ERROSION AND SEDIMENTATION
CONTROL DESIGN MANUAL
NWA

192-F

NORTHWEST ALASKAN PIPELINE COMPANY
3333 Michelson Dr.
Irvine, California 92730
(714) 975-6007

610.0

GOA-82-2207

November 24, 1982

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

Mr. W. T. Black
Director, Office of Engineering
Office of the Federal Inspector
2222 Martin
Irvine, CA 92715

Subject: Transmittal of Erosion and Sedimentation Control Design Manual

Dear Mr. Black:

Enclosed is the following confidential/proprietary report, identified in our "Key Activity Checklist; Revision No. 2," dated October 22, 1982, as Item No. 51:

Erosion and Sedimentation Control Design Manual, November 12, 1982

This report applies only to the Alaska pipeline segment of the Alaska Natural Gas Transportation System. Similar information pertaining to the Alaska Gas Conditioning Facility (AGCF) is included in AGCF design review package No. 5 which is incorporated by reference in the joint pipeline - AGCF Stipulation Plan No. 8, "Erosion and Sedimentation Control."

The enclosed information is considered confidential/proprietary by Northwest Alaskan Pipeline Company and remains the property of Alaskan Northwest Natural Gas Transportation Company, a partnership. The petition attached to this letter requests OFI to consider this material "BUSINESS" information pursuant to 10CFR Part 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 This material is protected as an unpublished work under the Copyright Law of the United States, 17 USC §101 et seq.

Very truly yours,

NORTHWEST ALASKAN PIPELINE COMPANY

George P. Wuerch
Manager, Regulatory
and Governmental Affairs

GPW/wpc
Enclosures (4 copies)

cc: N. Hengerer, OFI, Washington, D.C. (w/enclosure)
A. G. Ott, SPO, Fairbanks (w/2 copies of enclosure)

Enclosure to Northwest Alaskan Pipeline Company
Letter GOA-82-2207 of November 24, 1982 to
Mr. W. T. Black

PETITION FOR "BUSINESS" DESIGNATION
SUBMITTED TO OFI PURSUANT TO 10 CFR PART 1504

I. The information contained in the above referenced Northwest Alaskan Pipeline Company (NWA) letter, qualifies for a "BUSINESS" designation on the basis that it is confidential/proprietary, commercial information, the release of which may substantially impair the competitive position of the sponsors of the Alaska segment of the Alaska Natural Gas Transportation System (ANGTS). NWA has incurred substantial costs to develop the information, involving major expenditures, including both direct and indirect costs. Moreover, the sponsors do not have a final, unconditional Certificate of Public Convenience and Necessity from the Federal Energy Regulatory Commission (FERC), and the information clearly would be of substantial value to anyone contemplating the construction on the North Slope of Alaska or in similar climates and geologic regimes. Even after a final FERC certificate has been obtained, the information contained in the document submitted is of such a nature that it might be used in third-party litigation against the sponsors. NWA has given serious consideration to a request for a "SENSITIVE" designation and to the recent order from the International Trade Commission, Department of Commerce (e.g., 15 CFR Parts 379, 385 and 399, published F.R. Vol. 47, No. 2, January 15, 1982, p. 141) restricting export of technical data related to gas transmission. Although the less restrictive "BUSINESS" designation has been requested, the technology represented by this information clearly should not be disclosed except as authorized by NWA.

II. The OFI may contact the following named persons concerning this petition:

Mr. Edwin (Al) Kuhn, Director-Governmental Affairs
Northwest Alaskan Pipeline Company
1120 20th Street, NW
Washington, D.C. 20036
Phone: 202/872-0280

Mr. William J. Moses, General Counsel
Northwest Alaskan Pipeline Company
3333 Michelson Drive
Irvine, California 92730
Phone: 714/975-4003

Mr. George P. Wuerch, Manager-Regulatory and Governmental Affairs
Northwest Alaskan Pipeline Company
3333 Michelson Drive
Irvine, California 92730
Phone: 714/975-6560

MEMORANDUM

State of Alaska

TO: See Distribution

DATE: November 30, 1982

FILE NO:

TELEPHONE NO: 456-4835

FROM: Alvin G. Ott
State Pipeline Officer
Division of Land and Water Management
Department of Natural Resources

SUBJECT: Erosion and Sedimentation Control Design Manual

Attached for your review and comment is the Erosion and Sedimentation Control Design Manual as prepared by Northwest Alaskan Pipeline Company (NWA). Please review and submit comments to this office by January 7, 1983. The attached document is considered confidential/ proprietary and should therefore be treated in accordance with the Memorandum from Ott dated September 20, 1982 (Attachment #2). After you have completed the review process, please return the Erosion and Sedimentation Control Design Manual to this office. Should there be any questions concerning this transmittal, please contact me at 907-456-4835.

AGO

Attachments (1) Erosion and Sedimentation Control Design Manual

(2) Memorandum from Ott Dated September 20, 1982, Regarding Protection of Northwest Alaskan Pipeline Company Materials/Documents

DISTRIBUTION:

Larry Dietrick, Pipeline Monitor, Gas Pipeline Surveillance, Alaska Department of Environmental Conservation, Fairbanks
Lynn Harnisch, Civil Engineer, Division of Planning and Programming, Alaska Department of Transportation and Public Facilities, Fairbanks
Scott Grundy, Regional Supervisor, Habitat Division, Alaska Department of Fish and Game, Fairbanks
Jerry Brossia, District Manager, Division of Land and Water Management, Alaska Department of Natural Resources, Fairbanks

MEMORANDUM

State of Alaska

TO: See Distribution

DATE: September 20, 1982

FILE NO:

TELEPHONE NO:

FROM: Alvin G. Ott, State Pipeline Officer
Division of Land and Water Management
Department of Natural Resources

SUBJECT: Protection of Northwest Alaskan Pipeline Company Materials/Documents

The purpose of this memorandum is to advise all State agencies of the strict limitations on disclosure and copying of documents originated by Northwest Alaskan Pipeline Company (NWA). Following is a summary of the NWA position (see Attached letter from Kuhn to Ott):

(1) NWA maintains that two things have to occur to maintain the control necessary to protect specified NWA originated documents under the Federal Copyright Statute. The controls are (1) that the documents must be in the direct control of responsible State officials and (2) that NWA must be notified of any requests to access such documents and given the opportunity to object to disclosure. NWA further requests that the notification be in writing. (This procedure is basically in accordance with the Attorney Generals Opinion of 11/24/80. The only diffenence is that NWA appears to be covering a much broader range of documents.) If the Attorney General subsequently denies a NWA objection then the document can be released.

In any event the State Pipeline Officer does not make the decision, the Attorney Generals Office will on a case by case basis. It would be the State Pipeline Officer's responsibility to maintain the control (to log in the requests, make the proper notification to NWA, request advise from the Attorney Generals Office, and notify NWA of the intended State action);

(2) Reproduction of NWA-originated documents for State agency use from this day forward is authorized by NWA provided the documents are used for the purpose for which they were originally submitted, accountability of the documents is maintained, and the documents are stamped appropriately.

(3) NWA also specified what is to be done with previously submitted documents or copies thereof. Such documents are to be marked accordingly and would be subject to the controls as outlined in Item 1 above;

(4) NWA indicated that it was their intent to maintain many of the documents as confidential and trade secret materials. Exceptions may be made on a case by case basis;

(5) NWA identified further those documents for which the controls would not have to be imposed (see Enclosure A of Attached letter to Ott from Kuhn) and those for which controls should be imposed (see Enclosure B of the Kuhn letter). The controls as outlined by NWA also apply to any confidential, proprietary, or trade secret materials.

Assistance from the Attorney Generals Office has been requested. However, until further notice from this office all NWA materials (documents originated by NWA) should be treated in accordance with the provisions outlined in this memorandum with the exception of those documents listed in Enclosure A of the Kuhn letter. Each agency should establish procedures for maintaining control of the NWA materials and should notify the State Pipeline Officer (456-4835) of any requests for disclosure or copying of the NWA documents. Should there be any questions concerning the contents of this memorandum, please contact either me or Mr. Larry Dietrick at 456-4835.

AGO

Attachments (1) Letter from Kuhn to Ott dated July 29, 1982 (GOA-82-1091)

DISTRIBUTION:

Helen Beirne, Commissioner, Department of Health and Social Services, Juneau, Alaska
Carole Burger, Commissioner, Department of Administration, Juneau, Alaska
Wilson Condon, Attorney General, Department of Law, Juneau, Alaska
John Katz, Commissioner, Department of Natural Resources, Juneau, Alaska
Lee McAnerney, Commissioner, Department of Community and Regional Affairs, Juneau, Alaska
Ernst Mueller, Commissioner, Department of Environmental Conservation, Juneau, Alaska
William Nix, Commissioner, Department of Public Safety, Juneau, Alaska
Ronald Skoog, Commissioner, Department of Fish and Game, Juneau, Alaska
Robert Ward, Commissioner, Department of Transportation and Public Facilities, Juneau, Alaska
Charles Webber, Commissioner, Department of Commerce and Economic Development, Juneau, Alaska
Thomas Williams, Commissioner, Department of Revenue, Juneau, Alaska

CONFIDENTIAL/PROPRIETARY

EROSION AND SEDIMENTATION CONTROL DESIGN MANUAL

192-F

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

NORTHWEST ALASKAN PIPELINE COMPANY

NOVEMBER 12, 1982

EROSION AND SEDIMENTATION CONTROL DESIGN MANUAL

REV. NO.	REMARKS	APPROVED ORIGI-NATOR	ENGIN-EERING	ENVIRON-MENTAL AFFAIRS	CONSTRUC-TION
△					
△					
△					
△					
△0	ISSUE FOR REVIEW				

NORTHWEST ALASKAN PIPELINE COMPANY	DOC. NO. H22	
	DATE	REV.
	12 NOVEMBER 1982	0

TABLE OF CONTENTS

1.0 SCOPE

1.1 INTRODUCTION

Northwest Alaskan Pipeline Company (NWA) is authorized to construct, operate, maintain and terminate activities on the right-of-way in a manner which will balance environmental protection with economic practicality and technical capability. The most effective means of protecting the environment from erosion and sedimentation to avoid or minimize disturbances of the natural vegetation and ground surface stability. Disturbances of the natural ground surface stability may result in erosion which may cause siltation of streams, as well as endanger the integrity of the gas pipeline as well as adjacent facilities.

1.2 PURPOSE

Consistent with the Stipulation, NWA has developed a program of design and procedural means to control erosion and sedimentation. This manual establishes detailed design procedures for erosion sedimentation control and is to be used in conjunction with portions of the Pipeline Design Criteria Manual in which basic criteria and some procedures for the design of drainage, erosion and sediment control are presented. In the case of any conflict between this manual and the Pipeline Design Criteria Manual, the Pipeline Design Criteria Manual will govern.

1.3 OBJECTIVE

The office design includes predictable erosion problems using general parameters. Unpredictable erosion occurrences are also expected to occur during the progress of work. These occurrences will have to be responded to on an as needed basis as they develop in the field.

The purpose of the Erosion and Sedimentation Control Design Manual is to provide specific procedures and alternatives to initially assist office personnel in preparing a design, and later to enable field personnel to make necessary field design for unexpected erosion problems. It is to be used as a guide along with sound judgment to accomplish an effective erosion control program.

2.0 SUMMARY

This manual in conjunction with the Pipeline Design Criteria Manual addresses the detailed design of drainage, erosion and sedimentation controls. It is intended to be used by office design personnel, field personnel, inspection and maintenance personnel to select, design and implement drainage, erosion and sedimentation controls over the course of the project.

This document is organized as follows:

SECTION 3.0	Provides the designer information by which he can select the appropriate structure for a given situation.
SECTION 4.0	Provides office or field personnel information and basic procedures to design structures selected in accordance with Section 3.0.
SECTION 5.0	Provides the office personnel design methods and procedures for standard mile-by-mile erosion and sediment control structures and measures.
SECTION 6.0	Provides office personnel design options and possible solutions to specific drainage, erosion control, sediment control, thermal erosion control, aufeis control and debris control problems. These should only be implemented on a site-specific basis as part of the office design effort.
SECTION 7.0	Provides field personnel information to assist in selection and design of structures and measures where office design requires modification or unexpected problems occur.
SECTION 8.0	Contains tables, figures and nomographs referred to in other subsections.

3.0 STRUCTURES AND PRACTICES

3.1 GENERAL

Drainage routing and design of drainage, erosion, and sedimentation control structures will be based on the general guidelines below. Guidelines included in this section are not applicable to large streams and rivers crossed by the pipeline. They are covered by design considerations in Section 16.0, River, Stream and Wetland Crossings, of the Pipeline Design Criteria Manual.

The design for a specific segment will consider the following:

- Typical drainage situations
- Pipeline stream crossings
- Thermal erosion
- Thermal hydraulic erosion

3.2 SELECTION OF TEMPORARY VS. PERMANENT STRUCTURES

The selection of a temporary vs. a permanent structure will be made in accordance with Reference 4.

3.2.1 Temporary Structures

Temporary structures are defined as structures required during construction that will be removed (or upgraded to permanent status).

- Temporary rerouting of streams of intermittent summer flow is allowable. Drainage ways may be induced only if such routing minimizes the combined problems of drainage and erosion control. Temporary diversions will be sized to carry the flow actually experienced at the time of diversion unless other requirements are more stringent.

- Temporary rerouting of streams that flow for prolonged periods in the summer (other than fish streams) is allowable. For fish streams, temporary rerouting will be by individual stream consideration and will be designed as described in Section 4.0. Temporary diversions will be sized to carry the flow actually experienced at the time of diversion unless other requirements are more stringent.

- Diversion dikes will be used for rerouting, temporary diversions and temporary dewatering of portions of a streambed, where required.

- Temporary ditches, culverts, bridges, low water crossings, or similar structures are allowable to maintain trafficability of the workpad and/or protection during construction.

- If temporary erosion and sedimentation control structures which are designed to control erosion and/or sedimentation during construction are to be reclassified as permanent structures, they will be upgraded to meet permanent structural specifications or replaced during restoration operations.

3.2.2 Permanent Structures

Permanent drainage structures are defined as those that will remain in place after construction for the life of the pipeline system.

- Permanent routing out of the natural drainage way for cut-fill, side-cut, or overlay cross-section geometry will not be utilized unless pipe integrity may otherwise be jeopardized or an impractical hydraulic solution is encountered. Permanent rerouting out of natural drainage ways may be required on through-cut cross-section geometry but will be minimized in these instances.

- Permanent appurtenances required at fish streams will be by individual consideration and will be designed according to considerations listed in Section 4.0.

- As the utilization of permanent low water crossings minimizes potential obstructions to flow and fish passage, these structures are to be used in preference to culverts as permanent structures.

- Permanent erosion and sedimentation control structures will be designed and maintained to control erosion and/or sedimentation during the expected life of the pipeline.

3.2.3 Bypass Structures, Fluming and Pumping

Where bypass structures, fluming or pumping operations are only expected to last for a few days or weeks, they will be sized to carry the flow actually experienced at the time of installation unless other requirements are more stringent.

3.3 TYPICAL DRAINAGE SITUATIONS

3.3.1 Cross Drainage

3.3.1.1 Workpad or Access Road Crossing a Drainage

- General

  Cross drainage structures will be required when the construction zone crosses a defined drainage way. Structures will also be required to minimize ponding caused by the embankment or by thermal erosion.

- Drainage Structures

  Drainage structure selection in this case is discussed in Subsection 11.2.3 of the Pipeline Design Criteria Manual and as described in Figure 1. Insulated culverts and insulated low water crossings are required in areas where a thermal workpad is to be constructed.

- Erosion control structures

  A plunge basin, riprap apron, or letdown structure (Subsection 5.2) may be required at the downstream end of a culvert or low water crossing.

- Sedimentation control structures

  Sedimentation control will not normally be a problem in cross drainage structures, but where sedimentation control is required, effective temporary short-term measures include filter inlets, filter culverts and sediment barriers (Subsection 7.4). These are not allowed on fish streams, and the source of erosion must be controlled.

3.3.1.2 Concentration of Sheet Flow

- General

  This condition is applicable where existing sheet flow drainage patterns are to be intercepted and concentrated to pass runoff across an embankment (see Figure 4).

- Drainage structures

  - Cross drainage structures will be culverts or low water crossings which are discussed in Subsection 11.2.3 of the Pipeline Design Criteria Manual and will be spaced as described in Subsection 11.2.2 of the Pipeline Design Criteria Manual.

- Where ponding is undesirable (e.g. in thermally sensitive areas) or where the embankment would be overtopped by ponding, a cross or longitudinal drainage structure is required. Otherwise, sheet flow will normally be allowed to pond against the embankment.

- Longitudinal structures (See Figure 3) are drainage ditches or diversion levees (Subsection 11.2.4 of the Pipeline Design Criteria Manual). Drainage ditches and diversion levees can be designed to prevent ponding by placing them diagonally rather than transverse to the slope. This increases the effective grade of the structure.

- Drainage ditches are normally preferred over diversion levees except on thaw unstable soils.

o Erosion control structures

Erosion control for cross drainage structures is discussed in Subsection 3.3.1. Erosion control for longitudinal drainage structures is discussed in Subsection 3.3.2.

o Sedimentation control structures

Sedimentation control for intercepted sheet flow (See Figure 3) can include sediment filters or silt fences (Subsection 5.3). A sediment filter can be effectively used as an outlet structure for a diversion levee with minimal maintenance required. Silt fences can be used to advantage but require regular maintenance and are susceptible to damage by high water velocities.

3.3.1.3 Drainage Across a Cut Face

o General

This condition will occur where sheet flow or an existing drainage (see Figure 4) enters the construction zone at a cut face.

o Drainage structures

The preferred method for control of sheet flow across cut faces is discussed in Subsection 3.3.1.2. If this cannot be done, existing drainages can be passed across cut faces by using letdown structures (Subsection 5.2.6).

- Erosion control structures

  - The preferred erosion control structure for transporting drainages across cut slopes is a let down structure.

  - Where sheet flow crosses a cut face, the preferred method of erosion control is the use of interceptor ditches or diversion levees (Subsection 11.2.4 of the Pipeline Design Criteria Manual) in conjunction with letdown structures. The levee or ditch concentrate sheet flow to the letdown structure which transports the flow across the cut face. This should be considered as a temporary measure as the preferred permanent measure is permanent vegetation.

  - Other acceptable erosion control methods are temporary vegetative cover (especially if disturbance of the slope is anticipated in one or two years) and temporary covers (usually used in conjunction with revegetation efforts).

- Sedimentation Control Structures

  The preferred method of sedimentation control for drainage across a cut face is the use of silt fences. In some cases, a sediment filter may be more effective. In areas of high flow, sediment basins are the most efficient although sedimentation basins tend to require extensive maintenance and create considerable disturbance to the area (see Subsection 6.4.1).

3.3.1.4 Cross Drainage Adjacent to the Dalton or Elliott Highways

Where the workpad is adjacent to the Dalton or Elliott Highways and a highway drainage structure is encountered the structure will not be extended across the gas pipeline construction zone nor will the workpad be constructed across the drainage. Since no disturbance is created, no drainage, erosion or sedimentation control structures will be required (see Figure 2). Construction equipment travel across drainages is outlined in the Pipeline Design Criteria Manual Subsection 11.3.3 and Figures 5 through 9. Placement of ramps will be based on sight distance, embankment height, drainage spacing, etc.

3.3.2 <u>Longitudinal Drainage</u>

- General

  Longitudinal drainage structures will be required where sheet flow or minor drainages are intercepted and are to be conveyed along the construction zone for discharge into cross drainage structures or natural stream channels (see Figure 4).

- Temporary rerouting of streams of intermittent summer flow is allowable. Drainage ways may be induced only if such routing minimizes the combined problems of drainage and erosion control. The induced drainage way must have a section equal to or larger than the original natural drainage and a velocity equal to or less than the original natural drainage.

- Temporary rerouting of constant summer flow streams other than fish streams is allowable. The induced drainage way will be sized to carry the flow actually experienced at the time of installation unless other requirements are more stringent. For fish streams, temporary rerouting will be on a site-specific basis.

- Permanent routing out of the natural drainage way for cut-fill, side-cut, or overlay cross-section geometry will not be utilized unless pipe integrity may otherwise be jeopardized or an impractical hydraulic solution is encountered. Permanent rerouting out of natural drainage ways may be required on thru-cut cross-section geometry or material sites but will be minimized in these instances.

- Permanent appurtenances required at fish streams will be on a site-specific basis.

- Stable drainage ways shall be designed with utilization of permanent or temporary structures as applicable. Temporary velocity control structures shall be used in channels to be revegetated and when the design flow velocity is greater than the maximum allowable but less than 5 feet per second (maximum allowable velocity for an established vegetated channel). Permanent velocity control structures shall be used in channels which will not be revegetated or in which the design flow velocity is greater than 5 feet per second.

- During periods when minor drainage systems are active, any required minor drainage diversion structures should, if possible, be constructed prior to actual grading operations to prevent construction problems resulting from drainage.

- Ditch plugs are used to provide a means for minimizing the potential for seepage erosion and thermal degradation that may result from water flowing within the pipeline ditch (see Reference 7).

- Sedimentation of streams caused by flow within the open pipeline ditch at pipeline stream crossings can be controlled by the use of hard plugs, soft plugs, or other methods discussed in Subsection 7.5.

o Drainage Structures

  Drainage structures include diversion levees, ditches or channels.

o Erosion Control Structures

  Where ditches or channels are used, erosion control structures include ditch checks, plunge basins and riprap aprons (Subsection 5.2), energy dissipaters (Subsection 6.2.1), or channel liners (Subsection 5.2.7). Where flow on the embankment surface is a problem, effective erosion control measures include grading to drain, mechanical compaction (Subsection 11.2.4 of the Pipeline Design Criteria Manual), and water bars (Subsection 5.2.5).

  - Ditch checks are preferred as installation can be accomplished with minimal effort in a short amount of time. Ditch checks require frequent maintenance and may not be practical for diversion levees.

  - Permanent vegetation is the preferred long-term solution. Once it is established, it requires little or no maintenance. Permanent vegetation may be difficult to establish. Temporary covers may be required until vegetation is established.

  - Channel liners are the most effective for erosion control where steep grades are encountered and high water velocities are expected.

o Sedimentation Control

  Sedimentation control for ditches and channels include sediment traps (Subsection 7.4.3), silt fences (Subsections 5.3.2 and 7.4.4) and sedimentation basins (Subsection 6.4.1). The preferred sedimentation control structure when using a diversion levee is a sediment filter (Subsection 11.2.4.2 of the Pipeline Design Criteria Manual). The preferred sedimentation control device for runoff from embankment surfaces is the silt fence.

  - Sedimentation control in ditches includes sediment traps, silt fences or sediment filters. Sediment traps are preferred because of their simplicity and they can be constructed with a minimum effort and in a short period of time. Sediment traps trap coarser bed loads, and require regular maintenance. Silt fences are effective in removing finer materials but require regular maintenance and are susceptible to damage by high water velocities. Sediment filters require a large surface area to be effective and are therefore not the preferred sedimentation control measure for ditches.

- Erosion in Pipeline Ditch

  - Temporary ditch plugs and ditch dewatering are the preferred method to control hydraulic erosion in an open pipeline ditch.

  - Detrimental Thermal erosion in an open pipeline ditch is discussed in Subsection 7.3.1.

  - Ditch plugs are preferred to restrict seepage, erosion, and thermal degradation of the ditch following construction. Ditch plugs are discussed in Subsection 4.2.7.

3.3.3 Pipeline Stream Crossings

- General

  - Pipeline stream crossings are not discussed in detail in this document. A detailed discussion can be found in Section 16.0, River, Stream and Wetland Crossings, of the Pipeline Design Criteria Manual. This subsection does, however, discuss erosion and sedimentation control at such crossings.

  - The greatest impact to the stream by pipeline stream crossings is during construction. Techniques to minimize this impact are discussed in the following items.

- Drainage Structures

  On small streams, the preferred method to reduce impact is to divert the flow around the construction using temporary diversions (Subsection 7.2.1), fluming (Subsection 7.2.2) or bypass pumping (Subsection 7.2.3). In fish streams, fish should be protected, and provisions are required to allow upstream or downstream migration.

- Erosion Control
  - Erosion control measures include ditch checks, plunge basins and riprap aprons, energy dissipaters and channel liners (Subsections 5.2 and 6.2).
  - Riprap, where required for stream crossings, should be designed as described in Section 16.0, River, Stream, and Wetlands Crossings of the Pipeline Design Criteria Manual.
- Sedimentation Control
  - Sedimentation control measures which may be used during construction include sediment traps, silt fences, percolation ponds and sedimentation basins (Subsections 5.3, 6.4 and 7.4).
  - Sedimentation control measures which may be installed as part of restoration include unclassified riprap and revegetation in conjunction with geotextile temporary covers such as jute netting. Gill net type fabrics should not extend below the five-year flood stage in fish streams.

3.3.4 Thermal Erosion

Where it is necessary to construct cut slopes in thermally sensitive areas, it may be necessary to design for thermal erosion control. The preferred method of thermal erosion control is by controlled ablation (See Figure 22). If this method is used, drainage ditches of sufficient size to accommodate ice melt will be required along with ditch checks, sediment traps or other devices which can trap sediment and hold it at the toe of the cut face. This latter is an integral part of the controlled ablation process. It may be necessary to run ablation melt-off through a sedimentation basis before discharging it to an existing water course. If controlled ablation is not effective, a gravel buttress (See Figure 23) or insulated thermal blanket (See Figure 24) may be used depending on gravel availability. The potential for thermal erosion impact to adjacent or third-party facilities will be assessed. If required, a thermal analysis will be conducted and, where necessary, corrective measures will be recommended. Discussions on thermal erosion control methods can be found in Subsection 11.2.5 of the Pipeline Design Criteria Manual.

3.3.5 Thermal Hydraulic Erosion

Thermal balance of ice rich soils is an important consideration in design of drainage structures. Water moves through tundra when the active zone is thawed. Construction may raise or lower the bottom of the active zone and block or accelerate flow.

Blocked flow will be moved through the construction and released to continue movement in the tundra. Accelerated flow will cause concentrations and erosion. Measures to reduce concentration and acceleration of flows are discussed below:

- Blocked flow will be moved by
  - Appropriately spaced culverts to minimize ponding. Spacing will be at the sheet flow spacing found in Subsection 11.2.2 of the Pipeline Design Criteria Manual.
- Accelerated flow will be handled by
  - Filling the ditch along cuts or fills with gravel to trap sediment and retard flow.
  - Lining the ditch with manufactured insulation and gravel (see Figure 15).
  - Using metal half culverts to channel flow away. This approach will not be used when flow must enter the ditch from the side unless the half section is set low enough to collect flow (see Figure 15).

Figures 2 through 4 present visual descriptions to supplement discussions in Subsection 3.3.

Figure 1 is a simplified logic chart to aid in selection of cross drainage structures. This logic chart is not exhaustive and should be used merely as a guide.

Table 1 presents a summary of the potential advantages and disadvantages of a variety of treatment measures, given a specific source requiring erosion and sedimentation control. The measures are presented in this table in general order of preference for use. For any particular source of erosion or sediment the column will be followed down to the first applicable treatment method. This table is a guide and will be used in conjunction with site-specific details. It is expected that, in some circumstances, non-designated methods may be used, a combination of methods may be used, or methods may be selected in different priority.

4.0 DESIGN PROCEDURES AND METHODOLOGY

This section contains design procedures and methodology for the selection and design of drainage structures and erosion and sedimentation control structures and measures. This section is intended to provide information on basic design procedures and methodology to be used by the office and field personnel. Sample calculations are found in APPENDIX A.

4.1 INPUT DATA REQUIREMENTS FOR SELECTION AND DESIGN

4.1.1 General

Input data requirements are discussed in Subsection 11.2.1 of the Pipeline Design Criteria Manual. Additional input requirements include the following:

4.1.2 Access Requirements

Although it is necessary to provide access to all points along the pipeline both during construction and operation it is not required that work access directly down the workpad be provided. It is desirable and, in some cases, unavoidable, that block points be designed. Some examples of such block points would be large river crossings, some above-ground TAPS crossings, some sensitive fish stream crossings or other obstructions. At such locations, workpad access would be provided to each side of the block point, but not across it.

Where a potential block point exists, an access analysis will be conducted to determine if a crossing structure is required. Where such an analyses determines that a major permanent structure is required, it will be installed during the construction phase.

4.1.3 Soil Classification System

The Soil Erosion Classification System (SEC) has been selected for classifying soils for drainage and erosion. The SEC, Modified Unified Soil Classification (MUSC) (see Reference 6), and in-situ description of each soil and the particle size distribution for soils is presented in Table 2.

Table 3 shows the maximum design cut slopes for the grading of both thawed and frozen soils. These slopes should be used for design of drainage ditch and levee side slopes.

4.2 Hydraulic Design

In most cases where runoff is to be accommodated, the amount of flow can be estimated as described in References 5 and 8.

4.2.1 Open Channel Flow

Design procedures and methodology for open channel flow are discussed in Subsection 11.2.2 of the Pipeline Design Criteria Manual.

4.2.2 Culverts Operating under Inlet Control

Most culverts will be designed to operate under inlet control. For culverts crossing under the workpad, it has been determined that culverts should not back inlet water levels higher than the top of the culvert except on a site-specific basis. This requires a headwater to depth (HW/D) ratio of 1.0 for the design flood. For access roads, the maximum allowable HW/D ratio is 1.5. This should be checked on an individual basis to ensure that the headwater does not overtop the road. Culverts operating under inlet control can be designed using Nomographs D and E (see Subsection 5.1.1.2).

4.2.3 Culverts Operating under Outlet Control

Culverts with exceptional length or flat slopes will operate under outlet control. Culverts operating under outlet control can be designed using Nomographs H and I (see Subsection 5.1.1.2 and Reference 15).

4.2.4 Backwater Analysis

Where backwater is expected and could damage the environment or adjacent facilities, a backwater analysis may be required. Backwater analyses will generally be conducted using the HEC-2 computer program.

This computer program is described in detail in the HEC-2 User's Manual (See Reference 28).

4.2.5 Sheet Flow

Design methodologies and procedures for accommodation of sheet flow are discussed in Subsection 11.2.2.2 of the Pipeline Design Criteria Manual.

4.2.6 Equalization Culverts

Equalization culverts will be used where the workpad or access road crosses wetlands or active floodplains. If a predominant direction of flow can be identified, equalization culverts will be sized and spaced to accommodate the flow during the design flood. If no predominant direction of flow can be determined, equalization culverts will be 24-inch diameter at approximate 500 feet spacing. If a predominant direction of flow can be determined, spacing and size will be designed to accommodate the expected flow. Spacing will not exceed 500 feet. In wetlands, equalization culvert spacing will generally be 500 feet maximum. On active floodplains, where required, equalization culvert spacing will generally be 200 feet maximum.

4.2.7 Ditch Plugs

Ditch plug design procedures and methodology are discussed in Reference 7.

Water being diverted from the ditch will be diverted away from the pipeline ditch and conveyed by a drainage ditch or diversion levee, as appropriate, to the nearest natural drainage channel. Thermal degradation of ice rich soils or adverse impact to adjacent facilities should be considered when designing facilities to remove water leaving the pipeline ditch at ditch plug locations. If erosion and sedimentation control measures are required, they will be in accordance with Subsections 5.2 and 5.3.

5.0 ROUTINE DRAINAGE, EROSION AND SEDIMENT CONTROL DESIGN - PRE-CONSTRUCTION

5.1 DRAINAGE STRUCTURE DESIGN

5.1.1 Cross Drainage Structure Selection for Workpad and Access Roads (Traffic Structures)

Cross drainage structure selection will be in accordance with Subsection 11.2.3.1 of the Pipeline Design Criteria Manual.

For the purpose of design of structures to be used during construction, all access roads will be considered to have high traffic volumes. All workpads will be considered to have high traffic volume. During operations, the only high traffic volume points will be access points to high maintenance locations such as compressor stations, camps, valves, etc.

Traffic bridges will only be used where other structures cannot be economically designed to meet the criteria.

5.1.1.1 Low Water Crossing Design

Low water crossing design will be in accordance with Subsection 11.2.3.3 of the Pipeline Design Criteria Manual. Typical low water crossings are shown on Figures 5 through 9.

- o Where a Type IV low water crossing is required, the following considerations are required:
  - If pipe layers use the uninsulated portion of the crossing when the active layer is thawed, then some type of temporary protection such as mats, or mat bridges, should be provided to minimize damage to the tundra.
  - The preferred time for construction of a Type IV low water crossing is when the active layer is completely frozen. If scheduling does not permit this, the thaw front should be identified during construction, and the insulation required should be placed at that location.

5.1.1.2 Culvert Design

Culvert design will be in accordance with Subsection 11.2.3.4 of the Pipeline Design Criteria Manual. Culvert installation details are shown on Figures 10 through 14. Culverts can be designed using Nomographs C through P.

In addition to procedures presented in the Pipeline Design Criteria Manual, the following procedure will be used when designing pipe arch culverts in fish streams:

- o Determine required capacity (Q) and thalweg slope (S) as described for other culverts.

- o Pipe arch culverts in fish streams will be filled to 6 inches above the pipe invert.

- o Using Nomograph E, select a trial size as follows:

  - If size indicated falls between two standard sizes but closer to the smaller of the two, select the larger of the two.

  - If size indicated falls between two standard sizes but closer to the larger of the two, select one size larger than the larger of the two.

- o Select Manning's "n" for the pipe from Table 5.

- o Select Manning's "n" for fill material as the same as for streambed material from Table 4.

- o Determine a balanced Manning's "n" assuming full flow.

- o Determine the shape of the flow area based on the size and shape of the culvert and losing 6 inches in the bottom because of fill material.

- o Using Manning's equation or Nomograph C and the shape and balanced Manning's "n", determine flow capacity.

- o If capacity appears too small or larger than necessary, check for larger or smaller sizes using the above procedure.

- o Check for fish passage requirements as described in Subsection 11.2.3.4 of the Pipeline Design Criteria Manual using the above procedure.

5.1.1.3 Traffic Bridge Design

Traffic bridge design will be in accordance with Subsections 11.2.3.5 and 14.2.2 of the Pipeline Design Criteria Manual.

The primary concern during any bridge construction effort, whether single or multiple span or temporary or permanent, is minimization of streambed or bank disturbance. Although each bridge site is different, there are some general measures that can be applied where appropriate.

- Mat Type

  - Will be used at pipe layer crossings if required.

- Single Span Crossings

  - Some single span bridges can be effectively constructed without touching or crossing the stream or its exposed banks either by accessing the stream bank on both sides or by using a crane to hoist materials across until the bridge is in place. Methods that avoid in-stream work have the additional advantage of not being constrained by sensitive time periods.

  - Staging area should be minimized and kept back from the stream as much as possible. Heavy equipment should utilize the bridge approach roadway.

- Multiple Span Crossings

  - Avoid designs that involve long-term stream disturbance during construction; e.g., driven piles may be preferable to use of poured concrete and caissons. However, at certain times of the year, restrictions may be placed on proximity of pile driving operations to important fish areas.

  - If possible, in-stream work should occur during periods of least flow or when least impacts will occur.

  - Duration of in-stream work should be minimized.

  - In some situations, stream diversion should be considered to avoid working in flowing water.

  - Pile driving must not occur within 200 feet of known spawning areas when eggs, alevins, or adults are present without prior approval of the appropriate State and Federal agencies.

5.1.1.4 Drainage Ditches

Drainage ditch design will be in accordance with Subsection 11.2.3.6 of the Pipeline Design Criteria Manual.

5.2 EROSION CONTROL MEASURES

5.2.1 Temporary Diversions

Temporary diversions will be designed as described in Subsection 11.2.4.1.1 of the Pipeline Design Criteria Manual.

5.2.2 Ditch Checks

Ditch checks will be designed as described in Subsection 11.2.4.1.2 of the Pipeline Design Criteria Manual.

5.2.3 Grading to Drain and Mechanical Compaction

Wherever an embankment or other flat surface is constructed, it should be finish graded to direct any runoff to a designated location. A generally accepted industry standard is that, gravel surfaces should be sloped at least 2% and concrete or other similar surfaces should be sloped at least 0.5%.

On selected embankment surfaces where volume and velocity are expected to cause erosion on embankment surfaces the potential for erosion can be greatly reduced by mechanical compaction either by traditional means or by controlled passes by construction equipment.

5.2.4 Diversion Levees

Diversion levees will be designed as described in Subsection 11.2.4.1.4 of the Pipeline Design Criteria Manual.

The cross section for diversion levees shown on Figure 17 is merely a guide. Actual configuration of a diversion levee should be as dumped with a minimum top width and height as indicated. Diversion levees should be constructed using low permeability material or, if such material is not available, levees should be constructed using available material with a low permeability membrane as shown on Figure 17. If slope hydraulics dictate, a key may be required into the existing soil. Such a key should be of low permeability material.

Diversion levees are generally required because of thermally sensitive soils. Construction methods should be selected which will minimize the disturbance to the vegetative cover and underlying soil.

5.2.5 Water Bars

Water bars will be designed as described in Subsection 11.2.4.1.5 of the Pipeline Design Criteria Manual and as described below. Water bars are shown on Figure 18.

Water bar spacing is a function of embankment soil type, longitudinal slope, and design runoff. To establish the required spacing, the following procedure should be used:

- Select the spacing indicated on Table 7.

- o Find embankment surface area between water bars and establish runoff (Q) from Nomograph A or B.

- o Find maximum velocity (V) along embankment by using Manning's formula with Q and water bar longitudinal slope. (For Manning's formula, R = d for very wide channels.)

- o Find V along the water bar as described above using the water bar slope.

- o If V exceeds the erosive velocity (V_a) (Table 4) for the embankment soil type, the initial assumed water bar spacing should be reduced.

- o If any parameters required for the above calculations are unavailable, the spacing indicated on Table 7 should be used.

Water bar spacing will not exceed the maximum spacing shown in Table 7, (See Reference 2). Spacing may be decreased in the field depending upon location, soil type and embankment slope. Water bars will be placed, in general, as part of restoration. Water bars will generally not be used during construction but may be placed on a site-specific basis.

5.2.6 Letdown Structures

Letdown structures will be designed as described in Subsection 11.2.4.1.6 of the Pipeline Design Criteria Manual and as described below:

- o Establish design flow as described in Subsection 11.2.1 of the Pipeline Design Criteria Manual;

- o Determine the slope of the structure from site geometry;

- o Determine the cross section dimensions as described in Subsection 11.2.3.6 of the Pipeline Design Criteria Manual;

- o Determine lining materials as described in Subsection 5.2.7; and

- o Establish outlet requirements as described in Subsection 5.2.8 or 5.2.9.

5.2.7 Channel Liners

Channel liners are designed as described in Subsection 11.2.4.1.7 of the Pipeline Design Criteria Manual and as described below:

- o The flow velocity (V) and need for a channel liner are determined as part of the design of the principal drainage structure (ditch, letdown structure, etc.).

- Enter Table 4 and select the first channel liner material listed with an allowable velocity V_a equal to or greater than the design velocity.

- Check flow characteristics for lined channel by using Nomograph C. Determine flow depth and velocity.

- Deepen channel if necessary. If $V < V_a$, continue design.

- Show the channel liner as covering the channel bottom to a point one foot above the high water line.

- The nominal thickness of the channel liner is twice the D_{50} (median size of channel liner material) or 12 inches, whichever is more.

5.2.8 Riprap Aprons

Riprap aprons are designed to protect outlets of culverts, channels, or water crossings from scour as shown on Figure 19. They are required where outlet velocities exceed the maximum non-erosive velocity of the streambed material at the outlets, where exit inverts are at a natural grade, and erosive velocities can be dissipated before reaching the end of the riprap apron or where pipeline integrity requires protection from scour, but development of a scour hole downstream is acceptable. If this cannot be accomplished, a channel liner or plunge basin is required. Riprap aprons are designed as follows:

- The need for a riprap apron is established by meeting the above listed requirements.

- The outlet velocity (V) is established as part of the design of the principal drainage structure (culvert, LWC, etc.).

- The D_{50} size (median stone size by weight) required can be established from Nomograph Q or R assuming a rock density of 165 pounds per cubic foot and low turbulent flow.

- The nominal apron dimensions are established as shown on Figure 19.

- The nominal thickness of the apron is two times D_{50}, or 12 inches, whichever is more.

5.2.9 Plunge Basins

Plunge basins are designed to dissipate the energy of water flowing from the outlets of culverts, channels, or water crossings as shown on Figure 20 (See Reference 1). They are required where outlet velocities exceed the maximum non-erosive velocity of the streambed material at the outlets, where exit inverts area at a natural grade, or where culvert outlets are cantilevered from fill slopes. Plunge basins will not be used in fish streams. Dimensions for plunge basins for culverts up to 5 feet in diameter and discharge velocities up to 36 feet per second are contained in Figure 20.

Plunge basins are designed as follows:

- o The need for a plunge basin is established by meeting the above listed requirements.
- o The outlet velocity (V) is established as part of the design of the principal drainage structure (culvert, LWC, etc.).
- o The D_{50} size (median stone size by weight) required can be established from Nomograph Q or R assuming a rock density of 165 pounds per cubic foot and high turbulent flow.
- o The nominal basin dimensions are established as shown on Figure 20.
- o The riprap thickness is twice D_{50}.
- o Check downstream velocity using Nomograph C. If downstream velocity is greater than existing velocity, additional energy dissipation devices may be required (see Subsection 6.2).

5.2.10 <u>Riprap, Gabions, and Flexible Revetment Systems</u>

- o Riprap

  Riprap used as channel liner, riprap aprons, plunge basins, embankment protection, and other minor facilities can be designed using the simplified method described as follows: (for pipeline stream crossing requiring riprap the design method is discussed in Section 16.0, River, Stream and Wetland Crossings, of the Pipeline Design Criteria Manual).

  - Class

    Knowing the design velocity which is determined as part of the design of the principal structure, or which can be determined by using Nomograph C, enter Nomograph Q or R to establish the 50 percentile stone weight (W_{50}) and size (D_{50}), enter Table 8 to determine the class of riprap meeting these requirements (See Reference 27).

- Riprap Layer Thickness

  Procedures to determine riprap layer thickness are presented in Subsection 16.2.6.6.3 of the Pipeline Design Criteria Manual.

- Riprap Filters

  Design procedures for riprap filters are presented in Subsection 16.2.6.7 of the Pipeline Design Criteria Manual.

o Gabions

Gabions are riprap placed in wire baskets or in wire covered mats. They are generally used because rock of suitable size is not available (See Reference 30).

The design depends upon the size of rock available. The mesh size of the wire is also dependent upon the size of rock. Wire-enclosed riprap has been used in some instances as toe protection for other types of riprap. This type of protection is flexible, but the protection is limited to the life of the wire used for enclosing the stone.

The wire baskets are first formed and then filled with stone. The baskets are tied together to form a mattress and anchored to the slope. For light exposure, a continuous blanket of small stones retained between top and bottom spreads of wire fencing might suffice. On all designs the blanket should be divided into compartments so that one compartment can fail without losing all the blanket.

Gabions can be used in numerous situations including, but not limited to the following:

- Gabion Aprons

  A flexible gabion apron is designed to settle without fracture and adhere to the ground as scour occurs. Fill material ranging from 4 to 8 inches in size will guarantee uniform flexibility. Little or no excavation is required. The bed is roughly levelled or sloped and the gabion apron placed directly on the ground. Potholes are filled with material from the bed itself so that erosion will occur as uniformly as possible. To avoid lifting and overturning of an apron, a thickness of 12 to 18 inches is required. To provide effective protection, the gabion apron must be of sufficient length to reach the outer limit of the scour hole that will form. The projection of the apron beyond the toe of the embankment is generally 1½ to 2 times the estimated depth of scour.

- Gabion Channel Liners

Gabion channel liners should have a smooth alignment, free from projections and sharp bends.

Walls must be keyed solidly to the bank, both at upstream and downstream ends.

Short counterforts should be used to tie long walls into the bank at frequent intervals to prevent overflow from scouring a channel behind the wall.

The spacing of the counterforts depends on the nature of the bank material, but usually ranges between 9 and 21 ft.

The proper thickness of lining to use depends on such factors as the type of material through which the water flows; the velocity of flow; the sediment and bed loads; and the gradient of the channel and its curvature.

A nominal thickness of 12 inches is generally used when the channel is fairly straight, the side slopes less than 2:1, and the flow velocity about 10 feet per second or less.

A nominal thickness of 18 inches is used at curved sections and where the sideslopes are inclined to 1:1. If the velocity is greater than 15 feet per second, an energy dissipater is required (Subsection 6.2).

The stone fill should be graded so that the possibility of leaching is adequately reduced. In any case, it is very important that the gabions should be filled with stone small enough to allow at least two overlapping layers. A filter may be required or a permeable geotextile may be employed between the gabion lining and the slope, if needed.

A detailed discussion of gabions can be found in Reference 25.

- o Flexible Revetment Systems

  Flexible revetment systems should be designed where riprap is unavailable or where a smooth surface is required.

  Design of flexible revetment systems must consider the following (Reference 12):

  - The system must be able to resist the forces exerted by flowing water on the lining.
  - The system must have an adequate extent along the water course so that erosion adjacent to the lining will not cause its failure by undermining.
  - The system must prevent the leaching of underlying materials through openings in the lining.

  A detailed discussion of design of flexible revetment systems can be found in Reference 12.

5.3 SEDIMENTATION CONTROL MEASURES

Sedimentation controls are to be systematically integrated into the civil design using the following strategy. Wherever possible, sediment transport is to be countered at the source by protecting construction sites from water contact, by timing construction for dry periods (i.e., winter) or by effectively stabilizing areas of disturbance. Where these methods are not practical, or where, in spite of implementing them, there remains a reasonable risk that sediment will flow to water courses downslope, the proximity and nature of water courses likely to be affected will determine the additional steps to be taken.

To ensure consistency in the design, all water courses within the construction corridor will be evaluated to determine similarities in hydrology, water quality, use, and environmental sensitivity. This evaluation will produce a hierarchy of stream groups made up of streams requiring similar levels of protection. Streams that can tolerate high sediment loads due to their natural characteristics, because they are not fish habitat, or because they flow only minimal distances before confluences with more impact resistant water bodies (e.g., the ephemeral streams flowing into the Tanana) are to be afforded lesser protection. All other water courses are to be subjected to a case by case design analysis wherein the designer aided by project environmental personnel assesses the alignment segment within each particular stream's drainage to determine what type of sediment controls are to be used and where they are to be deployed. In all such cases where streams are considered sensitive to silt, first priority is to be given to land discharge, using designated vegetation infiltration areas to absorb silt laden construction water before contact with the stream.

Each land application area is to be designated and sized based on the anticipated volume of water and likely soil percolation to be encountered. This practice is expected to substantially reduce the number of instances of silty water discharges to surface waters. In cases where topography or vegetative sensitivity precludes this practice, the following measures are to be employed.

5.3.1 Percolation Ponds

Percolation ponds are designed as described in Subsection 11.2.4.2.1 of the Pipeline Design Criteria Manual and as described below:

- o Estimate the percolation rate from Table 9 which requires a knowledge of the SEC classification of the soil.

- o Determine the flow requiring treatment. This is either a given as in the case of wet processing or can be estimated as described in Subsection 11.2.1 of the Pipeline Design Criteria Manual.

- o Determine the expected volume of sediment. For point sources, take percent of material to be removed multiplied by the total volume to be processed. For non-point sources, take estimated suspended solids load multiplied by the total volume of water expected.

- o Pond area = average flow (cfs) divided by percolation rate (ft/sec). (Use 75% of estimated percolation rate to accommodate reduced percolation efficiency overtime.)

- o Pond depth required to contain silty water = peak flow multiplied by duration of peak divided by pond area.

