety area design standards. The existing RSA is deficient by 200 feet in width and lacks safety areas beyond either threshold. To improve these deficiencies, the RSA would be widened to the standard 500 feet, except on the south end of the runway where it would follow the existing embankment to avoid additional impacts to the Snake River (Figure 2). To accommodate the new RSAs, the northern embankment of the crosswind runway would be extended 1,600 ft and the runway thresholds would be shifted 600 ft to the north. Approaches from the north would use declared distances and displaced thresholds. This would allow aircraft approaching from the north to use the existing threshold locations for continued use of the existing navigational aids and the existing available runway length. Approaches from the north would have 1,600 ft of undershoot RSA, but the present condition of no overrun protection would persist. The southern threshold safety area would be a non-standard length of 600 ft for approaches and take-offs from the south; however, the threshold shift north would also allow the airport to maintain nighttime approach procedures from the south because it would eliminate airspace obstructions to correct a current FAA Flight Standards deficiency.

The NAVAIDs for RW 3 would be relocated, the new 600 feet of runway and shoulder surface would be paved due to the threshold shift, the existing drainage ditch west of the crosswind runway would need to be moved further west to allow widening of the safety area, and segments of Construction Road and a water utility line would be relocated to accommodate the new embankment. This proposed action would also include drainage improvements that would require relocation of a part of the Center Creek channel (see below). Approximately 280,000 cy of excavated material would be generated from the threshold shift and RSA extension. Usable material would be placed as fill on the new embankments of the main and crosswind runways. Unusable and excess usable excavated material would be stored in a DOT&PF stockpile area proposed as part of the project (see below).

2.2.1.3 Drainage Improvements

Center Creek currently flows towards the northern threshold of the crosswind runway from the east and then flows to the south in a ditch following the eastern border of airport development (Figure 2). The creek joins the Snake River near RM 0.5. The existing ditch fills with thick deposits of aufeis during winter months, which creates a safety hazard for the crosswind runway and poses an airport maintenance issue. Furthermore, it is necessary that the proposed crosswind runway embankment extension be constructed at a lower elevation than the existing ditch, and it would therefore be at risk of flooding during periods of high flow within the creek.

Improvements to the ditch and access for maintenance are needed to resolve the aufeis issues and prevent flooding problems. Center Creek and the existing dike on its west side would be shifted east to provide a buffer between the waterway and the new crosswind embankment. A road immediately west of the rerouted ditch would provide access for aufeis management. A 10-foot-tall dike would be constructed along the northern 900 feet of the ditch to ensure that flow and aufeis would be routed away from airport surfaces. The rerouted stream would rejoin the existing conveyance just southeast of the existing Runway 21 threshold. Additional drainage improvements along the creek would be necessary near the threshold 28 end of the proposed main runway safety area to move the drainage away from the area that would be filled by the proposed embankment extension and to reconnect the ditch to flow into the Snake River.

2.2.1.4 Stockpile Area

A stockpile area is needed near the airport to provide a storage area for clean fill generated from excavation associated with the various components of the Proposed Action. The stockpile area would be large enough for the project needs and be compatible with the Airport Master Plan and the Airport Layout Plan (ALP). Preferably, the stockpile site would require as little additional property acquisition as possible and would be contiguous to airport property so it could be used in the future for other purposes such as providing areas for snow storage, equipment storage and staging, material storage, use as an impound yard, or leasing for aviation purposes.

To accommodate these needs, a stockpile area would be constructed west of the relocated Construction Road. The stockpile area would measure approximately 1,055 feet by 650 feet, and be designed to accommodate all unused excavated material generated from the project. Material stored in this location would be stacked to a height of approximately 15 feet. The stockpile site would be accessed from the relocated Construction Road (Figure 2).

2.2.1.5 Construction Approach

The sequence of construction of the Snake River channel realignment is not fully developed but would be established to maximize work in isolation from the flowing river. Construction would be performed in a manner that would both minimize sediment and turbidity releases into the river and avoid creating channel constrictions in the river to the west of the Runway 10 end of the airport. The present plan calls for the following sequence:

- Excavate the new right bank down to the water table.
- Excavate the new right bank below the water table to just above the elevation of the ordinary high water (OHW) line of the river, leaving a berm in place between the flowing water of the river and the excavation. The berm would be large enough to isolate the excavation from the river.
- Apply slope stabilization treatments and revegetate cut slopes above the OHW line.
- Excavate and remove the remaining berm to the bottom elevations of the design channel in order to complete construction of the realigned channel. This work would be done during low flow periods in the Snake

River, such as the late summer or winter, in order to minimize sediment discharge to the river.

- Depending on the composition, gradation, and texture of materials exposed within the excavation for the realigned channel, the area of the future river bed and banks may be over-excavated to remove undesirable materials and then back-filled with a clean sand/gravel mix to form the bed and banks of the new channel.

- Silt curtains and other best management practices (BMPs) would be used where practicable to minimize silt release to the river.

- Once the construction of the realigned channel is complete, the extension of the RSA embankment into the river would be constructed. It is likely that, in order to minimize silt release into the river, a scour apron of the riprap embankment facing would be placed first in order to isolate the construction area from the river.

- The embankment inboard of the apron would then be constructed in lifts to the design elevations, with the riprap placed on the face of the embankment at regular intervals, as shown in Figure 3 (Section 1).

3.0 ESSENTIAL FISH HABITAT

3.1 Background

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act set forth the EFH provision to identify and protect important habitats of federally managed marine and anadromous fish species. Federal agencies that fund, permit, or undertake activities that may adversely affect EFH are required to consult with NMFS regarding the potential effects of their actions on EFH, and respond in writing to NMFS recommendations.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. ”Waters” include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate. ”Substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities (NMFS 1999).

NMFS authority to manage EFH is directly related to those species covered under Fishery Management Plans (FMPs) in the United States. The proposed Nome Airport project is located within an area designated as EFH for FMPs Bering Sea/Aleutian Islands (BSAI). The FMPs include 34 species or species complexes of groundfish, invertebrates (crab), and salmon resources (Table 1). Some of these species may occur in the immediate project area (lower Snake River and Nome Harbor). Most probable species to be found in the project area are indicated with an asterisk in Table 1. Several other species may be found in Norton Sound outside of Nome Harbor. Refer to the relevant EFH assessment reports (NMFS 2005) for life history stages of these species that may occur in the project vicinity. Assessment of the impacts to these species' EFH from the proposed project is based on this information.

3.2 Existing Environment

3.2.1 Physical Description and Water Quality

The Nome Airport lies in the southwestern corner of the Seward Peninsula immediately adjacent to Norton Sound to the south. The habitat surrounding the airport largely consists of tundra characteristic of the Seward Peninsula. The tundra vegetation is made up of dwarf lichens, shrubs, grasses, and sedges. The Snake River wraps around the western end of Runway 10 (Figure 2). Several small to medium sized tundra ponds also contribute to the landscape adjacent to the Nome Airport. These ponds are located within the broader Snake River flood plain upstream of the airport. Much of the area surrounding the Airport, including the Snake River channel itself, has been disturbed by past industrial and development beginning with gold mining.

Water quality in the Snake River appears to be reasonably good, however low levels of diesel-range organics and benzene have been detected in the sediments of the Snake River according to the Alaska Department of Environmental Conservation (ADEC). Since the 1950's until 1991 the Nome Tank Farm operated in the lower Snake River waterway and substantial releases of petroleum products have been documented by ADEC. Contamination of sediment, soils, and groundwater have also been associated with the Nome Tank Farm. Also, the West Nome Tank Farm located across the river from the Nome Tank Farm has had documented spills of contaminants into the waterway.

