FINAL
ROADBELT INTERTIE
RECONNAISSANCE ENGINEERING REPORT

CONTRACT TFSADNC17D0001, DELIVERY ORDER 20342920F00002

23 NOVEMBER 2020

NOTE

THIS PROJECT WAS A HIGH-LEVEL TECHNICAL FEASIBILITY STUDY TO DEVELOP A COST ESTIMATE AND DOES NOT PROPOSE A SPECIFIC ROUTE.

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ACRONYMS AND ABBREVIATIONS

ACEP ....Alaska Center for Energy and Power
ACSR ....aluminum conductor steel-reinforced cable
ADEC.............Alaska Department of Environmental Conservation
ADF&G..........Alaska Department of Fish and Game
ADNR ....Alaska Department of Natural Resources
AEA ....Alaska Energy Authority
AGC ....Alaska Geospatial Council
Agnew::Beck..Agnew::Beck Consulting, Inc.
AHMG ....*Alaska Habitat Management Guide*
AHRS ....Alaska Heritage Resources Survey
Ahtna..............Ahtna Environmental, Inc.
AMEC ....Alaska Mapping Executive Committee
AMI................Alaska Mapping Initiative
ANILCA ....Alaska National Interest Lands Conservation Act
AP&T ....Alaska Power and Telephone
APE ....Area of Potential Effect
ASGDC ....Alaska State Geo-Spatial Data Clearinghouse
Atlas ....Atlas to the Anadramous Waters Catalog
AWC ....Anadromous Waters Catalog
AWH..............*Alaska's Wildlife and Habitat*
BESS ....Battery Energy Storage System
BFS ....United States Department of the Treasury, Bureau of the Fiscal Service
BLM...............United States Department of the Interior, Bureau of Land Management
BMP ....Best Management Practice
CAD ....computer-aided design
Chugach ....Chugach Electric Association, Inc.
CFR ....Code of Federal Regulations
CHAT.............Crucial Habitat Assessment Tool
Commission ...Denali Commission
CVEA.............Copper Valley Electric Association
DCCED ....Department of Commerce, Community, and Economic Development
DCRA ....Division of Community and Regional Affairs
DEM...............digital elevation model
DGGS.............Division of Geological & Geophysical Surveys
DoD................United States Department of Defense
DOT&PF........Alaska Department of Transportation and Public Facilities
DSM...............digital surface model
EA ....Environmental Assessment
EPA ....United States Environmental Protection Agency
EPS.................Electric Power Systems, Inc.
ERO................Energy Reliability Organization

EROS ....Earth Resources Observation and Science
ESA ....Endangered Species Act
FAA................Federal Aviation Administration
FONSI ....Finding of No Significant Impact
GINA..............Geographic Information Network of Alaska
GIS ....geographic information system
GNIS ....GeoNorth Information Systems, LLC
GVEA ....Golden Valley Electric Association
IBS ....Integrated Business Suite
IFSAR ....Interferometric Synthetic Aperture Radar
kcmil ....kilo-circular-mil
kV...................kiloVolt
kW..................kiloWatt
LAND INFO ..LAND INFO Worldwide Mapping, LLC
LiDAR............Light Detection and Ranging
Maxar ....Maxar Technologies
MEA...............Matanuska Electric Association, Inc.
MOA ....memorandum of agreement
MSB ....Matanuska-Susitna Borough
MTP ....Master Title Plat
MW ....MegaWatt
n.d...................no date
NEPA ....National Environmental Policy Act
NHPA.............National Historic Preservation Act
NRC ....Nuclear Regulatory Commission
NRCS ....Natural Resources Conservation Service
NRHP.............National Register of Historic Places
NWI................National Wetlands Inventory
NWP...............Nationwide Permit
OEG ....Obstruction Evaluation Group
OHGW ....overhead ground wire
Quantum.........Quantum Spatial, Inc.
ROW ....right-of-way
RRC................Railbelt Reliability Council
RUS................Rural Utilities Service
SDMS.............Spatial Data Management System
SHPO ....State Historic Preservation Office
SMR ....Small Module Reactor
SOI ....Secretary of the Interior
SPOT..............*Satellite Pour l'Observation de la Terre*
SVC................static Volt-Ampere reactive compensator
T&E................threatened and endangered
TAPS..............Trans-Alaska Pipeline System

Trust ....Alaska Mental Health Trust Authority
UAF................University of Alaska Fairbanks
UAV...............unmanned aerial vehicle
USACE ....United States Army Corps of Engineers
USCG.............United States Coast Guard
USDA.............United States Department of Agriculture
USFWS ....United States Fish and Wildlife Service
USGS ....United States Geological Survey
VAR...............Volt-Ampere reactive
WAFWA........Western Association of Fish and Wildlife Agencies
WMS..............web map service
WOTUS ....waters of the United States

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EXECUTIVE SUMMARY

OBJECTIVE

The objective of the Roadbelt Intertie Project was to determine the technical feasibility of and budgetary development costs for completion of a transmission loop along the Alaska road system. This information will help determine the project's potential to reduce power costs for rural communities, support regional economic development opportunities, increase United States Department of Defense (DoD) facility resilience, and increase electric power reliability throughout the Alaska road system. **NOTE: THIS PROJECT WAS A HIGH-LEVEL TECHNICAL FEASIBILITY STUDY TO DEVELOP A COST ESTIMATE AND DOES NOT PROPOSE A SPECIFIC ROUTE.**

PROJECT CONFIGURATION

The Roadbelt Intertie Project assumes that new 230 kV transmission lines would be built from Sutton to Glennallen to Tok to Delta Junction, interconnecting islanded road system power utilities and creating a parallel path between the two most populated roadbelt areas. Some portions of the proposed Roadbelt Intertie had been studied previously; however, no comprehensive system studies had been performed.

Alternative utility interconnection configurations with 230 kV lines between Glennallen and Delta Junction and a smaller 138 kV radial line to Tok from either Glennallen or Delta Junction are possible. These alternatives were beyond the scope of this project but may warrant future consideration as they have some technical and cost advantages over the proposed configuration.

The cost basis alignment developed for this project is one of several routes that are possible between the desired interconnection points. It is by no means intended to represent the most feasible or the most preferred route as it has not gone through the environmental impact assessment and public scrutiny needed for route selection. Rather, it was selected as a reasonable representation for key design parameters needed to estimate probable construction costs.

Interconnection configuration, route selection, detailed physical feature design, and public engagement opportunities would occur during future design phases, if the project progresses.

ENVIRONMENTAL CONSIDERATIONS

Previous studies and public input regarding portions of the proposed route indicate that visual and recreational resources may be the most likely environmental categories with potentially significant impacts. Detailed evaluation of all potential environmental impact categories would occur during future design phases if the project progresses. Informal opportunities for public input are currently available. Formal public engagement would be integral to future project development phases, in accordance with national environmental protection regulations.

ESTIMATED COST

Development and construction of the Roadbelt Intertie Project is estimated to cost approximately $566 million (2020 dollars). This estimate is intended as a reconnaissance-level budgetary indication of the anticipated project cost, but it must be recognized that the actual cost could be substantially different due to the preliminary nature of design information at this stage. A reliable cost estimate would require a significant further effort including mapping and imagery acquisition, engineering investigations, environmental studies, feasibility-level design and construction planning, and an estimated project construction timeline. Annual operation and maintenance costs were also estimated.

CONCLUSIONS

Reconnaissance-level engineering evaluation of the Roadbelt Intertie Project indicates that it is technically feasible. Implementing it would increase DoD facility resilience and electric power reliability throughout the Alaska road system.

Recommended next steps for further evaluation of the Roadbelt Intertie Project include:

- Conduct system-wide economic evaluation of potential power cost impacts for all interconnected communities and DoD facilities.
- Perform quantitative cost/benefit evaluation of economic feasibility.
- Study and select optimal utility interconnection configuration (topology).
- Develop a range of transmission line route options satisfying the optimal topology.
- Design and perform environmental studies and engineering investigations, with public input in accordance with the National Environmental Policy Act (NEPA).
- Select transmission line route.
- Perform detailed design.

1.0 INTRODUCTION

Ahtna Environmental, Inc., (Ahtna) and its project subcontractors developed this report for the Denali Commission (Commission) under the United States Department of the Treasury, Bureau of the Fiscal Service (BFS) contract TFSADNC17D0001, order 20342920F00002.

1.1 Project Background

The Commission's mission is to promote rural development, with a focus on infrastructure needs. Recent stakeholder feedback indicates high interest in completion of a transmission loop along the eastern Alaska "roadbelt" to potentially reduce power costs for rural communities, support regional economic development opportunities, increase United States Department of Defense (DoD) facility resilience, and increase electric power reliability throughout the Alaska road system. Some portions of the proposed Roadbelt Intertie had been studied previously; however, no comprehensive system studies had been performed.

1.2 Project Objective

The objective of this Roadbelt Intertie Project was to assess the technical feasibility of and generate a cost estimate for new electric transmission lines following the road system on the east side of Alaska and any required upgrades to existing transmission systems. The proposed Roadbelt Intertie would complete an electric loop from Anchorage to Glennallen to Tok to Fairbanks. Project analysis included connections to Fort Greely, Chitina Hydropower, and Valdez, as well as any required upgrades to existing segments of the electric transmission system from Glennallen to Valdez, Delta Junction to Fairbanks, and along the Parks Highway.

1.3 Scope of Work Summary

Ahtna and its project subcontractors completed the following efforts between November 2019 and November 2020 to achieve the project objective:

- Conceptual Design
- Cost Basis Alignment Research
- Cost Estimation
- Public Awareness Campaign

Sections 2.0 through 5.0 of this report detail project efforts.

1.4 Project Team

Ahtna managed the overall project and provided expertise in imagery, geographic information systems (GIS), cultural resources, and environmental permitting. Ahtna subcontracted Electric Power Systems, Inc. (EPS) to provide transmission system design and analysis, cost estimation, and right-of-way (ROW) ownership research lead services. Ahtna personnel assisted with ROW ownership research at the direction of EPS' ROW lead. Ahtna subcontracted Agnew::Beck Consulting, Inc. (Agnew::Beck) to lead public awareness efforts.

2.0 CONCEPTUAL DESIGN

The project team reviewed past documentation and made assumptions to assess the technical feasibility of and prepare cost estimates for the Roadbelt Intertie, as detailed in the following sub-sections.

2.1 Project Configuration

Alaska currently has transmission line infrastructure between Fairbanks and Anchorage along the Parks Highway, as well as radial lines to various other communities and power generation facilities. The Roadbelt Intertie Project would complete an electric loop roughly following the road system from Anchorage to Glennallen to Tok to Fairbanks. The project location, approximate new transmission line study corridor, and relevant existing infrastructure locations are depicted on Figure 1.

2.2 Previous Studies

Multiple studies have been conducted that relate to the proposed Roadbelt Intertie in part or in total. The project team reviewed the reports listed in Table 2-1.

TABLE 2-1: PREVIOUS STUDIES

Year Published	Document Title	Prepared For	Prepared By
1989	Northeast Transmission Intertie Project	Alaska Power Authority	Power Engineers, Inc. and Hart-Crowser, Inc.
1989	Railbelt Intertie Reconnaissance Study – Benefit/Cost Analysis	Alaska Power Authority	Decision Focus, Inc.
1993	Analysis and Cost Estimate for the Proposed Sutton to Glennallen 138kV Transmission Intertie Project	Copper Valley Electric Association	Power Engineers, Inc.
1994	Copper Valley Intertie Feasibility Study	State of Alaska, Department of Community and Regional Affairs, Division of Energy	R. W. Beck, Dames & Moore, Inc. and Power Technologies, Inc.
1995	Copper Valley Intertie Feasibility Study Update	Alaska Industrial Development and Export Authority	CH2M Hill and R.W. Beck
2008	Distributing Alaska's Power: A technical and policy review of electric transmission in Alaska	Denali Commission	NANA Pacific
2010	Alaska Railbelt Regional Integrated Resource Plan (RIRP) Study	Alaska Energy Authority	Black & Veatch Corporation
2012	Watana Hydroelectric Study Transmission Connection to CVEA	MWH Americas, Inc.	Electric Power Systems, Inc.
2015	Interior Alaska Regional Energy Plan	Alaska Energy Authority	Tanana Chiefs Conference, Information Insights and WHPacific, Inc.

Year Published	Document Title	Prepared For	Prepared By
2016	Copper River Regional Energy Plan	Alaska Energy Authority	Copper Valley Development Association and Information Insights
2016	Tiekel River Hydropower Reconnaissance Study	Copper Valley Electric Association	MWH Americas, Inc.
2018	Northway to Tok Intertie Study	Northway Village Council	Dryden & Larue, Inc.
2019	ROW Research Report – Alaska Highway Milepost 1387 to Tok	Alaska Power & Telephone	Electric Power Systems, Inc.

2.3 Design Requirements

The project team contacted technical stakeholders including power utilities and potential commercial customers to help determine appropriate future load scenarios and other key design requirements. EPS utilized previous study information, technical stakeholder input, and current infrastructure information to establish project design requirements.

2.3.1 Power Utility Requirements

EPS solicited technical input from the Alaska Energy Authority (AEA), Matanuska Electric Association, Inc. (MEA), Alaska Power & Telephone (AP&T) and Copper Valley Electric Association (CVEA) to ensure that key Roadbelt Intertie design parameters encompass power utility requirements.

2.3.1.1 Railbelt Reliability Council

During this project, the State of Alaska passed legislation mandating that Railbelt utilities create an Energy Reliability Organization (ERO) that will guide decisions on new generation and transmission projects. In response, the six interconnected Railbelt utilities, along with six non-utility stakeholders, are actively organizing an ERO dubbed the Railbelt Reliability Council (RRC). The RRC will define and enforce electric reliability standards, coordinate joint planning through an integrated resource planning process, and ensure consistent interconnection protocols for utilities, independent power producers and other grid users. The RRC will also work with the Regulatory Commission of Alaska to develop a cost sharing methodology for assets that have a regional benefit and will also identify and facilitate implementation of effective ways for the Railbelt electric system to reduce electricity costs for ratepayers. Additional background information and current status of RRC implementation can be found at the RRC's website (https://alaskapower.org/rrc/).

Since the Roadbelt Intertie is designed to interconnect with the Railbelt electric system, further project planning and development would likely involve close coordination with the newly formed RRC.

2.3.2 Telecommunication Service Requirements

Ahtna attempted to contact the Alaska Telecom Association, the Matanuska Telephone Association, AP&T, AT&T, Copper Valley Telecom and GCI to determine if there is an interest/need in tapping the proposed Roadbelt Intertie transmission line for power. The response was minimal. Copper Valley Telecom said that their power needs were currently being met by CVEA. GCI initially expressed interest in discussing the matter, but subsequently indicated they were too busy responding to the COVID-19 pandemic to discuss the proposed intertie.

Although fiber-optic telecommunication cable has already been built out in much of the project study area, the proposed transmission line's lightning protection feature happens to have a side benefit that it can be easily upgraded to dual-purpose wire with fiber optic strands in the core, if the need for communication lines were to arise in the future.

2.3.3 Future Power Generation Considerations

EPS considered all known future generation plants during development of system study power transfer and electrical equipment requirements. The proposed transmission system has a capability of transferring at least 75 MegaWatts (MW) of firm power with an additional 50 MW of non-firm power from southcentral Alaska to Fort Greely/Fairbanks. Future generation could increase this power transfer capability depending upon its location and characteristics. Future renewable generation could be located anywhere along the transmission line with little impact on its transmission capability.

2.3.3.1 Chitina (Fivemile Creek) Hydropower

Chitina Hydropower is an approximately 300-400 kiloWatt (kW) run-of-river hydroelectric power plant currently under design and construction on Fivemile Creek adjacent to an existing Chitina Electric, Inc. diesel power plant (AEA, n.d.; Chitina Electric. Inc., n.d.; USDA, 2019). EPS analysis confirmed that the Chitina (Fivemile Creek) Hydropower unit could operate at its full capacity if connected to the proposed 230 kiloVolt (kV) transmission system through the existing 138 kV Glennallen-Valdez transmission line. This project does not include design of or costs for transmission line along the Edgerton Highway corridor that would be required to connect the unit to the grid.

2.3.3.2 Micronuclear Systems

Ahtna contacted George Roe at the Alaska Center for Energy and Power (ACEP) regarding the possibility of micronuclear reactor installations at DoD installations in interior Alaska and implications for the Roadbelt Intertie.

Mr. Roe indicated that there are several commercial entities working through the regulatory process to develop Small Module Reactors (SMRs). The Nuclear Regulatory Commission (NRC) is working to revise the traditional nuclear power plant regulatory process to better accommodate these much smaller power plants. Although encouraging, regulatory reform is not a fast process.

Mr. Roe believes a SMR could not be ready for install earlier than 2026, but likely longer. Proposed SMR output varies considerably from micronuclear units producing 1.5 – 10 MW up to approximately 300 MW. The University of Alaska Fairbanks (UAF) considered a 60 MW unit.

Commercial systems are not intended for installation only on military bases. However, Mr. Roe thinks that DoD facilities may be the best prospect for community and regulatory acceptance since they have extensive security protocols in place. Mr. Roe is not aware of any specific plans to install SMRs in the project study area.

The DoD is also looking to develop small nuclear microreactors designed to be forward deployed for use on remote operating bases (Project Pele). They are currently looking at the 1-5 MW size for that application.

The DoD's Office of the Under Secretary of Defense for Acquisition & Sustainment is working to develop a SMR in the 2-10 MW range for domestic military installations. That program is hoping to demonstrate a SMR at a permanent domestic military installation by 2027.

In summary, micronuclear generation systems do not appear to be an imminent addition to Alaska's power generation portfolio. However, micronuclear power generation system concepts are sized such that they could operate at full capacity if connected to the proposed 230 kV transmission system.

2.4 System Studies

EPS performed static and dynamic electrical system analyses to determine Roadbelt Intertie Project technical feasibility, new infrastructure design requirements, and existing infrastructure modification requirements. The existing Railbelt electrical system model was modified to simulate addition of the proposed Roadbelt Intertie configuration as described in Section 2.1, as well as one alternative configuration for comparison and possible future route selection consideration. The alternate configuration models placement of new transmission lines along the Richardson Highway from Gakona to Delta Junction, and a new radial transmission line from either Gakona or Delta Junction to Tok. Radial configurations do not include new transmission lines along the Alaska Highway from Tok to Delta Junction or the Glenn Highway between Gakona and Tok, and therefore do not have potential to reduce power costs for rural communities or economic developments along one of those two road segments, depending on which radial configuration was selected. Both model configurations have potential to increase DoD facility resilience and reliability throughout the Alaska road system. Cost estimates for the alternate model configuration were not developed since the project scope did not include it.

EPS analyzed steady state power flows and ran various transient stability simulations to evaluate a range of anticipated contingency conditions. Brief system study summaries are provided in the following sub-sections. Additional details are available in EPS' technical report (Appendix A).

2.4.1 Static Analyses

Power flows were evaluated for various transmission line designs, energization, topologies (route configurations), and steady-state voltage control. The steady-state power flow results include recommended interconnection route/path, line voltage, conductor sizing, line spacing, transformers, reactors, and static Volt-Ampere reactive (VAR) compensators (SVCs).

2.4.2 Dynamic Analyses

Transient stability simulations were conducted to evaluate performance of the combined new Roadbelt Intertie and existing Railbelt system during different contingency situations and under various seasonal loading scenarios. Transient stability is a concern for the Railbelt system that occurs after a transmission line or other system component failure occurs that can lead to cascading blackouts along the power system. The contingencies included new faults and trips that are a result of creating a second parallel transmission path between Anchorage and Fairbanks, and well-known contingencies in the Railbelt that can cause instability.

2.4.3 Results

Study results indicate that the proposed Roadbelt Intertie and the alternate model configuration are technically feasible. The recommended design for new Roadbelt Intertie transmission lines is 230 kV operating voltage, single conductor 795 kilo-circular-mil (kcmil) aluminum conductor steel-reinforced cable (ACSR) Drake, with 75% line compensation.

System analyses indicate that infrastructure modifications will be needed, including:

- Substation construction and/or upgrades at the following locations (Figure 1):
  - MEA O'Neill (Sutton)
  - CVEA Pump Station 11 (Glennallen)
  - AP&T Tok
  - Golden Valley Electric Association (GVEA) Jarvis Creek (Delta Junction)
- Communication system modifications including auto-scheduling of GVEA's Wilson Battery Energy Storage System (BESS) and protection and control of the new substations

The alternate model configuration appears to have some technical and cost advantages over the proposed Roadbelt Intertie configuration.

2.5 Cost Basis Assumptions

In order to estimate project development and construction costs, EPS made conceptual project design assumptions based on previous study information, technical stakeholder input, system study results, proven local construction practices, and industry standards. Brief cost basis assumption summaries are provided in the following sub-sections. Additional details are available in EPS' technical report (Appendix A).

2.5.1 Alignment

EPS developed a project cost basis alignment consisting of "Route Alternative D" from the 1994 *Copper Valley Intertie Feasibility Study* (Section 2.1) between Sutton to Glennallen, and a new alignment from Glennallen to Tok to Delta Junction. Routing for the project cost basis alignment east of Glennallen considered previous partial study information (where available), topography, land ownership, and environmental features such as wetlands and known culturally sensitive areas. Private parcels and environmentally sensitive areas were avoided where possible. Infrastructure was also sited to limit winter and helicopter construction.

The project cost basis alignment developed for this project is one of several routes that are possible between the desired interconnection points. It is by no means intended to represent the most feasible or the most preferred route as it has not gone through the environmental impact assessment and public scrutiny needed for route selection. Rather, it was selected as a reasonable representation for line length, angle structures, and terrain, soil, and access conditions needed to estimate probable construction costs.

2.5.2 Design Features

The project cost estimate was based on the following key design feature assumptions:

- 230 kV line voltage (determined by system studies as required to provide meaningful system-wide power transfers)
- overhead single 795 kcmil ACSR Drake conductor size and stranding (note that 230 kV buried lines are technically unproven for this application and would be significantly more expensive than overhead lines)
- 75% line compensation
- steel H-frame support structures with guyed, 3-pole tubular steel masts
- two 7/16" extra high strength steel overhead ground wires (OHGWs), for lightning protection
- ruling spans, average span lengths, foundation and anchor types based on generalized parameters defined for five loading/construction zones, extrapolated based on previous studies
- 120' ROW width

3.0 COST BASIS ALIGNMENT RESEARCH

The project team researched land use, imagery, cultural and environmental resources in the project study area as detailed in the below sub-sections. This information was used to help guide selection of the project cost basis alignment and to inform project cost estimates.

3.1 Land Use

The project team researched land ownership to guide project cost basis alignment selection and inform land acquisition cost estimation. Ahtna GIS personnel compiled a master parcel dataset for use during this project from various publicly available datasets and supplemental datasets digitized by EPS. Datasets were compiled in order and topology errors (overlaps and gaps) addressed to prioritize land ownership that may result in higher acquisition costs per EPS guidance. Topology errors were also addressed based on shape and graticule references (e.g. Section Grid) when possible. Data sources used in production of the master parcel dataset and figures are described below. Data definitions and limitations are included when available. Detailed land ownership analyses will be required during future project phases, as land ownership changes over time and public datasets are often generalized for overview use. The in-depth title research that would be needed for route selection and eventual acquisition was not part of this project's scope. Additional details regarding the land ownership research effort are included in EPS' technical report (Appendix A).

Figure 2A depicts the project master parcel dataset used for land acquisition cost estimation. Figure 2B depicts additional legislatively designated lands in the proposed project corridor area that may be relevant to future project impact evaluations.

3.1.1 General Land Use – Land Status

The Alaska Department of Natural Resources (ADNR) hosts the Alaska State Geo-Spatial Data Clearinghouse (ASGDC), providing public access to agency datasets to reduce redundancies and foster data sharing. As such, the ASGDC is a primary access point for ADNR lands data. ASGDC lands datasets are extracted from datasets used to produce the State status plats for their respective categories. Each dataset includes cases noted on the digital status plats up to one day prior to the date of extraction. Datasets obtained from the ASGDC for developing the project master parcel dataset include:

- Mental Health Trust – The Alaska Mental Health Trust Authority (Trust), a public corporation that contracts with the Alaska Permanent Fund Corporation to manage the cash corpus of the Trust and with ADNR to manage the land corpus.
- State Mining Claim – Mining claims may be 40 acres or 160 acres in size and remain active so long as rent is timely paid and annual labor requirements are met.
- State Selected Land – Federal lands selected or top-filed for a variety of reasons such as general purpose, expansion of communities, University of Alaska, and recreation.

- State TA/PAT – Lands approved or conveyed to the State for a variety of reasons such as general purpose, expansion of communities, University of Alaska, and recreation.
- Section Grid – Protracted section boundaries electronically generated using aliquot part algorithms developed by ADNR staff.
- Township Grid – Boundaries generated from radian measurements of township corner coordinates, represented to the nearest 0.001 second, recorded on official protraction diagrams from United States Bureau of Land Management (BLM) and ADNR.

The BLM Alaska Spatial Data Management System (SDMS) provides access to BLM-Alaska land record documents, reports, and web mapping tools, such as Master Title Plats (MTPs). Datasets obtained from BLM for developing the project master parcel dataset include:

- Native Allotment – Native Allotment lands
- Region Bnd – Native Corporation lands
- Village Bnd – Village lands

Supplemental datasets were digitized in computer-aided design (CAD) software by EPS and transferred to Ahtna for topology edits and compilation into the master parcel dataset. Parcels were digitized both by conversion from additional agency land parcel layers and manually based on agency online mapping tools, including the BLM MTP and ADNR Alaska Mapper. Digitized datasets include:

- Agriculture
- Federal Aviation Administration (FAA)
- Military
- Native Allotment
- Native Corporation
- Private
- State of Alaska

After the master parcel dataset was finalized, GIS analyst tools were used to calculate various land ownership statistics within a 120-foot corridor of the project cost basis alignment for use in EPS' land acquisition cost estimation efforts.

3.1.2 General Land Use – Special Use Areas

The Alaska State Legislature has designated 32 conservation areas, including state game refuges, critical habitat areas, and wildlife sanctuaries. Datasets outlining these areas are available through the Alaska Department of Fish and Game (ADF&G) web site. Additionally, the Alaska Board of Game has designated Controlled Use Areas around the state that restrict certain methods or means of the harvest of some game species. Ahtna queried all available datasets to identify those applicable to the proposed study corridor. Datasets obtained from ADF&G and illustrated on Figure 2B include:

- ADF&G Legislatively Designated Areas – All 32 conservation areas represented. No additional metadata included. Legislatively designated areas within the 2-mile project corridor include the Delta Junction State Bison Range and the Matanuska Valley Moose Range.
- ADF&G Game Areas with Restrictions – Categories includes Areas Closed to Hunting, Closed to Trapping, Controlled Use, and Management Areas. Areas were designated by the Board of Game and as listed in the Alaska Administration Code (AAC) – 5 AAC 92.550.
- ADNR Legislatively Designated Areas – Areas established by the Legislature for management of forest, recreational, and historical purpose, to protect and preserve natural habitat for fish and/or wildlife, and special restrictions not specifically tied to any previously mentioned purposes. Categories include Forest Legislative Desig, Multiple Use Legis, Parks Legislative Desig, and Wildlife Legis Desig. Dataset extracted from datasets used to produce the State status plats for their respective categories. Each dataset includes cases noted on the digital status plats up to one day prior to the date of extraction. Parks and Wildlife areas not displayed on Figure 2B due to overlap with the other layers relevant to the proposed project area.
- ADNR Recreational Use Areas – Recreation Land category represented. Land classification identifies the purposes for which state land can be used. Dataset extracted from datasets used to produce the State status plats for their respective categories. Each dataset includes cases noted on the digital status plats up to one day prior to the date of extraction.
- ADNR – Special Use Lands – Special Use Land category represented. Special use land designations are for the protection of archeological, biological, historic, recreational, scenic, scientific, or other special resource value warranting additional protections or requirements. Special use designations originate from an area or management plan, or at the director's discretion. Dataset extracted from datasets used to produce the State status plats for their respective categories. Each dataset includes cases noted on the digital status plats up to one day prior to the date of extraction.

3.2 Mapping and Imagery Availability

The Ahtna team utilized currently available public domain mapping and imagery data from government entities for use during this project. Ahtna also researched the availability of higher resolution and/or newer mapping and imagery products from private vendors over the entire project study corridor to support project cost estimation efforts. Figure 3 depicts currently available public domain imagery coverage as well as project study corridor area imagery data gaps that are assumed to require future project-specific imagery purchases.

The Alaska Statewide Digital Mapping Initiative initially identified the need to improve statewide mapping themes. This initiative was instrumental for obtaining federal funding for the Alaska Mapping Initiative (AMI), led by the United States Geological Survey (USGS) and with overview from the Alaska Mapping Executive Committee (AMEC). Together, these initiatives stemmed multi-agency collaboration in the acquisition of statewide orthorectified imagery and 3-dimensional elevation data. The Alaska Geospatial Council (AGC) was established in 2015 to improve geospatial activity in Alaska. The AGC is led by the ADNR Division of Geological & Geophysical Surveys (DGGS). The AGC is the local and regional voice of Alaska as it interfaces with the AMEC.

The State of Alaska purchased satellite imagery from the *Satellite Pour l'Observation de la Terre* (SPOT). GeoNorth Information Systems, LLC (GNIS) currently holds a contract with ADNR to host this imagery on a web map service (WMS) mosaic that covers the entire Roadbelt Intertie study corridor (AGC, n.d.). The SPOT imagery was collected from 2010-2016 and has 2.5 meter pixel resolution or better for the entire area. The SPOT imagery is licensed for federal, state, local and tribal use, as well as public non-commercial use. Licensing is available for commercial use through GNIS.

Interferometric Synthetic Aperture Radar (IFSAR) data derived digital surface models (DSMs) for Alaska are available through AMI, covering the entire Roadbelt Intertie study corridor. Multiple online portals are available to access IFSAR tiles in various formats, including the ADNR DGGS, USGS Earth Resources Observation and Science (EROS) Center, and The National Map, a collaborate. The IFSAR data was collected from 2010-2012 and has 5 meter pixel resolution. Ahtna developed digital topography to support Roadbelt Intertie Project conceptual design efforts from the IFSAR DSM data (DGGS, n.d.).

The Matanuska-Susitna Borough (MSB) collected imagery in 2011, 2016, 2017 and 2019 that covers some portions of the project study corridor (MSB, n.d). The MSB imagery has 1 foot pixel resolution. MSB collected Light Detection and Ranging (LiDAR) data in 2011 at the same time as the original imagery collection event. High resolution digital elevation models (DEMs) have been created from the 2011 LiDAR data that may be suitable for future engineering design tasks, but coverage of the project study corridor is limited.

The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) collected agricultural area imagery from 2012-2013 that covers portions of the northern Roadbelt Intertie study corridor. The NRCS imagery has 1 foot pixel resolution. It is currently available as a WMS through the University of Alaska's Geographic Information Network of Alaska (GINA, n.d.).

The State of Alaska's, Department of Commerce, Community, and Economic Development, Division of Community and Regional Affairs (DCRA) has collected imagery covering several villages near the project study corridor, including Copper Center, Tazlina, Glennallen, Gulkana, Gakona, Chistochina, Mentasta Lake, Tok, and Tanacross. The DCRA coverage is limited to the core village areas and the immediate Richardson Highway corridor, but it does offer some coverage of the project study corridor. The DCRA imagery was collected from 2001-2009 and has either 1 foot or 1/2 foot resolution, depending on the area. It is currently available as a streaming service or for download upon request (DCRA, n.d.).

Quantum Spatial, Inc. (Quantum), a private local vendor, indicated that they have relatively recent high-resolution imagery covering portions of the Richardson Highway, but that it likely would not cover study corridor areas away from the highway. Quantum also has partial older imagery coverage that overlaps with some of the DCRA imagery areas. Ahtna and Quantum concluded that it will likely be more cost-effective to fill project mapping and imagery data gaps with high-resolution satellite imagery.

Maxar Technologies' business unit DigitalGlobe owns a large quantity of archived high-resolution satellite imagery and offers new tasking for acquisition of current high-resolution satellite imagery (DigitalGlobe, n.d.). DigitalGlobe satellite imagery sales are currently handled by certified resellers such as LAND INFO Worldwide Mapping, LLC (LAND INFO). LAND INFO queried the DigitalGlobe satellite imagery archive against the imagery data gaps depicted on Figure 3. LAND INFO then provided estimated pricing for available archived and newly tasked satellite imagery purchases as well as post-processing costs such as orthorectification. Pricing assumptions such as archived imagery availability, acceptable imagery age, and imagery quality specifications (resolution, cloud-free, leaf-free, etc.) would need to be revisited during future project phases.

Unmanned aerial vehicle (UAV) imagery collection could be very cost-effective for areas of high interest such as substations and other infrastructure sites where ultra-high-resolution imagery would be beneficial. UAV imagery collection can generate high-resolution DSMs that would be suitable for detailed engineering purposes. UAV imagery collection costs are not specifically included in the project cost estimate.

Project-specific LiDAR data would likely be necessary for detailed design. A budget for LiDAR acquisition is included in EPS' engineering services cost estimate (Appendix A).

In summary, the project team utilized public domain topographic information and imagery for this reconnaissance-level engineering study. Mapping and imagery data purchases covering most if not all areas of the study corridor would be required during future project phases to obtain suitable high-resolution mapping and imagery data for detailed engineering design and environmental study work. Mapping and imagery data purchase budgets for both engineering design and environmental study purposes are included in the project cost estimate.

3.3 Cultural Resource Considerations

The Roadbelt Intertie Project is defined as an undertaking under Section 106 of the National Historic Preservation Act (NHPA) (Pub. L. No. 89-665, as amended by Pub. L. No. 96-515). Prior to authorizing an undertaking, the NHPA requires that federal agencies consider the potential effects of that undertaking on historic properties. The NHPA implementing regulations (36 Code of Federal Regulations [CFR] 800) define the process used to identify, evaluate, and assess effects on historic properties that may result from completing the undertaking. Historic properties are defined as any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places (NRHP) maintained by the Secretary of the Interior (SOI).

In an effort to avoid and/or minimize potential impacts to cultural resources and historic properties, a preliminary cultural resource desktop analysis was conducted. The primary objective of this analysis was to establish known cultural resource sensitivity areas for consideration in current and future project development phases.

3.3.1 Cultural Resources Study Area

As part of the NHPA Section 106 process, the lead federal agency for a project is responsible for defining the Area of Potential Effect (APE). The APE, as defined in NHPA implementing regulation 36 CFR § 800.16, is "...the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist...".

During the early design and engineering phases of a project, a broader study area can be used to conduct cultural resource research and investigations. The project study area can then be further refined to develop an APE as project engineering is finalized. For purposes of this preliminary desktop analysis, Ahtna defined the cultural project study area as a 1-mile (mi) buffer on either side of the project cost basis alignment.

3.3.2 Methodology

Ahtna queried the Alaska Department of Natural Resources, Office of History and Archaeology's Alaska Heritage Resources Survey (AHRS) Integrated Business Suite (IBS) database to identify known cultural resources and historic properties (i.e. AHRS sites) within the cultural study area. Locational information for the AHRS sites within the study area was aggregated on a per mile basis to establish known cultural resource sensitivity zones. Under the provisions of the Archaeological Resources Protection Act and the NHPA, specific AHRS site location information is restricted in distribution, and is not included in this report.

3.3.3 Preliminary Analysis Results

Figure 4 depicts AHRS site densities within the study corridor. Project engineers considered AHRS site densities during selection of the project cost basis alignment and project cost estimation. The documented cultural resource information will also facilitate future engineering and environmental planning efforts.

3.3.4 Limitations and Recommendations

This cultural desktop assessment is a high-level preliminary review of AHRS sites already identified within the study corridor for the Roadbelt Intertie Project. The data utilized in this assessment was obtained from the AHRS IBS. Potential AHRS IBS data limitations include:

- accuracy of current site location
- current site condition

- extent to which site boundaries were delineated and/or mapped

Cultural resources and historic properties may exist in areas without documented AHRS sites. It is recommended that additional desktop research be performed during future project phases, to include updated AHRS IBS database queries as well as previous cultural resource field survey coverage data gap analysis. This additional desktop research would help guide route selection and cultural resource field survey planning (i.e., identifying survey targets, creating march charts, etc.).

3.4 Environmental Considerations

Ahtna conducted a desktop analysis to identify environmental features along the proposed study corridor. Current environmental features were compared with features identified in previous studies, where applicable. This high-level environmental feature information was used to help gauge the estimated magnitude of future study, permitting, and mitigation requirements. It was not specifically considered during selection of the project cost basis alignment. Further environmental analyses will be required during future project phases, if the project moves forward.