- o If required depth is not available, excavation and/or berms will be required.

- o Determine depth of sediment = volume of sediment divided by pond area.

- o Determine disposition of deposited solids based on site-specific conditions.

5.3.2 Silt Fences

Silt fences (see Figure 21) will be designed as discussed in Subsection 11.2.4.2.2 of the Pipeline Design Criteria Manual and as described below:

- o Determine the design flow (Q). This is either a given parameter or can be estimated as described in Subsection 11.2.1 of the Pipeline Design Criteria Manual.

- Establish fabric EOS (Equivalent Opening Size) from manufacturer literature or from Reference 21. EOS must be less than the particle size to be removed.
- Establish fabric permeability (P) from manufacturer literature or from Reference 21 (permeability in cm/sec x 0.032 = permeability in ft/sec.).
- Area of fencing required: A = Q/P.
- Length of fencing required: L = perimeter of area to be protected or contained.
- Height of fencing required: H = A/L.
- If height is impractical, select a fabric with a greater permeability.
- Locate silt fence at bottom of slope perpendicular to drainage.
- Design ends of silt fence to ensure that all flow passes through the fence.

5.3.3 Sediment Filters

Sediment filters (see Figure 21) are designed as discussed in Subsection 11.2.4.2.3 of the Pipeline Design Criteria Manual.

6.0 SITE-SPECIFIC DESIGNS

This section outlines procedures for designing structures which may be selected by office personnel to control erosion and sedimentation to acceptable limits on a site-specific basis. Structures and measures described in this section should be used only if the previously described structures and measures cannot be used effectively. It is not intended that this section should preclude the use of other structures, measures, and designs which are not listed here. The items discussed in this section are merely suggestions for resolution of specific problems. If the designer can find a better solution to a specific problem than any described here, that solution should be utilized.

6.1 DRAINAGE STRUCTURES

6.1.1 Structural Plate Arch

A structural plate arch should be considered if large flows are anticipated, culvert or LWC criteria cannot be met, and a bridge is not practical. An example of a structural plate arch is shown on Figure 28.

Use of a structural plate arch can maintain original streambed and flow characteristics and can provide a large opening. A structural plate arch will often tend to be more expensive than other acceptable methods, has stringent foundation and buttress requirements and has the potential of sedimentation of stream during construction.

The design of plate arches will be based upon:

- o Foundation soils must be SEC classes G, D, Q or R.
- o 5-year frequency floods for temporary arches.
- o 50-year frequency flood for permanent arches.
- o Arch height will be 1/2 of arch width.
- o Metal foundation plates will be used.

The procedure for plate arch design is:

- o Determine the flow during the design flood as described in Subsection 11.2.1 of the Pipeline Design Criteria Manual.

- o Determine the existing flow depth, velocity and water way cross section at the required frequency flood. Nomograph C may be used for this if stream cross section and thalweg slope are known.

- Prepare a stream cross section containing
  - Existing channel conditions
  - Embankment and plate arch
  - Location of arch sills.
- Determine the flow depth, cross section, and velocity at the plate arch using the procedure described for pipe arch culverts in fish streams in Subsection 5.1.1.2.
- Enlarge the arch opening if area is reduced over 20% or velocity is increased over 25%.
- Evaluate the structure for discharge used on adjacent structures to ensure blockage or failure does not occur.
- Determine design vehicle loads from Section 14.0, Bridges, of the Pipeline Design Criteria Manual and design arch corrugations, gage, foundations and buttresses to withstand design loads. Reference 11 gives guidelines and data for structural design of structural plate arches.

6.2 EROSION CONTROL

6.2.1 Energy Dissipaters

6.2.1.1 Broken-Back Culvert

A broken-back culvert (see Figure 29) is a culvert where a significant change in grade in the culvert is used to promote a hydraulic jump inside or at the outlet of a culvert as an energy dissipater. A broken-back culvert is only practical in areas of high fill where upstream ponding is acceptable or where fills are constructed on steep cross slopes. A broken-back culvert is an effective energy dissipater only where supercritical flow exists in the culvert, sufficient tailwater exists, and streamflow is subcritical.

A broken-back culvert requires no special materials or equipment and involves the least cost of energy dissipaters.

A broken-back culvert increases potential for aufeis development and increases difficulty of maintenance.

Design of broken-back culverts will be based upon

- Standard culvert criteria
- Supercritical flow exists in the culvert.

The design procedures for a broken-back culvert are:

- After design discharge and tailwater are determined by procedures in Subsection 11.2.1 of the Pipeline Design Criteria Manual, the first step necessary in a broken-back culvert design is the establishment of the flow line profile. The downstream barrel should be as long as possible with a slope no steeper than that necessary to prevent puddling. The upstream barrel slope should be greater than critical slope and downstream barrel slope should be definitely less than critical slope.

- The culvert should be initially sized according to procedures outlined in Subsection 11.2.3.4 of the Pipeline Design Criteria Manual.

- At this point, the following conditions should be known: design discharge, culvert shape and size, culvert profile and tailwater depth.

  Determine uniform depth for upstream barrel with design discharge, slope, and culvert shape and size. Use Nomographs C through E to determine uniform depth and tailwater depth.

- As the water enters the downstream barrel at supercritical flow and uniform depth, the depth increases as the water moves downstream. Each depth in this region has a corresponding theoretical conjugate depth. This conjugate depth is that depth at which the same discharge would be flowing in a subcritical state after the occurrence of the hydraulic jump. Establish the location of the hydraulic jump which is at the point where the conjugate depth is less than or equal to the tailwater depth.

- The channel bottom should be protected against erosion caused by supercritical velocities to a point downstream from the hydraulic jump.

- A more detailed discussion of design procedures for a broken back culvert can be found in Reference 26.

6.2.1.2 Sills

Sills (See Figure 29) can be very effective in aiding the formation of a hydraulic jump and in spreading the water back to the natural stream width. Sills can be constructed using logs, railroad ties, sheet piling, gabions, concrete, etc.

A sill is simple to design, build and maintain; and is effective in dissipating energy and spreading the water back to the natural stream width.

A sill tends to be a debris and sediment trap and usually causes a water fall effect. A sill requires wingwalls at the outlet.

Design should include:

- o Location at the midpoint in the downstream culvert wing-wall
- o Height at least 1/2 the depth of the culvert barrel or 1/2 the rise in pipe arch culverts.
- o Riprap installed immediately downstream of the sill for a minimum distance of 10 feet to control the turbulence from the water fall effect.
- o A more detailed discussion of design procedures can be found in Reference 26.

6.2.1.3 Impact Basin

Impact basins are effective energy dissipaters (See Figure 29) but are relatively expensive facilities. Their design should be made in consulation with Reference 33.

6.2.2 Erosion Check

Erosion checks comprise a technique whereby porous, mat-like material is installed in a slit trench that is oriented perpendicular to the direction of flow in a ditch or swale. It prevents the formation of rills and gullies by permitting subsurface water migration without the removal of soil particles. Although erosion checks can be included in the design, they may also be included during construction.

A detailed discussion about erosion checks can be found in Reference 18.

6.3 DOWNSLOPE DEWATERING PREVENTION

At several locations along the pipeline, the existence of stands of sensitive vegetation or other environmental concerns specifically identified along the pipeline alignment require prevention of downslope dewatering caused by interception and concentration of sheet flow. Where this concern exists, concentrated sheet flow should be passed across the construction zone and spread out as frequently as possible.

6.3.1 Level Spreaders

Level spreaders (See Reference 18) provide erosion control and sediment retention during the transition from concentrated to sheet flow (see Figure 28). Level spreaders will be required in areas where sheet flow intercepted by embankments, roads, and workpad, or collected in swales, ditches, or channel are diverted to areas suitable for return to sheet flow.

Restrictions:

- o Level spreaders will not be located in permafrost areas.
- o Level spreaders will not be constructed on fills.
- o Formal design is not required, but extreme care must be used during construction to ensure that outlet lip is exactly level and uniform from end to end. Failure to meet these requirements will cause concentrated flow and consequent erosion of the stabilized area.

6.3.2 Diffuser Culverts

Flow may be spread in areas sensitive to dewatering by a diffuser culvert. The diffuser culvert will be parallel to the embankment toe, perforated, surrounded by cobbles or riprap and incorporated into the embankment. Diffuser culverts are very susceptible to icing and if they are to be used, they must be equipped with a thawing device such as thaw pipes.

6.3.3 Sandbag Diffusers

Since level spreaders cannot be used in permafrost areas and diffuser culverts are susceptible to freezing, an alternate method of diffusing culvert outflow is by the use of sandbags placed at the outlet and downstream from a culvert in such a manner as to spread the flow over a large area (see Figure 31).

6.4 SEDIMENTATION CONTROL

6.4.1 Sedimentation Basins

Sedimentation basins are considered the last resort for sedimentation control and are to be used only where other methods are clearly ineffectual. The design of sedimentation basins is discussed in Subsection 11.2.4 of the Pipeline Design Criteria Manual. Two applications are envisioned for sedimentation basins. The first is cases of non-point sources where erosion control practiced over a large area disturbance (eq. a cut slope or extensive fill) is, because of proximity, gradient, nature of the material or other factors, not considered fully effective in protecting a sensitive downslope watercourse. In these instances a downslope basin would be provided to intercept a given volume of sediment transported by runoff over the disturbed area. For cases involving point sources, where sediment of known size is carried by channelized flow at a predictable rate, basins are provided to settle out the design particle. The design approach differs for these two cases and is described below.

6.4.1.1 The procedure for design of sedimentation basins for non-point sources is as follows (See Reference 33):

- Determine the disturbed area contributing to sediment laden runoff inflow to the sedimentation basin.
- The basin should normally provide 67 cubic yards of storage below the outlet crest for each acre of disturbed water shed.
- The basin should be cleaned out when available volume drops to 27 cubic yards per acre. Table 11 can be used to estimate the amount of sediment that may be expected to accumulate in the basin.
- Length should be twice the width.
- Design baffels, spillways, etc. in accordance with Reference 29.

6.4.1.2 The procedure for design of sedimentation basins for point sources is as follows (See Reference 9):

- Obtain a particle size distribution for the sediment in the inflow water from Table 12 based on the landform type in which the site is located.
- Determine the inflow rate (Q):
  - for processing, this is given;
  - for ablating slopes, Q in cfs = volume of ice expected to ablate (Q_A) divided by 3 years (conservative estimate of time to stabilize slope) divided by 3 months per year (conservative estimate of active ablation duration) divided by 7×10^6 seconds per month

$$Q = Q_A/3/3/7 \times 10^6$$

- Determine the amount of sediment and percent of total flow (% sed) inflow:
  - for processing, this can be estimated by comparing unprocessed grain size distribution with processed grain size distribution.
  - For ablating slopes, this can be estimated using the ice content of the ablating soil.
- Determine allowable amount of sediment carried by the outflow based on permit requirements and the sensitivity of the potential receiving water.

- Determine effective dilution based on outflow and volume of flow in the receiving water body.
- Determine the percentage of incoming sediment (% removal) which must be removed to meet permit requirements by comparing concentration of sediment in the inflow with allowable concentration in the outflow.
- Determine the size of the smallest particle which must be removed to accomplish the required removal rate (design particle).
- Determine the settling velocity (V_s) from Table 10 for the design particle.
- Determine the minimum pond surface area $A_{min} = 1.2Q/V_s$.
- Determine detention time (T) required to settle the design particle through the supernatent horizon (S_d) (depth of water over wier or in culvert outlet).
- Determine volume required to provide detention time. V=QT
- Select trial width (W).
- Determine effective length (L) required. $L = V/WS_d$
- If L < 2W, select baffels as described in Reference 29.
- Check if LW > A. If not, increase L or W as convenient.
- Determine water depth $(d_w) = Q/LW$ (no less than S_d).
- Determine sediment storage volume required (V_{sed}).

  $V_{sed} = (\%_{sed})\ (\%_{removal})$
- Determine depth required to provide sediment storage volume (d_{sed}).

  $d_{sed} = V_{sed}/LW$
- Determine total depth required (d_T).

  $d_T = d_w + d_{sed} + 1'$ freeboard
- Design baffels, spillways, etc. in accordance with Reference 29.

6.4.2 Recycle Ponds

The design of recycle ponds is discussed in Subsection 11.2.4 of the Pipeline Design Criteria Manual.

A typical application of this method will be as a water source for wet processing where withdrawal must be from a stream.

A second typical application will be a pond which is excavated below groundwater level into which process water is pumped, and from which makeup water is removed and recycled. No surface water withdrawal is required in this case as process and makeup water are from groundwater flows. These basins will be filled in at the conclusion of the operation in a manner that will minimize the need to discharge.

Clean-out provisions will be included where calculations indicate sediment will accumulate to a level that intrudes into design settling zone. The preferred provision is tandem ponds where one can be used while the other is being cleaned out. Final disposition of accumulated sediment will be determined on a site-specific basis.

The procedure for designing recycling ponds is the same as for sediment basins for point sources except:

- o Outflow water quality is based on processing requirements.
- o State or Federal permit requirements do not control unless overflow is anticipated.

6.5 THERMAL EROSION CONTROL

All designs for the control of thermal erosion will be on a site-specific basis. Such designs are discussed in detail in Reference 20 and will consider the following:

6.5.1 Preventative Design

The preferred method of thermal erosion control is by selecting designs and measures which will minimize or eliminate thawing of ice rich soils. Such considerations include:

- o Minimize cuts in ice rich soils - Where workpad, access roads, or other facilities are built on ice rich soils, a workpad fill section construction is preferred (cut faces where thermal erosion is most likely to occur are thus eliminated).
- o Schedule construction - in areas of ditch stability concern, schedule pipeline construction for winter or shoulder months.
- o Adjust the alignment.

6.5.2 Controlled Ablation

Controlled ablation is discussed in Subsection 11.2.5 of the Pipeline Design Criteria Manual and are shown on Figure 22.

Drainage ditches of sufficient size to accommodate ice melt will be required along with ditch checks, sediment traps or other devices which can trap sediment and hold it at the toe of the cut face. This latter is an integral part of the controlled ablation process. It may be necessary to run ablation melt-off through a sedimentation basin before discharging it to an existing water course.

6.5.3 Gravel Buttresses

Gravel buttresses are discussed in Subsection 11.2.5 of the Pipeline Design Criteria Manual and are shown on Figure 23.

6.5.4 Insulated Thermal Blanket

Insulated thermal blankets are discussed in Subsection 11.2.5 of the Pipeline Design Criteria Manual and are shown on Figure 24.

6.5.5 Adjacent Facilities

The potential for thermal erosion impact to adjacent or third-party facilities will be assessed. If required, a thermal analysis will be conducted and where necessary corrective measures will be recommended (see Reference 6).

6.6 AUFEIS AND DEBRIS CONTROL

6.6.1 Aufeis Control

The causes for aufeis development are discussed in References 3, 17 and 20. The preferred designs for aufeis control are discussed in Subsection 11.2.3 of the Pipeline Design Criteria Manual. Other site-specific designs may be used.

Two such site-specific designs that have been used by the Alaska Department of Transportation are:

- Ice Fences or Dams

  Permanent earthworks may be constructed some distance upslope to contain or limit the buildup of ice. Sufficient storage space to contain the seasonal buildup is required; temporary fences of burlap or equivalent are effective in areas where the seepage is slow and in thin layers (See Subsection 6.6.3).

- Intercepting groundwater flow with ditches or perforated pipes and discharging it in an area where development of aufeis will not cause a problem.

6.6.2 Debris Control

Designs for debris control are discussed in Subsection 11.2.3.8 of the Pipeline Design Criteria Manual.

6.6.3 Aufeis and Debris Control Structures

6.6.3.1 Thaw Pipes or Wipes

Thaw pipes are usually ½-inch diameter galvanized pipe or equivalent hung approximately three inches below the top of the culvert with risers located so as to be accessible to a steam generator. Thaw wires are heat tracer wires either mounted as described for heat pipes or in some other manner to facilitate thawing of ice buildup in the culvert. Leads are provided for hookup with a generator or other acceptable power source (see Figure 30 and References 20 and 24).

6.6.3.2 Perched Relief Culverts or Modified LWC's

The use of perched relief culverts involves two or more culverts for one stream, one being at the customary location at the base of the embankment in the thalweg, and the other being at a higher elevation in the fill. The higher culvert is normally dry except during the spring, when due to the lower culvert being blocked by the accumulated ice, the initial spring runoff over the aufeis can be carried by the higher culvert. The lower culvert becomes cleared of ice as the spring thaw progresses, and eventually takes over the stream's flow, again leaving the higher culvert dry. This method is usable only where the topography permits or requires deep fills. The topography must provide adequate capacity in the icing accumulation area such that an entire winter's ice will not block the upper culvert. A modified LWC may be provided as shown on Figure 14 to safely pass spring runoff over the embankment. Where embankment fill height is insufficient to accommodate a perched relief culvert, a modified LWC can be used with moderate success (see Figure 14 and Reference 20).

6.6.3.3 Ice Fences

Ice fences (Reference 20) control the location of development of aufeis. The materials which have been used for ice fences include: lath, snow fence, or wire fencing, faced with building paper, sisal kraft paper, plastic sheeting, canvas, tar paper, galvanized metal roofing, cheesecloth, burlap, boards, insulated waterproof paper, brush, spruce trees, etc.; muskeg, sand, gravel or snow berms; railroad ties. Ice fences should only be considered where their use will not cause damage to the environment or adjacent facilities.

6.6.3.4 Debris Deflectors

The function of a debris deflector (See Figure 25 and Reference 11) is to cause debris to be diverted from the culvert inlet and to accumulate in a storage area where it can be removed after the flood subsides. The storage area provided must be adequate to retain the estimated type and quantity of debris accumulated during any one storm or between removal. The deflector should be built at the culvert entrance. If it is placed some distance upstream, debris may return to the channel between the deflector and the culvert inlet. The deflector requires little maintenance and reduces the collection of debris in front of the culvert inlet.

Debris deflectors are usually built of heavy rail or steel sections although timber and steel pipe are sometimes used. Single deflectors can be built over batteries of pipe culverts. Their structural stability and orientation with the flow make deflectors particularly suitable for large culverts and high velocity flow.

6.6.3.5 Debris Racks

A debris rack (See Figure 26 and Reference 11) is essentially a barrier across the stream channel which stops debris that is too large to pass through the culvert. Debris racks vary greatly in size and in the material used in their construction. Height of racks should allow some freeboard above the normal depth of flow in the upstream channel for the design flood. The rack may be vertical or inclined and may be placed over the culvert inlet or upstream from the culvert. Racks should not be placed in the plane of the culvert entrance, since they induce plugging when thus positioned. A means of access to the rack is necessary for maintenance. If a large debris storage area exists at the rack location, the frequency of maintenance is reduced and added safety is provided against overtopping during a single storm.

The total straining area of a rack should be at least ten times the cross-sectional area of the culvert being protected. Vertical bars are generally spaced from 1/2 to 2/3 the minimum culvert dimension. This spacing permits the lighter debris to pass through the rack and the culvert.

6.6.3.6 Debris Fins

Debris fins (See Reference 11) have been used successfully with large culverts where the debris consists of logs or other material that would pass through the pipe if oriented with their long dimensions parallel to the flow. The purpose of a fin is to aline debris so that it will pass through a culvert.

The debris fin is a thin wall installed parallel to the flow. It is usually located on the center line of a single culvert or as an extension of the interior walls of a multiple culvert installation. The upstream edge of the fin should be rounded and sloped toward the culvert to reduce impact, turbulence, and the probability of gathering debris.

A debris fin is usually constructed to the height of the culvert; hence, its effectiveness is limited after the inlet becomes submerged. Based on experience a fin length of 1.5 to 2 times the height is recommended.

6.6.3.7 Debris Risers

Debris risers (See Figure 27 and Reference 11) generally consist of a vertical culvert pipe and are usually suitable for culvert installations of less than 54-inch diameter. This type of debris-control structure is used where debris consists of flowing masses of clay, silt, sand, sticks, or medium floating debris without boulders. Risers are seldom structurally stable under high-velocity flow conditions because of their vulnerability to damage by impact. Risers placed above the streambed at the bottom of steep, narrow draws cause ponding with a subsequent reduction in velocity. Deposition of sediment follows as a consequence of the reduced velocity. The resulting flat-bottom basin gives maintenance personnel a place to work when either culvert clean-out or debris removal is necessary. This basin also causes deposition of heavier debris upstream at the entrance to the basin where the debris cannot clog the drainage structure.

7.0 EROSION AND SEDIMENT CONTROL DESIGN AND PRACTICES - FIELD DESIGN

7.1. GENERAL

If unexpected erosion or sedimentation occurs or is observed during construction activities, corrective action will be taken as soon as possible.

This section is intended to help field engineering personnel to select designs and measures which can be easily and rapidly implemented where unexpected conditions occur.

Such measures include but are not limited to:

- o Hydraulic Erosion
  - Temporary diversion
  - Fluming
  - Pumping
  - Channel liners
  - Temporary ditch checks
  - Temporary covers
- o Thermal Erosion
  - Backfill
  - Cover
  - Insulated drainage structures
- o Sedimentation
  - Vegetated filter areas
  - Sediment traps
  - Filter inlet
  - Filter culverts
  - Sediment barriers
  - Silt fences
  - Sediment filters

Some special considerations which should be made when constructing drainage, erosion and sediment control facilities include:

- o The preferred time to construct drainage, erosion and sedimentation control structures is before any other construction begins. This will ensure that any construction-induced erosion or sedimentation will be controlled before it becomes a problem.
- o In-stream construction activities during periods of fish sensitivity should be minimized . The Environmental Master Guide provides data as to sensitivity periods for work in fish streams.

- From the perspective of constructibility, the preferred time to conduct in-stream work is during periods of no flow or low flow. During periods of low flow, the amount of suspended solids carried by the stream is quite small, and construction which will stir up large amounts of sediment will significantly add to the concentration of suspended solids carried by the water.

- During breakup construction will have the least impact to water quality due to large concentrations of sediment.

- If in-stream activity is required in a small drainage which discharges into a large stream, although construction may cause the small stream to become very turbid, any impact to water quality will be minimized by the diluting effect of the large stream.

- Construction of drainage, erosion and sediment control structures will normally cause less impact if they are constructed during the winter when streams are frozen unless the area is a fish overwintering area. This is predicated by the requirement that drainage channels be readily identified during the winter.

  Some problems incurred by winter construction include:

  - Thalweg is harder to find.

  - If groundwater is encountered and aufeis forms, it is difficult to remove the ice.

  - Compaction requirements are much harder to achieve.

  - Snow removal must be considered.

  - Impact of mixing snow with backfill must be considered.

- Where an erosion or sedimentation problem is identified, the problem should be corrected as quickly as possible.

- Temporary restoration of the construction zone and particularly drainage, erosion and sedimentation control structures should be accomplished as soon as construction will allow but in no case after the end of that construction season.

- Permanent restoration should be accomplished after completion of construction in that area.

7.2 HYDRAULIC EROSION

7.2.1 Temporary Diversion

Temporary diversion of streams of intermittent or streams that flow for prolonged periods in the summer is allowable provided the diversion returns either to the original natural drainage way or to a different natural drainage way. Drainage ways may be induced only if such routing minimized the combined problems of drainage and erosion control. The induced drainage way must have a section equal to or larger than the original natural drainage and a velocity equal to or less than the original natural drainage.

7.2.2 Fluming

With small streams, it is often practical and desirable to pipe (flume) stream flow over the pipeline ditch while the excavation process is occurring. With this procedure, a half or full culvert or other pipe is installed in the stream prior to ditching. The stream flow will be directed through the flume. The pipeline ditch is then excavated underneath the flume and the pipe is installed. The stream channel can be nearly restored before removing the flume, resulting in a very clean procedure.

Flumes will be sized to carry the flow actually experienced at the time of installation unless other requirements are more stringent.

The following major points should be considered when planning a fluming operation:

- o Flumes should be constructed of pipe sections or other suitable materials of sufficient size and strength to carry the existing flow across the required span without causing excessive ponding at the inflow end.
- o The flume should be installed in the stream prior to ditching, and all flow should be directed through the flume or flumes.
- o Any dams should be composed of sandbags or clean fill material combined with visqueen, or other suitable methods such that erodible material is not exposed to flowing water.

- o Discharge points should be armored if outflow velocities may potentially erode the streambed or produce sedimentation. If outflow is potentially damaging to fish migrating downstream, the inflow end should be screened.

- o Potential ice buildup near adjacent facilities during freezing weather should be considered.

- o Natural stream flow should be restored as soon as practicable. Restoration of the stream channel should be nearly completed prior to removing the flume.

7.2.3 Pumping

An alternative to fluming is bypass pumping. Techniques are the same as described for fluming. In addition, pumping may be used for ditch dewatering.

The following factors should be considered when planning a pumping operation:

- o Discharge of water resulting from pipeline construction activities must comply with State and Federal discharge permits issued to the project and State water quality standards.

- o Temporary dams for bypass pumping should employ methods that do not increase sedimentation potential.

- o Bypass pumps should be adequate for the flow condition to prevent excessive ponding above the dam and to assure adequate downstream flow.

- o If fish are present, the water intake(s) will be centered in an enclosed screened box not to exceed ¼" mesh. The box size will be sufficiently large to allow fish to escape intake suction. The through screen velocity at the intake shall be designed not to exceed 0.5 fps even when up to 50 percent of the screened area is fouled with debris.

- o Discharge into a stream should be horizontal to the stream surface to avoid gas supersaturation caused by excess aeration of the water.

- o Discharge should be placed such that erosion of the streambed or banks is minimized or discharge points should be armored or provided with energy dissipation devices.

- o Discharge of sediment laden water may occur on terrestrial areas adjacent to a water course if the soils are relatively free draining, vegetation is not damaged by the sediment buildup, and the sediment laden water does not re-enter the water course.

7.2.4 Fluming and Pumping

A combination of fluming and bypass pumping may be appropriate in some circumstances. At the time of pipe installation, it may be advantageous to remove a flume and switch to pumps so that the pipe can be lowered directly into the ditch rather than pulled under the flume.

7.2.5 Temporary Ditch Checks and Channel Liners

Where erosion in a drainage ditch is observed, selection of a channel liner or ditch check should be used to solve the problem. If such erosion occurs at the outlet of a let down structure, or culvert, or a similar structure, an energy dissipater may be required which requires a site-specific design (Subsection 6.2). If a channel liner is to be selected, it should be designed as described in Subsection 5.2.7. If temporary ditch checks are to be used, use any one or a combination of those shown in Figure 16 and described in Subsection 5.2.2.

7.2.6 Temporary Covers

The use of temporary covers is effective for the control of erosion from wind, rain, seepage, and minor snow melt drainage for exposed soils on cut slopes, fill slopes, and other disturbed areas.

Vegetative cover is the preferred method of erosion control on slopes or other areas of general disturbance. Temporary revegetation cover for erosion control will be implemented only where further disturbance of an area is anticipated or when permanent seeding or transplanting schedule is delayed or outside timing windows.

- o Permanent revegetation of areas requiring long-term erosion protection will consist of seeding with native grasses and annual ryegrass and/or legumes.

- o Seed rates, types, fertilizer mixes, and mulches, as well as stabilizing techniques will be based upon physiographic region and the site-specific goals be they temporary or permanent. Except for temporary seeding, the actual seed species and other details of revegetation will be based on ongoing research and will be presented in the Detailed Restoration documents.

- Annual ryegrass will be used as a temporary measure for erosion control. Where rapid cover is desired to prevent or reduce erosion, annual rye will be planted alone. Annual ryegrass is fast growing, has an extensive root system, high seeding vigor and is acid soil tolerant. Additionally, it is inexpensive; when applied independent of other species, it provides a high biomass, great percent cover and substantial height during first year of growth. Since it is an annual grass, it does not persist, and, therefore, can be used independently only for temporary control.

Temporary covers are usually used in conjunction with temporary or permanent seeding, but can be used effectively for a short period as the only measure if construction that would eliminate the effectiveness of seeding is imminent. Temporary covers include but are not limited to (See Reference 1):

- Straw

  Straw may be applied on low-moisture, predominately fine-grained soils on cut slopes and fill slopes flatter than 1:1 and on other disturbed areas where seed has been applied. To meet specific situations, the rate of application may be reduced on slopes flatter than 2:1 or increased to protect excessively friable soils.

  Straw mulch may be anchored to the soil by one of the following methods depending on material availability and equipment limitations.

  - Anchor by using a V-type wheel land packer, crimper or similar implement.
  - Anchor by tacking with a tacking agent as described below under Tacking Agent and Soil Stabilizer.
  - Anchor by covering with netting.

  In swales and other low areas where minor drainage flow will concentrate, cover the straw mulch with jute net.

- Wood Cellulose Fiber

  Wood cellulose fiber mulch may be applied on cut slopes and fill slopes flatter than 1:1 and on other disturbed areas where seeding is applied. Where soils have extremely high moisture contents and/or visible seepage is present, mulch area with excelsior blanket.

  Wood cellulose fiber is normally applied hydraulically as a wood cellulose-water mixture which may include seed.

In areas where winds or drainage velocities are expected to displace the mulch, it may be necessary to tack the mulch with a tacking agent or to anchor the mulch with netting. In swales and other low areas where minor drainage flow will concentrate, cover the wood cellulose fiber with jute net.

- Excelsior Blanket

Excelsior blanket may be used as a mulch on high moisture and seepage areas in predominately fine-grained soils on cut slopes, fill slopes, and other disturbed areas.

If excelsior is not available or excessive moisture is a problem, use fiberglass.

- Fiberglass

Fiberglass mulch may be applied on extremely high-moisture, predominantly fine-grained soils and on seepage areas in predominately fine-grained soils on cut slopes, fill slopes, and other disturbed areas. When wind or drainage velocities are expected to displace the mulch, the fiberglass may be tacked with a tacking agent to provide a more stable mulch.

- Tacking Agent and Soil Stabilizer

A tacking agent and/or soil stabilizer may be used for the following purposes:

  - To provide a temporary membrane to retain soil moisture on low-moisture, coarse-grained soils that have been seeded.
  - To prevent displacement of straw, wood cellulose fiber, and fiberglass mulches by wind or water flow.
  - To stabilize soil against wind and/or water erosion.

The tacking agent and soil stabilizer may be polyvinyl acetate, acrylic emulsion, or equivalent. Apply the material, mixed as specified, to the mulch to be tacked or to the soil to be stabilized, at the rate specified. In swales and other low areas where drainage flow will concentrate, cover the soil stabilizer with jute net.

- Netting

Biodegradable netting may be used to tack wood cellulose fiber or straw used as mulches. Netting shall be rolled onto area and pinned in each direction and on all edges.

Netting should not extend below the five-year flood stage in fish streams. In certain instances, polypropylene netting may be used but will be removed after a specified time period.

- Jute Net

  Jute net or equivalent may be used in conjunction with straw, wood cellulose, soil stabilizer, and on areas not mulched to prevent erosion by minor concentrated drainage in swales and other low areas. After application of the mulch required, roll the netting onto the area. Jute net should not extend below the five-year flood stage in fish streams.

7.3 THERMAL EROSION

7.3.1 Ditch Wall

Where a pipeline ditch is excavated and shows signs of detrimental thermal degradation of the ditch walls, corrective measures should be taken and should be implemented immediately. Measures include:

- Placement of pipe and backfilling of ditch.
- Temporary backfilling of ditch;
- Reduce sun exposure;
- Apply foam insulation to ditch walls: or
- Reschedule.

7.3.2 Disturbed Areas

Where a cut face or other disturbed area begins to show signs of unexpected detrimental thermal erosion, corrective measures should be investigated.

Covers and corrective measures include:

- Cover affected area with boardstock insulation and gravel;
- Gravel buttress;
- Spray-on foam; or
- Remove ice-rich material and replace with moisture free soil (only effective if extent of thermally sensitive material is relatively small).

7.3.3 Insulated Drainage Structures

Where a drainage structure shows signs of unexpected thermal degradation, procedures should be initiated to stop any further degradation. If the structure is:

- o A low water crossing, based on site conditions, the structure may have to be removed and replaced with a Type IV LWC as shown on Figure 8.

- o A culvert, based on site conditions, the culvert may have to be removed and an insulated culvert installed as shown on Figure 13.

- o A drainage ditch, based on site conditions, insulation may be installed as shown on Figure 15.

In permafrost areas, installation of insulation should be designed to prevent water from seeping below the insulation.

7.4 SEDIMENTATION

7.4.1 Discharge of Silty Water within Floodplains

- o Summer discharges of silty water within floodplains should be to percolation ponds (Subsection 5.3.1) or gravel bars a sufficient distance from flowing water to permit the discharge to infiltrate and not directly contact the stream.

- o For winter-time discharges of silty water within floodplains the most practical alternative may be to discharge on top of the river ice, with the understanding that most rivers will have silt-laden discharges during breakup anyway. Precautions should be taken, however, to prevent silt intrusion into fish overwintering areas.

7.4.2 Vegetated Filter Areas

Discharge of sediment laden water onto designated vegetated areas is the most economic method of sedimentation control, and if correctly handled, will create the least environmental disturbance. This method requires periodic observations to ensure that the vegetation is not covered beyond its ability to recover.

For discharge of sediment laden water onto vegetated areas, the following considerations should be made (See Reference 10):

- o During the winter, overland flow could cause an ice layer over vegetation which could be harmful to the vegetation.

Therefore, use of vegetation as a siltation filter during the winter season should consider the potential for damage to the vegetation.

- Floodplain vegetation is adapted to siltation, so there is less concern for impacts due to depth of accumulation of silts.

- Overland discharge should pass through some type of energy dissipation device in order to prevent erosion. The potential for erosion can be determined by comparing the soil type with allowable velocities listed in Table 4. When maximum filtration effect of vegetation is a goal, desirability of achieving sheet flow may influence energy dissipater design more so than erosion considerations. Channelization of flow reduces the filtration efficiency of vegetative buffers. Energy dissipaters available to field personnel include but are not limited to:

  - Discharge over rocks
  - Discharge over straw bales
  - Discharge onto plywood or metal sheet
  - Perforated pipe
  - "T-bar" header
  - Fire hose discharging vertically up

7.4.3 Sediment Traps

Sediment traps (See Reference 18) are small temporary basins formed by excavating the bottom of constructed ditches to intercept sediment laden runoff and to trap and retain sediment. The devices generally trap only the coarser, bed load sediments and are most effective when used with ditch checks.

In general, sediment traps will be required within constructed drainage ditches when heavy sediment loads are anticipated and other trapping measures are precluded or otherwise impractical. Sediment traps may also be employed at points of discharge from disturbed areas and where other treatment measures are not practical.

7.4.4 Silt Fences

Silt fences are used as described in Subsection 11.2.4.2.2 of the Pipeline Design Criteria Manual and as shown on Figure 21.

7.4.5 Sediment Filters

Sediment filters are used as described in Subsection 11.2.4.2.3 of the Pipeline Design Criteria Manual and as shown on Figure 21.

7.4.6 Filter Inlets

A filter inlet (See Reference 18) is a temporary filter of gravel or crushed rock constructed at culvert or channel inlets. A ridge of filter material is built around the inlet. It is kept out of the drainage structure by boards across the throat; the filter material is about half as deep as the inlet opening. Large volumes of water flow over the top of this filter inlet.

Where very fine sediments are to be filtered, the filter inlet should be covered with filter fabric.

7.4.7 Filter Culverts

A filter culvert is a culvert filled with straw to trap sediments being carried through the culvert.

Because of the difficulty of clearly defining all the variables involved in a complete design of a filter culvert, no attempt will be made to determine such things as capacity and head loss through a filter culvert. Filter culverts will only be used for short time periods where low flows are experienced. The culvert will be filled with straw which will be confined at both ends. Methods of confinement include filter cloth or perforated metal plate or plywood firmly anchored to each end of the culvert. An alternative may be a 10 to 15 foot long section of perforated pipe at the outlet end. Where high flows may be anticipated, an alternate structure to protect from overtopping should be provided (see Figure 32).

7.4.8 Sediment Barriers

Temporary sediment barriers (See Reference 18) are built to retain sediment on-site by slowing storm runoff, causing the deposition of sediment at the structure, and filtering the effluent. Sediment barriers are berms, diversions, or other barriers, that are constructed of baled straw, sand bags, or filter gravel in filter fabric bags. Straw bales should be anchored to the ground.

Straw bales or sand bags must be installed so that runoff cannot escape freely under the bales or bags. (See Figure 32.)

7.4.9 Miscellaneous

- o Snow Removal

  Snow removal should be conducted so as to avoid drainage channeling longitudinally along the workpad or access road during breakup. Methods which can accomplish this include:

- Gap snow piles at prescribed intervals.

- Place temporary checks such as straw bales or sand bags along the area for storage of removed snow.

- Minimize unnecessary snow plowing as snow plowing activities tend to increase the amount of drifting snow.

- Where possible, blade snow off downslope edge of pad.

o Control of Erosion from Stockpiles

  In some cases it may be necessary to control the migration of sediment eroding from stockpiles. In this case, such measures as containment berms, sediment barriers or silt fences should be used as appropriate.

7.5 PIPELINE STREAM CROSSINGS

Small pipeline stream crossings can usually be constructed using fluming or pumping. Large pipeline stream crossings require special construction methods, some of which are discussed below:

o Temporary stream diversion should be considered as an alternative method under some special circumstances, especially when crossing braided streams within wide gravel floodplains. Flow should be returned to the original channel immediately following pipeline installation.

o A variety of ditching sequences and methods can be used to minimize sedimentation. Their use should be based on a site-specific evaluation. Alternatives include but are not limited to:

  - Hard Plug Method

    With this method, excavation starts at the far ends of the pipeline ditch and proceeds toward the river leaving a plug of natural material at the river's edge. The flowing water portion of the crossing is then excavated toward the bank with the plug material removed last. The pipe is installed, the river bank area is backfilled, the stream is restored, and the remaining ditch is backfilled. The advantage of this method is that the cut soils and pipeline ditch are exposed to flowing water for the minimum amount of time. Disadvantages include the necessity to excavate the hard plug from the side rather than digging the entire ditch in a continuous operation.

- Modified Hard Plug Method

  Basic operations are the same as above except that a small segment of ditch is excavated just inside of each river bank and filled with granular material. The loose fill area can then be used as a ramp for equipment to use while removing the hard plug and can be subsequently removed with relatively little difficulty because of its loose nature.

- Soft Plug Method

  Excavation proceeds in the conventional manner from the active channel proceeding outward to the ends of the crossing ditch. However, when the river bank portion has been removed it is replaced with a plug of granular material that prevents silty water from running down the pipeline ditch and entering the river during excavation of the lateral ditches. The soft plug is removed before installing the pipe.

- Many combinations of procedures may be applied on a site-specific basis.

o Silt curtains made of canvas or filter cloth should be considered for use during summer crossings in the absence of ditch plugs. Curtains should be placed across the pipeline ditch to isolate flowing water from the ditch. It should be emphasized that ditch plugs are generally preferable to silt curtains.

7.6 DITCH DEWATERING

Wherever the pipe ditch is excavated and subject to groundwater or surface water intrusion, it may be necessary to remove such water by pumping . Pumping methods are discussed in Subsection 7.2.3. The preferred discharge method is to a vegetated filter area (Subsection 7.4.2).

7.7 FAILURE OF STRUCTURES AND MEASURES

This section attempts to point out some of the more common signs that a drainage, erosion or sediment control structure has failed to accomplish what it was designed to do. It also gives field personnel some guidance in selection of corrective measures.

7.7.1 Sedimentation of Streams

Where unacceptable sedimentation of a stream is observed, the following should be considered:

- o Sedimentation might be due to clogged existing stilling basins, or overflowing sedimentation traps. In this case, clean out may be all that is required, or resizing based on site-specific conditions may be required.

- o If sedimentation is determined to be caused by thermal erosion procedures in Subsection 6.5 should be initiated.

7.7.2 Slough in Ditches

Sloughed material can collect in drainage ditches and be washed away in the next storm or thaw season. This material can collect to the extent that their rapid removal by flowing water can cause excessive sedimentation. Sloughed material will degrade the effectiveness of ditch liners. However, the accumulation of sloughed material at the base of ice-rich slopes is an important part of the stabilization process.

It is necessary to keep sloughed material from restricting flow of runoff and providing excessive ready sedimentation material. Sloughed materials tend to pond water in the ditch causing soft spots in the workpad.

An appropriate and long-lasting solution for minimizing sloughed materials is revegetation of the slope.

7.7.3 Erosion on Slopes

Erosion on slopes is important to control or eliminate in its early stages. Erosion on slopes is usually an indication of excessive flows across the slope.

Where the slope was designed to allow flow across the slope, it was probably designed with temporary or permanent vegetation along with a temporary cover. Slope erosion in this case is indicative of inadequacy of the temporary cover.

A solution in this case may be to build a diversion levee or ditch across the top of the slope to intercept overland flow. The diversion levee or ditch should direct the flow to an existing drainage structure or a natural drainage channel.

Where the slope is already protected by a diversion levee or ditch, slope erosion indicates failure of the diversion levee or ditch. In this case, the levee or ditch should be repaired, increased in size, or armored, if necessary.

7.7.4 Erosion of Ditch Bottom or Walls

Erosion of a drainage ditch bottom or walls indicates that actual water velocity is in excess of the erosive velocity of the material. In that case, the actual velocity should be estimated and an appropriate channel liner should be selected from Table 4. If the erosion is noted at the end of a culvert or letdown structure, a plunge basin or other energy dissipating device should be installed. Where fish passage must be provided, the device selected must not hamper fish passage.

7.7.5 Soft Spots on Working Surfaces

Soft, wet areas may develop on the roadway or workpad shoulders or surface during spring break-up, after heavy rains, or because of pumping of fines and water through the embankment. Soft spots are generally caused by the following:

- o Poor drainage causing ponding of excess water.
- o Unsatisfactory material on the working surface.
- o Degradation of the permafrost.

All three of these causes are closely related. Material segregation can occur which results in unsatisfactory material coming to the surface locally. This material is very sensitive to water content. Similarly, ponding of water will cause degradation of permafrost. Therefore, drainage control is very important in controlling soft spots in the roadway and workpads and reducing the potential for segregation and degradation of the permafrost.

Structural solutions, if correctly applied, are good solutions for controlling drainage. Acceptable maintenance practices for soft spot problems involve regrading the area to conform to drainage systems and using proper free draining materials. The placement of gravel without regrading will not solve chronic soft spot problems.

7.7.6 Icing

Aufeis can occur naturally, or it can occur as a direct result of roadway or pipeline construction activities. The naturally occurring aufeis may be aggravated by the presence of a roadway or a chilled pipeline.

Culvert icing constitutes one of the most costly phases of roadway maintenance in Alaska. It is important to minimize icing of culverts and ditches to prevent overtopping of the roadway and workpad with sheet ice.

During design, culverts with thaw pipes or thaw wires may be considered where aufeis has been anticipated.

Where aufeis has not been anticipated in design, or where methods other than thaw pipes or thaw wires have been designed and prove to be inadequate, the culvert may be cleared by installation of some form of space heater. After the culvert has been opened, solutions should be implemented as described in Subsection 6.6.

(See References 1, 11, 17, 20 and 23 for detailed discussion on the mechanics of aufeis and maintenance procedures associated with icing and aufeis).

7.7.7 Dust Control

Dust may be a problem on the project. The decision on whether to control dust, and if so, by which method, will be determined on a site-specific basis, and will be based on many factors, some of which include the following:

- Safety;
- Amount of dust ;
- Type and extent of use of the facility; and
- Environmental impact.

The following are acceptable dust palliatives (See Reference 1):

- Water

  The use of water has little or no environmental impact except at the point where it is obtained. When drawing water from streams or lakes, the environmental impact must be analyzed and considered.

- Waste Oil

  The use of waste oil as a dust palliative provided it contains less than 5% toxic diesel oils, ethylene glycol, solvents, etc., is an acceptable method provided the area to be treated is a permanent facility and is not an environmentally sensitive area. Areas specifically restricted are wetlands, within 100' of a stream or lake, within 50' of any fuel storage area or on or near any macadam surface. The use of waste oil as a dust palliative will require site-specific permit from the OFI or the SPCO.

- Chemical Dust Palliatives

  The use of chemical dust palliatives may be considered on a site-specific basis in areas where environmental or other considerations disallow the use of water or waste oil.

7.8 ROUTINE MAINTENANCE

Routine maintenance primarily involves regular inspection of facilities and correction of observed problems.

- Drainage Structures

  Drainage structures should be kept clear of debris and sediment build-up. The flow area should be unimpeded. Any debris or sediment build-up should be removed after each storm, and frequently during spring breakup (culverts in fish streams are designed with the bottom 20% filled with native material--this should be maintained) drainage ditches and low water crossings should be checked for scour holes which should be filled, and armored if necessary.

- Erosion Control Structures

  Erosion control structures should be kept clear of debris and sediment and should be checked for scour. If scour holes are observed, they should be filled, and armored if necessary. Ditch checks should have debris and sediment removed regularly, and should be regularly inspected for damage. Any observed damage should be repaired. Where damage is observed to revegetation areas or temporary covers, repairs will be effected and will be protected with geotextiles or other surface protection.

- Sediment Control Structures

  Most sediment control structures have a designed sediment storage capacity. Sediment control structures should be inspected regularly, after each storm, and frequently during spring breakup. Sediment buildup should be removed when it has reached 70% of capacity.

- Debris Structures

  Debris structures should be inspected after each storm and frequently during spring break-up. Debris should be removed and a clear opening to the entrance of the drainage structure should be maintained.

8.0 TABLES, FIGURES AND NOMOGRAPHS

8.1 TABLES

THIS TABLE PRESENTS A SUMMARY OF THE POTENTIAL ADVANTAGES AND DISADVANTAGES OF A VARIETY OF TREATMENT MEASURES, GIVEN A SPECIFIC SOURCE REQUIRING EROSION AND SEDIMENT CONTROL. THE MEASURES ARE PRESENTED IN THIS TABLE IN GENERAL ORDER OF PREFERENCE FOR USE. FOR ANY PARTICULAR SOURCE OF EROSION OR SEDIMENT THE COLUMN WILL BE FOLLOWED DOWN TO THE FIRST APPLICABLE TREATMENT METHOD. THIS TABLE IS A GUIDE AND WILL BE USED IN CONJUNCTION WITH SITE - SPECIFIC DETAILS. IT IS EXPECTED THAT, IN SOME CIRCUMSTANCES, NON - DESIGNATED METHODS MAY BE USED, A COMBINATION OF METHODS MAY BE USED, OR METHODS MAY BE SELECTED IN DIFFERENT PRIORITY.

