The Federal Inspector
Alaska Natural Gas Transportation System

Room 3412, Post Office Building
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20044

February 15, 1984

D-0025072

Mr. Edwin (Al) Kuhn
Director, Governmental Afairs
Northwest Alaskan Pipeline Company
1120 - 20th Street, N. W.
Suite S-700
Washington, D. C. 20036

Re: Design Criteria Manual - Section 13, Design Modes

Dear Mr. Kuhn:

The OFI has completed review of Revision 3 of DCM Section 13 dated February 8, 1984. You have been furnished comments by the State of Alaska and Alyeska on earlier revisions of this section, and it is understood that these issues have been resolved with the two parties. By this letter we are giving conditional approval to this section. Final approval will be given after the results of the Chilled Pipe Effects Report. The Thaw Mitigation Thermal Analysis Study, and Frost Heave Criteria and Methodology (DCM Appendix 21A) have been completed and any required adjustments have been made to Section 13 to reflect the results of these studies. It is understood that each of these additional studies is scheduled for completion in 1984.

We concur with the introduction to Section 13 that it is somewhat different than the other sections of the DCM. The subject is more conceptual and illustrative in nature than basic design criteria. It contains a broad spectrum of mode concepts which demonstrate how the design criteria will be used to resolve problems; it is not necessarily an all inclusive listing of modes nor should it preclude additional modes being added to resolve specific problems. The conceptual modes will be subject to continuing development and refinement even after final approval. This will occur through ensuing stages of design, and the modes will have to be evaluated with respect to field conditions, construction practices, and scheduling and regulatory requirements to determine if they technically and economically resolve the expected problems for mile-by-mile design. This section provides an excellent conceptual framework for further progress toward the final design.

Sincerely yours,

John T. Rhett

John T. Rhett
Federal Inspector

Washington, D.C. 20036
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GOA-84-1015

Rec'd 2/14/84
D0032427

February 13, 1984

"BUSINESS" Information for Federal Government Purposes in Accordance with 10 CFR 1504 (F.R. Vol. 46, No. 240, December 15, 1981, pages 61222 through 61234)

The Honorable John T. Rhett
Federal Inspector
Alaska Natural Gas Transportation System
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20044

Re: Section No. 13,
Pipeline Design Criteria Manual

Dear Mr. Rhett:

Enclosed is one (1) copy of Rev. 3, dated February 8, 1984, of Section 13.0 of the DCM, entitled "Design Modes." This document replaces the Rev. 2 version transmitted to OFI by our letter of October 13, 1983 (Kuhn to Black, GOA-83-1120). Also enclosed, for your convenience, is a list of the various changes incorporated in this revision.

This revision of Section 13 reflects extensive additional coordination with OFI staff, the State of Alaska, and Alyeska, i.e., beyond that reflected in the earlier version. This additional consultation is summarized as follows:

-- OFI Informal comments on Rev. 2 were received 11/16/82 and discussed at a subsequent meeting; further comments were received 1/11/84 and 1/24/84 which were reviewed and revisions agreed upon at a meeting in Irvine on 1/31/84.

-- State of Alaska Comments on Rev. 2 were contained in a letter of 11/21/84 (Brossia to Black) and a letter of 1/13/84 (Brossia to Kuhn), followed by an NWA-State meeting in Fairbanks on 1/26/84 which resulted in agreement upon revisions to be made to Section 13.

-- Alyeska Comments on Rev. 2 were contained in a letter of 11/16/83 (Harle to Kuhn), and a subsequent NWA-Alyeska meeting was held in Anchorage on 1/25/84 to review the comments and agree upon revisions to be made to Section 13.

As a result of this coordination, we believe we have reasonably satisfied all outstanding issues on DCM Section 13. At the same time, we recognize that certain work in the frost heave area, now underway, conceivably may affect Section 13, specifically the following documents:

-- Chilled Pipe Effects Report

-- Thaw Mitigation Thermal Analysis Study

-- Frost Heave Criteria and Methodology

Accordingly, your approval is requested, conditional upon later review of the aforementioned documents and resulting adjustments, if any, being made to Section 13.

The letter and the enclosed information is confidential/proprietary and remains the property of Alaskan Northwest Natural Gas Transportation Company, a partnership represented by Northwest Alaskan Pipeline Company. The petition attached to this letter requests the OFI to consider this material "BUSINESS" information pursuant to 10 CFR 1504. All rights are reserved to the enclosed work, and unauthorized reproduction is prohibited. This material is protected as an unpublished work under the Copyright Law of the United States, 17 USC §101 et seq. By copy of this letter to the State Pipeline Officer, the State is requested to keep this information confidential pursuant to the Alaska Statute 38.050.035(a)(9).

Yours truly,

NORTHWEST ALASKAN PIPELINE COMPANY

Edwin (Al) Kuhn
Director
Governmental Affairs

EAK/tp
Enclosures
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PIPELINE DESIGN CRITERIA MANUAL

DESIGN MODES

"BUSINESS" information for Federal Government purposes in accordance with 10 CFR 1504 (F.R. Vol. 46, No. 240, December 15, 1981, pages 61222 through 61234).

REV. NO.	REMARKS	APPROVED ENV.	APPROVED CONST.	APPROVED ENG.
3	GENERAL REVISIONS 8 FEBRUARY 1984			
2	GENERAL REVISIONS 7 OCTOBER 1983			
1	FINAL DESIGN 1 MAY 1982			

NORTHWEST ALASKAN PIPELINE COMPANY

DESIGN PACKAGE PL - 1	
SECTION 13.0	REV.
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13.0 DESIGN MODES

INTRODUCTION

SECTION 13.0 is basically a design mode evaluation and selection procedure which utilizes various pipeline design criteria mainly contained in other sections of the DCM. Additional design procedures and methodology related to SECTION 13.0 will be found in separate DCM supporting documents, e.g., Chilled Pipe Effects on Streams, Thaw Mitigation Thermal Evaluation and Sensitivity Study, Ditch Plug Report and various insulation reports and studies.

SECTION 13.0 should be viewed as providing a broad spectrum of mode concepts which have been developed to demonstrate how the design criteria will be used to resolve site specific problems. It is not intended to be a complete representation of all design modes that may be used during the mile-by-mile design. Some of the design modes in SECTION 13.0 will be used extensively while other concepts may be used very little. Other cost-effective modes will likely be developed and current concepts modified during final design for application to the most difficult construction areas of the pipeline alignment.

Certain aspects of the conceptual design modes in this Section, or modes still to be developed, may not satisfy all the requirements of the Federal Safety regulations. The unconventional construction modes that are required to protect sensitive arctic and sub-arctic areas of the route are not considered in the current Title 49 CFR 192. Design aspects such as the minimum cover over a buried pipeline and the corrosion protection effects of insulation around the buried pipeline are at variance with the current regulations. Such variances will be identified and specific waivers will be requested through the appropriate procedures during the progression of the Final Design.

Specifications and sample calculations are not included in this section.

13.0 DESIGN MODES

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13.0 DESIGN MODES

13.1 CODES AND CRITERIA

13.1.1 Codes

- o Code of Federal Regulations, Title 49 - Transportation, Part 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

- o ROW Stipulations

13.1.2 Criteria

The general criteria governing design modes are as follows:

- o Minimum depth of cover will be according to Title 49 CFR192.327, except for special mitigative modes where waivers are required.

- o Clearance between the ditch wall and the pipe, pipe insulation or concrete covered pipe will be 12 inches minimum.

- o Ditch wall slopes will be as vertical as field conditions will allow.

- o Depth of cover criteria for bouyancy control and river and stream scour are included in Subsections 16.1.2.1, 16.1.2.5, 16.2.8 and 16.2.14.

- o For bend design charts indicating minimum cover requirements at bends, see SECTION 20.0.

- o In areas of frost heave potential, and if consistent with other design requirements, cover may be reduced by the requirement for reduced uplift resistance and the requirement to permit seasonal thawing to extend as far below the top of the pipe as possible.

- o Cover over the pipe will be such that maximum unrestrained heave will not allow the top of the pipe to exceed the natural ground level, or in areas of cut, the finished cut elevation.

- o In areas of frost heave potential, cover depth at drainages (other than streams or rivers) will be a minimum of 1'0" more than the calculated long term unrestrained heave. (See Appendix A, SECTION 21.0.)

- o Unless otherwise specified, backfill will be mounded over the ditch to approximately 1 foot to allow for possible settlement of the backfill.

- o Requirements for and dimensions of boardstock insulation and buried pipe insulation will be determined by geothermal analyses.

- o Pipe gas thermal hydraulic analyses will also be used to determine the pipe insulation thickness for elevated pipe which may be exposed to climatic changes.

- o Allowable thaw settlement and allowable frost heave will be limited by pipe stress and strain criteria included in SECTIONS 20.0 and 21.0.

- o Allowable thaw settlement (See Subsections 9.1.2.5, 20.2.7, 21.1.2.2, 21.2.2.2 and 21.2.3.2.) and allowable frost heave (Section 21.0) will be limited by the potential impact upon third party facilities.

- o 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 20.0 and 21.0.)

- o The calculated effects of long term frost heave or pipe displacement will be considered in determining pipe depth of burial. (See SECTION 21.0, Appendix A.)

- o In thaw unstable [1] soils the design will 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, that a sufficient quantity of the soil remains frozen to ensure that design conditions are met. Any thaw settlement during the dormant period must meet criteria for pipeline integrity. (See SECTION 20.0.)

- o Stream, river and wetland crossings will be designed such that the impact to groundwater blockage, aufeis development, frost heave, temperature effects and environmental concerns will be minimized consistent with possible adverse effects.

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

- The mineral material used for the workpad extension can be common material that meets the workpad criteria as outlined in Subsections 9.1.2.5 and 9.1.2.6 and will comply with stablization and erosion protection as outlined in SECTIONS 11.0 and 12.0

- In areas not strictly designated as gas pipeline access, should it be determined that a barrier will be placed or installed to preclude unauthorized vehicles from driving over the pipe, that traffic barrier must not be such that it will act adversely as a snow fence against the highway but should be of open type design, such as a cable type guard rail, unless otherwise agreed upon with the ADOT/PF.

13.1.2.1 Bedding, Padding and Backfill

- Bedding and Padding

  - Native soils may be used for bedding and padding if they meet the bedding and padding specification.

  - Bedding and padding material gradation quality, moisture content and placement specifications will be written to ensure that the design friction angle between the pipe coating and the surrounding soil will be met (See Subsection 21.2.3.3.1) and that damage to the pipe coating or insulation will not result.

  - 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.

  - Bedding and padding material gradation quality, thickness, moisture content and placement specifications will be written to ensure that the vertical and lateral support will be provided to the pipe as required in SECTIONS 20.0 and 21.0

- Non-Frost Susceptible Backfill (NFS)

  - Where overexcavation of the ditch and replacement of native material is for frost heave mitigation, non-frost susceptible backfill will be used to backfill the overexcavated portions of the ditch below the pipe.

- Non-frost susceptible backfill will be granular materials having a particle size distribution in accordance with the gradation limits to be indicated in the ditch backfill specifications.

- Native soils may be used for NFS backfill if they meet the NFS specification.

o 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 expected surficial loading conditions. (See SECTION 20.0)

- Native or common backfill materials on bends (See SECTION 21.0) and buoyancy control (See SECTION 16.0) areas will be placed to maintain stability and provide adequate pipe restraint (See SECTION 20.0) as outlined in the specifications.

- Native soils may be used for backfill if they meet the backfill specifications.

- If native or common backfill meets the specifications, it may be used for bedding and padding.

13.1.2.2 Ditch Plugs

o A ditch plug system (See Figure 13-1) should fulfill each of the following requirements:

- Provide the necessary protection to the ditch walls, ditch bottom and ditch backfill, bedding and padding during the dormant period prior to the time that a frost bulb develops around the pipe. If ditch plugs are used with mode Type V or Type VI, these ditch plugs will be designed to restrict water flowing within the ditch during the design life of the gas pipeline if other methods are not used.

- Provide a low permeability barrier across the ditch cross section and will be keyed as required to the ditch walls and or ditch bottom to restrict waterflow 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 diversion berm to divert the water outflow away from the ditch and into the overall 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 TAPS oil pipeline and TAPS FGL) where the two ditches will intersect and where water exists (or the potential for water), ditch plugs will be placed on a site specific basis so as to isolate the water from one pipeline to the other and so as to not cause 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 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.

- Burial of the pipe in thaw unstable frozen soils will be avoided when practical. If impractical, a site specific ditch plug system will be designed as needed.

- o 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.

- o 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 6 percent fine-grained particles passing a No. 200 sieve or if consolidated bedrock is present.

- o The potential for short-term seepage erosion of the ditch backfill should be considered under certain conditions such as sag bends.

- o In frozen soils, ditch plugs may require keying into the ditch walls and ditch bottom with sufficient depth to take into consideration the potential development of a short-term thaw bulb during the dormant period as determined by geothermal analyses.

- o Ditch plugs may be required at site specific areas such as transitions or at certain areas where it is anticipated that the frost bulb may not develop around the pipe and where the flow of any ditch water would require restriction. In such cases the design elements (including keying to the ditch wall and ditch bottom) of the ditch plug would have to have a service life equal to the project design life and would require maintenance considerations for that period.

13.1.2.3 Ditch Wall Stability

- o Thaw degradation of the ditch wall prior to placing bedding, padding and backfill will be minimized.

- o The preferred protection for ditches excavated in soils with a thaw strain potential of 20 percent or more is to require shoulder 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.

- o To reduce the thaw degradation potential of frozen ditch walls and ditch bottom the entry of surface water into the ditch should be minimized.

13.1.2.4 Chilled Pipe Effects

Design criteria and considerations for chilled pipe effects on river and streams, wetlands and adjacent facilities is included in Subsections 3.12, 11.1.1, 11.2.3.7, 16.1.2.6, 16.2.9, 16.2.9.1, 16.2.10, 16.2.13 and 16.2.15. The project document "Chilled Pipe Effects on Streams" which includes additional criteria will be revised in 1984.

