# ALASKA STAND ALONE PIPELINE/*ASAP* PROJECT

## DESIGN BASIS – PIPELINE

002-C-27-BDC-YYY-0001

September 17, 2015

# NOTICE

# REVISION HISTORY

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| | | | Michael Baker Jr., Inc. | AGDC |
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| 0 | 9/17/2015 | Issued for Use | MBJ | Frank Richards |
| | | | | |

# FOREWORD

The purpose of Alaska Stand Alone Gas Pipeline/ASAP Pipeline Design Basis is to:

- Identify the project configuration that serves as the basis for project design and regulatory review
- Define design approaches and concepts
- Identify applicable codes and standards, governing legislation, and major design criteria
- Obtain consistency and compatibility for the major design aspects of the pipeline
- Obtain commitment to the design basis by all involved parties
- Provide a vehicle to communicate the pipeline design basis to stakeholders

The ASAP Pipeline Design Basis presents the design basis of the in-state gas pipeline to deliver conditioned gas from Prudhoe Bay to Cook Inlet, Alaska. The pipeline construction work plan, materials, and work elements will be consistent with the methodologies and criteria in this Design Basis. Construction requirements and associated cost estimations are separately developed and reported.

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AAC | Alaska Administrative Code |
| AASHTO | American Association of State Highway and Transportation Officials |
| AC | Alternating Current |
| ADEC | Alaska Dept. of Environmental Conservation |
| ADF&G | Alaska Dept. of Fish and Game |
| ADNR | Alaska Dept. of Natural Resources |
| ADOT&PF | Alaska Dept. of Transportation and Public Facilities |
| AGDC | Alaska Gasline Development Corp. |
| ANSI | American National Standards Institute |
| AOC | Abnormal operating condition |
| API | American Petroleum Institute |
| APSC | Alyeska Pipeline Service Company |
| ARRC | Alaska Railroad Corporation |
| AS | Alaska Statute |
| ASAP | Alaska Stand Alone Gas Pipeline |
| ASCE | American Society of Civil Engineers |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Standard Testing Materials |
| BLM | U.S. Bureau of Land Management |
| $C_2$ | Ethane |
| $C_3$ | Propane |
| $C_4$ | Butane |
| $C_5$ | Pentane |
| cf | Cubic feet |
| CFR | Code of Federal Regulations |
| CMMS | Computerized maintenance management system |
| $CO_2$ | Carbon dioxide |
| CP | Cathodic Protection |
| CMP | Compensatory Mitigation Plan |

| | |
|---|---|
| CSE | Copper sulfate electrode |
| CTOD | Crack tip opening displacement |
| DC | Direct current |
| DGGS | Alaska Division of Geological & Geophysical Surveys |
| DOT | U.S. Department of Transportation |
| EPA | U.S. Environmental Protection Agency |
| FAA | Federal Aviation Administration |
| FBE | Fusion bonded epoxy |
| FERC | Federal Energy Regulatory Commission |
| FHWA | Federal Highway Administration |
| FOC | Fiber optic cable |
| FTP | File transfer protocol |
| GCF | Gas Conditioning Facility |
| GIS | Geographic Information System |
| GPS | Global positioning system |
| $H_2S$ | Hydrogen sulfide |
| HDD | Horizontal directional drill(ing) |
| ILI | In-line inspection |
| LDS | Leak detection system |
| LF | Lineal feet |
| LiDAR | Light detection and ranging |
| M&R | Measurement and Regulation |
| MAOP | Maximum allowable operating pressure |
| MCE | Maximum credible earthquake |
| MLBV | Mainline block valve(s) |
| MMscfd | Million standard cubic feet per day |
| MP | Milepost; Sequential milepost along an alignment where MP = 0 is the start |
| NAVD | North American vertical datum |
| NGL | Natural gas liquid(s) |
| NGS | National Geodetic Survey |
| NIST | National Institute of Standards and Technology |

| | |
|---|---|
| NRCS | Natural Resources Conservation Service |
| NTSB | National Transportation Safety Board |
| O&M | Operations and Maintenance |
| pcf | Pounds per cubic foot |
| PHMSA | Pipeline and Hazardous Materials Safety Administration |
| PIMP | Pipeline Integrity Management Plan |
| psi | Pounds per square inch |
| psig | Pounds per square inch gage |
| REIL | Runway end identifier lights |
| ROW | Right-of-way |
| RTK | Real time kinematics |
| RTU | Remote telemetry unit |
| SCADA | Supervisory control and data acquisition |
| SCC | Stress corrosion cracking |
| SDA | Special design area |
| SMYS | Specified minimum yield strength |
| SWPPP | Storm Water Pollution Prevention Plan |
| TAPS | Trans Alaska Pipeline System |
| TBM | Temporary bench mark(s) |
| TCE | Temporary construction easement |
| TEG | Thermal electric generator |
| U.S. | United States of America |
| UPS | Uninterruptible Power System |
| USACE | U.S. Army Corps of Engineers |
| USGS | U.S. Geological Survey |
| UT | Ultrasonic testing |
| UTS | Ultimate tensile strength |
| VASI | Visual approach slope indicator |
| VOIP | Voice over IP |
| VSM | Vertical support member(s) |
| WAFRP | Work area field reference points |

| | |
|---|---|
| WAQTC | Western Alliance for Quality Transportation Construction |
| WSDOT | Washington State Department of Transportation |

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# 1. PIPELINE SYSTEM DESCRIPTION

The proposed Alaska Stand Alone Gas Pipeline/ASAP is a 36-inch-diameter natural gas line with a design flow rate of up to 500 million standard cubic feet per day (MMscfd) of hydrocarbon content. The pipeline system will be designed to transport natural gas with methane as the major component. Other hydrocarbons (ethane, propane, butane, and pentane) will also be present in small amounts, along with carbon dioxide and nitrogen.

Currently, Prudhoe Bay is a potential gas source identified for the Project and is the basis for the design composition and accompanying flow characteristics in this report. The pipeline structures, facilities, and related project components include the following:

- The ASAP v6.1 mainline is 36 inches in diameter and approximately 733 miles in length
- The lateral pipeline to Fairbanks (Fairbanks Lateral) v4.1 is 12 inches in nominal diameter; approximately 30 miles in length; and tied-in with the mainline approximately 4 miles west of the western end of Murphy Dome Road
- Mainline block valves are spaced approximately every 20 miles
- Permanent access roads
- Permanent workpad along select sections of the mainline

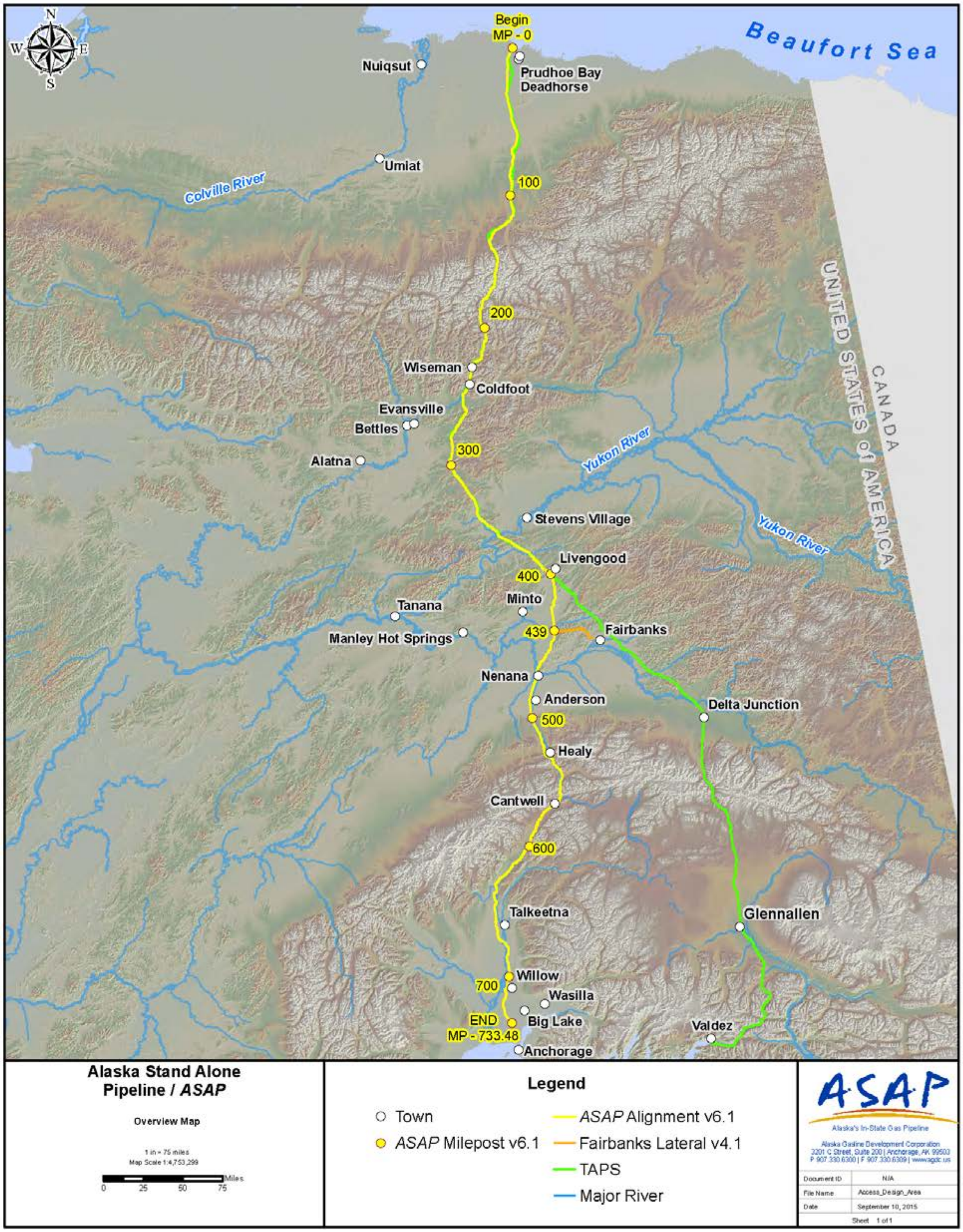
## 1.1 PIPELINE ALIGNMENT

The routing of the Alaska Stand Alone Gas Pipeline/ASAP is from Prudhoe Bay generally paralleling the Trans Alaska Pipeline System (TAPS) and Dalton Highway corridors to near Livengood, northwest of Fairbanks. At Livengood, the pipeline heads south and then joins the Parks Highway corridor west of Fairbanks near Nenana. From there, it continues south to a tie-in with the Beluga Pipeline (ENSTAR's distribution system) near Wasilla (Beluga Pipeline MP 39) providing access to tidewater at Cook Inlet.

The Fairbanks Lateral will take off from the mainline a few miles north of Dunbar. The Fairbanks Lateral will travel southeast to Fairbanks, a distance of approximately 30 miles to a location near the intersection of Sheep Creek Road and Tanana Drive, west of the University of Alaska Fairbanks (pending further development of the Fairbanks gas distribution system plan by others).

The ASAP mainline and Fairbanks Lateral routes are shown in Figure 1, Alaska Stand Alone Gas Pipeline/ASAP Mainline and Fairbanks Lateral Route.

**Figure 1. Alaska Stand Alone Gas Pipeline/ASAP Mainline and Fairbanks Lateral Route**



### 1.1.1 Gas Conditioning Plant to the Upper Dietrich River

The mainline begins at the Gas Conditioning Facility (GCF) in Prudhoe Bay and proceeds south generally paralleling TAPS. It trends more to the west in the silty uplands to avoid the gravelly Sag River floodplain, which would require deeper burial due to scour. The route parallels TAPS and the Sag River to Slope Mountain. It then crosses a gently rolling upland area and crosses the Kuparuk River. It enters the Brooks Range at Galbraith Lake, where the alignment crosses and then follows the Atigun River valley to the continental divide at Atigun Pass. From Atigun Pass, it crosses the Chandalar Shelf and drops into the Dietrich River valley.

This area is mainly permafrost and generally consists of flat to rolling terrain for the first 147 miles, from Prudhoe Bay to the second Atigun River crossing. Cobbles and boulders are embedded in much of the terrain. South of this point, large boulders, bedrock, and sidehill areas are prevalent in the Atigun River valley, through the pass, and across the Chandalar Shelf.

The vegetation varies from tundra to small shrubbery. No conventional clearing will be required except for minor brushing in stream swales.

### 1.1.2 Upper Dietrich River to South of Yukon River

The terrain between the upper Dietrich River and just south of the Yukon River near TAPS Pump Station 6 is divided between long, flat to gently rolling terrain, which follows major interior rivers including the Dietrich and the Middle Fork of the Koyukuk, and steep, choppy hills. The upper Dietrich River valley has a significant sidehill. The route follows the Dietrich River for approximately 28 miles, where the river joins the Bettles River to form the Middle Fork of the Koyukuk River. The pipeline crosses the Dietrich River and crosses to the east side of the Dalton Highway. The line crosses the highway several times, but is mainly on the east side of the highway where the sidehill is located. Intermittent wetlands occur along the route.

Significant major river crossings in this section include: two locations on the Dietrich River; three locations of the Middle Fork Koyukuk; a location south of the South Fork Koyukuk; and single crossings of the Jim River, Kanuti River, and the Yukon River. Many intermediate streams are also crossed, including Bonanza Creek, Prospect Creek, Douglas Creek, Fish Creek, Rosie Creek, Slate Creek, Marion Creek, and No Name Creek.

Over the 100 miles from the Dietrich River crossing to Prospect Creek the terrain ranges between flat and rolling. There, the terrain becomes choppy hills with very steep valleys. The soils include bedrock and weathered bedrock on the hills with permafrost soils and solifluction on the north slopes. The valleys are typically alluvium. The steep hills extend for 25 miles, then moderate but continue as rolling hills with bedrock on the high ground. Continuing south, there are a few steep hills with the terrain flattening out approaching the Yukon River. The south side of the Yukon is steep with a pinch point at TAPS Pump Station 6. The vegetation varies from light brush/timber to medium timber.

### 1.1.3 South of Yukon River to South of Yanert Fork

Beginning approximately 3 miles south of the Yukon River, the mainline continues southeast to Livengood Camp, where the alignment departs from the TAPS alignment. It then proceeds south through the Minto Flats for more than 65 miles to the Tanana River crossing at Nenana. The tie-in of the Fairbanks Lateral is located in this section. An Alaska Railroad siding at Dunbar is the site of a construction camp in this section. The Tanana River crossing is on the west side of the Nenana River. The route parallels the Nenana River on the west side for 25 miles to Rex, then re-joins the Parks Highway corridor to Healy and through Glitter Gulch, where the route takes a turn to the east to avoid McKinley Village and terminates at the Yanert Fork.

The first 90 miles of the route is choppy to rolling terrain with numerous steep hills (20-50% grade) with stream bottoms of flat, swampy valleys. From Nenana to near Healy, the route is very flat, characterized by warm permafrost ground conditions and numerous wetlands, including a few swampy areas in Minto Flats, west of the Nenana River to Rex, and east of the highway between Rex and Healy along the Intertie power line corridor. The terrain between Healy and Glitter Gulch is choppy with a number of high-banked incised streams and rocky ground. The 6-mile section at the south end of Glitter Gulch to the Yanert Fork requires a difficult, 4,160-foot long horizontal directional drill (HDD) to Lynx Creek to reach the short, but very mountainous, ending at the Yanert Fork.

Three HDD crossings are planned in this section, including the 3,620-foot Tanana River crossing, downstream of the existing Parks Highway bridge; a 2,310-foot crossing at a tributary to the Nenana River; and the 4,160-foot section from Glitter Gulch to Lynx Creek. Two aerial crossings are planned, including a 2,000-foot attachment to the Parks Highway bridge at Moody and a short aerial crossing at Lynx Creek (due to the presence of a seismic fault).

### 1.1.4 Yanert Fork to South Terminus (Beluga Pipeline MP 39)

The route continues from the south side of the Yanert River parallel to the Intertie power line for 10 miles before rejoining the Parks Highway on the east side of the Nenana River. From there to the town of Cantwell, the alignment parallels the Parks Highway. There is steep sidehill on the east side of the highway where the alignment is between the Intertie high voltage power line and a local power distribution line. The Nenana River is crossed in close proximity to the Denali Fault. The fault crossing will be aboveground on grade beams to provide for horizontal and vertical displacement in the event of a major earthquake. The town of Cantwell is avoided by staying east of the highway on the ridgeline until crossing the Jack River. Broad Pass is a relatively flat section, approximately 20 miles long, where the pipeline alignment is located through uplands confined by mapped wetlands or swamps on each side. Travelling south, several significant streams and small rivers with steep-sided valleys are crossed, including the Middle Fork Chulitna River, East Fork Chulitna River, Hardage Creek, Honolulu Creek, Little Honolulu Creek, and Hurricane Gulch. The alignment diverges east from the Parks Highway to gain elevation and cross Hurricane Gulch at a higher elevation where the right-of-way (ROW) can be graded instead of crossing at a lower elevation where a bridge would be required. The 13-mile section parallels the Intertie power line and intersects some swampy areas.

From here to the crossing of the Chulitna River, the line closely follows the highway. South of the Chulitna River, it continues adjacent to the Parks Highway, through Trapper Creek to the Susitna River (attached to the existing bridge). From the Susitna River, the route continues south to Deshka Landing. The route is located between the Parks Highway to the east and the Susitna River to the west. A large number of anadromous streams are crossed, including Montana Creek, Goose Creek, Sheep Creek, Caswell Creek, Kashwitna River, Little Willow Creek, and Willow Creek. From Deshka Landing to the terminus, the alignment departs from the highway corridor and heads cross country to the west of Red Shirt Lake and Big Lake before crossing the Little Susitna River. The final 5 miles is treed uplands and cleared farm land. The terminus is adjacent to an existing pig trap/valve station on the Beluga Pipeline.

### 1.1.5 Fairbanks Lateral

From the mainline tie-in, the Fairbanks Lateral heads due east for approximately 4 miles where it intersects Murphy Dome Road. It continues east for 7 miles, crossing rolling hills. At approximately 11 miles, the route follows the firebreak that parallels the Old Murphy Dome Road for about 8 miles. The route turns in a southeast direction and crosses Murphy Dome road and the Alaska Railroad. From this point, the alignment follows Schloesser Drive southeast to the pipeline terminus, just south of Sheep Creek Interchange.

### 1.1.6 Routing Guidelines

Routing guidelines have been developed so pipeline engineers can make consistent decisions when pipeline routing issues, such as typical crossings, property conflicts, and environmental site conflicts, arise. The selection of the best pipeline route is an iterative process that considers route length, environmental impact, cost, constructability, topography, existing infrastructure, pipeline operating characteristics, thermal conditions, and soil properties.

It is anticipated situations may be encountered where these guidelines cannot be followed. Resolution of these routing conflicts should be documented so similar conflicts can be resolved in a consistent and timely manner.

#### *1.1.6.1 General Guidelines and Routing Criteria*

- Make the alignment as short as possible.
- Locate the pipeline adjacent to existing transportation corridor ROW limits.
- The pipeline centerline will be a minimum 200 feet from the TAPS pipeline unless there is insufficient space or a crossing is required. An offset of 200 feet will allow for either working or spoil space adjacent to the TAPS ROW.

- The proposed permanent ASAP mainline ROW will not overlap the TAPS ROW, except at crossings or severe pinch points.
- Reroutes away from the typical transportation ROW or TAPS pipeline offset alignment will be required for the following reasons:
  - Pinch points due to insufficient space between the pipeline and other features such as waterbodies, steep terrain, structures, and commercial and urban development.
  - Obtaining better approaches to crossings of other pipelines, utility lines, railroad, and highways.
  - Environmental issues – avoidance of protected sensitive habitats; disturbances during sensitive life cycles for fish, birds, and mammals; high value wetlands; and cultural resource sites.
  - Property and land use issues.
  - Optimization of pipeline length.
- Minimize the use of induction bends (see Section 2.7.1, Field Bends, for design field bend angle per joint of pipe).
- Follow terrain perpendicular to contours.
- Minimize sidehill work on steep slopes to minimize sidehill cuts.
- Minimize routing within streambeds.
- Minimize routing through high value wetlands where possible.
- Minimize routing through areas containing cultural and historical resources.
- Stay adjacent to existing linear disturbances (e.g., transmission lines) where possible.
- Minimize creating new access roads by using existing roads and disturbed areas as much as possible.
- Identify all active faults that cross the alignment corridor.

#### *1.1.6.2 Guidelines for Typical Crossings*

Typical crossings include road, highway, railroad, foreign pipeline, foreign utility, small and intermediate stream, river, and fault crossings. At some typical crossings, it will be necessary to offset the alignment to allow for extra workspace or to keep a route point of intersection (PI) from being too close to the feature being crossed.

- Minimize crossings of TAPS and other foreign pipelines, roads, railroads, and utilities.
- Allow sufficient space to make changes in direction (i.e., PI) with field bends (see Section 2.7.1, Field Bends).
- Optimize river crossings (e.g., cross at a straight reach, flat banks).
- Optimize road, railroad, and fault crossings (as close to perpendicular as possible).
- Evaluate the typical offset from TAPS at major road and river crossings. This is site-specific and may require more or less offset.
- Crossings using methods other than typical open cut crossing methods may also require an additional offset for the temporary construction easement.

#### 1.1.6.3 Property and Environmental Site Conflict Resolution Guidelines

Guidelines are necessary to make consistent decisions at locations where the proposed pipeline ROW is in conflict with properties or environmental sites. For the purposes of these guidelines, a "property" is defined as a residential, agricultural, public building, public gathering site, designated public recreation area/site, commercial property, private, or public unoccupied lands. Environmental sites include protected flora and fauna, wetlands, and cultural resource sites.

Several criteria were considered during development of these guidelines, including regulatory compliance, and physical and functional impacts to subsistence use areas and resources and other environmentally important sites.

***Regulatory Compliance.*** The pipeline design will comply with 49 CFR 192.

***Access***. Creating new access to previously unopened areas will be avoided or minimized to reduce conflict between recreational (motorized and non-motorized) and subsistence users. All new temporary and permanent project access roads will be gated and locked as required by the landowners and permit conditions.

***Impacts to Property and Environmental Sites.*** Physical changes to the land include removal of fences, removal of trees, changes to topography, movement or demolition of buildings, and altered surface and subsurface water movement. Removing landscape/barrier trees with trunks greater than 3 inches or taller than 20 feet from residential private or commercial property should be avoided as these cannot be easily replaced from nursery stock. Functional use impacts include overall quality of life for residents, restricted access to property, owner building restrictions on the pipeline ROW, access allowances for pipeline operations, division of property, and loss or movement of buildings. For environmental or cultural resource sites, the value of the site can be degraded or lost.

Several mitigation measures can be incorporated to offset the physical and functional impacts to these lands:

- Provide minimum offsets, and possibly fencing of significant environmental resources.
- Limit or minimize the permanent ROW, but ensure adequate size to accommodate operations, maintenance, and future expansion.
- Limit construction ROW.
- Application of trenchless construction methods.
- Purchase property for installation of specific permanent facilities, such as compressor stations, block valve sites, and permanent access roads.

The temporary construction easements (TCE) on both the working and spoil sides of the pipe trench can be reduced for short distances to avoid property or environmental sites. However, a reduced TCE will require additional temporary workspace of an equivalent size in the vicinity of the restriction for equipment and materials.

If the physical or functional conflict cannot be resolved using the above criteria, then the following mitigation measures will be considered:

- Reroute around the conflict.
- Bore or directional drill under the conflict.
- Buy the property.
- In the case of wetlands, restore after construction to the extent practicable, or in the case of cultural resources, perform appropriate data recovery.

## 1.2 RIGHT-OF-WAY (ROW)

The ASAP ROW configuration takes into account safety, environmental, land, engineering, construction, and operational conditions and requirements.

### 1.2.1 Width

Permanent ROW on federal lands is 50 feet wide plus the diameter of the pipeline centered on the final pipeline location. For consistency, this will also be the ROW width for permanent ROW not on federal lands. Additional permanent ROW will be required in specific areas, such as block valve and meter station locations; sidehill cuts and fills; river crossings; and where permanent gravel workpad/maintenance roads are required. Construction ROW or TCE will be required on both sides of the permanent ROW for construction.

The ditch will be excavated using trenchers and/or backhoes to the depth required by the design, but in no cases less than specified in 49 CFR 192 (see Section 2.4.2, Depth of Cover). Typically, the extents of the TCE for the project will be 120 feet wide (40 feet on the spoil side and 80 feet on the working side, see drawing DB-ROW-01 in Appendix A). The spoil side is wide to keep the spoil pile low to prevent snow drifting on the ROW or into the ditch.

The TCE will be wider in areas of sidehill construction, with the maximum width being approximately 400 feet. In areas of particular environmental importance, it may be possible to reduce the TCE needs; however, this will have to be analyzed on a case-by-case basis.

The width of the working side will accommodate two side booms: a passing side boom (weights retracted) and a working side boom with weights extended. This will also provide sufficient space for trucks and other equipment to pass a working side boom. The workspace will also be wide enough to accommodate an automatic welding spread for a 36-inch diameter pipe. The spoil side will be used for trench spoil and, if required, separation of organic surface material or topsoil stripping.

The typical ROW layout for a tundra ice workpad is shown in drawing DB-ROW-01. The tundra ROW includes working from a standard ice workpad, constructed prior to ditching. The typical ROW layout for frost pack with ice road is shown in drawing DB-ROW-02. It is assumed only clearing will be done without grubbing, except for the trench line, for the frost pack ROW mode.

Once the ground freezes solid enough for equipment to drive on, the snow will be packed down to drive the frost deeper in early winter. This is followed by spraying water to form a firm ice layer.

A typical ROW layout for graded ROW with sidehill cuts is shown in drawings DB-ROW-03 and DB-ROW-03A. The minimum requirement for this layout is the pipeline must be laid in undisturbed soil. It cannot be placed in false fill from the ROW preparation. For efficient pipeline construction, it is important to have a minimum working side of 50 feet. This will allow for a working side boom, one passing lane and room for a welding shelter. The layout assumes some organic surface material or top soil stripping is required, and this material could be pushed up above the cut. Cut soil would be placed down slope. An additional gravel surface layer over the working side may be required where subgrade soils are fine grained and contain high moisture content. The required thickness of this layer is determined by the subgrade soil properties and construction season. As cross slopes increase, it may be more advantageous to construct the ROW using two benches (two-toned ROW) vs. a single cut (see drawing DB-ROW-03A). This determination will be made during final design.

A typical ROW layout for sidehill cut within highway ROW with lane closure is presented in drawing DB-ROW-03B.

Areas of fine-grained frozen soils may require excavation be avoided and a gravel work pad be constructed to level the working side and protect the active layer of in-situ soils. The minimum thickness of this work pad varies from 18 inches to 54 inches. The thickness depends on the ice content and gradation of the soils and whether construction will occur when the soils are likely to remain frozen or during thawing weather conditions. The organic surface layer will not be stripped prior to placing the gravel layer. The typical ROW when constructing a working surface using a gravel work pad is shown in drawing DB-ROW-04.

Drawing DB-ROW-05 provides a typical matted ROW for areas where underlying subgrade soils are too soft to withstand the equipment operating pressures and the thickness of gravel pad requirements are excessive.

Extra temporary construction easements will be required at crossings; the size depends upon the type and length of the crossing. Typical crossings include tertiary roads/trails/driveways, primary/secondary roads, railways, foreign pipelines, foreign underground utilities, waterbodies, and wetlands. Extra temporary construction easements will be required for sharp PIs, timber decks, and sidehill cut/fill and pushouts. See drawing DB-ROW-06 for extra temporary construction easement layout requirements.

In addition to the extra temporary construction easements, turn around areas and shooflies may be required for trucks and equipment occasionally, depending on the topography and location of access roads (see drawing DB-ROW-07).

### 1.2.2 Clearing

See Section 6.2.5.2, Clearing Criteria.

### 1.2.3 Erosion Control

See Section 6.2.5, Erosion Control Criteria.

### 1.2.4 Workpad

The workpad is that portion of the ROW encompassing the gravel or snow/ice working surface beneath which the pipeline is located, any travel lane adjacent to the pipeline, and additional fill required for construction. The workpad will be constructed where necessary to provide access and a work platform for the equipment required to install the pipe. The workpad width varies depending on the pipeline mode, terrain, and soil conditions.

#### *1.2.4.1 Travel Lane (Post Construction)*

The travel lane is that portion of the workpad adjacent to the aboveground and belowground pipeline used for surveillance, monitoring, maintenance, and emergency response. Travel lanes will remain in areas where the work pad is gravel or graded. Ice and frost pack ROW will not require travel lanes post construction. The travel lane must have a post construction shoulder-to-shoulder width of at least 12 feet and be sloped to minimize sheet flow drainage. It must not be routed over the pipeline at animal crossings or mode transitions. Minimum thickness of fill cover over belowground pipeline crossings is 4 feet. Special considerations must be taken into account to determine fill thickness at pipeline crossings for traffic with axle loads exceeding 50,000 pounds.

#### *1.2.4.2 Insulation*

Insulation may need to be installed along portions of permanent workpads to limit the thaw of underlying permafrost.

### 1.2.5 Embankments

The workpad embankment must be designed to:

- Have stable slopes.
- Minimize disturbance to natural terrain, vegetation, fish, and natural water.
- Avoid or minimize the degradation of permafrost which could jeopardize the pipeline foundation.
- Provide an adequate surface for access.
- Provide a working platform to install the pipe during construction.
- Ensure that localized stability conditions do not adversely affect the security of the pipeline or its supporting structures.

Width of the workpad is dependent on the terrain and construction mode. Gravel work pads may be partially reclaimed for use as bedding and padding where the gravel material meets the specifications for this material. After pipe installation, the workpad can be substantially regraded. The regrading is done to:

- More closely approximate the original ground configuration.
- Re-establish the natural drainage pattern as near as practical.
- Provide for long-term drainage, erosion control, and restoration.

### 1.2.6 Disposal Sites

Disposal sites to receive surplus excavated and waste material from the workpad may need to be selected. Re-use of all material excavated during grading operations to minimize transportation off-site will be the goal. Excavated material that is workable will be used to flatten slopes and provide material to mound over the pipe trench.

### 1.2.7 Signs and ROW Markers

49 CFR 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards requires posting markers on the ROW. Signs used to satisfy these requirements are classified as regulatory.

49 CFR §192.707, Line markers for mains and transmission lines, states:

> *(a) Buried pipelines. Except as provided in paragraph (b) of this section, a line marker must be placed and maintained as close as practical over each buried main and transmission line:*
>
> *(1) At each crossing of a public road and railroad; and*
>
> *(2) Wherever necessary to identify the location of the transmission line or main to reduce the possibility of damage or interference.*
>
> *(b) Exceptions for buried pipelines. Line markers are not required for the following pipelines:*
>
> *(1) Mains and transmission lines located offshore, or at crossings of or under waterways and other bodies of water.*
>
> *(2) Mains in Class 3 or Class 4 locations where a damage prevention program is in effect under §192.614.*
>
> *(3) Transmission lines in Class 3 or 4 locations until March 20, 1996.*
>
> *(4) Transmission lines in Class 3 or 4 locations where placement of a line marker is impractical.*

*(c) Pipelines aboveground. Line markers must be placed and maintained along each section of a main and transmission line that is located aboveground in an area accessible to the public.*

*(d) Marker warning. The following must be written legibly on a background of sharply contrasting color on each line marker:*

*(1) The word "Warning," "Caution," or "Danger" followed by the words "Gas (or name of gas transported) Pipeline" all of which, except for markers in heavily developed urban areas, must be in letters at least 1 inch (25 millimeters) high with ¼ inch (6.4 millimeters) stroke.*

*(2) The name of the operator and the telephone number (including area code) where the operator can be reached at all times.*

Other signs may be used along ASAP and related facilities to address a specific business need, but are not required to satisfy regulatory requirements. Signs used for this purpose are classified as informational. The use of informational signs is optional.

# 2. PIPELINE DESIGN

The proposed pipeline will be designed in accordance with 49 CFR 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards, which will take precedence over all other standards, such as ASME B31.8, Gas Transmission and Piping Systems, except where 49 CFR 192 explicitly states jurisdiction by reference to another standard or code.

## 2.1 PIPELINE HYDRAULICS

The gas composition for design is presented in Table 1, Design Gas Composition. Preliminary pipeline elevation and pressure profiles for summer and winter operating conditions for the nominal design flow rate of 517.8 MMscfd (500 MMscfd of hydrocarbon content) are presented in Figure 2, Pipeline Elevation and Pressure Profiles. Preliminary surrounding (ground for buried and air for aboveground fault crossings) and pipeline temperature profiles are shown in Figure 3, Preliminary Ground and Pipeline Temperature Profiles.

**Table 1 Design Gas Composition**

| COMPONENT | MOLE % |
|---|---|
| **Methane ($C_1$)** | 88.78 |
| **Ethane ($C_2$)** | 5.85 |
| **Propane ($C_3$)** | 1.69 |
| **i-Butane (i-$C_4$)** | 0.08 |
| **n-Butane (n-$C_4$)** | 0.12 |
| **Pentanes+($C_5$+)** | 0.06 |
| **Carbon Dioxide ($CO_2$)** | 2.76 |
| **Nitrogen ($N_2$)** | 0.67 |
| **Hydrogen Sulfide ($H_2S$)** | 0.00 (3 ppm) |

**Figure 2. Pipeline Elevation and Pressure Profiles**

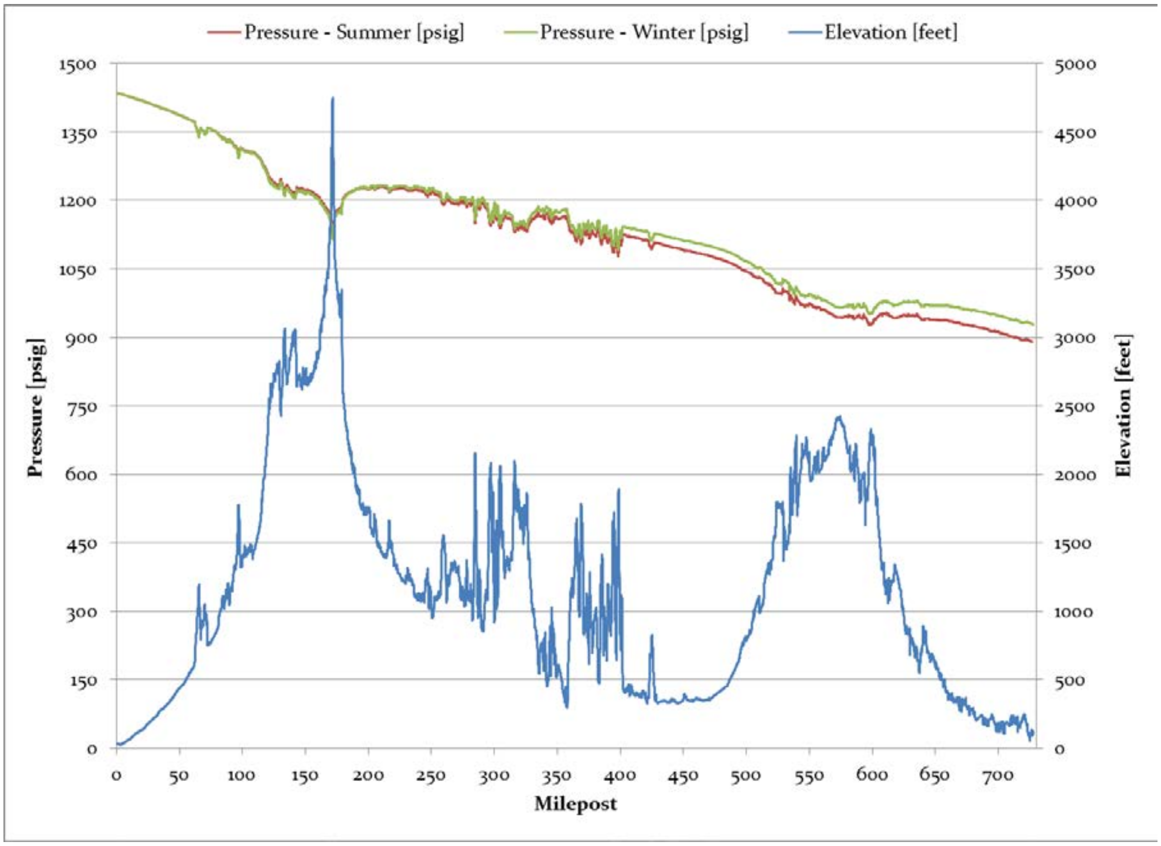
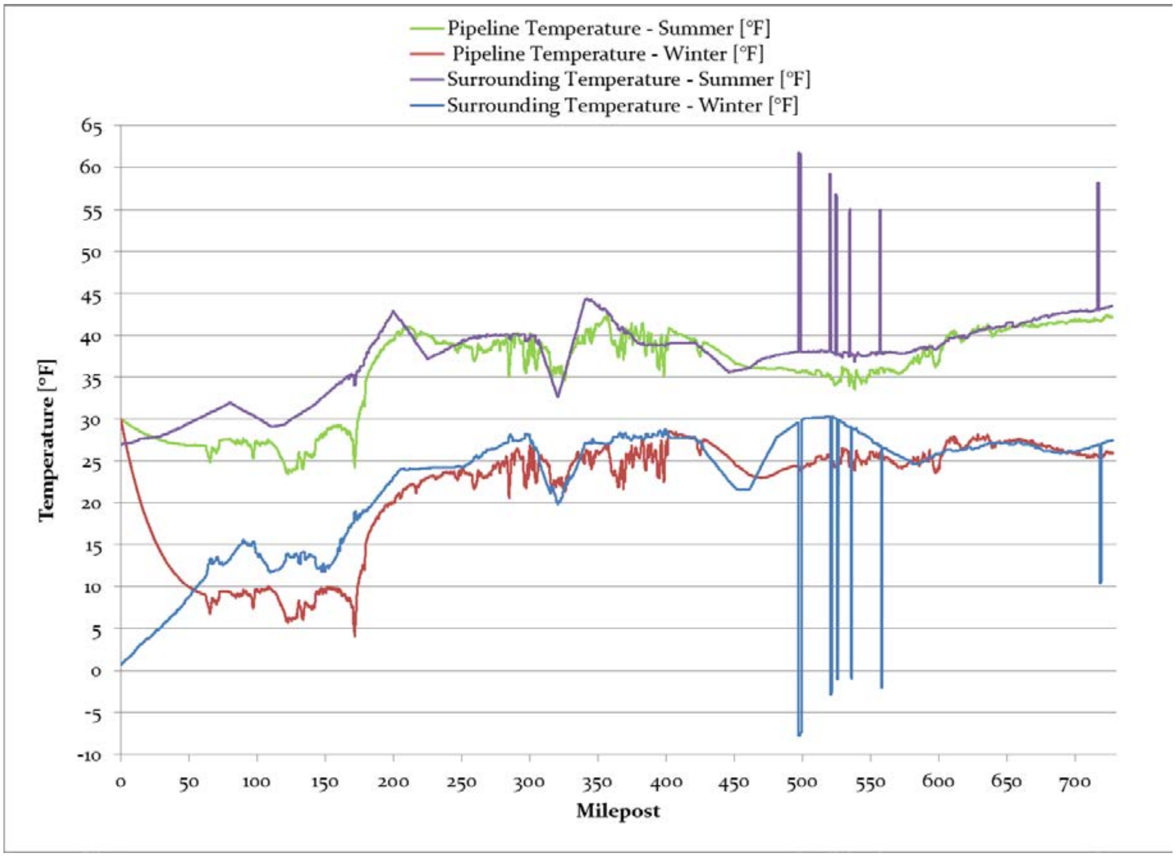


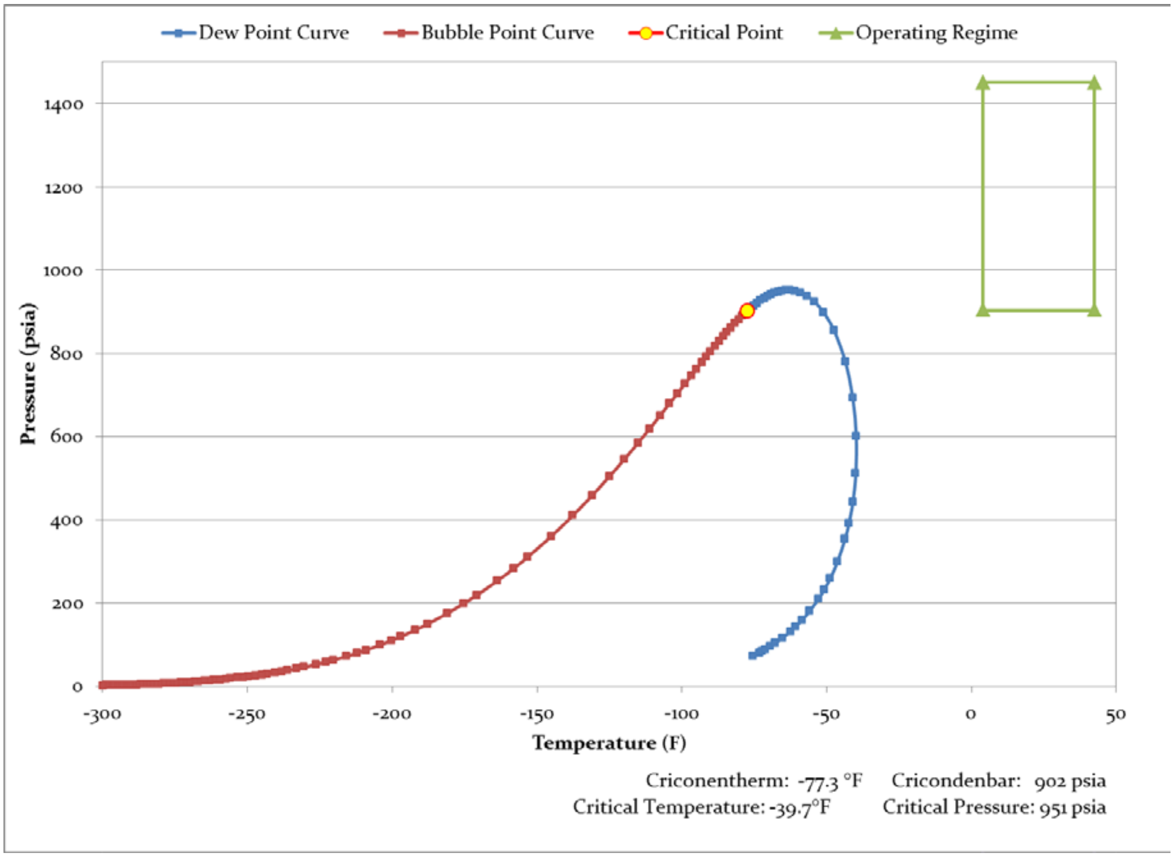
**Figure 3. Preliminary Ground and Pipeline Temperature Profiles**



### 2.1.1 Phase Envelope Considerations for Pipeline Design

The significance of the phase envelope for pipeline design lies in the potential transition from the single-phase gas region to the two-phase gas-liquid region. In this situation, condensate formation inside the pipeline will occur. It is important to recognize the volume of condensate cannot be determined simply by plotting points on the phase envelope. The volume of condensate can be determined by analyzing the gas phase compositions upstream and downstream of a potential condensation location (e.g., regulator, pipeline) and determining the gallons of liquids per thousand standard cubic feet of gas for the liquefiable components in each stream. A preliminary phase envelope based on the composition shown in Table 1, Design Gas Composition, is presented in Figure 4, Gas Phase Envelope. The key information to be gleaned from this figure is there is no chance of two-phase flow as the pressure/temperature conditions within the pipeline remain outside of the gas phase envelope in all instances.

**Figure 4. Gas Phase Envelope**



## 2.2 OVERPRESSURE PROTECTION

A pipeline overpressure protection system will be designed and installed in accordance with 49 CFR 192, which states in §192.195:

*(a) General requirements. Except as provided in §192.197, each pipeline that is connected to a gas source so that the maximum allowable operating pressure could be exceeded as the result of pressure control failure or of some other type of failure, must have pressure relieving or pressure limiting devices that meet the requirements of §§192.199 and 192.201.*

*(b) Additional requirements for distribution systems. Each distribution system that is supplied from a source of gas that is at a higher pressure than the maximum allowable operating pressure for the system must—*

*(1) Have pressure regulation devices capable of meeting the pressure, load, and other service conditions that will be experienced in normal operation of the system, and that could be activated in the event of failure of some portion of the system; and*

*(2) Be designed so as to prevent accidental overpressuring.*

The overpressure protection system will be installed upstream of the pipeline inlet and will consist of gas control monitoring with redundant pressure regulation.

## 2.3 PIPELINE MATERIALS

Pipeline design parameters are provided in Table 2, Pipeline Design Parameters.

**Table 2 Pipeline Design Parameters**

| DESIGN PARAMETER | ASAP MAINLINE | FAIRBANKS LATERAL |
|---|---|---|
| **Nominal Pipeline Diameter** | 36 inches | 12 inches |
| **Maximum Allowable Operating Pressure** | 1,480 psig | 1,480 psig |
| **Yield Strength (SMYS)** | 70,300 psi | 52,200 psi |
| **Pipe Specifications** | API 5L PSL2 | API 5L PSL2 |
| **Manufacturing Process** | DSAW | DSAW/HFW/SMLS |
| **Maximum Operating Temperature** | 60°F | 60°F |
| **Minimum Design Temperatures (for ductility analyses)** | –50°F for Aboveground; 0°F for Buried | –50°F for Aboveground; 0°F for Buried |
| **Wall Thickness, Weight per Foot** | | |
| **Location Class 1 F = 0.72** | 0.527 inches, 199.4 lb/ft | 0.330 inches, 43.7 lb/ft |
| **Location Class 2 F = 0.60** | 0.632 inches, 238.5 lb/ft | 0.330 inches, 43.7 lb/ft |
| **Location Class 3 F = 0.50** | 0.758 inches, 285.0 lb/ft | N/A |
| **Location Class 4 F = 0.40** | 0.948 inches, 354.5 lb/ft | N/A |
| *Note: The wall thicknesses for the Fairbanks Lateral exceed the minimum required pipe wall thickness based on the design factor – the wall thicknesses have been increased and rounded to the nearest commercially available thickness.* | | |

### 2.3.1 Line Pipe

Line pipe will be API 5L PSL2. The mainline pipe purchase specifications will include the following product specification and standards:

- Mainline Grade 5L X70
- Fairbanks Lateral Grade 5L X52
- Process of manufacture
- Chemical properties
- Mechanical properties (including longitudinal stress-strain behavior)
- Dimensions, weights, lengths, and end finishes
- Inspection and testing
- Marking
- Coating and protection
- Documents
- Pipe loading and transport

In addition to the material test reports required from the manufacturer for the mainline pipe, a certification of compliance with test results is required from the manufacturer for project acceptance of the mainline pipe.

The project approach to fracture control will consider crack initiation and propagation in the parent metal, seam welds, girth welds, and crack arrest.

To control fracture initiation in the parent metal, it is necessary to ensure the material has sufficient toughness for failure to be dominated by plastic collapse. To prevent brittle fracture, the pipe must have a ductile to brittle transition temperature less than the specified minimum operating temperature.

It is typically not necessary to require the seam weld toughness to match that of the parent metal. Consistent with general industry practice for gas transmission pipelines, pipe sections will be laid with the seam welds offset so that a crack initiating in the seam weld will only propagate for one pipe length. However, some level of toughness is required in the seam weld to give resistance to crack initiation, and this is set to be equivalent to the level required for flow stress dependent behavior in the parent pipe.

The most widely used predictive method for ductile fracture propagation and arrest is the Battelle "two curve" approach, where the crack tip driving force at arrest is considered and then a relationship is obtained between the arrest stress, the crack velocity, the pipeline dimensions, and material properties. This curve defines the driving force required to cause the crack to propagate; the driving force available is derived from modeling the decompression behavior of the escaping gas. Although the probability of ductile fracture propagation is low, the fracture length is further limited through a material specification of required minimum material toughness. In some cases, such as to address the low temperature considered for aboveground pipe segments, crack arrestors could be installed.

### 2.3.2 Crack Arrestors

Based on analysis of pipeline ductility and potential ductile fracture, crack arrestors will not be required on the buried pipeline for all planned wall thicknesses. On the aboveground sections, crack arrestors will be required if the sections are constructed of either of the two thinner walls (0.527- and 0.632-inch) due to the low minimum design temperature (see Table 2, Pipeline Design Parameters). Based on this information, the decision has been made to construct the aboveground sections using heavy-wall pipe (0.758-inch), which analysis shows will self-arrest.

### 2.3.3 Valves

All pipeline valves will be ANSI Class 600 with a maximum pressure rating of 1,480 psig. Mainline block valves (MLBV) and Fairbanks Lateral block valves will generally conform to API 6D, Specification for Pipeline Valves, and will be actuated. It is anticipated most MLBV will be installed below grade.

### 2.3.4 Flanges and Fittings

All pipeline flanges and fittings along the ASAP mainline and the Fairbanks Lateral will be ANSI Class 600 with a maximum pressure rating of 1,480 psig. Flanges and fittings will generally conform with ASME B16.5, Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24; ASME B16.9, Factory-Made Wrought Buttwelding Fittings: and ASME B16.47, Large Diameter Steel Flanges NPS 26 Through NPS 60: as appropriate.