GUIDE TO SELECTION OF EROSION AND SEDIMENTATION CONTROL MEASURES

		TREATMENT MEASURES	ADVANTAGES	DISADVANTAGES	EROSION OR SEDIMENT SOURCES: DITCHES & CHANNELS	EMBANKMENT SURFACES	CUT OR FILL SLOPES	CMP / LWC INSTALLATION	RIVER TRAINING STRUC / BRIDGE CONSTRUCTION	MATERIAL SITE DEWATERING	DITCH DEWATERING	HYDROSTATIC DISCHARGE	WET PROCESSING	ICE RICH SPOIL CONTAINMENT	GENERAL SURFACE DISTURBANCE	ACCIDENTALLY TORN ORGANIC MATERIAL	LETDOWN STRUCTURES	PIPELINE STREAM CROSSINGS	
EROSION CONTROL	KEEPING WATER FROM CONSTRUCTION ACTIVITIES	TEMPORARY DIVERSION	PROTECTED CHANNEL KEEPS FLOWS AWAY FROM CONSTRUCTION	POTENTIAL SILTATION DURING INSTALLATION MAY REQUIRE INTENSIVE RESTORATION WHEN OUT OF FLOODPLAIN			X	X	X	X	X				X			X	DEPENDENT ON STREAM BIOLOGY
		FLUMING	KEEPS WATER FROM CONSTRUCTION	POTENTIAL SILTATION DURING INSTALLATION					X	X	X							X	
		PUMPING	KEEPS WATER FROM CONSTRUCTION	EQUIPMENT INTENSIVE				X	X	X	X							X	
	SLOWING WATER TO ALLOWABLE VELOCITIES	DITCH CHECKS	MAINTAIN LOW VELOCITY AND CONTROL GRADE, TRAP SEDIMENT	CLOSE SPACING ON STEEP GRADES REQUIRES REGULAR CLEAN OUT	X											X	X		
		PLUNGE BASINS & APRONS	LOWER DISCHARGE VELOCITIES TO ALLOWABLE LEVELS, PROTECTS UNDERLYING SOILS	DIFFICULT TO ACCESS	X			X									X		SPECIAL PROCEDURES IN FISH STREAMS
		ENERGY DISSIPATORS	LOWER DISCHARGE VELOCITIES TO ALLOWABLE LEVELS	LARGE DISCHARGES MAY REQUIRE PERMANENT DISTURBANCE FOR STRUCTURE	X			X	X	X	X	X					X		SPECIAL PROCEDURES FOR FISH STREAMS
	KEEPING WATER FROM ERODIBLE AREAS	GRADING TO DRAIN	DIRECTING RUNOFF TO DESIRED AREA			X				X									
		DITCHES	KEEPS RUNOFF AWAY FROM SLOPES DECREASES PONDING AGAINST EMBANKMENTS	ACCESS MAY BE DIFFICULT HARDER TO BUILD IN ICE - RICH SOIL			X	X		X									
		DIVERSION LEVEES	KEEP RUNOFF AWAY FROM SLOPES (TEMPORARY OR PERMANENT)	ACCESS FOR CONSTRUCTION REQUIRE REGULAR MAINTENANCE			X							(1) X					
	PROTECTING ERODIBLE AREAS WITH COVERS FROM WATER	PERMANENT VEGETATION	LONG - TERM SOLUTION	SEASONAL, MAY BE DIFFICULT TO ESTABLISH	X	X	X							X	X	X	X		
		LETDOWN STRUCTURES	PREVENT GULLIES (TEMPORARY OR PERMANENT)	SITE SPECIFIC DESIGN REQUIRED, USUALLY REQUIRE ENERGY DISSIPATION STRUCTURE			X												NOT IN FISH PASSAGE STRUCTURES
		CHANNEL LINERS	MOST EFFECTIVE CONTROL FOR HIGH VELOCITY AND STEEP GRADE	SITE SPECIFIC DESIGN REQUIRED, USUALLY EXPENSIVE	X			X	X								X	X	
		TEMPORARY VEGETATION	MINIMIZES EROSION, PROVIDES STABILITY	SEASONAL SLOPE LIMITATIONS, MAY BE DIFFICULT TO ESTABLISH, INHIBITS REINVASION OF NATIVE PLANTS			X							X	X	X			
		TEMPORARY COVERS	WIDE VARIETY OF GEOTEXTILES AND OTHER MATERIALS, IMMEDIATE AND EFFECTIVE CONTROL, EASE OF INSTALLATION	MUST BE ANCHORED, ONLY TEMPORARY PROTECTION			X							X	X	X		X	NO FILL NET TYPE FABRICS IN FISH STREAMS
		WATER BARS	DIRECT RUNOFF TO PROTECTED DITCH, MINIMIZE EROSION ON SURFACE OF EMBANKMENT	MAY DISRUPT TRAFFIC, REQUIRE MAINTENANCE		X													
		MECHANICAL COMPACTION	NO DESIGN REQUIRED, MINIMIZES EROSION	INHIBITS REINVASION OF NATIVE PLANTS		X													
SEDIMENTATION CONTROL		PERCOLATION PONDS	SIMPLE, LARGE VOLUMES OF SILT CAN BE COLLECTED, NO DISCHARGE TO SURFACE WATERS	USABLE ONLY IN GRAVELLY AREAS			X	X	X	X	X	X	X					X	
		VEGETATED FILTER AREAS	SIMPLICITY AND CONVENIENCE NO DESIGN REQUIRED. NO INSTALLATION REQUIRED.	REQUIRES CONTINUOUS OVERSIGHT, REQUIRES CARE IN SELECTION OF SITE. SEASONAL.				X		X	X	X		(1) X					
		SEDIMENT TRAPS	SIMPLICITY, EASE OF CLEAN OUT AND RESTORATION.	TRAP ONLY COARSE LOAD, FREQUENT CLEAN OUT, NO CONTROL OF VELOCITY OR GRADE, SPACE NOT ALWAYS AVAILABLE	X			X	X	X	X						X		
		SILT FENCES	EASE OF INSTALLATION, EASE OF CLEAN OUT.	REQUIRE REGULAR MAINTENANCE, NO CONTROL OF VELOCITY OR GRADE	X	X	X	X	X					X					NOT IN FISH STREAMS
		SEDIMENT FILTERS	SIMPLICITY, NO DESIGN REQUIRED, EASE OF INSTALLATION, EFFECTIVE IN TRAPPING SEDIMENT.	FREQUENT CLEAN OUT ONLY TEMPORARY	X		X			X				X					NOT IN FISH STREAMS
		SEDIMENT BASINS	HANDLE LARGE FLOW VOLUMES, HIGH TRAPPING EFFICIENCY OF COARSE SEDIMENTS	REQUIRE SITE - SPECIFIC DESIGN EXPENSIVE, MAY REQUIRE INTENSIVE RESTORATION, NO TURBIDITY REDUCTION			X		X	X	X		X	X	X		X	X	NOT IN FISH STREAMS
		RECYCLE PONDS	ALLOWS WATER USE DURING PERIODS OF RESTRICTED WITHDRAWAL, DISTURBS RELATIVELY SMALL AREAS	RECYCLED WATER LESS EFFICIENT THAN CLEAN WATER MAY FILL RELATIVELY QUICKLY									X						
		UNCLASSIFIED RIPRAP	PROTECTS RESTORED STREAM BED AND BANK FROM EROSIVE FORCES	ONLY EFFECTIVE AT PIPELINE STREAM CROSSINGS														X	

TABLE 1

(1) REVERSE PRIORITY

TABLE 2

SOIL EROSION CLASSIFICATION

SEC	General Name with MUSCS Classification	In-situ Description	Percent Passing Sieve 3"	#4	#200
U	Frozen upland silt MH, ML, OL, OH, ML-SM, SM-ML, SM-ML, GM-ML	Permanently frozen silty soils with high ice content and organic matter. Massive ice is common.	100	>44	50-100
L	Loess ML	Wind-deposited silt with low moisture content, uniform appearance, of medium density and low in organic matter content.	100	-	55-100
Q	Sand SW, SP, SM, SC, SW-SM, SPSM SW-SC, SP-SC, ML-SM, CL-SC, SM-SC	Coarse and fine sandy soils. If free draining, low ice content when frozen	100	23-100	0-50
S	Silt ML, OL, GM-ML, SM-ML,	Silty soils consisting of more than 45% non-plastic fines. Massive ice is common in the frozen state.	100	-	45-100
O	Organic PT, OL, OH	Soils containing more than 10% organic matter by weight. Plant matter may be visible in soil profile.	-	-	-

TABLE 2 (Continued)

SOIL EROSION CLASSIFICATION

SEC	General Name with MUSCS Classification	In-situ Description	Percent Passing Sieve 3"	#4	#200
D	Dirty gravels GM, GM-GC, GC, ML-GM, CL-GC	Gravels or gravel-sand mixtures with 12 to 50% fines by weight. Commonly with high ice to massive ice in frozen state.	100	25-44	12-50
C	Clays CL, ML-CL, CH, MH-CH, GC-CL, SC-CL,	Clayey soils consisting of more than 50% fines of a plas tic nature. Moisture content variable, high ice possible in frozen state.	100	-	50-100
G	Clean Gravels GW, GP, GW-GM, GP-GM, GW-GC, GP-GC	Clean gravels, or gravel-sand mixtures with up to 12% fines by weight. Generally free draining with medium density and little ice when frozen.	100	<44	0-12
R_W	Weathered Rock	Severely weathered or fractured rock, and large cobbles to boulders with little amount of fines.	-	-	<5
R_C	Competent Bedrock	Competent bedrock exhibiting little weathering or freeze-thaw fracturing.	-	-	-

TABLE 3

SOIL EROSION CLASSIFICATION SLOPE STANDARDS

SEC Symbol	PERMAFROST* Soil Cut - Slopes	PERMAFROST* Soil Fill - Slopes+	NON-PERMAFROST* Soil Cut - Slopes	NON-PERMAFROST* Soil Fill -Slopes+
G	2:1	1-1/2:1	1-1/2:1	1-1/2:1
D	2:1	1-1/2:1	2:1	1-1/2:1
Q	2:1	1-1/2:1	1-1/2:1	1-1/2:1
L	1/4:1	2:1	1/4:1	1-1/2:1
S	1/4:1	2:1	2:1	1-1/2:1
U	1/4:1	2:1	--	- - -
C	2:1	2:1	1-1/2:1	1-1/2:1
O	**	2:1	**	1:1
R_C	1/4:1	1:1	1/4:1	1:1
R_W	1-1/2:1	1:1	1-1/2:1	1:1

* Maximum cut slope applies only to exposed cut faces, not to bench cuts.

** Organic material (O) will have the same design cut slope as required for the underlying natural soil.

\+ During construction fill slopes will be 1:1. During restoration slopes will be graded to (or flatter than) the slopes shown above.

NOTE: Slopes may be changed in special design areas.

(See Reference 6 for further detail.)

TABLE 4

ALLOWABLE VELOCITIES AND ROUGHNESS COEFFICIENTS FOR CHANNEL MATERIALS

Allowable Velocities and Roughness Coefficients

Channel Material	Allowable Velocity[1] (fps) (V_a)	Roughness Coefficient "n"[1]
Clean Gravel (SEC G)	2 - 6[1]	0.022 to 0.030
Dirty Gravel (SEC D)	2 - 4[1]	0.025 to 0.040
Sands (SEC Q)	1 - 4[1]	0.018 to 0.028
Silts, Loess (SEC S, L, U)	2	0.016 to 0.025
Clay (SEC C)	2	0.016 to 0.025
Coarse Gravel (3/4" to 3")	4 - 5[1]	0.030 to 0.050
Cobbles or Rock (3" to 8")	5 - 8[1]	0.040 to 0.070
Riprap[4]	10+[5]	0.025 to 0.050[5]
Gabions	15+[5]	0.025 to 0.030[5]
Bedrock	15+[5]	0.025 to 0.050[5]
Organic Mat	2 - 6[2]	0.025 to 0.030
Riparian Vegetation	Note 3	0.040 to 0.160
Dense Willows	Note 3	0.100 to 0.200
Timber Stands	Note 3	0.080 to 0.120

1 Use higher values for coarser materials and/or water already transporting colloidal material.
2 Use lower value for nonfibrous or thin layered organic, use higher value for fibrous, matted organics.
3 Same as underlying soils.
4 Riprap can be sized as shown on Figures 4-F or 4-G.
5 Allowable velocity and roughness coefficient varies depending on rock size, bank slope, etc.

(Data from References 14, 15, 25 and 31.)

TABLE 5

ROUGHNESS COEFFICIENTS FOR CORRUGATED METAL PIPES

Annular Corrugations	Size*	Roughness Coefficient "n"
2-2/3"x1/2"	12"-60"	0.024
	60"-120"	0.023
3"x1"	30"-144"	0.027
6"x1"	30"-60"	0.025
	66"-96"	0.024
	108"-144"	0.023
6"x2"	All Diameters	0.033
9"x2-1/2"	All Diameters	0.033
Helical Corrugations		
2-2/3"x1/2"	12"	0.011
	18"	0.014
	24"	0.016
	36"	0.019
	48"	0.020
3"x1"	36"	0.021
	48"	0.023
	54"	0.023
	60"	0.024
	66"	0.025
	72"	0.026
	72"	0.027

*Diameter or rise for arch pipes.

(Data from Reference 12.)

TABLE 6

COVER FOR CULVERTS*

Size	Construction Loads
Culverts	
to 48"	12"
54-72"	18"
72-96"	24"
over 96"	30"
Pipe Arches	
to 43 x 27 (36")	24"
50 x 31	30"
75 x 55	36"
81 x 59	42"
95 x 67	48"
117 x 79	60"

*From Reference 12.

TABLE 7

MAXIMUM SPACING OF WATER BARS

Project Section	Embankment Slope <10%	Embankment Slope 10% to 20%	Embankment Slope 20% to 30%	Embankment Slope >30%
Section 1 (Shts 1-24)	500	450	400	390
Section 2 (Shts 24-30)	500	450	340	390
Section 2 (Shts 31-40)	390	360	340	300
Section 3 (Shts 41-61)	390	360	340	300
Section 3 (Shts 61-66)	310	290	270	240
Section 4 (Shts 67-88)	260	250	230	200
Section 5 (Shts 89-110)	240	230	210	180
Section 6 (Shts 111-131)	240	230	210	180

NOTES:

1. This Table is based on the water bar spacing criteria successfully used by ALYESKA on TAPS (Reference 2). If any of the above-mentioned parameters are not known, the spacing shown on this table should be used.

2. Slope is along the centerline of the workpad. Spacing shown is in feet.

TABLE 8

CLASSES OF RIPRAP

Class	Percent Lighter by Weight	Limits of Stone Weight (W), lb.	Limits of Stone Spherical Diameter (D_s) in
I	100	50 - 125	10.0 - 13.6
	50	25 - 36	7.9 - 9.0
	15	8 - 16	5.4 - 6.8
II	100	180 - 450	15.3 - 20.8
	50	90 - 135	12.2 - 13.9
	15	28 - 56	8.2 - 10.4
III	100	410 - 1025	20.2 - 27.4
	50	205 - 310	16.0 - 18.4
	15	65 - 125	10.9 - 13.6
IV	100	1060 - 2650	27.7 - 37.6
	50	530 - 780	22.0 - 25.0
	15	165 - 330	14.9 - 18.8
V	100	2700 - 6750	37.8 - 51.3
	50	1350 - 2000	30.0 - 34.2
	15	420 - 850	20.3 - 25.7

NOTES:

1. Limits are based on a specific gravity of 2.65.
2. Limits of stone weight (W) are based on the criteria recommended by the U.S. Army Corps of Engineers.
3. Limits of spherical diameter (D_s) are derived with the equation:

$$D_s = 12 \left(\frac{6W}{\pi \gamma_s}\right)^{1/3}$$

where γ_s = specific weight (165 lb/ft³)

TABLE 9

TYPICAL PERCOLATION RATES

Soil Sec. Classification	Percolation Rate in Min/Inch	Percolation Rate in Ft/Sec
G	1	0.001389
D	2	0.000694
Q	3	0.000463
S	20	0.000069
L	25	0.000056
O	15	0.000093
C	45	0.000031
U	>60	<0.000023
R	>60	<0.000023

(Data adapted from information in Reference 22.)

TABLE 10

PARTICLE SETTLING VELOCITIES

	Material	Diameter (micron)	Approx. Sieve Size	Settling Rate cm/sec	Settling Rate ft/sec
1.	Coarse Sand	1000	#10	10.0	0.38
2.	Coarse Sand	200	#60	2.1	0.08
3.	Fine Sand	100	#140	0.8	0.03
4.	Fine Sand	60	#200	0.38	0.014
5.	Fine Sand	40	#270	0.21	0.008
6.	Silt	10		0.015	0.0005
7.	Coarse Clay	1		0.00015	0.00001
8.	Fine Clay	0.1		0.0000015	0.00000006

Adapted from information in Reference 9.

TABLE 11

NON-POINT SOURCE ANNUAL SEDIMENT YIELDS[1]

Area	Ton/Mi[2]	Cy/Mi[2]	Cy/Acre
Forest	24	11	0.02
Grassland	240	110	0.2
Cropland	4,800	2,200	3.4
Construction	17,000	7,600	12.0
Spoil Bank	27,000	12,000	19.0
Haul Road	57,000	26,000	40.0

[1]Based on Reference 29.

[2]Based on 165 #/ft.^{3}.

TABLE 12

APPROXIMATE GRADATION OF SMALL SOIL PARTICLES [illegible]ANDFORM[1]

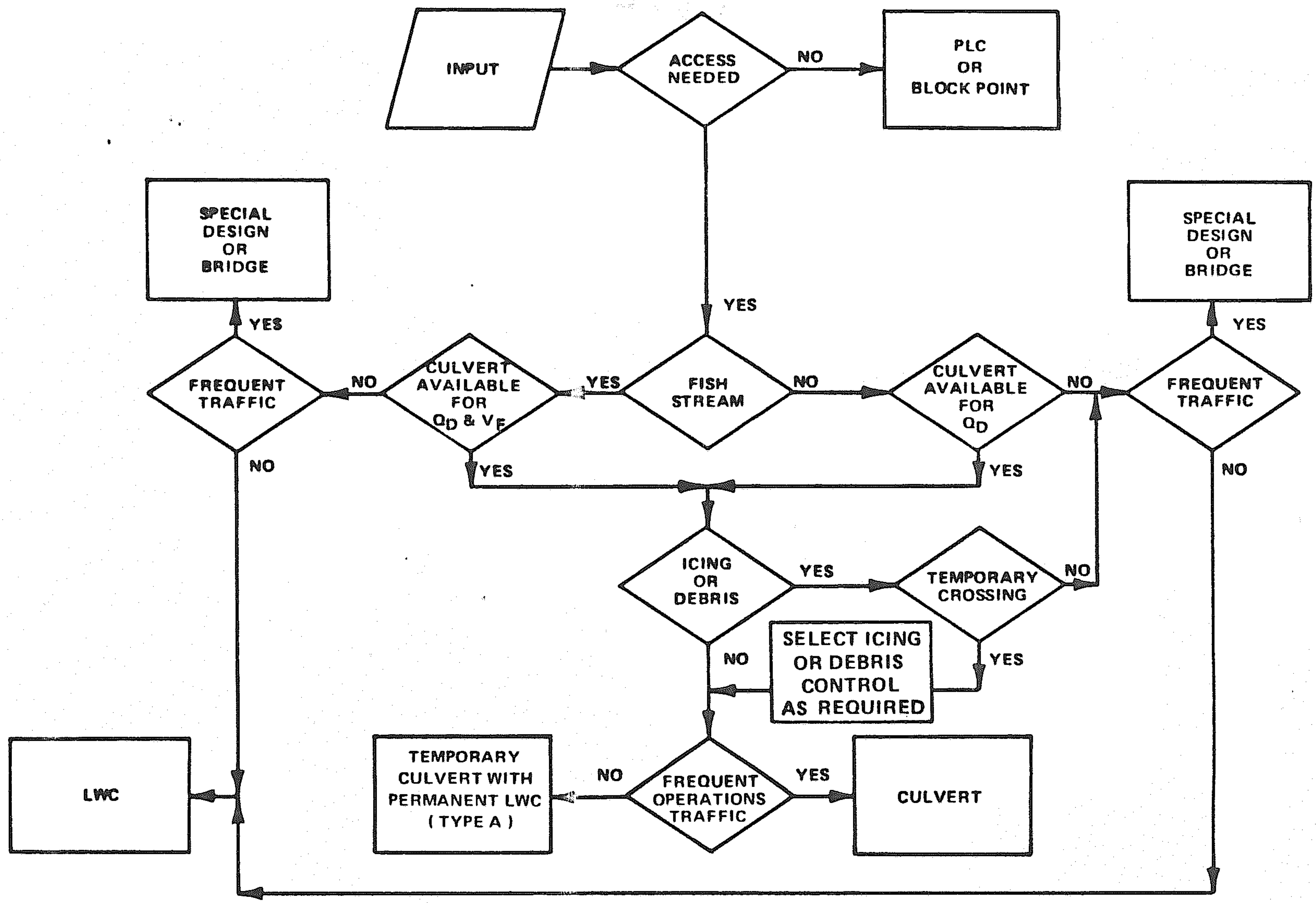
LANDFORM	#4 (6.3mm)	#10 (2.0mm)	#40 (0.42mm)	#200 (0.74mm)	#270[a] (0.053mm)	0.02mm	0.01mm[a]	0.005mm[a]	0.002mm	0.001mm[a]
	PERCENT FINER THAN									
Bx	78	67	47	29	27	16	13	10	5	1
Bx-r	78	68	54	41	37	24	18	14	7	3
Bx-r?	75	70	53	38	33	25	20	15	8	4
Bx-w	83	78	54	27	21	17	16	13	9	5
C?	65	60	51	37	32	22	17	12	6	1
Cs	71	64	53	38	32	27	20	13	5	0
El	100	100	98	82	65	33	25	17	6	0
El-Fp-c	100	99	98	80	65	31	24	16	6	0
Ell	100	100	98	86	72	37	32	23	8	3
Ell+Fp-c	99	99	99	88	68	26	18	12	3	0
Ell+Fs	80	77	71	55	40	17	15	12	10	4
Ell+Lt	99	96	92	69	60	43	32	23	11	2
Elu	100	100	99	95	77	39	30	20	6	0
Elx	100	99	98	95	77	38	27	17	6	0
Elx?	100	99	95	87	75	42	33	22	7	0
Es	100	100	95	8	7	4	2	1	1	1
F	80	75	35	27	20	20	16	15	6	5
F?	70	60	34	22	20	14	14	10	3	0
F+L	99	98	95	78	58	26	24	17	8	0
Ff	65	64	48	27	24	22	18	12	5	0
Ffg	45	33	20	12	10	7	6	5	2	2
Ffs+Fs	98	98	94	56	45	34	30	20	8	0
FG	52	41	23	10	9	6	5	3	1	1
Fp	62	50	34	20	16	10	10	6	2	0
Fp-c	99	98	95	65	50	26	20	14	5	0
Fp-c?	100	98	94	52	40	21	16	10	4	0
Fp-c+E	100	100	96	43	39	16	13	9	3	0
Fp-r	49	39	26	10	9	6	5	4	2	1
Fp-r?	56	49	36	21	20	17	16	16	7	10
Fpa-c	98	97	94	76	62	38	35	20	8	1
Fpb-c	91	88	81	57	42	33	26	20	10	5
Fpb-r	33	24	14	6	6	5	5	4	2	1
Fpc	28	30	34	21	20	10	8	6	3	3
Fpm-c	96	96	92	57	46	23	20	14	6	2
Fpm-r	62	49	29	9	9	5	4	3	1	0
Fps-c	100	100	95	79	55	40	30	21	10	0
Fps-r	98	98	83	11	11	6	6	5	2	1
Fs	99	98	96	86	65	35	27	8	7	0
Fs?	94	90	80	67	50	33	30	23	9	8
Fsa	100	99	97	49	43	15	14	10	3	0
Fss	100	99	98	94	82	43	42	28	11	6
G+GF	65	58	44	27	27	19	16	12	5	0
GF	50	37	22	12	12	9	8	7	3	3
GF?	54	45	24	12	12	8	7	5	2	1
GF+L	72	62	48	32	30	26	25	20	6	0
GF or L	87	82	73	-		-			-	
GFo	46	36	22	13	13	11	10	7	3	0
Gt	66	60	45	30	29	20	20	15	6	6
Gt?	81	77	59	44	40	27	21	15	7	1
Gto	56	59	47	35	34	33	33	22	15	10
Gty	56	50	38	28	24	19	16	13	8	6
Hf	47	38	26	17	16	15	15	11	5	1
Ht	68	57	37	27	19	15	12	10	2	0
Ib	57	54	47	39	35	26	22	17	13	8
Ig	80	74	56	38	25	19	10	7	3	0
Ig-r	88	83	69	31	29	15	12	8	3	0
Ig-r?	84	70	44	28	27	17	15	10	6	1
Ig-w	77	67	39	18	16	13	12	10	5	4
L	99	99	98	86	69	55	40	30	16	7
L?	97	95	89	65	52	45	42	33	15	15
Mc	49	38	29	10	10	6	5	4	2	1
N	72	57	39	27	23	13	6	4	4	2
N-r	71	61	45	42	37	22	21	16	7	4
N-w	79	67	42	26	24	20	17	13	8	4
Nl	85	71	46	28	24	13	10	7	3	0
Nl-r	66	57	40	31	30	22	15	12	5	2
Nl-w	76	67	38	34	29	25	20	15	8	3
Ns	60	47	33	21	17	13	10	7	3	2
Ns-r	76	69	56	42	37	23	19	13	6	0
Ns-u	67	48	25	9		-			-	
Ns-w	73	63	44	31	28	22	18	12	6	1
O	100	100	94	83	66	27	20	12	1	0
Sh	57	44	31	26	23	15	15	12	4	3
Sh-r	76	74	44	59	50	47	33	26	18	12
Sh-w	90	87	74	74	57	53	47	40	22	21
W	80	77	19	59		-			-	
?	63	62	47	12	12	8	6	4	1	0

[1]This table has been prepared from laboratory data and G.I.S. analysis.

[a]Interpolated data.

8.2 FIGURES

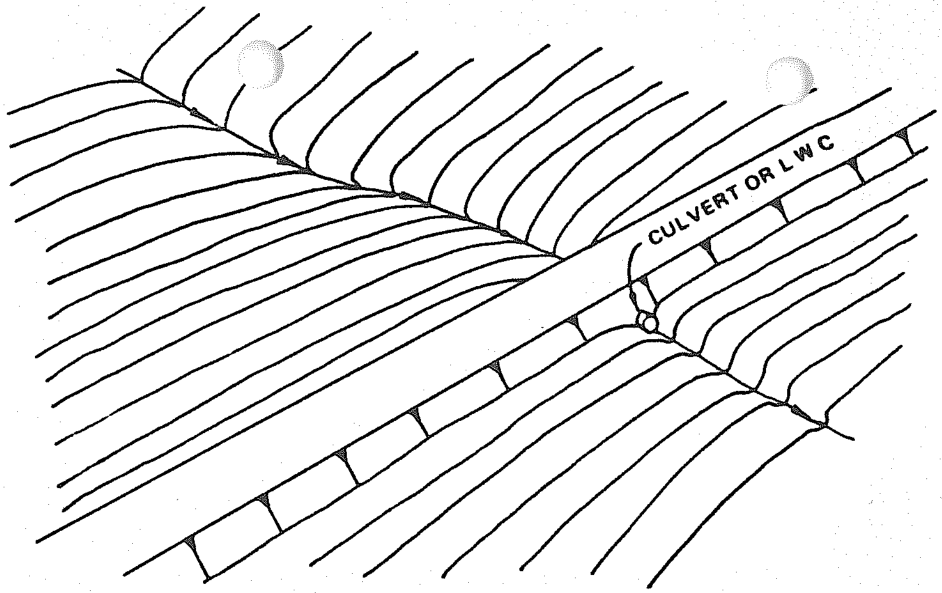
CROSS DRAINAGE SELECTION CHART



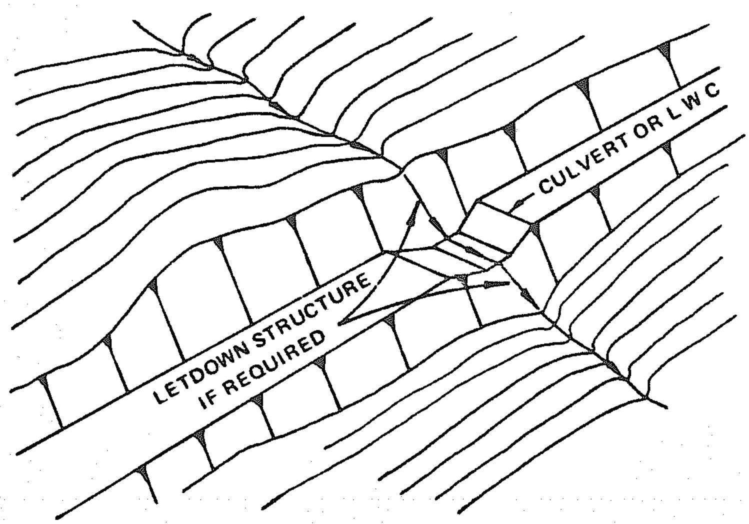
NOTES :

1. *ALL STEAM CROSSINGS ARE INDIVIDUAL DESIGNS AND MUST BE CHECKED FOR CONSTRUCTABILITY AND SITE SPECIFIC DATA.*
2. *SPECIAL DESIGN MAY BE A BRIDGE, SPECIAL MAINTENANCE PROVISION, BOTTOMLESS CULVERT, etc.*
3. *CHART IS FOR USE FOR BOTH TEMPORARY AND PERMANENT STRUCTURES.*
4. *THIS CHART IS INTENDED AS A GUIDE TO THE LOGIC PROCESS ONLY.*
5. *Q_D = DESIGN DISCHARGE ; V_F = FISH PASSAGE VELOCITY ; PLC = PIPE LAYER CROSSING.*

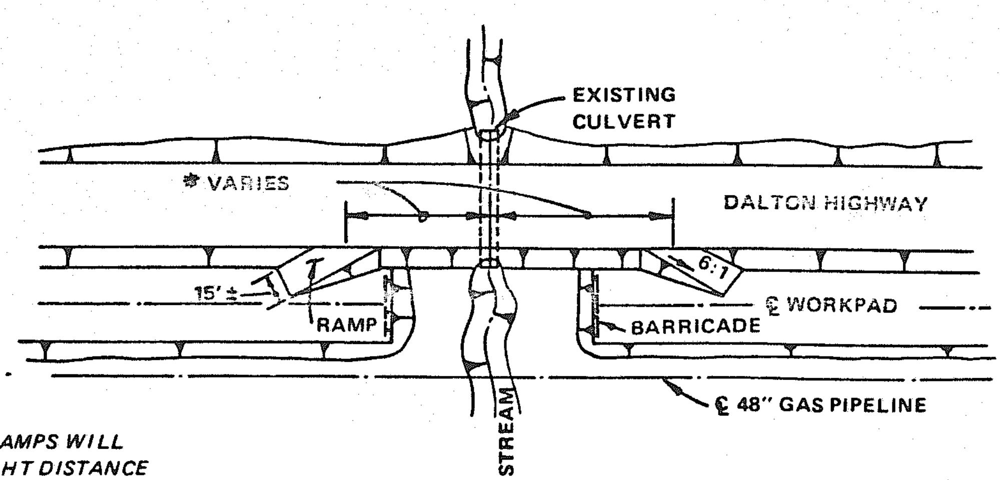
FIGURE 1



WORKPAD OR ACCESS ROAD FILL SECTION



WORKPAD OR ACCESS ROAD CUT/FILL SECTION

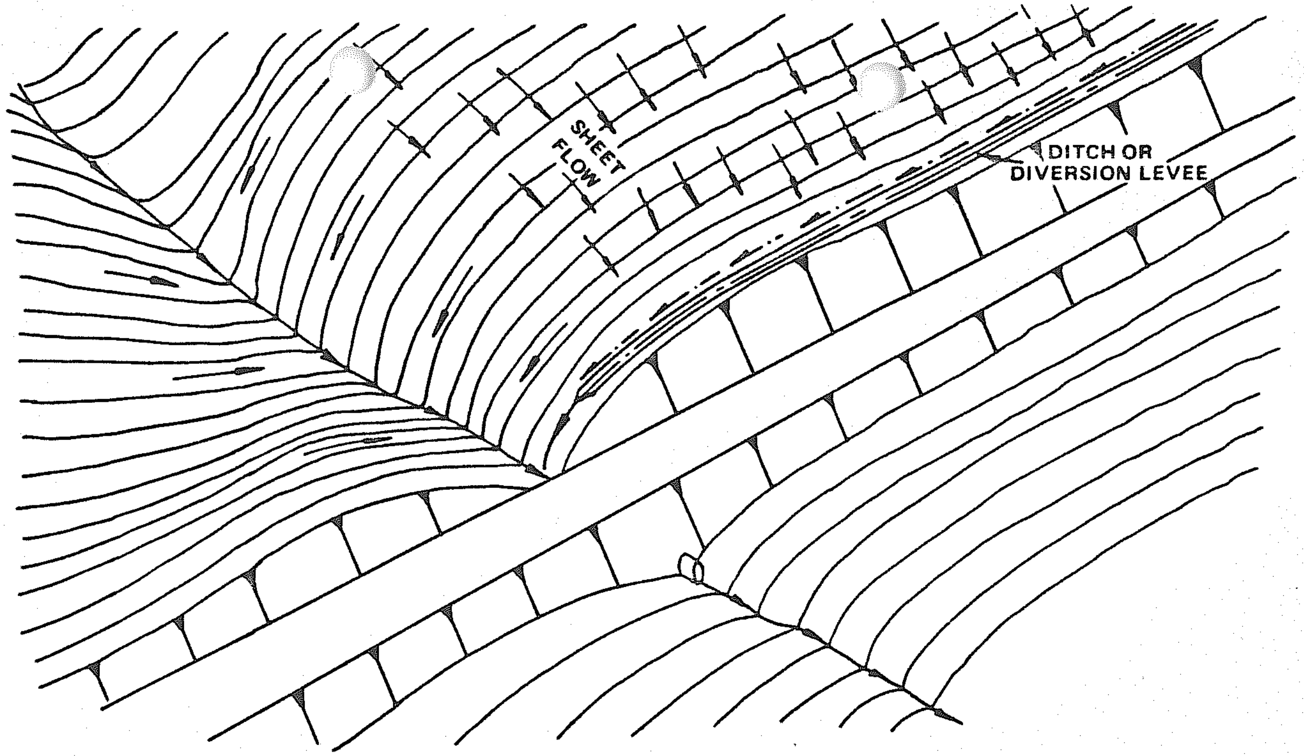


** PLACEMENT OF RAMPS WILL BE BASED ON SIGHT DISTANCE EMBANKMENT HEIGHT, DRAINAGE SPACING, ETC.*

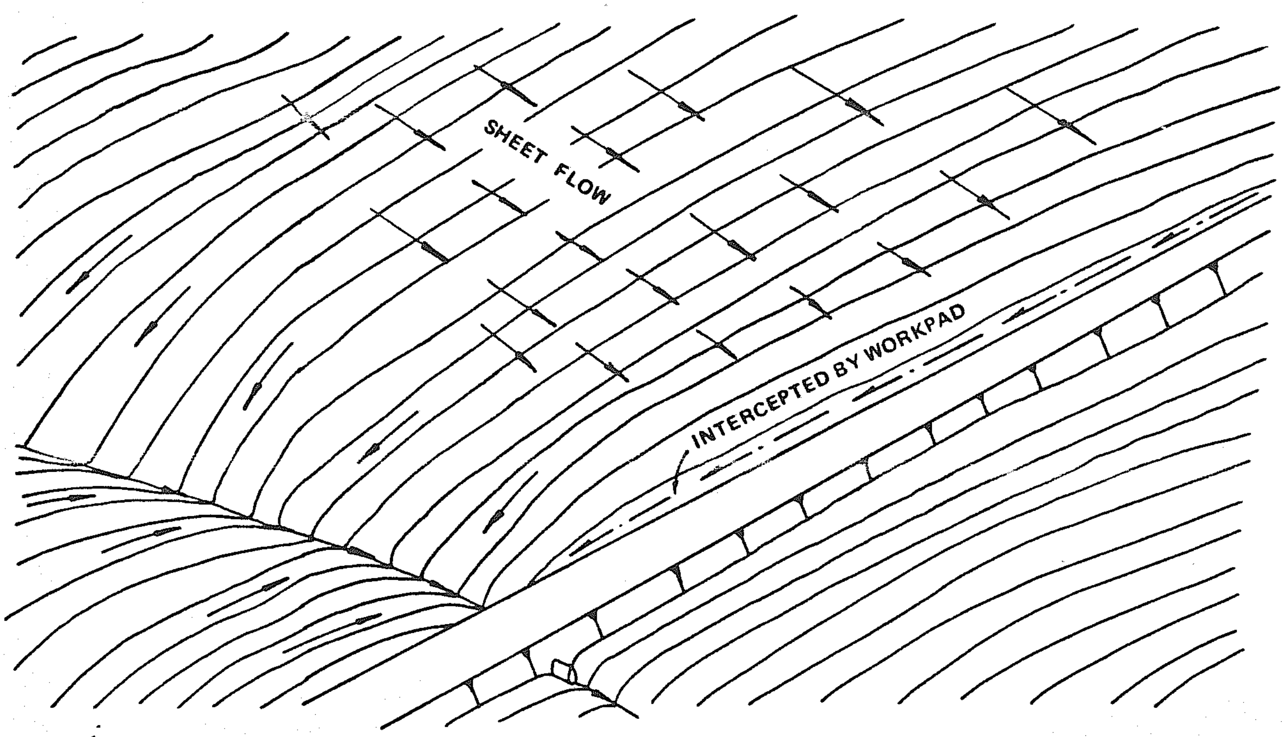
DRAINAGE CROSSING ADJACENT TO
DALTON OR ELLIOT HIGHWAY

DRAINAGE CROSSING BY WORKPAD OR ACCESS ROAD

FIGURE 2



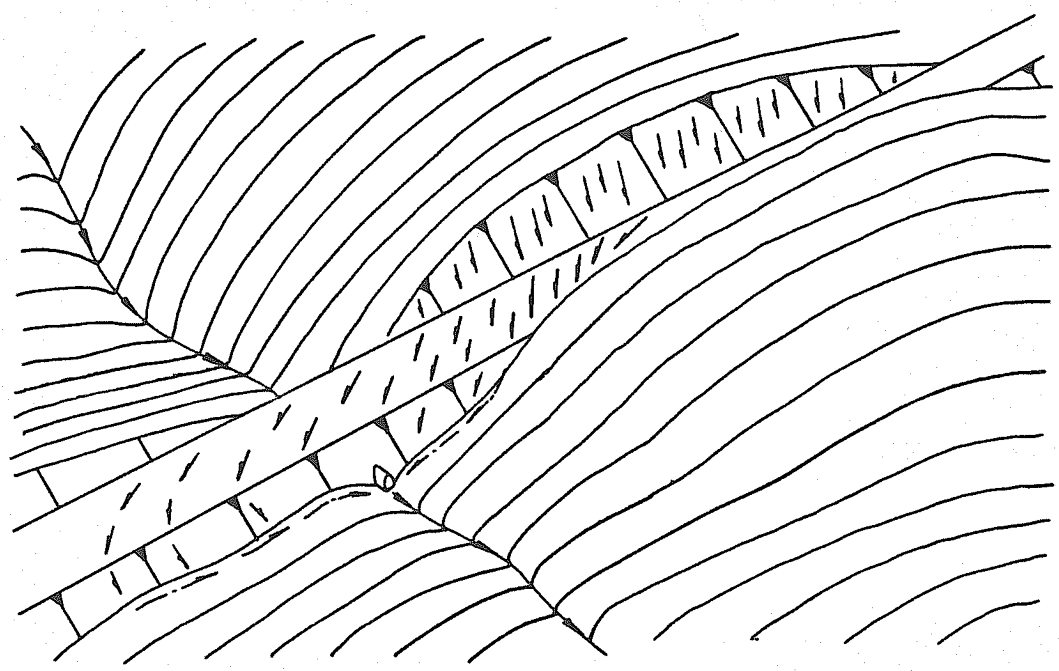
WORKPAD OR ACCESS ROAD IN CUT OR CUT/FILL SECTION



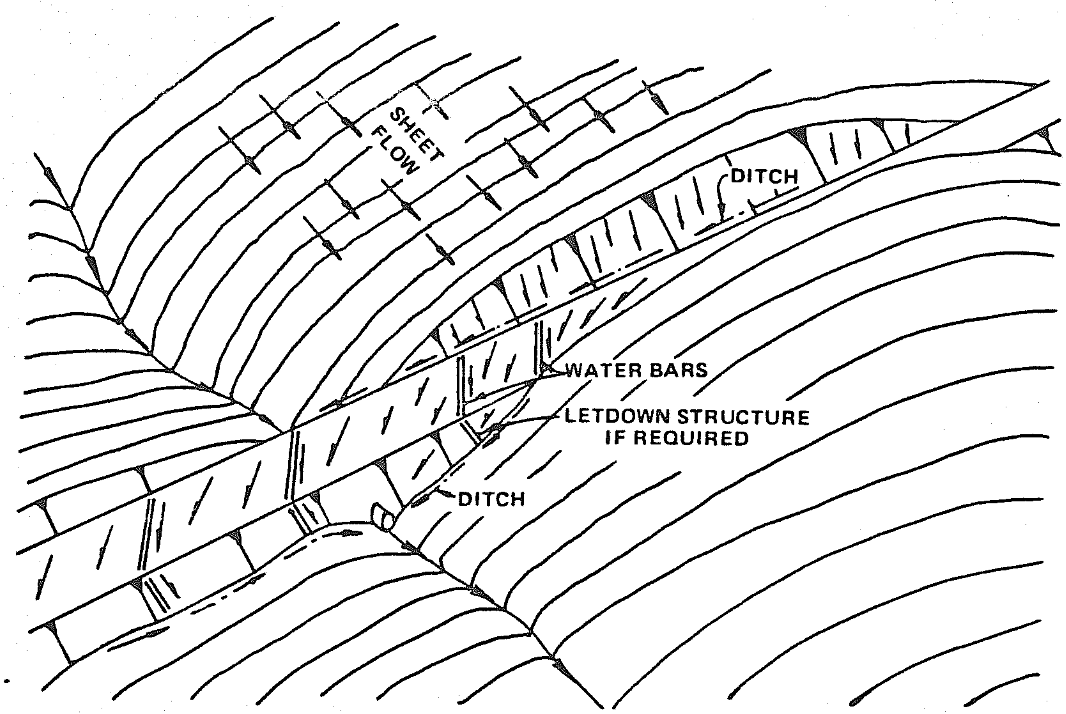
WORKPAD OR ACCESS ROAD IN FILL SECTION

CONCENTRATION OF SHEET FLOW

FIGURE 3



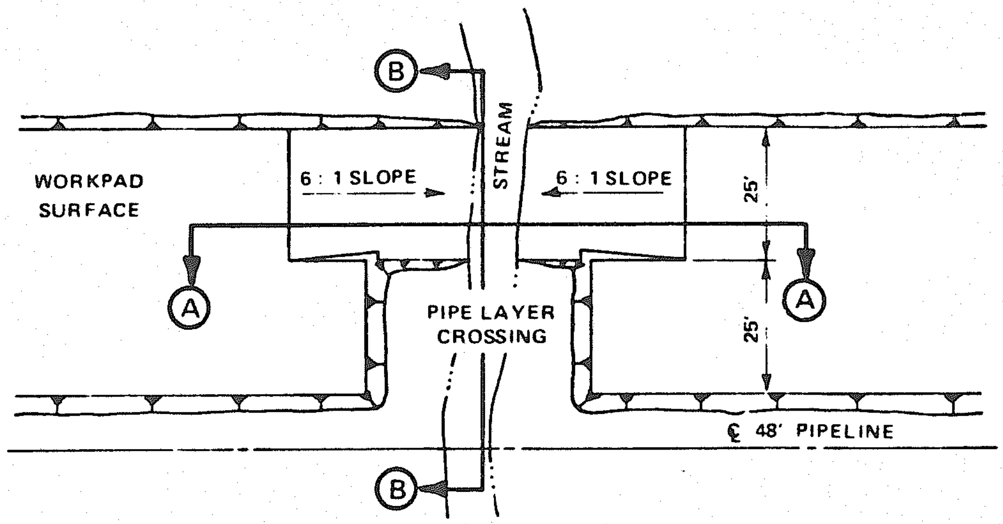
WITHOUT WATER BARS



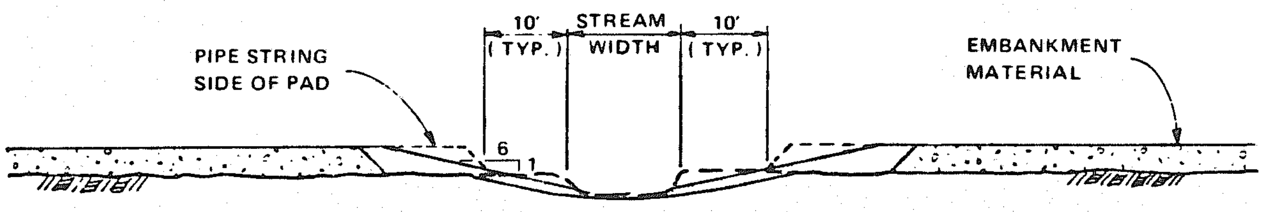
WITH WATER BARS

DRAINAGE ACROSS A CUT FACE AND LONGITUDINAL DRAINAGE
FIGURE 4

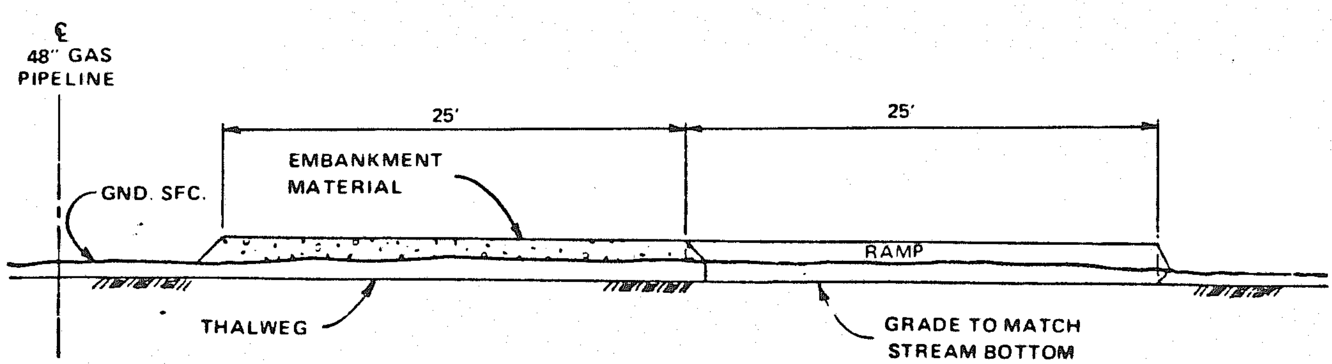
TYPICAL
TYPE I LOW WATER CROSSING
(FOR G & Q SOILS)



PLAN



SECTION A - A

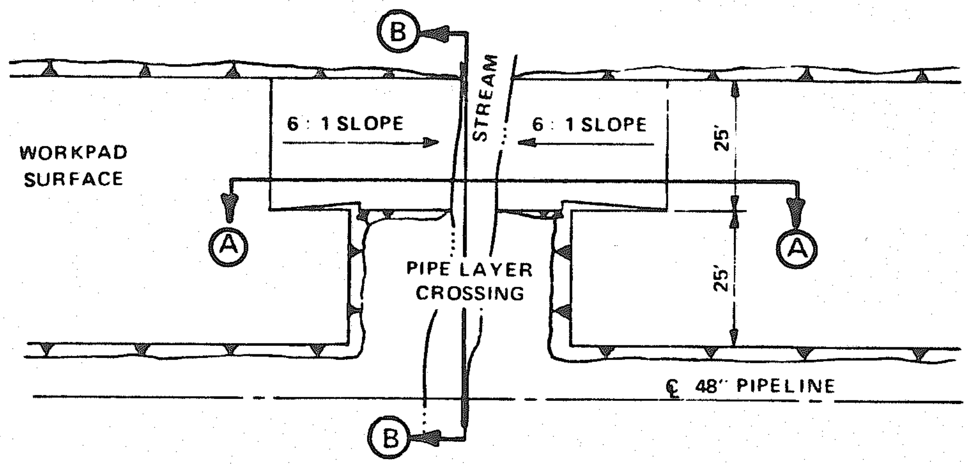


SECTION B - B

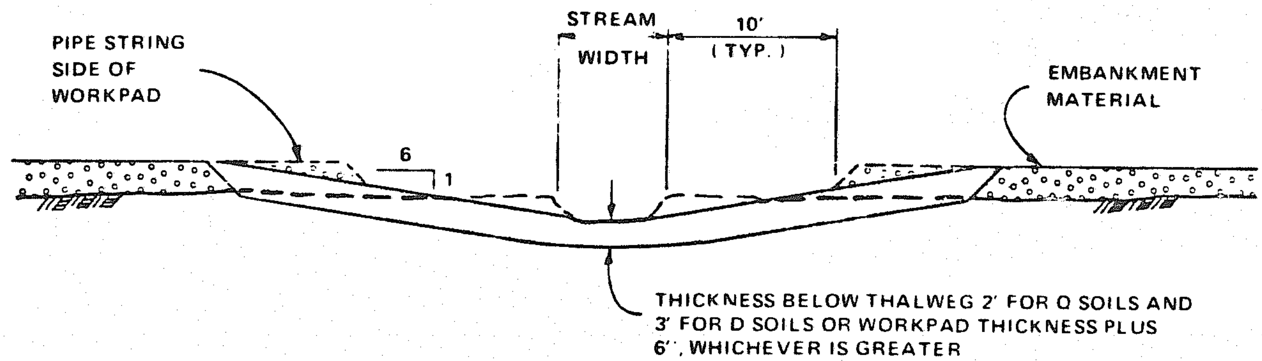
NOTES : 1. NATURAL STREAM ELEVATION, SLOPE, AND WIDTH WILL BE MAINTAINED THRU CROSSING AS PRACTICAL.
2. ONLY ONE TRAFFIC AREA WILL BE PROVIDED.
3. MATERIAL WILL BE GRADED AND ANGULAR.

