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ALASKA LNG

Wetlands Compensatory Mitigation Plan

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Alaska LNG
3201 C Street, Suite 2019
Anchorage, Alaska 99503
T: 907-330-6300
www.alaska-lng.com

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*This signature approves the most recent version of this document.

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1	All	Updated per USACE Comments and Nov 2019 Meeting

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

ACRONYMS AND ABBREVIATIONS

ACP .... Arctic Coastal Plain
ADEC.............................. Alaska Department of Environmental Conservation
ADF&G........................... Alaska Department of Fish and Game
ADNR .... Alaska Department of Natural Resources
Applicant .... Alaska Gasline Development Corporation
ASAP .... Alaska Stand Alone Pipeline
ASRC .... Arctic Slope Regional Corporation
ATV .... all-terrain vehicle
CEQ................................ Council on Environmental Quality
CFR .... Code of Federal Regulations
CMP .... Compensatory Mitigation Plan
DEIS .... Draft Environmental Impact Statement
EPA .... Environmental Protection Agency
FCI .... Functional Capacity Index
GMT1............................. Greater Mooses Tooth 1
HDD .... horizontal directional drilling
HGM .... hydrogeomorphic
HUC .... Hydrologic Unit Code
ILF .... in-lieu fee
LEDPA .... Least Environmentally Damaging Practicable Alternative
MOA .... Memorandum of Agreement
MP .... milepost
NLCD.............................. National Land Cover Database
PJD................................. Preliminary Jurisdictional Determination
PRM .... permittee-responsible mitigation
RSA .... Reimbursable Service Agreement
SEIS .... Supplemental Environmental Impact Statement
UIC................................. Ukpeagvik Inupiat Corporation
U.S. .... United States
USACE............................ United States Army Corps of Engineers
VSW .... Village Safe Water
WAA .... Wetland Assessment Area
WOUS............................ Waters of the United States

1. INTRODUCTION

Compensatory mitigation is a critical tool in helping the federal government meet legal requirements for activities associated with work in navigable waters and wetlands (33 Code of Federal Regulations [CFR] Parts 325 and 322; 40 CFR Part 230). Compensatory mitigation is considered only after all appropriate and practicable steps have been taken to first avoid and then minimize adverse impacts to the aquatic ecosystem, pursuant to 40 CFR Part 230 (i.e., Clean Water Act Section 404(b)(1) Guidelines). Compensatory mitigation can be carried out through four methods: 1) restoration of an existing wetland or aquatic site, 2) enhancement of an aquatic site's function, 3) establishment of a new aquatic site, or 4) preservation of an aquatic site (33 CFR Parts 325 and 332; 40 CFR Part 230).

The 2008 Mitigation Rule, developed by the United States (U.S.) Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA), addresses compensatory mitigation for unavoidable losses of aquatic resources and functions at a project site (33 CFR Parts 325 and 332; 40 CFR Part 230). The rule establishes standards, sets timeframes for decision-making, and establishes equivalent requirements and standards for three types of compensatory mitigation: mitigation banks, in-lieu fee (ILF) programs, and permittee-responsible mitigation (PRM) projects.

On June 15, 2018, the USACE and EPA signed a Memorandum of Agreement (MOA) concerning mitigation for wetland impacts in Alaska under Section 404 of the Clean Water Act (USACE and EPA 2018). The 2018 MOA recognized flexibilities that exist in the mitigation requirements for Clean Water Act Section 404 permits, and described how those flexibilities can be applied in Alaska given the abundance of wetlands and unique circumstances involved with Section 404 permitting in the state. The 2018 MOA also clarified how existing national policies regarding practicability determinations and regulatory flexibility can be implemented in Alaska while ensuring sound environmental stewardship of the state's ecologically important wetland resources.

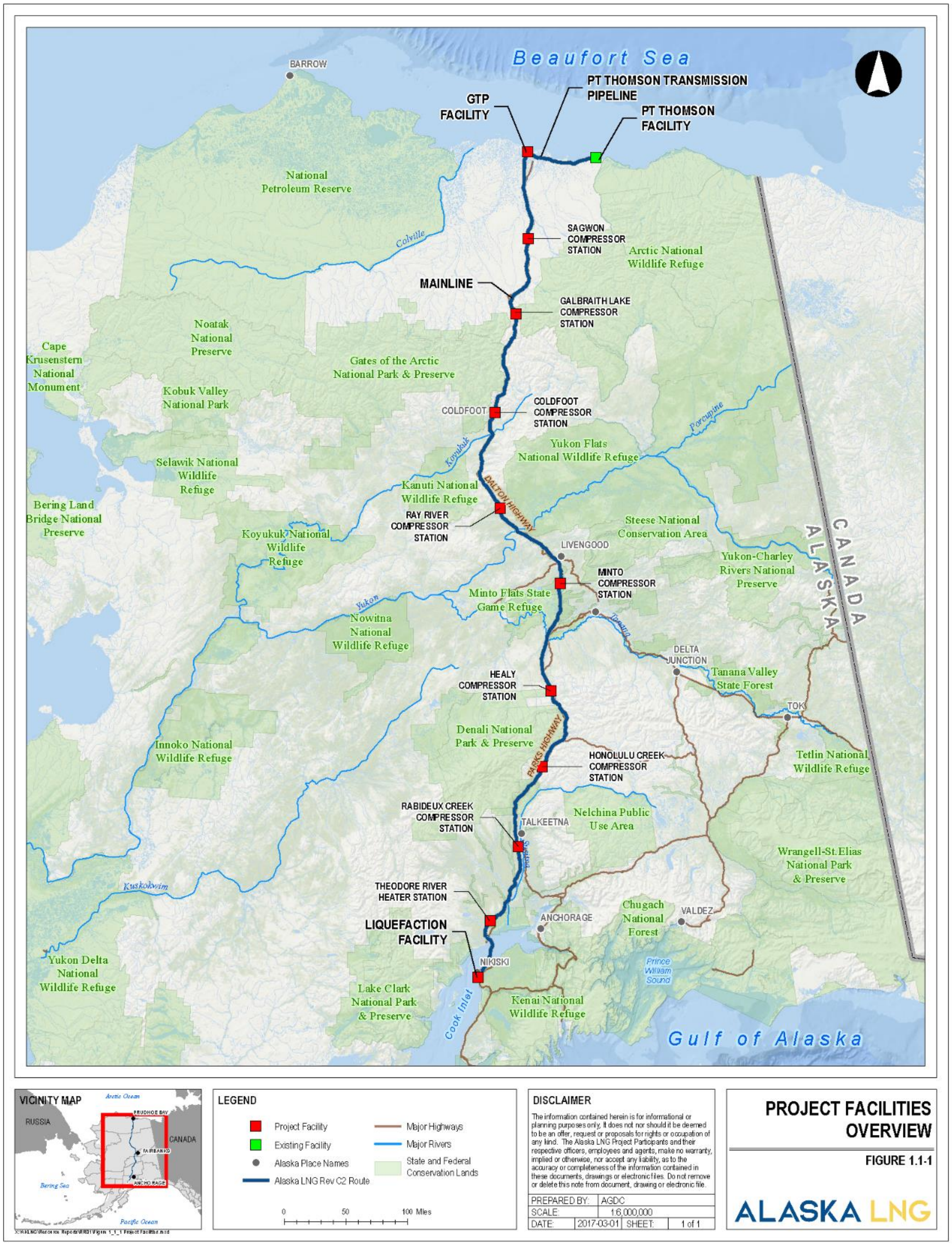
1.1. Purpose

This Wetlands Compensatory Mitigation Plan (CMP) describes the procedures by which the Alaska Gasline Development Corporation (The Applicant) will compensate for the unavoidable losses of Waters of the U.S. (WOUS), including jurisdictional wetlands, within the project area impacted by the Alaska LNG Project.

1.2. Project Description

The Alaska LNG Project will sell Alaska's North Slope gas to customers overseas and will also provide gas to in-state markets. The mostly buried 807-mile, 42-inch pipeline will transport natural gas from Prudhoe Bay to Nikiski, Alaska, where it will be liquefied and exported to overseas markets (Figure 1). The Project will cross three of Alaska's primary ecoregions: Northern, Interior, and Southcentral.

Figure 1. Alaska LNG Pipeline Route



The Alaska LNG pipeline alignment will avoid and minimize impacts to wetlands, where practicable. If impacts cannot be avoided or minimized, then any required compensatory mitigation for impacted wetlands will follow Subpart J of 40 CFR Part 230 Section 404(b)(1) 'Guidelines for Specification of Disposal Sites for Dredged or Fill Material' and 33 CFR 332 "Compensatory Mitigation for losses of Aquatic Resources". The Applicant designed the Alaska LNG Project with a commitment to take appropriate and practicable steps to avoid and minimize impacts to aquatic sites where practicable, prior to the consideration of compensatory mitigation options.

The Applicant will adhere to several traditional wetland protection measures, which include:

- Scheduling pipeline construction across wetlands during the winter to the maximum extent practicable
- Avoiding and minimizing ground-disturbing activity in wetland habitats
- Maintaining existing hydrologic systems
- Re-establishing vegetation that is typical of the general area
- Minimizing the number of stream crossings
- Using existing bridges or trenchless technology
- Providing secondary containment for fuel and lubricant stations in wetland areas with sufficient capacity to prevent release outside the station area
- Implementing procedures to minimize fuel and lubricant spills during construction
- Implementing procedures to limit spread of non-native invasive plants
- Minimizing temporary impact areas disturbed during construction activities where reasonably possible
- Favoring upland sites for permanent facilities where practicable
- Implementing dust abatement measures during construction to minimize dust deposition in wetlands
- Implementing a stormwater pollution prevention plan and an erosion and sediment control plan to prevent sediment deposition into adjacent wetlands

1.3. Regulatory Guidance for Avoidance, Minimization, and Compensatory Mitigation of Wetlands Impacts

Regulatory requirements for discharges of dredge and fill materials into WOUS are detailed in 40 CFR Part 230. The feasibility and appropriateness of compensatory mitigation for a particular aquatic resource type is to be addressed through the permitting process by district engineers (33 CFR Parts 325 and 332; 40 CFR Part 230). The Council on Environmental Quality (CEQ) has defined mitigation to include: avoiding impacts, minimizing impacts, rectifying impacts, reducing impacts over time, and compensating for impacts (40 CFR 1508.20). The types of mitigation enumerated by the CEQ are compatible with the requirements of the 404(b)(1) Guidelines. As a practical matter, they are combined by EPA to form three general types: avoidance, minimization, and compensatory mitigation.

1. Avoidance

   Section 40 CFR Part 230.10(a) requires that no discharge be permitted if there is a practicable alternative to the proposed discharge that will have less adverse impact to the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences. In addition, Section 230.10(a)(3) sets forth rebuttable presumptions that 1) alternatives for non-water dependent activities[1] that do not involve special aquatic sites are available, and 2) alternatives that do not involve special aquatic sites have a less adverse impact on the aquatic environment. Compensatory mitigation may not be used as a method to reduce environmental impacts in the evaluation of the Least Environmentally Damaging Practicable Alternatives (LEDPAs) as it pertains to the requirements of Section 230.10(a).

2. Minimization

   40 CFR Part 230.10(d) states that appropriate and practicable steps to minimize adverse impacts will be required through project modifications and permit conditions. Subpart H of the regulations (40 CFR 230.70-230.77) describes potential actions to minimize adverse effects of an activity.

3. Compensatory Mitigation

   Subpart J of the regulations (40 CFR Parts 230.91 – 230.98) defines standards and criteria for compensatory mitigation to offset unavoidable impacts to WOUS. Using permitting authority in conjunction with the regulations in Subpart J, compensation options for on-site and off-site permittee-responsible mitigation, mitigation banks, and ILF mitigation can be evaluated as options when impacts to WOUS are unavoidable. Appropriate and practicable compensatory mitigation may be required for unavoidable adverse impacts that remain after 'all appropriate and practicable' (40 CFR 230.91) minimization measures are instituted.

The June 18, 2018 MOA (USACE and EPA 2018) set out guidance for evaluating mitigation for wetland impacts in Alaska associated with discharge of dredged or fill materials by recognizing:

a. Avoiding wetlands may not be practicable where there is a high proportion of land in a watershed or region which is jurisdictional wetlands;

b. Restoring, enhancing, or establishing wetlands for compensatory mitigation may not be practicable due to limited availability of sites and/or technical or logistical limitations;

c. Compensatory mitigation options over a larger watershed scale may be appropriate given that compensation options are frequently limited at a smaller watershed scale;

d. Where a large proportion of land is under public ownership, compensatory mitigation opportunities may be available on public land;

[1] Non-water dependent implies that to meet its purpose and need, the project does not need to be situated in a special aquatic site.

e. Out-of-kind compensatory mitigation may be appropriate when it better serves the aquatic resource needs of the watershed; and

f. Applying a less rigorous permit review for small projects with minor environmental impacts is consistent with the Section 404 program regulations.

The Applicant has taken the regulations and the new MOA into account in developing the Alaska LNG Project Wetlands Mitigation Plan by focusing first on avoidance, then on minimization, and then on compensatory mitigation for project components.

1.4. Applicant-proposed Avoidance Measures

1.4.1. Ice Roads and Access Roads

Ice roads will be used in the Northern Ecoregion to avoid impacts associated with disturbing or filling wetlands. Approximately 51.25 miles of ice roads are planned project wide to avoid wetlands impacts, including 18.28 miles of ice roads for the PTTL, all in the Northern Ecoregion, and 32.97 miles of ice roads for the Rev C2 mainline, of which 32.71 miles are in the Northern Ecoregion. Access roads have been designed to avoid WOUS, where possible. The access roads have been located based on several factors, including slopes, existing roads, and delineated wetlands.

The access road grades to the material sites and pipeline cannot exceed 6 percent for any sustained period. After accounting for grade, the roadway design team used the ArcReader system to avoid high-value wetlands, where possible. Then, through the wetlands-viewing platform, field studies, and numerous revisions, access road plans were refined to reduce the number, widths, and fill depths of access roads. Access roads were eliminated by reviewing each access road for need while also reviewing locations and dimensions of existing roads in and along the corridor to determine if they were viable alternatives.

1.4.2. Ice Pads and Snow Packing

Ice pads and snow packing will be used during the process of trenching and burying the pipe in the Northern Ecoregion to avoid impacts associated with disturbing or filling wetlands. The ice or snow surface will allow heavy equipment to drive over the tundra to perform construction while only generating a narrow impact where the pipeline will be buried.

1.4.3. Preferential Use of Uplands or Previously Disturbed Areas

The Applicant has preferentially sited larger facilities, such as camps, pipe storage yards, and operations and maintenance facilities in previously disturbed areas and has opted to use existing access roads and material sites where practicable to minimize new disturbance to new wetlands. The Applicant may also improve stabilization of disturbed areas and use those areas, including placement of gravel on existing permafrost thaw to cover relic “tractor tracks”. By placing gravel in these types of disturbed areas to construct the Gas Treatment Plant (GTP) and ancillary features, the anthropogenically derived water that currently exists will be covered, and the pad prism[2] will serve to insulate the underlying permafrost, thus avoiding future thaw potential. The Applicant will also use uplands preferentially to wetlands where practicable. For example, the pipeline and block valves will be located in non-WOUS locations, where practicable, to avoid impacts from these facilities.

Limits of clearing, grubbing, and grading will be adjusted, where feasible, to avoid affecting WOUS habitats. Where clearing in WOUS could be avoided, limits to avoid impacts will be shown in the construction drawings and marked in the field. Excavated soils will be temporarily sidecast into the temporary construction easement. Upland locations will be used, when available, to avoid impacts to WOUS. The number of miles of pipeline and lateral that will be suitable for upland sidecasting will be determined during later design stages. Excess spoil material, including vegetation, trees, and roots from clearings will be removed and placed in upland areas for disposal or removal. New material sites will also preferentially target upland areas where practicable.

1.4.4. Open Water Avoidance

Where appropriate, pipeline waterbody crossings will avoid WOUS impacts by using trenchless technology or aerial-crossing structures. Impacts to WOUS will also be avoided for some access road crossings by using new or existing bridges where practicable. The Alaska LNG mainline pipeline will be attached to bridges at the Nenana River near Milepost (MP) 532.1 and Nenana River (#5) at MP 537.1. The Point Thomson Transmission Line (PTTL) will utilize aerial spans on vertical support members at the Shaviovik River East near milepost 25.5, the Kadleroshilik River at MP 35.3, the Sagavanirktok River Main Channel at MP 44.2, and the Sagavanirktok River Main Channel at MP 53.6 using an existing pipeline bridge.

Where ponds are crossed in winter (*e.g.*, the North Slope), construction will occur using an open-cut method and will be treated similar to trenching through a winter stream. The Project will have an approximately 5.5-foot-wide temporary impact to ponds, if crossed.

1.4.5. Material (Borrow) Sources

Material (borrow) sources were sited with avoidance of wetlands considered in design. Desktop analysis of wetlands data acquired during field studies helped to define wetland boundaries and incorporate avoidance measures (e.g., selection of largely upland areas) for material source exploration, as practicable. Engineers used the data to adjust boundaries of material sites, optimize the number and size of material sites required, limit haul distances, reduce the overall number of quarry sites versus borrow sites, and further avoid impacts to wetlands and waterbodies to the extent practicable.

In many instances, the use and expansion of existing material sources and access roads were incorporated into the design to reduce impacts to previously undisturbed locations, although new locations are still required. Proximity to the pipeline alignment was taken into account in the siting of material sources and access roads. Reductions in the total length of access roads helped to reduce the total volume of material

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[2] The design of project infrastructure is such that there should not be depressions in the granular pad surfaces which will cause water impoundments. Granular workpads will be designed to allow transverse surface sheet flow by the use of culverts as necessary.

needed. By design, the hauling of material over difficult wetland or riverine terrain was avoided to the extent practicable.

The design team have identified 153 material source sites that will be required for the project. These sites will occupy approximately a total of 5,755.45 acres, with approximately two-thirds existing on uplands (3,824.50 acres).

1.4.6. Collocation of Facilities

Several facilities will be collocated to further avoid impacts to wetlands. For instance, camps and pipe storage yards will be collocated at times to reduce the number of access roads required and associated disturbance.

1.5. Minimization Measures

In some areas, project impacts to wetlands will be temporary and compensatory mitigation is not proposed as there will be no long-term impacts to wetlands in these areas. For instance, ice roads and snow pack will be used to cross over wetlands in winter without substantially impacting them, and temporary workspaces that contain some wetlands will be used to stage materials, equipment, or other items and to provide space needed for construction (see Section 1.5.1, below). In these instances, lands will neither contain fill nor be permanently impacted and are expected to recover.

In select areas where certain types of boggy wetlands exist with soft sub-soils underlying them, and where construction would occur in summer, the project will use a push-pull technique to cross these short sections of wetlands, where practicable. The push-pull technique requires excavation of the ditch from temporary wood mats. Heavy equipment working on wood mats in these targeted areas may use low ground-bearing equipment to reduce disturbance to wetland vegetation and soils. Ditch spoils would be placed on either side of the crossing on the mats because the pipeline would be strung and welded outside the wetland, and the pipe string would be pushed and pulled into place. Backfill is accomplished in a similar manner working from mats in these limited instances.

Clearing or trenching may be considered temporary impact if the degraded wetland plant community is able to revegetate promptly after construction and hydrologic function is not substantially impacted, or if it returns. The Applicant has proposed restoration of the buried pipeline trenched area through crowning of the ditch, re-contouring of the soils, and implementation of its Revegetation Plan. The installation of the 42” pipeline, over bedding and padding where required, will fill a large portion of the total trench volume, providing enough remaining sediment for crowning of the ditch to a proper height, including in permafrost areas. Where required, samples of ditch spoils will be collected to determine the ice content and derive an estimate of the portion of the spoils that would be water. This will assist the Applicant in determining the level of settlement expected the first summer and in subsequent summers and will ultimately help to derive the appropriate crown height and re-contouring efforts needed along the filled trench.

A crown that settles to an elevation similar to preconstruction conditions after the first year would be ideal for the purposes of revegetation and for maintaining original hydrology and drainage. A trench surface that is slightly above or equal to preconstruction elevation after the first year is desirable, as this would promote the return of pre-construction wetlands hydrology and vegetation. A slightly concave surface would be less desirable as it is more likely to collect water. The goal of trench restoration is to blend the revegetated trench with the surrounding area in a manner that will meet basal vegetation cover standards and allow for approximate original land contours and hydrology. Robust monitoring and revegetation programs will be implemented in accordance with the project's Revegetation Plan.

1.5.1. Temporary Facilities

Temporary workspaces and false rights-of-way (ROWs) will be used in some locations during construction to minimize impacts to wetlands. Temporary work spaces will accommodate activities such as equipment movement, laying down materials, clearing vegetation above the root, and use of vehicles with low-pressure tires or tracks to minimize permanent impacts on wetlands through only a temporary (short-term) impact without the need for fill. False ROWs are areas that may require clearing for the pipe being installed through trenchless means to move over land as it is strung during installation, but no vehicles would operate on those False ROWs during the installation.

1.5.2. Revegetation

The Alaska LNG Project design will incorporate revegetation procedures to be implemented after construction to stabilize areas and prevent erosion, as well as to help regain partial hydrologic functions. The Alaska Department of Natural Resources (ADNR) - Plant Materials Center has worked with the Applicant to produce a revegetation plan based on the different ecoregions of the Project. Specific procedures and recommended seed types and seed mixes are provided in this plan.

Revegetation of impacted sites will begin in accordance with the project's Revegetation Plan. Land access agreements will also generally describe acceptable methods of revegetation and restoration upon Project completion.

1.5.3. Water Crossings and Water Management

Identifying appropriate crossing modes for streams and waterbodies intercepted by the Alaska LNG Mainline, PTTL, and access roads has been a critical component of minimizing impacts. A major hydrologic design process was conducted to avoid and minimize crossing impacts, including field surveys, stream classification/ characterization, a fish and wildlife habitat sensitivity analysis, and design of crossing techniques to minimize impacts.

Based on the current Project design, the Alaska LNG Project will directly impact waterbodies at 712 locations, of which 103 are salmon bearing (an additional 17 are not salmon-bearing, but contain other anadromous species). Impact locations are differentiated as Mainline pipeline crossings (523), PTTL pipeline crossings (105), access road crossings (79), and in-river material extraction impacts (5).

Streambank revegetation techniques will be defined for the stream crossing cuts to help reduce erosion and to provide for restoration success. Revegetation techniques for streambanks are included in Streambank Revegetation and Protection: A Guide for Alaska (Alaska Department of Fish and Game

[ADF&G] 2005). Natural drainage patterns will be maintained using appropriate ditching, culverts, and other measures to prevent ponding or drying. Pipeline installation in wetlands will include measures to limit the potential for water flow within the trench (e.g., ditch plugs). Culverts in fish-bearing waters will be installed in accordance with a valid ADF&G Fish Habitat permit. Culverts will be designed, as appropriate for surface flow.

Where feasible, alignment route alternatives were identified to avoid waterway crossings. In situations where complete avoidance was not possible or feasible, proximal crossing locations were identified where environmental impacts associated with in-stream construction efforts will be minimized. Where the alignment could not be adjusted, optimal construction seasons and modes to minimize impacts were identified.

Aquatic habitat and terrestrial wildlife habitat were avoided to the extent practicable. The Alaska LNG Draft Environmental Impact Statement (DEIS) provides examples of the efforts associated with fish and aquatic habitat impact avoidance and minimization (FERC 2019).

A procedural method was developed in support of preliminary stream crossing mode determinations and is documented in *AKLNG Stream Crossing Mode Determination Tree* (Applicant 2016). The method was used to identify design and construction complexity and the potential for environmental or pipeline integrity impacts. The method also identifies the environmentally preferred crossing mode for each stream classification and crossing modes that avoid and minimize impacts on aquatic resources. Streambank restoration procedures, stream crossing analyses, and reports have been developed by the Applicant to provide guidance for the design, construction, installation, maintenance, inspection, and performance evaluation of bank armoring and river training structures proposed for select stream crossings associated with the Alaska LNG pipeline.

For pipeline stream crossings, the Applicant will continue its systematic and comprehensive permit program to avoid and minimize fill and armor below ordinary high water. Streambed and river bank restoration will be accomplished using the methods outlined in the Alaska LNG *Streambed & Bank Restoration Manual* (AKLNG-4020-CCC-RTA-DOC-00005). The Manual is included in Appendix C. The final streambank restoration plan for each stream will be contingent on the streambed and stream bank composition, stream velocity, stream depth, and the crossing mode for each site.

1.5.4. Recovering Wetlands through GTP Mine Site and Reservoir Reclamation

North Slope mine sites and reservoirs when reclaimed provide opportunities for minimization of impacts to wetlands on the Arctic Coastal Plain (ACP). In accordance with Alaska LNG mine site reclamation and restoration plans[3], the GTP mine site will result in recovered ponded wetlands. Overburden from the mine site will be re-used to shape and contour the three-dimensional features of the GTP mine site, including adding a sloping littoral zone that can support diverse aquatic North Slope plant life and other organisms. The GTP Camp reservoir will hold water during operations, providing wetland functions such as supporting

[3] An overarching Restoration Plan and a Revegetation Plan have been provided to the USACE to outline practices that will be applied project-wide. Site-specific mine site restoration plans may be provided at a later date, as needed, by the contractor hired to develop and close material sites.

North Slope waterfowl. Upon termination of the operational phase, the GTP Camp reservoir will be treated similar to the reclaimed GTP mine site, resulting in additional recovered ponded wetlands.

1.6. The Degree of Project-Wide Watershed and Wetland Impacts

Alaska LNG comprises a GTP, an 807 mile-long mostly buried pipeline, and an LNG facility. The pipeline would traverse 185 HUC-12 watersheds, most of which are remote (i.e., little to no human development) with relatively unaltered hydrology, few impervious or compacted surfaces, and little urbanization. Following project construction, 105 of the 185 traversed watersheds (57%) would have approximately less than 1% of human-induced disturbance; 180 of the 185 traversed watersheds (97%) would have less than 5% human disturbance.

The difference between the level of human disturbance pre- and post-project within the 185 HUC-12 watersheds ranges from between <0.0001% to 4.1%. Significant impacts to aquatic resources are not anticipated in most watersheds traversed by the project.

The project would require work directly in 10,323.8 acres of wetlands. Work on ice over wetlands would occur over 8,782 acres, minimizing impact and making it only temporary. The approximate degrees of impacts from project activities are summarized below:

- 8,782 acres that would be accessed but not permanently impacted due to the used of ice pads, roads, and frost pack (about 25.5% of total land acreage accessed) (Impact Level 1).
- 4,544 acres that would be expected to recover most wetland functions. Areas affected by the pipeline trench, with proper construction and restoration techniques, are expected to recover and return to wetlands (about 13.2% of total land acreage accessed) (Impact Level 2).
- 4,922.8 acres that would either partially recover, would result in the creation of open water (e.g., reclaimed material sites), or would be converted to vegetated uplands or provide limited wetland functions (about 14.4% of total land acreage accessed) (Impact Level 3).
- 857 acres that would likely have a complete loss of wetland functions (about 2.5% of total land acreage accessed) (Impact Level 4).

The Applicant has proposed mitigation for impacts to wetlands where determined appropriate and practicable for acreage within Impact Levels 2 - 4 (i.e., the acreage for each of the non-negligible Impact Levels). Compensatory mitigation is not offered for areas where wetland impacts are minimized and expected to be non-existent or negligible, such as when work is done using ice pads, ice roads, or snowpack (i.e., Impact Level 1).

The compensatory mitigation that is offered through this plan is designed to offset unavoidable losses of aquatic resources and is based on a watershed-level analysis consistent with federal regulations and the 2018 Joint USACE-EPA Memorandum of Agreement (USACE and EPA 2018). Compensatory mitigation is required to offset losses of aquatic resources in watersheds that would, following construction of the Alaska LNG project, have a cumulative level of disturbance that is statistically significant, i.e., where measureable changes in functional capacity may occur. Compensatory mitigation will be for significant resource losses which are specifically identifiable, reasonably likely to occur, and of importance to the human or aquatic environment. (33 CFR 320.4(r)(2).

1.7. Determination of Substantive Watershed Impacts Requiring Compensatory Mitigation

1.7.1. Applicant's Initial Analysis and Determination

Urbanization and development are known to have a substantive impact on aquatic resources and functions once approximately 10 percent of land in a watershed is urbanized, disturbed, or converted to impervious surfaces (Baker and King 2010; Hilderbrand et al. 2010; Utz et al. 2009; Hicks and Larson 1997; May et al. 1997). Urbanization can begin to influence some biological parameters in watersheds when approaching this threshold. Below this threshold, impacts generally do not have a significant impact to overall water quality or aquatic biodiversity of the watershed (Hilderbrand et al. 2010; Schueler et al. 2009; Booth and Jackson 1997; Booth et al. 1996; Luchetti and Fuersteburg 1993; MWCOG 1992; Booth 1991; Weaver 1991; Limburg and Schmidt 1990; Steedmen 1988; Jones and Clark 1987; Klein 1979). Guidance on wetlands mitigation provided by the USACE for other recent Alaskan projects (e.g., Donlin Gold, the Alaska Stand Alone Pipeline, etc.) and in regulatory notices (e.g., the 2008 Mitigation Rule, the 2018 USACE-EPA MOA), provided the basis for the Applicant to use a watershed-level approach to determine where compensatory mitigation might be required due to significant aggregate impacts to watersheds. The USACE applied a conservative standard of 5% development to consider a watershed degraded or disturbed.

The Applicant used the National Land Cover Database (NLCD) and the Alaska LNG PreliminaryJurisdictional Determination (PJD) wetlands dataset to calculate an aggregate value of expected watershed disturbance following construction by summing the acreages of existing disturbance and new disturbance within each 12-digit Hydrologic Unit Code (HUC) watershed traversed by the Project. The Applicant followed USACE direction to perform a finer-scaled analysis for the Prudhoe Bay watershed using 12-digit HUC boundaries to determine which watersheds traversed by the Project would be considered degraded beyond 5% following project development. The Applicant sought and received input from the USACE on its analysis.

1.7.2. Procedures for Analysis and Determination of Mitigation Requirements

The USACE and the Applicant analyzed existing watershed impacts and expected project-related impacts within watersheds traversed by the project. The analysis was based on NLCD disturbances and other known impacts within the USACE's regulatory data management system for wetlands (i.e., ORM database). A series of steps was used to analyze where compensatory mitigation would be considered appropriate and practicable for offsetting substantive impacts to wetlands in affected watersheds. The following methods are based on Corps policy and precedent for compensatory mitigation analysis and were also incorporated into this analysis:

- Used the current Project footprint and the Preliminary Jurisdictional Determination (PJD) wetlands geodatabase layer in the analysis.

- Evaluated 12-digit HUC watersheds and freshwater wetlands impacts.
- Used a conservative threshold of 5 percent anthropogenic disturbance in watershed analysis to identify degraded watersheds.
- Established requirements for compensatory mitigation to include areas in which permanent impacts to wetlands would exist within 500 feet of any salmon-bearing waterbody crossing, regardless of watershed (non-salmon bearing streams containing other anadromous species were not included in this portion of the analysis).
- Removed ACP locations that would be reclaimed and recovered as ponded wetlands (GTP Mine site and reservoir).
- Removed marine / estuarine disturbances from the analysis (e.g., dredging, dredge disposal, or placement of pilings, infrastructure, gravel, or the subsea pipeline).
- Removed gravel excavation areas around the Sagavanirktok River from the analysis.
- Allowed for broader watersheds (e.g., 8-digit HUC or broader) to be used in evaluating permittee responsible mitigation options, as appropriate, consistent with the 2018 USACE-EPA MOA.

The USACE's analysis of the data resulted in the identification of degraded watersheds and wetland impact acreages (by type of wetland) summarized by the Applicant in Table 1. Based on the analysis, the project will offer compensatory mitigation to offset impacts to 362.61 acres of wetlands in these degraded watersheds using the strategies outlined in Table 1.

Table 1. Analysis of Wetlands Impacts (Acres) for Degraded Watersheds and Proposed Mitigation

Ecoregion	HUC-12	HUC-12	Proposed Mitigation	Corps HGM	Impact Acres
Northern	190604010104	Prudhoe Bay-Frontal Beaufort Sea	PRM	DEPRESS	76.15
				LACUSTRINF	0.61
				ORGSOILFLT	232.12
				RIVERINE	0.07
Interior	190803060907	Chena River	Tanana Bank Credits	DEPRESS	6.47
				ORGSOILFLT	36.17
Southcentral	190203021906	Salamatof Creek-Frontal Cook Inlet	Su-Knik Bank Credits and/ or Great Land Trust Released Credits*	DEPRESS	8.71
				LACUSTRINF	0.00
	190203021908	Meadow Creek	Su-Knik Bank Credits and/ or Great Land Trust Released Credits*	DEPRESS	1.98
				SLOPE	0.33
				TOTAL	**362.61**
Notes * = out of service area					

Table 2 reports the acreage of permanently impacted wetlands occurring within 500 feet of salmon-bearing waterbody crossings by the buried pipeline or access roads. Results are provided by watershed, reporting the type and acreage of wetlands impacted and mitigation strategy to address the impacts. The project will offer compensatory mitigation to offset impacts to 128.83 acres of wetland impacts around salmon-bearing waters.

Table 2. Analysis of Substantive Wetlands Impacts (Acres) within 500 Feet of Salmon-Bearing Waterbody Crossings outside Degraded Watersheds and Applicant-Proposed Mitigation

Ecoregion	HUC12	HUC12 Name	Proposed Mitigation**	Corps Hydrogeomorphic (HGM) Class	Acres of Wetlands within 500' of Salmon-Bearing Streams
Northern	190604021604	Town of Sagwon-Sagavanirktok River	PRM	RIVERINE	0.91
	190604021606	Franklin Bluffs-Sagavanirktok River	PRM	DEPRESS	0.02
				MINSOILFLT	0.06
				ORGSOILFLT	0.18
	190604021706	Sagavanirktok River Delta-Frontal Beaufort Sea	PRM	DEPRESS	0.00
				LACUSTRINF	0.00
				ORGSOILFLT	0.00
				RIVERINE	0.01
	190604030805	Outlet Shaviovik River	PRM	ORGSOILFLT	0.00
				RIVERINE	0.00
	190604031106	Mikkelsen Bay-Frontal Beaufort Sea	PRM	DEPRESS	0.00
				ORGSOILFLT	0.00
Interior	190803080903	Panguingue Creek	Tanana Bank Credits	ORGSOILFLT	1.04
				RIVERINE	0.42
	190803080904	Little Panguingue Creek-Nenana River	Tanana Bank Credits	ORGSOILFLT	1.26
	190803080907	Bear Creek	Tanana Bank Credits	ORGSOILFLT	4.59
				RIVERINE	0.00
				SLOPE	0.07
	190803080908	190803080908-Nenana River	Tanana Bank Credits	ORGSOILFLT	0.73
	190803081307	Seventeenmile Slough-Nenana River	Tanana Bank Credits	ORGSOILFLT	0.75
				RIVERINE	2.38
	190803090903	Hard Luck Creek-Chatanika River	Tanana Bank Credits	DEPRESS	0.21
				RIVERINE	0.42
	190804040504	Smoothface Mountain-Yukon River	Tanana Bank Credits*	ORGSOILFLT	2.06
	190901010503	Nugget Creek-Middle Fork Koyukuk River	Tanana Bank Credits*	DEPRESS	0.46
				ORGSOILFLT	0.83
				RIVERINE	0.73
				SLOPE	0.51
	190901010602	Marion Creek	Tanana Bank Credits*	RIVERINE	0.13
	190901010604	Slate Creek	Tanana Bank Credits*	ORGSOILFLT	0.20
				SLOPE	0.40
	190901020302	Eagle Creek-South Fork Koyukuk River	Tanana Bank Credits*	MINSOILFLT	0.90
				ORGSOILFLT	10.08

Ecoregion	HUC12	HUC12 Name	Proposed Mitigation**	Corps Hydrogeomorphic (HGM) Class	Acres of Wetlands within 500' of Salmon-Bearing Streams
				RIVERINE	1.51
				SLOPE	1.21
	190901020403	Outlet Prospect Creek	Tanana Bank Credits*	DEPRESS	0.22
				ORGSOILFLT	7.44
				RIVERINE	2.34
				SLOPE	7.12
	190901020505	Douglas Creek	Tanana Bank Credits*	DEPRESS	0.07
				ORGSOILFLT	4.18
				RIVERINE	3.17
				SLOPE	1.28
	190901020507	Grayling Creek-Jim River	Tanana Bank Credits*	DEPRESS	0.16
				ORGSOILFLT	2.77
				RIVERINE	1.44
				SLOPE	0.45
Southcentral	190205020103	Outlet Middle Fork Chulitna River	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	ORGSOILFLT	2.02
				RIVERINE	1.56
				SLOPE	0.06
	190205020203	Hardage Creek	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	RIVERINE	0.28
	190205020204	Outlet East Fork Chulitna River	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	RIVERINE	0.61
	190205020403	Outlet Honolulu Creek	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	RIVERINE	0.12
				SLOPE	0.04
	190205020412	Pass Creek	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	DEPRESS	0.18
				RIVERINE	0.32
	190205020414	Granite Creek-Chulitna River	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	RIVERINE	0.43
				SLOPE	1.41
	190205021001	Troublesome Creek	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	RIVERINE	0.68
	190205021003	Cygnet Lake-Chulitna River	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	ORGSOILFLT	1.20
				RIVERINE	1.28
				SLOPE	1.02
	190205042007	Outlet Yentna River	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	DEPRESS	1.55
				SLOPE	0.03
	190205050301	Trapper Creek	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	ORGSOILFLT	0.16
				RIVERINE	1.51
	190205050304	Rabideux Creek	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	ORGSOILFLT	2.83
				RIVERINE	5.42
				SLOPE	1.44
	190205050305		Su-Knik Bank Credits	ORGSOILFLT	0.10

Ecoregion	HUC12	HUC12 Name	Proposed Mitigation**	Corps Hydrogeomorphic (HGM) Class	Acres of Wetlands within 500' of Salmon-Bearing Streams
		Twister Creek-Susitna River	and/ or Great Land Trust Released Credits	RIVERINE	0.39
				SLOPE	0.13
	190205050906	Rockys Lakes	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	ORGSOILFLT	1.00
				RIVERINE	0.61
				SLOPE	0.29
	190205050909	190205050909	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	RIVERINE	0.80
	190205050910	Lower Kroto Creek	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	ORGSOILFLT	0.97
				RIVERINE	0.36
	190205051004	Fish Creek	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	DEPRESS	0.10
				ORGSOILFLT	0.41
	190205051005	Kroto Slough	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	DEPRESS	2.10
				ORGSOILFLT	0.41
	190205051006	Town of Susitna-Susitna River	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	SLOPE	0.67
	190205051111	Lower Alexander Creek	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	DEPRESS	0.34
				ORGSOILFLT	1.00
				RIVERINE	2.07
				SLOPE	1.87
	190205051304	Ivan River	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	ORGSOILFLT	1.88
				RIVERINE	0.88
				SLOPE	0.87
	190205051305	Lewis River	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	SLOPE	0.48
	190205051306	Outlet Susitna River	Su-Knik Bank Credits and/ or Great Land Trust Released Credits	RIVERINE	4.30
				SLOPE	6.16
	190206010408	Olson Creek	Great Land Trust Released Credits	RIVERINE	0.96
				SLOPE	0.93
	190206010409	Pretty Creek	Great Land Trust Released Credits	DEPRESS	0.02
				ORGSOILFLT	1.90
				RIVERINE	0.76
				SLOPE	2.60
	190206010410	Lower Beluga River	Su-Knik Bank Credits and/ or Great Land Trust Released Credits*	RIVERINE	0.82
				SLOPE	4.06
	190206011703	Outlet Theodore River	Great Land Trust Released Credits	RIVERINE	0.30
				SLOPE	0.63
	190206011901	Threemile Creek	Su-Knik Bank Credits	DEPRESS	0.06
				RIVERINE	0.23
				SLOPE	0.54

Ecoregion	HUC12	HUC12 Name	Proposed Mitigation**	Corps Hydrogeomorphic (HGM) Class	Acres of Wetlands within 500' of Salmon-Bearing Streams
			and/ or Great Land Trust Released Credits*		
				TOTAL	128.83

Notes
* = out of service area
**= Initial proposed mitigation is outlined here based on current available options. However, the Applicant may propose projects and/or other options if they become available at a later date and are acceptable to the USACE.