### 2.3.5 Coatings

The pipeline will be coated with fusion bonded epoxy (FBE) having a minimum thickness of 14 to 16 mils and compatible with the cathodic protection (CP) system. Typical coating will be 3M Scotchkote 6233 or equivalent. In certain areas, such as those utilizing a strain based design approach, the use of a low application temperature FBE may be required to avoid strain aging effects. In this case, the coating will be 3M Scotchkote 726 or equivalent.

Aboveground pipeline sections will have a layer of polyurethane foam and a galvanized steel jacket installed over the FBE. Pipe that cannot be FBE coated, such as spooled piping at metering or pigging facilities, will be coated with a primer and a suitable epoxy top coat.

In high abrasion areas, the coating system will be supplemented with an approved abrasion resistant overlay compatible with the cathodic protection.

Field joints will be coated with two-part 100% solids epoxy (Protal 7125 or equivalent) having a thickness of 30 mils. Alternatively, field applied FBE meeting the same requirements as the adjoining segments may be used. In high abrasion areas, the corrosion coating will be supplemented with an abrasion resistant overlay (POWERCRETE DD or equivalent).

Holidays and damaged coating will be repaired using either two-part epoxy or hot melt stick approved by the FBE powder manufacturer for use on their product.

## 2.4 BURIED PIPELINE DESIGN

### 2.4.1 Class Location

The pipeline alignment will be reviewed and appropriate Class Locations assigned in accordance with 49 CFR 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards. 49 CFR 192.5, Class Locations states:

(a) This section classifies pipeline locations for purposes of this part. The following criteria apply to classifications under this section.

(1) A "class location unit" is an onshore area that extends 220 yards (200 meters) on either side of the centerline of any continuous 1- mile (1.6 kilometers) length of pipeline.

(2) Each separate dwelling unit in a multiple dwelling unit building is counted as a separate building intended for human occupancy.

(b) Except as provided in paragraph (c) of this section, pipeline locations are classified as follows:

(1) A Class 1 location is:

(i) An offshore area; or

(ii) Any class location unit that has 10 or fewer buildings intended for human occupancy.

(2) A Class 2 location is any class location unit that has more than 10 but fewer than 46 buildings intended for human occupancy.

(3) A Class 3 location is:

(i) Any class location unit that has 46 or more buildings intended for human occupancy; or

(ii) An area where the pipeline lies within 100 yards (91 meters) of either a building or a small, well-defined outside area (such as a playground, recreation area, outdoor theater, or other place of public assembly) that is occupied by 20 or more persons on at least 5 days a week for 10 weeks in any 12-month period. (The days and weeks need not be consecutive.)

(4) A Class 4 location is any class location unit where buildings with four or more stories above ground are prevalent.

(c) The length of Class locations 2, 3, and 4 may be adjusted as follows:

(1) A Class 4 location ends 220 yards (200 meters) from the nearest building with four or more stories above ground.

(2) When a cluster of buildings intended for human occupancy requires a Class 2 or 3 location, the class location ends 220 yards (200 meters) from the nearest building in the cluster.

### 2.4.2 Depth of Cover

Project criteria for depth of cover are presented in Table 3, Depth of Cover Criteria.

**Table 3 Depth of Cover Criteria**

| LOCATION | MINIMUM DEPTH NORMAL SOIL (INCHES) | CONSOLIDATED ROCK (INCHES) |
|---|---|---|
| **Class 1 locations** | 30 | 18 |
| **Class 2, 3, and 4 locations** | 36 | 24 |
| **Drainage ditches of public roads and railroad crossings** | 36 | 24 |
| **Strain Based Design segments** | 36 | 36 |
| *Note: In strain based design segments the minimum depth of cover would be governed by the Alternative MAOP provision of 49 CFR 192.* | | |

### 2.4.3 Underground Clearance

Per 49 CFR 192.325, the pipeline must be installed with at least 12 inches of clearance from any other underground structure not associated with the pipeline. If this clearance cannot be attained, the pipeline must be protected from damage that might result from the proximity of the other structure. Owners of structures (such as foreign pipelines) may have their own criteria.

### 2.4.4 Ditch Modes

Several ditch modes have been derived to accommodate anticipated soil and terrain conditions along the proposed alignment. Ditch modes are designed and selected to ensure long term integrity of the pipeline and to protect nearby foreign structures and the environment. As more detailed terrain unit analyses, seismic characterizations, permafrost characterizations, and soils analyses are completed, more ditch modes may be developed.

#### 2.4.4.1 Mode I – Buried Pipe in Conventional Ditch

The Mode I ditch configuration will be used in frozen (permafrost) with predicted acceptable thaw settlement (see Appendix A drawing DB-MODE-01). Elements of this ditch mode are:

- Design cover will be based on Class Location and encroachment. Additional cover may be required for buoyancy control, river and stream scour, and vertical bend restraint.
- Bedding and padding may be required.
- Native or common backfill may be used.

#### 2.4.4.2 Mode II – Buried Pipe in Conventional Rock Ditch

The Mode II ditch configuration will be used in areas where the pipe will be placed in consolidated rock (see drawing DB-MODE-02). The rock trench is specifically for placing pipe in rock. There is a shallower burial depth because consolidated rock is expected to provide a stable foundation. Elements of this ditch mode are:

- Bedding and padding, or an approved alternative means of protecting the pipe and coating from damage, will be required.
- Native or common backfill may be used.

#### 2.4.4.3 Mode III – Buried Pipe with Over-Excavation

The Mode III ditch configuration may be used in areas of unacceptable soil conditions within the ditch to decrease the potential for thaw settlement, liquefaction, frost heave, etc. See drawing DB-MODE-03. Elements of this ditch mode are:

- The backfill for the over-excavated portion of the ditch will be non-frost susceptible mineral material.
- Bedding may not be required if non-frost susceptible material beneath the pipe meets the bedding specifications.
- Native or common backfill may be used.

#### 2.4.4.4 Mode IV – Buried Pipe in Aboveground Berm

The Mode IV ditch configuration may be used where the pipeline crosses other pipelines or utilities, or at fault crossings (see drawing DB-MODE-04). Elements of this design mode are:

- The pipe will be placed in an aboveground mineral material embankment. Material will likely be imported from sites outside the ROW.
- Where boardstock insulation is required, the insulation thickness and width and the distance between the pipe and insulation will be determined by geothermal analyses.
- Allowances for cross drainage must be made to control ponding of water or sheet flow against the berm.

- Geothermal analyses will be used to determine if culverts within the berm will require insulation.
- This design mode type will not be used on the windward side of a highway where snow drifting is known to, or could, occur, unless a minimum separation of 150 feet is maintained between the berm and the toe of the roadway.
- This design mode type will have limited use in selected areas only.

#### *2.4.4.5 Mode V – Stream or River Crossing – Buried Pipe*

This design mode may be used for crossing streams or rivers where minimal or acceptable adverse effects to fish habitat, the environment, or third party structures due to a buried gas line or aufeis development are anticipated (see drawing DB-MODE-05). Elements of this ditch mode are:

- Additional cover may be required for buoyancy control and river and stream scour.
- Bedding and padding may be required.

## 2.5 ABOVEGROUND PIPELINE DESIGN

Aboveground pipeline configurations may be used at select water crossings not conducive to typical buried or trenchless crossing designs or at fault crossings to accommodate fault displacements without exceeding pipeline stress criteria.

## 2.6 PIPELINE APPURTENANCES

### 2.6.1 Mainline Block Valves

Block valves will be spaced in accordance with 49 CFR 192.179, Transmission Line Valves. The spacing will not exceed 20 miles in Class 1 locations, 15 miles in Class 2 locations, 8 miles in Class 3 locations, and 5 miles in Class 4 locations. The spacing may be reduced to allow a valve to be installed in a more accessible location, with continuous accessibility being the primary consideration.

All mainline block valve assemblies will include bypass and blowdown piping and valving to allow pressure equalization across the mainline block valve and evacuation of the mainline on either side. Noise reduction devices may be installed on the blowdown stacks, if deemed necessary.

A typical Block valve site plan is shown in drawing DB-FAC-01A (see Appendix A). In cases where block valves are located in a remote area with no ready access, a helipad may be sited adjacent to the block valve (see drawing DB-FAC-01B). A typical MLBV piping plan is presented in drawing DB-FAC-02.

### 2.6.2 Launchers and Receivers

Launchers and receivers will be designed to accommodate a variety of In-line inspection (ILI) tool trains – multiple tools trained together to efficiently perform multiple types of inspections in a single run. Barrel design will consider the maximum tool length anticipated.

All launchers and receivers will have double block and bleed capabilities (i.e., two consecutive block valves with a bleed ring or pipe pup with bleed valve in between) to provide positive isolation from the pipeline downstream of the launcher and upstream of the receiver.

All branches greater than 25% of the main run diameter will be barred.

Spacing of launchers and receivers will take into consideration battery life and data storage limitations of the ILI tools expected to be deployed. In addition, the potential for liquids within the line will be evaluated and weighed in the determination of acceptable spacing.

### 2.6.3 In-Line Inspection Tools

In-line inspection (ILI) tools can be used to test for ovality, settlement, corrosion (internal and external), and cracking. These tools are often essential to an effective Pipeline Integrity Management Plan (PIMP). They can also provide validation of the effectiveness of the CP system, and detect other potential problems in advance of an incident or failure.

Criteria for monitoring curvature and pipe movement will be established and reconciled with the ILI vendors, including accuracy and sensitivity to changes.

Criteria for corrosion related anomalies to be targeted will be based on standard industry practice (typically in accordance with ASME B31G Manual for Determining Remaining Strength of Corroded Pipelines).

Access will be limited along many remote sections of the lines, therefore all tools should have at least one transmitter for determining location. Progress may need to be monitored by helicopter and readily available tool tracking equipment. Devices available for tool tracking in pipelines are:

- Strap-on pig signals: non-intrusive, passive devices that detect and record tool passage either magnetically or ultrasonically.
- Above Ground Markers (AGM): non-intrusive devices that detect and record tool passage. This device detects passage either magnetically, via extremely low frequency (ELF), or acoustically.

Strap-on pig signals may be able to be installed both aboveground and buried, depending upon manufacturer. In addition, remote interface options may be available which would allow connection with the Supervisory Control and Data Acquisition (SCADA) system.

Either type of device could be installed at predetermined locations. Active tracking may not be required in all cases provided a reliable means of locating a tool is available.

## 2.7 BENDING

### 2.7.1 Field Bends

Requirements for field bending of line pipe are given in 49 CFR 192 and ASME B31.8.

49 CFR 192.313, Bends and Elbows, states:

> *(a) Each field bend in steel pipe, other than a wrinkle bend made in accordance with §192.315, must comply with the following:*
>
> *(1) A bend must not impair the serviceability of the pipe.*
>
> *(2) Each bend must have a smooth contour and be free from buckling, cracks, or any other mechanical damage.*
>
> *(3) On pipe containing a longitudinal weld, the longitudinal weld must be as near as practicable to the neutral axis of the bend unless:*
>
> *(i) The bend is made with an internal bending mandrel; or*
>
> *(ii) The pipe is 12 inches (305 millimeters) or less in outside diameter or has a diameter to wall thickness ratio less than 70.*

ASME B31.8 Paragraph 841.23, Bends, Elbows, and Miters in Steel Pipelines and Mains, presents two methods for determining the maximum degree of bending on a field bend. The first is expressed as the maximum deflection in an arc length equal to the nominal outside diameter (3.2 and 1.9 degrees for the 12- and 36-inch nominal diameter pipe, respectively), and the second is expressed as the minimum radius as a function of the nominal outside diameter (18D and 30D for the 12- and 36-inch nominal diameter pipe, respectively).

The project design degree of bending as measured by deflection along the longitudinal axis on a field bend is 3.0 degrees and 1.5 degrees within an arc length equal to the nominal outside diameter for 12- and 36-inch nominal diameter pipe, respectively.

The theoretical maximum field bend angles for 40-, 60-, and 80-foot pipe joints based on the above criteria are presented in Table 4, Theoretical Maximum Field Bend Angles. Regardless, the maximum design field bend angle will be limited to 24 degrees due to issues with handling safety.

**Table 4 Theoretical Maximum Field Bend Angles**

| NOMINAL PIPE DIAMETER | JOINT LENGTH (FT) | END LENGTH (FT) | MAXIMUM BEND LENGTH (FT) | BEND DEG/DIA. (DEG) | BEND (DEG/LF) | THEORETICAL MAXIMUM BEND ANGLE (DEG) |
|---|---|---|---|---|---|---|
| **12** | 40 | 2 | 36 | 3.0 | 3.0 | 108 |
| | 60 | | 56 | | | 168 |
| | 80 | | 76 | | | 228 |
| **36** | 40 | 6 | 28 | 1.5 | 0.50 | 14 |
| | 60 | | 48 | | | 24 |
| | 80 | | 68 | | | 34 |
| **Actual maximum design field bend angle is limited to 24 degrees.** | | | | | | |

### 2.7.2 Induction Bends

Induction bends will be designed and fabricated according to ASME B16.49-2012, Factory-Made Wrought Steel, Buttwelding Induction Bends for Transportation and Distribution Systems. The minimum bend radius will be three pipeline diameters (3D) to accommodate passage of inline inspection tools. For the proposed 36-inch diameter pipeline, the minimum bend radius is 3 x 3 feet, or 9 feet.

The number of induction bends will be minimized due to higher fabrication, transportation, and installation costs.

### 2.7.3 HDD Sag Bends

The nominal design radius of sag and side bends on HDD installations in feet will be 100 times the nominal diameter of the pipeline in inches (1200 times the nominal diameter in feet per ASCE Publication Pipeline Design for Installation by Horizontal Directional Drilling). The resulting product will be the radius in feet. For the proposed 36-inch diameter pipeline, the nominal design radius for bends will be 3,600 feet.

## 2.8 BUOYANCY CONTROL

Pipe flotation calculations will determine buoyancy control requirements. The calculations will compare the buoyant force on the pipeline to the external forces required to keep the pipeline from floating. Elevated fluid specific gravities will be used in the calculations where appropriate to account for higher buoyant force generated in sediment-laden waters, or where warranted based on other considerations.

For wall thicknesses contemplated, the pipeline will be buoyant in high water table areas, at water crossings, and at directionally drilled crossings.

Depending on the overall length of the high water table areas being crossed and types of soils within these areas, buoyancy control may not be required. Where forces resisting flotation (pipe weight, overburden, soil strength) are 105% or more of the buoyant force (calculated using appropriate specific gravity), buoyancy control will not be required. Where the forces resisting flotation are less than 105% of the buoyant force, buoyancy control measures will be required.

Potential buoyancy control measures include increased pipe wall thickness, concrete coating, bolt-on weights, or saddlebag weights.

The wall thickness required to achieve 105% of the buoyant force when compared to the unit weight of water and ignoring resistance of backfill is 1.25 inches. Use of this thickness is not currently being considered as it is deemed impractical for this project.

Assuming a concrete coating unit weight of 140 pcf; a minimum coating thickness of 4.1, 3.5, 2.9, and 1.8 inches of concrete will be required to provide buoyancy control for pipe in Location Classes 1, 2, 3, and 4, respectively, based on the unit weight of water and ignoring resistance of backfill. An equivalent number of bolt-on or saddlebag weights can also be applied. If bolt-on or saddlebag weights are used, appropriate measures will be taken to ensure pipe coating integrity. For the different methods that will be used for buoyancy control, refer to Appendix A drawings DB-BC-01, DB-BC-02, and DB-BC-03.

Buoyancy control for HDD, if required, can be accomplished by installing a small pipe inside the main pipeline. The smaller pipe will be filled with water to provide the needed buoyancy control of the pipeline while it is being pulled into place.

## 2.9 WELDING

The line will be welded according to the requirements of API 1104, Welding of Pipelines and Related Facilities, and project-specific requirements. Specific welding procedures will be developed. All field welds will be inspected using ultrasonic, radiographic, or other approved methods.

Implementation of a strain based design will require the development of special welding procedures.

## 2.10 CROSSINGS

Several types of features will be crossed by the pipeline, including transportation alignments (trails, driveways, roads, highways, and railroads); waterbodies (streams, rivers, and wetlands); aboveground and belowground foreign pipelines; utilities; and faults.

Construction methods for crossings include open cut; trenchless methods, such as horizontal bore and HDD; new bridges; attaching to existing bridges; and aboveground moding. Open cut is typically used for smaller crossings where traffic or flow can be diverted while completing the crossing. Trenchless crossings are typically used on arterial roads, collector roads, and railroad crossings where service cannot be interrupted for long periods; at long crossings of waterbodies; and/or crossings of transportation infrastructure. Aboveground moding may be used at select water crossings and fault crossings.

Casings will not be used on any road or railroad crossings due to their potential to cause an adverse effect on corrosion control. To protect against third-party mechanical damage at transportation crossings, the pipeline will be buried deeper than normal and will have a thicker wall per 49 CFR 192.111 Design factor (*F*) for steel pipe, (b) and (c).

### 2.10.1 Highways and Roads

#### *2.10.1.1 Local Roads*

Local roads primarily serve to provide direct access to adjacent land; they offer the lowest level of mobility and provide access to higher functionally classed collector and arterial roads. A typical crossing of a local road is shown in Appendix A drawing DB-XING-01.

#### *2.10.1.2 Arterial and Collector Roads*

Collector roads offer an intermediate level of service between that provided by local roads and arterial roads; they provide land access service, collect traffic from local roads, serve small communities directly, provide traffic circulation in larger communities, connect communities to the arterial network, provide service to important traffic generators, and serve as intra-region travel corridors. Arterials connect communities and provide mobility so that traffic can move quickly and safely. The George Parks, Elliott and Dalton Highways are classified as arterials. A typical crossing of an arterial or collector road is shown in drawing DB-XING-02.

#### *2.10.1.3 Trails and Driveways*

Since the pipeline route parallels many arterial and collector roads within, or close to, their ROW, there will be many crossings of trails and driveways. A typical crossing of a trail or driveway is shown in drawing DB-XING-03.

### 2.10.2 Railways

The pipeline will cross the Alaska Railroad at several locations south of Cantwell. A typical layout for railway crossings is shown in drawing DB-XING-04.

### 2.10.3 Utilities

#### *2.10.3.1 Foreign Pipelines*

Normal practice requires crossing existing foreign pipelines and utility lines beneath the existing pipeline or utility. A minimum clear separation of 12 inches is required between the existing foreign pipeline/utility line and the proposed pipeline. Drawing DB-XING-05 shows a typical crossing of existing small diameter pipelines.

A typical crossing of an aboveground section of TAPS is illustrated in drawing DB-XING-06. The pipeline should cross as close as practicable to midway between the existing vertical support members (VSM) to avoid structural, and limit thermal, impacts to the VSM.

A typical crossing of a belowground section of TAPS is shown in drawing DB-XING-07. It is assumed TAPS has approximately 4 feet of cover. It is also assumed that Alyeska Pipeline Service Company (APSC) will accept the 12-inch minimum clearance; however, this is not confirmed. Minimum pipeline cover depth when crossing a belowground section of TAPS will be approximately 9 feet.

#### 2.10.3.2 Buried Cable

The pipeline alignment will cross several buried cables. They include fiber optic, coaxial cable, copper telecommunication, and electrical transmission lines. The ASAP mainline will have a minimum clearance of 36 inches from any existing uninsulated primary electrical line. Otherwise, the minimum clear separation is 12 inches between the pipeline and any existing buried cable. A typical crossing of existing buried cables is shown in drawing DB-XING-08.

## 2.11 HYDROSTATIC TESTING

All piping systems will be tested after construction to the requirements of 49 CFR 192 Subpart J, Test Requirements, and ASME B31.8-2010 – 841.3, Testing after Construction.

The ASAP transmission pipeline will be operated at hoop stresses greater than 30% specified minimum yield strength (SMYS). Per 49 CFR192.505 Strength test requirements for steel pipeline to operate at a hoop stress of 30 percent or more of SMYS (c), the strength test must be conducted by maintaining the internal pipe pressure at or above the test pressure for at least 8 hours before being placed in operation. An exception to the 8 hour test duration is provided in 49 CFR 192.505(e) which states “For fabricated units and short sections of pipe, for which a post installation test is impractical, a pre-installation strength test must be conducted by maintaining the pressure at or above the test pressure for at least 4 hours.”

The test medium will generally be water. Testing with air will only be allowed under specific conditions based on a case-by-case review. Where possible, water from a test section will be reused in the next test section. Appropriate environmental protections will be implemented when disposing of test water.

The Minimum Hydrostatic Test Pressure will be 125% of the pipeline maximum allowable operating pressure (MAOP) for Location Class 1, Division 2 and Location Class 2. The Minimum Hydrostatic Test Pressure will be 150% of the pipeline MAOP for Location Classes 3 and 4. Note 49 CFR 192 only requires the line to be tested to 110% of MAOP in Class 1 locations unless there is a building intended for human occupancy within 300 feet, in which case the test pressure must be at least 125% of MAOP. Thus, in certain special cases (i.e., very remote locations with very low probability of development) this lower test pressure may be considered.

The Maximum Hydrostatic Test Pressure will produce a stress of no more than 105% of the pipeline SMYS.

The calculated hydrostatic test pressures for the 36-inch mainline are presented in Table 5, Hydrostatic Test Pressures.

### Table 5 Hydrostatic Test Pressures

| LOCATION CLASS | MINIMUM TEST PRESSURE | MINIMUM TEST PRESSURE (PSIG) | MAXIMUM STRESS DUE TO TEST PRESSURE[1] | MAXIMUM TEST PRESSURE (PSIG) | MAXIMUM TEST ELEVATION DIFFERENTIAL[2] (FT) |
|---|---|---|---|---|---|
| **1** | 110% MAOP | 1,628 | 105% SMYS | 2,161 | 1,230 |
| | 125% MAOP | 1,850 | 105% SMYS | 2,161 | 717 |
| **2** | 125% MAOP | 1,850 | 105% SMYS | 2,591[3] | 1,712 |
| **3** | 150% MAOP | 2,220 | 105% SMYS | 3,108[3] | 2,049 |
| **4** | 150% MAOP | 2,220 | 105% SMYS | 3,887[3] | 3,846 |

*[1]Project defined*

*[2]Using difference between Maximum and Minimum Test Pressures.*

*[3]If pipe fittings are present within the test segment the maximum test pressure at the fitting location is limited to 150% MAOP*

# 3. GEOTECHNICAL DESIGN

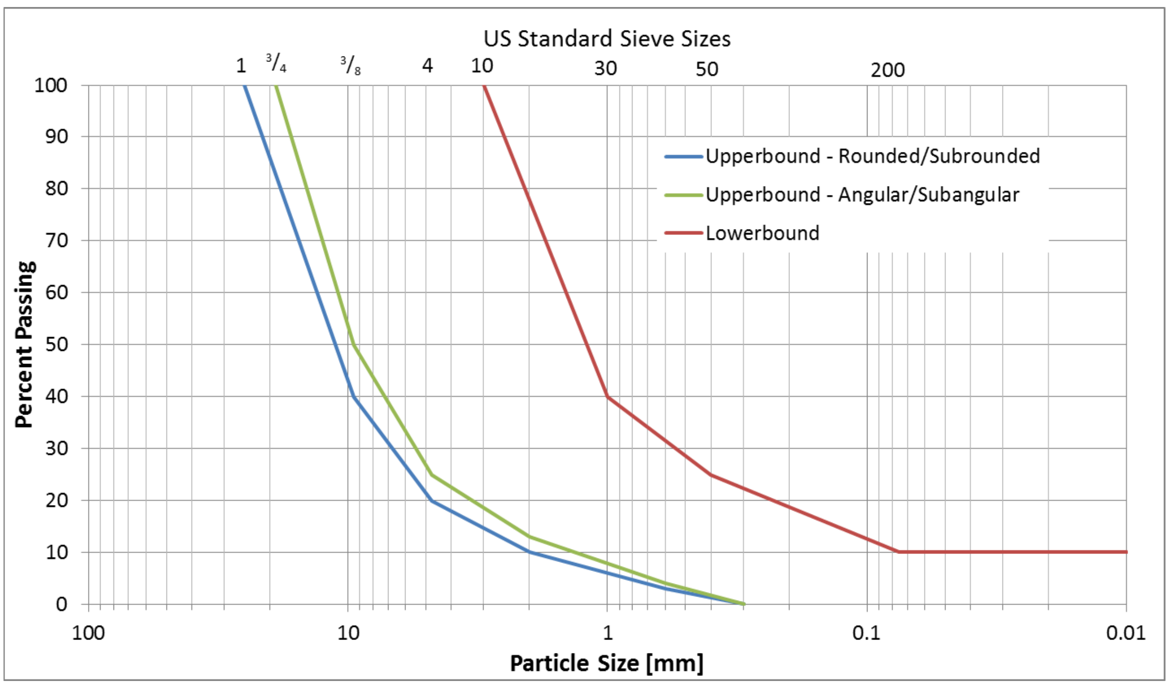
## 3.1 GEOTECHNICAL DESIGN CONSIDERATIONS

The ASAP spans a variety of unique geotechnical conditions, which directly affect the design of the pipeline and related facilities. The goal of the geotechnical design is to provide a stable foundation for the various pipeline elements so the system can operate effectively without undesirable consequences to the public or environment.

### 3.1.1 Material Selection, Backfill, and Compaction

Bedding, padding, and backfill specifications are important to ensure the longevity of the pipeline and performance of pipe coatings and corrosion protection systems. Pit-run sand and fine to medium gravels (rounded particles) provide the best bedding and padding from a corrosion control perspective because they minimize coating damage and are conducive to CP current flow. Excavated trench soil and workpad will be used for bedding, padding, and backfill to the maximum extent practicable. Where trench soil is not suitable, import material will be required. All bedding and padding material should meet the gradation presented in Figure 5, Bedding and Padding Gradations.

**Figure 5. Bedding and Padding Gradations**



Trench backfill will be placed to exclude coarse or angular particles that could damage the pipe or pipe coatings. Trenches should be kept free of ice and snow for winter work. When trenching in frozen terrains or placing frozen trench fill, frozen material must be pulverized until the trench bottom is smooth (conforming to the pipe contours) and free of voids. Where embankment fill placement occurs in the winter over frozen subgrade or by placement of frozen material, such fill must be allowed to thaw/settle over the following summer season and then compacted and graded to restore desired surface contours.

Materials for access roads, workpads, and other earthen structures will be designed for the loads anticipated for the life of the structure. In general, Standard Specifications for Highway Construction (ADOT&PF 2004) will be used (as appropriate) to support the construction of the project.

## 3.2 ROUTE GEOHAZARDS

Broadly defined, a geohazard is a geological and/or environmental condition with the potential to cause distress or damage to civil works. Common geohazards include earth movements associated with landslides and surface rupture or subsidence induced by seismicity. Geohazards common to pipelines in cold regions include frost heave and thaw settlement. Geohazards also include interdisciplinary processes such as erosion induced scour or lateral migration of drainage channels. Changes in site conditions induced by geohazard processes could load the pipeline, causing a pipeline integrity concern, or impact the ROW, causing an environmental concern. A geohazard assessment of the route ensures that effective design, construction, and operational mitigation measures are in place to reduce the potential for pipe integrity issues and to reduce the number of non-routine maintenance interventions.

The primary geohazards being evaluated for this project include:

- Frost Heave and Thaw Settlement (Geothermal)
- Seismicity/Tectonics
- Slope Stability
- Erosion and Buoyancy

Secondary hazards being evaluated, which also potentially impact the pipeline, include:

- Hydrotechnics – Watercourse Hydraulics
- Geochemical
- Unique Soil Structure

### 3.2.1 Geothermal Design Considerations

Design criteria for geothermal evaluation of ASAP route conditions are described in this section. Geothermal design considers the coupled effect of soil mechanics and heat transfer principles that drive physical processes which can impact the operational reliability and performance of the pipeline. Examples of these processes are:

- Frost bulb formation (including stream crossings).
- Frost heave beneath the pipe.
- Thawing of cleared ROW.
- Thaw settlement of ROW.
- Thaw settlement of the soils supporting the pipe or pipe bedding.
- Thaw penetration within a trench backfill above the pipe (nonsupporting), or within a workpad or other adjacent facility.

Since these processes are largely driven by changes in the thermal state of the soil regions surrounding the pipe, a framework for predicting the thermal state of the pipe is an initial step in the design evaluation process.

The preferred mode for the ASAP is buried and it is anticipated the pipeline will encounter thermal states ranging from continuous permafrost in the north, to discontinuous permafrost in the center, and thawed muskeg, alluvial, lacustrine, glacial moraine and outwash type soils in the central and southern regions.

Stipulation 3.15.1 of Appendix A in the Alaska Stand Alone Gas Pipeline/ASAP Right-of-Way Lease, ADL 418997 (ASAP ROW Lease) (ADNR 2011) states gravel work pads will be designed and constructed to protect the ground surface and prevent any thermal degradation of the permafrost. The design will utilize a point of compliance set approximately 50 feet outside the ROW for this stipulation. In general, changes to the thermal regime are anticipated due to construction activities. This is anticipated particularly in areas of warm or discontinuous permafrost where ground clearing prior to construction will result in at least short term thermal disturbance. The point of compliance outside the ROW provides the opportunity to meet the criteria while limiting large-scale thermal disturbance.

#### 3.2.1.1 Base Case Assumptions for Preliminary Design

Primarily to preserve the thermal stability of the soil around the ASAP project, the design base case is for the pipeline to operate close to ambient temperatures. At Prudhoe Bay, the gas will be conditioned to below 30°F year-round to avoid thawing permafrost. As the gas travels southward from the continuous permafrost of the North Slope, to discontinuous permafrost of the Alaska Interior, and through sporadic permafrost and seasonally frozen regions in Southcentral Alaska, the operating temperature will fluctuate based on several factors, including time of year, surrounding ambient ground temperature, and the Joule-Thomson effect.

Frost heave may occur where unfrozen frost susceptible soils exist in combination with other heave-favorable conditions, such as available water in prolonged freezing temperatures. Thaw settlement may occur where pipeline influence or construction disturbance lead to thawing of frozen ice-rich soils.

Mitigation for frost heave or thaw settlement depends on identifying portions of the alignment vulnerable to these geohazards, evaluating the depth extent of the hazard, and evaluating the structural interaction between the pipeline and surrounding soil. Mitigation is indicated if modeling suggests pipeline deflections could exceed allowable values. Frost heave can be mitigated by replacing frost susceptible soil with non-frost susceptible borrow material, by controlling the operational pipe temperature, by applying insulation to control ground freezing, and possibly by providing drainage measures to control moisture migration. Thaw settlement can be mitigated by replacing thaw unstable soils with compact structural fill, by installing thermosyphons or applying insulation to control ground thawing in localized areas, or by controlling the operational pipe temperature.

Based on the current pipeline configuration and operational characteristics as shown in Figure 3, Preliminary Ground and Pipeline Temperature Profiles, the system hydraulics indicate the operational pipeline will largely follow the ambient conditions of the subsurface rather than being an important heat source/sink. Consequently, frost heave is not thought to be a credible hazard to the pipeline in limited areas where the pipeline transitions from permafrost into a thawed but frost susceptible soil mass. Thaw settlement, mainly due to construction disturbance of the ROW, has been identified as a potential concern to the pipeline.

#### *3.2.1.2 Thaw Settlement — Parameters and Approach*

Geotechnical parameters necessary for thaw settlement analysis and design include soil data, such as particle size distribution, unit weight, and moisture (or ice) content; degree of saturation, porosity and specific gravity; thaw penetration rate; longitudinal resistance; load/deflection characteristics; and climatic data. Soil data is based on terrain unit analyses augmented by field and laboratory test results from geotechnical field investigations. Climatic data incorporates the most recent data from stations along the route. Limits of application of climatic data are based on geographic similarities along the line.

The approach to thaw settlement analysis is to couple route soils data with climatic data and pipeline thermal prediction. Pipeline thermal conditions are predicted using the hydraulics model as described in Section 2.1, Pipeline Hydraulics. The hydraulics model predicts temperatures along the pipeline for a given throughput and inlet temperature and pressure, initial soil temperatures, and gas properties as shown in Table 1, Design Gas Composition. The pressure and temperature of the flowing gas depends upon the heat flux through the pipe wall which, in turn, depends on the pipe interaction with the subsurface thermal state.

The temperature results from the pipeline hydraulics model are then input into a 2-dimensional geothermal model. The 2-dimensional finite element analysis is used to find the subsurface thermal conditions at various locations based on the combined effects of surface climatic variations and pipe wall temperature as defined by the pipeline hydraulics model. The output will be a series of "snapshots" along the pipeline of the changing thermal condition of the subsurface over time. The final outcome is an estimate of the magnitude and timing of thawing of initially frozen ground.

The thaw progression and geotechnical properties that define the soil's thaw settlement potential are input into predictive equations for thaw strain, i.e., the soil settlement predicted in a unit thawed depth of soil. The thaw strain equations will be validated against the field studies program, as well as from other data sources as appropriate. The equations will use such parameters as soil unit weight, moisture content, degree of saturation, and porosity to predict the magnitude of thaw settlement, given the depth of thaw. The magnitude of pipe strain resulting from the predicted thaw settlement will be analyzed by separate structural analysis (see Section 5, Pipe Stress Analysis) and compared to the strain demand limit.

Thaw settlement assessments will be performed for pipeline segments wherein frozen and mixed frozen/unfrozen (or uncertain thermal state) soils are expected within the design thaw bulb beneath the pipeline. The total magnitude of thaw settlement will be the summation of the individual thaw strains of each soil layer within the zone of thaw penetration.

#### *3.2.1.3 Thaw Penetration*

Parameters to be used in the thaw penetration analysis will include climatic conditions, thermal inputs from the pipeline or other structure being built, surface conditions, stratigraphy, soil moisture content (frozen and unfrozen), soil unit weight, soil make-up (organic versus mineral), latent heat of fusion, specific heat (frozen and thawed), and thermal conductivity. Thaw penetration for design problems other than those specifically addressed above will be estimated using technical procedures appropriate to the size, complexity, and significance of the problem. These procedures will include simple techniques such as hand calculations and the Modified Berggren Method, as well as finite element heat transfer models. The size and configuration of numerical models, including such considerations as 2-dimensional versus 3-dimensional and conduction-only versus conduction-plus-convection, will be considered as appropriate for the specific design problem being addressed, and may vary on a case-by-case basis.

### 3.2.2 Seismic / Tectonics

Stipulation 3.8.1 of the ASAP ROW Lease (ADNR 2011) states:

> *The Pipeline shall be designed to prevent gas leakage or damage to the Pipeline from the Design Contingency Earthquake (DCE). The DCE is defined as an earthquake with a five (5) percent probability of exceedance in fifty (50) years. Seismic ground-motion parameters shall be based on the U.S. Geological Survey (USGS) national seismic hazard maps for Alaska as appropriate to the particular pipeline or facility application, except for areas of special seismic hazards such as active faults, unstable slopes, or liquefaction zones. An engineer registered in the State of Alaska shall assess the design for each of these special seismic hazards.*

#### *3.2.2.1 Surface Fault Rupture*

Active faults located along the alignment will be identified. Section 3.9.3 of the ASAP ROW Lease Stipulations (ADNR 2011) states:

> *In a fault zone that is reasonably interpreted as active, the Pipeline shall meet the following minimum design criteria:*

> *(a) The Pipeline shall resist failure resulting in leakage from displacement in the foundation material resulting from the DCE on that fault zone;*
>
> *(b) No storage tank or compressor station shall be located within an active fault zone on State Land; and*
>
> *(c) The manner of pipe installation across the fault zone, location of valves on each side of the fault, and monitoring system shall be included in the design.*

At each active fault location, the design of the pipeline will be based on individual fault rupture parameters, including width of the fault crossing, angle of the fault relative to the pipeline, type of fault, and anticipated displacements (vertical and horizontal) associated with the particular fault type at each crossing. These parameters will be verified by a site-specific geologic field investigation.

#### 3.2.2.2 Shaking

The pipeline will be designed to resist the impacts of wave motion and direct deformation resulting from a seismic event.

#### 3.2.2.3 Liquefaction

Saturated soil formations exposed to earthquakes or other ground vibrations can develop internal high pore pressures which cause the soil mass to partially or totally lose its shear strength or liquefy. In the ASAP design, the soil is not liquefiable if:

(1) The soils are clay or clayey silts with a plasticity index greater than 7.
(2) The soils cannot become saturated.
(3) The soil mass is densely compacted (Nc60 > 30 blows per foot).
(4) The soils are, and will remain, frozen.
(5) The pipeline component is sited in rock.

Liquefaction analysis will start with screening level analysis using typical soil types correlated to terrain unit mapping, wetland extent as an indication of saturated soil conditions, and qualitative soil density (loose, medium, dense) interpreted from geologic deposition processes. Where the screening analysis suggests site conditions could liquefy with vibration, site specific exploration will be conducted to confirm site conditions for design. Exploration will confirm depth to water table or permafrost contact, recover soil samples for particle size gradation testing, and test in-situ relative density. Vibration input to the liquefaction analysis will be taken from online U.S. Geological Survey (USGS) probabilistic earthquake design resources. If the investigation indicates liquefaction may be a problem, additional investigation to assess the potential for buoyancy concerns, lateral spreading, slope stability, and dynamic densification will be conducted as required.

#### 3.2.2.4 Documentation

At the completion of the design, an Engineering Analysis and Report of the Design of the Pipeline, sealed by a registered Professional Engineer, will be prepared and submitted to the State of Alaska Pipeline Coordinators Office for review and acceptance. In accordance with Section 3.8.2 of the ASAP ROW Lease Stipulations (ADNR 2011), the report will assess and confirm the pipeline can withstand the Maximum Credible Earthquake (MCE) and will indicate any areas of high hazards, fault zones, and mitigation measures.

### 3.2.3 Slope Stability

The stability of the slopes along the alignment will be assessed. When practical, areas subject to mudflows, landslides, avalanches, rock falls, and other types of mass movement will be avoided. Where avoidance is not practical, the design, based on detailed field investigations and analysis, will provide measures to prevent the occurrence of, or protect the pipeline against, the effects of mass movements. This includes a special emphasis to identify areas of unusual cold-region-specific soil failure modes, such as solifluction, saturated soils on permafrost, and areas of seasonal groundwater flow or springs (ASAP ROW Lease Stipulation 3.10.1 [ADNR 2011])

The pipeline traverses numerous slopes along its route. Some of these slopes have conditions, such as ice-rich soils or river erosion at the toe of the slope, that make them susceptible to downslope movement, which could affect the pipe and ROW integrity. A screening process will be used, based on empirical evidence in current landforms (presence of displaced slide masses, grabens, sackungen, rotated trees, etc.), to identify possible unstable slopes. In a permafrost terrain, the slope failure might be related to creep of ice-rich debris; whereas in a thawed terrain, the slope failure might be caused by a low shear strength soil or change in site drainage. The slope failure mechanism(s) will be applied to terrain units and slope values along the ASAP route to identify potentially vulnerable slopes with similar conditions.

Primary analysis of the slope hazard will be by LiDAR survey combined with terrain unit mapping. Where feasible, ASAP alignment will be adjusted to avoid slopes exhibiting prior evidence of mass movement. If potentially unstable slopes cannot be avoided by realignment, site specific geotechnical reconnaissance and exploration will be conducted to evaluate the slope characteristics (angle, aspect, soil type, seepage, thermal state, etc.) and the slope hazard will be mitigated by flattening the slope angle, providing drainage improvements, constructing a buttress at the toe of the slope, and/or burial of the pipeline beneath the basal shear plane of the slide.

For static conditions, the calculated factor of safety for the slope must be at least 1.5. Slopes will be designed to withstand the dynamic conditions of the MCE as defined in Section 3.8 of the ASAP ROW Lease Stipulations (ADNR 2011) (denoted Design Contingency Earthquake) with a minimum factor of safety of 1.0 or demonstrated to have less than 5 inches of total slope movement.

# 4. HYDROLOGY DESIGN

## 4.1 RIVERS AND STREAMS

When engineering, environmental, or economic conditions permit, river and stream crossings will be accomplished using a suitable trenching method. Otherwise, use of trenchless construction methods such as HDD, attachment to existing highway bridges, or construction of new pipeline bridges will be considered. River and stream crossings will be designed to be fully compatible with existing adjacent facilities; i.e., other pipelines, river training structures, roads, and bridges.

### 4.1.1 Project Hydrologic Stream Classification System

The following hydrologic stream classification system is used to identify hydrologic and geomorphic characteristics of the streams crossed by the alignment. These characteristics include but are not limited to channel morphology, icing potential, scour, bank migration, potential surface water effects on adjacent facilities, and other crossing site considerations. This system provides the basis for hydrologic data gathering and analysis. Streams crossed by the pipeline will be categorized into one of the following classes.

#### 4.1.1.1.1 Class 1 Streams

- Relative scour potential and/or bank migration potential are considered to be high, presence of adjacent structures may induce detrimental backwater effects, or other problems exist that may affect pipeline integrity.

#### 4.1.1.1.2 Class 2 Streams

- Relative scour potential is considered to be moderate, bank migration or channel shifting potential is considered moderate to minor.

#### 4.1.1.1.3 Class 3 Streams

- Relative scour and bank migration potential are considered low.

### 4.1.2 Project Crossing Design Classification System

The following crossing design classification system is used to identify the level of detail required for crossing design and provided for construction. This system will also define the structure and content of design study reports for pipeline stream crossings. Design classes are not analogous with the Federal Energy Regulatory Commission (FERC) classifications. Each crossing will be categorized into one of the following classes.

#### 4.1.2.1.1 Minor Crossing Design

Minor Crossing Design streams can be crossed using standard drawings and specifications; cover depth does not exceed 5 feet and pipe crossing length does not exceed 50 feet.

The specified pipe crossing length assumes placement of a single 40-foot straight joint at minimum burial depth between field bends (see Section 2.7.1, Field Bends). The minimum channel elevation will be located as near the center of the 40-foot straight joint as is practicable.

Appendix A drawing DB-XING-09 illustrates a typical Minor Crossing.

#### 4.1.2.1.2 Intermediate Crossing Design

Intermediate Crossing Design streams can be crossed using standard drawings, but require site specific specifications; cover depth may exceed 5 feet and/or pipe crossing length may exceed 50 feet.

Appendix A drawing DB-XING-10 illustrates a typical Intermediate Crossing.

#### 4.1.2.1.3 Major Crossing Design

Major Crossing Design streams will require site specific drawings and specifications, and supporting site data. Such crossings may include trenchless crossings, trenched crossings requiring detailed guidance on construction (e.g., isolation), or crossings requiring supplemental bank armoring or river training structures.

### 4.1.3 Stream Crossing Mode Determination

Streams will be crossed by open cut, isolated open cut, and trenchless methods (e.g. HDD, Horizontal Directional Boring, etc.), and suspension from existing or newly constructed infrastructure. The mode determination procedure serves to identify the anticipated design complexity, magnitude of construction activity, and potential for environmental impact or pipeline integrity impact. Details of aerial photography, LiDAR, topographic survey, hydrologic, hydraulic, and geotechnical analysis, and assessments of environmental and adjacent facilities concerns will serve as the basis for the mode determination and classification of relative difficulty. The overall level of effort increases with the ascending order of crossing methods listed. The relative difficulty of crossing mode will be evaluated to help identify preferred and alternative mode options for each crossing, where relevant. The selection of crossing modes and identification of relative difficulty will be based on several categorical analyses, including the following.

#### 4.1.3.1.1 Engineering/Constructability Analysis

The engineering and constructability analysis for crossing mode determination will evaluate site-specific engineering concerns, particularly as they relate to trenching. Relevant concerns may include, but are not limited to:

- Unstable soils
- Steep approach and bank slopes
- Excessive scour and burial depth
- Excessive bank migration and setback requirements
- Limited access and staging area
- Adjacent infrastructure
- Impact to local hydraulics

The ultimate goal is to identify whether or not isolated/open cut trenching is practical and if so the level of design and construction difficulty associated with the crossing site. The presence and possible use of existing infrastructure will also be considered as an alternative crossing mode during this analysis.

##### 4.1.3.1.2 Fish Habitat Sensitivity Analysis

This analysis will target the identification of fish habitat presence, specifically anadromous and sensitive fish bearing stream crossings requiring special considerations due to migration, spawning, and overwintering habitat, and the potential impacts of construction (Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes, ADF&G 2013).

The fish habitat sensitivity analysis will provide support for crossing mode and construction timing window selection during the permitting process, and may guide further study into site specific fish habitat sensitivity and means of impact avoidance.

##### 4.1.3.1.3 Isolated Trenching Method Analysis

Various methods of isolated open cut trenching may be employed during construction, each with an added level of construction effort and cost. This analysis helps to identify the hydraulic conditions present that may dictate the method of isolated trenching. Methods of isolated trenching may include:

- Isolating flow using one or more flumes
- Isolating flow using the dam and pump method
- Diversion of flow
- Any practical combination of the above

The relative difficulty of the isolated trenching method is in part dependent on channel morphology, hydraulic conditions, ability to manage water, and post-construction mitigation requirements. Concerns identified in the engineering/constructability analysis will be referenced in support of the selected isolated trenching method.

#### 4.1.3.1.4 Trenchless Method Analysis

The trenchless method analysis will identify concerns associated with HDD feasibility, preference for existing infrastructure support, or possible construction of aerial spans. Feasibility of HDD will consider such concerns as:

- Length
- Soils
- Limited access or workspace
- Entry and/or exit point limitations
- “No Drill Zone” limitations that may relate to geotechnical and hydraulic design criteria
- Relative risk of failure
- Water source availability

Drawing DB-XING-11 shows the process for horizontal directional drilling.

Site-specific investigation and analyses may reveal a more appropriate crossing mode than initial determinations. Changes to the preferred crossing mode will be applied only on a stream-by-stream basis as the need arises.

## 4.2 RIVER AND STREAM CROSSING DESIGN

### 4.2.1 General Criteria

- Crossings will be buried except when engineering or environmental restraints prohibit burial.
- Heavy wall pipe may be used at select stream crossings, based on engineering, environmental, or construction considerations.
- Minimum required depth of cover at rivers and streams will be the greater of 5 feet or 120% of maximum scour, per Section 3.13.2 of the ASAP ROW Lease (ADNR 2011).
- Minimum depth of cover for floodplains will be 4 feet for “normal soils” and 3 feet for “consolidated rock.” Additional cover may be applied to the minimum depth of cover at selected crossings to account for channel scour and bank migration.
- Sagbends will be set back from the bank of the active channel to preclude pipe exposure caused by bank migration or channel shifting. Setback distances will be based on estimates of possible bank migration. Bank migration evaluations will be based on field assessment and photo comparison determination of historic bank migration.
- Setbacks will be measured horizontally from high bank (if discernible), tree line (if appropriate), water edge at flood stage (if applicable), water edge at high flow, or top of bank, to the calculated center of the sagbend. Setbacks may also be referenced to pipeline stationing.
- If the crossing is to be installed without fabricated bends (see Section 5.10, Minimum Free Stress Installation Radius), the terminus of the setback will be that point where the pipe rises above the minimum cover depth required for the crossing (drawing DB-XING-09).

- River, stream, floodplain, and wetland crossings will be designed to be fully compatible with existing adjacent facilities, i.e., other pipelines, river training works, roads, and bridges. River training structures will be designed such that existing facilities are not affected by unacceptable backwater upstream or by increased channel velocities downstream.
- Trenchless construction methods, such as HDD, will be considered for the installation of pipe beneath rivers, streams, or floodplains.
- Where HDD is used to install a crossing, the minimum burial depth on all portions of the pipeline within the limits of bank migration will be below the maximum predicted scour elevation.
- Pipe beneath rivers, streams, or floodplains will be installed to ensure that no portion of the pipeline is exposed to scour at stream banks or streambeds.

### 4.2.2 Hydrology

- Pipeline crossing designs will be based on a minimum 100-year flood recurrence interval event or maximum historic flood event, whichever is greatest.
- Design discharges will be based on existing hydrologic data (e.g., USGS, ADOT&PF), flood frequency analysis using available gaging data or regional regression equations (USGS 2003), or flood runoff modeling if alternative methods yield low confidence results.

### 4.2.3 Hydraulics

- Hydraulic analyses will be performed using step-backwater modeling (e.g., HEC-RAS v4.1) and normal depth methods, dependent on such factors as local hydrology, channel morphology, and relative difficulty of crossing mode.
- It may be determined that a 2-dimensional hydraulic model is required to develop a more accurate and detailed understanding of flow dynamics for establishing design criteria at critical crossings.
- Scour depths will be computed using regime theory and/or competent velocity methods for general scour and reasonable Z-factors for local scour. Results will be compared with evidence of historic scour.
- Channel migration and floodplain erosion will be assessed using both qualitative assessments (e.g., channel stability field assessments) and quantitative analyses (e.g., historic aerial imagery). Burial depth and/or use of river training structures will be specified to prevent exposure of the pipeline.

### 4.2.4 Bank Armoring and River Training Works

- Stream crossing design will not rely on bank armoring or river training works to maintain pipeline integrity without substantive reasoning, such as impractical overbank construction, presence of adjacent facilities, or environmental concerns.
- Structure type will be selected based on specific protection requirements, material availability, potential effects on adjacent facilities, and environmental concerns.

- Hydraulic analysis of pre- and post-construction conditions will be performed at bank revetment or river training work locations to assess potential impact on the pipeline and adjacent facilities. Factors to be assessed include scour, water surface elevation, flow velocities, bank erosion, and channel migration.
- Structure height requirements will be based on a site-specific analysis. Freeboard (the height of the structure above the design water surface elevation) will consider predicted ice jamming effects, debris accumulation, aufeis, and waves.
- Guide banks will allow for design flows to pass without endangering downstream facilities by scouring or by creating undesirable backwater effects.
- Spacing between adjacent river training structures will be selected based on site-specific evaluation.
- Revetments will be terminated in areas protected from erosive currents or will be keyed-in to the bank at their termination point.
- Where scour is anticipated, toes of river training structures will be protected by extending the armoring layer to the scour elevation or by providing a launching apron.
- Riprap design for revetments and channel stabilization aprons will be based on methodology adopted by the Federal Highway Administration (FHWA), or other appropriate methods.

