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13.0 DITCH CONFIGURATION

13.1 INTRODUCTION

This section contains an evaluation and selection procedure comprised of various design criteria contained in other sections of the Technical Information Supplement (TIS). Sections of the TIS relevant to ditch configuration include: Section 11 – Drainage and Erosion Control; Section 12 – Construction Rehabilitation; Section 16 – River, Stream and Wetland Crossings; Section 21 – Geotechnical/Geothermal Analysis; Section 27 – Insulation; Section 28 – Foreign Pipeline Crossings Section 30 – Corrosion Control and Section 32 – Construction.

This section also provides mode concepts that have been developed to demonstrate how the design criteria will be used for reasonably anticipated ROW conditions. It is not intended to be a complete representation of all design modes that may be used during the mile-by-mile design. Other cost-effective modes will likely be developed, and current concepts modified, during final design for application to the site-specific areas of the pipeline alignment. During the detailed design process, a guiding principle in the selection of design modes and construction details will be that a balance should be achieved between capital and operating costs.

13.2 CODES AND CRITERIA

13.2.1 Codes

- United States Code, Title 15 – Commerce and Trade, Chapter 15C – Alaska Natural Gas Transportation Act
- Clean Water Act, as amended, Title IV – Permits and Licenses
- Code of Federal Regulations, Title 18 – Conservation of Power and Water Resources
- Code of Federal Regulations, Title 33 – Navigation and Navigable Waters
- Code of Federal Regulations, Title 36 – Parks, Forests, and Public Property
- Code of Federal Regulations, Title 40 – Protection of the Environment
- Code of Federal Regulations, Title 43 – Public Lands: Interior
- Code of Federal Regulations, Title 44 – Emergency Management and Assistance (Part 9, Floodplain Management and Protection of Wetlands)
- Code of Federal Regulations, Title 49 – Transportation, Part 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
- Code of Federal Regulations, Title 50 – Wildlife and Fisheries

- Federal Right-of-Way Grant for the Alaska Natural Gas Transportation System Alaska Segment Serial No. F-24538 (December 1, 1980), as such may be updated and/or amended from time to time.
- Federal Energy Regulatory Commission conditional certificate of public convenience and necessity, issued on December 16, 1977, as such is finalized
- Alaska Statutes, Title 11 – Natural Resources
- Alaska Statutes, Title 16 – Fish and Game
- Alaska Statutes, Title 38 – Public Land
- Alaska Statutes, Tile 46 – Water, Air, Energy and Environmental Conservation
- Alaska Administrative Code, Title 5 – Fish and Game
- Alaska Administrative Code, Title 6 – Alaska Coastal Management Program
- Alaska Administrative Code, Title 11 – Natural Resources
- Alaska Administrative Code, Title 17 – Transportation and Public Facilities
- Alaska Administrative Code, Title 18 – Environmental Conservation

13.2.2 Criteria

The general criteria governing ditch configuration are as follows:

- Minimum depth of cover will be in accordance with Section 192.327 of CFR, Title 49, except for special mitigative areas where waivers are required.
- Ditch wall slopes will be as vertical as field conditions will allow.
- Depths of cover criteria for buoyancy control and river and stream scour are included in Section 16.
- Cover over the pipe will be such that frost heave will not allow the top of the pipe to exceed the natural ground level, or in areas of cut, the finished cut elevation.
- Unless otherwise specified, backfill will be mounded over the ditch to approximately one-foot to allow for possible settlement of the backfill.
- Requirements for, and dimensions of, boardstock insulation and buried pipe insulation will be determined by thermal analyses.
- Allowable thaw settlement and allowable frost heave will be limited by pipe stress and/or strain criteria included in Sections 20 and 21, and by the potential impact upon third party facilities.
- Allowable thaw penetration for the design will be limited by calculated allowable pipe settlement, soil support requirements at bends or embankments and terrain stability concerns. (See Sections 20 and 21).
- The calculated effects of long-term frost heave or pipe displacement will be considered in determining pipe depth of burial. (See Section 21).

- In thaw unstable1 soils the design will generally ensure that during operations the soil will be maintained frozen below the pipe and for some distance from the pipe centerline. This is to ensure that if long-term thaw develops below the workpad due to construction disturbance a sufficient quantity of frozen soil remains under the pipe to ensure adequate support. Also at side bends, where the design is based on the soil around the bend remaining frozen, the design will ensure that a sufficient quantity of the soil remains frozen to ensure that design conditions are met. Any thaw settlement during the dormant period shall meet criteria for pipeline integrity. (See Section 20).
- Stream, river, and wetland crossings will be designed such that the impact to groundwater, aufeis development, frost heave, temperature effects and environmental concerns will be minimized.
- The mineral material used to construct a workpad can be common material that meets the workpad criteria as outlined in Section 9 and will comply with stabilization and erosion protection as outlined in Sections 11 and 12.
- If a barrier is required to preclude unauthorized vehicles from driving over the buried pipe, or to protect elevated sections of the pipeline from accidental impact, it will be designed and sited to ensure free passage and movement of animals. The barrier will also be designed to avoid affecting the roadway adversely as a snow fence.