13.1.2.5 Insulation

- o Criteria for insulation are found in SECTION 27.0.
- o Fully insulated pipe or saddle insulation may be required for buried pipe to mitigate the effects of frost heave or thaw settlement respectively.
- o Fully insulated pipe will be required for elevated design modes which will be exposed to climatic changes.
- o Boardstock insulation may be required to maintain frozen soil conditions or reduce thaw penetration over and adjacent to the pipe and beneath the workpad.
- o Buried insulation thickness will be calculated from geothermal analyses based on the thermal properties for that type and density of insulation.

13.1.2.6 Bends

- o Criteria for stress and strain values and pipe/soil interaction for bend design are found in SECTIONS 20.0 and 21.0.

13.1.2.7 Crossings

- o Criteria for river, stream and wetland crossings and bridges are found in SECTIONS 14.0 and 16.0.
- o Criteria for road crossings are found in SECTION 15.0.
- o Fault crossing design will be site specific based on fault crossing considerations in SECTION 17.0.
- o Criteria for stress analysis at foreign pipeline crossings, road crossings and fault crossings are found in SECTION 20.0.
- o Foreign pipeline crossing criteria are in SECTION 28.0.

13.1.2.8 Construction Zone

- Considerations for construction scheduling and seasonal constraints are found in SECTION 3.0. 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 6.0.

- Criteria for cut and fill sections, workpad design and grading are included in SECTION 9.0.

- Criteria for clearing are included in SECTION 10.0.

- Criteria for drainage and erosion control are in SECTION 11.0.

- Criteria for restoration are in SECTION 12.0. Ditch cover and workpad extensions over the ditch must be compatible with the 6-inch minimum depth requirement for scarification as outlined in Subsection 12.1.2.

- Criteria for pipeline appurtenances are located in SECTION 25.0.

- Criteria for special protective berms, barricades and other devices required to protect TAPS, TAPS FGL and other foreign pipelines are included in SECTIONS 7.0 and 28.0.

13.1.2.9 Corrosion Control

- Criteria for corrosion control are found in SECTION 30.0.

13.1.2.10 Heat Pipes or Chill Probes

- Heat pipes or chill probes may be used to pre-freeze the unfrozen soils beneath the pipe when unacceptable heave is predicted or to maintain frozen soil conditions if unacceptable thaw settlement is predicted.

- Heat pipes or chill probes may be used to mitigate terrain stability problems.

- Heat pipes will be designed to be self-contained and self-sustaining systems.

- Chill probes will be maintained by mechanical refrigeration.

- o The transverse and longitudinal spacing of the heat pipes or chill probes as well as their size and length will be determined by geothermal analyses.

- o To ensure that the heat pipes or chill probes are functioning properly, a surveillance and monitoring program will be undertaken as outlined in the Stipulation 1.6.1 Plan No. 21, Surveillance and Maintenance.

- o The effect of heat pipes or chill probes on ground water will be considered in design.

13.2 DESIGN MODE DESCRIPTIONS

The design mode types outlined are design mode concepts that have been developed to date and which demonstrate how the design criteria will be used to design the gas pipeline to resolve site specific problems. As design progresses, some of the proposed design modes will be used extensively while others may be used very little. Other cost-effective 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 the most difficult construction 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 DCM.

13.2.1 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:

- o Uninsulated pipe will be used.

- o Buoyancy control design, flood plain and river and stream scour considerations will be according to Subsections 16.1.2.1, 16.1.2.5, 16.2.8 and 16.2.14.

- o Bedding and padding may be required.

- o Native or common backfill may be used.

13.2.2 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:

- o Uninsulated pipe will be used.
- o Buoyancy control design, flood plain and river and stream scour considerations will be according to Subsections 16.1.2.1, 16.1.2.5, 16.2.8 and 16.2.14.
- o Bedding and padding will be required.
- o Native or common backfill may be used.

13.2.3 Type III Buried Pipe In Soils With Unacceptable Settlement (Short and/or Long Term) (See Figure 13-4)

This type of ditch configuration will be used in frozen soils with unacceptable settlement (including unconsolidated rock) to prevent or limit thaw of the subsurface in order to prevent excess pipe settlement prior to start-up, maintain terrain stability, maintain workpad performance and/or prevent gas pipeline/workpad construction disturbance induced thaw settlement of adjacent facilities (TAPS, TAPS Fuel Gas Pipeline and Dalton Highway).

Elements of this ditch mode are:

- o Uninsulated pipe will be used.
- o Boardstock insulation across the top of the ditch will be required in both directions from pipe centerline. The extent and thickness will be determined by geothermal analyses. See Subsection 27.1.2.2 for additional thickness of insulation to compensate for possible mechanical damage. Multi-layered system will have staggered joints.
- o The workpad will be extended over the pipe ditch.
- o The thickness of the mineral material over the insulation will be a minimum of 18 inches. (See Subsection 9.1.2.5.)
- o The preferred time for placement of synthetically insulated embankments is during shoulder months when the ground surface and/or near surface soils are frozen (See Subsections 3.12 and 9.1.2.3). The minimum thickness of soil required to be frozen from the ground surface down

prior to installation of the insulation, will be determined by geothermal analyses. Some thawing of the surface soils may be permitted provided that:

- Support for the boardstock insulation is adequate.
- Geothermal design conditions are met.
- Criteria for adjacent third party facilities are met.

o Bedding and padding will be required.

o Native or common backfill may be used.

o At cross drainages the extension of the workpad will be eliminated to match gas pipeline workpad low water crossings or culverts as well as those of third party contiguous facilities. (See Subsection 9.1.2.1 and FIGURE 9-1B and Subsection 11.2.3.3.). Required insulation requirements are included in Subsection 11.2.3.3 and 11.2.3.4. Required minimum cover will be maintained.

13.2.4 Type IV Buried Pipe In Soils With Acceptable Settlement (Short and Long Term) (See FIGURE 13-5)

This type of design mode may be used along the entire alignment for frozen soils with acceptable settlement during the dormant period. This mode may be combined with a structural workpad.

Elements of this ditch mode are:

o The workpad will be extended over the ditch.

o The pipe will be uninsulated.

o Padding and bedding will be required.

o Native or common backfill may be used.

o At cross drainages extension of the workpad will be eliminated to match gas pipeline workpad low water crossings or culverts as well as those of third party contiguous facilities. (See Subsection 9.1.2.1 and FIGURE 9-1B and Subsection 11.2.3.3.). Required minimum cover will be maintained.

13.2.5 Type V Buried Pipe With Overexcavation and Full Insulation (See FIGURE 13-6)

This type of ditch configuration may be used in areas of unfrozen soils with predicted unacceptable heave for an uninsulated pipe and where permafrost which may thaw and cause unacceptable settlement is at an approximate depth of 35 feet or greater from the ground surface. This ditch type will not be used for transitions. Elements of this ditch type are:

- o The workpad will be extended over the ditch and will be designed and maintained throughout operations to allow no revegetation.
- o The pipe will be fully insulated.
- o The backfill for the overexcavated portion of the ditch will be non-frost susceptible mineral material.
- o Bedding may not be required if non-frost susceptible material beneath the pipe meets the bedding specifications.
- o Native or common backfill may be used.
- o Pipe insulation thickness, over excavation depth, and width of the extended workpad will be determined by geothermal analyses.
- o At cross drainages the extension of the workpad will be eliminated to match gas pipeline workpad low water crossings or culverts as well as those of third party contiguous facilities. (See Subsection 9.1.2.1 and FIGURE 9-1B and Subsection 11.2.3.3.). Required minimum cover will be maintained.

13.2.6 Type VI Buried Pipe With Saddle Insulation (See FIGURE 13-7)

This type of ditch configuration may be used in unfrozen soils when unacceptable heave is predicted for uninsulated pipe or as a transition mode between unfrozen and frozen soils.[1] The uninsulated pipe section at the bottom of the pipe will be designed to protect frozen thermal regimes to reduce the thaw settlement potential in transitions. The insulated saddle on the upper portion of the pipe permits strain relief to occur during the summer thaw back period.

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[1]Frozen soils may be soils with acceptable short and long term settlement only. In the case of unacceptable settlement, either long term or short term, additional mitigation such as heat pipes will be required.

Elements of this ditch mode are:

- o The workpad will be extended over the ditch and will be designed and maintained throughout operations to allow no revegetation.

- o The upper 300° (approximate) of the pipe will be insulated. The lower 60° (approximate) will receive no insulation.

- o Padding and bedding will be required.

- o The insulation thickness, portions of the pipe left uninsulated, properties of the backfill and width of extended workpad will be determined by geothermal analyses.

- o At cross drainages the extension of the workpad will be eliminated to match gas pipeline workpad low water crossings or culverts as well as those of third party contiguous facilities. (See Subsection 9.1.2.1 and FIGURE 9-1B and Subsection 11.2.3.3.). Required minimum cover depth will be maintained.

13.2.7 Type VII Buried Pipe With Heat Pipes or Chill Probes (See FIGURE 13-8)

This type of ditch configuration may be used in unfrozen soils with unacceptable heave or as a transition mode between frozen and unfrozen soils. Heat pipes or chill probes may be used to pre-freeze the unfrozen soils beneath the pipe when unacceptable heave is predicted or to maintain frozen soil conditions if unacceptable thaw settlement is predicted. Elements of this ditch type are:

- o The heat pipes or chill probes will be used in conjunction with Type I Conventional Ditch (See Subsection 13.2.1 for ditch configuration details). In addition, heat pipes or chill probes may be used with other ditch modes to mitigate terrain stability, frost heave and thaw settlement problems.

- o Spacing of heat pipes or chill probes transversely and longitudinally, size and length will be determined by geothermal analyses.

- o The heat pipes will be designed to be self-contained and self-sustaining systems.

- o Chill probes require maintenance by mechanical refrigeration.

- The effects of heat pipes or chill probes on ground water will be considered in the design.

- Open design type traffic barriers may be placed on a site specific basis to protect the aboveground portions of the thermal devices from vehicular traffic.

13.2.8 Type VIII Aboveground Pipe in a Berm (See FIGURE 13-9)

This design mode may be used where burial of an uninsulated pipe or pipe with saddle insulation would result in unacceptable heave or where there is predicted unacceptable thaw settlement in frozen soils. This mode may also be used at transition between unfrozen and frozen soils to limit any predicted unacceptable thaw settlement or frost heave. Elements of this design mode are:

- A fully insulated pipe will be placed aboveground in a mineral material embankment.

- The design of the insulation in the berm will be such that any frost heave or thaw settlement will be limited to all acceptable value.

- Any requirements for boardstock insulation, the insulation thickness and width, the distance between the insulated pipe and boardstock insulation (if required) will be determined by geothermal analyses. The potential for thermal/hydraulic erosion at the toe of the berm will be evaluated.

- Criteria for cross drainage is included in SECTION 11.0.

- Design modes Type IXc or IXd should be considered as alternate designs to culverts for cross drainage structures, depending upon environmental, construction and economic considerations.

- For fish streams where culverts are used to move water through the berm, low-water crossings will be used across the workpad to reduce the length of culverts to allow fish passage. (See Subsections 11.1.2, 11.2.3.3 and 11.2.3.4.)

- The spacing of cross drainage structures to control ponding of water or sheet flow against the berm or workpad will be determined as in Subsection 11.2.2.2. 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.

- o Geothermal analyses will be used to determine if culverts within the berm will require insulation. (See Subsection 11,2.3.4 and FIGURE 11-28.)

- o 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 feet is maintained between the berm and the toe of the roadway.

- o This design mode type should have limited use in selected areas only.

13.2.9 Type IXa Stream or River Crossing - Buried Fully Insulated Pipe (See FIGURE 13-10)

This type of ditch may be used for crossing designated fish streams and rivers or non-fish streams or rivers where potential aufeis development may present integrity problems to the gas pipeline, adjacent third party structures or facilities or unacceptable environmental problems. (See Subsections 13.1.2.4, 13.4.3 and 16.2.10 for details on chilled pipe effects on streams or rivers.) Elements of this ditch type are:

- o A fully insulated pipe will be used with the thickness of insulation being determined by geothermal analyses.

- o Minimum depth of cover in river or streams will be 4.0 feet or 120 percent of computed scour, whichever is greater. Minimum depth of cover in flood plains will be 2.5 feet unless scour, bank migration buoyancy control requirements dictate a greater depth of cover. (See Subsections 16.1.2.1, 16.1.2.5, 16.2.8 and 16.2.14.)

- o Bedding and padding may be required.

- o Design and environmental considerations are found in SECTION 16.0.

13.2.10 Type IXb Stream or River Crossing - Buried Uninsulated Pipe (See FIGURE 13-11)

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

- o A uninsulated pipe will be used.

- o Minimum depth of cover after allowances for long term frost heave in river or streams will be 4.0 feet or 120 percent of computed scour, whichever is greater. Minimum depth of cover in floodplains will be 2.5 feet unless scour, bank migration potential or buoyancy control requirements dictate a greater depth of cover (See Subsections 16.1.2.1, 16.1.2.5, 16.2.8 and 16.2.14).

- o Bedding and padding may be required.

- o Design and environmental considerations are also found in SECTION 16.0.

13.2.11 Type IXc Stream or River Crossing - Elevated Pipe With Berm Approaches (See FIGURE 13-12)

This design mode may be used to cross small water courses with a short span of elevated pipe where buried pipe crossing modes, or Types IXa or IXb are unacceptable. This design mode will be compared with design mode Type IXd to determine which is the preferred mode. Economic, environmental, engineering and construction aspects as well as adjacent third party facilities will be part of the consideration. This mode would generally be used in conjunction with Type VIII design mode when it is used for mile-by-mile construction. However, it may be used in conjunction with Type VIII when a short section of berm construction may be required just at banks of a stream or river. Elements of this design mode are:

- o Fully insulated pipe will be used in the berm with the thickness of insulation determined by geothermal analyses.

- o Fully insulated pipe will be used for elevated pipe spans with the insulation thickness being determined by pipe gas thermal hydraulic analyses.

- o The berm design elements are covered in Subsection 13.2.8.

- o The maximum pipe span will be determined according to criteria in SECTIONS 14.0 and 20.0.