In-depth environmental analysis of the Sutton to Glennallen portion of the study corridor was conducted and documented in the 1994 *Copper Valley Intertie Feasibility Study* (Section 2.1). The 1994 analysis identified environmental issues and areas expected to require further consideration during permitting and construction phases. The report was intended as the basis for an Environmental Assessment (EA), should one become necessary. The 1994 analysis considered two primary routes, with more alternative segments in some areas. The current project cost basis alignment is comparable to the routes and alternative segments analyzed at the time throughout the entire proposed project corridor.

The 1994 report described the affected environment, including wetlands/vegetation, water resources, aquatic ecology, wildlife including birds, mammals and threatened and endangered (T&E) species, land use and land status, cultural/historical resources, recreation, visual/scenic resources, air quality, and electric and magnetic fields. Similar datasets are available now, with updates and advanced modeling tools for spatially viewing data. Public domain datasets obtained from government entities for comparison to changes from 1994 are presented in Figures 5A – 5G and described in the following sub-sections.

3.4.1 Anadromous Waters Catalog (AWC)

The ADF&G Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes (AWC) and the Atlas to the AWC (Atlas) specify streams, rivers, or lakes that are protected for anadromous fish, as depicted in Figure 5A. The AWC is a numerical listing of the water bodies documented as being used by anadromous fish and the Atlas visually depicts these water bodies, and the fish history phases for which the water bodies are used (ADF&G, n.d.-a). Location information is primarily derived from USGS quadrant maps, field observations, and aerial photos. ADF&G data limitations note that over time, the relevant USGS quadrant maps may not be current for on-the-ground use. Additionally, some polygons are used to specify areas containing a number of water bodies supporting anadromous fish that cannot be depicted accurately on quadrant maps (1:63,360-scale). These polygons and lakes are both symbolized as waterbodies on Figure 5A. The AWC datasets are updated annually; however, many anadromous rearing locations have not yet been surveyed or documented.

In 1994, 14 anadromous streams were identified as crossed or directly downstream of the potential route alignments between Sutton and Glennallen, based on the 1992 AWC. The 2019 AWC includes 32 streams within the current proposed study corridor (Johnson, J., and B. Blossom, 2019a, 2019b).

3.4.2 National Wetlands Inventory

The United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps wetlands for the State of Alaska, as part of the Emergency Wetland Resources Act of 1986 (USFWS, n.d.). The NWI was first published in 1984, with the first update published in 1991 and additional updates planned at ten-year intervals. The next update is scheduled for 2020. The NWI indicates five possible wetland status categories in Alaska for each USGS quadrant map in production (1:63,360 scale).

The 1994 *Copper Valley Intertie Feasibility Study* (Section 2.1) also relied on the USFWS NWI and supplemented the analysis for missing sections using aerial photography. As in 1994, three wetland categories (palustrine, lacustrine, and riverine) are found within this project's proposed study corridor. The currently mapped area of each wetland category within the proposed study corridor is listed on Figure 5B for reference. However, regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used by the NWI. Not all wetland types depicted on Figure 5B may come under the Clean Water Act jurisdiction.

Recently, the definition and implementation regarding waters of the United States (WOTUS) was updated by regulatory agencies. The United States Environmental Protection Agency (EPA) and the United States Department of the Army published the Step One Rule to repeal the 2015 Clean Water Rule and return to the regulatory text prior to the 2015, effective December 2019. The Navigable Waters Protection Rule (Step Two) replaces the Step One Rule and categorizes jurisdictional waters into four categories, effective June 2020. The four federally regulated categories of WOTUS are as follows:

- Territorial seas and traditional navigable waters
- Perennial and intermittent tributaries
- Lakes, Ponds, and impoundments of jurisdictional waters
- Wetlands adjacent to jurisdictional waters

The scope of federal jurisdiction will depend on the definition of WOTUS and implementation of the Section 404 Permit Program under the Clean Water Act at the time of permitting.

3.4.3 Wildlife Species Concentration and Habitat Use

ADF&G provides the latest resources available for species and habitat assessment through an online open data portal (ADF&G, n.d.-b) and various other access points on the ADF&G website. Legacy ADF&G reports including the 1973 *Alaska's Wildlife and Habitat* (AWH) and the 1985 *Alaska Habitat Management Guide* (AHMG) continue as the basis for illustration of the distribution and concentrations of wildlife.

In 2016, ADF&G digitized the AWH data that was collected over many years, with dataset limitations provided individually. Generally, datasets were deliberately limited to simplify use of maps. ADF&G also digitized the AHMG data. The original maps were created using USGS quadrant maps at a 1:250,000 scale and divided into regions. The data was further categorized as Distribution, Human Use, and Community Use of species. The digitized areas and attributes of species data produced through these various sources are not identical but similar.

While ADF&G datasets were not available in 1994 in the same format, the AWH and the AHMG were the guiding basis for species habitat illustrated in the 1994 *Copper Valley Intertie Feasibility Study* (Section 2.1). Ahtna queried all available species datasets to identify ones applicable to the proposed study corridor. Selected applicable datasets were mapped for reference and comparison to the 1994 report. Datasets from the AWH were generally found to have larger coverage areas, thus more conservative. Datasets from the AHMG were found to contain additional attributes in some instances, such as rutting and calving areas. In areas of overlap between datasets, the AWH was prioritized with the AHMG overlain as applicable for supplemental habitat illustration. Regional datasets and select attributes were grouped as needed for cartographic purposes. Dataset limitations and attribute descriptions noted in published metadata are as follows:

- AWH Moose (Figure 5C) – Categories include Concentration Areas, Spring-Summer Concentrations, Fall Concentrations, Winter Concentrations and Distribution. ADF&G notes the categories chosen were deliberately limited to simplify use and when conflicting data was available, the most conservative interpretation was applied. Concentration areas refers to specific areas where moose group together for an essential activity. Spring-Summer Concentrations represent areas where parturient cows, yearlings, and some bulls concentrate on favored feeding areas. Fall Concentrations represent rutting and post-rutting distribution. Winter concentrations represent areas where moose concentrate during winter months. Distribution represents areas where moose are present, although may not be year-round and abundance is not a distinction. All categories displayed on Figure 5C, as applicable. The category Concentration Areas was not found within the project area.
- AHMG Moose (Figure 5C) – Categories include General Distribution, Known Calving Concentration Areas, Known Rutting Concentration Areas, and Known Winter Concentration Areas. Multiple categories are grouped where applicable. Known Calving Concentration Areas represent where concentrations of moose, especially parturient cows, have been observed during the calving period for more than one year.

Known Rutting Concentration Areas represent where concentrations have been observed during the rutting period for more than one year. General Distribution and Known Winter Concentration Areas not displayed on Figure 5C due to overlap with the AWH dataset.

- AWH Caribou (Figure 5D) – Categories include: Present, Calving, Summer Range, and Winter Range. Categories are summarized for individual caribou herds, where known. Individual herds may not summer or winter in the illustrated area at any given year but have done so at some time in recent years. Calving areas are used annually. All categories displayed on Figure 5D.
- AWH Caribou Migration Routes (Figure 5D) – Known, traditional migration routes depicted with arrows.
- AHMG Caribou (Figure 5D) – Categories include Known General Distribution, Known Calving Areas, Known Rutting Areas, Known Summer Concentration Areas, and Known Winter Use Areas. Multiple categories are grouped where applicable. Known Calving Areas represent areas where most calving by a specific herd has been observed. Known General Distribution and Known Winter Concentration Areas not displayed on Figure 5D due to overlap with the AWH dataset. The category Known Rutting Areas was not found within the project area.
- AWH Dall Sheep (Figure 5E) – The only mapping category used is Range. Too little data is available for specific populations to delineate lambing areas, winter ranges, etc. It is possible sheep are found where surveys have not been conducted and some habitat areas may not contain sheep at all seasons or all years.
- AHMG Dall Sheep (Not Presented) – Categories include General Distribution and Known Winter Use Areas. General Distribution and Known Winter Use Areas not displayed on Figure 5E due to overlap with the AWH dataset.
- AWH Primary Waterfowl Habitat in Alaska (Figure 5F) – Categories include Waterfowl Habitat and Pelagic Areas. Waterfowl breeding habitat plus habitat used mainly as feeding, resting, and staging areas. The category Pelagic Areas was not found within the project area.
- AHMG Trumpeter Swan (Figure 5F) – Categories include General Distribution, Known Dispersed Nesting and Brood-Rearing Areas, Known Molting Concentration Areas, Known Nesting and Brood-Rearing Concentration Areas, Known Spring and/or Fall Concentration Areas, and Known Spring Concentration Areas. All categories displayed on Figure 5F as one habitat group.
- AHMG Bald Eagle (Figure 5F) – Points represent sites where active or inactive Bald Eagle nests have been observed. No attributes are included within the dataset. Bald Eagle known concentration areas are not found within the project area.

Additionally, ADF&G participates with the Western Association of Fish and Wildlife Agencies (WAFWA), which developed an online Crucial Habitat Assessment Tool (CHAT) designed to inform the pre-planning phase of development projects with emphasis for energy and infrastructure development (ADF&G, n.d.-c). The tool is considered a work-in-progress but aims to manage and provide large data volumes and new tools for viewing data. As depicted on Figure 5G, the Alaska CHAT publishes aggregated and ranked data layers based on terrestrial and aquatic Species of Concern, freshwater integrity and species richness. A similar habitat assessment tool was not available in 1994 but the aggregated layers summarize data from ADF&G, which were available in 1994. Areas of each rank category that fall within the project study corridor were calculated for reference and are noted on Figure 5G.

In summary, potential environmental impacts, future study, and permitting requirements for the proposed project study corridor have not changed substantially from the 1994 environmental constraints analyses. Datasets have been updated over time and will continue to change with data availability and developments of analysis tools. Additional datasets and inter-agency analysis tools have also developed. Specific environmental considerations for the project will depend on route selection, data availability, agency coordination, and ground reconnaissance. Impacts can be minimized using protective measures, such as timing construction activities to avoid disruption to wildlife activities and following Best Management Practices (BMPs). The anticipated environmental impact evaluation and mitigation process is discussed further in the following section.

3.5 Environmental Impact Evaluation Process

The National Environmental Policy Act (NEPA) establishes requirements for environmental impact assessment, public input, and documentation regarding proposed actions. Various federal, state, and local agencies as well as land owners and other non-governmental stakeholders would be involved in the NEPA evaluation process.

3.5.1 Involved Agencies

The following federal, state and local agencies would likely be involved in Roadbelt Intertie Project environmental scoping, providing input to environmental documents, and/or permitting.

- USDA Rural Utilities Service (RUS): RUS approval may be required depending on how the project is funded. In some scenarios RUS might serve as the lead agency.
- USACE / EPA - Alaska Department of Environmental Conservation (ADEC): A USACE Clean Water Act Section 404 permit would be required where the project could affect waters of the United States, including wetlands. An EPA Section 401 water quality certification permit, administered by the ADEC, would be obtained concurrently with the Section 404 permit.
- United States Coast Guard (USCG): USCG consultation and/or permits for in or over-water structures may be required if the Roadbelt Intertie crosses navigable waters.
- BLM: The BLM administers land along both the Glenn and Richardson Highway portions of the proposed study corridor. A BLM ROW permit would be needed if the proposed Roadbelt Intertie would cross their lands. The BLM ROW permit would be coordinated through the Glennallen District Office.

- FAA: An obstruction evaluation determination is required for any project that may affect the national airspace, air navigation facilities, or airport capacity. Applicable aeronautical studies are conducted by the FAA's Obstruction Evaluation Group (OEG).
- ADF&G: ADF&G Title 16 Fish Habitat Permits would be required at all water body crossings designated as fish habitat.
- ADNR: ADNR may require as-built surveys related to a State of Alaska easement.
- DOT&PF: The Alaska Department of Transportation and Public Facilities (DOT&PF) has permit authority for utilities in their rights of way.
- SHPO: The SHPO would be consulted to evaluate the effects on cultural resources within the proposed route. Actions affecting cultural resources on BLM lands also require consultation with the SHPO. SHPO consultation is also necessary on private and native corporation lands.
- USFWS: The USFWS would be consulted about T&E species and migratory birds. Primary project concerns are related to the potential of electrical transmission lines to impact migratory birds.
- MSB: Projects within the MSB require a development permit that typically requires a 20-day review period and approval by the planning board for projects of this scale. MSB also requires a public involvement process.

In addition to coordination with the above agencies, the Alaska National Interest Lands Conservation Act (ANILCA) requires federal agencies to consult with the State of Alaska, affected units of state government, and affected Native corporations concerning projects on federal lands.

3.5.2 Environmental Impact Statement

The Roadbelt Intertie Project is too large to be considered for categorical exclusion from NEPA requirements. A lead federal agency would be established to coordinate preparation of an Environmental Assessment (EA), an Environmental Impact Statement (EIS) or both. Development of the EA and/or EIS would evaluate any environmental consequences of the proposed project, including need for further studies or mitigation, and provide formal opportunities for public input.

An EA determines whether a federal action has the potential to cause significant environmental effects. Generally, an EA includes a brief discussion of:

- Need for the proposed action
- Alternatives (when there is an unresolved conflict concerning alternative uses of available resources)
- The environmental impacts of the proposed action and alternatives
- A listing of agencies and persons consulted.

Based on the EA, one of the following actions would occur:

- If the agency determines that the action will not have significant environmental impacts, the agency will issue a Finding of No Significant Impact (FONSI), documenting why the agency has concluded that the proposed action would not result in significant environmental impacts.
- If the EA determines that the environmental impacts of a proposed federal action will be significant, an EIS would be prepared.

Proposed projects that are anticipated to have significant environmental impacts can omit EA preparation and proceed directly to preparation of a more detailed and rigorous EIS. It is assumed that preparation of an EIS would be required for the Roadbelt Intertie Project, due to its size. Note that EIS documents typically remain valid for 5 years.

3.5.2.1 Agency Consultations

During preparation of an EIS, consultations would be sought with various agencies including USFWS, ADF&G, SHPO, and FAA.

3.5.2.1.1 USFWS

The Endangered Species Act (ESA) directs all federal agencies to work to conserve endangered and threatened species and to use their authorities to further the purposes of the Act. Section 7 of the Act, called "Interagency Cooperation," is the mechanism by which federal agencies ensure the actions they take, including those they fund or authorize, do not jeopardize the existence of any listed species. USFWS is the lead agency for the ESA consultation.

3.5.2.1.2 ADF&G

ADF&G has the statutory responsibility for protecting freshwater anadromous fish habitat and providing free passage for all fish in freshwater bodies (AS 16.05.841-871). The Roadbelt Intertie Project will likely cross numerous waterbodies that support anadromous fish, requiring agency consultation and Title 16 Fish Habitat Permits.

3.5.2.1.3 Alaska State Historic Preservation Office Section 106 Consultation Concurrence

The applicant would consult with the SHPO on the project’s potential to impact historic properties. Historic properties are cultural resources eligible for the NRHP. Cultural resources include but are not limited to historic and prehistoric archaeological sites, built environment, and traditional cultural properties. Consultation will likely consist of defining direct and indirect (visual) APEs for the project, identifying cultural resources within the project’s APEs, determining if any of the cultural resources within the APEs are historic properties, and then requesting concurrence from SHPO on a Determination of Effect for the project. Determining whether cultural resources are historic properties or not may require additional research and/or field survey work.

Mitigation will be necessary if a Determination of Adverse Effect is made. Mitigation measures, if necessary, will be established in a Memorandum of Agreement (MOA). Likely parties to the

MOA include the applicant, federal and state government agencies, local native and community organizations, and land owners. Other parties may be discovered through the Section 106 Consultation process.

It is important to note that the lead federal agency for the EIS will not sign a Finding of No Significant Impact (FONSI) if the Section 106 Consultation process has not been completed. Getting a signed FONSI can take considerable time. Allow 18 to 24 months for this process. Expenses will revolve around whether additional archaeological survey is required and/or whether professional assistance is needed in developing a Determination of Effect.

3.5.2.1.4 FAA

The obstruction evaluation process begins at a regional level within the FAA, and involves all lines of business including Airports, Airway Facilities, Flight Standards, Flight Procedures, and Air Traffic. The governing regulation is 14 CFR Part 77, Safe, Efficient Use, and Preservation of the Navigable Airspace.

The FAA's philosophy in evaluating objects that may impact navigable airspace is that each is presumed to be a hazard until proven otherwise. This posture clearly favors the aeronautical community and is consistent with the FAA's overall mission of promoting aviation safety.

If a tower or other object is found to have a significant adverse impact, a "hazard" determination will be issued. However, in many of these cases, the FAA negotiates with the proponent until the conditions are met for a "no-hazard with conditions" determination. These efforts are a key benefit of the FAA's participation at this level.

3.5.2.2 Impact Categories

The Roadbelt Intertie Project location and features are such that all NEPA environmental impact categories must be analyzed during preparation of an EIS. Some of the anticipated impact categories are discussed further in the following sub-sections.

3.5.2.2.1 Visual

In considering the effects of proposed projects or activities on society and the environment, assessment of visual impacts is important to several types of resources. Visual impacts affect purely scenic resources and scenic experiences of the landscape. However, projects or activities may affect other resources and experiences that have an important visual component or aspect such as wild and scenic rivers, wilderness, or historic sites and trails.

Environmental reviews conducted during the 1994 study indicated that visual impacts were potentially one of the most significant impact categories for the Sutton to Glennallen portion of the Roadbelt Intertie project, and that likely has not changed.

3.5.2.2.2 Recreation

Recreation and special use areas are described as state or nationally managed land having scenic, historic, archaeological, scientific, biological, recreational, or other special resource values that warrant additional protections and special requirements (e.g. trail systems, parks, wildlife refuges, etc.). Figure 2B depicts some special use areas in the Roadbelt Intertie project area. Environmental reviews conducted during the 1994 study indicated that recreational impacts were potentially one of the most significant impact categories, and this likely is still the case.

The applicant will need to coordinate with local government planning departments, recreational service areas, and volunteer trail groups who maintain recreational trails traversed by the Roadbelt Intertie Project in order to avoid or reduce impacts to recreational use and access.

3.5.2.2.3 Wetlands and Waterways

A review of the project study corridor was conducted for the presence and distribution of wetlands and aquatic resources. The USFWS NWI Wetland Mapper was utilized to identify wetlands and water bodies in the project area.

The NWI Wetland Mapper indicated near complete coverage of the proposed project study corridor by freshwater emergent, freshwater forested scrub, freshwater pond, lakes, and rivers. All of these features and resources are regulated by the USACE. Fill placement and other discharges of construction materials into these features requires a section 404 permit from the USACE and may require mitigation and/or restoration of impacted habitats.

The proposed Roadbelt Intertie would cross numerous waterways that may be navigable waters and may require USCG and USACE approval for in or over-water structures.

3.5.2.2.4 Avian Resources

Preliminary research indicates that the project corridor are an important migration corridor and summer foraging area for waterfowl, and other various migratory birds.

Migration timing for birds has northern migrants arriving or passing through the project area between the last week of March and early June. South migrating species would be anticipated before ice-up.

Pre-construction surveys of bird use in planned intertie placement areas may be needed depending on consultation feedback from USFWS biologists.

Ground clearing and construction activities associated with the project should take into account the recommended "no-clearing" windows established by the USFWS. The no-clearing window during which vegetation removal should be avoided is June 1 to July 31. Adhering to the no-clearing window restriction will help the project comply with the Migratory Bird Treaty Act.

3.5.2.2.5 Other Mammals

The project corridor is expected to be within the range of numerous large and small mammals. Further consultation and analysis of the effects of the intertie placement is needed to ensure limited disruption to migrations and habitat access on a specific site basis.

3.5.2.2.6 Fisheries

Fish collection records provided by the ADF&G indicate the use of project area waterways by numerous resident and anadromous fish species. Records indicate the occurrence of pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*Oncorhynchus keta*), coho salmon (*Oncorhynchus kisutch*), sockeye salmon (*Oncorhynchus nerka*), Chinook salmon (*Oncorhynchus tshawytscha*), and Dolly Varden trout (*Salvelinus malma*) in project area waters that may be effected by the Roadbelt Intertie and other project development activities.

Waterway crossings and in-water structures in rivers, streams, and other waterways will require a Fish Habitat Permit from ADF&G and may trigger the need for mitigation activities and implementation of specific BMPs during project operation, maintenance, and development.

3.5.2.2.7 Threatened and Endangered Species

A cursory review of literature for the area does not show the presence of any T&E species.

3.5.3 Permit Requirements

The following are the minimum known required environmental permits for the Roadbelt Intertie Project:

- USACE Section 404 Permit with EPA-ADEC 401 Certification;
- BLM ROW Permit;
- FAA Obstruction Evaluation Determination;
- ADF&G Title 16 Fish Habitat Permits;
- MSB Development Permit; and
- Ahtna, Inc. Land Use Permit.

3.5.3.1 USACE Section 404 Permit / EPA-ADEC Section 401 Permit

Once the permit application is assigned, the public notice may not go out for a month. A typical permit application public notice period for an individual permit is 30 days. The USACE has no regulatory requirement for issuing the permit within a certain timeframe.

The USACE requires compensatory mitigation in all cases for wetlands loss. A Nationwide Permit (NWP) 12 could potentially apply to the Roadbelt Intertie Project if the total wetlands impacts are 0.5 acres or fewer. An NWP typically requires a 15-day review. However, as of April 2020, NWP 12 is in litigation and the USACE issued a directive not to process any NWP 12 verifications until further notice. If an applicable NWP is either not available or the project does not meet impacted wetlands acreage criteria, an individual Section 404 permit with a longer processing time would be required. The EPA-ADEC Section 401 water quality certification is issued concurrently with the 404 permit. There is a permit fee of $100. Total processing time can be 3 to 6 months. Note that the USACE will assess compensatory mitigation as a 1:1.5, 1:2 or 1:3 metric. This means that for every acre of impact, 1.5 acres, 2 acres, or 3 acres will have to be compensated for. The cost is based on the land values.

3.5.3.2 BLM ROW Permit

The BLM typically negotiates an agreement with the applicant where funds are set aside for BLM staff to process the ROW permit application. The resulting environmental document required would be prepared based on the lead federal agency statutes and regulations. If BLM is the lead federal agency, the agreement between the applicant and BLM will include funds for preparation of this document.

The BLM will also require an EIS per their regulations. The BLM may choose to complete this document, in which case it will require reimbursement from the applicant. The applicant may have the opportunity to hire a contractor to do the EIS; however, note that the applicant will want to coordinate with agencies prior to selecting a consultant and getting cost estimates. Cost estimates will depend on what special studies may be needed for the corridor. A contractor may be less expensive and more efficient, depending on the BLM staff availability. However, it is still subject to the BLM approval and must satisfy their requirements. The BLM reserves the right to deny a ROW permit even after the applicant pays these fees and conducts this research. The BLM suggests that applicants schedule a pre-application conference with their staff to learn about their issues and concerns. In general, the staff will be concerned about reasonable alternatives and why a certain route was selected over other routes.

There may be other fees besides the cost reimbursement to the federal agencies for staff time. The BLM staff may author the EIS or the applicant may hire a consultant to complete it. This can take at least 6 to 9 months and possibly a full year if the BLM is the lead federal agency and they decide to conduct field work.

3.5.3.3 FAA Obstruction Evaluation Determination

The FAA’s OEG conducts aeronautical studies for any object that may affect the national airspace, air navigation facilities, or airport capacity. In accordance with 14 CFR Part 77, an applicant must file notice at least 45 days before the start date of the proposed construction or alteration or the date an application for a construction permit is filed, whichever is earliest. However, the FAA recommends that notices be filed 60-90 days before planned construction. The aeronautical study process includes evaluations by various lines of business, and any identified impacts must be resolved before a final agency determination is issued. In addition, the proposal may warrant a 30-day public notice to obtain aeronautical impacts.

Once the FAA has completed an aeronautical study, a determination valid for 18 months is issued regarding the project's impact to air navigation. One of three responses is typically issued:

- Determination of No Hazard - The proposed project does not exceed obstruction standards and marking/lighting is not required.
- Determination of No Hazard with Conditions - The proposed project would be acceptable contingent upon implementing mitigating measures such as the marking and lighting of the structures.
- Determination of Hazard - The proposed project was determined to be a hazard to air navigation and may not be constructed.

3.5.3.4 ADF&G Title 16 Fish Habitat Permits

Any stream crossing will involve coordination with the ADF&G. Their permit processes allow for certain culverts or bridges that allow for resident fish passage and for anadromous fish in streams known to support such species. Fish passage permits are not difficult to obtain and do not routinely take more than a couple of months. Expenses in obtaining a fish passage permit are anticipated to be minimal.

3.5.3.5 MSB Development Permit

The MSB development permit application must be accompanied by a fee. The fee is $750 if in a Resource Development Zone or Transportation Corridor Zone. The Conditional Use Permit fee is $500. The permit can take 6 to 9 months to process depending on when the council meets.

3.5.3.6 Ahtna, Inc. Land Use Permit

This permit would be needed if the Roadbelt Intertie were to cross lands owned by Ahtna, Inc. Processing it would probably not be time consuming.

3.5.3.7 Summary

Table 3-1 summarizes the anticipated environmental permit requirements for the Roadbelt Intertie Project.

TABLE 3-1: ENVIRONMENTAL PERMIT REQUIREMENT MATRIX

Agency	Permit Name	Permit Coverage/Rationale
USACE / EPA-ADEC	404 Permit with EPA-ADEC 401 Certification	A USACE Clean Water Act Section 404 Permit would be required where the project could affect waters of the USA, including wetlands. An EPA Section 401 water quality certification permit administered by the ADEC would be obtained concurrently with the Section 404 permit.
BLM	ROW Permit	A BLM ROW permit would be needed if the proposed Roadbelt Intertie would cross BLM-managed lands.

Agency	Permit Name	Permit Coverage/Rationale
FAA	Obstruction Evaluation Determination	Determination of project's air navigation hazard and any required mitigation measures, conducted by the FAA's OEG.
ADF&G	Title 16 Fish Habitat Permits	ADF&G coordination regarding need for Title 16 fish habitat permits will be required for any stream crossings.
MSB	Development Permit	Projects within the MSB require a development permit that typically requires a 20-day review period and approval by the planning board for projects of this scale.
Ahtna, Inc.	Land Use Permit	This permit would be needed for the transmission line to cross any lands owned by Ahtna, Inc.

Key:
ADEC State of Alaska Department of Environmental Conservation
ADF&G State of Alaska Department of Fish and Game
BLM United States Department of the Interior, Bureau of Land Management
EPA United States Environmental Protection Agency
FAA Federal Aviation Administration
MSB Matanuska-Susitna Borough
ROW right-of-way
USACE United States Army Corps of Engineers

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4.0 COST ESTIMATION

Following selection of the Roadbelt Intertie cost basis alignment and design features, the project team estimated total project development costs as well as operation and maintenance costs. EPS also considered qualitative benefits of the project. Quantitative cost-benefit analyses were not conducted as they were not within the project scope; however, that would be a recommended next step if the project moves forward.

4.1 Cost Estimate Summary

Cost estimates for the Roadbelt Intertie Project are summarized in Table 4-1. Additional detail regarding the construction, engineering, and ROW acquisition cost estimates can be found in EPS' technical report (Appendix A). The estimated costs provided are intended to be EPS and Ahtna's professional opinion of the probable construction costs plus additional allowances for engineering, environmental studies, ROW acquisition, permitting activities, project management, and construction monitoring. The actual project costs could be substantially different from those indicated below depending on route selection, results of future design and environmental studies, market conditions, regulatory changes, or other factors.

TABLE 4-1: PROJECT DEVELOPMENT COST ESTIMATE SUMMARY

	Item	Amount (2020 Dollars)
	Construction	
	Transmission Line	$ 410 M
	Substation Modifications	$ 56 M
	Communication Modifications	$ 4 M
A	**Construction Subtotal (including Contingency)**	**$ 470 M**
B	**Engineering Services**	**$ 12 M**
C	**Environmental Services, ROW Acquisition, Permitting**	**$ 26 M**
	DESIGN AND CONSTRUCTION SUBTOTAL (A+B+C)	$ 508 M
D	**Construction Management (5% of A)**	**$ 23 M**
E	**Owner Costs (5% of A+B+C+D)**	**$ 26 M**
F	**Contingency on Non-Construction Costs (10% of B+C+D+E)**	**$ 9 M**
	TOTAL PROJECT DEVELOPMENT COST	**$ 566 M**

Operation and maintenance cost estimates for the Roadbelt Intertie Project are summarized in Table 4-2. Additional detail can be found in EPS' technical report (Appendix A).

TABLE 4-2: OPERATION AND MAINTENANCE COST ESTIMATE SUMMARY

Item	Amount (2020 Dollars)
Transmission Line O&M (first 10 years)	$ 400,000 per year
Transmission Line O&M (remainder of assumed 50-yr project life)	$ 800,000 per year
Substation O&M (total for O'Neill, Pump Station 11, Tok and Jarvis Creek)	$ 470,000 per year

4.2 Qualitative Cost Benefit Analysis

The Roadbelt Intertie Project offers several benefits. It would allow total transfers between the Southern and Northern Railbelt sections to increase from approximately 65-75 MW to 125 MW. In addition to the total energy transfer capacity improvement, the new line would increase electric power reliability throughout the Alaska road system by allowing at least 75 MW to be considered as firm power and not subject to interruption by any single line outage. Implementation of the Roadbelt Intertie Project would allow development of future generation in southcentral, interior, or eastern Alaska based on economics and not be geographically constrained. The new line would allow firm power deliveries to Fort Greely, which will substantially increase not only the amount of power that could be supplied to the facility, but the resiliency of that power. The new line would increase the Railbelt/Roadbelt's ability to accept renewable energy and provide significant spatial diversity for these resources. The project has potential economic benefits including reduced power costs for rural communities and support for regional economic development opportunities. The economic opportunity costs and potential environmental impacts of building the Roadbelt Intertie would be evaluated in detail during the NEPA process.

Although not included in the proposed Roadbelt Intertie Project design or cost, additional DoD facility resilience may be realized if the proposed Fossil Creek substation was also built, allowing Joint Base Elmendorf-Richardson to access redundant Railbelt/Roadbelt power through connection to MEA infrastructure.

5.0 PUBLIC AWARENESS CAMPAIGN

The Ahtna team assisted the Commission with project public engagement efforts as detailed in the following sub-sections.

5.1 Objectives

Public awareness campaign objectives were to:

1. let the public know early that a high-level preliminary reconnaissance engineering study was underway,
2. direct the public to a project website as a source of information and early public input mechanism, and
3. share that formal public meetings would be held during future design phases, if the project advances.

Detailed input regarding design features and transmission line routing was not solicited due to the conceptual nature of the design at this point in project development.

5.2 Stakeholder Messaging Team

In support of the Commission's public awareness campaign goals, the Ahtna team invited public relations stakeholders from the Ahtna Intertribal Resource Commission, AP&T, CVEA, GVEA, MEA and Tanana Chiefs Conference to join a stakeholder messaging team. GVEA declined to participate. Representatives of other listed entities participated in stakeholder messaging team teleconferences, provided input regarding public awareness campaign scheduling and format, and reviewed project communication materials prior to publication.

5.3 Project Website

The Ahtna team developed a project website (www.denali.gov/Roadbelt/Intertie/Information) to provide the public with project information as well as project-specific contact information for any questions or comments.

5.4 Public Awareness Meetings

Informational meetings were planned in 5 communities along the proposed transmission line study corridor. Scheduling discussions were initiated with contacts in Sutton, Chickaloon, Glacier View, Glennallen and Tok. However, the in-person public awareness meetings were cancelled due to the COVID-19 pandemic and associated safety measures implemented by state and local government agencies. In lieu of in-person meetings, a project flyer was developed and distributed to community contacts for circulation. If the project moves forward, route selection and a range of opportunities for public input, including public meetings or other forums, would occur during future design phase(s). The project flyer is provided in Appendix B.

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6.0 REFERENCES

Alaska Department of Commerce, Community, and Economic Development, Division of Community and Regional Affairs (DCRA), n.d. https://maps.commerce.alaska.gov/arcgis/rest/services/Community_Photos_Web/MapServer/WMTS, https://maps.commerce.alaska.gov/arcgis/rest/services/Community_Photos_Web/MapServer

Alaska Department of Fish and Game (ADF&G), n.d.-a. *Anadromous Waters Catalog – Overview*. https://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=main.home

ADF&G, n.d.-b. https://soa-adfg.opendata.arcgis.com/search?tags=Habitat

ADF&G, n.d.-c. *Critical Habitat Assessment Tool*. http://www.adfg.alaska.gov/index.cfm?adfg=chat.main

Alaska Department of Natural Resources, Division of Geophysical & Geophysical Surveys (DGGS), n.d. https://elevation.alaska.gov/

Alaska Energy Authority (AEA), n.d. *Fivemile Creek*. http://www.akenergyauthority.org/What-We-Do/Energy-Technology-Programs/Hydroelectric/Hydro-Projects/Fivemile-Creek

Alaska Geospatial Council (AGC), n.d. http://agc.dnr.alaska.gov/imagery_services.html, http://gis.dnr.alaska.gov/terrapixel/cubeserv/ortho

Chitina Electric, Inc., n.d. https://chitinaelectric.com/history.html

DigitalGlobe, n.d. https://discover.digitalglobe.com/

Geographic Information Network of Alaska (GINA), n.d. http://gina.alaska.edu/catalogs/7123-2013-usda-nrcs-big-delta-aerial-ortho-imagery, http://ogc.gina.alaska.edu/aerial

Johnson, J., and B. Blossom, 2019a. *Catalog of waters important for spawning, rearing, or migration of anadromous fishes - Interior Region*, effective June 1, 2019. Alaska Department of Fish and Game, Special Publication No. 19-02, Anchorage.

Johnson, J., and B. Blossom 2019b. *Catalog of waters important for spawning, rearing, or migration of anadromous fishes - Southcentral Region*, effective June 1, 2019. Alaska Department of Fish and Game, Special Publication No. 19-03, Anchorage.

Matanuska-Susitna Borough (MSB), n.d. https://data1-msb.opendata.arcgis.com/pages/msb-aerial-imagery

United States Department of Agriculture (USDA), 2019. *USDA Helps Remote Alaska Communities Offset High Energy Costs.* https://www.rd.usda.gov/newsroom/news-release/usda-helps-remote-alaska-communities-offset-high-energy-costs-0. 29 October.

