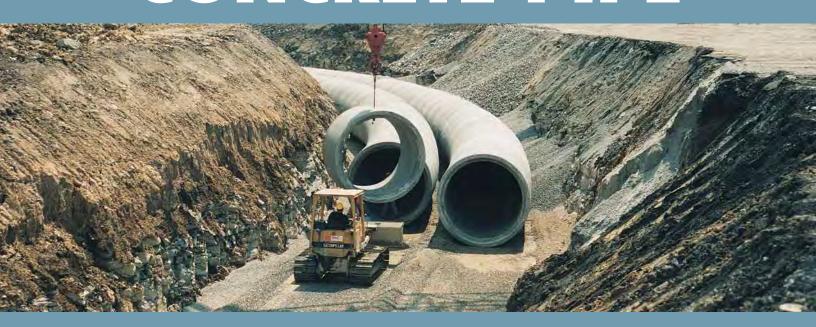
CONCRETE PIPE



DESIGN MANUAL

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Technical programs of the American Concrete Pipe Association, since its founding in 1907, have been designed to compile engineering data on the hydraulics, loads and supporting strengths and design of concrete pipe. Information obtained is disseminated to producers and consumers of concrete pipe through technical literature and promotional handbooks. Other important activities of the Association include development of product specifications, government relations, participation in related trade and professional societies, advertising and promotion, an industry safety program and educational training. These services are made possible by the financial support of member companies located throughout the United States, Canada, and in almost 30 foreign countries.

FOREWORD

The principal objective in compiling the material for this **CONCRETE PIPE DESIGN MANUAL** was to present data and information on the design of concrete pipe systems in a readily usable form. The Design Manual is a companion volume to the **CONCRETE PIPE HANDBOOK** which provides an up-to-date compilation of the concepts and theories which form the basis for the design and installation of precast concrete pipe sewers and culverts and explanations for the charts, tables and design procedures summarized in the Design Manual.

Special recognition is acknowledged for the contribution of the staff of the American Concrete Pipe Association and the technical review and assistance of the engineers of the member companies of the Association in preparing this Design Manual. Also acknowledged is the development work of the American Association of State Highway and Transportation Officials, American Society of Civil Engineers, U. S. Army Corps of Engineers, U. S. Federal Highway Administration, Bureau of Reclamation, Iowa State University, Natural Resources Conservation Service, Water Environment Federation, and many others. Credit for much of the data in this Manual goes to the engineers of these organizations and agencies. Every effort has been made to assure accuracy, and technical data are considered reliable, but no guarantee is made or liability assumed.

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CHAPTER 1INTRODUCTION

The design and construction of sewers and culverts are among the most important areas of public works engineering and, like all engineering projects, they involve various stages of development. The information presented in this manual does not cover all phases of the project, and the engineer may need to consult additional references for the data required to complete preliminary surveys.

This manual is a compilation of data on concrete pipe, and it was planned to provide all design information needed by the engineer when he begins to consider the type and shape of pipe to be used. All equations used in developing the figures and tables are shown along with limited supporting theory. A condensed bibliography of literature references is included to assist the engineer who wishes to further study the development of these equations.

Chapters have been arranged so the descriptive information can be easily followed into the tables and figures containing data which enable the engineer to select the required type and size concrete pipe without the lengthy computations previously required. All of these design aids are presently published in engineering textbooks or represent the computer analysis of involved equations. Supplemental data and information are included to assist in completing this important phase of the project, and illustrative example problems are presented in Chapters 2 through 4. A review of these examples will indicate the relative ease with which this manual can be used.

The revised Chapter 4 on Loads and Supporting Strengths incorporates the Standard Installations for concrete pipe bedding and design. The standard Installations are compatible with today's methods of installation and incorporate the latest research on concrete pipe. In 1996 the B, C, and D beddings, researched by Anson Marston and Merlin Spangler, were replaced in the AASHTO Bridge Specifications by the Standard Installations. A description of the B, C, and D beddings along with the appropriate design procedures are included in Appendix B of this manual to facilitate designs still using these beddings.

CHAPTER 2 HYDRAULICS OF SEWERS

The hydraulic design procedure for sewers requires:

- 1. Determination of Sewer System Type
- 2. Determination of Design Flow
- 3. Selection of Pipe Size
- 4. Determination of Flow Velocity

SANITARY SEWERS

DETERMINATION OF SEWER SYSTEM TYPE

Sanitary sewers are designed to carry domestic, commercial and industrial sewage with consideration given to possible infiltration of ground water. All types of flow are designed on the basis of having the flow characteristics of water.

DETERMINATION OF DESIGN FLOW

In designing sanitary sewers, average, peak and minimum flows are considered. Average flow is determined or selected, and a factor applied to arrive at the peak flow which is used for selecting pipe size. Minimum flows are used to determine if specified velocities can be maintained to prevent deposition of solids.

Average Flow. The average flow, usually expressed in gallons per day, is a hypothetical quantity which is derived from past data and experience. With adequate local historical records, the average rate of water consumption can be related to the average sewage flow from domestic, commercial and industrial sources. Without such records, information on probable average flows can be obtained from other sources such as state or national agencies. Requirements for minimum average flows are usually specified by local or state sanitary authorities or local, state and national public health agencies. Table 1 lists design criteria for domestic sewage flows for various municipalities. Commercial and industrial sewage flows are listed in Table 2. These tables were adapted from the "Design and Construction of Sanitary and Storm Sewers," published by American Society of Civil Engineers and Water Pollution Control Federation. To apply flow criteria in the design of a sewer system, it is necessary to determine present and future zoning, population densities and types of business and industry.

Peak Flow. The actual flow in a sanitary sewer is variable, and many studies have been made of hourly, daily and seasonal variations. Typical results of one study are shown in Figure I adapted from "Design and Construction of Sanitary and Storm Sewers," published by the American Society of Civil Engineers and Water Pollution Control Federation. Maximum and minimum daily flows are used in the design of treatment plants, but the sanitary sewer must carry the peak flow that will occur during its design life. This peak flow is defined as the mean

rate of the maximum flow occurring during a 15-minute period for any 12-month period and is determined by multiplying average daily flow by an appropriate factor. Estimates of this factor range from 4.0 to 5.5 for design populations of one thousand, to a factor of 1.5 to 2.0 for design population of one million. Tables 1 and 2 list minimum peak loads used by some municipalities as a basis for design.

Minimum Flow. A minimum velocity of 2 feet per second, when the pipe is flowing full or half full, will prevent deposition of solids. The design should be checked using the minimum flow to determine if this self-cleaning velocity is maintained.

SELECTION OF PIPE SIZE

After the design flows have been calculated, pipe size is selected using Manning's formula. The formula can be solved by selecting a pipe roughness coefficient, and assuming a pipe size and slope. However, this trial and error method is not necessary since nomographs, tables, graphs and computer programs provide a direct solution.

Manning's Formula. Manning's formula for selecting pipe size is:

$$Q = \frac{1.486}{n} AR^{2/3} S^{1/2}$$
 (1)

A constant $C_1 = \frac{1.486}{n}$ AR^{2/3} which depends only on the geometry and characteristics of the pipe enables Manning's formula to be written as:

$$Q = C_1 S^{1/2}$$
 (2)

Tables 3, 4, 5 and 6 list full flow values of C_1 for circular pipe, elliptical pipe, arch pipe, and box sections. Table A-1 in the Appendix lists values of $S^{1/2}$.

Manning's "n" Value. The difference between laboratory test values of Manning's "n" and accepted design values is significant. Numerous tests by public and other agencies have established Manning's "n" laboratory values. However, these laboratory results were obtained utilizing clean water and straight pipe sections without bends, manholes, debris, or other obstructions. The laboratory results indicated the only differences were between smooth wall and rough wall pipes. Rough wall, or corrugated pipe, have relatively high "n" values which are approximately 2.5 to 3 times those of smooth wall pipe.

All smooth wall pipes, such as concrete and plastic, were found to have "*n*" values ranging between 0.009 and 0.010, but, historically, engineers familiar with sewers have used 0.012 and 0.013. This "design factor" of 20-30 percent takes into account the difference between laboratory testing and actual installed conditions. The use of such design factors is good engineering practice, and, to be consistent for all pipe materials, the applicable Manning's "" laboratory value should be increased a similar amount in order to arrive at design values.

Full Flow Graphs. Graphical solutions of Manning's formula are presented for circular pipe in Figures 2 through 5 and for horizontal elliptical pipe, vertical elliptical pipe, arch pipe and box sections in Figures 6 through 19. When flow, slope and roughness coefficient are known, pipe size and the resulting velocity for full flow can be determined.

Partially Full Flow Graphs. Velocity, hydraulic radius and quantity and area of flow vary with the depth of flow. These values are proportionate to full flow values and for any depth of flow are plotted for circular pipe, horizontal elliptical pipe, vertical elliptical pipe, arch pipe, and box sections in Figures 20 through 24.

DETERMINATION OF FLOW VELOCITY

Minimum Velocity. Slopes required to maintain a velocity of 2 feet per second under full flow conditions with various "*n*" values are listed in Table 7 for circular pipe. The slopes required to maintain velocities other than 2 feet per second under full flow conditions can be obtained by multiplying the tabulated values by one-fourth of the velocity squared or by solving Manning's formula using Figures 2 through 19.

Maximum Velocity. Maximum design velocities for clear effluent in concrete pipe can be very high. Unless governed by topography or other restrictions, pipe slopes should be set as flat as possible to reduce excavation costs and consequently velocities are held close to the minimum.

STORM SEWERS

DETERMINATION OF SEWER SYSTEM TYPE

Storm sewers are designed to carry precipitation runoff, surface waters and, in some instances, ground water. Storm water flow is analyzed on the basis of having the flow characteristics of water.

DETERMINATION OF DESIGN FLOW

The Rational Method is widely used for determining design flows in urban and small watersheds. The method assumes that the maximum rate of runoff for a given intensity occurs when the duration of the storm is such that all parts of the watershed are contributing to the runoff at the interception point. The formula used is an empirical equation that relates the quantity of runoff from a given area to the total rainfall falling at a uniform rate on the same area and is expressed as:

$$Q = CiA \tag{3}$$

The runoff coefficient "C" and the drainage area "A" are both constant for a given area at a given time. Rainfall intensity " i ", however, is determined by using an appropriate storm frequency and duration which are selected on the basis of economics and engineering judgment. Storm sewers are designed on the basis that they will flow full during storms occurring at certain intervals. Storm frequency is selected through consideration of the size of drainage area, probable flooding, possible flood damage and projected development schedule for the area.

Runoff Coefficient. The runoff coefficient "C" is the ratio of the average rate of rainfall on an area to the maximum rate of runoff. Normally ranging between zero and unity, the runoff coefficient can exceed unity in those areas where rainfall occurs in conjunction with melting snow or ice. The soil characteristics, such as porosity, permeability and whether or not it is frozen are important considerations. Another factor to consider is ground cover, such as paved, grassy or wooded. In certain areas, the coefficient depends upon the slope of the terrain. Duration of rainfall and shape of area are also important factors in special instances. Average values for different areas are listed in Table 8.

Rainfall Intensity. Rainfall intensity "i "is the amount of rainfall measured in inches per hour that would be expected to occur during a storm of a certain duration. The storm frequency is the time in years in which a certain storm would be expected again and is determined statistically from available rainfall data.

Several sources, such as the U. S. Weather Bureau, have published tables and graphs for various areas of the country which show the relationship between rainfall intensity, storm duration and storm frequency. To illustrate these relationships, the subsequent figures and tables are presented as examples only, and specific design information is available for most areas. For a 2-year frequency storm of 30-minute duration, the expected rainfall intensities for the United States are plotted on the map in Figure 25. These intensities could be converted to storms of other durations and frequencies by using factors as listed in Tables 9 and 10 and an intensity-duration-frequency curve constructed as shown in Figure 26.

Time of Concentration. The time of concentration at any point in a sewer system is the time required for runoff from the most remote portion of the drainage area to reach that point. The most remote portion provides the longest time of concentration but is not necessarily the most distant point in the drainage area. Since a basic assumption of the Rational Method is that all portions of the area are contributing runoff, the time of concentration is used as the storm duration in calculating the intensity. The time of concentration consists of the time of flow from the most remote portion of the drainage area to the first inlet (called the inlet time) and the time of flow from the inlet through the system to the point under consideration (called the flow time). The inlet time is affected by the rainfall intensity, topography and ground conditions. Many designers use inlet times ranging from a minimum of 5 minutes for densely developed areas with closely spaced inlets to a maximum of 30 minutes for flat residential areas with widely spaced inlets. If the inlet time exceeds 30 minutes, then a detailed analysis is required because a very small inlet time will result in an overdesigned system while conversely for a very long inlet time the system will be underdesigned.

Runoff Area. The runoff area "A" is the drainage area in acres served by the storm sewer. This area can be accurately determined from topographic maps or field surveys.

SELECTION OF PIPE SIZE

Manning's Formula. Manning's formula for selecting pipe size is:

$$Q = \frac{1.486}{n} AR^{2/3} S^{1/2}$$
 (1)

A constant $C_1 = \frac{1.486}{n}$ AR^{2/3} which depends only on the geometry and characteristics of the pipe enables Manning's formula to be written as:

$$Q = C_1 S^{1/2}$$
 (2)

Tables 3, 4, 5 and 6 for circular pipe, elliptical pipe, arch pipe, and box sections with full flow and Table A-1 in the Appendix for values of C₁ and S^{1/2} respectively are used to solve formula (2). Graphical solutions of Manning's formula (1) are presented in Figures 2 through 5 for circular pipe, and Figures 6 through 19 for horizontal elliptical pipe, vertical elliptical pipe, arch pipe and box sections under full flow conditions.

Partial flow problems can be solved with the proportionate relationships plotted in Figure 20 through 24.

Manning's "n" Value. The difference between laboratory test values of Manning's "n" and accepted design values is significant. Numerous tests by public and other agencies have established Manning's "n" laboratory values. However, these laboratory results were obtained utilizing clean water and straight pipe sections without bends, manholes, debris, or other obstructions. The laboratory results indicated the only differences were between smooth wall and rough wall pipes. Rough wall, or corrugated pipe, have relatively high "n" values which are approximately 2.5 to 3 times those of smooth wall pipe.

All smooth wall pipes, such as concrete and plastic, were found to have "n" values ranging between 0.009 and 0.010, but, historically, engineers familiar with sewers have used 0.012 or 0.013. This "design factor" of 20-30 percent takes into account the difference between laboratory testing and actual installed conditions. The use of such design factors is good engineering practice, and, to be consistent for all pipe materials, the applicable Manning's "n" laboratory value should be increased a similar amount in order to arrive at design values.

DETERMINATION OF FLOW VELOCITY

Minimum Velocity. The debris entering a storm sewer system will generally have a higher specific gravity than sanitary sewage, therefore a minimum velocity of 3 feet per second is usually specified. The pipe slopes required to maintain this velocity can be calculated from Table 7 or by solving Manning's formula using Figures 2 through 19.

Maximum Velocity. Tests have indicated that concrete pipe can carry clear water of extremely high velocities without eroding. Actual performance records of storm sewers on grades up to 45 percent and carrying high percentages of solids indicate that erosion is seldom a problem with concrete pipe.

EXAMPLE PROBLEMS EXAMPLE 2 - 1 STORM SEWER FLOW

Given: The inside diameter of a circular concrete pipe storm sewer is 48

inches, "n" = 0.012 and slope is 0.006 feet per foot.

Find: The full flow capacity, "Q".

Solution: The problem can be solved using Figure 4 or Table 3.

Figure 4 The slope for the sewer is 0.006 feet per foot or 0.60 feet per 100 feet. Find this slope on the horizontal axis. Proceed vertically along the 0.60 line to the intersection of this line and the curve labelled 48 inches. Proceed horizontally to the vertical axis and read Q = 121 cubic feet per second.

Table 3 Enter Table 3 under the column n = 0.012 for a 48-inch diameter pipe and find C₁, = 1556. For S = 0.006, find S^{1/2} = 0.07746 in Table A-1. Then Q = 1556 X 0.07746 or 121 cubic feet per second.

Answer: Q = 121 cubic feet per second.

EXAMPLE 2 - 2 REQUIRED SANITARY SEWER SIZE

Given: A concrete pipe sanitary sewer with "n" = 0.013, slope of 0.6 percent and required full flow capacity of 110 cubic feet per second.

Find: Size of circular concrete pipe required.

Solution: This problem can be solved using Figure 5 or Table 3.

Figure 5 Find the intersection of a horizontal line through Q = 110 cubic feet per second and a slope of 0.60 feet per 100 feet. The minimum size sewer is 48 inches.

Table 3 For Q = 110 cubic feet per second and $S^{1/2} = 0.07746$

$$C_1 = \frac{Q}{S^{1/2}} = \frac{110}{0.07746} = 1420$$

In the table, 1436 is the closest value of C₁, equal to or larger than 1420, so the minimum size sewer is 48 inches.

Answer: A 48-inch diameter circular pipe would have more than adequate capacity.

EXAMPLE 2 - 3 STORM SEWER MINIMUM SLOPE

Given: A 48-inch diameter circular concrete pipe storm sewer, "n" = 0.012 and

flowing one-third full.

Find: Slope required to maintain a minimum velocity of 3 feet per second.

Solution: Enter Figure 20 on the vertical scale at Depth of Flow = 0.33 and project a horizontal line to the curved line representing velocity. On the horizontal scale directly beneath the point of intersection read a value of 0.81 which represents the proportional value to full flow.

$$\frac{V}{V_{\text{full}}} = 0.81$$

$$V_{\text{full}} = \frac{V}{0.81}$$

$$= \frac{3}{0.81}$$

Enter Figure 4 and at the intersection of the line representing 48-inch diameter and the interpolated velocity line of 3.7 read a slope of 0.088 percent on the horizontal scale.

Answer: The slope required to maintain a minimum velocity of 3 feet per second at one-third full is 0.088 percent.

EXAMPLE 2 - 4 SANITARY SEWER DESIGN

General: A multi-family housing project is being developed on 350 acres of rolling to flat ground. Zoning regulations establish a population density of 30 persons per acre. The state Department of Health specifies 100 gallons per capita per day as the average and 500 gallons per capita per day as the peak domestic sewage flow, and an infiltration allowance of 500 gallons per acre per day.

Circular concrete pipe will be used, "n"= 0.013, designed to flow full at peak load with a minimum velocity of 2 feet per second at one-third peak flow. Maximum spacing between manholes will be 400 feet.

Given: Population Density = 30 persons per acre

Average Flow = 100 gallons per capita per day
Peak Flow = 500 gallons per capita per day
Infiltration = 500 gallons per acre per day

Manning's Roughness = 0.0 13 (See discussion of Manning's

Coefficient "n" Value)

Minimum Velocity = 2 feet per second @ 1/3 peak flow

Find:

Design the final 400 feet of pipe between manhole Nos. 20 and 21, which serves 58 acres in addition to carrying the load from the previous pipe which serves the remaining 292 acres.

Solution: 1. Design Flow

Population-Manhole 1 to $20 = 30 \times 292 = 8760$ Population-Manhole 20 to $21 = 30 \times 58 = 1740$

Total population 10,500 persons

Peak flow-Manhole

1 to $20 = 500 \times 8760 = 4,380,000$ gallons per day

Infiltration-Manhole

1 to 20 - 500 X 292 = 146,000 gallons per day

Peak flow-Manhole

20 to 21 = 500 X 1740 = 870,000 gallons per day

Infiltration-Manhole

20 to 21 = 500 X 58 = 29,000 gallons per day

Total Peak flow = 5,425,000 gallons per day use 5,425,000 gallons per day or 8.4 cubic feet per second

2. Selection of Pipe Size

In designing the sewer system, selection of pipe begins at the first manhole and proceeds downstream. The section of pipe preceding the final section is an 18-inch diameter, with slope = 0.0045 feet per foot. Therefore, for the final section the same pipe size will be checked and used unless it has inadequate capacity, excessive slope or inadequate velocity.

Enter Figure 5, from Q = 8.4 cubic feet per second on the vertical scale project a horizontal line to the 18-inch diameter pipe, read velocity = 4.7 feet per second.

From the intersection, project a vertical line to the horizontal scale, read slope = 0.63 feet per 100 feet.

3. Partial Flow

Enter Figure 20, from Proportion of Value for Full Flow = 0.33 on the horizontal scale project a line vertically to "flow" curve, from intersection project a line horizontally to "velocity" curve, from intersection project a line vertically to horizontal scale, read Proportion of Value for Full Flow - 0.83.

Velocity at minimum flow = $0.83 \times 4.7 = 3.9$ feet per second.

Answer: Use 18-inch diameter concrete pipe with slope of 0.0063 feet per foot.

The preceding computations are summarized in the following tabular forms, Illustrations 2.1 and 2.2.

Illustration 2.1 - Population and Flow

	DR	AINAGE A	REA		Cum.					
Manhole No.	Zoning	Acres	Ultimate Population	Domestic	Indus- trial	Infil- tration	Total	Cum. Total	Flow cfs.	
19	From Preceeding Computations									
20	Multi- family	58	1740	.087	_	0.03	0.90	5.43	8.4	
21	Trunk Sewer Interceptor Manhole									

Illustration 2.2 - Sanitary Sewer Design Data

Manhole					Manhole Flow-line Elevations				
No.	Sta.	Flow cfs	Length ft.	Slope ft./ft.	Pipe Dia. in.	Velocity fps	Fall ft.	In	Out
19	46	7.0							389.51
20	50	8.4	400	0.0045	18	4.0	1.80	387.71	387.71
21	54		400	0.0063	18	4.7	2.52	385.19	

EXAMPLE 2 - 5 STORM SEWER DESIGN

General: A portion of the storm sewer system for the multi-family development is to serve a drainage area of about 30 acres. The state Department of Health specifies a 10-inch diameter minimum pipe size.

Circular concrete pipe will be used,"n" = 0.011, with a minimum velocity of 3 feet per second when flowing full. Minimum time of concentration is 10 minutes with a maximum spacing between manholes of 400 feet.

Given: Drainage Area A = 30 acres (total)

Runoff Coefficient C = 0.40

Rainfall Intensity i as shown in Figure 26

Roughness Coefficient n = 0.0 11 (See discussion of Manning's

"n" Value)

Velocity V = 3.0 feet per second (minimum at

full flow)

Find: Design of the storm system as shown in Illustration 2.3, "Plan for Storm Sewer Example," adapted from "Design and Construction of

Concrete Sewers," published by the Portland Cement Association.

system begins at the upper manhole and proceeds downstream.

Solution: The hydraulic properties of the storm sewer will be entered as they are determined on the example form Illustration 2.4, "Computation Sheet for Hydraulic Properties of Storm Sewer." The design of the

The areas contributing to each manhole are determined, entered incrementally in column 4, and as cumulative totals in column 5. The initial inlet time of 10 minutes minimum is entered in column 6, line 1, and from Figure 26 the intensity is found to be 4.2 inches per hour which is entered in column 8, line 1. Solving the Rational formula, Q = 1.68 cubic feet per second is entered in column 9, line 1. Enter Figure 3, for V = 3 feet per second and Q = 1.68 cubic feet per second, the 10-inch diameter pipe requires a slope = 0.39 feet per 100 feet. Columns 10, 12, 13, 14, 15 and 16, line 1, are now filled in. The flow time from manhole 7 to 6 is found by dividing the length (300 feet) between manholes by the velocity of flow (3 feet per second) and converting the answers to minutes (1.7 minutes) which is entered in column 7, line 1. This time increment is added to the 10-minute time of concentration for manhole 7 to arrive at 11.7 minutes time of concentration for manhole 6 which is entered in column 6, line 2.

From Figure 26, the intensity is found to be 4.0 inches per hour for a time of concentration of 11.7 minutes which is entered in column 8, line 2. The procedure outlined in the preceding paragraph is repeated for each section of sewer as shown in the table.

Answer: The design pipe sizes, slopes and other properties are as indicated in Illustration 2.4.

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Illustration 2.3-Plan for Storm Sewer Example

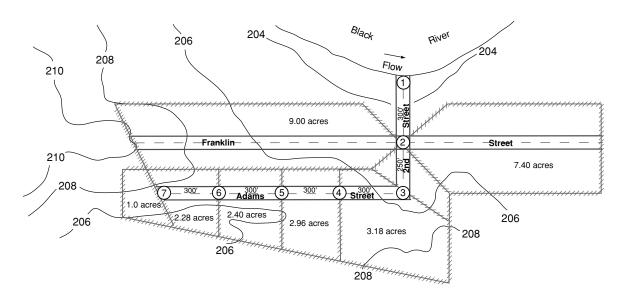


Illustration 2.4-Computation Sheet for Hydraulic Properties of Storm Sewer

	SEWER LOCATION		TRIBU- TARY AREA		TIME OF FLOW (minutes)) j		SEWER DESIGN PF						FILE
							per hour)								ation overt
Line Number	Street	From M. H. To M. H.	Increments Acres	Total Acres A	To Upper End	In Section	Rate of Rainfall (in. pe	Runoff (cfs.) Q	Slope (ft. per 100 ft.)	Diameter (in.)	Capacity (cfs.)	Velocity (fps.)	Length (ft.)	Upper End	Lower End
	1	2 3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Adams	7 6	1.00	1.00	10.0	1.7	4.2	1.68	0.39	10	1.7	3.0	300	200.00	198.83
2	Adams	6 5	2.28	3.28	11.7	1.7	4.0	5.25	0.18	18	5.3	3.0	300	198.16	197.62
3	Adams	5 4	2.40	5.68	13.4	1.3	3.8	8.63	0.23	21	8.65	3.8	300	197.37	196.68
4	Adams	4 3	2.96	8.64	14.7	1.2	3.7	12.0	0.23	24	13.0	4.1	300	196.43	195.74
5	2nd	3 2	3.18	11.82	15.9	0.9	3.6	17.0	0.23	27	17.0	4.5	250	195.49	194.91
6	2nd	2 1	17.84	29.66	16.8	-	3.5	41.6	0.30	36	42.0	6.1	300	194.41	193.51

EXAMPLE 2 - 6 SANITARY SEWER DESIGN

Given: A concrete box section sanitary sewer with "n" = 0.013, slope of 1.0% and required full flow capacity of 250 cubic feet per second.

Find: Size of concrete box section required for full flow.

Solution: This problem can be solved using Figure 19 or Table 6.

Figure 19 Find the intersection of a horizontal line through Q = 250 cubic feet per second and a slope of 1.0 feet per 100 feet. The minimum size box section is either a 6 foot span by 4 foot rise or a 5 foot span by 5

foot rise.

Table 6 For Q = 250 cubic feet per second and $S^{1/2} = 0.100$

$$C_1 = \frac{Q}{S^{1/2}} = \frac{250}{0.100} = 2,500$$

In Table 6, under the column headed n = 0.013, 3,338 is the first value of C₁, equal to or larger than 2,500, therefore a box section with a 5 foot span X a 5 foot rise is adequate. Looking further in the same column, a box section with a 6 foot span and a 4 foot rise is found to have a C₁, value of 3,096, therefore a 6 X 4 box section is also adequate.

Either a 5 foot X 5 foot or a 6 foot X 4 foot box section would have Answer: a full flow capacity equal to or greater than Q = 250 cubic feet per second.

CHAPTER 3 HYDRAULICS OF CULVERTS

The hydraulic design procedure for culverts requires:

- 1. Determination of Design Flow
- 2. Selection of Culvert Size
- 3. Determination of Outlet Velocity

DETERMINATION OF DESIGN FLOW

The United States Geological Survey has developed a nationwide series of water-supply papers titled the "Magnitude and Frequency of Floods in the United States." These reports contain tables of maximum known floods and charts for estimating the probable magnitude of floods of frequencies ranging from 1. 1 to 50 years. Table 11 indicates the Geological Survey regions, USGS district and principal field offices and the applicable water-supply paper numbers. Most states have adapted and consolidated those parts of the water-supply papers which pertain to specific hydrologic areas within the particular state. The hydrologic design procedures developed by the various states enable quick and accurate determination of design flow. It is recommended that the culvert design flow be determined by methods based on USGS data.

If USGS data are not available for a particular culvert location, flow quantities may be determined by the Rational Method or by statistical methods using records of flow and runoff. An example of the latter method is a nomograph developed by California and shown in Figure 27.

FACTORS AFFECTING CULVERT DISCHARGE

Factors affecting culvert discharge are depicted on the culvert cross section shown in Illustration 3.1 and are used in determining the type of discharge control.

Inlet Control. The control section is located at or near the culvert entrance, and, for any given shape and size of culvert, the discharge is dependent only on the inlet geometry and headwater depth. Inlet control will exist as long as water can flow through the barrel of the culvert at a greater rate than water can enter the inlet. Since the control section is at the inlet, the capacity is not affected by any hydraulic factors beyond the culvert entrance such as slope, length or surface roughness. Culverts operating under inlet control will always flow partially full.

Illustration 3.1 - Factors Affecting Culvert Discharge

D = Inside diameter for circular pipe

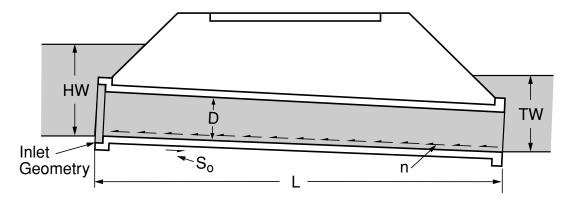
HW = Headwater depth at culvert entrance

L = Length of culvert

 Surface roughness of the pipe wall, usually expressed in terms of Manning's n

 S_0 = Slope of the culvert pipe

TW = Tailwater depth at culvert outlet



Outlet Control. The control section is located at or near the culvert outlet and for any given shape and size of culvert, the discharge is dependent on all of the hydraulic factors upstream from the outlet such as shape, slope, length, surface roughness, tailwater depth, headwater depth and inlet geometry. Outlet control will exist as long as water can enter the culvert at a greater rate than water can flow through it. Culverts operating under outlet control can flow either full or partially full.

Critical Depth. Critical flow occurs when the sum of the kinetic energy (velocity head) plus the potential energy (static or depth head equal to the depth of the flow) for a given discharge is at a minimum. Conversely, the discharge through a pipe with a given total energy head will be maximum at critical flow. The depth of the flow at this point is defined as critical depth, and the slope required to produce the flow is defined as critical slope. Capacity of a culvert with an unsubmerged outlet will be established at the point where critical flow occurs. Since under inlet control, the discharge of the culvert is not reduced by as many hydraulic factors as under outlet control, for a given energy head, a culvert will have maximum possible discharge if it is operating at critical flow with inlet control. The energy head at the inlet control section is approximately equal to the head at the inlet minus entrance losses. Discharge is not limited by culvert roughness or outlet conditions but is dependent only on the shape and size of the culvert entrance. Although the discharge of a culvert operating with inlet control is not related to the pipe roughness, the roughness does determine the minimum slope (critical slope) at which inlet control will occur. Pipe with a smooth interior can be installed on a very flat slope and still have inlet control. Pipe with a rough interior must be installed on a much steeper slope to have inlet control. Charts of critical depth for various pipe and box section sizes and flows are shown in Figures 28 through 32.

SELECTION OF CULVERT SIZE

The many hydraulic design procedures available for determining the required size of a culvert vary from empirical formulas to a comprehensive mathematical analysis. Most empirical formulas, while easy to use, do not lend themselves to proper evaluation of all the factors that affect the flow of water through a culvert. The mathematical solution, while giving precise results, is time consuming. A systematic and simple design procedure for the proper selection of a culvert size is provided by Hydraulic Engineering Circular No. 5, "Hydraulic Charts for the Selection of Highway Culverts" and No. 10, "Capacity Charts for the Hydraulic Design of Highway Culverts," developed by the Bureau of Public Roads. The procedure when selecting a culvert is to determine the headwater depth from the charts for both assumed inlet and outlet controls. The solution which yields the higher headwater depth indicates the governing control. When this procedure is followed, Inlet Control Nomographs, Figures 33 through 37, and Outlet Control Nomographs, Figures 38 through 41, are used.

An alternative and simpler method is to use the Culvert Capacity Charts, Figures 42 through 145. These charts are based on the data given in Circular No. 5 and enable the hydraulic solution to be obtained directly without using the double solution for both inlet and outlet control required when the nomographs are used.

Culvert Capacity Chart Procedure. The Culvert Capacity Charts are a convenient tool for selection of pipe sizes when the culvert is installed with conditions as indicated on the charts. The nomographs must be used for other shapes, roughness coefficients, inlet conditions or submerged outlets.

List Design Data

- A. Design discharge Q, in cubic feet per second, with average return period (i.e., Q25 or Q50, etc.).
- B. Approximate length L of culvert, in feet.
- C. Slope of culvert.
- D. Allowable headwater depth, in feet, which is the vertical distance from the culvert invert (flow line) at the entrance to the water surface elevation permissible in the headwater pool or approach channel upstream from the culvert.
- E. Mean and maximum flood velocities in natural stream.
- F. Type of culvert for first trial selection, including barrel cross sectional shape and entrance type.

Select Culvert Size

- A. Select the appropriate capacity chart, Figures 42 to 145, for the culvert size approximately equal to the allowable headwater depth divided by 2.0.
- B. Project a vertical line from the design discharge Q to the inlet control curve. From this intersection project a line horizontally and read the headwater depth on the vertical scale. If this headwater depth is more than the allowable, try the next larger size pipe. If the headwater depth is

less than the allowable, check the outlet control curves.

- C. Extend the vertical line from the design discharge to the outlet control curve representing the length of the culvert. From this intersection project a line horizontally and read the headwater depth plus S_oL on the vertical scale. Subtract S_oL from the outlet control value to obtain the headwater depth. If the headwater depth is more than the allowable, try the next larger size pipe. If the headwater depth is less than the allowable, check the next smaller pipe size following the same procedure for both inlet control and outlet control.
- D. Compare the headwater depths for inlet and outlet control. The higher headwater depth indicates the governing control.

Determine Outlet Velocity

- A. If outlet control governs, the outlet velocity equals the flow quantity divided by the flow cross sectional area at the outlet. Depending upon the tailwater conditions, this flow area will be between that corresponding to critical depth and the full area of the pipe. If the outlet is not submerged, it is usually sufficiently accurate to calculate the flow area based on a depth of flow equal to the average of the critical depth and the vertical height of the pipe.
- B. If inlet control governs, the outlet velocity may be approximated by Manning's formula using Figures 2 through 19 for full flow values and Figures 20 through 24 for partial flow values.

Record Selection

Record final selection of culvert with size, type, required headwater and outlet velocity.

Nomograph Procedure. The nomograph procedure is used for selection of culverts with entrance conditions other than projecting or for submerged outlets.

List Design Data

- A. Design discharge Q, in cubic feet per second, with average return period (i.e., Q25 or Q,50, etc.).
- B. Approximate length *L* of culvert, in feet.
- C. Slope of culvert.
- D. Allowable headwater depth, in feet, which is the vertical distance from the culvert invert (flow line) at the entrance to the water surface elevation permissible in the headwater pool or approach channel upstream from the culvert.
- E. Mean and maximum flood velocities in natural stream.
- F. Type of culvert for first trial selection, including barrel cross sectional shape and entrance type.

Select Trial Culvert Size

Select a trial culvert with a rise or diameter equal to the allowable headwater divided by 2.0.

Find Headwater Depth for Trial Culvert

A. Inlet Control

- (1) Given Q, size and type of culvert, use appropriate inlet control nomograph Figures 33 through 37 to find headwater depth:
 - (a) Connect with a straightedge the given culvert diameter or height(D) and the discharge Q; mark intersection of straightedge on HW/D scale marked (1).
 - (b) HW/D scale marked (1) represents entrance type used, read HW/D on scale (1). If another of the three entrance types listed on the nomograph is used, extend the point of intersection in (a) horizontally to scale (2) or (3) and read HW/D.
 - (c) Compute HW by multiplying HW/D by D.
- (2) If HW is greater or less than allowable, try another trial size until HW is acceptable for inlet control.

B. Outlet Control

- (1) Given Q, size and type of culvert and estimated depth of tailwater TW, in feet, above the invert at the outlet for the design flood condition in the outlet channel:
 - (a) Locate appropriate outlet control nomograph (Figures 38 through 41) for type of culvert selected. Find k_e, for entrance type from Table 12.
 - (b) Begin nomograph solution by locating starting point on length scale for proper $k_{\rm e}$.
 - (c) Using a straightedge, connect point on length scale to size of culvert barrel and mark the point of crossing on the "turning line."
 - (d) Pivot the straightedge on this point on the turning line and connect given discharge rate. Read head in feet on the head (H) scale.
- (2) For tailwater TW elevation equal to or greater than the top of the culvert at the outlet set h₀ equal to TW and find HW by the following equation:

$$HW = H + h_0 - S_0L \tag{3}$$

(3) For tailwater TW elevations less than the top of the culvert at the outlet, use $h_o = \frac{d_c + D}{2}$ or TW, whichever is the greater, where d_c , the critical depth in feet is determined from the appropriate critical depth chart (Figures 28 through 32).

- C. Compare the headwaters found in paragraphs A (*Inlet Control*) and B (*Outlet Control*). The higher headwater governs and indicates the flow control existing under the given conditions for the trial size selected.
- D. If outlet control governs and the HW is higher than acceptable, select a larger trial size and find HW as instructed under paragraph B. Inlet control need not be checked, if the smaller size was satisfactory for this control as determined under paragraph A.

Try Another Culvert

Try a culvert of another size or shape and repeat the above procedure.

Determine Outlet Velocity

- A. If outlet control governs, the outlet velocity equals the flow quantity divided by the flow cross sectional area at the outlet. Depending upon the tailwater conditions, this flow area will be between that corresponding to critical depth and the full area of the pipe. If the outlet is not submerged, it is sufficiently accurate to calculate flow area based on a depth of flow equal to the average of the critical depth and vertical height of the pipe.
- B. If inlet control governs, the outlet velocity may be approximated by Manning's formula using Figures 2 through 19 for full flow values and Figures 20 through 24 for partial flow values.

Record Selection

Record final selection of culvert with size, type, required headwater and outlet velocity.

EXAMPLE PROBLEMS EXAMPLE 3 - I

CULVERT CAPACITY CHART PROCEDURE

List Design Data

A. $Q_{25} = 180$ cubic feet per second $Q_{50} = 225$ cubic feet per second

B. L = 200 feet

C. $S_0 = 0.01$ feet per foot

D. Allowable HW = 10 feet for 25 and 50-year storms

E. TW = 3.5 feet for 25-year storm TW = 4.0 feet for 50-year storm

F. Circular concrete culvert with a projecting entrance, n = 0.012

Select Culvert Size

A. Try $D = \frac{HW}{2.0} = \frac{10}{2.0} = 5$ feet or 60 inch diameter as first trial size.

B. In Figure 54, project a vertical line from Q = 180 cubic feet per second

to the inlet control curve and read horizontally HW = 6.2. Since HW = 6.2 is considerably less than the allowable try a 54 inch diameter. In Figure 53, project a vertical line from Q = 180 cubic feet per second to the inlet control curve and read horizontally HW = 7.2 feet. In Figure 53, project a vertical line from Q = 225 cubic feet per second to the inlet control curve and read horizontally HW = 9.6 feet.

C. In Figure 53, extend the vertical line from Q = 180 cubic feet per second to the L = 200 feet outlet control curve and read horizontally $HW + S_0L = 8.0$ feet.

In Figure 53, extend the vertical line from Q=225 cubic feet per second to the L=200 feet outlet control curve and read horizontally $HW+S_0L=10.2$ feet.

 $S_0L = 0.01 \times 200 = 2.0 \text{ feet.}$

Therefore HW = 8.0 - 2.0 = 6.0 feet for 25-year storm HW = 10.2 - 2.0 = 8.2 feet for 50-year storm

D. Since the calculated HW for inlet control exceeds the calculated HW for outlet control in both cases, inlet control governs for both the 25 and 50-year storm flows.

Determine Outlet Velocity

B. Enter Figure 4 on the horizontal scale at a pipe slope of 0.01 feet per foot (1.0 feet per 100 feet). Project a vertical line to the line representing 54-inch pipe diameter. Read a full flow value of 210 cubic feet per second on the vertical scale and a full flow velocity of 13.5 feet

$$\frac{Q_{50}}{Q_{\text{Full}}} = \frac{225}{210} = 1.07.$$

per second. Calculate $\overline{Q_{\text{Full}}}$

Enter Figure 20 at 1.07 on the horizontal scale and project a vertical line to the "flow" curve. At this intersection project a horizontal line to the "velocity" curve. Directly beneath this intersection read V_{50}

 $\overline{V_{\text{Full}}}$ = 1.12 on the horizontal scale. Calculate V_{50} = 1.12 V_{Full} = 1.12 X 13.5 = 15.1 feet per second.

Record Selection

Use a 54-inch diameter concrete pipe with allowable HW = 10.0 feet and actual HW = 7.2 and 9.6 feet respectively for the 25 and 50 year storm flows, and a maximum outlet velocity of 15.1 feet per second.

EXAMPLE 3 - 2NOMOGRAPH PROCEDURE

List Design Data

A. $Q_{25} = 180$ cubic feet per second $Q_{50} = 225$ cubic feet per second

- B. L = 200 feet
- C. $S_0 = 0.01$ feet per foot
- D. Allowable HW = 10 feet for 25 and 50-year storms
- E. TW = 3.5 feet for 25-year storm TW = 4.0 feet for 50-year storm
- F. Circular concrete culvert with a projecting entrance, n = 0.012

Select Trial Culvert Size

$$D = \frac{HW}{2.0} = \frac{10}{2.0} = 5$$
 feet

Determine Trial Culvert Headwater Depth

A. Inlet Control

- (1) For Q = 180 cubic feet per second and D = 60 inches, Figure 33 indicates HW/D = 1.25. Therefore HW = 1.25 X 5 = 6.2 feet.
- (2) Since HW = 6.2 feet is considerably less than allowable try a 54-inch pipe.

For Q = 180 cubic feet per second and D = 54 inches, Figure 33 indicates HW/D = 1.6. Therefore $HW = 1.6 \times 4.5 = 7.2$ feet. For Q = 225 cubic feet per second and D = 54 inches, Figure 33

indicates HW/D = 2.14. Therefore $HW = 2.14 \times 4.5 = 9.6$ feet.

B. Outlet Control

- (I) TW = 3.5 and 4.0 feet is less than D = 4.5 feet.
- (3) Table 12, k_e , = 0.2.

For D = 54 inches, Q = 180 cubic feet per second, Figure 28 indicates d_{c} , 3.9 feet which is less than D = 4.5 feet. Calculate

$$h_o = \frac{d_{c+}D}{2} = \frac{3.9 + 4.5}{2} = 4.2$$
 feet.

For D = 54 inches, Q = 180 cubic feet per second, $k_{\rm e}$. = 0.2 and L = 200 feet.

Figure 38 indicates H = 3.8 feet.

Therefore $HW = 3.8 + 4.2 - (0.01 \times 200) = 6.0$ feet (Equation 3). For D = 54 inches, Q = 225 cubic feet per second, Figure 28

indicates d_c , = 4.2 feet which is less than D = 4.5 feet. Calculate

$$h_o = \frac{d_{c+}D}{2} = \frac{4.2 + 4.5}{2} = 4.3$$
 feet.

For D = 54 inches, Q = 225 cubic feet per second, k_e , = 0.2 and L = 200 feet.

Figure 38 indicates H = 5.9 feet.

Therefore $HW = 5.9 + 4.3 - (0.01 \times 200) = 8.2$ feet (Equation 3).

C. Inlet control governs for both the 25 and 50-year design flows.

Try Another Culvert

A 48-inch culvert would be sufficient for the 25-year storm flow but for the 50-year storm flow the HW would be greater than the allowable.

Determine Outlet Velocity

B. Enter Figure 4 on the horizontal scale at a pipe slope of 0.01 feet per foot (1.0 feet per 100 feet). Project a vertical line to the line representing 54-inch pipe diameter. Read a full flow value of 210 cubic feet per second on the vertical scale and a full flow velocity of 13.5 feet per second. Calculate

$$\frac{Q_{50}}{Q_{Full}} = \frac{225}{210} = 1.07.$$

Enter Figure 20 at 1.07 on the horizontal scale and project a vertical line to the "flow" curve. At this intersection project a horizontal line to the "velocity" curve. Directly beneath this intersection read V_{50}

 $\overline{V_{\text{Full}}}$ = 1.12 on the horizontal scale. Calculate V₅₀ = 1.12 V_{Full} = 1.12 X 13.5 = 15.1 feet per second.

Record Selection

Use a 54-inch diameter concrete pipe with allowable HW = 10.0 feet and actual HW = 7.2 and 9.6 feet respectively for the 25 and 50-year storm flows, and a maximum outlet velocity of 15.1 feet per second.

EXAMPLE 3 - 3CULVERT DESIGN

General: A highway is to be constructed on embankment over a creek draining 400 acres. The embankment will be 41-feet high with 2:1 side slopes and a top width of 80 feet. Hydraulic design criteria requires a circular concrete pipe, n = 0.012, with the inlet projecting from the fill. To prevent flooding of upstream properties, the allowable headwater is 10.0 feet, and the design storm frequency is 25 years.

Given: Drainage Area A = 400 acres

Roughness Coefficient n = 0.012 (See discussion of Manning's

"n" Value)

Headwater HW = 10 feet (allowable)

Find: The required culvert size.

Solution: 1. Design Flow

The design flow for 400 acres should be obtained using USGS data. Rather than present an analysis for a specific area, the design flow will be assumed as 250 cubic feet per second for a 25-year storm.

2. Selection of Culvert Size

The culvert will be set on the natural creek bed which has a one percent slope. A cross sectional sketch of the culvert and embankment indicates a culvert length of about 250 feet. No flooding of the outlet is expected.

Trial diameter HW/D = 2.0 feet $D = \frac{10}{2} = 5$ feet.

Enter Figure 54, from Q = 250 cubic feet per second project a line vertically to the inlet control curve, read HW = 8.8 feet on the vertical scale. Extend the vertical line to the outlet control curve for L = 250 feet, read H + S_0L = 9.6 on the vertical scale. S_0L = 250 X 0.01 = 2.5 feet. Therefore, outlet control HW = 9.6 - 2.5 = 7.1 feet and inlet control governs.

Enter Figure 53, from Q = 250 cubic feet per second project a line vertically to the inlet control curve, read HW = 10.8 feet which is greater than the allowable.

3. Determine Outlet Velocity

For inlet control, the outlet velocity is determined from Manning's formula. Entering Figure 4, a 60-inch diameter pipe with S_{\circ} = 1.0 foot per 100 feet will have a velocity = 14.1 feet per second flowing full and a capacity of 280 cubic feet per second. Enter Figure 20 with a Proportion of Value for Full Flow = 250

280 or 0.9, read Depth of Flow = 0.74 and Velocity Proportion = 1.13. Therefore, outlet velocity = 1.13 X 14.1 = 15.9 feet per second.

Answer: A 60-inch diameter circular pipe would be required.

EXAMPLE 3 - 4CULVERT DESIGN

General: An 800-foot long box culvert with an n = 0.012 is to be installed on a 0.5% slope. Because utility lines are to be installed in the embankment above the box culvert, the maximum rise is limited to 8 feet. The box section is required to carry a maximum flow of

1,000 cubic feet per second with an allowable headwater depth of 15 feet.

List Design Data

- A. Q = 1,000 cubic feet per second
- B. L = 800 feet
- C. $S_0 = 0.5\% = 0.005$ feet per foot
- D. Allowable HW = 15 feet
- E. Box culvert with projecting entrance and n = 0.012

Select Culvert Size

Inspecting the box section culvert capacity charts for boxes with rise equal to or less than 8 feet, it is found that a 8 X 8 foot and a 9 X 7 foot box section will all discharge 1,000 cubic feet per second with a headwater depth equal to or less than 15 feet under inlet control. Therefore, each of the two sizes will be investigated.

Determine Headwater Depth

8 X 8 foot Box Section

A. Inlet Control

Enter Figure 124, from Q = 1,000 project a vertical line to the inlet control curve. Project horizontally to the vertical scale and read a headwater depth of 14.8 feet for inlet control.

B. Outlet Control

Continue vertical projection from Q = 1,000 to the outlet control curve for L = 800 feet. Project horizontally to vertical scale and read a value for $(HW + S_oL) = 17.5$ feet. Then $HW = 17.5 - S_oL = 17.5 - (0.005 X 800) = 13.5$ feet for outlet control.

Therefore inlet control governs.

9 X 7 - foot Box Section

Entering Figure 127, and proceeding in a similar manner, find a headwater depth of 14.7 for inlet control and 13.1 feet for outlet control with inlet control governing.

Determine Outlet Velocity

Entering Table 6, find area and C_1 , value for each size box section and Table A-1 find value of $S^{1/2}$ for S_0 , = 0.005, then $Q_{\text{full}} = C_1 S^{1/2}$.

For 8 X 8 - foot Box Section

Qfull = 12700 X 0.07071 = 898 cubic feet per second

 $V_{\text{full}} = Q/A = 899 \div 63.11 = 14.2$ feet per second.

Then
$$\frac{Q_{partial}}{Q_{full}} = \frac{1000}{899} = 1.11.$$

Entering Figure 24.9 on the horizontal scale at 1.11, project a vertical line to intersect the flow curve. From this point, proceed horizontally to the right and intersect the velocity curve. From this point drop vertically to the horizontal scale and read a value of 1.18 for V_{partial}/V_{full} ratio.

Then

 $V_{partial} = 1.18 \text{ X } 14.2 = 16.8 \text{ feet per second}$

Proceeding in a similar manner for the 9 X 7 foot box section, Figure 24.7, find a V_{partial} = 16.9 feet per second.

Record Selection

Use either a 8 X 8 foot box section with an actual HW of 14.8 feet and an outlet velocity of 16.8 feet per second or a 9 X 7 foot box section with an actual HW of 14.7 feet and an outlet velocity of 16.9 feet per second.

CHAPTER 4

LOADS AND SUPPORTING STRENGTHS

The design procedure for the selection of pipe strength requires:

- I. Determination of Earth Load
- 2. Determination of Live Load
- 3. Selection of Bedding
- 4. Determination of Bedding Factor
- 5. Application of Factor of Safety
- 6. Selection of Pipe Strength

TYPES OF INSTALLATIONS

The earth load transmitted to a pipe is largely dependent on the type of installation. Three common types are Trench, Positive Projecting Embankment, and Negative Projecting Embankment. Pipelines are also installed by jacking or tunneling methods where deep installations are necessary or where conventional open excavation and backfill methods may not be feasible. The essential features of each of these installations are shown in Illustration 4.1.

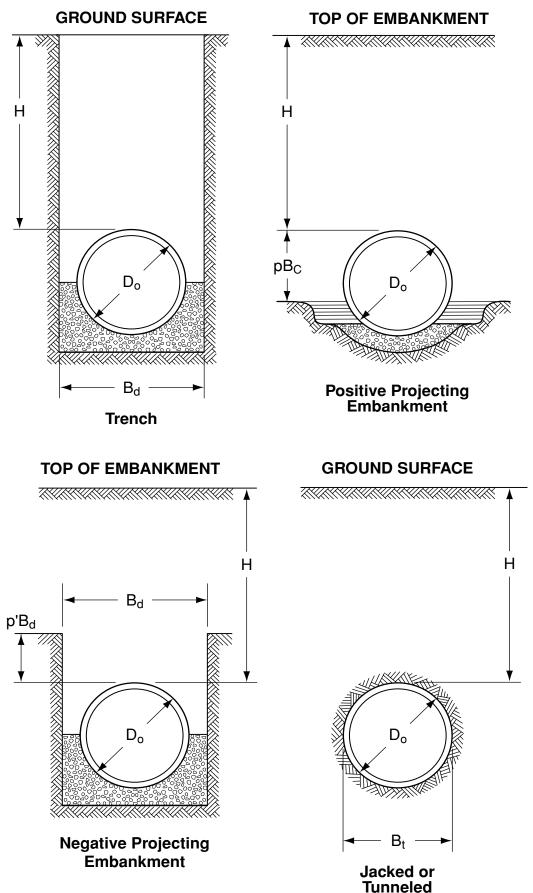
Trench. This type of installation is normally used in the construction of sewers, drains and water mains. The pipe is installed in a relatively narrow trench excavated in undisturbed soil and then covered with backfill extending to the ground surface.

Positive Projecting Embankment. This type of installation is normally used when the culvert is installed in a relatively flat stream bed or drainage path. The pipe is installed on the original ground or compacted fill and then covered by an earth fill or embankment.

Negative Projecting Embankment. This type of installation is normally used when the culvert is installed in a relatively narrow and deep stream bed or drainage path. The pipe is installed in a shallow trench of such depth that the top of the pipe is below the natural ground surface or compacted fill and then covered with an earth fill or embankment which extends above the original ground level.

Jacked or Tunneled. This type of installation is used where surface conditions make it difficult to install the pipe by conventional open excavation and backfill methods, or where it is necessary to install the pipe under an existing embankment. A jacking pit is dug and the pipe is advanced horizontally underground.

Illustration 4.1 Essential Features of Types of Installations



BACKGROUND

The classic theory of earth loads on buried concrete pipe, published in 1930 by A. Marston, was developed for trench and embankment conditions.

In later work published in 1933, M. G. Spangler presented three bedding configurations and the concept of a bedding factor to relate the supporting strength of buried pipe to the strength obtained in a three-edge bearing test.

Spangler's theory proposed that the bedding factor for a particular pipeline and, consequently, the supporting strength of the buried pipe, is dependent on two installation characteristics:

- 1. Width and quality of contact between the pipe and bedding.
- 2. Magnitude of lateral pressure and the portion of the vertical height of the pipe over which it acts.

For the embankment condition, Spangler developed a general equation for the bedding factor, which partially included the effects of lateral pressure. For the trench condition, Spangler established conservative fixed bedding factors, which neglected the effects of lateral pressure, for each of the three beddings. This separate development of bedding factors for trench and embankment conditions resulted in the belief that lateral pressure becomes effective only at trench widths equal to or greater than the transition width. Such an assumption is not compatible with current engineering concepts and construction methods. It is reasonable to expect some lateral pressure to be effective at trench widths less than transition widths. Although conservative designs based on the work of Marston and Spangler have been developed and installed successfully for years, the design concepts have their limitations when applied to real world installations.

The limitations include:

- · Loads considered acting only at the top of the pipe.
- · Axial thrust not considered.
- Bedding width of test installations less than width designated in his bedding configurations.
- Standard beddings developed to fit assumed theories for soil support rather than ease of and methods of construction.
- Bedding materials and compaction levels not adequately defined.

This section discusses the Standard Installations and the appropriate indirect design procedures to be used with them. The Standard Installations are the most recent beddings developed by ACPA to allow the engineer to take into consideration modern installation techniques when designing concrete pipe. For more information on design using the Marston/Spangler beddings, see Appendix B.

INTRODUCTION

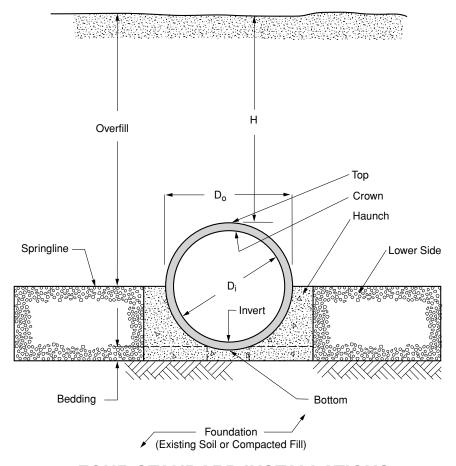
In 1970, ACPA began a long-range research program on the interaction of buried concrete pipe and soil. The research resulted in the comprehensive finite element computer program SPIDA, Soil-Pipe Interaction Design and Analysis, for the direct design of buried concrete pipe.

Since the early 1980's, SPIDA has been used for a variety of studies, including the development of four new Standard Installations, and a simplified microcomputer design program, SIDD, Standard Installations Direct Design.

The procedure presented here replaces the historical A, B, C, and D beddings used in the indirect design method and found in the appendix of this manual, with

the four new Standard Installations, and presents a state-of-the-art method for determination of bedding factors for the Standard Installations. Pipe and installation terminology as used in the Standard Installations, and this procedure, is defined in Illustration 4.2.

Illustration 4.2 Pipe/Installation Terminology



FOUR STANDARD INSTALLATIONS

Through consultations with engineers and contractors, and with the results of numerous SPIDA parameter studies, four new Standard Installations were developed and are presented in Illustration 4.4. The SPIDA studies were conducted for positive projection embankment conditions, which are the worst-case vertical load conditions for pipe, and which provide conservative results for other embankment and trench conditions.

The parameter studies confirmed ideas postulated from past experience and proved the following concepts:

- Loosely placed, uncompacted bedding directly under the invert of the pipe significantly reduces stresses in the pipe.
- Soil in those portions of the bedding and haunch areas directly under the pipe is difficult to compact.
- The soil in the haunch area from the foundation to the pipe springline provides significant support to the pipe and reduces pipe stresses.
- Compaction level of the soil directly above the haunch, from the pipe springline to the top of the pipe grade level, has negligible effect on pipe stresses. Compaction of the soil in this area is not necessary unless

required for pavement structures.

• Installation materials and compaction levels below the springline have a significant effect on pipe structural requirements.

The four Standard Installations provide an optimum range of soil-pipe interaction characteristics. For the relatively high quality materials and high compaction effort of a Type 1 Installation, a lower strength pipe is required. Conversely, a Type 4 Installation requires a higher strength pipe, because it was developed for conditions of little or no control over materials or compaction.

Generic soil types are designated in Illustration 4.5. The Unified Soil Classification System (USCS) and American Association of State Highway and Transportation Officials (AASHTO) soil classifications equivalent to the generic soil types in the Standard Installations are also presented in Illustration 4.5.

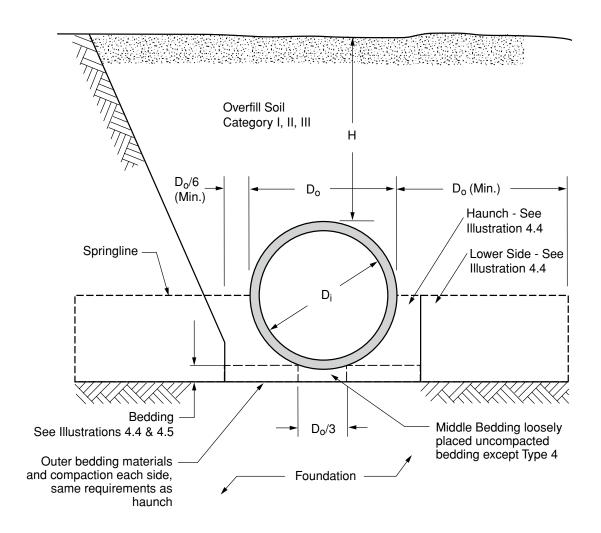


Illustration 4.3 Standard Trench/Embankment Installation

The SPIDA design runs with the Standard Installations were made with medium compaction of the bedding under the middle-third of the pipe, and with some compaction of the overfill above the springline of the pipe. This middle-third area under the pipe in the Standard Installations has been designated as loosely placed, uncompacted material. The intent is to maintain a slightly yielding bedding under the middle-third of the pipe so that the pipe may settle slightly into the bedding and achieve improved load distribution. Compactive efforts in the

Illustration 4.4 Standard Installations Soil and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	Do/24 minimum, not less than 75 mm (3"). If rock foundation, use Do/12 minimum, not less than 150 mm (6").	95% Category I	90% Category I, 95% Category II, or 100% Category III
Type 2	Do/24 minimum, not less than 75 mm (3"). If rock foundation, use Do/12 minimum, not less than 150 mm (6").	90% Category I or 95% Category II	85% Category I, 90% Category II, or 95% Category III
Type 3	Do/24 minimum, not less than 75 mm (3"). If rock foundation, use Do/12 minimum, not less than 150 mm (6").	85% Category I, 90% Category II, or 95% Category III	85% Category I, 90% Category II, or 95% Category III
Type 4	No bedding required, except if rock foundation, use Do/12 minimum, not less than 150 mm (6").	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

Notes:

- 1. Compaction and soil symbols i.e. "95% Category I"- refers to Category I soil material with minimum standard Proctor compaction of 95%. See Illustration 4.5 for equivalent modified Proctor values.
- 2. Soil in the outer bedding, haunch, and lower side zones, except under the middle1/3 of the pipe, shall be compacted to at least the same compaction as the majority of soil in the overfill zone.
- 3. For trenches, top elevation shall be no lower than 0.1 H below finished grade or, for roadways, its top shall be no lower than an elevation of 1 foot below the bottom of the pavement base material.
- 4. For trenches, width shall be wider than shown if required for adequate space to attain the specified compaction in the haunch and bedding zones.
- 5. For trench walls that are within 10 degrees of vertical, the compaction or firmness of the soil in the trench walls and lower side zone need not be considered.
- 6. For trench walls with greater than 10 degree slopes that consist of embankment, the lower side shall be compacted to at least the same compaction as specified for the soil in the backfill zone.

7. Subtrenches

- 7.1 A subtrench is defined as a trench with its top below finished grade by more than 0.1 H or, for roadways, its top is at an elevation lower than 1ft. below the bottom of the pavement base material.
- 7.2 The minimum width of a subtrench shall be 1.33 D_o or wider if required for adequate space to attain the specified compaction in the haunch and bedding zones.
- 7.3 For subtrenches with walls of natural soil, any portion of the lower side zone in the subtrench wall shall be at least as firm as an equivalent soil placed to the compaction requirements specified for the lower side zone and as firm as the majority of soil in the overfill zone, or shall be removed and replaced with soil compacted to the specified level.

middle-third of the bedding with mechanical compactors is undesirable, and could produce a hard flat surface, which would result in highly concentrated stresses in the pipe invert similar to those experienced in the three-edge bearing test. The most desirable construction sequence is to place the bedding to grade; install the pipe to grade; compact the bedding outside of the middle-third of the pipe; and then place and compact the haunch area up to the springline of the pipe. The bedding outside the middle-third of the pipe may be compacted prior to placing the pipe.

As indicated in Illustrations 4.3 and 4.4, when the design includes surface loads, the overfill and lower side areas should be compacted as required to support the surface load. With no surface loads or surface structure requirements, these areas need not be compacted.

Illustration 4.5 Equivalent USCS and AASHTO Soil Classifications for SIDD Soil Designations

	Representative S	oil Types	Percent (Compaction
SIDD Soil	USCS,	Standard AASHTO	Standard Proctor	Modified Proctor
Gravelly Sand (Category 1)	SW, SP, GW, GP	A1,A3	100 95 90 85 80 61	95 90 85 80 75 59
Sandy Silt (Category II)	GM, SM, ML, Also GC, SC with less than 20% passing #200 sieve	A2, A4	100 95 90 85 80 49	95 90 85 80 75 46
Silty Clay (Category III)	CL, MH, GC, SC	A5, A6	100 95 90 85 80 45	90 85 80 75 70 40

SELECTION OF STANDARD INSTALLATION

The selection of a Standard Installation for a project should be based on an evaluation of the quality of construction and inspection anticipated. A Type 1 Standard Installation requires the highest construction quality and degree of inspection. Required construction quality is reduced for a Type 2 Standard Installation, and reduced further for a Type 3 Standard Installation. A Type 4 Standard Installation requires virtually no construction or quality inspection. Consequently, a Type 4 Standard Installation will require a higher strength pipe, and a Type I Standard Installation will require a lower strength pipe for the same depth of installation.

LOAD PRESSURES

SPIDA was programmed with the Standard Installations, and many design runs were made. An evaluation of the output of the designs by Dr. Frank J. Heger produced a load pressure diagram significantly different than proposed by previous theories. See Illustration 4.6. This difference is particularly significant under the pipe in the lower haunch area and is due in part to the assumption of the existence of partial voids adjacent to the pipe wall in this area. SIDD uses this pressure data to determine moments, thrusts, and shears in the pipe wall, and then uses the ACPA limit states design method to determine the required reinforcement areas to handle the pipe wall stresses. Using this method, each criteria that may limit or govern the design is considered separately in the evaluation of overall design requirements. SIDD, which is based on the four Standard Installations, is a standalone program developed by the American Concrete Pipe Association.

The Federal Highway Administration, FHWA, developed a microcomputer program, PIPECAR, for the direct design of concrete pipe prior to the development of SIDD. PIPECAR determines moment, thrust, and shear coefficients from either of two systems, a radial pressure system developed by Olander in 1950 and a uniform pressure system developed by Paris in the 1920's, and also uses the ACPA limit states design method to determine the required reinforcement areas to handle the pipe wall stresses. The SIDD system has been incorporated into PIPECAR as a state-of-the-art enhancement.

DETERMINATION OF EARTH LOAD

Positive Projecting Embankment Soil Load. Concrete pipe can be installed in either an embankment or trench condition as discussed previously. The type of installation has a significant effect on the loads carried by the rigid pipe. Although narrow trench installations are most typical, there are many cases where the pipe is installed in a positive projecting embankment condition, or a trench with a width significant enough that it should be considered a positive projecting embankment condition. In this condition the soil along side the pipe will settle more than the soil above the rigid pipe structure, thereby imposing additional load to the prism of soil directly above the pipe. With the Standard Installations, this additional load is accounted for by using a Vertical Arching Factor, VAF. This factor is multiplied by the prism load, PL, (weight of soil directly above the pipe) to give the total load of soil on the pipe.

$$W = VAF \times PL \tag{4.1}$$

Unlike the previous design method used for the Marston/Spangler beddings there is no need to assume a projection or settlement ratio. The Vertical Arching Factors for the Standard Installations are as shown in Illustration 4.7. The equation for soil prism load is shown below in Equation 4.2.

The prism load, PL, is further defined as:

$$PL = \gamma_s \left[H + \frac{D_o(4 - \pi)}{8} \right] D_o \tag{4.2}$$

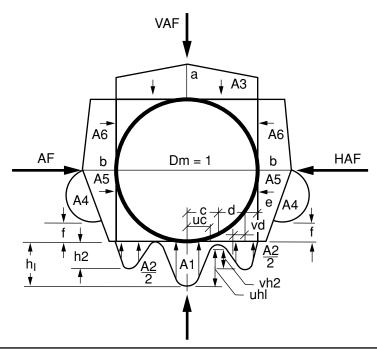
where:

 $\gamma_s = \text{soil unit weight, (lbs/ft}^3)$

H = height of fill, (ft)

D_o = outside diameter, (ft)

Illustration 4.6 Arching Coefficients and Heger Earth Pressure Distributions



Install	ation														
Type	VAF	HAF	A 1	A2	A3	A 4	A5	A6	а	b	С	е	f	u	V
1	1.35	0.45	0.62	0.73	1.35	0.19	0.08	0.18	1.40	0.40	0.18	0.08	0.05	0.80	0.80
2	1.40	0.40	0.85	0.55	1.40	0.15	0.08	0.17	1.45	0.40	0.19	0.10	0.05	0.82	0.70
3	1.40	0.37	1.05	0.35	1.40	0.10	0.10	0.17	1.45	0.36	0.20	0.12	0.05	0.85	0.60
4	1.45	0.30	1.45	0.00	1.45	0.00	0.11	0.19	1.45	0.30	0.25	0.00	-	0.90	

Notes:

- 1. VAF and HAF are vertical and horizontal arching factors. These coefficients represent non-dimensional total vertical and horizontal loads on the pipe, respectively. The actual total vertical and horizontal loads are (VAF) X (PL) and (HAF) X (PL), respectively, where PL is the prism load.
- 2. Coefficients A1 through A6 represent the integration of non-dimensional vertical and horizontal components of soil pressure under the indicated portions of the component pressure diagrams (i.e. the area under the component pressure diagrams). The pressures are assumed to vary either parabolically or linearly, as shown, with the non-dimensional magnitudes at governing points represented by h1, h2, uh1, vh2, a and b. Non-dimensional horizontal and vertical dimensions of component pressure regions are defined by c, d, e, vc, vd, and f coefficients.
- d is calculated as (0.5-c-e).
 h1 is calculated as (1.5A1) / (c) (1+u).
 h2 is calculated as (1.5A2) / [(d) (1+v) + (2e)]

Illustration 4.7 Vertical Arching Factor (VAF)

Standard Installation	VAF
Type 1	1.35
Type 2	1.40
Type 3	1.40
Type 4	1.45

Note:

Trench Soil Load. In narrow or moderate trench width conditions, the resulting earth load is equal to the weight of the soil within the trench minus the shearing (frictional) forces on the sides of the trench. Since the new installed backfill material will settle more than the existing soil on the sides of the trench, the friction along the trench walls will relieve the pipe of some of its soil burden. The Vertical Arching Factors in this case will be less than those used for embankment design. The backfill load on pipe installed in a trench condition is computed by the equation:

$$W_{d} = C_{d}\gamma_{s}B_{d}^{2} + \frac{D_{o}^{2}(4 - \pi)}{8}\gamma_{s}$$
 (4.3)

The trench load coefficient, C_d, is further defined as:

$$C_{d} = \frac{1 - e^{-2K\mu'} \frac{H}{B_{d}}}{2K\mu'}$$
 (4.4)

where:

 B_d = width of trench, (ft)

K = ratio of active lateral unit pressure to vertical unit pressure

 $\mu' = \tan \emptyset'$, coefficient of friction between fill material and sides of trench

The value of C_d can be calculated using equation 4.4 above, or read from Figure 214 in the Appendix.

Typical values of Ku' are:

 $K\mu' = .1924$ Max. for granular materials without cohesion

 $K\mu' = .165$ Max for sand and gravel $K\mu' = .150$ Max. for saturated top soil $K\mu' = .130$ Max. for ordinary clay

 $K\mu' = .110 \text{ Max for saturated clay}$

As trench width increases, the reduction in load from the frictional forces is offset by the increase in soil weight within the trench. As the trench width increases it starts to behave like an embankment, where the soil on the side of the pipe settles more than the soil above the pipe. Eventually, the embankment condition is reached when the trench walls are too far away from the pipe to help support the soil immediately adjacent to it. The transition width is the width of a

^{1.} VAF are vertical arching factors. These coefficients represent nondimensional total vertical loads on the pipe. The actual total vertical loads are (VAF) X (PL), where PL is the prism load.

trench at a particular depth where the trench load equals the embankment load. Once transition width is reached, there is no longer any benefit from frictional forces along the wall of the trench. Any pipe installed in a trench width equal to or greater than transition width should be designed for the embankment condition.

Tables 13 through 39 are based on equation (4.2) and list the transition widths for the four types of beddings with various heights of backfill.

Negative Projection Embankment Soil Load. The fill load on a pipe installed in a negative projecting embankment condition is computed by the equation:

$$W_n = C_n w B_d^2 \tag{4.5}$$

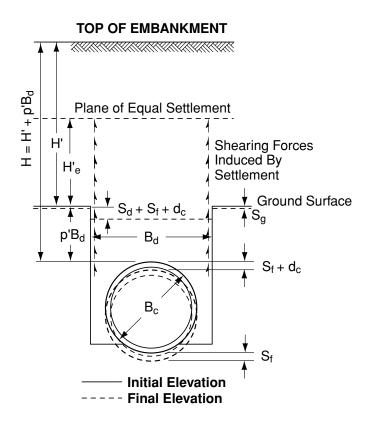
The embankment load coefficient C₂ is further defined as:

$$C_n = \frac{1 - e^{-2K\mu' \frac{H}{B_d}}}{2K\mu'}$$
 when H H_e (4.6)

$$C_{n} = \frac{1 - e^{-2K\mu' \frac{H_{e}}{B_{d}}}}{2K\mu'} + \left(\frac{H}{B_{d}} + \frac{H_{e}}{B_{d}}\right) e^{-2K\mu' \frac{H_{e}}{B_{d}}} \quad \text{when } H > H_{e}$$
 (4.7)

The settlements which influence loads on negative projecting embankment installations are shown in Illustration 4.8.

Illustration 4.8 Settlements Which Influence Loads Negative Projection Embankment Installation



The settlement ratio is the numerical relationship between the pipe deflection and the relative settlement between the prism of fill directly above the pipe and adjacent soil. It is necessary to define the settlement ratio for negative projection embankment installations. Equating the deflection of the pipe and the total settlement of the prism of fill above the pipe to the settlement of the adjacent soil, the settlement ratio is:

$$r_{sd} = \frac{S_g - (S_d + S_f + d_c)}{S_d}$$
 (4.8)

Recommended settlement ratio design values are listed in Table 40. The projection ratio (p') for this type of installation is the distance from the top of the pipe to the surface of the natural ground or compacted fill at the time of installation divided by the width of the trench. Where the ground surface is sloping, the average vertical distance from the top of the pipe to the original ground should be used in determining the projection ratio (p'). Figures 194 through 213 present fill loads in pounds per linear foot for circular pipe based on projection ratios of 0.5, 1.0, 1.5, 2.0 and settlement ratios of 0, -0.1, -0.3, -0.5 and -1.0. The dashed H = $p'B_d$ line represents the limiting condition where the height of fill is at the same elevation as the natural ground surface. The dashed H = H_e line represents the condition where the height of the plane of equal settlement (H_e) is equal to the height of fill (H).

Jacked or Tunneled Soil Load. This type of installation is used where surface conditions make it difficult to install the pipe by conventional open excavation and backfill methods, or where it is necessary to install the pipe under an existing embankment. The earth load on a pipe installed by these methods is computed by the equation:

$$W_t = C_t w B_t^2 - 2cC_t B_t \tag{4.9}$$

where:

 B_{t} = width of tunnel bore, (ft)

The jacked or tunneled load coefficient C, is further defined as:

$$C_{t} = \frac{1 - e^{-2K\mu' \frac{H}{B_{t}}}}{2K\mu'}$$
 (4.10)

In equation (4.9) the $C_t w B_t^2$ term is similar to the Negative Projection Embankment equation (4.5) for soil loads and the $2cC_tB_t$ term accounts for the cohesion of undisturbed soil. Conservative design values of the coefficient of cohesion for various soils are listed in Table 41. Figures 147, 149, 151 and 153 present values of the trench load term ($C_t w B_t^2$) in pounds per linear foot for a soil density of 120 pounds per cubic foot and Km' values of 0.165, 0.150, 0.130 and 0.110. Figures 148, 150, 152 and 154 present values of the cohesion term ($2cC_t B_t$) divided by the design value for the coefficient of cohesion (c). To obtain the total earth load for any given height of cover, width of bore or tunnel and type of soil, the value of the cohesion term must be multiplied by the appropriate coefficient of cohesion (c) and this product subtracted from the value of the trench load term.

FLUID LOAD

Fluid weight typically is about the same order of magnitude as pipe weight and generally represents a significant portion of the pipe design load only for large diameter pipe under relatively shallow fills. Fluid weight has been neglected in the traditional design procedures of the past, including the Marston Spangler design method utilizing the B and C beddings. There is no documentation of concrete pipe failures as a result of neglecting fluid load. However, some specifying agencies such as AASHTO and CHBDC, now require that the weight of the fluid inside the pipe always be considered when determining the D-load.

The Sixteenth Edition of the AASHTO Standard Specifications For Highway Bridges states: "The weight of fluid, W_F , in the pipe shall be considered in design based on a fluid weight, γ_w , of 62.4 lbs/cu.ft, unless otherwise specified."

DETERMINATION OF LIVE LOAD

To determine the required supporting strength of concrete pipe installed under asphalts, other flexible pavements, or relatively shallow earth cover, it is necessary to evaluate the effect of live loads, such as highway truck loads, in addition to dead loads imposed by soil and surcharge loads.

If a rigid pavement or a thick flexible pavement designed for heavy duty traffic is provided with a sufficient buffer between the pipe and pavement, then the live load transmitted through the pavement to the buried concrete pipe is usually negligible at any depth. If any culvert or sewer pipe is within the heavy duty traffic highway right-of-way, but not under the pavement structure, then such pipe should be analyzed for the effect of live load transmission from an unsurfaced roadway, because of the possibility of trucks leaving the pavement.

The AASHTO design loads commonly used in the past were the HS 20 with a 32,000 pound axle load in the Normal Truck Configuration, and a 24,000 pound axle load in the Alternate Load Configuration.

The AASHTO LRFD designates an HL 93 Live Load. This load consists of the greater of a HS 20 with 32,000 pound axle load in the Normal Truck Configuration, or a 25,000 pound axle load in the Alternate Load Configuration. In addition, a 640 pound per linear foot Lane Load is applied across a 10 foot wide lane at all depths of earth cover over the top of the pipe, up to a depth of 8 feet. This Lane Load converts to an additional live load of 64 pounds per square foot, applied to the top of the pipe for any depth of burial less than 8 feet. The average pressure intensity caused by a wheel load is calculated by Equation 4.12. The Lane Load intensity is added to the wheel load pressure intensity in Equation 4.13.

The HS 20, 32,000 pound and the Alternate Truck 25,000 pound design axle are carried on dual wheels. The contact area of the dual wheels with the ground is assumed to be rectangle, with dimensions presented in Illustration 4.9.

Illustration 4.9 AASHTO Wheel Load Surface Contact Area (Foot Print)

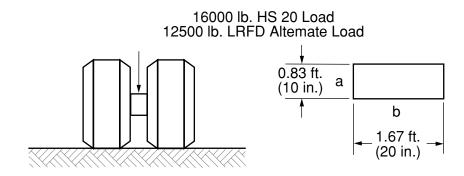
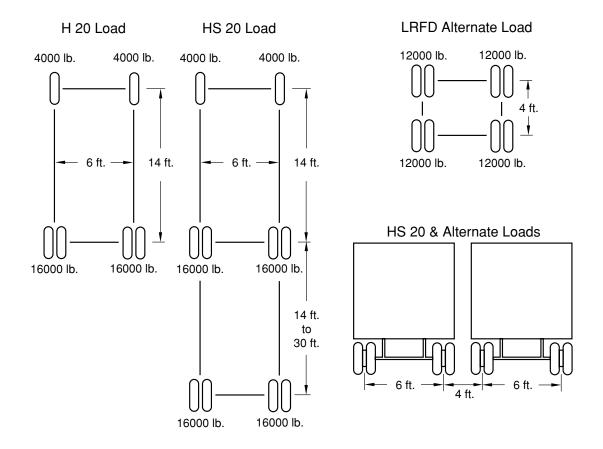


Illustration 4.10 AASHTO Wheel Loads and Wheel Spacings



Impact Factors. The AASHTO LRFD Standard applies a dynamic load allowance, sometimes called Impact Factor, to account for the truck load being non-static. The dynamic load allowance, IM, is determined by Equation 4.11:

$$IM = \frac{33(1.0 - 0.125H)}{100} \tag{4.11}$$

where:

H = height of earth cover over the top of the pipe, ft.

Load Distribution. The surface load is assumed to be uniformly spread on any horizontal subsoil plane. The spread load area is developed by increasing the length and width of the wheel contact area for a load configuration as shown in Illustration 4.13 for a dual wheel. On a horizontal soil plane, the dimensional increases to the wheel contact area are based on height of earth cover over the top of the pipe as presented in Illustration 4.11 for two types of soil.

Illustration 4.11 Dimensional Increase Factor, AASHTO LRFD

Soil Type	Dimensional Increase Factor
LRFD select granular	1.15H
LRFD any other soil	1.00H

As indicated by Illustrations 4.14 and 4.15, the spread load areas from adjacent wheels will overlap as height of earth cover over the top of the pipe increases. At shallow depths, the maximum pressure will be developed by an HS 20 dual wheel, since at 16,000 pounds it applies a greater load than the 12,500 pound Alternate Load. At intermediate depths, the maximum pressure will be developed by the wheels of two HS 20 trucks in the passing mode, since at 16,000 pounds each, the two wheels apply a greater load than the 12,500 pounds of an Alternate Load wheel. At greater depths, the maximum pressure will be developed by wheels of two Alternate Load configuration trucks in the passing mode, since at 12,500 pounds each, the four wheels apply the greatest load(50,000 pounds). Intermediate depths begin when the spread area of dual wheels of two HS 20 trucks in the passing mode meet and begin to overlap. Greater depths begin when the spread area b of two single dual wheels of two Alternate Load configurations in the passing mode meet and begin to overlap.

Since the exact geometric relationship of individual or combinations of surface wheel loads cannot be anticipated, the most critical loading configurations along with axle loads and rectangular spread load area are presented in Illustration 4.12 for the two AASHTO LRFD soil types.

Illustration 4.12 LRFD Critical Wheel Loads and Spread Dimensions at the Top of the Pipe

	Vehicle Traveling Perpendicular to Pipe										
	H, ft	P, Ibs	Spread a, ft	Spread b, ft	Figure						
Live Load	H + 1.15D _o < 2.05	16,000	a + 1.15H	b + 1.15H	3						
Distribution	2.05 - 1.15D _o < H < 5.5	32,000	a + 4 + 1.15H	b + 1.15H	4						
of 1.15 x H for Select	5.5 < H	50,000	a + 4 + 1.15H	b + 4 + 1.15H	5						
Granular Fill											
Live Load	H + 1.30D _o < 2.30	16,000	a + 1.00H	b + 1.00H	3						
Distribution	2.30 - 1.30 D _o < H < 6.3	32,000	a + 4 + 1.00H	b + 1.00H	4						
of 1.0 x H for Other Soils	6.3 < H	50,000 a + 4 + 1.00H		b + 4 + 1.00H	5						
	Vehicle Tra	aveling Para	llel to Pipe								
Live Load	H < 2.03	16,000	a + 1.15H	b + 1.15H	3						
Distribution	2.03 < H < 5.5	32,000	a + 4 + 1.15H	b + 1.15H	4						
of 1.15 x H for Select	5.5 <h< td=""><td>50,000</td><td>a + 4 + 1.15H</td><td>b + 4 + 1.15H</td><td>5</td></h<>	50,000	a + 4 + 1.15H	b + 4 + 1.15H	5						
Granular Fill											
Live Load	H < 2.33	16,000	a + 1.00H	b + 1.00H	3						
Distribution	2.33 < H < 6.3	32,000	a + 4 + 1.00H	b + 1.00H	4						
of 1.0 x H for Other Soils	6.3 < H	50,000	a + 4 + 1.00H	b + 4 + 1.00H	5						

Illustration 4.13 Spread Load Area - Single Dual Wheel

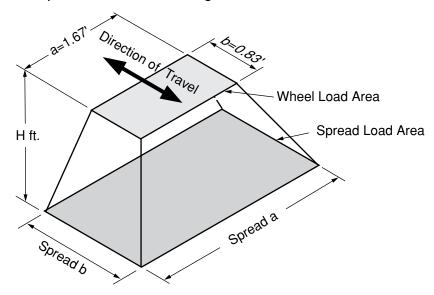


Illustration 4.14 Spread Load Area - Two Single Dual Wheels of Trucks in Passing Mode

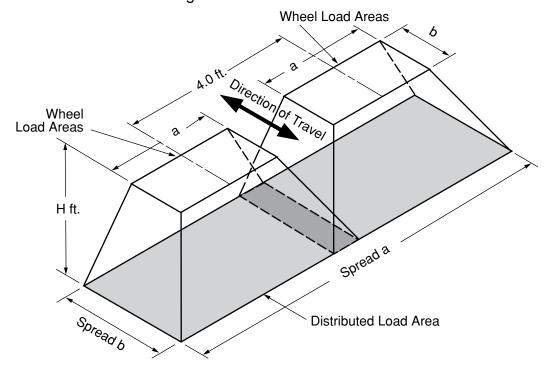
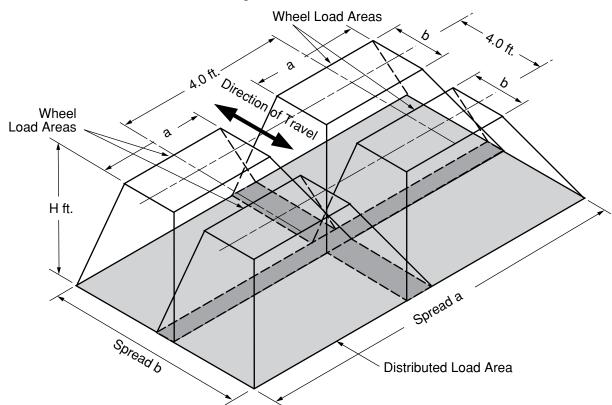


Illustration 4.15 Spread Load Area - Two Single Dual Wheels of Two Alternate Loads in Passing Mode



Average Pressure Intensity. The wheel load average pressure intensity on the subsoil plane at the outside top of the concrete pipe is:

$$w = \frac{P(1 + IM)}{A} \tag{4.12}$$

where:

w = wheel load average pressure intensity, pounds per square foot

P = total live wheel load applied at the surface, pounds

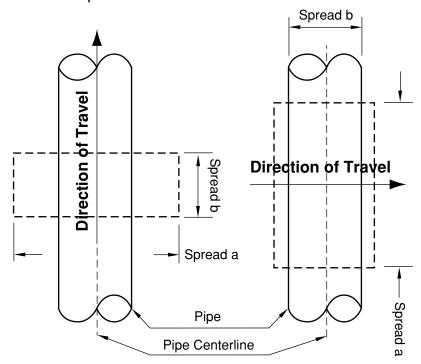
A = spread wheel load area at the outside top of the pipe, square feet

IM = dynamic load allowance

From the appropriate Table in Illustration 4.12, select the critical wheel load and spread dimensions for the height of earth cover over the outside top of the pipe, H. The spread live load area is equal to Spread a times Spread b. Select the appropriate dynamic load allowance, using Equation 4.11.

Total Live Load. A designer is concerned with the maximum possible loads, which occur when the distributed load area is centered over the buried pipe. Depending on the pipe size and height of cover, the most critical loading orientation can occur either when the truck travels transverse or parallel to the centerline of the pipe. Illustration 4.16 shows the dimensions of the spread load area, A, as related to whether the truck travel is transverse or parallel to the centerline of the pipe.

Illustration 4.16 Spread Load Area Dimensions vs Direction of Truck



Unless you are certain of the pipeline orientation, the total live load in pounds, $W_{\scriptscriptstyle T}$, must be calculated for each travel orientation, and the maximum calculated value must be used in Equation 4.14 to calculate the live load on the pipe in pounds per linear foot.

The LRFD requires a Lane Load, L_L , of 64 pounds per square foot on the top of the pipe at any depth less than 8 feet.

The total live load acting on the pipe is:

$$W_{T} = (W + L_{L}) L S_{L}$$

$$(4.13)$$

where:

 W_{τ} = total live load, pounds

w = wheel load average pressure intensity, pounds per square

foot (at the top of the pipe)

L = lane loading if AASHTO LRFD is used, pounds per square

foot

0≤H<8, L₁ = 64, pounds per square foot

 $H \ge 8$, $L_i = 0$

= dimension of load area parallel to the longitudinal axis of

pipe, feet

S₁ = outside horizontal span of pipe, B_c, or dimension of load area

transverse to the longitudinal axis of pipe, whichever is less,

feet

Total Live Load in Pounds per Linear Foot. The total live load in pounds per linear foot, W_L , is calculated by dividing the Total Live Load, W_T , by the Effective Supporting Length, L_a (See Illustration 4.17), of the pipe:

$$W_{L} = \frac{W_{T}}{L_{e}} \tag{4.14}$$

where:

W₁ = live load on top of pipe, pounds per linear foot

L_a = effective supporting length of pipe, feet

The effective supporting length of pipe is:

$$L_e = L + 1.75(3/4R_O)$$

where:

R_o = outside vertical Rise of pipe, feet

Illustration 4.17 Effective Supporting Length of Pipe

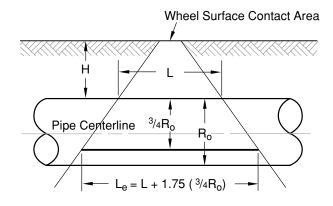
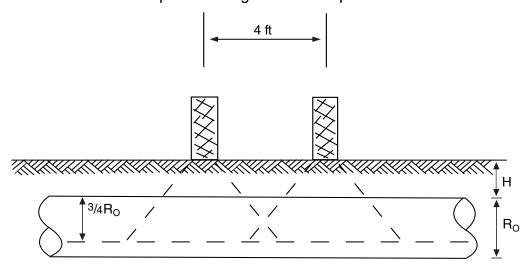


Illustration 4.18 Load Spread through Soil and Pipe



Airports. The distribution of aircraft wheel loads on any horizontal plane in the soil mass is dependent on the magnitude and characteristics of the aircraft loads, the aircraft's landing gear configuration, the type of pavement structure and the subsoil conditions. Heavier gross aircraft weights have resulted in multiple wheel undercarriages consisting of dual wheel assemblies and/or dual tandem assemblies. The distribution of wheel loads through rigid pavement are shown in Illustration 4.18.

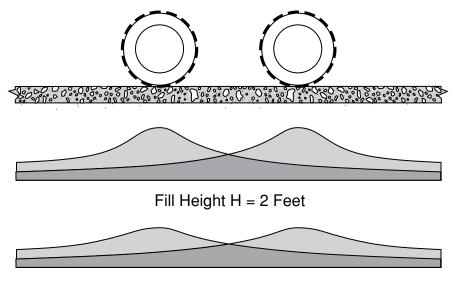
If a rigid pavement is provided, an aircraft wheel load concentration is distributed over an appreciable area and is substantially reduced in intensity at the subgrade. For multi-wheeled landing gear assemblies, the total pressure intensity is dependent on the interacting pressures produced by each individual wheel. The maximum load transmitted to a pipe varies with the pipe size under consideration, the pipe's relative location with respect to the particular landing gear configuration and the height of fill between the top of the pipe and the subgrade surface.

For a flexible pavement, the area of the load distribution at any plane in the soil mass is considerably less than for a rigid pavement. The interaction of pressure intensities due to individual wheels of a multi-wheeled landing gear assembly is also less pronounced at any given depth of cover.

In present airport design practices, the aircraft's maximum takeoff weight is used since the maximum landing weight is usually considered to be about three fourths the takeoff weight. Impact is not considered, as criteria are not yet available to include dynamic effects in the design process.

Rigid Pavement.

Illustration 4.19 Aircraft Pressure Distribution, Rigid Pavement



Fill Height H = 6 Feet

The pressure intensity is computed by the equation:

$$p(H,X) = \frac{CP}{R_0^2}$$
 (4.15)

where:

R

P = Load at the surface, pounds

C = Load coefficient, dependent on the horizontal distance (X), the vertical distance (H), and R_c

= Radius of Stiffness of the pavement, feet

R_s is further defined as:

$$R_{s} = \frac{4}{\sqrt{\frac{(Eh)^{3}}{12(1 - \mu^{2}) k}}}$$
 (4.16)

where:

E = modulus of elasticity of the pavement, pounds per square inch

h = pavement thickness, inches

 μ = Poisson's ratio (generally assumed 0.15 for concrete pavement)

k = modulus of subgrade reaction, pounds per cubic inch

Tables 46 through 50 present pressure coefficients in terms of the radius of stiffness as developed by the Portland Cement Association and published in the report "Vertical Pressure on Culverts Under Wheel Loads on Concrete Pavement Slabs." 3

Values of radius of stiffness are listed in Table 52 for pavement thickness and modulus of subgrade reaction.

Tables 53 through 55 present aircraft loads in pounds per linear foot for circular, horizontal elliptical and arch pipe. The Tables are based on equations

4.15 and 4.16 using a 180,000 pound dual tandem wheel assembly, 190 pounds per square inch tire pressure, 26-inch spacing between dual tires, 66-inch spacing between tandem axles, k value of 300 pounds per cubic inch, 12-inch, thick concrete pavement and an R_s, value of 37.44 inches. Subgrade and subbase support for a rigid pavement is evaluated in terms of k, the modulus of subgrade reaction. A k value of 300 pounds per cubic inch was used, since this value represents a desirable subgrade or subbase material. In addition, because of the interaction between the pavement and subgrade, a lower value of k (representing reduced subgrade support) results in less load on the pipe.

Although Tables 53 through 55 are for specific values of aircraft weights and landing gear configuration, the tables can be used with sufficient accuracy for all heavy commercial aircraft currently in operation. Investigation of the design loads of future jets indicates that although the total loads will greatly exceed present aircraft loads, the distribution of such loads over a greater number of landing gears and wheels will not impose loads on underground conduits greater than by commercial aircraft currently in operation. For lighter aircrafts and/or different rigid pavement thicknesses, it is necessary to calculate loads as illustrated in Example 4.10.

Flexible Pavement. AASHTO considers flexible pavement as an unpaved surface and therefore live load distributions may be calculated as if the load were bearing on soil. Cover depths are measured from the top of the flexible pavement.

Railroads. In determining the live load transmitted to a pipe installed under railroad tracks, the weight on the locomotive driver axles plus the weight of the track structure, including ballast, is considered to be uniformly distributed over an area equal to the length occupied by the drivers multiplied by the length of ties.

The American Railway Engineering and Maintenance of Way Association (AREMA) recommends a Cooper E80 loading with axle loads and axle spacing as shown in Illustration 4.19. Based on a uniform load distribution at the bottom of the ties and through the soil mass, the live load transmitted to a pipe underground is computed by the equation:

$$W_{L} = Cp_{o}B_{c}I_{f} (4.17)$$

where:

C = load coefficient

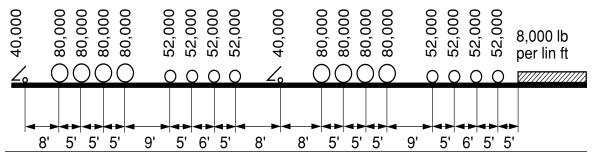
p_o = tire pressure, pounds per square foot

B = outside span of the pipe, feet

I, = impact factor

Tables 56 through 58 present live loads in pounds per linear foot based on equation (4.17) with a Cooper E80 design loading, track structure weighing 200 pounds per linear foot and the locomotive load uniformly distributed over an area 8 feet X 20 feet yielding a uniform live load of 2025 pounds per square foot. In accordance with the AREMA "Manual of Recommended Practice" an impact factor of 1.4 at zero cover decreasing to 1.0 at ten feet of cover is included in the Tables.

Illustration 4.20 Cooper E 80 Wheel Loads and Axel Spacing
Based on a uniform load distribution at the bottom of the ties and through the



³ Op. cit., p. 28

soil mass, the design track unit load, W_L , in pounds per square foot, is determined from the AREMA graph presented in Figure 215. To obtain the live load transmitted to the pipe in pounds per linear foot, it is necessary to multiply the unit load, W_L , from Figure 215, by the outside span, B_c , of the pipe in feet.

Loadings on a pipe within a casing pipe shall be taken as the full dead load, plus live load, plus impact load without consideration of the presence of the casing pipe, unless the casing pipe is fully protected from corrosion.

Culvert or sewer pipe within the railway right-of-way, but not under the track structure, should be analyzed for the effect of live loads because of the possibility of train derailment.

Construction Loads. During grading operations it may be necessary for heavy construction equipment to travel over an installed pipe. Unless adequate protection is provided, the pipe may be subjected to load concentrations in excess of the design loads. Before heavy construction equipment is permitted to cross over a pipe, a temporary earth fill should be constructed to an elevation at least 3 feet over the top of the pipe. The fill should be of sufficient width to prevent possible lateral displacement of the pipe.

SELECTION OF BEDDING

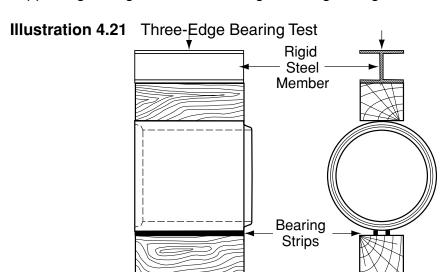
A bedding is provided to distribute the vertical reaction around the lower exterior surface of the pipe and reduce stress concentrations within the pipe wall. The load that a concrete pipe will support depends on the width of the bedding contact area and the quality of the contact between the pipe and bedding. An important consideration in selecting a material for bedding is to be sure that positive contact can be obtained between the bed and the pipe. Since most granular materials will shift to attain positive contact as the pipe settles, an ideal load distribution can be attained through the use of clean coarse sand, well-rounded pea gravel or well-graded crushed rock.

BEDDING FACTORS

Under installed conditions the vertical load on a pipe is distributed over its width and the reaction is distributed in accordance with the type of bedding. When the pipe strength used in design has been determined by plant testing, bedding

⁴ Equation (21) is recommended by WPCF-ASCE Manual, The Design and Construction of Sanitary Storm Sewers.

factors must be developed to relate the in-place supporting strength to the more severe plant test strength. The bedding factor is the ratio of the strength of the pipe under the installed condition of loading and bedding to the strength of the pipe in the plant test. This same ratio was defined originally by Spangler as the load factor. This latter term, however, was subsequently defined in the ultimate strength method of reinforced concrete design with an entirely different meaning. To avoid confusion, therefore, Spangler's term was renamed the bedding factor. The three-edge bearing test as shown in Illustration 4.20 is the normally accepted plant test so that all bedding factors described in the following pages relate the in-place supporting strength to the three-edge bearing strength.



Although developed for the direct design method, the Standard Installations are readily applicable to and simplify the indirect design method. The Standard Installations are easier to construct and provide more realistic designs than the historical A, B, C, and D beddings. Development of bedding factors for the Standard Installations, as presented in the following paragraphs, follows the concepts of reinforced concrete design theories. The basic definition of bedding factor is that it is the ratio of maximum moment in the three-edge bearing test to the maximum moment in the buried condition, when the vertical loads under each condition are equal:

$$B_{f} = \frac{M_{TEST}}{M_{FIELD}}$$
 (4.18)

where:

B_f = bedding factor

M_{TEST} = maximum moment in pipe wall under three-edge bearing test load, inch-pounds

M_{EIELD} = maximum moment in pipe wall under field loads, inch-pounds

Consequently, to evaluate the proper bedding factor relationship, the vertical load on the pipe for each condition must be equal, which occurs when the springline axial thrusts for both conditions are equal. In accordance with the laws of statics and equilibrium, M_{TEST} and M_{FIELD} are:

$$M_{TEST} = [0.318N_{FS}] \times [D + t]$$
 (4.19)

$$M_{FIELD} = [M_{FI}] - [0.38tN_{FI}] - [0.125N_{FI} \times c]$$
 (4.20)

where:

N_{FS} = axial thrust at the springline under a three-edge bearing test load, pounds per foot

D = inside pipe diameter, inchest = pipe wall thickness, inches

 M_{FI} = moment at the invert under field loading, inch-pounds/ft N_{FI} = axial thrust at the invert under field loads, pounds per foot

c = thickness of concrete cover over the inner reinforcement, inches

Substituting equations 4.19 and 4.20 into equation 4.18.

$$B_{f} = \frac{[0.318N_{FS}] \times [D+t]}{[M_{FI}] - [0.38tN_{FI}] - [0.125N_{FI} \times C]}$$
(4.21)

Using this equation, bedding factors were determined for a range of pipe diameters and depths of burial. These calculations were based on one inch cover over the reinforcement, a moment arm of 0.875d between the resultant tensile and compressive forces, and a reinforcement diameter of 0.075t. Evaluations indicated that for A, B and C pipe wall thicknesses, there was negligible variation in the bedding factor due to pipe wall thickness or the concrete cover, c, over the reinforcement. The resulting bedding factors are presented in Illustration 4.21.

Illustration 4.22 Bedding Factors, Embankment Conditions, B,

Pipe	5	Standard I	nstallatio	n					
Diameter	Type 1	Type 1 Type 2 Type 3 Ty							
12 in.	4.4	3.2	2.5	1.7					
24 in.	4.2	3.0	2.4	1.7					
36 in.	4.0	2.9	2.3	1.7					
72 in.	3.8	2.8	2.2	1.7					
144 in.	3.6	2.8	2.2	1.7					

Notes:

- 1. For pipe diameters other than listed in Illustration 4.21, embankment condition factors, B_{fe} can be obtained by interpolation.
- 2. Bedding factors are based on the soils being placed with the minimum compaction specified in Illustration 4.4 for each standard installation.

Determination of Bedding Factor. For trench installations as discussed previously, experience indicates that active lateral pressure increases as trench width increases to the transition width, provided the sidefill is compacted. A SIDD parameter study of the Standard Installations indicates the bedding factors are constant for all pipe diameters under conditions of zero lateral pressure on the pipe. These bedding factors exist at the interface of the pipewall and the soil and are called minimum bedding factors, $B_{\rm fo}$, to differentiate them from the fixed bedding factors developed by Spangler. Illustration 4.22 presents the minimum

bedding factors.

Illustration 4.23 Trench Minimum Bedding Factors, B_{fo}

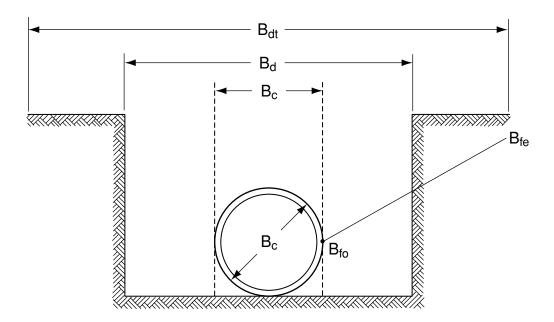
Standard Installation	Minimum Bedding Factor, B _{to}
Type 1	2.3
Type 2	1.9
Type 3	1.7
Type 4	1.5

Note:

- 1. Bedding factors are based on the soils being placed with the minimum compaction specified in Illustration 4.4 for each Standard Installation.
- 2. For pipe installed in trenches dug in previously constructed embankment, the load and the bedding factor should be determined as an embankment condition unless the backfill placed over the pipe is of lesser compaction than the embankment.

A conservative linear variation is assumed between the minimum bedding factor and the bedding factor for the embankment condition, which begins at transition width.

Illustration 4.24 Variable Bedding Factor



The equation for the variable trench bedding factor, is:

$$B_{fv} = \frac{[B_{fe} - B_{fo}][B_{d} - B_{c}]}{[B_{dt} - B_{c}]} + B_{fo}$$
 (4.22)

where:

 B_{c} = outside horizontal span of pipe, feet

 B_d = trench width at top of pipe, feet

B_{dt} = transition width at top of pipe, feet

B_{fe} = bedding factor, embankment B_{fo} = minimum bedding factor, trench B_{fo} = variable bedding factor, trench

Transition width values, B_{dt} are provided in Tables 13 through 39.

For pipe installed with 6.5 ft or less of overfill and subjected to truck loads, the controlling maximum moment may be at the crown rather than the invert. Consequently, the use of an earth load bedding factor may produce unconservative designs. Crown and invert moments of pipe for a range of diameters and burial depths subjected to HS20 truck live loadings were evaluated. Also evaluated, was the effect of bedding angle and live load angle (width of loading on the pipe). When HS20 or other live loadings are encountered to a significant value, the live load bedding factors, $\mathrm{B}_{\mathrm{fLL}}$, presented in Illustration 4.24 are satisfactory for a Type 4 Standard Installation and become increasingly conservative for Types 3, 2, and 1. Limitations on $\mathrm{B}_{\mathrm{fLL}}$ are discussed in the section on Selection of Pipe Strength.

Illustration 4.25 Bedding Factors, B_{f1}, for HS20 Live Loadings

Fill Heigl	ht,	Pipe Diameter, Inches									
Ft.	12	24	36	48	60	72	84	96	108	120	144
0.5	2.2	1.7	1.4	1.3	1.3	1.1	1.1	1.1	1.1	1.1	1.1
1.0	2.2	2.2	1.7	1.5	1.4	1.3	1.3	1.3	1.1	1.1	1.1
1.5	2.2	2.2	2.1	1.8	1.5	1.4	1.4	1.3	1.3	1.3	1.1
2.0	2.2	2.2	2.2	2.0	1.8	1.5	1.5	1.4	1.4	1.3	1.3
2.5	2.2	2.2	2.2	2.2	2.0	1.8	1.7	1.5	1.4	1.4	1.3
3.0	2.2	2.2	2.2	2.2	2.2	2.2	1.8	1.7	1.5	1.5	1.4
3.5	2.2	2.2	2.2	2.2	2.2	2.2	1.9	1.8	1.7	1.5	1.4
4.0	2.2	2.2	2.2	2.2	2.2	2.2	2.1	1.9	1.8	1.7	1.5
4.5	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.0	1.9	1.8	1.7
5.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.0	1.9	1.8

Application of Factor of Safety. The indirect design method for concrete pipe is similar to the common working stress method of steel design, which employs a factor of safety between yield stress and the desired working stress. In the indirect method, the factor of safety is defined as the relationship between the ultimate strength D-load and the 0.01 inch crack D-load. This relationship is specified in the ASTM Standards C 76 and C 655 on concrete pipe. The relationship between ultimate D-load and 0.01-inch crack D-load is 1.5 for 0.01 inch crack D-loads of 2,000 or less; 1.25 for 0.01 inch crack D loads of 3,000 or more; and a linear reduction from 1.5 to 1.25 for 0.01 inch crack D-loads between more than 2,000 and less than 3,000. Therefore, a factor of safety of 1.0 should be applied if the 0.01 inch crack strength is used as the design criterion rather than the ultimate strength. The 0.01 inch crack width is an arbitrarily chosen test criterion and not a criteri for field performance or service limit.

SELECTION OF PIPE STRENGTH

The American Society for Testing and Materials has developed standard specifications for precast concrete pipe. Each specification contains design, manufacturing and testing criteria.

ASTM Standard C 14 covers three strength classes for nonreinforced concrete pipe. These classes are specified to meet minimum ultimate loads, expressed in terms of three-edge bearing strength in pounds per linear foot.

ASTM Standard C 76 for reinforced concrete culvert, storm drain and sewer pipe specifies strength classes based on D-load at 0.01-inch crack and/or ultimate load. The 0.01-inch crack D-load ($D_{0.01}$) is the maximum three-edge-bearing test load supported by a concrete pipe before a crack occurs having a width of 0.01 inch measured at close intervals, throughout a length of at least 1 foot. The ultimate D-load (D_{ult}) is the maximum three-edge-bearing test load supported by a pipe divided by the pipe's inside diameter. D-loads are expressed in pounds per linear foot per foot of inside diameter.

ASTM Standard C 506 for reinforced concrete arch culvert, storm drain, and sewer pipe specifies strengths based on D-load at 0.01-inch crack and/or ultimate load in pounds per linear foot per foot of inside span.

ASTM Standard C 507 for reinforced concrete elliptical culvert, storm drain and sewer pipe specifies strength classes for both horizontal elliptical and vertical elliptical pipe based on D-load at 0.01-inch crack and/or ultimate load in pounds per linear foot per foot of inside span.

ASTM Standard C 655 for reinforced concrete D-load culvert, storm drain and sewer pipe covers acceptance of pipe designed to meet specific D-load requirements.

ASTM Standard C 985 for nonreinforced concrete specified strength culvert, storm drain, and sewer pipe covers acceptance of pipe designed for specified strength requirements.

Since numerous reinforced concrete pipe sizes are available, three-edge bearing test strengths are classified by D-loads. The D-load concept provides strength classification of pipe independent of pipe diameter. For reinforced circular pipe the three-edge-bearing test load in pounds per linear foot equals D-load times inside diameter in feet. For arch, horizontal elliptical and vertical elliptical pipe the three-edge bearing test load in pounds per linear foot equals D-load times nominal inside span in feet.

The required three-edge-bearing strength of non-reinforced concrete pipe is expressed in pounds per linear foot, not as a D-load, and is computed by the equation:

T.E.B =
$$\left[\left(\frac{W_E + W_F}{B_f} \right) + \frac{W_L}{B_{fLL}} \right] \times F.S.$$
 (4.23)

The required three-edge bearing strength of circular reinforced concrete pipe is expressed as D-load and is computed by the equation:

$$D-load = \left[\left(\frac{W_E + W_F}{B_f} \right) + \frac{W_L}{B_{fLL}} \right] \times \frac{F.S.}{D}$$
 (4.24)

The determination of required strength of elliptical and arch concrete pipe is computed by the equation:

D-load =
$$\left[\left(\frac{W_E + W_F}{B_f} \right) + \frac{W_L}{B_{fLL}} \right] \times \frac{F.S.}{S}$$
 where:

S = inside horizontal span of pipe, ft.

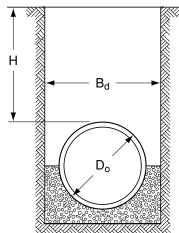
When an HS20 truck live loading is applied to the pipe, use the live load bedding factor, B_{fLL} , as indicated in Equations 4.23 – 4.25, unless the earth load bedding factor, B_f , is of lesser value in which case, use the lower B_f value in place of B_{fLL} . For example, with a Type 4 Standard Installation of a 48 inch diameter pipe under 1.0 feet of fill, the factors used would be $B_f = 1.7$ and $B_{fLL} = 1.5$; but under 2.5 feet or greater fill, the factors used would be $B_f = 1.7$ and $B_{fLL} = 1.7$ rather than 2.2. For trench installations with trench widths less than transition width, B_{fLL} would be compared to the variable trench bedding factor, B_f . Although their loads are generally less concentrated, the live load bedding factor may be conservatively used for aircraft and railroad loadings.

The use of the six-step indirect design method is illustrated by examples on the following pages.

EXAMPLE PROBLEMS

EXAMPLE PROBLEMS

EXAMPLE 4-1
Trench Installation



Given: A 48 inch circular pipe is to be installed in a 7 foot wide trench with 10 feet of cover over the top of the pipe. The pipe will be backfilled with sand and gravel weighing 110 pounds per cubic foot. Assume a Type 4 Installation.

Find: The required pipe strength in terms of 0.01 inch crack D-load.

1. Determination of Earth Load (W_F)

To determine the earth load, we must first determine if the installation is behaving as a trench installation or an embankment installation. Since we are not told what the existing in-situ material is, conservatively assume a $K\mu'$ value between the existing soil and backfill of 0.150.

From Table 23, The transition width for a 48 inch diameter pipe with a $K\mu'$ value of 0.150 under 10 feet of fill is:

$$B_{dt} = 8.5 \text{ feet}$$

Transition width is greater than the actual trench width, therefore the installation will act as a trench. Use Equations 4.3 and 4.4 to determine the soil load.

w = 110 pounds per cubic foot

H = 10 feet

 $B_d = 7 \text{ feet}$

 $K\mu' = 0.150$

$$D_{o} = \frac{48 + 2 (5)}{12}$$

Note: Wall thickness for a 48 inch inside diameter pipe with a B wall is 5-inches per ASTM C 76.

 $D_o = 4.83$ feet

The value of Cd can be obtained from Figure 214, or calculated using Equation 4.4.

$$C_d = \frac{1 - e^{-2(0.150)(\frac{10}{7})}}{(2)(0.150)}$$
 Equation 4.4

$$C_d = 1.16$$

$$W_d = (1.16)(110)(7)^2 + \frac{(4.83)^2(4 - \pi)}{8}$$
 (110) Equation 4.3

 $W_d = 6,538$ pounds per linear foot

 $W_e = W_d$ $W_E = 6,538$ earth load in pounds per linear foot

Weight of Fluid, W_F, for a 48' pipe

$$W_{E} = \gamma_{W} \times A$$

$$W_F = 62.4 \times \frac{\pi (D_1)^2}{4} = 62.4 \times \frac{\pi (4)^2}{4}$$

W_F = 784.1 pounds per linear foot

2. Determination of Live Load (W_L) From Table 42, live load is negligible at a depth of 10 feet.

3. Selection of Bedding

Because of the narrow trench, good compaction of the soil on the sides of the pipe would be difficult, although not impossible. Therefore a Type 4 Installation was assumed.

4. Determination of Bedding Factor, (B_{fv})

The pipe is installed in a trench that is less than transition width. Therefore, Equation 4.24 must be used to determine the variable bedding factor.

 $B_c = D_o$ $B_c = 4.83$ outside diameter of pipe in feet

 $B_d = 7$ width of trench in feet

 $B_{dt} = 8.5$ transition width in feet

 $B_{fe} = 1.7$ embankment bedding factor

 $B_{fo} = 1.5$ minimum bedding factor

$$B_{fv} = \frac{(1.7 - 1.5) (7 - 4.83)}{8.5 - 4.83} + 1.5$$
 Equation 4.24

 $B_{fv} = 1.62$

5. Application of Factor of Safety (F.S.)

A factor of safety of 1.0 based on the 0.01 inch crack will be applied.

6. Selection of Pipe Strength

The D-load is given by Equation 4.26

 $W_E = 6,538$ earth load in pounds per linear foot $W_F = 784$ fluid load in pounds per linear foot

 $W_1 = 0$ live load is negligible

 $B_f = B_{fv}$ $B_f = 1.62$ earth load bedding factor

 $B_{fLL} = N/A$ live load bedding factor is not applicable

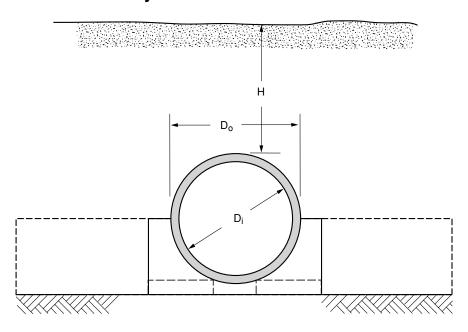
D = 4 inside diameter of pipe in feet

$$D_{0.01} = \left(\frac{6,538 + 784.1}{1.62}\right) \left(\frac{1}{4}\right)$$
 Equation 4.26

 $D_{0.01} = 1,130$ pounds per linear foot per foot of diameter

Answer: A pipe which would withstand a minimum three-edge bearing test load for the 0.01 inch crack of 1,130 pounds per linear foot per foot of inside diameter would be required.

EXAMPLE 4-2 Positive Projection Embankment Installation



Given: A 48 inch circular pipe is to be installed in a positive projecting embankment condition using a Type 1 installation. The pipe will be covered with 35 feet of 120 pounds per cubic foot overfill.

Find: The required pipe strength in terms of 0.01 inch D-load

Determination of Earth Load (W_E)
 Per the given information, the installation behaves as a positive projecting embankment. Therefore, use Equation 4.2 to determine the soil prism load and multiply it by the appropriate vertical arching factor.

$$D_o = \frac{48 + 2 (5)}{12}$$
 Note: The wall thickness for a 48-inch pipe with a B wall is 5-inches per ASTM C76.

 $D_o = 4.83$ outside diameter of pipe in feet

w = 120 unit weight of soil in pounds per cubic foot

H = 35 height of cover in feet

PL =
$$120 \left[35 + \frac{4.83 (4 - \pi)}{8} \right]$$
 4.83 Equation 4.2

PL = 20,586 pounds per linear foot

Immediately listed below Equation 4.2 are the vertical arching factors (VAFs) for the four types of Standard Installations. Using a VAF of 1.35 for a Type 1 Installation, the earth load is:

$$W_F = 1.35 \times 20,586$$

$$W_E = 27,791$$
 pounds per linear foot

Equation 4.1

Weight of Fluid, $W_{\scriptscriptstyle F}$, for a 48" pipe

$$W_F = \gamma_w \times A$$

$$W_F = 62.4 \times \frac{\pi (D_1)^2}{4} = 62.4 \times \frac{\pi (4)^2}{4}$$

$$W_F = 784.1$$
 pounds per linear foot

- 2. Determination of Live Load (W_L) From Table 42, live load is negligible at a depth of 35 feet.
- Selection of BeddingA Type 1 Installation will be used for this example
- Determination of Bedding Factor, (B_{fe})
 The embankment bedding factor for a Type 1 Installation may be interpolated from Illustration 4.21

$$\begin{array}{ll} B_{fe36} &=& 4.0 \\ B_{fe72} &=& 3.8 \\ B_{fe48} &=& \left(\frac{72 - 48}{72 - 36}\right) (4.0 - 3.8) + 3.8 \end{array}$$

- 5. Application of Factor of Safety (F.S.)
 A factor of safety of 1.0 based on the 0.01 inch crack will be applied.
- Selection of Pipe StrengthThe D-load is given by Equation 4.26

W_E = 27,791 earth load in pounds per linear foot

 $W_F = 784$ fluid load in pounds per linear foot

 $W_1 = 0$ live load is negligible

 $B_f = B_{fe} B_f = 3.93$ earth load bedding factor

 B_{fLL} = N/A live load bedding factor is not applicable

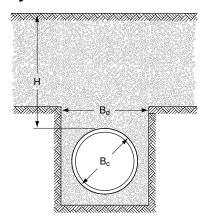
D = 4 inside diameter of pipe in feet

$$D_{0.01} = \left(\frac{27,791 + 784.1}{3.93}\right) \left(\frac{1.0}{4}\right)$$
 Equation 4.26

 $D_{0.01} = 1,818$ pounds per linear foot per foot of diameter

Answer: A pipe which would withstand a minimum three-edge bearing test for the 0.01 inch crack of 1,818 pounds per linear foot per foot of inside diameter would be required.

EXAMPLE 4-3 Negative Projection Embankment Installation



Given: A 72 inch circular pipe is to be installed in a negative projecting embankment condition in ordinary soil. The pipe will be covered with 35 feet of 120 pounds per cubic foot overfill. A 10 foot trench width will be constructed with a 5 foot depth from the top of the pipe to the natural ground surface.

Find: The required pipe strength in terms of 0.01 inch D-load

1. Determination of Earth Load (W_E)

A settlement ratio must first be assumed. The negative projection ratio of this installation is the height of soil from the top of the pipe to the top of the natural ground (5 ft) divided by the trench width (10 ft). Therefore the negative projection ratio of this installation is p' = 0.5. From Table 40, for a negative projection ratio of p' = 0.5, the design value of the settlement ratio is -0.1.

Enter Figure 195 on the horizontal scale at H = 35 feet. Proceed vertically until the line representing $B_d = 10$ feet is intersected. At this

point the vertical scale shows the fill load to be 27,500 pounds per linear foot for 100 pounds per cubic foot fill material. Increase the load 20 percent for 120 pound material since Figure 195 shows values for 100 pound material.

 $W_n = 1.20 \times 27{,}500$ $W_n = 33{,}000$ pounds per linear foot $W_E = W_n$ $W_E = 33{,}000$ earth load in pounds per linear foot

Weight of Fluid, W_F, for a 72" pipe

$$W_F = \gamma_w \times A$$

$$W_F = 62.4 \times \frac{\pi (D_1)^2}{4} = 62.4 \times \frac{\pi (6)^2}{4}$$

 $W_F = 1764$ pounds per linear foot

- 2. Determination of Live Load (W,) From Table 42, live load is negligible at a depth of 35 feet.
- 3. Selection of Bedding No specific bedding was given. Assuming the contractor will put minimal effort into compacting the soil, a Type 3 Installation is chosen.
- 4. Determination of Bedding Factor, (B_{fv}) The variable bedding factor will be determined using Equation 4.24 in the same fashion as if the pipe were installed in a trench.

$$B_c = \frac{72 + 2 (7)}{12}$$
 Note: The wall thickness for a 72-inch pipe with a B wall is 7-inches per ASTM C 76.

 $B_c = 7.17$ outside diameter of pipe in feet

 $B_d = 10$ trench width in feet

 $B_{fe} = 2.2$ embankment bedding factor (taken from Illustration 4.21)

 $B_{fo} = 1.7$ minimum bedding factor (taken from Illustration 4.22)

$$B_{fv} = \frac{(2.2 - 1.7) (10 - 7.17)}{14.1 - 7.17} + 1.7$$
 Equation 4.24
$$B_{fv} = 1.9$$

- 5. Application of Factor of Safety (F.S.) A factor of safety of 1.0 based on the 0.01 inch crack will be applied.
- 6. Selection of Pipe Strength The D-load is given by Equation 4.26

W_E = 33,000 earth load in pounds per linear foot

 $W_F = 1,764$ fluid load in pounds per linear foot

 $W_L = 0$ live load is negligible

 $B_f = B_{fv}$ $B_f = 1.9$ earth load bedding factor

 $B_{fLL} = N/A$ live load bedding factor is not applicable

D = 6 inside diameter of pipe in feet

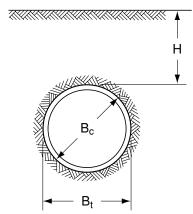
$$D_{0.01} = \left(\frac{33,000 + 1,764}{1.9}\right) \left(\frac{1.0}{6}\right)$$

Equation 4.26

 $D_{0.01} = 3,050$ pounds per linear foot per foot of diameter

Answer: A pipe which would withstand a minimum three-edge bearing test load for the 0.01 inch crack of 3,050 pounds per linear foot per foot of inside diameter would be required.

EXAMPLE 4-4 Jacked or Tunneled Installation



Given: A 48 inch circular pipe is to be installed by the jacking method of construction with a height of cover over the top of the pipe of 40 feet. The pipe will be jacked through ordinary clay material weighing 110 pounds per cubic foot throughout its entire length. The limit of excavation will be 5 feet.

Find: The required pipe strength in terms of 0.01 inch crack D-load.

Determination of Earth Load (W_E)
 A coefficient of cohesion value must first be assumed. In Table 41, values of the coefficient of cohesion from 40 to 1,000 are given for clay. A conservative value of 100 pounds per square foot will be used.

Enter Figure 151, Ordinary Clay, and project a horizontal line from H = 40 feet on the vertical scale and a vertical line from B_t = 5 feet on the horizontal scale. At the intersection of these two lines interpolate between the curved lines for a value of 9,500 pounds per linear foot, which accounts for earth load without cohesion. Decrease the load in proportion to 110/120 for 110 pound material since Figure 151 shows values for 120 pound material.

$$W_t = \frac{110}{120} \times 9,500$$

 $W_t = 8,708$ pounds per linear foot

Enter Figure 152, Ordinary Clay, and project a horizontal line from H = 40 feet on the vertical scale and a vertical line from B_t = 5 feet on the horizontal scale. At the intersection of these two lines interpolate between the curved lines for a value of 33, which accounts for the cohesion of the soil. Multiply this value by the coefficient of cohesion, c = 100, and subtract the product from the 8,708 value obtained from figure 151.

 $W_t = 8,708 - 100 (33)$ $W_t = 5,408$ pounds per linear foot $W_E = W_t$ $W_E = 5,408$ earth load in pounds per linear foot

Note: If the soil properties are not consistent, or sufficient information on the soil is not available, cohesion may be neglected and a conservative value of 8,708 lbs/ft used.

Weight of Fluid, W $_{\!\scriptscriptstyle F}$, for a 48" pipe W $_{\!\scriptscriptstyle F} = \gamma_{\!\scriptscriptstyle w} \; x \; A$

$$W_F = 62.4 \times \frac{\pi (D_1)^2}{4} = 62.4 \times \frac{\pi (4)^2}{4}$$

 $W_F = 784.1$ pounds per linear foot

- 2. Determination of Live Load (W_L) From Table 42, live load is negligible at 40 feet.
- Selection of Bedding
 The annular space between the pipe and limit of excavation will be filled with grout.
- 4. Determination of Bedding Factor (B_{fv}) Since the space between the pipe and the bore will be filled with grout, there will be positive contact of bedding around the periphery of the pipe. Because of this beneficial bedding condition, little flexural stress should be induced in the pipe wall. A conservative variable bedding factor of 3.0 will be used.
- 5. Application of Factor of Safety (F.S.)

 A factor of safety of 1.0 based on the 0.01 inch crack will be applied.

 6. Selection of Pipe Strength
- 6. Selection of Pipe Strength
 The D-load is given by Equation 4.26.

 $W_E = 5,408$ earth load in pounds per linear foot

 $W_F = 784$ fluid load in pounds per linear foot

 $W_L = 0$ live load is negligible

 $B_f = B_{fv}$ $B_f = 3.0$ earth load bedding factor

 $B_{fLL} = N/A$ live load bedding factor is not applicable

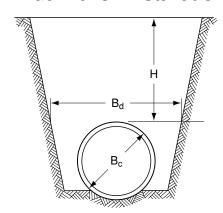
D = 4 inside diameter of pipe in feet

$$D_{0.01} = \left(\frac{5,408 + 784.1}{3.0}\right) \left(\frac{1.0}{4}\right)$$
 Equation 4.26

 $D_{0.01} = 516$ pounds per linear foot per foot of diameter

Answer: A pipe which would withstand a minimum three-edge bearing test load for the 0.01 inch crack of 516 pounds per linear foot per foot of inside diameter would be required.

EXAMPLE 4-5Wide Trench Installation



Given: A 24 inch circular non reinforced concrete pipe is to be installed in a 5 foot wide trench with 10 feet of cover over the top of the pipe. The pipe will be backfilled with ordinary clay weighing 120 pounds per cubic foot.

Find: The required three-edge bearing test strength for nonreinforced pipe and the ultimate D-load for reinforced pipe.

1. Determination of Earth Load (W_E)

To determine the earth load, we must first determine if the installation is behaving as a trench installation or an embankment installation. Assume that since the pipe is being backfilled with clay that they are using in-situ soil for backfill. Assume a $K\mu$ value between the existing soil and backfill of 0.130. We will assume a Type 4 Installation for this example.

From Table 17, the transition width for a 24 inch diameter pipe with a $K\mu'$ value of 0.130 under 10 feet of fill is:

 $B_{dt} = 4.8$

Since the transition width is less than the trench width, this installation will act as an embankment. Therefore calculate the prism load per

Equation 4.2 and multiply it by the appropriate vertical arching factor (VAF).

$$D_o = \frac{24 + 2 (3)}{12}$$
 Note: The wall thickness for a 24-inch pipe with a B wall is 3-inches per ASTM C76.

 $D_o = 2.5$ outside diameter of pipe in feet

w = 120 unit weight of soil in pounds per cubic foot

H = 10 height of cover in feet

$$PL = 120 \left[10 + \frac{2.5 (4 - \pi)}{8} \right] 2.5$$

Equation 4.2

PL = 3,080 pounds per linear foot

Immediately listed below Equation 4.2 are the vertical arching factors (VAF) for the four types of Standard Installations. Using a VAF of 1.45 for a Type 4 Installation, the earth load is:

$$W_E = 1.45 \times 3,080$$

$$W_E = 4,466$$
 pounds per linear foot

Equation 4.1

Weight of Fluid, W_F, for a 24" pipe

$$W_F = \gamma_w \times A$$

$$W_F = 62.4 \times \frac{\pi (D_1)^2}{4} = 62.4 \times \frac{\pi (2)^2}{4}$$

 $W_F = 196$ pounds per linear foot

- 2. Determination of Live Load (W_L) From Table 42, live load is negligible at a depth of 10 feet.
- 3. Selection of Bedding
 A Type 4 Installation has been chosen for this example
- 4. Determination of Bedding Factor, (B_{fe}) Since this installation behaves as an embankment, an embankment bedding factor will be chosen. From Illustration 4.21, the embankment bedding factor for a 24 inch pipe installed in a Type 4 Installation is:

$$B_{fe} = 1.7$$

- 5. Application of Factor of Safety (F.S.)
 A factor of safety of 1.0 based on the 0.01 inch crack will be applied.
- 6. Selection of Pipe Strength
 The D-load is given by Equation 4.26.

W_E = 4,466 earth load in pounds per linear foot

 $W_F = 196$ fluid load in pounds per linear foot

 $W_L = 0$ live load is negligible

 $B_f = B_{fe}$ $B_f = 1.7$ earth load bedding factor

B_{fLL} = N/A live load bedding factor is not applicable

D = 2 inside diameter of pipe in feet

The ultimate three-edge bearing strength for nonreinforced concrete pipe is given by Equation 4.25

TEB =
$$\left(\frac{4,466 + 196}{1.7}\right)$$
 1.5 Equation 4.25

TEB = 4,114 pounds per linear foot

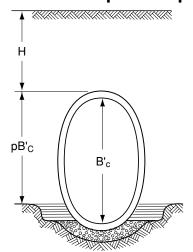
The D-load for reinforced concrete pipe is given by Equation 4.26.

$$D_{0.01} = \left(\frac{4,466 + 196}{1.7}\right) \left(\frac{1.0}{2}\right)$$
 Equation 4.26

 $D_{0.01} = 1,371$ pounds per linear foot per foot of diameter

Answer: A nonreinforced pipe which would withstand a minimum three-edge bearing test load of 4,114 pounds per linear foot would be required.

EXAMPLE 4-6
Positive Projection Embankment Installation
Vertical Elliptical Pipe



Given: A 76 inch x 48 inch vertical elliptical pipe is to be installed in a positive projection embankment condition in ordinary soil. The pipe will be covered with 50 feet of 120 pounds per cubic foot overfill.

Find: The required pipe strength in terms of 0.01 inch crack D-load.

1. Determination of Earth Load (W_E)

Note: The Standard Installations were initially developed for circular pipe, and their benefit has not yet been established for elliptical and arch pipe. Therefore, the traditional Marston/Spangler design method using B and C beddings is still conservatively applied for these shapes.

A settlement ratio must first be assumed. In Table 40, values of settlement ratio from +0.5 to +0.8 are given for positive projecting installation on a foundation of ordinary soil. A value of 0.7 will be used. The product of the settlement ratio and the projection ratio will be 0.49 (r_{sd} p approximately 0.5).

Enter Figure 182 on the horizontal scale at H = 50 feet. Proceed vertically until the line representing R x S = 76" x 48" is intersected. At this point the vertical scale shows the fill load to be 41,000 pounds per linear foot for 100 pounds per cubic foot fill material. Increase the load 20 percent for 120 pound material.

 $W_{c} = 1.20 \times 41,000$

 $W_c = 49,200$ per linear foot

 $W_E = W_c$ $W_E = 49,200$ earth load in pounds per linear foot

Weight of Fluid, W_F, for a 76" x 48" pipe

$$W_F = \gamma_w \times A$$

$$W_F = 62.4 \times \frac{\pi 6.33 \times 4}{4}$$

W_F = 1241 pounds per linear foot

- 2. Determination of Live Load (W_L) From Table 44, live load is negligible at a depth of 50 feet.
- 3. Selection of Bedding

Due to the high fill height you will more than likely want good support around the pipe, a Class B bedding will be assumed for this example.

4. Determination of Bedding Factor (B_{fe}) First determine the H/B_c ratio.

$$H = 50$$

$$B_c = \frac{48 + 2 (6.5)}{12}$$
 Note: the wall thickness for a 72" x 48" elliptical pipe is 6.5" per ASTM C507.

 $B_c = 5.08$ outside diameter of pipe in feet

$$H/B_c = 9.84$$

From Table 59, for an H/Bc ratio of 9.84, $\rm r_{sdp}$ value of 0.5, p value of 0.7, and a Class B bedding, an embankment bedding factor of 2.71 is obtained.

$$B_{fe} = 2.71$$

- 5. Application of Factor of Safety (F.S.)
 A factor of safety of 1.0 based on the 0.01 inch crack will be applied.
- 6. Selection of Pipe Strength

The D-load is given by Equation 4.27

 $W_F = 49,200$ earth load in pounds per linear foot

 $W_F = 1,242$ fluid load in pounds per linear foot

 $W_1 = 0$ live load is negligible

 $B_f = B_{fe}$ $B_f = 2.71$ earth load bedding factor

 $B_{fl.l} = N/A$ live load bedding factor is not applicable

S = 4 inside diameter of pipe in feet

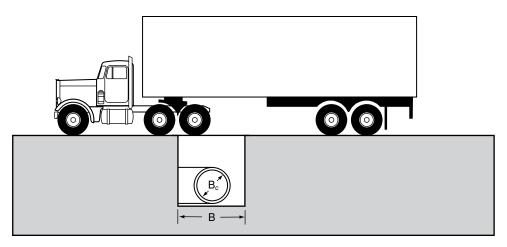
$$D_{0.01} = \left(\frac{49,200 + 1,241}{2.71}\right) \left(\frac{1.0}{4}\right)$$

Equation 4.27

 $D_{0.01} = 4,653$ pounds per linear foot per foot of diameter

Answer: A pipe which would withstand a minimum three-edge bearing test load for the 0.01 inch crack of 4,654 pounds per linear foot per foot of inside horizontal span would be required.

EXAMPLE 4-7 Highway Live Load



Given: A 24 inch circular pipe is to be installed in a positive projection embankment under an unsurfaced roadway and covered with 2.0 feet of 120 pounds per cubic foot backfill material.

Find: The required pipe strength in terms of 0.01 inch crack D-load.

Determination of Earth Load (W_E)
 Per the given information, the installation behaves as a positive projecting embankment. Therefore, use Equation 4.2 to determine the soil prism load and multiply it by the appropriate vertical arching factor.

$$D_o = \frac{24 + 2 (3)}{12}$$
 Note: The wall thickness for a 24-inch pipe with a B wall is 3-inches per ASTM C76.

 $D_o = 2.5$ outside diameter of pipe in feet

w = 120 unit weight of soil in pounds per cubic foot

H = 2 height of cover in feet

PL = 120
$$\left[2 + \frac{2.5 (4 - \pi)}{8}\right]$$
 2.5 Equation 4.2

PL = 680 pounds per linear foot

Assume a Type 2 Standard Installation and use the appropriate vertical arching factor listed below Equation 4.2.

$$VAF = 1.4$$

$$W_E = 1.40 \times 680$$

Equation 4.1

Weight of Fluid, W_F, for a 24" pipe

$$W_F = \gamma_w \times A$$

$$W_F = 62.4 \times \frac{\pi (2)^2}{4}$$

W_F = 196 pounds per linear foot

2. Determination of Live Load (W_L)

Since the pipe is being installed under an unsurfaced roadway with shallow cover, a truck loading based on AASHTO will be evaluated. From Table 42, for D = 24 inches and H = 2.0 feet, a live load of 1,780 pounds per linear foot is obtained. This live load value includes impact. $W_L = 1,780$ pounds per linear foot

Selection of Bedding

A Type 2 Standard Installation will be used for this example.

- 4. Determination of Bedding Factor, (B_{fe})
 - a.) Determination of Embankment Bedding Factor
 From Illustration 4.21, the earth load bedding factor for a 24 inch
 pipe installed in a Type 2 positive projecting embankment condition
 is 3.0.

$$B_{fe} = 3.0$$

b.) Determination of Live Load Bedding Factor, (B_{fLL}) From Illustration 4.24, the live load bedding factor for a 24 inch pipe under 2 feet of cover is 2.2.

$$B_{fl.i} = 2.2$$

Equation 4.26

- 5. Application of Factor of Safety (F.S.)
 A factor of safety of 1.0 based on the 0.01 inch crack will be applied.
- 6. Selection of Pipe Strength
 The D-load is given by equation 4.26

W_E = 952 earth load in pounds per linear foot

 $W_F = 196$ fluid load in pounds per linear foot

 $W_L = 1,780$ live load in pounds per linear foot

 $B_f = B_{fe}$ $B_f = 3$ earth load bedding factor

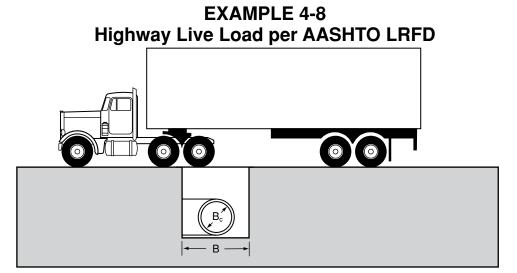
B_{fLL} = 2.2 live load bedding factor is not applicable

D = 2 inside diameter of pipe in feet

$$D_{0.01} = \left[\frac{952 + 196}{3.0} + \frac{1,780}{2.2} \right] \left(\frac{1.0}{2} \right)$$

 $D_{0.01} = 596$ pounds per linear foot per foot of diameter

Answer: A pipe which would withstand a minimum three-edge bearing test for the 0.01 inch crack of 596 pounds per linear foot per foot of inside diameter would be required.



Given: A 30-inch diameter, B wall, concrete pipe is to be installed as a storm drain under a flexible pavement and subjected to AASHTO highway loadings. The pipe will be installed in a 6 ft wide trench with a minimum of 2 feet of cover over the top of the pipe. The AASHTO LRFD Criteria will be used with Select Granular Soil and a Type 3 Installation.

Find: The maximum 0.01" D_{load} required of the pipe.

Determination of Earth Load (W_E)
 Per review of Table 19, the 6 ft. trench is wider than transition width.

Therefore, the earth load is equal to the soil prism load multiplied by the appropriate vertical arching factor.

$$D_o = \frac{30 + 2 (3.5)}{12}$$
 Note: The wall thickness for a 30-inch pipe with a B wall is 3.5-inches per ASTM C76.

D_o = 3.08 outside diameter of pipe in feet

w = 120 unit weight of soil in pounds per cubic foot

H = 2 height of cover in feet

$$PL = 120 \left[2 + \frac{3.08 (4 - \pi)}{8} \right] 3.08$$

PL = 861 pounds per linear foot

Illustration 4.7 lists the vertical arching factors (VAFs) for the four types of Standard Installations. Using a VAF of 1.40 for a Type 3 Installation, the earth load is:

$$W_E = 1.40 \times 861$$

Equation 4.1

W_E = 1,205 pounds per linear foot

The weight of concrete pavement must be included also. Assuming 150 pounds per cubic foot unit weight of concrete, the total weight of soil and concrete is:

$$W_E = 1,205 + 150 \times 1.0 \times 3.08$$

 $W_F^E = 1,655$ pounds per linear foot

Weight of Fluid, W_F, for a 30" pipe

$$W_F = \gamma_w \times A$$

$$W_F = 62.4 \times \frac{\pi (2.5)^2}{4}$$

 $W_F = 306$ pounds per linear foot

2. Review project data.

A 30-inch diameter, B wall, circular concrete pipe has a wall thickness of 3.5 inches, per ASTM C76 therefore

$$B_c = \frac{30 + 2 (3.5)}{12}$$

$$B_c = 3.08$$

And R_o, the outside height of the pipe, is 3.08 feet. Height of earth cover is 2 feet. Use AASHTO LRFD Criteria with Select Granular Soil Fill.

3. Calculate average pressure intensity of the live load on the plane at the outside top of the pipe.

From Illustration 4.12, the critical load, P, is 16,000 pounds from an HS 20 single dual wheel, and the Spread Area is:

A = (Spread a)(Spread b)

A = (1.67 + 1.15x2)(0.83 + 1.15x2)

A = (3.97)(3.13)A = 12.4 square feet

I.M. = 33(1.0-0.125H)/100I.M. = 0.2475 (24.75%)

W = P(1+IM)/A

W = 16,000(1+0.2475)/12.4

 $w = 1,610 \text{ lb/ft}^2$

4. Calculate total live load acting on the pipe.

$$W_{T} = (W + L_{I})LS_{I}$$

Assuming truck travel transverse to pipe centerline.

 $L_1 = 64$

L = Spread a = 3.97 feet

Spread b = 3.13 feet

 B_c = 3.08 feet, which is less than Spread b,

therefore $S_i = 3.08$ feet

 $W_{T}^{L} = (1,610 + 64) 3.97 \times 3.08 = 20,500 \text{ pounds}$



 $L_{\cdot} = 64$

Spread a = 3.97 feet

L = Spread b = 3.13 feet

B_c = 3.08 feet, which is less than Spread a,

therefore

 $S_i = 3.08 \text{ feet}$

 $W_{T} = (1,610 + 64) 3.08 \times 3.13 = 16,100 \text{ pounds}$

 W_{T} Maximum = 20,500 pounds; and truck travel is transverse to pipe centerline

5. Calculate live load on pipe in pounds per linear foot, (W,)

 $R_a = 3.08$ feet

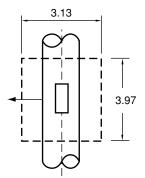
 $L_{e}^{"} = L + 1.75 (3/4Ro)$

 $L_a^e = 3.97 + 1.75(.75 \times 3.08) = 8.01 \text{ feet}$

 $\dot{W}_L = W_T/L_e$

 $W_{L}^{L} = 20,500/8.01 = 2,559$ pounds per linear foot

The pipe should withstand a maximum live load of 2,559 pounds per linear foot.



6. Determination of Bedding Factor, (B,)

a) Determination of Embankment Bedding Factor
 The embankment bedding factor for a Type 3 Installation may be interpolated from Illustration 4.21

$$B_{fe24} = 2.4$$

$$B_{fe36} = 2.3$$

$$B_{fe30} = \frac{36 - 30}{34 - 24} (2.4 - 2.3) + 2.3$$

$$B_{fe30} = 2.3$$

b) Determination of Live Load Bedding Factor

From Illustration 4.24, the live load bedding factor for a 30 inch pipe under 3 feet of cover (one foot of pavement and two feet of soil) can be interpolated

$$B_{fLL24} = 2.4$$

 $B_{fLL36} = 2.2$
Therefore $B_{fIL30} = 2.3$

7. Application of Factor of Safety (F.S.)
A factor of safety of 1.0 based on the 0.01 inch crack will be applied.

8 Selection of Pipe Strength

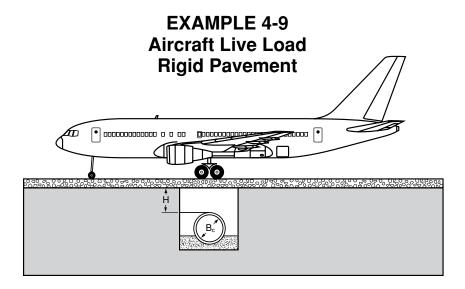
 $W_E = 1,655$ earth load in pounds per linear foot $W_F = 307$ fluid load in pounds per linear foot $W_L = 2,559$ live load in pounds per linear foot $B_f = B_{fe}$ $B_f = 2.35$ earth load bedding factor $B_{fLL} = 2.3$ live load bedding factor is not applicable

D = 2.5 inside diameter of pipe in feet

$$D_{0.01} = \left[\frac{1,655 + 306}{2.35} + \frac{2,559}{2.3} \right] \left(\frac{1.0}{2.5} \right)$$
 Equation 4.26

 $D_{0.01} = 779$ pounds per linear foot per foot of diameter

Answer: A pipe which would withstand a minimum three-edge bearing test for the 0.01 inch crack of 779 pounds per linear foot per foot of inside diameter would be required.



Given: A 12 inch circular pipe is to be installed in a narrow trench, B_d = 3ft under a 12 inch thick concrete airfield pavement and subject to heavy commercial aircraft loading. The pipe will be covered with 1.0 foot (measured from top of pipe to bottom of pavement slab) of sand and gravel material weighing 120 pounds per cubic foot.

Find: The required pipe strength in terms of 0.01 inch crack D-load.

Determination of Earth Load (W_E)
 Per review of Table 13, the 3 ft. trench is wider than transition width. Therefore, the earth load is equal to the soil prism load multiplied by the appropriate vertical arching factor.

$$D_0 = \frac{12 + 2(2)}{12}$$
 Note: The wall thickness for a 12-inch pipe with a B wall is 2-inches per ASTM C76.

D_o = 1.33 outside diameter of pipe in feet

w = 120 unit weight of soil in pounds per cubic foot

H = 1 height of cover in feet

PL =
$$120 \left[1 + \frac{1.33 (4 - \pi)}{8} \right]$$
 1.33 Equation 4.2

PL = 182 pounds per linear foot

Immediately listed below Equation 4.2 are the vertical arching factors (VAFs) for the four types of Standard Installations. Using a VAF of 1.40 for a Type 2 Installation, the earth load is:

$$W_E = 1.40 \times 182$$
 Equation 4.1

 $W_E = 255$ pounds per linear foot

The weight of concrete pavement must be included also. Assuming 150 pounds per cubic foot unit weight of concrete, the total weight of soil and concrete is:

 $W_E = 255 + 150 \times 1.0 \times 1.33$

 $W_E^L = 455$ pounds per linear foot

Weight of Fluid, W_E, for a 12" pipe

$$W_F = \gamma_w \times A$$

$$W_F = 62.4 \times \frac{\pi (1)^2}{4}$$

 $W_F = 49$ pounds per linear foot

2. Determination of Live Load (W₁)

It would first be necessary to determine the bearing value of the backfill and/or subgrade. A modulus of subgrade reaction, k=300 pounds per cubic inch will be assumed for this example. This value is used in Table 53A and represents a moderately compacted granular material, which is in line with the Type 2 Installation we are using.

Based on the number of undercarriages, landing gear configurations and gross weights of existing and proposed future aircrafts, the Concorde is a reasonable commercial aircraft design loading for pipe placed under airfields. From Table 53A, for D=12 inches and H=1.0 foot, a live load of 1,892 pounds per linear foot is obtained.

W₁ = 1892 pounds per linear foot

3. Selection of Bedding

Since this installation is under an airfield, a relatively good installation is required, therefore use a Type 2 Installation.

4. Determination of Bedding Factor, (B_{fe})

a.) Determination of Embankment Bedding Factor

From Illustration 4.21, the embankment bedding factor for a 12 inch pipe installed in a positive projecting embankment condition is 3.2.

$$B_{fe} = 3.2$$

b.) Determination of Live Load Bedding Factor

From Illustration 4.24, the live load bedding factor for a 12 inch pipe under 2 feet of cover (one foot of pavement and one foot of soil) is 2.2.

$$B_{fLL} = 2.2$$

5. Application of Factor of Safety (F.S.)

A factor of safety of 1.0 based on the 0.01 inch crack will be applied.

6. Selection of Pipe Strength The D-load is given by Equation 4.26

W_E = 455 earth load in pounds per linear foot

 $W_F = 49$ fluid load in pounds per linear foot

 $W_L = 1,892$ live load in pounds per linear foot

 $B_f = B_{fe}$ $B_f = 3.2$ earth load bedding factor

 B_{fLL} = 2.2 live load bedding factor is not applicable

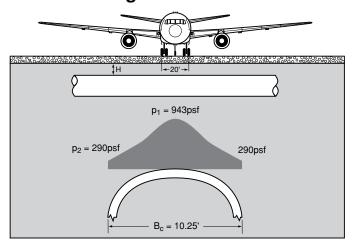
D = 1 inside diameter of pipe in feet

$$D_{0.01} = \left[\frac{455 + 49}{3.2} + \frac{1,892}{2.2} \right] \left(\frac{1.0}{1.0} \right)$$

Equation 4.26

Answer: A pipe which would withstand a minimum three-edge bearing test for the 0.01 inch crack of 1,018 pounds per linear foot per foot of inside diameter would be required.

EXAMPLE 4-10 Aircraft Live Load Rigid Pavement



Given: A 68 inch x 106 inch horizontal elliptical pipe is to be installed in a positive projecting embankment condition under a 7 inch thick concrete airfield pavement and subject to two 60,000 pound wheel loads spaced 20 feet, center to center. The pipe will be covered with 3-feet (measured from top of pipe to bottom of pavement slab) of sand and gravel material weighing 120 pounds per cubic foot.

Find: The required pipe strength in terms of 0.01 inch crack D-load.

Determination of Earth Load (W_E)
 Note: The Standard Installations were initially developed for circular

pipe, and their benefit has not yet been established for elliptical and arch pipe. Therefore, the traditional Marston/Spangler design method using B and C beddings is still conservatively applied for these shapes.

A settlement ratio must first be assumed. In Table 40, values of settlement ratio from +0.5 to +0.8 are given for positive projecting installations on a foundation of ordinary soil. A value of 0.7 will be used. The product of the settlement ratio and the projection ratio will be 0.49 (r_{sd} p approximately 0.5).

Enter Figure 187 on the horizontal scale at H = 3 ft. Proceed vertically until the line representing R x S = 68" x 106" is intersected. At this point the vertical scale shows the fill load to be 3,400 pounds per linear foot for 100 pounds per cubic foot fill material. Increase the load 20 percent for 120 pound material.

 $W_d = 3,400 \times 1.2$

 $W_d = 4,080$ pounds per linear foot

outside span of pipe is:

$$B_c = \frac{106 + 2 (8.5)}{12}$$
 Note: The wall thickness for a 68"x106" ellipitical pipe is 8.5-inches per ASTM C76.

 $B_c = 10.25$ feet

Assuming 150 pounds per cubic foot concrete, the weight of the pavement is:

 $W_p = 150 \times 7/12 \times 10.25$

 $W_p = 897$ pounds per linear foot

 $\dot{W_E} = W_d + W_p$

 $W_E = 4,977$ pounds per linear foot

Weight of Fluid, W_F , for a 68" x 106" pipe $W_F = \gamma x A$

$$W_F = 62.4 \times \frac{\pi (5.67 \times 8.83)}{4}$$

W_F = 2454 pounds per linear foot

2. Determination of Live Load (W_L)

Assuming a modulus of subgrade reaction of k = 300 pounds per cubic inch and a pavement thickness of h = 7 inches, a radius of stiffness of 24.99 inches (2.08 feet) is obtained from Table 52. The wheel spacing in terms of the radius of stiffness is $20/2.08 = 9.6 \, R_s$, therefore the maximum live load on the pipe will occur when one wheel is directly over the centerline of the pipe and the second wheel disregarded. The pressure intensity on the pipe is given by Equation 4.15:

$$P_{(X,H)} = \frac{C \times P}{R_s^2}$$

The pressure coefficient (C) is obtained from Table 46 at x = 0 and H = 3feet.

For $x/R_s = 0$ and $H/R_s = 3/2.08 = 1.44$, C = 0.068 by interpolation between $H/R_s = 1.2$ and $H/R_s = 1.6$ in Table 46.

$$p_1 = \ \frac{(0.068)(60,000)}{(2.08)^2}$$

Equation 4.15

p₁ = 943 pounds per square foot

In a similar manner pressure intensities are calculated at convenient increments across the width of the pipe. The pressure coefficients and corresponding pressures in pounds per square foot are listed in the accompanying table.

			x/R_s					
Point	0.0	0.4	0.8	1.2	1.6	2.0	2.4	2.8
Pressure								
Coefficient C	0.068	0.064	0.058	0.050	0.041	0.031	0.022	0.015
Pressure psf	943	887	804	693	568	430	305	208

For convenience of computing the load in pounds per linear foot, the pressure distribution can be broken down into two components; a uniform load and a parabolic load.

The uniform load occurs where the minimum load is applied to the pipe

$$\frac{x}{R_s} = \frac{\frac{1}{2} B_c}{R_s} = \frac{5.13}{2.08}$$

$$\frac{X}{R_s} = 2.5$$

The pressure, p₂, is then interpolated between the points 2.4 and 2.8 from the chart $x\bar{R}_s$ above, and equal to 290 pounds per square foot.

The parabolic load (area of a parabola = 2/3ab, or in this case 2/3 (p,p₂)B₂ has a maximum pressure of 653 pounds per foot.

Therefore the total live load, (W_i) is equal to:

$$W_L = p_2 \times B_c + 2/3 (p_1 - p_2)B_c$$

 $\begin{array}{l} W_{L} = p_{2} \ x \ B_{c} + 2/3 \ (p_{1} - p_{2}) B_{c} \\ W_{L} = 290 \ x \ 10.25 + 2/3 (943 - 290) 10.25 \\ W_{L} = 7{,}435 \ pounds \ per \ linear \ foot \end{array}$

3. Selection of Bedding

A Class B bedding will be assumed for this example.

- 4. Determination of Bedding Factor, (B_{fa})
 - a.) Determination of Embankment Bedding Factor

From Table 60, a Class B bedding with p = 0.7, $H/B_c = 3$ ft/10.25 ft. = 0.3, and $r_{sd}p = 0.5$, an embankment bedding factor of 2.42 is obtained.

$$B_{fe} = 2.42$$

b.) Determination of Live Load Bedding Factor Live Load Bedding Factors are given in Illustration 4.24 for circular pipe. These factors can be applied to elliptical pipe by using the span of the pipe in place of diameter. The 106" span for the elliptical pipe in this example is very close to the 108" pipe diameter value in the table. Therefore, from Illustration 4.24, the live load bedding factor for a pipe with a span of 108 inches, buried under 3.5 feet of fill (3 feet of cover plus 7 inches of pavement is approx. 3.5 feet) is 1.7.

$$B_{fl} = 1.7$$

- 5. Application of Factor of Safety (F.S.)
 A factor of safety of 1.0 based on the 0.01 inch crack will be applied.
- 6. Selection of pipe strength

The D-load given is given by Equation 4.27

 $W_E = 49,277$ earth load in pounds per linear foot

 $W_F = 2,453$ fluid load in pounds per linear foot

 $W_L = 7,435$ live load in pounds per linear foot

 $B_f = B_{fe}$ $B_f = 2.42$ earth load bedding factor

 B_{fLL} = 1.7 live load bedding factor

S = 106/12

S = 8.83 inside span of pipe in feet

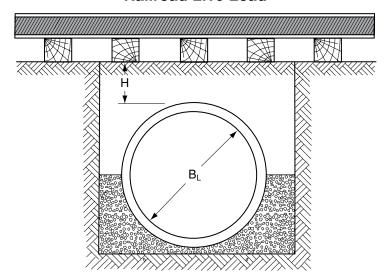
$$D_{0.01} = \left[\frac{4,977 + 2,454}{2.42} + \frac{7,435}{1.7} \right] \left(\frac{1.0}{8.83} \right)$$

Equation 4.27

 $D_{0.01}$ = 843 pounds per linear foot per foot of diameter

Answer: A pipe which would withstand a minimum three-edge bearing test load for the 0.01 inch crack of 843 pounds per linear foot per foot of inside horizontal span would be required.

EXAMPLE 4-11Railroad Live Load



Given: A 48 inch circular pipe is to be installed under a railroad in a 9 foot wide trench. The pipe will be covered with 1.0 foot of 120 pounds per cubic foot overfill (measured from top of pipe to bottom of ties).

Find: The required pipe strength in terms of 0.01 inch crack D-load.

1. Determination of Earth Load (W_F)

The transition width tables do not have fill heights less than 5 ft. With only one foot of cover, assume an embankment condition. An installation directly below the tracks such as this would probably require good granular soil well compacted around it to avoid settlement of the tracks. Therefore assume a Type 1 Installation and multiply the soil prism load by a vertical arching factor of 1.35.

$$D_o = \frac{48 + 2 (5)}{12}$$
 Note: The wall thickness for a 48-inch pipe with a B wall is 5-inches per ASTM C76.

 $D_o = 4.83$ outside diameter of pipe in feet

w = 120 unit weight of soil in pounds per cubic foot

H = 1 height of cover in feet

$$PL = 120 \left[1 + \frac{4.83 (4 - \pi)}{8} \right] 4.83$$
 Equation 4.2

PL = 880 pounds per linear foot

PL = 880 pounds per linear foot

Immediately listed below Equation 4.2 are the vertical arching factors (VAFs) for the four types of Standard Installations. Using a VAF of 1.35 for a Type 1 Installation, the earth load is:

 $W_F = 1.35 \times 880$

W_E = 1,188 pounds per linear foot

Equation 4.1

Weight of Fluid, W_F, for a 48" pipe

$$W_F = \gamma_w \times A$$

$$W_F = 62.4 \times \frac{\pi (4)^2}{4}$$

W_F = 784.1 pounds per linear foot

2. Determination of Live Load (W,)

From Table 56, for a 48 inch diameter concrete pipe, H = 1.0 foot, and a Cooper E80 design load, a live load of 13,200 pounds per linear foot is obtained. This live load value includes impact.

 $W_1 = 13,200$ pounds per linear foot

3. Selection of Bedding

Since the pipe is in shallow cover directly under the tracks, a Type 1 Installation will be used.

- 4. Determination of Bedding Factor, (B_{fe})
 - a.) Determination of Embankment Bedding Factor

The embankment bedding factor for 48 inch diameter pipe in a Type 1 Installation may be interpolated from Illustration 4.21.

$$\begin{split} B_{fe36} &= 4.0 \\ B_{fe72} &= 3.8 \\ B_{fe} &= \frac{72 - 48 (4.0 - 3.8)}{72 - 36} + 3.8 \\ B_{fe} &= 3.93 \end{split}$$

b.) Determination of Live Load Bedding Factor

From Illustration 4.24, the live load bedding factor for a 48 inch pipe installed under 1 foot of cover is:

$$B_{fll} = 1.5$$

5. Application of Factor of Safety (F.S.)

A factor of safety of 1.0 based on the 0.01 inch crack will be applied.

6. Selection of Pipe Strength

The D-load is given by Equation 4.26

W_E = 1,188 earth load in pounds per linear foot

W_F = 784 fluid load in pounds per linear foot

 W_L = 13,200 live load in pounds per linear foot

 $B_f = B_{fe}$ $B_f = 3.93$ earth load bedding factor

 B_{fLL} = 1.5 live load bedding factor is applicable

D = 4

$$D_{0.01} = \left[\frac{1,188 + 784.1}{3.93} + \frac{13,200}{1.5} \right] \left(\frac{1.0}{4} \right)$$

Equation 4.26

 $D_{0.01} = 2,325$ pounds per linear foot per foot of diameter

Answer: A pipe which would withstand a minimum three-edge bearing test for the 0.01 inch crack of 2,326 pounds per linear foot per foot of inside diameter would be required.

CHAPTER 5SUPPLEMENTAL DATA

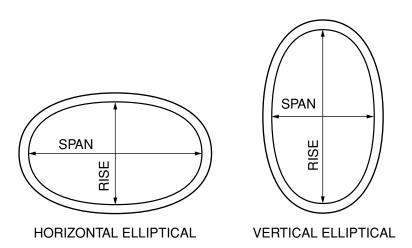
CIRCULAR CONCRETE PIPE

Illustration 5.2 includes tables of dimensions and approximate weights of most frequently used types of circular concrete pipe. Weights are based on concrete weighing 150 pounds per cubic foot. Concrete pipe may be produced which conforms to the requirements of the respective specifications but with increased wall thickness and different concrete density.

ELLIPTICAL CONCRETE PIPE

Elliptical pipe, shown in Illustration 5.1, installed with the major axis horizontal or vertical, represents two different products from the stand-point of structural strength, hydraulic characteristics and type of application. Illustration 5.3 includes the dimensions and approximate weights of elliptical concrete pipe.

Illustration 5.1 Typical Cross Sections of Horizontal Elliptical and Vertical Elliptical Pipe



Horizontal Elliptical (HE) Pipe. Horizontal elliptical concrete pipe is installed with the major axis horizontal and is extensively used for minimum cover conditions or where vertical clearance is limited by existing structures. It offers the hydraulic advantage of greater capacity for the same depth of flow than most other structures of equivalent water-way area. Under most embankment conditions, its wide span results in greater earth loadings for the same height of cover than for the equivalent size circular pipe and, at the same time, there is a reduction in effective lateral support due to the smaller vertical dimension of the section. Earth loadings are normally greater than for the equivalent circular pipe in

Illustration 5.2 Dimensions and Approximate Weights of Concrete Pipe

ASTM C 14 - Nonreinforced Sewer and Culvert Pipe, Bell and Spigot Joint.							
CLASS 1			CLA	SS 2	CLASS 3		
Internal Diameter, inches	Minimum Wall Thickness, inches	Approx. Weight, pounds per foot	Minimum Wall Thickness, inches	Approx. Weight, pounds per foot	Minimum Wall Thickness, inches	Approx. Weight, pounds per foot	
4	5/8	9.5	3/4	13	7/8	15	
6	5/8	17	3/4	20	1	24	
8	3/4	27	7/8	31	1 1/8	36	
10	7/8	37	1	42	1 1/4	50	
12	1	50	1 3/8	68	1 3/4	90	
15	1 1/4	80	1 5/8	100	1 7/8	120	
18	1 1/2	110	2	160	2 1/4	170	
21	1 3/4	160	2 1/4	210	2 3/4	260	
24	2 1/8	200	3	320	3 3/8	350	
27	3 1/4	390	3 3/4	450	3 3/4	450	
30	3 1/2	450	4 1/4	540	4 1/4	540	
33	3 3/4	520	4 1/2	620	4 1/2	620	
36	4	580	4 3/4	700	4 3/4	700	

ASTM C 76 - Reinforced Concrete Culvert, Storm Drain and Sewer Pipe, Bell and Spigot Joint.

	1 0							
	WALL A	WALL B						
Internal Diameter, inches	Minimum Wall Thickness inches	Approximate Weight, pounds per foot	Minimum Wall Thickness, inches	Approximate Weight,pounds per foot				
12	1 3/4	90	2	110				
15	1 7/8	120	2 1/4	150				
18	2	160	2 1/2	200				
21	2 1/4	210	2 3/4	260				
24	2 1/2	270	3	330				
27	2 5/8	310	3 1/4	390				
30	2 3/4	360	3 1/2	450				

These tables are based on concrete weighing 150 pounds per cubic foot and will vary with heavier or lighter weight concrete.

Illustration 5.2 (Continued) Dimensions and Approximate Weights of Concrete Pipe

ASTM C 76 - Reinforced Concrete Culvert, Storm Drain and Sewer Pipe, Tongue and Groove Joints

	WALL A	- 9	WA	LL B	WALL C		
Internal Diameter inches	Minimum Wall Thickness, inches	Approximate Weight, pounds per foot	Minimum Wall Thickness, inches	Approximate Weight, pounds per foot	Minimum Wall Thickness, inches	Approximate Weight, pounds per foot	
12	1 3/4	79	2	93		_	
15	1 7/8	103	2 1/4	127		_	
18	2	131	2 1/2	168		_	
21	2 1/4	171	2 3/4	214		_	
24	2 1/2	217	3	264	3 3/4	366	
27	2 5/8	255	3 1/4	322	4	420	
30	2 3/4	295	3 1/2	384	4 1/4	476	
33	2 7/8	336	3 3/4	451	4 1/2	552	
36	3	383	4	524	4 3/4	654	
42	3 1/2	520	4 1/2	686	5 1/4	811	
48	4	683	5	867	5 3/4	1011	
54	4 1/2	864	5 1/2	1068	6 1/4	1208	
60	5	1064	6	1295	6 3/4	1473	
66	5 1/2	1287	6 1/2	1542	7 1/4	1735	
72	6	1532	7	1811	7 3/4	2015	
78	6 1/2	1797	7 1/2	2100	8 1/4	2410	
84	7	2085	8	2409	8 3/4	2660	
90	7 1/2	2395	8 1/2	2740	9 1/4	3020	
96	8	2710	9	3090	9 3/4	3355	
102	8 1/2	3078	9 1/2	3480	10 1/4	3760	
108	9	3446	10	3865	10 3/4	4160	

Illustration 5.2 (Continued) Dimensions and Approximate Weights of Concrete Pipe

Large Sizes of Pipe Tongue and Groove Joint						
Internal Diameter Inches	Internal Diameter Feet	Wall Thickness Inches	Approximate Weight, pounds per foot			
114	9 1/2	9 1/2	3840			
120	10	10	4263			
126	10 1/2	10 1/2	4690			
132	11	11	5148			
138	11 1/2	11 1/2	5627			
144	12	12	6126			
150	12 1/2	12 ¹ /2	6647			
156	13	13	7190			
162	13 1/2	13 1/2	7754			
168	14	14	8339			
174	14 1/2	14 1/2	8945			
180	15	15	9572			

These tables are based on concrete weighing 150 pounds per cubic foot and will vary with heavier or lighter weight concrete.

the trench condition, since a greater trench width is usually required for HE pipe. For shallow cover, where live load requirements control the design, loading is almost identical to that for an equivalent size circular pipe with the same invert elevation.

Vertical Elliptical (VE) Pipe. Vertical elliptical concrete pipe is installed with the major axis vertical and is useful where minimum horizontal clearances are encountered or where unusual strength characteristics are desired. Hydraulically, it provides higher flushing velocities under minimum flow conditions and carries equal flow at a greater depth than equivalent HE or circular pipe. For trench conditions the smaller span requires less excavation than an equivalent size circular pipe and the pipe is subjected to less vertical earth load due to the narrower trench. The structural advantages of VE pipe are particularly applicable in the embankment condition where the greater height of the section increases the effective lateral support while the vertical load is reduced due to the smaller span.

CONCRETE ARCH PIPE

Arch pipe, as shown in Illustration 5.4, is useful in minimum cover situations or other conditions where vertical clearance problems are encountered. It offers the hydraulic advantage of greater capacity for the same depth of flow than most other structures of equivalent water-way area. Structural characteristics are

Illustration 5.3 Dimensions and Approximate Weights of Elliptical Concrete Pipe

ASTM C 507-Reinforced Concrete Elliptical Culvert,							
Storm Drain and Sewer Pipe							
Equivalent Round Size, inches	Minor Axis, inches	Major Axis, inches	Minimum Wall Thickness, inches	Water-Way Area, square feet	Approximate Weight, pounds per foot		
18	14	23	2 3/4	1.8	195		
24	19	30	3 1/4	3.3	300		
27	22	34	3 1/2	4.1	365		
30	24	38	3 3/4	5.1	430		
33	27	42	3 3/4	6.3	475		
36	29	45	4 1/2	7.4	625		
39	32	49	4 3/4	8.8	720		
42	34	53	5	10.2	815		
48	38	60	5 1/2	12.9	1000		
54	43	68	6	16.6	1235		
60	48	76	6 1/2	20.5	1475		
66	53	83	7	24.8	1745		
72	58	91	7 1/2	29.5	2040		
78	63	98	8	34.6	2350		
84	68	106	8 1/2	40.1	2680		
90	72	113	9	46.1	3050		
96	77	121	9 1/2	52.4	3420		
102	82	128	9 3/4	59.2	3725		
108	87	136	10	66.4	4050		
114	92	143	10 1/2	74.0	4470		
120	97	151	11	82.0	4930		
132	106	166	12	99.2	5900		
144	116	180	13	118.6	7000		

similar to those of horizontal elliptical pipe in that under similar cover conditions it is subject to the same field load as a round pipe with the same span. For minimum cover conditions where live load requirements control the design, the loading to which arch pipe is subjected is almost identical to that for an equivalent size circular pipe with the same invert elevation. Illustration 5.5 includes the dimensions and approximate weights of concrete arch pipe.

Illustration 5.4 Typical Cross Section of Arch Pipe

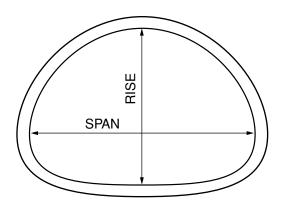
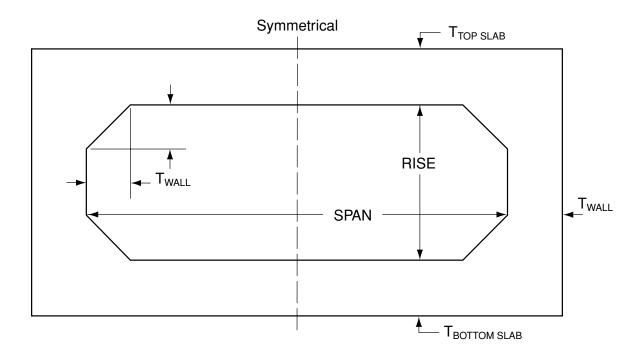


Illustration 5.5 Dimensions and Approximate Weights of Concrete Arch Pipe

ASTM C 506 - Reinforced Concrete Arch Culvert, Storm Drain and Sewer Pipe							
Equivalent Round Size, inches	Minimum Rise, inches	Minimum Span, inches	Minimum Wall Thickness, inches	Water-Way Area, square feet	Approximate Weight, pounds per foot		
15	11	18	2 1/4	1.1	_		
18	13 1/2	22	2 1/2	1.65	170		
21	15 1/2	26	2 3/4	2.2	225		
24	18	28 1/2	3	2.8	320		
30	22 1/2	36 1/4	3 1/2	4.4	450		
36	26 5/8	43 3/4	4	6.4	595		
42	31 ⁵ /16	51 ¹ /8	4 1/2	8.8	740		
48	36	58 1/2	5	11.4	880		
54	40	65	5 1/2	14.3	1090		
60	45	73	6	17.7	1320		
72	54	88	7	25.6	1840		
84	62	102	8	34.6	2520		
90	72	115	8 1/2	44.5	2750		
96	77 1/4	122	9	51.7	3110		
108	87 1/8	138	10	66.0	3850		
120	96 7/8	154	11	81.8	5040		
132	106 1/2	168 3/4	10	99.1	5220		

Illustration 5.6 Typical Cross Section of Precast Concrete Box Sections



CONCRETE BOX SECTIONS

Precast concrete box sections, as shown in Illustration 5.6, are useful in minimum cover and width situations or other conditions where clearance problems are encountered, for special waterway requirements, or designer preference. Illustration 5.7 includes the dimensions and approximate weights of standard precast concrete box sections. Special design precast concrete box sections may be produced which conform to the requirements of the respective specifications but in different size and cover conditions.

Illustration 5.7 Dimensions and Approximate Weights of Concrete Box Sections

ASTM C1433 - PRECAST REINFORCED CONCRETE BOX SECTIONS						
Span (Ft.)	Rise (Ft.)	Top Slab	Γhickness (in. Bot. Slab) Wall	Waterway Area (Sq. Feet)	Approx. Weigh† (lbs/ft)
3	2	7	6	4	5.8	830
3	3	7	6	4	8.8	930
4	2	7 1/2	6	5	7.7	1120
4	3	7 1/2	6	5	11.7	1240
4	4	7 1/2	6	5	15.7	1370
5	3	8	7	6	14.5	1650
5	4	8	7	6	19.5	1800
5	5	8	7	6	24.5	1950
6	3	8	7	7	17.3	1970
6	4	8	7	7	23.3	2150
6	5	8	7	7	29.3	2320
6	6	8	7	7	35.3	2500
7	4	8	8	8	27.1	2600
7	5	8	8	8	34.1	2800
7	6	8	8	8	41.1	3000
7	7	8	8	8	48.1	3200
8	4	8	8	8	31.1	2800
8	5	8	8	8	39.1	3000
8	6	8	8	8	47.1	3200
8	7	8	8	8	55.1	3400
8	8	8	8	8	63.1	3600
9	5	9	9	9	43.9	3660
9	6	9	9	9	52.9	3880
9	7	9	9	9	61.9	4110
9	8	9	9	9	70.9	4330
9	9	9	9	9	79.9	4560
10	5	10	10	10	48.6	4380
10	6	10	10	10	58.6	4630
10	7	10	10	10	68.6	4880
10	8	10	10	10	78.6	5130
10	9	10	10	10	88.6	5380
10	10	10	10	10	98.6	5630
11	4	11	11	11	42.3	4880
11	6	11	11	11	64.3	5430
11	8	11	11	11	86.3	5980
11	10	11	11	11	108.3	6530
11	11	11	11	11	119.3	6810
12	4	12	12	12	46.0	5700
12	6	12	12	12	70.0	6300
12	8	12	12	12	94.5	6900
12	10	12	12	12	118.0	7500
12	12	12	12	12	142.0	8100

SPECIAL SECTIONS

Precast Concrete Manhole Sections. Precast manholes offer significant savings in installed cost over cast-in-place concrete, masonry or brick manholes and are universally accepted for use in sanitary or storm sewers. Precast, reinforced concrete manhole sections are available throughout the United States and Canada, and are generally manufactured in accordance with the provisions of American Society for Testing and Materials Standard C 478.

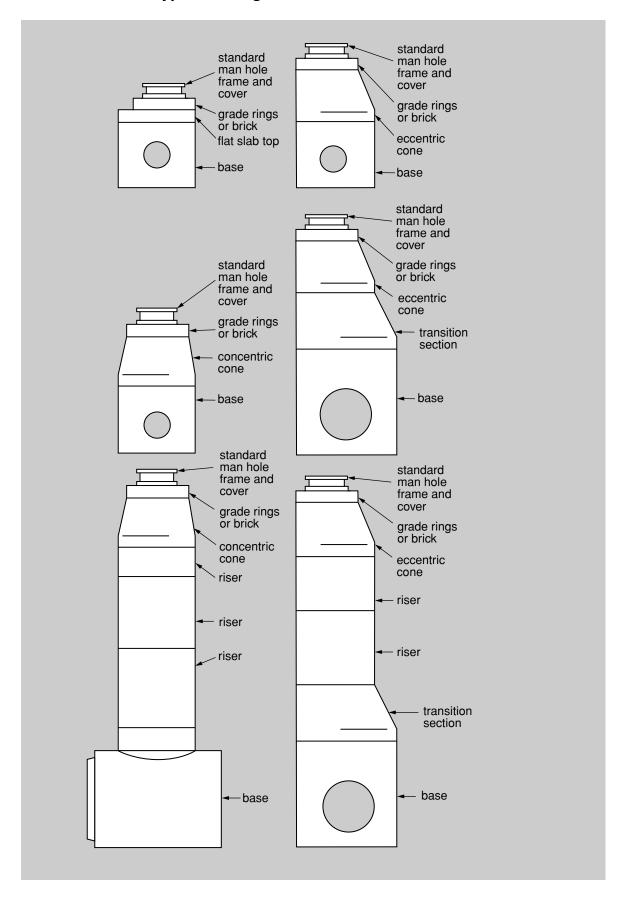
The typical precast concrete manhole as shown in Illustration 5.8 consists of riser sections, a top section and grade rings and, in many cases, precast base sections or tee sections. The riser sections are usually 48 inches in diameter, but are available from 36 inches up to 72 inches and larger. They are of circular cross section, and a number of sections may be joined vertically on top of the base or junction chamber. Most precast manholes employ an eccentric or a concentric cone section instead of a slab top. These reinforced cone sections affect the transition from the inside diameter of the riser sections to the specified size of the top opening. Flat slab tops are normally used for very shallow manholes and consist of a reinforced circular slab at least 6-inches thick for risers up to 48 inches in diameter and 8-inches thick for larger riser sizes. The slab which rests on top of the riser sections is cast with an access opening.

Precast grade rings, which are placed on top of either the cone or flat slab top section, are used for close adjustment of top elevation. Cast iron manhole cover assemblies are normally placed on top of the grade rings.

The manhole assembly may be furnished with or without steps inserted into the walls of the sections. Reinforcement required by ASTM Standard C 478 is primarily designed to resist handling stresses incurred before and during installation, and is more than adequate for that purpose. Such stresses are more severe than those encountered in the vertically installed manhole. In normal installations, the intensity of the earth loads transmitted to the manhole risers is only a fraction of the intensity of the vertical pressure.