Since the late 1800's placer gold mining has disturbed much of the wetlands and nearshore environment around Nome. Beginning in the mid 1980's offshore mining technologies extended gold extraction efforts offshore into Norton Sound. Concerns have been raised regarding the potential risk of heavy metal contamination from mining activities in the adjacent marine waters. Despite the potential for elevated concentrations of heavy metal contamination in the nearshore, particularly as a result of dredging activities (resuspension), gross bioaccumulation of heavy metals in the tissues of red king crabs were not observed (Jewett and Naidu 2000).

3.2.2 Snake River Habitat

The Snake River is a remarkably low gradient stream that has been highly altered over the lower mile and a half. The river is straightened and channelized along Seppala Drive and the airport for approximately 0.9 miles. Riprap characterizes most of the left bank and a substantial portion of the right bank. During our visit, riparian vegetation was largely lacking or limited to grasses and small herbs on the left bank and limited in extent on the right bank that has been disturbed by fill and industrial activities over the last century. The stream bed, where visible in this reach, appeared to be a mix of silt-covered cobbles and artificial materials including quarry spalls from riprap and industrial debris. Some areas of more natural sand bottom were also present. Adult salmon were seen to be rolling in this reach on September 19, 2009.

Approximately 600 feet above the bridge on the right bank, and upstream of the end for Runway 3 on the left bank, the shorelines begin to take on more natural characteristics with a more natural flood plain, increasing riparian vegetation in the form of willows, sedges, and grasses. In several areas the flood plain included connected or isolated sloughs with emergent *Carex* dominated vegetation. In other areas, *Carex* dominated the vegetation on low benches and extended to or into the waters edge. The bed in this reach was a uniform mix of coarse to fine sand, and silt with coarser materials where currents are stronger. Stream flow was laminar and gradient uniformly low. Arctic grayling (*Thymallus arcticus*) were common in this reach and abundant in a large pool created by a former equipment ford near the west end of Runway 10, near the downstream end of the realigned channel.

In the project area at the end of Runway 10, stream bank and valley walls are substantially impacted and support little riparian vegetation. The right bank where excavation would occur is an area that has been previously mined and is primarily gravel with only scattered colonizing willows and herbaceous vegetation. The left bank has a limited area of fringing marsh near the OHW line below the toe of the existing runway fill and riprap protection.

Above the end of Runway 10, the river is subject to fluctuations in water level due to tides and storm surges in Norton Sound. Upstream of the airport, conditions described above for the right bank became characteristic of both banks and riparian vegetation, dominated by willows 5 to 6 feet tall, was thick on both sides of straight reaches. On the insides of bends, *Carex* and grass benches were common. On the outsides of bends, steeper eroding cut banks of the willow-dominated taller vegetation were typical. Even along straighter reaches, the willow and grass sod of the tundra was slumping into the channel margin although the overall impression was one of slow change, perhaps as permafrost melts back from the river, rather than rapid erosion by river forces.

These conditions continued for several miles upstream to the vicinity of a weir operated by the Norton Sound Economic Development Corporation (NSEDC).

At the upper end of the observed reach, several small schools of adult salmon were seen—usually along the deeper slots on the outside of bends where stronger current flows result in coarser sand and even small gravel that may be used for spawning. The first significant riffle habitats were also seen near and above the weir location and the first significant tributary entered from the west about 0.3 river miles below the weir.

Not surprisingly, the stream has no large, habitat-forming wood, but deeper water, root masses, and overhanging roots and stems of willows provided cover in the reach surveyed. Beavers had constructed warrens out of willow stems out into the river from the shoreline in at least two places.

From “Si” Larson, a Nome resident and biologist with the NSEDC, it was learned that although the weir is typically pulled before the coho salmon (*Oncorhynchus kisutch*) migration runs are completed, there is an estimated run size of about 100 coho in the Snake River, along with a few Chinook salmon (*O. tshawytscha*). Chum salmon (*O. keta*), is the most important species in local fisheries and run sizes have been lower in recent years. The NSEDC does not appear to have conducted any research on juvenile salmon in the system.

While not an EFH species, Arctic grayling are also present within the lower reaches of the Snake River. Many population studies have been conducted by the Alaska Department of Fish and Game (ADF&G) on grayling in the rivers around Nome as this species is a prized sport fish. According to the most recent publically available study, the Snake River supports over 1,100 Arctic grayling greater than 250 millimeters (mm) and 952 greater than 350 mm (Gryska 2004). Grayling are very active feeders during the short summer period when they primarily consume drifting aquatic insects; feeding drastically declines during the winter months. Grayling are a highly adaptable species; they grow rapidly in their first 3 to 6 years of life and may spawn many times during their 30 year life span. These fish are also tolerant of low dissolved oxygen conditions, giving them the ability to survive long periods under winter ice (http://www.adfg.alaska.gov/index.cfm?adfg=arcticgrayling.main).

3.2.3 Nome Harbor

The Snake River flows into Norton Sound through the dredged basin of Nome Harbor. In recent times, the US Army Corps of Engineers has been responsible for maintenance of navigation depths in the harbor and for construction and maintenance of breakwaters. The present harbor configuration has the harbor entrance protected from seas by two long breakwaters that shelter an area termed the outer harbor. Each breakwater has a breach nearshore that was included in the design to allow passage of small boats and along-shore migrating fish and marine life. A substantial area of fill at the approximate location of the natural Norton Sound shoreline further protects the inner harbor and provides some industrial land on either side of the new river mouth. On the outside of the western portion of this fill, a sand beach has become established by sand transported to the east along the beach and through the breach in the western breakwater. The storm berm behind this beach is littered with logs, likely of Yukon River origin. The beach itself is quite clean and low boulders below the water line supported limited amounts of annual algae (*Ulva intestinalis* and/or *U. prolifera)*. Significant algal growths in shallow waters of Norton Sound are limited by winter ice. Marine organisms in the drift here included rockweed (*Fucus* sp.) and shells of two clams, *Tellina* sp. and razor clam (*Siliqua* sp.).

The inner portion of the harbor is in roughly a “U” shape. The western arm of the U has generally low-gradient (in some places almost natural) shorelines and carries the flow of the Snake River. The eastern arm of the U, into which Dry Creek flows in a constructed channel, has steep, constructed shorelines providing for industrial uses. The outer portions of the inner harbor along the base of the U are also heavily industrialized with steep riprap or vertical sheet pile occupying much of the shoreline. This area and the eastern portion of the harbor has recently been reconstructed to create more deepwater moorage and to change the mouth of the river to flow directly south into the outer harbor. Where beaches exist (e.g., along the western arm of the U and the northern portion of the base of the U), they were often littered with industrial debris, including a major metal debris dump area in the southwest corner of the harbor.

The larger western lobe of the inner harbor had a relatively shallow beach on the eastern shore that is cobble that became increasing fine toward the Snake River mouth and created the primary launch in the city for small boats. Several starry flounder (*Platichthys stellatus*) and one small sculpin (Family Cottidae) were seen near shore in this area. On the opposite, western shore of the Snake River mouth (west arm of the U) is a *Carex*-dominated brackish marsh that is surrounded by low gradient sand and mudflats. Very small fish seen here in the fall of 2009 may have been ninespine stickleback (*Pungitius pungitius*). Farther south, this marsh and flat is truncated by encroaching fill, although another small patch of marsh was present just south of the major metal debris dump area.