13.2.2.1 Bedding, Padding, and Backfill

- Bedding and Padding
  - Native soils that meet the specifications for bedding and padding will be used.
  - Bedding and padding material gradation quality, thickness, moisture content, and placement specifications will be written to ensure that damage to the pipe coating or insulation will not result. The specifications will also ensure that the vertical, lateral, and longitudinal support will be provided to the pipe as required in Sections 20 and 21.
  - Bedding and padding will be required for conventional Rock Ditch (Type II) or for other ditch types at locations where native ditch materials could damage the pipe, pipe coating or insulation.
- Non-Frost Susceptible Backfill (NFS)
  - Where over-excavation of the ditch and replacement of native material is required for frost heave mitigation, NFS material will be used to backfill the over-excavated portions of the ditch below the pipe.
  - NFS backfill will be granular materials having a particle size distribution in accordance with the gradation limits to be indicated in the ditch backfill specifications.

[1] Soils with unacceptable thaw settlement during the dormant and/or operating phases of the gas pipeline.

  - Native soils may be used for NFS backfill if they meet the NFS specification.
- Native or Common Backfill
  - In situ soils having moisture contents less than the liquid limit or 50 percent by dry weight of the material, whichever is less, may be used as native or common backfill. Additional consideration will be given to surficial loading conditions (see Section 20).
  - Native or common backfill materials on bends (see Section 21) and buoyancy control (see Section 16) areas will be placed to maintain stability and provide adequate pipe restraint (see Section 20) as outlined in the specifications.
  - Native soils may be used for backfill and/or bedding and padding if they meet the backfill specifications.

13.2.2.2 Ditch Plugs

- A ditch plug system (see Figure 13-1) will satisfy the following requirements:
  - Provide the necessary protection to the ditch walls, bottom and backfill, and bedding and padding during the dormant phase. If ditch plugs are used with mode Type III, they will be designed to restrict water flowing within the ditch during the design life of the gas pipeline, unless other methods are used.
  - Provide a low permeability barrier across the ditch cross section, and keyed as required to the ditch walls and or ditch bottom, to restrict water flow within the ditch and/or around the ditch plug.
  - Provide an outlet for the controlled exit of ditch water to the ground surface to control seepage of water upslope of the ditch plug.
  - Provide for surface grading or a diversion berm to divert the water outflow away from the ditch and into the construction zone drainage pattern.
- Ditch plugs will be required:
  - At stream crossings where there is a possibility of diverting stream flow into the ditch and away from the normal channel flow. Ditch plugs will be placed at both sides of the stream.
  - At all foreign pipeline crossings (including both Trans Alaska Pipeline System [TAPS] oil pipeline and fuel gas line [FGL]) ditch plugs will be placed, on a site specific basis. The ditch plugs will be placed where the two ditches intersect and where water exists (or the potential for water), so as to isolate the water from one pipeline to the other and to avoid thermal/hydraulic erosion at the crossing.
  - At locations where it is desirable to block water flowing in the ditch to minimize the development of icings and aufeis at a downslope location. Ditch plugs will be placed at a sufficient distance upslope to form discharge to an area with less damage potential.

  - At locations where concentrated groundwater flow entering the pipeline ditch is encountered during construction. Ditch plugs will be placed downslope from where the water is flowing into the ditch.
  - At locations where flow from cross drainages, such as low water crossings, might be diverted into or along the ditch. Ditch plugs will be placed on the downslope side of the crossing or as required.
  - At highway crossings where water (or the potential for water) exists in the gas pipeline ditch, ditch plugs will be placed on a site-specific basis so as to isolate the crossing from flowing ditch water.
- Ditch plugs will not be required along steep slopes if soil-cement backfill is used. Soil-cement backfill will not be used in areas where frost heave concerns require lower uplift resistances.
- Ditch plugs will not be required where the in situ ditch wall materials below the top of the pipe consist of unfrozen soils which contain less than six percent fine-grained particles passing a No. 200 sieve or if consolidated bedrock is present. The potential for short-term seepage erosion of the ditch backfill may require ditch plugs under certain conditions such as sag bends and where consolidated bedrock is present in the ditch below the top of the pipe.

13.2.2.3 Ditch Wall Stability

- The preferred protection for ditches excavated in soils with a thaw strain potential of 20 percent or more is to require shoulder month or winter construction. For soils with thaw strain potential of less than 20 percent other mitigating conditions such as slope aspect and open ditch time should be considered and site specific decisions made.
- To reduce the thaw degradation potential of frozen ditch walls and ditch bottom, the entry of surface water into the ditch will be minimized.

13.2.2.4 Chilled Pipe Effects

Design criteria and considerations for chilled pipe effects on river and streams, wetlands and adjacent facilities are included in Sections 3, 11, and 16. The project document "Chilled Pipe Effects on Streams" * February 1985, includes additional criteria and methodology.

13.2.2.5 Insulation

Criteria for insulation are found in Section 27.

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- Fully insulated pipe or ditch insulation may be required for buried pipe to mitigate the effects of frost heave or thaw settlement respectively.
- Fully insulated pipe will be required for elevated design modes that will be exposed to climatic changes.
- Buried insulation thickness will be calculated from geothermal analyses based on the thermal properties for that type and density of insulation.

13.2.2.6 Crossings

- Criteria for river, stream and wetland crossings and bridges are found in Sections 14 and 16.
- Criteria for road crossings are found in Section 15.
- Fault crossing design will be site specific based on fault crossing considerations in Section 17.
- Criteria for stress analysis at foreign pipeline, road, and fault crossings are in Section 20.
- Foreign pipeline crossing criteria are in Section 28.