FIGURE 5

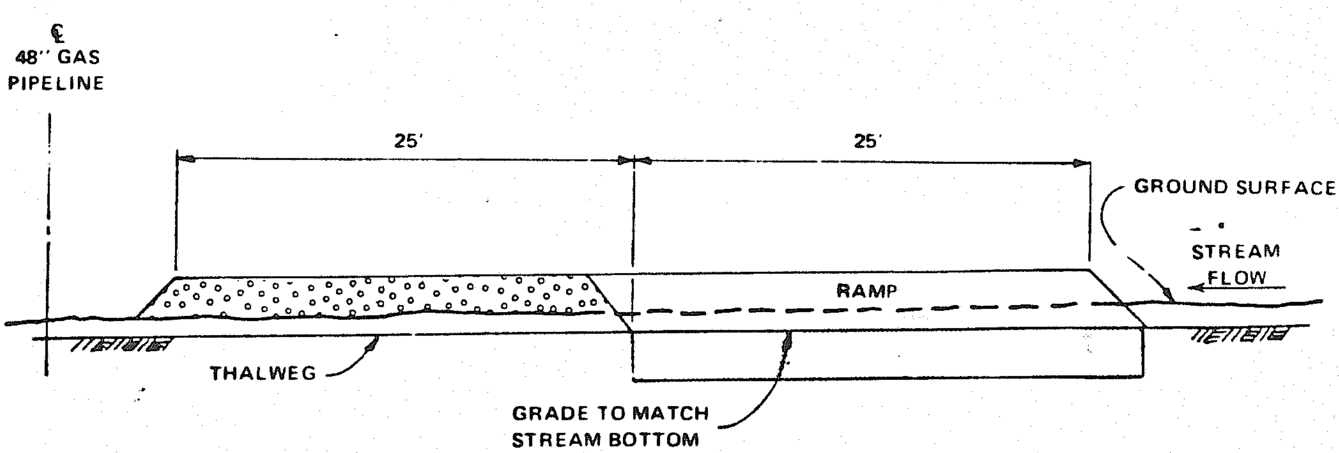
TYPICAL
TYPE II LOW WATER CROSSING
(FOR D & Q SOILS)



PLAN



SECTION A - A



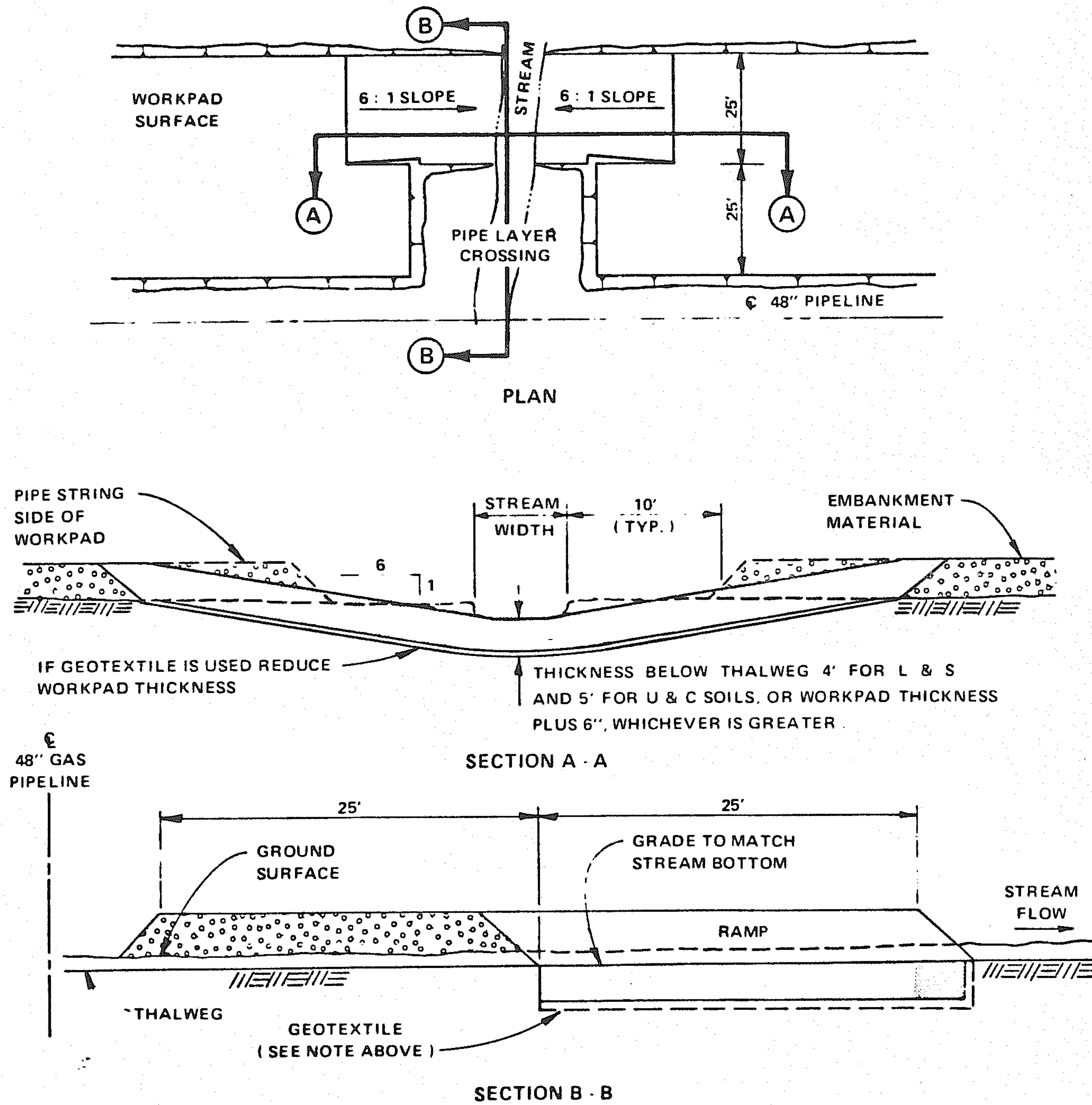
SECTION B - B

NOTE :

1. *NATURAL STREAM ELEVATION, SLOPE, AND WIDTH WILL BE MAINTAINED THRU CROSSING AS PRACTICAL.*
2. *ONLY ONE TRAFFIC AREA WILL BE PROVIDED.*
3. *MATERIAL WILL BE GRADED AND ANGULAR.*

FIGURE 6

TYPICAL
TYPE III LOW WATER CROSSING
(FOR L, S, U, & C SOILS)

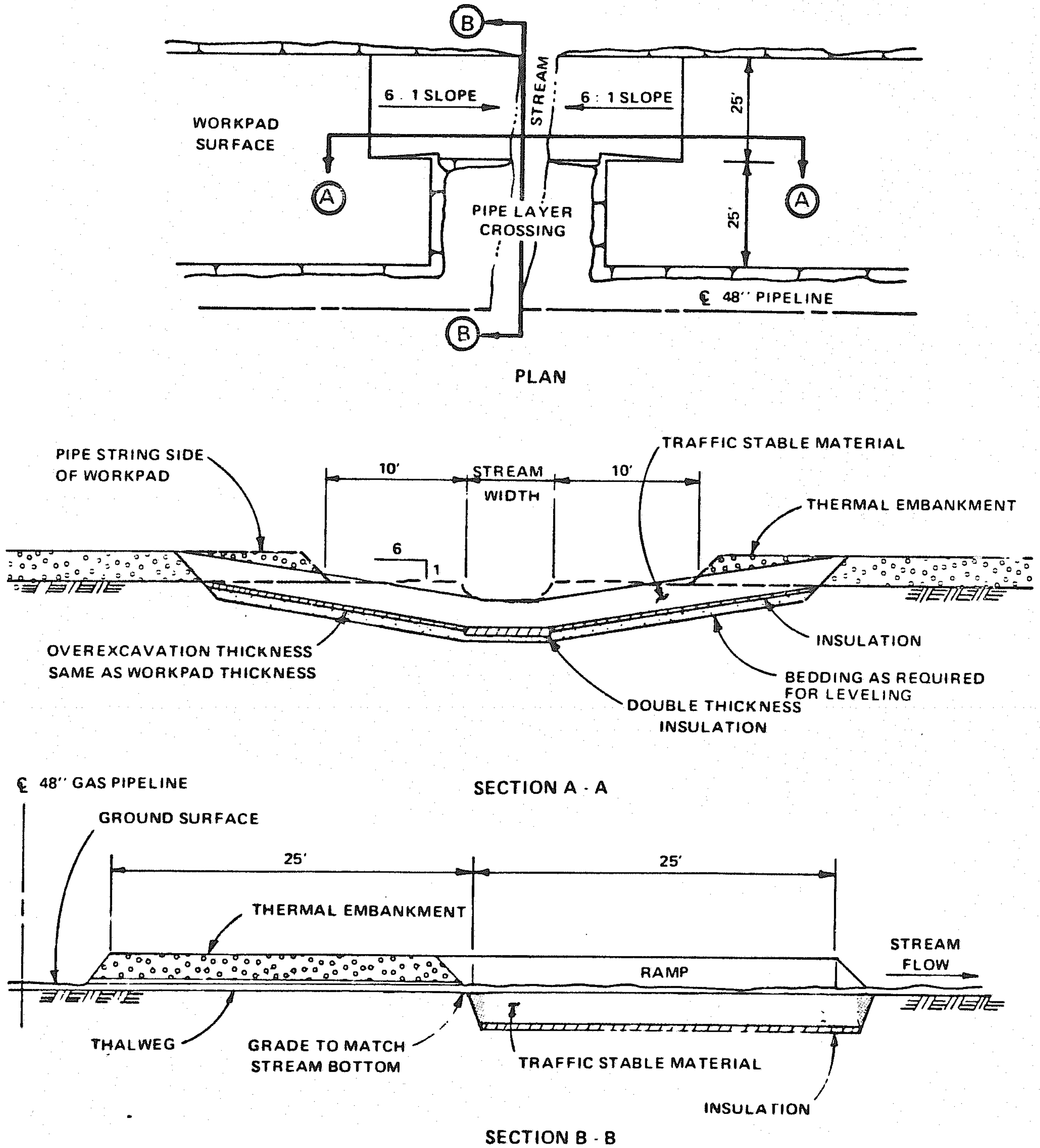


NOTE :

1. *NATURAL STREAM ELEVATION, SLOPE, AND WIDTH WILL BE MAINTAINED THRU CROSSING AS PRACTICAL.*
2. *ONLY ONE TRAFFIC AREA WILL BE PROVIDED.*
3. *MATERIAL WILL BE GRADED AND ANGULAR.*

FIGURE 7

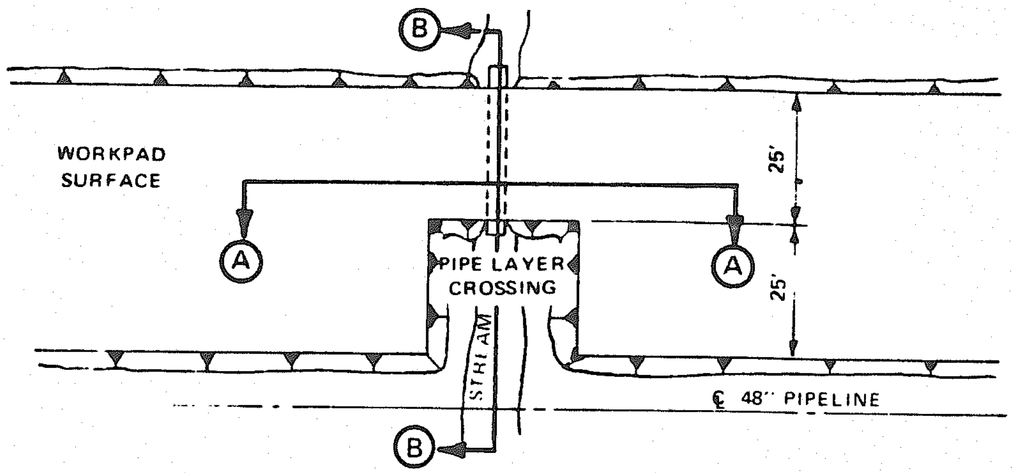
TYPICAL
TYPE IV LOW WATER CROSSING
(ALL SOILS REQUIRING THERMAL DESIGN)



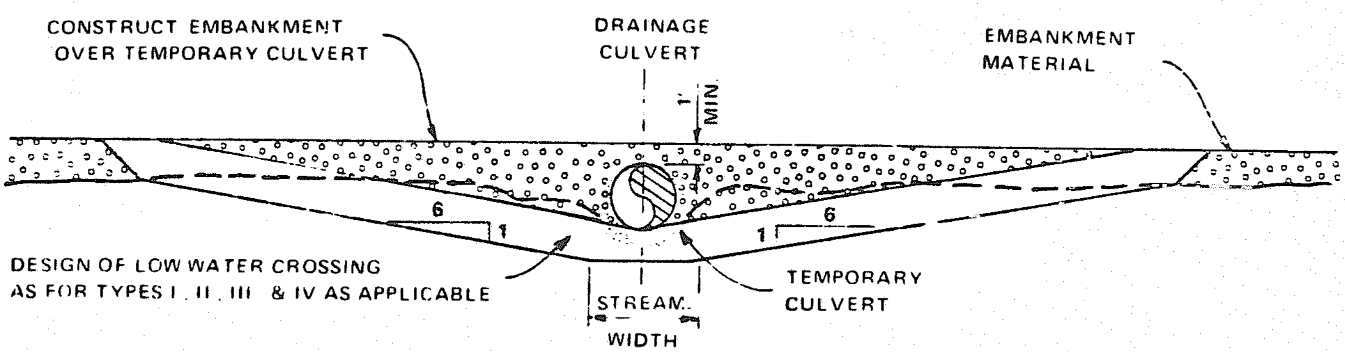
NOTES :
1. *NATURAL STREAM ELEVATION, SLOPE, AND WIDTH WILL BE MAINTAINED THRU CROSSING AS PRACTICAL.*
2. *ONLY ONE TRAFFIC AREA WILL BE PROVIDED.*
3. *MATERIAL WILL BE GRADED AND ANGULAR.*
4. *CONSTRUCTION WILL OCCUR AFTER FREEZEBACK OF THE ACTIVE LAYER.*
5. *INSULATION WILL BE DESIGNED TO LIMIT 3 - YEAR THAW TO THE BOTTOM OF THE INSULATION.*
6. *CONSTRUCTION DURING SHOULDER MONTHS OR STRUCTURAL SUPPORT*

FIGURE 8

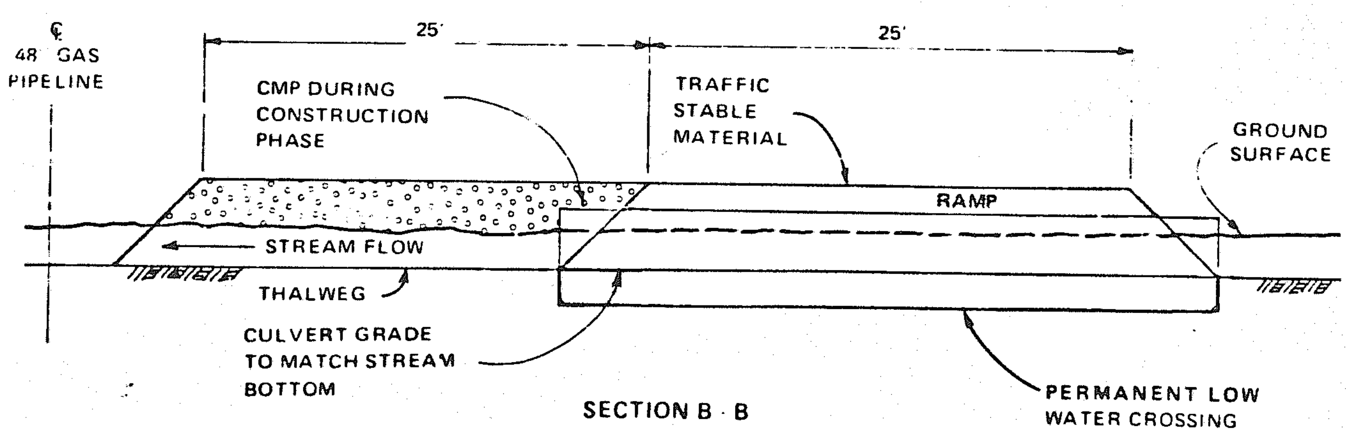
TYPICAL
TYPES I A, II A, III A, OR IV A LOW WATER CROSSINGS
(WHERE CROSSING ACCESS IS REQUIRED DURING CONSTRUCTION)



PLAN



SECTION A A

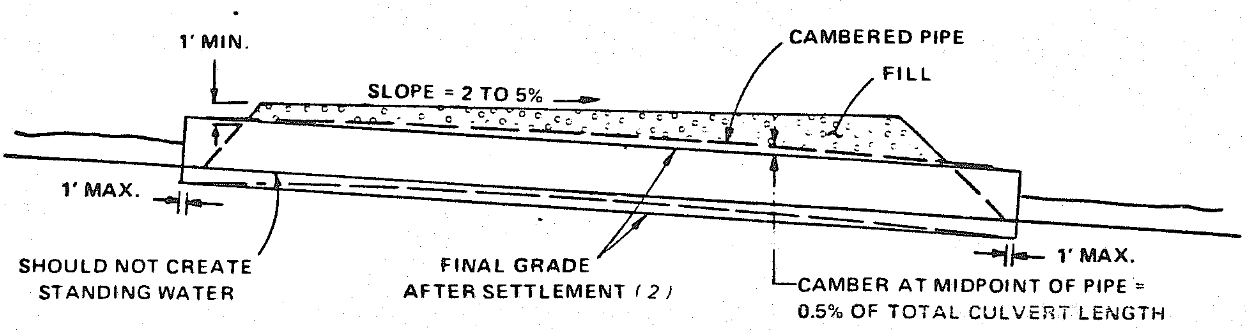


SECTION B - B

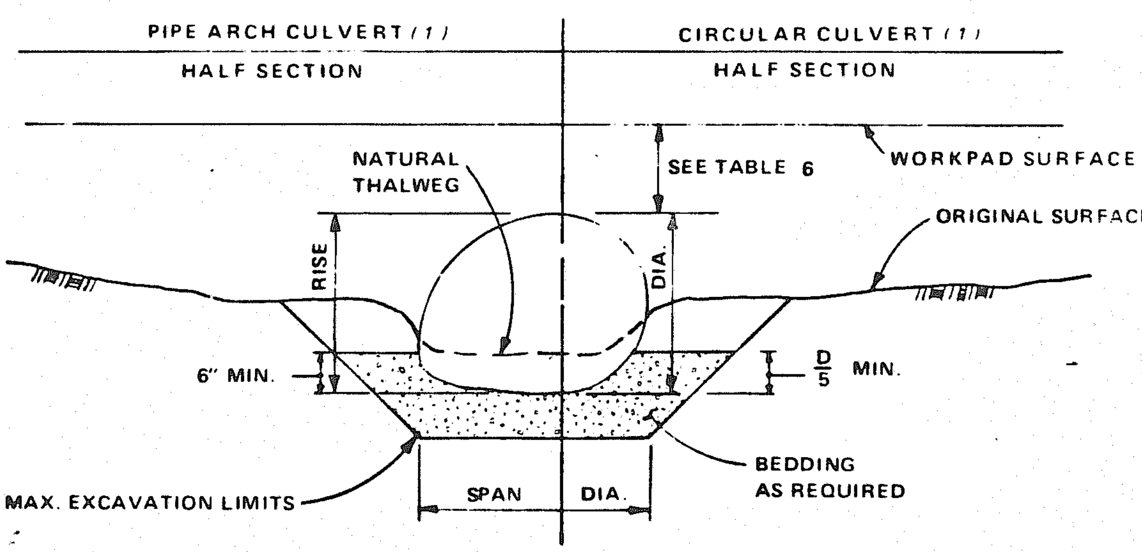
NOTES:
1. *CMP REMOVED DURING RESTORATION TO PROVIDE LWC FOR OPERATIONS VEHICLES.*
2. *LOW WATER CROSSING WITH TEMPORARY CULVERT IS DESIGNATED AS TYPE IA, IIA, IIIA, OR IVA, DEPENDING ON LOW WATER CROSSING REQUIREMENTS (SEE FIGURES ON TYPE I, II, III, OR IV LWC).*
3. *NATURAL STREAM ELEVATION, SLOPE, AND WIDTH WILL BE MAINTAINED THRU CROSSING AS PRACTICAL.*
4. *ONLY ONE TRAFFIC AREA WILL BE PROVIDED.*
5. *MATERIAL WILL BE GRADED AND ANGULAR.*
6. *IN FISH STREAMS, BOTTOM OF CULVERT TO BE PLACED 20% OF DIAMETER BELOW THALWEG.*
7. *IN FISH STREAMS, AFTER TEMPORARY CULVERT IS REMOVED, RECONNECT THE THALWEG TO APPROXIMATE PRECONSTRUCTION FLOW CHARACTERISTICS.*

FIGURE 9

TYPICAL CULVERT PLACEMENT IN FISH STREAMS



LONGITUDINAL SECTION



CROSS SECTION

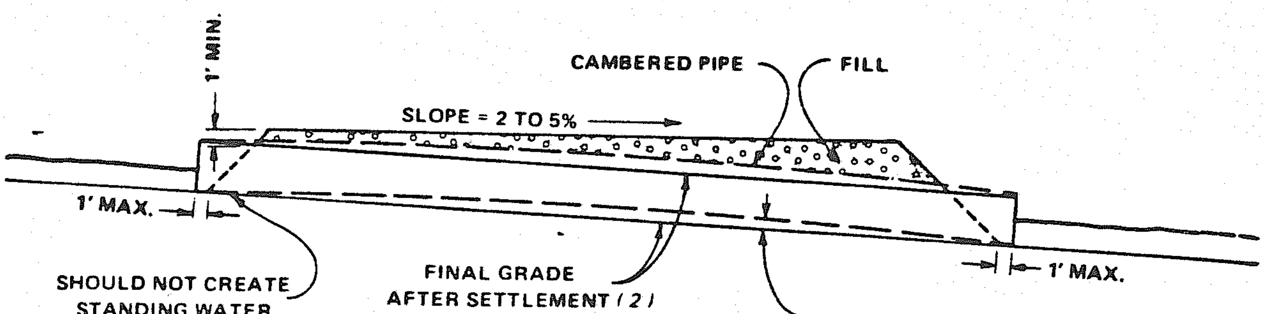
NOTES: 1. CULVERT WILL BE CORRUGATED METAL PIPE.

2. ONE FIFTH OF THE DIAMETER OF ROUND PIPE CULVERTS AND THE BOTTOM 6" OF PIPE-ARCH CULVERTS WILL BE SET BELOW THE THALWEG OF THE NATURAL STREAM.

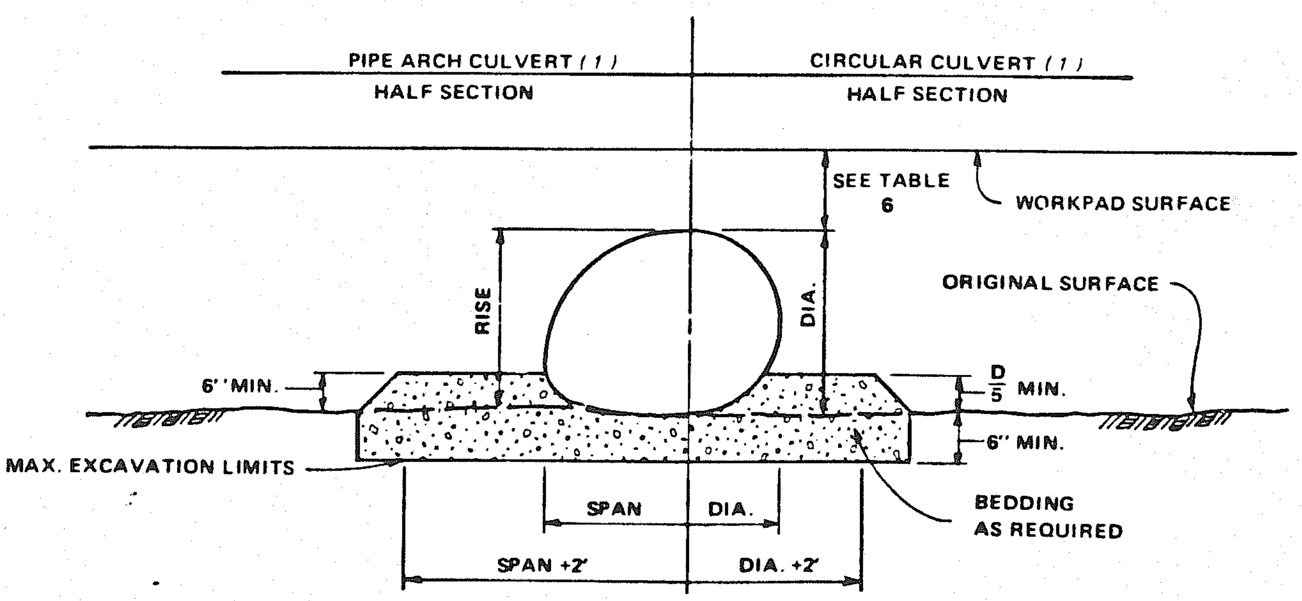
3. THE EXTENSION OF THE CULVERT BEYOND THE TOE MEANS BEYOND ANY ARMORED LAYER.

FIGURE 10

TYPICAL CULVERT PLACEMENT ON THAW - STABLE SOILS



LONGITUDINAL SECTION

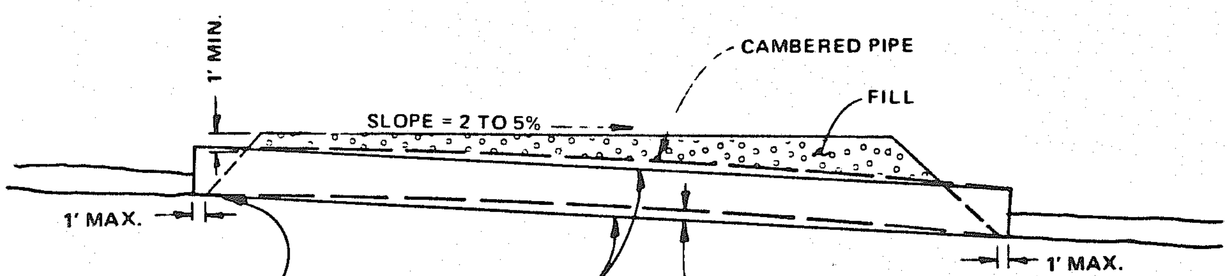


CROSS SECTION

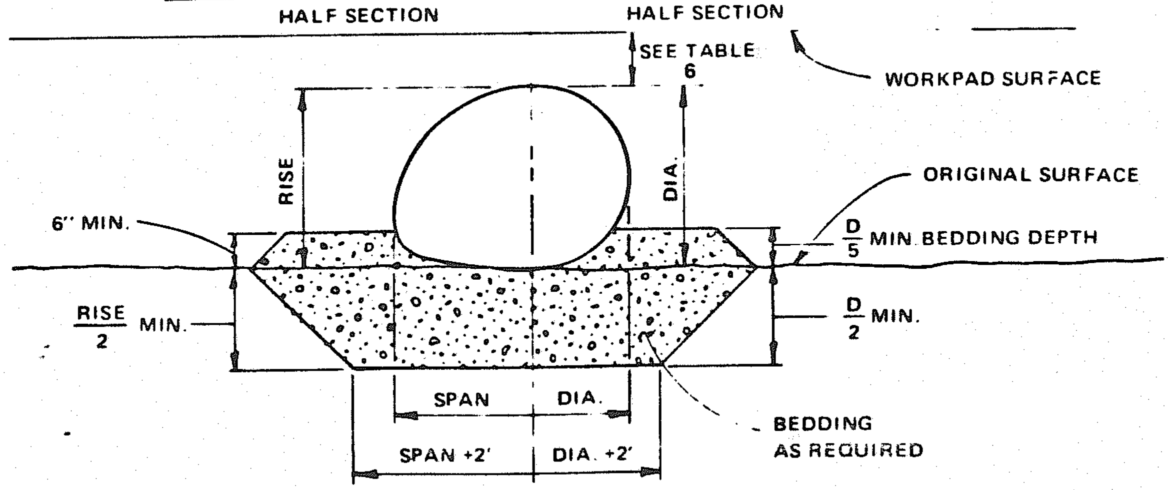
NOTES : 1. CULVERT WILL BE CORRUGATED METAL PIPE.
2. CULVERT GRADE WILL MATCH STREAM BED.
3. THE EXTENSION OF THE CULVERT BEYOND THE TOE MEANS BEYOND ANY ARMORED LAYER.

FIGURE 11

TYPICAL CULVERT PLACEMENT ON THAW - UNSTABLE SOILS



LONGITUDINAL SECTION

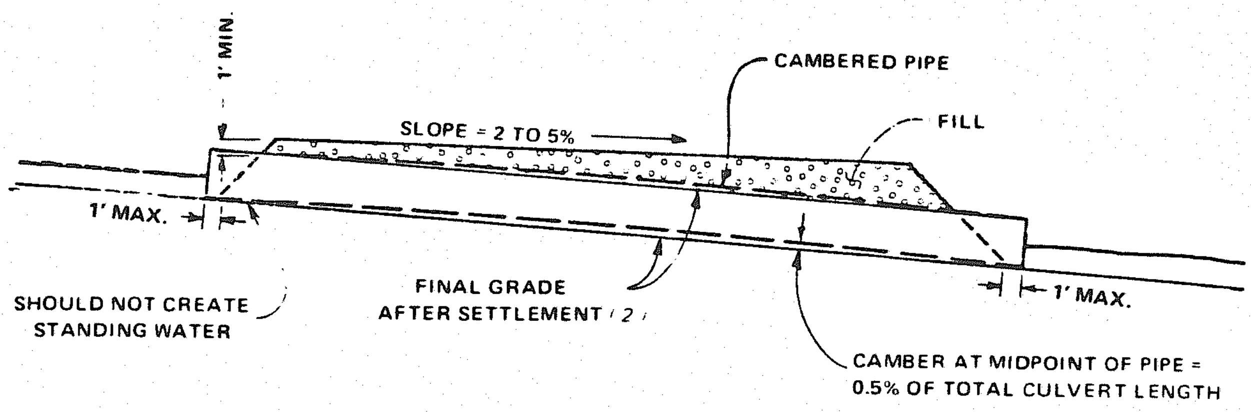


CROSS SECTION

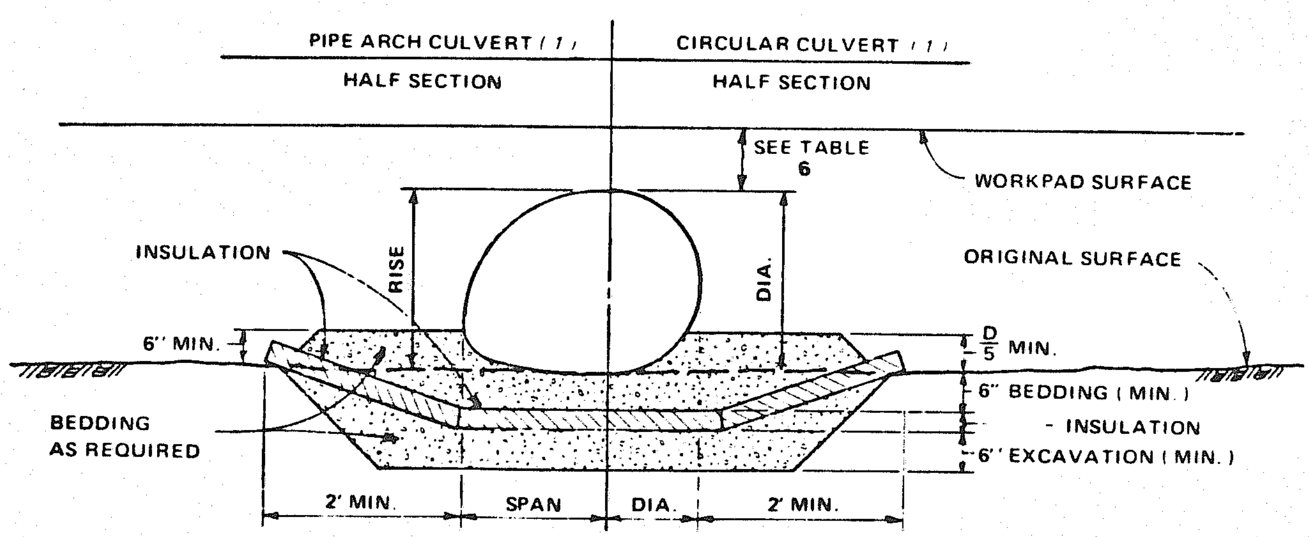
NOTES : 1. CULVERT WILL BE CORRUGATED METAL PIPE.
2. CULVERT GRADE WILL MATCH STREAM BED.
3. THE EXTENSION OF THE CULVERT BEYOND THE TOE MEANS BEYOND ANY ARMORED LAYER.

FIGURE 12

TYPICAL
INSULATED CULVERT PLACEMENT
ON THAW - UNSTABLE SOILS



LONGITUDINAL SECTION

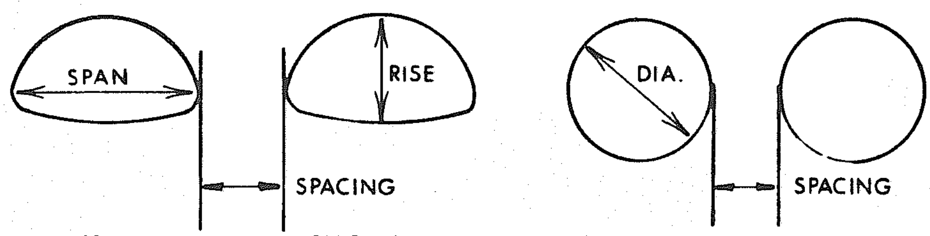


CROSS SECTION

NOTES : 1. CULVERT WILL BE CORRUGATED METAL PIPE.
2. CULVERT GRADE WILL MATCH STREAM BED.
3. THIS DESIGN SHOULD BE USED WHERE EXPECTED THAW STRAIN EXCEEDS 1 FOOT.
4. CONSTRUCTION SHOULD BE SCHEDULED DURING SHOULDER MONTHS.
5. THE EXTENSION OF THE CULVERT BEYOND THE TOE MEANS BEYOND ANY ARMORED LAYER.

FIGURE 13

TYPICAL
MULTIPLE CULVERT PLACEMENT

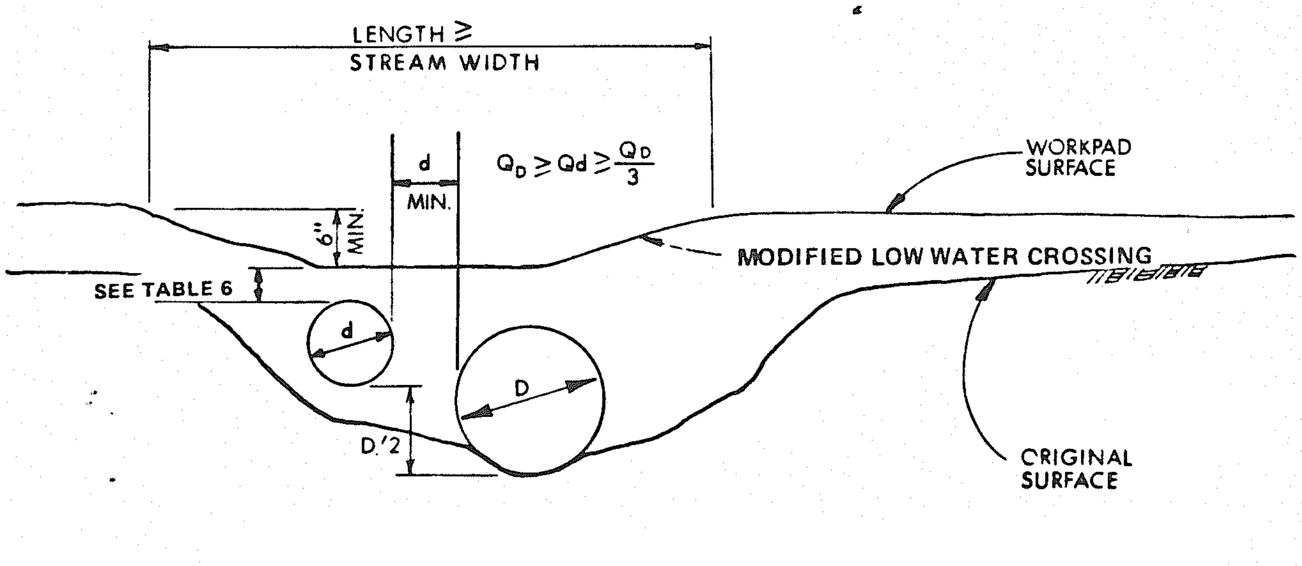


SPAN	SPACING
UP TO 36"	12"
36" TO 108"	1/3 SPAN
108 AND UP	36"

DIAMETER	SPACING
UP TO 24"	12"
24" TO 72"	1/2 DIA.
72" AND UP	36"

CULVERT SPACING FOR MULTIPLE INSTALLATIONS

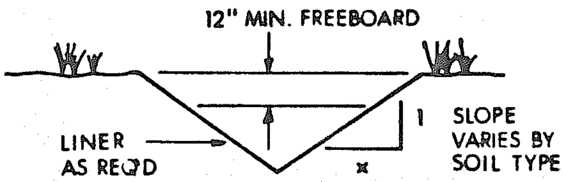
NOTES: 1. CULVERTS WILL BE CORRUGATED METAL PIPE.
2. CULVERT GRADE WILL MATCH STREAM BED.



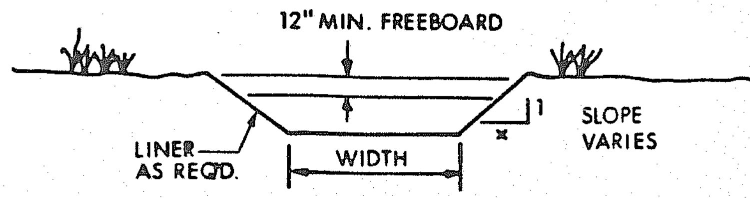
PERCHED RELIEF CULVERT WITH MODIFIED LWC
FOR AUFEIS OR DEBRIS CONTROL

FIGURE 14

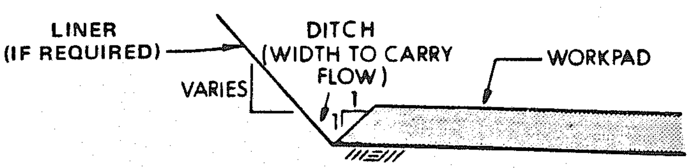
TYPICAL DITCHES AND CHANNELS



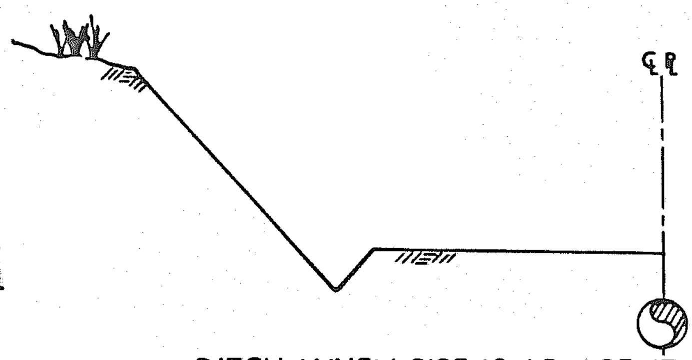
DITCH



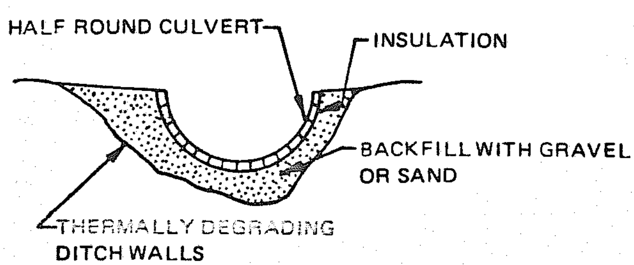
CHANNEL

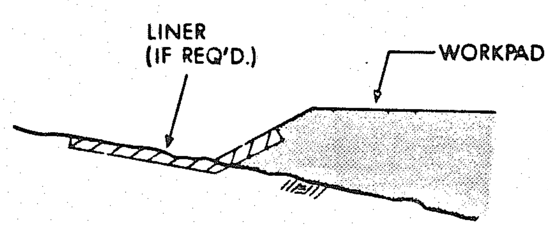


DITCH WHEN WORKPAD IS ADJACENT TO CUT SLOPE

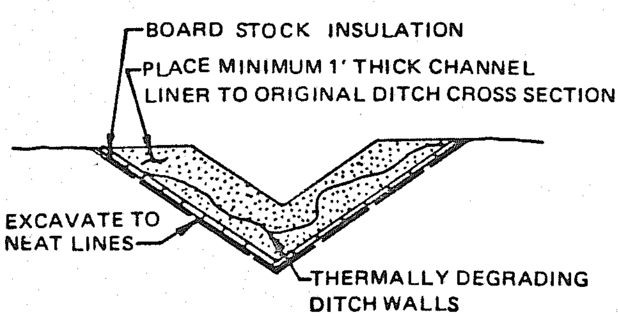


DITCH WHEN PIPE IS ADJACENT TO CUT SLOPE

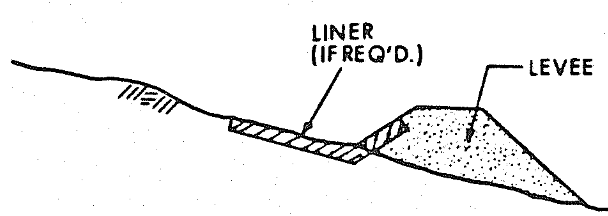




DITCH UPHILL OF WORKPAD



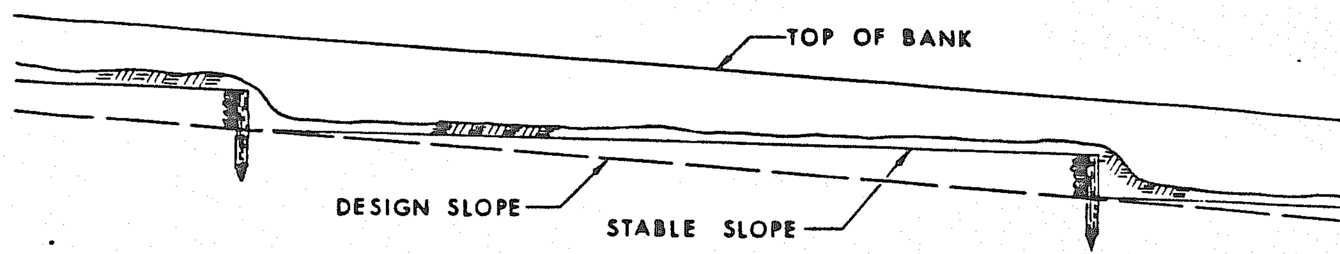
MITIGATION FOR THERMALLY DEGRADING DITCHES



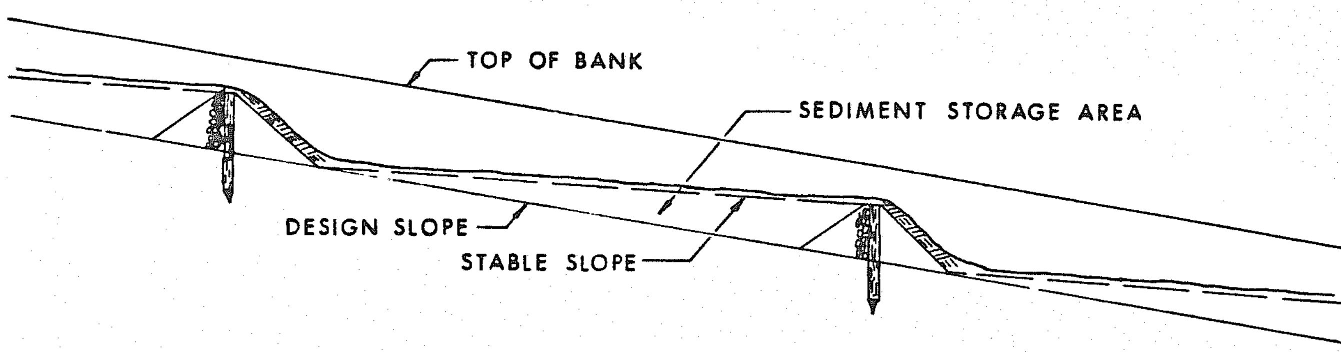
DITCH AGAINST DIVERSION LEVEE

FIGURE 15

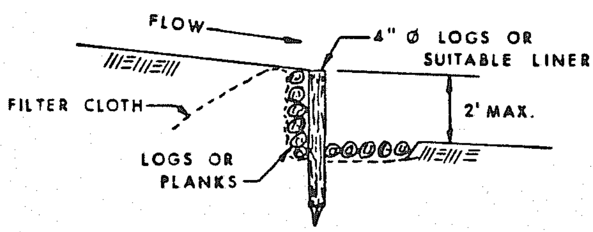
DITCH CHECKS



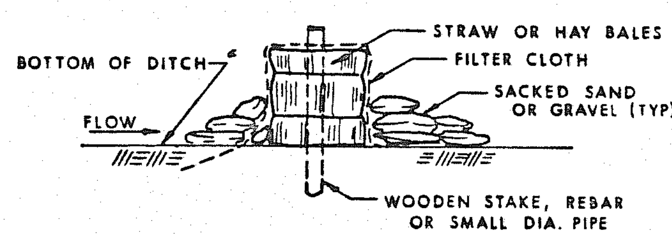
TYPE I DRAINAGE DITCH CHECK



TYPE II & II A DRAINAGE DITCH CHECK

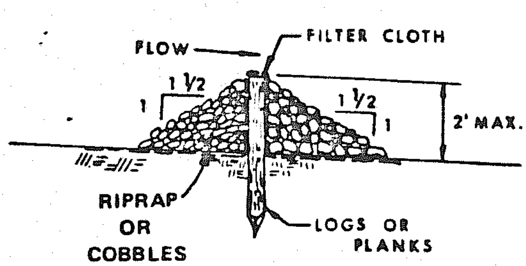


TYPE I

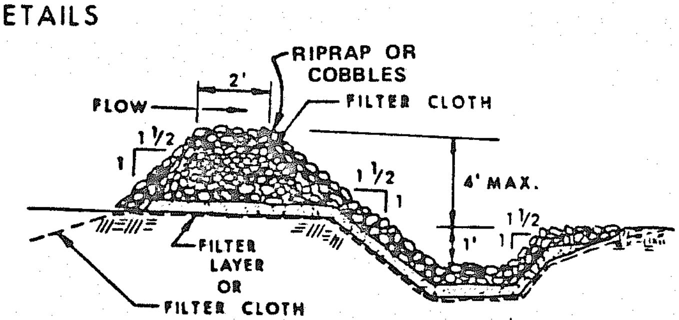


TYPE II (TEMPORARY)

DETAILS



TYPE II

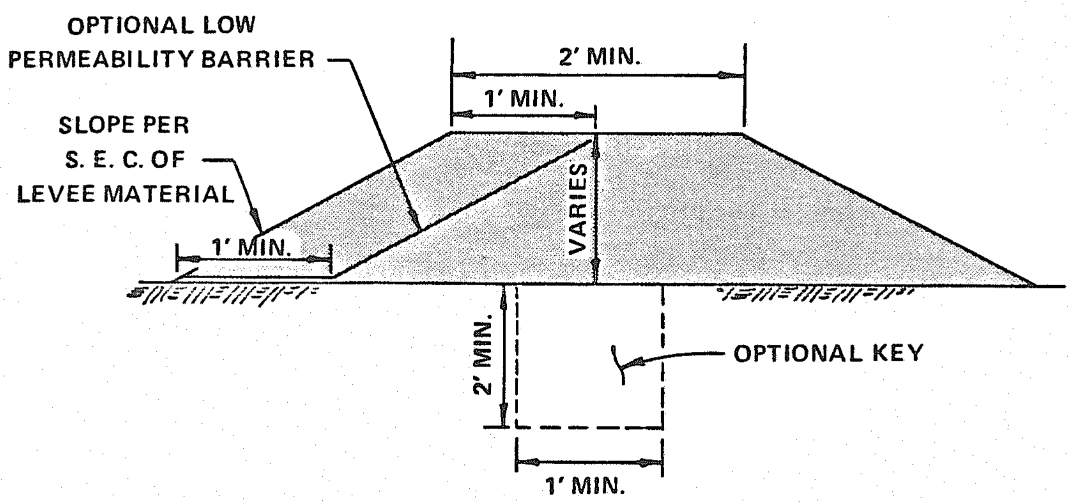


TYPE IIA (STEEP SLOPES)

ADAPTED FROM REFERENCE 2

FIGURE 16

DIVERSION LEVEE



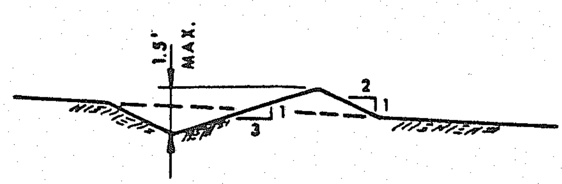
DETAIL DIVERSION LEVEE

NOTES : 1. SECTION OF LEVEE IS OPTIMIZED FOR PURPOSES OF DESIGN.
2. LEVEE TO BE CONSTRUCTED USING LOW PERMEABILITY MATERIAL.
3. LOW PERMEABILITY MEMBRANE MAY BE USED IN PLACE OF LOW PERMEABILITY MATERIAL IF LOW PERMEABILITY MATERIAL IS NOT AVAILABLE.
4. SLOPE HYDRAULICS MAY REQUIRE THAT THE LEVEE BE KEYED INTO THE EXISTING GROUND.

