APPENDIX A

Part I: The ASAP Belowground Pipeline Mode: Selection, Construction, Operation, and Maintenance on Alaska's North Slope

Part II: PHMSA Response Letter

- Page Intentionally Left Blank -

ALASKA STAND ALONE PIPELINE/*ASAP* PROJECT

The ASAP Belowground Pipeline Mode: Selection, Construction, Operation, and Maintenance on Alaska's North Slope

ASAP-22-RTA-DDD-DOC-00066

July 12, 2016

NOTICE

THIS DOCUMENT CONTAINS CONFIDENTIAL AND PROPRIETARY INFORMATION AND SHALL NOT BE DUPLICATED, DISTRIBUTED, DISCLOSED, SHARED OR USED FOR ANY PURPOSE EXCEPT AS MAY BE AUTHORIZED BY AGDC IN WRITING.

Alaska Gasline Development Corporation
3201 C Street, Suite 200
Anchorage, AK 99503
www.agdc.us
907-330-6300

REVISION HISTORY

Revision	Date	Comment	Approval	
			Company Preparing Report	AGDC
0	3/24/2015		AGDC	K Stevenson / M Thompson
1	7/12/2016	Admin corrections	AGDC	K. Stevenson
2	01/08/2018	Minor admin and footprint corrections	AGDC	K. Stevenson

ACRONYMS AND ABBREVIATIONS

%	Percent
ACP	Arctic Coastal Plain
ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
AGDC	Alaska Gasline Development Corporation
AG	Aboveground
ASAP	Alaska Stand Alone Pipeline
BG	Belowground
BiOP	Biological Opinion
BLM	Bureau of Land Management
CAPEX	Capital Expenditure
CFR	Code of Federal Regulations
DEIS	Draft Environmental Impact Statement
DOT	Department of Transportation
EIS	Environmental Impact Statement
EPA	United State Environmental Protection Agency
ERL	Environment, Regulatory, and Land
FEIS	Final Environmental Impact Statement
FWS	Fish and Wildlife Service
GCF	Gas Conditioning Facility

GEMAR	Geohazard Evaluation and Mitigation Analysis Report
GIS	Geographical Information System
HDD	Horizontal Directional Drilling
HSM	Horizontal Support Member
HSSE	Health, Safety, Security, and Environment
LiDAR	Light Detection and Ranging
LSAW	longitudinal Submerged Arc Welded
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NSB	North Slope Borough
P&CM	Pipeline and Civil Maintenance
Put	Putuligayuk
ROD	Record of Decision
ROW	Right-of-Way
Sag	Sagavanirktok
SEIS	Supplemental Environmental Impact Statement
SHPO	State Historic Preservation Office
TAPS	Trans-Alaska Pipeline System
US	United States
USACE	United States Army Corps of Engineers
VSM	Vertical Support Member
WBS	Work Breakdown Structure

TABLE OF CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

The Alaska Stand Alone Pipeline (ASAP) Project has proposed to construct a buried natural gas pipeline in winter along the first 60 miles of its route on Alaska's North Slope (AGDC, 2015a). The pipeline will transect the Arctic Coastal Plain (ACP) from a gas conditioning facility (GCF) near Prudhoe Bay to the foothills of the Brooks Range in an area characterized by continuous permafrost and Arctic tundra. ASAP will be oriented in a north-to-south direction along the west side of the Dalton Highway, and the first 60 miles of the pipeline will operate at below-freezing temperatures year-round.

The United States (US) Fish and Wildlife Service (FWS), the US Environmental Protection Agency (EPA), and the US Army Corps of Engineers (USACE) have raised questions about whether burying the pipe belowground in permafrost might lead to the degradation of that permafrost, cause pipe slumping or structural issues, erode soils, cause large swaths of perennial ponded water over the pipe, or accelerate climate change in the Arctic. ASAP has undertaken a comprehensive evaluation of aboveground (AG) and belowground (BG) modes for its pipeline on the North Slope, and will demonstrate through this report a summary of its findings that indicate that the BG mode is the preferred option for reasons related to engineering constructability, operational reliability, and to health, safety, security and the environment (HSSE). ASAP will further demonstrate through this report that the structural and environmental concerns raised by the agencies can be alleviated by mitigating impacts through a set of standards and proven procedures developed for engineering design, construction, stabilization, and monitoring, as they have been for other buried North Slope pipeline projects.

1. INTRODUCTION

1.1 PROJECT BACKGROUND

The ASAP Project is the Alaska Gas Development Corporation's (AGDC's) in-state natural gas pipeline project designed to provide an affordable, long-term energy solution to Fairbanks, the Southcentral region, and to as many other Alaskan communities as possible. The 733-mile, 36-inch pipeline is proposed to deliver natural gas from Prudhoe Bay to Southcentral Alaska, where it will tie in to the existing ENSTAR system. A proposed 30-mile, 12-inch lateral pipeline will connect the mainline to Fairbanks.

1.2 ASAP'S ENVIRONMENTAL IMPACT STATEMENT (EIS) EVALUATION

An Environmental Impact Statement (EIS) was prepared for the ASAP Project in 2012 when the ASAP Project was proposed as buried on the North Slope, with the exception of the first 6 miles (USACE 2012a,b). Today, these first 6 miles are also proposed as buried. Public scoping and agency review of the ASAP Project occurred during the EIS process, pursuant to the National Environmental Policy Act (NEPA). Agencies and the general public were provided with the opportunity to review and comment on the approximately 54 miles of North Slope BG pipe, and several agencies contributed to the Draft EIS (DEIS) and Final EIS (FEIS) evaluation of the Project (USACE 2012a,b).

The USACE received very few comments on AG or BG pipe mode or design during the DEIS and FEIS. One comment that was made during the DEIS comment period came from the Center for Biological Diversity, which expressed concerns over the AG design impacting caribou over the first 6 miles of the route, citing "adverse impacts" to large migratory mammals. Their comments also mentioned that the AG portion of the pipeline on the North Slope could "delay caribou movements" and that it might disturb herds or individuals. They also stated:

> *The Bureau of Land Management has identified numerous potential adverse effects of less extensive pipelines and also indicates that onshore gas activities, especially roads, can displace caribou and reduce caribou densities for miles. Snow drifts under a pipeline can block or interrupt caribou movements. (Center for Biological Diversity comment in DEIS - USACE, 2012a).*

Furthermore, the USFWS reviewed the ASAP Project during the EIS review period and published the results of its evaluation in a formal legal document, termed a Biological Opinion (BiOp), dated July 10, 2012. The BiOp was included as an appendix of the FEIS (USACE 2012b); the National Marine Fisheries Service (NMFS) provided a letter of concurrence, also attached to the FEIS. In its BiOp, the USFWS specifically identified and described the AG and the BG mode on the North Slope, including geographic and design features of each (USACE 2012b). The BiOp expressed no concern over impacts associated with use of the BG mode through permafrost areas, nor did it reference any expected impacts to water, soils, or endangered species habitat. To the contrary, the USFWS stated that the proposed design is "not likely to adversely affect Steller's eiders" and is "not likely to jeopardize the continued existence of spectacled eiders or polar bears, and is not likely to destroy or adversely modify polar bear critical habitat" (USACE 2012b).

1.3 SETTING

The arctic environment of the North Slope creates unique challenges for pipeline design in a relatively remote working environment, including cold temperatures, permafrost, and the hydrology of the ACP.

1.3.1 Temperature

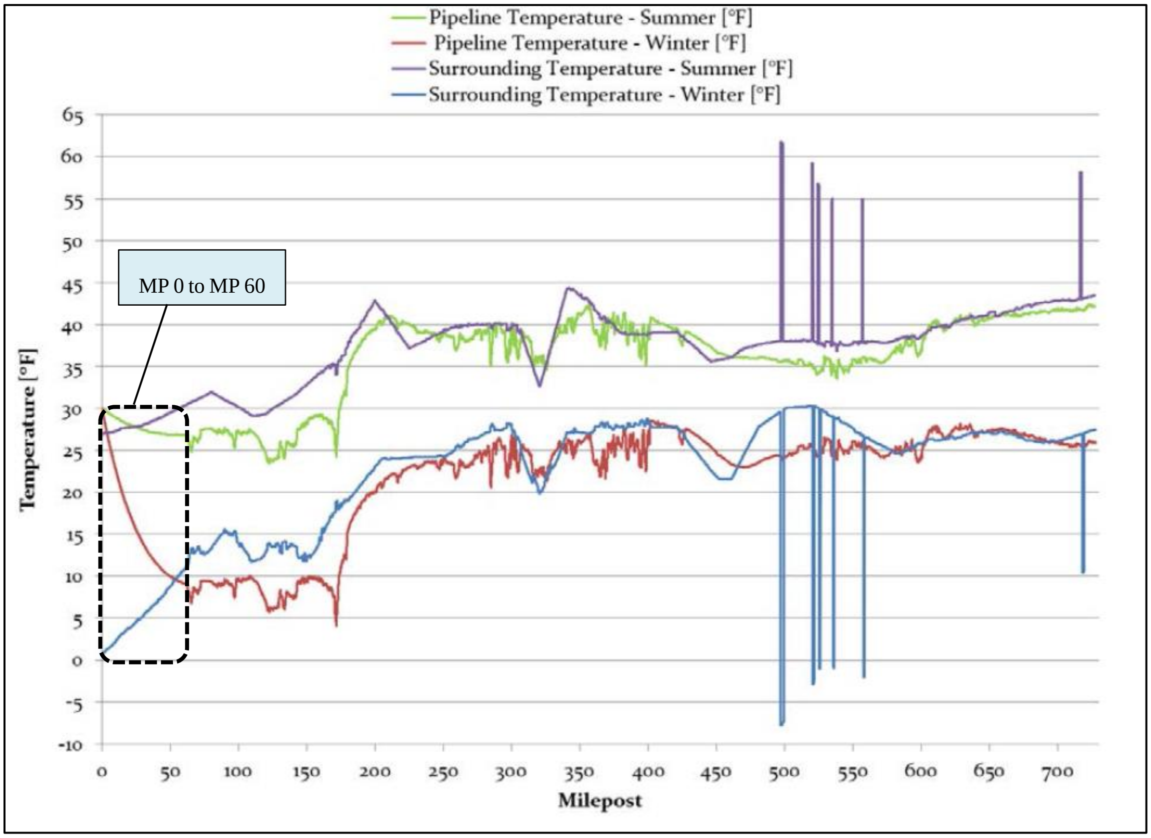
The area north of the Brooks Range is a cold weather environment with seasonal temperature averages generally ranging from -15ºF in winter to +35ºF in the summer (WRCC 2016). The cold and warm weather extremes north of the Brooks Range can range from -60ºF in winter to +85ºF in summer, depending on location (WRCC 2016).