United States Fish and Wildlife Service (USFWS), n.d. https://www.fws.gov/alaska/pages/wetlands/wetlands-inventory

FIGURES

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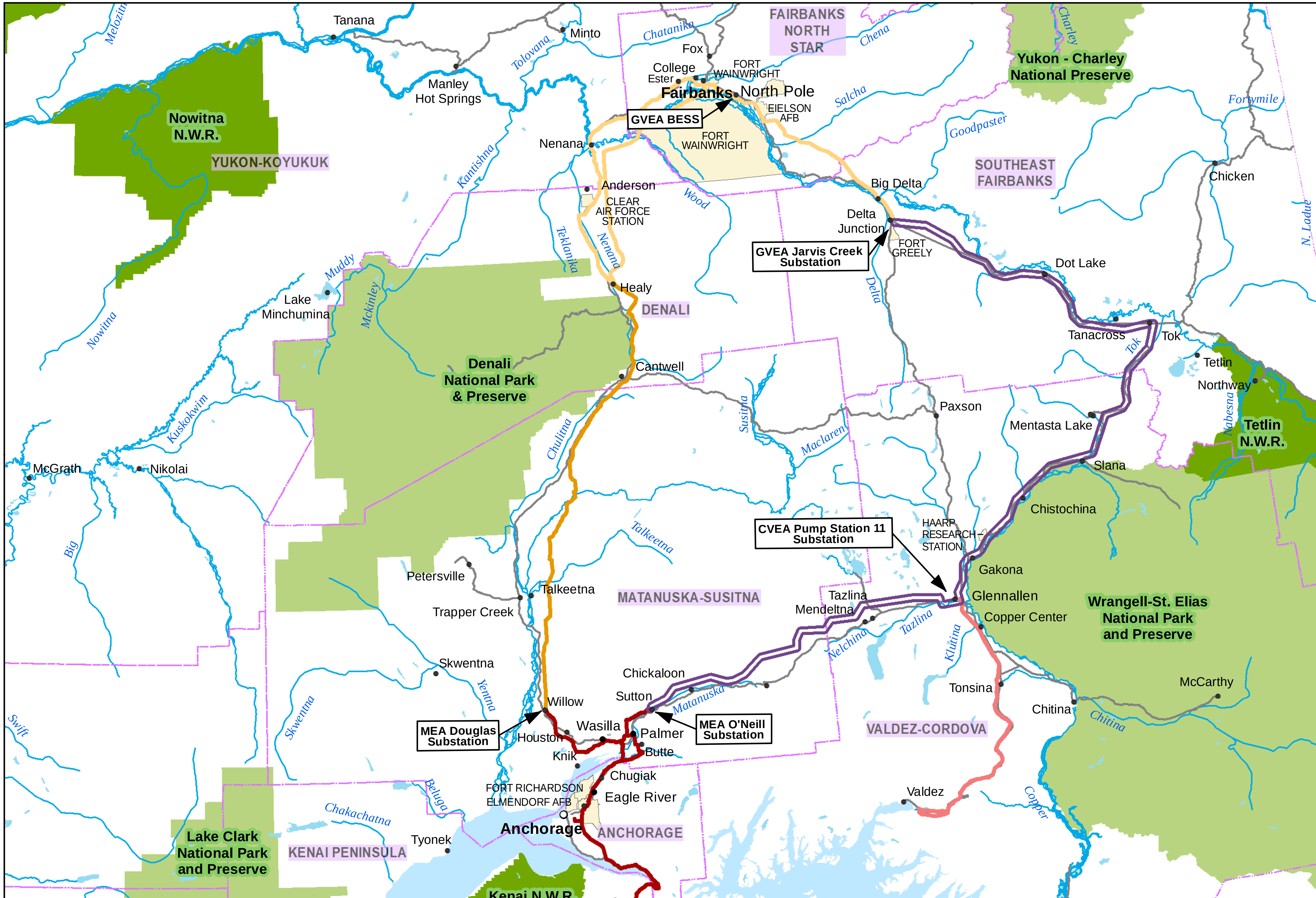

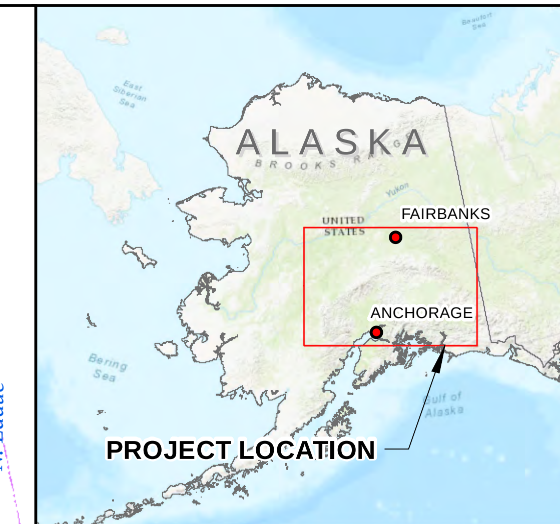

LEGEND

- New Transmission Line Study Corridor (approximate)

State Features

- State Road
- Alaska Intertie (approximate)
- Other Railbelt Transmission Lines (approximate)
- CVEA Transmission Lines (approximate)
- GVEA Transmission Lines (approximate)
- River
- Lakes
- Borough or Census Area Boundary
- Military Installation, Range and Training Area Boundary
- National Park Service Boundary
- National Wildlife Refuge Boundary

NOTES

Acronyms and Abbreviations:
- AFB - Air Force Base
- BESS - Battery Energy Storage System
- CVEA - Copper Valley Electric Association
- GVEA - Golden Valley Electric Association
- MEA - Matanuska Electric Association, Inc.
- N.W.R. - National Wildlife Refuge
- US - United States

Data Sources (Entity, Date/Version):
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Borough Area Boundary - US Census, 2015
- Military Installation - US Department of Defense, 2019
- National Park Boundary - US National Park Service, 2019
- National Wildlife Refuge Boundary - US Fish and Wildlife Service, 2019

MAP PROJECTION

Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 35 Miles

1 in = 35 miles

N

DENALI COMMISSION ALASKA

Project Configuration

ROADBELT INTERTIE RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 1

FILE: C:\Users\kholmes\Desktop\DC_Roadbelt\AutoCAD-GIS\NativeFiles\MXD\Figure1.mxd

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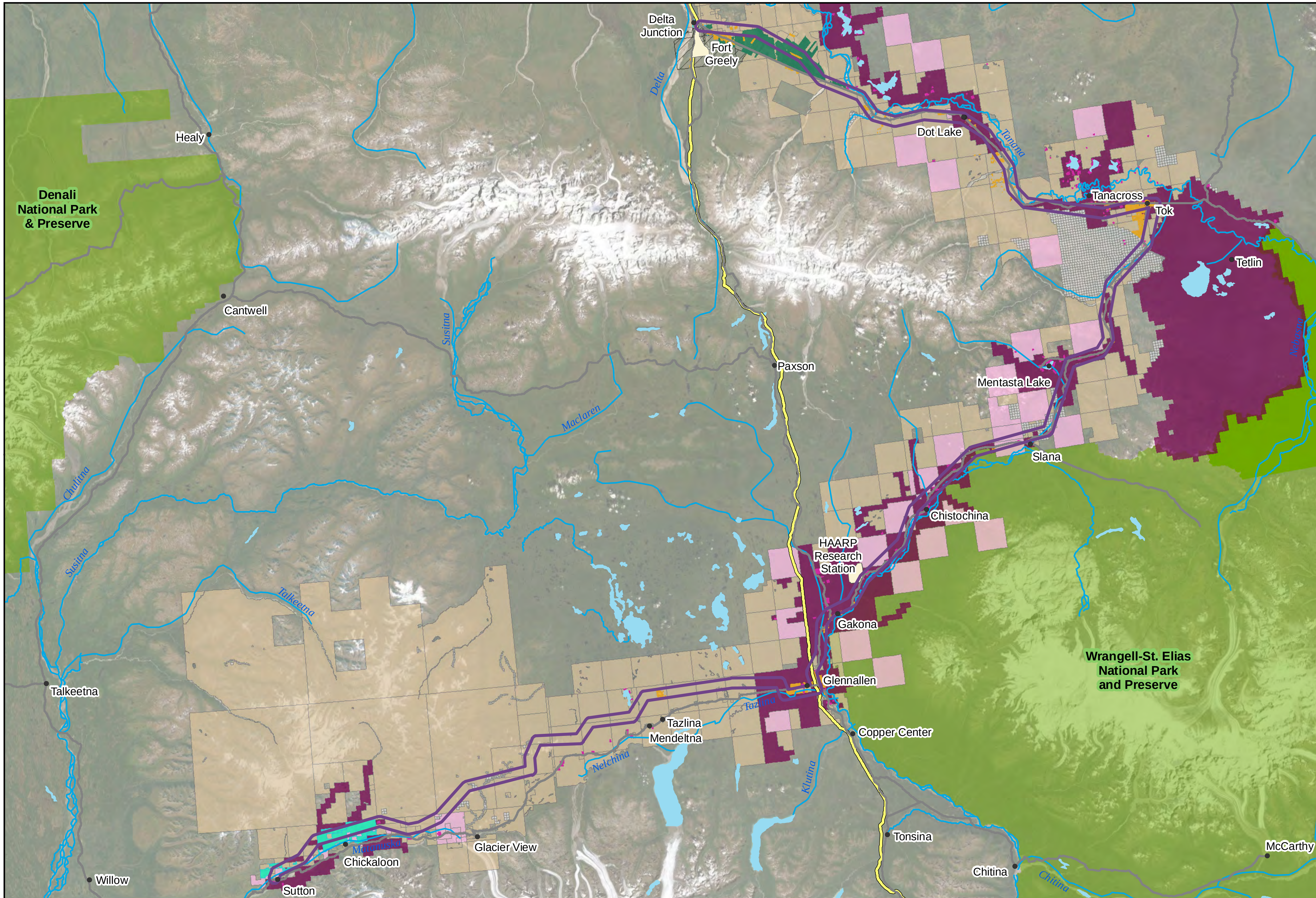

LEGEND

New Transmission Line Study Corridor (approximate)

Land Ownership Type

- Agriculture (digitized)
- Mental Health Trust (ADNR)
- Military (digitized)
- Native Allotment
- Private (digitized)
- Region (BLM)
- State Mining Claim (ADNR)
- State of Alaska
- Village (BLM)

State Features

- State Road
- TAPS
- River
- Lake
- Military Installation, Range and Training Area Boundary
- National Park Service Boundary
- National Wildlife Refuge Boundary

NOTES

Acronyms and Abbreviations:
- ADNR - Alaska Department of Natural Resources
- BLM - US Bureau of Land Management
- TAPS - Trans-Alaska Pipeline System
- US - United States

Data Sources (Entity, Date/Version):
- Land Ownership - various
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Military Installation - US Department of Defense, 2019
- National Park Boundary - US National Park Service, 2019
- National Wildlife Refuge Boundary - US Fish and Wildlife Service, 2019
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION

Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20 Miles

1 in = 20 miles

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DENALI COMMISSION ALASKA

General Land Use
Land Status

ROADBELT INTERTIE RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 2A

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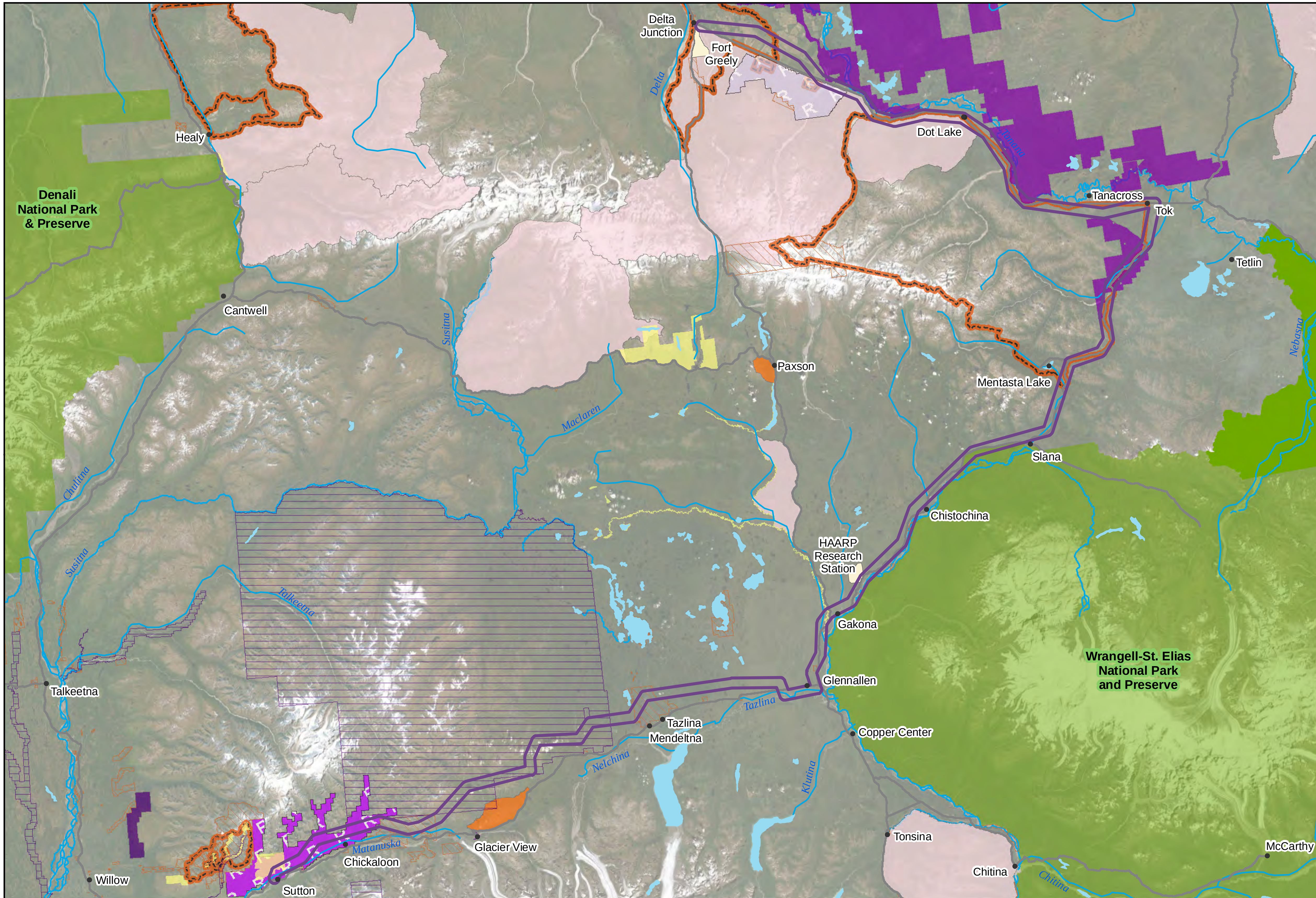

LEGEND

New Transmission Line Study Corridor (approximate)

ADFG Conservation Areas

- Delta Junction Bison Range
- Matanuska Valley Moose Range
- Willow Mountain CHA

ADFG Restrictive Hunting Areas

- Management Area
- Controlled Use Area
- Closed Area

ADNR Legislatively Designated Areas

- Forest
- Multiple Use

Additional Categorized Lands

- ADNR Recreational Use
- ADNR Special Use

State Features

- State Road
- River
- Lake
- Military Installation, Range and Training Area Boundary
- National Park Service Boundary
- National Wildlife Refuge Boundary

NOTES

Acronyms and Abbreviations:
- ADFG - Alaska Department of Fish and Game
- ADNR - Alaska Department of Natural Resources
- CHA - Critical Habitat Area
- US - United States

Data Sources (Entity, Date/Version):
- ADFG Conservation Areas - ADFG, 2020
- ADFG Restrictive Hunting Areas - ADFG, 2017
- ADNR Legislatively Designated Areas - ADNR, 2020
- ADNR Recreational Use - ADNR, 2020
- ADNR Special Use - ADNR, 2020
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Military Installation - US Department of Defense, 2019
- National Park Boundary - US National Park Service, 2019
- National Wildlife Refuge Boundary - US Fish and Wildlife Service, 2019
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION
Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20 Miles
1 in = 20 miles

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DENALI COMMISSION ALASKA

General Land Use
Special Use Areas

ROADBELT INTERTIE
RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 2B

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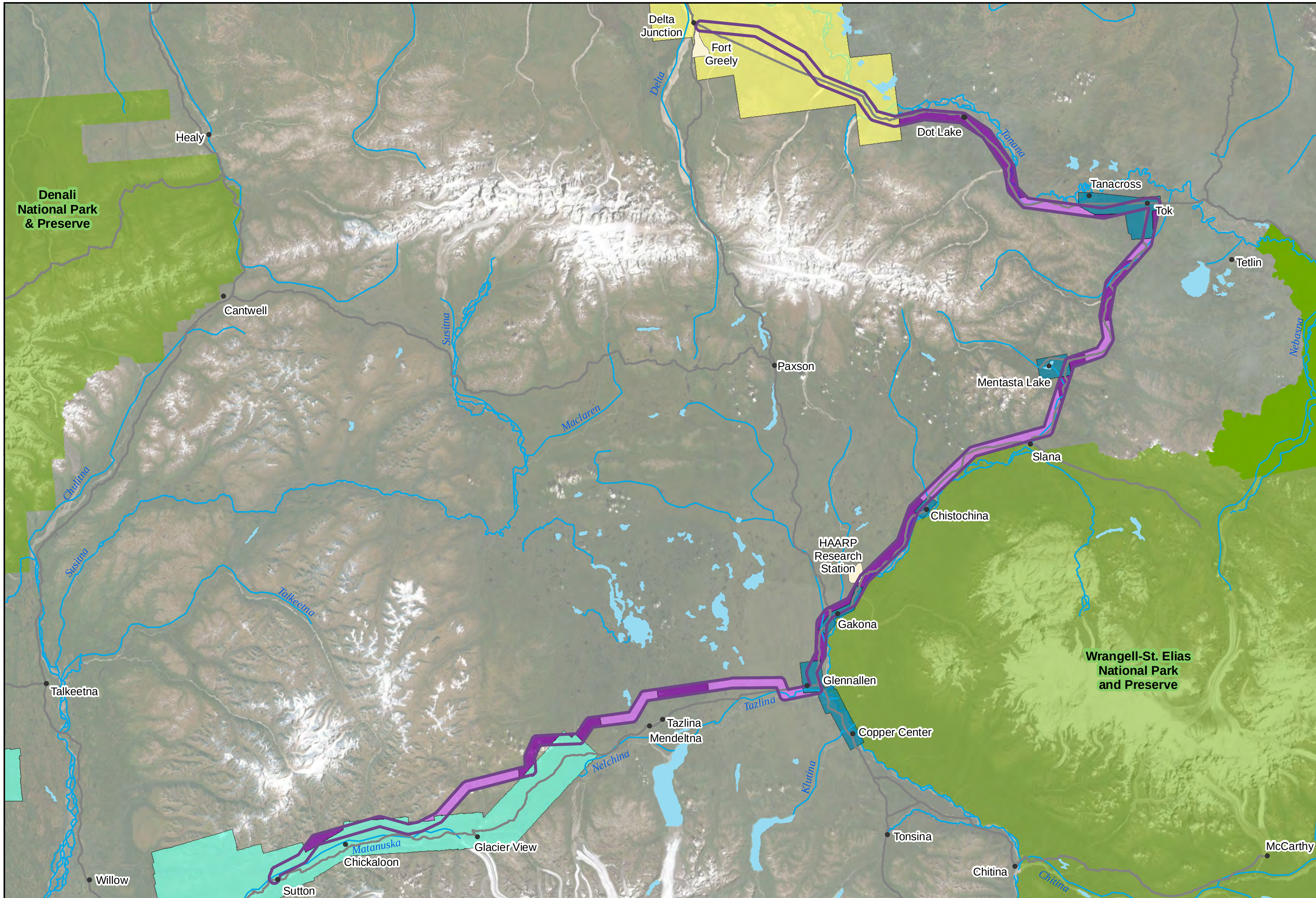

LEGEND

New Transmission Line Study Corridor (approximate)

Existing Public Domain Imagery

- DCRA
- MSB
- NRCS

Future Satellite Imagery Purchase

- DigitalGlobe - Archived
- DigitalGlobe - New Tasking

State Features

- State Road
- River
- Lake
- Military Installation, Range and Training Area Boundary
- National Park Service Boundary
- National Wildlife Refuge Boundary

NOTES

1. Alaska statewide orthomosaic imagery (SPOT 2.5 meter) and IFSAR data available for the entire study corridor.

Acronyms and Abbreviations:
- DCRA - Alaska Division of Community and Regional Affairs
- IFSAR - Interferometric Synthetic Aperture Radar
- MSB - Matanuska-Susitna Borough
- NRCS - US Department of Agriculture, Natural Resources Conservation Service
- SPOT - *Satellite Pour l'Observation de la Terre*
- US - United States

Data Sources (Entity, Date/Version):
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Military Installation - US Department of Defense, 2019
- National Park Boundary - US National Park Service, 2019
- National Wildlife Refuge Boundary - US Fish and Wildlife Service, 2019
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION

Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20 Miles
1 in = 20 miles

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DENALI COMMISSION ALASKA

Imagery Availability

ROADBELT INTERTIE
RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 3

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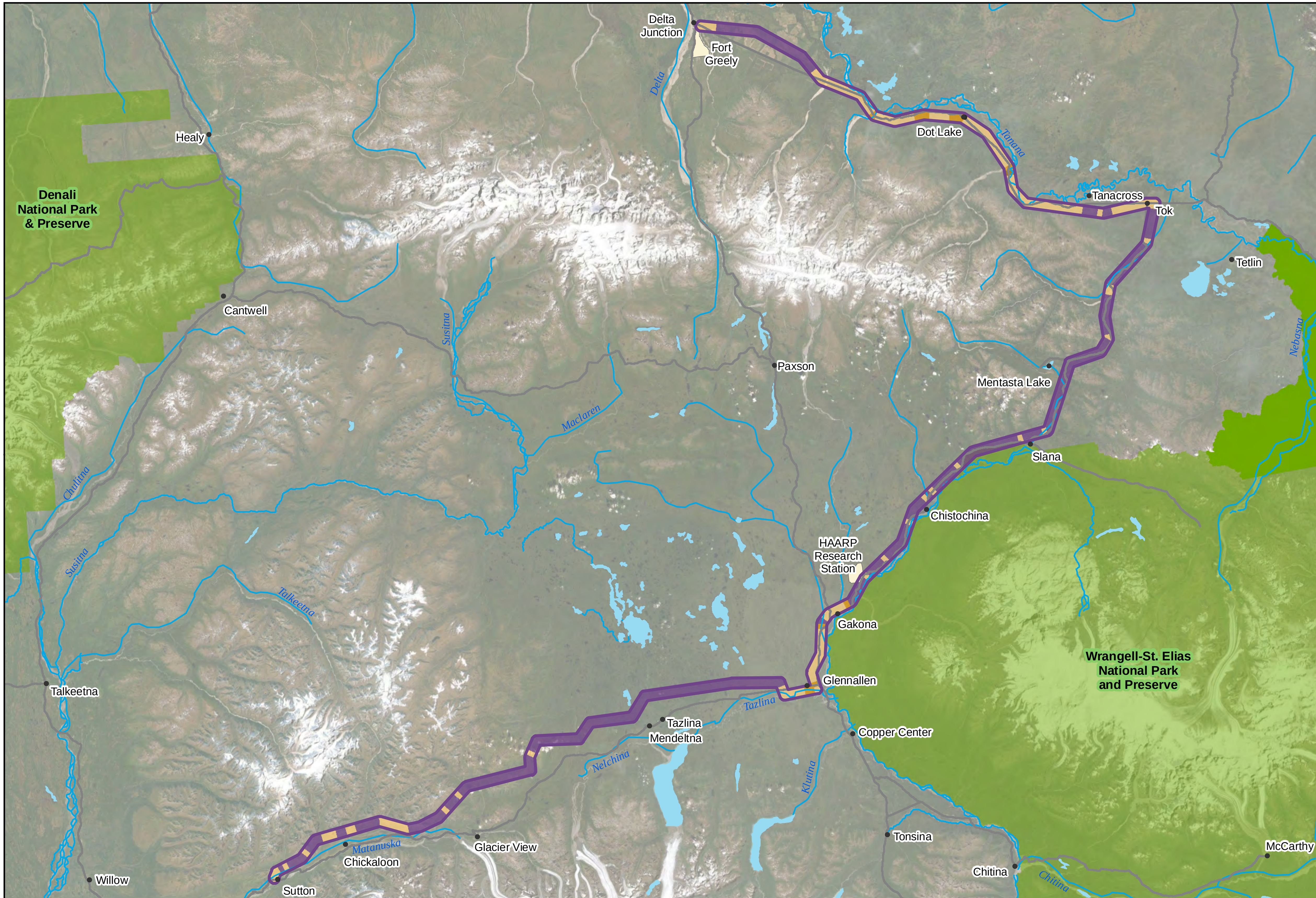

LEGEND

New Transmission Line Study Corridor (approximate)

AHRS Summary
- 0 AHRS Sites per Mile
- 1-5 AHRS Sites per Mile
- 6-10 AHRS Sites per Mile
- 11+ AHRS Sites per Mile

State Features
- State Road
- River
- Lake
- Military Installation, Range and Training Area Boundary
- National Park Service Boundary
- National Wildlife Refuge Boundary

NOTES

Acronyms and Abbreviations:
- AHRS - Alaska Heritage Resources Survey
- US - United States

Data Sources (Entity, Date/Version):
- AHRS Summary - Ahtna, 2020
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Military Installation - US Department of Defense, 2019
- National Park Boundary - US National Park Service, 2019
- National Wildlife Refuge Boundary - US Fish and Wildlife Service, 2019
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION
Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20 Miles
1 in = 20 miles

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Documented Cultural Sensitivity Zones

ROADBELT INTERTIE
RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 4

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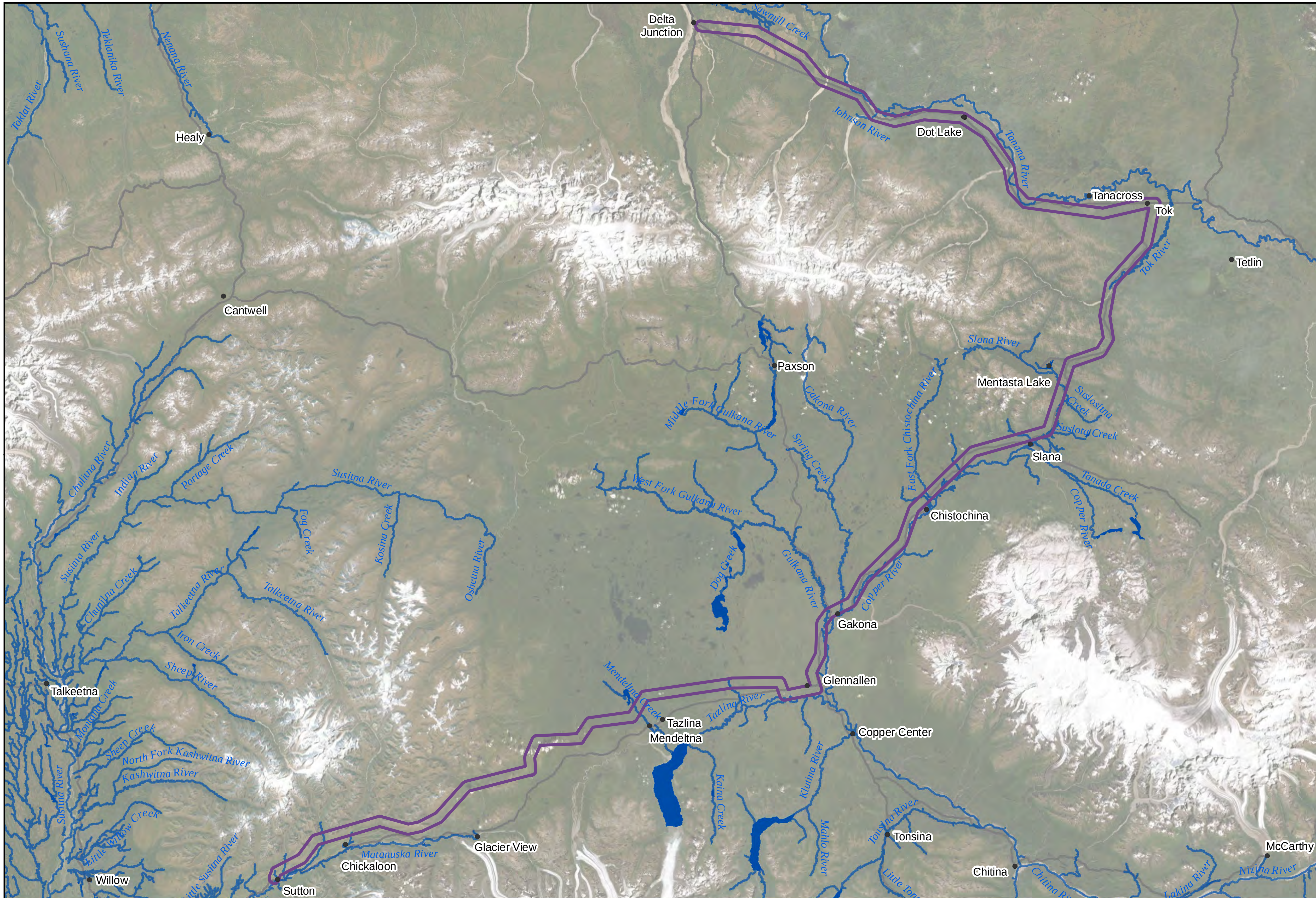

LEGEND

New Transmission Line Study Corridor (approximate)

AWC Feature Type

AWC Stream

AWC Waterbody

State Features

State Road

NOTES

Acronyms and Abbreviations:
- AWC - Anadromous Waters Catalog
- US - United States

Data Sources (Entity, Date/Version):
- AWC datasets - Alaska Department of Fish and Game, 2019
- State Road - Alaska Department of Transportation, 2019
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION

Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20 Miles

1 in = 20 miles

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DENALI COMMISSION ALASKA

Environmental Features
Anadromous Waters

ROADBELT INTERTIE
RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 5A

FILE: C:\Users\kholmes\Desktop\DC_Roadbelt\AutoCAD-GIS\NativeFiles\MXD\EnvC_MXD\Figure5A_AWC.mxd

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LEGEND

New Transmission Line Study Corridor (approximate)

Wetland Type (Area within Study Corridor)

- Palustrine (108,055 acres)
- Lacustrine (2,197 acres)
- Riverine (11,922 acres)

State Features

- State Road
- River
- Lake

NOTES

Acronyms and Abbreviations:
- US - United States

Data Sources (Entity, Date/Version):
- Wetlands - US Fish and Wildlife Service, 2017
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION

Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20 Miles

1 in = 20 miles

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Environmental Features
Wetlands

ROADBELT INTERTIE
RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 5B

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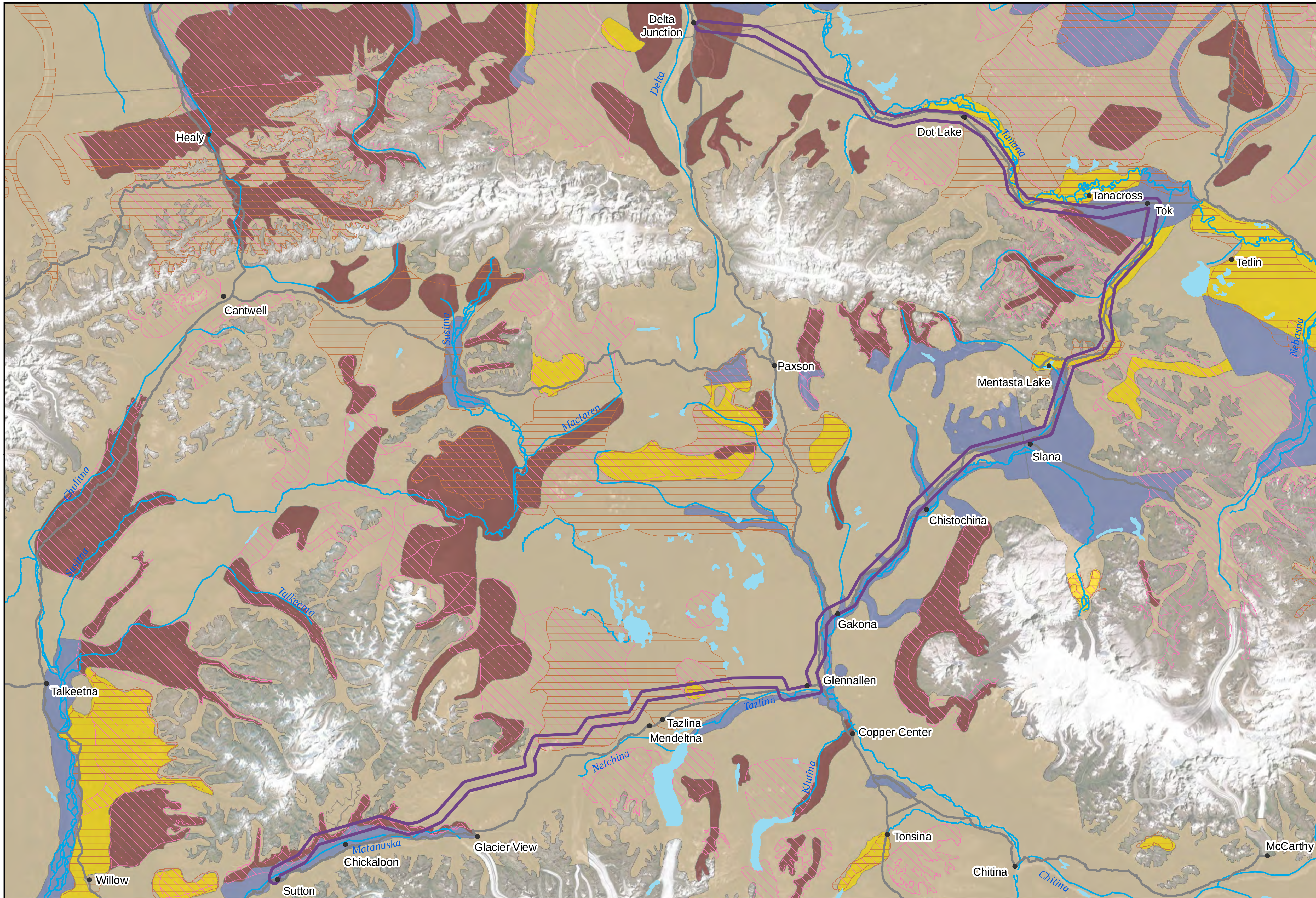

LEGEND

New Transmission Line Study Corridor (approximate)

AWH - Moose

- Spring-Summer Concentration
- Fall Concentration
- Winter Concentration
- Distribution

AHMG - Moose

- Known Calving Concentration
- Known Rutting Concentration
- Known Calving and Rutting Concentration

State Features

- State Road
- River
- Lake

NOTES

Acronyms and Abbreviations:

- ADFG - Alaska Department of Fish and Game
- AHMG - *Alaska Habitat Management Guide*
- AWH - *Alaska's Wildlife and Habitat*
- US - United States

Data Sources (Entity, Date/Version):

- AWH - ADFG, 2016
- AHMG - ADFG, 2020
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION

Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20 Miles

1 in = 20 miles

N

DENALI COMMISSION ALASKA

Environmental Features
Moose Habitat

ROADBELT INTERTIE RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 5C

FILE: C:\Users\kholmes\Desktop\DC_Roadbelt\AutoCAD-GIS\NativeFiles\MXD\EnvC_MXD\Figure5C_Moose.mxd

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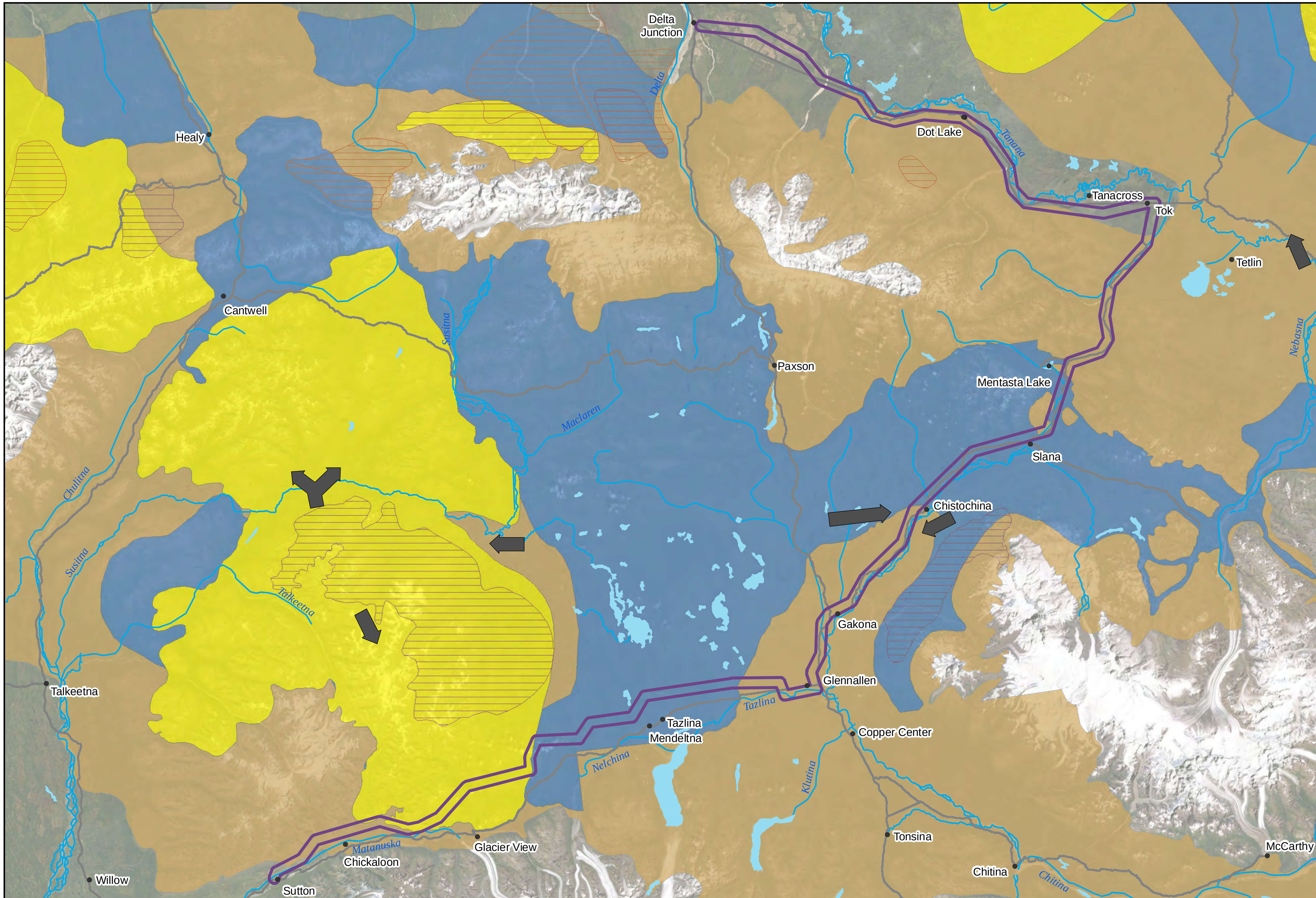