3.2.4 Norton Sound Shoreline

The existing shoreline of Norton Sound west of the mouth of Nome Harbor has been heavily affected by gold mining activities for many decades, yet may largely resemble the natural beach condition, except in recently disturbed areas. This apparent paradox results from the fact that the beach is largely composed of a mix of sand, coarse gravel, and cobbles that, although they may be moved and sorted by a short-term quest for gold, ultimately are resorted by strong wave action into a relatively natural beach structure and gradient.

An exception to the general condition of the mid- and lower beach described above is the gradual widening of the upper beach and backshore as the harbor breakwater is approached from the west. As a result of the predominantly easterly transport of sediments along this portion of Norton Sound shoreline, a large “fillet” of sand and gravel has accumulated in front of the bluff creating a very broad backshore. This fillet of sand has built out to and often through the breach in the west breakwater; resulting sedimentation in the breach and outer harbor requires periodic dredging (Joy Baker, Nome Harbor Master).

On these sand and gravel beaches outside the breakwater and to the west , drift animals included the clams seen inside the outer harbor (*Tellina* and *Siliqua*) along with *Hiatella* sp., unidentified sponges and hydroids, and egg masses of a moon snail (Naticidae).

3.2.5 Essential Fish Habitat

The lower Snake River adjacent to the Nome RSA Expansion area is EFH for up to five species of adult anadromous salmon that use the area for migration and by juveniles during their early life history. According to the ADF&G Fish

Distribution Database, the Snake River is used by Chinook, chum, coho, pink (*O. gorbuscha*), and sockeye salmon (*O. nerka*; Table 1). Juvenile salmon from the Snake River, as well as those from adjacent streams including the Nome River may use the nearshore and Nome Harbor area during their spring outmigration, feeding along marine shorelines, gaining size and swimming ability before moving into more offshore waters. This behavior is particularly characteristic of pink, chum, and Chinook salmon (see reviews in Groot and Margolis 1991), but young-of-the-year coho and sockeye salmon may also be found along the shoreline. In the nearshore, juvenile salmonids feed on a variety of prey including small crustaceans, insects, and fish (e.g., Nemeth et al. 2006).

Nome Harbor provides EFH for juvenile and adult salmon on their migrations between freshwater and marine habitats. It likely also provides EFH for red king crab, cottids, and possibly several other fish species.

Nearshore waters of Norton Sound provide EFH for these same species (salmon, crab, cottids) and many others (Table 1). These waters also likely harbor a myriad of potential predators on juvenile salmonids, including larger fish (e.g., rockfish, gadids, other salmonids), piscivorous birds (e.g., grebes, cormorants, herons), and marine mammals (seals, sea lions, whales). To avoid these predators, juvenile salmonids benefit from the presence of shoreline complexity (e.g., large wood, rocks, kelp beds) that provide escape and hiding spaces. Shallow slopes are also believed to provide refuge for small fish from certain larger predators (e.g., Heiser and Finn 1970).

In limited trawl surveys off the entrance to Safety Sound, (Nemeth et al. 2006) found species for which EFH has been designated. Chum salmon juveniles and Pacific sand lance (*Ammodytes hexapterus*) were the only EFH species taken.

4.0 EFFECTS OF THE PROPOSED ACTION ON EFH

The proposed Nome Airport Expansion project is located within an area designated as EFH for three FMPs—the BSAI Groundfish Management Plan, the BSAI King and Tanner Crab Management Plan, and the Alaska Stocks of Pacific Salmon Management Plan (Table 1). Of the 34 species and species complexes which are federally managed under these plans, several are known or highly likely to occur within the project area, including the five Pacific salmon species, red king crab, the sculpin complex, and several species of flatfish, rockfish, and forage fish.

Project activities that would directly affect the identified EFH species are temporary in nature and separated into short-term construction related impacts and long-term impacts resulting from the project and future project operations. The duration of temporary impacts associated with the Proposed Action would span the duration of construction within the river (a total of approximately 90 days) to the point of permanent establishment of riparian vegetation (approximately one or more years after completion of construction. Short-term, construction related impacts (those on the order of hours to months) would include:

- Water quality impacts in the form of increased turbidity levels resulting from stream bed and bank work. Excavation will expose fine sediments that will easily become suspended once flow is introduced into the channel; the suspended sediment plume may reach Norton Sound during the initial period of high flow after channel realignment.
- Reduced food production and impaired feeding efficiency due to high suspended sediment loads.
- Reduction in benthic productivity may result from sedimentation in downstream reaches and possibly in the harbor area.
- In-stream habitat loss during construction; minor loss could persist until the new channel has become stabilized with riparian vegetation and until in-stream insect generation is comparable to that in the present channel.
- Disturbance from increased construction-related work traffic and noise during in-stream work and work near the channel.

Longer-term impacts, those on the order of a year or more, may include:

- A slight net increase in channel habitat.
- Reduced habitat function during the time required to establish productive riparian vegetation and marsh habitats along the stream margin.
- Periodic increases in sedimentation during storm events while the new channel bed materials are being sorted.

4.1 Short-Term Impacts

4.1.1 Water Quality

Work in the active Snake River channel and flow over newly constructed surfaces in the channel would cause temporary impacts to water quality in and downstream of the realigned channel segment. Limited work in Center Creek also has a potential to contribute suspended sediment to the Snake River. The increases in turbidity and suspended sediment would occur especially during construction and during the first several high flow events. Sediment would be carried downstream into the harbor area where reduced velocities would cause settling of larger sediment particles and potential minor accumulations on the banks and seabed within the harbor. Because of the limited area of wetted, newly constructed surfaces that would be exposed to erosion, it is unlikely that significant accumulation of sediment would occur in the harbor or that the plume would extend through the harbor and out into Norton Sound.

For purposes of impact analysis, it is presumed that turbidity in the lower Snake River and harbor would exceed a few hundred nephelometric turbidity units (NTU) immediately following construction. During subsequent periods of high river flow or during strong tidal outflow, turbidity levels could again be elevated for periods of a day or two; frequency of such events would decline over time as the banks and bed of the new river reach become “armored” with sand.

Juvenile salmon have been shown to avoid areas of unacceptably high turbidities (Servizi 1988), although they may seek out areas of moderate turbidity (10 to 80 NTU), presumably as refuge against predation (Cyrus and Blaber 1987a and 1987b). Feeding efficiency of juveniles is impaired by turbidities in excess of 70 NTU, well below sublethal stress levels (Bisson and Bilby 1982). However, Houghton, et al. (2006) report that juvenile salmon apparently fed well in waters averaging over 400 NTU in Knik Arm. Reduced preference by adult salmon homing to spawning areas has been demonstrated where turbidities exceed 30 NTU (20 mg/L suspended sediments). However, Chinook salmon exposed to 650 mg/L of suspended volcanic ash following the Mt. St. Helens eruption were still able to find their natal water (Whitman et al. 1982).

Based on these data, it is probable that the elevated suspended sediment load and turbidity generated by the proposed action would only minimally affect EFH for juvenile salmonids and groundfish, such as flatfish, and sculpins that may be present in the lower Snake River and in Nome Harbor.

Adverse effects would likely be short term (days) through inhibition of feeding success.

Adverse affects would be minimized by conducting the work with the greatest potential for generating sediment outside of periods of major juvenile salmon outmigration. Upstream migration of adult salmon is not expected to be significantly inhibited by high turbidity. Thus, the impacts on salmon during the first year are expected to be minor.

The proposed river realignment portion of the Airport expansion project is small and construction would be completed in a single construction season. With planned shoreline stabilization, the potential for long-term sediment generation is minimal.