## 4.3 WETLANDS

As stated in Section 1.1.6, Routing Guidelines, the pipeline alignment will avoid high value wetlands where practicable. If high value wetlands cannot be avoided, then mitigation for impacted wetlands will follow 40 CFR 230 Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material. The 404(b)(1) Guidelines require a project to follow a mitigation sequence for placing fill in waters of the U.S. including wetlands:

> Step 1: Avoid – Adverse impacts to aquatic resources are to be avoided and no discharge shall be permitted if there is a practicable alternative with less adverse impact.
>
> Step 2: Minimize – If impacts cannot be avoided, appropriate and practicable steps to minimize adverse impacts must be taken.
>
> Step 3: Compensate – Appropriate and practicable compensatory mitigation is required for unavoidable adverse impacts which remain. The amount and quality of compensatory mitigation may not substitute for avoiding and minimizing impacts.

Pipeline design will adhere to the above process to ensure U.S. Army Corps of Engineers (USACE) 404 permit guidelines are met. A color-coded representation of the functions and services of delineated wetlands will be developed to allow easy recognition when the pipeline or ancillary facilities are being routed within high value wetlands and waters of the United States. The categories of wetlands defined by USACE are:

##### 4.3.1.1.1 Category I

Category I wetlands are those which:

(1) Provide habitat for threatened or endangered species that has been documented;
(2) Represent a high quality example of a rare wetland type;
(3) Are rare within a given region;
(4) Provide habitat for very sensitive or important wildlife or plants; and/or
(5) Are undisturbed and contain ecological attributes that are impossible or difficult to replace.

Examples of the latter are mature very productive forested wetlands unique to an ecoregion that may take a century to develop, and certain bogs and fens with their special plant populations that have taken centuries to develop. Mitigation ratios may range from a low of 2:1 to a high of 3:1 for preservation.

##### 4.3.1.1.2 Category II

Theses wetlands can be important for a variety of wildlife species and can be critical for the watershed depending on where they are located. Category II wetlands do not provide critical habitat for any threatened or endangered species or species of concern. Generally these wetlands are pristine, not fragmented, and common but more productive and sustain higher biodiversity compared to Category III wetlands. Mitigation ratios may range from a low of 1:1 to 2:1 for preservation.

##### 4.3.1.1.3 Category III

These wetlands are usually plentiful in the watershed often with the least biodiversity. Category III wetlands are not rare or unique and overall productivity and species diversity are relatively low. These wetlands may be impacted by man (or by fire or other natural events) and are not considered to be "pristine" examples and as a result, in some cases require less than 1:1 mitigation ratios.

A stoplight categorization system with the following definitions is recommended for routing design assistance:

- Red: Category I, Waters of the highest value such as streams, lakes, and ponds. These are the highest USACE mitigation ratio areas that will require the most stringent justification for filling.
- Yellow: Category I, Wetlands of highest value. These are the highest USACE mitigation ratio areas that will require the most stringent justification for filling.
- Green: Category II, Wetlands of slightly less value than Category I wetlands. These are high USACE mitigation ratio areas that will require stringent justification for filling.

In designing a pipeline or access road, the fill impacts should be located within the green mapped areas, or no color areas to the maximum extent practicable to avoid Category I waters and wetlands. Routing and designing facilities in red or yellow mapped areas should be avoided.

Two types of impacts need to be considered. The Compensatory Mitigation Plan (CMP) will present how the ASAP Project will compensate for the permanent unavoidable losses of Waters of the United States including wetlands, streams, and creeks in the project area. Individual permits resulting in the loss of wetlands impossible or difficult to replace within a human lifetime will be considered a permanent impact. The CMP will outline how the ASAP Project will acquire the necessary mitigation to offset the permanent functional losses to waters and wetlands from the proposed project.

Temporary impacts also consider the ancillary facilities associated with the total project. The USACE requires details on access roads to pipe, access roads to gravel pits, gravel pits, camps, pipe storage yards, waste areas, block valves, gas condition plants, ports, bridges, and the stream crossings be submitted as part of the 404 permit application.

Temporary wetland impacts, such as the construction zone clearing prior to construction and the placement of construction mats for equipment access, do not require compensatory mitigation as long as the pre-existing wetland conditions, functions, and services are restored adequately. Clearing or trenching may be considered temporary if the degraded wetland plant community is able to re-vegetate promptly after construction. Placement of clean mats for construction access through a wetland is a protective measure, and will not result in wetland degradation. The details of the restoration and revegetation plan are required for USACE in the CMP.

Heavy equipment working in Category I or II in the summer may also work on mats (see drawing DB-ROW-05), or use low ground bearing equipment to reduce the wetland vegetation and soil disturbance. Wetland crossings with soft sub soils completed during the summer may be constructed using a push-pull technique. This technique requires excavation of the ditch from temporary mats (typically wood mats with approximate dimensions of 20 feet x 4 feet x 12 inches). Ditch spoil can be placed on either side of the ditch on the mats because the pipeline will be strung and welded outside the wetland and the pipe string pushed and pulled into place. Backfill of the pipeline is accomplished in a similar manner using excavators on mats.

The design will incorporate restoration and stabilization procedures to be implemented immediately after construction to prevent erosion. Revegetation of the site needs to begin as soon as onsite conditions allow, and in the same growing season as the disturbance unless conditions warrant additional time. If practicable, native vegetation and soils removed for construction will be stockpiled separately and used for site rehabilitation in accordance with ASAP ROW Lease Stipulation 2.6.2 (ADNR 2011) which states *"Surface materials taken from disturbed areas shall be stockpiled and utilized during Restoration unless otherwise approved by the Pipeline Coordinator."* If soil and organic materials are not available from the project site for rehabilitation, other local native materials may be used. Other organic materials (including seed) may be used only if identified in the CMP.

Species to be used for seeding and planting must comply with the following order of preference:

(1) Species native to the site.
(2) Species native to the area.
(3) Species native to the state.

Re-vegetated areas eventually need to have enough cover to sufficiently control erosion without silt fences, and vegetation barriers. Best management practices (BMP) specify the proper use of silt fences and sediment barriers.

Project design will be conducted in a manner that prevents adverse surface flow. Natural drainage patterns will be maintained using appropriate ditching, culverts, and other measures to prevent ponding or drying. All culverts in fish bearing waters must be installed in accordance with a valid Alaska Department of Fish & Game Fish Habitat permit. The BMP specify the proper use of culverts for surface flow.

Relocated stream channels will be designed to avoid excessive loss of flow through the bed and dewatering of the stream channel. Relocated stream channels will approximate the length, meander pattern, gradient, channel cross-section, substrate, and flow velocity of the original stream channel. The relocation of stream channels will include the establishment of a floodplain. The floodplain will be of similar dimension and form as the original, or sized to convey the 100-year flood while retaining the channel, substrate, and floodplain characteristics without significant down- or head-cutting.

Pipeline installation in wetlands will include measures to eliminate the potential for water flow within the trench (e.g., ditch plugs).

Excess spoil material, including vegetation, trees, and roots from clearing will be removed from the wetlands and moved to upland or disturbed location for permanent disposal.

Excavated material temporarily sidecast into wetlands will be underlain with geotextile, ice pads, or similar material, to allow removal to the maximum extent practicable with the least damage to the underlying wetland vegetation.

Stream bank revegetation techniques will be defined for the stream cross cuts to help reduce erosion and to provide for restoration success. Revegetation techniques for stream banks are included in Streambank Revegetation and Protection: A Guide for Alaska (ADF&G 2005).

The Department of Army permit applications drawings include the design of the following when placed in waters and wetlands:

- Construction fill pads.
- Access roads.
- Culverts.

- Relocated stream channels;
- Fill below Ordinary High water of stream channels.
- Buried pipe and pipe plugs.
- Sidecast material.
- Waste material.
- Logs, stumps, organic debris.
- PSYs and camps.
- Laydown yards.
- Valve locations.
- GCF locations.
- Vertical support members for pipes.
- Log storage yards.
- Facilities in marine waters.
- Facilities in, on, over, and under navigable waters.

Buoyancy control measures for the pipeline in high water table areas, such as wetlands, are addressed in Section 2.8, Buoyancy Control.

# 5. PIPE STRESS ANALYSIS

## 5.1 INTRODUCTION

This section outlines the stress analysis design criteria, and the design procedures established to ensure the fundamental safety and structural integrity of the pipeline. Applicable regulations, codes, and criteria pertaining to stress analysis are presented. The types of loads, loading conditions, and combinations of loads are identified and discussed. The design criteria for acceptable levels of stress and strain in the pipe are established for all identified loading conditions. The appropriate methods and procedures of analysis to be used in the final design are subsequently defined.

## 5.2 APPLICABLE CODES AND REGULATIONS

- Code of Federal Regulations, Title 49 - Transportation, Part 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards.
- American Institute of Steel Construction (AISC). ANSI-AISC 360-05 Specification for Structural Steel Buildings and Commentary. March 2005.
- American Petroleum Institute, "Specification for Line Pipe," API 5L.
- American Petroleum Institute, "Recommended Practice for Railroad Transportation of Line Pipe," API 5L1.
- American Petroleum Institute, "Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels," API 5LW.
- American Society of Civil Engineers, "Minimum Design Loads for Buildings and Other Structures," ASCE/SEI 7-10.
- American Society of Mechanical Engineers, "Gas Transmission and Distribution Piping Systems," ASME B31.8-2010.
- ADL 418997, Alaska Stand Alone Gas Pipeline/ASAP Right-Of-Way Lease

## 5.3 CLASSIFICATION OF LOADING CONDITIONS

The loadings are classified as to their effect on stress and strain as either primary or secondary. Definitions of primary and secondary stress vary between codes and are not specifically stated in 49 CFR 192. The project definitions are as outlined below:

- A **primary load** is a load which is not self-limiting and cannot be relieved by yielding or distortion. Primary loads on a pipeline include internal pressure and dead load of the pipe and its contents.
- A **secondary load** is a load which is self-limiting and can be relieved by yielding or distortion. Such a load is caused by movement of supports, restraint of adjacent parts, or self-constraint of the structure. Secondary loads on a buried pipeline include the effects of temperature changes, the effects of earthquake and the effects of movement of the surrounding soil media caused by displacement at bends and differential settlement or frost heave.

The conditions for which the pipe design is analyzed are classified as follows:

- Transportation loads are those imposed during handling, loading, stacking and shipping of the pipe.
- Construction loads are loads resulting from construction traffic and handling.
- Pre-operation loads include settlement that may occur after installation, and during the hydrostatic testing.
- Design operating loads are the sustained loads imposed by normal operations of the pipeline and the maximum expected loads resulting from movement at bends, and settlement. Wind and snow loads are included for aboveground pipe segments.
- Design maximum loads (contingency loads) include design operating loads combined with occasional loads, such as loads from extreme conditions with a low probability of occurrence during the lifetime of the pipeline, such as the MCE as stipulated by Section 3.8 of the ASAP ROW Lease (ADNR 2011).

## 5.4 DESIGN LOADS

The design loads to be considered for the pipeline analysis and design are included in the following sections.

### 5.4.1 Internal Pressure

Internal pressure is a primary load which induces primary circumferential tensile stress and strain in the pipe wall by expanding the pipe radially. If the pipe is unrestrained, pressure also induces axial tensile stress by expanding the pipe longitudinally. Once buried, the pipeline is restrained and axial tensile stress develops as a result of Poisson's effect. Internal pressure governs the required pipe wall thickness in accordance with the requirements of 49 CFR 192.

For a given operating pressure, the wall thickness required to meet this limitation is calculated using Barlow's formula in the following form:

$$t = PD/[2S (F \times E \times T)]$$

where:

| | |
|---|---|
| t | is the pipe wall thickness (inches) |
| P | is the design operating pressure (psig) |
| D | is the pipe outside diameter (inches) |
| S | is the specified minimum yield (psi) |
| F | is the design factor |
| E | is the longitudinal joint factor |
| T | is the temperature derating factor |

The factor F is determined by Class Location in accordance with 49 CFR 192.111.

The factors E and T are determined in accordance with 49 CFR 192.113 and 192.115, respectively, and are equal to 1.0.

The component of hoop stress resulting from internal pressure is determined using Barlow's formula as presented below:

$$\sigma_h = PD/2t$$

where:

| | |
|---|---|
| $\sigma_h$ | is the hoop stress (psi) |
| P | is the internal pressure (psig) |
| D | is the pipe outside diameter (inches) |
| t | is the pipe wall thickness (inches) |

In the unrestrained condition (e.g., aboveground piping), longitudinal stresses are defined by the product of the internal pressure and the area of the pipe divided by the area of the steel:

$$\sigma_L = A_P P/A_s$$

where:

| | |
|---|---|
| $\sigma_L$ | is the longitudinal stress (psi) |
| $A_P$ | is the cross-sectional flow area of the pipe, ($in^2$) |
| P | is the internal pressure (psig) |
| $A_s$ | is the cross-sectional area of pipe steel ($in^2$) |

In the restrained condition (e.g., buried piping), longitudinal stresses are defined by the product of Poisson's ratio and the hoop stress:

$$\sigma_L = \nu PD/2t$$

where:

| | |
|---|---|
| $\nu$ | is Poisson's ratio, 0.3 |

### 5.4.2 Dead Load

Dead loads include the weight of the pipe, its contents, and externally applied loads such as corrosion or abrasion coatings, concrete coating, or concrete weights.

### 5.4.3 Temperature Differential

The buried pipeline will be partially or fully restrained from expansion or contraction by the backfill and surrounding soil medium. Any change in temperature of the pipe steel after installation will induce secondary longitudinal stress. A rise or fall in the pipeline steel temperature during operation or testing will induce compressive or tensile membrane stress respectively. The elastic analysis for buried pipe considers full restraint at maximum positive and negative temperature differential.

Longitudinal membrane stresses caused as a result of the temperature differential in the fully restrained pipeline are defined by:

$$\sigma_L = E\alpha(T - T_i)$$

where:

| | |
|---|---|
| $\sigma_L$ | is the longitudinal stress (psi) |
| $E$ | is the modulus of elasticity (psi) |
| $\alpha$ | is the coefficient of thermal expansion (in/in/°F) |
| $T$ | is the temperature in question (°F) |
| $T_i$ | is the installation temperature (°F) |

In unrestrained aboveground segments of the pipeline, the thermal expansion and contraction produces longitudinal force and induces secondary longitudinal bending stress at bends, offsets, and supports. The design temperature differentials will be input into an elastic analysis in combination with other applicable loads.

### 5.4.4 Overburden and Vehicular Loads

The weight of the backfill above the buried pipe will deform the pipe and induce a circumferential bending stress in the pipe. The overburden load may be conservatively taken as equal to the weight of the soil prism above the pipe:

$$W_O = \gamma HD$$

where:

| | |
|---|---|
| $W_O$ | is the overburden load (plf) |
| $\gamma$ | is the backfill unit weight (pcf) |
| $D$ | is the pipe outside diameter (ft) |
| $H$ | is the height of fill above the top of the pipe (ft) |

Additional load will be transmitted to the pipe at highway crossings from vehicular traffic. Applicable wheel loads which have been factored for impact will be applied as a surcharge to the pipe in addition to the overburden. Determination of the total load W for use in equations will be made as follows:

$$W = W_O + W_S$$

where:

$W_O$ is the appropriate overburden load
$W_S$ is the surcharge load due to the applied wheel loading

The deformation and circumferential stress response of the pipe to the combined effects of the overburden and design vehicular loads are functions of the backfill load, the properties of the pipe, and the properties of the soil around the pipe. The resulting deformation and circumferential stress will be calculated considering the effect of the load transmitted through the subsurface to the pipe using soil mechanical properties appropriate for the specific site, and the pipe mechanical properties. Analysis may be concluded though accepted manual calculations, e.g., Spangler, or by appropriate finite element analysis. Typical analyses will be performed for evaluation of level road crossings with required cover. Where appropriate, detailed analysis may be performed at site-specific road crossings. The detailed calculations will be contained in the final design package. In certain site-specific locations where detailed soils data are available, the overburden load may be calculated with consideration of the arching effect.

The weight of the backfilled soil over the pipe is a primary load, bearing on the upper surface of the pipe and inducing a circumferential bending stress in the pipe wall. In areas where settlement may occur or in areas where the ditch bottom profile will not provide uniform support to the pipe, the overburden load may induce longitudinal stresses and strains in the pipe prior to operations.

The case of settlement is analyzed in accordance with Section 5.7, Differential Ground Movement. In cases where the construction specifications allow non-uniform support of the pipe or in site-specific locations where actual support conditions are determined, the residual longitudinal strain from overburden loading will be included in determining the total longitudinal strain for comparison with the criteria allowables. The residual strain will be calculated as the strain resulting from the bending moment in the unpressurized pipe caused by the weight of the overburden extending over a span equal to the allowable unsupported length of pipe.

### 5.4.5 Buoyancy

The effect of buoyant uplift on the buried pipe will also be considered as a dead load. Buoyant uplift can occur in areas where the pipeline is partially or fully submerged in water or saturated soil-water medium. Seismic activity may also cause a buoyant effect in certain liquefiable soils.

### 5.4.6 Snow, Ice, and Wind Loads

The aboveground segments of the pipeline will be subjected to loading from snow, ice, and wind. These produce longitudinal bending stresses, which will be considered primary loads.

### 5.4.7 Seismic Loads

Body waves, including compression waves and shear waves, propagate radially from the source of earthquake energy release (hypocenter) into the surrounding rock and soil medium. Compression waves cause axial compressive and tensile strains in the ground in a radial direction away from the hypocenter. Shear waves cause shear strains in the ground perpendicular to these radial lines. When the compression waves and shear waves are reflected by interaction with the ground surface, surface waves (Love waves and Rayleigh waves) are generated. Except at very large distances from the epicenter, the magnitude of surface waves are much less than body waves.

In the buried pipeline, the passage of these ground waves will incur longitudinal and bending strains as it conforms to the associated ground strains. In most cases, these strains are relatively small, and welded pipelines in good condition typically do not incur damage. Propagating seismic waves also give rise to hoop membrane strains and shearing strains in buried pipelines, but these strains are even smaller and may be neglected.

Resulting membrane and bending stresses are considered secondary.

The maximum axial strain, $\varepsilon_g$, induced in a buried pipeline by seismic wave propagation can be approximated using the formula presented in American Lifelines Alliance (ALA), Guidelines for Design of Buried Steel Pipelines (ALA 2001):

$$\varepsilon_g = V_g/\alpha C_S$$

where:

| | |
|---|---|
| $\varepsilon_g$ | is the maximum longitudinal membrane strain (in/in) |
| $\alpha$ | is the ground strain coefficient:<br>= 1.0 for compression and Rayleigh waves, and<br>= 2.0 for shear waves; |
| $C_S$ | is the propagation velocity of the seismic wave (in/sec) |
| $V_g$ | is the maximum horizontal ground velocity (in/sec) |

The apparent propagation velocity is the inverse of the "slowness," a term used in seismology. The slowness is a function of the source-to-site geometry and the wave propagation velocity along the entire path of propagation typically ranging from 6,560 to 11,480 fps (2.0 to 3.5 km/sec). Hence, an apparent propagation velocity of 6,560 fps (2 km/sec) can generally be taken as a lower bound estimate that will provide a maximum estimate of ground strain. The direction of wave propagation is typically assumed to be the longitudinal direction of the pipeline, since this assumption results in the largest axial strain effect applied to the buried pipeline, although the direction may be chosen as the actual seismic propagation direction if site-specific or source specific information is available.

If there is no slippage of the pipeline relative to the surrounding soil, then the maximum axial strain in the pipeline is equal to the maximum ground strain, evaluated as:

$$\varepsilon_g = V_{max}/\alpha C_S$$

If slippage occurs, then pipeline longitudinal strains will be less than the ground strain, i.e., the maximum axial strain in the pipe is:

$$\varepsilon_g = f\, V_{max}/\alpha C_S$$

where:

f — Reduction factor ($f \leq 1.0$) to account for the slippage effect. Present analysis uses a value of 1.0 for "f" which can be seen to produce a conservative estimate of the induced axial strain. Lower values of "f" are permitted if specific conditions justify their use. Appropriate justification will be provided for any lower value used in final design. In no case will "f" be less than 0.5.

For the aboveground sections of pipeline (such as fault crossings) and its support system, the reference earthquake ground motions are in the horizontal plane, and the effects of vertical ground motion will be considered as being equal to two-thirds of the horizontal. These ground motions will be applied to produce the maximum effects on the pipeline and its supports.

## 5.5 LOAD COMBINATIONS

Design loads occurring simultaneously will be combined and the resulting stresses and strains will be limited in accordance with the design criteria specified this section. Loading combinations to be analyzed are outlined in Table 6, Load Combinations for Buried Pipe, and Table 7, Load Combinations for Aboveground Pipe.

**Table 6 Load Combinations for Buried Pipe**

| LOADS | COMBINATIONS 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Design Pressure | X | X | | X | X | | X | X | X |
| Test Pressure | | | | | | X | | | |
| Zero Gage Pressure | | | X | | | | | | |
| Operating Temperature Differential | | | | X | X | | X | X | X |
| Test Temperature Differential | | | | | | X | | | |
| Dead Load - Operating | | | | X | X | | X | X | X |
| Dead Load - Test | | | | | | X | | | |
| Seismic Ground Motion | | | | | | | X | X | X |
| Overburden | | X | X | | | | | X | |
| Traffic Loads | | X | X | | | | | | |
| Buoyancy | | | | | X | | | | X |

**Table 7 Load Combinations for Aboveground Pipe**

| LOADS | COMBINATIONS 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Design Pressure | X | X | | X | X | |
| Test Pressure | | | | | | X |
| Operating Temperature Differential | | | X | X | X | |
| Test Temperature Differential | | | | | | X |
| Dead Load - Operating | | X | | X | X | |
| Dead Load - Test | | | | | | X |
| Seismic Displacements | | | | | X | |
| Wind | | X | | | | |
| Snow/Ice | | X | | | | |

### 5.5.1 Maximum Allowable Stresses and Strains

#### *5.5.1.1 Maximum Allowable Stress Levels*

The maximum allowable stress levels will be as follows:

**Table 8 Allowable Stresses – Hoop Stress All Cases**

| CLASS LOCATION | ALLOWABLE | LOAD COMBINATION (TABLE 6 AND TABLE 7) |
|---|---|---|
| 1 | 0.72 SMYS | 1 |
| 2 | 0.60 SMYS | 1 |
| 3 | 0.50 SMYS | 1 |
| 4 | 0.40 SMYS | 1 |

**Table 9 Allowable Stresses in Buried Pipe**

| DESCRIPTION | ALLOWABLE | LOAD COMBINATION (TABLE 6) |
|---|---|---|
| Circumferential Bending Stress from design or zero pressure, over-burden, and traffic loads | 0.90 SMYS (ASME B31.8, 833.9) | 2<br>3 |
| Longitudinal Stress from design gage pressure, temperature differ-ential, and other operating loads | 0.90 SMYS (ASME B31.8, 833.3) | 4<br>5 |
| Effective Stress from design or zero gage pressure, temperature differential, and other operating loads | 0.90 SMYS (ASME B31.8, 833.4) | 4<br>5 |
| Effective Stress from test pressure, test temperature differential, and test dead load | 1.00 SMYS (ASME B31.8, 833.4) | 6 |
| Effective Stress from design pressure, temperature differential, other operating loads, and MCE | 1.15 SMYS (Project Design) | 7<br>8<br>9 |

**Table 10 Allowable Stresses Aboveground Pipe**

| DESCRIPTION | ALLOWABLE | LOAD COMBINATION (TABLE 7) |
|---|---|---|
| Longitudinal Stress from design pressure, operating dead load, and occasional loads (wind, snow, and ice loads) | 0.75 SMYS (ASME B31.8, 833.6) | 2 |
| Expansion stress from temperature differential | Varies (ASME B31.8, 833.8) | 3 |
| Effective Stress from design pressure, temperature differential, and operating dead load | 0.90 SMYS (ASME B31.8, 833.4) | 4 |
| Effective Stress from design pressure, temperature differential, oper-ating dead load, and MCE | 1.10 SMYS (Project Criteria) | 5 |
| Effective Stress from test pressure, test temperature differential, and test dead load | 1.00 SMYS (ASME B31.8, 833.4) | 6 |

#### *5.5.1.2 Allowable Curvature*

The allowable curvature is based on the curvature computed from the allowable longitudinal compressive strain or the allowable longitudinal tensile strain, whichever results in a smaller value. The allowable curvature will consider deductions for the membrane strains that may arise concurrently with the bending.

### 5.5.2 Maximum Allowable Stress Levels for Transportation and Stacking

Circumferential bending stress during rail or truck transport (API RP-5L1): 0.30 Ultimate Tensile Strength (UTS).

Circumferential bending stress during marine transport (API RP-5L5): SMYS/(1+g) (where g is taken as 0.4 unless recommended higher by shipper).

Circumferential bending stress during yard stacking: 0.50 SMYS.

### 5.5.3 Maximum Allowable Pipe Ovalling

The maximum allowable decrease in pipe diameter resulting from overburden and wheel loading will be 5% of the pipe diameter ($\Delta x < 0.05D$).

### 5.5.4 Elastic Stability

Pipeline sections subjected to axial compression loadings will be checked for column buckling in accordance with the Euler formula. The maximum unsupported span will be limited to 80% of the calculated critical buckling span considering appropriate boundary conditions.

## 5.6 NONLINEAR ANALYSES FOR BURIED PIPE

### 5.6.1 General

Nonlinear analyses will be performed on the buried pipe to consider the effects of secondary stress and strain produced by geotechnical conditions.

The purpose of the nonlinear analysis is to provide a more realistic representation of structural behavior to determine either load-deformation or load-strain relations for the structure and/or its individual elements. Nonlinear analyses are based upon an idealization of actual material properties. The analyses are complex mathematical models requiring the use of computer programs. The steel stress-strain relationship, as given by a representative stress-strain curve, is a basic input required for completing these computations.

Studies will be conducted to investigate pipe stress and strain under anticipated design loading conditions and soil response. The objective of the studies will be to determine the limits of pipe displacement and deformation allowed by the criteria limits. Via the analysis, pipe curvature changes occurring under design loadings can be related to the allowable levels.

### 5.6.2 Input Modeling for Pipe Stress Analysis

The accuracy of the results from a pipe stress computer analysis is dependent upon the techniques used in preparing the program input. A suitable procedure for input modeling is discussed below.

To perform a computer analysis, four categories of input to the program are required:

- Geometrical Configuration
- Material Properties of the Pipe

- Soil Resistance Properties
- Loading Conditions

The geometrical configuration is idealized by representing a section of pipe which is divided into a number of segments.

Pipe material properties will be input by specifying a series of data points on the stress vs. strain curves in the hoop, longitudinal-compressive, and longitudinal-tensile directions; a value for Poisson's ratio;, and the-coefficient of thermal expansion. The pipe diameter and wall thickness will also be specified.

Soil restraint is represented as a series of discrete spring functions acting along the discrete segments within the analysis model. For example, uplift soil restraining functions may be represented by a multi-linear force-displacement function.

Loadings will include gravity (self-weight, overburden, etc.), internal pressure, temperature differential, and imposed displacements such as those caused by thaw settlement of the supporting soils. The computer program combines the applied loads in a particular sequence as specified by the user. Each load step is considered a continuation from the previous load step; the stresses, strains, loads, and displacements at each element will be given at the end of each load step.

### 5.6.3 Three-Dimensional Effects

For most situations, the pipeline is considered to lie in a single plane in finite sections sufficiently long to be analyzed independently in a 2-dimensional design analysis. For these conditions, the significant dynamic loads caused by earthquakes may be represented as equivalent axial static temperature loads. Certain site-specific areas or special designs may require the consideration of a 3-dimensional configuration and/or dynamic loading, such as a trench vertical displacement at sidebends.

## 5.7 DIFFERENTIAL GROUND MOVEMENT

At some locations along the pipeline, geotechnical conditions may exist that will cause displacement of the soil around the pipe, such as displacement of the soil due to thaw settlement.

At any location where differential soil displacement may occur, the soil movement will have the effect of inducing a loading action on the pipe, the magnitude of these induced forces being a function of the amount of movement and the soil properties. Depending on the nature of the phenomenon, these displacements may be any combination of transverse movement (producing bending of the pipe) or axial movement (producing a tension-compression effect in the pipe). Design cases of soil displacement will be analyzed using an appropriate nonlinear procedure as discussed in Section 5.6, Nonlinear Analyses For Buried Pipe.

In the nonlinear analysis, the soil movement is represented as a displacement of the soil springs. Both transverse and axial movements may be represented. The analysis will follow the two-stage procedure outlined below:

(1) Soil load-displacement characteristics for the displacement of the pipeline in relation to the soil will be determined.
(2) Pipeline response will be calculated incorporating the following behavior phenomena:

  - Soil behavior
  - Pipe material behavior
  - Pipe operating conditions - internal pipe pressure and differential temperature

### 5.7.1 Route Characterization for Differential Displacement Studies

A buried pipeline is essentially continuously supported by the ditch bottom. It is recognized, however, that certain geotechnical conditions could cause vertical movement of the supporting soil which then must be evaluated for potential distress conditions that could arise in the pipe.

Ground movement studies may be performed at specific locations, such as thaw unstable regions. The majority of the pipeline, however, will traverse areas where accurate information about localized ground movements cannot be specifically determined. The general approach method for non-site-specific locations is outlined below:

- Classify the design cases into Soil Groups, based upon combinations of end conditions, soil types outside the zone of settlement and soil types within the zone of settlement.
- Determine the soil load displacement functions for each selected Soil Group for a range of cover depths and a range of pipe operating conditions (e.g., temperature differential).
- Develop the input models for a computer analysis for a range of spans for the selected Soil Groups, depths of cover, and pipe operating conditions.
- Perform analyses for the range of potential ditch bottom movement for each combination of soil group, depth of cover, and pipe operating conditions. The allowed ditch bottom movement for each span is the ditch bottom movement at which the allowable pipe limits are reached.
- Determine the **critical span** at which the allowable ditch bottom movement will be at a minimum from the analyses sets. This will be the total allowable ditch bottom movement, independent of span, for a given soil group, depth of cover, and pipe operating condition.

From these analyses, design charts will be developed identifying the allowable movement for each soil group at each depth of cover and pipe operating condition. The values obtained from the analyses will be then mapped to the route soil conditions and pipe operating conditions along the pipeline alignment, identifying areas where mitigation is required.

## 5.8 BEND ANALYSIS

As the pipeline traverses the route, changes in pipeline alignment, terrain, grade elevation, and ditch conditions dictate that field bends will be required. These field bends will be made by means of bending machines. For practical purposes, and to prevent wrinkling or other damage to the gas pipeline, a 36-inch diameter pipe will be bent to a minimum radius of curvature of 90 feet (minimum radius of factory bends will be 9 feet) (see Section 2.7.2, Induction Bends).

When a bent section of pipe is subjected to loading, such as hydrostatic test pressure, operating pressure, variations in temperature, seismic loading etc., straining of the pipe will occur and the pipe will tend to be displaced from its original position. This pipe displacement will be resisted by the stiffness of the pipe, the longitudinal restraint between the soil and pipe, and the transverse soil resistance.

The permissible amount of displacement and axial straining at a bend are checked by conducting elastic-plastic analyses of bends using the pipe stress computer program. The allowable bend angles will be determined from these studies.

## 5.9 ABOVEGROUND HARDWARE SUPPORT CRITERIA

Aboveground pipeline supports will be designed in compliance with AISC 360-05 Specification for Structural Steel Buildings and Commentary since their behavior is primarily elastic under both design operating and design contingency conditions.

The depth of seasonal thawing must be considered in determining the capacity of piles. For ASAP, the depth of seasonal thaw is designated as 5 feet for all soils except for free-draining soils where the seasonal thaw is designated as 8 feet. These values will be verified using thermal modeling.

## 5.10 MINIMUM FREE STRESS INSTALLATION RADIUS

As the pipe is installed, it must conform to the trench, which results in stresses and strains within the pipe. It is desirable that the pipe remain elastic under these conditions. This can be accomplished by maintaining a minimum free stress installation radius. Since the elastic limit stress is approximately 75% of the yield stress for API 5LX materials, the minimum free stress installation radius should not generate bending stresses that exceed 0.75 SMYS.

The relationship of bending stress to curvature in a pipe is given by the formula:

$$\rho = \frac{D \cdot E}{2 \cdot \sigma_a}$$

where:

D is the pipe diameter (inches)

E is the Modulus of Elasticity (30,000,000 psi)
$\sigma a$ is the allowable stress (psi)
$\rho$ is the radius of curvature (inches)

The minimum free stress installation radii for the 36-inch diameter mainline pipe and the 12-inch nominal diameter Fairbanks Lateral pipe are presented in Table 11, Minimum Bending Radius (Installation).

**Table 11 Minimum Bending Radius (Installation)**

| PIPE DIAMETER | MINIMUM FREE STRESS INSTALLATION RADIUS |
|---|---|
| **36-inch** | 853 feet |
| **12-inch** | 302 feet |

# 6. CIVIL DESIGN

## 6.1 LAND REQUIREMENTS

Land use requirements associated with the construction and subsequent operation of the ASAP system is divided into two categories: temporary and permanent.

Temporary land requirements include the Temporary Construction Easement (TCE), and temporary project facilities (e.g., camps, laydown yards, and access roads). In addition to the typical 120 foot wide TCE, extra TCE will be required for the following uses:

- Road, trail, rail, and driveway crossings.
- Arterial and collector road crossings.
- Foreign pipeline and cable crossings.
- Stream crossings.
- Wetland crossings.
- Vehicle turnaround.
- Block valve installation sites.
- Launcher and receiver sites.
- Mine sites.

Permanent land requirements include long-term, operational ROW and gas processing facility sites. For the purposes of this report, the term "permanent" is relative to the operational life of the pipeline—the land that will be required as long as the pipeline system is operational.

When construction is complete, a permanent ROW will be established. The permanent ROW will facilitate operation and maintenance activities.

Permanent ROW land quantities will be based on the following assumptions:

- All permanent ROW on federal land (e.g., BLM) will be 53 feet wide based on the Mineral Lease Act and guidance from BLM during the development of the ASAP ROW Application and Plan of Development, which indicated BLM generally issues a permanent grant of 25 feet on either side of the pipeline centerline, plus the width of the pipe. Therefore, the permanent width of the ROW for a 36-inch pipeline would be 53 feet.

- Mainline permanent ROW on all other state and private land will be 53 feet.

## 6.2 DRAINAGE AND EROSION CONTROL

Drainage and erosion controls are mandatory requirements to be considered for construction and maintenance along the ASAP system, including those in the pipeline ROW, at facilities associated with the pipeline and its construction, at airports, and along access roads. The controls are necessary to address potential adverse effects that alter natural drainage patterns. These effects are usually related to flooding, erosion, or degradation of water quality. This section establishes erosion control criteria to minimize these impacts.

Drainage and erosion control consists of methods and facilities to convey surface runoff and control erosion. Criteria for drainage design are based upon accepted engineering practices with special consideration for arctic conditions that prevail in Alaska. A description of the stream classification system and the stream crossing design criteria is provided in Section 4, Hydrology Design. Stream crossing classifications will be used to determine the type of drainage structure appropriate to the access road design. General criteria for river training structures (including spur dikes, revetments, and dikes) are discussed in Section 4.2.4, Bank Armoring and River Training Works.

### 6.2.1 General Criteria

Criteria for drainage design are based upon accepted engineering practices with special consideration for the arctic conditions that prevail in Alaska.

- Culverts and bridges will be designed to accommodate a 50-year flood (permanent structures) or 5-year flood (temporary structures) in accordance with criteria established by American Association of State Highway and Transportation Officials (AASHTO) and FHWA, and endorsed by ADOT&PF. Sizes will be increased as necessary to mitigate ice and debris.
- Placement of drainage structures required for fish passage will be authorized by AS Title 16.05.840, Fishway Required, and AS Title 16.05.870, Protection of Fish and Game.
- Design of drainage improvements will provide erosion control measures to accommodate runoff produced by rainfall and snowmelt that is reasonably characteristic of the region.
- Minimum depth of cover will generally be 1-foot over culverts but cover depth and culvert material will be in accordance with ADOT&PF Standard Specifications for Highway Construction (2004) and the associated current published standard drawings.
- Aprons will be used to reduce scour where necessary, and will extend at least one pipe diameter downstream.
- Access roads crossing floodways or floodplains will consider the predicted water surface rise.
- Drainage and erosion control measures will be implemented to maintain compliance with State of Alaska water quality standards.
- Activities will not be performed that may create new lakes, drain existing lakes, permanently divert natural drainages, permanently alter stream hydraulics, or disturb significant areas of stream beds unless such activities, along with necessary mitigation measures, are approved.
- Erosion controls will be constructed to minimize erosion and lessen the possibility of forming new drainage channels resulting from pipeline system activities. Facilities will be designed to minimize disturbance to the thermal regime.
- Disturbance to vegetation will be minimized. Surface materials taken from disturbed areas will be used for restoration unless otherwise approved. Disturbed areas will be stabilized.

Stabilization practices, as determined by site-specific needs, include seeding, planting, mulching, and placement of mat binders, soil binders, rock or gravel blankets, or structures.

### 6.2.2 Hydrology

Hydrologic calculation methods will be consistent with the stream classification determination discussed in Section 4.1, Rivers and Streams. For drainage areas outside the limits of the regional regression equations, analysis will be based on the practical flood routing methods. Permanent access road drainage features will be designed based on the 50-year flood event. Temporary access road drainage features will be designed based on the 5-year flood event. Bridge crossings will be designed based on a minimum of the 50-year flood event or greater if conditions dictate. As a minimum, design will conform to State of Alaska Department of Transportation & Public Facilities (ADOT&PF) Alaska Highway Drainage Manual (ADOT&PF 2006).

Hydrologic analyses for the design and implementation of erosion and sediment controls will comply with 40 CFR 122, EPA Administered Permit Programs: The National Pollutant Discharge Elimination System, and the U.S. Environmental Protection Agency (EPA) Construction General Permit requirements (Permit No. AKR 100000 and Permit No. AKR 100001), as applicable.

### 6.2.3 Hydraulics

Hydraulic analysis will be conducted using 1-dimensional models consistent with the criteria outlined in Section 4.2.3, Hydraulics. The specific model used will be dependent on the presence or absence and type of drainage structure. Streams that contain fish require special hydraulic design considerations. Design procedures and supplemental design resources identified in the MOA (ADF&G/ADOT&PF 2001), Anadromous Salmonid Passage Facility Design (NMFS 2011), and HEC-26 (FHWA 2010) will be used to satisfy fish passage needs at culvert crossings. Hydraulic design parameters will be based on hydraulic analyses performed at each crossing. Additional resources may be referenced to support aquatic organism passage and culvert design.

### 6.2.4 Temporary and Permanent Storm Water Management

#### *6.2.4.1 Temporary Drainage Features*

Temporary rerouting of streams with intermittent summer flow is allowable, either returning to the original natural drainage way or to a different natural drainage way prior to exiting the immediate project area. Induce drainage ways only if such routing minimizes the combined problems of drainage and erosion control. Temporary drainage structures will be removed when construction is complete.

Temporary rerouting of constant summer flow streams other than designated fish streams is allowable if the rerouting returns to the existing natural watercourse prior to exit from the immediate project area. For designated fish streams, temporary rerouting will be by specific permit only. The rerouting will be implemented only after review and approval by the ADF&G and receipt of a Title 16 Fish Habitat permit.

#### 6.2.4.2 Permanent Drainage Features

Permanent rerouting of the natural drainage way will be minimized. Permanent structures at designated fish streams will be designed to meet ADF&G criteria and specifications for fish passage.

The site must be graded generally at slopes of 0.5 to 1.0% to prevent the formation of puddles and seep holes. Slopes of 10:1 for 10 feet must be provided to carry water away from foundations.

Culverts will be designed based on a maximum headwater depth of 1.5 times the pipe diameter for the design runoff (HW/D < 1.5) and as allowed by embankment height. Pipe gage must be determined in accordance with ADOT&PF standard drawings D-04.10 and D-05.10, "Aluminum Culvert Pipe & Arch Tables" and "Steel Culvert Pipe & Arch Tables."

#### 6.2.4.3 Fish Passage

Culverts and other drainage structures in fish streams will be designed to allow fish passage, based on ADF&G standards. A Fish Habitat permit for work in anadromous fish waterbodies and where work might block passage of resident fish will be obtained. Such work may include placing culverts. Anadromous waterbodies are identified by ADF&G in the "Catalog of Waters Important for the Spawning, Rearing and Migration of Anadromous Fishes."

#### 6.2.4.4 Stormwater Pollution Prevention

Appropriate pollution controls for drainage systems must be designed to maintain water quality in accordance with State of Alaska water quality criteria. Treatment systems in areas where drainage includes accumulated precipitation in oil storage containment dikes, runoff from areas of potential spillage, and other areas where runoff can come into contact with contaminants will be provided.

### 6.2.5 Erosion Control Criteria

Erosion control will be provided wherever design flow velocities or other conditions will cause unacceptable erosion of natural soils or fill materials. Threshold flow velocities at which erosion control becomes necessary will be based on the soil type and frozen/thawed condition during the runoff period. Erosion control methods will be used to limit disturbed areas, divert flow around disturbed areas, reduce runoff velocities, and protect soil from erosive forces.

#### 6.2.5.1 Erosion and Sediment Control Plan

The federal EPA National Pollutant Discharge Elimination System (NPDES) Stormwater Rules for Construction Activities govern what must be included in the Stormwater Pollution Prevention Plan and the Erosion and Sediment Control Plan for the project.

The Erosion and Sediment Control Plan contains specific procedures for clearing, earthwork, temporary and permanent drainage control, hydraulic and thermal erosion control, site cleanup, revegetation, restoration, and maintenance. Combinations of these procedures form the general erosion control design for a specific site. The specific design is defined by determining the water discharge value and applying the appropriate solution provided in the erosion control plan.

### *6.2.5.2 Clearing Criteria*

#### 6.2.5.2.1 Clearing Limits

Areas to be cleared will be limited to the minimum required for efficient construction operations, consistent with minimal terrain disturbance, and without extending beyond approved clearing boundaries or ROW.

#### 6.2.5.2.2 Clearing Methods

Machine clearing will be limited as much as possible to areas of cut and/or fill, overlay, and temporary spoil disposal areas, particularly in areas of permafrost. Hand clearing will be used in other areas.

Trees, snags, and other woody material in connection with clearing operations will be removed so the resulting stumps are not higher than 6 inches, measured from the ground on the uphill side. Felled trees and other material cut in connection with clearing operations will be placed in the clearing area away from any water courses.

The project will not skid or yard logs across any watercourse, and drainages will not be blocked with clearing debris. Non-merchantable timber will be removed to an approved disposal site where it can be spread and buried in nonstructural embankments, burned, chipped, or stored. If possible, the material will be mulched and spread over the ROW or used in brush berms as an erosion and sedimentation control device along the ROW and access road alignments. Merchantable timber will be cut to length, trimmed and stacked in timber decks at locations along the access roads and made available to the public in conformance to ASAP ROW Lease (ADNR 2011), Exhibit A, Stipulation 2.7 Timber Clearing, Salvage and Utilization.

### *6.2.5.3 Earthwork Criteria*

Cut slopes will be designed based on slope stability and erosion control considerations.

### *6.2.5.4 Hydraulic Erosion Control Criteria*

#### 6.2.5.4.1 Limiting Flow Velocities

Ditch liners, ditch check dams, and drop-down structures will be used to reduce flow velocities. To minimize flow velocities in drainage ditches on steep grades, ditch checks will be used for grades in excess of 5% installed on the downstream side of cross-drain inlets.

##### 6.2.5.4.2 Diversion Structures

Water-diverting barriers will be used on slopes where flowing water may be a problem. Requirements depend on soil characteristics, storm intensities, and slope angle.

##### 6.2.5.4.3 Culvert Outlet Protection

Riprap will be used at culvert outlets as required. The use of stilling basins will be minimized to reduce erosion at culvert outlets. Stilling basins will not be used in permafrost areas unless underlying soil is thaw stable.

#### *6.2.5.5 Revegetation Criteria*

Revegetation will be used as an erosion control measure as soon as seeding constraints allow, depending on the time required for revegetation to take hold. Re-seeding, if it occurs, will use native or native cultivars specified by the Natural Resources Conservation Service (NRCS) for Alaska. Selected seed mixtures will be based on site conditions, ability to survive for desirable periods of time, ability to provide soil stabilization, maintenance requirements, and commercial availability.

#### *6.2.5.6 Thermal Erosion Control Criteria*

Thermal erosion may occur where frozen, ice-rich soils are disturbed. Design procedures will eliminate or minimize surface subsidence or ponding due to thermal erosion. The magnitude of the disturbed area, the thaw rate, and potential soil erosion will be minimized to reduce thermal erosion. Existing vegetation will be left intact where feasible to protect the surface and help minimize erosion problems where preservation of the thermal regime is important.

##### 6.2.5.6.1 Buried Pipeline

Where the pipeline is buried and soils above the level of the pipe axis are fine-grained and/or ice-rich, design procedures will minimize surface subsidence or ponding due to thermal erosion. The following design alternatives will be considered:

- Excavation of ice rich soils and backfill with thawed, preferably granular soil.
- Overfill during trench backfill to offset any thaw subsidence that may occur.
- Revegetation used to stabilize the fine grained and/or ice rich soils above the pipe.

## 6.3 ACCESS ROADS

During construction, access roads, both permanent for use during the operational life of the pipeline and temporary, will be required for equipment to reach the pipeline ROW, block valves, camps, laydown yards, and material sites from existing roads. For longer access roads, equipment turnouts may be needed. The majority of access roads will be constructed of gravel. Roads on the North Slope which are only needed for temporary access during freezing conditions will be constructed of ice. A typical ice road cross section is shown in Appendix A drawing DB-AR-04.

Low water crossings, culverts or bridges will be installed at stream and drainage crossings to maintain surface drainage across the road. Erosion control systems will be installed on moderate and steep slopes. See Section 6.2, Drainage and Erosion Control, for details of erosion and sedimentation control.

**Table 12 Access Road Design Criteria**

| | |
|---|---|
| **References and Design Criteria** | AASHTO (American Association of State Highway and Transportation Officials) Guidelines for Geometric Design of Very Low Volume Local Roads ADT (Average Daily Traffic) Less than or equal to 400 vehicles per day, 2001 |
| | AASHTO - A Policy on Geometric Design of Highways and Streets, 2004<br>Alaska Department of Transportation and Public Facilities Statewide (ADOT&PF). 2013. Alaska Highway Preconstruction Manual.<br>Alaska Department of Natural Resources (ADNR). Alaska Stand Alone Pipeline/ASAP Right of Way Lease (2011). |
| **Functional Classification** | A functional classification of "Rural Industrial/Commercial Access Road" has been selected based upon the low volume of traffic and the type of vehicles anticipated. |
| **Design Speed** | 20 mph |
| **Traffic Volume** | < 100 vehicles per day |
| **Maximum Longitudinal Grade** | 12% |
| **Crown Slope** | 2% |
| **Rate of vertical curvature (K) for crest/sag curves** | 4/17 |
| **Maximum superelevation rate** | 6% |
| **Horizontal curve radius, minimum/desirable** | 115 – 155 feet |
| **Horizontal curve minimum length** | 300 feet |
| **Geometric Design Vehicle** | Pipe haul truck capable of hauling 80 foot pipe sections |
| **Minimum Spacing of Access Roads** | 5 miles preferred, 20 miles maximum |

### 6.3.1 Road and Right-of-Way (ROW) Width

Total ROW width is 10 feet outside of the as-built toe of slope. This width will encompass a 30-foot wide road, shoulder to shoulder; with variable depth of embankment and 2:1 side slopes, 10 feet either side of the road for drainage ditches, and 2:1 or steeper daylight back slopes. See typical drawings DB-AR-01, DB-AR-02, and DB-AR-03.

At all intersections, the access road minimum intersection radii will be 50' to accommodate turning vehicles. A driveway permit will be required to intersect the state highways. AAC Chapter 17, Section 20, "Driveways and Approach Roads," establishes the authority for ADOT&PF to regulate the placement of driveways or approach roads within the state highway ROW. Intersection criteria excerpted from the ADOT&PF Preconstruction Manual (2013) are as follows:

**Table 13 Intersection Criteria**

| PUBLIC ROAD INTERSECTED | STOPPING SIGHT DISTANCE (FT) | CORNER CLEARANCE (FT) | DISTANCE BETWEEN DRIVEWAYS (FT) | LANDING | MAXIMUM LANDING GRADE | MAXIMUM ALGEBRAIC DIFFERENCE IN GRADE |
|---|---|---|---|---|---|---|
| **Dalton Hwy** | 495 | 100 | 75 | 30 | ±2% | 8% |
| **Elliott Hwy** | 495 | 60 | 50 | 30 | ±2% | 8% |
| **Parks Hwy** | 645 | 100 | 75 | 30 | ±2% | 8% |

For long access roads, equipment turnarounds may be needed and will be a minimum 100 feet long x 60 feet wide.

### 6.3.2 Road Section

Design, materials, and construction practices employed for roads will be in accordance with safe and proven engineering practice. Access roads will be designed and constructed in accordance with federal and state road standards.