LEGEND

New Transmission Line Study Corridor (approximate)

AWH - Caribou

- Calving
- Summer Range
- Winter Range
- Present
- Migration Routes

AHMG - Caribou

- Calving

State Features

- State Road
- River
- Lake

NOTES

Acronyms and Abbreviations:
- ADFG - Alaska Department of Fish and Game
- AHMG - *Alaska Habitat Management Guide*
- AWH - *Alaska's Wildlife and Habitat*
- US - United States

Data Sources (Entity, Date/Version):
- AWH - ADFG, 2016
- AHMG - ADFG, 2020
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION

Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20 Miles

1 in = 20 miles

N

DENALI COMMISSION ALASKA

Environmental Features
Caribou Habitat

ROADBELT INTERTIE
RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 5D

FILE: C:\Users\kholmes\Desktop\DC_Roadbelt\AutoCAD-GIS\NativeFiles\MXD\EnvC_MXD\Figure5D_Caribou.mxd

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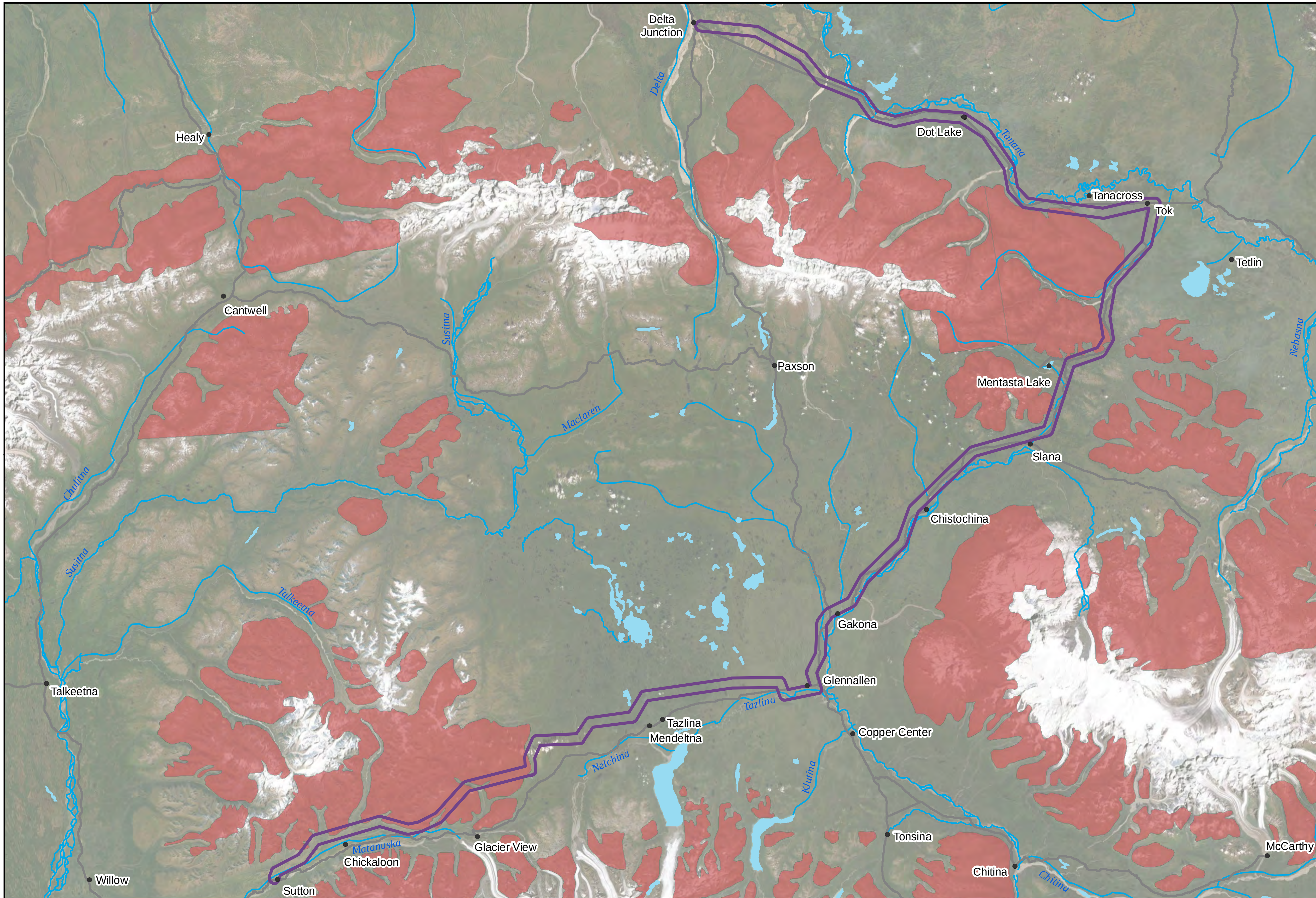

LEGEND

New Transmission Line Study Corridor (approximate)

AWH - Dall Sheep

Range

State Features

State Road

River

Lake

NOTES

Acronyms and Abbreviations:
- ADFG - Alaska Department of Fish and Game
- AWH - *Alaska's Wildlife and Habitat*
- US - United States

Data Sources (Entity, Date/Version):
- AWH - ADFG, 2016
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION

Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20 Miles

1 in = 20 miles

N

DENALI COMMISSION ALASKA

Environmental Features
Dall Sheep Habitat

ROADBELT INTERTIE
RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 5E

FILE: C:\Users\kholmes\Desktop\DC_Roadbelt\AutoCAD-GIS\NativeFiles\MXD\EnvC_MXD\Figure5E_DallSheep.mxd

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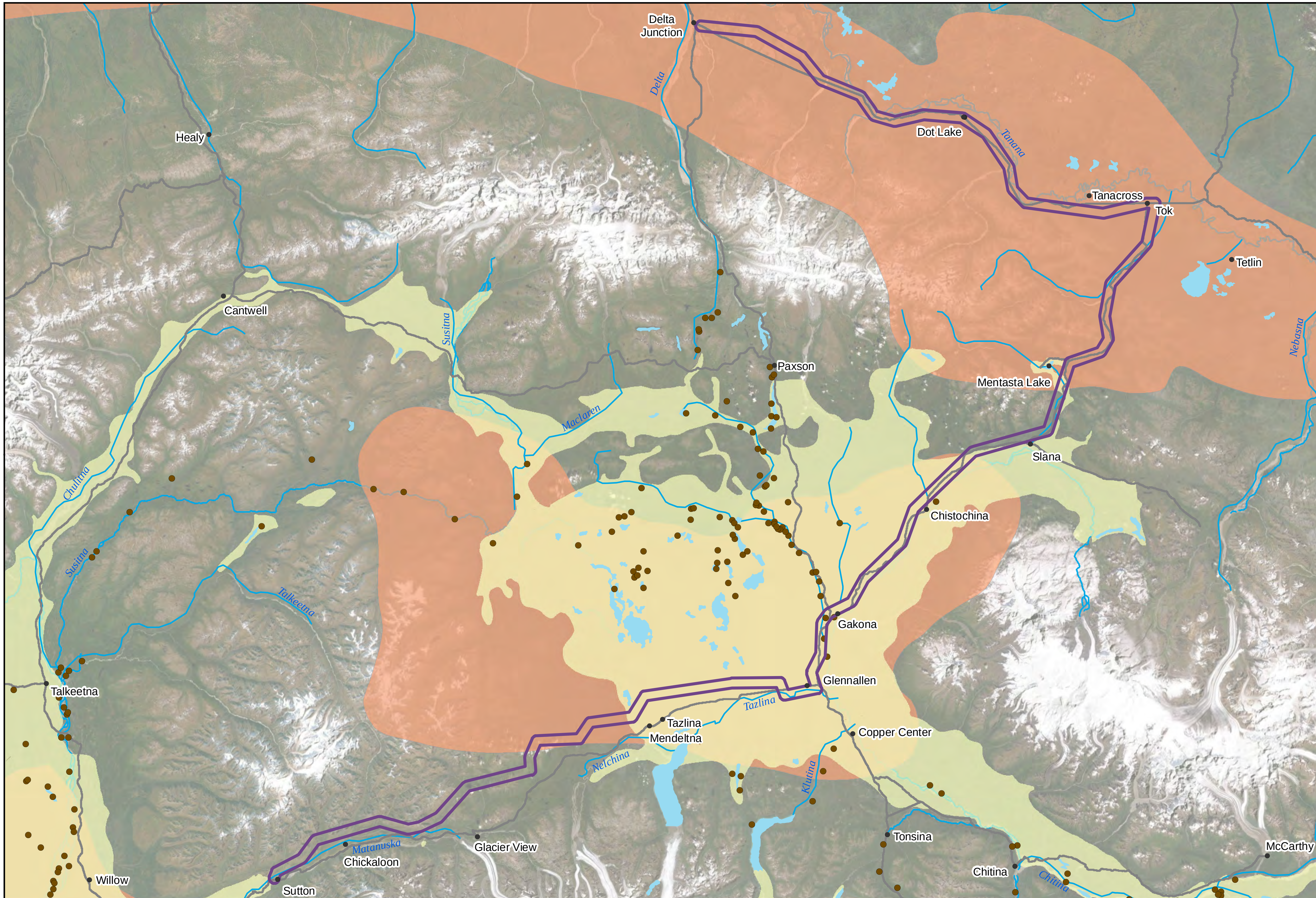

LEGEND

New Transmission Line Study Corridor (approximate)

AWH - Waterfowl

Primary Waterfowl Habitat

AHMG - Trumpeter Swans

Trumpeter Swan Habitat

AHMG - Bald Eagles

Bald Eagle Nest

State Features

State Road

River

Lake

NOTES

Acronyms and Abbreviations:
- ADFG - Alaska Department of Fish and Game
- AHMG - *Alaska Habitat Management Guide*
- AWH - *Alaska's Wildlife and Habitat*
- US - United States

Data Sources (Entity, Date/Version):
- AWH - ADFG, 2016
- AHMG - ADFG, 2020
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION
Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20
Miles
1 in = 20 miles

N

DENALI COMMISSION ALASKA

Environmental Features
Bald Eagle Nests and Waterfowl Habitat

ROADBELT INTERTIE
RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 5F

FILE: C:\Users\kholmes\Desktop\DC_Roadbelt\AutoCAD-GIS\NativeFiles\MXD\EnvC_MXD\Figure5F_Waterfowl.mxd

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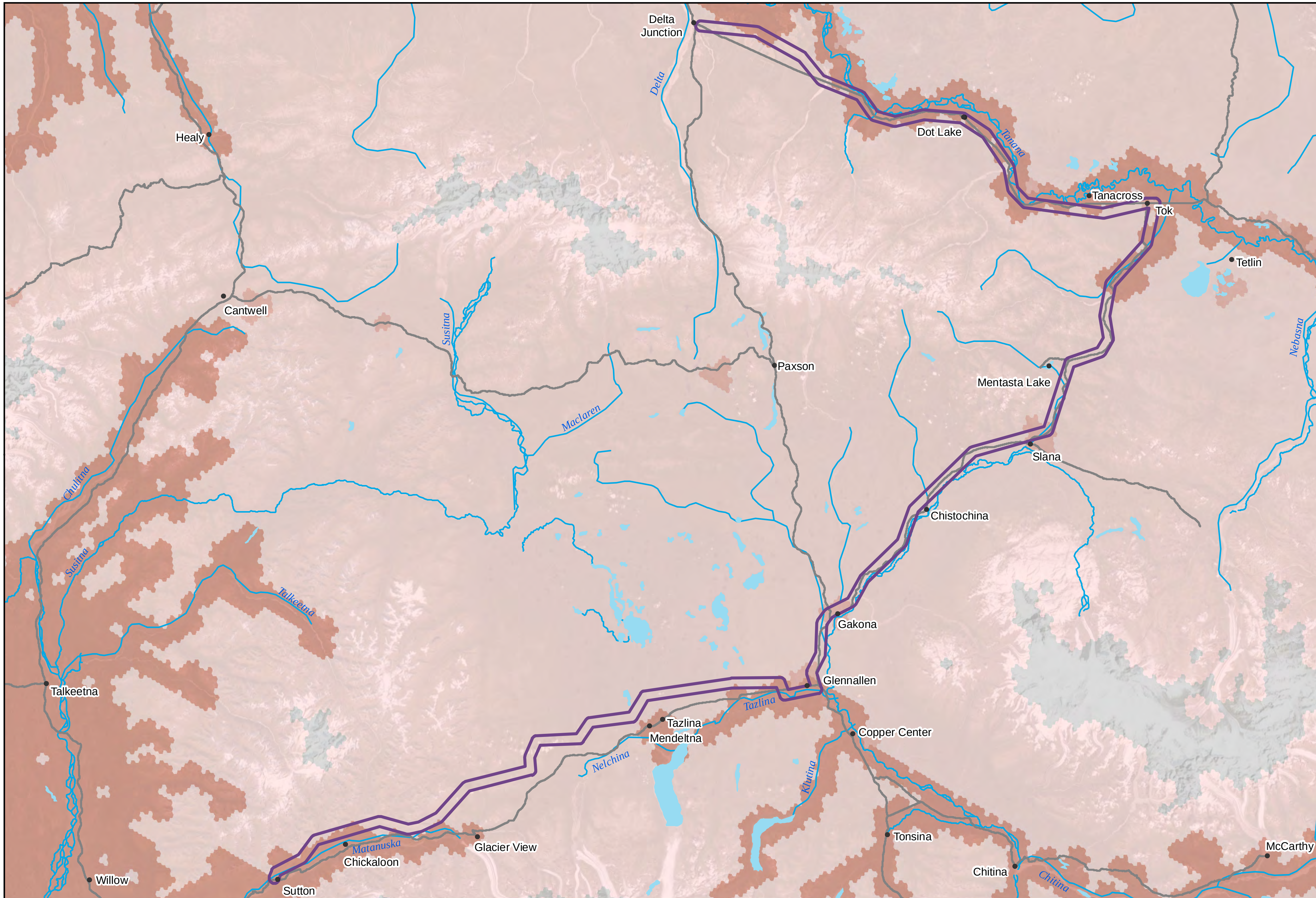

LEGEND

New Transmission Line Study Corridor (approximate)

Alaska CHAT - Species of Concern Rank (Area within Study Corridor)

- 0 - No Rank
- 1 - Most Crucial (0 acres)
- 2 - (0 acres)
- 3 - (9,181 acres)
- 4 - (115,582 acres)
- 5 - (324,704 acres)
- 6 - Least Crucial (17,470 acres)

State Features

- State Road
- River
- Lake

NOTES

Acronyms and Abbreviations:
- CHAT - Crucial Habitat Assessment Tool
- US - United States
- WAFWA - Western Association of Fish and Wildlife Agencies

Data Sources (Entity, Date/Version):
- Alaska CHAT - WAFWA, 2020
- State Road - Alaska Department of Transportation, 2019
- River - Natural Earth, 4.1.0, and Alaska Department of Natural Resources, 2020
- Lakes - Alaska Department of Natural Resources, 2020
- Aerial Imagery - ESRI basemaps, 2020

MAP PROJECTION

Coordinate System: NAD 1983 Alaska Albers
Projection: Albers
Datum: North American 1983
Units: Meter

0 20 Miles

1 in = 20 miles

N

DENALI COMMISSION ALASKA

Environmental Features
Species of Concern

ROADBELT INTERTIE RECONNAISSANCE ENGINEERING REPORT

Drawn by: AEI

Date: 10/20/2020

FIGURE 5G

FILE: C:\Users\kholmes\Desktop\DC_Roadbelt\AutoCAD-GIS\NativeFiles\MXD\EnvC_MXD\Figure5G_CHAT_SpecCon.mxd

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APPENDIX A

EPS Engineering Report

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Roadbelt Intertie Reconnaissance Engineering Report

EPS Project #19-0490

November 20, 2020

David W. Burlingame, PE
Dr. James W. Cote, PE
Greg Huffman, PE
Tim Mullikin, RLS

Summary of Changes

Version	Date	Comments
0	May 21, 2020	Initial Release to Ahtna Environmental
1	June 16, 2020	Released to Ahtna
2	August 28, 2020	Incorporated Ahtna comments - issued final
3	October 19, 2020	Final report released
4	November 20, 2020	Utility revisions incorporated

Table of Contents

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1 Purpose and Scope of the Report

The purpose of this report is to provide a determination on the feasibility of constructing a transmission line from the Alaska Railbelt electrical system near Sutton, through Glennallen, and on to Tok. It will reconnect to the Railbelt electrical system again near Fort Greely, Alaska. Development and construction cost estimates were also developed that can be used to evaluate the line's economic feasibility in the future.

This transmission line would serve as a second transmission line between the southern and northern portions of the Railbelt. It would transmit power from the southern portion of the Railbelt to the Fairbanks area, as well as serve the communities of Glennallen, Valdez and Tok. It will also provide firm, reliable service to Fort Greely.

The feasibility of the line was determined by technical studies to evaluate the ability of the proposed line to transmit the required amount of power, evaluating if a transmission line corridor is possible for the route, and finally developing cost estimates for the proposed transmission line and the equipment needed to allow the line to function when interconnected to the Railbelt.

A key element of the evaluation was an estimate on the line's length and an assessment of possible locations for the line. To estimate the length of the line and evaluate the construction costs, a possible alignment for the line had to be developed. The alignment developed for the feasibility study was based on one of several routes that are possible between the desired interconnection points. It does not represent a recommended or preferred route, but a route thought to be a good route for the basis of cost estimates and electrical studies.

An important aspect of the route is that electrical studies completed for this project indicate that in order to provide meaningful transfer levels between Anchorage and Fairbanks, the line's operating voltage must be 230 kV. The 230 kV operating voltage precludes any consideration of underground cables along the route. This was a consideration in the route used for the feasibility analysis. Land cables at 230 kV are technically feasible in larger systems and are frequently used in larger cities in the Lower 48. The use of 230 kV land cables can be divided into two types, oil-filled cables and solid-dielectric cables. 230 kV oil-filled submarine cables have been in service in Alaska for well over 30 years, but have limited length, and require significant reactive compensation to control the high voltages created by the capacitance of the submarine cables. Due the large amount of capacitance inherent in these cables, they are not feasible for the proposed transmission line. Solid-dielectric cables have significantly lower capacitance that might allow for limited use in the system; however, these cables have not been used in areas of high-frost movement. Without significant study and review, these cables would not be recommended in this application. If used, the solid-dielectric cables may increase the line construction unit costs by 3-4 times per mile.

During the course of the electrical studies, it became apparent that there are significant advantages to an alternative to the line's proposed routing from Sutton – Glennallen – Tok – Fort Greely (Topology 1). For purposes of power transfer from southcentral Alaska to Fort Greely and Fairbanks, a 230 kV line that is routed from Sutton to near Glennallen to Fort Greely with a radial tap to serve Tok (Topology 2), has the ability to transmit larger amounts of power in a more reliable and cost effective manner than Topology 1. Topology 2 has the same ability to serve loads in Glennallen and Tok via the radial line, but the throughput from Sutton to Fort Greely is significantly better. The downside is that the Tok and possibly the Glennallen/Valdez loads would be served from a single transmission line.

The benefits of the proposed line were not quantified during this study. The new transmission line, in either Topology 1 or 2 would allow firm transfers between the south and the north of at least 75 MW and non-firm transfers between the Southern and Northern Railbelt sections to increase from approximately 65-75 MW to 125 MW. The new line would allow future generation to be developed in southcentral Alaska, Fairbanks/interior Alaska, or the Glennallen/Tok area based on economics and not be geographically constrained. The line would allow firm power deliveries to Fort Greely, which would substantially increase not only the amount of power that could be supplied to the facility, but the resiliency of that power. The new line would increase the Railbelt/Roadbelt's ability to accept renewable energy and provide significant spatial diversity for these resources.

2 Transmission Line Description and Designs

2.1 Voltage Selection

Electric Power Systems Inc. (EPS) in conjunction with the Denali Commission and Ahtna Environmental, Inc. completed a reconnaissance engineering study that determined the feasibility and technical details of completing a second proposed interconnection between the Anchorage Bowl region and Fairbanks. The proposed route begins in the existing Railbelt system tying in to the Matanuska Electric Association (MEA) system, traversing east to the Copper Valley Electric Association (CVEA) system in Glennallen, continuing northeast to the Alaska Power & Telephone (AP&T) system in Tok, and finally terminating in the Golden Valley Electric Association (GVEA) system near Delta Junction.

This Roadbelt Intertie would provide a second parallel path for power to flow from South to North thus increasing capacity of the power transfer between GVEA and the Southern Railbelt utilities. In addition, this new path would interconnect the CVEA system and the AP&T system to the existing Railbelt utilities allowing for less expensive power, more reliability for all interconnected utilities, and improved service for Alaska electricity consumers.

The power flow results indicate that 230 kV construction using 795 ACSR (Drake) or 954 kcmil single conductor transmission lines between O'Neill substation in Sutton (MEA), and Jarvis Creek substation in Delta Junction (GVEA) are the top conductor selections, with 795 kcmil used for the final studies and cost estimates. Both topologies that were modeled are feasible. Topology 1 connects directly from Sutton, to Glennallen, to Tok, to Delta Junction in series. Topology 2 connects from Sutton to Glennallen, then directly to Delta Junction with a radial line built at 138 kV from Glennallen to Tok. Both topologies achieve the primary goals of creating a second parallel interconnection and interconnecting CVEA and AP&T.

The transient stability results indicate that the second topology, with a lower voltage radial line to Tok, is generally more stable and requires less controls and reactive support to ensure stability. This is primarily due to the lower electrical distance between MEA and GVEA that can be achieved by building from Sutton to Glennallen to Delta Junction without looping through Tok, but instead, radially connecting from Glennallen to Tok. It is clear that both topologies will require support from GVEA's Wilson Battery Energy Storage System (BESS) and new Static VAr Compensating (SVC) devices along the proposed transmission corridor in order to provide reliable and stable power during contingency events.

Both modeled topologies would be capable of supporting additional generation and load considerably above and beyond that simulated in the studies with little impact to the transfer capability of the line. The electrical studies and their results are presented in more detail in Section 6.

2.2 Route and Construction Assumptions

Generally, we used previous studies, land ownership maps, and wetland and topography maps to develop three possible segments for a 230kV intertie route from Sutton to Glennallen, Tok, and Delta Junction. We avoided wetlands as much as possible to limit the amount of winter construction, as well as steep and inaccessible terrain to limit the amount of more expensive helicopter construction. Routes were also developed to avoid mapped native allotments, State of Alaska Mental Health Trust Authority lands, private parcels, and Alaska Heritage Resources Survey (AHRS) cultural sites. The routes are by no means intended to be the most feasible or the most preferred as they have not gone through the environmental assessment and public scrutiny needed to select a route for final design. Rather they were selected as a reasonable representation for line length, angle structures, and terrain, soil, and access conditions needed to estimate probable construction costs.

2.2.1 Segment 1: Sutton-Glennallen

In 1993 the State of Alaska Division of Energy solicited a feasibility study for a 138 kV transmission line route from Sutton to Glennallen. R. W. Beck provided a detailed feasibility study report (the Beck Report). This incorporated engineering analyses and public comments for four potential routes. We used the "apparent preferred route" identified in the Beck Report as the basis of our cost estimate for this segment. We did not alter the route selected from this study for our estimate. This route begins at a proposed new substation approximately 0.7 miles west of Sutton. It traverses 135 miles east toward Glennallen avoiding the Matanuska Valley Moose Range, native lands, several private parcels, and unpatented mining claims. This route stays north of the Glenn Highway (generally 1-3 miles from the roadway) until it crosses to the south about 6.5 miles west of Glennallen. It avoids most wetland areas until almost 42 miles west of Glennallen where interspersed wetlands are encountered to the terminus at Copper Valley Electric Association (CVEA) Pump Station 11 Substation. Line length of this section is approximately 135 miles.

2.2.2 Segments 2 & 3: Glennallen-Tok & Tok-Delta Junction

The study route from Glennallen to Tok begins at the Pump Station 11 Substation and generally follows the Tok Cut-Off Highway for 142 miles to its terminus at the Tok Power Plant. The route from the Tok Power Plant to Delta Junction generally follows the Alaska Highway for approximately 111 miles to its terminus at the Golden Valley Electric Association (GVEA) Jarvis Creek Substation south of Delta Junction.

Much of these routes are located within the highway corridor, but do veer away to avoid wetlands, culturally sensitive areas, private parcels and native lands. The basis for these routes using existing road right of ways, is to avoid environmentally sensitive areas as much as possible through the mountains and wetlands, while limiting helicopter and winter construction and providing easier access for maintenance.

2.2.3 Radial Option – 138 kV Tap from Lake Louise/Glennallen to Tok

While not within the scope of our cost estimate, we did examine the possibility of revising the above routes by turning north along Segment 1 at Lake Louise Road (approximately 43 miles west of Glennallen) and routing a 230 kV transmission line through the mountains straight to the Jarvis Creek Substation. Assuming this route would require a 138 kV tap from Lake Louise Rd east to Glennallen, then north to the Tok Power Plant, the total approximate lengths for new transmission lines would be 247 miles for 230 kV and 178 miles for 138 kV. Another option would be a radial line from Delta Junction to Tok, which may offer considerable advantages in terrain and topology. These options were not priced since it was not in the scope of work, but the routes have significant benefits for power transfer from Anchorage to Fort Greely/Fairbanks when compared to the proposed route. For the purposes of this study, the Glennallen – Tok radial route modeled as Topology 2 and the Delta Junction – Tok radial route described here are essentially the same in terms of electrical performance.

2.3 Design Criteria

Our electrical studies found 230 kV the optimal voltage and 795 kcmil a feasible conductor size (one conductor per phase) for the intertie. Conductors are available in a variety of materials, types and strandings, with Aluminum Conductor Reinforced with Steel (ACSR) by far the most common type for long distance transmission lines. The steel gives the aluminum conductor additional strength, which reduces sag and allows for longer spans using the same structure height as all-aluminum conductors. U.S. Department of Agriculture Rural Utilities Service (RUS) recommends 795 kcmil as the minimum ACSR size for 230 kV. based on a combination of radio noise, corona, and mechanical sag and strength considerations. "Drake" conductor is a popular 795 kcmil ACSR stranding (26/7), and all Railbelt utilities use it. The Beluga lines all use 795 kcmil ACSR "Drake" and Chugach Electric Association, Inc. (Chugach) has made that conductor size and stranding their standard for both sub-transmission and transmission lines. The University-Eklutna double circuit 230 kV lines uses Drake conductor, as does MEA's Eklutna Generation Station-Hospital Substation double circuit 115 kV line. Drake conductor and associated hardware are also well stocked in GVEA's inventory, since many of their transmission lines use it including the North Pole-Carney 138 kV line and the Clear Switchyard-Clear AFB Substation 230 kV line.

We believe Alaska weather conditions warrant use of a strong ACSR and have based our cost estimates on using 795 kcmil ACSR “Drake” conductor. During final design, heavy loading areas, long spans, or sections of the line may be encountered where conductors even stronger than Drake will better serve the design. Several options are available. These include using aluminum alloy conductor (AACSR), aluminum conductor supported with high-strength or ultra-high strength steels (ACSS/HS or ACSS/HS285), and alumoweld conductor, which consists of high-strength steel strands coated with aluminum. Previous studies for a line between Sutton and Glennallen did not include OHGWs in their design or estimates. This does not contradict the designs of many existing transmission lines in southcentral Alaska, although the interties between Anchorage and Fairbanks have OHGWs installed or have designs that can accommodate the addition of OHGWs. Increased lightning occurrences have been reported in the areas of the Railbelt Intertie in recent years, likely due to changing weather patterns. The section of the line between Glennallen – Tok - Fort Greely may experience considerably higher lightning levels than the Sutton – Glennallen section. For the purposes of estimating costs of the Roadbelt Intertie, we believe it prudent to include OHGWs for the entire line section. Given the importance and price of the project, adding the extra reliability seems prudent. Unless detailed meteorological studies find little chance of lightning strikes, we believe the line should be protected from lightning. A side benefit of installing OHGWs, is they can be used to transmit communications with fiber optic strands in their core (OPGW). OPGWs can either be installed initially, or the higher cost of OPGWs can be deferred to a later date when and if the need for communication lines arises. We have assumed two 7/16” extra-high strength steel OHGWs will be installed for the entire route.

We believe the four loading/construction zones identified in the Beck Report are reasonable and expandable to the Glennallen-Tok-Delta Junction sections. These four zones were initially divided by changes in climate for the purpose of establishing design loads but were also found to roughly parallel changes in terrain, soils, and vegetation. They were therefore taken as equivalent construction zones with distinct construction season, clearing and access needs.

The Beck Report characterizes the four zones as follows:

Zone 1 stretches from Sutton to Caribou Creek in the Matanuska River Valley. It is generally heavily to moderately forested with alder, cottonwood, white spruce, and birch on the western end of the zone. Glacial till is dominant soil type with pockets of muskeg and rock outcroppings. No permafrost is expected, which makes direct embedment foundations practical. There is limited access to the ROW from the Glenn Highway unless the few existing trails can be upgraded for use. Access overland along the ROW is possible. Year-round construction is possible.

Zone 2 lies in the Copper River Basin and east of Syncline Mountain. The terrain is barren at higher elevations and moderately forested with predominantly black spruce from Slide Mountain eastward. The soils are characterized by extensive muskeg, wetlands, and permafrost. No new access roads are assumed, but there will be good access in winter. Construction will take place in winter with foundations using driven piles to minimize the damage to wetland areas.

Zone 3 is located at elevations generally greater than 3,300 feet that did not fit into Zone 4. This includes backcountry valleys in the Talkeetna Mountains. Soils will be mostly glacial till and colluvial with pockets of muskeg and wetlands. No permafrost is anticipated except possibly on north facing slopes. Direct embedment foundations are likely to be practical. Construction will require a combination of helicopter and limited overland access to the ROW. Access along the ROW is assumed practical between major streams. Open lands are prevalent with little or no clearing required. Zone 3 would be mostly non-winter construction with some fringe winter construction likely in wetland/muskeg areas.

Zone 4 includes route segments at high elevations such as the areas north of Strelshla Mountain and Chitna Pass. The dominant soil types are expected to be glacial till and colluvial soils with increased presence of rock. Zone 4 will require all-helicopter construction with no overland access assumed. Construction would be restricted to non-winter periods only. No clearing is anticipated.

For the Glennallen–Tok–Delta Junction sections, we believe Zone 2 loading and construction is a reasonable fit, except there are sections where direct embedment foundations and non-winter construction will be possible. Our cost estimates assume a 50/50 split for direct embedment and pile foundations for the 253 miles between Glennallen and Delta Junction. Loading for Zone 1 applies to approximately the first 37 miles of line coming from Sutton. It is typical of loading used on lines in the Anchorage bowl and Mat-Su areas except for the extreme combined ice/snow and wind load case. This load case applies 2.5 inches of radial wet snow or rime ice (30 pcf) to the conductors in combination with 20 mph (1 psf) winds. This large accumulation of snow on the conductors is equivalent to 1.69 inches of radial glazed ice (57 pcf). This loading will control the vertical strengths of the cross arms, suspension insulator assemblies, etc. It would also control structure heights if it was a criterion for the design ground clearances. We believe it is reasonable to design structure strength for this loading, but not to include it as a ground clearance condition due to its anticipated rare and short duration occurrences. Rather, the extreme ice loading (1 inch radial glazed ice) will control ground clearances.

NESC Heavy and Extreme Loadings for Zones 2 and 3 are the same as Zone 1 except they are assumed to occur at colder temperatures. Both of these zones use 1.5 inches of radial ice for the extreme ice loading, which will control structure heights (ground clearances) and vertical strengths. Zone 2 is by far the most commonly used for the selected routes and is characterized by relatively flat terrain with high probability need for deep pile foundations and winter construction. Zone 3 is used for about 32 miles between Sutton and Glennallen where elevations exceed 3,300 feet.

Zone 4 is only used for about 4 miles in the high elevation areas (Strelshla Mountain and Chitna Pass) in between Sutton and Glennallen. Its loading conditions are expected to be the worst of the entire intertie. Extreme wind loading is assumed to be 125 mph (40 psf) and extreme ice loading assumes 2 inches of radial ice. The extreme combined ice/snow and wind loading is based on 2 inches of radial glazed ice in combination with 75 mph (14 psf) wind. This loading case will control the design for this zone, being more than twice the unit transverse loading of the other zones.

Table 1 below lists the design loading criteria from the Beck Report with our recommended adjustments noted in the footnotes.

Table 1: Assumed Study Design Criteria

LOAD CASE	PAREMETER	UNIT	ZONE 1	ZONE 2	ZONE 3	ZONE 4
NESC Heavy	Radial Ice	in	0.5	0.5	0.5	0.5
	Wind Speed	mph	40	40	40	40
	Wind Force	lb/sf	4	4	4	4
	Temperature	˚F	0	-20 (1)	-20 (1)	-20 (1)
	Wind L. F.	-	2.50	2.50	2.50	2.50
	Vertical L. F.	-	1.50	1.50	1.50	1.50
	Tension L. F.	-	1.65	1.65	1.65	1.65
Extreme Ice	Radial Ice	in	1.0	1.5	1.5	2.0
	Temperature	˚F	30	20	20	20
	Wind L. F.	-	1.10	1.10	1.10	1.10
	Vertical L. F.	-	1.10	1.10	1.10	1.10
	Tension L. F.	-	1.10	1.10	1.10	1.10
Extreme Wind	Wind Speed	mph	100	100	100	125
	Wind Force	lb/sf	26	26	26	40
	Temperature	˚F	20	10	10	10
	Wind L. F.	-	1.10	1.10	1.10	1.10
	Vertical L. F.	-	1.10	1.10	1.10	1.10
	Tension L. F.	-	1.10	1.10	1.10	1.10
Extreme Combined Ice/snow and Wind (2)	Radial Ice	in	0.0	1.0	1.5	2.0
	Radial Snow	in	2.5	0.0	0.0	0.0
	Snow Density	pcf	30	n/a	n/a	n/a
	Ice Equiv.	in	1.69	1.00	1.50	2.00
	Wind Speed	mph	20	40	40	75
	Wind Force	lb/sf	1	4	4	14
	Temperature	˚F	30	20	20	20
	Wind L. F.	-	1.10	1.10	1.10	1.10
	Vertical L. F.	-	1.10	1.10	1.10	1.10
	Tension L. F.	-	1.10	1.10	1.10	1.10

(1) EPS recommends using a reduced temerature for NESC Heavy Loading in Zones 2, 3 and 4.
(2) The Extreme Combined Ice/Snow and Wind load case is used for structure strength but is not considered for ground clearances.

The NESC requires minimum ground clearance for 230 kV lines of 18.5 feet for areas non-accessible to vehicular traffic, and 22.5 feet for areas susceptible to vehicular traffic. We believe several feet of contingency should be added to these values to account for survey and construction tolerances, snow ground cover, and increased sag due to unbalanced snow/ice conditions. We propose adding about six feet of contingency for Zone 2, and 12 feet contingency for Zones 1, 3, and 4.

2.4 Alaskan Transmission Line Discussion

The first long-distance, high-voltage, lines built in southcentral Alaska typically used wood H-frame or aluminum lattice X-towers or Y-towers for tangent structures (the structures that support the transmission line along fairly straight runs).

Wood H-Frame

Steel X-Tower

Steel Y-Tower

Wood H-frames were direct embedded into the ground and sometimes used cross-bracing. The cross bracing allows for the use of lighter poles by making the structure act as a braced frame in the transverse direction (direction perpendicular to the line). Angle structures were guyed. Medium to large angle structures typically used one pole for each phase resulting in three poles. This type of construction is economical but has a relatively short life expectancy of 40-60 years due to the natural deterioration of wood poles. Wood poles are also susceptible to insect, woodpecker, bear, and fire damage.

We do not recommend the use of cross bracing (X-bracing) on new construction in Alaska for several reasons. A cross-braced structure is strong and stiff in the plane of the frame, but it still behaves as a cantilever structure in the longitudinal direction (direction parallel to the line). This presents some weaknesses in the structure system, such as possible insufficient strength for longitudinal loading caused by differential ice loading on the conductors, avalanche loading, the lack of flexibility to resist foundation movement (i.e. pile jacking), and poor dynamic behavior caused by earthquakes, avalanches, etc. It is noted that the 1964 Alaska earthquake caused significant damage to some braced H-frames, but no or minimal damage to adjacent unbraced H-frames.