Combining the totals in Tables 1 and 2 results in a total of 491.44 acres of impacts to freshwater wetlands that will be offset through compensatory mitigation described in this plan. A list of third party mitigation providers that have service areas within the watersheds where compensatory mitigation will be required is provided in each of the above tables (1 and 2). The letters "PRM" are used for areas where the Applicant has selected to provide PRM because no other option for purchasing credits is currently available. The maps in Appendix A depict the information graphically for each watershed, by ecoregion and describe the total percent change (d) between pre- and post-project.

2. OBJECTIVES

The Applicant's objective is to provide appropriate and practicable compensatory mitigation for project wetland impacts as identified by the USACE (Tables 1 and 2, above). The Applicant will utilize third party mitigation providers, where available and applicable, and PRM (preservation) or ILF for projects in areas requiring mitigation outside of approved third party provider service areas. The means for providing compensatory mitigation and the process for identifying wetland credits and debits are discussed in later sections. North Slope debit calculations are discussed below, whereas debit calculations for other regions will be provided prior to securing the third party credits for the Alaska LNG Project.

2.1. North Slope

For North Slope wetlands mitigation, the Applicant evaluated options to compensate for unavoidable, substantive impacts to predominately palustrine wetlands identified in six HUC-12 watersheds within the ACP of Alaska's Northern Ecoregion (Tables 1 and 2). The ACP comprises several watersheds that are connected by a ubiquitous, complex landscape of nearly contiguous palustrine, lacustrine, and estuarine wetlands. Vegetative species diversity, composition, and function are consistent along the entire ACP.

The ACP is generally flat terrain with minimal topographic relief, underlain by continuous permafrost. Due to the limited precipitation on the North Slope, the active zone of the permafrost provides the hydrology necessary for wetlands to develop and thrive. The minimal topographic relief results in larger wetland areas with connected hydrologic functions. This complex of wetlands and other WOUS are integrated components of the water cycle in the arctic and provide a connection to the Beaufort and Chukchi seas. The key functions of ACP wetlands include nutrient cycling, waterfowl habitat, avian nesting and foraging, terrestrial mammal foraging, carbon sequestration, and human subsistence and cultural activities in this ecoregion.

To evaluate options to address unavoidable impacts to wetlands on the North Slope, the Applicant contracted with the ADNR through a Reimbursable Service Agreement (RSA) to perform an investigation of potential restoration opportunities on the North Slope that do not currently have a responsible party identified[4]. Table 3, shows the four opportunities identified by the ADNR investigation.

Table 3. Permittee Responsible Mitigation Opportunities for the Northern Ecoregion Identified by ADNR[4]

Site Name	General Location	Coordinates	HUC-8	Service Area Provider	Project Description	Remarks
Abandoned Drum Removal	Various unidentified locations	NA	Various	None	Survey North Slope and document abandoned drum locations	Non Traditional. No way to value the ecological uplift or credit
Survey Old Drill Site Reserve Pits	Various unidentified locations	NA	Various	None	Survey North Slope and document old drill site locations	Non Traditional. No way to value the ecological uplift or credit
Last Chance Wayside	Haul Road-Foothills	69.42209, -148.691141	19060401	None	Upgrade facility for public use	Can't value ecological uplift. Upgrades will be to uplands
Amoco Aufeis Pad	North Slope	69.149934, -149.571909	19180309	None	Gravel pad removal and return to wetland habitat	Time lag and risk result in minimal credit. Unable to place protection instrument

The four potential restoration opportunities identified by ADNR are considered to be impracticable as a result of:

- Concerns about high risks of successful restoration and time lag for achieving success; or
- Lack of ability to demonstrate ecological uplift.

Since no practicable wetlands restoration opportunities could be identified on the North Slope, the Applicant sought opportunities for preservation of wetlands under threat from development. The Applicant identified and evaluated PRM opportunities associated with funding a project, or projects, under the Alaska Department of Environmental Conservation (ADEC) Village Safe Water Program and,

[4] The Applicant entered into a contract in 2018 with the ADNR Office of Project Management to provide a list of potential projects for the Alaska Stand Alone Pipeline Project (ASAP), which traverses the same ecoregions and many of the same locations as Alaska LNG. Reporting was issued in electronic format in mid-2018 as: "ASAP Mitigation DNR Potential Projects List".

secondarily, the preservation of various wetland parcels. Quotes for parcels were obtained and potential protection instruments were considered.

If a current state agency process for evaluation and funding of projects is determined acceptable to the USACE for use of mitigation funds (e.g., ADEC's VSW Program), the Applicant will seek USACE approval to provide compensatory mitigation dollars to that agency as the mechanism for completing projects beneficial to wetlands, waters, or water quality on the North Slope or in other regions of Alaska. ADEC's VSW program provides funding to Alaska communities for water and sewer studies and construction projects. ADEC maintains a Priority List of projects identified by the VSW program for multiple communities. VSW projects provide both safe drinking water and wastewater treatment facilities and/or upgrades to existing facilities in rural Alaskan villages. Wastewater improvements help to increase the water quality and sanitation around private residences and the community as a whole where residents are forced to use "honey buckets" in lieu of flush toilets. Should the USACE approve this form of mitigation, the Applicant will provide project-specific plans for a VSW Program-sponsored wastewater upgrade.

Should the VSW Program option for mitigation not be approved, then protecting western ACP wetlands through preservation is proposed as PRM for offsetting impacts to wetlands within the degraded ACP watershed traversed by the Alaska LNG Project. While there is a lack of available land for preservation in the Prudhoe Bay watershed, protecting central and western ACP wetlands would prevent foreseeable degradation thereby maintaining ecosystem benefits across the ACP. The preservation of such lands under threat will benefit ACP wetlands, which possess connectivity through the movement of water and through shared habitat. Protecting ACP wetlands will serve to mitigate effects experienced in the eastern oil and gas development region of Prudhoe Bay.

The Applicant sought to preserve western ACP lands containing predominately palustrine wetlands on private or borough-owned lands. Specific parcels identified were within one of three locations in order to offset Alaska LNG's North Slope wetlands impacts:

1. Cape Halkett, owned by Arctic Slope Regional Corporation (ASRC);
2. A parcel near Utqiagvik (Barrow) that is owned by Ukpeagvik Inupiat Corporation (UIC) with current designation for study by the Naval Arctic Research Laboratory (NARL); or
3. Land within the Meltwater East region, which abuts the Kuparuk Oil and Gas Development Unit owned by the North Slope Borough.

All three locations are within the ACP and have ample high quality wetlands habitats. Protecting wetlands within Cape Halkett or in Utqiagvik has been demonstrated to be ecologically significant and in areas of preferable mitigation. Therefore, land preservation within Cape Halkett or Utqiagvik appear to be appropriate and practicable mitigation for North Slope ACP.

In summary, for North Slope PRM, the Applicant proposes use of ADEC's VSW Program and funding of a village wastewater improvement project(s) as practicable mitigation that would provide positive environmental benefit; however, the Applicant intends to continue coordinating with USACE towards the preservation of lands at Cape Halkett or at Utqiagvik as an alternative form of mitigation should the VSW Program option not be viable.

2.2. Interior and Southcentral Alaska

The Applicant contracted with ADNR through an RSA to identify potential opportunities for compensatory mitigation of Interior Ecoregion impacts through restoration or preservation. ADNR identified potential opportunities in the Interior for restoration mitigation[4] (Table 4). However, these potential opportunities are not located in impacted HUCs. The projects identified by ADNR are located within HUCs already serviced by the Tanana Bank, from whom the Applicant has proposed to purchase credits.

Table 4. Permittee Responsible Mitigation Opportunities in the Interior Ecoregion Identified by ADNR[4]

Site Name	General Location	Coordinates	HUC-8	Service Area Provider	Project Description	Remarks
Bev Loop Trail	Interior, Chatanika River	65.0214, -148.4148	19080309	Tanana Bank	Upgrade portions of major trail	Project not located in HUC requiring uplift from impacts
Lower Landing, Chatanika River	Interior, Chatanika River	64.9779, -148.6828	19080309	Tanana Bank	Upgrade river access road situated in wetlands	Project not located in HUC requiring uplift from impacts
Mount Ryan	Interior, Mount Ryan	65.3043, -146.1206	19080309	Tanana Bank	Upgrade trail < ½ mi.	Project not located in HUC requiring uplift from impacts

Due to the Project avoidance and minimization mitigation mentioned previously, the lack of third party providers and practicable PRM projects to compensate substantive, unavoidable impacts outside of available provider service areas, the Applicant is proposing to purchase additional credits from Tanana Bank as compensation for these Interior Ecoregion impacts. This would entail either a one-time approval from the Alaska District Engineer to expand the service area (see Preamble of 2008 Mitigation Rule) or a formal modification of the instrument in order to cover all of the Interior areas impacted by the Project.

There is negligible difference in wetland function between wetlands existing inside the Tanana Bank service area versus those outside the service area in the Interior Ecoregion, for which additional bank credits will be purchased. The nexus is apparent in that the wetlands on either side of the boundary containing similar HGM and Cowardin classes and perform similar functions. There are also similarities in the species of aquatic organisms, waterfowl, and terrestrial wildlife that are supported by these wetlands, regardless of what side of the instrument's boundary they exist. This action is consistent with the 2008 Mitigation Rule which mentions that certain minor exceptions may be approved when they are more environmentally or ecologically preferable. Furthermore, the 1995 Federal Banking Guidance[5] supports the use of ecoregions as service areas for mitigation banks. Furthermore, the geographic extent of a service area should, to the extent environmentally desirable, be guided by the cataloging unit of the

[5] Federal Register. 1995. Federal Guidance for the Establishment, Use and Operation of Mitigation Banks (FR 60(228) 58605. This guidance was replaced by the 2008 Mitigation Rule.

Hydrologic Unit map of the United States and the ecoregion of the Ecoregions of the United States or section of the Descriptions of the Ecoregions of the United States (Marsh et al. 1996).

In the Interior Ecoregion, compensation will be offered through the purchase of mitigation credits from the Tanana Watershed Umbrella Stream and Wetland Mitigation Bank (Tanana Bank). The service area boundaries for Tanana Bank and the impacted watersheds in the Interior Ecoregion are shown on maps provided in Appendix A. The Applicant will purchase credits to offset substantive, unavoidable impacts to 61.51 acres of wetlands in 14 watersheds existing within the Interior Ecoregion, as shown in Tables 1 and 2. Of these, approximately 49.62 acres are not located within third party provider service areas. These impacts are related to areas of the Alaska LNG Project occurring within 500 feet of a salmon-bearing waterbody crossings (Table 2, above) in areas not considered to have substantive watershed impacts (e.g., outside degraded watersheds), as determined by the USACE.

In the Southcentral Ecoregion, compensation will be offered through the purchase of banked credits from SuKnik Wetlands Mitigation Bank or released credits from Great Land Trust, as shown in Table 1, above, or another approved provider if other options become available. The service area boundaries for SuKnik and Great Land Trust and the impacted watersheds in the Southcentral Ecoregion are shown on maps provided in Appendix A. The Applicant will purchase credits to offset substantive, unavoidable impacts to 66.12 acres of wetlands in 27 watersheds existing within the Southcentral Ecoregion. A total of 16.71 acres of wetlands in the Southcentral Ecoregion are not located in third party provider service areas, with almost all substantive, unavoidable impacts to wetlands existing within the service area boundaries for SuKnik Bank and/or the slightly broader boundaries for Great Land Trust.

The boundary for Great Land Trust is defined by the Mat-Su Borough Political Boundary (Appendix A). The impacts outside of the Great Land Trust service area exist within only a few miles of its boundary on the shores of Cook Inlet. The Cook Inlet Basin comprises four larger HUC watershed units, all draining into Cook Inlet, and for that reason support the same species of aquatic organisms, waterfowl, and terrestrial wildlife. Portions of Cook Inlet and coastal area wetlands are also already included within the Great Land Trust's boundary to the northeast (Appendix A). Similar to what was described above for the Interior Ecoregion, there is almost no functional difference between wetlands contained inside versus outside the service area, as the wetlands contain very similar HGM classes (e.g., PEM1, PSS1B) and Cowardin classifications.

Since there are negligible differences in wetland function between wetlands existing inside the third party providers' service area boundaries versus outside, the above statements pertaining to the 2008 Mitigation Rule and Federal Banking Guidance would also apply in the Southcentral Ecoregion. Therefore, the Applicant proposes to purchase these additional credits from a third party provider as compensation for impacts to wetlands lying just outside of the service area and/or adjacent to Cook Inlet.

Debits for these reported impacts within the Interior and Southcentral Ecoregions will be calculated according to the appropriate method used by each third party provider prior to final credit purchase. At that time, the Applicant will also re-confirm availability of credits from Tanana Bank and either SuKnik or Great Land Trust, or another approved provider.

3. NORTH SLOPE MITIGATION

The Applicant offers options for North Slope mitigation that include funding a project under the VSW Program or preservation of North Slope parcels under threat. Funding a VSW project is the preferred option . The Applicant will continue working with the USACE and with other interested parties (such as ADEC's VSW program managers or various North Slope entities) to determine steps for establishing the funding mechanism.

For preservation, the North Slope PRM sites evaluated by the Applicant to compensate for ACP impacts were selected based on overall watershed needs, a lack of practicable on-site alternatives, the need for the project to be ecologically self-sustaining, and the likelihood of meeting the success criteria. The criteria evaluated and applied in the selection of mitigation sites was based on the requirements of 33 CFR Parts 332.3(h) and 332.4 and are discussed in detail below. This section does not discuss site selection criteria when using third party providers, as that is not required for a mitigation plan as defined in 33 CFR 332.4.

3.1. Watershed Needs

Because no third party providers exist on the North Slope, the Applicant investigated PRM opportunities within the local 12-digit HUCs identified by the USACE as requiring compensatory mitigation (Tables 1 and 2, above). USACE directed the Applicant to first explore PRM within local 12-digit HUCs where impacts were located, and if no opportunities were identified, to expand the research out to the 10-digit and then 8-digit HUCs for watersheds in which compensatory mitigation will be required (Tables 1 and 2, above). For the ACP watersheds requiring mitigation, if still no PRM opportunities were found to exist, the Applicant was to expand research outward to the broader ACP because of the ubiquitous nature of ACP wetlands and their inherent connection to the Beaufort and Chukchi seas. This approach is consistent with USACE/EPA joint guidance (USACE and EPA 2018) that allows flexibility in wetlands mitigation because of Alaska's unique wetland coverage and the potential for limited availability of mitigation options. As noted above, continuous permafrost limits drainage, resulting in widespread, ponded, slow-flowing water northward along the gravitational gradient towards the Beaufort and Chukchi Seas. The ACP wetlands impacted by the Alaska LNG Project provide limited functions to their individual local watersheds due to the currently degraded nature of the wetlands from surrounding development and other anthropogenic impacts.

As shown in Table 3, above, ADNR did identify a number of practicable out-of-kind non-traditional projects. Examples of these non-traditional projects include abandoned drum mapping studies and survey of wildcat drill sites to develop a comprehensive list of features and issues. However, these projects do not have the ability to generate a credit given the current credit methodology. A further discussion with the USACE confirmed that these non-traditional projects are unlikely to be ecologically preferable. Additionally, the ADNR confirmed that removing state-owned lands zoned for oil and gas development from the public domain is not an option for the North Slope. Finally, the timeframe for accomplishing this work prior to the start of construction would be problematic given the current Project schedule.

The Applicant intends to continue coordinating with USACE to evaluate other opportunities for compensatory mitigation as they become available. For example, if an approved ILF would be able to modify its service area to support future restoration or enhancement projects, the Applicant could potentially consider those options in lieu of the VSW Program or preservation.

Due to the lack of appropriate and practicable PRM restoration opportunities, the Applicant proposes to provide funding to ADEC for use in the VSW Program. If approved, the Applicant will provide a project-specific CMP for upgrades or installation of wastewater facilities at a remote village. There are currently no villages on the North Slope on the VSW Priority List. One of the villages on the List is Kivalina which is located in the adjacent Northwest Arctic Borough. Providing Kivalina with a portable wastewater treatment facility would help the villagers treat wastewater now and provide the added benefit of being portable because the village is scheduled to be relocated due to shoreline erosion at the current site.

Alternatively, the Applicant identified areas of Cape Halkett (Figure 2) and Utqiagvik (Figure 3) as ecologically preferable sites for PRM preservation. The Applicant is currently working with land owners to determine the exact locations within the Parent Parcels that preservation will occur; therefore, Figures 2 and 3 show the entire parent parcels under consideration. While both parcels fall outside the 12-, 10-, and 8-digit HUCs of Alaska LNG impacts, they fall within the ubiquitous North Slope wetlands complex; they are available for preservation, and this would meet the objectives of preserving western ACP wetlands functions that are potentially under threat from development. This approach is consistent with USACE/EPA joint guidance (USACE and EPA 2018) regarding mitigation for impacts to wetland areas in Alaska.

Figure 2. Cape Halkett Parent Parcel

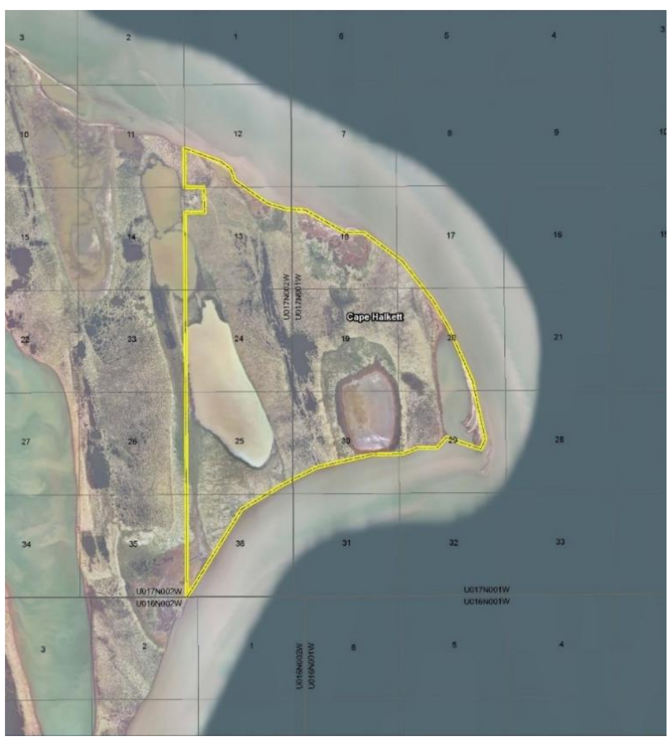
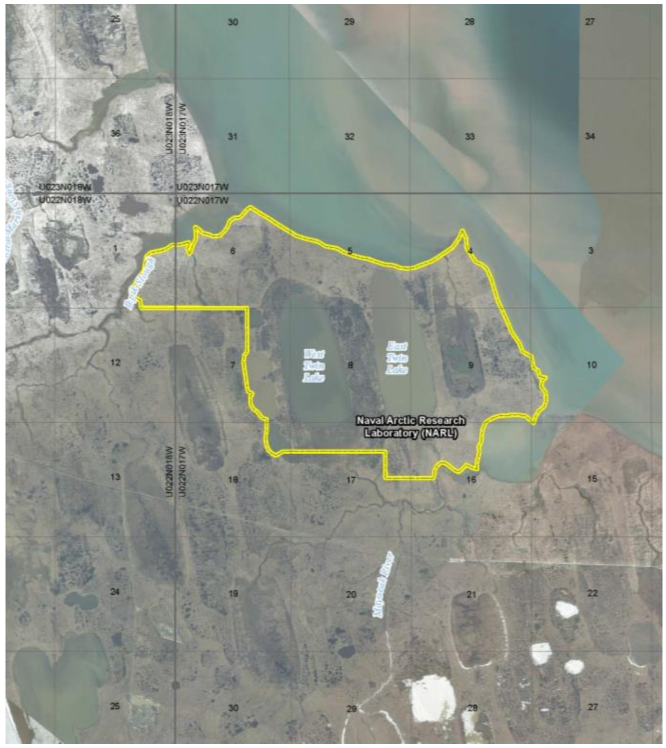


Figure 3. Utqiagvik Parent Parcel



The Cape Halkett wetlands and the Utqiagvik wetlands have no direct anthropogenic impacts and represent the ubiquitous palustrine wetlands present on the ACP; therefore, they provide important chemical and biological functions to the ACP wetlands. Their high level of chemical and biological function and contribution to the ecological sustainability of the ACP are evidenced by their functional capacity index (FCI) score of 1.0. Similar Cape Halkett wetlands were recently preserved as compensatory mitigation for the GMT1 project, which indicates their preservation is appropriate and practicable to the District Engineer. The Cape Halkett wetlands are privately-owned and are available for resource development to either support offshore oil or gas projects or to develop the land as ASRC determines necessary. Finally, the Cape Halkett wetlands will be preserved in perpetuity through a protection instrument. Protecting these valuable wetlands will result in preventing foreseeable degradation and maintaining ecosystem benefits in an area of the ACP, and will be appropriate and practicable under 33 CFR 332.3(h).

The Utqiagvik parcel contains two large freshwater lakes (East Twin and West Twin Lakes), frontage on Iklik Slough, and coastal frontage on the Chukchi Sea. The wetlands represent pristine habitat and contain many important functions for wildlife on the ACP. Specifically, the wetlands are habitat for birds, small mammals, caribou, and polar bear, which can be impacted by increased urbanization. The lands are in close proximity to a gravel road connecting the town to nearby gas fields, which include a natural gas processing facility and gas pipeline. Selection of the undisturbed area would ensure no future encroachments related to expanded urbanization or oil and gas development would occur in these wetlands. As the UIC parcel in Utqiagvik is under threat from both urbanization and oil and gas development, this preservation of this parcel would provide for important wetland functions to remain into perpetuity for this important area.

In the event significant changes occur prior to commencement of construction (for example, the preservation parcels and protection instrument are no longer available, alternative parcels are available, or new mitigation options become available, etc.), the Applicant will provide an option for equivalent alternative mitigation.

3.2. Onsite Alternatives

No on-site alternatives for compensatory mitigation are available. The Applicant requires the project features constructed for Alaska LNG for the design life (30 years) of the Project. Restoring these features after that timeframe will not generate practicable credit.

3.3. Practicability of Results being Ecologically Self-Sustaining

Beyond the lack of appropriate and practicable opportunities, the difficulty and risk associated with wetlands restoration on the ACP that will provide the required functional uplift and necessary credits to offset debits makes this option impracticable. This is especially true, given the likelihood of long-term continual maintenance and adaptive management strategies currently required for restoration. However, the funding of VSW project(s) is readily available and "wastewater treatment" is specifically mentioned as a mitigation option in the joint USACE/EPA Mitigation MOA for Alaska..

Should the VSW program mitigation option not be approved, the Applicant proposes to protect Cape Halkett through a protection instrument acceptable to the Corps, similar to the instrument developed and approved for the GMT1 project. Generally, allowed uses in the protection instrument will relate to subsistence use and traditional use activities that do not result in altering the surface hydrology or wetlands function. Restricted uses will include, but are not limited to, construction of permanent structures, gravel fill for resource exploration pads and the like, and all-terrain vehicle (ATV) use that significantly disturbs the surface (i.e., ATVs and non-approved summer tundra travel). Winter snowmachine traveling will be allowed if ground conditions could support that mode of travel. The Applicant will work with ASRC to develop instrument stipulations to meet the intent of wetlands preservation commitments and ASRC will then manage access accordingly.

A copy of the final protection instrument will be provided to the USACE when it is recorded. The Applicant will provide an example of the protection instrument acceptable to the Corps in the Final Wetlands Compensatory Mitigation Plan.

The Applicant proposes to continue working with the USACE to explore options for mitigation through preservation as an alternative to funding a project(s) under the VSW Program to offset unavoidable substantive impacts to wetlands on the North Slope where no mitigation bank or ILF service areas exist (for southcentral and interior Alaska, the use of approved mitigation banks and/or ILFs is proposed where debits / credits exist within established service areas).

4. ALASKA LNG BASELINE INFORMATION

4.1.1. Northern Ecoregion

Alaska LNG Project impacts occurring in the Northern Ecoregion requiring mitigation are restricted to freshwater wetlands (marine / estuarine excluded) on the ACP in the degraded Prudhoe Bay – Frontal Beaufort Sea watershed, and wetlands within 500 feet of salmon-bearing stream crossings. Based on multiple years of wetlands mapping and PJD data from the USACE, the Applicant determined that Alaska LNG construction in the Northern Ecoregion will require compensatory mitigation to offset impacts to 89.23 acres of depressional wetlands, 1.00 acre of riverine wetlands, 0.61 acres of lacustrine fringe wetlands, 367.81 acres of organic soil flat wetlands, and 0.06 acres of mineral soil flat wetlands.

Palustrine wetlands in the ACP are composed of emergent sedges and grasses, such as cotton grass and water sedge, as well as dwarf shrubs, including dwarf birch and various willows. Widespread coverage of mosses and lichens also exists. The area is underlain by continuous permafrost with an active layer to approximately 3 feet below ground surface. Soils are primarily histosols and histic epipedons, with some hydric mineral soils located in dryer areas. Wetland hydrology is dominated by saturated soils conditions with seasonally and permanently inundated inclusions.

The Applicant utilized the recent USACE Operational Draft Regional Guidebook for the Rapid Assessment of Wetlands in the North Slope Region of Alaska (USACE 2017) and the Alaska District's Credit-Debit Methodology (USACE 2016) to determine the Alaska LNG Project debits. This methodology was used in the USACE-approved Wetlands CMP for the Applicant's Alaska Stand Alone Pipeline (ASAP) Project (the Applicant 2018), as described in a final Supplemental Environmental Impact Statement (SEIS) (USACE 2018). A copy of the assessment worksheets is located in Appendix B. Table 5, below, summarizes the pre- and post-Project FCI and debits incurred by the Alaska LNG Project utilizing the USACE methodologies. It describes the impacts and debits by Wetland Assessment Area (WAA) and wetlands HGM Class per the USACE methodology. The functional assessment performed for the ACP wetlands impacts indicates the wetlands have experienced significant anthropogenic impacts from local industrial development.

Table 5. North Slope Debit Analysis

WAA	Average FCI Score Pre Project	Average FCI Score Post Project	Hectares of Impact	Debit
WAA1	0.92	0.00	29.39	27.04
WAA2	0.88	0.00	128.36	112.96
WAA3	0.93	0.00	0.07	0.07
WAA4	0.52	0.00	3.99	2.07
		Totals	**161.81**	**142.14**

4.1.2. Interior Ecoregion

The Interior Ecoregion extends from Atigun Pass, southward to Broad Pass near Cantwell, Alaska. Major ecological and land features in this region include the Yukon River and Denali National Park. The Alaska LNG Fairbanks Lateral also extends to the City of Fairbanks from a Mainline intersection point just east of the Minto Flats. Alaska LNG Project impacts occurring in the Interior Ecoregion requiring mitigation are restricted to degraded watersheds between the Brooks Range and Alaska Range, as well as wetlands occurring within 500 feet of salmon-bearing stream crossings. Based on multiple years of wetlands mapping and PJD data from the USACE, the Applicant determined that Alaska LNG construction in the Interior Ecoregion will result in impacts to 15.03 acres of depressional wetlands, 12.53 acres of riverine wetlands, 72.10 acres of organic soil flat wetlands, 0.90 acres of mineral soil flat wetlands, and 11.03 acres of slope wetlands.

The Interior Ecoregion's palustrine wetlands in the degraded watersheds are made up primarily of flat HGM class wetlands, along with slope and depressional HGM class wetlands. Riverine systems are made up of upper and lower perennial rivers and intermittent streams.

Interior wetlands are composed of predominately palustrine scrub shrub wetlands that consist of willows, dwarf birch and stunted black spruce. Forested wetlands are made up primarily of taller black spruce. The Interior has wide spread palustrine emergent wetlands and forested wetlands composed of sedge, forbes and grasses.

Soils in the Interior Ecoregion are primarily composed of histic epipedons and hydric mineral soils. Histosols are abundant in muskeg wetlands in low lying areas of Minto Flats and the Nenana River Basin. Many Slope wetlands are located along the south side of the Brooks Range leading to the Yukon River, the major drainage feature dominating the Interior Ecoregion.

The Applicant will perform the required debit calculation and submit it to the Corps of Engineers for review and approval prior to final credit purchase and before project impacts requiring compensatory mitigation occur in the Interior Ecoregion.

4.1.3. Southcentral Ecoregion

The Southcentral Ecoregion extends from Broad Pass near Cantwell, Alaska to the Alaska LNG terminus at Nikiski, Alaska. The major ecological and land features in the Southcentral Ecoregion include the Chulitna River Susitna River, and numerous other salmon-bearing streams feeding these major rivers. Alaska LNG Project impacts occurring in the Southcentral Ecoregion requiring mitigation are restricted to freshwater wetlands (marine / estuarine excluded) in degraded watersheds between the Alaska Range and Cook Inlet and wetlands occurring within 500 feet of salmon-bearing stream crossings. Based on multiple years of wetlands mapping and PJD data from the USACE, the Applicant determined that Alaska LNG construction in the Southcentral Ecoregion will result in impacts to 15.03 acres of depressional wetlands, 24.68 acres of riverine wetlands, less than 0.01 acres of lacustrine fringe wetlands, 13.88 acres of organic soil flat wetlands, 0.90 acres of mineral soil flat wetlands, and 23.55 acres of slope wetlands.

The palustrine wetlands are made up primarily of flat HGM class wetlands, followed by depressional and slope HGM class wetlands. Riverine systems are made up of upper and lower perennial rivers and intermittent streams. Southcentral wetlands are comprised of palustrine scrub shrub wetlands made up of willows, dwarf birch and stunted black spruce. Forested wetlands are made up primarily of taller black spruce. The Southcentral Ecoregion has wide spread palustrine emergent wetlands and forested wetlands composed of sedge, forbes and grasses.

Wetland soils in the Southcentral Ecoregion are primarily composed of histic epipedons and hydric mineral soils. Histosols are abundant in muskeg wetlands in low lying areas of the Susitna River and Talkeetna, Alaska. Some slope wetlands are located near Talkeetna and south of Broad Pass, leading to the Susitna River, the major drainage feature dominating the Southcentral Ecoregion.

The Applicant will perform the required debit calculation and submit it to the Corps of Engineers for review and approval prior to final credit purchase and before project impacts requiring compensatory mitigation occur in the Southcentral Ecoregion.

5. DETERMINATION OF CREDITS

5.1. Permittee Responsible Mitigation (PRM)

5.1.1. PRM Site Baseline Information

As a form of PRM providing funds to ADEC for the VSW program would work similar to providing funds to an ILF Sponsor. ADEC would then use the funds for a project on the Priority List under the VSW Program. The Applicant can provide a project-specific plan for typical wastewater treatment facility installation or upgrade. Many remote Alaska villages are located within or adjacent to waters of the US, including wetlands. For example, Kivalina is located on a barrier island north of Kotzebue. The island is undergoing shoreline erosion which may cause the village to move to another location near the coast but on the mainland. Kivalina is located in a coastal area of low topographic relief, consisting of gentle sloping, rubble covered hills separated by broad expanses of tundra. The island is located between a lagoon at the mouth of the Kivalina River and the Chukchi Sea. The island is comprised of riverine and marine sediments made up mostly of gravel and sands on the beaches with ice-rich frozen silts farther inland. Kivalina is located in an area of discontinuous permafrost.

The alternative (back-up) PRM site is located in the ACP and made up of pristine palustrine emergent wetlands with saturated- to permanently-flooded hydrologic conditions. The underlying soils are histosols and histic epipedons within the active zone of continuous permafrost. The Cape Halkett wetlands have an HGM class of flat and depression that are similar, and of a greater FCI, than the wetlands impacted by the Alaska LNG project.

The formal aquatic site assessment[6] and credit determination for Cape Halkett will be completed once a site is selected and included in the Final Wetlands Compensatory Mitigation Plan. The Applicant will utilize the USACE North Slope Rapid Assessment method used for the Alaska LNG impacts. As mentioned above, the Cape Halkett wetlands are not impacted by anthropogenic development of any kind; therefore, their FCI score will be 1.0. The preservation mitigation will effectively offset the Alaska LNG debits (Table 5).

The Applicant will utilize approved third party providers for the Interior and Southcentral Ecoregions. The Applicant will utilize each third party's methodology that was used to define their credits to determine the number of debits produced by the Alaska LNG impacts requiring compensation (Table 1 and 2);

[6] An assessment of wetland functions under preconstruction conditions will be performed, as needed and in accordance with appropriate methodology, to evaluate the value of wetlands.

therefore, a credit determination is not necessary. The debit determination for Alaska LNG will suffice for requesting the appropriate credits from the third party providers. That debit determination will be completed and submitted to the Corps of Engineers for review and approval prior to purchasing the credits from the third party.

6. MITIGATION WORK PLAN

The Applicant will use a phased compensatory mitigation approach in which mitigation funding will be directed to a third party holder and will be dispersed on an annual basis in accordance with expected wetland impacts for the upcoming year (phased mitigation). Under this approach, the Applicant will distribute the necessary funds to ADEC for the VSW Program for the Northern Ecoregion and approved mitigation banks or ILFs for the Interior and Southcentral Ecoregions to offset those impacts prior to construction.

If funding the VSW Program is not viable and preservation is selected for the Northern Ecoregion, then prior to construction, the Applicant will provide the USACE a copy of the executed restriction with the landowner for the PRM. If the Fund is viable and preferred, the USACE will verify funding with the approved third party holder prior to construction. For the Interior and Southcentral Ecoregions, copies of contracts with third party providers (i.e., approved mitigation banks or ILFs) indicating the Applicant and the third party providers' commitment to providing and securing the appropriate credits necessary to offset Alaska LNG wetlands compensatory mitigation requirements will be provided prior to construction. At that time, the Applicant will also provide an updated early works and Project construction schedule indicating when final credits are expected to be purchased based on the timing of construction in each particular phase. The schedule will be updated if the annual construction plan changes significantly. The Applicant will provide the USACE with a copy of the sales receipt for the credits prior to placing dredged or fill material related to each phase of construction. In the event significant changes in mitigation options occur prior to commencement of construction (e.g., if the ASRC / UIC parcel and protection instrument are no longer available, or new approved third party mitigation options become available, etc.), the Applicant will provide an option for equivalent alternative mitigation. Regardless of the option used, all necessary credits would be secured prior to construction in each phase.