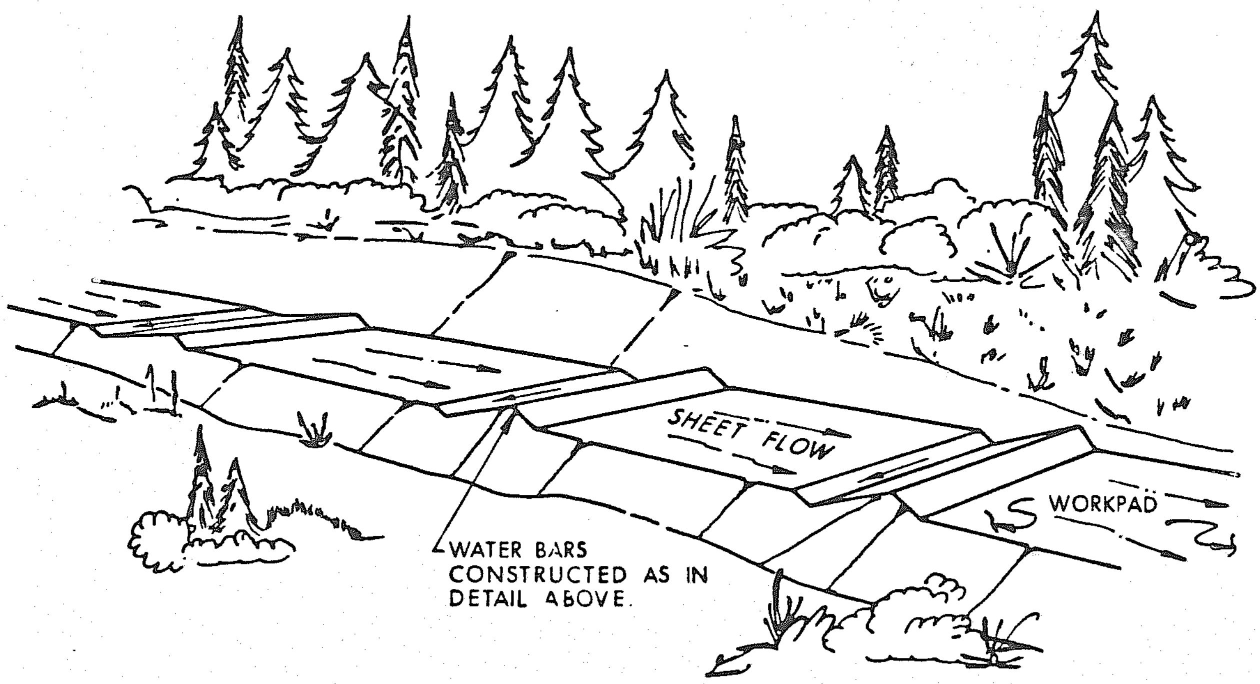
ADAPTED FROM
REFERENCE 2

FIGURE 17

WATER BARS



DETAIL

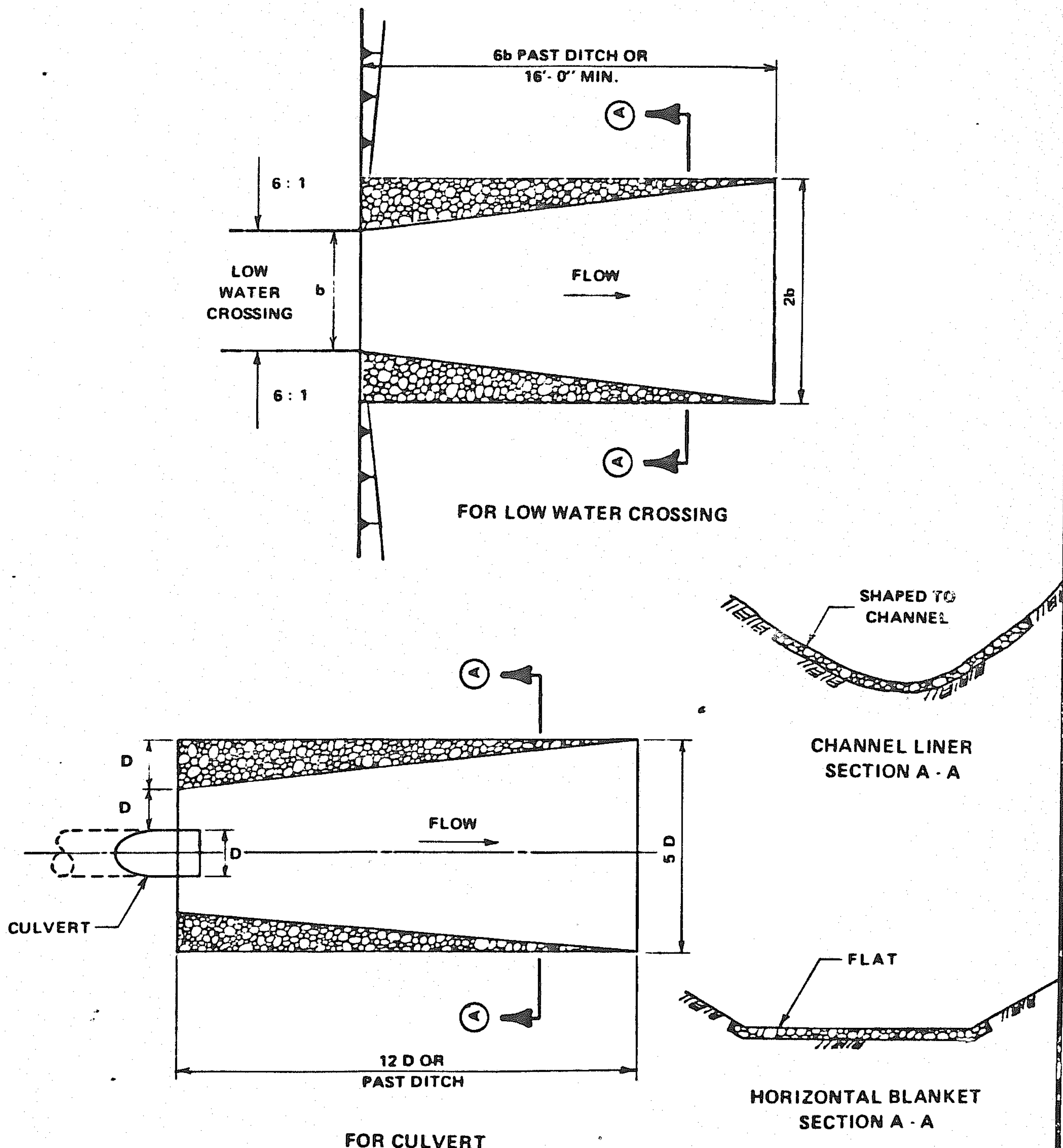


WATER BARS

ADAPTED FROM
REFERENCE 2

FIGURE 18

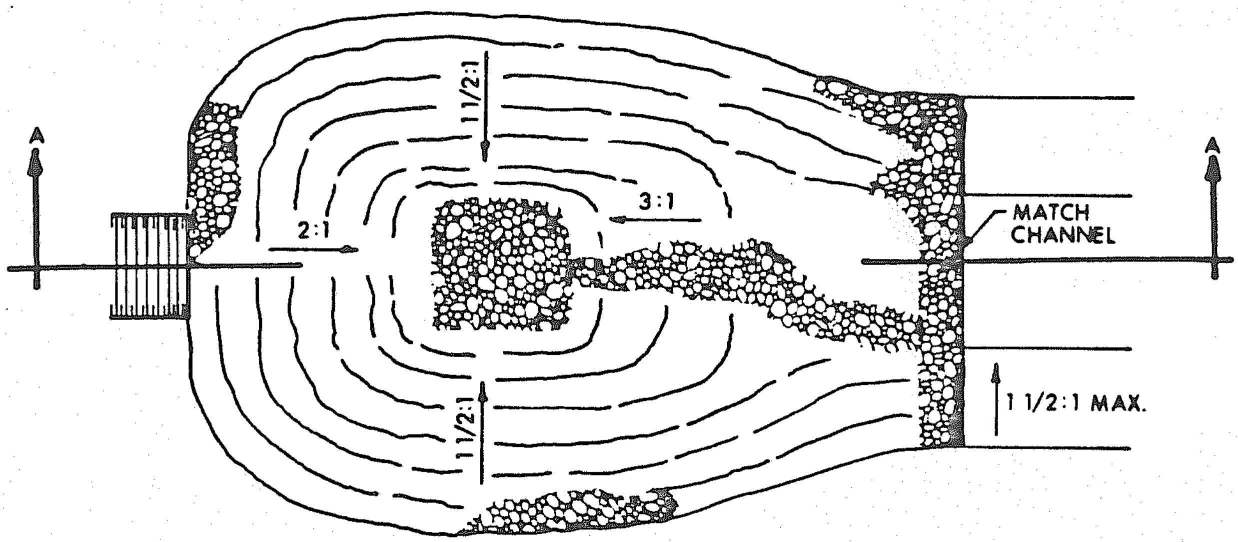
CHANNEL LINING - RIPRAP
BLANKET OR CHANNEL LINER



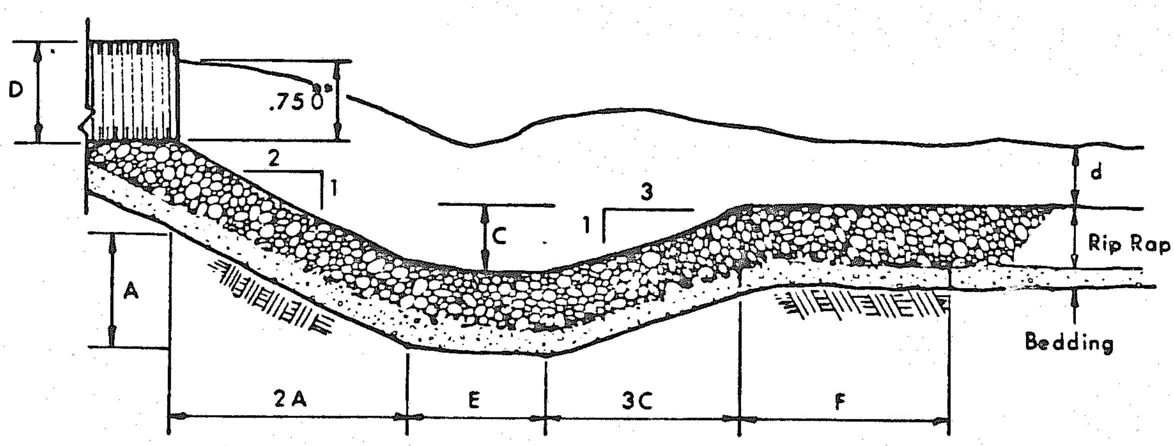
ADAPTED FROM
REFERENCE 16

FIGURE 19

PLUNGE BASIN



PLAN



SECTION A-A

PLUNGE BASIN DIMENSIONS, FEET

* PIPE DIAM. OR CHANNEL BOTTOM WIDTH IN INCHES	Vel. < 18 FPS					18 < Vel. < 24 FPS					24 < Vel. < 36 FPS				
	A	C	E	d	F	A	C	E	d	F	A	C	E	d	F
24	3	1.5	3	1.5	4	3	1.5	5	1.5	4	4	2.0	7	1.5	4
30	3	1.5	3	2.0	4	3	1.5	5	2.0	4	4	2.0	7	2.0	4
36	3	1.5	3	2.5	5	3	1.5	5	2.5	5	4	2.0	7	2.5	5
42	3	1.5	3	3.0	5	3	1.5	5	3.0	5	4	2.0	7	3.0	5
48	3	1.5	3	3.0	6	4	2.0	5	3.0	6	5	2.5	7	3.0	6
60	4	2.0	3	4.0	8	4	2.0	5	4.0	8	6	3.0	7	4.0	8
Riprap	18" Class I					24" Class II					30" Class III				
Bedding	6 inches					8 inches					10 inches				

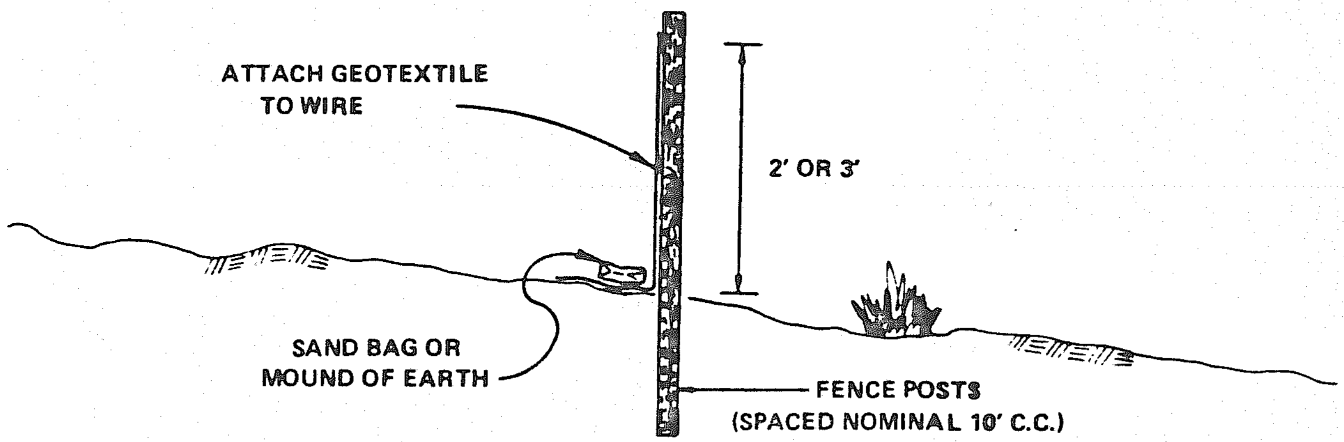
WHERE PLUNGE BASIN IS USED FOR A CULVERT, USE PIPE DIAMETER OR SPAN. WHERE PLUNGE BASIN IS USED FOR A CHANNEL OR A LETDOWN STRUCTURE, USE INLET CHANNEL BOTTOM WIDTH.

***) WHERE PLUNGE BASIN IS USED FOR A CULVERT, USE 0.75 OF PIPE DIAMETER OR RISE. WHERE PLUNGE BASIN IS USED FOR A CHANNEL OR A LETDOWN STRUCTURE, USE INLET CHANNEL DESIGN DEPTH.*

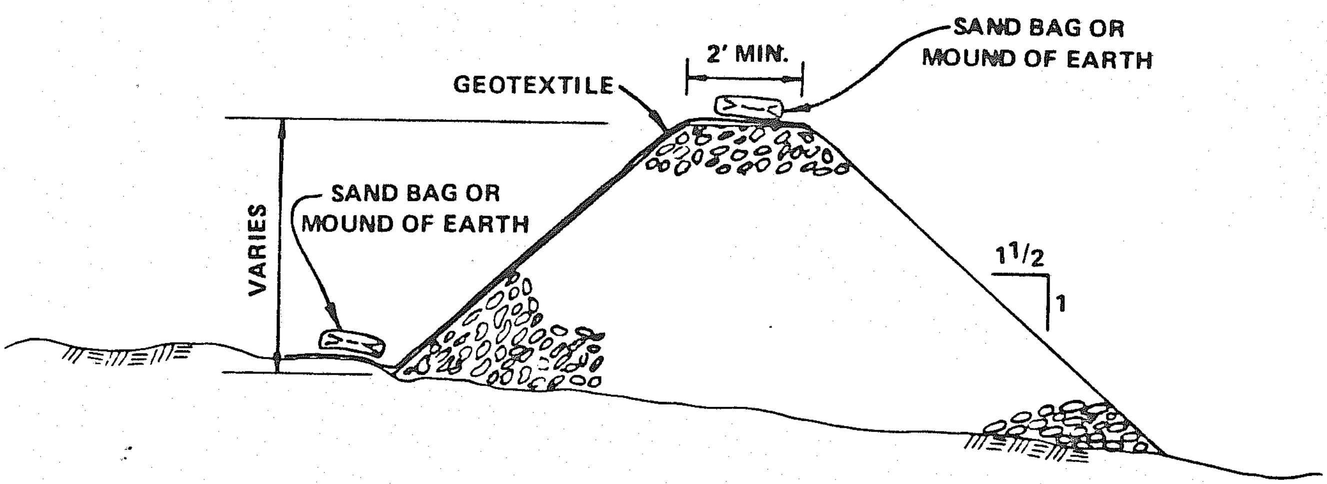
ADAPTED FROM REFERENCE 1

FIGURE 20

SEDIMENT CONTROL MEASURES



SILT FENCE



SEDIMENT FILTER

FIGURE 21

ABLATED SLOPE

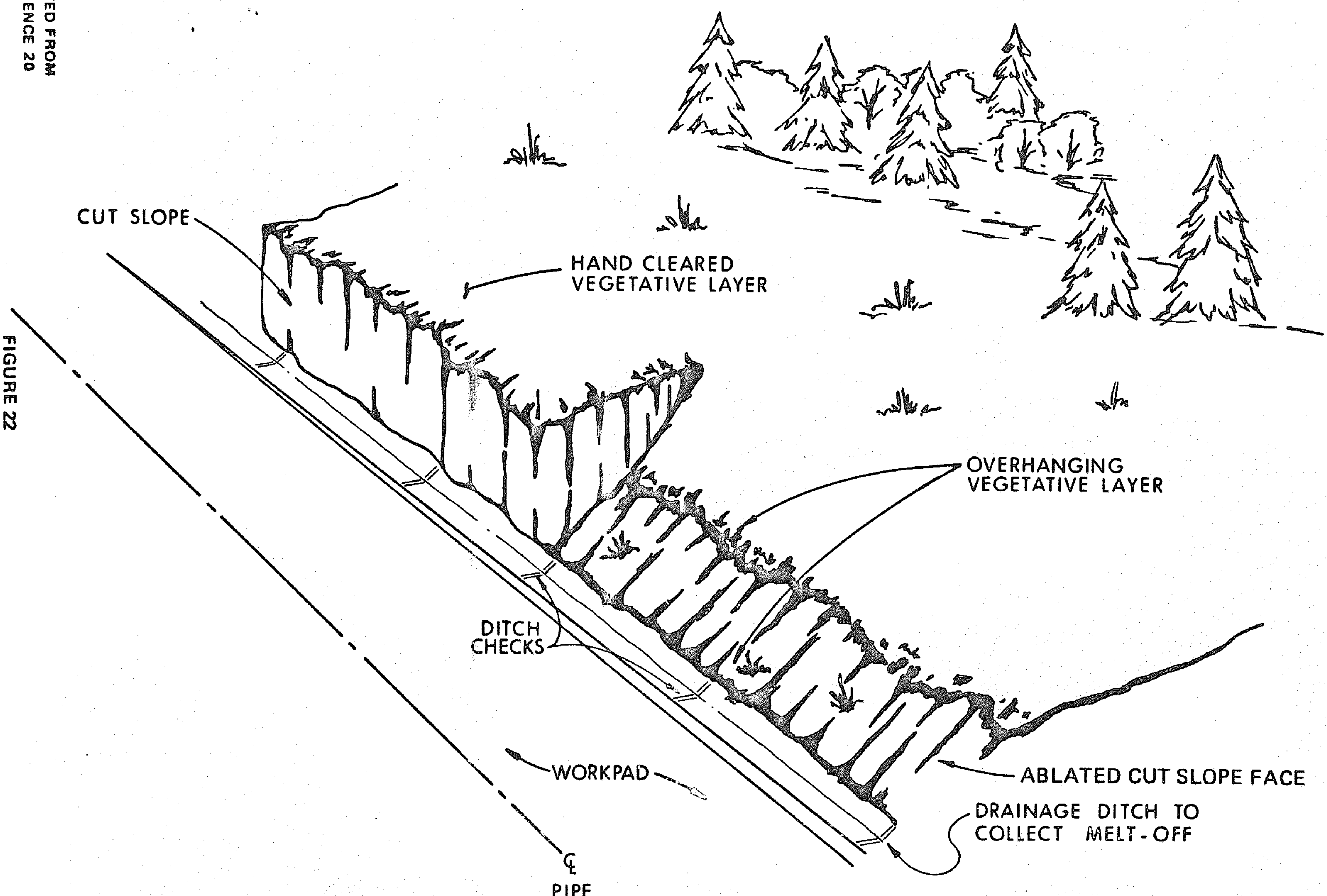
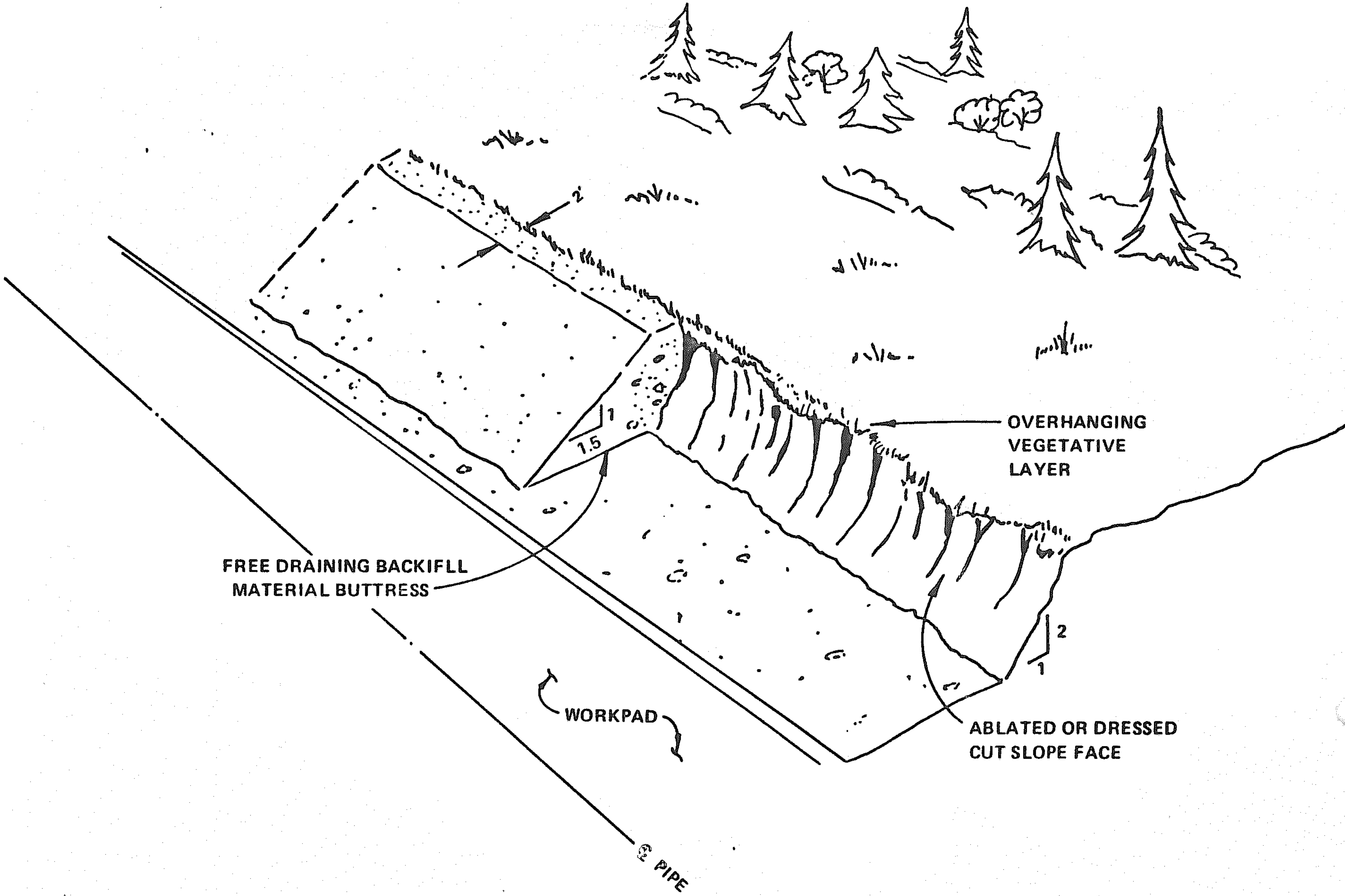


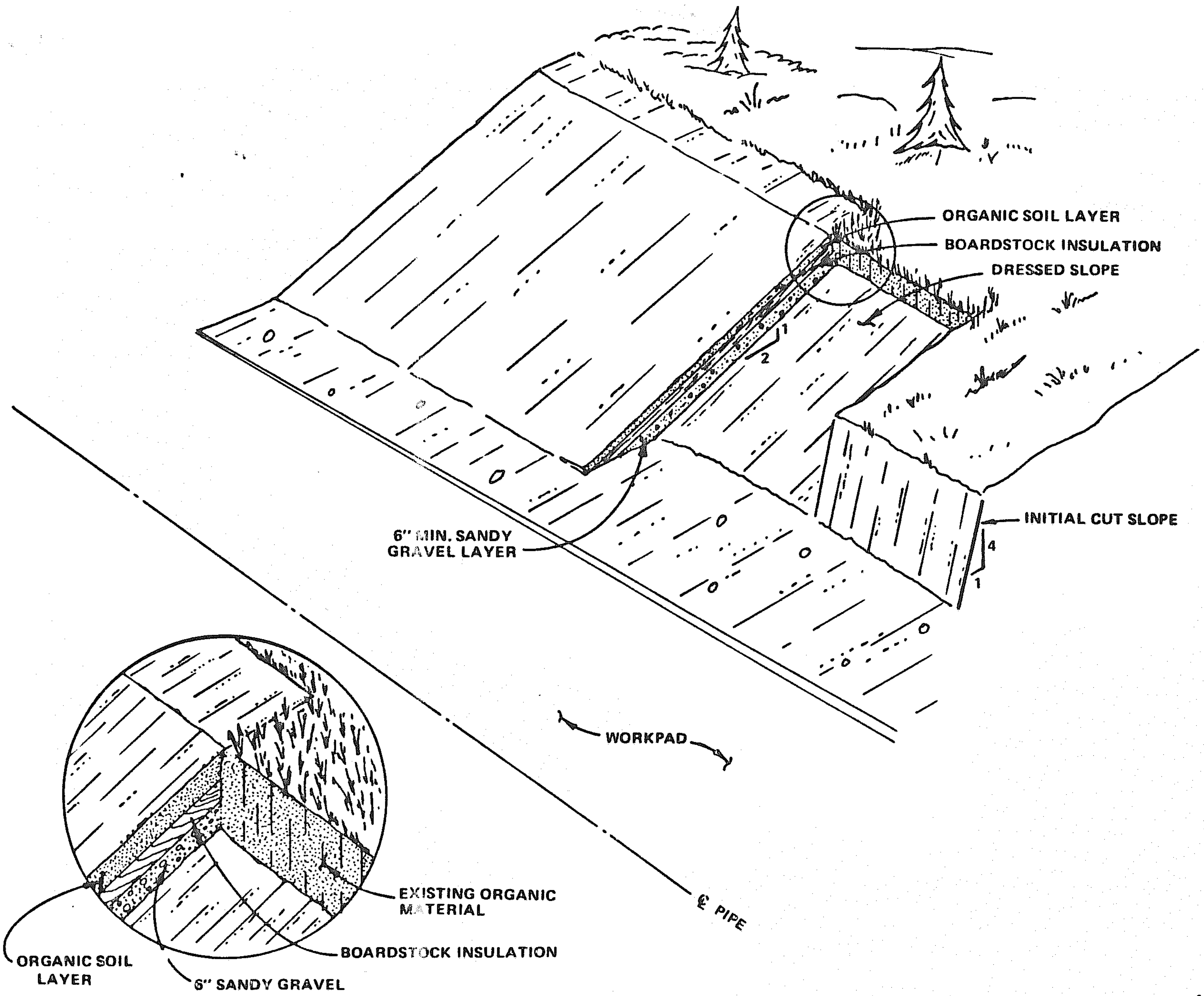
FIGURE 22

ADAPTED FROM REFERENCE 20



ADAPTED FROM REFERENCES 2 AND 20

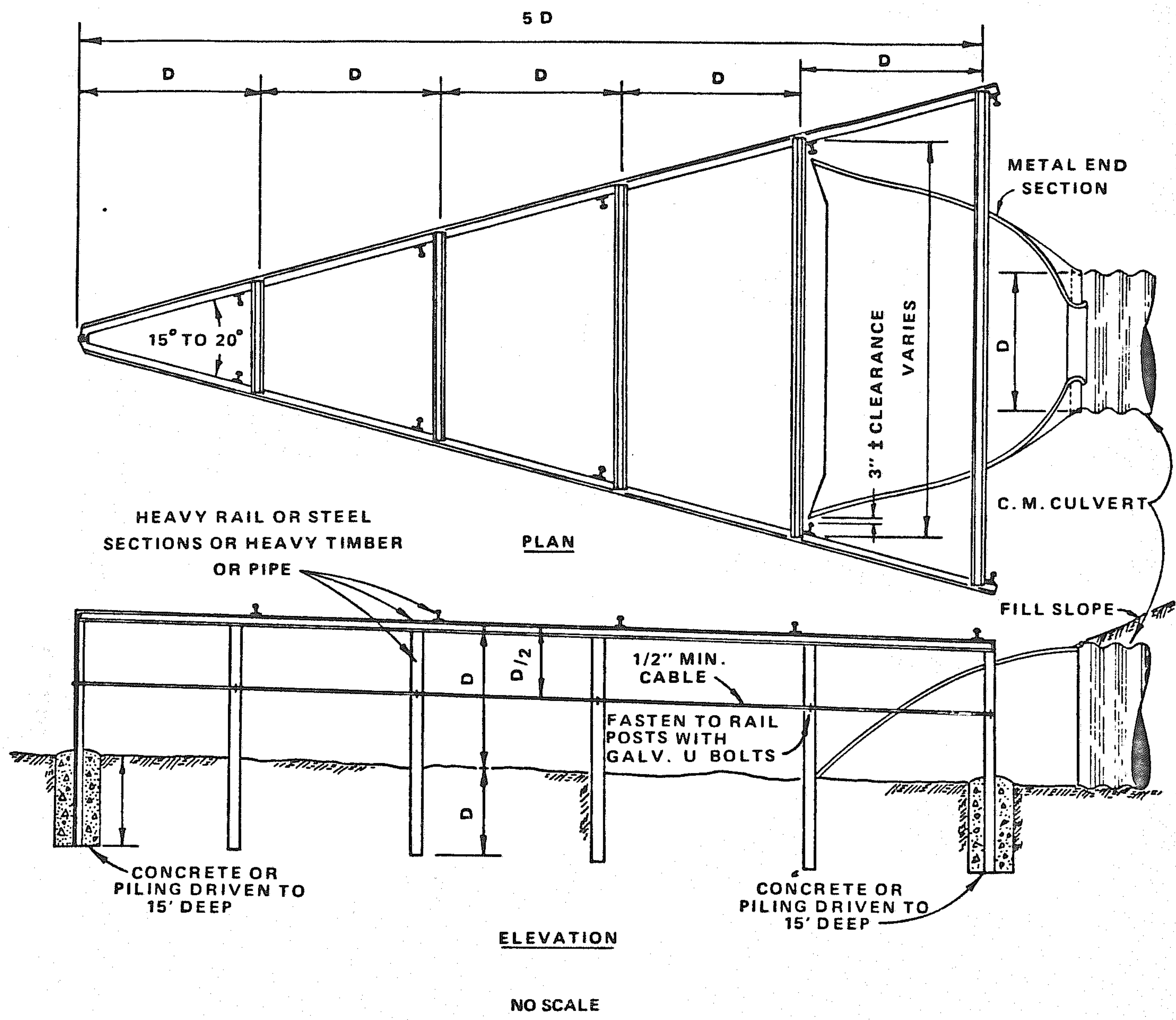
GRAVEL BUTTRESS
FIGURE 23



ADAPTED FROM REFERENCES 2, 19 AND 20

INSULATED THERMAL BLANKET

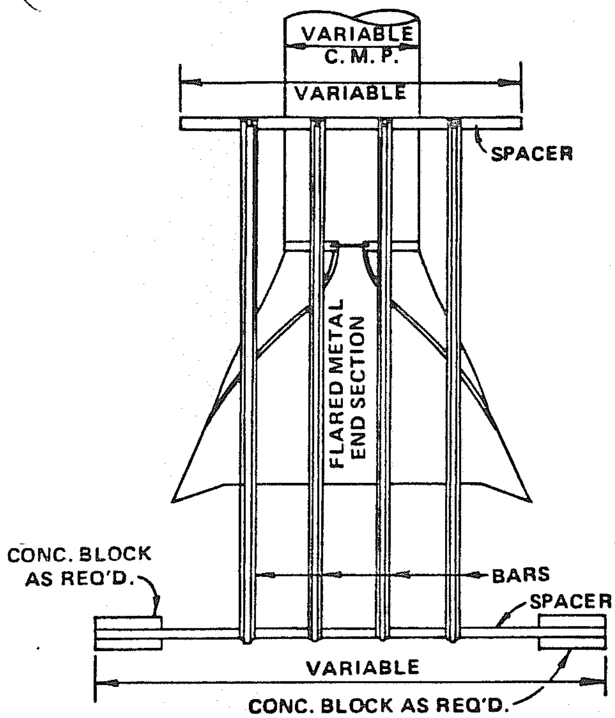
FIGURE 24



DEBRIS DEFLECTOR

FIGURE 25

ADAPTED FROM REFERENCE 11

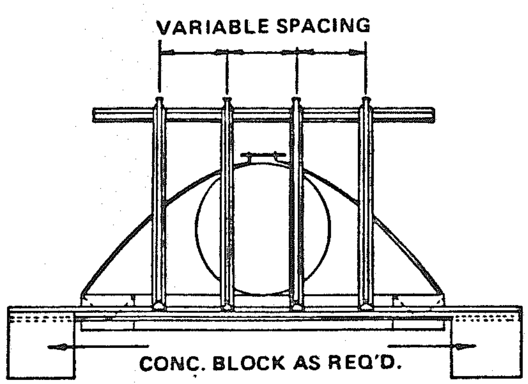


PLAN

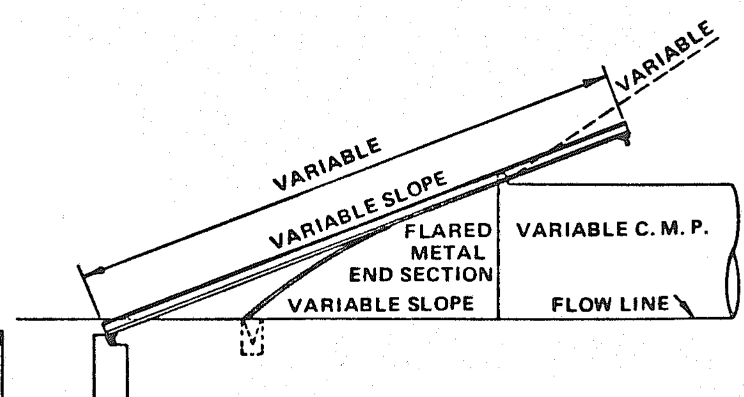
BAR SPACING FOR VARIOUS CULVERTS		
C. M. P.	BARS REQUIRED	BAR SPACING
18"	3	1' - 0"
24"	4	1' - 2"
30"	4	1' - 4"
36"	4	1' - 8"
42"	5	1' - 8"
48"	5	1' - 9"
> 48"	DIAMETER IN FT. +1	DIAMETER / 3

REQUIRED LENGTH OF BARS			
C. M. P.	SLOPE OF BAR	BAR LENGTH	MATERIAL
18"	3 : 1	8' - 3"	STD. 3" PIPE OR 25 TO 40 LB. RAIL
24"	3 : 1	11' - 0"	
30"	3 : 1	12' - 0"	
36"	3 : 1	13' - 6"	40# TO 60# RAIL OR STEEL I's
42"	3 : 1	15' - 0"	
48"	3 : 1	16' - 6"	
> 48"	3 : 1	3 X DIAMETER + 4'	

LENGTH OF SPACERS			
C. M. P.	TOP SPACER	BOTTOM SPACER	MATERIAL
18"	6' - 0"	8' - 0"	4" X 4" X 3/8" ∠'s
24"	7' - 0"	10' - 0"	40 TO 60 LB. RAIL OR 3" PIPE
30"	7' - 6"	11' - 0"	
36"	8' - 0"	12' - 6"	
42"	9' - 0"	13' - 9"	
48"	10' - 0"	15' - 0"	
> 48"	2 X DIAMETER + 2'	3 X DIAMETER + 3'	



FRONT ELEVATION



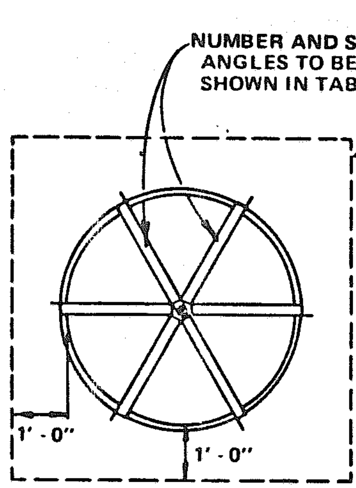
RIGHT SIDE ELEVATION

NOTES: MINIMUM BAR SPACING 0' - 10".
MAXIMUM BAR SPACING = DIAMETER / 2
GRADIENTS STEEPER THAN 15% MAY REQUIRE SPECIAL TREATMENT.
SIZES SHOWN ARE MINIMUMS TO BE USED.
HEAVIER SECTIONS PERMITTED IN ALL CASES.

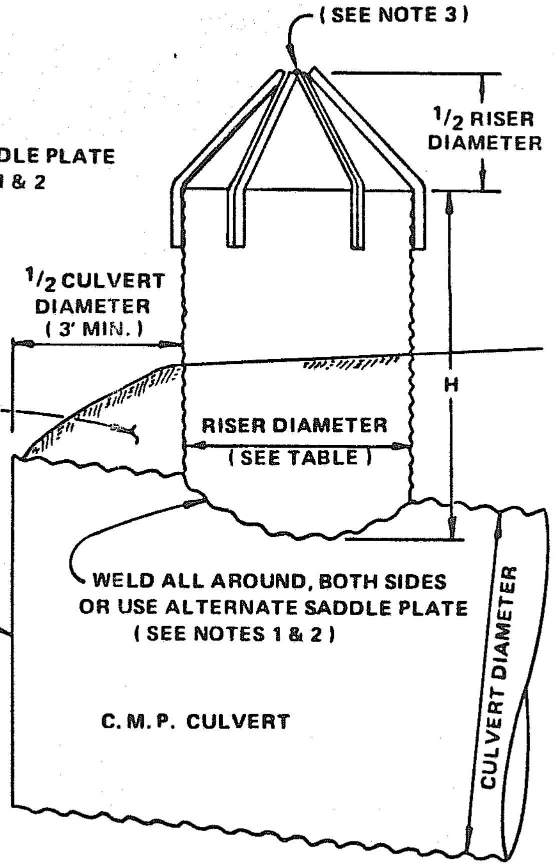
ADAPTED FROM
REFERENCE 11

DEBRIS RACK

FIGURE 26



TOP VIEW
NO SCALE



ELEVATION
NO SCALE

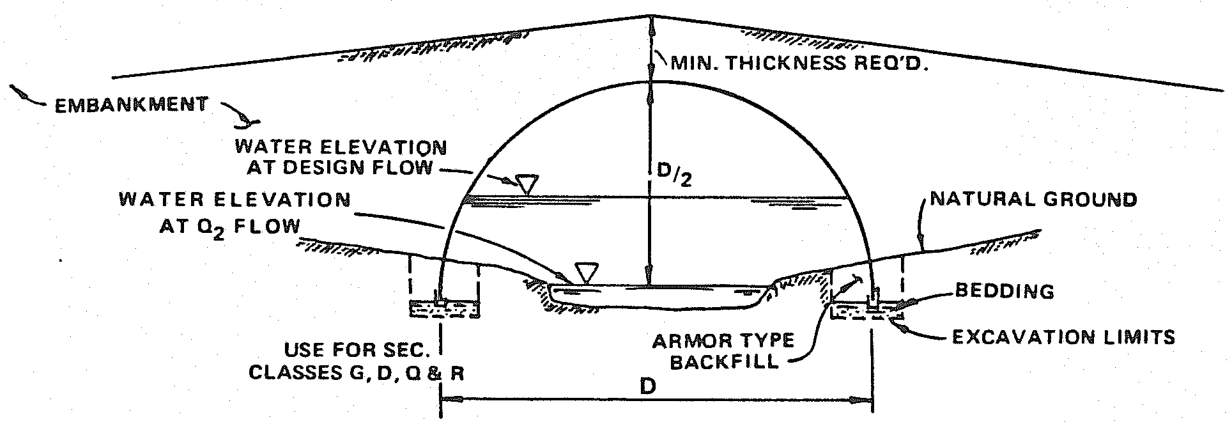
CULVERT DIAM.	RISER		RISER CAGE				
	C. M. P.		STEEL				
	DIAM.	H	ANGLE SIZE	NO. OF PIECES	LENGTH, FT.		
INCHES	IN.	FT.			A FT. IN.	B IN.	L
36	24		2" x 2" x 1/4"	4	1' - 5"	2"	2' - 7"
42	24		2" x 2" x 1/4"	"	1' - 5"	2"	2' - 7"
48	30	NO HIGHER THAN TOP OF EMBANKMENT	2 1/2" x 2 1/2" x 1/4"	"	1' - 10"	3"	3' - 1"
54	36		" " "	"	2' - 1"	[illegible]	[illegible] - 4"
60	42		" " "	"	2' - 6"	3"	3' - 9"
66	42		" " "	"	2' - 6"	3"	3' - 9"
72	48		" " "	"	2' - 10"	3"	4' - 1"
78	48		" " "	"	2' - 10"	3"	4' - 1"
84	54		3" x 3" x 1/4"	"	3' - 3"	3"	4' - 6"
90	60		" " "	"	3' - 6"	3"	4' - 9"
96	60		" " "	"	3' - 6"	3"	4' - 9"

NOTES :

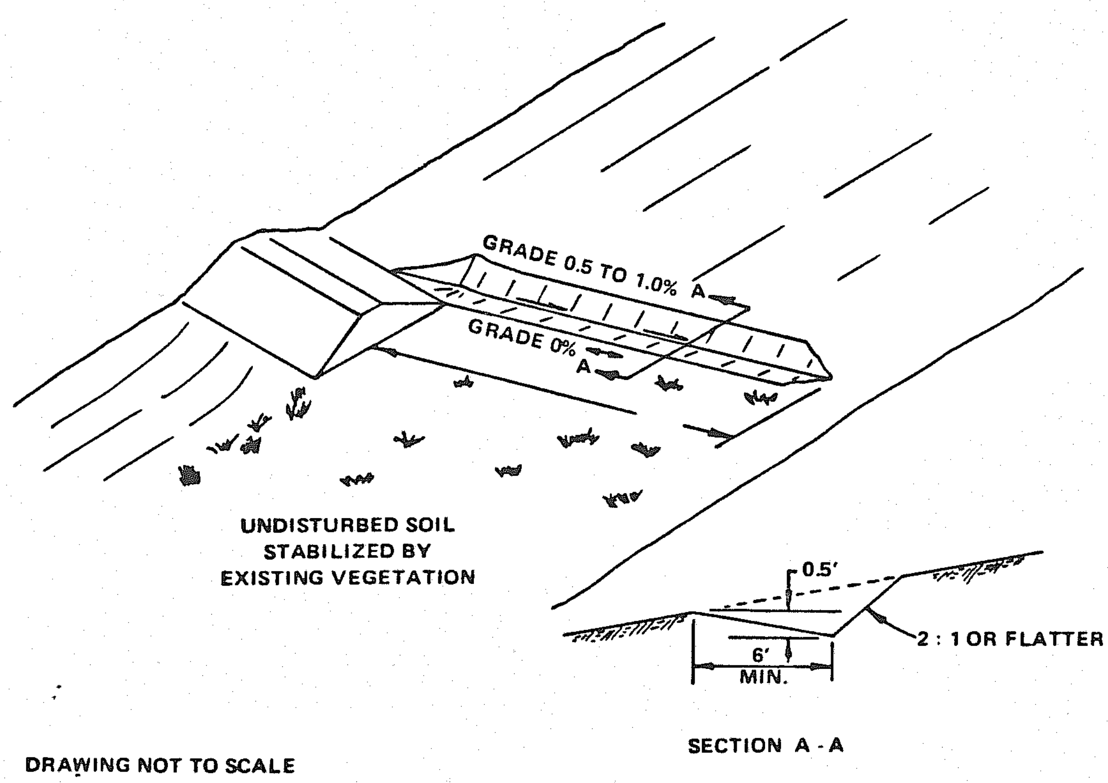
1. *RISER TO BE FASTENED TO CULVERT BY WELDING OR SHOP-MADE CORRUGATED METAL SADDLE PLATE.*
2. *SADDLE PLATE SHALL BE SAME GAGE METAL AS TOP CULVERT PLATES.*
3. *CAGE ANGLES SHALL BE EITHER WELDED OR BOLTED TO RISER, AND TOP JOINT OF CAGE ANGLES SHALL BE EITHER WELDED OR BOLTED. BOLT DIAMETER SHALL BE TWICE ANGLE THICKNESS.*
4. *ALL ANGLES NUTS AND BOLTS SHALL BE GALVANIZED.*
5. *ALL WELDS ON GALVANIZED METAL SHALL BE TREATED WITH ZINC DUST IN ACCORDANCE WITH SECTION 66 - 1.02 G OF THE STANDARD SPECIFICATIONS.*
6. *RISER SHALL BE PLACED IN A VERTICAL POSITION.*
7. *IN POPULATED AREAS, RISER SHALL BE ENCLOSED BY A CHAIN LINK FENCE OR OTHER SUITABLE ENCLOSURE, AS DIRECTED BY THE ENGINEER*

DEBRIS RISER
FIGURE 27

ADAPTED FROM
REFERENCE 11



TYPICAL STRUCTURAL PLATE STEEL ARCH



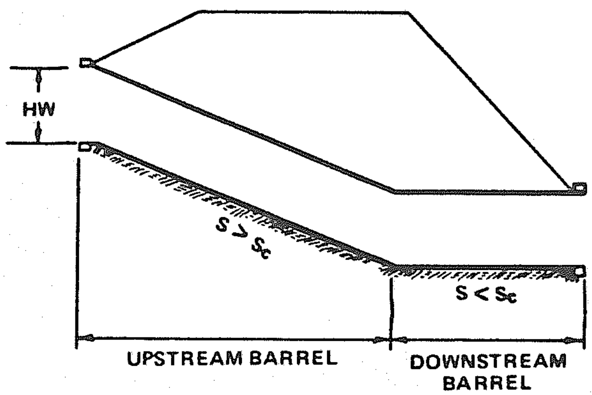
LEVEL SPREADER

NOTE : LEVEL SPREADERS SHOULD NOT BE USED IN THAW UNSTABLE PERMAFROST AREAS.