1.3.2 Continuous Permafrost and the Active Layer

The ACP is characterized as having shallow underlying continuous permafrost, except within major active stream and river systems and thaw bulbs beneath water bodies (AGDC 2014; 2015b). Permafrost underlies all areas of the North Slope of Alaska except beneath some deep lakes and river channels (Streletskiy et al. 2014). Continuous permafrost on the North Slope or on the ACP is perennially frozen soil that ranges from less than 650ft to more than 1950 ft thick (Osterkamp et al. 1985). Permafrost underlies an active layer of soil that thaws each year and holds vegetation. Active layer thickness generally ranges from 1 – 2 ft on the North Slope (Streletskiy et al. 2014; Zhang et al. 1997). The thickness of the active layer increases from the Arctic coast to the foothills of the Brooks Range and is directly proportional to summer air temperatures and thawing index (Zhang et al., 1997); however, there is large spatial variability owing to differences in soil types and associated organic layers. The active layer becomes thinner as distance from the Sagavanirktok ('Sag') River and other major waterbodies increases (BLM 2002b).

On the ACP, most of the pipelines existing between the production fields and the central processing facilities over permafrost are warm or hot pipelines and are supported AG by vertical support members (VSMs). These systems include multi-phase production lines, water injection lines, and other liquid lines, all of which generally must remain warm in order to operate. Warm or hot pipelines buried in thaw-unstable, perennially frozen subsurface would transfer heat to the ground, causing thermal degradation of the permafrost, leading to pipe thaw settlement (thaw beneath the pipe), surface slumping (thaw in the active layer and fill above the pipe), potential pipe integrity issues, and disruption of surface water flow. In contrast to these warm or hot pipelines, the proposed ASAP BG pipeline would operate at below-freezing temperatures year-round (8 – 30ºF in winter; 25 – 30 ºF in summer) on the North Slope (Figure 1) and would transport a gaseous product with low heat transfer properties.

Figure 1. Projected Pipeline and Surrounding Temperatures for ASAP During Operations



Temperature profiles modeled for the Alaska Stand Alone Pipeline (ASAP) during operations. The green and red lines represent the modeled temperature inside the pipe during operations in summer and winter, respectively. The purple and blue lines represent the modeled temperature on the outside of the pipe during operations during summer and winter, respectively. The first 60 miles are highlighted by the black dashed box.

1.3.3 Hydrology of the Arctic Coastal Plain

1.3.3.1 A Low Precipitation Environment

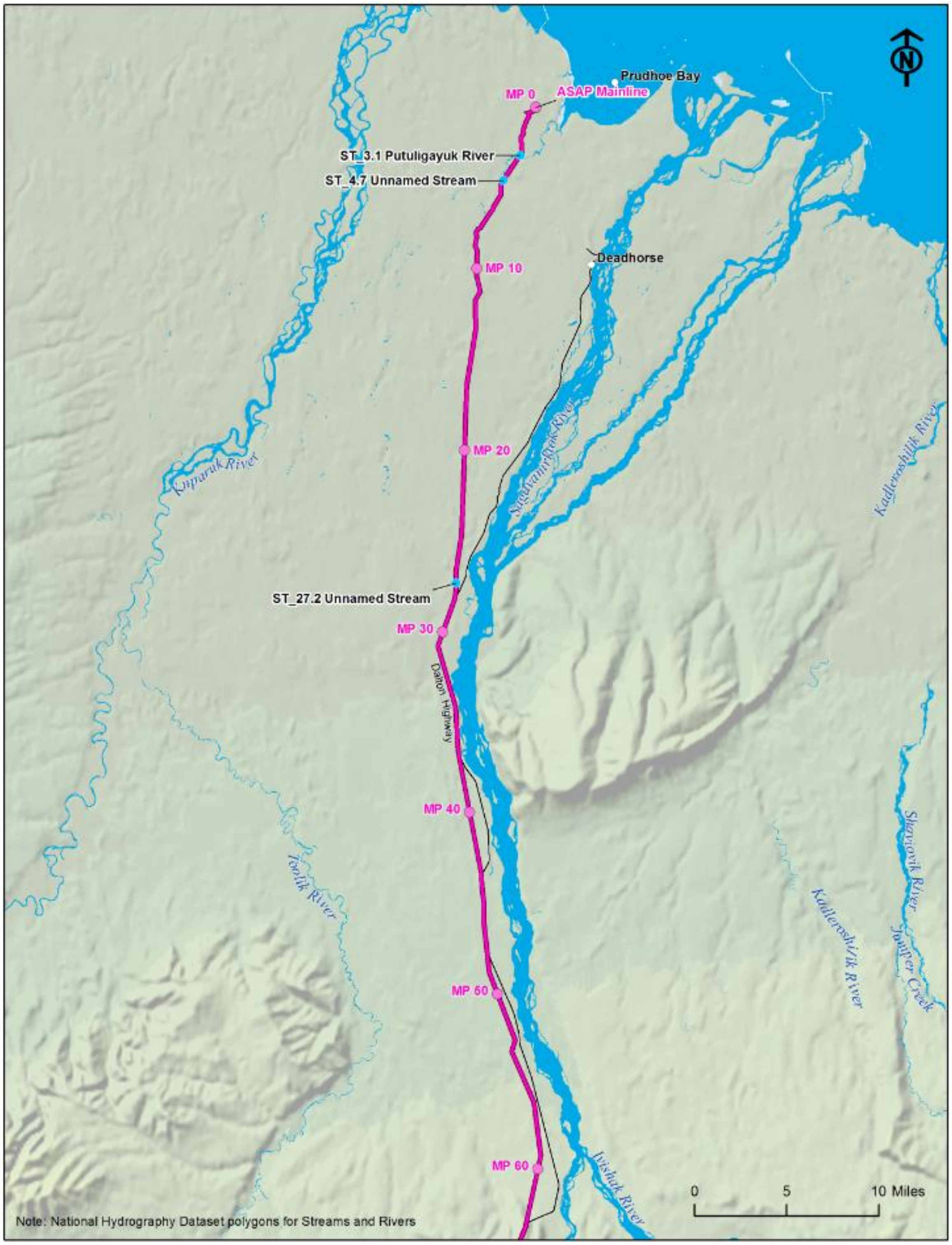
The ACP and the North Slope receive a limited amount of precipitation each year. Barrow, Prudhoe Bay, and Nuiqsut each average less than 5 inches of rainfall per year (WRCC 2016). Barrow and Prudhoe Bay receive less than 35 inches of snowfall per year (WRCC 2016).

1.3.3.2 A Low-Gradient Environment

The ACP is a wetland environment because the area is generally flat and lies at a low elevation, allowing little movement of rain or snowmelt runoff, except that which is channeled off of the Brooks Range into major systems running south-to-north, like the Sag or Colville Rivers, which both drain into the Beaufort Sea. Floods are generally reflected in the larger waterbodies on the North Slope as there are no significant elevation changes.

The underlying continuous permafrost on the ACP keeps water from draining downward, so most water either ponds or moves very slowly in a lateral fashion over time down very mild gravitational gradients (i.e., sheet water flow) until it reaches a major stream draining into the Arctic Ocean or slowly drains there itself. Because of this very mild gradient and the low elevation of the ACP, only three waterbodies on the ACP fit the USACE's wetlands criteria for a stream in the first 60 miles (Figure 2; AGDC, 2015a). These streams and other waterbodies on the North Slope that are crossed by the ASAP mainline appear incapable of producing significant erosional energy.

Figure 2. Mainline Stream Crossings for Waterbodies Fitting USACE's Wetlands Criteria for a Stream



The ASAP Mainline crosses only 3 waterbodies fitting the USACE wetlands criteria for a stream for the first 60 miles on the pipeline route on the North Slope.

1.3.4 Climate Change

Climate is complex in a place as expansive and geographically diverse as Alaska. There are many natural drivers of climate, including the effects of multiple pressure systems (e.g., Siberian High, Arctic High, and Aleutian Low Pressure Systems), the Circumpolar Vortex (a persistent, large-scale cyclonic circulation in the middle and upper troposphere centered over the Polar region of the Northern Hemisphere where it surrounds the Polar Highs and exists as part of the Polar Front), ocean currents and oscillating sea surface temperatures (regulators of atmospheric temperature through the physical exchange of heat, water, and momentum), and climatic cycles or climatic events of varying durations (e.g., the 20−30-year Pacific Decadal Oscillation cycle; the 5-year El Niño-Southern Oscillation cycle; the 1−2-year El Niño and LaNiña events) (see summaries in Stevenson et al. 2012; Alessa et al. 2011).

Long-term climatic data sets from weather stations around Alaska are useful for studying short- and long-term trends in climate. Climatic cycles or patterns and the interplay between them can be identified and interpreted through statistical analyses and represented graphically. However, several cautions must be taken in analyzing long-term climatic data in order to avoid reporting misleading or erroneous conclusions, including referencing correct time scales, applying appropriate starting and ending reference dates, or using appropriate statistical approaches in the analysis and interpretation of climate data, as these factors can all influence outcomes (Stevenson et al. 2012; Alessa et al. 2011; Bone et al. 2010).

Global climate models that have been developed in part and used by University of Alaska climate scientists have indicated that a 5-9ºF degree raise in temperature is expected for the Arctic over the next century (ICIA 2004). This is consistent with North Slope data trends in past decades, which have shown patterns towards increasing air temperature and decreasing precipitation. For instance, in Barrow, Alaska temperature increased from 1956 to 2006 (a 50-year period) by +3.2ºF, and annual precipitation decreased by -1.28 inches (Alessa et al, 2011). An analysis of Barrow temperatures with separate starting and ending reference dates from 1949 – 2009 (a 60-year period) showed an increase of +4.5ºF (Stevenson et al. 2012).

Permafrost temperature and thickness have also changed since the 1980s, reflecting increasing air temperature, snow depth, and longer periods of ice-free conditions on the Arctic Ocean near coastal locations. Permafrost data for Alaska's North Slope has been compiled, characterized and mapped in detail (USFWS, 2015). Multi-decadal data show that permafrost temperature is changing along a north-south bioclimatic gradient with temperatures currently ranging from 15.8 to 21.2ºF at Coastal Plain sites and 21.2 to 24.8ºF at Foothills sites (Streletskiy et al. 2014). Variations in the length of thaw season and thawing index are major factors that influence permafrost temperatures during the summer, and interactions of wind, microrelief, vegetation, and especially seasonal snow cover are major factors affecting temperatures of permafrost and ground surface temperature in winter (Zhang et al. 1997; Marchand 1996). Inter- and intra-annual variability in ambient air temperature and depth of snow cover will ultimately influence temperatures at the ground surface, in the active layer, and at the surface of permafrost. However, the result is that the integrity of the permafrost at the depth of pipe burial (~6 ft) will be maintained because the North Slope portion of the pipeline will operate at temperatures as low as 8ºF and will never exceed 30ºF.

Global climate model predictions for the Arctic over the next century (ICIA 2004) are not expected to substantially impact ASAP operations on the North Slope because ASAP is a BG pipeline buried in at least 6ft of permafrost and operating at below-freezing temperatures. The permafrost on the North Slope is expected to continue warming, but increases in the active layer are not substantial enough to impact pipeline integrity in the next century due to the ASAP's design (see Sections 2 and 3, below, for design factor evaluations and specifics regarding engineering design, construction, operation, monitoring, and maintenance).