7. MAINTENANCE PLAN

ADEC reports on funding sources and dollars spent on VSW projects annually. Once constructed, ADEC turns the VSW project over to the village for maintenance. Tanana Bank and SuKnik maintenance plans have already been approved in their respective third party instruments.

If preservation is used as mitigation and due to their remote nature, maintenance is not expected for the Cape Halkett or Utqiagvik preservation parcel on the ACP. Any maintenance will be part of adaptive management, if necessary.

8. PERFORMANCE STANDARDS

The performance standards for the VSW Program are stated in the construction design template and documented in other forms that ADEC keeps on file. The project upon completion is turned over to the village with a plan for charging a recommended user fee to help maintain the treatment facility. Once the funds are distributed to ADEC, the Applicant will rely on the state agency and the project proponent to keep the necessary records. Similarly, for the Interior and Southern Ecoregions mitigation banks and ILF sponsors would keep their own records.

If preservation is chosen as compensatory mitigation in the Northern Ecoregion, the Cape Halkett and Utqiagvik parcel preservation will be considered achieved when a conservation easement is secured and monitoring confirms the FCI for the parcel is stable and reflects the same or better overall FCI, determined from the desktop analysis. In addition, the performance standards related to the permanent protection instrument (i.e., conservation easement) will be considered achieved once it is determined through monitoring that only allowed uses under the instrument are occurring at the parcel. The schedule for meeting the performance standards is based on the decision points defined in the monitoring plan, below. Performance standards for the third party provider credits are approved as part of their operating instrument.

9. MONITORING PLAN

The Applicant will rely on ADEC or the third party provider (i.e., mitigation bank or ILF) to meet USACE requirements for monitoring. The Applicant is not responsible for monitoring on third party provider parcels that have an approved operating instrument.

If preservation is used, the Applicant will work with the USACE, as necessary, to develop a final approved monitoring plan prior to final parcel preservation and execution of the protection instrument acceptable to the Corps (e.g., signing of a deed restriction or other instrument). It is anticipated the plan will involve ground-truthed investigations on a periodic basis that will investigate specific pre-selected data points for wetlands composition and functional capacity. Functional capacity will be determined using the current USACE methodology.

Monitoring will be conducted in the first year after the executed protection instrument, and will include additional monitoring events at Years 5, 10, and 20. The monitoring plan will include decision points at Years 5 and 10 that determine if further monitoring is necessary and whether or not the performance standards have been achieved. With USACE concurrence on the Applicant's determination, monitoring will either cease, or will continue at the next scheduled event, unless adaptive management becomes necessary. Monitoring will occur in the summer of each monitoring year and a report of findings will be provided to the USACE by December 31st of each monitoring year.

10. LONG-TERM MANAGEMENT

Long-term management of VSW projects (i.e., wastewater treatment facilities) is included in the agreement between the project proponent and ADEC and is not the responsibility of the Applicant. Long-term management of third party parcels (i.e., mitigation bank or ILF lands) is included in the approved operating instrument and is not the responsibility of the Applicant.

ASRC and UIC are the landowners of the parent parcels within which the proposed preservation (back-up option) would occur (i.e., placement of a conservation easement on a specific parcel). Long-term management of the parcel and adherence to requirements in the approved protection instrument will be the responsibility of the landowner (ASRC / UIC). However, the Applicant will enter into an agreement with the landowner to verify the management objectives are being achieved (e.g., monitoring).

11. ADAPTIVE MANAGEMENT

Adaptive management is not the responsibility of the Applicant on third party provider parcels (i.e., mitigation bank or ILF lands). Likewise, adaptive management is not the responsibility of the Applicant for projects funded under the VSW Program.

Adaptive management would be required for the selected land at Cape Halkett or Utqiagvik as part of PRM if the performance standards are not being achieved by Year 5 of monitoring, or if anything other than allowed uses are found to occur on the parcel. A specific adaptive management plan will be developed, if necessary. Adaptive management could include, but is not limited to, placing protective fencing, more frequent monitoring, seeding, or restoring damaged tundra. In the event adaptive management is needed, the Applicant will develop the adaptive management plan in coordination with the landowner.

12. FINANCIAL ASSURANCE

The Applicant will provide proof of transfer of funds to ADEC for the VSW Program for the North Slope Credits and secure third party credits for the Interior and Southcentral Ecoregion credits prior to initiating construction of project features requiring compensatory mitigation under conditions noted in this plan. The Applicant is an independent public corporation of the State of Alaska, but has a legal existence independent of and separate from the state. Under AS 31.25.080(a), the Applicant may enter into agreements. A pledge that Applicant makes of its corporate assets or revenue to the payment of an obligation is valid and binding on the Applicant (AS 31.25.180), and expenses that it incurs are paid from its own revenues and assets (AS 31.25.240).

13. REFERENCES

Alaska Gasline Development Corporation (Applicant). 2016. AKLNG Stream Crossing Mode Determination Tree. Produced by WorleyParsons. Document Numbers USAP-WP-GLZZZ-00-000001-000 and AKLNG-4020-GGG-LIS-DOC-00001. 53pp.

Applicant. 2018. ASAP Wetlands Compensatory Mitigation Plan. Alaska Stand Alone Pipeline Project. ASAP-22-PLN-REG-DOC-00003. Transmitted as final to USACE on September 13, 2018. Approved by USACE through USACE Record of Decision, 2019.

Alaska Department of Fish and Game. 2005. Streambank Revegetation and Protection: A Guide for Alaska. http://www.adfg.alaska.gov/index.cfm?adfg=streambankprotection.main. Accessed on April 30th, 2018.

Baker, M. E., and King, R. S. 2010. A New Method for Detecting and Interpreting Biodiversity and Ecological Community Thresholds. Methods in Ecology and Evolution 1:25-37.

Booth, D. 1991. Urbanization and the Natural Drainage System - Impacts, Solutions and Prognoses. Northwest Environmental Journal. 7(1): 93-118.

Booth, D.B. and Jackson C.R. 1997. Urbanization of Aquatic Systems: Degradation Thresholds, Stormwater Detection, and the Limits of Mitigation. Paper No. 96163 of the Journal of the American Water Resources Association. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1752-1688.1997.tb04126.x. Accessed on April 30th, 2018.

Booth, D.B, Montgomery, D. R., and Bethel, J. 1996. Large Woody Debris in Urban Streams of the Pacific Northwest. In: Effects of Watershed Development and Management on Aquatic Ecosystems, L.A. Roesner (Editor). Engineering Foundation Conference Proceedings, Snowbird, Utah, August 4-9, 1996. Pp. 178-197.

Federal Energy Regulatory Commission (FERC). Alaska LNG Draft Environmental Impact Statement. February 2019.

Hicks, A.L. and J.S. Larson. 1997. The Impact of Urban Stormwater Runoff on Freshwater Wetlands and the Role of Aquatic Invertebrate Bioassessment. The Environment Institute, University of Massachusetts. Amherst, MA.

Hilderbrand, R.H., R.M. Utz, S.A. Stranko, and R.L. Raesly. 2010. Applying Thresholds to Forecast Potential Biodiversity Loss from Human Development. Journal of the North American Benthological Society 29(3):1009-1016.

Jones, R. and C. Clark. 1987. Impact of Watershed Urbanization on Stream Insect Communities. American Water Resources Association. Water Resources Bulletin. 15(4).

Klein, R. 1979. Urbanization and Stream Quality Impairment. Water Resources Bulletin 15:948-963.

Limburg, K and R. Schmidt. 1990. Patterns of Fish Spawning in Hudson River Tributaries – Response to an Urban Gradient? Ecology 71(4): 1231-1245.

Luchetti, G and R. Fuersteburg, 1993. Relative Fish Use in Urban and Non-urban streams. Proceedings. Conference on Wild Salmon. Vancouver, British Columbia.

Marsh, L.L., Porter, D.R., and Salveson, D.A. (Eds.). 1996. Mitigation Banking: Theory and Practice. Washington, DC: Island Press.

May, C. R. Horner, J. Karr, B. Mar, and E. Welch. 1997. Effects of urbanization on small streams in the Puget Sound Lowland Ecoregion. Watershed Protection Techniques 2(4): 483-494.

Metropolitan Washington Council of Governments (MWCOG), 1992. Watershed Restoration Sourcebook. Department of Environmental Programs, MWCOG, Washington, DC.

Schueler, T. R., Fraley-McNeal, L., and Cappiella, K. 2009. Is Impervious Cover Still Important? Review of Recent Research. Journal of Hydrologic Engineering 14:309-315.

Steedman, R. J. 1988. Modification and Assessment of an Index of Biotic Integrity to Quantify Stream Quality in Southern Ontario. Canadian Journal of Fisheries and Aquatic Sciences. 45:492-501.

USACE. 2016. Alaska District: Credit Debit Methodology. Version 1.0. Available online at: http://www.poa.usace.army.mil/Portals/34/docs/regulatory/specialpns/2016/_Alaska%20District%20Credit%20Debit%20Methodology%20Version%201.pdf?ver=2016-09-21-132006-233

USACE. 2017. Operational Draft Regional Guidebook for the Rapid Assessment of Wetlands in the North Slope Region of Alaska. http://www.poa.usace.army.mil/Portals/34/docs/regulatory/specialpns/SPN-2017-484_SPN_.pdf?ver=2017-10-02-161948-843. Accessed on April 30th, 2018.

USACE. 2018. Alaska Stand Alone Pipeline (ASAP) Final Supplemental Environmental Impact Statement. June 22.

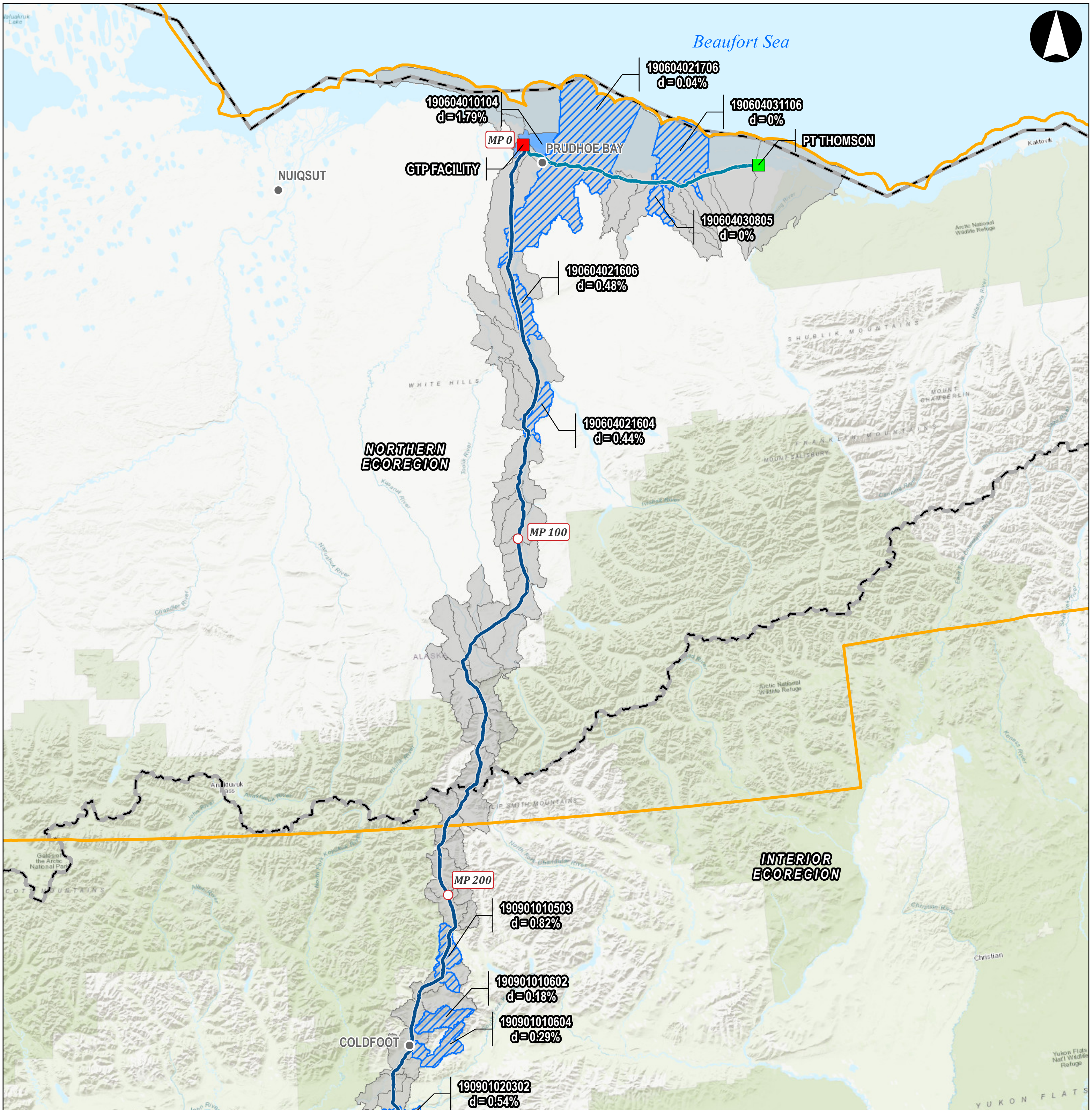
USACE and EPA. 2018. Memorandum of Agreement Between the Department of the Army and the Environmental Protection Agency Concerning Mitigation Sequence for Wetlands in Alaska Under Section 404 of the Clean Water Act.

Utz, R. M., Hilderbrand, R. H., and Boward, D. M. 2009. Identifying Regional Differences in Threshold Responses of Aquatic Invertebrates to Land Cover Gradients. Ecological Indicators 9:556-567.

Weaver, L.A. 1991. Low-Intensity Watershed Alteration Effects on Fish Assemblage Structure and Function in a Virginia Piedmont Stream. Unpub. M.S. Thesis. Virginia Commonwealth University. 77 pp.

APPENDIX A

HUC-12 Mapping



VICINITY MAP

ALASKA LNG PROJECT

HUC12 Watershed Condition and Wetland Mitigation Service Areas

- Project Facility
- Existing Facility
- Alaska LNG Rev D Route
- PTTL Rev D Route
- Ecoregion

d = "delta" or difference between pre- and post-project disturbance to HUC12 watershed

HUC12 Conpensatory Mitigation Required

Post-Project Watershed Condition

- USACE Undegraded (<5% Disturbed)
- USACE Degraded (>=5% Disturbed)

Permanent Wetlands Impact within 500' of Salmon-Bearing Stream Crossing

- No
- Yes

Wetland Mitigation Service Area

- North Slope Borough
- Su-Knik 2013 Wetlands Bank
- Su-Knik HUC8 Watershed
- Su-Knik HUC6 Watershed
- Primary Tanana Flats
- Secondary Tanana Basin
- Great Land Trust

0 10 20 30 40 50 Miles

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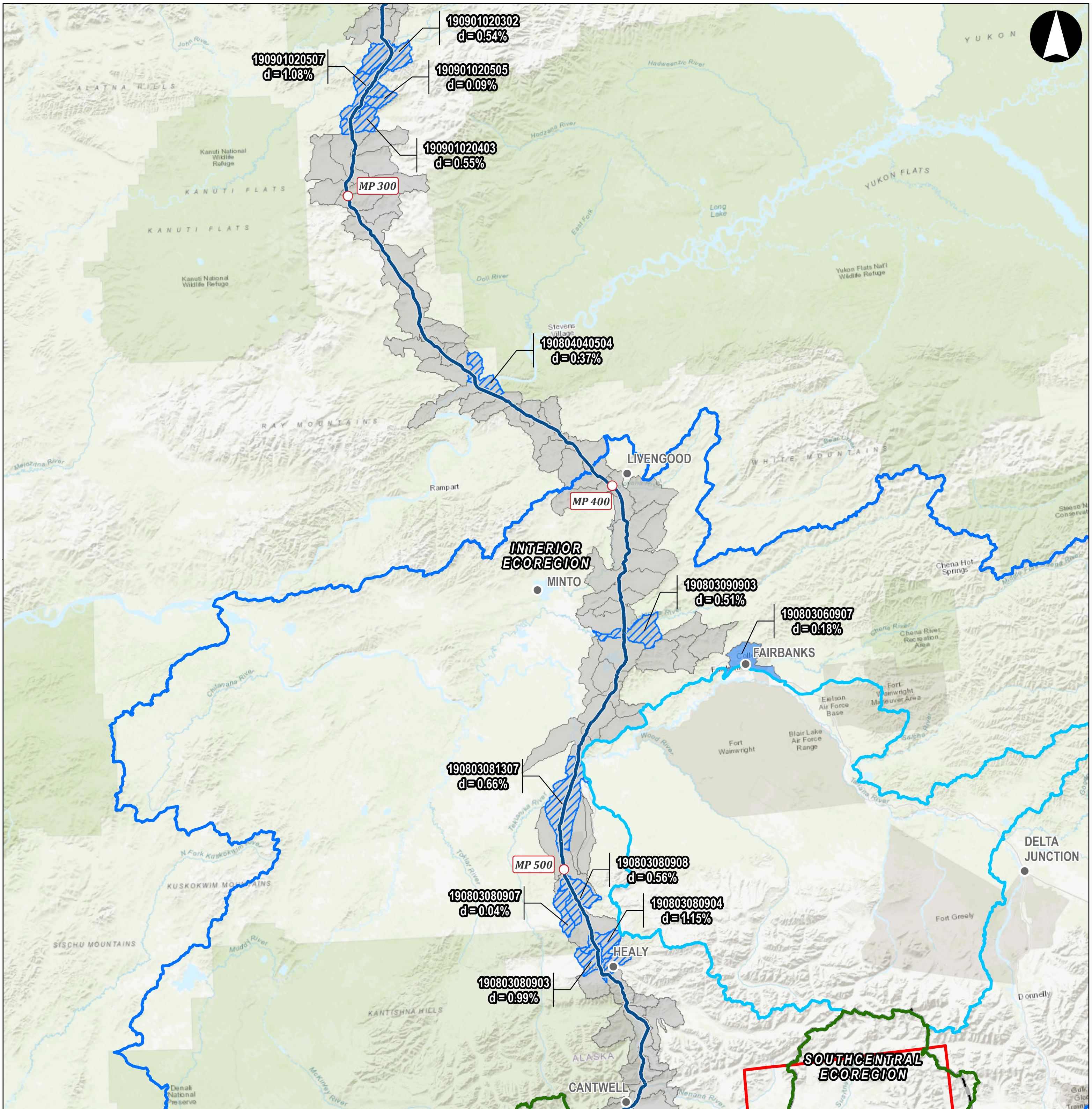

ALASKA LNG PROJECT

HUC12 Watershed Condition and Wetland Mitigation Service Areas

- Project Facility
- Existing Facility
- Alaska LNG Rev D Route
- PTTL Rev D Route
- Ecoregion

d = "delta" or difference between pre- and post-project disturbance to HUC12 watershed

HUC12 Conpensatory Mitigation Required Wetland Mitigation Service Area

Post-Project Watershed Condition
- USACE Undegraded (<5% Disturbed)
- USACE Degraded (>=5% Disturbed)

Permanent Wetlands Impact within 500' of Salmon-Bearing Stream Crossing
- No
- Yes

- North Slope Borough
- Su-Knik 2013 Wetlands Bank
- Su-Knik HUC8 Watershed
- Su-Knik HUC6 Watershed
- Primary Tanana Flats
- Secondary Tanana Basin
- Great Land Trust

0 10 20 30 40 50 Miles

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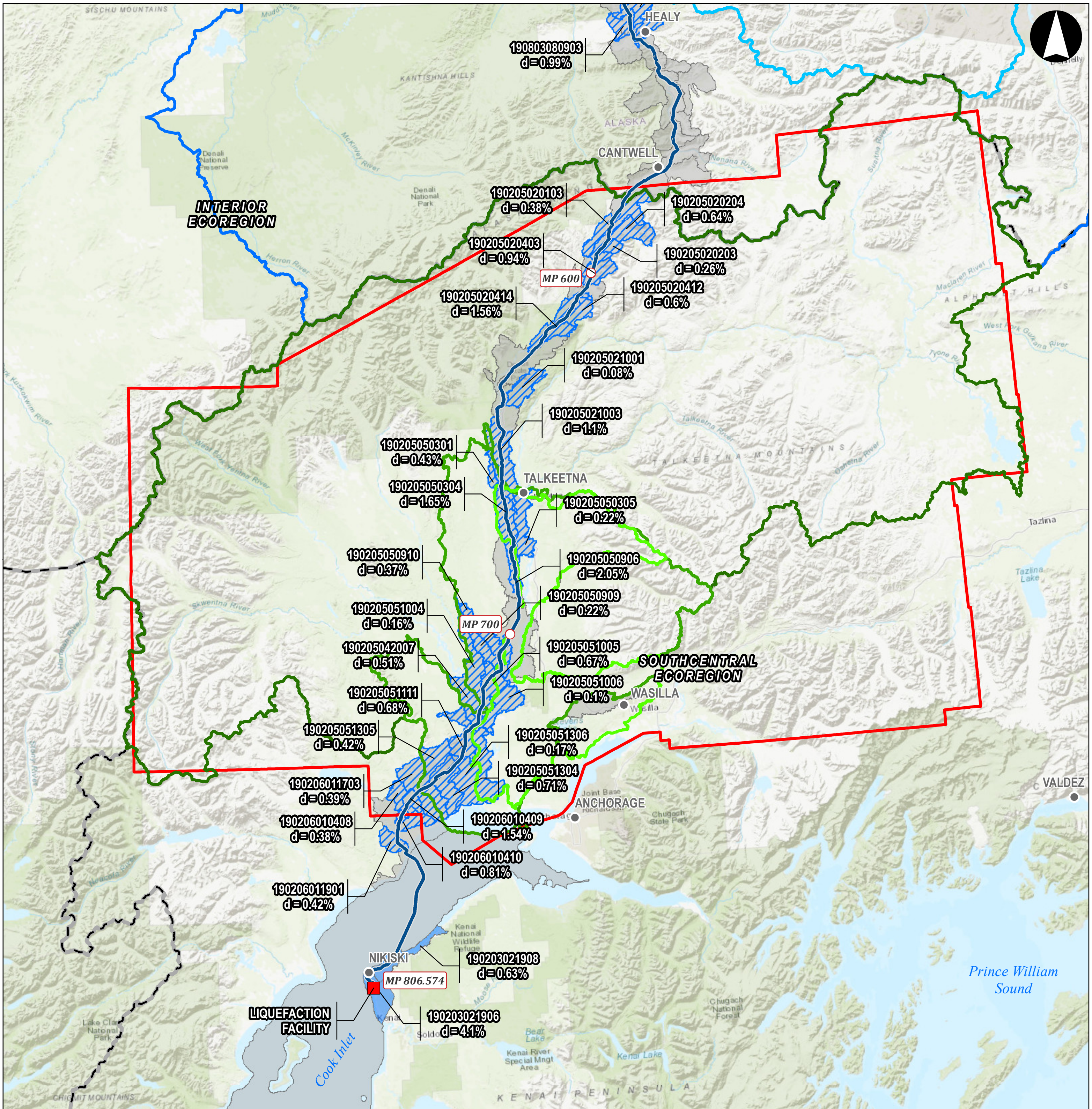

ALASKA LNG PROJECT

HUC12 Watershed Condition and Wetland Mitigation Service Areas

- Project Facility
- Existing Facility
- Alaska LNG Rev D Route
- PTTL Rev D Route
- Ecoregion

d = "delta" or difference between pre- and post-project disturbance to HUC12 watershed

HUC12 Conpensatory Mitigation Required

Post-Project Watershed Condition
- USACE Undegraded (<5% Disturbed)
- USACE Degraded (>=5% Disturbed)

Permanent Wetlands Impact within 500' of Salmon-Bearing Stream Crossing
- No
- Yes

0 10 20 30 40 50 Miles

Wetland Mitigation Service Area
- North Slope Borough
- Su-Knik 2013 Wetlands Bank
- Su-Knik HUC8 Watershed
- Su-Knik HUC6 Watershed
- Primary Tanana Flats
- Secondary Tanana Basin
- Great Land Trust

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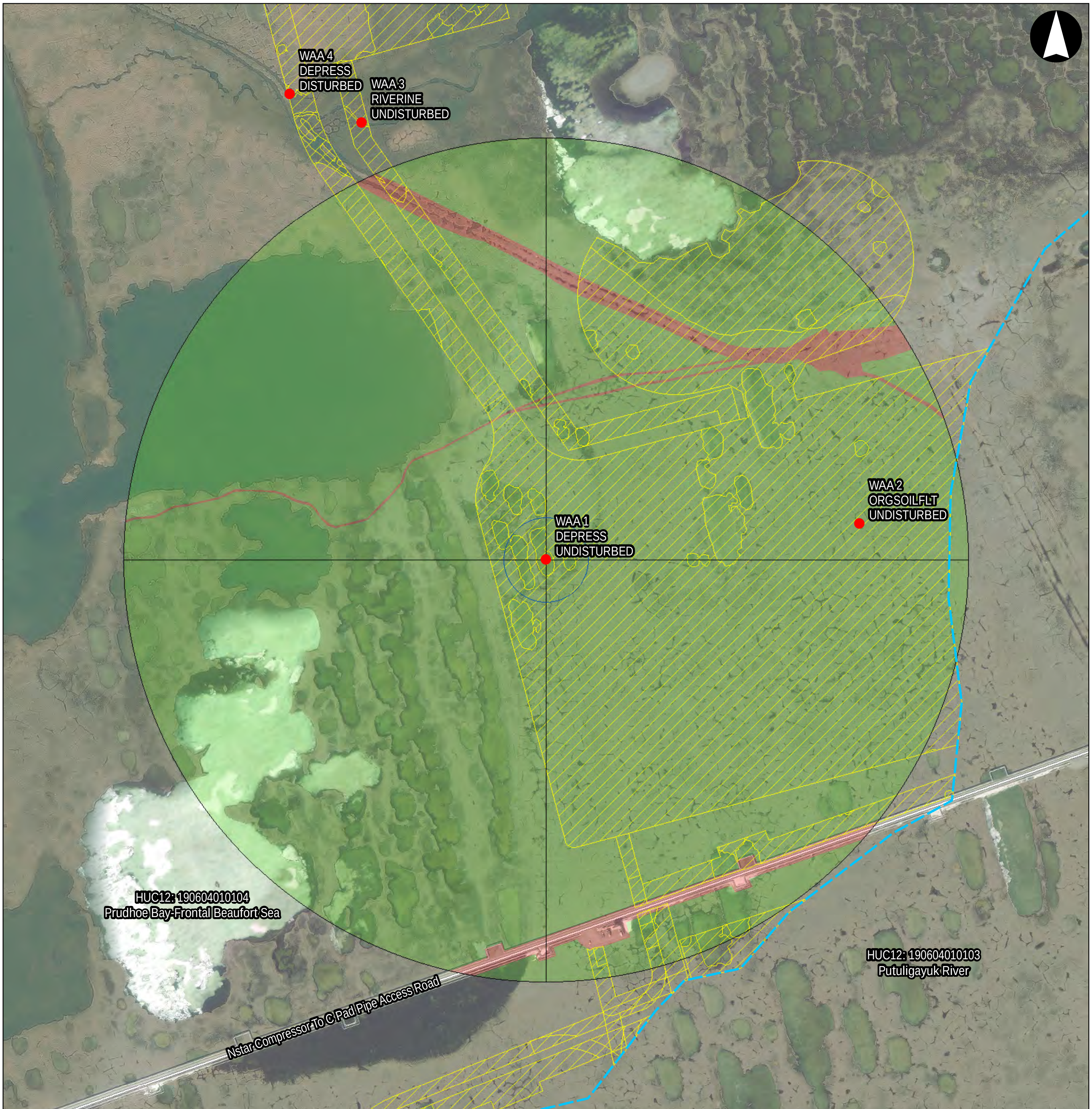
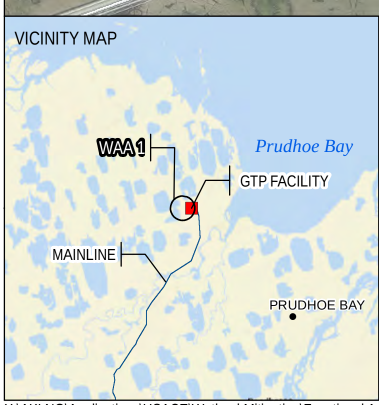
APPENDIX B

Wetland Assessments





ALASKA LNG PROJECT

Functional Assessment - WAA 1 800m

HUC12 Watershed Boundary

Alaska LNG Project Footprint Mitigation Area

Permanent Impact to Wetlands

Functional Assessment

Target

Target Quadrants (80m/800m)

Target Disturbance (80m/800m)

Disturbed

Undisturbed

Anthropogenic Water (80m)

No Water Present

0 100 200 300 Meters

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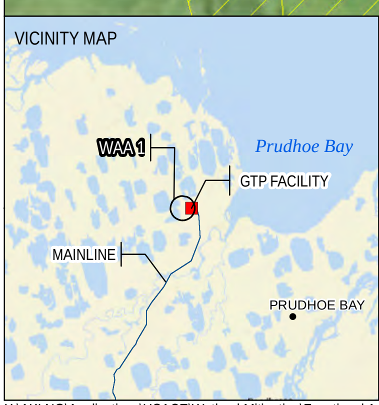

ALASKA LNG PROJECT

Functional Assessment - WAA 1 80m

HUC12 Watershed Boundary
Alaska LNG Project Footprint Mitigation Area
Permanent Impact to Wetlands
Functional Assessment
Target
Target Quadrants (80m/800m)
Target Disturbance (80m/800m)
Undisturbed
Anthropogenic Water (80m)
No Water Present

0 10 20 30 Meters

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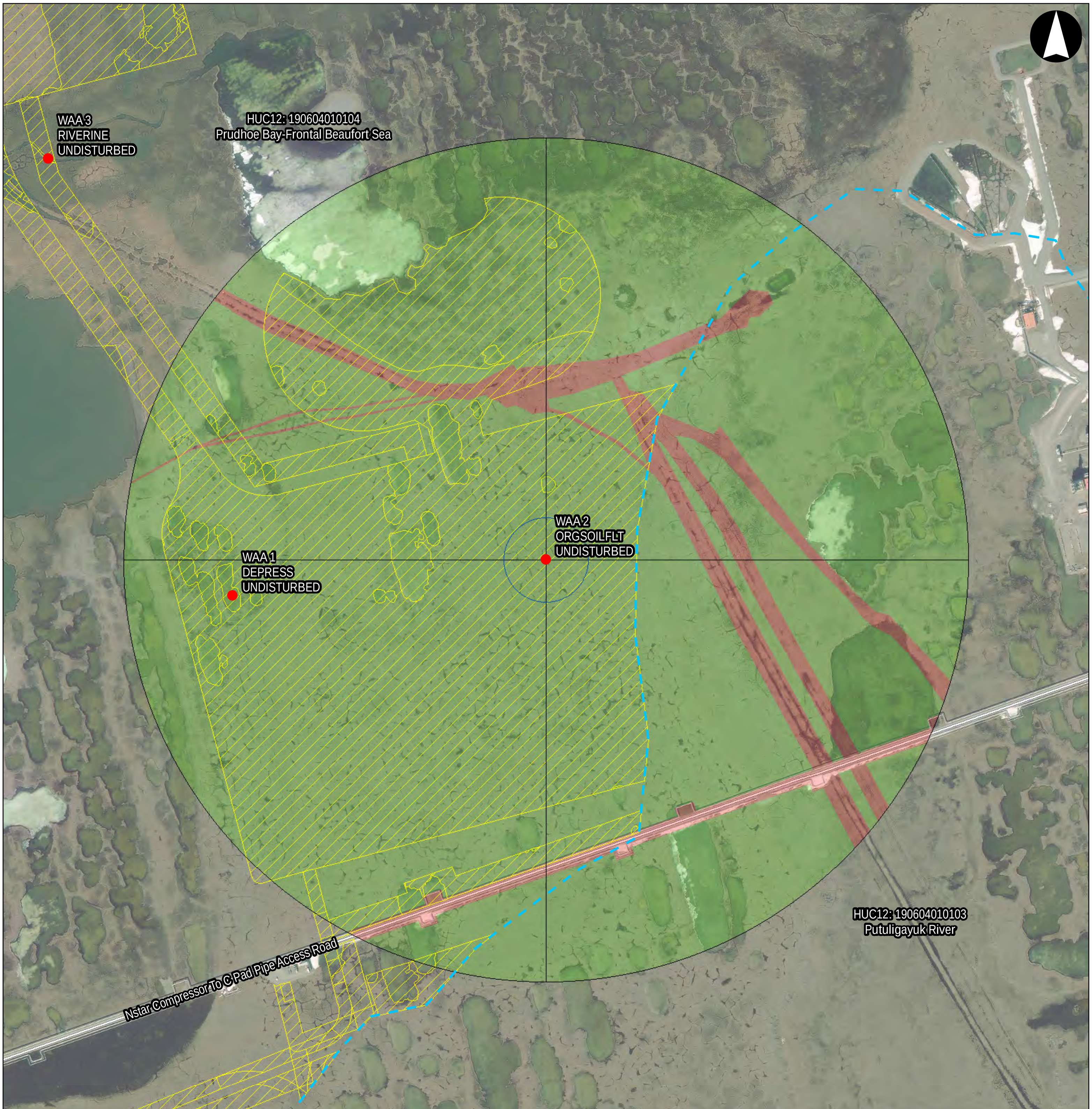

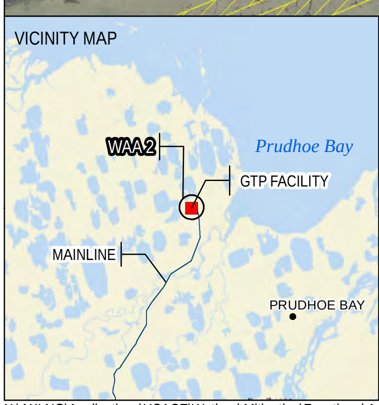

ALASKA LNG PROJECT

Functional Assessment - WAA 2 800m

HUC12 Watershed Boundary

Alaska LNG Project Footprint Mitigation Area

Permanent Impact to Wetlands

Functional Assessment

Target

Target Quadrants (80m/800m)

Target Disturbance (80m/800m)

Disturbed

Undisturbed

Anthropogenic Water (80m)

No Water Present

0 100 200 300 Meters

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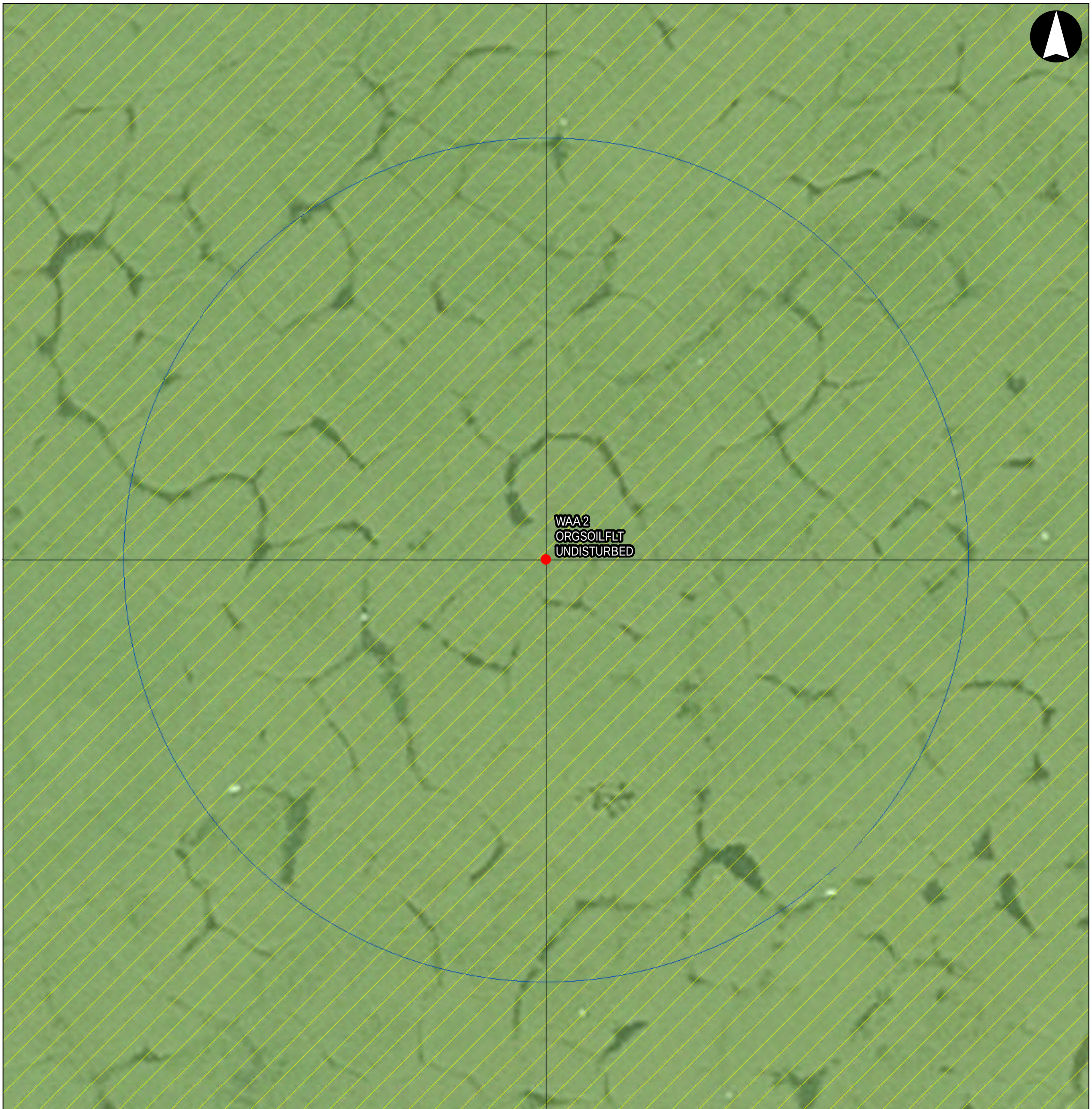