- o The elements of this design mode may be combined with the elements of mode Type IXd where vertical supports may be used to support the required pipe span if free span is not acceptable.

- o General environmental and design considerations for elevated stream or river crossings are found in SECTIONS 14.0 and 16.0.

- o 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 feet is maintained between the berm and the toe of the roadway.

13.2.12 Type IXd Stream or River Crossing - Elevated Pipe on a Structure Supported by Vertical Supports (See FIGURE 13-13)

This design mode may be used to cross streams or rivers with elevated pipe where buried pipe crossing modes, Types IXa and IXb are unacceptable. This design mode will be compared with design mode Type IXc to determine which is the preferred mode. Economic, environmental, engineering and construction aspects as well as adjacent third party facilities will be part of the consideration. Elements of this design mode are:

- o Full insulated pipe will be used and the thickness will be determined by pipe gas thermal hydraulic analyses.

- o The aboveground structural design, maximum span of pipe and spacing of the vertical supports will be determined according to the criteria and procedures in SECTIONS 14.0 and 20.0.

- o The criteria for determing the embedment length of the vertical supports and other geotechnical considerations are found in SECTION 21.0.

- o The elements of this design mode may be combined with the elements of mode Type IXc where berms may be used for the river or stream bank approaches and additional structural support of the pipe is required with vertical supports.

- o General environmental and design considerations for stream or river crossings are found in SECTIONS 14.0 and 16.0.

13.3 DESIGN MODE SELECTION

The mode selection procedure is typified in Figure 13-14. The methodology consists of a set of steps which address the geotechnical/geothermal conditions as well as other problems that may potentially affect the integrity of the gas pipeline, the environmental and adjacent facilities.

The selection procedure includes the mode concepts which have been developed to date. Other cost-effective modes will likely be developed and the current design mode concepts may be modified during final design. However, the basic design mode selection is outlined to demonstrate the application of the criteria. The final design modes may include some slight differences than presently displayed on FIGURE 13-14.

13.3.1 Soil Data Input for Frost Heave Correlation Equation

Selection of soil parameters for use in the frost heave correlation equation will be done on the basis of borehole and laboratory data combined with geological/geotechnical judgement. During the final design effort, statistical analyses of each landform on a physiographic province and subprovince basis will be developed. Design gradation frequency curves indicating the percent by weight passing certain sizes will be constructed for each landform using data from an individual physiographic province or subprovince. These graphs will show the 10, 25, 50, 75 and 90 percent frequency curves as described in Appendix 21-A Subsection 3.4.1. The curves describe the data in terms of the frequency with which a certain value or a number less than or equal to that value occurs in the data base. For example, a value of 80 percent on the Y-axis where the 75 percent curve crosses the No. 200 sieve on the X-axis means that: 75 percent of the samples in the data base for that landform and physiographic province or subprovince have 80 percent or less passing the No. 200 sieve.

The soil dry density associated with the design gradation curve is chosen by taking the average of all dry densities of the soils for which the gradations closely approximate the design gradation curve for the landform (See Appendix A, SECTION 21.0). Dry densities corresponding to unusually large percentages of organic content will be excluded from the average as they would be unrealistic for soils below the pipe (a highly organic soil will have less than the same soil with fewer organics: The heave correlation equation would however predict greater heave for the more organic soil since the overall density is less). This information is accessible in the Geotechnical Information System (GIS), a computerized geotechnical data base system. The water content corresponding to 100 percent saturation for the chosen gradation will be calculated from the corresponding specific gravity data in GIS.

If laboratory data from a borehole within a landform should prove to be more conservative than that from the design gradation curve of the same landform and if that data should be from a soil layer ten feet or more in thickness within the upper 25 feet of the landform, these data will be used in the design for the entire depth of that landform unless other data or geological reasoning would limit the extent of this layer. If the layer is less than ten feet thick, the design will use the thickness of the layer and assume that it occurs everywhere in the landform at that depth unless other data or geological reasoning would limit the extent laterally or vertically of this layer. The rest of the landform will be designed for the design gradation curve where the layer is of this limited thickness.

Figure 13-15 identifies the steps for decision making that will be followed in developing the heave design parameters from the available borehole data and other information sources.

13.3.2 Soil Data Input for Mode Selection

Soil data for use in mode selection will be developed from several sources (See SECTION 3.0). All available data will be used. Primary sources will be the borehole and laboratory test data acquired by the project. They will be used wherever they are available. For those areas where borehole data are not available, a careful examination of data from nearby sites in the same landform will be made. Should the data from nearby sites not be adequate for a cost effective design, it will be determined during the design if a very conservative design is appropriate or if additional data should be acquired through drilling additional boreholes. The critical nature of the site specific design and any related third party facilities need to be considered.

Some variation in soil properties will be found in all landforms but in some relatively homogeneous landforms they will vary over a much narrower range than others. Eolian, and lacustrine processes tend to deposit generally well sorted material and so produce relatively homogeneous landforms, at least over reasonably short distances. Colluvial, fluvial and glacial processes typically deposit poorly sorted material and tend to form generally heterogeneous landforms. Variations in soil properties of all landforms tend to increase with proximity to the landform boundaries.

Inter-fingering of units and gradational transitions as well as geological spacial relationships of adjacent landforms or units are to be considered in the interpretation of soil and landform information.

For areas without site specific borehole information, the statistical properties discussed in Subsection 13.3.1 and the distribution of the data will be useful for interpretation of the soils between available boreholes. No simple formula can be relied upon to provide information where none exists. Sound geological/geotechnical judgment must be applied to the information that is available to estimate soil properties between borehole sites.

For frost heave analysis the important parameters are subsurface thermal state, location north or south of Atigun Pass (i.e., climate conditions), burial depth, soil type and grain size, dry density, water content, gas temperature (obtain from gas temperature profile), shear strength and bearing capacity of each soil layer, backfill soil type and uplift resistance.

Differential settlement analysis for the pipe requires data on subsurface thermal state, location per design climatic zones, trial burial depth, surficial organic layer thickness, soil type and frozen/thawed dry density (for estimating thaw strain potential bearing capacity and side shear resistance), gas temperature, preliminary construction season (both workpad and pipeline), expected extent of surface disturbance (where stripping, if any), preliminary workpad cross section, areas of potential massive ice, preliminary flotation control measures (concrete coated or weighted pipe), preliminary ditch plug design, surface slope and azimuth and backfill soil type and density (for estimating overburden and downdrag) and length of dormant period.

Thaw penetration or thaw depth is an essential parameter used in several analysis and design procedures. Estimates of thaw for workpad design and terrain stability analyses are included in SECTION 21.0. Thaw estimates for thaw settlement analyses, thermal assesment of effects on third party facilities, pipe/soil interaction at bends and frost heave analyses will be based on analyzing the results of computer thermal modeling. Parameters and data needed to determine the potential thaw depth include: Thermal and index properties of the soil; adjacent facility location and type; construction zone configuration; workpad thickness and ground water data.

Workpad structural thickness and potential settlement analyses require data on surface soil types and frozen dry densities (for estimating thaw strain potential), organic layer thickness, construction season, moisture content and Atterberg limits of subgrade soils, slope and azimuth, preliminary embankment thickness and location for climatic zones.

Assessments of potential thaw settlement adjacent to or beneath the Dalton Highway require the same data as for workpad analysis plus an estimate of the highway embankment thickness and shoulder slopes.

For assessing the potential for thaw below and around the TAPS fuel gas pipeline, additional data on the fuel gas pipeline burial depth, existing insulation and backfill soil type and condition are required. (See Subsection 3.10.)

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.

The need for pipe flotation control can be assessed outside of designated wetlands and floodplains (where flotation control analyses are always required) with data on potential ice content and thaw depth, preliminary burial depth, preliminary ditch plug design, slope, potential for surface water infiltration to ditch, backfill soil type and density and length of dormant period.

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.

Terrain stability analyses require data on slope (cross, longitudinal and true slopes) and azimuth, preliminary construction zone cross section (cut or fill, embankment thickness, etc.), preliminary ditch mode, subsurface thermal state, soil types and dry densities (for estimating shear strength parameter and thaw strain potentials), location and proximity of adjacent facilities, standard penetration test blow counts (for liquefaction potential), preliminary construction season (for both workpad and pipeline), expected extent of surface disturbance, thickness of surficial organic layer, location as per climatic zones, preliminary pipeline burial depth, areas of potential massive ice or peat, preliminary ditch plug design, gas temperature, water table depth, location as per design earthquake zones, workpad material type and density (for estimating permeability) and length of dormant period.

13.3.3 Design Mode Selection Procedure

This procedure includes selecting the design mode which satisfies the design considerations or designating specific segments or sites for special design analyses and mitigative designs. Workpad configuration is included in SECTION 9.0.

Designers will have available the following documents/data:

- o Pipeline Design Criteria Manual.
- o All supplemental documents supporting the DCM.
- o Results of the latest pipe gas thermal hydraulics calculations showing annual average gas temperatures along the alignment as a function of time of year and year of operation.
- o All Route Soil Condition sheets and Geotechnical Design Input sheets for the alignment sections of interest.
- o 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.
- o All pertinent design charts for allowable pipe settlement, bend design, allowable heave, structural and thermal workpad design, ditch plugs, bouyancy control, trench stability, drainage control and terrain stability.
- o All Pipeline, Civil and Environmental Alignment Sheet series.
- o Site specific environmental data.
- o Results of preliminary and final terrain stability analyses for slopes within the section.
- o Crossing designations.
- o Construction schedule.
- o Haul analysis.

Using the above data and documents the designer will then make the mode selection using the following guidelines. The mode selections for each alignment sheet will be checked by a mode review committee to ensure consistency and compatibility through out the alignment.

The following are general guidelines for the step-by-step process of mile-by-mile mode selection:

- o Assemble each of the items shown as input data on the left side of Figure 13-14:

  - Preliminary design mode will include any previous work on the design modes that will be valuable for the selection procedure.

  - Preliminary workpad configuration involves utilizing any previously determined workpad requirements and limitations or cross-sections developed from survey data.

  - Soil layers, thermal state and soil properties will be developed by review of the borehole logs, Route Soil Condition (RSC) Alignment Sheets 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.

  - The frost heave correlation equation will be used to provide frost heave estimates and evaluate the relative conservatism of various soils with respect to frost heave.

  - Steel properties of the pipe will be use in stress analysis.

  - Soil resistance functions will be used for bend analysis.

  - Design thaw strains will be taken from design charts in SECTION 21.0 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.

- Bend design soil types will be determined for use in bend analysis.

- Fault design parameters will be used to develop any site specific designs at designated faul crossings, if required.

- Third party criteria and design information will be used to help evaluate potential impacts on third party structures and facilities.

- Environmental data will be used during the design effort.

The design mode selection process consists of two methodologies or investigations proceeding in a parallel or simultaneous effort. The upper portion of the chart outlines the mode selection process emphasizing pipe settlement and frost heave. The lower portion of the chart considers a large variety of factors.

- o The upper portion of Figure 13-14 starts with a decision as to the presence of consolidated bedrock suitable for the use of a rock ditch. A "yes" decision indicates that the material has been determined to be sound enough to act as rock rather than as a soil. Design mode Type II will be designated. (See FIGURE 13-3.) If a no decision is made the process continues.

- o Three possible choices exist for the thermal state of the soil. It may be frozen, unfrozen or a mixture of the two.

  - For frozen materials, mode Type IV will be designated for soils with acceptable settlement, while mode Type III will be designated for soils with unacceptable settlement.

  - For unfrozen material an estimate of frost heave will be required. If pipe strain due to heave is acceptable using an uninsulated pipe then mode Type I will be designated. If the strain caused by the heave resulting from mode Type I is unacceptable, mode Type VI will be checked. If heave from mode Type VI is not acceptable but the permafrost table is greater than

35 feet from the surface either mode Type V or Type VII will be used. If the permafrost is less than 35 feet from the surface and thaw settlement from mode Type V is acceptable (with respect to pipe strain), either mode Type V or mode Type VIII will be used, depending upon economic, adjacent third party facilities and environmental considerations. If thaw settlement from mode V is unacceptable a decision on the use of either mode Type VII or VIII must be made based upon economic,adjacent third party facilities and environmental considerations.

- For mixed or uncertain thermal state both thaw settlement and frost heave must be considered. If effects of short term thaw are unacceptable then either mode Type VII or VIII will be designated based upon economic, adjacent third party facilities and environmental considerations. If both short and long term thaw are acceptable then, the frost heave requirements govern mode selection. If short term thaw is acceptable but long term thaw with mode Type I or Type VI is not (i.e., long term thaw extends beneath the frost bulb or restricts the frozen zone beneath the pipe to an unacceptable value), the selection will be mode Types VII or VIII based on economic, adjacent third party facilities and environmental concerns.

o The lower portion of the chart shows the process of checking for special conditions. This lower branch of the chart is followed in parallel with the upper branch and each of these items is checked regardless of the mode selected in the upper portion. The first block at the left asks whether or not flowing water is expected in the ditch. If so, ditch plugs will be indicated in the design. If no water is expected the chart moves on to the next question.

o If the location is not a stream crossing, the procedure continues into the other site specific crossings or considerations. If it is, then the criteria of SECTIONS 14.0 and 16.0 must be satisfied. A special design will be designated if a major aerial pipeline bridge is planned. If the crossing is not a major aerial pipeline bridge, then ditch plug requirements will be considered. If the stream is designated a fish stream or if a potential environmental or aufeis problem is expected or if it is in a known aufeis area mode Type IXa is preferred if acceptable. If mode Type IXa is not acceptable a choice of mode Type IXc or IXd will be based upon environmental, adjacent third party facilities and economic considerations. If the stream is not a fish stream, and no environmental or aufeis problems exist, mode Type IXb will be selected if all other requirements are met. Should any stream coincide with a foreign pipeline crossing, a special design will be developed.

- If the site is not a stream crossing it will be considered for site specific design if it is a road crossing, foreign pipeline crossing or a fault crossing. Each of the remaining four checks will be accommodated by mitigation such as insulation, soil replacement, mode Type V or other designs, where possible, however site specific design will be used where this is not possible. They are:

  - Adjacent third party facilities.