4.1.2 Reduced Productivity from Siltation

Levels of sediment deposition along Snake River shorelines and on the bottom of the lower river and in Nome Harbor cannot be predicted with accuracy but are expected to be minimal (less than 1 or 2 mm). Deposition that may occur on river shorelines that are periodically inundated by tidal or river flow fluctuations or influenced by wave action would be short-term; wave action would tend to resuspend the materials which would subsequently be transported to settle in more quiescent areas, either in deeper portions of the harbor or offshore in Norton Sound. Deposition in these areas would be similar to natural deposition that occurs during spring high river flow events.

Short-term covering of river shoreline vegetation may reduce the rates of photosynthesis for plants or seedlings. Epiphytic diatom growth may be reduced in the short term and secondary consumers (e.g., insects and crustaceans) that feed on these plants could be affected. However, the small area of disturbance in relation to size of the Snake River watershed suggests that any such effects would be localized and unmeasurable.

4.1.3 Altered Instream Habitat

For some time following construction, in-stream habitat provided in that 0.9-mile segment of the channel may not be of the same quality as that in the existing channel. The bed and portions of the banks may be relatively unstable and stream side vegetation would be poorly developed. Deep water areas would be present; however, overall fish habitat quality may be diminished from that which exists in the present channel.

4.1.4 Construction Noise and Disturbance

Construction noise would be largely isolated from aquatic habitat and hence should not adversely impact EFH for local salmon except during the excavation below OHW on the right bank of the realigned reach and during rock placement and fill along the left bank. During those activities, heavy equipment (excavator and/or bull dozer) would need to work inside the wetted area of the Snake River.

The effect of these actions on salmon and their EFH would be minimized by timing of the events during periods when few salmon (adults or juveniles) are expected to be present. Noise and disturbance of equipment working in the stream could be expected to cause whatever fish are present in that reach of the stream to move away from the work area.

4.1.5 Net Short-Term Effects

The major net effect of the proposed construction on EFH species would be a short period of episodic elevated suspended sediment levels in the lower 2.3 miles of the Snake River and in Nome Harbor. Duration of such events cannot be fully predicted; however, some reduced habitat quality and minimally reduced feeding opportunities for EFH species may occur. To minimize adverse effects on EFH for Alaska salmon stocks, inwater work would be restricted to periods when few juvenile salmonids are expected to be present. Brief periods of high turbidity in the lower river are not expected to adversely impact upstream migrations of adult salmon. EFH species expected to be present in Nome Harbor and adjacent shorelines in Norton Sound include red king crab, rockfish, sculpins, and flatfish. Some of these species may temporarily leave any areas where the potential turbidity plume from the river may interfere with their successful utilization of the habitat.

4.2 Long-Term Impacts

Over a year, it is expected that the new channel alignment and disturbed bed and bank areas will become armored with sand from instream placement and from bedload transport from upstream. This would stabilize the channel bed and banks and reduce the incidence of sediment suspension and transport that is expected in the first few months following flow diversion. Long-term effects on riparian habitat will occur during the time that vegetation is becoming established within disturbed areas of the proposed action along the stream channel. However, in the longer term, shoreline riparian conditions on the right bank, at least, may be improved over the present disturbed conditions.

4.3 Net Effects

Construction activities during the proposed Nome Airport project would cause short-term and longer-term effects on EFH for salmon as the result of turbidity and suspended sediment plumes, as well as from minimally reduced benthic productivity where siltation occurs. Minor longer-term effects on fish habitat would perpetuate until riparian vegetation could be established along the banks of the realigned channel. Effects on in-stream EFH for salmon would be minimized by doing inwater construction during periods when few juvenile salmon are present. Duration of measurable effects on juvenile salmon would be unlikely to last more than one season following construction but would be dependent on the rate of channel stabilization and on the rate of development of riparian vegetation. Adult salmon migrations and spawning would not be impacted.

Localized use of EFH in Nome Harbor by crab and groundfish is unlikely to be reduced even temporarily as a result of habitat loss or alteration by siltation.

Because the realigned channel segment would be relatively small and would be engineered to mimic the existing floodway cross section and to resist erosion, no permanent effects on fish habitat (EFH) are expected. The same would hold for the potential for permanent effects downstream where no permanent effects are expected on EFH for crab or groundfish in the Nome Harbor or Norton Sound.

4.4 Mitigation and Best Management Practices

The first step in mitigation sequencing is to avoid or minimize impacts to the extent practicable. Location requirements for most project components limit the amount of avoidance or minimization achievable. For example, the RSA expansion must be adjacent to the active surface of the runway; lateral RSA expansion was reduced based on, among other things, the extent of riverine habitat that would be affected. Available alternatives that achieved the project purpose and need were evaluated, in part, on the degree to which EFH impacts could be avoided or minimized, resulting in the present preferred Snake River diversion.

During design, potential negative impacts of rechanneling a reach of the Snake River were largely eliminated by adoption of the EMAS alternative. However, some level of short term effect of siltation and lost benthic habitat productivity in and downstream of the realigned channel segment would be unavoidable.

During construction, a number of best management practices would be employed to minimize construction impacts on riverine habitat and resources. These would include the following:

- Timing of inwater work to avoid periods of high juvenile salmonid abundance;
- Planning construction sequencing to minimize the duration and severity of silt generation and transport; and
- Use of BMPs such as berms and silt curtains to reduce sediment released to the river during construction of the realignment.

5.0 CONCLUSIONS AND DETERMINATION OF EFFECT

Construction of the Proposed Action may adversely affect the EFH for BSAI salmon, both in the short- and longer-term. Minor short-term and longer-term effects may result from avoidance and loss of feeding opportunities as a result of siltation and turbidity expected following realignment of the Snake River channel. Effects lasting more than one open water season are expected to be insignificant, lasting though the period required for re-establishment of riparian vegetation.

Adverse effects to EFH managed salmon would be minimal and localized to Snake River stocks, short to intermediate in duration (affecting only a single year class), and minor in severity (localized loss of feeding opportunities). These effects would not reduce the overall long-term value of EFH in Nome Sound. Mitigation actions would be prescribed that would offset these impacts. Therefore, with mitigation to offset any minor and localized impacts, the Proposed Action is expected to have **no adverse effect** on EFH for BSAI stocks of Pacific salmon, crab, or groundfish.

6.0 REFERENCES

Bisson, P.A., and R.E. Bilby, 1982. Avoidance of Suspended Sediment by Juvenile Coho Salmon. North American Journal of Fisheries Management, 4:371-374.

Cyrus, D.P., and S.J.M. Blaber, 1987a. The Influence of Turbidity on Juvenile Marine Fishes in Estuaries. Part 1: Field Studies at Lake St. Lucia on the Southeastern Coast of Africa. Journal of Experimental Marine Biology and Ecology, 109:53–70.

Cyrus, D.P., and S.J.M. Blaber, 1987b. The Influence of Turbidity on Juvenile Marine Fishes in Estuaries. Part 2: Laboratory Studies, Comparisons with Field Data and Conclusions. Journal of Experimental Marine Biology and Ecology, 109:71–91.

Groot, C., and L. Margolis, 1991. Pacific Salmon Life Histories. UBC Press, Vancouver, B.C., Canada.

Gryska, A.D., 2004. Abundance and Length and Age Composition of Arctic Grayling in the Snake River, 2001. Alaska Dept. of Fish and Game, Fishery Data Series No. 04-15, Anchorage, Alaska.

Heiser, D.W., and E.L. Finn, Jr., 1970. Observations of Juvenile Chum and Pink Salmon in Marina and Bulkhead Areas. Supplemental Progress Report, Puget Sound Studies, Washington Department of Fisheries, Management and Research Division, Olympia, Washington.

Houghton, J.P., J.E. Starkes, and D. Ormerod, 2006. The Blind Eating the Blind? The Ecology of Knik Arm, Alaska. Presentation at the American Fisheries Society 136th Annual Meeting, Lake Placid, NY, August 2006.