1.4 SCOPE

The North Slope segment of the ASAP pipeline is considered to be the first 60 miles, from the GCF to the Brooks Range Foothills (this is approximately the current Trans-Alaska Pipeline System (TAPS) Pump Station 2, or the base of the Foothills).

The scope of this report is to provide information on:

- ASAP's evaluation of design factors for the BG and AG modes for the first 60 miles of the mainline includes:
  - Safety & Security
  - Operational Reliability
  - Line Pipe Technology
  - Engineering Design and Constructability
  - VSM Movement
  - Logistics and Schedule
  - Environmental Impacts
  - Cost
- A description of construction, operation, and maintenance of the selected BG mainline includes:
  - Pipe Burial
  - Freezing and Thawing
  - Construction Methods
  - Mitigation Measures
  - Maintenance and Monitoring
  - ASAP Contractor Experience
  - Overview of ASAP's Plans for Soil Stabilization and Revegetation
  - Overview of ASAP's Plans for Water Management
- Evaluation and Selection of the Season of Construction

2. DESIGN FACTOR EVALUATIONS FOR ABOVEGROUND AND BELOWGROUND MODES

Several factors were considered in the analysis and selection of the pipeline mode, including: safety and security, operational reliability, available line pipe technology, logistics and schedule, engineering design and constructability, environmental impacts, and cost. Following a review of both design modes, the ASAP Project selected the BG mode as the preferred option for the North Slope.

2.1 PIPELINE SAFETY AND SECURITY

2.1.1 Construction Phase Safety and Security

Construction and personnel safety risk increases with an AG mode. This is a direct correlation with the increase in vehicle and equipment traffic and usage required to haul and install at least 5,000 VSMs and Horizontal Support Members (HSMs) prior to installation of the AG pipeline. The AG pipe must be hoisted, balanced, and secured at a height of at least 7ft to allow for wildlife passage, as required by North Slope Borough ordinance. The increased traffic and handling and extended construction season associated with AG construction would result in an increased probability for staff safety incidents.

2.1.2 Operational Phase Safety and Security

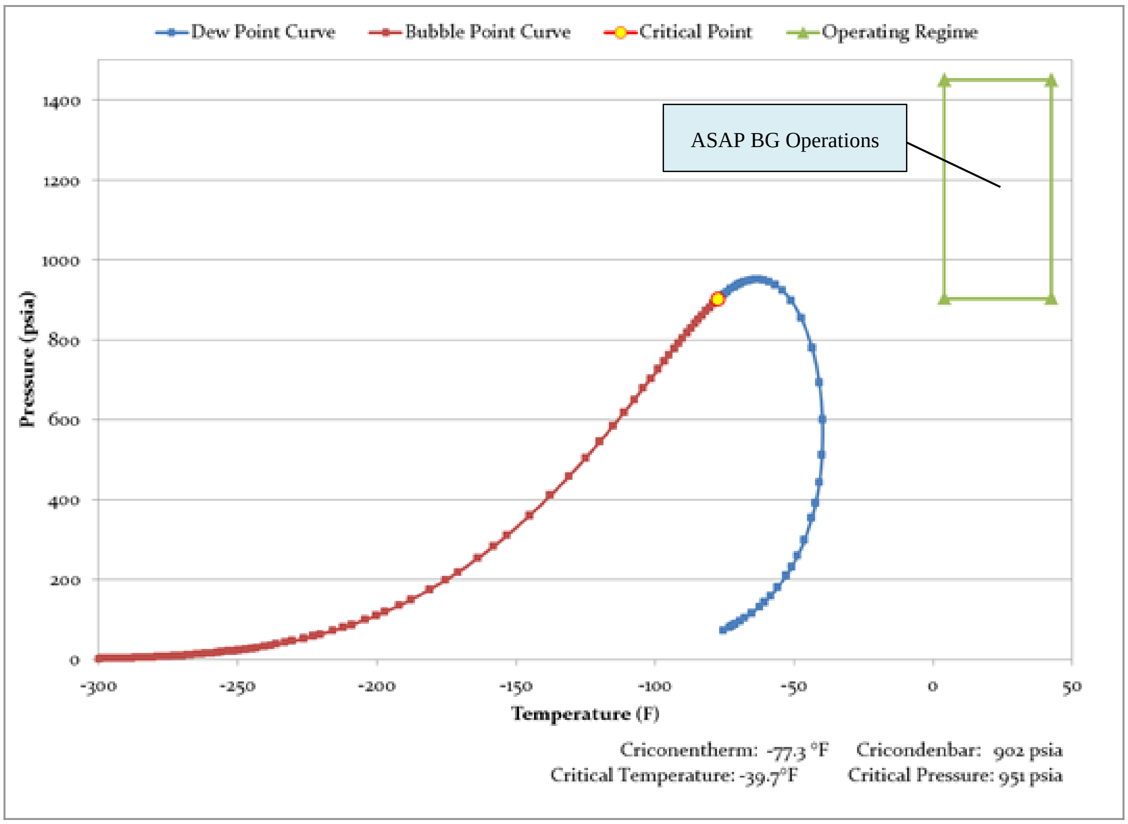
BG pipeline design and operations for natural gas transmission have proven reliability as it pertains to pipeline integrity and security. In the unlikely event of a BG pipeline failure, the intact sections adjacent to ruptures are restrained and in the event of ignition, protected from the effects of thermal radiation by the surrounding soil beyond the ends of the rupture. A near-vertical flame is typical of a relatively short BG pipeline failure.

The AG pipe is less secure than the BG mode, and it is more vulnerable to accidental and intentional damage (i.e., sabotage). An AG line could explode or leak if it is hit by accidental or intentional bullet strikes (a concern that arose in public meetings over Point Thomson development). The pipe and VSMs are vulnerable to strikes from aircraft and ground-based vehicles. The AG pipe is also more vulnerable to terrorism attacks. Rupture of the AG gas transmission pipeline could cause significant damage to the support structures, along with consequent service disruption, potentially requiring mobilization of a significant reconstruction effort.

2.2 OPERATIONAL RELIABILITY

The phase envelope is a significant consideration in natural gas pipeline mode evaluation on the North Slope because of the potential for the transported gas to transition from a single-phase (gas) to two phases (gas-liquid). There is no chance of two-phase flow as long as the pressure and temperature conditions within the pipeline remain outside of the gas phase envelope in all instances (e.g., the BG scenario, as BG temperatures will never get cold enough). However, in the event of a prolonged shutdown during winter that resulted in a pressure drop, the AG mode would subject the pipeline to hydrocarbon liquid dropout at cold ambient temperatures (Figure 3). This would subsequently lead to substantial pooling of liquids at low elevations or at low spots and bends in the pipe.

Figure 3. ASAP Phase Envelope Diagram



Belowground (BG) temperatures will never be low enough to put the pipeline at risk of hydrocarbon liquid dropout and severe mechanical disruption (e.g., it can never move completely from the green box, representing operational pressure / temperature, to inside the red/blue phase envelope, during which liquid dropout occurs). Reduced pressure during prolonged shut down during a cold winter in the aboveground (AG) mode would put the pipeline at risk of moving inside the phase envelope, causing extensive pooling of liquids and severe mechanical disruption.

Should this scenario occur for the AG design, condensate formation inside the GCF and the pipeline will occur. The volume of condensate yielded can be predicted by analyzing the gas phase compositions upstream and downstream of a potential condensation location and determining the gallons of liquids per thousand standard cubic feet of gas for the liquefiable components in each stream.

The ASAP GCF and pipeline are not designed to manage a liquid volume load from the mainline. Hydrocarbon liquid dropout in the AG pipeline could result in an extended shutdown due to the difficulty in cleaning, drying, and restarting a blocked pipeline. In contrast, a winter shutdown of the BG pipeline would never result in hydrate formation since the winter ground temperature is warmer than the temperature at which single phase gas can become a two-phase gas-liquid combination.

2.3 LINE PIPE TECHNOLOGY

The BG case design temperature of 5ºF is colder than the winter soil temperature at the depth of the buried pipe. The AG case design temperature of -50ºF is due to the arctic winter air ambient temperature. At this temperature or below, special operational measures, such as lowering pipeline pressure, may be required. Pipe sources may be limited to large longitudinal Submerged Arc Welded (LSAW) pipe manufacturers due to the large diameter, wall thickness, grade strength and low temperature design requirements of the pipe. For AG pipe, the number of potential manufacturers will be even more limited due to pipe specifications requiring increased wall thickness and lower temperature design capabilities.

2.4 ENGINEERING DESIGN AND CONSTRUCTABILITY

For the AG mode, the VSM installation process is extremely costly, time consuming, and would require increased logistical efforts, material handling challenges, and additional schedule risk. When compared with the BG case, the AG case would require a substantial increase in barge shipping and domestic highway truck traffic for hauling additional materials, such as VSMs, HSMs, slides, guides, and anchors. AG installation is also likely to result in greater personnel and scheduling challenges, including the need for more out-of-state labor or more in-state labor training. The AG mode would require a separate weld qualification program, in addition to that for the mainline for workers and installation of VSMs structures noted above.

The BG case would require the use of an ice pad for transport of the pipe on heavy equipment, including a chain trencher, sidebooms, and trucks (see Section 3 and Figure 4, below, for more detailed construction information). A trencher running over an ice pad would cut a 5-ft wide trench through the soil to minimize impacts of construction. Bedding and padding would be installed against vertical sidewalls. Soils would be scraped back into the trench and crowned with additional spoil. Spoils will fall to approximately 2 feet either side of the trench over undisturbed ground to from the slopes of a mound or crown over the pipeline, which will settle. Winter construction would result in a lower probability of staff safety incidents.

Former Alyeska Pipeline Service Company staff recommend crowning the surface of the filled trench with soil in winter to an elevation slightly above the surface of the tundra. The goal is to have an even-lying surface at the impacted area over the pipe in summer, once processes of thawing, natural gravity compaction, and some drainage have occurred so that stabilization through revegetation and maintenance can proceed. After installation, the pipe would be monitored as part of the field surveillance program to address slumping, heaving, or ponding issues, employing the maintenance cycle standard of "Monitor, Detect, Correct" to ensure that these conditions are addressed in a timely manner.

The AG mode would require installation of the pipe on more than 5,000 VSMs, similar to what TAPS uses in its aboveground sections, to support the large diameter pipeline above the tundra. This assumes a single VSM structure. If a dual VSM structure is required (two vertical support members at every location) this number could increase to over 10,000 VSMs.

The VSM installation process required for an AG mode is more costly, more time consuming, and more complex than the BG mode. Increased and more complicated logistical efforts include additional material handling challenges, more barge, rail, and highway truck traffic, additional schedule and safety risk, a more challenging welding and balancing procedures, and increased structural challenges and risks related to wind or frost heaving, leading to VSM movement.

Complex welding and balancing procedures are required for the AG mode because pipe tolerances are much more exacting. AG installation would be more complicated, would take longer, and would potentially result in personnel and scheduling challenges to ensure additional experience was applied to the pipeline installation process. For these reasons, it is possible that the AG mode could add an additional year to pipe installation and disrupt the project-wide construction schedule.