  - Environmental concerns.

  - Bends.

  - Terrain stability concerns.

- As a final check, each selected mode will be checked against any designated mitigation. If all checks are acceptable the final mode selection will be included on the construction drawings. If all checks are not acceptable the procedure will have to be repeated to evaluate alternative solutions.

13.4 OTHER DESIGN CONSIDERATIONS

13.4.1 Methodology for Ditch Plug Design

Ditch plug design methodology delineates the application of the criteria given in Subsection 13.1.2.2 to:

- Periods of concern.

  - Construction.

  - Dormant (between construction of a segment and start-up).

  - Initial operation.

- Soil conditions.

  - Frozen

  - Unfrozen

To control seepage erosion ditch plugs will be spaced at the maximum distances shown in TABLE 13-1 and in accordance with the design spacings in Alyeska Report HD-017. 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.

The design process is schematically shown in FIGURE 13-16. Appropriate design conditions will consider thermal state, expected thaw, thaw strain, slope, 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 type of plug to be used will be determined based upon, other design aspects such as frost heave effects, availability, cost and effectiveness of the construction material. Depending upon site specific conditions the ditch plugs may have to be keyed into the ditch wall. The following materials will be considered:

- o Low Permeability Barrier

  - Foamed-in-place polyurethane.

  - Sand bags or gravel with a low permeability layer at the upslope side. The layer may be plastic, asphaltic or other low permeability material which 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 expected performance requirements. No single material may be suitable for use under all conditions. Specific requirements will be outlined in the spefications. Under some situations long term protection may be required of the material.

- o Filter

  A gravel filter zone will be constructed immediately upstream of the barrier. Filter material will be granular material meeting the 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.

- o 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.

Ditch plugs will be designed considering the anticipated water flows during the dormant period conditions.

13.4.2 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 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:

- Scheduling ditch excavation of ice-rich soil during shoulder 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 by using temporary ditch plugs.

Soils which have sloughed into the ditch bottom will remain unless it does not meet the bedding, padding and ditch profile specifications.

13.4.3 Chilled Pipe Effects

The methodology and procedures for the design aspects related to the effects of a buried chilled gas pipe on the environment is included in the project report "Chilled Pipe Effects on Streams" to be revised in 1984.

13.4.4 Transitions

Transitions between design modes will be selected and designed to protect the integrity of the gas pipeline and protect the environment and adjacent facilities.

Table 13-2 indicates the design mode type that may be required in a transition area. Generally the more conservative of the two mode types at a transition will be continued at least 100 feet into the adjacent mode. For some combination of incompatible mode types, an intermediate mode type will be required throughout the area between them. This intermediate mode type may be extended 100 feet into the two adjacent mode types if the mode is compatible with the soil conditions.

As the table indicates, the ability to identify accurately the transition area has a strong bearing as to the need for intermediate mode type. However, some transitions will always require an intermediate mode due to the variability of the soil and thermal condition.

The design location of the transition will be such that field changes will be minimized. Verification of transitions will be done in the field, prior to or at the time of construction. The beginning and ending of transition will be based on all available data, but more specifically borehole information, geophysical data and aerial photography interpretation.

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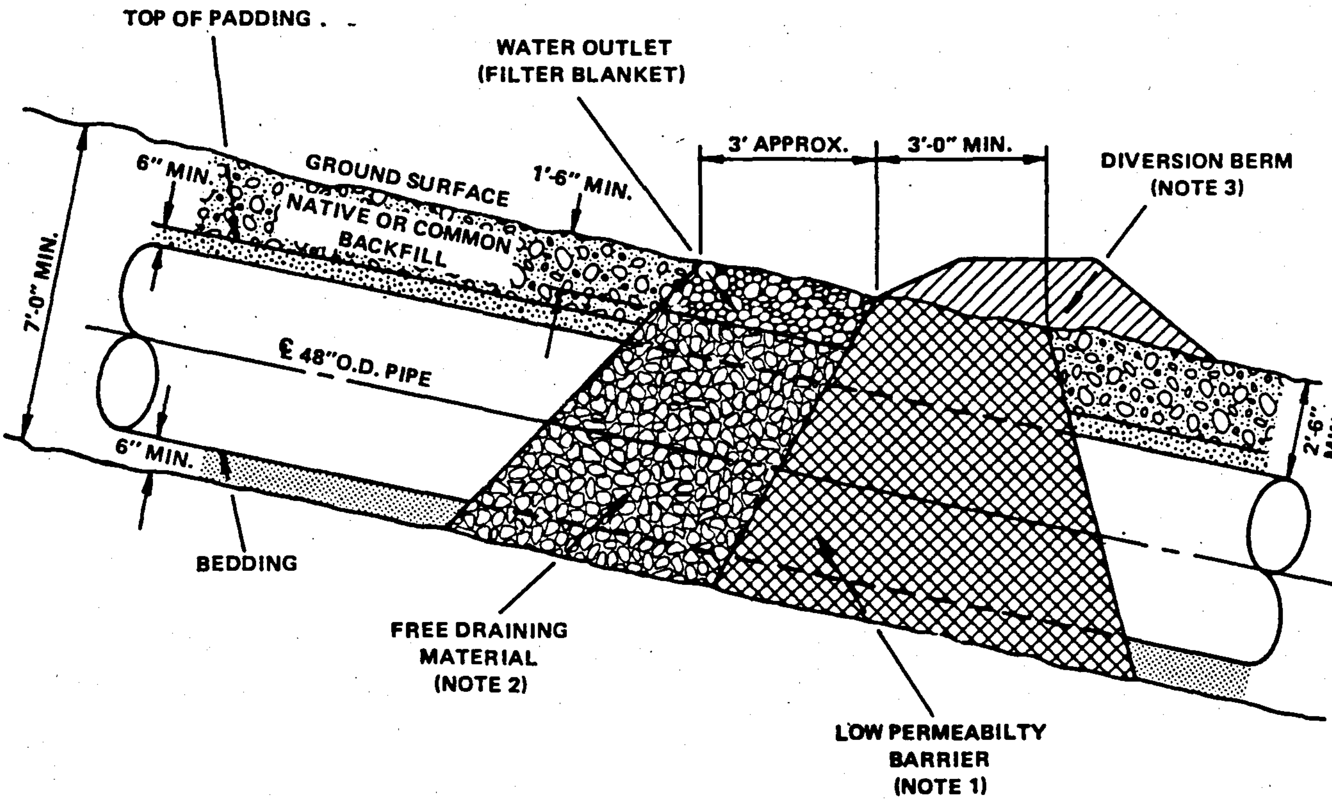
TYPICAL
DITCH PLUG



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 WHICH WILL MEET THE SPECIFICATIONS FOR LOW PERMEABILITY.

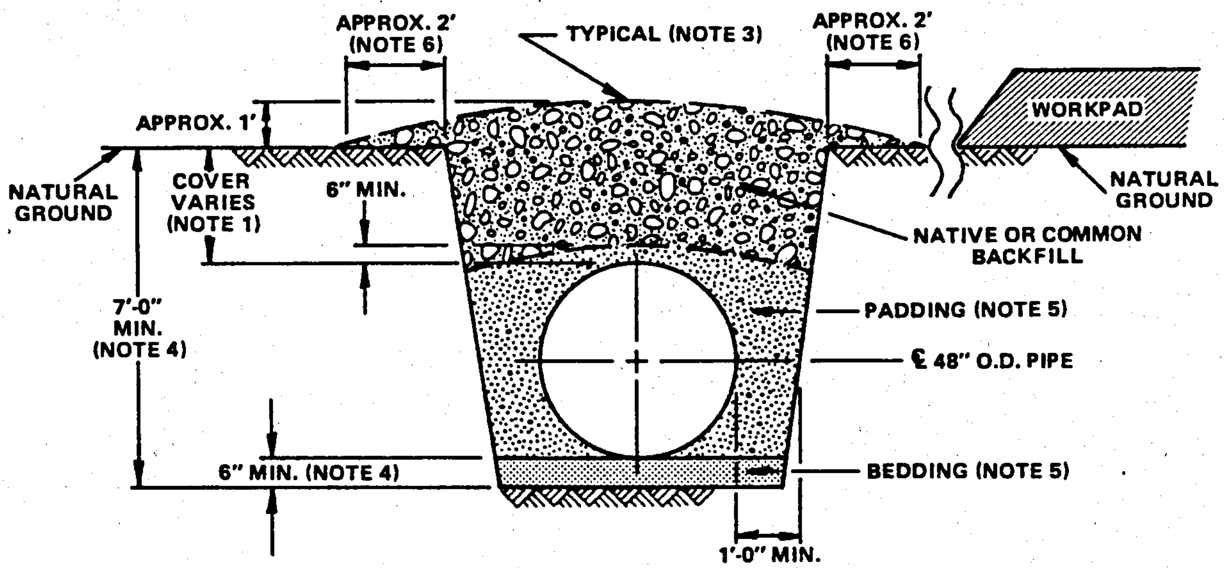
2. MAY BE COMPOSED OF BEDDING, PADDING OR BACKFILL MATERIAL IF THE FREE DRAINING REQUIREMENT IS ACCOMMODATED.

3. WHERE DIVERSION BERMS ARE REQUIRED, THEY WILL BE DESIGNED ACCORDING TO THE CRITERIA IN SECTION 11.0 AND RESTORED ACCORDING TO SECTION 12.0.

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. IF DITCH PLUGS ARE USED WITH TYPE V OR VI, THE DITCH PLUG WILL BE DESIGNED TO RESTRICT WATER FLOWING IN THE DITCH DURING THE DESIGN LIFE OF THE GAS PIPELINE IF OTHER METHODS ARE NOT USED.

FIGURE 13-1

TYPE I BURIED PIPE IN CONVENTIAL DITCH
(UNFROZEN SOILS WITH PREDICTED ACCEPTABLE HEAVE)

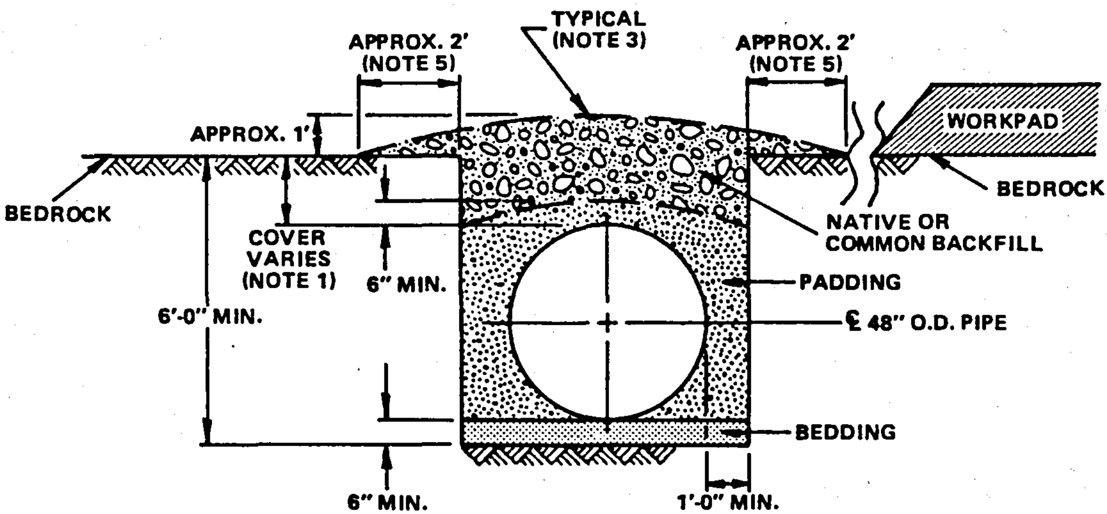


NOTES:

1. MINIMUM DEPTH OF COVER: 2'-6", CLASS 1 LOCATIONS; 3'-0", CLASS 2, 3, 4 LOCATIONS SEE SUBSECTIONS 16.1.2.1, 16.1.2.5, 16.2.8 AND 16.2.14 FOR BUOYANCY CONTROL DESIGN AND RIVER AND STREAM SCOUR CONSIDERATIONS. SEE SECTION 20.0 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 (SEE SUBSECTION 13.1.2).
2. DITCH WALL SLOPES WILL BE AS VERTICAL AS FIELD CONDITIONS WILL ALLOW.
3. FOR FINISHED GRADING AND RESTORATION DETAILS SEE SECTIONS 11.0 AND 12.0.
4. IF BEDDING IS REQUIRED MINIMUM DITCH DEPTH IS 7'-0", OTHERWISE PIPE RESTS 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. (SEE SECTION 9.0).

FIGURE 13-2

TYPE II BURIED PIPE IN CONVENTIONAL ROCK DITCH

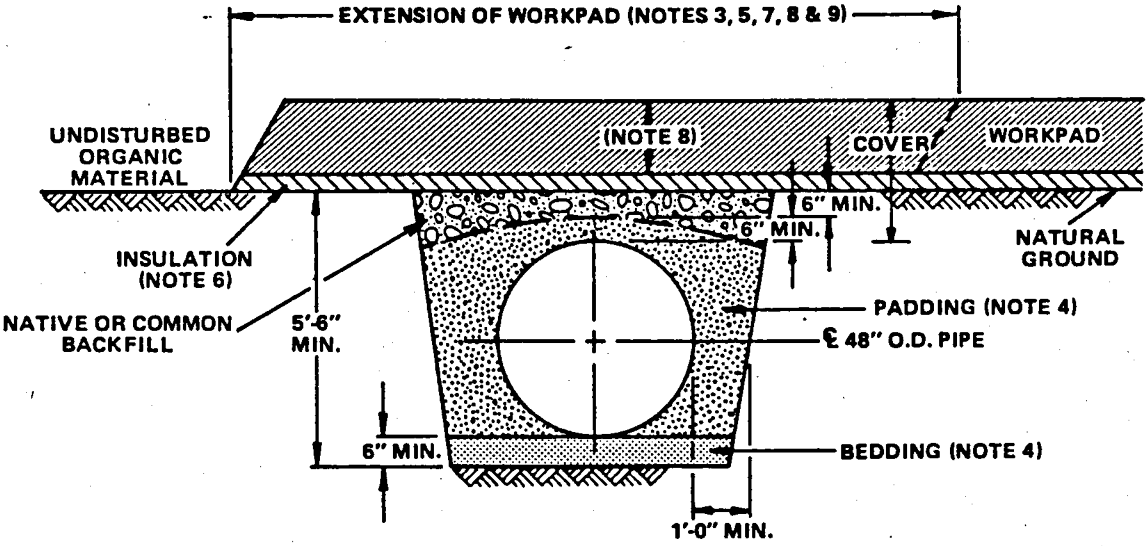


NOTES:

1. MINIMUM DEPTH OF COVER: 1'-6", CLASS 1 LOCATIONS; 2'-0", CLASS 2, 3, 4 LOCATIONS. SEE SUBSECTIONS 16.1.2.1, 16.1.2.5, 16.2.8 AND 16.2.14 FOR BUOYANCY CONTROL DESIGN AND RIVER AND STREAM SCOUR CONSIDERATIONS. SEE SECTION 20.0 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 11.0 AND 12.0.
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 9.0).