13.2.2.7 Construction Zone

- Considerations for construction scheduling and seasonal constraints are found in Section 3. Some design modes are time dependent upon the period of year they are constructed as well as length of dormant period.
- Criteria for spoil disposal within the construction zone are included in Section 6.
- Criteria for cut and fill sections, workpad design and grading are included in Section 9.
- Criteria for clearing are included in Section 10.
- Criteria for drainage and erosion control are in Section 11.
- Criteria for restoration are in Section 12. Ditch cover and workpad extensions over the ditch must be compatible with the six-inch minimum depth requirement for scarification as outlined in Section 12.
- Criteria for pipeline appurtenances are located in Section 25.
- Criteria for special protective berms, barricades and other devices required to protect TAPS, TAPS FGL and other foreign pipelines are included in Sections 7 and 28.

13.2.2.8 Corrosion Control

Criteria for corrosion control are found in Section 30.

13.3 DESIGN MODE DESCRIPTIONS

The design mode types outlined demonstrate how the design criteria will be used to design the gas pipeline to resolve anticipated ROW alignment conditions. Other modes will likely be developed to resolve anticipated environmental and technical problems. Also, the current mode designs may be modified during final design for application to site specific areas along the pipeline alignment to ensure the integrity of the gas pipeline and the protection of the environment and adjacent facilities as outlined in the TIS.

13.3.1 Type I Buried Pipe In Conventional Ditch (See Figure 13-2)

This type of ditch configuration will be used in unfrozen soils with predicted acceptable frost heave. Elements of this ditch mode are:

- Uninsulated pipe will be used.
- Buoyancy control design, floodplain, river and stream scour considerations will be according to Section 16.
- Bedding and padding may be required.
- Native or common backfill may be used.

13.3.2 Type II Buried Pipe In Conventional Rock Ditch (see Figure 13-3)

This type of ditch configuration will be used in areas where the pipe will be placed in consolidated rock. Elements of this ditch mode are:

- Uninsulated pipe will be used.
- 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.

13.3.3 Type III Buried Pipe With Over-excavation and/or Insulation (See Figure 13-4)

This type of ditch configuration may be used in areas of unfrozen soils with predicted unacceptable heave for an un-insulated pipe and where permafrost may thaw and cause unacceptable settlement. Elements of this ditch type are:

- The pipe may be fully insulated.
- 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.

- Where required, pipe insulation and thickness, over excavation depth, will be determined by geothermal analyses. Depending on the site specific conditions, over-excavation without insulation or insulation without over-excavation may suffice to mitigate pipe integrity concerns.

13.3.4 Type IV Aboveground Pipe in a Berm (See Figure 13-5)

This design mode may be at fault crossings where the pipe may be subjected to large displacements during a contingency event or where the pipeline crosses other pipelines or utilities. Elements of this design mode are:

- The pipe will be placed aboveground in a mineral material embankment.
- Insulation of the pipe in the berm may be required to ensure that any frost heave will be limited to an acceptable value.
- Where boardstock insulation is required, the insulation thickness and width, the distance between the pipe and insulation will be determined by geothermal analyses.
- Criteria for cross drainage are included in Section 11.
- The spacing of cross drainage structures to control ponding of water or sheet flow against the berm or workpad will be determined as in Section 11. The spacing of culverts and other drainage structures should coincide with those of adjacent third party facilities, if applicable, so as to not direct cross drainage against the facility.
- Geothermal analyses will be used to determine if culverts within the berm will require insulation. (See Section 11)
- This design mode type should 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 should have limited use in selected areas only.

13.3.5 Type V Stream or River Crossing – Buried Insulated Pipe (See Figure 13-6)

This type of ditch may be used for crossing designated fish streams and rivers, or non-fish streams or rivers, where potential aufeis and frost bulb development may present integrity problems to the gas pipeline, adjacent third party structures or facilities, or unacceptable environmental problems. Elements of this ditch type are:

- An insulated pipe will be used with the thickness of insulation being determined by geothermal analyses.
- Minimum depth of cover will be set in accordance with criteria presented in Section 16.
- Bedding and padding may be required.

13.3.6 Type VI Stream or River Crossing – Buried Uninsulated Pipe (See Figure 13-7)

This design mode may be used for crossing streams or rivers where no adverse effects are anticipated to fish habitat, environment or third party structures due to a buried chilled gas pipe or aufeis development. The elements of this ditch mode are:

- An uninsulated pipe will be used.
- Minimum depth of cover will be set in accordance with criteria presented in Section 16.
- Bedding and padding may be required.

13.4 DESIGN MODE SELECTION

The methodology consists of a set of steps that address the geotechnical/geothermal conditions as well as other problems that may potentially affect the integrity of the gas pipeline, environment or adjacent facilities. Decisions on design modes and details will balance the capital cost of facilities with the cost of operation and maintenance of the pipeline.

13.4.1 Soil Data Input for Mode Selection

All available soil data will be used in mode selection. For those areas where borehole data are not available, a careful examination of data from nearby sites in the same landform will be made. If the design cannot be adequately based upon this data, additional soil investigations will be considered.

Ditch wall stability assessments require information on preliminary construction season and ditch depth, soil types and frozen dry densities (for estimating thaw strain potential), areas of expected massive ice, slope and azimuth and potential for surface water infiltration.