2.4.1 Wind Induced Vibration

The AG mode would be required to address wind induced vibration (WIV), a phenomena in which wind damages a linear structure by forcing it to vibrate at its natural frequency. WIV famously lead to the destruction of the Tacoma Narrows bridge in 1940, and there have been some instances of pipelines impacted by WIV failures on the North Slope. AG pipelines must be modeled for their susceptibility to WIV. The effects of WIV are mitigated by placing appropriate weights and tuning structures on near the center of the span between the VSMs. AG pipelines on the North Slope that possess a north-south alignment are typically more susceptible to WIV than pipelines with an east-west alignment, because the prevailing winds blow in an east-west direction in the Kuparuk and Alpine areas. BG pipelines are not susceptible to WIV, and do not require weight or tuning structure setting, monitoring, or maintenance.

2.4.2 Frost Heaving and Thaw Settlement

The AG pipeline would be susceptible to uplift bending if the VSM support structure moved due to frost heave. VSM holes can extend from the surface down to a 15-20ft depth and can collect water when open or while they are settling. VSMs also conduct heat between the air and the ground. In certain conditions these processes can exacerbate frost heaving and lead to VSM upheaval. VSM upheaval is usually mitigated during the design phase of the project by utilizing geotechnical information and predicting how much VSM embedment is required to reduce movement. Engineers typically add additional VSM length below grade to mitigate against vertical movement.

When a VSM moves upward after pipeline installation, the conventional maintenance solution is to drill and set two more VSMs on either side of the heaving VSMs (this requires ice road access on both sides of the pipe) and then provide support at grade while the pipe is lowered onto the

HSM. Additional maintenance will still be required for the heaving VSM, as it will probably continue to heave and will need to be cut to keep from impacting the pipeline. VSMs in wet areas also have a tendency to settle and drop in elevation. In an AG scenario, thaw settlement that causes a VSM to drop in elevation could place stress on the pipe and the adjacent VSMs.

BG pipelines are susceptible to frost heaving and settlement, but because VSMs are not used in the BG mode, there are no issues related to open holes collecting water or having long, metal posts conduct heat between the ground and the air. Based on geotechnical data, ASAP engineers believe the risk of BG pipe heaving is very low for the first 60 miles. For the BG mode, long, continuous segments of pipe surface area are supported by the ground. This allows the BG pipe to more easily tolerate moderate heaving and exhibit flexibility better than an AG pipe, which is supported by pipe shoes, which are relatively short when compared to the length of the pipe span. The BG pipe is bedded with thaw-stable, non-frost susceptible materials and will operate at below-freezing temperatures of 8 – 30ºF in winter and 25 – 30ºF in summer (Figure 1). This helps to mitigate against permafrost degradation, pipe thaw settlement, and surface slumping. Pipeline integrity will be monitored regularly through the use of inline inspection devices (smart pigs).

2.5 LOGISTICS AND SCHEDULE

North of the Brooks Range, the end of the winter season is late April or early May. This yields a duration from early January to late April for pipeline construction of up to 120 days. An AG design would require installation of VSMs at approximately 5,000 locations. It is possible that an AG design could require two winter seasons: the first for installation of VSMs and the second for the installation of the pipe. This would impact cost, schedule, and simultaneous operations with other mainline spreads, camp space, and logistics.

For BG design only one winter season would be required. The winter section lengths were planned to allow as much time as possible between the completion of the pipe laying and the end of season dates, allowing adequate time to complete coating, cathodic protection, lowering-in, bedding, padding, backfill, tie-ins and cleanup.

The civil contractor will construct an ice work pad on the ROW prior to pipe stringing. Frost packing of the ROW with tundra-legal equipment could begin in November, but on tundra ice pad construction is assumed to start in early or mid-December. The ice pad crew will ensure that enough ROW is prepared ahead of the pipe lay crew. The entire section is flat terrain and will be constructed during the winter pipe lay season.

2.6 ENVIRONMENTAL IMPACT

2.6.1 Soils and Hydrology

The BG mode requires specific procedures for adequately controlling soil erosion along the constructed pipeline (see Section 3, below). ASAP is working with the Alaska Department of Natural

Resources (ADNR) Plant Materials Center to develop specific revegetation procedures in a Revegetation and Erosion Stabilization Plan for the Project. Implementation of these specific procedures will help to reduce soil erosion and improve stability through revegetation and other means.

The BG mode also requires specific procedures for adequately managing water along the constructed pipeline, including surface water and subsurface hydrologic flow (see Section 3, below). ASAP has retained the services of individuals with over 30 years of experience stabilizing and maintaining TAPS on the North Slope to assist in the development of these procedures. Based on the recommendations of these individuals, the ASAP goal is to maintain natural surface water flow patterns with as little change as possible.

ASAP's goal will be to maintain a stable surface and to adequately manage water and drainage within the ROW during operations and maintenance. ASAP will apply a programmatic maintenance cycle standard of "Monitor, Detect, Correct" to its soil stabilization and water management efforts during the operations and maintenance phase of the Project so that any potential issues related to erosion, slumping, ponding, or inadequate drainage can be addressed in a timely manner.

2.6.2 Permafrost

Impacts to North Slope permafrost will be minimized by:

- Constructing in winter and restricting impacts to the organic layer to a very small footprint (a 5-ft wide trench will be dug and filled with thaw stable bedding and padding, the pipe, and trench spoils in winter. Spoils will fall to approximately 2 feet either side of the trench over undisturbed ground to from the slopes of a mound or crown over the pipeline, which will settle).

- Use of ice pads, frost packing, and ice roads during winter construction to avoid unneeded disturbance to the organic layer.

- Reducing the pipe dormancy period to only two years and maintaining a year-round operational temperature of the pipe that is below freezing for the first 60 miles (see Figure 1).

- Maintaining existing surface water channels in their natural flow path to avoid water seepage into the area of the filled trench.

- Seeding the first summer after construction with a mixture of annuals and native seeds to regrow the organic layer and replace a vegetative covering as soon as possible.

- Instituting a programmatic maintenance cycle standard of "Monitor, Detect, Correct" for hydrology

2.6.3 Wetlands, Vegetation, and Land

The overall acreage impact to wetlands and vegetation on the North Slope due to the pipeline would be greater for the BG design than the AG design because of trenching, in comparison with the "posthole footprint" that would result from VSM installation under the AG option. However, in the BG mode, a route was selected to avoid wetlands of higher functional values whenever possible. Upland areas were targeted, and open water areas were avoided where possible.

Seeding and revegetation for the BG mode will be done with approved seed mixes that include native species and other annuals. As noted above, ASAP will work with the ADNR Plant Materials Center to develop a specific plan for revegetation and stabilization that will provide specific information on seed mixes, mulches, aerial or hydroseed applications, clearing, maintenance and monitoring. Upon completion of use of the ROW, ASAP will be required by lease stipulation to restore the land to the satisfaction of ADNR.

2.6.4 Endangered Species and Other Fauna

Habitat for eiders and other waterfowl is potentially impacted by the AG and the BG design. The BG design would have more impacts to wetlands, but the difference in how waterfowl would use the area over or under the pipe is unknown and may be negligible. The BG alignment was specifically selected to minimize impacts to existing ponds and other higher value wetlands. It is not known if the visual perception of an AG pipeline or disturbance from a BG pipeline could deter birds or fragment habitat, or even be used as a means of navigation from the air. The AG pipeline would be expected to result in some minimal nighttime bird strikes resulting in mortality or injury.

While habitat is often only discussed or mapped 2-dimensionally, the reality is that habitat is the 3-dimensional space that fauna occupy or use. Behavior and habitat use by waterfowl and other fauna could conceivably be even more impacted by an AG pipe and VSMs (visual disturbance, strikes, shading and plant growth, snow accumulation or blockage, and long-wave radiation impacts on snow); whereas the BG design would be a revegetated corridor maintained for operation.

Wildlife migration and subsistence users would not be impacted substantially by the BG mode, but the AG mode could potentially impact wildlife migration and subsistence activities. Subsistence users have previously commented on the impacts of proposed AG features on the North Slope. Transcripts from the TAPS renewal Draft EIS Public Hearing in Barrow Alaska (Bureau of Land Management [BLM], 2002a) recorded North Slope Borough (NSB) Mayor George Ahmaogak's public testimony, as he spoke on behalf of the NSB in regard to his concern about additional AG features that could impact wildlife on the North Slope. Mayor Ahmaogak commented that:

> "Caribou migration patterns were altered, changed by construction of the Trans-Alaska Pipeline system and the associated Dalton Highway. Studies, scientific studies utilizing radio collars on caribou indicated that to a great extent, these obstacles continue to impede the free movement

> of the affected North Slope herds… Subsistence users in our communities of Nuiqsut and Anaktuvuk Pass have long noted these changes and they have to cope with the absence of game in traditional harvest areas." (BLM, 2002a)

An additional AG feature on the North Slope in the same vicinity of TAPS and the Dalton Highway could potentially impact caribou behavior and movement. Burying the pipeline on the North Slope is likely to reduce impacts to wildlife migration and movement, particularly caribou (Smith and Cameron, 1992; Lawhead et al., 2006). A BG pipe mode would also reduce viewshed impacts to human residents. An AG pipeline for 60 miles is a substantial 30+ year permanent viewshed impact compared with a BG trench that will be stabilized, in part, through revegetation. Snowdrifts caused by the AG mode and VSMs also can present an impedance and a safety hazard to hunters or other travelers traversing the tundra by snowmachine.

As stated above, the USFWS reviewed the ASAP Project and its potential impacts in its published BiOp, dated July 10, 2012, and determined that the proposed design "is not likely to adversely affect Steller's eiders" and "is not likely to jeopardize the continued existence of spectacled eiders or polar bears, and is not likely to destroy or adversely modify polar bear critical habitat".

2.7 COST

The AG mode will have a higher installation cost than the BG mode and will substantially increase the Project's capital expenditures (CAPEX) (Table 1). The higher costs associated with the AG mode are associated with increased amounts of materials, material transportation and handling, and more staffing time due to a longer installation process. These higher costs associated with the AG pipe would be passed on to consumers (residents, businesses, government entities, and projects) through higher tariffs and burner tip rates, whereas the BG gas would provide cheaper gas for Alaskans.

2.8 SUMMARY OF DESIGN FACTOR EVALUATIONS

The design factors evaluations described above for the AG and BG modes are summarized in Table 1, below.