FIGURE 13-3

TYPE III BURIED PIPE IN SOILS WITH UNACCEPTABLE SETTLEMENT (SHORT AND/OR LONG TERM)

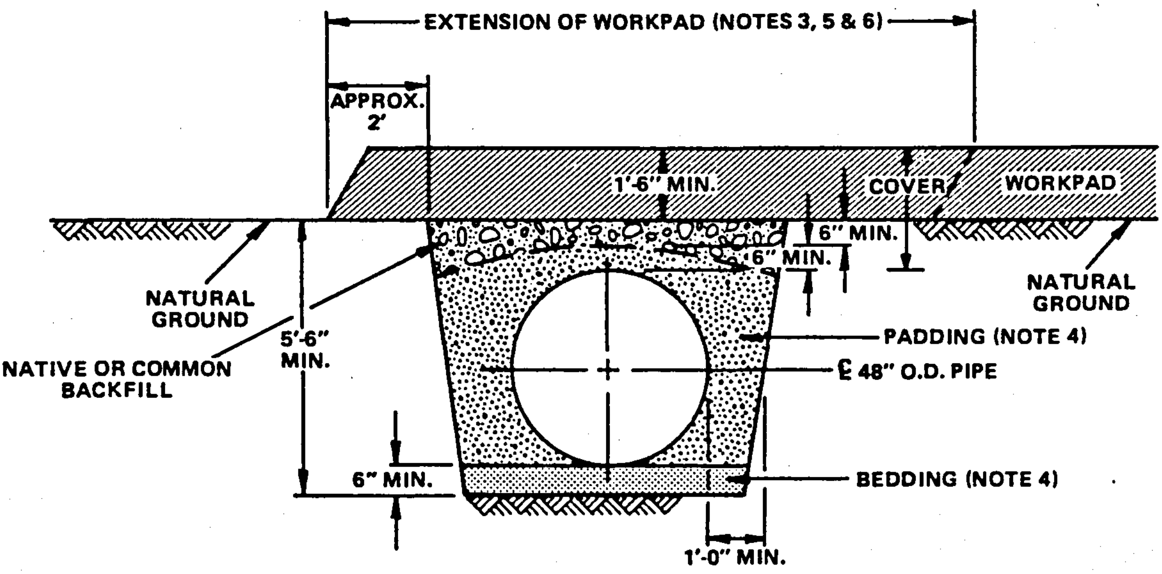


NOTES:

1. MINIMUM DEPTH OF COVER (INCLUDING EXTENSION OF WORKPAD): 2'-6", CLASS 1 LOCATIONS; 3'-0", CLASS 2, 3, 4 LOCATIONS. SEE SUBSECTIONS 16.1.2.1, 16.1.2.5, 16.2.8 AND 16.2.14 FOR BUOYANCY CONTROL DESIGN AND RIVER AND STREAM SCOUR CONSIDERATIONS. SEE SECTION 20.0 FOR BEND DESIGN CHARTS FOR MINIMUM COVER REQUIREMENTS AT BENDS.
2. DITCH WALL SLOPES WILL BE AS VERTICAL AS FIELD CONDISTIONS WILL ALLOW.
3. FOR FINISHED GRADING AND RESTORATION DETAILS SEE SECTIONS 11.0 AND 12.0.
4. NATIVE SOILS MAY BE USED FOR BEDDING AND PADDING IF THEY MEET THE BEDDING AND PADDING SPECIFICATIONS.
5. THE WORKPAD AND INSULATION WILL BE EXTENDED OVER DITCH.
6. INSULATION THICKNESS AND INSULATION WIDTH REQUIREMENTS AS DETERMINED BY GEOTHERMAL ANALYSES; MULTI-LAYERED SYSTEMS WILL HAVE STAGGERED JOINTS. FOR DETAILS ON BOARDSTOCK INSULATION. SEE SECTION 27.0.
7. AT CROSS DRAINAGES THE EXTENSION OF THE WORKPAD WILL BE ELIMINATED TO MATCH WORKPAD LOW WATER CROSSINGS OR CULVERTS AS WELL AS THIRD PARTY CONTIGUOUS FACILITIES. (SEE SUBSECTION 9.1.2.1 AND FIGURE 9-1B AND SUBSECTION 11.2.3.3.). INSULATION REQUIREMENTS FOR LOW WATER CROSSINGS OR CULVERTS ARE INCLUDED IN SUBSECTIONS 11.2.33 AND 11.2.3.4. REQUIRED MINIMUM COVER WILL BE MAINTAINED.
8. THE THICKNESS OF THE MINERAL MATERIAL OVER THE INSULATION WILL BE A MINIMUM OF 18 INCHES.
9. THE PREFERRED TIME FOR PLACEMENT OF SYNTHETICALLY INSULATED EMBACKMENTS IS WHEN THE GROUND SURFACE AND/OR NEAR SURFACE SOILS ARE FROZEN. (SEE SUBSECTIONS 3.12 AND 9.1.2.3). FOR OTHER DESIGN CONSIDERATIONS FOR PLACING INSULATION, GEOTHERMAL ASPECTS AND ADJACENT THIRD PARTY FACILITIES, SEE SUBSECTION 13.2.3.

FIGURE 13-4

TYPE IV BURIED PIPE IN SOILS WITH ACCEPTABLE SETTLEMENT (SHORT AND LONG TERM)

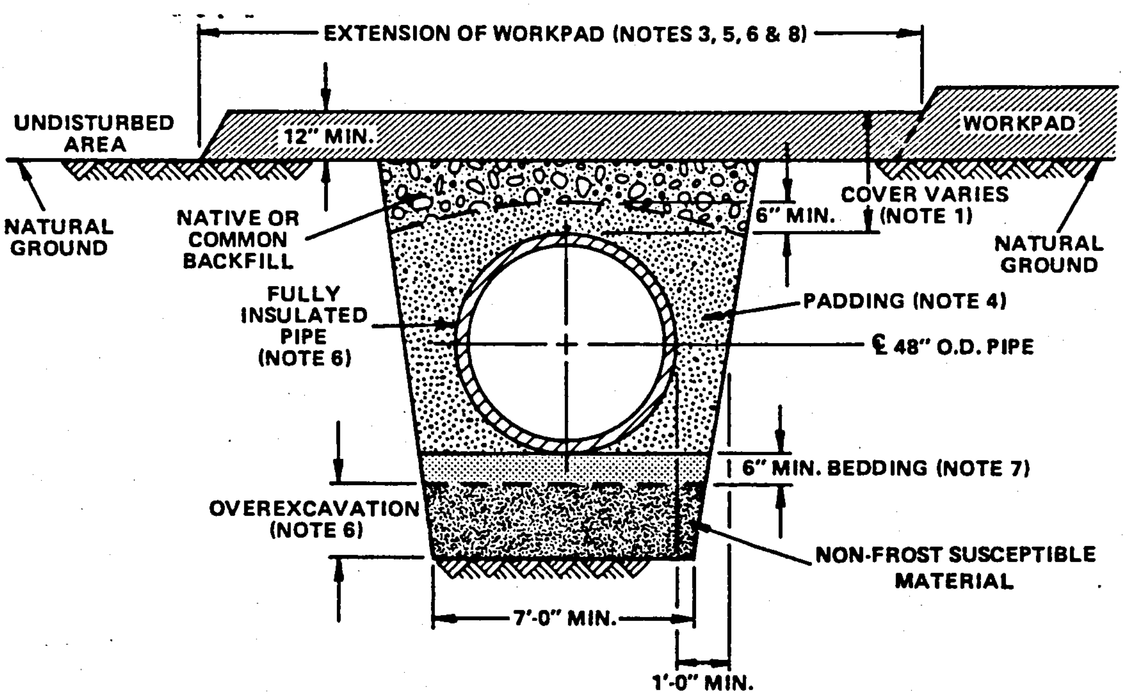


NOTES:

1. MINIMUM DEPTH OF COVER (INCLUDING EXTENSION OF WORKPAD): 2'-6", CLASS 1 LOCATIONS; 3'-0", CLASS 2, 3, 4 LOCATIONS. SEE SUBSECTIONS 16.1.2.1, 16.1.2.5, 16.2.8 AND 16.2.14 FOR BUOYANCY CONTROL DESIGN AND RIVER AND STREAM SCOUR CONSIDERATIONS. SEE SECTION 20.0 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 11.0 AND 12.0.
4. NATIVE SOILS MAY BE USED FOR BEDDING AND PADDING IF THEY MEET THE BEDDING AND PADDING SPECIFICATIONS.
5. THE WORKPAD WILL BE EXTENDED OVER THE DITCH.
6. AT CROSS DRAINAGES THE EXTENSION OF THE WORKPAD WILL BE ELIMINATED TO MATCH GAS PIPELINE WORKPAD LOW WATER CROSSINGS OR CULVERTS, AS WELL AS THIRD PARTY CONTIGUOUS FACILITIES. (SEE SUBSECTION 9.1.2.1 AND FIGURE 9-1B AND SUBSECTION 11.2.3.3). REQUIRED MINIMUM COVER WILL BE MAINTAINED.

FIGURE 13-5

TYPE V BURIED PIPE WITH OVEREXCAVATION AND FULL INSULATION
(UNFROZEN SOILS WITH UNACCEPTABLE HEAVE AND THAW UNSTABLE PERMAFROST BELOW 35' FROM GROUND SURFACE)



NOTES:

1. MINIMUM DEPTH OF COVER (INCLUDING EXTENSION OF WORKPAD); 2'-6", CLASS 1 LOCATIONS; 3'-0", CLASS 2, 3, 4 LOCATIONS. SEE SUBSECTIONS 16.1.2.1, 16.1.2.5, 16.2.8 AND 16.2.14 FOR BUOYANCY CONTROL DESIGN AND RIVER AND STREAM SCOUR CONSIDERATIONS. SEE SECTION 20.0 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. (SEE SUBSECTION 13.1.2).

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

3. FOR FINISHED GRADING AND RESTORATION DETAILS SEE SECTIONS 11.0 AND 12.0.

4. IMPORTED PADDING IS NOT REQUIRED WHEN NATIVE BACKFILL MEETS PADDING SPECIFICATIONS.

5. THE WORKPAD WILL BE EXTENDED OVER THE DITCH AND WILL BE DESIGNED AND MAINTAINED THROUGHOUT OPERATIONS TO ALLOW NO REVEGETATION.

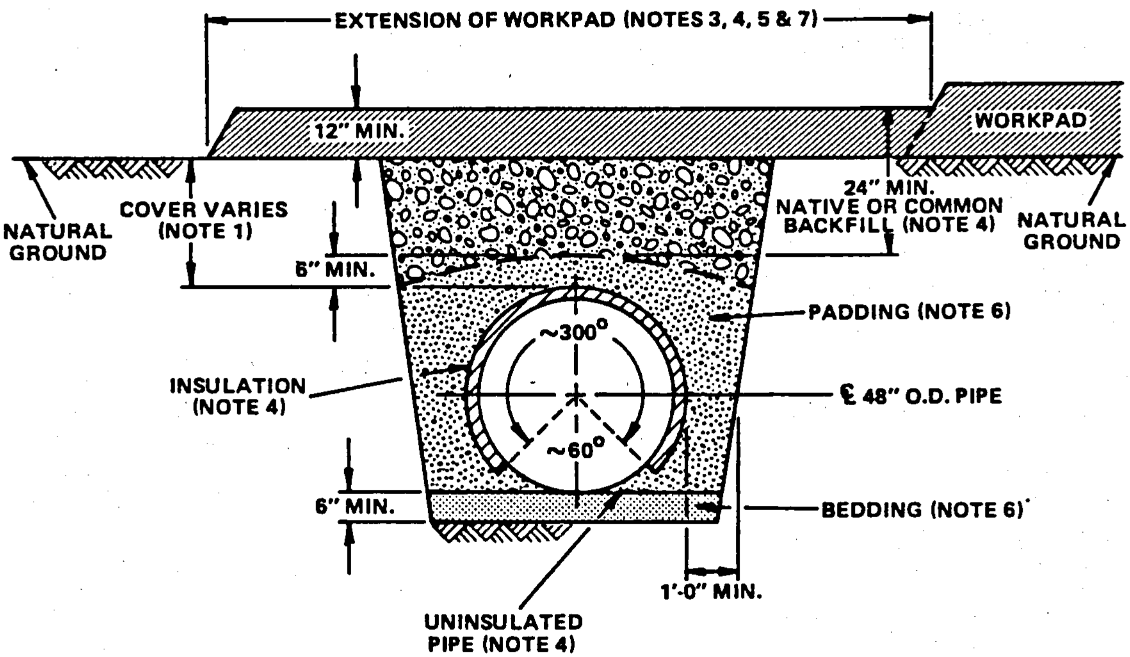
6. PIPE INSULATION THICKNESS, OVER EXCAVATION DEPTH AND WIDTH OF BERM WILL BE DETERMINED BY GEOTHERMAL ANALYSES, (SEE SECTION 21.0). FOR DETAILS ON PIPE INSULATION, (SEE SECTION 27.0).