Jewett, S.C., and S. Naidu, 2000. Assessment of Heavy Metals in Red King Crabs Following Offshore Placer Gold Mining. Mar. Poll. Bull. Vol. 40, No. 6, pp.478–490.

NMFS, 1999. Essential Fish Habitat Consultation Guidance. Office of Habitat Conservation, National Marine Fisheries Service, Silver Spring, Maryland.

NMFS, 2005. Essential Fish Habitat Final Supplemental Environmental Impact Assessment. Volume II. Appendix F. http://alaskafisheries.noaa.gov/habitat/ seis/final/Volume_II/Appendix_F.pdf

Nemeth, M., B. Williams, B. Haley, and S. Kinneen, 2006. An Ecological Comparison of Juvenile Chum Salmon from Two Watersheds in Norton Sound, Alaska: Migration, Diet, Estuarine Habitat, and Fish Community Assemblage. Final Report for 2003 & 2004. Prepared for: Norton Sound Disaster Relief Fund by LGL Alaska Research Associates, Inc. and the Norton Sound Economic Development Corporation.

Servizi, J.A., 1988. Sublethal Effects of Dredged Sediments on Juvenile Salmon. C.A. Simenstad, editor. Effects of Dredging on Anadromous Pacific Coast Fishes. University of Washington, Seattle, Washington.

Whitman, R.P., T.P. Quinn, and E.L. Brannon, 1982. Influence of Suspended Volcanic Ash on Homing Behavior of Adult Chinook Salmon. Transactions of the American Fisheries Society, 111:6–69.

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TABLE

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Table 1 – Description of Essential Fish Habitat for Bering Sea and Aleutian Islands (BSAI) Area

Salmon Species	Freshwater Eggs	Freshwater Larvae and Juveniles	Estuarine Juveniles	Marine Juveniles	Marine Immature and Maturing Adults	Freshwater Adults
Pink	1	1	1	1	1	1
Chum	1	1	1	1	1	1
Sockeye	1	1	1	1	1	1
Chinook	1	1	1	1	1	1
Coho	1	1	1	1	1	1

	Eggs	Larvae	Early Juvenile	Late Juvenile	Adult
BSAI Species					
Walleye pollock	1	1	X	1	1
Pacific cod	X	1	X	1	1
Yellowfin sole	X	X	X	1	1
Greenland turbot	1	1	X	1	1
Arrowtooth flounder	X	X	X	1	1
Rock sole	X	1	X	1	1
Alaska plaice	1	X	X	1	1
Rex sole	X	X	X	1	1
Dover sole	X	X	X	1	1
Flathead sole	1	1	X	1	1
Sablefish	X	1	X	1	1
Pacific ocean perch	X	1	X	1	1
Shortraker/rougheye rockfish	X	1	X	X	1
Northern rockfish	X	1	X	X	1
Thornyhead rockfish	X	1	X	1	1
Yelloweye rockfish	X	1	X	1	1
Dusky rockfish	X	1	X	X	1
Atka mackerel	X	1	X	X	1
Skates	X	X	X	X	1
Sculpins	X	X	X	1	1
Sharks	X	X	X	X	X
Forage fish complex	X	X	X	X	X
Squid	X	X	X	1	1
Octopus	X	X	X	X	X
BSAI Crab Species					
Red king crab	inferred	X	X	1	1
Blue king crab	inferred	X	X	1	1
Golden king crab	inferred	X	X	1	1
Tanner crab	inferred	X	X	1	1
Snow crab	inferred	X	X	1	1

Notes:
X – No information available.
1 – Information available.

Source:
NMFS 2005.

Table 2 - Habitat Area and Features, Pre- and Post-Diversion[1]

Time/Location	Length (ft)	Wetted Area (acres[2])	Deep Water (%[3])	Intact Riparian (ft)	Marsh Bench (ft)
Pre-Construction					
Existing channel	6,350	29	40	2,520	3,000
Post-Construction					
New Channel	4,700	22	50	-	1,620
Blind slough	2,200	10	30	1,200	1,740
Difference	550	3	-	(1,320)	360

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Notes:

1 All numbers are very approximate and based on aerial photographs and conceptual designs; it is assumed that the cutoff river channel remains open as a blind slough.

2 Assumed average width of 200 feet.

3 Percent of wetted area deeper than approximately 3 feet.

FIGURES

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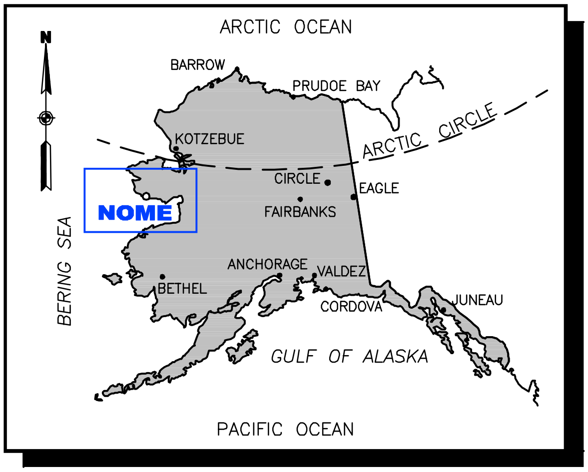
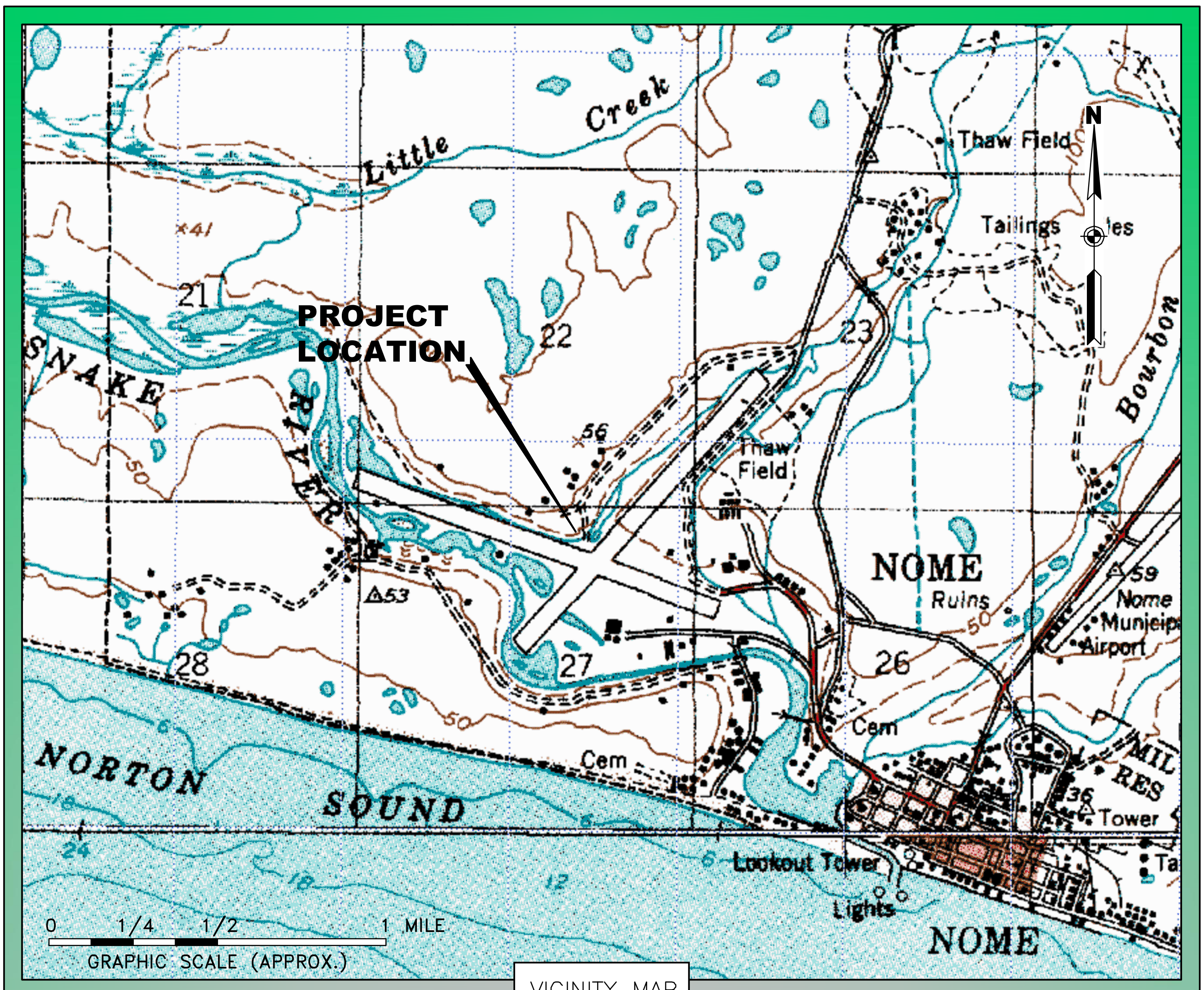