The maximum allowable depth of a typical precast concrete manhole with regard to lateral earth pressures is in excess of 300 feet or, for all practical purposes, unlimited, Because of this, the critical or limiting factor for manhole depth is the supporting strength of the base structure or the resistance to crushing of the ends of the riser section. This phenomena, being largely dependent on the relative settlement of the adjacent soil mass, does not lend itself to precise analysis. Even with extremely conservative values for soil weights, lateral pressure and friction coefficients, it may be concluded several hundred feet can be safely supported by the riser sections without end crushing, based on the assumption that provision is made for uniform bearing at the ends of the riser sections and the elimination of localized stress concentrations.

Illustration 5.8 Typical Configuration of Precast Manhole Sections



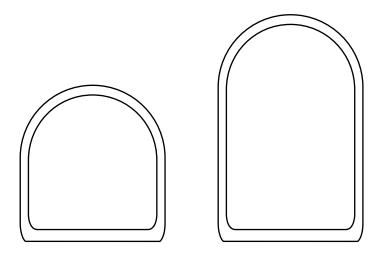
When confronted with manhole depths greater than those commonly encountered, there may be a tendency to specify additional circumferential reinforcement in the manhole riser sections. Such requirements are completely unnecessary and only result in increasing the cost of the manhole structure.

A number of joint types may be used for manhole risers and tops, including mortar, mastic, rubber gaskets or combinations of these three basic types for sealing purposes. Consideration should be given to manhole depth, the presence of groundwater and the minimum allowable leakage rates in the selection of specific joint requirements.

Flat Base Pipe. Flat base pipe as shown in Illustration 5.9 has been used as cattle passes, pedestrian underpasses and utility tunnels. It is normally furnished with joints designed for use with mortar or mastic fillers and may be installed by the conventional open trenching method or by jacking.

Although not covered by any existing national specification, standard designs have been developed by various manufacturers which are appropriate for a wide range of loading conditions.

Illustration 5.9 Typical Cross Sections of Flat Base Pipe



STANDARD SPECIFICATIONS FOR CONCRETE PIPE

Nationally accepted specifications covering concrete pipe along with the applicable size ranges and scopes of the individual specifications are included in the following list.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 14 Concrete Sewer, Storm Drain and Culvert Pipe: Covers nonreinforced concrete pipe intended to be used for the conveyance of sewage, industrial wastes, storm water, and for the construction of culverts in sizes from 4 inches through 36 inches in diameter.

- ASTM C 76 Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe: Covers reinforced concrete pipe intended to be used for the conveyance of sewage, industrial wastes, and storm waters, and for the construction of culverts. Class I 60 inches through 144 inches in diameter; Class II, III, IV and V 12 inches through 144 inches in diameter. Larger sizes and higher classes are available as special designs.
- ASTM C 118 Concrete Pipe for Irrigation or Drainage: Covers concrete pipe intended to be used for the conveyance of irrigation water under low hydrostatic heads, generally not exceeding 25 feet, and for use in drainage in sizes from 4 inches through 24 inches in diameter.
- ASTM C 361 Reinforced Concrete Low-Head Pressure Pipe: Covers reinforced concrete pipe intended to be used for the construction of pressure conduits with low internal hydrostatic heads generally not exceeding 125 feet in sizes from 12 inches through 108 inches in diameter.
- ASTM C 412 Concrete Drain Tile: Covers nonreinforced concrete drain tile with internal diameters from 4 inches to 24 inches for Standard Quality, and 4 inches to 36 inches for Extra-Quality, Heavy-Duty Extra-Quality and Special Quality Concrete Drain Tile.
- ASTM C 443 Joints for Circular Concrete Sewer and Culvert Pipe, with Rubber Gaskets: Covers joints where infiltration or exfiltration is a factor in the design, including the design of joints and the requirements for rubber gaskets to be used therewith for pipe conforming in all other respects to ASTM C 14 or ASTM C 76.
- ASTM C 444 Perforated Concrete Pipe: Covers perforated concrete pipe intended to be used for underdrainage in sizes 4 inches and larger.
- ASTM C 478 Precast Reinforced Concrete Manhole Sections: Covers precast reinforced concrete manhole risers, grade rings and tops to be used to construct manholes for storm and sanitary sewers.
- ASTM C 497 Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile: Covers procedures for testing concrete pipe and tile.
- ASTM C 505 Nonreinforced Concrete Irrigation Pipe With Rubber Gasket Joints: Covers pipe to be used for the conveyance of irrigation water with working pressures, including hydraulic transients, of up to 30 feet of head. Higher pressures may be used up to a maximum of 50 feet for 6 inch through 12 inch diameters, and 40 feet for 15 inch through 18 inch diameters by increasing the strength of the pipe.

- ASTM C 506 Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe: Covers pipe to be used for the conveyance of sewage, industrial waste, and storm water and for the construction of culverts in sizes from 15 inch through 132 inch equivalent circular diameter. Larger sizes are available as special designs.
- ASTM C 507 Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe: Covers reinforced elliptically shaped concrete pipe to be used for the conveyance of sewage, industrial waste and storm water, and for the construction of culverts. Five standard classes of horizontal elliptical, 18 inches through 144 inches in equivalent circular diameter and five standard classes of vertical elliptical, 36 inches through 144 inches in equivalent circular diameter are included. Larger sizes are available as special designs.
- ASTM C 655 Reinforced Concrete D-load Culvert, Storm Drain and Sewer Pipe: Covers acceptance of pipe design and production pipe based upon the D-load concept and statistical sampling techniques for concrete pipe to be used for the conveyance of sewage, industrial waste and storm water and construction of culverts.
- ASTM C 822 Standard Definitions and Terms Relating to Concrete Pipe and Related Products: Covers words and terms used in concrete pipe standards.
- ASTM C 877 External Sealing Bands for NonCircular Concrete Sewer, Storm Drain and Culvert Pipe: Covers external sealing bands to be used for noncircular pipe conforming to ASTM C 506, C 507, C 789 and C 850.
- ASTM C 923 Resilient Connectors Between Reinforced Concrete Manhole Structures and Pipes: Covers the minimum performance and material requirements for resilient connections between pipe and reinforced concrete manholes conforming to ASTM C 478.
- ASTM C 924 Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method: Covers procedures for testing concrete pipe sewer lines when using the low-pressure air test method to demonstrate the integrity of the installed material and construction procedures.
- ASTM C 969 Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines: Covers procedures for testing installed precast concrete pipe sewer lines using either water infiltration or exfiltration acceptance limits to demonstrate the integrity of the installed materials and construction procedure.

- ASTM C 985 Nonreinforced Concrete Specified Strength Culvert, Storm Drain, and Sewer Pipe: Covers nonreinforced concrete pipe designed for specified strengths and intended to be used for the conveyance of sewage, industrial wastes, storm water, and for the construction of culverts.
- ASTM C 990 Joints for Concrete Pipe, Manholes, and Precast Box Sections
 Using Preformed Flexible Sealants: Covers joints for precast
 concrete pipe, box, and other sections using preformed flexible
 joint sealants for use in storm sewers and culverts which are not
 intended to operate under internal pressure, or are not subject to
 infiltration or exfiltration limits.
- ASTM C 1103 Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines: Covers procedures for testing the joints of installed precast concrete pipe sewer lines, when using either air or water under low pressure to demonstrate the integrity of the joint and construction procedure.
- ASTM C 1131 Least Cost (Life Cycle) Analysis of Concrete Culvert, Storm Sewer, and Sanitary Sewer Systems: Covers procedures for least cost (life cycle) analysis (LCA) of materials, systems, or structures proposed for use in the construction of concrete culvert, storm sewer and sanitary sewer systems.
- ASTM C 1214 Test Method for Concrete Pipe Sewerlines by Negative Air Pressure (Vacuum) Test Method: Covers procedures for testing concrete pipe sewerlines, when using the negative air pressure (vacuum) test method to demonstrate the integrity of the installed material and the construction procedures.
- ASTM C 1244 Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test: Covers procedures for testing precast concrete manhole sections when using the vacuum test method to demonstrate the integrity of the installed materials and the construction procedures.
- ASTM C 1417 Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design: Covers the manufacture and acceptance of precast concrete pipe designed to conform to the owner's design requirements and to ASCE 15-93 (Direct Design Standard) or an equivalent design specification.
- ASTM C 1433 Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers: Covers single-cell precast reinforced concrete box sections intended to be used for the construction of culverts

for the conveyance of storm water and industrial wastes and sewage.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 86	Concrete Sewer, Storm Drain, and Culvert Pipe: Similar to ASTM C 14.
AASHTO M 170	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe: Similar to ASTM C 76.
AASHTO M 175	Perforated Concrete Pipe: Similar to ASTM C 444.
AASHTO M 178	Concrete Drain Tile: Similar to ASTM C 412.
AASHTO M 198	Joints for Circular Concrete Sewer and Culvert Pipe, Using Flexible Watertight Gaskets: Similar to ASTM C 990.
AASHTO M 199	Precast Reinforced Concrete Manhole Sections: Similar to ASTM C 478.
AASHTO M 206	Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe: Similar to ASTM C 506.
AASHTO M 207	Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe: Similar to ASTM C 507.
AASHTO M 242	Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe: Similar to ASTM C 655.
AASHTO M 259	Precast Reinforced Concrete Box Sections for Culverts, Storm Drains and Sewers: Similar to ASTM C 789.
AASHTO M 262	Concrete Pipe and Related Products: Similar to ASTM C 882.
AASHTO M 273	Precast Reinforced Box Section for Culverts, Storm Drains, and Sewers with less than 2 feet of Cover Subject to Highway Loadings: Similar to ASTM C 850.
AASHTO T 280	Methods of Testing Concrete Pipe, Sections, or Tile: Similar to ASTM C 497.
AASHTO M 315	Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets: Similar to ASTM C 443.

PIPE JOINTS

Pipe joints perform a variety of functions depending upon the type of pipe and its application. To select a proper joint, determine which of the following characteristics are pertinent and what degree of performance is acceptable.

Joints are designed to provide:

- 1. Resistance to infiltration of ground water and/or backfill material.
- 2. Resistance to exfiltration of sewage or storm water.
- 3. Control of leakage from internal or external heads.
- 4. Flexibility to accommodate lateral deflection or longitudinal movement without creating leakage problems.
- 5. Resistance to shear stresses between adjacent pipe sections without creating leakage problems.
- 6. Hydraulic continuity and a smooth flow line.
- 7. Controlled infiltration of ground water for subsurface drainage.
- 8. Ease of installation.

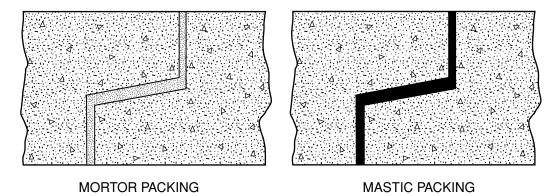
The actual field performance of any pipe joint depends primarily upon the inherent performance characteristics of the joint itself, the severity of the conditions of service, and the care with which it is installed.

Since economy is important, it is usually necessary to compare the installed cost of several types of joints against pumping and treatment costs resulting from increased or decreased amounts of infiltration.

The concrete pipe industry utilizes a number of different joints, listed below, to satisfy a broad range of performance requirements. These joints vary in cost, as well as in inherent performance characteristics. The field performance of all is dependent upon proper installation procedures.

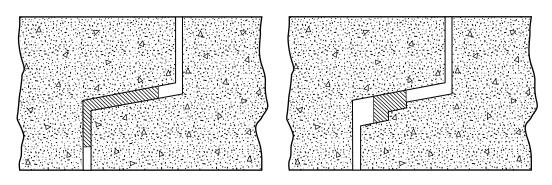
· Concrete surfaces, either bell and spigot or tongue and groove, with some packing such as cement mortar, a preformed mastic compound, or a trowel applied mastic compound, as shown in Illustration 5.10. These joints have no inherent watertightness but depend exclusively upon the workmanship of the contractor. Field poured concrete diapers or collars are sometimes used with these joints to improve performance. Joints employing mortar joint fillers are rigid, and any deflection or movement after installation will cause cracks permitting leakage. If properly applied, mastic joint fillers provide a degree of flexibility without impairing watertightness. These joints are not generally recommended for any internal or external head conditions if leakage is an important consideration. Another jointing system used with this type joint is the external sealing band type rubber gasket conforming to ASTM C 877. Generally limited to straight wall and modified tongue and groove configurations, this jointing system has given good results in resisting external heads of the magnitude normally encountered in sewer construction.

Illustration 5.10 Typical Cross Sections of Joints With Mortar or Mastic Packing



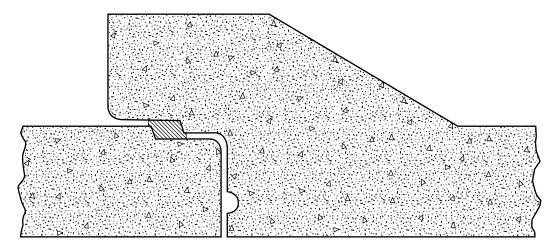
Concrete surfaces, with or without shoulders on the tongue or the groove, with a compression type rubber gasket as shown in Illustration 5.11.
 Although there is wide variation in joint dimensions and gasket cross section for this type joint, most are manufactured in conformity with ASTM C 443. This type joint is primarily intended for use with pipe manufactured to meet the requirements of ASTM C 14 or ASTM C 76 and may be used with either bell and spigot or tongue and groove pipe.

Illustration 5.11 Typical Cross Sections of Basic Compression Type Rubber Gasket Joints



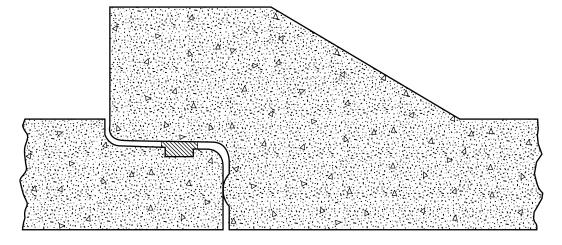
Concrete surfaces with opposing shoulders on both the bell and spigot for use with an 0-ring, or circular cross section, rubber gasket as shown in Illustration 5.12. Basically designed for low pressure capability, these joints are frequently used for irrigation lines, waterlines, sewer force mains, and gravity or low head sewer lines where infiltration or exfiltration is a factor in the design. Meeting all of the requirements of ASTM C 443, these type joints are also employed with pipe meeting the requirements of ASTM C 361. They provide good inherent watertightness in both the straight and deflected positions, which can be demonstrated by plant tests.

Illustration 5.12 Typical Cross Sections of Opposing Shoulder Type Joint With 0-ring Gasket



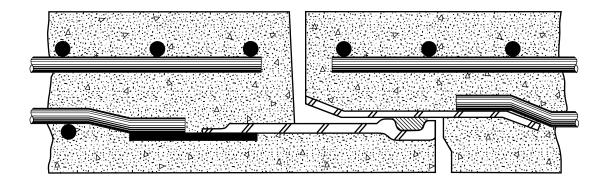
 Concrete surfaces with a groove on the spigot for an 0-ring rubber gasket, as shown in Illustration 5.13. Also referred to as a confined 0-ring type joint, these are designed for low pressure capabilities and are used for irrigation lines, water lines, sewer force mains, and sewers where infiltration or exfiltration is a factor in the design. This type joint, which provides excellent inherent watertightness in both the straight and deflected positions, may be employed to meet the joint requirements of ASTM C 443 and ASTM C 361.

Illustration 5.13 Typical Cross Section of Spigot Groove Type Joint With 0-ring Gasket



 Steel bell and spigot rings with a groove on the spigot for an 0-ring rubber gasket, as shown in Illustration 5.14. Basically a high pressure joint designed for use in water transmission and distribution lines, these are also used for irrigation lines, sewer force mains, and sewers where infiltration or exfiltration is a factor in the design. This type of joint will meet the joint requirements of ASTM C 443 and ASTM C 361. Combining great shear strength and excellent inherent watertightness and flexibility, this type joint is the least subject to damage during installation.

Illustration 5.14 Typical Cross Section of Steel End Ring Joint With Spigot Groove and 0-ring Gasket



Since both field construction practices and conditions of service are subject to variation, it is impossible to precisely define the field performance characteristics of each of the joint types. Consultation with local concrete pipe manufacturers will provide information on the availability and cost of the various joints. Based on this information and an evaluation of groundwater conditions, the specifications should define allowable infiltration or exfiltration rates and/or the joint types which are acceptable.

JACKING CONCRETE PIPE

Concrete pipelines were first jacked in place by the Northern Pacific Railroad between 1896 and 1900. In more recent years, this technique has been applied to sewer construction where intermediate shafts along the line of the sewer are used as jacking stations.

Reinforced concrete pipe as small as 18-inch inside diameter and as large as 132-inch inside diameter have been installed by jacking.

Required Characteristics of Concrete Jacking Pipe. Two types of loading conditions are imposed on concrete pipe installed by the jacking method; the axial load due to the jacking pressures applied during installation, and the earth loading due to the overburden, with some possible influence from live loadings, which will generally become effective only after installation is completed.

It is necessary to provide for relatively uniform distribution of the axial load around the periphery of the pipe to prevent localized stress concentrations. This is accomplished by keeping the pipe ends parallel within the tolerances prescribed by ASTM C 76, by using a cushion material, such as plywood or hardboard,

between the pipe sections, and by care on the part of the contractor to insure that the jacking force is properly distributed through the jacking frame to the pipe and parallel with the axis of the pipe. The cross sectional area of the concrete pipe wall is more than adequate to resist pressures encountered in any normal jacking operation. For projects where extreme jacking pressures are anticipated due to long jacking distances or excessive unit frictional forces, higher concrete compressive strength may be required, along with greater care to avoid bearing stress concentrations. Little or no gain in axial crushing resistance is provided by specifying a higher class of pipe.

For a comprehensive treatment of earth loads on jacked pipe see Chapter 4. The earth loads on jacked pipe are similar to loads on a pipe installed in a trench with the same width as the bore with one significant difference. In a jacked pipe installation the cohesive forces within the soil mass in most instances are appreciable and tend to reduce the total vertical load on the pipe. Thus the vertical load on a jacked pipe will always be less than on a pipe in a trench installation with the same cover and, unless noncohesive materials are encountered, can be substantially less.

With the proper analysis of loadings and selection of the appropriate strength class of pipe, few additional characteristics of standard concrete pipe need be considered. Pipe with a straight wall, without any increase in outside diameter at the bell or groove, obviously offers fewer problems and minimizes the required excavation. Considerable quantities of modified tongue and groove pipe have been jacked, however, and presented no unusual problems.

The Jacking Method. The usual procedure in jacking concrete pipe is to equip the leading edge with a cutter, or shoe, to protect the pipe. As succeeding lengths of pipe are added between the lead pipe and the jacks, and the pipe jacked forward, soil is excavated and removed through the pipe. Material is trimmed with care and excavation does not precede the jacking operation more than necessary. Such a procedure usually results in minimum disturbance of the natural soils adjacent to the pipe.

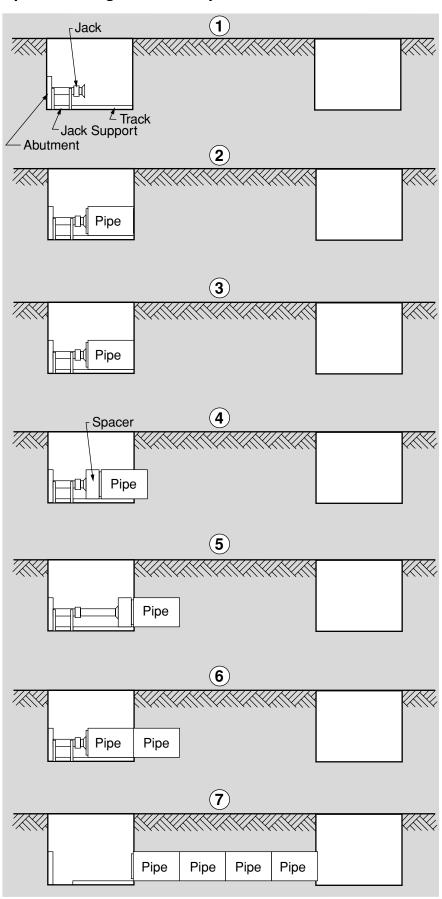
Contractors occasionally find it desirable to coat the outside of the pipe with a lubricant, such as bentonite, to reduce the frictional resistance. In some instances, this lubricant has been pumped through special fittings installed in the wall of the pipe.

Because of the tendency of jacked pipe to "set" when forward movement is interrupted for as long as a few hours, resulting in significantly increased frictional resistance, it is desirable to continue jacking operations until completed.

In all jacking operations it is important that the direction of jacking be carefully established prior to beginning the operation. This requires the erection of guide rails in the bottom of the jacking pit or shaft. In the case of large pipe, it is desirable to have such rails carefully set in a concrete slab. The number and capacity of the jacks required depend primarily upon the size and length of the pipe to be jacked and the type of soil encountered.

Illustration 5.15 Steps in Jacking Concrete Pipe

- 1. Pits are excavated on each side. The jacks will bear against the back of the left pit so a steel or wood abutment is added for reinforcement. A simple track is added to guide the concrete pipe section. The jack(s) are positioned in place on supports.
- **2.** A section of concrete pipe is lowered into the pit.
- **3.** The jack(s) are operated pushing the pipe section forward.
- **4.** The jack ram(s) are retracted and a "spacer" is added between the jack(s) and pipe.
- **5.** The jack(s) are operated and the pipe is pushed forward again.
- 6. It may become necessary to repeat the above steps 4 and 5 several times until the pipe is pushed forward enough to allow room for the next section of pipe. It is extremely important, therefore, that the strokes of the jacks be as long as possible to reduce the number of spacers required and thereby reduce the amount of time and cost. The ideal situation would be to have the jack stroke longer than the pipe to completely eliminate the need for spacers.
- **7.** The next section of pipe is lowered into the pit and the above steps repeated. The entire process above is repeated until the operation is complete.



Backstops for the jacks must be strong enough and large enough to distribute the maximum capacity of the jacks against the soil behind the backstops. A typical installation for jacking concrete pipe is shown in Illustration 5.15.

BENDS AND CURVES

Changes in direction of concrete pipe sewers are most commonly effected at manhole structures. This is accomplished by proper location of the inlet and outlet openings and finishing of the invert in the structure to reflect the desired angular change of direction.

In engineering both grade and alignment changes in concrete pipelines it is not always practical or feasible to restrict such changes to manhole structures. Fortunately there are a number of economical alternatives.

Deflected Straight Pipe. With concrete pipe installed in straight alignment and the joints in a home (or normal) position, the joint space, or distance between the ends of adjacent pipe sections, will be essentially uniform around the periphery of the pipe. Starting from this home position any joint may be opened up to a maximum permissible joint opening on one side while the other side remains in the home position. The difference between the home and opened joint space is generally designated as the pull. This maximum permissible opening retains some margin between it and the limit for satisfactory function of the joint. It varies for different joint configurations and is best obtained from the pipe manufacturer.

Opening a joint in this manner effects an angular deflection of the axis of the pipe, which, for any given pull is a function of the pipe diameter. Thus, given the values of any two of the three factors; pull, pipe diameter, and deflection angle, the remaining factor may be readily calculated.

The radius of curvature which may be obtained by this method is a function of the deflection angle per joint and the length of the pipe sections. Thus, longer lengths of pipe will provide a longer radius for the same pull than would be obtained with shorter lengths. The radius of curvature is computed by the equation:

$$R = \frac{L}{2(\tan \frac{1}{2} x \frac{\Delta}{N})}$$

where:

R = Radius of curvature, feet

L = Average laid length of pipe sections measured along the centerline, feet

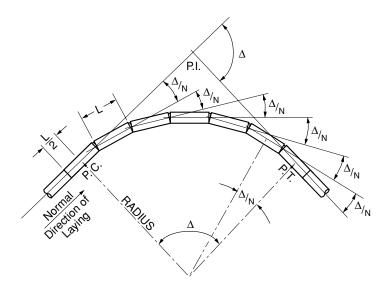
 Δ = Total deflection angle of curve, degrees

N = Number of pipe with pulled joints

 $\frac{\Delta}{N}$ = Total deflection of each pipe, degrees

Using the deflected straight pipe method, Illustration 5.16 shows that the P.C. (point of curve) will occur at the midpoint of the last undeflected pipe and the P.T. (point of tangent) will occur at the midpoint of the last pulled pipe.

Illustration 5.16 Curved Alignment Using Deflected Straight Pipe



Radius Pipe. Sharper curvature with correspondingly shorter radii can be accommodated with radius pipe than with deflected straight pipe. This is due to the greater deflection angle per joint which may be used. In this case the pipe is manufactured longer on one side than the other and the deflection angle is built in at the joint. Also referred to as bevelled or mitered pipe, it is similar in several respects to deflected straight pipe. Thus, shorter radii may be obtained with shorter pipe lengths; the maximum angular deflection which can be obtained at each joint is a function of both the pipe diameter and a combination of the geometric configuration of the joint and the method of manufacture.

These last two factors relate to how much shortening or drop can be applied to one side of the pipe. The maximum drop for any given pipe is best obtained from the manufacturer of the pipe since it is based on manufacturing feasibility.

The typical alignment problem is one in which the total Δ angle of the curve and the required radius of curvature have been determined. The diameter and direction of laying of the pipe are known. To be determined is whether the curve can be negotiated with radius pipe and, if so, what combination of pipe lengths and drop are required. Information required from the pipe manufacturer is the maximum permissible drop, the wall thicknesses of the pipe and the standard lengths in which the pipe is available. Any drop up to the maximum may be used as required to fit the curve.

Values obtained by the following method are approximate, but are within a range of accuracy that will permit the pipe to be readily installed to fit the required alignment.

The tangent of the deflection angle, $\frac{\Delta}{N}$ required at each joint is computed by the equation:

$$\tan \frac{\Delta}{N} = \frac{L}{R + D/2 + t}$$

where:

 Δ = Total deflection angle of curve, degrees

N = Number of radius pipe

L = The standard pipe length being used, feet

R = Radius of curvature, feet

D = Inside diameter of the pipe, feet

t = Wall thickness of the pipe, feet

The required drop in inches to provide the deflection angle, $\frac{\Delta}{N}$ computed by the equation:

Drop =
$$12(D + 2t) \tan \frac{\Delta}{N}$$

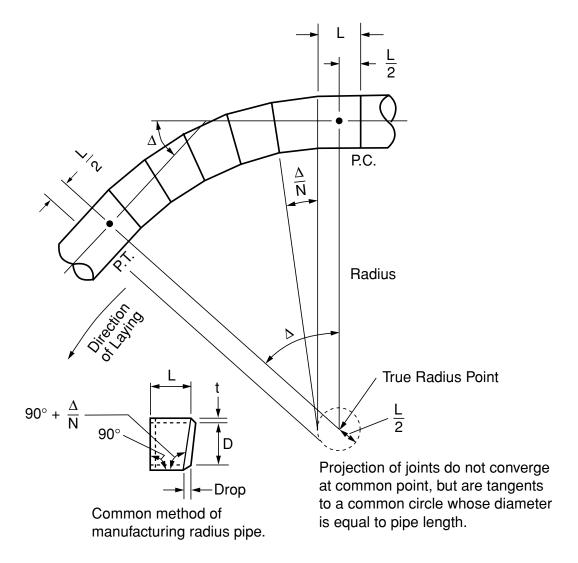
The number of pieces of radius pipe required is equal to the length of the circular curve in feet divided by the centerline length of the radius pipe (L - 1/2 Drop). Minor modifications in the radius are normally made so this quotient will be a whole number.

If the calculated drop exceeds the maximum permissible drop, it will be necessary to either increase the radius of curvature or to use shorter pipe lengths. Otherwise special fittings must be used as covered in the next section.

It is essential that radius pipe be oriented such that the plane of the dropped joint is at right angles to the theoretical circular curve. For this reason lifting holes in the pipe must be accurately located, or, if lifting holes are not provided, the top of the pipe should be clearly and accurately marked by the manufacturer so that the deflection angle is properly oriented.

It should also be noted that a reasonable amount of field adjustment is possible by pulling the radius pipe joints in the same manner as with deflected straight pipe.

Illustration 5.17 Curved Alignment Using Radius Pipe



As indicated in Illustration 5.17, the P.C. (point of curve) falls at the midpoint of the last straight pipe and the P.T. (point of tangent) falls one half of the standard pipe length back from the straight end of the last radius pipe. To assure that the P.C. will fall at the proper station it is generally necessary that a special short length of pipe be installed in the line, ahead of the P.C.

Bends and Special Sections. Extremely short radius curves cannot be negotiated with either deflected straight pipe or with conventional radius pipe. Several alternatives are available through the use of special precast sections to solve such alignment problems.

Sharper curves can be handled by using special short lengths of radius pipe rather than standard lengths. These may be computed in accordance with the methods discussed for radius pipe.

Certain types of manufacturing processes permit the use of a dropped joint on both ends of the pipe, which effectively doubles the deflection. Special bends,

or elbows can be manufactured to meet any required deflection angle and some manufacturers produce standard bends which provide given angular deflection per section.

One or more of these methods may be employed to meet the most severe alignment problems. Since manufacturing processes and local standards vary, local concrete pipe manufacturers should be consulted to determine the availability and geometric configuration of special sections.

SIGNIFICANCE OF CRACKING

The occurrence, function and significance of cracks have probably been the subject of more misunderstanding and unnecessary concern by engineers than any other phenomena related to reinforced concrete pipe.

Reinforced concrete pipe, like reinforced concrete structures in general, are made of concrete reinforced with steel in such a manner that the high compressive strength of the concrete is balanced by the high tensile strength of the steel. In reinforced concrete pipe design, no value is given to the tensile strength of the concrete. The tensile strength of the concrete, however, is important since all parts of the pipe are subject to tensile forces at some time subsequent to manufacture. When concrete is subjected to tensile forces in excess of its tensile strength, it cracks.

Unlike most reinforced concrete structures, reinforced concrete sewer and culvert pipe is designed to meet a specified cracking load rather than a specified stress level in the reinforcing steel. This is both reasonable and conservative since reinforced concrete pipe may be pretested in accordance with detailed national specifications.

In the early days of the concrete pipe industry, the first visible crack observed in a three-edge bearing test was the accepted criterion for pipe performance. However, the observation of such cracks was subject to variations depending upon the zeal and eyesight of the observer. The need soon became obvious for a criterion based on a measurable crack of a specified width. Eventually the 0.01-inch crack, as measured by a feeler gage of a specified shape, became the accepted criterion for pipe performance.

The most valid basis for selection of a maximum allowable crack width is the consideration of exposure and potential corrosion of the reinforcing steel. If a crack is sufficiently wide to provide access to the steel by both moisture and oxygen, corrosion will be initiated. Oxygen is consumed by the oxidation process and in order for corrosion to be progressive there must be a constant replenishment.

Bending cracks are widest at the surface and get rapidly smaller as they approach the reinforcing steel. Unless the crack is wide enough to allow circulation of the moisture and replenishment of oxygen, corrosion is unlikely. Corrosion is even further inhibited by the alkaline environment resulting from the cement.

While cracks considerably in excess of 0.01-inch have been observed after a period of years with absolutely no evidence of corrosion, 0.01-inch is a conservative and universally accepted maximum crack width for design of reinforced concrete pipe.

- Reinforced concrete pipe is designed to crack. Cracking under load indicates that the tensile stresses have been transferred to the reinforcing steel.
- A crack 0.01-inch wide does not indicate structural distress and is not harmful.
- Cracks much wider than 0.01-inch should probably be sealed to insure protection of the reinforcing steel.
- An exception to the above occurs with pipe manufactured with greater than 1 inch cover over the reinforcing steel. In these cases acceptable crack width should be increased in proportion to the additional concrete cover.

SEWAGE FLOWS USED FOR DESIGN

City	Year of Data	Average rate of water consumption, in gpcd	Population served. In thousands	Per capita sewage flow average 2. in gpcd 1	Sewer design basis in gpcd ¹	Remarks	Cıty	Year of Data	Average rate of water consumption.	Population served. in thousands	Per capita sewage flow average 2 in gpcd 1	Sewer design basis in gpcd '	Remarks
Baltimore, Md.	1	160	1.300	100	135 x factor	Factor 4 to 2	Little Rock, Ark.	1	20	100	20	100	I
Berkeley, Calif.	I	9/	113	99	92	1	Los Angeles, Calif.	1965	185	2.710	82	•	*85 gpcd1 residential multi-
Boston, Mass.	i	145	801	140	150	Flowing half full			Ö	0	Ş		Direction only ranges
Cfeveland, Ohio 3	1946	1	ı	100	i	ı	Cos Angeles County Sanitation District	1964	007	3.500	•	ı	from 50 to 90 gpcd1 depend-
Cranston, R.I. ³	1943	1	1	119	167	ı							ing on cost of water, type
Des Moines, Iowa 3	1949	ı	1	100	200	1				•			of residence, etc. Domestic
Grand Rapids, Mich.	1	178	200	189.5	200	ı				•	•		90 gpcd1
Great Peoria, Illinois	1960	06	150	75	800	Based on 12 persons per	Madison, Wisc. ³	1937	ı	1	ı	300	Maximum hourly rate
					8.500	acre for lateral and trunk sewers respectively	Memphis, Tenn.	1	125	450	100	100	. 1
Greenville County	1959	110	200	150	300	Service area includes city of	Milwaukee, Wisc. ³	1945	4	1	125	1	All in 12 hr-250-gpcd 1 rate
South Carolina	,	:	3	}	}	Greenville, 1 Sewers 24" and	Orlando, Fla.	ı	150	7.5	20	190	1
						less designed to flow 1/2 full	Painesville. Ohio 3	1947	í	ı	125	009	includes infiltration and
						than 24" designed to have							roof water
						1' freeboard	Rapid City, S. Dak.	1	122	4	121	125	1
Hagerstown, Md.	ı	100	38	901	250	1	Rochester, N.Y.3	1946	ı	1	1	250	New York State Board of
Jefferson County, Ala.	1	102	200	100	300	ı							Health standard
Johnson County, Kans	1958			_			Santa Monica, Calif.	ı	137	75	92	92	1
Indian Creek							Shreveport, La.	1961	125	165	1	1	Sewer design is 150 gpcd ¹
Main Sewer Dist.	ı	0/	98	9	675	Most houses have basements with interior							pius buo gp acre per day infiltration. Sewers 24" in
						foundation drains							diameter and less designed
Main Sewer Dist.	1	02	70	09	1.350	Most houses have		<u></u>					than 24" designed to have
						foundation drains	Springfield Macc 3	1949				000	150 and was used on a
Kansas City, Mo.	1958	ı	200	9	675	For trunks and interceptors		?		!		2	special project
					1.350	For laterals and submains.	St. Joseph, Mo.	1960	1	82	125	450	Main Sewers
						Many houses have						320	Interceptors
						foundation drains	Toledo, Ohio 3	1946	1	1	1	160	1
Lancaster County, Neb.	1962	167	148	85	400	Serves City of Lincoln	Washington, D. C.,	1946			100	2 to 3.3 x	1
Las Vegas, Nev.	1	410	45	500	250	ı	Suburban Sanitary District3	1000	150	5	•00	average	City complete by the body of the first of the
Lincoln, Neb.	1964			09	See remarks	For lateral sewers max.	Woming Mich	0061	 PC I	3	. 70	9	sewage flow, not including
(Lateral Dists.)						Tiow by formula: peak flow= 5 x avg. flow÷(Pop in 1000's)0-2							infiltration or industrial flow
			1		7								

¹ Gallons per capita per day. To convert to liters per capita per day multiply by 3.8.

Measure or estimated domestic sewage.
 Stanley and Warren J. Kaufman, Journal, Boston Soc. of Civil Engrs., October, 1953, p. 317, Table 2.

Table 2

SEWER CAPACITY ALLOWANCES FOR COMMERCIAL AND INDUSTRIAL AREAS

Citu	Year	Commercial	la do abrilla
City	data	Commercial 135 gpcd ² (range 6,750 to 13,500 gpd per acre),	Industrial
Baltimore, Md. ¹	1949	resident population	7,500 gpd per acre minimum
Berkeley, Calif	_	—	50,000 gpd per acre
Buffalo, N.Y.3	_	60,000 gpd per acre	—
Cincinnati, Ohio ³	_	40,000 gpd per acre	_
Columbus, Ohio 1	1946	40,000 gpd per acre; excess added to residential	_
		amount	
Cranston, R.I.1	1943	25,000 gpd per acre	_
Dallas, Texas	1960	30,000 gpd per acre added to domestic rate for	_
		down town:	
		60,000 gpd per acre for tunnel relief sewers	
Detroit, Mich.	-	50,000 gpd per acre	_
Grand Rapids, Mich.	-	40-50 gpcd, ² office buildings	250,000 gpd per acre
		400-500 gpd per room, hotels	
		200 gpd per bed, hospitals	
		200-300 gpd per room, schools	
Hagerstown, Md.	-	180-250 gpd per room, hotels	_
		150, gpd per bed, hospitals	
	l	120-150 gpd per room, schools	
Houston, Texas	1960	Office Bldgs. — 0.36 gal per sq ft per day (peak)	_
		Retail Space — 0.20 gp sq ft pd (peak)	
		Hotels — 0.93 gp sq ft pd (peak)	
Las Vegas, Nev.	-	310-525 gpd per room, resort hotels	_
]	15 gpcd, ² schools	
Lincoln, Neb.	1962	7,000 gpd per acre	_
Los Angeles, Calif.	1965	Commercial, 11,700 gpd per acre	
	1 1	Industrial, 0.024 cfs per acre	
		Hospital, 0.75 mgd per hospital	
		School, 0.12 mgd per school	
		University, 0.73 mgd per university	
Los Angeles County	1964	10,000 gpd per acre, avg.	_
Sanitation District	1050	25,000 gpd per acre, peak	10 000 1
Kansas City, Mo.	1958	5,000 gpd per acre	10,000 gpd per acre
Memphis, Tenn.	-	2,000 gpd per acre	2,000 gpd per acre
Milwaukee, Wis. ¹	1945	60,500 gpd per acre	-
Santa Monica, Calif.	-	9,700 gpd per acre, commercial	13,600 gpd per acre
05		7,750 gpd per acre, hotels	
Shreveport, La.	1000	3,000 gpd per acre	
St. Joseph, Mo.	1962	6,000 gpd per acre	_
St. Louis, Mo.	1960	90,000 gpd per acre avg.	_
Talada Ohial	1046	165,000 gpd per acre peak	
Toledo, Ohio 1	1946	15,000 to 30,000 gpd per acre, average to peak allowances	_
Toronto	1960	63,500 gpd per acre downtown sewers	_
TOTOTILO	1900	00,000 gpu per acre domittoms senera	

¹ "Sewer Capacity Design Practice," by William E. Stanley and Warren J. Kaufman, Journal, Boston Soc. of Civ., Engrs., October, 1953. p. 320, Table 3.

² Gallons per capita per day.

³ Sludge & Sewage Treatment, Harold Bobbitt, 6-Edition, John Wiley & Sons.

Table 3

FULL FLOW COEFFICIENT VALUES CIRCULAR CONCRETE PIPE

D Pipe	A Area	R Hydraulic	V	alue of $C_1 =$	1.486 n x A x F	{ ² / ₃
Diameter (inches)	(Square Feet)	Radius (Feet)	n=0.010	n=0.011	n=0.012	n=0.013
8	0.349	0.167	15.8	14.3	13.1	12.1
10	0.545	0.208	28.4	25.8	23.6	21.8
12	0.785	0.250	46.4	42.1	38.6	35.7
15	1.227	0.312	84.1	76.5	70.1	64.7
18	1.767	0.375	137	124	114	105
21	2.405	0.437	206	187	172	158
24	3.142	0.500	294	267	245	226
27	3.976	0.562	402	366	335	310
30	4.909	0.625	533	485	444	410
33	5.940	0.688	686	624	574	530
36	7.069	0.750	867	788	722	666
42	9.621	0.875	1308	1189	1090	1006
48	12.566	1.000	1867	1698	1556	1436
54	15.904	1.125	2557	2325	2131	1967
60	19.635	1.250	3385	3077	2821	2604
66	23.758	1.375	4364	3967	3636	3357
72	28.274	1.500	5504	5004	4587	4234
78	33.183	1.625	6815	6195	5679	5242
84	38.485	1.750	8304	7549	6920	6388
90	44.170	1.875	9985	9078	8321	7681
96	50.266	2.000	11850	10780	9878	9119
102	56.745	2.125	13940	12670	11620	10720
108	63.617	2.250	16230	14760	13530	12490
114	70.882	2.375	18750	17040	15620	14420
120	78.540	2.500	21500	19540	17920	16540
126	86.590	2.625	24480	22260	20400	18830
132	95.033	2.750	27720	25200	23100	21330
138	103.870	2.875	31210	28370	26010	24010
144	113.100	3.000	34960	31780	29130	26890

Table 4

FULL FLOW COEFFICIENT VALUES ELLIPTICAL CONCRETE PIPE

Pipe Size	Approximate Equivalent Circular	A Area	R Hydraulic	V	alue of C ₁ = -	1.486 n × A × F	R ^{2/3}
R x S (HE) S x R (VE) (Inches)	Diameter (Inches)	(Square Feet)	Radius (Feet)	n = 0.010	n = 0.011	n = 0.012	n = 0.013
14 x 23	18	1.8	0.367	138	125	116	108
19 x 30	24	3.3	0.490	301	274	252	232
22 x 34	27	4.1	0.546	405	368	339	313
24 x 38	30	5.1	0.613	547	497	456	421
27 x 42	33	6.3	0.686	728	662	607	560
29 x 45	36	7.4	0.736	891	810	746	686
32 x 49	39	8.8	0.812	1140	1036	948	875
34 x 53	42	10.2	0.875	1386	1260	1156	1067
38 x 60	48	12.9	0.969	1878	1707	1565	1445
43 x 68	54	16.6	1.106	2635	2395	2196	2027
48 x 76	60	20.5	1.229	3491	3174	2910	2686
53 x 83	66	24.8	1.352	4503	4094	3753	3464
58 x 91	72	29.5	1.475	5680	5164	4734	4370
63 x 98	78	34.6	1.598	7027	6388	5856	5406
68 x 106	84	40.1	1.721	8560	7790	7140	6590
72 x 113	90	46.1	1.845	10300	9365	8584	7925
77 x 121	96	52.4	1.967	12220	11110	10190	9403
82 x 128	102	59.2	2.091	14380	13070	11980	11060
87 x 136	108	66.4	2.215	16770	15240	13970	12900
92 x 143	114	74.0	2.340	19380	17620	16150	14910
97 x 151	120	82.0	2.461	22190	20180	18490	17070
106 x 166	132	99.2	2.707	28630	26020	23860	22020
116 x 180	144	118.6	2.968	36400	33100	30340	28000

Table 5

FULL FLOW COEFFICIENT VALUES CONCRETE ARCH PIPE

Pipe Size	Approximate Equivalent Circular	A	R	Va	alue of $C_1 = \frac{1}{2}$.486 n x A x R	2/3
R x S (Inches)	Diameter (Inches)	Area (Square Feet)	Hydraulic Radius (Feet)	n = 0.010	n = 0.011	n = 0.012	n = 0.013
11 x 18	15	1.1	0.25	65	59	54	50
13½ x 22	18	1.6	0.30	110	100	91	84
15½ x 26	21	2.2	0.36	165	150	137	127
18 x 28½	24	2.8	0.45	243	221	203	187
22½ x 36¼	30	4.4	0.56	441	401	368	339
26% x 43¾	36	6.4	0.68	736	669	613	566
31½ x 51½	42	8.8	0.80	1125	1023	938	866
36 x 58½	48	11.4	0.90	1579	1435	1315	1214
40 x 65	54	14.3	1.01	2140	1945	1783	1646
45 x 73	60	17.7	1.13	2851	2592	2376	2193
54 x 88	72	25.6	1.35	4641	4219	3867	3569
62 x 102	84	34.6	1.57	6941	6310	5784	5339
72 x 115	90	44.5	1.77	9668	8789	8056	7436
77¼ x 122	96	51.7	1.92	11850	10770	9872	9112
87⅓ x 138	108	66.0	2.17	16430	14940	13690	12640
96 % x 154	120	81.8	2.42	21975	19977	18312	16904
106 ½ x 168 ¾	132	99.1	2.65	28292	25720	23577	21763

FULL FLOW COEFFICIENT VALUES
PRECAST CONCRETE BOX SECTIONS

n = 0.01334600 7070 18500 21300 6390 11700 17700 24100 27400 7050 3000 00861 27000 13000 15700 $= 1.486/n(A \times R^{2/3})$ 3700 16100 8020 10462 n = 0.01229700 21400 37500 20000 23000 930 12730 19200 26100 7630 14100 17400 3698 11300 14100 17000 Hydraulic Radius (Feet) 2.14 2.46 2.59 1.52 2.02 2.85 1.55 1.73 2.31 2.41 1.67 142.00 86.32 94.00 118.00 43.88 70.88 108.32 119.32 46.00 Square 79.88 48.61 58.61 68.61 78.61 88.61 98.61 42.32 64.32 Feet) Area Span x Rise X 12 10 X 10 11 X 10 12 X 10 **Box Size** 11 X 11 11 X 6 11 X 8 12 X 4 12 X 6 (Feet) 9 ∞ 6 4 ∞ 6 ъ X 01 10 X 10 X × × 6 × 6 × 6 ׺ 10 X × n = 0.013 $= 1.486/n(A \times R^{2/3})$ 989 4240 3100 5430 3740 5160 6650 1700 1240 1840 1630 2460 3340 2030 8200 4420 = 0.0125880 2700 1770 2660 3620 2200 3350 4590 4050 5590 7200 8880 4790 6630 8760 0090 Hydraulic Radius (Feet) 1.16 1.56 1.33 1.78 0.90 1.04 0.98 1.30 1.25 1.42 1.52 .39 40. 89.1 1.82 1.60 2.07 Square 23.32 15.65 14.50 19.50 24.50 17.32 29.32 35.32 27.11 34.11 41.11 48.11 31.11 63.11 Feet) 39.11 Span x Rise Box Size (Feet) 7 X 7 ∞ ×κ × ×9 × 4 × × 9 X 9 × × × × × × × × × × × × × Ŋ 9 ω ∞ ω

Table 7

SLOPES REQUIRED FOR V = 2fps AT FULL AND HALF FULL FLOW

Pipe Diameter		Slope	in %	
(Inches)	n = 0.010	n = 0.011	n = 0.012	n = 0.013
8	0.197	0.238	0.284	0.332
10	0.147	0.178_	0.213	0.248
12	0.115	0.139	0.166	0.194
15	0.086	0.104	0.123	0.145
18	0.067	0.081	0.097	0.114
21	0.055	0.066	0.079	0.092
24	0.046	0.055	0.066	0.077
27	0.039	0.047	0.056	0.065
30	0.034	0.041	0.049	0.057
33	0.030	0.036	0.043	0.051
36	0.027	0.032	0.038	0.045
42	0.022	0.026	0.031	0.036
48	0.018	0.022	0.026	0.031
54	0.015	0.019	0.022	0.027
60	0.013	0.016	0.019	0.023
66	0.012	0.014	0.017	0.020
72	0.011	0.013	0.015	0.018
78	0.010	0.011	0.014	0.016
84	0.009	0.010	0.012	0.015
90	0.008	0.010	0.011	0.013
96	0.007	0.009	0.010	0.012
102	0.007	0.008	0.010	0.011
108	0.006	0.007	0.009	0.010
114	0.006	0.007	0.008	0.010
120	0.005	0.006	0.008	0.009
126	0.005	0.006	0.007	0.008
132	0.004	0.006	0.007	0.008
138	0.004	0.005	0.006	0.007
144	0.004	0.005	0.006	0.007

Note: For a velocity V other than 2fps, multiple the above by $\frac{V^2}{4}$.

RUNOFF COEFFICIENTS FOR VARIOUS AREAS

DESCRIPTION OF AREA	RUNOFF COEFFICIENTS
Business:	
Downtown areas	0.70 to 0.95
Neighborhood areas	0.50 to 0.70
Residential:	
Single-family areas	0.30 to 0.50
Multi units, detached	0.40 to 0.60
Multi units, attached	0.60 to 0.75
Residential (suburban)	0.25 to 0.40
Apartment dwelling areas	0.50 to 0.70
Industrial:	
Light areas	0.50 to 0.80
Heavy areas	
Parks, cemeteries	
Playgrounds	
Railroad yard areas	
Unimproved areas	

Table 9

RAINFALL INTENSITY CONVERSION FACTORS

Duration in Minutes	Factor	Duration in Minutes	Factor
5	2.22	40	0.8
10	1.71	50	0.7
15	1.44	60	0.6
20	1.25	90	0.5
30	1.00	120	0.4

Table 10

RECURRENCE INTERVAL FACTORS

Recurrence Interval in Years	Factor
2	1.0
5	1.3
10	1.6
25	1.9
50	2.2

Table 11

NATIONWIDE FLOOD-FREQUENCY PROJECTS

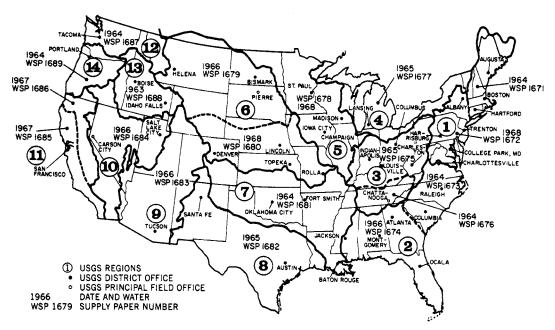


Table 12

ENTRANCE LOSS COEFFICIENTS

Coefficient k_e to apply to velocity head $\frac{V^2}{2g}$ for determination of head loss at entrance to a structure, such as a culvert or conduit, operating full or partly full with control at the outlet.

Entrance head loss $H_e = k_e \frac{V^2}{2g}$

-9	
TYPE OF ENTRANCE	COEFFICIENT ke
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	
Rounded (radius = 1/12D)	
End-Section conforming to fill slope	
Note: "End Section conforming to fill slope" are the sections common facturers. From limited hydraulic tests they are equivalent in op both inlet and outlet control. Some end sections, incorporating design have a superior hydraulic performance.	eration to a headwall in
TYPE OF STRUCTURE AND DESIGN OF	
ENTRANCE BOX, REINFORCED CONCRETE	COEFFICIENT ke
Headwall parallel to embankment (no wing walls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension	0.2
Wing walls at 30° to 75° to barrel	
Square-edged at crown	
Crown edge rounded to radius of 1/12 barrel dimension	0.2
Wing walls at 10° to 25° to barrel	
Square-edged at crown	0.5
Wing walls parallel (extension of sides)	
Square-edged at crown	
	0.7
	n 7

Table 13

Pipe Size = 12"

		Type 4	2.4	2.5	2.6	2.7	2.7	2.8	2.9	3.0	3.0	3.1	3.2	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.8	3.8	3.9	3.9	3.9
	0.110	Type 3	2.4	2.5	2.5	5.6	2.7	2.7	2.8	5.9	5.9	3.0	3.1	3.1	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	3.6	3.7	3.8	3.8	3.9	3.9
	Ku' = 0	Type 2	2.4	2.5	2.5	5.6	2.7	2.7	2.8	5.9	2.9	3.0	3.1	3.1	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	3.6	3.7	3.8	3.8	3.9	3.9
		Type 1	2.3	2.4	2.5	2.5	5.6	2.7	2.7	2.8	2.9	2.9	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.8	3.8
		Type 4	2.5	2.6	2.7	2.8	2.9	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.1	4.2	4.2
	0.130	Type 3	2.4	2.5	2.6	2.7	2.8	2.9	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9	3.9	4.0	4.1	4.1	4.1
F	Ku' = 0	Type 2	2.4	2.5	5.6	2.7	2.8	2.9	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9	3.9	4.0	4.1	4.1	4.1
Transition Widths (FT)		Type 1	2.4	2.5	2.6	2.6	2.7	2.8	2.9	5.9	3.0	3.1	3.2	3.2	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.7	3.8	3.9	3.9	4.0	4.0	4.0
nsition M		Type 4	5.6	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.4	4.4
Trar	0.150	Type 3	2.5	5.6	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.2	4.2	4.3	4.4	4.4
	Ku' = 0	Type 2	2.5	5.6	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.2	4.2	4.3	4.4	4.4
		Type 1	2.4	2.5	5.6	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.8	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.3	4.3
		Type 4	5.6	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.6	4.6
	0.165	Type 3	5.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.3	3.4	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.0	4.0	4.2	4.3	4.3	4.4	4.5	4.5	4.5
	Ku' = 0.	Type 2	5.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.3	3.4	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.5	4.5
		Type 1	2.5	5.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.4	3.5	3.6	3.7	3.7	3.8	3.9	4.0	4.0	4.1	4.2	4.2	4.3	4.4	4.4	4.4
			2	9	7	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	56	27	28	59	30

Table 14

Pipe Size = 15"

		Type 4	2.9	3.0	3.1	3.1	3.2	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.3	4.4	4.4	4.5	4.5
	0.110	Type 3	2.8	2.9	3.0	3.0	3.1	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.7	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.2	4.2	4.3	4.3	4.4	4.4
	Ku' = 0	Type 2	2.8	2.9	3.0	3.0	3.1	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.7	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.2	4.2	4.3	4.3	4.4	4.4
		Type 1	2.7	2.8	2.9	3.0	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.5	3.6	3.6	3.7	3.8	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.2	4.3	4.3
		Type 4	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.6	3.7	3.7	3.8	3.9	4.0	4.0	4.1	4.2	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.8	4.8
	0.130	Type 3	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.5	4.5	4.6	4.6	4.6
_	Ku' = 0.	Type 2	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.5	4.5	4.6	4.6	4.6
Transition Widths (FT)		Type 1	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.2	4.2	4.3	4.4	4.4	4.5	4.5	4.5
sition W		Type 4	3.0	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.1	4.2	4.3	4.4	4.5	4.5	4.6	4.7	4.7	4.8	4.9	4.9	2.0	2.0
Tran	0.150	Type 3	3.0	3.1	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.8	3.9	4.0	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.8	4.8	4.9	4.9
	Ku' = 0	Type 2	3.0	3.1	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.8	3.9	4.0	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.8	4.8	4.9	4.9
		Type 1	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.8	3.9	4.0	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.5	4.6	4.7	4.7	4.8	4.8
		Type 4	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.7	4.8	4.8	4.9	2.0	5.1	5.1	5.2	5.2
	0.165	Type 3	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.7	4.7	4.8	4.9	5.0	2.0	5.1	5.1
	Ku' = 0.	Type 2	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.7	4.7	4.8	4.9	2.0	2.0	5.1	5.1
		Type 1	2.9	3.0	3.1	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.8	4.9	2.0	5.0
			2	9	7	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	56	27	28	29	30

Table 15

ipe Size = 18'

		4																										
		Type 4	3.3	3.4	3.5	3.6	3.7	3.7	3.8	3.9	4.0	4.0	4.1	4.2	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.8	4.8	4.9	4.9	2.0	5.0
	0.110	Type 3	3.2	8.8	3.4	3.5	9.6	9.6	2.8	3.8	6.6	6.6	4.0	4.1	1.4	4.2	4.3	4.3	4.4	4.5	4.5	4.6	4.6	4.7	4.8	4.8	6.4	4.9
	Ku'=	Type 2	3.2	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.5	4.5	4.6	4.6	4.7	4.8	4.8	4.9	4.9
		Type 1	3.1	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.2	4.2	4.3	4.3	4.4	4.5	4.5	4.6	4.6	4.7	4.8	4.8
		Type 4	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.7	4.7	4.8	4.9	2.0	2.0	5.1	5.2	5.2	5.3	5.3
	0.130	Type 3	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.8	4.9	2.0	2.0	5.1	5.2	5.2
Æ	Ku' = 0	Type 2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.8	4.9	2.0	2.0	5.1	5.2	5.2
Transition Widths (FT)		Type 1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.4	4.5	4.6	4.7	4.7	4.8	4.9	4.9	2.0	2.0	5.0
nsition V		Type 4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.9	2.0	2.0	5.1	5.2	5.3	5.3	5.4	5.5	9.6	5.6
Tra	0.150	Type 3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.7	4.8	4.9	4.9	2.0	5.1	5.2	5.2	5.3	5.4	5.4	5.4
	Ku' = (Type 2	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.7	4.8	4.9	4.9	5.0	5.1	5.2	5.2	5.3	5.4	5.4	5.4
		Type 1	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.7	4.7	4.8	4.9	2.0	2.0	5.1	5.2	5.3	5.3	5.3
		Type 4	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	2.0	5.0	5.1	5.2	5.3	5.4	5.5	5.5	9.5	2.5	5.8	5.8
	0.165	Type 3	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.8	4.9	2.0	5.1	5.2	5.3	5.3	5.4	5.5	9.5	9.9	5.6
	Ku' = 0	Type 2	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.8	4.9	2.0	5.1	5.2	5.3	5.3	5.4	5.5	9.5	9.6	5.6
		Type 1	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.9	2.0	5.1	5.1	5.2	5.3	5.4	5.4	5.5	5.5
-			2	9	7	æ	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	56	27	28	59	30

Table 16

Pipe Size = 21"

		Type 4	3.8	3.9	4.0	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.8	4.9	4.9	2.0	5.1	5.1	5.2	5.2	5.3	5.4	5.4	5.5	5.5
	= 0.110	Type 3	3.7	3.8	3.8	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.5	4.6	4.7	4.7	4.8	4.9	4.9	2.0	5.1	5.1	5.2	5.2	5.3	5.4	5.4
	Υ Έ	Type 2	3.7	3.8	3.8	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.5	4.6	4.7	4.7	4.8	4.9	4.9	5.0	5.1	5.1	5.2	5.2	5.3	5.4	5.4
		Type 1	3.6	3.6	3.7	3.8	3.9	4.0	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.5	4.6	4.7	4.7	4.8	4.9	4.9	5.0	5.1	5.1	5.2	5.2	5.2
		Type 4	3.9	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.1	5.2	5.2	5.3	5.4	5.5	5.5	5.6	5.7	5.7	5.8	5.8
	0.130	Type 3	3.8	3.9	3.9	4.0	4.1	4.2	4.3	4.4	4.5	.46	4.6	4.7	4.8	4.9	2.0	2.0	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.7	2.7
<u></u>	Ku' = 0	Type 2	3.8	3.9	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.9	2.0	2.0	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	2.2	2.2
Transition Widths (FT)		Type 1	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.1	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.5
sition W		Type 4	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	2.0	2.0	5.1	5.2	5.3	5.4	5.5	9.6	9.6	5.7	5.8	5.9	5.9	6.0	6.1	6.1
Tran	0.150	Type 3	3.8	3.9	4.1	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.3	5.4	5.5	5.6	2.7	5.7	5.8	5.9	0.9	0.9
	Ku' = 0	Type 2	3.8	3.9	4.1	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.9	2.0	5.1	5.2	5.3	5.3	5.4	5.5	9.6	2.2	2.2	5.8	5.9	0.9	0.9
		Type 1	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	2.0	5.1	5.1	5.2	5.3	5.4	5.4	5.5	5.6	2.2	5.7	5.8	2.8
		Type 4	4.0	4.1	4.2	4.4	4.5	4.6	4.7	4.8	4.9	2.0	5.1	5.2	5.3	5.4	5.5	9.6	5.6	2.7	5.8	5.9	0.9	6.1	6.1	6.2	6.3	6.3
	0.165	Type 3	3.9	4.0	4.1	4.2	4.4	4.5	4.6	4.7	4.8	4.9	2.0	5.1	5.2	5.2	5.3	5.4	5.5	9.6	2.7	5.8	5.8	5.9	0.9	6.1	6.2	6.2
	Ku' = 0.	Type 2	3.9	4.0	4.1	4.2	4.4	4.5	4.6	4.7	4.8	4.9	2.0	5.1	5.2	5.5	5.3	5.4	5.5	9.6	2.2	5.8	5.8	5.9	0.9	6.1	6.2	6.2
		Type 1	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	2.0	5.1	5.2	5.3	5.4	5.5	5.5	9.6	5.7	5.8	5.9	0.9	0.9	0.9
			2	9	7	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	59	30

Table 17

Pipe Size = 24"

		Type 4	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.9	2.0	2.0	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.7	5.7	5.8	5.9	5.9	0.9	6.0
	0.110	Type 3	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.7	4.7	4.8	4.9	2.0	2.0	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.7	2.2	2.8	5.8	5.8
	Ku' = 0	Type 2	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.7	4.7	4.8	4.9	2.0	2.0	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.7	2.2	2.8	5.8	5.8
		Type 1	4.0	4.1	4.1	4.2	4.3	4.4	4.5	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.0	5.1	5.2	5.3	5.3	5.4	5.4	5.5	9.9	9.6	2.2	5.7
		Type 4	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.2	5.3	5.4	5.5	5.6	5.6	2.2	5.8	5.9	5.9	0.9	6.1	6.2	6.2	6.3	6.3
	0.130	Type 3	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.1	5.2	5.3	5.3	5.4	5.5	9.6	2.2	2.2	5.8	5.9	5.9	0.9	6.1	6.2	6.2
F	Ku' = 0	Type 2	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.1	5.2	5.3	5.3	5.4	5.5	9.6	2.5	2.2	5.8	5.9	5.9	0.9	6.1	6.2	6.2
Transition Widths (FT)		Type 1	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.0	5.1	5.2	5.3	5.4	5.4	5.5	5.6	5.7	5.7	5.8	5.9	6.3	0.9	6.0
sition W		Type 4	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	0.9	0.9	6.1	6.2	6.3	6.4	6.5	6.5	9.9	9.9
Trar	0.150	Type 3	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.7	2.8	6.3	0.9	6.1	6.2	6.2	6.3	6.4	6.5	6.5
	Ku' = 0	Type 2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.7	5.8	6.3	0.9	6.1	6.2	6.2	6.3	6.4	6.5	6.5
		Type 1	4.1	4.2	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.2	5.3	5.4	5.5	5.6	2.5	5.8	5.8	6.3	0.9	6.1	6.2	6.2	6.3	6.3
		Type 4	4.5	4.6	4.7	4.8	4.9	5.0	5.2	5.3	5.4	5.5	9.6	2.5	5.8	6.3	0.9	6.1	6.1	6.2	6.3	6.4	6.5	9.9	6.7	8.9	8.9	8.9
	165	Type 3	4.3	4.5	4.6	4.7	4.8	4.9	2.0	5.1	5.2	5.3	5.4	5.5	9.5	2.5	5.8	5.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	6.7	6.7
	Ku' = 0.165	Type 2	4.3	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	6.7	6.7
		Type 1	4.2	4.3	4.4	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	2.2	5.8	6.5	6.5	0.9	6.1	6.2	6.3	6.4	6.4	6.5	6.5
			5	9	2	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Table 18

Pipe Size = 27"

	Type 4	4.7	4.8	4.9	4.9	2.0	5.1	5.2	5.3	5.3	5.4	5.5	5.6	5.6	2.2	5.8	6.3	5.9	0.9	6.1	6.1	6.2	6.3	6.3	6.4	6.5	6.5
.110	Type 3	4.5	4.6	4.7	4.8	4.9	5.0	5.0	5.1	5.2	5.3	5.3	5.4	5.5	5.6	5.6	2.2	5.8	5.8	5.9	6.0	6.1	6.1	6.2	6.2	6.3	6.3
Ku' = 0	Type 2	4.5	4.6	4.7	4.8	4.9	5.0	2.0	5.1	5.2	5.3	5.3	5.4	5.5	9.6	9.6	2.2	5.8	2.8	6.3	0.9	6.1	6.1	6.2	6.2	6.3	6.3
	Type 1	4.4	4.5	4.6	4.6	4.7	4.8	4.9	2.0	2.0	5.1	5.2	5.3	5.3	5.4	5.5	9.6	5.6	2.2	2.8	5.8	6.3	0.9	0.9	6.1	6.2	6.2
	Type 4	4.8	4.9	5.0	5.1	5.2	5.3	5.3	5.4	2.5	5.6	2.5	5.8	5.9	0.9	0.9	6.1	6.2	6.3	6.4	6.4	6.5	9.9	6.7	6.7	8.9	8.9
.130	Type 3	4.6	4.7	4.8	4.9	2.0	5.1	5.2	5.3	5.4	5.5	2.5	5.6	2.2	5.8	6.5	0.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	9.9	9.9
Ku' = 0	Type 2	4.6	4.7	4.8	4.9	2.0	5.1	5.2	5.3	5.4	5.5	2.5	5.6	2.2	5.8	6.5	0.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	9.9	9.9
	Type 1	4.5	4.6	4.7	4.8	4.9	5.0	2.0	5.1	5.2	5.3	5.4	5.5	5.6	9.6	2.2	2.8	5.9	0.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	6.5
	Type 4	4.9	5.0	5.1	5.2	5.3	5.4	5.5	9.6	2.5	5.8	6.3	6.0	6.1	6.2	6.3	6.4	6.5	6.5	9.9	6.7	8.9	6.9	7.0	0.7	7.1	7.1
.150	Type 3	4.7	4.8	4.9	5.0	5.1	5.5	5.4	5.5	9.6	5.7	2.5	5.8	5.9	0.9	6.1	6.2	6.3	6.4	6.5	6.5	9.9	6.7	8.9	6.9	7.0	7:0
Ku' = 0	Type 2	4.7	4.8	4.9	5.0	5.1	5.2	5.4	2.5	9.6	2.2	2.3	5.8	5.9	0.9	6.1	6.2	6.3	6.4	6.5	6.5	9.9	6.7	8.9	6.9	7.0	7.0
	Type 1	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	9.5	5.7	5.8	5.9	6.0	0.9	6.1	6.2	6.3	6.4	6.5	6.6	6.6	6.7	6.8	6.8
	Type 4	4.9	5.0	5.2	5.3	5.4	5.5	5.6	2.2	5.8	5.9	0.9	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.4
165	Type 3	4.8	4.9	5.0	5.1	5.2	5.4	5.5	5.6	2.2	5.8	6.3	6.0	6.1	6.2	6.3	6.4	6.5	9.9	6.7	6.7	6.8	6.9	7.0	7.1	7.2	7.2
Ku' = 0.	Type 2	4.8	4.9	5.0	5.1	5.2	5.4	5.5	9.5	2.2	5.8	6.3	6.0	6.1	6.2	6.3	6.4	6.5	9.9	6.7	6.7	6.8	6.9	7.0	7.1	7.2	7.2
	Type 1	4.6	4.7	4.9	5.0	5.1	5.2	5.3	5.4	2.5	5.6	2.3	5.8	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	6.8	8.9	6.9	7.0	7:0
		2	9	7	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	= 0.165 Ku' = 0.150 Ku' = 0.130 Ku'	Ku' = 0.165 Ku' = 0.150 Ku' = 0.130 Ku' = 0.110 1 Type 2 Type 3 Type 3 Type 4 Type 4 Type 4 Type 3 Type 3 Type 4 Type 3 Type 3 Type 3 Type 4 Type 3 Type 4 Type 3 Type 4 Type 3 Type 3 Type 4 Type 3 Type 4 Type 4 Type 3 Type 4 Type 3 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 3 Type 4 T	Ku' = 0.165 Ku' = 0.150 Ku' = 0.150 Ku' = 0.130 Ku' = 0.130 Ku' = 0.110 Type 1 Type 2 Type 3 Type 3 Type 4 Type 4 Type 3 Type 3	Ku'= 0.165 Ku'= 0.150 Ku'= 0.130 Ku'= 0.110 Type 1 Type 2 Type 3 Type 4 Type 4 Type 4 Type 4 Type 4 Type 3 Type 3	Type 1 Type 2 Type 3 Type 3 Type 4 Type 4 Type 3 Type 3 Type 3 Type 3 Type 3 Type 4 Type 3 Type 3 Type 3 Type 3 Type 4 Type 4 Type 3 Type 4 Type 4 Type 3 Type 3 Type 4 Type 3 Type 4 Type 4 Type 4 Type 4 Type 4 Type 4 Type 3 Type 3<	Ku'= 0.150 Ku'= 0.150 Ku'= 0.130 Ku'= 0.110 Type 1 Type 2 Type 3 Type 4 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 3 Type 4 Type 3 Type 3	Ku'= 0.165 Ku'= 0.150 Ku'= 0.130 Ku'= 0.130 Ku'= 0.110 Type 1 Type 2 Type 3 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 3 Typ	Type 1 Type 2 Type 3 Type 4 Type 4 Type 3 Type 4 Type 3 Type 3 Type 4 Type 4 Type 4 Type 4 Type 4 Type 4 Type 3 Type 3 Type 3 Type 3 Type 4 Type 4 Type 3 Type 3 Type 3 Type 3 Type 4 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 4 Type 3 Type 3 Type 3 Type 4 Type 3 Type 3	Type 1 Type 2 Type 3 Type 4 Type 3 Type 3 Type 4 Type 4 Type 4 Type 3 Type 3	Type 1 Type 2 Type 3 Type 4 Type 3 Type 3 Type 4 Type 3 Type 4 Type 3 Type 4 Type 4 Type 3 Type 4 Type 3 Type 4 Type 3 Type 3 Type 3 Type 4 Type 3 Type 4 Type 3 Type 3 Type 3 Type 3 Type 4 Type 4 Type 3 Type 4 Type 3 Type 4 Type 4 Type 4 Type 3 Type 4 Type 3 Type 3	Type 1 Type 2 Type 4 Type 3 Type 4 Type 5 Type 3 Type 4 Type 4 Type 3 Type 4 Type 4 Type 4 Type 4 Type 3 Type 4 Type 3 Type 4 Type 4	Ku' = 0.165 Ku' = 0.165 Ku' = 0.165 Ku' = 0.130 Type 2 Type 2 Type 3 Type 4 Type	Type 1 Type 2 Type 3 Type 4 Type 4	Type 1 Type 2 Type 4 Type 3 Type 4 Type 4	Type 1 Type 2 Type 3 Type 4 Type 4 Type 3 Type 4 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 3 Type 4 4.5 4.6 4.6 4.8 4.4 4.5 4.6 4.6 4.7 4.7 4.9 4.6 4.6 4.7 4.7 4.9 4.6 4.7 4.7 4.9 4.0 4.6 4.6 4.8 4.9 4.0	Type 1 Type 2 Type 3 Type 4 Type 5 Type 3 Type 4 Type 3 Type 4 Type 4	Type 1 Type 2 Type 3 Type 3 Type 4 Type 4 Type 4 Type 3 Type 4 Type 3 Type 4 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 4 Type 4 Type 4 Type 3 Type 4 Type 3 Type 3 Type 3 Type 3 Type 3 Type 4 Type 4	Type 1 Type 2 Type 3 Type 4 Type 4	Type 1 Type 2 Type 3 Type 4 Type 4	$VU_1 = 0.165$ $VU_1 = 0.130$ $VU_2 $	Viy=0 $Viy=0$ <	$Vij_{i}=0.165$ $Vij_{i}=$	Type 1 Type 2 Type 3 Type 3 Type 4 Type 4	Type 1 Type 2 Type 3 Type 3 Type 4 Type 5 Type 4 Type 4 Type 5 Type 4 Type 5 Type 4 Type 5 Type 5 Type 5 Type 5 Type 4 Type 4 Type 4 Type 5 Type 5 Type 6 Type 6	Year Null Null <t< th=""><th>Number 1 Number 1 Number 1 Number 2 Number 3 Number 3 Number 4 Number 3 Number 4 Number 3 Number 4 Number 3 Number 4 Number 4 Number 3 Number 4 Number 4</th><th>Total Line Note of the control Line Note of the control Line Note of Line</th></t<>	Number 1 Number 1 Number 1 Number 2 Number 3 Number 3 Number 4 Number 3 Number 4 Number 3 Number 4 Number 3 Number 4 Number 4 Number 3 Number 4 Number 4	Total Line Note of the control Line Note of the control Line Note of Line

Table 19

 $^{\circ}$ ipe Size = 30 $^{\circ}$

			Type 4	5.1	5.2	5.3	5.4	5.5	5.5	5.6	5.7	5.8	5.9	5.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	6.5	9.9	6.7	6.7	6.8	6.9	6.9	6.9
		0.110	Type 3	2.0	5.1	5.1	5.2	5.3	5.4	5.5	5.5	5.6	5.7	5.8	5.9	5.9	0.9	6.1	6.2	6.2	6.3	6.4	6.4	6.5	9.9	9.9	2.9	8.9	8.9
		Ku' = (Type 2	2.0	5.1	5.1	5.2	5.3	5.4	5.5	5.5	5.6	5.7	5.8	6.3	5.9	0.9	6.1	6.2	6.2	6.3	6.4	6.4	6.5	9.9	9.9	6.7	8.9	8.9
			Type 1	4.8	4.9	5.0	5.1	5.1	5.2	5.3	5.4	5.5	5.5	5.6	2.7	5.8	5.8	5.9	0.9	6.1	6.1	6.2	6.3	6.3	6.4	6.5	6.5	9.9	9.9
			Type 4	2.5	5.3	5.4	5.5	9.6	2.2	5.8	5.9	0.9	6.1	6.2	6.2	6.3	6.4	6.5	9.9	2.9	8.9	8.9	6.9	2.0	7.1	7.1	7.2	7.3	7.3
		0.130	Type 3	5.1	5.2	5.3	5.4	5.4	5.5	5.6	5.7	5.8	5.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	6.7	6.7	8.9	6.9	7.0	2.0	7.1	7.1
		Ku' = 0.	Type 2	5.1	5.2	5.3	5.4	5.4	5.5	5.6	2.2	5.8	5.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	6.7	6.7	8.9	6.9	2.0	2.0	7.1	7.1
oths (FT)	2	-	Type 1	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.7	5.8	5.9	0.9	6.1	6.2	6.2	6.3	6.4	6.5	9.9	9.9	6.7	8.9	6.9	6.9	6.9
Transition Widths			Type 4	5.3	5.4	5.5	9.6	2.7	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	6.7	8.9	6.9	2.0	7.1	7.2	7.3	7.4	7.5	2.5	9.2	9.7
Trans		0.150	Type 3	5.1	5.3	5.4	5.5	9.6	2.2	5.8	6.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	2.9	8.9	8.9	6.9	2.0	7.1	7.2	7.3	7.4	7.4	7.4
		Ku' = 0.1	Type 2	5.1	5.3	5.4	5.5	9.6	5.7	5.8	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	2.9	8.9	8.9	6.9	2.0	7.1	7.2	7.3	7.4	7.4	7.4
		-	Type 1 T	2.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	8.9	8.9	6.9	2.0	7.1	7.2	7.3	7.3
			Type 4 T	5.4	5.5	5.6	2.2	5.8	0.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	8.9	6.9	0.7	7.1	7.2	7.3	7.4	7.5	9.2	7.7	7.8	6.2	6.7
		35	Type 3 T	5.2	5.3	5.4	9.6	2.2	5.8	5.9	0.9	6.1	6.2	6.3	6.4	9.9	6.7	8.9	6.9	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.7	7.7	7.7
		Ku' = 0.165	Type 2 T	5.2	5.3	5.4	9.6	2.2	5.8	5.9	0.9	6.1	6.2	6.3	6.4	9.9	6.7	8.9	6.9	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.7	7.7	7.7
		_	Type 1 T	2.0	5.2	5.3	5.4	5.5	9.6	5.7	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	8.9	6.9	2.0	7.1	7.1	7.2	7.3	7.4	7.5	7.5
				2		2	8	6	10	=	12	13	14	15	16	17	18		20	21	22	23	24	25	26	27	28	59	30
									_	_	_	_	_	_	_	_	_	_	7	7	0	7	7	7	0	0	7	2	က

Table 20

Pipe Size = 33"

		Type 4	9.6	5.7	5.8	5.8	5.9	0.9	6.1	6.2	6.2	6.3	6.4	6.5	9.9	9.9	6.7	8.9	6.9	6.9	2.0	7.1	7.1	7.2	7.3	7.4	7.4	7.4
	0.110	Type 3	5.4	5.5	9.6	2.7	2.2	5.8	6.3	0.9	6.1	6.1	6.2	6.3	6.4	6.5	6.5	9.9	6.7	6.7	8.9	6.9	2.0	2.0	7.1	7.2	7.2	7.2
	Ku' = 0	Type 2	5.4	5.5	9.6	2.2	2.2	5.8	6.3	0.9	6.1	6.1	6.2	6.3	6.4	6.5	6.5	9.9	6.7	6.7	8.9	6.9	2.0	2.0	7.1	7.1	7.2	7.2
		Type 1	5.2	5.3	5.4	5.5	5.6	9.6	2.5	5.8	6.5	0.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	9.9	6.7	8.9	8.9	6.9	2.0	7.1	7.1
		Type 4	2.2	5.8	5.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	6.7	8.9	6.9	2.0	7.1	7.1	7.2	7.3	7.4	2.2	2.2	9.2	7.7	7.8	7.8
	0.130	Type 3	5.5	5.6	2.7	5.8	5.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	6.7	6.8	6.9	2.0	7.0	7.1	7.2	7.3	7.4	7.4	2.5	9.2	9.7
F	Ku' = 0	Type 2	5.5	5.6	2.2	5.8	5.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	6.7	6.8	6.9	7.0	7.0	7.1	7.2	7.3	7.4	7.4	2.5	9.2	9.2
Transition Widths (FT)		Type 1	5.3	5.4	5.5	5.6	5.7	5.8	6.3	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	6.7	6.8	6.9	6.9	7.0	7.1	7.2	7.2	7.3	7.4	7.4
Sition W		Type 4	5.8	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	6.8	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.2	7.7	7.8	6.7	7.9	8.0	8.1	8.1
Trar	0.150	Type 3	5.6	5.7	5.8	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	6.8	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.7	2.7	7.8	2.8	6.7	7.9
	Ku' = C	Type 2	9.6	5.7	5.8	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	6.8	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.7	7.7	7.8	7.8	7.9	7.9
		Type 1	5.4	5.5	9.9	5.7	5.8	5.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	6.8	6.8	6.9	2.0	7.1	7.2	7.3	7.4	2.2	9.2	9.7	7.7	7.7
		Type 4	5.8	5.9	6.1	6.2	6.3	6.4	6.5	6.7	8.9	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.2	7.7	7.8	2.9	8.0	8.1	8.2	8.3	8.4	8.4
	0.165	Type 3	9.6	5.8	6.3	0.9	6.1	6.2	6.4	6.5	9.9	6.7	8.9	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.2	7.7	7.8	6.7	8.0	8.1	8.2	8.2
	Ku' = 0	Type 2	9.6	5.8	6.3	0.9	6.1	6.2	6.4	6.5	9.9	6.7	8.9	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.2	7.7	7.8	6.7	8.0	8.1	8.2	8.2
		Type 1	5.5	5.6	2.2	5.8	5.9	6.1	6.2	6.3	6.4	6.5	9.9	2.9	8.9	6.9	2.0	7.1	2.7	7.3	7.4	7.5	9.7	2.7	7.8	6'2	8.0	8.0
			2	9	7	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	56	27	28	29	30

Table 21

Size = 36

		Type 4	0.9	6.1	6.2	6.3	6.4	6.4	6.5	9.9	6.7	6.8	6.9	6.9	2.0	7.1	7.2	7.2	7.3	7.4	7.5	7.5	9.2	7.7	7.8	7.8	2.9	2.9
	0.110	Type 3	5.8	5.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	6.7	6.7	8.9	6.9	2.0	2.0	7.1	7.2	7.3	7.3	7.4	2.2	7.6	7.6	7.7	7.7
	Ku' = (Type 2	5.8	5.9	0.9	6.1	6.2	6.3	6.3	6.4	6.5	9.9	6.7	6.7	6.8	6.9	7.0	2.0	7.1	7.2	7.3	7.3	7.4	2.2	9.2	9.2	7.7	7.7
		Type 1	9.9	2.2	5.8	6.6	0.9	6.1	6.1	6.2	6.3	6.4	6.5	6.5	9.9	6.7	8.9	6.9	6.9	2.0	7.1	7.1	7.2	7.3	7.4	7.4	7.5	7.5
		Type 4	6.1	6.2	6.3	6.4	6.5	9.9	6.7	8.9	6.9	2.0	7.1	7.2	7.3	7.3	7.4	2.2	9.7	7.7	7.8	6.2	6.7	8.0	8.1	8.2	8.3	8.3
	0.130	Type 3	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	8.9	6.9	2.0	7.1	7.1	7.2	7.3	7.4	7.5	9.2	7.7	7.7	7.8	7.9	8.0	8.1	8.1
<u></u>	Ku' = 0	Type 2	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	2.9	8.9	6.9	2.0	7.1	7.1	7.2	7.3	7.4	7.5	9.2	7.7	7.7	7.8	7.9	8.0	8.1	8.1
idths (FI		Type 1	2.2	2.8	5.9	0.9	6.1	6.2	6.3	6.4	6.5	9.9	6.7	8.9	6.9	6.9	2.0	7.1	7.2	7.3	7.4	7.5	2.5	9.2	7.7	7.8	7.8	7.8
Transition Widths (FT		Type 4	6.2	6.3	6.4	6.5	6.7	8.9	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.7	7.7	7.8	6.7	8.0	8.1	8.2	8.2	8.3	8.4	8.5	9.8	8.6
Tran	0.150	Type 3	0.9	6.1	6.2	6.3	6.5	9.9	6.7	8.9	6.9	7.0	7.1	7.2	7.3	7.4	7.5	9.7	7.7	7.8	6.2	8.0	8.0	8.1	8.2	8.3	8.4	8.4
	Ku' = 0	Type 2	0.9	6.1	6.2	6.3	6.5	9.9	6.7	8.9	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.7	7.7	7.8	6.2	8.0	8.0	8.1	8.2	8.3	8.4	8.4
		Type 1	5.8	5.9	0.9	6.2	6.3	6.4	6.5	9.9	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	2.2	9.2	7.7	7.7	7.8	6.7	8.0	8.1	8.2	8.2
		Type 4	6.3	6.4	6.5	9.9	6.8	6.9	2.0	7.1	7.2	7.3	7.4	9.2	7.7	7.8	6.7	8.0	8.1	8.2	8.3	8.4	8.5	9.8	8.7	8.8	8.9	8.9
	0.165	Type 3	6.1	6.2	6.3	6.4	9.9	6.7	6.8	6.9	2.0	7.1	7.2	7.4	7.5	9.7	7.7	7.8	6.7	8.0	8.1	8.2	8.3	8.4	8.5	8.6	9.8	8.6
	Ku' = 0.	Type 2	6.1	6.2	6.3	6.4	9.9	6.7	6.8	6.9	2.0	7.1	7.2	7.4	7.5	9.7	7.7	7.8	6.7	8.0	8.1	8.2	8.3	8.4	8.5	8.6	9.8	8.6
		Type 1	5.9	0.9	6.1	6.2	6.4	6.5	9.9	6.7	8.9	6.9	2.0	7.2	7.3	7.4	7.5	9.2	7.7	7.8	6.7	8.0	8.1	8.2	8.2	8.3	8.4	8.4
			2	9	7	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	56	27	28	29	30

Table 22

2DIC																												
		Type 4	2.0	2.0	7.1	7.2	7.3	7.3	7.4	2.5	9.2	7.7	7.8	7.8	6.7	8.0	8.1	8.2	8.2	8.3	8.4	8.5	8.5	8.6	8.7	8.8	8.8	8.8
	0.110	Type 3	6.7	6.8	6.9	7.0	2.0	7.1	7.2	7.3	7.4	7.5	7.5	9.2	7.7	2.8	6.7	6.7	8.0	8.1	8.2	8.2	8.3	8.4	8.5	8.5	8.6	8.6
	Ku' = 0	Type 2	6.7	8.9	6.9	2.0	2.0	7.1	7.2	7.3	7.4	7.5	7.5	9.7	7.7	7.8	6.7	6.7	8.0	8.1	8.2	8.2	8.3	8.4	8.5	8.5	9.8	9.8
		Type 1	6.5	9.9	9.9	6.7	8.9	6.9	2.0	7.1	7.1	7.2	7.3	7.4	7.5	2.5	9.2	7.7	7.8	2.9	6.7	8.0	8.1	8.2	8.2	8.3	8.4	8.4
		Type 4	2.0	7.1	7.2	7.3	7.4	7.5	9.7	7.7	7.8	6.7	8.0	8.1	8.2	8.3	8.4	8.4	8.5	9.8	8.7	8.8	8.9	9.0	9.0	9.1	9.5	9.5
	0.130	Type 3	8.9	6.9	2.0	7.1	7.2	7.3	7.4	2.5	9.2	7.7	7.8	6.7	6.7	8.0	8.1	8.2	8.3	8.4	8.5	9.8	9.8	8.7	8.8	8.9	0.6	9.0
	Ku' = 0.	Type 2	8.9	6.9	2.0	7.1	7.2	7.3	7.4	2.5	9.2	7.7	7.8	6.7	6.7	8.0	8.1	8.2	8.3	8.4	8.5	9.8	9.8	8.7	8.8	8.9	9.0	9.0
dths (FT		Type 1	9.9	6.7	8.9	6.9	2.0	7.1	7.2	7.2	7.3	7.4	7.5	9.7	7.7	8.7	6.7	8.0	8.1	8.2	8.2	8.3	8.4	8.5	9.8	8.7	8.7	8.7
Transition Widths (FT)		Type 4	7.1	7.2	7.3	7.5	9.7	7.7	7.8	6.7	8.0	8.1	8.2	8.3	8.4	8.5	9.8	8.7	8.8	8.9	0.6	9.1	9.5	9.3	9.4	9.5	9.6	9.6
Transit	0.150	Type 3	6.9	2.0	7.1	7.2	7.3	7.4	9.7	7.7	7.8	6.7	8.0	8.1	8.2	8.3	8.4	8.5	9.8	8.7	8.8	8.9	0.6	9.1	9.1	9.5	9.3	9.3
	Ku' = 0.	Type 2	6.9	2.0	7.1	7.2	7.3	7.4	9.7	7.7	7.8	6.7	8.0	8.1	8.2	8.3	8.4	8.5	9.8	8.7	8.8	8.9	0.6	9.1	9.1	9.5	9.3	9.3
		Type 1	6.7	8.9	6.9	2.0	7.1	7.2	7.3	7.4	7.5	9.7	7.7	6.7	8.0	8.1	8.2	8.3	8.4	8.4	8.5	9.8	8.7	8.8	8.9	9.0	9.1	9.1
		Type 4	7.2	7.3	7.4	7.5	7.7	7.8	6.7	8.0	8.1	8.3	8.4	8.5	9.8	8.7	8.8	8.9	0.6	9.1	9.5	9.3	9.4	9.5	9.6	9.7	9.8	9.8
	65	Type 3		7.1	7.2	7.3	7.4	9.7	7.7	7.8	6.7	8.0	8.1	8.2	8.4	8.5	9.8	8.7	8.8	8.9	0.6	9.1	9.5	9.3	9.4	9.2	9.6	9.6
	Ku' = 0.165	Type 2		7.1	7.2	7.3	7.4	9.7	7.7	7.8	6.7	8.0	8.1	8.2	8.4	8.5	9.8	8.7	8.8	8.9	9.0	9.1	9.5	9.3	9.4	9.5	9.6	9.6
		Type 1		6.9	2.0	7.1	7.2	7.3	7.4	9.2	7.7	7.8	6.7	8.0	8.1	8.2	8.3	8.4	9.8	8.7	8.8	8.9	9.0	9.1	9.5	9.3	9.3	9.3
			2	9	7	8	6	10	=	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Table 23

Pipe Size = 48"

			Type 4	2.8	2.8	6.7	8.0	8.1	8.1	8.2	8.3	8.4	8.5	8.6	8.6	8.7	8.8	8.9	9.0	9.0	9.1	9.5	9.3	9.4	9.4	9.5	9.6	9.7	9.7
		0.110	Type 3	7.5	9.2	9.2	7.7	7.8	7.9	8.0	8.1	8.1	8.2	8.3	8.4	8.5	8.5	8.6	8.7	8.8	8.9	8.9	9.0	9.1	9.2	9.2	9.3	9.4	9.4
		Ku' = 0	Type 2	7.5	9.7	9.7	7.7	7.8	7.9	8.0	8.1	8.1	8.2	8.3	8.4	8.5	8.5	9.8	8.7	8.8	8.9	8.9	9.0	9.1	9.2	9.2	9.3	9.4	9.4
		•	Type 1	7.2	7.3	7.4	7.5	7.5	9.2	7.7	7.8	6.7	8.0	8.0	8.1	8.2	8.3	8.4	8.4	8.5	9.8	8.7	8.8	8.8	8.9	9.0	9.1	9.1	9.1
			Type 4	6.2	6.7	8.0	8.1	8.2	8.3	8.4	8.5	9.8	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.3	9.4	9.5	9.6	9.7	9.8	6.6	10.0	10.0	10.0
		0.130	Type 3	9.2	7.7	7.8	6.7	8.0	8.1	8.2	8.2	8.3	8.4	8.5	9.8	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.4	9.5	9.6	9.7	9.8	9.8
	<u>_</u>	Ku' = 0	Type 2	9.2	7.7	7.8	6.7	8.0	8.1	8.2	8.2	8.3	8.4	8.5	9.8	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.4	9.5	9.6	9.7	9.8	9.8
	Transition Widths (FT)		Type 1	7.3	7.4	2.7	9.7	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	9.8	9.8	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.3	9.4	9.5	9.5
<u>.</u>	sition W		Type 4	8.0	8.0	8.2	8.3	8.4	8.5	9.8	8.7	8.8	8.9	9.0	9.1	9.5	9.3	9.4	9.5	9.6	9.7	9.8	6.6	10.0	10.1	10.2	10.3	10.4	10.4
	Trar	0.150	Type 3	7.7	7.8	6.7	8.0	8.1	8.2	8.3	8.4	8.5	8.7	8.8	8.9	9.0	9.1	9.5	9.3	9.4	9.5	9.6	9.7	9.8	6.6	10.0	10.1	10.2	10.2
		Ku' = 0	Type 2	7.7	7.8	6.7	8.0	8.1	8.2	8.3	8.4	8.5	8.7	8.8	8.9	9.0	9.1	9.5	9.3	9.4	9.5	9.6	9.7	9.8	6.6	10.0	10.1	10.2	10.2
		•	Type 1	7.4	2.2	9.7	7.7	7.8	8.0	8.1	8.2	8.3	8.4	8.5	9.8	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	8.6	6.6	9.6
			Type 4	8.0	8.1	8.2	8.4	8.5	9.8	8.7	8.8	9.0	9.1	9.5	6.3	9.4	9.2	9.6	9.7	6.6	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.7
		.165	Type 3	7.8	6.7	8.0	8.1	8.2	8.3	8.5	9.8	8.7	8.8	8.9	0.6	9.2	9.3	9.4	9.2	9.6	6.7	9.8	6.6	10.0	10.1	10.2	10.3	10.4	10.4
		Ku' = 0.165	Type 2	7.8	6.7	8.0	8.1	8.2	8.3	8.5	9.8	8.7	8.8	8.9	0.6	9.2	9.3	9.4	9.2	9.6	6.7	9.8	6.6	10.0	10.1	10.2	10.3	10.4	10.4
			Type 1	2.5	9'2	2.7	8.7	0.8	8.1	8.2	8.3	8.4	9.5	2.8	8.8	6.8	0.6	1.6	8.2	6.3	9.4	9.5	9.6	2.6	8.6	6.6	10.0	1.01	10.1
				2	9	2	80	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

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Table 24

Pipe Size = 54"

	Ku' = 0.110	Type 1 Type 2 Type 3 Type 4	8.1 8.4 8.4 8.7	8.2 8.5 8.5 8.8	8.2 8.5 8.5 8.8	8.3 8.6 8.6 8.9	8.4 8.7 8.7 9.0	8.5 8.8 8.8 9.0	8.5 8.8 8.8 9.1	8.6 8.9 8.9 9.2	8.7 9.0 9.0 9.3	8.8 9.1 9.1 9.4	8.9 9.2 9.2 9.5	9.0 9.3 9.3 9.5	9.0 9.3 9.3 9.6	9.1 9.4 9.4 9.7	9.2 9.5 9.5 9.8	9.9 9.6 9.6 8.9	9.4 9.7 9.7 9.9	9.4 9.7 9.7 10.0	9.5 9.8 9.8 10.1	9.6 9.9 9.9 10.2	9.7 10.0 10.0 10.3	9.8 10.1 10.1 10.3	9.8 10.1 10.1 10.4	9.9 10.2 10.2 10.5	10.0 10.3 10.3 10.6	0 0 7
		Type 4	8.8	8.9	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	6.6	10.0	10.1	10.2	10.3	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	77
	- 0.130	Type 3	8.5	9.8	9.8	8.7	8.8	8.9	9.0	9.1	9.5	9.3	9.4	9.2	9.6	9.7	9.8	6.6	10.0	10.1	10.1	10.2	10.3	10.4	10.5	10.6	10.7	1
Ē	Ku'=	Type 2	8.5	8.6	8.6	8.7	8.8	8.9	9.0	9.1	9.5	9.3	9.4	9.5	9.6	9.7	9.8	6.6	10.0	10.1	10.1	10.2	10.3	10.4	10.5	10.6	10.7	1
Transition Widths (FT)		Type 1	8.2	8.3	8.4	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	2.6	9.8	6.6	6.6	10.0	10.1	10.2	10.3	10.4	,
Insition		Type 4	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	6.6	10.0	10.1	10.2	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.4	7 77
Tra	0.150	Type 3	8.6	8.7	8.8	8.9	9.0	9.1	9.5	9.3	9.4	9.5	9.6	9.7	6.6	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	777
	Ku'=	Type 2	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	6.6	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	7 77
		Type 1	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.5	9.6	9.7	9.8	6.6	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	0
		Type 4	8.9	9.0	9.2	9.3	9.4	9.5	9.6	9.7	6.6	10.0	10.1	10.2	10.3	10.4	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	77
	0.165	Type 3	8.6	8.7	8.9	9.0	9.1	9.2	9.3	9.2	9.6	9.7	9.8	6.6	10.0	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	7
	Ku' = 0	Type 2	9.8	8.7	8.9	9.0	9.1	9.5	9.3	9.5	9.6	9.7	9.8	6.6	10.0	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	,
		Type 1	8.3	8.4	8.6	8.7	8.8	8.9	9.0	9.2	9.3	9.4	9.5	9.6	9.7	6.6	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	,
			Ŋ	9	7	ω	တ	10	=	12	13	14	15	16	17	18	19	20	21	22	23	24	25	56	27	28	59	ć

Table 25

Pipe Size = 60"

Kui = 0.165 Kui = 0.150 I Vpee 2 Type 3 Type 4 Type 3 Type 3 Type 3 Type 3 Type 4 Type 3 Type 3 <th< th=""><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>•</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></th<>								•								
Ku = 0.165 Ku = 0.150 Ku = 0.150 Ku = 0.130 1 Vype 2 type 3 type 4 type 2 type 3 type 4 type 3 type 4 type 3 type 4 type 3 type 3 type 3 type 4 type 3 type 4 type 3 type 3 type 4 type 3 type 3 type 4 type 4 type 3 type 4 type 4 type 4 type 4 type 3 type 4 type 3 type 3 type 3 type 4 type 3 type 4 type 3 type 4 type 3							Tra	nsition V	Vidths (F	Œ.						
1 Type 2 Type 3 Type 4 Type 3		Ku' = (0.165			Ku' = (0.150		•	Ku' = (0.130		•	Ku' = (0.110	
9.5 9.6 9.9 9.0 9.6 9.9 9.0 9.4 9.7 9.7 9.6 9.6 9.6 9.9 9.1 9.4 9.4 9.8 9.7 9.7 10.1 9.3 9.6 9.6 9.0 9.4 9.4 9.8 9.9 9.9 10.2 9.4 9.8 9.6 10.0 9.2 9.5 9.9 10.0 10.0 10.2 9.4 9.8 10.1 9.3 9.6 9.0 9.4 9.7 9.9 10.0 10.0 10.3 9.5 9.9 9.9 10.2 9.4 9.8 10.1 10.1 10.1 10.4 9.6 10.0 10.3 9.5 9.9 9.9 9.9 9.9 9.9 9.9 9.9 9.9 9.9 9.0 9.0 9.0 9.0 9.0 9.0 9.0 9.0 9.0 9.0 9.0 9.0 9.0 9.0 9.	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4
9.6 9.6 <th>9.2</th> <th>9.5</th> <th>9.5</th> <th>6.6</th> <th>9.1</th> <th>9.2</th> <th>9.2</th> <th>9.8</th> <th>9.0</th> <th>9.4</th> <th>9.4</th> <th>6.7</th> <th>8.9</th> <th>9.3</th> <th>9.3</th> <th>9.6</th>	9.2	9.5	9.5	6.6	9.1	9.2	9.2	9.8	9.0	9.4	9.4	6.7	8.9	9.3	9.3	9.6
9.7 9.7 10.1 9.3 9.6 9.6 10.0 9.2 9.5 9.6 </td <td>9.3</td> <td>9.6</td> <td>9.6</td> <td>10.0</td> <td>9.2</td> <td>9.6</td> <td>9.6</td> <td>6.6</td> <td>9.1</td> <td>9.4</td> <td>9.4</td> <td>9.8</td> <td>9.0</td> <td>9.3</td> <td>9.3</td> <td>9.7</td>	9.3	9.6	9.6	10.0	9.2	9.6	9.6	6.6	9.1	9.4	9.4	9.8	9.0	9.3	9.3	9.7
9.5 9.9 9.9 9.9 9.9 9.0 <td>9.4</td> <td>9.7</td> <td>9.7</td> <td>10.1</td> <td>9.3</td> <td>9.6</td> <td>9.6</td> <td>10.0</td> <td>9.2</td> <td>9.5</td> <td>9.5</td> <td>6.6</td> <td>9.1</td> <td>9.4</td> <td>9.4</td> <td>9.7</td>	9.4	9.7	9.7	10.1	9.3	9.6	9.6	10.0	9.2	9.5	9.5	6.6	9.1	9.4	9.4	9.7
9.6 10.0 10.0 10.3 9.5 9.9 10.2 9.4 9.7 9.7 10.0 9.8 10.1 10.1 10.4 9.6 10.0 10.3 9.5 9.8 9.9 9.0 <td< td=""><td>9.5</td><td>9.9</td><td>6.6</td><td>10.2</td><td>9.4</td><td>9.8</td><td>9.8</td><td>10.1</td><td>9.3</td><td>9.6</td><td>9.6</td><td>6.6</td><td>9.1</td><td>9.5</td><td>9.5</td><td>9.8</td></td<>	9.5	9.9	6.6	10.2	9.4	9.8	9.8	10.1	9.3	9.6	9.6	6.6	9.1	9.5	9.5	9.8
9.8 10.1 10.4 9.6 10.0 10.0 10.3 9.5 9.8 9.9 10.1 9.9 10.2 10.2 10.2 10.2 10.2 10.2 10.0 10.0 10.0 9.9 9.9 9.0	9.6	10.0	10.0	10.3	9.5	6.6	6.6	10.2	9.4	9.7	9.7	10.0	9.2	9.5	9.5	9.6
9.9 10.2 10.5 9.8 10.1 10.1 10.4 9.6 9.9 9.9 10.2 10.0 10.3 10.6 9.9 10.2 10.5 10.5 9.9 10.0	9.8	10.1	10.1	10.4	9.6	10.0	10.0	10.3	9.5	9.8	9.8	10.1	9.3	9.6	9.6	9.6
10.0 10.3 10.3 10.6 9.9 10.2 10.5 9.7 10.0 10.0 10.3 10.2 10.5 9.7 10.0 10.0 10.3 10.2 10.6 9.8 10.1 10.1 10.4 10.2 10.	6.6	10.2	10.2	10.5	9.8	10.1	10.1	10.4	9.6	6.6	6.6	10.2	9.4	9.7	9.7	10.0
10.1 10.4 10.4 10.8 10.0 10.3 10.3 10.6 9.8 10.1 10.4 10.4 10.5 10.6 9.8 10.1 10.1 10.4 10.5 10.2 10.2 10.5 10.5 10.5 10.5 10.5 10.2 10.5 1	10.0	10.3	10.3	10.6	6.6	10.2	10.2	10.5	9.7	10.0	10.0	10.3	9.5	9.8	9.8	10.1
10.2 10.6 10.6 10.9 10.1 10.4 10.4 10.7 9.9 10.2 10.5 10.5 10.4 10.7 10.7 10.6 10.5 10.8 10.0 10.3 10.5 10.5 10.5 10.8 10.1 10.2 10.5 10.6 10.9 10.1 10.4 10.7 10.6 10.6 10.9 10.9 10.1 10.4 10.7 10.7 10.0 10.3 10.6 10.6 10.9 10.9 10.1 10.4 10.7 10.7 10.7 10.7 10.8 10.8 10.8 10.8 10.8 10.8 10.8 10.8 10.8 10.9	10.1	10.4	10.4	10.8	10.0	10.3	10.3	10.6	9.8	10.1	10.1	10.4	9.6	6.6	6.6	10.2
10.4 10.7 10.7 11.0 10.2 10.5 10.8 10.0 10.3 10.3 10.6 10.6 10.8 10.0 10.3 10.3 10.6 10.6 10.9 10.1 10.4 10.7 10.6 10.9 10.1 10.4 10.7 10.6 10.9 10.1 10.4 10.7 10.6 10.9 10.1 10.4 10.7 10.7 10.0 10.1 10.4 10.7 10.7 10.0 10.1 10.4 10.7 10.0 <td< td=""><td>10.2</td><td>10.6</td><td>10.6</td><td>10.9</td><td>10.1</td><td>10.4</td><td>10.4</td><td>10.7</td><td>6.6</td><td>10.2</td><td>10.2</td><td>10.5</td><td>9.6</td><td>10.0</td><td>10.0</td><td>10.3</td></td<>	10.2	10.6	10.6	10.9	10.1	10.4	10.4	10.7	6.6	10.2	10.2	10.5	9.6	10.0	10.0	10.3
10.5 10.8 10.1 10.6 10.6 10.9 10.1 10.4 10.7 10.6 10.9 10.1 10.4 10.7 10.7 10.0 10.1 10.5 10.5 10.8 10.9 10.6 10.9 11.2 10.4 10.5 10.8 10.2 10.2 10.6 10.9 10.9 10.2 10.6 10.9 10.9 10.2 10.6 10.9 10.9 11.0 10.1 10.6 10.9 10.9 11.0 10	 10.4	10.7	10.7	11.0	10.2	10.5	10.5	10.8	10.0	10.3	10.3	10.6	9.7	10.0	10.0	10.4
10.6 10.9 10.9 11.2 10.4 10.7 10.7 11.0 10.1 10.5 10.8 10.8 11.2 10.0 10.9 10.9 11.2 10.2 10.6 10.9 10.9 11.2 10.2 10.6 10.9 10.9 11.3 10.2 10.6 10.9 10.9 11.3 10.2 10.6 10.9 11.0 11.1 11.0 11.0 11.1 11.0 11.0 11.1 11.0 11.0 11.1 11.0 11.2 <th< td=""><td> 10.5</td><td>10.8</td><td>10.8</td><td>11.1</td><td>10.3</td><td>10.6</td><td>10.6</td><td>10.9</td><td>10.1</td><td>10.4</td><td>10.4</td><td>10.7</td><td>8.6</td><td>10.1</td><td>10.1</td><td>10.4</td></th<>	 10.5	10.8	10.8	11.1	10.3	10.6	10.6	10.9	10.1	10.4	10.4	10.7	8.6	10.1	10.1	10.4
10.7 11.0 11.0 11.4 10.5 10.8 11.2 10.6 10.9 10.9 11.2 10.6 10.9 10.9 11.2 10.7 10.0 10.0 10.8 11.2 11.5 10.6 10.9 10.9 11.3 10.7 10.7 11.0 11.1 11.4 11.4 11.7 10.8 11.2 11.5 10.8 10.8 10.1 11.1 11.2 11.5 11.6 11.9 11.3 11.6 10.6 10.9 11.2 11.2 11.2 10.5 10.8 10.9 11.1 11.2 11.5 11.6 11.3 11.4 11.4 11.7 10.7 11.0 11.4 11.4 11.7 10.7 11.0 11.4 11.4 11.4 11.4 11.7 10.7 11.0 11.4 11.4 11.4 11.4 11.7 11.0 11.0 11.4 11.4 11.4 11.4 11.7 11.7 11.7	10.6	10.9	10.9	11.2	10.4	10.7	10.7	11.0	10.1	10.5	10.5	10.8	6.6	10.2	10.2	10.5
10.8 11.2 11.5 10.6 10.9 10.9 11.3 10.7 10.7 10.0 10.9 11.3 11.2 11.6 10.7 11.0 11.4 10.4 10.8 10.7 11.1 11.1 11.4 11.4 11.5 11.2 11.2 11.5 10.6 10.8 10.8 11.1 11.2 11.5 11.6 11.9 11.3 11.3 11.5 10.5 10.9 10.9 11.3 11.3 11.6 11.6 11.9 11.0 11.4 11.4 11.4 11.7 10.7 11.0 11.4 11.4 11.4 11.7 11.2 11.6 11.5 11.5 11.5 11.5 11.6 11.7 11.7	10.7	11.0	11.0	11.4	10.5	10.8	10.8	11.2	10.2	10.6	10.6	10.9	10.0	10.3	10.3	10.6
10.9 11.3 11.6 10.7 11.0 11.0 11.4 10.4 10.8 10.8 11.1 11.1 11.4 11.4 11.7 10.8 11.2 11.5 10.5 10.8 10.8 11.2 11.2 11.5 11.5 11.8 10.9 11.3 11.6 10.6 10.9 10.9 11.3 11.3 11.6 11.6 11.9 11.0 11.4 11.7 10.7 11.0 11.4 11.4 11.4 11.7 11.7 11.6 11.6 11.6 11.9 10.9 11.1 11.4 11.5 11.8 12.1 11.1 11.6 11.6 11.9 10.9 11.2 11.6 11.6 11.6 11.9 11.2 11.6 11.7 11.7 11.7 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.1 11.2 11.2 11.2 11.2 1	10.8	11.2	11.2	11.5	10.6	10.9	10.9	11.3	10.3	10.7	10.7	11.0	10.0	10.4	10.4	10.7
11.1 11.4 11.7 10.8 11.2 11.5 11.5 10.8 10.9 11.2 11.2 11.5 11.5 11.8 10.9 11.3 11.6 10.6 10.9 10.9 11.3 11.3 11.6 11.6 11.9 11.0 11.1 11.1 11.0 11.0 11.4 11.4 11.7 11.7 11.5 11.5 11.6 11.9 10.9 11.1 11.4 11.5 11.8 11.2 11.6 11.9 10.9 11.2 11.5 11.5 11.6 11.9 12.3 11.3 11.7 11.7 11.0 11.3 11.6 11.7 12.0 12.0 12.0 11.0 11.3 11.6 11.7 11.6 11.7 11.7 12.0 12.0 12.1 11.1 11.4 11.4 11.7 11.6 11.9 11.6 11.9 11.9 12.2 12.2 12.6 11.6 12.0 12.0 12.0 12.0 12.0 12.0 12.0 12.	10.9	11.3	11.3	11.6	10.7	11.0	11.0	11.4	10.4	10.8	10.8	11.1	10.1	10.4	10.4	10.8
11.2 11.5 11.6 11.8 10.9 11.3 11.6 10.6 10.9 10.9 11.3 11.3 11.6 11.6 11.6 11.7 11.7 11.7 11.0 11.0 11.4 11.4 11.7 10.7 11.0 11.0 11.4 11.4 11.7 11.7 11.7 11.8 10.9 11.1 11.4 11.4 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.6 11.7	11.1	11.4	11.4	11.7	10.8	11.2	11.2	11.5	10.5	10.8	10.8	11.2	10.2	10.5	10.5	10.8
11.3 11.6 11.6 11.9 11.0 11.4 11.7 10.7 11.0 11.0 11.4 11.4 11.7 11.5 11.5 11.8 10.9 11.1 11.1 11.4 11.5 11.8 11.9 11.9 11.9 10.9 11.2 11.5 11.5 11.6 11.9 11.9 11.2 11.7 11.7 12.0 11.0 11.3 11.3 11.6 11.7 12.0 12.0 12.4 11.4 11.8 12.1 11.1 11.4 11.7 11.7 11.1 11.4 11.7 11.9 11.9 12.2 11.5 11.6 11.7 11.6 11.9 11.9 12.2 11.5 11.6 11.9 11.9 12.2 11.5 11.6 11.9 11.9 12.2 11.5 11.6 11.9 11.9 12.0 12.0 12.0 11.6 11.9 11.9 12.0 12.0 12.0 12.0 12.0 12.0 12.0 12.0 12.0 12.0 12.0 12.0 12.0 <td< td=""><td>11.2</td><td>11.5</td><td>11.5</td><td>11.8</td><td>10.9</td><td>11.3</td><td>11.3</td><td>11.6</td><td>10.6</td><td>10.9</td><td>10.9</td><td>11.3</td><td>10.3</td><td>10.6</td><td>10.6</td><td>10.9</td></td<>	11.2	11.5	11.5	11.8	10.9	11.3	11.3	11.6	10.6	10.9	10.9	11.3	10.3	10.6	10.6	10.9
11.4 11.7 11.7 12.0 11.1 11.5 11.8 10.8 11.1 11.1 11.4 11.5 11.8 11.8 11.2 11.6 11.6 11.9 10.9 11.2 11.2 11.5 11.6 11.9 11.9 11.9 11.7 11.7 11.7 11.0 11.3 11.3 11.6 11.6 11.7 12.0 12.0 12.4 11.4 11.8 11.9 12.2 11.4 11.4 11.7 11.8 12.1 12.1 12.1 11.5 11.6 12.0 <td< td=""><td>11.3</td><td>11.6</td><td>11.6</td><td>11.9</td><td>11.0</td><td>11.4</td><td>11.4</td><td>11.7</td><td>10.7</td><td>11.0</td><td>11.0</td><td>11.4</td><td>10.4</td><td>10.7</td><td>10.7</td><td>11.0</td></td<>	11.3	11.6	11.6	11.9	11.0	11.4	11.4	11.7	10.7	11.0	11.0	11.4	10.4	10.7	10.7	11.0
11.5 11.8 11.8 12.1 11.2 11.6 11.9 10.9 11.2 11.2 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.5 11.6 11.5 11.6 11.9 11.9 12.2 11.2 11.5 11.9 11.9 12.2 11.5 11.6 11.9 12.0 12.0 12.0 11.6 11.9 11.9 12.0 12.0 12.0 12.0 11.6 11.9 11.9 12.0	11.4	11.7	11.7	12.0	11.1	11.5	11.5	11.8	10.8	11.1	11.1	11.4	10.5	10.8	10.8	11.1
11.6 11.9 11.9 12.3 11.3 11.7 11.7 11.7 12.0 11.3 11.3 11.3 11.3 11.6 11.7 12.0 12.0 12.4 11.4 11.4 11.4 11.4 11.4 11.7 11.7 11.8 12.1 12.1 12.5 11.5 11.9 11.9 12.2 11.5 11.5 11.8 11.8 11.9 12.2 12.2 12.6 11.6 12.0 12.0 12.3 11.2 11.6 11.9 11.0 12.0 <td> 11.5</td> <td>11.8</td> <td>11.8</td> <td>12.1</td> <td>11.2</td> <td>11.6</td> <td>11.6</td> <td>11.9</td> <td>10.9</td> <td>11.2</td> <td>11.2</td> <td>11.5</td> <td>10.5</td> <td>10.8</td> <td>10.8</td> <td>11.2</td>	 11.5	11.8	11.8	12.1	11.2	11.6	11.6	11.9	10.9	11.2	11.2	11.5	10.5	10.8	10.8	11.2
11.7 12.0 12.0 12.4 11.4 11.8 11.8 12.1 11.4 11.5 11.5 11.5 11.8 11.8 11.8 11.8 11.8 11.8 11.8 11.8 11.9 11.0 12.0 <t< td=""><td> 11.6</td><td>11.9</td><td>11.9</td><td>12.3</td><td>11.3</td><td>11.7</td><td>11.7</td><td>12.0</td><td>11.0</td><td>11.3</td><td>11.3</td><td>11.6</td><td>10.6</td><td>10.9</td><td>10.9</td><td>11.2</td></t<>	 11.6	11.9	11.9	12.3	11.3	11.7	11.7	12.0	11.0	11.3	11.3	11.6	10.6	10.9	10.9	11.2
11.8 12.1 12.1 12.5 11.5 11.9 11.9 12.2 11.2 11.5 11.5 11.5 11.6 11.9 12.2 12.2 12.6 11.6 12.0 12.0 12.0 12.3 11.2 11.6 11.9 11.0 12.0 12.0 12.0 12.0 12.0 12.0 12.0 11.6 11.6 11.6	11.7	12.0	12.0	12.4	11.4	11.8	11.8	12.1	11.1	11.4	11.4	11.7	10.7	11.0	11.0	11.3
11.9 12.2 12.2 12.6 11.6 12.0 12.0 12.3 11.2 11.6 11.6 11.9	11.8	12.1	12.1	12.5	11.5	11.9	11.9	12.2	11.2	11.5	11.5	11.8	10.8	11.1	11.1	11.4
110 120 120 126 116 120 120 123 110 116 116 110	11.9	12.2	12.2	12.6	11.6	12.0	12.0	12.3	11.2	11.6	11.6	11.9	10.8	11.2	11.2	11.5
1.3 1	11.9	12.2	12.2	12.6	11.6	12.0	12.0	12.3	11.2	11.6	11.6	11.9	10.8	11.2	11.2	11.5

Table 26

Pipe Size = 66"

							Tra	nsition V	Transition Widths (FT)	F.						
		Ku' = 0	0.165			Ku' = (0.150			Ku' = (0.130			Ku' =	0.110	
	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4
2	10.1	10.4	10.4	10.8	10.0	10.4	10.4	10.7	6.6	10.3	10.3	10.7	8.6	10.2	10.2	10.6
9	10.2	10.5	10.5	10.9	10.1	10.4	10.4	10.8	10.0	10.3	10.3	10.7	6.6	10.2	10.2	10.6
7	10.3	10.6	10.6	11.0	10.2	10.5	10.5	10.9	10.0	10.4	10.4	10.8	6.6	10.3	10.3	10.6
80	10.4	10.7	10.7	11.1	10.3	10.6	10.6	11.0	10.1	10.5	10.5	10.9	10.0	10.3	10.3	10.7
တ	10.5	10.8	10.8	11.2	10.4	10.7	10.7	11.1	10.2	10.6	10.6	10.9	10.1	10.4	10.4	10.8
10	10.6	11.0	11.0	11.3	10.5	10.8	10.8	11.2	10.3	10.7	10.7	11.0	10.1	10.5	10.5	10.9
11	10.7	11.1	11.1	11.4	10.6	10.9	10.9	11.3	10.4	10.8	10.8	11.1	10.2	10.6	10.6	10.9
12	10.8	11.2	11.2	11.6	10.7	11.1	11.1	11.4	10.5	10.9	10.9	11.2	10.3	10.7	10.7	11.0
13	11.0	11.3	11.3	11.7	10.8	11.2	11.2	11.5	10.6	11.0	11.0	11.3	10.4	10.7	10.7	11.1
14	11.1	11.4	11.4	11.8	10.9	11.3	11.3	11.6	10.7	11.1	11.1	11.4	10.5	10.8	10.8	11.2
15	11.2	11.6	11.6	11.9	11.0	11.4	11.4	11.7	10.8	11.1	11.1	11.5	10.6	10.9	10.9	11.3
16	11.3	11.7	11.7	12.0	11.1	11.5	11.5	11.8	10.9	11.2	11.2	11.6	10.6	11.0	11.0	11.3
17	11.4	11.8	11.8	12.2	11.3	11.6	11.6	12.0	11.0	11.3	11.3	11.7	10.7	11.1	11.1	11.4
18	11.6	11.9	11.9	12.3	11.4	11.7	11.7	12.1	11.1	11.4	11.4	11.8	10.8	11.2	11.2	11.5
19	11.7	12.0	12.0	12.4	11.5	11.8	11.8	12.2	11.2	11.5	11.5	11.9	10.9	11.2	11.2	11.6
20	11.8	12.1	12.1	12.5	11.6	11.9	11.9	12.3	11.3	11.6	11.6	12.0	11.0	11.3	11.3	11.7
21	11.9	12.3	12.3	12.6	11.7	12.0	12.0	12.4	11.4	11.7	11.7	12.1	11.0	11.4	11.4	11.7
22	12.0	12.4	12.4	12.7	11.8	12.1	12.1	12.5	11.5	11.8	11.8	12.2	11.1	11.5	11.5	11.8
23	12.1	12.5	12.5	12.8	11.9	12.2	12.2	12.6	11.6	11.9	11.9	12.3	11.2	11.6	11.6	11.9
24	12.2	12.6	12.6	13.0	12.0	12.3	12.3	12.7	11.6	12.0	12.0	12.4	11.3	11.6	11.6	12.0
25	12.4	12.7	12.7	13.1	12.1	12.5	12.5	12.8	11.7	12.1	12.1	12.4	11.4	11.7	11.7	12.1
56	12.5	12.8	12.8	13.2	12.2	12.6	12.6	12.9	11.8	12.2	12.2	12.5	11.5	11.8	11.8	12.2
27	12.6	12.9	12.9	13.3	12.3	12.7	12.7	13.0	11.9	12.3	12.3	12.6	11.5	11.9	11.9	12.2
28	12.7	13.0	13.0	13.4	12.4	12.8	12.8	13.1	12.0	12.4	12.4	12.7	11.6	12.0	12.0	12.3
58	12.8	13.2	13.2	13.5	12.5	12.9	12.9	13.2	12.1	12.5	12.5	12.8	11.7	12.0	12.0	12.4
30	12.8	13.2	13.2	13.5	12.5	12.9	12.9	13.2	12.1	12.5	12.5	12.8	11.7	12.0	12.0	12.4

Table 27

Pipe Size = 72"

		Type 4	11.5	11.5	11.6	11.6	11.7	11.8	11.8	11.9	12.0	12.1	12.1	12.2	12.3	12.4	12.5	12.6	12.6	12.7	12.8	12.9	13.0	13.1	13.1	13.2	13.3	13.3
	0.110	Type 3	11.1	11.1	11.2	11.2	11.3	11.4	11.4	11.5	11.6	11.7	11.8	11.9	11.9	12.0	12.1	12.2	12.3	12.3	12.4	12.5	12.6	12.7	12.8	12.8	12.9	12.9
	Ku' = 0.110	Type 2	11.1	11.1	11.2	11.2	11.3	11.4	11.4	11.5	11.6	11.7	11.8	11.9	11.9	12.0	12.1	12.2	12.3	12.3	12.4	12.5	12.6	12.7	12.8	12.8	12.9	12.9
		Type 1	10.7	10.7	10.8	10.8	10.9	11.0	11.1	11.1	11.2	11.3	11.4	11.5	11.6	11.6	11.7	11.8	11.9	12.0	12.1	12.1	12.2	12.3	12.4	12.5	12.5	12.5
		Type 4	11.6	11.6	11.7	11.8	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.4	13.5	13.6	13.7	13.7
	.130	Type 3	11.2	11.2	11.3	11.4	11.5	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.2	13.3	13.3
F.	Ku' = 0.130	Type 2	11.2	11.2	11.3	11.4	11.5	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.2	13.3	13.3
Transition Widths (FT)		Type 1	10.8	10.8	10.9	11.0	11.1	11.2	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.0
Sition W		Type 4	11.7	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.1	14.1
Trar	.150	Type 3	11.3	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.7
	Ku' = 0.150	Type 2	11.3	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.7
		Type 1	10.9	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.1	13.2	13.3	13.4	13.4
		Type 4	11.8	11.8	11.9	12.0	12.1	12.2	12.3	12.5	12.6	12.7	12.8	12.9	13.1	13.2	13.3	13.4	13.5	13.6	13.8	13.9	14.0	14.1	14.2	14.3	14.4	14.4
	.165	Type 3	11.3	11.4	11.5	11.6	11.7	11.8	12.0	12.1	12.2	12.3	12.4	12.6	12.7	12.8	12.9	13.0	13.1	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.0
	Ku' = 0.165	Type 2	11.3	11.4	11.5	11.6	11.7	11.8	12.0	12.1	12.2	12.3	12.4	12.6	12.7	12.8	12.9	13.0	13.1	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.0
		Type 1	10.9	11.0	11.1	11.2	11.3	11.5	11.6	11.7	11.8	11.9	12.1	12.2	12.3	12.4	12.5	12.6	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.7	13.7
			2	9	7	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	56	27	28	59	30

Table 28

Pipe Size = 78"

						Tra	nsition V	Transition Widths (FT)	F.						
	Ku'=	= 0.165			Ku' = (0.150			Ku' = (0.130			Ku'=	0.110	
Туре	1 Type 2	2 Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4
11.8				11.7	12.2	12.2	12.6	11.6	12.1	12.1	12.5	11.5	12.0	12.0	12.5
11.9	12.3	12.3	12.8	11.8	12.2	12.2	12.7	11.7	12.1	12.1	12.6	11.6	12.0	12.0	12.5
12.0	12.4	12.4	12.8	11.9	12.3	12.3	12.7	11.7	12.2	12.2	12.6	11.6	12.1	12.1	12.5
12.1	12.5	12.5	12.9	12.0	12.4	12.4	12.8	11.8	12.3	12.3	12.7	11.7	12.1	12.1	12.5
12.2	12.6	12.6	13.0	12.1	12.5	12.5	12.9	11.9	12.3	12.3	12.8	11.7	12.2	12.2	12.6
12.3	12.7	12.7	13.1	12.2	12.6	12.6	13.0	12.0	12.4	12.4	12.8	11.8	12.2	12.2	12.7
12.4	12.8	12.8	13.3	12.3	12.7	12.7	13.1	12.1	12.5	12.5	12.9	11.9	12.3	12.3	12.7
12.5	13.0	13.0	13.4	12.4	12.8	12.8	13.2	12.2	12.6	12.6	13.0	12.0	12.4	12.4	12.8
12.7	13.1	13.1	13.5	12.5	12.9	12.9	13.3	12.3	12.7	12.7	13.1	12.1	12.5	12.5	12.9
12.8	13.2	13.2	13.6	12.6	13.0	13.0	13.4	12.4	12.8	12.8	13.2	12.1	12.6	12.6	13.0
12.9	13.3	13.3	13.7	12.7	13.1	13.1	13.5	12.5	12.9	12.9	13.3	12.2	12.6	12.6	13.0
13.0	13.4	13.4	13.9	12.8	13.2	13.2	13.7	12.6	13.0	13.0	13.4	12.3	12.7	12.7	13.1
13.1	13.6	13.6	14.0	12.9	13.4	13.4	13.8	12.7	13.1	13.1	13.5	12.4	12.8	12.8	13.2
13.3	13.7	13.7	14.1	13.0	13.5	13.5	13.9	12.8	13.2	13.2	13.6	12.5	12.9	12.9	13.3
13.4	. 13.8	13.8	14.2	13.2	13.6	13.6	14.0	12.9	13.3	13.3	13.7	12.6	13.0	13.0	13.4
13.5	13.9	13.9	14.3	13.3	13.7	13.7	14.1	13.0	13.4	13.4	13.8	12.6	13.0	13.0	13.5
13.6	14.0	14.0	14.4	13.4	13.8	13.8	14.2	13.1	13.5	13.5	13.9	12.7	13.1	13.1	13.5
13.7	14.1	14.1	14.6	13.5	13.9	13.9	14.3	13.1	13.6	13.6	14.0	12.8	13.2	13.2	13.6
13.8	14.3	14.3	14.7	13.6	14.0	14.0	14.4	13.2	13.7	13.7	14.1	12.9	13.3	13.3	13.7
14.0	14.4	14.4	14.8	13.7	14.1	14.1	14.5	13.3	13.8	13.8	14.2	13.0	13.4	13.4	13.8
14.1	14.5	14.5	14.9	13.8	14.2	14.2	14.6	13.4	13.8	13.8	14.3	13.1	13.5	13.5	13.9
14.2	14.6	14.6	15.0	13.9	14.3	14.3	14.7	13.5	13.9	13.9	14.4	13.1	13.5	13.5	14.0
14.3	14.7	14.7	15.1	14.0	14.4	14.4	14.8	13.6	14.0	14.0	14.4	13.2	13.6	13.6	14.0
14.4	. 14.8	14.8	15.2	14.1	14.5	14.5	14.9	13.7	14.1	14.1	14.5	13.3	13.7	13.7	14.1
14.5	14.9	14.9	15.4	14.2	14.6	14.6	15.1	13.8	14.2	14.2	14.6	13.4	13.8	13.8	14.2
14.5	14.9	14.9	15.4	14.2	14.6	14.6	15.1	13.8	14.2	14.2	14.6	13.4	13.8	13.8	14.2

Table 29

Pipe Size = 84"

								•								
							Tra	Transition Widths (FT)	Vidths (F	[
		Ku' = 0	0.165			Ku' = (0.150			Ku' = (0.130			Ku'=	0.110	
	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4
2	12.6	13.1	13.1	13.6	12.5	13.0	13.0	13.5	12.4	12.9	12.9	13.4	12.3	12.8	12.8	13.3
9	12.6	13.1	13.1	13.6	12.6	13.0	13.0	13.5	12.4	12.9	12.9	13.4	12.3	12.8	12.8	13.3
7	12.7	13.2	13.2	13.7	12.6	13.1	13.1	13.6	12.5	13.0	13.0	13.4	12.4	12.8	12.8	13.3
ω	12.8	13.3	13.3	13.8	12.7	13.2	13.2	13.7	12.6	13.0	13.0	13.5	12.4	12.9	12.9	13.4
6	12.9	13.4	13.4	13.9	12.8	13.3	13.3	13.7	12.7	13.1	13.1	13.6	12.5	13.0	13.0	13.4
10	13.0	13.5	13.5	14.0	12.9	13.4	13.4	13.8	12.7	13.2	13.2	13.7	12.6	13.0	13.0	13.5
1	13.2	13.6	13.6	14.1	13.0	13.5	13.5	13.9	12.8	13.3	13.3	13.7	12.6	13.1	13.1	13.5
12	13.3	13.7	13.7	14.2	13.1	13.6	13.6	14.0	12.9	13.4	13.4	13.8	12.7	13.2	13.2	13.6
13	13.4	13.9	13.9	14.3	13.2	13.7	13.7	14.1	13.0	13.5	13.5	13.9	12.8	13.2	13.2	13.7
14	13.5	14.0	14.0	14.4	13.3	13.8	13.8	14.2	13.1	13.6	13.6	14.0	12.9	13.3	13.3	13.8
15	13.6	14.1	14.1	14.5	13.5	13.9	13.9	14.4	13.2	13.7	13.7	14.1	13.0	13.4	13.4	13.8
16	13.8	14.2	14.2	14.7	13.6	14.0	14.0	14.5	13.3	13.8	13.8	14.2	13.0	13.5	13.5	13.9
17	13.9	14.3	14.3	14.8	13.7	14.1	14.1	14.6	13.4	13.9	13.9	14.3	13.1	13.6	13.6	14.0
18	14.0	14.5	14.5	14.9	13.8	14.2	14.2	14.7	13.5	13.9	13.9	14.4	13.2	13.7	13.7	14.1
19	14.1	14.6	14.6	15.0	13.9	14.3	14.3	14.8	13.6	14.0	14.0	14.5	13.3	13.7	13.7	14.2
20	14.2	14.7	14.7	15.1	14.0	14.5	14.5	14.9	13.7	14.1	14.1	14.6	13.4	13.8	13.8	14.3
21	14.4	14.8	14.8	15.3	14.1	14.6	14.6	15.0	13.8	14.2	14.2	14.7	13.5	13.9	13.9	14.3
22	14.5	14.9	14.9	15.4	14.2	14.7	14.7	15.1	13.9	14.3	14.3	14.8	13.5	14.0	14.0	14.4
23	14.6	15.0	15.0	15.5	14.3	14.8	14.8	15.2	14.0	14.4	14.4	14.9	13.6	14.1	14.1	14.5
24	14.7	15.2	15.2	15.6	14.4	14.9	14.9	15.3	14.1	14.5	14.5	15.0	13.7	14.1	14.1	14.6
25	14.8	15.3	15.3	15.7	14.6	15.0	15.0	15.4	14.2	14.6	14.6	15.1	13.8	14.2	14.2	14.7
56	14.9	15.4	15.4	15.8	14.7	15.1	15.1	15.6	14.3	14.7	14.7	15.2	13.9	14.3	14.3	14.8
27	15.1	15.5	15.5	16.0	14.8	15.2	15.2	15.7	14.4	14.8	14.8	15.3	14.0	14.4	14.4	14.8
28	15.2	15.6	15.6	16.1	14.9	15.3	15.3	15.8	14.5	14.9	14.9	15.3	14.0	14.5	14.5	14.9
59	15.3	15.7	15.7	16.2	15.0	15.4	15.4	15.9	14.6	15.0	15.0	15.4	14.1	14.6	14.6	15.0
30	15.3	15.7	15.7	16.2	15.0	15.4	15.4	15.9	14.6	15.0	15.0	15.4	14.1	14.6	14.6	15.0

Table 30

Pipe Size = 90"

Table 31

Pipe Size = 96"

Г																													1
			Type 4	15.2	15.2	15.2	15.2	15.3	15.3	15.4	15.4	15.5	15.6	15.7	15.7	15.8	15.9	16.0	16.1	16.1	16.2	16.3	16.4	16.5	16.5	16.6	16.7	16.8	16.8
		0.110	Type 3	14.7	14.7	14.7	14.7	14.7	14.8	14.8	14.9	15.0	15.1	15.1	15.2	15.3	15.4	15.5	15.5	15.6	15.7	15.8	15.9	16.0	16.0	16.1	16.2	16.3	16.3
		Ku' = 0.110	Type 2	14.7	14.7	14.7	14.7	14.7	14.8	14.8	14.9	15.0	12.1	15.1	15.2	15.3	15.4	15.5	15.5	15.6	15.7	15.8	15.9	16.0	16.0	16.1	16.2	16.3	16.3
			Type 1	14.1	14.1	14.1	14.1	14.2	14.3	14.3	14.4	14.5	14.6	14.6	14.7	14.8	14.9	15.0	15.0	15.1	15.2	15.3	15.4	15.5	15.5	15.6	15.7	15.8	15.8
			Type 4	15.3	15.3	15.3	15.4	15.4	15.5	15.6	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2	17.2	17.2
		0.130	Type 3	14.8	14.8	14.8	14.8	14.9	15.0	15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.6	16.7	16.7
	(F	Ku' = 0	Type 2	14.8	14.8	14.8	14.8	14.9	15.0	15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.6	16.7	16.7
	Transition Widths (FT)		Type 1	14.2	14.2	14.2	14.3	14.4	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.0	16.1	16.2	16.2
•	sition V		Type 4	15.4	15.4	15.5	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.2	17.3	17.4	17.5	17.6	17.7	17.7
	Tra	0.150	Type 3	14.9	14.9	14.9	15.0	15.1	15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.8	16.9	17.0	17.1	17.2	17.2
		Ku' = (Type 2	14.9	14.9	14.9	15.0	15.1	15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.8	16.9	17.0	17.1	17.2	17.2
			Type 1	14.3	14.3	14.4	14.4	14.5	14.6	14.7	14.8	14.9	15.0	12.1	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.4	16.5	16.6	16.7	16.7
	•		Type 4	15.5	15.5	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.4	16.5	16.6	16.7	16.8	17.0	17.1	17.2	17.3	17.4	17.5	17.7	17.8	17.9	18.0	18.0
		.165	Type 3	14.9	14.9	15.0	12.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	16.0	16.1	16.2	16.3	16.4	16.6	16.7	16.8	16.9	17.0	17.2	17.3	17.4	17.5	17.5
		Ku' = 0.165	Type 2	14.9	14.9	15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	16.0	16.1	16.2	16.3	16.4	16.6	16.7	16.8	16.9	17.0	17.2	17.3	17.4	17.5	17.5
			Type 1	14.3	14.4	14.5	14.5	14.6	14.7	14.9	15.0	15.1	15.2	15.3	15.4	15.6	15.7	15.8	15.9	16.1	16.2	16.3	16.4	16.5	16.6	16.8	16.9	17.0	17.0
				5	9	7	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	56	27	28	59	30

Table 32

Pipe Size = 102"

	Ku' = 0.110	e 4 Type 1 Type 2 Type 3 Type 4	.3 15.0 15.6 15.6 16.2	.3 15.0 15.6 15.6 16.2	.3 15.0 15.6 15.6 16.2	.3 15.0 15.6 15.6 16.2	.3 15.1 15.6 15.6 16.2	.4 15.1 15.7 15.7 16.2	.5 15.2 15.7 16.3	.6 15.2 15.8 15.8 16.3	.6 15.3 15.9 15.9 16.4	7 15.4 15.9 15.9 16.5	8 15.5 16.0 16.0 16.6	.9 15.6 16.1 16.1 16.6	0.0 15.6 16.2 16.2 16.7	15.7 16.3 16.3 16.8	22 15.8 16.3 16.3 16.9	3 15.9 16.4 16.4 17.0	.4 16.0 16.5 16.5 17.0	5 16.0 16.6 16.6 17.1	.6 16.1 16.7 16.7 17.2	7 16.2 16.7 16.7 17.3	.8 16.3 16.8 16.8 17.4	39 16.4 16.9 16.9 17.4	0.0 16.5 17.0 17.0 17.5	1 16.5 17.1 17.1 17.6	1.71	16.6 17.2 17.2
	0.130	Type 3 Type	15.7 16.3	15.7 16.3	15.7 16.3	15.7 16.3	15.8 16.3	15.9 16.4	15.9 16.5	16.0 16.6	16.1 16.6	16.2 16.7	16.3 16.8	16.4 16.9	16.5 17.0	16.6 17.1	16.7 17.2	16.8 17.3	16.8 17.4	16.9 17.5	17.0 17.6	17.1 17.7	17.2 17.8	17.3 17.9	17.4 18.0	17.5 18.1	17.6 18.2	
	Ku' = 0.	Type 2	15.7	15.7	15.7	15.7	15.8	15.9	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.8	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	
		Type 1	15.1	15.1	15.1	15.2	15.2	15.3	15.4	15.5	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	
()		Type 4	16.4	16.4	16.4	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.1	18.2	18.3	18.4	18.5	18.6	
=	0.150	Type 3	15.8	15.8	15.8	15.9	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	18.0	18.1	
	Ku' = (Type 2	15.8	15.8	15.8	15.9	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	18.0	18.1	
		Type 1	15.2	15.2	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.8	16.9	17.0	17.1	17.2	17.3	17.4	17.5	
		Type 4	16.5	16.5	16.5	16.6	16.6	16.7	16.8	16.9	17.0	17.2	17.3	17.4	17.5	17.6	17.7	17.9	18.0	18.1	18.2	18.3	18.5	18.6	18.7	18.8	18.9	
	0.165	Type 3	15.9	15.9	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	17.0	17.1	17.2	17.3	17.4	17.6	17.7	17.8	17.9	18.0	18.2	18.3	18.4	
	Ku' = 0	Type 2	15.9	15.9	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	17.0	17.1	17.2	17.3	17.4	17.6	17.7	17.8	17.9	18.0	18.2	18.3	18.4	
		Type 1	15.2	15.3	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.1	16.2	16.3	16.4	16.5	16.7	16.8	16.9	17.0	17.1	17.3	17.4	17.5	17.6	17.7	17.8	
			2	9	2	80	6	10	7	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	

Table 33

Pipe Size = 108"

								Trai	Transition Widths (FT)	Vidths (F	ı.						
1561 1796			K1,=(165			K11'=(-	Κ -, -	130			K.	0 110	
16.1 16.8 16.8 17.4 16.1 16.7 16.0 16.6 16.8 16.8 16.8 17.4 16.0 16.6 17.3 15.9 16.5 <th< th=""><th></th><th>Type 1</th><th>Type 2</th><th>ι ο</th><th>Type 4</th><th>Type 1</th><th>Type 2</th><th>Type 3</th><th>Type 4</th><th>Type 1</th><th></th><th>Type 3</th><th>Type 4</th><th>Type 1</th><th></th><th>Type 3</th><th>Type 4</th></th<>		Type 1	Type 2	ι ο	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1		Type 3	Type 4	Type 1		Type 3	Type 4
16.1 16.8 16.8 17.4 16.1 16.0 16.6 16.6 16.6 16.6 16.6 16.9 16.9 16.5 <th< th=""><th>5</th><th>16.1</th><th>16.8</th><th>16.8</th><th>17.4</th><th>16.1</th><th>16.7</th><th>16.7</th><th>17.4</th><th>16.0</th><th>16.6</th><th>16.6</th><th>17.3</th><th>15.9</th><th>16.5</th><th>16.5</th><th>17.2</th></th<>	5	16.1	16.8	16.8	17.4	16.1	16.7	16.7	17.4	16.0	16.6	16.6	17.3	15.9	16.5	16.5	17.2
162 168 168 168 169 160 <td>9</td> <td>16.1</td> <td>16.8</td> <td>16.8</td> <td>17.4</td> <td>16.1</td> <td>16.7</td> <td>16.7</td> <td>17.4</td> <td>16.0</td> <td>16.6</td> <td>16.6</td> <td>17.3</td> <td>15.9</td> <td>16.5</td> <td>16.5</td> <td>17.2</td>	9	16.1	16.8	16.8	17.4	16.1	16.7	16.7	17.4	16.0	16.6	16.6	17.3	15.9	16.5	16.5	17.2
16.3 16.9 <th< td=""><td>7</td><td>16.2</td><td>16.8</td><td>16.8</td><td>17.4</td><td>16.1</td><td>16.7</td><td>16.7</td><td>17.4</td><td>16.0</td><td>16.6</td><td>16.6</td><td>17.3</td><td>15.9</td><td>16.5</td><td>16.5</td><td>17.2</td></th<>	7	16.2	16.8	16.8	17.4	16.1	16.7	16.7	17.4	16.0	16.6	16.6	17.3	15.9	16.5	16.5	17.2
16.4 17.0 17.0 16.2 16.9 16.4 16.1 16.7 16.7 16.3 16.9 16.9 16.9 16.9 16.0 <th< td=""><td>80</td><td>16.3</td><td>16.9</td><td>16.9</td><td>17.5</td><td>16.2</td><td>16.8</td><td>16.8</td><td>17.4</td><td>16.0</td><td>16.6</td><td>16.6</td><td>17.3</td><td>15.9</td><td>16.5</td><td>16.5</td><td>17.2</td></th<>	80	16.3	16.9	16.9	17.5	16.2	16.8	16.8	17.4	16.0	16.6	16.6	17.3	15.9	16.5	16.5	17.2
16.5 17.1 17.7 16.3 16.9 17.9 16.9 <th< td=""><td>6</td><td>16.4</td><td>17.0</td><td>17.0</td><td>17.6</td><td>16.2</td><td>16.8</td><td>16.8</td><td>17.4</td><td>16.1</td><td>16.7</td><td>16.7</td><td>17.3</td><td>15.9</td><td>16.5</td><td>16.5</td><td>17.2</td></th<>	6	16.4	17.0	17.0	17.6	16.2	16.8	16.8	17.4	16.1	16.7	16.7	17.3	15.9	16.5	16.5	17.2
16.6 17.2 17.2 16.4 17.0 17.0 17.0 16.0 <th< td=""><td>10</td><td>16.5</td><td>17.1</td><td>17.1</td><td>17.7</td><td>16.3</td><td>16.9</td><td>16.9</td><td>17.5</td><td>16.1</td><td>16.7</td><td>16.7</td><td>17.3</td><td>16.0</td><td>16.6</td><td>16.6</td><td>17.2</td></th<>	10	16.5	17.1	17.1	17.7	16.3	16.9	16.9	17.5	16.1	16.7	16.7	17.3	16.0	16.6	16.6	17.2
16.7 17.3 17.3 17.3 17.3 16.3 <th< td=""><td>11</td><td>16.6</td><td>17.2</td><td>17.2</td><td>17.7</td><td>16.4</td><td>17.0</td><td>17.0</td><td>17.6</td><td>16.2</td><td>16.8</td><td>16.8</td><td>17.4</td><td>16.0</td><td>16.6</td><td>16.6</td><td>17.2</td></th<>	11	16.6	17.2	17.2	17.7	16.4	17.0	17.0	17.6	16.2	16.8	16.8	17.4	16.0	16.6	16.6	17.2
16.8 17.4 18.0 16.6 17.2 17.2 17.8 16.4 17.0 17.0 17.0 16.0 16.7 16.7 17.2 17.3 16.3 16.4 17.0 17.0 17.0 16.0 <th< td=""><td>12</td><td>16.7</td><td>17.3</td><td>17.3</td><td>17.8</td><td>16.5</td><td>17.1</td><td>17.1</td><td>17.7</td><td>16.3</td><td>16.9</td><td>16.9</td><td>17.5</td><td>16.1</td><td>16.7</td><td>16.7</td><td>17.3</td></th<>	12	16.7	17.3	17.3	17.8	16.5	17.1	17.1	17.7	16.3	16.9	16.9	17.5	16.1	16.7	16.7	17.3
1.5. 1.5. 18.1 16.7 17.3 17.3 17.3 16.5 17.1 17.6 16.5 16.9 16.9 16.5 17.1 17.2 17.2 17.2 17.2 17.2 17.2 17.2 17.2 16.9 16.9 17.2 <th< td=""><td>13</td><td>16.8</td><td>17.4</td><td>17.4</td><td>18.0</td><td>16.6</td><td>17.2</td><td>17.2</td><td>17.8</td><td>16.4</td><td>17.0</td><td>17.0</td><td>17.6</td><td>16.2</td><td>16.7</td><td>16.7</td><td>17.3</td></th<>	13	16.8	17.4	17.4	18.0	16.6	17.2	17.2	17.8	16.4	17.0	17.0	17.6	16.2	16.7	16.7	17.3
17.0 17.6 18.2 16.8 17.4 17.4 18.0 16.6 17.2 <th< td=""><td>14</td><td>16.9</td><td>17.5</td><td>17.5</td><td>18.1</td><td>16.7</td><td>17.3</td><td>17.3</td><td>17.9</td><td>16.5</td><td>17.1</td><td>17.1</td><td>17.6</td><td>16.2</td><td>16.8</td><td>16.8</td><td>17.4</td></th<>	14	16.9	17.5	17.5	18.1	16.7	17.3	17.3	17.9	16.5	17.1	17.1	17.6	16.2	16.8	16.8	17.4
17.1 17.7 18.3 16.9 17.5 18.1 16.7 17.2 17.2 17.2 17.9 16.4 17.0 17.0 17.3 17.8 17.8 17.6 17.7 17	15	17.0	17.6	17.6	18.2	16.8	17.4	17.4	18.0	16.6	17.2	17.2	17.7	16.3	16.9	16.9	17.5
17.3 17.8 17.8 17.0 <th< td=""><td>16</td><td>17.1</td><td>17.7</td><td>17.7</td><td>18.3</td><td>16.9</td><td>17.5</td><td>17.5</td><td>18.1</td><td>16.7</td><td>17.2</td><td>17.2</td><td>17.8</td><td>16.4</td><td>17.0</td><td>17.0</td><td>17.5</td></th<>	16	17.1	17.7	17.7	18.3	16.9	17.5	17.5	18.1	16.7	17.2	17.2	17.8	16.4	17.0	17.0	17.5
17.4 18.0 18.0 18.0 18.0 17.0 <td< td=""><td>17</td><td>17.3</td><td>17.8</td><td>17.8</td><td>18.4</td><td>17.0</td><td>17.6</td><td>17.6</td><td>18.2</td><td>16.8</td><td>17.3</td><td>17.3</td><td>17.9</td><td>16.5</td><td>17.0</td><td>17.0</td><td>17.6</td></td<>	17	17.3	17.8	17.8	18.4	17.0	17.6	17.6	18.2	16.8	17.3	17.3	17.9	16.5	17.0	17.0	17.6
175 18.1 18.1 18.2 17.8 18.4 17.0 17.5 18.1 16.6 17.2 17.2 17.2 176 18.2 18.2 17.4 18.0 18.6 17.1 17.6 18.2 16.7 17.3 17.3 17.3 177 18.2 18.2 18.4 18.0 18.1 18.1 18.6 17.1 17.7 18.3 16.8 17.4 17.4 17.4 17.4 17.7 18.3 18.9 17.2 17.7 17.7 18.4 18.7 17.2 17.8 17.8 17.4 <td>18</td> <td>17.4</td> <td>18.0</td> <td>18.0</td> <td>18.5</td> <td>17.2</td> <td>17.7</td> <td>17.7</td> <td>18.3</td> <td>16.9</td> <td>17.4</td> <td>17.4</td> <td>18.0</td> <td>16.6</td> <td>17.1</td> <td>17.1</td> <td>17.7</td>	18	17.4	18.0	18.0	18.5	17.2	17.7	17.7	18.3	16.9	17.4	17.4	18.0	16.6	17.1	17.1	17.7
176 18.2 18.8 17.4 18.0 18.5 17.1 17.6 17.5 18.2 16.7 17.3 17.3 17.3 17.3 17.3 17.3 17.3 17.3 17.3 17.3 17.3 17.4 17.5	19	17.5	18.1	18.1	18.6	17.3	17.8	17.8	18.4	17.0	17.5	17.5	18.1	16.6	17.2	17.2	17.8
17.7 18.3 18.3 18.3 18.5 18.1 18.1 18.6 17.1 17.7 18.3 16.8 17.4 17.4 17.9 18.4 18.4 19.0 17.6 18.2 18.2 18.7 17.2 17.8 17.8 16.9 17.4 17.4 17.8 18.4 16.9 17.4 17.9 18.5 17.0 17.4 17.9 18.5 17.2 17.2 17.9 18.5 17.2 17.2 17.9 18.5 17.2 17.2 17.9 18.5 17	20	17.6	18.2	18.2	18.8	17.4	18.0	18.0	18.5	17.1	17.6	17.6	18.2	16.7	17.3	17.3	17.9
17.9 18.4 18.4 19.0 17.6 18.2 18.7 17.2 17.8 17.8 18.4 16.9 17.4 17.4 17.4 18.0 18.0 18.6 19.1 17.7 18.3 18.9 17.3 17.9 17.9 18.5 17.0 17.5 17	21	17.7	18.3	18.3	18.9	17.5	18.1	18.1	18.6	17.1	17.7	17.7	18.3	16.8	17.4	17.4	17.9
18.0 18.6 18.6 19.1 17.7 18.3 18.3 17.3 17.3 17.9 17.9 17.9 17.9 17.9 17.9 17.9 17.9 17.5 17.5 17.0 17.5 17.5 17.5 18.0 <th< td=""><td>22</td><td>17.9</td><td>18.4</td><td>18.4</td><td>19.0</td><td>17.6</td><td>18.2</td><td>18.2</td><td>18.7</td><td>17.2</td><td>17.8</td><td>17.8</td><td>18.4</td><td>16.9</td><td>17.4</td><td>17.4</td><td>18.0</td></th<>	22	17.9	18.4	18.4	19.0	17.6	18.2	18.2	18.7	17.2	17.8	17.8	18.4	16.9	17.4	17.4	18.0
18.1 18.7 18.8 19.2 17.8 18.4 18.4 18.0 17.4 18.0 18.0 18.0 18.0 18.0 18.0 18.0 18.0 18.0 18.0 18.0 18.0 18.0 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.1 18.2 18.2 18.2 18.2 18.2 18.2 18.2 18.2 18.2 17.2 <th< td=""><td>23</td><td>18.0</td><td>18.6</td><td>18.6</td><td>19.1</td><td>17.7</td><td>18.3</td><td>18.3</td><td>18.9</td><td>17.3</td><td>17.9</td><td>17.9</td><td>18.5</td><td>17.0</td><td>17.5</td><td>17.5</td><td>18.1</td></th<>	23	18.0	18.6	18.6	19.1	17.7	18.3	18.3	18.9	17.3	17.9	17.9	18.5	17.0	17.5	17.5	18.1
18.2 18.8 18.8 19.4 17.9 18.5 19.1 17.5 18.1 18.1 18.7 17.1 17.7 17.7 17.2 17.8 17.2 17.8 17.7 17.8 17.2 17.8 17.8 17.8 17.8 17.8 17.8 17.8 17.8 17.8 17.8 17.8 17.8 17.9 17.9 17.9 17.9 17.9 17.9 17.9 17.9 17.9 17.9 17.9 17.9 17.9 17.9 18.0 <th< td=""><td>24</td><td>18.1</td><td>18.7</td><td>18.7</td><td>19.2</td><td>17.8</td><td>18.4</td><td>18.4</td><td>19.0</td><td>17.4</td><td>18.0</td><td>18.0</td><td>18.6</td><td>17.0</td><td>17.6</td><td>17.6</td><td>18.2</td></th<>	24	18.1	18.7	18.7	19.2	17.8	18.4	18.4	19.0	17.4	18.0	18.0	18.6	17.0	17.6	17.6	18.2
18.318.918.919.518.018.618.618.017.618.218.218.817.217.817.817.817.817.817.817.817.917.917.917.917.918.619.119.119.119.218.818.819.417.818.418.418.418.418.418.418.418.418.418.418.418.418.417.917.917.917.918.719.319.319.818.918.919.517.918.519.117.518.018.0	22	18.2	18.8	18.8	19.4	17.9	18.5	18.5	19.1	17.5	18.1	18.1	18.7	17.1	17.7	17.7	18.3
18.519.019.019.618.118.718.317.718.318.318.317.317.917.917.917.917.917.918.619.119.119.119.119.218.918.919.517.918.518.418.018.018.018.018.018.018.719.319.319.818.918.919.517.918.518.519.117.518.018.018.0	26	18.3	18.9	18.9	19.5	18.0	18.6	18.6	19.2	17.6	18.2	18.2	18.8	17.2	17.8	17.8	18.3
18.619.119.119.518.818.819.417.818.418.418.418.917.917.817.818.418.918.918.918.517.918.518.518.518.518.518.518.018.018.0	27	18.5	19.0	19.0	19.6	18.1	18.7	18.7	19.3	17.7	18.3	18.3	18.9	17.3	17.9	17.9	18.4
18.719.319.319.818.418.918.918.919.517.918.518.518.518.518.518.518.518.518.518.518.018.0	28	18.6	19.1	19.1	19.7	18.3	18.8	18.8	19.4	17.8	18.4	18.4	19.0	17.4	17.9	17.9	18.5
18.7 19.3 19.8 18.4 18.9 18.5 17.9 18.5 18.5 19.1 17.5 18.0 18.0 18.0	59	18.7	19.3	19.3	19.8	18.4	18.9	18.9	19.5	17.9	18.5	18.5	19.1	17.5	18.0	18.0	18.6
	30	18.7	19.3	19.3	19.8	18.4	18.9	18.9	19.5	17.9	18.5	18.5	19.1	17.5	18.0	18.0	18.6

Table 34

Pipe Size = 114"

	Ki.' – 0 110	0.130 KU =	Type 3 Type 4 Type 1 Type 2 Type 3 Type 4	17.6 18.3 16.8 17.5 17.5 18.2	17.6 18.3 16.8 17.5 17.5 18.2	17.6 18.3 16.8 17.5 17.5 18.2	17.6 18.3 16.8 17.5 17.5 18.2	17.6 18.3 16.8 17.5 17.5 18.2	17.6 18.3 16.8 17.5 17.5 18.2	17.7 18.3 16.9 17.5 17.5 18.2	17.8 18.4 16.9 17.6 17.6 18.2	17.9 18.5 17.0 17.6 17.6 18.2	17.9 18.6 17.1 17.7 18.3	18.0 18.6 17.2 17.8 17.8 18.4	18.1 18.7 17.2 17.8 17.8 18.4	18.2 18.8 17.3 17.9 17.9 18.5	18.3 18.9 17.4 18.0 18.0 18.6	18.4 19.0 17.5 18.1 18.1 18.7	18.5 19.1 17.6 18.2 18.2 18.8	18.6 19.2 17.6 18.2 18.2 18.8	18.7 19.3 17.7 18.3 18.9	18.8 19.4 17.8 18.4 18.4 19.0	18.9 19.5 17.9 18.5 18.5 19.1	19.0 19.6 18.0 18.6 18.6 19.2	19.1 19.7 18.0 18.6 18.6 19.2	19.2 19.8 18.1 18.7 18.7 19.3	19.3 19.9 18.2 18.8 18.8 19.4	101 001 001 001
) oq		יי עמי	pe 1 Type 2	16.9 17.6	16.9 17.6	16.9 17.6	16.9 17.6	16.9 17.6	17.0 17.6	17.1 17.7	17.2 17.8	17.2 17.9	17.3 17.9	17.4 18.0	17.5 18.1	17.6 18.2	17.7 18.3	17.8 18.4	17.9 18.5	18.0 18.6	18.1 18.7	18.2 18.8	18.3 18.9	18.4 19.0	18.5 19.1	18.6 19.2	18.7 19.3	18.8 19.4
Transition Widths (ET)			Type 4 Type	18.4 16	18.4 16	18.4 16	18.4 16	18.4 16	18.4 17	18.5	18.6 17	18.7 17	18.8 17	18.9 17	19.0 17	19.1	19.2 17	19.3	19.4 17	19.5 18	19.6 18	19.8 18	19.9 18	20.0 18	20.1 18	20.2	20.3 18	20.4
F	150	0.150	Type 3	17.7	17.7	17.7	17.7	17.7	17.8	17.9	18.0	18.1	18.2	18.3	18.4	18.5	18.6	18.7	18.8	18.9	19.0	19.2	19.3	19.4	19.5	19.6	19.7	19.8
	K	ָרָי ביי	e 1 Type 2	.0 17.7	.0 17.7	.0 17.7	.0 17.7	17.7	.2 17.8	.3 17.9	.4 18.0	.5 18.1	.6 18.2	.7 18.3	18.4	.9 18.5	.0 18.6	.1 18.7	.2 18.8	.3 18.9	.4 19.0	.6 19.2	.7 19.3	.8 19.4	.9 19.5	.0 19.6	.1 19.7	.2 19.8
			Type 4 Type	18.4 17.0	18.4 17.0	18.4 17.0	18.4 17.0	18.5 17.1	18.6 17.2	18.7 17.3	18.8 17.4	18.9 17.5	19.0 17.6	19.1 17.7	19.2 17.8	19.3 17.9	19.4 18.0	19.6 18.	19.7 18.2	19.8 18.3	19.9 18.	20.0 18.6	20.2 18.7	20.3 18.8	20.4 18.	20.5 19.0	20.6 19.	20.7 19.
	165	201.0	Type 3	17.7	17.7	17.7	17.8	17.9	17.9	18.0	18.1	18.3	18.4	18.5	18.6	18.7	18.8	19.0	19.1	19.2	19.3	19.4	19.5	19.7	19.8	19.9	20.0	20.1
	K1, - 0 165	_ KU = (Type 2	17.7	17.7	17.7	17.8	17.9	17.9	18.0	18.1	18.3	18.4	18.5	18.6	18.7	18.8	19.0	19.1	19.2	19.3	19.4	19.5	19.7	19.8	19.9	20.0	20.1
			Type 1	17.0	17.0	17.1	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.9	18.0	18.1	18.2	18.3	18.5	18.6	18.7	18.8	18.9	19.1	19.2	19.3	19.4	19.5
				2	9	7	∞	တ	10	7	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	59

Table 35

Pipe Size = 120"

Math Math								Tra	Transition Widths (FT)	Vidths (F	F.						
178 186 186 186 196 187 187 184 184 184 184 186 <th></th> <th></th> <th>Ku' = (</th> <th>).165</th> <th></th> <th></th> <th>Ku' = (</th> <th>0.150</th> <th></th> <th></th> <th>Ku' = (</th> <th>).130</th> <th></th> <th></th> <th>Ku' =</th> <th>0.110</th> <th></th>			Ku' = ().165			Ku' = (0.150			Ku' = ().130			Ku' =	0.110	
178 186 186 186 186 186 186 186 186 187 178 186 186 186 186 186 186 186 186 186 186 186 183 178 185 183 177 184 184 192 176 183 183 1728 186 186 193 178 185 183 177 184 184 192 176 183 183 180 186 186 193 178 185 183 177 184 184 184 182 176 183 183 183 183 183 184 185 183 184		Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4
178 186 186 187 185 183 177 184 184 195 178 185 <th>5</th> <th>17.8</th> <th>18.6</th> <th>18.6</th> <th>19.3</th> <th>17.8</th> <th>18.5</th> <th>18.5</th> <th>19.3</th> <th>17.7</th> <th>18.4</th> <th>18.4</th> <th>19.2</th> <th>17.6</th> <th>18.3</th> <th>18.3</th> <th>19.1</th>	5	17.8	18.6	18.6	19.3	17.8	18.5	18.5	19.3	17.7	18.4	18.4	19.2	17.6	18.3	18.3	19.1
17.8 18.6 18.6 18.3 17.8 18.5 <th< th=""><th>9</th><th>17.8</th><th>18.6</th><th>18.6</th><th>19.3</th><th>17.8</th><th>18.5</th><th>18.5</th><th>19.3</th><th>17.7</th><th>18.4</th><th>18.4</th><th>19.2</th><th>17.6</th><th>18.3</th><th>18.3</th><th>19.1</th></th<>	9	17.8	18.6	18.6	19.3	17.8	18.5	18.5	19.3	17.7	18.4	18.4	19.2	17.6	18.3	18.3	19.1
17.9 18.6 18.6 18.3 17.5 18.4 18.4 18.5 <th< td=""><td>7</td><td>17.8</td><td>18.6</td><td>18.6</td><td>19.3</td><td>17.8</td><td>18.5</td><td>18.5</td><td>19.3</td><td>17.7</td><td>18.4</td><td>18.4</td><td>19.2</td><td>17.6</td><td>18.3</td><td>18.3</td><td>19.1</td></th<>	7	17.8	18.6	18.6	19.3	17.8	18.5	18.5	19.3	17.7	18.4	18.4	19.2	17.6	18.3	18.3	19.1
18.0 18.7 18.7 18.9 18.5 18.3 17.5 18.5 18.5 18.4 18.4 18.4 18.4 18.4 18.4 18.5 18.5 18.3 17.5 18.5 <th< td=""><td>8</td><td>17.9</td><td>18.6</td><td>18.6</td><td>19.3</td><td>17.8</td><td>18.5</td><td>18.5</td><td>19.3</td><td>17.7</td><td>18.4</td><td>18.4</td><td>19.2</td><td>17.6</td><td>18.3</td><td>18.3</td><td>19.1</td></th<>	8	17.9	18.6	18.6	19.3	17.8	18.5	18.5	19.3	17.7	18.4	18.4	19.2	17.6	18.3	18.3	19.1
18.1 18.2 18.3 18.6 18.7 18.3 18.4 <th< td=""><td>6</td><td>18.0</td><td>18.7</td><td>18.7</td><td>19.3</td><td>17.9</td><td>18.5</td><td>18.5</td><td>19.3</td><td>17.7</td><td>18.4</td><td>18.4</td><td>19.2</td><td>17.6</td><td>18.3</td><td>18.3</td><td>19.1</td></th<>	6	18.0	18.7	18.7	19.3	17.9	18.5	18.5	19.3	17.7	18.4	18.4	19.2	17.6	18.3	18.3	19.1
18.2 18.8 19.5 18.0 18.7 18.2 18.5 18.6 18.7 18.7 18.3 18.5 18.5 18.6 18.5 18.6 18.5 <th< td=""><td>10</td><td>18.1</td><td>18.7</td><td>18.7</td><td>19.4</td><td>17.9</td><td>18.6</td><td>18.6</td><td>19.3</td><td>17.8</td><td>18.4</td><td>18.4</td><td>19.2</td><td>17.6</td><td>18.3</td><td>18.3</td><td>19.1</td></th<>	10	18.1	18.7	18.7	19.4	17.9	18.6	18.6	19.3	17.8	18.4	18.4	19.2	17.6	18.3	18.3	19.1
18.3 18.9 <th< td=""><td>11</td><td>18.2</td><td>18.8</td><td>18.8</td><td>19.5</td><td>18.0</td><td>18.7</td><td>18.7</td><td>19.3</td><td>17.8</td><td>18.5</td><td>18.5</td><td>19.2</td><td>17.6</td><td>18.3</td><td>18.3</td><td>19.1</td></th<>	11	18.2	18.8	18.8	19.5	18.0	18.7	18.7	19.3	17.8	18.5	18.5	19.2	17.6	18.3	18.3	19.1
18.4 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 18.0 <th< td=""><td>12</td><td>18.3</td><td>18.9</td><td>18.9</td><td>19.6</td><td>18.1</td><td>18.8</td><td>18.8</td><td>19.4</td><td>17.9</td><td>18.6</td><td>18.6</td><td>19.2</td><td>17.7</td><td>18.3</td><td>18.3</td><td>19.1</td></th<>	12	18.3	18.9	18.9	19.6	18.1	18.8	18.8	19.4	17.9	18.6	18.6	19.2	17.7	18.3	18.3	19.1
18.6 19.1 19.1 19.8 18.3 19.0 19.0 19.0 18.1 18.1 18.2 18.3 19.0 19.0 19.0 18.0 18.1 18.1 18.1 19.0 18.0 18.0 18.1 18.1 18.0 <th< td=""><td>13</td><td>18.4</td><td>19.0</td><td>19.0</td><td>19.7</td><td>18.2</td><td>18.9</td><td>18.9</td><td>19.5</td><td>18.0</td><td>18.6</td><td>18.6</td><td>19.3</td><td>17.8</td><td>18.4</td><td>18.4</td><td>19.1</td></th<>	13	18.4	19.0	19.0	19.7	18.2	18.9	18.9	19.5	18.0	18.6	18.6	19.3	17.8	18.4	18.4	19.1
18.6 19.3 19.3 19.9 18.4 19.1 19.1 19.7 18.2 18.8 18.9 <th< td=""><td>14</td><td>18.5</td><td>19.1</td><td>19.1</td><td>19.8</td><td>18.3</td><td>19.0</td><td>19.0</td><td>19.6</td><td>18.1</td><td>18.7</td><td>18.7</td><td>19.4</td><td>17.8</td><td>18.5</td><td>18.5</td><td>19.1</td></th<>	14	18.5	19.1	19.1	19.8	18.3	19.0	19.0	19.6	18.1	18.7	18.7	19.4	17.8	18.5	18.5	19.1
18.7 19.4 19.4 20.0 18.5 19.2 19.8 18.3 18.9 18.9 18.9 18.9 18.0 <th< td=""><td>15</td><td>18.6</td><td>19.3</td><td>19.3</td><td>19.9</td><td>18.4</td><td>19.1</td><td>19.1</td><td>19.7</td><td>18.2</td><td>18.8</td><td>18.8</td><td>19.5</td><td>17.9</td><td>18.5</td><td>18.5</td><td>19.2</td></th<>	15	18.6	19.3	19.3	19.9	18.4	19.1	19.1	19.7	18.2	18.8	18.8	19.5	17.9	18.5	18.5	19.2
18.8 19.5 19.5 20.1 18.6 19.3 19.3 19.3 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0 18.0 <th< td=""><td>16</td><td>18.7</td><td>19.4</td><td>19.4</td><td>20.0</td><td>18.5</td><td>19.2</td><td>19.2</td><td>19.8</td><td>18.3</td><td>18.9</td><td>18.9</td><td>19.5</td><td>18.0</td><td>18.6</td><td>18.6</td><td>19.3</td></th<>	16	18.7	19.4	19.4	20.0	18.5	19.2	19.2	19.8	18.3	18.9	18.9	19.5	18.0	18.6	18.6	19.3
19.0 19.6 19.6 19.6 19.6 19.6 19.6 19.6 19.6 19.7 19.7 19.7 19.7 19.7 19.7 19.7 19.7 19.7 19.7 19.7 19.7 19.6 19.5 19.5 19.6 20.2 18.6 19.3 19.3 19.9 18.8 18.8 18.8 18.8 18.8 18.9 18.9 18.8 18.8 18.8 18.9 18.9 18.8 18.8 19.9 18.9 18.8 18.9 <th< td=""><td>17</td><td>18.8</td><td>19.5</td><td>19.5</td><td>20.1</td><td>18.6</td><td>19.3</td><td>19.3</td><td>19.9</td><td>18.3</td><td>19.0</td><td>19.0</td><td>19.6</td><td>18.0</td><td>18.7</td><td>18.7</td><td>19.3</td></th<>	17	18.8	19.5	19.5	20.1	18.6	19.3	19.3	19.9	18.3	19.0	19.0	19.6	18.0	18.7	18.7	19.3
19.1 19.7 20.4 18.9 19.5 19.1 18.5 19.2 19.5 19.5 19.5 20.1 18.5 19.2 19.6 19.6 20.1 18.5 19.3 19.3 19.9 18.3 18.8 18.8 18.2 18.2 18.9 <th< td=""><td>18</td><td>19.0</td><td>19.6</td><td>19.6</td><td>20.3</td><td>18.7</td><td>19.4</td><td>19.4</td><td>20.0</td><td>18.4</td><td>19.1</td><td>19.1</td><td>19.7</td><td>18.1</td><td>18.8</td><td>18.8</td><td>19.4</td></th<>	18	19.0	19.6	19.6	20.3	18.7	19.4	19.4	20.0	18.4	19.1	19.1	19.7	18.1	18.8	18.8	19.4
19.2 19.8 19.8 20.5 19.0 19.6 19.6 20.2 18.6 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 18.9 18.9 18.9 18.9 18.9 18.9 18.9 18.9 18.9 18.9 18.9 18.9 18.9 18.9 18.0 <th< td=""><td>19</td><td>19.1</td><td>19.7</td><td>19.7</td><td>20.4</td><td>18.9</td><td>19.5</td><td>19.5</td><td>20.1</td><td>18.5</td><td>19.2</td><td>19.2</td><td>19.8</td><td>18.2</td><td>18.8</td><td>18.8</td><td>19.5</td></th<>	19	19.1	19.7	19.7	20.4	18.9	19.5	19.5	20.1	18.5	19.2	19.2	19.8	18.2	18.8	18.8	19.5
19.3 20.0 20.0 20.0 19.1 19.7 20.3 18.7 19.4 19.4 19.4 20.0 18.4 19.0 19.0 19.4 20.1 20.1 20.7 19.2 19.8 19.6 18.5 19.5 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.2 19	20	19.2	19.8	19.8	20.5	19.0	19.6	19.6	20.2	18.6	19.3	19.3	19.9	18.3	18.9	18.9	19.6
19.4 20.1 20.1 20.1 20.1 19.8 19.8 20.5 18.8 19.5 19.5 19.5 19.5 19.5 19.5 19.5 19.5 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.2 <th< td=""><td>21</td><td>19.3</td><td>20.0</td><td>20.0</td><td>20.6</td><td>19.1</td><td>19.7</td><td>19.7</td><td>20.3</td><td>18.7</td><td>19.4</td><td>19.4</td><td>20.0</td><td>18.4</td><td>19.0</td><td>19.0</td><td>19.6</td></th<>	21	19.3	20.0	20.0	20.6	19.1	19.7	19.7	20.3	18.7	19.4	19.4	20.0	18.4	19.0	19.0	19.6
19.6 20.2 20.2 20.2 20.2 19.9 19.9 20.6 18.9 19.6 19.6 19.6 19.6 19.6 19.6 19.2 18.5 19.2 19.2 19.2 19.2 19.2 19.2 19.2 19.2 19.2 19.2 19.2 19.2 19.2 19.2 19.6 20.3 20.1 20.1 20.3 19.1 19.7 20.4 18.7 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.4 20.0 20.5 19.3 19.4 20.9 19.3 19.9 19.4 19.4 20.0 20.0 20.2 19.4 19.4 20.0 20.0 20.2 20.1 19.4 20.0 20.0 20.2 19.2 19.4 19.4 20.0 20.0 20.2 20.1 20.0 20.0 20.2 19.2 19.2 19.2 20.1 20.0 <th< td=""><td>22</td><td>19.4</td><td>20.1</td><td>20.1</td><td>20.7</td><td>19.2</td><td>19.8</td><td>19.8</td><td>20.5</td><td>18.8</td><td>19.5</td><td>19.5</td><td>20.1</td><td>18.5</td><td>19.1</td><td>19.1</td><td>19.7</td></th<>	22	19.4	20.1	20.1	20.7	19.2	19.8	19.8	20.5	18.8	19.5	19.5	20.1	18.5	19.1	19.1	19.7
19.7 20.3 20.3 21.0 19.4 20.0 20.0 20.7 19.0 19.6 19.6 20.3 18.6 19.2 19.2 19.2 19.8 20.4 20.4 21.1 19.5 20.1 20.1 20.8 19.1 19.7 19.7 19.7 19.7 19.3 19.3 19.3 20.0 20.6 20.6 21.2 19.6 20.3 20.3 20.9 19.2 19.8 19.8 19.4 19.4 19.8 19.9 19.8 19.9 19.4 19.4 19.9 19.9 19.9 19.9 19.5 19.7 19.7 19.7 19.7 19.7<	23	19.6	20.2	20.2	20.8	19.3	19.9	19.9	20.6	18.9	19.6	19.6	20.2	18.5	19.2	19.2	19.8
19.8 20.4 20.4 21.1 19.5 20.1 20.3 20.8 19.1 19.7 19.7 20.4 18.7 19.3 19.3 19.3 19.3 19.3 19.3 19.3 19.7 19.3 19.4 20.5 19.8 19.4 19.4 19.8 20.5 19.4 19.4 20.0 20.0 20.7 19.0 19.5 20.1 20.1 20.9 19.5 19.5 19.5 20.1 20.1 20.9 19.5 19.5 19.5 20.1 20.1 20.8 19.0 19.7 19.7 19.7 19.7 19.7 19.7 19.7 19.7 19.7 <th< td=""><td>24</td><td>19.7</td><td>20.3</td><td>20.3</td><td>21.0</td><td>19.4</td><td>20.0</td><td>20.0</td><td>20.7</td><td>19.0</td><td>19.6</td><td>19.6</td><td>20.3</td><td>18.6</td><td>19.2</td><td>19.2</td><td>19.9</td></th<>	24	19.7	20.3	20.3	21.0	19.4	20.0	20.0	20.7	19.0	19.6	19.6	20.3	18.6	19.2	19.2	19.9
19.9 20.6 20.6 21.2 19.6 20.3 20.3 20.9 19.2 19.8 19.8 19.8 19.8 19.8 19.4 19.4 19.4 19.8 19.6 19.4 19.9 19.9 19.9 19.9 19.9 19.9 19.9 19.9 19.9 19.9 19.5 19.5 19.5 19.5 19.5 19.5 19.5 19.5 19.5 19.6 19.6 19.6 19.6 19.6 19.7 <th< td=""><td>25</td><td>19.8</td><td>20.4</td><td>20.4</td><td>21.1</td><td>19.5</td><td>20.1</td><td>20.1</td><td>20.8</td><td>19.1</td><td>19.7</td><td>19.7</td><td>20.4</td><td>18.7</td><td>19.3</td><td>19.3</td><td>20.0</td></th<>	25	19.8	20.4	20.4	21.1	19.5	20.1	20.1	20.8	19.1	19.7	19.7	20.4	18.7	19.3	19.3	20.0
20.0 20.7 20.8 21.3 19.7 20.4 21.0 19.3 19.9 19.9 19.9 19.9 19.9 19.5 19.5 19.5 20.2 20.8 20.8 20.4 20.5 21.1 19.4 20.0 20.0 20.7 19.0 19.6 19.6 20.3 20.9 20.9 21.6 20.0 20.6 21.2 19.5 20.1 20.1 20.8 19.0 19.7 19.7 20.3 20.9 20.9 21.6 20.0 20.6 21.2 19.5 20.1 20.1 20.8 19.0 19.7 19.7	56	19.9	20.6	20.6	21.2	19.6	20.3	20.3	20.9	19.2	19.8	19.8	20.5	18.8	19.4	19.4	20.0
20.2 20.8 20.8 21.4 19.8 20.5 20.1 19.4 20.0 20.0 20.0 19.6 19.6 19.6 19.6 19.6 19.6 19.6 19.6 19.7 <th< td=""><td>27</td><td>20.0</td><td>20.7</td><td>20.7</td><td>21.3</td><td>19.7</td><td>20.4</td><td>20.4</td><td>21.0</td><td>19.3</td><td>19.9</td><td>19.9</td><td>20.6</td><td>18.9</td><td>19.5</td><td>19.5</td><td>20.1</td></th<>	27	20.0	20.7	20.7	21.3	19.7	20.4	20.4	21.0	19.3	19.9	19.9	20.6	18.9	19.5	19.5	20.1
20.3 20.9 20.9 21.6 20.0 20.6 21.2 19.5 20.1 20.1 20.8 19.0 19.7 19.7 20.3 20.9 20.9 21.6 20.6 20.6 21.2 19.5 20.1 20.1 20.8 19.0 19.7 19.7	28	20.2	20.8	20.8	21.4	19.8	20.5	20.5	21.1	19.4	20.0	20.0	20.7	19.0	19.6	19.6	20.2
20.3 20.9 20.9 21.6 20.0 20.6 20.6 21.2 19.5 20.1 20.1 20.8 19.0 19.7 19.7	59	20.3	20.9	20.9	21.6	20.0	20.6	20.6	21.2	19.5	20.1	20.1	20.8	19.0	19.7	19.7	20.3
	30	20.3	20.9	20.9	21.6	20.0	20.6	20.6	21.2	19.5	20.1	20.1	20.8	19.0	19.7	19.7	20.3

Table 36

Pipe Size = 126"

		4												<u>.</u> .	٠.								_	_	_			<u>.</u>
		Type 4	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.2	20.2	20.3	20.4	20.5	20.5	20.6	20.7	20.8	20.9	20.9	21.0	21.1	21.2	21.2
	0.110	Type 3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.4	19.4	19.5	19.6	19.6	19.7	19.8	19.9	20.0	20.0	20.1	20.2	20.3	20.4	20.4	20.5	20.5
	Ku' =	Type 2	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.4	19.4	19.5	19.6	19.6	19.7	19.8	19.9	20.0	20.0	20.1	20.2	20.3	20.4	20.4	20.5	20.5
	•	Type 1	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.6	18.7	18.7	18.8	18.9	19.0	19.0	19.1	19.2	19.3	19.4	19.5	19.5	19.6	19.7	19.8	19.9	19.9
		Type 4	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.3	20.4	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2	21.3	21.4	21.5	21.6	21.7	21.7
	0.130	Type 3	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5	19.6	19.7	19.8	19.9	20.0	20.0	20.1	20.2	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.0
(F.	Ku' = (Type 2	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5	19.6	19.7	19.8	19.9	20.0	20.0	20.1	20.2	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.0
Transition Widths (FT)	•	Type 1	18.6	18.6	18.6	18.6	18.6	18.6	18.7	18.8	18.8	18.9	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9	20.0	20.0	20.1	20.2	20.3	20.3
nsition V		Type 4	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.4	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.3	21.4	21.5	21.6	21.7	21.8	21.9	22.0	22.1	22.1
Tra	0.150	Type 3	19.5	19.5	19.5	19.5	19.5	19.5	19.6	19.7	19.8	19.8	19.9	20.0	20.2	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2	21.4	21.5	21.5
	Ku' = (Type 2	19.5	19.5	19.5	19.5	19.5	19.5	19.6	19.7	19.8	19.8	19.9	20.0	20.2	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2	21.4	21.5	21.5
	•	Type 1	18.7	18.7	18.7	18.7	18.7	18.8	18.9	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9	20.0	20.1	20.2	20.4	20.5	20.6	20.7	20.8	20.8
		Type 4	20.3	20.3	20.3	20.3	20.3	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.2	21.3	21.4	21.5	21.6	21.8	21.9	22.0	22.1	22.2	22.3	22.5	22.5
	.165	Type 3	19.5	19.5	19.5	19.5	19.6	19.6	19.7	19.8	19.9	20.0	20.1	20.3	20.4	20.5	20.6	20.7	20.8	21.0	21.1	21.2	21.3	21.4	21.6	21.7	21.8	21.8
	Ku' = 0.165	Type 2	19.5	19.5	19.5	19.5	19.6	19.6	19.7	19.8	19.9	20.0	20.1	20.3	20.4	20.5	20.6	20.7	20.8	21.0	21.1	21.2	21.3	21.4	21.6	21.7	21.8	21.8
	-	Type 1	18.8	18.8	18.8	18.8	18.8	18.9	19.0	19.1	19.2	19.3	19.5	19.6	19.7	19.8	19.9	20.1	20.2	20.3	20.4	20.5	20.7	20.8	20.9	21.0	21.1	21.1
			2	9	7	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	56	27	28	29	30

Table 37

Pipe Size = 132"

		Type 4	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.2	21.3	21.4	21.4	21.5	21.6	21.7	21.8	21.8	21.9	22.0	22.1	22.1
	0.110	Type 3	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.3	20.4	20.4	20.5	20.6	20.7	20.7	20.8	20.9	21.0	21.1	21.1	21.2	21.3	21.4	21.4
	Ku' = (Type 2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.3	20.4	20.4	20.5	20.6	20.7	20.7	20.8	20.9	21.0	21.1	21.1	21.2	21.3	21.4	21.4
		Type 1	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5	19.5	19.6	19.7	19.7	19.8	19.9	20.0	20.0	20.1	20.2	20.3	20.4	20.5	20.5	20.6	20.7	20.7
		Type 4	21.3	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.3	21.4	21.4	21.5	21.6	21.7	21.8	21.9	22.0	22.1	22.2	22.3	22.4	22.5	22.6	22.6
	0.130	Type 3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.4	20.5	20.6	20.7	20.7	20.8	20.9	21.0	21.1	21.2	21.3	21.4	21.5	21.6	21.7	21.8	21.9	21.9
F	Ku' = 0	Type 2	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.4	20.5	20.6	20.7	20.7	20.8	20.9	21.0	21.1	21.2	21.3	21.4	21.5	21.6	21.7	21.8	21.9	21.9
/idths (F		Type 1	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.6	19.7	19.8	19.9	19.9	20.0	20.1	20.2	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2	21.2
Transition Widths (FT)		Type 4	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.4	21.5	21.5	21.6	21.7	21.8	21.9	22.1	22.2	22.3	22.4	22.5	22.6	22.7	22.8	22.9	23.0	23.0
Trar	0.150	Type 3	20.4	20.4	20.4	20.4	20.4	20.4	20.5	20.6	20.6	20.7	20.8	20.9	21.0	21.1	21.2	21.3	21.5	21.6	21.7	21.8	21.9	22.0	22.1	22.2	22.3	22.3
	Ku' = 0	Type 2	20.4	20.4	20.4	20.4	20.4	20.4	20.5	20.6	20.6	20.7	20.8	20.9	21.0	21.1	21.2	21.3	21.5	21.6	21.7	21.8	21.9	22.0	22.1	22.2	22.3	22.3
		Type 1	19.6	19.6	19.6	19.6	19.6	19.7	19.7	19.8	19.9	20.0	20.1	20.2	20.3	20.4	20.5	20.6	20.8	20.9	21.0	21.1	21.2	21.3	21.4	21.5	21.6	21.6
		Type 4	21.3	21.3	21.3	21.3	21.3	21.3	21.4	21.4	21.5	21.6	21.7	21.8	22.0	22.1	22.2	22.3	22.4	22.5	22.7	22.8	22.9	23.0	23.1	23.3	23.4	23.4
	.165	Type 3	20.5	20.5	20.5	20.5	20.5	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2	21.4	21.5	21.6	21.7	21.8	22.0	22.1	22.2	22.3	22.4	22.6	22.7	22.7
	Ku' = 0.165	Type 2	20.5	20.5	20.5	20.5	20.5	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2	21.4	21.5	21.6	21.7	21.8	22.0	22.1	22.2	22.3	22.4	22.6	22.7	22.7
		Type 1	19.7	19.7	19.7	19.7	19.7	19.8	19.9	20.0	20.1	20.2	20.3	20.4	20.5	20.7	20.8	20.9	21.0	21.1	21.3	21.4	21.5	21.6	21.7	21.9	22.0	22.0
			2	9	7	8	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	56	27	28	29	30

Table 38

Pipe Size = 138"

							Trai	nsition V	Transition Widths (FT)	 E						
		Ku' = 0	0.165			Ku' = (0.150			Ku' = (0.130			Ku'=	0.110	
	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4
2	20.6	21.5	21.5	22.3	20.5	21.4	21.4	22.3	20.4	21.3	21.3	22.2	20.3	21.2	21.2	21.1
9	20.6	21.5	21.5	22.3	20.5	21.4	21.4	22.3	20.4	21.3	21.3	22.2	20.3	21.2	21.2	22.1
7	20.6	21.5	21.5	22.3	20.5	21.4	21.4	22.3	20.4	21.3	21.3	22.2	20.3	21.2	21.2	22.1
∞	20.6	21.5	21.5	22.3	20.5	21.4	21.4	22.3	20.4	21.3	21.3	22.2	20.3	21.2	21.2	22.1
6	20.6	21.5	21.5	22.3	20.5	21.4	21.4	22.3	20.4	21.3	21.3	22.2	20.3	21.2	21.2	22.1
10	20.7	21.5	21.5	22.3	20.5	21.4	21.4	22.3	20.4	21.3	21.3	22.2	20.3	21.2	21.2	22.1
Ξ	20.7	21.5	21.5	22.3	20.6	21.4	21.4	22.3	20.4	21.3	21.3	22.2	20.3	21.2	21.2	22.1
12	20.8	21.6	21.6	22.4	20.7	21.4	21.4	22.3	20.5	21.3	21.3	22.2	20.3	21.2	21.2	22.1
13	20.9	21.7	21.7	22.5	20.8	21.5	21.5	22.3	20.5	21.3	21.3	22.2	20.3	21.2	21.2	22.1
14	21.0	21.8	21.8	22.6	20.9	21.6	21.6	22.4	20.6	21.4	21.4	22.2	20.4	21.2	21.2	22.1
15	21.2	21.9	21.9	22.7	21.0	21.7	21.7	22.5	20.7	21.4	21.4	22.2	20.4	21.2	21.2	22.1
16	21.3	22.0	22.0	22.8	21.1	21.8	21.8	22.6	20.8	21.5	21.5	22.3	20.5	21.2	21.2	22.1
17	21.4	22.1	22.1	22.9	21.2	21.9	21.9	22.7	20.9	21.6	21.6	22.4	20.6	21.3	21.3	22.1
18	21.5	22.2	22.2	23.0	21.3	22.0	22.0	22.8	21.0	21.7	21.7	22.4	20.6	21.4	21.4	22.1
19	21.6	22.4	22.4	23.1	21.4	22.1	22.1	22.9	21.1	21.8	21.8	22.5	20.7	21.5	21.5	22.2
20	21.7	22.5	22.5	23.2	21.5	22.2	22.2	23.0	21.1	21.9	21.9	22.6	20.8	21.5	21.5	22.3
21	21.9	22.6	22.6	23.3	21.6	22.3	22.3	23.1	21.2	22.0	22.0	22.7	20.9	21.6	21.6	22.3
22	22.0	22.7	22.7	23.4	21.7	22.4	22.4	23.2	21.3	22.1	22.1	22.8	21.0	21.7	21.7	22.4
23	22.1	22.8	22.8	23.6	21.8	22.6	22.6	23.3	21.4	22.2	22.2	22.9	21.0	21.8	21.8	22.5
24	22.2	23.0	23.0	23.7	21.9	22.7	22.7	23.4	21.5	22.3	22.3	23.0	21.1	21.9	21.9	22.6
25	22.3	23.1	23.1	23.8	22.0	22.8	22.8	23.5	21.6	22.4	22.4	23.1	21.2	21.9	21.9	22.7
26	22.5	23.2	23.2	23.9	22.1	22.9	22.9	23.6	21.7	22.5	22.5	23.2	21.3	22.0	22.0	22.7
27	22.6	23.3	23.3	24.0	22.3	23.0	23.0	23.7	21.8	22.5	22.5	23.3	21.4	22.1	22.1	22.8
28	22.7	23.4	23.4	24.2	22.4	23.1	23.1	23.8	21.9	22.6	22.6	23.4	21.5	22.2	22.2	22.9
59	22.8	23.6	23.6	24.3	22.5	23.2	23.2	23.9	22.0	22.7	22.7	23.5	21.5	22.3	22.3	23.0
30	22.8	23.6	23.6	24.3	22.5	23.2	23.2	23.9	22.0	22.7	22.7	23.5	21.5	22.3	22.3	23.0

Table 39

Pipe Size = 144"

	4									I		1											ı		ı		
	Type	23.1	23.1	23.1	23.1	23.1	23.1	23.1	23.1	23.1	23.1	23.1	23.1	23.1	23.1	23.1	23.2	23.3	23.3	23.4	23.5	23.6	23.6	23.7	23.8	23.9	23.9
0.110	Type 3	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.3	22.3	22.4	22.5	22.6	22.6	22.7	22.8	22.9	23.0	23.0	23.1	23.1
Ku'=	Type 2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.3	22.3	22.4	22.5	22.6	22.6	22.7	22.8	22.9	23.0	23.0	23.1	23.1
	Type 1	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.4	21.5	21.6	21.6	21.7	21.8	21.9	22.0	22.0	22.1	22.2	22.3	22.4	22.4
	Type 4	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.3	23.4	23.4	23.5	23.6	23.7	23.8	23.9	24.0	24.1	24.2	24.3	24.4	24.4
130	Type 3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.4	22.5	22.6	22.7	22.8	22.9	22.9	23.0	23.1	23.2	23.3	23.4	23.5	23.6	23.6
Ku' = 0.	Type 2	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.4	22.5	22.6	22.7	22.8	22.9	22.9	23.0	23.1	23.2	23.3	23.4	23.5	23.6	23.6
	Type 1	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.5	21.5	21.6	21.7	21.8	21.9	22.0	22.1	22.2	22.3	22.4	22.5	22.6	22.7	22.8	22.9	22.9
	Type 4	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.4	23.5	23.6	23.7	23.8	23.9	24.0	24.1	24.2	24.3	24.4	24.5	24.6	24.7	24.8	24.8
150	Type 3	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.5	22.6	22.7	22.8	22.9	23.0	23.1	23.2	23.3	23.4	23.5	23.6	23.8	23.9	24.0	24.1	24.1
Ku' = 0.	Type 2	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.5	22.6	22.7	22.8	22.9	23.0	23.1	23.2	23.3	23.4	23.5	23.6	23.8	23.9	24.0	24.1	24.1
	Type 1	21.4	21.4	21.4	21.4	21.4	21.4	21.5	21.5	21.6	21.7	21.8	21.9	22.0	22.1	22.2	22.3	22.4	22.6	22.7	22.8	22.9	23.0	23.1	23.2	23.3	23.3
	4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.5	23.6	23.7													2	25.2
65	က																									24.4	24.4
Ku' = 0.1		22.4	22.4	22.4	22.4			22.4	22.5						23.1						23.8	23.9	24.1	24.2	24.3	24.4	24.4
	Type 1	21.5	21.5	21.5	21.5	21.5	21.5			21.8	21.9															7	23.7
		2	9	7	8	6	10	11	12	13	14				18						24	25	56	27	28	29	
	0.150	Ku' = 0.165 Ku' = 0.150 Ku' = 0.150 Ku' = 0.130 Ku' = 0.130 Ku' = 0.110 1 Type 2 Type 3 Type 4 Type 3 Type 4 Type 3 Type 3 Type 4 Type 1 Type 2 Type 2 Type 2 Type 3 Type 3 Type 4 Type 1 Type 2 Type 3 Type 3 Type 4 Type 4 Type 2 Type 3 Type 3 Type 4 Type 3 Type 4 Type 4 Type 3 Type 4 Type 4 Type 3 Type 4 Type 4	Ku' = 0.165 Ku' = 0.150 Ku' = 0.150 Ku' = 0.130 Ku' = 0.130 Ku' = 0.130 Ku' = 0.110 Type 1 Type 2 Type 3 Type 4 Type 4 Type 4 Type 4 Type 3 Type 3 Type 4 Type 4 Type 2 Type 3 Type 3 Type 4 Type 4 Type 3 Type 3 Type 4 Type 4 Type 3 Type 3 Type 3 Type 4 Type 3 Type 4 Type 4 Type 3 Type 4 Type 4 Type 3 Type 4 Type 4<	Type 1 Type 2 Type 3 Type 4 Type 5 Type 3 Type 3 Type 4 Type 4 Type 5 Type 5 Type 5 Type 5 Type 6 Type 7 Type 7<	Type 1 Type 2 Type 3 Type 4 Type 3 Type 4 Type 3 Type 4 Type 4 Type 4 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 4 Type 3 Type 3 Type 4 Type 3 Type 3<	Type 1 Type 2 Type 3 Type 4 Type 3 Type 3 Type 4 Type 4 Type 4 Type 4 Type 3 Type 3 Type 3 Type 4 Type 4 Type 3 Type 3 Type 4 Type 4 Type 3 Type 3 Type 3 Type 4 Type 3 Type 3<	Type 1 Type 2 Type 4 Type 3 Type 4 Type 5 Type 3 Type 4 Type 7 Type 3 Type 4 Type 4 Type 3 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 3 Type 3 Type 4 Type 3 Type 4 Type 3 Type 3 Type 4 Type 3 Type 3<	Type 1 Type 2 Type 3 Type 4 Type 3 Type 4 Type 3 Type 4 Type 4 Type 3 Type 3	Type 1 Type 3 Type 4 Type 4 Type 4 Type 4 Type 5 Type 3 Type 4 Type 4 Type 4 Type 4 Type 4 Type 5 Type 4 Type 5 Type 4 Type 4 Type 4 Type 4 Type 4 Type 4 Type 5 Type 6 Type 7 Type 5 Type 6 Type 7 Type 5 Type 5 Type 5 Type 6 Type 6 Type 7 Type 6 Type 7 Type 7	Type 1 Type 2 Type 3 Type 4 Type 4 Type 4 Type 4 Type 3 Type 3 Type 4 Type 3 Type 4 Type 3 Type 3 Type 4 Type 3 Type 3 Type 4 Type 4 Type 4 Type 4 Type 3 Type 3 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 3 Type 4 Type 4 Type 4 Type 3 Type 4 Type 4 Type 4 Type 3 Type 3 Type 3 Type 4 Type 4 Type 3 Type 3 Type 3 Type 4 Type 3 Type 3 Type 3 Type 3 Type 3 Type 4 Type 3 Type 3	Type 1 Type 2 Type 3 Type 4 Type 4 Type 4 Type 4 Type 4 Type 5 Type 4 Type 5 Type 4 Type 4 Type 5 Type 7 Type 7	Nu = 0.165 Ku' = 0.166 Ku' = 0.165 Ku' = 0.150 Ku' = 0.130 Ku' = 0.130 Ku' = 0.140 Vpe 2 Type 1 Type 2 Type 3 Type 4 Type 4 Type 4 Type 5 Type 4 Type 4 Type 5 Type 4 Type 5 Type 4 Type 5 Type 4 Type 4 Type 4 Type 5 Type 4 Type 5 Type 5 Type 6 Type 7 <	Viv. = Image: Type 1 Fiv. = 1.150 Fiv. = 1.150	Viv. = 0.165 Kui = 0.166 Kui = 0.166 Kui = 0.150 Kui = 0.130 Kui = 0.130 Kui = 0.146 Type 2 Type 4 Type 5 Type 5 Type 7 Type 4 Type 4 Type 4 Type 5 Type 5 Type 7 Type 7	Viv. = Image of the control of the contr	Type I Type I	Type I Type I	Type I Type I	Vper Type 2 Type 3 Type 4 Type 5 Type 4 Type 5 Type 7 Type 3 Type 4 Type 7 Type 5 Type 5 Type 7 Type 5 Type 7 Type 7 <th< td=""><td>Viv. = 0.165 Kui = 0.160 Kui = 0.160 Kui = 0.160 Kui = 0.160 Viped Viped</td><td>Viv.= 0.165 Kui = 0.130 Kui = 0.140 Fuje 2 Viv. = 0.140 Viv. = 0.140</td><td>$Viv.^{2} = 0.165$ $Viv.^{2} = 0.150$ $Viv.^{2} = 0.130$ $Viv.^$</td><td>Viv. = 0.166 Kui = 0.160 Kui =</td><td>Vij = 0.166 $Vij = 0.166$ $Vij =$</td><td>$Viv_1=0.165$ $Viv_1=0.165$ $Viv_1=0.165$ $Viv_1=0.165$ $Viv_1=0.165$ $Viv_1=0.165$ $Viv_2=0.165$ $Viv_2=$</td><td>Vivi = 0.166 Nume of the section Nume of the section</td><td>NAME NAME <t< td=""></t<></td></th<>	Viv. = 0.165 Kui = 0.160 Kui = 0.160 Kui = 0.160 Kui = 0.160 Viped Viped	Viv.= 0.165 Kui = 0.130 Kui = 0.140 Fuje 2 Viv. = 0.140 Viv. = 0.140	$Viv.^{2} = 0.165$ $Viv.^{2} = 0.150$ $Viv.^{2} = 0.130$ $Viv.^$	Viv. = 0.166 Kui = 0.160 Kui =	Vij = 0.166 $Vij = 0.166$ $Vij =$	$Viv_1=0.165$ $Viv_1=0.165$ $Viv_1=0.165$ $Viv_1=0.165$ $Viv_1=0.165$ $Viv_1=0.165$ $Viv_2=0.165$ $Viv_2=$	Vivi = 0.166 Nume of the section Nume of the section	NAME NAME <t< td=""></t<>

Table 40

DESIGN VALUES OF SETTLEMENT RATIO

	Settlem Ratio	
Installation and Foundation Condition	Usual Range	Design Value
Positive Projecting	0.0 to +1.0	
Rock or Unyielding Soil	+1.0	+1.0
*Ordinary Soil	+0.5 to +0.8	+0.7
Yielding Soil	0.0 to +0.5	+0.3
Zero Projecting		0.0
Negative Projecting	-1.0 to 0.0	
p' = 0.5		-0.1
p' = 1.0		-0.3
p' = 1.5		-0.5
p' = 2.0		-1.0

^{*}The value of the settlement ratio depends on the degree of compaction of the fill material adjacent to the sides of the pipe. With good construction methods resulting in proper compaction of bedding and sidefill materials, a settlement ratio design value of +0.5 is recommended.