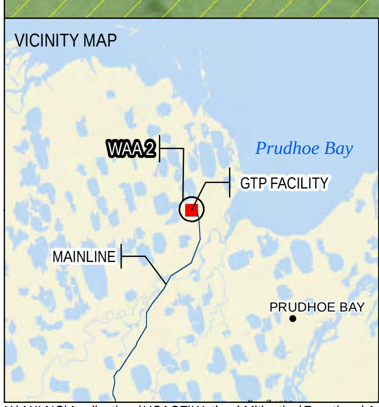

ALASKA LNG PROJECT

Functional Assessment - WAA 2 80m

HUC12 Watershed Boundary

Alaska LNG Project Footprint Mitigation Area

Permanent Impact to Wetlands

Functional Assessment

Target

Target Quadrants (80m/800m)

Target Disturbance (80m/800m)

Undisturbed

Anthropogenic Water (80m)

No Water Present

0 10 20 30 Meters

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DATE:	3/19/2019
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SHEET:	4 of 8

VICINITY MAP

ALASKA LNG PROJECT

Functional Assessment - WAA 3 800m

HUC12 Watershed Boundary

Alaska LNG Project Footprint Mitigation Area

Permanent Impact to Wetlands

Functional Assessment

Target

Target Quadrants (80m/800m)

Target Disturbance (80m/800m)

Disturbed

Undisturbed

Anthropogenic Water (80m)

Water Present

No Water Present

0 100 200 300 Meters

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SCALE:	1:10,000
SHEET:	5 of 8

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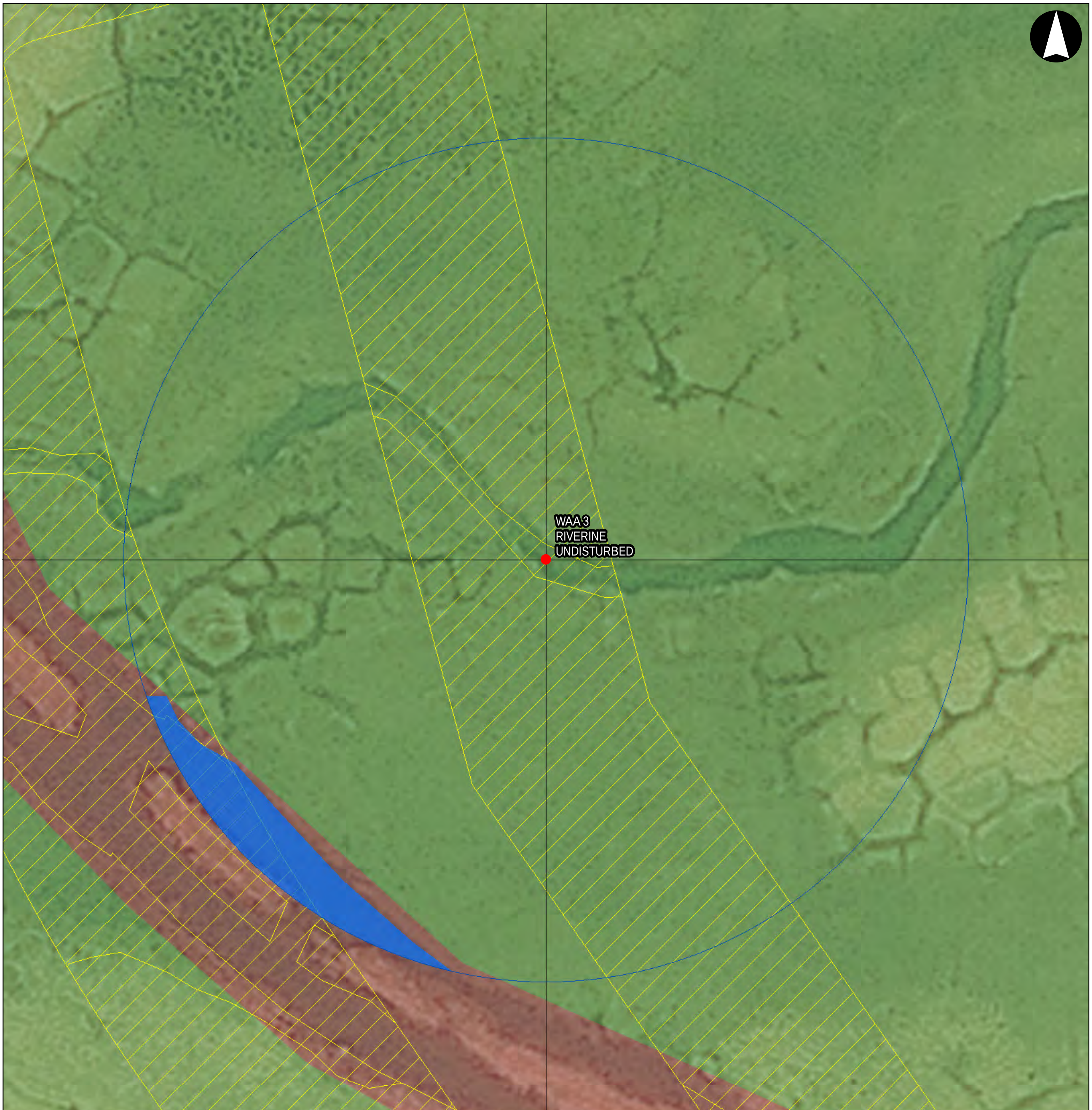

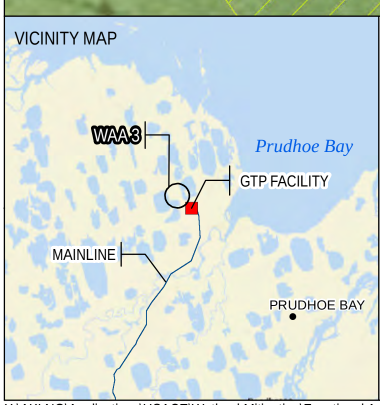

ALASKA LNG PROJECT

Functional Assessment - WAA 3 80m

HUC12 Watershed Boundary

Alaska LNG Project Footprint Mitigation Area

Permanent Impact to Wetlands

Functional Assessment

Target

Target Quadrants (80m/800m)

Target Disturbance (80m/800m)

Disturbed

Undisturbed

Anthropogenic Water (80m)

Water Present

No Water Present

0 10 20 30 Meters

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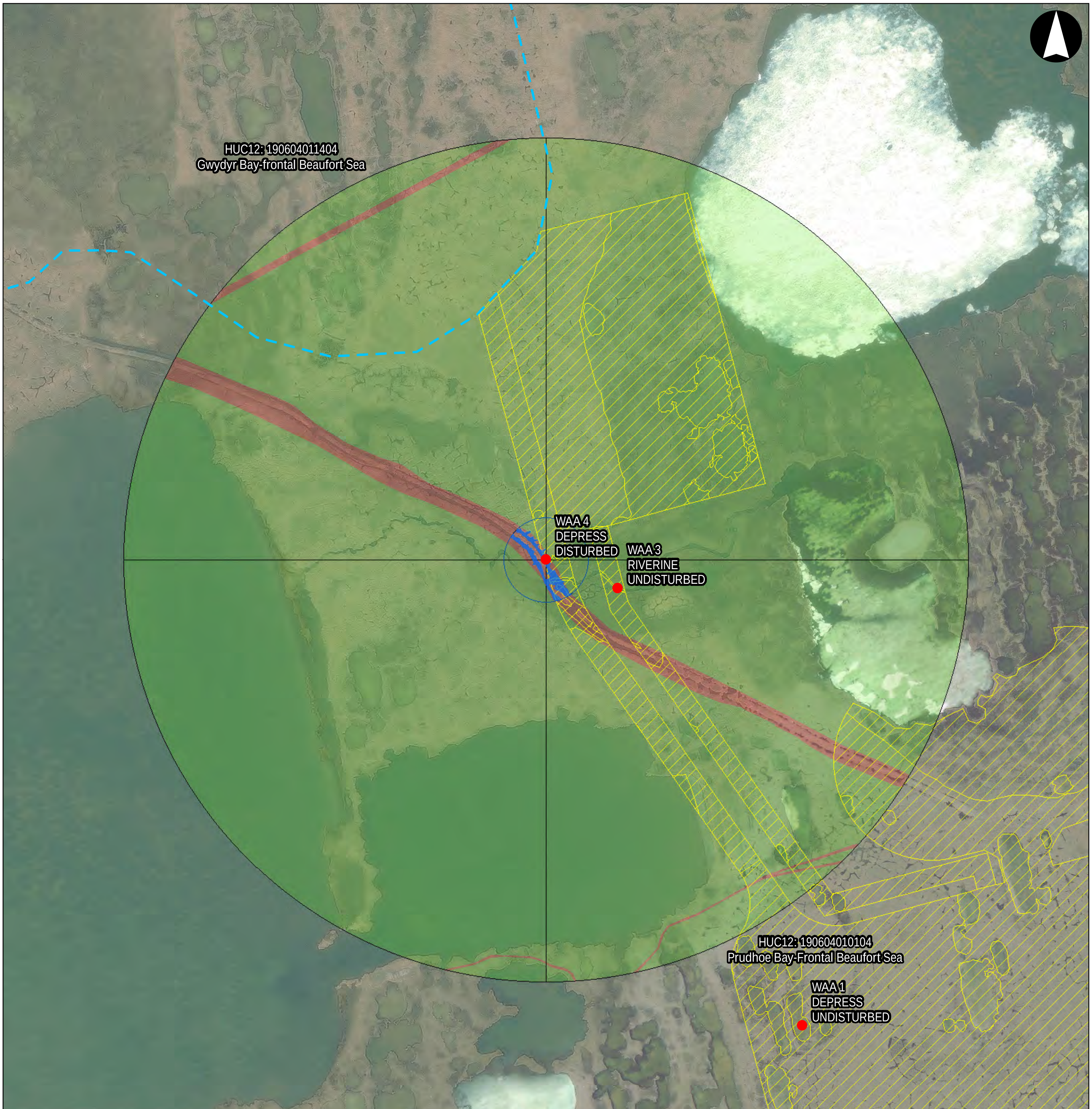
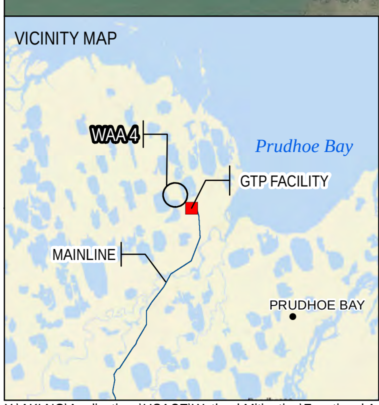
DATE:	3/19/2019
SCALE:	1:1,000
SHEET:	6 of 8





ALASKA LNG PROJECT

Functional Assessment - WAA 4 800m

HUC12 Watershed Boundary

Alaska LNG Project Footprint Mitigation Area

Permanent Impact to Wetlands

Functional Assessment

Target

Target Quadrants (80m/800m)

Target Disturbance (80m/800m)

Disturbed

Undisturbed

Anthropogenic Water (80m)

Water Present

No Water Present

0 100 200 300 Meters

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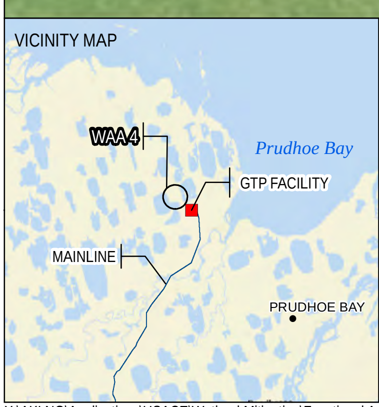
DOCUMENT ID:	Appendix B
DATE:	3/19/2019
SCALE:	1:10,000
SHEET:	7 of 8



ALASKA LNG PROJECT

Functional Assessment - WAA 4 80m

HUC12 Watershed Boundary
Alaska LNG Project Footprint Mitigation Area
Permanent Impact to Wetlands
Functional Assessment
Target
Target Quadrants (80m/800m)

Target Disturbance (80m/800m)
Disturbed
Undisturbed
Anthropogenic Water (80m)
Water Present
No Water Present

0 10 20 30 Meters

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DATE:	3/19/2019
SCALE:	1:1,000
SHEET:	8 of 8

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Rapid Assessment Score Summary						
Assessment Area	**Hectares**	**Habitat**	**Hydrology**	**Biogeochemical Cycling**	**On-site Modifier**	**Average**
WAA1	29.4	0.75	1.00	1.00		0.92
WAA2	128	0.73	0.98	0.93		0.88
WAA3	0.069	0.98	0.93	0.90		0.93
WAA4	3.99	0.70	0.60	0.28		0.52
WAA5		#REF!	#REF!	#REF!	#REF!	#REF!
WAA6		#REF!	#REF!	#REF!	#REF!	#REF!
WAA7		#REF!	#REF!	#REF!	#REF!	#REF!
WAA8		#REF!	#REF!	#REF!	#REF!	#REF!
WAA9		#REF!	#REF!	#REF!	#REF!	#REF!
WAA10		#REF!	#REF!	#REF!	#REF!	#REF!

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section A: Desk Top (Offsite) Data			
Site Name/Location:	WAA1	Latitude/UTM Northing:	70.3186542
Date:	3/20/2019	Longitude/UTM Easting:	-148.5680423
Impact/Mitigation:	Impact	Pre/Post:	Pre-Project
Region:	Arctic Coastal Plain	Coordinate System:	NAD83
HGM Class:	Depression	Imagery Source (Year):	AGDC 2013-2015
Investigator(s):	AGDC		

Determine values for variables 1-5 using an 80 meter radius plot.			
1	**V_{LLD}**	Local Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	0
		V_{LLD} Subindex Score	***1.00***
2	**V_{SW}**	Anthropogenically Derived Surface Water - percent of the plot (0 - 100) occupied by surface water derived from human activities, including thermokarst if directly associated, and conspicuously linked.	0
		V_{SW} Subindex Score	***1.00***
3	**V_{IH}**	Impediment to Hydrology - number of quarter segments (0 - 4) assignable in any direction that have hydrologic impediments.	0
		V_{IH} Subindex Score	***1.00***
4	**V_{DD}**	Evidence of Dust - accumulation of sediment on vegetation, appearing as areas of discoloration.	No
5	**V_{TK}**	Evidence of Thermokarst	No
Determine values for variables 6-8 using an 800 meter radius plot.			
6	**V_{LD}**	Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	4
		V_{LD} Subindex Score	***1.00***
7	**V_{IW}**	Impediment to Wildlife - number of quarter segments (0 - 4) assignable in any direction with impediments to the free movement of wildlife.	2
		V_{IW} Subindex Score	***0.50***
8	**V_{DR}**	Distance to Roadway - minimum distance in meters (0 - 800) to a roadway of any size, class, or condition.	684
		V_{DR} Subindex Score	***1.00***
		Habitat Assessment Score	***0.75***
		Hydrology Assessment Score	***1.00***
		Biogeochemical Cycling Assessment Score	***1.00***

Remarks

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section B: Onsite Data Collection			
Site Name/Location:	WAA1	Latitude/UTM Northing:	
Sampling Date:		Longitude/UTM Easting:	
Region:		Coordinate System:	

HGM Class:	Depression	Dominant Vegetation:	
Field Team:			

Determine values for the following variables:

1	V_{LDD}	Dust presence on vegetation within assessment area?	
2	V_{LTK}	Thermokarst features within assessment area?	
3	V_{MT}	Microtopography Sampling using two 30m transects situated in each cardinal direction from established plot center. Establish a level line above vegetation and record distance to ground level at 1m intervals.	

Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)		Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)
1		16			1		16	
2		17			2		17	
3		18			3		18	
4		19			4		19	
5		20			5		20	
6		21			6		21	
7		22			7		22	
8		23			8		23	
9		24			9		24	
10		25			10		25	
11		26			11		26	
12		27			12		27	
13		28			13		28	
14		29			14		29	
15		30			15		30	
Sum of Microtopography Variability:							***V_{MT} Subindex Score:***	

4 V_{SR}	**Species Richness** tally for vascular plants using 4 randomly assigned 1m^2 quadrats within each quadrant created from transect lines:		
Quadrat 1:		Quadrat 3:	
Quadrat 2:		Quadrat 4:	
Average Species Richness:		***V_{SR} Subindex Score:***	

5 V_{BG}	**Bare Ground** percent cover (0-100%) estimates using four randomly assigned 1m^2 quadrats within each transect quadrant:		
Quadrat 1:		Quadrat 3:	
Quadrat 2:		Quadrat 4:	
Average Bare Ground Percentage		***V_{BG} Subindex Score:***	

Site Notes/Remarks:	
On-Site Assessment Score	

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT		
Section C: Summary of Assessment Scores		
On-Site Variable Subindex Scores		
V_{MT}	Microtopography	
V_{SR}	Average species richness	
V_{BG}	Average percent bare ground	
V_{LDD}	Local evidence of dust deposition	
V_{LTK}	Local evidence of thermokarst	
Off-Site Variable Subindex Scores		
V_{LLD}	Local landscape disturbance	1.00
V_{SW}	Anthropogenically derived surface water	1.00
V_{IH}	Impediment to hydrology	1.00
V_{DD}	Evidence of dust	No
V_{LD}	Landscape disturbance	1.00
V_{IW}	Impediment to wildlife	0.50
V_{DR}	Distance to roadway	1.00
V_{TK}	Evidence of thermokarst	No
Assessment Scores		
	Habitat	***0.75***
	Hydrology	***1.00***
	Biogeochemical	***1.00***
	On-site Modifer	
	AVERAGE SCORE	***0.92***

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section A: Desk Top (Offsite) Data			
Site Name/Location:	WAA2	Latitude/UTM Northing:	70.31913997
Date:	3/20/2019	Longitude/UTM Easting:	-148.5522097
Impact/Mitigation:	Impact	Pre/Post:	Pre-Project
Region:	Arctic Coastal Plain	Coordinate System:	NAD83
HGM Class:	Flat	Imagery Source (Year):	AGDC 2013-2015
Investigator(s):	AGDC		

Determine values for variables 1-5 using an 80 meter radius plot.

1	V_{LLD}	Local Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	0
		V_{LLD} Subindex Score	***1.00***
2	V_{SW}	Anthropogenically Derived Surface Water - percent of the plot (0 - 100) occupied by surface water derived from human activities, including thermokarst if directly associated, and conspicuously linked.	0
		V_{SW} Subindex Score	***1.00***
3	V_{IH}	Impediment to Hydrology - number of quarter segments (0 - 4) assignable in any direction that have hydrologic impediments.	0
		V_{IH} Subindex Score	***1.00***
4	V_{DD}	Evidence of Dust - accumulation of sediment on vegetation, appearing as areas of discoloration.	No
5	V_{TK}	Evidence of Thermokarst	No

Determine values for variables 6-8 using an 800 meter radius plot.

6	V_{LD}	Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	8
		V_{LD} Subindex Score	***0.93***
7	V_{IW}	Impediment to Wildlife - number of quarter segments (0 - 4) assignable in any direction with impediments to the free movement of wildlife.	2
		V_{IW} Subindex Score	***0.50***
8	V_{DR}	Distance to Roadway - minimum distance in meters (0 - 800) to a roadway of any size, class, or condition.	551
		V_{DR} Subindex Score	***1.00***

Habitat Assessment Score	***0.73***
Hydrology Assessment Score	***0.98***
Biogeochemical Cycling Assessment Score	***0.93***

Remarks

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section B: Onsite Data Collection			
Site Name/Location:	WAA2	Latitude/UTM Northing:	
Sampling Date:		Longitude/UTM Easting:	
Region:		Coordinate System:	

HGM Class:	Flat	Dominant Vegetation:	
Field Team:			

Determine values for the following variables:

1	V_{LDD}	Dust presence on vegetation within assessment area?	
2	V_{LTK}	Thermokarst features within assessment area?	
3	V_{MT}	Microtopography Sampling using two 30m transects situated in each cardinal direction from established plot center. Establish a level line above vegetation and record distance to ground level at 1m intervals.	

Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)		Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)
1		16	24		1		16	
2		17			2		17	
3		18			3		18	
4		19			4		19	
5		20			5		20	
6		21			6		21	
7		22			7		22	
8		23			8		23	
9		24			9		24	
10		25			10		25	
11		26			11		26	
12		27			12		27	
13		28			13		28	
14		29			14		29	
15		30			15		30	
Sum of Microtopography Variability:					***V_{MT} Subindex Score:***			

4 V_{SR}	**Species Richness** tally for vascular plants using 4 randomly assigned $1m^2$ quadrats within each quadrant created from transect lines:			
Quadrat 1:			Quadrat 3:	
Quadrat 2:			Quadrat 4:	
Average Species Richness:			***V_{SR} Subindex Score:***	

5 V_{BG}	**Bare Ground** percent cover (0-100%) estimates using four randomly assigned $1m^2$ quadrats within each transect quadrant:			
Quadrat 1:			Quadrat 3:	
Quadrat 2:			Quadrat 4:	
Average Bare Ground Percentage			***V_{BG} Subindex Score:***	

Site Notes/Remarks:	
On-Site Assessment Score	

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT		
Section C: Summary of Assessment Scores		
On-Site Variable Subindex Scores		
V_{MT}	Microtopography	
V_{SR}	Average species richness	
V_{BG}	Average percent bare ground	
V_{LDD}	Local evidence of dust deposition	
V_{LTK}	Local evidence of thermokarst	
Off-Site Variable Subindex Scores		
V_{LLD}	Local landscape disturbance	1.00
V_{SW}	Anthropogenically derived surface water	1.00
V_{IH}	Impediment to hydrology	1.00
V_{DD}	Evidence of dust	No
V_{LD}	Landscape disturbance	0.93
V_{IW}	Impediment to wildlife	0.50
V_{DR}	Distance to roadway	1.00
V_{TK}	Evidence of thermokarst	No
Assessment Scores		
	Habitat	***0.73***
	Hydrology	***0.98***
	Biogeochemical	***0.93***
	On-site Modifer	
	AVERAGE SCORE	***0.88***

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section A: Desk Top (Offsite) Data			
Site Name/Location:	WAA3	Latitude/UTM Northing:	70.32615273
Date:	3/20/2019	Longitude/UTM Easting:	-148.5768161
Impact/Mitigation:	Impact	Pre/Post:	Pre-Project
Region:	Arctic Coastal Plain	Coordinate System:	NAD83
HGM Class:	Riverine	Imagery Source (Year):	AGDC 2013-2015
Investigator(s):	AGDC		

Determine values for variables 1-5 using an 80 meter radius plot.

1	V_{LLD}	Local Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	4
		V_{LLD} Subindex Score	***0.90***
2	V_{SW}	Anthropogenically Derived Surface Water - percent of the plot (0 - 100) occupied by surface water derived from human activities, including thermokarst if directly associated, and conspicuously linked.	3
		V_{SW} Subindex Score	***0.81***
3	V_{IH}	Impediment to Hydrology - number of quarter segments (0 - 4) assignable in any direction that have hydrologic impediments.	0
		V_{IH} Subindex Score	***1.00***
4	V_{DD}	Evidence of Dust - accumulation of sediment on vegetation, appearing as areas of discoloration.	No
5	V_{TK}	Evidence of Thermokarst	No

Determine values for variables 6-8 using an 800 meter radius plot.

6	V_{LD}	Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	3
		V_{LD} Subindex Score	***1.00***
7	V_{IW}	Impediment to Wildlife - number of quarter segments (0 - 4) assignable in any direction with impediments to the free movement of wildlife.	0
		V_{IW} Subindex Score	***1.00***
8	V_{DR}	Distance to Roadway - minimum distance in meters (0 - 800) to a roadway of any size, class, or condition.	800
		V_{DR} Subindex Score	***1.00***

Habitat Assessment Score	***0.98***
Hydrology Assessment Score	***0.93***
Biogeochemical Cycling Assessment Score	***0.90***

Remarks

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section B: Onsite Data Collection			
Site Name/Location:	WAA3	Latitude/UTM Northing:	
Sampling Date:		Longitude/UTM Easting:	
Region:		Coordinate System:	

HGM Class:	Riverine	Dominant Vegetation:	
Field Team:			

Determine values for the following variables:

1 V_{LDD}	Dust presence on vegetation within assessment area?	
2 V_{LTK}	Thermokarst features within assessment area?	
3 V_{MT}	Microtopography Sampling using two 30m transects situated in each cardinal direction from established plot center. Establish a level line above vegetation and record distance to ground level at 1m intervals.	

Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)		Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)
1		16	24		1		16	
2		17			2		17	
3		18			3		18	
4		19			4		19	
5		20			5		20	
6		21			6		21	
7		22			7		22	
8		23			8		23	
9		24			9		24	
10		25			10		25	
11		26			11		26	
12		27			12		27	
13		28			13		28	
14		29			14		29	
15		30			15		30	
Sum of Microtopography Variability:					***V_{MT} Subindex Score:***			

4 V_{SR}	**Species Richness** tally for vascular plants using 4 randomly assigned $1m^2$ quadrats within each quadrant created from transect lines:			
Quadrat 1:			Quadrat 3:	
Quadrat 2:			Quadrat 4:	
Average Species Richness:			***V_{SR} Subindex Score:***	

5 V_{BG}	**Bare Ground** percent cover (0-100%) estimates using four randomly assigned $1m^2$ quadrats within each transect quadrant:			
Quadrat 1:			Quadrat 3:	
Quadrat 2:			Quadrat 4:	
Average Bare Ground Percentage			***V_{BG} Subindex Score:***	

Site Notes/Remarks:	
On-Site Assessment Score	

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT

Section C: Summary of Assessment Scores

On-Site Variable Subindex Scores

V_{MT}	Microtopography	
V_{SR}	Average species richness	
V_{BG}	Average percent bare ground	
V_{LDD}	Local evidence of dust deposition	
V_{LTK}	Local evidence of thermokarst	

Off-Site Variable Subindex Scores

V_{LLD}	Local landscape disturbance	0.90
V_{SW}	Anthropogenically derived surface water	0.81
V_{IH}	Impediment to hydrology	1.00
V_{DD}	Evidence of dust	No
V_{LD}	Landscape disturbance	1.00
V_{IW}	Impediment to wildlife	1.00
V_{DR}	Distance to roadway	1.00
V_{TK}	Evidence of thermokarst	No

Assessment Scores

Habitat	***0.98***
Hydrology	***0.93***
Biogeochemical	***0.90***
On-site Modifer	
AVERAGE SCORE	***0.93***

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section A: Desk Top (Offsite) Data			
Site Name/Location:	WAA4	Latitude/UTM Northing:	70.32666548
Date:	3/20/2019	Longitude/UTM Easting:	-148.5804001
Impact/Mitigation:	Impact	Pre/Post:	Pre-Project
Region:	Arctic Coastal Plain	Coordinate System:	NAD83
HGM Class:	Depression	Imagery Source (Year):	AGDC 2013-2015
Investigator(s):	AGDC		

Determine values for variables 1-5 using an 80 meter radius plot.

1	V_{LLD}	Local Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	29
		V_{LLD} Subindex Score	***0.28***
2	V_{SW}	Anthropogenically Derived Surface Water - percent of the plot (0 - 100) occupied by surface water derived from human activities, including thermokarst if directly associated, and conspicuously linked.	14
		V_{SW} Subindex Score	***0.13***
3	V_{IH}	Impediment to Hydrology - number of quarter segments (0 - 4) assignable in any direction that have hydrologic impediments.	0
		V_{IH} Subindex Score	***1.00***
4	V_{DD}	Evidence of Dust - accumulation of sediment on vegetation, appearing as areas of discoloration.	No
5	V_{TK}	Evidence of Thermokarst	Yes

Determine values for variables 6-8 using an 800 meter radius plot.

6	V_{LD}	Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	4
		V_{LD} Subindex Score	***1.00***
7	V_{IW}	Impediment to Wildlife - number of quarter segments (0 - 4) assignable in any direction with impediments to the free movement of wildlife.	0
		V_{IW} Subindex Score	***1.00***
8	V_{DR}	Distance to Roadway - minimum distance in meters (0 - 800) to a roadway of any size, class, or condition.	800
		V_{DR} Subindex Score	***1.00***

Habitat Assessment Score	***0.70***
Hydrology Assessment Score	***0.60***
Biogeochemical Cycling Assessment Score	***0.28***

Remarks

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section B: Onsite Data Collection			
Site Name/Location:	WAA4	Latitude/UTM Northing:	
Sampling Date:		Longitude/UTM Easting:	
Region:		Coordinate System:	

HGM Class:	Depression	Dominant Vegetation:	
Field Team:			

Determine values for the following variables:

1	V_{LDD}	Dust presence on vegetation within assessment area?	
2	V_{LTK}	Thermokarst features within assessment area?	
3	V_{MT}	Microtopography Sampling using two 30m transects situated in each cardinal direction from established plot center. Establish a level line above vegetation and record distance to ground level at 1m intervals.	

Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)		Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)
1		16	24		1		16	
2		17			2		17	
3		18			3		18	
4		19			4		19	
5		20			5		20	
6		21			6		21	
7		22			7		22	
8		23			8		23	
9		24			9		24	
10		25			10		25	
11		26			11		26	
12		27			12		27	
13		28			13		28	
14		29			14		29	
15		30			15		30	
Sum of Microtopography Variability:					***V_{MT} Subindex Score:***			

4	V_{SR}	**Species Richness** tally for vascular plants using 4 randomly assigned 1m^2 quadrats within each quadrant created from transect lines:		
Quadrat 1:			Quadrat 3:	
Quadrat 2:			Quadrat 4:	
Average Species Richness:			***V_{SR} Subindex Score:***	

5	V_{BG}	**Bare Ground** percent cover (0-100%) estimates using four randomly assigned 1m^2 quadrats within each transect quadrant:		
Quadrat 1:			Quadrat 3:	
Quadrat 2:			Quadrat 4:	
Average Bare Ground Percentage			***V_{BG} Subindex Score:***	

Site Notes/Remarks:	
On-Site Assessment Score	

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT

Section C: Summary of Assessment Scores

On-Site Variable Subindex Scores

V_{MT}	Microtopography	
V_{SR}	Average species richness	
V_{BG}	Average percent bare ground	
V_{LDD}	Local evidence of dust deposition	
V_{LTK}	Local evidence of thermokarst	

Off-Site Variable Subindex Scores

V_{LLD}	Local landscape disturbance	0.28
V_{SW}	Anthropogenically derived surface water	0.13
V_{IH}	Impediment to hydrology	1.00
V_{DD}	Evidence of dust	No
V_{LD}	Landscape disturbance	1.00
V_{IW}	Impediment to wildlife	1.00
V_{DR}	Distance to roadway	1.00
V_{TK}	Evidence of thermokarst	Yes

Assessment Scores

Habitat	*0.70*
Hydrology	*0.60*
Biogeochemical	*0.28*
On-site Modifer	
AVERAGE SCORE	*0.52*

Appendix C

Alaska LNG Streambed & Bank Restoration Manual

Public

Streambed & Bank Restoration Manual

December 21, 2017

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Alaska LNG
3201 C Street, Suite 200
Anchorage, Alaska 99503
T: 907-330-6300
www.alaska-lng.com

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Approver Signature*					

*This signature approves the most recent version of this document.

MODIFICATION HISTORY

Rev	Section	Modification
B	All	Addition of Attachment 1 and enumeration of stream types in text body
0	All	Update of Table1, Section 4.4, and Attachment 1. Updated to new report format.

TABLE OF CONTENTS

List of Tables

List of Figures

List of Attachments

ACRONYMS AND ABBREVIATIONS

ADF&G............................Alaska Department of Fish & Game
AGDC.............................Alaska Gasline Development Corporation
Alaska LNG ....Alaska Liquefied Natural Gas
AWC ....Anadromous Waters Catalog
DEC................................Alaska Department of Environmental Conservation
DNR ....Alaska Department of Natural Resources
OHW..............................Ordinary High Water
TAPS ....Trans-Alaska Pipeline System
AWC ....Anadromous Waters Catalog
DEC................................Alaska Department of Environmental Conservation
DNR ....Alaska Department of Natural Resources

EXECUTIVE SUMMARY

The primary purpose of this stream restoration manual is to provide a general description of stream types to be crossed by the proposed Alaska LNG project and to present current accepted methods to best restore the physical and biological integrity of the streams, associated banks, and riparian habitat so they function at pre-construction conditions.

The major topics of discussion include a description of regional stream types, preliminary assignment of stream type to each of the pipeline stream crossings, and general discussion of recommended restoration techniques. Stream types typically found within each of the three geographic regions spanned by the project are described and classified using the Rosgen stream classification method. Each of the pipeline stream crossings associated with the Mainline and PTTL have been assigned a preliminary stream type, using best available data, and are presented in tabular format as attachments to this document. Though tabulated stream types are limited to pipeline crossings this document is relevant to other project infrastructure that have the potential to impact streams. Streambed restoration objectives and methods, largely limited to material replacement and grading, are provided. For to each of the bank restoration techniques a general description, discussion of methods, and applications and limitations of are provided, including typical drawings where relevant. This document does not specify the preferred restoration technique(s) to be used at each specific crossing, but is intended to be referenced when evaluating and selecting crossing-specific restoration technique(s) during final design and construction.

1. PURPOSE AND SCOPE

The purpose of this document is to identify current accepted methods to best restore the physical and biological integrity of the streams, associated banks, and riparian habitat impacted by the Alaska LNG project so they function at pre-construction. This manual provides a brief description of the general stream types crossed by the proposed project using the Rosgen (1996) stream classification system. It describes protection and restoration methods with an emphasis on the use of natural methods (bioengineering), combinations of natural and structural elements (biotechnical), and traditional bank armoring techniques (e.g., riprap, gabions walls). Use of the term “restoration” will refer to both bioengineering and biotechnical techniques required at each crossing. This document does not go into detail of the specific design methods of hard bank armoring (e.g. riprap revetments). Nor is this document intended to replace guidance established by the Federal Energy Regulatory Commission (2013), but rather to provide supplemental detail of specific restoration methods.

In a broad context, recommended restoration techniques are based on region, stream type (Rosgen 1996), hydrologic function, and gradient (Table 1). Preliminary stream types have been identified for each stream crossing using best available data and are subject to change prior to construction and stream restoration (Attachment 1 and Attachment 2). At a more local level, restoration is further defined by the stream reach, associated aquatic and riparian habitat characteristics, and fish assemblages within that reach. Initially, restoration of the streambanks will be performed for sediment and erosion control that could occur after construction. Ultimately, the goal is to establish long term natural plant growth and bank stability. These goals will support the aquatic communities associated with the stream reaches and/or eliminate annual maintenance requirements. Additionally, the State of Alaska Department of Fish and Game (ADF&G) and other agencies regulate activities within anadromous or otherwise fish bearing streams. Bank protection and restoration techniques may be subject to approval by these regulating agencies.

Over the years many restoration techniques have been developed by biologists, botanists, hydrologists, and engineers and put into practice by private and government entities. Detailed descriptions of the most widely used restoration techniques in Alaska are described in this manual. Stream channel morphology and hydrology must be well understood for each crossing to ensure effective restoration. In almost all instances, restoration at an individual site will combine multiple techniques to yield immediate and short term stability and long term benefits. Although stream restoration at each crossing will be site specific, the same suite of techniques can be used among similar stream types. As the ecoregions change from north to south, plant communities will change (Gallant et al. 1995), but the techniques employed may remain the same. To develop a systematic approach to restoration, the crossings have been categorized by stream type, gradient, and geographic region. Within each category, a group of techniques will be recommended for the generalized stream types (Table 1).

Once streambank restoration is complete, continued monitoring of the site to determine the effectiveness of the restoration and provide maintenance will be needed. Monitoring will provide important information on the processes that occur within disturbed aquatic ecosystems (see Davis and Muhlberg 2002). Following the first year of restoration, a rapid assessment of all sites is recommended to verify the stability and function of each stream has been restored. A more intensive monitoring program should be developed to target those streams known or expected to present inherent restoration difficulties (e.g., beaded streams). During initial restoration work, issues may be identified that will cause a site to be added to the targeted post-restoration efforts.