#### *6.3.2.1 Road Subgrade*

Soils conditions vary significantly throughout the project area. The structural section of the roads will vary accordingly. It is intended that structural embankments will adequately support working loads in summer and winter conditions (including permitted overload vehicles) without subgrade bearing capacity failure. However, surface rutting may occur. The roads are designed with the intention that they will require regular maintenance during the construction period when heavy equipment traffic will be the norm. Post construction loads will be infrequent light duty truck traffic, which will not cause significant rutting. Where subgrade soils are consolidated sand and gravel, the ground will be cleared and grubbed prior to placing material meeting ADOT&PF select Type A requirements modified to meet local borrow source quality. Where subgrade soils are deep organic layers or ice rich permafrost, preparation will consist of clearing and placement of geotextile reinforcement fabric prior to placing Select Type A. The goal will be minimum ground disturbance.

#### *6.3.2.2 Road Subbase*

Road subbase will be a minimum 24 inches deep and placed on a recently prepared subgrade. Deeper sections and insulation may be required for thermal protection of thaw unstable permafrost. Subbase material will generally meet ADOT&PF specification 703-2.07, Type A, which has aggregate less than 3 inches in the top foot of the structural section. The material will be moisture conditioned and compacted to 90% per ASTM D 1557 with maximum 12-inch lifts. The gradation and quality requirements are as follows:

Type A aggregate will contain no muck, frozen materials, roots, sod or other deleterious matter and have a plasticity index not greater than 6 as tested by the Western Alliance for Quality Transportation Construction (WAQTC) Field Operating Procedures for AASHTO T 89 and T 90. It will meet the following gradation requirements as tested by WAQTC Field Operating Procedures for AASHTO T 27/T 11:

| SIEVE SIZE | PERCENT PASSING BY WEIGHT |
|---|---|
| **3 in** | 100 |
| **No. 4** | 20-55 |
| **No. 200** | 0-12<br>(determined on the minus 3-inch portion of the sample) |

The material will contain a maximum of 12% of optimum moisture by weight when placed to ensure compactability. Material gradation may be modified to allow use of locally available material so long as the engineering properties are not compromised.

#### *6.3.2.3 Culverts*

Minimum cover for culverts will generally be 12 inches assuming 12 gage or better culvert material in accordance with ADOT&PF standard drawings for drainage structures.

For conceptual design, it was assumed culverts will be located at the access road intersection with public roads. Additional culverts every 500 feet of road length are assumed.

Where necessary, inlet and outlet erosion protection will be implemented in accordance with FHWA and ADOT&PF methods and standards.

### 6.3.3 Access Control

A variety of methods to prevent unauthorized access on the newly constructed roads will be used. These can be berms, bollards and gates. A combination of berms with steel bollards and gates similar to APSC access road control is the most likely method.

## 6.4 AIRFIELDS

The project airfields will provide camp access, mobilization and demobilization of construction personnel, and air support for the construction program. Emergency personnel evacuations, vital equipment and parts, and time-sensitive supplies will require air transportation. Existing airstrips along the ROW will be used. All selected airports are of adequate size needed for this project.

**Table 14 Project Airfields**

| AIRPORT/STRIP | FAA CODE | OWNER | LENGTH (FEET) | WIDTH (FEET) | SURFACE TYPE/COND. | PROJECT USE |
|---|---|---|---|---|---|---|
| **Anchorage** | ANC | DOT/PF | 11,584 | 150 | Asphalt / Good | Hub |
| **Deadhorse** | SCC | DOT/PF | 6,500 | 150 | Asphalt / Good | Hub |
| **Fairbanks** | FAI | DOT/PF | 11,800 | 150 | Asphalt / Good | Hub |
| **Galbraith Lake** | GBH | DOT/PF | 5,182 | 150 | Gravel / Good | Primary |
| **Healy River Strip** | HRR | DOT/PF | 2,912 | 60 | Asphalt / Good | Alternate |
| **Prospect Creek** | PPC | DOT/PF | 4,968 | 150 | Gravel / Good | Primary |
| **Talkeetna** | TKA | DOT/PF | 3,500 | 75 | Asphalt / Good | Alternate |
| **Cantwell** | TTW | Private | 2,080 | 30 | Gravel / Fair | Alternate |
| **Clear** | Z84 | DOT/PF | 4,000 | 100 | Asphalt / Good | Alternate |
| **Chandalar Shelf** | 5CD | DOT/PF | 2,529 | 70 | Gravel / Good | Alternate |
| **Coldfoot** | CXF | DOT/PF | 4,000 | 100 | Gravel / Good | Alternate |
| **Livengood Camp** | 4AK | DOT/PF | 3,000 | 50 | Gravel / Good | Alternate |
| **Nenana Municipal** | ENM | Nenana, AK | 4,600 | 100 | Asphalt / Good | Alternate |

### 6.4.1 Airstrip Upgrade Requirements

Currently, no upgrades to proposed airstrips are anticipated.

### 6.4.2 Helipads

The use of helicopters for movement of personnel and materials will be significant. As such, a helicopter management plan will be developed as the project progresses. Once complete, this plan will be implemented throughout the project life-cycle. New helipads constructed for access to block valves which are not accessible via access road may be required. See drawing DB-FAC-01B for dimensions and details.

## 6.5 RESTORATION

The ASAP route crosses numerous climatic zones. The pipeline extends from the arctic coastal plain at Prudhoe Bay, through taiga, boreal forest, and mountain ranges of interior Alaska, to the coastal lands in the south central region. In a broad sense, climate along the route is reflected by the presence or absence of permafrost, which has an important bearing on pipeline construction techniques, and on the approach to restoration. Restoration plans must also deal with stabilization of steep slopes, surface drainage patterns, poorly drained organic and coarse-textured soils, and arctic-alpine areas.

### 6.5.1 Restoration Limitations

A diverse array of climatic and terrain conditions affect the type of restoration measures that may be applicable to any particular site. A gradient toward a milder climate is represented from north to south and parallels both a decrease in the presence of permafrost and a decrease in restoration complexity.

#### 6.5.1.1 Continuous Permafrost

Permafrost presents restoration problems associated with thermal erosion (soil destabilization resulting from thawing). To maintain stability of pipeline berms or coverings, it is critical to reestablish surface insulation. On a long-term basis, surface insulation is best provided through revegetation of disturbed areas. In some instances, it may be necessary to provide surface insulation using organic mulches or artificial materials until an insulating vegetation cover is reestablished.

Since permafrost is associated with colder climates, winter conditions in these areas often retard plant growth and limit the number of species that can be successfully used for revegetation. Even domesticated species adapted to northern climates are susceptible to winter kill in arctic and alpine areas. Thus, a combination of cold hardy domesticated seed and native stock seed may be required to establish an insulating cover until native species can invade the site. Re-seeding, if it occurs, must use native or native cultivars specified by the State of Alaska, Department of Natural Resources, Division of Agriculture, Plant Materials Center, and as specified by permit.

#### 6.5.1.2 Discontinuous Permafrost

In general, revegetation should be easier in discontinuous permafrost than in areas of continuous permafrost. Alpine areas of the interior mountains, though, have limitations to plant growth similar to those imposed by permafrost. Replacing the organic mat, along with rootstocks and seeds, will be considered as a way to revegetate these areas. Application of fertilizer, if allowed, would stimulate growth of new plants from the organic material.

#### 6.5.1.3 Permafrost-Free Areas

The southern portion of the line should present the fewest reclamation problems. Erosion control techniques may be required to prevent stream sedimentation and soil loss on steep slopes. Revegetation should be established relatively quickly. Rapid reinvasion of native species, including trees and shrubs, would be expected and may require control if vegetation density becomes a problem for pipeline monitoring.

### 6.5.2 General Reclamation Techniques

Factors entailed in reclamation of the project area are discussed below.

#### 6.5.2.1 Erosion Control

Numerous techniques may be used where erosion problems are anticipated. Selection of the appropriate technique is determined by terrain, soil, and surface and groundwater patterns. The objective is to dissipate the energy of surface wind or water flow and to physically stabilize soils. Techniques include the use of rock or shale to construct serrated cuts or diversion berms along steep longitudinal slopes or provide riprap to stabilize steep side slopes. Netting, plastic sheeting, and mulches can be used to temporarily control erosion on less severe sites until vegetation is established.

#### 6.5.2.2 Drainage Control

Erosion control methods should be used to control drainage wherever appropriate. Culverts and diversion structures may be needed to maintain original surface water patterns and minimize ponding and breaching of the berms during heavy precipitation or break-up. Downdrains that control flow velocity into a culvert may be required where terrain is steep. Diversion channels, levees, and benches can also be used along steep slopes to reduce surface water velocity and erosion. Diversion ditches may be required in low-lying areas to prevent excessive ponding. The velocity of streams through culverts should not exceed the rate where outflow erosion cannot be controlled and fish movement is impeded. Energy dissipation structures may be required at culvert outlets where unusually high velocities are anticipated.

#### 6.5.2.3 Revegetation

Once surface stability is attained, disturbed areas will be revegetated to assist with long term erosion control. This is the primary step in reestablishing the natural plant community.

Revegetation programs in the arctic have traditionally relied primarily on domesticated grass species, as the availability of seed from native species has been limited. This situation has changed and it is now feasible to provide a mixture of both domesticated and native species adapted to all areas of the proposed pipeline route. Use of native species is important because some domesticated species may prevent natural invasion and are prone to winter-kill. To minimize this problem, species related to natural stock should be used in seed mixes. Selected plant species must also be compatible with climatic conditions along the route. Re-seeding must use native or native cultivars specified by the NRCS for Alaska and as specified by permit.

### 6.5.3 Monitoring and Maintenance

Follow-up inspections of all disturbed areas after the first and second growing seasons will be conducted to determine the success of revegetation.

Revegetation will be considered successful if upon visual survey the density and cover of non-nuisance vegetation are similar in density and cover to adjacent undisturbed lands. Revegetation efforts will be continued until revegetation is successful.

Reclamation will be considered successful if the ROW surface condition is similar to adjacent undisturbed lands, construction debris is removed (unless requested otherwise by the landowner or land managing agency), and proper drainage has been restored.

Efforts to control unauthorized off-road vehicle use, in cooperation with landowners, will continue throughout the life of the project. Signs, gates, and vehicle trails will be maintained as necessary.

## 6.6 SURVEY

ASAP survey requirements are divided into three general categories: Pre-Construction Survey, Construction Survey, and As-Built Survey.

Survey data will be collected, stored, and used to produce accurate mapping using CADD and Geographical Information Systems (GIS). These maps, and the data stored in the project geodatabase, will be used throughout the detailed design, planning, construction, and operation of the pipeline system.

### 6.6.1 Pre-Construction Survey

Pre-construction survey activities will establish horizontal and vertical control. Data acquisition will generally be through aerial techniques (e.g., LiDAR) using the alignment survey control points to ground truth this acquisition. The data is stored to the project GIS for further mapping, planning, and permit support needs.

In most cases, survey control points will be established along the alignment at a frequency of 2 points per mile. Additional control points will be established at waterways, highways, valve locations, access roads, and pipeline facility sites. Existing survey control points will be used to the extent possible.

### 6.6.2 Construction Survey and Staking

The scope of surveying services for support of construction includes staking centerline and boundaries of the work pad, highway crossings, camp sites, laydown storage areas, double jointing and/or coating yards, access roads, extra TCE boundaries at river and stream crossings, boundaries of critical habitat, and protected vegetation and locations of all structures, such as valve sites, maintenance yards, etc.

All survey control is developed and verified in the preconstruction scope – no further survey control is required by the spread contractors.

Survey crews will be dedicated, according to spread, throughout active periods of construction. These crews will be responsible for staking work areas, valve locations, access roads, and preparations for other daily operations.

### 6.6.3 As-Built Survey

As-built surveys will be completed to record the location of the pipeline as constructed. This data is used as a baseline for future operational considerations and includes recording the location of field joints, anchors, VSM, waterway crossings, valve locations, access roads, and permanent facilities. All survey information is collected in a startup operations electronic data management system and, as applicable, referenced in the project GIS system. Two as-built survey crews are anticipated to be allocated to each spread. All as-built survey data acquisition will meet State of Alaska requirements."

### 6.6.4 Field Survey Methods

Temporary control points, or temporary bench marks (TBMs) will typically consist of 5/8-inch diameter x 30-inch long rebar with 2-inch diameter aluminum caps stamped with an identifier.

State Plane Coordinates and NAVD 88 elevations of control points and TBMs are established using survey-grade sub-centimeter GPS equipment and either static observations or real time kinematics (RTK) methods.

Static observations are preferred. Static observations require setting up two GPS base stations on monuments with published GPS values and using GPS rover units at the project control points at each site. The base stations remain on the control monuments while the rover units are moved from one project control point to another. Each site requires static observation on two control points to assign xyz values and a grid bearing.

This provides quick, precise locations for project control and acts as a check on the published data control monuments occupied by the GPS base stations. By using multiple GPS rover units, several project control points can be located each day.

The RTK method may be used to transfer horizontal and vertical data if there is accurate published control within 6 miles and line-of-sight. A second known position within 6 miles would be required as a check to verify accurate data collection using RTK.

### 6.6.5 Control Monuments

Control monuments used to tie project control points and TBMs to State Plane Coordinates and NAVD 88 elevations generally consist of National Geodetic Survey (NGS) monuments located along the ADOT&PF highways. NGS monuments that have been visited within the last 10 years and adjusted based on GPS ties are to be used. If identified control monuments are too far apart, control can be set closer to the project sites by the above-described static observation method.

### 6.6.6 Survey Data Management

Survey data will be downloaded, checked, and transmitted to the project office at the end of each day. Field data will be collected in Alaska State Plane Coordinates and NAVD 88 elevations, all in feet. Conversion to the project datum will be performed for submittals and entry into the project GIS database. Electronic files are downloaded and backed up daily. Field books are copied or scanned to PDF daily and transferred from field offices to a secure FTP site on the project server.

# 7. MATERIAL SITES

## 7.1 REGULATORY BASIS

### 7.1.1 Right of Way Stipulations

The State of Alaska Right-of-Way Lease for the Alaska Stand Alone Gas Pipeline/ASAP (ADNR 2011) contains project stipulations in Appendix A. Stipulations for material sites are contained in Section 1.23 and are presented below.

*1.23.1 Purchase of Materials*

*1.23.1.1 If the Lessee requires materials from State Land, the Lessee shall make application to purchase such materials in accordance with appropriate State laws and regulations. No materials shall be removed from State Land by the Lessee without the approval of the Pipeline Coordinator.*

*1.23.1.2 Insofar as possible, use of existing material sites shall be authorized in preference to new sites.*

*1.23.1.3 Gravel and other materials shall not be taken from streambeds, riverbeds, lakeshores, or outlets of lakes, unless the taking is approved by the Pipeline Coordinator.*

*1.23.2 Layout of Material Sties*

*1.23.2.1 Material site boundaries shall be shaped in such a manner as to blend with the surrounding natural land patterns. Regardless of the layout of material sites, primary emphasis shall be placed on prevention of soil erosion and damage to vegetation.*

In addition, the development and operation of material sites may come under the environmental requirements of Section 2 of the Stipulations regarding environmental disturbance and reclamation. These include general pollution prevention requirements, disturbance of natural waters, erosion and sedimentation, stockpiling excavated material, restoration and revegetation, timber clearing and salvage, fish and wildlife protection, use of explosives, vegetative screens and buffers, and contingency plans.

### 7.1.2 Permits

Design requirements and guidelines for the development, operation, and potential reclamation of the material sites are a function of the applicable permitting agencies. The specific agencies will be a function of land ownership and jurisdiction.

## 7.2 MATERIAL SITE IDENTIFICATION

The assessment of mineral materials required for construction of the project is ongoing. Material requirements are determined with respect to quantities, qualities, locations, and schedules. Estimates of the material site target quantities are based on the design of the project. Accuracy of estimates will increase as design progresses.

### 7.2.1 Development of Quantity Estimates

Estimated target quantities are established from the plans and specifications with contingencies for rejections, geological uncertainties, or adjustments in construction planning. As the design progresses, adjustments are made in assigning contingencies to reflect the increased level of confidence in estimates.

### 7.2.2 Initial Material Source Selection

Identifying prospective material sources is accomplished through office evaluation of existing data and field reconnaissance of sources appearing to have the most potential for project use. Geologists, engineers, and construction and environmental personnel skilled in evaluating arctic and subarctic conditions use available data to identify and screen prospective sources. Aerial photography, satellite imagery, engineering terrain analysis, geologic maps, topographic maps, and any other maps or materials which document geologic or environmental features in the project corridor are used to identify prospective material sources and potential access routes to the sources.

### 7.2.3 Identification and Screening of Prospects

Geologic and geomorphic interpretations are used to identify preliminary prospects from landforms and terrain units with the following characteristics:

- A size sufficient to support development of a material source to fulfill a major portion of the target quantity determined for a material haul segment
- Corridors to provide feasible access to project work areas

Preference is given to prospects within or adjacent to areas with previous material site development or disturbance. Prospects are screened to minimize the probability of encountering unresolvable conflicts with the criteria. Each prospect and its potential access corridors are reexamined as additional data are obtained to select the best prospects for continued consideration. The screening process includes the following:

- Consideration for the use of previously developed or permitted material sites.
- Consideration of environmental factors to reduce potential development in areas where there is:
    - Undisturbed areas
    - Archaeological or historic sites

  - Restricted fish and wildlife habitats
  - High value wetlands
  - Locations highly visible from highways or public use areas
  - Encroachments on buffer strips
  - Locations with historic icing, drainage, erosion, or stability problems
- Consideration of impacts on health and safety and third party facilities by minimizing selections which will require:
  - Activities near TAPS
  - Activities near third-party facilities
  - Materials hauling across the TAPS oil pipeline or along its workpad
  - Excavations or materials hauling near public campgrounds or picnic areas
- Consideration of construction difficulties by minimizing selections which will require:
  - Excavations in permafrost soils
  - Removal of large amounts of overburden
  - Clearing heavy timber
  - Construction of long or elaborate access roads
  - Materials hauling across bridges or low water crossings
  - Materials hauling along steep grades
  - Extensive hauls of common borrow
  - Extensive hauls of select materials

### 7.2.4 Identification and Screening of Prospects

Reconnaissance and exploration plans are prepared for prospective material sources that have been identified and screened by the preliminary activities. Each prospective material source is assigned a number for identification purposes and designated as a prospective site for either field reconnaissance or field exploration. Plan view drawings on photomosaics (or topographic maps where no photography is available) and narratives are prepared to delineate the prospect area and describe the field activities. The reconnaissance and exploration plans, along with the other required documents, are submitted in support of field program permit applications.

### 7.2.5 Site Reconnaissance

Proposed material sites located within a mile of road access will be visited by a site reconnaissance team prior to mobilization of the exploration team. The site reconnaissance team will evaluate access considerations and the stability of the ground surface, mark areas for clearing (as required), mark borehole locations for utility clearances, and other reconnaissance activities. They will also observe if there are any significant surface expressions that could impact the suitability of the source area for development.

### 7.2.6 Field Exploration

Subsurface exploration is conducted at each site in accordance with the approved exploration plans to confirm geologic conditions and obtain material samples for determination of index properties. The number of boreholes will be a function of the following parameters:

(1) Size of the Source Area – The size of the potential source area will be a function of the quantity of material required, depth and thickness of the deposits, and other factors. In areas where variable overburden or discontinuous permafrost is anticipated, more borings may be used to identify the optimal area of development.

(2) Risk – More boreholes are anticipated in areas where limited information is available to reduce the potential that the quantity required exceeds the available material and reduce the risk of geological surprises during development.

(3) Extent of Available Information – Related to risk, the number of boreholes would be reduced in areas where historic information is available.

(4) Type of Material Required – Less explorations generally are required in areas where common borrow is required versus more highly specified materials.

(5) Geologic Complexity – More borings would be anticipated in areas of anticipated complex subsurface conditions, such as kames or alluvial fans, relative to outwash or floodplain deposits.

ADOT&PF has removed recommendations for borehole spacing from the Engineering Geology and Geotechnical Explorations Procedures Manual (ADOT&PF 2007). There is no identified guidance available regarding the borehole spacing from AASHTO. The Washington State Department of Transportation (WSDOT) Material Source Investigation Report, Geotechnical Design Manual M 46-03 (21.2(c)) (2014) states that "*On the basis of geological considerations, the number, location, depth, and type of test pits or test borings are determined. In absence of geological examination, the test pits or test borings are spaced roughly every 150 to 200 feet on a grid, and extend to the base of the deposit, or to the depth required to provide the needed quantities. A significantly greater spacing (up to 500 feet) is used for nonexclusive leased sites*". The material source investigations will be conducted in a generally similar manner to historic ADOT&PF investigations and WSDOT guidance, assuming the source areas are located on nonexclusive leased sites.

## 7.3 MATERIAL SITE PERMITTING

### 7.3.1 Mining Plan Development

For each site investigated, a mining plan will be developed in general accordance with ADOT&PF practices, as applicable. For some existing sources with an existing permit holder (such as ADOT&PF), a mining plan may have been developed. In these cases, the ASAP Project mining plan will incorporate the requirements of the existing plan as applicable. In the event of concurrent co-development of a site, Alaska Gasline Development Corporation (AGDC) and the other parties will agree on a development strategy prior to beginning operations.

At a minimum the mining plan will consist of:

- A general description of the site.
- A legal description of the site.
- Survey and field staking requirements.
- Buffer requirements.
- Identification of the area of material extraction.
- Slopes (temporary and permanent) and other grading information.
- Identification of contractor processing and support areas.
- Identification of contractor fuel and waste storage areas.
- Stockpile (temporary and long-term areas.
- Equipment and devices.
- Sanitation requirements.
- General hazmat location information.
- Reclamation plans.
- Excavation slope requirements.

The mining plan may have to address additional requirements, depending on the particular land-owner.

### 7.3.2 Storm Water Design

Erosion and sediment control measures will be designed for each material source based on site-specific conditions. The basis of design for these requirements will be the current State of Alaska Construction General Permit (SOA n.d.).[1] As part of the permit, a Storm Water Pollution Prevention Plan (SWPPP) will be developed to describe the steps and documentation required to reduce the potential for sedimentation and erosion.

The SWPPP will include:

- Project overview.
- Contacts and responsibilities.
- Description of construction activity.
- Site maps.
- Discharge locations.
- Identification of receiving waters, wetlands, and any prescribed limitations of discharge.
- Documentation of eligibility as it applies to endangered species.
- Applicable federal, state, tribal, and local requirements.

[1] State of Alaska Construction General Permit available at http://dec.alaska.gov/water/wnpspc/stormwater/Index.htm

- Control measures/best management practices utilized.
- Inspection requirements.
- Monitoring requirements.
- Record keeping.
- Update requirements.

Best management practices and control measures will be developed in accordance with Alaska Department of Environmental Conservation (ADEC). Best Management Practices for Gravel/Rock Aggregate Extraction Projects (ADEC 2012).

### 7.3.3 Fish Habitat

It is the general intent of the ASAP material source program to obtain materials from upland areas and not from streambeds, riverbeds, lakeshores, or outlets of lakes. However, in some circumstances, a significant cost benefit may be realized by using streams or waterbodies to obtain material. Design of material sources and material source access may require obtaining a Fish Habitat permit. If the site is located above ordinary high water or in an uplands area, a Fish Habitat permit will generally not be required, unless the access to the site crosses a fish bearing stream. For sites located near streams, particularly if they are located within ordinary high water, a Fish Habitat permit will be required.

The permit application will require the following information:

- Project description.
- Name of waterbody impacted.
- Project plans showing site access, surface elevation contours, location of temporary facilities and work areas.
- Excavation sequencing.
- Fuel storage locations.
- Excavation cross section.
- Time of year of work.
- Stream diversion and channelization details (if applicable).
- Type of material to be removed.
- Vehicles by size and type that will be used in stream.
- Water body characteristics.
- Available hydraulic information.
- Precautions to insure fish and other aquatic are protected from adverse impacts.

Design requirements for culverts and other stream crossings are presented in Section 4, Hydrology Design.

# 8. TAPS INTERFACE ISSUES

The proposed ASAP pipeline will roughly parallel TAPS from Prudhoe Bay to Livengood. The rugged terrain and physical constraints along the route will force proximate location of the two pipelines at several locations and will require a number of crossings.

The ASAP pipeline has been routed, wherever possible, in locations away from TAPS. Construction using joint workpads is not proposed. The only areas of long-term impact are in the pinch points along the route, at pipeline crossings, and where permanent access roads cross TAPS.

## 8.1 OVERVIEW

Dialogue with TAPS technical representatives will be required throughout the design process to coordinate design, construction and operational plans. Once the project shifts to operations this dialogue also transition from design and construction issues to operations and maintenance needs.

All plans for work within the TAPS ROW will be communicated prior to commencement of activities with their ROW.

## 8.2 TAPS CROSSINGS

As stated above a number of crossings of the Trans Alaska Pipeline, within both buried and aboveground sections, will be required. These crossings will be by both the ASAP and associated access roads.

All crossings of the TAPS will be designed as close to perpendicular a possible to minimize the total length of potential impact. Site-specific plans will be developed for all crossings.

A baseline TAPS ROW assessment will be conducted for any activity that may require disruption to free-access or physical disturbance to the ROW. The assessment will identify required mitigative measures to return the ROW to same level of service as prior to the activity.

### 8.2.1 Buried Pipeline

Design of crossings of TAPS buried sections will consider:

- Site-specific thermal interactions.
- Interference/interaction of the cathodic protection systems.
- Need for potential hand excavation of the existing pipeline.
- Impacts of construction equipment during construction.

### 8.2.2 Aboveground Pipeline

Design of crossings of TAPS aboveground sections will consider:

- Crossing as near mid-span between pipe supports as possible.
- Measures to prevent direct impact to the pipeline by construction equipment such as headache bars.
- Need for potential hand excavation in near proximity of the existing pipeline.

### 8.2.3 Permanent ASAP Access Crossings

ASAP will require permanent access roads which may cross TAPS. Design of these crossings will consider:

- Impacts of the design vehicle to TAPS.
- Providing additional cover over TAPS.
- Providing guardrails at the crossing locations to prevent vehicles from leaving the designated access road.
- Providing headache bars on either side of any crossings of TAPS aboveground sections to prevent impacts to TAPS.

## 8.3 OPERATIONAL PLANNING

ASAP operational planning will consider:

- Interaction/interference between the ASAP cathodic protection system and that of TAPS.
- Emergency response plans.
- Opportunities for conducting joint reconnaissance/surveillance with TAPS operations.
- Opportunities for conducting joint field projects.
- Continued communications with TAPS operations.

# 9. SCADA SYSTEM

The pipeline will be monitored and controlled from a control center through a SCADA system.

The SCADA system must allow the pipeline operators to efficiently and effectively supervise pipeline operations in real time. Data acquisition and storage will be required, together with provision for reports using historical data. Data retention and management must be in compliance with applicable federal and state regulatory requirements.

Additionally, some manual operational control functions will be provided through the system.

## 9.1 OPERATIONS CONTROL CENTER

The primary central SCADA system will be located at the Operations Control Center within the Gas Conditioning Facility. This facility will be used as the primary control and operations center for the pipeline.

### 9.1.1 SCADA System

The scan rate will be fast enough to minimize overpressure conditions (overpressure control system), provide responsive abnormal operation indications to controllers, and detect small leaks within technology limitations.

The SCADA system must meet the requirements of regulations developed based on the National Transportation Safety Board (NTSB), Supervisory Control and Data Acquisition (SCADA) in Liquid Pipelines, Safety Study, NTSB/SS-05/02 (2005), specifically including the following.

#### *9.1.1.1 General Control Room Management*

The U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) has implemented regulations designed to enhance safety by requiring operators of pipeline facilities to implement control room management procedures. Congress enacted the Pipeline Inspection, Protection, Enforcement and Safety Act (PIPES Act), directing PHMSA to issue regulations requiring each operator of a gas or hazardous liquid pipeline to develop, implement, and submit management plans designed to reduce risks associated with human factors in the control room. The design of the SCADA system must meet the requirements of 49 CFR 192.631 and API RP 1168, Pipeline Control Room Management (API 2008).

Operator displays will adhere to guidance provided in API RP 1165 sections 1, 4, 8, 9, 11.1, and 11.3, Recommended Practice for Pipeline SCADA Displays (API 2007b), and 49 CFR 192.631 (c), *Provide adequate information*.

Point-to-point display screens and SCADA system inputs must be verified before placing the line in service.

Operators must have a policy for the review and audit of alarms for false alarm reduction and near miss or lessons learned criteria.

Shift change procedures for controllers must be developed and implemented, and must be scientifically based, set appropriate work and rest schedules, and consider circadian rhythms and human sleep and rest requirements in-line with guidance provided by NTSB recommendation P-99-12 issued June 1, 1999 and 49 CFR 192.631.

#### 9.1.1.2 Fatigue Management

Methods should be implemented to prevent controller fatigue that could inhibit the controller's ability to carry out defined roles and responsibilities. The mechanics of size and location of operator screens, keyboards, and chairs will be considered when designing the SCADA system.

#### 9.1.1.3 Alarm Management

Alarming strategy will comply with 49 CFR 192.631 and API RP 1167, Pipeline SCADA Alarm Management (API 2010b). Alarm management policy and procedures will address:

- Alarm priorities determination.
- Controllers' authority and responsibility.
- Clear alarm and event descriptors that are understood by controllers.
- Number of alarms.
- Potential systemic system issues.
- Unnecessary alarms.
- Controller's performance regarding alarm or event response.
- Alarm indication of abnormal operating conditions (AOCs).
- Combination AOCs or sequential alarms and events.
- Workload concerns.

#### 9.1.1.4 Training

The training and qualification plan (including simulator training) for controllers will be in compliance to 49 CFR 192.631 and API RP 1168 and will:

- Emphasize procedures for detecting and mitigating leaks.
- Include a fatigue management plan and implementation of a shift rotation schedule that minimizes possible fatigue concerns and is scientifically based, sets appropriate work and rest schedules, and considers circadian rhythms and human sleep and rest requirements in-line with NTSB recommendation P-99-12 issued June 1, 1999.
- Define controller maximum hours of service limitations.

- Meet the requirements of regulations developed as a result of the guidance provided in the ASME B31Q, Pipeline Personnel Qualification Standard (2014), for developing qualification program plans.
- Include and implement a full training simulator capable of replaying for training purposes near miss or lesson learned scenarios.
- Implement tabletop and field exercises no less than 5 times per year that allow controllers to provide feedback to the exercises, participate in exercise scenario development, and be active participants in the exercise.
- Include field visits for controllers accompanied by field personnel who will respond to call outs for that specific facility location.
- Provide facility specifics in regard to the position certain equipment devices will default to upon power loss.
- Include color blind and hearing provisions and testing if these are required to identify alarm priority or equipment status.
- Include task specific abnormal operating conditions and generic abnormal operating conditions training components.
- If controllers are required to respond to "800" calls, include a training program conveying proper procedures for responding to emergency calls, notification of other pipeline operators in the area when affecting a common pipeline corridor, and education in the types of communications supplied to emergency responders and the public using API Recommended Practice 1162, Public Awareness Programs for Pipeline Operators (API RP 1162 the most recent version incorporated in 49 CFR 192.616).
- Implement on-the-job training component intervals established by performance review to include thorough documentation of all items covered during oral communication instruction.
- Implement a substantiated qualification program for re-qualification intervals addressing program requirements for what circumstances will result in qualifications being revoked; implementing procedure documentation regarding how long a controller can be absent before a period of review, shadowing, retraining, or re-qualification is required, and addressing interim performance verification measures between re-qualification intervals.

#### 9.1.1.5 Calibration and Maintenance

The calibration and maintenance plan for the instrumentation and SCADA system will be developed using guidance provided in API RP 1130, Computational Pipeline Monitoring for Liquid Pipelines (API 2007) where applicable and 49 CFR 192.631.

A Computerized Maintenance Management System (CMMS) should be implemented to track, prioritize, and document equipment repairs. Controller log notes will be periodically reviewed for concerns regarding mechanical problems. This information will be tracked and prioritized. Maintenance of field related instrumentation repairs affecting SCADA data (local or remote) will also be tracked, prioritized and documented.

#### 9.1.1.6 Gas Measurement Validation

A gas measurement validation system should be used to balance, store, and manage vital gas measurement data. It should also validate the meter output with check calculations and store meter setpoints and configuration information; it becomes the main tool in the corporate measurement exception resolution effort. This system should also integrate with field laptops to gather data on meter proving and testing and comply with API Manual of Petroleum Measurement Standards (MPMS) Chapter 11.1 (2004).

#### 9.1.1.7 Other

- Implement individual controller log-in provisions.
- Provide SCADA computer process load information tracking.

### 9.1.2 Backup SCADA Location

The necessity of a backup SCADA system will be evaluated based on NIST Special Publication 800-53 (NIST 2013) as an alternative processing site and an alternative storage site. Alternate processing sites are geographically distinct from primary processing sites. An alternate processing site provides processing capability in the event the primary processing site is not available or accessible. Issues considered will include inclement weather, accessibility, terrorist attacks, etc. Should a backup SCADA and storage site be necessary, it could be located at a preselected site, such as the Fairbanks Lateral Facility Operations and Maintenance (O&M) office. A SCADA backup system will be tested at least once each calendar year, but at intervals not to exceed 15 months according to meet the testing requirements of 49 CFR 192.631.

### 9.1.3 System Databases

#### 9.1.3.1 Real-Time Database

The SCADA system will incorporate a real-time database and historian. The information on these databases will be used to generate operations reports and trends.

#### 9.1.3.2 Business Database

The SCADA system will send necessary information to a business database/historian. The information will be used to file reports to outside entities, such as government regulators and provide information for business analysis. For security either a Demilitarized Zone or a Waterfall Unidirectional Security Gateway will be used for data sharing between the corporate network database and the SCADA network database.

### 9.1.4 Leak Detection and Emergency Response

A SCADA system will be implemented to collect measurements and data along the pipeline, including flow rate through the pipeline, operational status, pressure, and temperature readings. This information may be used to assess the status of the pipeline. The SCADA system will provide pipeline personnel with real-time information about equipment malfunctions, leaks, or any other unusual activity along the pipeline.

#### 9.1.4.1 Leak Detection System (LDS) Plan

The Leak Detection System (LDS) Plan will include provisions for:

- Implementing applicable provisions in API RP 1130, Computational Pipeline Monitoring for Liquid Pipelines (API 2007).
- Addressing the following leak detection system testing and validation issues:
    - Routine testing to ensure degradation has not affected functionality.
    - Validation of the ability of the LDS to detect small leaks and modification of the LDS as necessary to enhance its accuracy to detect small leaks.
    - Conduct a risk analysis of pipeline segments to identify additional actions that would enhance public safety or environmental protection.
    - Developing data validation plan (ensure input data to SCADA is valid).
- Defining leak detection criteria in the following areas:
    - Minimum size of leak to be detected regardless of pipeline conditions (slack, transient, etc., as related to the ASAP pipeline configuration.
    - Leak location accuracy for various pipeline conditions.
- Response time for various pipeline conditions.
- Providing redundancy plans for hardware and software and a periodic test requirement for equipment to be used live (also applies to SCADA equipment).

#### 9.1.4.2 Emergency Response Plan

The pipeline operator will develop and implement an Emergency Response Plan in accordance with 49 CFR 192.615 to minimize the hazards resulting from a pipeline emergency, including a leak. The Emergency Response Plan will at a minimum include:

- Procedures for receiving, identifying, and classifying notices of events which require immediate response by the operator.
- Procedures for notifying fire, police, and other public officials as necessary; establishing and maintaining adequate means of communication with appropriate officials; and coordinating responses in the event of an emergency.
- Procedures for the prompt and effective response to a notice of emergency events, including gas detection inside or near a building, fire near or involving the pipeline or related facilities, explosions near or involving the pipeline or related facilities, or a natural disaster.
- Availability of personnel, equipment, tools, and materials needed at the scene of an emergency.
- Procedures for emergency shutdown and pressure reduction in any section of the pipeline system as necessary to minimize hazards to life or property.
- Procedures for protecting life and property in the event of an emergency.

#### 9.1.4.3 Pipeline Modeling and Operator Training

Pipeline modeling will aid in pipeline operations and future design by providing transient fluid flow simulation of the gas network. Control system analysis, equipment performance analysis, temperature analysis, composition analysis, and pressure-flow capacity analysis can be simulated. The model will be able to provide the necessary information (real values or simulated values) to a pipeline simulator used for operator training. The integrated simulation and training system must also provide a convenient way to test changes to the SCADA system before being implemented. This will be used to minimize the risk of incorrectly matching the system changes, as well as reducing the time and the cost of implementation.

## 9.2 FIELD LOCATIONS

### 9.2.1 Block Valve Control and Valve Locations

Block valves will be remotely controlled and actuated; the SCADA system will be capable of closing the valve and monitoring the valve position, upstream pressure, and downstream pressure so as to minimize the response time in the case of a failure. Earthquake and temperature monitoring will be included where applicable.

An Uninterruptible Power System (UPS) will be required for each block valve location consisting of a battery backup system and a small gas fired generator in case of emergencies. UPS and lightning protection according to NFPA 780 (2013) is required to ensure communications are maintained during inclement weather. Block valves must be capable of closure at all times.

A building will be required to house the UPS, remote telemetry unit (RTU), fiber optic communications amplifier, and other support equipment in order to maintain cyber security. The building should be designed to use low power equipment, LED lighting, and provide protection for personnel during adverse weather.

Access to block valve facilities should be restricted via employee key card and keypad access. The facility should be monitored by remote controlled video cameras.

The equipment at the site will be designed and configured to enhance safe operations of the pipeline. In case of a simultaneous communications failure and a pipeline failure, it is imperative the operation of the block valve act independently with local logic solving features. The safety system should be designed in compliance to IEC 61511 / ISA 84 as a Safety Instrumented System (SIS) and achieve a Safety Integrity Level (SIL) of 2 as a minimum.

Equipment at block valve locations includes:

- Pressure transmitters, located both upstream and downstream of the block valve. The information from these devices will be used to calculate a rate of change of pressure to determine if a line break has occurred. The pressure also will be used as a part of the pipeline leak detection system. The tubing of these devices should be electrically isolated from the pipeline system. The transmitters should be mounted in a clamshell enclosure giving full access with a small heater to ensure instruments stay above the temperature rating of the device.

- Valve position feedback will be required for proper monitoring. The conduit for this device will need a small heater to prohibit moisture build up in the conduit system.
- Weather station. A small weather station providing wind, temperature, and other information.
- Seismic sensors may be required in earthquake prone areas. Information from these devices may also be used to trigger closure of the valve.
- Intrusion alarms used to trigger the SCADA system to alert operators of unauthorized entry into the area.
- Security camera with pan, tilt, and zoom. The security camera should take occasional low resolution snap shots, and if motion is sensed, it should alert the SCADA operator and begin recording. Compressed data should be sent over the fiber network.
- Security camera server. To limit the bandwidth required for the overall network, it is recommended that video storage be implemented at each location. This information will be available on demand at any other location.
- Thermal electric generator (TEG) operation and alarms.
- Generator operation and alarms.
- Control system operation and alarms.
- Fiber optic amplifier and ethernet managed switches
- Voice over IP telephone (VOIP).
- Employee card reader to ensure only Operator Qualified (OpQual) personnel are assigned to tasks and track location in case of emergency.
- Gas detection alarms for un-odorized gas within the generator area.
- CP deep well anode test site if necessary.
- CP impressed current rectifier if necessary. If a rectifier is located at the block valve site then the alarms should be tied into the local RTU.

In-line tool passage sensors may be required at select locations.

In the event a particular valve must be located in an area where the communications to the SCADA system is not feasible, a line break valve control system using differential pressure, rate of pressure drop, or other widely-accepted method may be an acceptable alternative to remote valve control. (49 CFR 192.620)

### 9.2.2 Cathodic Protection

Rectifiers will communicate to the SCADA system and comply with 49 CFR 192.465, External corrosion control: Monitoring. Each cathodic protection rectifier or other impressed current power source must be monitored to ensure it is operating.

### 9.2.3 Measurement and Regulation Sites

The Measurement and Regulation (M&R) sites will have a building to house the UPS, RTU, fiber optic communications amplifier, and other support equipment to maintain cyber security. The building should be designed to use low power equipment, LED lighting, and provide protection for personnel from adverse weather.

Access to M&R facilities should be restricted via employee key card and keypad access. The facility should be monitored by remote controlled video cameras.

The control system at the M&R facility will comply with the safety requirements of IEC 61511 / ISA 84 where applicable.

The M&R site will provide a redundant communication path to the SCADA system. The volume and frequency of measurement and regulation data transmitted to the SCADA system will be based on the leak detection requirements, pipeline modeling requirements, and 49 CFR 192. Lightning protection will be implemented according to NFPA 780.

Gas chromatographs will be required at all measurement and regulations sites. Other equipment at a custody transfer station may include a filter separator, tankage, gas measurement, flow control, regulation, gas line heaters, and odorizing equipment. This equipment should be pre-packaged, and mounted on skids with appropriate enclosures. The controls and instrumentation should be pre-wired and tubed on each skid with loop drawings showing proper terminations.

Control equipment may include all the devices above and the equipment listed here:

- Liquid levels and alarms.
- Differential pressure measurement across devices.
- Gas measurement and totalization.
- Gas measurement meter tube run way switching.
- Gas quality analysis, including heating value, and dew point.
- Pressure regulation control and run switching, including relief valves.
- Flow control.
- Odorant injection pumps and odorant flow control.
- Line heater control, including temperature control of the gas, emissions control of the line heater, and fuel measurement of line heater consumption.
- Customer equipment support for power and data sharing; this may include RTU, measurement, and regulation buildings.

The design and layout of this equipment must ensure enclosures will meet the proper hazardous location criteria according to the National Electrical Code (NEC), arc flash, and battery installations of NFPA 70E (2014), and working space requirements of the Occupational Safety and Health Administration (OSHA).

## 9.3 SCADA SECURITY

Design of the SCADA system will comply with API STD 1164, Pipeline SCADA Security (2009), NIST SP800-53 (2013), and North American Electric Reliability Corporation (NERC). CIP (Critical Infrastructure Protection) CIP-002-1 through CIP-009-2 (previously NERC 1300) where applicable and NIST SP 800-82, Guide to Industrial Control Systems Security (2011). The SCADA system must be on a stand-alone network. The SCADA network will not handle business traffic, such as telephone or email, and access to it will be restricted.

Effectively integrating security into SCADA requires defining and executing a comprehensive program that addresses all aspects of security, ranging from identifying objectives to day-to-day operation and ongoing auditing for compliance and improvement. Elements of this program are defined in NIST SP 800-82 as:

- Obtain senior management buy-in.
- Build and train a cross-functional team.
- Define charter and scope.
- Define specific SCADA and control system policies and procedures.
- Define and inventory SCADA and control system assets.
- Perform a risk and vulnerability assessment.
- Define the mitigation controls.
    - The mitigation controls include business continuity planning, disaster recovery planning, configuration management, malicious code detection, intrusion detection system (IDS), and change management. These documented controls will be developed during design and integrated into the SCADA and automation systems.
- Provide training and raise security awareness for SCADA and control system staff.

The SCADA security controls developed by this team are the management, operational, and technical controls (i.e., safeguards or countermeasures) prescribed for an informational system to protect the confidentiality, integrity, and availability of the system and its information. These controls will follow the NIST Framework for Improving Critical Infrastructure Cybersecurity (2014).

It is recommended ISA/IEC 62443 (IEC v.d.) be followed to determine the risk and vulnerability. By defining acceptable risk each security zone can be assessed using the seven functional requirements to calculate a Security Assurance Level (SAL). This is similar to the Safety Integrity Level (SIL) used to assess risk for Safety Instrumented Systems.

**Table 15 Probability vs Consequence Security Assurance Level (SAL) Level**

| CORRESPONDING PROBABILITY | CONSEQUENCES | | | |
|---|---|---|---|---|
| | NO IMPACT | MINOR | MAJOR | VERY SEVERE |
| **High** | Medium Risk SAL 2 | High Risk SAL 3 | Very High Risk SAL 4 | Very High Risk SAL 4 |
| **Medium** | Medium Risk SAL 2 | High Risk SAL 3 | Very High Risk SAL 4 | Very High Risk SAL 4 |
| **Low** | Low Risk SAL 1 | Medium Risk SAL 2 | Medium Risk SAL 2 | High Risk SAL 3 |
| **Very Low** | Low Risk SAL 1 | Low Risk SAL 1 | Medium Risk SAL 2 | High Risk SAL 3 |

Cyber security countermeasures may be necessary in the event of high risk. Should countermeasures be necessary for field devices and remote locations, AGA Report No. 12 (AGA 2006) will provide necessary guidance.

A network management and monitoring system will be installed to track network health. This system will also be used to track the physical inventory of all SCADA assets.

A Security Information and Event Management (SIEM), focusing on Log and Event Management, will be specified. This system monitors the network devices and contains the firewall rules. In the event of a network anomaly, an alarm will be generated and the network will take action based on the predetermined rules.

Interfaces to the SCADA system will follow the NIST Cybersecurity Framework (NIST 2014) and comply with ISA/IEC 62443 (IEC v.d.), NIST SP 800-53 (2013), NIST SP800-82 (2011).

# 10. TELECOMMUNICATION SYSTEM NETWORK

The telecommunication system network will be a fiber optic cable (FOC) system installed within the ASAP ROW for the entire length of the mainline and Fairbanks Lateral. The system will connect the Pipeline Operations Control Center and O&M offices in Prudhoe Bay, the backup SCADA control center, O&M offices in Fairbanks, and the O&M office in Wasilla to all block valves and other control/monitoring facilities along the pipeline. This fiber optic cable system will connect to GCI's existing fiber optic network at each of the control center/O&M offices, creating a diverse fiber optic network of two resilient packet rings, ensuring continuing operation in the event of a cut in the fiber optic cable at any point in the system. A Recommended Telecommunication System Schematic showing this proposed system is included as Figure 6, Telecommunication System Schematic.

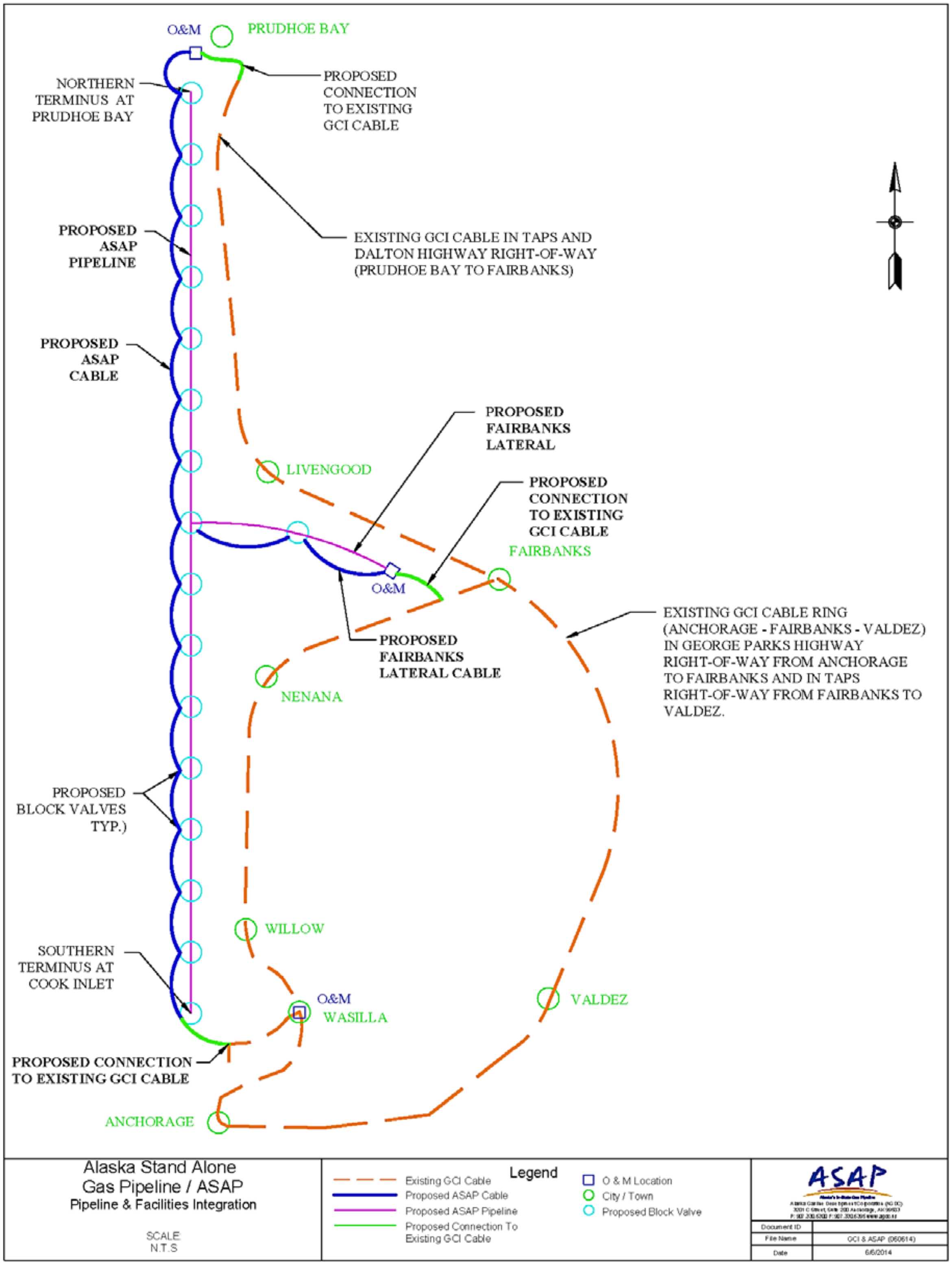
The proposed FOC system will be installed primarily belowground near the pipeline ROW, except in specific areas where existing features require the FOC to be installed aerially. Below ground installation near the ROW ensures the construction, operation, and maintenance of the FOC will not interfere with the established standards of the ASAP pipeline and facilities while also maximizing the integrity of the FOC system to ensure uninterrupted communications service for ASAP. Where the FOC system must be installed aerially, specific construction methods and equipment will be used to provide protection from exposure to arctic elements and from other detrimental impacts.