LOCATION MAP
NO SCALE

NOME AIRPORT, NOME, ALASKA
T. 11 S., R. 34 W.,
SEC. 21, 22, 23, 26, 27, 28
KATEEL RIVER MERIDIAN
Map Compiled with USGS Quads
AK NOME C–2; AK NOME C–1; and AK NOME B–1



VICINITY MAP

LOCATION & VICINITY MAP

NOME AIRPORT
RUNWAY SAFETY AREA EXPANSION
NOME, ALASKA
DOT&PF Project No 61413

APRIL
2012

FIGURE
1

Drawing Name: I:\1182800\Dwgs\N\Nome\EFH_Assessment\1182800_Draft EFH_Fig-01_Loc_Vic_Map.dwg PLOTTED: Apr 03, 2012 – 10:55am

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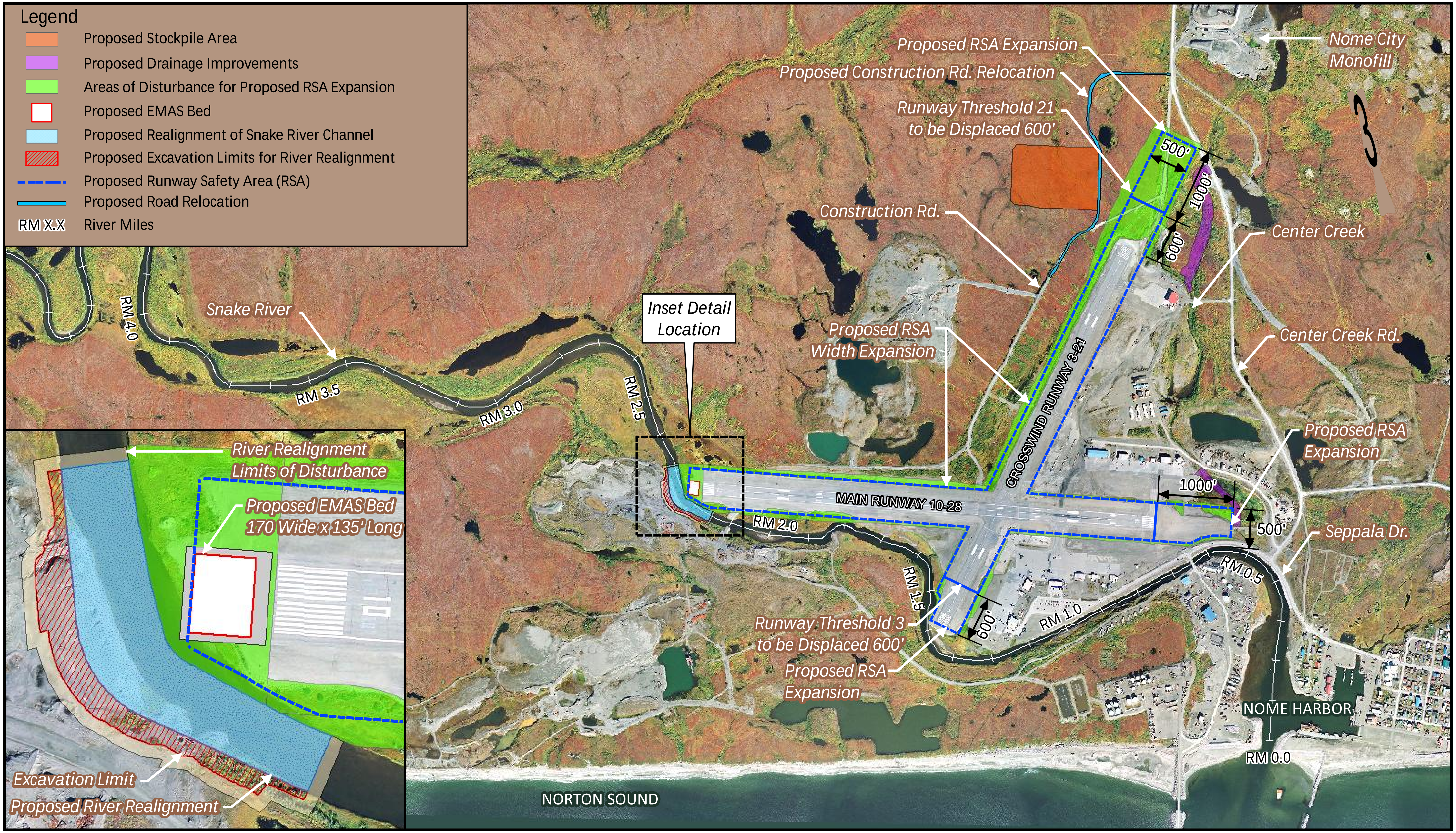