7. 6" MINIMUM BEDDING THICKNESS NOT REQUIRED WHEN NON-FROST SUSCEPTIBLE MATERIAL BENEATH THE PIPE MEETS THE BEDDING SPECIFICATIONS.

8. AT CROSS DRAINAGES THE EXTENSION OF THE WORKPAD WILL BE ELIMINATED TO MATCH GAS PIPELINE WORKPAD LOW WATERCROSSINGS OR CULVERTS, AS WELL AS THIRD PARTY CONTIGUOUS FACILITIES. (SEE SUBSECTION 9.1.2.1 AND FIGURE 9-1B AND SUBSECTION 11.2.3.3). REQUIRED MINIMUM COVER WILL BE MAINTAINED.

FIGURE 13-6

TYPE VI BURIED PIPE WITH SADDLE INSULATION
(UNFROZEN SOILS WITH PREDICTED HEAVE WHICH MAY CAUSE UNACCEPTABLE STRAIN OR TRANSITIONS BETWEEN FROZEN SOILS AND UNFROZEN SOILS)



NOTES:

1. MINIMUM DEPTH OF COVER (INCLUDING EXTENSION OF WORKPAD): 2'-6", CLASS 1 LOCATIONS; 3'-0", CLASS 2, 3, 4 LOCATIONS. SEE SUBSECTIONS 16.1.2.1, 16.1.2.5, 16.2.8 AND 16.2.14 FOR BUOYANCY CONTROL DESIGN AND RIVER AND STREAM SCOUR CONSIDERATIONS. SEE SECTION 20.0 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. (SEE SUBSECTION 13.1.2).

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

3. FOR FINISHED GRADING AND RESTORATION DETAILS SEE SECTIONS 11.0 AND 12.0.

4. INSULATION THICKNESS, PORTION OF PIPE LEFT UNINSULATED, PROPERTIES OF THE NATIVE OR COMMON BACKFILL AND WIDTH OF BERM WILL BE DETERMINED BY GEOTHERMAL ANALYSES. (SEE SECTION 21.0).

5. THE WORKPAD WILL BE EXTENDED OVER THE DITCH AND WILL BE DESIGNED AND MAINTAINED THROUGHOUT OPERATIONS TO ALLOW NO REVEGETATION.

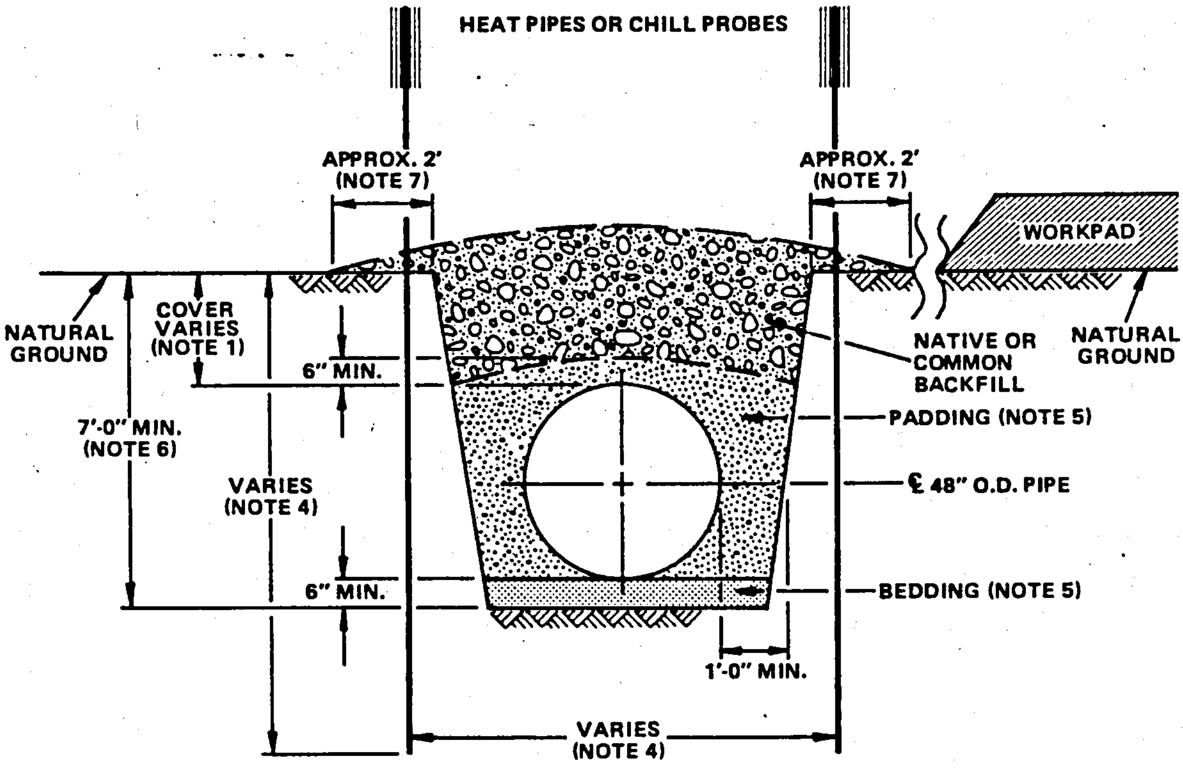
6. NATIVE SOIL MAY BE USED FOR BEEDING AND PADDING IF THEY MEET THE BEEDING AND PADDING SPECIFICATIONS.

7. AT CROSS DRAINAGES THE EXTENSION OF THE WORKPAD WILL BE ELIMINATED TO MATCH GAS PIPELINE WORKPAD LOW WATER CROSSINGS OR CULVERTS, AS WELL AS THIRD PARTY CONTIGUOUS FACILITIES. (SEE SUBSECTION9.1.2.1 AND FIGURE 9-18 AND SUBSECTION 11.2.3.3). REQUIRED MINIMUM COVER WILL BE MAINTAINED.

FIGURE 13-7

TYPE VII BURIED PIPE WITH HEAT PIPES OR CHILL PROBES

(UNFROZEN SOILS WITH UNACCEPTABLE HEAVE OR TRANSITIONS BETWEEN UNFROZEN AND FROZEN SOILS)

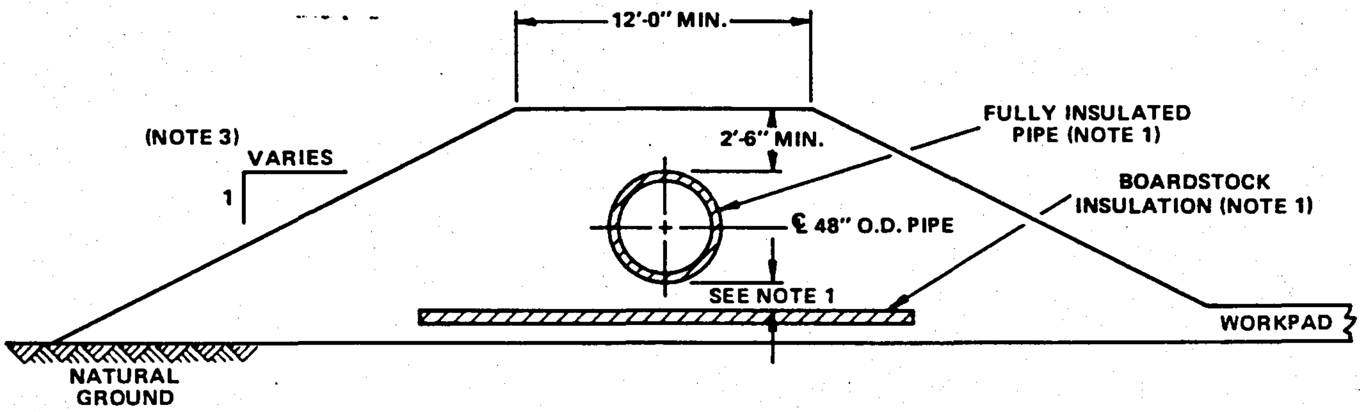


NOTES:

1. MINIMUM DEPTH OF COVER: 2'-6", CLASS 1 LOCATIONS; 3'-0", CLASS 2, 3, 4 LOCATIONS.
2. DITCH WALL SLOPES WILL BE AS VERTICAL AS FIELD CONDITIONS WILL ALLOW.
3. FOR FINISHED GRADING AND RESTORATION DETAILS SEE SECTIONS 11.0 AND 12.0.
4. SPACING OF HEAT PIPES OR CHILL PROBES TRANSVERSLY AND LONGITUDINALLY, SIZE AND LENGTH WILL BE DETERMINED BY GEOTHERMAL ANALYSES. (SEE SECTION 21.0). CHILL PROBES REQUIRE MAINTAINANCE BY MECHANICAL REFRIGERATION.
5. NATIVE SOIL MAY BE USED FOR BEDDING AND PADDING IF THEY MEET THE BEDDING AND PADDING SPECIFICATIONS.
6. IF BEDDING IS REQUIRED MINIMUM DITCH DEPTH IS 7'-0", OTHERWISE PIPE RESTS ON NATIVE SOIL AND MINIMUM DITCH DEPTH IS 6'-6".
7. MOUNDED BACKFILL WILL EXTEND APPROXIMATELY TWO FEET FROM THE EDGE OF THE DITCH WALL. DISTANCE FROM THE TOE OF THE WORKPAD AND THE TOR OF THE MOUNDED BACKFILL VARIES. (SEE SECTION 9.0).
8. TRAFFIC BARRIERS MAY BE PLACED ON A SITE SPECIFIC BASIS TO PROTECT THE ABOVE-GROUND PORTIONS OF THE THERMAL DEVICES FROM VEHICULAR TRAFFIC. IF ADJACENT TO THE HIGHWAY, OPEN TYPE BARRIERS WILL BE REQUIRED TO PREVENT SNOW DRIFTING.
9. THE EFFECTS OF HEAT PIPES OR CHILL PROBES ON GROUND WATER WILL BE CONSIDERED IN THE DESIGN.

FIGURE 13-8

TYPE VIII ABOVEGROUND PIPE IN A BERM
(UNFROZEN SOILS WITH UNACCEPTIBLE HEAVE OR FROZEN SOILS WITH UNACCEPTABLE THAW SETTLEMENT AND AT TRANSITIONS BETWEEN UNFROZEN AND FROZEN SOILS)

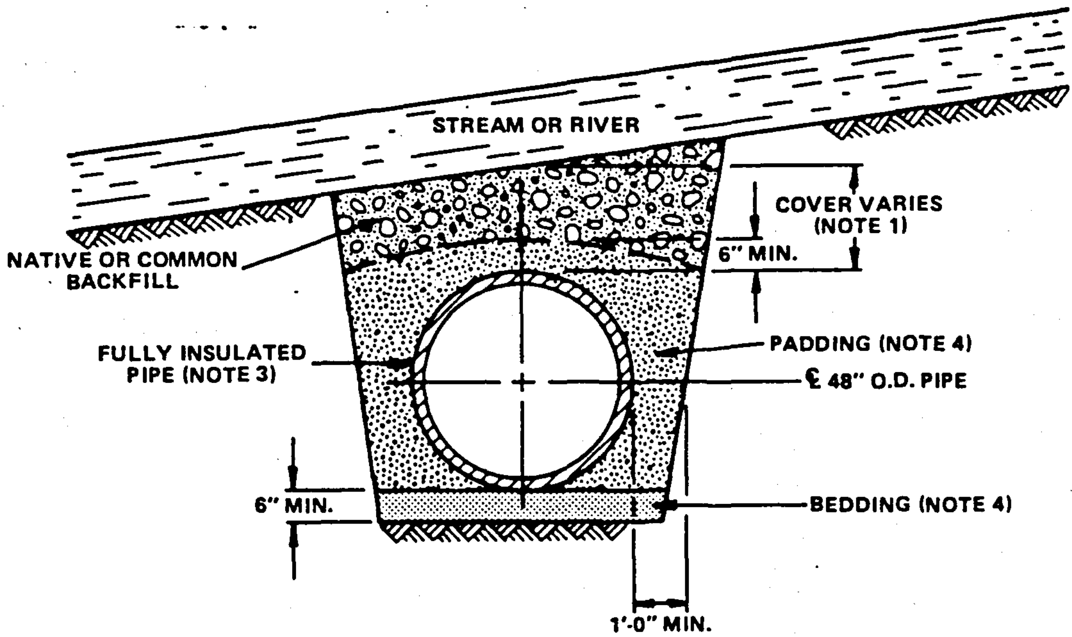


NOTES:

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, AND THE POTENTIAL FOR THERMAL/HYDRAULIC EROSION AT THE TOE OF THE BERM WILL BE EVALUATED. FOR DETAILS ON INSULATION, SEE SECTION 27.0.
2. FOR FINISHED GRADING AND RESTORATION DETAILS SEE SECTIONS 11.0 AND 12.0. THE EMBANKMENT WILL GENERALLY BE DESIGNED FOR NO REVEGATATION.
3. SIDE SLOPES WILL VARY BUT WILL NOT BE STEEPER THAN SLOPES OF 2 HORIZONTAL TO 1 VERTICAL TO ALLOW PASSAGE OF LARGE MAMMALS.
4. THE BERM MATERIAL WILL BE COMPOSED OF RELATIVELY FREE-DRAINING MINERAL.
5. CRITERIA FOR CROSS DRAINAGE IS SAME AS FOR WORKPAD AND IS FOUND IN SECTION 11.0.
6. DESIGN MODES IXc OR IXd SHOULD BE CONSIDERED AS ALTERNATIVE DESIGNS TO CULVERTS FOR CROSS DRAINAGE STRUCTURES, DEPENDING UPON ENVIRONMENTAL, CONSTRUCTION, ADJACENT THIRD PARTY FACILITIES AND ECONOMIC CONSIDERATIONS.
7. FOR FISH STREAMS WHERE CULVERTS ARE USED TO MOVE WATER THROUGH THE BERM, LOW-WATER CROSSINGS WILL BE USED ACROSS THE WORKPAD TO REDUCE THE LENGTH OF THE CULVERTS AND ALLOW FOR PASSAGE OF THE FISH. (SEE SUBSECTIONS 11.1.2, 11.2.3.3 AND 11.2.3.4).
8. GEOTHERMAL ANALYSES WILL BE USED TO DETERMINE IF CULVERTS WITHIN THE BERM WILL REQUIRE INSULATION. (SEE SUBSECTION 11.2.3.4 AND FIGURE 11-28).
9. THE SPACING OF CROSS DRAINAGE STRUCTURES TO CONTROL PONDING OR SHEET FLOW AGAINST THE BERM OR WORKPAD WILL BE DETERMINED AS IN SUBSECTION 11.2.2.2. THE SPACING OF CULVERTS AND OTHER DRAINAGE STRUCTURES SHOULD COINCIDE WITH THOSE OF ADJACENT THIRD PARTY FACILITIES, IF APPLICABLE, SO AS TO NOT DIRECT DRAINAGE AGAINST THE FACILITY.
10. 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 SEPERATION OF 150' IS MAINTAINED BETWEEN THE BERM AND THE TOE OF THE ROADWAY.
11. THIS DESIGN MODE TYPE SHOULD HAVE LIMITED USE AT SELECTED AREAS ONLY.