Table 1. ASAP Aboveground & Belowground Design Factor Evaluation Summary

FACTOR	ABOVEGROUND (AG) MODE	BELOWGROUND (BG) MODE
Pipeline Safety & Security	▪ Would result in a higher likelihood of staff safety incidents; greater exposure from more complex logistics, longer to construct. ▪ More susceptible to accidental damage (e.g., accidental bullet strike) and rupture. ▪ More susceptible to terrorism or sabotage. ▪ VSMs and snow accumulation may cause increased risk or hindrance to cross-country winter travelers.	▪ Would result in a lower likelihood of staff safety incidents. ▪ Reduced probability to rupture due to accidental damage from external impact. ▪ Less likely to be struck or sabotaged due to buried mode. ▪ No risk to winter travelers.
Operational Reliability	▪ Potential for significant hydrocarbon liquid dropout during winter shutdown; slugging issue and longer restart time impacts gas delivery. ▪ The pipe supports are designed to generally minimize thaw settlement or frost heave. Large settlements, should they occur, can be detected visually. ▪ Maintenance work requires only access to pipeline (no digging). ▪ Pipe may be more susceptible to corrosion due to the need for insulative jacketing, which can trap water. ▪ May attract lightning once the pipe moves upward in elevation towards Atigun.	▪ No liquid dropout potential because gas remains at BG soil temperature and never reaches the critical temperature at which heavier hydrocarbons in the gaseous phase convert to liquid. ▪ Potential for settlement and frost heave remediation during operations. ▪ The position of buried piping would be monitored using in-line inspection tools containing an inertial measurement unit. The position data from each tool run can be compared to previous passes to determine whether excessive displacement has occurred. ▪ Maintenance work could require construction of access roads, maintenance area workpads and excavation of the pipe. ▪ Buried pipe will not attract lightning.
Line Pipe Technology	▪ Requires step-out technology for high pressure & toughness. ▪ -50°F + environment, increases schedule risk (limited procurement options globally) and pipeline integrity risk (TAPS used 3 mainline pipe suppliers).	▪ BG line pipe is proven technology, and it doesn't require low temperature steel toughness requirements.
Logistics and Schedule	▪ More complex logistics due to higher pipe tolerance and a more exacting installation process; installation of VSMs is time consuming. ▪ Increased logistical challenges related to transport and storage of materials. ▪ Increased logistical challenges related to training or scheduling of experienced welders to install pipe at 7ft, as required by North Slope ordinance. ▪ Possibly two construction seasons (1 for VSMs, one for pipeline).	▪ Easier logistics of installation – chain trencher over ice pad; rigid side walls, easy welding / balancing; use of padding. ▪ Fewer materials to ship. ▪ One construction season.

FACTOR	ABOVEGROUND (AG) MODE	BELOWGROUND (BG) MODE
Engineering Design and Constructability	▪ Challenging line pipe weld qualification program. ▪ Induction bends may be needed at expansion loops, road crossings, and pipe rack crossings. ▪ Insulation and jacketing needed to reduce the effects of heat transfer; these jackets can trap water and may make the pipe more susceptible to corrosion. ▪ Pipe rack jumpers are needed to cross existing pipelines, primarily in the northernmost portion of the pipeline; can be complicated. ▪ No cathodic protection required. ▪ All AG pipelines must be modeled for susceptibility to WIV; can be mitigated through with balancing with weights / tuning mechanisms. ▪ Susceptible to VSM movement from heaving and pinpoint pipe stress; cut and replaced VSMs that have heaved require continued monitoring and maintenance; can be mitigated somewhat with longer VSMs.	▪ Requires implementation of procedures required for impact avoidance and stabilization in permafrost areas. ▪ Potential need for import of thaw stable backfill materials, ditch plugs, and other mitigation methods to ensure trench stabilization. ▪ Increased reclamation efforts during operations. ▪ BG construction can be completed sooner than the AG. Maintaining snow-free trench with multiple crews between trench and backfill will be challenging. ▪ Potentially no need for induction bends except at gas treatment facility tie-in. ▪ No need for insulation, as the gas will be operated below freezing to avoid thawing permafrost and ambient soil temperatures remain above the critical temperature year round. ▪ No need for jumpers, as the pipeline will be buried under the existing pipelines and will cross them near mid-span between supports, where feasible. ▪ Cathodic protection required for BG pipelines. ▪ WIV is not a consideration for BG pipelines. ▪ Frost heaving is a minor concern; long segments of pipe have more surface area resting on the ground.
Environmental Impacts	▪ VSMs reduce pipeline impact to wetlands. ▪ Increased direct / indirect impacts to subsistence activities and users. ▪ Communities and non-government organizations express concern over impacts to subsistence activities and pipe in viewshed. ▪ Low susceptibility to erosion; low to moderate level of stabilization effort required. ▪ Major permanent visual resource impacts from ground and air – the AG pipeline will impact viewshed at ground observer height of 7–12ft.	▪ Pipeline impacts to the organic layer minimized to 5ft wide ground disturbance; spoils will fall to approximately 2 feet either side of the trench over previously undisturbed ground to from the slopes of a mound or crown over the pipeline, which will settle; Mitigatable impacts to waters and wetlands ▪ Minimal direct / indirect impacts to subsistence activities or users. ▪ No pipe in the viewshed. ▪ Erosion concerns mitigated with proper design, geotechnical information and water management / revegetation plans. ▪ Increased stabilization efforts expected in first 5 years. ▪ Minor long-term visual resource impacts – surface disturbance initially; revegetation.
Cost	▪ Higher capital expenditure (CAPEX) – significant cost upfront ▪ Higher permanent materials cost; driven mostly by mainline pipe and vertical support system. ▪ Transportation cost of materials will be substantial. ▪ Higher staffing cost due to greater installation time will be substantial	▪ Lower CAPEX – fewer materials and ease of installation. ▪ Some added cost and logistics for select bedding/ padding material.

3. THE BELOWGROUND PIPELINE MODE (SELECTED)

The BG pipe option was evaluated for constructability, safety, security, as well as proposed avoidance, mitigation, and stabilization measures in permafrost areas. The ASAP pipeline is projected to operate at 32ºF or colder temperature over the first construction spread and function as an ambient temperature pipeline. In the case of ASAP, the gas will enter the pipe in permafrost areas at below freezing temperature and will remain below freezing for the first 175 miles of the pipeline (Figure 1).

3.1 PRE-CONSTRUCTION PLANNING

3.1.1 Geohazard Avoidance and Special Design Area Engineering

The ASAP Project route and pipeline design were developed and refined in consideration of extensive hydrologic, geologic, and geotechnical data. ASAP has developed a robust geotechnical program where engineers have acquired a significant body of information that will continually be supplemented up through construction to best inform the engineering design team. This information was utilized in evaluation of the BG and AG modes and the route alignment. As part of this program, ASAP engineers have acquired and reviewed:

- Orthorectified aerial photography (approximately 3,733 sq. mi.)
- Digital elevation modeling (DEM) derived from LiDAR surveys (approximately 2,079 sq. mi.)
- Terrain unit mapping
- Borehole soils data (including access to over 10,000 discrete boreholes)
- Permafrost investigations and ground temperature monitoring
- Geohazard Evaluation and Mitigation Analysis Reports (GEMARs) covering topics such as Hydrotechnics, Soil Geochemistry, Unique Soil Structure, Surface Fault Rupture, Tectonics and Seismicity, Landslides (slope stability), Erosion and Buoyancy, Freezing of Thawed Soils and Thawing of Frozen Soils
- Assessments of potentially active tectonic faults
- Trip reports from multiple field reconnaissance investigations or site visits

These engineering reviews were important for long-term soil stabilization, pipeline integrity, avoiding burial of the pipe in areas sensitive to thaw degradation, and burial of the pipe in areas susceptible to seismic disturbance or major fault movements. Special design areas included fault crossings, water crossings and pinch points (e.g. Atigun Pass, Denali commercial area). ASAP also worked with the Alaska Division of Geological and Geophysical Surveys (DGGS) and supported their efforts to identify and assess of geologic hazards along the ASAP pipeline route, although the majority of these potential hazards were south of the Brooks Range.

Conditions have been identified through ASAP's geotechnical program that may cause ditch displacement and subsequent pipe curvature and distress. This requires experience in identification of those surface characteristics that have been shown to contribute to potential route hazards, followed by an extensive subsurface investigation program to identify the remaining hazard, and, finally, analytical design tools to quantify the effect on pipe behavior. As the samples recovered from the boreholes are processed by soil laboratories, the results feed into the projects' respective geospatial information system (GIS) and geotechnical databases, and then are used in the evaluation of route hazards. The process of route threat identification, evaluation, and avoidance is an ongoing process for which many aspects will continue throughout the operational life of the project.

3.1.2 Avoidance of High Value Wetlands

Most of the North Slope is considered wetlands. However, wetlands vary in their intrinsic value based on the function they provide in the ecosystem. The ASAP Rev 6.1 route used aerial photography and approved wetland field survey methods to delineate wetlands, develop an aquatic site assessment to rank functions and values of wetlands, and to route the pipeline around open water and higher value wetlands where possible.

3.1.3 Waterways Analysis

ASAP's waterways engineers have spent several summers of field work assessing flow and stream bank characteristics of the streams along the ASAP pipeline route. The reason for this work is that it will be important for ASAP construction engineers to maintain existing surface water flow following burial of the pipe in winter. ASAP plans to carry out work on the North Slope in winter when water is frozen, and then work in the years following construction to ensure minimal disruption to surface water flow patterns, ensuring that water does not get directed into the trench and instead continues in its naturally flowing direction towards larger waterbodies.