## 10.1 SYSTEM COMPONENTS

### 10.1.1 Fiber Optic Cable

The fiber optic cable selected for the ASAP telecommunications system network must possess the physical attributes to operate at full capacity with minimal impact to transmission rate or quality under temperature conditions that are occasionally expected to be –50°F or below and in some areas that are constantly below freezing. The fibers must be able to provide the necessary transmission rate of the systems being serviced by the cable. The size of the cable (i.e., number of fibers) will be determined based upon the required capacity of the features or systems being serviced by the FOC and the number of facilities to be serviced along the route. The cable will be delivered on 20,000-foot reels, which is the typical industry standard for cable length before signal regeneration is typically required.

## Figure 6. Telecommunication System Schematic



### 10.1.2 Buried Installation – Mainline and Fairbanks Lateral

For the majority of its length, the cable will be buried, installed in a protective plastic innerduct sized to allow the cable to be pulled within allowable pulling tolerances. The innerducts will be flexible enough to allow for bends to be formed in the field where possible for changes in both horizontal and vertical alignment. Where the innerduct cannot be bent to the desired curvature, preformed sweeps having a minimum radius of 4 feet will be used. Excavated trenches around innerducts will be backfilled with sand or other small-grained materials to allow the innerducts to slightly adjust alignment within the trench due to rock slides or tremors. A minimum of 3 innerducts will be installed during trenching operations, providing 1 for cable installation, 1 for use during possible future cable replacement, and 1 as a spare for emergency uses.

### 10.1.3 Cable Splicing & Splice Manholes

Reels of cable will be spliced together at patch panels in the MLBV structures where the ends of the cable are within 2,000 feet of the structure. Where the ends of the cable are not within 2,000 feet of the MLBV, the cables will be spliced in Splice Manholes installed 3 feet from the edge of the pipeline ROW. The manhole will be of sufficient size to allow access to the cable within the manhole and to allow for racking of cable loops and splice enclosures within the manhole. The manhole will be of sufficient composition to provide a permanent enclosure unaffected by exposure to severe arctic elements. A grounding rod will be installed in undisturbed earth in the vicinity of every splice. Sufficient slack cable on each side of cable splices will be coiled and racked in MLBV structures and splice manholes.

### 10.1.4 Pull Boxes

Quazite Pull Boxes will be installed approximately every 2,000 feet along the cable alignment to facilitate cable installation. Pull boxes will also be installed at significant PI in the cable alignment and within the fenced area at MLBV, launcher/receiver sites, and at pipeline termini. The pull boxes will be of sufficient size to permit access and hold coiled cable, and installed flush to the existing ground surface. The bottom of the pull box will be open, set on a 6-inch thick layer of aggregate. Twenty feet of slack cable will be coiled and laid in each pull box.

### 10.1.5 Galvanized Steel Casing Pipe

In the areas where the cable system is to be attached to an existing bridge, a galvanized steel casing pipe will be attached to the structure to house the innerducts. Attachment of the casing pipe to the bridge structure is yet to be determined. It is anticipated steel hangers will be used to attach the casing pipe to the structure. The steel casing pipe will be threaded and connected into 100-foot long sections that will be connected using expansion joints.

### 10.1.6 HDPE Casing Pipe

An HDPE pipe will be installed to serve as a casing for the innerducts at all horizontal bores (jack and bores), HDD locations, and vertical attachments to structures where protection of the innerducts is required.

### 10.1.7 Duct Plugs

Duct plugs will be installed in the ends of all casing pipes and innerducts to eliminate or minimize debris or water from accumulating in or passing through the innerducts and conduits. Blank duct plugs will be installed in the ends of all vacant innerducts. Simplex duct plugs will be installed in the ends of all innerducts housing a fiber optic cable. Triplex duct plugs will be installed in the ends of all casing pipes around the three innerducts.

### 10.1.8 Grounding Rods

Grounding rods will be installed at all cable splices manholes. A 5/8-inch diameter grounding rod, 8 feet long, will be driven into undisturbed earth adjacent to the manhole. A #6 AWG insulated solid copper ground wire will be attached to the rod. The other end of the ground wire will be attached to the splice casing.

### 10.1.9 Cable Markers

Marker stakes will be installed at both sides of road, railroad, utility, and other pipeline crossings, at both ends of horizontal bores and HDDs, and at sufficient distances along the route to ensure visibility in both directions from any marker. The markers will be flat and flexible, approximately 4 inches wide and 66 inches long. Marker Numbers, Splice (S) or Pull Box (P) Designations, and Warning signs noting ownership and contact information will be affixed to the markers.

## 10.2 SPECIAL DESIGN CONSIDERATIONS

### 10.2.1 Brush/Forest Fires

At the few areas where the FOC system is installed aerially, the system will be designed to prevent the loss of telecommunication service caused by brush/forest fire.

### 10.2.2 Frost Action/Permafrost

The FOC system will be designed to accommodate differential movement caused by frost heaving or thaw settlement. A design will be submitted which demonstrates the maximum tolerable displacement of all critical components of the FOC system in all surface and subsurface conditions to be encountered along the FOC alignment. When the expected displacements exceed the tolerable displacements in any condition, a mitigative plan must be demonstrated to lower the estimated displacement to allowable limits.

The FOC system will be designed to minimize water infiltration into any conduit or casing where freezing may occur.

#### 10.2.3 Slope Stability

The FOC system will be designed to prevent loss of telecommunication service caused by slope instability or other ground movement. Special consideration will be given to the stability of any cuts and fills. Criteria will be established to identify potentially unstable slopes where the FOC system is to be installed. Potentially unstable slopes will be identified.

#### 10.2.4 Rock Fall/Avalanche

The FOC system will be designed to prevent loss of telecommunication services through rock fall or avalanche. All FOC components within the limits of the rock fall/avalanche potential limits will be demonstrated to withstand the increased overburden and/or direct forces caused by the rock fall/avalanche or a mitigative plan will be detailed to eliminate integrity problems during the event.

#### 10.2.5 Corrosion

The FOC system will be designed to prevent system deterioration due to water or other means. All critical components will address possible sources of corrosion (or other material degradation, e.g., UV) based on the material composition and experience with the hardware. Rates of degradation will be documented for each source of material/component degradation. Each component will be demonstrated to sustain system integrity at the maximum corrosion rate over the design life. Where it cannot be demonstrated degradation will not affect the integrity of the system, a mitigative plan will be detailed to maintain full system integrity.

#### 10.2.6 Security

The FOC system will be designed to minimize the possibility of loss of telecommunication service through acts of sabotage. A risk analysis of the FOC system will be completed. The risk analysis will address natural hazards and sabotage, terrorism, vandalism, and accidents. Higher risk areas along the FOC alignment will be identified. A plan will be detailed to maintain system integrity for any identified hazard for higher risk locations.

### 10.3 CONNECTIONS AT BLOCK VALVES, LAUNCHERS/RECEIVERS AND PIPELINE TERMINI

At all block valves and intermediate launcher/receiver locations, a small structure will be installed inside a fenced secure area to house the RTU and hardware for the SCADA and telecommunication systems and the power generator equipment for the site. Pull boxes will be set on the standard alignment once inside the fenced area. The general alignments of the “incoming” and “outgoing” innerducts from the pull boxes to the structures will be separated as far apart as possible to minimize the chance of the innerducts being simultaneously impacted by future construction.

## 10.4 CONNECTION TO EXISTING GCI FIBER OPTIC NETWORK

At the GCF, GCI will install cable to the various facilities as required, including the pipeline telecommunications system. Therefore, connection to the GCI system is included as part of the GCF development and not as a separate item for the telecommunication system.

At the south terminus of the mainline and the east terminus of the Fairbanks Lateral, the telecommunication system will connect with the existing GCI system. It is assumed connection to the GCI system will occur at the nearest point and the characteristics of GCI's fiber optic cable network can meet the requirements of the ASAP telecommunications system.

## 10.5 POWER FOR THE FIBER OPTIC NETWORK

Power for the fiber optic cable signal at the O&M offices will be provided by the local commercial electric power provider. Gas-powered generators will be installed at the O&M offices to provide a back-up electric power source in the event of commercial power outage. Electrical power at block valve structures and other facilities along the pipeline will be provided by the local commercial electric power provider, where available. A UPS system will be required for each site consisting of a battery backup system and a small gas-fired generator in case of emergencies. However, commercial power is not expected to be available at many of the facilities along the pipeline. In this case, electric power at those facilities will be provided by TEG in addition to the UPS.

## 10.6 SATELLITE BACKUP CONTROL SYSTEM

Satellite communication will provide a backup control system to the fiber optic line at critical locations. The extent of the system has not been determined. As the design becomes more refined, the need and quantity of satellite receivers will be determined and a cost estimate developed.

# 11. CORROSION CONTROL

This section outlines the basic CP design criteria established to mitigate corrosion and maintain structural integrity. Applicable regulations, codes, and criteria pertaining to CP are presented.

## 11.1 APPLICABLE CODES AND REGULATORY REQUIREMENTS

The primary governing criteria for the construction and operation of the proposed natural gas transmission line is 49 CFR 192. This federal regulation is administered by the U.S. Department of Transportation Office of Pipeline Safety, which is part of PHMSA. Of particular interest for cathodic protection requirements are the following:

- Subpart Part I – Requirements for Corrosion Control
- Appendix D – Criteria for Cathodic Protection and Determination of Measurements

The primary industry technical organization responsible for the development of standard recommended corrosion control practices is NACE International. The two NACE cathodic protection standard practices that will play a key role in the design, construction, and monitoring of the cathodic protection system for this pipeline are:

- SP0169-2013, Control of External Corrosion on Underground or Submerged Metallic Piping Systems
- RP0104-2004, The Use of Coupons for Cathodic Protection Monitoring Applications

ASAP will be required to have CP applied to all buried and submerged sections of the pipeline. Monitoring and maintenance requirements will also be required to demonstrate the pipeline is adequately protected from corrosion. Since strain based design is being considered for portions of the mainline, PHSMA special conditions may apply. The effect of these possible conditions on corrosion control design and monitoring requirements has not yet been fully established.

## 11.2 CATHODIC PROTECTION

CP will be applied by one of two methods. The first is through the use of sacrificial anodes. This methodology is sometimes referred to as a galvanic anode system because the anodes are higher (more active) in the galvanic series than the steel they are protecting

The second method of CP uses a DC current source (usually supplied by an AC to DC rectifier) and is often referred to as an impressed current system. This method of CP operates by impressing a DC current through the soil by way of an anode groundbed. There are many configurations for impressed current CP systems.

Coupon monitoring stations will be placed at intervals necessary to evaluate the effectiveness of the CP system.

### 11.2.1 Design Considerations

The following design considerations will be addressed as the project progresses from a preliminary engineering phase to a formal design development phase. Many of the issues are interrelated and resolving one may impact the ability to resolve another.

#### *11.2.1.1 Soils*

Differing soil types are anticipated along the pipeline route. Soil characteristics will likely include silt, sand, gravels, peat, organics, rock, ice, and water. Water content in each of these soil types could vary significantly depending on location and time of year. Many of these soils will freeze seasonally and some may be frozen year round. Where soils are aerated and saturated with water, higher corrosion rates are anticipated. Where soils remain frozen throughout the year, external corrosion rates should be minimal.

Soil resistivity, which depends largely upon the nature and amount of dissolved salts in the soil, affects the rate of corrosion. The lower the resistivity, the better the soil conducts current flow and the greater the soil corrosivity. Low resistivity soils may contain high concentrations of soluble salts. The salts attack the protective oxide films on the steel surface, accelerating the rate of the electrochemical reactions.

Soil resistivities and how they affect the corrosivity of the soil and CP current distribution to the pipeline will be analyzed. Soil resistivities along the pipeline route may range from a few thousand ohm-cm to highs exceeding 1,000,000+ ohm-cm. The microenvironment near the pipeline surface may also be quite different than the bulk soil in the surrounding area. Each type of soil in each region requires a careful analysis to assist in the planning process for a CP installation.

Soil pH is often considered to be one of the controlling factors in underground corrosion. Soil pH is a measure of the environment's hydrogen-ion activity. In low pH environments (acidic), the protective corrosion films on steel are de-stabilized, resulting in localized or accelerated corrosion. In neutral pH environments, sulfate-reducing anaerobic bacteriological corrosion may occur. In high pH environments (alkaline), steel develops protective passive films.

Soil pH along the pipeline route will vary significantly (approximately 5-8). The varying pH may present localized corrosion conditions that will need to be addressed.

#### *11.2.1.2 Telluric Currents*

The concern over telluric currents is they cannot be controlled because they are generated by changes in the earth's magnetic field. Where telluric currents come into contact with a pipeline, they can collect and discharge using the pipeline as a low resistance path between regions of high and low resistivity. When CP levels get too high, they can cause coatings to fail prematurely. Where CP is insufficient, corrosion will likely occur. Where the current leaves the pipeline in concentrated locations, pitting can occur. Given this information, it is critical to address the safe collection and discharge of telluric currents on a well coated pipeline.

Telluric current effects will be accounted for by installing resistive bonds and galvanic anodes (current discharge capabilities) as determined necessary.

#### *11.2.1.3 High Voltage Power Lines*

The pipeline will run next to or cross the ROW of a high voltage electrical power transmission line. If the pipeline is not properly grounded and AC interference mitigation measures are not properly implemented at the time of construction, accelerated corrosion could result. AC grounding mats and/or cells will be installed where possible adverse AC interference affects may occur.

#### *11.2.1.4 Road Crossings*

Whenever possible, cased road crossings will be avoided. Cased crossings can create zones where the pipe is shielded from the CP current and create ongoing testing, monitoring and repair problems.

#### *11.2.1.5 Buried Field Joints*

Coating of field joints is often problematic and requires specific attention during the design and construction phases of this project. Certified coating inspectors should be used to inspect and monitor the field coating application during the construction phase of this project. If field joints are not coated properly, accelerated corrosion rates may occur near the field weld heat affected zone and an additional demand will be placed on the CP system.

#### *11.2.1.6 Stress Corrosion Cracking (SCC)*

SCC is known to occur under a narrow range of conditions in which cyclical stresses and environmental conditions in the soil combine to cause a form of cracking in the steel known as stress corrosion cracking. This most frequently occurs within a short distance of the compressor stations, where pressure in the pipeline is less constant, the line is still warm from the hot gases exiting the compressors and the CP system is nearby and is operating at high levels. ASAP will not have intermediate compressor stations, so this phenomenon should have minimal impact.

### 11.2.2 Criteria for Cathodic Protection

Title 49 CFR 192, Appendix D states:

> *Criteria for cathodic protection—*
>
> *Steel, cast iron, and ductile iron structures.*
>
> *(1) A negative (cathodic) voltage of at least 0.850 volt, with reference to a saturated copper-copper sulfate half-cell. Determination of this voltage must be made with the protective current applied, and in accordance with sections II and IV of this appendix.*

*(2) A negative (cathodic) voltage shift of at least 300 millivolts. Determination of this voltage shift must be made with the protective current applied, and in accordance with sections II and IV of this appendix. This criterion of voltage shift applies to structures not in contact with metals of different anodic potentials.*

*(3) A minimum negative (cathodic) polarization voltage shift of 100 millivolts. This polarization voltage shift must be determined in accordance with sections III and IV of this appendix.*

*(4) A voltage at least as negative (cathodic) as that originally established at the beginning of the Tafel segment of the E-log-I curve. This voltage must be measured in accordance with section IV of this appendix.*

*(5) A net protective current from the electrolyte into the structure surface as measured by an earth current technique applied at predetermined current discharge (anodic) points of the structure.*

## 11.3 CORROSION CONTROL MONITORING

Title 49 CFR 192.465 for external corrosion control monitoring of pipelines states:

*(a) Each pipeline that is under cathodic protection must be tested at least once each calendar year, but with intervals not exceeding 15 months, to determine whether the cathodic protection meets the requirements of §192.463. However, if tests at those intervals are impractical for separately protected short sections of mains or transmission lines, not in excess of 100 feet (30 meters), or separately protected service lines, these pipelines may be surveyed on a sampling basis. At least 10 percent of these protected structures, distributed over the entire system must be surveyed each calendar year, with a different 10 percent checked each subsequent year, so that the entire system is tested in each 10–year period.*

*(b) Each cathodic protection rectifier or other impressed current power source must be inspected six times each calendar year, but with intervals not exceeding 2 1/2 months, to insure that it is operating.*

*(c) Each reverse current switch, each diode, and each interference bond whose failure would jeopardize structure protection must be electrically checked for proper performance six times each calendar year, but with intervals not exceeding 2 1/2 months. Each other interference bond must be checked at least once each calendar year, but with intervals not exceeding 15 months.*

*(d) Each operator shall take prompt remedial action to correct any deficiencies indicated by the monitoring.*

*(e) After the initial evaluation required by §§192.455(b) and (c) and 192.457(b), each operator must, not less than every 3 years at intervals not exceeding 39 months, reevaluate its unprotected pipelines and cathodically protect them in accordance with this subpart in areas in which active corrosion is found. The operator must determine the areas of active corrosion by electrical survey. However, on distribution lines and where an electrical survey is impractical on transmission lines, areas of active corrosion may be determined by other means that include review and analysis of leak repair and inspection records, corrosion monitoring records, exposed pipe inspection records, and the pipeline environment.*

### 11.3.1 Test Station Type and Spacing

CP coupon style test stations will be installed along the entire length of the pipeline to assess the adequacy of the CP system and to correct for voltage drops, including those associated with telluric currents. A CP coupon test station, with dual coupons (CP and free corroding coupons), will be installed approximately every 1/2 mile (minimizing splices to the magnesium ribbon between test stations), in high consequence areas, at river and creek crossings, and at significant terrain changes. GPS synchronized current interrupters, powered by solar panels or lithium dry cell batteries, will be installed at all coupon test station locations to facilitate monitoring and CP survey activities.

CP coupons represent the best available technology for monitoring CP effectiveness in this environment. Coupons should have a baseline set of potential readings taken after they are installed and then again after CP has been applied to the pipeline. A 2-coupon system will be used so native or free corroding potentials can be determined without waiting long periods for polarization decay. This will facilitate summer CP surveys and improve survey crew efficiency.

Coupons assess the adequacy of a CP system and may be used to determine compliance with criteria outlined by the regulations and industry standards. A minimum of -850 mV (CSE) polarized potential and/or 100 mV polarization are the criteria typically used to indicate whether adequate cathodic protection has been achieved. Additionally, coupons can provide a means of determining the current density to the pipeline in the area of the coupon. Current density is dependent on the amount of cathodic protection and induced AC current in an area.

The coupons will be sized to represent a large coating defect for a 36-inch diameter pipeline with a high quality coating. The exact size of the coupon will be determined in the final design phase of this project.

# 12. REFERENCE DOCUMENTS

40 CFR 122. EPA Administered Permit Programs: The National Pollutant Discharge Elimination System.

40 CFR 230. Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material.

49 CFR 192. Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards.

Alaska Department of Environmental Conservation (ADEC). 2012. Best Management Practices for Gravel/Rock Aggregate Extraction Projects. September 2012. https://dec.alaska.gov/water/wnpspc/protection_restoration/BestMgmtPractices/Docs/GravelRockExtractionBMPManual.pdf

Alaska Department of Fish and Game (ADF&G). 2005. Streambank Revegetation and Protection: A Guide for Alaska. Revised April 2005.

Alaska Department of Fish and Game (ADF&G). 2013. Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes.

Alaska Department of Fish and Game / 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. August 2001.

Alaska Department of Natural Resources (ADNR). 2011. Alaska Stand Alone Pipeline/ASAP Right-of-Way Lease, ADL 418997. June 29, 2011.

Alaska Department of Transportation and Public Facilities (ADOT&PF). 2004. Standard specifications for highway construction.

Alaska Department of Transportation and Public Facilities (ADOT&PF). June 13, 2006. Alaska Highway Drainage Manual.

Alaska Department of Transportation and Public Facilities (ADOT&PF). November 15, 2013. Alaska Highway Preconstruction Manual.

Alaska Department of Transportation and Public Facilities (ADOT&PF). 2004. Standard Specifications for Highway Construction.

Alaska Department of Transportation and Public Facilities (ADOT&PF). 2013. Alaska Highway Preconstruction Manual.

Alaska Department of Transportation and Public Facilities (ADOT&PF). 2007. Engineering Geology and Geotechnical Explorations Procedures Manual. http://www.dot.state.ak.us/stwddes/dcspubs/index.shtml#

Alaska Statute (AS) Title 16: Fish and Game.

American Association of State Highway Transportation Officials (AASHTO). 2004. A Policy on Geometric Design of Highways and Streets.

American Association of State Highway Transportation Officials (AASHTO). 2001. Guidelines for Geometric Design of Very Low Volume Local Roads (ADT≤400).

American Gas Association (AGA). 2006. Cryptographic Protection of SCADA Communications. AGA Report No. 12. March 14, 2006.

American Institute of Steel Construction (AISC). 2005. ANSI-AISC 360-05 Specification for Structural Steel Buildings and Commentary. March 2005.

American Lifelines Alliance (ALA). 2001. Guidelines for the Design of Buried Steel Pipelines. American Lifelines Alliance, a public-private partnership between the Federal Emergency Management Agency (FEMA) and the American Society of civil Engineers (ASCE). July 2001 (with addenda through February 2005).

American Petroleum Institute (API). 2004. API Manual of Petroleum Measurement Standards (MPMS). Chapter 11.1 - Temperature and Pressure Volume Correction Factors (VCF) Software for Generalized Crude Oils, Refined Products, and Lubricating Oils (Single User), Includes September 2007 Addendum 05/01/2004.

American Petroleum Institute (API). 2007. API RP 1130. Computational Pipeline Monitoring for Liquid Pipelines. First Edition. 2007.

American Petroleum Institute (API). 2007b. API RP 1165 (R2012), Recommended Practice for Pipeline SCADA Displays, First Edition. 01/01/2007.

American Petroleum Institute (API). 2008. API RP 1168, Pipeline Control Room Management. First edition. September 1, 2008.

American Petroleum Institute (API). 2009. API STD 1164. Pipeline SCADA Security.

American Petroleum Institute (API). 2010. API Recommended Practice 1162. Public Awareness Programs for Pipeline Operators. The most recent version incorporated in 49 CFR 192.616. Current version 12/01/2010.

American Petroleum Institute (API). 2010b. API RP 1167, Pipeline SCADA Alarm Management. First Edition. 12/01/2010.

American Petroleum Institute (API). API 1104. Welding of Pipelines and Related Facilities. 20th edition.

American Petroleum Institute (API). API 5L. Specification for Line Pipe. 44th edition.

American Petroleum Institute (API). API 5L1. Recommended Practice for Railroad Transportation of Line Pipe. 6th edition.

American Petroleum Institute (API). API 5L2. Recommended Practice for Internal Coating of Line Pipe for Non-Corrosive Gas Transmission Service. 4th edition.

American Petroleum Institute (API). 1975. API 5L5. Recommended Practice for Marine Transportation of Line Pipe. 1st edition.

American Petroleum Institute (API). API 5L9. Recommended Practice for External Fusion Bonded Epoxy Coating of Line Pipe. 1st edition.

American Petroleum Institute (API). 2009. API 5LW. Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels. 3rd edition 2009.

American Petroleum Institute (API). API 6D. Specifications for Pipeline Valves. 24th edition 2014

American Society of Civil Enginers (ASCE). 2005. Manuals and Reports on Engineering Practice No. 108. Pipeline Design for Installation by Horizontal Directional Drilling.

American Society of Civil Engineers (ASCE). 2010. ASCE/SEI 7-10. Minimum Design Loads for Buildings and Other Structures.

ASME International (ASME). 2013. ASME B16.5. Pipe Flanges and Flanged Fittings: NPS ½ Through NPS 24 Metric/Inch Standard.

ASME International (ASME). 2012. ASME B16.9. Factory-Made Wrought Buttwelding Fittings.

ASME International (ASME). 2011. ASME B16.47. Large Diameter Steel Flanges: NPS 26 through NPS 60 Metric/Inch Standard.

ASME International (ASME). 2012. ASME B16.49. Factory-Made Wrought Steel, Buttwelding Induction Bends for Transportation and Distribution Systems.

ASME International (ASME). 2014. ASME B31Q-2014. Pipeline Personnel Qualification. 06/30/2014.

ASME International (ASME). 2010. ASME B31.8. Gas Transmission and Distribution Piping Systems.

ASTM International. ASTM D 1557. 2009. Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort.

Blench, T. 1969. Mobile-Bed Fluviology. Edmonton, Canada: University of Alberta Press. 1969.

Canadian Standards Association. CSA Z662-11. 2011. Oil and gas pipeline systems.

International Electrotechnical Commission (IEC). 2004. IEC 61511-SER. Functional safety - Safety instrumented systems for the process industry sector. 11/30/2004.

International Electrotechnical Commission (IEC). v.d. IEC 62443. Industrial communication networks - Network and system security. Parts have various dates (v.d.).

International Society of Automation (ISA). 2011. ISA TR84.00.04. Guidelines on the Implementation of ANSI/ISA-84.00.01-2004 (IEC 61511). 10/14/2011.

Michael Baker Jr., Inc. (Baker). 2012. Geotechnical Data Report, Tanana River Crossing at Nenana, Alaska. 002-C-24-R-G-0006 Supersedes 121283-MBJ-RPT-023 Rev A. Prepared for Alaska Gasline Development Corp. 2012.

NACE International. NACE RP0104-2004, The Use of Coupons for Cathodic Protection Monitoring Applications.

NACE International. NACE SP0169-2013. Control of External Corrosion on Underground or Submerged Metallic Piping Systems.

National Fire Protection Association (NFPA). 2013. NFPA (Fire) 780. Standard for the Installation of Lightning Protection Systems, 2014 Edition. 06/17/2013.

National Fire Protection Association (NFPA). 2014. NFPA (Fire) 70E. Standard for Electrical Safety in the Workplace, 2015 Edition. 07/29/2014.

National Institute of Standards and Technology (NIST). 2011. NIST SP 800-82. Guide to Industrial Control Systems Security. June 2011.

National Institute of Standards and Technology (NIST). 2013. NIST SP 800-53. Security and Privacy Controls for Federal Information Systems and Organizations. Revision 4. April 2013.

National Institute of Standards and Technology (NIST). 2014. Framework for Improving Critical Infrastructure Cybersecurity. Version 1.0. February 12, 2014.

National Transportation Safety Board (NTSB). 1999. Recommendation P-99-12.

National Transportation Safety Board (NTSB). 2005. Supervisory Control and Data Acquisition (SCADA) in Liquid Pipelines, Safety Study. NTSB/SS-05/02. November 29, 2005.

North American Electric Reliability Corporation (NERC). CIP (Critical Infrastructure Protection) CIP-002-1. Cyber Security — Critical Cyber Asset Identification.

North American Electric Reliability Corporation (NERC). CIP (Critical Infrastructure Protection) CIP-003. Security Management Controls.

North American Electric Reliability Corporation (NERC). CIP (Critical Infrastructure Protection) CIP-004. Personnel and Training.

North American Electric Reliability Corporation (NERC). CIP (Critical Infrastructure Protection) CIP-005. Electronic Security Perimeters.

North American Electric Reliability Corporation (NERC). CIP (Critical Infrastructure Protection) CIP-006. Physical Security.

North American Electric Reliability Corporation (NERC). CIP (Critical Infrastructure Protection) CIP-007. Systems Security Management.

North American Electric Reliability Corporation (NERC). CIP (Critical Infrastructure Protection) CIP-008. Incident Reporting and Response Planning.

North American Electric Reliability Corporation (NERC). CIP (Critical Infrastructure Protection) CIP-009. Recovery Plans for Critical Cyber Assets.

R&M Engineering. 1969. Soils Report Yukon River Crossing No. 1. May 1969.

R&M Engineering. 1970. Trans Alaska Pipeline System Soils and Geology Yukon River Underwater Crossing #4. August 1970.

State of Alaska (SOA). n.d. Construction General Permit. http://dec.alaska.gov/water/wnpspc/stormwater/Index.htm (current).

U.S. Army Corps of Engineers (USACE). 1987. Hydraulic Design Criteria. Coastal & Hydraulics Laboratory. Engineer Research and Development Center. November 1, 1987.

U.S. Department of Transportation Federal Highway Administration. 2012. Evaluating Scour at Bridges. Hydraulic Engineering Circular No. 18 Publication No. FHWA-HIF-12-003. Fifth Edition. U.S. Department of Transportation. April 2012.

U.S. Environmental Protection Agency (USEPA) Construction General Permit (Permit No. AKR 100000 and Permit No. 100001).

U.S. Geological Survey (USGS). 2003. Estimating the Magnitude and Frequency of Peak Stream Flows for Ungaged Sites in Alaska and Conterminous Basins in Canada.

U.S. Geological Survey (USGS). 2011. "Alaska." USGS Earthquake Hazards Program. 2011. http://earthquake.usgs.gov/hazards/products/ak/ (accessed April 2011).

# APPENDIX A - DESIGN BASIS DRAWINGS

| SHEET | TITLE |
|---|---|
| DB-00A | SHEET INDEX |
| DB-ROW-01 | TYPICAL RIGHT OF WAY TUNDRA ICE WORKPAD |
| DB-ROW-02 | FROST PACKED RIGHT OF WAY HIGH SPEED ICE TRAVEL LANE |
| DB-ROW-03 | TYPICAL RIGHT OF WAY WITH 1 LEVEL CUT |
| DB-ROW-03A | TYPICAL RIGHT OF WAY GRADED PAD WITH TWO TONED CUT |
| DB-ROW-03B | TYPICAL RIGHT OF WAY WITHIN HIGHWAY ROW |
| DB-ROW-04 | TYPICAL RIGHT OF WAY GRAVEL WORKPAD |
| DB-ROW-05 | TYPICAL MATTED RIGHT OF WAY |
| DB-ROW-06 | EXTRA TEMPORARY CONSTRUCTION EASEMENT |
| DB-ROW-07 | RIGHT OF WAY TURN AROUNDS |
| DB-FAC-01A | FACILITIES – BLOCK VALVE SITE PLAN |
| DB-FAC-01B | FACILITIES – BLOCK VALVE W/ HELI PAD SITE PLAN |
| DB-FAC-02 | FACILITIES – MAINLINE BLOCK VALVE |
| DB-MODE-01 | BURIED PIPE IN CONVENTIONAL DITCH |
| DB-MODE-02 | BURIED PIPE IN CONVENTIONAL ROCK DITCH |
| DB-MODE-03 | BURIED PIPE WITH OVER-EXCAVATION |
| DB-MODE-04 | PIPE IN ABOVE GROUND BERM |
| DB-MODE-05 | BURIED PIPE TYPICAL STREAM OR RIVER CROSSINGS |
| DB-BC-01 | BUOYANCY CONTROL – CONTINUOUS CONCRETE COATING |
| DB-BC-02 | BUOYANCY CONTROL – BOLT-ON CONCRETE RIVER WEIGHT |
| DB-BC-03 | BUOYANCY CONTROL – SADDLE BAG TYPE WEIGHT |
| DB-XING-01 | ROAD CROSSINGS – LOCAL ROADS |
| DB-XING-02 | ROAD CROSSINGS – ARTERIAL/COLLECTOR ROADS |
| DB-XING-03 | ROAD CROSSINGS – TRAILS/DRIVEWAYS |
| DB-XING-04 | ROAD CROSSINGS – RAILWAY CROSSING |
| DB-XING-05 | FOREIGN PIPELINE CROSSINGS |
| DB-XING-06 | FOREIGN PIPELINE CROSSINGS TAPS ABOVE GROUND |
| DB-XING-07 | FOREIGN PIPELINE CROSSINGS TAPS BELOW GROUND |
| DB-XING-08 | BURIED CABLE CROSSINGS |
| DB-XING-09 | WATERBODY CROSSINGS – TYPICAL FOR MINOR CROSSINGS |
| DB-XING-10 | WATERBODY CROSSINGS – TYPICAL FOR INTERMEDIATE CROSSINGS |
| DB-XING-11 | HORIZONTAL DIRECTIONAL DRILL CROSSING |
| DB-AR-01 | TYPICAL ACCESS ROAD IN FILL |
| DB-AR-02 | TYPICAL ACCESS ROAD WITH 1 LEVEL CUT |
| DB-AR-03 | TYPICAL ACCESS ROAD WITH 2 LEVEL CUT |
| DB-AR-04 | TYPICAL ICE ROAD |
| DB-CC-01 | CATHODIC PROTECTION – TYPICAL IMPRESSED CURRENT GROUNDBED DETAIL |
| DB-CC-02 | CATHODIC PROTECTION – MAGNESIUM OR ZINC RIBBON ANODE PLAN |
| DB-CC-03 | CATHODIC PROTECTION – TYPICAL COUPON TEST STATION DETAIL |
| DB-CC-04 | CATHODIC PROTECTION – TYPICAL TEST STATION JUNCTION BOX DETAIL |
| | |

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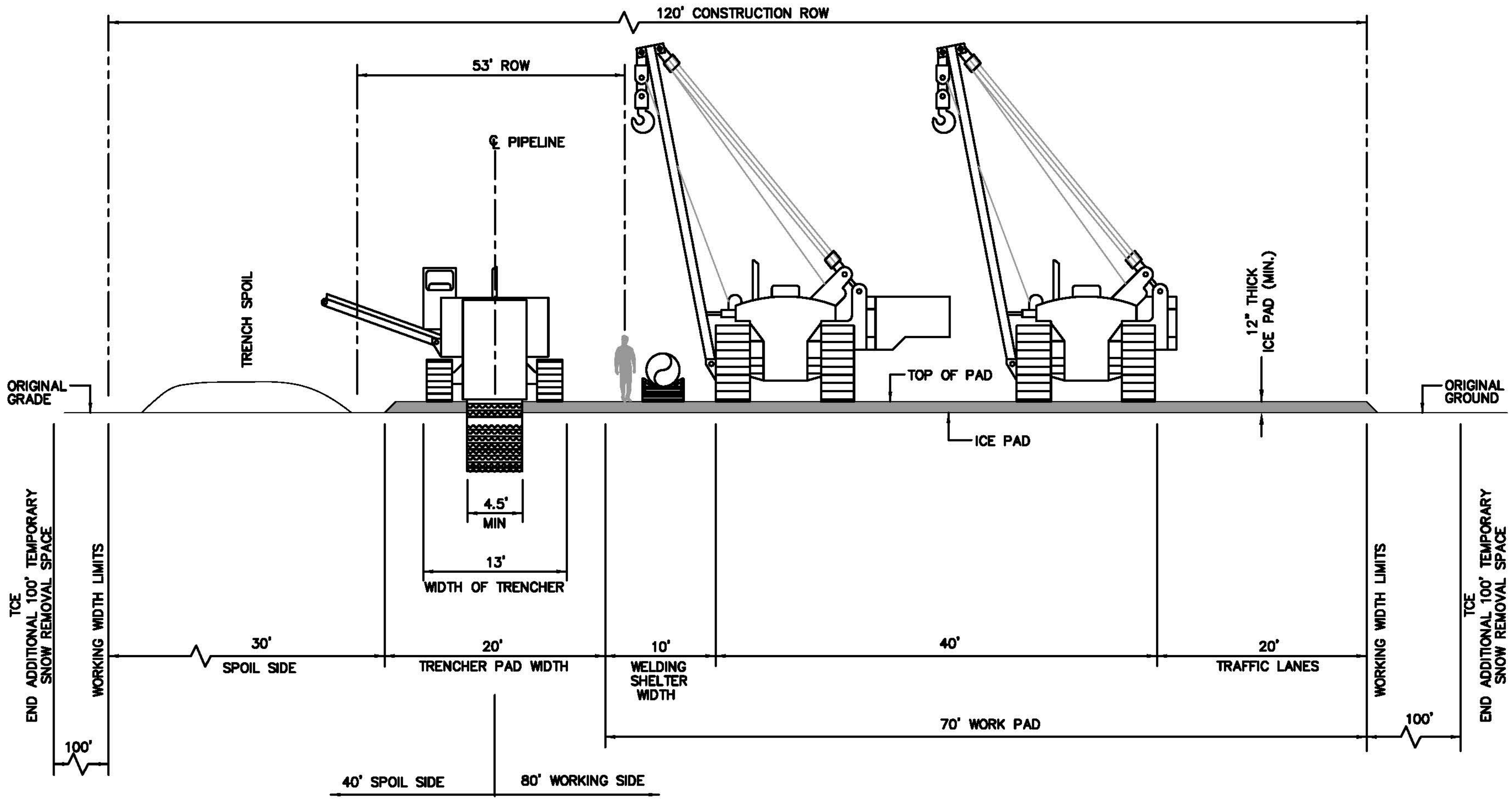
ALASKA STAND ALONE GAS PIPELINE/ASAP
SHEET INDEX



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-00A |




**TRENCH NOTES**

1. TRENCH OVER-EXCAVATION: 6" FOR BEDDING.
2. DEPTH OF COVER: 30" AT CLASS 1; 36" AT CLASS 2, 3, 4 & STRAIN BASED DESIGN SEGMENTS; 48" AT PARALLEL ENCROACHMENT & UNCASED ROADWAY AND RAIL ROAD CROSSINGS; ADDITIONAL DEPTH MAY BE REQUIRED FOR BUOYANCY CONTROL AND & AT STREAM CROSSINGS.
3. DEPTH OF COVER MEASURED FROM TOP OF PIPE TO GRADE BETWEEN TUSSOCKS. ASSUME 12" FROM TOP OF TUSSOCK TO BOTTOM.
4. TRENCH SLOPE: AS SOIL CONDITIONS ALLOW.
5. WIDTH OF TOP OF TRENCH WILL VARY DEPENDING UPON TRENCH DEPTH, WIDTH NEEDED FOR TIE-INS, WHETHER SUBSURFACE SOILS ARE THAWED OR FROZEN AND CHARACTERISTICS OF FROZEN SOILS RELATIVE TO BLASTING.
6. TRENCH SPOIL BULK FACTOR: 15%.

**GENERAL NOTES**

1. DEPTH OF ORGANIC LAYER WILL VARY DEPENDING UPON VEGETATION TYPE.
2. ADDITIONAL 100 FT TEMPORARY SNOW REMOVAL SPACE ON EACH SIDE IN ARCTIC AND/OR ALPINE (TREELESS) AREAS IS NEEDED TO FEATHER OUT SNOW TO PREVENT DRIFTS FROM FORMING
3. NO STRIPPING REQUIRED.

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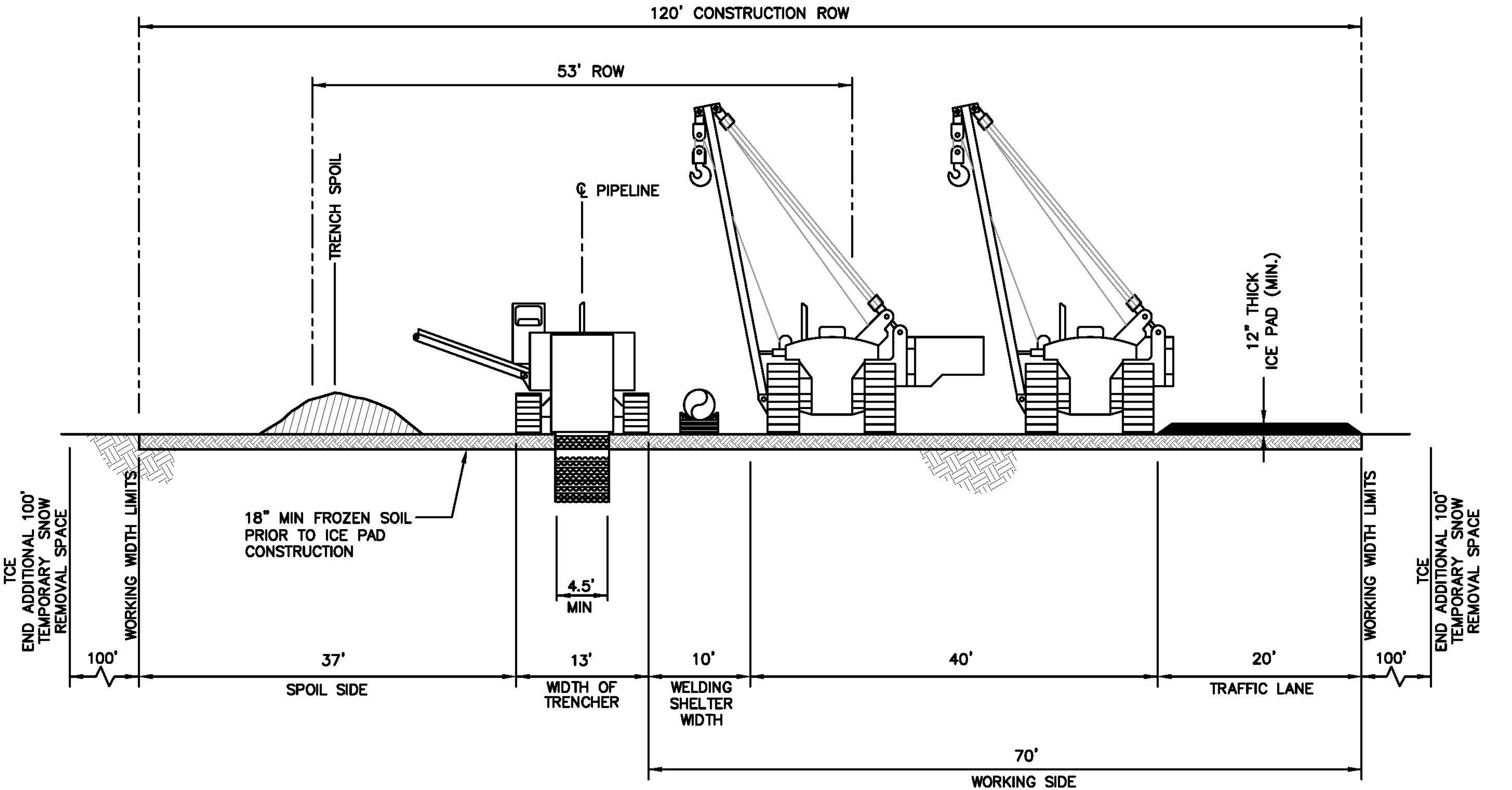
**ALASKA STAND ALONE GAS PIPELINE/*ASAP***
TYPICAL RIGHT OF WAY
TUNDRA ICE WORKPAD



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-ROW-01 |




**TRENCH NOTES**

1. TRENCH OVER-EXCAVATION: 6" FOR BEDDING.
2. DEPTH OF COVER: 30" AT CLASS 1; 36" AT CLASS 2, 3, 4 & STRAIN BASED DESIGN SEGMENTS; 48" AT PARALLEL ENCROACHMENT & UNCASED ROADWAY AND RAIL ROAD CROSSINGS; ADDITIONAL DEPTH MAY BE REQUIRED FOR BUOYANCY CONTROL AND & AT STREAM CROSSINGS.
3. DEPTH OF COVER MEASURED FROM TOP OF PIPE TO GRADE BETWEEN TUSSOCKS. ASSUME 12" FROM TOP OF TUSSOCK TO BOTTOM.
4. TRENCH SLOPE: AS SOIL CONDITIONS ALLOW.
5. WIDTH OF TOP OF TRENCH WILL VARY DEPENDING UPON TRENCH DEPTH, WIDTH NEEDED FOR TIE-INS, WHETHER SUBSURFACE SOILS ARE THAWED OR FROZEN AND CHARACTERISTICS OF FROZEN SOILS RELATIVE TO BLASTING.
6. TRENCH SPOIL BULK FACTOR: 15%.

**GENERAL NOTES**

1. DEPTH OF ORGANIC LAYER WILL VARY DEPENDING UPON VEGETATION TYPE.
2. ADDITIONAL 100 FT TEMPORARY SNOW REMOVAL SPACE ON EACH SIDE IN ARCTIC AND/OR ALPINE (TREELESS) AREAS IS NEEDED TO FEATHER OUT SNOW TO PREVENT DRIFTS FROM FORMING
3. NO STRIPPING REQUIRED.

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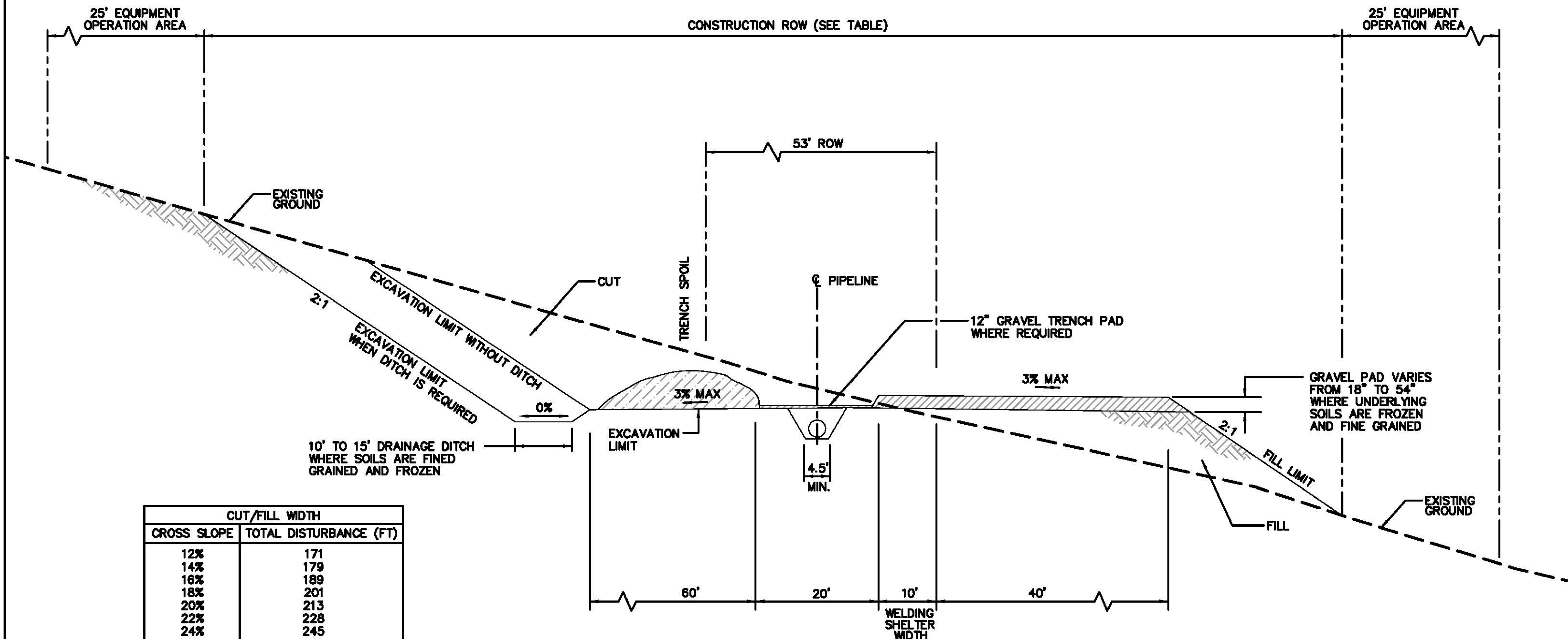
**ALASKA STAND ALONE GAS PIPELINE/*ASAP***
FROST PACKED RIGHT OF WAY
HIGH SPEED ICE TRAVEL LANE



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| SEPTEMBER 14, 2014 | 0B | N.T.S. | DB-ROW-02 |




| CUT/FILL WIDTH | |
|---|---|
| CROSS SLOPE | TOTAL DISTURBANCE (FT) |
| 12% | 171 |
| 14% | 179 |
| 16% | 189 |
| 18% | 201 |
| 20% | 213 |
| 22% | 228 |
| 24% | 245 |
| 26% | 264 |
| 28% | 287 |
| 30% | 315 |

## TRENCH NOTES

1. TRENCH OVER-EXCAVATION: 6" FOR BEDDING.
2. DEPTH OF COVER: 30" AT CLASS 1; 36" AT CLASS 2, 3, 4 & STRAIN BASED DESIGN SEGMENTS; 48" AT PARALLEL ENCROACHMENT & UNCASED ROADWAY AND RAIL ROAD CROSSINGS; ADDITIONAL DEPTH MAY BE REQUIRED FOR BUOYANCY CONTROL AND & AT STREAM CROSSINGS.
3. DEPTH OF COVER MEASURED FROM TOP OF PIPE TO GRADE BETWEEN TUSSOCKS. ASSUME 12" FROM TOP OF TUSSOCK TO BOTTOM.
4. TRENCH SLOPE: AS SOIL CONDITIONS ALLOW.
5. WIDTH OF TOP OF TRENCH WILL VARY DEPENDING UPON TRENCH DEPTH, WIDTH NEEDED FOR TIE-INS, WHETHER SUBSURFACE SOILS ARE THAWED OR FROZEN AND CHARACTERISTICS OF FROZEN SOILS RELATIVE TO BLASTING.
6. TRENCH SPOIL BULK FACTOR: 15%.
7. PIPELINE MUST BE LOCATED IN UNDISTURBED GROUND.