Table 41

DESIGN VALUES OF COEFFICIENT OF COHESION

Type of Soil	Values of c
Clay	
Soft	40
Medium	250
Hard	1000
Sand	
Loose Dry	0
Silty	100
Dense	300
Top Soil	
Saturated	100

Table 42

HIGHWAY LOADS ON CIRCULAR PIPE POUNDS PER LINEAR FOOT

										P	ΙPΙ	E S	S12	ZΕ	D	11	N i	N	CF	ŧΕ	s																
		12	15	18	21	24	27	30	33	36	39	42	48	54	9	99	72	78	84	90	96	102	108	114	120	126	132	138	144	-							
	9.0	130	160	190	210	240	260	280	300	330	350	370	410	440	480	510	540	570	009	630	650	680	700	730	750	770	790	810	830	,	ate						
	8.0	160	190	220	250	280	300	330	360	380	410	430	470	520	260	290	630	099	069	720	750	780	810	830	860	880	900	920	940	-	alternä			ers.			
ı.	7.0	190	230	260	300	330	360	390	420	450	480	510	260	610	650	700	740	780	810	850	880	910	940	970	066	1020	1040	1070	1090		ers, or	כוממפ		4 ft. on centers			
N FEET	6.0	230	280	320	360	400	440	480	510	550	580	610	670	730	780	830	880	920	096	1000	1040	1070	1110	1140	1170	1200	1220		1280		cente ו	ב ב ב		4 ft. or			
PIPE IN	5.0	290	350	400	450	500	560	290	630	670	710	750	820	890	950	1010	1060	1110	1160	1210	1250	1290	1330	1362	1400	1430	1460	1490	1470		ual-tired wheels, 4 ft. on centers, or alternate		-	. ທົ			
P OF	4.0	380	450	520	580	640	700	750	810	860	910	950	1040	1120	1190	1260	1330	1390	1360	1310	1270	1240	1230	1260	1280	1300	1290	1250	1210	-	heels,	ghts.			÷		
ABOVE TOP OF	3.5	450	540	620	069	760	830	890	096	1020	1070	1130	1230	1320	1400	1480	1		1	1360	_	1350	1380	1410	1420	1380	1330	1290	1250		HTO HS 20, two 16,000 lb. dual-tired wheels,	tired wheels, 4 it. on centers pipe sizes and/or fill heights	-	dual-tired dual-tired	incianificant	9	
H ABO	3.0	550	099	750	840	930	1010	1080	1160	1230	1290	1360	1470	1580	1680	1640	1570	1520	_	1470	1500	1530		1540	1480	1430	1380	1340	1300		dual-ti	o, 4 It. nd/or		0.5 and 1.0 ft., a single 16,000 lb. 1.5 through 4.0 ft., two 16,000 lb.	0	מום	
FILL	2.5	760	006	1030	1150	1270	1380	1480	1580	1670	1760	1840	1990	2050	1960	1880	1810	1770	1810	1850	1880	1910	1830	1760	1700	1640	1580	1530	1480		00 lb.	wneers izes a		le 16,0 /o 16,0	ng.		
T OF	2.0	1080	1280	1460	1620	1780	1930	2070	2200	2330	2440	2560	2480	2360	2250	2160	2190	2240	2290	2330	2290	2190	2090	2010	1930	1860	1800	1730	1670		/o 16,0	pipe s		a sing) ft tw	e loadi	5	
HEIGHT OF FILL	1.5	1470	1740	1970	2190	2400	2590	2770	2950	2930	2850	2770	2620	2490	2450	2520	2580	2630	2730	2530	2410	2300	2200	2110		_	1870	_	1740		20, tv	12,000 ib. dual-tired wheels, or intermediate pipe sizes an		l.0 ft., igh 4.0	ternate loading.	10.0	
-	1.0	2080	2360	2610	2820	3010	2940	2830	2930	2810	2670	2550			1990				1		1380	1320		_	7		_		980	oadway.	TO HS	nterm		and .	oft. all	E 5	
	0.5	3780	4240	4110	3920	4100	3880	3620	3390	3190	3010	2860	2590	2360	2170	2010	1870	1750	1650	1550	1470	1390	1320	1260	1210	1160	1110	1070	1020	-	AASH.	our 12 te for i	ads:	0 - I I	<u>^ </u>	200	
B	(#,Č	1.33	1.63	1.92	2.21	2.50	2.79	3.08	3.38	3.67	3.96	4.25	4.83	5.42	6.00	6.58	7.17	7.75	8.33	8.92	9.50	10.08	10.67	11.25	11.83	12.42	3.0	13.58	4.1	Unsurfaced	Loads - AA	loading, tour 12,000 ib. dual- Interpolate for intermediate	Critical load	a. For H	c. For	iruck iive	
		12	15	18	21	24	27	30	33	36	36	42	. 4	54	09	99	72	7.8	84	06	96	102	108	114	120	126	132	138	144	1			2		r	'n	
										S	31	HC)N	11	Ji	a	3:	Z1:	s =	ad	ld									DATA:		NOTES:					

Table 43

HIGHWAY LOADS ON HORIZONTAL ELLIPTICAL PIPE

POUNDS PER LINEAR FOOT

								S	X	PIP Ri					ES																
		23×14	30×19	34X22	38X24	42X27	45X29	49X32	53X34	60X38	68X43	76×48	83X53	91X58	98X63	106X68	113X72	121X77	128×82	136X87	143X92	151X97	166×106	180×116							
	9.0	230	290	320	350	380	410	440	470	520	570	610	099	700	740	780	820	850	890	920	950	980	1040	1090							
	8.0	270	350	380	420	450	490	520	550	610	099	710	770	810	860	006	950	066	1020	1060	1090	1130	1190	1250							
ET	7.0	330	420	460	200	530	580	610	650	720	780	840	900	096	1010	1060	1110	1150		_	1280	1320	1390	1440		ernate					
IN FE	6.0	400	510	550	009	640	700	740	780	860	940	1010	1080	1140	1210	_	_	1370	1420	1460	1510	1550	1600	1560		or alte	nded.		enters.		
: PÍPE	5.0	200	630	069	750	800	860	920	970	1060	1150	1240	1320	1390	1460	1530	1600	1660	1710	1760	1800	1810	1730	1650		, two 16,000 lb. dual-tired wheels, 4 ft. on centers, or alternate	ual-tired wheels, 4 ft. on centers with impact included ate pipe sizes and/or fill heights.		rt., a single 10,000 lb. dual-lifed wheel. 4.0 ft., two 16,000 lb. dual-tired wheels, 4 ft. on centers.		
TOP OF	4.0	950	810	880	096	1020	1100	1170	1230	1350	1460	1560	1600	1550	1510	1520	1560	1610	1650	1640	1590	1540	1450	1370		ft. on c	th impa	-	eel. eels, 4 f		
	3.5	770	096	1050	1140	1210	1310	1380	1460	1590	1720	1730	1680	1620	1660	1720	1770	1820	1780	1720	1660	1610	1510	1430		eels. 4	ters wii ghts.	1	ed whe	نب	
H ABOVE	3.0	940	1170	1280	1380	1470	1580	1670	1760	1920	1890	1820	1770	1840	1900	1960	2010	1930	1870	1810	1740	1690	1580	1490		ired wh	wheels, 4 ft. on centers sizes and/or fill heights	1	dual-til dual-til	gnifica	
FILL	2.5	1300	1610	1750	1890	2010	2160	2280	2380	2280	2190	2180	2270	2350	2420	2440	2340	2240	2160	2090	2010	1940	1820	1700		dual-t	s, 4 ft. and/or	1	300 lb.	are insi	
HT OF	2.0	1840	2270	2470	2650	2820	2890	2820	2750	2630	2690	2810	2910	3010	2980	2840	2710	2590	2500	2400	2310	2230	2080	1940		.000 lb.	wheel sizes	-	81e 10, wo 16,(ling. more (
HEIGHT	1.5	2490	3060	3330	3270	3200	3090	3010	2950	3110	3250	3380	3480	3370	3190	3030	2890	2760	2650	2540	2440	2350	2180	2030		two 16	lual-tired ate pipe		, a sur 1.0 ft., t	nate loading. 0.0 ft. or more are insignificant	
	1.0	3380	3450	3640	3450	3310	3100	2960											1530			1340	1240	1150		ау. HS 20,	0 lb. du rmedia	7	rough 2		
	0.5	4940	4610	4300	4040	3840	3560	3380	3210	2930	2690	2480	2310	2160	2020	1910	1800	1710	1630	1560	1490	1420	1310	1210	1	SHTO	r 12,00 for inte	<u> S:</u>	- 1.5 th	> 4.0 ft. ads for	
Equiv.	(in.)	18	24	27	30	33	36	39	42	8 4	54	09	99	72	78	84	06	96	102	108	114	120	132	144	0	Unsurraced roadway. Loads — AASHTO HS 20	loading, four 12,000 lb. d Interpolate for intermedia	Critical loads:	a. For $H=0.5$ and 1.0 ft., a single b. For $H=1.5$ through 4.0 ft., two	c. For H > 4.0 ft. alter Truck live loads for H = 1	
		23×14	30X19	34X22	38X24	42X27	45X29	49X32	53X34	60X38	68X43	76×48	83X53	91X58	98X63	106X68	113X72	121X77	128×82	136×87	143X92	151X97	166×106	180×116	_	I. Unsi 2. Load	load 1. Inter	<u>ت</u>	نه ن	c. 3. Truc	
								SE	1H	IC SE					S	1									+ C	DAIA:	NOTES:				

HIGHWAY LOADS ON VERTICAL ELLIPTICAL PIPE

POUNDS PER LINEAR FOOT

					s		PI R					ES	8							
		29×45	32X49	34X53	38×60	43×68	48×76	53X83	58X91	63×98	68×106	72X113	77×121	82X128	87×136	92X143	97X151	106×166	116X180	
	9.0	270	280	300	330	360	380	410	430	450	470	490	510	520	540	550	570	009	620	ate
	8.0	310	330	350	380	410	440	470	490	520	540	260	580	900	620	630	650	680	710	alterna J. rrs.
 -	7.0	370	390	410	450	480	520	550	580	009	630	650	680	069	710	730	750	780	810	rrs, or cluded
N FEE	6.0	450	470	4 90	540	580	620	650	680	710	740	770	790	820	840	860	880	910	950	cente pact in
GHT OF FILL H ABOVE TOP OF PIPE IN FEET	5.0	550	580	009	650	700	750	790	820	860	890	920	950	970	1000	1020	1040	1080	1120	, two 16,000 lb. dual-tired wheels, 4 ft. on centers, or alternate ual-tired wheels, 4 ft. on centers with impact included. ate pipe sizes and/or fill heights. ft., a single 16,000 lb. dual-tired wheel. 4.0 ft., two 16,000 lb. dual-tired wheels, 4 ft. on centers. ate loading.
P OF	4.0	690	730	260	820	880	930	980	1020	1060	1100	1130	1140	1110	1080	1040	1010	096	970	eels, 4 ters w ghts. red wh red wh
VE TC	3.5	820	860	900	970	1030	1090	1140	1190	1240	1270	1220	1160	1140	1110	1070	1040	1060	1080	red wh on cen ill heig dual-tii dual-tii
I ABO	3.0	980	1030	1070	1160	1230	1300	1360	1420	1370	1310	1270	1220	1180	1140	1140	1150	1180	1110	dual-tii , 4 ft. c nd/or f 00 lb. c 00 lb. c
	2.5	1330	1390	1450	1550	1650	1740	1700	1630	1560	1500	1440	1390	1380	1390	1410	1430	1350	1260	30 lb. c zes ar zes ar e 16,0 o 16,00 g.
T 0F I	2.0 [1850	1930	2010	2150	2140	2040	1940	1850	1770	1700	1680	1700	1720		1720	1650	1530	1420	o 16,00 tired w oipe si s single ft., tw loadin t. or m
HEIGH	1.5	2460	2560	2530	2380	2250	2140	40	1930	00	1920	20	70	1950	70	1790	1710	1580	1470	20, two
	1.0	2250	2290	2200	2000	1840	1700	1570	1470	1380	1300	1230	1160	1110	1060	1010	970	890	820	oadway. HTO HS 20 12,000 lb. d or intermedis: 0.5 and 1.0 1.5 through 4.0 ft. altern ids for H=1
	0.5	2720	2560	2420			1830	1690	1570		1370					1060	1010	920	850	urfaced roadway. Is — AASHTO HS 20, two 16,000 ng, four 12,000 lb. dual-tired wh polate for intermediate pipe size all loads: For H = 0.5 and 1.0 ft., a single For H = 1.5 through 4.0 ft., two For H > 4.0 ft. alternate loading a live loads for H = 10.0 ft. or mo
Equiv.	(in.)	36		42			09				<u> </u>	06	96	102		114	120	132	144	Unsurfaced roadway. Loads—AASHTO HS 20, two 16,000 lb. dual-tired wheels, 4 ft. on centers, or a loading, four 12,000 lb. dual-tired wheels, 4 ft. on centers with impact included Interpolate for intermediate pipe sizes and/or fill heights. Critical loads: a. For H = 0.5 and 1.0 ft., a single 16,000 lb. dual-tired wheel. b. For H = 1.5 through 4.0 ft., two 16,000 lb. dual-tired wheels, 4 ft. on cente c. For H > 4.0 ft. alternate loading. Truck live loads for H = 10.0 ft. or more are insignificant.
		29X45	32X49	34×53	38X60	43×68	48×76	53X83	58X91	86XE9	68×106	72×113	77×121	82X128	87X136	92X143	97X151	106×166	116×180	
					\$	E2)H			۷I	Я							1	1	DATA: NOTES:

Table 45

HIGHWAY LOADS ON ARCH PIPE

POUNDS PER LINEAR FOOT

				ΡI	PE	S	ΙZ	Œ	S	X	R	IN		NC	Н	ES	\$		
		18×11	22X13	26×15	27×18	36×22	44×27	51X31	58X36	65X40	73X45	88×54	102X62	115X72	122X78	138X88	154×97	169×106	
	9.0	190	220	260	280	340	400	450	200	550	009	069	770	820	850	930	066	1040	ate
	8.0	220	260	300	330	400	470	530	590	640	700	800	890	950	066	1070	1140	1200	alterr d. ers.
	7.0	270	320	360	400	480	260	630	700	260	820	940	1040	1120	1160	1250	1330	1390	0, two 16,000 lb. dual-tired wheels, 4 ft. on centers, or alternate dual-tired wheels, 4 ft. on centers with impact included. liate pipe sizes and/or fill heights. Oft., a single 16,000 lb. dual-tired wheel. n 4.0 ft., two 16,000 lb. dual-tired wheels, 4 ft. on centers. rnate loading. 10.0 ft. or more are insignificant.
N FEE	6.0	330	390	450	480	580	680	760	840	910	066	1130	1250	1330	1370	1480	1570	1600	n cent ipact ii 4 ft. o
GHT OF FILL H ABOVE TOP OF PIPE IN FEET	5.0	410	480	260	009	720	840	940	1040	1120	1210	1370	1510	1610	1660	1780	1810	1750	ired wheels, 4 ft. o on centers with im fill heights. dual-tired wheel. dual-tired wheels,
OP OF	4.0	530	630	720	770	930	1070	1200	1320	1420	1530	1590	1520	1580	1610	1640	1540	1480), two 16,000 lb. dual-tired wheels, 4 ft. fual-tired wheels, 4 ft. on centers with ate pipe sizes and/or fill heights. ft., a single 16,000 lb. dual-tired wheel 4.0 ft., two 16,000 lb. dual-tired wheel nate loading.
VE T(3.5	640	750	860	920	1110	1270	1420	1560	1680	1770	1660	1720	1790	1820	1710	1600	1540	o. dual-tired wheels sls, 4 ft. on centers and/or fill heights ,000 lb. dual-tired ,000 lb. dual-tired are insignificant.
H ABC	3.0	780	910	1050	1120	1340	1540	1720	1880	1940	1870	1840	1970	2020	1940	1800	1680	1610	000 lb. dual-t wheels, 4 ft. sizes and/or gle 16,000 lb. wo 16,000 lb. ing.
FILL	2.5	1080	1260	1440	1530	1840	2110	2340	2330	2250	2170	2360	2510	2360	2250	2080	1930	1850	300 lb. wheel sizes a sizes a fle 16,0
IT OF	2.0	1530	1780	2030	2160	2580	2950	2830	2700	2680	2810	3020	2990	2730	2600	2390	2220	2110), two 16,000 lb dual-tired whee iate pipe sizes ft., a single 16 14.0 ft., two 16 nate loading. 0.0 ft. or more
HEIGH	1.5	2090	2420	2750	2930		3180	3020	3110	3250	3380	3530	3200	2910	2760	2530	2330	2220	5 20, tv b. dua ediate 1.0 ft., ugh 4.(= 10.0
	0.1	2960	3330	3640	3440	3580	3270	2980	2730	2550	2360	2080	1870	1690	1600	1450	1330	1270	roadway. SHTO HS 20, r 12,000 lb. du for intermedia ls: = 0.5 and 1.0 f = 1.5 through ads for H= 1C
	0.5	4910	4930	5200	4800	4220	3790	3400	3090	2860	2620	2280	2030	1820	1710	1550	1410	1340	urfaced ros Is – AASH ng, four 12 polate for cal loads: For H = 0. For H = 1.
Equiv.	(in.)	15	18	21	24	30	36	42	48	54	9	72	84	06	96	108	120	132	Unsurfaced roadway. Loads—AASHTO HS 20, two 16,000 lb. dual-tired wheels, 4 ft. on centers, or a loading, four 12,000 lb. dual-tired wheels, 4 ft. on centers with impact included Interpolate for intermediate pipe sizes and/or fill heights. Critical loads: a. For H = 0.5 and 1.0 ft., a single 16,000 lb. dual-tired wheel. b. For H = 1.5 through 4.0 ft., two 16,000 lb. dual-tired wheels, 4 ft. on cente c. For H > 4.0 ft. alternate loading. Truck live loads for H = 10.0 ft. or more are insignificant.
		18X11	22×13	26×15	29×18	36X22	44×27	51X31	58X36	65X40	73X45	88X54	102X62	115×72	122×78	138×88	154×97	169×106	
				SΞ	ЗΗ	10	NI	NI	B	×	ζ 9	E 3	Z	IS	30	ilc	j		DATA: NOTES

Table 46

PRESSURE COEFFICIENTS FOR A SINGLE LOAD

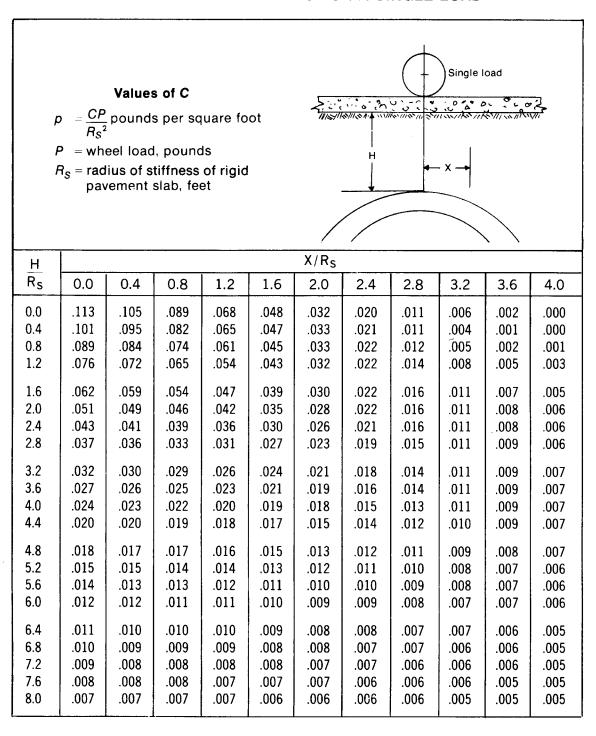


Table 47
PRESSURE COEFFICIENTS FOR TWO LOADS SPACED 0.8R_S APART

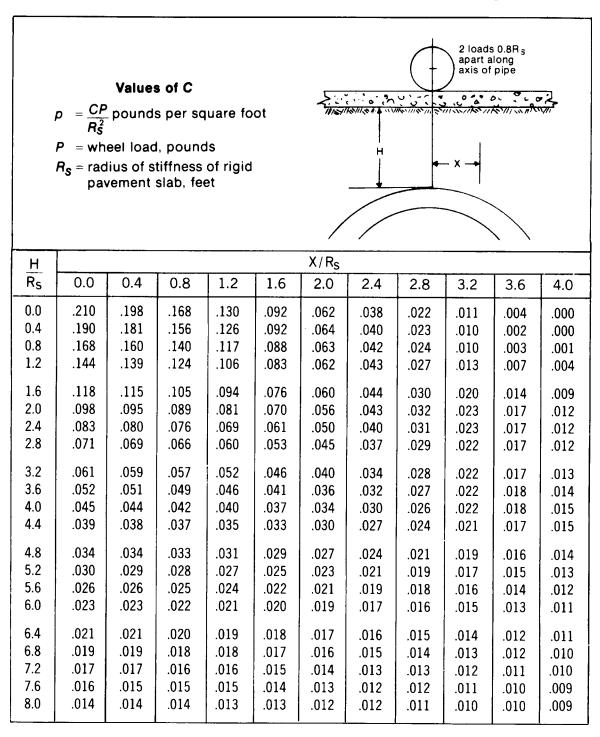


Table 48
PRESSURE COEFFICIENTS FOR TWO LOADS SPACED 1.6R_S APART

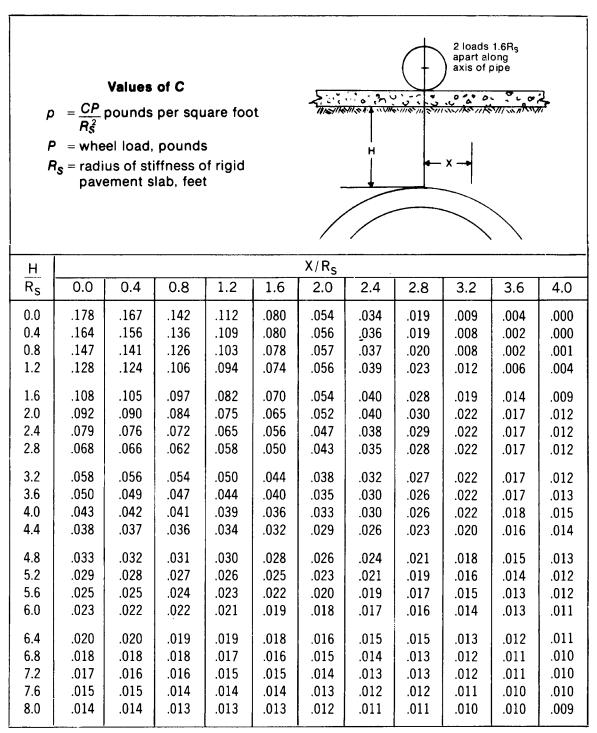


Table 49
PRESSURE COEFFICIENTS FOR TWO LOADS SPACED 2.4R_s APART

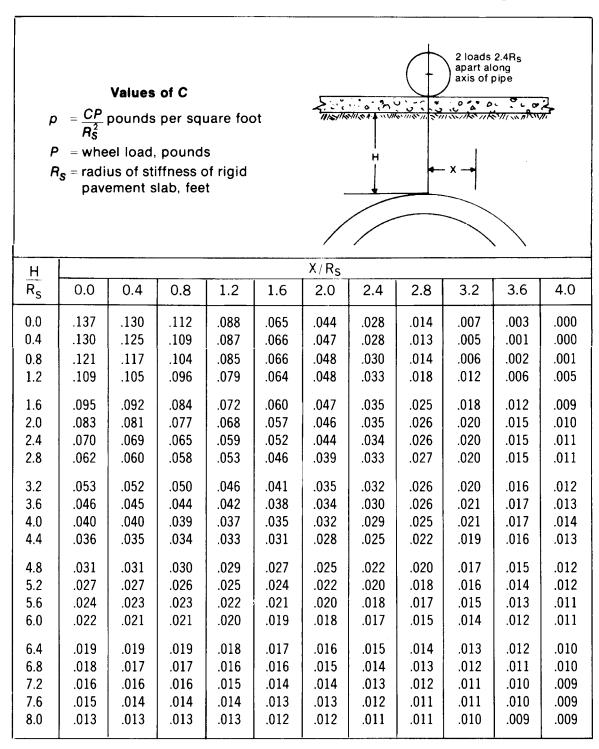


Table 50
PRESSURE COEFFICIENTS FOR TWO LOADS SPACED 3.2R_S APART

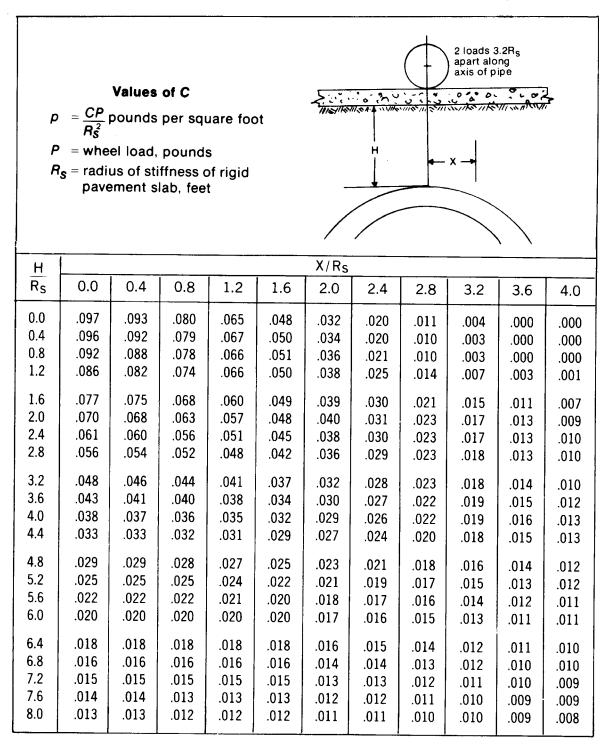


Table 51

PRESSURE COEFFICIENTS FOR A SINGLE LOAD APPLIED ON SUBGRADE OR FLEXIBLE PAVEMENT

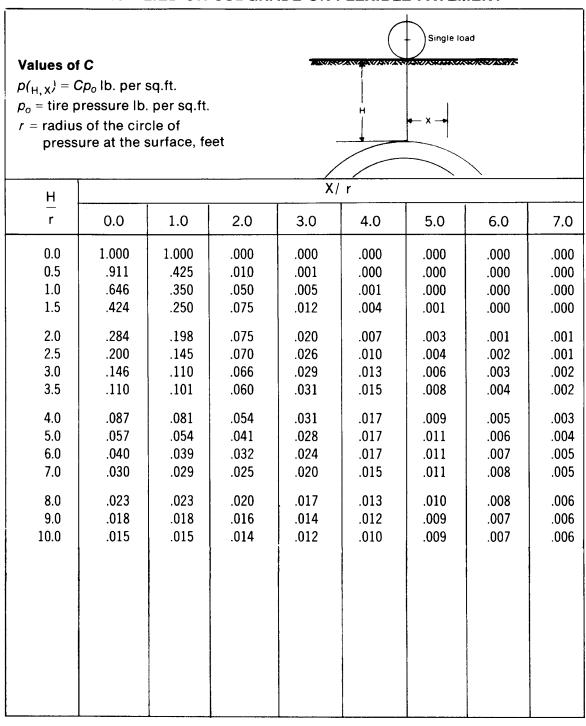


Table 52

VALUES OF RADIUS OF STIFFNESS $R_{\mbox{\scriptsize S}}$ IN INCHES FOR RIGID PAVEMENT SLAB

Slab				Value	es of k				
h (in)	50	100	150	200	250	300	350	400	500
(in.)	-								
6	34.84	29.30	26.47	24.63	23.30	22.26	21.42	20.72	19.59
6.5	36.99	31.11	28.11	26.16	24.74	23.64	22.74	22.00	20.80
7	39.11	32.89	29.72	27.65	26.15	24.99	24.04	23.25	21.99
7.5 8	41.19	34.63	31.29	29.12 30.57	27.54	26.32	25.32	24.49	23.16
	43.23	36.35	32.85		28.91	27.62	26.58	25.70	24.31
8.5	45.24	38.04	34.37	31.99	30.25	28.91	27.81	26.90	25.44
9	47.22	39.71	35.88	33.39	31.58	30.17	29.03	28.08	26.55
9.5	49.17	41.35	37.36	34.77	32.89	31.42	30.23	29.24	27.65
10	51.10	42.97	38.83	36.14	34.17	32.65	31.42	30.39	28.74
10.5	53.01	44.57	40.28	37.48	35.45	33.87	32.59	31.52	29.81
11	54.89	46.16	41.71	38.81	36.71	35.07	33.75	32.64	30.87
11.5	56.75	47.72	43.12	40.13	37.95	36.26	34.89	33.74	31.91
12	58.59	49.27	44.52	41.43	39.18	37.44	36.02	34.84	32.95
12.5	60.41	50.80	45.90	42.72	40.40	38.60	37.14	35.92	33.97
13	62.22	52.32	47.27	43.99	41.61	39.75	38.25	36.99	34.99
13.5	64.00	53.82	48.63	45.26	42.80	40.89	39.35	38.06	35.99
14	65.77	55.31	49.98	46.51	43.98	42.02	40.44	39.11	36.99
14.5	67.53	56.78	51.31	47.75	45.16	43.15	41.51	40.15	37.97
15	69.27	58.25	52.63	48.98	46.32	44.26	42.58	41.19	38.95
15.5	70.99	59.70	53.94	50.20	47.47	45.36	43.64	42.21	39.92
16	72.70	61.13	55.24	51.41	48.62	46.45	44.70	43.23	40.88
16.5	74.40	62.56	56.53	52.61	49.75	47.54	45.74	44.24	41.84
17	76.08	63.98	57.81	53.80	50.88	48.61	46.77	45.24	42.78
17.5	77.75	65.38	59.08	54.98	52.00	49.68	47.80	46.23	43.72
18	79.41	66.78	60.35	56.16	53.11	50.74	48.82	47.22	44.66
19	82.70	69.54	62.84	58.48	55.31	52.84	50.84	49.17	46.51
20	85.95	72.27	65.30	60.77	57.47	54.92	52.84	51.10	48.33
21	89.15	74.97	67.74	63.04	59.62	56.96	54.81	53.01	50.13
22	92.31	77.63	70.14	65.28	61.73	58.98	56.75	54.89	51.91
23	95.44	80.26	72.52	67.49	63.83	60.98	58.68	56.75	53.67
24	98.54	82.86	74.87	69.68	65.90	62.96	60.58	58.59	55.41

$$R_S = \sqrt[4]{\frac{Eh^3}{12(1-u^2)k}}$$

where

E = 4,000,000 psiu = 0.15

therefore

$$R_s = 24.1652 \sqrt[4]{\frac{h^3}{k}}$$

Aircraft Loads On Circular Pipe Under Rigid Pavement Pounds Per Linear Foot

	Height	Height of Fill Measured From Top of Pipe To Surface of Subgrade	asured	red From To	p of Pipe	To Surf	face of S	ubgrade	a	
		Height of	of Fill H	Fill H Above	Top of Grade	rade				
	1	2	3	4	. 5	9	7	8	6	10
12		1789	1623	1453	1266	1130	866	877	773	989
15		2154	1975	1779	1542	1377	1216	1069	942	835
18		2537	2327	2084	1817	1622	1433	1260	1111	984
21		2918	2677	2397	2091	1865	1649	1451	1279	1090
24	3527	3297	3025	2709	2363	2110	1863	1640	1447	1280
27	3932	3567	3371	2931	2635	2352	2076	1829	1615	1427
30	4333	4049	3714	3328	2905	2592	2288	2016	1782	1575
33	4732	4421	4055	3636	3175	2832	2498	2203	1949	1722
36	5128	4790	4395	3941	3442	3069	2707	2388	2115	1868
42	5912	5520	5065	4546	3973	3540	3120	2755	2446	2160
48	6682	6237	5725	5142	4496	4003	3528	3118	2774	2449
54	7437	6940	6371	5726	5010	4459	3930	3477	3097	2735
09	8174	7628	7004	6297	5512	4905	4325	3831	3415	3018
99	8892	8298	7621	6855	6002	5341	4714	4180	3729	3297
72	9588	8948	8220	7396	6480	2767	5095	4522	4037	3571
78	10260	9577	8799	7921	6943	6183	5468	4857	4338	3840
84	10900	10180	9358	8427	7392	6587	5831	5184	4632	4105
90	11520	10760	9894	8916	7827	0869	6186	5503	4920	4365
96	12100	11310	10410	9385	8246	7362	6531	5813	5199	4620
102	12660	11840	10900	9837	8615	7732	2989	6116	5471	4870
108	13190	12340	11370	10270	9042	8090	7193	6409	5735	5112
114	13540	12680	11690	10560	9312	8338	7419	6614	5919	5279
120	14010	13120	12110	10960	9296	8674	7727	6892	6170	5507
126	14450	13540	12510	11340	10020	8668	8024	7162	6413	5726
138	15230	14300	13240	12030	10680	2096	8583	7672	6877	6143
144	15580	14640	13560	12340	10980	6886	8842	7910	7095	6342

0,000 Pound Dual-Tandem Gear Assembly. 190 pounds per square inch tire pressure. 26-inch c/c spacing between dual tires. 66-inch spacing between for and aft tandem tires. k-300 pounds per cubic inch. R_S-37.44 inches. h-12 inches. E-4,000,000 pounds per uare inch. u-0.15. Interpolate for intermediate fill heigths.

Table 54

Aircraft Loads Horizonal Elliptical Pipe Under Rigid Pavement

Pounds Per Linear Foot Height of Fill Measured From Top of Pipe To Surface of Subgrade

	•			-	-			,		
		Height	of Fill H	bove	Top of Grade	rade				
	-	2	2 3	4	C	9	7	œ	တ	10
14x23	3354	3136	2875	2576	2247	2006	1771	1560	1375	1216
19x30	4276	3996	3664	3285	2867	2559	2258	2989	1759	1554
22x34	4789	4474	4104	3679	3213	2866	2528	2229	1973	1742
24x38	5297	4949	4538	4072	3557	3172	2798	2467	2187	1931
27x42	5745	5365	4922	4417	3660	3440	3032	2677	2376	2097
29x45	6244	5829	5349	4803	4199	3739	3295	2911	2587	2284
32x49	6737	6288	5772	5185	4533	4036	3557	3144	2797	2469
34x53	7223	6741	6188	5561	4864	4329	3816	3375	3005	2654
38x60	8070	7530	6914	6217	5441	4842	4269	3781	3370	2978
- 43x68	8993	8392	7077	6933	6071	5403	4769	4229	3773	3336
48x76	9879	9221	8471	7623	0899	5947	5256	4667	4167	3687
53x83	10630	9925	9121	8212	7202	6415	2677	5045	4507	3992
58x91	11430	10680	9819	8847	7765	6925	6136	5458	4879	4324
63x98	12100	11310	10410	9385	8246	7362	6531	5813	5199	4620
68x106	12810	11980	11040	9963	8765	7836	6962	6200	5547	4940
72x113	13400	12540	11560	10450	9205	8240	7330	6532	5846	5213
77x121	14010	13120	12110	10690	9296	8674	7727	6892	6170	5507
82x128	14480	13570	12540	11360	10040	9021	8045	7181	6430	5741
87x136	14970	14040	12990	11790	10450	9336	8389	7495	6715	5997
92x143	15390	14450	13380	12160	10810	9730	9698	7875	6971	6229
97x151	15810	14860	13780	12550	11180	10080	9019	8072	7245	6481
106x166	16490	15520	14440	13210	11830	10690	9574	8586	7729	6931
116x180	17000	16030	14960	13740	12350	11180	10040	10925	8145	7323

0,000 Pound Dual-Tandem Gear Assembly. 190 pounds per square inch tire pressure. 26-inch c/c spacing between dual tires. 66-inch spacing between for and aft tandem tires. k-300 pounds per cubic inch. R_S-37.44 inches. h-12 inches. E-4,000,000 pounds per uare inch. u-0.15. Interpolate for intermediate fill heigths.

Table 55

Aircraft Loads On Arch Pipe Under Rigid Pavement

Pounds Per Linear Foot Height of Fill Measured From Top of Pipe To Surface of Subgrade

		Height	of Fill H	Above ⁻	Top of Grade	rade				
	-	2	3	4	2	9	7	8	6	10
11x18	2656	2483	2277	2039	1778	1588	1403	1234	1087	962
13- ¹ / ₂ x22	3180	2973	2727	2442	2130	1908	1679	1478	1303	1153
15- ¹ / ₂ x26	3701	3460	3173	2843	2481	2214	1955	1722	1519	1343
18x28- ¹ / ₂	4047	3782	3469	3109	2712	2421	2137	1882	1663	1470
22-1/2x36-1/4	5043	4698	4322	3876	3385	3019	2662	2348	2104	1836
26- ⁵ / ₈ x43- ³ / ₄	5954	5559	5136	4610	4030	3590	3164	2794	2482	2191
31- ⁵ / ₁₆ x51- ¹ / ₈	6914	6452	5923	5321	4653	4142	3650	3228	2872	2536
36x58- ¹ / ₂	7808	7286	6899	6014	5262	4683	4122	3654	3257	2878
40x65	8587	8013	7358	6617	5794	5155	4548	4031	3595	3178
45x73	9490	8857	8135	7320	6412	2029	5040	4474	3993	3532
54x88	11080	10350	9513	8569	7518	6701	5934	5276	4715	4180
62x102	12420	11620	10690	9645	8479	7575	6724	2987	5355	4764
72x115	13470	12610	11620	10510	9258	8289	7374	6573	5882	5246
77- ¹ / ₄ x122	14010	13120	12110	10960	9296	8674	7727	6892	6170	2207
87- ¹ / ₈ x138	15080	14150	13090	11880	10540	9481	8468	7997	6780	6056
96- ⁷ / ₈ x154	15940	14990	13910	12680	11300	10190	9122	8167	7334	6562
$^{-}106^{-1}/_{2}x168^{-3}/_{4}$	16440	10 15480 14390	14390	13170	11780	10640	9535	8551	7695	6889

10,000 Pound Dual-Tandem Gear Assembly. 190 pounds per square inch tire pressure. 26-inch c/c spacing between dual tires. 66-inch c spacing between for and aft tandem tires. k-300 pounds per cubic inch. R_S-37.44 inches. h-12 inches. E-4,000,000 pounds per uare inch. u-0.15. Interpolate for intermediate fill heigths.

Table 56

RAILROAD LOADS ON CIRCULAR PIPE POUNDS PER LINEAR FOOT

					F	PIP	E S	SIZ	ZE-	11	NS	ID	E	DI.	А٨	۱E	TE	R	D	IN	IN	ICI	ΗE	S				!	
		12	15	18	21	24	27	30	33	36	42	48	54	9	99	72	78	84	90	96	102	108	114	120	126	132	138	144	
	30	210	250	300	340	390	430	480	520	570	099	750	840	930	1020	1110	1200	1290	1380	1470	1560	1650	1710	1800	1890	1980	2070	2160	
	25	290	350	410	480	540	009	670	730	790	920	1040	1160	1290	1420	1540	1670	1800	1920	2050	2180	2300	2390	2520	2640	2770	2890	3020	
	20	420	510	610	200	190	890	980	1070	1160	1350	1530	1720	1900	2090	2270	2460	2640	2820	3010	3200	3380	3510	3700	3880	4060	4250	4430	oad o be of
	18	490	900	710	810	920	1030	1140	1240	1350	1570	1780	2000	2210	2430	2640	2860	3070	3290	3500	3720	3940	4090	4300	4520	4730	4950	5160	notive I umed t oottom
	16	290	720	840	970	1100	1230	1360	1480	1610	1870	2130	2380	2640	2900	3150	3410	3670	3920	4180	4440	4690	4880	5130	5390	5650	2900	6160	Locon ure assi pe to b
	14	720	880	1030	1190	1350	1500	1660	1820	1980	2290	2600	2920	3230	3550	3860	4180	4490	4800	5120	5430	5750	5970	6290	0099	6910	7230	7540	set c/c. struct p of pi
FEET	12	880	1070	1260	1450	1640	1830	2020	2220	2410	2790	3170	3560	3940	4320	4710	2090	5470	5860	6240	6620	7010	7280	2660	8040	8420	8810	9190	sed 5 fe of track from to
PIPE IN	10	1090	1330	1570	1810	2050	2290	2520	2760	3000	3480	3960	4440	4910	5390	5870	6350	6820	7300	7780	8250	8740	9070	9560	10000	10500	11000	11500	xles spac Weight c
TOP OF	6	1260	1540	1820	2100	2370	2650	2930	3200	3480	4030	4590	5140	2690	6250	6800	7350	7900	8460	9010	9560	10100	10500	11100	11600	12200	12700	13300	pound axles spaced 5 feet c/c. Locomotive load 20 feet. Weight of track structure assumed to be of fill measured from top of pipe to bottom of heights.
ABOVE	8	1480	1800	2130	2450	2770	3100	3420	3740	4070	4710	5360	0009	6650	7300	7950	8590	9240	0686	10500	11200	11800	12300	12900	13600	14200	14900	15500	consisting of four 80,000-pound axles spaced 5 feet c/c. Locomotive load uted over an area 8 feet \times 20 feet. Weight of track structure assumed to be. Impact included. Height of fill measured from top of pipe to bottom of ediate pipe sizes and/or fill heights.
FILL H	7	1720	2100	2480	2850	3230	3610	3980	4360	4740	5500	6250	7000	7750	8510	9260	10000	10800	11500	12300	13000	13800	14300	15100	15800	16600	17300	18100	g of four an area ncluded.
HT OF	9	2010	2450	2890	3330	3770	4210	4640	5080	5520	6400	7280	8160	9040	9920	10800	11700	12600	13400	14300	15200	16100	16700	17600	18500	19300	20200	21100	consisting of four uted over an area Impact included ediate pipe sizes a
HEIG	2	2340	2860	3370	3880	4390	4900	5420	5930	6450	7470	8500	9520	10500	11600	12600	13600	14600	15700	16700	17700	18800	19500	20500	21500	22500	23600	24600	
	4	2700	3300	3890	4470	5070	2660	6250	6840	7430	8610	9226	11000	12200	13300	14500	15700	16900	18100	19300	20400	21600	22500	23700	24800	26000	27200	28400	O design hiformity s per line olate for
	-	3060	3720	4390	2060	5730	6400	7070	7740	8400	9740	11100	12400	13800	15100	16400	17800	19100	20400	21800	23100	24500	25400	26800	28100	29400	30800	32100	Cooper E80 design loading consisting of four 80,000-pound axles spaced 5 feet c/c. Locomotive loan assumed uniformity distributed over an area 8 feet x 20 feet. Weight of track structure assumed to table pounds per linear foot. Impact included. Height of fill measured from top of pipe to bottom of ties. Interpolate for intermediate pipe sizes and/or fill heights.
	7	3400	4140	4890	5630	6370	7120	7860	8610	9350	10800	12300	13800	15300	16800	18300	19800	21200	22700	24200	25700	27200	28300	29800	31200	32700	34200	35700	CC ass: 20
	_	3630	4430	5220	6020	6810	7610	8400	9200	10000	11600	13200	14800	16400	17900	19500	21100	22700	24300	25900	27500	29100	30200	31800	33400	35000	36600	38200	
		12	15	18	21	24	27	30	33	36	42	48	54	60	99	72	78	84	90	96	102	108	114	120	126	132	138	144	
						168		NI	N	1 0	1 &	1 3 .	L3	M	∀ 10	3 =	DE	ISI	NI-	-3	ZI	S =	141	d					

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RAILROAD LOADS ON HORIZONTAL ELLIPTICAL PIPE

POUNDS PER LINEAR FOOT

	PIP	E S	ΙZ	Ε	_	IN	SI	DI	ΕI	RI	SE	×	S	P.A	١N	R	×	S	11	N I	N	Cŀ	ΗE	S		
		14X23	19X30	22X34	24X38	27×42	29×45	32X49	34×53	38X60	43×68	48X76	53X83	58X91	86XE9	68X106	72X113	77×121	82X128	87×136	92X143	97X151	106×166	116X180		
	30	370	470	530	290	640	700	750	810	910	1030	1150	1250	1360	1470	1580	1690	1800	1900	2010	2110	2230	2440	2640		
	25	510	099	740	820	890	970	1050	1130	1280	1440	1600	1740	1900	2050	2210	2350	2520	2650	2800	2950	3110	3410	3700	D 9	.
	20	260	096	1080	1200	1310	1420	1540	1660	1870	2110	2350	2560	2800	3010	3250	3460	3700	3890	4120	4330	4570	5010	5440	otive los	מל ליני
	18	880	1120	1260	1400	1520	1660	1800	1940	2180	2460	2740	2980	3260	3500	3780	4030	4300	4530	4800	5040	5320	5840	6330	loading consisting of four 80,000 pound axles spaced 5 feet c/c. Locomotive load	ייים לייים
	16	1040	1340	1500	1670	1820	1980	2140	2310	2600	2930	3260	3560	3890	4180	4510	4800	5130	5410	5720	6010	6340	0269	7550	feet c/c.	A SUIDCU
ш	14	1280	1640	1840	2040	2220	2420	2630	2830	3190	3590	4000	4360	4760	5120	5520	5880	6290	6620	7010	7370	7770	8530	9250	aced 5 1	4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
HEIGHT OF FILL H ABOVE TOP OF PIE	12	1560	2000	2240	2490	2710	3000	3200	3450	3890	4380	4870	5310	5800	6240	6730	7170	2660	8070	8540	8980	9470	10400	11300	axles sp	WEIGHT.
OVE TO	10	1940	2490	2800	3110	3380	3680	3990	4300	4850	5460	0/09	6620	7230	7780	8380	8940	9260	10100	10600	11200	11800	12300	14100	punod	20 leet.
H AB(6	2250	2890	3240	3600	3910	4270	4630	4980	5610	6330	7040	7670	8380	9010	9730	10400	11100	11700	12300	13000	13700	15000	16300	80,000	Leer A
OF FILI	8	2630	3370	3790	4200	4570	4910	5410	5820	6560	7390	8220	8960	9790	10500	11400	12100	12900	13600	14400	15200	16000	17600	19000	of four	מקונים ס
IGHT (7	3070	3930	4420	4900	5330	5820	6300	6780	7650	8620	9580	10400	11400	12300	13300	14100	15100	15900	16800	17700	18600	20500	22200	sisting an	Over an
Ŧ	9	3580	4580	5150	5710	6220	6780	7340	7910	8910	10000	11200	12200	13300	14300	15500		17600	18500	19600	20600	21700	23800		ding cor	distributed Over all afea o reet X ZV reet. Weight Or hards structure assumined to be ass foot impact included Height of fill measured from ton of nine to hottom of
	5	4170	5350	6010	6670	7250	7910	8570	9230	10400	11700	13000	14200	15500	16700		19200 16500	20500	21600	22900			27800			
	4	4810	6170	6930	2690	8360	9120	9880	10600	12000	13500	15000	16400	17900	19300	20800	22100	23700	24900	26300	27700	29200	32100	34800	E80 de	ion spur
	က	5440	6970	7830	8690	9460	10300	11200	12000	13600	15300	17000	18500	20200	21800	23500	25000	26800	28200	29800	31300	33100	36300	39400	Cooper E80 design	200 pounds par ling
	2	0909	7760	8710	0296	10500	11500	12400	13400	15100	17000	18900	20600	22500	24200	26100	27800	29800	31300	33200	34900	36800	40400	43800	- •	
	-	6470	8290	9310	10300	11200	12300	13300	14300	16100	18200	20200	22000	24100	25900	27900	29800	31800	33500	35400	37300	39300	43100	46800		
		14×23	19X30	22X34	24X38	27×42	29×45	32X49	34 X53	38X60	43×68	48×76	53X83	58X91	63X98	68×106	72X113	77×121	82X128	87X136	92X143	97X151	106X166	116X180		
	S3	СН	NI	N	11 \$	\$ >	()	1 1:	4	/d:	S >	⟨ }	35	IH	3	۵ı	12	NI.	_	3	ZI	s :	∃d	Ы		

Zou pounds per linear 100t. Impact included. Height of fill mittes. Interpolate for intermediate pipe sizes and/or fill heights.

Table 58

RAILROAD LOADS ON ARCH PIPE POUNDS PER LINEAR FOOT

<u></u>					C1.7		1010											_		$\overline{}$
			P	IPE	SIZ	E —	INS	SIDE	: HI	SE)	K SP	'AN	RX	-						
		11×18	13×22	15×26	18×29	22×36	27 X 44	31×51	36×58	40×65	45×73	54×88	62×102	72×115	78×122	88×138	97X154	106×169		
	30	290	350	410	440	260	670	770	880	980	1100	1310	1520	1700	1800	2030	2270	2430		:
	25	400	480	929	620	780	930	1080	1230	1370	1520	1830	2120	2370	2520	2840	3160	3390	₽ ₩ ₩	
	20	009	710	830	910	1140	1370	1590	1810	2010	2240	2700	3110	3480	3700	4170	4650	4980	otive loa ned to b ottom c	
	18	700	830	970	1060	1330	1590	1850	2110	2340	2610	3140	3630	4060	4300	4860	5410	5800	Cooper E80 design loading consisting of four 80,000 pound axles spaced 5 feet c/c. Locomotive load assumed uniformly distributed over an area 8 feet x 20 feet. Weight of track structure assumed to be 200 pounds per linear foot. Impact included. Height of fill measured from top of pipe to bottom of ties. Interpolate for intermediate pipe sizes and/or fill heights.	:
	16	820	066	1160	1260	1590	1900	2200	2510	2790	3120	3740	4330	4840	5130	5800	6450	6920	eet c/c. : structu op of p	
FEET	14	1010	1210	1410	1550	1940	2320	2700	3070	3410	3820	4590	5300	5930	6290	7100	7910	8480	aced 5 f of track 1 from t	
PIPE IN	12	1230	1480	1720	1890	2370	2830	3290	3750	4160	4650	5590	6460	7220	0992	8650	9630	10300	axles sp Weight neasurec	
H ABOVE TOP OF	10	1540	1840	2150	2350	2950	3530	4100	4670	5190	5800	0269	8050	9010	9560	10800	12000	12900	pound 20 feet. of fill n	
BOVE -	6	1780	2140	2490	2730	3420	4090	4750	5420	6010	6720	8080	9330	10400	11100	12500	13900	14900	80,000 feet x Height I/or fill	
FILLHA	8	2080	2500	2910	3190	4000	4780	5560	6330	7020	7850	9440	10900	12200	12900	14600	16300	17400	of four n area 8 cluded. iizes anc	
P.	7	2420	2910	3390	3720	4660	5570	6470	7380	8180	9150	11000	12700	14200	15100	17000	19000	20300	nsisting over ar npact in te pipe s	
HEIGHT	9	2820	3390	3960	4330	5430	6500	7550	8600	9540	10700	12800	14800	16600	17600	19800	22100	23700	Cooper E80 design loading consisting of four 80,000 pound assumed uniformly distributed over an area 8 feet x 20 feet 200 pounds per linear foot. Impact included. Height of fill ites. Interpolate for intermediate pipe sizes and/or fill heights.	
	2	3300	3960	4610	5050	6340	7580	8810	10000	11100	12400	15000	17300	19300	20500	23100	25800	27600	Cooper E80 design loading assumed uniformly distribu 200 pounds per linear for ties. Interpolate for interme	
	4	3800	4560	5320	5830	7300	8740	10200	11600	12800	16200 14400	21700 19500 17200	19900	22300	23700	26700	29700	31900	E80 de 1 unifor unds pe erpolate	
	3	4300	5160	6020	6590	8260	9880	12800 11500	13100	14500	16200	19500	22500	25200	26800	30200	33600	36100	Cooper assumed 200 poi ties. Int	
	2	4780	5740	0699	7330	9190	11000		14600	17300 16100 14500 12800	19300 18100	21700	25100	28000	29800	33600	37400	40100		
	-	5110	6130	7150	7840	9820	11800	13700	15600	17300	19300	23200	26800	30000	31800	35900	40000	42900		
		11×18	13X22	15×26	18×29	22×36	27×44	31×51	36×58	40×65	45×73	54×88	62×102	72×115	78×122	88X138	97X154	106X169		
			SE	СНІ	NIN	JI S	ΧŁ	'N E	√ 4S	EΧ	รเล	DE	ISN	ı – :	3ZI	5 3 6	IId			

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Table 59

BEDDING FACTORS FOR VERTICAL ELLIPTICAL PIPE
POSITIVE PROJECTING EMBANKMENT INSTALLATIONS

H B _c			ASS B DDING					ASS C			H B _c
					p =	= 0.9					
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	
0.5	-	-	_	_	_	-	_	_	_	_	0.5
1.0	-	3.66	3.66	3.66	3.66	-	2.70	2.70	2.70	2.70	1.0
1.5	_	3.66	3.66	3.66	3.66	2.70	2.70	2.70	2.70	2.70	1.5
2.0 3.0	3.66	3.66	3.66	3.66	3.66	2.70 2.70	2.70	2.70 2.70	2.70 2.64	2.70 2.48	2.0 3.0
5.0	3.66 3.66	3.66 3.66	3.66 3.61	3.54 3.37	3.26 3,13	2.70	2.70 2.70	2.68	2.54	2.40	5.0
10.0	3.66	3.66	3.46	3.27	3.03	2.70	2.70	2.59	2.48	2.34	10.0
15.0	3.66	3.66	3.52	3.21	3.00	2.70	2.70	2.57	2.45	2.32	15.0
	I					= 0.7		L	L	l.	
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	
0.5				-	-	2.53	2.53	2.53	2.53	2.53	0.5
1.0	3.35	3.35	3.35	3.35	3.35	2.53	2.53	2.53	2.53	2.53	1.0
1.5	3.35	3.35	3.25	3.16	3.16	2.53	2.53	2.47	2.42	2.42	1.5
2.0	3.35	3.27	3.01	2.91	2.91	2.53	2.48	2.33	2.27	2.27	2.0
3.0	3.35	3.13	2.94	2.80	2.68	2.53	2.40	2.29	2.20	2.13	3.0
5.0	3.35	3.05	2.85	2.74	2.63	2.53	2.36	2.23	2.17	2.10	5.0
10.0	3.35	2.97	2.80	2.71	2.59	2.53	2.31	2.22	2.14	2.07	10.0
15.0	3.35	2.95	2.78	2.68	2.58	2.53	2.30	2.21	2.13	2.06	15.0
	 			r	P =	= 0.5		· · · · · · · · · · · · · · · · · · ·		I	
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	
0.5	2.80	2.80	2.80	2.80	2.80	2.20	2.20	2.20	2.20	2.20	0.5
1.0	2.77	2.48	2.48	2.48	2.48	2.18	2.00 1.98	2.00	2.00 1.95	2.00 1.95	1.0 1.5
1.5 2.0	2.67 2.63	2.46 2.44	2.43 2.37	2.40 2.34	2.40 2.34	2.12 2.10	1.98	1.97	1.95	1.93	2.0
3.0	2.59	2.41	2.36	2.31	2.27	2.10	1.96	1.92	1.89	1.86	3.0
5.0	2.55	2.40	2.33	2.30	2.26	2.04	1.95	1.90	1.88	1.85	5.0
10.0	2.53	2.38	2.32	2.29	2.25	2.03	1.94	1.90	1.87	1.84	10.0
15.0	2.52	2.38	2.31	2.28	2.24	2.02	1.93	1.90	1.87	1.84	15.0
	*·····································	·····			p =	= 0.3		I			
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	
0.5	2.18	2.17	2.16	2.16	2.16	1.80	1.79	1.79	1.79	1.79	0.5
1.0	2.15	2.10	2.10	2.10	2.10	1.78	1.74	1.74	1.74	1.74	1.0
1.5	2.14	2.10	2.09	2.08	2.08	1.77	1.74	1.74	1.73	1.73	1.5
2.0	2.13	2.10	2.08	2.07	2.07	1.77	1.74	1.73	1.73	1.73	2.0
3.0	2.13	2.09	2.08	2.07	2.06	1.76	1.74	1.73	1.72	1.72	3.0
5.0	2.12	2.09	2.08	2.07	2.06	1.76	1.74	1.73	1.72	1.71	5.0
10.0	2.12	2.09	2.08	2.06	2.05	1.76	1.74	1.73	1.72	1.71	10.0 15.0
15.0	2.12	2.09	2.07	2.06	2.05	1.76	1.74	1.73	1./2	1./1	13.0
				ZE	RO PR	OJECTING)				
			1.98					1.66			
	L					L					

POSITIVE PROJECTING EMBANKMENT INSTALLATIONS

Table 60

BEDDING FACTORS FOR HORIZONTAL ELLIPTICAL PIPE

H B _c			ASS B DDING		,			ASS C			H B _c
					p =	0.9					
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	r _{sd} p = 0	0.1	0.3	0.5	1.0	
0.5	2.72	2.65	2.65	2.65	2.65	2.14	2.10	2.10	2.10	2.10	0.5
1.0	2.58	2.49	2.49	2.49	2.49	2.05	2.00	2.00	2.00	2.00	1.0
1.5	2.34	2.46	2.42	2.40	2.38	2.03	1.97	1.95	1.94	1.92	1.5
2.0	2.52	2.44	2.41	2.39	2.37	2.01	1.96	1.95	1.93	1.92	2.0
3.0	2.50	2.43	2.40	2.38	2.34	2.00	1.96	1.94	1.92	1.90	3.0
5.0	2.48	2.42	2.39	2.36	2.33	1.99	1.95	1.93	1.91	1.89	5.0
10.0	2.47	2.41	2.37	2.35	2.33	1.98	1.94	1.92	1.91	1.89	10.0
15.0	2.46	2.40	2.36	2.35	2.32	1.98	1.94	1.92	1.91	1.89	15.0
	-, , , , , , <u>-</u>		l		D =	0.7	l		L	<u> </u>	L
	$r_{sd}p = 0$	0.1	0.2	0.5		$r_{sdp} = 0$	0.1	0.2	0.5	1.0	l
		0.1	0.3	0.5	1.0		0.1	0.3	0.5	1.0	
0.5	2.46	2.42	2.42	2.42	2.42	1.98	1.95	1.95	1.95	1.95	0.5
1.0	2.40	2.35	2.35	2.35	2.35	1.94	1.90	1.90	1.90	1.90	1.0
1.5	2.38	2.33	2.31	2.30	2.28	1.92	1.89	1.88	1.87	1.86	1.5
2.0	2.37	2.32	2.31	2.29	2.28	1.92	1.89	1.88	1.87	1.86	2.0
3.0	2.36	2.32	2.30	2.29	2.27	1.91	1.88	1.87	1.86	1.85	3.0
5.0	2.35	2.32	2.29	2.28	2.26	1.90	1.88	1.87	1.86	1.84	5.0
10.0	2.34	2.31	2.28	2.27	2.26	1.90	1.88	1.86	1.85	1.84	10.0
15.0	2.34	2.31	2.28	2.27	2.25	1.90	1.88	1.86	1.85	1.84	15.0
				T :	p =	0.5	1	1		, · · · · ·	<u> </u>
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	
0.5	2.27	2.25	2.25	2.25	2.25	1.85	1.84	1.84	1.84	1.84	0.5
1.0	2.25	2.23	2.23	2.23	2.23	1.84	1.82	1.82	1.82	1.82	1.0
1.5	2.24	2.22	2.21	2.21	2.20	1.83	1.82	1.81	1.81	1.80	1.5
2.0	2.24	2.22	2.21	2.20	2.20	1 83	1.82	1.81	1.81	1.80	2.0
3.0	2.24	2.22	2.21	2.20	2.19	1.83	1.82	1.81	1.81	1.80	3.0
5.0	2.23	2.22	2.21	2.20	2.19	1.83	1.82	1.81	1.80	1.80	5.0
10.0	2.23	2.22	2.20	2.20	2.19	1.83	1.82	1.81	1.80	1.80	10.0
15.0	2.23	2.21	2.20	2.20	2.19	1.82	1.81	1.81	1.80	1.80	15.0
			·	.	p =	0.3	·	•	•		*
	$r_{sd}p = 0$	0.1	0.3	10.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	
0.5	2.16	2.16	2.16	2.16	2.16	1.78	1.78	1.78	1.78	1.78	0.5
1.0	2.16	2.15	2.15	2.15	2.15	1.78	1.77	1.77	1.77	1.77	1.0
1.5	2.16	2.15	2.15	2.15	2.15	1.78	1.77	1.77	1.77	1.77	1.5
2.0	2.16	2.15	2.15	2.15	2.15	1.78	1.77	1.77	1.77	1.77	2.0
3.0	2.16	2.15	2.15	2.15	2.14	1.78	1.77	1.77	1.77	1.77	3.0
5.0	2.16	2.15	2.15	2.15	2.14	1.78	1.77	1.7.7	1.77	1.77	5.0
10.0	2.16	2.15	2.15	2.15	2.14	1.78	1.77	1.77	1.77	1.77	10.0
15.0	2.16	2.15	2.15	2.15	2.14	1.78	1.77	1.77	1.77	1.77	15.0
		<u> </u>	1	ZE	RO PRO	JECTING	L	L	1		1
			2.12					1.75			
			۲.1۲					1.70			<u> </u>

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Table 61

BEDDING FACTORS FOR ARCH PIPE
POSITIVE PROJECTING EMBANKMENT INSTALLATIONS

H B _c			ASS B		<u>.</u>			ASS C			H B _c
		BEI	DDING				BE	DDING	i 		D _C
	r.n. – 0		1		p =						
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	
0.5	2.72	2.65	2.65	2.65	2.65	2.14	2.10	2.10	2.10	2.10	0.5
1.0	2.58	2.49	2.49	2.49	2.49	2.05	2.00	2.00	2.00	2.00	1.0
1.5	2.34	2.46	2.42	2.40	2.38	2.03	1.97	1.95	1.94	1.92	1.5
2.0	2.52	2.44	2.41	2.39	2.37	2.01	1.96	1.95	1.93	1.92	2.0
3.0	2.50	2.43	2.40	2.38	2.34	2.00	1.96	1.94	1.92	1.90	3.0
5.0	2.48	2.42	2.39	2.36	2.33	1.99	1.95	1.93	1.91	1.89	5.0
10.0 15.0	2.47 2.46	2.41 2.40	2.37 2.36	2.35 2.35	2.33 2.32	1.98 1.98	1.94 1.94	1.92 1.92	1.91 1.91	1.89 1.89	10.0 15.0
10.0	2.40	2.40	2.00	2.00		<u> </u>	1.01	1.02	1.01	2.00	10.0
	r .n = 0				P =	r .		T	Γ		
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	
0.5	2.46	2.42	2.42	2.42	2.42	1.98	1.95	1.95	1.95	1.95	0.5
1.0	2.40	2.35	2.35	2.35	2.35	1.94	1.90	1.90	1.90	1.90	1.0
1.5	2.38	2.33	2.31	2.30	2.28	1.92	1.89	1.88	1.87	1.86	1.5
2.0	2.37	2.32	2.31	2.29	2.28	1.92	1.89	1.88	1.87	1.86	2.0
3.0	2.36	2.32	2.30	2.29	2.27	1.91	1.88	1.87	1.86	1.85	3.0
5.0	2.35	2.32	2.29	2.28	2.26	1.90	1.88	1.87	1.86	1.84	5.0
10.0	2.34	2.31	2.28	2.27	2.26	1.90	1.88	1.86	1.85	1.84	10.0
15.0	2.34	2.31	2.28	2.27	2.25	1.90	1.88	1.86	1.85	1.84	15.0
					p =	0.5		···		,	
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	
0.5	2.27	2.25	2.25	2.25	2.25	1.85	1.84	1.84	1.84	1.84	0.5
1.0	2.25	2.23	2.23	2.23	2.23	1.84	1.82	1.82	1.82	1.82	1.0
1.5	2.24	2.22	2.21	2.21	2.20	1.83	1.82	1.81	1.81	1.80	1.5
2.0	2.24	2.22	2.21	2.20	2.20	1.83	1.82	1.81	1.81	1.80	2.0
3.0	2.24	2.22	2.21	2.20	2.19	1.83	1.82	1.81	1.81	1.80	3.0
5.0	2.23	2.22	2.21	2.20	2.19	1.83	1.82	1.81	1.80	1.80	5.0
10.0	2.23	2.22	2.20	′2.20	2.19	1.83	1.82	1.81	1.80	1.80	10.0
15.0	2.23	2.21	2.20	2.20	2.19	1.82	1.81	1.81	1.80	1.80	15.0
					P=	0.3		·			
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	
0.5	2.16	2.16	2.16	2.16	2.16	1.78	1.78	1.78	1.78	1.78	0.5
1.0	2.16	2.15	2.15	2.15	2.15	1.78	1.77	1.77	1.77	1.77	1.0
1.5	2.16	2.15	2.15	2.15	2.15	1.78	1.77	1.77	1.77	1.77	1.5
2.0	2.16	2.15	2.15	2.15	2.15	1.78	1.77	1.77	1.77	1.77	2.0
3.0	2.16	2.15	2.15	2.15	2.14	1.78	1.77	1.77	1.77	1.77	3.0
5.0	2.16	2.15	2.15	2.15	2.14	1.78	1.77	1.77	1.77	1.77	5.0
10.0	2.16	2.15	2.15	2.15	2.14	1.78	1.77	1.77	1.77	1.77	10.0
15.0	2.16	2.15	2.15	2.15	2.14	1.78	1.77	1.77	1.77	1.77	15.0
	I	L	Į.	ZE	RO PRO	JECTING		1	-	<u> </u>	•
			2.12					1.75			
			2.12					, 0			

Table 62

Class V

Special Design

Class III Class II

12.10.4.3 of the AASHTO LRFD Bridge Design Specification, 4th Edition, 2007 with 2008 Interim. Live load was distributed through the pipe in accordance with Chapter The following Fill Height Tables have been developed by the American Concrete Pipe Association (ACPA) using the indirect design method in accordance with Section Class IV Class of the ACPA Concrete Pipe Design Manual

Type 1 Bedding

Fill Height Tables are based on:

- 1. $\gamma s = 120 \text{ pcf}$
- 2. AASHTO HL-93 live load
- 3. Positive Projecting Embankment Condition this gives conservative results in comparison to trench conditions

4. A Type 1 installation requires greater soil stiffness from the surrounding soils than the Type 2, 3, and 4 installations, and is thus harder to achieve. Therefore, field verification of soil properties and compaction levels should be pairbheight (feet)

	-			. -				<u>`</u>							
1 2 3 4 5 6	3 4 5	4 5	ß		v	9	7	8	6	10	1	12	13	14	15
1850 1100 800 700 650 625	800 700 650	700 650	650		625		650	675	700	750	800	825	006	950	1000
1725 1025 775 675 625 625	775 675 625	675 625	625		625		625	650	200	725	775	825	875	925	975
1550 975 750 650 600 600	009 029 052	009 059	009	0	009		625	650	675	725	775	800	875	925	975
1300 950 725 625 600 600	725 625 600	625 600	009		09		625	650	675	725	750	800	875	925	950
1150 925 700 625 600 600	700 625 600	625 600	009		09	0	625	650	675	725	750	800	875	925	950
1025 900 700 625 600 600	700 625 600	625 600	009		09	0	625	650	675	725	750	800	875	925	975
975 825 675 625 600 600	675 625 600	625 600	009		09	0	625	650	675	725	775	825	875	925	975
925 775 675 600 600 600	009 009 229	009 009	009		09	0	625	650	700	725	775	825	875	925	975
900 725 675 600 600 600	009 009 229	009 009	009)09		625	650	200	725	775	825	006	950	975
825 650 650 600 600 600	009 009 059	009 009	009		009		625	650	200	750	775	825	006	950	1000
875 650 600 600 600 600 600	009 009 009	009 009	009		009)	625	675	200	750	800	825	900	950	1000
825 650 550 600 600 600	220 000 000	009 009	009		009		029	675	725	750	800	875	925	950	1000
825 650 550 550 600 625	250 550 600	220 600	009		625	2	029	675	725	277	800	875	925	975	1025
825 675 550 550 600 625	250 550 600	250 600	009		625		029	200	725	775	825	900	925	975	1025
800 700 550 550 600 625	250 550 600	250 600	009		625		675	200	750	775	825	900	950	1000	1050
725 675 600 600 600 625	009 009 009	009 009	009		625		675	200	750	800	875	900	950	1000	1050
700 650 625 600 625 650	625 600 625	600 625	625		650		675	725	750	800	875	925	975	1025	1075
650 650 625 600 625 650	625 600 625	600 625	625		650		675	725	775	825	875	925	975	1025	1075
625 625 625 625 625 650	625 625 625	625 625	625	ıO	650		200	725	775	825	006	950	1000	1050	1100
625 625 625 625 675	625 625 650	625 650	029		675		200	750	800	825	006	950	1000	1050	1100
650 600 625 625 650 675	625 625 650	625 650	650		675	10	725	750	800	875	925	975	1025	1075	1150

Table																						
Class IV Class V Special Design			30	1500	1475	1475	1450	1475	1475	1475	1500	1500	1525	1525	1525	1550	1550	1575	1575	1575	1600	1600
Class IV Class V Special I			59	1450	1425	1425	1425	1425	1425	1425	1450	1450	1475	1475	1475	1500	1500	1525	1525	1525	1525	1550
_ = =		•	28	1400	1375	1375	1375	1375	1375	1375	1400	1400	1425	1425	1425	1450	1450	1475	1475	1475	1475	1500
Class II Class III			27	1350	1325	1325	1325	1325	1325	1325	1350	1350	1375	1375	1375	1400	1400	1425	1425	1425	1425	1450
			26	1300	1275	1275	1275	1275	1275	1300	1300	1300	1325	1325	1325	1350	1350	1375	1375	1375	1375	1400
			25	1250	1225	1225	1225	1225	1225	1250	1250	1250	1275	1275	1275	1300	1300	1300	1325	1325	1325	1350
g			24	1200	1175	1175	1175	1175	1175	1200	1200	1200	1225	1225	1225	1250	1250	1250	1275	1275	1275	1300
Bedding		Fill Height (feet)	23	1150	1125	1125	1125	1125	1125	1150	1150	1150	1175	1175	1175	1200	1200	1200	1225	1225	1225	1250
Type 1		Fill Hei	22	1100	1075	1075	1075	1075	1075	1100	1100	1100	1125	1125	1125	1150	1150	1150	1175	1175	1175	1175
–			21	1050	1025	1025	1025	1025	1025	1050	1050	1050	1075	1075	1075	1100	1100	1100	1125	1125	1125	1125
			20	1000	975	975	975	926	1000	1000	1000	1025	1025	1025	1025	1050	1050	1050	1075	1075	1075	1075
			19	950	950	925	925	950	950	950	950	975	975	975	975	1000	1000	1000	1025	1025	1025	1025
			18	006	006	006	006	006	006	006	006	928	922	928	928	026	026	026	975	975	975	975
oased on: os/ft³ oad	ion		17	850	850	098	850	058	850	850	058	928	875	928	928	006	006	928	925	925	925	925
bles are k t of 120 lb 520 live lo	nt installat		16	800	800	800	800	008	800	800	008	825	825	825	825	850	850	820	875	875	875	875
I Height Tables are based on: A soil weight of 120 lbs/ft ³ AASHTO HS20 live load	Embankment installation		Pipe i.d. (inches)	12	15	18	21	24	27	30	33	36	42	48	54	60	99	72	78	84	90	96

Table 64

Class II Class IV
Class III Special Design

Type 1 Bedding

Fill Height Tables are based on:

A soil weight of 120 lbs/ft³
 AASHTO HS20 live load
 Embankment installation

	45	2225	2200	2200	2175	2200	2200	2225	2225	2250	2250	2275	2275	2300	2325	2325	2350	2350	2350	2375
	44	2175	2150	2150	2150	2150	2150	2175	2175	2200	2200	2225	2225	2250	2250	2275	2300	2300	2300	2325
	43	2125	2100	2100	2100	2100	2100	2125	2125	2150	2150	2175	2175	2200	2200	2225	2225	2250	2250	2275
	42	2075	2050	2050	2050	2050	2050	2075	2075	2100	2100	2125	2125	2150	2150	2175	2175	2200	2200	2225
	41	2025	2000	2000	2000	2000	2000	2025	2025	2050	2050	2075	2075	2100	2100	2125	2125	2150	2150	2175
	40	1975	1950	1950	1950	1950	1950	1975	1975	2000	2000	2025	2025	2050	2050	2075	2075	2100	2100	2100
	39	1925	1900	1900	1900	1900	1900	1925	1950	1950	1950	1975	1975	2000	2000	2025	2025	2050	2050	2050
Fill Height (feet)	38	1875	1850	1850	1850	1850	1875	1875	1900	1900	1900	1925	1925	1950	1950	1975	1975	2000	2000	2000
Fill Heig	28	1825	1800	1800	1800	1800	1825	1825	1850	1850	1850	1875	1875	1900	1900	1925	1925	1950	1950	1950
	98	1775	1750	1750	1750	1750	1775	1775	1800	1800	1800	1825	1825	1850	1850	1875	1875	1900	1900	1900
	35	1725	1725	1700	1700	1700	1725	1725	1750	1750	1750	1775	1775	1800	1800	1825	1825	1825	1850	1850
	34	1700	1675	1650	1650	1650	1675	1675	1700	1700	1700	1725	1725	1750	1750	1775	1775	1775	1800	1800
	33	1650	1625	1600	1600	1600	1625	1625	1650	1650	1675	1675	1675	1700	1700	1725	1725	1725	1750	1750
	35	1600	1575	1550	1550	1575	1575	1575	1600	1600	1625	1625	1625	1650	1650	1675	1675	1675	1700	1700
	31	1550	1525	1500	1500	1525	1525	1525	1550	1550	1575	1575	1575	1600	1600	1625	1625	1625	1650	1650
	Pipe i.d. (inches)	12	15	18	21	24	27	30	33	36	42	48	54	09	99	72	78	84	06	96

Table 65

Class V Special Design Class IV Class II Class III

Fill Height Tables are based on:

|)
 | | 10 | 10 | 10 | 10 | 10
 | 10 |
 | 10 |
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 | | | |
 | | 10 | | |
|------------|-----------------------|---|--|--|---
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--|---|--|--|--|--|---|---|---|
| | 09 | 2975 | 2925 | 2925 | 2925 | 2925
 | 2925 | 2950
 | 2975 | 3000
 | 3000 | 3025
 | 3025 | 3020 | 3075 | 3100
 | 3100 | 3125 | 3125 | 3150 |
| | 59 | 2925 | 2875 | 2875 | 2875 | 2875
 | 2875 | 2900
 | 2925 | 2950
 | 2950 | 2975
 | 2975 | 3000 | 3025 | 3050
 | 3050 | 3075 | 3075 | 3100 |
| | 58 | 2875 | 2825 | 2825 | 2825 | 2825
 | 2825 | 2850
 | 2875 | 2900
 | 2900 | 2925
 | 2925 | 2950 | 2975 | 3000
 | 3000 | 3025 | 3025 | 3050 |
| | 57 | 2825 | 2775 | 2775 | 2775 | 2775
 | 2775 | 2800
 | 2825 | 2850
 | 2850 | 2875
 | 2875 | 2900 | 2925 | 2950
 | 2950 | 2975 | 2975 | 2975 |
| | 56 | 2775 | 2725 | 2725 | 2725 | 2725
 | 2750 | 2750
 | 2775 | 2800
 | 2800 | 2825
 | 2825 | 2850 | 2875 | 2900
 | 2900 | 2900 | 2925 | 2925 |
| | 55 | 2725 | 2700 | 2675 | 2675 | 2675
 | 2700 | 2700
 | 2725 | 2750
 | 2750 | 2775
 | 2775 | 2800 | 2825 | 2850
 | 2850 | 2850 | 2875 | 2875 |
| | 54 | 2675 | 2650 | 2625 | 2625 | 2625
 | 2650 | 2650
 | 2675 | 2700
 | 2700 | 2725
 | 2725 | 2750 | 2775 | 2800
 | 2800 | 2800 | 2825 | 2825 |
| jht (feet) | 53 | 2625 | 2600 | 2575 | 2575 | 2575
 | 2600 | 2600
 | 2625 | 2650
 | 2650 | 2675
 | 2675 | 2700 | 2725 | 2750
 | 2750 | 2750 | 2775 | 2775 |
| Fill Heig | 52 | 2575 | 2550 | 2525 | 2525 | 2525
 | 2550 | 2550
 | 2575 | 2600
 | 2600 | 2625
 | 2625 | 2650 | 2675 | 2675
 | 2700 | 2700 | 2725 | 2725 |
| | 51 | 2525 | 2500 | 2475 | 2475 | 2475
 | 2500 | 2500
 | 2525 | 2550
 | 2550 | 2575
 | 2575 | 2600 | 2625 | 2625
 | 2650 | 2650 | 2675 | 2675 |
| | 50 | 2475 | 2450 | 2425 | 2425 | 2425
 | 2450 | 2450
 | 2475 | 2500
 | 2500 | 2525
 | 2525 | 2550 | 2575 | 2575
 | 2600 | 2600 | 2625 | 2625 |
| | 49 | 2425 | 2400 | 2375 | 2375 | 2375
 | 2400 | 2425
 | 2425 | 2450
 | 2450 | 2475
 | 2475 | 2500 | 2525 | 2525
 | 2550 | 2550 | 2575 | 2575 |
| | 48 | 2375 | 2350 | 2325 | 2325 | 2350
 | 2350 | 2375
 | 2375 | 2400
 | 2400 | 2425
 | 2425 | 2450 | 2475 | 2475
 | 2500 | 2500 | 2525 | 2525 |
| | 47 | 2325 | 2300 | 2275 | 2275 | 2300
 | 2300 | 2325
 | 2325 | 2350
 | 2350 | 2375
 | 2375 | 2400 | 2425 | 2425
 | 2450 | 2450 | 2450 | 2475 |
| | 46 | 2275 | 2250 | 2225 | 2225 | 2250
 | 2250 | 2275
 | 2275 | 2300
 | 2300 | 2325
 | 2325 | 2350 | 2375 | 2375
 | 2400 | 2400 | 2400 | 2425 |
| | Pipe i.d.
(inches) | 12 | 15 | 18 | 21 | 24
 | 27 | 30
 | 33 | 36
 | 42 | 48
 | 54 | 09 | 99 | 72
 | 78 | 84 | 90 | 96 |
| | Fill Height (feet) | 47 48 49 50 51 52 53 54 55 56 57 58 59 60 | 47 48 49 50 51 2525 2375 2425 2475 2525 2525 2525 2625 2675 2725 2725 27 | 47 48 49 50 51 52 53 54 55 56 57 58 59 60 :300 2350 2400 2450 2500 2500 2600 2650 2700 2725 2775 2825 2875 2925 2975 :300 2350 2460 2560 2600 2650 2700 2725 2775 2825 2875 2925 | 47 48 49 50 51 52 53 54 55 56 57 58 59 60 :325 2375 2425 2425 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2400 2500 2500 2600 2650 2700 2725 2775 2825 2875 2925 :275 2325 2425 2475 2525 2575 2625 2675 2775 2825 2875 2925 :275 2325 2375 2475 2525 2575 2625 2675 2775 2825 2875 2925 | 47 48 49 50 51 52 53 54 55 56 57 58 59 60 :325 2375 2425 2475 2525 2575 2625 2675 2775 2725 2775 2825 2925 2975 :300 2350 2400 2550 2600 2650 2700 2725 2775 2825 2875 2925 :275 2325 2426 2475 2525 2575 2625 2675 2725 2725 2775 2825 2875 2925 :275 2325 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :275 2325 2375 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 <t< td=""><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 :325 2375 2425 2475 2525 2625 2675 2725 2775 2825 2875 2925 2975 :300 2350 2400 2450 2550 2600 2650 2700 2725 2775 2825 2875 2925 :275 2325 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :275 2325 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2925 :300 2355 2475 2525 2575 2625 2675 2775 2775 2825 2875 2925 :300 2350 2425 2475 2525 2575 2625 2675 2775 2775 2825 2</td><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 :325 2375 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2400 2450 2520 2600 2650 2700 2725 2775 2825 2875 2925 :275 2325 2375 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2356 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2400 2520 2605 2700 2750 2775 2875 2</td><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 :300 2375 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2400 2450 2500 2500 2650 2600 2650 2700 2725 2775 2825 2875 2925 :275 2325 2375 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2875 2825 :300 2450 2500 2500 2600 2</td><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 325 2375 2425 2475 2525 2575 2625 2675 2775 2775 2825 2875 2925 3300 2350 2400 2450 2560 2600 2650 2705 2775 2825 2875 2925 2275 2326 2400 2450 2526 2675 2775 2725 2775 2825 2875 2925 2376 2326 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2925 2300 2326 2475 2525 2575 2625 2675 2775 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 <td< td=""><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 3300 2350 2425 2475 2625 2675 2725 2775 2825 2875 2975 2300 2350 2460 2450 2550 2600 2650 2705 2775 2825 2875 2925 2275 2325 2375 2425 2475 2525 2675 2725 2775 2825 2875 2925 2375 2325 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2875</td><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 325 2375 2425 2475 2525 2575 2625 2675 2775 2825 2875 2925 320 2350 2400 2450 2526 2676 2626 2700 2725 2775 2825 2875 2925 2375 2326 2476 2526 2676 2626 2676 2726 2775 2825 2875 2925 2376 2426 2476 2526 2675 2675 2675 2775 2726 2875 2892 2875 2892 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2892 2892 2892 3300 2350 240 250 260 260 260 270<!--</td--><td>47 48 49 50 51 52 53 54 56 57 58 59 60 :325 2375 2425 2475 2525 2575 2625 2775 2775 2825 2875 2925 :300 2350 240 2450 2550 2600 2650 2775 2725 2775 2825 2875 2925 :275 2326 240 2450
 2550 2600 2650 2775 2725 2775 2825 2875 2925 :275 2326 2476 2625 2675 2725 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2825 2875 2875 2875 2875 2875 2875 2</td><td>47 48 49 50 51 52 54 55 56 57 58 59 60 325 2375 2425 2475 2525 2675 2675 2775 2825 2875 2925 2975 330 235 2426 2476 2526 2675 2675 2775 2825 2875 2925 230 236 240 2456 2560 2600 2650 2775 2725 2775 2825 2875 2892 2897 2892 2897 2892 2897 2892 2897 2892 2892 2897 2892 2897 2892 2897 2892 2897 2892</td><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 3235 2375 2425 2475 2526 2575 2675 2675 2775 2825 2875 2925 2975 3300 2350 2400 2450 2576 2600 2650 2700 2725 2775 2825 2875 2925 2300 2350 2400 2450 2526 2575 2625 2675 2775 2725 2775 2825 2875 2925 2875 2625 2675 2775 2725 2775 2825 2875 2825 2875 2625 2675 2775 2725 2775 2825 2875 2825 2875 2875 2825 2875 2875 2775 2825 2875 2825 2875 2875 2875 2875 2875 2875 2875 2875 2875 2875</td><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 3325 2375 2475 2525 2575 2625 2775 2775 2825 2875 2925 330 2350 2400 2450 2550 2600 2650 2700 2725 2775 2825 2875 2925 2375 2426 2476 2526 2675 2625 2675 2775 2825 2875 2825 2370 2326 2476 2526 2575 2625 2675 2775 2725 2775 2825 2875 2825 2875 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825</td><td>47 48 49 50 51 52 54 55 56 57 58 59 60 3325 2345 2425 2475 2526 2575 2625 2775 2825 2875 2925 2975 330 2350 2400 2450 2500 2500 2650 2700 2725 2775 2825 2875 2925 2350 2400 2450 2500 2600 2650 2700 2725 2775 2825 2875 2925 2375 2326 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2862 2675 2775 2725 2875 2862 2875 2775 2825 2875 2862 2875 2775 2775 2825 2875 2862 2875 2775 2825 2875 2862 2875 2775 2825 2875 2875 2875</td><td>47 48 49 50 51 52 53 54 56 57 58 59 60 335 242 50 51 52 53 54 56 57 58 59 60 336 2476 2476 2626 2675 2675 2726 2776 2825 2875 2826 2876 2876 2826 2876</td><td>47 48 49 50 51 52 54 56 57 58 59 60 332 2375 2426 2475 2526 2675 2775 2775 2825 2875 2926 2975 330 236 2476 2526 2575 2626 2676 2775 2825 2875 2926 2975 236 236 240 2450 2560 260 2660 270 2775 2825 2875 2925 2376 2426 2476 2526 2675 2625 2675 2775 2775 2825 2875 2925 2376 2426 2475 2526 2675 2626 2675 2775 2775 2825 2875 2826 2875 2875 2625 2675 2776 2776 2876 2876 2876 2876 2876 2876 2876 2876 2876 2876 2876 28</td><td>47 48 49 50 51 52 53 54 56 57 58 59 60 3325 2375 2425 2475 2525 2675 2675 2775 2825 2875<!--</td--></td></td></td<></td></t<> | 47 48 49 50 51 52 53 54 55 56 57 58 59 60 :325 2375 2425 2475 2525 2625 2675 2725 2775 2825 2875 2925 2975 :300 2350 2400 2450 2550 2600 2650 2700 2725 2775 2825 2875 2925 :275 2325 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :275 2325 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2925 :300 2355 2475 2525 2575 2625 2675 2775 2775 2825 2875 2925 :300 2350 2425 2475 2525 2575 2625 2675 2775 2775 2825 2 | 47 48 49 50 51 52 53 54 55 56
 57 58 59 60 :325 2375 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2400 2450 2520 2600 2650 2700 2725 2775 2825 2875 2925 :275 2325 2375 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2356 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2400 2520 2605 2700 2750 2775 2875 2 | 47 48 49 50 51 52 53 54 55 56 57 58 59 60 :300 2375 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2400 2450 2500 2500 2650 2600 2650 2700 2725 2775 2825 2875 2925 :275 2325 2375 2425 2475 2525 2575 2625 2675 2725 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2875 2825 :300 2450 2500 2500 2600 2 | 47 48 49 50 51 52 53 54 55 56 57 58 59 60 325 2375 2425 2475 2525 2575 2625 2675 2775 2775 2825 2875 2925 3300 2350 2400 2450 2560 2600 2650 2705 2775 2825 2875 2925 2275 2326 2400 2450 2526 2675 2775 2725 2775 2825 2875 2925 2376 2326 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2925 2300 2326 2475 2525 2575 2625 2675 2775 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 <td< td=""><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 3300 2350 2425 2475 2625 2675 2725 2775 2825 2875 2975 2300 2350 2460 2450 2550 2600 2650 2705 2775 2825 2875 2925 2275 2325 2375 2425 2475 2525 2675 2725 2775 2825 2875 2925 2375 2325 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2875</td><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 325 2375 2425 2475 2525 2575 2625 2675 2775 2825 2875 2925 320 2350 2400 2450 2526 2676 2626 2700 2725 2775 2825 2875 2925 2375 2326 2476 2526 2676 2626 2676 2726 2775 2825 2875 2925 2376 2426 2476 2526 2675 2675 2675 2775 2726 2875 2892 2875 2892 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2892 2892 2892 3300 2350 240 250 260 260 260 270<!--</td--><td>47 48 49 50 51 52 53 54 56 57 58 59 60 :325 2375 2425 2475 2525 2575 2625 2775 2775 2825 2875 2925 :300 2350 240 2450 2550 2600 2650 2775 2725 2775 2825 2875 2925 :275 2326 240 2450 2550 2600 2650 2775 2725 2775 2825 2875 2925 :275 2326 2476 2625 2675 2725 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2825 2875 2875 2875 2875 2875 2875 2</td><td>47 48 49 50 51 52 54 55 56 57 58 59 60 325 2375 2425 2475 2525 2675 2675 2775 2825 2875 2925 2975 330 235 2426 2476 2526 2675 2675 2775 2825 2875 2925 230 236 240 2456 2560 2600 2650 2775 2725 2775 2825 2875 2892 2897 2892 2897 2892 2897 2892 2897 2892 2892 2897 2892 2897 2892 2897 2892 2897 2892</td><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 3235 2375 2425 2475 2526 2575 2675 2675 2775 2825 2875 2925 2975 3300 2350 2400 2450 2576 2600 2650 2700 2725 2775 2825 2875 2925 2300 2350 2400 2450 2526 2575 2625 2675 2775 2725 2775 2825 2875 2925 2875 2625 2675 2775 2725 2775 2825 2875 2825 2875 2625 2675 2775 2725 2775 2825 2875 2825 2875 2875 2825 2875 2875 2775 2825 2875 2825 2875 2875 2875 2875 2875 2875 2875 2875 2875 2875</td><td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 3325 2375 2475 2525 2575 2625 2775 2775 2825 2875 2925 330 2350 2400 2450 2550 2600 2650 2700 2725 2775 2825 2875 2925 2375 2426 2476 2526 2675 2625 2675 2775 2825 2875 2825 2370 2326 2476 2526 2575 2625 2675 2775 2725 2775 2825 2875 2825 2875 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875
2825 2875 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825</td><td>47 48 49 50 51 52 54 55 56 57 58 59 60 3325 2345 2425 2475 2526 2575 2625 2775 2825 2875 2925 2975 330 2350 2400 2450 2500 2500 2650 2700 2725 2775 2825 2875 2925 2350 2400 2450 2500 2600 2650 2700 2725 2775 2825 2875 2925 2375 2326 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2862 2675 2775 2725 2875 2862 2875 2775 2825 2875 2862 2875 2775 2775 2825 2875 2862 2875 2775 2825 2875 2862 2875 2775 2825 2875 2875 2875</td><td>47 48 49 50 51 52 53 54 56 57 58 59 60 335 242 50 51 52 53 54 56 57 58 59 60 336 2476 2476 2626 2675 2675 2726 2776 2825 2875 2826 2876 2876 2826 2876</td><td>47 48 49 50 51 52 54 56 57 58 59 60 332 2375 2426 2475 2526 2675 2775 2775 2825 2875 2926 2975 330 236 2476 2526 2575 2626 2676 2775 2825 2875 2926 2975 236 236 240 2450 2560 260 2660 270 2775 2825 2875 2925 2376 2426 2476 2526 2675 2625 2675 2775 2775 2825 2875 2925 2376 2426 2475 2526 2675 2626 2675 2775 2775 2825 2875 2826 2875 2875 2625 2675 2776 2776 2876 2876 2876 2876 2876 2876 2876 2876 2876 2876 2876 28</td><td>47 48 49 50 51 52 53 54 56 57 58 59 60 3325 2375 2425 2475 2525 2675 2675 2775 2825 2875<!--</td--></td></td></td<> | 47 48 49 50 51 52 53 54 55 56 57 58 59 60 3300 2350 2425 2475 2625 2675 2725 2775 2825 2875 2975 2300 2350 2460 2450 2550 2600 2650 2705 2775 2825 2875 2925 2275 2325 2375 2425 2475 2525 2675 2725 2775 2825 2875 2925 2375 2325 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2875 | 47 48 49 50 51 52 53 54 55 56 57 58 59 60 325 2375 2425 2475 2525 2575 2625 2675 2775 2825 2875 2925 320 2350 2400 2450 2526 2676 2626 2700 2725 2775 2825 2875 2925 2375 2326 2476 2526 2676 2626 2676 2726 2775 2825 2875 2925 2376 2426 2476 2526 2675 2675 2675 2775 2726 2875 2892 2875 2892 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2892 2892 2892 3300 2350 240 250 260 260 260 270 </td <td>47 48 49 50 51 52 53 54 56 57 58 59 60 :325 2375 2425 2475 2525 2575 2625 2775 2775 2825 2875 2925 :300 2350 240 2450 2550 2600 2650 2775 2725 2775 2825 2875 2925 :275 2326 240 2450 2550 2600 2650 2775 2725 2775 2825 2875 2925 :275 2326 2476 2625 2675 2725 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2825 2875 2875 2875 2875 2875 2875 2</td> <td>47 48 49 50 51 52 54 55 56 57 58 59 60 325 2375 2425 2475 2525 2675 2675 2775 2825 2875 2925 2975 330 235 2426 2476 2526 2675 2675 2775 2825 2875 2925 230 236 240 2456 2560 2600 2650 2775 2725 2775 2825 2875 2892 2897 2892 2897 2892 2897 2892 2897 2892 2892 2897 2892 2897 2892 2897 2892 2897 2892</td> <td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 3235 2375 2425 2475 2526 2575 2675 2675 2775 2825 2875 2925 2975 3300 2350 2400 2450 2576 2600 2650 2700 2725 2775 2825 2875 2925 2300 2350 2400
2450 2526 2575 2625 2675 2775 2725 2775 2825 2875 2925 2875 2625 2675 2775 2725 2775 2825 2875 2825 2875 2625 2675 2775 2725 2775 2825 2875 2825 2875 2875 2825 2875 2875 2775 2825 2875 2825 2875 2875 2875 2875 2875 2875 2875 2875 2875 2875</td> <td>47 48 49 50 51 52 53 54 55 56 57 58 59 60 3325 2375 2475 2525 2575 2625 2775 2775 2825 2875 2925 330 2350 2400 2450 2550 2600 2650 2700 2725 2775 2825 2875 2925 2375 2426 2476 2526 2675 2625 2675 2775 2825 2875 2825 2370 2326 2476 2526 2575 2625 2675 2775 2725 2775 2825 2875 2825 2875 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825</td> <td>47 48 49 50 51 52 54 55 56 57 58 59 60 3325 2345 2425 2475 2526 2575 2625 2775 2825 2875 2925 2975 330 2350 2400 2450 2500 2500 2650 2700 2725 2775 2825 2875 2925 2350 2400 2450 2500 2600 2650 2700 2725 2775 2825 2875 2925 2375 2326 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2862 2675 2775 2725 2875 2862 2875 2775 2825 2875 2862 2875 2775 2775 2825 2875 2862 2875 2775 2825 2875 2862 2875 2775 2825 2875 2875 2875</td> <td>47 48 49 50 51 52 53 54 56 57 58 59 60 335 242 50 51 52 53 54 56 57 58 59 60 336 2476 2476 2626 2675 2675 2726 2776 2825 2875 2826 2876 2876 2826 2876</td> <td>47 48 49 50 51 52 54 56 57 58 59 60 332 2375 2426 2475 2526 2675 2775 2775 2825 2875 2926 2975 330 236 2476 2526 2575 2626 2676 2775 2825 2875 2926 2975 236 236 240 2450 2560 260 2660 270 2775 2825 2875 2925 2376 2426 2476 2526 2675 2625 2675 2775 2775 2825 2875 2925 2376 2426 2475 2526 2675 2626 2675 2775 2775 2825 2875 2826 2875 2875 2625 2675 2776 2776 2876 2876 2876 2876 2876 2876 2876 2876 2876 2876 2876 28</td> <td>47 48 49 50 51 52 53 54 56 57 58 59 60 3325 2375 2425 2475 2525 2675 2675 2775 2825 2875<!--</td--></td> | 47 48 49 50 51 52 53 54 56 57 58 59 60 :325 2375 2425 2475 2525 2575 2625 2775 2775 2825 2875 2925 :300 2350 240 2450 2550 2600 2650 2775 2725 2775 2825 2875 2925 :275 2326 240 2450 2550 2600 2650 2775 2725 2775 2825 2875 2925 :275 2326 2476 2625 2675 2725 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2775 2825 2875 2925 :300 2350 2475 2525 2575 2625 2675 2775 2825 2875 2875 2875 2875 2875 2875 2 | 47 48 49 50 51 52 54 55 56 57 58 59 60 325 2375 2425 2475 2525 2675 2675 2775 2825 2875 2925 2975 330 235 2426 2476 2526 2675 2675 2775 2825 2875 2925 230 236 240 2456 2560 2600 2650 2775 2725 2775 2825 2875 2892 2897 2892 2897 2892 2897 2892 2897 2892 2892 2897 2892 2897 2892 2897 2892 2897 2892 | 47 48 49 50 51 52 53 54 55 56 57 58 59 60 3235 2375 2425 2475 2526 2575 2675 2675 2775 2825 2875 2925 2975 3300 2350 2400 2450 2576 2600 2650 2700 2725 2775 2825 2875 2925 2300 2350 2400 2450 2526 2575 2625 2675 2775 2725 2775 2825 2875 2925 2875 2625 2675 2775 2725 2775 2825 2875 2825 2875 2625 2675 2775 2725 2775 2825 2875 2825 2875 2875 2825 2875 2875 2775 2825 2875 2825 2875 2875 2875 2875 2875 2875 2875 2875 2875 2875 | 47 48 49 50 51 52 53 54 55 56 57 58
 59 60 3325 2375 2475 2525 2575 2625 2775 2775 2825 2875 2925 330 2350 2400 2450 2550 2600 2650 2700 2725 2775 2825 2875 2925 2375 2426 2476 2526 2675 2625 2675 2775 2825 2875 2825 2370 2326 2476 2526 2575 2625 2675 2775 2725 2775 2825 2875 2825 2875 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 2875 2825 | 47 48 49 50 51 52 54 55 56 57 58 59 60 3325 2345 2425 2475 2526 2575 2625 2775 2825 2875 2925 2975 330 2350 2400 2450 2500 2500 2650 2700 2725 2775 2825 2875 2925 2350 2400 2450 2500 2600 2650 2700 2725 2775 2825 2875 2925 2375 2326 2475 2525 2575 2625 2675 2775 2725 2775 2825 2875 2862 2675 2775 2725 2875 2862 2875 2775 2825 2875 2862 2875 2775 2775 2825 2875 2862 2875 2775 2825 2875 2862 2875 2775 2825 2875 2875 2875 | 47 48 49 50 51 52 53 54 56 57 58 59 60 335 242 50 51 52 53 54 56 57 58 59 60 336 2476 2476 2626 2675 2675 2726 2776 2825 2875 2826 2876 2876 2826 2876 | 47 48 49 50 51 52 54 56 57 58 59 60 332 2375 2426 2475 2526 2675 2775 2775 2825 2875 2926 2975 330 236 2476 2526 2575 2626 2676 2775 2825 2875 2926 2975 236 236 240 2450 2560 260 2660 270 2775 2825 2875 2925 2376 2426 2476 2526 2675 2625 2675 2775 2775 2825 2875 2925 2376 2426 2475 2526 2675 2626 2675 2775 2775 2825 2875 2826 2875 2875 2625 2675 2776 2776 2876 2876 2876 2876 2876 2876 2876 2876 2876 2876 2876 28 | 47 48 49 50 51 52 53 54 56 57 58 59 60 3325 2375 2425 2475 2525 2675 2675 2775 2825 2875 </td |

Table 66

Class IV	Class V	Special Design
Class I	Class II	Class III

Type 2 Bedding

Fill Height Tables are based on:
1. A soil weight of 120 lbs/ft³
2. AASHTO HS20 live load
3. Embankment installation

	15	1100	1075	1075	1075	1100	1100	1100	1100	1125	1125	1125	1125	1125	1150	1150	1150	1150	1150	1175
	14	1025	1025	1025	1025	1025	1025	1025	1050	1050	1050	1050	1050	1075	1075	1075	1075	1075	1100	1100
	13	950	950	950	950	950	975	975	975	975	975	975	1000	1000	1000	1025	1025	1025	1025	1025
	12	900	875	875	875	006	900	006	006	006	925	925	925	925	950	950	950	950	950	950
	11	825	825	825	825	825	825	825	850	850	850	850	850	850	875	875	875	875	875	875
	10	750	750	750	750	775	775	277	277	775	775	775	800	800	800	800	800	825	825	825
	6	200	200	200	700	700	700	200	200	725	725	725	725	725	725	750	750	750	750	750
Fill Height (feet)	8	029	625	625	625	650	650	029	029	650	650	650	650	675	675	675	675	675	675	675
Fill Heig	2	222	229	229	575	575	575	229	2/2	009	009	009	009	009	009	009	625	625	625	625
	9	525	525	525	525	525	525	525	525	525	525	550	250	220	220	220	220	220	220	220
	5	500	475	475	475	475	475	475	475	475	475	475	200	500	200	200	200	200	200	500
	4	475	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
	3	475	475	450	450	450	450	450	425	425	425	425	425	425	400	400	400	400	400	400
	2	650	625	009	575	575	250	220	220	525	525	200	475	450	450	450	450	425	425	425
	1	1150	1075	1025	1000	950	006	098	008	775	675	625	009	2/2	2/2	275	525	475	450	425
	Pipe i.d. (inches)	12	15	18	21	24	27	30	33	36	42	48	54	09	99	72	82	84	06	96

Table 67

Class IV	Class V	Special Design	
Class I	Class II	Class III	

Type 2 Bedding

Fill Height Tables are based on:
1. A soil weight of 120 lbs/ft³
2. AASHTO HS20 live load
3. Embankment installation

-		_													
		17	18	19	20	21	22	23	24	25	26	27	28	29	30
12 11	1150 12	1225	1275	1350	1425	1500	1550	1625	1700	1750	1825	1900	1975	2050	2125
15 11	1150 12	1200	1275	1325	1400	1475	1550	1625	1675	1750	1825	1875	1950	2025	2100
11 11	1150 12	1200	1275	1350	1400	1475	1550	1600	1675	1750	1825	1875	1950	2025	2100
21 11	1150 12	1200	1275	1350	1400	1475	1550	1625	1675	1750	1825	1900	1975	2025	2100
24 11	1150 12	1225	1300	1350	1425	1500	1550	1625	1700	1775	1850	1900	1975	2050	2125
27 11	1150 12	1225	1300	1350	1425	1500	1575	1625	1700	1775	1850	1925	1975	2050	2125
30 11	1150 12	1225	1300	1350	1425	1500	1575	1650	1700	1775	1850	1925	2000	2050	2125
33 11	1150 12	1225	1300	1375	1425	1500	1575	1650	1725	1800	1850	1925	2000	2075	2150
36 11	1175 12	1250	1300	1375	1450	1525	1600	1650	1725	1800	1875	1950	2000	2075	2150
42 11	1175 12	1250	1325	1375	1450	1525	1600	1675	1725	1800	1875	1950	2025	2075	2150
48 11	1175 12	1250	1325	1400	1450	1525	1600	1675	1725	1800	1875	1950	2025	2100	2150
54 11	1175 12	1250	1325	1400	1450	1525	1600	1675	1750	1825	1875	1950	2025	2100	2175
60 12	1200 12	1250	1325	1400	1475	1550	1600	1675	1750	1825	1900	1975	2050	2100	2175
66 12	1200 12	1275	1350	1400	1475	1550	1625	1700	1775	1825	1900	1975	2050	2125	2200
72 12	1200 12	1275	1350	1425	1500	1550	1625	1700	1775	1850	1925	2000	2050	2125	2200
78 12	1200 12	1275	1350	1425	1500	1575	1625	1700	1775	1850	1925	2000	2050	2125	2200
84 12	1225 12	1275 1	1350	1425	1500	1575	1625	1700	1775	1850	1925	2000	2075	2125	2200
90 12	1225 12	1275 1	1350	1425	1500	1575	1650	1700	1775	1850	1925	2000	2075	2125	2200
96 12	1225 13	1300	1350	1425	1500	1575	1650	1700	1775	1850	1925	2000	2075	2150	2200

Table 68

Class IV	Class V	Special Design	
Class I	Class II	Class III	

Type 2 Bedding

Fill Height Tables are based on:
1. A soil weight of 120 lbs/ft³
2. AASHTO HS20 live load
3. Embankment installation

		0	5.	55	0	2	2	5	0	55	5.	55	55	0	5	5	5	5	5	5
	45	3150	3125	3125	3150	3175	3175	3175	3200	3225	3225	3225	3225	3250	3275	3275	3275	3275	3275	3275
	44	3100	3075	3050	3075	3100	3100	3125	3125	3150	3150	3150	3175	3175	3200	3200	3200	3200	3200	3200
	43	3025	3000	3000	3000	3025	3025	3050	3050	3075	3075	3075	3100	3100	3125	3125	3125	3125	3125	3125
	42	2950	2925	2925	2925	2950	2975	2975	2975	3000	3000	3000	3025	3025	3050	3075	3075	3075	3075	3075
	41	2875	2850	2850	2875	2900	2900	2900	2925	2925	2925	2950	2950	2975	2975	3000	3000	3000	3000	3000
	40	2800	2775	2775	2800	2825	2825	2825	2850	2850	2850	2875	2875	2900	2900	2925	2925	2925	2925	2925
	39	2750	2725	2725	2725	2750	2750	2750	2775	2800	2800	2800	2800	2825	2825	2850	2850	2850	2850	2850
Fill Height (feet)	38	2675	2650	2650	2650	2675	2675	2700	2700	2725	2725	2725	2725	2750	2775	2775	2775	2775	2775	2775
Fill Heig	37	2600	2575	2575	2600	2600	2625	2625	2625	2650	2650	2650	2675	2675	2700	2700	2700	2700	2700	2700
	98	2525	2500	2500	2525	2550	2550	2550	2575	2575	2575	2222	2600	2600	2625	2625	2625	2625	2625	2625
	35	2450	2450	2450	2450	2475	2475	2475	2500	2500	2500	2525	2525	2525	2550	2575	2575	2575	2575	2575
	34	2400	2375	2375	2375	2400	2400	2400	2425	2425	2450	2450	2450	2475	2475	2500	2500	2500	2500	2500
	33	2325	2300	2300	2300	2325	2325	2350	2350	2375	2375	2375	2375	2400	2400	2425	2425	2425	2425	2425
	32	2250	2225	2225	2250	2250	2275	2275	2275	2300	2300	2300	2300	2325	2325	2350	2350	2350	2350	2350
	31	2175	2150	2150	2175	2200	2200	2200	2200	2225	2225	2225	2250	2250	2275	2275	2275	2275	2275	2275
	Pipe i.d. (inches)	12	15	18	21	24	27	30	33	36	42	48	54	09	99	72	78	84	06	96

Table 69

Class IV	Class V	Special Design	1
Class I	Class II	Class III	_

Type 3 Bedding

Fill Height Tables are based on:

1. A soil weight of 120 lbs/ft³ 2. AASHTO HS20 live load 3. Embankment installation

	18	1650	1600	1600	1600	1600	1600	1625	1625	1650	1650	1650	1675	1700	1700	1725	1725	1725	1725	1725
	17	1550	1525	1525	1525	1525	1525	1525	1550	1550	1575	1575	1575	1600	1600	1625	1625	1625	1625	1650
	16	1475	1450	1425	1425	1450	1450	1450	1450	1475	1475	1475	1500	1500	1525	1525	1550	1550	1550	1550
	15	1375	1375	1350	1350	1350	1375	1375	1375	1400	1400	1425	1425	1425	1450	1450	1475	1475	1475	1475
	14	1300	1275	1275	1275	1275	1275	1300	1300	1300	1325	1325	1350	1350	1350	1375	1375	1375	1375	1375
	13	1200	1200	1200	1200	1200	1200	1200	1225	1225	1225	1250	1250	1250	1275	1275	1300	1300	1300	1300
	12	1125	1100	1100	1100	1100	1125	1125	1125	1150	1150	1150	1150	1175	1175	1200	1200	1200	1200	1200
	11	1050	1025	1025	1025	1025	1025	1050	1050	1050	1050	1075	1075	1075	1100	1100	1100	1100	1125	1125
t (feet)	10	950	950	950	950	950	950	950	950	975	975	975	1000	1000	1000	1025	1025	1025	1025	1025
Fill Height (feet)	6	875	875	850	820	850	875	875	875	875	900	006	006	925	925	925	925	950	950	950
F	8	800	775	775	775	775	800	800	800	800	800	825	825	825	850	850	850	850	850	850
	7	725	700	700	200	700	200	725	725	725	725	725	750	750	750	775	775	775	775	775
	9	650	650	650	650	650	650	650	650	650	650	650	675	675	675	675	675	700	700	700
	2	009	575	575	575	575	575	575	2/2	575	009	009	009	009	009	009	009	625	625	625
	4	220	550	525	525	525	525	525	525	525	525	525	525	525	550	250	220	550	550	250
	3	220	525	525	200	200	200	200	200	200	200	200	200	200	475	475	475	475	475	475
	2	700	675	650	625	009	009	009	2/2	2/2	575	220	525	200	200	200	200	200	200	475
	1	1175	1100	1050	1000	975	925	875	825	800	700	029	625	625	009	009	220	525	475	450
	Pipe i.d. (inches)	12	15	18	12	24	22	08	88	98	42	48	54	09	99	22	8/	84	06	96

Table 70

Class II Class IV
Class III Special Design

Type 3 Bedding

Fill Height Tables are based on:

1. A soil weight of 120 lbs/ft³ 2. AASHTO HS20 live load 3. Embankment installation

		1			ı				I	I										
	35	3150	3100	3075	3075	3075	3100	3125	3125	3150	3175	3175	3200	3225	3250	3250	3250	3275	3275	3275
	34	3050	3025	3000	3000	3000	3000	3025	3050	3075	3075	3100	3100	3125	3150	3175	3175	3175	3175	3175
	33	2975	2925	2900	2900	2900	2925	2950	2950	2975	3000	3000	3025	3025	3050	3075	3075	3075	3075	3075
	32	2875	2850	2825	2825	2825	2825	2850	2875	2900	2900	2900	2925	2950	2975	3000	3000	3000	3000	3000
	31	2800	2750	2725	2750	2725	2750	2750	2775	2800	2800	2825	2850	2850	2875	2900	2900	2900	2900	2900
	30	2700	2675	2650	2650	2650	2650	2675	2700	2725	2725	2725	2750	2775	2775	2800	2800	2800	2800	2800
	29	2600	2575	2550	2550	2550	2575	2575	2600	2625	2625	2650	2650	2675	2700	2725	2725	2725	2725	2725
	28	2525	2475	2475	2475	2475	2475	2500	2525	2525	2550	2550	2575	2575	2600	2625	2625	2625	2625	2625
nt (feet)	27	2425	2400	2375	2375	2375	2400	2400	2425	2450	2450	2475	2475	2500	2525	2525	2525	2525	2550	2550
Fill Height (feet)	56	2350	2300	2300	2300	2300	2300	2325	2350	2350	2375	2375	2400	2400	2425	2450	2450	2450	2450	2450
ш	25	2250	2225	2200	2200	2200	2225	2225	2250	2275	2275	2275	2300	2325	2325	2350	2350	2350	2350	2350
	24	2175	2125	2125	2125	2125	2125	2150	2150	2175	2175	2200	2200	2225	2250	2250	2250	2275	2275	2275
	23	2075	2050	2025	2025	2025	2050	2050	2075	2100	2100	2100	2125	2125	2150	2175	2175	2175	2175	2175
	22	2000	1950	1950	1950	1950	1950	1975	1975	2000	2000	2025	2025	2050	2050	2075	2075	2075	2075	2100
	21	1900	1875	1850	1850	1875	1875	1875	1900	1925	1925	1925	1950	1950	1975	2000	2000	2000	2000	2000
	20	1825	1775	1775	1775	1775	1775	1800	1800	1825	1825	1850	1850	1875	1875	1900	1900	1900	1900	1900
	19	1725	1700	1675	1675	1700	1700	1700	1725	1750	1750	1750	1750	1775	1800	1800	1800	1800	1825	1825
	Pipe i.d. (inches)	12	15	18	21	24	27	96	33	98	42	48	54	09	99	72	82	84	06	96

Table 71

Class IV	Class V	Special Design	
Class I	Class II	Class III	

Type 4 Bedding

Fill Height Tables are based on:

1. A soil weight of 120 lbs/ft³ 2. AASHTO HS20 live load 3. Embankment installation

Pipe I.d. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 14 15 145 150 1550 1550 1550 1550 1550 1550 1550 1550 1550 1550 1550 1550 1550 1550 1550 1550 1550 1550 1575 1450 1550 1575 1450 1550 1750 1825 1560 1750 1825 1560 1750 1825 1500 2000 21 1455 880 700 750 8825 925 1050 1156 1275 1400 1550 1750 1825 1500 2000 2000 2000 2000 1000 1125 1250 1475 1600 1750 1875 1900 2000 2000 2000 1100 1125 1250 1475 1600 1775 1800 1900 1000 1100							Fill Heig	Fill Height (feet)							
950 750 800 875 950 1075 1200 1325 1450 1575 1700 1825 1950 1950 900 750 775 850 950 1050 1150 1250 1675 1700 1525 1650 1775 1900 850 700 750 825 925 1050 1150 1250 1375 1500 1600 1775 1900 800 700 725 800 900 1000 1125 1250 1475 1600 1725 1850 800 700 725 800 900 1000 1125 1255 1350 1475 1600 1725 1850 800 700 1000 1100 1225 1350 1475 1600 1700 1825 750 675 725 800 900 1000 1100 1225 1350 1475 1600 1700 1825<	 _	8	ო	4		9	7	ω	တ	10	£	12	13	41	15
900 750 775 850 950 1150 1275 1400 1525 1650 1757 1400 1625 1650 1775 1900 850 725 925 1050 1150 1250 1375 1500 1625 1750 1900 850 700 725 800 900 1000 1125 1250 1475 1600 1725 1800 800 700 725 800 900 1000 1125 1250 1475 1600 1725 1800 800 700 1000 1100 1225 1350 1475 1600 1725 1850 775 675 725 800 900 1000 1100 1225 1350 1475 1600 1700 1825 750 650 725 800 900 1000 1100 1225 1350 1475 1700 1825 602 650 <td>1550</td> <td>950</td> <td>750</td> <td>800</td> <td></td> <td>950</td> <td>1075</td> <td>1200</td> <td>1325</td> <td>1450</td> <td>1575</td> <td>1700</td> <td>1825</td> <td>1950</td> <td>2100</td>	1550	950	750	800		950	1075	1200	1325	1450	1575	1700	1825	1950	2100
1375 860 725 750 825 925 1050 1150 1375 1500 1602 1750 1870	1450	006	750	277		950	1050	1150	1275	1400	1525	1650	1775	1900	2050
1325 850 700 750 825 925 1025 1125 150 1600 1750 1600 1750 1875 1870 1600 1752 1850 1600 1752 1850 1150 800 700 725 800 900 1000 1125 1250 1475 1600 1725 1850 925 775 875 876 900 1000 1100 1225 1350 1475 1600 1700 1850 925 775 875 800 900 1000 1100 1225 1350 1475 1600 1700 1850 850 750 870 900 1000 1100 1225 1350 1475 1700 1825 1850 850 750 870 900 1000 1100 1225 1350 1475 1700 1825 850 850 800 900 1000 1100 </td <td>1375</td> <td>850</td> <td>725</td> <td>750</td> <td>825</td> <td>925</td> <td>1050</td> <td>1150</td> <td>1250</td> <td>1375</td> <td>1500</td> <td>1625</td> <td>1750</td> <td>1900</td> <td>2025</td>	1375	850	725	750	825	925	1050	1150	1250	1375	1500	1625	1750	1900	2025
1275 825 700 725 800 900 1120 1125 1350 1475 1600 1725 1850 1150 800 700 725 800 900 1100 1125 1350 1475 1600 1700 1850 925 775 870 900 1000 1100 1225 1350 1475 1600 1700 1850 850 750 870 900 1000 1100 1225 1350 1475 1600 1700 1850 750 675 725 800 900 1000 1100 1225 1350 1450 1700 1825 675 676 725 800 900 1000 1100 1225 1350 1450 1700 1825 675 625 725 800 900 1000 1100 1225 1350 1475 1700 1825 650 575	1325	850	200	750	825	925	1025	1125	1250	1375	1500	1600	1750	1875	2000
1150 800 700 725 800 900 1000 1125 1350 1475 1600 1725 1850 1025 800 675 725 800 900 1000 1100 1225 1350 1475 1600 1700 1850 850 775 675 725 800 900 1000 1100 1225 1350 1475 1600 1700 1825 750 675 675 802 900 1000 1100 1225 1350 1475 1600 1700 1825 675 670 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 675 625 620 725 800 900 1000 1105 1225 1350 1450 1575 1700 1825 650 575 600 700 800 1000 1100 1125	1275	825	700	725	800	006	1000	1125	1250	1350	1475	1600	1725	1850	1975
1025 800 675 725 800 900 1000 1100 1225 1350 1475 1600 1700 1825 850 775 675 725 800 900 1000 1100 1225 1350 1475 1600 1700 1825 850 750 675 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 700 675 650 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 675 600 675 800 900 1000 1100 1225 1350 1450 1575 1700 1825 675 600 650 700 800 1000 1105 1225 1350 1475 1600 1700 1825 650 575 600 700 800 1000 1125	1150	800	700	725	800	006	1000	1125	1225	1350	1475	1600	1725	1850	1975
955 775 675 725 800 900 1000 1100 1225 1350 1475 1600 1700 1825 750 650 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 750 650 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 675 625 650 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 650 675 625 700 800 900 1000 1125 1225 1350 1475 1600 1700 1825 650 575 600 700 800 900 1000 1125 1250 1350 1475 1600 1700 1825 650 575 600 700 800 900 1000	1025	800	675	725	800	006	1000	1100	1225	1350	1475	1600	1700	1850	1950
850 750 675 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 750 750 675 650 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 675 675 650 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 675 600 650 700 800 900 1000 1125 1350 1475 1600 1700 1825 650 575 600 700 800 900 1000 1125 1256 1350 1475 1600 1700 1825 650 575 600 700 800 1000 1125 1250 1350 1475 1600 1700 1825 550 575 600 700 800 1025	925	775	675	725	800	006	1000	1100	1225	1350	1475	1600	1700	1825	1950
750 650 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 700 675 650 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 675 605 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 650 575 625 700 800 900 1000 1125 1225 1350 1475 1600 1700 1825 650 575 600 700 800 900 1000 1125 1250 1350 1475 1600 1700 1825 575 600 700 800 900 1025 1125 1250 1350 1475 1600 1700 1825 550 575 600 700 800 1025 1125 1250	850	750	675	725	800	006	1000	1100	1225	1350	1450	1575	1700	1825	1950
700 675 650 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 675 625 625 725 800 900 1000 1100 1225 1350 1450 1575 1700 1825 650 575 600 700 800 900 1000 1125 1225 1350 1475 1600 1700 1825 650 575 600 700 800 900 1000 1125 1250 1350 1475 1600 1700 1825 575 600 700 800 900 1025 1125 1250 1350 1475 1600 1725 1850 555 600 700 800 1025 1125 1250 1375 1600 1725 1850 555 575 600 700 800 900 1025 1125 1250	750	750	650	725	800	006	1000	1100	1225	1350	1450	1575	1700	1825	1950
6756256507258009001000110012251350145015751700182565065070080090010001125122513501475160017001825650575600700800900100011251225135014751600170018256255756007008009001000112512501350147516001700182555057560070080090010251125125013751475160017251850550575600700800900102511251250137514751600172518505255756007008009251025115012501375160017251850	200	675	650	725	800	006	1000	1100	1225	1350	1450	1575	1700	1825	1950
67560065070080090010001125122513501475160017001825650575600700800900100011251225135014751600170018256255756007008009001000112512501350147516001700182557560070080090010251125125013501475160017251850550575600700800900102511251250137514751600172518505505756007008009251025115012501375160017251850	675	625	650	725	800	006	1000	1100	1225	1350	1450	1575	1700	1825	1950
6505756257008009001000112512251350147516001700182565057560070080090010001125125013501475160017001825550575600700800900102511251250137514751600172518505505756007008009001025112512501375147516001725185055157560070080092510251150125013751600160017251850	675	009	650	200	800	006	1000	1100	1225	1350	1450	1575	1700	1825	1950
65057560070080090010001125122513501475160017001825625575600700800900102511251250137514751600172518505505756007008009001025112512501375147516001725185055557560070080092510251150125013751500160017251850	029	275	625	002	800	006	1000	1125	1225	1350	1475	1600	1700	1825	1950
625575600700800900100011251250135014751600170018255755756007008009001025112512501375147516001725185055057560070080090510251150125013751475160017251850	029	275	009	200	800	006	1000	1125	1225	1350	1475	1600	1700	1825	1950
575670700800900102511251250135014751600172518505505756007008009001025112512501375147516001725185052557560070080092510251150125013751500160017251850	625	275	009	002	800	006	1000	1125	1250	1350	1475	1600	1700	1825	1950
5505756007008009001025112512501375147516001725185052557560070080092510251150125013751500160017251850	275	275	009	200	800	006	1025	1125	1250	1350	1475	1600	1725	1850	1950
525 575 600 700 800 925 1025 1150 1250 1375 1500 1600 1725 1850	250	275	009	200	800	006	1025	1125	1250	1375	1475	1600	1725	1850	1950
	525	275	009	002	800	925	1025	1150	1250	1375	1500	1600	1725	1850	1975

Table 72

Class II Class V Class IV Class III Special Design

Type 4 Bedding

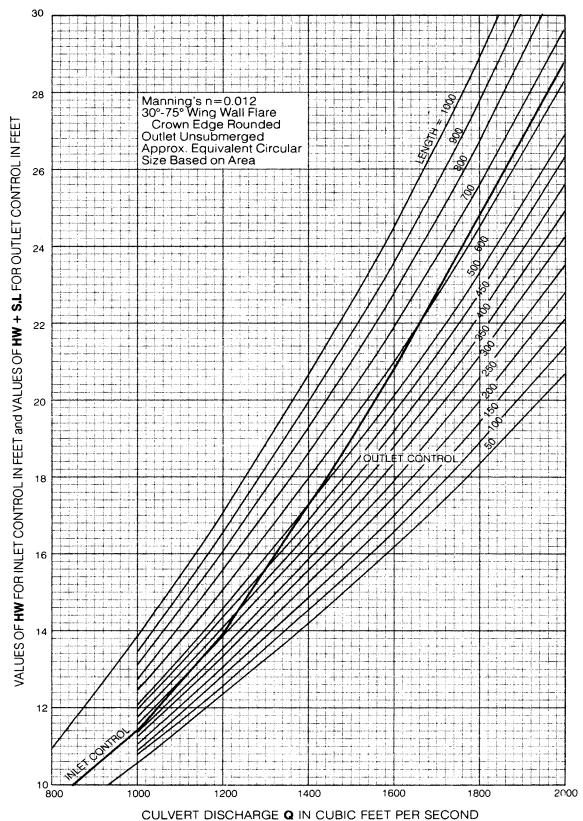
Fill Height Tables are based on:

A soil weight of 120 lbs/ft³
 AASHTO HS20 live load
 Embankment installation

				Fill Height (feet)	ht (feet)			
Pipe i.d. (inches)	16	17	18	19	20	21	22	23
12	2225	2350	2500	2625	2775	2700	3025	3175
15	2175	2300	2450	2550	2700	2825	2950	3100
18	2125	2275	2400	2525	2650	2775	2900	3050
21	2125	2250	2375	2500	2625	2750	2875	3000
24	2100	2225	2350	2475	2600	2725	2850	2975
27	2075	2200	2325	2450	2575	2700	2825	2950
30	2075	2200	2325	2450	2575	2700	2825	2950
33	2075	2200	2325	2450	2575	2700	2825	2950
36	2075	2200	2325	2450	2550	2675	2800	2925
42	2050	2175	2300	2425	2550	2675	2800	2925
48	2050	2175	2300	2425	2550	2675	2800	2925
54	2050	2175	2300	2425	2550	2675	2800	2925
60	2050	2175	2300	2425	2550	2650	2775	2900
66	2050	2175	2300	2425	2550	2675	2775	2900
72	2050	2175	2300	2425	2550	2675	2800	2900
78	2075	2175	2300	2425	2550	2675	2800	2900
84	2075	2200	2300	2425	2550	2675	2800	2925
90	2075	2200	2325	2425	2550	2675	2800	2925
96	2075	2200	2325	2450	2550	2675	2800	2925

Figure 1

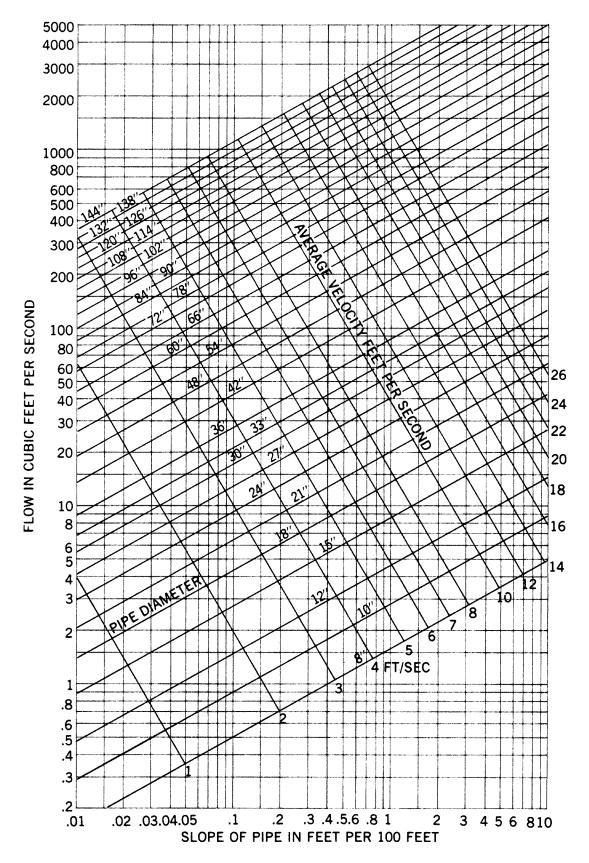




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Figure 2

FLOW FOR CIRCULAR PIPE FLOWING FULL



BASED ON MANNING'S EQUATION n=0.010

Figure 3

FLOW FOR CIRCULAR PIPE FLOWING FULL BASED ON MANNING'S EQUATION n=0.011

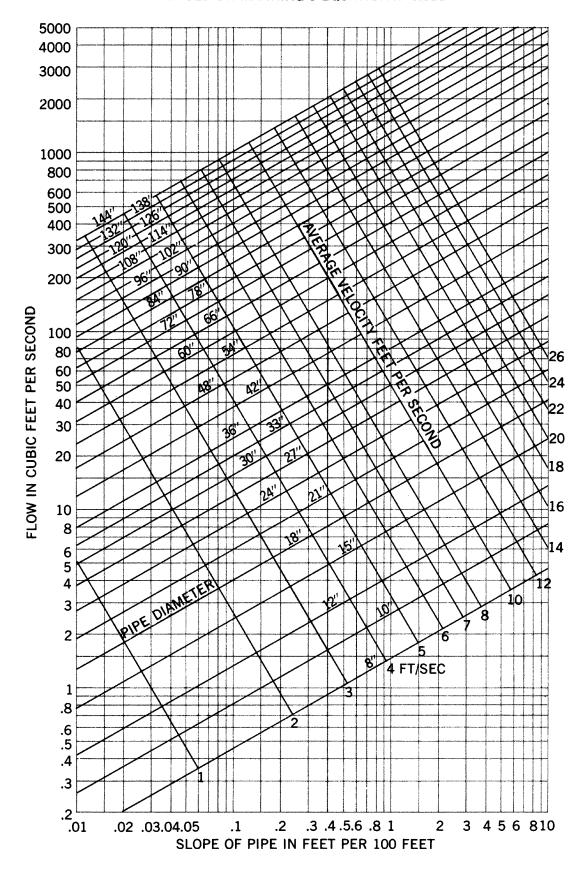


Figure 4

FLOW FOR CIRCULAR PIPE FLOWING FULL BASED ON MANNING'S EQUATION n=0.012

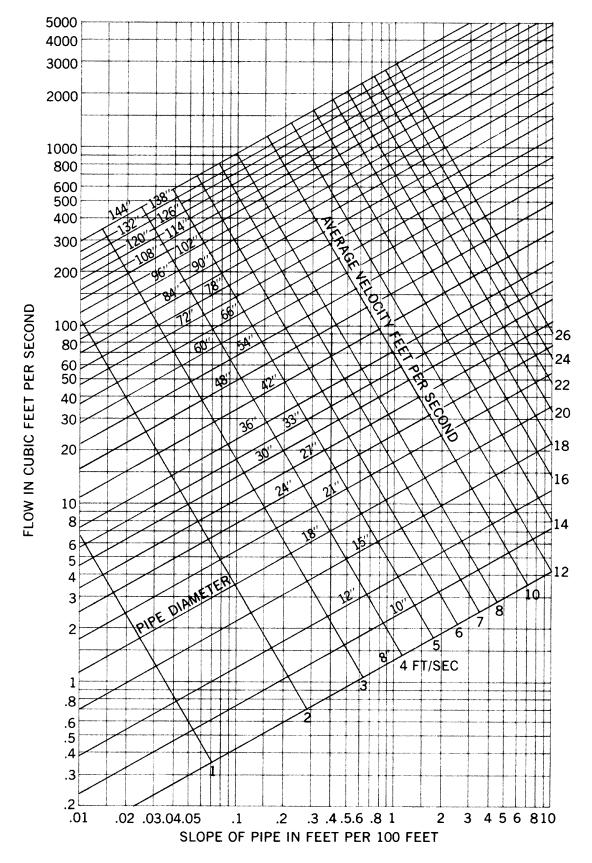


Figure 5

FLOW FOR CIRCULAR PIPE FLOWING FULL BASED ON MANNING'S EQUATION n=0.013

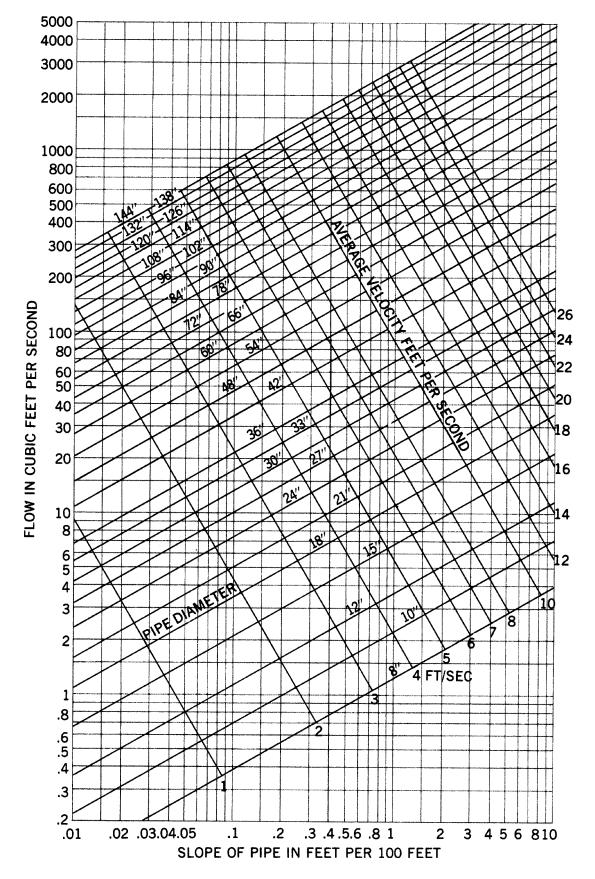


Figure 6 FLOW FOR HORIZONTAL ELLIPTICAL PIPE FLOWING FULL BASED ON MANNING'S EQUATION n=0.010

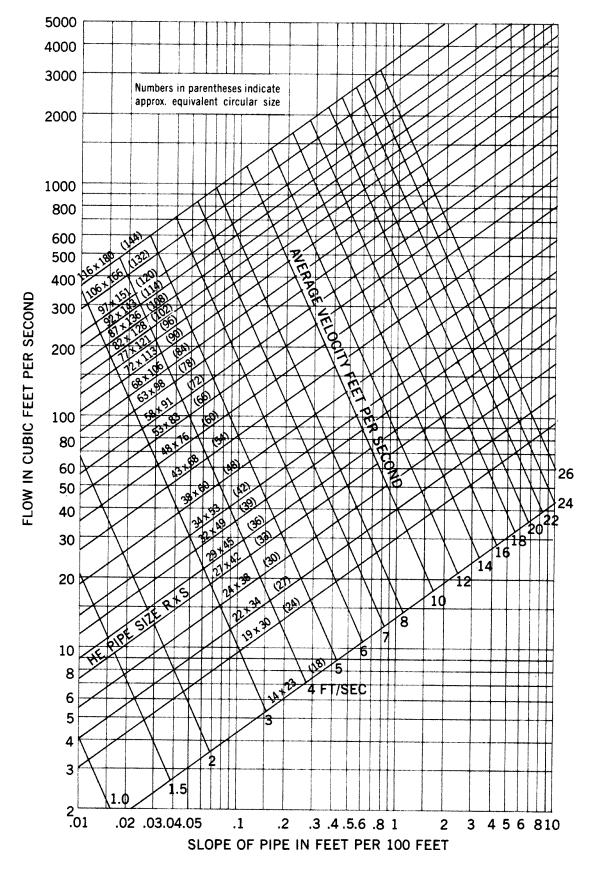
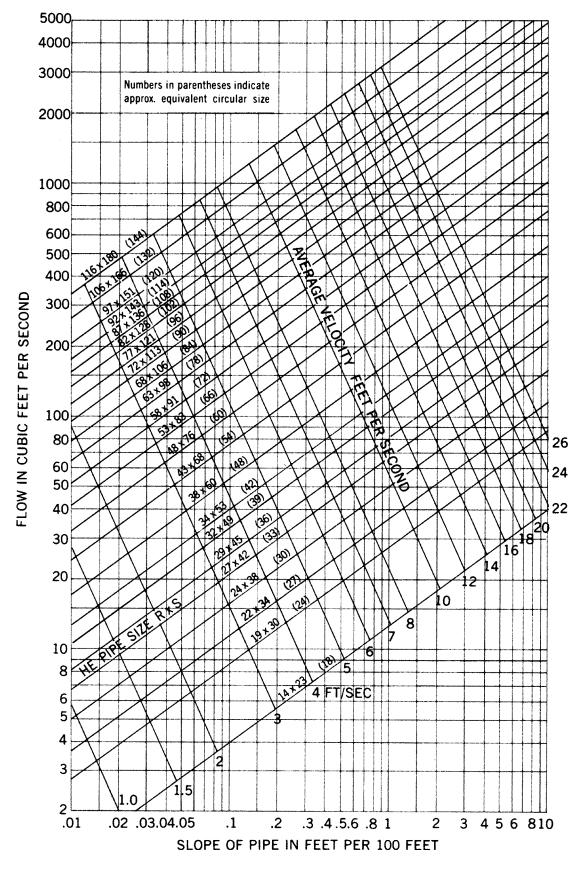
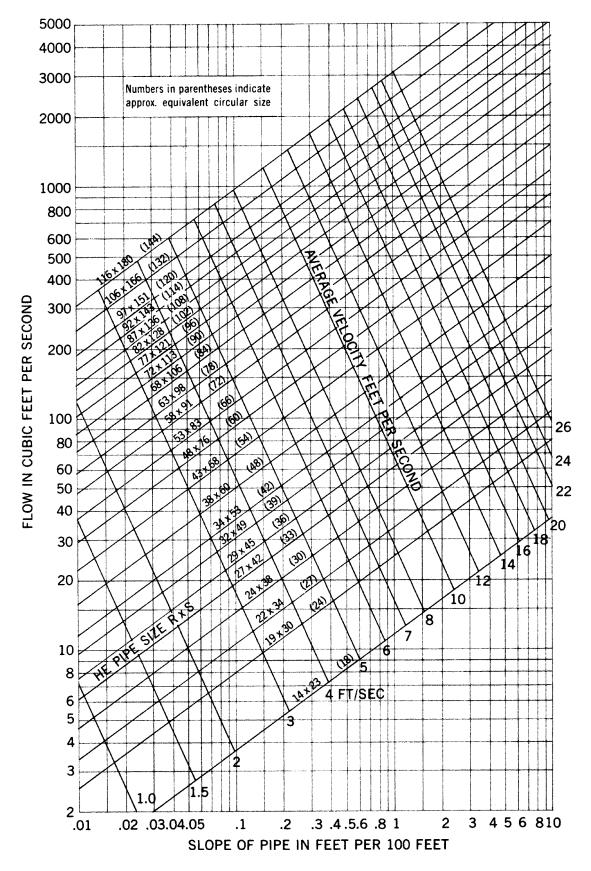


Figure 7

FLOW FOR HORIZONTAL ELLIPTICAL PIPE FLOWING FULL
BASED ON MANNING'S EQUATION n=0.011



FLOW FOR HORIZONTAL ELLIPTICAL PIPE FLOWING FULL BASED ON MANNING'S EQUATION n=0.012



FLOW FOR HORIZONTAL ELLIPTICAL PIPE FLOWING FULL
BASED ON MANNING'S EQUATION n=0.013

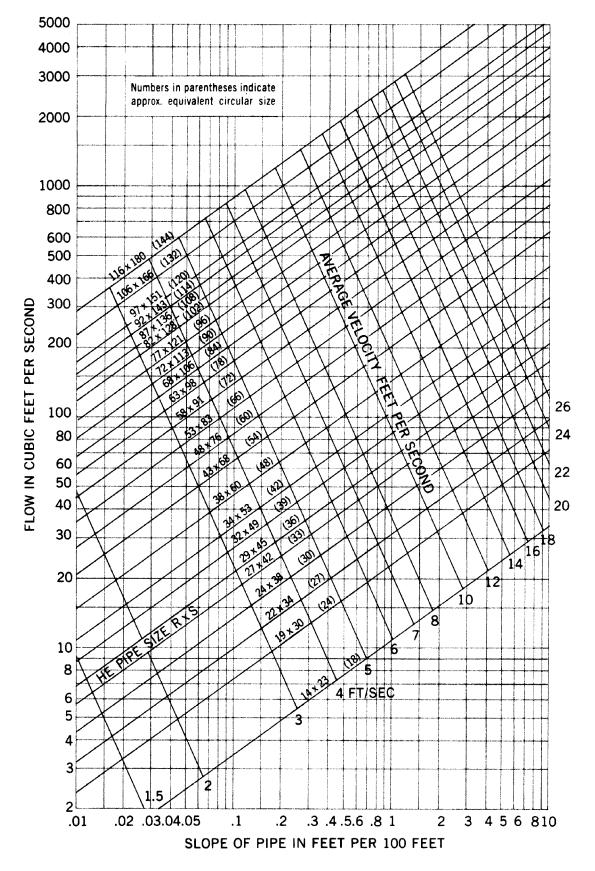
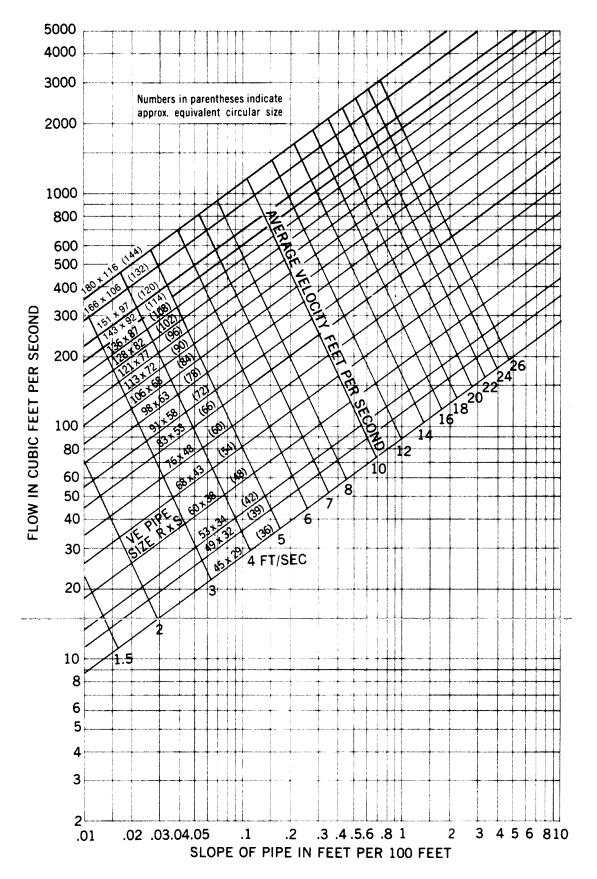


Figure 10

FLOW FOR VERTICAL ELLIPTICAL PIPE FLOWING FULL BASED ON MANNING'S EQUATION n=0.010



FLOW FOR VERTICAL ELLIPTICAL PIPE FLOWING FULL BASED ON MANNING'S EQUATION n=0.011

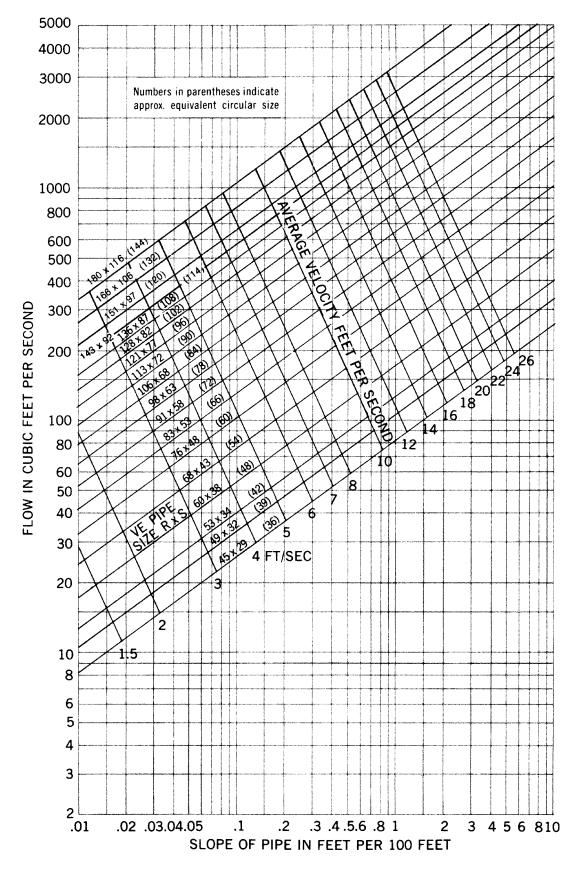


FIGURE 12

FLOW FOR VERTICAL ELLIPTICAL PIPE FLOWING FULL
BASED ON MANNING'S EQUATION n=0.012

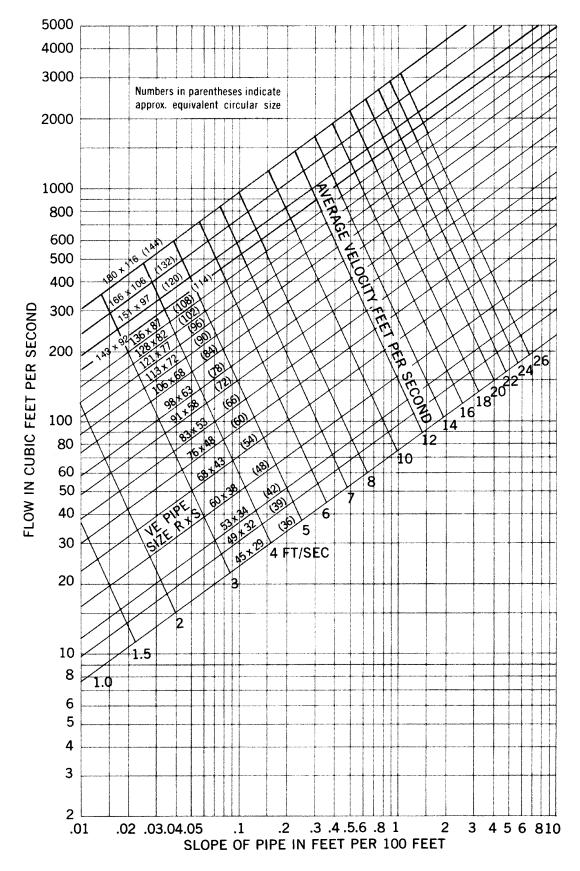


Figure 13

FLOW FOR VERTICAL ELLIPTICAL PIPE FLOWING FULL

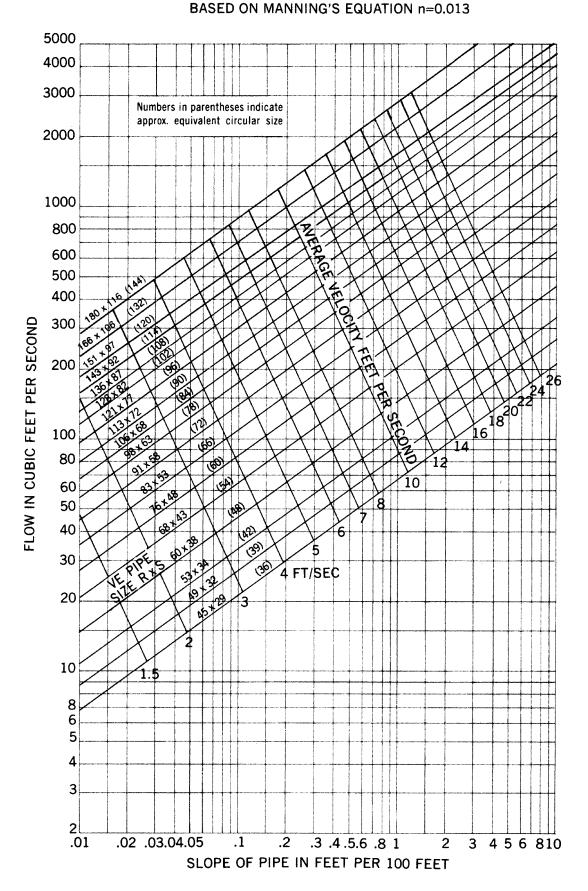
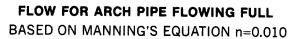


Figure 14



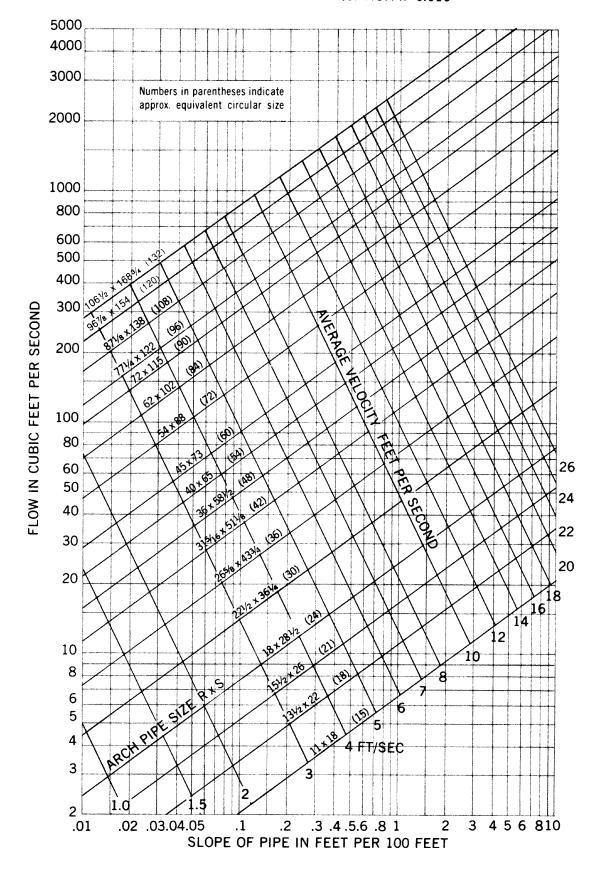


Figure 15

FLOW FOR ARCH PIPE FLOWING FULL BASED ON MANNING'S EQUATION n=0.011

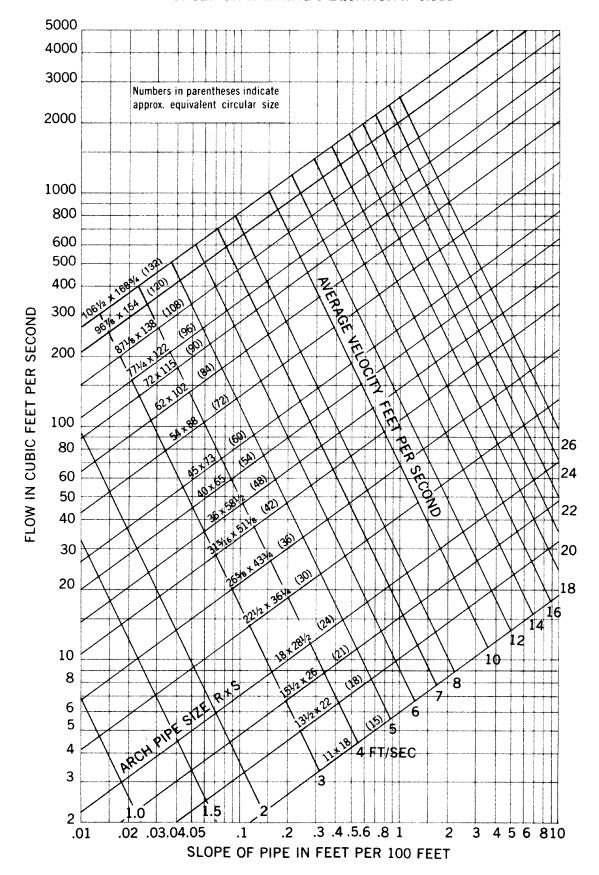
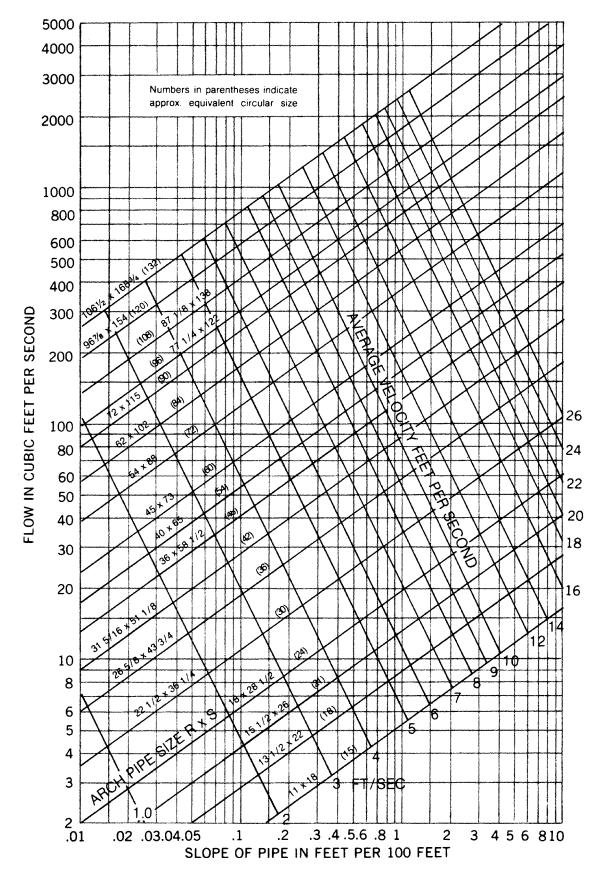