Table 1: Recommended Restoration Techniques by Stream Type

Region	Stream Type	Effort	4.2 Reseeding	4.3 Transplanting	4.4 Vegetative Mat	4.5 Live Staking	4.6 Branch Packing	4.7 Brush Layering	4.8 Brush Mattress	4.9 Coir Logs	4.10 Coir Mat Lifts	4.11 Live Fascine	4.12 Live Siltation	4.13 Root Wads	4.14 Tree Revetment	4.15 Vegetated Cribwall	4.16 Vegetated Gabions	4.17 Vegetated Riprap
Arctic	**2.2.1 Small Beaded or Tundra Streams**	High	x	x	o	x		x								x		
Arctic	**2.2.2 High to Moderate Gradient**	Medium						x	x			x						
Arctic	**2.2.3 Braided**	Medium				x		x	x			x						
Interior	**2.3.1 Low Gradient Palustrine**	High	x		x			x		x					x	x		
Interior	**2.3.2 Floodplain**	Medium				x			x			x		x	x			
Interior	**2.3.3 Braided and Anastomosing**	Medium/High	x		x	x		x	x	x	x		x		x	x		x
Interior	**2.3.4 High to Moderate Gradient**	Low	x					x	x			x						
South-central	**2.3.1 Low Gradient Palustrine**	High			x		x	x	x	x	x				x	x		
South-central	**2.4.2 Floodplain**	Medium	x							x	x	x	x	x	x			
South-central	**2.4.3 Low Gradient Braided/Anastomosing**	Medium/High	x		x	x		x	x	x	x		x		x	x		x
South-central	**2.4.4 High to Moderate Gradient**	Low						x	x			x					x	

Note:
0 – The successful use of vegetative mat in restoring wetland tundra is limited, while there are no stream restoration projects known to the authors that have successfully implemented vegetated mat in the Arctic region. For these reasons the selection of vegetated mat cannot be recommended as a proven method in the Arctic region. More discussion is provided in Section 4.4 of this document.

2. STREAM TYPES

2.1. Introduction

The proposed Alaska LNG project crosses multiple stream types from the Arctic to Southcentral regions of Alaska. The stream types typically found within each of the three broad regions are described, and each stream type is classified using the Rosgen stream classification (1996). The three regions are, from north to south: Arctic, Interior, and Southcentral.

2.2. Arctic Region

The Arctic region encompasses the whole of the North Slope of Alaska, from the Arctic Ocean to Atigun Pass.

2.2.1. Small Beaded or Tundra Streams (Rosgen stream type E)

Photo 1: Arctic Region Beaded Stream

(Photo Source: Http://Ine.Uaf.Edu/Werc/Projects/Arp-Fishcreek/)

From approximately Alaska LNG Mainline milepost (MP) 21 to MP 152, the northernmost portion of the alignment, the project will cross approximately 46 beaded and tundra streams (Photo 1). These low gradient streams are common throughout the Arctic Coastal Plain. They originate near the foothills of the Brooks Range and eventually drain into larger rivers or directly into the Beaufort Sea. The majority of these are small meandering streams overlaying permafrost, while some form deep pools giving the streams a beaded appearance (Oswood et al. 1989). The beads form where thermal erosion occurs along underlying ice wedge polygons. Often the beads will overlay permanently thawed sediment bulbs (Oswood et al. 1989). When the vegetative layer is disturbed, the underlying permafrost is susceptible to thermal degradation.

- If streambanks are not restored adequately, they can experience undercutting, resulting in collapse due to thermal degradation (Walker and McCloy 1969).

Stream flow peaks during spring breakup. The flow then steadily diminishes throughout the summer, and experiences lowest flow in late fall before freeze up. Freeze up occurs in the winter, when streams typically freeze completely in all but the deepest (> 2m) pools (Arp et al. 2014). These streams have an important role in the connectivity of fish habitat. During spring breakup, migratory fish move into these seasonally productive habitats to feed and spawn (Morris 2003). Timing is important in the annual out-migration back to overwintering grounds. Fish require enough time foraging to build up energy reserves, but also must out-migrate before freeze up to avoid being stranded (Heim et al. 2014).

- Restoration efforts need to minimize disturbance to fish habitat and preserve the connectivity of these streams.

Small beaded and tundra stream channels have a relatively high width to depth ratio with steep banks. The riparian vegetation typically begins at ordinary high water (OHW) and is comprised of the same or similar plant communities as the surrounding tundra. Common tundra/riparian plant communities consist of cottongrass (*Eriophorum* spp.), sedges (*Carex* spp.), dwarf/scrub willow (*Salix spp.*) and dwarf birch (*Betula nana*), pendantgrass and tundra grasses (*Arctophila fulva* and *Dupontia* spp.), sphagnum moss (*Sphagnum* spp.), and various Arctic dwarf shrubs (e.g. *Vaccinum* spp.) (Viereck et al. 1992).

2.2.2. High to Moderate Gradient Streams (Rosgen stream types A & B)

Photo 2: Arctic Region High to Moderate Gradient Stream

The project will cross approximately 43 high to moderate gradient mountain streams (Photo 2) in the Arctic region. The streams originate near Atigun Pass and eventually drain into the Atigun River. Similar to the Arctic Coastal Plain, stream flow occurs primarily between spring breakup and fall freeze up (Curran 2003). Stream flow is often intermittent and dependent on surface runoff and springs. Flow tends to peak during spring melt and fall rain events (Craig and McCart 1975). The substrate of these high energy streams is primarily cobble with some boulder and gravel. The steep gradient of these streams limits fish presence and fish habitat values are generally low or non-existent. High to moderate gradient streams tend to have a low width/depth ratio, are slightly incised, and exhibit little sinuosity.

- If a pipeline crossing has a higher to lower gradient transition, the active channel may break up into more than one channel, creating small braided sections.

Riparian vegetation consists of a tundra mat resting on a thin veneer of soil (Scott 1978) or is absent altogether. Common riparian plant communities (when present) consist of willows and birch (*Salix* spp. and *Betula* spp.), cottongrass (*Eriophorum* spp.), sedges (*Carex* spp.), and various Arctic forbes (e.g. *Chamerion latifolium*) (Viereck et al. 1992).

2.2.3. Braided Streams (Rosgen stream type D)

Photo 3: Arctic Region Braided Stream

The project will cross approximately 17 braided streams (Photo 3) in the Arctic region. The Atigun River and its tributaries will be crossed at a number of locations where the stream channels are highly braided. The crossing on the upper section of the Atigun River is in a broad valley at a large glacial outwash plain with several active drainage channels within the floodplain. The upper section of the Atigun River is an alluvial fan feature where the streams transition from steep high energy stretches spilling into the valley floor (USDA Forest Service 1992). The multiple channels feature various bar types and unvegetated islands that likely shift in response to runoff events. The substrate is dominated by gravel with interspersed cobble and sand. Fish may use this habitat for rearing and the associated clear water tributaries as spawning grounds. The deeper channels or pools found within the braided complex free of bottom fast ice may serve as overwintering habitat.

Arctic braided stream riparian vegetation is generally comprised of scrub willows and birch (*Salix* spp. and *Betula* spp.), river beauty (*Chamerion latifolium*), horsetails (*Equisetum* spp.), and various dwarf shrubs (e.g. *Vaccinium* spp.) and tundra grasses (*Dupontia* spp.) (*Viereck* et al. 1992).

2.3. Interior Region

The Interior region spans from Atigun Pass through Cantwell.

2.3.1. Low Gradient Palustrine Streams (Rosgen stream type E)

Photo 4: Interior Region Low Gradient Palustrine Stream

The project will cross approximately 82 low gradient palustrine streams (Photo 4) in the Interior region. These relatively slow meandering streams are associated with low relief landforms and wetlands. These streams are slightly entrenched and have low channel width/depth ratios with established channel banks. Low gradient palustrine streams can be very sensitive to disturbance and rapidly convert to other stream types (Rosgen 1996). Because habitat features such as undercut banks, overhanging vegetation, and numerous pocket pools are present, these streams typically have high rearing, spawning, and overwintering fish habitat values.

Common riparian plant communities consist of black spruce (*Picea mariana*), willows and birches (*Salix* spp. and *Betula* spp.), sedges and cottongrass (*Carex* spp. and *Eriophorum* spp.), reed bent grass (*Calamagrostis* spp.), and wetland shrubs (*Vaccinium* spp., *Ledum* spp., and *Myrica gale*.) (*Viereck* et al. 1992).

2.3.2. Floodplain Streams (Rosgen stream type C)

Photo 5: Interior Region Floodplain Stream

Approximately 38 floodplain streams will be crossed (Photo 5) in the Interior region. These streams are commonly associated with alluvial valley bottoms and are often sinuous in nature (USDA Forest Service 2006). During high water events, it is common for these streams to overflow their banks and inundate the surrounding floodplain. Floodplain streams are dominated by pools, riffles, and point bars making them relatively high in fish habitat value. Large woody debris is a common feature in these streams, increasing the stream's fish habitat value by providing low flow areas used for rearing, overwintering and predator avoidance. At many crossings, the outside streambank is under-cut and highly vegetated while the inside bank consists of a low gravel bar with riparian vegetation clear of the river (Bisson 2006).

- Floodplain streambanks are composed of unconsolidated alluvial material susceptible to erosion.

Common riparian plant communities consist of spruce (*Picea* spp.), willows and birch (*Salix* spp. and *Betula* spp.), alder (*Alnus* spp.), and poplar (*Populus* spp.) (*Viereck* et al. 1992).

2.3.3. Braided and Anastomosing Streams (Rosgen stream types D & DA)

Photo 6: Interior Region Anastomosing Stream

Approximately 23 braided streams will be crossed by the project in the Interior region. Similar to Arctic braided streams, stream morphologies range from the alluvial fan process where the streams transition from steep high energy stretches to valley floors, to large glacial outwash plains with multiple active drainage channels. These streams provide rearing and overwintering fish habitat. Due to shifting channels and potentially high sediment loads, spawning habitat may be limited to off channel back waters where upwelling occurs. Vegetation is largely absent or discontinuous on the various bars and islands found in braided streams. Common riparian plant communities consist of willows (*Salix* spp.), birch (*Betula* spp.), alder (*Alnus* spp.), poplar (*Populus* spp.), and spruce (*Picea* spp.) (*Viereck* et al. 1992).

The project will cross approximately 9 Interior region anastomosing (branched) streams (Photo 6). Anastomosing streams are found in areas of low relief similar to palustrine streams. Unlike braided streams, the bars and islands of anastomosing streams can be highly vegetated with plant communities very similar to the adjacent bank riparian vegetation. Streambanks between channels are highly stable and migration within channels is slow. Habitat features such as undercut banks, overhanging vegetation and numerous pocket pools are present. These features provide high rearing, spawning and overwintering fish habitat values.

- Restoration at these sites will treat each vegetated island or bar as its own discrete bank and riparian habitat.

Common riparian plant communities consist of black spruce (*Picea mariana*), willows and birch (*Salix* spp. and *Betula* spp.), sedges and cottongrasses (*Carex* spp. and *Eriophorum* spp.), reed bent grass (*Calamagrostis* spp.), and various wetland shrubs (*Vaccinium* spp., *Ledum* spp., and *Myrica* spp.) (*Viereck* et. al., 1992).

2.3.4. High to Moderate Gradient Streams (Rosgen stream types A & B)

Photo 7: Interior Moderate Gradient Stream

The project will cross approximately 130 high to moderate gradient streams (Photo 7) in the Interior region. Similar to the Arctic region streams, these are typically steep mountain streams that begin in the upper headwater regions. The majority of these streams drain into the Dietrich and Middle Fork Koyukuk Rivers in the north of the Interior region and the Nenana River in the south. These streams are usually low to moderately incised, characterized by step-pool channels, and containing substrate consisting of larger gravels and cobbles typical of high energy flows. The upper reaches of these streams are often ephemeral in nature with flows associated with spring thaws or rain events. Fish habitat values are low given the intermittent flows and high gradients; although at the confluence of larger more turbid streams, they may create clear water pools used for rearing. Common riparian plant communities consist of willows (*Salix* spp.), birch (*Betula* spp.), alders (*Alnus* spp.), poplar (*Populus* spp.), and spruce (*Picea* spp.) (*Viereck* et al. 1992). Herbaceous species vary with elevation and soil type.

2.4. Southcentral Region

The Southcentral region spans from Cantwell through to the project terminus on the Kenai Peninsula.

2.4.1. Low Gradient Palustrine Streams (Rosgen stream types DA & E)

Photo 8: Southcentral Region Palustrine Stream

In the Southcentral region, the project will cross approximately 55 low gradient palustrine streams (Photo 8). These slow meandering streams are associated with low relief landforms and wetlands. They are slightly entrenched and have low channel width to depth ratios. These streams have established channel banks, but can be very sensitive to disturbance and rapidly convert to other stream types (Rosgen 1996). Many of these palustrine streams are anastomosing with bars and islands that can be highly vegetated with plant communities very similar to the adjacent bank riparian vegetation. Streambanks between channels are highly stable and migration within channels is slow.

Because habitat features such as undercut banks, overhanging vegetation, and numerous pocket pools are present, these streams typically have high rearing, spawning and overwintering fish habitat values. A number of these crossings are anadromous according to the ADF&G Anadromous Waters Catalog (AWC). Southcentral low gradient palustrine stream riparian vegetation is generally comprised of black spruce (*Picea mariana*), willows (*Salix* spp.), birch (*Betula* spp.), sedges (*Carex* spp.), bog labrador tea (*Ledum groenlandicum*), heath shrubs (*Vaccinium* spp., and *Myrica gale*.), sedges (*Carex* spp.), reed bent grass (*Calamagrostis* spp.), and mosses (*Spagnum* spp., *Hylocomium splendens*, and *Pleurozium schreberi*) (*Viereck* et al. 1992).

2.4.2. Floodplain Streams (Rosgen stream type C)

Photo 9: Southcentral Floodplain Stream

Approximately 15 Floodplain streams (Photo 9) will be crossed by the project in the Southcentral region. These lower gradient streams are commonly associated with alluvial valley bottoms and are often sinuous in nature (USDA Forest Service 2006). During high water events, flow commonly overbanks the active stream channel inundating the surrounding floodplain. Banks are composed of unconsolidated alluvial material that can be susceptible to erosion. Floodplain streams are dominated by pools, riffles, and point bars making them high in fish habitat value. Large woody debris is a common feature in these streams; this component can increase the fish habitat value by providing low flow areas used for rearing, overwintering, and predator avoidance. Many of these streams are very productive and support populations of all five Pacific salmon species. Almost all are streams listed as anadromous in the ADF&G AWC.

- These streams support a substantial sport fishing industry that must be taken into consideration when developing restoration plans.

Southcentral floodplain stream riparian vegetation is generally comprised of spruce (*Picea* spp.), poplars and cottonwoods (*Populus* spp.), birch (*Betula* spp.), willows (*Salix* spp.), alder (*Alnus* spp.), and a diverse herbaceous understory that varies by soil type. Typical herbaceous species include reed bent grass (*Calamagrostis* spp.), cow parsnip (*Heracleum lanatum*), devil's club (*Oplopanax horridus*), horsetails (*Equisetum* spp.), Highbush cranberry (*Viburnum edule*), and rose (*Rosa acicularis*) (*Viereck* et al. 1992).

2.4.3. Low Gradient Braided/Anastomosing Streams (Rosgen stream type D)

Photo 10: Southcentral Region Low Gradient Braided Stream

Approximately 4 low gradient braided and anastomosing (branched) streams will be crossed by the project in the Southcentral region (Photo 10). Stream morphologies range from the alluvial fan process where the streams transition from steeper high energy stretches to valley floors with multiple active drainage channels. These streams provide rearing and overwintering fish habitat. Due to shifting channels and potentially high sediment loads, spawning habitat may be limited to off channel back waters where upwelling occurs. Vegetation is largely absent or discontinuous on the various bars and islands found in braided streams. Common riparian plant communities of braided streams consist of willows (*Salix* spp.), birch (*Betula* spp.), alder (*Alnus* spp.), poplar (*Populus* spp.), and spruce (*Picea* spp.) (*Viereck* et al. 1992). Common riparian plant communities of anastomosing streams consist of black spruce (*Picea mariana*), willows and birch (*Salix* spp. and *Betula* spp.), sedges and cottongrasses (*Carex* spp. and *Eriophorum* spp.), reed bent grass (*Calamagrostis* spp.), and various wetland shrubs (*Vaccinium* spp., *Ledum* spp., and *Myrica* spp.) (*Viereck* et. al., 1992).

2.4.4. High to Moderate Gradient Streams (Rosgen stream types A & B)

Photo 11: Southcentral Region Moderate Gradient Stream

The project will cross approximately 34 high to moderate gradient streams (Photo 11) in the Southcentral region. The majority of these streams fall within the typical high gradient classification. They are characterized by low to moderately incised channels featuring step-pools, with larger gravel, cobble, and boulder substrate. Unlike the steep gradient streams of the Arctic and Interior regions, these streams tend to have permanent flow throughout the year. Several of the moderate gradient streams in the Southcentral region are productive salmon bearing streams. These streams often have high value spawning habitat in and around the proposed crossings. For example, the upstream and downstream stretch of the Honolulu Creek crossing is dominated by rapids, with large cobble and boulders as substrate. This stretch of river is likely used only as a migration corridor. Within the reaches above and below the crossing, however, high value spawning rearing and overwintering habitat can be found. Southcentral high to moderate gradient stream riparian vegetation is generally comprised of spruce (*Picea* spp.), birch (*Betula* spp.), willows (*Salix* spp.), Alder (*Alnus* spp.), reed bent grass (*Calamagrostis* spp.), rose (*Rosa acicularis*), fireweed (*Chamerion angustifolium*), and various herbaceous understory species depending on soil type (*Viereck* et al. 1992).

3. STREAMBED RESTORATION TECHNIQUES

3.1. Introduction

Streambeds are essential for maintaining channel slope, profile, stability, form, and function. The form and function of streambeds affect oxygenation, bed material degradation and aggradation, and sediment loads. Site-specific streambed materials are crucial for maintaining fish spawning habitat and certain channel features are essential to fish rearing.

The main objectives in restoration of the streambed include:

- Match existing bed material layering to ensure the natural armoring process is continuous
- Match existing slope and general configuration to ensure continuity of the stream bed through the impacted reach. An anomaly in the channel bed can quickly lead to headcutting, instability and unraveling of the equilibrium of the channel.
- Match existing surface bed material to ensure consistent habitat in the area of disturbance.

3.2. Material Placement

In streambeds, the substrate materials should be replaced in the same order and configuration they occurred in for successful habitat restoration, erosion control, and scour prevention. During excavation of crossings, sort and stockpile coarse bed materials (e.g. cobbles and gravels). Backfilling will generally consist of replacing the excavated material, however, clean gravel may be used as backfill when excavated materials increase potential downstream sedimentation, increase scour potential, or do not provide sufficient groundwater flow around the pipe. Where surface material has been segregated, in the case of an armor layer overlying fine grain materials, subsurface material will be replaced in the stratified order it was removed.

Streambed slope and structure and configuration should ideally be returned to its approximate pre-disturbance condition. Some problematic crossings will require engineered solutions. These solutions should aim to preserve and restore preconstruction conditions. In some cases, it may be appropriate to mound streambed materials over the pipeline to allow for settlement of materials. In streams that lack streambank and riparian vegetation (e.g. steep gradient mountain streams) replace streambank materials to protect any softer underlying soils.

4. BANK RESTORATION TECHNIQUES

4.1. Introduction

Several strategies for streambank restoration have been implemented in Alaska. These strategies are intended to protect, stabilize, and revegetate disturbed streambanks to their pre-disturbance condition and function. Identification of site characteristics and choice of restoration methods are important. Site features, such as soil types and moisture conditions, temperature ranges, growing season, and physical characteristics, play a role in determining the best methods for a particular site. In nearly all cases, multiple methods are employed at each site to achieve restoration and pre-construction function of a disturbed streambank. This manual is a general overview and describes several of the more effective techniques for revegetation. During the planning phase, the following guides should be referenced:

- Streambank Revegetation and Protection (ADF&G 2005)
- Tundra Treatment Guidelines (Alaska Department of Environmental Conservation [DEC])
- A Revegetation Manual for Alaska (Wright 2008; Alaska Plants Material Center, Alaska Department of Natural Resources [DNR])
- Interior Alaska Revegetation and Erosion Control Guide (Czapla and Wright 2012; Alaska Plants Material Center, DNR)
- Alaska Coastal Revegetation and Erosion Control Guide (Wright and Czapla 2013; Alaska Plants Material Center, DNR)
- A Soil Bioengineering Guide for Streambank and Lakeshore Stabilization. (Eubanks, C.E. and D. Meadows 2005; U.S. Department of Agriculture Forest Service)

4.2. Reseeding

Photo 12: Grass Seeds

Photo Source: Http://Plants.Alaska.Gov/Seedtest.Html

4.2.1. Description

Reseeding is a revegetation method that establishes plant communities, protects against erosion, and returns visual aesthetics to disturbed sites with the appropriate plant seeds. Native species seed cultivars (Photo 12) should be used to establish initial ground cover at the disturbed sites. Many cultivars are commercially available in Alaska. Where commercial cultivars are not applicable to a site, it may be more appropriate to harvest and sow indigenous seeds from restoration sites to promote natural revegetation. The use of appropriate plant species adapted to a particular site will increase the effectiveness of the restoration effort.

4.2.2. Methods

Planning and timing are the most crucial components of the reseeding. Timing and environmental concerns need to be considered to optimize seed germination and growth. Seeding should coincide with the optimal growing season. In many locations in Alaska, this window of opportunity is quite short. In the event seeding cannot be conducted during optimal times, there are techniques for sowing dormant seeds.

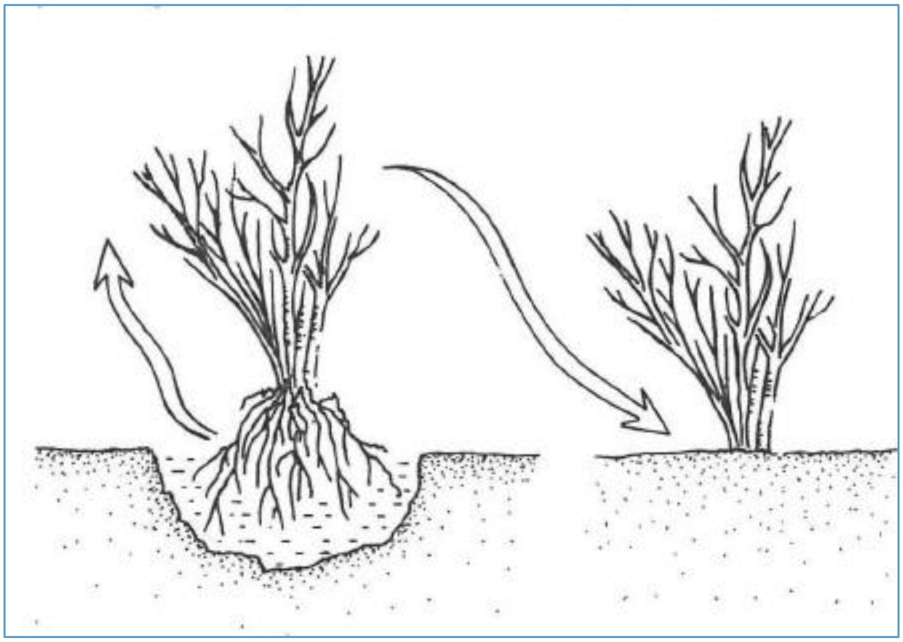
Prior knowledge of the site characteristics is essential when choosing plant species and sowing rates. Soil types and moisture characteristics will also drive site preparation methods and fertilizer mixtures. Early in the planning stage, consult with the Alaska Plants Material Center (http://plants.alaska.gov/) to determine seed types, seed availability, planting practices, and techniques. Once harvested or sourced, seeds can be sowed with small handheld seed spreaders or large mechanized equipment. Handheld spreaders are relatively inexpensive to operate, but can be labor intensive and inefficient because of seeding overlap or gaps. Larger mechanized equipment such as drills or hydro-seeders can sow more precisely and efficiently, but can add complexity and cost to the restoration effort. Plan carefully to avoid introducing non-native invasive plant species. Seed retailers in Alaska are typically required to specify if their products are free of invasive weeds.

4.2.3. Application and Limitations

Reseeding is appropriate for low gradient stable banks and is typically performed in conjunction with other restoration methods. Sowing is appropriate in upper riparian areas above OHW to avoid seeds washing away. Typically these upper riparian habitats adjacent to low gradient streams (Rosgen stream types C & E) are suitable for reseeding. Reseeding class D braided stream sites may be suitable if the effort is applied outside of the floodplain. This method does not provide immediate erosion control. Areas with high erosion potential should be reseeded in conjunction with mulch or erosion matting. In all instances where reseeding is used, fertilizer will be applied to promote plant growth. Use caution when fertilization occurs near streambanks to ensure no runoff enters the stream. Environmental factors such as wind and rain may reduce the effectiveness of reseeding by removing the seeds before they have a chance to germinate.

4.3. Transplanting

Figure 1: Transplanting (ADF&G 2005)



4.3.1. Description

Transplanting is a revegetation method that immediately establishes protective vegetation and plant communities. Whole live plants, portions of vegetative mat, or plugs of vegetation are sourced or harvested and replanted at the restoration site (Figure 1). Ideally, native plants should be harvested at or near the site before construction. Use of native species adapted for site conditions reduces restoration costs and increases survivability and the likelihood of success in establishing a functioning plant community.

4.3.2. Methods

Plants can be harvested from adjacent areas or salvaged from the crossing site prior to construction. Harvesting can be accomplished by mechanized equipment or by hand depending on access and sensitivity of the donor site. During harvesting, care should be taken to avoid damage to roots. Harvested plants must be protected from the elements, kept sufficiently moist, and replanted as soon as possible (ideally the same day as harvest). Shoots should be trimmed back to compensate for stress and root loss and to stimulate new growth (ADF&G 2005). To improve survival rates, transplants should be watered until established.

4.3.3. Application and Limitations

Transplanting can be performed in almost all applications, particularly if it is accompanied with other restoration techniques providing some form of erosion control. In the Arctic regions, transplanting is preferred because it quickly establishes vegetation over a short growing season. Transplanting along or within stream channels should occur after spring breakup to prevent ice and floodwater damage. When compatible plants are used, transplanting is effective in a wide range of soil conditions, from the very wet (hydric) to dryer (mesic-xeric) upland types (ADF&G 2005). This method is successful in all ecoregions within Alaska when compatible plant species are used. However, transplanting can be labor intensive and can become costly to maintain compared to other techniques (e.g., reseeding).

4.4. Vegetative Mat

Photo 13: Placing Vegetative Mat as Restoration Treatment (North Fork Native Plants)

(Photo Source: Http://Www.Northforknativeplants.Com/Applications.Php)

4.4.1. Description

Vegetative mat is a revegetation method similar to transplanting that provides immediate cover to disturbed sites. Intact vegetative mat with the soil attached is harvested and applied to graded banks and riparian areas following disturbance (Photo 13). This method can be used successfully in most locations south of the Arctic region and is only limited by the ability to effectively harvest, transport, and stockpile viable mats.

4.4.2. Methods

Vegetative mats can be obtained by harvesting the material either from the impacted site prior to construction or a proximal donor site. Vegetative mats can be harvested with machinery or by hand at sensitive sites. Ideally, vegetative mats are harvested from the restoration site prior to construction. Harvested and stockpiled mats must be protected and kept moist prior to transplanting. Alternatively, vegetative mats can be harvested from proximal donor sites, however donor sites will require subsequent restoration treatment, potentially negating the benefit of using vegetative mats over other treatments. After transplanting, care should be taken to avoid leaving any roots exposed along the edges of the mat to avoid plant death through desiccation (ADF&G 2005).

4.4.3. Applications

Vegetative mats are an excellent technique for providing immediate erosion control. They establish immediate protection and promote rapid revegetation of endemic species at disturbed sites. Locally harvested mats provide intact and adapted plant communities. In the Southcentral region, vegetative mats can be used to speed up the restoration effort for those streams that experience heavy foot traffic (e.g., Sheep Creek). Vegetative mats are labor intensive and may not be feasible at all sites. In the Arctic region, there is a considerable lack of past stream restoration projects with proven success in implementing vegetative mats. For winter construction spreads, particularly in the Arctic, the ability to harvest from the impacted site and stockpile over the winter season is both impractical and unlikely to yield a viable mat. Use of a chilled pipeline and reduced erosive forces of low gradient streams will limit the added benefits offered by the vegetative mat over other treatments. For these reasons a vegetative mat is unlikely to be a preferred restoration treatment, but possibly a secondary mitigative action.

4.5. Live Staking

Photo 14: Preparing Dormant Cuttings for Live Stake Planting (Eubanks, C.E. and D. Meadows 2005)

4.5.1. Description

Live staking is a low-tech revegetation method that uses dormant cuttings (see ADF&G 2005 for collection timing) to quickly revegetate and stabilize a disturbed site. Dormant cuttings are planted into the ground and roots establish in 2 to 6 weeks (Eubanks, C.E. and D. Meadows 2005) providing anchoring and support to streambanks. Live staking is most effective when used in conjunction with other revegetation and stabilization methods.

4.5.2. Methods

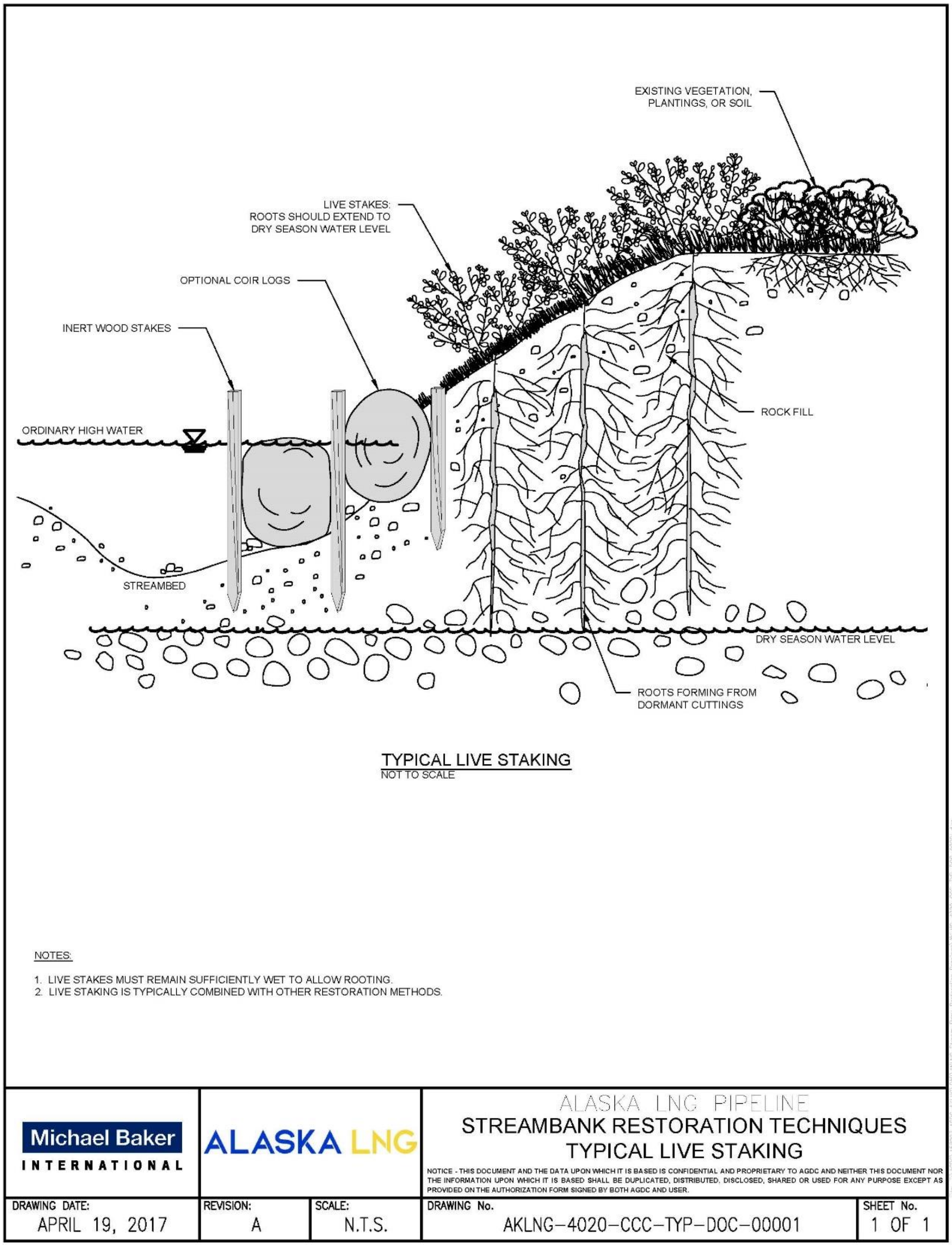
The live staking method (Figure 2) involves planting live stakes made from dormant cuttings directly into the soil at the restoration site. Dormant cuttings can be purchased or harvested from nearby donor sites and are collected from species that are found in riparian areas and can generate roots quickly without intervention (Photo 14). In Alaska, willows (Salix spp.), Balsam Poplar and Cottonwood (Populus spp.) and Red Osier Dogwood (Cornus stolonifera) are commonly used (ADFG 2005) for this method.

Live stakes can be installed at any point on the bank slope as long as the underlying soil remains sufficiently moist to allow root growth. The live stakes are planted into pilot holes and compacted then watered to remove air spaces. Live stakes should be planted 1 to 3 feet apart in a triangular pattern (ADF&G 2005), and must be buried with their growing tips exposed with at least ¾ of its length buried to promote healthy rooting. Rooting occurs within 4 to 6 weeks when the live stakes are kept sufficiently moist.

4.5.3. Application and Limitations

Live staking is an inexpensive yet labor intensive technique that can be used in all regions. Low gradient floodplains generally support large stands of willow that provide a good source of dormant cuttings. The biggest challenge with live staking is maintaining a site where the soil will be sufficiently wet during the crucial 4 to 6 week rooting period (ADF&G 2005). Rooting success is highly dependent on moist soil conditions. In Arctic regions, planting in upper alpine areas should be avoided as these locations may be too dry to support root propagation.

Figure 2: Typical Live Staking



4.6. Branch Packing

4.6.1. Description

Branch packing is a revegetation and stabilization method that fills, stabilizes, and revegetates small holes and slumps on streambanks with dormant cuttings and compacted backfill. Branch packing controls erosion, traps sediment, and promotes natural revegetation. Branch packing can be combined with live staking and other methods for maximum stability and protection.

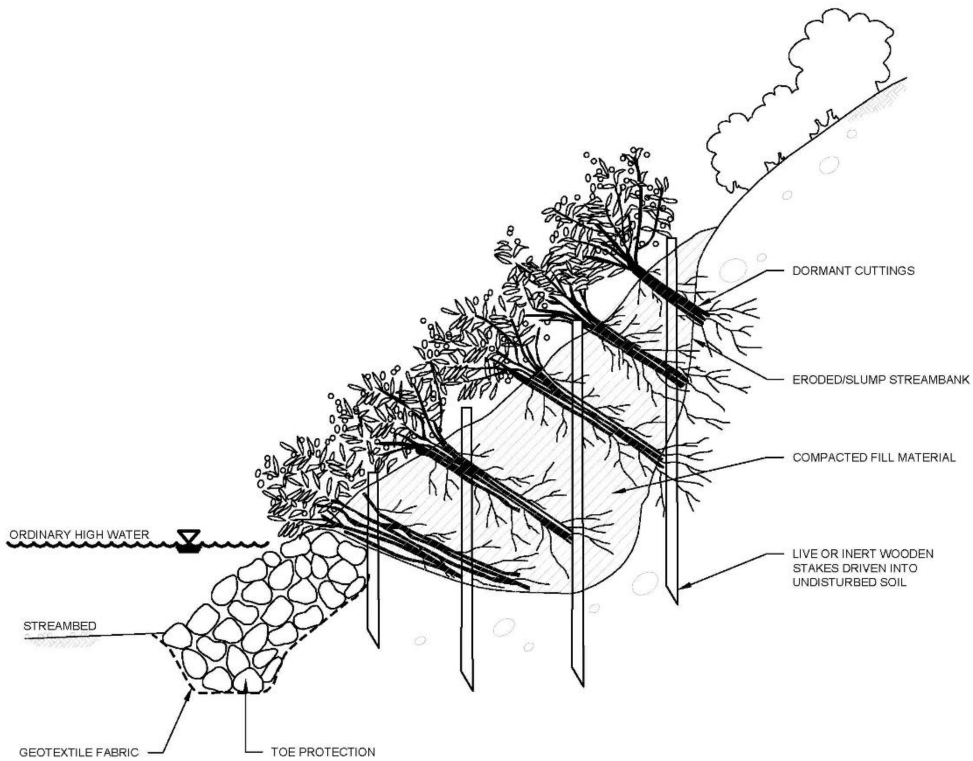
4.6.2. Methods

Dormant cuttings and soil fill are layered in the hole or slump in a crisscross configuration and compacted to remove air spaces (Figure 3). Either live stakes or inert wooden stakes are used to stabilize and anchor the cuttings until they develop roots. Similar to the brush layering method, dormant cuttings should be placed with growing tips exposed and trimmed to encourage growth. Soil must remain sufficiently moist for roots to develop. Depending on site conditions and location to be filled, the slope toe may require stabilization prior to filling.

4.6.3. Applications and Limitation

Branch packing is an inexpensive and effective method for repairing small localized slumps and holes. This method establishes vegetation quickly and provides immediate slope reinforcement. Branch packing is only appropriate for relatively small holes and slumps (less than 4 feet deep and wide) located above bankfull level on slopes greater than 2:1. The soil must be sufficiently wet during the crucial 4 to 6 week rooting period for the dormant cuttings to survive (ADF&G 2005). At sites where further erosion is likely, toe stabilization should be performed before branch packing is attempted.