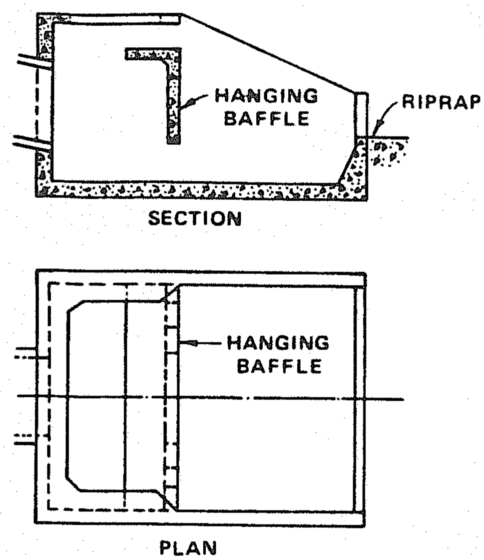
SITE SPECIFIC DRAINAGE STRUCTURES

FIGURE 28

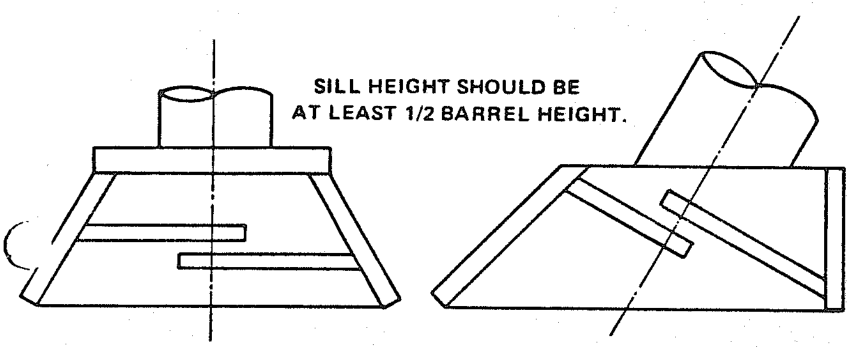
ADAPTED FROM REFERENCE 11 AND 18



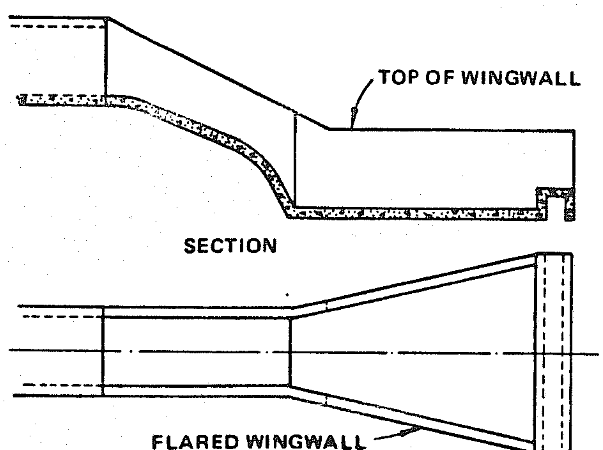
BROKEN BACK CULVERT



IMPACT BASIN



SILLS

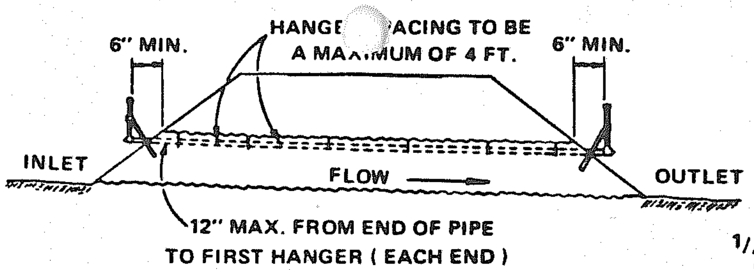


RADIAL FLOW ENERGY DISSIPATER

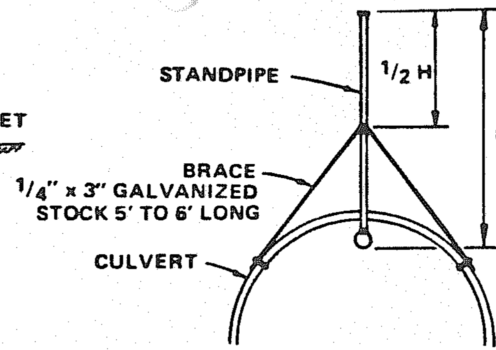
ENERGY DISSIPATERS

FIGURE 29

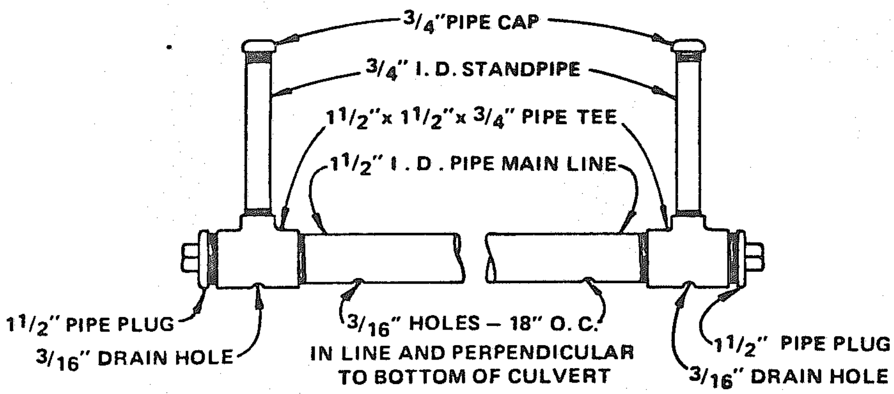
ADAPTED FROM REFERENCE 26



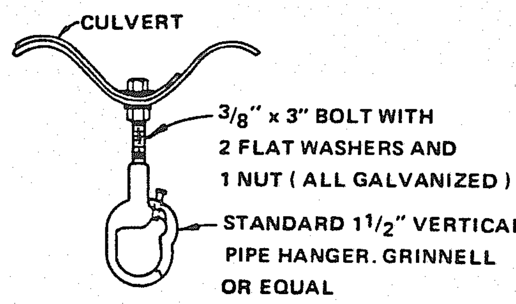
LOCATION OF THAW PIPE



LOCATION OF STANDPIPE BRACE



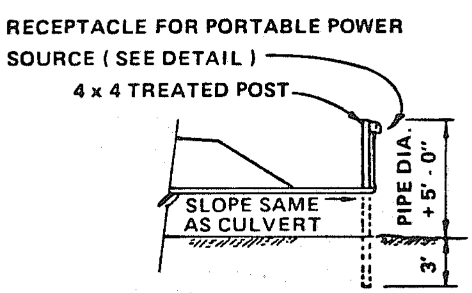
STANDARD SINGLE THAW PIPE



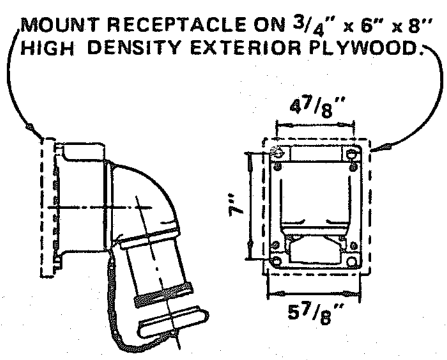
THAW PIPE HANGER DETAIL

NOTES FOR THAW PIPE INSTALLATION :

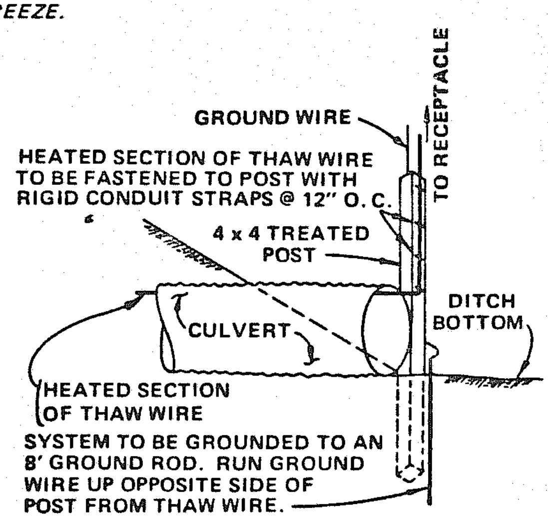
1. *ALL MAIN LINE PIPES AND STANDPIPES TO BE STANDARD GALVANIZED STEEL PIPE A.S.T.M. A - 120 - 69 WITH STANDARD FITTINGS.*
2. *HEIGHT OF ALL STANDPIPES TO BE 1/2 THE HEIGHT OF CULVERT COVER OR 5' WHICHEVER IS LESS.*
3. *1 1/2" MAIN LINE AND STANDPIPES TO BE FILLED WITH 50 - 50 ANTIFREEZE.*
4. *1 1/2" THAW PIPE SHALL BE BRACED AS SHOWN ABOVE.*



THAW WIRE RISER DETAIL



THAW WIRE RECEPTACLE DETAIL



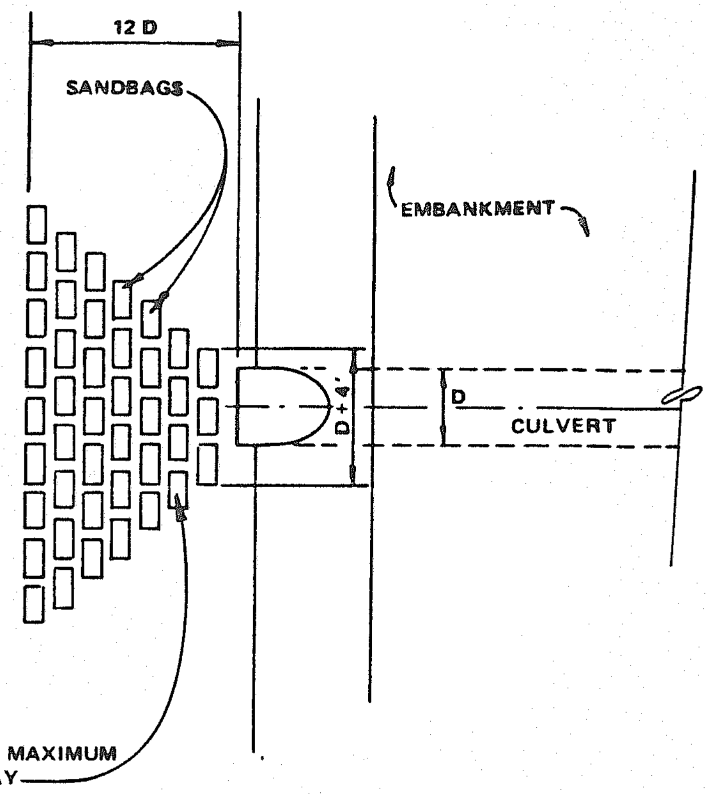
GROUNDING AND FASTENING DETAIL

NOTES FOR THAW WIRE INSTALLATION :

1. *THAW WIRE INSTALLATION SHALL BE THE SAME AS FOR THAW PIPES EXCEPT AS NOTED AND SHOWN.*
2. *THE HEATED SECTION OF THE THAW WIRE SHALL BE STAINLESS STEEL SHEATHED, MINERAL INSULATED.*
3. *THE COLD LEAD SHALL BE OF THE TYPE AND SIZE RECOMMENDED BY THE MANUFACTURER OF THE HEATED SECTION BEING SUPPLIED OR AS SHOWN ON THE PLANS. IF THE LEAD IS NOT THE METAL ENCASED TYPE, IT SHALL BE INSTALLED IN 1 1/4" RIGID METAL CONDUIT.*

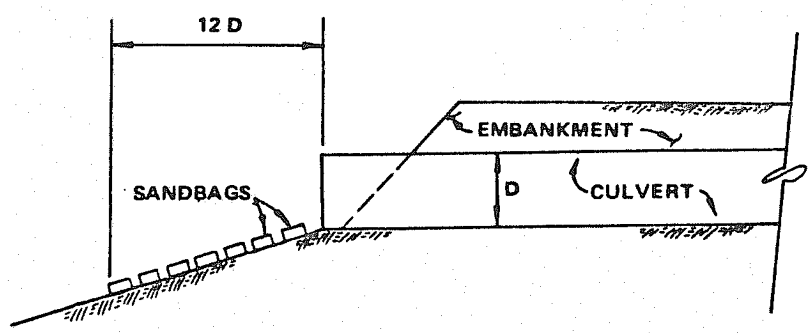
THAW PIPE AND THAW WIRE DETAILS
FIGURE 30

ADAPTED FROM
REFERENCE 24



PLAN

NOT TO SCALE

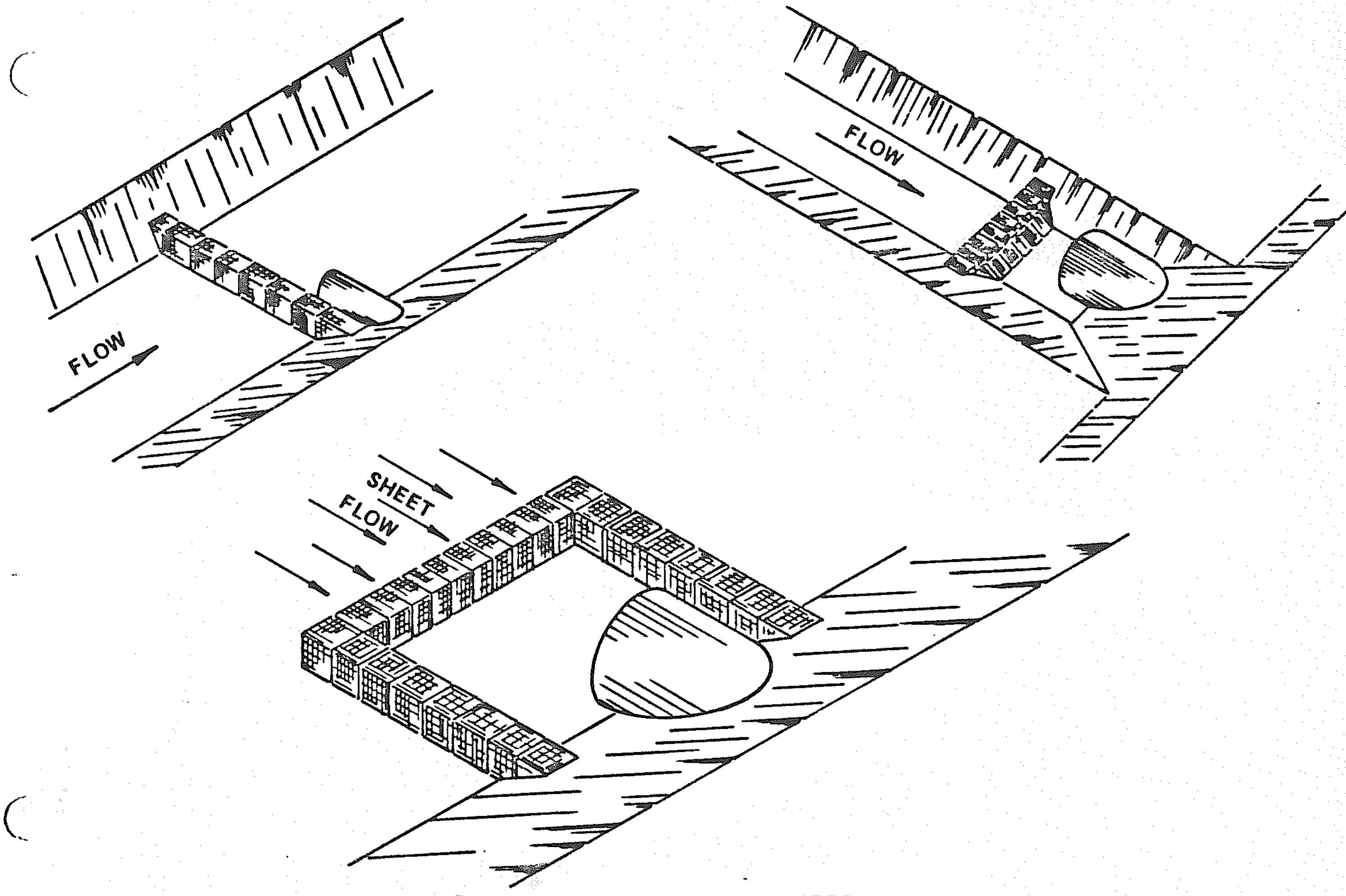


ELEVATION

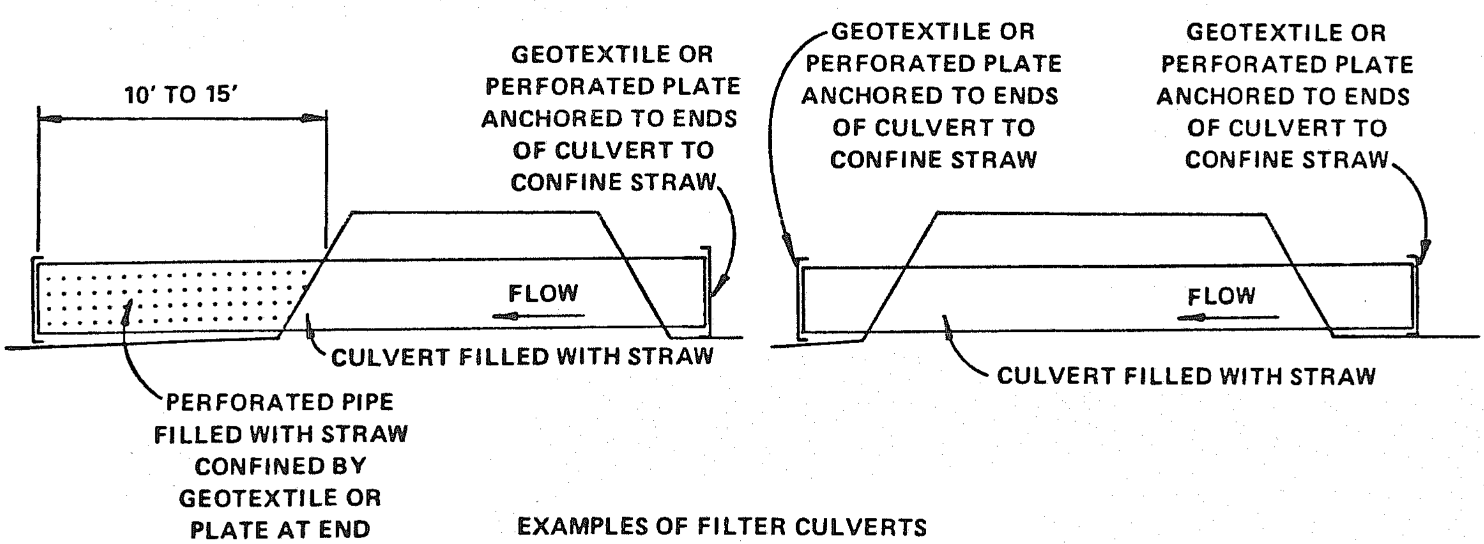
NOTES :

1. *SANDBAGS PLACED ON TUNDRA NOT TO DAMAGE VEGETATIVE MAT.*
2. *6" MAXIMUM SPACING BETWEEN BAGS AND ROWS*
3. *FOR USE IN PERMAFROST TO DIFFUSE CULVERT FLOWS TO PROTECT FROM DOWNSLOPE DEWATERING.*

SANDBAG DIFFUSER
FIGURE 31



EXAMPLES OF SEDIMENT BARRIERS

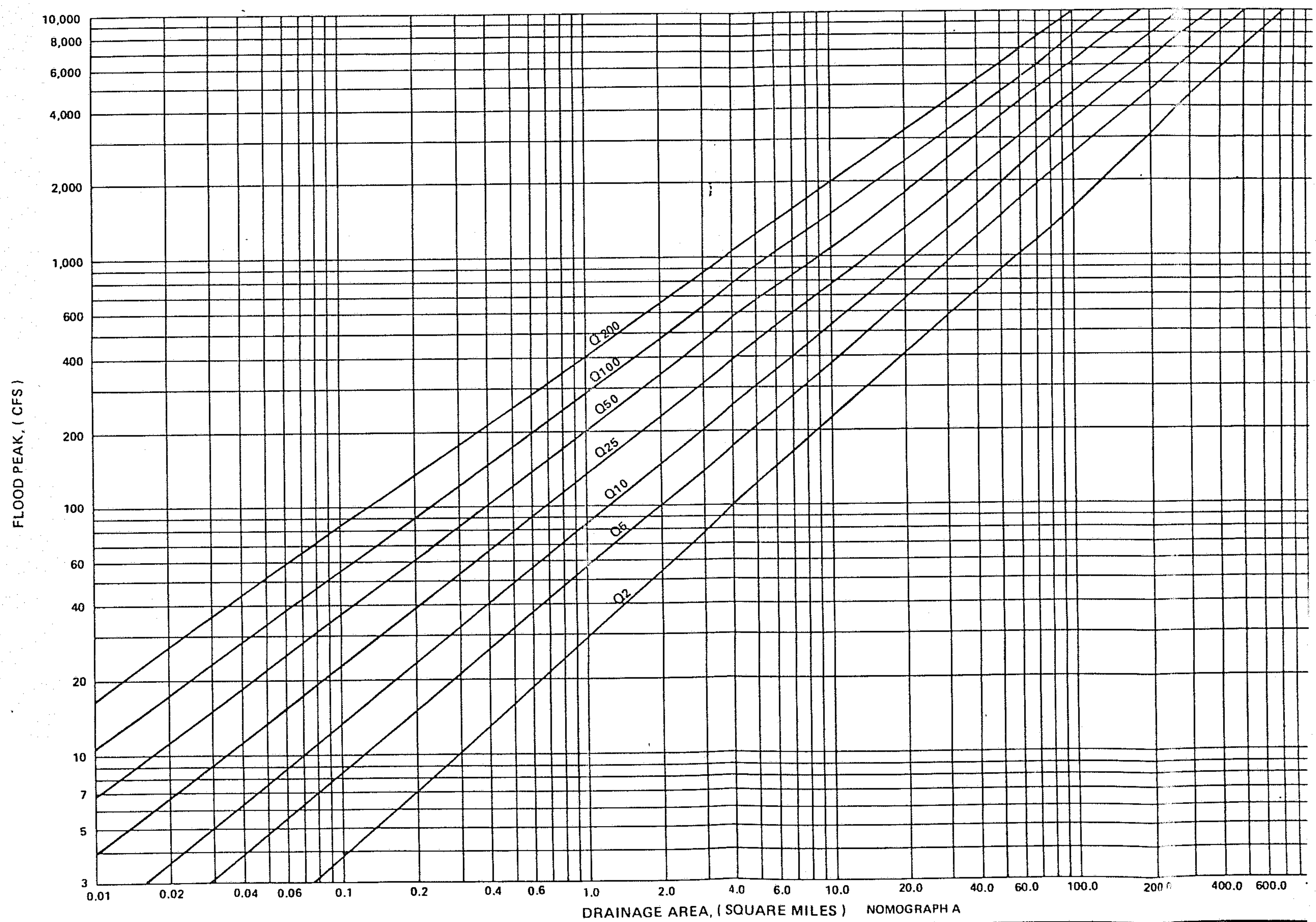


EXAMPLES OF FILTER CULVERTS

FIGURE 32

8.3 NOMOGRAPHS

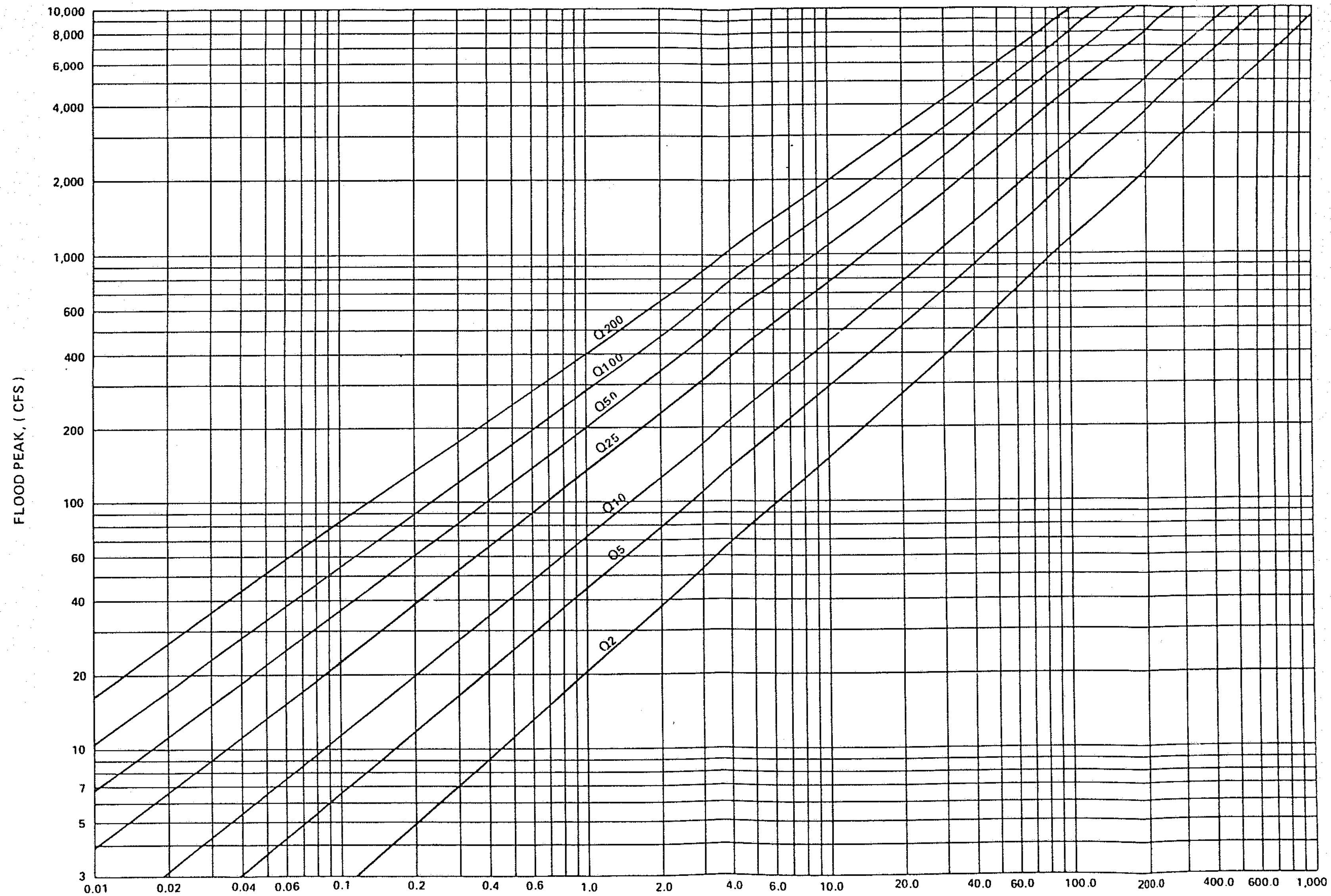
RELATION OF FLOOD PEAK TO DRAINAGE AREA BASED ON 25% CONFIDENCE LIMIT
FOR THE NORTH SLOPE AND KOYUKUK RIVER DRAINAGE BASINS



NOMOGRAPH A

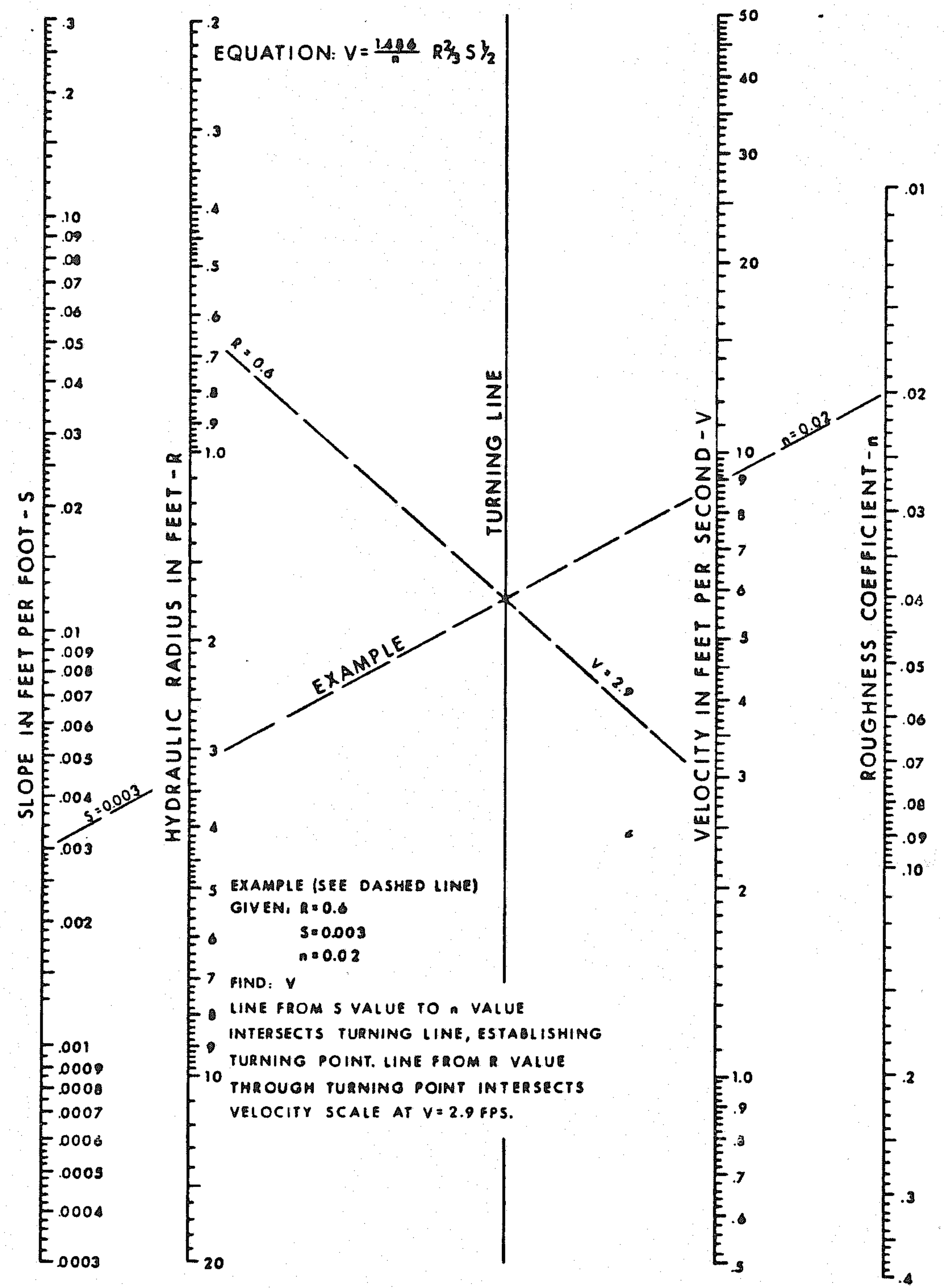
NWA

RELATION OF FLOOD PEAK TO DRAINAGE AREA BASED ON 25% CONFIDENCE LIMIT FOR THE TANANA AND YUKON RIVER DRAINAGE BASINS



NOMOGRAPH B

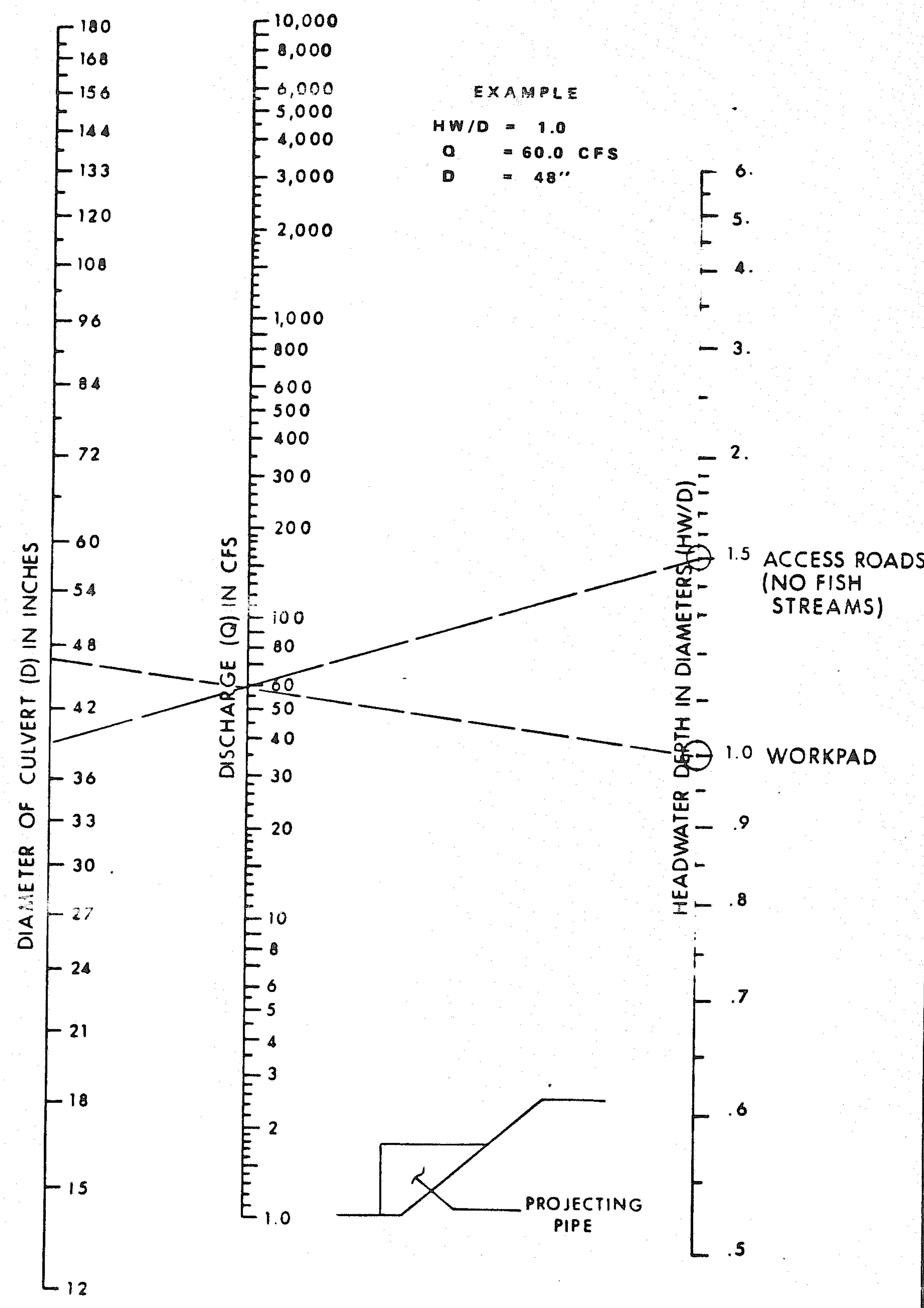
NOMOGRAPH FOR MANNING FORMULA



ADAPTED FROM
REFERENCE 31

NOMOGRAPH C

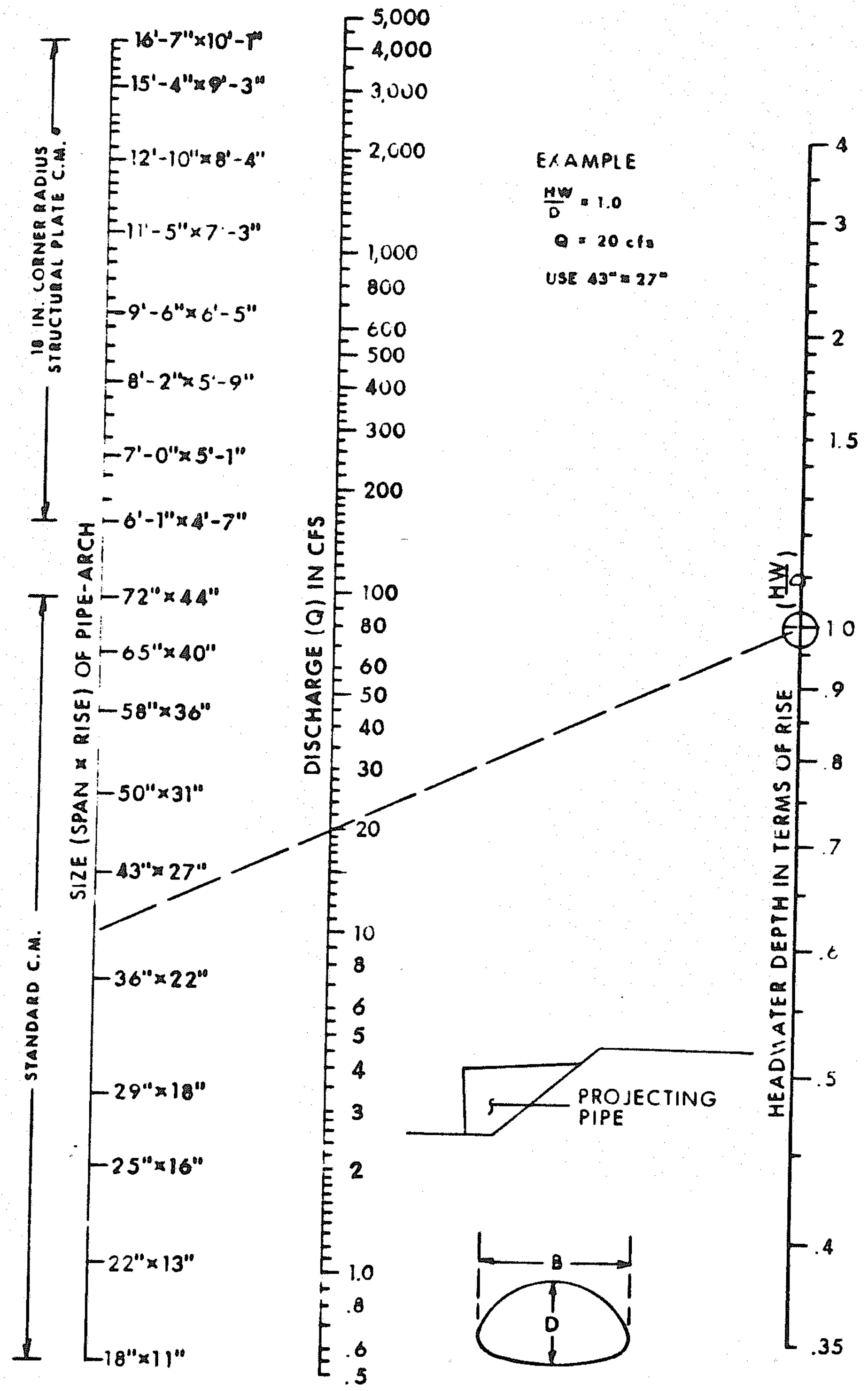
DISCHARGE FOR C.M. PIPE CULVERTS WITH INLET CONTROL



ADAPTED FROM REFERENCE 32

NOMOGRAPH D

DISCHARGE FOR C.M. PIPE-ARCH CULVERTS WITH INLET CONTROL

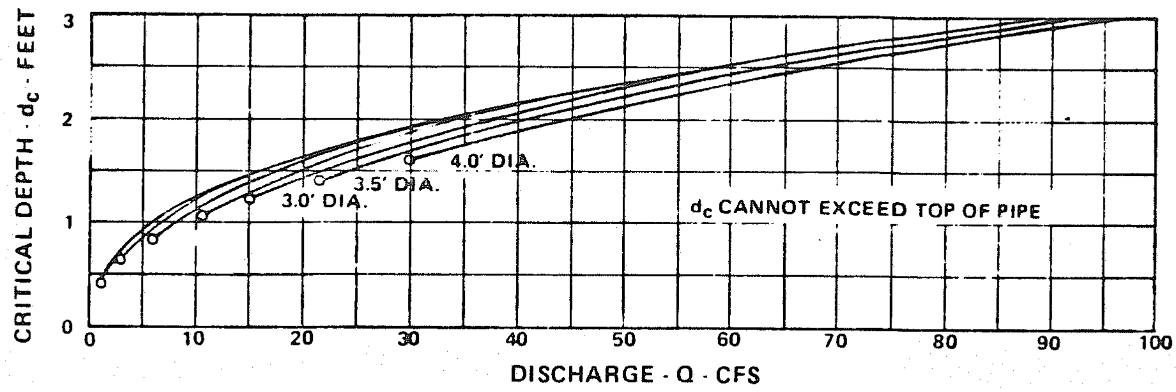


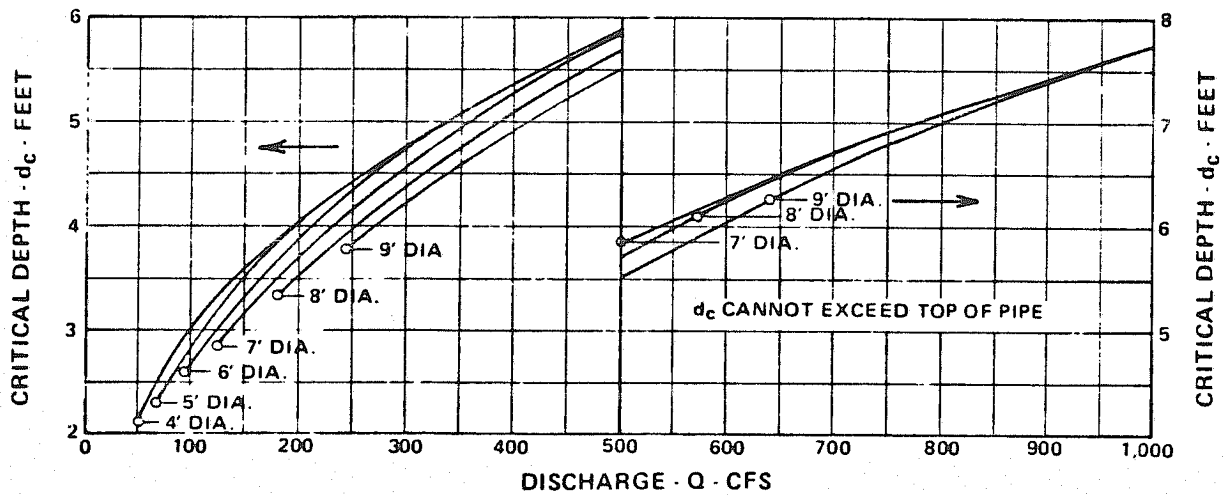
*ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