Figure 16

FLOW FOR ARCH PIPE FLOWING FULL BASED ON MANNING'S EQUATION n 0.012



FLOW FOR ARCH PIPE FLOWING FULL
BASED ON MANNING'S EQUATION n=0.013

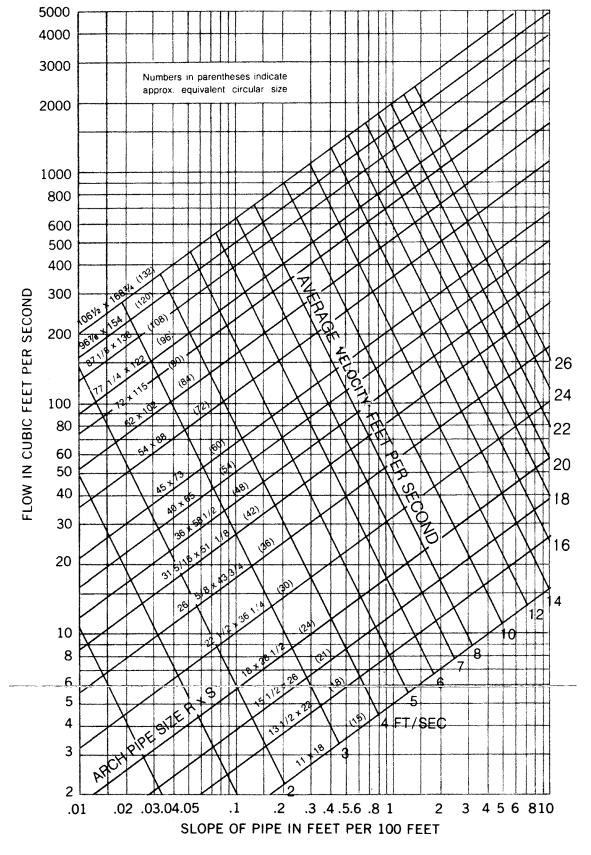


Figure 18.1



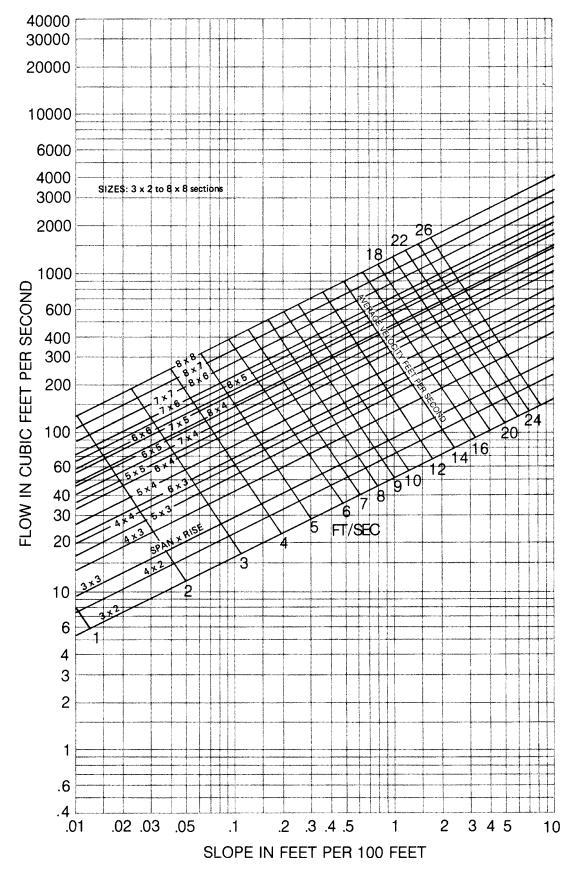


Figure 18.2 FLOW FOR BOX SECTIONS FLOWING FULL BASED ON MANNINGS EQUATION n=0.012

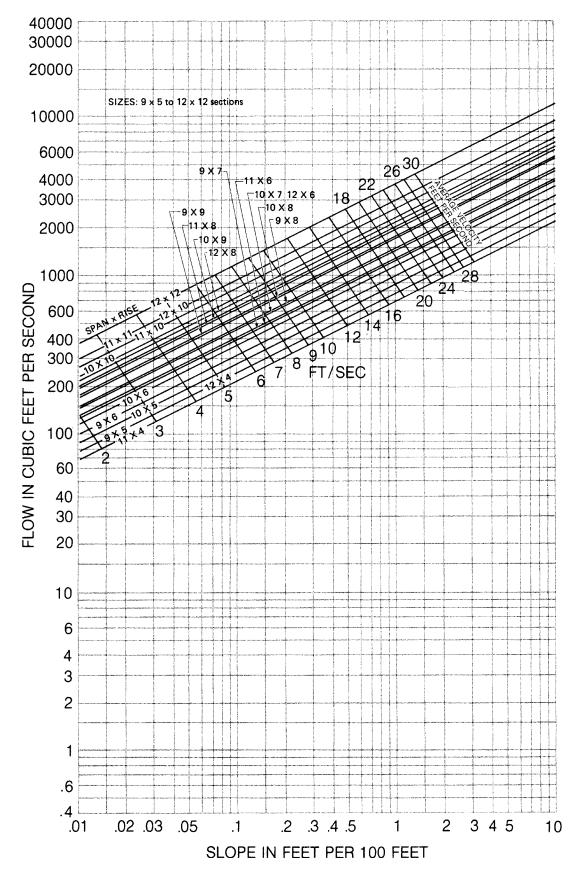


Figure 19.1



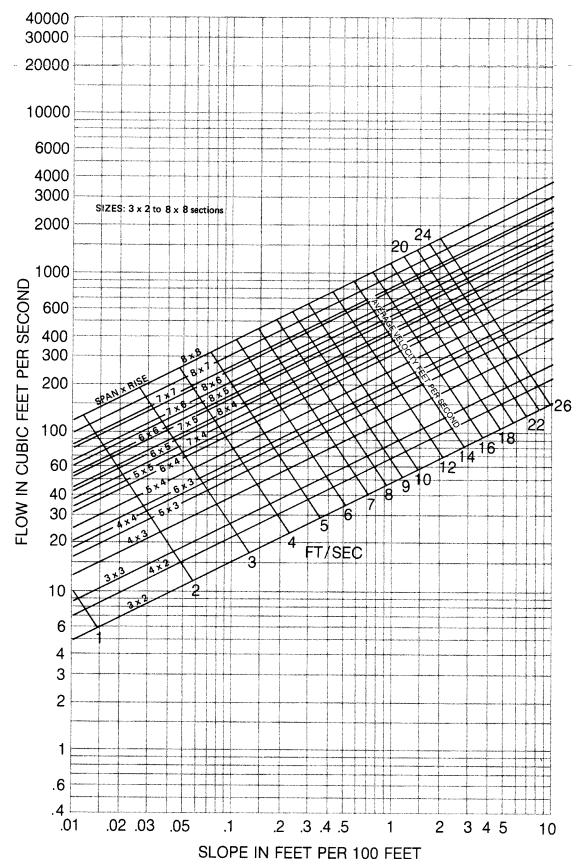


Figure 19.2



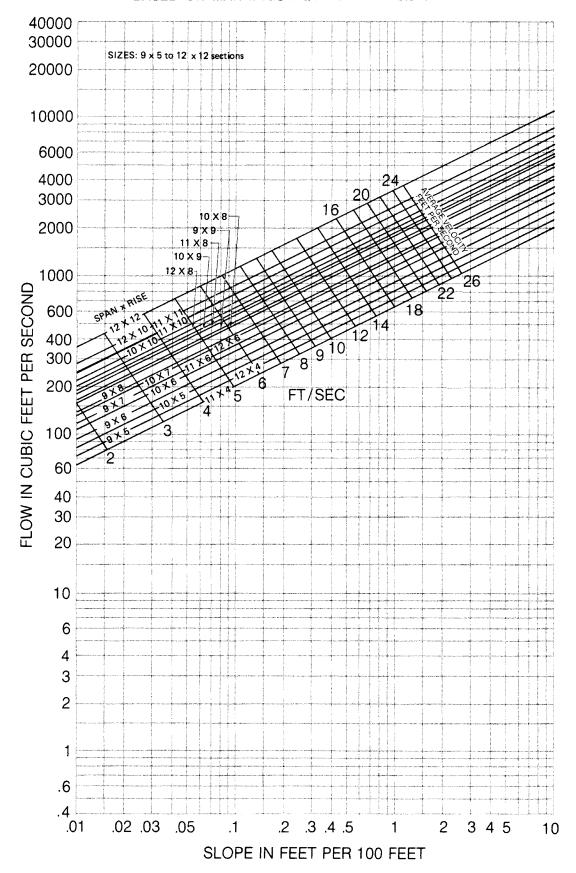


Figure 20



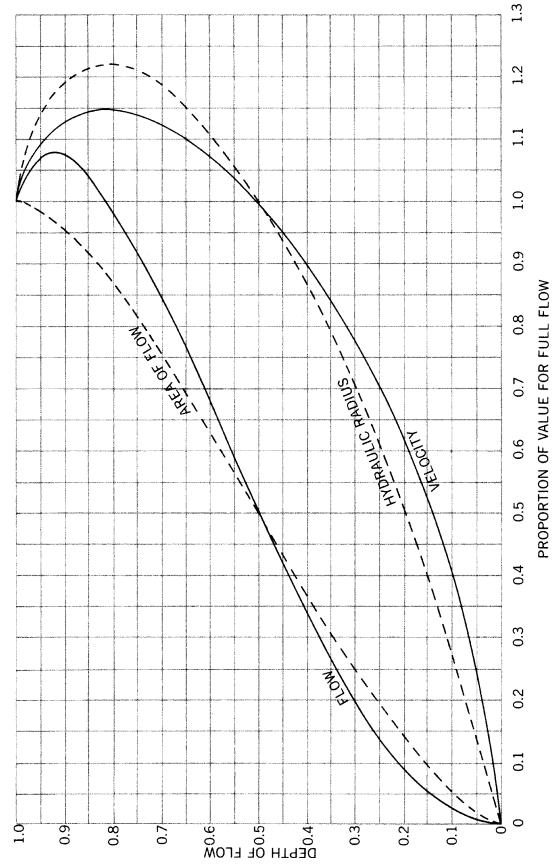


Figure 21

RELATIVE VELOCITY AND FLOW IN
HORIZONTAL ELLIPTICAL PIPE FOR ANY DEPTH OF FLOW

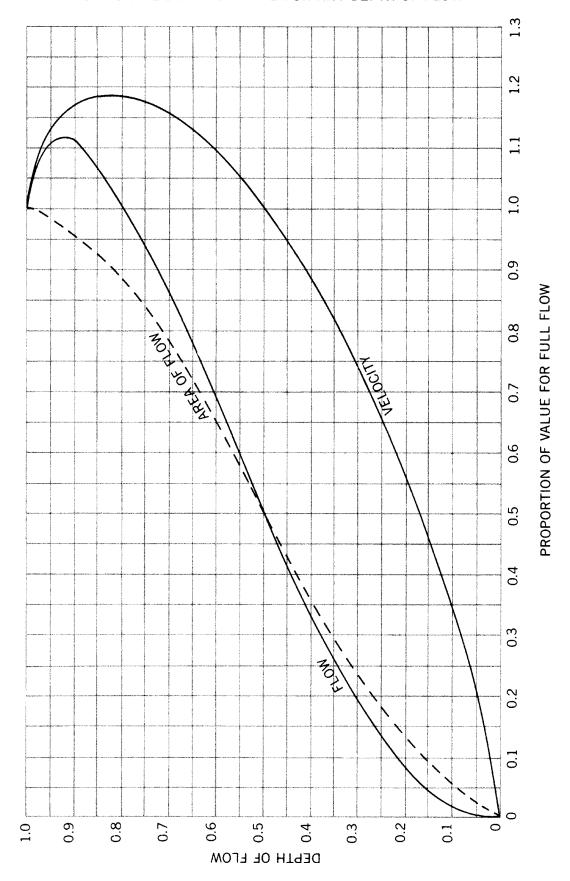


Figure 22

RELATIVE VELOCITY AND FLOW IN VERTICAL ELLIPTICAL PIPE FOR ANY DEPTH OF FLOW

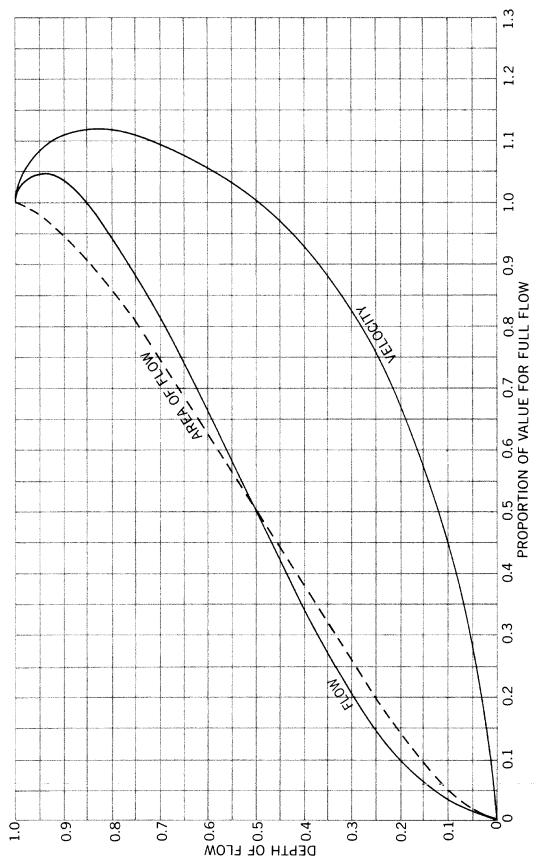


Figure 23



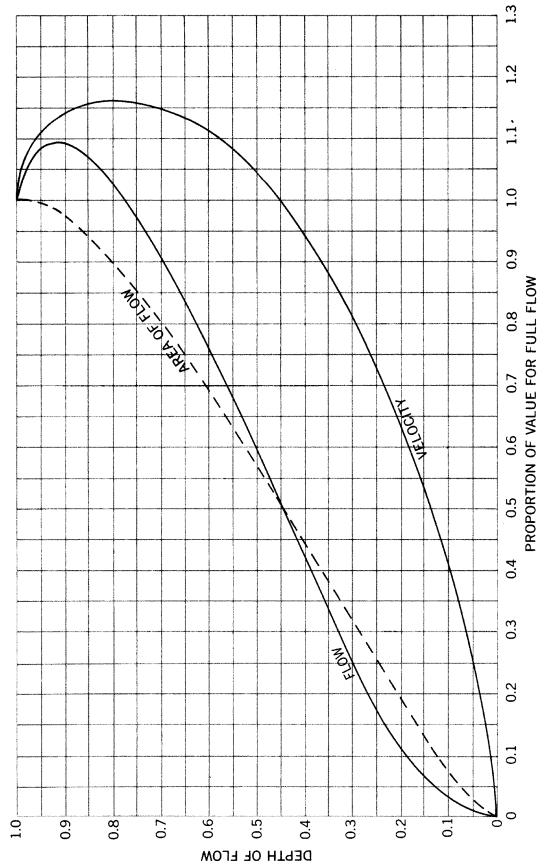


Figure 24.1



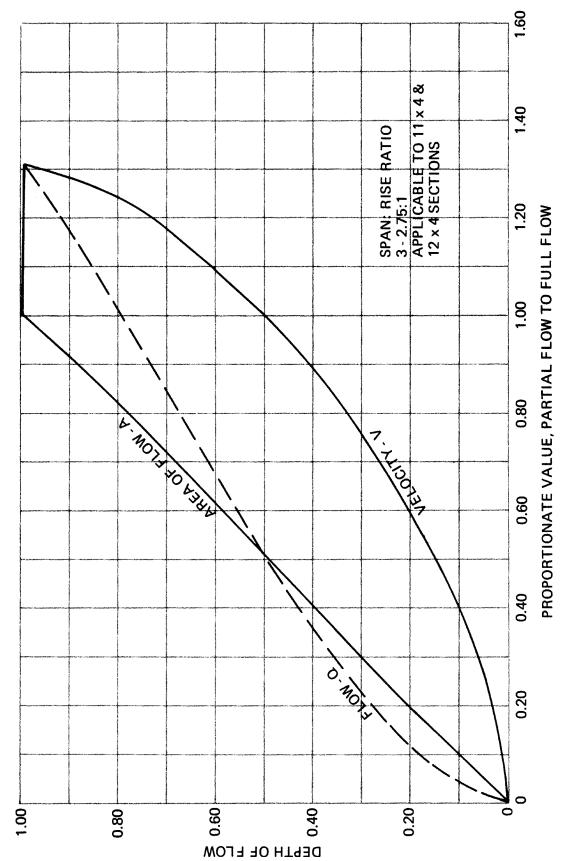


Figure 24.2

RELATIVE VELOCITY AND FLOW IN PRECAST BOX

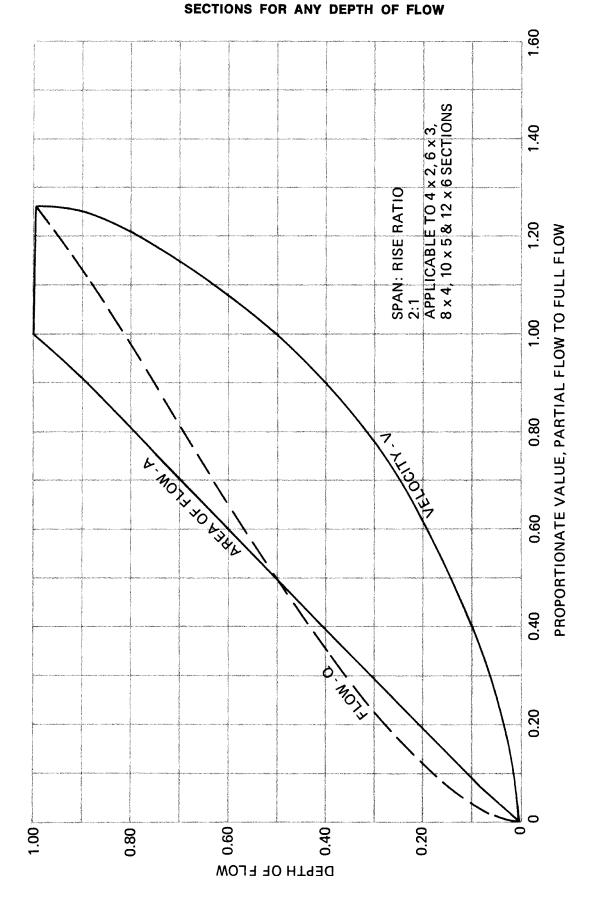


Figure 24.3

RELATIVE VELOCITY AND FLOW IN PRECAST BOX

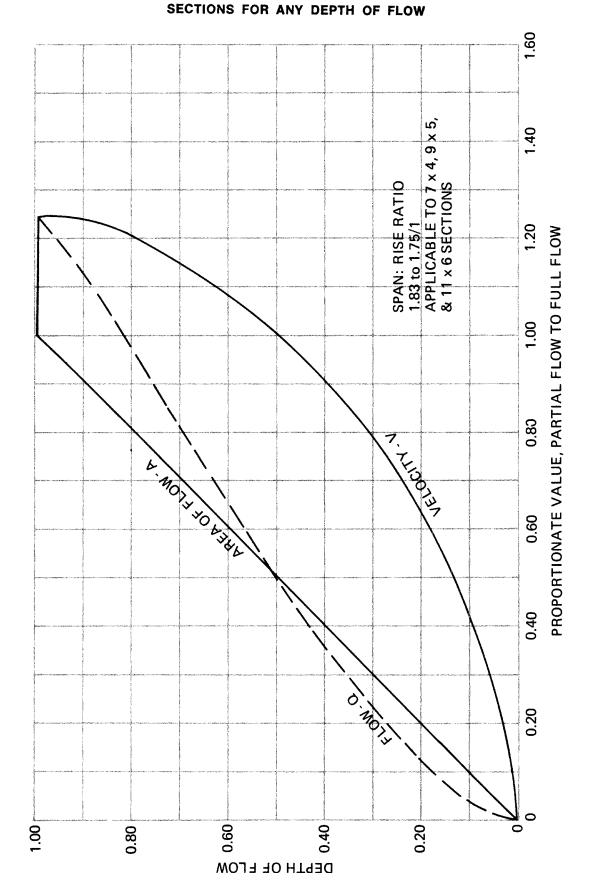


Figure 24.4

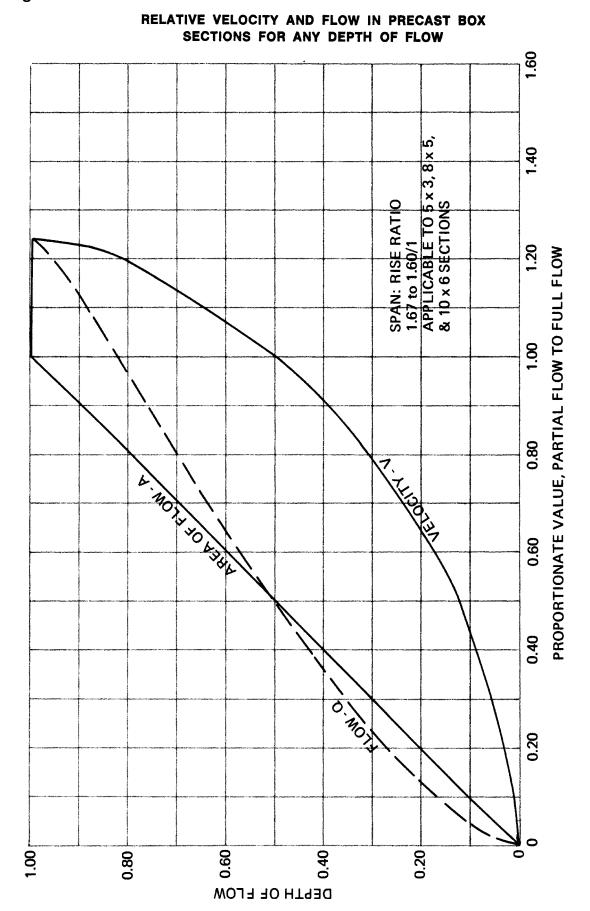


Figure 24.5



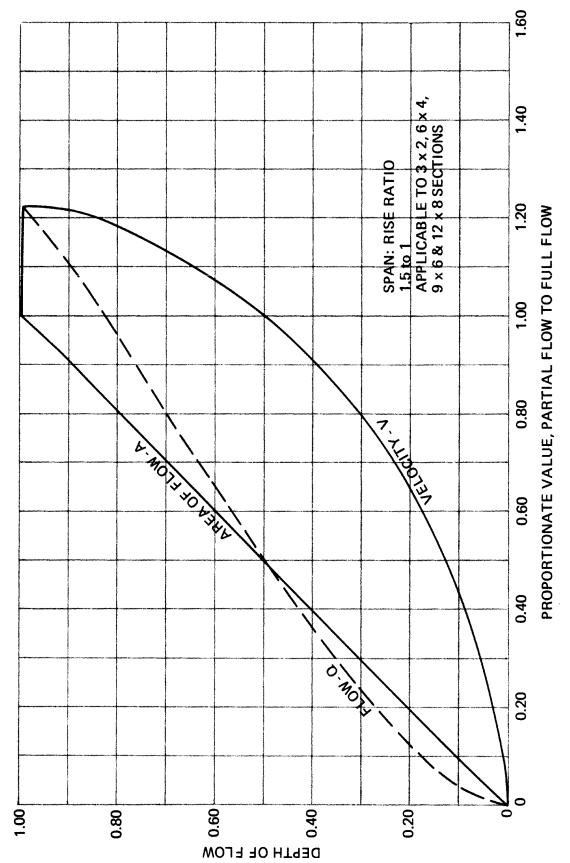


Figure 24.6



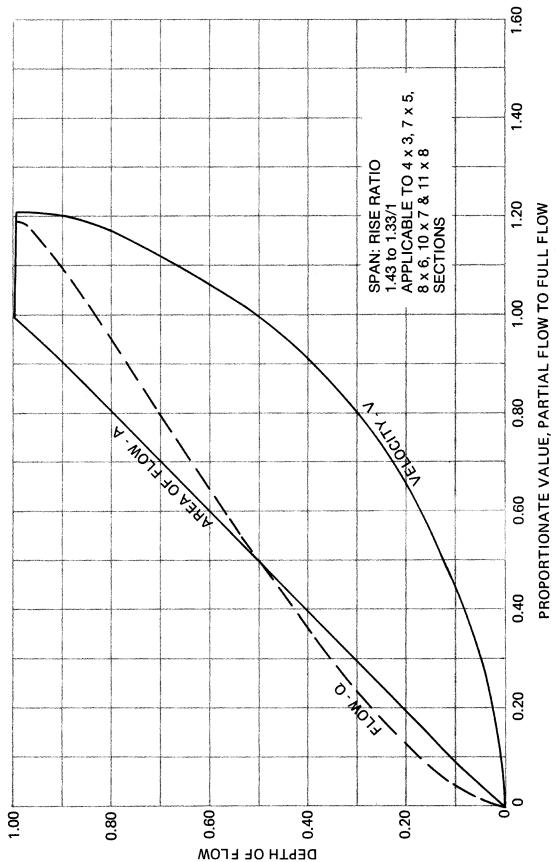


Figure 24.7

RELATIVE VELOCITY AND FLOW IN PRECAST BOX SECTIONS FOR ANY DEPTH OF FLOW

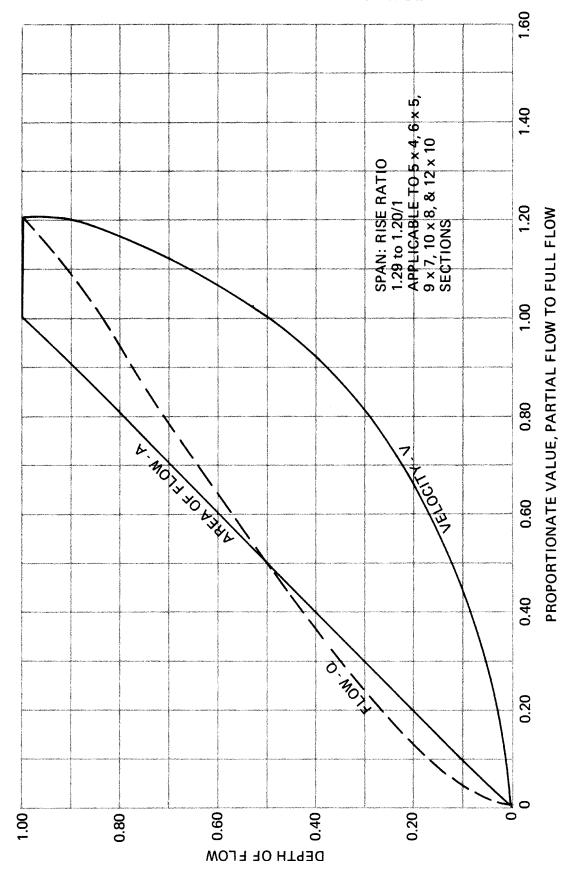


Figure 24.8

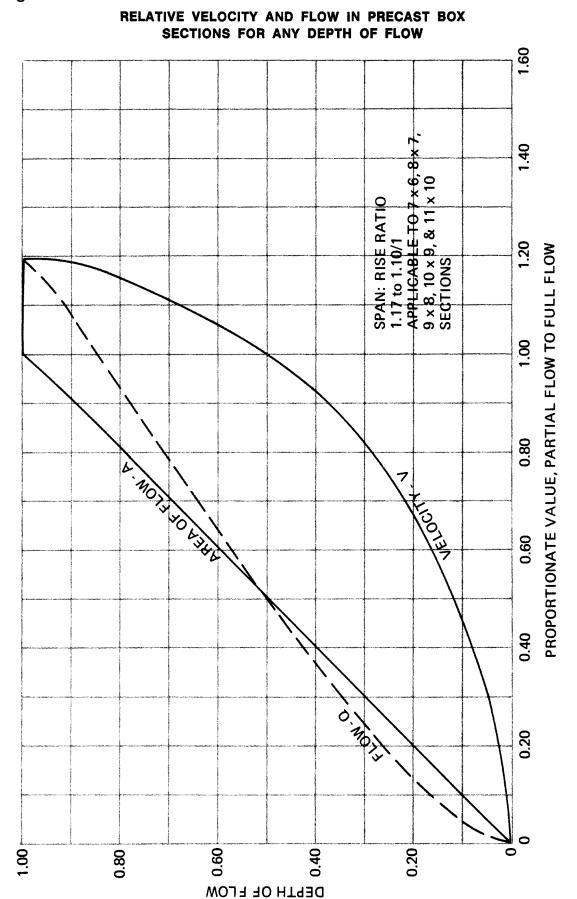


Figure 24.9

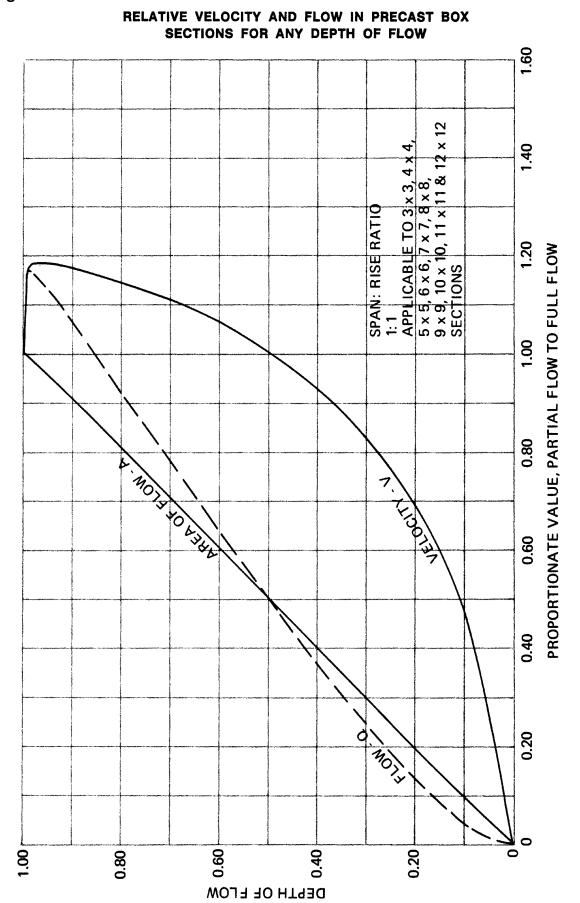
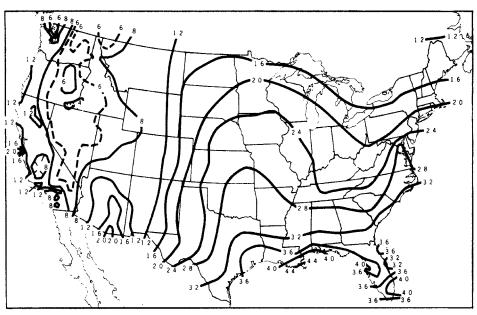


Figure 25

MAP OF THE UNITED STATES 2-YEAR, 30-MINUTE RAINFALL INTENSITY



ADAPTED FROM CHART 2, RAINFALL FREQUENCY ATLAS OF THE UNITED STATES, U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU, TECHNICAL PAPER NO. 40 MAY 1961

Figure 26

INTENSITY-DURATION CURVE

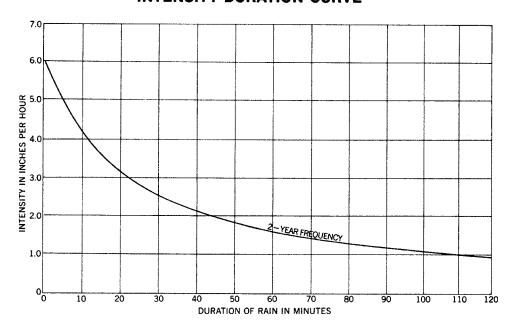


Figure 27
CALIFORNIA CHART "A" FOR CALCULATION OF "DESIGN DISCHARGES"

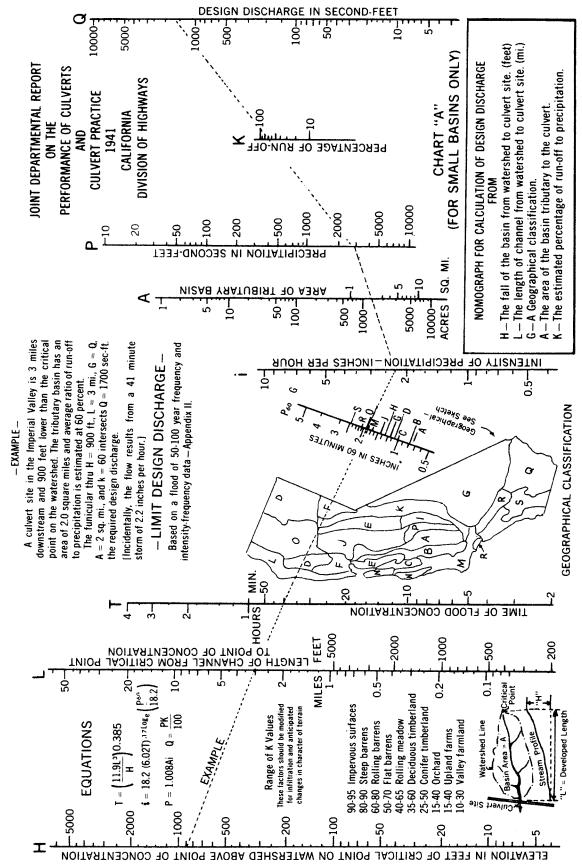


Figure 28

CRITICAL DEPTH CIRCULAR PIPE

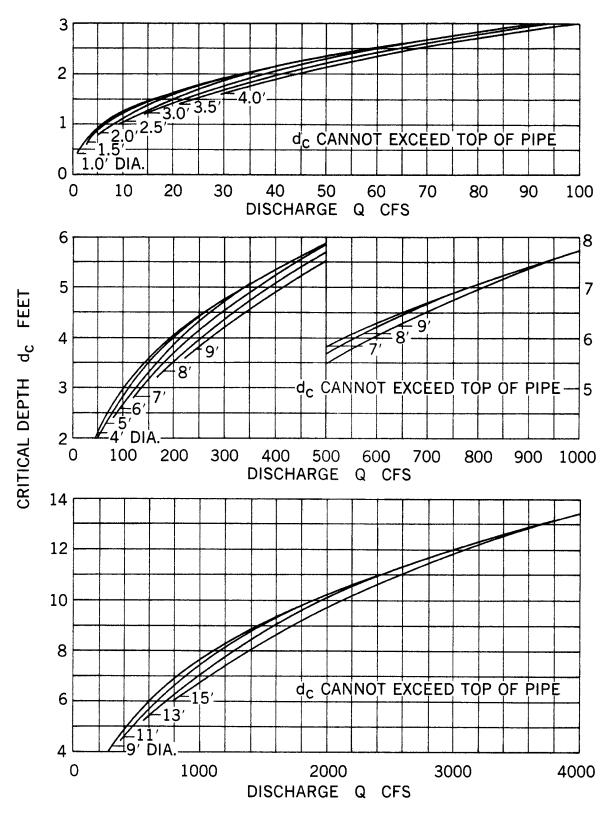
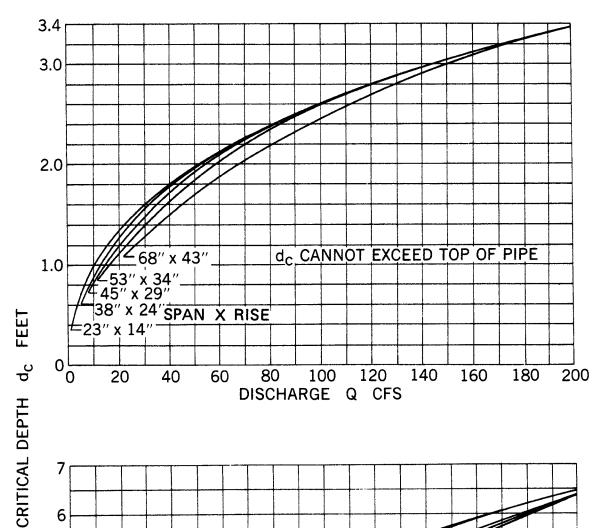


Figure 29





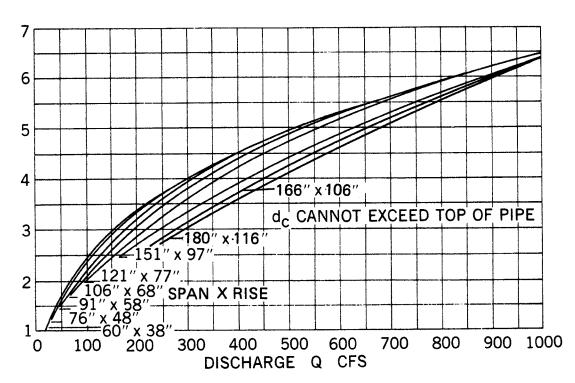
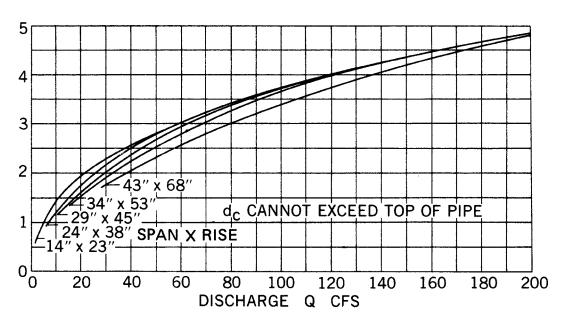


Figure 30

CRITICAL DEPTH VERTICAL ELLIPTICAL PIPE



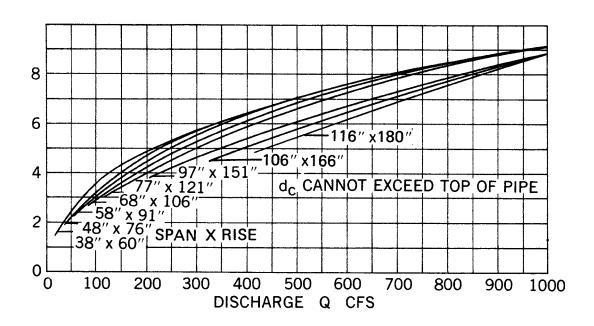
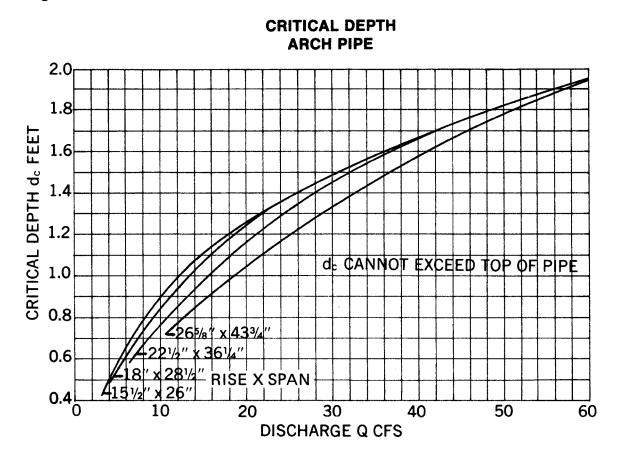


Figure 31.1



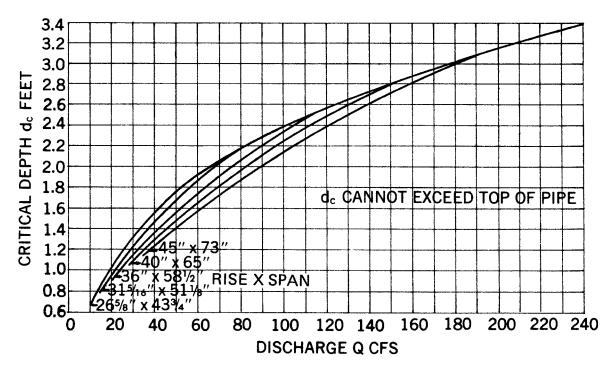


Figure 31.2

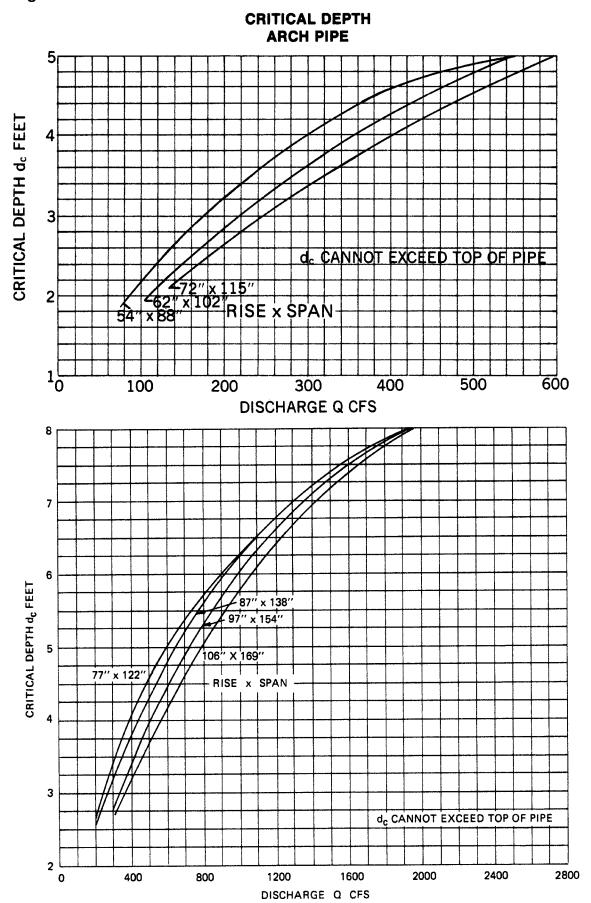
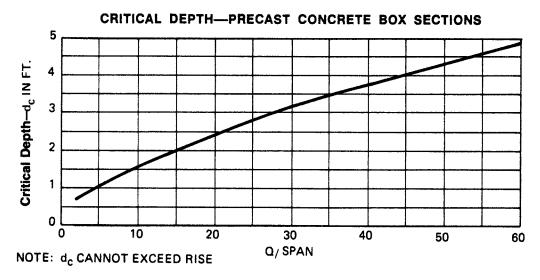


Figure 32



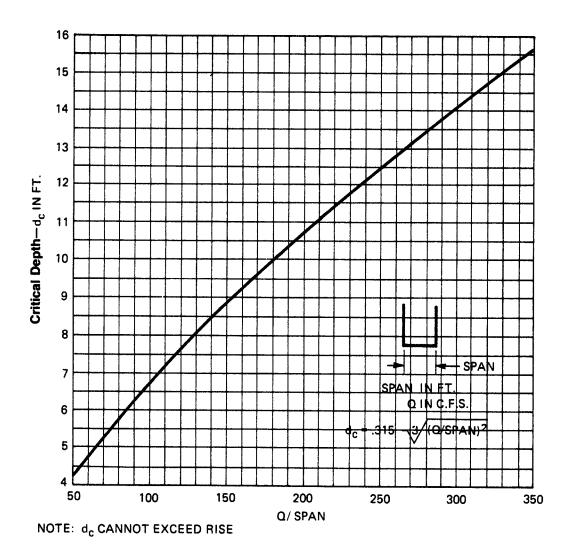
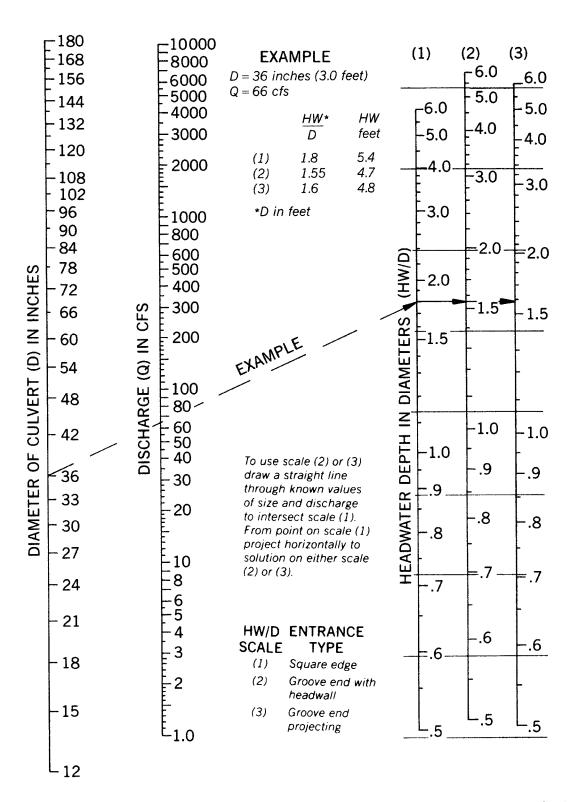


Figure 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE
PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3 REVISED MAY 1964

Figure 34

HEADWATER DEPTH FOR HORIZONTAL ELLIPTICAL
CONCRETE PIPE CULVERTS WITH INLET CONTROL

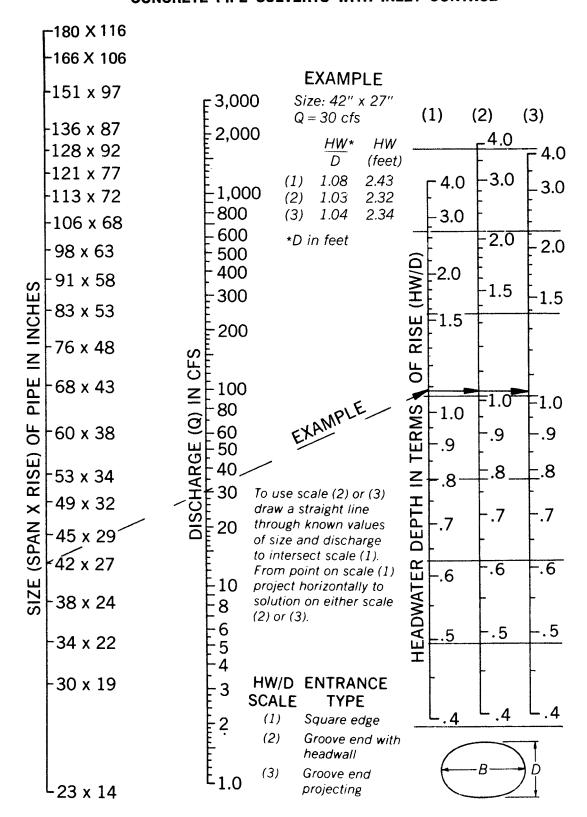


Figure 35

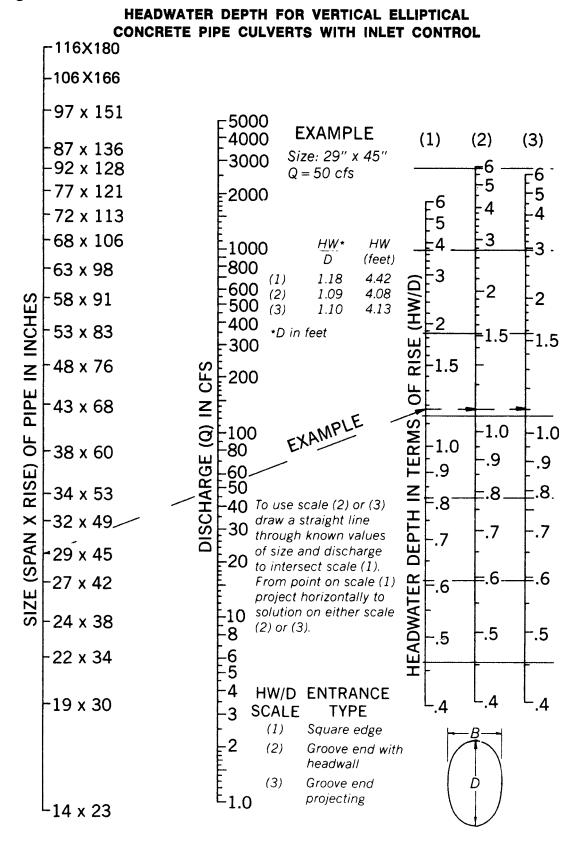


Figure 36

HEADWATER DEPTH FOR CONCRETE ARCH CULVERTS
WITH INLET CONTROL

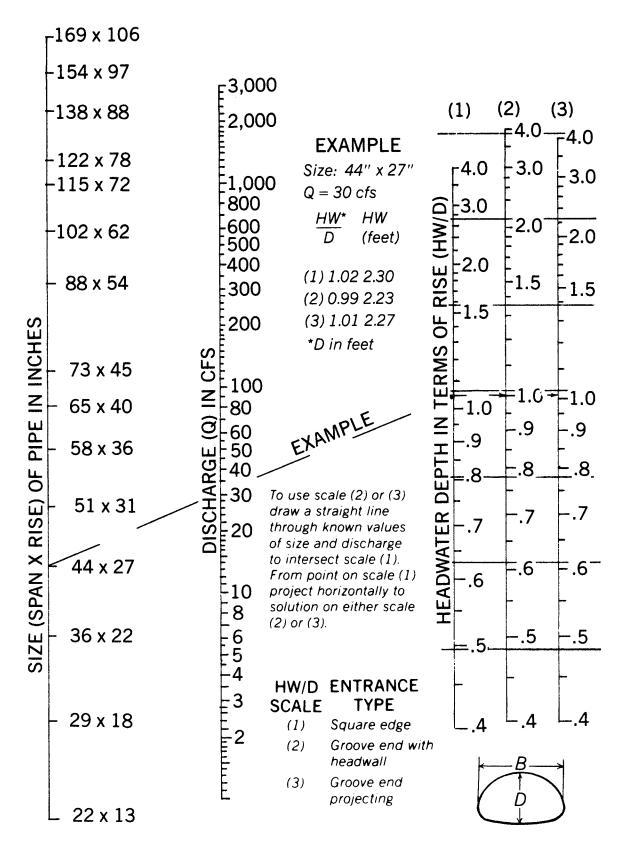
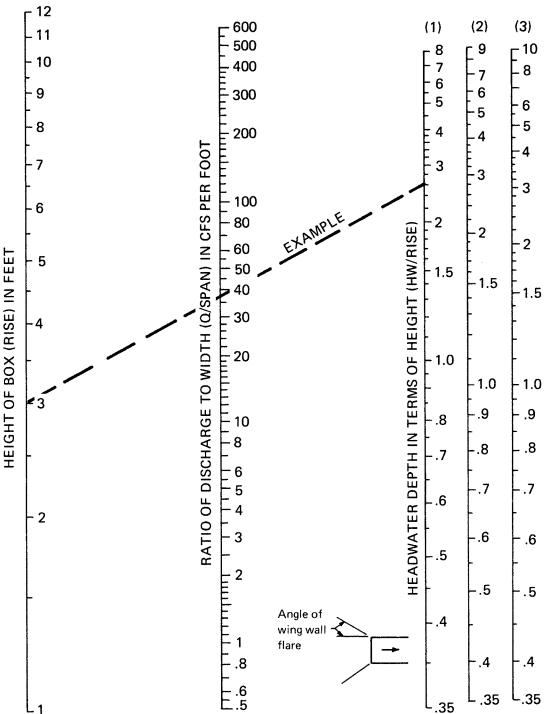


Figure 37





EXAMPLE			
6' x 3' Box Q = 225 cfs			
Q/Span = 37.5 cfs/ft			
	HW	HW	
Inlet	Rise	ft	
(1)	2.6	7.8	

HW SCALE	WING WALL FLARE
(1)	30° to 75°
(2)	90° and 15°
(3)	Oo (extensions
	of sides)

To use scale (2) or (3) project horizontally to scale (1), then use straight inclined line through rise and Q scales, or reverse as illustrated.

Figure 38

HEAD FOR CIRCULAR CONCRETE PIPE CULVERTS FLOWING FULL n = 0.012

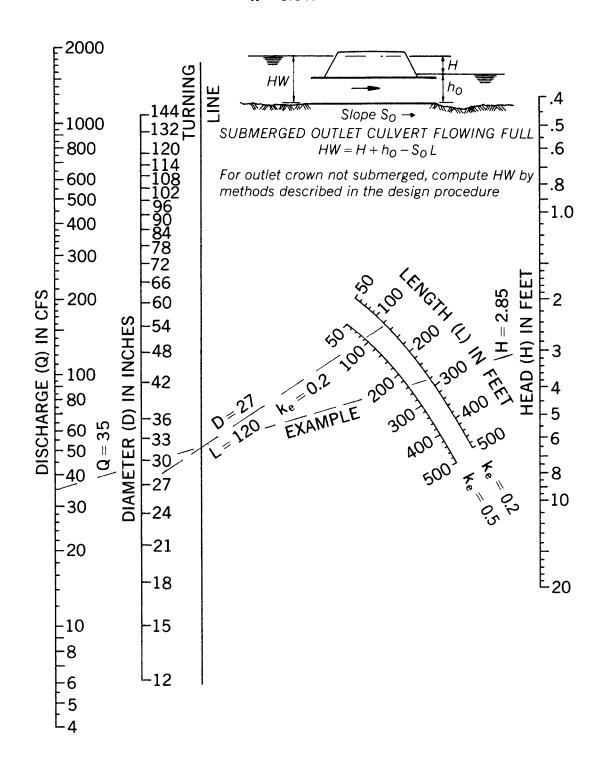


Figure 39

HEAD FOR ELLIPTICAL CONCRETE PIPE CULVERTS FLOWING FULL n = 0.012

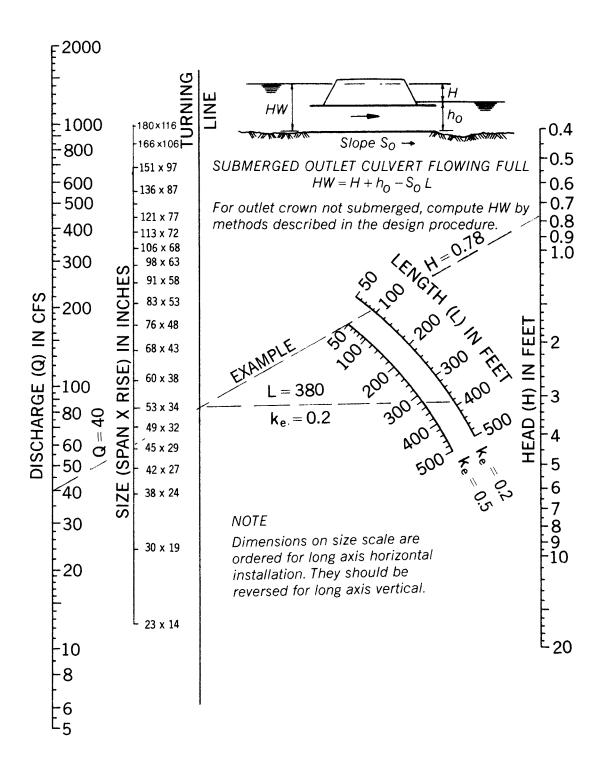


Figure 40

HEAD FOR CONCRETE ARCH CULVERTS FLOWING FULL

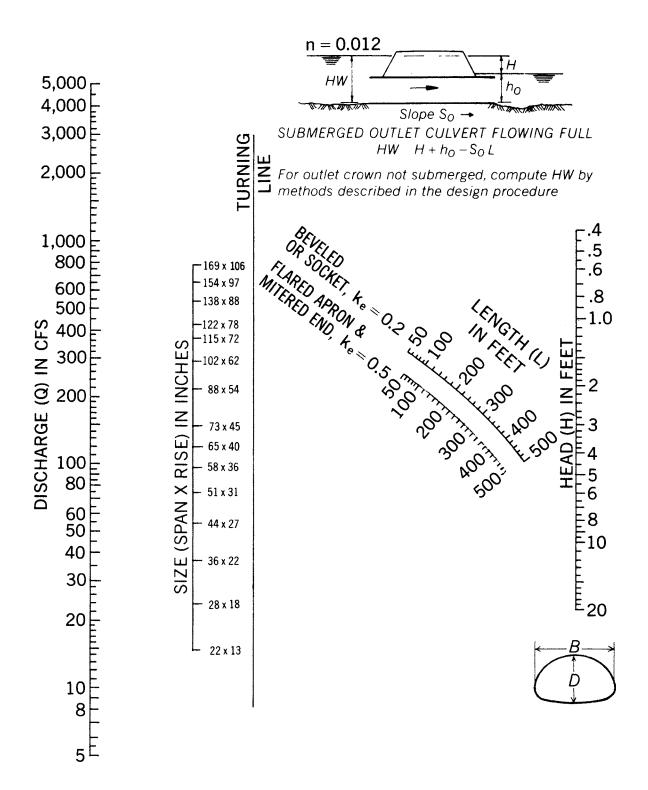


Figure 41

HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL n=0.012

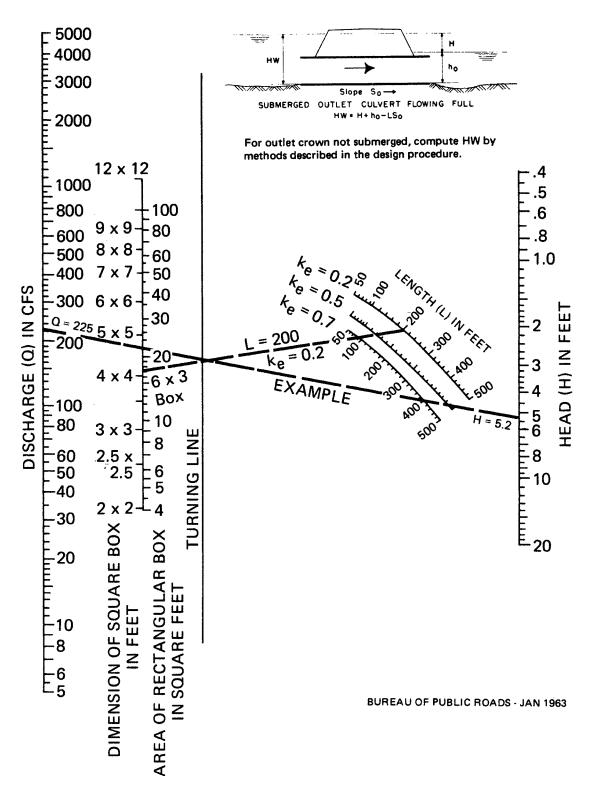


Figure 42

CULVERT CAPACITY 12-INCH DIAMETER PIPE

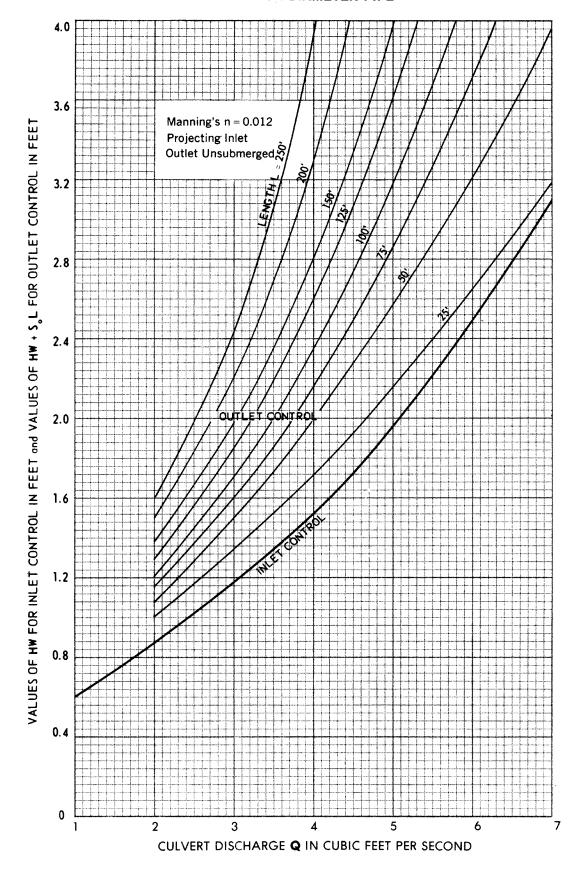


Figure 43



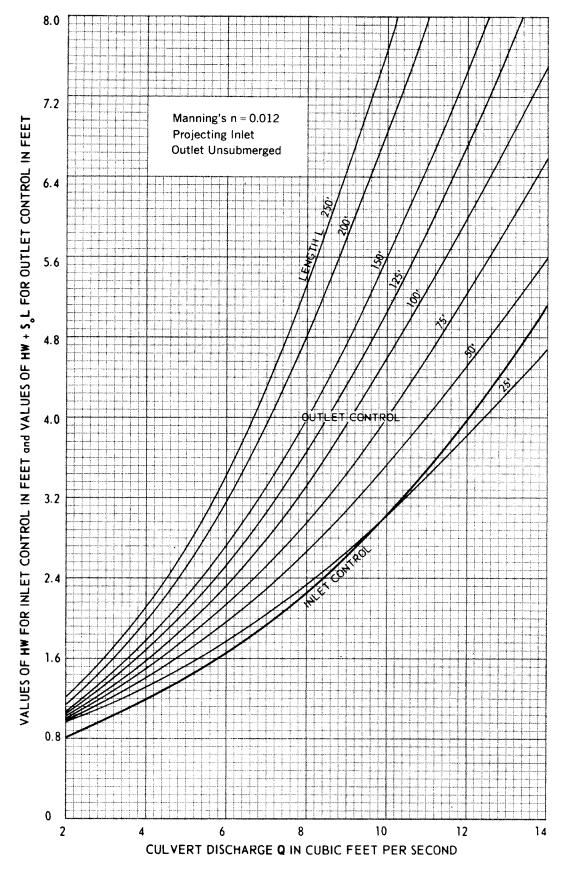


Figure 44

CULVERT CAPACITY 18-INCH DIAMETER PIPE

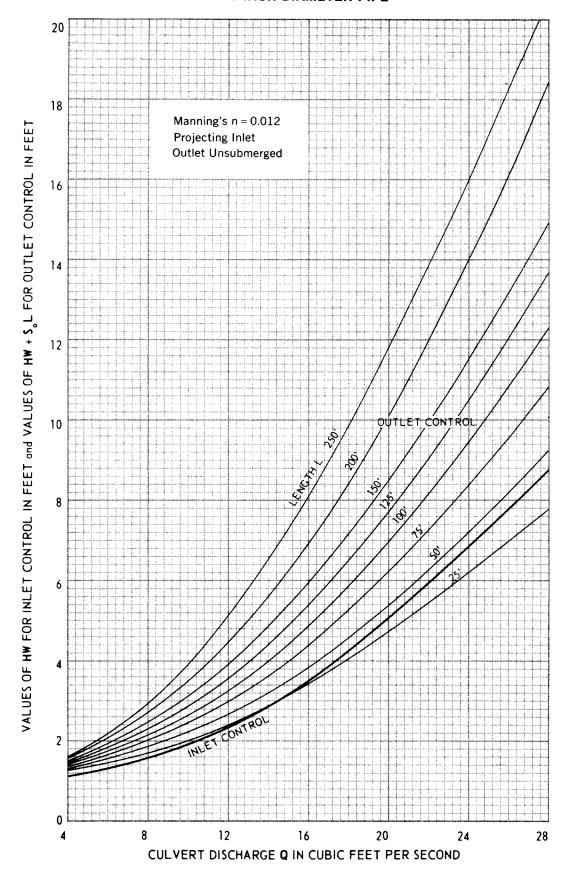
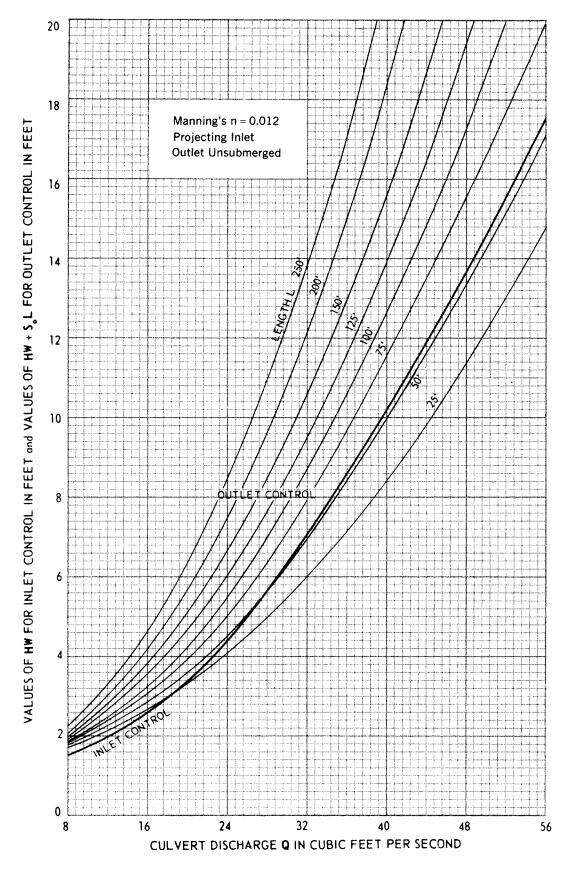


Figure 45





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Figure 46



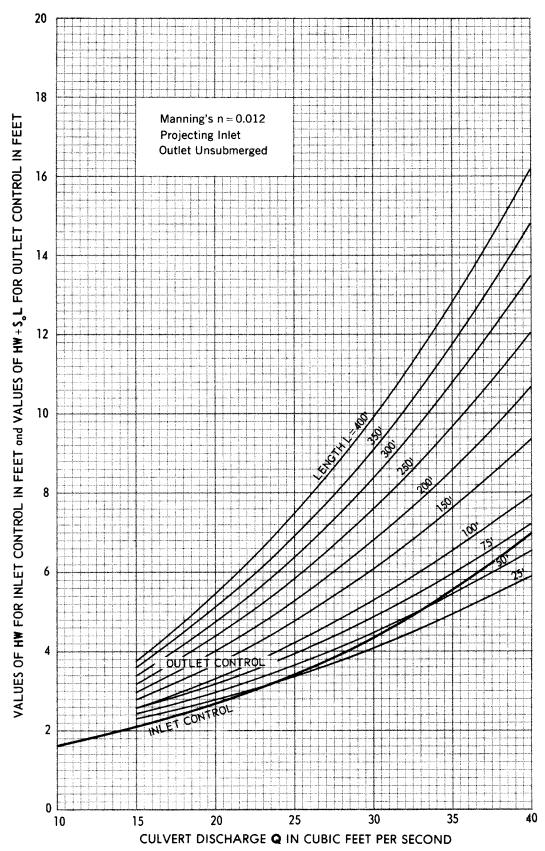


Figure 47



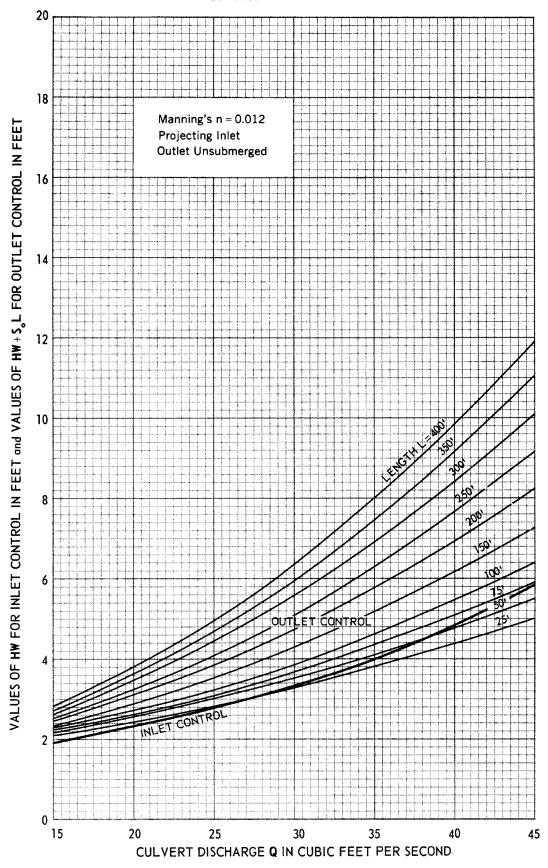


Figure 48

CULVERT CAPACITY 30-INCH DIAMETER PIPE

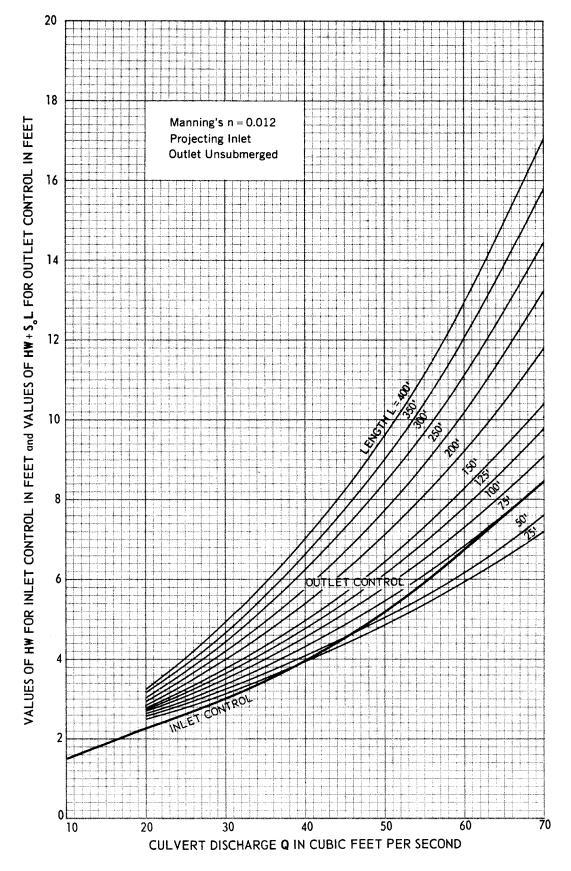


Figure 49

CULVERT CAPACITY 33-INCH DIAMETER PIPE

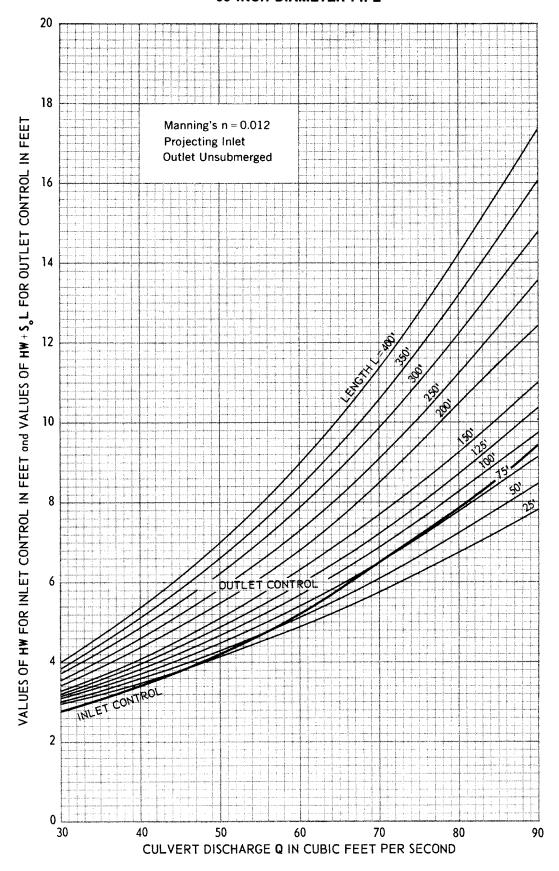


Figure 50

CULVERT CAPACITY 36-INCH DIAMETER PIPE

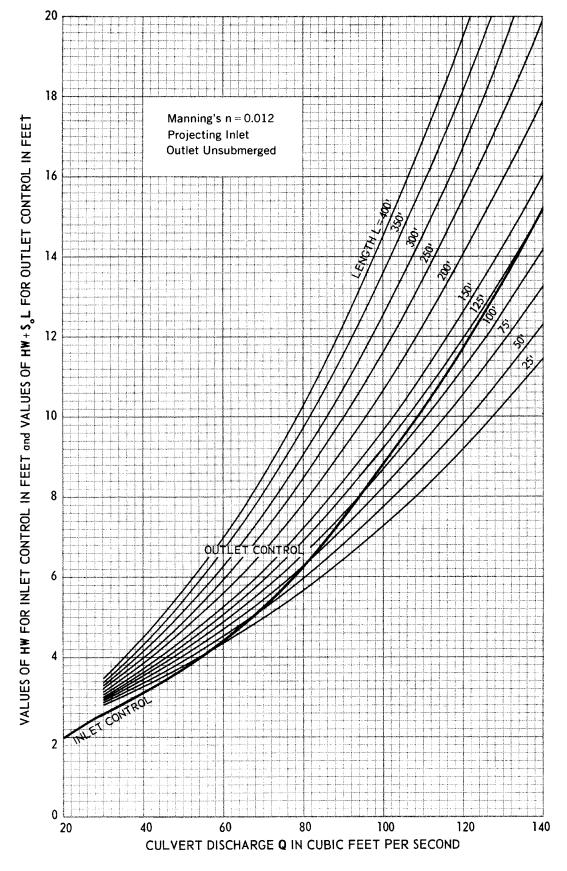


Figure 51

CULVERT CAPACITY 42-INCH DIAMETER PIPE

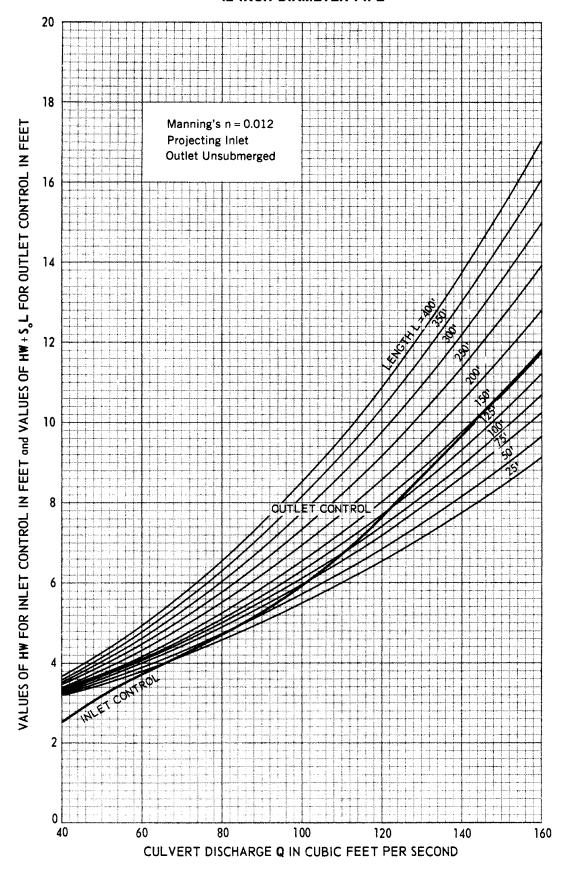
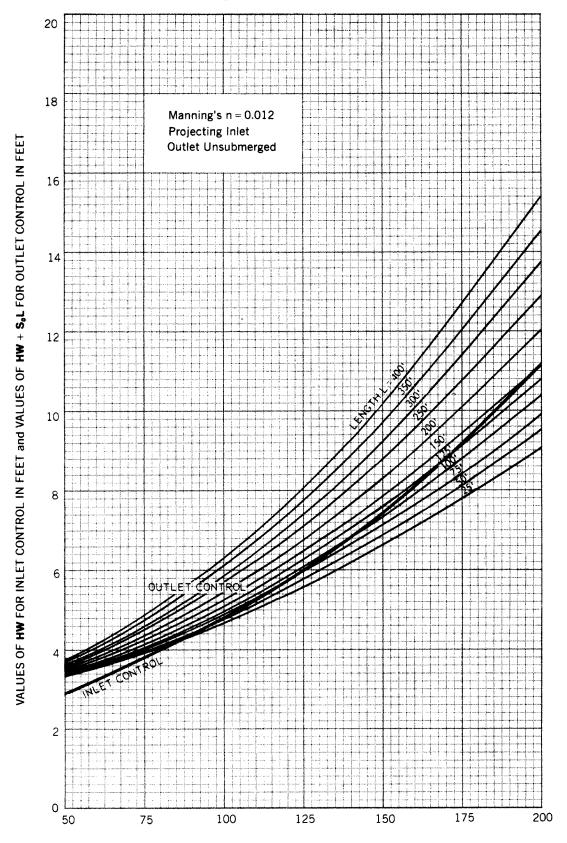


Figure 52

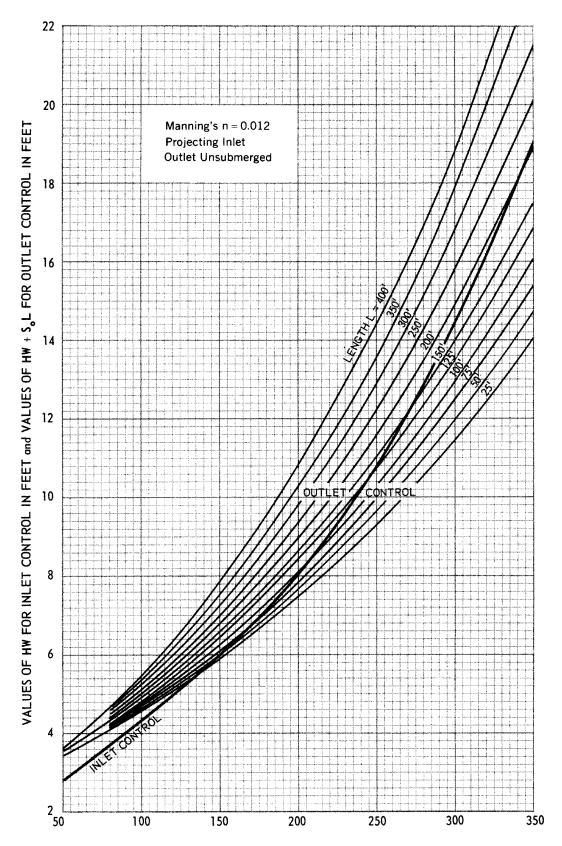




CULVERT DISCHARGE Q IN CUBIC FEET PER SECOND

Figure 53

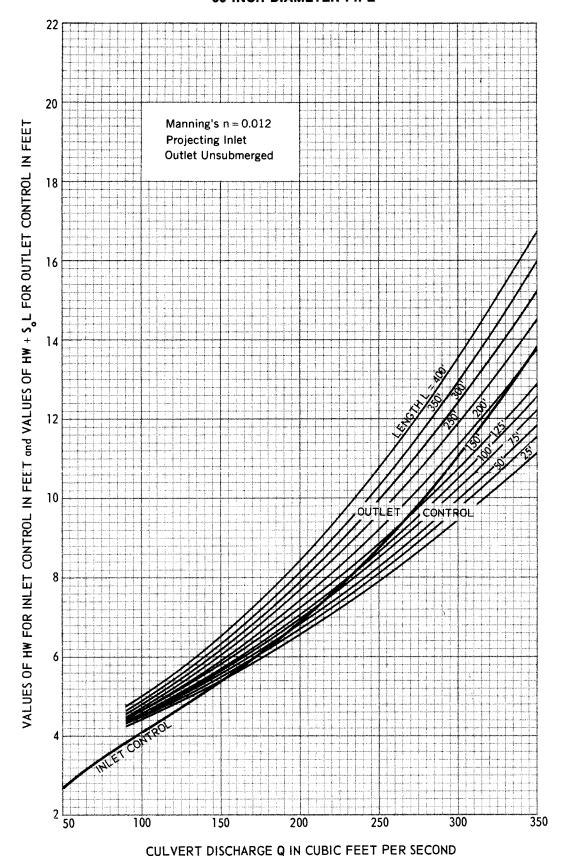
CULVERT CAPACITY 54-INCH DIAMETER PIPE



CULVERT DISCHARGE Q IN CUBIC FEET PER SECOND

Figure 54

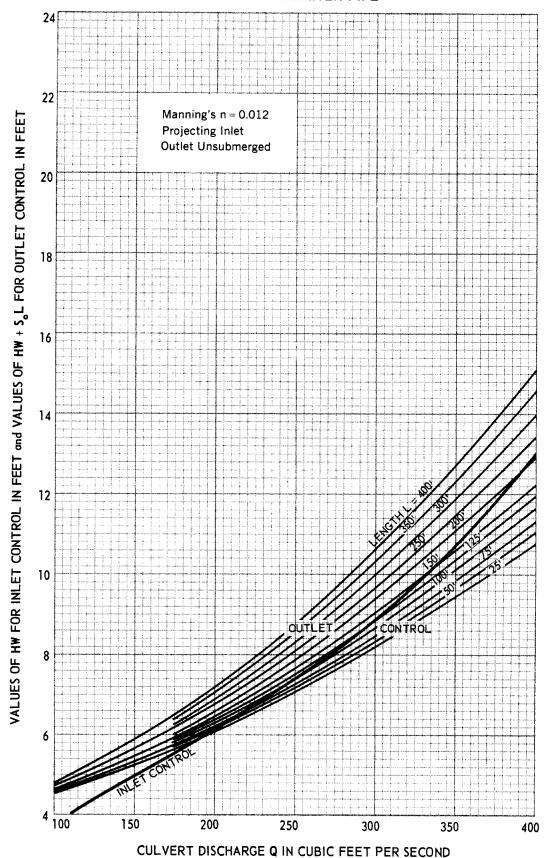
CULVERT CAPACITY 60-INCH DIAMETER PIPE



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Figure 55





American Concrete Pipe Association • www.concrete-pipe.org

Figure 56



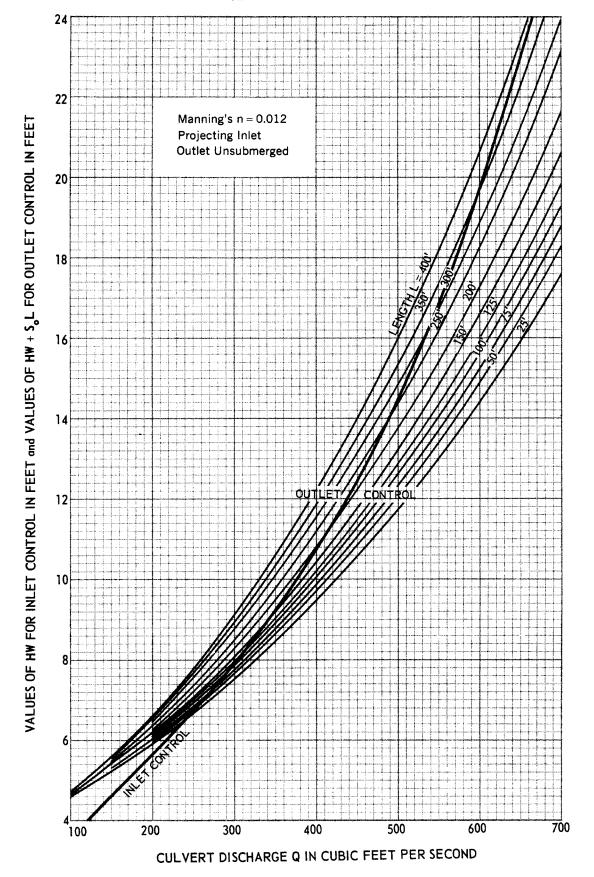
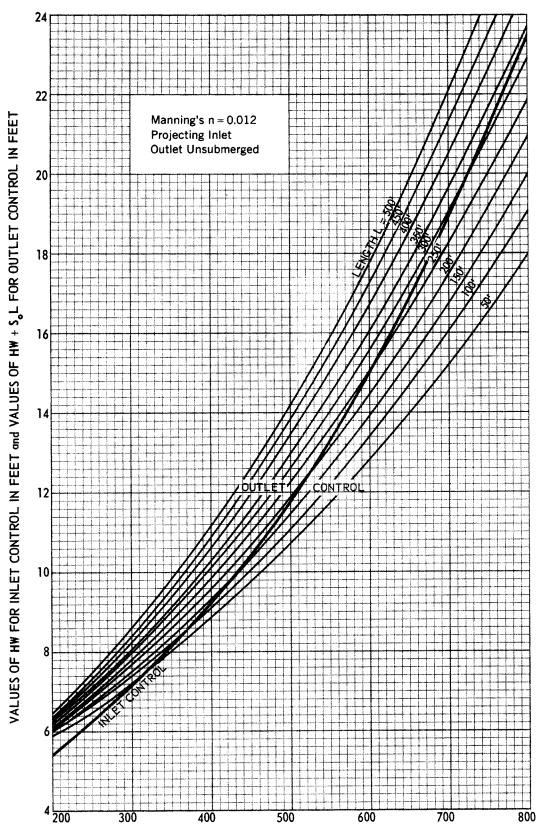


Figure 57

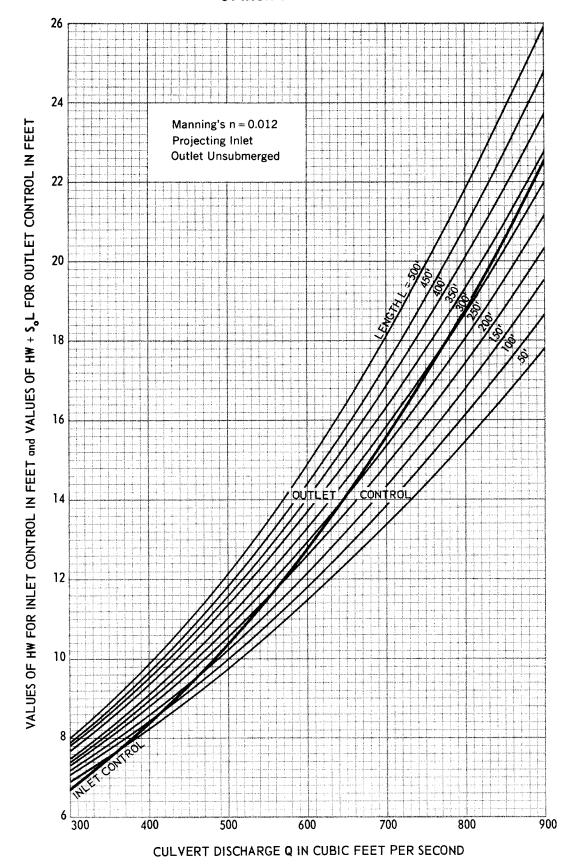
CULVERT CAPACITY 78-INCH DIAMETER PIPE



CULVERT DISCHARGE Q IN CUBIC FEET PER SECOND

Figure 58

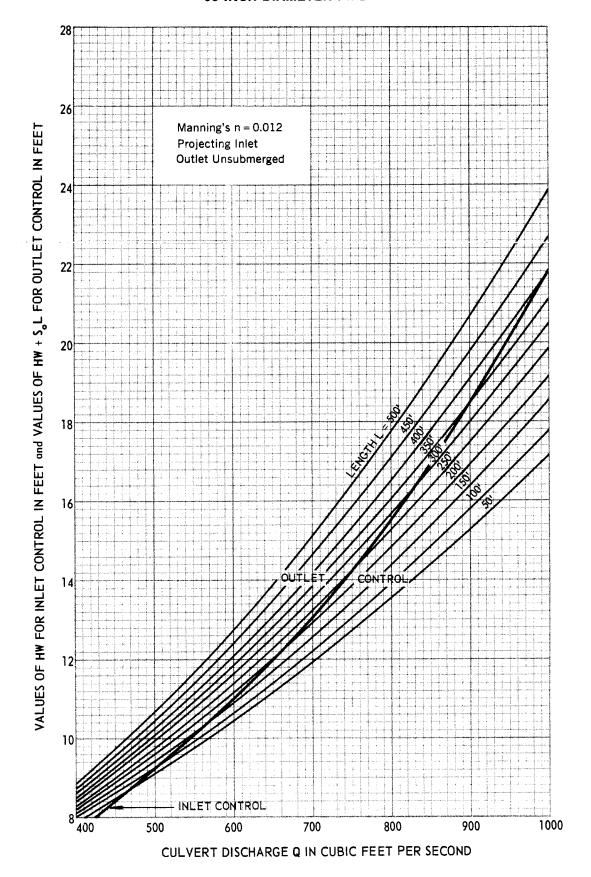
CULVERT CAPACITY 84-INCH DIAMETER PIPE



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Figure 59

CULVERT CAPACITY 90-INCH DIAMETER PIPE



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Figure 60

CULVERT CAPACITY 96-INCH DIAMETER PIPE

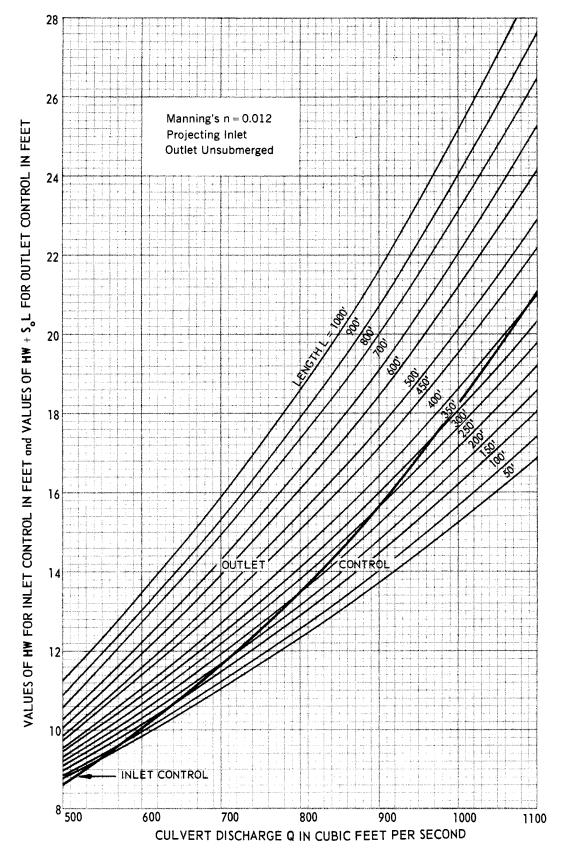
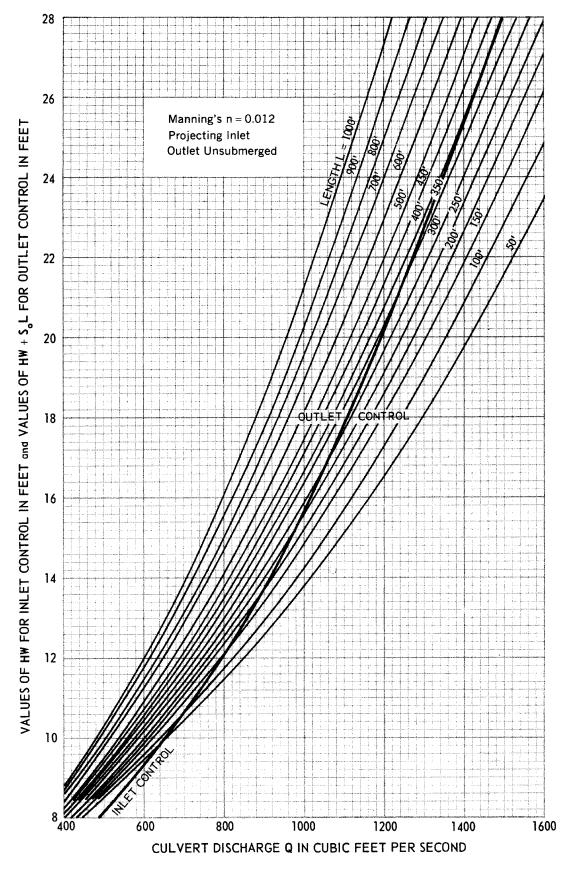


Figure 61





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Figure 62

CULVERT CAPACITY 108-INCH DIAMETER PIPE

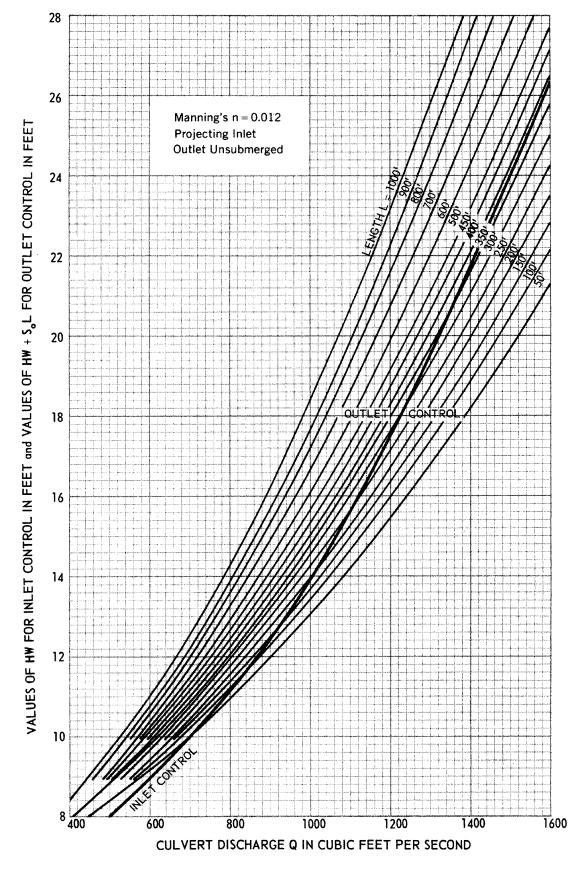


Figure 63



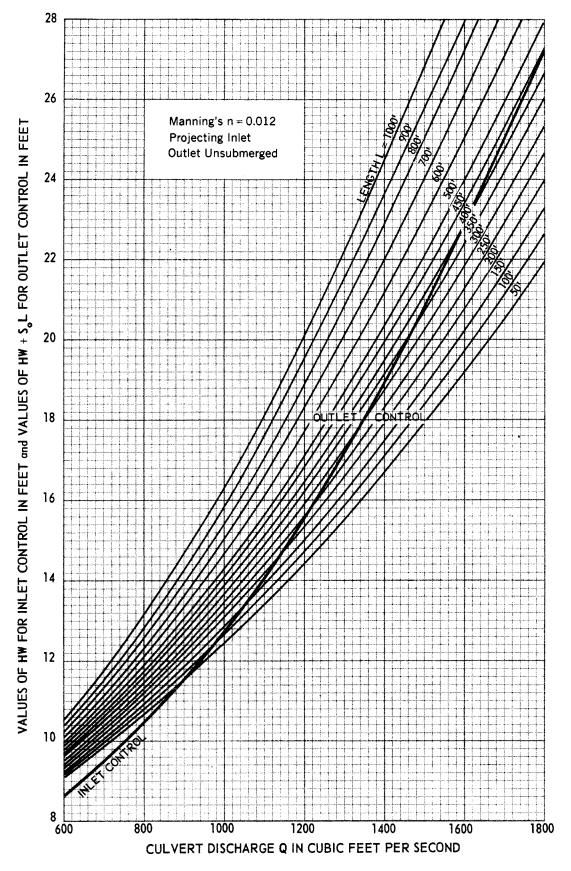


Figure 64



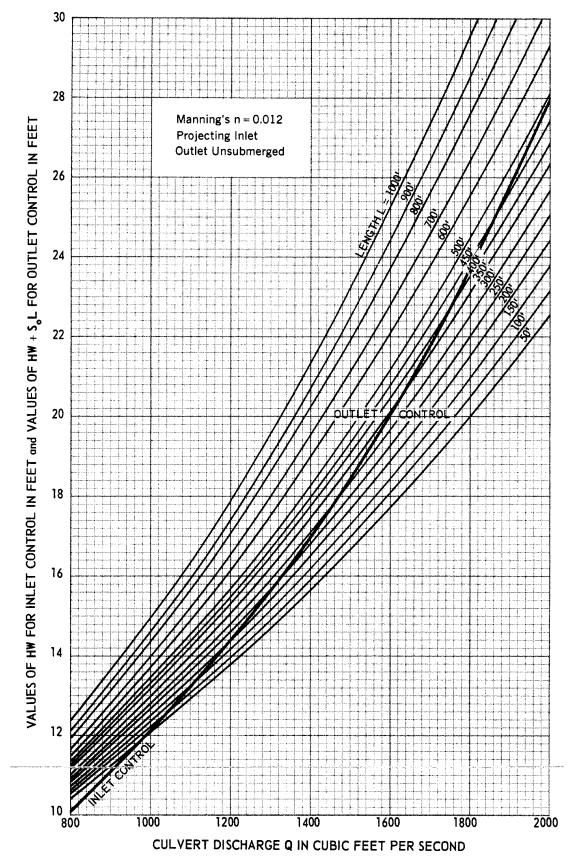


Figure 65

CULVERT CAPACITY 132-INCH DIAMETER PIPE

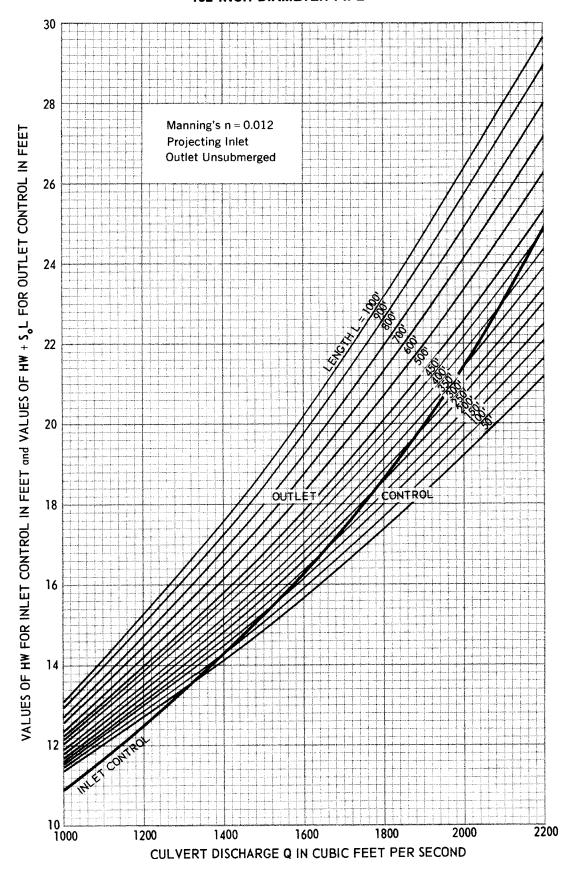


Figure 66

CULVERT CAPACITY 144-INCH DIAMETER PIPE

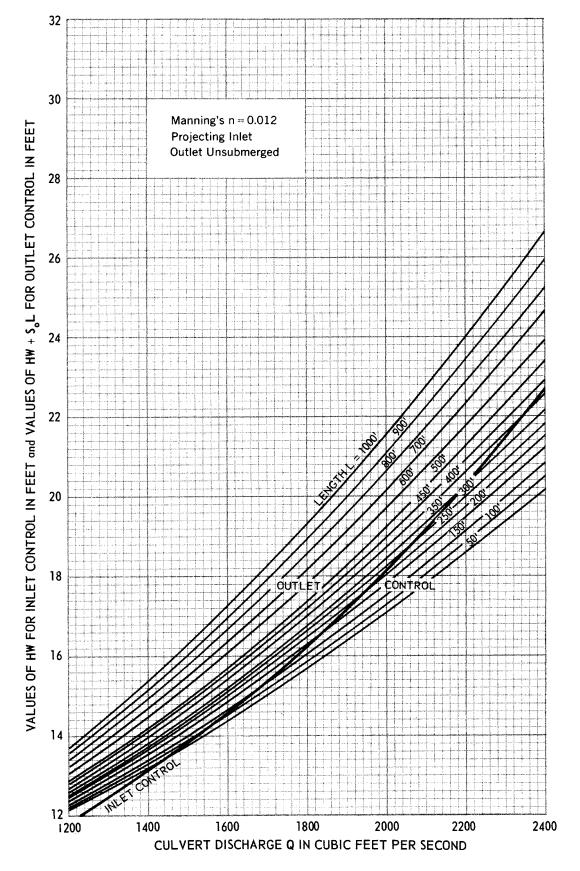


Figure 67

CULVERT CAPACITY 14 x 23-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 18-INCH CIRCULAR

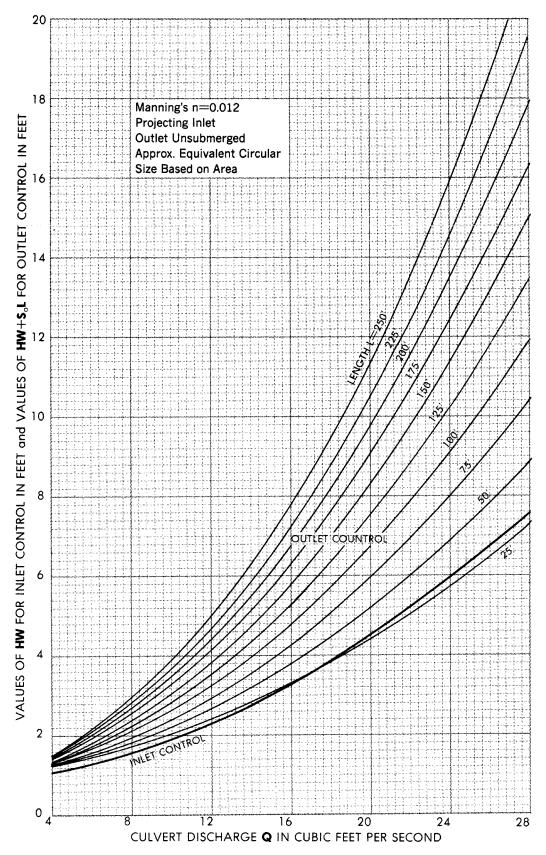


Figure 68

CULVERT CAPACITY 19 x 30-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 24-INCH CIRCULAR

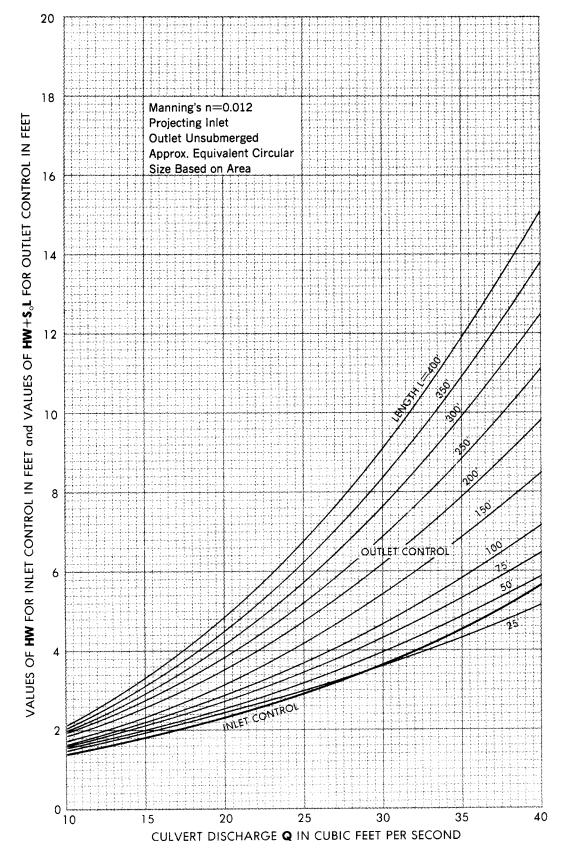


Figure 69

CULVERT CAPACITY 24 x 38-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 30-INCH CIRCULAR

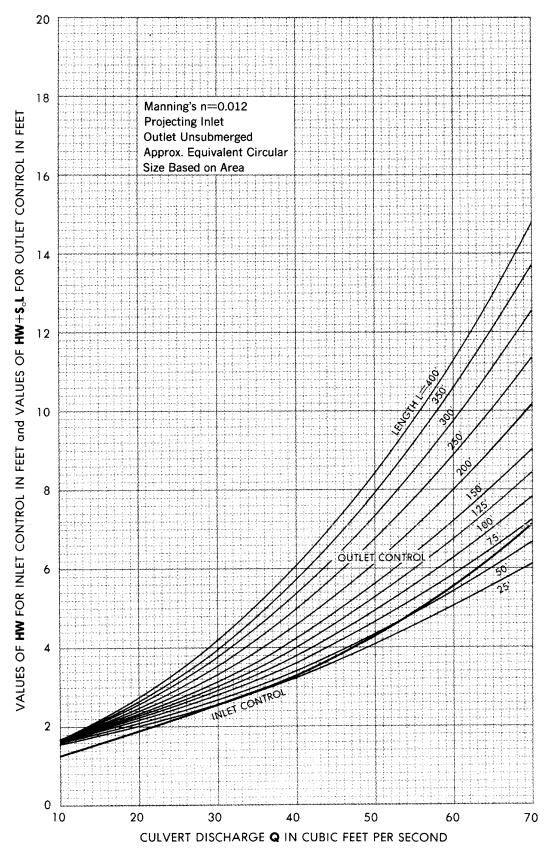


Figure 70

CULVERT CAPACITY 29 x 45-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 36-INCH CIRCULAR

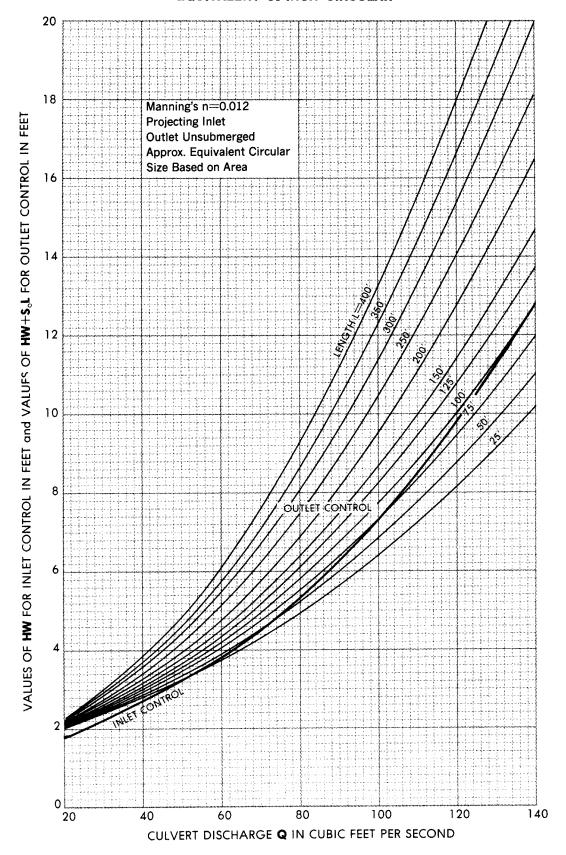


Figure 71

CULVERT CAPACITY 34 x 54-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 42-INCH CIRCULAR

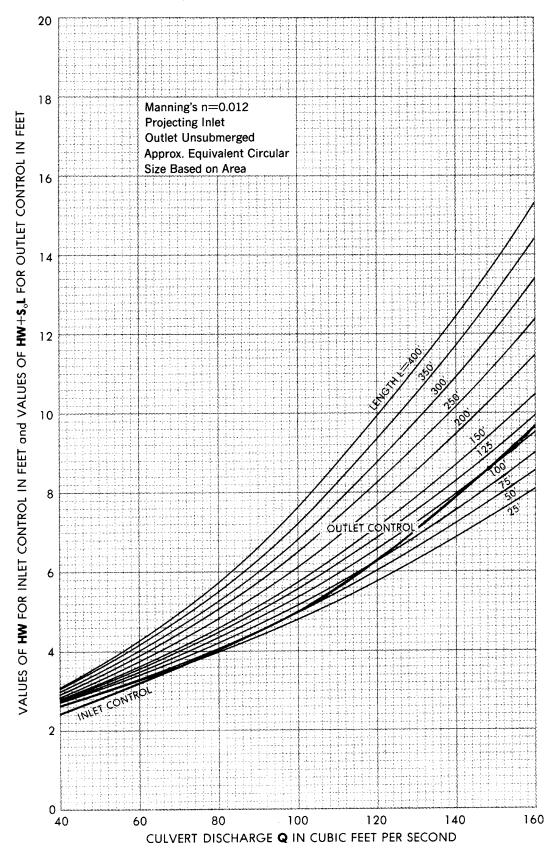


Figure 72

CULVERT CAPACITY 38 x 60-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 48-INCH CIRCULAR

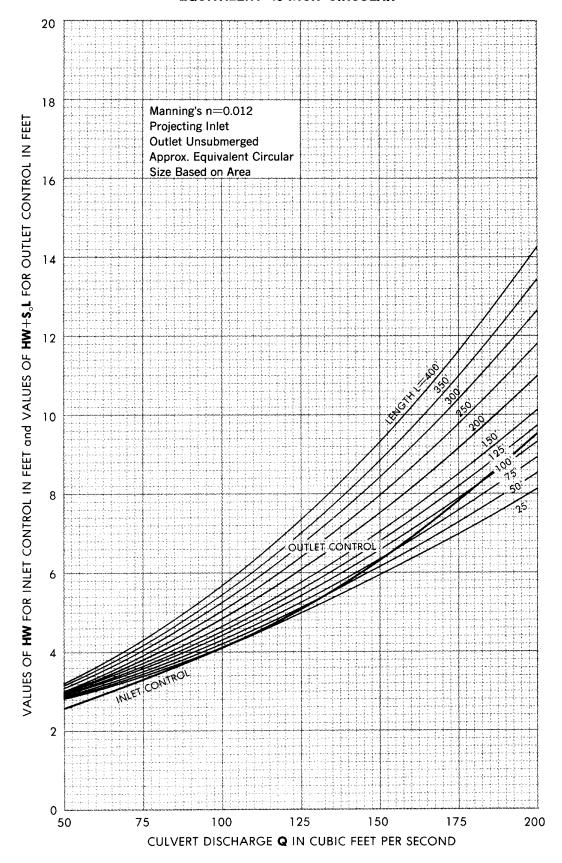


Figure 73

CULVERT CAPACITY 43 x 68-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 54-INCH CIRCULAR

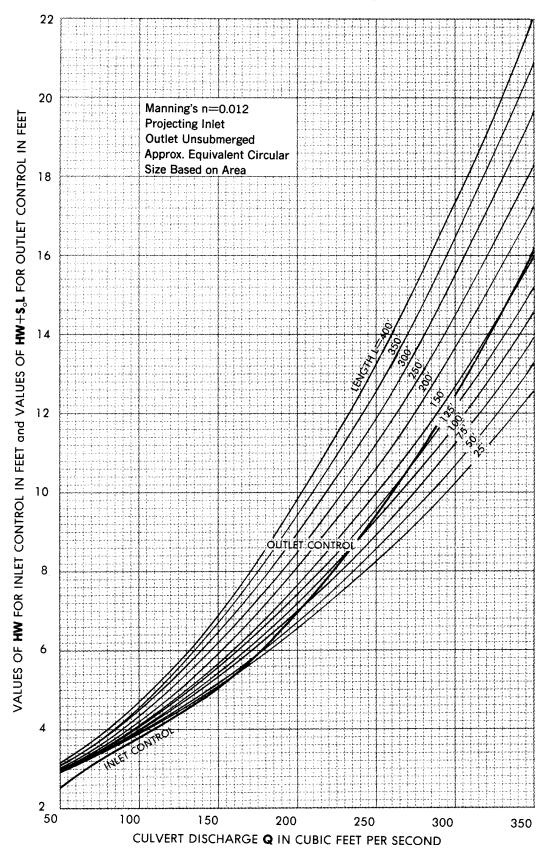


Figure 74

CULVERT CAPACITY 48 x 76-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 60-INCH CIRCULAR

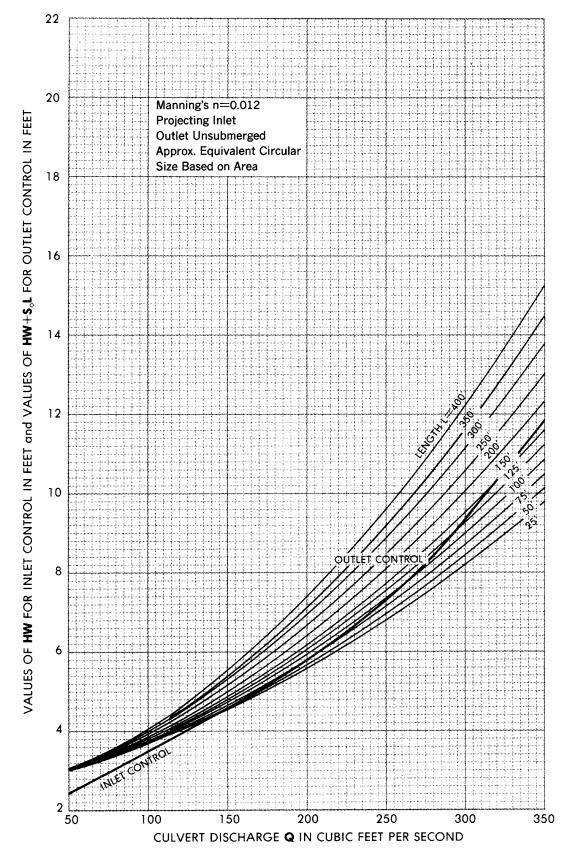


Figure 75

CULVERT CAPACITY 53 x 83-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 66-INCH CIRCULAR

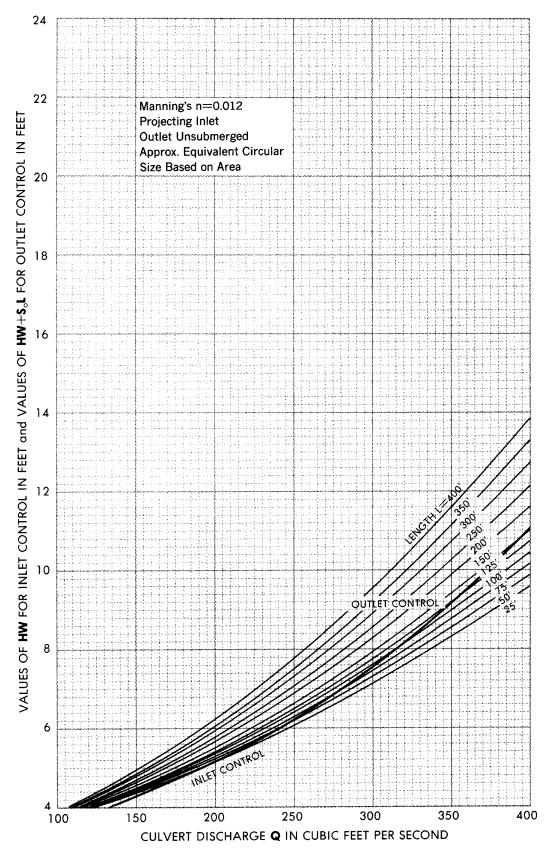


Figure 76

CULVERT CAPACITY 58 x 91-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 72-INCH CIRCULAR

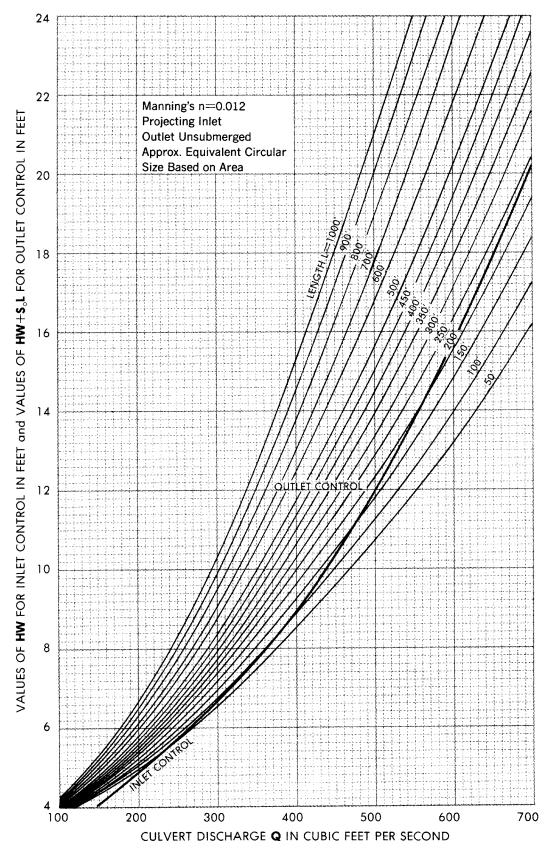


Figure 77

CULVERT CAPACITY 63 x 98-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 78-INCH CIRCULAR

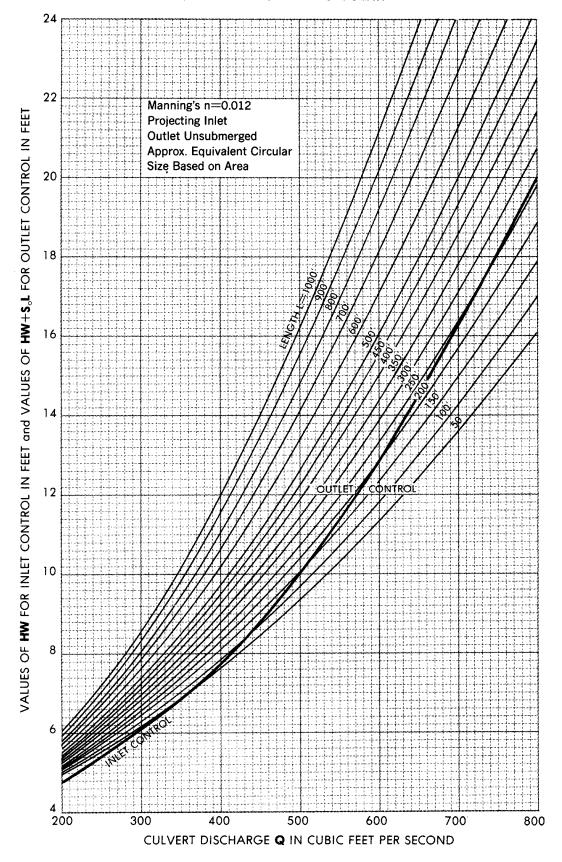


Figure 78

CULVERT CAPACITY 68 x 106-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 84-INCH CIRCULAR

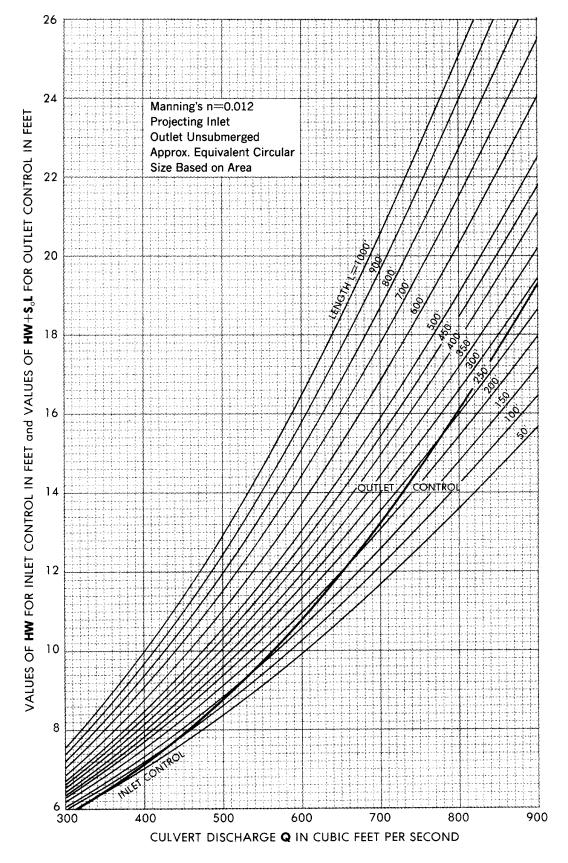


Figure 79

CULVERT CAPACITY 72 x 113-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 90-INCH CIRCULAR

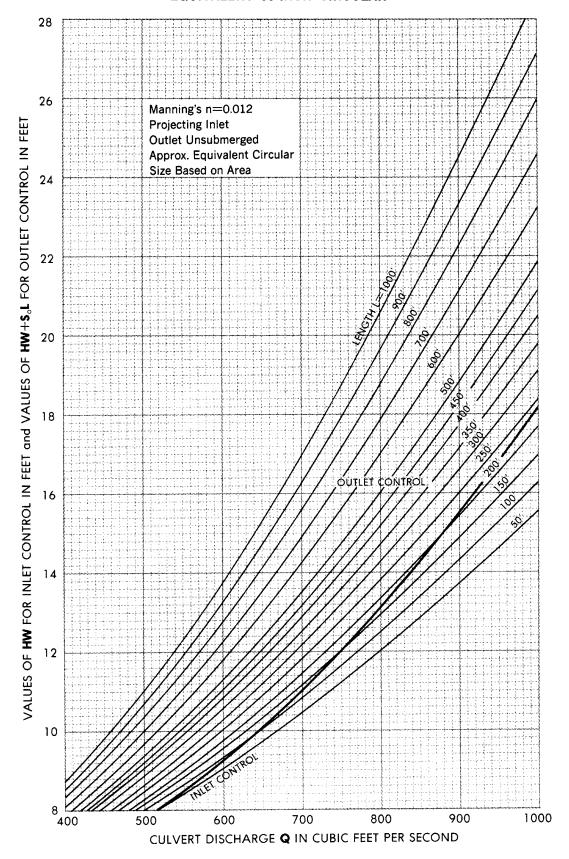


Figure 80

CULVERT CAPACITY 77 x 121-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 96-INCH CIRCULAR

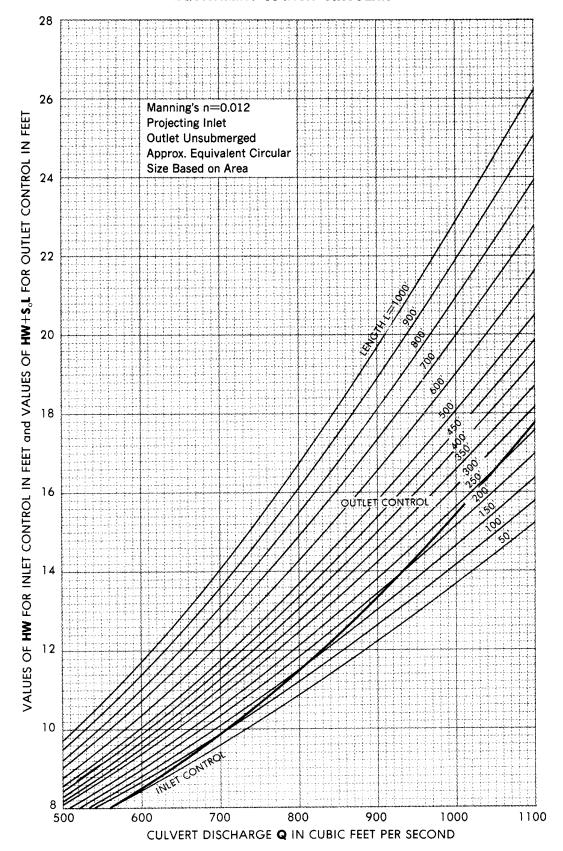


Figure 81

CULVERT CAPACITY 82 x 128-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 102-INCH CIRCULAR

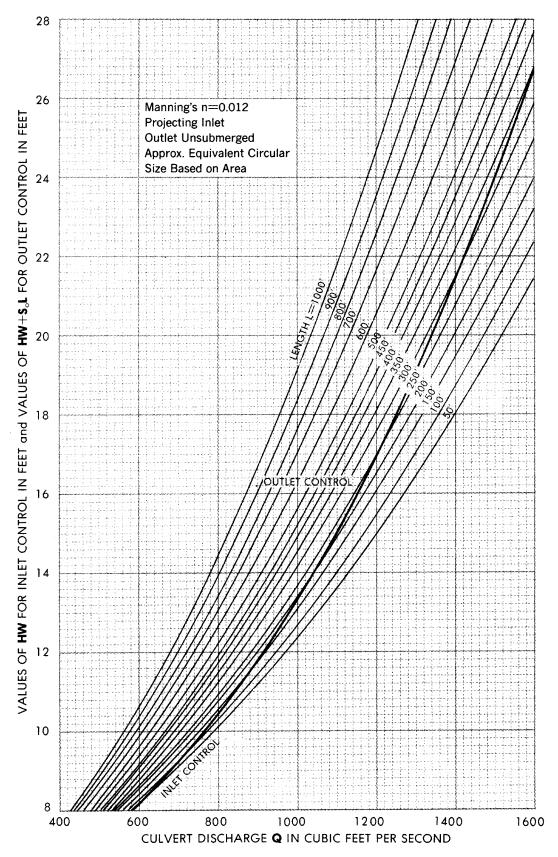


Figure 82

CULVERT CAPACITY 87 x 136-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 108-INCH CIRCULAR

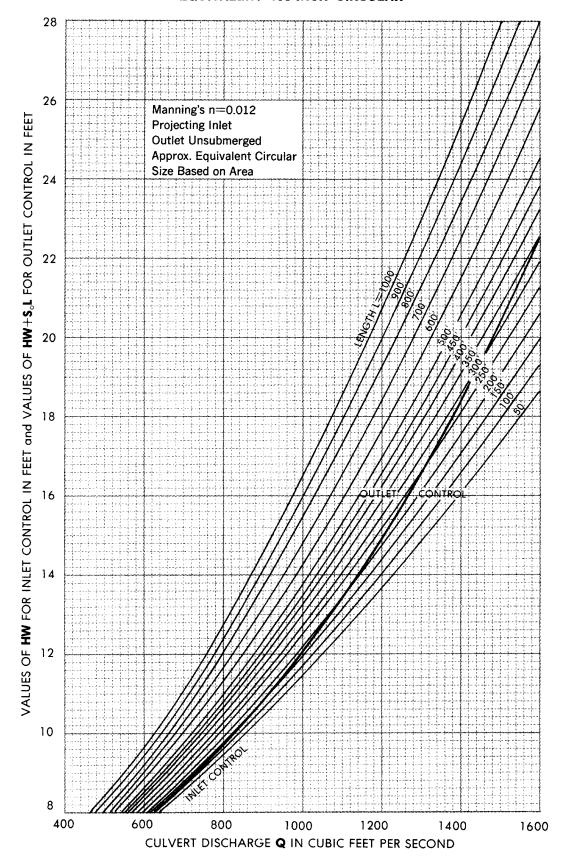


Figure 83

CULVERT CAPACITY 92 x 143-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 114-INCH CIRCULAR

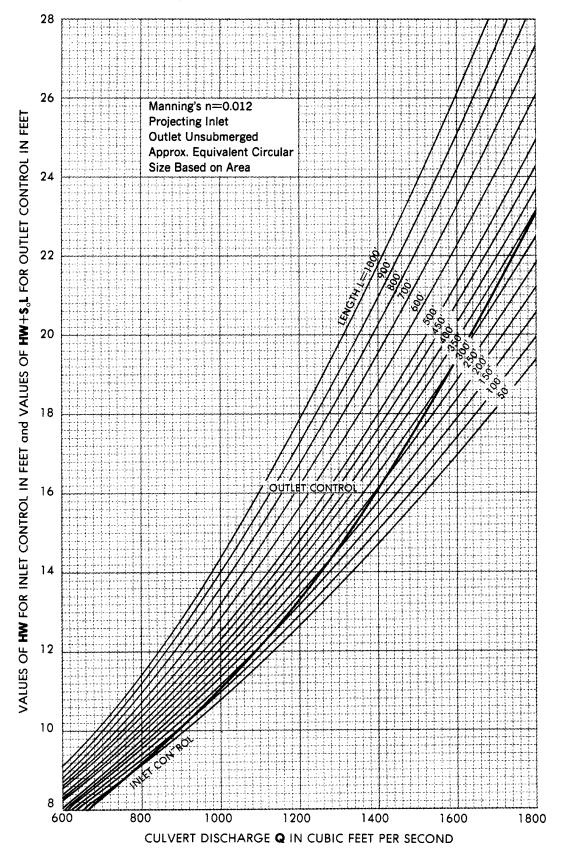


Figure 84

CULVERT CAPACITY 97 x 151-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 120-INCH CIRCULAR

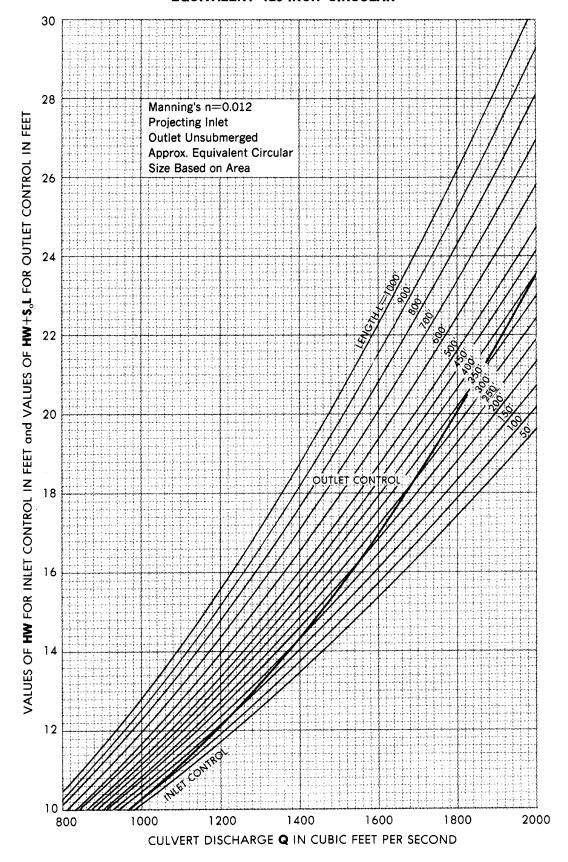


Figure 85

CULVERT CAPACITY 106 x 166-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 132-INCH CIRCULAR

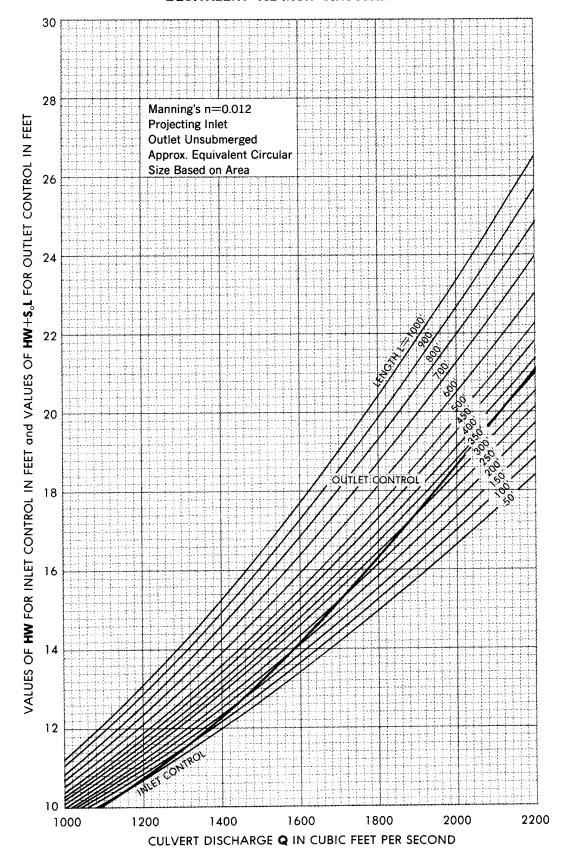


Figure 86

CULVERT CAPACITY 116 x 180-INCH (RISE x SPAN) HORIZONTAL ELLIPTICAL EQUIVALENT 144-INCH CIRCULAR

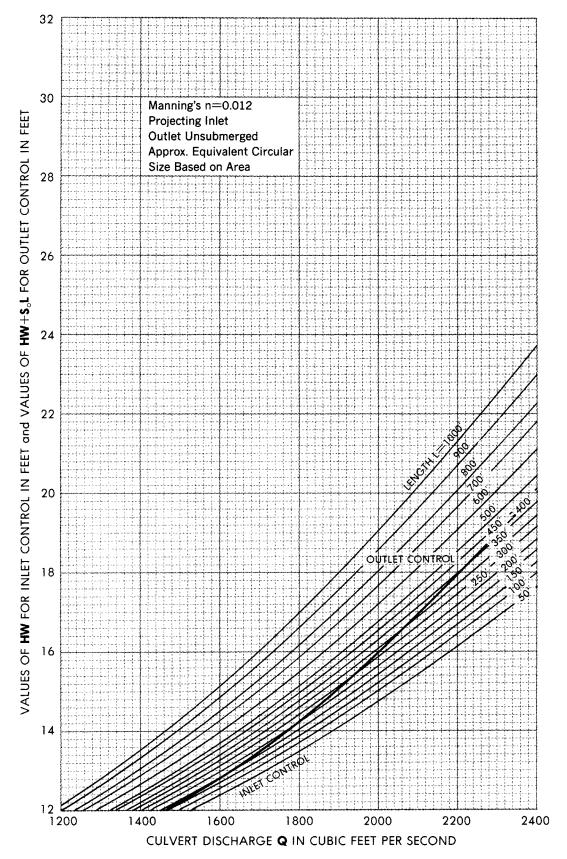


Figure 87

CULVERT CAPACITY 11 x 18-INCH (RISE x SPAN) ARCH EQUIVALENT 15-INCH CIRCULAR

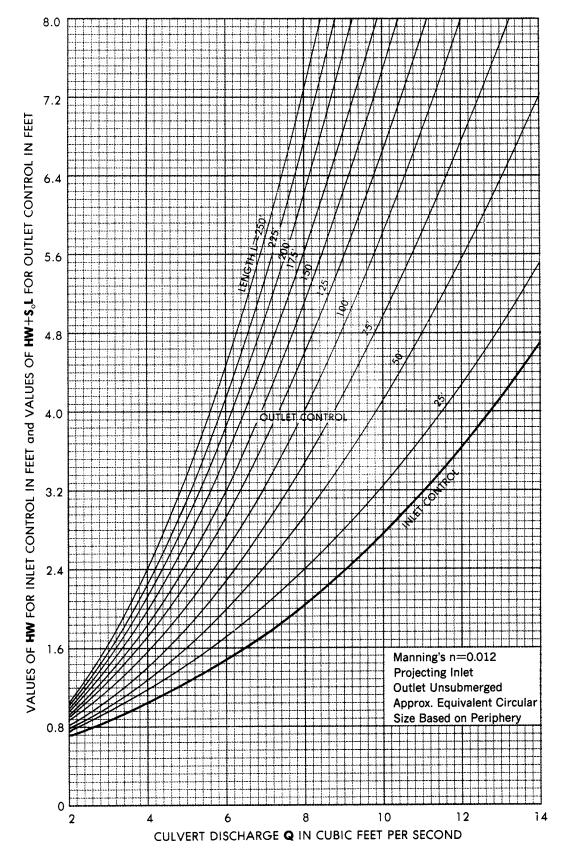


Figure 88

CULVERT CAPACITY 13 x 22-INCH (RISE x SPAN) ARCH EQUIVALENT 18-INCH CIRCULAR

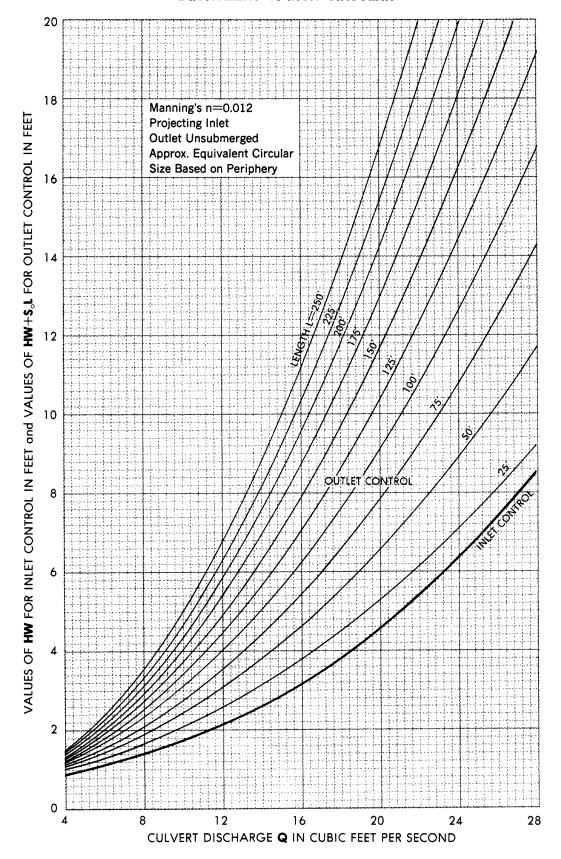
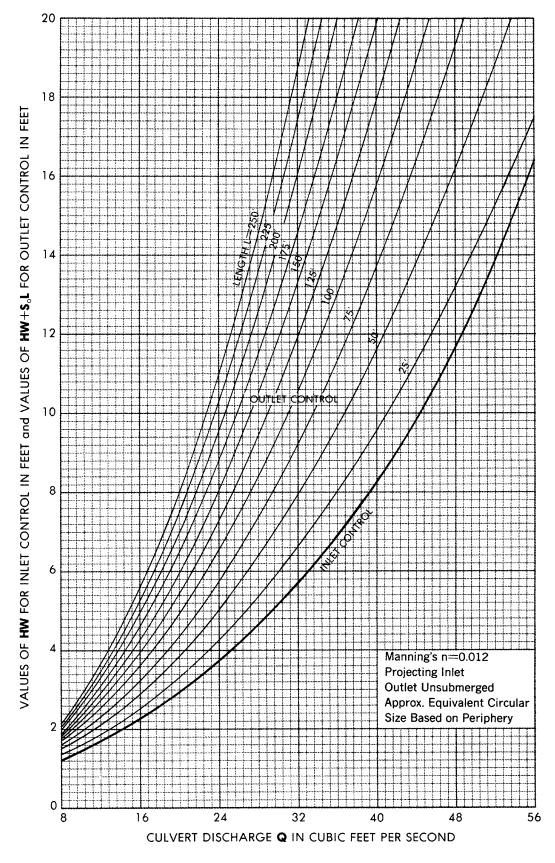


Figure 89





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Figure 90

CULVERT CAPACITY 18 x 28-INCH (RISE x SPAN) ARCH EQUIVALENT 24-INCH CIRCULAR

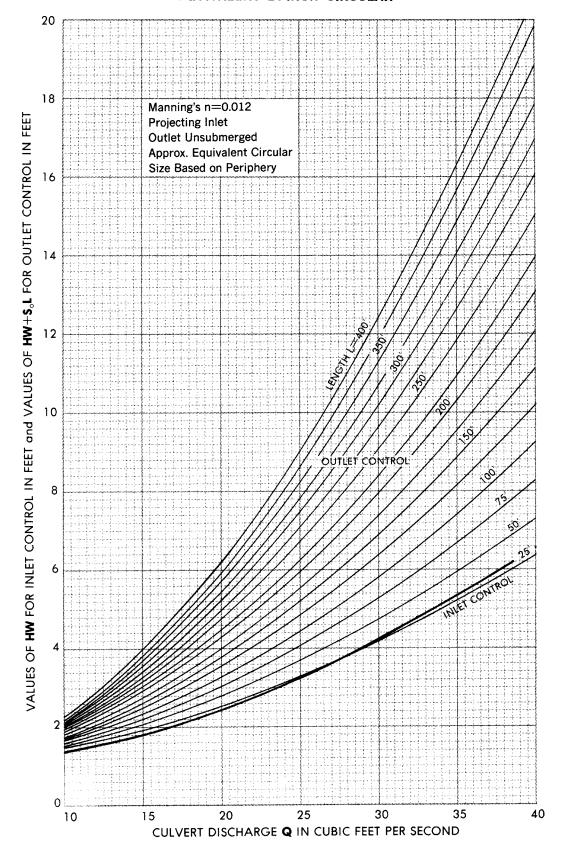


Figure 91

CULVERT CAPACITY 22 x 36-INCH (RISE x SPAN) ARCH EQUIVALENT 30-INCH CIRCULAR

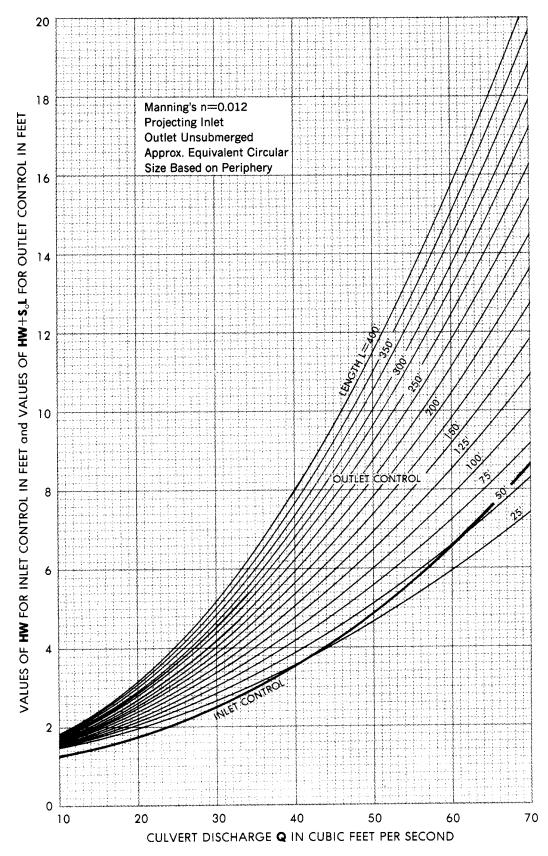


Figure 92

CULVERT CAPACITY 27 x 44-INCH (RISE x SPAN) ARCH EQUIVALENT 36-INCH CIRCULAR

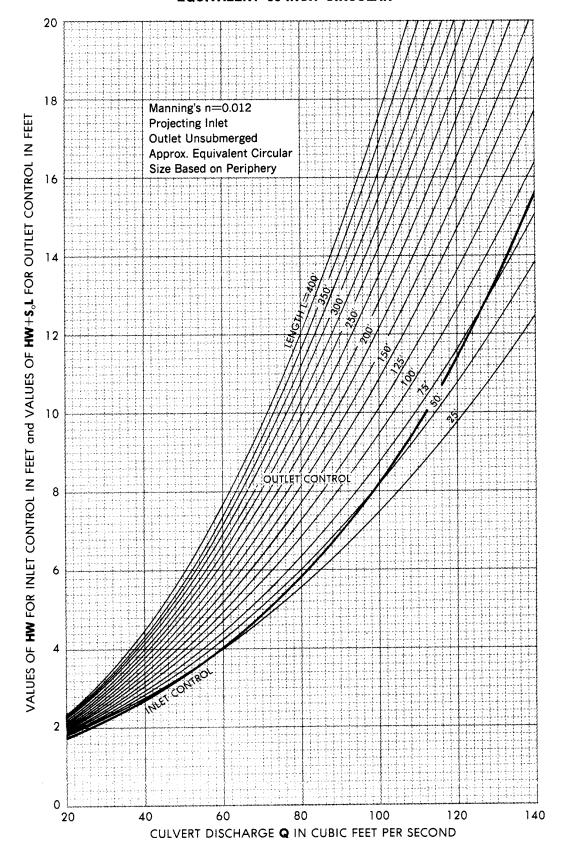


Figure 93

CULVERT CAPACITY 31 x 51-INCH (RISE x SPAN) ARCH EQUIVALENT 42-INCH CIRCULAR

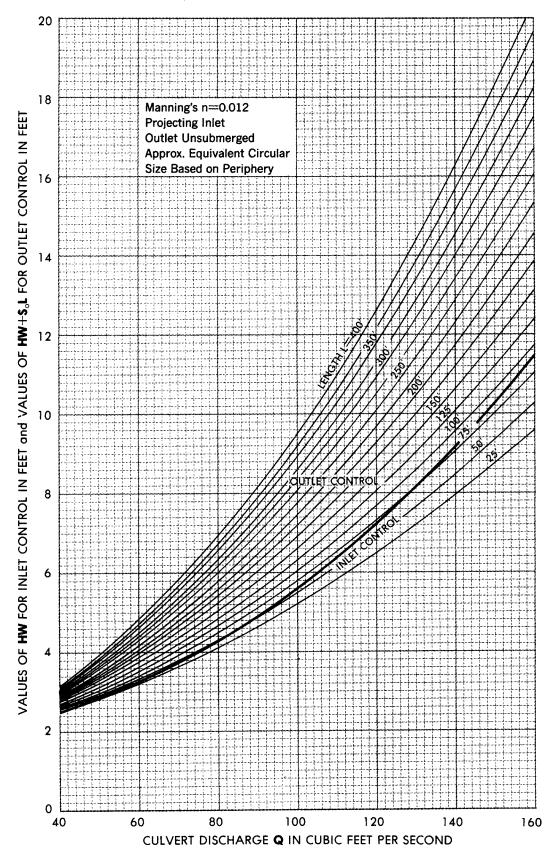


Figure 94

CULVERT CAPACITY 36 x 58-INCH (RISE x SPAN) ARCH EQUIVALENT 48-INCH CIRCULAR

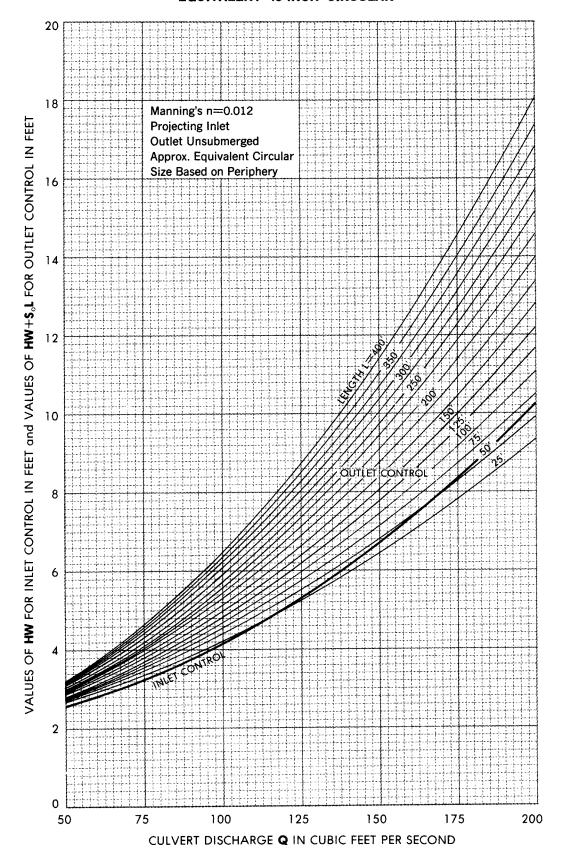


Figure 95

CULVERT CAPACITY 40 x 65-INCH (RISE x SPAN) ARCH EQUIVALENT 54-INCH CIRCULAR

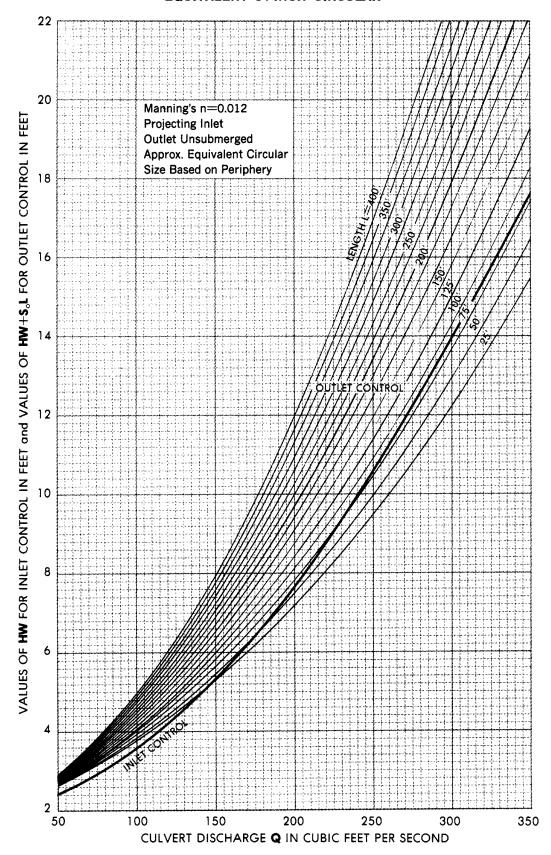


Figure 96

CULVERT CAPACITY 45 x 73-INCH (RISE x SPAN) ARCH EQUIVALENT 60-INCH CIRCULAR

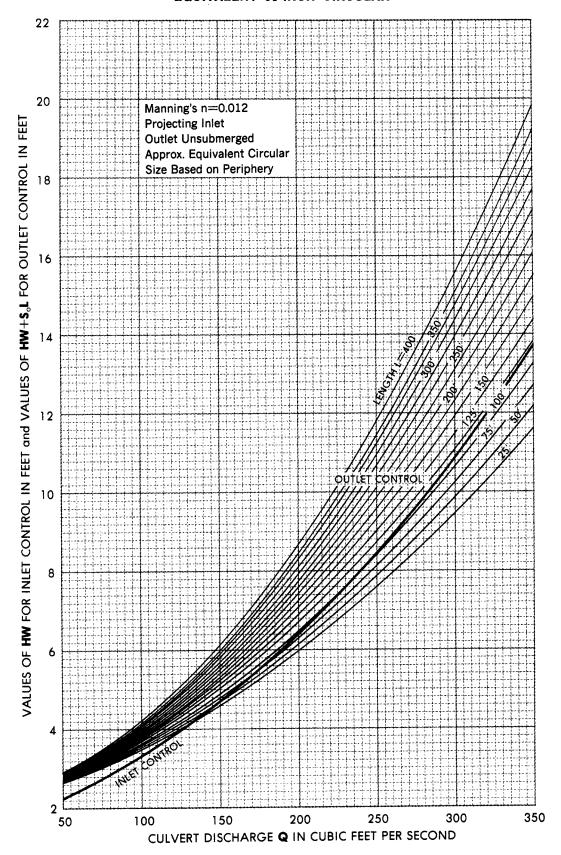


Figure 97

CULVERT CAPACITY 54 x 88-INCH (RISE x SPAN) ARCH EQUIVALENT 72-INCH CIRCULAR

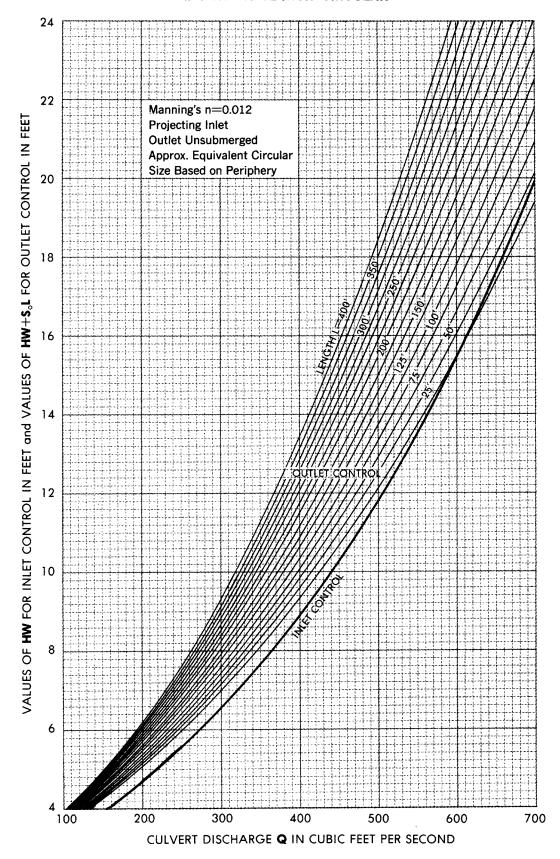
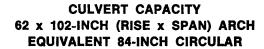


Figure 98



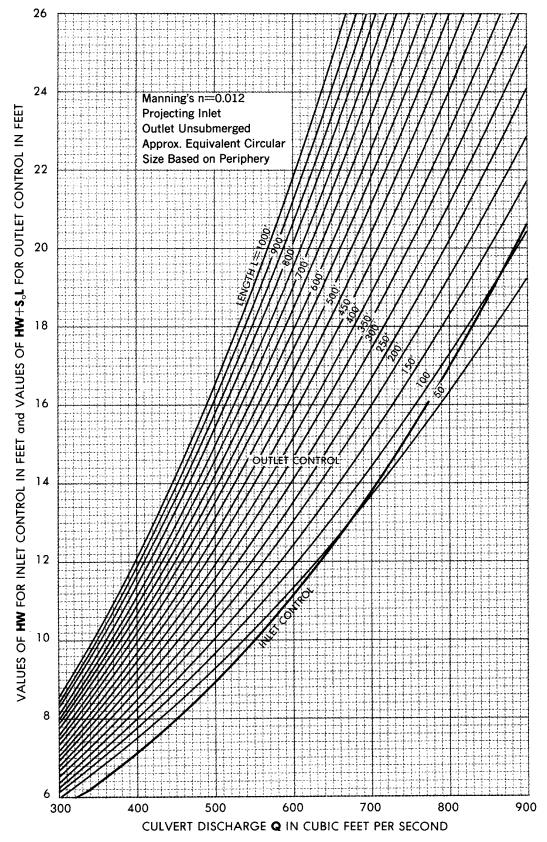


Figure 99

CULVERT CAPACITY 72 x 115-INCH (RISE x SPAN) ARCH EQUIVALENT 90-INCH CIRCULAR

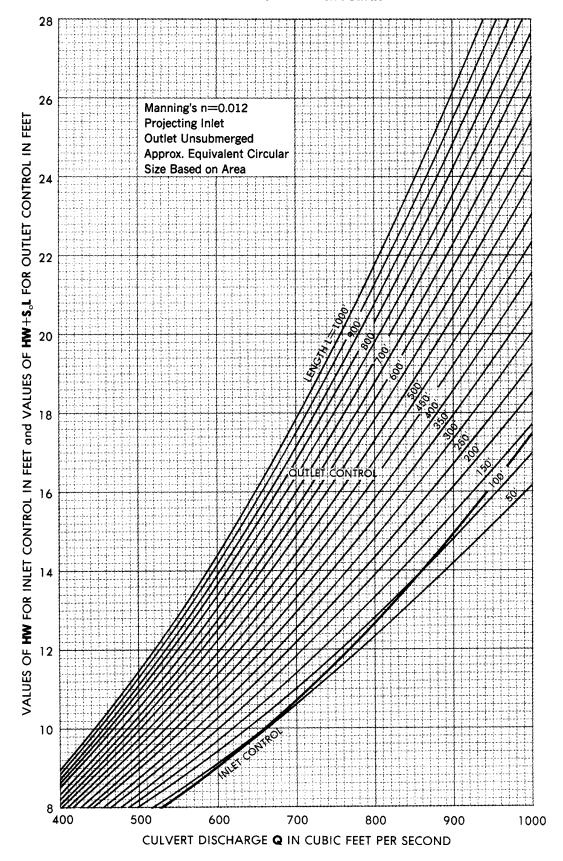


Figure 100

CULVERT CAPACITY 77 x 122-INCH (RISE x SPAN) ARCH EQUIVALENT 96-INCH CIRCULAR

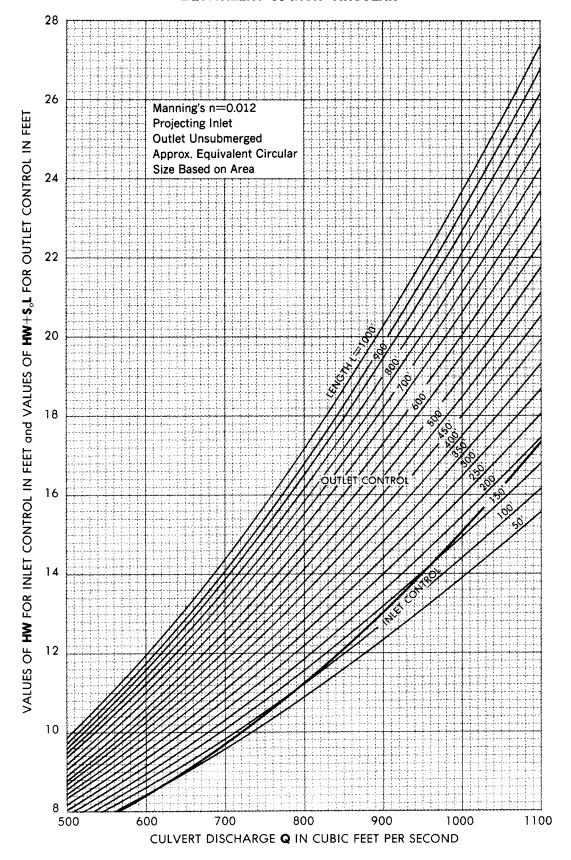


Figure 101



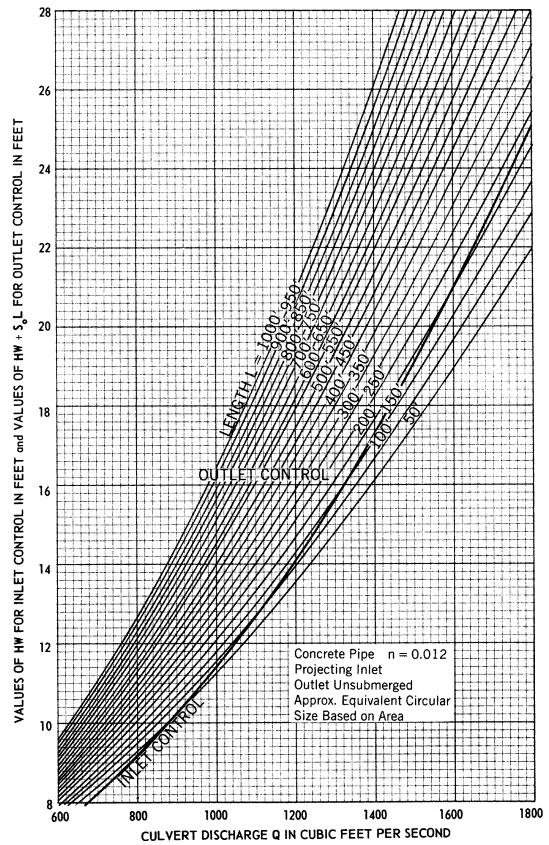


Figure 102

CULVERT CAPACITY 97 x 154-INCH (RISE x SPAN) ARCH EQUIVALENT 120-INCH CIRCULAR

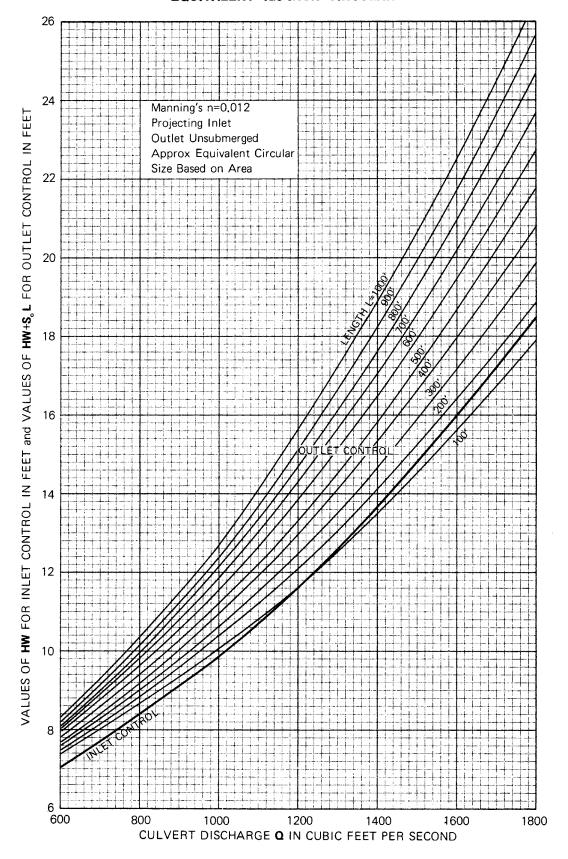


Figure 103

CULVERT CAPACITY 106 x 169-INCH (RISE x SPAN) ARCH EQUIVALENT 132-INCH CIRCULAR

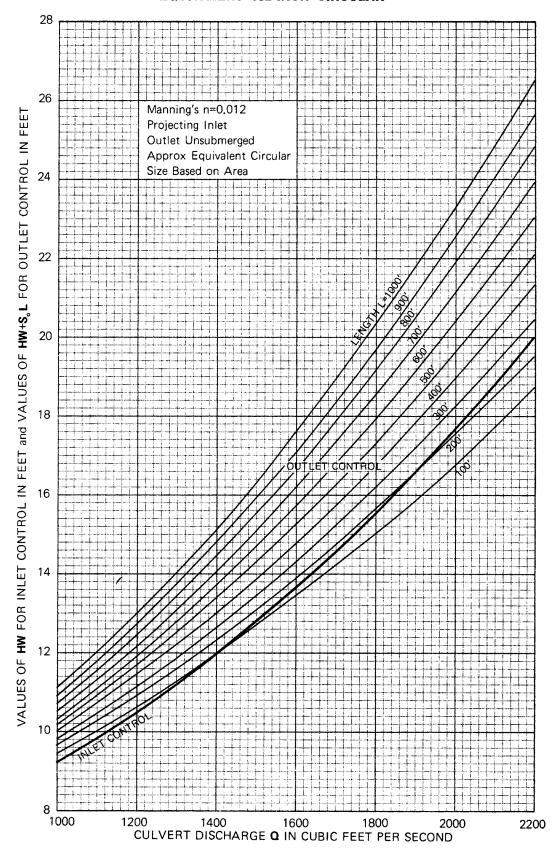


Figure 104



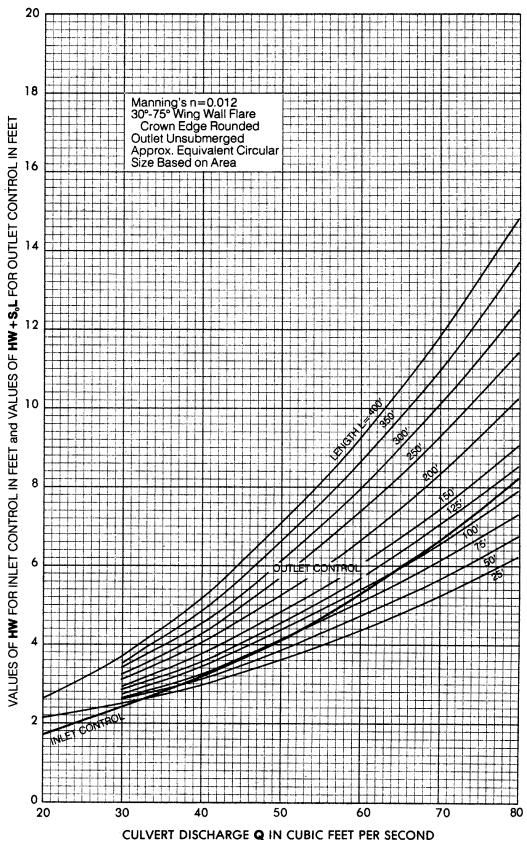


Figure 105



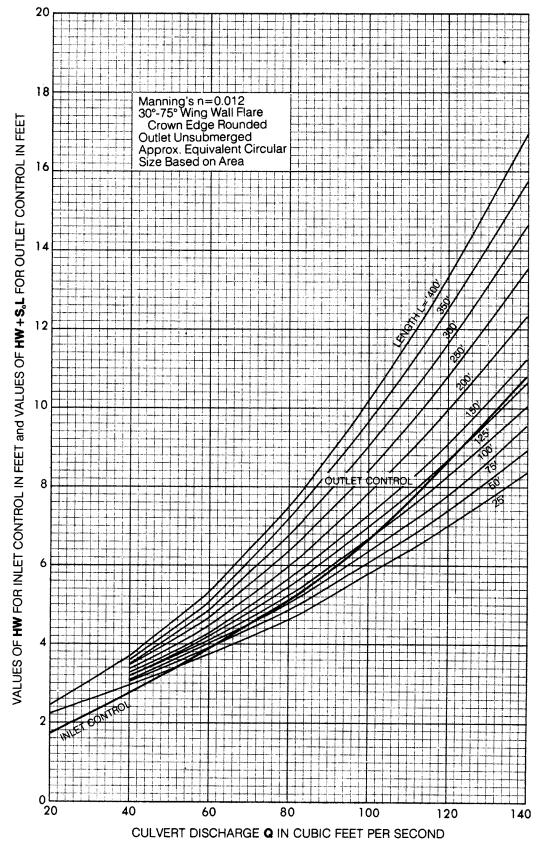


Figure 106



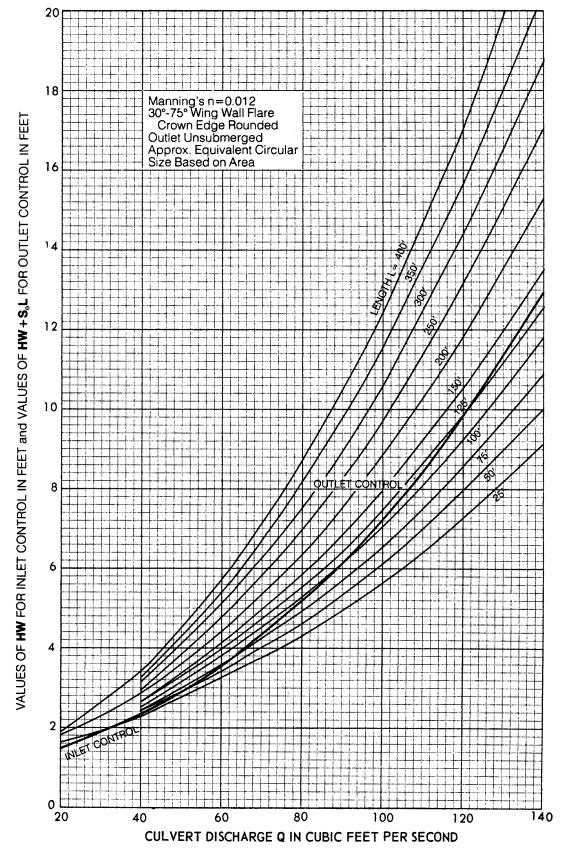


Figure 107



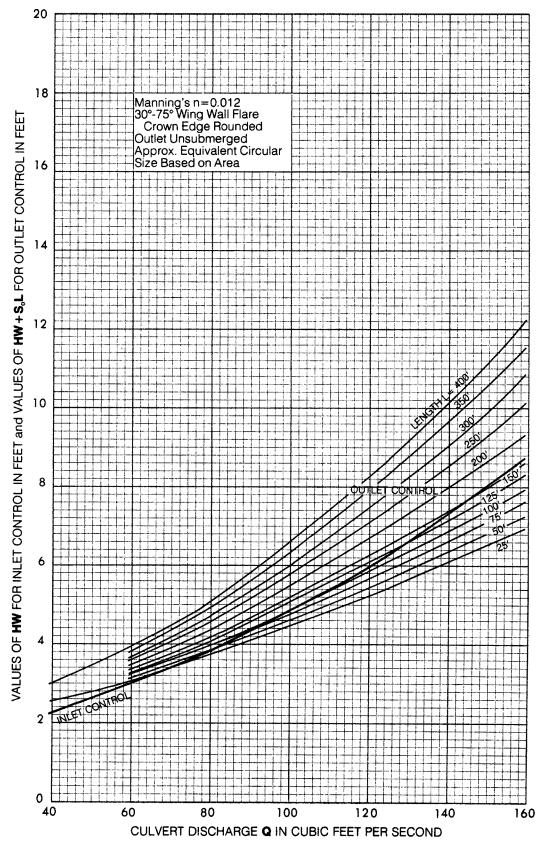


Figure 108

CULVERT CAPACITY 4 x 4-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 54-INCH CIRCULAR

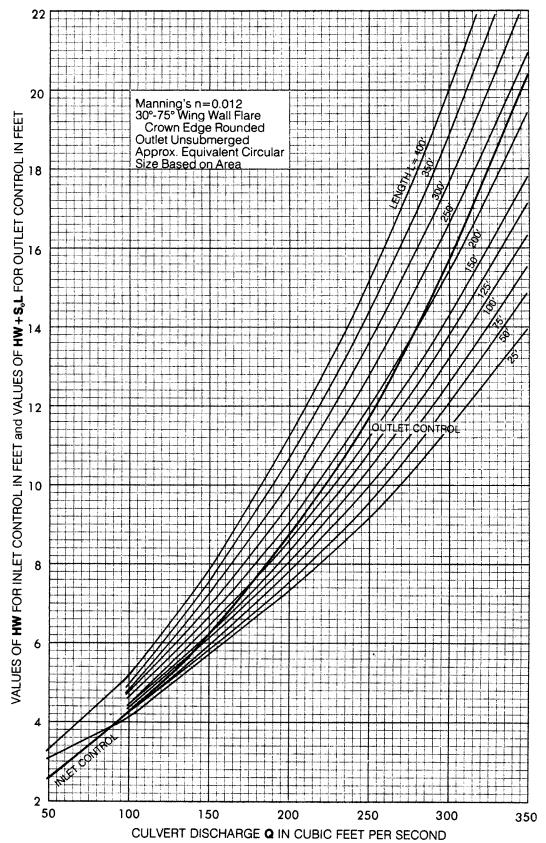


Figure 109



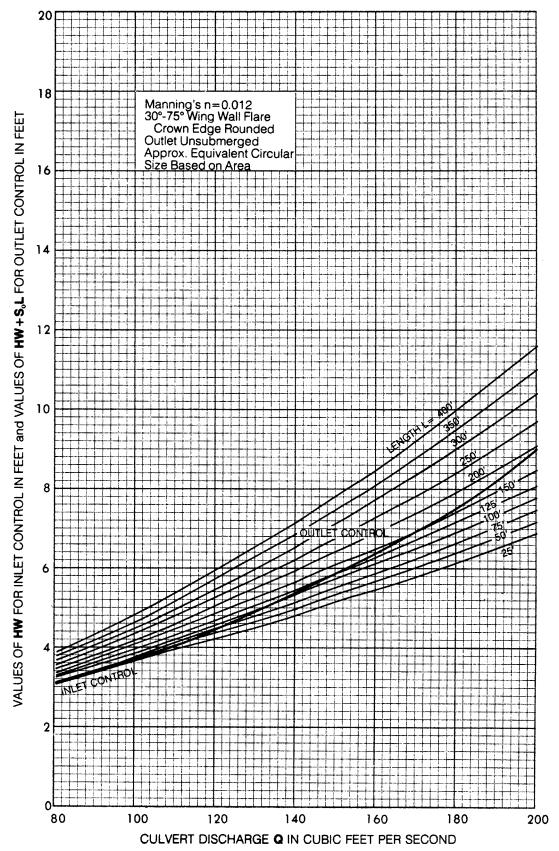


Figure 110

CULVERT CAPACITY 5 x 4-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 60-INCH CIRCULAR

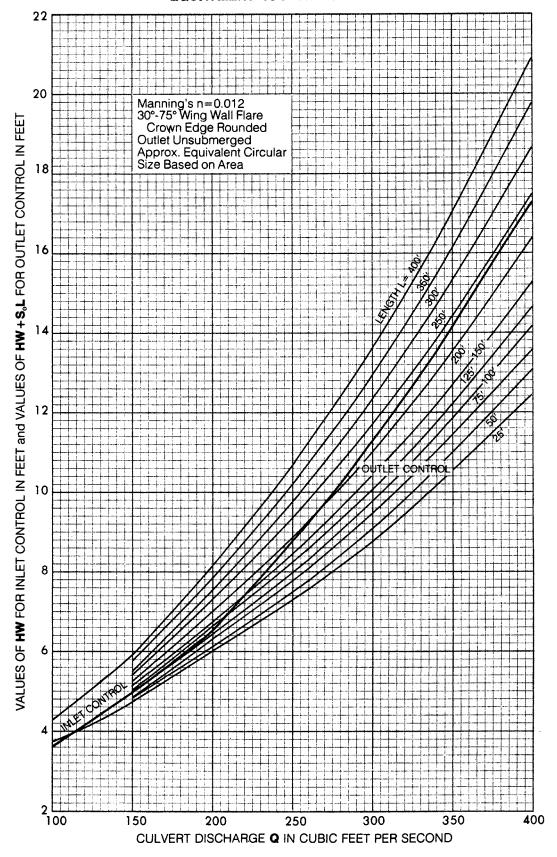


Figure 111



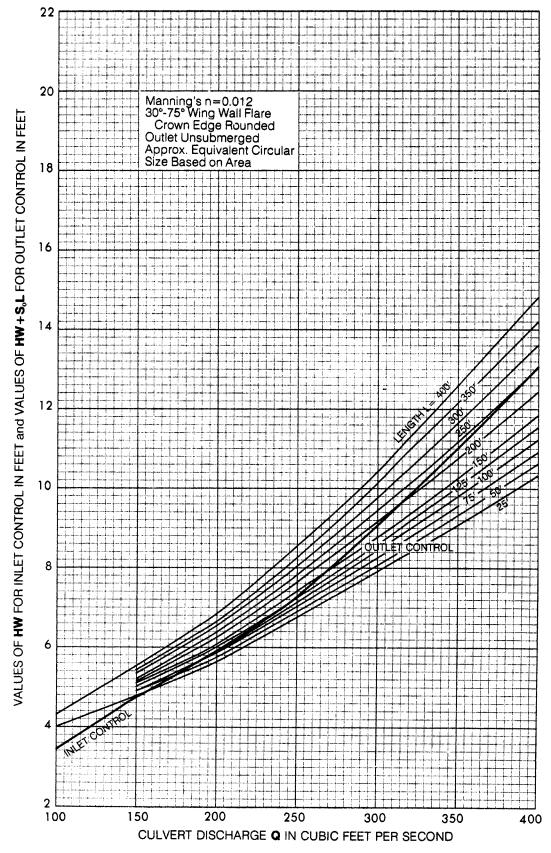


Figure 112

CULVERT CAPACITY 6 x 3-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 57-INCH CIRCULAR

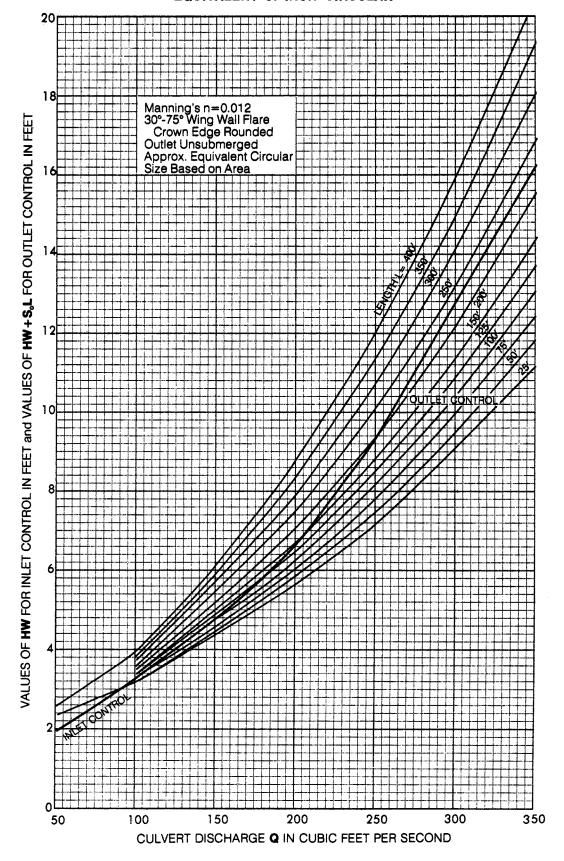


Figure 113



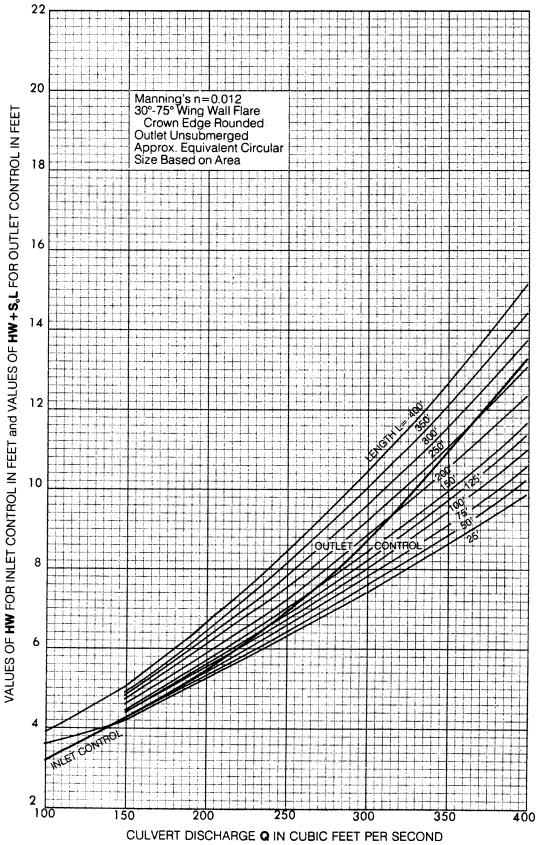


Figure 114

CULVERT CAPACITY 6 x 5-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 75-INCH CIRCULAR