Figure 3: Typical Branch Packing



TYPICAL BRANCH PACKING
NOT TO SCALE

NOTES:

1. ROOT/LEAFED CONDITION OF DORMANT CUTTING IS NOT REPRESENTATIVE OF THE TIME OF INSTALLATION.

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TYPICAL BRANCH PACKING

DRAWING DATE:	REVISION:	SCALE:	DRAWING No.	SHEET No.
APRIL 19, 2017	A	N.T.S.	AKLNG-4020-CCC-TYP-DOC-00002	1 OF 1

4.7. Brush Layering

Photo 15: Brush Layering Installation at Scheffler Creek

(Photo source: http://americorpsaslc.blogspot.com/2012/07/scheffler-creek-restoration-how-to.html)

4.7.1. Description

Brush layering (Photo 15) is a revegetation method that stabilizes, protects, and revegetates existing or filled slopes with dormant cuttings by combining layers of these cuttings with soil to rebuild slopes. Cuttings control run-off and erosion and aid in creating the microenvironments and moisture regimes that promote natural revegetation.

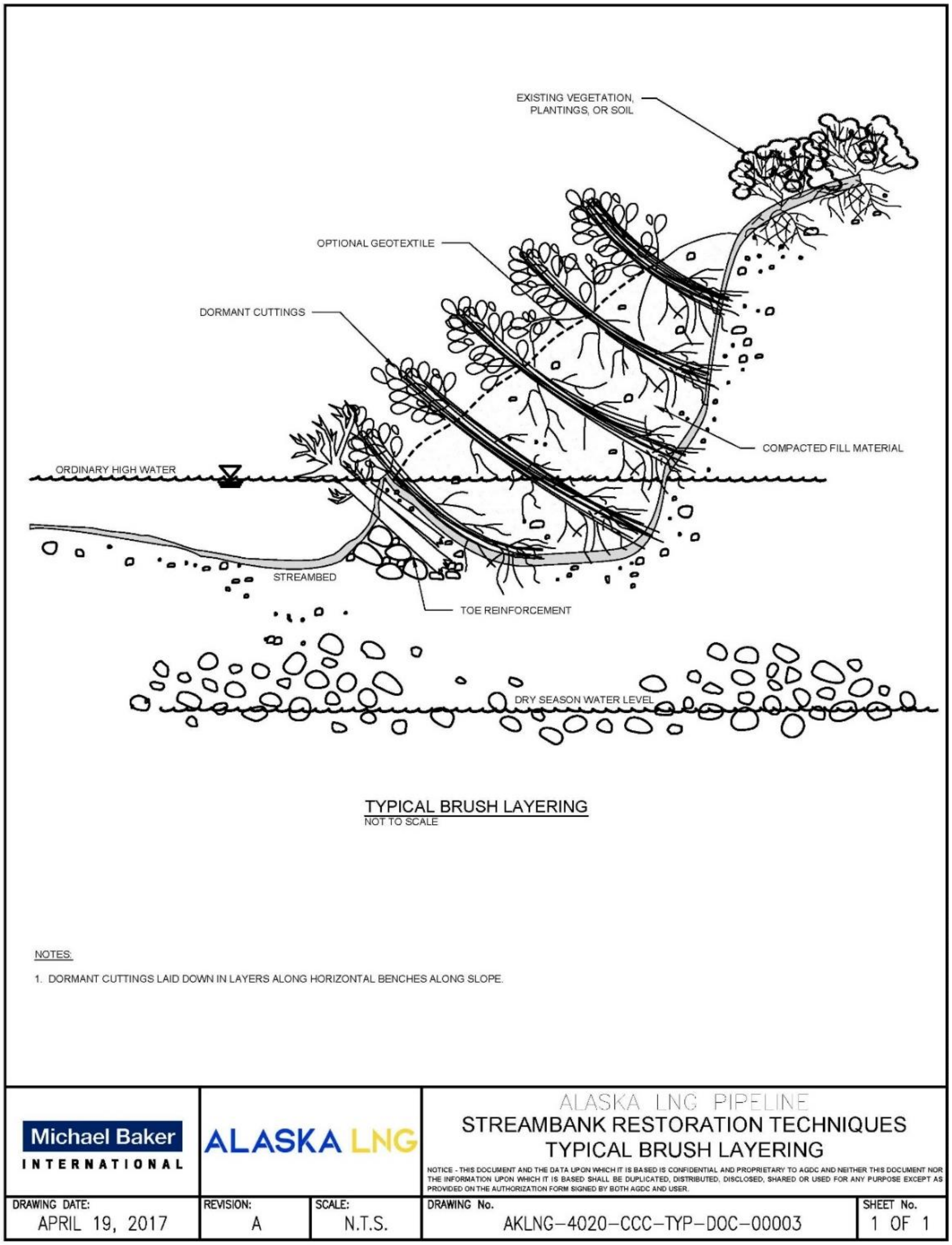
4.7.2. Methods

Dormant cuttings are laid on horizontal benches along a slope (Photo 14, Figure 4) and perpendicular to the slope face. The bench surface should slope back into the slope by 10 to 20 degrees off horizontal and rows should be between 3 and 5 feet apart depending on location. Layers begin at the base of the slope and progress upward. Cuttings must be alive with branches intact, and be laid in a crisscross or overlapping pattern with growing tips exposed. The growing tips are trimmed to encourage growth and each brush layer is then topped with compacted fill.

4.7.3. Applications and Limitations

Brush layering works to reinforce the soil while cuttings establish roots. This method breaks up slope lengths and adds resistance to sliding and shear displacement. Brush layering can be installed on existing or filled slopes, slumps, or as a patch. Brush layering should be combined with toe stabilization. Brush layering is not effective on outside bends, in some cases high flows can cause the soil between the layers to wash away.

Figure 4: Typical Brush Layering



4.8. Brush Mattress

Photo 16: Brush Mattress Installation Secured with Jute Twine (ADFG 2005)

4.8.1. Description

Brush mattresses are a revegetation and protection method that creates a protective layer over streambanks using woven dormant cuttings (Photo 16). The cuttings trap sediment and native seeds as they develop roots. This method promotes natural revegetation and provides long term bank stabilization.

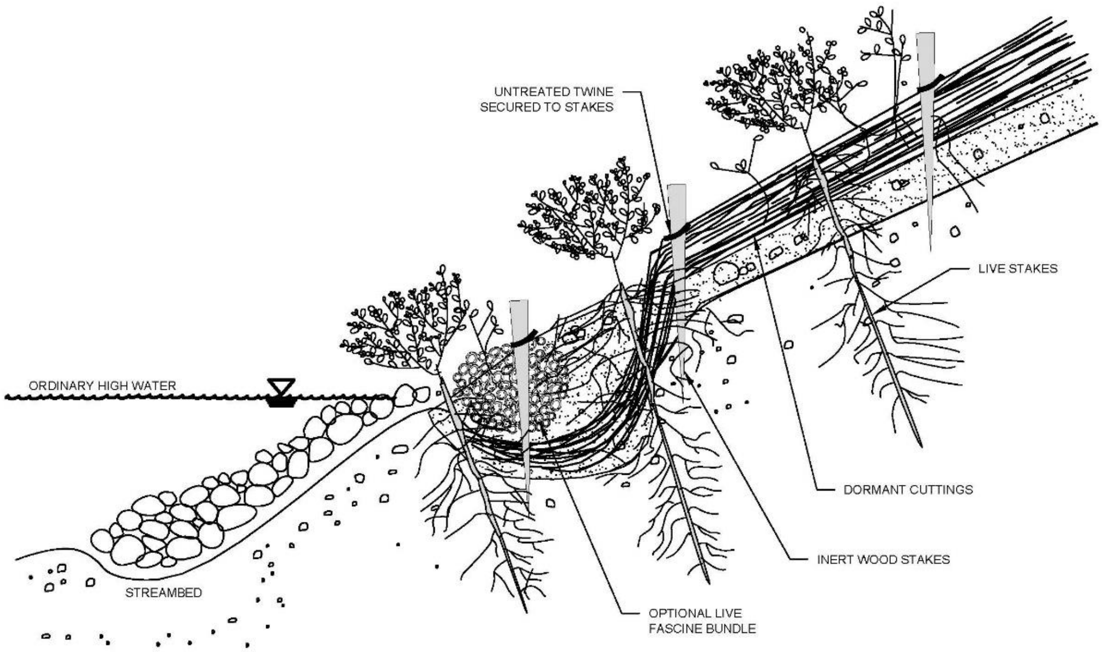
4.8.2. Methods

The lower edge of the brush mattress is typically anchored with a live fascine (dormant cuttings wrapped into bundles; Figure 5). Dormant cuttings are laid over the streambank to provide coverage of approximately 4 cuttings every 6 inches. Stakes are driven into the streambank between the cuttings to anchor the wire that secures the cuttings to the streambank. The mattress can be supplemented with additional live stakes. After the mattress is secured, soil is placed around and between the branches to create ground contact and promote root growth.

4.8.3. Applications and Limitations

Brush mattresses are effective at high velocity sites requiring surface protection against erosion. This method requires a stable streambank and is not applicable for unstable slopes and sites experiencing mass movements.

Figure 5: Typical Brush Mattress



TYPICAL BRUSH MATTRESS
NOT TO SCALE

NOTES:

1. SOIL COMPACTED AROUND DORMANT CUTTINGS TO ENSURE GOOD CONTACT TO PROMOTE ROOTING.

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TYPICAL BRUSH MATTRESS

DRAWING DATE:	REVISION:	SCALE:	DRAWING No.	SHEET No.
APRIL 19, 2017	A	N.T.S.	AKLNG-4020-CCC-TYP-DOC-00004	1 OF 1

4.9. Coir Logs

Photo 17: Coir Logs Installed at Slikok Creek (Weiner 2000)

4.9.1. Description

Coir logs (Photo 17) are an erosion protection method that traps sediments, native seeds, and promotes revegetation as they decompose. Coir logs are commercially-produced bundles of coconut fiber and bound together with biodegradable netting. They provide temporary bank protection in low velocity sites during the revegetation process.

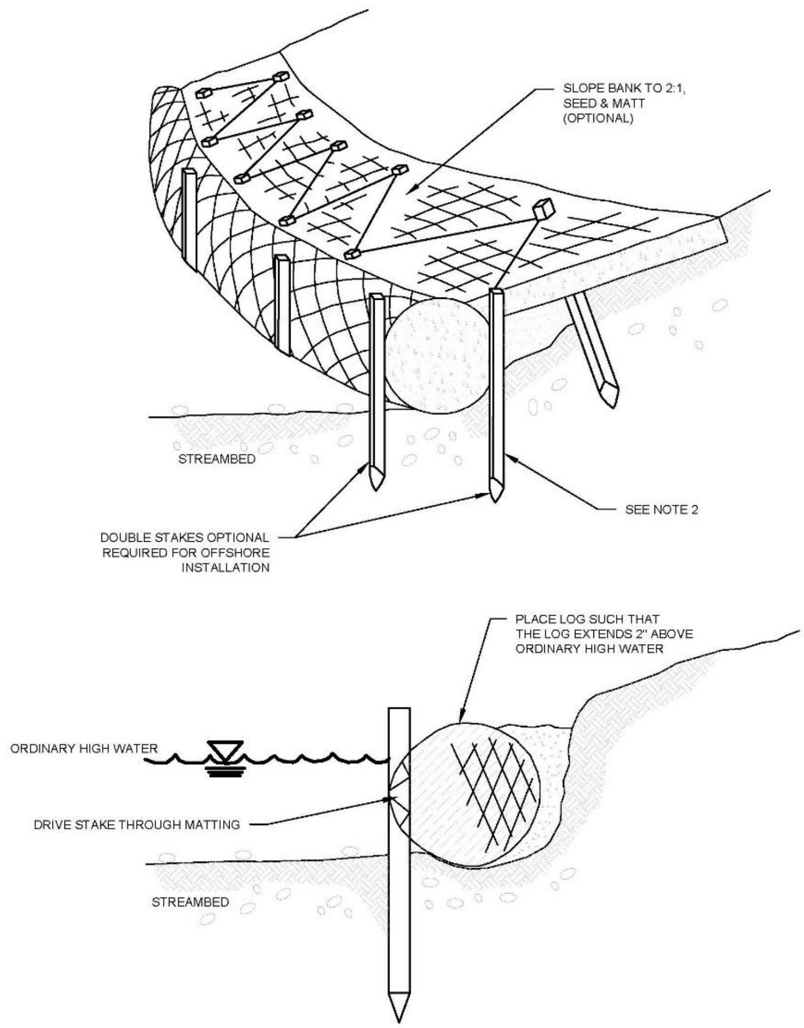
4.9.2. Methods

Coir logs are typically installed in shallow trenches or terraces and buried 2/3 into the soil to ensure good contact with the substrate along their entire length (Figure 6). The logs are anchored with live or inert wooden stakes and biodegradable twine. Cables and anchors can be used to secure the installation where necessary. Coir logs are often combined with seeding, transplants, and various other revegetation methods. Coconut fiber coir matting is also commercially available and can be fixed to low gradient slopes for additional protection.

4.9.3. Applications and Limitations

Coir logs are only appropriate for low velocity sites where natural revegetation is desired. Coir logs are easily installed and biodegradable. Due to their biodegradable nature, they are a temporary measure that works best when combined with other bioengineering and restoration methods. Coir logs do not provide effective toe or erosion protection in high velocity areas.

Figure 6: Typical Coir Logs



TYPICAL COIR LOGS

NOT TO SCALE

NOTES:

1. PLACE LOGS PARALLEL TO THE STREAMBANK ALONG A HORIZONTAL CONTOUR.
2. LIVE STAKES CAN BE USED IN ADDITION TO INERT WOOD TO PROMOTE REVEGETATION.

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TYPICAL COIR LOGS

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DRAWING DATE:	REVISION:	SCALE:	DRAWING No.	SHEET No.
APRIL 19, 2017	A	N.T.S.	AKLNG-4020-CCC-TYP-DOC-00005	1 OF 1

4.10. Coir Mat Lifts

Photo 18: Coir Mat Lift Installation with Brush Layering

(Photo source: http://www.rolanka.com/GN/apply-soillift.html)

4.10.1. Description

Coir mat lifts (Photo 18) are a protection and restoration method similar to brush layering. The coir mat lift creates successive layers of encapsulated fill that form steps or terraces. With the coir mat method, the layers of compacted fill (lifts) are encapsulated within biodegradable coconut fiber fabric (coir mat). These coir mat lifts provide immediate bank stability and erosion control by capturing sediments and native seeds. When combined with layers of dormant cuttings, coir mat lifts promote rapid revegetation and long-term stability.

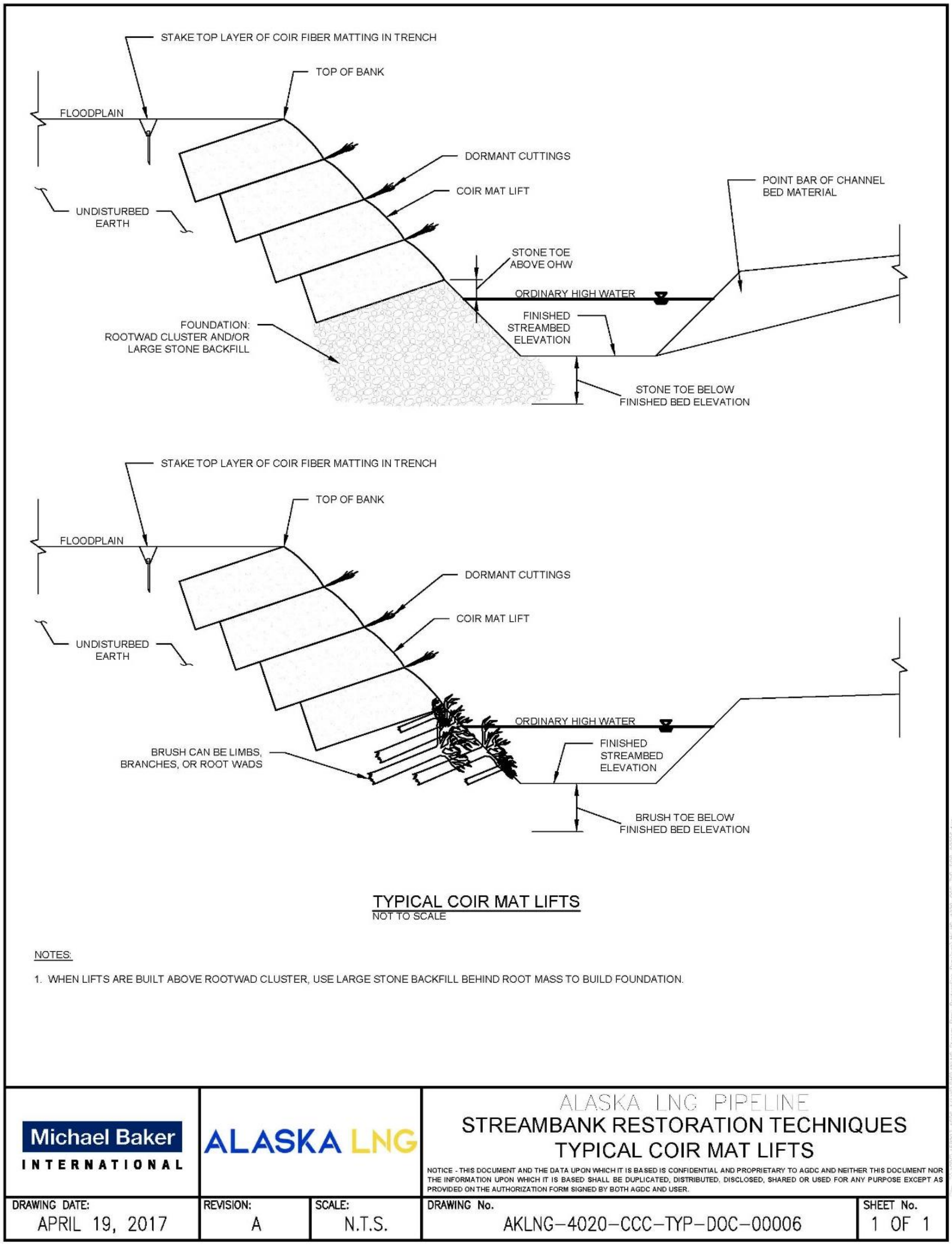
4.10.2. Methods

Coir mat lifts are usually installed on top of a rock toe or other streambank toe stabilization construction (Figure 7). Soil fill suitable for plant growth is laid down on the coir mat (or in some instances non-biodegradable geotextiles) to create the lift. The soil is compacted and enclosed within the coir mat and stakes are used to secure it and maintain the desired bank contour forming the soil lift. Between each soil lift, brush cuttings can be layered to maximize the function of the lifts and promote rapid revegetation.

4.10.3. Applications nd Limitations

Coir mat lifts work well for steep slope reconstruction 1:1 or steeper, and for outside bends. They allow rapid revegetation when combined with brush layering. Coir mat lifts are complex and expensive and often require toe stabilization prior to installation.

Figure 7: Typical Coir Mat Lifts



4.11. Live Fascine

Photo 19: Live Fascine Bundles Prior to Installation

(Photo source: https://solsticelight.wordpress.com/2013/02/27/how-to-stabilize-a-stream-part-1/)

4.11.1. Description

Live fascines are a revegetation method using long bundles of dormant cuttings (Photo 19) placed in contour trenches on streambanks to reduce erosion, reduce the potential for shallow sliding, and promote rapid revegetation. This method offers minimal site disturbance and creates terraces conducive to native plant colonization. Live fascines are inexpensive and are very effective at stabilizing soils once established.

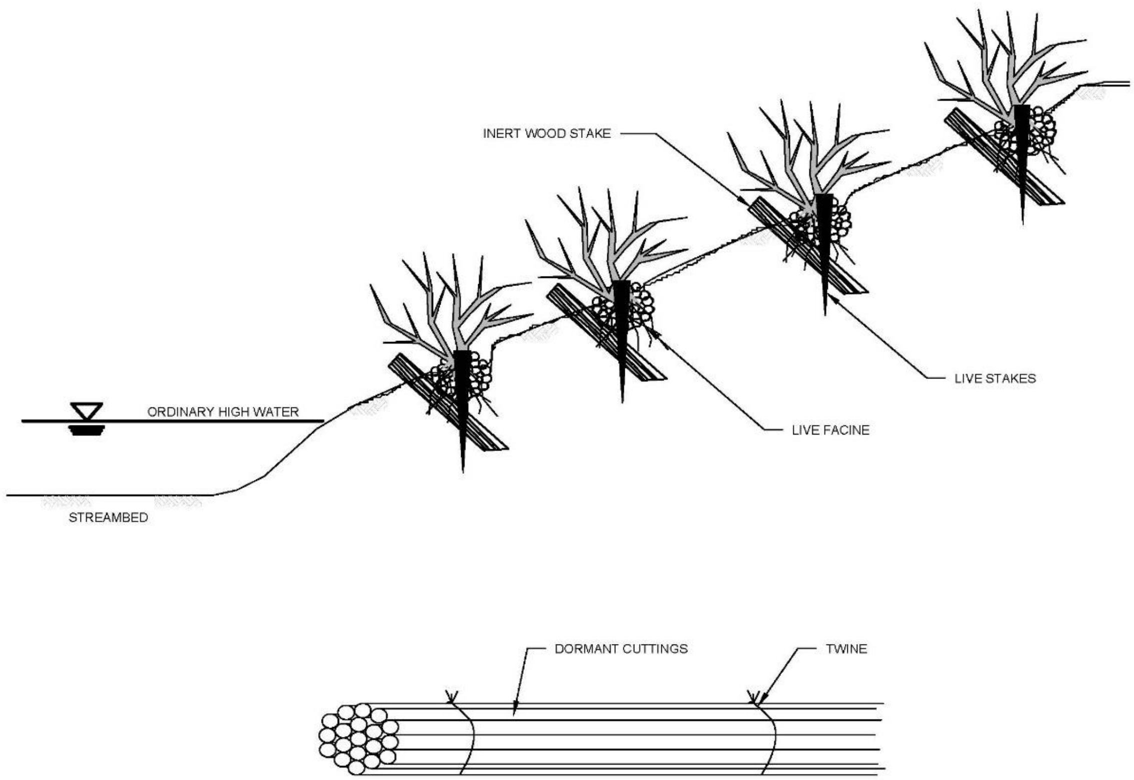
4.11.2. Methods

Dormant cuttings are wrapped into bundles (fascines) with biodegradable twine (Figure 8). Shallow contour trenches angling down and back into the streambank are excavated. The fascines are laid within the trenches and buried to approximately ¾ of the bundle's diameter leaving part of the bundle exposed. The bundles are then secured with live and/or inert stakes to the bottom of the trenches. Soil and water are used to tamp around the bundles to remove air pockets and provide good soil contact for root development. Live fascines can be installed singly or in multiple rows and in a variety of configurations depending on site needs.

4.11.3. Applications and Limitations

Live fascines reduce the slope of a streambank with a series of terraces slowing water velocity, retaining soil, and collecting native seeds. Live fascine installation is not appropriate for unstable slopes experiencing mass movements. Live fascines must be installed above OHW and bankfull levels. Live fascine construction requires large amounts of dormant cuttings for bundle construction and sufficient moisture for rooting to be successful.

Figure 8: Typical Live Fascines



TYPICAL LIVE FASCINES
NOT TO SCALE

NOTES:

1. BURY FASCINES APPROXIMATELY 3/4 THE DEPTH OF BUNDLE.

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TYPICAL LIVE FASCINES

DRAWING DATE:	REVISION:	SCALE:	DRAWING No.	SHEET No.
APRIL 19, 2017	A	N.T.S.	AKLNG-4020-CCC-TYP-DOC-00007	1 OF 1

4.12. Live Siltation

Photo 20: Live Siltation during Construction (ADF&G 2005)

4.12.1. Description

The live siltation method stabilizes, protects, and revegetates the toe of a bank with a combination of dormant cuttings, soil, gravel, and other materials in a trench at OHW designed to trap sediment and protect against wave and wind erosion (Photo 20). This method provides immediate cover and fish habitat during the revegetation process.

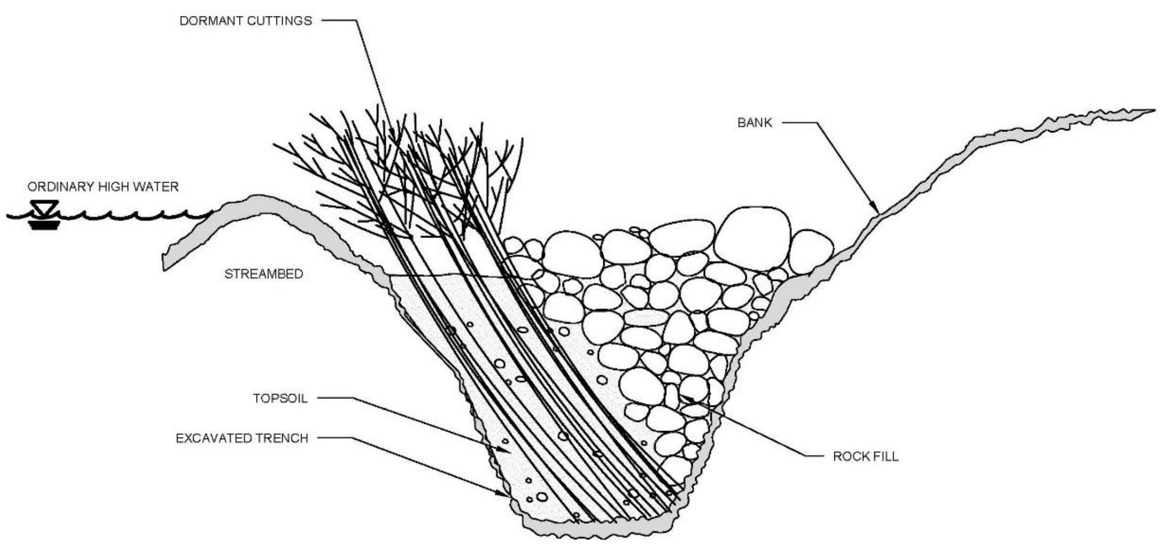
4.12.2. Methods

A V-shape trench is excavated above the OHW level parallel to the toe of the streambank. Dormant cuttings are laid within the trench and angled out towards the water (Figure 9). The trench is then backfilled with gravel or similar materials, and the surface is secured with gravel or bundles. Live siltation can be installed in multiple rows in conjunction with other slope stabilization and revegetation methods.

4.12.3. Applications and Limitations

Live siltation is appropriate where immediate fish habitat is desired in addition to bank stability. This method is most effective where water is shallow, velocity slow, and the slope low. To reduce the potential for washout, both the upstream and downstream ends of the structure need to transition smoothly into stable streambanks. Live siltation should not be used in high velocity and high slope conditions due to washout potential.

Figure 9: Typical Live Siltation



TYPICAL LIVE SILTATION
NOT TO SCALE

NOTES:

1. DORMANT CUTTINGS SHOULD BE ORIENTED TOWARDS STREAM CENTERLINE.

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4.13. Root Wads

Photo 21: Root Wad Installation using Excavation and Trenching Method prior to Backfilling along the Chena River

(Photo Source: http://www.newsminer.com/news/local_news/project-uses-root-wad-technique-to-restore-bank-of-chena/article_384c758e-395e-11e3-99f7-001a4bcf6878.html?mode=image&photo=1)

4.13.1. Description

Root wads are a bank toe protection and stabilization method using the intact root fans of harvested trees with the bole (trunk) attached (Photo 21). Root wads provide immediate toe revetment and juvenile fish habitat. Root wads trap sediment, native seeds, and debris and are often used in conjunction with other slope stabilizing and revegetation methods.

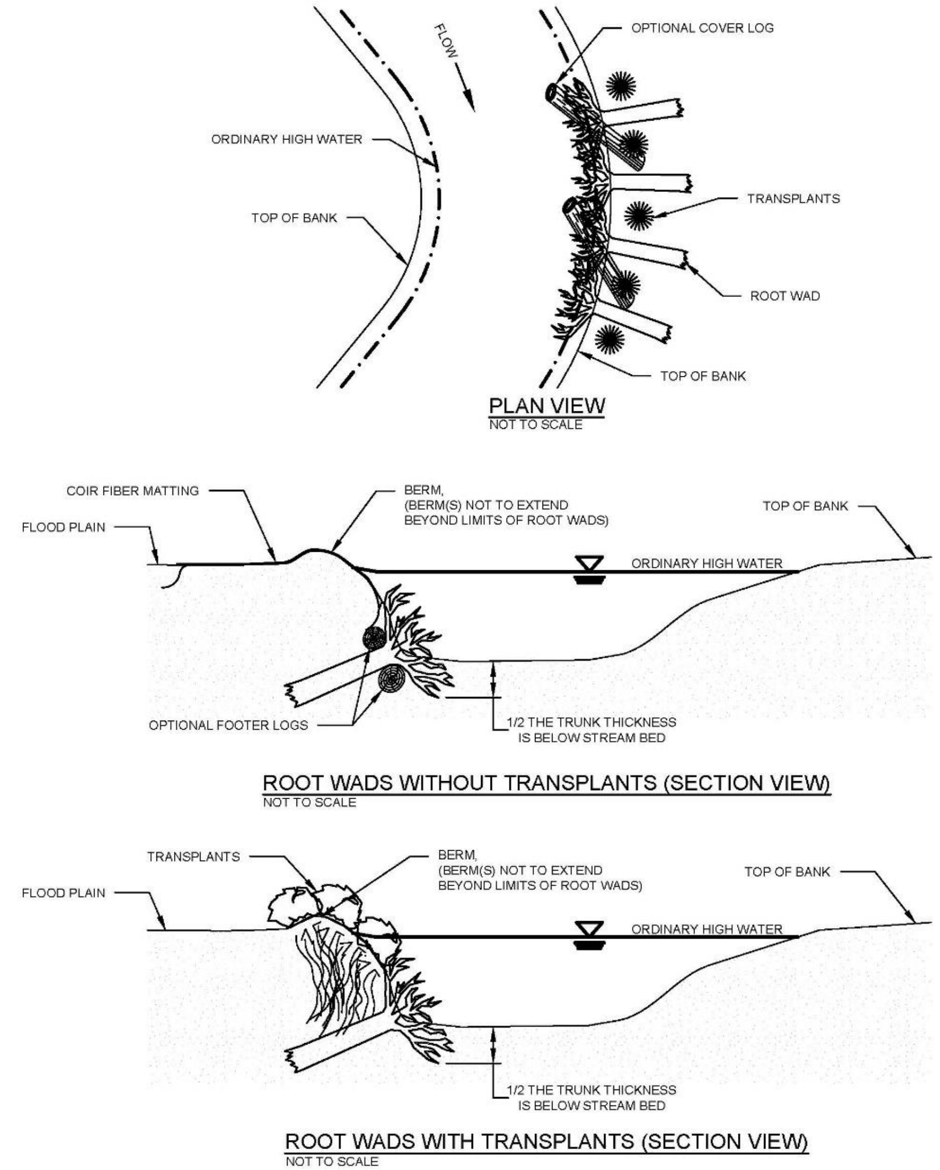
4.13.2. Methods

Root wads (Figure 10) are installed by either driving the root wad into the streambank bole first, or by excavation and trenching at the toe of slope. The excavation and trenching installation requires placement of footer logs at the toe of slope parallel to the streambank. Boulders or artificial anchors are used to stabilize the footer logs. The root wads are then laid perpendicular to the footer logs and bank behind the footer logs. The root fan should be sunk to ½ of the root fan depth flush with the streambank and be angled slightly into the flow. Root fans should overlap to provide continuous protection and tie into a stable streambank on either side. The root wads are topped with boulders for stability then backfilled; other restoration methods are typically used above them.

4.13.3. Applications and Limitation

Root wads are effective in high velocity sites requiring immediate stabilization. Root wad installation tends to be expensive and equipment intensive. It also requires available trees and boulders of sufficient size for construction.

Figure 10: Typical Root Wads



NOTES:

1. A FOOTER LOG SHOULD BE INSTALLED UNDERNEATH THE ROOT WAD WHEN USING THE EXCAVATION AND TRENCHING METHOD.
2. ORIENT ROOT WADS UPSTREAM TO DEFLECT FLOW.

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4.14. Tree Revetments

Photo 22: Spruce Tree Revetment on the Bank of the Chena River

(Photo source: http://akssf.org/default.aspx?id=2474)

4.14.1. Description

Tree revetments (Photo 22) are a bank protection method that reduces erosion, traps sediments, and provides valuable fish habitat. It is a simple, inexpensive, and effective method using readily available spruce trees, cables, and earth anchors.

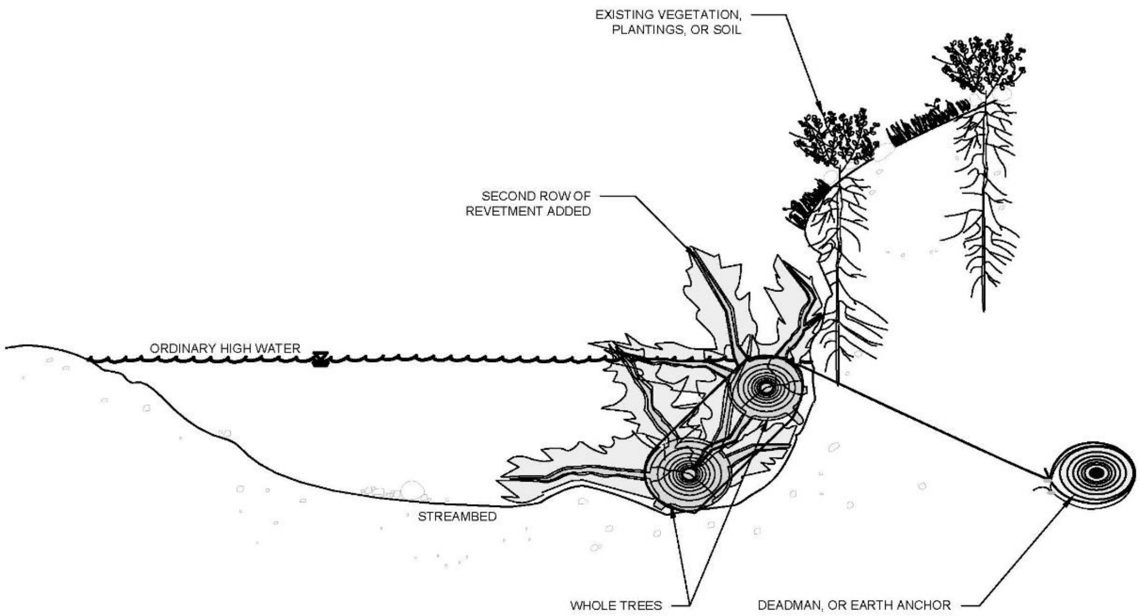
4.14.2. Methods

Intact spruce trees are laid parallel to the streambank in an overlapping pattern with their tops oriented downstream (Figure 11). They are anchored against the streambank with steel cables and earth anchors.

4.14.3. Applications and Limitations

Tree revetments are cost effective and easy to install. Spruce trees are readily available in most areas of Interior and Southcentral Alaska. Tree revetments, as a restorative method, are not permanent. The trees decay and break down and the revetments require frequent and regular maintenance which can be problematic in remote locations.

Figure 11: Typical Tree Revetments



TYPICAL TREE REVETMENTS
NOT TO SCALE

NOTES:

1. TYPICAL INSTALLATION IN ALASKA USES SPRUCE TREES.
2. ORIENT TREES PARALLEL TO STREAM BANK WITH TOPS POINTING DOWNSTREAM.

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4.15. Vegetated Cribwall

Photo 23: Vegetated Cribwall Installed along the Kenai River

(Photo source: http://www.sotir.com/case_studies/study_soldotna_detail.html)

4.15.1. Description

Vegetated cribwalls (Photo 23) are a protection and stabilization method using timber, rock, and soil combined with transplants or dormant cuttings. Vegetated cribwalls provide slope reconstruction and stabilization and are used to reduce the slope of an existing bank. They are effective in high velocity and erosion-prone sites and where the slope toe is unstable or disturbed.

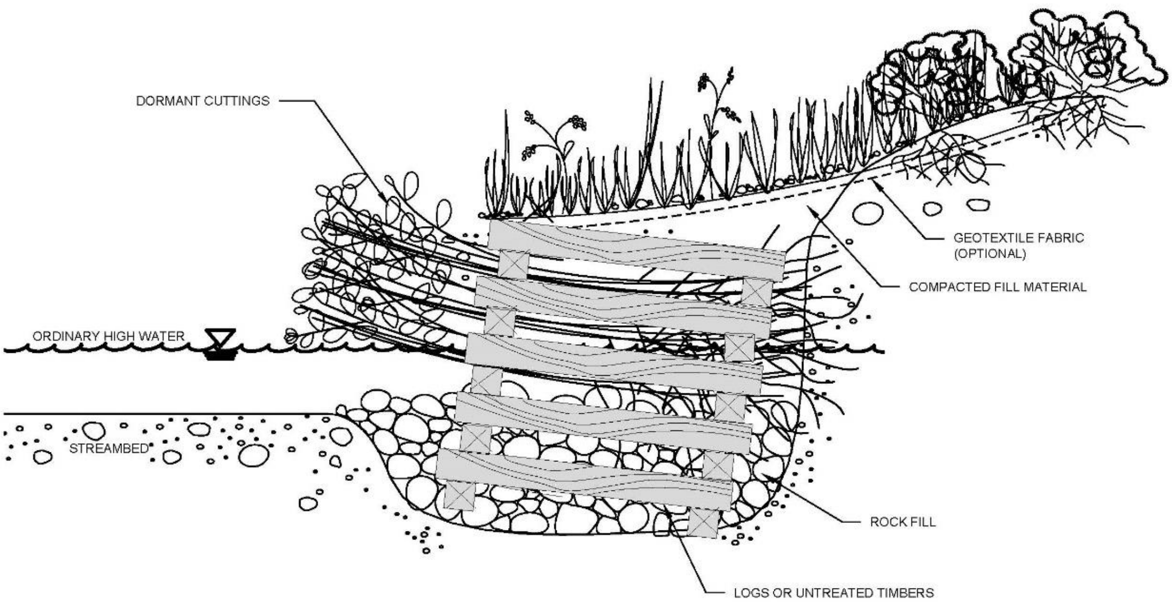
4.15.2. Methods

Vegetated cribwall construction (Figure 12) requires excavating below the existing streambed to create a stable foundation. Logs or untreated timbers are placed and secured within the excavation in an alternating log-cabin like configuration (cribs). The cribs are filled with rock until level with the streambed. Dormant cuttings are incorporated in the same manner as brush layering and backfilled with soil. Additional cribs may be added until the prescribed height and slope are achieved in either a vertical or stepped configuration. Over time, as the dormant cuttings develop roots and vegetation is established, they assume the structural function of the timbers as they decay, providing long-term stability to the restoration site.