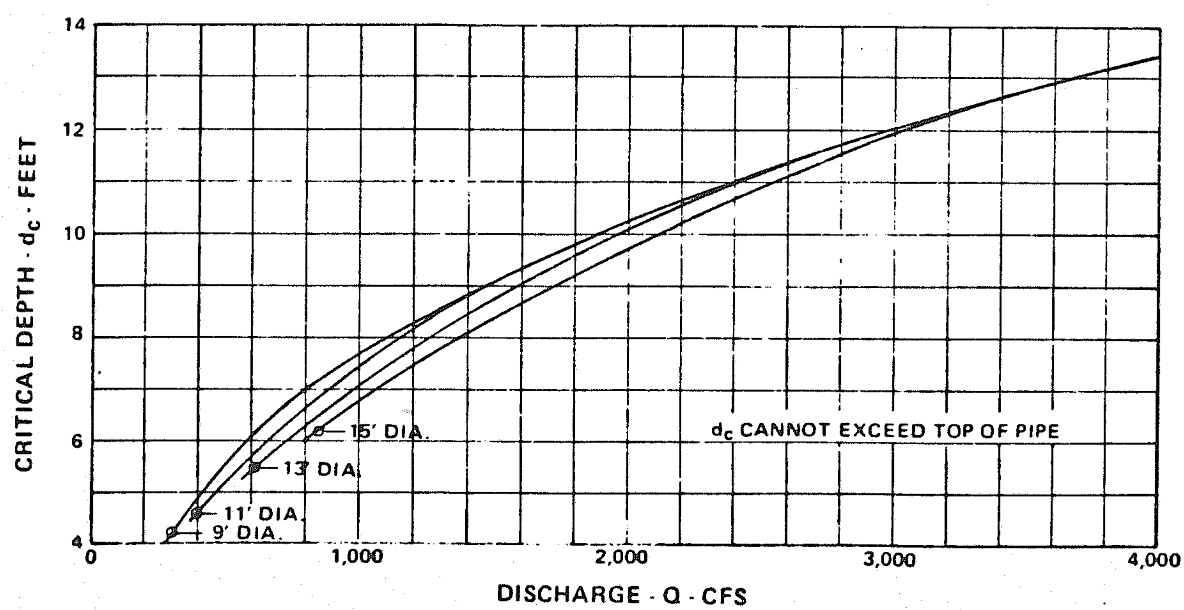
NOMOGRAPH E

ADAPTED FROM REFERENCE 32

CRITICAL DEPTH
FOR C.M. PIPE CULVERT



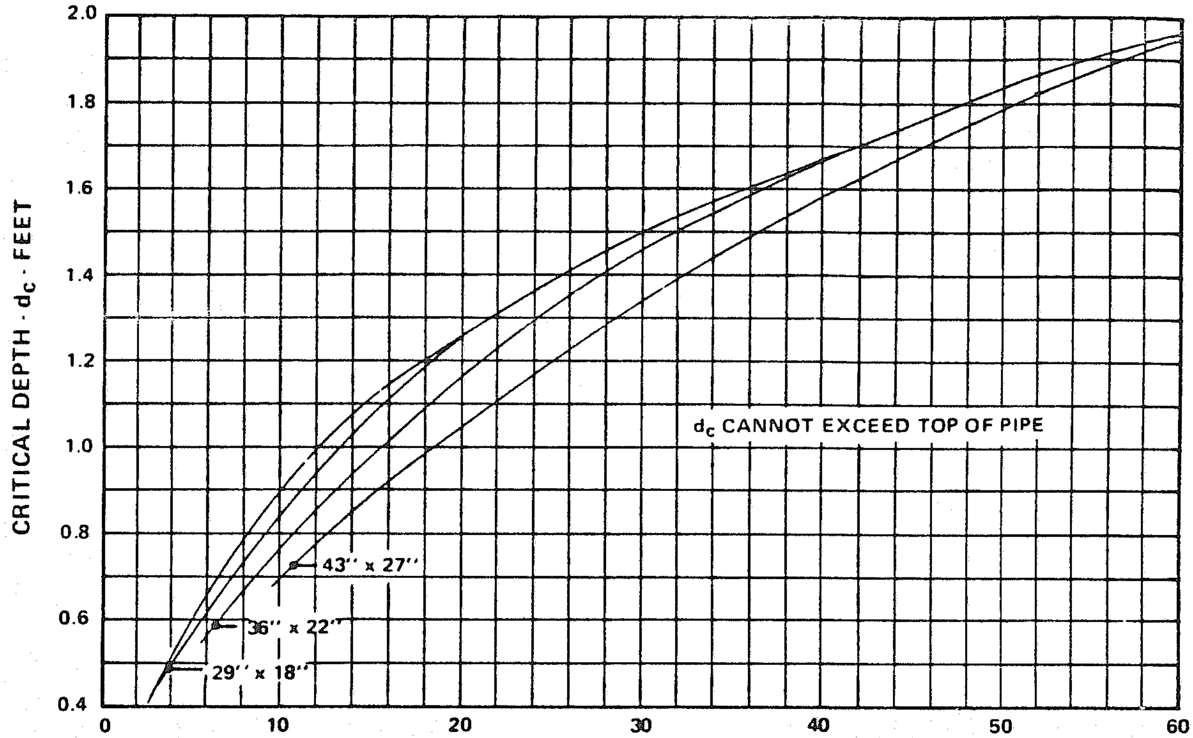


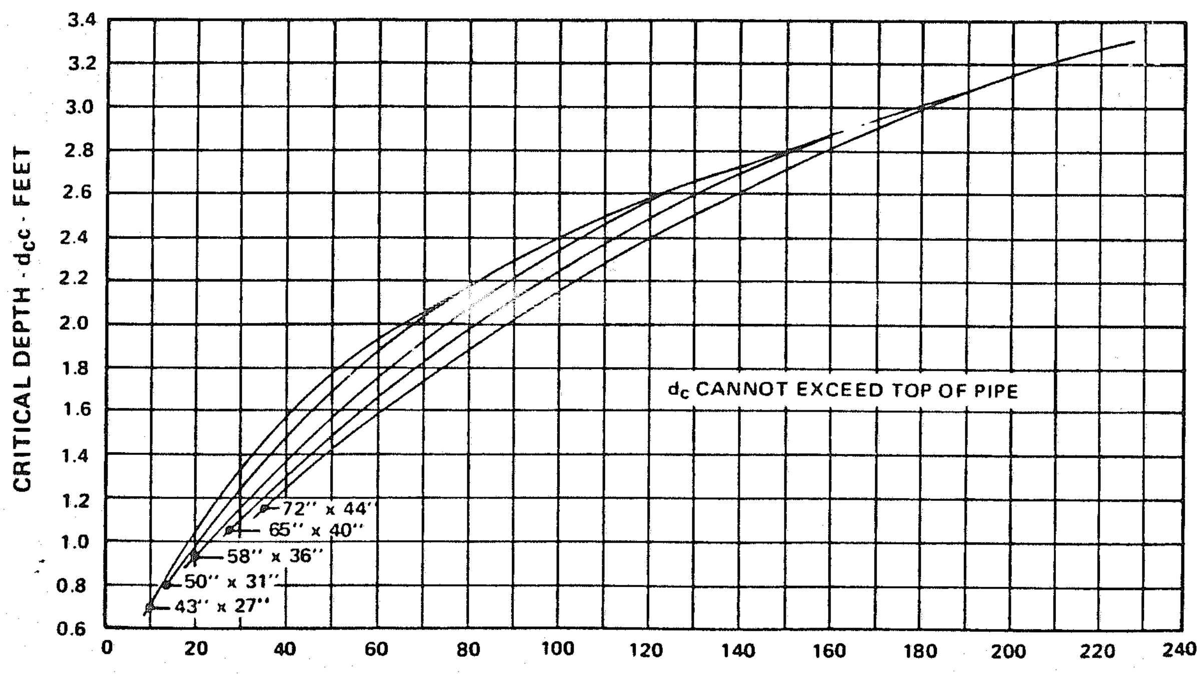


ADAPTED FROM
REFERENCE 32

NOMOGRAPH F

CRITICAL DEPTH
FOR C.M. PIPE - ARCH CULVERT

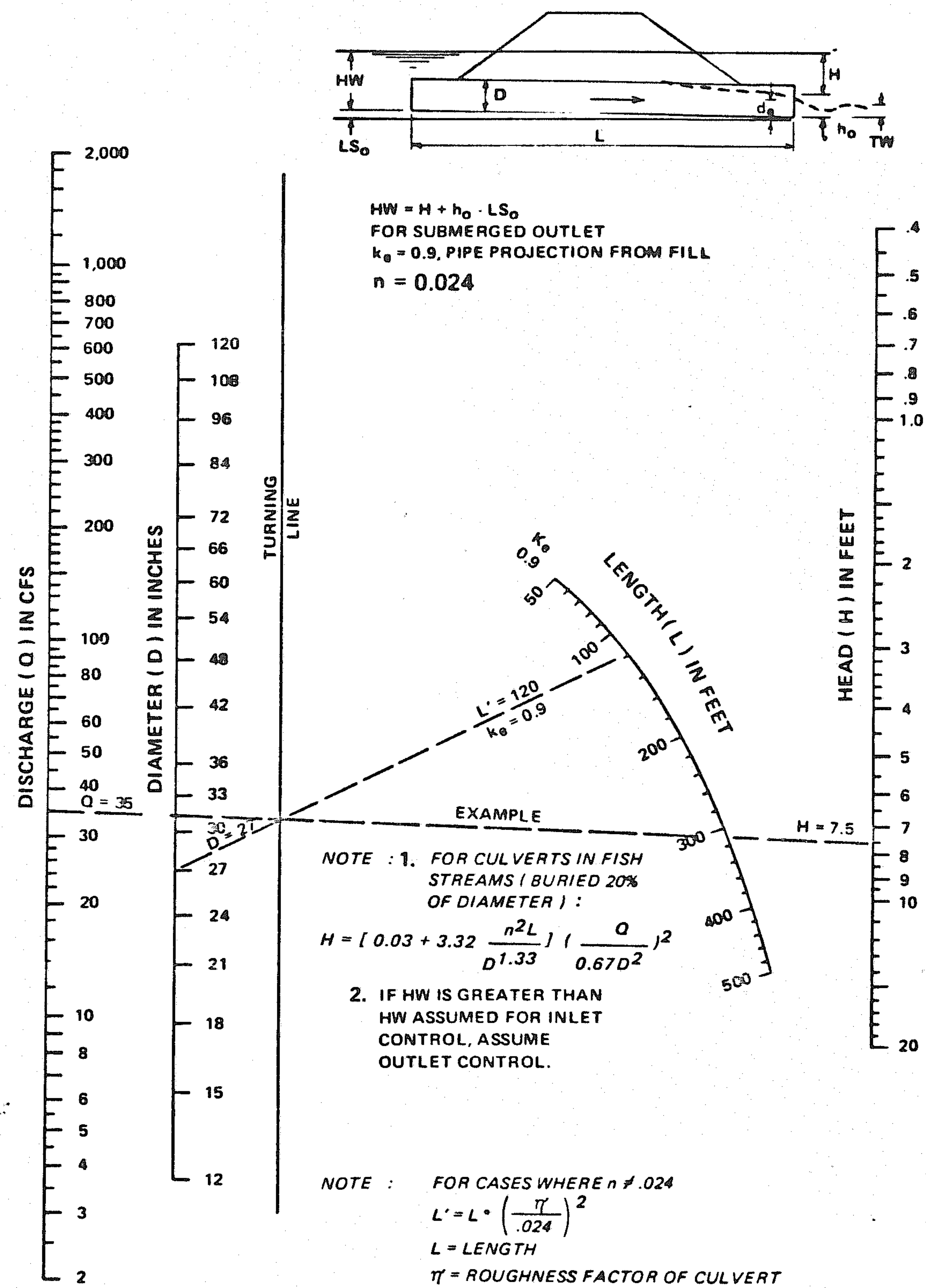




ADAPTED FROM
REFERENCE 32

NOMOGRAPH G

DISCHARGE FOR C.M. PIPE CULVERT WITH OUTLET CONTROL



$HW = H + h_o \cdot LS_o$
FOR SUBMERGED OUTLET
$k_e = 0.9$, PIPE PROJECTION FROM FILL
$n = 0.024$

NOTE : 1. FOR CULVERTS IN FISH STREAMS (BURIED 20% OF DIAMETER) :

$$H = \left[0.03 + 3.32 \frac{n^2 L}{D^{1.33}} \right] \left(\frac{Q}{0.67 D^2} \right)^2$$

2. IF HW IS GREATER THAN HW ASSUMED FOR INLET CONTROL, ASSUME OUTLET CONTROL.

NOTE : FOR CASES WHERE $n \neq .024$

$$L' = L \cdot \left(\frac{n}{.024} \right)^2$$

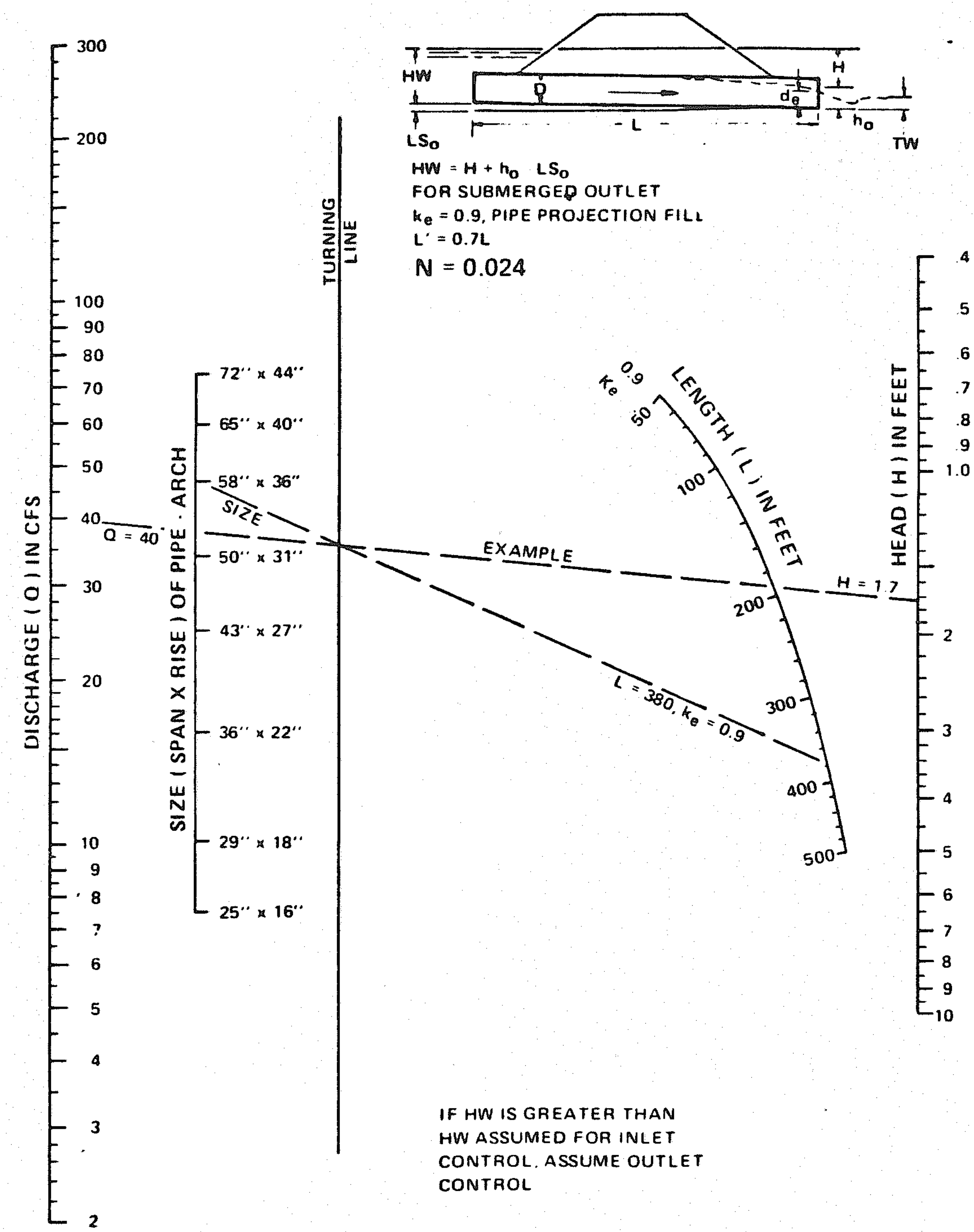
L = LENGTH

n = ROUGHNESS FACTOR OF CULVERT

ADAPTED FROM REFERENCE 32

NOMOGRAPH H

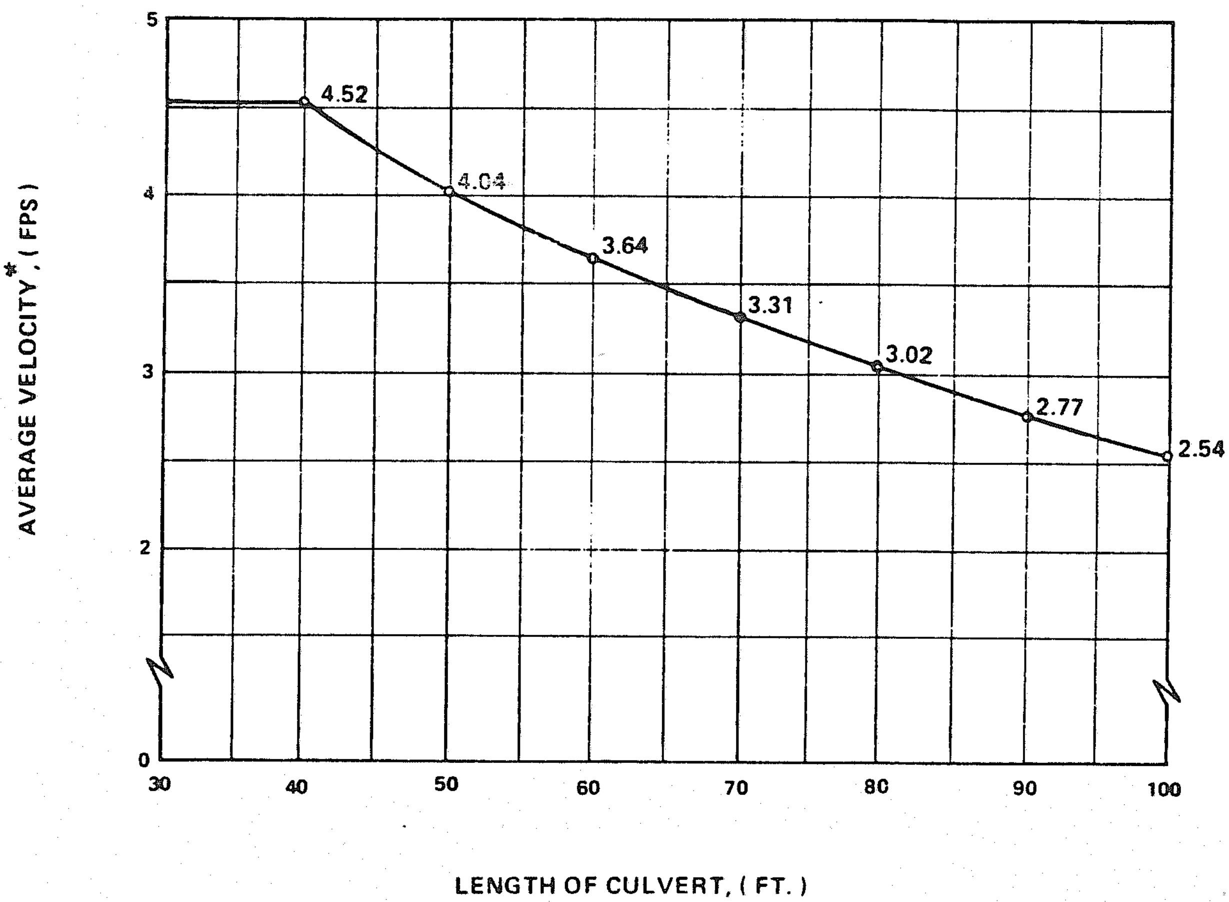
DISCHARGE FOR C.M. PIPE - ARCH CULVERT WITH OUTLET CONTROL



ADAPTED FROM
REFERENCE 32

NOMOGRAPH I

MAXIMUM ALLOWABLE VELOCITIES FOR FISH PASSAGE AT Q_2 FLOOD

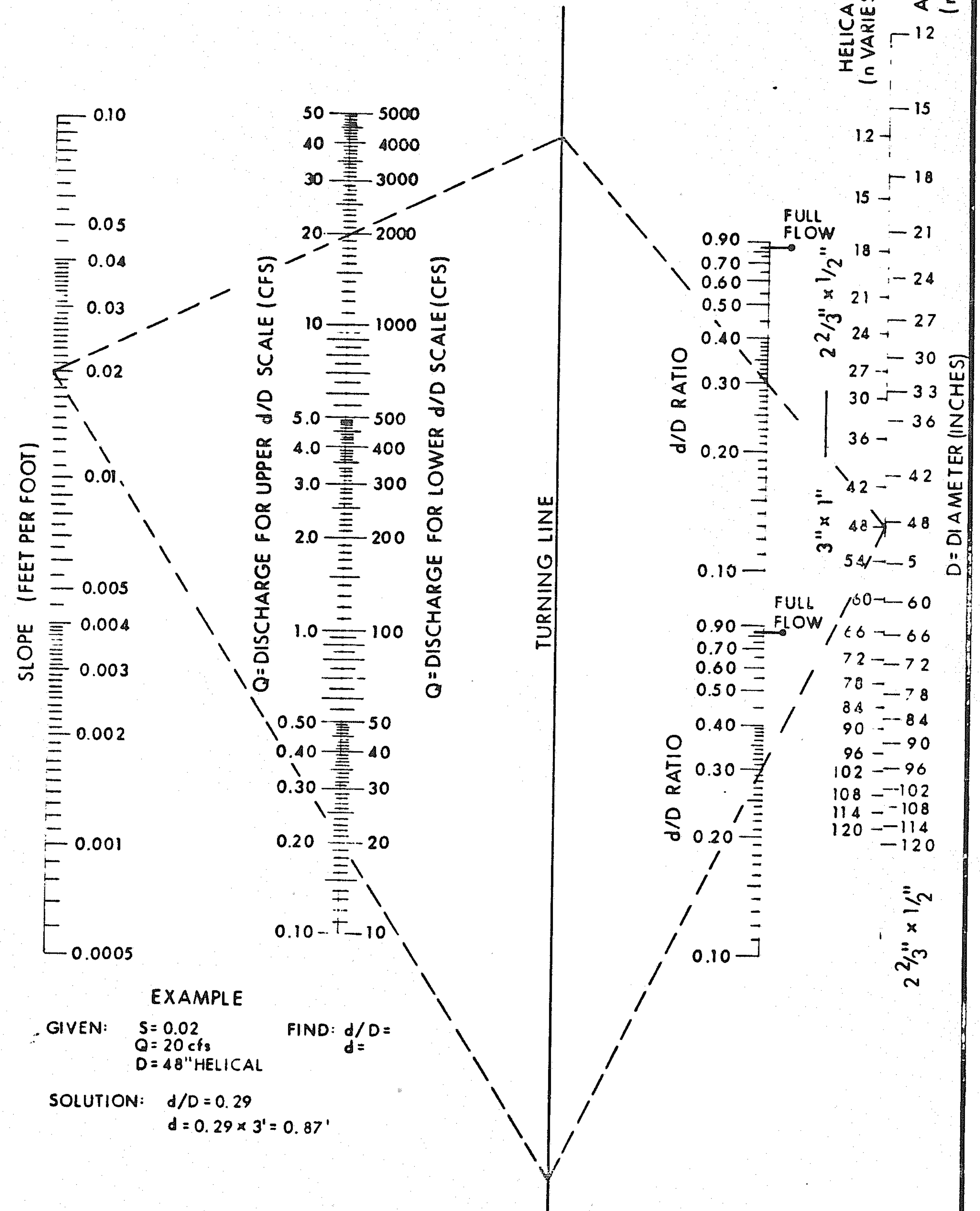


* AVERAGE VELOCITY SHOULD BE DETERMINED AT THE SECTION WITH MINIMUM DEPTH WITHIN THE CULVERT.

ADAPTED FROM REFERENCE 4

NOMOGRAPH J

UNIFORM FLOW FOR C.M. PIPE CULVERTS



EXAMPLE

GIVEN: S = 0.02
Q = 20 cfs
D = 48" HELICAL

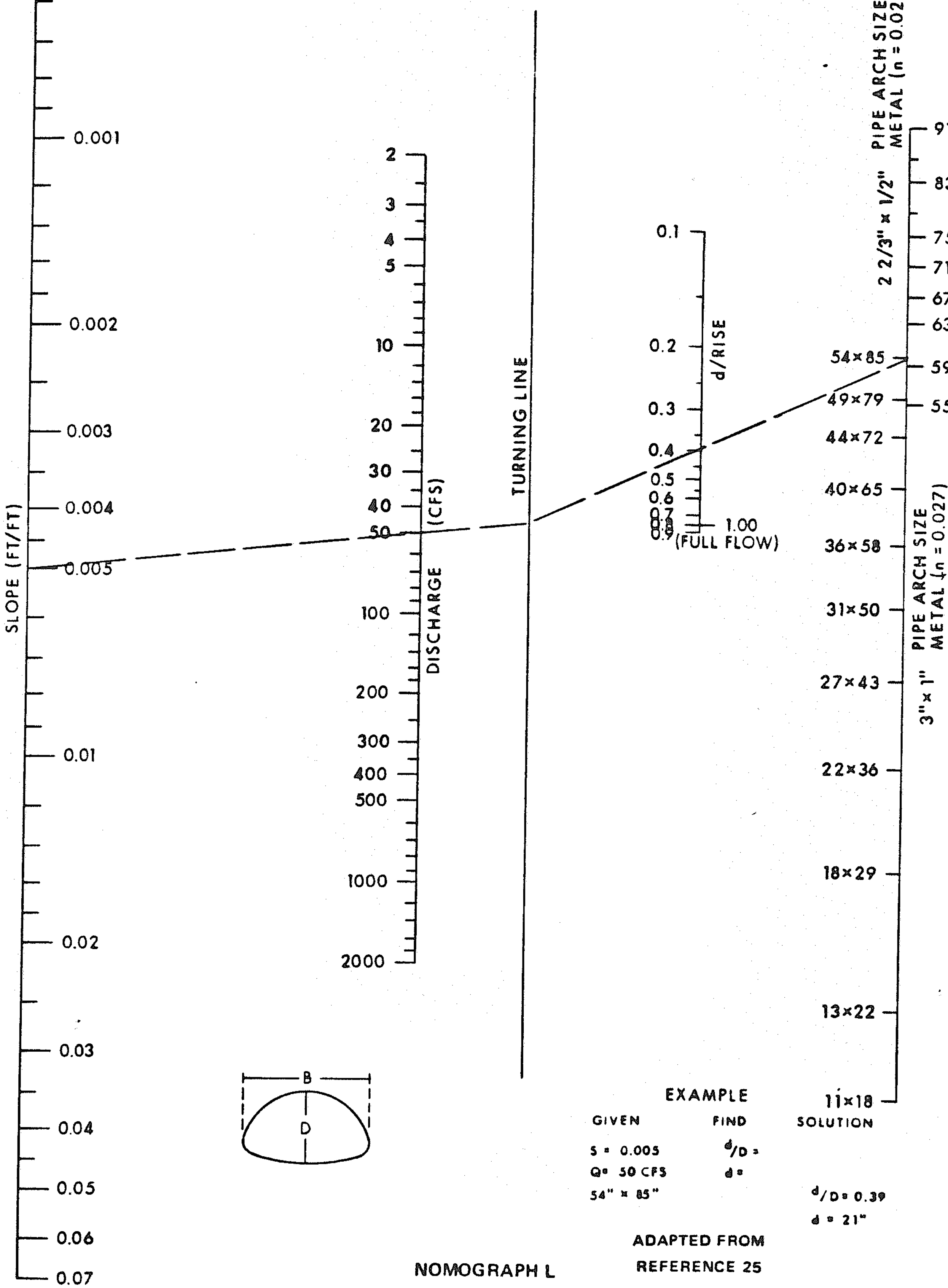
FIND: d/D =
d =

SOLUTION: d/D = 0.29
d = 0.29 × 3' = 0.87'

ADAPTED FROM REFERENCE 25

NOMOGRAPH K

UNIFORM FLOW FOR PIPE ARCH



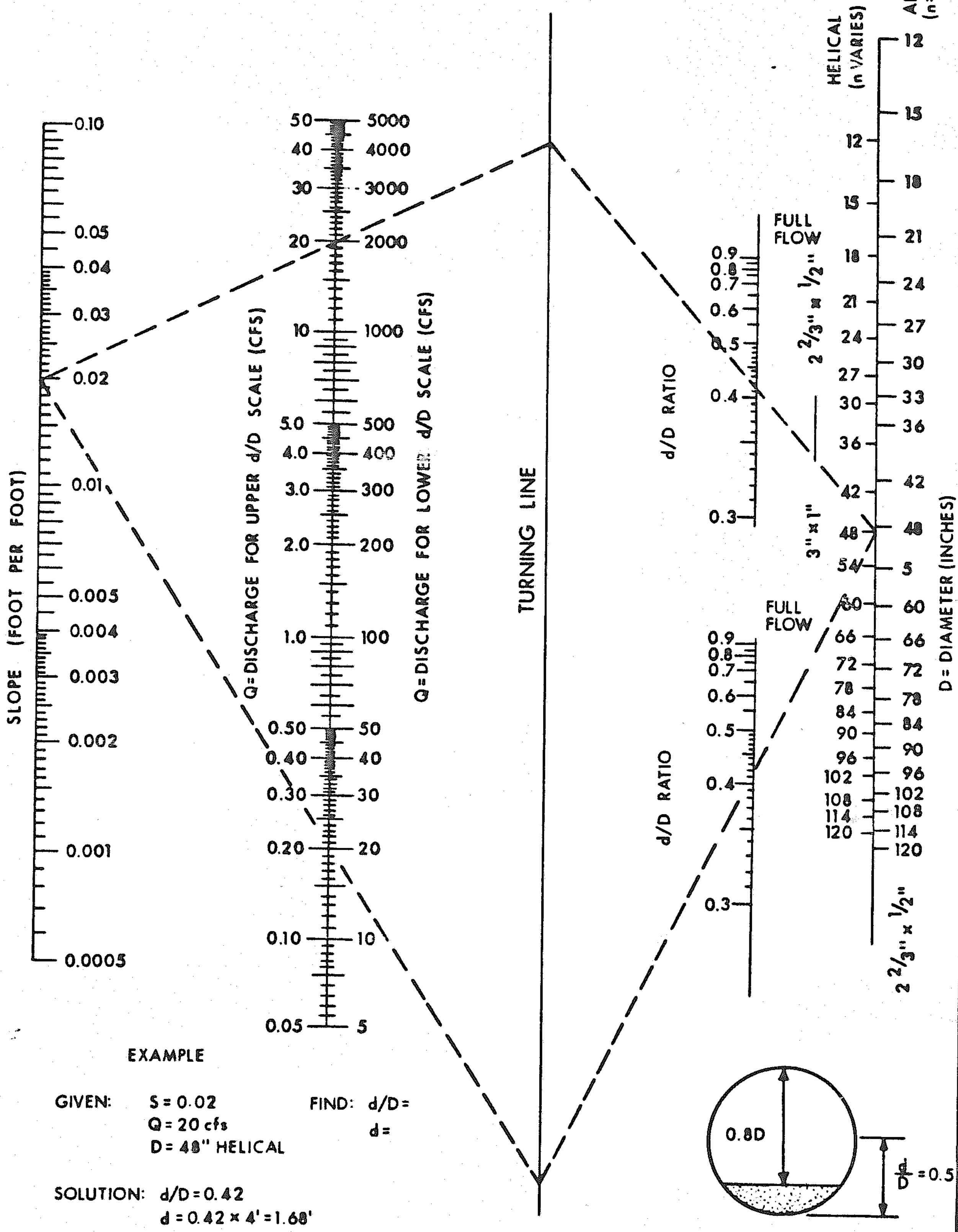
EXAMPLE

GIVEN	FIND	SOLUTION
S = 0.005	d/D =	
Q = 50 CFS	d =	
54" × 85"		d/D = 0.39
		d = 21"

ADAPTED FROM REFERENCE 25

NOMOGRAPH L

UNIFORM FLOW FOR 20% SILTED C.M PIPE CULVERTS



EXAMPLE

GIVEN: S = 0.02
Q = 20 cfs
D = 48" HELICAL

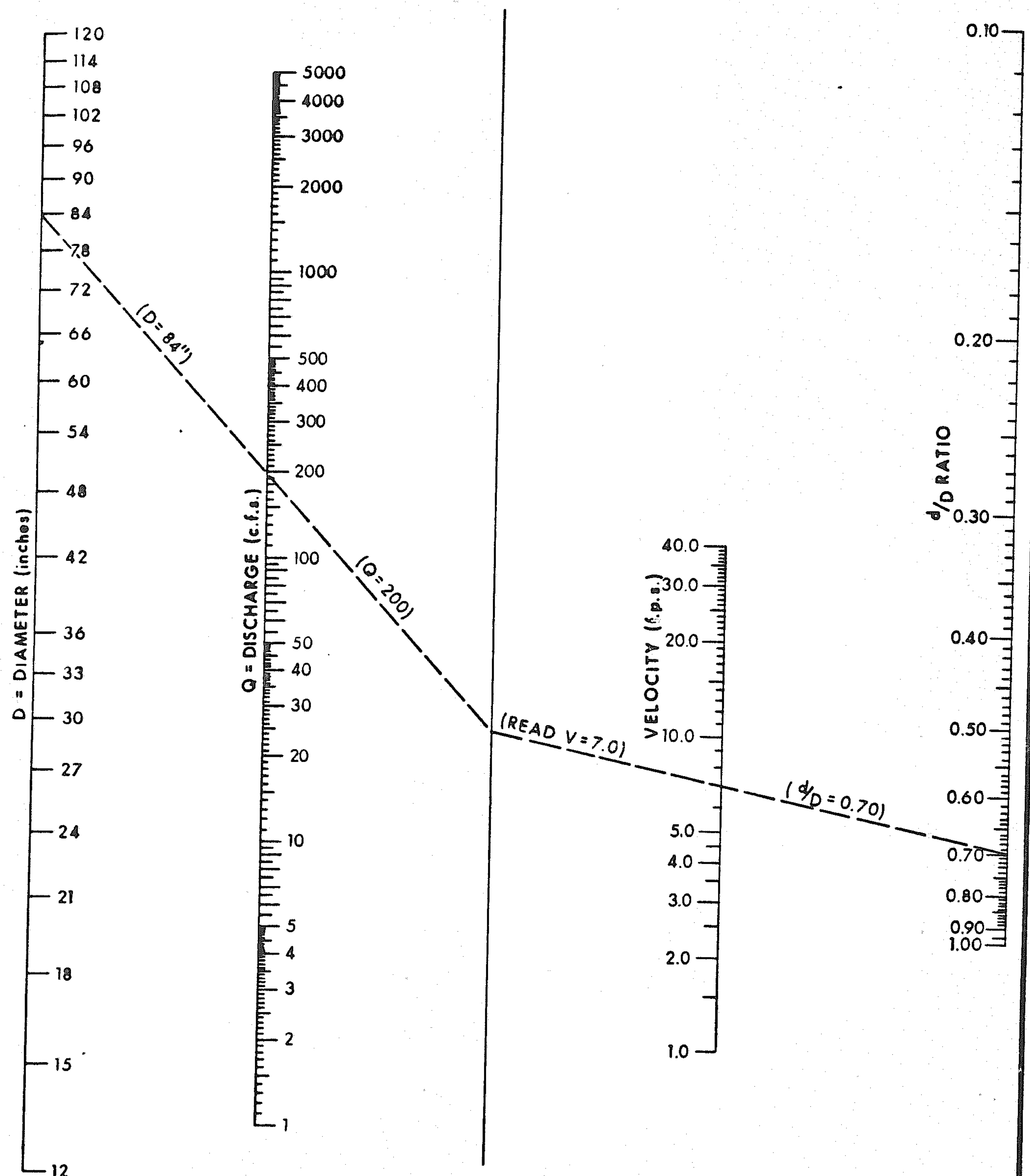
FIND: d/D =
d =

SOLUTION: d/D = 0.42
d = 0.42 × 4' = 1.68'

NOMOGRAPH M

VELOCITY IN PIPE CONDUITS

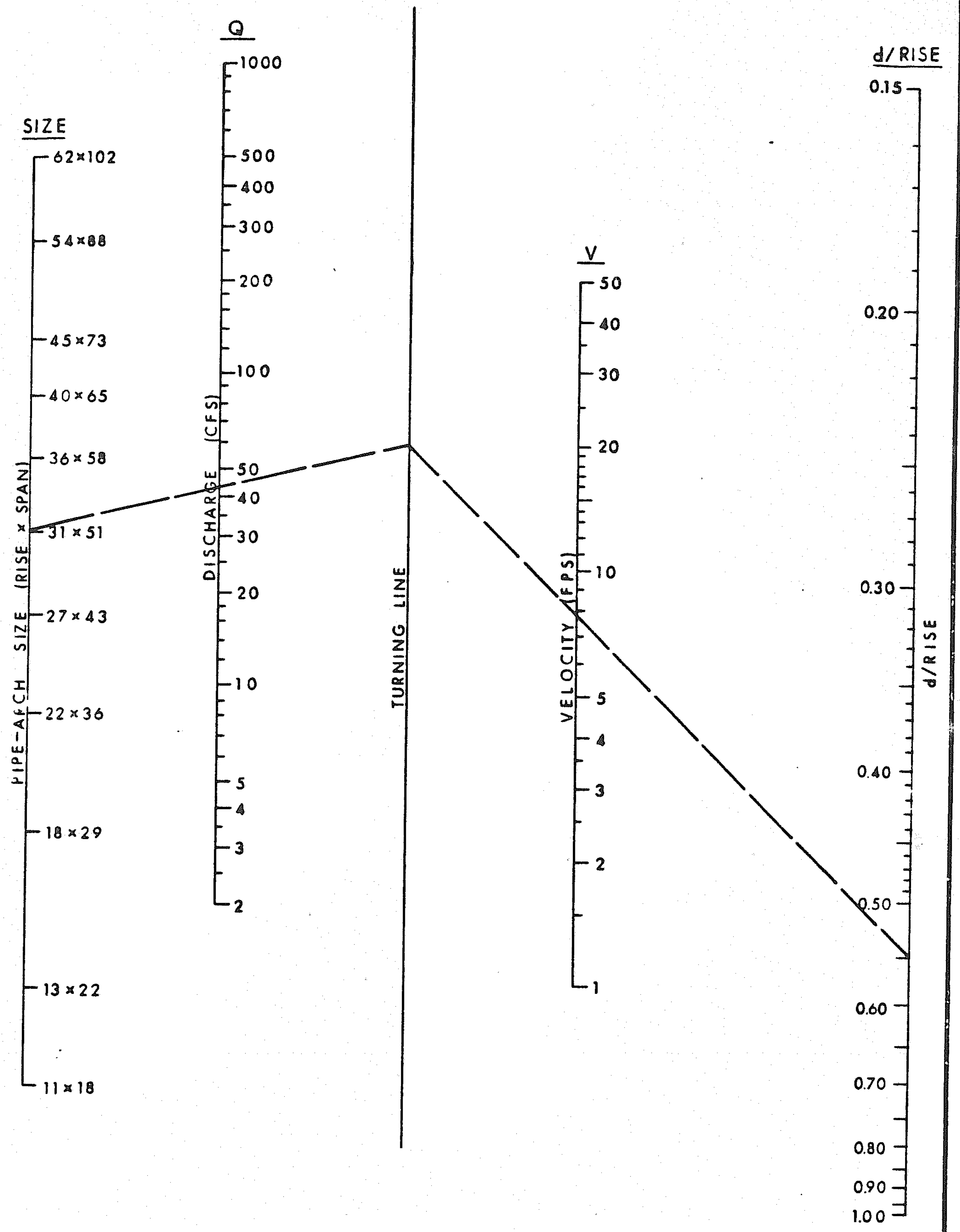
BASED ON Q = VA



ADAPTED FROM
REFERENCE 25

NOMOGRAPH N

VELOCITY IN PIPE-ARCH

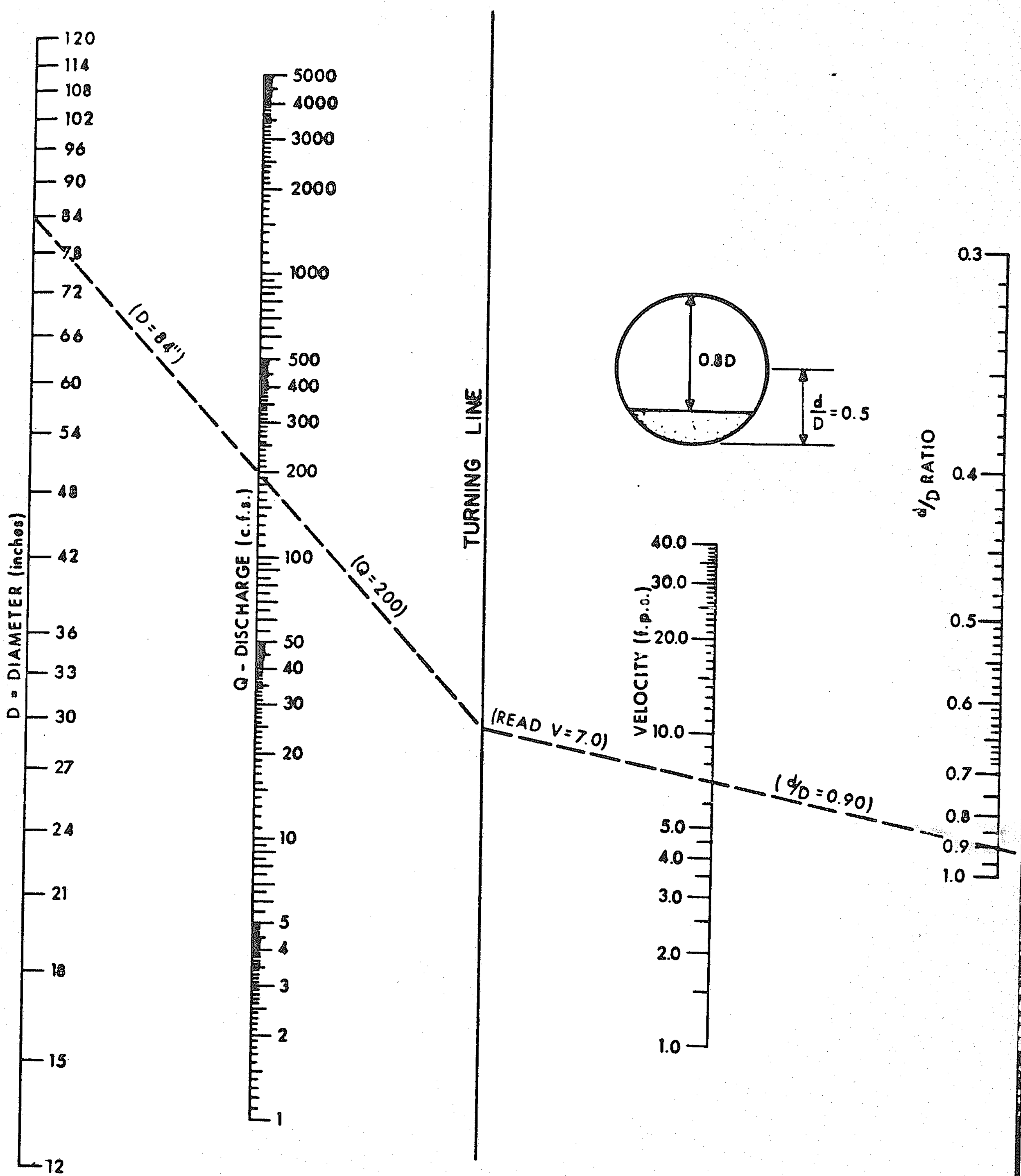


NOMOGRAPH O

ADAPTED FROM REFERENCE 25

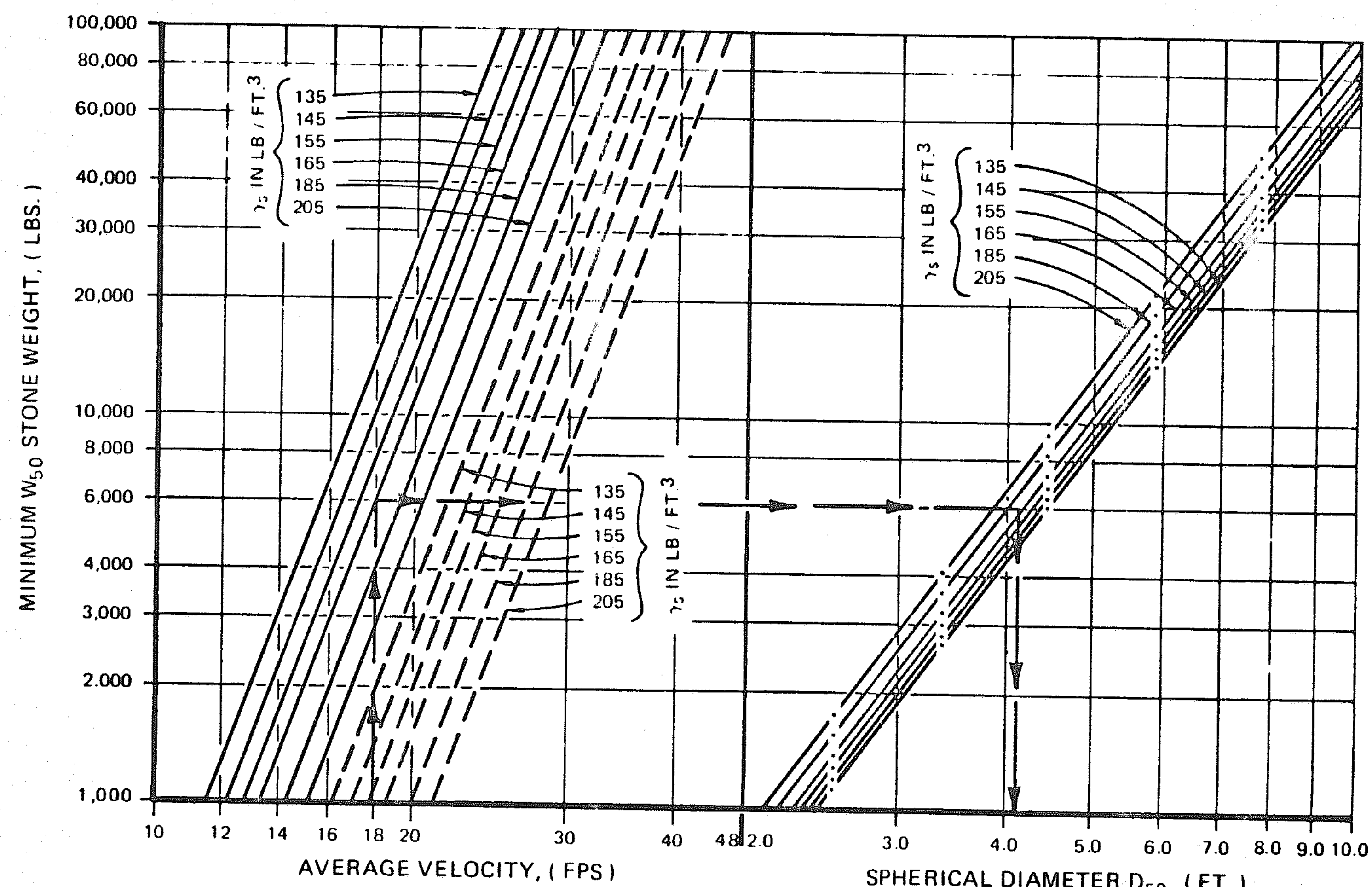
VELOCITY IN 20% SILTED PIPE CONDUITS

BASED ON Q = VA



NOMOGRAPH P

DETERMINATION OF RIPRAP STONE WEIGHT AND DIAMETER



BASIC EQUATIONS

$$V = C\left[2g\left(\frac{\gamma_s - \gamma_w}{\gamma_w}\right)\right]^{1/2}\left(D_{50}\right)^{1/2}$$

$$D_{50} = \left(\frac{6W_{50}}{\pi\gamma_s}\right)^{1/3}$$

WHERE :

V = VELOCITY, (FPS)

γ_s = SPECIFIC STONE WEIGHT, (LB / FT.^{3})

γ_w = SPECIFIC WEIGHT OF WATER, (62.5 LB / FT.^{3})

W_{50} = WEIGHT OF STONE. SUBSCRIPT DENOTES PERCENT OF TOTAL WEIGHT OF MATERIAL CONTAINING STONE OF LESS WEIGHT.

D_{50} = SPHERICAL DIAMETER OF STONE HAVING THE SAME WEIGHT AS W_{50}.

C = ISBASH CONSTANT (0.86 FOR HIGH TURBULENCE LEVEL FLOW AND 1.20 FOR LOW TURBULENCE LEVEL FLOW).

g = ACCELERATION OF GRAVITY, (FT. / SEC.^{2}).

——— HIGH TURBULENCE (STILLING BASINS).