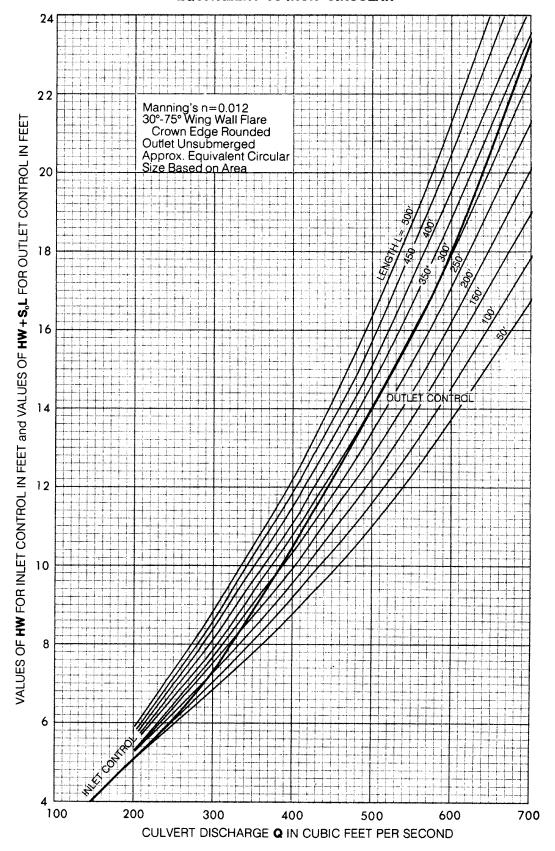


Figure 115



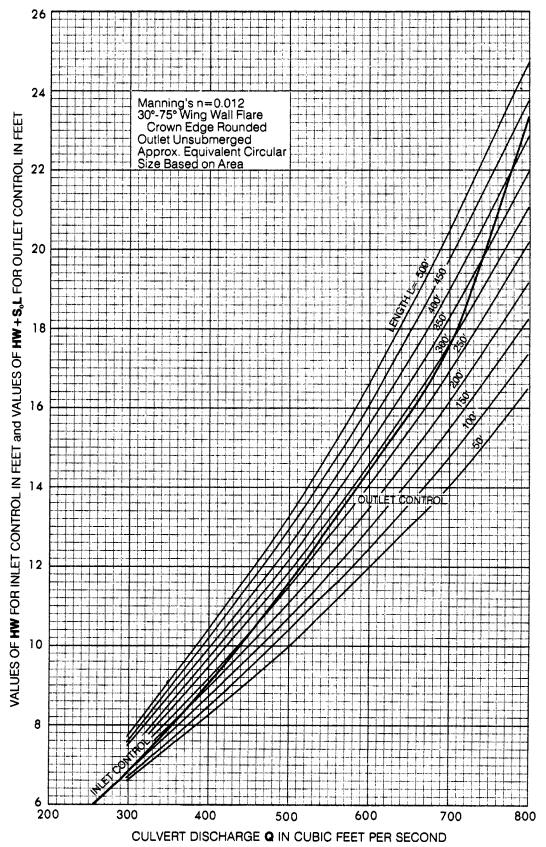


Figure 116

7 x 4-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 71-INCH CIRCULAR

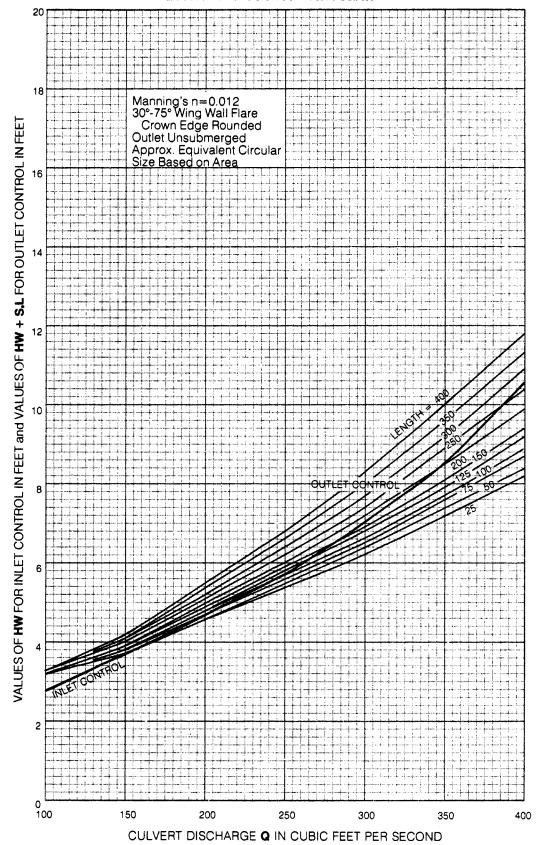


Figure 117

CULVERT CAPACITY 7 x 5-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 79-INCH CIRCULAR

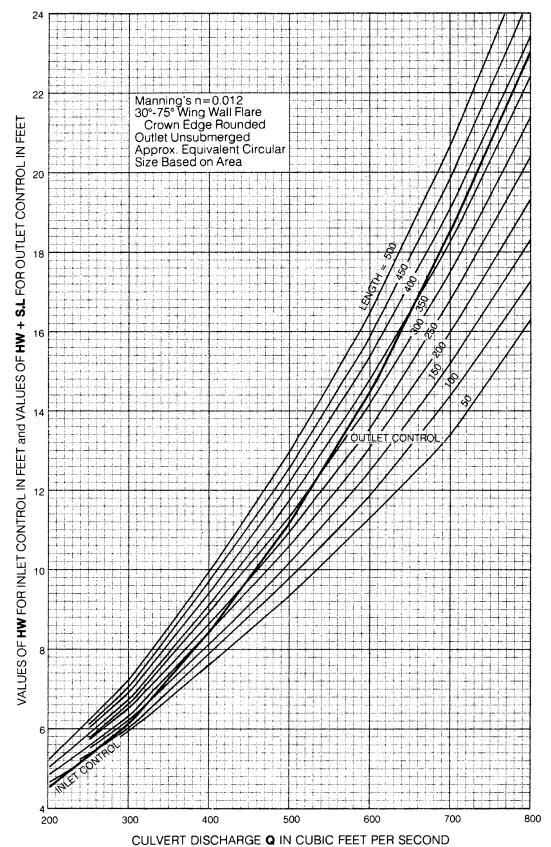


Figure 118



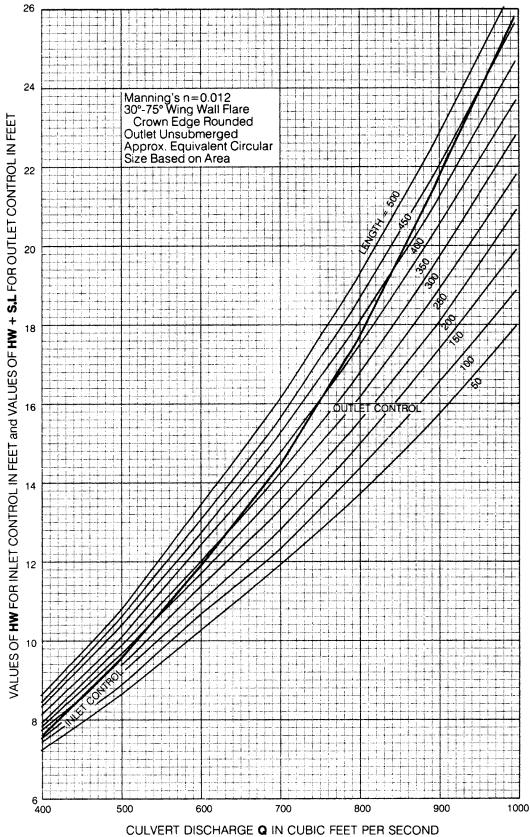


Figure 119



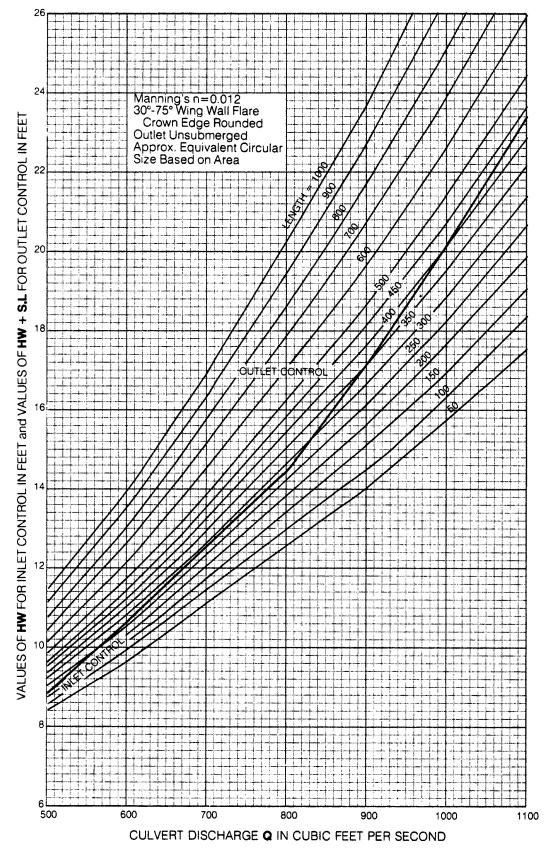


Figure 120

CULVERT CAPACITY 8 x 4-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 76-INCH CIRCULAR

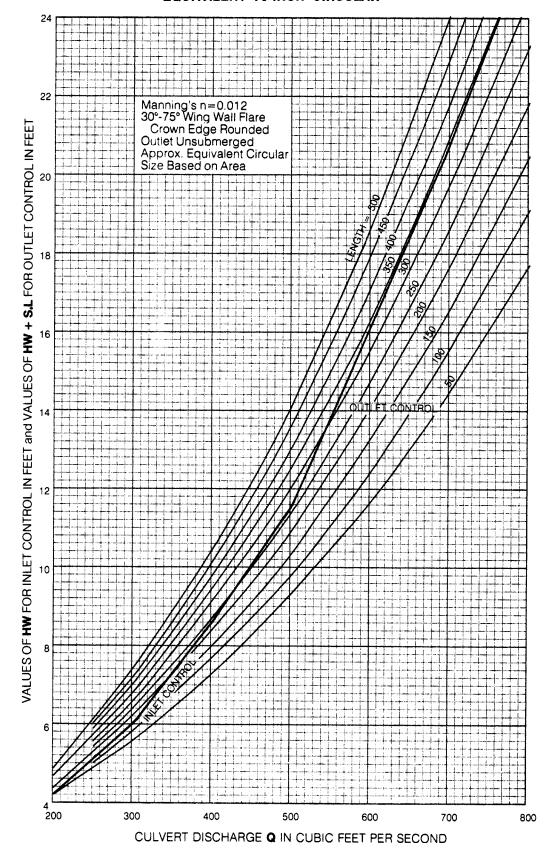


Figure 121

CULVERT CAPACITY 8 x 5-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 85-INCH CIRCULAR

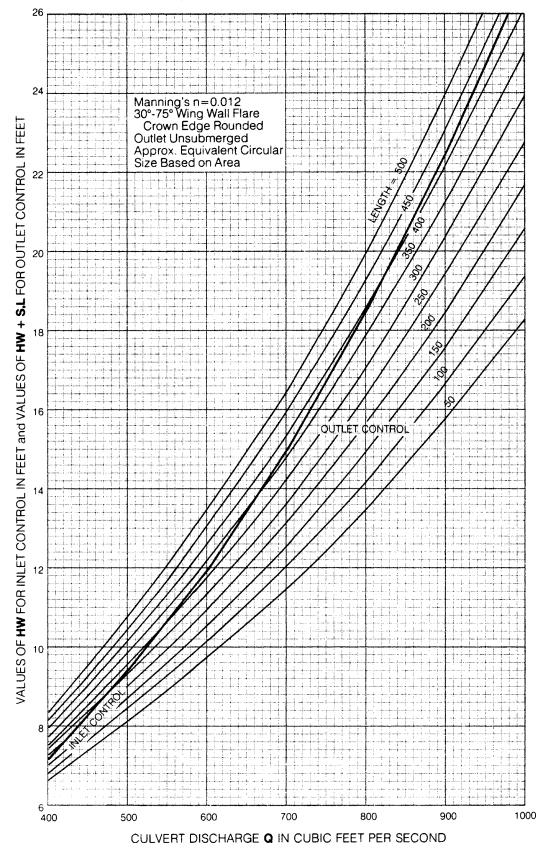


Figure 122

CULVERT CAPACITY 8 x 6-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 93-INCH CIRCULAR

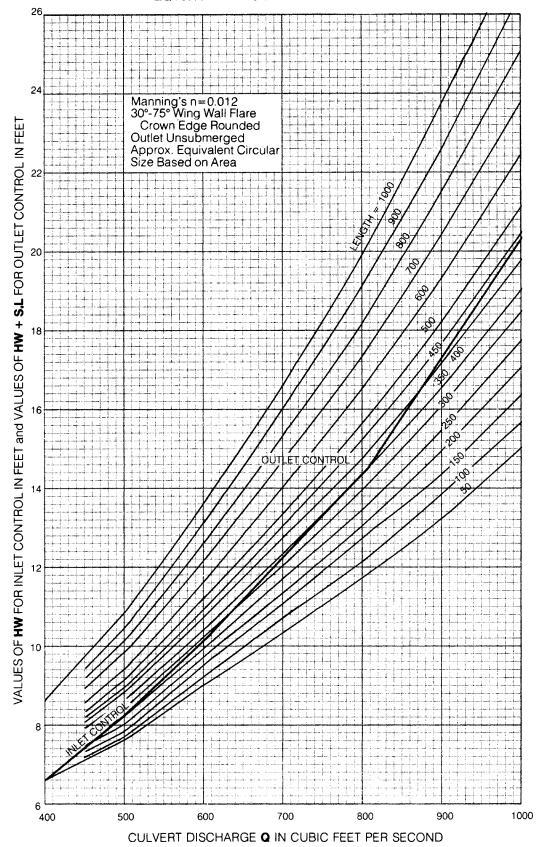


Figure 123



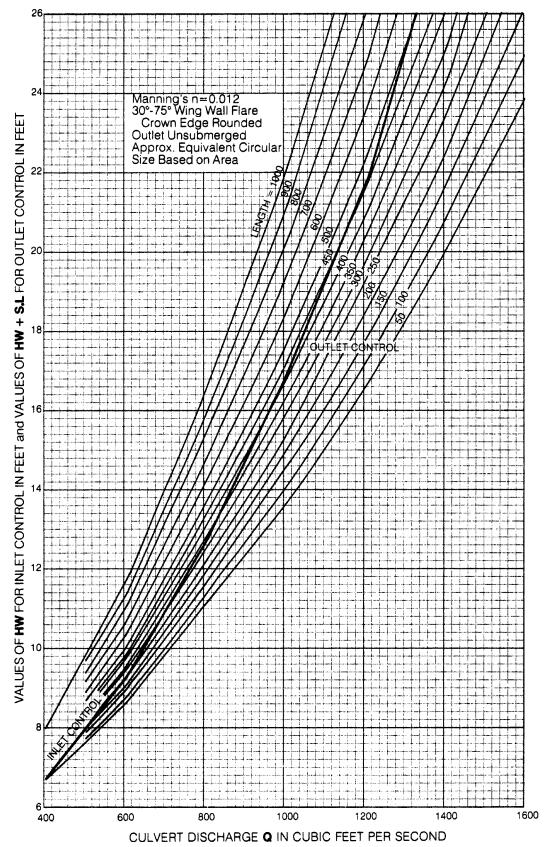


Figure 124



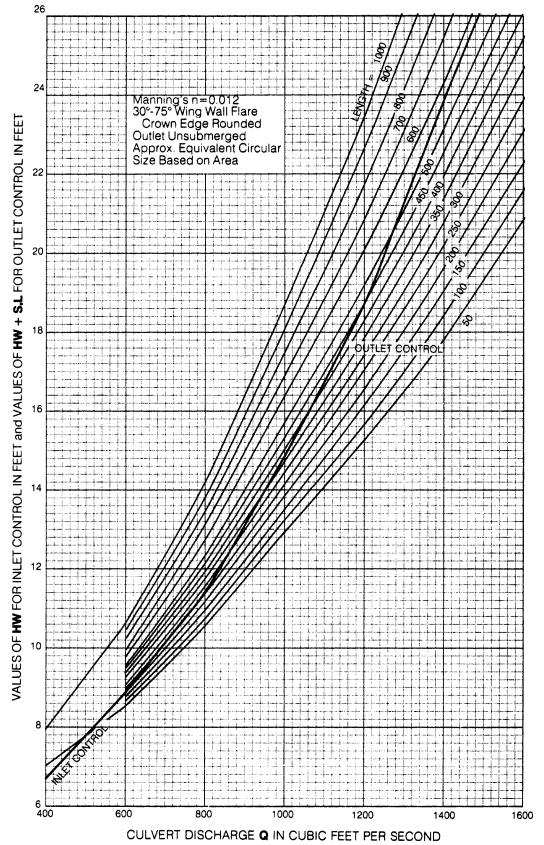


Figure 125



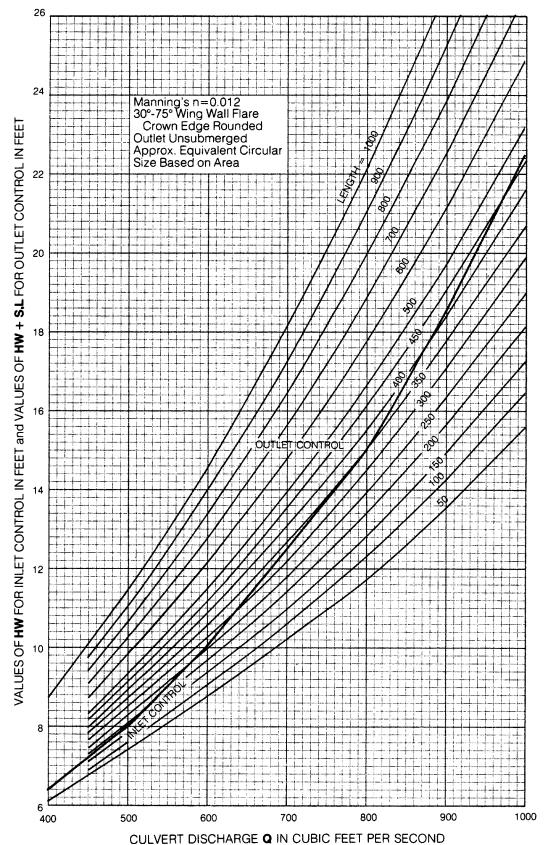


Figure 126

9 x 6-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 99-INCH CIRCULAR

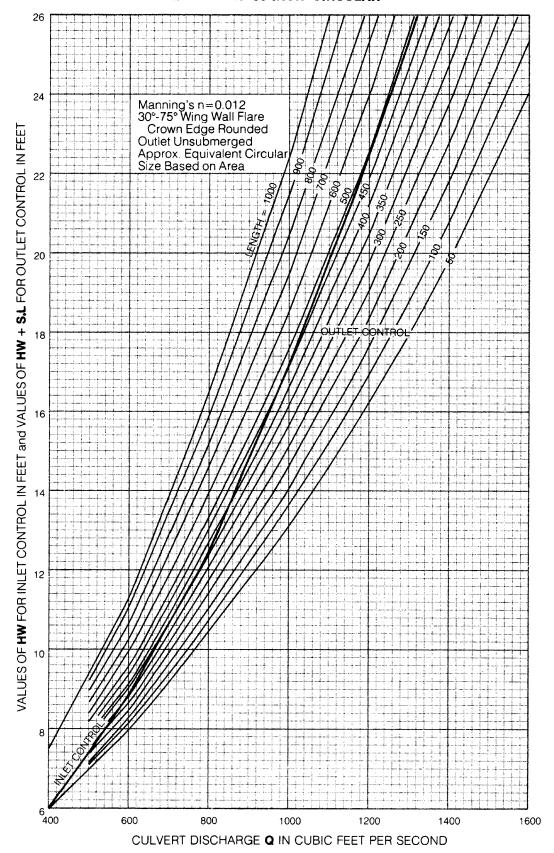


Figure 127

CULVERT CAPACITY 9 x 7-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 107-INCH CIRCULAR

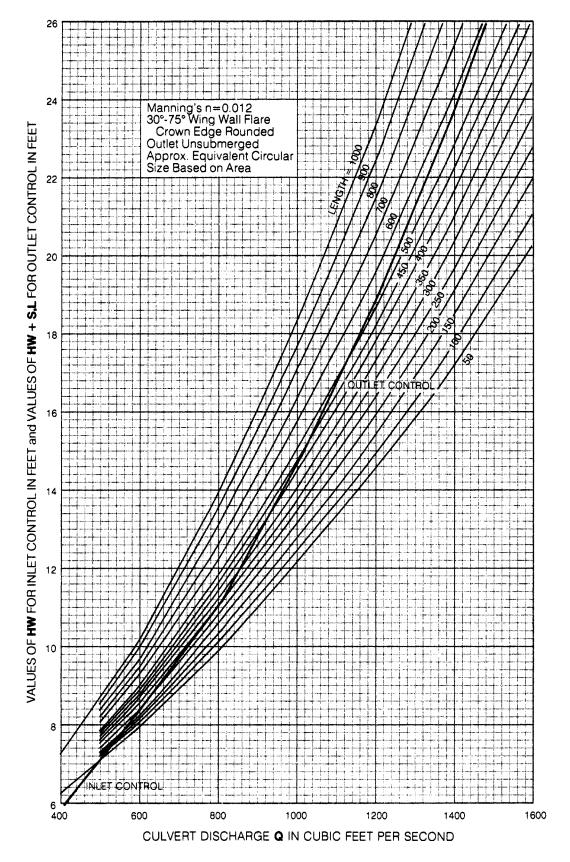


Figure 128



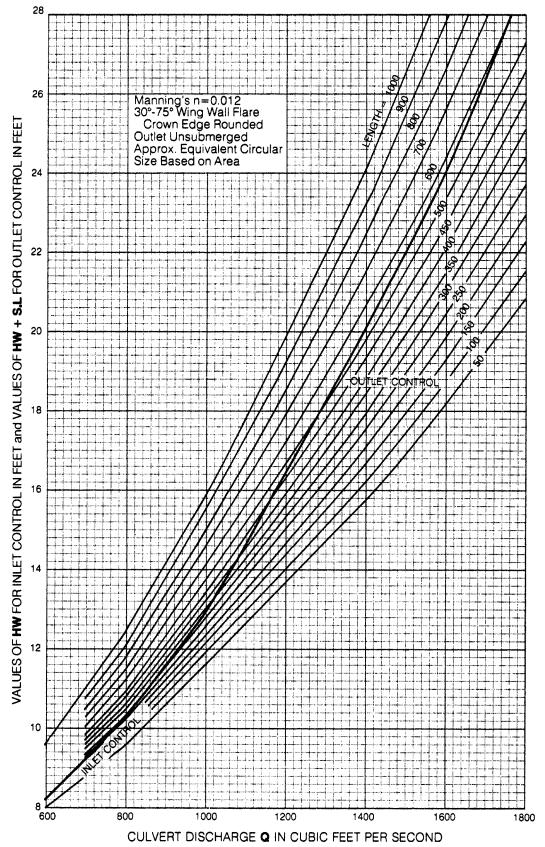


Figure 129

9 x 9-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 121-INCH CIRCULAR

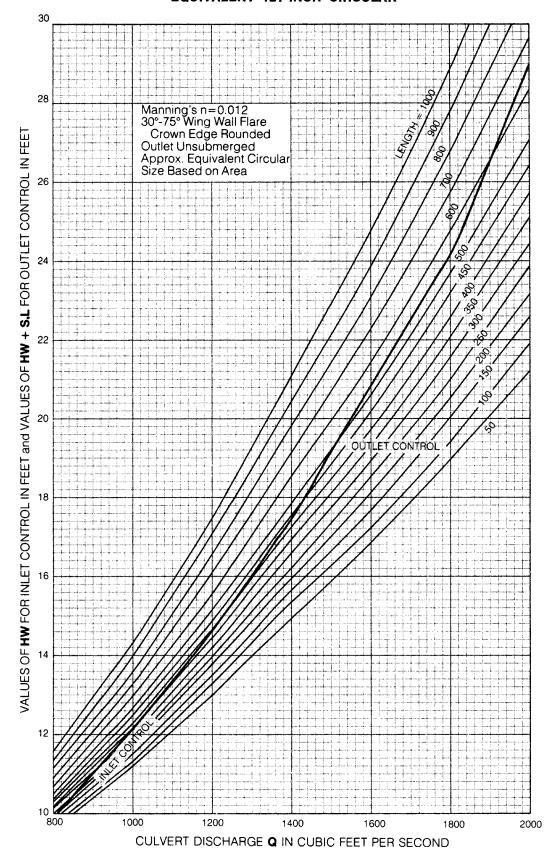


Figure 130



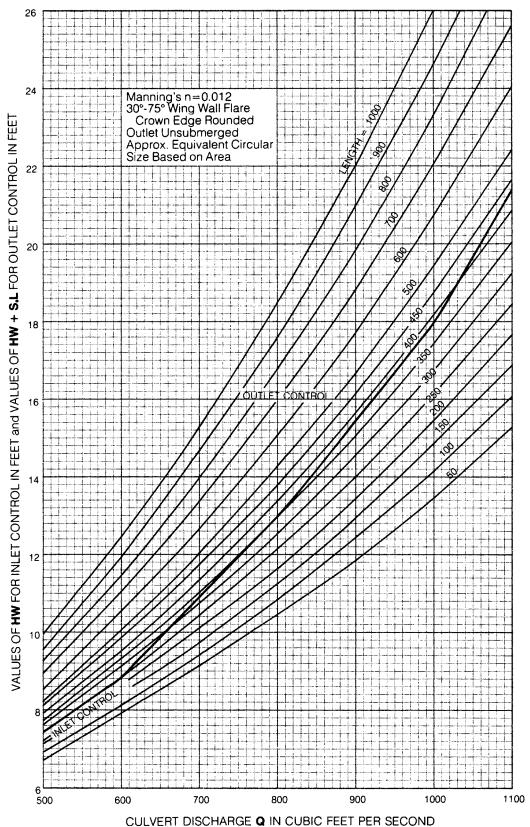


Figure 131

CULVERT CAPACITY 10 x 6-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 104-INCH CIRCULAR

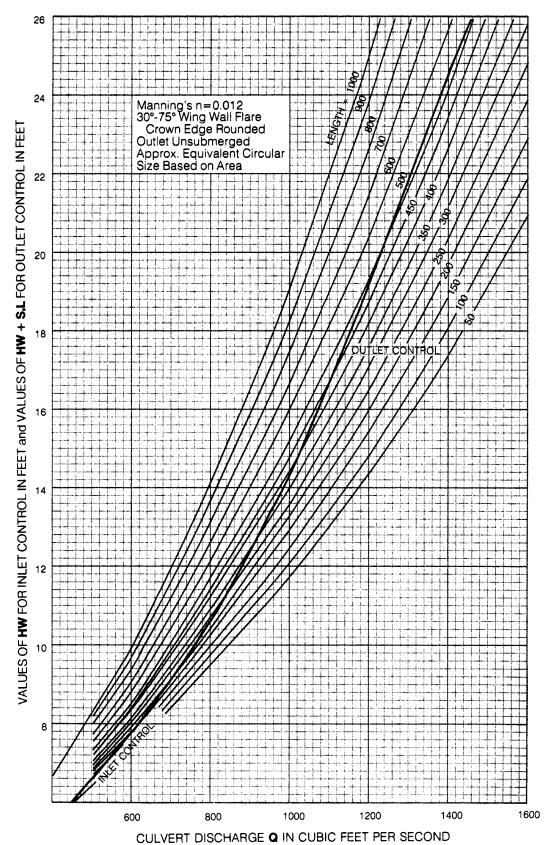
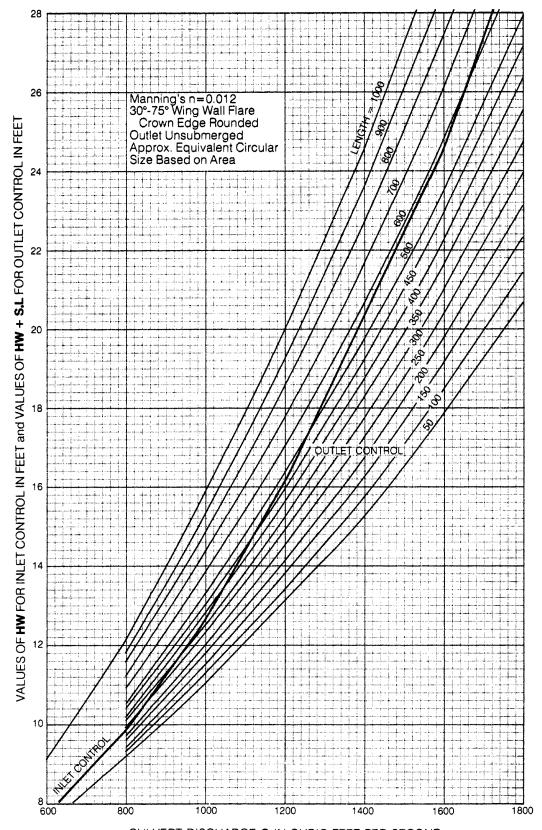


Figure 132

CULVERT CAPACITY 10 x 7-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 112-INCH CIRCULAR



CULVERT DISCHARGE ${f Q}$ IN CUBIC FEET PER SECOND

Figure 133



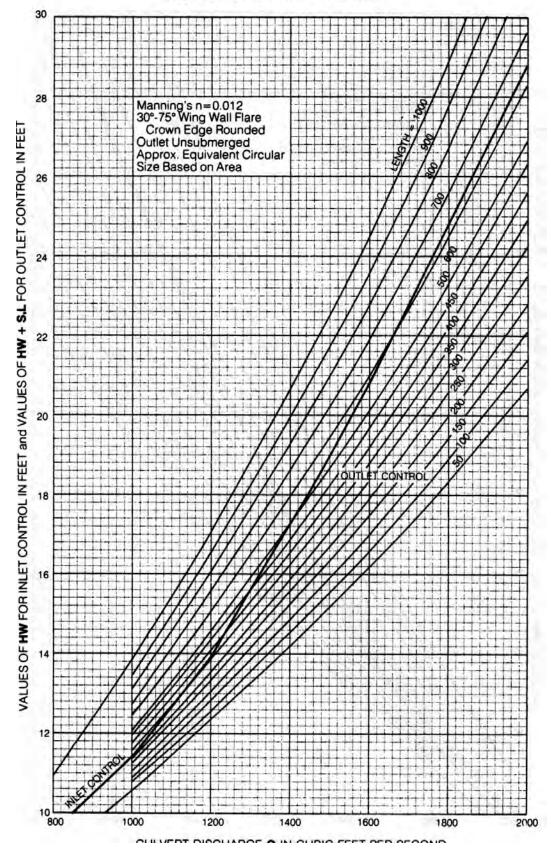


Figure 134

CULVERT CAPACITY 10 x 9-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 128-INCH CIRCULAR

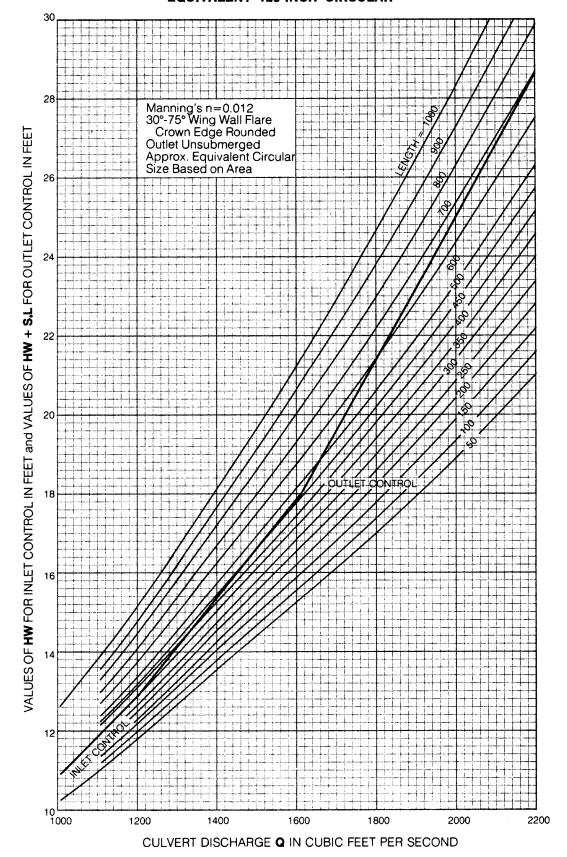


Figure 135

CULVERT CAPACITY 10 x 10-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 135-INCH CIRCULAR

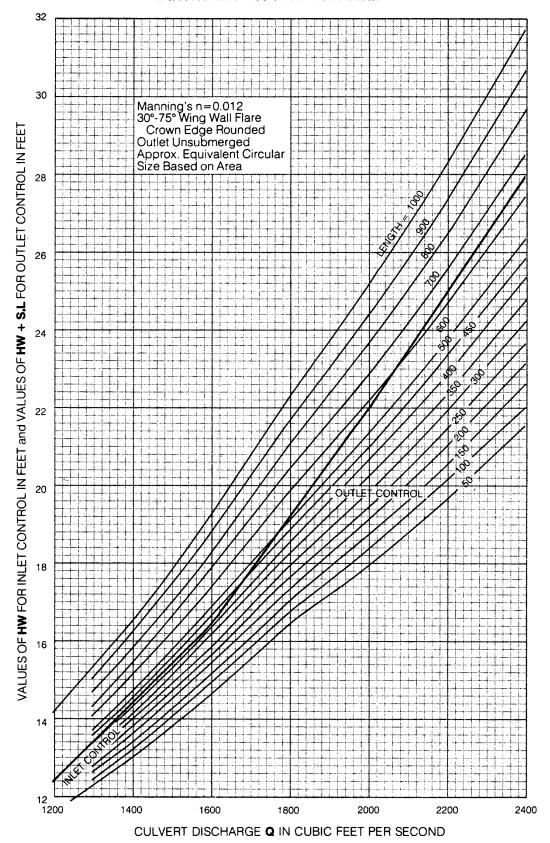


Figure 136

CULVERT CAPACITY 11 x 4-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 88-INCH CIRCULAR

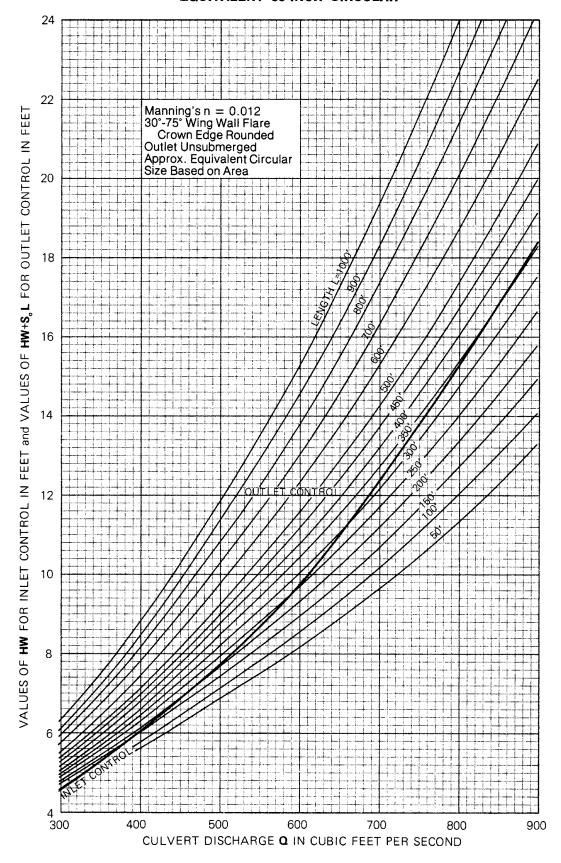


Figure 137

CULVERT CAPACITY 11 x 6-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 109-INCH CIRCULAR

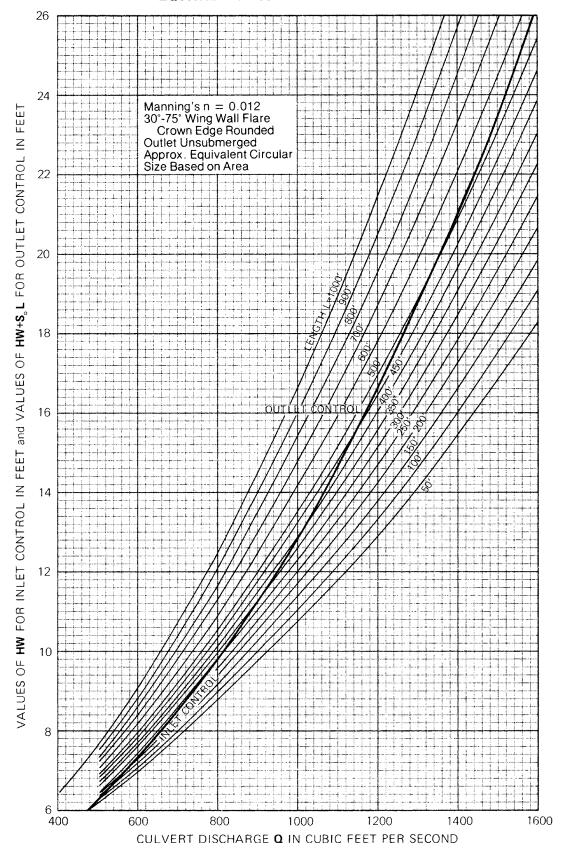


Figure 138

CULVERT CAPACITY 11 x 8-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 126-INCH CIRCULAR

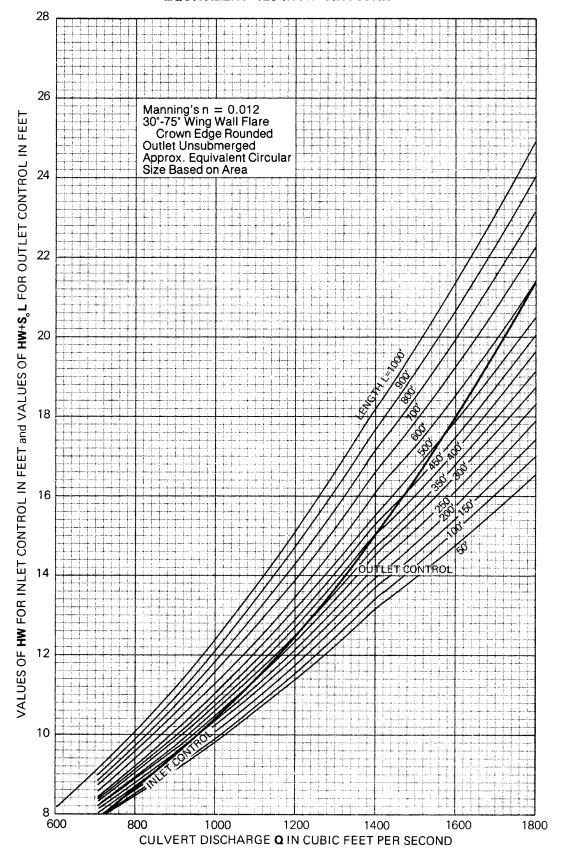


Figure 139

CULVERT CAPACITY 11 x 10-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 141-INCH CIRCULAR

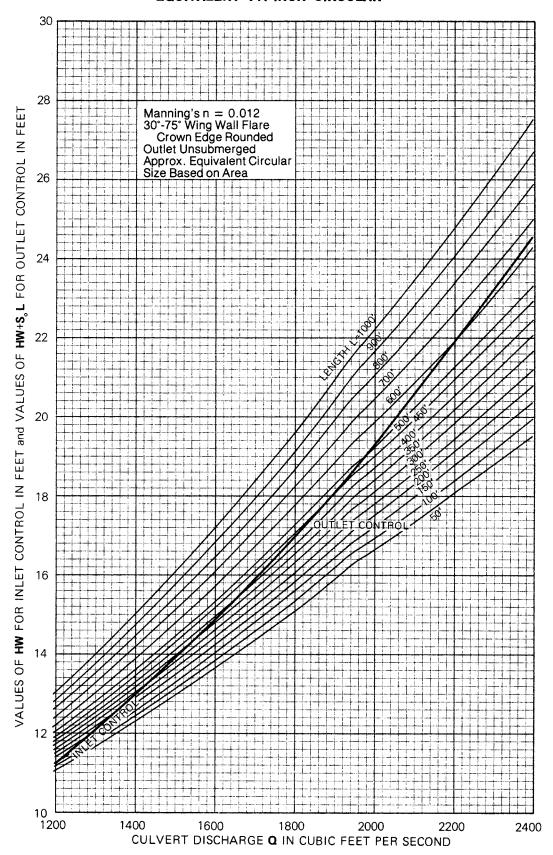


Figure 140

CULVERT CAPACITY 11 x 11-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 148-INCH CIRCULAR

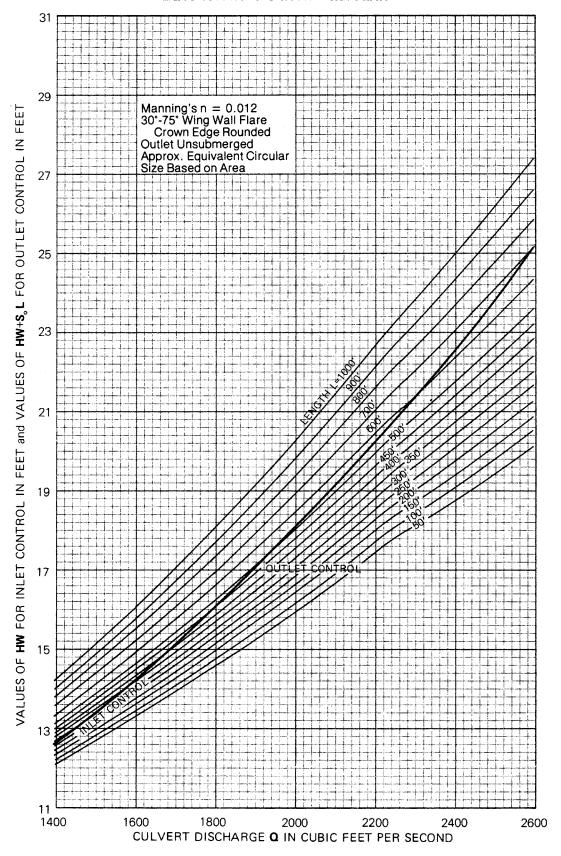


Figure 141

CULVERT CAPACITY 12 x 4-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 92-INCH CIRCULAR

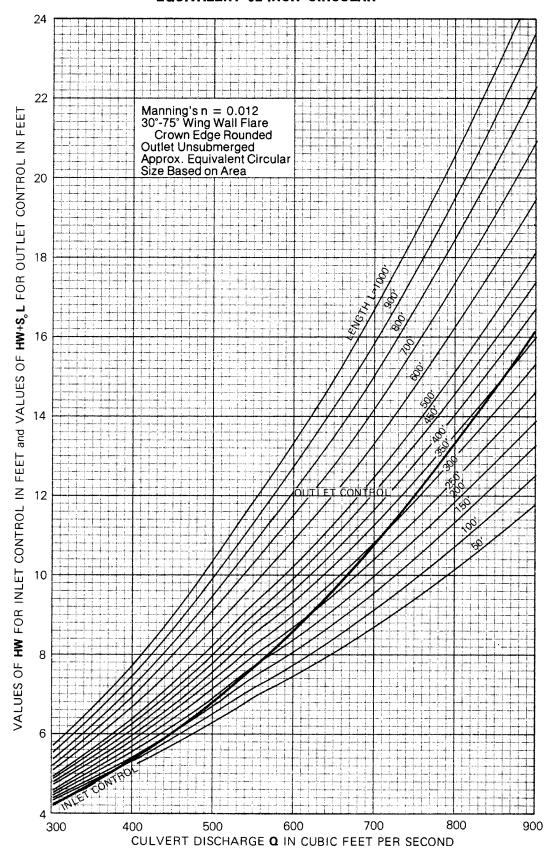


Figure 142

CULVERT CAPACITY 12 x 6-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 113-INCH CIRCULAR

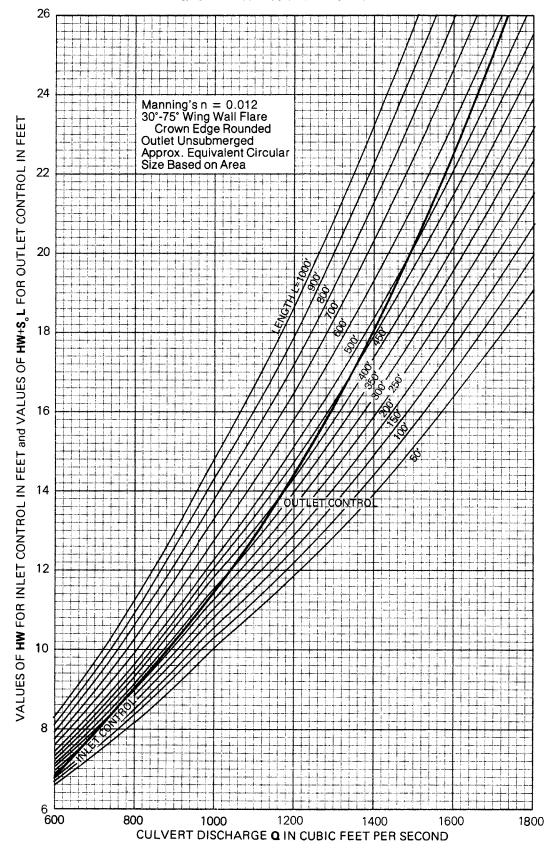


Figure 143



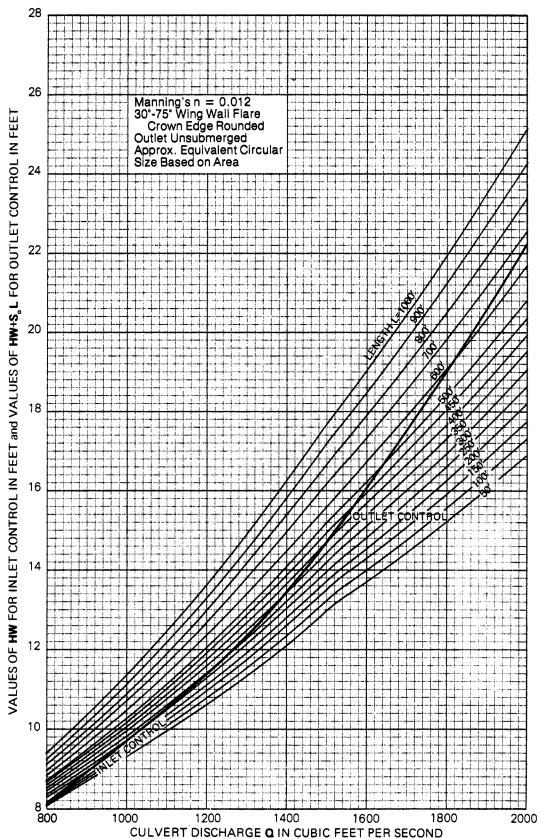


Figure 144

CULVERT CAPACITY 12 x 10-FOOT (SPAN x RISE) BOX CIRCULAR EQUIVALENT 147-INCH CIRCULAR

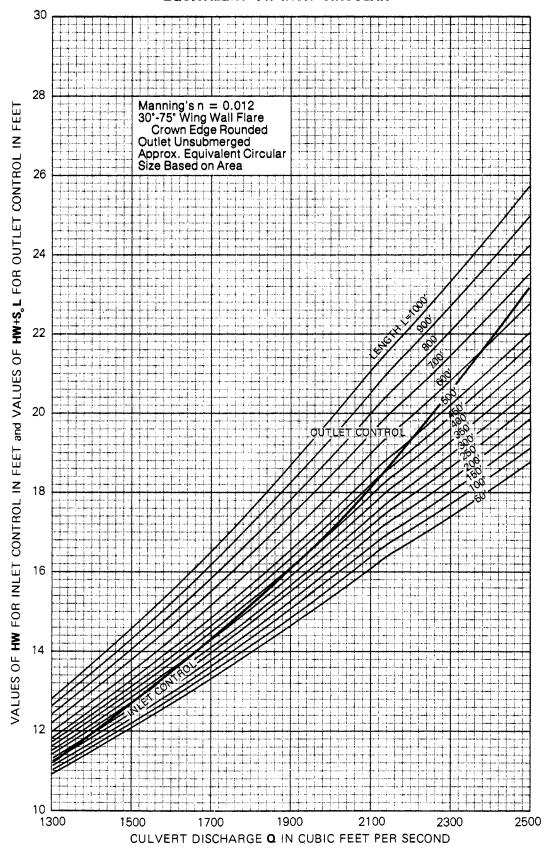


Figure 145

CULVERT CAPACITY 12 x 12-FOOT (SPAN x RISE) BOX SECTION EQUIVALENT 161-INCH CIRCULAR

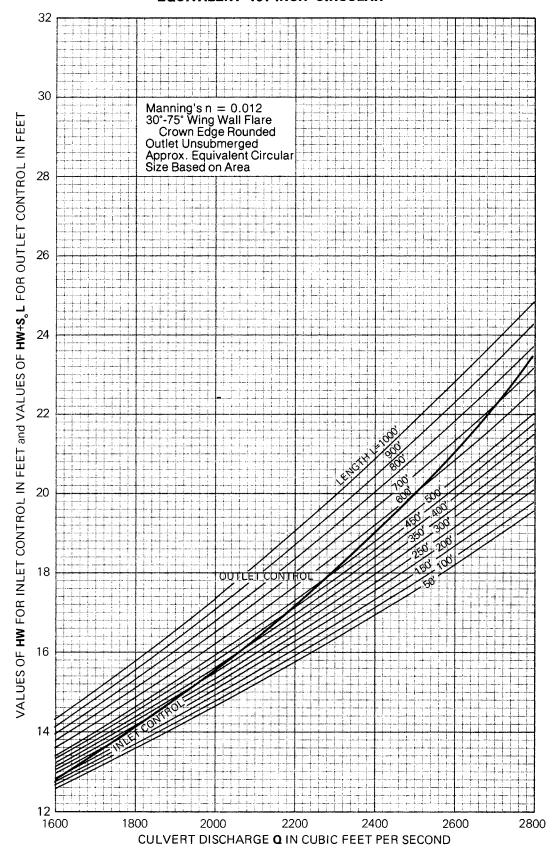
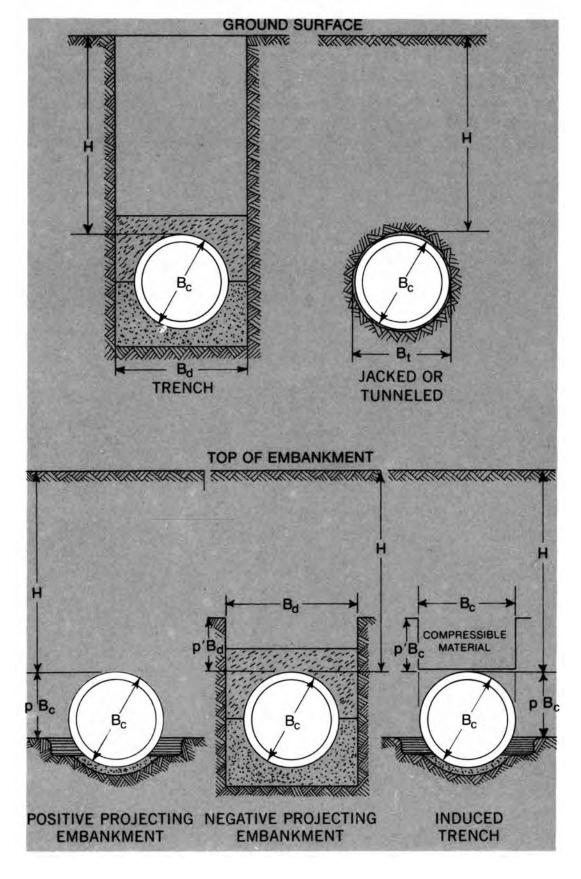


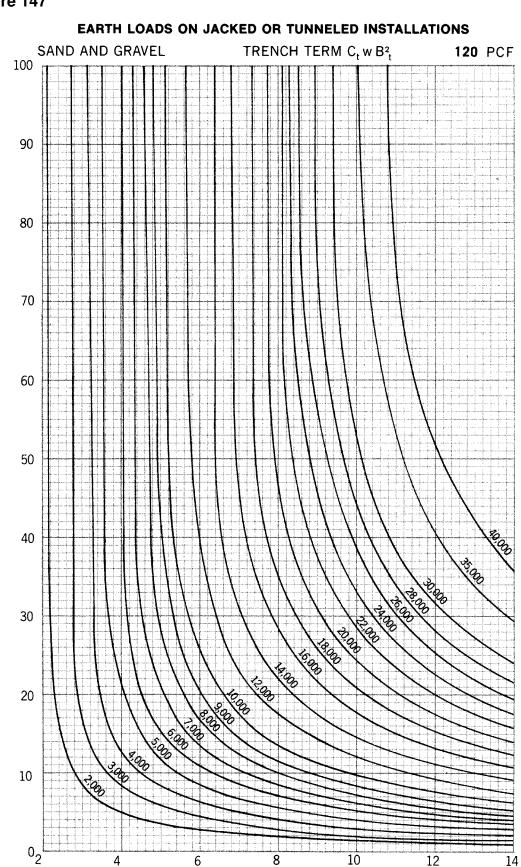
Figure 146

ESSENTIAL FEATURES OF TYPES OF INSTALLATIONS



HEIGHT OF COVER H IN FEET

Figure 147



For earth weighing other than 120 pounds per cubic foot, multiply loads by w/120.

MAXIMUM WIDTH OF EXCAVATION $oldsymbol{B}_t$ IN FEET

Figure 148

EARTH LOADS ON JACKED OR TUNNELED INSTALLATIONS

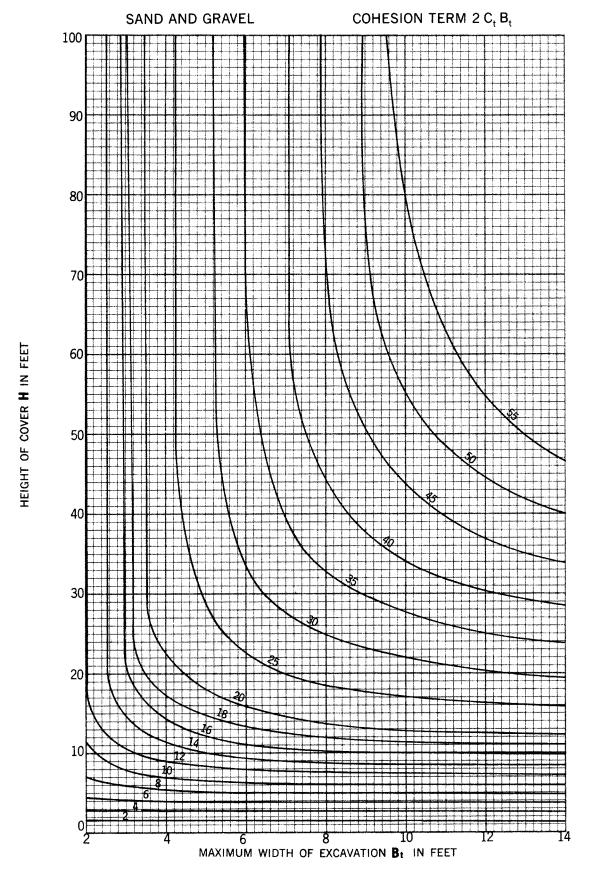
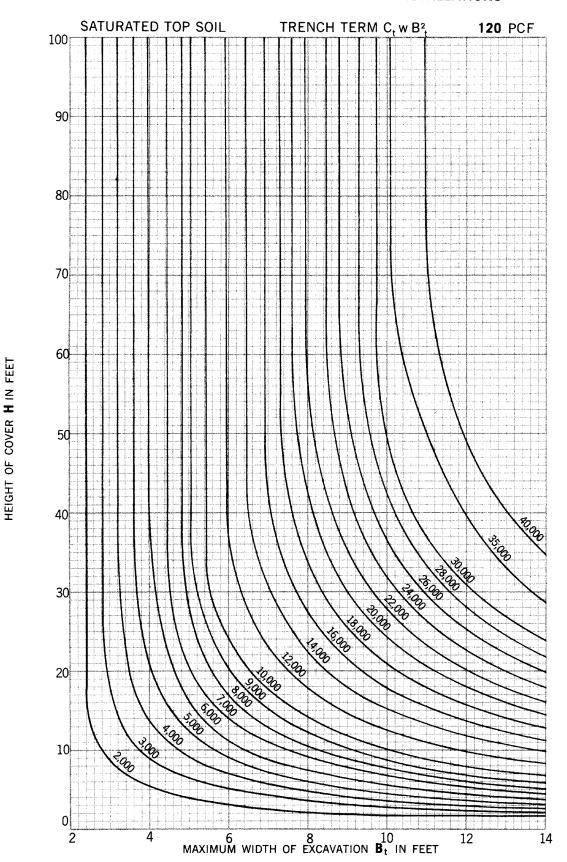


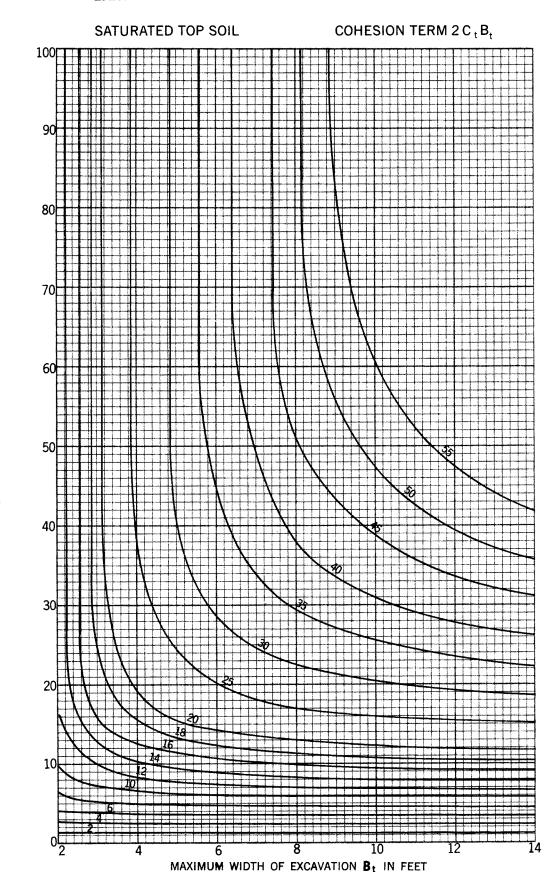
Figure 149

EARTH LOADS ON JACKED OR TUNNELED INSTALLATIONS



For earth weighing other than 120 pounds per cubic foot, multiply loads by w/120.

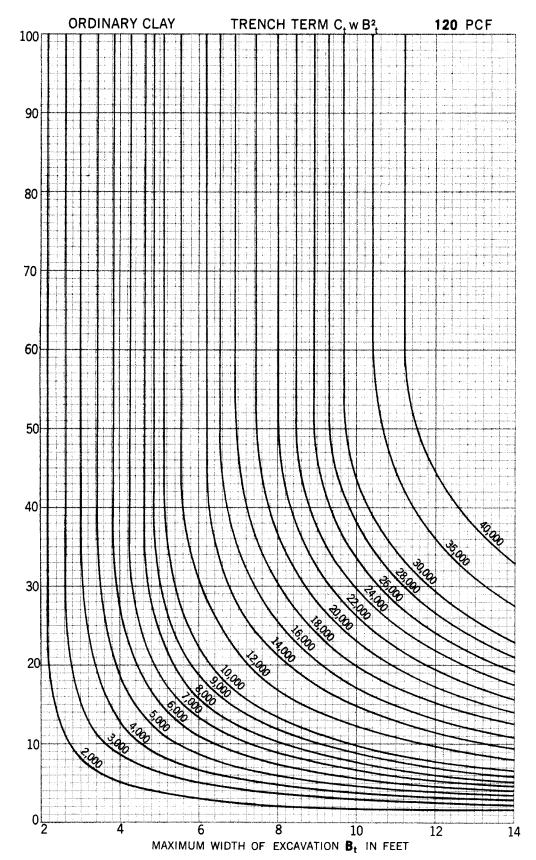
EARTH LOADS ON JACKED OR TUNNELED INSTALLATIONS



HEIGHT OF COVER H IN FEET

Figure 151

EARTH LOAD ON JACKED OR TUNNELED INSTALLATIONS



For earth weighing other than 120 pounds per cubic foot, multiply loads by w/120.

Figure 152

EARTH LOADS ON JACKED OR TUNNELED INSTALLATIONS

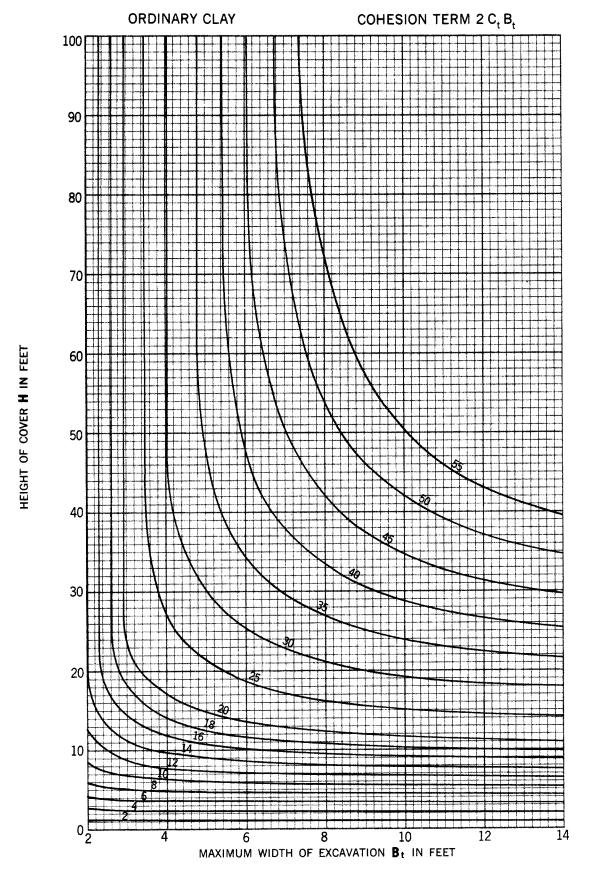
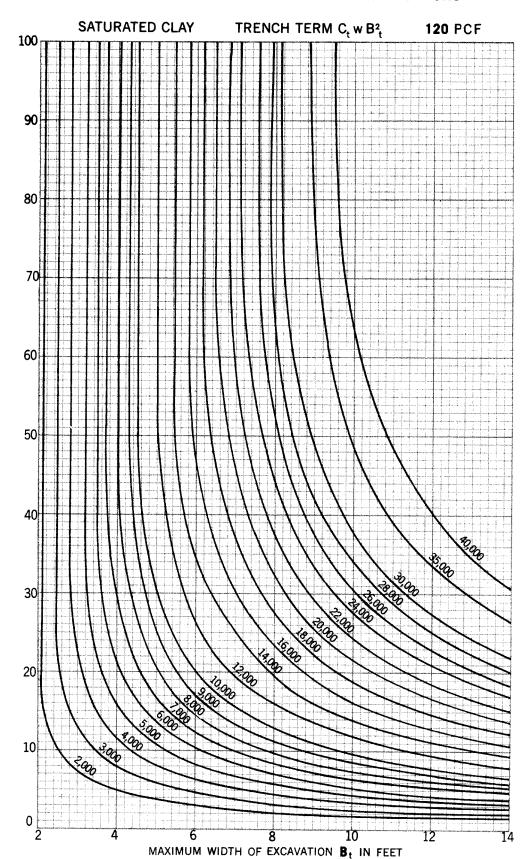


Figure 153

HEIGHT OF COVER H IN FEET

EARTH LOADS JACKED OR TUNNELED INSTALLATIONS



For earth weighing other than 120 pounds per cubic foot, multiply loads by w/120.

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Figure 154

EARTH LOADS ON JACKED OR TUNNELED INSTALLATIONS

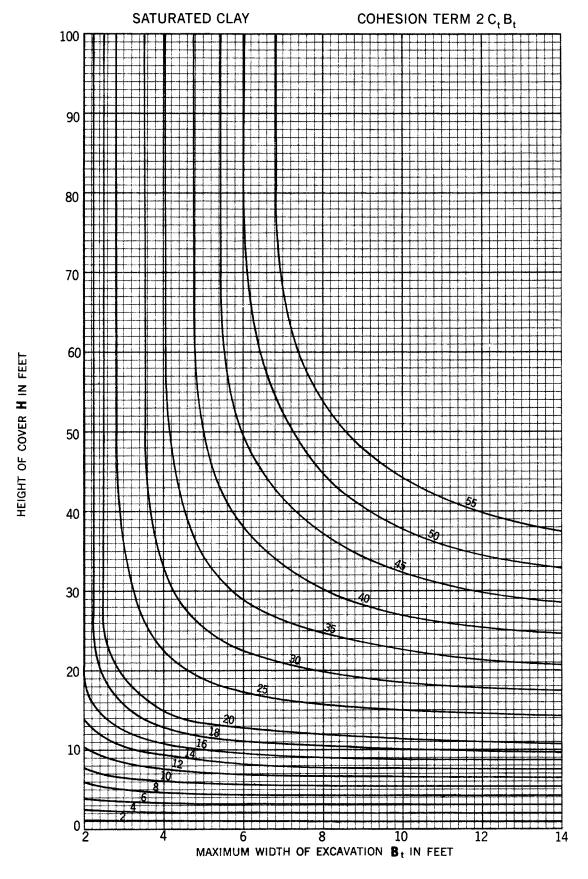
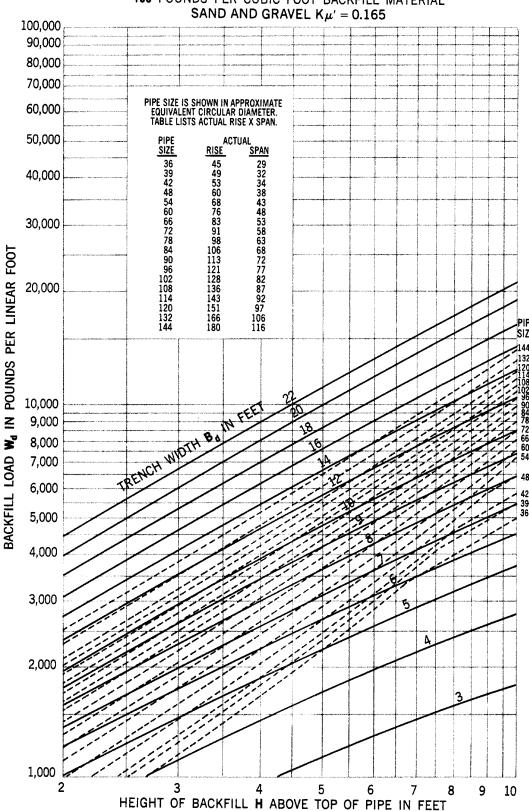


Figure 155

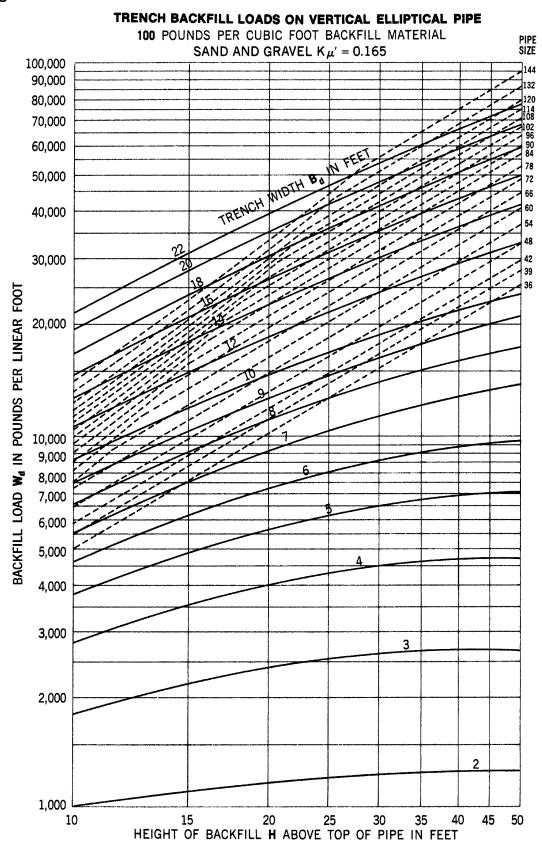




For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and $\rho=0.7$ in the embankment equation

Figure 156

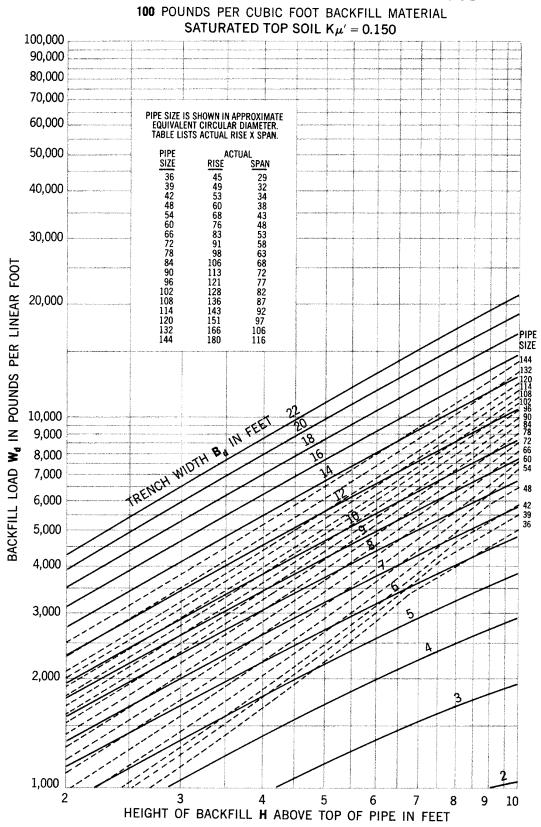


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K_{\mu}=0.19$, $r_{sd}=0.7$ and $\rho=0.7$ in the embankment equation

Figure 157

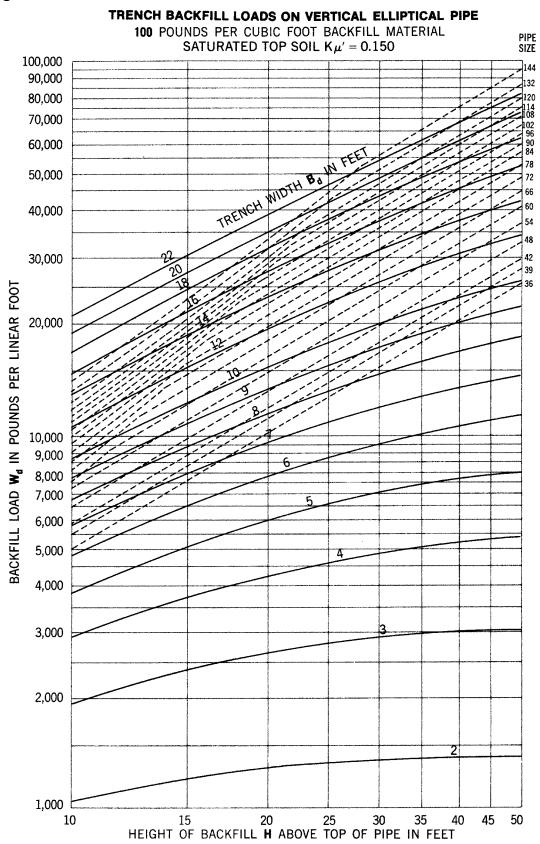
TRENCH BACKFILL LOADS ON VERTICAL ELLIPTICAL PIPE



For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K_{\mu}=0.19$, $r_{sd}=0.7$ and p=0.7 in the embankment equation

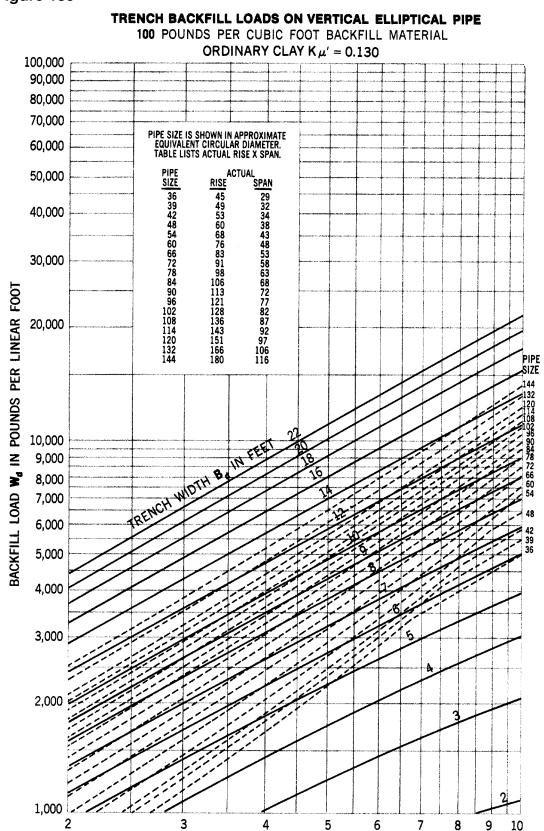
Figure 158



For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on K $_{\mu}$ = 0.19, $r_{\rm sd}$ = 0.7 and p = 0.7 in the embankment equation

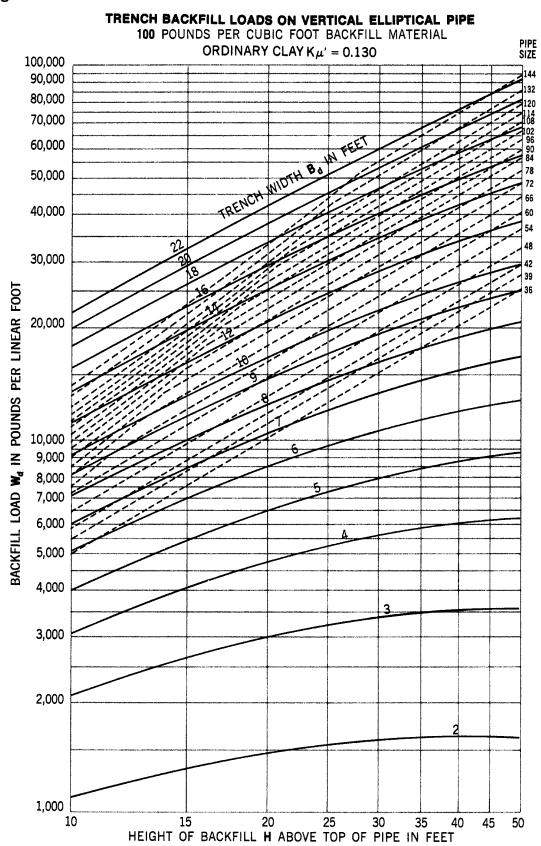
Figure 159



HEIGHT OF BACKFILL **H** ABOVE TOP OF PIPE IN FEET For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{\text{sd}}=0.7$ and p=0.7 in the embankment equation

Figure 160



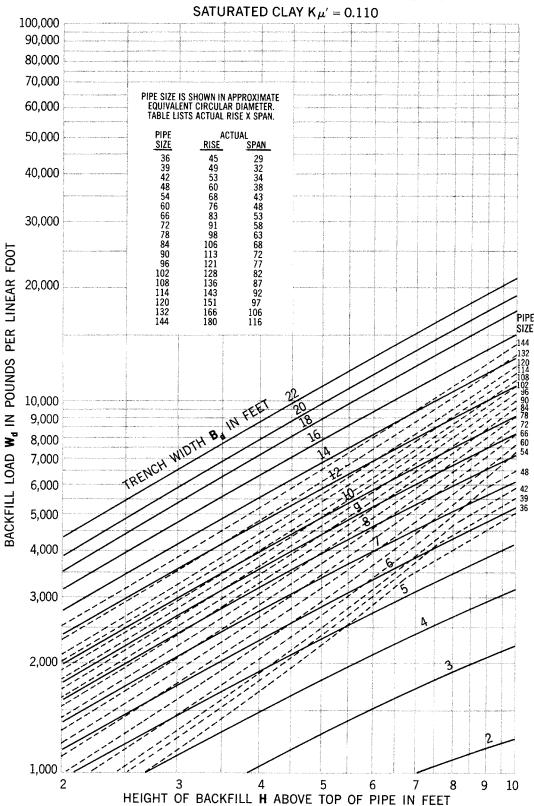
For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and p=0.7 in the embankment equation

Figure 161

TRENCH BACKFILL LOADS ON VERTICAL ELLIPTICAL PIPE

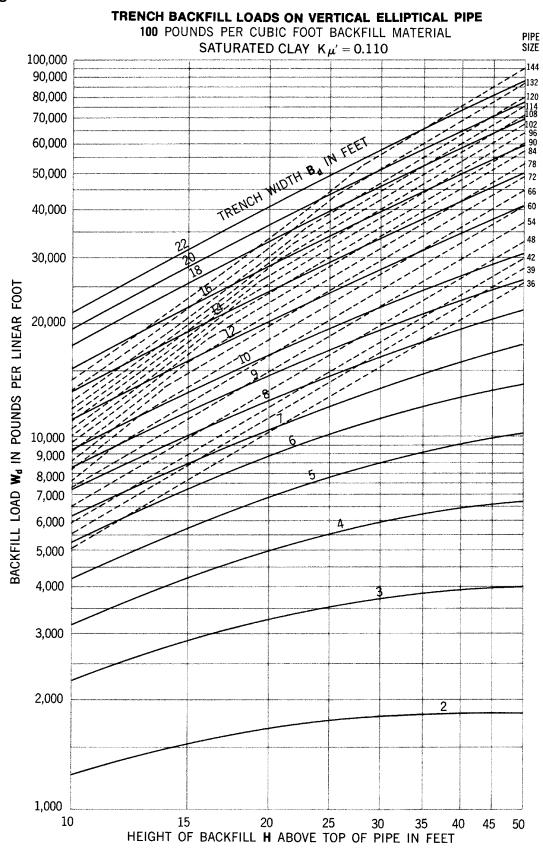
100 POUNDS PER CUBIC FOOT BACKFILL MATERIAL



For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and $\rho=0.7$ in the embankment equation

Figure 162

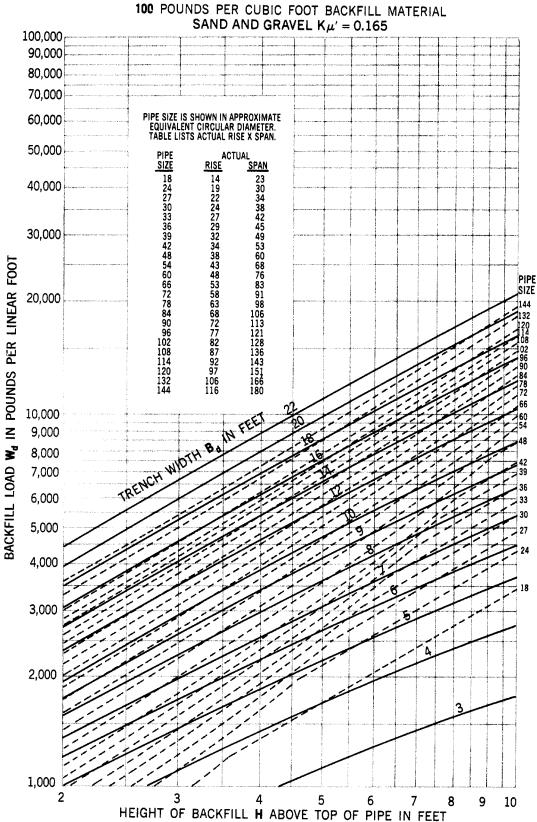


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on K μ = 0.19, $r_{\rm sd}$ = 0.7 and p = 0.7 in the embankment equation

Figure 163

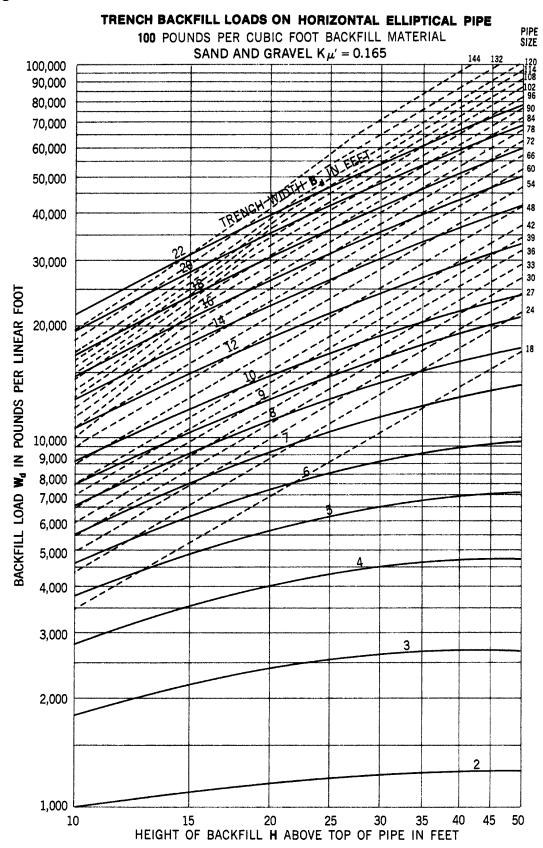




For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and $\rho=0.7$ in the embankment equation

Figure 164

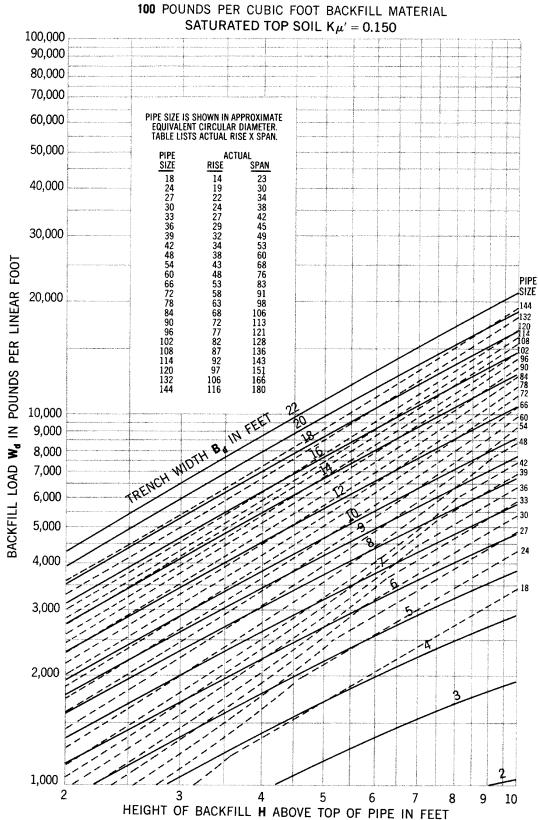


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and p=0.7 in the embankment equation

Figure 165

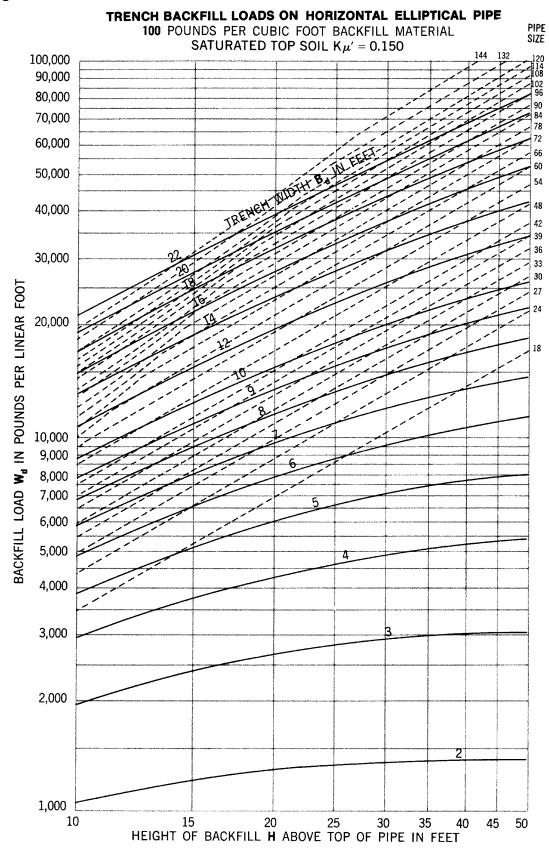
TRENCH BACKFILL LOADS ON HORIZONTAL ELLIPTICAL PIPE



For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K_{\mu}=0.19$, $r_{sd}=0.7$ and p=0.7 in the embankment equation

Figure 166

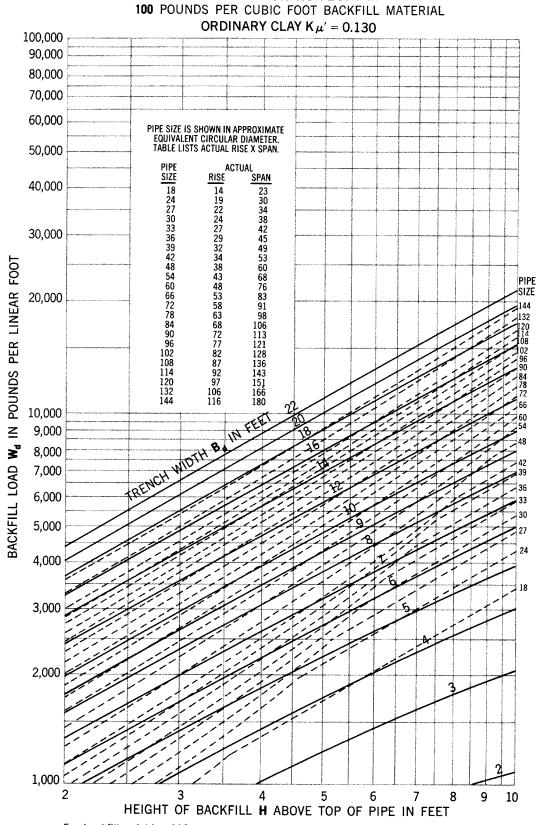


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on K $_{\mu}$ = 0.19, $r_{\rm sd}$ = 0.7 and ρ = 0.7 in the embankment equation

Figure 167

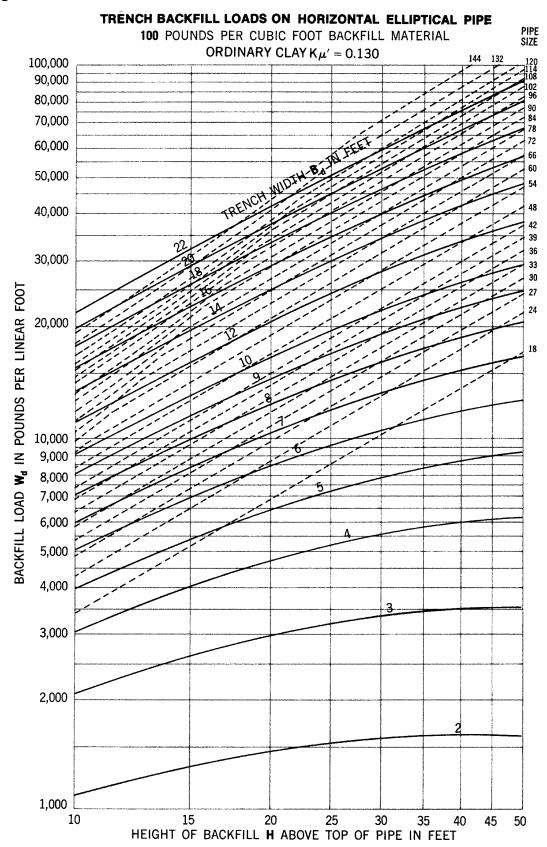
TRENCH BACKFILL LOADS ON HORIZONTAL ELLIPTICAL PIPE



For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and $\rho=0.7$ in the embankment equation

Figure 168

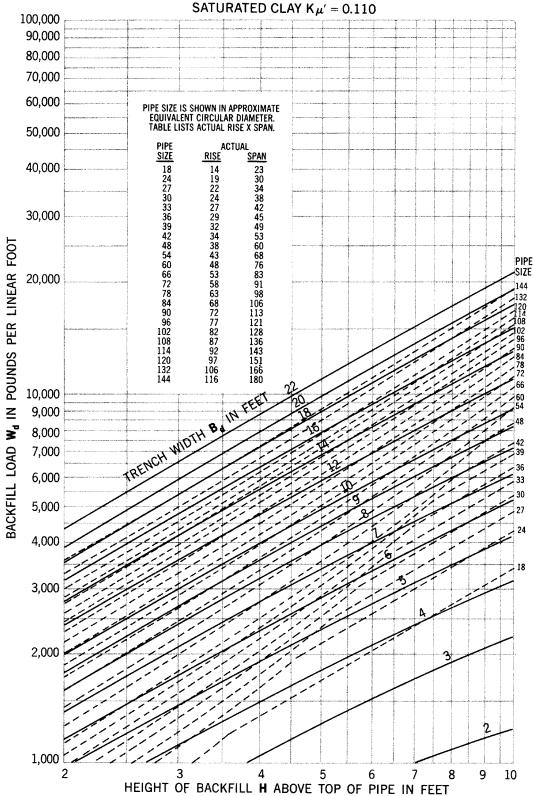


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and p=0.7 in the embankment equation

Figure 169

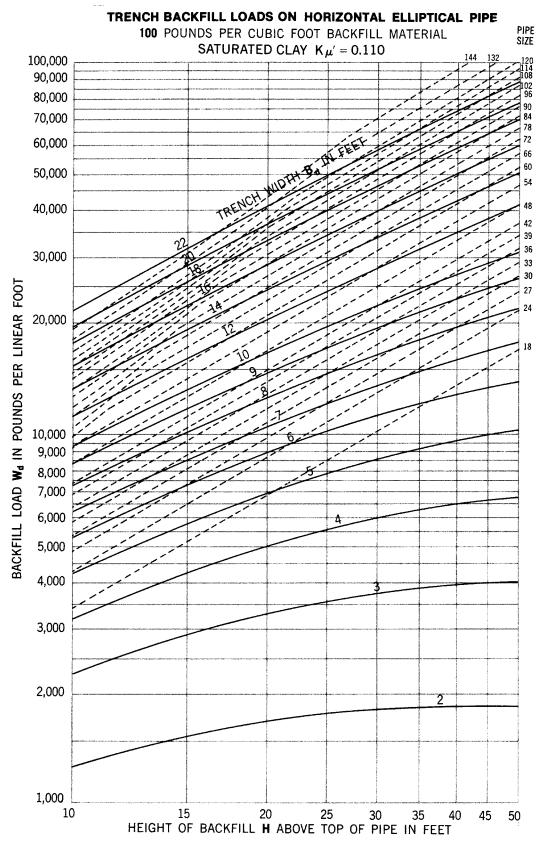
TRENCH BACKFILL LOADS ON HORIZONTAL ELLIPTICAL PIPE 100 POUNDS PER CUBIC FOOT BACKFILL MATERIAL



For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and p=0.7 in the embankment equation

Figure 170

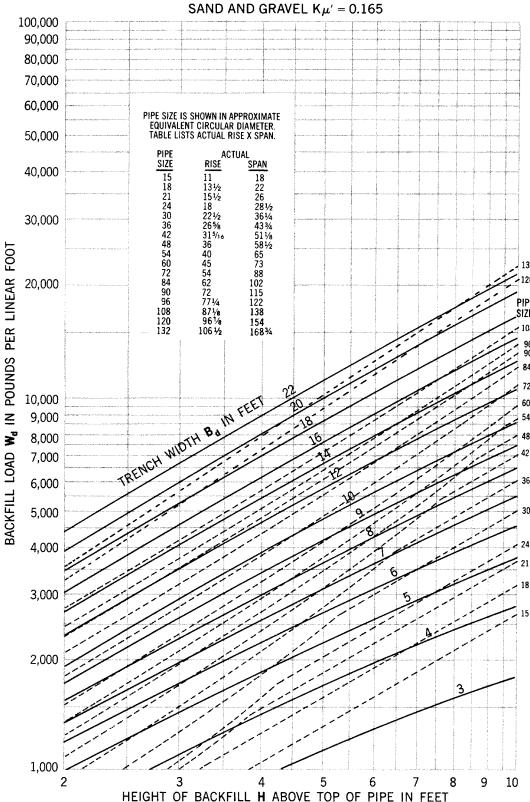


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on K $_{\mu}$ = 0.19, r_{sd} = 0.7 and ρ = 0.7 in the embankment equation

Figure 171

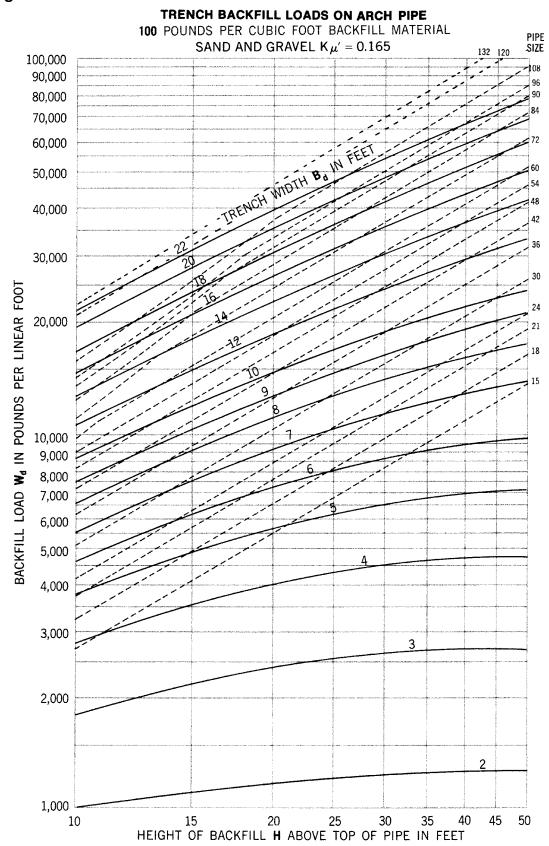
TRENCH BACKFILL LOADS ON ARCH PIPE 100 POUNDS PER CUBIC FOOT BACKFILL MATERIAL



For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and p=0.7 in the embankment equation

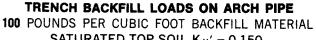
Figure 172

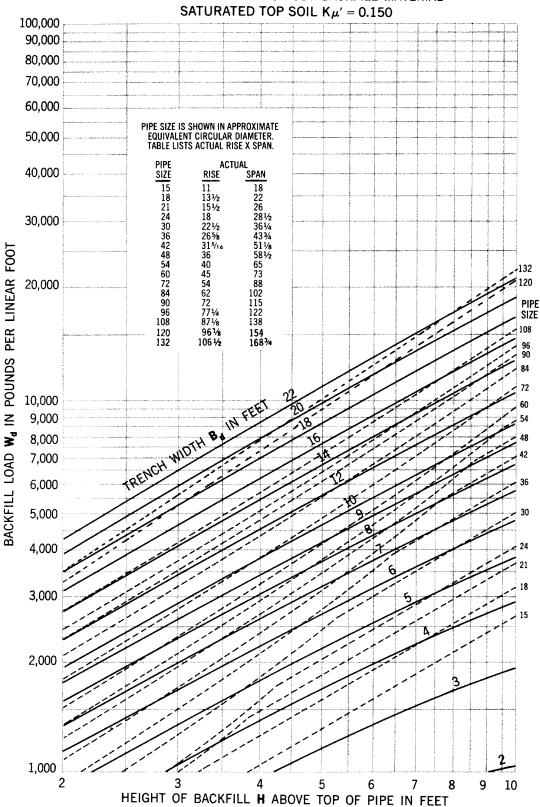


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K_{\mu}=0.19$, $r_{\rm sd}=0.7$ and p=0.7 in the embankment equation

Figure 173

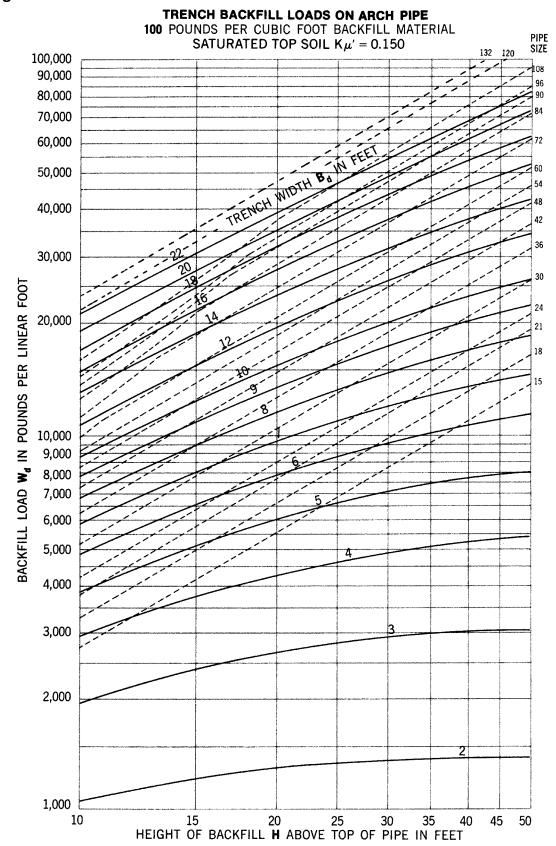




For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on K μ = 0.19, r_{sd} = 0.7 and ρ = 0.7 in the embankment equation

Figure 174

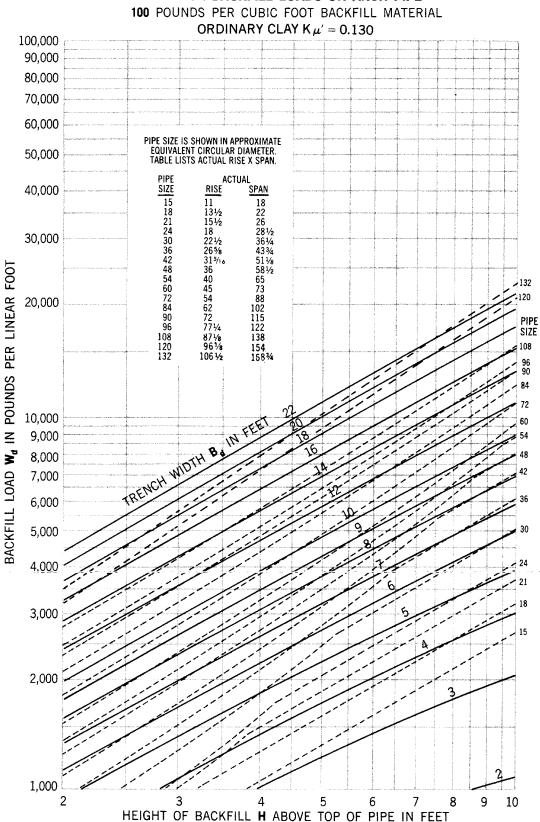


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on K μ = 0.19, r_{sd} = 0.7 and ρ = 0.7 in the embankment equation

Figure 175

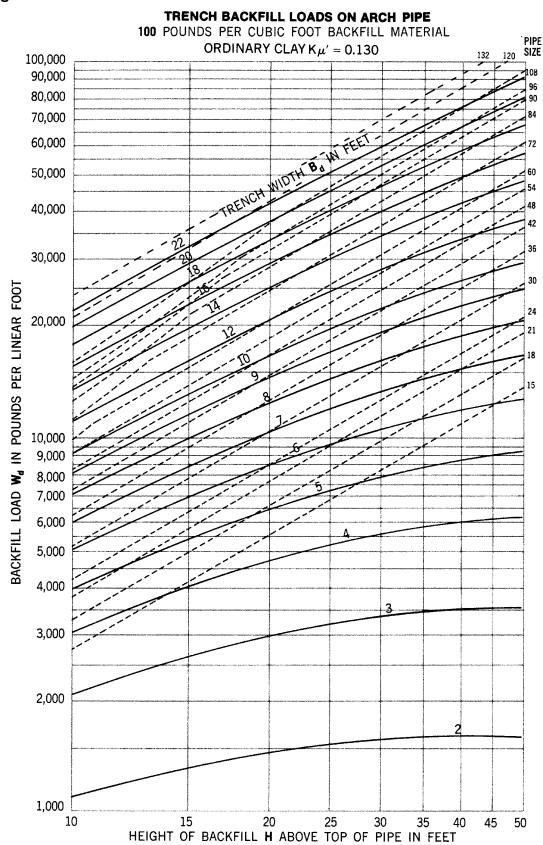
TRENCH BACKFILL LOADS ON ARCH PIPE



For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and p=0.7 in the embankment equation

Figure 176



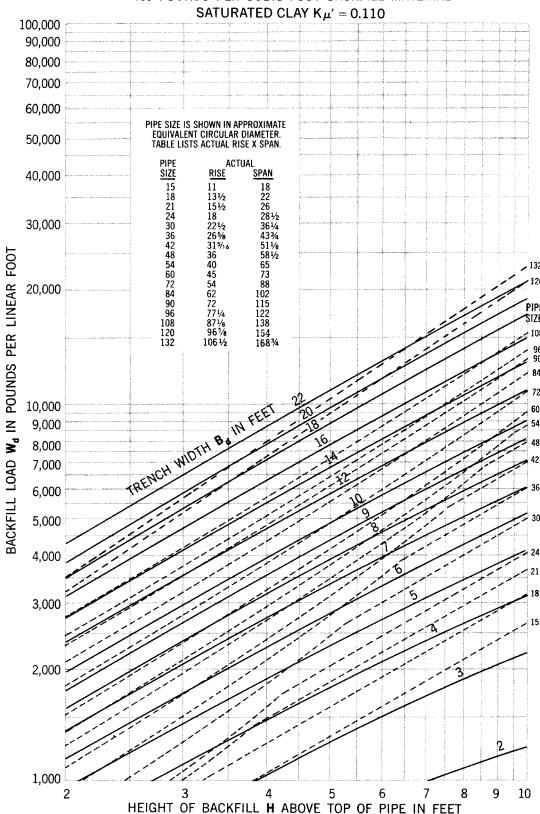
For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and p=0.7 in the embankment equation

Figure 177

TRENCH BACKFILL LOADS ON ARCH PIPE

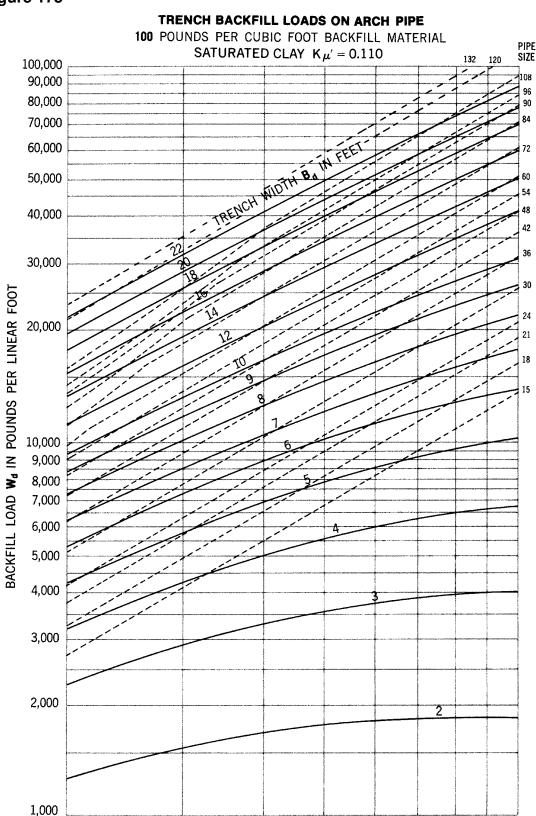
100 POUNDS PER CUBIC FOOT BACKFILL MATERIAL



For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and $\rho=0.7$ in the embankment equation

Figure 178



HEIGHT OF BACKFILL **H** ABOVE TOP OF PIPE IN FEET For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

25

30

40

50

20

15

Transition loads and widths based on K $_{\mu}$ = 0.19, $r_{\rm sd}$ = 0.7 and ρ = 0.7 in the embankment equation

Figure 179

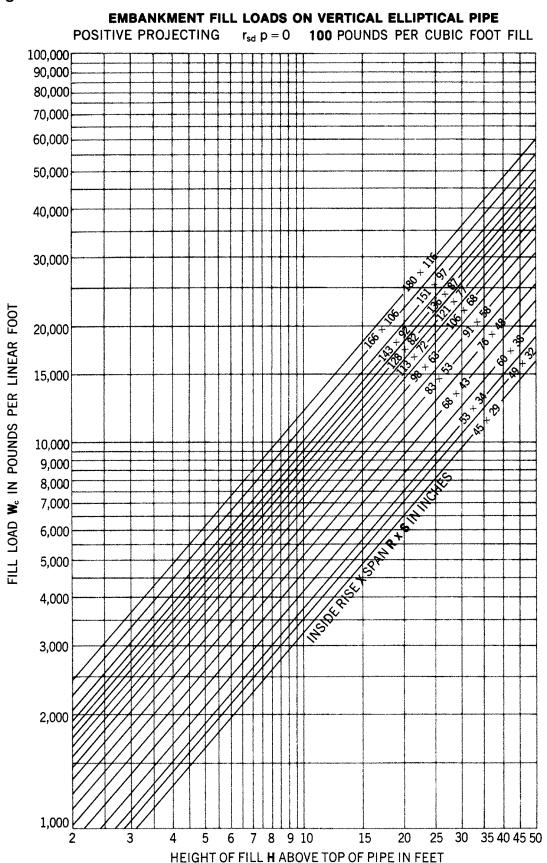


Figure 180

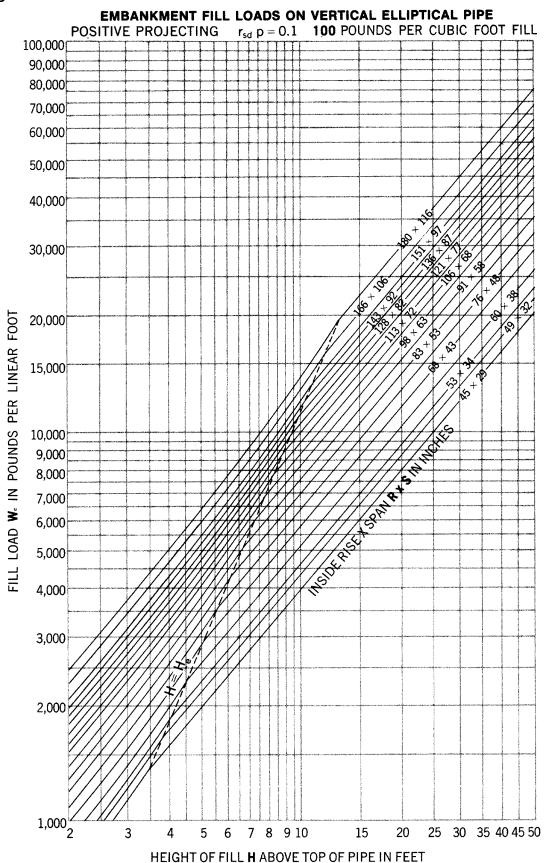


Figure 181

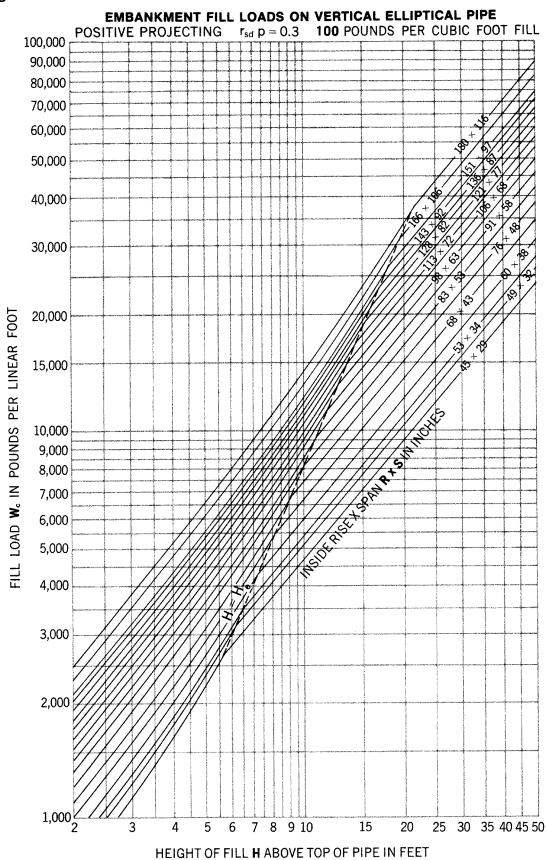
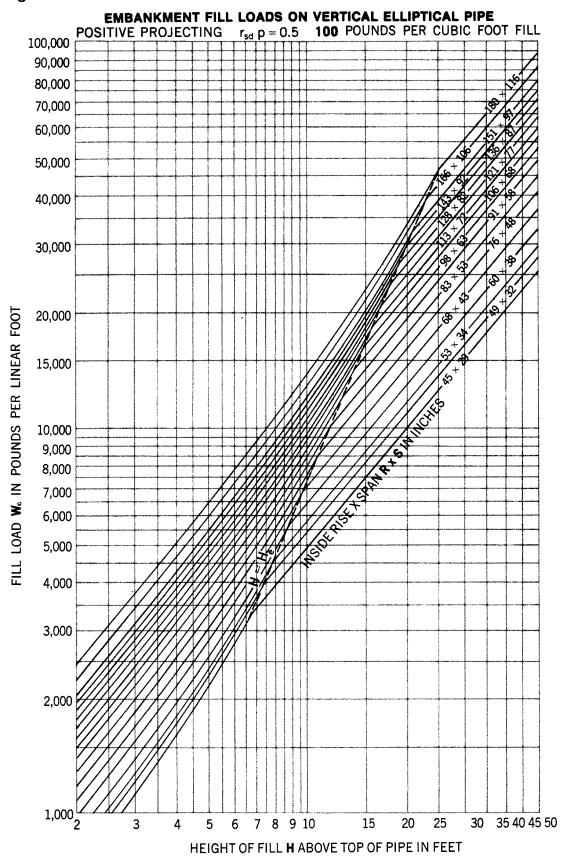


Figure 182



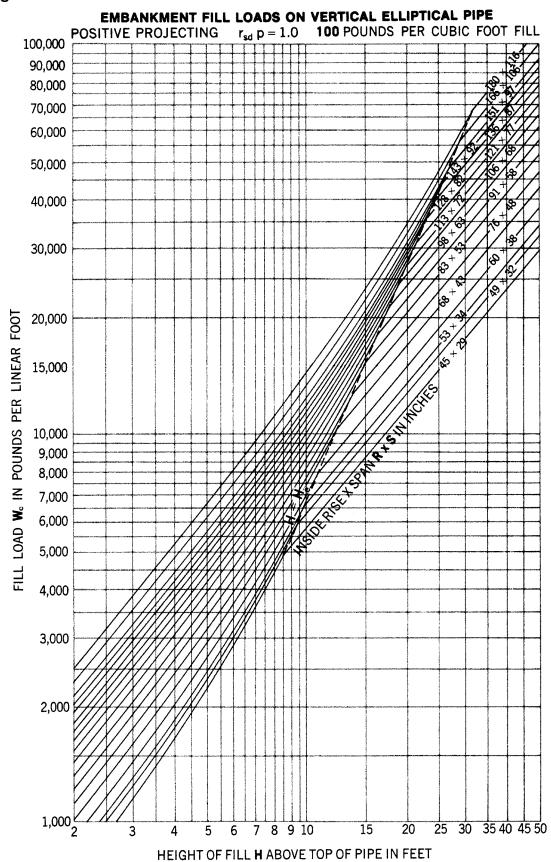
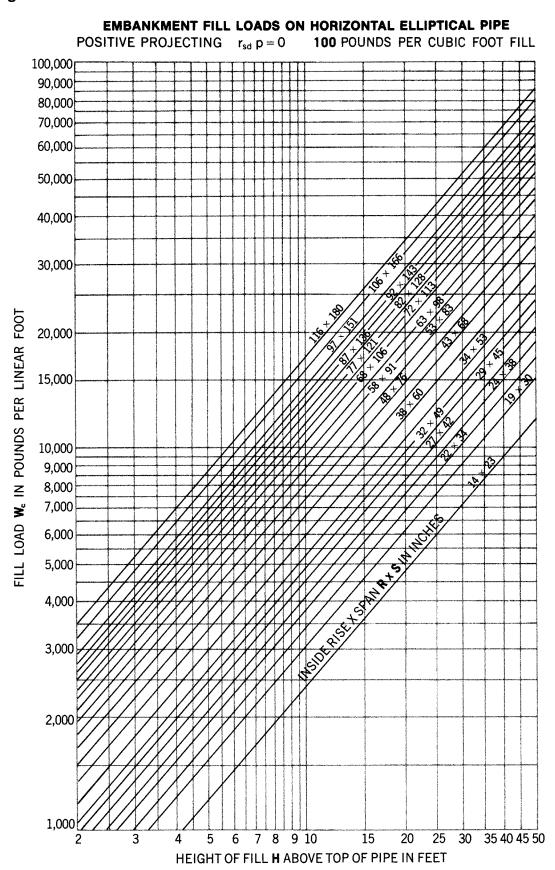


Figure 184



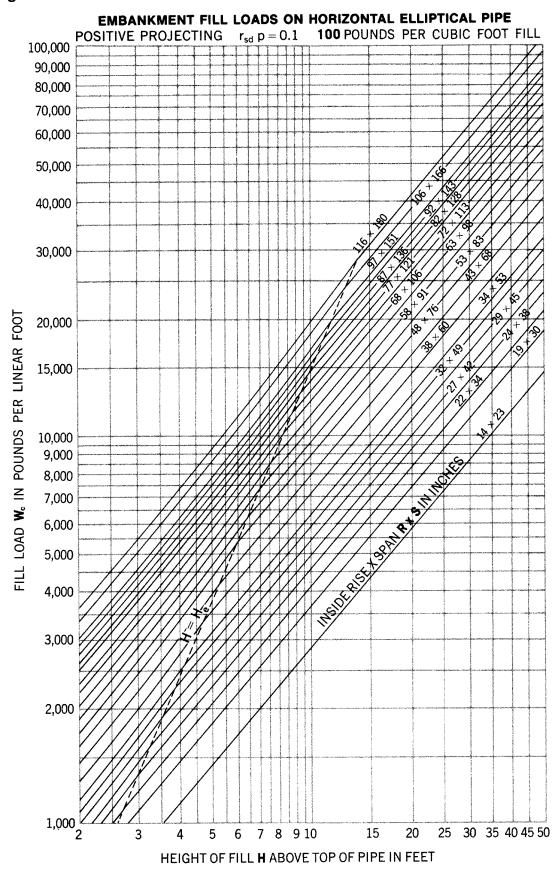
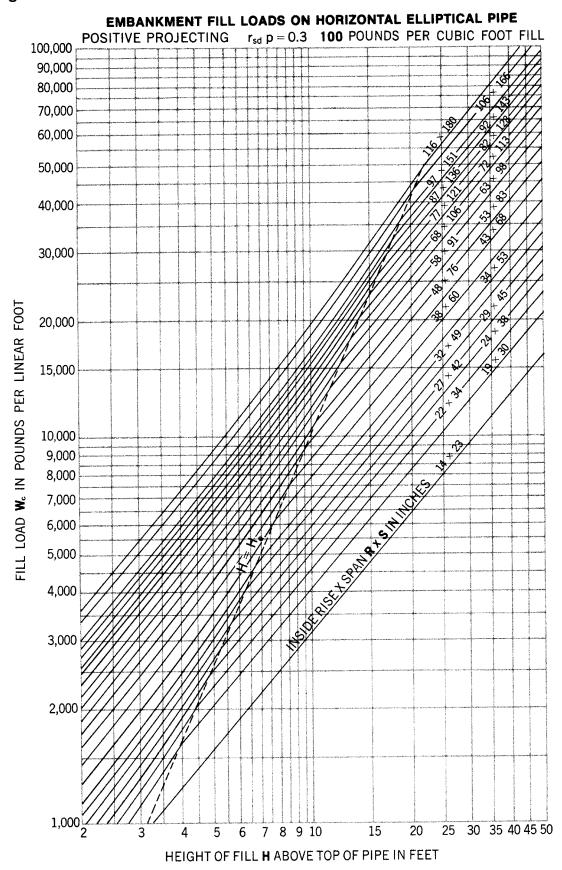


Figure 186



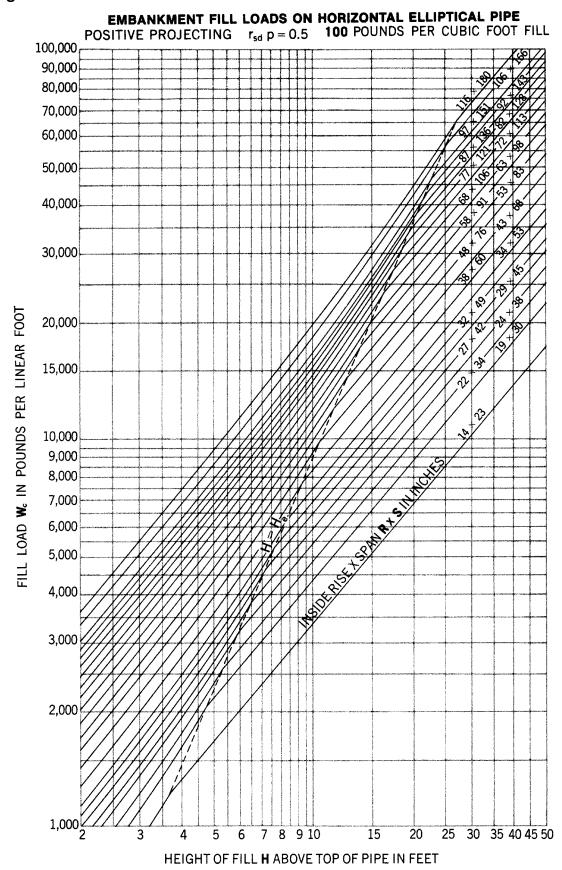
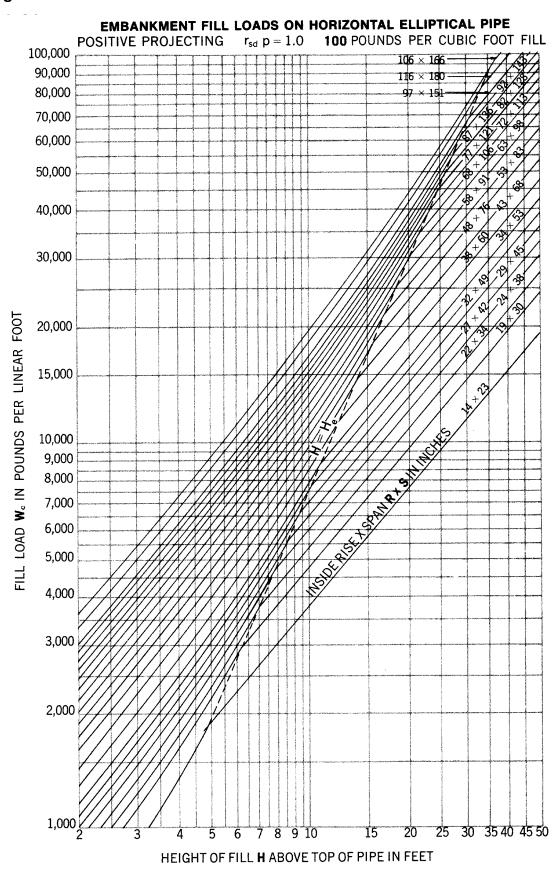


Figure 188



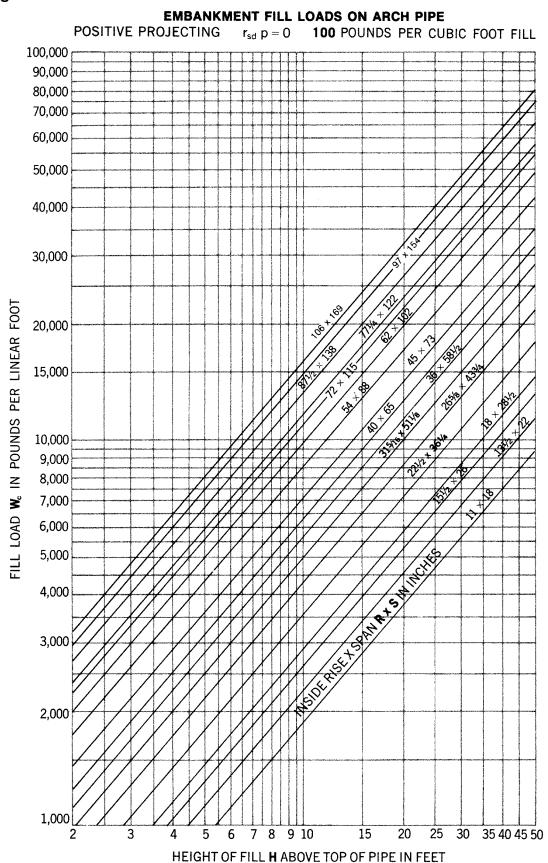


Figure 190

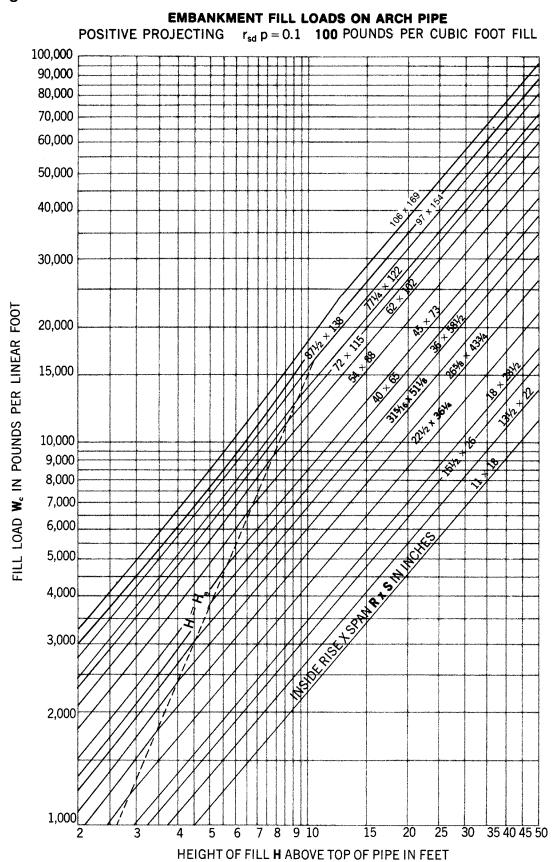


Figure 191

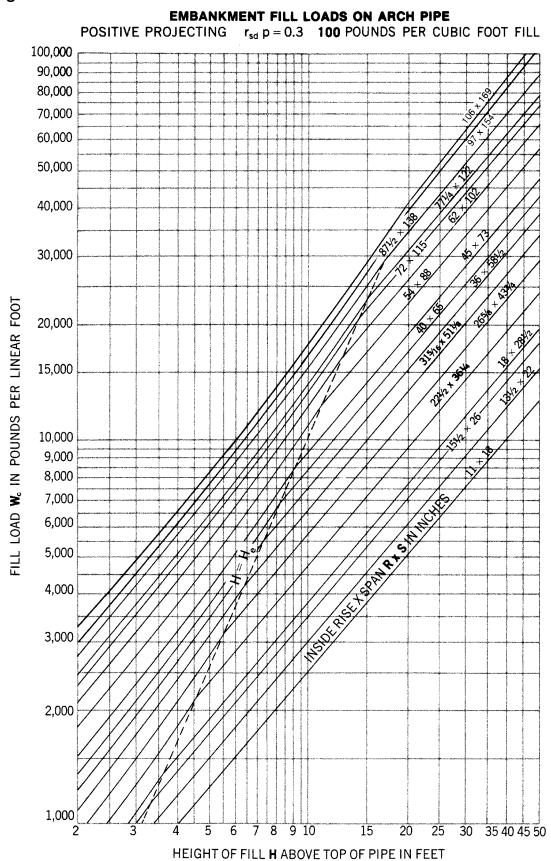


Figure 192

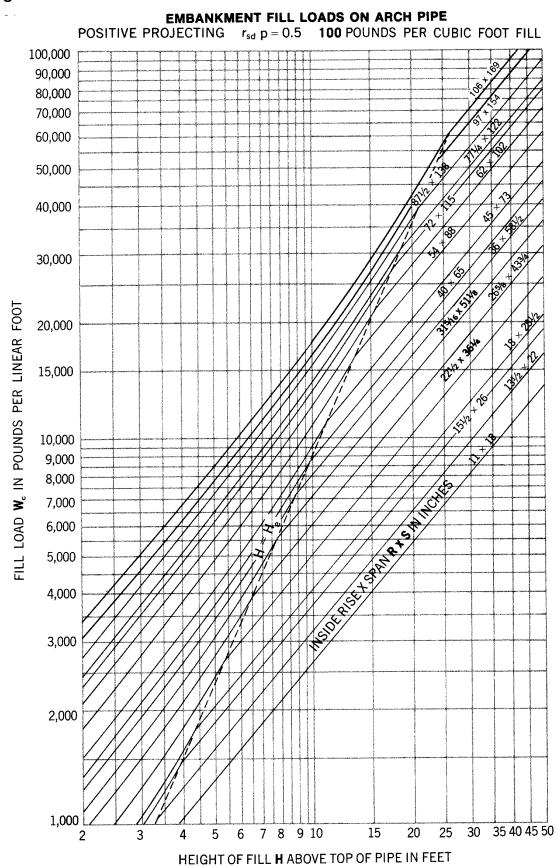


Figure 193

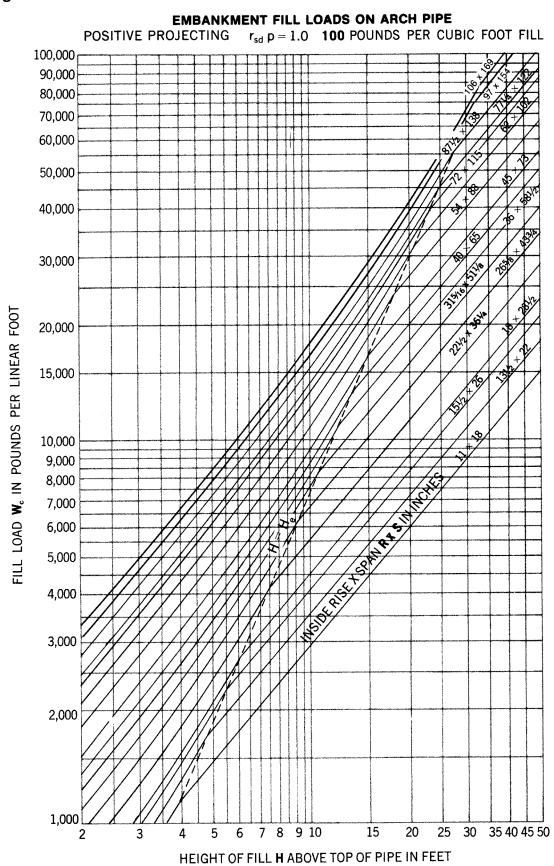


Figure 194

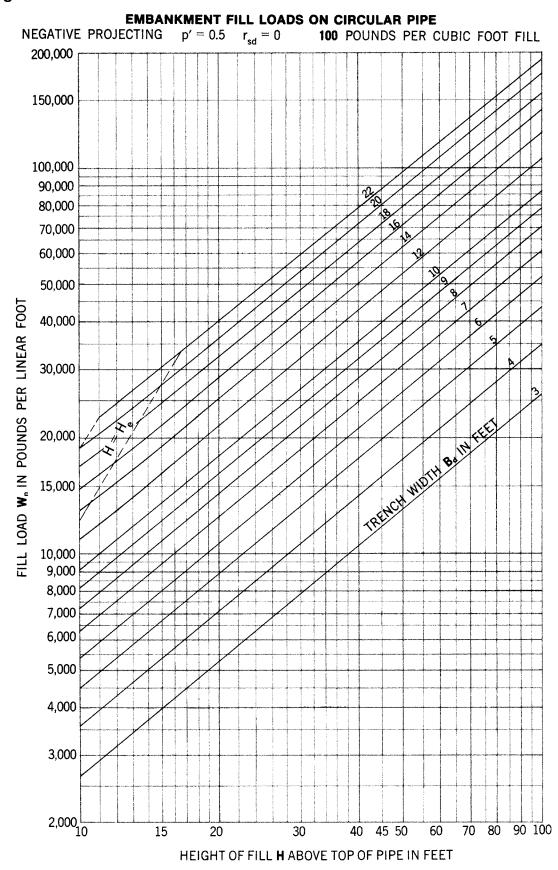


Figure 195

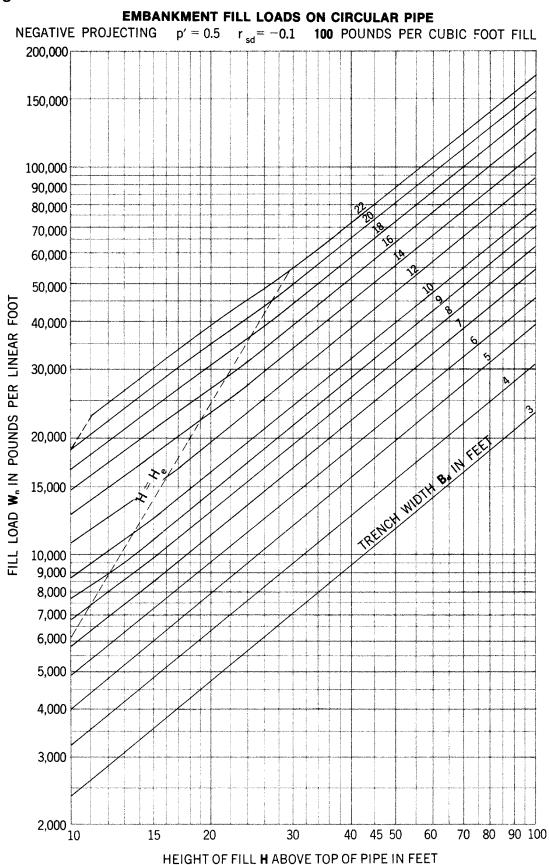


Figure 196



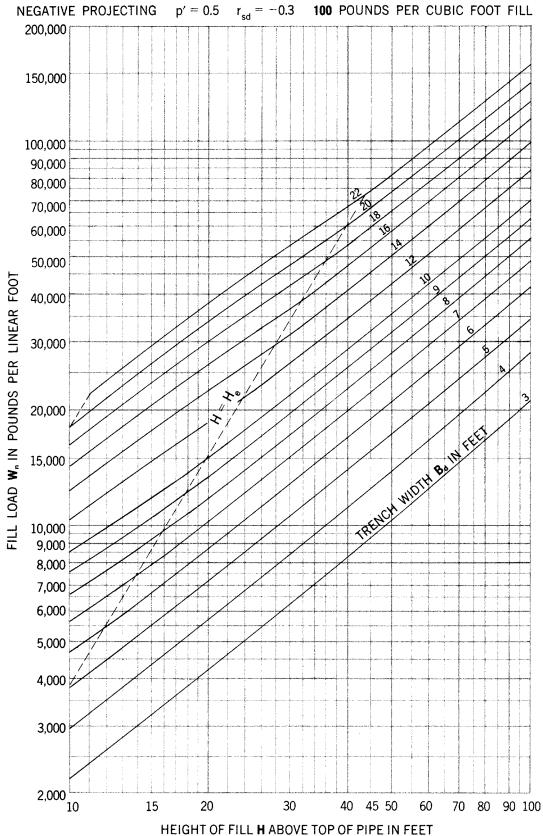


Figure 197

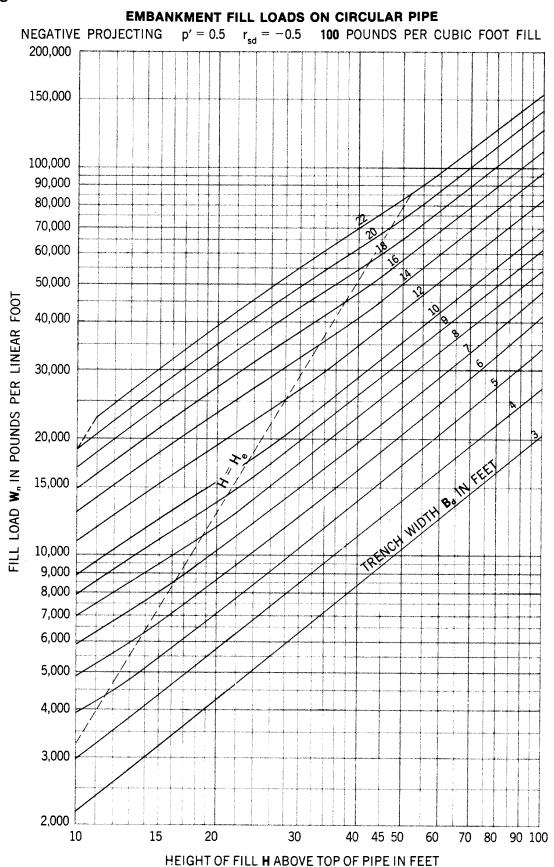


Figure 198



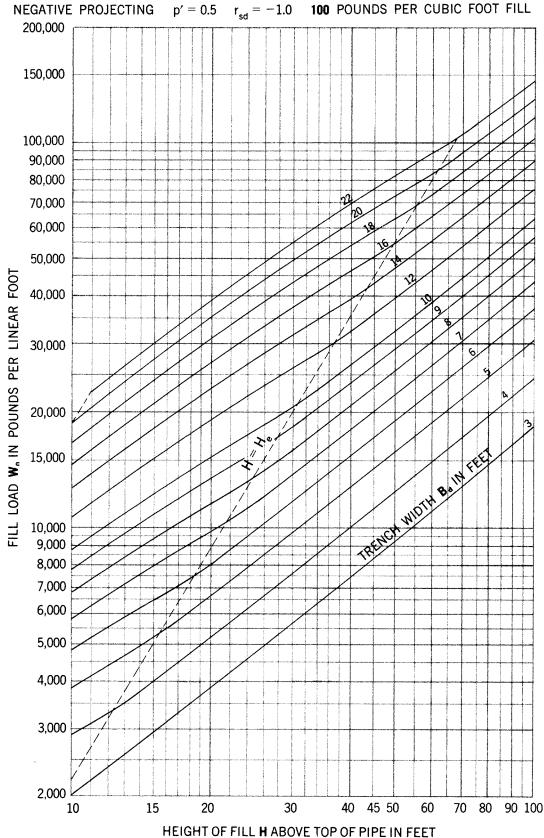


Figure 199

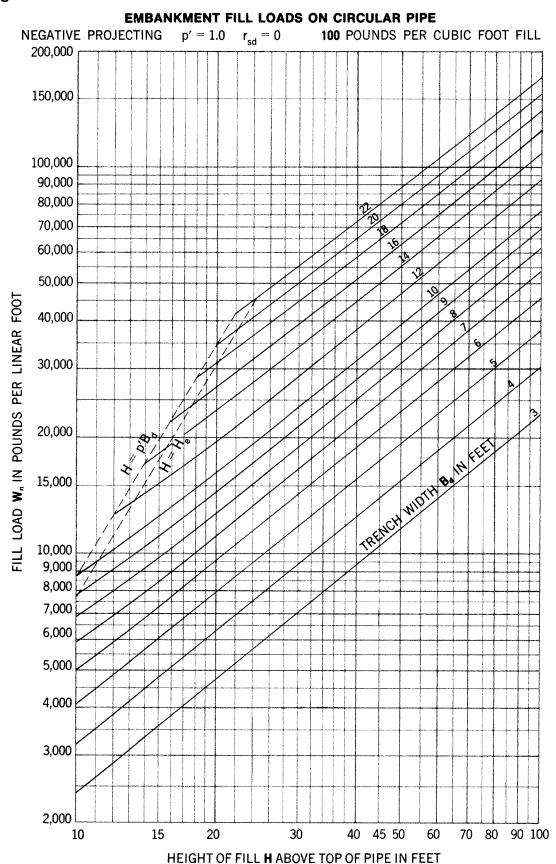
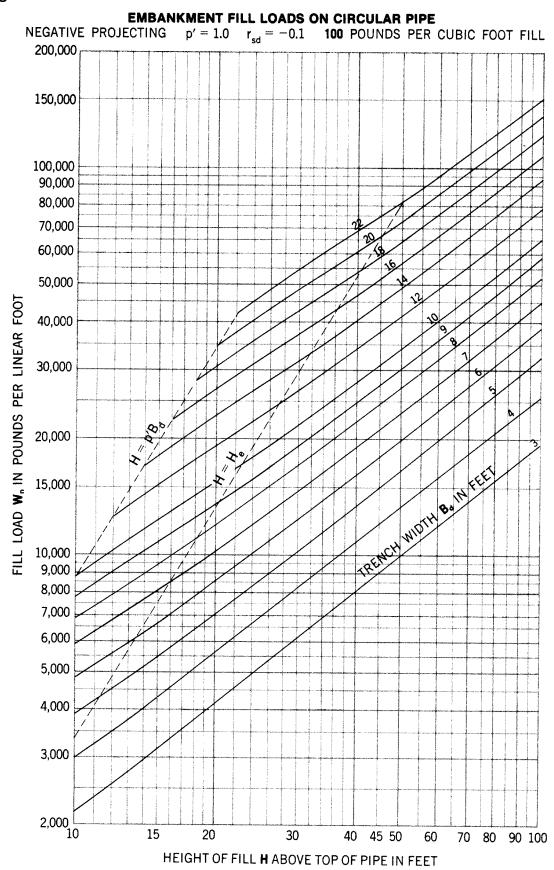


Figure 200



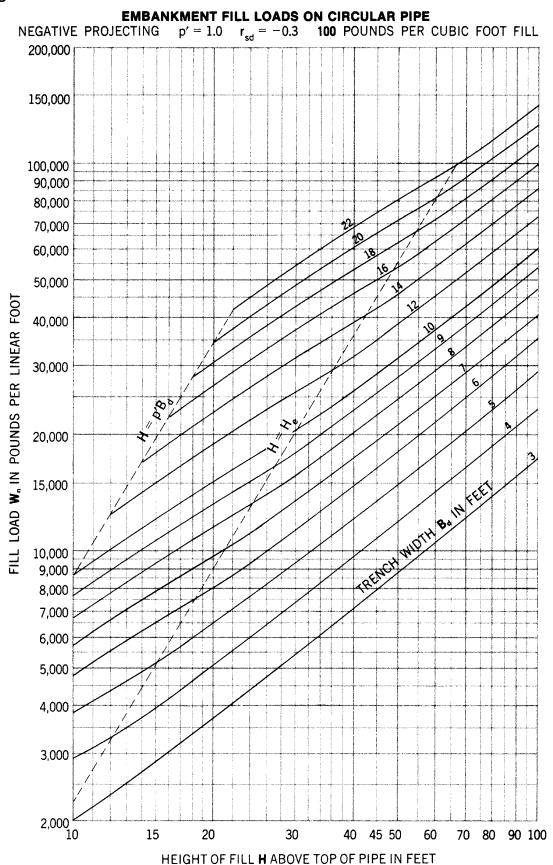
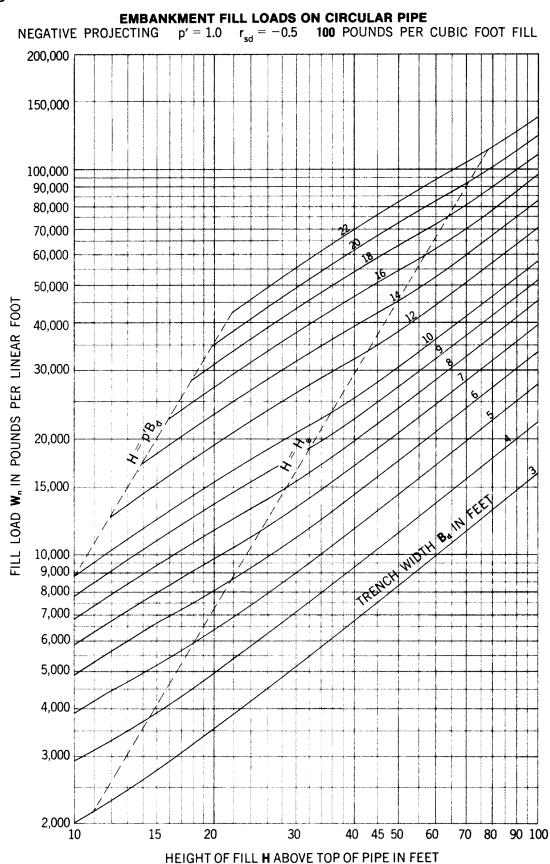


Figure 202



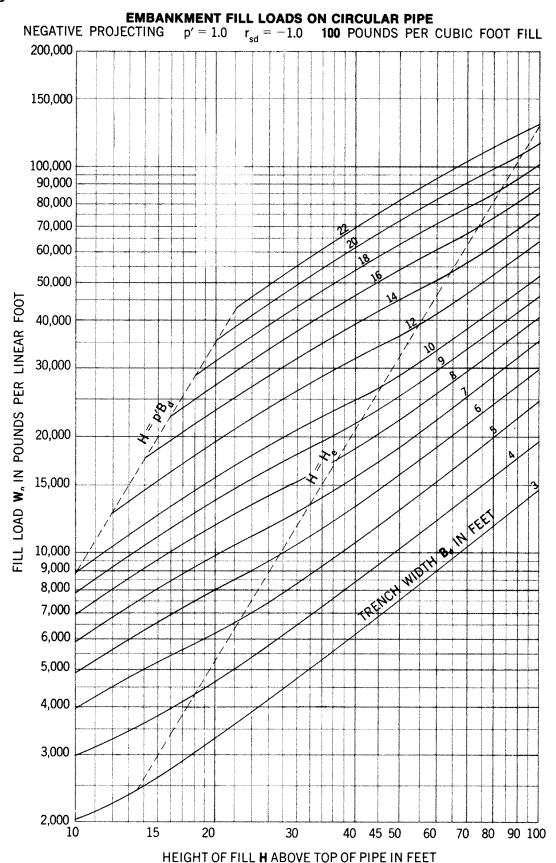
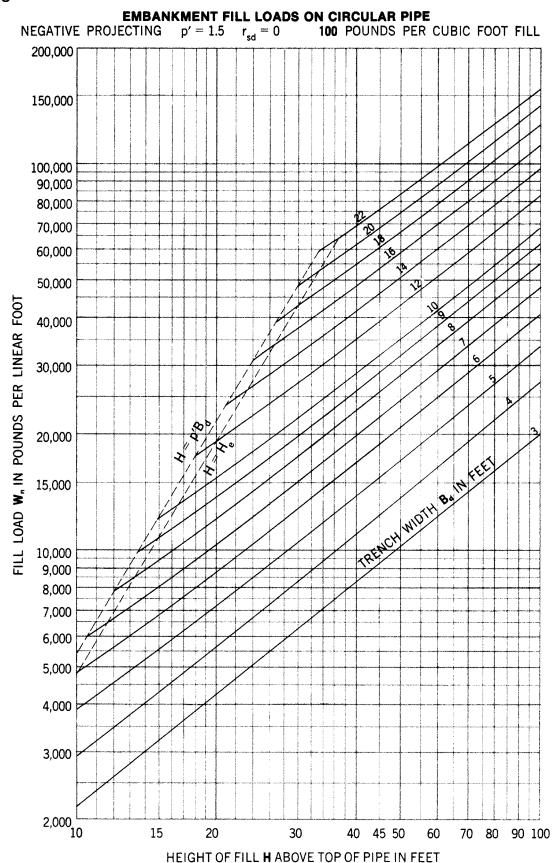


Figure 204



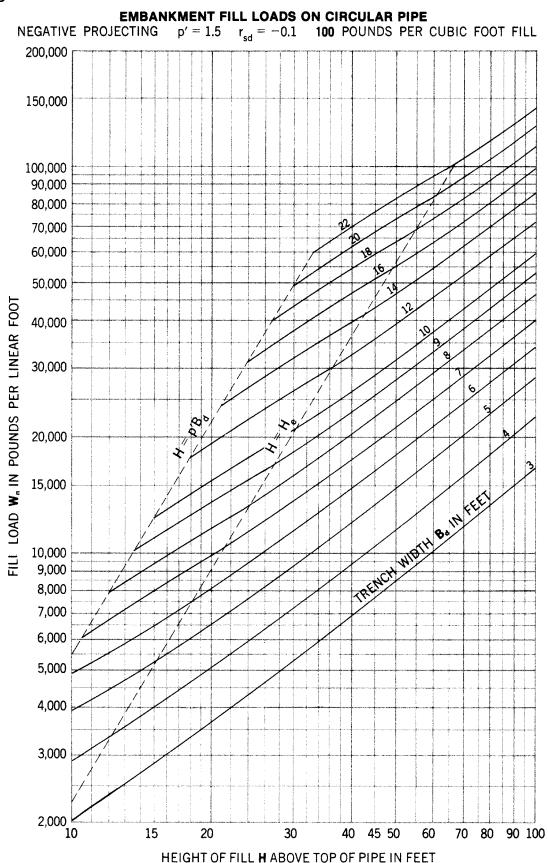
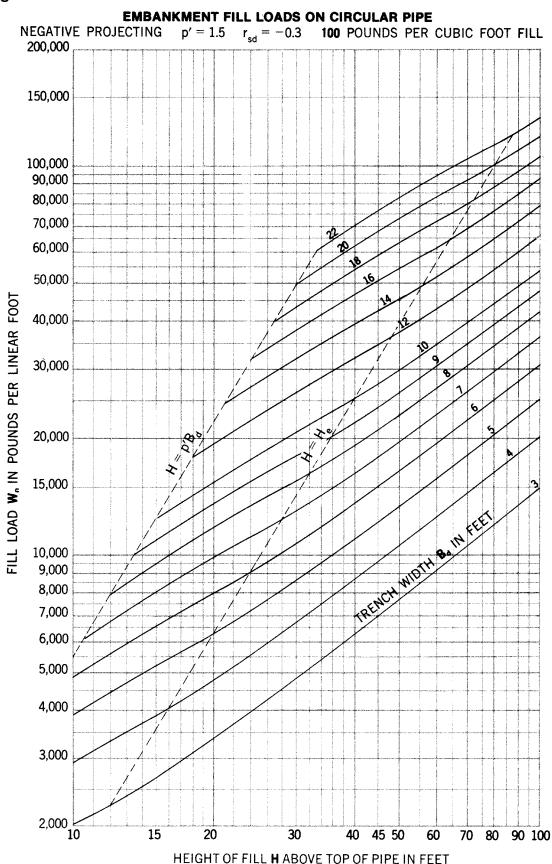


Figure 206



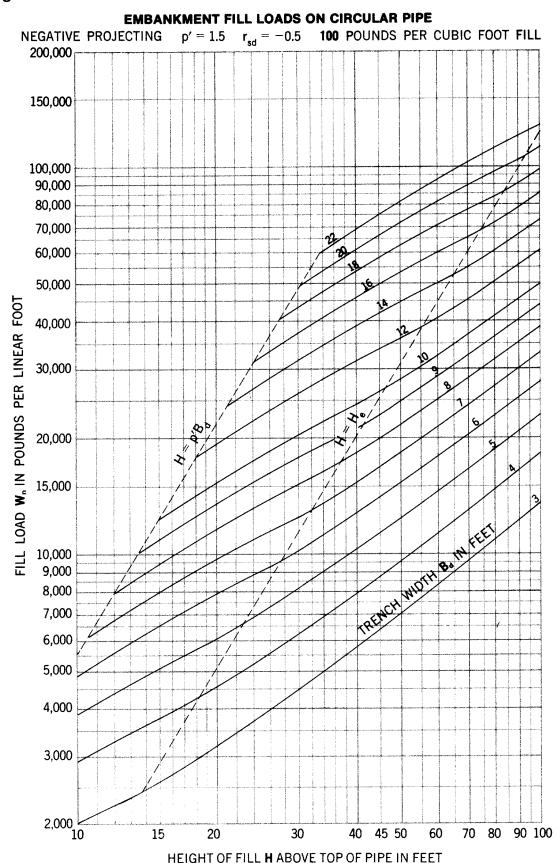
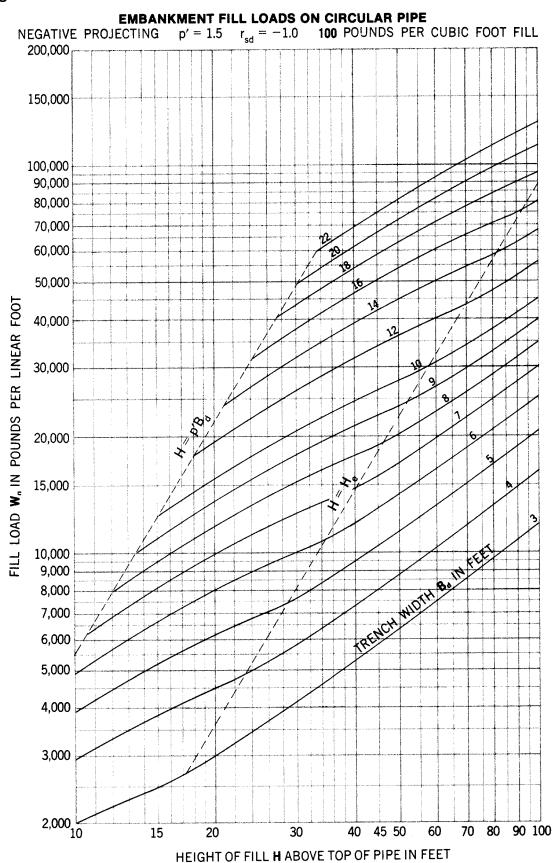


Figure 208



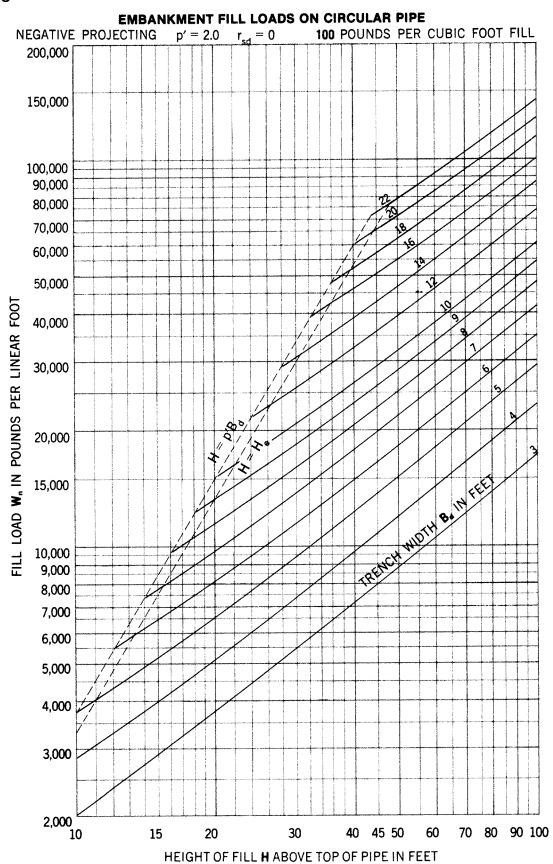
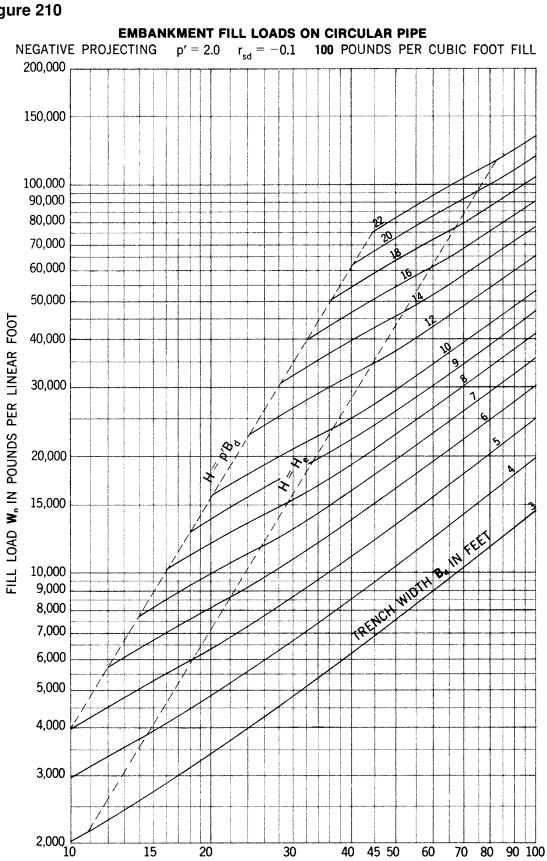


Figure 210



For fill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds increase 20%, etc. Interpolate for intermediate trench widths.

HEIGHT OF FILL H ABOVE TOP OF PIPE IN FEET

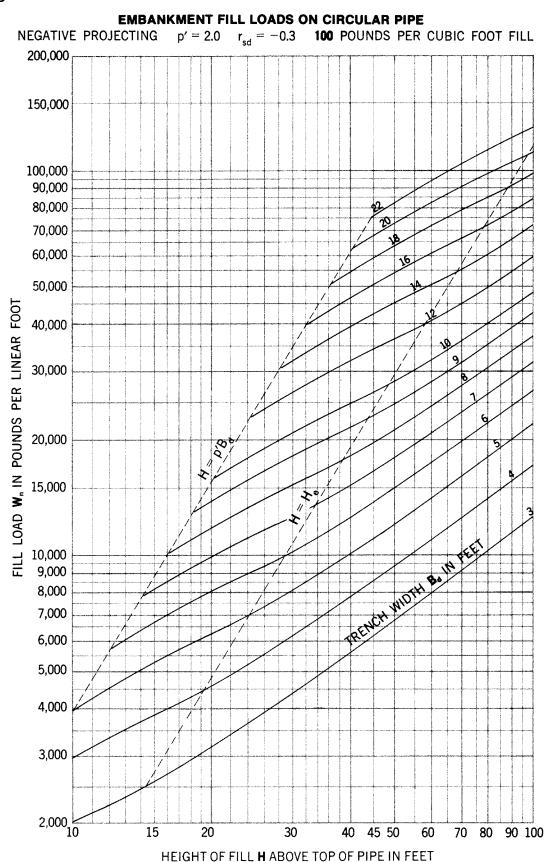
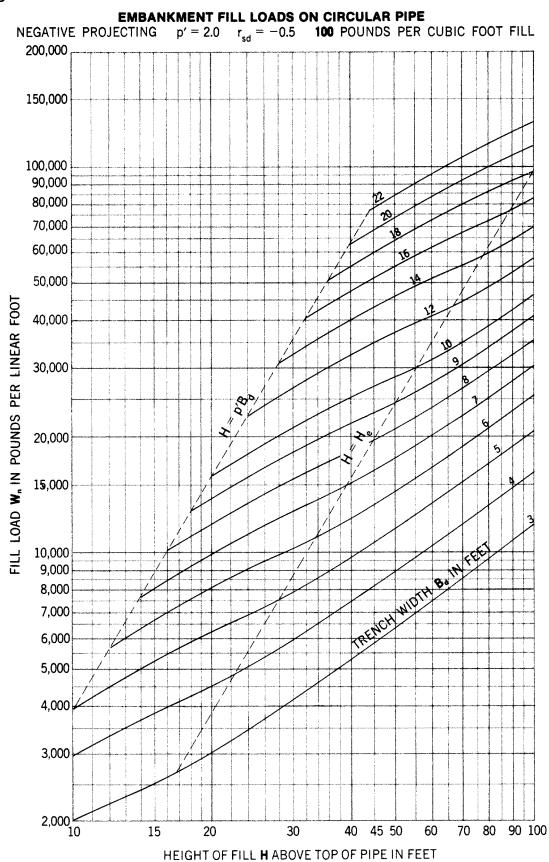


Figure 212



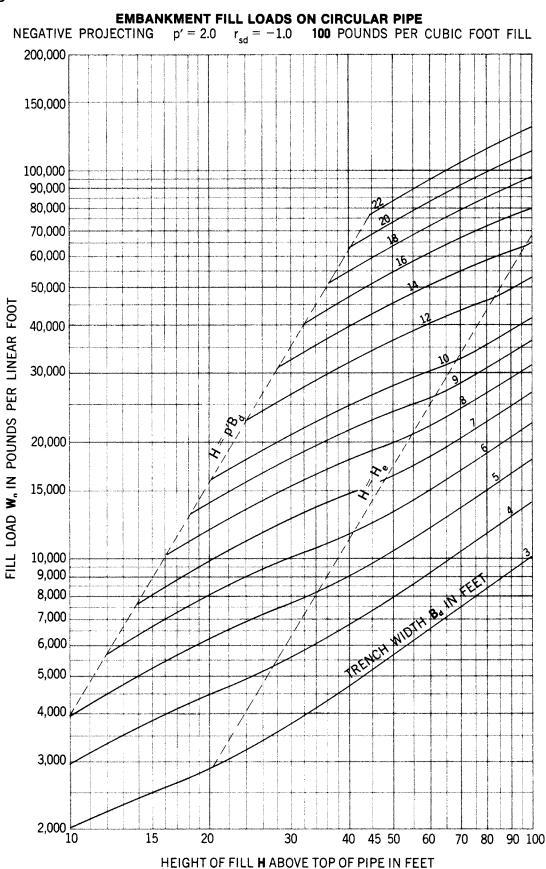


Figure 214

LOAD COEFFICIENT DIAGRAM FOR TRENCH INSTALLATIONS

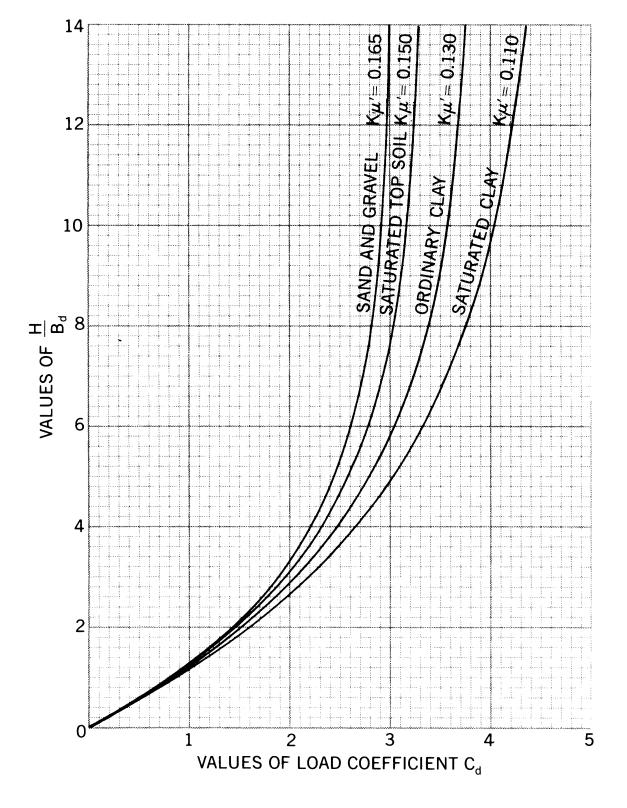
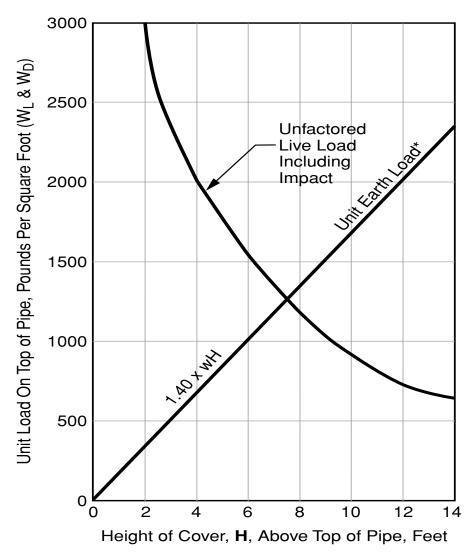


Figure 215 Loads on Concrete Pipe Installed Under Railways



*Fill for embankment installations DL/Bc = 1.40wH with w = 18.85kN/m3 1.40 = Vertical Arching Factor

* Fill for embankment installations DL/B_c = 1.40wH with w = 120pcf 1.40 = Vertical Arching Factor

[&]quot;Part 10 Reinforced Concrete Culvert Pipe, Chapter 8, Concrete Structures and Foundations, AREMA Manual of Railway Engineering", American Railway Engineering and Maintenance-of-Way Association, 1999.

Appendix A

Table A-1

SQUARE ROOTS OF DECIMAL NUMBER(S^{1/2} IN MANNING'S FORMULA)

No.	0	. – 1	2	3	. – 4	. – 5	6	7	.–8	9
.00001	.003162	.003317	.003464	.003606	.003742	.003873	.004000	.004123	.004243	.004359
.00002	.004472	.004583	.004690	.004796	.004899	.005000	.005099	.005196	.005292	.005385
.00003	.005477	.005568	.005657	.005745	.005831	.005916	.006000	.006083	.006164	.006245
.00004	.006325	.006403	.006481	.006557	.006633	.006708	.006782	.006856	.006928	.007000
.00005	.007071	.007141	.007211	.007280	.007348	.007416	.007483	.007550	.007616	.007681
.00006	.007746	.007810	.007874	.007937	.008000	.008062	.008124	.008185	.008246	.008307
.00007	.008367	.008426	.008485	.008544	.008602	.008660	.008718	.008775	.008832	.008888
.00008	.008944	.009000	.009055	.009110	.009165	.009220	.009274	.009327	.009381	.009434
.00009	.009487	.009539	.009592	.009644	.009695	.009747	.009798	.009849	.009899	.009950
.00010	.010000	.010050	.010100	.010149	.010198	.010247	.010296	.010344	.010392	.010440
.0001	.01000	.01049	.01095	.01140	.01183	.01225	.01265	.01304	.01342	.01378
.0002	.01414	.01449	.01483	.01517	.01549	.01581	.01612	.01643	.01673	.01703
.0003	.01732	.01761	.01789	.01817	.01844	.01871	.01897	.01924	.01949	.01975
.0004	.02000	.02025	.02049	.02074	.02098	.02121	.02145	.02168	.02191	.02214
.0005	.02236	.02258	.02280	.02302	.02324	.02345	.02366	.02387	.02408	.02429
.0006	.02449	.02470	.02490	.02510	.02530	.02550	.02569	.02588	.02608	.02627
.0007	.02646	.02665	.02683	.02702	.02720	.02739	.02757	.02775	.02793	.02811
.0008	.02828	.02846	.02864	.02881	.02898	.02915	.02933	.02950	.02966	.02983
.0009	.03000	.03017	.03033	.03050	.03066	.03082	.03098	.03114	.03130	.03146
.0010	.03162	.03178	.03194	.03209	.03225	.03240	.03256	.03271	.03286	.03302
.001	.03162	.03317	.03464	.03606	.03742	.03873	.04000	.04123	.04243	.04359
.002	.04472	.04583	.04690	.04796	.04899	.05000	.05099	.05196	.05292	.05385
.003	.05477	.05568	.05657	.05745	.05831	.05916	.06000	.06083	.06164	.06245
.004	.06325	.06403	.06481	.06557	.06633	.06708	.06782	.06856	.06928	.07000
.005	.07071	.07141	.07211	.07280	.07348	.07416	.07483	.07550	.07616	.07681
.006	.07746	.07810	.07874	.07937	.08000	.08062	.08124	.08185	.08246	.08307
.007	.08367	.08426	.08485	.08544	.08602	.08660	.08718	.08775	.08832	.08888
.008	.08944	.09000	.09055	.09110	.09165	.09220	.09274	.09327	.09381	.09434
.009	.09487	.09539	.09592	.09644	.09695	.09747	.09798	.09849	.09899	.09950
.010	.10000	.10050	.10100	.10149	.10198	.10247	.10296	.10344	.10392	.10440
.01	.1000	.1049	.1095	.1140	.1183	.1225	.1265	.1304	.1342	.1378
.02	.1414	.1449	.1483	.1517	.1549	.1581	.1612	.1643	.1673	.1703
.03	.1732	.1761	.1789	.1817	.1844	.1871	.1897	.1924	.1949	.1975
.04	.2000	.2025	.2049	.2074	.2098	.2121	.2145	.2168	.2191	.2214
.05	.2236	.2258	.2280	.2302	.2324	.2345	.2366	.2387	.2408	.2429
.06	.2449	.2470	.2490	.2510	.2530	.2550	.2569	.2588	.2608	.2627
.07	.2646	.2665	.2683	.2702	.2720	.2739	.2757	.2775	.2793	.2811
.08	.2828	.2846	.2864	.2881	.2898	.2915	.2933	.2950	.2966	.2983
.09	.3000	.3017	.3033	.3050	.3066	.3082	.3098	.3114	.3130	.3146
.10	.3162	.3178	.3194	.3209	.3225	.3240	.3256	.3271	.3286	.3302

Table A-2

THREE-EIGHTHS POWERS OF NUMBERS

No.	0	2	4	6	8	No.	0	2	4	6	8
0	.00	.55	.71	.83	.92	50	4.34	4.40	4.46	4.52	4.58
1	1.00	1.07	1.13	1.19	1.25	60	4.64	4.70	4.76	4.81	4.87
2	1.30	1.34	1.39	1.43	1.47	70	4.92	4.97	5.02	5.07	5.12
3	1.51	1.55	1.58	1.62	1.65	80	5.17	5.22	5.27	5.31	5.36
4	1.68	1.71	1.74	1.77	1.80	90	5.41	5.45	5.49	5.54	5.58
5	1.83	1.86	1.88	1.91	1.93	100	5.62	5.67	5.71	5.75	5.79
6	1.96	1.98	2.01	2.03	2.05	110	5.83	5.87	5.91	5.95	5.98
7	2.07	2.10	2.12	2.14	2.16	120	6.02	6.06	6.10	6.13	6.17
8	2.18	2.20	2.22	2.24	2.26	130	6.20	6.24	6.28	6.31	6.35
9	2.28	2.30	2.32	2.34	2.35	140	6.38	6.41	6.45	6.48	6.51
10	2.37	2.39	2.41	2.42	2.44	150	6.55	6.58	6.61	6.64	6.68
11	2.46	2.47	2.49	2.51	2.52	160	6.71	6.74	6.77	6.80	6.83
12	2.54	2.56	2.57	2.59	2.60	170	6.86	6.89	6.92	6.95	6.98
13	2.62	2.63	2.65	2.66	2.68	180	7.01	7.04	7.07	7.10	7.12
14	2.69	2.71	2.72	2.73	2.75	190	7.15	7.18	7.21	7.24	7.27
15	2.76	2.77	2.79	2.80	2.81	200	7.29	7.32	7.35	7.37	7.40
16	2.83	2.84	2.86	2.87	2.88	210	7.43	7.46	7.48	7.51	7.54
17	2.89	2.91	2.92	2.93	2.94	220	7.56	7.58	7.61	7.63	7.66
18	2.96	2.97	2.98	2.99	3.00	230	7.69	7.71	7.73	7.76	7.78
19	3.02	3.03	3.04	3.05	3.06	240	7.81	7.83	7.86	7.88	7.91
20	3.08	3.09	3.10	3.11	3.12	250	7.93	7.95	7.98	8.00	8.02
21	3.13	3.14	3.15	3.17	3.18	260	8.05	8.07	8.09	8.12	8.14
22	3.19	3.20	3.21	3.22	3.23	270	8.16	8.18	8.21	8.23	8.25
23	3.24	3.25	3.26	3.27	3.28	280	8.27	8.30	8.32	8.34	8.36
24	3.29	3.30	3.31	3.32	3.33	290	8.38	8.40	8.43	8.45	8.47
25	3.34	3.35	3.36	3.37	3.38	300	8.49	8.51	8.53	8.55	8.57
26	3.39	3.40	3.41	3.42	3.43	310	8.60	8.62	8.64	8.66	8.68
27	3.44	3.45	3.46	3.47	3.48	320	8.70	8.72	8.74	8.76	8.78
28	3.49	3.50	3.51	3.52	3.53	330	8.80	8.82	8.84	8.86	8.88
29	3.54	3.54	3.55	3.56	3.57	340	8.90	8.92	8.94	8.96	8.98
30	3.58	3.59	3.60	3.61	3.62	350	9.00	9.01	9.03	9.05	9.07
31	3.62	3.63	3.64	3.65	3.66	360	9.09	9.11	9.13	9.15	9.17
32	3.67	3.68	3.69	3.69	3.70	370	9.18	9.20	9.22	9.24	9.26
33	3.71	3.72	3.73	3.74	3.74	380	9.28	9.30	9.31	9.33	9.35
34	3.75	3.76	3.77	3.78	3.79	390	9.37	9.39	9.40	9.42	9.44
35	3.79	3.80	3.81	3.82	3.83	400	9.46	9.48	9.49	9.51	9.53
36	3.83	3.84	3.85	3.86	3.87	410	9.55	9.56	9.58	9.60	9.61
37	3.87	3.88	3.89	3.90	3.91	420	9.63	9.65	9.67	9.68	9.70
38	3.91	3.92	3.93	3.94	3.94	430	9.72	9.73	9.75	9.77	9.78
39	3.95	3.96	3.97	3.97	3.98	440	9.80	9.82	9.83	9.85	9.87
40	3.99	4.00	4.00	4.01	4.02	450	9.88	9.90	9.92	9.93	9.95
41	4.03	4.03	4.04	4.05	4.05	460	9.97	9.98	10.00	10.01	10.03
42	4.06	4.07	4.08	4.08	4.09	470	10.05	10.06	10.08	10.09	10.11
43	4.10	4.10	4.11	4.12	4.13	480	10.13	10.14	10.16	10.17	10.19
44	4.13	4.14	4.15	4.15	4.16	490	10.21	10.22	10.24	10.25	10.27
45	4.17	4.18	4.18	4.19	4.20	500	10.28	10.30	10.31	10.33	10.34
46	4.20	4.21	4.22	4.22	4.23	510	10.36	10.37	10.39	10.41	10.42
47	4.24	4.24	4.25	4.26	4.26	520	10.44	10.45	10.47	10.48	10.50
48	4.27	4.28	4.28	4.29	4.30	530	10.51	10.52	10.54	10.55	10.57
49	4.30	4.31	4.32	4.32	4.33	540	10.58	10.60	10.61	10.63	10.64

Table A-3

TWO-THIRDS POWERS OF NUMBERS

No.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.000	.046	.074	.097	.117	.136	.153	.170	.186	.201
.1	.215	.229	.243	.256	.269	.282	.295	.307	.319	.331
.2	.342	.353	.364	.375	.386	.397	.407	.418	.428	.438
.3	.448	.458	.468	.477	.487	.497	.506	.515	.525	.534
.4	.543	.552	.561	.570	.578	.587	.596	.604	.613	.622
.5 .6 .7 .8	.630 .711 .788 .862 .932	.638 .719 .796 .869 .939	.647 .727 .803 .876 .946	.655 .735 .811 .883 .953	.663 .743 .818 .890 .960	.671 .750 .825 .897 .966	.679 .758 .832 .904 .973	.687 .765 .840 .911 .980	.695 .773 .847 .918 .987	.703 .781 .855 .925 .993
1.0	1.000	1.007	1.013	1.020	1.027	1.033	1.040	1.046	1.053	1.059
1.1	1.065	1.072	1.078	1.085	1.091	1.097	1.104	1.110	1.117	1.123
1.2	1.129	1.136	1.142	1.148	1.154	1.160	1.167	1.173	1.179	1.185
1.3	1.191	1.197	1.203	1.209	1.215	1.221	1.227	1.233	1.239	1.245
1.4	1.251	1.257	1.263	1.269	1.275	1.281	1.287	1.293	1.299	1.305
1.5	1.310	1.316	1.322	1.328	1.334	1.339	1.345	1.351	1.357	1.362
1.6	1.368	1.374	1.379	1.385	1.391	1.396	1.402	1.408	1.413	1.419
1.7	1.424	1.430	1.436	1.441	1.447	1.452	1.458	1.463	1.469	1.474
1.8	1.480	1.485	1.491	1.496	1.502	1.507	1.513	1.518	1.523	1.529
1.9	1.534	1.539	1.545	1.550	1.556	1.561	1.566	1.571	1.577	1.582
2.0	1.587	1.593	1.598	1.603	1.608	1.613	1.619	1.624	1.629	1.634
2.1	1.639	1.645	1.650	1.655	1.660	1.665	1.671	1.676	1.681	1.686
2.2	1.691	1.697	1.702	1.707	1.712	1.717	1.722	1.727	1.732	1.737
2.3	1.742	1.747	1.752	1.757	1.762	1.767	1.772	1.777	1.782	1.787
2.4	1.792	1.797	1.802	1.807	1.812	1.817	1.822	1.827	1.832	1.837
2.5	1.842	1.847	1.852	1.857	1.862	1.867	1.871	1.876	1.881	1.886
2.6	1.891	1.896	1.900	1.905	1.910	1.915	1.920	1.925	1.929	1.934
2.7	1.939	1.944	1.949	1.953	1.958	1.963	1.968	1.972	1.977	1.982
2.8	1.987	1.992	1.996	2.001	2.006	2.010	2.015	2.020	2.024	2.029
2.9	2.034	2.038	2.043	2.048	2.052	2.057	2.062	2.066	2.071	2.075
3.0	2.080	2.085	2.089	2.094	2.099	2.103	2.108	2.112	2.117	2.122
3.1	2.126	2.131	2.135	2.140	2.144	2.149	2.153	2.158	2.163	2.167
3.2	2.172	2.176	2.180	2.185	2.190	2.194	2.199	2.203	2.208	2.212
3.3	2.217	2.221	2.226	2.230	2.234	2.239	2.243	2.248	2.252	2.257
3.4	2.261	2.265	2.270	2.274	2.279	2.283	2.288	2.292	2.296	2.301
3.5	2.305	2.310	2.314	2.318	2.323	2.327	2.331	2.336	2.340	2.345
3.6	2.349	2.353	2.358	2.362	2.366	2.371	2.375	2.379	2.384	2.388
3.7	2.392	2.397	2.401	2.405	2.409	2.414	2.418	2.422	2.427	2.431
3.8	2.435	2.439	2.444	2.448	2.452	2.457	2.461	2.465	2.469	2.474
3.9	2.478	2.482	2.486	1.490	2.495	2.499	2.503	2.507	2.511	2.516
4.0	2.520	2.524	2.528	2.532	2.537	2.541	2.545	2.549	2.553	2.558
4.1	2.562	2.566	2.570	2.574	2.579	2.583	2.587	2.591	2.595	2.599
4.2	2.603	2.607	2.611	2.616	2.620	2.624	2.628	2.632	2.636	2.640
4.3	2.644	2.648	2.653	2.657	2.661	2.665	2.669	2.673	2.677	2.681
4.4	2.685	2.689	2.693	2.698	2.702	2.706	2.710	2.714	2.718	2.722
4.5	2.726	2.730	2.734	2.738	2.742	2.746	2.750	2.754	2.758	2.762
4.6	2.766	2.770	2.774	2.778	2.782	2.786	2.790	2.794	2.798	2.802
4.7	2.806	2.810	2.814	2.818	2.822	2.826	2.830	2.834	2.838	2.842
4.8	2.846	2.850	2.854	2.858	2.862	2.865	2.869	2.873	2.877	2.881
4.9	2.885	2.889	2.893	2.897	2.901	2.904	2.908	2.912	2.916	2.920

Table A-4

EIGHT-THIRDS POWERS OF NUMBERS

No.	.00	.02	.04	.06	.08	No.	.00	.02	.04	.06	.08
0.1 0.2 0.3 0.4 0.5	.002 .014 .040 .087 .157	.004 .018 .048 .099	.005 .022 .056 .112 .193	.008 .028 .066 .126 .213	.010 .034 .076 .141 .234	5.1 5.2 5.3 5.4 5.5	77.1 81.2 85.4 89.8 94.3	77.9 82.0 86.3 90.6 95.2	78.7 82.8 87.1 91.5 96.1	79.5 83.7 88.0 92.4 97.0	80.3 84.5 88.9 93.3 98.0
0.6	.256	.279	.304	.330	.358	5.6	98.9	99.8	101	102	103
0.7	.386	.416	.448	.481	.516	5.7	104	105	106	107	108
0.8	.552	.589	.628	.669	.711	5.8	109	110	111	112	113
0.9	.755	.801	.848	.897	.948	5.9	114	115	116	117	118
1.0	1.000	1.054	1.110	1.168	1.228	6.0	119	120	121	122	123
1.1	1.29	1.35	1.42	1.49	1.55	6.1	124	125	126	128	129
1.2	1.63	1.70	1.77	1.85	1.93	6.2	130	131	132	133	134
1.3	2.01	2.10	2.18	2.27	2.36	6.3	135	137	138	139	140
1.4	2.45	2.55	2.64	2.74	2.84	6.4	141	142	144	145	146
1.5	2.95	3.05	3.16	3.27	3.39	6.5	147	148	150	151	152
1.6	3.50	3.62	3.74	3.86	3.99	6.6	153	155	156	157	158
1.7	4.12	4.25	4.38	4.51	4.65	6.7	160	161	162	163	165
1.8	4.79	4.94	5.08	5.23	5.39	6.8	166	167	169	170	171
1.9	5.54	5.69	5.85	6.02	6.18	6.9	173	174	175	177	178
2.0	6.35	6.52	6.69	6.87	7.05	7.0	179	181	182	183	185
2.1	7.23	7.42	7.60	7.80	7.99	7.1	186	188	189	190	192
2.2	8.19	8.39	8.59	8.80	9.00	7.2	193	195	196	198	199
2.3	9.22	9.43	9.65	9.87	10.10	7.3	201	202	203	205	206
2.4	10.33	10.56	10.79	11.03	11.27	7.4	208	209	211	212	214
2.5	11.51	11.76	12.01	12.26	12.52	7.5	216	217	219	220	222
2.6	12.8	13.0	13.3	13.6	13.9	7.6	223	225	226	228	230
2.7	14.1	14.4	14.7	15.0	15.3	7.7	231	233	234	236	238
2.8	15.6	15.9	16.2	16.5	16.8	7.8	239	241	243	244	246
2.9	17.1	17.4	17.7	18.1	18.4	7.9	248	249	251	253	254
3.0	18.7	19.1	19.4	19.7	20.1	8.0	256	258	259	261	263
3.1	20.4	20.8	21.1	21.5	21.9	8.1	265	266	268	270	272
3.2	22.2	22.6	23.0	23.4	23.7	8.2	273	275	277	279	281
3.3	24.1	24.5	24.9	25.3	25.7	8.3	282	284	286	288	290
3.4	26.1	26.6	27.0	27.4	27.8	8.4	292	293	295	297	299
3.5	28.2	28.7	29.1	29.5	30.0	8.5	301	303	305	307	309
3.6	30.4	30.9	31.4	31.8	32.3	8.6	310	312	314	316	318
3.7	32.7	33.2	33.7	34.2	34.7	8.7	320	322	324	326	328
3.8	35.2	35.7	36.2	36.7	37.2	8.8	330	332	334	336	338
3.9	37.7	38.2	38.7	39.3	39.8	8.9	340	342	344	346	348
4.0	40.3	40.9	41.4	42.0	42.5	9.0	350	353	355	357	359
4.1	43.1	43.6	44.2	44.8	45.3	9.1	361	363	365	367	369
4.2	45.9	46.5	47.1	47.7	48.3	9.2	372	374	376	378	380
4.3	48.9	49.5	50.1	50.7	51.4	9.3	382	385	387	390	391
4.4	52.0	52.6	53.3	53.9	54.5	9.4	394	396	398	400	403
4.5	55.2	55.9	56.5	57.2	57.9	9.5	405	407	409	412	414
4.6	58.5	59.2	59.9	60.6	61.3	9.6	416	419	421	423	426
4.7	62.0	62.7	63.4	64.1	64.8	9.7	428	429	433	435	437
4.8	65.6	66.3	67.0	67.8	68.5	9.8	440	442	445	447	449
4.9	69.3	70.0	70.8	71.6	72.3	9.9	452	454	457	459	462
5.0	73.1	73.9	74.7	75.5	76.3	10.0	464	467	469	472	474

Table A-5

SQUARE ROOTS AND CUBE ROOTS OF NUMBERS

No.	Square Root	Cube Root	No.	Square Root	Cube Root	No.	Square Root	Cube Root	No	Square Root	Cube Root
1	1.000	1.000	26	5.099	2.963	51	7.141	3.708	76	8.718	4.236
2	1.414	1.260	27	5.196	3.000	52	7.211	3.733	77	8.775	4.254
3	1.732	1.442	28	5.292	3.037	53	7.280	3.756	78	8.832	4.273
4	2.000	1.587	29	5.385	3.072	54	7.348	3.780	79	8.888	4.291
5	2.236	1.710	30	5.477	3.107	55	7.416	3.803	80	8.944	4.309
6	2.449	1.817	31	5.568	3.141	56	7.483	3.826	81	9.000	4.327
7	2.646	1.913	32	5.657	3.175	57	7.550	3.849	82	9.055	4.345
8	2.828	2.000	33	5.745	3.208	58	7.616	3.871	83	9.110	4.362
9	3.000	2.080	34	5.831	3.240	59	7.681	3.893	84	9.165	4.380
10	3.162	2.154	35	5.916	3.271	60	7.746	3.915	85	9.220	4.397
11	3.317	2.224	36	6.000	3.302	61	7.810	3.937	86	9.274	4.414
12	3.464	2.289	37	6.083	3.332	62	7.874	3.958	87	9.327	4.431
13	3.606	2.351	38	6.164	3.362	63	7.937	3.979	88	9.381	4.448
14	3.742	2.410	39	6.245	3.391	64	8.000	4.000	89	9.434	4.465
15	3.873	2.466	40	6.325	3.420	65	8.062	4.021	90	9.487	4.481
16	4.000	2.520	41	6.403	3.448	66	8.124	4.041	91	9.539	4.498
17	4.123	2.571	42	6.481	3.476	67	8.185	4.062	92	9.592	4.514
18	4.243	2.621	43	6.557	3.503	68	8.246	4.082	93	9.644	4.531
19	4.359	2.668	44	6.633	3.530	69	8.307	4.102	94	9.695	4.547
20	4.472	2.714	45	6.708	3.557	70	8.367	4.121	95	9.747	4.563
21	4.583	2.759	46	6.782	3.583	71	8.426	4.141	96	9.798	4.579
22	4.690	2.802	47	6.856	3.609	72	8.485	4.160	97	9.849	4.595
23	4.796	2.844	48	6.928	3.634	73	8.544	4.179	98	9.900	4.610
24	4.899	2.885	49	7.000	3.659	74	8.602	4.198	99	9.950	4.626
25	5.000	2.924	50	7.071	3.684	75	8.660	4.217	100	10.000	4.642

For Square Roots — moving the decimal point 2 places in the number requires a change of 1 place in the square root. For Cube Roots — moving the decimal point 3 places in the number requires a change of 1 place in the cube root.