4.15.3. Applications and Limitations

Vegetated cribwalls are labor intensive and costly to construct. Live cribwalls should not be used where a stream is actively down cutting as it will undermine and destabilize the construction. This method involves significant streambed excavation. Live cribwalls are appropriate for high erosion, high velocity sites (e.g., outside bends), and effectively armor streambanks from erosion. They also discourage the formation of split channels.

Figure 12: Typical Vegetated Cribwalls



TYPICAL VEGETATED CRIBWALLS
NOT TO SCALE

NOTES:

1. CRIBWALL SHOULD BE CONSTRUCTED FROM BELOW STREAMBED TO AVOID UNDERCUTTING AND TO PROVIDE A STABLE FOUNDATION.

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4.16. Vegetated Gabions

Photo 24: Dormant Cuttings Integrated into Gabion Construction

(Photo source: http://www.calgarycitynews.com/2014/11/another-stretch-of-flood-damaged.html)

4.16.1. Description

Gabions are wire baskets filled with stones to rebuild, protect, and reduce erosion at high velocity sites. They can be constructed in multiple configurations (walls, terraces, or blankets) depending on site needs. Gabions also trap sediments and dissipate energy from high velocity flow. Gabions are most effective when combined with transplants and dormant cuttings (Photo 24) to provide long-term stability and increased aesthetics to the restoration site.

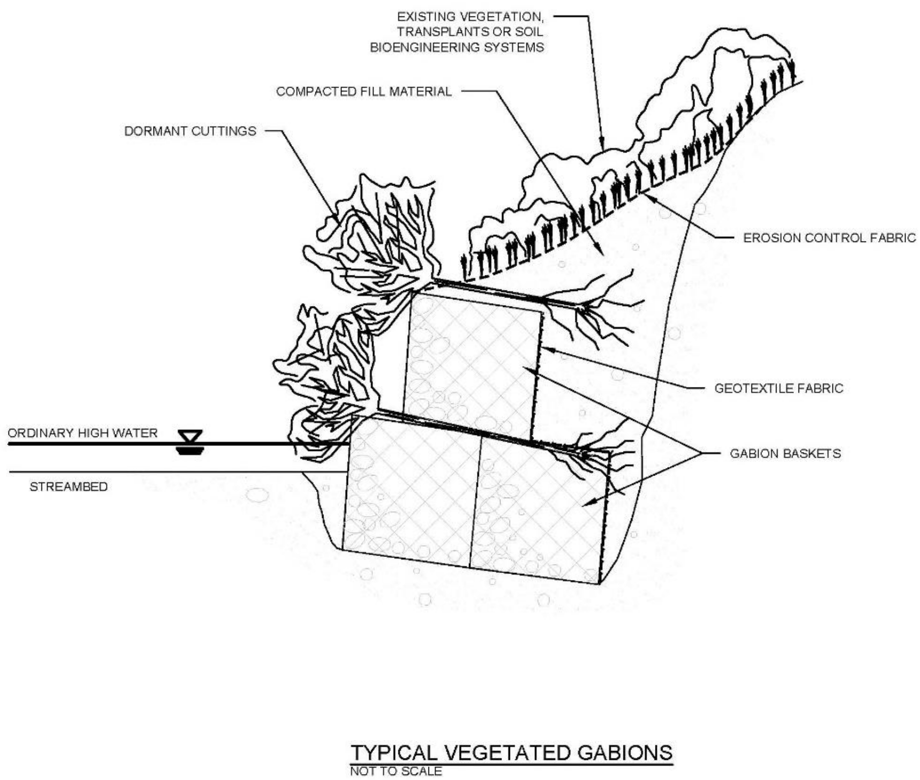
4.16.2. Methods

Gabions are constructed of galvanized wire mesh and filled with rock fill (Figure 13). The disturbed site is excavated to the streambed to allow gabion placement and to mitigate undercutting. Gabion baskets are placed on filter or geotextile fabric, anchored together, filled with rocks, and backfilled to form the new streambank. Gabion faces should be angled slightly downstream to minimize shearing potential during high velocity events. Dormant cuttings and/or transplants are integrated into the construction to promote rapid root formation providing permanent stability to the restoration.

4.16.3. Applications and Limitations

Gabions provide long-term streambank stabilization in steep slopes where scouring or under cutting may occur. Gabions are inappropriate at sites where water-borne debris or ice can damage the gabion mesh causing loss of stones, or where foot traffic is likely. Gabions may require regular and costly maintenance.

Figure 13: Typical Vegetated Gabions



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4.17. Vegetated Riprap

Photo 25: Vegetated Riprap with Willow Live Staking along the Chena River.

(Photo source: http://www.fws.gov/alaska/fisheries/fieldoffice/fairbanks/bieber.htm)

4.17.1. Description

Vegetated riprap (Photo 25) is a protective armoring method that uses a layer of rocks (traditional riprap) for immediate protection combined with live vegetation. Dormant cuttings, transplants, and/or live stakes are interspersed between the rocks to promote rapid revegetation and long term stability to streambanks. Riprap provides fish cover and traps sediments and native seeds.

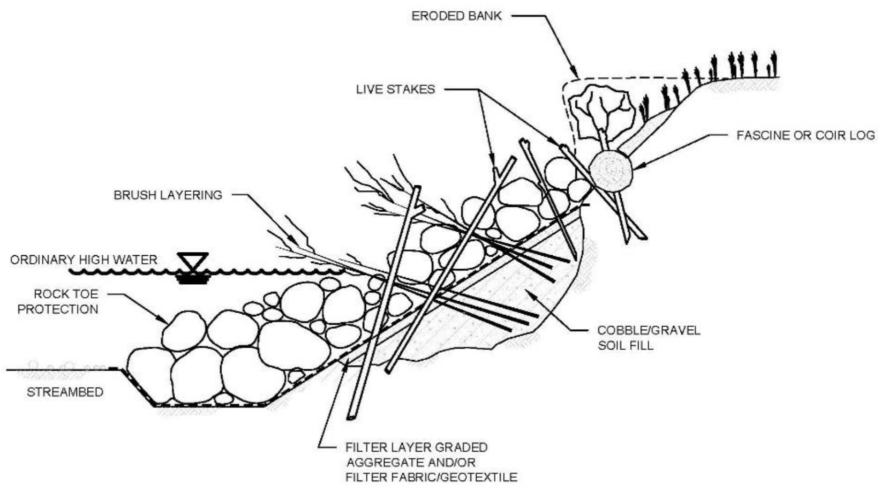
4.17.2. Methods

Riprap installations (Figure 14) are layers of graded rock over a filter material covering the disturbed streambank. The toe of slope is reinforced with large grade rocks and boulders, and the slope is filled to the desired contour. A filter layer is installed and topped with the appropriate sized rock riprap. Dormant cuttings can be laid horizontally under the rock layer in fascines, or vertically as live stakes or branch packing. Transplants can also be integrated to speed the revegetation process.

4.17.3. Applications and Limitations

Vegetated riprap is a permanent and durable restoration method appropriate for high velocity flow conditions. However, it is expensive to design, source materials, and install.

Figure 14: Typical Vegetated Riprap



TYPICAL VEGETATED RIPRAP
NOT TO SCALE

NOTES:

1. MULTIPLE REVEGETATION METHODS CAN BE COMBINED WITH RIPRAP AS SHOWN.

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5. REFERENCES

Alaska Department of Fish and Game (ADF&G). 2005. Streambank Revegetation and Protection. A Guide for Alaska. Revision of Original Technical Report No. 98-3 March 1998, ADF&G and Department of Natural Resources. Revised by J. Walter and D. Hughes.

Alaska Department of Fish and Game and Alaska Department of Transportation and Public Facilities (ADF&G/ADOT&PF). 2001. Memorandum of Agreement Between Alaska Department of Fish and Game and Alaska Department of Transportation and Public Facilities for the Design, Permitting, and Construction of Culverts for Fish Passage. Juneau Alaska.

Arp, C.D., M.S. Whitman, B.M. Jones, G. Grosse, B.V. Gaglioti1, and K.C. Heim. 2014. Beaded streams of Arctic permafrost landscapes. Biogeosciences Discussion, 11, 11391 – 11441. www.biogeosciences-discuss.net.

Craig, P.C. and P.J. McCart. 1975. Classification of stream types in Beaufort Sea drainages between Prudhoe Bay, Alaska, and the MacKenzie Delta, NW.T., Canada. Aquatic Environments Limited, Crossfield, Alberta, Canada.

Curran, J.H., D.F. Meyer, and G.D. Tasker. 2003. Estimating the magnitude and frequency of peak streamflows for ungaged sites on streams in Alaska and conterminous basins in Canada: U.S. Geological Survey Water-Resources Investigations Report 03-4188, 101 p.

Czapla, Philip K., Stoney J. Wright (Czapla and Wright). 2012. Interior Alaska revegetation and erosion control guide. Alaska Plant Materials Center, Division of Agriculture, Alaska Department of Natural Resources, Palmer AK.

Davis, J.C. and G.A. Muhlberg. 2002. The evaluation of wetland and riparian restoration projects. Alaska Department of Fish and Game, Habitat Division, Anchorage, AK.

Eubanks, C.E. and D. Meadows. 2005. A soil bioengineering guide for streambank and lakeshore stabilization. U.S. Department of Agriculture Forest Service, Technology and Development Program, San Dimas, CA. http://fsweb.sdtdc.wo.fs.fed.us.

Federal Energy Regulatory Commission (FERC). 2013. Wetland and Waterbody Construction and Mitigation Procedures. May 2013 Version. Office of Energy Projects. Washington DC.

Gallant, A.L., E.F. Binnian, J.M. Omernik, and M.B. Shasby. 1995. Ecoregions of Alaska. U.S. Geological Survey Professional Paper 1567, U.S. Government Printing Office, Washington DC.

Heim, K.C., M.S. Wipfli, M.S. Whitman, C.D. Arp, J. Adams, and J.A. Falke. 2014. Environmental correlates of Arctic Grayling seasonal movement on the Arctic Coastal Plain, Alaska. Submitted to Transactions of the American Fisheries Society.

Morris, W.A. 2003. Seasonal movements and habitat use of Arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), and broad whitefish (*Coregonus nasus*) within the Fish Creek drainage of the National Petroleum Reserve-Alaska, 2001-2002. Technical Report No. 03- 02. Alaska Department of Natural Resources, Office of Habitat Management and Permitting. Juneau. 110 pp.

Oswood, M.W., K.R. Everett, and D.M. Schell. 1989. Some physical and chemical characteristics of an arctic beaded stream. Ecography, 12: 290–295.

Rosgen, D.L. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Scott K.M., 1978. Effects of permafrost on stream channel behavior in Arctic Alaska. Department of Interior, Geological Survey, Washington, DC.

United States Department of Agriculture Forest Service (USDA Forest Service). 1992. Channel Type User Guide. Revised 2006.

Viereck, L.A., C.T. Dyrness, A.R. Batten, and K.J. Wenzlick. 1992. The Alaska vegetation classification. Gen. Tech. Rep. PNW-GTR-286. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 278 p.

Walker, H.J. and J. M. McCloy. 1969. Morphological change in two arctic deltas: Arctic Institute North American Research Paper, No. 49, 91p.

Weiner, A. 2000. Kenai River habitat restoration and recreation enhancement project, Exxon Valdez Oil Spill Restoration Project Final Report (Restoration Project 99180). Alaska.

Wright, S.J. 2008. A revegetation manual for Alaska. Alaska Plant Materials Center, Division of Agriculture, Alaska Department of Natural Resources, Palmer AK.

Wright, Stoney J. and Philip K. Czapla (Wright and Czapla). 2013. Alaska coastal revegetation and erosion control guide. Alaska Plant Materials Center, Division of Agriculture, Alaska Department of Natural Resources, Palmer AK.

ATTACHMENT 1

Preliminary Stream Type of Mainline Stream Crossings

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
MAINLINE WATERBODY CROSSING					
3.23	WPC001-B	Putuligayuk River	PN	Dry Ditch	Small Beaded or Tundra Stream
4.89	WPC001.1	Drainage Ditch	IN	Frozen Cut	Small Beaded or Tundra Stream
8.98	WPC004.1	Unnamed Stream	PN	Frozen Cut	Small Beaded or Tundra Stream
13.7	WPC008.01	Pond	P	Frozen Cut	NA
13.78	WPC008.02	Pond	P	Frozen Cut	NA
14.07	WPC008.03	Pond	P	Frozen Cut	NA
14.26	WPC008.04	Pond	P	Frozen Cut	NA
14.37	WPC008.05	Pond	P	Frozen Cut	NA
14.52	WPC008.06	Pond	P	Frozen Cut	NA
15.6	WPC008.07	Pond	P	Frozen Cut	NA
15.8	WPC008.08	Pond	P	Frozen Cut	NA
15.87	WPC008.09	Pond	P	Frozen Cut	NA
16.11	WPC008.10	Pond	P	Frozen Cut	NA
16.34	WPC008.11	Pond	P	Frozen Cut	NA
16.4	WPC008.12	Pond	P	Frozen Cut	NA
16.66	WPC008.13	Pond	P	Frozen Cut	NA
16.77	WPC008.14	Pond	P	Frozen Cut	NA
17.64	WPC008.15	Pond	P	Frozen Cut	NA
17.74	WPC008.16	Pond	P	Frozen Cut	NA
18.59	WPC008.17	Pond	P	Frozen Cut	NA
21.45	WPC008.18	Unnamed Tributary To Sagavanirktok River	IN	Frozen Cut	Small Beaded or Tundra Stream
27.38	WPC011-B	Sagavanirktok River Side Channel	PN	Frozen Cut	Small Beaded or Tundra Stream
35.22	WPC012	Thelma Creek	IN	Frozen Cut	Small Beaded or Tundra Stream
35.58	WPC013	Pond	IN	Frozen Cut	NA
38.05	WPC013.01	Sagavanirktok River Side Channel-Short Creek	P	Frozen Cut	NA

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
39.66	WPC013.011	Sylvia Creek #1	IN	Frozen Cut	Small Beaded or Tundra Stream
39.95	WPC013.012	Sylvia Creek #2	IN	Frozen Cut	Small Beaded or Tundra Stream
40.41	WPC013.013	Sylvia Creek #3	IN	Frozen Cut	Small Beaded or Tundra Stream
41.61	WPC013.02	Pond	IN	Frozen Cut	NA
41.75	WPC013.021	Sagavanirktok River Side Channel	IN	Frozen Cut	NA
42.79	WPC013.022	Unnamed Tributary to Sagavanirktok River	IN	Frozen Cut	NA
44.14	WPC013.023	Pond	P	Frozen Cut	NA
69.1	WPC016	Unnamed Tributary to Sagavanirktok River	IN	Open Cut	Small Beaded or Tundra Stream
69.87	WPC016.1-C	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
72.13	WPC017-B	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
74.65	WPC018	Unnamed Tributary to Mark Creek	IN	Open Cut	High to Moderate Gradient
74.85	WPC019	Mark Creek #1	PN	Open Cut	Small Beaded or Tundra Stream
76.85	WPC020	Mark Creek #2	PN	Open Cut	Small Beaded or Tundra Stream
77.08	WPC021	Mark Creek #3	IN	Open Cut	Small Beaded or Tundra Stream
77.2	WPC022	Mark Creek #4	IN	Open Cut	Small Beaded or Tundra Stream
80.29	WPC022.1	Pond	P	Open Cut	NA
82.89	WPC024-B	Unnamed Tributary to Sagavanirktok River	PN	Open Cut	Small Beaded or Tundra Stream
85	WPC024.1-B	Unnamed Tributary to Sagavanirktok River	IN	Frozen Cut	Small Beaded or Tundra Stream
85.55	WPC025-C	Unnamed Tributary to Sagavanirktok River	PN	Open Cut	Small Beaded or Tundra Stream
86.69	WPC025.01	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
87.17	WPC025.1	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
87.8	WPC025.2-C	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
88.26	WPC026-C	Unnamed Tributary to Sagavanirktok River	PN	Open Cut	Small Beaded or Tundra Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
90.3	WPC026.2	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
90.34	WPC027-B	Dan Creek	PN	Open Cut	Small Beaded or Tundra Stream
93.07	WPC027.1-B	Lori Creek	PN	Open Cut	Small Beaded or Tundra Stream
99.19	WPC028	Arthur Creek North Branch No. 2	PN	Open Cut	Small Beaded or Tundra Stream
100.65	WPC029	Arthur Creek	PN	Open Cut	Small Beaded or Tundra Stream
101.62	WPC030	Gustafson Gulch	PN	Open Cut	Small Beaded or Tundra Stream
102.86	WPC031	Unnamed Tributary to Sagavanirktok River	IN	Open Cut	Small Beaded or Tundra Stream
103.25	WPC032	Unnamed Tributary to Sagavanirktok River	IN	Open Cut	High to Moderate Gradient
103.85	WPC033	Polygon Creek	PN	Open Cut	Small Beaded or Tundra Stream
104.67	WPC034	Poison Pipe Creek	PN	Open Cut	Small Beaded or Tundra Stream
105.08	WPC035	Climb Creek	PN	Open Cut	Small Beaded or Tundra Stream
105.69	WPC036	Dennis Creek	PN	Open Cut	Small Beaded or Tundra Stream
106.09	WPC036.1	Unnamed Stream	IN	Open Cut	Small Beaded or Tundra Stream
106.79	WPC037	Rudy Creek North Branch	PN	Open Cut	Small Beaded or Tundra Stream
107.32	WPC038	Rudy Creek South Branch	IN	Open Cut	Small Beaded or Tundra Stream
108.64	WPC039	Oksrukuyik Creek #1	PN	Open Cut	Braided Stream
110.65	WPC039.1	Unnamed Stream	IN	Open Cut	Small Beaded or Tundra Stream
115.49	WPC039.2-C	Unnamed Tributary to Sagavanirktok River	IN	Dry Ditch	Small Beaded or Tundra Stream
121.59	WPC040	Oksrukuyik Creek #2	PN	Dry Ditch	Small Beaded or Tundra Stream
121.84	WPC040.05	Unnamed Stream	IN	Dry Ditch	High to Moderate Gradient
124.47	WPC040.06	Unnamed Stream	IN	Dry Ditch	Small Beaded or Tundra Stream
126.14	WPC040.1	Unnamed Tributary to Sagavanirktok River	IN	Dry Ditch	Small Beaded or Tundra Stream
128.18	WPC041	Unnamed Tributary to Toolik River	IN	Dry Ditch	Small Beaded or Tundra Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
128.59	WPC042-B	Toolik River	PN	Dry Ditch	Small Beaded or Tundra Stream
129.29	WPC043-B	East Fork Kuparuk River	PN	Dry Ditch	Small Beaded or Tundra Stream
130.89	WPC044	Kuparuk River	PN	Dry Ditch	Small Beaded or Tundra Stream
132.31	WPC044.1	Unnamed Tributary to Kuparuk River	IN	Open Cut	Braided Stream
132.74	WPC044.2	Unnamed Stream	IN	Open Cut	Small Beaded or Tundra Stream
136.4	WPC044.3	Terry Creek	IN	Open Cut	Braided Stream
136.78	WPC046	Mack Creek	PN	Open Cut	Small Beaded or Tundra Stream
137.22	WPC047	Ed Creek	PN	Open Cut	Small Beaded or Tundra Stream
137.71	WPC048-B	Jill Creek	IN	Open Cut	High to Moderate Gradient
141.84	WPC049	Tributary to Galbraith Lake	IN	Open Cut	Small Beaded or Tundra Stream
142.58	WPC050	Tributary to Galbraith Lake	IN	Open Cut	High to Moderate Gradient
143.19	WPC051	Tributary to Galbraith Lake	IN	Open Cut	High to Moderate Gradient
145.22	WPC052-B	Atigun River #1	PN	Dry Ditch	Braided Stream
146.86	WPC053	Unnamed Tributary to Tee Lake Outlet	IN	Dry Ditch	High to Moderate Gradient
146.94	WPC054	Tributary to Tee Lake Inlet	IN	Dry Ditch	High to Moderate Gradient
148.09	WPC055	Tee Lake Inlet	IN	Dry Ditch	High to Moderate Gradient
148.37	WPC056	Tee Lake Inlet	IN	Dry Ditch	Braided Stream
148.78	WPC057	Holden Creek	PN	Dry Ditch	Braided Stream
150.1	WPC057.1	Unnamed Tributary to Mainline Spring Creek	IN	Open Cut	Small Beaded or Tundra Stream
151.1	WPC058	Roche Mountonnee Creek	IN	Dry Ditch	High to Moderate Gradient
152.39	WPC058.005	Unnamed Tributary to Atigun River	IN	Open Cut	High to Moderate Gradient
153.37	WPC058.01	Unnamed Tributary to Atigun River	IN	Open Cut	Small Beaded or Tundra Stream
153.81	WPC059	Unnamed Stream	IN	Open Cut	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
154.34	WPC059.1	Unnamed Tributary to Atigun River	IN	Open Cut	High to Moderate Gradient
155.36	WPC060	Waterhole Creek	PN	Dry Ditch	Braided Stream
155.64	WPC061	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
155.85	WPC062	Unnamed Tributary to Atigun River	PN	Open Cut	High to Moderate Gradient
156.5	WPC063	Unnamed Tributary to Tyler Creek	IN	Dry Ditch	High to Moderate Gradient
157.5	WPC063.1	Tyler Creek	PN	Dry Ditch	High to Moderate Gradient
157.54	WPC063.2	Tyler Creek	IN	Dry Ditch	High to Moderate Gradient
157.57	WPC063.3	Tyler Creek	IN	Dry Ditch	High to Moderate Gradient
157.65	WPC064	Trevor Creek	IN	Dry Ditch	High to Moderate Gradient
158.17	WPC064.1	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
158.25	WPC064.2	Unnamed Tributary to Atigun River	IN	Open Cut	High to Moderate Gradient
158.51	WPC064.3	Unnamed Tributary to Atigun River	IN	Open Cut	High to Moderate Gradient
158.59	WPC064.4	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
159.22	WPC064.45	Unnamed Tributary to Atigun River	IN	Open Cut	High to Moderate Gradient
160.61	WPC064.5	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
160.78	WPC065	Unnamed Tributary to Who Creek	IN	Open Cut	High to Moderate Gradient
160.82	WPC066	Unnamed Tributary to Who Creek	IN	Open Cut	High to Moderate Gradient
162.01	WPC066.01	Unnamed Stream	IN	Open Cut	Small Beaded or Tundra Stream
162.14	WPC066.02	Unnamed Tributary to Atigun River	IN	Open Cut	Small Beaded or Tundra Stream
162.36	WPC067	Unnamed Tributary to Atigun River	IN	Open Cut	High to Moderate Gradient
162.5	WPC068	Unnamed Tributary to Atigun River	IN	Open Cut	High to Moderate Gradient
163	WPC068.1	Unnamed Tributary to Atigun River	IN	Open Cut	Braided Stream
163.39	WPC069	Unnamed Tributary to Atigun River	IN	Open Cut	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
163.79	WPC070	Unnamed Tributary to Atigun River	IN	Dry Ditch	High to Moderate Gradient
164.1	WPC071	Unnamed Tributary to Atigun River	IN	Dry Ditch	High to Moderate Gradient
164.24	WPC071.1	Unnamed Tributary to Atigun River	IN	Open Cut	High to Moderate Gradient
164.97	WPC072	Unnamed Tributary to Atigun River	IN	Open Cut	High to Moderate Gradient
165.24	WPC073	Unnamed Tributary to Atigun River	IN	Dry Ditch	High to Moderate Gradient
165.38	WPC074	Unnamed Tributary to Atigun River	IN	Dry Ditch	High to Moderate Gradient
165.57	WPC074.1	Unnamed Tributary to Atigun River	IN	Dry Ditch	Braided Stream
165.63	WPC075	Unnamed Tributary to Atigun River	IN	Dry Ditch	Braided Stream
166.24	WPC075.1	Atigun River #2A	PNM	Frozen Cut	Braided Stream
166.65	WPC076	Atigun River #2B	PNM	Frozen Cut	Braided Stream
167.11	WPC076.2	Atigun River #2D	PNM	Frozen Cut	Braided Stream
167.61	WPC076.4	Atigun River #2E	IN	Frozen Cut	Braided Stream
167.76	WPC076.5	Unnamed Tributary to Atigun River	IN	Frozen Cut	High to Moderate Gradient
168.08	WPC076.6	Atigun River #2F	PNM	Frozen Cut	Braided Stream
168.6	WPC082	Unnamed Tributary to Atigun River	IN	Frozen Cut	Braided Stream
168.63	WPC082.1	Atigun River #2G	PNM	Frozen Cut	Braided Stream
169.35	WPC082.2	Unnamed Tributary to Atigun River	IN	Dry Ditch	High to Moderate Gradient
171.06	WPC082.3	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
171.86	WPC083	Unnamed Stream	PNM	Dry Ditch	Braided and Anastamosing Stream
171.93	WPC083.1	Unnamed Stream	IN	Dry Ditch	High to Moderate Gradient
173.48	WPC084.1	Unnamed Tributary to North Fork Chandalar River	IN	Dry Ditch	High to Moderate Gradient
173.84	WPC086.1	Unnamed Tributary to North Fork Chandalar River	IN	Dry Ditch	Braided and Anastamosing Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
174.24	WPC086.2	Unnamed Stream	IN	Dry Ditch	High to Moderate Gradient
174.36	WPC086.3	Unnamed Stream	IN	Dry Ditch	High to Moderate Gradient
175.28	WPC089.1	Unnamed Tributary to North Fork Chandalar River	IN	Dry Ditch	High to Moderate Gradient
175.75	WPC089.2	Unnamed Tributary to North Fork Chandalar River	IN	Dry Ditch	Braided and Anastamosing Stream
175.79	WPC089.3	Unnamed Tributary to North Fork Chandalar River	IN	Dry Ditch	Braided and Anastamosing Stream
175.86	WPC089.4	Unnamed Stream	IN	Open Cut	Braided and Anastamosing Stream
175.92	WPC089.5	Unnamed Stream	IN	Open Cut	Braided and Anastamosing Stream
179.16	WPC095-B	Dietrich River #1	PNM	Frozen Cut	Braided and Anastamosing Stream
180.71	WPC096	Wetfoot Creek	PNM	Open Cut	High to Moderate Gradient
181.31	WPC098-C	Dietrich River #2	PNM	Open Cut	Braided and Anastamosing Stream
181.88	WPC098.1	Oskar`s Eddy	IN	Open Cut	High to Moderate Gradient
182.97	WPC098.2	Unnamed Tributary to Dietrich River	IN	Open Cut	High to Moderate Gradient
183.64	WPC100	Unnamed Tributary to Dietrich River	IN	Open Cut	High to Moderate Gradient
183.84	WPC101	Unnamed Tributary to Dietrich River	IN	Open Cut	High to Moderate Gradient
184.53	WPC102	Unnamed Tributary to Dietrich River	IN	Dry Ditch	High to Moderate Gradient
185.06	WPC103	Unnamed Tributary to Dietrich River	IN	Open Cut	High to Moderate Gradient
185.46	WPC103.1	Unnamed Stream	IN	Dry Ditch	High to Moderate Gradient
187.56	WPC104	Nutirwik Creek	PN	Dry Ditch	Floodplain Stream
188.74	WPC105	Unnamed Tributary to Dietrich River	IN	Dry Ditch	Floodplain Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
188.88	WPC106	Unnamed Tributary to Dietrich River	IN	Dry Ditch	Floodplain Stream
188.99	WPC107	Unnamed Tributary to Dietrich River	PN	Dry Ditch	Floodplain Stream
189.18	WPC108	Beaver Dam Brook	IN	Dry Ditch	Floodplain Stream
189.69	WPC109	Unnamed Tributary to Dietrich River	PN	Dry Ditch	High to Moderate Gradient
189.96	WPC110	Unnamed Tributary to Dietrich River	IN	Open Cut	High to Moderate Gradient
190.71	WPC111	Tracey's Trickle	IN	Dry Ditch	Braided and Anastamosing Stream
193.65	WPC112	Ruff Creek	PNM	Open Cut	Braided and Anastamosing Stream
195.09	WPC113	Steep Creek	PN	Dry Ditch	Braided and Anastamosing Stream
196.29	WPC113.1	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
197.67	WPC113.2	Unnamed Stream	IN	Dry Ditch	High to Moderate Gradient
197.75	WPC114	Unnamed Tributary to Dietrich River	IN	Open Cut	High to Moderate Gradient
199.09	WPC115	Unnamed Tributary to Dietrich River	PNM	Dry Ditch	High to Moderate Gradient
199.9	WPC116	Unnamed Tributary to Dietrich River	IN	Dry Ditch	High to Moderate Gradient
200.59	WPC117	Number Lakes Creek	IN	Dry Ditch	High to Moderate Gradient
200.98	WPC117.5	Unnamed Tributary to Dietrich River	IN	Dry Ditch	High to Moderate Gradient
201.85	WPC118	Snowden Creek	PN	Dry Ditch	Braided and Anastamosing Stream
202.23	WPC118.1	Unnamed Tributary to Dietrich River	IN	Open Cut	High to Moderate Gradient
202.61	WPC119	Unnamed Tributary to Dietrich River	IN	Open Cut	High to Moderate Gradient
202.83	WPC120	Unnamed Tributary to Dietrich River	IN	Open Cut	High to Moderate Gradient
203.49	WPC121	Sahr's Slough	IN	Open Cut	High to Moderate Gradient
203.85	WPC121.1	Unnamed Stream	IN	Dry Ditch	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
204.76	WPC122	Disaster Creek	PN	Dry Ditch	Braided and Anastamosing Stream
207.48	WPC123	Brockman Creek	PNM	Dry Ditch	Braided and Anastamosing Stream
208.26	WPC124	1415 Lake Inlet No. 1	IN	Open Cut	Low Gradient Palustrine Stream
208.77	WPC125	Dietrich River #3	PNM	Open Cut	Floodplain Stream
209.17	WPC126	Eva Creek	PN	Dry Ditch	High to Moderate Gradient
210.69	WPC126.1	Unnamed Stream	IN	Dry Ditch	Low Gradient Palustrine Stream
211.13	WPC127	Middle Fork Koyukuk River	PNM	Trenchless	Floodplain Stream
213.32	WPC129-B	West Fork Sukakpak Creek	IN	Dry Ditch	Low Gradient Palustrine Stream
214.61	WPC129.1-B	Unnamed Stream	IN	Dry Ditch	High to Moderate Gradient
218.53	WPC130	Linda Creek	PN	Dry Ditch	Floodplain Stream
219.07	WPC131	Gold Creek	PN	Dry Ditch	Floodplain Stream
219.55	WPC132	Unnamed Tributary to Middle Fork Koyukuk River	IN	Open Cut	Low Gradient Palustrine Stream
219.86	WPC133-B	Sheep Creek	PN	Dry Ditch	Braided and Anastamosing Stream
220.15	WPC134-B	Wolf Pup Creek	IN	Dry Ditch	Low Gradient Palustrine Stream
221.13	WPC135-B	Nugget Creek	PN	Dry Ditch	Floodplain Stream
223.24	WPC136	Over Creek	IN	Dry Ditch	Low Gradient Palustrine Stream
223.58	WPC137	Rainbow Gulch	IN	Dry Ditch	High to Moderate Gradient
224.85	WPC138	Coon Gulch	IN	Dry Ditch	High to Moderate Gradient
224.97	WPC138.1	Coon Gulch	IN	Dry Ditch	High to Moderate Gradient
225.87	WPC139	Montana Gulch	IN	Dry Ditch	High to Moderate Gradient
226.24	WPC139.1	Unnamed Stream	IN	Dry Ditch	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
227	WPC140	Bluff Gulch	IN	Dry Ditch	High to Moderate Gradient
229.12	WPC141	Minnie Creek	PN	Frozen Cut	Floodplain Stream
230.4	WPC142	Unnamed Tributary to Middle Fork Koyukuk River	IN	Frozen Cut	High to Moderate Gradient
230.53	WPC143	Unnamed Tributary to Middle Fork Koyukuk River	IN	Frozen Cut	High to Moderate Gradient
233.06	WPC144	Dry Gulch	IN	Frozen Cut	High to Moderate Gradient
234.19	WPC145	Unnamed Tributary to Middle Fork Koyukuk River	IN	Frozen Cut	High to Moderate Gradient
234.31	WPC145.1	Unnamed Stream	IN	Frozen Cut	Low Gradient Palustrine Stream
235.54	WPC146	Unnamed Tributary to Middle Fork Koyukuk River	IN	Frozen Cut	Low Gradient Palustrine Stream
235.95	WPC147	Pence's Pond	IN	Frozen Cut	Low Gradient Palustrine Stream
236.51	WPC148	Marion Creek	PN	Frozen Cut	Floodplain Stream
237.58	WPC149	Mary Angel Creek	IN	Frozen Cut	Low Gradient Palustrine Stream
239.83	WPC150	Clara Creek	IN	Frozen Cut	Braided and Anastamosing Stream
240.44	WPC150.1	Unnamed Stream	IN	Frozen Cut	Low Gradient Palustrine Stream
241.02	WPC151	Slate Creek #1	PN	Frozen Cut	Floodplain Stream
242.7	WPC152	Spring Slough (Horseshoe)	IN	Open Cut	Braided and Anastamosing Stream
246.21	WPC153	Rosie Creek	PN	Dry Ditch	Floodplain Stream
246.63	WPC154	Unnamed Tributary to Rosie Creek	IN	Open Cut	High to Moderate Gradient
246.78	WPC155	South Fork Rosie Creek	IN	Open Cut	High to Moderate Gradient
247.85	WPC156	Unnamed Tributary to Middle Fork Koyukuk River	IN	Open Cut	High to Moderate Gradient
248.04	WPC157	Unnamed Tributary to Middle Fork Koyukuk River	IN	Open Cut	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
248.22	WPC157.1	Unnamed Tributary to Middle Fork Koyukuk River	IN	Open Cut	High to Moderate Gradient
249.21	WPC157.12	Unnamed Tributary to Middle Fork Koyukuk River	IN	Open Cut	Low Gradient Palustrine Stream
249.24	WPC157.2	Unnamed Stream	PN	Dry Ditch	Low Gradient Palustrine Stream
249.41	WPC158	Jackson Slough	IN	Open Cut	High to Moderate Gradient
250.63	WPC159-C	Trent's Trickle	IN	Open Cut	High to Moderate Gradient
252.01	WPC159.1	Ninety-Six Creek	IN	Open Cut	Low Gradient Palustrine Stream
253.46	WPC160.1	South Fork Windy Arm Creek	IN	Open Cut	Low Gradient Palustrine Stream
254.42	WPC161	Chapman Creek	PN	Open Cut	Low Gradient Palustrine Stream
255.03	WPC161.1	Unnamed Tributary to Chapman Creek	IN	Open Cut	Low Gradient Palustrine Stream
255.69	WPC162-B	Crossroads Creek (No.2)	IN	Open Cut	Low Gradient Palustrine Stream
258.66	WPC162.1	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
259.22	WPC162.2	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
260.72	WPC163	South Fork Koyukuk River	PN	Dry Ditch	Floodplain Stream
260.99	WPC163.1	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
262.81	WPC164	Aba-dabba Creek	PN	Open Cut	High to Moderate Gradient
263.16	WPC164.1	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
263.54	WPC164.2	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
263.65	WPC165	Unnamed Tributary to Elwood Creek (No.3)	IN	Open Cut	High to Moderate Gradient
264.47	WPC165.05	Unnamed Tributary to Grayling Creek	IN	Open Cut	Low Gradient Palustrine Stream
265.29	WPC165.1	Unnamed Tributary to Grayling Creek	IN	Open Cut	High to Moderate Gradient
265.49	WPC166	Grayling Creek	IN	Open Cut	High to Moderate Gradient
265.95	WPC166.1	Unnamed Stream	IN	Open Cut	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
266.27	WPC166.2	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
266.93	WPC167	Grayling Creek	PN	Open Cut	Low Gradient Palustrine Stream
268.17	WPC168	Unnamed Tributary to Grayling Creek	IN	Open Cut	Low Gradient Palustrine Stream
271.03	WPC169	Unnamed Tributary to Jim River	IN	Open Cut	High to Moderate Gradient
272.06	WPC169.1	Drainage Ditch	P	Open Cut	High to Moderate Gradient
272.47	WPC170	Jim River	PN	Open Cut	Floodplain Stream
272.55	WPC170.1	Unnamed Stream	PN	Open Cut	Floodplain Stream
273.41	WPC170.2	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
274	WPC170.3	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
274.77	WPC171	Douglas Creek	PN	Open Cut	Braided and Anastamosing Stream
275.8	WPC171.1	Unnamed Tributary to Jim River (Gas Bubble Slough)	IN	Open Cut	Low Gradient Palustrine Stream
278.72	WPC172	Unnamed Tributary to Jim River	IN	Open Cut	Low Gradient Palustrine Stream
280.62	WPC173-C	Unnamed Tributary to Prospect Creek	IN	Open Cut	Low Gradient Palustrine Stream
281.35	WPC174	Prospect Creek	PN	Open Cut	Floodplain Stream
281.66	WPC175	Unnamed Tributary to Prospect Creek	IN	Open Cut	Low Gradient Palustrine Stream
285.86	WPC176-C	Little Nasty Creek	PN	Open Cut	Braided and Anastamosing Stream
286.28	WPC177-C	South Fork Little Nasty Creek	PN	Open Cut	Low Gradient Palustrine Stream
288.48	WPC178	North Fork Bonanza Creek	PN	Open Cut	Floodplain Stream
290.13	WPC181	South Fork Bonanza Creek	PN	Open Cut	Floodplain Stream
293.72	WPC182	Pung's Crossing Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
297.22	WPC183	Alder Mountain Creek	IN	Dry Ditch	High to Moderate Gradient
298.83	WPC184-B	Fish Creek #1	PN	Dry Ditch	Floodplain Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
300.34	WPC185	Middle Fork Fish Creek	PN	Dry Ditch	Braided and Anastamosing Stream
301.54	WPC186-C	South Fork Fish Creek	PN	Open Cut	Low Gradient Palustrine Stream
304.82	WPC187	Unnamed Tributary to Kanuti River	IN	Open Cut	High to Moderate Gradient
305.26	WPC188	Unnamed Tributary to Kanuti River	IN	Open Cut	High to Moderate Gradient
307.13	WPC189	Kanuti River	PN	Open Cut	Low Gradient Palustrine Stream
310.2	WPC190	Caribou Mountain Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
312.7	WPC191	Unnamed Tributary to Olson's Lake Creek	IN	Open Cut	High to Moderate Gradient
313.12	WPC192	Olson's Lake Creek	IN	Open Cut	High to Moderate Gradient
316.12	WPC193	Unnamed Tributary to Finger Mountain Creek	IN	Open Cut	High to Moderate Gradient
316.57	WPC194	Finger Mountain Creek	IN	Open Cut	High to Moderate Gradient
317.42	WPC195	Eight-Five Creek	IN	Open Cut	High to Moderate Gradient
318.95	WPC196	Smokey Creek	IN	Open Cut	High to Moderate Gradient
319.25	WPC197	Unnamed Tributary to Smokey Creek	IN	Open Cut	High to Moderate Gradient
319.75	WPC198	Middle Branch West Fork Dall River	IN	Open Cut	Low Gradient Palustrine Stream
322.1	WPC199	South Branch West Fork Dall River	PN	Dry Ditch	Low Gradient Palustrine Stream
323.46	WPC200-B	Unnamed Tributary to South Branch West Fork Dall River	IN	Open Cut	Low Gradient Palustrine Stream
323.93	WPC200.5	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
324.08	WPC201-B	Unnamed Tributary to South Branch West Fork Dall River	IN	Open Cut	High to Moderate Gradient
325.87	WPC202-B	Unnamed Tributary to North Fork Ray River	IN	Open Cut	High to Moderate Gradient
327.28	WPC202.1	Unnamed Tributary to North Fork Ray River	IN	Open Cut	High to Moderate Gradient
328.71	WPC203	Unnamed Tributary to Fed Creek	IN	Open Cut	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
329.43	WPC204	Fed Creek	IN	Open Cut	High to Moderate Gradient
334.13	WPC205	North Fork Ray River	PN	Open Cut	Low Gradient Palustrine Stream
337.59	WPC207	Unnamed Tributary to North Fork Ray River	IN	Open Cut	Low Gradient Palustrine Stream
340.66	WPC208	Hamlin Hills Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
341.79	WPC209	Eight-O-Clock Creek	IN	Dry Ditch	High to Moderate Gradient
343.45	WPC210	Unnamed Tributary to Ray River	IN	Dry Ditch	High to Moderate Gradient
344.84	WPC211	Unnamed Tributary to Ray River	IN	Dry Ditch	High to Moderate Gradient
346.25	WPC212	Unnamed Tributary to Ray River	IN	Dry Ditch	High to Moderate Gradient
347.63	WPC213	Unnamed Tributary to Ray River	IN	Dry Ditch	High to Moderate Gradient
349.19	WPC214	Phelps Creek	IN	Open Cut	Low Gradient Palustrine Stream
351.35	WPC214.1	Unnamed Tributary to Ray River	IN	Frozen Cut	Low Gradient Palustrine Stream
352.94	WPC214.2	Unnamed Tributary to Ray River	IN	Frozen Cut	Low Gradient Palustrine Stream
354.76	WPC215	Woodchopper Creek	IN	Frozen Cut	Low Gradient Palustrine Stream
355.63	WPC216	Burbot Creek	IN	Frozen Cut	Low Gradient Palustrine Stream
356.47	WPC217	Yukon River	PN	Trenchless	Floodplain Stream
358.6	WPC217.1	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
364.72	WPC218	Unnamed Tributary to Isom Creek	IN	Open Cut	High to Moderate Gradient
365.87	WPC219	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
365.98	WPC220	Unnamed Tributary to Isom Creek	IN	Open Cut	Low Gradient Palustrine Stream
366.83	WPC221	Isom Creek	IN	Dry Ditch	Low Gradient Palustrine Stream
369.69	WPC222	Unnamed Tributary to Hess Creek	IN	Open Cut	High to Moderate Gradient
369.9	WPC222.1	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
371.35	WPC223	Unnamed Tributary to Hess Creek	IN	Dry Ditch	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
372.19	WPC224	Unnamed Tributary to Hess Creek	IN	Open Cut	High to Moderate Gradient
373.77	WPC225	Hot Cat Creek	IN	Dry Ditch	Low Gradient Palustrine Stream
374.94	WPC226	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
375.53	WPC227	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
376.59	WPC228	Unnamed Tributary to Hess Creek	IN	Frozen Cut	Low Gradient Palustrine Stream
377.02	WPC228.1	Unnamed Stream	IN	Frozen Cut	High to Moderate Gradient
377.6	WPC229	Unnamed Tributary to Hess Creek	IN	Frozen Cut	High to Moderate Gradient
378.13	WPC229.1	Unnamed Stream	IN	Frozen Cut	High to Moderate Gradient
380.09	WPC229.2	Unnamed Stream	IN	Frozen Cut	High to Moderate Gradient
380.36	WPC229.3	Unnamed Stream	IN	Frozen Cut	High to Moderate Gradient
380.45	WPC229.4	Unnamed Stream	IN	Frozen Cut	High to Moderate Gradient
380.56	WPC229.5	Unnamed Stream	IN	Frozen Cut	High to Moderate Gradient
381.59	WPC230	Hess Creek Side Channel	PN	Open Cut	Floodplain Stream
381.75	WPC231	Hess Creek	PN	Dry Ditch	Floodplain Stream
381.85	WPC231.1	Hess Creek Side Channel	IN	Frozen Cut	Floodplain Stream
385.76	WPC232.1	Erickson Creek #1	PN	Open Cut	Low Gradient Palustrine Stream
386.6	WPC232.2	Unnamed tributary to Erickson Creek	PN	Open Cut	High to Moderate Gradient
386.89	WPC232.3	Unnamed Tributary to Erickson Creek	PN	Open Cut	High to Moderate Gradient
387.9	WPC232.4	Erickson Creek #2	PN	Open Cut	Low Gradient Palustrine Stream
391.31	WPC233.1	Erickson Creek	IN	Open Cut	Low Gradient Palustrine Stream
395.69	WPC234	Lost Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
398.97	WPC235	Unnamed Tributary to West Fork Tolovana River	IN	Open Cut	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
402.02	WPC235.1	Unnamed Creek (Tolovana River Oxbow)	P	Open Cut	Floodplain Stream
402.21	WPC236	Tolovana River	PN	Dry Ditch	Floodplain Stream
402.3	WPC236.1	Tolovana River Oxbow #2	P	Frozen Cut	Floodplain Stream
402.73	WPC237	Unnamed Tributary to Tolovana River	IN	Frozen Cut	Low Gradient Palustrine Stream
403.5	WPC238	Shorty Creek	IN	Frozen Cut	Low Gradient Palustrine Stream
405.3	WPC239	Winter Creek	IN	Frozen Cut	High to Moderate Gradient
405.9	WPC239.1	Unnamed Tributary to Tolovana River	PN	Frozen Cut	High to Moderate Gradient
407.54	WPC240	Eagle Creek #1	PN	Frozen Cut	High to Moderate Gradient
408.69	WPC242	Unnamed Tributary to Tolovana River	PN	Frozen Cut	High to Moderate Gradient
430.46	WPC259	Tatalina River	PN	Dry Ditch	Low Gradient Palustrine Stream
432.09	WPC260	Unnamed Tributary to Tatalina River	PN	Frozen Cut	Low Gradient Palustrine Stream
432.57	WPC261	Unnamed Tributary to Washington Creek	IN	Frozen Cut	Low Gradient Palustrine Stream
432.76	WPC262	Washington Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
439.11	WPC263	Chatanika River	PN	Dry Ditch	Low Gradient Palustrine Stream
439.3	WPC264	Chatanika River Oxbow	P	Open Cut	Low Gradient Palustrine Stream
439.64	WPC264.1	Unnamed Stream	PN	Open Cut	Low Gradient Palustrine Stream
439.88	WPC264.2	Unnamed Tributary to Goldstream Creek	IN	Frozen Cut	Low Gradient Palustrine Stream
442.36	WPC266-C	Unnamed Tributary to Goldstream Creek	IN	Frozen Cut	Low Gradient Palustrine Stream
443.27	WPC266.1-C	Unnamed Tributary to Goldstream Creek	IN	Frozen Cut	Low Gradient Palustrine Stream
444.03	WPC268	Unnamed Tributary to Goldstream Creek	IN	Dry Ditch	Low Gradient Palustrine Stream
445.34	WPC269.5	Unnamed Tributary to Minto Lakes	IN	Open Cut	Low Gradient Palustrine Stream
446.42	WPC270	Unnamed Tributary to Goldstream Creek	IN	Dry Ditch	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
448.74	WPC271	Unnamed Tributary to Goldstream Creek	IN	Frozen Cut	High to Moderate Gradient
449.6	WPC272	Unnamed Tributary to Goldstream Creek	IN	Frozen Cut	High to Moderate Gradient
450.52	WPC273	Unnamed Tributary to Goldstream Creek	IN	Frozen Cut	High to Moderate Gradient
452.26	WPC273.1	Unnamed Tributary to Goldstream Creek	IN	Frozen Cut	High to Moderate Gradient
453.76	WPC273.2	Unnamed Tributary to Goldstream Creek	IN	Frozen Cut	High to Moderate Gradient
454.99	WPC274	Goldstream Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
465.65	WPC274.1	Unnamed Stream	PN	Dry Ditch	Low Gradient Palustrine Stream
465.81	WPC275-B	Little Goldstream Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
469.33	WPC275.3	Unnamed Tributary to Tanana River	IN	Frozen Cut	Low Gradient Palustrine Stream
469.93	WPC275.4	Unnamed Tributary to Tanana River	IN	Frozen Cut	Low Gradient Palustrine Stream
472.98	WPC276-B	Tanana River	PN	Trenchless	Braided and Anastamosing Stream
474.33	WPC276.1	Unnamed Stream	IN	Frozen Cut	Low Gradient Palustrine Stream
476.04	WPC279-B	Nenana River #1	PN	Open Cut	Floodplain Stream
478.5	WPC280	Unnamed Stream	IN	Dry Ditch	Low Gradient Palustrine Stream
483.39	WPC280.1	Unnamed Tributary to Nenana River	IN	Frozen Cut	Low Gradient Palustrine Stream
485.51	WPC281	Unnamed Tributary to Nenana River	PN	Dry Ditch	Low Gradient Palustrine Stream
486.91	WPC281.1	Unnamed Tributary to Nenana River	IN	Frozen Cut	Low Gradient Palustrine Stream
489.21	WPC282	Nenana River #2	PNM	Dry Ditch	Floodplain Stream
501.49	WPC285	Birch Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
502.12	WPC285.2	Unnamed Stream	IN	Frozen Cut	Low Gradient Palustrine Stream
504.65	WPC286	Bear Creek	PN	Frozen Cut	Floodplain Stream
504.86	WPC287	June Creek	PN	Frozen Cut	Floodplain Stream
506.68	WPC287.05	Unnamed Tributary to Nenana River	IN	Open Cut	Low Gradient Palustrine Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
507.76	WPC287.1-C	Unnamed Tributary to Nenana River	PN	Frozen Cut	Low Gradient Palustrine Stream
512.73	WPC288	Rock Creek	PN	Frozen Cut	Floodplain Stream
515.75	WPC289	Slate Creek #2	PN	Frozen Cut	Floodplain Stream
519.6	WPC290	Little Panguingue Creek	PN	Frozen Cut	High to Moderate Gradient
520.97	WPC291	Panguingue Creek	PN	Dry Ditch	Floodplain Stream
523.56	WPC292	Unnamed Tributary to Nenana River	IN	Dry Ditch	Low Gradient Palustrine Stream
525.88	WPC293	Dry Creek	IN	Open Cut	Braided and Anastamosing Stream
530.37	WPC294	Antler Creek	PN	Dry Ditch	High to Moderate Gradient
531.43	WPC295	Unnamed Tributary to Nenana River	PN	Dry Ditch	High to Moderate Gradient
531.86	WPC295.1	Manmade Ditch	IN	Open Cut	High to Moderate Gradient
532.13	WPC296-B	Nenana River #3	PN	Aerial Span	Floodplain Stream
532.4	WPC297	Coyote Creek	PN	Open Cut	High to Moderate Gradient
532.75	WPC298	Dragonfly Creek	PN	Open Cut	High to Moderate Gradient
533.15	WPC299	Eagle Creek #2	PN	Open Cut	High to Moderate Gradient
533.93	WPC300	Fox Creek	PN	Open Cut	High to Moderate Gradient
534.27	WPC301-C	Grizzly Creek	PN	Open Cut	High to Moderate Gradient
534.91	WPC302-B	Hornety Creek	PN	Open Cut	High to Moderate Gradient
535.1	WPC303-B	Iceworm Gulch	PN	Open Cut	High to Moderate Gradient
536.21	WPC304-B	Junco Creek	PN	Open Cut	High to Moderate Gradient
537.03	WPC305	Kingfisher Creek	PN	Open Cut	High to Moderate Gradient
537.9	WPC306	Lynx Creek	PN	Aerial Span	High to Moderate Gradient
538.59	WPC308	Montana Creek	PN	Open Cut	High to Moderate Gradient
539.5	WPC309-B	Unnamed Tributary to Nenana River	IN	Open Cut	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
541.59	WPC309.1	Unnamed Tributary to Nenana River	PN	Open Cut	High to Moderate Gradient
542.16	WPC309.2	Unnamed Stream	PN	Open Cut	High to Moderate Gradient
542.46	WPC309.3	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
542.92	WPC310	Yanert Fork	PN	Open Cut	Floodplain Stream
551.42	WPC311	Carlo Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
553	WPC312	Pinch Point Pond (3P)	P	Open Cut	NA
556.32	WPC317	Slime Creek	PN	Dry Ditch	High to Moderate Gradient
558.3	WPC317.1	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
559.58	WPC318	Unnamed Tributary to Nenana River	IN	Dry Ditch	Low Gradient Palustrine Stream
560.67	WPC319.1	Unnamed Tributary to Nenana river	PN	Open Cut	Floodplain Stream
560.98	WPC320-C	Nenana River #4	PN	Open Cut	Braided and Anastamosing Stream
561.16	WPC320.6	Unnamed Tributary to Nenana River	PN	Open Cut	High to Moderate Gradient
562.98	WPC320.7	Unnamed Tributary to Nenana River	PN	Open Cut	High to Moderate Gradient
564.62	WPC322	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
566.89	WPC323	Jack River	PN	Dry Ditch	Floodplain Stream
567.13	WPC323.1	Unnamed Tributary to Jack River	IN	Open Cut	High to Moderate Gradient
567.24	WPC323.2	Unnamed Tributary to Jack River	IN	Open Cut	High to Moderate Gradient
568.82	WPC324	Unnamed Tributary to Cantwell Creek	PN	Dry Ditch	Floodplain Stream
577.83	WPC325	Unnamed Tributary to Cantwell Creek	IN	Dry Ditch	Low Gradient Palustrine Stream
582.87	WPC327	Tsaani Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
583.89	WPC327.1	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
586.34	WPC328	Middle Fork Chulitna River	PNM	Open Cut	Floodplain Stream
586.87	WPC329-B	Fourth of July Creek	PN	Dry Ditch	High to Moderate Gradient