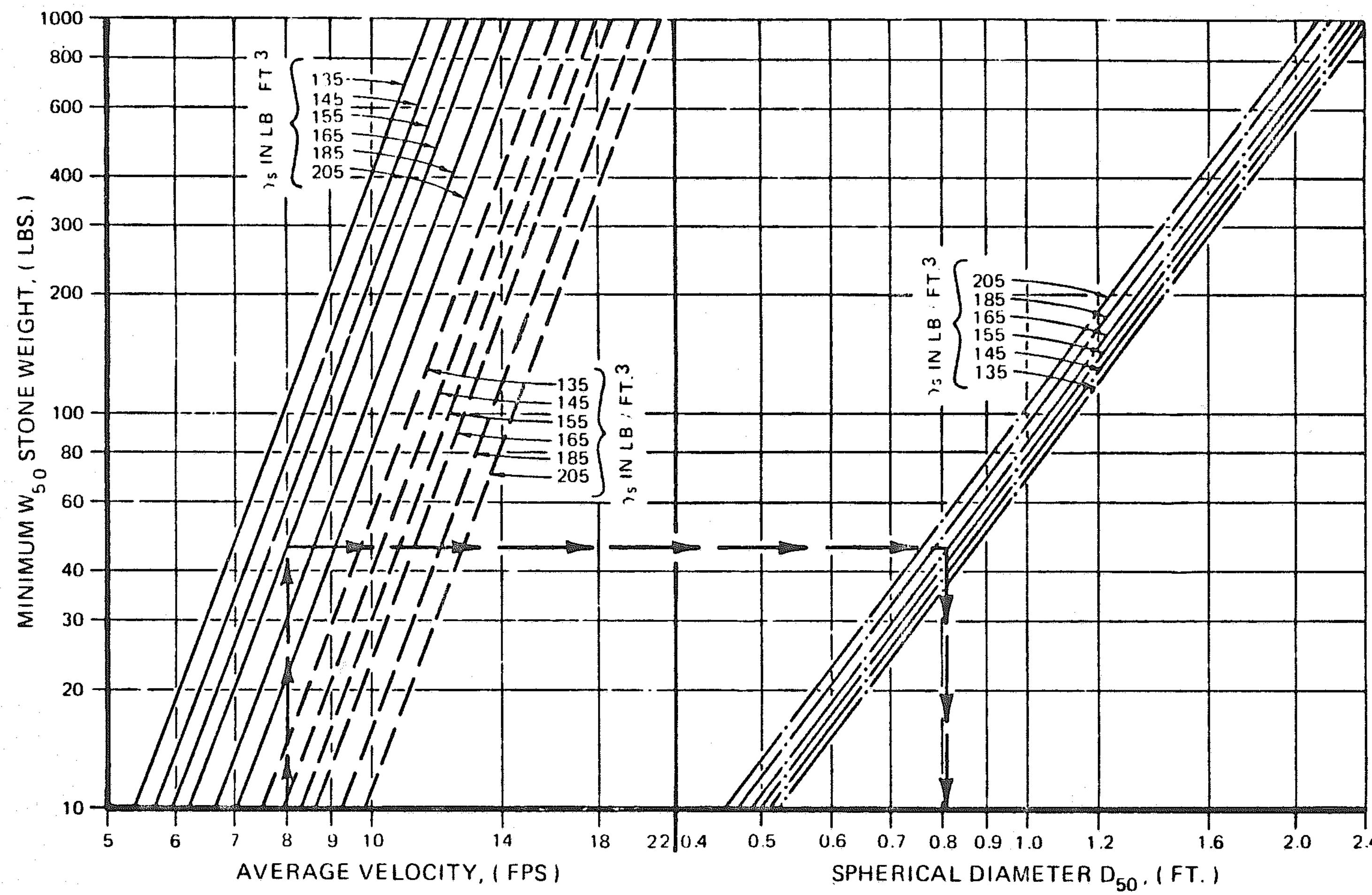
— — LOW TURBULENCE (CHANNEL STABILIZATION APRONS).

—·— WEIGHT VS. DIAMETER.

ADAPTED FROM REFERENCE 27

NOMOGRAPH Q

DETERMINATION OF RIPRAP STONE WEIGHT AND DIAMETER



BASIC EQUATIONS

$$V = C\left[2g\left(\frac{\gamma_s - \gamma_w}{\gamma_w}\right)\right]^{1/2}\left(D_{50}\right)^{1/2}$$

$$D_{50} = \left(\frac{6W_{50}}{\pi\gamma_s}\right)^{1/3}$$

WHERE . V — VELOCITY, (FPS)

γ_s — SPECIFIC STONE WEIGHT, (LB / FT.^{3})

γ_w — SPECIFIC WEIGHT OF WATER, (62.5 LB / FT.^{3})

W_{50} - WEIGHT OF STONE. SUBSCRIPT DENOTES PERCENT OF TOTAL WEIGHT OF MATERIAL CONTAINING STONE OF LESS WEIGHT.

D_{50} — SPHERICAL DIAMETER OF STONE HAVING THE SAME WEIGHT AS W_{50}.

C - ISBASH CONSTANT (0.86 FOR HIGH TURBULENCE LEVEL FLOW AND 1.20 FOR LOW TURBULENCE LEVEL FLOW).

g - ACCELERATION OF GRAVITY, (FT. / SEC.^{2}).

——— HIGH TURBULENCE (STILLING BASINS).

— — LOW TURBULENCE (CHANNEL STABILIZATION APRONS).

—·— WEIGHT VS. DIAMETER.

FROM U. S. ARMY CORPS OF ENGINEERS HYDRAULIC DESIGN CHART 712 - 1

NOMOGRAPH R

9.0 REFERENCES

1. ALYESKA Pipeline Service "Construction Zone Right-of-Way Erosion Control Plan" Anchorage, Alaska, June 1974.

2. ______________ "Volume 4 Field Design Change Manual for Erosion Control Where Geotechnical Conditions Differ from Those Used in Design", Anchorage, Alaska, June 1975.

3. Northwest Alaskan Pipeline Company, Document H03, "Design Approach for Chilled Gas Pipeline Effects on Streams" being prepared.

4. ______________ Document H23 "Methodology for Selection of Temporary vs. Permanent Structures" being prepared.

5. ______________ Document H12, "Flood Frequency Determination", Revision 6, September 1982.

6. ______________ Document H20, "Geotechnical Methodology", Revision 0, being prepared.

7. ______________ Document H02, "Ditch Plug Methodology" Revision 0, September 1982.

8. ______________ Document H11, "Pipeline Design Flood", Revision 4, September 1982.

9. Alaska Department of Environmental Conservation. Alaska Water Quality Management Planning Program Non-Point Source Study Series Sec. 208, PL 92-500, 95-217. Manual of Recommended Practices for Transportation Corridor Development, Roads, Railroads, Pipelines, Subdivision. May 1980.

10. ______________ Region II, Gas Pipeline Surveillance, "Methodology for Siltation Control" being prepared for State of Alaska.

11. Alaska Department of Highways, "Hydraulics Manual", Juneau, Alaska.

12. American Steel Institute, "Handbook of Steel Drainage and Highway Construction Products", 2nd Edition.

13. Armortec, Inc., "Bank and Channel Protection" Technical Bulletin BC-1.

14. Bohan, J. P. "Erosion and Riprap Requirements at Culvert and Storm Drain Outlets," Research Report H-70-2, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, January 1970.

15. Chow, V. T. "Open Channel Hydraulics," McGraw-Hill Book Company, New York, 1959.

16. Fletcher, B. P. and J. L. Grace "Practical Guidance for Estimating and Controlling Erosion at Culvert Outlets," Miscellaneous Paper H-72-5, U.A. Army Corps of Engineer Waterways Experiment Station, Vicksburg, Mississippi, May 1972.

17. Londagin, H. E. "A Treatise on Control of Culvert and Roadway Icing," Department of Highways, State of Alaska.

18. Maryland Department of Water Resources "Guideline for Erosion and Sediment Control Planning and Implementation" Annapolis, Maryland August 1972.

19. Murfitt, A. W., et al, "Design and Construction of Roads on Muskeg in Arctic and Subarctic Regions".

20. National Research Council of Canada, Associate Committee on Geotechnical Research "Permafrost Engineering Design and Construction" Toronto, Canada 1981.

21. Ontario Ministry of Transportation and Communications, "Engineering Geotextiles, Properties, Use Criteria, Tests and List of Acceptable Products," Report EM-45.

22. Seelye, E. E., "Design", John Wiley & Sons, Inc., 1947.

23. State of Alaska Memorandum Sigman to Files "Effects of Stream Siltation on Aquatic Life", File 1003.11, May 13, 1982.

24. State of Alaska Department of Transportation and Public Facilities, "Standard Drawings".

25. Terra Aqua Conservation "Bekaert Gabions".

26. Texas Highway Department "Hydraulics Manual", Austin, Texas, September 1970.

27. U.S. Army Corps of Engineers "Hydraulic Design Criteria-Stone Stability Velocity vs. Stone Diameter" Paper No. 712-1, September 1970.

28. ______________ "HEC-2, Water Surface Profiles," User's Manual, Hydrologic Engineering Center, Davis, California, January 1981.

29. U.S. Environmental Protection Agency, "Erosion and Sediment Control-Surface Mining in the Eastern U.S." Technology transfer seminar publication #EPA62513-76-006, October 1976.

30. U.S. Department of Transportation-Bureau of Public Roads, "Use of Riprap for Bank Protection", Washington, D. C. June 1967.

31. ______________ "Design Charts for Open-Channel Flow," Hydraulic Design Series No. 3, U.S. Department of Transportation, August 1961 (2nd Printing, December 1980).

32. ______________ "Hydraulic Charts for the Selection of Highway Culverts," Hydraulic Engineering Circular No. 5, June 1980.

33. U.S. Soil Conservation Service "Engineering Field Manual", 1975.

APPENDIX A

DESIGN EXAMPLES

The design examples presented in this section are only for the purpose of illustrating design procedures described in this document. Although specific situations and locations have been selected for these examples, no effort has been made to verify actual field conditions. In some cases, actual field data has been deliberately modified or ignored so that the example can be better or more graphically presented.

LIST OF DESIGN EXAMPLES

A-1 LOW WATER CROSSING - PEC CREEK

Step 1: Compile All Available Data

a. Location: Unnamed (Pec) Creek - RX-049-1
MP276.40 A/S 49 Sta 173+55
Survey Book 478 Page 58-64

b. From Civil Alignment Sheet 049 MUSC soil type is ML

c. From Table 2 Soil SEC type is S

d. From GDI 049 thermal stability is not a concern

e. From Civil Alignment Sheets 048 and 049,
   - Access to north is not available because of Jim River Crossing
   - Frequent construction traffic access required by Jim River Crossing
   - Access is required for operations access to Jim River

f. From Environmental Master Guide level I sheet 049: no fish present

g. From survey data: thalweg slope = 3.14%,
channel width = 15 feet, channel depth = 3.5 feet
streambed vegetation = willows + grass

h. From Quadrangle Maps: watershed area = 0.7 sq. mi.

i. From Civil Alignment Sheet: no adjacent facility

j. From C.Z. Worksheet 049: structural workpad thickness = 30"

k. From aufeis observations survey: no historical aufeis development

l. From debris observations: no historical debris problems

Step 2: Select Structure

a. Based on access requirements, permanent LWC with temporary culvert.

Step 3: Select LWC Type

a. Based on thermal stability, Type IV not required.

b. Based on SEC soil type S, Type III required (Figure 7).

c. Based on construction access requirements, a temporary culvert is required.

d. LWC thickness = 4' (Figure 7).

e. Therefore, select Type IIIA LWC four feet thick.

Step 4: Select LWC Channel Slope, Elevation and Width

a. Inlet and outlet elevations same as existing.

b. Slope same as existing = 3.14%.

c. Width: Based on channel width of 15'; LWC width = 35 feet (Figure 7).

Step 5: Determine Design Flow

a. LWC to be designed as a permanent structure, therefore, Q_{50} to be used.

b. Based on watershed area of 0.7 square mile Q_{50} = 125 cfs (Nomograph A).

Step 6: Determine Design Flow Velocity and Depth

a. Manning's "n" = 0.10 for riparian vegetation (Table 4).

b. Maximum depth of flow through LWC is 5.5 feet. (from scale plot of stream cross section with LWC)

c. Assume depth = 1.85 feet
   - A = 40 sq.ft.; P = 32 ft. (from scale plot)
   - R = A/P = 1.25
   - V = 3.0 fps (Nomograph C)
   - Q = 120 cfs Assumption close enough (<10% error)
   - d_{50} = 1.85 feet

d. d_{50} = 1.85 ft. < 5.5 feet (LWC capacity)

e. LWC capacity is adequate.

f. V_{50} = 3.0 fps

Step 7: <u>Check for Fish Passage</u>

a. No fish presence, therefore, fish passage is not a concern.

Step 8: <u>Check for Compatibility with Adjacent Structures</u>

a. No adjacent structures, therefore, compatibility is not a concern.

Step 9: <u>Check for Erosion in LWC</u>

a. Workpad material is SEC G, D or Q.
b. V_a for G, D, or Q is 1-6 fps (Table 4)
c. V_{50} = 3.0 fps
d. Use only coarse grained sand or gravel in LWC (this falls in the upper range of V_a).

Step 10: <u>Check for Erosion in Streambed</u>

a. Streambed material is SEC S.
b. V_a = 2 fps (Table 4).
c. $V_{50} > V_a$
d. Therefore, protect streambed with apron of coarse gravel - V_a = 4-5 fps (Table 4) with:
length = 6 x channel width (90')
width = 2 x channel width (30') (Figure 19).
e. No additional protection required.

SUMMARY:

a. Type IIIA LWC
b. Thickness = 4'
c. Slope = 3.14%
d. Width = 35'
e. Traffic course: coarse grained sand or gravel
f. Downstream protection: coarse gravel apron 90' x 30'
g. Culvert as described in Example A-2.

A-2 CULVERT OPERATING UNDER INLET CONTROL - PEC CREEK

Step 1: Compile All Available Data

a. Same crossing as Example A-1. See Example A-1 for listing of data.

Step 2: Select Structure

a. Based on Example A-1, a temporary culvert is required as part of a Type IIIA Low Water Crossing.

Step 3: Select Length

a. Length = 37' (from scale plot)

Step 4: Determine Design Flow

a. Culvert to be a temporary structure, therefore Q_5 to be used.

b. Based on watershed area of 0.7 square mile Q_5 = 42 cfs (Nomograph A).

Step 5: Select Culvert Slope, Elevation and Skew

a. Inlet and outlet elevations at existing stream thalweg

b. Slope same as existing = 3.14%

c. Skew = 1° (from scale plot)

Step 6: Determine Mannings "n" Values

a. Culvert n = 0.024 max (Table 5)

b. Streambed n = 0.10 (from Example A-1)

Step 7: Determine Trial Culvert Size

a. Assuming inlet control, HW/D = 1.0, D = 42" (Nomograph D)

Step 8: Determine Inlet or Outlet Control

a. $d_c = 2'$ (Nomograph F)

b. $h_o' = (d_c + D)/2 = 2.75'$

c. Determine depth of tailwater (TW) (Nomograph C)

- Assume depth = 1.0'
- A = 21.6 sq.ft. and P = 30.0 ft (from scale plot)
- R = A/P = 0.72
- V = 2.1 fps
- Q = 45 cfs - assumption close enough (<10% error)
- TW = d = 1.0'

d. Compare h_o' with TW: h_o' (2.75') > TW (1.0')
Therefore $h_o = h_o' = 2.75'$

e. H = 0.8 (Nomograph H)

f. HW outlet control = $H + h_o - L(S)$
$= 0.8 + 2.75 - 37(0.0314) = 2.39$ ft.

g. HW inlet control: HW/D = 0.95 (Nomograph D)
HW = 0.95D = 0.95(3.5) = 3.33 ft.

h. HW inlet control > HW outlet control,
therefore inlet control governs.

Step 9: Determine Flow Velocity and Depth

a. d/D = 0.5 (Nomograph K)

b. $V_5 = 8.7$ fps (Nomograph N)

Step 10: Determine Minimum Cover over Culvert

a. Minimum cover for 42" culvert = 12" (Table 6).

Step 11: Check for Workpad Stability

a. Depth at inlet = 3.33 ft.

b. Depth to top of workpad = 3.5' + 1.0' = 4.5 ft.

c. Workpad stable if depth of water is less than 80% of fill height.

d. 80% of 4.5' = 3.6'

e. 3.33' < 3.6', therefore embankment is stable.

Step 12: <u>Check for Fish Passage</u>

a. No fish presence, therefore fish passage is not a concern.

Step 13: <u>Check for Upstream and Downstream Channel Protection</u>

a. V_{inlet} = 2 fps (Nomograph C and from scale plot)

b. V_a = 2 fps (from Example A-1)

c. $V_{inlet} = V_a$; therefore upstream protection not required

d. V_{outlet} = 8.7 fps (Nomograph N)

e. $V_{outlet} > V_a$; therefore downstream protection is required (Example A-12 or A-13)

Step 14: <u>Check for Thermal Stability</u>

a. Thermal stability is not a concern.

Step 15: <u>Check for Aufeis Potential</u>

a. No historical aufeis development.

Step 16: <u>Check for Debris Potential</u>

a. No observed debris potential.

Step 17: <u>Check for Compatibility with Adjacent Structures</u>

a. No adjacent structures, therefore compatibility is not a concern.

SUMMARY:

a. 42" culvert in Type IIIA LWC

b. Cover = 12"

c. Length = 37'

d. Slope = 3.14%

e. Skew = 1°

f. No upstream protection

g. Downstream protection as in Example A-12 or A-13

A-3 FISH STREAM CULVERT OPERATING UNDER OUTLET CONTROL - POLYGON CREEK

Step 1: Compile All Available Information

a. Location: Unnamed (Polygon) Creek - RX-019-1-FH
MP 105.12 A/S 19 Sta 4300+22
Survey Book 289 Page 13

b. From Civil Alignment Sheet 019, MUSC soil type is ML

c. From Table 2 Soil SEC type is S

d. From GDI 019 thermal stability is a concern - thaw strain is 51%, thaw depth is 2'

e. From Civil Alignment Sheets 018 and 019, Access to south: 6,500'; access to north: 11,500'

f. From Environmental Master Guide level I - this is a fish habitat

g. From survey data: thalweg slope = 0.2%, channel width = 15 feet, channel depth = 4 feet streambed vegetation = grass

h. From Quadrangle Maps: watershed area = 0.65 sq. mi.

i. From Civil Alignment Sheet: no adjacent facility

j. From C.Z. Worksheet: workpad thickness = 30"

k. From aufeis observations: no historical aufeis development

l. From debris observations: no historical debris problems

Step 2: Select Structure

a. Crossing structure is required for construction.

b. Crossing structure is not required for operations.

c. Select temporary culvert.

Step 3: <u>Select Length</u>

a. Length = 59' (from scale plot)

Step 4: <u>Determine Design Flow</u>

a. Culvert is a temporary structure, therefore Q_5 to be used.

b. Based on watershed area of 0.65 sq. mi. Q_5 = 40 cfs (Nomograph A).

c. Culvert must pass fish, therefore Q_2 must be analyzed.

d. Q_2 = 30 cfs (Nomograph A).

Step 5: <u>Select Culvert Slope, Elevation and Skew</u>

a. Slope same as existing = 0.2%.

b. Inlet and outlet elevations 0.2D below thalweg (fish stream requirement).

c. Skew = 29° (from scale plot).

Step 6: <u>Determine Mannings "n"</u>

a. Culvert n = 0.024 max (Table 5)

b. Streambed n = 0.03 (Table 4)

Step 7: <u>Determine Trial Culvert Size</u>

a. Assuming inlet control and HW/D = 0.8, D = 48" (Nomograph D)

Step 8: <u>Determine Inlet or Outlet Control</u>

a. $d_c = 1.7'$ (Nomograph F)

b. $h_o' = (d_c + D)/2$ ("D" is effective height which, for fish streams is 80% of diameter)

$= (1.7 + 0.8(4))/2 = 1.45'$

c. Determine depth of tailwater (TW) (Nomograph C)

- Assume depth = 3.5'
- A = 17.5 sq.ft. and P = 13.0 ft (from scale plot)
- R = A/P = 1.35
- V = 2.5 fps
- Q = 43.8 cfs - assumption close enough (<10% error)
- TW = d = 3.5'

d. Compare h_o' with TW: h_o' (1.45') < TW (3.5')

Therefore h_o = TW = 3.5'

e. H = 0.5 (Nomograph-H)

f. HW outlet control = $H + h_o - L(S)$

$= 0.5 + 3.5 - 59(0.002) = 3.88$ ft.

g. HW inlet control: HW/D = 0.75 (Nomograph D)

HW = 0.75D = 3.0 ft.

h. HW inlet control < HW outlet control, therefore outlet control governs.

Step 9: <u>Determine Size for Outlet Control</u>

a. For d/D = 0.85, D = 60" (Nomograph M).

b. Maximum allowable HW = 0.8D = 0.8(5) = 4'.

c. HW_{max} (4') > HW (3.88'), therefore D = 60" is acceptable.

Step 10: <u>Determine Flow Velocity and Depth</u>

a. $d_5/D = 0.7$ (Nomograph M)

b. $d_2/D = 0.5$ (Nomograph M)

c. V_5 = 3.6 fps (Nomograph P)

d. V_2 = 2.8 fps (Nomograph P)

Step 11: <u>Determine Minimum Cover over Culvert</u>

a. Minimum cover for 60" culvert = 18" (Table 6).

Step 12: <u>Check for Workpad Stability</u>

a. Depth at inlet = 3.88 ft.

b. Depth to top of workpad = 4' + 1.5' = 5.5 ft.

c. Workpad stable if depth of water is less than 80% of fill height.

d. 80% of 5.5' = 4.4'

e. 3.88' < 4.4', therefore embankment is stable.

Step 13: <u>Check for Fish Passage</u>

a. V_F for a culvert 59' long is 3.7 fps (Nomograph J).

b. V_F (3.7 fps) > V_2 (2.8 fps).

c. Therefore fish passage provided.

Step 14: <u>Check for Upstream and Downstream Protection</u>

a. V_{inlet} = 2.5 fps (Nomograph C and from scale plot)

b. V_a for workpad material (SEC G, D or Q) is 1-6 fps (Table 4)

c. $V_{inlet} > V_a$; therefore upstream protection required

d. Protect embankment and stream bottom at inlet end with coarse gravel (V_a = 4-6 fps) (Table 4)

e. V_{outlet} = 3.6 fps (Nomograph C)

f. V_a for streambed material (SEC S) = 2 fps (Table 4)

g. $V_{outlet} > V_a$; therefore downstream protection is required

h. Provide an apron of coarse gravel (V_a = 4-6 fps) downstream.

Step 15: <u>Check for Thermal Stability</u>

a. Thermal stability is a concern.

b. Expected thaw settlement is 1.02'.

c. Select insulation as shown on Figure 13.

d. Insulation thickness to be determined by thermal model.

Step 16: <u>Check for Aufeis Potential</u>

a. No historical aufeis development.

Step 17: <u>Check for Debris Potential</u>

a. No observed debris potential.

Step 18: <u>Check for Compatibility with Adjacent Structures</u>

a. No adjacent structures, therefore compatibility is not a concern.

SUMMARY:

a. 60" temporary insulated culvert placed 12" below thalweg

b. Cover = 18"

c. Length = 59'

d. Slope = 0.2%

e. Skew = 29°

f. Upstream protection: coarse gravel liner

g. Downstream protection: coarse gravel apron

A-4 TRAFFIC BRIDGE HYDRAULICS - WASHINGTON CREEK

Step 1: Compile All Available Information

a. Location: Washington Creek - RX-078-2-FH
MP 439.77 A/S 78 Sta 1821+90
Survey Book 776 Page 4

b. From Civil Alignment Sheet 78, MUSC soil type is ML

c. From Table 2 Soil SEC type is S

d. From GDI 078 thermal stability is not a concern

e. From Civil Alignment Sheet 078,
Access to south: 21,500'; access to north: 2100'

f. From Environmental Master Guide Level I -
this is a fish habitat

g. From survey data: thalweg slope = 0.1%,
channel width = 36 feet, channel depth = 8 feet
streambed vegetation = none - silt

h. From Quadrangle Maps: watershed area is 75.6 sq. mi.

i. From Civil Alignment Sheet:
adjacent facility - TAPS downstream

j. From C.Z. Worksheet: workpad thickness: 30"

k. From aufeis observation survey: no historical aufeis development

l. From debris observations: no historical debris problem

Step 2: Select Structure

a. Crossing structure is required for construction.

b. Crossing structure is not required for operations.

c. Select temporary bridge.

Step 3: Determine Design Flow

a. Bridge designed as a temporary structure.
Therefore Q_5 to be used.

b. Based on watershed area of 75.6 sq. mi.
Q_5 = 1700 cfs (Nomograph B).

Step 4: <u>Determine Flow Geometry for Design Flood</u>

a. n for SEC S is 0.016 (Table 4).

b. S = 0.1%

c. Assume depth = 7.3 ft.

- A = 183 sq.ft. and P = 33 ft (from scale plot)
- R = A/P = 5.55
- V = 9.4 fps (Nomograph-C)
- Q = 1720 cfs - assumption close enough (<10% error)
- d_5 = 7.3'

d. V_5 - 9.4 fps

Step 5: <u>Establish Bridge Height and Length</u>

a. Height = d_5 + 4' = 11.3'

b. Length = 75' (from scale plot)

Step 6: <u>Check for Fish Passage</u>

a. Stream geometry is unaffected, therefore no impact to fish passage.

Step 7: <u>Check for Compatibility with Adjacent Structures</u>

a. TAPS is downstream. TAPS design Q = 2316 cfs

b. Determine depth during TAPS design flow

- Assume depth = 103 ft.
- A = 272.5 sq. ft. P = 53.7 (from scale plot)
- R = 5.07
- V = 8.7 fps (from Nomograph-C)
- Q = 2371 cfs - assumption close enough (<10% error)
- d_{TAPS} = 10.3 ft.

c. d_{TAPS} (10.3') < Height (11.3')
therefore bridge will not obstruct TAPS design flow

d. Therefore no impact.

Step 8: <u>Structural Design</u>

a. Not included as part of this example.

b. Low chord 11.3 ft. above thalweg.

c. Length 75 ft.

d. Structural data not determined.

A-5 DRAINAGE DITCH - MS 37-3A

Step 1: Compile All Available Information

a. Location: Material Site 37-3 Aliquot A
   Near MP 209.5 A/S 37

b. Purpose: To carry flow around TAPS SWDS 104-2

c. From MMAP 37-3 Soil type is silty sand

d. From Table 2 SEC soil type is S

e. Thermal stability is not a concern

f. From MMAP 37-2 ΔEL - 10' Length = 800'

g. From MMAP 37-2 Watershed area = 0.013 sq. mi.

h. Adjacent facility: TAPS SWDS 104-2

i. From thermal and groundwater analysis:
   no aufeis potential

j. No debris potential

Step 2: Determine Design Flow

a. Ditch to be a permanent structure,
   therefore Q_{50} to be used.

b. Based on watershed area of 0.013 sq. mi.
   Q_{50} = 9 cfs (Nomograph A).

Step 3: Determine Ditch Side Slopes

a. Based on SEC S, side slopes at 2:1 (Table 3).

Step 4: Determine Ditch Length and Slope

a. Length = 800 ft.

b. Slope = 10/800 = 1.25%

Step 5: Determine Ditch Shape and Flow Depth

a. Assume triangular shape.

b. Assume depth = 1'

- A = 2 sq.ft. and P = 4.5 sq.ft. (from scale plot)
- R = A/P = 0.44
- N = 0.02 (Table 4 for SEC S)
- V = 4.7 (Nomograph C)
- Q = 9.4 cfs - assumption close enough (<10% error)
- d_{50} = 1'

Step 6: Establish Ditch Depth

a. Ditch depth = d_{50} + 1' freeboard
= 1' + 1' = 2'

Step 7: Establish Flow Velocity

a. V_{50} = 4.7 fps

Step 8: Check for Ditch Checks or Channel Liner Requirement

a. V_a for SEC S = 2 fps (Table 4).

b. V_{50} (4.7 fps) > V_a (2 fps)

c. See Examples A-8 or A-11.

Step 9: Check for Thermal Stability

a. Thermal stability not a concern.

Step 10: Check for Known Aufeis or Debris Problems

a. None known.

Step 11: Check for Compatibility with Adjacent Structures

a. Ditch ties into existing ditch at each end.

b. Ditch is required to resolve compatibility problem with TAPS SWDS 104-2.

SUMMARY:

a. Design ditch located as shown on MMAP 37-2.

b. Depth = 2'

c. Slope = 1.25%

d. Side slopes = 1:2

e. Erosion protection as described in Example A-8 or A-11.

A-6 SHEET FLOW - 63-AMS-3

Step 1: Compile All Available Information

a. Location: Near MP 358.3 A/S 63
Access Road 63-AMS-3

b. Purpose: Access to MS 64-0.8

c. Description: Sheet flow is being intercepted by access road rising from a drainage crossing across a side hill with no defined drainage paths.

d. From Route Soil Conditions Sheet 063: MUSC soil type is ML.

e. From Table 2 SEC soil type is S

f. Thermal stability is not a concern

g. From Quadrangle Map: Watershed area is 0.5 sq. mi.

h. From Civil Alignment Sheet 063 and Quadrangle Map: slope along road is 5%; ground slope is 10%.

i. From Vegetation Type Mapping Sheet 063, vegetation is timber stand.

j. Access road thickness is 30", material SEC D (from M.S. gradation curves).

k. Access road is temporary, so existing drainage patterns will be approximated for fill section after completion of construction.

l. From thermal and groundwater analysis, no aufeis potential.

m. No apparent debris problem potential.

n. No adjacent facility.

Step 2: Determine Design Flow at End of Fill Section

a. Access road is designed as a temporary structure, therefore, Q_5 to be used.

b. Based on watershed area of 0.5 sq. mi.
Q_5 = 30 cfs (Nomograph A)

Step 3: Determine Side Slopes

a. Ground slopes 10% to road.

b. Embankment side slope = 1:1.

Step 4: Determine Embankment Capacity

a. Maximum depth of flow = 80% embankment thickness
= 0.8(30") = 24" = 2'

b. Flow area = 2' x 2')/2 + (2' x 10)(2')/2 = 22 sq. ft.

- $P = \sqrt{(2^2 + 2^2)} + \sqrt{(2^2 + 20^2)} = 23$
- $R = A/P = 0.96$
- $S = 5\%$
- $n = 0.10$ for vegetation (Table 4)
- $V = 3.3$ fps
- $Q_{capacity} = 73$ cfs (Nomograph C)

c. $Q_{capacity}$ (73) > Q_5(30) therefore road is not overtopped.

Step 5: Determine Flow Velocity

a. Assume $d_5 = 1.5'$

- $A = 12.4$
- $P = 17.2$
- $R = 0.72$
- $V = 2.7$ (Nomograph C)
- $Q = 33$ cfs - assumption close enough (error = 10%)

$V_5 = 2.7$ fps

Step 6: Check for Erosion Protection

a. V_a for embankment 2-4 (Table 4)
$V_5 < V_a$; no protection required.

b. V_a for vegetation = 2 (Table 4)
$V_5 > V_a$; protection required.

c. Consider ditch checks or other means not analyzed here.

SUMMARY:

a. No special structure is required.

b. No embankment protection is required.

c. Velocity reduction to protect existing soil will be required (not designed here).

A-7 EQUALIZATION CULVERTS - WETLANDS

Step 1: Compile All Available Information

a. Location: wetland from MP 641.7 to MP 642.9
A/S 114

b. From GDI 114 MUSC soil type is SM

c. From Table 2 SEC soil type is Q

d. From GDI 114, thermal stability is not a concern.

e. From Quadrangle Map: watershed area is 11 sq. mi.

f. From Civil Alignment Sheet 114, no adjacent facility

g. Thermal and groundwater analysis indicate no aufeis potential

h. From Vegetation Mapping: vegetation type is wet tundra

Step 2: Select Structure

a. Based on access requirements, select temporary equalization culverts in pre-prepared LWCs.

Step 3: Determine Design Flow

a. Culverts to be designed as temporary structures, Q_5 to be used.

b. Q_5 = 280 cfs (from Nomograph B)

Step 4: Check Spacing for Minimum Size Culvert

a. Minimum size culvert is 24"

b. Capacity of 24" culvert is 11 cfs (Nomograph D) (HW/D = 1)

c. Number culverts required = 280 cfs/11 cfs each = 25 culverts

d. Spacing = 6340 ft./25 each = 250 ft.

e. Too close (judgment call)

Step 5: <u>Check Spacing for 30" Culvert</u>

a. Capacity of 30" culvert is 20 cfs (Nomograph-D) (HW/D = 1)

b. Number culverts required = 280/20 = 14 culverts

c. Spacing = 6340 ft./14 = 450 ft.

SUMMARY:

a. Select 30" equalization culverts

b. Use 14 culverts spaced at 450 ft. centered at MP 642.3

A-8 DITCH CHECKS - MS 37-3A

Step 1: Compile All Available Information

a. Same as Example A-5. See Example A-5 for listing of data.

b. V_a = 2 fps (from Example A-5)

c. V_{50} = 4.7 fps (from Example A-5)

Step 2: Determine Whether Velocity or Sediment is to be Controlled

a. Velocity is to be controlled.

Step 3: Select Trial Ditch Check Height

a. Select 18" (this is the size if straw bales are used)

Step 4: Determine Spacing

a. $L = h/S_D - S_s$

b. $S_D = 0.05$

c. $S_s = 0.0022$ (Nomograph C for Q = 9, n = 0.02, R = 0.44, V = 2)

d. h = 1.5 ft.

e. L = 1.5/(0.05 - 0.002) = 31 ft.

SUMMARY:

a. Use 18" high ditch checks

b. Spacing 31 ft.

A-9 DIVERSION LEVEE - 63-AMS-3

Step 1: Compile All Available Information

a. Same as Example A-6 except as follows:

b. Assume thermal stability is a concern and that sheet flow should not be allowed to pond or run along the road embankment which would promote thermal-hydraulic erosion.

c. Levee material is SEC S.

d. Q_5 = 30 cfs (from Example A-6).

Step 2: Determine Longitudinal and Cross Slope

a. Longitudinal slope = 5%

b. Cross slope = 10%

Step 3: Determine Manning's "n" Factors and Allowable Velocities

a. Levee material - SEC S - n=0.02, V_a=2 (Table 4)

b. Vegetation - timber stand - n=0.10, V_a=2

Step 4: Determine Levee Side Slopes

a. Levee material is SEC S.

b. Side slope = 2:1 (Table 3).

Step 5: Determine Type and Quantity of Flow

a. Sheet flow (Example A-6)

b. Q_5 = 30 cfs (Example A-6)

Step 6: Determine Depth of Flow

a. n (vegetation) = 0.10

b. Assume depth = 1.4'

- A = (2x1.4)(1.4)/2+(10x1.4)(1.4)/2=11.8 s.f.
- P = $\sqrt{((2x1.4)^2+1.4^2)}$ + $\sqrt{((10x1.4)^2+1.4^2)}$ = 17.2 ft.
- R = 0.69
- V = 2.6 fps
- Q = 30.7 cfs assumption close enough (<10% error)

Step 7: Determine Velocity

a. n (Levee) = 0.02

b. Assume depth = 0.75

- A = (2x0.75)(0.75)/2 + (10x0.75)(0.75)/2 = 3.4 sf.
- P = √((2x0.75)²+0.79²) + √((10x0.75)²+0.75²) = 9.2'
- R = 0.37
- V = 8.5 fps
- Q = 28.9 cfs assumption close enough (<10% error)

Step 8: Height of Levee

a. Select height so d = 80% of levee height (H)

b. H = 3/0.80 = 1.75'

Step 9: Erosion Protection

a. V_a = 2 fps

b. V_5 = 8.5 fps

c. $V_5 > V_a$ therefore protection required

d. Select ditch checks as designed in Example A-8.

SUMMARY:

a. Diversion levee 1.79 ft. high.

b. Side slope = 2:1

c. Erosion protection per Example A-8.

A-10 WATER BARS

Step 1: Compile All Available Information

a. Location: MP 519.9 to MP 519.9 A/S 092.

b. From material site gradation curve - workpad material SEC D

c. Workpad width = 50'

d. Longitudinal slope = 17%

e. Workpad cross slope = 5%

Step 2: Select Trial Spacing

a. Spacing = 230 ft. (Table 7)

Step 3: Find Embankment Surface Area Between Water Bars

a. Area = 230 x 50 = 11,500 sq. ft. = 0.0004 sq. mi.

Step 4: Determine Runoff

a. Q_{50} = 1 cfs (Nomograph B extended)

Step 5: Determine Velocity Along Embankment

a. R = d = Q/W = 1 cfs/50 ft. = 0.02

b. n = 0.025 (Table 4)

c. V = 1.6 fps (Nomograph C extended)

Step 6: Check for Erosion of Embankment Material

a. V_a for SEC D = 4 fps (Table 4)

b. V (1.6) < V_a(4); therfore no erosion of embankment material

Step 7: <u>Determine Velocity Along Water Bar</u>

a. Assume Water Bar Skew = 0° S = 5%

b. Assume flow depth = 0.3 ft.

- $A = (0.3 \times 3)\ 0.3 = 0.27$ sq. ft.
- $P = 2\sqrt{((0.3 \times 3)^2 + 0.3^2)} = 1.9$ ft.
- $R = A/P = 0.14$
- $V = 3.6$ fps (Nomograph C)
- $Q = 0.97$ close enough (<10% error)

c. $V = 3.6$ fps

Step 8: <u>Check for Erosion Along Water Bar</u>

a. $V_a = 4$ fps

b. V (3.6 fps) $< V_a$ (4 fps); therfore no erosion of water bar

Step 9: <u>Check for Erosion of Embankment Side Slope</u>

a. Slope = 1:1 = 100%

b. n for SEC D = 0.029

c. Assume same shape as water bar

d. Assume flow depth = 0.14 ft.

- $A = (0.14 \times 3)\ 0.14^2 = 0.059$
- $P = 2\sqrt{((0.14 \times 3)^2 + 0.14^2)} = 0.88$
- $R = A/P = 0.067$
- $V = 17$ fps (Nomograph C)
- $Q = 1$ cfs

e. $V\ (17) > V_a\ (4)$ - Erosion protection required

SUMMARY:

a. Water bar spacing 230 ft.

b. Erosion protection down embankment slope (suggest letdown structure).

A-11 CHANNEL LINER - MS 37-3A

Step 1: Compile All Available Information

a. Same as Example A-5. See Example A-5 for listing of data.

b. Q_{50} = 9 cfs (from Example A-5)

c. V_{50} = 4.7 fps (from Example A-5)

d. V_a = 2 fps (from Example A-5)

e. Side slopes = 2:1 (from Example A-5)

f. Depth = 2'

Step 2: Select Channel Liner Trial No. 1

a. Select coarse gravel (V_a = 4-5 fps from Table 4)

Step 3: Check Flow Characteristics for Trial No. 1

a. S = 1.25%

b. n = 0.04 (Table 4)

c. Assume depth d = 1.25 ft.

- A = 3.13 sq. ft.
- P = 0.04 ft.
- R = 0.56
- V = 2.8 fps (Nomograph C)
- Q = 8.76 close enough (<10% error)

Step 4: Select Channel Liner Trial No. 2

a. Select clean gravel (SEC G) (V_a = 2-6 fps from Table 4)

Step 5: Check Flow Characteristics for Trial No. 2

a. n = 0.025 (Table 4)

b. Assume depth d = 1.05 ft.

- A = 2.21
- P = 4.7
- R = 0.47
- V = 4
- Q = 8.8 close enough (<10% error)

Step 6: Select Channel Liner

a. For trial No. 2

b. V_a = 2-6 fps

c. Use coarser sizes so $V_a > 4$ fps

d. V = 4 fps

e. $V < V_a$

f. Use trial No. 2.

Step 6: Determine Channel Depth

a. 1' freeboard required

b. Flow depth 1.05 ft.

c. Therefore channel depth = 1.05 + 1 = 2.05 ft.

Step 7: Determine Liner Thickness

a. D_{50} = 3/4"

b. Thickness = 12" or $2(D_{50})$, whichever is more

c. Thickness = 12"

SUMMARY:

a. Line Channel with coarse sized clean gravel 12" thick.

b. Increase channel depth to 2.05 ft.

A-12 RIPRAP APRON

Step 1: Compile All Available Information

a. Same as Example A-2. See Example A-1 for listing of data.

b. D = 42" (from Example A-2)

c. V = 8.7 fps (from Example A-2)

d. V_a = 2 fps (from Example A-2)

Step 2: Determine Riprap Size

a. Assume rock density = 165 lb/cu ft.

b. Assume low turbulant flow

c. D_{50} = 0.5 ft. (Nomograph R)

Step 3: Determine Thickness

a. Thickness = 2 (D_{50}) or 12", whichever is more

b. Thickness = 12"

Step 4: Determine Dimensions from Figure 19

a. Apron dimensions = 17.5 ft. x 42 ft.

SUMMARY:

a. Apron Dimensions = 17.5 ft. x 42 ft.

b. Riprap D_{50} = 0.5 ft.

c. Riprap Thickness = 1.0 ft.

d. A scour hole will probably develop at downstream end of apron. If this is not acceptable, use plunge basin (Example A-13).

A-13 PLUNGE BASIN

Step 1: Compile All Available Information

a. Same as Example A-2. See Example A-1 for listing of data.

b. D = 42" (from Example A-2)

c. V = 8.7 fps

d. V_a = 2 fps

Step 2: Determine Dimensions from Figure 20

a. Basin dimensions A = 3'; C = 1.5'; E = 3'; F = 5'

Step 3: Determine Riprap Size

a. Assume rock density = 165 lb/cu ft.

b. Assume high turbulant flow

c. D_{50} = 0.95 ft. (Nomograph R)

d. Class I (Figure 20)

Step 4: Determine Thickness

a. Thickness = 18" (Figure 20)

Step 5: Check for Erosion Downstream

a. Stream width = 15'

b. Flow depth = 3' (Figure 20)

c. V = Q/A = 42/15(3) = 0.93 fps

d. V(0.93) < V_a(2); therefore no downstream erosion

SUMMARY:

a. Basin Dimensions: A = 3'; C = 1.5'; E = 3'; F = 5'

b. Riprap D_{50} - 0.95 ft.

c. Riprap Thickness = 18"

A-14 SILT FENCE - STAGING AREA

Step 1: Compile All Available Information

a. Location: Tanana River Crossing Staging Area
   MP 539.4 A/S 96

b. Disturbed area 500' x 100'

c. Particle size to be removed = #140 seive (from gradation curve)

d. Silt fence required along 500' side

Step 2: Select Fabric

a. Particle size to be removed = 0.105 mm

b. Acceptable E.O.S. = 0.105 mm

c. Acceptable fabrics are Typar 3601 or Nicofab 300
   - E.O.S. 0.096 mm (Reference 21)
   - Permeability (P) = 1.4×10^{-2} cm/sec
     = 4.48×10^{-4} ft/sec (Reference 21)

Step 3: Determine Flow

a. Facility is temporary - Q_5 should be used

b. Q_5 = 0.9 cfs (Nomograph B extended)

Step 4: Determine Dimensions of Fencing

a. Area = A = Q/P = $0.9/4.48 \times 10^{-4}$ = 2009 sq.ft.

b. Length = L = 500 ft.

c. Height = A/L = 2009/500 = 4 ft.

SUMMARY:

a. Select silt fence using Typar 3601 or Nicofab 300

b. Length = 500 ft.

c. Height = 4 ft.

A-15 RECYCLE POND - MS 30-1

Step 1: Compile All Available Information

a. Location: MS 30-1 Near MP 166 A/S 30

b. From MMAP 30-1 - Purpose - Wet processing water supply

c. Water use = 2800 gpm

d. Expected losses: seepage = 300 gpm; processing = 5%

e. Processed material: 30,000 cy concrete aggregate
Gradation: <3" - 60%; <#4 - 15%; <#200 - 1%
(from specs*)

f. Water for processing must have no more than 200 ml/l sediment.

Step 2: Obtain Particle Size Distribution

a. From Route Soil Conditions: Landform is Ffg

b. From Table 12, particle size distribution is:
#4-45%; #10-30%; #40-20%; #200-12%; #270-10%;
0.02mm-7%; 0.01mm-6%; 0.005mm-5%; 0.002mm-2%;
0.001mm-1%

Step 3: Determine Inflow Rate

a. Q = 2800 gpm = 6.24 cfs

Step 4: Determine Amount of Sediment in Inflow

a. Remove from 45% to 15% smaller than #4
= 30% particles smaller than #4
from 12% to 5% smaller than #200
= 7% particles smaller than #200

b. 30% of 30,000 cy = 10,000 cy = 270,000 cu ft

*Note: Gradation shown is from AASHTO specs. actual gradation for this project may differ.

Step 5: <u>Determine Acceptable Amount of Sediment in Outflow</u>

a. 200 ml/l or 20%

Step 6: <u>Determine Percent Removal</u>

a. (30% - 20%)/30% = 30% removal

Step 7: <u>Determine Design Particle Size</u>

a. 30% of solids must be removed.

b. From particle size distribution, remove 0.02mm particle.

Step 8: <u>Determine Settling Velocity</u>

a. V_s - 0.005 FPS (Table 10)

Step 9: <u>Determine Minimum Pond Surface Area</u>

a. $A = 1.2\ Q/V_s = 1.2(6.24)/0.0005 = 14{,}966$ sq ft

Step 10: <u>Determine Detention Time</u>

a. Set outlet to provide 18" supernatent.

b. $T = S_d/V_s = 1.9/0.0005 = 3{,}000$ sec

Step 11: <u>Determine Settling Volume</u>

a. $V = QT = 6.25(3{,}000) = 18{,}710$ cu ft

Step 12: <u>Select Trial Width</u>

a. W = 100 ft.

Step 13: <u>Determine Trial Length</u>

a. $L = V/WS_d = 18{,}710/100(1.9) = 125$ ft.

b. $WL = 12{,}500 < 14{,}966$

c. $L = A/W = 14{,}966/100 = 150$ ft.

Step 14: Determine Water Depth

a. d_w = TQ/LW = 3,000(6.24)/150(100) = 1.25'

b. Supernatent = 1.9'

c. d_w = 1.5'

Step 15: Determine Sediment Storage Volume

a. V_{sed} = 270,000 cu ft

Step 16: Determine Sediment Depth

a. d_{sed} = V_{sed}/LW = 270,000/100(150) = 18 ft.

b. 18 ft is impractical

c. Double length

d. d_{sed} = 270,000/100(300) = 9 ft

Step 17: Determine Total Depth

a. d = 1.5 + 9 + 1 = 11.5 ft.

SUMMARY:

a. Pond is 100' x 300' x 11.9'.

b. Baffels, spillways, etc. in accordance with Reference 29.

A-16 SEDIMENTATION BASIN - MS 96-1

Step 1: Compile All Available Information

a. Location: MS 96-1 Near MP 540 off A/S 96

b. From MMAP 96-1 - Purpose is to remove sediment from runoff from Aliquots 2, 3 and 4 prior to discharge to Delta River.

c. Maximum flow = 10,000 gpm (from MMAP 96-1)

d. Disturbed area = 18 acres

e. Expected active use = 3 years

Step 2: Determine Required Basin Volume

a. A = 18 acres

b. V = (67 cy/acre)18 acres = 1206 cy = 32,562 cu ft

Step 3: Estimate Amount of Sediment

a. From Table 11, yield is 19 cy/acre/year

b. Yield = 19 x 18 = 342 cy/year

c. Expected life = 3 years

d. Total yield = 1026 cy = 27,702 cu ft

Step 4: Estimate Clean Out Frequency

a. Clean out when accumulation = 27 cy/acre

b. 27 cy/acre(18 acres) = 486 cy

c. Number of times cleaned out = total yield/clean out volume = 1026 cy/486 cy = 2.11
Clean out twice during 3 year life.

Step 5: Select Depth

a. d = 5'

b. Total depth = d + 1' freeboard = 6'

Step 6: Determine Pond Surface Area and Dimensions

a. $A = V/d = 32,562/5 = 6513$ sq ft

b. $L = 2W$

c. $LW = A$; $2W^2 = A = 6513$

d. $W = 58'$

e. $L = 116'$

Step 7: Design Baffels, Spillways, etc. in Accordance with Reference 29.

SUMMARY:

a. Dimensions: 116' x 58' x 6'

b. Clean out twice.