Our experience is there is no cost savings in using braced H-frames in Alaska. The material, shipping and labor costs to install the braces in Alaska usually outweigh the cost savings of using lighter poles. We believe you get a universally stronger and more flexible structure by not using cross braces at approximately the same cost of using cross braces.

Aluminum lattice X-towers are used for several circuits of 138 kV and 230 kV transmission from the Beluga Power plant to Pt. Mackenzie and Teeland Substations in the Anchorage–Wasilla area. They were chosen for their light weight, simple hinged structure, foundation attachment, and the flexibility to survive pile jacking. Using lattice members (angle shapes bolted into a truss configuration) is an effective way to minimize structural materials. Aluminum alloy metals offer a good strength to weight ratio. Most of the aluminum lattice X-towers weigh less than 10,000 lbs.

Aluminum Lattice X-Tower

Aluminum Lattice Y-Tower

Using hinged or pinned connections to the foundations also saves structure weight and foundation costs because it allows the structure to behave as a truss (or in the case of guyed structures, as a strut) where structure members are predominantly axial loaded and have to resist very little bending moment. If designed to do so, hinged and pinned base structures can also be easily rotated from a horizontal position to a vertical position and vice versa. Most of the X-towers use driven H-pile foundations than can be installed with relatively light, all-terrain equipment such as Nodwells. The towers are guyed fore and aft with two guys on each side sharing a common anchor (total of four guys, two anchors and two foundations). The guys usually incorporate a breakaway or collapsible mechanism to relieve guy tension in the event of foundation jacking or extreme longitudinal loading.

Lattice X-towers are conducive to remote, lowland construction where the terrain is generally flat, and wetland and soil conditions necessitate winter construction. Lightweight tracked equipment can be used to drive piles for foundations and anchors. It can also be used to transport and erect the towers. The towers can survive moderate pile jacking and/or anchor pullout before they require repairs. Also, pile foundation repairs are relatively easy because a leg of the lightweight towers can easily be disconnected from its foundation while the pile is re-driven.

Medium to large angle and dead-end structures on the Beluga lines consist of three aluminum lattice masts that are pin connected to their foundation and guyed in multiple directions.

The Beluga lines have held up fairly well over time with few structural problems other than occasional pile jacking.

The Healy to Fairbanks 138 kV line was constructed in the mid 1960s using aluminum lattice Y-towers. Like the aluminum lattice X-tower, it is a lightweight structure with a pinned foundation connection. It requires only one foundation, but four guys and anchors. This line uses guyed aluminum lattice mast structures for angle structures similar to the Beluga lines. It still operates in fairly good condition today. It too has experienced some pile jacking, but mostly to the masts of the angle structures. The Y-towers have not experienced much pile jacking. This is likely because they are guyed and anchored in four directions with enough strength to resist the upward push of the single foundation. The mast structures on the other hand are guyed strongly to resist the wire tensions due to the line angle, but not in enough directions to resist the foundation jacking. Many of these masts have experienced upward and outward (lean away from the resultant of the conductor tensions) displacement.

Since the 1960s and '70s, use of aluminum transmission line structures has become almost obsolete due to the much more favorable pricing of steel. Lattice structures are also not used nearly as much, except for the very high voltage lines where structures need to be broader (for increased phase spacing), taller (for increased ground clearance and longer spans) and stronger (for larger or bundled conductors and longer spans).

The advent of large brake presses, which can form steel plate into long, tapered, tubes with polygon-shaped cross sections, started to make tubular steel structures more economical than lattice structures in the 1970s for transmission lines up to about 345 kV. Tapered members save material by using smaller tube diameters where there is less loading, and 6, 8, 12 and 16-sided polygon-shaped sections allow more efficient use of the material to resist loading. Although tubular steel structures are still heavier than lattice structures, they are much less labor intensive to assemble.

Given the successful performance of lattice X-towers, tubular steel X-towers began to be used for major Alaska transmission lines in the post oil boom era, including the Anchorage to Fairbanks 345 kV Intertie (Willow to Healy), the Solomon Gulch 138 kV line (Valdez to Glennallen), the Tyee 138 kV line (Wrangell/Petersburg), the Bradley Lake line (Homer), and the Northern 230 kV Intertie (Healy to Fairbanks). However, use of X-towers in hilly and mountainous terrain caused problems not found in the low flatlands they were originally designed for. Instead of deep pile foundations used for the wet, deep-organic soils of lowlands, shallower foundations were often used for the mineral soils of the uplands. These included direct embedded pile sections and grout-anchored concrete blocks. There have been several cases of soils eroding from around these shallow foundations to the extent that they can no longer resist the spreading effect from the tower's legs.

A X-tower installed on uneven terrain requires either one high reveal foundation, or differential leg lengths. In order for a X-tower with uneven legs to be tilted up or laid down, the hinge axis of each leg must be colinear, or special pinned connections, such as ball and socket types, must be used to provide an axis of rotation that bisects each leg's pinned connection. Another problem found with using X-towers in rolling terrain is the increased chance of damage from wind vibration. Long, slender, circular members, such as the legs of tall tubular steel X-towers, are prone to severe fatigue damage under certain wind conditions that cause the members to vibrate at a high frequency. These wind conditions typically are laminar and less than 20 mph. They occur more often in hilly terrain where funneling and channeling can occur, than in open flatlands where winds are gustier.

Other structure types used in recent years for long transmission lines in Alaska include tubular steel, guyed Vee towers for the Tyee 138 kV line improvements, and tubular steel Y-towers for the Swan–Tyee 138 kV Intertie. The guyed Vee towers used to improve the Tyee line are similar to guyed Y-towers, in that they have a single pinned-base foundation and a guy and anchor in four quadrants. They were inserted in almost every span of the existing line to improve ground clearances. They were flown to each site in an "H" configuration with a helicopter and lowered in between the existing conductors. Ground crews then pulled the legs together, pinned them to the foundation, and attached the guys to the anchors before the helicopter released the structure.

The Swan-Tyee Intertie was installed in the rough mountainous region of southeast Alaska. Access to almost every structure site was by helicopter only. This required use of innovative foundation and structure systems. Foundations consist of micro-pile clusters and the basic tangent structure type is un-guyed, tubular steel Y-towers.

All of the lines and structure types mentioned thus far are single circuit with three phases configured in a flat or horizontal position. They use free-swinging, suspension type insulators on their non-deadend structures. This is an economical construction type for long lines where adequate right of way is available. It allows for longer spans, which usually prove to be more economical. It also prevents phase contacts that can occur on vertically- configured structures when heavy ice-loaded upper conductors sag down into lower conductors with no or little ice, or when conductors shed their ice and “jump.”

Transmission line designers must be careful not to stretch the span lengths too far, especially for lines using over-sized conductors for their immediate needs. The Anchorage-Fairbanks (Willow-Healy) line for example was designed for future 345 kV using bundled 954 kcmil conductor and long spans. It is operated at 138 KV and has had chronic problems at the southern end with ice/snow loaded conductors sagging down to near the ground. The electrical load on the line is often too little to thermally heat the conductors enough to prevent heavy ice and snow accumulations. The additional sag is compounded when adjacent spans drop their ice or snow, causing large tension differentials in the conductors. The differential tensions cause the suspension insulators to swing towards the higher-tension span, adding slack and sag to the iced span.

The original Tyee 138 kV line had similar problems until span lengths were drastically reduced by insetting new Vee structures in between the original structures. The Solomon Gulch 138 kV line has also experienced several ice/snow-loaded clearance problems.

If vertically configured structures are used in high ice-prone areas such as southcentral Alaska, they should be used only for short spans or where plenty of vertical separation has been incorporated into the design. Double circuit lines usually have no choice other than be vertically configured. They typically use davit arms with suspension or Vee insulators, or horizontally braced (horizontal Vee) insulator system.

Isokeraunic levels in southcentral Alaska have historically been low, and many of the major transmission lines in the state have operated reliably without any lightning protection. A couple of the lines previously mentioned, the Anchorage–Fairbanks 345 kV Intertie (Willow–Healy), and the Healy–Fairbanks 138 kV line along the Parks Highway, do have overhead ground wires (OHGW) for lightning protection. The Northern 230 kV Intertie (Healy–Fairbanks) was designed for an optical ground wire (OPGW), which is an overhead ground wire with interior fiber optics, and an OHGW. These were never installed due to budget constraints. GVEA is the only Alaska utility that routinely installs OHGWs on their transmission lines.

The selection of a structure type is highly dependent of soil conditions, foundation type, terrain conditions, and access. Foundations are a major contributor to the cost of transmission lines, especially in Alaska where remote conditions, soils with deep organics and/or permafrost, and frost jacking are prevalent.

Structure sites accessible to heavy equipment can afford to have heavy, moment-resisting foundations such as those needed for un-guyed structures. Sites inaccessible by overland equipment must use helicopter compatible equipment such as Menzie Mucks (walking spider excavator) and portable drilling units. These types of equipment are not capable of excavating deep holes or driving large piles. Deep foundations at these locations must therefore use rock anchors or micro-piles. These foundation units resist axial loading well but are not adept to resisting large lateral or overturning loads without clustering several of them together. Pinned-base structures such as guyed Y-towers would work well for helicopter construction because the structures are light-weight and the supporting foundations and anchors are predominantly axial loaded and can be installed with helicopter compatible equipment. In extremely rugged terrain, helicopters may be needed to move equipment between each foundation and anchor location at the same site so minimizing the number of ground penetrations may become important.

The Beck Report evaluated seven different structure types; 1) single steel pole, 2) single wood pole, 3) guyed steel X-frame, 4) unbraced steel H-frame, 5) braced steel H-frame, 6) unbraced wood H-frame, and 7) braced wood H-frame. Because of weight, strength, and flexibility restrictions, only the guyed steel X-frame and unbraced steel H-frame were considered applicable to all zones. That report found the unbraced steel H-frame to be the most economical structure type and assumed its use for the entire route between Sutton and Glennallen in their cost estimates. We do not dispute this structure type is a feasible choice, especially in areas where overland access is available and frost jacking is not a huge concern. This would include Zone 1 and many sections of Zone 2 between Glennallen and Delta Junction. It may be possible to save some capital costs by using wood H-frames in these areas, but wood does not provide the reliability, longevity, nor fire-resistance that steel does. It is noted that CVEA has had problems with carpenter ants hollowing their wood poles in the Copper River Basin, and Homer Electric Association has had problems with bears eating or otherwise damaging wood poles in their service area.

We also assumed the use of steel H-frames for the entire length of the intertie. Angle and deadend structures are assumed to be guyed 3-pole tubular steel masts with the same foundation types used for the tangent H-frame structures. Typical H-frame and 3-pole running angle structures are shown in Figures A and B (Appendix A). Should this project progress to final design, a detailed structure study should be performed to determine the best structure and foundations types for the various sections of the intertie. We suspect steel X-towers will be competitive with the steel H-frame in Zone 2, especially in wetland and deep organic soil areas where frost jacking is most likely to occur. The X-tower is lighter and responds better to frost jacking than H-frames do. Smaller and more standardized pile foundations can be used with X-towers because their leg attachments are hinged or pinned (no overturning moment), and there is relatively little change in base reactions with changes in tower height. The X-tower also offers easier repairs for its foundations and better longitudinal loading capacity since it is guyed fore and aft.

But X-towers are more complicated to design, fabricate and assemble than are steel H-frames, so their cost may not necessarily be less despite being lighter in weight. X-towers also require longitudinal guys and anchors, requiring twice the ground setups/penetrations as self-supporting H-frames.

Although the high elevations of Zone 4 make up a very small fraction of the total intertie route, it will be the costliest to construct on a per mile basis. The extreme loading conditions and difficult access (all helicopter access assumed) will likely make its per mile construction costs 40% - 65% greater than the other line sections. Again, there may be a more economical structure type that is better suited for this section than the steel H-frame. Rock anchors and micro-piles will be the likely foundation and anchor type and a lightweight structure system relying on axial base reactions, such as guyed Y-towers will save on structure and foundation costs. This cost savings will need to be weighed against the cost of extra ground setups/penetrations for the five foundation/anchors needed for guyed Y-towers, versus two needed for steel H-frames.

3 Transmission Cost Estimates

3.1 Transmission Line Construction Costs

We broke the intertie route into five segments, and estimated construction costs for each segment individually. The five segments are the four zones defined in the Beck Report, with the addition of a fifth segment comprised of the long section from Glennallen to Delta Junction. Approximate line lengths, angle structures, uplift structures and long span structures were estimated from the route corridors previously discussed. Ruling span and average span lengths were chosen for each segment based on our experience with similar transmission lines in Alaska. Considerations for this include structure heights and strengths, right of way width, and clearance issues caused by heavy ice/snow loading. A 120-foot-wide ROW was assumed for the study, and maximum span lengths were calculated to keep the conductors within the ROW under extreme wind conditions. Table 2 provides a summary of the spans used for each segment, along with typical phase spacings used with the ROW width and span lengths.

Table 2: Design Loading Criteria

	Sutton to Glennallen				Glennallen to Delta Junction
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 2
Ruling Span, ft.	900	900	900	750	900
Average Span, ft.	800	850	800	650	850
Max. Span for 120' ROW, ft.	1050	1000	1000	850	1000
Phase Spacing, ft.	18	18	18	17	18

ROW widths should be further studied if this project progresses. Wider ROW may be needed where longer spans are desired. But for the purposes of estimating transmission line costs, we universally used 120 feet as the standard ROW width for the anticipated structure type and span lengths.

Quantities of tangent structures for each segment were estimated by dividing the segment length by the average span length and deducting the angle, deadend and special structure quantities. A typical structure height was calculated using design ground clearances, maximum sags, and structure configuration. Structure strength and weights were then estimated by applying the design loading and using basic principles of steel pole sizing.

Assumed foundation and anchor types include:

***Zone 1**:* direct embedment foundations with concrete slug or helical (screw) anchors

***Zone 2, Sutton - Glennallen**:* driven pipe pile foundations and anchors

***Zone 3**:* direct embedment foundations with concrete slug or helical (screw) anchors

***Zone 4**:* rock anchor and micro-pile foundations and anchors

***Zone 2, Glennallen – Delta Jct.**:* 50% driven pipe pile foundations and anchors and 50% direct embedment foundations with concrete slug or helical (screw) anchors

Unit costs for ROW clearing, structures, foundations, guys, anchors, framing, conductor, and accessories were used to estimate the construction cost. Unit costs were taken from recent, Alaska transmission lines using similar construction. Unit costs were adjusted for inflation and dissimilarities in construction types and locations. Nominal costs were included for construction surveys and camp costs. Mobilization/demobilization costs were assumed to be 5% of the total construction costs.

No costs were included for communication attachments, or underbuild facilities. Costs for two shield or static wires were included in the estimates.

A summary of the estimated unit construction costs per mile for each of the five line segments are presented in Table 3 as follows:

Table 3: Transmission Line Budgetary Unit Construction Costs per Mile

	Sutton to Glennallen				Glennallen to Delta Junction
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 2
Approx. Construction Cost per mile	$816k	$961k	$894k	$1,448k	$844k

The average construction cost per mile for the entire 388-mile-long intertie was estimated to be $871k/mile, excluding contingency.

Reasonable contingencies need to be applied to our construction estimates based on the many unknowns and assumptions made for this high-level engineering study. A route has not been selected, geotechnical and environmental studies have not been made, and it is not known what effects the current COVID-19 pandemic or other conditions will have on the transmission line material and labor markets during procurement and construction. These issues may increase or decrease line costs, but we believe it prudent to base our project development cost estimates on “bad-case scenarios” by including sizable contingencies that increase costs. We have included a 15% contingency on material costs and 25% on installation (labor) costs. Total intertie construction cost is estimated to be $410 million, or $1,056k/mile, with these contingencies.

Non-construction costs also must be included in the total development cost estimate. These include engineering services (surveying, geotechnical, meteorological, and line design), right of way services (title, surveying, appraisal, and land acquisition), regulatory permitting (DNR, DOT, FAA, BLM, Mat-Su Borough, DoD, etc.), environmental studies and permits (NEPA Process/EIS, public meetings, ADF&G, Corps/ADEC permits, etc.), construction management, and owner costs. We have assumed construction management fees will be 5% of the total construction costs, owner costs will be 5% of the total project costs, and have included a 10% contingency on all non-construction costs.

Non-construction costs specific to the transmission line were estimated as follows:

LIDAR Mob	$78k
LIDAR	$582k
Geotech investigation	$2,000k
Meteorological study	$150k
Transmission design	$3,500k

3.2 Transmission Line O&M Costs

Based on transmission line costs provided by GVEA and CVEA, we estimate the operation and maintenance (O&M) costs associated with the transmission line to be $400k/year for the first 10 years and $800k/year for the remainder of the project’s assumed 50 year life.

4 Substation and Communication System Modification Costs

System studies indicate that modifications will be required at four existing substation locations; namely, MEA's O'Neill Substation near Sutton, CVEA's Pump Station 11 Substation near Glennallen, AP&T's Tok Substation, and GVEA's Jarvis Creek Substation near Delta Junction. In addition, some system-wide communication system modifications are needed.

4.1 Substation Modification Costs

Budgetary cost estimates for substation modifications were prepared based on the design configurations documented in the following sub-sections.

4.1.1 O'Neill Substation

O'Neill Substation is an existing MEA substation that serves MEA's distribution system along the Glenn Highway. The station will require a complete reconstruction to add 115 kV protective breakers, a 230 kV protective breaker, a 115 kV to 230 kV 75 MVA transformer, and a line connected reactor. This equipment will be installed in a new or rebuilt station in the vicinity of the existing station that includes ground grid, protection controls, control building and other miscellaneous equipment.

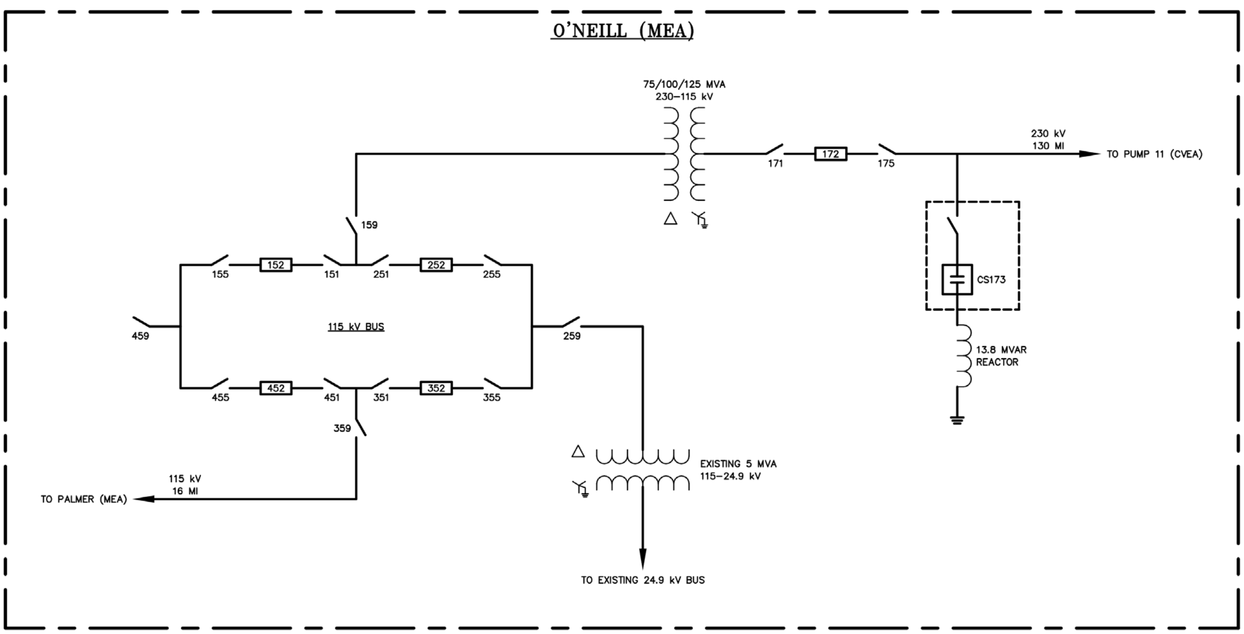

Figure 1: O'Neill Substation Modification One-Line Diagram

Item Description	Extended Contractor Labor	Extended Contractor Material	Extended OFM	Extended Total
GROUP A: STRUCTURES	302,400	19,000	239,600	561,000
Unassigned	302,400	19,000	239,600	561,000
GROUP B: SWITCHING	25,200	9,450	172,000	206,650
Unassigned	25,200	9,450	172,000	206,650
GROUP C: CIRCUITS AND BUSWORK	229,446	155,500		384,946
Unassigned	229,446	155,500		384,946
GROUP E: CIRCUIT BREAKERS	109,200	2,200	550,000	661,400
Unassigned	109,200	2,200	550,000	661,400
GROUP F: FOUNDATIONS	421,901	45,051		466,952
Unassigned	421,901	45,051		466,952
GROUP G: TRANSFORMERS	143,920	28,200	3,092,600	3,264,720
Unassigned	143,920	28,200	3,092,600	3,264,720
GROUP K: CONDUIT AND CABLE	151,313	134,915		286,228
Unassigned	151,313	134,915		286,228
GROUP M: SITE WORK	486,275	146,650		632,925
Unassigned	486,275	146,650		632,925
GROUP N: FENCE AND SIGNS	91,800	209,090		300,890
Unassigned	91,800	209,090		300,890
GROUP O: GROUNDING	217,159	154,356		371,515
Unassigned	217,159	154,356		371,515
GROUP Q: SWITCHGEAR	67,200	25,000	1,000,000	1,092,200
Unassigned	67,200	25,000	1,000,000	1,092,200
GROUP S: YARD LIGHTS	17,323	10,260	9,675	37,257
Unassigned	17,323	10,260	9,675	37,257
Total	2,263,137	939,672	5,063,875	8,266,683
Insurance (3% on CL & CM)				96,084
Contingency (10% on CL & CM)				320,281
Mob/Demob (5% on CL & CM)				160,140
Heated Equip Storage (0.5% on CM & OFM)				30,018
Engineering (12% on CL, CM, & OFM))				992,002
Project Management (3% on CL, CM, & OFM))				248,001
Subtotal				10,113,209
Performance Bond				56,000
Total Estimate				10,169,209

Figure 2: O'Neill Substation Budgetary Cost Estimate

4.1.2 Pump Station 11 Substation

Pump Station 11 is an existing CVEA substation that serves as a major delivery point in their 138 kV system between Glennallen and Valdez. The station would be expanded to include a 230 kV ring bus, a line connected reactor to each 230 kV line terminal, a 138 kV/ 230 kV 50 MVA transformer, a Static VAR system and a tie to CVEA's existing 138 kV bus.

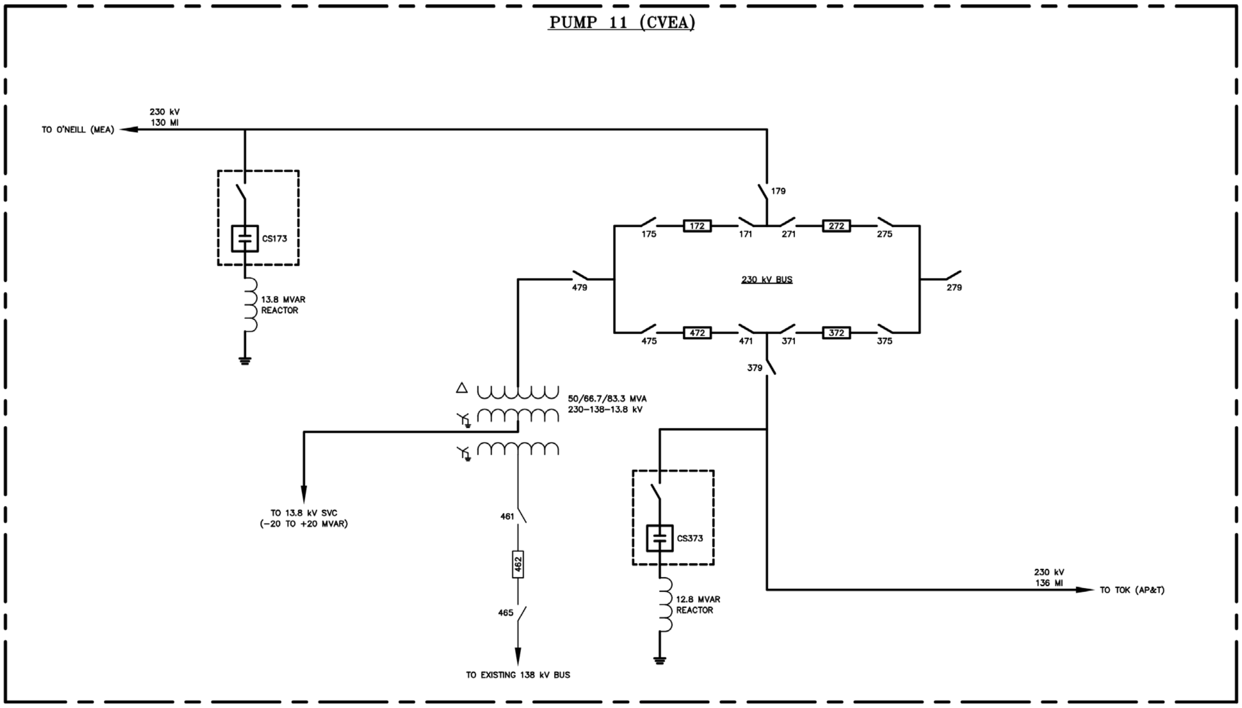

Figure 3: Pump Station 11 Substation Modification One-Line Diagram

Electric Power Systems Inc. Consulting Engineers

Engineer's Estimate Summary

Item Description	Extended Contractor Labor	Extended Contractor Material	Extended OFM	Extended Total
GROUP A: STRUCTURES	330,400	21,000	254,600	606,000
Unassigned	330,400	21,000	254,600	606,000
GROUP B: SWITCHING	95,000	9,450	192,000	296,450
Unassigned	95,000	9,450	192,000	296,450
GROUP C: CIRCUITS AND BUSWORK	237,846	156,250		394,096
Unassigned	237,846	156,250		394,096
GROUP E: CIRCUIT BREAKERS	151,200	3,300	875,000	1,029,500
Unassigned	151,200	3,300	875,000	1,029,500
GROUP F: FOUNDATIONS	539,109	55,159		594,268
Unassigned	539,109	55,159		594,268
GROUP G: TRANSFORMERS	140,000	34,150	3,494,600	3,668,750
Unassigned	140,000	34,150	3,494,600	3,668,750
GROUP K: CONDUIT AND CABLE	214,550	190,290		404,839
Unassigned	214,550	190,290		404,839
GROUP M: SITE WORK	498,573	154,483		653,056
Unassigned	498,573	154,483		653,056
GROUP N: FENCE AND SIGNS	91,800	209,090		300,890
Unassigned	91,800	209,090		300,890
GROUP O: GROUNDING	217,159	154,356		371,515
Unassigned	217,159	154,356		371,515
GROUP Q: SWITCHGEAR	67,200	25,000	1,000,000	1,092,200
Unassigned	67,200	25,000	1,000,000	1,092,200
GROUP S: YARD LIGHTS	43,290	29,120	24,187	96,596
Unassigned	43,290	29,120	24,187	96,596
GROUP U: SVC			11,000,000	11,000,000
Unassigned			11,000,000	11,000,000
Total	2,626,126	1,041,648	16,840,387	20,508,160
Insurance (3%)				**110,033**
Contingency (10%)				**366,777**
Mobilization/Demobilization (5%)				**183,389**
Heated Equipment Storage (0.5%)				**89,410**
Engineering (12%)				**2,460,979**
Project Management (3%)				**615,245**
Subtotal				**24,333,993**
Performance Bond				**56,000**
Total Estimate				**24,389,993**

Figure 4: Pump Station 11 Substation Budgetary Cost Estimate

4.1.3 Tok Substation

Tok Substation is a new substation. It includes a 230 kV line reactor to both Pump 11 and Jarvis Substations, a 12 MVA 24.9 kV/230 kV transformer, a 4-breaker 230 kV ring bus and a connection to the Tok 24.9 kV system.

Electric Power Systems Inc. Consulting Engineers
ELECTRIC POWER SYSTEMS ePs inc.

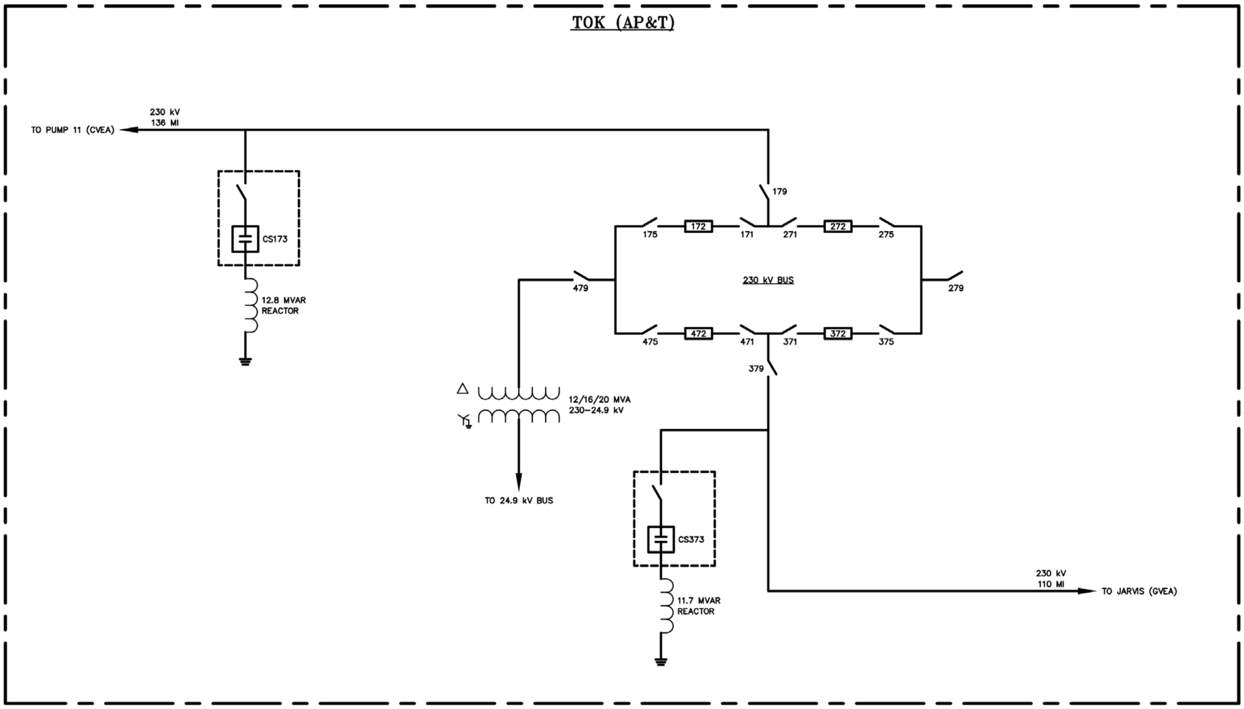

Figure 5: Tok Substation Modification One-Line Diagram

Engineer's Estimate Summary

Item Description	Extended Contractor Labor	Extended Contractor Material	Extended OFM	Extended Total
GROUP A: STRUCTURES	296,800	19,000	235,400	551,200
Unassigned	296,800	19,000	235,400	551,200
GROUP B: SWITCHING	84,000	8,100	168,000	260,100
Unassigned	84,000	8,100	168,000	260,100
GROUP C: CIRCUITS AND BUSWORK	237,846	156,250		394,096
Unassigned	237,846	156,250		394,096
GROUP E: CIRCUIT BREAKERS	134,400	3,000	810,000	947,400
Unassigned	134,400	3,000	810,000	947,400
GROUP F: FOUNDATIONS	524,103	53,221		577,324
Unassigned	524,103	53,221		577,324
GROUP G: TRANSFORMERS	135,520	31,100	2,431,600	2,598,220
Unassigned	135,520	31,100	2,431,600	2,598,220
GROUP K: CONDUIT AND CABLE	214,550	190,290		404,839
Unassigned	214,550	190,290		404,839
GROUP M: SITE WORK	498,573	154,483		653,056
Unassigned	498,573	154,483		653,056
GROUP N: FENCE AND SIGNS	91,800	209,090		300,890
Unassigned	91,800	209,090		300,890
GROUP O: GROUNDING	217,159	154,356		371,515
Unassigned	217,159	154,356		371,515
GROUP Q: SWITCHGEAR	67,200	25,000	1,000,000	1,092,200
Unassigned	67,200	25,000	1,000,000	1,092,200
GROUP S: YARD LIGHTS	43,290	29,120	24,187	96,596
Unassigned	43,290	29,120	24,187	96,596
Total	2,545,240	1,033,010	4,669,187	8,247,436
Insurance (3% on CL & CM)				**107,347**
Contingency (10% on CL & CM)				**357,825**
Mob/Demob (5% on CL & CM)				**178,912**
Heated Equip Storage (0.5% on CM & OFM)				**28,511**
Engineering (12% on CL, CM, & OFM)				**989,692**
Project Management (3% on CL, CM, & OFM)				**247,423**
Subtotal				**10,157,148**
Performance Bond				**56,000**
Total Estimate				**10,213,148**

Figure 6: Tok Substation Budgetary Cost Estimate

4.1.4 Jarvis Creek Substation

Jarvis Creek Substation is a modification to an existing GVEA substation. It includes the expansion of the station to include a new 138 kV bay and a 138 kV/ 230 kV transformer.

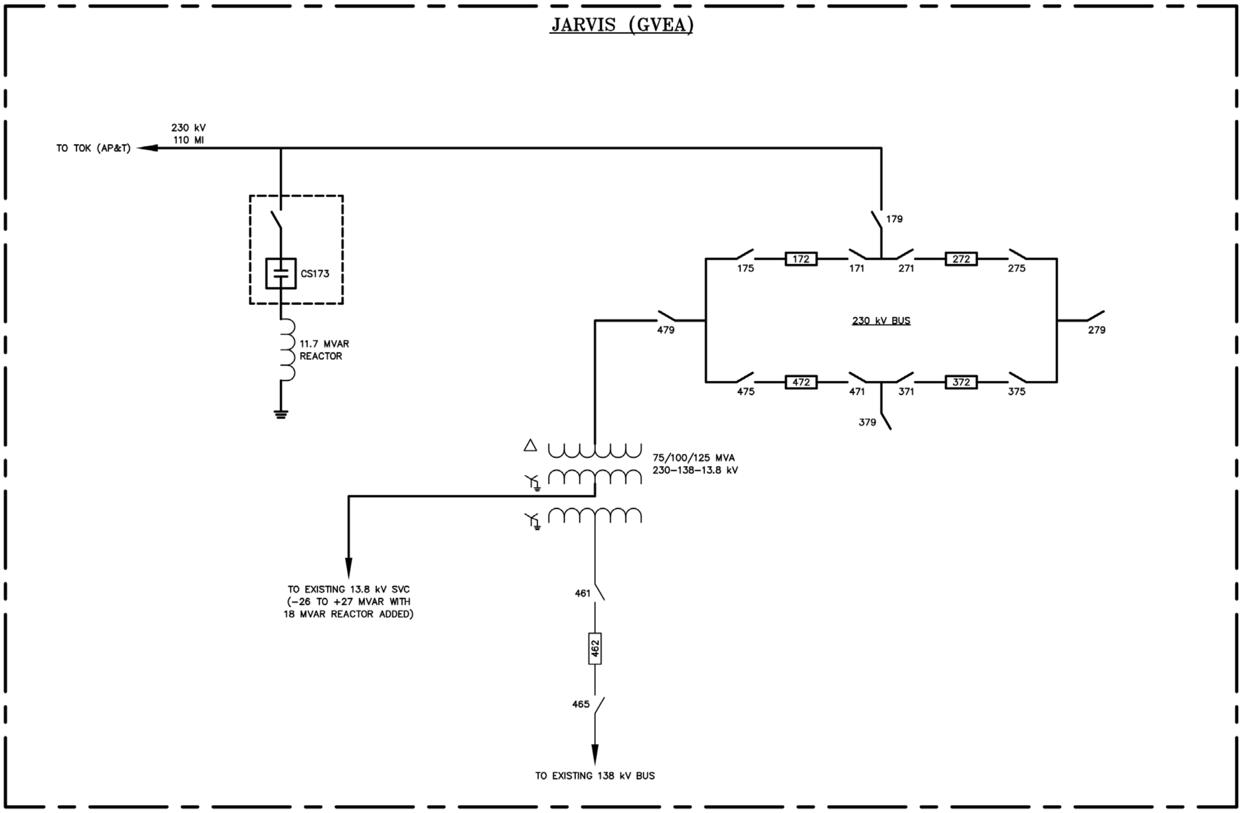

Figure 7: Jarvis Creek Substation Modification One-Line Diagram

Item Description	Extended Contractor Labor	Extended Contractor Material	Extended OFM	Extended Total
GROUP A: STRUCTURES	330,400	21,000	254,600	606,000
Unassigned	330,400	21,000	254,600	606,000
GROUP B: SWITCHING	95,000	9,450	192,000	296,450
Unassigned	95,000	9,450	192,000	296,450
GROUP C: CIRCUITS AND BUSWORK	237,846	156,250		394,096
Unassigned	237,846	156,250		394,096
GROUP E: CIRCUIT BREAKERS	134,400	2,800	700,000	837,200
Unassigned	134,400	2,800	700,000	837,200
GROUP F: FOUNDATIONS	453,384	49,117		502,501
Unassigned	453,384	49,117		502,501
GROUP G: TRANSFORMERS	114,800	28,350	2,819,600	2,962,750
Unassigned	114,800	28,350	2,819,600	2,962,750
GROUP K: CONDUIT AND CABLE	214,550	190,290		404,839
Unassigned	214,550	190,290		404,839
GROUP M: SITE WORK	498,573	154,483		653,056
Unassigned	498,573	154,483		653,056
GROUP N: FENCE AND SIGNS	91,800	209,090		300,890
Unassigned	91,800	209,090		300,890
GROUP O: GROUNDING	217,159	154,356		371,515
Unassigned	217,159	154,356		371,515
GROUP Q: SWITCHGEAR	67,200	25,000	1,000,000	1,092,200
Unassigned	67,200	25,000	1,000,000	1,092,200
GROUP S: YARD LIGHTS	43,290	29,120	24,187	96,596
Unassigned	43,290	29,120	24,187	96,596
GROUP U: SVC			1,500,000	1,500,000
Unassigned			1,500,000	1,500,000
Total	2,498,401	1,029,306	6,490,387	10,018,093

Insurance (3% on CL & CM)	105,831
Contingency (10% on CL & CM)	352,771
Mob/Demob (5% on CL & CM)	176,385
Heated Equip Storage (0.5% on CM & OFM)	37,598
Engineering (12% on CL, CM, & OFM)	1,202,171
Project Management (3% on CL, CM, & OFM)	300,543
Subtotal	12,193,393
Performance Bond	56,000
Total Estimate	12,249,393

Figure 8: Jarvis Creek Substation Budgetary Cost Estimate

4.2 Substation O&M Costs

We estimate the substation O&M costs for the O'Neill, Pump Station 11, Tok and Jarvis Creek stations to average $470k/year total for all four stations. The cost assumed that each station was maintained by the host utility and was based on average maintenance costs provided for the Alaska Intertie substations and CVEA's substation maintenance.