Table A-6

DECIMAL EQUIVALENTS OF INCHES AND FEET

		DECI	WAL	EGUIVA	ILENI	3 UF	INCHES	AND	FEE	ı	
Fra	octions of	Inch Equiv- alents to Foot	Fra	octions of	Inch Equiv- alents to Foot	Fra	octions of	Inch Equiv- alents to Foot	Fr	actions of	Inch Equiv- alents to Foot
Inch	Foot	Frac- tions	Inch	Foot	Frac- tions	Inch	Foot	Frac- tions	Inch	Foot	Frac- tions
	.005208 .010417	1/16 1/8		.255208 .260417	3½ 3½ 3½		.505208 .510417	6½ 6½		.755208 .760417	9½ 9½ 8
1/64	.015625 .020833 .026042	3/16 1/4 5/16	17/64	.265625 .270833 .276042	3 ³ / ₁₆ 3 ¹ / ₄ 3 ⁵ / ₁₆	33/64	.515625 .520833 .526042	6 ³ /16 6 ¹ /4 6 ⁵ /16	49/64	.765625 .770833 .776042	9 ³ / ₁₆ 9 ¹ / ₄ 9 ⁵ / ₁₆
1/32	.031250 .036458 .041667	3/8 7/16 1/2	9/32	.281250 .286458 .291667	33/8 37/16 31/2	17/32	.531250 .536458 .541667	63/8 6 ⁷ /16 6 ¹ /2	25/32	.781250 .786458 .791667	93/8 97/16 91/2
3/64	.046875 .052083 .057292	9/16 5/8 11/ ₁₆	19/64	.296875 .302083 .307292	3%16 35/8 311/16	35/64	.546875 .552083 .557292	6%4 6% 611/16	51/64	.796875 .802083 .807292	9%16 95/8 911/16
1/16	.062500 .067708 .072917	3/4 13/ ₁₆ 7/8	5/16	.312500 .317708 .322917	3 ³ / ₄ 3 ¹³ / ₁₆ 3 ⁷ / ₈	9/16	.562500 .567708 .572917	6¾ 6¹¾ 6⅓ 6¾	13/16	.812500 .817708 .822917	9¾ 9¹³/₁6 9¾
5/64	.078125 .083333 .088542	15/16 1 11/16	21/64	.328125 .333333 .338542	3 ¹⁵ /16 4 4 ¹ /16	37/64	.578125 .583333 .588542	6 ¹⁵ /16 7 7 ¹ /16	53/64	.828125 .833333 .838542	9 ¹⁵ / ₁₆ 10 10 ¹ / ₁₆
3/32	.093750 .098958 .104167	1½8 1¾16 1¼4	11/32	.343750 .348958 .354167	4½ 4¾ 6 4¼	19/32	.593750 .598958 .604167	7½ 7¾ 6 7¼	²⁷ / ₃₂	.843750 .848958 .854167	10½ 10¾ 10¼ 10¼
7/64	.109375 .114583 .119792	15/16 13/8 17/16	²³ /64	.359375 .364583 .369792	4 ⁵ / ₁₆ 4 ³ / ₈ 4 ⁷ / ₁₆	39/64	.609375 .614583 .619792	75/16 73/8 77/16	55/64	.859375 .864583 .869792	105/16 103/8 107/16
1/8	.125000 .130208 .135417	1½ 1% 1% 1%	3/8	.375000 .380208 .385417	4½ 4% 4% 45%	5⁄8	.625000 .630208 .635417	7½ 7% 75/8	7/8	.875000 .880208 .885417	10½ 10% 10% 10%
%4	.140625 .145833 .151042	111/16 13/4 113/16	²⁵ / ₆₄	.390625 .395833 .401042	4 ¹¹ / ₁₆ 4 ³ / ₄ 4 ¹³ / ₁₆	41/64	.640625 .645833 .651042	7 ¹ 1/ ₁₆ 7 ³ / ₄ 7 ¹³ / ₁₆	⁵⁷ /64	.890625 .895833 .901042	10 ¹ / ₁₆ 10 ³ / ₄ 10 ¹³ / ₁₆
5/32	.156250 .161458 .166667	17/8 115/16 2	13/32	.406250 .411458 .416667	47/8 4 ^{15/} 16 5	²¹ / ₃₂	.656250 .661458 .666667	7	²⁹ /32	.906250 .911458 .916667	10 % 10 ½ 11
11/64	.171875 .177083 .182292	2½16 2½8 2¾16	²⁷ /64	.421875 .427083 .432292	5½16 51/8 5¾16	43/64	.671875 .677083 .682292	8 ¹ / ₁₆ 8 ¹ / ₈ 8 ³ / ₁₆	59/64	.921875 .927083 .932292	11½ 11½ 11½ 11¾
3/16	.187500 .192708 .197917	2½ 25/16 23/8	7/16	.437500 .442708 .447917	5½ 5½ 5¾ 5¾	11/16	.687500 .692708 .697917	8½ 85/16 83/8	15/16	.937500 .942708 .947917	11½ 11½ 11½ 11¾
13/64	.203125 .208333 .213542	2 ⁷ /16 2 ¹ /2 2 ⁹ /16	29/64	.453125 .458333 .463542	5½ 5½ 5% 6	45/64	.703125 .708333 .713542	8 ⁷ /16 8 ¹ /2 8 ⁹ /16	61/64	.953125 .958333 .963542	11½ 11½ 11% 11%
7/32	.218750 .223958 .229167	25/8 2 ¹ 1/ ₁₆ 23/4	15/32	.468750 .473958 .479167	55/8 511/16 53/4	²³ / ₃₂	.718750 .723958 .729167	85/8 811/16 83/4	31/32	.968750 .973958 .979167	115/8 1111/16 113/4
15/64	.234375 .229583 .244792	2 ¹³ / ₁₆ 2 ⁷ / ₈ 2 ¹⁵ / ₁₆	31/64	.484375 .489583 .494792	5 ¹³ /16 5 7/8 5 ¹⁵ /16	47/64	.734375 .739583 .744792	8 ¹³ / ₁₆ 87/ ₈ 8 ¹⁵ / ₁₆	⁶³ / ₆₄	.984375 .989583 .994792	11 ¹³ / ₁₆ 11 ⁷ / ₈ 11 ¹⁵ / ₁₆
1/4	.2500	3	1/2	.5000	6	3/4	.7500	9	1	1.0000	12

Table A-7

VARIOUS POWERS OF PIPE DIAMETERS

P Dia	ipe neter							
ln.	Ft.(D)	D1/3	D ² / ³	D4/3	D ₈ / ₃	D ⁵ / ²	D16/3	D⁴
6	0.50	0.794	0.630	0.397	0.157	0.177	0.025	0.063
8	0.67	0.874	0.763	0.582	0.339	0.363	0.115	0.198
9	0.75	0.909	0.825	0.681	0.464	0.487	0.216	0.316
10	0.83	0.941	0.886	0.784	0.615	0.634	0.378	0.482
12	1.00	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	1.25	1.077	1.160	1.347	1.813	1.747	3.287	2.441
16	1.33	1.101	1.211	1.468	2.154	2.053	4.638	3.160
18	1.50	1.145	1.310	1.717	2.948	2.756	8.693	5.063
21	1.75	1.205	1.452	2.109	4.447	4.051	19.78	9.379
24	2.00	1.260	1.587	2.520	6.35	5.657	40.32	16.00
27	2.25	1.310	1.717	2.948	8.69	7.594	75.56	25.63
30	2.50	1.357	1.842	3.393	11.51	9.882	132.5	39.06
33	2.75	1.401	1.963	3.853	14.84	12.54	220.3	57.19
36	3.00	1.442	2.080	4.327	18.72	15.59	350.4	81.0
39	3.25	1.481	2.194	4.814	23.17	19.04	537.1	111.6
42	3.50	1.518	2.305	5.314	28.24	22.92	797.5	150.1
45	3.75	1.554	2.414	5.826	33.94	27.23	1152.	197.8
48	4.0	1.587	2.520	6.35	40.32	32.00	1626.	256.0
54	4.5	1.651	2.726	7.43	55.20	42.96	3047.	410.1
60	5.0	1.710	2.924	8.55	73.10	55.90	5344.	625.0
66	5.5	1.765	3.116	9.71	94.25	70.94	8883.	915.1
72	6.0	1.817	3.302	10.90	118.8	88.2	14130	1296
78	6.5	1.866	3.483	12.13	147.1	107.7	21654	1785
84	7.0	1.913	3.659	13.39	179.3	129.6	32148	2401
90	7.5	1.957	3.832	14.68	215.5	154.0	46451	3164
96	8.0	2.000	4.00	16.00	256	181.0	65536	4096
102	8.5	2.041	4.17	17.35	301	210.6	90552	5220
108	9.0	2.080	4.33	18.72	350	243.0	122827	6561
114	9.5	2.118	4.49	20.12	405	278.2	163879	8145
120	10.0	2.154	4.64	21.54	464	316	215443	10000
132	11.0	2.224	4.95	24.46	598	401	358173	14641
144	12.0	2.289	5.24	27.47	755	499	569680	20736
156	13.0	2.351	5.53	30.57	934	609	873031	28561
168	14.0	2.410	5.81	33.74	1140	733	1296200	38416
180	15.0	2.466	6.08	36.99	1370	871	1872800	50625

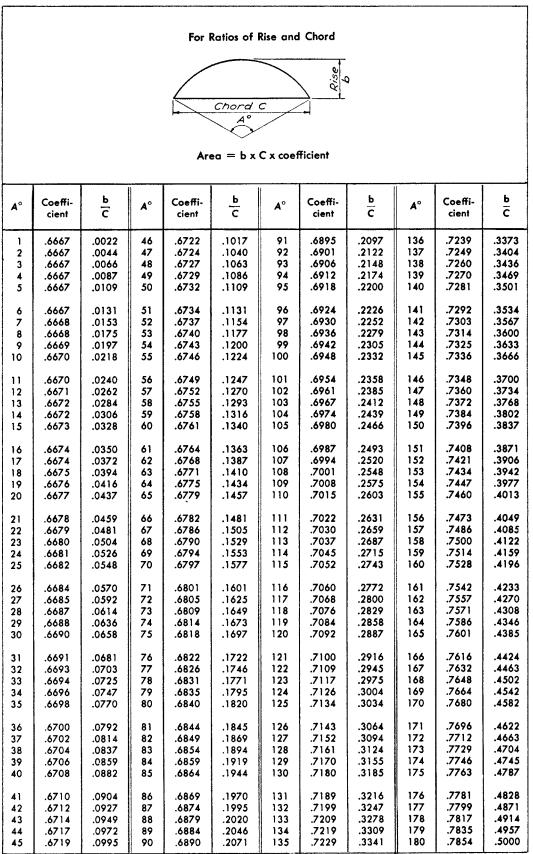
Table A-8

AREAS OF CIRCULAR SECTIONS (Square Feet)

Diam	neter						-		
Inches	Feet and inches	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	0-0		.0001	.0003	.0008	.0014	.0021	.0031	.0042
1	0-1	.0055	.0069	.0085	.0103	.0123	.0144	.0167	.0192
2	0-2	.0218	.0246	.0276	.0308	.0341	.0376	.0413	.0451
3	0-3	.0491	.0533	.0576	.0621	.0668	.0717	.0767	.0819
4	0-4	.0873	.0928	.0985	.1044	.1104	.1167	.1231	.1296
5	0-5	.1364	.1433	.1503	.1576	.1650	.1726	.1803	.1883
6	0-6	.1963	.2046	.2131	.2217	.2304	.2394	.2485	.2578
7	0-7	.2673	.2769	.2867	.2967	.3068	.3171	.3276	.3382
8	0-8	.3491	.3601	.3712	.3826	.3941	.4057	.4176	.4296
9	0-9	.4418	.4541	.4667	.4794	.4922	.5053	.5185	.5319
10	0-10	.5454	.5591	.5730	.5871	.6013	.6157	.6303	.6450
11	0-11	.6600	.6750	.6903	.7057	.7213	.7371	.7530	.7691
12	1-0	.7854	.8018	.8185	.8353	.8522	.8693	.8866	.9041
13	1-1	.9218	.9396	.9575	.9757	.9940	1.013	1.031	1.050
14	1-2	1.069	1.088	1.108	1.127	1.147	1.167	1.187	1.207
15	1-3	1.227	1.248	1.268	1.289	1.310	1.332	1.353	1.375
16	1-4	1.396	1.418	1.440	1.462	1.485	1.507	1.530	1.553
17	1-5	1.576	1.600	1.623	1.647	1.670	1.694	1.718	1.743
18	1-6	1.767	1.792	1.817	1.842	1.867	1.892	1.917	1.943
19	1-7	1.969	1.995	2.021	2.047	2.074	2.101	2.127	2.154
20	1-8	2.182	2.209	2.237	2.264	2.292	2.320	2.348	2.377
21	1-9	2.405	2.434	2.463	2.492	2.521	2.551	2.580	2.610
22	1-10	2.640	2.670	2.700	2.731	2.761	2.792	2.823	2.854
23	1-11	2.885	2.917	2.948	2.980	3.012	3.044	3.076	3.109
24	2-0	3.142	3.174	3.207	3.241	3.274	3.307	3.341	3.375
25	2-1	3.409	3.443	3.477	3.512	3.547	3.581	3.616	3.652
26	2-2	3.687	3.723	3.758	3.794	3.830	3.866	3.903	3.939
27	2-3	3.976	4.013	4.050	4.087	4.125	4.162	4.200	4.238
28	2-4	4.276	4.314	4.353	4.391	4.430	4.469	4.508	4.547
29	2-5	4.587	4.627	4.666	4.706	4.746	4.787	4.827	4.868
30	2-6	4.909	4.950	4.991	5.032	5.074	5.115	5.157	5.199
31	2-7	5.241	5.284	5.326	5.369	5.412	5.455	5.498	5.541
32	2-8	5.585	5.629	5.673	5.717	5.761	5.805	5.850	5.895
33	2-9	5.940	5.985	6.030	6.075	6.121	6.167	6.213	6.259
34	2-10	6.305	6.351	6.398	6.445	6.492	6.539	6.586	6.634
35	2-11	6.681	6.729	6.777	6.825	6.874	6.922	6.971	7.020
36	3-0	7.069	7.118	7.167	7.217	7.266	7.316	7.366	7.416
37	3-1	7.467	7.517	7.568	7.619	7.670	7.721	7.773	7.824
38	3-2	7.876	7.928	7.980	8.032	8.084	8.137	8.190	8.243
39	3-3	8.296	8.349	8.402	8.456	8.510	8.564	8.618	8.672
40	3-4	8.727	8.781	8.836	8.891	8.946	9.001	9.057	9.113
41	3-5	9.168	9.224	9.281	9.337	9.393	9.450	9.507	9.564
42	3-6	9.621	9.678	9.736	9.794	9.852	9.910	9.968	10.03
43	3-7	10.08	10.14	10.20	10.26	10.32	10.38	10.44	10.50
44	3-8	10.56	10.62	10.68	10.74	10.80	10.86	10.92	10.98
45	3-9	11.04	11.11	11.17	11.23	11.29	11.35	11.42	11.48
46	3-10	11.54	11.60	11.67	11.73	11.79	11.86	11.92	11.98
47	3-11	12.05	12.11	12.18	12.24	12.31	12.37	12.44	12.50
48	4-0	12.57	12.63	12.70	12.76	12.83	12.90	12.96	13.03
49	4-1	13.10	13.16	13.23	13.30	13.36	13.43	13.50	13.57

Table A-9

AREAS OF CIRCULAR SEGMENTS



C DIRTESY OF CONCRETE REINFORCING STEEL INSTITUTE

Table A-10

AREA, WETTED PERIMETER AND HYDRAULIC RADIUS OF PARTIALLY FILLED CIRCULAR PIPE

d	area	wet. per.	hyd. rad.	d	area	wet. per.	hyd. rad.
D	D²	D	D	D	D²	D	D
0.01	0.0013	0.2003	0.0066	0.51	0.4027	1.5908	0.2531
0.02	0.0037	0.2838	0.0132	0.52	0.4127	1.6108	0.2561
0.03	0.0069	0.3482	0.0197	0.53	0.4227	1.6308	0.2591
0.04	0.0105	0.4027	0.0262	0.54	0.4327	1.6509	0.2620
0.05	0.0147	0.4510	0.0326	0.55	0.4426	1.6710	0.2649
0.06 0.07 0.08 0.09	0.0192 0.0242 0.0294 0.0350 0.0409	0.4949 0.5355 0.5735 0.6094 0.6435	0.0389 0.0451 0.0513 0.0574 0.0635	0.56 0.57 0.58 0.59 0.60	0.4526 0.4625 0.4723 0.4822 0.4920	1.6911 1.7113 1.7315 1.7518 1.7722	0.2676 0.2703 0.2728 0.2753 0.2776
0.11	0.0470	0.6761	0.0695	0.61	0.5018	1.7926	0.2799
0.12	0.0534	0.7075	0.0754	0.62	0.5115	1.8132	0.2821
0.13	0.0600	0.7377	0.0813	0.63	0.5212	1.8338	0.2842
0.14	0.0668	0.7670	0.0871	0.64	0.5308	1.8546	0.2862
0.15	0.0739	0.7954	0.0929	0.65	0.5404	1.8755	0.2881
0.16	0.0811	0.8230	0.0986	0.66	0.5499	1.8965	0.2899
0.17	0.0885	0.8500	0.1042	0.67	0.5594	1.9177	0.2917
0.18	0.0961	0.8763	0.1097	0.68	0.5687	1.9391	0.2933
0.19	0.1039	0.9020	0.1152	0.69	0.5780	1.9606	0.2948
0.20	0.1118	0.9273	0.1206	0.70	0.5872	1.9823	0.2962
0.21	0.1199	0.9521	0.1259	0.71	0.5964	2.0042	0.2975
0.22	0.1281	0.9764	0.1312	0.72	0.6054	2.0264	0.2987
0.23	0.1365	1.0003	0.1364	0.73	0.6143	2.0488	0.2998
0.24	0.1449	1.0239	0.1416	0.74	0.6231	2.0714	0.3008
0.25	0.1535	1.0472	0.1466	0.75	0.6318	2.0944	0.3017
0.26	0.1623	1.0701	0.1516	0.76	0.6404	2.1176	0.3025
0.27	0.1711	1.0928	0.1566	0.77	0.6489	2.1412	0.3032
0.28	0.1800	1.1152	0.1614	0.78	0.6573	2.1652	0.3037
0.29	0.1890	1.1373	0.1662	0.79	0.6655	2.1895	0.3040
0.30	0.1982	1.1593	0.1709	0.80	0.6736	2.2143	0.3042
0.31	0.2074	1.1810	0.1755	0.81	0.6815	2.2395	0.3044
0.32	0.2167	1.2025	0.1801	0.82	0.6893	2.2653	0.3043
0.33	0.2260	1.2239	0.1848	0.83	0.6969	2.2916	0.3041
0.34	0.2355	1.2451	0.1891	0.84	0.7043	2.3186	0.3038
0.35	0.2450	1.2661	0.1935	0.85	0.7115	2.3462	0.3033
0.36	0.2546	1.2870	0.1978	0.86	0.7186	2.3746	0.3026
0.37	0.2642	1.3078	0.2020	0.87	0.7254	2.4038	0.3017
0.38	0.2739	1.3284	0.2061	0.88	0.7320	2.4341	0.3008
0.39	0.2836	1.3490	0.2102	0.89	0.7384	2.4655	0.2996
0.40	0.2934	1.3694	0.2142	0.90	0.7445	2.4981	0.2980
0.41	0.3032	1.3898	0.2181	0.91	0.7504	2.5322	0.2963
0.42	0.3130	1.4101	0.2220	0.92	0.7560	2.5681	0.2944
0.43	0.3229	1.4303	0.2257	0.93	0.7612	2.6061	0.2922
0.44	0.3328	1.4505	0.2294	0.94	0.7662	2.6467	0.2896
0.45	0.3428	1.4706	0.2331	0.95	0.7707	2.6906	0.2864
0.46	0.3527	1.4907	0.2366	0.96	0.7749	2.7389	0.2830
0.47	0.3627	1.5108	0.2400	0.97	0.7785	2.7934	0.2787
0.48	0.3727	1.5308	0.2434	0.98	0.7816	2.8578	0.2735
0.49	0.3827	1.5508	0.2467	0.99	0.7841	2.9412	0.2665
0.50	0.3927	1.5708	0.2500	1.00	0.7854	3.1416	0.2500

Table A-11

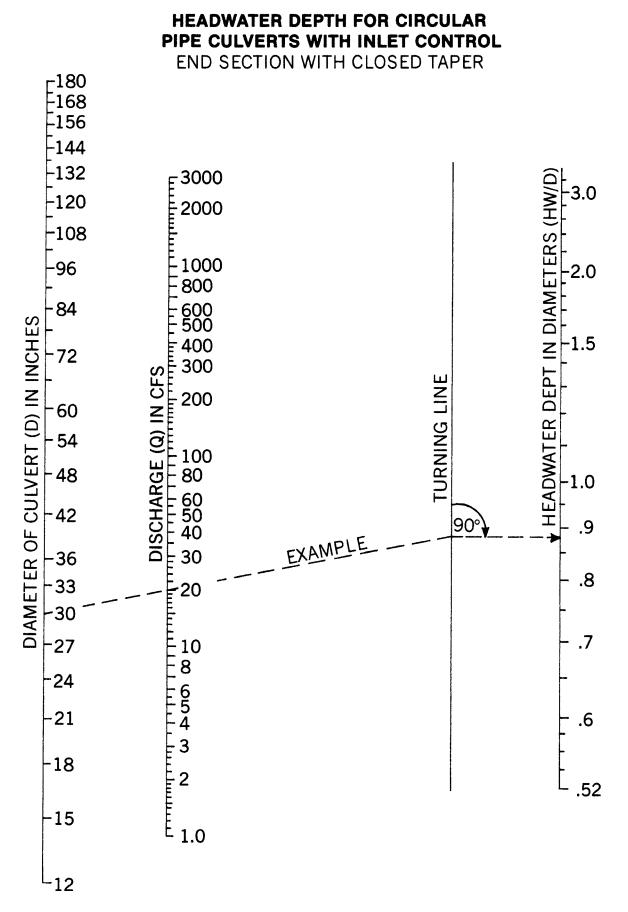
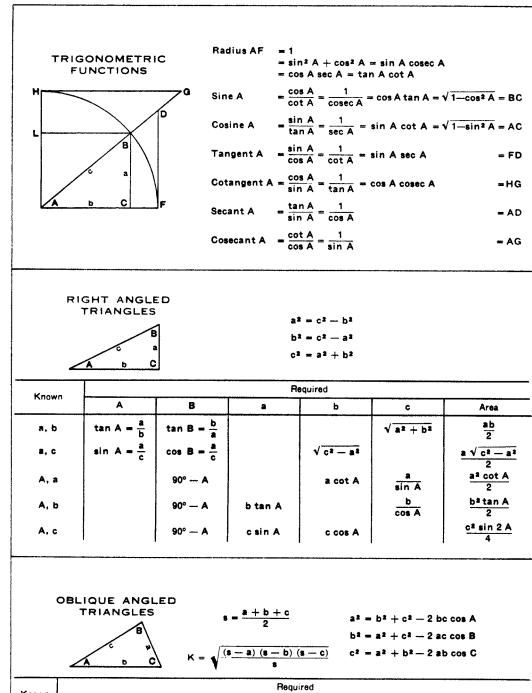


Table A-12

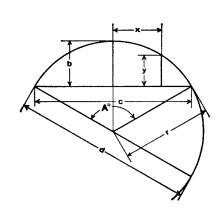
TRIGONOMETRIC FORMULAS



Known	Required								
Kilowii	Α	В	ပ	b	С	Area			
a, b, c	$\tan\frac{1}{2}A =$	$\tan\frac{1}{2}B =$	$\tan\frac{1}{2}C =$			√s (s-a) (s-b) (s-c			
	<u>K</u> s—a	<u> </u>	<u> </u>						
a, A, B			180°(A+B)	a sin B	a sin C				
a, b, A		$\sin B = \frac{b \sin A}{a}$			b sin C				
a, b. C	$\tan A = \frac{a \sin C}{b - a \cos C}$				$\sqrt{a^2+b^2-2ab\cos C}$	ab sin C			

Table A-13

PROPERTIES OF THE CIRCLE



Circumference = 6.28318 r = 3.14159 dDiameter = 0.31831 circumference

 $= 3.14159 r^2$

Arc
$$a = \frac{\pi r A^{\circ}}{180^{\circ}} = 0.017453 r A^{\circ}$$

Angle A° =
$$\frac{180^{\circ} \text{ a}}{\pi \text{ r}}$$
 = 57.29578 $\frac{\text{a}}{\text{r}}$

$$Radius r = \frac{4b^2 + c^2}{8b}$$

Chord c =
$$2\sqrt{2 br - b^2}$$
 = $2 r \sin \frac{A}{2}$

Rise b =
$$r - \frac{1}{2} \sqrt{4 r^2 - c^2} = \frac{c}{2} \tan \frac{A}{4}$$

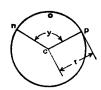
= $2 r \sin^2 \frac{A}{4} = r + y - \sqrt{r^2 - x^2}$

$$y = b - r + \sqrt{r^2 - x^2}$$

 $x = \sqrt{r^2 - (r + y - b)^2}$

Diameter of circle of equal periphery as square = 1.27324 side of square Side of square of equal periphery as circle = 0.78540 diameter of circle Diameter of circle circumscribed about square = 1.41421 side of square = 0.70711 diameter of circle

CIRCULAR SECTOR



r = radius of circle y = angle ncp in degrees Area of Sector ncpo = $\frac{1}{2}$ (length of arc nop \times r)

= Area of Circle
$$\times \frac{y}{360}$$

$$= 0.0087266 \times r^2 \times y$$

CIRCULAR SEGMENT



x = chord b = rise

Area of Segment nop = Area of Sector ncpo — Area of triangle ncp

$$= \frac{(\text{Length of arc nop } \times r) - x (r - b)}{2}$$

Area of Segment nsp = Area of Circle - Area of Segment nop

VALUES FOR FUNCTIONS OF π

 $\pi = 3.14159265359$, $\log = 0.4971499$

 $\pi^2 = 9.8696044$, $\log = 0.9942997$ $\frac{1}{\pi} = 0.3183099$, $\log = \overline{1}.5028501$ $\sqrt{\frac{1}{\pi}} = 0.5641896$, $\log = \overline{1}.7514251$

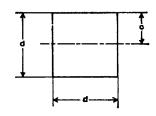
 $\pi^3 = 31.0062767$, $\log = 1.4914496$ $\frac{1}{\pi^2} = 0.1013212$, $\log = \overline{1.0057003}$ $\frac{\pi}{180} = 0.0174533$, $\log = \overline{2.2418774}$ $\sqrt{\pi} = 1.7724539$, $\log = 0.2485749$ $\frac{1}{\pi^8} = 0.0322515$, $\log = \overline{2.5085500}$ $\frac{180}{\pi} = 57.2957795$, $\log = 1.7581226$

Note: Logs of fractions such as $\overline{1}$:5028501 and $\overline{2}$.5085500 may also be written 9.5028501 - 10 and 8.5085500 - 10 respectively.

Table A-14a

SQUARE

Axis of moments through center



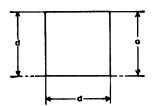
$$1 - \frac{d^4}{12}$$

$$r = \frac{d}{\sqrt{12}} = .288676 d$$

$$z = \frac{d^3}{4}$$

SQUARE

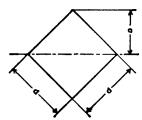
Axis of moments on base



$$r = \frac{d}{d^2} = .577350 d$$

SQUARE

Axis of moments on diagonal



c =
$$\frac{d}{\sqrt{2}}$$
 = .707107 d

$$1 - \frac{d^4}{40}$$

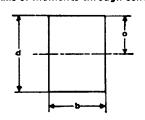
$$S = \frac{d^3}{6\sqrt{2}} = .117851 d^3$$

$$r = \frac{d}{\sqrt{35}} = .288675 d$$

$$z = \frac{2c^3}{2} - \frac{d^3}{2c^{1/3}} - .235702d^3$$

RECTANGLE

Axis of moments through center



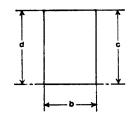
$$i = \frac{bd^3}{12}$$

$$r = \frac{d}{\sqrt{12}} = .288675 d$$

Table A-14b

RECTANGLE

Axis of moments on base



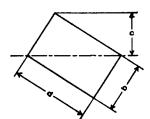
$$i = \frac{bd^3}{3}$$

$$S = \frac{bd^2}{3}$$

$$r = \frac{d}{\sqrt{2}} = .577350 d$$

RECTANGLE

Axis of moments on diagonal



$$c = \frac{bd}{\sqrt{b^2 + d^2}}$$

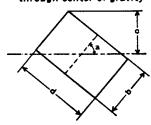
$$b^{2}d^{2} = \frac{b^{2}d^{2}}{6(b^{2}+d^{2})}$$

$$8 = \frac{b^2d^2}{6\sqrt{b^2+d^2}}$$

$$r = \frac{bd}{\sqrt{6(b^2 + d^2)}}$$

RECTANGLE

Axis of moments any line through center of gravity



$$c = \frac{b \sin a + d \cos a}{2}$$

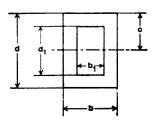
$$I = \frac{bd (b^2 \sin^2 a + d^2 \cos^2 a)}{12}$$

$$8 = \frac{bd (b^2 \sin^2 a + d^2 \cos^2 a)}{6 (b \sin a + d \cos a)}$$

$$r = \sqrt{\frac{b^2 \sin^2 a + d^2 \cos^2 a}{12}}$$

HOLLOW RECTANGLE

Axis of moments through center



$$A = bd - b_1d_1$$

$$c = \frac{d}{2}$$

$$i = \frac{bd^3 - b_1d_1^3}{12}$$

$$S = \frac{bd^3 - b_1d_1^3}{6d}$$

$$r = \sqrt{\frac{bd^3 - b_1d_1^3}{12 A}}$$

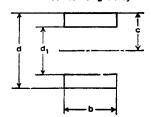
$$Z = \frac{bd^2}{4} - \frac{b_1d_1^2}{4}$$

Table A-14c

PROPERTIES OF GEOMETRIC SECTIONS

EQUAL RECTANGLES

Axis of moments through center of gravity



$$A = b (d - d_1)$$

$$c = \frac{d}{2}$$

$$I = \frac{b (d^3 - d_1^3)}{40}$$

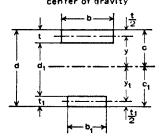
$$S = \frac{b (d^3 - d_1^3)}{6d}$$

$$r = \sqrt{\frac{d^3 - d_1^3}{12(d - d_1)}}$$

$$Z = \frac{b}{4} (d^2 - d)^2$$

UNEQUAL RECTANGLES

Axis of moments through center of gravity



$$A = bt + b_1t_1$$

$$c = \frac{\frac{1/2}{2}bt^2 + b_1t_1(d - \frac{1/2}{2}t_1)}{A}$$

$$I = \frac{bt^3}{12} + bty^2 + \frac{b_1t_1^3}{12} + b_1t_1y_1^2$$

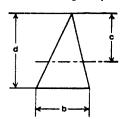
$$S = \frac{1}{c} \qquad S_1 = \frac{1}{c_1}$$

$$=\sqrt{\frac{1}{A}}$$

$$Z = \frac{A}{2} \left[d - \left(\frac{t + t_1}{2} \right) \right]$$

TRIANGLE

Axis of moments through center of gravity



$$A = \frac{bd}{2}$$

$$c = \frac{2d}{3}$$

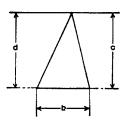
$$I = \frac{bd^3}{36}$$

$$S = \frac{bd^2}{24}$$

$$r = \frac{d}{\sqrt{18}} = .235702 d$$

TRIANGLE

Axis of moments on base



$$A = \frac{bd}{2}$$

$$c = d$$

$$I = \frac{bd^3}{12}$$

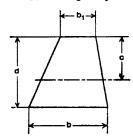
$$S = \frac{bd^2}{12}$$

$$r = \frac{d}{\sqrt{c}} = .408248 d$$

Table A-14d

TRAPEZOID

Axis of moments through center of gravity



$$A = \frac{d(b+b_1)}{2}$$

$$c = \frac{d(2b + b_1)}{3(b + b_1)}$$

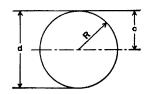
$$I = \frac{d^3 (b^2 + 4 bb_1 + b_1^2)}{36 (b + b_1)}$$

$$S = \frac{d^2 (b^2 + 4 bb_1 + b_1^2)}{12 (2b + b_1)}$$

$$r = \frac{d}{6(b+b_1)} \sqrt{2(b^2+4bb_1+b_1^2)}$$

CIRCLE

Axis of moments through center



$$A = \frac{\pi d^2}{4} = \pi R^2 = .785398 d^2 = 3.141593 R^2$$

$$c = \frac{d}{2} = R$$

$$I = \frac{\pi d^4}{64} = \frac{\pi R^4}{4} = .049087 d^4 = .785398 R^4$$

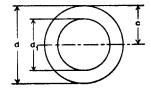
$$S = \frac{\pi d^3}{32} = \frac{\pi R^3}{4} = .098175 d^3 = .785398 R^3$$

$$r = \frac{d}{4} = \frac{R}{2}$$

$$Z = \frac{d^3}{6}$$

HOLLOW CIRCLE

Axis of moments



$$A = \frac{\pi(d^2 - d_1^2)}{4} = .785398 (d^2 - d_1^2)$$

$$c = \frac{d}{2}$$

$$I = \frac{\pi(d^4 - d_1^4)}{64} = .049087 (d^4 - d_1^4)$$

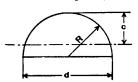
$$S = \frac{\pi(d^4 - d_1^4)}{32d} = .098175 \frac{d^4 - d_1^4}{d}$$

$$r = \frac{\sqrt{d^2 + d_1^2}}{4}$$

$$z = \frac{d^3}{6} - \frac{d^{13}}{6}$$

HALF CIRCLE

Axis of moments through center of gravity



$$A = \frac{\pi R^2}{2} = 1.570796 R^2$$

$$c = R \left(1 - \frac{4}{3\pi}\right) = .575587 R$$

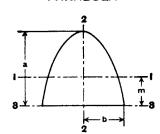
$$I = R^4 \left(\frac{\pi}{8} - \frac{8}{9\pi} \right) = .109757 R^4$$

$$S = \frac{R^3 (9\pi^2 - 64)}{24 (3\pi - 4)} = .190687 R^3$$

$$r = R \frac{\sqrt{9\pi^2 - 64}}{6\pi} = .264336 R$$

Table A-14e

PARABOLA



$$A = \frac{4}{3}ab$$

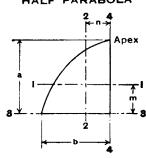
$$m = \frac{2}{5}a$$

$$i_1 = \frac{16}{175} a^3 b$$

$$i_2 = \frac{4}{45}ab^2$$

$$l_3 = \frac{32}{105} a^3 b$$

HALF PARABOLA



$$A = \frac{2}{3}$$
 at

$$m = \frac{2}{7}a$$

$$n = \frac{3}{9}b$$

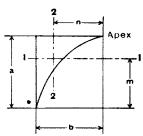
$$l_1 = \frac{8}{175} a^3$$

$$l_2 = \frac{19}{490} ab^3$$

$$I_3 = \frac{16}{106} a^3 b$$

$$I_4 = \frac{2}{15} ab^3$$

COMPLEMENT OF HALF PARABOLA



$$A = \frac{1}{2} at$$

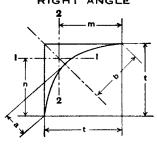
$$m = \frac{7}{10}a$$

$$n = \frac{3}{4} t$$

$$l_1 = \frac{37}{2100} a^3 t$$

$$I_2 = \frac{1}{80} ab^3$$

PARABOLIC FILLET IN RIGHT ANGLE



$$a = \frac{t}{2\sqrt{2}}$$

$$b = \frac{t}{\sqrt{2}}$$

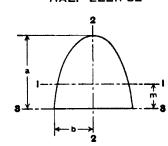
$$A = \frac{1}{6} t^2$$

$$m = n = \frac{4}{5}$$

$$l_1 = l_2 = \frac{11}{2100} t^4$$

Table A-14f

* HALF ELLIPSE



$$A = \frac{1}{2} \pi ab$$

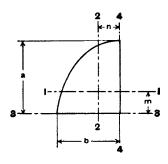
$$m = \frac{4a}{a}$$

$$I_1 = a^3b \left(\frac{\pi}{8} - \frac{8}{9\pi}\right)$$

$$l_2 = \frac{1}{8} \pi a b^3$$

$$l_3 = \frac{1}{R} \pi a^3 b$$

* QUARTER ELLIPSE



$$A = \frac{1}{4} \pi a t$$

$$m = \frac{4a}{3\pi}$$

$$n = \frac{4b}{2\pi}$$

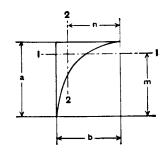
$$I_1 = a^3b \left(\frac{\pi}{16} - \frac{4}{9\pi}\right)$$

$$I_2 = ab^3 \left(\frac{\pi}{16} - \frac{4}{9\pi} \right)$$

$$i_3 = \frac{1}{16} \pi a^3 b$$

$$I_4 = \frac{1}{16} \pi ab^3$$

* ELLIPTIC COMPLEMENT



$$A = ab \left(1 - \frac{\pi}{4}\right)$$

$$m = \frac{a}{6\left(1-\frac{\pi}{4}\right)}$$

$$n = \frac{b}{6\left(1-\frac{\pi}{4}\right)}$$

$$l_1 = a^3b \left(\frac{1}{3} - \frac{\pi}{16} - \frac{1}{36\left(1 - \frac{\pi}{4}\right)}\right)$$

$$l_2 = ab^3 \left(\frac{1}{3} - \frac{\pi}{16} - \frac{1}{36 \left(1 - \frac{\pi}{4} \right)} \right)$$

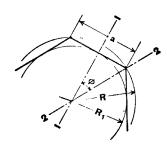
f * To obtain properties of half circle, quarter circle and circular complement substitute f a=f b=f R.

Table A-15

PROPERTIES OF GEOMETRIC SECTIONS AND STRUCTURAL SHAPES

REGULAR POLYGON

Axis of moments through center



$$\phi = \frac{180^\circ}{}$$

$$a = 2\sqrt{R^2 - R_1^2}$$

$$R = \frac{a}{0.0 \text{ m}}$$

$$R_1 = \frac{a}{a}$$

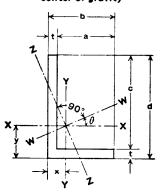
$$A = \frac{1}{4} na^2 \cot \phi = \frac{1}{2} nR^2 \sin 2\phi = nR_1^2 \tan \phi$$

$$I_1 = I_2 = \frac{A(6R^2 - a^2)}{24} = \frac{A(12R_1^2 + a^2)}{48}$$

$$r_1 = r_2 = \sqrt{\frac{6R^2 - a^2}{24}} = \sqrt{\frac{12R_1^2 + a^2}{4R}}$$

ANGLE

Axis of moments through center of gravity



Z-Z is axis of minimum I

 $\tan 2\theta = \frac{2 \text{ K}}{1 - 1}$

A =
$$t(b+c)$$
 $x = \frac{b^2 + ct}{2(b+c)}$ $y = \frac{d^2 + at}{2(b+c)}$

K = Product of Inertia about X-X & Y-Y

$$= \frac{abcdt}{4(b+c)}$$

$$I_{x} = \frac{1}{3} \left(t(d-y)^{3} + by^{3} - a(y-t)^{3} \right)$$

$$I_{\gamma} = \frac{1}{3} \left(t(b-x)^3 + dx^3 - c(x-t)^3 \right)$$

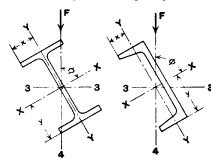
$$I_z = I_x \sin^2\theta + I_y \cos^2\theta + K \sin^2\theta$$

$$I_{w} = I_{x} \cos^{2}\theta + I_{y} \sin^{2}\theta - K \sin^{2}\theta$$

K is negative when heel of angle, with respect to c. g., is in 1st or 3rd quadrant, positive when in 2nd or 4th quadrant.

BEAMS AND CHANNELS

Transverse force oblique through center of gravity



$$l_{\mathbf{x}} = l_{\mathbf{x}} \sin^2 \phi + l_{\mathbf{y}} \cos^2 \phi$$

$$I_4 = I_X \cos^2 \phi + I_Y \sin^2 \phi$$

$$f_b = M \left(\frac{y}{I_x} \sin \phi + \frac{x}{I_y} \cos \phi \right)$$

where M is bending moment due to force F.

Table A-16

FOUR PLACE LOGARITHM TABLES

			10011	PLACE	LOGAI	/ 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	IADLL	, 		
No.	0	1	2	3	4	5	6	7	8	9
10 11 12 13 14 15 16 17 18	0000 0414 0792 1139 1461 1761 2041 2304 2553 2788	0043 0453 0828 1173 1492 1790 2068 2330 2577 2810	0086 0492 0864 1206 1523 1818 2095 2355 2601 2833	0128 0531 0899 1239 1553 1847 2122 2380 2625 2856	0170 0569 0934 1271 1584 1875 2148 2405 2648 2878	0212 0607 0969 1303 1614 1903 2175 2430 2672 2900	0253 0645 1004 1335 1644 1931 2201 2455 2695 2923	0294 0682 1038 1367 1673 1959 2227 2480 2718 2945	0334 0719 1072 1399 1703 1987 2253 2504 2742 2967	0374 0755 1106 1430 1732 2014 2279 2529 2765 2989
20 21 22 23 24 25 26 27 28 29	3010 3222 3424 3617 3802 3979 4150 4314 4472 4624	3032 3243 3444 3636 3820 3997 4166 4330 4487 4639	3054 3263 3464 3655 3838 4014 4183 4346 4502 4654	3075 3284 3483 3674 3856 4031 4200 4362 4518 4669	3096 3304 3502 3692 3874 4048 4216 4378 4533 4683	3118 3324 3522 3711 3892 4065 4232 4393 4548 4698	3139 3345 3541 3729 3909 4082 4249 4409 4564 4713	3160 3365 3560 3747 3927 4099 4265 4425 4579 4728	3181 3385 3579 3766 3945 4116 4281 4440 4594 4742	3201 3404 3598 3784 3962 4133 4298 4456 4609 4757
30 31 32 33 34 35 36 37 38	4771 4914 5051 5185 5315 5441 5563 5682 5798 5911	4786 4786 5065 5198 5328 5453 5575 5694 5809 5922	4800 4942 5079 5211 5340 5465 5587 5705 5821 5933	4814 4955 5092 5224 5353 5478 5599 5717 5832 5944	4829 4969 5105 5237 5366 5498 5611 5729 5843 5955	4843 4983 5119 5250 5378 5502 5623 5740 5855 5966	4857 4957 5132 5263 5391 5514 5635 5752 5866 5977	4871 5011 5145 5276 5403 5527 5647 5763 5877 5988	4886 5024 5159 5289 5416 5539 5658 5775 5888 5999	4900 5038 5172 5302 5428 5551 5670 5786 5899 6010
40 41 42 43 44 45 46 47 48 49	6021 6128 6232 6335 6435 6532 6628 6721 6812 6902	6031 6138 6243 6345 6444 6542 6637 6730 6821 6911	6042 6149 6253 6355 6454 6551 6646 6739 6830 6920	6053 6160 6263 6365 6464 6561 6656 6749 6839 6928	6064 6170 6274 6375 6474 6571 6665 6758 6848 6937	6075 6180 6284 6385 6484 6580 6675 6767 6857 6946	6085 6191 6294 6395 6493 6590 6684 6776 6866 6955	6096 6201 6304 6405 6503 6599 6693 6785 6875	6107 6212 6314 6415 6513 6609 6702 6794 6884 6972	6117 6222 6325 6425 6522 6618 6712 6803 6893 6981
50 51 52 53 55 55 57 59	6990 7076 7160 7243 7324 7404 7482 7559 7634 7709	6998 7084 7168 7251 7332 7412 7490 7566 7642 7716	7007 7093 7177 7259 7340 7419 7497 7574 7649 7723	7016 7101 7185 7267 7348 7427 7505 7582 7657 7731	7024 7110 7193 7275 7356 7435 7513 7589 7664 7738	7033 7118 7202 7284 7364 7443 7520 7597 7672 7745	7042 7126 7210 7292 7372 7451 7528 7604 7679 7752	7050 7135 7218 7300 7380 7459 7536 7612 7686 7760	7059 7143 7226 7308 7388 7466 7543 7619 7694 7767	7067 7152 7235 7316 7396 7474 7551 7627 7701
60 61 62 63 64 65 66 67 68 69	7782 7853 7924 7993 8062 8129 8195 8251 8325 8388	7789 7860 7931 8000 8069 8136 8202 8267 8331 8395	7796 7868 7938 8007 8075 8142 8209 8274 8338 8401	7803 7875 7945 8014 8082 8149 8215 8280 8344 8407	7810 7882 7952 8021 8089 8156 8222 8287 8351 8414	7818 7889 7959 8028 8096 8162 8228 8228 8293 8357 8420	7825 7896 7966 8035 8102 8169 8235 8299 8363 8426	7832 7903 7973 8041 8109 8176 8241 8306 8370 8432	7839 7910 7980 8048 8116 8182 8248 8312 8376 8439	7846 7917 7987 8055 8122 8189 8254 8319 8382 8445
70 71 72 73 74 75 76 77 78 79	8451 8513 8573 8633 8692 8751 8808 8865 8921 8976	8457 8519 8579 8639 8698 8756 8814 8871 8927 8982	8463 8525 8585 8645 8704 8762 8820 8876 8932 8987	8470 8531 8591 8651 8710 8768 8825 8825 8882 8938	8476 8537 8597 8657 8716 8774 8831 8887 8943 8998	8482 8543 8603 8663 8722 8779 8837 8893 8949	8488 8549 8609 8669 8727 8785 8842 8899 8954 9009	8494 8555 8615 8675 8733 8791 8848 8904 8960 9015	8500 8561 8621 8681 8739 8797 8854 8910 8965 9020	8506 8567 8627 8686 8745 8802 8859 8915 8971 9025
80 81 82 83 84 85 86 87 88	9031 9085 9138 9191 9243 9294 9345 9395 9445 9494	9036 9090 9143 9196 9248 9299 9350 9400 9450 9499	9042 9096 9149 9201 9253 9304 9355 9405 9455 9504	9047 9101 9154 9206 9258 9309 9360 9410 9460 9509	9053 9106 9159 9212 9263 9315 9365 9415 9465 9513	9058 9112 9165 9217 9269 9320 9370 9420 9469 9518	9063 9117 9170 9222 9274 9325 9375 9425 9474 9523	9069 9122 9175 9227 9279 9330 9380 9430 9479 9528	9074 9128 9180 9232 9284 9335 9385 9435 9484 9533	9079 9133 9186 9238 9289 9340 9390 9440 9489 9538
90 91 92 93 94 95 96 97 98 99	9542 9590 9638 9685 9731 9777 9823 9868 9912 9956	9547 9595 9643 9689 9736 9782 9827 9872 9917 9961	9552 9600 9647 9694 9741 9786 9832 9877 9921 9965	9557 9605 9652 9699 9745 9745 9836 9881 9926 9969	9562 9609 9657 9703 9750 9755 9841 9886 9930 9974	9566 9614 9661 9708 9754 9845 9890 9934 9978	9571 9619 9666 9713 9759 9805 9850 9894 9939 9983	9576 9624 9671 9717 9763 9859 9854 9899 9943 9987	9581 9628 9675 9722 9768 9814 9859 9903 9948 9991	9586 9633 9680 9727 9773 9818 9863 9908 9952 9996

Table A-17a

A	TO CONVERT	INTO	MULTIPLY BY	TO CONVERT	INTO	MULTIPLY BY
Section Sect	TO CONVERT		myem et Di	10 001112111		
series se meters someles 1,552 10 ⁻³² cubic meters someles someles 1,552 10 ⁻³² cubic meters against (U. S. Ing.) 26,42 acres so syards 4,860. cubic meters process of the some some some some some some some som						
series sa miles acres say ands 4,840 cubic meters agains (I.S. Ing.) acre-feet agains 3,259 10° cubic meters atmospheres amospheres on of mercury (10°C) 23.30 cubic meters atmospheres in of mercury (10°C) 23.30 cubic yards cubic yards atmospheres in of mercury (10°C) 23.30 cubic yards cubic yards atmospheres in of mercury (10°C) 23.30 cubic yards cubic yards atmospheres by a feet of water (14°C) 23.30 cubic yards cubic yards atmospheres by a feet of water cubic centimeters of mercury cubic yards atmospheres by a feet of water cubic centimeters of mercury cubic yards atmospheres by a feet of water cubic centimeters of mercury cubic yards yar		•				
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acre-feet gallons user-feet ga						
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cubic feet/min cubic feet/sec pounds of water/min cubic feet/sec 62.43 G cubic inches cubi		•				
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cubic meters culcms 10° gallons of water pounds of water 8.3453						
cubic meters cu feet 35.31 gallons/min cu ft/sec 2.228 x I						
Annual Annu	cubic meters	cu feet	35.31	gallons/min	cu ft/sec	2.228 x 10 ⁻³

Table A-17b

FREQUENTLY USED CONVERSION FACTORS								
TO CONVERT	INTO	MULTIPLY BY	TO CONVERT	INTO	MULTIPLY BY			
gallons/min	cu ft/hr	8.0208	kilometers/hr	feet/sec	0.0112			
gallons/day	cu ft/sec	1.5472 x 10 ⁻⁶	kilometers/hr	knots	0.9113 0.5396			
grains (troy)	grams	0.06480	kilometers/hr	meters/min	16.67			
grains (troy)	ounces (avdp)	2.0833 x 10 ⁻³	kilometers/hr	miles/hr	0.6214			
grams	grains	15.43	knots	feet/hr	6,080.			
grams	kilograms	0.001	knots	kilometers/hr	1.8532			
grams	milligrams	1,000.	knots	nautical miles/hr	1.0			
grams	ounces (avdp)	0.03527	knots	statute miles/hr	1.151			
grams	ounces (troy)	0.03215	knots	yards/hr	2,027.			
grams	pounds	2.205 x 10-3	knots	feet/sec	1.689			
grams/cm	pounds/inch	5.600 x 10 ⁻³						
grams/cu cm	pounds/cu ft	62.43		L				
grams/cu cm	pounds/cu in	0.03613	links (engineer's)	inches	12.0			
grams/liter	pounds/cu ft	0.062427	links (surveyor's)	inches	7.92			
grams/sq cm	pounds/sq ft	2.0481	liters	bushels (U. S. dry)	0.02838			
			liters	cu cm	1,000.0			
	Н		liters	cu feet	0.03531			
hectograms	grams	100.0	liters	cu inches	61.02			
hectoliters	liters	100.0	liters	cu meters	0.001			
hectometers	meters	100.0	liters	cu yards	1.308 x 10 ⁻³			
hours	days	4.167 x 10 ⁻²	liters	gallons (U.S. liq.)	0.2642			
hours	weeks	5.952 x 10 ³	liters	pints (U. S. liq.)	2.113			
			liters	quarts (U.S. lig.)	1.057			
	J		liters/min	cu ft/sec	5.886 x 10 ⁻⁴			
inches	centimeters	2.540	liters/min	gals/sec	4.403 x 10 ⁻³			
inches	meters	2.540 x 10 ⁻²						
inches	miles	1.578 x 10 ⁻⁵		M				
inches	millimeters	25.40	meters	centimeters	100.0			
inches	mils	1,000.0	meters	feet	3.281			
inches	yards	2.778 x 10 ⁻²	meters	inches	39.37			
inches of mercury	atmospheres	0.03342	meters	kilometers	0.001			
inches of mercury	feet of water	1.133	meters	miles (naut.)	5.396 x 10 ⁻⁴			
inches of mercury	kgs/sq.cm	0.03453	meters	miles (stat.)	6.214 x 10 ⁻⁴			
inches of mercury	kgs/sq meter	345.3	meters	millimeters	1.000.0			
inches of mercury	pounds/sq ft	70.73	meters	yards	1.094			
inches of mercury	pounds/sq in	0.4912	meters/min	cms/sec	1.667			
inches of water (at 4°C)	atmospheres	2.458 x 10 ⁻³	meters/min	feet/min	3.281			
inches of water (at 4°C)	inches of mercury	0.07355	meters/min	feet/sec	0.05468			
inches of water (at 4°C)	kgs/sq cm	2.540 x 10 ⁻³	meters/min	knots	0.03238			
inches of water (at 4°C) inches of water (at 4°C)	ounces/sq in pounds/sq ft	0.5781 5.204	meters/min	miles/hr	0.03728			
inches of water (at 4°C)	pounds/sq in	0.03613	meters/sec	feet/min	196.8			
menes of water (at 4 C)	pounds/sq m	0.03013	meters/sec	feet/sec	3.281			
	K		meters/sec	kilometers/hr	3.6			
hilannan		000 005	meters/sec	kilometers/min	0.06			
kilograms	dynes	980,665.	meters/sec	miles/hr	2.237			
kilograms kilograms	grams pounds	1,000.0 2.205	meters/sec	miles/min	0.03728			
kilograms	tons (long)	9.842 x 10 ⁴	micrograms microliters	grams liters	10- ° 10- °			
kilograms	tons (short)	1.102 x 10 ⁻³	microns	meters	1 x 10-6			
kilograms/cu meter	grams/cu cm	0.001	miles (naut.)	feet	6,080.27			
kilograms/cu meter	pounds/cu ft	0.06243	miles (naut.)	kilometers	1.853			
kilograms/cu meter	pounds/cu in.	3.613 x 10 ⁻⁵	miles (naut.)	meters	1,853.			
kilograms/cu meter	pounds/mil-foot	3.405 x 10 ⁻¹⁰	miles (naut.)	miles (statute)	1.1516			
kilograms/meter	pounds/ft	0.6720	miles (naut.)	yards	2,027.			
kilograms/sq cm	atmospheres	0.9678	miles (statute)	centimeters	1.609 x 105			
kilograms/sq cm	feet of water	32.81	miles (statute)	feet	5,280.			
kilograms/sq cm	inches of mercury	28.96	miles (statute)	inches	6.336 x 104			
kilograms/sq cm	pounds/sq ft	2,048.	miles (statute)	kilometers	1.609			
kilograms/sq cm	pounds/sq in	14.22	miles (statute)	meters	1,609.			
kilograms/sq meter	atmospheres	9.678 x 10 ⁻⁵	miles (statute)	miles (naut.)	0.8684			
kilograms/sq meter	feet of water	3.281 x 10 ⁻¹	miles (statute)	yards	1,760.			
kilograms/sq meter	inches of mercury	2.896 x 10 ⁻¹	miles/hr	cms/sec	44.70			
kilograms/sq meter	pounds/sq ft	0.2048	miles/hr	feet/min	88.			
kilograms/sq meter	pounds/sq in	1.422 x 10 ⁻⁵	miles/hr	feet/sec	1.467			
kilograms/sq mm	kgs/sq meter	106	miles/hr	kms/hr	1.609			
kiloliters kilometers	liters	1,000.0	miles/hr	kms/min	0.02682			
kilometers	centimeters	105	miles/hr	knots	0.8684			
kilometers kilometers	feet inches	3,281. 3.937 x 104	miles/hr	meters/min	26.82			
kilometers	meters	1,000.0	miles/hr	miles/min	0.1667			
kilometers	miles	0.6214	miles/min miles/min	cms/sec	2,682.			
kilometers	millimeters	106	miles/min miles/min	feet/sec	88.			
kilometers	yards	1.094.	miles/min	kms/min knots/min	1.609 0.8684			
kilometers/hr	cms/sec	27.78	miles/min	miles/hr	60.0			
kilometers/hr	feet/min	54.68	mil-feet	cu inches				
Anometer S/III	reet/mitt	J4.08	19 9 1-11111	cu inches	9.425 x 10 ¢			

Table A-17c

TO CONVERT	INTO	MULTIPLY BY	TO CONVERT	INTO	MULTIPLY BY
milliers	kilograms	1,000.	pounds/sq ft	atmospheres	4.725 x 10 4
Millimicrons	meters	1 x 10 ⁻⁹	pounds/sq ft	feet of water	0.01602
milligrams	grams	0.001	pounds/sq ft	inches of mercury	0.01414
milliliters	liters	0.001 0.1	pounds/sq ft pounds/sq in.	kgs/sq meter atmospheres	4.882 0.06804
millimeters millimeters	centimeters feet	3.281 x 10 ⁻³	pounds/sq in.	feet of water	2.307
millimeters	inches	0.03937	pounds/sq in.	inches of mercury	2.036
millimeters	kilometers	10-6	pounds/sq in.	kgs/sq meter	703.1
millimeters	meters	0.001	pounds/sq in	pounds/sq ft	144.0
millimeters	miles	6.214 x 10 ⁻⁷		^	
millimeters	yards	1.094 x 10 ⁻³		Q	
million gals/day	cu ft/sec	1.54723	quadrants (angle)	degrees	90.0
mils mils	centimeters feet	2.540 x 10 ⁻³ 8.333 x 10 ⁻⁵	quadrants (angle)	minutes	5,400.0
mils	inches	0.001	quadrants (angle)	radians	1.571
mils	kilometers	2.540 x 10 ⁻⁸	quadrants (angle)	seconds	3.24 x 10 ⁵
mils	yards	2.778 x 10 ⁻⁵		R	
minutes (angles)	degrees	0.01667	radians		67.20
myriagrams	kilograms	10.0	radians	degrees minutes	57.30 3,438.
myriameters	kilometers	10.0	radians	quadrants	0.6366
myriawatts	kilowatts	10.0	radians	seconds	2.063 x 10 ⁵
	0		rods	chain (Gunters)	.25
	U		rods	meters	5.029
ounces	drams	16.0	rods (Surveyors' meas.)	yards	5.5
ounces	grains	437.5	rods	feet	16.5
ounces	grams	28.349527		S	
ounces ounces	pounds ounces (troy)	0.0625 0.9115			
ounces	tons (long)	2.790 x 10 ⁻⁵	square centimeters	sq feet	1.076 x 10 ⁻³
ounces	tons (metric)	2.835 x 10 ⁻⁵	square centimeters	sq inches	0.1550
ounces (fluid)	cu inches	1.805	square centimeters square centimeters	sq meters sq miles	0.0001 3.861 x 10-11
ounces (fluid)	liters	0.02957	square centimeters	sq millimeters	100.0
ounces (troy)	grains	480.0	square centimeters	sq yards	1.196 x 10 ⁻⁴
ounces (troy)	grams	31.103481	square feet	acres	2.296 x 10-5
ounces (troy) ounces (troy)	ounces (avdp.) pounds (troy)	1.09714 0.08333	square feet	sq cms	929.0
ounces/sq in.	pounds/sq in.	0.0625	square feet	sq inches	144.0
		0.0020	square feet square feet	sq meters	0.09290 3.587 x 10-8
	P		square feet	sq miles sq millimeters	9.290 x 10 ⁴
pints (dry)	cu inches	33.60	square feet	sq yards	0.1111
pints (liq.)	cu cms	473.2	square inches	sq cms	6.452
pints (liq.)	cu feet	0.01671	square inches	sq feet	6.944 x 10 ⁻³
pints (liq.)	cu inches	28.87	square inches	sq millimeters	645.2
pints (liq.)	cu meters	4.732 x 10 ⁻⁴	square inches	sq yards	7.716 x 10 ⁻⁴
pints (liq.) pints (liq.)	cu yards gallons	6.189 x 10 4 0.125	square kilometers	acres	247.1
pints (liq.)	liters	0.4732	square kilometers square kilometers	sq cms sq ft	1010 10.76 x 106
pints (fig.)	quarts (fig.)	0.5	square kilometers	sq inches	1.550 x 10°
Pounds (advp)	ounces (troy)	14.5833	square kilometers	sq meters	106
pounds	drams	256.	square kilometers	sq miles	0.3861
pounds	grams	453.5924	square kilometers	sq yards	1.196 x 10°
pounds	kilograms	0.4536	square meters	acres	2.471 x 10 ⁻⁴
pounds pounds	ounces ounces (troy)	16.0 14.5833	square meters	sq cms sq feet	104 10.76
pounds	pounds (troy)	1.21528	square meters square meters	sq inches	1,550.
pounds	tons (short)	0.0005	square meters	sq miles	3.861 x 10 ⁻⁷
pounds (troy)	ounces (avdp.)	13.1657	square meters	sq millimeters	106
pounds (troy)	ounces (troy)	12.0	square meters	sq yards	1.196
pounds (troy)	pounds (avdp.)	0.822857	square miles	acres	640.0
pounds (troy)	tons (long)	3.6735 x 10 ⁻⁴	square miles	sq feet	27.88 x 10°
pounds (troy) pounds (troy)	tons (metric) tons (short)	3.7324 x 10 ⁴ 4.1143 x 10 ⁴	square miles square miles	sq kms	2.590
pounds of water	cu feet	0.01602	square miles	sq meters sq yards	2.590 x10° 3.098 x 10°
pounds of water	cu inches	27.68	square millimeters	sq cms	0.01
pounds of water	gallons	0.1198	square millimeters	sq feet	1.076 x 10 ⁻⁵
pounds/cu ft	grams/cu cm	0.01602	square millimeters	sq inches	1.550 x 10 ⁻³
pounds/cu ft	kgs/cu meter	16.02	square mils	sq cms	6.452 x 10-6
pounds/cu ft	pounds/cu in.	5.787 x 10 ⁻⁴	square mils	sq inches	10-6
pounds/cu in	gms/cu cm	27.68 2.769 v 104	square yards	acres	2.066 x 10 ⁻⁴
pounds/cu in pounds/cu in	kgs/cu meter pounds/cu ft	2.768 x 10 ⁴ 1,728.	square yards square yards	sq cms sq feet	8,361. 9.0
pounds/ft	kgs/meter	1,728.	square yards	sq inches	1,296.
pounds/in.	gms/cm	178.6	square yards	sq meters	0.8361
•	-				

Table A-17d

TO CONVERT	INTO N	BULTIPLY BY	TO CONVERT	INTO	MULTIPLY BY
square yards square yards	sq miles sq millimeters T	3.288 x 10 ⁻⁷ 8.361 x 10 ⁵	tons (short) tons (short) tons (short)	ounces (troy) pounds pounds (troy)	29,166.66 2,000. 2,430.56
temperature (°C)+273	absolute temperature (°C) 1.0	tons (short) tons (short) tons (short)/sq ft	tons (long) tons (metric) kgs/sq meter	0.89287 0.9078 9,765.
temperature (°C)+17.78	temperature (°F)	1.8	tons (short)/sq ft tons of water/24 hrs	pounds/sq in. pounds of water/hr	2,000. 83.333
temperature (°F)+460	absolute temperature (°F) 1.0	tons of water/24 hrs tons of water/24 hrs	gallons/min cu ft/hr	0.16643 1.3349
temperature (°F)—32 tons (long)	temperature (°C) kilograms	5/9 1,016.		Y	
tons (long)	pounds	2,240.	yards	centimeters	91.44
tons (long)	tons (short)	1.120	yards	kilometers	9.144 x 10-4
tons (metric)	kilograms	1,000.	yards	meters	0.9144
tons (metric)	pounds	2,205.	yards	miles (naut.)	4.934 x 10 4
tons (short)	kilograms	907.1848	yards	miles (stat.)	5.682 x 10 ⁻⁴
tons (short)	ounces	32,000.	yards	millimeters	914.4

TABLE A-18

METRIC CONVERSION OF DIAMETER

in	mm	in	mm	in	mm	in	mm
6 8 10 12 15 18 21 24 27	150 200 250 300 375 450 525 600 675	30 33 36 39 42 45 45 48 51 54	750 825 900 975 1050 1125 1200 1275 1350	57 60 63 66 69 72 78 84 90	1425 1500 1575 1650 1725 1800 1950 2100 2250	96 102 108 114 120 132 144 156 168	2400 2550 2700 2850 3000 3300 3600 3900 4200

TABLE A-19
METRIC CONVERSION OF WALL THICKNESS

in	mm	in	mm	in	mm	in	mm
1 1-1/2 2 2-1/4 2-3/8 2-1/2 2-5/8 2-3/4 2-7/8 3	25 38 50 56 59 63 66 69 72 75	3-1/8 3-1/4 3-1/2 3-3/4 3-7/8 4 4-1/8 4-1/4 4-1/2 4-3/4	79 82 88 94 98 100 103 106 113	5 5-1/4 5-1/2 5-3/4 6 6-1/4 6-1/2 6-3/4 7 7-1/2	125 131 138 144 150 156 163 169 175 188	8 8-1/2 9 9-1/2 10 10-1/2 11 11-1/2 12 12-1/2	200 213 225 238 250 263 275 288 300 313

APPENDIX B

LOADS AND SUPPORTING STRENGTHS

Based on Marston/Spangler Design Procedure

The design procedure for the selection of pipe strength requires:

- I. Determination of Earth Load
- 2. Determination of Live Load
- 3. Selection of Bedding
- 4. Determination of Bedding Factor
- Application of Factor of Safety
- 6. Selection of Pipe Strength

TYPES OF INSTALLATIONS

The earth load transmitted to a pipe is largely dependent on the type of installation, and the three common types are Trench, Positive Projecting Embankment, and Negative Projecting Embankment. Pipe are also installed by jacking or tunneling methods where deep installations are necessary or where conventional open excavation and backfill methods may not be feasible. The essential features of each of these installations are shown in Figure 146.

Trench. This type of installation is normally used in the construction of sewers, drains and water mains. The pipe is installed in a relatively narrow trench excavated in undisturbed soil and then covered with backfill extending to the ground surface.

$$W_d = C_d w B_d^2$$
 B1

Cd is further defined as:

$$C_{d} = \frac{1 - e^{-2K\mu'} \frac{H}{B_{d}}}{2K\mu'}$$
 B2

Note: In 1996 AASHTO adopted the Standard Installations as presented in Chapter 4 of this manual, and eliminated the use of the Marston/Spangler beddings and design procedure for circular concrete pipe. The Standard Installations and the design criteria in Chapter 4 are the preferred method of ACPA. The older and less quantitative Marston/Spangler beddings and the design method associated with them are presented in this Appendix for those agencies and individuals still using this method.

Tables B1 through B30 are based on equation (B1) and list backfill loads in pounds per linear foot for various heights of backfill and trench widths. There are four tables for each circular pipe size based on $K\mu' = 0.165$, 0.150, 0.130 and 0.110. The "Transition Width" column gives the trench width at which the backfill load on the pipe is a maximum and remains constant regardless of any increase in the width of the trench. For any given height of backfill, the maximum load at the transition width is shown by **bold type**.

Figures B1 through B8 also present backfill loads for circular pipe installed in a trench condition. For elliptical and arch pipe, Figures 155 through 178 in the main body of the manual may be used. The solid lines represent trench widths and the dashed lines represent pipe size for the evaluation of transition widths and maximum backfill loads. If, when entering the figures from the horizontal axis, the dashed line representing pipe size is interesected before the solid line representing trench width, the actual trench width is wider than the transition width and the maximum backfill load should be read at the intersection of the height of backfill and the dashed line representing pipe size.

Positive Projecting Embankment. This type of installation is normally used when the culvert is installed in a relatively flat stream bed or drainage path. The pipe is installed on the original ground or compacted fill and then covered by an earth fill or embankment. The fill load on a pipe installed in a positive projecting embankment condition is computed by the equation:

$$W_c = C_c w B_c^2$$
 B3

C, is further defined as:

$$C_c = \ \frac{e^{\ 2K\mu}\frac{H}{B_c}-1}{2K\mu} \quad \text{when } H \leq H_e \label{eq:cc}$$

$$C_c = \frac{e^{2K\mu}\frac{H_e}{B_c} - 1}{2K\mu'} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{2K\mu}\frac{H_e}{B_c} \quad \text{when } H > H_e \qquad B5$$

The settlements which influence loads on positive projecting embankment installations are shown in Illustration B1. To evaluate the $H_{\rm e}$ term in equation (B5), it is necessary to determine numerically the relationship between the pipe deflection and the relative settlement between the prism of fill directly above the pipe and the adjacent soil. This relationship is defined as a settlement ratio, expressed as:

$$r_{sd} = \frac{(S_m + S_g) - (S_f + d_c)}{S_m}$$
 B6

1. Pipe widths are based on a wall thickness equivalent to thicknesses indicated for Wall B in ASTM C 76 and designated thicknesses in other applicable ASTM Standards. Loads corresponding to these wall thicknesses are sufficiently accurate for the normal range of pipe widths for any particular pipe size. For extra heavy wall thicknesses, resulting in a pipe width considerably in excess of the normal range, interpolation within the Tables and Figures may be necessary.

Illustration B.1 Settlements Which Influence Loads
Positive Projecting Embankment Installation

TOP OF EMBANKMENT H - H_e Plane of Equal Settlement Shearing Forces Η Induced By H_{e} Settlement $S_f + d_c$ $S_m + S_g$ Critical Plane pB'c B_{c} B'c **Ground Surface** Initial Elevation Final Elevation

The fill load on a pipe installed in a positive projecting embankment condition is influenced by the product of the settlement ratio (rsd) and the projection ratio (p). The projection ratio (p) is the vertical distance the pipe projects above the original ground divided by the outside vertical height of the pipe (B'c). Recommended settlement ratio design values are listed in Table B-31.

Figures B-9 through B-13 include fill loads in pounds per linear foot for circular pipe under various fill heights and pipe sizes based on r_{sdp} values of 0, 0.1, 0.3, 0.5 and 1.0. For elliptical pipe, Figures 179 through 193 in the main body of the manual may be used. The dashed $H = H_e$ line represents the condition where the height of the plane of equal settlement (H_e) is equal to the height of fill (H).

Negative Projecting Embankment. This type of installation is normally used when the culvert is installed in a relatively narrow and deep stream bed or drainage path. The pipe is installed in a shallow trench of such depth that the top of the pipe is below the natural ground surface or compacted fill and then covered with an earth fill or embankment which extends above the original ground level. The fill load on a pipe installed in a negative projecting embankment condition is computed by the equation:

$$W_n = C_n w B_d^2$$
 B7

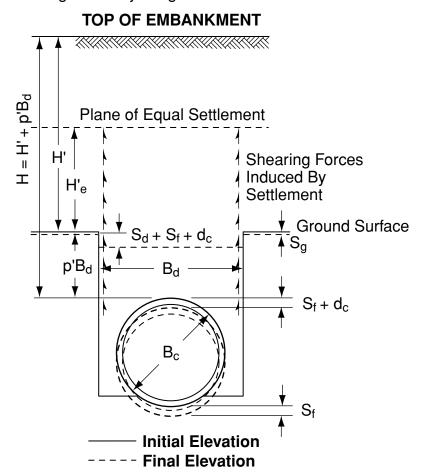
Cn is further defined as:

$$C_n = \ \frac{e^{-2K\mu}\frac{H}{B_d}-1}{-2K\mu} \quad \text{when } H \leq H_e \label{eq:cn}$$
 B8

$$C_{n} = \frac{e^{-2K\mu} \frac{H_{e}}{B_{d}} - 1}{-2K\mu'} + \left(\frac{H}{B_{d}} - \frac{H_{e}}{B_{d}}\right) e^{-2K\mu} \frac{H_{e}}{B_{d}} \text{ when } H > H_{e}$$
 B9

When the material within the subtrench is densely compacted, equation (B7) can be expressed as $W_n = C_n w B_d B'_d$ where B'_d is the average of the trench width and the outside diameter of the pipe.

Illustration B.2 Settlements Which Influence Loads
Negative Projecting Embankment Installation



The settlements which influence loads on negative projecting embankment installations are shown in Illustration B2. As in the case of the positive projecting embankment installation, it is necessary to define the settlement ratio. Equating

the deflection of the pipe and the total settlement of the prism of fill above the pipe to the settlement of the adjacent soil:

$$r_{sd} = \frac{S_g - (S_d + S_f + d_c)}{S_d}$$
 B10

Recommended settlement ratio design values are listed in Table B-31. The projection ratio (p') for this type of installation is the distance from the top of the pipe to the surface of the natural ground or compacted fill at the time of installation divided by the width of the trench. Where the ground surface is sloping, the average vertical distance from the top of the pipe to the original ground should be used in determining the projection ratio (p'). Figures 194 through 213 present fill loads in pounds per linear foot for circular pipe based on projection ratios of 0.5, 1.0, 1.5, 2.0 and settlement ratios of 0, -0.1, -0.3, -0.5 and -1.0. The dashed H = p'Bd line represents the limiting condition where the height of fill is at the same elevation as the natural ground surface. The dashed H = He, line represents the condition where the height of the plane of equal settlement (He) is equal to the height of fill (H).

SELECTION OF BEDDING

A bedding is provided to distribute the vertical reaction around the lower exterior surface of the pipe and reduce stress concentrations within the pipe wall. The load that a concrete pipe will support depends on the width of the bedding contact area and the quality of the contact between the pipe and bedding. An important consideration in selecting a material for bedding is to be sure that positive contact can be obtained between the bed and the pipe. Since most granular materials will shift to attain positive contact as the pipe settles an ideal load distribution can be attained through the use of clean coarse sand, well-rounded pea gravel or well-graded crushed rock.

Trench Beddings. Four general classes of bedding for the installation of circular pipe in a trench condition are illustrated in Figure B-14. Trench bedding for horizontal elliptical, arch and vertical elliptical pipe are shown in Figure B-15.

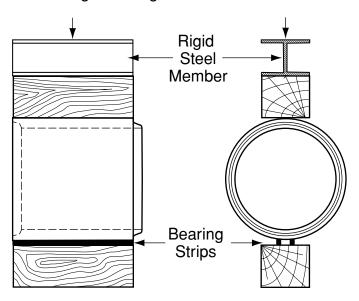
Embankment Beddings. Four general classes of bedding for the installation of circular pipe in an embankment condition are shown in Figure B-16. Embankment beddings for horizontal elliptical, arch and vertical elliptical pipe are shown in Figure B-17. Class A through D bedding classifications are presented as a guideline which should be reasonably attainable under field conditions. To assure that the in-place supporting strength of the pipe is adequate, the width of the band of contact between the pipe and the bedding material should be in accordance with the specified class of bedding. With the development of mechanical methods for subgrade preparation, pipe installation, backfilling and compaction, the flat bottom trench with granular foundation is generally the more practical method of bedding. If the pipe is installed in a flat bottom trench, it is

essential that the bedding material be uniformly compacted under the haunches of the pipe.

DETERMINATION OF BEDDING FACTOR

Under installed conditions the vertical load on a pipe is distributed over its width and the reaction is distributed in accordance with the type of bedding. When the pipe strength used in design has been determined by plant testing, bedding factors must be developed to relate the in-place supporting strength to the more severe plant test strength. The bedding factor is the ratio of the strength of the pipe under the installed condition of loading and bedding to the strength of the pipe in the plant test. This same ratio was defined originally by Spangler as the load factor. This latter term, however, was subsequently defined in the ultimate strength method of reinforced concrete design with an entirely different meaning. To avoid confusion, therefore, Spangler's term was renamed the bedding factor. The three-edge bearing test as shown in Illustration B.3 is the normally accepted plant test so that all bedding factors described below relate the in-place supporting strength to the three-edge bearing strength.

Illustration B.3 Three-Edge Bearing Test



The bedding factor for a particular pipeline, and consequently the supporting strength of the buried pipe, depends upon two characteristics of the installation:

- Width and quality of contact between the bedding and the pipe
- Magnitude of the lateral pressure and the portion of the vertical area of the pipe over which it is effective

Since the sidefill material can be more readily compacted for pipe installed in a positive projection embankment condition, the effect of lateral pressure is considered in evaluating the bedding factor. For trench installations, the effect of lateral pressure was neglected in development of bedding factors. Instead of a general theory as for the embankment condition, Spangler, from analysis of test installations, established conservative fixed bedding factors for each of the standard classes of bedding used for trench installations.

Trench Bedding Factors. Conservative fixed bedding factors for pipe installed in a narrow trench condition are listed below the particular classes of beddings shown in Figures B-14 and B-15.

Both Spangler and Schlick, in early lowa Engineering Experiment Stations publications, postulate that some active lateral pressure is developed in trench installations before the transition width is reached. Experience indicates that the active lateral pressure increases as the trench width increases from a very narrow width to the transition width, provided the sidefill is compacted. Defining the narrow trench width as a trench having a width at the top of the pipe equal to or less than the outside horizontal span plus one foot, and assuming a conservative linear variation, the variable trench bedding factor can be determined by:

$$B_{fv} = (B_{fe} - B_{ft}) \left[\frac{B_d - (B_c + 1.0)}{B_{dt} - (B_c + 1.0)} \right] + B_{ft}$$
 B11

Where:

Bc = outside horizontal span of pipe, feet

Bd = trench width at top of pipe, feet

Bdt = transition width at top of pipe, feet

Bre = bedding factor, embankment

Bft = fixed bedding factor, trench

B_{fv} = variable bedding factor, trench

A six-step design procedure for determining the trench variable bedding factor is:

- Determine the trench fixed bedding factor, Bft
- Determine the trench width. Bd
- Determine the transition width for the installation conditions, Bdt
- Determine H/Bc ratio, settlement ratio, rsd, projection ratio, p, and the product of the settlement and projection ratios, rsdp
- · Determine positive projecting embankment bedding factor, Bfe
- Calculate the trench variable bedding factor, Bfv

Positive Projecting Embankment Bedding Factors. For pipe installed in a positive projecting embankment condition, active lateral pressure is exerted against the sides of the pipe. Bedding factors for this type of installation are computed by the equation:

$$B_{f} = \frac{A}{N - x\alpha}$$
 B12

For circular pipe q is further defined as:

$$q = \frac{pK}{C_c} \left(\frac{H}{B_c} + \frac{p}{2} \right) \le 0.33$$
 B13

For elliptical and arch pipe q is further defined as:

$$q = \frac{pB'_{c}K}{C_{c}B_{c}^{2}}\left(H + \frac{pB'_{c}}{2}\right) \le 0.33$$
 B14

The value of q, as determined by equations B13 and B 14, shall not exceed 0.33.

Tables B32 and B33 list bedding factors for circular pipe. For elliptical and arch pipe bedding factors may be found in Tables 59 through 61 in the main body of the manual.

Negative Projecting Embankment Bedding Factors. The methods described for determining trench bedding factors should be used for negative projecting embankment installations.

APPLICATION OF FACTOR OF SAFETY

The total earth and live load on a buried concrete pipe is computed and multiplied by a factor of safety to determine the pipe supporting strength required. The safety factor is defined as the relationship between the ultimate strength D-load and the 0.01-inch crack D-load. This relationship is specified in the ASTM standards on reinforced concrete pipe. Therefore, for reinforced concrete pipe a factor of safety of 1.0 should be applied if the 0.01-inch crack strength is used as the design criterion. For nonreinforced concrete pipe a factor of safety of 1.25 to 1.5 is normally used.

SELECTION OF PIPE STRENGTH

Since numerous reinforced concrete pipe sizes are available, three-edge bearing test strengths are classified by D-loads. The D-load concept provides strength classification of pipe independent of pipe diameter. For reinforced circular pipe the three-edge bearing test load in pounds per linear foot equals D-load X inside diameter in feet. For arch, horizontal elliptical and vertical elliptical pipe the three-edge bearing test load in pounds per linear foot equals D-load X nominal inside span in feet.

The required three-edge bearing strength of non-reinforced concrete pipe is expressed in pounds per linear foot, not as a D-load, and is computed by the equation:

$$T.E.B. = \frac{W_L + W_E}{B_f} X F.S.$$
 B15

The required three-edge bearing strength of circular reinforced concrete pipe is expressed as D-load and is computed by the equation:

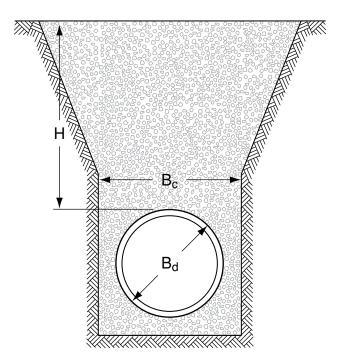
$$D-load = \frac{W_L + W_E}{B_f \times D} \times F.S.$$
 B16

The determination of required strength of elliptical and arch concrete pipe is computed by the equation:

D-load =
$$\frac{W_L + W_E}{B_f \times S} \times F.S.$$
 B17

EXAMPLE PROBLEMS

EXAMPLE B-1 Trench Installation



Given:

A 48 inch circular pipe is to be installed in a 7 foot wide trench with 35 feet of cover over the top of the pipe. The pipe will be backfilled with sand and gravel weighing 110 pounds per cubic foot.

Find: The required pipe strength in terms of 0.01 inch crack D-load.

Solution: 1. Determination of Earth Load (WE)

From Table B-14A, Sand and Gravel, the backfill load based on 100 pounds per cubic foot backfill is 12,000 pounds per linear foot. Increase the load 10 percent for 110 pound backfill material.

$$Wd = 1.10 X 12,000$$

Wd = 13,200 pounds per linear foot

2. Determination of Live Load (WL)

From Table 42, live load is negligible at a depth of 35 feet.

3. Selection of Bedding

A Class B bedding will be assumed for this example. In actual design, it may be desirable to consider other types of bedding in order to arrive at the most economical overall installation.

4. Determination of Bedding Factor (Bf)

The trench variable bedding factor, B_{fv} is given by Equation B11:

$$B_{fv} = (B_{fe} - B_{ft}) \left[\frac{B_d - (B_c + 1.0)}{B_{dt} - (B_c + 1.0)} \right] + B_{ft}$$

Step 1. From Figure B-14, for circular pipe installed on a Class B bedding, the trench fixed bedding factor, B_{ft}, is 1.9.

Step 2. A trench width, Bd, of 7 feet is specified.

Step 3. The transition width, Bdt, determined from Table B-14A is 11.4 feet.

Step 4.
$$H/Bc = 35/4.8 = 7.3$$

From Table B-31, the rsd design range of values for ordinary soil is +0.5 to +0.8. Assume an rsd value of +0.5. For a granular Class B bedding p = 0.5, then rsdp = $0.5 \times 0.5 = 0.25$.

Step 5. From Table B-32 for
$$H/B_c = 7.3$$
, $p = 0.5$, $r_{sd}p = 0.25$ and a Class B bedding, $B_{fe} = 2.19$.

Step 6. The trench variable bedding factor is:

$$B_{fv} = (2.19 - 1.9) \left[\frac{7 - (4.8 + 1.0)}{11.4 - (4.8 + 1.0)} \right] + 1.9$$

$$B_{tv} = 1.96$$

Use a variable bedding factor, B_{fv} of 1.96 to determine the required D-load pipe strength.

- Application of Factor of Safety (F.S.)
 A factor of safety of 1.0 based on the 0.01-inch crack will be applied.
- Selection of Pipe Strength
 The D-load is given by Equation B16:

$$D_{0.01} = \frac{W_L + W_E}{B_f \times D} \times F.S.$$

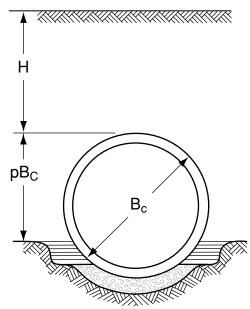
 W_{L+} $W_{E} = W_{d} = 13,200$ pounds per linear foot

$$D_{0.01} = \frac{13,200}{1.96 \times 4.0} \times 1.0$$

 $D_{0.01} = 1684$ pounds per linear foot per foot of inside diameter

Answer: A pipe which would withstand a minimum three-edge bearing test load for the 0.01 inch crack of 1684 pounds per linear foot per foot of inside diameter would be required.

EXAMPLE B-2Positive Projecting Embankment Installation



Given: A 48 inch circular pipe is to be installed in a positive projecting embankment condition in ordinary soil. The pipe will be covered with 35 feet of 110 pounds per cubic foot overfill.

Find: The required pipe strength in terms of 0.01 inch crack D-load.

Solution: 1. Determination of Earth Load (WE)

A settlement ratio must first be assumed. In Table B-31 values of settlement ratio from +0.5 to +0.8 are given for positive projecting installations on a foundation of ordinary soil. A conservative value of 0.7 will be used with an assumed projection ratio of 0.7. The product of the settlement ratio and the projection ratio will be 0.49 ($r_{sdp} = 0.5$).

Enter Figure B-12 on the horizontal scale at H = 35 feet. Proceed vertically until the line representing D = 48 inches is intersected. At this point the vertical scale shows the fill load to be 25,300 pounds per linear foot for 100 pounds per cubic foot fill material. Increase the load 10 percent for 110 pound material.

 $W_c = 1.10 \text{ X } 25,300$ $W_c = 27,800 \text{ pounds per linear foot}$

- 2. Determination of Live Load (WL) From Table 42, live load is negligible at a depth of 35 feet.
- Selection of Bedding
 A Class B bedding will be assumed for this example. In actual design, it may be desirable to consider other types of bedding in order to arrive at the most economical overall installation.
- 4. Determination of Bedding Factor (B_f) The outside diameter for a 48 inch diameter pipe is 58 inches = 4.83 feet. From Table B-32, from an H/B_c ratio of 7.25, r_{sd}p value of 0.5, p value of 0.7 and Class B bedding, a bedding factor of 2.34 is obtained.
- Application of Factor of Safety (F.S.)
 A factor of safety of 1.0 based on the 0.01 inch crack will be applied.
- Selection of Pipe Strength
 The D-load is given by equation B16:

$$D_{0.01} = \frac{W_L + W_E}{B_f \times D} \times F.S.$$

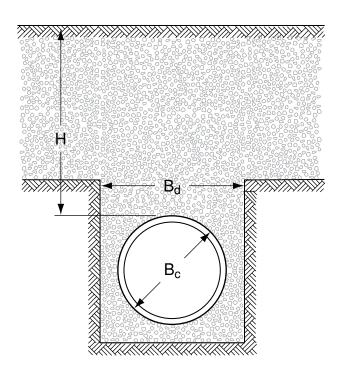
 W_{L+} $W_{E} = W_{c} = 27,800$ pounds per linear foot

$$D_{0.01} = \frac{27,800}{2.34 \times 4.0} \times 1.0$$

 $D_{0.01} = 2970$ pounds per linear foot per foot of inside diameter

Answer: A pipe which would withstand a minimum three-edge bearing test load for the 0.01 inch crack of 2970 pounds per linear foot per foot of inside diameter would be required.

EXAMPLE B-3
Negative Projecting Embankment Installation



Given:

A 48 inch circular pipe is to be installed in a negative projecting embankment condition in ordinary soil. The pipe will be covered with 35 feet of 110 pounds per cubic foot overfill. A 7 foot trench width will be constructed with a 7 foot depth from the top of the pipe to the natural ground surface.

Find: The required pipe strength in terms of 0.01 inch crack D-load.

Solution: 1. Determination of Earth Load (WE)

A settlement ratio must first be assumed. In Table B-31, for a negative projection ratio, p' = 1.0, the design value of the settlement ratio is -0.3.

Enter Figure 201 on the horizontal scale at H = 35 feet. Proceed vertically until the line representing $B_d = 7$ feet is intersected. At this point the vertical scale shows the fill load to be 15,800 pounds per linear foot for 100 pounds per cubic foot fill material. Increase the load 10 percent for 110 pound material.

 $W_n = 1.10 \times 15.800$

Wn = 17,380 pounds per linear foot

- 2. Determination of Live Load (WL) From Table 42, live load is negligible at a depth of 35 feet.
- Selection of Bedding
 A Class B bedding will be assumed for this example. In actual design, it may be desirable to consider other types of bedding in order to arrive at the most economical overall installation.
- 4. Determination of Bedding Factor (B_f)
 The trench variable bedding factor, B_f, is given by Equation B11:

$$B_{fv} = (B_{fe} - B_{ft}) \left[\frac{B_d - (B_c + 1.0)}{B_{dt} - (B_c + 1.0)} \right] + B_{ft}$$

- Step 1. From Figure B-14, for circular pipe installed on a Class B bedding, the trench fixed bedding factor, Bft, is 1.9.
- Step 2. A trench width, Bd, of 7 feet is specified.
- Step 3. The transition width, Bdt, determined from Table B-14 is 11.4 feet.
- Step 4. H/Bc = 35/4.8 = 7.3From Table B-31, the rsd design range of values for ordinary soil is +0.5 to +0.8. Assume an rsd value of +0.5. For a granular Class B bedding p = 0.5, then rsdp = $0.5 \times 0.5 = 0.25$.
- Step 5. From Table B-32, for H/Bc = 7.3, p = 0.5, $r_{sd}p = 0.25$ and a Class B bedding, Bfe = 2.19.
- Step 6. The trench variable bedding factor is:

$$B_{fv} = (2.19 - 1.9) \left[\frac{7 - (4.8 + 1.0)}{11.4 - (4.8 + 1.0)} \right] + 1.9$$

$$B_{fv} = 1.96$$

Use a variable bedding factor, B_{fv}, of 1.96 to determine the required D-load pipe strength.

- Application of Factor of Safety (F.S.)
 A factor of safety of 1.0 based on the 0.01 inch crack will be applied.
- 6. Selection of Pipe Strength
 The D-load is given by equation B16:

$$D_{0.01} = \ \frac{W_L + W_E}{B_f \ x \ D} \ \ x \ F.S.$$

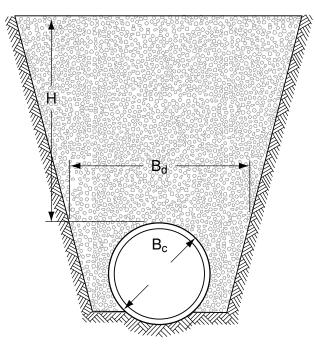
 W_{L+} $W_{E} = W_{n} = 17,380$ pounds per linear foot

$$D_{0.01} = \frac{17,380}{1.96 \times 4.0} \times 1.0$$

 $D_{0.01} = 2217$ pounds per linear foot per foot of inside diameter

Answer: A pipe which would withstand a minimum three-edge bearing test load for the 0.01 inch crack of 2217 pounds per linear foot per foot of inside diameter would be required.

EXAMPLE B-4Wide Trench Installation



Given:

A 24 inch circular pipe is to be installed in a 5 foot wide trench with 9 feet of cover over the top of the pipe. The pipe will be backfilled with ordinary clay weighing 120 pounds per cubic foot.

Find:

The required three-edge bearing test strength for nonreinforced pipe and the ultimate D-load for reinforced pipe.

Solution: 1. Determination of Earth Load (WE)

From Table B-8C, the transition width for H = 9 feet is 4'-8". Since the actual 5 foot trench width exceeds the transition width, the backfill load based on 100 pounds per cubic foot backfill is 3,331 pounds per linear foot as given by the bold type. Increase the load 20 percent for 120 pound backfill material.

 $W_d = 1.20 \times 3,331$ Wd = 3,997 pounds per linear foot

- 2. Determination of Live Load (WL) From Table 42, the live load is 240 pounds per linear foot.
- 3. Selection of Bedding A Class C bedding will be assumed for this example.
- 4. Determination of Bedding Factor (B_f) Since the trench is beyond transition width, a bedding factor for an embankment condition is required.

The outside diameter for a 24 inch diameter pipe is 30 inches = 2.5feet. H/Bc = 3.6. From Table B-31, the rsd design range of values for ordinary soil is +0.5 to +0.8. Assume an rsd value of +0.5. For shaped Class C bedding p = 0.9, then $r_{sd}p = 0.5 \times 0.9 = 0.45$. From Table B-33, a bedding factor of 2.07 is obtained.

- 5. Application of Factor of Safety (F.S.) A factor of safety of 1.5 based on the three-edge bearing strength for nonreinforced pipe and ultimate D-load for reinforced pipe will be applied.
- 6. Selection of Pipe Strength The three-edge bearing strength for nonreinforced pipe is given by equation B15:

T.E.B. =
$$\frac{W_L + W_E}{B_f}$$
 X F.S.

 $W_L + W_E = W_d = 4,237$ pounds per linear foot

T.E.B. =
$$\frac{4,237}{2.07}$$
 X 1.5

T.E.B. = 3,070 pounds per linear foot

The D-load for reinforced pipe is given by equation B16:

$$D_{ult.} = \frac{W_L + W_E}{B_f \times D} \times F.S.$$

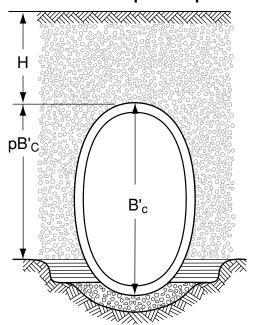
$$D_{ult.} = \frac{4,237}{2.07 \times 2.0} \times 1.5$$

D_{ult.} = 1,535 pounds per linear foot per foot of inside diameter

Answer: A nonreinforced pipe which would withstand a minimum three edge bearing test load of 3,070 pounds per linear foot would be required.

A reinforced pipe which would withstand a minimum three-edge bearing test load for the ultimate load of 1,535 pounds per linear foot per foot inside diameter would be required.

EXAMPLE B-5
Positive Projecting Embankment Installation
Vertical Elliptical Pipe



Given:

A 76 inch X 48 inch vertical elliptical pipe is to be installed in a positive projecting embankment condition in ordinary soil. The pipe will be covered with 50 feet of 120 pounds per cubic foot overfill.

Find:

The required pipe strength in terms of 0.01 inch crack D-load.

Solution: 1. Determination of Earth Load (WE)

A settlement ratio must first be assumed. In Table B-31 values of settlement ratio from +0.5 to +0.8 are given for positive projecting installations on a foundation of ordinary soil. A value of 0.5 will be used. The product of the settlement ratio and the projection ratio will be 0.35 (rsdp = 0.3).

Enter Figure 181 on the horizontal scale at H = 50 feet. Proceed vertically until the line representing R X S = 76" X 48" is intersected. At this point the vertical scale shows the fill load to be 37,100 pounds per linear foot for 100 pounds per cubic foot fill material. Increase the load 20 percent for 120 pound material.

 $W_c = 1.20 \times 37,100$

W_c = 44,520 pounds per linear foot

- 2. Determination of Live Load (WL) From Table 44, live load is negligible at a depth of 50 feet.
- 3. Selection of Bedding A Class B bedding will be assumed for this example.
- 4. Determination of Bedding Factor (Bf) From Table 59, for an H/Bc, ratio of 9.84, rsdp value of 0.3, p value of 0.7 and a Class B bedding, a bedding factor of 2.80 is obtained.
- 5. Application of Factor of Safety (F.S.) A factor of safety of 1.0 based on the 0.01 inch crack will be applied.
- 6. Selection of Pipe Strength The D-load is given by equation B17:

$$D_{0.01} = \frac{W_L + W_E}{B_f \times S} \times F.S.$$

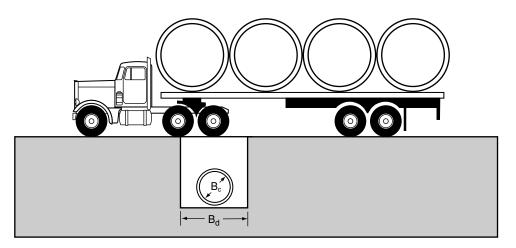
 W_{L+} $W_{E} = W_{c} = 44,520$ pounds per linear foot

$$D_{0.01} = \frac{44,520}{2.80 \times 4.0} \times 1.0$$

 $D_{0.01} = 3,975$ pounds per linear foot per foot of inside horizonal span

Answer: A pipe which would withstand a minimum three-edge bearing test load for the 0.01 inch crack of 3,975 pounds per linear foot per foot of inside horizontal span would be required.

EXAMPLE B-6Highway Live Load



Given: A 12 inch circular pipe is to be installed in a narrow trench $B_d \le (B_c + 1.0)$, under an unsurfaced roadway and covered with 1.0 foot of 120

pounds per cubic foot backfill material.

Find: The required pipe strength in terms of 0.01 inch crack D-load.

Solution: 1. Determination of Earth Load (WE)

For pipe installed with less than 3 feet of cover, it is sufficiently accurate to calculate the backfill or fill load as being equal to the weight of the prism of earth on top of the pipe.

Wd = wHBc

 $W_d = 120 X 1.0 X 1.33$

Wd = 160 pounds per linear foot

- Determination of Live Load (WL)
 Since the pipe is being installed under an unsurfaced roadway with shallow cover, a truck loading based on legal load limitations should be evaluated. From Table 42, for D = 12 inches, H = 1.0 foot and AASHTO loading, a live load of 2,080 pounds per linear foot is
- 3. Selection of Bedding
 A Class C bedding will be assumed for this example.

obtained. This live load value includes impact.

- Determination of Bedding Factor (Bf)
 From Figure B-14, for circular pipe installed on a Class C bedding, a bedding factor of 1.5 is obtained.
- Application of Factor of Safety (F.S.)
 A factor of safety of 1.0 based on the 0.01 inch crack will be applied.
- 6. Selection of Pipe Strength The D-load is given by equation B16:

$$D_{0.01} = \frac{W_L + W_E}{B_f \times D} \times F.S.$$

$$D_{0.01} = \frac{2,080 + 160}{1.5 \times 1.0} \times 1.0$$

 $D_{0.01} = 1,493$ pounds per linear foot per foot of inside diameter

Answer: A pipe which would withstand a minimum three-edge bearing test load for the 0.01-inch crack of 1,443 pounds per linear foot per foot of inside diameter would be required.

Appendix B Tables & Figures

Table B-1

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	3'-3"																											3024	3109	3217	3296	3400	3405	2415
: PIPE	3,-0,,																						2451	2553	7007	2843	2935	2877	2889	2899	2909	2918	2925	
O dC	2'-9"																	1983	2074	2173	2269	2362	2373	2388	2401	2425	2435	2444	2451	2459	2465	2471	2476	000
AT T(26"													1602	1701	1797	1887	1915	1934	1951	1966	1979	1991	2001	2010	9000	2032	2038	2043	2048	2052	2055	2058	1000
IDTH	2'-3"									1227	1320	1416	1512	1512	1534	1553	1570	1584	1597	1608	1618	1627	1634	1641	1047	1656	1660	1663	1666	1669	1671	1673	1675	010
CH &	2'-0"					848	942	1037	1132	1143	1170	1192	1212	1229	1243	1256	1266	1276	1284	1291	1296	1301	1306	1310			1320	1322	1323					000
TRENCH WIDTH AT TOP OF	1,-6.,1		564	658	753	802	836	865	890	910	928		955		974	981	286	392			_	-+		010	_		+-	_	1017		-		-	
	1.9-1	470	524	565	598	626	648	999	681	694	704	712	719	724	729	733	736	738		_		+		746 1			† 	748 1	748 1	749 1	_		-	7.0
	1:3"	363	- /	423	444	460	473	483	491	497	502	ဖွ	60	2	ი	5				<u>∞</u>	519	519	519	520	250	520	520	520	520	520	\dashv			-
ż		9						 	<u> </u>	2:		4" 506	509		6" 513	6" 515	7" 516	L									<u> </u>			4" 52				R
ATRAN-	WIDTH	<u></u>		1'- 9" 42	_			 					<u> </u>	2				L						3-0-2			<u> </u>	3,	3'- 3"	3'- 4"	3'- 4"	3'- 5"	3, 5,	2.0
ATRAN-	3'-6" WIDTH	9						 	<u> </u>	2:	3.	.4	<u> </u>	2	9	9		L							7 7	3 2.	3'- 2"	3, 3,	3'- 3"	3217 3'- 4"	3296 3- 4"	3400 3'- 5"	3503 3'- 5"	2000
7	0" 3'-3" 3'-6" WIDTH	9						 	<u> </u>	2:	3.	.4	<u> </u>	2	9	9		L		2'- 9"	2:-10"	2'-11"	2'-11"	, o	27.49	2843 3'- 2"	2935 3'- 2"	3024 3'- 3"	3109 3'- 3"	3099 3217 3'- 4"	3109 3296 3'- 4"	3118 3400 3'- 5"	3126 3503 3'- 5"	
OF PIPE	3'-0" 3'-3" 3'-6" WIDTH	9						 	<u> </u>	2:	3.	.4	<u> </u>	2	9	5 6"	2 7"	2 8"	5 8	2'- 9"	210"	2362	2451	2553 3'- 0"	2614 2749 3'- 1"	2626 2843 3-2"	2637 2935 3'- 2"	2646 3024 3'- 3"	2654 3109 3'- 3"	2662 3099 3217 3 4"	2669 3109 3296 3'- 4"	2675 3118 3400 3'- 5"	2680 3126 3503 3'- 5"	10000 0100 0100 0100 I
OF PIPE	2'-9" 3'-0" 3'-3" 3'-6" WIDTH	9						 	<u> </u>	2:	3.	2'- 4"	2 - 4"	2 5	2'- 6"	5 6	1887 2'- 7"	1983 2'- 8"	2074	2173 2'- 9"	2163 2269 2:-10"	21// 2362 2'-11"	2190 2451	2201 2553 3'- 0"	2221 2614 2749 3: 1"	2229 2626 2843 3 2	2236 2637 2935 3'- 2"	2242 2646 3024 3'- 3"	2247 2654 3109 3'- 3"	2252 2662 3099 3217 3 4"	2257 2669 3109 3296 3 4 "	2261 2675 3118 3400 3'- 5 "	2264 2680 3126 3503 3'- 5"	
OF PIPE	2'-6" 2'-9" 3'-0" 3'-3" 3'-6" WIDTH	9						2:- 0::	2'- 1"	2:- 2:.	2'- 3"	1416 2'- 4"	1512 2 4	1602	1701 2'- 6"	1797 2 6"	1758 1887 2'- 7"	1775 1983 2'- 8"	1790 2074 2'- 8"	1802 2173 2'- 9"	1814 2163 2269 2:-10"	1824 21/7 2362 2:-11"	1832 2190 2451	1840 2201 2553 3'- 0"	1852 2221 2614 2749 3: 1"	1857 2229 2626 2843 3-2"	1862 2236 2637 2935 3- 2"	1866 2242 2646 3024 3:- 3"	1869 2247 2654 3109 3'- 3"	1872 2252 2662 3099 3217 3'- 4 "	1875 2257 2669 3109 3296 3 4 "	1877 2261 2675 3118 3400 3'- 5 "	1879 2264 2680 3126 3503 3-5"	100 to 100 100 100 100 100 100 100 100 100 10
OF PIPE	2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" WIDTH	9			1,-10		1,1	2'- 0"	1132 2'- 1"	1227	1320 2'- 3"	1364 1416 2'- 4"	1387 1512 2 - 4"	1407 1602 2:- 5:-	1424 1701 2'- 6"	1439 1797 2'- 6"	1452 1758 1887 2'- 7 "	1463 1775 1 983 2'- 8"	1473 1790 2074 2'- 8 "	1481 1802 2173	1488 1814 2163 2269 2:-10"	1494 1824 21// 2362 2:-11"	1500 1832 2190 2451	1504 1840 2201 2553 3- 0 "	1512 1852 2221 2614 2749	1515 1857 2229 2626 2843 3-2"	1517 1862 2236 2637 2935 3'- 2"	1520 1866 2242 2646 3024 3:-3"	1521 1869 2247 2654 3109 3'- 3"	1523 1872 2252 2662 3099 3217 3 4 "	1525 1875 2257 2669 3109 3296 3'- 4 "	1526 1877 2261 2675 3118 3400 3'- 5 "	1527 1879 2264 2680 3126 3503 3'- 5"	14500 14004 10054 1000 10400 1000 100 100 100 100 100 10
OF PIPE	2'-0" 2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" WIDTH	9		1: 9"	753 1:10"	848	7 942	1037	1044 1132 2'- 1"	1070 1227 2'- 2"	1091 1320 2'- 3"	1110 1364 1416 2:- 4"	1125 1387 1512 2 - 4"	1138 1407 1602 2:- 5	1149 1424 1701 2'- 6"	1159 1439 1797 2 6 "	1167 1452 1758 1887 2'- 7"	1174 1463 1775 1983 2 8"	1179 1473 1790 2074 2'- 8"	1184 1481 1802 2173 2 '- 9 "	1189 1488 1814 2163 2269 2:-10 "	1192 1494 1824 21/7 2362 2:-11"	1195 1500 1832 2190 2451	1198 1504 1840 2201 2553 3-0"	1201 1512 1852 2221 2614 2749	1203 1515 1857 2229 2626 2843 3'- 2"	1204 1517 1862 2236 2637 2935 3'- 2"	1205 1520 1866 2242 2646 3024 3'-3 "	1206 1521 1869 2247 2654 3109 3-3"	1207 1523 1872 2252 2662 3099 3217 3-4 "	1208 1525 1875 2257 2669 3109 3296 3 4"	1208 1526 1877 2261 2675 3118 3400 3'- 5"	1209 1527 1879 2264 2680 3126 3503 3 5"	11000 11E30 11001 100E3 100EB 10100 100EB 101
J H	11-9" 2'-0" 2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" WIDTH		1-8"	1: 9"	722 753 11-10"	758 848	787 942 11-11"	811 1037	831 1044 1132 2'- 1"	848 1070 1227 2"	861 1091 1320 2'- 3"	873 1110 1364 1416 2'- 4"	882 1125 1387 1512	890 1138 1407 1602 2 5.	896 1149 1424 1701 2'- 6"	902 1159 1439 1797 2:- 6"	906 1167 1452 1758 1887	910 1174 1463 1775 1983 2'- 8"	913 1179 1473 1790 2074	915 1184 1481 1802 2173 2. 9"	917 1189 1488 1814 2163 2269 2:-10"	919 1192 1494 1824 2177 2362	921 1195 1500 1832 2190 2451	922 1198 1504 1840 2201 2553 3-0 "	924 1201 1512 1852 2221 2614 2744	924 1203 1515 1857 2229 2626 2843 3:- 2"	925 1204 1517 1862 2236 2637 2935 3: 2"	925 1205 1520 1866 2242 2646 3024 31-3"	926 1206 1521 1869 2247 2654 3109 3'- 3"	926 1207 1523 1872 2252 2662 3099 3217 3-4 "	926 1208 1525 1875 2257 2669 3109 3296 3. 4"	926 1208 1526 1877 2261 2675 3118 3400 3'- 5"	927 1209 1527 1879 2264 2680 3126 3503 3'- 5"	007 17000 14004 1004 10067 10000 3000 1 0: -
OF PIPE	1'-6" 1'-9" 2'-0" 2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" WIDTH	1 6"	499 564	535 658	564 722 753 1:10"	587 758 848	606 787 942 11-11"	621 811 1037 2:- 0"	633 831 1044 1132 2 1"	642 848 1070 1227 2 2 "	650 861 1091 1320 2 '- 3"	656 873 1110 1364 1416 2:- 4"	661 882 1125 1387 1512	665 890 1138 1407 1602 2 - 5	668 896 1149 1424 1701 2'- 6 "	671 902 1159 1439 1797 2:- 6 "	673 906 1167 1452 1758 1887 2: 7"	675 910 1174 1463 1775 1983 2 8 "	676 913 1179 1473 1790 2074 2. 8 "	677 915 1184 1481 1802 2173 2'- 9 "	678 917 1189 1488 1814 2163 2269 2-10 "	679 919 1192 1494 1824 21/7 2362 2:-11"	679 921 1195 1500 1832 2190 2451 2.11"	680 922 1198 1504 1840 2201 2553 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	680 924 1201 1512 1852 2221 2614 2749 3'- 1"	680 924 1203 1515 1857 2229 2626 2843 3 2. "	681 925 1204 1517 1862 2236 2637 2935 3'- 2 "	681 925 1205 1520 1866 2242 2646 3024 3 3 "	681 926 1206 1521 1869 2247 2654 3109 3'- 3"	681 926 1207 1523 1872 2252 2662 3099 3217 3:- 4 "	681 926 1208 1525 1875 2257 2669 3109 3296 3 4 "	681 926 1208 1526 1877 2261 2675 3118 3400 3'- 5 "	681 927 1209 1527 1879 2264 2680 3126 3503 3'- 5 "	1 804 007 1000 1800 1004 0067 060E 0100 009E 01
OF PIPE	11-9" 2'-0" 2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" WIDTH	347 470	499 564	398 535 658 11: 9"	416 564 722 753	429 587 758 848 1:-11"	439 606 787 942	621 811 1037 2:- 0"	633 831 1044 1132 2 1"	642 848 1070 1227 2 2 "	650 861 1091 1320 2 '- 3"	656 873 1110 1364 1416 2:- 4"	661 882 1125 1387 1512	665 890 1138 1407 1602 2 - 5	668 896 1149 1424 1701 2'- 6 "	671 902 1159 1439 1797 2 6 "	673 906 1167 1452 1758 1887 2: 7"	471 675 910 1174 1463 1775 1983 2'- 8 "	472 676 913 1179 1473 1790 2074	472 677 915 1184 1481 1802 2173 2. 9 "	472 678 917 1189 1488 1814 2163 2269 2:-10 "	679 919 1192 1494 1824 21/7 2362 2:-11"	4/2 6/9 921 1195 1500 1832 2190 2451	473 680 922 1198 1504 1840 2201 2553 3.0"	473 680 924 1201 1512 1852 2221 2614 2749 31-1"	473 680 924 1203 1515 1857 2229 2626 2843 3:- 2"	473 681 925 1204 1517 1862 2236 2637 2935 3: 2"	473 681 925 1205 1520 1866 2242 2646 3024 3: 3"	473 681 926 1206 1521 1869 2247 2654 3109 3 :- 3 "	473 681 926 1207 1523 1872 2252 2662 3099 3217 3. 4 "	681 926 1208 1525 1875 2257 2669 3109 3296 3 4 "	473 681 926 1208 1526 1877 2261 2675 3118 3400 3-5 "	473 681 927 1209 1527 1879 2264 2680 3126 3503 3: 5"	22.00 2000 2000

Tab

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	ATRAN-			TREN	S E S	THE	AT TO	TRENCH WIDTH AT TOP OF PIPE	PIPE			ATRAN-	
3'-6"		1'-3"	1'-6"	16,,	2:-0:.	2:-3"	2'-6"	2,-9	30	3'-3"	3'-6"	WIDTH	
	1'- 5"	415	470									1'- 4"	2
	1'- 6"	463	564									1'- 5"	9
	1: 7"	503	658									1. 6.	7
	1. 8.	536	90/	753								1: 7"	œ
	1. 9.	564	749	848								1 7	
	1 9	588	286	942								1. 8.	은
1	1:10	607	818	1037								1'- 9"	
	1:41"	624	846	1084	1132		-w-a-					1'-10"	12 H
	2 0	638	870	1120	1227							1'-10"	ا ا
	2 0	649	891	1152	1320							1'-11"	\ \ \
	2. 1.	629	606	1180	1416							1:-11"	
1	2. 2	299	924	1205	1512							2 0	
	2'- 2"	674	938	1227	1537	1602						2'- 1"	
	2'- 3"	989	949	1247	1567	1701						2'- 1"	
	2'- 4"	685	626	1264	1593	1797						2'- 2"	
	2: 4"	689	968	1279	1616	1887						2'- 2"	
	2'- 5"	692	975	1292	1637	1983						2'- 3"	
	2 5"	695	982	1304	1656	2074						2'- 3"	
	2 6	697	286	1314	1673	2058	2173					2- 4"	
	2'- 6"	669	892	1323	1688	2080	2269						
	2'- 7"	701	966	1331	1701	2101	2362						
	2'- 8"	702	1000	1339	1714	2120	2451					2- 5"	
	2. 8.	704	1003	1345	1724	2136	2553						
	2:- 9::	705	1005	1350	1734	2152	2652					2'- 6"	, 8
	2 9.:	705	1008	1355	1743	2166	2619	2749				2'- 7"	
	210	206	1010	1360	1751	2178	2638	2843				2 7"	
	2:-10"	707	1011	1363	1758	2190	2655	2935				2'- 8"	
	2'-11"	707	1013	1367	1764	2200	2670	3024				2 8	32 1
	2:-11	208	1014	1370	1769	2209	2685	3109				2 8	
	3 0	708	1015	1372	1774	2218	2698	3217					34 □
	3 0	708	1016	1374	1779	2226	2710	3296				2'- 9"	
	3'- 1"	708	1017	1376	1783	2233	2721	3244	3400			2'-10"	
	3'- 1"	709	1018	1378	1787	2239	2731	3259	3503			2:-10"	37
	3'- 2"	209	1018	1380	1790	2245	2740	3273	3605			2'-11"	38
	3 2"	709	1019	1381	1793	2250	2749	3285	3671			2'-11"	30
	3, 5	709	1010	1000	1705	つつなな	2750	2007	2700		_		4

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. A Transition loads (**bold type**) and widths based on Kμ-0.19, r_{sd}p-0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

O

TRENCH WIDT ORDINARY

2'-0"

1'-9"

.φ

1.-3.

1133 1139 1156 1159

827 827 833 838 846 846 846 851 851 857 857 859 859

594 595 596

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET

862 862 862

009 009

864 864 864 864

598 599 599

583 586 589 591

757 774

560

801

574

753 848 942

649 683 712

Table B-2

								HE	EIC	3 H	łΤ	С	F	В	AC	CK	FI						VE		О		0			ÞΕ		FE						
		ZΤ	ري ا ـ	. .		. &		- 2	=	12	13	14		16	1.	9" 18	<u>.</u>	<u></u>	21	22	23	2	22	50	27	- 58 - 1	<u>8</u>						35				္က -	_
ò	ATRAN	SITION	1. 9	1'-11"	2.0	2. 1	2-2	2 _. 3	2-3	2- 4	2.5	2. 6	2-7	5 - 8	2, 8	2.9	2'-10"	2'-11"	2'-11"	3'- 0	3.1	3'- 1	3.	3	3,-	 4	3,-			9 6				3'- 9"	3'- 9"	310	3'-10'	3-11
		4.0									-			Γ														T			4004	4124	4241	4384	4495	4603	4740	4877
		36	-						l					\vdash					-					-		<u>~</u>	4	9	_				-					⊣
Ç	, w	<u></u>	<u> </u>						_					-					_		•	_	_					-					_					3950
5	F PIPE	33																	_		2788	2910	3041	3154				_	3319				-+					3433
O 100 X	OP O	3.0															2308	2429	2553	2673	2699	2727	2753	2777	2798	2817	2834	2850	2864	2877	5883	2899	2909	2918	2925	2932	2939	2945
LAT NEAR	AT TOP OF	29											1818	1942	2065	2182	2203	2236	2265	2292	2315	2336	2355	2373	2388	2401	2414	2425	2435	2444	7451	2459	2465	2471	2476	2480	2485	2488
TAL ER LII	DITH	26"								1458	1575	1698	1738	1777	1812	1843	1870	1894	1915	1934	1951	1966		1991						_	_		-+					5066
INS P	Ĭ X	2'-3"				696	1088	1213	1332		1389 1	1426	1459 1	1487	1512 1	1534 1	1553 1	1570 1	1584	1597 1	1608 1	1618 1	\neg	1634 1				_					_					1679 2
LOADS IN POUNDS PER LINEAR FOOT	TRENCH WIDTH	20		724	847	931	987 10							ļ.				-	-		÷			-				+			_		+					\dashv
IRE!		<u>-</u>	e e					6 1035	5 107	0 11112	0 1143	8 1170	2 1192	5 1212	5 1229	1243			2 1276		1 1291		\vdash	_			_	+		_		_	-+	·				1330
Z è		19	603	655	713	761	805	836	-		910	928	945	955	962	974		1887	_		100			_				$^+$				_	+					1019
PE A⊦		1,-6	474	524	565	298	626	648	999	681	694	704	712	719	724	729	733	736	738	740	742	743	744	745	746	747	747	748	/48	748	44	749	749	749	749	749	749	/49
																																						_
ਕਂ≤	ا لما	ZΤ	=			:	2	=	=	=	:	=	=	Ξ	=	=	=		2	•	2				•	*							-	-				. 1
CULA	TRAN-	WIDTH	1'-10"	1:-11"	2 0	2'- 1"	2. 2.	2'- 3"	2 4.	2. 5"	2- 6	2. 7"	2 8"	2- 9"	2:-10"	2-10	2′-11″	3-0	3'- 1"	3. 2.	3- 2	3 3.	3- 4	3- 4	3- 5	9		3. 7	,	က် ကြွင်		3,- 6.	3'-10"	3'-11"	3'-11"	4- 0		- 4
CIRCULA BACKFILL MA	ATRAN-		110	1:-11"	2 0	2'- 1"		2'- 3"	2:- 4"	2'- 5"	2- 6"	2 7"	2- 8		2:-10"	2:-10"	2′-11"		3'- 1"		3- 2"		3- 4"	3'- 4"	 3 5.	3-6	'n	ώ č	, ,	, ,	<u>۔</u>		-					877 4- 1
ON CIRCULA	ATRAN-	40	110	1:-1	2:- 0	2- 1"		2- 3	2- 4"	2'- 5"	2- 6"	2 7"	2'- 8"		2:-10"	2-10	2'-11"		3'- 1"		3. 2.		3	3,	<u>က်</u>	'n		3646 3'-	3//6	3880 3'-	4004	4124	4241	4384	4495	4603	4740	26 4877 4-1
NDS ON CIRCULA UBIC FOOT BACKFILL MA'	1	3'-6" 4'-0"	110"	1:-11:	2 0	2'- 1"		2'- 3"	2:- 4"	2. 5.	2'- 6"	2'- 7"	2'- 8"		2:-10"	2'-10"	2′-11″		3'- 1"	<u>ښ</u>	3,	.; .;	3041 3'-	3154 3'-	3278 3'-	3398 3-	3514 3	3492 3646 3-	3512 3//6 3-	3530 3880 3 -	3546 4004 5-	3561 4124	3575 4241	3587 4384	3598 4495	3608 4603	3618 4740	3626
LOADS ON CIRCULAR PIPE IN TRENCH INSTALLATION PER CUBIC FOOT BACKFILL MATERIAL LOADS IN POUNDS PER LINEAR FOOT 165	PIPE	3'-3" 3'-6" 4'-0"	1:-10"	1:11"	2 0"	2'- 1"		2'- 3"	2:- 4"	2'- 5"	2'- 6"	2'- 7"	2 8"					3,	5 2553 3'- 1"	2673 3	2788 3'-	2910 3	2947 3041 3:-	2972 3154 3'-	2994 3278 3'-	3014 3398 3'-	3032 3514 3:-	3048 3492 3646 3	3003 3312 3//6 3-	3076 3530 3880 3	3088 3346 4004 3-	3099 3561 4124	3109 3575 4241	3118 3587 4384	3126 3598 4495	3133 3608 4603	3139 3618 4740	3142 3626
	PIPE	3'-0" 3'-3" 3'-6" 4'-0"	1:-10	1.11.1	2:- 0"	2'- 1"		2'- 3"	2 4"	2'- 5"	2, 2,	2'- 7"	2.2.	2'-	2065	2182	2308	2429 3	2456	2484 2673 3-	2510 2788 3'-	2532 2910 3-	2552 2947 3041 3.	2571 2972 3154 3'-	2587 2994 3278 3'-	2601 3014 3398 3:-	2614 3032 3514 3:-	2626 3048 3492 3646 3 '-	203/ 3003 3312 31/6 3-	2646 3076 3530 3880 3 -	2024 3088 3546 4004 3-	2662 3099 3561 4124	2669 3109 3575 4241	2675 3118 3587 4384	2680 3126 3598 4495	2685 3133 3608 4603	2689 3139 3618 4740	2693 3142 3626
	AT TOP OF PIPE	2'-9" 3'-0" 3'-3" 3'-6" 4'-0"	1:-10"	1:11	2 0	2'- 1"		2- 3"	2:- 4"	2'- 5"	2, 2,	1698 2'- 7"	1818 2'- 8"	2'-		2182	2308	3,	2456	2484 2673 3-	2510 2788 3'-	2532 2910 3-	2552 2947 3041 3.	2571 2972 3154 3'-	2587 2994 3278 3'-	2601 3014 3398 3:-	2614 3032 3514 3:-	2626 3048 3492 3646 3 '-	203/ 3003 3312 31/6 3-	2646 3076 3530 3880 3 -	2024 3088 3546 4004 3-	2662 3099 3561 4124	2669 3109 3575 4241	2675 3118 3587 4384	2680 3126 3598 4495	2685 3133 3608 4603	2689 3139 3618 4740	3142 3626
	AT TOP OF PIPE	3'-0" 3'-3" 3'-6" 4'-0"	1:-10"	1:11	2:- 0"	2:-1"		2.	2:-	2.	2.2	1595 1698 2 7"	2.2.	2'-	2065	2182	2057 2308	2429 3	2107 2456	2128 2484 2673 3-	2510 2788 3'-	2163 2532 2910 3-	2177 2552 2947 3041 3.	2190 2571 2972 3154 3-	2201 2587 2994 3278 3'-	2212 2601 3014 3398 3'-	2221 2614 3032 3514 3:-	2229 2626 3048 3492 3646 3 -	2230 2037 3003 3312 31/6 3-	2242 2646 3076 3530 3880 3 -	2247 2054 3088 3546 4004 S-	2252 2662 3099 3561 4124	2257 2669 3109 3575 4241	2261 2675 3118 3587 4384	2264 2680 3126 3598 4495	2267 2685 3133 3608 4603	2270 2689 3139 3618 4740	2693 3142 3626
	AT TOP OF PIPE	2'-9" 3'-0" 3'-3" 3'-6" 4'-0"	1:-10	131	2:- 0"		2.	2	1332 2	1458 2	1575 2'-	1595	1632 1818 2:-	1664 1942 2'-	1693 1993 2065	1717 2027 2182	1739 2057 2308	1758 2083 2429 3-	1775 2107 2456	1790 2128 2484 2673 3'-	1802 2146 2510 2788 3'-	1814 2163 2532 2910 3-	1824 2177 2552 2947 3041 3-	1832 2190 2571 2972 3154 3 -	1840 2201 2587 2994 3278 3 '-	1846 2212 2601 3014 3398 3-	1852 2221 2614 3032 3514 3	1857 2229 2626 3048 3492 3646 3	1002 2230 2003 3012 3//6 3-	1866 2242 2646 3076 3530 3880 3 7-	1809 2247 2034 3088 3346 4004 3	1872 2252 2662 3099 3561 4124	1875 2257 2669 3109 3575 4241	1877 2261 2675 3118 3587 4384	1879 2264 2680 3126 3598 4495	1881 2267 2685 3133 3608 4603	2270 2689 3139 3618 4740	1884 2272 2693 3142 3626
	AT TOP OF PIPE	2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" 4'-0"	603		847 2:- 0"	888 969 2'- 1"	2.	2	1228 1332 2	1270 1458 2	1306 1575 2	1337 1595	1364 1632 1818 2	1387 1664 1942 2'-	1407 1693 1993 2065	1424 1717 2027 2182	1439 1739 2057 2308	1452 1758 2083 2429 3'-	1463 1775 2107 2456	1473 1790 2128 2484 2673 3-	1481 1802 2146 2510 2788 3 '-	1488 1814 2163 2532 2910 3-	1494 1824 2177 2552 2947 3041 3 '-	1500 1832 2190 2571 2972 3154 3-	1504 1840 2201 2587 2994 3278 3 '-	1508 1846 2212 2601 3014 3398 3-	1512 1852 2221 2614 3032 3514 3:	1515 1857 2229 2626 3048 3492 3646 3	1317 1802 2230 2037 3003 3312 3776 3-	1520 1866 2242 2646 3076 3530 3880 3 *-	127 1809 2247 2024 3088 3346 4004 3	1523 1872 2252 2662 3099 3561 4124	1525 1875 2257 2669 3109 3575 4241	1526 1877 2261 2675 3118 3587 4384	1527 1879 2264 2680 3126 3598 4495	1528 1881 2267 2685 3133 3608 4603	1529 1882 2270 2689 3139 3618 4740	1529 1884 2272 2693 3142 3626
BACKFILL LC *100POUNDS PER SAND AND GRAVEL KI'-D	PIPE	" 2'-0" 2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" 4'-0"	603	724	847	696 888	937 1088 2'-	7 979 1213 2	1014 1228 1332 2-	1044 1270 1458 2 -	1070 1306 1575	1091 1337 1595	1110 1364 1632 1818 2 -	1125 1387 1664 1942 2'-	1138 1407 1693 1993 2065	1149 1424 1717 2027 2182	1159 1439 1739 2057 2308	1167 1452 1758 2083 2429	1174 1463 1775 2107 2456	1179 1473 1790 2128 2484 2673 3 -	1184 1481 1802 2146 2510 2788	1189 1488 1814 2163 2532 2910	1192 1494 1824 2177 2552 2947 3041	1195 1500 1832 2190 2571 2972 3154 3 -	1198 1504 1840 2201 2587 2994 3278	1200 1508 1846 2212 2601 3014 3398 3	1201 1512 1852 2221 2614 3032 3514 3	1203 1515 1857 2229 2626 3048 3492 3646 3	1204 1317 1802 2230 2837 3003 3312 3776 3-	1205 1520 1866 2242 2646 3076 3530 3880 3 7-	1200 1321 1808 2247 2634 3088 3346 4004 3-	1207 1523 1872 2252 2662 3099 3561 4124	1208 1525 1875 2257 2669 3109 3575 4241	1208 1526 1877 2261 2675 3118 3587 4384	1209 1527 1879 2264 2680 3126 3598 4495	1209 1528 1881 2267 2685 3133 3608 4603	1210 1529 1882 2270 2689 3139 3618 4740	1210 1529 1884 2272 2693 3142 3626
	AT TOP OF PIPE	1-9" 2'-0" 2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" 4'-0"	566 603	628 724	680 847	722 888 969	758 937 1088 2'-	5 787 979 1213 2'-	811 1014 1228 1332 2-	831 1044 1270 1458 2 -	848 1070 1306 1575 2 -	861 1091 1337 1595	873 1110 1364 1632 1818 2 -	882 1125 1387 1664 1942	890 1138 1407 1693 1993 2065	896 1149 1424 1717 2027 2182	902 1159 1439 1739 2057 2308	906 1167 1452 1758 2083 2429 3:-	910 1174 1463 1775 2107 2456	913 1179 1473 1790 2128 2484 2673 3	915 1184 1481 1802 2146 2510 2788 3'-	917 1189 1488 1814 2163 2532 2910 3.	919 1192 1494 1824 2177 2552 2947 3041 3-	921 1195 1500 1832 2190 2571 2972 3154 3	922 1198 1504 1840 2201 2587 2994 3278 3'-	923 1200 1508 1846 2212 2601 3014 3398 3:-	924 1201 1512 1852 2221 2614 3032 3514 3:	924 1203 1515 1857 2229 2626 3048 3492 3646 3 -	353 1204 1317 1602 2230 2037 3003 3312 31/6 3-	925 1205 1520 1866 2242 2646 3076 3530 3880 3:	320 1200 1321 1809 2247 2034 3088 3340 4004 3-	926 1207 1523 1872 2252 2662 3099 3561 4124	926 1208 1525 1875 2257 2669 3109 3575 4241	926 1208 1526 1877 2261 2675 3118 3587 4384	927 1209 1527 1879 2264 2680 3126 3598 4495	1 927 1209 1528 1881 2267 2685 3133 3608 4603	927 1210 1529 1882 2270 2689 3139 3618 4740	92/ 1210 1529 1884 22/2 2693 3142 3626
BACKFILL LC *100POUNDS PER SAND AND GRAVEL KI'-D	AT TOP OF PIPE	" 2'-0" 2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" 4'-0"	454 566 603	628 724	535 680 847	722 888 969	587 758 937 1088	5 787 979 1213 2'-	811 1014 1228 1332 2-	831 1044 1270 1458 2 -	848 1070 1306 1575 2 -	861 1091 1337 1595	873 1110 1364 1632 1818 2 -	661 882 1125 1387 1664 1942 2 '-	665 890 1138 1407 1693 1993 2065	668 896 1149 1424 1717 2027 2182	671 902 1159 1439 1739 2057 2308	673 906 1167 1452 1758 2083 2429 3:	675 910 1174 1463 1775 2107 2456	676 913 1179 1473 1790 2128 2484 2673 3 ⁻	677 915 1184 1481 1802 2146 2510 2788 3'-	678 917 1189 1488 1814 2163 2532 2910 3:	679 919 1192 1494 1824 2177 2552 2947 3041 3	679 921 1195 1500 1832 2190 2571 2972 3154 3	680 922 1198 1504 1840 2201 2587 2994 3278 3'-	680 923 1200 1508 1846 2212 2601 3014 3398 3:-	680 924 1201 1512 1852 2221 2614 3032 3514 3:	924 1203 1515 1857 2229 2626 3048 3492 3646 3 -	353 1204 1317 1882 2236 2037 3003 3312 376 3-	681 925 1205 1520 1866 2242 2646 3076 3530 3880 3:	920 1200 1321 1869 2247 2034 3088 3346 4004 3-	681 926 1207 1523 1872 2252 2662 3099 3561 4124	681 926 1208 1525 1875 2257 2669 3109 3575 4241	681 926 1208 1526 1877 2261 2675 3118 3587 4384	681 927 1209 1527 1879 2264 2680 3126 3598 4495	681 927 1209 1528 1881 2267 2685 3133 3608 4603	681 927 1210 1529 1882 2270 2689 3139 3618 4740	081 927 1210 1529 1884 2272 2693 3142 3626

Table B-2 Continued

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	"3 '0	٥-ç							l																			1						·	4603	4740	4877	
PIPE 110		5-5																						-				2776	0//0	2000	125	1241	4384	4495	4434	4458	4480	
SATURATED CLAY Kμ'-0.110 TRENCH WIDTH AT TOP OF PIPE	10.0	200																						3154	3278	3398	3514	3646	8000	3707	3750	3776	3798	3819	3838	3856	3873	
AY K	1000	£-7																2429	2553	2673	2788	2910	3041	3008	3041	3071	3099	3125	0 4 4 6	3100	2011	322B	3244	3259	3273	3285	3297	
ED CI		۰ ۲												1942	2065	2182	2308	2352	2393	2431	2465	2497	2526	2552	2576	2599	2619	2038	0000	2685	2000	2710	2721	2731	2740	2749	2756	
CH W		5.2							1332	1458	1575	1698	1818	1819	1864	1905	1942	1975	2005	2033	2058	2080	2101	2120	2136	2152	2166	21/8	2000	2200	2218	22.06	2233	2239	2245	2250	2255	
SAT	1000	<u>۲</u>			847	696	1088	1213	1276	1332	1383	1428	1469	1505	1537	1567	1593	1616	1637	1656	1673	1688	1701	1714	1724	1734	1743	1/51	0071	1769	1777	1779	1783	1787	1790	1793	1795	20%; etc
		٩	603	724	814	882	943	966	1042	1084	1120	1152	1180	1205	1227	1247	1264	1279	1292	1304	1314	1323	1331	1339	1345	1350	1355	1360	1367	1370	1979	1374	1376	1378	1380	1381	1382	rease 2
_ م		ρ	531	298	959	90/	749	786	818	846	870	89.1	606	924	938	949	959	896	975	982	286	992	966	1000	1003	1005	1008	0101	2 5	1015	1015	1018	1017	1018	1018	10 19	1019	* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.
ż	Z	Ξ		<u>.</u>		<u>.</u>	<u>.</u> .	-			. 4	. ‡4		9	7	_		6	6	<u>.</u>			<u>.</u>	o					, -	, 4	·ů	, ic	و ر	9			8	er cubic
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O PE		3-3																							3278	3398	3514	3646	0//0	3770	27.12	3815	3834	3851	3868	3883	3896	loads 1
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7 K		5-8													2065	2182	2308	2429	2553	2545	2578	2607	2635	2659	2682	2702	2721	2738	50.72	1917	2704	0000	2811	2820	2828	2835	2842	foot, in
Y CLA		5-6							\int		1575	1698	1818	1942	1993	2034	2070	2103	2133	2159	2184	2205	2225	2242	2258	2273	2286	7622	2300	7306	2222	2340	2346	2352	2357	2362	2366	r cubic
ORDINARY CLAY Kµ'0.130 TRENCH WIDTH AT TOP OF PIPE		2-3						1213	1332	1458	1513	1560	1603	1640	1674	1703	1730	1754	1775	1793	1810	1825	1838	1850	1861	1870	1878	1886	7801	1000	000	1013	1916	1920	1922	1925	1927	inds per
ORD ENC		5.0.		724	847	696	1088	1119	1170	1215	1254	1289	1319	1346	1369	1390	1408	1424	1438	1450	1461	1470	1478	1486	1492	1498	1502	1507		15.17	2 4	15.00	1524	1525	1527	1528	1529	10 pon
1	: ;	16.	603	694	761	819	898	911	948	979	1007	1030	1051	1068	1083	1096	1107	1117	1125	1133	1139	1144	1149	1153	1156	1159	1162	1164	100	1160	1 20	177	1172	1173	1173	1174	1174	* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foo
		9-1	501	559	809	649	683	712	736	757				811	819	827	833	838	842	846	849		854	855	857	858	829	860	000	202	200	700	863	863	864	864	864	kfill wei
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Table B-3

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	4.0.															_					7,00	3892	4041	4201	4340	4493	4642	4786	4950	4916	4946	4974	5000	5024	5047
PIPE	3,-6"	-																3150	3301	3445	3595	3643	3679	3712	3743	3771	3796	3820	3842	3861	3380	3896	3912	3926	3939
POF	3'-3"													2547	2698	2842	2994	3014	3058	3099	3136	3201	3229	3255	3278	3300	3319	3337	3353	3368	3381	3393	3405	3415	3424
AT TO	30										2094	2241	2395	2451	2504	2551	2593	2632	2667	5699	2727	27777	2798	2817	2834	2850	2864	2877	2889	2899	2909	2918		2932	2939
THO	29						1495	1645	1795	1946	1973		2080	2126	2167	2203	2236				2336	+	_		2414	-	2435	2444	2451	2459	2465	2471	2476		2485
N H	26"				1193	1344	1455	\vdash		1645	1695	1738	1777	1812	1843	1870	1894				1966	+	_	2010		+		2038	2043		2052	2055			2064
TRENCH WIDTH AT TOP OF	2'-3"	743	893	1043	1106	1179	1242	├			1426	1459	1487	1512	1534	1553	1570				1618	+		1647				1663 2	1666	1669 2	1671 2	1673 2			1678
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JF PIPE	3'-6" 4'-0" 4																		3301	3287	3325	3392	3421	3447	3471	3492 4493	3512 4472	3530 4502	3546 4529	3561 4555	3575 4578	3587 4599	3598 4619	3608 4637	3618 4654
R	-3" 3'-6" 4'-0" 4												2395	1 2547	2698	2735	2780	2821	2857 3301	2891 3287	2920 3325	2972 3392	2994 3421	3014 3447	3032 3471	3048 3492 4493	3063 3512 4472	3076 3530 4502	3088 3546 4529	3099 3561 4555	3109 3575 4578	3118 3587 4599	3126 3598 4619	3133 3608 4637	3139 3618 4654
R	-3" 3'-6" 4'-0" 4							\vdash		1946	2094	2241	2258	2306	2350	2389 2735	2425 2780	2456 2821	2484 2857 3301	2510 2891 3287	2532 2920 3325	2571 2972 3392	2587 2994 3421	2601 3014 3447	2614 3032 3471	2626 3048 3492 4493	2637 3063 3512 4472	2646 3076 3530 4502	2654 3088 3546 4529	2662 3099 3561 4555	2669 3109 3575 4578	3587 4599	2680 3126 3598 4619	2685 3133 3608 4637	2689 3139 3618 4654
R	-3" 3'-6" 4'-0" 4							1645	1748	1810	1864	1912 2241	_			2057 2389 2735	2083 2425 2780	2107 2456 2821	2128 2484 2857 3301	2146 2510 2891 3287	2163 2532 2920 3325	2190 2571 2972 3392	2201 2587 2994 3421	2212 2601 3014 3447	2221 2614 3032 3471	2229 2626 3048 3492 4493	2236 2637 3063 3512 4472	2242 2646 3076 3530 4502	2247 2654 3088 3546 4529	2252 2662 3099 3561 4555	2257 2669 3109 3575 4578	3118 3587 4599	2264 2680 3126 3598 4619	2685 3133 3608 4637	3139 3618 4654
R	-3" 3'-6" 4'-0" 4			1043	1193	1344		\vdash	1748	1810		2241	2258	2306	2350	2389 2735	2083 2425 2780	2107 2456 2821	2128 2484 2857 3301	2146 2510 2891 3287	2532 2920 3325	2190 2571 2972 3392	2201 2587 2994 3421	2212 2601 3014 3447	2221 2614 3032 3471	2229 2626 3048 3492 4493	2236 2637 3063 3512 4472	2242 2646 3076 3530 4502	2247 2654 3088 3546 4529	2252 2662 3099 3561 4555	2257 2669 3109 3575 4578	2675 3118 3587 4599	2264 2680 3126 3598 4619	2267 2685 3133 3608 4637	2689 3139 3618 4654
TRENCH WIDTH AT TOP OF PIPE	2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" 4'-0" 4	743	893	984 1043	1059 1193	•	1388	1645	1505 1748	1553 1810	1864	1912 2241	1955 2258	1993 2306	2027 2350	2057 2389 2735	1758 2083 2425 2780	1775 2107 2456 2821	1790 2128 2484 2857 3301	1802 2146 2510 2891 3287	2163 2532 2920 3325	1832 2190 2571 2972 3392	1840 2201 2587 2994 3421	1846 2212 2601 3014 3447	1852 2221 2614 3032 3471	1857 2229 2626 3048 3492 4493	1862 2236 2637 3063 3512 4472	1866 2242 2646 3076 3530 4502	1869 2247 2654 3088 3546 4529	2252 2662 3099 3561 4555	1875 2257 2669 3109 3575 4578	2261 2675 3118 3587 4599	1879 2264 2680 3126 3598 4619	1881 2267 2685 3133 3608 4637	2270 2689 3139 3618 4654
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R	2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" 4'-0" 4	089		984	888 1059	937 1124	1180 1388	1014 1228 1450 1645	1044 1270 1505 1748	1070 1306 1553 1810	1337 1595 1864	1110 1364 1632 1912 2241	1387 1664 1955 2258	1407 1693 1993 2306	1149 1424 1717 2027 2350	1439 1739 2057 2389 2735	1167 1452 1758 2083 2425 2780	1174 1463 1775 2107 2456 2821	1179 1473 1790 2128 2484 2857 3301	1184 1481 1802 2146 2510 2891 3287	1488 1814 2163 2532 2920 3325	1195 1500 1832 2190 2571 2972 3392	1198 1504 1840 2201 2587 2994 3421	1508 1846 2212 2601 3014 3447	1201 1512 1852 2221 2614 3032 3471	1203 1515 1857 2229 2626 3048 3492 4493	1204 1517 1862 2236 2637 3063 3512 4472	1205 1520 1866 2242 2646 3076 3530 4502	1206 1521 1869 2247 2654 3088 3546 4529	1523 1872 2252 2662 3099 3561 4555	1525 1875 2257 2669 3109 3575 4578	1526 1877 2261 2675 3118 3587 4599	1209 1527 1879 2264 2680 3126 3598 4619	1209 1528 1881 2267 2685 3133 3608 4637	1529 1882 2270 2689 3139 3618 4654
R	2'-0" 2'-3" 2'-6" 2'-9" 3'-0" 3'-3" 3'-6" 4'-0" 4	999 999	628 761	830 984	722 888 1059	9 758 937 1124	979 1180 1388	11 811 1014 1228 1450 1645	12 831 1044 1270 1505 1748	13 848 1070 1306 1553 1810	14 861 1091 1337 1595 1864	15 873 1110 1364 1632 1912 2241	16 882 1125 1387 1664 1955 2258	17 890 1138 1407 1693 1993 2306	18 896 1149 1424 1717 2027 2350	19 902 1159 1439 1739 2057 2389 2735	20 906 1167 1452 1758 2083 2425 2780	21 910 1174 1463 1775 2107 2456 2821	22 913 1179 1473 1790 2128 2484 2857 3301	23 915 1184 1481 1802 2146 2510 2891 3287	24 917 1189 1488 1814 . 2163 2532 2920 3325	921 1195 1500 1832 2190 2571 2972 3392	27 922 1198 1504 1840 2201 2587 2994 3421	28 923 1200 1508 1846 2212 2601 3014 3447	29 924 1201 1512 1852 2221 2614 3032 3471	30 924 1203 1515 1857 2229 2626 3048 3492 4493	31 925 1204 1517 1862 2236 2637 3063 3512 4472	32 925 1205 1520 1866 2242 2646 3076 3530 4502	33 926 1206 1521 1869 2247 2654 3088 3546 4529	34 926 1207 1523 1872 2252 2662 3099 3561 4555	35 926 1208 1525 1875 2257 2669 3109 3575 4578	36 926 1208 1526 1877 2261 2675 3118 3587 4599	927 1209 1527 1879 2264 2680 3126 3598 4619	927 1209 1528 1881 2267 2685 3133 3608 4637	1210 1529 1882 2270 2689 3139 3618 4654

Table B-3 Continued

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SATURATED CLAY Kµ'-0.110	TRENCH WIDTH AT TOP OF	26			~	~	₩	5 1495	6 1645	9 1795	5 1946	5 2012	0 2082	9 2145			2 2307	_	-	_				\vdash				-+					-+	_				5 2756	efc.
S	TRE	2'-3"	3		6 1043	1193	2 1344	2 1435	6 1516	2 1589	3 1655	8 1715	9 1770	5 1819			3 1942	_	7 2005									+		-2		_	7				_	5 2255	e 20%;
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۵		1,-9,	649	737	814	882	943	966	1042	1084	1120	1152	1180	1205	1227	1247	1264	1279	1292	1304	1314	1323	1331	1339	1345	1350	1355	1360	1363	1367	0/81	1372	13/4	1376	1378	1380	1381	1382	ic foot, aation
	ATRAN-	WIDTH	5 0"		2 2		2'- 4"	2'- 5"	5 6"	2 7"	2 8"	2 8"	5 9	210		3-0.	3 0	3'- 1"		3'- 2"	3. 3.		3-5"		3'- 6"	3 6					9-6	3-10	3-11	3'-11"	4. 0	4. 0."	<u>+-</u> 1	4'- 1"	* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. ▲ Transition loads (bold type) and widths based on Kµ—0.19, r _S dp—0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths
		4,-6"		•																																	5842	5983	120 pou he emba
		40.1																									4340	4493	4642	4786	4950	2082	5243	5397	5549	2697	9999	2696	0%; for 0.5 in tl ns
30	PIPE	36"																				3595	3739	3892	4041	4201	4165	4504	4240	4274	4305	4334	4361	4386	4409	4431	4451	4470	loads 1 , rsdp— ch widtl
-0.13	OF	3,-3,,																2994	3150	3301	3445	3466		_				+								3868		3896	ncrease μ=0.19 /or tren
АҮ Кр	AT TO	3,-0												-		2698	2842		╌	2947		3029		-				\rightarrow					-+			3333		3353	toot, ii ed on K kfill and
ORDINARY CLAY Kµ'-0.130	DTH ,	29								1795	1946	2094	2241			2378	2426		1 2509	2545	_	2607	$\overline{}$	-				+					-+			2828		3 2842	er cubio tths bas s of bac
DINA	CH W	. 56					1344	1495	1645) 1713	3 1781	1843	3 1898	\vdash	_	_			-	3 2159			_	_				-+					+			2 2357		7 2366	ounds p and wic heights
OR	TRENCH WIDTH AT TOP	. 2'-3"	-	893	1043	1193) 1258	1334	1400	5 1460	1513	9 1560	9 1603	3 1640	_	0 1703		1 1754			1 1810	0 1825	_	_				+					-		-	7 1922		9 1927	g 110 p Id type) nediate
	-	50	7 743		1 919	9 994	8 1060	1 1119	8 1170	9 1215	7 1254		1 1319	\vdash				7 1424	5 1438	3 1450	9 1461	4 1470				_	_	\dashv					-+						For backfill weighing 110 pounds per cubic foot, increase loads 109 Transition loads (bold type) and widths based on Kμ-0.19, r _{Sd} p0. Interpolate for intermediate heights of backfill and/or trench widths
		1,-9,	5 617		7 761	8 819	898 6	10 911	11 948	12 979	13 1007	14 1030	15 1051	16 1068	17 1083	18 1096	19 1107	20 1117	21 1125	22 1133		24 1144			27 1156			_								38 1173		40 1174	backfill i sition lo polate f
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Table B-4

							ŀ	ΗE	:10	àH	T	0	F	В	<u>ـــ</u>	K	FII	LL	Н		B	ΟV	Έ.	TC	P	0	F	PI	PE	 :,	FE	E	T			
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12"	ATRAN-	WIDTH	2'- 7"	2'- 8"	2:-10"	2'-11"	3'- 0"	3'- 1"	3. 2.	3'- 3"	3. 4	3'- 5"	3'- 6			3'- 9'	3'-10"	3'-11"				7 - 7	4 4	4'- 5"	4'- 5"	4'- 6"			4- 8	4'- 9"	4'-10"	410	4'-11"	2 0.	2.0	5. 2
-		2,-0																									5969	6188	6381	6269	6774	9269	7173	7365	7583	7976
		46"																		1	4581	47.77	5174	5377	5225	5784	5836	5895	5950	6002	6050	6095	6137	6177	6214	6248
0.150	PIPE	4.0.								······································	_			3186	3385	3588	3780	3979	4177	4377	4383	4401	4574	4629	4680	4727	4771	4811	4849	4884	4916	4946	4974	2000	5024	5067
	P	3'-6"									2581	2785	2986	3047	3132	3210	3282	3347	3408	3463		3604	+	3679	3712	3743						_				3950
LATI(EAR F SOIL	AT TOP	33	-					1982	2182	2385				-								3130	_	3229	3255	3278	-									3424
TALI ER LIN TOP	DTH /	3.0			1385	1585		~	L_									-				0753	-	2798	2817		_					_				2945
I INS NDS P ATED	M H	29	985			<u> </u>																2330 2	+-	2388 2	2401 2	2414 2	-					\dashv				2489
N TRENCH INSTALLATION LOADS IN POUNDS PER LINEAR FOOT SATURATED TOP SOIL Kµ'—	TRENCH WIDTH	26 2	626	<u> </u>									1738 2	⊢								1979 2	+	2001 2								_				2064 2 2066 2
TRE DADS I S/	F	2'-3" 2	821					-					_	⊢				-				1627	+-	1641 2	1647 2		\rightarrow									1679 2
ADS ON CIRCULAR PIPE IN TRENCH INSTALLATION SUBIC FOOT BACKFILL MATERIAL LOADS IN POUNDS PER LINEAR FOOT 65 SATURATED TOP SOIL Kµ'		20	703						-			_						\dashv				1301	+	1310 1	1313 1		-					-				1329 1
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FILL JNDS F	AT TOP C	3'-6"								2385	2581	2720	2809	2890	2964	3032	3093	3148	3199	3245	3287	3360	1						3530	3546						3618
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BACKFILL LO *100 POUNDS PER ID GRAVEL Kµ'0.1	VIDTH AT	30				1585	1713	1819	1914	1998	2074	2142	2203	2258	2306	2350 2686	2389 2735	2425	2456	2484	2510	2552	2571	2587	2601	2614	2626	2637	2646	2654	2662	5669	2675	2680	2685	2693
BACK *100PC ID AND GRAVE	CH WIDTH AT	59 30	L.,	1185	1302	1414 1585	1513 1713	1601 1819	1679 1914	1748 1998	1810 2074	1864 2142	1912 2203	1955 2258	1993 2306	2027 2350 2686	2057 2389 2735	2083 2425	2107 2456	2128 2484	2146 2510	2103 2332	2190 2571	2201 2587	2212 2601	2221 2614	2229 2626	2236 2637	2242 2646	2247 2654	2252 2662	2257 2669	2261 2675	2264 2680	2267 2685	2272 2693
BACKFILL LO *100POUNDS PER SAND AND GRAVEL Kµ'0.1	TRENCH WIDTH AT	30	915 985	1185	1142 1302	1235 1414 1585	1513 1713	1601 1819	1450 1679 1914	1505 1748 1998	1553 1810 2074	1595 1864 2142	1632 1912 2203	1664 1955 2258	1693 1993 2306	1717 2027 2350 2686	1739 2057 2389 2735	1758 2083 2425	1775 2107 2456	1790 2128 2484	1802 2146 2510	1824 2153 2532	1832 2190 2571	1840 2201 2587	1846 2212 2601	1852 2221 2614	1857 2229 2626	1862 2236 2637	1866 2242 2646	1869 2247 2654	1872 2252 2662	1875 2257 2669	1877 2261 2675	1879 2264 2680	1881 2267 2685	1882 2270 2689
BACK *100PC SAND AND GRAVE	TRENCH WIDTH AT	59 30	915	1036 1185	1142 1302	1235 1414 1585	1316 1513 1713	1388 1601 1819	1228 1450 1679 1914	1270 1505 1748 1998	1306 1553 1810 2074	1337 1595 1864 2142	1364 1632 1912 2203	1387 1664 1955 2258	1407 1693 1993 2306	1424 1717 2027 2350 2686	1739 2057 2389 2735	1452 1758 2083 2425	1463 1775 2107 2456	1473 1790 2128 2484	1481 1802 2146 2510	1400 1804 2103 2332	1832 2190 2571	1504 1840 2201 2587	1846 2212 2601	1852 2221 2614	1515 1857 2229 2626	1517 1862 2236 2637	1520 1866 2242 2646	1521 1869 2247 2654	1523 1872 2252 2662	1525 1875 2257 2669	1526 1877 2261 2675	1879 2264 2680	1881 2267 2685	2272 2693
12" BACK *100PC SAND AND GRAVE	TRENCH WIDTH AT	. 56 59 30	797 915	1036 1185	984 1142 1302	1059 1235 1414 1585	1124 1316 1513 1713	1180 1388 1601 1819	1228 1450 1679 1914	1270 1505 1748 1998	1306 1553 1810 2074	1337 1595 1864 2142	1364 1632 1912 2203	1387 1664 1955 2258	1407 1693 1993 2306	1424 1717 2027 2350 2686	1439 1739 2057 2389 2735	1452 1758 2083 2425	1463 1775 2107 2456	1473 1790 2128 2484	1481 1802 2146 2510	1824 2153 2532	1500 1832 2190 2571	1504 1840 2201 2587	1508 1846 2212 2601	1512 1852 2221 2614	1515 1857 2229 2626	1517 1862 2236 2637	1520 1866 2242 2646	1521 1869 2247 2654	1523 1872 2252 2662	1525 1875 2257 2669	1526 1877 2261 2675	1527 1879 2264 2680	1528 1881 2267 2685	1882 2270 2689

Table B-4 Continued

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10	PIPE	40																4177	4377	4581	4777	4979	5174	5377	5575	5784	5950	6021	8809	6151	6211	6268	6322	6373	6421	20
SATURATED CLAY Kµ'0.110	P	3-6"						t					T	3385	3588	3780	3979	+			4336					4668	+					 		_		-
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O C	DTH	30					1982	2812	2385	2514	2625	2729	2825	2914	2998	3075	3147	3213	3275	3333	3387	3436	3483	3526	3566	3603	3669	3699	3727	3752	3776	3798	3819	3838	3856	2
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SA	TRENCH WIDTH AT TOP	2'-6"	985	1306	1435	1554	1662	1761	1852	1935	2012	2082	2145	2204	2258	2307	2352	2393	2431	2465	2497	2526	2552	2576	2599	2619	2655	2670	2685	2698	2710	2721	2731	2740	2749	0%; e
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30	PIPE	4'-0" 4'-6" 5'-0"	2:- 6"		2:-10	2'-11	3'- 0	3- 1	3'- 2'	3'- 2'	3'- 3'	3- 4	3,	3.	3588	3780	3979	4177	4377	4581	4777	4979 4	5018 5174 4	5089 5377 4-	5156 5575 4-	5219 5784 4'-	5333 6188 4'-	5385 6381 4'-	5433 6569 4'-	5478 6774 4'-		5561 6815 7173 4'-	5598 6870 7365 4	6921 7583 4'-	5666 6970 7765	loads 10%; for 120 pounds p
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Кµ'0.130	OF PIPE	3'-6" 4'-0" 4'-6" 5'-0"	2'- 6"	2. 2.	2'-10'	2:-11		8		3.	3'.		3186 3'-	3385 3'-	3474 3588	3562 3780	3645 3979	3721 4177	3792 4377	3858 4581	3919 4777	3975 4979 4	4028 5018 5174 4	4077 5089 5377 4'-	4122 5156 5575 4-	4165 5219 5784 4-	4240 5333 6188 4'-	4274 5385 6381 4'-	4305 5433 6569 4'-	4334 5478 6774 4'-	4361 5521 6757	4386 5561 6815 7173 4'-	4409 5598 6870 7365 4	4431 5633 6921 7583 4 '-	4451 5666 6970 7765	t, increase loads 10%; for 120 pounds p
AY Kµ'—0.130	TOP OF PIPE	3'-3" 3'-6" 4'-0" 4'-6" 5'-0"	2 6					2182	2385	2581 3'-	2785 3'-	2838	2932 3186 3-	3019 3385 3:-	3099 3474 3588	3173 3562 3780	3242 3645 3979	3305 3721 4177	3363 3792 4377	3417 3858 4581	3466 3919 4777	3512 3975 4979 4	3554 4028 5018 5174 4	3593 4077 5089 5377 4'-	3630 4122 5156 5575 4-	3663 4165 5219 5784 4-	3722 4240 5333 6188 4'-	3748 4274 5385 6381 4'-	3772 4305 5433 6569 4'-	3794 4334 5478 6774 4'-	3815 4361 5521 6757	3834 4386 5561 6815 7173 4 -	3851 4409 5598 6870 7365 4	3868 4431 5633 6921 7583 4'-	3883 4451 5666 6970 7765	ic foot, increase loads 10%; for 120 pounds p
Y CLAY Kµ'-0.130	AT TOP OF PIPE	3'-6" 4'-0" 4'-6" 5'-0"	2:- 6		1585 2-10			2182	2385	2581 3'-	2785 3'-		2932 3186 3-	3385 3'-	3474 3588	3173 3562 3780	3242 3645 3979	3305 3721 4177	3363 3792 4377	3417 3858 4581	3466 3919 4777	3512 3975 4979 4	3554 4028 5018 5174 4	3593 4077 5089 5377 4'-	3630 4122 5156 5575 4-	4165 5219 5784 4-	3722 4240 5333 6188 4'-	3748 4274 5385 6381 4'-	4305 5433 6569 4'-	4334 5478 6774 4'-	3815 4361 5521 6757	3834 4386 5561 6815 7173 4 -	3851 4409 5598 6870 7365 4	3868 4431 5633 6921 7583 4'-	4451 5666 6970 7765	r cubic foot, increase loads 10%; for 120 pounds p
NARY CLAY Kµ'-0.130	AT TOP OF PIPE	3'-0" 3'-3" 3'-6" 4'-0" 4'-6" 5'-0"	2.2		1585	1786	1982	2127 2182 3	2238 2385	2339 2581 3'-	2432 2785 3'-	2518 2838	2596 2932 3186 3-	2668 3019 3385 3-	2734 3099 3474 3588	2794 3173 3562 3780	2849 3242 3645 3979	2900 3305 3721 4177	2947 3363 3792 4377	2989 3417 3858 4581	3029 3466 3919 4777	3064 3512 3975 4979 4	3097 3554 4028 5018 5174 4	3128 3593 4077 5089 5377 4'-	3155 3630 4122 5156 5575 4-	3181 3663 4165 5219 5784 4-	3225 3722 4240 5333 6188 4'-	3245 3748 4274 5385 6381 4 -	3263 3772 4305 5433 6569 4 -	3279 3794 4334 5478 6774 4'-	3294 3815 4361 5521 6757	3308 3834 4386 5561 6815 7173 4 '-	3321 3851 4409 5598 6870 7365 4	3333 3868 4431 5633 6921 7583 4 -	3343 3883 4451 5666 6970 7765	ds per cubic foot, increase loads 10%; for 120 pounds p
RDINARY CLAY Kµ'—0.130	AT TOP OF PIPE	2'-9" 3'-0" 3'-3" 3'-6" 4'-0" 4'-6" 5'-0"	1185	1385	1543 1585	1666 1786	1778 1982	1880 2127 2182 3	1973 2238 2385	2057 2339 2581 3'-	2134 2432 2785 3'-	2204 2518 2838	2267 2596 2932 3186 3-	2325 2668 3019 3385 3-	2378 2734 3099 3474 3588	2426 2794 3173 3562 3780	2469 2849 3242 3645 3979	2509 2900 3305 3721 4177	2545 2947 3363 3792 4377	2578 2989 3417 3858 4581	2607 3029 3466 3919 4777	2635 3064 3512 3975 4979	2659 3097 3554 4028 5018 5174 4	2682 3128 3593 4077 5089 5377 4 '-	2702 3155 3630 4122 5156 5575 4'-	2721 3181 3663 4165 5219 5784 4:	2753 3225 3722 4240 5333 6188 4'-	2767 3245 3748 4274 5385 6381 4' -	2780 3263 3772 4305 5433 6569 4 '-	2791 3279 3794 4334 5478 6774 4' -	2802 3294 3815 4361 5521 6757	2811 3308 3834 4386 5561 6815 7173 4 '-	2820 3321 3851 4409 5598 6870 7365 4	2828 3333 3868 4431 5633 6921 7583 4'-	2835 3343 3883 4451 5666 6970 7765	pounds per cubic foot, increase loads 10%, for 120 pounds p
ORDINARY CLAY Kµ'-0.130	AT TOP OF PIPE	2'-6" 2'-9" 3'-0" 3'-3" 3'-6" 4'-0" 4'-6" 5'-0"	985	1243 1385	1357 1543 1585	1461 1666 1786	1554 1778 1982	1638 1880 2127 2182	1713 1973 2238 2385	1781 2057 2339 2581 3'-	1843 2134 2432 2785 3'-	1898 2204 2518 2838	1948 2267 2596 2932 3186 3-	1993 2325 2668 3019 3385 3'-	2034 2378 2734 3099 3474 3588	2070 2426 2794 3173 3562 3780	2103 2469 2849 3242 3645 3979	2133 2509 2900 3305 3721 4177	2159 2545 2947 3363 3792 4377	2184 2578 2989 3417 3858 4581	2205 2607 3029 3466 3919 4777	2225 2635 3064 3512 3975 4979 4	2242 2659 3097 3554 4028 5018 5174 4	2258 2682 3128 3593 4077 5089 5377 4' -	22/3 2/02 3155 3630 4122 5156 5575 4 -	2286 2721 3181 3663 4165 5219 5784 4 °-	2308 2753 3225 3722 4240 5333 6188 4'-	2317 2767 3245 3748 4274 5385 6381 4' -	2326 2780 3263 3772 4305 5433 6569 4	2333 2791 3279 3794 4334 5478 6774 4	2340 2802 3294 3815 4361 5521 6757	2346 2811 3308 3834 4386 5561 6815 7173 4 '-	2352 2820 3321 3851 4409 5598 6870 7365 4	2357 2828 3333 3868 4431 5633 6921 7583 4'-	2362 2835 3343 3883 4451 5666 6970 7765	110 pounds per cubic foot, increase loads 10%; for 120 pounds p
ORDINARY CLAY Kµ'-0.130	TOP OF PIPE	2'-9" 3'-0" 3'-3" 3'-6" 4'-0" 4'-6" 5'-0"	1185	1243 1385	1543 1585	1666 1786	1554 1778 1982	1638 1880 2127 2182	1713 1973 2238 2385	1781 2057 2339 2581 3'-	1843 2134 2432 2785 3'-	1898 2204 2518 2838	1948 2267 2596 2932 3186 3-	1993 2325 2668 3019 3385 3'-	2034 2378 2734 3099 3474 3588	2070 2426 2794 3173 3562 3780	2103 2469 2849 3242 3645 3979	2133 2509 2900 3305 3721 4177	2159 2545 2947 3363 3792 4377	2184 2578 2989 3417 3858 4581	2205 2607 3029 3466 3919 4777	2225 2635 3064 3512 3975 4979	2242 2659 3097 3554 4028 5018 5174 4	2258 2682 3128 3593 4077 5089 5377 4' -	22/3 2/02 3155 3630 4122 5156 5575 4 -	2721 3181 3663 4165 5219 5784 4:	2308 2753 3225 3722 4240 5333 6188 4'-	2317 2767 3245 3748 4274 5385 6381 4' -	2326 2780 3263 3772 4305 5433 6569 4	2333 2791 3279 3794 4334 5478 6774 4	2340 2802 3294 3815 4361 5521 6757	2346 2811 3308 3834 4386 5561 6815 7173 4 '-	2352 2820 3321 3851 4409 5598 6870 7365 4	2828 3333 3868 4431 5633 6921 7583 4'-	2362 2835 3343 3883 4451 5666 6970 7765	ghing 110 pounds per cubic foot, increase loads 10%; for 120 pounds p
ORDINARY CLAY Kµ'-0.130	AT TOP OF PIPE	. 2-3" 2-6" 2-9" 3-0" 3-3" 3-6" 4-0" 4-6" 5-0"	854 985 973 1115 11 85 97	1079 1243 1385	1174 1357 1543 1585	1258 1461 1666 1786	1334 1554 1778 1982	1400 1638 1880 2127 2182	1460 1713 1973 2238 2385	1513 1781 2057 2339 2581 3'-	1560 1843 2134 2432 2785 3'-	1603 1898 2204 2518 2838	1640 1948 2267 2596 2932 3186 3 -	1674 1993 2325 2668 3019 3385 3'-	1703 2034 2378 2734 3099 3474 3588	1730 2070 2426 2794 3173 3562 3780	1754 2103 2469 2849 3242 3645 3979	1775 2133 2509 2900 3305 3721 41 77	1793 2159 2545 2947 3363 3792 4377	1810 2184 2578 2989 3417 3858 4581	1825 2205 2607 3029 3466 3919 4777	1838 2225 2635 3064 3512 3975 4979	1850 2242 2659 3097 3554 4028 5018 5174	1861 2258 2682 3128 3593 4077 5089 5377 4'-	18/0 22/3 2/02 3155 3630 4122 5156 5575 4°-	18/8 2286 2721 3181 3663 4165 5219 5784 4: 1886 2207 2728 3204 3603 4204 6279 6069	1892 2308 2753 3225 3722 4240 5333 6188 4'-	1898 2317 2767 3245 3748 4274 5385 6381 4' -	1904 2326 2780 3263 3772 4305 5433 6569 4 '-	1908 2333 2791 3279 3794 4334 5478 6774 4 '-	1913 2340 2802 3294 3815 4361 5521 6757	1916 2346 2811 3308 3834 4386 5561 6815 7173 4 '-	1920 2352 2820 3321 3851 4409 5598 6870 7365 4	1922 2357 2828 3333 3868 4431 5633 6921 7583 4' -	1925 2362 2835 3343 3883 4451 5666 6970 7765	If weighing 110 pounds per cubic foot, increase loads 10%, for 120 pounds p
ORDINARY CLAY Kµ'—0.130	AT TOP OF PIPE	2'-6" 2'-9" 3'-0" 3'-3" 3'-6" 4'-0" 4'-6" 5'-0"	985	919 1079 1243 1385	994 1174 1357 1543 1585	1060 1258 1461 1666 1786	1119 1334 1554 1778 1982	1400 1638 1880 2127 2182	1460 1713 1973 2238 2385	1513 1781 2057 2339 2581 3'-	1289 1560 1843 2134 2432 2785	1319 1603 1898 2204 2518 2838	1346 1640 1948 2267 2596 2932 3186 3'-	1674 1993 2325 2668 3019 3385 3 '-	1703 2034 2378 2734 3099 3474 3588	1408 1730 2070 2426 2794 3173 3562 3780	1424 1754 2103 2469 2849 3242 3645 3979	1438 1775 2133 2509 2900 3305 3721 4177	1450 1793 2159 2545 2947 3363 3792 4377	1461 1810 2184 2578 2989 3417 3858 4581	1470 1825 2205 2607 3029 3466 3919 4777	1478 1838 2225 2635 3064 3512 3975 4979	1486 1850 2242 2659 3097 3554 4028 5018 5174 4	1492 1861 2258 2682 3128 3593 4077 5089 5377 4 -	1498 18/0 22/3 2/02 3155 3630 4122 5156 5575 4°-	2286 2721 3181 3663 4165 5219 5784 4 °-	1511 1892 2308 2753 3225 3722 4240 5333 6188 4'-	1514 1898 2317 2767 3245 3748 4274 5385 6381 4' -	1904 2326 2780 3263 3772 4305 5433 6569 4 '-	1519 1908 2333 2791 3279 3794 4334 5478 6774 4 ·	1522 1913 2340 2802 3294 3815 4361 5521 6757	1524 1916 2346 2811 3308 3834 4386 5561 6815 7173 4 -	1525 1920 2352 2820 3321 3851 4409 5598 6870 7365 4	1527 1922 2357 2828 3333 3868 4431 5633 6921 7583 4 -	2362 2835 3343 3883 4451 5666 6970 7765	ckill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pound