0 1,500 3,000

Scale in Feet

PROPOSED ACTION

NOME AIRPORT
RUNWAY SAFETY AREA IMPROVEMENTS
NOME, ALASKA
DOT&PF Project No. 61413

APRIL 2012

FIGURE 2

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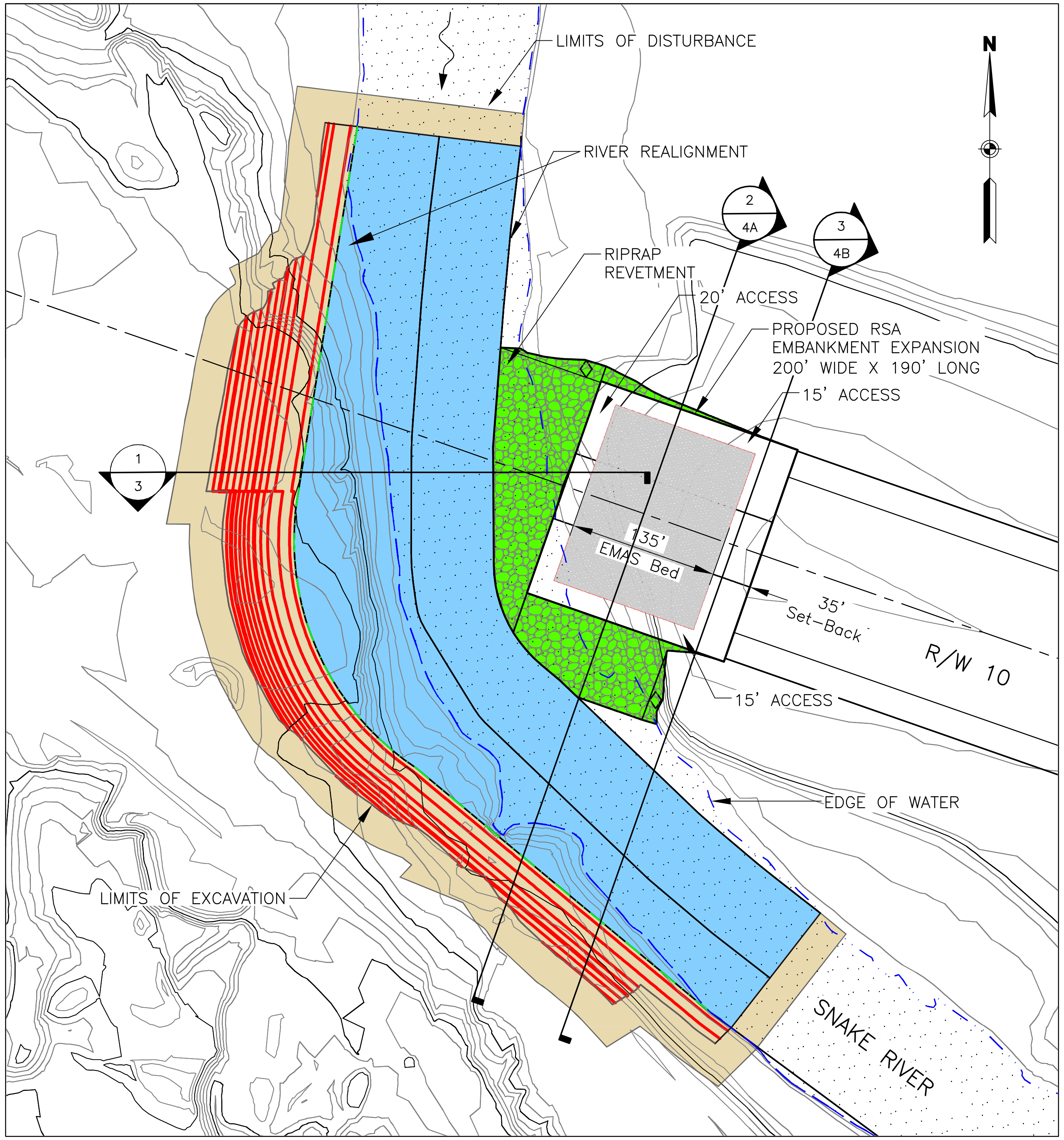
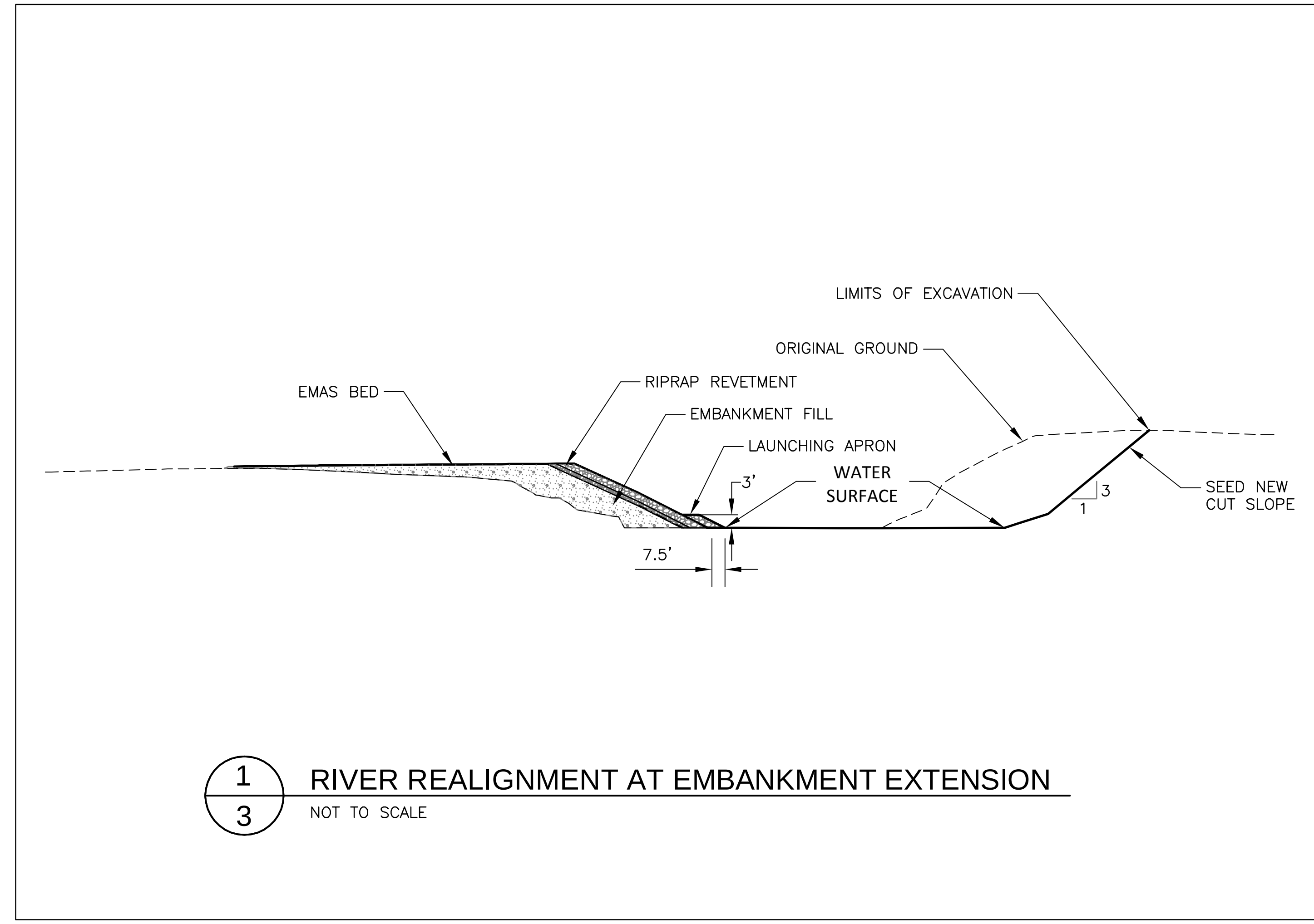


RIVER REALIGNMENT AND EMAS PLAN



TYPICAL SECTION

CONCEPT

PROPOSED RIVER REALIGNMENT Nome Airport Runway Safety Area Expansion Nome, Alaska DOT&PF Project No 61413	APRIL 2012
	Figure 3