4.3 Communication System Modification Costs

Installation of fiber-optic conductors in one of the shield wires is estimated to cost approximately $3 million, including all design and contingencies. Modification of the auto-scheduling and terminal equipment is estimated at $500,000. The use of existing fiber communications along portions in lieu of installing the shield wire fiber-optics in the line could lower the initial communications investment.

5 Land Cost

The land cost component is an estimate to acquire permits or easements from landowners to design and construct an electrical transmission line from Sutton, Alaska to Glennallen to Tok to Delta Junction. This estimate is based on the best available data to identify parcels and the type of parcel ownership such as private, Native Corporation or government agency over one alignment. The total corridor width is 120 feet. The selected corridor is representative of a potential route suitable for the feasibility assessment of this project. The route used for cost selection in no way indicates a preferred route or probable route for the corridor. If the project moves forward, a route selection study that includes public meetings and input review by state, federal and local agencies and organizations should be used to select a preferred route.

Outside the Matanuska Susitna Borough (MSB) taxing authority, determining an exact parcel count and specific ownership is labor intensive and outside the scope of this project. Some assumptions were made, such as when there is evidence that both the State of Alaska (SOA) and a Native corporation have an interest in a given parcel. In this case, it was presumed that the Native corporation owns the parcel. This presumption of private ownership over state is generally true but detailed parcel by parcel title research was not performed.

Every route will have a unique set of permit requirements, parcels, and ownership. The route selected as a representative corridor for purposes of this feasibility assessment generally avoids Native Allotment parcels and the clusters of private ownership along the highway, but does include six miles along the highway in Tok through dense development. Factors that would skew this land cost estimate for other alignments include the following:

- A change in the quantity of labor-intensive land acquisitions such as the National Park Service, restricted Native Allotments, and Military.
- Poor public relations creating a project-wide animosity.
- Failure to consider eminent domain as a last resort but essential tool for land rights acquisition.
- Significant changes in government agency permitting fees or procedures.
- New laws requiring purchase of more area than is necessary, such as Minnesota's "Buy the Farm" statute.

5.1 Estimated Cost

The estimated cost for land acquisition is roughly $19,000,000. This includes title research to identify parcels and owners, a right of way survey to identify parcel boundaries and draw parcel maps, appraisals, direct compensation to purchase easements and the labor to acquire easements. Permits for the following are included: State of Alaska; Department of Natural Resources and Department of Transportation; Bureau of Land Management; U.S. Military; and the Matanuska Susitna Borough.

5.2 Presumptions & Risk Analysis

Standards and minimum requirements for the appraisal, surveying and acquisition may be dictated by funding sources. It is presumed that land negotiations and appraisals will follow the Uniform Act of 1971. A field survey to determine easement areas is included. Title research is included to determine parcels and parcel ownership.

In addition to standards imposed by funding sources, the desired level of risk also is a factor. The standard of proposed title research stops short of "marketable title," the highest level of title research. A lower standard of title research that is proposed is also possible, and along with that, a higher risk of trespass and legal problems.

The proposed Right of Way survey will not set property corners of the parent parcel or easement corners. It will result in a description that can be staked by a land surveyor.

Appraisals are necessary to comply with the Uniform Act of 1971, but if the funding source does not require that, then a few "typical" appraisals can be obtained and used as a basis of compensation to the landowners. A few eminent domain condemnations are included. Electric transmission lines are among the least popular right of way corridors to purchase. Some landowners will not sign an easement document regardless of the money offered, and it will be necessary to condemn to clear title in some cases. The judicious use of eminent domain, as a last resort, is an essential tool to complete a long right of way corridor.

5.3 Incentive Payments

One approach to purchasing easements is to offer an incentive for signing early (i.e. 90 days from the date of offer). An incentive program increases the direct compensation to the landowners. It often saves money by reducing the labor needed to acquire the easements, while shortening the negotiating time for the average landowner. It also tends to "level the playing field" between the more business savvy and less sophisticated landowners. The Alaska Department of Transportation and Public Facilities (DOT) has employed incentive payments for several road projects by offering a sliding scale of inducement of about 30%.

5.3.1 Recommendations

Right of Way acquisition costs are a small percentage of the cost for a project such as this one, but represents a high risk to the project's timeline, constructability and construction costs. There will always be differences of opinion as to land values, with the ultimate price being one agreed to by the landowner. The costs of offering more than the appraised value has little impact on the overall construction costs but may accelerate land acquisition and mitigate any public opposition to the project.

Adding an incentive payment of 30% of direct easement costs for signing easements promptly will most likely expedite land acquisition and result in some savings in the time and money to negotiate easement purchases.

Follow the *Uniform Relocation Assistance and Real Property Acquisition Act of 1970* in guiding appraisals and acquisitions. If certain federal funding is used for ANY aspect of the project, those funds are in jeopardy if the Uniform Act is not followed. Following the *Uniform Act* also establishes procedures to help the constructing organization to prevail in eminent domain actions.

5.4 Methodology

The Easement-Land cost aspect of the study was a collaboration between Electric Power Systems (EPS) and AHTNA, who providing base mapping and ownership type research to identify the "path of least resistance" for potential routes from a land impact view.

A geo-referenced base map was created to identify existing parcels, with the prime source being Geographic Information System (GIS) files from State of Alaska (SOA), Federal Bureau of Land Management (BLM), and the Matanuska Susitna Borough (MSB). These files reflect initial source creation of parcels such as BLM and SOA patents, but once the patents are issued, that government agency generally stops tracking that piece of land, so more recent transfers or subdivisions of land may not be depicted. There are some parcels created by deed that are not reflected in the GIS files, but as a whole the GIS parcels are adequate to avoid clusters of development and identify Native Allotment parcels which are among the most difficult to obtain easements across. Once an agency transfers ownership to another entity, they stop tracking and updating the GIS files. This can result in overlapping GIS files reflecting different ownership for the same parcel of land. For example, the BLM may issue a patent or tentative approval to the State of Alaska for a parcel, then a Native corporation selects the same parcel, resulting in the State deeding it back to the BLM, who later transfers it to the Native corporation.

The GIS files are not a reliable source to identify ALL private parcels, and research to identify all private parcels outside organized Boroughs is labor intensive. The scope of research did not include identifying every parcel and every or ownership of every parcel, but some additional research was performed to identify parcels not reflected in the GIS database. *BLM Master Title Plats and Patents* were obtained to clarify ownership of GIS files and to provide a basis for the cost estimate.

5.5 Existing Corridors

5.5.1 Highways

The highways are obvious, convenient locations for a transmission line. They offer ease of access to construct and maintain the line, but development along highway corridors typically greatly increases the number of private land holdings requiring acquisition, as well as the number of complaints from landowners and others.

Most of Alaska's highway rights of way are easement interests, created by Public Land Orders (PLOs). The Alaska Department of Transportation and Public Facilities (DOT) has the ability to permit utilities in their rights of way. In cases where the underlying ownership of the highway ROW is federal, including Native Allotments, then a permit or easement from the underlying fee owner is required in addition to the DOT permit. Generally the DOT forces utilities in the outer 10 feet of the ROW, and it is necessary to obtain an easement outside the ROW for safety clearances, and desirable to obtain a full width ROW (1/2 width outside the ROW) for clearing and maintenance.

5.5.2 Pipelines

It was necessary to move large quantities of fuel to the Fairbanks area during World War II to support military operations in the Alaska interior. The CANOL (Canadian Oil) pipeline was constructed between 1942 and 1944, connecting oilfield in the Canadian Northwest Territories to a refinery in Whitehorse. From there, fuel was passed to Ladd Field, now Ft. Wainwright. The Canadian portion was only in full operation for a year, but the Skagway to Fairbanks line operated for another ten years. Much of the ROW for the pipeline was relinquished in the 1970's.

The Haines-Fairbanks pipeline was an 8-inch diameter pipeline constructed between 1953 to 1955. A 1970 investigation into the deterioration of the pipeline led to closing the Haines to Tok section, and the Tok to Fairbanks section was closed in 1973. Most of this pipeline does not have an easement that remained when the land ownership changed, but was rather a 44LD513 title notation. The duration of a 44LD513 designation is that it cannot be transferred outside of federal ownership, and ceases to exist when the purpose for the reservation ends. These pipeline corridors are not considered available for any future transmission line project.

5.5.3 RCA Easement

"An easement and right-of-way to operate, maintain, repair and patrol an overhead open wire and underground communication line or lines, and appurtenances […]" exists along the Alaska Communication Systems cable, which was conveyed to RCA Alaska Communications, Inc., by easement deed dated January 10, 1971. This easement exists along much of the Glenn and Alaska Highways, and is routinely recognized as an existing encumbrance by the majority of conveyances of private and state properties. Various utilities now hold interest in different segments of the route, but cannot unilaterally expand the type of use to include electric transmission lines. Like many of the early military lines, this line was in a convenient location relative to the road system at the time, and it is a popular location for communication lines along the Glenn and Alaska highways.

5.5.4 Direct Land Costs

This category reflects an estimate on what money would be paid to the landowner for an electrical transmission line easement. Land sales were researched in the project area for the last five years and were used as a basis for a per-acre cost for the easement. Generally, the smaller the parcel, the better the access, and the greater the cost per acre.

5.5.5 Direct Land Costs, Specific Methods

A base map showing parcels was developed to select viable routes. We provided a route generated in AutoCAD and/or PLS-CADD for comment and review of land issues.

Once a feasible route was refined, a GIS program was used to buffer the alignment 60 feet both sides of the centerline. This 120-foot-wide strip was then chopped into shorter strips according to the parcels it crossed by intersecting the buffered strip with the parcel boundaries. Information, including the intersected area and the parent parcel size was extracted and exported to an Excel spreadsheet. Each intersected area is categorized according to the type of owner, centerline length within the parcel along with the area.

Each parcel categorized by ownership, for example, a public ownership such as State of Alaska where no easement would be purchased directly, or a private owner such as an individual or Native entity where an easement would be purchased. Private parcels were further classified according to the size of the parent parcel, and a value per acre applied based on similar sales research.

5.5.6 Indirect Land Costs

Indirect land costs include efforts to survey, map, appraise and acquire easements from private owners, and survey and permitting costs for other types of owners such as the State of Alaska.

The effort to acquire easements through negotiated settlements was made presuming the Uniform Relocation Assistance and Real Property Acquisition Act of 1970 (Uniform Act) will be followed. This sets minimum standards for the appraisal and negotiation process. In the case of some owners such as the State of Alaska, an easement is not directly purchased, but there are other costs associated with obtaining that easement or permit, such as an as-built survey for a DNR permit.

5.5.7 Appraisals

The Uniform Act requires a narrative appraisal to establish Fair Market Value (FMV) as a base line minimum for an offer amount. Certain acquisitions of small size and value can be made with a less expensive appraisal waiver document, but for estimating purposes full appraisals were used for each parcel. If funding sources do not require the Uniform Act to be followed, fewer appraisals will be required for the acquisition.

5.5.8 Private Parcels

Generally, small private parcels were avoided, but there are a number of small private parcels along the highway through the Tok core area that could not be avoided. DOT will generally require transmission lines near the edge of the ROW strip and can deny placing a transmission line inside the ROW if reasonable alternatives are available. Transmission line rights of way along the edge of the highway ROWs increases the chances of impacting private property, but can result in needing only half of the ROW width on private land, which reduces the direct impact to the private parcel.

5.5.9 Mining Claims

Mining claims on state land represent a private interest on SOA owned land. SOA DNR requires a letter of non-objection or similar from the mining interest, so mining claims are counted as private parcels for cost estimation.

5.5.10 Surveying

Right of way surveying and mapping, which accurately related the transmission line to parcel boundaries is required for some aspects, such as perfecting the SOA DNR easement. A DNR-standard as-built survey alone can cost $10,000 per mile depending on the number of survey monuments that need to be found or set.

It is possible to acquire an easement across a parcel with no survey using a “blanket” easement. Blanket easements are more difficult to negotiate. Well-informed landowners realize they can create a cloud on the title of the whole property, and will not sign.

While the GIS lines provide an efficient avenue to planning and estimating, a field survey is necessary to establish good locations. There are several sections in the Tok area where the GIS lines are more than 1/4 mile from the correct positions, and many of the more remote U.S. Surveys GIS lines can be even farther from their actual location on the ground.

The cost of a right of way survey can vary substantially according to the final route location. The use of a helicopter is expensive, but in some remote areas is the most cost-effective method of access. A right of way survey may not be required for all parcels. A high percentage of the route is across SOA managed land, which does require a high-quality survey.

While most of the route crosses large, sometimes un-surveyed territory, there are some “urban” type parcels requiring a more intensive surveying effort to determine boundary lines. The survey cost estimate includes an additive element for these high-density parcel areas.

5.5.11 Government Permits

Permission to build and maintain an electric line across government managed land such as the State of Alaska is in the form of a permit. The application usually includes a Plan of Development which identifies environmental concerns, and how the work methods will address those concerns. It is presumed that the Plan of Development will be created by the environmental contractor. The only permits included in this estimate are the State of Alaska, DNR & DOT, Mat-Su Borough (for their public process for transmission lines), the BLM and the Military.

5.5.12 Eminent Domain--Condemnation

Electric transmission lines are sometimes seen as unpopular improvements due to their impact on the viewshed and a relatively common perception of health hazards related to the close proximity to power lines.

While the use of eminent domain must be used as a last resort under the Uniform Act and cannot be used as an explicit threat, it is a necessary element to complete a long linear project. If a landowner refuses to settle voluntarily and a condemnation is filed with the court, most landowners settle before going to trial. If an impasse is reached and condemnation is not filed and this becomes common knowledge, the number of people refusing to sign often increases dramatically.

Eminent domain also has a leveling effect in situations when some landowners are knowledgeable in business, but other less-knowledgeable landowners face the same objective standards set by the court, which can result in unequal outcomes. Experience shows that the use of eminent domain to clear title can be necessary as some landowners will not sign voluntarily regardless of the compensation offered.

One element of a successful eminent domain exercise is a need and necessity conclusion based on comparing multiple routes, which is beyond the scope of this feasibility study.

5.5.13 Budgetary Land Cost Estimates

5.5.13.1 Regulatory Permitting Costs

Regulatory Permitting								
Landowner Category	Specific Landowner Type	QUANTITY OF PERMITS	Permit Cost, Each	Subtotal Permit Costs	Asbuilt Surveys, Additional to ROW Survey	Number of Parcels	Subtotals	
SOA	DNR	2	$30,000	$60,000	$200,000	84	$260,000	
SOA	DOT	10	$5,000	$50,000	$100,000		$150,000	
USA	BLM	1	$50,000	$50,000	$50,000	None on this alignment	$100,000	
USA	MILITARY	1	$50,000	$50,000	$40,000	3	$90,000	
BOROUGH	MSB	1	$20,000	$20,000	$20,000	1	$40,000	
						88	**$640,000**	**TOTAL**

5.5.13.2 Title & Surveying Costs

Title Research, Right of Way Surveying Costs												
# Survey Monuments (Mons)	# Parcels	Production Rate, Mons/Day to Survey	Crew-Days	Helicopter Crew Days	Driving Crew Days	Crew Wages & Lodging /Day	Helicopter / Day	General ROW Mapping/Mile	Parcel Maps Each	Title Reports & Rural Research, Average / Parcel		
1700	280	6	283	142	142	$4,500	$12,000	$2,500	$2,000	$3,000		
						Crew Wages & Lodging subtotal	Helicopter	General ROW Mapping Subtotal	Parcel Maps	Title Research Total	**Subtotal Rows**	
						$1,275,000	$1,700,000	$1,000,000	$560,000	$840,000	**$5,375,000**	
Additional Urban Area Surveying, 3 Mons/Private Parcel						Additional Crew Wages & Lodging subtotal		Additional Urban / Private Parcel Mapping, $1000/parcel	Urban Area Parcel Maps Additional Detail			
270	90	6	45	No Heli	All Driving	$202,500	None	$90,000	$90,000		**$382,500**	
											$5,757,500	**TOTAL**

5.5.13.3 Land Acquisition Costs, Summary

Land Acquisition Costs										
Landowner Category	Specific Landowner Type	Number of Parcels	Distinct Parent Parcel Owners	Direct Land Costs	Appraisals ($6000 each)	Negotiation Costs ($10,000 individuals each, $20,000 for Native corporations, $50,000 for Native allotments)	Condemnation to Cure Title Defects & Negotiation Impasses, File in Court, (20 @ $100,000 each)	Condemnation, Trial, (5 @ $300,000 each)	Subtotals	
CITY	Delta Jct	1	1	$5,000	$6,000	$9,000			$20,000	
PRIVATE	PRIVATE	79	79	$514,011	$474,000	$711,000	$2,000,000	$1,500,000	$5,199,011	
PRIVATE	MINING CLAIM	75	17	$609,358	$102,000	$153,000			$864,358	
PRIVATE	AG. LEASE	16	16	$544,111	$96,000	$144,000			$784,111	
PRIVATE	UNIV. OF AK.	0	0			$0			$0	
PRIVATE	MENTAL HEALTH	6	1	$397,089	$36,000	$9,000			$442,089	
PRIVATE	NATIVE VILLAGE	29	9	$4,336,104	$174,000	$180,000			$4,690,104	
PRIVATE	NATIVE REGIONAL	12	3	$487,938	$72,000	$60,000			$619,938	
RESTRICTED	NATIVE ALLOTMENT	1	5	$50,000	$6,000	$50,000			$106,000	
		219	**131**	**$6,943,611**	**$966,000**	**$1,316,000**	**$2,000,000**	**$1,500,000**	**$12,725,611**	**Subtotals**
		(SOA Parcels							**$640,000**	**Regulatory Permitting**
		Not Included)								
									$5,757,500	**Title, Surveying, Appraisals**
									$19,123,111	**TOTAL**

6 Electrical System Studies

6.1 Introduction

This section provides the transmission planning results that highlight necessary hardware and topology changes, power flow analyses, and transient stability analyses. The steady-state power flow results include considerations such as interconnection route/path, line voltage, conductor sizing, line spacing, transformers, reactors, and SVCs. This section also includes the in-depth line compensation and voltage support simulations.

The transient stability (dynamic) work explores the feasibility of the two most-promising designs from the steady-state power flow results. The dynamic simulations were performed on various Railbelt seasonal cases that include all of the additional hardware and interconnections added during the power flow studies. The dynamic simulations also included known critical contingencies (failures of critical power system components) within the Railbelt, as well as new contingencies that become possible with the new Roadbelt Intertie. Remedial Action Schemes (RASs) and dynamic SVC models are evaluated in order to control the transient response for some of the more severe contingencies.

The transmission lines were evaluated using criteria consistent with planning criteria used in the existing Railbelt system to ensure that the CVEA and Tok systems experience the same level of service as the rest of the interconnected system. These criteria are listed below and further defined in following sections.

Steady-State

- Capable of 75 MW of firm transfer from Southcentral AK to Fairbanks
- Capable of 125 MW of non-firm transfer from Southcentral AK to Fairbanks
- Thermal limits of any transmission line impacted by the new line are not exceeded
- Steady-state voltages above 0.98 and below 1.03 on the entire system
- Energization of open lines' voltage profile below 1.05
- Stability
- No contingency results in cascading failures
- No contingency results in loss of synchronism across any transmission line or loss of unit
- At least 75 MW of firm power transfer following any single contingency
- Transient voltage swings must stay above 0.8 pu.

6.2 Topological Overview

The proposed Roadbelt Intertie will provide a second path for power to flow between the Anchorage Bowl area and Fairbanks while simultaneously interconnecting other islanded utilities and municipalities along the way. This will create a transmission corridor electrically parallel to the existing Alaska Intertie which begins at the Douglas substation in MEA, runs north through Healy, and terminates in the GVEA system.

In general, this new interconnection will be a route that begins in the MEA system and interconnects to the CVEA system near Glennallen, continues to the AP&T system in Tok, and terminates in the GVEA system. The relevant mileages between the various substations are shown in Table 4 below. Two slightly different topologies are described in the following subsections that both achieve the described interconnection goals.

Electric Power Systems Inc. Consulting Engineers

Due to the necessity of completing the electrical studies and possible line routings concurrently, there were certain assumptions made for the completion of the electrical studies. Differences between the line routing and configuration used in the electrical studies and the possible routes used in the cost estimating are not significant to the results of the study.

Examples are the line miles between stations and the location of some stations along the route. The representation of Gakona as a bus in the PSS/E model is for electrical modeling only. It does not represent an actual substation at Gakona. Load in Gakona will continue to be served via CVEA’s 24.9 kV network from Glennallen. Gakona simply represents a physical location where AK-1 and AK-4 highways diverge, and it serves as a natural physical location in the area where the double circuit in Topology 2 below might diverge.

Table 4: Distance Between Substations

From Substation	To Substation	Miles
O'Neill	Pump 11	130
Pump 11	Gakona	16
Gakona	Tok	120
Tok	Jarvis	110
Pump 11	Tok	136
Gakona	Jarvis	136

6.2.1 Topology 1

The first topology includes the original path as described in the project plan. This path connects each city/area/substation in series beginning in Sutton, following highway AK-1 east to Glennallen, continuing north-east to Tok, then following AK-2 northwest to Delta Junction. A diagram of the connections and substations along this proposed route can be found in Figure 9 below.

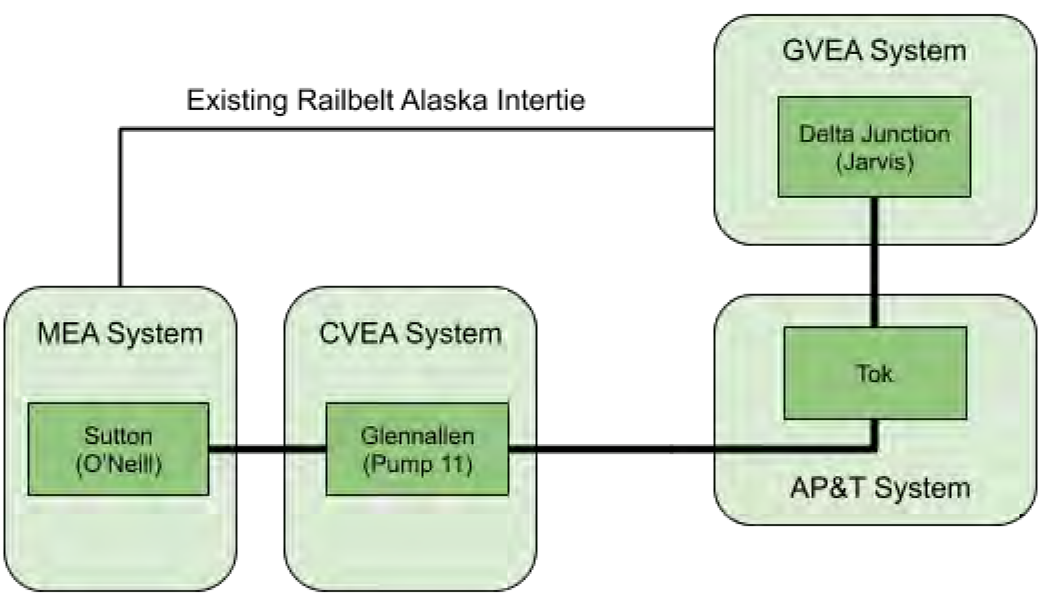

Figure 9: Topology 1 - Transmission Line Path for the Roadbelt Intertie

6.2.2 Topology 2

EPS evaluated an additional topology for consideration as seen in Figure 10 below. This second topology slightly alters the configuration seen in Topology 1 by connecting Tok radially from Pump 11 instead of making a series connection from Glennallen, through Tok, to Delta Junction.

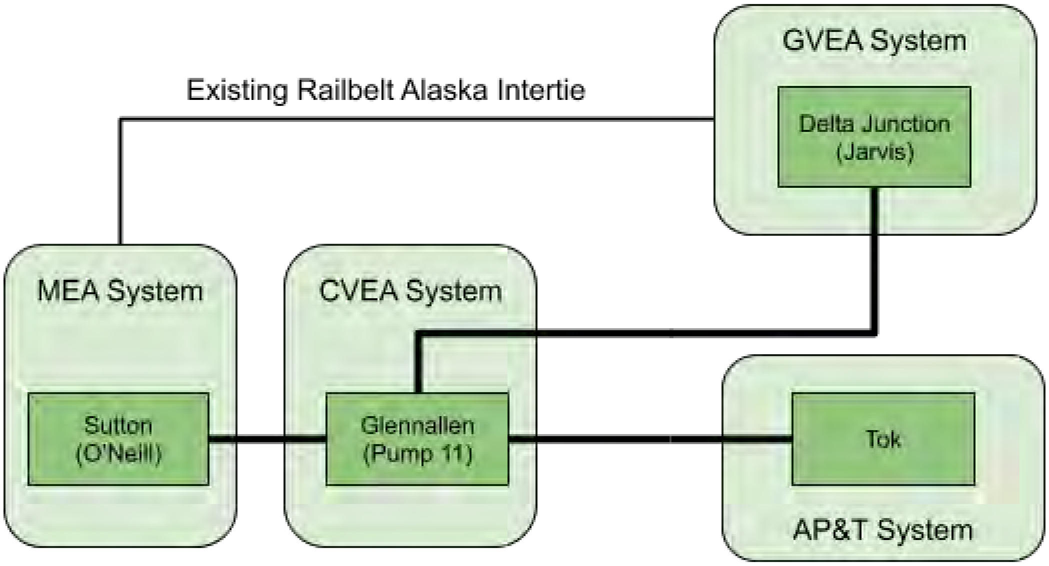

Figure 10: Topology 2 - Transmission Line Path for the Roadbelt Intertie

There are several anticipated advantages to Topology 2. First, the primary transmission path from the Anchorage Bowl to the Fairbanks area is shortened. In effect, the overall impedance of the path that carries the bulk of the power North is decreased. Not only will this decrease the losses, but it will also strengthen the connection between utilities during transient events. This is revisited in the subsections that follow.

Second, the transmission line that connects Tok can be built at a lower kV/MVA rating because it no longer needs to have the capability to carry the bulk of the power flow from South to North, all the way into the GVEA system. The Tok connection will only need to be built to support anticipated load near the Tok area. The costs for this alternative were not evaluated.

6.3 Railbelt PSS/E Model Modifications

Multiple changes to the existing PSS/E Railbelt database were needed in order to simulate the new transmission interconnection. Besides calculating impedances and adding the new transmission lines to the database, EPS also made the following additions/modifications:

1. Expanded O'Neill substation to include a 138 or 230 kV bus with a 75 MVA, 7% impedance transformer that connects to the existing 115 kV system.
2. Incorporated the full CVEA PSS/E model including:
    a. 138 kV and 24.9 kV systems
    b. All major generation sources (Allison Creek Hydro, Solomon Gulch Hydro, Valdez Diesel, and Glennallen Diesel).
    c. Added typical dynamic models, with some standard parameters for Allison Creek Hydro, Solomon Gulch Hydro, Valdez Diesel, and Glennallen Diesel facilities. Where possible,

assumptions were made about the dynamic model parameters according to size, fuel type, and some limited existing parameter data provided by CVEA.

d. Updated system loads and dispatch according to CVEA guidance.

3. In the 230 kV cases, added a new bus at Pump 11 (CVEA) to interconnect CVEA to the rest of the Railbelt. In the 138 kV cases the connection was made at the existing Pump 11 bus.
    a. The 230 kV cases also required a new transformer. Given the need for reactive compensation, this transformer was modeled as 3-winding (230/138/24.9 kV) where the reactive compensation device was attached to the 24.9 kV tertiary winding.
    b. During the transient stability work (See Section 6.5), EPS determined that dynamic models for the SVCs were required. These devices were modeled as a CSSCST standard library model and tuned appropriately for the desired response on the Glennallen – Palmer line section.
    c. The Transformer at Pump 11 was modeled as a 50 MVA transformer with 8% impedance.

4. The Tok system was modeled as a 230 kV bus with a step-down transformer to 24.9 kV. The low side included a single static load at 3 MW. (In the alternate topology case this was a 138 kV bus with step-down transformer to 24.9 kV). Loads at Tok could grow significantly without impacting the study results.
    a. In the Topology 1 configuration there was an SVC modeled on the low side of the transformer to control the 230 kV bus voltage.

5. The GVEA connection was directly interconnected to the existing Jarvis bus in the 138 kV cases, but required an additional bus and transformer in the 230 kV cases.
    a. The 230/138 kV transformer was modeled as a 75 MVA transformer with 7% impedance.
    b. The reactive capability of the existing SVC at Jarvis was modified to provide the necessary compensation based on the charging of the new transmission lines. This was done by adding an appropriately sized fixed reactor to shift the range of the SVC in the reactive direction.

6.4 Steady-State Power Flow Simulations

This section discusses results that were obtained from steady-state power flow simulations. The results were used to determine the viability of both Topology 1 and 2, determine the most reasonable voltage levels and transmission line characteristics, and determine the reactive compensation needed along the new path.

6.4.1 Transmission Line Parameters

EPS evaluated multiple transmission line configurations and options, as shown in Table 5. This initial set of line configurations was chosen based on the following:

1. Mileages as discussed in Table 4 above.
2. The combination of the new line and the existing Anchorage-Fairbanks Intertie should provide 75 MW of firm transmission between Anchorage and Fairbanks.
3. The new line and the existing Anchorage-Fairbanks Intertie should provide 125 MW of total flow northward including firm and non-firm transmission.
4. Existing transmission lines in Alaska use similar construction/sizing.

Table 5: Transmission Line Conductor and kV Configurations

kV	Conductor	Phase to Phase Spacing	GMD	Single or Bundled
138	556.5 ASCR - Dove	18.25'	23	Single
138	795 ASCR - Drake	18.25'	23	Single
230	795 ASCR - Drake	19.5'	24.5	Single
230	795 ASCR - Drake	20.5'	25.8	Double Conductor Bundle (1')
230	954 ASCR - Cardinal	19.5'	24.5	Single
230	954 ASCR - Cardinal	20.5'	25.8	Double Conductor Bundle (1')

The impedance characteristics specific to the mileages in Topology 1 and Topology 2 were calculated for each of the options presented in Table 5. These results are depicted in Table 6.

Table 6: Roadbelt Intertie Line Impedances

138 kV -- 556.5 Dove Single Conductor -- 23' GMD			
470 A -- 112 MVA			
Route	R (pu)	X (pu)	B (pu)
O'Neill to Pump 11	0.1352	0.5462	0.1306
Pump 11 to Gakona	0.0166	0.0672	0.0161
Gakona to Tok	0.1248	0.5042	0.1205
Tok to Jarvis	0.1144	0.4622	0.1105
Total Series Impedance	0.391	1.5798	0.3777
% of 230kV 795 Sing. Cond	430.1%	282.2%	35.4%

138 kV -- 795 Drake Single Conductor -- 23' GMD			
590 A -- 141 MVA			
Route	R (pu)	X (pu)	B (pu)
O'Neill to Pump 11	0.0800	0.5322	0.1343
Pump 11 to Gakona	0.0098	0.0655	0.0165
Gakona to Tok	0.0739	0.4912	0.1240
Tok to Jarvis	0.0677	0.4503	0.1137
Total Series Impedance	0.2314	1.5392	0.3885
% of 230kV 795 Sing. Cond	254.6%	274.9%	36.4%

230 kV -- 795 Drake Single Conductor -- 24.5' GMD			
590 A -- 141 MVA			
Route	R (pu)	X (pu)	B (pu)
O'Neill to Pump 11	0.0314	0.1936	0.3692
Pump 11 to Gakona	0.0039	0.0238	0.0454
Gakona to Tok	0.0290	0.1787	0.3408
Tok to Jarvis	0.0266	0.1638	0.3124
Total Series Impedance	0.0909	0.5599	1.0678
% of 230kV 795 Sing. Cond	N/A	N/A	N/A

230 kV -- 795 Drake Double Conductor Bundle -- 25.8' GMD			
590 A -- 141 MVA			
Route	R (pu)	X (pu)	B (pu)
O'Neill to Pump 11	0.0157	0.1458	0.4846
Pump 11 to Gakona	0.0020	0.0179	0.0596
Gakona to Tok	0.0145	0.1346	0.4474
Tok to Jarvis	0.0133	0.1234	0.4101
Total Series Impedance	0.0455	0.4218	1.4017
% of 230kV 795 Sing. Cond	50.0%	75.3%	131.3%

230 kV -- 954 Cardinal Single Conductor -- 24.5' GMD			
650 A -- 259 MVA			
Route	R (pu)	X (pu)	B (pu)
O'Neill to Pump 11	0.0277	0.1913	0.3738
Pump 11 to Gakona	0.0034	0.0235	0.0460
Gakona to Tok	0.0256	0.1766	0.3450
Tok to Jarvis	0.0235	0.1619	0.3163
Total Series Impedance	0.0802	0.5533	1.0811
% of 230kV 795 Sing. Cond	88.2%	98.8%	101.2%

230 kV -- 954 Double Conductor Bundle -- 25.8' GMD			
650 A -- 259 MVA			
Route	R (pu)	X (pu)	B (pu)
O'Neill to Pump 11	0.0139	0.1448	0.4888
Pump 11 to Gakona	0.0017	0.0178	0.0602
Gakona to Tok	0.0128	0.1337	0.4512
Tok to Jarvis	0.0118	0.1226	0.4136
Total Series Impedance	0.0401	0.4189	1.4137
% of 230kV 795 Sing. Cond	44.1%	74.8%	132.4%

230 kV -- 795 Drake Single Conductor -- 24.5' GMD			
590 A -- 141 MVA			
Route (Topology 2)	R (pu)	X (pu)	B (pu)
O'Neill to Pump 11 (230 kV	0.0314	0.1936	0.3692
Pump 11 to Gakona (230 k	0.0039	0.0238	0.0454
Gakona to Jarvis (230 kV)	0.0328	0.2025	0.3862
Total Series Impedance	0.0681	0.4199	0.8008
% of 230kV 795 Sing. Cond	75.0%	75.0%	75.0%
Pump 11 to Tok (138kV)	0.0912	0.5625	0.1390

230 kV -- 954 Double Conductor Bundle -- 25.8' GMD			
590 A -- 141 MVA			
Route (Topology 2)	R (pu)	X (pu)	B (pu)
O'Neill to Pump 11 (230 kV	0.0157	0.1458	0.4846
Pump 11 to Gakona (230 k	0.0020	0.0179	0.0596
Gakona to Jarvis (230 kV)	0.0164	0.1526	0.5070
Total Series Impedance	0.0341	0.3163	1.0513
% of 230kV 795 Sing. Cond	37.5%	56.5%	98.5%
Pump 11 to Tok (138kV)	0.0912	0.5625	0.1390

The values presented in Table 6 yield some immediate results that helped narrow down the transmission line options available.