3.2 CONSTRUCTION OF THE BELOWGROUND PIPE

3.2.1 Ice Roads, Ice Pads, and Frost Packing

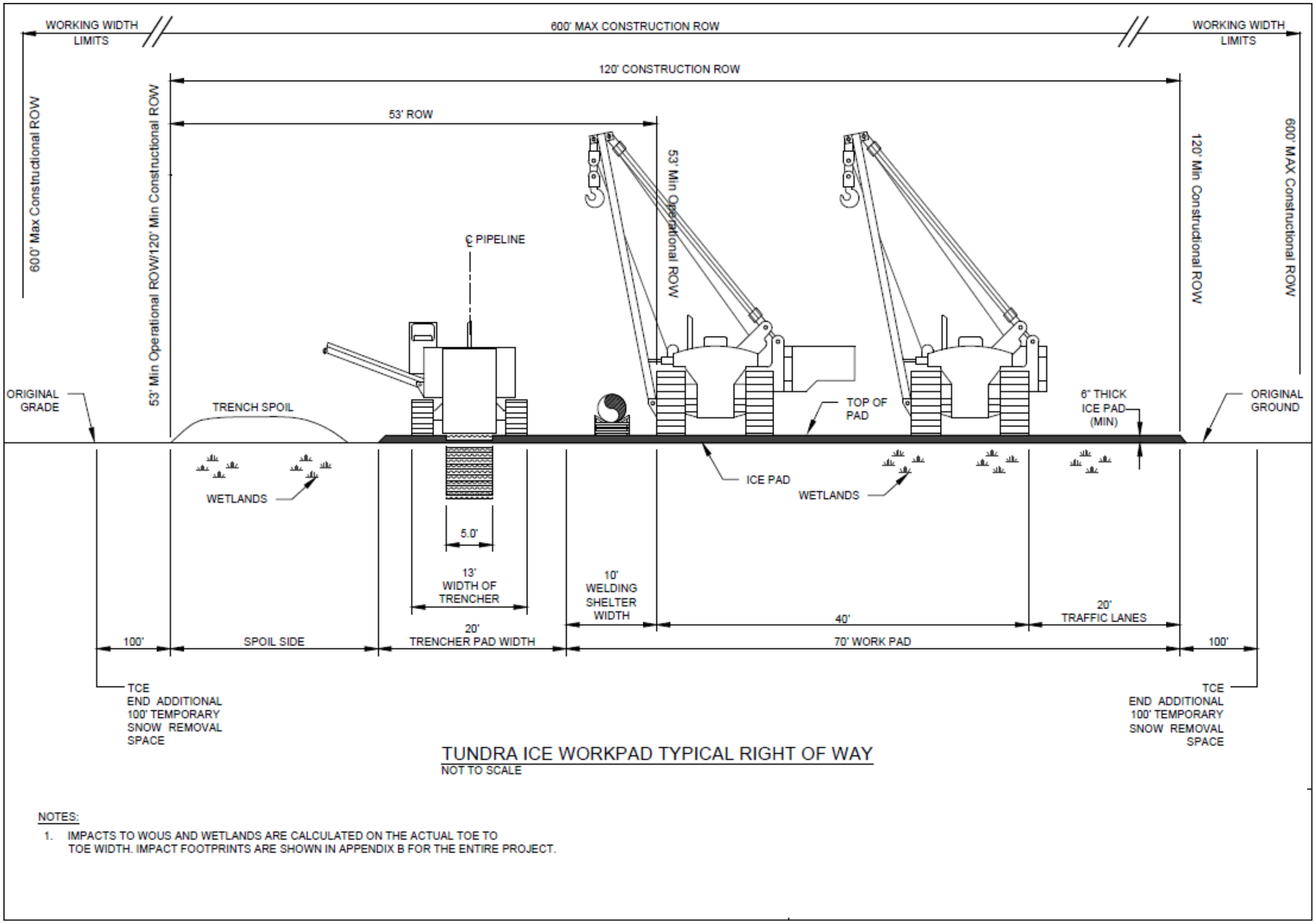
Mitigation measures will be used during pipeline construction on the North Slope to protect high value wetlands and avoid disturbing the organic layer and permafrost. Ice roads and pads will be constructed in order to provide a flat, stable working surface and move heavy equipment along the pipeline route on the North Slope. Frost packing (use of condensed snow as a driving surface) will also be used in some areas, where possible.

3.2.2 Trenching and Pipe Installation

Heavy equipment working over an ice workpad (trencher, sidebooms and trucks) will work north-to-south to dig a 5ft-wide trench to the desired depth (generally, 6ft.), casting spoils to the opposite side of the trench (Figure 4). Heavy equipment and trucks will drive on the working side of the trench, which will be protected by an ice pad and result in no impact to wetlands from transportation (Figure 4). A trencher, which is not compatible with large cobble or boulder areas, can be used because of the presence of a uniform deposit of fine-grained soils within trench depth on the ACP. The trencher will drive over an ice pad while digging the trench. Trench spoils will be cast onto the spoils side of the trench (opposite the working side of the trench), onto either ice, frost packing or snow out to the extent of the construction ROW. Soils will be backfilled into the trench after installation (see below for more detail). Spoils will fall to approximately 2 feet either side of the backfilled trench over undisturbed ground to from the slopes of a mound or crown over the pipeline, which will settle in spring with thaw. This will result in a 9-ft wide permanent impact to wetlands and uplands for the first 62 miles of the pipeline. Some spoil material may be re-distributed as needed along the route to best facilitate revegetation and limit open water areas.

Upon digging the trench, construction teams will assess surficial and subsurface hydrology, as well as the potential for erosion and ponding. Engineers will use this information to inform their decisions for placing ditch plugs or other subsurface hydrologic control measures where possible.

Figure 4. ASAP Pipeline Construction on Alaska's North Slope



Installation of the BG pipe on the North Slope in winter would occur using a 5-ft wide chain trencher operating over an ice pad. The rigidity of the frozen soils and the soil type would presumably allow workers in and out of the ditch without need for expanding the side slopes of the ditch.

3.2.3 Thaw-stable Bedding and Padding Material

After trenching is completed, non-native bedding and padding material will be added. This material will be mined to meet project specifications. The bedding material will be thaw-stable in order to provide required structural support to the pipeline and avoid settlement.

3.2.4 Ditch Plug Installation

Ditch plugs are designed to stop water flow through the trench line and therefore mitigate against undesired waterflow or seepage; they can be made from different types of materials (Figure 5). Ditch plugs are typically installed on each side of an excavated water crossing and in other locations along the ROW as required and directed by the owner's ROW inspector. They are useful in avoiding French drain effects, and can be used to direct and inhibit the flow of water. Experts who formerly worked on TAPS with Alyeska Pipeline Service Company have recommended a higher number of ditch plugs on ASAP than was used on TAPS to help control water and reduce ponding. Ditch plugs will also be used in the trench on either side of stream crossings to ensure water does not penetrate into the ditch.

Figure 5. Ditch Plugs Made from Different Types of Materials

Examples of different types of ditch plugs used for water management in buried pipeline construction.

3.2.5 Ditch Backfilling

The pipeline will be placed within the trench during the same winter construction season in which it is dug. The pipe will be padded with thaw-stable material, and the remaining portion of the trench will be filled with native trench spoils or other select backfill. Per federal regulation, at least 30 inches of normal soil cover must be used to cover the pipe. During construction, soil will be replaced soon after the pipeline section is laid down to reduce the introduction of snow or rain into the trench. Seeding of the backfilled trench will be monitored after construction to confirm that the reseeded ditch line supports continued long-term plant populations and that fill above the pipe does not erode.

3.2.6 Crowning

The excess trench material will be used in trench crowning (a very slight mounding over the pipe), contouring terrain, and other stabilization and mitigation efforts. While most spoils will be used in the crowning or contouring process, it is possible that some excess material could be hauled off to disposal sites (i.e. material sites), depending on Project operational and maintenance needs at that time. The slope of the crown over the trench is critical to stabilizing soils and directing ponding, thereby mitigating some potential impacts related to erosion and drainage. In crowning, the native material that is replaced over the trench is almost near to flat.

Crowning is a procedure that is important for both soil stabilization and water management. It is characterized as a mild mounding of trench spoils above the pipeline trench to an appropriate finish grade that will help to direct moisture away from the top of the pipe and mitigate against slumping. Crowning promotes movement of water along a desired vertical and horizontal gradient. As the ditch soils thaw in spring, the extra weight and height of soil will compact the soil below and bring the surface above the pipeline near to flat.

- Options available to direct flow from the crowned trench line include:
- Installation of wattles (intentional depressions) at an angle and at predetermined spacing along the crowned trench line based on slope angle to direct flow away from the ditch line.
- Installation of flexible piping to carry offsite and upgradient water across the ditch line to vegetated downslope areas.
- Periodic installation of armored flow breaks in the crowned section to transfer water from one side of the ditch line to the other for storm drainage.
- Use of native fill berms to direct flow away from the crowned ditch at specified intervals based on slope.
- Construction of drainage channels to direct flow from the construction area.
- Installation of permanent culverts in some areas.
- Development of earthen ditch blocks used to retain or direct water.
- Use of gravel or gabion channels or swales.

3.2.7 Terrain Contouring

Terrain contouring is a procedure that is important for both soil stabilization and water management. It is the use of excess ditch spoils and/or other materials to contour surrounding terrain in an effort to control reduce erosion through the control of hydrologic movement, as needed to promote preferential surface and subsurface flows. Material sites, camp sites, ice roads and pads, temporary-use areas, and temporary access roads will be re-contoured and restored to an acceptable condition as required by applicable permits. Generally, revegetation of disturbed areas is planned for long-term stabilization.

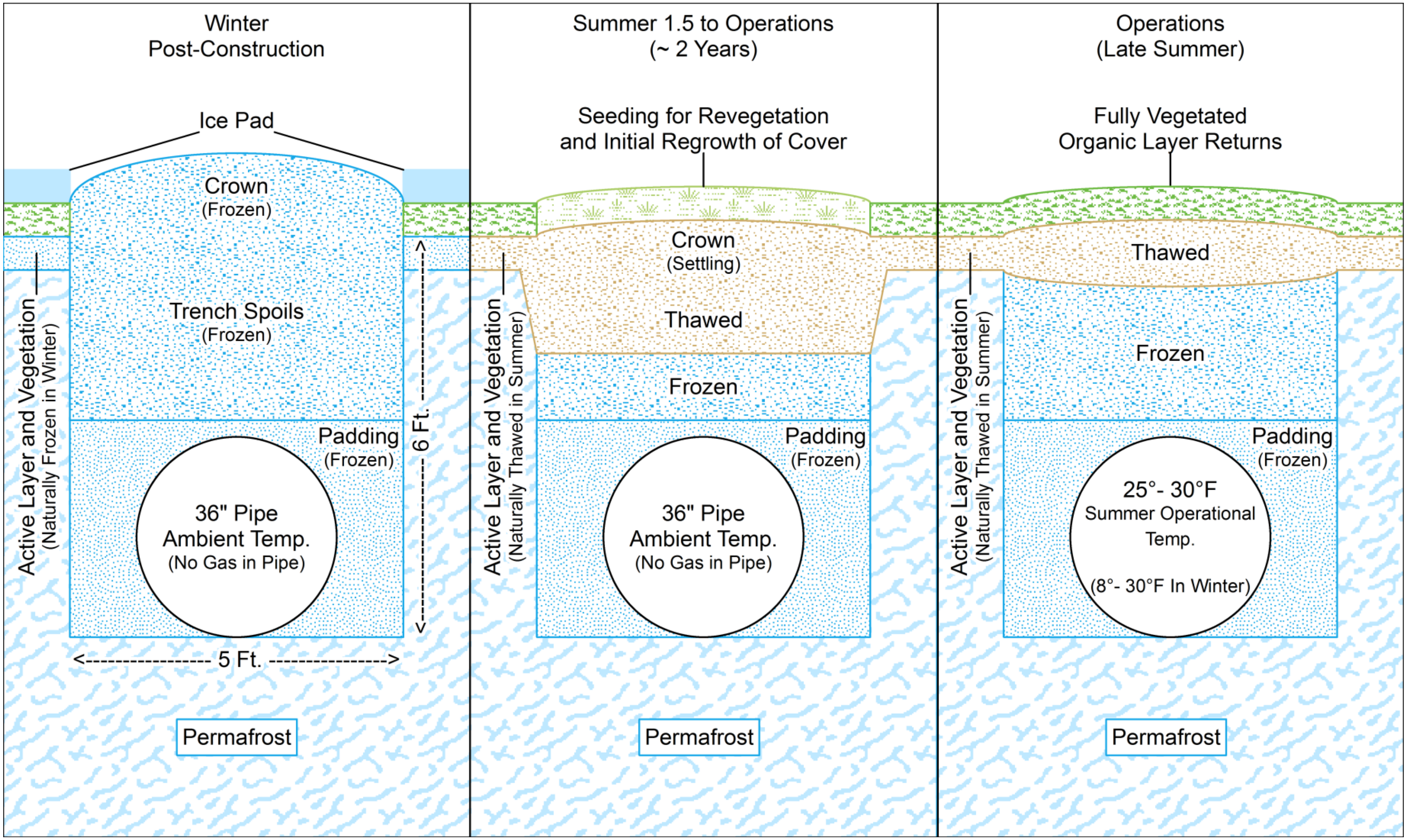
3.2.8 Cleanup

Following pipe installation, ditch backfilling, and hydrotesting, crews will perform cleanup, including leveling of the pipeline ROW and shaping of a crown over the pipeline ditch, as required. Crews will dispose of remaining scrap materials, timber, or other debris. Wood debris will be disposed of, and scrap materials and rubbish will be hauled to designated waste accumulation locations, incinerated, hauled to a permitted landfill for disposal, or some combination. Crews will be equipped with dozers, front-end loaders, and dump trucks to facilitate clearing and construction ROW cleanup. Snow pad areas will require a summer cleanup check to verify that construction materials were removed from the construction ROW. Remaining debris will be removed using low-ground-pressure vehicles to minimize disturbance to surface vegetation.