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
589.77	WPC330	East Fork Chulitna River	PN	Open Cut	Floodplain Stream
590.63	WPC330.1-C	Unnamed Stream	PN	Open Cut	Low Gradient Palustrine Stream
593.84	WPC331	Hardage Creek	PN	Dry Ditch	High to Moderate Gradient
594.24	WPC332-C	Unnamed Tributary to East Fork Chulitna River	PN	Open Cut	High to Moderate Gradient
596.64	WPC333	Antimony Creek	PN	Open Cut	High to Moderate Gradient
598.5	WPC334	Honolulu Creek	PN	Dry Ditch	Floodplain Stream
599.31	WPC335-C	Unnamed Tributary to Honolulu Creek	PN	Open Cut	High to Moderate Gradient
601.05	WPC336	Unnamed Tributary to Honolulu Creek	PN	Dry Ditch	High to Moderate Gradient
601.75	WPC337	Little Honolulu Creek	PN	Dry Ditch	High to Moderate Gradient
603.49	WPC338	Hurricane Gulch	PN	Dry Ditch	High to Moderate Gradient
603.93	WPC339	Unnamed Stream	IN	Dry Ditch	Low Gradient Palustrine Stream
606.95	WPC340-B	Granite Creek (South)	PN	Dry Ditch	High to Moderate Gradient
609.45	WPC341-C	Division Creek	PN	Open Cut	High to Moderate Gradient
610.21	WPC341.1	Unnamed Stream	PN	Dry Ditch	High to Moderate Gradient
612.41	WPC343-B	Pass Creek #2	PN	Dry Ditch	Low Gradient Palustrine Stream
614.6	WPC344	Little Coal Creek	PN	Dry Ditch	High to Moderate Gradient
616.56	WPC345	Unnamed Tributary to Chulitna River	PN	Dry Ditch	High to Moderate Gradient
618.12	WPC346	Horseshoe Creek	PN	Dry Ditch	High to Moderate Gradient
621.34	WPC346.1	Unnamed Tributary of Chulitna River	IN	Dry Ditch	High to Moderate Gradient
634.22	WPC347	Byers Creek	PN	Open Cut	Floodplain Stream
638.03	WPC348	Unnamed Tributary to Chulitna River	PN	Dry Ditch	Low Gradient Palustrine Stream
638.45	WPC348.1	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
640.84	WPC349	Troublesome Creek	PN	Open Cut	Floodplain Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
641.79	WPC350	Chulitna River	PNM	Trenchless	Braided and Anastamosing Stream
642.77	WPC350.1	Unnamed Tributary to Chulitna River	PN	Open Cut	Low Gradient Palustrine Stream
650.76	WPC353-C	Unnamed Tributary to Chulitna River	PN	Open Cut	Low Gradient Palustrine Stream
653.05	WPC354	Unnamed Tributary to Chulitna River	PN	Open Cut	Low Gradient Palustrine Stream
655.16	WPC355-C	Unnamed Tributary to Chulitna River	IN	Open Cut	Low Gradient Palustrine Stream
658.27	WPC356	Unnamed Tributary to Chulitna River	PN	Open Cut	Low Gradient Palustrine Stream
658.99	WPC356.1	Unnamed Tributary to Chulitna River	IN	Open Cut	Low Gradient Palustrine Stream
659.12	WPC357	Unnamed Tributary to Chulitna River	IN	Open Cut	Low Gradient Palustrine Stream
660.07	WPC358	Unnamed Tributary to Chulitna River	IN	Open Cut	Low Gradient Palustrine Stream
661.31	WPC359-C	Unnamed Tributary to Chulitna River	PN	Open Cut	Low Gradient Palustrine Stream
663.67	WPC360	Trapper Creek	PN	Open Cut	Low Gradient Palustrine Stream
666.54	WPC362	Unnamed Tributary to Rabideux Creek	PN	Dry Ditch	Braided and Anastamosing Stream
668.25	WPC363	Unnamed Tributary to Rabideux Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
669.99	WPC364	Sawmill Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
670.1	WPC364.1	Unnamed Tributary to Sawmill Creek	PN	Frozen Cut	Low Gradient Palustrine Stream
672.29	WPC365	Unnamed Tributary to Rabideux Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
673.38	WPC367	Queer Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
678.08	WPC367.03	Unnamed Stream	IN	Frozen Cut	Low Gradient Palustrine Stream
678.48	WPC368	Unnamed Tributary of Queer Creek	IN	Frozen Cut	Low Gradient Palustrine Stream
681.65	WPC368.3	Unnamed Stream	IN	Frozen Cut	Low Gradient Palustrine Stream
682.13	WPC368.6	Unnamed Stream	IN	Frozen Cut	Low Gradient Palustrine Stream
704.72	WPC373-B	Deshka River	PN	Trenchless	Floodplain Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
705.61	WPC373.1	Unnamed Tributary of Deshka River	PN	Frozen Cut	Floodplain Stream
706.3	WPC373.2	Unnamed Tributary of Deshka River	PN	Dry Ditch	Low Gradient Palustrine Stream
706.72	WPC373.3	Unnamed Stream	IN	Dry Ditch	Low Gradient Palustrine Stream
707.03	WPC373.4	Unnamed Stream	IN	Frozen Cut	Low Gradient Palustrine Stream
707.71	WPC373.5	Unnamed Tributary of Deshka River	PN	Dry Ditch	Low Gradient Palustrine Stream
709.06	WPC373.6	Unnamed Tributary of Deshka River	PN	Dry Ditch	Low Gradient Palustrine Stream
715.97	WPC374	Unnamed Tributary to Kroto Slough	PN	Dry Ditch	Braided and Anastamosing Stream
720.4	WPC375	Fish Creek #2	PN	Dry Ditch	Floodplain Stream
720.94	WPC376	Yentna River	PN	Open Cut	Braided and Anastamosing Stream
725.74	WPC377	Anderson Creek	PN	Dry Ditch	Floodplain Stream
727.82	WPC378	Alexander Creek	PN	Dry Ditch	Low Gradient Palustrine Stream
729.41	WPC379	Unnamed Tributary to Alexander Creek	IN	Dry Ditch	High to Moderate Gradient
730.82	WPC380	Pierce Creek	PN	Dry Ditch	High to Moderate Gradient
732.83	WPC380.1	Granite Creek (North Fork)	PN	Dry Ditch	Low Gradient Palustrine Stream
734.17	WPC382-C	Granite Creek (South Fork)	PN	Dry Ditch	High to Moderate Gradient
735.11	WPC382.002	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
736	WPC382.01	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
736.98	WPC382.014	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
737.08	WPC382.016	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
737.17	WPC382.017	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
737.39	WPC382.018	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
739.73	WPC382.03	Ivan River	IN	Dry Ditch	Low Gradient Palustrine Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
740.18	WPC382.04-C	Unnamed Tributary to Ivan River	IN	Open Cut	Low Gradient Palustrine Stream
740.38	WPC382.042	Unnamed Tributary to Ivan River	IN	Open Cut	Low Gradient Palustrine Stream
740.48	WPC382.044	Unnamed Tributary to Ivan River	IN	Open Cut	Low Gradient Palustrine Stream
740.86	WPC382.05-C	Unnamed Tributary to Ivan River	PN	Open Cut	High to Moderate Gradient
741.06	WPC382.052	Tributary to Ivan River	PN	Open Cut	High to Moderate Gradient
741.36	WPC382.054	Unnamed Tributary to Ivan River	PN	Open Cut	High to Moderate Gradient
743.49	WPC382.056	Unnamed Tributary to Ivan River	PN	Open Cut	Low Gradient Palustrine Stream
744.11	WPC382.06-C	Tributary to Ivan River	PN	Open Cut	Low Gradient Palustrine Stream
745.4	WPC382.07-C	Lewis River Floodplain A	PN	Open Cut	Low Gradient Palustrine Stream
745.58	WPC386-C	Tributary of Lewis River	PN	Open Cut	Low Gradient Palustrine Stream
745.73	WPC386.1-C	Unnamed Tributary of Lewis River (Floodplain B)	PN	Open Cut	Low Gradient Palustrine Stream
746.77	WPC386.14	Unnamed Tributary of Lewis River	PN	Open Cut	High to Moderate Gradient
747.41	WPC386.2-C	Unnamed Tributary of Lewis River	PN	Open Cut	High to Moderate Gradient
748.53	WPC387-C	Theodore River	PN	Open Cut	Floodplain Stream
749.61	WPC387.1-C	Unnamed Stream	IN	Open Cut	High to Moderate Gradient
750.06	WPC388-C	Pretty Creek	PN	Open Cut	Low Gradient Palustrine Stream
750.83	WPC388.01-C	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
751.38	WPC388.03-C	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
751.67	WPC388.04-C	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
752.25	WPC388.05-C	Unnamed Tributary to Pretty Creek	PN	Open Cut	Low Gradient Palustrine Stream
752.62	WPC388.06-C	Unnamed Tributary to Pretty Creek	PN	Open Cut	Low Gradient Palustrine Stream
754.13	WPC388.1	Olson Creek	PN	Dry Ditch	Floodplain Stream
756.62	WPC388.2-C	Unnamed Tributary to Beluga River	IN	Open Cut	Low Gradient Palustrine Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
757.17	WPC389-C	Beluga River	PN	Open Cut	Floodplain Stream
763.07	WPC390	Unnamed Tributary to Threemile Creek	IN	Open Cut	Low Gradient Palustrine Stream
763.94	WPC391	Threemile Creek	PN	Dry Ditch	Floodplain Stream
779.46	WPC-CI	Cook Inlet	Not Applicable	Open Cut / Pipe lay	Coastal Inlet
793.5	WPC391.5	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
797.79	WPC392.1	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
797.91	WPC392.2	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
800.61	WPC392.4	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream
804.55	WPC415	Unnamed Stream	IN	Open Cut	Low Gradient Palustrine Stream

Notes:

a Proposed crossing method is based on Mainline Rev C2. No waterbodies are crossed by the Liquefaction Facility. Aerial crossings are aboveground with no impact to waterbodies.

b Flow regime based on USGS National Hydrographic Dataset (NHD) and LiDAR imagery. Perennial = PN; Perennial – Multiple = PNM; Intermittent = IN; Artificial Path = AP; and Pond/Open Water = P.

c Preliminary Stream Type based on the Rosgen stream classification system. Stream type was assigned using limited available data, which may include but is not limited to aerial imagery, LiDAR DEM, USGS Topographic maps, field survey data, and ground imagery. Stream types are considered preliminary and will require final stream type classification prior to stream restoration.

ATTACHMENT 2

Preliminary Stream Type of PTTL Stream Crossings

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
PTTL WATERBODY CROSSING					
0.65	WPT001	C Creek	IN	Aerial Span	Small Beaded and Tundra Stream
1.39	WPT003	Pond	P	Aerial Span	NA
1.64	WPT003.1	Pond	P	Aerial Span	NA
1.69	WPT003.2	Unnamed Stream	IN	Aerial Span	Small Beaded and Tundra Stream
1.88	WPT006	D Creek	PN	Aerial Span	Small Beaded and Tundra Stream
2.87	WPT014	East E Creek	IN	Aerial Span	Small Beaded and Tundra Stream
2.95	WPT014.1	E Creek	PN	Aerial Span	Small Beaded and Tundra Stream
3.46	WPT016	18A Creek	PN	Aerial Span	Small Beaded and Tundra Stream
3.59	WPT017	Pond	P	Aerial Span	NA
3.7	WPT019	Pond	P	Aerial Span	NA
4.47	WPT022-B	F Creek	PN	Aerial Span	Small Beaded and Tundra Stream
5.82	WPT024	G Creek	PN	Aerial Span	Small Beaded and Tundra Stream
6.99	WPT032	H Creek	IN	Aerial Span	Small Beaded and Tundra Stream
8.25	WPT040	I Creek	PN	Aerial Span	Small Beaded and Tundra Stream
9.23	WPT043	J Creek	PN	Aerial Span	Small Beaded and Tundra Stream
10.58	WPT048	K Creek	PN	Aerial Span	Small Beaded and Tundra Stream
12.48	WPT061	L Creek	PN	Aerial Span	Small Beaded and Tundra Stream
14.29	WPT070	N Creek	PN	Aerial Span	Small Beaded and Tundra Stream
15.08	WPT072	M Creek	PN	Aerial Span	Small Beaded and Tundra Stream
16.05	WPT072.1	Pond	P	Aerial Span	NA
16.83	WPT073	O Creek	PN	Aerial Span	Small Beaded and Tundra Stream
18.77	WPT080	East Badami Creek	PN	Aerial Span	Braided Stream
19.34	WPT081-B	Middle Badami Creek	PN	Aerial Span	Small Beaded and Tundra Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
20.42	WPT084-B	West Badami Creek	PN	Aerial Span	Small Beaded and Tundra Stream
22.24	WPT091-B	Unnamed Stream	IN	Aerial Span	Small Beaded and Tundra Stream
22.64	WPT091.1	Pond	P	Aerial Span	NA
23.35	WPT096	Pond	P	Aerial Span	NA
24.26	WPT102	Unnamed Stream	PN	Aerial Span	Small Beaded and Tundra Stream
24.76	WPT104	Unnamed Stream	PN	Aerial Span	Small Beaded and Tundra Stream
24.85	WPT106	Pond	P	Aerial Span	NA
24.9	WPT106.1	Pond	P	Aerial Span	NA
25.48	WPT107	Shaviovik River East	PN	Open Cut	Braided Stream
25.7	WPT108	Shaviovik River East Overflow	PN	Aerial Span	Braided Stream
25.9	WPT110	Shaviovik River West	PN	Aerial Span	Braided Stream
26.06	WPT113	Shaviovik River West	IN	Aerial Span	Braided Stream
26.48	WPT115	Unnamed Tributary to Shaviovik River	PN	Aerial Span	Small Beaded and Tundra Stream
26.88	WPT116	Unnamed Tributary to Shaviovik River	PN	Aerial Span	Small Beaded and Tundra Stream
27.24	WPT117	Unnamed Tributary to Shaviovik River	PN	Aerial Span	Small Beaded and Tundra Stream
27.3	WPT118	Unnamed Tributary to Shaviovik River	IN	Aerial Span	Small Beaded and Tundra Stream
28.87	WPT118.01	Pond	P	Aerial Span	NA
29.36	WPT118.02	Pond	P	Aerial Span	NA
29.54	WPT118.1	Pond	P	Aerial Span	NA
29.65	WPT128-B	Unnamed Stream	IN	Aerial Span	Small Beaded and Tundra Stream
30	WPT128.05	Pond	P	Aerial Span	NA
30.14	WPT128.1	Pond	P	Aerial Span	NA
30.76	WPT128.3	Pond	P	Aerial Span	NA
31.17	WPT135	Pond	P	Aerial Span	NA
31.53	WPT135.1	Pond	P	Aerial Span	NA

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
31.73	WPT137	Unnamed Stream	IN	Aerial Span	Small Beaded and Tundra Stream
32	WPT137.1	Pond	P	Aerial Span	NA
32.21	WPT137.2	Pond	P	Aerial Span	NA
32.31	WPT140	Unnamed Stream	IN	Aerial Span	Small Beaded and Tundra Stream
32.46	WPT140.5	Pond	P	Aerial Span	NA
32.53	WPT141	Pond	P	Aerial Span	NA
33.04	WPT141.1	Pond	P	Aerial Span	NA
33.53	WPT141.3	Pond	P	Aerial Span	NA
33.83	WPT141.4	Pond	P	Aerial Span	NA
33.95	WPT145-B	Unnamed Tributary to Kadleroshilik River	PN	Aerial Span	Small Beaded and Tundra Stream
34.42	WPT148	Unnamed Tributary to Kadleroshilik River	IN	Aerial Span	Small Beaded and Tundra Stream
34.56	WPT149	Unnamed Tributary to Kadleroshilik River	IN	Aerial Span	Small Beaded and Tundra Stream
34.89	WPT150	Unnamed Tributary to Kadleroshilik River	IN	Aerial Span	Small Beaded and Tundra Stream
34.92	WPT151	Unnamed Tributary to Kadleroshilik River	IN	Aerial Span	Small Beaded and Tundra Stream
35.32	WPT152	Kadleroshilik River	PN	Open Cut	Braided Stream
35.55	WPT153	Pond	P	Aerial Span	NA
35.87	WPT154	Pond	P	Aerial Span	NA
36.84	WPT155	Unnamed Stream	PN	Aerial Span	Small Beaded and Tundra Stream
38.1	WPT155.1	Pond	P	Aerial Span	NA
39.06	WPT155.11	Pond	P	Aerial Span	NA
39.74	WPT159	Pond	P	Aerial Span	NA
39.92	WPT159.01	Pond	P	Aerial Span	NA
40.15	WPT159.02	Pond	P	Aerial Span	NA
40.33	WPT159.2	Pond	P	Aerial Span	NA
40.38	WPT159.3	Pond	P	Aerial Span	NA
40.59	WPT167	Pond	P	Aerial Span	NA

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
40.71	WPT168	Pond	P	Aerial Span	NA
40.82	WPT168.1	Pond	P	Aerial Span	NA
40.97	WPT168.2	Pond	P	Aerial Span	NA
41.36	WPT168.3	Pond	P	Aerial Span	NA
41.46	WPT169.1	Pond	P	Aerial Span	NA
41.95	WPT169.3	Pond	P	Aerial Span	NA
42.32	WPT174	East Sagavanirktok Creek	PN	Aerial Span	Small Beaded and Tundra Stream
42.38	WPT175	Pond	P	Aerial Span	NA
42.7	WPT176	Pond	P	Aerial Span	NA
42.96	WPT177	Pond	P	Aerial Span	NA
44.21	WPT181-B	Sagavanirktok River - Main Channel	PN	Open Cut	Braided Stream
44.77	WPT182-B	Unnamed Tributary to Sagavanirktok River	IN	Aerial Span	Small Beaded and Tundra Stream
45.02	WPT182.1	Unnamed Tributary to Sagavanirktok River	PN	Aerial Span	Small Beaded and Tundra Stream
45.15	WPT182.2	Unnamed Tributary to Sagavanirktok River	PN	Aerial Span	Small Beaded and Tundra Stream
45.9	WPT192-B	Pond	P	Aerial Span	NA
46.14	WPT194	Pond	P	Aerial Span	NA
46.17	WPT194.1	Pond	P	Aerial Span	NA
46.89	WPT196	Pond	P	Aerial Span	NA
49.07	WPT197-B	Unnamed Tributary to Sagavanirktok River	PN	Aerial Span	Small Beaded and Tundra Stream
50.15	WPT197.1	Pond	P	Aerial Span	NA
50.52	WPT197.2	Unnamed Tributary to Sagavanirktok River	PN	Aerial Span	Small Beaded and Tundra Stream
51.17	WPT200	Unnamed Tributary to Sagavanirktok River	PN	Aerial Span	Small Beaded and Tundra Stream
51.82	WPT201	Unnamed Tributary to Sagavanirktok River	PN	Aerial Span	Small Beaded and Tundra Stream
52.29	WPT202	Unnamed Tributary to Sagavanirktok River	PN	Aerial Span	Small Beaded and Tundra Stream
53.51	WPT204	Sagavanirktok River - West Channel	PN	Aerial Span	Braided Stream

Milepost	Crossing ID [a]	Waterbody Name	Flow Regime [b]	Proposed Crossing Method	Preliminary Stream Type [c]
56.33	WPT209	Unnamed Stream	IN	Aerial Span	Small Beaded and Tundra Stream
56.42	WPT209.1	Pond	P	Aerial Span	NA
56.47	WPT211	Pond	P	Aerial Span	NA
58.48	WPT214	Pond	P	Aerial Span	NA
59.55	WPT215	Unnamed Tributary to Putuligayuk River	PN	Aerial Span	Small Beaded and Tundra Stream
61.23	WPT221-B	Putuligayuk River	PN	Aerial Span	Small Beaded or Tundra Stream

Notes:

a Proposed crossing method is based on PTTL Rev C. Aerial crossings are aboveground with no impact to waterbodies.

b Flow regime based on USGS National Hydrographic Dataset (NHD) and LiDAR imagery. Perennial = PN; Perennial – Multiple = PNM; Intermittent = IN; Artificial Path = AP; and Pond/Open Water = P.

c Preliminary Stream Type based on the Rosgen stream classification system. Stream type was assigned using limited available data, which may include but is not limited to aerial imagery, LiDAR DEM, USGS Topographic maps, field survey data, and ground imagery. Stream types are considered preliminary and will require final stream type classification prior to stream restoration.