FIGURE 13-9

TYPE IXa STREAM OR RIVER CROSSING– BURIED FULLY INSULATED PIPE



NOTES:

1. MINIMUM DEPTH OF COVER WILL BE 4'-0" OR 120 PERCENT OF COMPUTED NET SCOUR WHICHEVER IS GREATER. SEE SUBSECTIONS 16.1.2.1, 16.1.2.5, 16.2.8 AND 16.2.14 FOR BUOYANCY CONTROL AND SCOUR CONSIDERATIONS. SEE SECTION 20.0 FOR MINIMUM COVER REQUIREMENTS AT BENDS.

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

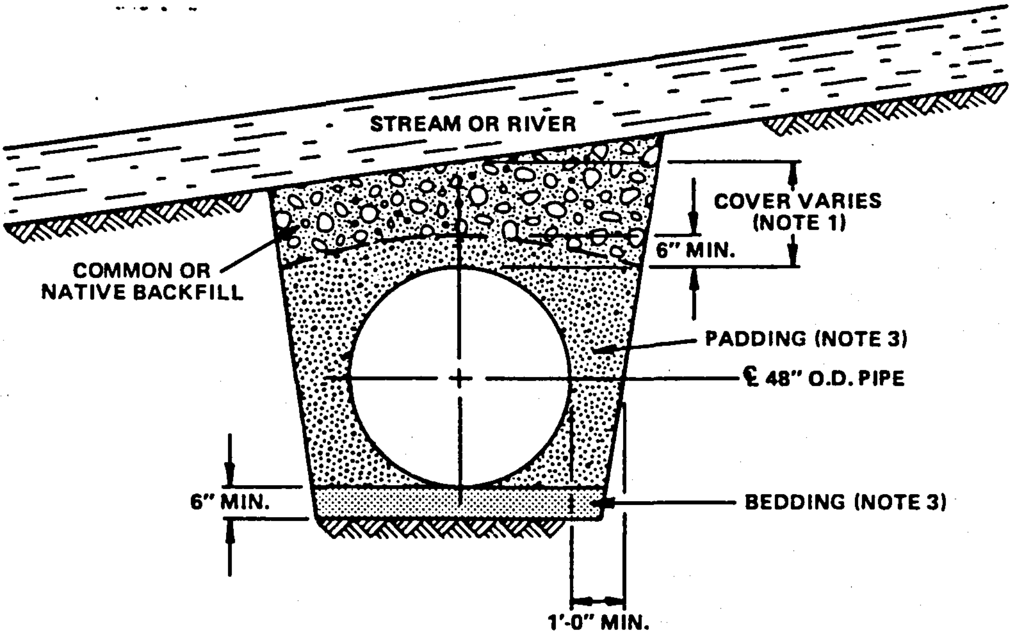
3. PIPE INSULATION THICKNESS WILL BE DETERMINED BY GEOTHERMAL ANALYSES. (SEE SUBSECTIONS 16.1.2.6, 16.2.7, 16.2.1.0 AND SECTION 21.0). FOR DETAILS ON INSULATION SEE SECTION 27.0.

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

5. DITCH PLUGS WILL BE PLACED ACCORDING TO SUBSECTIONS 13.1.2.2 AND 13.4.1.

FIGURE 13-10

TYPE IXb 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 (AFTER ALLOWANCES FOR CALCULATED LONG TERM FROST HEAVE) WILL BE: 4'-0" OR 120 PERCENT OF COMPUTED NET SCOUR WHICHEVER IS GREATER. SEE SUBSECTIONS 16.1.2.1, 16.1.2.5, 16.2.8 AND 16.2.14 FOR BUOYANCY CONTROL AND SCOUR CONSIDERATIONS. SEE SECTION 20.0 FOR MINIMUM COVER REQUIREMENTS AT BENDS.

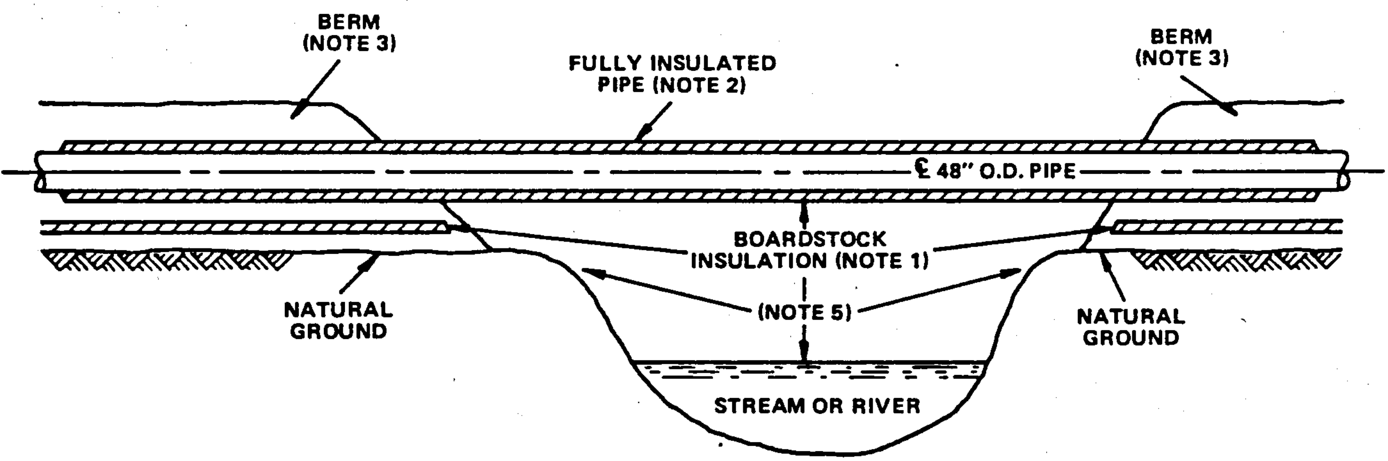
2. DITCH WALL SLOPES WILL BE AS VERTICAL AS FIELD CONDITIONS WILL ALLOW.

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.

FIGURE 13-11

TYPE IXc STREAM OR RIVER CROSSING–
ELEVATED PIPE WITH BERM APPROACHES



NOTES:

1. THE NEED FOR BOARDSTOCK INSULATION IN THE BERM, THE INSULATION THICKNESS AND WIDTH, THE DISTANCE BETWEEN THE INSULATED PIPE AND THE BOARDSTOCK INSULATION (IF REQUIRED) WILL BE DETERMINED BY GEOTHERMAL ANALYSES (SEE SECTION 21.0). FOR DETAILS ON BOARDSTOCK INSULATION SEE SECTION 27.0.

2. PIPE INSULATION THICKNESS WILL BE DETERMINED BY GAS THERMAL HYDRAULIC ANALYSES. FOR DETAILS ON CIRCULAR PIPE INSULATION SEE SECTION 27.0.

3. SEE FIGURE 13-9 FOR DETAILS OF BERM DESIGN.

4. MAXIMUM SPAN WILL BE DETERMINED ACCORDING TO CRITERIA AND PROCEDURES IN SECTIONS 14.0 AND 20.0.

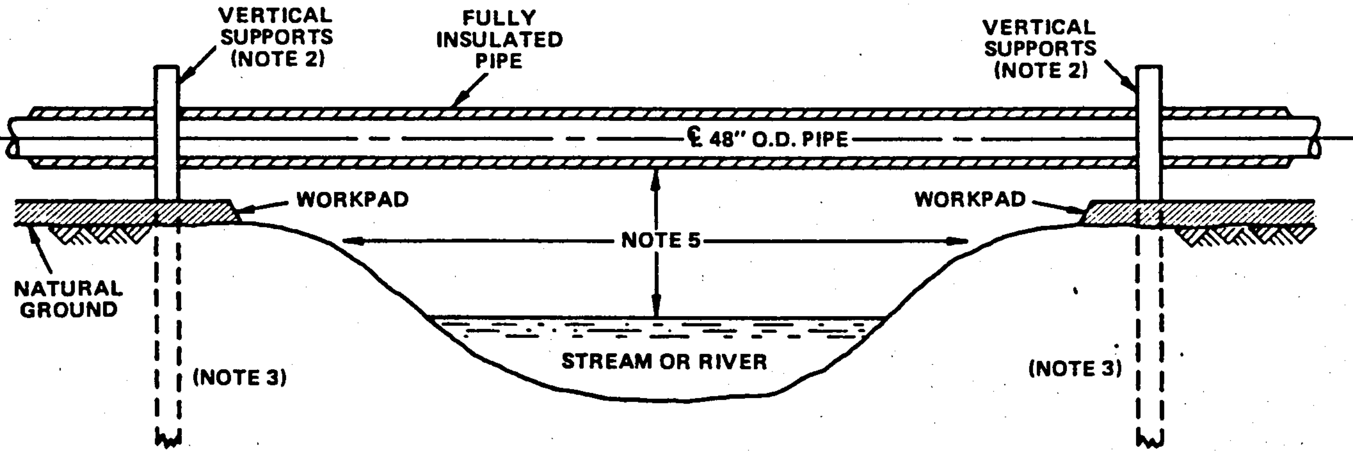
5. FOR MINIMUM CLEARANCE CRITERIA SEE SECTION 14.1.2.1. FOR BANK PROTECTION CRITERIA SEE SUBSECTION 16.2.6.

6. GENERAL DESIGN CONSIDERATIONS FOR RIVER AND STREAM CROSSINGS ARE OUTLINED IN SECTIONS 14.0 AND 16.0.

7. THIS DESIGN MODE TYPE SHOULD NOT BE USED ON THE WINDWARD SIDE OF A HIGHWAY WHERE SNOW DRIFTING IS KNOW TO OCCUR, OR COULD OCCUR, UNLESS A MINIMUM SEPERATION OF 150' IS MAINTAINED BETWEEN THE BERM AND THE TOE OF THE ROADWAY.

FIGURE 13-12

TYPE IXd STREAM AND RIVER CROSSING – ELEVATED PIPE ON A STRUCTURE SUPPORTED BY VERTICAL SUPPORTS



NOTES:

1. PIPE INSULATION THICKNESS WILL BE DETERMINED BY PIPE GAS THERMAL HYDRAULIC ANALYSES. FOR DETAILS IN PIPE INSULATION, SEE SECTION 27.0.

2. MAXIMUM SPAN AND VERTICAL SUPPORTS SPACING WILL BE DETERMINED ACCORDING TO CRITERIA AND PROCEDURES IN SECTIONS 14.0 AND 20.0.

3. HEAT PIPES WILL BE USED IF VERTICAL SUPPORTS ARE PLACED IN FROZEN SOIL SOUTH OF ATIGUN PASS WHEN THE DESIGN IS BASED ON FROZEN SOIL STRENGTHS. EMBEDMENT LENGTH OF VERTICAL SUPPORTS WILL BE DETERMINED AS OUTLINED IN SECTION 21.0.