Pipe bends can be analyzed with data on preliminary burial depth, water table depth, soil types and dry densities (for estimating bearing, and/or side bend resistance and thaw strain potentials), preliminary backfill type and density (for estimating vertical soil resistance and axial restraint), and all other data listed above for pipeline differential settlement analysis.

Ditch plug design requires input on ditch slope and azimuth, preliminary burial depth, backfill soil type and density (for estimating permeability), subsurface thermal state and soil type/density (for estimating permeability and thaw strain potential), source of water (TAPS oil pipeline ditch or normal surface runoff, etc.), gas temperature, construction season and length of dormant period. Location of stream crossings, foreign pipeline crossings or other site specific areas where ditch plugs may be required will be needed.

13.4.2 Design Mode Selection Procedure

This procedure includes selecting the design mode that satisfies the design considerations or designating specific segments or sites for special design analyses and mitigative designs. Workpad configuration is included in Section 9.

Designers will have available the following documents/data:

- Pipeline Criteria, including supplemental documents supporting the Criteria.
- Results of the pipe gas thermal hydraulics calculations showing gas temperatures along the alignment as a function of time of year and year of operation.
- All available geotechnical data.
- All borehole logs (field and final) and laboratory test data for the alignment sections and for the entire alignment. The data include results of statistical analyses of alignment soil index properties.
- All pertinent design charts or methodologies for allowable pipe settlement bend design, allowable heave, structural and thermal workpad design, ditch plugs, buoyancy control, trench stability, and drainage control and terrain stability.
- All pipeline, civil and environmental alignment sheet series.
- Site-specific environmental data.
- Results of preliminary and final terrain stability analyses for slopes within the section.
- Crossing designations.
- Construction schedule.
- Haul analysis.
- Using the above data and documents the designer will then make the mode selection considering the following:
- Soil layers, thermal state and soil properties will be developed by review of the borehole logs, engineering terrain unit analysis, and laboratory data for the area. Boundaries of the design segments will be determined based upon how adequately the soil conditions can be represented by a particular idealized stratigraphy. Initially the segment boundaries correspond to the terrain unit boundaries. However, the segment breakdown may be varied to reflect accurately the subsurface conditions.
- Climatological data will be selected on the basis of design area location.
- Preliminary construction schedule information will be used to evaluate time of construction for seasonal effects and requirements.
- Design gas temperatures will be used in thermal calculations.
- Frost heave estimates, using project approved criteria, will be completed and used to evaluate the relative conservatism of various soils with respect to frost heave.
- Soil resistance functions will be used for bend analysis.
- Design thaw strains will be determined as discussed in Section 21 for use in thaw settlement analysis.
- Organic soil layer thickness will be used for workpad design and thermal analysis.
- Ditch degradation potential will be used in construction scheduling.

- Environmental data will be used during the design effort.
- Three possible choices exist for the thermal state of the soil. It may be frozen, unfrozen or a mixture of the two.

13.5 OTHER DESIGN CONSIDERATIONS

13.5.1 Methodology for Ditch Plug Design

Ditch plug design methodology delineates the application of the criteria given in Section 13.2.2 to:

- Periods of concern.
  - Construction.
  - Dormant (between construction of a segment and start-up).
  - Initial operation.
  - Long term (under some specific field conditions such as areas where it is anticipated that a frost bulb may not develop around the pipe).
- Soil conditions.
  - Frozen.
  - Unfrozen.

  Ditch plugs used to limit thermal degradation will be installed at a spacing to be determined based upon design mode, longitudinal slope, and soil type or a site-specific basis.

  Appropriate design conditions will consider thermal state, expected thaw, thaw strain, slope, and backfill and in-situ soil types. When plugs are needed for both seepage erosion and thermal degradation, plugs placed at the closer of the two spacings will serve both purposes. The following materials will be considered:
- Low permeability barrier.
  - Sand bags or gravel with a low permeability layer at the upslope side. The layer may be plastic, asphaltic, or other low permeability material that will provide the necessary protection during the dormant period prior to operation.
  - The use of any particular material for a low permeability barrier will be governed by the expected local field conditions and performance requirements. No single material may be suitable for use under all conditions. Specific requirements will be outlined in the specifications. Under some situations long term protection may be required.
- Filter

  A gravel filter zone will be constructed immediately upstream of the barrier. Filter material will be granular material meeting specified gradation limits. The filter material will be pervious enough to allow water seepage without building up excess hydrostatic pressure. The voids in the filter material will be of such size to minimize the erosion of the surrounding soil and the clogging of the filter system.

- Diversion berm or surface grading.

  Surface grading or a diversion berm contiguous to ditch plugs will be designed to control seepage water exiting from the pipe ditch and divert it to the surrounding drainage systems. Location and dimensions of the berm or grading requirements will be compatible with the drainage, erosion and restoration criteria.

13.5.2 Ditch Wall Stability

The preferred protection for ditches excavated in soils with a thaw strain potential of 20 percent or more is to require shoulder or winter month construction. For soils with thaw strain potential of less than 20 percent other mitigating conditions such as slope, aspect and open ditch time should be considered and site specific decisions made.

These areas which have a potential for ditch instability will be identified during design and will be indicated on the construction drawings.

Methods to prevent or minimize the potentially unstable conditions that may occur during ditch excavation are:

- Schedule ditch excavation of ice-rich soil during shoulder or winter months.
- Minimize the time that the ditch remains open.
- Apply ditch coverings such as insulation.