## GENERAL NOTES

1. DEPTH OF ORGANIC LAYER WILL VARY DEPENDING UPON VEGETATION TYPE.
2. ADDITIONAL 100 FT TEMPORARY SNOW REMOVAL SPACE ON UPHILL SIDE IN ARCTIC AND/OR ALPINE (TREELESS) AREAS IS NEEDED TO FEATHER OUT SNOW TO PREVENT DRIFTS FROM FORMING.

Alaska's In-State Gas Pipeline

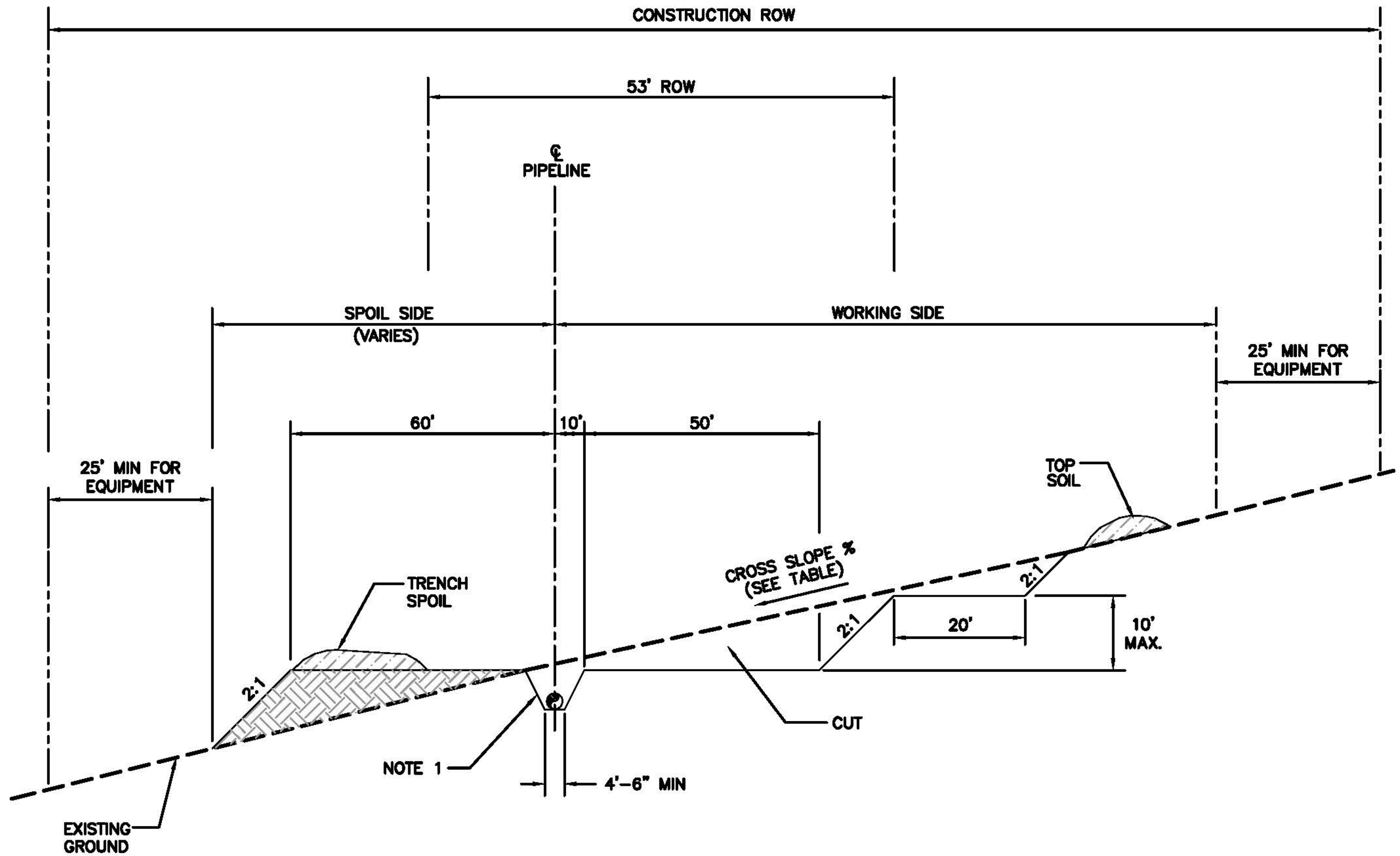
# ALASKA STAND ALONE GAS PIPELINE/*ASAP*

## TYPICAL RIGHT OF WAY

## GRADED WORKPAD WITH 1 LEVEL CUT



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-ROW-03 |




25% GRADE AS DRAWN

| CROSS SLOPE | CONSTRUCTION ZONE SPOIL SIDE | CONSTRUCTION ZONE WORKING SIDE | TOTAL DISTURBANCE |
|---|---|---|---|
| % | 2:1 | | 2:1 |
| 30% | 135' | 190' | 380' |
| 28% | 124' | 171' | 350' |
| 26% | 115' | 155' | 320' |
| 24% | 107' | 143' | 300' |
| 22% | 100' | 132' | 290' |
| 20% | 94' | 122' | 270' |
| 18% | 89' | 114' | 260' |
| 16% | 84' | 107' | 250' |
| 14% | 80' | 101' | 240' |
| 12% | 76' | 95' | 230' |
| 10% | 73' | 89' | 220' |

GENERAL NOTES

1. PIPELINE MUST BE LOCATED IN UNDISTURBED GROUND.

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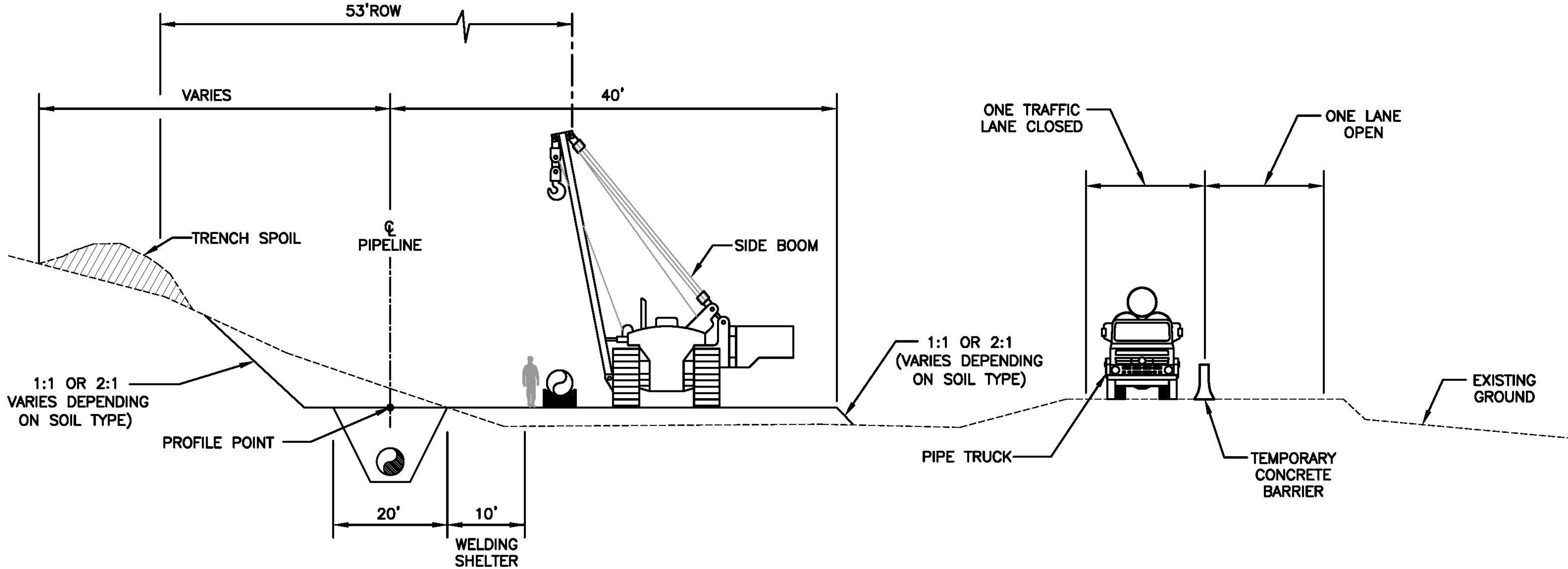
# ALASKA STAND ALONE GAS PIPELINE/*ASAP*
## TYPICAL RIGHT OF WAY
## GRADED WORKPAD WITH TWO TONED CUT



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-ROW-03A |




TRENCH NOTES

1. TRENCH OVER-EXCAVATION: 6" FOR BEDDING.
2. DEPTH OF COVER: 30" AT CLASS 1; 36" AT CLASS 2, 3, 4 & STRAIN BASED DESIGN SEGMENTS; 48" AT PARALLEL ENCROACHMENT & UNCASED ROADWAY AND RAIL ROAD CROSSINGS; ADDITIONAL DEPTH MAY BE REQUIRED FOR BUOYANCY CONTROL AND & AT STREAM CROSSINGS.
3. DEPTH OF COVER MEASURED FROM TOP OF PIPE TO GRADE BETWEEN TUSSOCKS. ASSUME 12" FROM TOP OF TUSSOCK TO BOTTOM.
4. TRENCH SLOPE: AS SOIL CONDITIONS ALLOW.
5. WIDTH OF TOP OF TRENCH WILL VARY DEPENDING UPON TRENCH DEPTH, WIDTH NEEDED FOR TIE-INS, WHETHER SUBSURFACE SOILS ARE THAWED OR FROZEN AND CHARACTERISTICS OF FROZEN SOILS RELATIVE TO BLASTING.
6. TRENCH SPOIL BULK FACTOR: 15%.
7. PIPELINE MUST BE LOCATED IN NATIVE GROUND.

GENERAL NOTES

1. DEPTH OF ORGANIC LAYER WILL VARY DEPENDING UPON VEGETATION TYPE.
2. ADDITIONAL 100 FT TEMPORARY SNOW REMOVAL SPACE ON EACH SIDE IN ARCTIC AND/OR ALPINE (TREELESS) AREAS IS NEEDED TO FEATHER OUT SNOW TO PREVENT DRIFTS FROM FORMING.

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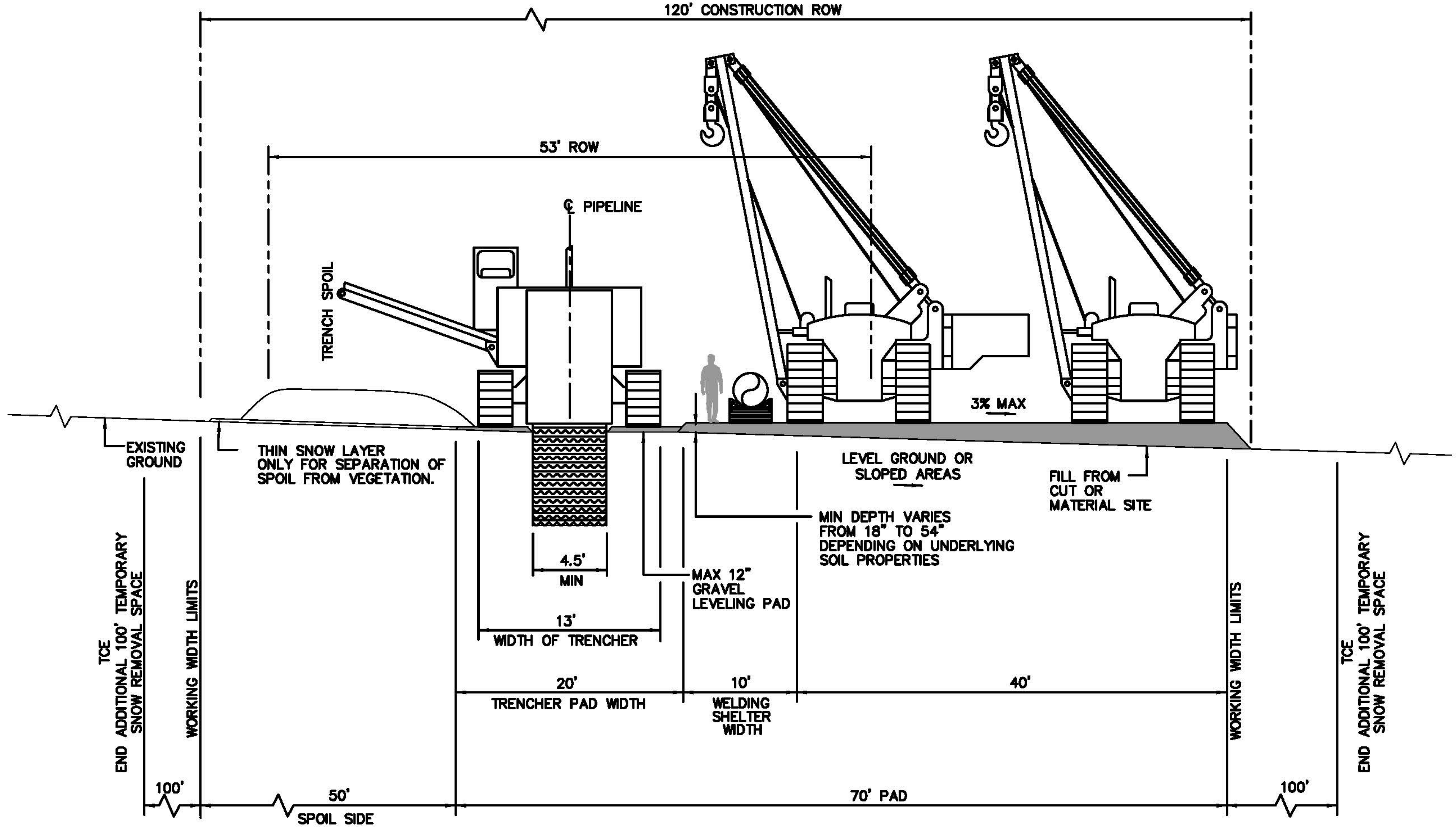
ALASKA STAND ALONE GAS PIPELINE/*ASAP*
TYPICAL RIGHT OF WAY
WITHIN HIGHWAY ROW



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-ROW-03B |




**TRENCH NOTES**

1. TRENCH OVER-EXCAVATION: 6" FOR BEDDING.
2. DEPTH OF COVER: 30" AT CLASS 1; 36" AT CLASS 2, 3, 4 & STRAIN BASED DESIGN SEGMENTS; 48" AT PARALLEL ENCROACHMENT & UNCASED ROADWAY AND RAIL ROAD CROSSINGS; ADDITIONAL DEPTH MAY BE REQUIRED FOR BUOYANCY CONTROL AND & AT STREAM CROSSINGS.
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5. WIDTH OF TOP OF TRENCH WILL VARY DEPENDING UPON TRENCH DEPTH, WIDTH NEEDED FOR TIE-INS, WHETHER SUBSURFACE SOILS ARE THAWED OR FROZEN AND CHARACTERISTICS OF FROZEN SOILS RELATIVE TO BLASTING.
6. TRENCH SPOIL BULK FACTOR: 15%.

**GENERAL NOTES**

1. DEPTH OF ORGANIC LAYER WILL VARY DEPENDING UPON VEGETATION TYPE.
2. ADDITIONAL 100 FT TEMPORARY SNOW REMOVAL SPACE ON EACH SIDE IN ARCTIC AND/OR ALPINE (TREELESS) AREAS IS NEEDED TO FEATHER OUT SNOW TO PREVENT DRIFTS FROM FORMING
3. NO STRIPPING REQUIRED.

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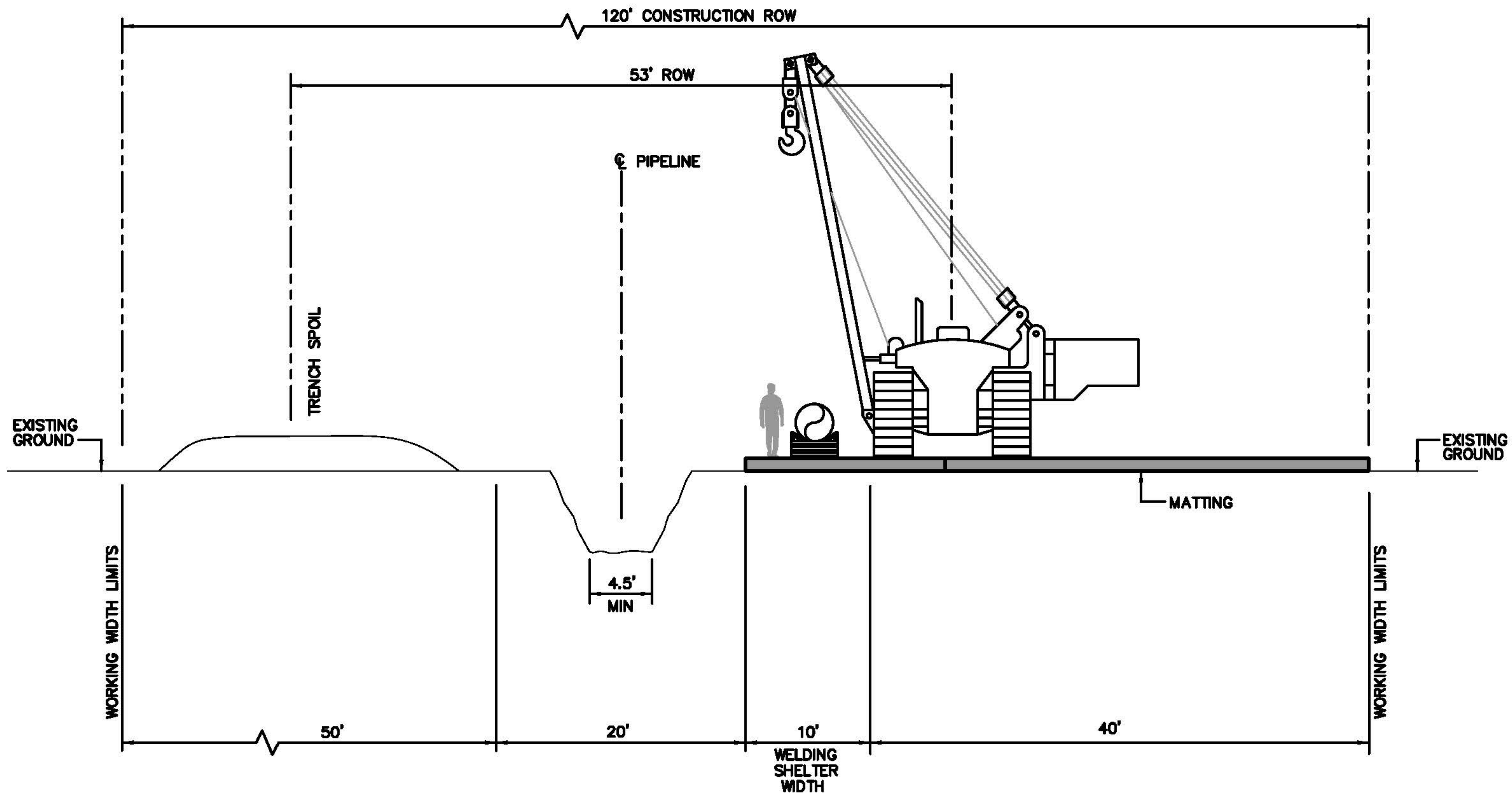
**ALASKA STAND ALONE GAS PIPELINE/*ASAP***
TYPICAL RIGHT OF WAY
GRAVEL WORKPAD



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-ROW-04 |




TRENCH NOTES

1. TRENCH OVER-EXCAVATION: 6" FOR BEDDING.
2. DEPTH OF COVER: 30" AT CLASS 1; 36" AT CLASS 2, 3, 4 & STRAIN BASED DESIGN SEGMENTS; 48" AT PARALLEL ENCROACHMENT & UNCASED ROADWAY AND RAIL ROAD CROSSINGS; ADDITIONAL DEPTH MAY BE REQUIRED FOR BUOYANCY CONTROL AND & AT STREAM CROSSINGS.
3. DEPTH OF COVER MEASURED FROM TOP OF PIPE TO GRADE BETWEEN TUSSOCKS. ASSUME 12" FROM TOP OF TUSSOCK TO BOTTOM.
4. TRENCH SLOPE: AS SOIL CONDITIONS ALLOW.
5. WIDTH OF TOP OF TRENCH WILL VARY DEPENDING UPON TRENCH DEPTH, WIDTH NEEDED FOR TIE-INS, WHETHER SUBSURFACE SOILS ARE THAWED OR FROZEN AND CHARACTERISTICS OF FROZEN SOILS RELATIVE TO BLASTING.
6. TRENCH SPOIL BULK FACTOR: 15%.

GENERAL NOTES

1. DEPTH OF ORGANIC LAYER WILL VARY DEPENDING UPON VEGETATION TYPE.

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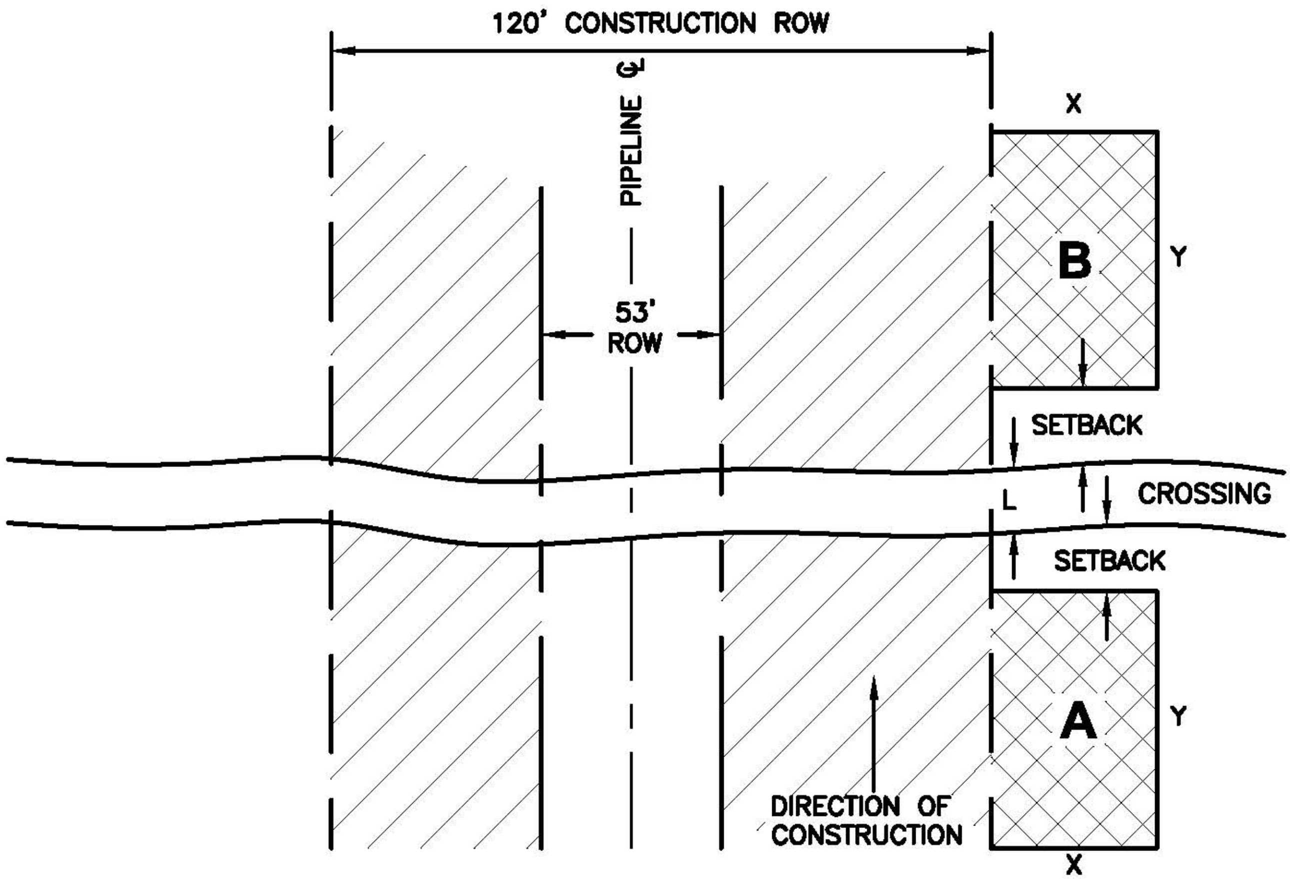
ALASKA STAND ALONE GAS PIPELINE/*ASAP*
TYPICAL
MATTED RIGHT OF WAY



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-ROW-05 |




| CROSSING TYPE | CROSSING METHOD | EXTRA TEMPORARY CONSTRUCTION EASEMENT 'A' | | | EXTRA TEMPORARY CONSTRUCTION EASEMENT 'B' | | |
|---|---|---|---|---|---|---|---|
| | | X (FT) | Y (FT) | SETBACK (FT) | X (FT) | Y (FT) | SETBACK (FT) |
| LOCAL ROADS/TRAILS/DRIVEWAY | OPEN CUT *** | 50 | 150 | 0 | 50 | 150 | 0 |
| ARTERIAL/COLLECTOR ROADS | HORIZONTAL BORE | 80 | 500 | 0 | 80 | 300 | 0 |
| RAILWAY | HORIZONTAL BORE | 80 | 500 | 0 | 80 | 300 | 0 |
| FOREIGN PIPELINE OR CABLE | OPEN CUT | 50 | 150 | 0 | 50 | 150 | 0 |
| TYPE C WATERBODY | OPEN CUT | 80 | 300 | 50 | 80 | 300 | 50 |
| TYPE A & B WATERBODY | OPEN CUT, HDD | 80 | L X 1.2 | 50 | 80 | 500 | 50 |
| WETLAND | OPEN CUT, PUSH/PULL | 100 | L X 1.2 | 50 | 100 | 300 | 50 |
| VEHICLE TURNAROUND | N/A | 100 | 150 | N/A | N/A | N/A | N/A |
| BLOCK VALVE | N/A | 80 | 300 | N/A | N/A | N/A | N/A |
| SIDE HILL CUTS | N/A | * | ** | N/A | N/A | N/A | N/A |
| TIMBER DECK | N/A | **** | **** | N/A | N/A | N/A | N/A |

* EQUAL TO SIDE-HILL CUT LENGTH
** SEE DB-ROW-04 AND DB-ROW-4A FOR MORE INFORMATION
*** EXCEPT FOR TAPS PUMP STATION ACCESS ROADS.
**** TIMBER WORKSPACE TO BE DETERMINED.

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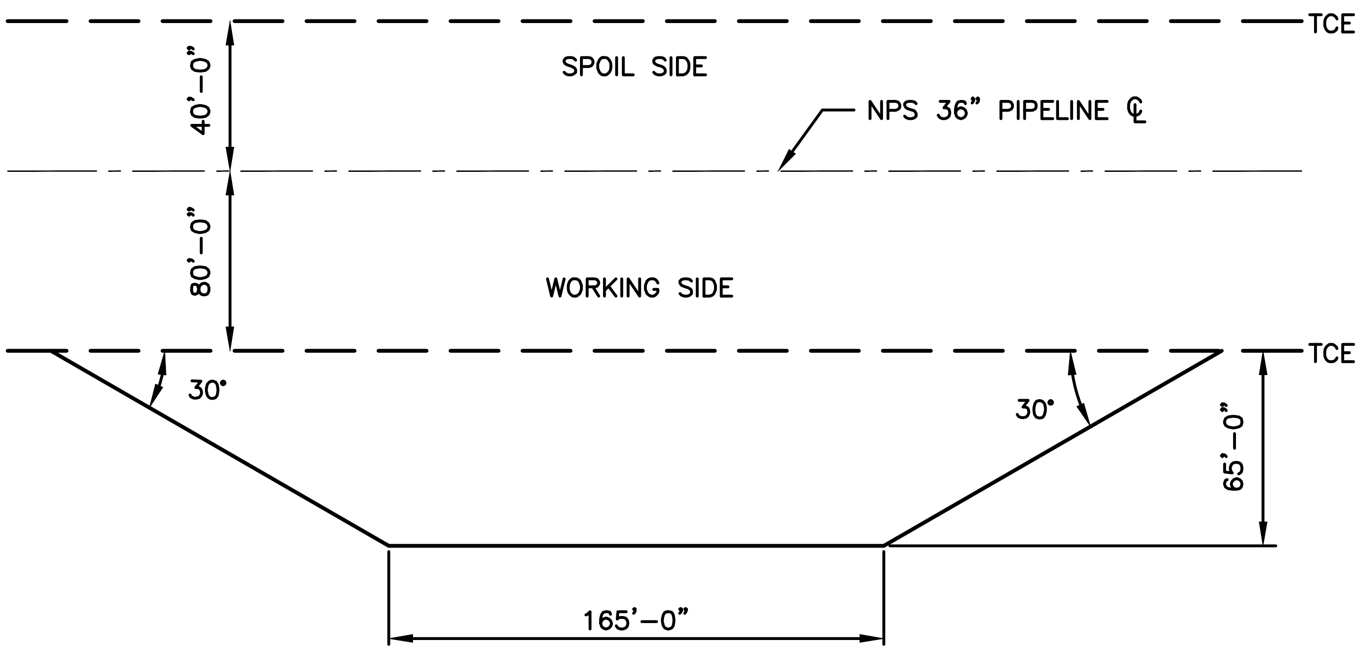
# ALASKA STAND ALONE GAS PIPELINE/ASAP
## EXTRA TEMPORARY CONSTRUCTION EASEMENT



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-ROW-06 |




NOTES:

1. TURN AROUNDS WILL BE PLACED AT EVERY 1 TO 6 MILES AS REQUIRED.
2. TOPOGRAPHY WILL DICTATE THE EXACT LOCATION OF THE TURN AROUNDS.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*
RIGHT OF WAY
TURN AROUNDS



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-ROW-07 |

File: C:_OfficeWork\AGDC\NOV2014-BOD\DB-ROW-S.dwg

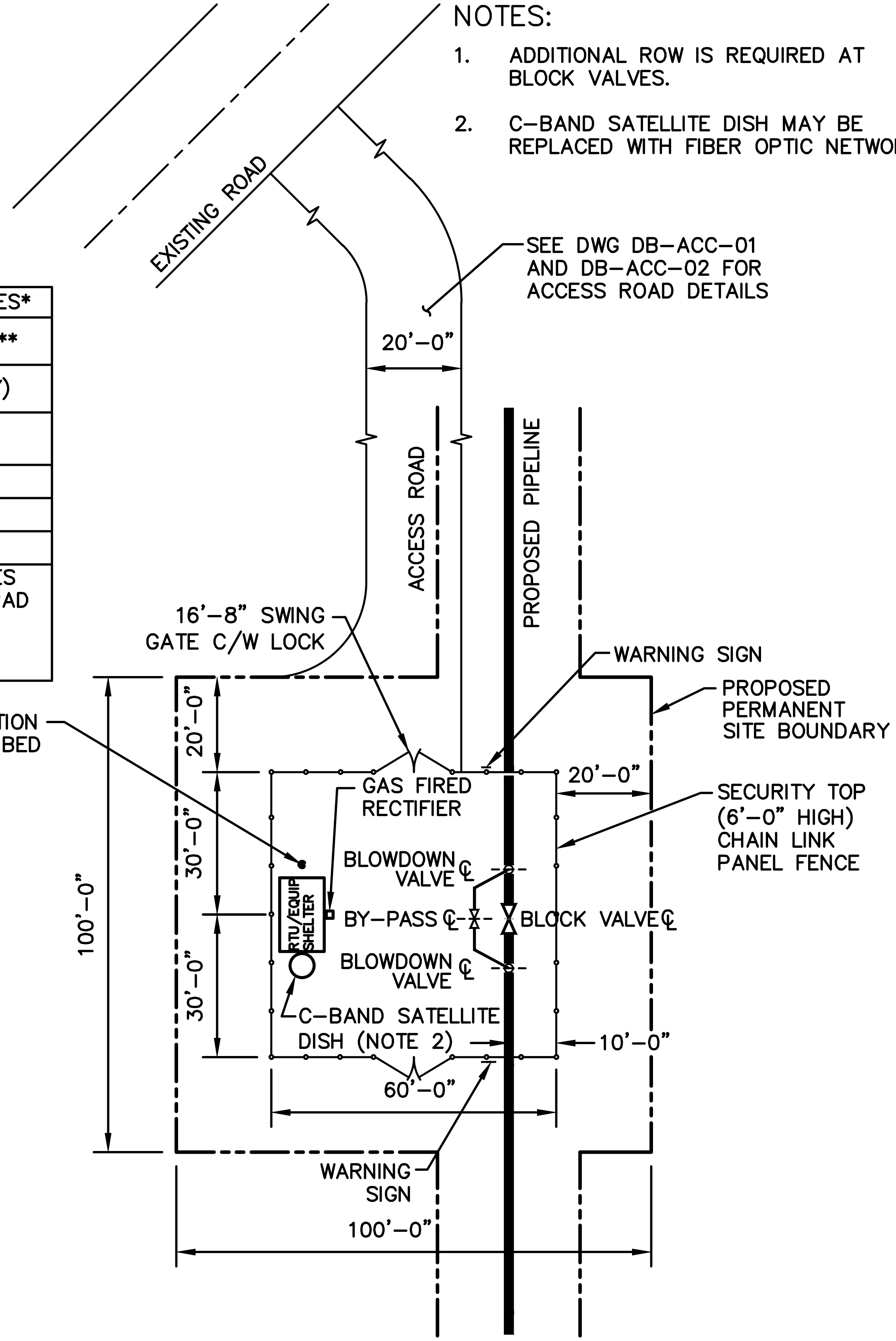
Plot Date: 11/14/2014 8:26 AM

NOTES:

1. ADDITIONAL ROW IS REQUIRED AT BLOCK VALVES.
2. C-BAND SATELLITE DISH MAY BE REPLACED WITH FIBER OPTIC NETWORK.

| ASSUMED QUANTITIES* | |
|---|---|
| AGGREGATE DEPTHS (FT) | QTY** (CY) |
| 2 | 326 |
| 3 | 533 |
| 4 | 770 |
| 5 | 1037 |

*ASSUMES QUANTITIES FOR BLOCK VALVE PAD ONLY
**ASSUMES 2:1 EMBANKMENT SLOPE

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***

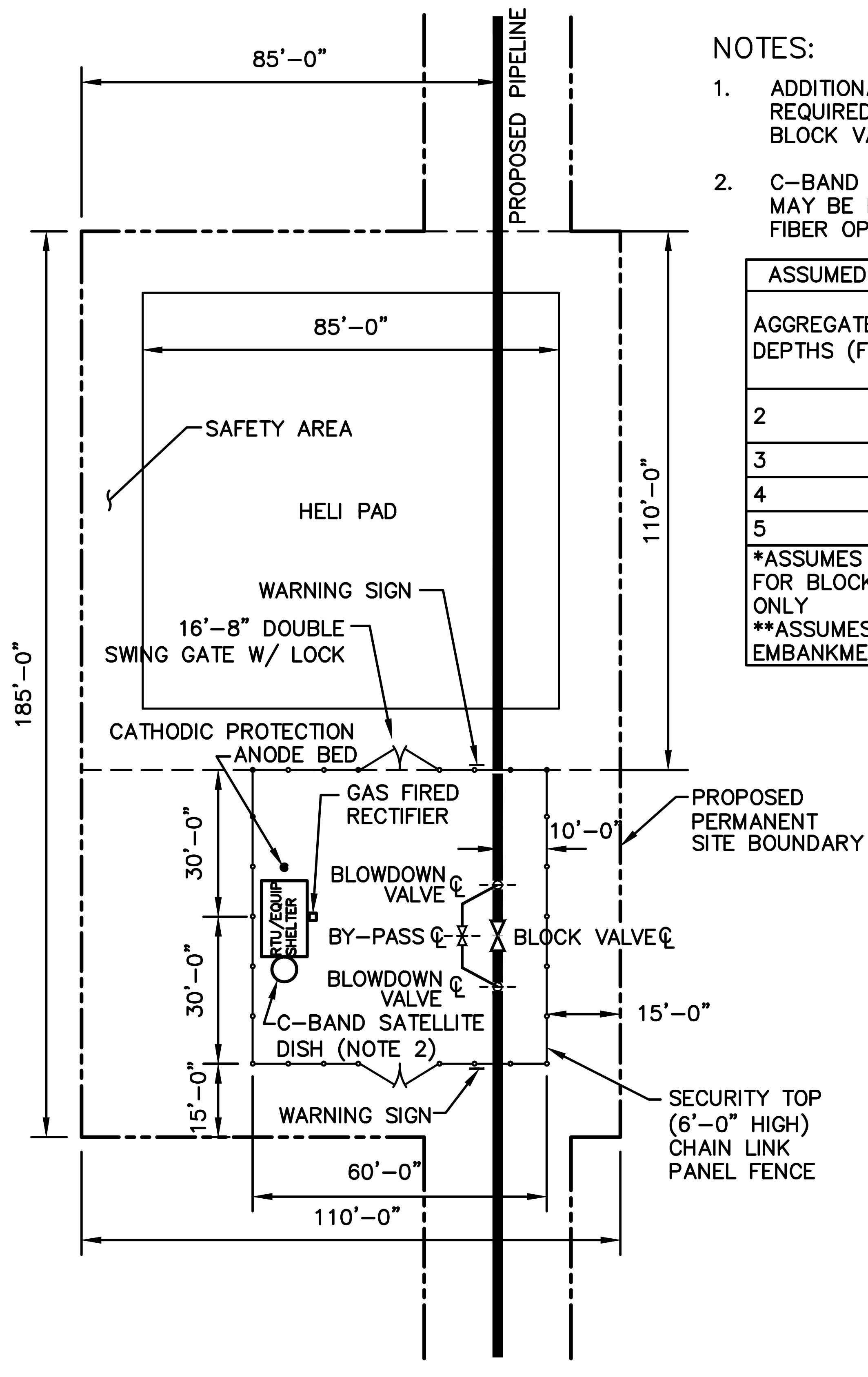
FACILITIES -

BLOCK VALVE SITE PLAN



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-FAC-01A |

Plot Date: 11/14/2014 8:33 AM




NOTES:

1. ADDITIONAL ROW IS REQUIRED AT BLOCK VALVES.
2. C–BAND SATELLITE DISH MAY BE REPLACED WITH FIBER OPTIC NETWORK.

| ASSUMED QUANTITIES* | |
|---|---|
| AGGREGATE DEPTHS (FT) | QTY** (CY) |
| 2 | 326 |
| 3 | 533 |
| 4 | 770 |
| 5 | 1037 |

*ASSUMES QUANTITIES FOR BLOCK VALVE PAD ONLY
**ASSUMES 2:1 EMBANKMENT SLOPE

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Alaska's In-State Gas Pipeline

# ALASKA STAND ALONE GAS PIPELINE/*ASAP*
## FACILITIES -
## BLOCK VALVE W/ HELI PAD SITE PLAN



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB–FAC–01B |

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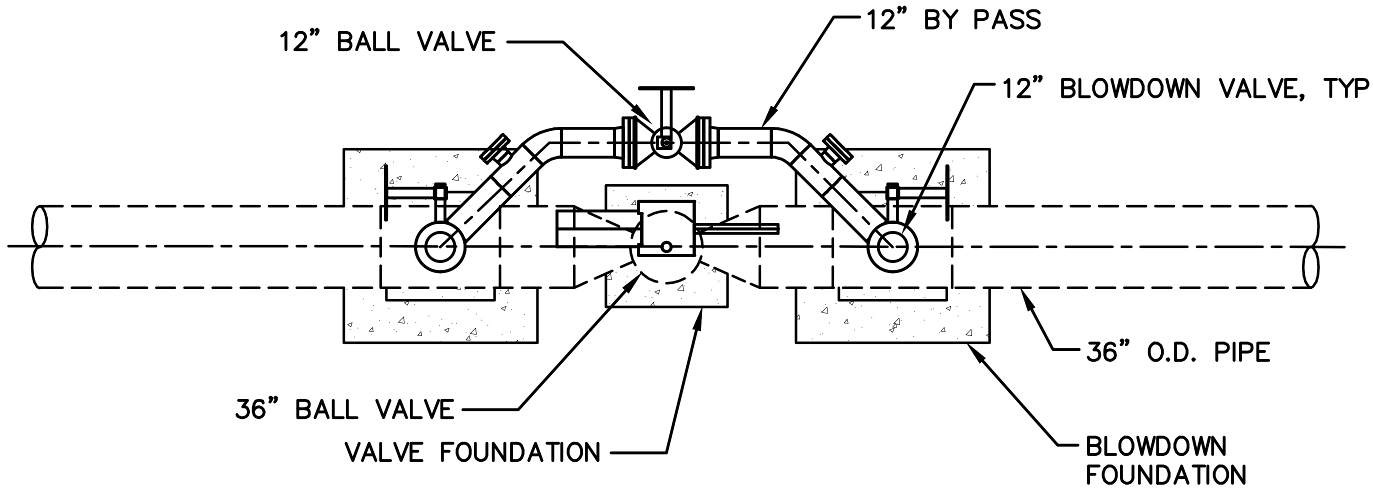
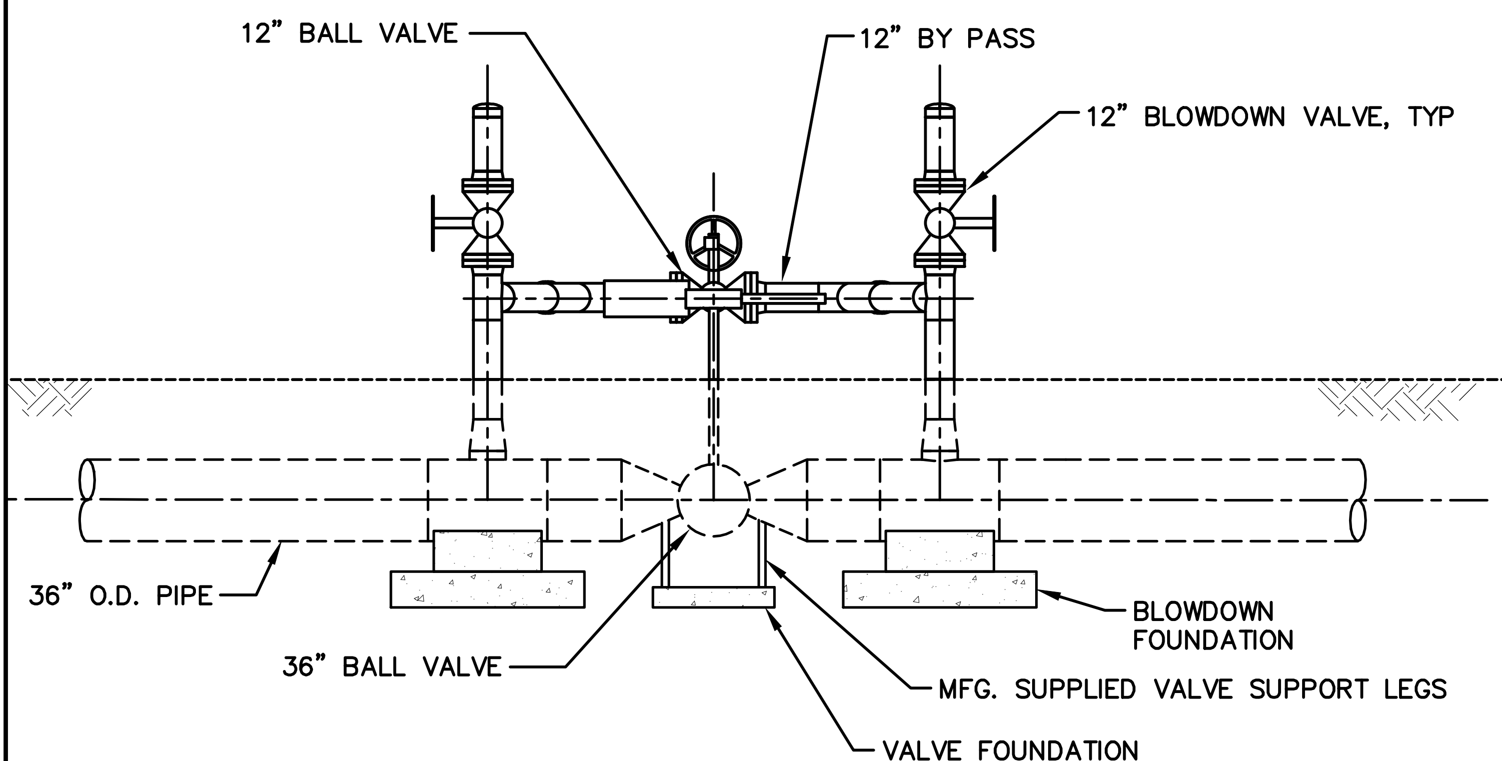



PLAN




ELEVATION

NOTE:

1. FOUNDATION DESIGN TO BE FINALIZED DURING DETAILED ENGINEERING.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*

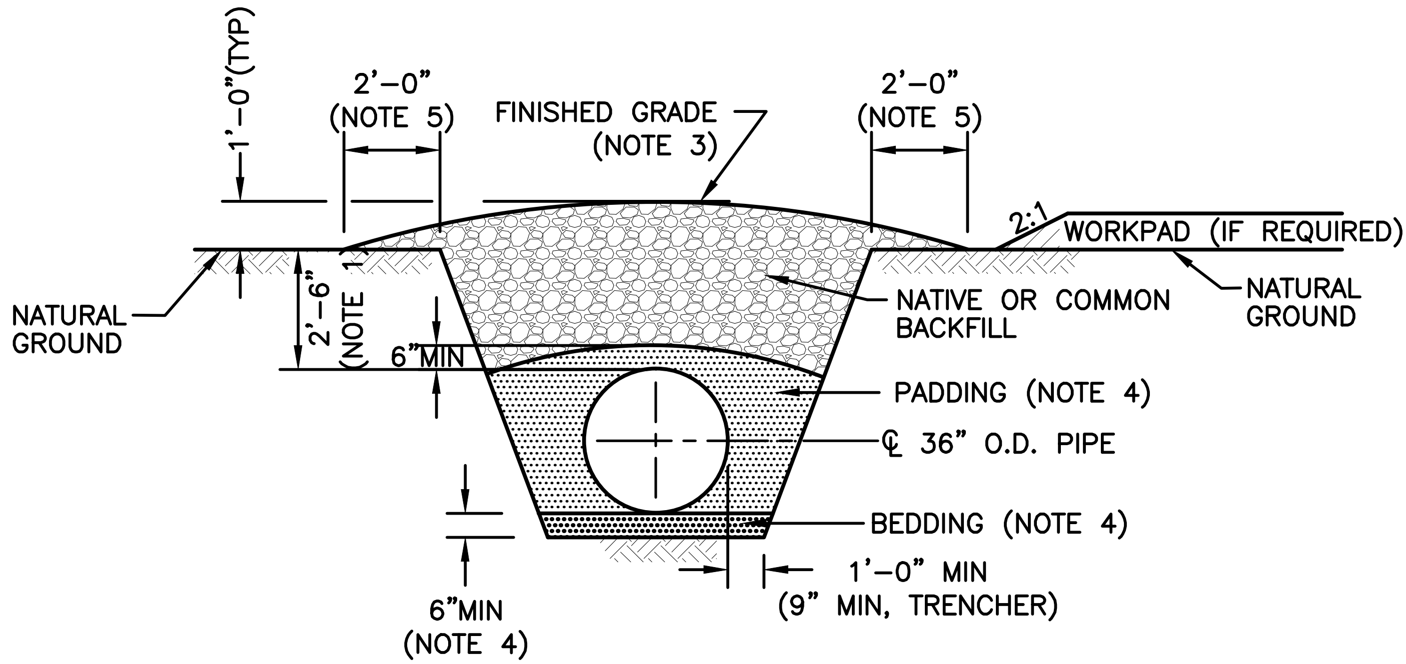
FACILITIES -

MAINLINE BLOCK VALVE



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-FAC-02 |

Plot Date: 11/14/2014 6:35 AM




## NOTES:

1. MINIMUM DEPTH OF COVER: 30", CLASS 1 LOCATIONS; 36", CLASS 2, 3, 4 LOCATIONS. ADDITIONAL COVER MAY BE REQUIRED FOR BUOYANCY CONTROL, RIVER AND STREAM SCOUR, AND BENDS.
2. DITCH WALL SLOPES WILL BE AS VERTICAL AS FIELD CONDITIONS WILL ALLOW.
3. FINISHED GRADING AND RESTORATION DETAILS PER PROJECT EROSION CONTROL BEST MANAGEMENT PRACTICES.
4. 6" MINIMUM BEDDING NOT REQUIRED WHEN NATIVE SOILS MEET THE BEDDING AND PADDING SPECIFICATION. NATIVE SOILS MAY BE USED FOR BEDDING AND PADDING IF THEY MEET THE BEDDING AND PADDING SPECIFICATIONS.
5. MOUNDED BACKFILL WILL EXTEND APPROXIMATELY TWO FEET FROM THE EDGE OF THE DITCH WALL. DISTANCE FROM THE TOE OF THE WORKPAD (IF REQUIRED) AND TOE OF THE MOUNDED BACKFILL VARIES.