4. FOR FINISHED GRADING AND RESTORATION DETAILS, SEE SECTIONS 11.0 AND 12.0.

5. FOR MINIMUM CLEARANCE CRITERIA SEE SECTION 14.1.2.1. FOR BANK PROTECTION CRITERIA SEE SUBSECTION 16.2.6.

6. GENERAL DESIGN CONSIDERATIONS FOR RIVER AND STREAM CROSSINGS ARE OUTLINED IN SECTIONS 14.0 AND 16.0.

FIGURE 13-13

GENERALIZED MODE SELECTION METHODOLGY

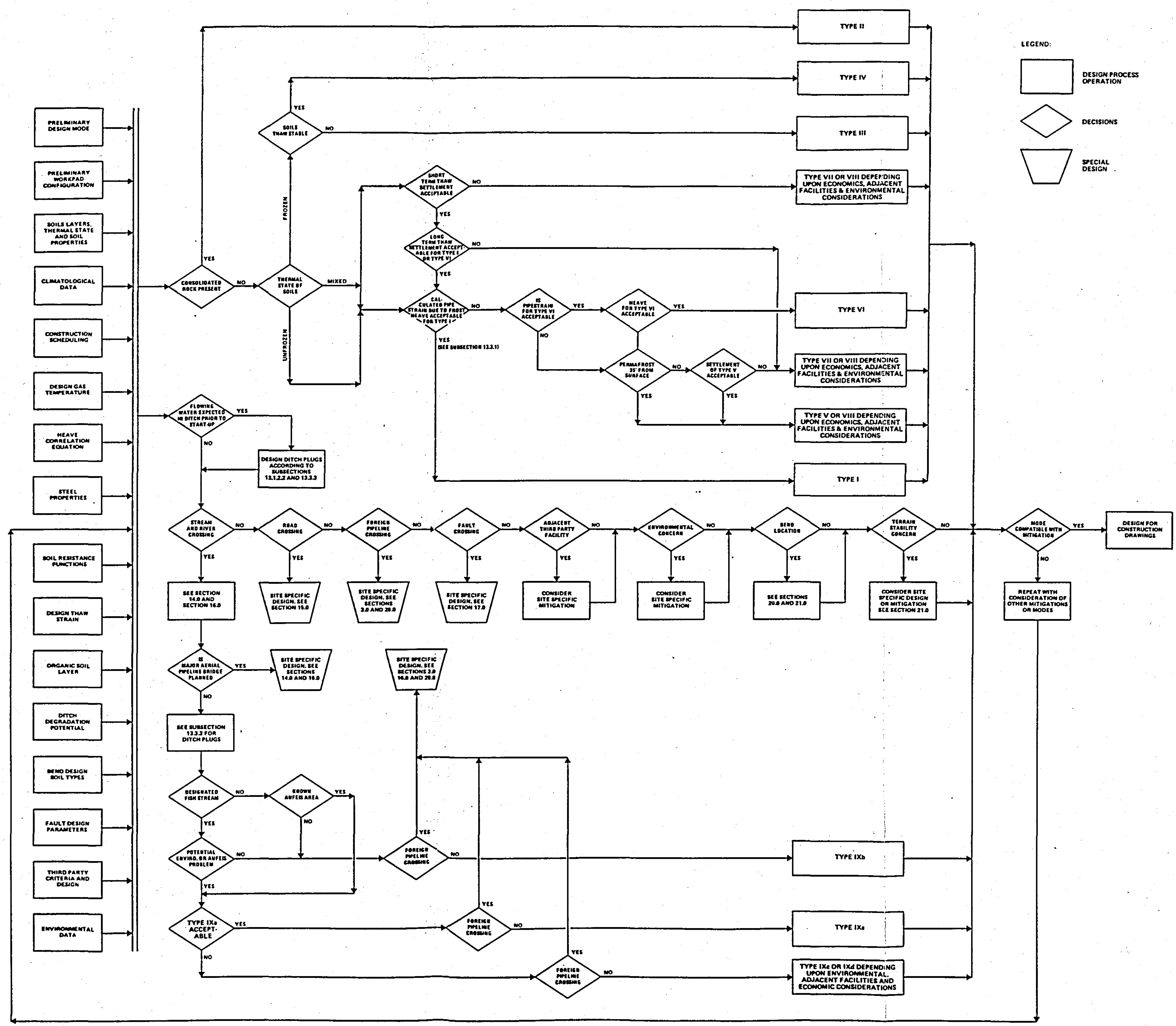


FIGURE 13-14

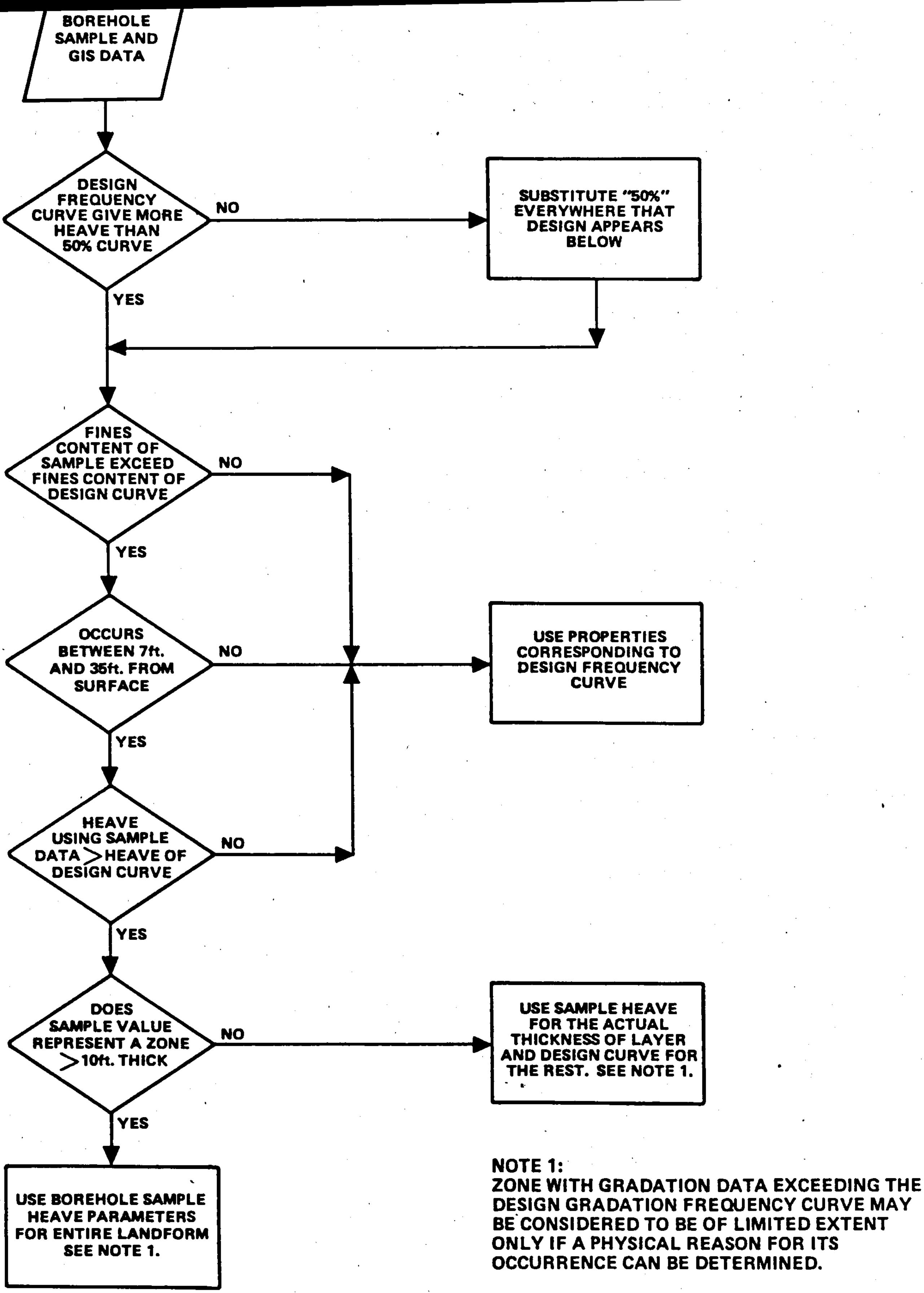

BOREHOLE SAMPLE AND GIS DATA
DESIGN FREQUENCY CURVE GIVE MORE HEAVE THAN 50% CURVE
NO
SUBSTITUTE "50%" EVERYWHERE THAT DESIGN APPEARS BELOW
YES
FINES CONTENT OF SAMPLE EXCEED FINES CONTENT OF DESIGN CURVE
NO
YES
OCCURS BETWEEN 7ft. AND 35ft. FROM SURFACE
NO
USE PROPERTIES CORRESPONDING TO DESIGN FREQUENCY CURVE
YES
HEAVE USING SAMPLE DATA > HEAVE OF DESIGN CURVE
NO
YES
DOES SAMPLE VALUE REPRESENT A ZONE > 10ft. THICK
NO
USE SAMPLE HEAVE FOR THE ACTUAL THICKNESS OF LAYER AND DESIGN CURVE FOR THE REST. SEE NOTE 1.
YES
USE BOREHOLE SAMPLE HEAVE PARAMETERS FOR ENTIRE LANDFORM SEE NOTE 1.
NOTE 1:
ZONE WITH GRADATION DATA EXCEEDING THE DESIGN GRADATION FREQUENCY CURVE MAY BE CONSIDERED TO BE OF LIMITED EXTENT ONLY IF A PHYSICAL REASON FOR ITS OCCURRENCE CAN BE DETERMINED.

FIGURE 13-15

LOGIC DIAGRAM FOR DITCH PLUG REQUIREMENTS

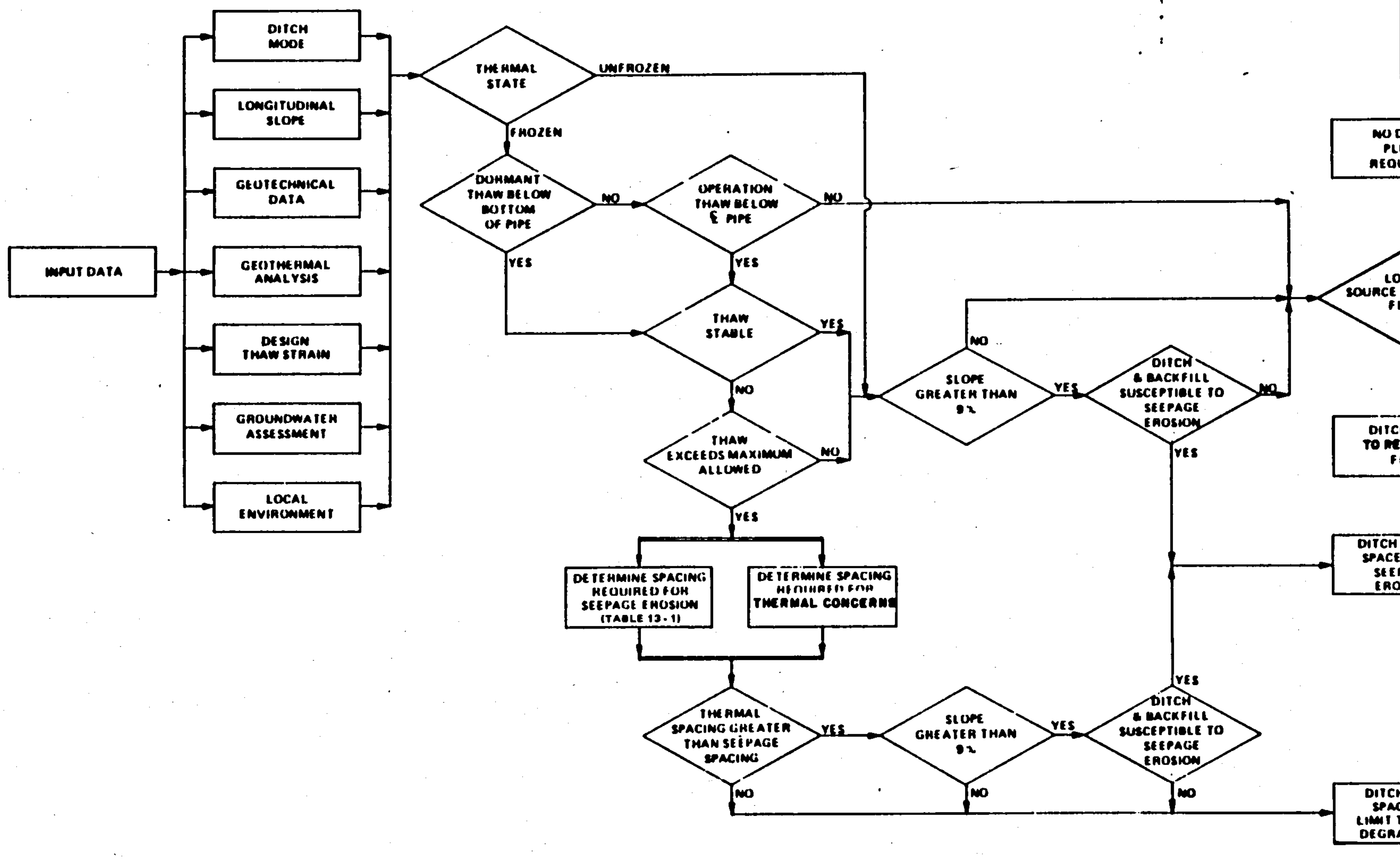


FIGURE 13 - 16

TABLE 13-1

MAXIMUM PLUG SPACING TO RESTRICT SEEPAGE EROSION[2]

LONGITUDINAL GROUND SLOPE (PERCENT)	MAXIMUM SPACING MEASURES ALONG THE SLOPE[2] (FEET)
0-3	NO DITCH PLUG REQUIRED
3-9	AT SIGNIFICANT "V" OR "L" SAGBENDS ONLY[3]
9-12	400
12-15	250
15-20	200
20-25	150
25-30	125
> 30	100

Notes:

1. The values shown in this Table are extracted from Alyeska report HD-017, "Ditch Plug Design and Location Field Manual," June 18, 1975. (With Modifications.)

2. In addition, ditch plugs are to be placed at significant sagbends and significant overbends with slopes oriented in the same direction. No ditch plug is required if the slopes are in opposite directions for this particular situation. A significant sagbend is defined as an abrupt sagbend where the difference in slope angle exceeds 5 percent and the steeper of the two slopes exceeds 3 percent. A significant overbend is defined as an abrupt overbend with both slopes oriented in the same direction with the difference in slope angles exceeding 5 percent and the steeper of the two slopes exceeding 9 percent.

3. A significant "V" sagbend has both slopes greater than 3 percent and in opposite directions. A significant "L" sagbend has the lower slope between 3 percent in the opposite direction of the upper slope and 9 percent in the same direction.

TABLE 13-2

INTERMEDIATE MODE TYPE TRANSITION SELECTION CHART FOR TRANSITIONS

DESIGN MODE	TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V	TYPE VI	TYPE VII	TYPE VIII	TYPE IXa	TYPE IXb	TYPI IXc
TYPE I		*	*(VII)	*	*(VI,VII, VIII)	*	*	*	*	*	*
TYPE II	*		*(VII)	*	*(VI,VII, VIII)	*	*	*	*	*	*
TYPE III	*(VII)	*(VII)		*	*(VI,VII)	*	*	VII	VII	*	*
TYPE IV	*	*	*		*(VI,VII, VIII)	*	*	*	*	*	*
TYPE V	*(VI,VII, VIII)	*(VI,VII, VIII)	*(VI,VII)	*(VI,VII, VIII)		*	*	*	*	*	*
TYPE VI	*	*	*	*	*		*	*	*	*	*
TYPE VII	*	*	*	*	*	*		*	*	*	*
TYPE VIII	*	*	VII	*	*	*	*		*	*(VII)	*
TYPE IXa	*	*	VII	*	*	*	*	*		–	–
TYPE IXb	*	*	*	*	*	*	*	*(VII)	–		–
TYPE IXc	*	*	*	*	*	*	*	*	–	–	
TYPE IXd	*	*	VII	*	*	*	*	*	–	–	–

*No intermediate mode required at the transition.
*(Mode Type) - May require a intermediate mode if transition cannot be clearly defined.
-No transition mode required.

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