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foo ▲Transition loads (bold type) and widths based on Kµ—0.19, r_{sd}p—0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET

Table B-5

CALLIAR PIPE IN TRENCH INSTALLATION ATTOCHOLAGE ATTACH ATT	2939 3424 3939 5047 6248 7530 9510 5: 9" 39 2945 3433 3950 5067 6280 7577 9785 5: 10" 40
9500 6-0" 6-0" 4-6" 5-0" 6-0" 4-6" 5-0" 6-0" 4-6" 5-0" 6-	3424 3939 5047 6248 7530 9510 5 ⁺ 3433 3950 5067 6280 7577 9785 5 ⁺
9F PIPE 4'-6" 5'-0" 6'-0" 3900 4142 4382 4382 4524 4624 4624 4624 4629 5192 5192 5192 5192 5193 51	3424 3939 5047 6248 7530 9510 3433 3950 5067 6280 7577 9785
9F PIPE 3900 4142 4382 4382 4382 4870 5123 5123 5123 5123 5124 5125 6091 5577 6091 5557 6091 6091 6091 6091 6091 6091 6091 6091	3424 3939 5047 6248 7530 3433 3950 5067 6280 7577
9F PIPE 442 4382 4624 4624 4870 5593 5593 5593 5593 5593 5593 5593 559	3424 3939 5047 6248 3433 3950 5067 6280
	3424 3939 5047 3433 3950 5067
ATRAN- STATURATE LOADS IN POUNDS PER LINEAR FOOL	3424 3939 3433 3950
DOT BACKFILL MATERIAL LOADS IN POUNDS PER LINEAR SOT BACKFILL MATERIAL LOADS IN POUNDS PER LINEAR SOT BACKFILL MATERIAL LOADS IN POUNDS PER LINEAR SOT BATUMATED TOP SOI BATUM	3424
NCIRCULAR PIPE IN TRENCH INSTA DOT BACKFILL MATERIAL LOADS IN POUNDS PER L SITION 23" 2'-6" 2'-9" 3'-0" 3'-3" 3'-4" 1179 1375 1576 1180 1203 3'-8" 1179 1375 1576 1180 1203 3'-9" 1242 1455 1674 1896 2122 3'-11" 1346 1510 1692 3'-11" 1346 1510 1692 3'-11" 1346 1510 1692 3'-11" 1346 1510 1692 3'-11" 1346 1526 1536 1357 4'- 0" 1389 1645 1910 2'82 2460 4'- 1" 1348 1545 1674 1200 2'83 230 2639 4'- 5" 1553 1870 2'83 2'85 2'80 2'809 4'- 5" 1553 1870 2'80 2'809 2'809 4'- 5" 1554 1915 2'265 2'809 2'909 4'- 6" 1557 1934 2'292 2'867 3'058 4'- 8" 1557 1934 2'292 2'867 3'058 4'- 9" 1627 1934 2'292 2'867 3'058 4'- 9" 1627 1991 2'353 2'77 3'201 6'588 5'- 2" 1641 2'001 2'388 2'798 3'299 6'588 5'- 2" 1665 2'049 2'44 2'877 3'377 1656 2'049 2'45 2'45 2'899 3'388 2' 8' 200 2'32 2'45 2'405	
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#100PC SAND AND GRAVE TRENCH WIDTH AT 2-9" 3-0" 3-3" 3-4 1033 1153 1203 1176 1317 1448 1176 1317 1448 1170 1317 1448 1170 1317 1448 1170 1317 1448 1170 1317 1317 1317 11748 1998 2254 251 1181 2041 226 1181 2041 206 1181 204 1	0 2689 2 2693
	2 2270 4 2272
2.6° 1036 1036 1136	1882
2.3. 987 987 1059 1128 1128 1128 1128 1128 1128 1130 1140 1140 1140 1150 11	1529 1529
A HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET	8 4

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET

Table B-5 Continued

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0.110	AT TOP OF PIPE	46						_				60	7		2	_	-		_		_		$\overline{}$	\vdash				5 7081	_			1 7458	-		2 7696			5 7902
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ĽΑΥ	I AT 1	36						2429	2672	2920	3162	3258	3399	3531	3655	3772	3881	3984	4080	4171	4256	4336	4411	4481	4548	4610	4668	4723	4774	4823	4868	4911	4951	4988	5024	202	5088	5117
SATURATED CLAY Kμ'0.110	IDTH	33			1692	1938	2183	2361	2520	2670	2809	2940	3061	3175	3282	3381	3474	3561	3642	3718	3789	3855	3917	3975	4029	4079	4126	4171	4212	4250	4286	4320	4351	4381	4408	4434	4458	4480
JRAT	N H	30	1203	1448	1642	1815	1976	2126	2264	2394	2514	2625	2729	2825	2914	2998	3075	3147	3213	3275	3333	3387	3436	3483	3526	3566	3603	3637	3669	3699	3727	3752	3776	3798	3819	3838	3856	3873
SATI	TRENCH WIDTH	59	1133	1310	1473	1624		1892	2011	2121	2222	2315						2743	2796		-		\neg	_				3125			3192	3211	3228		3259			3297
	F	56 2	1011	1165 1	1306	1435 1	1554 1	1662 1	_	1852 2	1935 2	2012 2	2082 2	2145					2393 2									2638 3				2698 3	2710 3	2721 3	2731 3			2756 3
•			889 10		1140 13	1248 14	1346 11	1435 16	_	1589 18	1655 19	1715 20	1770 20	1819 2				-	2005 23									2178 20	_		2209 2	2218 26	2226 2		2239 2			2255 2
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		09																													8046	8290	8556	8789	9045	9265	9510	9785
		20																					6091	6350	6588	6833	7070	7319	7561	7818	7886	7974	8057	8136	8211	8282	8350	8414
_	PIPE	4'-6"														4382	4624	4870	5123	5368	5603	5851	5951	6054	6151	6243	6330	6412	6489	6562	6631	9699	6757	6815	6870	6921	0269	7016
0.130	OF PI	40	_							2920	3162	3408	3647	3900	4142	4243		·0	4582		4773			-				_			_	<u></u>	5521	_	5598	_	·^	9699
ORDINARY CLAY Kµ'-0.1	TOP (3'-6" 4					2183	429	_				-	3276 3		3474 4		_	3721 4					4028		4122 5		-			4305 6				4409 5		4451	-
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RYC	/IDI	3,-3	က	<u> </u>	<u> </u>			<u></u>	├-	_				⊢	_	_		_	⊢				_	-				-										
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OR	TRENCH WIDTH	5,-6	1095	1259	1408	1543	1666	1778	⊢−				2204	⊢					2509			2607		2659				2738			2780	2791	2802	2811	_		2835	
	-	56"	974	1115	1243	1357	1461	1554	1638	1713	1781	1843	1898	1948	1993	2034	2070	2103	2133	2159	2184	2205	2225	2242	2258	2273	2286	2297	2308	2317	2326	2333	2340	2346	2352	2357	2362	2366
		2'-3"	854	973	1079	1174	1258	1334	1400	1460	1513	1560	1603	1640	1674	1703	1730	1754	1775	1793	1810	1825	1838	1850	1861	1870	1878	1886	1892	1898	1904	1908	1913	1916	1920	1922	1925	1927
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* For backfill weighing 110 pounds per cubic foot, increase loads 10%, for 120 pounds per cubic foot, increase 20%; etc. ▲ Transition loads (**bold type**) and widths based on Kµ—0.19, r_sdp—0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-6

								ł	НE	10	٦٢	ΙT	0	F	В	Α(CK	FI	LL	. F	1 /	۱B	30	VE	Ξ 7	0	P ()F	P	IP	Ε,	FE	ΞE	T			
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à	.	TRAN	WIDTH	3.6	3'- 7	3'- 9"	3'-10"	3'-11"	4'- 1'	4'- 2'	4'- 3'	4'- 4"	4'- 5"	4- 6"	4- 7	4'- 8"	4'- 9"	4'-10"	4'-11'	5'- 0'	5- 1	5. 5	5.3	5'- 4	5. 5	5 6	5- 7	ָ מי מי			5'-11"	.0 -,9		6:- 1"	6. 2"		6'- 5
_		*	7.0	-											Τ														T				2	8	စ္က	8 8 	2 8
			├							_		_			L									_									10070	10020 10340	10630		11520
	0		.09	L																	6324	9	6887	7189	7455	1768	8044	8344	8901	9198	9488	9771	9914	10020	10110	10200	10380
	0.15(PIPE	2,-0.												4584	4877	5168	5444	5737	6035	6107	6236	6358	6473	6582	6684	6780	08/0	7036	7111	7182	7249	7312	7372	7428	7480	7577
Z	주 - '	P OF	46"						2855	3145	3431	3718	4012	4298	4426	4576	4716	4848		5085								5773	╁	5950	6002	6050	6095	6137	6177	6214	6280
ATIC	OIL	T T0	40		1700	1989	2277			-				3601 4	3726 4	3843 4	3950 4	4050 4		-								4/2/ 3	+		4884 6		-			5024 6	
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二 二 二 二 二 二 二 二 二 二	IRAT	TRENCH WIDTH AT TOP	3'-3"	1301	1497	1675	1838	1986	2122	2245	2357	2460	2553	2639	2716	2787	2852	2911	2962	3014	3058	3099	3136	3170	3201	3229	3255	3300	3319	3337	3353	3368	3381	3393	3405	3415	3424
N TRENCH INSTALLATION	SATURATED TOP SOIL Kµ'-0.150	TRE	3'-0"	1180	1353	1510	1652	1780	1896	2001	2096	2182	2260	2330	2394	2451	2504	2551	2593	2632	2667	2699	2727	2753	2777	2798	2817	2024	2864	2877	2889	2899	2909	2918	2925	2832	2945
			2'-9"	1059	1210	1346	1467	1576	1674	1761	1840	1910	1973	2030	2080	2126	2167	2203	2236	2265	2292	2315	2336	2355	2373	2388	2401	24 14 24 25	2435	2444	2451	2459	2465	2471	2476	7480 7486	2488 2488
DADS ON CIRCULAR PIPE IN TRENCH INSTALLATION	a		2'-6"			_			\dashv					1738	1777	1812 2	1843 2	1870	1894					-			2010		+		2043 2		-			1007	
PIF	<u>ל</u>		2		~	_			+-		_	<u>~</u>	<u>~</u>	-	-	=	=	=	Ξ	-	-		-	-	<u>~</u>	~	5 17	δ δ	5	×	≈	~	~	×	~ ~		V 60
LAF	Y N	Å Š	WIDTH		ڞٙ	3'-10"	<u>-</u>	<u>.</u>	5	, m				 	6	410	-	<u>.</u>	<u>-</u>	<u>.</u>	ن	<u>.</u> 4	5.	 				- c	- `	<u>-</u>	5	<u></u>	بن ش	4		ء ۾	- to
J C C	בר בר	ATRAN	N N	ä	က်	ë	3'-11"	4.	4	4	4	4	4	4	4	4-1	4'-11"	5,	5.	ດ້	à	ດ່	5	ج.	່ວ່	ا مُن			, io	ڼ		6	6	6	6	هٔ مُ	9 6
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m ¥	GF	DT	36"	1411	1603	1793	1966	2123	2266	2396	2514	2622	2720	2809	2890	2964	3032	3093	3148	3199	3245	3287	3325	3360	3392	3421	3447	3492	3512	3530	3546	3561	3575	3587	3598	3618	3626
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) ANC	CH WI	3'-3"	1274	1460	1628	1780	1917	2041	2153	2254	2345	2428	2502	2570	2631	2686	2735	2780	2821	28	58	23	53	2972	2994	3033	3048	3063	3076	3088	3099	3109	3118	3126	0100	9 5
	SAND AND	RENCH WI	3'-3"		<u> </u>				-						<u> </u>														╄				_				
	SAND AND GRAVEL Kµ'-0.	TRENCH WIDTH AT TOP	. 30 33	1153	1317	1464	1596	1713	1819	1914	1998	2074	2142	2203	2258	2306	2350	2389	2425	2456	2484	2510	2532	2552	2571	2587	2614	2626	2637	2646	2654	2662	5669	2675	2680	0890	2693
<u>*</u>	SAND AND	TRENCH WI	2'-9" 3'-0" 3'-3"	1033 1153 1	1176 1317	1302 1464	1414 1596	1513 1713	1601 1819	1679 1914	1748 1998	1810 2074	1864 2142	1912 2203	1955 2258	1993 2306	2027 2350	2057 2389	2083 2425	2107 2456	2128 2484	2146 2510	2163 2532	2177 2552	2190 2571	2201 2587	2212 2601	9090 5000	2236 2637	2242 2646	2247 2654	2252 2662	2257 2669	2261 2675	2264 2680	2201 2689	2272 2693
*	SAND AND	TRENCH WI	. 30 33	915 1033 1153 1	1036 1176 1317	1142 1302 1464	1235 1414 1596	1316 1513 1713	1601 1819	1450 1679 1914	1748 1998	1553 1810 2074	1864 2142	1912 2203	1955 2258	1993 2306	1717 2027 2350	1739 2057 2389	2083 2425	1775 2107 2456	1790 2128 2484	1802 2146 2510	1814 2163 2532	2177 2552	1832 2190 2571	1840 2201 2587	1840 2212 2601	1857 2229 2626	2236 2637	1866 2242 2646	1869 2247 2654	2252 2662	1875 2257 2669	1877 2261 2675	1879 2264 2680	1882 2207 2683	2272 2693

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET

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Table B-6 Continued

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10070	9771	10070	10340	10630	10940	11220	11520
8927	8817	$\overline{}$		9132			9408
7541	7458	7541	7620	9692	7768	7836	7902
6211	6151	6211	6268	6322	6373	6421	6466
4951	4911	4951	4988	5024	5057	5088	5117
4351	4320	4351	4381	4408	4434	4458	4480
37.76	3752	3776	3798	3819	3838	3856	3873
3228	3211	3228	3244	3259	3273		
		-+					2756
5'- 9"		. G	5'-10"	510	5'-11"	09	6'- 0"
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5521	5478 6696	5521 6/5/ 805/	5561 6815 8136	2298 6870	6921	6970 8350	7016
4361 5521	4334 5478 6696	4361 5521 6757 8057	4386 5561 6815 8136	4409 5598 6870	4431 5633 6921	4451, 5666 6970 8350	5696 7016
3815 4361 5521	3794 4334 5478 6696 3815 4361 5521 6757	3815 4361 5521 6/5/ 805/	3834 4386 5561 6815 8136	3851 4409 5598 6870	3868 4431 5633 6921	3883 4451 5666 6970 8350	4470 5696 7016
3294 3815 4361 5521	3279 3794 4334 5478 6696 3294 3294 3815 4361 5521 6757	3294 3815 4361 5521 6/5/ 805/	3308 3834 4386 5561 6815 8136	3321 3851 4409 5598 6870	3333 3868 4431 5633 6921	3343 3883 4451 5666 6970 8350	3896 4470 5696 7016
2802 3294 3815 4361 5521	2791 3279 3794 4334 5478 6696 2802 3294 3815 4361 5521 6757	2802 3294 3815 4361 5521 6757 8057	2811 3308 3834 4386 5561 6815 8136	2820 3321 3851 4409 5598 6870	2828 3333 3868 4431 5633 6921	2835 3343 3883 4451 5666 6970 8350	2842 3353 3896 4470 5696 7016
35 2340 2802 3294 3815 4361 5521	2791 3279 3794 4334 5478 6696 2802 3294 3815 4361 5521 6757	35 2340 2802 3294 3815 4361 5521 6757 8057	36 2346 2811 3308 3834 4386 5561 6815 8136	2352 2820 3321 3851 4409 5598 6870	2357 2828 3333 3868 4431 5633 6921	2362 2835 3343 3883 4451 5666 6970 8350	2366 2842 3353 3896 4470 5696 7016
	9771 5 '- 8 " 2698 3211 3752 4320 4911 6151 7458		5- 9" 2710 3228 3776 4351 4951 6211 7541	5. 9" 2710 3228 3776 4351 4951 6211 7541 5.10" 2721 3244 3798 4381 4988 6268 7620	5-9" 2710 3228 3776 4351 4951 6211 7541 5-10" 2721 3244 3798 4381 4988 6268 7620 5-10" 2731 3259 3819 4408 5024 6322 7696	5-9" 2710 3228 3776 4351 4951 6211 7541 5-10" 2721 3244 3798 4381 4988 6268 7620 5-10" 2731 3259 3819 4408 5024 6322 7696 5-11" 2740 3273 3838 4434 5057 6373 7768	10070 5- 9" 2710 3228 3776 4351 4951 6211 7541 10340 5-10" 2721 3244 3798 4381 4988 6268 7620 10630 5-10" 2731 3259 3819 4408 5024 632 7696 10940 5-11" 2740 3273 3838 4434 5057 6373 7768 11220 6-0" 2749 3285 3856 4458 5088 6421 7836

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.
▲ Transition loads (bold type) and widths based on Kµ-0.19, r_{Sd}p-0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-7

				-			Н	ΞI	GI	- T	C	F	В	A	CK	F	L	. H	1 /	١E	30	VE	: T	0	Р	01	FF	211	PE	., I	FE	E	T			
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ATRAN-	WIDTH WIDTH	3-11	4		4-7-	4. 5.	4-6	4. 7	4'- 8	4'-10"	4'-11	5.0	5.	5. 2	5'- 3"	5. 4.	5. 5"	5'- 6"	2 7	5'- 8"	5'- 9"	5'-10"	5'-11"	0-9	6- 1	6- 2	6-3		9		9			69	0-10	2 - 1
	1.02																								9266	9593		10260	10590	10920	11250	11580	11910	12230	12920	13250
	0-,9																		7273	7591	7916	8255	8582	8928	9040	9185	9322	9453	9577	9695	9807	9914			10200	
- PIPE	.99												5273	5606	5934	6274	6598	6942	7046	7207	7360	7504	7641	7771	7893	8010	8120	8224	8323	8416	8505	8588	8998	8743	8881	8945
P O	50							3612	3947	4280	4610	4942	5142	5328	5503	5668	5823	5969	6107	6236	6358	6473	6582	6684	6780	0/89	6955	1030	7111	781/	7249	7312	7372	7428	7530	7577
AT T(4'-6"			2284	2617	2950	3282	3507	3717	3912	4095	4266	4426	4576	4716	4848	4970	5085	5192	5293	5387	5475	5557	5634	5/06	5//3	5836	2682	5950	2009	6050	6095	6137	6177	6248	6280
TRENCH WIDTH AT TOP OF	40	1617	1951	2178	2406		2814	2996	3164	3321	3466	3601	3726	3843	3950	4050	4143	4229	4309	4383	4451	4515	4574	4629	4680	4727	4771	104	4849	4884	4916	4946	4974	5000	5047	5067
CH V	36	1545	1786	2009			2581	2743	2892	3030	3158	3275	3384	3484	3576	3662	3741	3813	3881	3943	4000	4053	4101			4226			4325	4352	4378	4402	4424	4444	4480	4496
TRE	36	1423	1641	1842			2350	2492	2623	2743	2853	2954	3047	3132	3210	3282	3347					\rightarrow					3//1	08/0	3850	3842	3861	3880	3896	3912	3939	3950
	3'-3"	1301	1497	1675			2122	2245	2357	2460	2553	2639	2716	2787	2852	2911									3235	3278	3300	000	3337	5555		_	3393	3405	3424	3433
	3,-0	1180	1353	1510	1652	1780	1896	2001	2096	2182	2260	2330	2394	2451	2504	2551	2593	2632	2667	2699	2727	2753	2777	2798	781/	2834	2820	4004	1887	2009	2899	2909	2918	2925	2030	2945
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ATRAN-	WIDTH	4'- 0"	4'- 1	4. 3"	4- 4	4'- 6	4- 7	4-8	4'-10"	4'-11"	5'- 0		5'- 3"	5'- 4"	5. 5.	5, 6	5'- 7		5'- 9'	5-10	9-0	9	- o	, 6	9 6	ָה ס	ָה ה ה	9 1	- 0	-0	6-9	610	6'-11"	0 - 7	7. 2	7 3
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ATT	46"			2284	2617			L					L_									_			0349		5504					-		5729		
TRENCH WIDTH AT TOP OF	40	1617		2127	2342				3046		3320		_				_							4325			4440					-		4619		
VCH V	39			1959	2153				2779								_1						2000									4		4097		
TRE	36			3 1793	1966				1 2514								-					_		046			3512		0000			4		3608		
	اشا	1274	1460	1628	1780	1917	2041	2153				_					_	5 2821					7 7 7 7				+-		9700			-		3120		
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Table B-7 Continued

		·					Н	E	G	Η.	T	ЭF	: E	3A	CI	<f< th=""><th>IL</th><th>L</th><th>Н</th><th>Α</th><th>В</th><th>٥V</th><th>Έ</th><th>T</th><th>OF</th><th>) (</th><th>)F</th><th>Р</th><th>ΙP</th><th>Ε,</th><th>F</th><th>E</th><th>ΕT</th><th>•</th><th></th><th></th><th></th><th></th><th></th></f<>	IL	L	Н	Α	В	٥V	Έ	T	OF) ()F	Р	ΙP	Ε,	F	E	ΕT	•					
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	ATRAN-	WIDTH	3 9"	310	3'-11"	4'- 0"	4'- 1"	4'- 3"	4'- 3"	4. 4"	4'- 5"	4. 6"	4 7	4. 8	4'- 9"	4-10	4'-11"	5 0.	5'- 0"	5- 1"	5'- 2"	5'- 3"	5'- 4"	5'- 4"	5. 5.	5'- 6"	5'- 7"	2 7"		2 9	5'-10"	5'-10"	5'-11"	 9 0.	.0	6'- 1"	6'- 2"	6. 2.	
		1.02																																			12920	13250	
		.09																										_		10590				_				12590	
.110	F PIPE	.9-,5																	_	7273	7591			8582		_												10970	
くずし	OP O	20							L				4942	5273	2606		6274	6298	6942	7047	7233		7581						_									9408	
YY I	AT T	4'-6"						3282	3612	3947		4610	4783	⊢	5195		2568	5742	2907	6064	6214		6493	-			_					7458	_		_	_		7902	
SATURATED CLAY Kµ'0.110	TRENCH WIDTH AT TOP OF	40			2284	2617	2839		3301	3513	3714	3905	4085	4256	4417		4714	4851	4981	5104				-				-					-	6268				6466	
TURA	NCH /	3,-6	1617		2152				3039	3230			3740	_	4034		4295	4414	4527	4633		4828		_									-					5780	٤
SA	TRE	36	1501	1749	1982		2405		2779	2949			3399	⊢	3655		3881	3984	4080	4171	4256	4336						•		_			┪					5117	0.700
		3:-3	1378	_		_	2190	_	1 2520	2670	2809	2940	3061	_	3282	_	3474	3561	⊢		3789	3822	3917					-+		_								4480	ncrease
۵		3Q.	1255	1456	1642	1815	1976	2126	2264	2394	2514	2625	2729	2825	2914	2998	3075	3147	3213	3275	3333	3387	3436	3483	3526	3566	3603	3637	3669	3698	3727	3752	3776	3798	3819	3838	3856	3873	r foot i
	ATRAN-	WIDTH	310	3'-11"	4 1	4. 2	4 3	4-4	4-5	4'- 7"	4'- 8"	4'- 9"	4'-10"	4'-11"	2. 0	5'- 1"	5'- 2"	5. 3"	. 1	5. 5"	5. 5.	5. 6"	5 7	5, 8, 8,	5 9	5′-10"	5'-10"	511	0 .9	- 1	6'- 2"	6 2	6'- 3"	6'- 4"			99	29	Ear housell unidding 110 pounds par cubic foot increase loads 10% for 130 pounds par cubic foot increase 20% at
		1.0-,2																			•••		•••						1	10590	10920	11250	11580	11910	12230	12580	12920	13250	120 001
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* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. ▲ Transition loads (**bold type**) and widths based on Kµ – 0.19, r_Sdp – 0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

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Table B-8

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	12.6"					_	10	_	7 4456		5209	5 5580	2 5870	3 6094	3 6305	3 6506	3 6696	9 6876	7 7046	3 7207	3 7360	3 7504						8224		2 8416	9 8505	8588		8743		8881
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	3,-6	1423	1641	1842	2026	2195	2350	2492	2623	2743	2853	2954	3047	3132	3210	3282	3347	3408	3463	3514	3561	3604	3643	3679	3712	3743	3771	3796	3820	3842	3861	3880	3896	3912	3926	3939
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2576 46" 46" 2200 2588 2954 2954 46" 45" | 46" 50" 66" 70" 76" 80" MIDTH 1819 43" 1501 1749 2044 2199 43" 6-0" 6-6" 70" 76" 8-0" MIDTH 1819 44" 1749 2044 2199 42" 6-6" 70" 76" 8-0" MIDTH 2576 44" 1789 2045 2323 2576 44" 78" 84" 78" 84" 78" 84" 78" 84" 18" 84" 18" 85" 8 | 46" 50" 66" 70" 76" 80" MIDTH (1819) 36" 60" 66" 70" 76" 80" MIDTH (1819) 42" 50" 66" 70" 76" 80" MIDTH (1819) 42" 5-2" 60" 66" 70" 76" 80" MIDTH (1819) 42" 5-2" 5-2" 60" 66" 70" 76" 82" 5-2" 5-2" 5-2" 62" 82" 5-2" 82" 5-2" 62" 82" | 46. 50. 66. 70. 76. 80. MIDTH (1819) 1819 4 3" 1501 1748 1819 4 2" 6-6" 70. 76" 8-0" MIDTH (1819) 2199 4 4" 1749 2044 2199 4 3" 6 4 3" 6 2576 4 6" 1982 2323 2576 4 4" 7 7 2200 2588 2954 4 5" 8 4 5" 8 3158 3331 4 8" 2405 2839 3331 4 5" 8 4 5" 9 3663 4081 4 8" 4 11" 2779 3301 3828 4081 40.8" 4 9" 11 | 4-6" 5-0" 6-6" 7-0" 7-6" 8-0" MIDTH Area 3-6" 4-6" 5-0" 6-6" 7-0" 7-6" 8-0" MIDTH MIDTH Area 4-7" 5-6" 6-0" 6-6" 7-0" 7-6" 8-0" MIDTH Area 4-2" 5-6" 6-0" 6-6" 7-0" 7-6" 8-0" MIDTH Area 4-2" 5-219 4-2" 5-219 4-3" 6-2" 6-4" 4-3" 6-4" 4-3" 6-4" 4-3" 6-4" 4-3" 6-4" 4-3" 6-4" 4-3" 6-4" 4-4" 7" 7-3" 6-4" 7-3" 6-4" 7-3" 6-4" 7-3" 6-4" 7-3" 6-4" 7-3" 6-4" 7-4"< | 4-6" 5-0" 6-6" 7-0" 7-6" 8-0" MIDTH
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3-2 3-2 </td><td> 14.6 5.6 6.6 6.7 6.6 7.0 7.6 8.0 WIDTH 3.6 4.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 3.6 4.5 7.0 7.6 8.0 WIDTH 3.6 7.0 7.6 6.0 6.0 6.0 6.0 6.0 7.0 7.6 8.0 WIDTH 3.6 3.3 3</td><td> 4.6 5.0 6.6 6.7 7.0 7.6 8.0 WIDTH 3.6 4.2 4.5 5.0 5.0 6.6 7.0 7.6 6.0 7.0 7.6 8.0 MIDTH 3.6 3.3 </td><td> 4.4° 5.4° 5.4° 6.4° 6.4° 7.4° 7.4° 7.4° 8.4° 8.4° 4.4° 8.4° 8.4° 5.4° 5.4° 6.4° 7.4° 7.4° 7.4° 8.4° 9.10 1.48 1819 8.4° </td><td> 1819 1.00 </td><td> 1819 1.0
1.0 1.0</td></th<></td></th<></td></th<></td></t<></td></th<></td></th<> | 4-6" 5-0" 6-0" 6-0" 7-0" 7-6" 9-0" 6-0" <th< td=""><td>46. 5.0. 5.0. 6.0. 6.0. 7.0. 7.0. 7.0. 3.0. 4.0. <t< td=""><td> 4.6° 5.0° 5.6° 6.0° 6.6° 7.0° 7.6° 8.0° WIDTH 3.6° 4.0° 5.6° 5.0° 5.6° 6.0° 6.0° 7.0° 7.6° 8.0° WIDTH 3.6° 4.0° 4.0° 7.0° 7.6° 8.0° WIDTH 3.6° 4.0° 7.0° 7.6° 8.0° 9.0° 9.0° 9.0° 4.0°</td><td>4.5. 5.0. <th< td=""><td>4.4° 5.0° 5.0° 6.0° 6.0° 7.0° 4.1° 7.0° 4.1° 4.1° 4.1° <th< td=""><td> 14.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 18.10 17.8 18.10 17.8 18.10 17.8 18.10 17.8 18.10 18.2
 18.2 1</td><td>4-5° 5-6° 5-7° <th< td=""><td> 4.5° 5.0° 5.5° </td><td> 1819 </td><td> 1819 2-6 6-6 6-6 7-0 7-6 8-0 WIOTH 3-6 4-0 5-6 5-0 6-6 7-0 7-6 8-0 WIOTH 3-6 3-2 </td><td> 14.6 5.6 6.6 6.7 6.6 7.0 7.6 8.0 WIDTH 3.6 4.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 3.6 4.5 7.0 7.6 8.0 WIDTH 3.6 7.0 7.6 6.0 6.0 6.0 6.0 6.0 7.0 7.6 8.0 WIDTH 3.6 3.3 3</td><td> 4.6 5.0 6.6 6.7 7.0 7.6 8.0 WIDTH 3.6 4.2 4.5 5.0 5.0 6.6 7.0 7.6 6.0
 7.0 7.6 8.0 MIDTH 3.6 3.3 </td><td> 4.4° 5.4° 5.4° 6.4° 6.4° 7.4° 7.4° 7.4° 8.4° 8.4° 4.4° 8.4° 8.4° 5.4° 5.4° 6.4° 7.4° 7.4° 7.4° 8.4° 9.10 1.48 1819 8.4° </td><td> 1819 1.00 </td><td> 1819 1.0</td></th<></td></th<></td></th<></td></t<></td></th<> | 46. 5.0. 5.0. 6.0. 6.0. 7.0. 7.0. 7.0. 3.0. 4.0. <t< td=""><td> 4.6° 5.0° 5.6° 6.0° 6.6° 7.0° 7.6° 8.0° WIDTH 3.6° 4.0° 5.6° 5.0° 5.6° 6.0° 6.0° 7.0° 7.6° 8.0° WIDTH 3.6° 4.0° 4.0° 7.0° 7.6° 8.0° WIDTH 3.6° 4.0° 7.0° 7.6° 8.0° 9.0° 9.0° 9.0° 4.0°
4.0° 4.0°</td><td>4.5. 5.0. <th< td=""><td>4.4° 5.0° 5.0° 6.0° 6.0° 7.0° 4.1° 7.0° 4.1° 4.1° 4.1° <th< td=""><td> 14.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 18.10 17.8 18.10 17.8 18.10 17.8 18.10 17.8 18.10 18.2 1</td><td>4-5° 5-6° 5-7° <th< td=""><td> 4.5° 5.0° 5.5° </td><td> 1819
1819 1819 </td><td> 1819 2-6 6-6 6-6 7-0 7-6 8-0 WIOTH 3-6 4-0 5-6 5-0 6-6 7-0 7-6 8-0 WIOTH 3-6 3-2 </td><td> 14.6 5.6 6.6 6.7 6.6 7.0 7.6 8.0 WIDTH 3.6 4.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 3.6 4.5 7.0 7.6 8.0 WIDTH 3.6 7.0 7.6 6.0 6.0 6.0 6.0 6.0 7.0 7.6 8.0 WIDTH 3.6 3.3 3</td><td> 4.6 5.0 6.6 6.7 7.0 7.6 8.0 WIDTH 3.6 4.2 4.5 5.0 5.0 6.6 7.0 7.6 6.0 7.0 7.6 8.0 MIDTH 3.6 3.3 </td><td> 4.4° 5.4° 5.4° 6.4° 6.4° 7.4° 7.4° 7.4° 8.4° 8.4° 4.4° 8.4° 8.4° 5.4° 5.4° 6.4° 7.4° 7.4° 7.4° 8.4° 9.10 1.48 1819 8.4° </td><td> 1819 1.00
1.00 1.00 </td><td> 1819 1.0</td></th<></td></th<></td></th<></td></t<> | 4.6° 5.0° 5.6° 6.0° 6.6° 7.0° 7.6° 8.0° WIDTH 3.6° 4.0° 5.6° 5.0° 5.6° 6.0° 6.0° 7.0° 7.6° 8.0° WIDTH 3.6° 4.0° 4.0° 7.0° 7.6° 8.0° WIDTH 3.6° 4.0° 7.0° 7.6° 8.0° 9.0° 9.0° 9.0° 4.0° | 4.5. 5.0. <th< td=""><td>4.4° 5.0° 5.0° 6.0° 6.0° 7.0° 4.1° 7.0° 4.1° 4.1° 4.1° <th< td=""><td> 14.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 18.10 17.8 18.10 17.8 18.10 17.8 18.10 17.8 18.10 18.2
18.2 18.2 18.2 18.2 18.2 18.2 18.2 18.2 18.2 18.2 18.2 18.2 18.2 1</td><td>4-5° 5-6° 5-7° <th< td=""><td> 4.5° 5.0° 5.5° </td><td> 1819 </td><td> 1819 2-6 6-6 6-6 7-0 7-6 8-0 WIOTH 3-6 4-0 5-6 5-0 6-6 7-0 7-6 8-0 WIOTH 3-6 3-2 </td><td> 14.6 5.6 6.6 6.7 6.6 7.0 7.6 8.0 WIDTH 3.6 4.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 3.6 4.5 7.0 7.6 8.0 WIDTH 3.6 7.0 7.6 6.0 6.0 6.0 6.0 6.0 7.0 7.6 8.0 WIDTH 3.6 3.3 3</td><td> 4.6 5.0 6.6 6.7 7.0 7.6 8.0 WIDTH 3.6 4.2 4.5 5.0 5.0 6.6 7.0 7.6 6.0 7.0 7.6 8.0 MIDTH 3.6 3.3
3.3 3.3 </td><td> 4.4° 5.4° 5.4° 6.4° 6.4° 7.4° 7.4° 7.4° 8.4° 8.4° 4.4° 8.4° 8.4° 5.4° 5.4° 6.4° 7.4° 7.4° 7.4° 8.4° 9.10 1.48 1819 8.4° </td><td> 1819 1.00 </td><td> 1819 1.0</td></th<></td></th<></td></th<> | 4.4° 5.0° 5.0° 6.0° 6.0° 7.0° 4.1° 7.0° 4.1° 4.1° 4.1° <th< td=""><td> 14.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 18.10 17.8 18.10 17.8 18.10 17.8 18.10 17.8 18.10 18.2
 18.2 1</td><td>4-5° 5-6° 5-7° <th< td=""><td> 4.5° 5.0° 5.5° </td><td> 1819 </td><td> 1819 2-6 6-6 6-6 7-0 7-6 8-0 WIOTH 3-6 4-0 5-6 5-0 6-6 7-0 7-6 8-0 WIOTH 3-6 3-2 </td><td> 14.6 5.6 6.6 6.7 6.6 7.0 7.6 8.0 WIDTH 3.6 4.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 3.6 4.5 7.0 7.6 8.0 WIDTH 3.6 7.0 7.6 6.0 6.0 6.0 6.0 6.0 7.0 7.6 8.0 WIDTH 3.6 3.3
3.3 3</td><td> 4.6 5.0 6.6 6.7 7.0 7.6 8.0 WIDTH 3.6 4.2 4.5 5.0 5.0 6.6 7.0 7.6 6.0 7.0 7.6 8.0 MIDTH 3.6 3.3 </td><td> 4.4° 5.4° 5.4° 6.4° 6.4° 7.4° 7.4° 7.4° 8.4° 8.4° 4.4° 8.4° 8.4° 5.4° 5.4° 6.4° 7.4° 7.4° 7.4° 8.4° 9.10 1.48 1819 8.4° </td><td> 1819 1.00 </td><td> 1819 1.0</td></th<></td></th<> | 14.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 18.10 17.8 18.10 17.8 18.10 17.8 18.10 17.8 18.10 18.2
18.2 1 | 4-5° 5-6° 5-7° <th< td=""><td> 4.5° 5.0° 5.5° </td><td> 1819 </td><td> 1819 2-6 6-6 6-6 7-0 7-6 8-0 WIOTH 3-6 4-0 5-6 5-0 6-6 7-0 7-6 8-0 WIOTH 3-6 3-2 </td><td> 14.6 5.6 6.6 6.7 6.6 7.0 7.6 8.0 WIDTH 3.6 4.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 3.6 4.5 7.0 7.6 8.0 WIDTH 3.6 7.0 7.6 6.0 6.0 6.0 6.0 6.0 7.0 7.6 8.0 WIDTH 3.6 3.3
 3.3 3</td><td> 4.6 5.0 6.6 6.7 7.0 7.6 8.0 WIDTH 3.6 4.2 4.5 5.0 5.0 6.6 7.0 7.6 6.0 7.0 7.6 8.0 MIDTH 3.6 3.3 </td><td> 4.4° 5.4° 5.4° 6.4° 6.4° 7.4° 7.4° 7.4° 8.4° 8.4° 4.4° 8.4° 8.4° 5.4° 5.4° 6.4° 7.4° 7.4° 7.4° 8.4° 9.10 1.48 1819 8.4° </td><td> 1819 1.00 </td><td> 1819 1.0</td></th<> | 4.5° 5.0° 5.5°
5.5° 5.5° | 1819 1819 | 1819 2-6 6-6 6-6 7-0 7-6 8-0 WIOTH 3-6 4-0 5-6 5-0 6-6 7-0 7-6 8-0 WIOTH 3-6 3-2 | 14.6 5.6 6.6 6.7 6.6 7.0 7.6 8.0 WIDTH 3.6 4.6 5.0 5.6 6.0 6.6 7.0 7.6 8.0 WIDTH 3.6 4.5 7.0 7.6 8.0 WIDTH 3.6 7.0 7.6 6.0 6.0 6.0 6.0 6.0 7.0 7.6 8.0 WIDTH 3.6 3.3 3 | 4.6 5.0 6.6 6.7 7.0 7.6 8.0 WIDTH 3.6 4.2 4.5 5.0 5.0 6.6 7.0 7.6 6.0 7.0 7.6 8.0 MIDTH 3.6 3.3 | 4.4° 5.4° 5.4° 6.4° 6.4° 7.4° 7.4° 7.4° 8.4° 8.4° 4.4° 8.4° 8.4° 5.4° 5.4° 6.4° 7.4° 7.4° 7.4° 8.4° 9.10 1.48 1819 8.4°
8.4° 8.4° | 1819 1.00 | 1819 1.0 |

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. ▲Transition loads (**bold type**) and widths based on Kµ—0.19, r_sdp—0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-9

		ď	ດແ	۰ ۱	- α		HE								 CK : ⊈	FI		- H	55 +	3 3		VE		OF 52 53	2 0		PI				35 E	T %	37	38	36
ATRAN-	WIDTH	4'-11"	5. 3.	5'- 5"	5'- 7"	5'- 8"	5'-10"	5'-11"	6. 1"	6- 2	6- 3"	6'- 5"	99	29		6 9"	6'-10"	7 0"						9-1	- 60		710"	7:-11"	8. 08	8- 1:	5	ښ ښ	4	ŗ	
	0-,6																													15640	16140	16570			17980
	8.0.																							12860	13340	13810	14270	14710	15180	15370	15590	15800	16010		16390
F PIPE	92																			_	11020			12400			13320	13540	13740	13940	14130			14650	14810
OP 0	1.0.													7791	8250	8711	9179	9643			_	_		11200			12010	12190	12360	12530	12690				11760 13260
1 AT T	.99								5478	5938	6401	6862	7330	7657	7947	8223	8488	8740		9211		-		10030			10720	10870	11010	11150	11280		_		11760
TRENCH WIDTH AT TOP OF	09				3620	4085	4551	5015	5414	5735	6040	6331	8099	6871	7121	7359	7585	7800				-+		8889			 	9577	9692	1086	9914		10110	<u> </u>	10290
NCH	26"		2686	3155	3565	3911	4239	4549	4843	5121	5384	5634	5870	6094	6305	9059	9699	9289		7207				7803			8224	8323	8416	8505	8288		8743		7530 8881
TRE	20	2119		_	3176		3759	4026	4277	4513	4735	4945	5142	5328	5503	9999	5853	969				-		6780			5 7036	7111	7182		7312				
	46"	1913	-		2790			3507	3717	3912	4095	4266	4426	4576	4716	4848	3 4970	5082				+		5206			5882	9 5950	6002		9092		6177		6248
	4.0.	1667	1932	2178	2406	2617	2814	2996	3164	3321	3466	3601	3726	3843	3950	4050	4143	4229	4309	4383	4451	4515	45/4	4629	4727	4771	4811	4849	4884	4916	4946	4974	2000	5024	5047
																																-			
AN-	DI H		. 4		 	10		<u>-</u>		.4	ວ້	 6	÷	0	10.	٥.	<u>-</u>	5.	ب	<u>.</u>		<u> </u>	.				<u>-</u>		<u>ښ</u>	<u>.</u> 4		9		6	6
ATRAN-	WDTH WDTH	2 0	5'- 4"	5 6"	5. 8	5-10"	5'-11"	6'- 1"		6 4"	6. 5.	9	6. 8	.6 - 9	610	7 0	7 1"	7 2"	7 3"	7 4"	7 5	7-7	8 - 1	7 - 9	7:-12	8- 0.	8	<u>.</u>	∞	<u></u>	<u></u>	∞	፟	&	<u></u>
ATRAN-	06	2 0.,	5'- 4"	2,- 6"	5. 8.,	5'-10"	5'-11"	6- 1"		6 4	6'- 5"	99		.6 - 9	610	7 0	7:- 1"	7'- 2"	7'- 3"	7'- 4"	7:-	7	- 1			· &	14270 8'-	14710 8-	15180 8-	15640 8'-	16140 8'-	16570 8-	17050 8'-	17520 8-	17980 8'-
4	0608	2,- 0	5'- 4"	5'- 6"	5 8	5'-10"	5'-11"	1 9		6 4"	6'- 5"	99		69	6'-10"	1 0	2	7'-		7	7	11500	11960	12400	13340	13810 8'-	13990 14270 8'-	14210 14710 8'-	14420 15180 8'-	14620 15640 8'-	14820 16140 8 '-	15000 16570 8'-	15180 17050 8'-	15350 17520 8 -	15510 17980 8'-
PIPE	060892	2,- 0,	5'- 4"	5'- 6"	2:- 8:-	5'-10"	5-11"	9		6 4"	6'- 5"	9 -,9	9	-9			9179 7'-	9643 7'-	10110 7	10570 7'-	11020 7'-	11370 11500 7:-	11620 11960 7-	11850 12400	13340	13810 8'-	2690 13990 14270 8'-	12880 14210 14710 8:-	13060 14420 15180 8'-	13230 14620 15640 8 '-	14820 16140 8 '-	15000 16570 8'-	13700 15180 17050 8'-	13840 15350 17520 8'-	13980 15510 17980 8'-
PIPE	06089202	2,- 0,,	5'- 4"	2,- 0,	2:- 8:	5'-10"	5'-11"		9	9	-,9	-,9	7330 6-	7791 6'-	8250	8711	9064 9179 7	9331 9643 7'-	9585 10110 7-	9827 10570 7'-	10060 11020 7	10280 11370 11500 7:-	10490 11620 11960 7-	11850 12400	13340	11240 12490 13810 8'-	11400 12690 13990 14270 8 '-	11560 12880 14210 14710 8:-	11710 13060 14420 15180 8'-	11860 13230 14620 15640 8'-	12000 13390 14820 16140 8 '-	12130 13550 15000 16570 8-	12250 13700 15180 17050 8'-	12370 13840 15350 17520 8 '-	12490 13980 15510 17980 8'-
PIPE	0608920299	2,- 0,:	5'- 4"	2- 6"				1 5015	5478 6:-	5938 6	6401 6'-	6862 6'-	7120 7330 6-	7401 7791 6'-	7669 8250	7923 8711	8164 9064 9179 7-	8394 9331 9643 7'-	8612 9585 10110 7-	8820 9827 10570 7'-	9017 10060 11020 7-	9204 10280 11370 11500 7	9382 10490 11620 11960 7-	9552 10690 11850 12400	9866 11060 12290 13340	10010 11240 12490 13810 8'-	10150 11400 12690 13990 14270 8-	10280 11560 12880 14210 14710 8-	10400 11710 13060 14420 15180 8-	10520 11860 13230 14620 15640 8 -	10640 12000 13390 14820 16140 8'-	10740 12130 13550 15000 16570 8:-	12250 13700 15180 17050 8'-	10940 12370 13840 15350 17520 8-	11040 12490 13980 15510 17980 8:-
PIPE	06 08 0 9 9	5'- 0"	20-	2	3620 5'-	4085	4551	4951 5015	5270 5478 6'-	5572 5938 6	5858 6401 6'-	6128 6862 61-	6384 7120 7330 6'-	6626 7401 7791 6 '-	6855 7669 8250	7072 7923 8711	7277 8164 9064 9179 7'-	7472 8394 9331 9643 7'-	7656 8612 9585 10110 7'-	7830 8820 9827 10570 7'-	7994 9017 10060 11020 7'-	8150 9204 10280 11370 11500 7	8298 9382 10490 11620 11960 7.	8438 9552 10690 11850 12400	8695 9866 11060 12290 13340	8814 10010 11240 12490 13810 8'-	8926 10150 11400 12690 13990 14270 8 '-	9032 10280 11560 12880 14210 14710 8-	9132 10400 11710 13060 14420 15180 8-	9227 10520 11860 13230 14620 15640 8 -	9317 10640 12000 13390 14820 16140 8'-	9402 10740 12130 13550 15000 16570 8'-	9483 10850 12250 13700 15180 17050 8'-	9559 10940 12370 13840 15350 17520 8:-	9631 11040 12490 13980 15510 17980 8-
PIPE	06 8 20 20 8 80	-12	2686 5:-	3155 5-	3494 3620 5'-	3824 4085	4135 4551	4428 4951 5015	4704 5270 5478 6 '-	4964 5572 5938 6:-	5209 5858 6401 6'-	5439 6128 6862 6:	5656 6384 7120 7330 6'-	5861 6626 7401 7791 6 '-	6053 6855 7669 8250	6234 7072 7923 8711	6405 7277 8164 9064 9179 7'-	6566 7472 8394 9331 9643 7'-	6717 7656 8612 9585 10110 7	6860 7830 8820 9827 10570 7'-	6994 7994 9017 10060 11020 7'-	7121 8150 9204 10280 11370 11500 7:-	7240 8298 9382 10490 11620 11960 7	7352 8438 9552 10690 11850 12400	7557 8695 9866 11060 12290 13340	7651 8814 10010 11240 12490 13810 8 '-	7739 8926 10150 11400 12690 13990 14270 8 '-	7822 9032 10280 11560 12880 14210 14710 8 *-	7901 9132 10400 11710 13060 14420 15180 8-	7974 9227 10520 11860 13230 14620 15640 8 '-	8044 9317 10640 12000 13390 14820 16140 8-	8109 9402 10740 12130 13550 15000 16570 8:-	8171 9483 10850 12250 13700 15180 17050 8-	8229 9559 10940 12370 13840 15350 17520 8	8283 9631 11040 12490 13980 15510 17980 8-
4	2-0., 2-6., 6-0., 6-6., 7-0., 7-6., 8-0., 9-0	2119 5'-	2477 2686 5-	2802 3155 5-	3107 3494 3620 5:-	3393 3824 4085	3660 4135 4551	7 3910 4428 4951 5015	4144 4704 5270 5478 6'-	4363 4964 5572 5938 6:-	4568 5209 5858 6401 6. -	4760 5439 6128 6862 6-	4940 5656 6384 7120 7330 6:-	5108 5861 6626 7401 7791 6'-	5266 6053 6855 7669 8250	5413 6234 7072 7923 8711	5552 6405 7277 8164 9064 9179 7	5681 6566 7472 8394 9331 9643 7'-	5802 6717 7656 8612 9585 10110 7-	5915 6860 7830 8820 9827 10570 7'-	6021 6994 7994 9017 10060 11020 7 '-	6120 7121 8150 9204 10280 11370 11500 7	6213 /240 8298 9382 10490 11620 11960 7-	6300 7352 8438 9552 10690 11850 1 2400	6458 7557 8695 9866 11060 12290 1 3340	6529 7651 8814 10010 11240 12490 13810 8'-	6596 7739 8926 10150 11400 12690 13990 14270 8 '-	6659 7822 9032 10280 11560 12880 14210 14710 8 °-	6717 7901 9132 10400 11710 13060 14420 15180 8 '-	6772 7974 9227 10520 11860 13230 14620 15640 8 '-	6823 8044 9317 10640 12000 13390 14820 16140 8 -	6871 8109 9402 10740 12130 13550 15000 16570 8 '-	6916 8171 9483 10850 12250 13700 15180 17050 8 -	6958 8229 9559 10940 12370 13840 15350 17520 8	6998
PIPE	46" 50" 56" 60" 66" 70" 76" 81-0" 90"	1883 2119 5	2184 2477 2686 5:-	2463 2802 3155 5:-	2723 3107 3494 3620 5:-	2964 3393 3824 4085	3189 3660 4135 4551	3397 3910 4428 4951 5015	3591 4144 4704 5270 5478 6'-	3771 4363 4964 5572 5938 6	3938 4568 5209 5858 6401 6'-	4093 4760 5439 6128 6862 65-	4238 4940 5656 6384 7120 7330 6:-	4372 5108 5861 6626 7401 7791 6 '-	4497 5266 6053 6855 7669 8250	4613 5413 6234 7072 7923 8711	4720 5552 6405 7277 8164 9064 9179 7'-	4820 5681 6566 7472 8394 9331 9643 7'-	4913 5802 6717 7656 8612 9585 10110 7 -	5000 5915 6860 7830 8820 9827 10570 7 '-	5080 6021 6994 7994 9017 10060 11020 7'-	5155 6120 7121 8150 9204 10280 11370 11500 7 :	5224 6213 /240 8298 9382 10490 11620 11960 7-	5289 6300 7352 8438 9552 10690 11850 12400	5404 6458 7557 8695 9866 11060 12290 13340	5456 6529 7651 8814 10010 11240 12490 13810 8 '-	5504 6596 7739 8926 10150 11400 12690 13990 14270 8 '-	5549 6659 7822 9032 10280 11560 12880 14210 14710 8 °-	5590 6717 7901 9132 10400 11710 13060 14420 15180 8 '-	5629 6772 7974 9227 10520 11860 13230 14620 15640 8 '-	5665 6823 8044 9317 10640 12000 13390 14820 16140 8 -	5698 6871 8109 9402 10740 12130 13550 15000 16570 8 -	5729 6916 8171 9483 10850 12250 13700 15180 17050 8 -	5758 6958 8229 9559 10940 12370 13840 15350 17520 8 -	5784 6998 8283 9631 11040 12490 13980 15510 1 7980 8 -
PIPE	2-0., 2-6., 6-0., 6-6., 7-0., 7-6., 8-0., 9-0	1638 1883 2119 5	2184 2477 2686 5	2127 2463 2802 3155 5:	2342 2723 3107 3494 3620 5 ⁻	9 2540 2964 3393 3824 4085	2723 3189 3660 4135 4551	11 2891 3397 3910 4428 4951 5015	12 3046 3591 4144 4704 5270 5478 6:-	13 3189 3771 4363 4964 5572 5938 6	14 3320 3938 4568 5209 5858 6401 6. -	15 3441 4093 4760 5439 6128 6862 6. -	16 3553 4238 4940 5656 6384 7120 7330 6 -	17 3655 4372 5108 5861 6626 7401 7791 6.	18 3750 4497 5266 6053 6855 7669 8250	19 3837 4613 5413 6234 7072 7923 8711	20 3917 4720 5552 6405 7277 8164 9064 9179 7 '-	21 3991 4820 5681 6566 7472 8394 9331 9643 7'-	22 4058 4913 5802 6717 7656 8612 9585 10110 7-	23 4121 5000 5915 6860 7830 8820 9827 10570 7 -	24 4179 5080 6021 6994 7994 9017 10060 11020 7	25 4232 5155 6120 7121 8150 9204 10280 11370 11500 7	26 4280 5224 6213 7240 8298 9382 10490 11620 11960 7-	6300 7352 8438 9552 10690 11850 1 2400	29 4405 5404 6458 7557 8695 9866 11060 12290 13340	30 4440 5456 6529 7651 8814 10010 11240 12490 13810 8 '-	31 4472 5504 6596 7739 8926 10150 11400 12690 13990 14270 8 :	32 4502 5549 6659 7822 9032 10280 11560 12880 14210 14710 8 °-	33 4529 5590 6717 7901 9132 10400 11710 13060 14420 15180 8 '-	34 4555 5629 6772 7974 9227 10520 11860 13230 14620 15640 8 -	35 4578 5665 6823 8044 9317 10640 12000 13390 14820 16140 8·	36 4599 5698 6871 8109 9402 10740 12130 13550 15000 16570 8	4619 5729 6916 8171 9483 10850 12250 13700 15180 17050 8 -	4637 5758 6958 8229 9559 10940 12370 13840 15350 17520 8	6998 8283 9631 11040 12490 13980 15510 17980 8 '-

Table B-9 Continued

	-	2	9 1	_	&		E					ZF OF	5 E					_ .L &				>V ₹)F				F				37	38	39	40
ATRAN-	WIDTH	4'- 9"				5'- 5"	. e.				5 9	2,-10,,	09	6'- 1"	6'- 1"	6'- 2"	6'- 3"	6:- 4"	6 5"				69	6'-10"	6'-10"	6-11		7- 1"	7 2"	7'- 2"	7:- 3"	7. 4"		92	92	7 7"	7:- 8"	7 8"
	0-,6)
Т ш	8'-0"							\downarrow		•									_										_	_	_	_		_	_	17520	17980	18430
FPIP	92																											13810					16140		17050	17180	17420	17660
OP O	1.0							\downarrow						L							10570		11500					_	13860				14860	_	15310	15520	15730	15940
ATT	9-,9													7330	7791	8250	8711	9179	9643	10110	10390	10680	10960									13130	13330	13530	13720	13900	14070	14240
META	09							4			5938	6401	6862	7262	7590	2006	8210	8504	8787	9059	9322		9820							<u>. </u>	<u> </u>	11660	11830	11990	12150	12300	12450	12590
TRENCH WIDTH AT TOP OF PIPE	2:-6"	_		_	3620	4085		4	4884		5222	5882	6203	6499	6784	7057	7319	7571	┺-	8046	8270		8691									10220	10360	10490	10620	10740	10860	10970
TREN	2,-0	2119	2636	3012	3371	3715	4045	_		4661	4950	5226	5490	5743	5885	6216	6438	6650	6853	7047	7233	7410	7581		7899	8048	8191	8328	8458	8583	8703	8817	8927	9032	9132	9228	9320	9408
	46"	1996	2340	2667	2979	3276	2550	8000	3828	4085	4329	4562	4783	4994	5195	5386	5568	5742	5907	6064	6214	6357	6493	6622	6745	6863	6974	7081	7182	7278	7370	7458	7541	7620	9692	7768	7836	7902
ا د	40	1748	2044	2323	2588	2839	2076	0/00	3301	3513	3714	3905	4085	4256	4417	4570	4714	4851	4981	5104	5220	5329	5433	5532	5625	5713	2679	5876	2950	6021	8809	6151	6211	6268	6322	6373	6421	6466
± :	Z E				5.	=					_	-	<u> </u>					=			_		:	<u> </u>	Ē.		<u>.</u> 4	5	-		<u> </u>			<u> </u>	-			1.
ATRAN	WIDTH	4'-10"		5- 4	5,	5. 7.	· à		510		6.0	6. 1	6'- 2	9:		6. 5				6:-10	6′-10″	7 0	7: 1	7'- 1	7: 2	7:3	7 - 7	7. 5	.92	7-7	7: 8		7:-10"	7:-10"	7:-11"	 8. 0.	8.	8
	.0-,6																																				17980	18430
	80.																													14710	15180	15640	16140	16570	17050	17520	17680	17910
PIPE	9-,2														-								11500	11960	12400	12860	13340	13810	14270	14500	14740	14980	15200	15420	15640	14250 15840	16040	14580 16230
	1.0.2																	9179	9643	10110	10570	11020	11400	11670	11930	12180	12430	12660	12890	13100	13310	13520	13710	13900	14080 15640	14250	14420	14580
	9-,9		•									6401	6862	7330	7791	8250	8711	8948	9234		9774	10030	10270	10510				11360	11550	11730	11910	12080	12240	12400	12550	12700	12840	12970
THA!	0-,9					4085	456.4	4001	5015	5478	5938	6297	6617	6924	7217	7498	7768	8025	8272	8509	8735		9159	9358				10070		10380	10530	10670	10810	10940	11060	11180	11290	11400
TRENCH WIDTH AT TOP OF PI	26"		2686	3155	3620	4031	0 0	4382	4717	5036	5341	5632	5909	6173	6425	9999	6895	7114	7323	7522	7712	7893	9908	8230	8387	8537	_	8817	8947	9071		9302	9410	9513	9610	9704	9793	9878
ENC!	2,-0	2119	2577	2933	3272	3593	0000	388	4188	4463	4724	4972	5207	5430	5643	5844	6035	6216	6388	6552	6707	6855	6994	7127	7253	7373	7486	7594	7697	7794	7886	7974	8057	8136	8211	8282	8350	8414
IR	4'-6"	1954	2281	2590	2882		0 7	3418	3663	3894	4113	4319	4514	4698	4871	5035	5 190	5336	5473	5603			5951	6054	6151	6243	6330	6412	6489	6562	6631	9699	6757	6815	6870	6921	0269	7016
	4.0	17071		2249	2495			-		3332	3510			-					+				4942	5018		5156		5278		5385	5433	5478		5561	5598	5633	9999	9699
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Table B-10

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ATRAN-	WIDTH	5'- 3"	5 7"			6. 2"		6-5		- 6		7 0"	<u>.</u>	7 2"		7- 4"					- č		į.	<u>ښ</u>	.4	. 5					-	8-11
	100				,						-					T																
	0-,6																					14120	14630	15130	15650	16150	16640	17170	17680	18 180	18670	19200
: PIPE	80																	11580	12090	12610	13110	13870	14140	14410	14660	14910	15140	15370	15590	15800	160 10	16200
JO GC	92												8542	9045	9559	10060	10920	11280	11570	11850	12120	12630	12870	13100	13320	13540	13740	13940	14 130	143 10	•	14650
AT TOP	.02								6512	7019	7526	8034	8450	8781	8606	9401	9092	10240	10490	10740	10970	11410	11620	11820	12010	12190	12360	12530	12690	12840	12990	13130
TRENCH WIDTH	9-,9					4474	4983	5492	9003	6702	7035	7353	7657	7947	8223	8488	8981	9211	9431	9641	984 -	10220	10390	10560	10720	10870	11010	11150	11280	11410	11530	11640
> HON	09		2880	3450	3963	4348	4721	5076	54 4	6040	6331	8099	6871	7121	7359	7585	8005	8200	8385	8561	62/2	9040	9185	9322	9453	9577	9698	9807	-	_	10110	10200
TRE	26"	2258	2814	3200	3565	3911	4239	4549	4843	5384	5634	5870	6094	6305	9059	9699	7046	7207	7360	7504	7771	7893	8010	8120	8224	8323			\rightarrow	8668	8743	8814
	5'-0"	2159	2519	2857	3176	3477	3759	4026	4277	47.35	4945	5142	5328	5503	2668	5823	6107	6236	6358	6473	2869	6780	6870	6955	2036	7111	7182	7249	7312	7372	7428	7480
	46"	1913	2225	2517	2790	3045	3284	3507	37.17	7005	4266	4426	4576	4716	4848	4970	5192	5293	5387	5475	1000	5706	5773	5836	5895	5950	6002	6050	6095	6137	6177	6214
ż	Z E		∞	<u>-</u>	<u>:</u>		. 4				.0	<u>-</u>		. 4					 0	- ċ	v ċ	4	5.	9	1	.6	810		 O	-		
ATRAN.	WIDTH	5'-	5.	5'-11"	. <u>'</u>		6	•	, ç	6-11	7-	7	7	7.	7	i 'i	7.7	7:-10"	ώ.	80 6	οà	, ep	80	80	∞	φ ;	∞	8'-11"				6
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ш	06											-				9	2 6	9	0	30 12610	13630		14630		15650	16150	20 16640	17170	17680	06 11 00		Ö.
F PIPE	80											4	মূ	57	6	00		. —	12090	12480	12030	13280	13530	13770	13990	14210	14420	14620	14820	15000	15180	15350
OF	.0892							-	2 6		9	34 8034	36 8542			10060	10570	10850	11120 12090	11370 12480	11620 12760	12070 13280	12290 13530	12490 13770	12690 13990	12880 14210	13060 14420	13230 14620	13390 14820	13550 15000	13700 15180	13840 15350
AT TOP OF	089202				<u> </u>	7	9	2000				7864	8186	8492	8785	9064 10060	0501 10200 1	9827 10850 1	10060 11120 12090	10280 11370 12480	10490 11620 12760	10880 12070 13280	11060 12290 13530	11240 12490 13770	11420 12690 13990	11560 12880 14210	11710 13060 14420	11860 13230 14620	11200 13390 14820	12130 13550 15000	12250 13700 15180	12370 13840 15350
AT TOP OF	.08 .92 .02 .99		00	9				5492	0.00 4.00 7.00 7.00	65.13	6824	7120 7864	7401 8186	7669 8492	7923 8785	8164 9064 10060	8612 0505 10570 1	8820 9827 10850 1	9017 10060 11120 12090	9204 10280 11370 12480	9382 10490 11620 12760	9713 10880 12070 13280	9866 11060 12290 13530	10010 11240 12490 13770	10150 11420 12690 13990	10280 11560 12880 14210	10400 11710 13060 14420	10520 11860 13230 14620	10640 11200 13390 14820	10740 12130 13550 15000	10850 12250 13700 15180	10940 12370 13840 15350
AT TOP OF	08 20 20 80			13 3450	3883	4259	4615	4951 5492	5570 6185	5858 6513	6128 6824	6384 7120 7864	6626 7401 8186	6855 7669 8492	7072 7923 8785	7277 8164 9064 10060	7656 8612 0505 10570 1	7830 8820 9827 10850 1	7994 9017 10060 11120 12090	8150 9204 10280 11370 12480	8298 9382 10490 11620 12760	8570 9713 10880 12070 13280	8695 9866 11060 12290 13530	8814 10010 11240 12490 13770	8926 10150 11420 12690 13990	9032 10280 11560 12880 14210	9132 10400 11710 13060 14420	9227 10520 11860 13230 14620	9317 10640 11200 13390 14820	9402 10740 12130 13550 15000	9483 10850 12250 13700 15180	9559 10940 12370 13840 15350
OF	5-6 6-0 6-6 7-0 7-6 8-0	2258	2771	3143	3494 3883	3824 4259	4135 4615	4428 4951 5492	4704 5270 534 I	5200 5858 6513	5439 6128 6824	5656 6384 7120 7864	5861 6626 7401 8186	6053 6855 7669 8492	6234 7072 7923 8785	6405 7277 8164 9064 10060	6217 7656 8612 0505 10570 1	6860 7830 8820 9827 10850 1	6994 7994 9017 10060 11120 12090	7121 8150 9204 10280 11370 12480	7240 8298 9382 10490 11620 12760	7458 8570 9713 10880 12070 13280	7557 8695 9866 11060 12290 13530	7651 8814 10010 11240 12490 13770	7739 8926 10150 11420 12690 13990	7822 9032 10280 11560 12880 14210	7901 9132 10400 11710 13060 14420	7974 9227 10520 11860 13230 14620	8044 9317 10640 11200 13390 14820	8109 9402 10740 12130 13550 15000	8171 9483 10850 12250 13700 15180	8229 9559 10940 12370 13840 15350
AT TOP OF	08 20 20 20 20	2129 2258	2477 2771	2802 3143	3107 3494 3883	3393 3824 4259	3660 4135 4615	3910 4428 4951 5492	4144 4104 3270 3841 4363 4064 5573 6185	4568 5209 5858 6513	4760 5439 6128 6824	4940 5656 6384 7120 7864	5108 5861 6626 7401 8186	5266 6053 6855 7669 8492	5413 6234 7072 7923 8785	5552 6405 7277 8164 9064 10060	5800 6217 7656 8619 0505 10500	5915 6860 7830 8820 9827 10850	6021 6994 7994 9017 10060 11120 12090	6120 7121 8150 9204 10280 11370 12480	6213 7240 8298 9382 10490 11620 12760	6382 7458 8570 9713 10880 12070 13280	6458 7557 8695 9866 11060 12290 13530	6529 7651 8814 10010 11240 12490 13770	6596 7739 8926 10150 11420 12690 13990	6659 7822 9032 10280 11560 12880 14210	6717 7901 9132 10400 11710 13060 14420	6772 7974 9227 10520 11860 13230 14620	6823 8044 9317 10640 11200 13390 14820	6871 8109 9402 10740 12130 13550 15000	6916 8171 9483 10850 12250 13700 15180	6958 8229 9559 10940 12370 13840 15350
AT TOP OF	5-6 6-0 6-6 7-0 7-6 8-0	1883 2129 2258	2477 2771	2463 2802 3143	2723 3107 3494 3883	3393 3824 4259	3660 4135 4615	3397 3910 4428 4951 5492	4704 5270 534 I	3938 4568 5209 5858 6513	4093 4760 5439 6128 6824	4238 4940 5656 6384 7120 7864	4372 5108 5861 6626 7401 8186	4497 5266 6053 6855 7669 8492	4613 5413 6234 7072 7923 8785	5552 6405 7277 8164 9064 10060	4820 3681 6366 7472 6384 9331 10260 1	5000 5915 6860 7830 8820 9827 10850	5080 6021 6994 7994 9017 10060 11120 12090	5155 6120 7121 8150 9204 10280 11370 12480	5224 6213 /240 8298 9382 10490 11620 12760	5349 6382 7458 8570 9713 10880 12070 13280	5404 6458 7557 8695 9866 11060 12290 13530	5456 6529 7651 8814 10010 11240 12490 13770	5504 6596 7739 8926 10150 11420 12690 13990	5549 6659 7822 9032 10280 11560 12880 14210	5590 6717 7901 9132 10400 11710 13060 14420	5629 6772 7974 9227 10520 11860 13230 14620	5665 6823 8044 9317 10640 11200 13390 14820	5698 6871 8109 9402 10740 12130 13550 15000	5729 6916 8171 9483 10850 12250 13700 15180	5758 6958 8229 9559 10940 12370 13840 15350

Table B-10 Continued

		5	9 1	_	&		E 01					2)F			CI C	•	5 IF	L 02	21 H)F						ET		37	 88	 66	2
ATRAN-	WIDTH	4 9"		2-5	5'- 4"	5'- 5"	5-6		. 6	o 6			0	<u> </u>	÷	6 2	ب ش	.4	į,		. 7		, è	_		_			7: 1"		-	7 3"		7 5"		1 6"	7 7"	7 8"	7 8"
	0-,6							I																															
	80																			******																	17520	17980	18430
PIPE	9-,2																												13810	14270	14710	15180	15640	16140	16570	17050	17180	17420	17660
TRENCH WIDTH AT TOP OF PIPE	1.0.1																				10570			0001	11960	12400			13600			14380	14620	14860	15090	15310	15520	15730	15940
AT T(9-,9													7330	7791	8250			9643	ŀ									_		12700	12920	13130	13330		13720	13900	14070	14240
MIDTH	0-,9							5015						7262	7590	2062			1					-4	_						11300	11480	11660	11830	_	12150	12300	12450	
CH V	26"				3620	4085	4551	┸					6203	6499	6784	7057			↓.		_			+					8096		9356	10080	10220			10620	10740	10860	10970
TRE	2,-0	2119			3371	3715	4045	+					5490	5743	5985	6216			+					4					8328		8283		8817	_	-	9132	9228	9320	9408
	4'-6"	1996			2979	3276		+				4562	4783	4994	5195	5386		_	┿					-					7081		7278	7370	7458	7541	<u> </u>	9692	1768	7836	7902
·	4.0.,	1748	2044	2323	2588	2839	3076	2201	200	3513	3714	3905	4085	4256	4417	4570	4714	4851	400	104	5000	5550	2 2	5433	5532	5625	5713	5797	5876	5950	6021	8809	6151	6211	6268	6322	6373	6421	6466
TRAN-	WIDTH	4'-10"			5 5"	2 7		2 0	01.0		0 -,9	6. 1.	6 2.	6. 3.	6'- 4"							101	- i		7:- 1"	7 2"	7:- 3"	7 4"	7 5"	7 6	7'- 7"	7 8"	7'- 8"	710"	710"	7-11"	8- 0″	8 1	8. 2
	.0-,6					•		I																														17980	18430
	8.0.																			•••											14710	15180	15640	16140	16570	17050	17520		
PIPE	9-,2																							11500	11960	12400	12860	13340	13810	14270	14500	14740	14980		15420	15640	15840	16040	
OF P	1.02																	9179		_			07011					12430	12660	11550 12890 142	13100	133 10	13520	13710	13900		14250	14420	
T 10P	99											6401	6862	7330	7791	8250						- 1	00001	10270	10510	10730	10950		11360		11730	11910	12080						
ZHA ZHA	09					4085		4				6297	6617	6924	7217				┸			6/30		_			9731		10070	10230	10380	10530	10670	10810	10940	11060	11180	11290	
TRENCH WIDTH AT TOP OF PI	5.6"		2686	3155	3620	4031		4			5341	5632	5909	6173					1					-	_		8537	8680	8817	8947	9071	9189			┺-		9704	9793	
RENC	5.0.	2119	2577	2933	3272			4			4724	4972	5207	5430	5643				4					-			7373	7486	7594	1697	7794	7886	7974		₩				
F	46"	1954		2590	2882		_	4			4113	4319	4514	4698					4					-			6243	6330	6412	6489	6562	6631			₩				
	4,0	1707	1987	2249	2495		_				3510	3676	3832	3978					1			4//3					5156	5219	5278	5333	5385	5433							
- 1		ıO	9	7	œ	σ	5	2 ;	_	•	5	4	15								3 6 ∀ E						28	Α£ 8	8	3	32		34	EI 35		37	38	39	40

Table B-11

		5	9	7	80	Н б	유	IG =	12 H	₽ T	4	15 F	B.⁄ ≌	Ç Ç		F11						E .		9 2 3 3			ڪ IIج		, i	34 FE			37	38
ATRAN-	WIDTH		2 7	5'-10"	09		6'- 3"		99	9. 7.	69	610	1 0	7: 1"	7:- 2"	7:- 3"	7 4"	9 - 1	9 .	o è	7 .	7:-11	.0		8'- 2"	 3.			 6.	8 7.		6	8'-10"	
	100"				•									·																				
	06																							14120	14630	15130	15650	16150	16640	17170	17680	18180	18670	0000
PIPE	80																		9	1580	12030	13110	13630	13870	14140	14410	14660	14910			15590			0000
P OF	1.92													8542	9045	9559	0900	10580		08211		_			12870	3100	13320		3740	3940	14130			A AGEO
AT TOP OF	7.0."									6512	7019	7526	8034	8450	8781	8606	-	_	, ,	10240	0490	10970	11200	11410	1620	1820	2010	12190	12360 1	12530	2690			0000
IDTH	9-,9				•	4474	4983	5492	6003	6354	6702	7035	7353	7657	7947	8223	8488	8740			9431	+	_		0380	0560	10720		1010	_	1280	.	'	0,0
TRENCH WIDTH	09		2880	3450	3963	4348	4721	9209	5414	5735	6040	6331	8099	6871	7121	7359	7585	7800	8005	8200	6363	8729	8889	9040	9185	9322	9453	9577	9692	1086	9914	10020	0110	000
TREN	26"	2258	2814	3200	3565	3911	4239	4549	4843	5121	5384	5634	5870	6094	6305	9059	9699	9/89	7046	7027	7504	7641	7771	7893	8010	8120	8224	8323	8416	8505	8588			
•	20	2159	2519	2857	3176	3477	3759		4277	4513	4735	4945	5142	5328	5503	5668	5823	2969	6107	6236	6338	6582	6684	6780	0289	6955	2036	7111	7182	7249	7312	7372	7428	
		_					3284			3912							\rightarrow				5387	+	5634	_	5773	5836	5895	5950	6002	6050	6095	6137	6177	
	46"	1913	2225	2517	2790	3045	32	35	37	36	40	4266	4426	45	4716	4848	4970	5085	5192	20	0 4	2 3	ď	2	5	2	Š	5	9	9	8	61	61	
																										1								
ATRAN-	WIDTH	3:		=	<u></u>	 	-4	 			<u> </u>		<u> </u>							25 01-7	- -	- ~	ė	. 4	8. 5.	8 6	8 7		018	8'-11" 60	 	9 1	9 2	
ATRAN-		3:				<u>ب</u>	-4	 	÷				<u> </u>		<u>.</u> 4) ÷	- 20	ic.	8- 4	8 5.	98	8'- 7"	.6 -,8	810	8'-11"	.0 -6	18180 9'- 1"	18670 9'- 2"	_
	WIDTH	3:				<u>ب</u>	-4	 	÷				<u> </u>		<u>.</u> 4		92	7. 8	7. 9	01-7	0 - 0	13110 8'- 2"	13630 8'- 3"	14120 8'- 4"	14630 8'- 5"	15130 8'- 6"	15650 8- 7"	16150 8'- 9"	16640 8'-10"	17170 8'-11"	17680 9- 0"	18180 9'- 1"	18220 18670 9'- 2"	
PIPE	8'-0" 9'-0" 10'-0" WIDTH	3:				<u>ب</u>	-4	 	÷				7:- 1"	7 3"	7- 4"	7 5"	92	10580	11070	11580 / -10	12400 12610	12760 13110 8'- 2"	13030 13630 8'- 3"	13280 14120 8'- 4"	13530 14630 8'- 5"	13770 15130 8'- 6"	13990 15650 8- 7"	14210 16150 8'- 9"	14420 16640 8'-10"	14620 17170 8-11"	14820 17680 9- 0"	15000 17990 18180 9'- 1"	15180 18220 18670 9'- 2 "	
OF PIPE	76" 8'-0" 9'-0" NIDTH	3:				<u>ب</u>	-4	9 -,9	.89	69	6-11"	1 0	8034 7'- 1"	8542 7'- 3"	9045 7'- 4"	9559 7'- 5"	10060 7 6"	10280 10580 7 8"	10570 11070 7'- 9"	10850 11580	0 - 0	11690 19760 13110 8'- 2"	11850 13030 13 630 8'- 3"	12070 13280 14120 8- 4"	12290 13530 14630 8'- 5 "	12490 13770 15130 8'- 6"	12690 13990 15650 8- 7"	12880 14210 16150 8- 9 "	13060 14420 16640 8'-10"	13230 14620 17170 8:-11"	13390 14820 17680 9'- 0"	13550 15000 17990 18180 9'- 1"	13700 15180 18220 18670 9'- 2"	
OF PIPE	8'-0" 9'-0" 10'-0" WIDTH	3:				6'- 3"	6'- 4"	9 -,9	89	6512 6 9"	7019 6'-11"	7526 7'- 0"	7864 8034 7'- 1"	8186 8542 7'- 3"	8492 9045 7'- 4"	8785 9559 7'- 5"	9064 10060 7'- 6"	9331 10280 10580	9585 10570 11070	9827 10850 11580	11060 11120 12090	10280 11370 12450 12010 8- 2"	10490 11850 13030 13630 8'- 3"	10880 12070 13280 14120 8'- 4"	11060 12290 13530 14630 8'- 5"	11240 12490 13770 15130 8'- 6 "	11420 12690 13990 15650 8- 7"	11560 12880 14210 16150 8- 9 "	11710 13060 14420 16640 8'-10 "	11860 13230 14620 17170 8-11"	11200 13390 14820 17680 9'- 0 "	12130 13550 15000 17990 18180 9'- 1"	12250 13700 15180 18220 18670 9'- 2 "	
OF PIPE	76" 8'-0" 9'-0" NIDTH	3:	5, 8	5-11"	3963 6'- 1"	4474 6'- 3"	4983	5492 6'- 6"	5841 6003 6'- 8"	6185 6512 6 9 "	6513 7019 6'-11"	6824 7526 7'- 0"	7120 7864 8034 7'- 1"	7401 8186 8542 7'- 3"	7669 8492 9045 7'- 4"	7923 8785 9559 7'- 5''	8164 9064 10060 7'- 6 "	8394 9331 10280 10580	8612 9585 10570 11070 7'- 9"	8820 9827 10820 11380 C	901/ 10060 11120 12030	9204 10280 11370 12480 12010 6-1	9559 10500 11850 13030 13630 8: 3"	9713 10880 12070 13280 14120 8 4"	9866 11060 12290 13530 14630 8'- 5"	10010 11240 12490 13770 15130 8'- 6"	10150 11420 12690 13990 15650 8:- 7 "	10280 11560 12880 14210 16150 8:- 9 "	10400 11710 13060 14420 16640 8:10"	10520 11860 13230 14620 17170 8:-11"	10640 11200 13390 14820 17680 9'- 0"	10740 12130 13550 15000 17990 18180 9- 1"	10850 12250 13700 15180 18220 18670 9'- 2"	
OF PIPE	70" 7'-6" 8'-0" 9'-0" 10'-0" WIDTH	.8 -3.		3450 5'-11"	3883 3963 6: 1"	4259 4474 6'- 3"	4615 4983 6'- 4"	4951 5492 6'- 6''	5270 5841 6003 6'- 8"	5572 6185 6512 6- 9"	5858 6513 7019 6'-11"	6128 6824 7526 7'- 0"	6384 7120 7864 8034 7'- 1"	6626 7401 8186 8542 7'- 3 "	6855 7669 8492 9045 7 '- 4 "	7072 7923 8785 9559 7'- 5"	7277 8164 9064 10060 7'- 6 "	7472 8394 9331 10280 10580	7656 8612 9585 10570 11 070	01-7 0830 18820 18850 17380 1887	7994 9017 10060 11120 1 2090	8298 9204 10280 11370 12400 12010 8-2"	8438 9552 10450 11850 13030 13830 8: 3"	8570 9713 10880 12070 13280 14120 8 ⁻ 4"	8695 9866 11060 12290 13530 14630 8:- 5"	8814 10010 11240 12490 13770 15130 8-6 "	8926 10150 11420 12690 13990 15650 8:- 7 "	9032 10280 11560 12880 14210 16150 8:- 9"	9132 10400 11710 13060 14420 16640 8'-10"	9227 10520 11860 13230 14620 17170 8-11"	9317 10640 11200 13390 14820 17680 9'- 0"	9402 10740 12130 13550 15000 17990 18180 9-1"	9483 10850 12250 13700 15180 18220 18670 9- 2 "	
PIPE	HIOLUS 10-0" 8-0" 8-0" WIDTH	2258 5 3"	2771 2880 5'- 8"	3143 3450 5'-11"	3494 3883 3963 6- 1"	3824 4259 4474 6 3 "	4135 4615 4983 6- 4"	4428 4951 5492 6'- 6''	4704 5270 5841 6003 6'- 8"	4964 5572 6185 6512	5209 5858 6513 7019 6-11"	5439 6128 6824 7526 7'- 0"	5656 6384 7120 7864 8034 7'- 1"	5861 6626 7401 8186 8542 7'- 3 "	6053 6855 766 9 8492 9045 7 '- 4 "	6234 7072 7923 8785 9559 7'- 5 "	6405 7277 8164 9064 10060 7: 6 "	6566 7472 8394 9331 10280 10580	6717 7656 8612 9585 10570 11 070 7'- 9"	6860 /830 8820 9827 10850 11580 6850 6850 6850 6850 6850 6850 6850 6	5994 7994 9017 10060 11120 12090 3-0	72240 8238 9382 10480 11570 12480 12010 8: 2"	7259 8438 0559 10600 11850 13030 13630 8'- 3"	7458 8570 9713 10880 12070 13280 14120 8 - 4 "	7557 8695 9866 11060 12290 13530 14630 8'- 5"	7651 8814 10010 11240 12490 13770 15130 8-6"	7739 8926 10150 11420 12690 13990 15650 8- 7 "	7822 9032 10280 11560 12880 14210 16150 8-9 "	7901 9132 10400 11710 13060 14420 16640 8:-10"	7974 9227 10520 11860 13230 14620 17170 8-11 "	8044 9317 10640 11200 13390 14820 17680 9'- 0"	8109 9402 10740 12130 13550 15000 17990 18180 9'- 1 "	8171 9483 10850 12250 13700 15180 18220 18670 9'- 2"	
OF PIPE	S-0" 5-6" 6-0" 6-6" 7-0" 7-6" 8-0" 9-0" 10-0 WIDTH	2129 2258 5: 3"	2477 2771 2880 5'- 8"	2802 3143 3450 5-11"	3107 3494 3883 3963 6- 1"	3393 3824 4259 4474 6'- 3"	3660 4135 4615 4983 6'- 4 "	3910 4428 4951 5492 6- 6"	4144 4704 5270 5841 6003	4363 4964 5572 6185 6512	4568 5209 5858 6513 7019 65-11"	4760 5439 6128 6824 7526 7'- 0"	4940 5656 6384 7120 7864 8034 7'- 1"	5108 5861 6626 7401 8186 8542	5266 6053 6855 7669 8492 9045 7'- 4 "	5413 6234 7072 7923 8785 9559 7'- 5 "	5552 6405 7277 8164 9064 10060 7- 6 "	5681 6566 7472 8394 9331 10280 10580 7 · 8	5802 6717 7656 8612 9585 10570 11070 7-9"	5915 6860 7830 8820 9827 10850 1086 1086 1086 1086 1086 1086 1086 108	6021 6994 7994 9017 10060 11120 1 2090	6120 7121 8130 9204 10280 11370 12480 12010 8- 2"	6200 7250 8438 0550 10600 11850 13630 8: 3"	6382 7458 8570 9713 10880 12070 13280 14120 8 °- 4 "	6458 7557 8695 9866 11060 12290 13530 14630 8'- 5 "	6529 7651 8814 10010 11240 12490 13770 15130 8-6 "	6596 7739 8926 10150 11420 12690 13990 15650 8'- 7 "	6659 7822 9032 10280 11560 12880 14210 16150 8'- 9 "	6717 7901 9132 10400 11710 13060 14420 16640 8-10 "	6772 7974 9227 10520 11860 13230 14620 17170 8-11 "	6823 8044 9317 10640 11200 13390 14820 17680 9'- 0"	6871 8109 9402 10740 12130 13550 15000 17990 18180 9'- 1 "	6916 8171 9483 10850 12250 13700 15180 18220 18670 9-2 "	
OF PIPE	5-6" 6-0" 6-6" 7-0" 7-6" 8-0" 9-0" 10-0" WIDTH	2129 2258 5: 3"	2477 2771 2880 5'- 8"	2802 3143 3450 5-11"	3107 3494 3883 3963 6- 1"	3393 3824 4259 4474 6'- 3"	4135 4615 4983 6- 4"	3910 4428 4951 5492 6- 6"	4704 5270 5841 6003 6'- 8"	4363 4964 5572 6185 6512	4568 5209 5858 6513 7019 6-11"	4760 5439 6128 6824 7526 7'- 0"	4940 5656 6384 7120 7864 8034 7'- 1"	5108 5861 6626 7401 8186 8542	5266 6053 6855 7669 8492 9045 7'- 4 "	6234 7072 7923 8785 9559 7'- 5 "	5552 6405 7277 8164 9064 10060 7- 6 "	5681 6566 7472 8394 9331 10280 10580 7 · 8	5802 6717 7656 8612 9585 10570 11070 7-9"	5915 6860 7830 8820 9827 10850 1086 1086 1086 1086 1086 1086 1086 108	5994 7994 9017 10060 11120 12090 3-0	6120 7121 8130 9204 10280 11370 12480 12010 8- 2"	7259 8438 0559 10600 11850 13030 13630 8'- 3"	6382 7458 8570 9713 10880 12070 13280 14120 8 °- 4 "	6458 7557 8695 9866 11060 12290 13530 14630 8'- 5 "	6529 7651 8814 10010 11240 12490 13770 15130 8-6 "	6596 7739 8926 10150 11420 12690 13990 15650 8'- 7 "	7822 9032 10280 11560 12880 14210 16150 8-9 "	7901 9132 10400 11710 13060 14420 16640 8:-10"	6772 7974 9227 10520 11860 13230 14620 17170 8-11 "	8044 9317 10640 11200 13390 14820 17680 9'- 0"	6871 8109 9402 10740 12130 13550 15000 17990 18180 9'- 1 "	6916 8171 9483 10850 12250 13700 15180 18220 18670 9-2 "	2 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6

Interpolate for intermediate heights of backfill and/or trench widths

Table B-11 Continued

SATURATED CLAY Kµ'-0.110

- NAN-			TREN	TRENCH WIDTH	/IDTH	ΑŢ	TOP OF	: PIPE			TRAN-	
DTH	46"	5'-0"	5'-6"	0-,9	99	02	92	0-,8	06	100"	WIDTH	
<u></u>	1996	2244	2258								2'- 0"	2
<u>.</u>	2340	2636	2880								5'- 5"	9
.6	2667	3012	3357	3450							5'- 8"	_
:11.	2979	3371	3765	3963							5'- 9"	80
. 0.	3276	3715	4156	4474							5'-10"	
<u>-</u>	3559	4045	4533	4983							.09	P 유
რ	3828	4360	4894	5431	5492						6'- 1"	-
. 4	4085	4661	5241	5824	6003						6'- 2"	
. 2.	4329	4950	5225	6204	6512						6'- 3"	
 •	4562	5226	5895	6570	7019						6'- 4"	Z Z DF
	4783	5490	6203	6922	7526						6'- 5''	
 .6	4994	5743	6499	7262	8034						99	
-10.	5195	2882	6784	7590	8402	8542					9	
-11:	5386	6216	7057	2006	8761	9045					89	
- o.	5568	6438	7319	8210	9109	9559					.69	
<u> </u>	5742	6650	7571	8504	9445	10060					6'-10"	20
. 2	2002	6853	7813	8787	9770	10580					6'- '1"	
٠ ئ	6064	7047	8046	9059	10080	11070					7 0"	55 A
.4	6214	7233	8270	9322	10390	11460	11580				7 1"	
. 5.	6357	7410	8485	92:56	10680	11800	12090					
 	6493	7581	8691	9820	10960	12120	12610				7 2	
- 7	6622	7743		10060	11240	12440	13110					
	6745	7899		10280	11500	12740	13630					OF ☆
6	6863	8048		10500	11760	13030	14120					
 .o.	6974	8191	9439	10710	12010	13320	14630					೧೯ ೪
_ 	7081	8328	$\overline{}$	_	12250	13600	14960	15130			1 1	
0	7182	8458			12480		15270	15650				E :
<u> </u>	7278	8583	9656	11300	12700		15570	16150				
. 2	7370	8703	10080	11480	12920			16640			7 9"	
	7458	8817	10220	11660	13130			17170			7:-10"	
.4	7541	8927	10360	11830	13330	14860	16410	17680			7:-11	ET %
. 2	7620	9032		11990	13530	15090	16670	18180				
. 2	9692	9132		12150	13720		16930	18670			 8.	37
9	1768	9228	10740		13900		17180	18860	19200			88
	7836		10860		14070			19140	19730			39
0	7.805	8408	109/0	12590	14240	15940	1/660	19410	20240		8-3"	⊋

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. ▲Transition loads (bold type) and widths based on Kµ—0.19, r_{sd}p—0.5 in the embankment equation 10,-0, .0-.6 16720 17680 16980 | **18180** 15840 | 17460 | 8.-0 14740 16190 10950 | 12180 | 13440 | 14120 13720 14630 TRENCH WIDTH AT TOP OF PIPE .9-.2 11670 12850 10520 11070 10820 11580 10030 11120 12090 11400 12610 7.0 ..9-.9 2.-6 94 10 60.35 5.0 5. 84.14 5 190 HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET

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ORDINARY CLAY Ku'-0.130

Table B-12

							Н	ΕI	G	ΗТ	. ()F	В	Α	CK	FI	LL	. Ի	A	В	ΟV	Έ	TC	P	0	F	ΡI	PE	:,	FE	ΞE	Т			
-	7	- T	_	9		ω .	o ;	2 ;	= ;	7 0	2 7	+ +	2 4	1	- 2	- 6	20	2	22			2 6		58	29	30	31	32	33	34	35	36			39
TRAN	SITION		5. 6.	5-11		9 2	ָה		6-10 6-11	7	7. 2.	7. 3.	7. 5.	7. 6.	7- 7"	7:- 8"	7'-10"	7:-11"	8		, , ,	ģ	.98	8'- 7"	8'- 8"	8.9	810.	8'-11"	9,-0	9 1"	9'- 2"	9'- 3"	9 5.		9-6
	-	100											T																	18620	19190	750	300	20840	370
	- 1	90 10						\dagger					+					-				-		15350	15890	16450	16990	17520	18080	183 10 18	18590 19	18870 19750	19130 20300	19390 20	19640 21370
PE		1						+					+							080	0 0	5 8	06	20 15:											00 196
OF P		9-8				<u></u>							+		17	20	30	20			60 13120	90 14240	80 14790							·				10 177	30 18000
TOP	0.0	Q 8						+		- 0	6	9	E		23 9817	10370	20 10930	0 11470	70 12030		70 12660			13870										50 16210	14810 16390
HAT	i	9-)					o +	- 6	v «	6 7060			5 8717	0 9261	1 9623	8 9981	1 10320				0/511 0/0		0 12380							0 13940	0 14130	0 14310	0 14480	0 14650	0 1481
TRENCH WIDTH AT TOP OF PIPE	1	O-				7876		-			_		3 8105	7 8450	7 8781	3 9098	3 9401	<u> </u>			1 10490		11200	0 11410	11620										11760 13260 14810 16390 18000 1860
NOT	10	٥		3730		4289		-					7,353		7947	8223					96431		10030					·							
TRE	1 0	ρ 9		3038		3930		-	5414	5735	6040	6331	8099	6871	7121	7359					8385	8729	8888	9040	9185	9322	9453				-				10290
		9-0	2394	2814	3500	3011	4239	4549	4843	5121	5384	5634	5870	6094	6305	6506	9699	9289	7046		7504	7641	7771	7893	8010	8120	8224	8323	8416	8505	8588	8998	8743	8814	8881
			6	9	76	77	3759	4026	4277	4513	4735	4945	5142	5328	5503	2668	5823	5969	6107	6236	6473	6582	6684	6780	6870	6955	7036	7111	7182	7249	7312	7372	7428	7480	7530
		م ا	2159	2519	2176	3477	37	8	5 4	45	47	49	5	53	55	56	58	56	9	9	<u>ي</u> 0	10	9	9	9	9	7	7	,	7	~	7	7	7	2
		2 2	215	702	2 6	2 6	37	9 6	42	45	47	49	51	53	55	99	58	56	9	- G	<u>ئ</u> ه][0	9	9	9	9	_	7	_		~	7	7	_	7 7
TRAN-		1	5'- 7" 2159		- i				- ;-	7. 3" 45	7:- 4" 47		7. 7" 51			<u> </u>	8 0.	-		4 11	n '9				-	.06	91	_	_	.:.					
ATRAN-	NOILION	HIGIM			: :				- ;-	7 3" 45			J			<u> </u>	 o	-		4 11	n '9			0	-	.06	6	9- 2	9 - 4	9. 5.	96	9 7	8 6	6.	9-10
ATRAN-	SITION 10.01	HIQIM 0-01			: :				- ;-	7 3" 45			J			<u> </u>	 o	-		4 11	n '9	8 - 8	68	810		.0 -6	16990 9-1	17520 9'- 2"	18080 9 4	18620 9. 5"	96	9 7	20300 9 8	6.	9-10
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OF PIPE	SITION IS	HLQIM 0-01 0-6 0-8 0-7 0-7 0-0	27	3730		4695. 4846	5097 5401	5478 5952	5841 6415 6508	6185 6803 7060 7'- 3"	6513 7174 7609 7:- 4"	6824 7527 8160 7:- 5"	7120 7864 8614 8717 7 7"	7401 8186 8977 9261	7669 8492 9324 9817 7- 9 "	7923 8785 9657 10370 7:-11"	8164 9064 9975 10930 8 - 0 "	8394 9331 10280 11240 11470 8 · 1"	8612 9585 105/0 115/0 12030 8:- 3"	0027 10821 10830 12380	9204 10280 111370 12480 13670 8 °. 6 °.	9382 10490 11620 12760 13920 14240 8- 8"	9552 10690 11850 13030 14220 14790 8- 9 "	9713 10880 12070 13280 14510 15350 8-10 "	9866 11060 12290 13530 14790 15890 8:11"	10010 11240 12490 13770 15060 16450 9- 0"	10150 11400 12690 13990 15320 16670 16990 9- 1"	10280 11560 12880 14210 15570 16950 17520 9- 2 "	10400 117 10 13000 14420 15810 17230 18080 9 - 4	10520 11860 13230 14620 16040 17490 18620 9 - 5"	10640 12000 13390 14820 16270 17740 19190 9'- 6"	10740 12130 13550 15000 16480 17990 19750 9- 7"	10850 12250 13700 15180 16690 18220 20300 9'- 8 "	10940 12370 13840 15350 16890 18450 20840 9-9 "	11120 12600 14110 15670 17260 18880 21370 9:10
PIPE	SITION IS	H10M 0-01 0-8 0-9 0-8 0-7 0-7 0-9 0-9	2394	3038	3883 4289	4259 4695 4846 6: 8:	4615 5097 5401	4951 5478 5952	5270 5841 6415 6508	5572 6185 6803 7060 7-3"	5858 6513 7174 7609 7 '- 4 "	6128 6824 7527 8160 7'- 5"	6384 7120 7864 8614 8717 7. 7"	6626 7401 8186 8977 9261	6855 7669 8492 9324 9817 7'- 9 ''	7072 7923 8785 9657 10370 7:11"	7277 8164 9064 9975 10930 8'- 0 "	7472 8394 9331 10280 11240 11470 8: 1"	7656 8612 9585 10570 11570 1 2030 8- 3:	7000 0000 0000 11000 100	8150 9204 10280 11370 12480 13670 8: 6"	8298 9382 10490 11620 12760 13920 14240 8-8"	8438 9552 10690 11850 13030 14220 14790 8-9"	8570 9713 10880 12070 13280 14510 15350 8:10"	8695 9866 11060 12290 13530 14790 15890 8:11"	8814 10010 11240 12490 13770 15060 1 6450 9· 0"	8926 10150 11400 12690 13990 15320 16670 16990 9-1"	9032 10280 11560 12880 14210 15570 16950 17520 9'- 2"	9132 10400 11710 13060 14420 15810 17230 18080 9-4	9227 10520 11860 13230 14620 16040 17490 18620 9-5 "	9317 10640 12000 13390 14820 16270 17740 19190 9'- 6"	9402 10740 12130 13550 15000 16480 17990 19750 9-7"	9483 10850 12250 13700 15180 16690 18220 20300 9'- 8 "	9559 10940 12370 13840 15350 16890 18450 20840 9: 9"	963 11040 12490 13980 13510 17080 18670 21370 9-10 9700 11120 12600 14110 15670 17260 18880 21940 9-11
OF PIPE	SITION IS	H10M 0-01 0-6 0-8 0-8 0-7 0-7 0-9 0-9	2394	3143 3485 3730	3404 3883 4280	3824 4259 4695 4846 6: 8"	4135 4615 5097 5401	4951 5478 5952	4704 5270 5841 6415 6508	4964 5572 6185 6803 7060	5209 5858 6513 7174 7609	5439 6128 6824 7527 8160 7:- 5"	5656 6384 7120 7864 8614 8717	5861 6626 7401 8186 8977 9261 7-8"	6053 6855 7669 8492 9324 9817 7'- 9 "	6234 7072 7923 8785 9657 10370 7:11"	6405 7277 8164 9064 9975 10930 8 · 0 "	6566 7472 8394 9331 10280 11240 11470 8 · 1"	6717 7656 8612 9585 10570 11570 12030 8:- 3::	6004 7004 0017 1060 11130 12130 6: E:	7121 8150 9204 10280 11370 12480 13670 8°- 6"	7240 8298 9382 10490 11620 12760 13920 14240 8-8"	7352 8438 9552 10690 11850 13030 14220 14790 8- 9 "	7458 8570 9713 10880 12070 13280 14510 15350 8-10 "	7557 8695 9866 11060 12290 13530 14790 15890 8:11"	7651 8814 10010 11240 12490 13770 15060 16450 9· 0"	7.39 8926 10150 11400 12690 13990 15320 16670 16990 9- 1"	10280 11560 12880 14210 15570 16950 17520 9- 2 "	300 9 132 10400 11/10 13000 14420 13810 1/230 18080 9 4	7974 9227 10520 11860 13230 14620 16040 17490 18620 9 - 5 "	8044 9317 10640 12000 13390 14820 16270 17740 19190 9 °- 6 "	8109 9402 10740 12130 13550 15000 16480 17990 19750 9-7"	8171 9483 10850 12250 13700 15180 16690 18220 20300 9-8"	8229 9559 10940 12370 13840 15350 16890 18450 20840 9· 9 ··	8283 9631 11040 12490 13980 13510 117080 18670 21370 9:10
OF PIPE	SITION S.8 .0.0 .0.8 .8 .0.0 .0.8 .8 .0.0 .0.9	H1GIM 0-01 0-6 0-9 0-8 0-7 0-7 0-9 0-0 0-0	2394	3143 3485 3730	3404 3883 4280	3824 4259 4695 4846	4135 4615 5097 5401	4428 4951 5478 5952	4704 5270 5841 6415 6508	5572 6185 6803 7060 7-3"	5858 6513 7174 7609 7 '- 4 "	6128 6824 7527 8160 7'- 5"	6384 7120 7864 8614 8717 7. 7"	5861 6626 7401 8186 8977 9261 7-8"	6053 6855 7669 8492 9324 9817 7· 9 "	6234 7072 7923 8785 9657 10370 7:11"	6405 7277 8164 9064 9975 10930 8 · 0 "	6566 7472 8394 9331 10280 11240 11470 8 · 1"	7656 8612 9585 10570 11570 1 2030 8- 3:	6004 7004 0017 1060 11130 12130 6: E:	7121 8150 9204 10280 11370 12480 13670 8°- 6"	7240 8298 9382 10490 11620 12760 13920 14240 8-8"	7352 8438 9552 10690 11850 13030 14220 14790 8- 9 "	7458 8570 9713 10880 12070 13280 14510 15350 8-10 "	7557 8695 9866 11060 12290 13530 14790 15890 8:11"	8814 10010 11240 12490 13770 15060 1 6450 9· 0"	7.39 8926 10150 11400 12690 13990 15320 16670 16990 9- 1"	9032 10280 11560 12880 14210 15570 16950 17520 9'- 2"	300 9 132 10400 11/10 13000 14420 13810 1/230 18080 9 4	7974 9227 10520 11860 13230 14620 16040 17490 18620 9-5 "	8044 9317 10640 12000 13390 14820 16270 17740 19190 9°- 6°''	8109 9402 10740 12130 13550 15000 16480 17990 19750 9-7"	8171 9483 10850 12250 13700 15180 16690 18220 20300 9-8"	8229 9559 10940 12370 13840 15350 16890 18450 20840 9· 9 ··	963 11040 12490 13980 13510 17080 18670 21370 9-10 9700 11120 12600 14110 15670 17260 18880 21940 9-11
OF PIPE	NOILS "0.01" "0.0" "9.8" "0.8"	H10IM 0-01 0-6 0-8 0-8 0-7 0-7 0-0 0-0 0-6 0-6	2129 2375 2394	3143 3485 3730	3107 3404 3883 4280	3824 4259 4695 4846	3660 4135 4615 5097 540 1	3910 4428 4951 5478 5952	12 4144 4704 5270 5841 6415 6508	4363 4964 5572 6185 6803 7060	14 4568 5209 5858 6513 7174 7609 7. 4"	15 4760 5439 6128 6824 7527 8160 77. 5"	5656 6384 7120 7864 8614 8717	17 5108 5861 6626 7401 8186 8977 9261 7. 8 "	5266 6053 6855 7669 8492 9324 9817 7'- 9 "	19 5413 6234 7072 7923 8785 9657 10370 7:11"	20 5552 6405 7277 8164 9064 9975 10930 8 · 0"	21 5681 6566 7472 8394 9331 10280 11240 11470 8: 1"	22 5802 6/1/ /656 8612 9585 105/0 11570 12030 8- 3:	23 3813 6660 7630 6620 8627 10630 11330 13330 65 4	25 6120 7121 8150 9204 10280 11370 12480 13670 8: 6 "	6213 7240 8298 9382 10490 11620 12760 13920 14240 8-8"	27 6300 7352 8438 9552 10690 11850 13030 14220 14790 8 - 9 "	28 6382 7458 8570 9713 10880 12070 13280 14510 15350 8:10 "	29 6458 7557 8695 9866 11060 12290 13530 14790 15890 8:11 "	30 6529 7651 8814 10010 11240 12490 13770 15060 16450 9· 0"	31 0590 7/39 8926 10150 11400 12690 13990 15320 16670 16990 9- 1-	32 6539 7822 9032 10280 11560 12880 14210 15570 16950 1 7520 9- 2 "	33 07 17 7901 9152 10400 17 10 13060 14420 15810 17230 18080 9-4	34 6772 7974 9227 10520 11860 13230 14620 16040 17490 18620 9 · 5 "	35 6823 8044 9317 10640 12000 13390 14820 16270 17740 19190 9 · 6"	36 6871 8109 9402 10740 12130 13550 15000 16480 17990 19750 9 -7"	6916 8171 9483 10850 12250 13700 15180 16690 18220 20300 9-8 "	8229 9559 10940 12370 13840 15350 16890 18450 20840 9· 9 ··	8283 9631 11040 12490 13980 13510 117080 18670 21370 9:10

Table B-12 Continued

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0.130	PE 1	8'-6" 9'-0" 10'-0'				9	.9	9	.9	9-		7	7	-,2	7'-		- 7	.7 0930 7:	1470 7					14240	14/90	15350	15890	16000	06601	17860 18080 81	17070 18620 8:	18260 19190	18550 19750	18830 20300	19100 20840	19360 21060 21370	19610 21340 21940	pase loads 10%; for 120 pounds pro.19, r _{Sdp} —0.5 in the embankme trench wirths
Кµ′—0.130	PE 1	8:-0" 8'-6" 9:-0" 10:-0"				9	.;9	9	.9	9		7-7	3160 7'-	3717	3261 7'-	9817 7		3820 10930 7 :	1190 11470 7'-	12030	12580	13120	136/0	14040 14240	14380 14/90	14710 15350	15890	16000	06601 05001	159 10 17350 17520 8:-	16460 17970 18620 8:-	16720 18260 19190	18550 19750	18830 20300	19100 20840	17680 19360 21060 21370	17910 19610 21340 21940	nt, increase loads 10%; for 120 pounds part Kμ-0.19, r _{Sd} p-0.5 in the embankme and tor trench wirths
2LAY Kµ'-0.130	PE 1	7'-6" 8'-0" 8'-6" 9'-0" 10'-0"				9						-,2 609	050 8160 7'-	J	823 9261 7'-		10370	10820	11190	11540 12030	11890 12580	12220 13120	12540 136/0	12030 14040 14240	13150 14380 14/90	13440 14710 15350	13720 15020 15890	1399U 1533U 16450	14250 15630 16990	14240 15910 17350 17520 8:-	14980 16460 17970 18620 81	15200 16720 18260 19190	15420 16980 18550 19750	18830 20300	19100 20840	16040 17680 19360 21060 21370	16230 17910 19610 21340 21940	ibic foot, increase loads 10%; for 120 pounds pased on Kµ—0.19, r _{Sd} p—0.5 in the embankme acktill and/or trench widths
4RY CLAY Kµ'-0.130	PE 1	7'-0" 7'-6" 8'-0" 8'-6" 9'-0" 10'-0"		, S				5401	5952	6508	9 0901	-, 1 609 1	8050	8443	8823	9188	9540 10370	9880 10820	10210 11190	10520 11540 12030	10820 11890 12580	11100 1250 13150	11670 12540 136/0	11070 12030 14040 14240	13150 14380 14/90	13440 14710 15350	13720 15020 15890	12000 13990 15330 16450	12890 14200 13630 16990	13310 14200 13910 1/350 1/320 8-	13520 14980 16460 17970 18620 87.	13710 15200 16720 18260 19190	13900 15420 16980 18550 19750	14080 15640 17220 18830 20300	14250 15840 17460 19100 20840	14420 16040 17680 19360 21060 21370	16230 17910 19610 21340 21940	per cubic foot, increase loads 10%; for 120 pounds pridths based on $K\mu$ –0.19, $r_{Sd}p$ –0.5 in the embankme that of backfill and for trench widths
3DINARY CLAY Kµ'—0.130	PE 1	6-6" 7'-0" 7'-6" 8'-0" 8'-6" 9'-0" 10'-0"	-:6	5'-	3730	4289	4846	5357 5401	5784 5952	6194 6508	.9 2000 2000 2000 2000	2969	7331 8050	7681 8443	8017 8823	8340 9188	8650 9540 10370	8948 9880 10820	9234 10210 11190	9509 10520 11540 12030	9774 10820 11890 12580	10030 11120 12220 13120	102/0 1400 2540 136/0	10210 11670 12630 44040 14240	10730 11930 13150 14380 14790	10950 12180 13440 14710 15350	1100 12430 13720 15020 15890	11350 12550 13880 13330 16450	11330 12890 14230 13630 16990	11/30 13/00 14300 13910 1/350 1 /520 8-	12080 13520 14980 16460 17920 18620 8°	12240 13710 15200 16720 18260 19190	12400 13900 15420 16980 18550 19750	12550 14080 15640 17220 18830 20300	12700 14250 15840 17460 19100 20840	12840 14420 16040 17680 19360 21060 21370	12970 14580 16230 17910 19610 21340 21940	counds per cubic foot, increase loads 10%; for 120 pounds p and widths based on $K\mu$ -0.19, $r_{Sd}p$ -0.5 in the embankme sheinths of backfill and/or trench widths
ORDINARY CLAY Kµ'-0.130		60" 66" 7'-0" 7'-6" 8'-0" 8'-6" 9'-0" 10'-0"	-: 9	3038	3622 3730	4056 4289	44/1 4846	2 4869 5357 540 1	5249 5784 5952	5614 6194 6508	5963 6589 7060	6297 6967	6617 7331 8050	6924 7681 8443	7217 8017 8823	7498 8340 9188	7768 8650 9540 10370	8025 8948 9880 10820	8272 9234 10210 11190	8509 9509 10520 11540 12030	8735 9774 10820 11890 12580	0352 10030 11120 12220 13120	9139 10270 11400 12340 13670	95.00 103.10 1167.0 1265.0 140.40 14 2.40	9348 10/30 11930 13150 14380 14/90	9/31 10950 12180 13440 14/10 15350	9909 11100 12430 13720 15020 15890	10070 11380 12890 13890 15330 16450	10230 11330 12830 14230 13830 18830	10500 11750 15100 14500 15910 17550 17520 8-	10670 12080 13520 14980 16460 17970 18620 8°	10810 12240 13710 15200 16720 18260 19190	10940 12400 13900 15420 16980 18550 19750	11060 12550 14080 15640 17220 18830 20300	11180 12700 14250 15840 17460 19100 20840	11290 12840 14420 16040 17680 19360 21060 21370	11400 12970 14580 16230 17910 19610 21340 21940	g 110 pounds per cubic foot, increase loads 10%; for 120 pounds protipol and widths based on $K\mu$ -0.19, r_{SQP} -0.5 in the embankme neglaps beinths of backfill and/or trench widths
ORDINARY CLAY Kµ'-0.130	PE 1	5-6" 6'-0" 6'-6" 7'-0" 7'-6" 8'-0" 8'-6" 9'-0" 10'-0	2394	2873 3038	3277 3622 3730 6:-	3663 4056 4289	4031 4471 4846	4382 4869 5357 540 1	4717 5249 5784 5952	5036 5614 6194 6508	5341 5963 6589 7060 6. :	5632 6297 6967	5909 6617 7331 8050	6173 6924 7681 8443	6425 7217 8017 8823	6666 7498 8340 9188	6895 7768 8650 9540 10370	7114 8025 8948 9880 10820	7323 8272 9234 10210 11190	7522 8509 9509 10520 11540 12030	7712 8735 9774 10820 11890 12580	0000 0000 10000 11100 1220 13100	6000 9139 102/0 11400 12340 136/0	0220 9300 10310 11070 12030 14040 14640	8387 9348 10/30 11930 13150 14380 14/90	833/ 9/31 10930 12180 13440 14/10 15350	0000 9900 11100 12430 13720 15020 15890	8017 10070 11360 12090 13890 15330 16450	0847 10250 11350 12890 14250 15630 16990	90/1 10360 11/30 13/00 14300 13810 1/350 1/520 8:-	9302 10670 12080 13520 14980 16460 17920 18620 8°	9410 10810 12240 13710 15200 16720 18260 19190	9513 10940 12400 13900 15420 16980 18550 19750	9610 11060 12550 14080 15640 17220 18830 20300	9704 11180 12700 14250 15840 17460 19100 20840	9793 11290 12840 14420 16040 17680 19360 21060 21370	9878 11400 12970 14580 16230 17910 19610 21340 21940	reighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds prids (bold type) and widths based on Kµ—0.19, r _{Sd} p—0.5 in the embankment intermediate heights of backfill and/or trench widths
ORDINARY CLAY Kµ'—0.130	PE 1	60" 66" 7'-0" 7'-6" 8'-0" 8'-6" 9'-0" 10'-0"	2201 2394 5:-	2577 2873 3038 5'-	2933 3277 3622 3730	32/2 3663 4056 4289	3593 4031 4471 4846	3898 4382 4869 5357 540 1	4188 4717 5249 5784 5952	4463 5036 5614 6194 6508	4724 5341 5963 6589 7060 6:-	4972 5632 6297 6967	5207 5909 6617 7331 8050	5430 6173 6924 7681 8443	5643 6425 7217 8017 8823	5844 6666 7498 8340 9188	6035 6895 7768 8650 9540 10370	6216 7114 8025 8948 9880 10820	6388 7323 8272 9234 10210 11190	6552 7522 8509 9509 10520 11540 12030	6707 7712 8735 9774 10820 11890 12580	0000 1000 1000 11100 12220 13100 1000 10	7107 8000 8108 102/0 11400 12340 136/0	7059 0007 0540 10010 11010 12000 14040 14640	7272 0507 0704 10050 11930 13150 14380 14790	7406 0600 0006 11160 12180 13440 14710 15350	7604 0000 9900 11100 12430 13720 15020 15890	7807 8047 10300 11500 13000 13990 13330 16430	7204 0024 10230 11330 12890 14230 13830 13830 2204 2204 0024 10230 14230	7886 9189 10530 11530 13430 14540 15310 17520 17520 8-	7974 9302 10670 12080 13520 14980 16460 17970 18620 8:	8057 9410 10810 12240 13710 15200 16720 18260 19190	8136 9513 10940 12400 13900 15420 16980 18550 19750	8211 9610 11060 12550 14080 15640 17220 18830 20300	8282 9704 11180 12700 14250 15840 17460 19100 20840	8350 9793 11290 12840 14420 16040 17680 19360 21060 21370	8414 9878 11400 12970 14580 16230 17910 19610 21340 21940	ckfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds p tion loads (bold type) and widths based on Kµ-0.19, r _{Sd} p-0.5 in the embankme state for infermediate beinhts of backfill and for trench wirths
C ORDINARY CLAY Kµ'-0.130	PE 1	5-6" 6'-0" 6'-6" 7'-0" 7'-6" 8'-0" 8'-6" 9'-0" 10'-0	2201 2394 5:-	2873 3038	2933 3277 3622 3730	32/2 3663 4056 4289	9 3593 4031 4471 4846	3898 4382 4869 5357 540 1	11 4188 4717 5249 5784 5952	12 4463 5036 5614 6194 6508	13 4724 5341 5963 6589 7060 6:-	14 4972 5632 6297 6967	15 5207 5909 6617 7331 8050	16 5430 6173 6924 7681 8443	17 5643 6425 7217 8017 8823	18 5844 6666 7498 8340 9188	19 6035 6895 7768 8650 9540 10370	20 6216 7114 8025 8948 9880 10820	21 6388 7323 8272 9234 10210 11190	22 6552 7522 8509 9509 10520 11540 12030	23 6707 7712 8735 9774 10820 11890 12580	24 0033 1083 0832 10030 11120 12220 13100 10230 2320 232	25 0334 0000 3139 102/0 11400 12540 136/0	20 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	27 7220 6527 6234 10050 11930 13150 14380 14790	28 /3/3 633/ 9/31 10930 12180 13440 14/10 15350	29 7400 0000 9900 11100 12430 13720 15020 15890	30 7394 6617 10070 11360 12960 13990 13330 16450	31 7037 0034 10230 11330 12690 14230 13030 16990	90/1 10360 11/30 13/00 14300 13810 1/350 1/520 8:-	34 7974 9302 10670 12080 13520 14080 16460 17020 18620 8:	35 8057 9410 10810 12240 13710 15200 16720 18260 19190	36 8136 9513 10940 12400 13900 15420 16980 18550 19750	8211 9610 11060 12550 14080 15640 17220 18830 20300	9704 11180 12700 14250 15840 17460 19100 20840	8350 9793 11290 12840 14420 16040 17680 19360 21060 21370	8414 9878 11400 12970 14580 16230 17910 19610 21340 21940	* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. Arransition loads (bold type) and widths based on Kµ-0.19, r _{Sd} p-0.5 in the embankment equation intervalate for intermediate heights of backfill and/or trench widths

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Table B-13

					. &		HE	:10	iH	T	0	F			CK		LL	. +	1 /			VE		0		0		PI		Ξ,	FE	EE					
ATRAN-	WIDTH	9.	6'- 5"	610	7 3"	7 5	7- 7" 10	7:- 8"	7'-10" 12	7-11" 18	8 0	8- 2" 15	8'- 3" 16	8'- 5"	8'- 6"	8. 8. 19	8 9" 20	8'-10" 2	8'-11" 22	9'- 1" 23	9 2" 24	9 3" 25				9 8	9'- 9" 30	9'-10" 3	9'-11" 32	10'- 0" 33	10'- 1" 3	10'- 2" 35	10'- 3" 36		10. 5" 38	10'- 6" 39	10. 7" 40
	11.0																													•	21540	22190	22830	23500	24110	24760	
	001																										19000		20280	20920	21310	21670		22350	22670	22990	
F PIPE	96				·····																15190	15830							19130	19470	19800	20120	20430	20730	21020	21300	
OP O	.06															11980	12630	13270	13900		14870		-						17710	18010	18310	18590	18870	17560 19130	19390	19640	
I AT T	8,-6"			,								9434	10070	10710	11350	11770	12190	12610	13000		13760	14120									16830	17080	17320		17780	18000	18210
TRENCH WIDTH AT TOP OF	80.											9177	9625	10060	10470	10870	11260	11630			12660	12980				14140	14410		14910	15140	15370	15590	15800	11530 12990 14480 16010	16200	16390	18570
VCH V	9-,2				4932	5582	6181	L				8459	8863	9250	9623	9981	10320	10660								12870			13540	13740	13940	14130	14310	14480	14650	14810	11860 13390 14960 16570
TREI	1.02			4114	4740	5227	5693				1369	7745	8105	8450	8781	8606	9401	9695			10490	10740	_			11620	11820		12190		12530	12690	11410 12840	12990	11640 13130	13260	13300
	9-,9		3361	3888	4348	4787	5206	_				7035	7353	7657	7947	8223	8488	8740			9431						10560		10870	11010	11150	11280				11760	
	0-,9	2671	3110	3543	3956	4348	4721	2076	5414	5735	6040	6331	8099	6871	7121	7359	7585	7800	8005	8200	8385	8561	8729	8889	9040	9185	9322	9453	9577	9692	9807	9914	10020	10110	10200	10290	10380
ż	WIDTH	-	9	611	7: 4"	9		710"	7'-11"		8'- 2"	8'- 4"	 9	7		8'-10"	8:-11"	<u>:</u>	5		. 4			.		9'-11"			5	 	.4	5.	7	 	G		
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Ш	100														<u>.</u>		-	0,	9	0	0		0 16470	17090	0 17740	30 18380	7700 19000		0 19760	0 20100	0 20440	0 20760	0 21060	0 21360		0 21940	0/22210
F PIPE	96													0	0	0		_	_	-	_		_		-	_	-	-	-	•	0 18950	0 19240	17990 19520	0 1978	18450 20040	0 20290	0 20530
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	.9909	2622 2671	3066 3361	3485 38	3883 42	4259 46							6384 71	6626 74	6855 76	7072 79						- 1					8814 10010		9032 10280		9227 10520	9317 10640	9402 10740	9483 10850	9559 10940	9631 11040	9700 11130
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Table B-13 Continued

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SATURATED CLAY Kµ'0.110	TRENCH WIDTH AT TOP OF PIPE	8'-6"															11980	12630	13270	13900	14550	15190	15640	16080	16510	16930	17340	17730	18120	18500	18860	19220	19570	19910	20240	20560	20870	71180
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′ Kµ′—0.130	•	9-6" 10'-0" 11'-0"	5'-11"	6- 4		7.1.	7 3"	7 5	.9 - 12		.6 -,2	7:-10"	7:41	8'- 0'			· · · · · · · · · · · · · · · · · · ·	88.	13270	13900 8'-	14550	15190	15830 8'-1	16470 9'-	16870 17090 9'-	17280 17740 9'-	17670 18380 9'-	18060 19000 9 '-	18430 19670 9'-	18790 20280 9'-	19140 20640 20920	19490 21020 21540 9'-	19820 21390 22190 9'-	21750 22830	22100 23500	20760 22440 24110	21060 22770 24510 24760 10 -	21340 23100 24010 23400 10-
CLAY Kµ'0.130	•	8'-6" 9'-0" 9'-6" 10'-0" 11'-0"	5:11"	6. 4.		71	7 3"	7 5	.9 - ,	7- 7"	-,2			-88	10710 8'-	11350 8'-	11980 8'-	12630 8'-	13170 13270	13610 13900 8-	14040 14550	14450 15190	14850 15830 8'-1	16470 9'-	16870 17090 9'-	17280 17740 9'-	16340 17670 18380 9'-	16690 18060 19000 9-	17020 18430 19670 9 '-	17350 18790 20280 9'-	17660 19140 20640 20920	17970 19490 21020 21540 9-	18260 19820 21390 22190 9-	21750 22830	22100 23500	20760 22440 24110	19360 21060 22770 24510 24760 10 -	130 10 2 1340 23 100 24870 23400 10-
ARY CLAY Kµ'0.130	•	8'-0" 8'-6" 9'-0" 9'-6" 10'-0" 11'-0"	5'-11"	6-4			7.7	227 7 5"	-,2	362 7510 7- 7"	8150 7'-	8789	9434	10070	10450 10710 8:-	10900 11350 8-	11340 11980 8'-	11760 12630 8'-	12180 13170 13270	12570 13610 13900 8'-	12960 14040 14550	13330 14450 15190	13690 14850 15830 8:-1	14040 15240 1 6470 9'-	14380 15620 16870 17090 9'-	14710 15990 17280 17740 9'-	15020 16340 17670 18380 9'-	15330 16690 18060 19000 9 '-	15630 17020 18430 19670 9'-	15910 17350 18790 20280 9'-	16190 17660 19140 20640 20920	16460 17970 19490 21020 21540 9:-	16720 18260 19820 21390 22190 9-	16980 18550 20140 21750 22830	17220 18830 20460 22100 23500	17460 19100 20760 22440 24110	17680 19360 21060 22770 24510 24760 10 -	1/3/01/130/01/21/340/23/00/240/01/23400/10-
3DINARY CLAY Kµ'0.130	•	7'-6" 8'-0" 8'-6" 9'-0" 9'-6" 10'-0" 11'-0"	5'-11"	.96		4932	5582		-,2	7362	7848 8150 7	8318 8789	8772 9434	9210 10070 8'-	9633 10450 10710 8	10040 10900 11350 8'-	10440 11340 11980 8'-	10820 11760 12630 8'-	11190 12180 13170 13270	11540 12570 13610 13900 8'-	11890 12960 14040 14550	12220 13330 14450 15190	12540 13690 14850 15830 8:-1	12850 14040 15240 16470 9'-	13150 14380 15620 16870 17090 9'-	13440 14710 15990 17280 17740 9 -	13720 15020 16340 17670 18380 9'-	13990 15330 16690 18060 19000 9'-	14250 15630 17020 18430 19670 9'-	14500 15910 17350 18790 20280 9'-	14740 16190 17660 19140 20640 20920	14980 16460 17970 19490 21020 21540 9:-	16720 18260 19820 21390 22190 9-	16980 18550 20140 21750 22830	17220 18830 20460 22100 23500	17460 19100 20760 22440 24110	16040 17680 19360 21060 22770 24510 24760 10 -	10230 1/310 13010 21340 23100 24010 23400 10-
ORDINARY CLAY Kµ'0.130	•	70" 76" 80" 86" 90" 96" 100" 110"		.90	4114	4844 4932 7-	5355 5582 7	5847	6321 6869 7:-	6777 7362	7217 7848 8150 7'-	7641 8318 8789	8050 8772 9434	1 8443 9210 10070 8'-	8823 9633 10450 10710 8-	9188 10040 10900 11350 8'-	9540 10440 11340 11980 8'-	9880 10820 11760 12630	10210 11190 12180 13170 13270	10520 11540 12570 13610 13900 8'-	10820 11890 12960 14040 14550	11120 12220 13330 14450 15190	11400 12540 13690 14850 15830 8:-1	11670 12850 14040 15240 16470 9-	11930 13150 14380 15620 16870 17090 9'-	12180 13440 14710 15990 17280 17740 9 '-	12430 13720 15020 16340 17670 18380 9'-	12660 13990 15330 16690 18060 19000 9-	12890 14250 15630 17020 18430 19670 9'-	13 100 14500 15910 17350 18790 20280 9 -	13310 14740 16190 17660 19140 20640 20920	13520 14980 16460 17970 19490 21020 21540 9:-	13710 15200 16720 18260 19820 21390 22190 9:-	16980 18550 20140 21750 22830	14080 15640 17220 18830 20460 22100 23500	14250 15840 17460 19100 20760 22440 24110	14420 16040 17680 19360 21060 22770 24510 24760 10 -	14300 10230 17310 13010 21340 23100 24070 23400 10-
ORDINARY CLAY Kµ'0.130	TRENCH WIDTH AT TOP OF PIPE	6'-6" 7'-0" 7'-6" 8'-0" 8'-6" 9'-0" 9'-6" 10'-0" 11'-0"		3361	3908 4114	4450 4844 4932 7-	4912 5355 5582 7:	5357 5847	5784 6321 6869 7'-	6194 6777 7362	6589 7217 7848 8150 7'-	6967 7641 8318 8789	7331 8050 8772 9434	7681 8443 9210 10070 8'-	8017 8823 9633 10450 10710 8-	8340 9188 10040 10900 11350 8'-	8650 9540 10440 11340 11980 8 '-	8948 9880 10820 11760 12630 8'-	9234 10210 11190 12180 13170 13270	9509 10520 11540 12570 13610 13900 8'-	9774 10820 11890 12960 14040 14550	10030 11120 12220 13330 14450 15190	10270 11400 12540 13690 14850 15830 8:-1	10510 11670 12850 14040 15240 16470 9-	10730 11930 13150 14380 15620 16870 17090 9.	10950 12180 13440 14710 15990 17280 17740 9'-	11160 12430 13720 15020 16340 17670 18380 9'-	11360 12660 13990 15330 16690 18060 19000 99-	11550 12890 14250 15630 17020 18430 19670 9'-	11730 13100 14500 15910 17350 18790 20280 9'-	11910 13310 14740 16190 17660 19140 20640 20920	12080 13520 14980 16460 17970 19490 21020 21540 9 -	12240 13710 15200 16720 18260 19820 21390 22190 9 '-	12400 13900 15420 16980 18550 20140 21750 22830	14080 15640 17220 18830 20460 22100 23500	14250 15840 17460 19100 20760 22440 24110	12840 14420 16040 17680 19360 21060 22770 24510 24760 10 -	129/0 14300 10230 1/310 13010 21340 23100 240/0 23400 10-
ORDINARY CLAY Kµ'0.130	•	70" 76" 80" 86" 90" 96" 100" 110"		3361	3908 4114	4450 4844 4932 7	5355 5582 7	5357 5847	6321 6869 7:-	6777 7362	6589 7217 7848 8150 7'-	7641 8318 8789	8050 8772 9434	1 8443 9210 10070 8'-	8823 9633 10450 10710 8-	9188 10040 10900 11350 8'-	9540 10440 11340 11980 8'-	9880 10820 11760 12630	9234 10210 11190 12180 13170 13270	9509 10520 11540 12570 13610 13900 8'-	9774 10820 11890 12960 14040 14550	10030 11120 12220 13330 14450 15190	10270 11400 12540 13690 14850 15830 8:-1	10510 11670 12850 14040 15240 16470 9-	10730 11930 13150 14380 15620 16870 17090 9'-	10950 12180 13440 14710 15990 17280 17740 9'-	11160 12430 13720 15020 16340 17670 18380 9'-	11360 12660 13990 15330 16690 18060 19000 99-	11550 12890 14250 15630 17020 18430 19670 9'-	11730 13100 14500 15910 17350 18790 20280 9'-	11910 13310 14740 16190 17660 19140 20640 20920	13520 14980 16460 17970 19490 21020 21540 9:-	13710 15200 16720 18260 19820 21390 22190 9:-	16980 18550 20140 21750 22830	17220 18830 20460 22100 23500	17460 19100 20760 22440 24110	14420 16040 17680 19360 21060 22770 24510 24760 10 -	129/0 14300 10230 1/310 13010 21340 23100 240/0 23400 10-
C ORDINARY CLAY Kµ'0.130	•	6'-6" 7'-0" 7'-6" 8'-0" 8'-6" 9'-0" 9'-6" 10'-0" 11'-0"	2671	3361	3622 3968 4114	4056 4450 4844 4932	4471 4912 5355 5582 7:-	4869 5357 5847	5784 6321 6869 7'-	12 5614 6194 6777 7362	13 5963 6589 7217 7848 8150 7	14 6297 6967 7641 8318 8789	15 6617 7331 8050 8772 9434	6924 7681 8443 9210 10070 8-	17 7217 8017 8823 9633 10450 10710 8	18 7498 8340 9188 10040 10900 11350 8' -	19 7768 8650 9540 10440 11340 11980 8'-	20 8025 8948 9880 10820 11760 12630 8' -	21 8272 9234 10210 11190 12180 13170 13270	22 8509 9509 10520 11540 12570 13610 13900 8 -	23 8735 9774 10820 11890 12960 14040 14550	24 8952 10030 11120 12220 13330 14450 15190	25 9159 10270 11400 12540 13690 14850 15830 8 *-1	26 9358 10510 11670 12850 14040 15240 16470 9-	27 9548 10730 11930 13150 14380 15620 16870 17090 9-	28 9731 10950 12180 13440 14710 15990 17280 17740 9 '-	29 9905 11160 12430 13720 15020 16340 17670 18380 9'-	11360 12660 13990 15330 16690 18060 19000 99-	31 10230 11550 12890 14250 15630 17020 18430 19670 9 -	32 10380 11730 13100 14500 15910 17350 18790 20280 9'-	33 10530 11910 13310 14740 16190 17660 19140 20640 20920	34 10670 12080 13520 14980 16460 17970 19490 21020 21540 9 '-	35 10810 12240 13710 15200 16720 18260 19820 21390 22190 9 '-	36 10940 12400 13900 15420 16980 18550 20140 21750 22830	14080 15640 17220 18830 20460 22100 23500	11180 12700 14250 15840 17460 19100 20760 22440 24110	11290 12840 14420 16040 17680 19360 21060 22770 24510 24760 10 -	129/0 14300 10230 1/310 13010 21340 23100 240/0 23400 10-

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. A Transition loads (**bold type**) and widths based on Kμ-0.19, r_{SdP}-0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-14

			5	9	7	- 8	6		IG		T (4 Ol	- 1	BA ©		۲F و و			4 4		2 % OVI	 7 8	0	P C			PE	33	FE	35 H	T %	37	38	39
	ATRAN-	WIDTH	4.9	 	. ₄	 	. 5		. 9		6 .			, .		<u> </u>	 &		9'-10"			<u>ب</u>	4 :	- i	. . .	<u>.</u> 6	10'-10"	10'-11"		<u>-</u>	ب س	4 :	່ດ້ະ	- i-
-	T ▼	120	9		_	_	œ	8	8		× 0		7	ກໍ່ເ			6	6	6	6 5	<u> </u>	70,	<u>0</u>	- ¢	<u>5</u>	5	2	ᄋ	-	<u> </u>			2/410 11-	
		1.0.1																		7230	1960	18680	19400	202120	21590	2320	23020	23740					20770	
שלויטואורם וסג יסור ואן –טיוטס	: PIPE	1001					•••••										14330	15060	15770	16510		-		18940 2		20180 2				**+			20/922	23290 2
1	OP OF	.96											2000	11420	==		4	14580	15060	15530	16420	Ψ.		18040		+						20730	21020	21580
3	HATT	0-,6									-	0066	-	11160	- 1-		13140	_	7	14460		-		16380		17390	_	·			_		19390	19880
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		0299			-	_		-				51 2010	+	7553 81		_	8488 94	-		9211 102		$\overline{}$	Ψ	10220 114 10390 116	<u> </u>	10720 120		•					11640 131	
L																											<u>, , , , , , , , , , , , , , , , , , , </u>							
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		120															-		_	~ -		_	<u> </u>			22320	23020	3740	24490	25220	25930	26680	24940 27410	2210 25620 28820
بار	ַּעָ)-0" 11'-0"						ı					i								: ::	⋍				C	0	С		al	\overline{c}		₹ ō	562(
3 3	<u>-</u>							_					+			0	0			0 16510		18680	0 19400	0 20850				23040	23440	23840	0 24210	00 24580	00 243	2 6
	9 P	=								*******	- 3	9 6	06	0.70	10 12870		00 14330	15060	15640	16120	17020	17450	17870	18660	19040			0100 23040	23440	23840	1060	80 21360 2458	90 21940 253	30 22210 25
	10P OF P	9'-6" 10							776	208	235	222 3300	380 10890	390 11420			760 13700 14330	15060	15640	16120	17020	17450	17870	17360 18660	17700 19040			0100 23040	23440	23840	990 19520 21060 24210	220 19780 21360 2458	20240 21860	20530 22210
TO TO THE TANK OF THE	OTH AT TOP OF P	9-0" 9-6" 10					287				9235	9833		1130 10890 11420	11860 12710	12320 13210	1820 12760 13700 14330	15060	13590 14610 15640	13980 15050 16120	14730 15870 17020	15080 16260 17450	15420 16640 17870	15/50 1/010 182/0	16370 17700 19040	16670 18030 19410	16950 18350 19760	17230 18660 20100 23040	17490 18950 20440 23440	17740 19240 20760 23840	17990 19520 2	18220 19780 21360	18670 20290 21940	18880 20530 22210
	CH WIDTH AT TOP OF P	8'-6" 9'-0" 9'-6" 10						7041	2009	8153		9180 9855	3004	10130	11010 11860 12710	11420 12320 13210	0890 11820 12760 13700 14330	15060	13590 14610 15640	13980 15050 16120	13600 14730 15870 17020	13920 15080 16260 17450	14220 15420 16640 17870	14790 16070 17360 18660	15060 16370 17700 19040	15320 16670 18030 19410	15570 16950 18350 19760	15810 17230 18660 20100 23040	16040 17490 18950 20440 23440	16270 17740 19240 20760 23840	17990 19520 2	16690 18220 19780 21360	12080 18430 20040 21860 17080 18670 30380 31840	17260 18880 20530 22210
	TRENCH WIDTH AT TOP OF P	9-0" 9-6" 10		3691		5354	6014	6555 7041	7074 7609	75/1 8153	8049 8676 9235	9180 9855	8948 9004		10160 11010 11860 12130	10540 11420 12320 13210	9975 10890 11820 12760 13700 14330	15060	13590 14610 15640	13980 15050 16120	12480 13600 14730 15870 17020	13920 15080 16260 17450	13030 14220 15420 16640 17870	15/50 1/010 182/0	13770 15060 16370 17700 19040	13990 15320 16670 18030 19410	14210 15570 16950 18350 19760	14420 15810 17230 18660 20100 23040	14620 16040 17490 18950 20440 23440	13390 14820 16270 17740 19240 20760 23840	13550 15000 16480 17990 19520 2	13700 15180 16690 18220 19780 21360	13840 13330 18630 18430 2040 2 1860 13980 15510 17080 18670 20390 21940	15670 17260 18880 20530 22210
AN ALACA CONTRACTOR OF THE CON	TRENCH WIDTH AT TOP OF PIPE	8'-0" 8'-6" 9'-0" 9'-6" 10	2950	3658	4173 4490	4665 5057 5354	5134 5573 6014	5581 6067 6555 7041	6008 6540 7074 7609	6415 6992 7571 8153	5803 /425 8049 8676 9235	7527 6235 6208 9180 9833	7521 8235 8948 9004	7864 8614 9370 10130	8492 9324 10160 11010 11860 12710	8785 9657 10540 11420 12320 13210	9064 9975 10890 11820 12760 13700	9331 10280 11240 12200 13180 14160 15060	9585 10570 11570 12570 13590 14610 15640	9827 10850 11880 12930 13980 15050 16120 10060 11120 12350 13350 15470 16580	10280 11370 12480 13600 14730 15870 17020	10490 11620 12760 13920 15080 16260 17450	10690 11850 13030 14220 15420 16640 17870	10880 12070 13280 14510 15750 17010 18270 11060 12290 13530 14790 16070 17360 18660	11240 12490 13770 15060 16370 17700 19040	11400 12690 13990 15320 16670 18030 19410	11560 12880 14210 15570 16950 18350 19760	13060 14420 15810 17230 18660 20100 23040	13230 14620 16040 17490 18950 20440 23440	13390 14820 16270 17740 19240 20760 23840	12130 13550 15000 16480 17990 19520 2	12250 13700 15180 16690 18220 19780 21360	12370 13840 13330 18630 16430 20040 21660	12600 14110 15670 17260 18880 20530 22210
A TO GOT HE CATOLOGICA	TRENCH WIDTH AT TOP OF P	7:-6" 8:-0" 8:-6" 9:-0" 9:-6" 10	2870 2950	3361 3658	3829 4173 4490	4273 4665 5057 5354	4695 5134 5573 6014	5097 5581 6067 6555 7041	5478 6008 6540 7074 7609	5841 6415 6992 7571 8153	7820 8676 9235	6513 7174 7539 8508 9160 9853	7100 7201 6611 6610	8614 93/0 10130	7669 8492 9324 10160 11010 11860 1230	7923 8785 9657 10540 11420 12320 13210	8164 9064 9975 10890 11820 12760 13700	8394 9331 10280 11240 12200 13180 14160 15060	8612 9585 10570 11570 12570 13590 14610 15640	10850 11880 12930 13980 15050 16120 11120 12180 13270 14360 15470 16580	9204 10280 11370 12480 13600 14730 15870 17020	10490 11620 12760 13920 15080 16260 17450	9552 10690 11850 13030 14220 15420 16640 17870	12070 13280 14510 15750 17010 18270 12290 13530 14790 16070 17360 18660	10010 11240 12490 13770 15060 16370 17700 19040	10150 11400 12690 13990 15320 16670 18030 19410	10280 11560 12880 14210 15570 16950 18350 19760	10400 11710 13060 14420 15810 17230 18660 20100 23040	10520 11860 13230 14620 16040 17490 18950 20440 23440	10640 12000 13390 14820 16270 17740 19240 20760 23840	10740 12130 13550 15000 16480 17990 19520 2	10850 12250 13700 15180 16690 18220 19780 21360	13840 13330 18630 18430 2040 2 1860 13980 15510 17080 18670 20390 21940	11120 12600 14110 15670 17260 18880 20530 22210

Table B-14 Continued

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			5	9	7	80	6	9	Ξ	12	13	7	15	16	17	18	19	50	21	22	23	24	25	56	27	58	53	ဓ	31	35	33	34	35	36	37	38	36	6
	ATRAN-	WIDTH	6 5"	6	7 2"	9/	7:-11	8. 1.	8- 2.	8'- 3'	8- 5			 8-	.68	8'-10"	9 0.	9 0.	9- 2"	9'- 3"		9. 5"	96		9 8	9 8	9′-10″	9′-10″		-		10'- 2"	10 3"		10'- 5"			10'- 7"
		12:-0																																				
		110																													23740	24490	25220	25930	26680	27410	28130	28820
110	- PIPE	100																						18680	19400	20120	20850	21590	22320	23020	23460	23940	24410	24870	25310			26600
,μ' — 0.	AT TOP OF	96																	15060	15770	16510	17230	17960	18560	19070	19570	20060	20540	21010	21470	21920	22360	22780	23200	23610	24010	22630 24400	24780
LAY K	AT T(06											10690	11420	12150	12870	13600	14330	14780	15310	15830	16340	16840	17320	17790	18250	18700	19130	19560	19980	20380	20780	21170	21550	21920	22280	22630	22970
red C	/ІОТН	8'-6"						7041	7776	8208	9235	9966	10570	11140	11690	12230	12760	13270	13770	14260	14730	15200	15640	16080	16510		17340	17730	18120	18500	18860	19220	19570	19910	20240	20560	20870	21180
SATURATED CLAY Κμ'0.110	TRENCH WIDTH	80					6287	6994	7593	8176	8744	9295	9832	10360	10860	11360	11840	12310	12760	13200	13640	14060	14460	14860	15240	15620	15990	16340	16690	17020	17350	17670	17980	18280	18570	18860	19140	19410
SAT	TREN	92			4490	5354	5932	6500	7051	7586	8106	8611	9101	2296	10040	10490	10920	11350	11760	12160	12540	12920	13290	13640	13990	14320	14650	14960	15270	15570	15860	16140	16410	16670	16930	17180	17420	17660 19410
		7:-0:		3691	4398	4951	5487	9009	6059	2669	7470	7928	8372	8802	9218	9622	10010	10390	10760	11120	11460	11800	12120	12440	12740	13030			13860	14120	14380	14620	14860	15090	15310	15520	15730	15940
۵		99	2950	3529	4051	4555	5042	5514	5969	6410	6836	7247	7645	8030	8402	8761	9109	9445	0226	10080	10390	10680	109601			11760	12010	12250	12480	12700	12920	13130	13330	13530	13720	13900		14240
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28820 12.-0. 11'-0" 22570 24490 19020 20370 10,-0... **17960** TRENCH WIDTH AT TOP OF PIPE ORDINARY CLAY Ku'-0.130 18060 19440 ..9-.6 13 160 13600 13670 14330 14650 15770 15 20 16340 17670 19/30 12400 13900 15420 16980 18550 20 30 ..0-.6 8.-6" 14980 16460 8,-0 1,-6,, 1.0.7 HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET

For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. ATransition loads (**bold type**) and widths based on Kµ−0.19, r_{sdp}−0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

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Table B-15

								HE	ΞIC			_	F		Α(_			. +	1 /			VE		OI)F		Р			EE					_
	ż	Z E	2.2				.6	10	<u>-</u>	12	8. 13	9" 14	15.		-	- 18	5" 19	20.	8" 21	9. 25	7.	0" 24	22	 20		28	2 6	8 .	9,	3.8	0		2. 36		4" 38	33	
	ATRAN.	WIDTH	7.7	7: 7	7:-11"	8 7	% -0	6	9	96	9.	9,	9′-11	10,-	102	10'- 4	10'- 5	10.		10'- 9		11:- 0	11:- 1			11. 2		= ==	11'- 9	11'-11"	12'- 0		12'- 2	12'- 3		12.	12. 7
		13:-0																														28250	29090	29910	30720	31500	32330
		12:-0																					20120	20930	21750	22580	24190	250 10	25840	26650	27440		28480	28970	29440		30340
	PIPE	11,-0,,												12780	13600	14420	15230	16050	16860	17680	18490	_				21540			23480	23940	24380	24800	25220	25630		26410	26780
	P OF	10:-01									10330	11150	11970	12710	<u> </u>		14480	15040					17590			18940			20570				22010 2	22350 2			23290 2
	AT TC	.9-,6						7809	8683	9507	10130 1	102201	11350 1	11930 1			13570 1	14090					16420 1	16850 1		1,660			19130 2	19470 2			20430	20730 2			21580 2
	DTH,	0-,6					6765	7653	8287	8901	9494 1	10070	10620 1	11160 1			12670 1	13140 1								16380 1	1707011		17710				18870 2	19130 2			19880 2
	IM HC	.98				5790	6554	7161	7748	8315	8862	9389 1		10390 1		11320 1	11770 1	12190 1								15120 1		_	16300 11				17320 1	17560 1		18000	18210 1
	TRENCH WIDTH AT TOP OF	80		4030	4880	5529	6110	6671	7210	7730	8231	8713	9177	9625 1		0470 1	10870 1	1260 1								138/0			14910 1				15800 1	16010		16390 1	16570 1
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	▼	9'-6" 10'-0" 11'-0" 12'-0" 13'-0"	7 3	7-7	9,-8	.60		7809 9	-,6	9322 9507 9-6	9937 10330 9-	11150	11830 11970	11660 12430 12780	12200 13010 13600	12710 13570 14420 10'-	13210 14120 15230	13700 14640 16050	16860	17680 11'-	15050 16120 18280 18490	15470 16580 18820 19310	15870 17020	19860 20930 1	20360 21750 11'-	17360 18660 21300 22380 11:	17700 19040 21760 24190	18030 19410 22200 25010	18350 19760 22630 25540 25840 12	18660 20100 23040 26030 26650 12-	18950 20440 23440 26500 27440 12	19240 20760 23840 26970 28250 12'-	27420 29090 12-	19780 21360 24580 27860 29910 12-	21660 24940 28290 30720	20290 21940 25290 28710 31500	20530 22210 25620 29110 32330
טויט איז ארוט טוע	▼	9-0" 9-6" 10-0" 11-0" 12-0" 13-0"	7 3	7-7			6765	7534 7809 9'-	8146 8683 9.	8737 9322 9507 9-	9306 9937 10330 9-	9855 10530 11150	10380 11110 11830 11970	10890 11660 12430 12780	11380 12200 13010 13600	11860 12710 13570 14420 10'-	12320 13210 14120 15230	12760 13700 14640 16050	13180 14160 15150 16860	13590 14610 15640 17680 11'-	13980 15050 16120 18280 18490	14360 15470 16580 18820 19310	14730 15870 17020	15080 16260 17450 19860 20930	15420 16640 17870 20360 21750 11:	17360 18660 21300 22380 11:	17700 19040 21760 24190	16670 18030 19410 22200 25010	16950 18350 19760 22630 25540 25840 12	17230 18660 20100 23040 26030 26650 12-	17490 18950 20440 23440 26500 27440 12	17740 19240 20760 23840 26970 28250 12	17990 19520 21060 24210 27420 29090 12'-	19780 21360 24580 27860 29910 12-	21660 24940 28290 30720	20290 21940 25290 28710 31500	20530 22210 25620 29110 32330
טאונט איז	▼	8'-6" 9'-0" 9'-6" 10'-0" 11'-0" 12'-0" 13'-0"	7.	4030 7:- 7		5790 8'-	6456 6765	7044 7534 7809 9 -	7609 8146 8683 9	8153 8737 9322 9507 9 -	8676 9306 9937 10330 9-	9180 9855 10530 11150	9664 10380 11110 11830 11970	10130 10890 11660 12430 12780	10580 11380 12200 13010 13600	11010 11860 12710 13570 14420 10-	11420 12320 13210 14120 1 5230	11820 12760 13700 14640 16050	12200 13180 14160 15150 16860	12570 13590 14610 15640 17680 11:-	12930 13980 15050 16120 18280 18490	13270 14360 15470 16580 18820 19310	13600 14730 15870 17020	13920 15080 16260 17450 19860 20930	14220 15420 16640 17870 20360 21750	14310 13730 17010 18270 20840 22380 11-	15060 16370 17700 19040 21760 24190	15320 16670 18030 19410 22200 25010	15570 16950 18350 19760 22630 25540 25840 12	15810 17230 18660 20100 23040 26030 26650 12	16040 17490 18950 20440 23440 26500 27440 12	16270 17740 19240 20760 23840 26970 28250 12.	17990 19520 21060 24210 27420 29090 12'-	16690 18220 19780 21360 24580 27860 29910 12-	16890 18450 20040 21660 24940 28290 30720	17080 18670 20290 21940 25290 28710 31500	17260 18880 20530 22210 25620 29110 32330
SAIND AIND GRAVEL NY -0.103	TRENCH WIDTH AT TOP OF PIPE ATRA	. 8'-0" 8'-6" 9'-0" 9'-6" 10'-0" 11'-0" 12'-0" 13'-0"	7.2		4880 8'-	5451 5790 8'-	6014 6456 6765	6555 7044 7534 7809 9 '-	7074 7609 8146 8683 9-	7571 8153 8737 9322 9507 9 °-	8049 8676 9306 9937 10330 9-	8508 9180 9855 10530 11150	8948 9664 10380 11110 11830 11970	9370 10130 10890 11660 12430 12780	9775 10580 11380 12200 13010 13600	10160 11010 11860 12710 13570 14420 10'-	10540 11420 12320 13210 14120 15230	10890 11820 12760 13700 14640 16050	11240 12200 13180 14160 15150 16860	11570 12570 13590 14610 15640 17680 17680	11880 12930 13980 15050 16120 18280 18490	12190 13270 14360 15470 16580 18820 19310	12480 13600 14730 15870 17020	12760 13920 15080 16260 17450 19860 20930	13030 14220 15420 16640 17870 20360 21750 11:	13580 14310 13730 17010 18270 20840 22380 11:	13770 15060 16370 17700 19040 21760 24190	13990 15320 16670 18030 19410 22200 25010	14210 15570 16950 18350 19760 22630 25540 25840 12	14420 15810 17230 18660 20100 23040 26030 26650 12	14620 16040 17490 18950 20440 23440 26500 27440 12-	14820 16270 17740 19240 20760 23840 26970 28250 12:	15000 16480 17990 19520 21060 24210 27420 29090 12'-	15180 16690 18220 19780 21360 24580 27860 29910 12-	15350 16890 18450 20040 21660 24940 28290 30720	15510 17080 18670 20290 21940 25290 28710 31500	17260 18880 20530 22210 25620 29110 32330
	▼	7'-6" 8'-0" 8'-6" 9'-0" 9'-6" 10'-0" 11'-0" 12'-0" 13'-0"	3238	3954	4518 4880 8'-	5057 5451 5790 8 '-	5573 6014 6456 6765	6067 6555 7044 7534 7809 9	6540 7074 7609 8146 8683 8-9-	6992 7571 8153 8737 9322 9507 9.	7425 8049 8676 9306 9937 10330 9-	7839 8508 9180 9855 10530 11150	8235 8948 9664 10380 11110 11830 11970	10130 10890 11660 12430 12780	8977 9775 10580 11380 12200 13010 13600	9324 10160 11010 11860 12710 13570 14420	9657 10540 11420 12320 13210 14120 15230	9975 10890 11820 12760 13700 14640 16050	10280 11240 12200 13180 14160 15150 16860	10570 11570 12570 13590 14610 15640 17680 17680	10850 11880 12930 13980 15050 16120 18280 18490	11120 12190 13270 14360 15470 16580 18820 19310	11370 12480 13600 14730 15870 17020	12760 13920 15080 16260 17450 19860 20930	13030 14220 15420 16640 17870 20360 21750 11:	13580 14310 13730 17010 18270 20840 22380 11:	13770 15060 16370 17700 19040 21760 24190	13990 15320 16670 18030 19410 22200 25010	14210 15570 16950 18350 19760 22630 25540 25840 12	14420 15810 17230 18660 20100 23040 26030 26650 12	13230 14620 16040 17490 18950 20440 23440 26500 27440 12-	14820 16270 17740 19240 20760 23840 26970 28250 12:	15000 16480 17990 19520 21060 24210 27420 29090 12'-	15180 16690 18220 19780 21360 24580 27860 29910 12-	15350 16890 18450 20040 21660 24940 28290 30720	15510 17080 18670 20290 21940 25290 28710 31500	17260 18880 20530 22210 25620 29110 32330
	▼	. 8'-0" 8'-6" 9'-0" 9'-6" 10'-0" 11'-0" 12'-0" 13'-0"	3118 3238 7.	3954	4173 4518 4880 8'-	4665 5057 5451 5790 8 :	9 5134 5573 6014 6456 6765	5581 6067 6555 7044 7534 7809 9-	11 6008 6540 7074 7609 8146 8683 9 -	12 6415 6992 7571 8153 8737 9322 9507 9.	13 6803 7425 8049 8676 9306 9937 10330 9 -	14 7114 7839 8508 9180 9855 10530 11150	15 7527 8235 8948 9664 10380 11110 11830 11970	16 7864 8614 9370 10130 10890 11660 12430 12780	17 8186 8977 9775 10580 11380 12200 13010 13600	18 8492 9324 10160 11010 11860 12710 13570 14420 10 -	19 8785 9657 10540 11420 12320 13210 14120 15230	20 9064 9975 10890 11820 12760 13700 14640 16050	21 9331 10280 11240 12200 13180 14160 15150 16860	9585 10570 11570 12570 13590 14610 15640 17680 11670	23 9827 10850 11880 12930 13980 15050 16120 18280 18490	24 10060 11120 12190 13270 14360 15470 16580 18820 19310	25 10280 11370 12480 13600 14730 15870 17020	26 10490 11620 12760 13920 15080 16260 17450 19860 20930	27 10690 11850 13030 14220 15420 16640 17870 20360 21750 111:	28 10860 12070 13530 14310 13730 17360 18860 21300 22380 11:	30 11240 12490 13770 15060 16370 17700 19040 21760 24190	11400 12690 13990 15320 16670 18030 19410 22200 25010	32 11560 12880 14210 15570 16950 18350 19760 22630 25540 25840 12	33 11710 13060 14420 15810 17230 18660 20100 23040 26030 26650 12 '-	34 11860 13230 14620 16040 17490 18950 20440 23440 26500 27440 12 '-	35 12000 13390 14820 16270 17740 19240 20760 23840 26970 28250 12 :	36 12130 13550 15000 16480 17990 19520 21060 24210 27420 29090 12 '-	15180 16690 18220 19780 21360 24580 27860 29910 12-	12370 13840 15350 16890 18450 20040 21660 24940 28290 30720	12490 13980 15510 17080 18670 20290 21940 25290 28710 31500	20530 22210 25620 29110 32330

Table B-15 Continued

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	ATRAN-	WIDTH	7 0"	7. 4"	7 8"	8- 1	8'- 5"	8′-10″	9 0	9'- 2"	9'- 3"		9'- 5"			9'- 9''	9′-10″	9'-11"	10'- 0"	10'- 1"	10'- 2"				10,- 6"			10,- 9"	10,-10		11 0"	11:- 1"	11'- 2"	11'- 3"	11'- 4"	11'- 5"	11'- 6"	11'- 7"
		13'-0"													•																							
	111	12'-0"																														27440	28250	29090	29910	30720	31500	32330
1110	F PIPE	11'-0"																		17680	18490										26650		27690	28230	28760	29280	29790	30290
Kμ'—0	0 d0.	100								_	_	_	_			14420	15230	16050	16860												23460	23940	24410	24870	25310	25750	26180	26600
CLAY	4 AT 1	9-,6								9507	10330			_		13980	14600	-	0 15800	16380	16940		_		0 19070	19570) 22780	23200	0 23610	24010	24400	24780
SATURATED CLAY Kµ'-0.110	TRENCH WIDTH AT TOP OF PIPE	0-,6				_	5	6 7809	6 8683	8 9360	3 10020		,-	-	_	0 13100	0 13680	0 14240	0 14780									_			0 20380	0 20780	0 21170	0 21550	0 21920	0 22280	0 22630	0 22970
ATUR/	ENCH	86			0	14 5790	8 6765	7489	3 8136		9383		-	÷			12760		0 13770		14730	00 15200	_	_							0 18860	0 19220	30 19570	30 19910	70 20240	30 20560	10 20870	0 21180
Š	TRE	80		20	16 4880	17 5744	32 6378	00 6994	51 7593		9744			_		_	20 11840		30 12760	30 13200					-			_			30 17350		17980	70 18280	30 18570	30 18860	20 19140	30 19410
		0 7'-6	3238	3827 4030	4398 4746	4951 5347	5487 5932	6006 6500	6509 7051		7470 8106	_	_	_	_	9622 10490	10010 10920	90 11350	10760 11760	20 12160			$\overline{}$	_				-			14380 15860	20 16140	60 16410	5090 16670	15310 16930	5520 17180	5730 17420	15940 17660
ا ۵		.02	32	38	43	49	54	09	65	69	74	79	83	88	92	96	100	10390	107	11120	11460	11800	121	124	127	130	133	13600	138	141	143	14620	14860	150	153	155	157	159
	TRAN-	WIDTH	7:- 1"	7 5"	7:-10"	8- 2"	8'- 7"	06	9'- 3"	9 4"	9'- 5"	9 7	9, 8	.66	9'-11"	10'- 0"	10'- 2"	10'- 3"	10'- 4"	10'- 5"		10'- 8"	10'- 9"	10'-10"	10'-11"	11'- 0"	1: 1:	11:- 2"			11'- 6"	11. 7"	11: 7"	11. 9"	11:-10"	11:-11"	12:- 0"	12: 1"
		130.							T																													
		12'-0"																									23380			25840	26650	27440	28250	29090	29910	30720	28020 31500	32100 32330
o	John	11:-0															15	16050		176	18490	17850 19310	20120	20930	21750					24690	25200	25700	26190	23380 26660	27130	27580		28460
— 0.13	OF F	100										11150		12780	13600	14420	14990	15600	16180	16750	17310 187										22150	22570			23760	24140	24510	24870
√ Υ Κμ΄	\T TOF	9-,6					10	6	8683	9507	10330	11050		12310		13500	14070	14630	15170	15700	0 16210	0 16710	16020 17200		18130		19020	19440				21020	21390	21750	22100	J 22440	22770	23100
ORDINARY CLAY Kµ'-0.130	TRENCH WIDTH AT TOP OF PIPE	.06				0	7 6765	3 7809	9 8481	7 9126	7 9754	9 10360		0 11530		0 12630	0 13160	0 13670	0 14170	0 14650		0 15580										0 19490	0 19820	0 20140	0 20460	0 20760	0 21060	0 21340
DINAF	CH WI	8,-6.			20	35 5790	42 6687	30 7323	98 7939		32 9117	98 9679		31 10750		00 11760	12250	30 12720	30 13170	70 13610			90 14850								90 17660	30 17970	20 18260	30 18550	20 18830	30 19100	30 19360	19610
OR	TREN	80.	38	30	61 4880	39 5635	98 6242	38 6830	59 7398		48 8482			10 9981	33 10450	10900	11340	20 11760	30 12180	40 12570	30 12960	20 13330	13690					90 15330	50 15630		40 16190	14980 16460	15200 16720	20 16980	40 17220	40 17460	40 17680	30 17910
		76"	3194 3238	3764 4030	4314 4661	4844 5239	5355 5798	5847 6338	121 6859	_	17 7848	41 8318		8443 9210		9188 10040	9540 10440	9880 10820	10 11190	20 11540	20 11890	20 12220		_				2660 13990		00 14500	13310 14740	3520 1498	13710 1520	13900 15420	14080 15640	50 15840	20 16040	80 16230
		1.0.	L	6 37					632	12 67	3 7217	14 7641		16 84	17 88	18 91			21 10210	22 10520	23 10820	24 11120	25 11400	_	27 119	_		30 126	_	32 13100	33 133	34 135	35 137	Ľ	<u> </u>	38 14250	39 14420	40 14580
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Table B-16

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ATRAN-	WIDTH	7 9"	8'- 1"	8'- 6"	8'-11"	9'- 3"		10'- 1"	<u>.</u> 4	 		10'-10"	10'-11"	11: 1"	11'- 2"	11'- 3"	 2			11. 41	:	12: 1"	12'- 2"	<u>.</u> 4	ئ	 6		12'- 8" 3	12'-10" 3	12'-11" 3	13:- 0" 3	13'- 2" 3	ë.	13'- 4" 3
	14'-0"									_		-	Ī	_	_	_		_				Ī	_	_	_	_	_	_	Ξ.	_	_	32140 1		33970 1
	130																					23150	24060	24960	25860	26760	27680	28560	29460	30380	31270	31790 3		32900 3
BIPE:	150													15020	15930	16830	17740	18640	19540	21240	22240	1	23560						26960	27480	27990	28480		29440
AT TOP OF PIPE	11.0										12300	13210	14120	14960	15650	16310	16960	17580	18200	107.90	19940	20480	21020	21540	22040	22540	23020			24380	24800	25220	25630	26020
1 AT T	901								-	_	_	12810	13480	14140	14780	15400	_	_	7 7	18240		19270	19760		20700	21150	21590		22440	22840	23230	23610		24340
MIDT	0.01						_	-	_	-	_	12080	12710	13320	13910	14480				17110		18050	18500		<u> </u>	$\overline{}$			20950	21310	21670	22010		22670
TRENCH WIDTH	9-,6					7246	~			_	_	11350	11930	12500	13040	13570	-		7 1	15080		16850	17260	<u> </u>					•	19800	20120	20430		21020
TRE	0-,6				4 6226	4 6997		_			_	9 10620	09111	08911	12180	0 12670		_	14030	_		1				***			18010	18310	18590	0 18870		19390
	. 9-8				9 5924	0 6554	•	_			_	7 9899	5 10390	0 10870	0 11320	0 11770	-		13000			0 14460	0 14800				_	_	0 116570	0 16830	0 17080	0 17320		0 117780
	8,-0.	3522	4298	4925	5529	6110	6671	7210	7730	8231	87.13	9177	9625	10060	10470	10870	11260	1 1630	11980	12660	12980	13290	13580	13870	14140	14410	14660	14910	15140	15370	15590	15800	16010	16200
ATRAN-	WIDTH	7:-10"	8- 2"	8'- 7''	9 0	9. 5	9'-10"		10 6"	10'- 8''	1010	11:- 0"	1-1	11. 3"	11:- 4"	6.	11: 7:	6 - -	1-11		2.3	2'- 4"	2 6		2. 8	12'-10"						13 5		13'- 8''
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	1,0,											1	ļ.				- 1												9460	380	1270	714	õ	
	3'-0" 14'-0"					··														1340	2240	3150	4060	4960	5860	09/9	7680	8560	9020 29460	9610 30380	0150 31270		1190 33090	1690 33
PIPE	0" 13'-0"												14120	15020	15930	16830	17740	18640	19540	21080 21340	21690 22240	22290 23150	22870 24060	23430 24960		24510 26760	25030 27680	540 28560	29050	29610	30150	420 30680	860 31190	290 31690
P OF PIPE	0" 13'-0"									11390	12300		14	14650 15020	15300 15930		16540 17740	= ;	17.20 19340	18820 21080 21340	19350 21690 22240	19860 22290 23150	20360 22870 24060	20840 23430 24960	21300 23980 25860	21760 24510 26760	22200 25030 27680	540 28560	26030 29050	26500 29610	26970 30150	27420 30680	27860 31190	28290 31690
AT TOP OF PIPE	13'-0"								10480		11890 12300	12560 13210	13980 14	14650 15	15300 15	15930	15590 16540 17740	17 140 18	12100 10200 2040	18820	19350 21	19860 22	19110 20360 22870 24060	20840 23	21300 23	21760 24510	22200 25030	22630 25540 28560	23040 26030 29050	23440 26500 29610	23840 26970 30150	24210 27420 30680	24580 27860 31190	24940 28290 31690
IIDTH AT TOP OF PIPE	0" 13'-0"						8331	9224	9908 10480	105/0 11200	11210 11890	11830 12560 13210	12430 13200 13980 14	13010 13830 14650 15	13570 14430 15300 15	15020 15930	15590 16540	16 140 17 140 18	15640 16680 17720 19	16580 17700 18820	17020 18180 19350 21	18650 19860 22			18660 19980 21300 23	20400 21760 24510	19410 20800	19760 21190 22630 25540 28560	20100 21570 23040 26030 29050	20440 21930 23440 26500 29610	22290 23840 26970 30150	22630 24210 27420 30680	24580 27860 31190	24940 28290 31690
JCH WIDTH AT TOP OF PIPE	10'-6" 11'-0" 12'-0" 13'-0"					7246	8025 8331	8685 9224	9322 9908 10480	9937 10570 11200	10530 11210 11890	11110 11830 12560 13210	11660 12430 13200 13980 14	12200 13010 13830 14650 15	12710 13570 14430 15300 15	13210 14120 15020 15930	13700 14640 15590 16540	14160 15150 16140 17140 18	14610 15640 16680 17720 1	15470 16580 17700 18820	15870 17020 18180 19350 21	18650 19860 22			17360 18660 19980 21300 23	17700 19040 20400 21760 24510	18030 19410 20800	19760 21190 22630 25540 28560	20100 21570 23040 26030 29050	18950 20440 21930 23440 26500 29610	22290 23840 26970 30150	22630 24210 27420 30680	24580 27860 31190	24940 28290 31690
TRENCH WIDTH AT TOP OF PIPE	9.0" 9'-6" 10'-0" 10'-6" 11'-0" 12'-0" 13'-0"				6226	6899 7246	7534 8025 8331	8146 8685 9224	8737 9322 9908 10480	9306 9937 10570 11200	9855 10530 11210 11890	10380 11110 11830 12560 13210	10890 11660 12430 13200 13980 14	12200 13010 13830 14650 15	12710 13570 14430 15300 15	13210 14120 15020 15930	13700 14640 15590 16540	14160 15150 16140 17140 18	13590 14610 15640 16680 17720 19	14360 15470 16580 17700 18820	14730 15870 17020 18180 19350 21	18650 19860 22	15420 16640 17870	15750 17010 18270	16070 17360 18660 19980 21300 23	16370 17700 19040 20400 21760 24510	16670 18030 19410 20800	19760 21190 22630 25540 28560	20100 21570 23040 26030 29050	17490 18950 20440 21930 23440 26500 29610	17740 19240 20760 22290 23840 26970 30150	17990 19520 21060 22630 24210 27420 30680	24580 27860 31190	24940 28290 31690
TRENCH WIDTH AT TOP OF PIPE	8'-6" 9'-0" 9'-6" 10'-0" 10'-6" 11'-0" 12'-0" 13'-0"		4368	5210	5845 6226	6456 6899 7246	7044 7534 8025 8331	7609 8146 8685 9224	8153 8737 9322 9908 10480	86/6 9306 993/ 105/0 11200	9180 9855 10530 11210 11890	9664 10380 11110 11830 12560 13210	10130 10890 11660 12430 13200 13980 14	10580 11380 12200 13010 13830 14650 15	11010 11860 12710 13570 14430 15300 15	11420 12320 13210 14120 15020 15930	11820 12760 13700 14640 15590 16540	14160 15150 16140 17140 18	125/0 13590 14610 15640 16680 17720 1	13270 14360 15470 16580 17700 18820	13600 14730 15870 17020 18180 19350 21	13920 15080 16260 17450 18650 19860 22	14220 15420 16640 17870	14510 15750 17010 18270	14790 16070 17360 18660 19980 21300 23	15060 16370 17700 19040 20400 21760 24510	15320 16670 18030 19410 20800	19760 21190 22630 25540 28560	20100 21570 23040 26030 29050	17490 18950 20440 21930 23440 26500 29610	17740 19240 20760 22290 23840 26970 30150	17990 19520 21060 22630 24210 27420 30680	24580 27860 31190	24940 28290 31690
TRENCH WIDTH AT TOP OF PIPE	9.0" 9'-6" 10'-0" 10'-6" 11'-0" 12'-0" 13'-0"	3522	4368	4864 5210	5451 5845 6226	6014 6456 6899 7246	6555 7044 7534 8025 8331	7074 7609 8146 8685 9224	7571 8153 8737 9322 9908 10480	8049 8676 9306 9937 10570 11200	8508 9180 9855 10530 11210 11890	8948 9664 10380 11110 11830 12560 13210	9370 10130 10890 11660 12430 13200 13980 14	9775 10580 11380 12200 13010 13830 14650 15	10160 11010 11860 12710 13570 14430 15300 15	10540 11420 12320 13210 14120 15020 15930	10890 11820 12760 13700 14640 15590 16540	11240 12200 13180 14160 15150 16140 17200	13390 14610 15640 16680 17720 1	12190 13270 14360 15470 16580 17700 18820	12480 13600 14730 15870 17020 18180 19350 21	12760 13920 15080 16260 17450 18650 19860 22	13030 14220 15420 16640 17870	13280 14510 15750 17010 18270	13530 14790 16070 17360 18660 19980 21300 23	13770 15060 16370 17700 19040 20400 21760 24510	13990 15320 16670 18030 19410 20800	14210 15570 16950 18350 19760 21190 22630 25540 28560	14420 15810 17230 18660 20100 21570 23040 26030 29050	14620 16040 17490 18950 20440 21930 23440 26500 29610	14820 16270 17740 19240 20760 22290 23840 26970 30150	15000 16480 17990 19520 21060 22630 24210 27420 30680	15180 16690 18220 19780 21360 22960 24580 27860 31190	21660 23290 24940 28290 31690

Table B-16 Continued

8-0° 8-6° 9-0° 9-6° 10·0° 10·6° 11·0° 12·0° 13·0° 14·0° 4368 5093 5268 6226 6236 6226 6378 6820 72.0 13·0° 14·0° 11·0° 12·0° 13·0° 14·0° 5744 6142 6226 9953 10480 9223 10480 9223 10480 9223 10480 9223 10480 1200	14-0 WIDTH	C ORDINARY CLAY Kµ'—0.130	ORDINARY CLAY K	ORDINARY CLAY K	ORDINARY CLAY K ENCH WIDTH AT TO	INARY CLAY K	CCLAY K TH AT TO	$\xi \mid \xi$	실분	-0.130 OF PI	_ BE			▲ TRAN-	L	اه	7	SATURATED CLAY Kµ'-0.110 TRENCH WIDTH AT TOP OF PIPE	RATE -	DCLA	₹ Kg	-0.1	10 PIPE			TRAN-		
7. 8 352 7. 7 8. 0 4568 8. 2 7. 17 8. 0 4568 8. 2 7. 17 8. 0 5248 6824 7246 8. 33 9. 1 7593 7884 8331 8. 33 9. 6 7583 1326 8880 9225 9486 10. 2 7593 7884 8331 1036 11390 99.17 10. 3 8744 8383 10020 11300 12040 1206 100.17 10. 4 8775 9826 9827 10570 11300 1206 11400 11300 1206 11400 11300 1206 11400 1300 1206 1406 10.0.17 10.	8331 7. 7. 7. 5 8225 9486 8. 3" 7 7. 71" 6 9225 9486 9. 0" 9 9. 0" 9 9225 9486 9. 0" 9 9. 0" 9 953 10480 1310 11390 1320 10. 1" 13 11360 12050 12300 12780 14180 10. 2" 10. 1" 13 12040 12780 1340 15020 10. 5" 10. 5" 16 12040 12780 14180 15020 15020 10. 5" 10. 5" 16 12040 12780 14180 15020 15020 10. 5" 10. 5" 16 12040 15780 14180 15020 1740 17740 10. 5" 10. 5" 16 15800 1480 15020 15340 15530 14480 15020 15340 1650 1980 200 10. 5" 10. 5" 11 23 16380 1480 1680 1980 200 200 200 200 200 200 200 200 200 2	20 130	8-6. 9-0. 9-6. 10-0. 10-6. 11-0. 12-0. 13-0.	9.0. 9.6. 10.0. 10.6. 13.0. 13.0.	20 130	20 130	20 130	20 130	20 130	20 130		14.	Ţ.	SITION	1	<u> </u>		٥	9	9	9	9-1-		<u> </u>	•	SITION		
4368 5268 5268 8.331 7-117 7-117 5034 5268 724 6126 8.331 8.332 9.342 9.47	8331 7-11" 6 8331 8-3" 7 9225 9486 9-0" 9 9953 10480 9-0" 9 9953 10480 9-0" 9 9-0" 10 11360 12050 12300 10-2" 11 12 11360 12050 12300 10-2" 10-2" 11 13 11360 12050 12300 10-1" 13 10-2" 10-1" 13 12040 12780 13480 1502 10-1" 13 16 17 17 13800 14800 1502 1502 10-1" 17 18 19-1" 17 18 19-1" 17 23 14 10-1" 18 19-1" 11 18 19-1" 19-1" 11 19-1" 11 19-1" 11 19-1" 11 11 11-1" 12-1" 13 14 10-1" 11 11-1"	5 3522	3522									·	╁	7. 8"	Ι.,,	L	,			1		1_	┷	┸		7 7"	2	
5093 5268 6224 8.31 8.31 8.31 8.31 8.31 8.31 8.31 8.31 8.31 8.31 8.31 8.31 8.31 8.31 8.31 8.32 8.32 8.32 8.32 8.32 8.32 9.4 1 9.4 1 9.4 1 9.4 1 1 9.4 1 1 9.4 1	83.31 8 - 3" 7 83.31 8 - 7" 8 8 - 7" 8 92.25 9486 9-0" 9 9-0" 9 99.31 10480 1310 11390 10-1" 13 11360 12080 12300 12300 10-2" 10-1" 13 12040 12780 13490 14120 10-2" 10-2" 14 12040 12780 1480 1502 10-1" 13 15 1380 1480 1502 1502 10-1" 11 13 1380 1480 1502 1500 10-1" 13 16 1380 1480 1500 1500 10-1" 11 11 23 1480 1500 1520 1480 10-40 10-1" 11 12 15210 1680 1500 20240 2040 10-1" 20 11-1" 12 15210 1680		4368											8'- 0"	_	1368										7:-11"	9	
6.374 6142 6226 8.77 8.77 6.934 7.846 8331 8.36 925 9486 9.47 7.593 8136 8680 925 9486 92.9 9.11 8176 8768 9360 9953 11480 11300 1200 100-17 100-17 9244 9383 1060 11300 12300 12300 100-17 100-17 100-17 9832 10570 11300 12040 12780 1480 1500 100-18 100-17 100-18 100	8331 86.7" 8 9225 9486 9.0" 9 9953 10480 9.0" 9 10660 13140 11390 11390 10.1" 13 11360 12050 12300 100.2" 10.1" 13 12040 12780 13490 14120 10.2" 10.2" 14 12040 12780 13490 14120 160.2" 10.2" 10.2" 11 13 1350 14180 1500 1500 10.2" 10.2" 10.2" 11 12 14 10.2" 10.2" 10.2" 14 10.2" 10.2" 10.2 11 12 14 10.2" 10.2 11 12 14 12 14 10.2 10.2 10.2 11 12 14 12 14 12 14 12 14 12 14 12 14 12 14 12 14 12 14 <t< td=""><th>5268</th><th>5268</th><td>5268</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>4)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>æ. 3.</td><td>_</td><td></td></t<>	5268	5268	5268											4)											æ. 3.	_	
6378 6824 7246 99.0 99.0 6994 7489 7486 8331 94.4 1 7593 8136 9325 9486 9255 9486 95.0 8176 8768 9360 9325 10480 100.1 100.1 1 9295 982 10670 11360 12040 12780 13210 10.2 10.5 1 10360 11400 11920 12700 13400 14120 10.5 1 10.5 1 10.5 1 10.5 1 10.5 1 10.5 10.	8331 96.0 97.0 99.4 10 9525 9486 97.4 10 1130 </td <th>5635 6031 6226</th> <th>6031 6226</th> <td>6031 6226</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>.6 - 8</td> <td>4)</td> <td></td> <td></td> <td>526</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td> <u>7</u></td> <td>∞</td> <td></td>	5635 6031 6226	6031 6226	6031 6226										.6 - 8	4)			526								<u>7</u>	∞	
6994 7488 7894 8331 9.4 9.4 7593 8136 8880 9225 9486 95.3 10.0 10.1 10.1 10.1 10.1 10.1 10.1 10.2 10.1 10.2 10.1 10.2 10.1 10.2	8331 96.4% 97.4% 10 9525 9486 9-9.7 11 9953 10480 11390 10.1 12 1060 11310 10.2 14 13 1060 12300 10.2 14 13 12040 12780 13210 10.2 16 17 13200 14180 1602 10.6 10.7 18 19 10.7 18 19 10.7 18 19 10.7 18 19 10.7 18 19 11.7 18 19 11.7 18 19 11.7 18 19 11.7 18 19 11.7 18 19 10.7 18 19 10.7 18 19 10.7 18 19 10.7 18 19 19 11.7 18 19 11.7 18 19 11.7 18 19 11.7 18 19 11.7 18 11	9 6242 6687 7132 7246	6687 7132	6687 7132										9'- 1"												9'- 0''	<u>б</u>	Н
7593 8136 8880 9225 9486 9528 910480 9521 9481 9511 <	9-11" 1750 1816 8689 9225 9486	7323 7816 8331	7323 7816 8331	7323 7816 8331	8331	8331								9 6.	_											9'- 4"	2	E
8176 8768 9360 9953 10480 8744 9383 10020 10300 1330 100.2 9825 9982 10670 1360 12780 13210 100.2 9832 10570 1300 12780 13210 100.2 100.2 10380 14180 1520 14180 1502 14180 100.6 100.5 11360 12230 1310 1380 14860 15740 15930 100.6 100.6 11340 12230 13400 1480 15210 1480 1500 100.6 100.7 100.7 11340 1220 1480 15210 1480 1520 1480 1680 1910 100.6 10.6 </td <td>10 - 2" 8176 8768 9360 10480 109 39 104 17 17 17 17 17 17 17 17 17 18 18 8748 19 10 36 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 47 16 10 47 16 10 47 16 10 47 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16<!--</td--><th>7398 7939 8481 9023 9486</th><th>7939 8481 9023 9486</th><td>7939 8481 9023 9486</td><td>9023 9486</td><td>9023 9486</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>9'-11"</td><td></td><td></td><td></td><td></td><td></td><td>486</td><td></td><td></td><td></td><td></td><td></td><td>.6</td><td>Ξ</td><td>G</td></td>	10 - 2" 8176 8768 9360 10480 109 39 104 17 17 17 17 17 17 17 17 17 18 18 8748 19 10 36 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 37 16 10 47 16 10 47 16 10 47 16 10 47 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16 16 </td <th>7398 7939 8481 9023 9486</th> <th>7939 8481 9023 9486</th> <td>7939 8481 9023 9486</td> <td>9023 9486</td> <td>9023 9486</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>9'-11"</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>486</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>.6</td> <td>Ξ</td> <td>G</td>	7398 7939 8481 9023 9486	7939 8481 9023 9486	7939 8481 9023 9486	9023 9486	9023 9486								9'-11"						486						.6	Ξ	G
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9832 10570 11300 12040 12780 14120 100-57 100-57 10360 1140 11920 12700 13490 14120 100-57 100-57 10860 11690 12520 13560 14860 15740 16830 100-77 100-77 11360 12520 13680 14860 1550 16460 16830 100-77 100-77 11360 12520 14860 1550 16460 1550 16920 1740 160-70 100-10 12760 13270 14240 15800 16820 1740 18640 160-10 100-10 13200 14260 15800 16840 18050 1960 2020 2040 111-0 13200 14260 1580 18650 1980 2040 111-0 111-0 13200 14260 1580 1860 1800 1900 2030 2040 111-0 14460 1520 <	10· 6" 9832 10570 13300 12040 13210 13210 13200 14180 14180 1520 14180 1520 14180 1520 14180 1520 14180 1520 14180 1520 14180 1520 14180 1520 1640 16530 1640 16830 10· 17 10· 17 10· 17 10· 17 11 12	14 8998 9679 10360 11050 11730 12300	9679 10360 11050 11730	9679 10360 11050 11730	11050 11730	11050 11730		12300							<u> </u>						300				-	10 2"	14) F
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11360 12230 13100 13980 14860 15740 16930 100-7 11840 12760 13680 14600 15530 16460 16830 17740 10-10 12760 13770 14240 15210 16180 17440 18640 18510 19540 10-11 13200 14260 15310 16380 17440 18510 19540 10-11 13200 14260 1530 16940 18650 1960 20280 20440 11-0 13600 15200 16840 18650 19800 20430 21640 14-1 11-1 1 11-1 1	11.1 1.1 1.2 1.1 1.2 1.	17 10450 11270 12090 12910 13740 14570 15020	11270 12090 12910 13740 14570	11270 12090 12910 13740 14570	12910 13740 14570	12910 13740 14570	14570		15020					10'-10"	Ξ						020	······································				6	17	CI
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* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot ▲ Transition loads (**bold type**) and widths based on Kµ—0.19, r_{sd}p—0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-17

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1	10'-0" 10'-6" 11'-0" 11'-6" 12'-0" 13'-0" 14'-0" 15'-0" WIDTH	5	.68	5660	9 -,6	7342 7735 9:-11"	8025 8517 8865 10'- 4"	8685 9224 9764 10061	9322 9908 10500 11080 11330	9937 10570 11200 11840 12440	10530 11210 11890 12570 13260 13440	11830 12560 13290 14020 14450	11660 12430 13200 13980 14750 15440	12200 13010 13830 14650 15470 16300 16440 12'- 1"	12710 13570 14430 15300 16170 17040 17430 12- 3"	13210 14120 15020 15930 16840 17760 18420	13700 14640 15590 16540 17500 18460 19410 12'- 6"	15150 16140 17140 18140 19140 20410	140 10 10040 10080 17720 18700 19810 21330	15470 16580 17700 18820 19950 21080 23370	17020 18180 19350 20520 21690 24060 24360 13'- 1"	17450 18650 19860 21070 22290 24740 25360 13'- 3"	17870 19110 20360 21610 22870 25410 26350 13'- 4"	17010 18270 19550 20840 22130 23430 26050 27330 13- 6 "	17360 18660 19980 21300 22640 23980 26680 28340 13-7"	17700 19040 20400 21760 23130 24510 27300 29310 13'- 9"	18030 19410 20800 22200 23610 25030 27900 30320 13'-10"	19760 21190 22630 24080 25540 28480 31300 13-11"	23040 24530 26030 29050 32110 32280 14'- 1"	24970 26500 29610 32740 33290 14'- 2"	23840 25400 26970 30150 33360 34270 14 '- 4"	30680 33970 35270 14'- 5 "	26220 27860 31190 34560 36240 14'- 6 "	

Table B-17 Continued

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TRENCH WIDTH AT TOP OF PIPE	13'-0"																					24360	25360			28340	29310		31300	32280	33290	34270	35050	35750	36440	37110	37780
OP OF	12'-0"															18420	19410	20410	21390	22380	23370	24060	24820	25560		26990	_	_	29050	29710	30360	31000	31620	32240	32840	33430	34020
AT T	116"	L											15440	16440	17430	18320	19110	19890	20650	21400	22130	22850	23560	24250			26250	26890	27520	28140	28740	29340	29920	30490	31060	31610	22150
MIDTH	111-0								11330	12440	13440	_	15060	15850	16630	17390	18130	18860	19580	20280	20970	21640							26000	26570	27140	27690	28230	28760	29280	29790	30200
V HO	10'-6"							10060		11950	12740	•	14270	15020	15740	16460	17160	17840	18510		19800	20430	21050	21650					24480	25010	25530	26040	26540	27030	27510	27980	00110
TREN	10.0.						8865	9770	10550	11310	12050		13490	14180	14860	15530	16180	16820	17440	18050	18650	19230		20360			21960		22970	23460	23940	24410	24870	25310	25750	26180	26600
	9-,6				8999	7735	8480	9225	9953	10660	11360	_		13350	13980	14600	15210	15800	16380	15830 16940	17490			19070					21470	21920	22360	22780	23200	23610	24010	24400	247BD
	06	3807	4707	2660	6233	7270	7984	8680	9360	10020	10670	11300	11920	12520	13100	13680	14240	14780	15310	15830	16340	16840	17320	17790	18250	18700	19130	19560	19980	20380	20780	21170	21550	21920	22280	22630	22970
ż	N E	3	7	<u>:</u>	. 4			9	0		 	. 4		7	 6	0	<u>.</u> .	<u>-</u>		3,			7		.6	-	 	-	5	3,		2.		60	6	 O	
▲ TRAN	NOLLIN WIDTH	8	80	8'-11"	6	6		6	10'-10"	11.	11:	11:-			1:	11'-10"		12'-				12.	12'-	12.	12.		13,		13		13.	13.	13,	13,	13.	13'-10"	12',11'
	15:-0:																																				

For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

d

2469d 2520d

2309d

3000d

2253d

▲ Transition loads **(bold type)** and widths based on $K\mu$ —0.19, $r_{sd}p$ —0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

O

14'-0"

13'-0"

12:-0...