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***

MODE I - BURIED PIPE IN CONVENTIONAL DITCH



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-MODE-01 |

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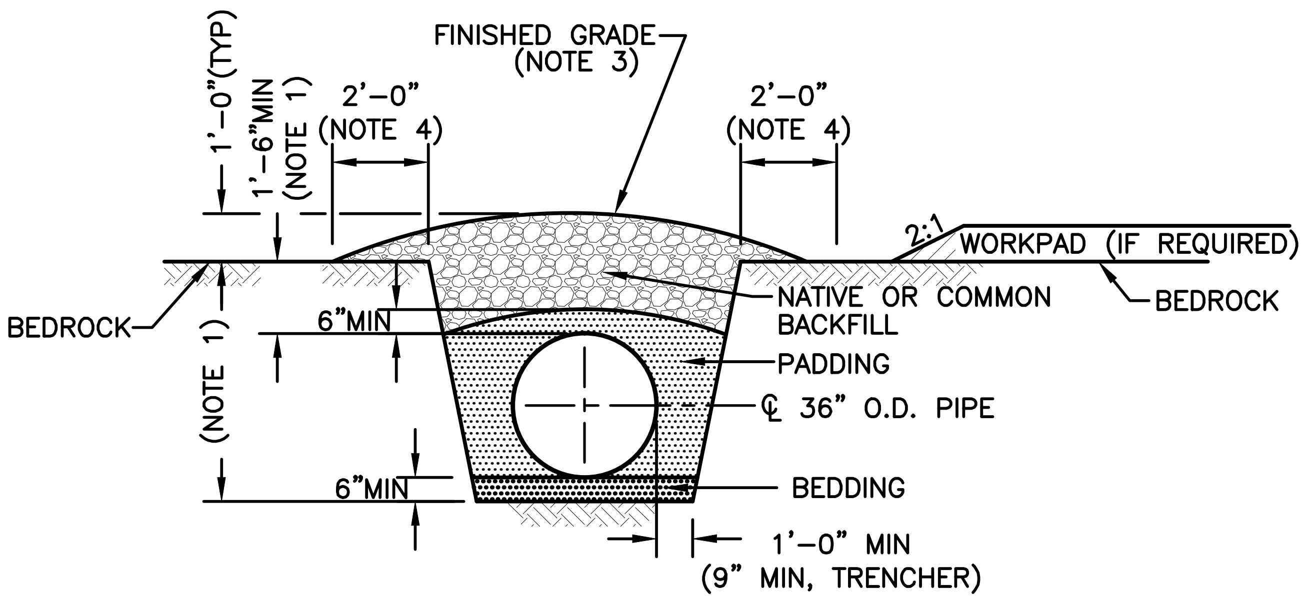


## NOTES:

1. MINIMUM DEPTH OF COVER: 18" AT CLASS 1 LOCATIONS; 24" AT CLASS 2, 3, 4 LOCATIONS. ADDITIONAL COVER MAY BE REQUIRED FOR BUOYANCY CONTROL, RIVER AND STREAM SCOUR, AND BENDS.

2. DITCH WALL SLOPES WILL BE AS VERTICAL AS FIELD CONDITIONS WILL ALLOW.

3. FINISHED GRADING AND RESTORATION DETAILS PER PROJECT EROSION CONTROL BEST MANAGEMENT PRACTICES.

4. MOUNDED BACKFILL WILL EXTEND APPROXIMATELY TWO FEET FROM THE EDGE OF THE DITCH WALL. DISTANCE FROM THE TOE OF THE WORKPAD (IF REQUIRED) AND TOE OF THE MOUNDED BACKFILL VARIES.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*

MODE II - BURIED PIPE IN
CONVENTIONAL ROCK DITCH



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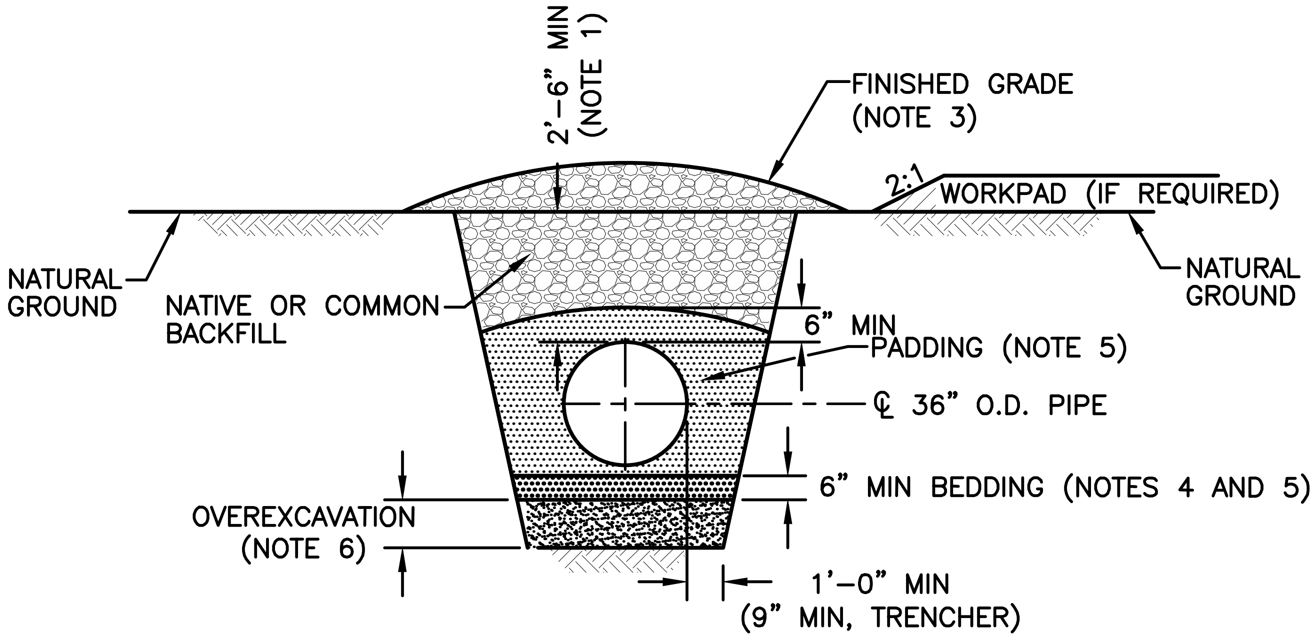
|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB–MODE–02 |

Plot Date: 11/14/2014 8:48 AM




NOTES:

1. MINIMUM DEPTH OF COVER: 30" AT CLASS 1 LOCATIONS; 36" AT CLASS 2, 3, 4 LOCATIONS. ADDITIONAL COVER MAY BE REQUIRED FOR BUOYANCY CONTROL, RIVER AND STREAM SCOUR, AND BENDS.

2. DITCH WALL SLOPES WILL BE AS VERTICAL AS FIELD CONDITIONS WILL ALLOW.

3. FINISHED GRADING AND RESTORATION DETAILS PER PROJECT EROSION CONTROL BEST MANAGEMENT PRACTICES.

4. BEDDING NOT REQUIRED WHEN NATIVE SOILS MEET THE BEDDING AND PADDING SPECIFICATIONS.

5. NATIVE SOILS MAY BE USED FOR BEDDING AND PADDING IF THEY MEET THE BEDDING AND PADDING SPECIFICATIONS.

6. PIPE OVER EXCAVATION DEPTH WILL BE DETERMINED BY GEOTHERMAL ANALYSES. FOR PRELIMINARY QUANTITIES ASSUME 12" OVEREXCAVATION.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*
MODE III - BURIED PIPE
WITH OVER-EXCAVATION



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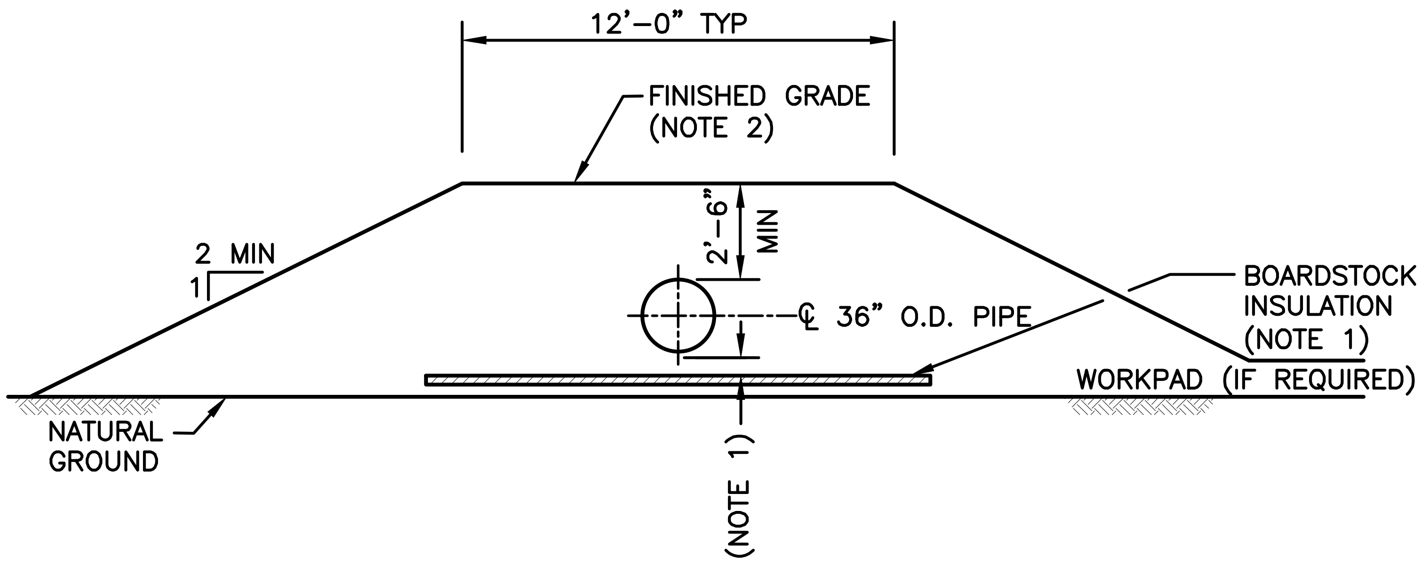


NOTES:

1. IF INSULATION REQUIRED, THICKNESS, WIDTH, AND THE DISTANCE BETWEEN THE NATURAL GROUND INSULATION AND THE PIPE WILL BE DETERMINED BY GEOTHERMAL ANALYSES.
2. FINISHED GRADING AND RESTORATION DETAILS PER PROJECT EROSION CONTROL BEST MANAGEMENT PRACTICES. THE EMBANKMENT WILL GENERALLY HAVE NO REVEGETATION.
3. THE BERM MATERIAL WILL BE COMPOSED OF FREE-DRAINING MINERAL MATERIAL.
4. CRITERIA FOR CROSS DRAINAGE IS SAME AS FOR WORKPAD.
5. GEOTHERMAL ANALYSES WILL BE USED TO DETERMINE IF CULVERTS WITHIN THE BERM WILL REQUIRE INSULATION.
6. THIS DESIGN MODE TYPE SHOULD NOT BE USED ON THE WINDWARD SIDE OF A HIGHWAY WHERE SNOW DRIFTING IS KNOWN TO OCCUR, OR COULD OCCUR, UNLESS A MINIMUM SEPARATION OF 150' IS MAINTAINED BETWEEN THE BERM AND THE TOE OF THE ROADWAY.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*
MODE IV - BURIED PIPE IN ABOVE GROUND BERM



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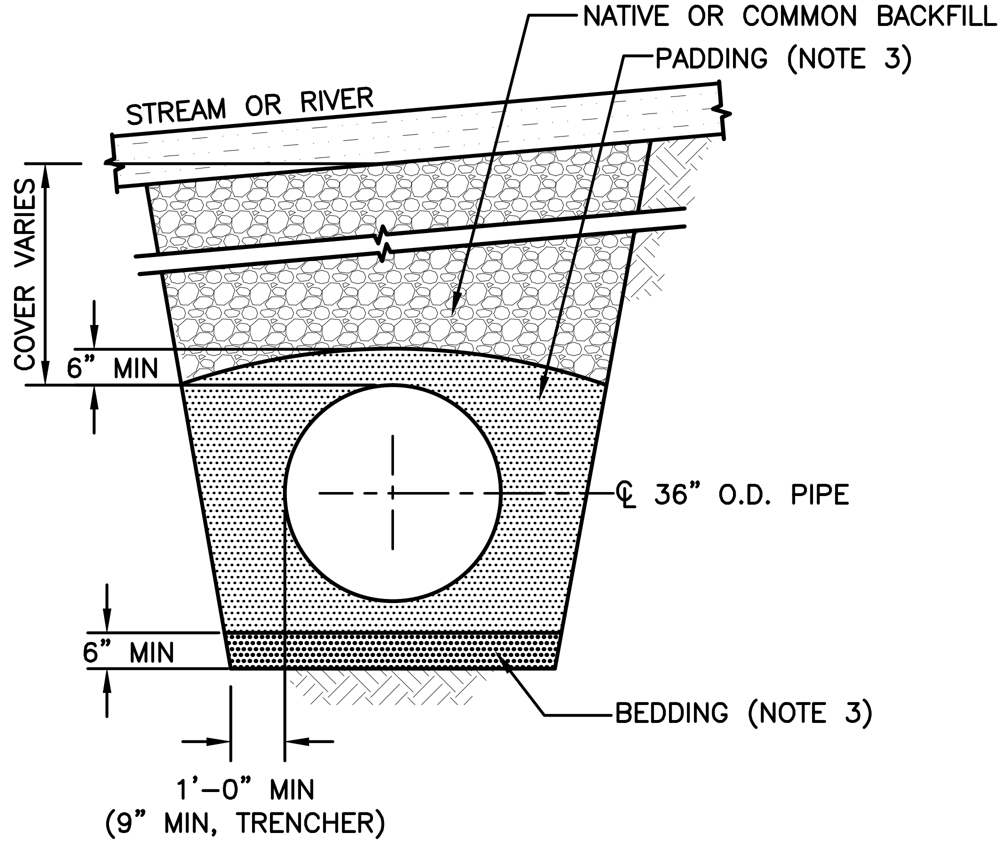


## NOTES:

1. MINIMUM DEPTH OF COVER, BUOYANCY CONTROL, AND SCOUR CONSIDERATIONS TO BE DETERMINED. IF BUOYANCY CONTROL REQUIRED, CONCRETE COATING, SADDLE BAGS, OR BOLT ON WEIGHTS TO BE IDENTIFIED.
2. DITCH WALL SLOPES WILL BE AS VERTICAL AS FIELD CONDITIONS WILL ALLOW.
3. NATIVE SOILS MAY BE USED FOR PADDING AND BEDDING IF THEY MEET THE PADDING AND BEDDING SPECIFICATIONS FOR CONCRETE COATED PIPE.
4. DITCH PLUGS WILL BE PLACED ON EACH SIDE OF CROSSING.

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***

MODE V - BURIED PIPE IN CONVENTIONAL STREAM OR RIVER CROSSING



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| NOVEMBER 14, 2014 | 0B | N.T.S. | DB–MODE–05 |

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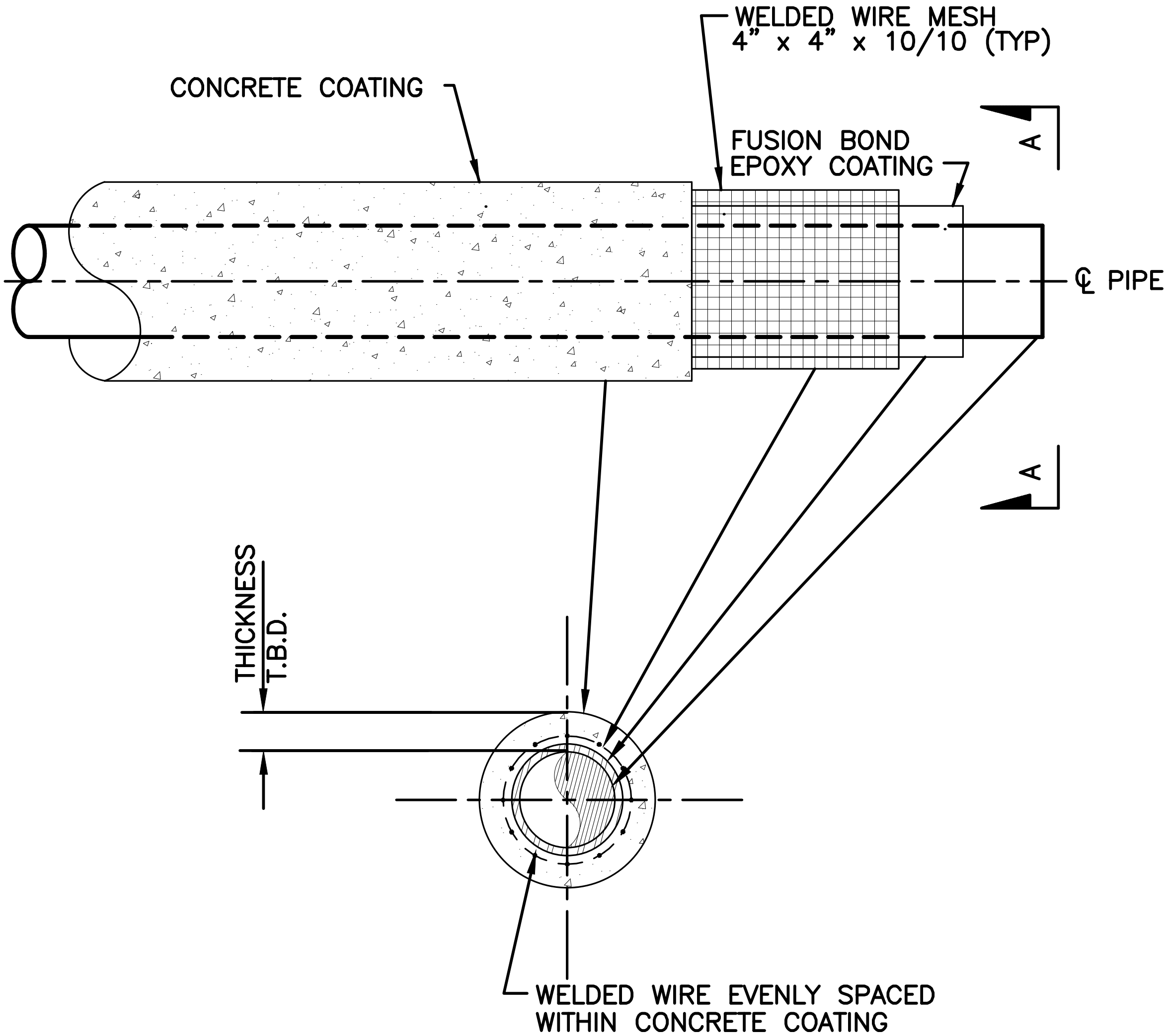


SECTION A–A

NOTES:

1. CONCRETE SHALL ATTAIN A MINIMUM COMPRESSIVE STRENGTH OF 2500 psi AT 28 DAYS. MINIMUM CONCRETE DENSITY SHALL BE 140 lbs/$ft^3$. CONCRETE SHALL BE PLACED TO ENSURE A UNIFORM CONSISTENCY.

2. PIPE SHALL BE HANDLED TO PREVENT DAMAGE TO EXTERNAL COATING AND PIPE ENDS. CONCRETE COATING SHALL BE APPLIED DIRECTLY TO PROTECTIVE COATING AND PLACED IN A MANNER THAT THE PIPE PROTECTIVE COATING WILL NOT BE DAMAGED.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*
BUOYANCY CONTROL -
CONTINUOUS CONCRETE COATING



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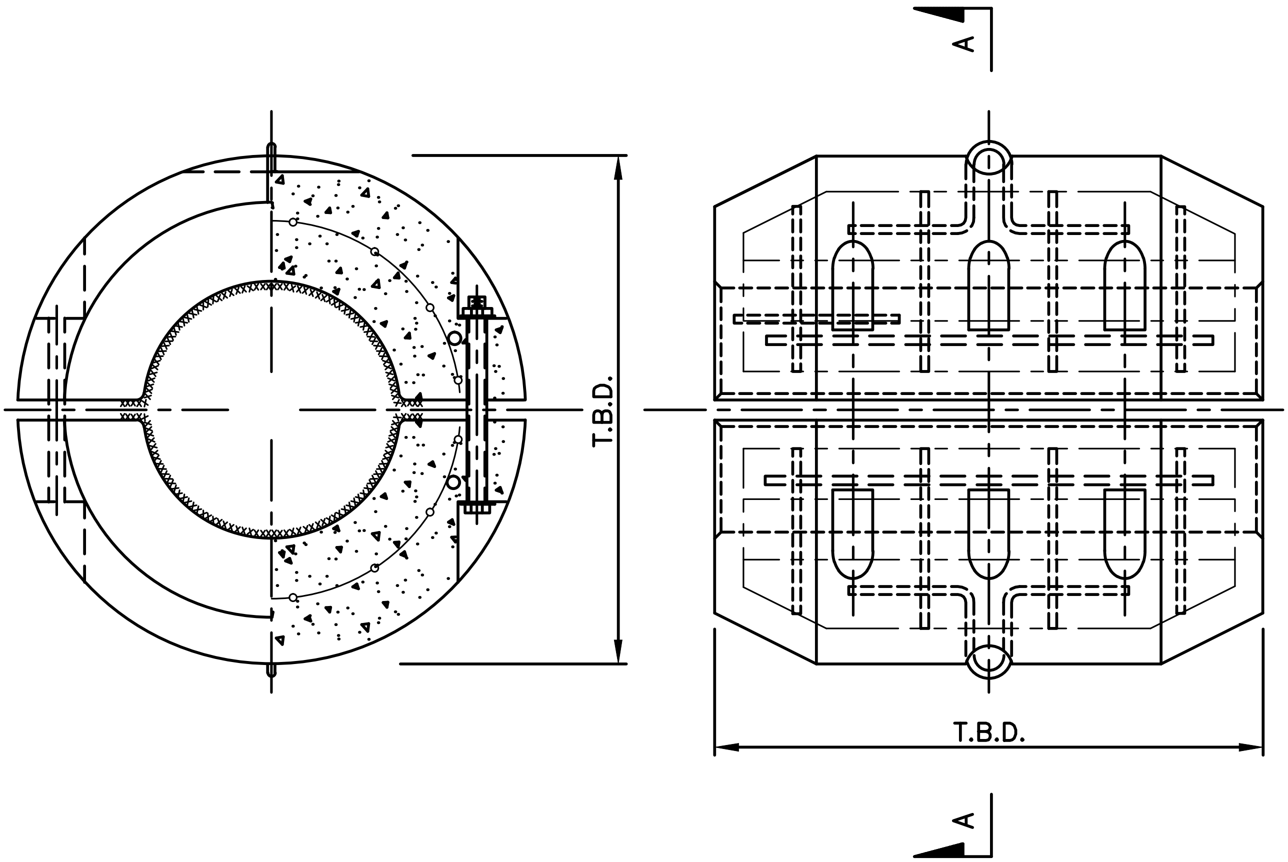


SECTION A–A

SIDE

NOTES:

1. CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 2500 psi AFTER 28 DAYS.
2. CONCRETE SHALL HAVE A MINIMUM DENSITY OF 140 lbs/ft$^3$
3. CONCRETE MINIMUM WEIGHT AND SPACING TO BE DETERMINE.

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***

BUOYANCY CONTROL -

BOLT-ON CONCRETE RIVER WEIGHT



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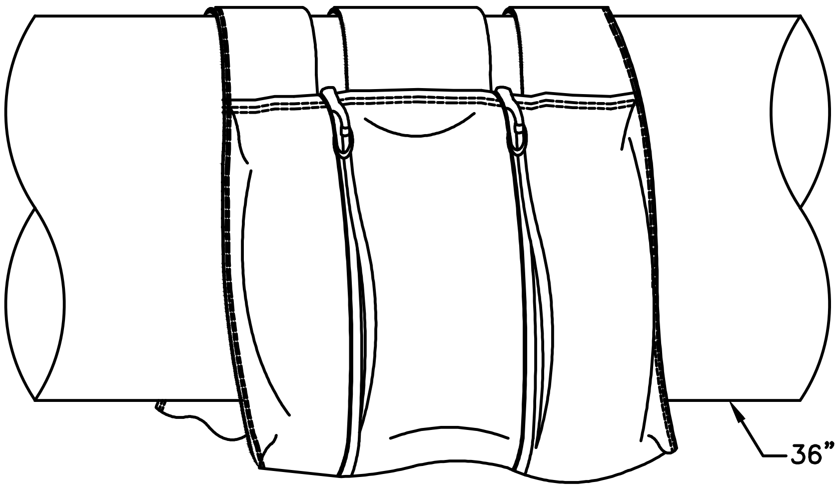


NOTE:

1. SADDLE BAG TYPE, WEIGHT, AND SPACING WILL BE DETERMINED DURING DETAILED DESIGN

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BUOYANCY CONTROL - SADDLE BAG TYPE WEIGHT



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|---|---|---|---|
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-BC-03 |

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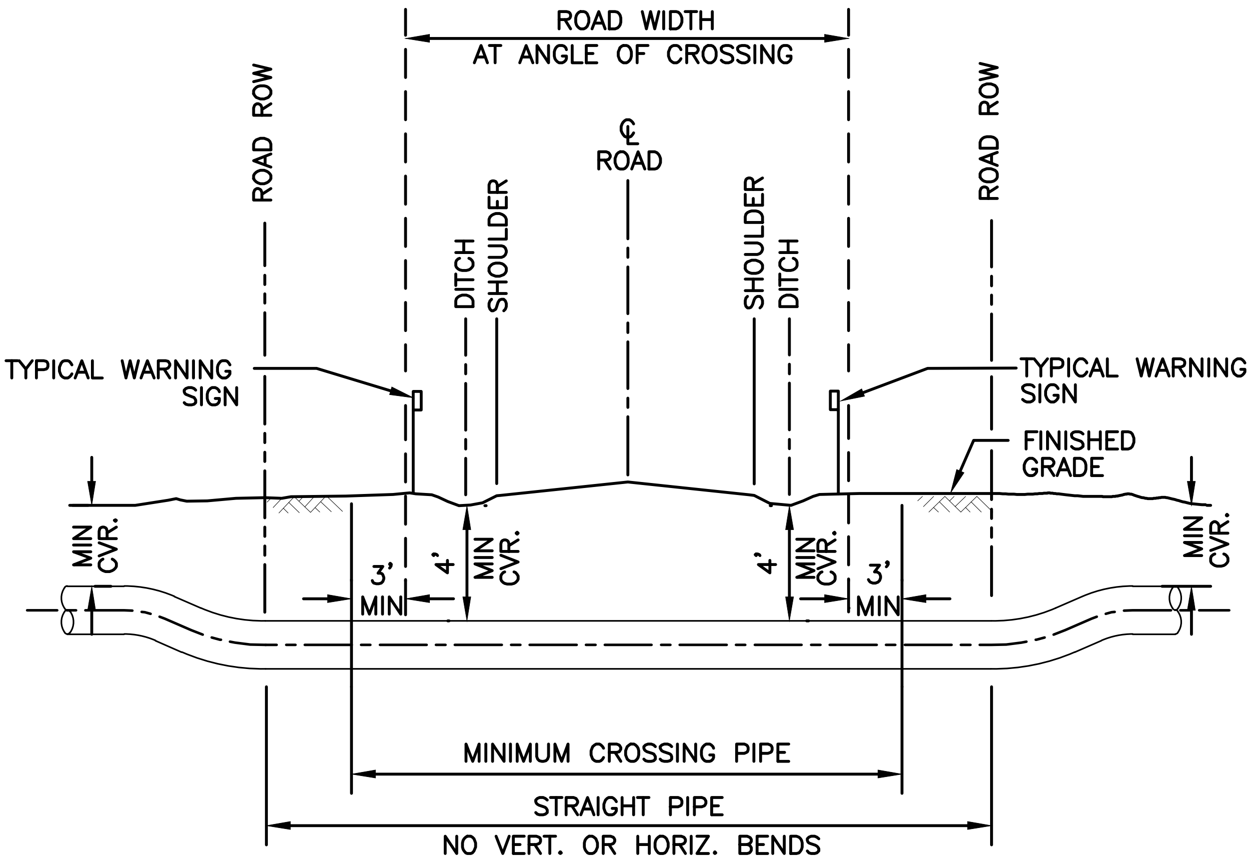


NOTES:

1. LOCAL ROAD, TYPICALLY A MINOR 2 LANE PAVED OR UNPAVED ROAD WITH SMALL SHOULDERS AND DITCHES. INCLUDES STATE & BOROUGH ROADS, PRIVATE, LEASE OR ACCESS ROADS. TYPICAL CROSSING PIPE LENGTH FOR LOCAL ROAD = 50' AT 90° CROSSING ANGLE.

2. LOCAL ROAD CROSSINGS SHALL BE CONSTRUCTED BY OPEN CUT METHOD, UNLESS OTHERWISE SPECIFIED. ALL TAPS PUMP STATION ACCESS ROADS SHALL BE BORED.

3. FOR TYPICAL EXTRA TEMPORARY WORKSPACE SEE DRAWING DB–ROW–06.

4. THE CONSTRUCTED PIPELINE SHALL BE STRAIGHT WITH NO VERTICAL OR HORIZONTAL BENDS BETWEEN ROAD RIGHT–OF–WAY BOUNDARIES.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*
ROAD CROSSINGS -
LOCAL ROADS



| DRAWING DATE: | REVISION: | SCALE: | SHEET No. |
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| NOVEMBER 14, 2014 | 0B | N.T.S. | DB–XING–01 |

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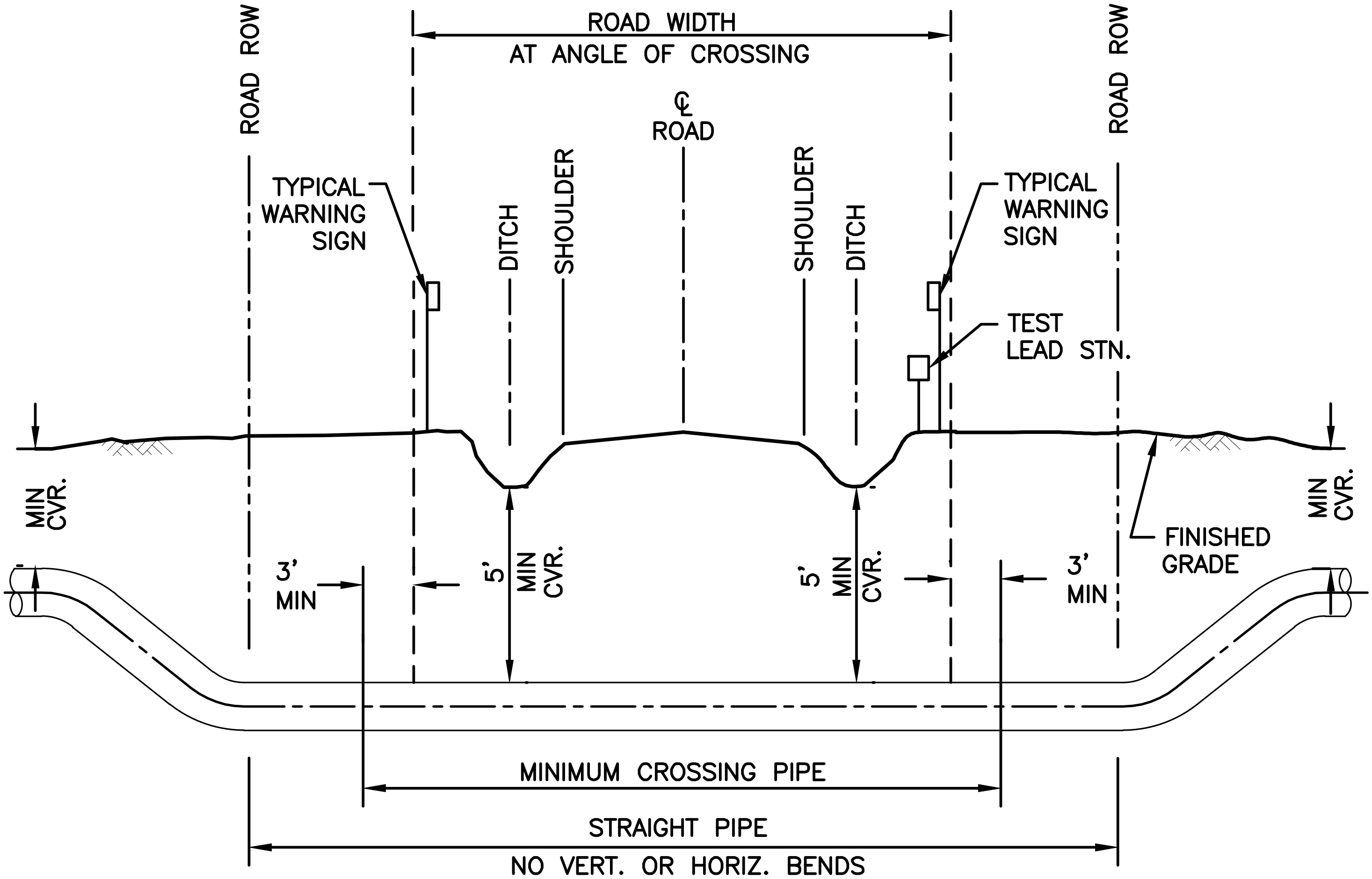


NOTES:

1. ARTERIAL ROAD, TYPICALLY A 2 OR 4 LANE PAVED, UNDIVIDED OR DIVIDED HIGHWAY WITH SHOULDERS AND DITCHES. INCLUDES THE DALTON, ELLIOT AND PARKS HIGHWAYS. TYPICAL CROSSING PIPE LENGTH FOR 4 LANE ARTERIAL ROAD = 160' AT 90° CROSSING. TYPICAL CROSSING PIPE LENGTH FOR 2 LANE ARTERIAL ROAD = 80' AT 90° CROSSING.

2. COLLECTOR ROAD TYPICALLY A 2 LANE UNPAVED OR PAVED, UNDIVIDED HIGHWAY WITH SHOULDERS AND DITCHES. INCLUDES STATE HIGHWAY, U.S. HIGHWAY AND BOROUGH ROADS. TYPICAL CROSSING PIPE LENGTH FOR SECONDARY ROAD = 80' AT 90° CROSSING.

3. MEDIAN AND ADDITIONAL 2 LANES FOR ARTERIAL ROAD, NOT SHOWN. ASSUME 12' LANES, 4' SHOULDERS, 20' DITCHES, 50' MEDIAN (ARTERIAL ONLY)

4. CROSSING SHALL BE CONSTRUCTED USING BORE METHOD UNLESS OTHERWISE SPECIFIED.

5. THE CONSTRUCTED PIPELINE SHALL BE STRAIGHT WITH NO VERTICAL OR HORIZONTAL BENDS BETWEEN ROAD ROW BOUNDARIES.

6. FOR TYPICAL EXTRA TEMPORARY WORKSPACE FOR ARTERIAL AND COLLECTOR ROAD CROSSINGS SEE DRAWING DB-ROW-06.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*
ROAD CROSSINGS -
ARTERIAL/COLLECTOR ROADS



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| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-XING-02 |

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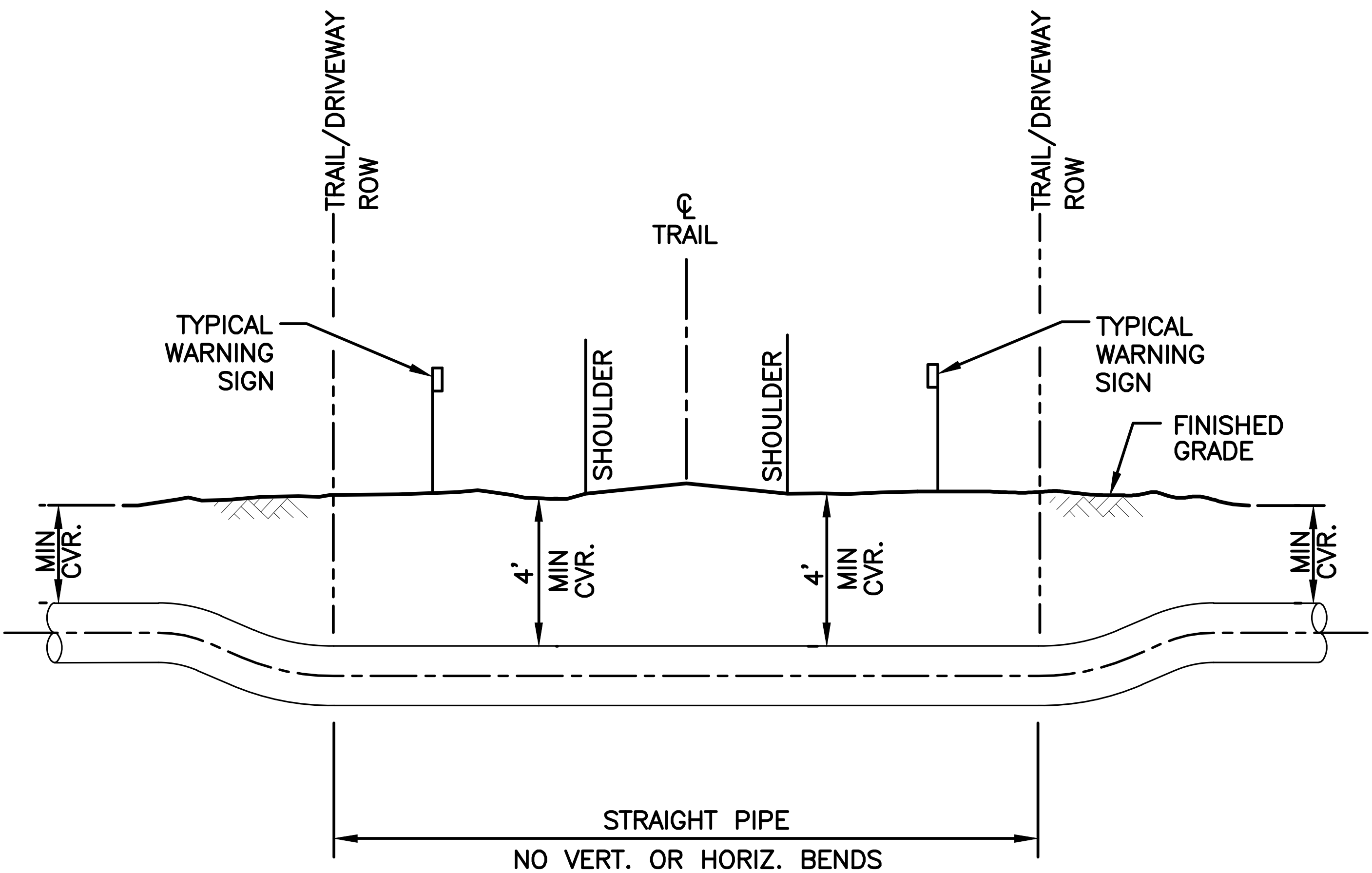


## NOTES:

1. TRAIL/DRIVEWAY CROSSINGS SHALL BE CONSTRUCTED BY OPEN CUT METHOD, UNLESS OTHERWISE SPECIFIED.
2. FOR EXTRA TEMPORARY WORKSPACE, SEE DRAWING DB–ROW–06.
3. ASSUME A 20' TRAIL/DRIVEWAY WIDTH AT 90°.
4. THE CONSTRUCTED PIPELINE SHALL BE STRAIGHT WITH NO VERTICAL OR HORIZONTAL BENDS BETWEEN TRAIL/DRIVEWAY ROW.

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***

ROAD CROSSINGS -
TRAILS/DRIVEWAYS



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| NOVEMBER 14, 2014 | 0B | N.T.S. | DB–XING–03 |

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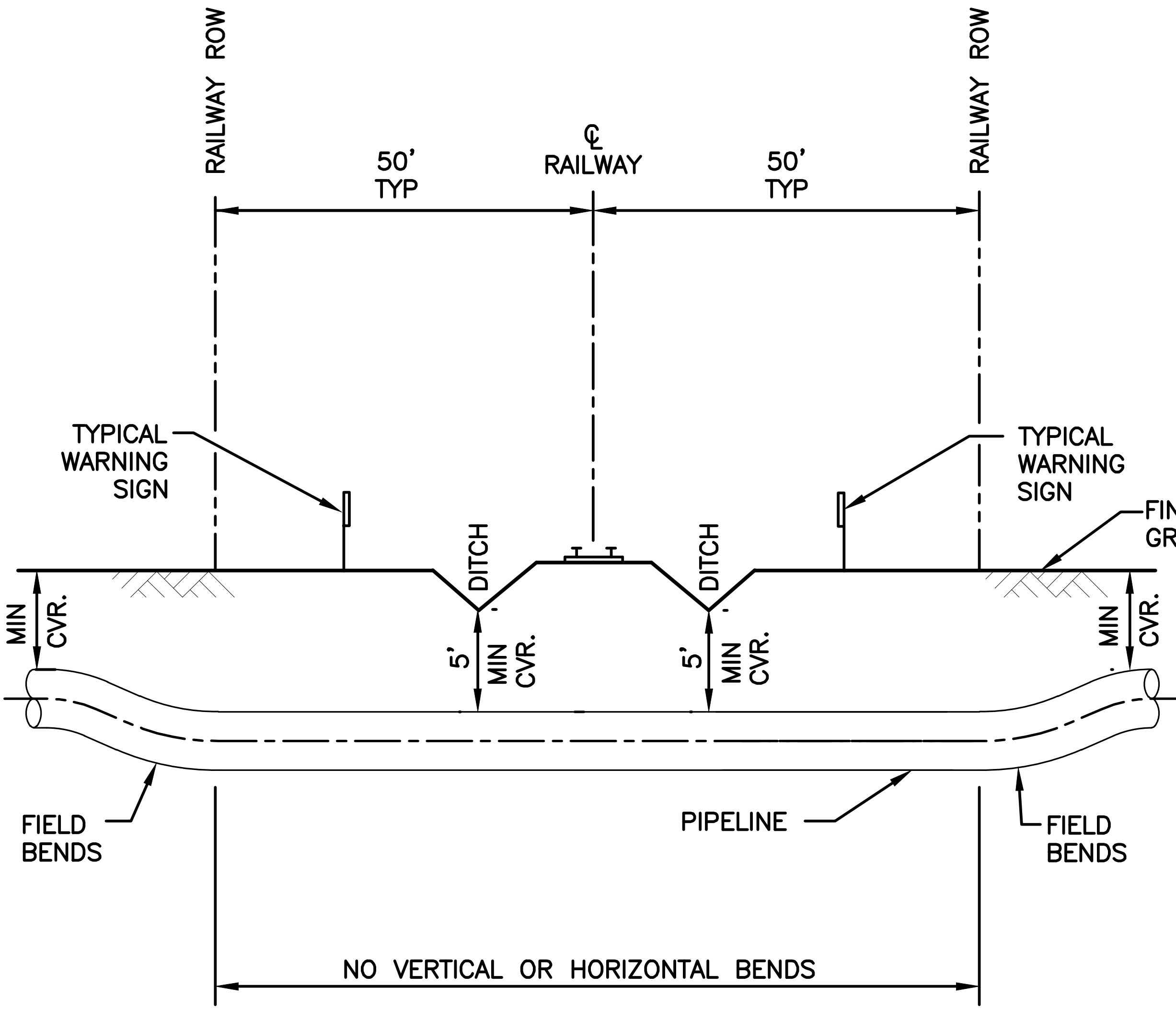


NOTES:

1. ALL RAILWAY CROSSINGS SHALL BE BORED.
2. THE CONSTRUCTED PIPELINE SHALL BE STRAIGHT WITH NO VERTICAL OR HORIZONTAL BENDS WHITIN RAILWAY ROW.

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***

ROAD CROSSINGS -
RAILWAY CROSSING



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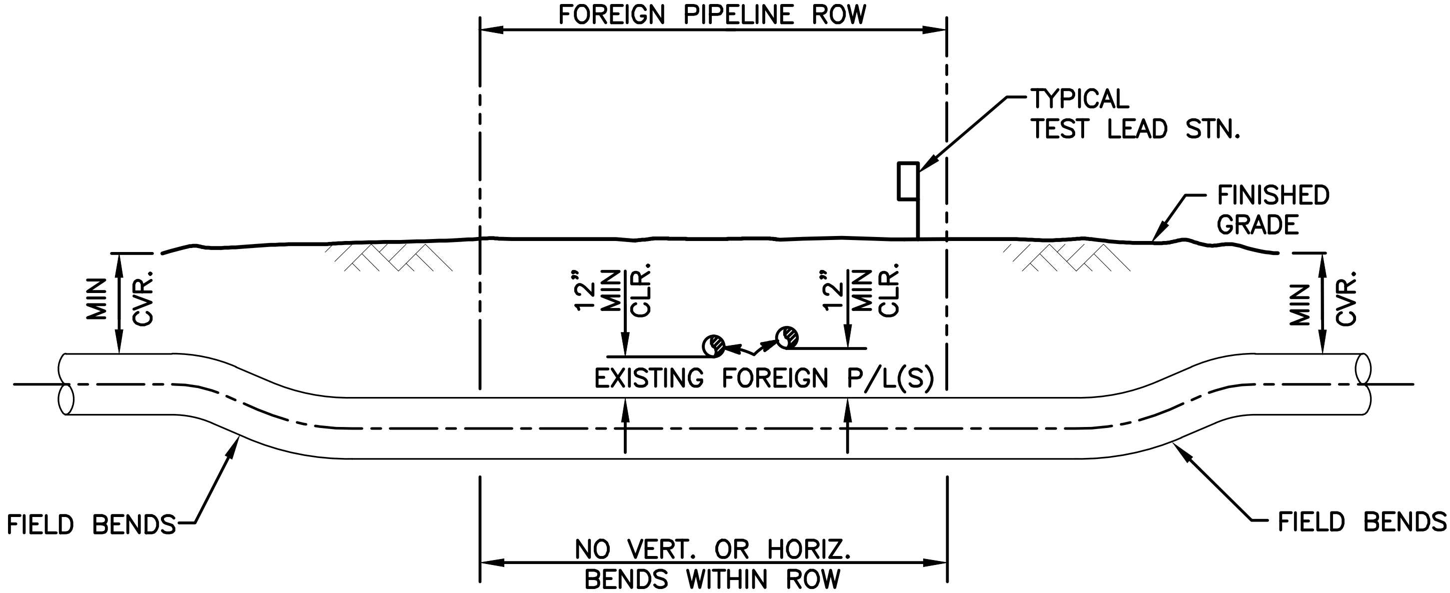
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-XING-04 |




NOTES:

1. FOREIGN PIPELINE LOCATIONS & DEPTHS TO BE DETERMINED IN ADVANCE OF PIPELINE CONSTRUCTION AND CONFIRMED BY EXPOSING THE FOREIGN PIPELINES.

2. SEE DB–XING–06 & DB–XING–07 FOR TAPS PIPELINE CROSSINGS.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*
FOREIGN PIPELINE
CROSSINGS



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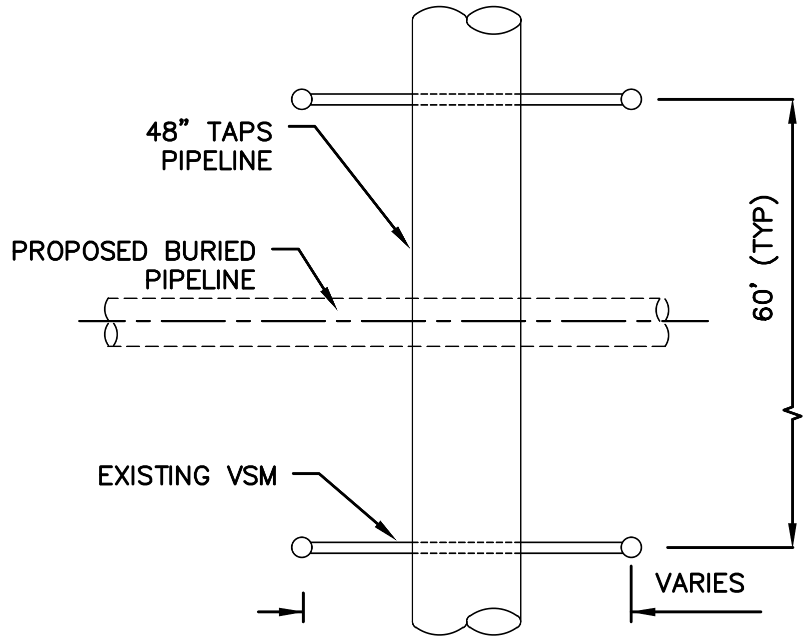
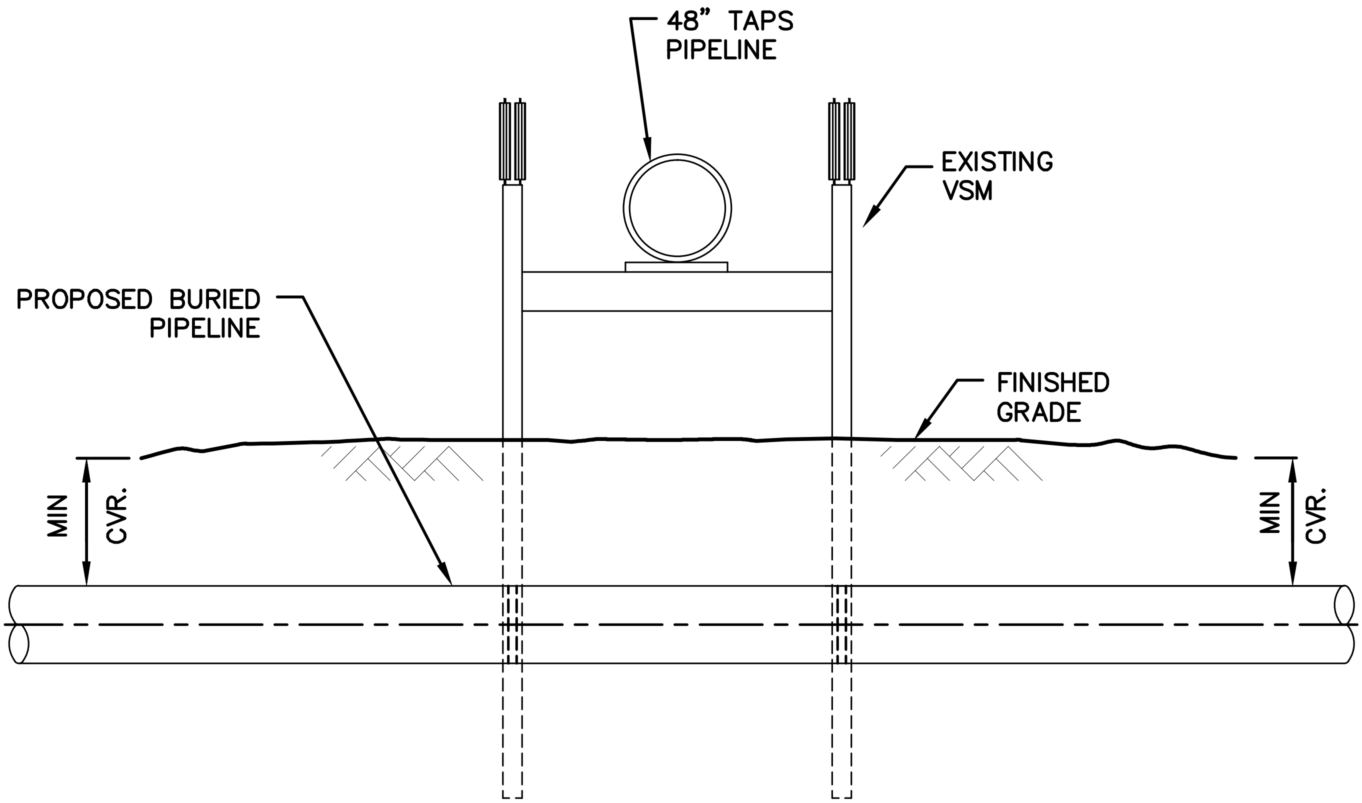
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB–XING–05 |




NOTE:
1. ALIGNMENT SHALL CROSS AS NEAR MID-SPAN BETWEEN SUPPORTS AS PRACTICABLE.