3.2.9 Dormant Period

The BG pipe and surrounding material (bedding/padding, trench spoils, crown) and permafrost will remain frozen in place up through spring/summer melt (Figure 6). At that time, the crown and back-filled trench spoils will settle over the pipe and the thaw-stable bedding. The surrounding permafrost will melt slightly around the portion of the trench that thaws (Figure 6). The pipe will lay dormant at ambient temperature for approximately two years without any flow of gas while construction and testing of the GCF and pipeline occur and are completed.

Figure 6. Construction, Operation, and Maintenance of the ASAP Belowground Pipe in North Slope Permafrost (MP0 – MP60)



3.3 POST-CONSTRUCTION MONITORING AND MAINTENANCE

3.3.1 Experienced Personnel and Precedent

The ASAP Project has retained the services of engineers and environmental scientists with 30 years of experience in stabilizing soils and managing hydrologic issues associated with other buried pipelines in Alaska, including some on the North Slope. These experts include Pipeline and Civil Maintenance (P&CM) engineers for Alyeska Pipeline Service Company and other experts who have experience with TAPS, a pipeline that has several belowground sections on the North Slope. These experts have first-hand knowledge and experience implementing successive-year soil stabilization and water management techniques and assessing needs to mitigate against erosion. These individuals have contributed to the development of stabilization measures for the first five years after construction and to the long-term maintenance planning efforts for ASAP.

3.3.2 Trench Stabilization

Monitoring and re-stabilization will occur in the years after construction of the pipeline to ensure resulting environmental impacts are minimized and that any unexpected impacts are addressed through additional required action. Stabilization of the backfilled ditch may be a multi-year process in some areas, particularly areas with fine-grained, ice-rich soils. Rehabilitation, especially in ice-rich soils, may require trench maintenance and long-term thermal stabilization activities before the habitat achieves stability.

3.3.3 Erosion Control

Storm drainage design at the surface above the pipe will help to control flow along the crowned ditch and the Project. The crown will settle as a result of thawing. Temporary and permanent erosion and sediment control procedures and drainage controls will be designed to work in concert to provide acceptable erosion and sediment control for the project.

Erosion control measures for ditch excavations performed through stream beds and banks will be applied as soon as the backfill is placed into the ditch to complete pipe coverage. Specific materials to use for erosion control of the bed and banks will be determined on a case-by-case basis and identified in the construction plans for each crossing.

The Project will develop appropriate methods to respond to local conditions based on existing terrain, geology, hydrology, slope, disturbed area, thermal regime, climate, and other factors in the final design and relevant plans.

3.3.4 Revegetation

Areas that are impacted by construction will be re-seeded with natural vegetation to improve stabilization of soils and minimize erosion around the pipe. ASAP will work with the ADNR Plant Materials Center to develop a specific Revegetation and Erosion Stabilization Plan.

Soil stabilization procedures were developed through consultation with former P&CM engineers and scientists with first-hand experience in implementing successive-year soil stabilization techniques and assessing needs to mitigate against erosion for buried Arctic pipelines. Procedures for ensuring soil stabilization include geohazard avoidance and special design area engineering, use of engineered material for bedding and padding, soil replacement and stabilization at installation, crowning, terrain contouring, armoring, revegetation, fertilization, control of non-native plants, and through monitoring and maintenance for several years after construction. Seeding and revegetation would be done with approved seed mixtures of annuals and native species and re-shaping of the ditch spoil after initial thawing would be done to prevent any ponding due to thaw slump.

Spring seeding of the impacted area promotes vegetative growth and the stability of soils to minimize erosion around the pipeline. Seeding of the disturbed corridor will be conducted in consultation with the BLM and State of Alaska and will adhere to the ADNR Plant Materials Center Revegetation Manual for Alaska (Wright, 2009). The methods and procedures outlined in the manual provide specific regional information for revegetation of disturbed areas with native plants to limit the potential for colonization by invasive species. A Non-native Invasive Plant Prevention Plan will also be developed and consulted to limit the potential for colonization by invasive species.

Seed mixes will be developed for different geographic areas and fertilizers applied at an optimum rate per acre. Hand methods, hydroseeding, and aerial seeding will be employed to stabilize surfaces as required and will be identified in more specific planning documents leading up to construction.

ASAP will continue to re-seed and monitor the success of vegetation as necessary while the ROW is being used for maintenance during operations. As required by the ROW lease, upon completion of use, the lands will be restored to the satisfaction of the landowner.

3.3.5 Fertilization

The application of fertilizer will be conducted in consultation with ADNR. Standard practices and planning will be followed so that adequate volume, type, and quality of fertilizer are used where needed. Ground-disturbed areas may be fertilized, if appropriate, as construction progresses. Erosion control measures will be applied on top of the seed and fertilizer application. As project development proceeds, specific uses will be determined. Fertilizers will be used sparingly in areas where invasive plants are known to exist in order to limit their infiltration.

3.3.6 Control of Non-Native Plants

Procedures will be developed in consultation with ADNR to control the introduction and spread of non-native invasive plants during pre-construction, construction, and monitoring phases of the Project. Invasive plants can be introduced from the use of airports (particularly at gravel airstrips), material sites, and temporary-use areas, such as pipe storage yards (PSYs) and camps. Control of invasive plants is likely to be a requirement of ROW lease stipulations to restore land to the satisfaction of different land owners.

3.3.7 Operation of the Belowground Pipe

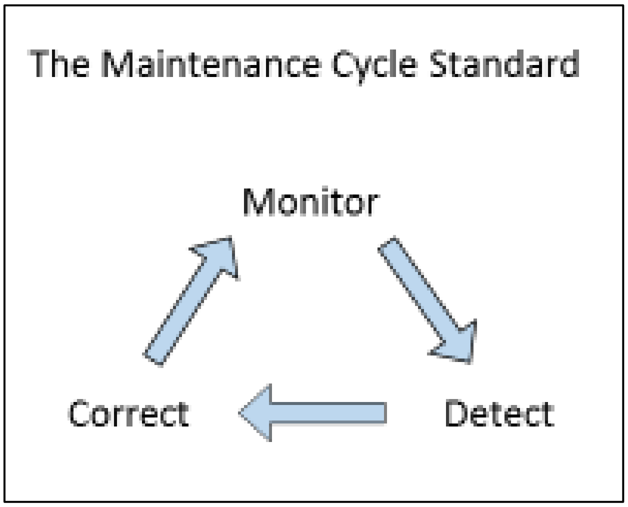
When ASAP completes construction and testing and begin operations, it will transport gas and operate at below freezing temperatures (8 - 30ºF) on the North Slope (Figure 1, Figure 6). No compressors will be required, as all compression for 500MMscfd will come from the GCF. ASAP will transport gas along its route through the North Slope region and ACP en-route to customers in Fairbanks, the Southcentral region, and other Alaskan communities.

3.3.8 ASAP Field Surveillance Program

Soils and water will be monitored regularly after installation of the pipe following the programmatic maintenance cycle standard of "Monitor, Detect, Correct" (Figure 7). Where depressions or slumping occurs in spring / summer, additional ditch spoil will be placed to flatten the surface and reduced the amount of standing water. For the first several years after construction soil stabilization efforts will focus strongly on control of erosion through revegetation per the methods above and water management. If, after several years of revegetation efforts, plant cover does not sufficiently return to stabilize soils, ASAP will consider alterations to the methodologies of its revegetation procedures in consultation with ADNR to encourage additional growth.

ASAP will monitor the pipeline in the years after construction to determine where modifications may be needed to ensure proper water management. Crews will document and inspect areas of ponding water over the pipe and recommend site-specific improvements in subterranean infrastructure or water flow to ensure that prolonged ponding is limited or reduced. Additional improvements may be added in certain areas, depending on the level of moisture, drying, and settling that occurs over and around the pipe.

Figure 7. Programmatic Maintenance Cycle Standard for ASAP



It is possible that some ponding could occur along the route in areas directly over the trench intermittently during the first spring after soils thaw, but will then drain as temperatures warm surrounding soils near the surface. The north-to-south configuration of the pipeline means that the direction of sheet water flow will be directed by the downward gravitational gradient of the terrain, moving from higher elevations near the Brooks Range foothills, north to the lower elevations of the coastal areas near the Beaufort Sea. The pipe, running parallel to this flow gradient, will generally not inhibit the slow movement of groundwater along this gradient. The lack of a mound, or high-slope crown, over the trench will keep water from ponding in trenches on either side of the mound.

The low or nearly-flat, sloped crown will encourage proper drainage, and in some instances, initial ponding directly over the trench in areas where subsidence occurs. Historic knowledge from experts who have worked on TAPS and North Slope buried pipelines believe the initial temporary impacts associated with constructing the pipeline will be manageable with regard to stabilization, especially for a below-freezing temperature pipe. Based on the recommendations of experts in BG pipe erosion control and water management, increased stabilization efforts will be required for the first 5 years following construction.

4. THE ABOVEGROUND PIPELINE MODE (NOT SELECTED)

The AG pipe option was not selected by ASAP for the first 60 miles of the pipeline on the North Slope. The engineering reasons for not selecting this option lie in challenges to constructability, increased operational risk, more complex logistics, and a resulting higher project costs. Other HSSE considerations are the security of the AG line, impacts to visual resources, public comments on impacts to subsistence species, such as caribou, environmental impacts to aquatic habitat, and impacts to non-aquatic wildlife during both construction and operations.

The AG procedure requires more equipment, more material, more temporary support infrastructure, and more time to construct than the relatively simpler process of trenching, bedding, padding, and covering with backfill. There is also increased time and effort required for balancing the VSMs and aligning the pipe on the VSMs.