First, the 138 kV Dove option would be operating at 67% of its conductor rating under normal single line flows, resulting in losses that exceed typical values.

Second, given that the resistance and reactance (R & X) values for 138 kV 795 conductor are about 275% above the rating of the next highest 230 kV 795 conductor option, it was evident that the losses at the 138 kV level would be prohibitive. This was confirmed in the power flow simulations outlined in subsequent subsections below.

Third, the comparison of Topology 1 and Topology 2 230 kV 795 conductor indicates that Topology 2 resulted in 25% lower overall impedance and charging due to the decrease in mileage directly between

Anchorage and Fairbanks. This alternative was not evaluated for line costs but should be evaluated if the project moves forward.

Finally, the double conductor bundle options, while decreasing the overall impedance of the path between Anchorage and Fairbanks, have significant increases in charging (on the order of 30% higher). The reactive charging increase due to bundling is problematic for the system.

6.4.2 Investigation of Losses

EPS developed multiple cases based on the official seasonal Railbelt load cases (Summer Valley [SV], Summer Peak [SP], and Winter Peak [WP]) for various transfer levels between Anchorage and Fairbanks. The core base cases included 20 MW, 50 MW, 70 MW, 75MW, and 125 MW transfers to the north. Appendix B contains the detailed unit commitment and dispatches used in these cases.

The most limiting case, in terms of losses, for the new transmission corridor is the maximum expected firm transfer of 75 MW measured at O'Neill substation (with the Alaska Intertie open). This particular case demonstrates the highest losses that could be expected on the new line (see Table 7).

Table 7: Alaska Intertie Open -- 75 MW Firm Flows on Roadbelt Intertie

Line Configuration	Losses (MW)
Topology 1 -- 138 kV -- 556.5 Single Cond.	17.6
Topology 1 -- 138 kV -- 795 Single Cond.	11.3
Topology 1 -- 230 kV -- 795 Single Cond.	4.7
Topology 1 -- 230 kV -- 795 Double Cond. Bundle	2.4
Topology 1 -- 230 kV -- 954 Single Cond.	4.1
Topology 2 -- 230 kV -- 795 Single Cond.	3.5

As expected, both 138 kV options indicate a prohibitive amount of losses ranging from 15-23% of the transfer. The remaining cases indicate more reasonable amounts of losses. Other criteria such as amount of reactive compensation, physical characteristics, line performance during transient events, and costs were factored into the final selection used for cost estimating and feasibility.

6.4.3 Investigation of Reactive Compensation Requirements

Reactive compensation was needed to develop a cost-effective transmission path between Anchorage and Fairbanks. Line reactors, static VAR compensators, and/or other shunt reactance is typically needed to counteract the added MVAR requirement of a long, high-voltage transmission line.

Depending on the voltage level and the loading on a transmission line, the line either acts as a source or sink of MVARs depending on whether the loading on the line falls above or below its Surge Impedance Loading (SIL). In the case of a 230 kV transmission line, the SIL is about 140 MW. At the max firm flow on the new intertie of 75 MW, there will be significant charging current into the system from the line.

Different scenarios were simulated in order to determine the amount of reactive compensation needed in order to decrease the effects of line charging.

6.4.4 Line Energization

Energization of a parallel transmission path is the worst case for voltage magnitude and voltage angle differences found at any substation along the two parallel paths. EPS studied the power flow conditions that model the energization of either the Roadbelt Intertie or the Alaska Intertie. In each of the cases, one of the two ties is open, and the resulting substation voltages and voltage across the open breaker were evaluated.

6.4.4.1 Line Energization Voltage Magnitude

Large amounts of reactive compensation were needed in order to minimize the voltage drop across any open breaker along a parallel transmission path like the proposed Roadbelt Intertie. The criteria used for the maximum allowable node voltage at the open breaker was 1.05 per unit (PU). EPS studied each breaker position along the new path from O'Neill to Jarvis and obtained the maximum bucking (Voltage lowering) and boosting (voltage raising) needed in order to ensure that the open end of any line remains under 1.05 PU and the voltage across the open breaker is minimized. This defines the amount of reactive compensation needed in order to control the voltage across an open line, right before attempting to close the line. Table 8 highlights the results.

Table 8: Range of Reactive Compensation Required to Energize the Roadbelt Intertie

	O'Neill (MVAR)		Pump 11 (MVAR)		Tok (MVAR)		Jarvis (MVAR)	
	Inductive	Capacitive	Inductive	Capacitive	Inductive	Capacitive	Inductive	Capacitive
No Line Compensation								
Topology 1 -- 230 kV 795 Single Cond.	-75	0 *	-92	0	-77	0	-42	0
Topology 1 -- 230 kV 795 Double Cond.	-93	0 *	-130	0	-123	0	-55	0
Topology 1 -- 230 kV 954 Single Cond.	-75	0 *	-94	0	-78	0	-43	0
Topology 2 -- 230 kV 795 Single Cond.	-75	0 *	-125	0	-3.3	10	-62	7
With 75% Line Compensation								
Topology 1 -- 230 kV 795 Single Cond.	0 **	0**	-15	12	-18	0	-6	0
Topology 1 -- 230 kV 795 Double Cond.	0 **	0**	-23	11	-38	0	-10	19
Topology 1 -- 230 kV 954 Single Cond.	0 **	0**	-15	12	-19	0	-6	0
Topology 2 -- 230 kV 795 Single Cond.	0 **	0**	-22	10	0	4	-18	7
* Voltage at O'Neill was allowed to settle around 1.02 PU instead of adding capacitive compensation to raise the voltage to 1.05 PU.								
** Voltage at O'Neill was between 1.01 and 1.05 resulting in no reactive compensation requirement.								

Table 8 includes cases with 75% fixed line compensation (bottom half of the table). This means that charging due to the line capacitance was counteracted by adding a fixed line reactor to both ends of each long line section with a total reactance equal to 75% of the line's charging. The only line that does not include fixed line reactors is between Pump 11 and Gakona since the charging due to this short line is negligible.

6.4.4.2 Line Energization Voltage Angle Analysis

One of the other main considerations when studying the energization of parallel transmission paths is the voltage angle across an open breaker. Since Anchorage and Fairbanks are still interconnected via the Alaska Intertie (with the new Roadbelt Intertie open), attention must be focused to the angular difference between the two regions. Table 9 below shows results for three different tie flows.

Table 9: Range of Angular Differences Across Open Breakers During Energization

AK Intertie Flow	Min. Angle	Max Angle
69 - 73 MW	40°	45°
48 - 52 MW	28°	32°
17 - 21 MW	11°	15°

As anticipated, higher initial flows along the Alaska Intertie result in greater angular difference. In other systems an angle of 30 degrees is acceptable for closing the open breaker and that criteria was used in this study. Final criteria will need to be established for the acceptable range in angle difference across the open breaker. In order to reduce the open breaker angle, either the transfer along the closed path needs to be reduced, or supplemental control such as a phase shifting transformer would be required along either the Alaska Intertie or along the Roadbelt Intertie. A phase-shifting transformer was not included in the conceptual design for the system as operational changes can easily change the phase angle to allow for breaker closing.

6.4.5 Both Lines Energized

Although the limiting case for determining the amount of required reactive compensation is the energization case highlighted in the previous section, analysis was done for the amount of reactive compensation needed during normal operation when the Roadbelt Intertie is energized. This provides the range of additional reactive compensation needed during different seasonal load cases, as well as during different northbound MW transfer levels.

The bus voltage target for this set of "normal operation" cases was 1.02 PU along the Roadbelt transmission corridor. The results are shown in Table 10 below where negative values indicate bucking MVARs (inductive compensation) and positive values indicate boosting MVARs (capacitive compensation).

Table 10: Reactive Compensation to hold 1.02 PU voltage at various MW flow levels.

Case	MW Flow Level	O'Neill (MVAR)	Pump 11 (MVAR)	Tok (MVAR)	Jarvis (MVAR)
No Line Compensation					
Topology 1 -- 230 kV 795 Single Cond.	20	-9.9	-35.5	-35.9	-16.3
	50	-9.1	-34.2	-35.0	-15.2
	70	-4.6	-25.4	-33.9	-11.3
	75*	9.0	-16.7	-26.5	-0.5
	125	2.6	-20.6	-29.8	-5.2
Topology 1 -- 230 kV 795 Double Cond.	20	-21.4	-51.9	-48.5	-23.3
	50	-19.1	-50.8	-47.7	-23.1
	70	-13.5	-39.4	-46.7	-19.8
	75*	1.7	-32.8	-41.0	-12.1
	125	-3.8	-35.2	-43.1	-14.9
Topology 1 -- 230 kV 954 Single Cond.	20	-9.9	-34.3	-36.5	-16.8
	50	-8.6	-34.9	-35.6	-16.0
	70	-3.8	-26.0	-34.5	-12.2
	75*	11.1	-17.4	-27.1	-2.1
	125	4.1	-21.3	-30.5	-6.7
Topology 2 -- 230 kV 795 Single Cond.	20	-9.9	-51.0	-0.4	-24.0
	50	-8.9	-49.5	-0.5	-22.5
	70	-4.2	-33.0	-8.1	-18.1
	75*	9.0	-23.2	-9.4	-6.0
	125	4.1	-26.6	-8.9	-10.1
With 75% Fixed Line Compensation					
Topology 1 -- 230 kV 795 Single Cond.	20	-6.4	-5.8	-8.1	-7.3
	50	-5.7	-4.7	-7.3	-6.1
	70	-1.4	0.9	-6.3	-2.1
	75*	40.7	8.8	0.7	15.0
	125	34.2	5.3	-2.4	10.2
Topology 1 -- 230 kV 795 Double Cond.	20	-8.2	-10.3	-11.2	-9.6
	50	-6.0	-9.4	-10.5	-9.3
	70	-0.5	-3.5	-9.6	-5.9
	75*	43.2	2.3	-4.4	8.0
	125	37.7	0.2	-6.3	5.1
Topology 1 -- 230 kV 954 Single Cond.	20	-6.0	-6.0	-8.3	-7.5
	50	-4.9	-4.9	-7.5	-6.6
	70	-0.2	0.7	-6.5	-2.8
	75*	43.2	8.4	0.4	13.5
	125	36.2	5.0	-2.7	8.9
Topology 2 -- 230 kV 795 Single Cond.	20	-6.3	-10.4	1.7	-9.4
	50	-5.5	-9.1	1.6	-7.8
	70	-0.9	3.1	-5.7	-3.3
	75*	40.6	11.7	-7.0	15.2
	125	35.8	8.7	-6.5	11.0
* The existing Alaska Intertie is open in these cases.					

In Table 10 above, the results indicate that the double conductor bundle cases typically require about 1.5 to 2 times the amount of reactive compensation compared to the single conductor cases. Additionally, the single conductor 795 and 954 cases are very similar in terms of the reactive compensation needed. Topology 2 does require a higher concentration of compensation needed at Pump 11 and Jarvis substations, but overall indicates less compensation needed.

When the fixed 75% line reactors were evaluated, the amount of additional compensation went down significantly. The one set of outliers in these cases are the two high-flow cases (75 MW on the Roadbelt Intertie only, and 125 MW flow case that is split between the Alaska Intertie and the Roadbelt Intertie). The high amounts of charging needed in these cases is due to holding the voltages to 1.02 PU. The 795 Drake conductor cases were re-run with more relaxed voltage constraints allowing bus voltages to range between 1.03 PU and 0.98 PU. These cases resulted in a better relationship between node voltage and the variable compensation needed in addition to the fixed line reactors. The results for various flow levels are presented in Table 11 below.

Table 11: Reactive Compensation at Pump 11 & Jarvis with 75% Line Compensation

	MW Flows	Reactive Compensation		Voltages			
		Pump 11 (MVAR)	Jarvis (MVAR)	O'Neill (PU)	Pump 11 (PU)	Tok (PU)	Jarvis (PU)
Topology 1 -- 230 kV 795 Single Cond.	20	-7.5	-10.4	1.027	1.030	1.038	1.030
	50	-5.9	-8.6	1.027	1.030	1.036	1.030
	70	-0.5	-2.8	1.023	1.027	1.035	1.030
	75*	5	9.4	0.985	0.980	0.980	0.985
	125	1.6	0.3	0.993	0.990	0.992	0.990
Topology 2 -- 230 kV 795 Single Cond.	20	-6.5	-6.6	1.027	1.030	1.018	1.030
	50	-5.2	-5	1.027	1.030	1.020	1.030
	70	-1.6	-0.5	1.023	1.027	1.046	1.028
	75*	1.1	5.3	0.985	0.980	1.007	0.980
	125	0.1	0.3	0.991	0.989	1.014	0.987
* The Existing Alaska Intertie is open in these cases.							

The power flow results in Table 11 indicate that no variable compensation is needed at O'Neill or Tok in order to satisfy these relaxed voltage conditions. Pump 11 and Jarvis substations provide the best location for compensation, resulting in the most effective minimal installation of variable reactive compensation for both Topology 1 and Topology 2.

6.4.6 Summary of Power Flow Findings

1. The amount of losses at 138 kV are prohibitive. Any of the 230 kV options provide MW loss ranges that are acceptable.

2. Topology 2 has lower overall impedance between the Fairbanks and Anchorage areas. This topology will likely provide the best MW and MVAR efficiency. The entire path can be built with single conductor construction and still obtain low line losses.

3. The power flow results indicate that the top two designs both use single conductor 795 ACSR Drake at 230 kV. 954 Rail conductor was also evaluated and offers some loss advantages, however, for this study, 795 Drake was used in the final studies. Both Topology 1 and Topology 2 are viable, though stability simulations were run to determine whether additional RAS measures or reactive compensation is needed during critical contingencies.

4. In both topologies, reactive compensation is needed at Pump 11 and Jarvis – though the amount of compensation is slightly higher in the case of Topology 1. In both cases line reactors help to minimize the range of variable reactive compensation needed.

    a. Without line reactors, the energization of the Roadbelt Intertie will require significant variable compensation – on the order of 40 to 130 MVARs at each of the four substations.

    b. Alternatively, with 75% fixed line reactor compensation, the power flow results indicate that variable SVC reactive compensation between -20 and +20 MVARs at both Pump 11 and Jarvis would suffice for maintaining voltage within a tolerable range.

5. Given the large range of variable reactive compensation noted in point 4a above, EPS recommends 75% line compensation on the longer transmission line segments of the new intertie. The following table (Table 12) details the specific line reactor MVAR sizing of the final 2 feasibility options.

Table 12: Recommended Line Reactor Sizing

	Line Segment	Reactor Size at each Terminal (MVAR)	Total Reactive Line Compensation (MVAR)
Topology 1 -- 230 kV 795 Single Cond.	O'Neill to Pump 11	13.8	27.6
	Gakona to Tok	12.8	25.6
	Tok to Jarvis	11.7	23.5
	TOTAL		76.7
Topology 2 -- 230 kV 795 Single Cond.	O'Neill to Pump 11	13.8	27.6
	Gakona to Jarvis	14.5	29
	Pump 11 to Tok (Radial Line)	5	10
	TOTAL		66.6

6. The existing Jarvis SVC already provides a range of -8 to +45 MVARs. Given the initial approximation of -20 to +20 of variable compensation at Jarvis, this existing SVC should suffice, if the overall reactive compensation is shifted toward the inductive side (i.e. adding a fixed reactor of about -18 MVARs would shift the SVC range such that it operates between -26 and +27 MVARs).

7. During energization, a large voltage angle across the open breaker can occur at high flow levels along the opposite path. If an angle criterion of 30 degrees is selected, then the maximum allowable flow on the in-service intertie (e.g. the Alaska Intertie) will be about 50 MW when trying to energize one of the interties. A phase shifting transformer would be able to improve this transfer limit during energization.

6.5 Transient Stability Analyses

The results from the steady-state power flows discussed above indicate that two different configurations are suitable for a new Roadbelt Intertie between MEA and GVEA while simultaneously interconnecting both CVEA and AP&T to the Railbelt system. The two designs that were studied further with transient stability simulations are:

1. Topology 1 – all construction at 230 kV – single conductor 795 ACSR (Drake).

2. Topology 2 – Sutton to Glennallen to Delta Junction constructed at 230 kV with an additional radial line from Glennallen to Tok constructed at 138 kV. All using single conductor 795 ACSR (Drake).

The steady-state power flow simulations confirmed that line reactors are needed along with at least 20 MVARs of variable reactor support at multiple locations along the new intertie. The power flow energization simulations only provide the minimum (maximum negative) reactor sizing, and do not address the worst-case condition for sizing in the positive (capacitive) direction. EPS conducted transient stability simulations to determine the amount of boosting reactive support needed to prevent instabilities and low voltage conditions during contingencies.

Based on our experience, certain contingencies are well known for creating stability problems within the Railbelt transmission system. Taking into consideration these known contingencies as well as issues that could arise by adding a parallel North-South interconnection between GVEA and MEA, EPS developed the following set of contingencies to study (Table 13):

Table 13: List of Transient Stability Contingencies Studied

Contingency #	Type	Location	Note
1	3-Phase Line Fault (4 Cycle)	230 kV -- O'Neill to Pump 11	Roadbelt Intertie (South)
2	3-Phase Line Fault (4 Cycle)	230 kV -- Pump 11 to Gakona	Roadbelt Intertie (Middle)
3	3-Phase Line Fault (4 Cycle)	230 kV -- Jarvis to Gakona	Roadbelt Intertie (North)
4	3-Phase Line Fault (4 Cycle)	203/138 kV -- Tok to Pump 11	Roadbelt Intertie (Middle/Radial)
5	3-Phase Line Fault (5 Cycle)	138 kV -- Teeland to Douglas	Alaska Intertie (South)
6	3-Phase Line Fault (5 Cycle)	138 kV -- Goldhill to Ester	Near Alaska Intertie (North)
7	3-Phase Line Fault (4 Cycle)	230 kV -- Teeland to Pt. Mackenzie	Known Problematic Fault Critical Path in CEA/MEA
8	3-Phase Line Fault (4 Cycle)	230 kV -- West Trm. to East Trm.	Known Problematic Fault Undersea Cable -- CEA
9	Unit Trip	Healy CC #2	GVEA Unit
10	Unit Trip	Beluga Unit 5	Large Anchorage Bowl Unit (CEA)
11	Unit Trip	Entire North Pole Combine Cycle Plant	Large GVEA facility near North end of new Intertie

Each contingency listed was simulated in conjunction with each of the applicable cases defined in Appendix B. Cases 1-8 represent Topology 2 with various seasonal load scenarios and intertie flows; and Cases 9-16 represent Topology 1 with the same seasonal loading and intertie flows.

The official Railbelt PSS/E database includes three seasonal load conditions, namely Summer Valley (SV), Summer Peak (SP), and Winter Peak (WP). These represent the maximum and minimum load conditions experienced seasonally in Alaska as well as changes in line and unit ratings based on the temperature extremes.

The Northern intertie flows range from 20 MW up to 125 MW. According to the specifications of the project, the new Roadbelt line is anticipated to increase the maximum northbound transfer from about 60-75 MW of non-firm energy (on the existing Alaska Intertie) to at least 75 MW of firm energy and an additional 50 MW of non-firm energy (shared between the existing Alaska Intertie and the proposed Roadbelt Intertie). Besides increasing total transfer capacity, one primary goal of the new line is to create a firm 75 MW transfer capacity from the Anchorage Bowl region to Fairbanks. This firm capacity is anticipated to provide various economic and operational benefits to all utilities involved, helping to increase efficiencies and pass along savings to rate-payers.

6.5.1 Initial Stability Results

The first transient stability simulations did not involve any RASs or dynamic SVC devices. The initial set of results reflect the natural response of the Railbelt system to the contingencies in Table 13. A table of the results for Topology 1 can be found in Table 14.

Table 14: Topology 1 Transient Stability Results -- No RAS, No SVCs

	Case #	9	10	11	12	13	14	15	16
	Transfer	20 MW	50 MW	70 MW	75 MW -- AK Intertie Open	125 MW	70 MW	75 MW -- AK Intertie Open	125 MW
	Season	SV	SV	SP	SP	SP	WP	WP	WP
#	Contingency								
1	230 kV Line Fault -- O'Neill to Pump 11					Out of Step			Out of Step
2	230 kV Line Fault -- Pump 11 to Gakona					Out of Step			Out of Step
3	230 kV Line Fault -- Gakona to Tok					Out of Step			Out of Step
4	230 kV Line Fault -- Tok to Jarvis					Out of Step			Out of Step
5	138 kV Line Fault -- Teeland to Douglas			Poor Voltage Recovery	Poor Voltage Recovery	Out of Step	Poor Voltage Recovery	Poor Voltage Recovery	Out of Step
6	138 kV Line Fault -- Goldhill to Ester								
7	230 kV Line Fault -- Teeland to Pt. Mackenzie				Poor Voltage Recovery	Poor Voltage Recovery		Poor Voltage Recovery	Poor Voltage Recovery
8	230 kV Line Fault-- West Trm. to East Trm.				Poor Voltage Recovery			Poor Voltage Recovery	
9	Healy CC #2 Trip							Out of Step	
10	Beluga Unit 5 Trip								
11	Entire North Pole Combine Cycle Plant Trip				Out of Step			Out of Step	

As seen in the table, the majority of cases result in a stable system that does not experience any transient stability issues. All contingencies run in the summer valley season do not have a problem. The loss of Beluga Unit 5 does not result in any issues, and faults between Goldhill and Ester do not have any significant issues.

The results do indicate that faults along the new Roadbelt Intertie, faults that trip the Alaska Intertie, and losses of generation in GVEA can cause out-of-step conditions that separate the north from the south and result in severe voltage issues, significant load shedding, and ultimate system collapse.

In addition, due to the lack of dynamic SVC support along the new Roadbelt corridor, some of the contingencies exhibit poor voltage recovery. EPS flagged various simulation results that indicated voltage recovery that was prolonged (> 0.5 seconds), had significant voltage oscillation (poorly damped swings between north and south), and/or had post-fault voltage dips below 0.8 PU. A couple of examples of poor voltage response can be found below in subsection 6.5.2.

A similar table for Topology 2 can be found below (Table 15) depicting the transient stability results without any additional controls, RASs, or SVCs.

Table 15: Topology 2 Transient Stability Results -- No RAS, No SVCs

	Case #	1	2	3	4	5	6	7	8
	Transfer	20 MW	50 MW	70 MW	75 MW -- AK Intertie Open	125 MW	70 MW	75 MW -- AK Intertie Open	125 MW
	Season	SV	SV	SP	SP	SP	WP	WP	WP
#	Contingency								
1	230 kV Line Fault -- O'Neill to Pump 11					Out of Step			Out of Step
2	230 kV Line Fault -- Pump 11 to Gakona					Out of Step			Out of Step
3	230 kV Line Fault -- Jarvis to Gakona					Out of Step			Out of Step
4	230 kV Line Fault -- Tok to Pump 11								
5	138 kV Line Fault -- Teeland to Douglas				Poor Voltage Recovery	Out of Step	Poor Voltage Recovery	Poor Voltage Recovery	Out of Step
6	138 kV Line Fault -- Goldhill to Ester							Poor Voltage Recovery	
7	230 kV Line Fault -- Teeland to Pt. Mackenzie				Poor Voltage Recovery	Poor Voltage Recovery		Poor Voltage Recovery	Poor Voltage Recovery
8	230 kV Line Fault-- West Trm. to East Trm.				Poor Voltage Recovery			Poor Voltage Recovery	
9	Healy CC #2 Trip							Poor Voltage Recovery	
10	Beluga Unit 5 Trip								
11	Entire North Pole Combine Cycle Plant Trip				Poor Voltage Recovery			Out of Step	

6.5.2 Example of Poor Transient Stability Response – Voltage Issues

Besides indicating failed simulations due to out-of-step trips, the results in Tables 14 and 15 also indicate some simulations that had "poor voltage recovery." As explained, EPS identified those contingencies and cases that had voltage profiles with extended recovery times (> 0.5 sec of depressed voltages), those voltage profiles that had extensive oscillation between the north and south, as well as any post-fault voltage dips below 0.8 PU.

Figures 11 through 13 depict some examples of poor voltage responses that were vastly improved by the addition of SVCs as discussed later in Section 6.5.5.

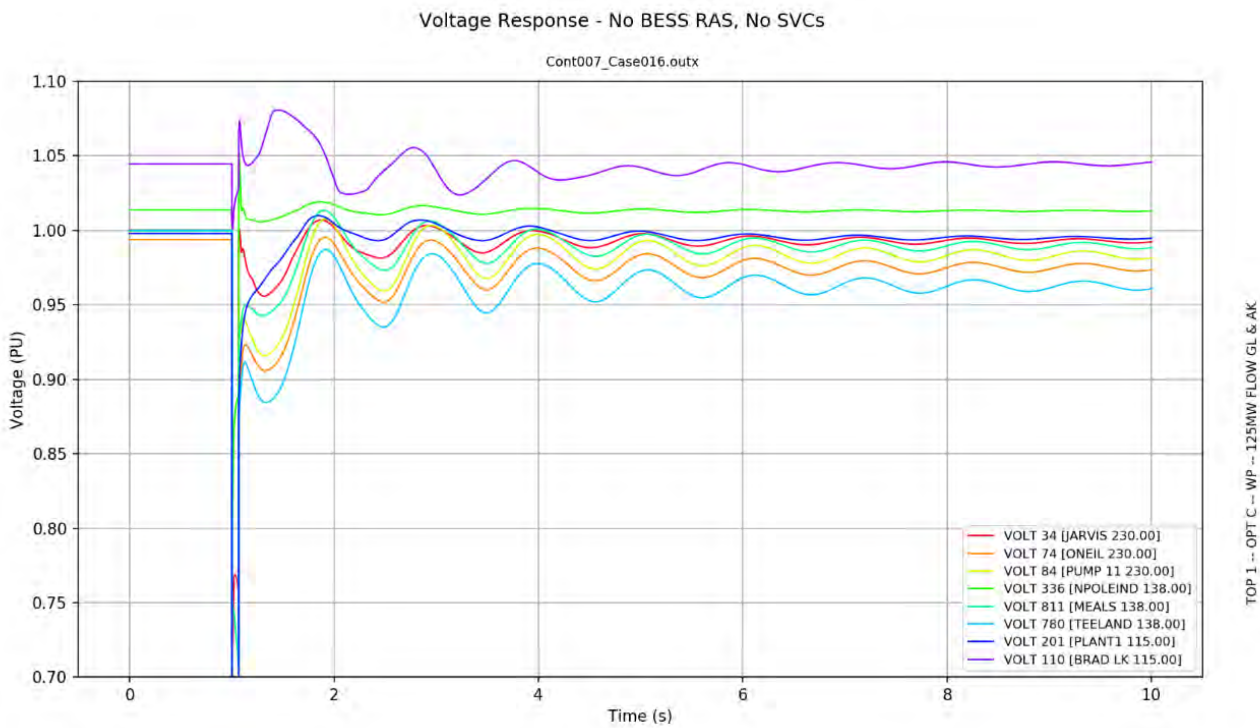

Figure 11: Teeland to Pt. McKenzie Fault - WP 125 MW Transfers - Voltage Oscillations

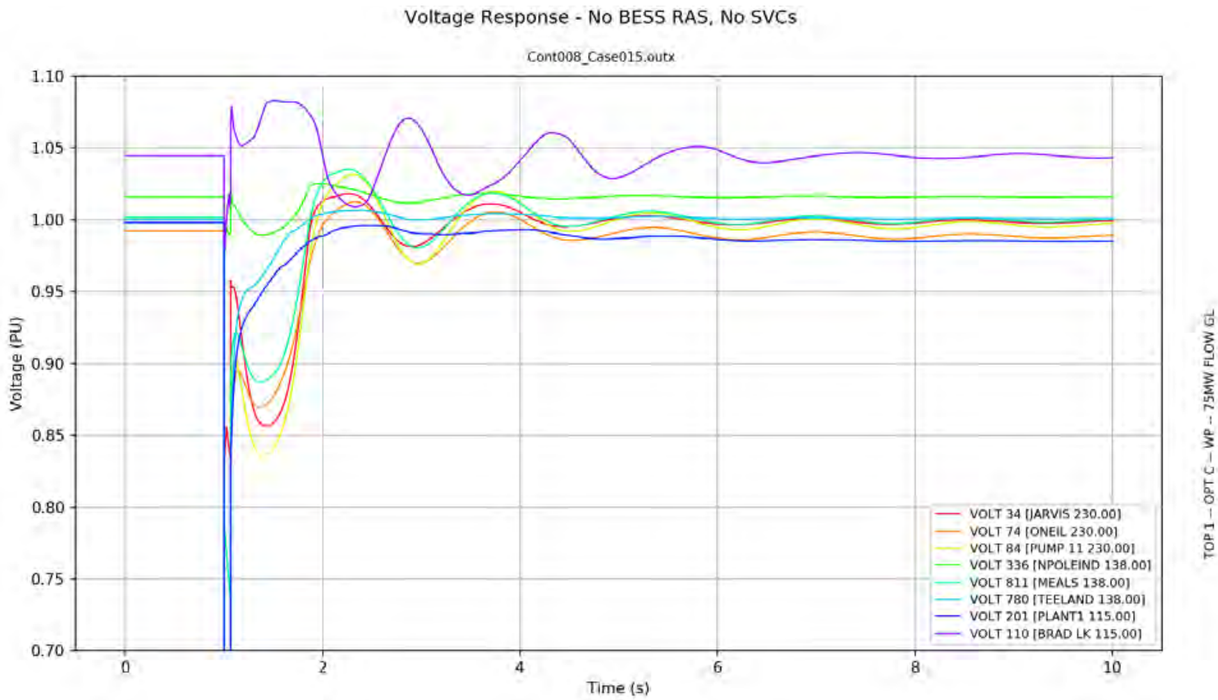

Figure 12: 230 kV Undersea Cable Fault - WP 75 MW Transfer via Roadbelt Intertie 1 second prolonged voltage dip

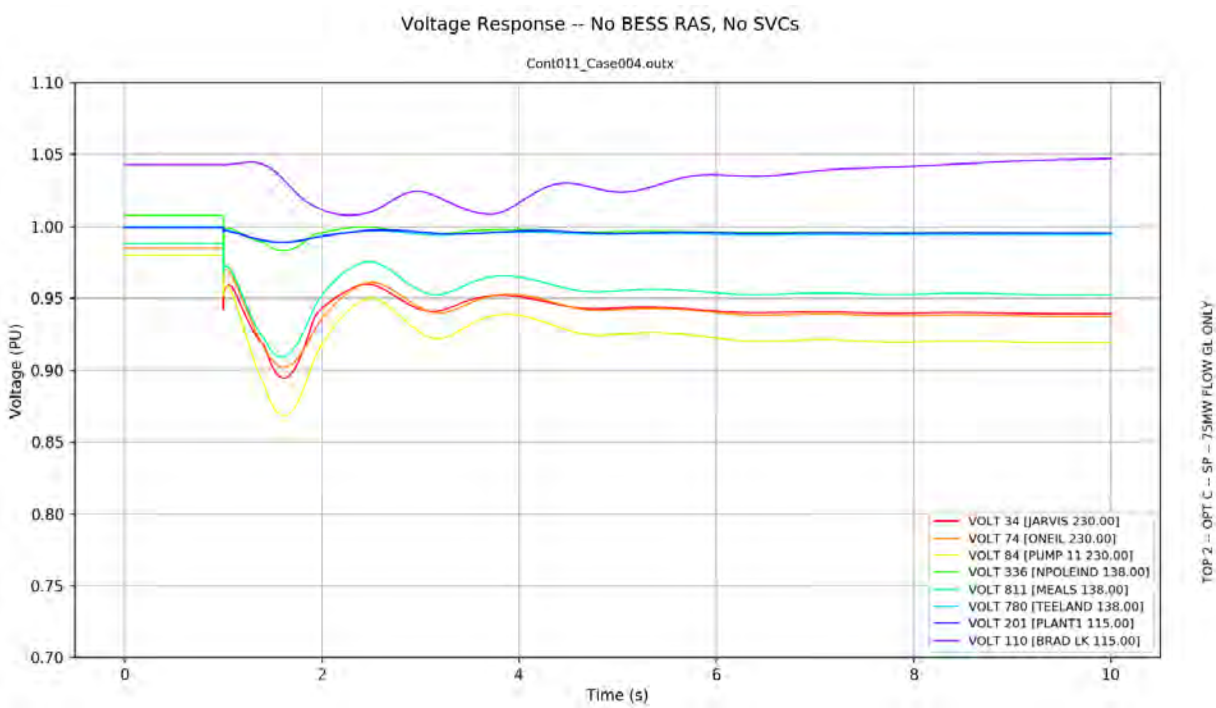

Figure 13: North Pole Plant Trip – Summer Peak 75 MW Transfer on Roadbelt Intertie – Depressed Voltage along Glennallen Corridor.

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6.5.3 Implementation of RASs and SVCs

In order to mitigate the instability or poor response in some of the cases highlighted above, EPS implemented both auto-scheduling of the Wilson Battery Energy Storage System (BESS) in GVEA as a RAS, as well as dynamically tuned SVCs at various points along the Roadbelt Intertie.

Auto-scheduling the Wilson BESS as a RAS is something that the Railbelt already uses during severe faults that cause trips of the Alaska Intertie. This means that additional logic & relay communications would need to be added for faults along the new Roadbelt Intertie, as well as for some larger GVEA unit trips. This is a feasible RAS that mitigates some of the more severe responses seen in Tables 14 and 15.

The substation placement and sizing of the SVCs for voltage support were informed by the original power flow results presented in Section 6.4, as well as iterative transient stability simulations to obtain the best MVAR and voltage response.

6.5.4 Wilson ESS Auto-Scheduling – RAS Implementation

In order to mitigate the out-of-step trips seen in the results above, EPS initiated auto-scheduling of the Wilson BESS to 100% output (40 MW) for all of the contingencies that indicated out-of-step or severe voltage dip issues in both Topology 1 and 2. The most severe contingencies were those that went out-of-step, the worst being Contingency 5 (fault and trip Teeland to Douglas - Alaska Intertie Trip) in the Winter Peak 125 MW transfer cases (Cases 8 and 16).

The BESS was auto-scheduled to ramp to 100% output 3 cycles after the fault was detected by the relay (in this case, 2 cycles before the 5-cycle fault is cleared). With the BESS set to full output, Topology 1 still results in an out-of-step condition, meaning additional controls or RASs are needed. However, Topology 2 does result in a stable condition, and is depicted in Figures 14 and 15 below. Note the vast improvement over the out-of-step trip that occurs with no RAS in place.