Thawing of ice-rich soils may be caused by water flowing in the ditch. This thawing will be minimized by controlling the flow of water along the ditch using temporary ditch plugs.

13.6 FIGURES AND TABLES

13.7 BIBLIOGRAPHY

Alyeska Project Report No. HD-107, "Ditch Plug Design and Location Field Manual," * June 18, 1975.

ANNGTC Project Report. "Chilled Pipe Effects on Streams,"* February 1985.

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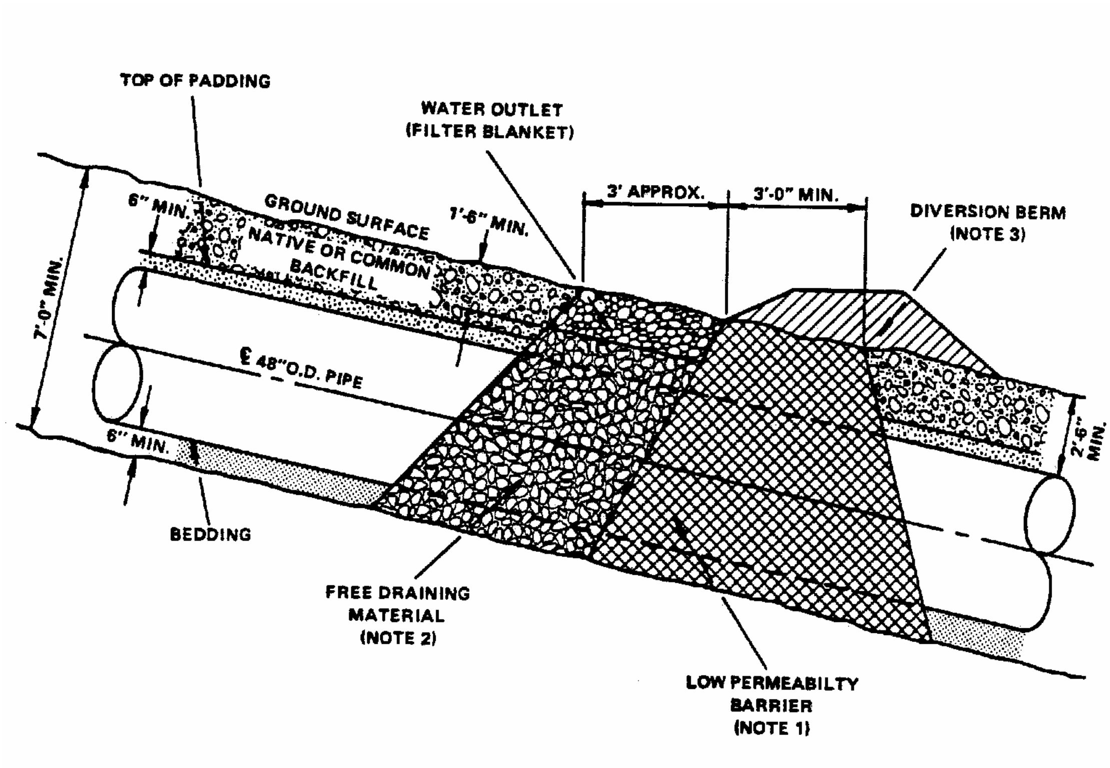

Figure 13-1 Typical Ditch Plug

Notes:

1. *Low permeability barrier may be composed of polyurethane foam material or sand bags and/or gravel with a low permeability layer at the upslope side. The layer may be plastic, asphaltic, gunite or other material that will meet the specifications for low permeability.*
2. *May be composed of bedding, padding or backfill material if the free draining requirement is accommodated.*
3. *Where diversion berms are required, they will be designed according to the criteria in section 11 and restored according to Section 12.*
4. *In frozen soils, ditch plugs may require keying into the ditch walls and bottom with sufficient depth to take into consideration the potential development of a thaw bulb during the dormant period as determined by geothermal analyses.*