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***
FOREIGN PIPELINE CROSSINGS
TAPS ABOVE GROUND



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| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-XING-06 |

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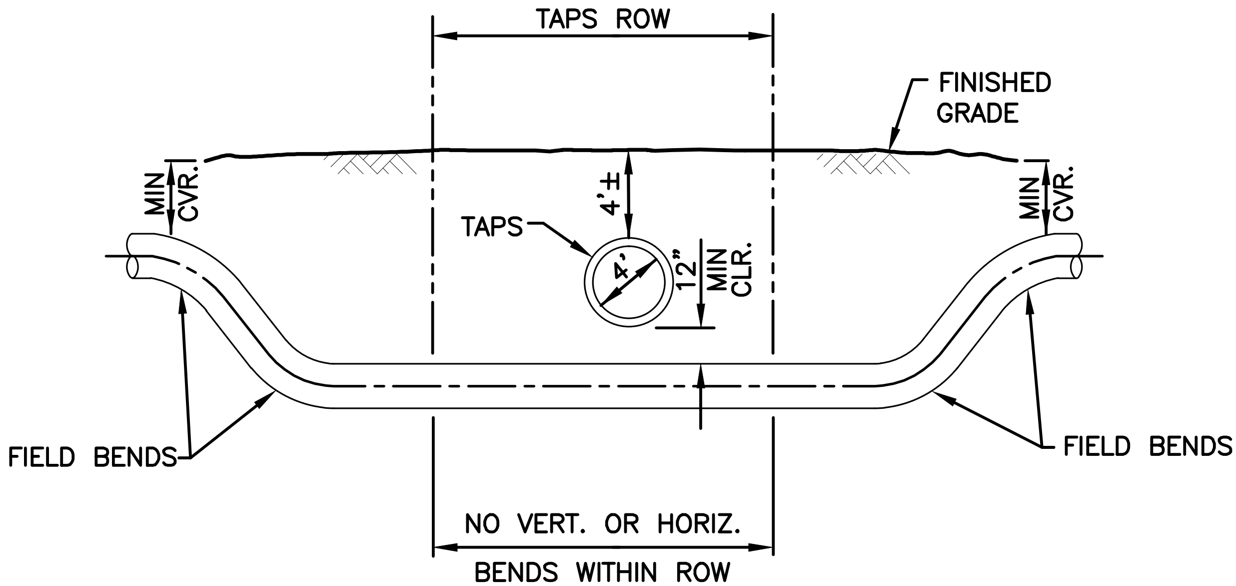


NOTES:

1. FOREIGN PIPELINE LOCATIONS & DEPTHS TO BE DETERMINED IN ADVANCE OF PIPELINE CONSTRUCTION AND CONFIRMED BY EXPOSING THE FOREIGN PIPELINES.
2. MINIMUM CLEAR SPACING 12" (MINIMUM CODE REQUIREMENT).
3. CROSSING BENEATH THE BURIED TAPS LINE SHOWN; CROSSING ABOVE THE BURIED TAPS LINE WILL EACH BE SITE-SPECIFIC DESIGN.

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***

FOREIGN PIPELINE CROSSINGS

TAPS BELOW GROUND



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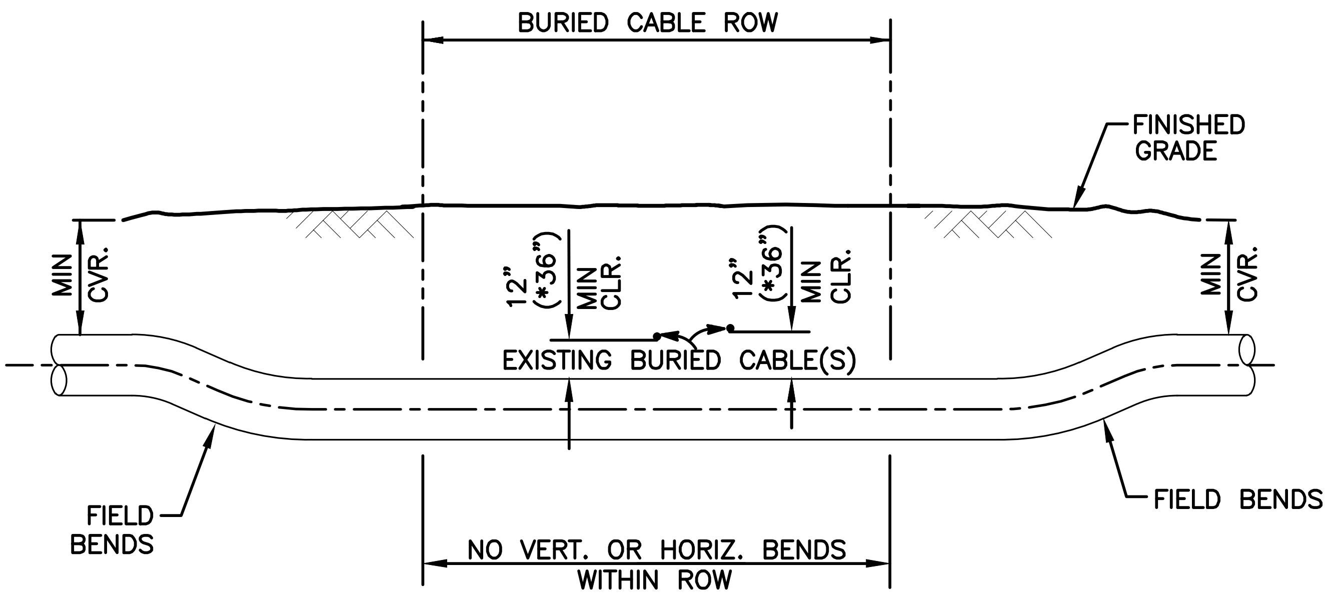


NOTES:

1. BURIED CABLE LOCATIONS & DEPTHS TO BE DETERMINED IN ADVANCE OF PIPELINE CONSTRUCTION AND CONFIRMED BY EXPOSING THE BURIED CABLES.

2. * MINIMUM CLEARANCE SHALL BE 36" WHERE THE PIPELINE CROSSES UNINSULATED PRIMARY ELECTRICAL CROSSINGS.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*

BURIED CABLE CROSSINGS



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| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-XING-08 |

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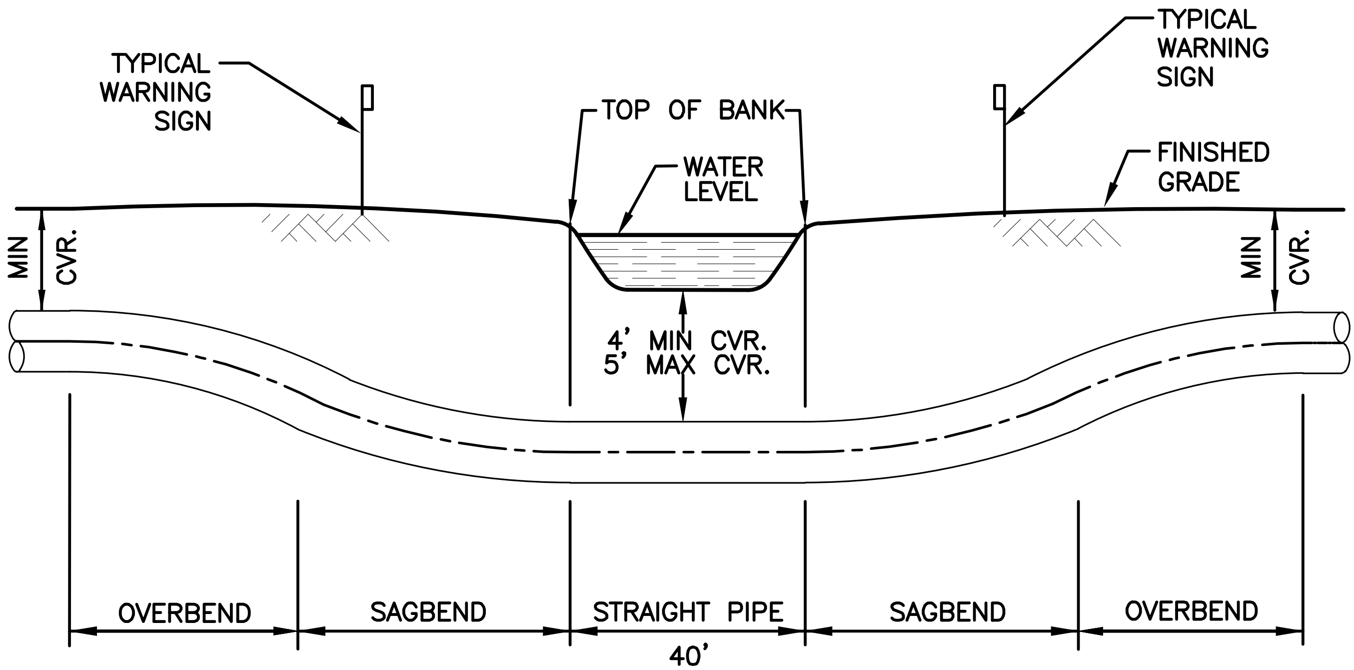


NOTES:

1. WATERBODY CROSSING WILL BE INSTALLED BY THE OPEN-CUT OR OTHER METHOD, UNLESS OTHERWISE NOTED.

2. BUOYANCY CONTROL REQUIREMENTS TO BE DETERMINED.

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***
WATERBODY CROSSINGS -
TYPICAL FOR MINOR CROSSINGS



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| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-XING-09 |

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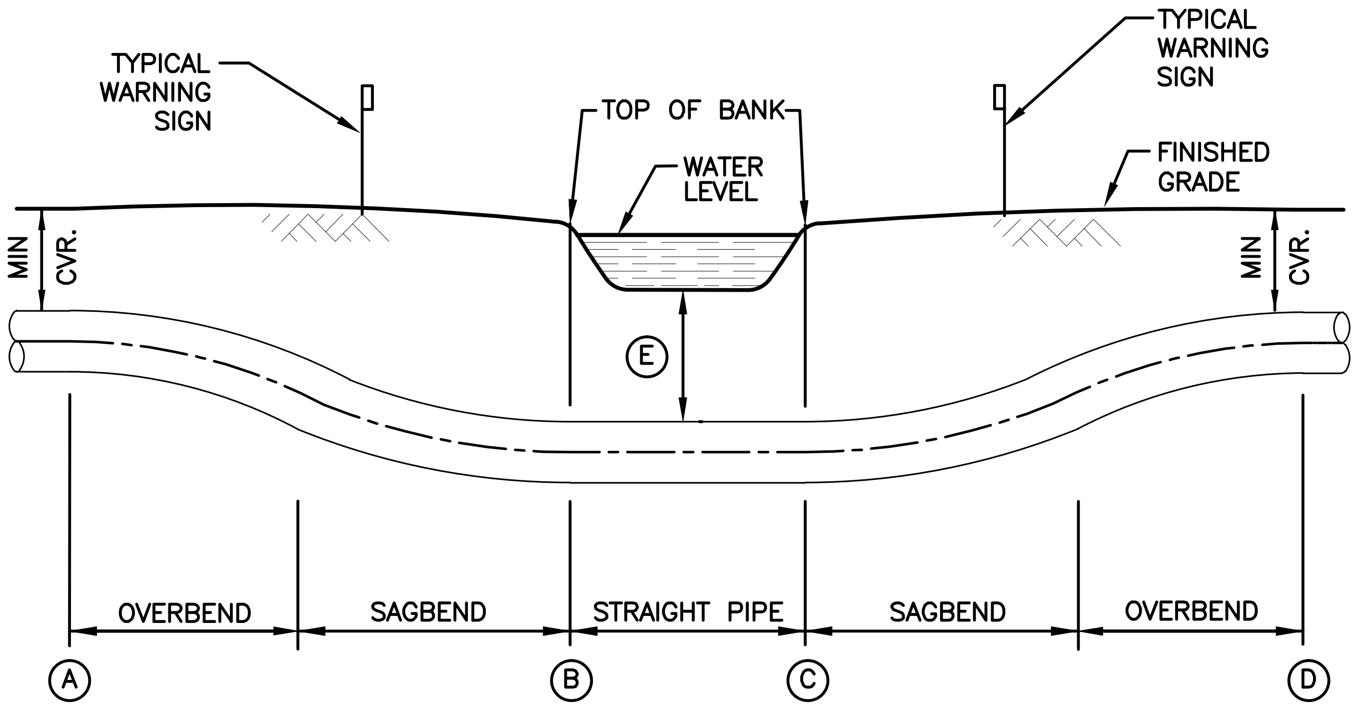


NOTES:

1. WATERBODY CROSSING WILL BE INSTALLED BY THE OPEN–CUT OR OTHER METHOD, UNLESS OTHERWISE NOTED.
2. BUOYANCY CONTROL REQUIREMENTS TO BE DETERMINED.
3. Ⓐ, Ⓑ, Ⓒ, AND Ⓓ REFERENCE PIPELINE STATIONING SPECIFIC TO THE CROSSING.
4. Ⓔ IS MINIMUM BURIAL DEPTH SPECIFIC TO THE CROSSING.

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ALASKA STAND ALONE GAS PIPELINE/*ASAP*
WATERBODY CROSSINGS -
TYPICAL FOR INTERMEDIATE CROSSINGS



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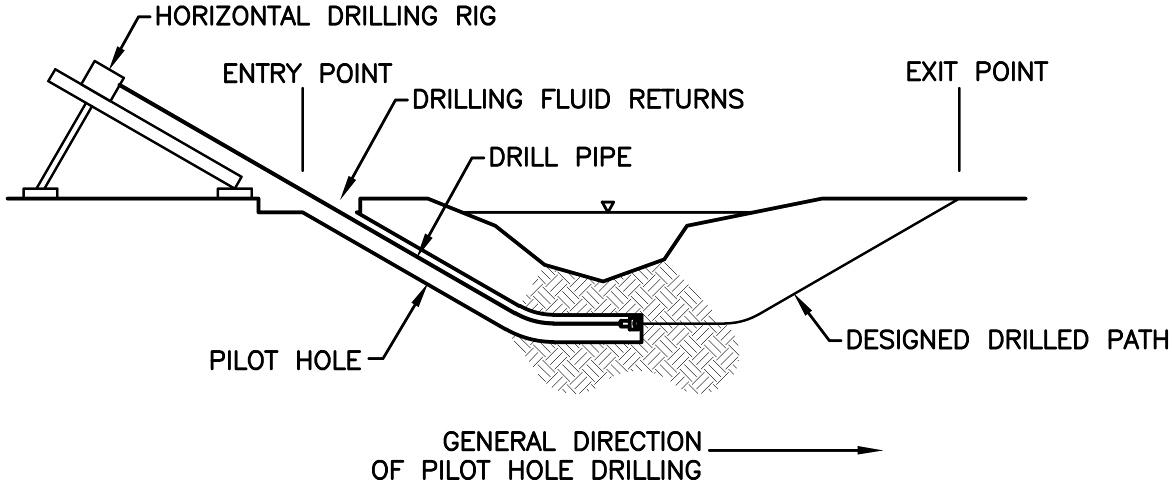
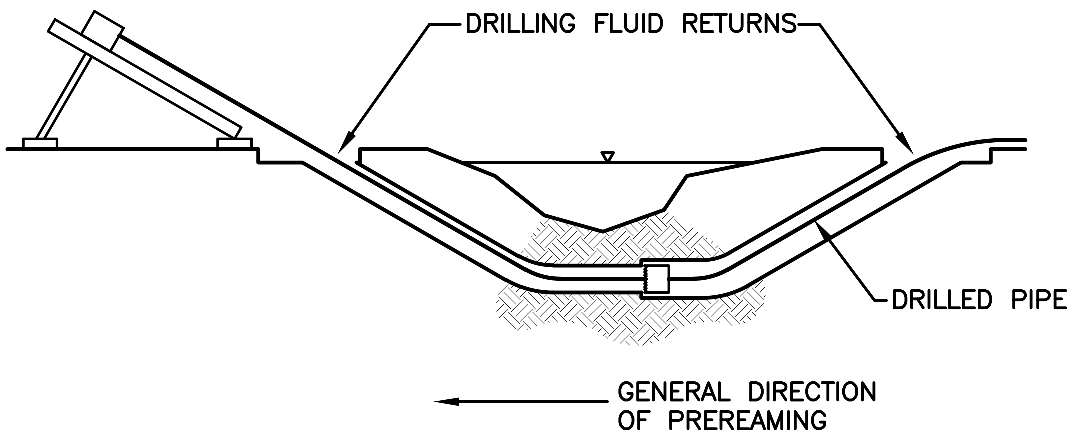
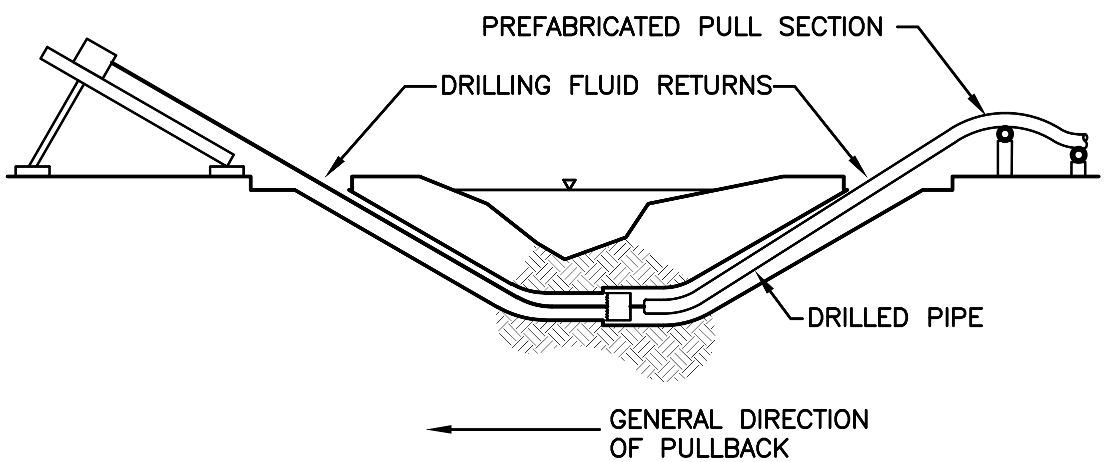
## STAGE 1: PILOT HOLE DIRECTIONAL DRILLING




## STAGE 2: REAMING




## STAGE 3: PULLBACK

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***
HORIZONTAL DIRECTIONAL
DRILL CROSSING



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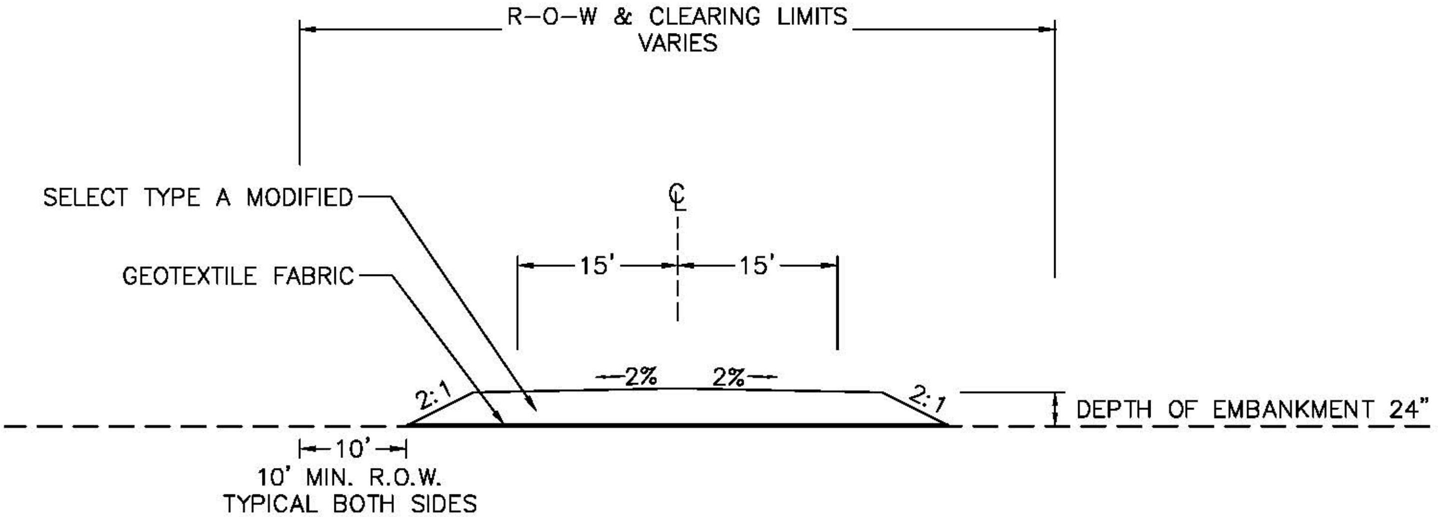


| PERMANENT AND TEMPORARY ACCESS ROAD |
|---|
| 2' MAX. SELECT TYPE A MODIFIED<br>GEOTEXTILE FABRIC UNDER FILL |

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# ALASKA STAND ALONE GAS PIPELINE/*ASAP*
## TYPICAL ACCESS ROAD
## IN FILL



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| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-AR-01 |

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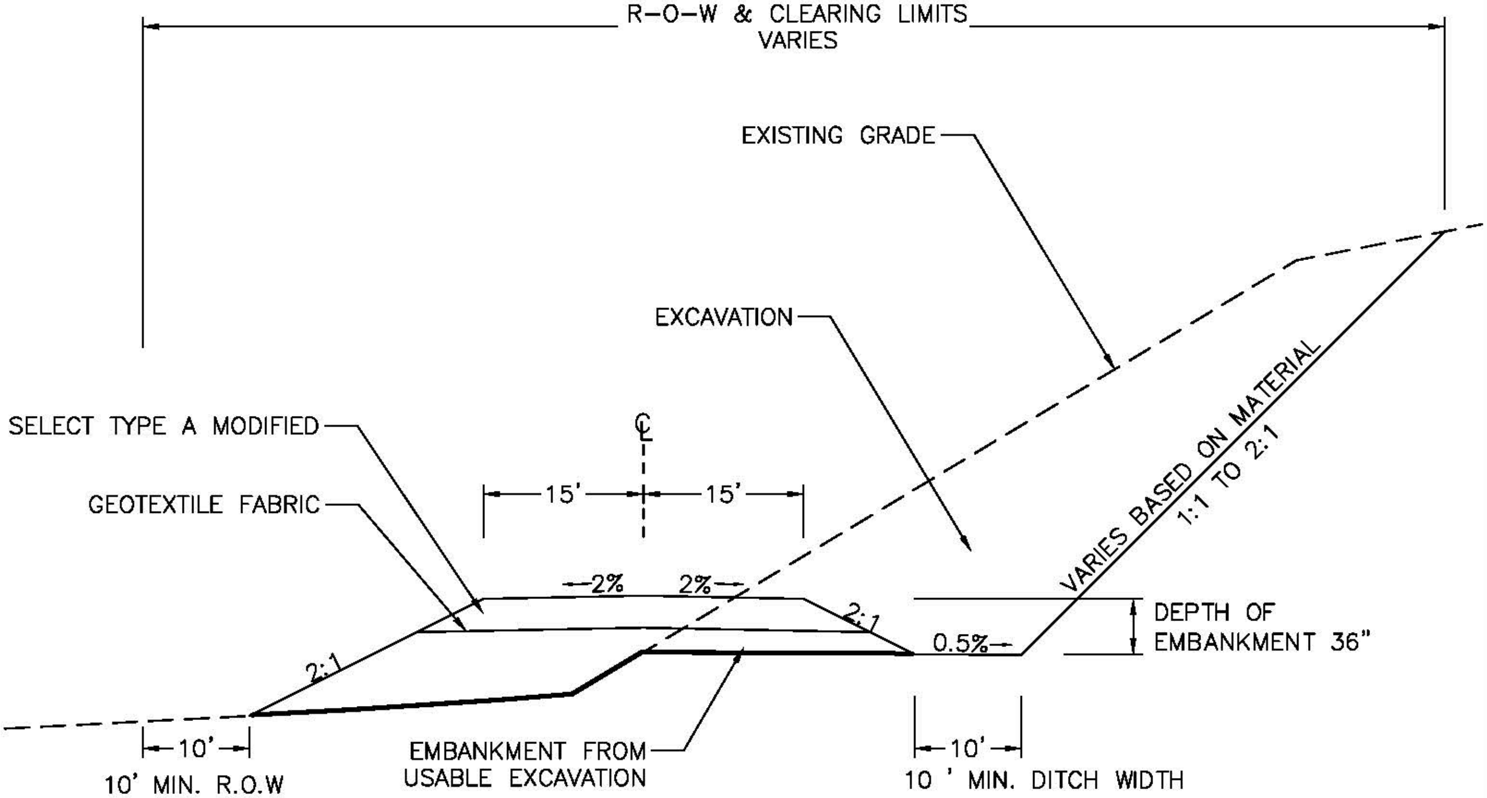


| PERMANENT AND TEMPORARY ACCESS ROAD |
|---|
| 2' SELECT TYPE A MODIFIED<br>GEOTEXTILE FABRIC UNDER FILL |

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# ALASKA STAND ALONE GAS PIPELINE/*ASAP*
## TYPICAL ACCESS ROAD
## WITH 1 LEVEL CUT



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| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-AR-02 |

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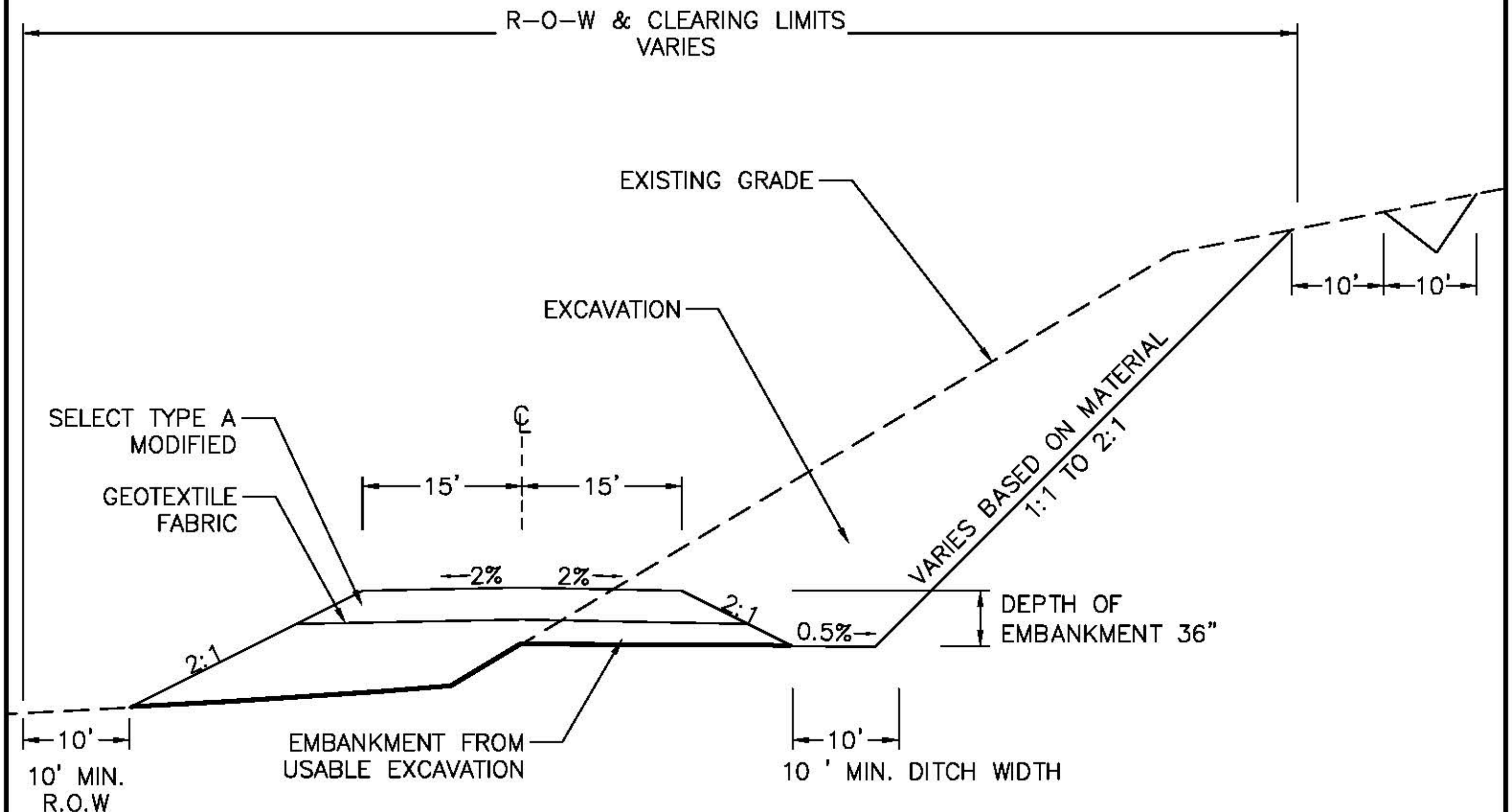


| PERMANENT AND TEMPORARY ACCESS ROAD |
| --- |
| 2' SELECT TYPE A MODIFIED |
| GEOTEXTILE FABRIC UNDER FILL |

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# ALASKA STAND ALONE GAS PIPELINE/*ASAP*
## TYPICAL ACCESS ROAD
## WITH 2 LEVEL CUT



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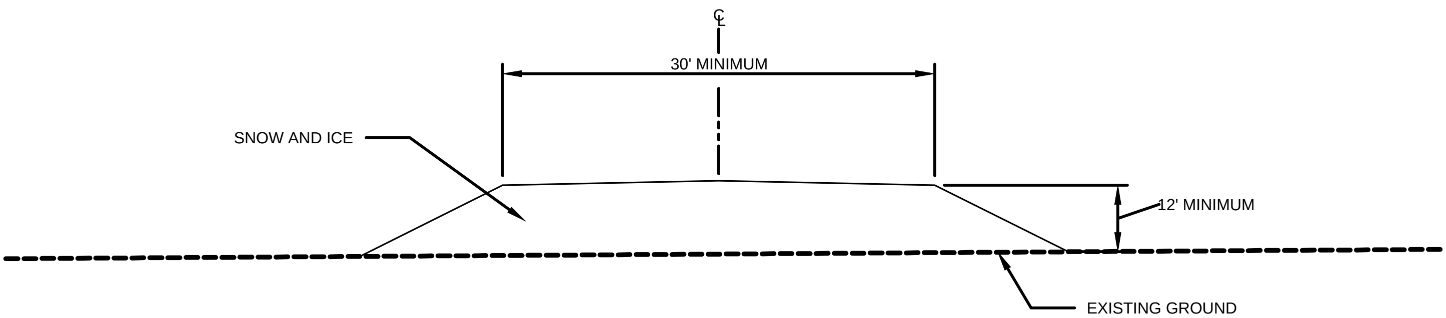
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-AR-03 |




TYPICAL ICE ROAD
NOT TO SCALE

Baker

ASAP
Alaska's In-State Gas Pipeline

ALASKA STAND ALONE GAS PIPELINE/ASAP

TYPICAL ICE ROAD



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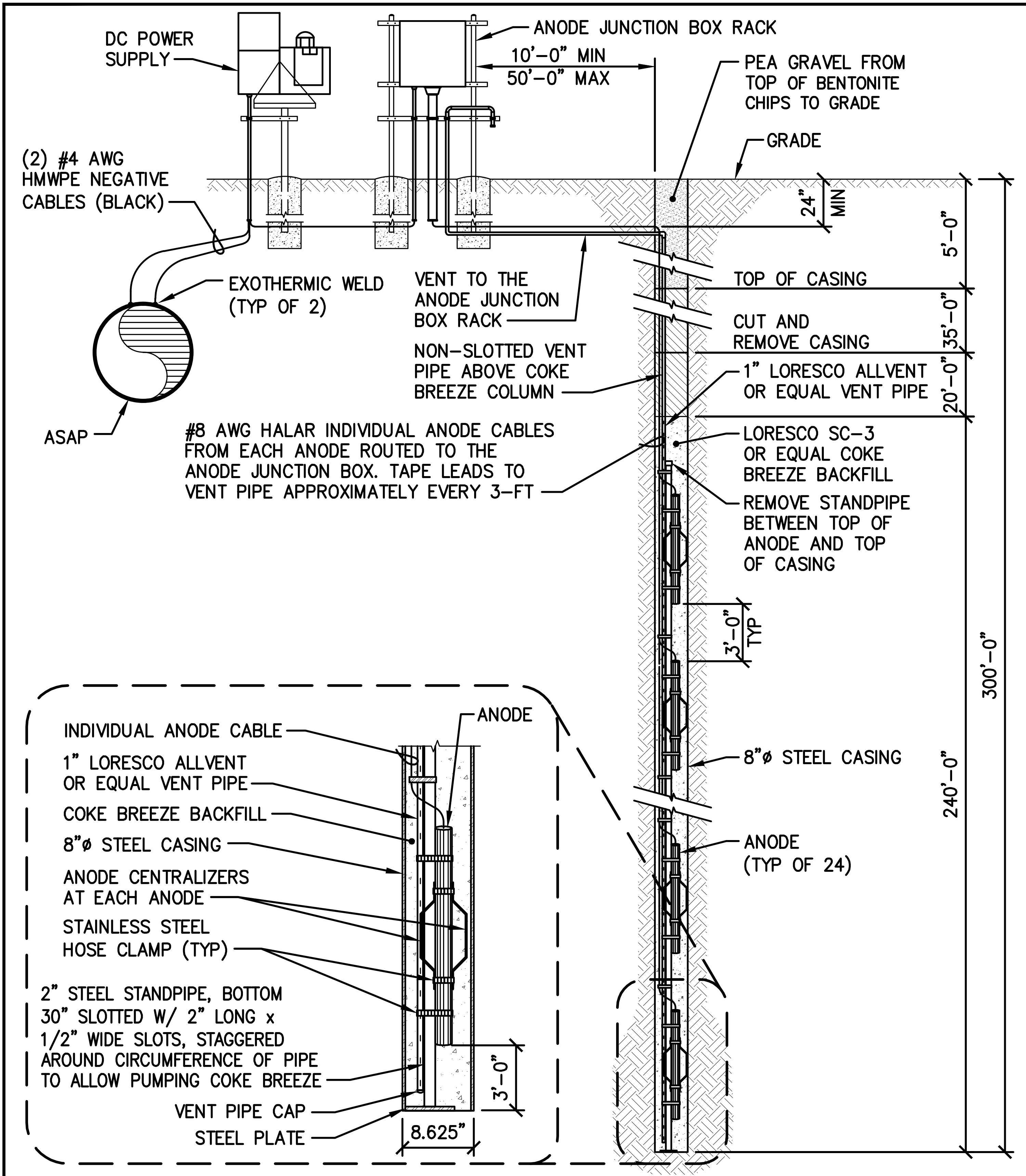


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# ALASKA STAND ALONE GAS PIPELINE/*ASAP*

## CATHODIC PROTECTION

## TYPICAL IMPRESSED CURRENT GROUNDBED DETAIL



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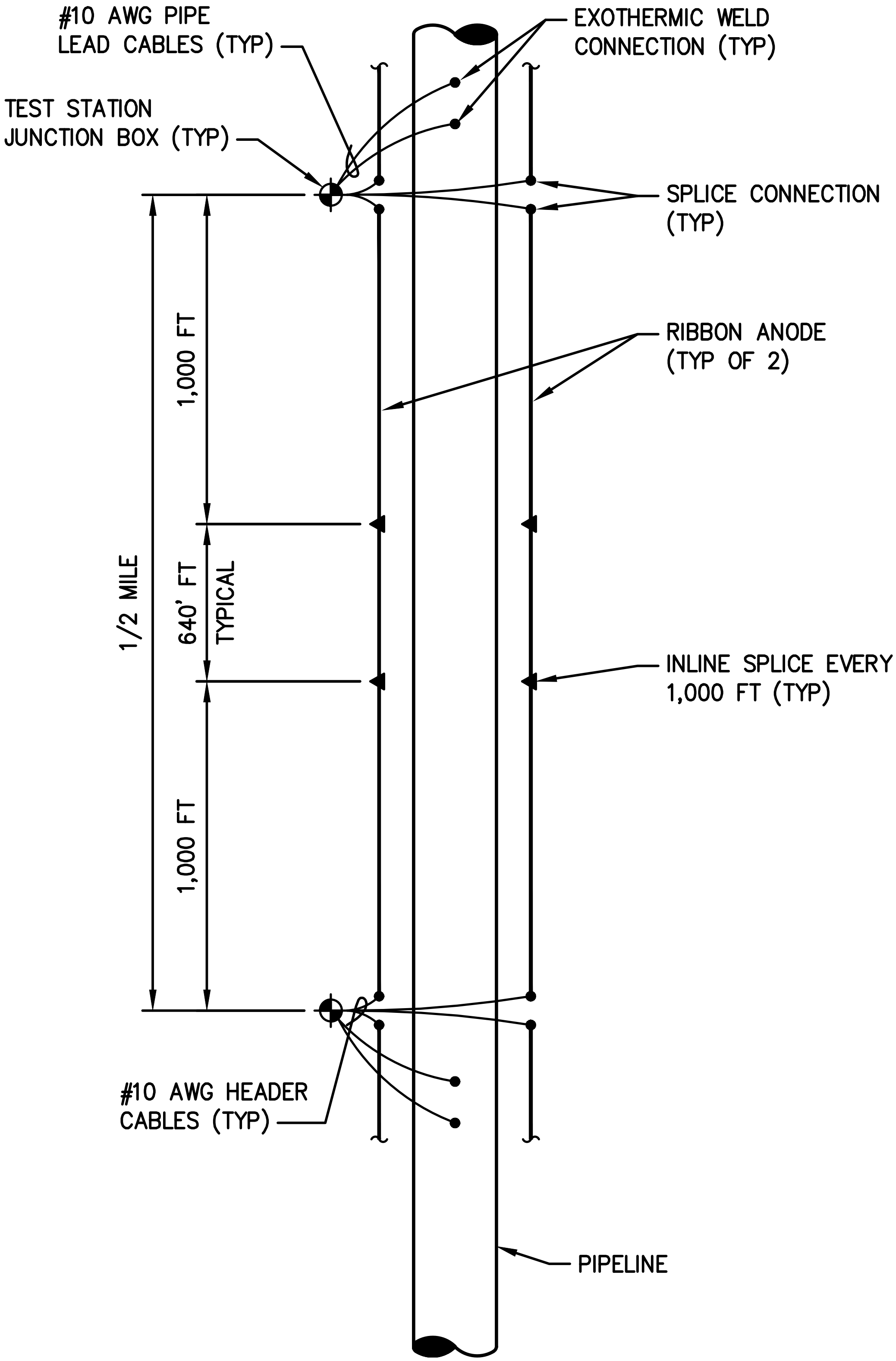
| NOVEMBER 14, 2014 | 0B | N.T.S. | DB-CC-01 |

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***
CATHODIC PROTECTION
MAGNESIUM OR ZINC RIBBON ANODE PLAN



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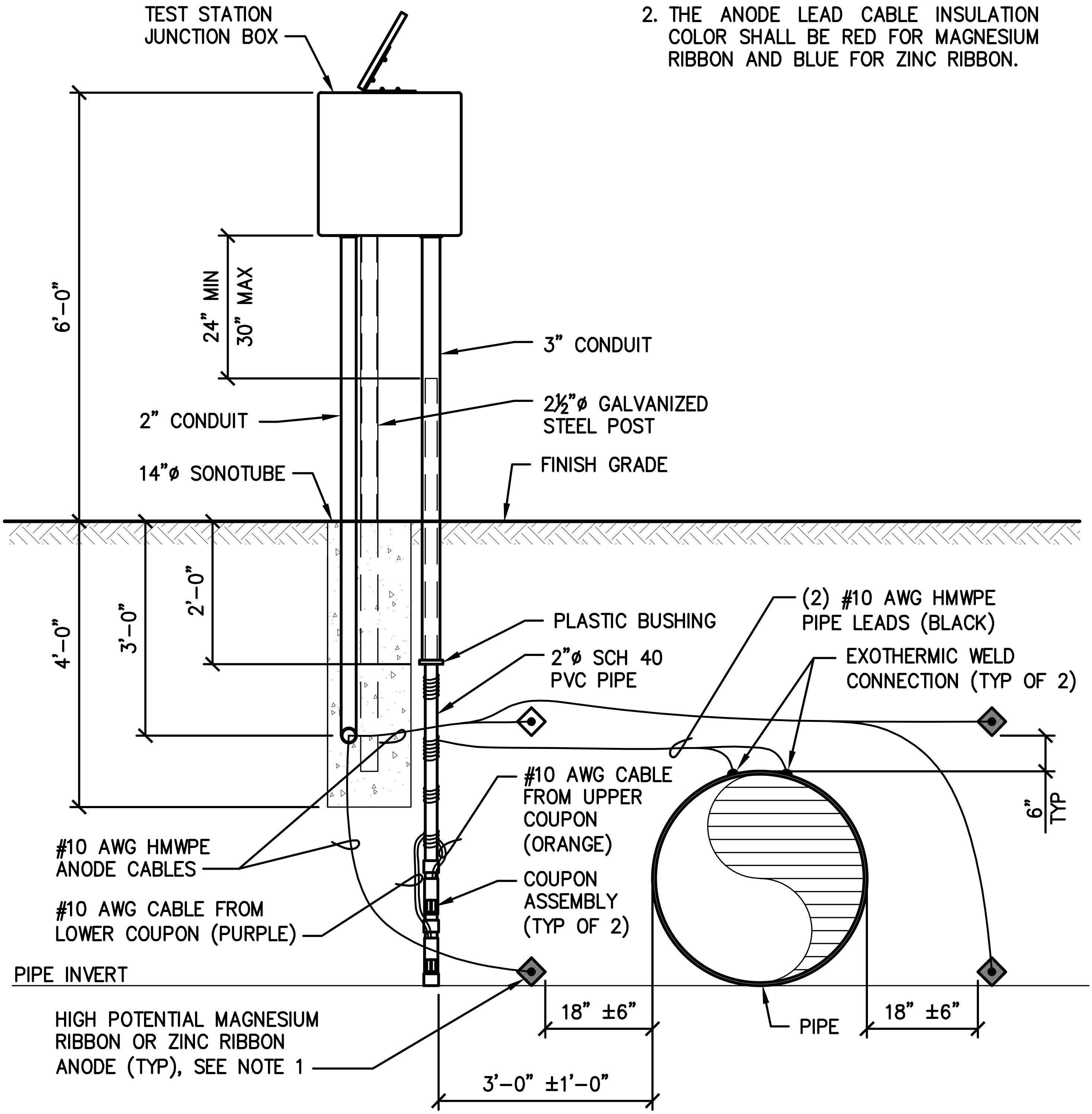
NOTES:

1. AT LOCATIONS WHERE THREE ANODE RIBBONS OCCUR, PLACE RIBBONS AS INDICATED BY THE SHADED SYMBOLS.
2. THE ANODE LEAD CABLE INSULATION COLOR SHALL BE RED FOR MAGNESIUM RIBBON AND BLUE FOR ZINC RIBBON.

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# ALASKA STAND ALONE GAS PIPELINE/*ASAP*
## CATHODIC PROTECTION
## TYPICAL COUPON TEST STATION DETAIL



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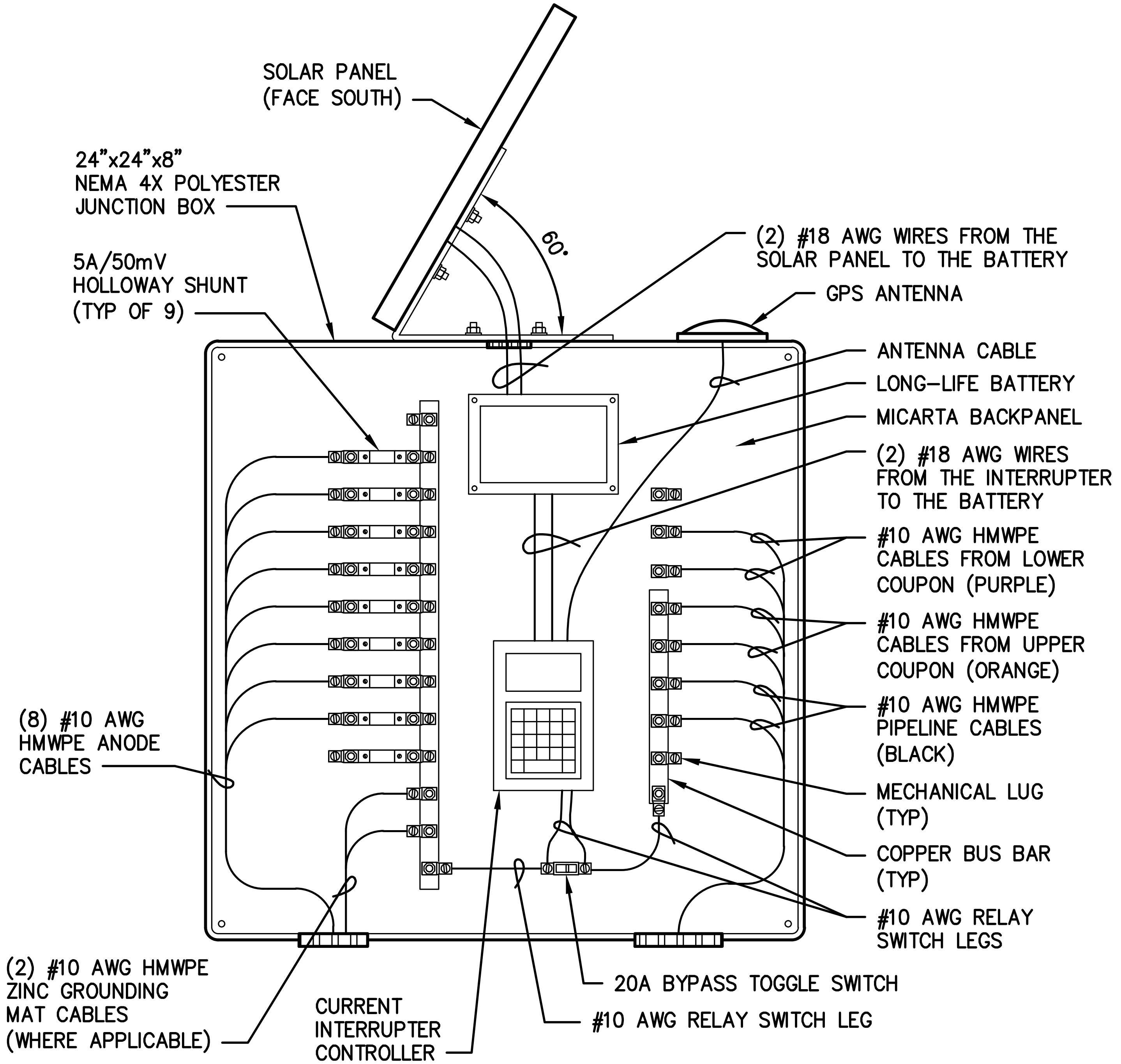


NOTE:
1. LABEL ALL CABLES WITH HEAT SHRINK LABELS INDICATING THE CABLE ORIGIN.

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**ALASKA STAND ALONE GAS PIPELINE/*ASAP***
CATHODIC PROTECTION
TYPICAL TEST STATION JUNCTION BOX DETAIL



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