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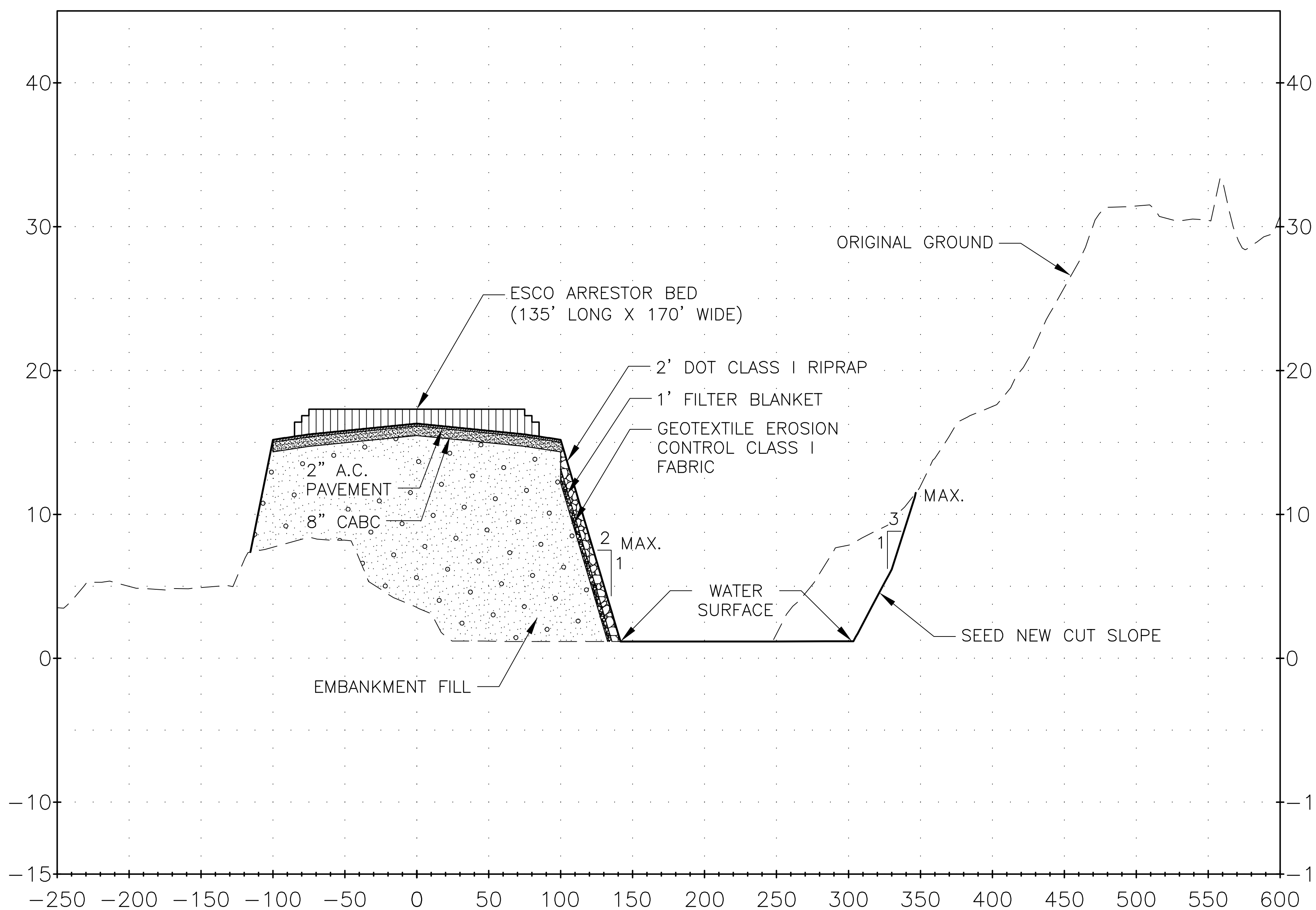

2 / 4A EMBANKMENT EXTENSION FOR EMAS BED

SCALE: 1"=100' H, 1"−10' V

CONCEPT

CHANNEL REALIGNMENT SECTION VIEWS

Nome Airport
Runway Safety Area Expansion
Nome, Alaska
DOT&PF Project No 61413

APRIL 2012

Figure 4A

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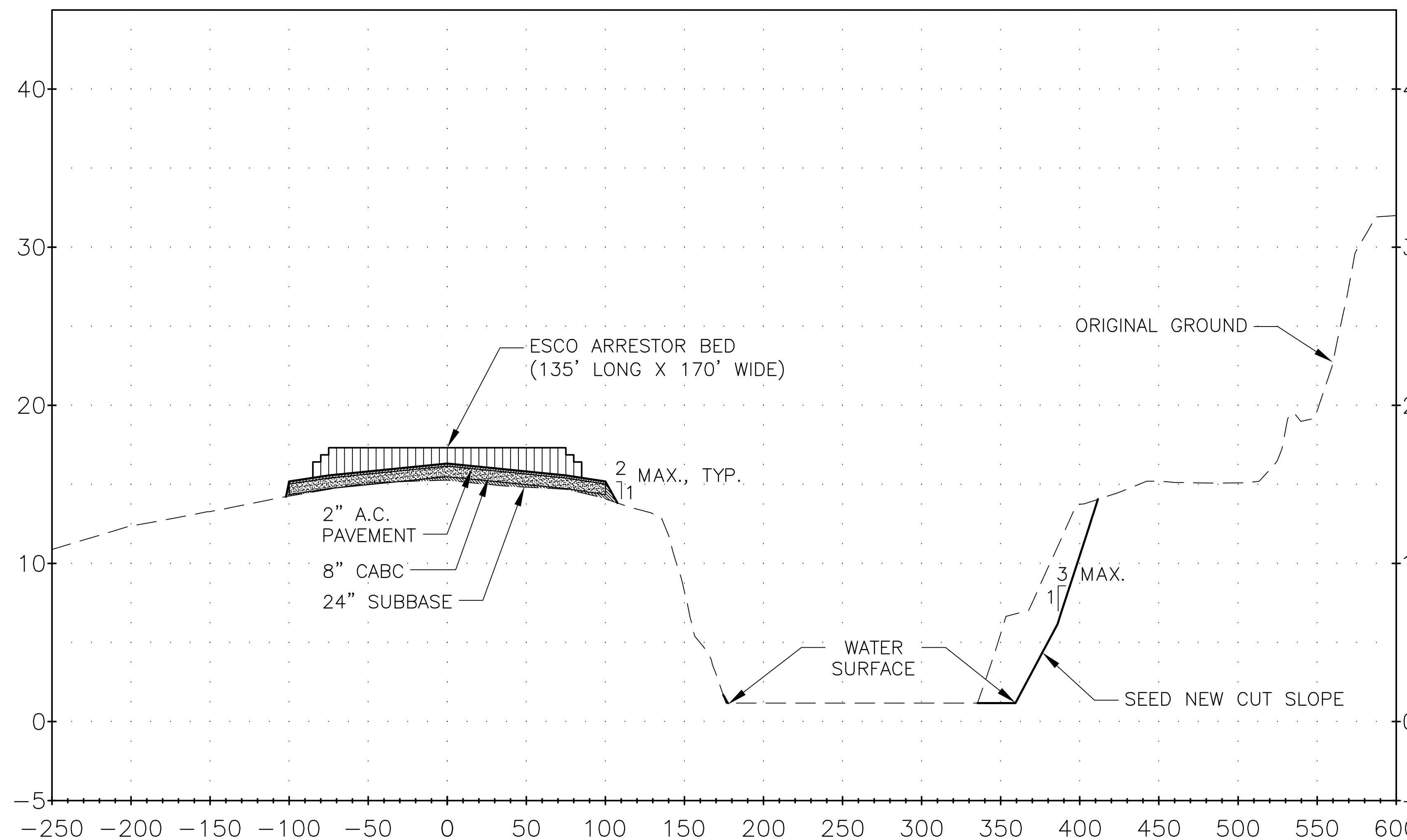

3
4B

EMAS BED TYPICAL SITE PREPARATION

SCALE: 1"=100' H, 1"–10' V

CONCEPT

CHANNEL REALIGNMENT SECTION VIEWS

Nome Airport
Runway Safety Area Expansion
Nome, Alaska
DOT&PF Project No 61413

APRIL
2012

Figure
4B

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