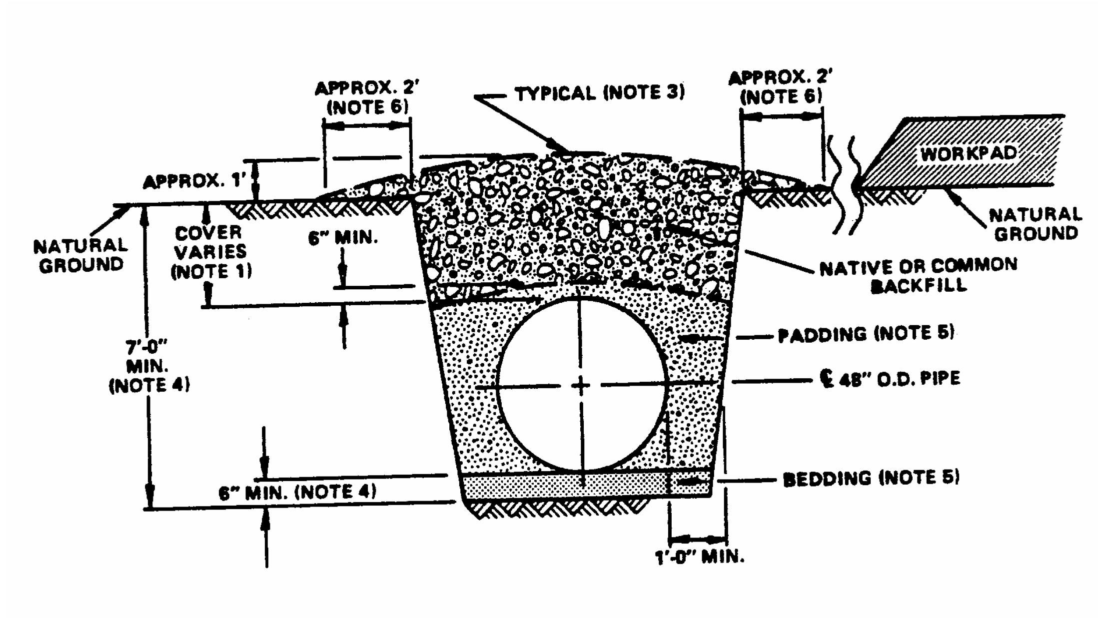

Figure 13-2 Type I Buried Pipe in Conventional Ditch
(Unfrozen soils with predicted acceptable heave)

Notes:

1. *Minimum depth of cover: 2’6”, Class 1 locations; 3’-0”, Class 2, 3, 4 locations see Section 16 for buoyancy control design and river and stream scour considerations. See Section 20 for bend design charts for minimum cover requirements at bends. In areas of potential frost heave the cover will provide for calculated long term unrestrained heave.*
2. *Ditch wall slopes will be as vertical as field conditions will allow.*
3. *For finished grading and restoration details see Sections 11 and 12.*
4. *If bedding is required minimum ditch depth is 7’-0”, otherwise pipe rest on native soil and minimum ditch depth is 6’-6”.*
5. *Native soils may be used for bedding and padding if they meet the bedding and padding specifications.*
6. *Mounded backfill will extend approximately two feet from the edge of the ditch wall. Distance from the toe of the workpad and toe of the mounded backfill varies.*

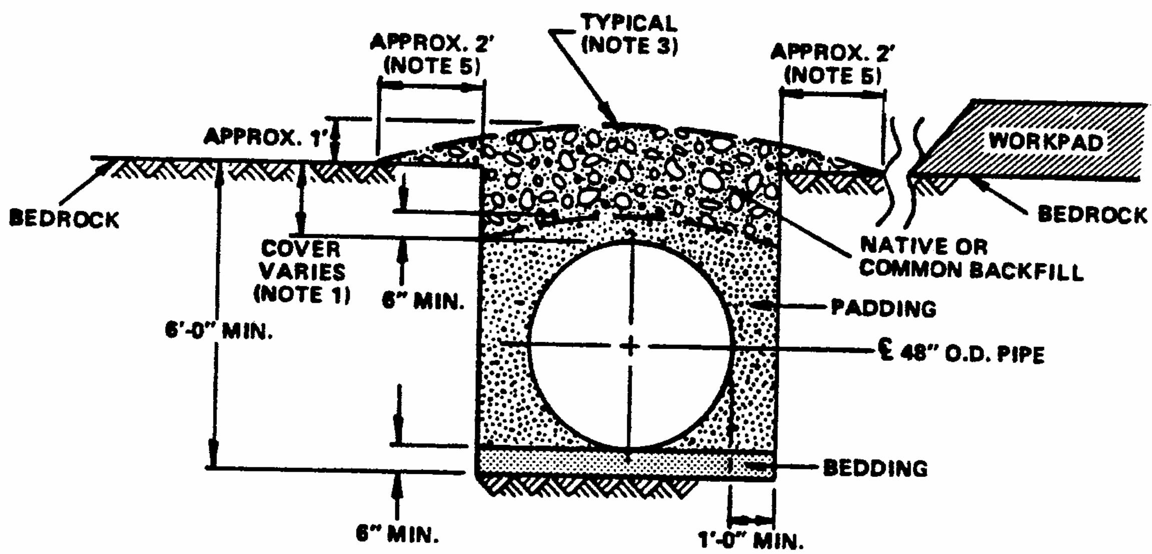

Figure 13-3 Type II Buried Pipe in Conventional Rock Ditch

Notes:

1. *Minimum depth of cover: 1'6", Class 1 locations; 2'-0", Class 2, 3, 4 locations. See Section 16 for buoyancy control design and river and stream scour considerations. See Section 20 for bend design charts for minimum cover requirements at bends.*
2. *Ditch wall slopes will be as vertical as field conditions will allow.*
3. *For finished grading and restoration details see Sections 11 and 12.*
4. *Bedding and padding will be required.*
5. *Mounded backfill will extend approximately two feet from the edge of the ditch wall. Distance from the toe of the workpad and toe of the mounded backfill varies. (See Section 9)*