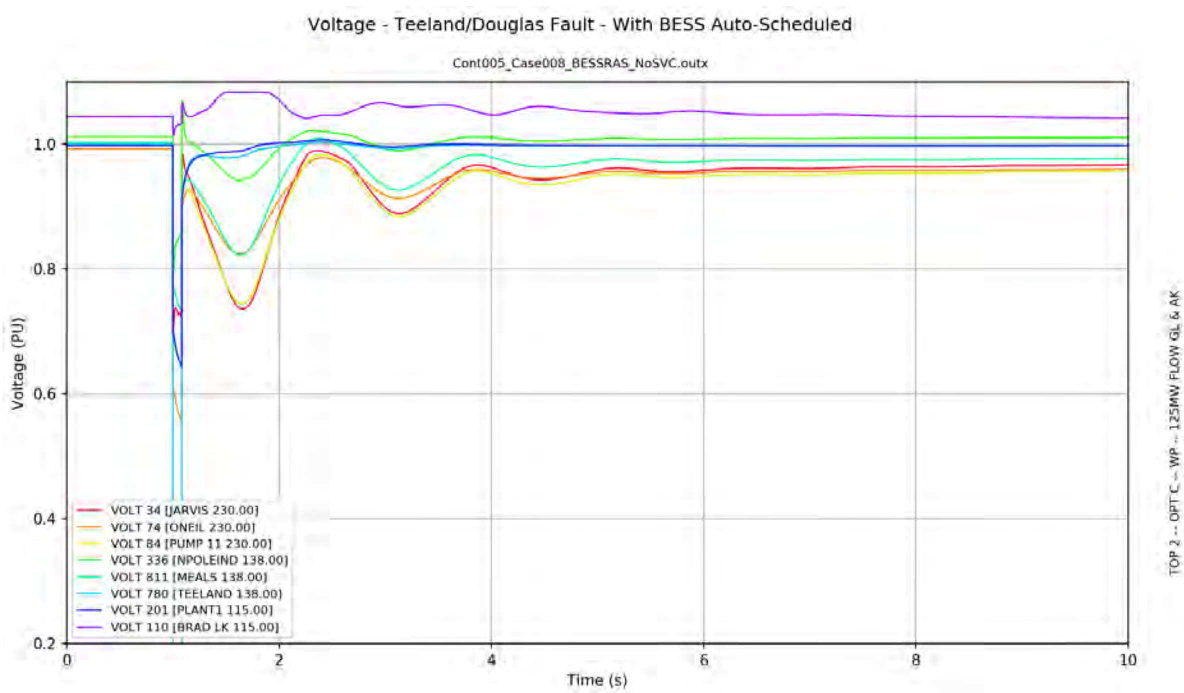

Figure 14: Topology 2 Voltage Response during AK Fault and Trip – BESS RAS Only

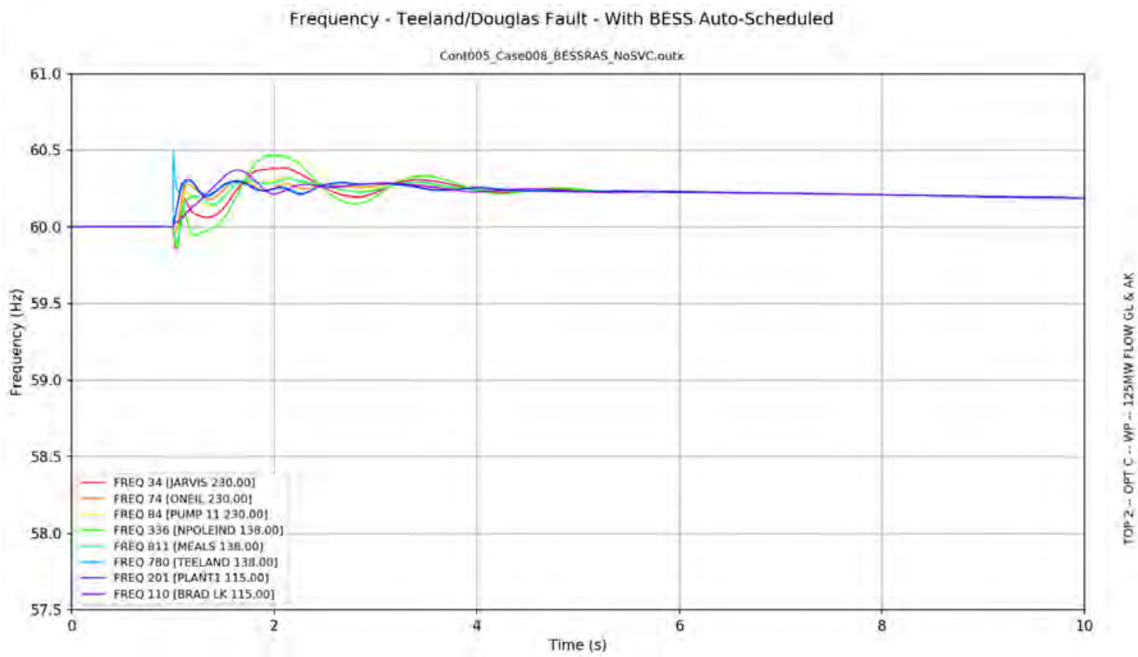

Figure 15: Topology 2 Frequency Response during AK Fault and Trip -- BESS RAS Only

Although the simulation results above indicate that Topology 2 is stable, the voltage profile in Figure 14 does not meet the desired post-fault recovery voltage. Coupled with the fact that Topology 1 still experiences out-of-step conditions in this scenario, this low post-fault voltage dip indicates that the Roadbelt Intertie needs further voltage support between Sutton and Delta Junction – namely SVCs need to be placed strategically along the new path.

6.5.5 Adding SVCs along the Roadbelt Intertie

While studying the various transient stability simulation responses, it became evident that Topology 1 is generally less stable and more prone to collapse without additional fast reactive support provided by SVCs, and Topology 2 in some cases (one of which is highlighted in Section 6.5.2 above) still experiences severely depressed post-fault voltage profiles.

Therefore, additional SVC support is needed at one or more points along the new transmission line path between Sutton and Delta Junction. A set of suitable configurations were determined for each of the two topologies:

Topology 1:

- New Pump 11 SVC: -20 MVAR to +40 MVAR
- New Tok SVC: -20 MVAR to +30 MVAR
- Existing Jarvis SVC: -8 MVAR to +45 MVAR
    - With a -18 MVAR Fixed Reactor

Topology 2:

- New Pump 11 SVC: -20 MVAR to +30 MVAR
- Existing Jarvis SVC: -8 MVAR to +45 MVAR
    - With a -18 MVAR Fixed Reactor

The voltage and frequency response for both topologies are depicted below for the worst performing contingency: Contingency 5, Cases 8 and 16 (Alaska Intertie Fault and Trip, during Winter Peak 125 MW Transfer conditions). These results show that this contingency and loading scenario are survivable and within acceptable frequency and voltage tolerances as long as the Wilson BESS RAS and SVC voltage support are in place as described above.

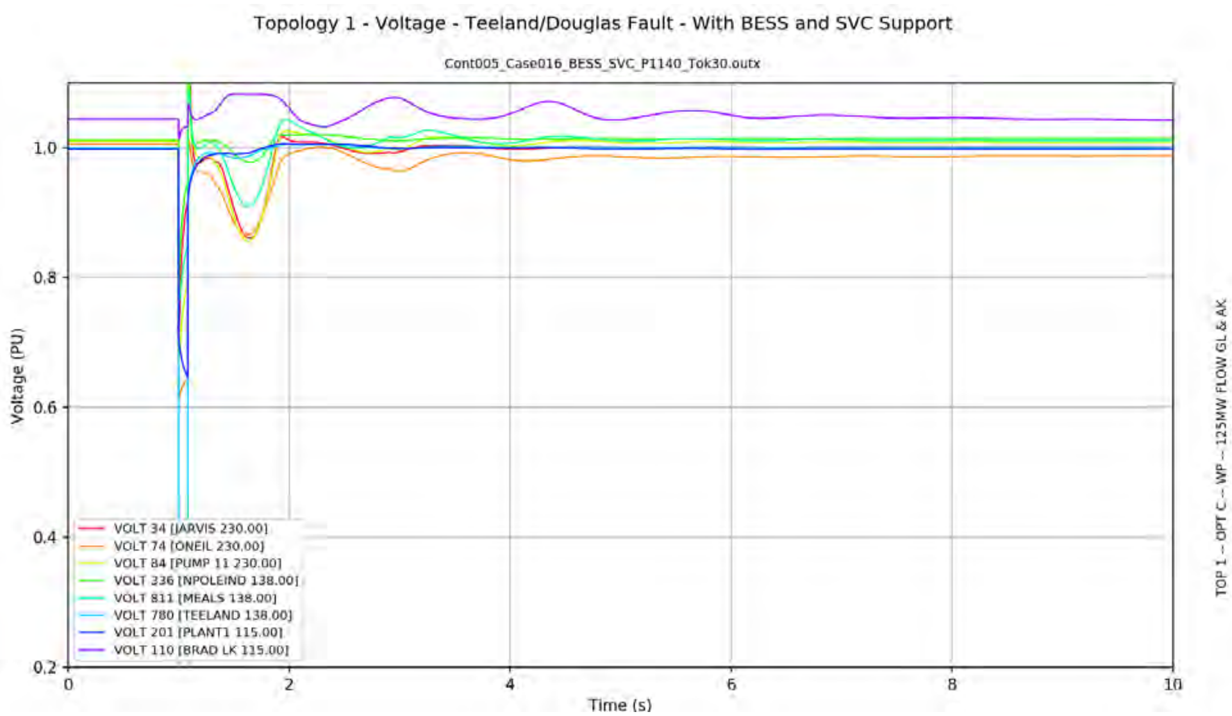

Figure 16: Topology 1 Voltage Response -- AK Intertie Fault -- with BESS RAS and SVCs

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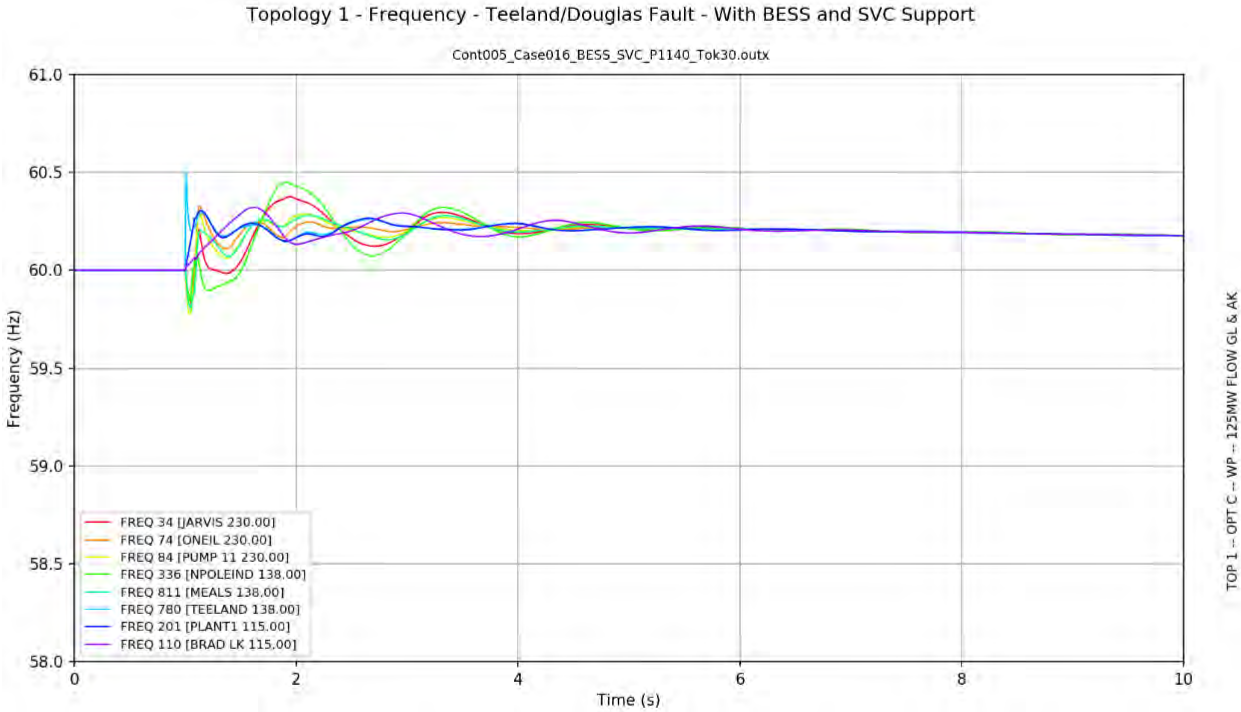


Figure 17: Topology 1 Freq. Response -- AK Intertie Fault -- with BESS RAS and SVCs

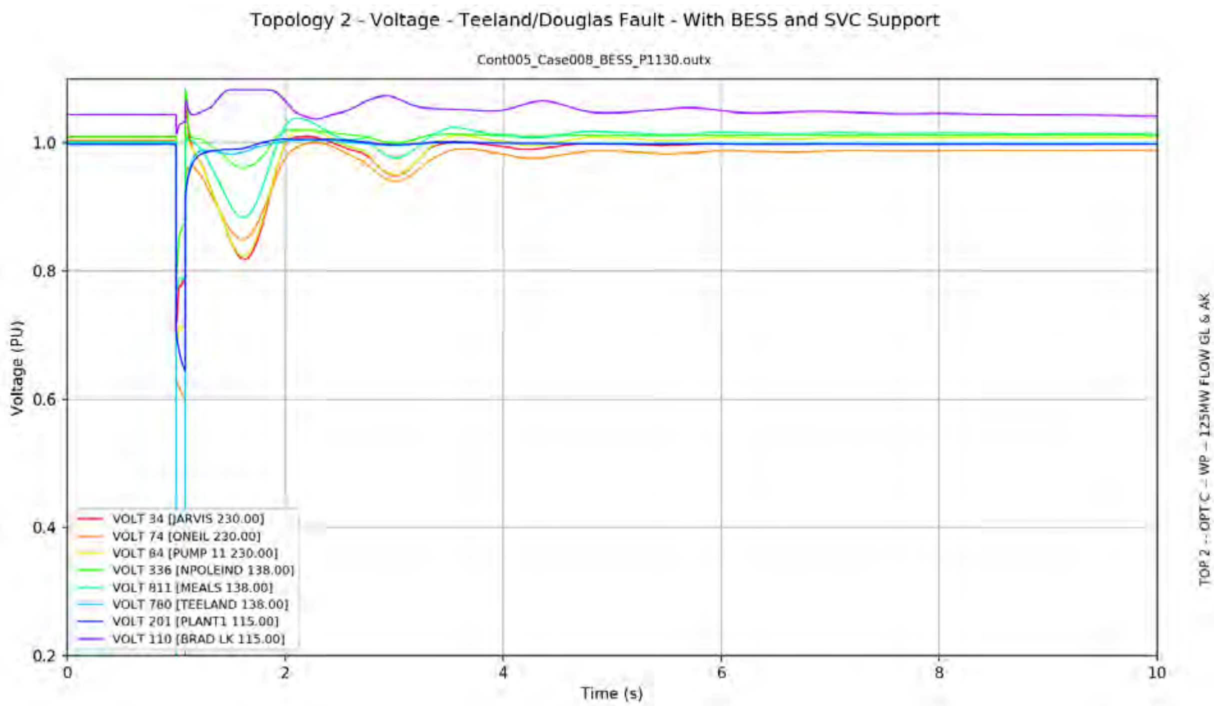


Figure 18: Topology 2 Voltage Response -- AK Intertie Fault -- with BESS RAS and SVCs

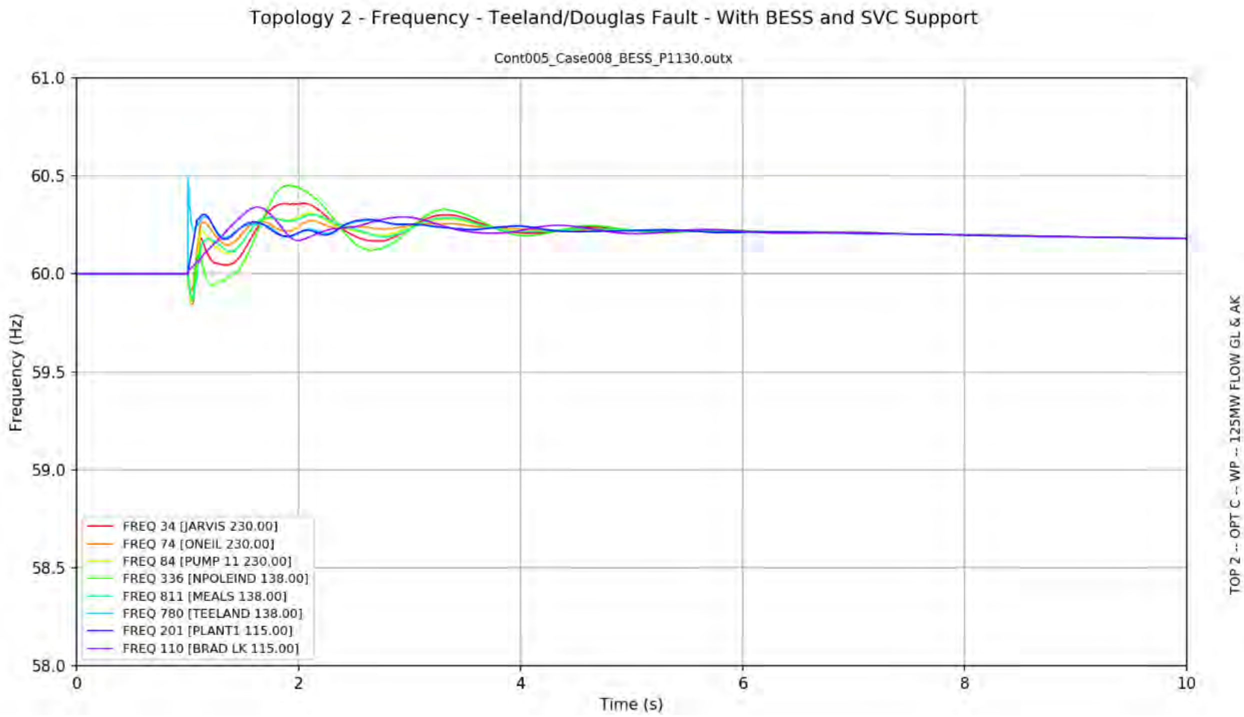


Figure 19: Topology 2 Freq. Response -- AK Intertie Fault -- with BESS RAS and SVCs

With the SVCs in place, all of the simulations that had poor voltage performance or out-of-step contingencies highlighted in Tables 14 and 15 above were resolved (Figures 16-19). With a combination of BESS support following certain contingencies, and dynamically tuned SVCs placed along the new Roadbelt corridor, both Topology 1 and Topology 2 are feasible alternatives for achieving a second intertie between the Anchorage Bowl and Fairbanks.

6.6 System Study Conclusions

The Roadbelt Intertie feasibility study involved significant modifications to the existing Railbelt database, power flow simulations, and transient stability simulations.

Power flows were evaluated for various transmission line designs, energization, interconnecting new areas/utilities to the Railbelt, and steady-state voltage control along the new transmission path.

Transient stability simulations were conducted to evaluate the performance of the Railbelt and new Roadbelt Intertie during different contingency situations and under various seasonal loading scenarios. The contingencies included new faults and trips that are a result of creating a second parallel transmission path between Anchorage and Fairbanks, as well as well-known contingencies in the Railbelt that can cause instability.

The recommendations of this interconnection study are summarized below:

1. Both Topology 1 and Topology 2 are feasible – though increases in SVC size and placement are required for Topology 1 due to the higher overall line length and impedance between Anchorage

and Fairbanks. Topology 2 also has a radial component from Pump 11 to Tok that can be built at 138 kV which should decrease the cost of this option over Topology 1.

2. 230 kV construction with single conductor 795 ACSR Drake or 954 Rail is the recommended transmission line design – this option best balances ampacity / MVA rating, overall impedance between Anchorage and Fairbanks, losses, and amount of reactive support needed. The 795 alternative was used for the final studies and cost estimates, however the final conductor selection should be made during project design.

3. EPS evaluated a new parallel 115 kV transmission line between the interconnection point at O'Neill and the existing connection at O'Neill tap. Through power flow and transient stability simulations, it appears that this additional line is not needed. However, in order to decrease the likelihood of MEA faults interrupting the Roadbelt Intertie, EPS recommends upgrading the O'Neill tap to be a full substation by adding breakers and protection equipment. Doing so will provide additional reliability and robustness to the new Roadbelt Intertie.

4. Due to the length of the line segments and the charging introduced by the proposed line design, line reactors are needed along the new Roadbelt transmission path. EPS proposes that 75% line compensation is sufficient. The line reactor sizes used int h studies and cost estimates are listed below:

Table 16: Recommended Line Reactor Sizing

	Line Segment	Reactor Size at each Terminal (MVAR)	Total Reactive Line Compensation (MVAR)
Topology 1 -- 230 kV 795 Single Cond.	O'Neill to Pump 11	13.8	27.6
	Gakona to Tok	12.8	25.6
	Tok to Jarvis	11.7	23.5
	TOTAL		76.7
Topology 2 -- 230 kV 795 Single Cond.	O'Neill to Pump 11	13.8	27.6
	Gakona to Jarvis	14.5	29
	Pump 11 to Tok (Radial Line)	5	10
	TOTAL		66.6

5. The energization cases for the Roadbelt Intertie revealed that approximately -20 MVARs of variable reactor support is needed at Pump 11 and Jarvis in order to match voltage on either side of the open breaker prior to closing. In addition, a significant angle difference across this open breaker (which may prevent a syncho-check relay from allowing a close action) is present if flows from South to North are greater than 50 MW. One solution is to require minimal flows from South to North when closing either the Alaska or Roadbelt Intertie, or to use phase shifting transformers to close the angle difference between Anchorage and Fairbanks prior to energizing one of the interties.

6. The transient stability results indicated that more variable reactive capacity is needed at Pump 11 and Tok for Topology 1, and only at Pump 11 in Topology 2. The recommended SVC ranges accounting for energization and stability following contingencies are highlighted below:

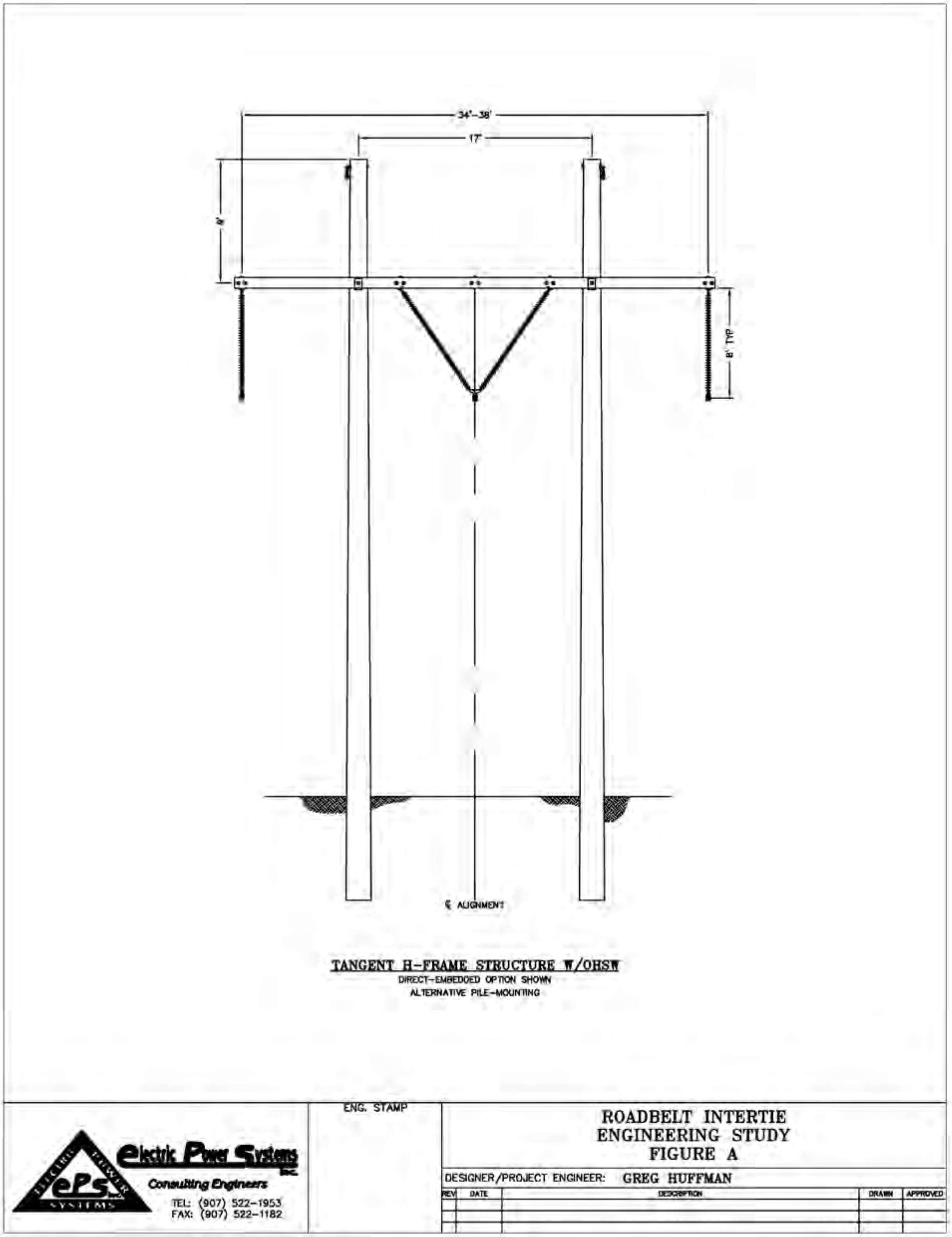
- Topology 1:
    - New Pump 11 SVC: -20 MVAR to +40 MVAR
    - New Tok SVC: -20 MVAR to +30 MVAR

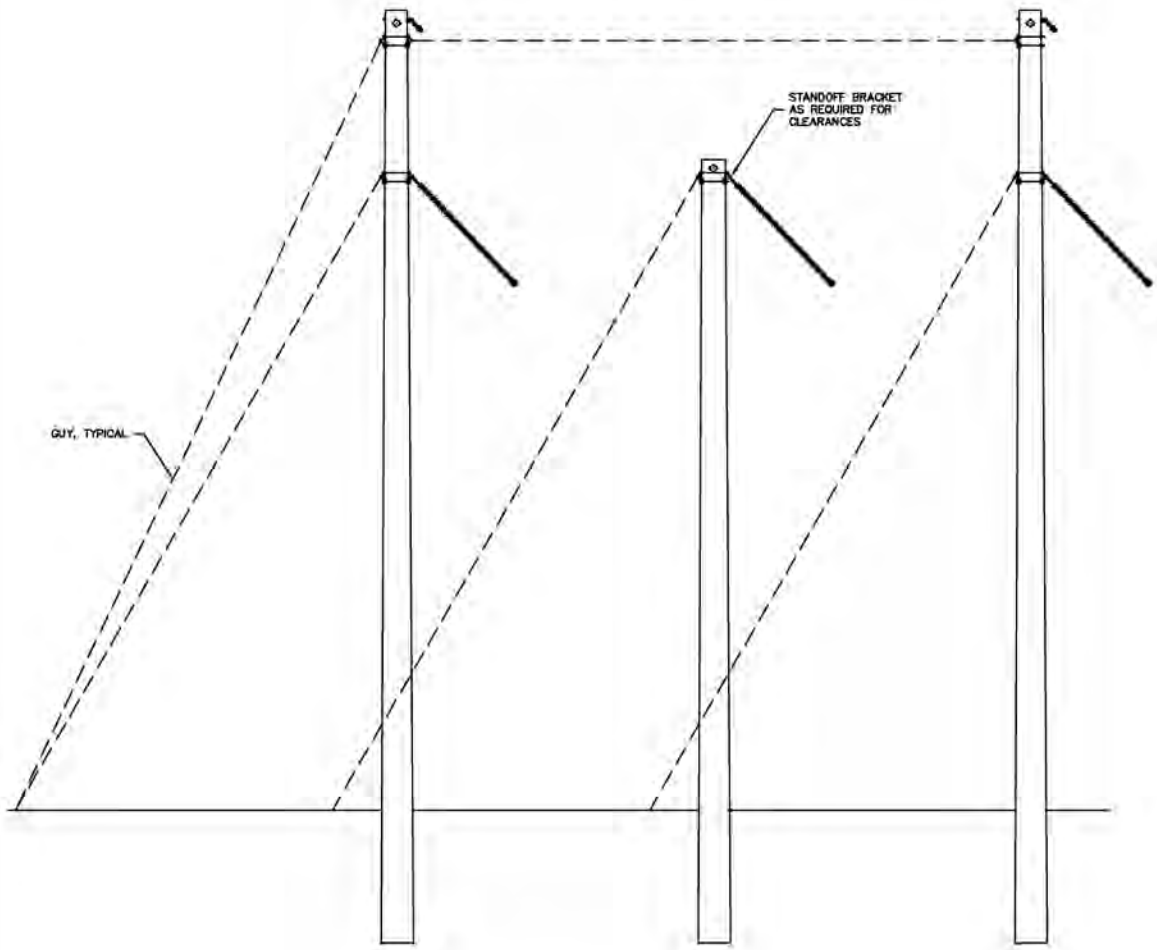
  - Existing Jarvis SVC: -8 MVAR to +45 MVAR
    - With a -18 MVAR Fixed Reactor
- Topology 2:
  - New Pump 11 SVC: -20 MVAR to +30 MVAR
  - Existing Jarvis SVC: -8 MVAR to +45 MVAR
    - With a -18 MVAR Fixed Reactor

7. In addition to dynamically tuned SVCs placed along the Roadbelt Intertie, the GVEA Wilson BESS must be auto-scheduled following any fault that interrupts the high-flow and high-load cases or for a significant loss of generation in the GVEA area. Winter Peak and Summer Peak flows of 125 MW indicated that severe out-of-step trips can occur in both Topology 1 and Topology 2 without additional support via a RAS that auto-schedules the BESS to full output. SVCs alone will not prevent this out-of-step trip from occurring, nor will the BESS RAS alone provide for adequate voltage support. Both solutions are needed. Both Topologies are feasible, however it is apparent that Topology 2 requires less overall reactive support and has less contingencies that require full BESS output to maintain stability.

8. The addition of a new Roadbelt Intertie will also require that the tuning of the Jarvis SVC be revisited. The new intertie significantly changes the electrical characteristics of the system around Jarvis, necessitating a re-tuning of the Jarvis SVC.

Appendix A – Structure Design Figures





RUNNING ANGLE 3-POLE STRUCTURE W/OHSW
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ENG. STAMP

ROADBELT INTERTIE
ENGINEERING STUDY
FIGURE B

DESIGNER/PROJECT ENGINEER: GREG HUFFMAN

REV	DATE	DESCRIPTION	DRAWN	APPROVED

Appendix B – Cases, Unit Commitment, and Dispatch

Case #	Case 1 & 9	Case 2 & 10	Case 3 & 11	Case 4 & 12	Case 5 & 13	Case 6 & 14	Case 7 & 15	Case 8 & 16
Season	SV	SV	SP	SP	SP	WP	WP	WP
Total Northbound Intertie Flow	20 MW	50 MW	70 MW	75 MW -- Glenallen Intertie Only	125 MW	70 MW	75 MW -- Glenallen Intertie Only	125 MW
WILSON BESS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLDOTNA 1			25.7	25.7	25.7	28.7	28.7	28.7
BRADLY 1	32.2	32.2	24.3	24.3	22.0	32.4	32.4	32.4
BRADLY 2	18.0	18.0	13.4	13.4	17.0	36.6	36.6	36.6
TESORO 1	1.5	1.5	4.0	4.0	4.0	5.0	5.0	5.0
TESORO 2	1.4	1.4	4.0	4.0	4.0	5.0	5.0	5.0
NIKISKI 1	34.5	34.5	32.2	32.2	32.2	37.6	37.6	37.6
NIKISKI 2	14.4	14.4	20.8	20.8	20.8	15.6	15.6	15.6
PLANT 1 UNIT 3			28.0	28.0	28.0	32.0	32.0	32.0
PLANT 1 UNIT 4			28.0	28.0	28.0			
PLANT 2 UNIT 9	26.5	37.0	44.0	44.0	44.0	49.0	49.0	49.0
PLANT 2 UNIT 10	26.5	37.0	45.0	45.0	45.0	49.0	49.0	49.0
PLANT 2 UNIT 11	10.0	20.0	24.7	24.7	24.7	27.4	27.4	27.4
BELUGA 3					51.5			58.0
BELUGA 5			50.0	50.0	55.0	69.0	69.0	69.0
SPP 11			37.0	37.0	37.0	50.0	50.0	50.0
SPP 12	37.5	37.5	37.0	37.0	37.0	50.0	50.0	50.0
SPP 13	37.6	37.1	37.0	37.0	37.0	50.0	50.0	50.0
SPP 10	19.0	19.0	28.5	28.5	28.5	38.6	38.6	38.6
COOPER 1	10.2	10.2				5.0	5.0	5.0
EKLUTNA HYDRO 1			11.7	12.1	11.6	7.3	12.7	7.3
EKLUTNA HYDRO 2			11.9	11.9	11.9	19.0	19.0	19.0
HCCP#2-G						48.3	48.3	54.0
HLP#1-G	25.2	25.2	25.2	24.5	21.0	20.0	20.0	22.5
EVA WIND	7.9	7.9	6.0	6.0	6.0			
ZENDER 1	8.7							
ZENDER 2	8.7		6.0	5.0				
CHENA 5	23.0	23.0	23.0	23.0	22.4	23.0	23.0	23.0
NORTH POLE CC 3	33.0	23.0	33.0	33.0		48.0	48.0	
NORTH POLE CC 4	7.0	5.1	7.0	7.0		10.6	10.6	
UAF 1	0.5	0.5						
UAF 2	0.5	0.5						
UAF 3	3.0	3.0	7.5	7.5	7.2	6.5	4.0	6.5
FORT WAINWRIGHT 1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
FORT WAINWRIGHT 3			5.0	5.0	5.0	4.0	4.0	4.0
FORT WAINWRIGHT 4			5.0	5.0	5.0	5.0	5.0	5.0
EIELSON 3	5.0	5.0	5.0	5.0	5.0	4.0	4.0	4.0
EIELSON 4			5.0	5.0	5.0	4.0	4.0	4.0
EGS 1	13.7	13.7	14.0	15.0	14.0	14.3	14.3	14.3
EGS 2			14.0	15.0	14.0	14.3	14.3	14.3
EGS 3						14.3	14.3	14.3
EGS 4						14.3	14.3	14.3
EGS 5	13.7	13.7	14.0	15.0	14.0	14.3	14.3	14.3
EGS 6			13.9	14.7	13.9	14.3	14.3	14.3
EGS 7						14.3	14.3	14.3
EGS 9	13.7	13.7	14.0	15.0	14.0	14.3	14.3	14.3
EGS 10			13.9	14.7	13.9	14.3	14.3	14.3
SOLOMON GULCH 1	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
SOLOMON GULCH 2	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
VALDEZ 11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
VALDEZ 12	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
VALDEZ 4	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
VALDEZ 5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
GLENALLEN 6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
GLENALLEN 7	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
ALLISON	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1

SP = Summer Peak, SV = Summer Valley, WP = Winter Peak

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APPENDIX B

Public Awareness Flyer

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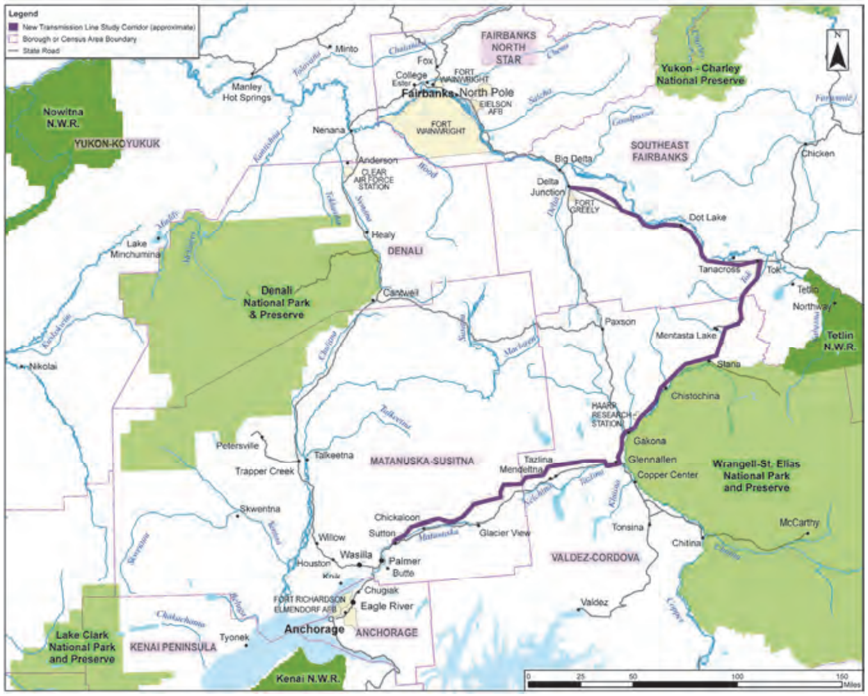
Roadbelt Intertie Project

Is an electric transmission system from Anchorage to Glennallen to Tok to Fairbanks possible?

The Denali Commission is analyzing the technical feasibility of an Eastern “roadbelt” electric transmission line. Results of the analysis will be summarized in a report.

Project Goals

- Reduce power costs for rural communities along the proposed route
- Support regional economic development opportunities
- Increase Department of Defense facility resilience
- Provide critical redundancy throughout the road system, increasing reliability and reducing long term costs



Questions? More information? Feedback?

- Check out our website: https://www.denali.gov/Roadbelt/Intertie/Information
- Contact Denali Commission Project Staff:
  Roadbeltquestions@denali.gov
  907-271-1414 (phone); 907-271-1415 (fax)

Project Timeline

**Future phases will be determined by other parties and are not steps in the Roadbelt Intertie reconnaissance report.*

NOV 2019 - MAY 2020
Technical Feasibility and Cost Estimation

SUMMER 2020
Public Awareness and Publish Report

FUTURE PHASES*
Funding Opportunities, Route Selection, NEPA Evaluation, Public Meetings

DENALI COMMISSION ALASKA

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