In the AG design that was not selected for the North Slope component of the project, the pipeline is supported at intervals by engineered structures, typically constructed of steel or concrete. The impacts of WIV and frost heaving of VSMs create unique challenges. The vertical separation of the pipe from the subsurface eliminates consideration for geohazards resulting from changes in subsurface support, such as thaw settlement. The support structure is typically a round structural member with embedment designed to resist axial and longitudinal loadings transmitted to the support from the pipeline. The pipe itself, not being constrained by surrounding soil, is thus free to expand and contract in response to such loadings as operational changes in temperature. Consequently, the longitudinal stresses induced in the pipeline are relatively small, provided the supports are spaced appropriately. However, the displacement of the pipe on the supports must be accounted for by installation of expansion loops.

This type of installation is typical on the North Slope of Alaska where hot, buried pipelines could disrupt the permafrost conditions. It was also the solution of choice for TAPS to mitigate the effect of thaw settlement; approximately half of its length is aboveground (>400 miles). Natural gas pipelines, which typically run chilled or near ambient temperature, have less of a technical requirement to avoid burial.

The technical disadvantages to the AG scenario include flow assurance considerations for the natural gas product to ensure there is no liquid dropout that could collect and cause internal corrosion. The pipe material may be subject to low temperatures from the ambient conditions, and may require special fracture control provisions. There are also well-known disadvantages for its use which may be more pronounced for ASAP, especially if used along the Dalton Highway Corridor: the configuration is highly visible, must allow for passage beneath the pipe, must allow for lateral variations in the ROW to accommodate expansion loops, and would be subject to additional security concerns.

5. CONSTRUCTION SEASON

5.1 WINTER CONSTRUCTION (SELECTED)

The ASAP Project selected winter season construction for a natural gas pipeline on the North Slope. Construction on the North Slope is proposed to occur using ice roads and frost packing to minimize the impacts of vehicles and heavy equipment, which would require gravel roads and pads and increased permanent impact to prolific wetlands in this region. Ice roads and frost packing will mitigate against additional permanent impacts that would otherwise result from road and pad construction.

Winter construction will result in a 5-ft wide trench, from which the organic layer and permafrost will be removed down to approximately 6 vertical ft. The pipe and padding material will be added, and the trench will be backfilled with native material. Additional wetlands and uplands will be covered out to approximately 2 ft either side of the trench to accommodate the toe of the slope in the mound over the ditch. The is material will be used in stabilization of the trench and additional mild crowning if slumping occurs, prior to revegetation (AGDC, 2015a). The fine soils on the North Slope allow for use of the chain trenching technology (Figure 4), creating a greater ease of logistics in winter for this linear project, and accelerating the speed at which construction can occur (AGDC, 2015a).

5.2 SUMMER CONSTRUCTION (NOT SELECTED)

Environmental impacts to the sensitive tundra from operating vehicles in summer far outweighs the winter use of ice pads and ice roads. Environmental impacts in the Northern ecoregion are generally limited in winter to the width of the impact associated with placing and covering the pipe. In summer, however, impacts would be substantially greater. Costs and schedule would also increase, as gravel roads or clearers and graders would be needed.

6. CONCLUSION

The ASAP Project compiled and reviewed available information on the safety and security, operability, available line pipe technology, logistics, constructability, environmental impacts, and costs associated with the construction and operation of a natural gas pipeline in Arctic Alaska. It developed a robust geotechnical and engineering program, and it analyzed a significant body of data and information to support its assessment of pipeline design mode. ASAP determined that a BG mode is preferable to an AG mode for several reasons related to engineering constructability, operational reliability, and reasons related to HSSE. The BG mode results in a safer and more secure design with a high degree of constructional and operational integrity that will ease logistics of construction and operational maintenance. The BG design uses available technology to avoid and minimize environmental impacts, and it uses proven mitigation methods developed by staff with over 30 years of experience in water management and erosion control for BG Arctic pipelines. In the BG mode, efforts towards stabilization of lands through erosion control, such as revegetation, and water management will occur by implementing a proven programmatic maintenance cycle standard that is expected to require an increased effort in the first 5 years after construction.

REFERENCES

Alaska Gasline Development Corporation (AGDC). 2014. Plan of Development. October, 2014. Available online at http://asapgas.agdc.us/documents.html

Alessa, L., Altaweel, M., Kliskey, A., Bone, C., Schnabel, W., and Stevenson, K. 2011. Alaska's freshwater resources: Issues affecting local and international interests. Journal of the American Water Resources Association 47(1):143-157.

AGDC. 2015a. Joint Application for Permit (404 / 10). December 29, 2015. Submitted to the USACE in January 2016.

AGDC. 2015b. Design Basis – Pipeline. Alaska Stand Alone Pipeline Project. Sept 17, 2015. 002-C-27-BDC-YYY-0001.

AGDC. 2015c. Addendum to the 2014 Plan of Development. October 2, 2015.

Arctic Climate Impact Assessment (ACIA). 2004. Impacts of a Warming Arctic – Highlights. Cambridge University Press. 18pp.

Bone, C., Alessa, L., Kliskey, A., and Altaweel, M. 2010. The influence of statistical methods and reference dates on describing temperature changes in Alaska. Journal of Geophysical Research 115:D19122, 12 pp., doi:10.1029/2010JD014289.

Bureau of Land Management (BLM). 2002a. Proceedings of the TAPS Renewal DEIS Public Hearing – "Comments and Responses". Barrow, Alaska. August 9, 2002.

BLM. 2002b. Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way. Environmental Impact Statement. BLM/AK/PT-02/026+2880+990

Farouki, O.T. 1981. Thermal properties of soils. USACE Cold Regions Research and Engineering Laboratory (CRREL). CRREL Monograph 81-1. Hanover, NH USA. 151pp.

Lawhead, B.E., Parrett, J.P., Prichard, A.K., Yokel, D.A. 2006. A literature review and synthesis on the effect of pipeline height on caribou crossing success. BLM Alaska Open File Report 106.

Marchand, P.J. 1996. "Life in the Cold. An Introduction to Winter Ecology". Third Edition. University Press of New England, Hanover, NH. p. 304.

Osterkamp, T.E., Peterson, J.K., and Collet, T.S. 1985. Permafrost thicknesses in the Oliktok Point, Prudhoe Bay and Mikkelsen Bay areas of Alaska. Cold Regions Science and Technology 11(2):99-105. http://dx.doi.org/10.1016/0165-232X(85)90010-2

Smith, W.T. and Cameron, R.D. 1992. "Caribou responses to development infrastructures and mitigation measures implemented in the Central Arctic Region. Research on the potential effects of petroleum development on wildlife and their habitat, Arctic National Wildlife Refuge interim report, 1988-1990". T.R. McCabe, B. Griffith, N.E. Walsh, and D.D. Young, eds. Fairbanks, Alaska: Alaska Fish and Wildlife Research Center and Arctic National Wildlife Refuge. pp. 79-86.

Streletskiy, D., Brown, D., Clow, G., Kholodov, A., Klene, A., Nelson, F., Romanovsky, V., Saybold, C., Shiklomanov, N., Urban, F., and Yoshikawa, K. 2014. "Permafrost – active layer observations on the North Slope of Alaska". Book of Abstracts of EUCOP4 – 4th European Conference on Permafrost. June 18-21, Évora, Portugal. p. 434.

Stevenson, K., Alessa, L., Altaweel, M., Kliskey, A.D., Krieger, K.E. 2012. Minding our methods: How choice of time series, reference dates, and statistical approach can influence the representation of temperature change. Environmental Science & Technology 46, 7435 – 7441. dx.doi.org/10.1021/es2044008

U.S. Army Corps of Engineers (USACE). 2012a. Draft Environmental Impact Statement. Alaska Stand Alone Pipeline. January.

USACE. 2012b. Final Environmental Impact Statement. Alaska Stand Alone Pipeline. October.

U.S. Fish and Wildlife Service (USFWS). 2015. "Permafrost Database Development, Characterization, and Mapping for Northern Alaska". Final Report prepared by T. Jorgenson (Alaska Ecoscience), M. Kanevskiy, (UAF INE),Y. Shur (UAF INE), J. Grunblatt (UAF GINA), C. Ping (UA-Palmer), G. Michaelson (UA-Palmer). p. 46.

Western Regional Climate Center (WRCC). 2016. Historical database and climate summaries. Available online at: http://www.wrcc.dri.edu/. Accessed March 23, 2016.

Wright, S. A revegetation manual for Alaska. Alaska Plant Materials Center. Alaska Department of Natural Resources.

Zhang, T., Osterkamp, T.E., and Stamnes, K. 1997. Effects of climate on the active layer and permafrost on the North Slope of Alaska, U.S.A. Permafrost and Periglacial Processes 8(1): 45-67.

- Page Intentionally Left Blank -

U.S. Department
of Transportation

**Pipeline and Hazardous
Materials Safety
Administration**

1200 New Jersey Avenue, SE
Washington, D.C. 20590

January 16, 2018

Mr. Frank T. Richards, P.E.
Senior Vice President, Program Management
Alaska Gasline Development Corporation
3201 C Street, Suite 200
Anchorage, Alaska 99503

Dear Mr. Richards:

The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) received your email on November 24, 2017, requesting a response to your June 15, 2017, letter where Alaska Gasline Development Corporation (AGDC) informed PHMSA that AGDC would no longer be pursuing a Special Permit for using a Strain Based Design (SBD) for the proposed Alaska Stand Alone Pipeline (ASAP). Currently, SBD methodology is not covered by our Federal Pipeline Safety Regulations as a method for the selection of pipe materials, pipeline design, and operation. Previously, our letter to Mr. Keith Meyer, President of AGDC, dated January 17, 2017, outlined why SBD would require a special permit. It was our understanding, based on AGDC's letter to PHMSA dated June 15, 2017, that based on further geotechnical analysis and a decision by AGDC to utilize thicker wall pipe, that AGDC had determined there was no need for a SBD Special Permit. PHMSA understands that AGDC believes that the proposed construction could be accomplished in full compliance with 49 CFR Part 192, in particular sections 192.53, 192.103, 192.111, 192.317, and 192.619.

As you are aware, Part 192 requires that pipeline wall thickness be able to "maintain the structural integrity of the pipeline under temperature and other environmental conditions that may be anticipated" and "withstand anticipated external pressures and loads that will be imposed on the pipe after installation" to include strains imposed by permafrost and discontinuous permafrost soils. Current PHMSA research shows that even relatively small levels of corrosion, such as 20-percent or greater wall loss decrease the strain capacity for a segment of pipe. Failure to appropriately account for these external forces risk conformance with federal safety standards or worse may lead to a pipeline release.

Therefore, PHMSA is no longer considering your request for a special permit to allow deviation from our pipeline safety design regulations, 49 CFR Part 192, Subpart C – Pipe Design. We also understand that AGDC does not intend to request any other special permit for the ASAP project. Should your decision change and a special permit is needed for the ASAP project, please submit an application pursuant to 49 CFR §190.341.

If you have any questions, please do not hesitate to contact Chris Hoidal at 720-963-3171 or chris.hoidal@dot.gov.

Sincerely,

Alan K Mayberry
Associate Administrator for Pipeline Safety

cc: Ms. Sandy Gibson, Project Manager, U.S. Army Corps of Engineers CEPOA-RD-S, P.O. Box 6898, Elmendorf AFB, AK 99506-0898