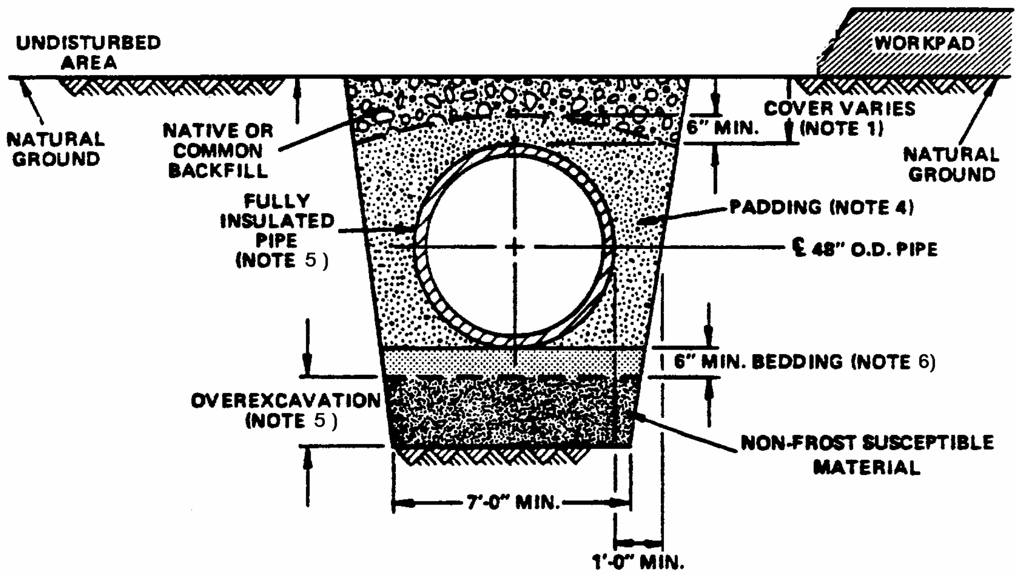

Figure 13-4 Type III Buried Pipe with Over Excavation and/or Insulation

NOTES:

1. *Minimum depth of cover: 2'4". Class 1 locations; 3'-0". Class 2,3,4 locations. See Section 16 for buoyancy control design and river and stream scour considerations. See Section 20.0 for send design charts for minimum cover requirements at sends. In areas of potential frost heave the cover will provide for calculated long term unrestrained heave. (See Section 13).*
2. *Ditch wall slopes will be as vertical as field conditions will allow.*
3. *For finished grading and restoration details see Sections 11 and 12.*
4. *Imported padding is not required when native backfill meets padding specifications.*
5. *Pipe insulation thickness, over excavation depth and width of berm will be determined by geothermal analyses,(see Section 21). For details on pipe insulation see Section 27.*
6. *6" minimum bedding thickness not required when non-frost susceptible material beneath the pipe meets the bedding specifications.*

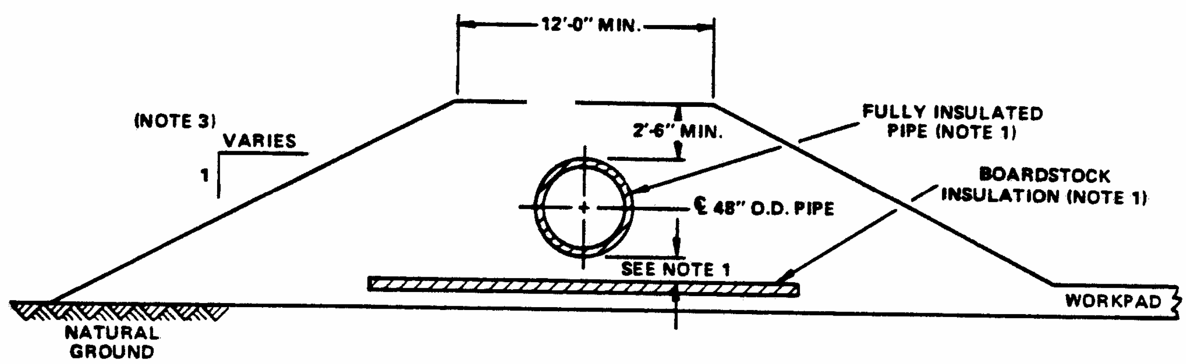

Figure 13-5 Type IV Aboveground Pipe in a Berm (Unfrozen Soils with Unacceptable Heave or Frozen Soils with Unacceptable Thaw Settlement and at Transitions between Unfrozen and Frozen Soils)

Notes:

1. *The requirements for boardstock insulation, the insulation thickness and width, the distance between the natural ground, the insulated pipe and boardstock insulation (if required) will be determined by geothermal analyses.*
2. *For finished grading and restoration details see sections 11.0 and 12.0. The embankment will generally be designed for no revegetation.*
3. *Side slopes will vary but will not be steeper than slopes of 2 horizontal to 1 vertical to allow passage of big game animals.*
4. *The berm material will be composed of relatively free-draining mineral material.*
5. *Criteria for cross drainage are same as for workpad.*
6. *Geothermal analyses will be used to determine if culverts within the berm will require insulation. (see Section 21).*
7. *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.*

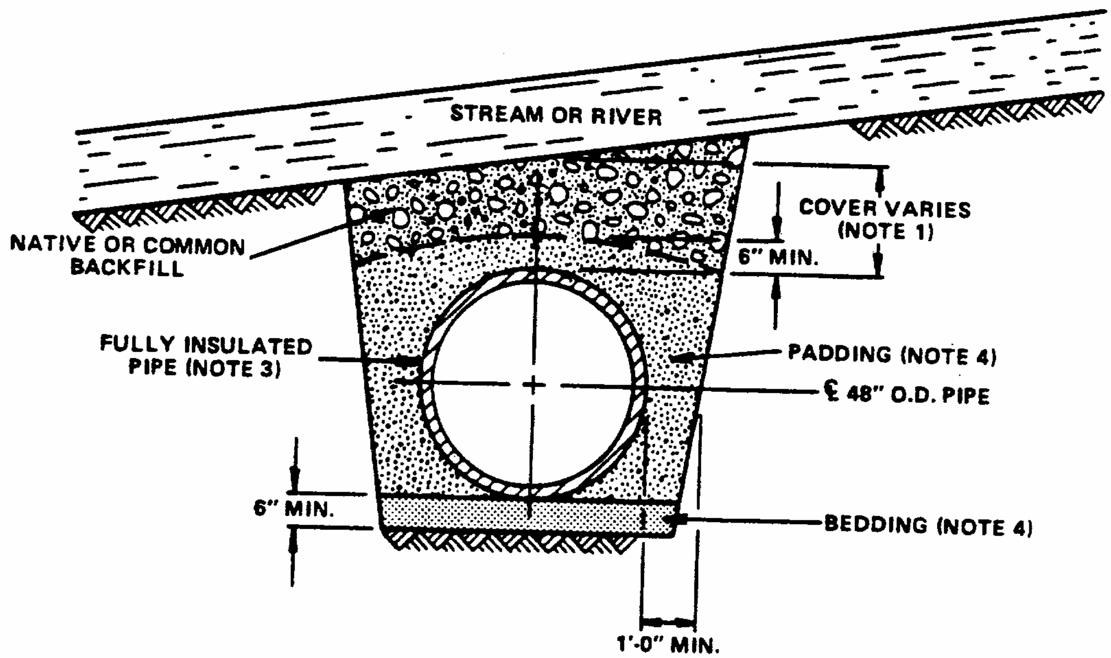

Figure 13-6 Type V Stream or River Crossing
Buried Insulated Pipe

Notes:

1. *Minimum depth of cover, buoyancy control, and scour considerations will be in accordance with Section 16. See Section 20.0 for minimum cover requirements at bends.*
2. *Ditch wall slopes will be as vertical as field conditions will allow.*
3. *Pipe insulation thickness will be determined by geothermal analyses. (see section 16 and Section 21.0). For details on insulation see Section 27.0.*
4. *Native soils may be used for padding and bedding of they meet the padding and bedding specifications. Ditch plugs will be placed according to subsections 13.1.2.2 and 13.4.1.*

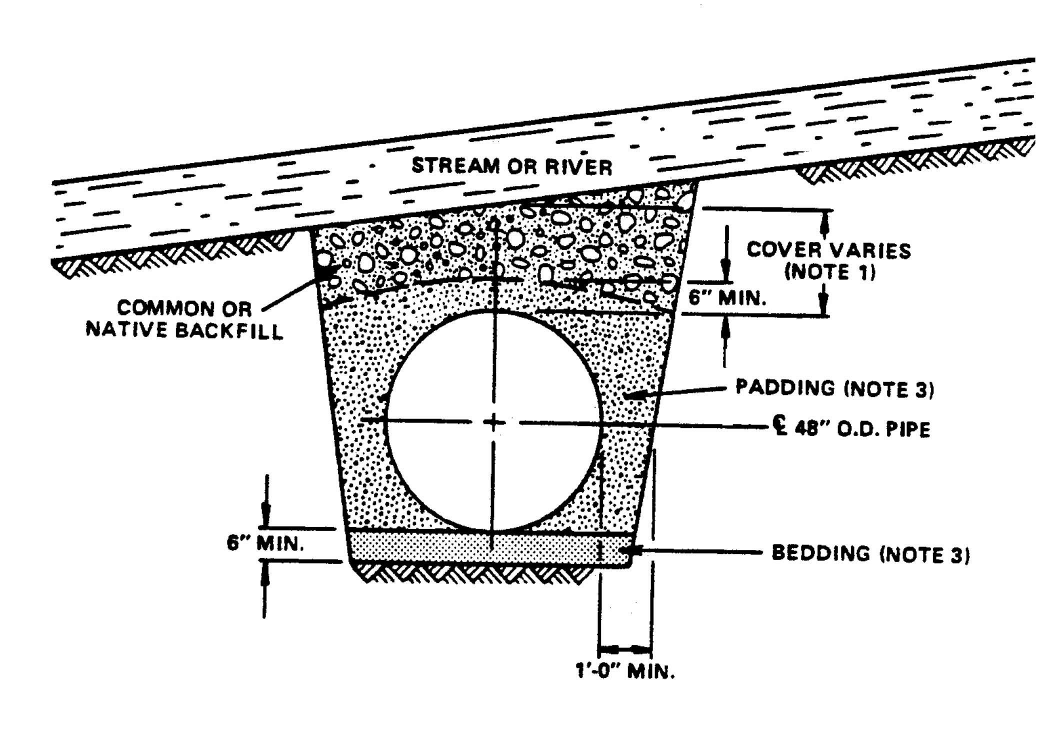

Figure 13-7

Type VI Stream or River Crossing-Buried Uninsulated Pipe (For Streams or Rivers Where No Anticipated Adverse Effects are Expected Due to a Buried Chilled Gas Pipe or Aufeis Development)

NOTES:

1. *Minimum depth of cover, buoyancy control, and scour considerations will be in accordance with Section 16. See Section 20.0 for minimum cover requirements at bends.*
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.*
4. *Ditch plugs will be placed according to subsections 13.1.2.2 and 13.3.3.*