11.-6"

11.0..

10.-6"

10-0"

.9-6

9'-0"

TRENCH WIDTH AT TOP OF PIPE ORDINARY CLAY Ku'-0.130

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET

2076d

Table B-18

		Z.	9	2	. 00		HE º º	E10	⊣ £ ∞	TI ص	0	F	В	A(°E K	FI 6	LL 8	. -	55 7	13 13 13	24 0	25 SE	. T	27 0	28 A	23 O	30 02	ع PI	95 35	<u>.</u> ,	¥	35 H	T %	37	38
TRAN-	WIDTH	8:-11.	9- 3"	9 8	10 0	10'- 5"	10'- 9" 1	11:- 2" 1	11: 7" 1	2'- 0''	12'- 3" 1	12'- 5" 1	12'- 7" 1	12'- 9" 1	12'-11"	13'- 0" 1	5			٥		 6	<u>-</u>	 	14'- 1" 2	5	. 4	5.	<u>.</u> _	14'- 8" 3	14'- 9" 3	14'-10" 3	15'- 0" 3	-	15'- 2"
1	160"				-	=	=	Ī	_	-	-	-	Ī	-	-	-	-	Ë	<u>+</u>	-	-	=		-	<u>-</u>	_	-	,	<u>-</u>	-	<u> </u>	_	-	<u> </u>	
	2.0.,														•										29760	30840	31910	32990	34060	35150	36200	37310	38350	39220 3	39920 40540
PIPE	Ε-																21110	22200	23270	24360	25420	26520	27590							33120 3	33800	34470 3	35130		26200
OP OF	130 140						-				14590	15690	16780	17860	18950	20030	20820	21640				24700	25420	26120	26810	27480		28790	29410	30030	30630	31220	31790	32350	20000
AT TO	12:-0									13340	14170	15010	15820	16620	17390	18150		19600						23560	24160	24750		25890	26430	26960	27480	27990	28480	28970	00110
TRENCH WIDTH AT TOP OF PIPE	11'-6"							┖		12680	13490	14280	15040		16520	17230	17920	18590												25440	25920	26390	26850		01100
NCH \	11:-0	_				_	9417			12040	12800	13540	14260		15650	16310	16960						20480) 23940	24380	24800	25220		00000
TRE	901			_	_	7 8239	9 9133	9 9911	0 10670	0 11400	0 12120	0 12810	0 13480	0 14140	0 14780	0 15400	0 16000	0 16580					0 19270	0 19760					0 22020	0 22440	0 22840	0 23230	0 23610		0,000
	.001	7		90909	5 7121	2 7887				0 10760	0 11430	0 12080	0 12710		0 13910	0 14480	0 15040	15580												.0 20950	0 21310	0 21670	0 22010		01000
	96	4097	5053	9969	6715	7442	8146	8828	9488	0130	0750	1350	1930	2500	3040	13570	4090	4580	15060	5530	15980	16420	6850	17260	17660	18040	8420	18780	19130	19470	19800	20120	20430	7	C
		ļ			***			<u> </u>				-	-		<u> </u>	÷	1	1,		÷	_	-1		_	_				_	_	-	2	5	20	
TRAN-	WIDTH	06	9 4"	9 9	1	901	10:-11"	1 4"		12:- 2"	9.				-	<u>ښ</u>	.4					-	5	<u>ښ</u>		9		<u>.</u> .6		15'- 0"	-	 			į
ATRAN-		.,0 -,6			10 1	10 6	10'-11"			12:- 2"					-	ن	.4		7		_	.o	5	<u>ښ</u>	<u> </u>					0	15- 1"	15 3"	15'- 4"	15 5"	
ATRAN-	160	.,0 -,6			10 1	10,- 6"	10,-11			12'- 2"	9.				-	<u>ښ</u>	.4					14'- 0"	14'- 2"	14'- 3"	14'- 5"	14'- 6"	14'- 8"	14'- 9"	1410	15'- 0"	15- 1"	37310 15- 3"	15'- 4"	39450 15'- 5"	
PIPE	-	.,0 -,6			10 1.	10'- 6"	10:-11"			12 2"	9.				-	20030 13'- 3"	21110 13'- 4"	13 6"	23270 13'- 7"	24360 13'- 9"	13'-11"	520 14'- 0"	27210 27590 14'- 2"	27960 28670 14'- 3"	28700 29760 14'- 5"	410 30840 14'- 6" 1	110 31910 14'- 8"	790 32990 14'- 9"	31460 34060 14'-10"	32110 35150 15'- 0 "	-	360 36610 37310 15 - 3"	33970 37300 38350 15- 4 "	34560 37970 39450 15:- 5 "	
OF PIPE ▲	130" 140" 150" 160"	.,0 -,6			10 1	10 6	10,-11			13340 12'-	14590 12'- 6"	15690 12'- 8"	16780 12'-10"	17860 12'-11"	18780 18950 13'- 1" 1	19600 20030 13'- 3"	20390 21110 13- 4"	21160 22200 13'- 6"	21910 23270 13'- 7" 1	22650 24360 13'- 9"	23360 25420 13'-11"	24060 26520 14'- 0"	24740 27210 27590 14'- 2 "	25410 27960 28670 14'- 3"	26050 28700 29760 14'- 5"	26680 29410 30840 14'- 6 " 1	27300 30110 31910 14'- 8"	27900 30790 32990 14'- 9 "	28480 31460 34060 14'-10 "	29050 32110 35150 15'- 0 "	29610 32740 35910 36200 15 '- 1"	30150 33360 36610 37310 15'- 3"	30680 33970 37300 38350 15'- 4"	31190 34560 37970 39450 15- 5"	. L. C. L. C. C. C. T. C.
OF PIPE ▲	12'-0" 13'-0" 14'-0" 15'-0" 16'-0"	.,0 -,6			10 1	10 6"	10,-11		11960	13120 13340 12:-	13940 14590 12'- 6" 1	14750 15690 12:- 8"	15530 16780 12'-10"	16300 17860	17040 18780 18950 13'- 1" 1	17760 19600 20030 13'- 3"	18460 20390 21110 13'- 4"	19140 21160 22200 13'- 6"	19810 21910 23270 13'- 7"	20450 22650 24360 13'- 9"	21080 23360 25420 13'-11"	21690 24060 26520 14'- 0"	22290 24740 27210 27590 14'- 2 "	22870 25410 27960 28670 14'- 3"	23430 26050 28700 29760 14'- 5"	23980 26680 29410 30840 14'- 6" 1	24510 27300 30110 31910 14'- 8"	25030 27900 30790 32990 14'- 9"	25540 28480 31460 34060 14'-10 "	26030 29050 32110 35150 15'- 0 "	26500 29610 32740 35910 36200 15 '- 1"	26970 30150 33360 36610 37310 15'- 3"	27420 30680 33970 37300 38350 15- 4"	27860 31190 34560 37970 39450 15:- 5 "	
OF PIPE ▲	11'-6" 12'-0" 13'-0" 14'-0" 15'-0" 16'-0"	06			10 1	10 6.'		10660	11670 11960 111-	12480 13120 1 3340 12	13260 13940 14590 12'- 6 "	14020 14750 15690	14750 15530 1 6780 12'-10"	15470 16300 17860	16170 17040 18780 18950 13'- 1"	16840 17760 19600 20030 13'- 3"	17500 18460 20390 21110 13'- 4"	18140 19140 21160 22200 13'- 6"	18760 19810 21910 23270 13'- 7"	19360 20450 22650 24360 13'- 9"	19950 21080 23360 25420 13'-11"	20520 21690 24060 26520 14'- 0 "	21070 22290 24740 27210 27590 14'- 2"	21610 22870 25410 27960 28670 14'- 3"	22130 23430 26050 28700 29760 14'- 5"	22640 23980 26680 29410 30840 14'- 6"	23130 24510 27300 30110 31910 14'- 8"	23610 25030 27900 30790 32990 14'- 9"	24080 25540 28480 31460 34060 14'-10"	24530 26030 29050 32110 35150 15'- 0"	24970 26500 29610 32740 35910 36200 15 '- 1"	25400 26970 30150 33360 36610 37310 15'- 3"	25810 27420 30680 33970 37300 38350 15- 4 "	26220 27860 31190 34560 37970 39450 15'- 5"	
OF PIPE ▲	11'-0" 11'-6" 12'-0" 13'-0" 14'-0" 15'-0" 16'-0"	.,0 -,6					9417	10310 10660 11:-	11080 11670 11960 11-	11840 12480 13120 1 3340 12.	12570 13260 13940 14590 1	13290 14020 14750 15690	13980 14750 15530 16780	14650 15470 16300 17860	15300 16170 17040 18780 18950 13'- 1" 1	15930 16840 17760 19600 20030 13'- 3"	16540 17500 18460 20390 21110 13'- 4"	17140 18140 19140 21160 22200 13'- 6"	17720 18760 19810 21910 23270 13'- 7"	18280 19360 20450 22650 24360 13'- 9"	18820 19950 21080 23360 25420 13'-11"	19350 20520 21690 24060 26520 14'- 0"	19860 21070 22290 24740 27210 27590 14'- 2"	20360 21610 22870 25410 27960 28670 14- 3"	20840 22130 23430 26050 28700 29760 14'- 5"	21300 22640 23980 26680 29410 30840 14'- 6 " 1	21760 23130 24510 27300 30110 31910 14'- 8"	22200 23610 25030 27900 30790 32990 14'- 9"	22630 24080 25540 28480 31460 34060 14'-10"	23040 24530 26030 29050 32110 35150 15: 0"	23440 24970 26500 29610 32740 35910 36200 15 - 1"	23840 25400 26970 30150 33360 36610 37310 15- 3"	24210 25810 27420 30680 33970 37300 38350 15'- 4"	24580 26220 27860 31190 34560 37970 39450 15:- 5 "	" L. C. L. COOO O. T. C. COOO O. COOO O. C.
PIPE	" 10'-6" 11'-0" 11'-6" 12'-0" 13'-0" 14'-0" 15'-0" 16'-0"	.0 -6		-,6	7121	8239	9010 9417	9764 10310 10660 11:-	10500 11080 11670 11960 111-	11200 11840 12480 13120 13340 12.	11890 12570 13260 13940 14590	12560 13290 14020 14750 15690 12: 8 "	13200 13980 14750 15530 16780 12'- 10 "	13830 14650 15470 16300 17860	15300 16170 17040 18780 18950 13'- 1" 1	15020 15930 16840 17760 19600 20030 13- 3 "	15590 16540 17500 18460 20390 21110 13'- 4"	16140 17140 18140 19140 21160 22200 13- 6 "	16680 17720 18760 19810 21910 23270	17190 18280 19360 20450 22650 24360 13'- 9"	17700 18820 19950 21080 23360 25420 13'-11"	18180 19350 20520 21690 24060 26520 14'- 0"	18650 19860 21070 22290 24740 27210 27590 14'- 2"	19110 20360 21610 22870 25410 27960 28670 14'- 3"	19550 20840 22130 23430 26050 28700 29760 14'- 5"	19980 21300 22640 23980 26680 29410 30840 14'- 6" 1	20400 21760 23130 24510 27300 30110 31910 14'- 8"	20800 22200 23610 25030 27900 30790 32990 14'- 9"	21190 22630 24080 25540 28480 31460 34060 14-10"	21570 23040 24530 26030 29050 32110 35150 15'- 0"	21930 23440 24970 26500 29610 32740 35910 36200 15:- 1 "	22290 23840 25400 26970 30150 33360 36610 37310 15:- 3"	22630 24210 25810 27420 30680 33970 37300 38350 15- 4 "	22960 24580 26220 27860 31190 34560 37970 39450 15'- 5"	"C .1. C. 10. C.
OF PIPE ▲	10'-0" 10'-6" 11'-0" 11'-6" 12'-0" 13'-0" 14'-0" 15'-0" 16'-0"		-6	-,6 0909	7031 7121	7786 8239	8517 9010 9417	9224 9764 10310 1 0660 11:-	9908 10500 11080 11670 11960	10570 11200 11840 12480 13120 13340 12-	11210 11890 12570 13260 13940 1 4590	11830 12560 13290 14020 14750 1 5690 12 8"	12430 13200 13980 14750 15530 16780	13010 13830 14650 15470 16300 17860	13570 14430 15300 16170 17040 18780 18950 13: 1"	14120 15020 15930 16840 17760 19600 20030 13'- 3"	14640 15590 16540 17500 18460 20390 21110 13'- 4 "	15150 16140 17140 18140 19140 21160 22200 13'- 6"	15640 16680 17720 18760 19810 21910 23270	16120 17190 18280 19360 20450 22650 24360 13'- 9"	16580 17700 18820 19950 21080 23360 25420 13:-11"	17020 18180 19350 20520 21690 24060 26520 14'- 0"	17450 18650 19860 21070 22290 24740 27210 27590 14'- 2"	17870 19110 20360 21610 22870 25410 27960 28670 14- 3"	18270 19550 20840 22130 23430 26050 28700 29760 14-5"	18660 19980 21300 22640 23980 26680 29410 30840 14'- 6"	19040 20400 21760 23130 24510 27300 30110 31910 14- 8"	19410 20800 22200 23610 25030 27900 30790 32990 14'- 9"	19760 21190 22630 24080 25540 28480 31460 34060 14:-10 "	20100 21570 23040 24530 26030 29050 32110 35150 15: 0"	20440 21930 23440 24970 26500 29610 32740 35910 36200 15:- 1 "	20760 22290 23840 25400 26970 30150 33360 36610 37310 15- 3"	21060 22630 24210 25810 27420 30680 33970 37300 38350 15'- 4"	21360 22960 24580 26220 27860 31190 34560 37970 39450 15- 5 "	00000 0000 0000 0000 0000 0000 0000 0000
OF PIPE ▲	-0" 10'-6" 11'-0" 11'-6" 12'-0" 13'-0" 14'-0" 15'-0" 16'-0"	4097		-, 6 0909 E069	6635 7031 7121	7342 7786 8239	8025 8517 9010 9417	9764 10310 10660 11:-	10500 11080 11670 11960 111-	9937 10570 11200 11840 12480 13120 13340	10530 11210 11890 12570 13260 13940 1 4590 1	11110 11830 12560 13290 14020 14750 1 5690	11660 12430 13200 13980 14750 15530 1 6780	12200 13010 13830 14650 15470 16300 17860	12710 13570 14430 15300 16170 17040 18780 18950	15020 15930 16840 17760 19600 20030 13- 3 "	13700 14640 15590 16540 17500 18460 20390 21110 13'- 4"	16140 17140 18140 19140 21160 22200 13- 6 "	14610 15640 16680 17720 18760 19810 21910 23270 13'- 7"	15050 16120 17190 18280 19360 20450 22650 24360 13'- 9"	15470 16580 17700 18820 19950 21080 23360 25420 13-11"	15870 17020 18180 19350 20520 21690 24060 26520 14- 0 "	16260 17450 18650 19860 21070 22290 24740 27210 27590 14'- 2 "	16640 17870 19110 20360 21610 22870 25410 27960 28670 14'- 3"	18270 19550 20840 22130 23430 26050 28700 29760 14-5"	18660 19980 21300 22640 23980 26680 29410 30840 14'- 6 "	17700 19040 20400 21760 23130 24510 27300 30110 31910 14'- 8"	18030 19410 20800 22200 23610 25030 27900 30790 32990 14- 9 "	19760 21190 22630 24080 25540 28480 31460 34060 14:-10 "	21570 23040 24530 26030 29050 32110 35150 15'- 0"	18950 20440 21930 23440 24970 26500 29610 32740 35910 36200 15 - 1"	22290 23840 25400 26970 30150 33360 36610 37310 15:- 3"	22630 24210 25810 27420 30680 33970 37300 38350 15- 4 "	21360 22960 24580 26220 27860 31190 34560 37970 39450 15- 5 "	10 11 10 100 000 01 110 000 01 000 01 000 01 000 00

Table B-18 Continued

	ATRAN-	WIDTH	8; 6; 6;	9-10	.6 -,6		10'- 5"	1010	11'- 2"	11: 7"	11'-10"	12 0							12-8	01-21	13'. 0"		13'- 3"	13'- 3"			13'- 6''			13'- 9"	13'-11"		14- 0			14- 3
		-0." 16'-0"																																40540	41590	42680
10	PIPE	4'-0" 15'-0"																				27590	0298	0926	30840	31910	32990	4060	15150	36200	7310	38350				415/0 42
µ'-0.1	P OF	12'-0" 13'-0" 14'-0"											16780	17860	18950	20030	21110	22200	23270	24360	26520		28170 28670	28990 29760	29790 3		31360 3	32120 34060	32870 35150	33610 3	34330 37310	35050 3	35750 39450	31060 32840 36440 40060	37110 4	377804
LAY K	AT TC	120								13240 13340		Σ.		17530	18400	19250	20090	20920	21720	22520	23300	24820	25560	26280	26990	27690	28380	29050	29710	30360	31000	31620	32240	32840	33430	34020
TED C	MIDTH	11'-6"						_			14124	-				18320		19890			22130			24930	25600				28140				30490			32150
SATURATED CLAY Kµ'-0.110	TRENCH WIDTH AT TOP OF PIPE	" 11'-0"				6		-										0 18860	0 19580		0 20970		0 22950	0 23580	00 24 200	30 24820	22470 23940 25410	30 26000	23460 25010 26570	30 27140	10 27690	26540 28230	30 28760			30290
/S	TRE)" 10'-6"			21	8165 8239	8976 9417				· -	80 13520								50 19160	20 19800			00 22240	40 22820	60.23380	70 2394	22970 24480	60 2501		10 26040	70 2654	25310 27030	25750 27510		00 28440
•		9'-6" 10'-0"	4097	0909	6937 7121	7717 81		_				12040 12780		13350 14180						16940 18050	17490 18650	18560 19800		19570 20900	20060 21440						22780 24410		23610 253			24780 26600
۵ ا		-,6	4 2	, <u>w</u>	9	7.	8	6	ői	10	=	15(15.		13	74	15,	- 15 <u>.</u>	9	9	7 6	2 0	0	19	50	8	21	5	21	22	22	23	23	24	24	24 Jubic foo
	ATRAN-	WIDTH	8'-10"	9. 6	9'-11"	10'- 3"	10'- 8"	11'- 0"	11'- 5"	11'-10"	12'- 1"	12 3	12'- 4"	12 6	12:- 7"	12 9"	12'-10"	12:-11"	13'- 1"	13'- 2"	13-3	13'-6	13'- 7"	13'- 8"	13'- 9"	13'-11"	14'- 0"	14:- 1::	14'- 2"	14'- 3"	14'- 5"	14'- 5"	14'- 7"	14'- 8"	14'- 9"	0 35790 39520 42680 14:10" 24780 26600 28440
		16'-0"																																		130 001
		15'-0"																						_	_	_		34060	35150	36200	37310		0 39450	38160 40540	0 41590	42680
0	1 1									-							_		0	0						0	0	0			OI		Ō	16	38850	39520
13	: PIPE)" 14'-0"									00	00	06	9	0	8	0				30 25420			70 29760	10 30840	3 19 10	32990	33780	34540	35290	20 36030	30 36750				<u>و</u> ا
ζμ′—0.130	OP OF PIPE	-0" 13'-0" 14'-0"								_	_	_	_			$\overline{}$	_1	22200	23140	23970	24780	26360	27120	27870	28610	27900	28560	30720 33780	31400 34540	32070 35290	32720	33360	33390	34600	35200	ōl"
٠	H AT TOP OF PIPE	12'-0"								13340	14490	15370	16220	17060	17890	18690	19480	20240 22200	21000 23140	21740 23970	22460 24780	26360	27120	25190 27870	25840 28610	26470 27900	28560	27700 30720 33780	28290 31400 34540	28870 32070 35290	32720	33360	33390	31070 34600	31590 35200	ōl"
٠	WIDTH AT TOP OF PIPE	11'-6" 12'-0"					9417		11960	12950 13340	13800 14490	14630 15370	15440 16220	16230 17060	17000 17890	17760 18690	18500 19480	19230 20240 22200	19930 21000 23140	20620 21740 23970	21300 22460 24780	22610 23850 26360	23240 24530 27120	23860 25190 27870	24460 25840 28610	25050 26470 27900	25630 27090 28560	26190 27700 30720 33780	26740 28290 31400 34540	27280 28870 32070 35290	27810 29440 32720	28320 30000 33360	28830 30540 33990	29320 31070 34600	29800 31590 35200	ōl"
ORDINARY CLAY Kµ'-0.13	ENCH WIDTH AT TOP OF PIPE	11'-0" 11'-6" 12'-0"				8239		10660	11490 11960	12310 12950 13340	13110 13800 14490	13890 14630 15370	14650 15440 16220	15400 16230 17060	16130 17000 17890	16840 17760 18690	17530 18500 19480	18210 19230 20240 22200	18870 19930 21000 23140	19520 20620 21740 23970	20150 21300 22460 24780	21370 22610 23850 25380	21950 23240 24530 27120	22530 23860 25190 27870	23090 24460 25840 28610	23640 25050 26470 27900	24170 25630 27090 28560	24690 26190 27700 30720 33780	25200 26740 28290 31400 34540	25700 27280 28870 32070 35290	26190 27810 29440 32720	26660 28320 30000 33360	27130 28830 30540 33990	27580 29320 31070 34600	28020 29800 31590 35200	ōl"
٠	TRENCH WIDTH AT TOP OF PIPE	11'-6" 12'-0"			7121	8024	8805 9300	9566 10110 10660	10310 10900 11490 11960	11030 11670 12310 12950 13340	11730 12420 13110 13800 14490	12420 13160 13890 14630 15370	13090 13870 14650 15440 16220	13740 14570 15400 16230 17060	14370 15250 16130 17000 17890	14990 15910 16840 17760 18690	15600 16560 17530 18500 19480	16180 17190 18210 19230 20240 22200	16750 17810 18870 19930 21000 23140	17310 18410 19520 20620 21740 23970	17850 19000 20150 21300 22460 24780	18360 19370 20700 21900 23160 23360	19400 20670 21950 23240 24530 27120	19890 21200 22530 23860 25190 27870	20370 21720 23090 24460 25840 28610	20830 22230 23640 25050 26470 27900	21280 22720 24170 25630 27090 28560	21720 23200 24690 26190 27700 30720 33780	22150 23670 25200 26740 28290 31400 34540	22570 24130 25700 27280 28870 32070 35290	22980 24580 26190 27810 29440 32720	23380 25020 26660 28320 30000 33360	25440 27130 28830 30540 33990	25860 27580 29320 31070 34600	24510 26260 28020 29800 31590 35200	ōl"
٠	TRENCH WIDTH AT TOP OF PIPE	10'-6" 11'-0" 11'-6" 12'-0"		0909 2	6825	7578 8024	8310 8805 9300	9023 9566 10110 10660	9717 10310 10900 11490 11960	10390 11030 11670 12310 12950 13340	11050 11730 12420 13110 13800 14490	12420 13160 13890 14630 15370	12310 13090 13870 14650 15440 16220	12910 13740 14570 15400 16230 17060	13500 14370 15250 16130 17000 17890	14070 14990 15910 16840 17760 18690	14630 15600 16560 17530 18500 19480	15170 16180 17190 18210 19230 20240 22200	15700 16750 17810 18870 19930 21000 23140	16210 17310 18410 19520 20620 21740 23970	19000 20150 21300 22460 24780	17670 18900 20130 20100 21800 23100 23380 17670 18900 20130 21370 22610 23850 26360	18130 19400 20670 21950 23240 24530 27120	18580 19890 21200 22530 23860 25190 27870	19020 20370 21720 23090 24460 25840 28610	19440 20830 22230 23640 25050 26470 27900	19850 21280 22720 24170 25630 27090 28560	20250 21720 23200 24690 26190 27700 30720 33780	22150 23670 25200 26740 28290 31400 34540	21020 22570 24130 25700 27280 28870 32070 35290	21390 22980 24580 26190 27810 29440 32720	21750 23380 25020 26660 28320 30000 33360	25440 27130 28830 30540 33990	22440 24140 25860 27580 29320 31070 34600	22770 24510 26260 28020 29800 31590 35200	26660 28460 30270 3210

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. A Transition loac(s (**bold type**) and widths based on Kμ-0.19, r_{Sd}p-0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-19

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PIPE	111-6" 12-0" 13-0" 14-0" 15-0" 16-0" 17-0" WIDTH	96		10,- 3,-	10. 8	8739	9966	10850 11250	11670 12260 12600	12480 13120 1 4020 12'- 9"	13260 13940 15320 15510 13'- 2"	14020 14750 16220 16890 13'- 5"	14750 15530 17090 18080 13'- 7"	15470 16300 17950 19250	16170 17040 18780 20430 13:-11"	16840 17760 19600 21440 21600 14'- 1 "	17500 18460 20390 22320 22780 14'- 3"	18140 19140 21160 23190 23940 14'- 5"	18760 19810 21910 24030 25110 14: 6 "	19360 20450 22650 24860 26280	1995U 2108U 2335U 2555U 2745U 14- 9"	21070 22290 24740 27210 29780 15- 0"	21610 22870 25410 27960 30540 30940 15'- 2"	22130 23430 26050 28700 31360 32120 15'- 3"	22640 23980 26680 29410 32160 33280 15'- 5 "	23130 24510 27300 30110 32940 34460 15- 6"	23610 25030 27900 30790 33710 35600 15'- 7"	24080 25540 28480 31460 34460 36770 15'- 9"	24530 26030 29050 32110 35190 37950 15:11 "	24970 26500 29610 32740 35910 39100 16'- 0 "	25400 26970 30150 33360 36610 39890 40290 16'- 1"	25810 27420 30680 33970 37300 40660 41460 16'- 3"	26220 27860 31190 34560 37970 41410 42600 16 - 4 "	26610 28290 31690 35140 38630 42150 43760 16: 5 "	27360 29110 32660 36260 39900 43580 46100 16- 8 "
	SITION 11'-0" 12'-0" 13'-0" 14'-0" 15'-0" 16'-0" 17'-0" WIDTH	96		10, 3"	7570	8676 8739 11- 1"	9503 9966 11'- 6"	10310 10850 11250 111:41"	11080 11670 12260 12600 12: 3"	11840 12480 13120 1 4020	12570 13260 13940 15320 15510 13: 2"	13290 14020 14750 16220 16890	13980 14750 15530 17090 18080 13'- 7 "	14650 15470 16300 17950 19250	15300 16170 17040 18780 20430	15930 16840 17760 19600 21440 21600 14'- 1"	16540 17500 18460 20390 22320 22780 14'- 3"	18140 19140 21160 23190 23940 14'- 5"	17720 18760 19810 21910 24030 25110 14: 6"	1828U 1936U 2045U 2265U 2486U 2628U	18820 19930 21080 23380 23860 27450 14- 9"	19860 21070 22290 24740 27210 29780 15: 0 "	20360 21610 22870 25410 27960 30540 30940 15'- 2"	20840 22130 23430 26050 28700 31360 32120 15'- 3"	21300 22640 23980 26680 29410 32160 33280 15'- 5 "	21760 23130 24510 27300 30110 32940 34460 15'- 6"	22200 23610 25030 27900 30790 33710 35600 15'- 7"	22630 24080 25540 28480 31460 34460 36770 15'- 9"	23040 24530 26030 29050 32110 35190 37950 15:11"	23440 24970 26500 29610 32740 35910 39100 16'- 0"	23840 25400 26970 30150 33360 36610 39890 40290 16'- 1"	24210 25810 27420 30680 33970 37300 40660 41460 16- 3"	26220 27860 31190 34560 37970 41410 42600 16 - 4 "	24940 26610 28290 31690 35140 38630 42150 43760 16'- 5 "	25290 26990 28710 32180 35710 39270 42870 44940 16- 7 25620 27360 29110 32660 36260 39900 43580 46100 16- 8"
PIPE	106" 110" 116" 120" 130" 140" 150" 160" 170" WIDTH	.9 -6	9.11"	6457	7427 7570 10: 8"	8231 8676 8739	9010 9503 9966 11'- 6"	9764 10310 10850 1 1250	10500 11080 11670 12260 12600 12.3"	11200 11840 12480 13120 1 4020 1120 14020	11890 12570 13260 13940 15320 15510 13:- 2"	12560 13290 14020 14750 16220 16890 132- 5"	13200 13980 14750 15530 17090 18080	13830 14650 15470 16300 17950 19250	14430 15300 16170 17040 18780 20430	15020 15930 16840 17760 19600 21440 21600 144. 1 "	15590 16540 17500 18460 20390 22320 22780 14'- 3"	16140 17140 18140 19140 21160 23190 23940	16680 17720 18760 19810 21910 24030 25110 14. 6 "	17 19U 1828U 1936U 2445U 2265U 2486U 2628U	17.00 18820 18930 2380 2380 25860 27430 14: 9"	18650 19860 21070 22290 24740 27210 29780 15- 0"	19110 20360 21610 22870 25410 27960 30540 30940 15'- 2 "	19550 20840 22130 23430 26050 28700 31360 32120 15'- 3"	19980 21300 22640 23980 26680 29410 32160 33280 15'- 5"	21760 23130 24510 27300 30110 32940 34460 15'- 6"	22200 23610 25030 27900 30790 33710 35600 15'- 7"	21190 22630 24080 25540 28480 31460 34460 36770 15'- 9"	21570 23040 24530 26030 29050 32110 35190 37950 15:11"	21930 23440 24970 26500 29610 32740 35910 39100 16'- 0 "	23840 25400 26970 30150 33360 36610 39890 40290 16'- 1"	24210 25810 27420 30680 33970 37300 40660 41460 16- 3"	22960 24580 26220 27860 31190 34560 37970 41410 42600 16'- 4 "	24940 26610 28290 31690 35140 38630 42150 43760 16'- 5 "	25290 26990 28710 32180 35710 39270 42870 44940 16- 7 25620 27360 29110 32660 36260 39900 43580 46100 16- 8"
PIPE	SITION 11'-0" 12'-0" 13'-0" 14'-0" 15'-0" 16'-0" 17'-0" WIDTH	96	9.11"	6457	7427 7570	8231 8676 8739	9010 9503 9966 11'- 6"	9764 10310 10850 1 1250	10500 11080 11670 12260 12600 12.3"	11840 12480 13120 1 4020	12570 13260 13940 15320 15510 13: 2"	13290 14020 14750 16220 16890	13980 14750 15530 17090 18080 13'- 7 "	13830 14650 15470 16300 17950 19250	15300 16170 17040 18780 20430	15930 16840 17760 19600 21440 21600 14'- 1"	15590 16540 17500 18460 20390 22320 22780 14'- 3"	16140 17140 18140 19140 21160 23190 23940	16680 17720 18760 19810 21910 24030 25110 14. 6 "	1828U 1936U 2045U 2265U 2486U 2628U	17700 18820 18930 23380 23380 25860 27430	18650 19860 21070 22290 24740 27210 29780 15- 0"	19110 20360 21610 22870 25410 27960 30540 30940 15'- 2 "	19550 20840 22130 23430 26050 28700 31360 32120 15'- 3"	19980 21300 22640 23980 26680 29410 32160 33280 15'- 5"	21760 23130 24510 27300 30110 32940 34460 15'- 6"	22200 23610 25030 27900 30790 33710 35600 15:- 7"	21190 22630 24080 25540 28480 31460 34460 36770 15'- 9"	21570 23040 24530 26030 29050 32110 35190 37950 15:11"	21930 23440 24970 26500 29610 32740 35910 39100 16'- 0 "	23840 25400 26970 30150 33360 36610 39890 40290 16'- 1"	22630 24210 25810 27420 30680 33970 37300 40660 41460 16'- 3 "	26220 27860 31190 34560 37970 41410 42600 16 - 4 "	24940 26610 28290 31690 35140 38630 42150 43760 16'- 5 "	25290 26990 28710 32180 35710 39270 42870 44940 16- 7 25620 27360 29110 32660 36260 39900 43580 46100 16- 8 "
PIPE	106" 110" 116" 120" 130" 140" 150" 160" 170" WIDTH	4384	5395	6250 6457 10: 3"	7031 7427 7570	7786 8231 8676 8739	9010 9503 9966 11'- 6"	9764 10310 10850 1 1250	12 9908 10500 11080 11670 12260 12600 1200 1200 1200	13 10570 11200 11840 12480 13120 1 4020 12. 9 "	11890 12570 13260 13940 15320 15510 13:- 2"	15 11830 12560 13290 14020 14750 16220 16890 13°- 5"	12430 13200 13980 14750 15530 17090 18080 18080 132- 7"	17 13010 13830 14650 15470 16300 17950 19250 19250	14430 15300 16170 17040 18780 20430	19 14120 15020 15930 16840 17760 19600 21440 21600	14640 15590 16540 17500 18460 20390 22320 22780 14'- 3"	21 15150 16140 17140 18140 19140 21160 23190 23940 14:- 5"	22 15640 16680 17720 18760 19810 21910 24030 25110 14. 6 "	23 1012U 1719U 1828U 1836U 2045U 2248U 2248U 144- 8	17.00 18820 18930 2380 2380 25860 27430 14: 9"	26 17450 18650 19860 21070 22290 24740 27210 29780 15: 0 "	17870 19110 20360 21610 22870 25410 27960 30540 30940 15'- 2 "	28 18270 19550 20840 22130 23430 26050 28700 31360 32120 15'- 3"	29 18660 19980 21300 22640 23980 26680 29410 32160 33280 15· 5 "	30 19040 20400 21760 23130 24510 27300 30110 32940 34460 15'- 6"	19410 20800 22200 23610 25030 27900 30790 33710 35600 15: 7"	32 19760 21190 22630 24080 25540 28480 31460 34460 36770 15'- 9 "	33 20100 21570 23040 24530 26030 29050 32110 35190 37950 15:11 "	20440 21930 23440 24970 26500 29610 32740 35910 39100 16'- 0 "	35 20760 22290 23840 25400 26970 30150 33360 36610 39890 40290 16· 1''	36 21060 22630 24210 25810 27420 30680 33970 37300 40660 41460 16:- 3"	21360 22960 24580 26220 27860 31190 34560 37970 41410 42600 16- 4"	21660 23290 24940 26610 28290 31690 35140 38630 42150 43760 16'- 5 "	25290 26990 28710 32180 35710 39270 42870 44940 16- 7 25620 27360 29110 32660 36260 39900 43580 46100 16- 8"

Table B-19 Continued

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I AT TOP OF PIP	140" 15:-0"										16240	17690	18660	19610	20540	21440 23160	22320 24270	23 190 25220 25	24030 26160 26	24860	25000	27210 29700 31	27960 30540 33120	28700 31360	29410 32160	30110	30790	31460 34460	32110 35190	32740 35910	33360	33970	34560 37970 41410 44	35140 38630 42150 4
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TRENCH WIDTH AT TOP OF PIP	11'-6" 12'-0" 13'-0" 14'-0" 15'-0"			6597 6854	7823 8021	8231 8676 9121	9503 9997 10520	9764 10310 10850 11390	10500 11080 11670 12260 13250	11200 11840 12480 13120 14390	11890 12570 13260 13940 15320 16240	12560 13290 14020 14750 16220 17690	13200 13980 14750 15530 17090 18660	13830 14650 15470 16300 17950 19610	14430 15300 16170 17040 18780 20540	15020 15930 16840 17760 19600 21440 23160	15590 16540 17500 18460 20390 22320 24270	16140 17140 18140 19140 21160 23190 25220 25	1668U 1772U 1876U 1981U 2191U 2403U 2616U 26	17 190 18280 19360 20450 22650 24860	1995U Z 108U Z336U Z566U	18650 19860 21070 22290 24740 27210 29700 31	21610 22870 25410 27960 30540 33120	19550 20840 22130 23430 26050	19980 21300 22640 23980 26680 29410 32160	20400 21760 23130 24510 27300 30110	20800 22200 23610 25030 27900 30790	21190 22630 24080 25540 28480 31460 34460	21570 23040 24530 26030 29050 32110 35190	21930 23440 24970 26500 29610 32740 35910	22290 23840 25400 26970 30150 33360	22630 24210 25810 27420 30680 33970	22960 24580 26220 27860 31190 34560	38 23290 24940 26610 28290 31690 35140 38630 42150 4

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	TRAN-	WIDTH	10'- 0"			11'- 4"	11'- 9"	12'- 1"	12'- 6"	12'-11"	13'- 3"		14. 0	14'- 2"	14'- 3"	14'- 5"	9 14	14'- 8"	14'- 9"	14'-10"				15'- 4"					511	1.1.1		16 3"	16 - 4"	2 91	2	891
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-0.130	PE	15'-0" 16'-0" 17'-0" 18'-0"						12'- 1"		12'-11"	13'-	13'-	14'-	14'-	14'-	14'-	24420 14-	25680 14'-	26940 14'-	28200	29460	30430 30720 15	31400 319/0	32340 33230 15:-	33270 34470 15-	34190 35/40	35090 36970 15-	33970 30230	32200 40720	28540 41800 42000	39360 42710 43240	43610 44500 16'-	44490 45770 16-	45360 47010 16'-	46220 48270	43280 47060 49500 16'-
/ Kµ'—0.130	PE	16'-0" 17'-0" 18'-0"						12'- 1"		12:-11"	13'-	13'-	14'-	14'-	14'-	14'-	24420 14-	25680 14'-	26940 14'-	28200	29460	30430 30720 15	31400 319/0	32340 33230 15:-	33270 34470 15-	34190 35/40	35090 36970 15-	33970 30230	32200 40720	28540 41800 42000	39360 42710 43240	43610 44500 16'-	44490 45770 16-	45360 47010 16'-	46220 48270	43280 47060 49500 16'-
CLAY Kµ'—0.130	PE	14'-0" 15'-0" 16'-0" 17'-0" 18'-0"					-		12'-	12'-1	16240 13'-	17840 13-	19360 14'-	20410 20630 14'-	21420 21900 14'-	22410 23160 14'-	23390 24420	24340 25680 14'-	25280 26940 14'-	26200 28200	2/110 29460	28000 30430 30720	28870 31400 31970	29730 32340 33230 15.	30570 33270 34470 15:	31390 34190 35/40	35090 36970 15-	33970 30230	33750 38640 38490 34540 37700 40720	35290 28540 41800 42000	36030 39360 42710 43240	36750 40170 43610 44500 16'-	37460 40970 44490 45770	38160 41750 45360 47010 16'-	38850 42520 46220 48270	39520 43280 47060 49500 16'-
ARY CLAY Kμ'0.130	PE	13'-0" 14'-0" 15'-0" 16'-0" 17'-0" 18'-0"						11860	12'-	12'-1	16240 13'-	16850 17840 13'-	17800 19360 14'-	18730 20410 20630 14'-	19650 21420 21900 14:	20550 22410 23160 14'-	21430 23390 24420	22290 24340 25680 14'-	23140 25280 26940 14:-	23970 26200 28200	24/80 2/110 29460	25580 28000 30430 30720	2636U 288/U 3140U 319/U	27120 29730 32340 33230 15-	27870 30570 33270 34470 15-	28610 31390 34190 35/40 15-	29330 32200 35090 3 6970 15-	30030 33200 33370 30030	31400 34540 37700 40720	32070 35290 28540 41800 42000	32720 36030 39360 42710 43240	33360 36750 40170 43610 44500 16	37460 40970 44490 45770	34600 38160 41750 45360 47010 16:-	35200 38850 42520 46220 48270	35790 39520 43280 47060 49500 16'-
RDINARY CLAY Kµ'-0.130	PE	12'-0" 13'-0" 14'-0" 15'-0" 16'-0" 17'-0" 18'-0"				=	10520 11'-	11740 11860	12680 13250 12:-	13600 14710 12:-1	14490 15870 16240 13:-	15370 16850 17840 13'-	16220 17800 19360 14'-	17060 18730 20410 20630 14'-	17890 19650 21420 21900	18690 20550 22410 23160 14:-	19480 21430 23390 24420	20240 22290 24340 25680 14'-	21000 23140 25280 26940 14'-	21740 23970 26200 28200	22460 24780 27110 29460	23160 25580 28000 30430 30720 15-	23850 26360 28870 31400 31970	24530 27120 29730 32340 33230 15-	25190 27870 30570 33270 34470	25840/ 28610/ 31390/ 34190/ 35/ 40	2564/U 2933U 3220U 3509U 369/U 15-	27090 50000 50000 50370 50500 50500 50500	27 700 307 20 337 60 36640 33490	28870 32070 35290 28540 41800 42000	29440 32720 36030 39360 42710 43240	30000 33360 36750 40170 43610 44500 16:-	30540 33990 37460 40970 44490 45770	31070 34600 38160 41750 45360 47010 16:-	31590 35200 38850 42520 46220 48270	32100 35790 39520 43280 47060 49500 16'-
ORDINARY CLAY Kµ'-0.130	PE	11'-6" 12'-0" 13'-0" 14'-0" 15'-0" 16'-0" 17'-0" 18'-0"		-01	111-	9242	10290 10520 111-	11200 11740 11860	12090 12680 13250 12	12950 13600 14710 12'-1	13800 14490 15870 16240 13:-	14630 15370 16850 17840 13'-	15440 16220 17800 19360 14'-	16230 17060 18730 20410 20630 14'-	17000 17890 19650 21420 21900	17760 18690 20550 22410 23160 14'-	18500 19480 21430 23390 24420	19230 20240 22290 24340 25680 14'-	19930 21000 23140 25280 26940 14'-	20620 21740 23970 26200 28200	21300 22460 24780 27110 29460	23160 25580 28000 30430 30720 15-	23850 26360 28870 31400 31970	23240 24530 27120 29730 32340 33230 15-	23860 25190 27870 30570 33270 34470	24460 25840 28610 31390 34190 35740	25050 26470 29330 32200 35090 36970 15-	23030 27030 33000 33000 30300 30400	26740 28290 34400 34540 37700 40720	27280 28870 32070 35290 28540 41800 42000	27810 29440 32720 36030 39360 42710 43240	28320 30000 33360 36750 40170 43610 44500 16'-	28830 30540 33990 37460 40970 44490 45770	29320 31070 34600 38160 41750 45360 47010 16'-	29800 31590 35200 38850 42520 46220 48270	30270 32100 35790 39520 43280 47060 49500 16'-
ORDINARY CLAY Kµ'-0.130		111-0" 111-6" 12-0" 13-0" 14-0" 15-0" 16-0" 17-0" 18-0"	-01	6854	8021	8917 9242 111.	9796 10290 10520 111-	10650 11200 11740 11860	11490 12090 12680 13250 12.	12310 12950 13600 1 4710 12:-1	13110 13800 14490 15870 16240 13:-	13890 14630 15370 16850 17840	14650 15440 16220 17800 19360	16230 17060 18730 20410 20630 14'-	16130 17000 17890 19650 21420 21900	16840 17760 18690 20550 22410 23160 14'-	17530 18500 19480 21430 23390 24420	18210 19230 20240 22290 24340 25680	18870 19930 21000 23140 25280 26940 14'-	19520 20620 21740 23970 26200 28200	20150 21300 22460 24780 27110 29460 15-	20/60 21960 23160 25580 28000 30430 30720	213/0 22610 23850 26360 288/0 31400 319/0	21950 23240 24530 27120 29730 32340 33230 15-	22530 23860 25190 27870 30570 33270 34470 15-	23090 24460 25840 28610 31390 34190 35740	2364U 25U5U 2647U 2933U 3220U 35U9U 3697U 15-	24 170 23030 27030 30030 33000 33370 30400	25200 26740 28290 31400 34540 37700 40720	25700 27280 28870 32070 35290 28540 41800 42000	26190 27810 29440 32720 36030 39360 42710 43240	26660 28320 30000 33360 36750 40170 43610 44500 16'-	27130 28830 30540 33990 37460 40970 44490 45770	27580 29320 31070 34600 38160 41750 45360 47010 16'-	28020 29800 31590 35200 38850 42520 46220 48270	28460 30270 32100 35790 39520 43280 47060 49500 16'-
ORDINARY CLAY Kµ'-0.130	PE	11'-6" 12'-0" 13'-0" 14'-0" 15'-0" 16'-0" 17'-0" 18'-0"		6854	8021	9242	10290 10520 111-	11200 11740 11860	12090 12680 13250 12	12950 13600 14710 12'-1	13800 14490 15870 16240 13:-	13890 14630 15370 16850 17840 13:-	14650 15440 16220 17800 19360	16230 17060 18730 20410 20630 14'-	16130 17000 17890 19650 21420 21900	17760 18690 20550 22410 23160 14'-	17530 18500 19480 21430 23390 24420	18210 19230 20240 22290 24340 25680	18870 19930 21000 23140 25280 26940 14'-	19520 20620 21740 23970 26200 28200	20150 21300 22460 24780 27110 29460 15-	20/60 21960 23160 25580 28000 30430 30720	213/0 22610 23850 26360 288/0 31400 319/0	21950 23240 24530 27120 29730 32340 33230 15-	22530 23860 25190 27870 30570 33270 34470 15-	23090 24460 25840 28610 31390 34190 35740	25050 26470 29330 32200 35090 36970 15-	24 170 23030 27030 30030 33000 33370 30400	24030 20 30 27 700 307 20 337 00 30040 33430	25700 27280 28870 32070 35290 28540 41800 42000	26190 27810 29440 32720 36030 39360 42710 43240	28320 30000 33360 36750 40170 43610 44500 16'-	28830 30540 33990 37460 40970 44490 45770	29320 31070 34600 38160 41750 45360 47010 16'-	28020 29800 31590 35200 38850 42520 46220 48270	30270 32100 35790 39520 43280 47060 49500 16'-
C ORDINARY CLAY Kµ'—0.130	PE	111-0" 111-6" 12-0" 13-0" 14-0" 15-0" 16-0" 17-0" 18-0"	-01	6748 6854 10-	7620 8021	8471 8917 9242 11'-	9300 9796 10290 10520 1051	10650 11200 11740 11860	12 10900 11490 12090 12680 13250 12 .	13 11670 12310 12950 13600 14710 12*-1	14 12420 13110 13800 14490 15870 16240 13'-	13160 13890 14630 15370 16850 17840 13:-	16 13870 14650 15440 16220 17800 19360	17 14570 15400 16230 17060 18730 20410 20630 14 .	18 15250 16130 17000 17890 19650 21420 21900	19 15910 16840 17760 18690 20550 22410 23160	20 16560 17530 18500 19480 21430 23390 24420	21 17190 18210 19230 20240 22290 24340 25680 14'-	22 17810 18870 19930 21000 23140 25280 26940 14-	23 18410 19520 20620 21740 23970 26200 28200	24 199000 20150 21300 22460 24780 27110 29460 15:	25 19570 20760 21960 23160 25580 28000 30430 30720 15-	26 20130 21370 22610 23850 26360 28870 31400 31970	27 20670 21950 23240 24530 27120 29730 32340 33230 15-	28 21200 22530 23860 25190 27870 30570 33270 34470 15-	29 21/20 23090 24460 25840 28610 31390 34190 35/40 15:	30 22230 23640 25050 26470 28330 32200 35090 36970 15-	0.505 0	23670 25900 26740 28290 31400 34540 37700 40720	34 24130 25700 27280 28870 32070 35290 28540 41800 42000	35 24580 26190 27810 29440 32720 36030 39360 42710 43240	36 25020 26660 28320 30000 33360 36750 40170 43610 44500 16 '-	25440 27130 28830 30540 33990 37460 40970 44490 45770	25860 27580 29320 31070 34600 38160 41750 45360 47010 16'-	29800 31590 35200 38850 42520 46220 48270	26660 28460 30270 32100 35790 39520 43280 47060 49500 16-

Table B-21

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	19-0																										***************************************						_
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TOP (16'-0" 17'-0"						-					<u> </u>	9	88	9	8	9 9	28790 29890 30150	20 3 1500		20 34180	00 35520			10 39560	20 4059	00 4156	39370 42520 43560	20 43460	60 4439	80 4530	90 4619	7077 00
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4	<u> </u>	.6									÷	<u> </u>		7		<u> </u>		n =	r ic	- io				5.	<u>_</u>				.6		18 0	48940 18'- 2"	
PIPE	18-0" 19-0"	.6									÷	<u> </u>		7		15'-11"	-0		יייי ייייי ייייייייייייייייייייייייייי		16'-10"	1611	36860 17'- 1"	220 17'- 2"	17'- 4"	17'- 5"	17:- 7"	43560 17'- 8"	14. 9	17:-11"	18 0	48940 18'- 2"	
PIPE	170" 180" 190"	.6									14'- 8"	15'- 1"	15 6"	15 7	15 9.	15'-11"	27440	30150	31500	32840	34180	35520 16-11"	36720 36860 17:- 1"	37700 38220 17'- 2"	38660 39560 17'- 4"	39600 40880 17'- 5"	17:- 7"	41420 43560 17 '- 8 "	42310 44940 17'- 9"	43180 46280 17:-11"	44040 47620 18'- 0"	48940 18'- 2"	
PIPE	16'-0" 17'-0" 18'-0" 19'-0"	.6							13,-10,"	14'- 3"	14'- 8"	20340 15'- 1"	22010 15'- 6"	23380 15'- 7"	24740 15'- 9"	26090	2/2/0 2/440	28300 28730	30290 31500	31250 32840	32200 34180 16:-10"	33120 35520 16:-11"	34030 36720 36860 17:- 1"	34920 37700 38220 17- 2"	35790 38660 39560 17'- 4"	36640 39600 40880 17'- 5"	37480 40520 42230 17: 7"	38300 41420 43560 17 '- 8 "	39100 42310 44940 17 '- 9 "	39890 43180 46280 17:-11"	40660 44040 47620 18'- 0"	48940 18'- 2"	
PIPE	150" 160" 170" 180" 190"	.6					13 0	13'- 5"	1310.	17000	18640 14'- 8"	20230 20340 15'- 1"	21270 22010 15'- 6"	22290 23380 15'- 7"	23290 24740 15'- 9"	24270 26090 15'-11"	25220 27270 27440	22070 20300 28790	27970 30290 31500	28840 31250 32840	29700 32200 34180	30540 33120 35520 16:-11"	31360 34030 36720 36860 17: 1"	32160 34920 37700 38220 17'- 2"	32940 35790 38660 39560 17'- 4"	33710 36640 39600 40880	34460 37480 40520 42230 17'- 7"	35190 38300 41420 43560 17'- 8"	35910 39100 42310 44940 17'- 9 "	36610 39890 43180 46280 17:-11"	37300 40660 44040 47620 18'- 0"	37970 41410 44870 48360 48940 18:- 2"	
PE	13'-0" 14'-0" 15'-0" 16'-0" 17'-0" 18'-0" 19'-0"	601			9757	11090	12470	13450 13920	15430	16690 17000	16220 17690 18640 14'- 8"	17090 18660 20230 20340	17950 19610 21270 22010 15- 6"	18780 20540 22290 23380 15'- 7"	19600 21440 23290 24740 15'- 9"	20390 22320 24270 26090 15:-11"	21160 23190 25220 27270 27440	23650 24860 27770 20300 30450	23360 25660 27970 30290 31500	24060 26450 28840 31250 32840	24740 27210 29700 32200 34180	25410 27960 30540 33120 35520 16:11"	26050 28700 31360 34030 36720 36860	26680 29410 32160 34920 37700 38220	27300 30110 32940 35790 38660 39560 17'- 4"	27900 30790 33710 36640 39600 40880	28480 31460 34460 37480 40520 42230 17- 7"	29050 32110 35190 38300 41420 43560 17'- 8"	29610 32740 35910 39100 42310 44940 17- 9 "	30150 33360 36610 39890 43180 46280 17:-11"	30680 33970 37300 40660 44040 47620 18: 0"	31190 34560 37970 41410 44870 48360 48940 18: 2"	
PIPE	14'-0" 15'-0" 16'-0" 17'-0" 18'-0" 19-0"	.601	/809		9462	10490 11090	11390 12470	12260 13450 13920 13-5"	13120 14390 1 5430	13940 15320 16690 17000	17690 18640 14'- 8"	15530 17090 18660 20230 20340	19610 21270 22010 15'- 6"	17040 18780 20540 22290 23380	17760 19600 21440 23290 24740 15'- 9"	18460 20390 22320 24270 26090 15'-11"	19140 21160 23190 25220 27270 27440	24850 25050 28300 28790 16: 3:	21080 23360 25660 27970 30290 31500	21690 24060 26450 28840 31250 32840	22290 24740 27210 29700 32200 34180	22870 25410 27960 30540 33120 35520 16:-11"	23430 26050 28700 31360 34030 36720 36860 17: 1"	23980 26680 29410 32160 34920 37700 38220	24510 27300 30110 32940 35790 38660 39560 17'- 4"	25030 27900 30790 33710 36640 39600 40880 17'- 5"	25540 28480 31460 34460 37480 40520 42230	26030 29050 32110 35190 38300 41420 43560 17'- 8"	26500 29610 32740 35910 39100 42310 44940 17'- 9"	26970 30150 33360 36610 39890 43180 46280 17:-11"	27420 30680 33970 37300 40660 44040 47620 18'- 0"	27860 31190 34560 37970 41410 44870 48360 48940 18:- 2"	1 . 4 . 4

Table B-21 Continued

	ATRAN-	WIDTH		10- 9-			12'- 2"	12'- 6"		13'- 3"	13 6"	1311	14'- 4"	14'- 8"	1410	15'- 0"		15. 2"	15'- 3"	15'- 5"	15'- 6"	15- 7"	15'- 8"	15. 9"	1510	16 0	16 1"	16'- 2"	16'- 3"	16 4"	16'- 5"	16. 7	16 8"	16. 8"	16'-10"	16'-11"	16'-11"	
		19'-0"																																				
SATURATED CLAY Ky'-0.110	TRENCH WIDTH AT TOP OF PIPE	17:-0" 18:-0"			44																						260	880	230	260	940	280	620	48940	50310	920	52960	
4Y Ky'-	T TOP	160 17																27440	28790	30150	31500	2840	4180	5520	9860	8220	30580 33490 36400 39330 39560	31360 34360 37360 40380 40880	38310 41420 42230	39240 42440 43560	36880 40160 43450 44940	37690 41060 44450 46280	28230 31620 35050 38490 41950 45430 47620		2360 50 3			
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'URATI	ICH W	13'-0" 14'-0" 15'-0"								15430	17000	18640		19200 20890 3	20170 21950 23380	21120 23000 24740	22060 24030 26090	22980 25040 2	26040		25640 27990		29880	30800	28990 31710	29790 32610 35430 38220	33490	34360 3	35210	32870 36050 3	36880	37690	38490	39280 42830 46400	32840 36440 40060 43700 47360	40820	37780 41570 45390 49230	
SAT	TREN						11090	12470		15170	16200 17000		18220	19200	20170	21120			23880			26500	27340	28170	28990	29790	30580	31360	32120	32870	33610	34330	35050	35750	36440	37110	37780	. 7000
		" 12'-0"	9	7 5 7260			9 10960			0 13880	0 14820	0 15740				0 19250	0 20090		0 21720		0 23300	0 24060	0 24820	0 25560	0 26280	0 26990	0 27690	0 28380	0 29050	0 29710		0 3 1000	0 31620	0 32240	0 32840	0 33430	30290 34020	00000
۵		110	4963	6087	8132	0906	6966	10860	11740	12590	13430	14250	15060	15850	16630	17390	18130	18860	19580	20280	20970	21640	22300	22950	23580	24200	24820	25410	26000	26570	27140	27690	2823	28760	29280	29790	3029	in fact
	TRAN-	WIDTH	10. 7"	10'-11"	7 -	11:-11:	12'- 3"	12 8"		13'- 5"				15'- 0"	15'- 1"		15'- 5"	15'- 6"	15'- 7"	15'- 9"	15'-10"	16'- 0"	16'- 1''	16. 3"	16:- 4"	16'- 5"	16'- 7"	16'- 8"	16'- 9"	16'-10"	16'-11"	17: 1"	17:- 2"	17:- 3"	17:- 4"		17 6"	tree ages often
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30	OF PIPE)" 18'-0"																					0	0	Q	0	0	0	0	0	0	46070 46280	47060 47620	48030 48940	0 50310	49940 51650	50860 52960	100 to 200 to
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LAY K	I AT T(15'-0" 16'-0"										540	340		190 23380	24280 24740	25350 26090		27440 28790		29450 31500		31400 33930	32340 34970	270 35990	190 37000	35090 37990		36840 39920	700 40870	540 41800	39360 42710	170 43610	970 44490		520 46220	39520 43280 47060	412 6224
ARY C	WIDTH	14'-0" 15								15430	17000	18330 18640	19380 20340	20410 22010	21420 23190	22410 24;		24340 26	25280 27		27110 29	28000 30430	28870 31	29730 32	30570 33270	31390 34190	32200 350	33000 35	33780 36	34540 37700	35290 38540	36030 393	3750 40	37460 40970	38160 41750	38850 42520	520 43	
ORDINARY CLAY Kµ'	TRENCH WIDTH AT TOP	130 1					11090	12470				16850 18			19650 21						24780 27		26360 28	27120 29	27870 30	28610 31			30720 33	31400 34		32720 36		33990 37		35200 38	5790 38	
•	TR	12:-0		7260	8482	9757	10790			13600 1		15370 1		17060 1	17890 1		19480 2			21740 2	22460 2	23160 2	23850 2	24530	25190				27700 3	28290 3		29440 3	30000	30540 3	31070 3	31590 3	32100 35790	100
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* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. ▲Transition loads (**bold type**) and widths based on Kµ—0.19, r_sdp—0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-22

		_	2	9	7	 00			IGI			E E	91 B/	AC -	K e	FI 6	LL 8	- - -	55 25	B در	7 0 7	72 VE	T %	OF 52 52	2 C		اط اط	95 PE	33	FE FE	35 E		37	38	96 4 04
.,96	ATRAN-	WIDTH	11'- 3"	11'- 7"	11:-11"				13'- 5'	14'- 3"	14'- 7"		15'- 5"	15'-10"	16'- 2"	16'- 4"	16'- 7"	16'- 8"	16'-10"	17 0				17. 6"			18 0					18 - 6"	18 - 8	18:10	19 0.
ADS ON CIRCULAR PIPE IN TRENCH INSTALLATION CUBIC FOOT BACKFILL MATERIAL LOADS IN POUNDS PER LINEAR FOOT B SATURATED TOP SOIL Kµ'—0.150	TRENCH WIDTH AT TOP OF PIPE	130" 14'-0" 15'-0" 16'-0" 17'-0" 18'-0" 19'-0" 20'-0"				8937	10260	-	12630 13080 13630 1458 0		15550 16930 17750	17960 19430	17390 18960 20540 21180	19950 21620	20910 22670 24440		22770 24720 26680		24560 26700 28840	25420 27650 19890 32040	26270 28590 30920 33260	27 100 295 10 3 1930 34360	27910 30410 32920 35450	26120 [28700 31290 33900 36510 37790	30240 33010 35790 38590	30980 33840 36710 39600	31710 34650 37620 40590	32420 35450 38500 41560 44640	33120 36240 39370 42520 45690	33800 37000 40220 43460 46720	34470 37760 41060 44390 47730	35130 38490 41880 45300 48730	35770 39220 42690 46190 49710	36390 39920 43480 47070 50670	37610 41300 45020 48780
Ä B	TRAN-	12:-0	11'- 3" 5251		<u>.</u>	5 8700	9 9671	2 " 10620	13'- 7" 11540 12 13'-11" 12440 13	13320	14'- 9" 14170 15	2" 15010	15'- 7" 15820 17	1" 16620	5 " 17390	7" 18150	18890	19600	1" 20310	3 20990	4" 21660	6" 223 10	22940	17'- 9" 23560 26 17'-11" 24.160 26	24750	25330	4" 25890	5" 26430	26960	27480	27990	28480	1" 28970	2 29440	. 5" 29890
DADS ON CIRCULAR PIF 8 CUBIC FOOT BACKFILL MATERIAL 165	4	0., 500		-	12	- 12	12	13		14		15	15	16	16	16	16	17	17	17	17	17	17	17	40650 18	2080				810	1210	0640	52090		56360
BACKFILL LO *100POUNDS PER SAND AND GRAVEL Kµ'—0.1	TRENCH WIDTH AT TOP OF PIPE	16-0" 17-0" 18-0" 19										19430	21180	22940 23000		25150 26270		27270	28300	29300 31540	30290 32610	31250 33670	32200	33120 35720 37790	34920 37700 40490	35790 38660 41540	36640	37480 40520 43580	38300 41420 44570	39100 42310 45540	39890 43180 46500	40660 44040 47440	44870 48360	45690 49260	
96" sand an	TRENCH V	2'-0" 13'-0" 14'-0" 15'-0"	5251	6432			10260	11480	1390 12480 1 3080 2260 13450 1 4580	14390	13940 15320 16690 17750	14750 16220 17690 19160	15530 17090 18660 20230	16300 17950 19610 21270	17040 18780 20540 22290	17760 19600 21440 23290	18460 20390 22320 24270	19140 21160 23190 25220	21910 24030	22650 24860	23360 25660	24060 26450	24740 27210	22870 25410 27960 30540	26680 29410	27300 30110	25030 27900 30790 33710	28480 31460	29050 32110	29610 32740	30 150 33360	30680 33970	31190 34560	31690 35140	29110 32660 36260 39900
∢		12,		9			6	10	## 12 12 12 12 12 12 12 12 12 12 12 12 12		14	15	16	17	18	19	50	21	52	23	54	52	56		0 00	3 8	31	32	33	34	35	98			39 40 29 29

Table B-22 Continued

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	19'-0" 20'-0"																																			
TRENCH WIDTH AT TOP OF PIPE		-				•••••												_											_	_	_	_		_	_	_
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WIDTI	16'-0"	<u> </u>										_		23000	24820	26270	27720	29160	30370	31550	32710		34980	06098				0 40380	0 41420	0 45440	0 43450	0 44450				0 48300
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	12'-0"	5251	6432	7659	8937	9956	10960	11950	12930	13880	14820	15740	16640	17530	18400	19250	20090	20920	21720	22520	23300	24060	24820	25560	26280	26990	27690	28380	29050	29710	30360	31000	31620	32240	32840	33430
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IM H	15.0"						-		_	_	17750	19430		22090		24280) 25350	26400	27440	28450	29450	30430	31400	32340	33270	34 190	35090	35970	36840	37700	38540	39360				0 42520
TRENCH WIDTH AT TOP OF PIPE	14.0				_			13080	14580	0 16130	0 17260	0 18330	0 19380	0 204 10		0 224 10	0 23390	0 24340			0 27110	0 28000	0 28870	0 29730		0 31390	0 32200	0 33000	0 33780	0 34540	0 35290	0 36030	0 36750	0 37460	0 38160	0 38850
	130."	+	- 2	6	4 8937	2 10260	0 11650	0 12840	0 13870	0 14880	0 15870	0 16850	0 17800	0 18730		0 20550	0 21430	0 22290	0 23 140	0 23970	0 24780	0 25580	0 26360	0 27120	0 27870	0 28610	0 29330	0 30030	0 30720	0 31400	0 32070	0 32720		0 33990		0 35200
	120	1_		1659		9812	10790	11740	12680	13600	14490	15370	16220	17060	17890	18690	19480	20240	21000		1 22460		3850	24530	25 190	25840	26470	27090	27700	28290	28870	29440	30000	30540		31590
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* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. ▲ Transition loads (**bold type**) and widths based on Kµ—0.19, r_{sd}p—0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

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Table B-23

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144.0	NHAN-	WIDTH	11'- 9"	12. 2"	12'- 6"	12'-10"	13'- 3"	13'- 7"	14'- 0"	14'- 4"	14'- 9"	15'- 2"	15'- 6"	16'- 0"	16'- 5"	16'- 9"	17 2"	17: 4"	17'- 6"	17 8"	17'- 9"	17:-11"	18'- 1"	18 3"	18 - 4	18 - 6		6-8	18 -10	18'-11	19 1	19'- 3"	19'- 4"	19'- 5"	19'- 7"	19'- 8"	19'-10"
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		12.0	5539	9899	2206	8700	9671	10620	11540	12440	3320	14170	15010	15820	16620	17390	18150	18890	19600	20310	20990		22310	22940 25420										28480			29890
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J	<u> </u>	16'-0" 17'-0"						_				18510	240	21800 2	22940 23	24060 25820	25150 27010	26220 28180 29330	27270 29320 30870	28300 30440 32400	29300 31540 33780	30290 32610	250 33	200 3 200 3	120 35	320 33	920 3	3000	240 33	00 00 00	300	100	390 4:	360 4	34560 37970 41410 44870 48360	150 4	870 46
O IV	<u>₹</u>	15.0" 16							8	5	တ္ထ		80 20	30 21			90 25	70 26	20 27				40 31	00 32	40 33	60 34	00 34	S S	00000	200	30	10 39	10 39	00 40 40	70 41	30 42	70 42
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10.5	벌	. 14.0					10780	12210	-	_	_	16690	_	-	19610			22320							27960	2870	2947	24510 27300 30110 32940 35790 38660 41540 44420 44590	30/8	3140	321	3274	3336	27420 30680 33970 37300 40660 44040 47440 50850	3456	3514	32180 35710 39270 42870 46500
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Table B-23 Continued

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	ATRAN-	WIDTH	11.	11'-11"	2	2	12′-11″	13'-	13	13'-11	14	14-	15'- (15.	15'-10"	16'-	- 9	-91	16'-10	16'-11"	17.	17'-	17'- 3	1	17'- (-'-	1.	17'-	17:-11	18'-	,	-2	 2.		-8		
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8	TRE	14'-0"						12210	13700	15240	16460	17590	18710	19800	20890	21950	23000	24030	25040	26040	27020	27990	28940	29880	30800	31710	32610	33490	34360	35210	36050	36880	37690	38490	3928	4006	40820 41570
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130	V	19'-0" 20'-0" 22'-0"		12	- 27	7		13	13	41	141	41	15	15	16	16			021	000	040	091	080	000	120	150 41540	350 43070	320 44590	9	47640	49150	50650	80	10	55200	56300 56740	57420 58250 58530 59770
,—0.130	V	18'-0" 19'-0" 20'-0" 22'-0"		12	- 7	12.		13	13	14	141	14	15	15				29330	0 30870	32400	33940	35460	086980	038500	0 40020	0 41450 41540	0 42650 43070	0 43820 44590	9	47640	49150	50650	80	10	55200	52640 56300 56740	53670 57420 58250 54690 58530 59770
Y Кµ'—0.130	V	19'-0" 20'-0" 22'-0"		12	- 27			13	13	14	14		15	15					30530 30870	31760 32400		34150 35460	35320 36980	36470 38500	37600 40020	38720 41450 41540	39820 42650 43070	40900 43820 44590	9	47640	49150	50650	80	10	55200	52640 56300 56740	53670 57420 58250 54690 58530 59770
SLAY Кµ′—0.130	V	170" 18:-0" 19:-0" 20:-0" 22:-0"		12	- 2 - 3	-72		13	13	14	14				23890	25820	27780	29290 29330			32960	34150	35320			38720 41450	39820 42650	7990 40900 43820 44590	9	43020 46120 47640	44050 47250 49150	45070 48360 50650	46070 49450 52180	47060 50530 53710	55200	48990 52640 56300 56740	49940 53670 57420 58250 50860 54690 58530 59770
RY CLAY Kµ'-0.130	V	16.0" 17.0" 18.0" 19.0" 20.0" 22.0"		12	- 2 - 3			13					20240	22030	23770 23890	24970 25820	26150 27780	27320 29290 29330	28470	29600	30700 32960	31800 34150	32870 35320	33930	34970	35990 38720 41450	37000 39820 42650	37990 40900 43820 445	38960 41970 44980 46110	39920 43020 46120 47640	40870 44050 47250 49150	41800 45070 48360 50650	46070 49450 52180	47060 50530 53710	44490 48030 51590 55200	45360 48990 52640 56300 56740	46220 49940 53670 57420 58250 47060 50860 54690 58530 59770
JINARY CLAY Kµ'-0.130	V	15.0" 16.0" 17.0" 18.0" 19.0" 20.0" 22.0"		12	- 21					15240	16850	18510	19810 20240	20960 22030	22090 23770 23890	23190 24970 25820	24280 26150 27780	25350 27320 29290 29330	26400 28470	27440 29600	28450 30700 32960	29450 31800 34150	30430 32870 35320	31400 33930	32340 34970	35990 38720 41450	37000 39820 42650	35090 37990 40900 43820 445	35970 38960 41970 44980 46110	39920 43020 46120 47640	37700 40870 44050 47250 49150	38540 41800 45070 48360 50650	46070 49450 52180	47060 50530 53710	44490 48030 51590 55200	45360 48990 52640 56300 56740	42520 46220 49940 53670 57420 58250 43280 47060 50860 54690 58530 59770
ORDINARY CLAY Kµ'—0.130	V	15.0" 16.0" 17.0" 18.0" 19.0" 20.0" 22.0"		12	- 21					15240	16850	18510	19810 20240	20960 22030	22090 23770 23890	23190 24970 25820	24280 26150 27780	25350 27320 29290 29330	26400 28470	27440 29600	28450 30700 32960	29450 31800 34150	30430 32870 35320	31400 33930	32340 34970	35990 38720 41450	37000 39820 42650	35090 37990 40900 43820 445	35970 38960 41970 44980 46110	39920 43020 46120 47640	37700 40870 44050 47250 49150	38540 41800 45070 48360 50650	46070 49450 52180	47060 50530 53710	44490 48030 51590 55200	45360 48990 52640 56300 56740	42520 46220 49940 53670 57420 58250 43280 47060 50860 54690 58530 59770
ORDINARY CLAY Kµ'-0.130	TRENCH WIDTH AT TOP OF PIPE SITION	140" 150" 160" 170" 180" 190" 200" 220"					10780	12210	13700	15060 15240	16170 16850	17260 18510	18330 19810 20240	19380 20960 22030	20410 22090 23770 23890	21420 23190 24970 25820	22410 24280 26150 27780	23390 25350 27320 29290 29330	24340 26400 28470	25280 27440 29600	26200 28450 30700 32960	27110 29450 31800 34150	28000 30430 32870 35320	28870 31400 33930	29730 32340 34970	30570 33270 35990 38720 41450	31390 34190 37000 39820 42650	32200 35090 37990 40900 43820 445	33000 35970 38960 41970 44980 46110	33780 36840 39920 43020 46120 47640	34540 37700 40870 44050 47250 49150	35290 38540 41800 45070 48360 50650	46070 49450 52180	47060 50530 53710	44490 48030 51590 55200	45360 48990 52640 56300 56740	42520 46220 49940 53670 57420 58250 43280 47060 50860 54690 58530 59770
ORDINARY CLAY Kµ'-0.130	V	13.0" 14.0" 15.0" 16.0" 17.0" 18.0" 19.0" 20.0" 22.0"	-,-		0000	9392	107.10 107.80	11780 12210	12840 13700	13870 15060 15240	14880 16170 16850	15870 17260 18510	16850 18330 19810 20240	17800 19380 20960 22030	18730 20410 22090 23770 23890	19650 21420 23190 24970 25820	20550 22410 24280 26150 27780	21430 23390 25350 27320 29290 29330	22290 24340 26400 28470	23140 25280 27440 29600	23970 26200 28450 30700 32960	24780 27110 29450 31800 34150	25580 28000 30430 32870 35320	26360 28870 31400 33930	27120 29730 32340 34970	27870 30570 33270 35990 38720 41450	28610 31390 34190 37000 39820 42650	29330 32200 35090 37990 40900 43820 445	30030 33000 35970 38960 41970 44980 46110	30720 33780 36840 39920 43020 46120 47640	31400 34540 37700 40870 44050 47250 49150	32070 35290 38540 41800 45070 48360 50650	32720 36030 39360 42710 46070 49450 52180	33360 36750 40170 43610 47060 50530 53710	33990 37460 40970 44490 48030 51590 55200	34600 38160 41750 45360 48990 52640 56300 56740	35200 38850 42520 46220 49940 53670 57420 58250 35790 39520 43280 47060 50860 54690 58530 59770
ORDINARY CLAY Kµ'-0.130	V	140" 150" 160" 170" 180" 190" 200" 220"	-,-		0000	9392	107.10 107.80	11780 12210	12840 13700	13870 15060 15240	16170 16850	15870 17260 18510	18330 19810 20240	19380 20960 22030	20410 22090 23770 23890	21420 23190 24970 25820	22410 24280 26150 27780	23390 25350 27320 29290 29330	22290 24340 26400 28470	23140 25280 27440 29600	23970 26200 28450 30700 32960	24780 27110 29450 31800 34150	25580 28000 30430 32870 35320	26360 28870 31400 33930	27120 29730 32340 34970	27870 30570 33270 35990 38720 41450	28610 31390 34190 37000 39820 42650	29330 32200 35090 37990 40900 43820 445	30030 33000 35970 38960 41970 44980 46110	30720 33780 36840 39920 43020 46120 47640	31400 34540 37700 40870 44050 47250 49150	35290 38540 41800 45070 48360 50650	46070 49450 52180	47060 50530 53710	44490 48030 51590 55200	34600 38160 41750 45360 48990 52640 56300 56740	42520 46220 49940 53670 57420 58250 43280 47060 50860 54690 58530 59770
C ORDINARY CLAY Kµ'-0.130	V	13.0" 14.0" 15.0" 16.0" 17.0" 18.0" 19.0" 20.0" 22.0"	5539		1,34 0000	88 4 9392	9812 10710 10780	11780 12210	12840 13700	12 12680 13870 15060 15240	13 13600 14880 16170 16850	14 14490 15870 17260 18510	15 15370 16850 18330 19810 20240	16 16220 17800 19380 20960 22030	17 17060 18730 20410 22090 23770 23890	18 17890 19650 21420 23190 24970 25820	19 18690 20550 22410 24280 26150 27780	20 19480 21430 23390 25350 27320 29290 29330	21 20240 22290 24340 26400 28470	22 21000 23140 25280 27440 29600	21740 23970 26200 28450 30700 32960	24 22460 24780 27110 29450 31800 34150	25 23160 25580 28000 30430 32870 35320	26 23850 26360 28870 31400 33930	27 24530 27120 29730 32340 34970	28 25190 27870 30570 33270 35990 38720 41450	29 25840 28610 31390 34190 37000 39820 42650	26470 29330 32200 35090 37990 40900 43820 445	31 27090 30030 33000 35970 38960 41970 44980 46110	32 27700 30720 33780 36840 39920 43020 46120 47640	33 28290 31400 34540 37700 40870 44050 47250 49150	34 28870 32070 35290 38540 41800 45070 48360 50650	35 29440 32720 36030 39360 42710 46070 49450 52180	36 30000 33360 36750 40170 43610 47060 50530 53710	33990 37460 40970 44490 48030 51590 55200	31070 34600 38160 41750 45360 48990 52640 56300 56740	35200 38850 42520 46220 49940 53670 57420 58250 35790 39520 43280 47060 50860 54690 58530 59770

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. ▲Transition loads (**bold type**) and widths based on Kµ—0.19, r_{sd}p—0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

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Table B-24

									IG	iΗ	T	0	F	В	٩C	K	FI	LL	. -		۱B	0	VE		0		OI	FF	PIF	È,	F	E	Ε	T				
	<u></u>		2	9	7	8				12	13	4	15	<u> </u>	17	18	19	20	21	22	23		22	56	27		_							36	37	38		40
108′′	ATRAN	WIDTH	12 5"	12'- 9"	13'- 1"	13'- 5"	1310.	14'- 2"	14'- 7"	14'-11"	5-4	15'- 9"	16'- 1'	.9 -,91	16'-11"	17: 4	17'- 9"	18'- 2"	18:- 4"	18'- 6"	18'- 8"	18'-10"	19'- 0"	19'- 1'	19'- 2'	19'- 4"	19 6"	19 7"	19 9.		, i	20- 1	20 2"	20'- 4"	20'- 5"	20'- 7"	20'- 8"	20'-10"
19		550	-	_	_	_		_	_	_	_	_	_	Ē	_		_	Ξ	Ē		_	·	_	Ē	_	Ξ.	_				-			N	.,			
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Ö	ш	11.0																						0	_	_	_	0				53550	22190	292	58400	299	59050 61590	631
0.45	F PIP	0,07																						40690	4231	43920	4553	47 130	48740	50350		53270	5446	2263	9679	5793	5905	6016
NO Y	PO	0-,61																30940	32580	34220	35840	37460	39080	40520	41770	43000	44210	45400	46580	48870		49990	51090 54460	52170	53240 56790	54290	55330	56340
LATI EAR I SOIL	AT TO	180											•••			26780	28820		31890	33150	34390		36800	37980 40520	39140 41770 42310	0220	1390	2490	3280	4040	0000	46720	7730	8730	49710	0290	1620	2550
TALI R LIN TOP	TH /	110.4											21070	910	24810	26220 2	27440 2	28650 3	29830 3	30990 3	32140 3		34360 3	450 3	36510 3	37560 40270	38590 41390 44210 45530	39600 42490	3/620 40590 43580 46580	41560 44640 47730	020	460 4	390 4	300 4	1904	070 5	930 5	780 5
INS DS PE TED	4 WIE	1									80			22120 22910			70 27			40 30	90 32	20 33	30 34	32920 35450	96 00	50 37	<u> 86</u> 06	10 39	20 40	14 00	2 2	20 43	60 44	80 45	90 46	80 47	60 47	20 48
N TRENCH INSTALLATION LOADS IN POUNDS PER LINEAR FOOT SATURATED TOP SOIL Kµ'—0.150	TRENCH WIDTH AT TOP OF PIPE	16:0						0	0		0 11580		0 20920		0 23290	0 24440	0 25570		0 27770		0 29890		0 3 1930	0 329	0 33300	0 34850	0 35790	0 36710	0 3/6	35450 38500 41560 44640 47730 50350	200	37000 40220 43460	37760 41060 44390 47730	0 418	39220 42690 46190	39920 43480 47070 50670 54290 57930 59990	37010 40620 44260 47930 51620 55330	0 450
REN SS IN SAT	TRE	15.0				_	_	12780					19440	20540	21620	22670	23710						29510				330 10	33840	3465	35450		00/8	3776	3846)	3855	3885	4062	4 130
E COAC		14.0			8468	9857	11300	12600	13720	14810	15880	16930	17960	18960	19950	20910		22770		24560	25420	26270	27 100	27910		29480	30240	30980	31710	32420	77 1 50	33800	34470	35130	35770	36390	37010	37610
PE B		30	5833	7127	8403	9496	10560	11610	12630	13630	14600	15550	16480	17390	18280	19150	20000	20820	21640	22430	23200	23960	24700	25420	26120	26810	27480	28140	28790 31710 34650	00.000	0000	30630	31220 34470	31790 35130 38490 41880 45300 48730 52170 55630 56780	32350	32900 36390	33430	33950 37610 41300 45020 48780 52550 56340 60160 63190
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ULAR	RAN-	NDTH NDTH	. 5	10	 8		-11.	4	 80	<u>.</u>	 9 .		 			9 .	0	. 5.	7	6	'-11"	0	. 5	·- 4''	9	8	10	. 0	- 6	N .		ا م		6	11	0	. .	. 2
IRCULAR ACKFILL MATE	ATRAN-	O" WIDTH	12'- 5"	12:-10	13 3	13 7.:	13:-11"	14. 4"	14. 8	15'- 1"	12 6	15'-11"	16:- 3	16. 8"	17 1"	17 6"	18 0	18'- 5"	18 7	18'- 9"	18'-11"			19'- 4"	19 6	19'- 8"	. 19'-10"	20 0	20- 1	20.5		20 5	20. 7	20'- 9"	20'-11"			90 21'- 2"
N CIRCULAR OT BACKFILL MATE	ATRAN-	22.0	12 5"	1510	13 3	13 7"	1311"	14'- 4"	14 8	15'- 1"	15'- 6"	15'-11"	16'- 3"	16 8	17 1"	12 6	18 0	18'- 5"	18 7	18'- 9"	18'-11"	19'- 0"		19'- 4"	19 6	19'- 8"	19'-10"				2 2	50.						1
SON CIRCULAR	V	21.0" 22.0"	12'- 5"	12'-10"	13 3"	13'- 7"	13:-11"	14'- 4"	14'- 8"	15'- 1"	15'- 6"	15'-11"	16'- 3"	16'- 8"	17:- 1"	17 6"	18'- 0"	18'- 5"	18'- 7"	18 9	18'-11"		19	19	19		•		48740	50350	000	53550 20-	55190	26780	58400	29990	61230 61590	62360 63190
OADS ON CIRCULAR PIPE IN TRENCH INSTALLATION R CUBIC FOOT BACKFILL MATERIAL LOADS IN POUNDS PER LINEAR FOOT 165 B SATURATED TOP SOIL KU'	V	21.0" 22.0"	12 5"	12'-10"	13 3"	13'- 7"	1311	14'- 4"	14'- 8"	15'- 1"	15'- 6"	15'-11"	16'- 3"	16 8"	17'- 1"	17'- 6"	18'- 0"	18'- 5"	18 7.:	18 9"	18'-11"		19	19	19		•	7 130	3530 48740	50350	000	53550 20-	55190	26780	58400	29990	61230 61590	62360 63190
	V	200" 210" 22'-0"	12 5"	12'-10"	13 3"	13 7	13:-11"	14'- 4"	14'- 8"	15'- 1"	15'- 6"	15'-11"	16'- 3"	16 8	17: 1"	17 6"	18 0	18'-					19	19	19		•	7 130	3530 48740	50350	000	53550 20-	55190	26780	58400	29990	57520 61230 61590	28560 62360 63190
	V	19:0" 20:0" 21:0" 22:0"	12'- 5"	1210	13 3"	13'- 7"	13'-11"	14'- 4"	14'- 8"	15'- 1"	15'- 6"	15'-11"	16'- 3"		17'-	17:-	18	18'-					19	19	19		•	7 130	3530 48740	50350	000	53550 20-	55190	26780	51860 55380 58400	52850 56460 59990	53830 57520 61230 61590	54780 58560 62360 63190
	V	18.0" 19.0" 20.0" 21.0" 22.0"	12 5	12'-10"	13 3"	13 7"	1311"	14'- 4"	14'- 8"	15'- 1"	15'- 6"	15-11"	16'-		24810 17	26780 17'-	28820 18'-	18'-		32590 34220	33780 35840	34950 37460	19	19	19		40490 43290 45530	7 130	3530 48740	50350	000	53550 20-	55190	26780	51860 55380 58400	52850 56460 59990	53830 57520 61230 61590	51020 54780 58560 62360 63190
	V	170" 180" 190" 200" 210" 220"	12 5	12'-10"	13 3"	13'- 7"	1311"	14'- 4"				15-1	21070 16'-	22910	24620 24810 17'-	25820 26780 17'-	27010 28820 18'-	28180 30140 30940 18'-	29320 31370 32580	32590 34220	31540 33780 35840	34950 37460	19	19	19		40490 43290 45530	7 130	3530 48740	50350	000	53550 20-	55190	26780	51860 55380 58400	52850 56460 59990	53830 57520 61230 61590	51020 54780 58560 62360 63190
	V	16.0" 17.0" 18.0" 19.0" 20.0" 21.0" 22.0"	12. 5"	12'-10"	13 3"	13'- 7"				15920	17580	19290 15'-1	20640 21070 16'-	21800 22910	22940 24620 24810 17'-	24060 25820 26780 17'-	25150 27010 28820 18'-	28180 30140 30940 18'-	29320 31370 32580	32590 34220	29300 31540 33780 35840	30290 32610 34950 37460	19	19	19		40490 43290 45530	7 130	3530 48740	50350	000	53550 20-	55190	26780	51860 55380 58400	52850 56460 59990	53830 57520 61230 61590	51020 54780 58560 62360 63190
BACKFILL LO *100POUNDS PER SAND AND GRAVEL Ku'—0.1	TRENCH WIDTH AT TOP OF PIPE	15-0" 16-0" 17-0" 18-0" 19-0" 20-0" 21-0" 22-0"	12. 5"	15'-10"				12780	14330	15820 15920	16960 17580	18070 19290 15:-1	19160 20640 21070 16'-	20230 21800 22910	21270 22940 24620 24810	22290 24060 25820 26780 17'-	23290 25150 27010 28820 18'-	24270 26220 28180 30140 30940 18'-	25220 27270 29320 31370 32580	26160 28300 30440 32590 34220	27070 29300 31540 33780 35840	27970 30290 32610 34950 37460	28840 31250 33670 36100 38530 39080 19'-	29700 32200 34710 37220 39750 40690 19-	19		40490 43290 45530	7 130	3530 48740	50350	000	53550 20-	55190	26780	51860 55380 58400	52850 56460 59990	53830 57520 61230 61590	39900 43580 47290 51020 54780 58560 62360 63190
BACKFILL LO *100POUNDS PER SAND AND GRAVEL Ku'—0.1	V	16.0" 17.0" 18.0" 19.0" 20.0" 21.0" 22.0"	12 5"	15,-10				12780	14330	15820 15920	16960 17580	16690 18070 19290 15:-1	17690 19160 20640 21070 16'-	21800 22910	19610 21270 22940 24620 24810	24060 25820 26780 17'-	23290 25150 27010 28820 18'-	24270 26220 28180 30140 30940 18'-	25220 27270 29320 31370 32580	26160 28300 30440 32590 34220	24860 27070 29300 31540 33780 35840	25660 27970 30290 32610 34950 37460	28840 31250 33670 36100 38530 39080 19'-	29700 32200 34710 37220 39750 40690 19-	19		40490 43290 45530	7 130	3530 48740	50350	000	53550 20-	55190	26780	51860 55380 58400	52850 56460 59990	53830 57520 61230 61590	39900 43580 47290 51020 54780 58560 62360 63190
	V	14.0" 15.0" 16.0" 17.0" 18.0" 19.0" 20.0" 21.0" 22.0"	5833	7127 12:-10"	8468	9857	11300	12470 12780	13560 14330	14630 15820 15920	15680 16960 17580	16690 18070 19290 15:-1	17690 19160 20640 21070 16'-	18660 20230 21800 22910	19610 21270 22940 24620 24810	20540 22290 24060 25820 26780	21440 23290 25150 27010 28820	22320 24270 26220 28180 30140 30940 18'-	23190 25220 27270 29320 31370 32580	24030 26160 28300 30440 32590 34220	24860 27070 29300 31540 33780 35840	25660 27970 30290 32610 34950 37460	26450 28840 31250 33670 36100 38530 39080 19'-	27210 29700 32200 34710 37220 39750 40690 19-	27960 30540 33120 35720 38330 40950 42310 19:-	28700 31360 34030 36720 39420 42130 43920	29410 32160 34920 37700 40490 43290 45530	30110 32940 35790 38660 41540 44420 47130	30/90 33/10 36640 39600 42560 45540 48530 48740	31460 34460 31480 40320 43380 46640 49/20 30330 20-	- 07 Oct. 10 O	32/40 33910 339100 43210 43540 48/80 32040 53550 20 -	33360 36610 39890 43180 46500 49830 53180 55190	33970 37300 40660 44040 47440 50850 54290 56780	34560 37970 41410 44870 48360 51860 55380 58400	35140 38630 42150 45690 49260 52850 56460 59990	35710 39270 42870 46500 50150 53830 57520 61230 61590	36260 39900 43580 47290 51020 154780 58560 62360 63190
BACKFILL LO *100POUNDS PER SAND AND GRAVEL Ku'—0.1	V	15-0" 16-0" 17-0" 18-0" 19-0" 20-0" 21-0" 22-0"	12.	7127	8337 8468	9857	10460 11300	11480 12470 12780	12480 13560 14330	13450 14630 15820 15920	14390 15680 16960 17580	15320 16690 18070 19290	19160 20640 21070 16'-	20230 21800 22910	21270 22940 24620 24810	22290 24060 25820 26780 17'-	23290 25150 27010 28820 18'-	20390 22320 24270 26220 28180 30140 30940	25220 27270 29320 31370 32580	21910 24030 26160 28300 30440 32590 34220	24860 27070 29300 31540 33780 35840	24 23360 25660 27970 30290 32610 34950 37460	25 24060 26450 28840 31250 33670 36100 38530 39080 19 -	26 [24740 27210 29700 32200 34710 37220 39750 40690 19·	27 25410 27960 30540 33120 35720 38330 40950 42310 19·	26050 28700 31360 34030 36720 39420 42130 43920	29 26680 29410 32160 34920 37700 40490 43290 45530	30 27300 30110 32940 35790 38660 41540 44420 47130	2/900 30/90 33/10 36640 39600 42560 45540 48530 48740	50350	502 O CO	29610 32740 33910 39100 43210 43540 48780 52040 53550 20 -	30150 33360 36610 39890 43180 46500 49830 53180 55190	30680 33970 37300 40660 44040 47440 50850 54290 56780	31190 34560 37970 41410 44870 48360 51860 55380 58400	35140 38630 42150 45690 49260 52850 56460 59990	32180 35710 39270 42870 46500 50150 53830 57520 61230 61590	39900 43580 47290 51020 54780 58560 62360 63190

Table B-24 Continued

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	ATRA SITI			12'- 1	- 13	13-	13.	14'-	14.	14.	15'-	15	15'-1	16.	· ·	1 2	<u>-</u> į	-	17′-10	18.	18.	18.	18'-	18.	18	18'-1	18′-1	19'-	19'-	19'-	19,-	19.	19	19 8	19'-10	10,-11	.00	3	20.	50,	20 pounds t
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Q	√ BE	21.0" 22'-0"		12 1	13'- (-13-	13	14'-	14'-	14'-	15		15.70	191		- 97	- !	-)	17'-10	18 0	18.	18- 3		18'- (18	18:-1	18	19'-	47 130	48740 19'-	50350 19'-	51950 19'-	53550	55190	56780	58400	0000	OFFEC	61180 61590	62380 63 190	loads 10%; for 120 pounds p
0.130	PIPE	21.0" 22'-0"		12 1	13 (13	13	14'-	-14'-	14.	15'-		15:-10	16:-		77.77	- !		17'-10	18 0	18								47 130	48740 19'-	50350 19'-	51950 19'-	53550	55190	56780	58400	0000	OFFEC	61180 61590	62380 63 190	ease loads 10%; for 120 pounds p
(μ'—0.130	OF PIPE	19'-0" 20'-0" 21'-0" 22'-0"		12	13 (13.	13.	14'-	14'-	14'-	15.		15:10	191	2 4						34220 18	35840	37460						46750 47130	48740 19'-	49240 50350 19'-	50450 51950 19'-	51650 53550	52840 55190	54010 56780	55160 58400	56300 50000	OFFICE COCCE	57420 61180 61590	58530 62380 63190	increase loads 10%; for 120 pounds t
4Y Kµ'—0.130	OF PIPE	18'-0" 19'-0" 20'-0" 21'-0" 22'-0"		12'- 1	13.	13	13	14'-	14'-	14'-	15.		15:11			26700	20000				33920 34220 18	35220 35840	36510 37460	37770 39080	39020 40690	40240 42310		41450 43920	43820 46750 47130	48740 19'-	49240 50350 19'-	50450 51950 19'-	51650 53550	52840 55190	50530 54010 56780	55160 58400	52640 56300 5000	OFFICE CONTRACTOR	53670 57420 61180 61590	54690 58530 62380 63190	toot, increase loads 10%; for 120 pounds t
, CLAY Kµ'—0.130	AT TOP OF PIPE	18'-0" 19'-0" 20'-0" 21'-0" 22'-0"		12'- 1	13.	-13	13-	14'-	14'-	14'-	15.		15:-10			26700	20000				33920 34220 18	35220 35840	36510 37460	37770 39080	39020 40690	40240 42310		41450 43920	43820 46750 47130	48740 19'-	49240 50350 19'-	50450 51950 19'-	51650 53550	52840 55190	50530 54010 56780	55160 58400	52640 56300 5000	OFFICE CONTRACTOR	53670 57420 61180 61590	54690 58530 62380 63190	cubic foot, increase loads 10%; for 120 pounds t
ARY CLAY Kµ'0.130	AT TOP OF PIPE	17.0" 18.0" 19.0" 20.0" 21.0" 22.0"		15 1	13 (-13-	13-	14'-	14'-	14"-				22910	0.00	24010	20,00,000	78030 78820	29290 30940	30530 32580	31760 33920 34220 18	32960 35220 35840	36510 37460	37770 39080	39020 40690	37600 40240 42310	38780 41450 43920	38720 41450 43920	43820 46750 47130	48740 19'-	43020 46120 49240 50350 19'-	44050 47250 50450 51950 19'-	45070 48360 51650 53550	46070 49450 52840 55190	50530 54010 56780	55160 58400	52640 56300 5000	OFFICE CONTRACTOR	49940 53670 57420 61180 61590	50860 54690 58530 62380 63190	s per cubic foot, increase loads 10%; for 120 pounds t
DINARY CLAY Kµ'-0.130	AT TOP OF PIPE	16.0" 17.0" 18.0" 19.0" 20.0" 21.0" 22.0"		15	13 (13	13.	14'-			17580	19290	21070	22540 22910	0.02720	23.7.7. 26.750 36.790	Z49/0 Z0/20 Z0/20	Z8030 Z8030 Z88 Z0	27320 29290 30940	28470 30530 32580	29600 31760 33920 34220 18	30700 32960 35220 35840	31800 34150 36510 37460	32870 35320 37770 39080	33930 36470 39020 40690	37600 40240 42310	38780 41450 43920	37000 38720 41450 43920	37990 40900 43820 46750 47130	48740 19'-	39920 43020 46120 49240 50350 19 '-	40870 44050 47250 50450 51950	41800 45070 48360 51650 53550	427 10 46070 49450 52840 55190	43610 47060 50530 54010 56780	55160 58400	52640 56300 5000	OFFICE CONTRACTOR	46220 49940 53670 57420 61180 61590	47060 50860 54690 58530 62380 63190	ounds per cubic foot, increase loads 10%; for 120 pounds t
ORDINARY CLAY Kµ'-0.130	AT TOP OF PIPE	16.0" 17.0" 18.0" 19.0" 20.0" 21.0" 22.0"		15 1	13.	13.	-13:-	14'-	14330 14'-	15920	17460 17580		19810 21070	20960 22540 22910	20000 00220 00000	01 07 07 07 07 07 07 07 07 07 07 07 07 07	23 130 2431 0 261 00 00 00 00 00 00 00 00 00 00 00 00 00	74.28U 20 13U 28U3U 2882U	25350 27320 29290 30940	26400 28470 30530 32580	27440 29600 31760 33920 34220 18	28450 30700 32960 35220 35840	29450 31800 34150 36510 37460	30430 32870 35320 37770 39080	31400 33930 36470 39020 40690	32340 34970 37600 40240 42310	33270 35990 38780 41450 43920	34190 37000 38720 41450 43920	35090 37990 40900 43820 46750 47130	48740 19'-	39920 43020 46120 49240 50350 19 '-	37700 40870 44050 47250 50450 51950 19'-	38540 41800 45070 48360 51650 53550	39360 42710 46070 49450 52840 55190	43610 47060 50530 54010 56780	55160 58400	52640 56300 5000	OFFICE CONTRACTOR	42520 46220 49940 53670 57420 61180 61590	43280 47060 50860 54690 58530 62380 63190	10 pounds per cubic foot, increase loads 10%; for 120 pounds p
ORDINARY CLAY Kµ'-0.130	OF PIPE	150" 160" 170" 180" 190" 200" 210" 220"		151	13.	13.			14330	15920	17460 17580	18650 19290	19810 21070	20960 22540 22910	20000 00220 00000	01 07 07 07 07 07 07 07 07 07 07 07 07 07	23 130 2431 0 261 00 00 00 00 00 00 00 00 00 00 00 00 00	74.28U 20 10U 28U3U 2882U	25350 27320 29290 30940	26400 28470 30530 32580	27440 29600 31760 33920 34220 18	28450 30700 32960 35220 35840	29450 31800 34150 36510 37460	30430 32870 35320 37770 39080	31400 33930 36470 39020 40690	32340 34970 37600 40240 42310	33270 35990 38780 41450 43920	34190 37000 38720 41450 43920	35090 37990 40900 43820 46750 47130	48740 19'-	39920 43020 46120 49240 50350 19 '-	37700 40870 44050 47250 50450 51950 19'-	38540 41800 45070 48360 51650 53550	39360 42710 46070 49450 52840 55190	43610 47060 50530 54010 56780	55160 58400	52640 56300 5000	OFFICE CONTRACTOR	42520 46220 49940 53670 57420 61180 61590	43280 47060 50860 54690 58530 62380 63190	ing 110 pounds per cubic foot, increase loads 10%, for 120 pounds t
ORDINARY CLAY Kµ'-0.130	AT TOP OF PIPE	14.0" 15.0" 16.0" 17.0" 18.0" 19.0" 20.0" 21.0" 22.0"	12:-		13	9857	11300	12780	13930 14330	15060 15920	16170 17460 17580	17260 18650 19290	18330 19810 21070	19380 20960 22540 22910	00000 00000 00000 00000	24400 23400 23400 02460 02460 02460	2 1420 23 190 2491 0 201	224 10 24280 26 130 28030 28820	23390 25350 27320 29290 30940	24340 26400 28470 30530 32580	25280 27440 29600 31760 33920 34220 18	26200 28450 30700 32960 35220 35840	27110 29450 31800 34150 36510 37460	28000 30430 32870 35320 37770 39080	28870 31400 33930 36470 39020 40690	29730 32340 34970 37600 40240 42310	30570 33270 35990 38780 41450 43920	31390 34190 37000 38720 41450 43920	32200 35090 37990 40900 43820 46750 47130	48740 19'-	39920 43020 46120 49240 50350 19 '-	34540 37700 40870 44050 47250 50450 51950 19'-	38540 41800 45070 48360 51650 53550	36030 39360 42710 46070 49450 52840 55190	43610 47060 50530 54010 56780	37460 40970 44490 48030 51590 55160 58400	52640 56300 5000	Oracle Control Oracle Control Oracle Control Oracle Control	38850 42520 46220 49940 53670 57420 61180 61590	39520 43280 47060 50860 54690 58530 62380 63190	weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds p
ORDINARY CLAY Kµ'-0.130	AT TOP OF PIPE	150" 160" 170" 180" 190" 200" 210" 220"			13.	9857			14330	15920	17460 17580	17260 18650 19290	18330 19810 21070	19380 20960 22540 22910	0.0000 0.0000 0.0000	244 10 223 0 231 0 240 10 23 0 23 0 3 20 20 20 20 20 20 20 20 20 20 20 20 20	2 1420 23 190 2491 0 201	224 10 24280 26 130 28030 28820	23390 25350 27320 29290 30940	26400 28470 30530 32580	27440 29600 31760 33920 34220 18	28450 30700 32960 35220 35840	29450 31800 34150 36510 37460	28000 30430 32870 35320 37770 39080	28870 31400 33930 36470 39020 40690	32340 34970 37600 40240 42310	33270 35990 38780 41450 43920	34190 37000 38720 41450 43920	35090 37990 40900 43820 46750 47130	19'-	43020 46120 49240 50350 19'-	37700 40870 44050 47250 50450 51950 19'-	41800 45070 48360 51650 53550	39360 42710 46070 49450 52840 55190	50530 54010 56780	55160 58400	38160 41750 45360 48000 50640 56300 50000	Oracle Control Oracle Control Oracle Control Oracle Control	38850 42520 46220 49940 53670 57420 61180 61590	43280 47060 50860 54690 58530 62380 63190	kfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds p
C ORDINARY CLAY Kµ'-0.130	AT TOP OF PIPE	14.0" 15.0" 16.0" 17.0" 18.0" 19.0" 20.0" 21.0" 22.0"	5833	7127	8468	9610 9857	11300	12780	13930 14330	12 13870 15060 15920	13 14880 16170 17460 17580	14 15870 17260 18650 19290	16850 18330 19810 21070	16 17800 19380 20960 22540 22910	0.0000 0.0000 0.0000 0.0000 0.0000	10 10 10 10 10 10 10 10 10 10 10 10 10 1	10 13030 57130 5430 5430 67130	19 20350 224 10 24280 28 130 28830 28830	20 21430 23390 25350 27320 29290 30940	21 22290 24340 26400 28470 30530 32580	23140 25280 27440 29600 31760 33920 34220	23 23970 26200 28450 30700 32960 35220 35840	27110 29450 31800 34150 36510 37460	25 25580 28000 30430 32870 35320 37770 39080	26 26360 28870 31400 33930 36470 39020 40690	27 27120 29730 32340 34970 37600 40240 42310	28 27870 30570 33270 35990 38780 41450 43920	29 28610 31390 34190 37000 38720 41450 43920	30 29330 32200 35090 37990 40900 43820 46750 47130	48740 19'-	32 30720 33780 36840 39920 43020 46120 49240 50350 19'-	34540 37700 40870 44050 47250 50450 51950 19'-	34 32070 35290 38540 41800 45070 48360 51650 53550	35 32720 36030 39360 42710 46070 49450 52840 55190	36 33360 36750 40170 43610 47060 50530 54010 56780	37460 40970 44490 48030 51590 55160 58400	34600 38160 41750 45360 48900 50540 56300 59900	Office Company Control	38850 42520 46220 49940 53670 57420 61180 61590	39520 43280 47060 50860 54690 58530 62380 63190	* For backfill weighing 110 pounds per cubic foot, increase loads 10%, for 120 pounds per cubic foot, increase 20%; etc.

Table B-25

TRENCH WID"H AT TOP OF PIPE	170" 18'-jj" 19'-0" 20'-0" 21'-0" 22'-0" 23'-0" WIDTH	12'-11"	13 4"		14:- 0"	14'- 4"	14'- 9" 10	15'- 2" 11	15'- 6" 12	15'-11" 13	16'- 3" 14	16'- 8"	17. 1" 16		17:-11"	18 - 4 19	- .	19'- 1"	19- 3" 22	ž	7	19'- 9" 25	19′-11″ 26			20'- 4 29		20'- 9" 32	20'-10" 33	 o				21. 5" 38
ICH WID-H AT TOP OF PIPE	19'-0" 20'-0" 21'-0" 22'-0"																		_	-	_	_	T	•••		• •		N	~					
ICH WID"H AT TOP OF PIPE	19'-0" 20'-0" 21'-0")	0		
ICH WID"H AT TOP OF PIF													L											0	0 0	o c		0	0	0	57840 58120	59810	61490	54290 57930 61580 63220
ICH WID"H AT TOP (•							 ,	0	0	0	0	0	0	0 4454	0 46240			0 53030	0 54730	0 56420	0 5784	0 5910	0 60350	0 61580
ICH WID"H AT																0	0	34190	032280	36640 37700	39410	0 41120	0 4282	0 4440	43000 45730 46240	0 4703	0 4958	0 5083	0 52060	0 53270	0 54460	0 5563	10 56790	54290 57930
ICH WID	[£												0,	8	Ş	10 29820	306110 31970	31830 33960	50 35310		09628 00	39240	37930 40520 42820	36510 39140 41770 44400 44540	37560 402/U 43000 45730	38390 4 320 442 10 47030	34650 37620 40590 43530 46580 49580	35450 38500 41560 44640 47730 50830	39370 42520 45630 48870		30 51090	30 5217	10 53240	70 542E
호	0									-	20	06	00 237770	24970 25720	20 27740	40 293110	50 3061					60 368110	50 3793	10 39 14	37560 402/0	00 4243	90 4353	60 4461	20 4563	60 4672	37760 41060 44390 47730	00 4873	39220 42690 46190 497110	36390 38920 43480 47070 50670
								9	8		00 20070	20 21890	22120 23700		40 26220	70 27440	80 28650	70 29830	40 30990	90 32140	20 33260	31930 34360	32920 35450	00 365			20 405	00 415	70 425	20 434	60 443	80 453(90 4619	80 4/0
TR	.0 160					91.					18320 19700	19440 20920		21620 23290	22670 24440	23710 25570	20 26680	25720 27770	00 28840	27650 29890				90 33900	32160 34850	40 36710	50 376	50 385	40 393	00 402	60 4 10	90 418	20 426	201434
	140" 15'-0"	6121	7472	8870							16930 183	17960 194	18960 20540	19950 216	209 10 226	21850 237	22770 24720		24560 26700			27 100 295 10			29480 32160				33120 36240		34470 377		35770 392	3201388
żź				.6	- 5						<u>. </u>		3:-					7.4											ж ж		l	_		_
ATRAN-				13.	- 4	14	14-11		15.	16.	16.	16'-10"	17:	17	18.	981	18'-1	19		19.	19'-11"			8	2 8	2010.	21 (21'- ;		21'- (21.	21	7 - 10
	230																					-						_	0	0	0	0	0 (
Ж)" 22'-0"																					0	0	2 9	2 9	2 9	0	0 53030	54070 54730	553 10 56420	56530 58120	57740 59810	58920 61490	7700
OF PIPE	0" 21'-0"						1						_					00	<u>0</u>	8			_		10 46240 10 47940		147		90 5407	10 5531	30 5653	0 5774		
TOP (0" 20'-0"						+								8	20		30 34190	40 359	30 3770	30 39410	38530 40970	39750 42280	00 43380	30 44840 30 46 100	30 47320	40 4850	40 497	20 50890	30 52040		50 54290	51860 55380	71222
IH AT	.0610-									··			70	20	277		40 31970	70 334	90 347	80 360	50 37290	00 385	20 397	30 40930	90 432	40 44430	60 455	80 466	70 477	40 487	00 498	40 508	181 C 109	5 y 5 7 5 6
TRENCH WIDTH AT TOP OF	17:-0" 18:-0"						1				20		180 23770	24620 25720			28180 30140	29320 31370 33430	30440 32590 34740 35980	31540 33780 36030 37700	10 34950	70 36 100		00700	37700 40490 43290	38660 41540	00 425	20 435	20 445	10 455	80 465	40 474	70 483	いっけしつの
ENC	16'-0'' 17'	 -						920	8		19460 20070	20640 21890		22940 246)60 25E		26220 281	27270 293	28300 304	29300 315	30290 32610	31250 33670	32200 34710	02/55/02	20 307	986 386	396	80 405	00 414	00 423	90 43 1	60 440	50 448) t = 3
TR	15'-0" 16'				01501	11810																28840 312	29/00/322	30340 33 120 337 20 38330 40930 43380	32160 34920	32940 35790	7 10 36E	34460 37480 40520 43580 46640 49720	35 190 38300 41420 44570 47720	910 39	36610 39890 43 180 46500 49830	300 40¢	37970 41410 44870 48360 51860 38630 43150 45650 40360 52860	1111111
	140" 15	6121	14/2									17690 19		19610 21				23 190 25				20450 28	62 01272	28700 31	29410 32		30790 33710 36640 39600 42560 45540 48530		32110 35	32740 35910 39100 42310 45540 48780	33360 36		34300 378	2
	7	20																						77 77			31 30						37 34	_

Table B-25 Continued

	ATRAN-	WIDTH	12'- 9" 13'- 1"	13'- 5"	13'- 9"	14'- 0"	14'- 9"	15'- 1"	15'- 5"	15'- 9"	16'- 2"	16'- 6"	16'-10"	17 3"	17 8"	18'- 1"	18'- 5"	18'- 6"	18 8	18'-10"	18'-11"	19 0	19'- 2"	19'- 3"	19 5"	19 6		19 8	19'-10"	19'-11"	20 0	20 1	20'- 2"	20 4"		20 6
		230																																		
	ш	. 55.0					-																										_	_	_	
0.110	F PIP	21,-0,																					_	_	_		_	_	_	_)	59810	61490	63220	64900	66290
Κμ' – C	0 d0.	19.0" 20.0" 21.0"		······································												_		_	_	_	_		44540	46240	47940			23030		56420	54670 58120	55930 59450	57180 60790	58410 62120 63220	59630 63420 64900	60830 64720
ZAY.	HAT T											L		_	_	31970	34190	35980	37700	39410	41120	42820	44060	45440	46800	48150									2963	
SATURATED CLAY Kµ'-0.110	TRENCH WIDTH AT TOP OF PIPE	170" 18:-0"									_		_	27740	26750 28640 29820	31940	27110 29180 31260 33340 34190	32550 34720	36090	27990 30350 32710 35070 37440	31390 33850 36310 38770	29880 32420 34980 37530 40090 42820	33440 36090 38740 41390 44060 44540	31710 34440 37180 39930 42680 45440 46240	32610 35430 38260 41100 43950 46800 47940	36400 39330 42260 45210	37360 40380 43410 46450	38310 41420 44540 47670	36050 39240 42440 45660 48880	36880 40160 43450 46760 50080	41060 44450 47850 51260	41950 45430 48920 52420	39280 42830 46400 49980 53580	40060 43700 47360 51030 54710	40820 44550 48300 52060 55840	41570 45390 49230 53080 56950
TURA	NCH /							_	_	_	21890	22980 23770	24250 25720	27300	28640	29960	31260	32550	33850	32070	36310	37530	38740	38830	0 41100	42260) 43410	144540	45660	7 46760	47850	48920	49980	51030	52060	23080
SA	TRE	. 160						16600	18300	17590 18980 20070	21690			0 255 10		26000 27980 29960) 2918(30370	29280 31550 33820	32710	33820	34980	36096	37180	38260	39330) 40380) 41420) 4244(43450	44450	45430	46400	47360	48300	49230
		. 150"	- 0		0	13350	14950	15310 16500	0 17750) 1898(20200	9800 21390	22570	23730	23000 24870		27110) 29280	30320	31390	32420	33440	3444(3543(36400	3736(38310	39240) 40160	41060	41950) 42830) 43700) 4455(7 45390
۵		140	6121	8870	103 10	11810 12960	14140	1531	16460	1759	18710	1980	20890	21950	2300	24030	25040	26040	27020	2799(28940	2988	30800	3171	3261	33490	34360	35210	3605(3688	37690	38490	3928	4006	4082	4157
	TRAN-	WIDTH		3 7.:	13'-11"		<u>-</u>	<u>.</u> 4	 8	 o	5.	.,6			 o	5	 6	<u> </u>	÷	3,	4		7	6		 0	<u> </u>	რ	<u>.</u> 4			÷	6	<u>.</u>		-
		- 🗀	 .		<u>, T</u>	14'- 3'' 14'- 7''	4'-11"	'n	.89	<u>.</u>	<u>.</u>		17.	17	18'- 0"	<u>.</u>	- 2	18'-11"	19'-	19,	19,-	19'-	19'- 7"	19'- 9"	19′-10″	20.	50	, 20		20.	20 7"	20	20.	20'-11"	21'- 0"	21-
	ATRAN-		12'-10"	3,			Ť	_	<u>~</u>	<u>=</u>	=	Ė	_	_	_	_	_									-	2	~	~	~	∾	2	~			
	ATR.	230	12.	13			Ė		"		<u>-</u>		-	_	_	_												~	~ —	<u>~</u>	2	- 2				0
	TTR.	22.0 23.0	12.	13.		-			<u>~</u>	<u>+</u>	<u> </u>			_	_																			-		06599
130	7	210" 22'-0" 23'-0"	12.	13.	-13	+						-		_						0	0	0		Q	·		51320	53030				59810	61490	0 63220		0 66250 66590
u'0.130	OF PIPE	20'-0" 21'-0" 22'-0" 23'-0"	12.	13.	-13													0				0 42820		0 46240	0 47940	49640	51030 51320	52360 53030	53670 54730	54960 56420	56240 58120	57500 59810	58740 61490		61180 64900	62380 66250 66590
-AY Kμ'0.130	OF PIPE	19.0" 20.0" 21.0" 22.0" 23.0"	12:	13.	13	***			~							31970	34190	0 32980	37490	38870					45480	46750 49640	48000 51030 51320	49240 52360 53030	50450 53670 54730	51650 54960 56420	56240 58120	57500 59810	58740 61490		61180 64900	0 58530 62380 66250 66590
RY CLAY Kµ'-0.130	OF PIPE	18'-0" 19'-0" 20'-0" 21'-0" 22'-0" 23'-0"	12:	13.									25720	27740	29820	31270 31970	32600 34190	33920	37490	38870					42650 45480	43820 46750 49640	44980 48000 51030 51320	49240 52360 53030	50450 53670 54730	51650 54960 56420	56240 58120	57500 59810	58740 61490		53670 57420 61180 64900	54690 58530
łDINARY CLAY Kµ'-0.130	OF PIPE	17'-0" 18'-0" 19'-0" 20'-0" 21'-0" 22'-0" 23'-0"	12.	13.							21890	23770	25450 25720	26750 27740	28030 29820	29290 31270 31970	30530 32600 34190	31760 33920	32960 35220 37490	34150 36510 38870	35320 37770 40230	36470 39020 41570			39820 42650 45480	40900 43820 46750 49640	44980 48000 51030 51320	49240 52360 53030	50450 53670 54730	51650 54960 56420	56240 58120	57500 59810	58740 61490		53670 57420 61180 64900	50860 54690 58530
ORDINARY CLAY Kµ'-0.130	7	160" 170" 180" 190" 200" 210" 220" 230"	12:	13.				16600	18300	20070	21300 21890	22540 23770	23770 25450 25720	24970 26750 27740	26150 28030 29820	27320 29290 31270 31970	28470 30530 32600 34190	29600 31760 33920	30700 32960 35220 37490	31800 34150 36510 38870	35320 37770 40230	36470 39020 41570	34970 37600 40240 42890	35990 38720 41450 44190	37000 39820 42650 45480	37990 40900 43820 46750 49640	38960 41970 44980 48000 51030 51320	39920 43020 46120 49240 52360 53030	50450 53670 54730	51650 54960 56420	56240 58120	57500 59810	58740 61490		53670 57420 61180 64900	50860 54690 58530
ORDINARY CLAY Kµ'-0.130	OF PIPE	15.0" 16.0" 17.0" 18.0" 19.0" 20.0" 21.0" 22.0" 23.0"				11810	14950	16250 16600	17460 18300	18650 20070	19810 21300 21890	20960 22540 23770	22090 23770 25450 25720	23 190 24970 26750 277 40	24280 26150 28030 29820	25350 27320 29290 31270 31970	26400 28470 30530 32600 34190	27440 29600 31760 33920	28450 30700 32960 35220 37490	29450 31800 34150 36510 38870	30430 32870 35320 37770 40230	31400 33930 36470 39020 41570	32340 34970 37600 40240 42890	33270 35990 38720 41450 44190	34190 37000 39820 42650 45480	35090 37990 40900 43820 46750 49640	35970 38960 41970 44980 48000 51030 51320	36840 39920 43020 46120 49240 52360 53030	37700 40870 44050 47250 50450 53670 54730	38540 41800 45070 48360 51650 54960 56420	56240 58120	57500 59810	58740 61490		42520 46220 49940 53670 57420 61180 64900	43280 47060 50860 54690 58530
ORDINARY CLAY Kµ'—0.130	OF PIPE	-0" 16'-0" 17'-0" 18'-0" 19'-0" 20'-0" 21'-0" 22'-0" 23'-0"	5 6121 12: 6 7472 13:	8870	10310			16600	16170 17460 18300	20070	21300 21890	22540 23770	22090 23770 25450 25720	23 190 24970 26750 277 40	26150 28030 29820	27320 29290 31270 31970	26400 28470 30530 32600 34190	25280 27440 29600 31760 33920	28450 30700 32960 35220 37490	27110 29450 31800 34150 36510 38870	28000 30430 32870 35320 37770 40230	28870 31400 33930 36470 39020 41570	32340 34970 37600 40240 42890	30570 33270 35990 38720 41450 44190	31390 34190 37000 39820 42650 45480	32200 35090 37990 40900 43820 46750 49640	33000 35970 38960 41970 44980 48000 51030 51320	33780 36840 39920 43020 46120 49240 52360 53030	34540 37700 40870 44050 47250 50450 53670 54730	35290 38540 41800 45070 48360 51650 54960 56420	36030 39360 42710 46070 49450 52840 56240 58120	57500 59810	58740 61490	52640 56300	38850 42520 46220 49940 53670 57420 61180 64900	50860 54690 58530

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. ▲Transition loads (**bold type**) and widths based on Kµ—0.19, r_sdp—0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-26

		Z,	တ		മ		₽ 1E	EIC	1£ 2						CK 2°		LL 8				24 O	SS SV	٦ چ	0		O 83			PE ~	•		ΞE		. ~	m	Ф
ż	S E	2	.6		 2:		<u> </u>		:	3.		-	1.0		3.	<u></u>	<u>-</u>	3" 21		1" 23	<u>~</u>			3" 27			30	31	4" 32	33			-		1 38	
ATRAN	WIDTH	13'-	13'-	14.	14'-	14'-10	15'-	15'- (15'-11	16'-	16'-	17.	17'- (17'-10"	18'-	18	19,-	19,-	19'-11"	50-	50,-		50 ,-	20'- 8"	2010	20'-11"	- LZ	21	21.	21-	21'- 7"	21'- 8"	21'-10"	21'-11"	22. 1	22'- 2"
	230																																		65510	67250
	220														7												51430	53200	54960	56710	58470	60240	1990	3740	5240	6540
PIPE	4																			39040	40820	42600	4370	6140	2900			2600		2560 	26560 S	7840 (6	9 100 6	0350	1580 e	2790 6
TRENCH WIDTH AT TOP OF PIPE	7.0.0																32730	34980	37240	38900 3	310 4	1690 4	3060 4	400	5730 4	030	3320 5	9280 2	830 5	5090		1460 5	630 5	3790 6	930 6	9050
T TO	ο														28430	540				640 38	960 40	240 4	520 43	770 4	000	210 47	400 48	580 46	730 50	870 5	990 S	060 27	170 55	240 56	290 57	330 56
TH A	-0 19											22490	410	26390	27990 28	29310 30540	30610 32580	31890 33	150 35	34390 36640	900 37	800 38	980 40	140 41	270 43	390 44	42490 45400 48320	580 46	340 47	390 4 8	720 49	730 51	730 52	710 53	370 54	320 55 570 55
TRENCH WIDTH AT TOP OF PIPE	16:0" 17:0" 18:0" 19:0" 20:0" 21:0"	_						-		30	20630	22400 22	23700 24410	24970 26 :	26220 279	27440 293		29830 31	26700 28840 30990 33150 35310	32140 34	33260 35600 37960 40310	34360 36800 39240 41690	35450 37980 40520 43060 44370	36510 39140 41770 44400 46140	37560 40270 43000 45730 47900	38590 41390 44210 47030	39690 45	31710 34650 37620 40590 43580 46580 49580 52600	35450 38500 41560 44640 47730 50830 53940	36240 39370 42520 45690 48870 52060 55260	37000 40220 43460 46720 49990 53270	37760 41060 44390 47730 5 1090 54460 57840	35130 38490 41880 45300 48730 52170 55630 59100 61990	39220 42690 46190 49710 53240 56790 60350 63740	36390 39920 43480 47070 50670 54290 57930 61580 65240 65510	37010 40620 44260 47930 51620 55330 59050 62790 66540 67250
ENC	0" 17.	_					8	8	96	60 18830								36Z OZ	40 306	90 321		30 343	20 354	365	50 375		10 396	20 405	00 415	70 425	20 434	60 443	80 453	90 461	80 470	60 479
TH	1			91	ဂ္ဌ	<u>0</u>	00 13760	10 15400	00 1 1000	70 18460	20 19700	40 20920	40 22120	20 23290	70 24440	10 25570	20 26680	20 27770	30 288	50 29890	30 30920	10 3 1930	30410 32920	33300			10 367 10	30 376	₅₀ 385	40 393	30 402	30 4 10	90 418	20 426	20 434	20 442
	150	9	n	0 9161	0 10650	0 12180	0 13600	0 14810	0 16000	17170	0 18320	0 19440	0 20540	0 21620	0 22670	0 23710						0 29510	0 304				0 33840	0 346	0 3546	0 3624	0 3700	0 3776	0 3849		0 3992	0 4062
	140	6330	7723	9100	10290	11460	12600	13720	14810	15880	16930	17960	18960	19950	20910	21850	22770	23670	24560	25420	26270	27100	27910	28700	29480	30240	30980	3171	32420	33120	33800	34470	3513	35770	3639	3701
ż	SE SE	2	 0	<u>.</u>		<u>_</u> _	 	<u>.</u>	<u>.</u>	5.		3,	<u>.</u>			-		G	5		. 0		6	0	: :					 	_	<u>.</u> _	3	<u>.</u> 4	6.	
ATRAN-		13 5"	13'-10"	14'- 2"	14'- 7"	14'-11"	15'- 3"	15. 8"	16:- 1"	16 5	16'-10"	17 3"	17 8"	18'- 1"	18 6	18'-11"		19'- 9"	20 2	20 4	50,- 6	20.	2010	21'- 0"	21'- 1"	21. 3.	21'- 5"	21'- 7"	21 8"	21'-10"		22	22	22'- 4"	.55 6	22 7"
ATRAN-	230	13'- 5"	1310	14. 2"	14'- 7"	14'-11"	15'- 3"	15'- 8"	16'- 1"	16:- 5:.	16'-10"	17 3"	17. 8"	18'- 1"	18. 6.	18'-11"		19'- 9"	20 2	20 4"	50,- 6	20 8	2010	21 0"	21'- 1"	21- 3	21'- 5"	21'- 7"	21 8			22	22	22	22	22.
	22'-0" 23'-0"	13'- 5"	13'-10"	14 2"	14'- 7"	14'-11"	15'- 3"	15'- 8"	16'- 1"	16 5"	16'-10"	17'- 3"	17 8"	18'- 1"	18. 6	18'-11"		19'- 9"	20 5	20'- 4"				21.	21	21.	21		21			22	22	22	22	22.
PIPE	230	13'- 5"	1310	14 2"	14'- 7"	14'-11"	15'- 3"	15'- 8"	16'- 1"	16'- 5"	16'-10"	17'- 3"	17'- 8"	18'- 1"	18 6"	1811.		-61	- 50	- 20				21	21	21.	21		21			22	61200 61990 22'-	22	22.	61230 64960 67250 22:- 7"
PIPE	21'-0" 22'-0" 23'-0"	13'- 5"	1310	14. 2"	14'- 7"	14'-11"	15'- 3"	15'- 8"	16 1"	16. 5"	16:-10	17'- 3"	17 8"	18'- 1"	18 6"	1811.	19'-	19,-	37240 20'-	39040 20'-	40820	42600	44370	46140	47570 47900 21-	48910 49660	50230 51430 21'-	51530 53200	52810 54960 21	54070 56710	55310 58470	56530 59900 60240 22'-	57740 61200 61990 22'-	58920 62470 63740 22'-	60080 63720 65510 22-	61230 64960 67250 22 -
PIPE	21'-0" 22'-0" 23'-0"	13 5"	1310	14 2"	14'- 7"	14'-11"	15'- 3"	15'- 8"	16'- 1"	16. 5"		17 3"	17. 8"	18.			19'-	19,-	37240 20'-	39040 20'-	40820	42600	44370	46140	47570 47900 21-	48910 49660	50230 51430 21'-	51530 53200	52810 54960 21	54070 56710	55310 58470	56530 59900 60240 22'-	57740 61200 61990 22'-	58920 62470 63740 22'-	60080 63720 65510 22-	61230 64960 67250 22 -
PIPE	190" 20'-0" 21'-0" 22'-0" 23'-0"	13'- 5"	13'-10"	14. 2"	14'- 7"	14-11"	15- 3"	15'- 8"	16'- 1"	16 5"		17	-141	18.			19'-	19,-	37240 20'-	39040 20'-	40820	42600	44370	46140	47570 47900 21-	48910 49660	50230 51430 21'-	51530 53200	52810 54960 21	54070 56710	55310 58470	56530 59900 60240 22'-	57740 61200 61990 22'-	58920 62470 63740 22'-	60080 63720 65510 22-	61230 64960 67250 22 -
PIPE	190" 20'-0" 21'-0" 22'-0" 23'-0"	13'- 5"	1310	14 2"	14'- 7"	14'-11"	15'- 3"	15'-	-191	16:-		17	-141	18.			19'-	19,-	37240 20'-	39040 20'-	40820	42600	44370	46140	47570 47900 21-	48910 49660	50230 51430 21'-	51530 53200	52810 54960 21	54070 56710	55310 58470	56530 59900 60240 22'-	57740 61200 61990 22'-	58920 62470 63740 22'-	60080 63720 65510 22-	61230 64960 67250 22 -
PIPE	17.0" 18.0" 19.0" 20.0" 21.0" 22.0" 23.0"	13 5"	1310"	14. 2"	14'- 7"	14'-1	15.	15'-	-191	16:-		17	-141	18.			19'-	19,-	37240 20'-	39040 20'-	40820	42600	44370	46140	47570 47900 21-	48910 49660	50230 51430 21'-	51530 53200	52810 54960 21	54070 56710	55310 58470	56530 59900 60240 22'-	57740 61200 61990 22'-	58920 62470 63740 22'-	60080 63720 65510 22-	61230 64960 67250 22 -
	160" 170" 180" 190" 200" 210" 220" 230"	13 5"	13,-10			141	13760	15400	17010 17090 16:-	18240 18830 16:	19460 20630	17	21800 23380 24410 17'-	22940 24620 26290 26390 18'-	24060 25820 27600 28430	25150 27010 28880 30540	19'-	19,-	37240 20'-	39040 20'-	40820	42600	44370	46140	47570 47900 21-	48910 49660	50230 51430 21'-	51530 53200	52810 54960 21	54070 56710	55310 58470	56530 59900 60240 22'-	57740 61200 61990 22'-	58920 62470 63740 22'-	60080 63720 65510 22-	61230 64960 67250 22 -
PIPE	15'-0" 16'-0" 17'-0" 18'-0" 19'-0" 20'-0" 21'-0" 22'-0" 23'-0"	13:-				12180	13460 13760	15400	17010 17090 16:-	18240 18830 16:	19460 20630	17	21800 23380 24410 17'-	21270 22940 24620 26290 26390 18 ′-	24060 25820 27600 28430	25150 27010 28880 30540	19'-	19,-	37240 20'-	39040 20'-	27970 30290 32610 34950 37290 39640 40820	42600	44370	46140	47570 47900 21-	32160 34920 37700 40490 43290 46100 48910 49660	32940 35790 38660 41540 44420 47320 50230 51430 21 '-	51530 53200	52810 54960 21	54070 56710	55310 58470	56530 59900 60240 22'-	37300 40660 44040 47440 50850 54290 57740 61200 61990 22'-	58920 62470 63740 22'-	38630 42150 45690 49260 52850 56460 60080 63720 65510 22 -	39270 42870 46500 50150 53830 57520 61230 64960 67250 22 .
PIPE	160" 170" 180" 190" 200" 210" 220" 230"	6330		9034 9161		12180	13460 13760 15:-	15400	14630 15820 17010 17090	18240 18830 16:		15 17690 19160 20640 22120 22490	-141	22940 24620 26290 26390 18'-	24060 25820 27600 28430	25150 27010 28880 30540	22320 24270 26220 28180 30140 32100 32730 19-	23190 25220 27270 29320 31370 33430 34980	24030 26160 28300 30440 32590 34740 36900 37240 20:-	24860 27070 29300 31540 33780 36030 38280 39040 20 -	25660 27970 30290 32610 34950 37290 39640 40820	26450 28840 31250 33670 36100 38530 40970 42600	27210 29700 32200 34710 37220 39750 42280 44370	27960 30540 33120 35720 38330 40950 43580 46140	28/00 31360 34030 36720 39420 42130 44840 47570 47900 21 '-	29410 32160 34920 37700 40490 43290 46100 48910 49660	30110 32940 35790 38660 41540 44420 47320 50230 51430 21 .	30790 33710 36640 39600 42560 45540 48530 51530 53200	31460 34460 37480 40520 43580 46640 49720 52810 54960 21 .	32110 35190 38300 41420 44570 47720 50890 54070 56710	35910 39100 42310 45540 48780 52040 55310 58470	56530 59900 60240 22'-	37300 40660 44040 47440 50850 54290 57740 61200 61990 22'-	58920 62470 63740 22'-	38630 42150 45690 49260 52850 56460 60080 63720 65510 22 -	61230 64960 67250 22 -

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Table B-26 Continued

		220.																																			6904	
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SATURATED CLAY Kµ'-0.110	AT TC	.0-,6															12730	14980	00698	38360 39040	39810 40820	11240	12660	38740 41390 44060 46140	15440	00891	18150	19490	0180	52110	23400	94670	55930	57180	584 10	08969	60830 64720 68620 69040	
D D	DTH /	80												6390	8430	0540	31940 32730	3340 3	4720	0609	7440	8770	0600	1390	2680	3950 4	5210 4	6450 4	7670	8880	0800	1260	2420	3580	4710	5840	6950	
JRATE	H WI	1.0.2									20630	22490	24410	25940 26390	27300 28430	28640 30540	29960 3	1260 3	2550 3	3820 3	5070 3	6310 3	7530 4	8740 4	39930 42680 45440	1100 4	2260 4	34104	4540 4	5660 4	6760 5	7850 5	8920 5	9980	1030 5	2060 5	3080 5	
SATL	TRENCH WIDTH AT TOP OF PIPE	160 170 180 190 200 210 220						15400	17090	18830	20380 2	21690 2	22980 2	24250 2	25510 2	26750 2	27980 2	29180 31260 33340 34980	30370 32550 34720 36900 37240	31550 33820 36090	32710 35070 37440	3850 3	4980 3	3090	7180 3	3260 4	9330 4	3380 4	1420 4	2440 4	3450 4	4450 4	5430 4	3400 4	7360 5	3300 5	9230 5	%; etc.
	⊢	120 16			9650	12180	13760	15240 1	16500 11	17750 11	18990 20	20200	21390 2	22570 2	23730 25	24870 2		7110 29	3200 30	29280 3	320 33	28940 31390 33850 36310 38770 41240	29880 32420 34980 37530 40090 42660 44370	30800 33440 36090	31710 34440 37180	32610 35430 38260 41100 43950 46800	33490 36400 39330 42260 45210 48150 51100 51430	34360 37360 40380 43410 46450 49490 52530 53200	35210 38310 41420 44540 47670 50810 53950 54960	36050 39240 42440 45660 48880 52110 55350	36880 40160 43450 46760 50080 53400 56730 58470	37690 41060 44450 47850 51260 54670 58100 60240	38490 41950 45430 48920 52420 55930 59450 61990	39280 42830 46400 49980 53580 57180 60790 63740	40060 43700 47360 51030 54710 58410 62120 65510	40820 44550 48300 52060 55840 59630 63420 67250	41570 45390 49230 53080 56950	ase 20
۵		140 15	6330	9161	10520 10650	11750 12	13960 13	14140 15	15310 16	16460 17	17590 18	187 10 20	19800 21	20890 22	21950 23	23000 24	24030 26	25040 27110	26040 28200	27020 29	27990 30350	940 31	880 32	800 33	710 34	610 35	490 36	360 37	210 38	020 36	880 40	690 41	490 41	280 42	060 43	820 44	570 45	t, incre
_		14	9	- 6	9	Ξ	12	14	15	16	17	18	19	20	21	23	24	25	56	27	27	58	59	30	31	32	33	34	35	36	36	37	38	39	40	40	4	bic foo
	ATRAN-	WIDTH	13'- 4"	13'- /"	14'- 4"	14'- 8"	15. 0"	15'- 4"	15'- 8"	16'- 1"	16'- 5"	16:-10"	17:- 3"	17-71	18'- 0"	18'- 4"	18'- 9"	19'- 2"	19'- 7''	19'- 8"	19'-10"		20'- 1"	20'- 3"	20'- 4"	20:- 6"	20 7	20′- 9″	2010	20:-11	21:- 1"	. 2	. 3.	. 2.	21 6	21'- 7"	9.	s per cu
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.—0.130	P OF PIPE																	34980		39040	40820	42600	0 44120 44370	45540 46140	46940 41900	48320 49660	49680 51430	5 1030 53 200	52360 54960	23670 56710	54960 58280 5847) 56240 59650 6024	57500 61000 6199	58740 62340 637 4	59970 63660 655 1	61180 64960 672	62380 66250 690	ncrease loads 10%; t
λΥ Kμ'—0.130	NT TOP OF PIPE	190" 20'-0" 21'-0"														30540	32730	34680 34980		37490 39040	38870 40820	40230 42600	41570 44120 44370	42890 45540 46140	44190 46940 47900	45480 48320 49660	46750 49680 51430	48000 51030 53200	49240 52360 54960	50450 53670 56710	51650 54960 58280 5847	52840 56240 59650 6024	540 10 57500 61000 6199	55160 58740 62340 6374	56300 59970 63660 6551	57420 61180 64960 672	58530 62380 66250 690	foot, increase loads 10%; h
Y CLAY Kμ'0.130	OTH AT TOP OF PIPE	190" 20'-0" 21'-0"											24400	26390	28430	29910 30540	31270 32730	32600 34680 34980		35220 37490 39040	36510 38870 40820	37770 40230 42600	39020 41570 44120 44370	40240 42890 45540 46140	41450 44190 46940 47900	42650 45480 48320 49660	43820 46750 49680 51430	44980 48000 51030 53200	46120 49240 52360 54960	47250 50450 53670 56710	48360 51650 54960 58280 5847	49450 52840 56240 59650 6024	50530 54010 57500 61000 6199	51590 55160 58740 62340 6374	52640 56300 59970 63660 6551	53670 57420 61180 64960 672	54690 58530 62380 66250 690	r cubic foot, increase loads 10%; f
INARY CLAY Kµ'-0.130	H WIDTH AT TOP OF PIPE									18830	20630	22490	24130 24400	25450 26390	26750 28430	28030 29910 30540	čί	30530 32600 34680 34980		32960 35220 37490	34150 36510 38870 40820	35320 37770 40230 42600	36470 39020 41570 44120 44370	37600 40240 42890 45540 46140	38720 41450 44190 46940 47900	39820 42650 45480 48320 49660	40900 43820 46750 49680 51430	41970 44980 48000 51030 53200	43020 46120 49240 52360 54960	44050 47250 50450 53670 56710	45070 48360 51650 54960 58280 5847	46070 49450 52840 56240 59650 6024	47060 50530 54010 57500 61000 61990	48030 51590 55160 58740 62340 637 4	48990 52640 56300 59970 63660 655 1	49940 53670 57420 61180 64960 672	50860 54690 58530 62380 66250 690	nds per cubic foot, increase loads 10%; f
ORDINARY CLAY Kµ'-0.130		170" 18-0" 19-0" 20-0" 21-0"						15400	17090	=	Ñ	21300 22490	22540 24130 24400	23770	24970	26150 28030 29910 30540	27320 29	3(31760 33920 36090	32960 35220 37490	31800 34150 36510 38870 40820	32870 35320 37770 40230 42600	33930 36470 39020 41570 44120 44370		35990 38720 41450 44190 46940 47900	37000 39820 42650 45480 48320 49660	37990 40900 43820 46750 49680 51430	38960 4 1970 44980 48000 5 1030 53200	39920 43020 46120 49240 52360 54960	40870 44050 47250 50450 53670 56710	41800 45070 48360 51650 54960 58280 5847	42710 46070 49450 52840 56240 59650 6024	43610 47060 50530 54010 57500 61000 6199	44490 48030 51590 55160 58740 62340 637 4	45360 48990 52640 56300 59970 63660 6551	46220 49940 53670 57420 61180 64960 672	47060 50860 54690 58530 62380 66250 690	10 pounds per cubic foot, increase loads 10%; for
ORDINARY CLAY Kµ'-0.130	TRENCH WIDTH AT TOP OF PIPE	160" 170" 18'-0" 19'-0" 20'-0" 21'-0"			10650	12180	13760	15020 15400	16250 17090	=	20030 2	21300 2	22540 2	23770	24970	26150	27320 29	3(31760 33920 36090	30700 32960 35220 37490	29450 31800 34150 36510 38870 40820	32870	33930	34970	32990	34190 37000 39820 42650 45480 48320 49660	35090 37990 40900 43820 46750 49680 51430	35970 38960 41970 44980 48000 51030 53200	36840 39920 43020 46120 49240 52360 54960	37700 40870 44050 47250 50450 53670 56710	38540 4 1800 45070 48360 5 1650 54960 58280 5847	39360 42710 46070 49450 52840 56240 59650 6024	10170 43610 47060 50530 54010 57500 61000 6199	10970 44490 48030 51590 55160 58740 62340 637 4	11750 45360 48990 52640 56300 59970 63660 6551	12520 46220 49940 53670 57420 61180 64960 672	13280 47060 50860 54690 58530 62380 66250 690	thing 110 pounds per cubic foot, increase loads 10%; f
ORDINARY CLAY Kµ'-0.130		15.0" 16.0" 17.0" 18.0" 19.0" 20.0" 21.0"	6330	9161	0410 10650	1600 12180		15020	5060 16250 17090	17460 18750 1	18650 20030 2	19810 21300 2	22540 2	22090 23770	23190 24970	24280 26150	25350 27320 29	26400 28470 30	27440 29600 31760 33920 36090	28450 30700 32960 35220 37490	29450	30430 32870	33930	34970	32990	1390 34190 37000 39820 42650 45480 48320 49660	12200 35090 37990 40900 43820 46750 49680 51430	13000 35970 38960 41970 44980 48000 51030 53200	3780 36840 39920 43020 46120 49240 52360 54960	4540 37700 40870 44050 47250 50450 53670 56710	5290 38540 41800 45070 48360 51650 54960 58280 5847	6030 39360 42710 46070 49450 52840 56240 59650 60240	6750 40170 43610 47060 50530 54010 57500 61000 6199	7460 40970 44490 48030 51590 55160 58740 62340 637 4	8160 41750 45360 48990 52640 56300 59970 63660 6551	8850 42520 46220 49940 53670 57420 61180 64960 672	9520 43280 47060 50860 54690 58530 62380 66250 69040	till weighing 110 pounds per cubic foot, increase loads 10%; f
C ORDINARY CLAY Kµ'-0.130		160" 170" 18'-0" 19'-0" 20'-0" 21'-0"	5 6330		10410	11600	12780	15020	12 15060	13 16170 17460 18750 1	14 17260 18650 20030 2	18330 19810 21300 2	16 19380 20960 22540 2	17 20410 22090 23770	18 21420 23190 24970	19 22410 24280 26150	20 23390 25350 27320 29	21 24340 26400 28470 30	22 25280 27440 29600 31760 33920 36090	23 26200 28450 30700 32960 35220 37490	24 27110 29450	25 28000 30430 32870	26 28870 31400 33930	27 29730 32340 34970	28 30570 33270 35990	29 31390 34190 37000 39820 42650 45480 48320	30 32200 35090 37990 40	31	32	33	34 35290	32 36030	36 36750 40170 43610 4	37 37460 40970 44490 48030 51590 55160 58740 62340 63740	38 38160 41750 45360 48990 52640 56300 59970 63660 65510	38850	40 39520 43280 47060 50860 54690 58530 62380 66250 690	* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, a Arransition loads (bold type) and widths based on Kμ-0.19, r_{SQ}p-0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-27

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HIE:	22'-0"																			42740		48340	50210		53910				29860	61230	62590	63920	65240																																																																				
P OF	21:-0																	38440	40860	42670	45610	47040 48340	48460	49860	51240	52600	53940	55260	26560	57840	59100	60350	61580																																																																				
AT TC	200														31560	33780	02098	37480	38900	40310	43060	44400	45730	47030	48320	49580	50830	52060	53270	54460	55630	56790	47070 50670 54290 57930																																																																				
TRENCH WIDTH AT TOP OF PIPE	19'-0"						T						27310	29400	31190 31560	32580 33780	33960	35310 37480	36640 38900	37960 40310	34360 38800 39240 4 1890 35450 37980 40520 43060	41770 44400	43000 45730	38590 41390 44210 47030	45400	34650 37620 40590 43580 46580 49580 52600	41560 44640 47730 50830	42520 45690 48870 52060	49990 53270	51090 54460	38490 41880 45300 48730 52710 55630 59100	53240 56790	54290																																																																				
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ATRAN-	WIDTH 15'-0"	0	5		- ;							•	7	19'- 1 " 226		19'-10"		6			21 8		21'-11" 32	-5	<u>-</u> 4			22'- 8" 36			23:- 1"	23 2"	22. V.																																																																				
ATRAN-	24'-0" WIDTH 15'-0"	0	5		- ;	ء د	, ,	- i-				 س	7		5			6						22 2	22'- 4"	22 5	22 7"	22'- 8"	22:-10"	22'-11"	23:- 1"	23 2"	22.																																																																				
_	23'-0" 24'-0" WIDTH 15'-0"	0	5		- ;	ء د	, ,	- i-				 س	7		5			50 9	21 2"	21'- 4"	21. 8.	21 9	21'-11"	22 2	53910 22'- 4"	22 5	57630 22'- 7"	59470 22'- 8"	22:-10"	22'-11"	23:- 1"	23 2"	22. V.																																																																				
_	i0" 23'-0" 24'-0" WIDTH 15'-0"	0	5		- ;	ء د	, ,	- i-				 س	7		5		20 3"	50 9"	0860 21'- 2"	21'- 4"	21. 8.	21 9	50210 21'-11"	51730 52060 22'- 2 "	53150 53910 22'- 4"	54540 55770 22°- 5"	55910 57630 22'- 7"	57260 59470 22'- 8 "	58590 61320 22:-10"	59900 63160 22:-11"	61200 64670 64990 23 '- 1"	23 2"	22.																																																																				
_	21'-0" 22'-0" 23'-0" 24'-0" WIDTH 15'-0"	0	5		- ;	ء د	, ,	- i-				 س	7	19'- 1"	19. 2.	19'-10"	20 3"	50 9"	0860 21'- 2"	21'- 4"	21. 8.	21 9	50210 21'-11"	51730 52060 22'- 2 "	50230 53150 53910 22'- 4"	51530 54540 55770 22'- 5 "	55910 57630 22'- 7"	54070 57260 59470 22'- 8 "	55310 58590 61320 22'-10"	56530 59900 63160 22:-11"	61200 64670 64990 23 '- 1"	58920 62470 66030 66840 23 - 2 "	ACCOC ACC	_	200" 210" 220" 230" 240" WIDTH 150"	0	5		- ;	ء د	, ,	- i-				18'- 3"	18 7	29400 19'- 1"	31560 19'- 5"	19'-10"	20 3"	50 9"	38280 40530 40860 21'- 2"	39640 41990 42740	21. 8.	21 9	50210 21'-11"	51730 52060 22'- 2 "	50230 53150 53910 22'- 4"	48530 51530 54540 55770 22 '- 5 "	49720 52810 55910 57630 22'- 7 "	50890 54070 57260 59470 22'- 8 "	52040 55310 58590 61320 22:-10 "	53180 56530 59900 63160 22'-11"	61200 64670 64990 23 '- 1"	58920 62470 66030 66840 23 - 2 "	ACCOC ACC	_	19'-0" 20'-0" 21'-0" 22'-0" 23'-0" 24'-0" WIDTH 15'-0"	0	5		- ;	ء د	, ,	- i-		17. 5	17:-10"	25280	27310 18- 7"	29370 29400 19'- 1"	30750 31560 19'- 5"	32100 33780 19:10"	33430 35500 36070 20- 3"	34740 36900 38440 20'- 9 "	36030 38280 40530 40860 21'- 2"	37290 39640 41990 42740 21'- 4 "	21. 8.	21 9	50210 21'-11"	51730 52060 22'- 2 "	50230 53150 53910 22'- 4"	48530 51530 54540 55770 22 '- 5 "	49720 52810 55910 57630 22'- 7 "	50890 54070 57260 59470 22'- 8 "	48780 52040 55310 58590 61320 22:-10 "	49830 53180 56530 59900 63160 22:-11"	61200 64670 64990 23 '- 1"	51860 55380 58920 62470 66030 66840 23'- 2"	52850 56460 60080 63230 67370 68710 23'- 4"
_	18'-0" 19'-0" 20'-0" 21'-0" 22'-0" 23'-0" 24'-0" WIDTH 15'-0"	0	5		- ;	ء د	16: 3:	2 - 19	17. 0"	21410	23320	25280	27310 18- 7"	27600 29370 29400	28880 30750 31560	30140 32100 33780 19'-10"	31370 33430 35500 36070 20'- 3"	32590 34740 36900 38440 20'- 9"	33780 36030 38280 40530 40860 21'- 2 "	34950 37290 39640 41990 42740 21 - 4 "	21. 8.	21 9	50210 21'-11"	51730 52060 22'- 2 "	50230 53150 53910 22'- 4"	48530 51530 54540 55770 22 '- 5 "	49720 52810 55910 57630 22'- 7 "	50890 54070 57260 59470 22'- 8 "	48780 52040 55310 58590 61320 22:-10 "	49830 53180 56530 59900 63160 22:-11"	61200 64670 64990 23 '- 1"	51860 55380 58920 62470 66030 66840 23'- 2"	100060 50850 56460 60080 63700 67370 68710 03 1																																																																				
TRENCH WIDTH AT TOP OF PIPE	17-0" 18-0" 19-0" 20-0" 21-0" 22-0" 23-0" 24-0" WIDTH 15-0"	0	5	14'- 9"		15. 6.	16. 3"		19560	20840 21410	22120 23320	23380 24960 25280	24620 26290 27310	25820 27600 29370 29400	27010 28880 30750 31560 19'- 5"	28180 30140 32100 33780 19:-10"	29320 31370 33430 35500 36070 20'- 3 "	32590 34740 36900 38440 20'- 9"	31540 33780 36030 38280 40530 40860 21: 2"	32610 34950 37290 39640 41990 42740	21. 8.	21 9	50210 21'-11"	51730 52060 22'- 2 "	50230 53150 53910 22'- 4"	48530 51530 54540 55770 22 '- 5 "	49720 52810 55910 57630 22'- 7 "	50890 54070 57260 59470 22'- 8 "	48780 52040 55310 58590 61320 22:-10 "	49830 53180 56530 59900 63160 22:-11"	61200 64670 64990 23 '- 1"	51860 55380 58920 62470 66030 66840 23'- 2"	100060 50850 56460 60080 63700 67370 68710 03 1																																																																				
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Table B-27 Continued

	ATRAN-	WIDTH	13 9"		14'- 5"	14 9	15'- 1"	15'- 5"	15 9"	16:- 0"	16 5"	16 9"	17 1"	17 5"	17'-10"	18'- 2"	18'- 6"	18:-11"	19'- 4"	19'- 9"	20'- 1"	20'- 3"	20'- 4"	20'- 5"	20 8"	20'- 9"	20′-10″	21 0"	21'- 1"	21'- 2"	21'- 3"	21 4"	21 6"	21 7"	21'- 8"	21 9"	21'-10"	21'-11"
		24'-0"																																				
		190" 200" 210" 22'-0" 23'-0"							_																				_	_	_	_	_	_	_	_	_	
.110	F PIP	550																			_	_	_		_	_	_	_	55770	53950 57100 57630	55350 58590 59470	56730 60070 61320	58100 61530 63160	59450 62980 64990	66840	68710	70540	64720 68620 72370
0-,4)	OP O	21'-0"																			40860	42740	4462C	46490	46720 48340	50210	49660 52060	51100 53910	52530 55590	57100	28290	02009	61530	62980	64410	65830	67230	68620
Ϋ́	AT T	200																	36070	38440	40640	42190	43710	45220	46720	48200	49660				55350			59450	60790	62120	63420	64720
ED C	/IDTH	190														29080 29400	31560	33780	35420	36900	38360	37440 39810 42190 42740	38770 41240 43710 44620	42660	44060	45440	46800	48150	49490	50810	52110	53400	54670	55930	57180	58410	59630	56950 60830
SATURATED CLAY Kµ'-0.110	TRENCH WIDTH AT TOP OF PIPE	180											23320	25280		29080	28640 30520 31560	31940	31260 83340 35420	34720	36090	37440	38770	40090	41390	42680	43950	45210	46450	47670	48880	50080	51260	52420	53580	54710	55840	26920
SAT	TREN	17'-0"									19560	21410	21690 23180 23320	24570 25280		27300	28640	29960	31260	32550	31550 33820 36090 38360 40640 40860	30350 32710 35070	31390 33850 36310	34980 37530 40090 42660 45220 46490	33440 36090 38740 41390 44060	34440 37180 39930 42680 45440 48200 50210	35430 38260 41100 43950 46800	39330 42260 45210 48150	37360 40380 43410 46450 49490	38310 41420 44540 47670 50810	39240 42440 45660 48880 52110	40160 43450 46760 50080 53400	41060 44450 47850 51260	41950 45430 48920 52420 55930	42830 46400 49980 53580 57180 60790 64410 66840	43700 47360 51030 54710 58410 62120 65830 68710	44550 48300 52060 55840 59630 63420 67230 70540	45390 49230 53080
		16'-0"					12690	3950 14330	5240 16020	17760	19050 19560	20380 21410	21690	22980	24250	25510	26750	27980	29180	30370	31550	32710	33850	34980	36090	37180	38260	39330	40380	41420	42440	43450	44450	45430	46400	47360	48300	49230
۵		15:-0	6619	8068	9563	11100	12650	13950	15240	16500				21390	22570		24870	26000	27110	28200	29280	30350	31390	32420	33440	34440	35430	36400	37360	38310	39240	40160	41060	41950	42830	43700	44550	45390
	— Г		ļ																																		_	;
	TRAN-	WIDTH	13'-11"	14'- 2"	14'- 6"	14'-10"	15- 2"	15'- 7"	15'-11"	16 - 3"	16'- 7"	17'- 0"	17'- 4"	17'- 9"	18 1.	18'- 6"	18 - 10"	19'- 4"	19'- 8"	20: 1"	20'- 5"	20'- 8"	20'-10"	20'-11"	21'- 1"	21'- 2"	21'- 4"	21'- 5"	21'- 7"	21'- 8"	21'- 9"	21'-11"	22'- 0"	22'- 2"	22'- 3"	22'- 5"	22. 6"	66250 70120 72370 22 7" 45390 49230 53080
		24'-0"																																				-
		230 2																																64990	6840	8710	0540	2370
	щ	22'-0"			•				_																8340	0210	2060	3910	5770	7630	9470	1320	3160	4510 6	62340 65940 66840	63660 67350 68710	64960 68740 70540	66250 70120 72370
0.130	OF PIPE	21'-0"																		38440	40860	42740	44620	46490	48200 48340	49690 50210	51160 52060	52620 53910	54060 55770	55480 57630	56890 59470	58280 61320	59650 63160	61000 64510	2340 6	3660 6	4960 6	625017
Κμ΄ –		200 2																33780	9209		39760		42690 4	44120 4				_	_	52360 5	53670 5	54960 5						
CLAY	HAT	19'-0" 2													27310	29400	31560	33240 3	34680 36070	36090	37490 3	38870 41230	2230 4	41570 4	2890 4	4190 4	5480 4			49240 5	3450 5	51650 5	52840 5	54010 5	55160 58740	3300 21	7420 6	3230 6
IARY	WIDT	18'-0'' 1											23320		27 130 2 .	28530 2 3	299 10 3			33920 3	35220 3	36510 3	37770 40230	39020 4	40240 42890 45540	1450 4		43820 4	44980 4	46120 4	7.250 5(3360 5	49450 5	50530 5	51590 5	5640 5	9029	?cl 0691
ORDINARY CLAY Kµ'-0.130	TRENCH WIDTH AT TOP	17'-0" 18		••••						17760	19560	21410	22790 2 3		25450 27					31760 33	32960 35	34150 36	35320 37	36470 39	37600 40	38720 41450 44190 46940		40900 43	41970 4	43020 46	44050 47250 50450	45070 48360	46070 49	090	48030 51	48990 52640 56300 59970	49940 53670 57420 61180	75 098
0	TRE	16'-0" 17				· · · · ·	12690	330	16020			20030 21	21300 22								30700 32			33930 36	34970 37	32990 38		37990 40		39920 43	870 44	41800 45	42710 46	610 47	490 48	360 48		090
		15'-0" 16	6619	8908	9563		12500 12	13770 14330		16250 17	17460 18	18650 20				23 190 24				27440 29	28450 30			31400 33	32340 34	33270 35		35090 37		36840 39	37700 40870	38540 41	39360 42	40170 43610 47060	40970 44490	41750 45360	42520 46220	43280 47060 50860 54690 58530 62380
		15	<u> </u>	9	_		9 12	10 13	11 15	12 16	13 17.	14 18	.,		17 22	18 23	19 24	_	21 26	22 27	23 28	24 29	25 30		27 32					32 36								40 43280 47060 50860 54690 58530 62380
O							_	L∃	3:		30	lle	<u> </u>	10	<u>d</u>	0	T	3/	۱С	8	A	Н	٦:	11:	KŁ	٥,					Н.							_] '

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. A Transition loads (**bold type**) and widths based on Kµ—0.19, r_{sd}p—0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-28

						п	ΕI	IGI	ΗТ	. C)F	В	A(ck	FΙ	LL	. H	ΙΑ	۰В٥	O١	/E	TC	P	0	F	Ы	r_{E}	:. I	FE	: E	Т		
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¥.	· · · · ·	14.	4	15'-	15.	16.	2 4	4 6	17.	17.	18	- 28	<u></u>	19′-	19.	50	50.	21,-	21	- 2	22.2	22	22.	55.	22.	2							
	25.0																											6221(6415(9099	68020	6993(01011 07600
	230									_											48580	50540	52490	54440	56390	58320	60260	61680 62210	63160 64150	64630 66080	9090	67500 69930	0250
F							\dagger												42060	9 8										61230 6	290	920 6	34230 37 330 0 1300 03240
OFF	0" 22	-					+					_				20	8	8	70 42	42670 44600	44150 46620 45610 48160	40 49	60 51	49860 52700	40 54	00 22	53940 57050	<u>60 58</u>	69 09	40 61	00 62	50 63	3
10 10	20:-0" 21:-0" 22:-0"						+							0	_	0 34850	0 371	0 39580			0 441	0 470	0 484	0 498	0 51240	49580 52600 55620	0 539	52060 55260 58460	53270 56560 59860	0 57840	0 591	0 603	2
T V							1							30380	32580	34560	33960 36030 37180	37480	38900	40310	36800 39240 41690 44150 46620 37980 40520 43060 45610 48160	39140 41770 44400 47040 49690	40270 43000 45730 48460	47030	48320	4958	50830	5206	5327	54460	5563	53240 56790 60350 63920 67500 69930	200
	190										24150	26170	28240	29770	31190	32580	33960	35310	36640	37960	39240	41770	43000	44210	45400	46580	47730	48870	49990	5,1090	52170	53240	04780
<u>≯</u>	180								20290	22190		25280		27990	293 10	30610					37980	9140	0220	41390	2490	3580	44640	2690	46720	47730	8730		
TRENCH WIDTH AT TOP OF PIPE	170 1					4000	16640	18440				23700 2	24970 2	26220 2	27440 2	28650 3		30880 3			35450 3	365 10 3	37560 4	38590 4	39600 42490 45400	590 4	41560 4	42520 45690 48870		44390 4	300	190 4	200
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_	200" 21'-0" 22'-0" 23'-0" 25'-0" WIDTH 15'-0"			<u>.</u> 4	 	:	 		- i		180.	18,- 9"	28240 19'- 2"	30380 19'- 7"	19-11.	20'- 5"	.6 -,02	36900 39060 39580 21'- 3"	38280 40530 42060 21'- 8 "	39640 41990 44340 44600 22'- 1"	45420 45800 46620 22: 4 44820 47360 48580 22:- 5 "	46210 48840 50540 22'- 7 "	47570 50300 52490 22'-10"	48910 51730 54440 23'- 0 "	47320 50230 53150 56070 56390 23:- 1 "	48530 51530 54540 57550 58320 23'- 3 "	52810 55910 59020 60260 23'- 4"	54070 57260 60460 62210 23:- 7 "	55310 58590 61880 64150 23'- 9"	2310	24'- 0"	58920 62470 66030 69930 24: 1 :	2 - 12 0 10 10 10 10 10 10 10 10 10 10 10 10 1
_	19.0" 20.0" 21.0" 22.0" 23.0" 25.0" WIDTH 15.0"			<u>.</u> 4	 	:	 	-01-91 	17. 7"		24150	18,- 9"	28240 19'- 2"	29370 30380 19'- 7"	30750 32580 19:11"	32100 34070 34850 20'- 5"	33430 35500 37180 20'- 9 "	34740 36900 39060 39580	36030 38280 40530 42060 21- 8 "	3/290 39640 41990 44340 44600	39750 42280 44820 47360 48580 22:- 4	46210 48840 50540 22'- 7 "	47570 50300 52490 22'-10"	48910 51730 54440 23'- 0 "	47320 50230 53150 56070 56390 23:- 1 "	48530 51530 54540 57550 58320 23'- 3 "	52810 55910 59020 60260 23'- 4"	54070 57260 60460 62210 23:- 7 "	55310 58590 61880 64150 23'- 9"	2310	50850 54290 57740 61200 64670 68020 24:- 0 "	5186U 5538U 5892U 624/U 6603U 69930 24- 1	25000 20100 00150 00150 0100 0100 0100 0
_	18.0" 19.0" 20.0" 21.0" 22.0" 23.0" 25.0" WIDTH			<u>.</u> 4	 	16'- 1	6 - 01	10-10	17. 7"		24150	24960 26170	26290 27970 28240 19'- 2"	27600 29370 30380 19'- 7"	30750 32580 19:11"	32100 34070 34850 20'- 5"	31370 33430 35500 37180 20'- 9 "	32590 34740 36900 39060 39580 21'- 3 "	36030 38280 40530 42060 21- 8 "	34950 37290 339640 41990 44340 44600	39750 42280 44820 47360 48580 22:- 4	46210 48840 50540 22'- 7 "	47570 50300 52490 22'-10"	48910 51730 54440 23'- 0 "	47320 50230 53150 56070 56390 23:- 1 "	48530 51530 54540 57550 58320 23'- 3 "	52810 55910 59020 60260 23'- 4"	54070 57260 60460 62210 23:- 7 "	55310 58590 61880 64150 23'- 9"	2310	50850 54290 57740 61200 64670 68020 24:- 0 "	5186U 5538U 5892U 624/U 6603U 69930 24- 1	25000 20100 00150 00150 0100 0100 0100 0
TRENCH WIDTH AT TOP OF PIPE	170" 18-0" 19-0" 20-0" 21-0" 22-0" 23-0" 25-0" WIDTH 15-0"			12. 4.	-88-	16'- 1	6 - 01	10-10	17. 7"		22120 23600 24150	23380 24960 26170	24620 26290 27970 28240	25820 27600 29370 30380 19'- 7"	27010 28880 30750 32580 19-11"	28180 30140 32100 34070 34850 20'- 5"	29320 31370 33430 35500 37180 20'- 9 "	30440 32590 34740 36900 39060 39580	31540 33780 36030 38280 40530 42060 21'- 8"	32610 34950 37290 39640 41990 44340 44600	39750 42280 44820 47360 48580 22:- 4	46210 48840 50540 22'- 7 "	47570 50300 52490 22'-10"	48910 51730 54440 23'- 0 "	47320 50230 53150 56070 56390 23:- 1 "	48530 51530 54540 57550 58320 23'- 3 "	52810 55910 59020 60260 23'- 4"	54070 57260 60460 62210 23:- 7 "	55310 58590 61880 64150 23'- 9"	2310	50850 54290 57740 61200 64670 68020 24:- 0 "	5186U 5538U 5892U 624/U 6603U 69930 24- 1	25000 20100 00150 00150 0100 0100 0100 0
_	18.0" 19.0" 20.0" 21.0" 22.0" 23.0" 25.0" WIDTH		14-11"	9966	11560	13140 13210 16:- 1"	14750 14800	12/20 16640	18240 19530 20290	19460 20840 22190	20640 22120 23600 24150	23380 24960 26170	22940 24620 26290 27970 28240 19'- 2 "	24060 25820 27600 29370 30380 19: 7"	25150 27010 28880 30750 32580 19-11"	26220 28180 30140 32100 34070 34850 20 °- 5 "	27270 29320 31370 33430 35500 37180 20'- 9 "	28300 30440 32590 34740 36900 39060 39580 21'- 3 "	29300 31540 33780 36030 38280 40530 42060 21- 8"	30/290 32610 34950 37/290 39640 41990 44340 44600	39750 42280 44820 47360 48580 22:- 4	33120 35720 38330 40950 43580 46210 48840 50540 22'- 7 "	34030 36720 39420 42130 44840 47570 50300 52490 22'-10 "	34920 37700 40490 43290 46100 48910 51730 54440 23 · 0 "	47320 50230 53150 56070 56390 23:- 1 "	48530 51530 54540 57550 58320 23'- 3 "	37480 40520 43580 46640 49720 52810 55910 59020 60260 23 :- 4 "	38300 41420 44570 47720 50890 54070 57260 60460 62210 23:- 7 "	39100 42310 45540 48780 52040 55310 58590 61880 64150 23 '- 9 "	2310	50850 54290 57740 61200 64670 68020 24:- 0 "	5186U 5538U 5892U 624/U 6603U 69930 24- 1	12 120 120 12 120 120 120 120 120 120 12
_	170" 18-0" 19-0" 20-0" 21-0" 22-0" 23-0" 25-0" WIDTH 15-0"		14-11"	9966	11560	13140 13210 16:- 1"	14750 14800	12/20 16640	18240 19530 20290	19460 20840 22190	20640 22120 23600 24150	23380 24960 26170	22940 24620 26290 27970 28240 19'- 2 "	24060 25820 27600 29370 30380 19: 7"	25150 27010 28880 30750 32580 19-11"	26220 28180 30140 32100 34070 34850 20 °- 5 "	27270 29320 31370 33430 35500 37180 20'- 9 "	28300 30440 32590 34740 36900 39060 39580 21'- 3 "	29300 31540 33780 36030 38280 40530 42060 21- 8"	30/290 32610 34950 37/290 39640 41990 44340 44600	39750 42280 44820 47360 48580 22:- 4	33120 35720 38330 40950 43580 46210 48840 50540 22'- 7 "	34030 36720 39420 42130 44840 47570 50300 52490 22'-10 "	34920 37700 40490 43290 46100 48910 51730 54440 23 · 0 "	47320 50230 53150 56070 56390 23:- 1 "	48530 51530 54540 57550 58320 23'- 3 "	37480 40520 43580 46640 49720 52810 55910 59020 60260 23 :- 4 "	38300 41420 44570 47720 50890 54070 57260 60460 62210 23:- 7 "	39100 42310 45540 48780 52040 55310 58590 61880 64150 23 '- 9 "	2310	50850 54290 57740 61200 64670 68020 24:- 0 "	5186U 5538U 5892U 624/U 6603U 69930 24- 1	2 120 100 10 10 10 10 10 10 10 10 10 10 10 1
<u>▼</u>	16.0" 17.0" 18.0" 19.0" 20.0" 21.0" 22.0" 23.0" 25.0" WIDTH	6908	8414	9731 9966 15: 4"	11000 11560	13210	11 14660 14750 1 6640	14000 13730 16640 157. 3	13 16960 18240 19530 2020	18070 19460 20840 221 90	15 19160 20640 22120 23600 24150	16 20230 21800 23380 24960 26170	17 21270 22940 24620 26290 27970 28240	25820 27600 29370 30380 19'- 7"	19 23290 25150 27010 28880 30750 32580 19:-11 "	20 24270 26220 28180 30140 32100 34070 34850 20'- 5"	21 25220 27270 29320 31370 33430 35500 37180 20'- 9 "	26160 28300 30440 32590 34740 36900 39060 39580	23 27070 29300 31540 33780 36030 38280 40530 42060 21'- 8"	27970 30290 32610 34950 37290 39640 41990 44340 44600	25 28700 32200 34710 37220 39750 42280 44820 47360 48580 22 - 5 "	27 30540 33120 35720 38330 40950 43580 46210 48840 50540 22'- 7"	28 31360 34030 36720 39420 42130 44840 47570 50300 52490 22'-10"	29 32160 34920 37700 40490 43290 46100 48910 51730 54440 23 0 "	30 32940 35790 38660 41540 44420 47320 50230 53150 56070 56390 23 ·· 1"	3 1 33710 36640 39600 42560 45540 48530 51530 54540 57550 58320 23 - 3 "	32 34460 37480 40520 43580 46640 49720 52810 55910 59020 60260 23-4"	33 35190 38300 41420 44570 47720 50890 54070 57260 60460 62210 23:- 7 "	34 35910 39100 42310 45540 48780 52040 55310 58590 61880 64150 23 - 9 "	36610 39890 43180 46500 49830 53180 56530 59900 63280 66080 23-10 "	36 37300 40660 44040 47440 50850 54290 57740 61200 64670 68020 24 · 0 "	58920 62470 66030 69930 24: 1 :	7 - 17 0.01 0.01 0.01 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

Table B-28 Continued

B.																																	
						ΙΕΙ	G	Н	Γ (ЭF	E	3A	_						0			ЭF	, C	F	PI	PE	Ξ,	FE	E	Т			
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ATRAN-	SITION	WIU H	14'- 8'' 15'- 0''		15'- 8"		16'- 3"	16 7"					18'- 4"	18'- 9"	19'- 1"	19 6	19:-10"		21'- 1"						21. 9	22'. 0"		22. 3		22. 5.			22 - 8"
	25'-0"	2 2																															
	07.86	20.07																									61840 62210	63410 64150	64970 66080	665 10 68020	68040 60020	71870	
BIPE:		222																	44600						56390								
OP OF	20.70" 21.50"	2		m													00100	39090 39380	44560						54060						64440	62120 65830	63420 67230
AT T(100																37180			43710					51100					- 1			
MIDTH													28240				35420			41240	42660	41390 44060	45440	46800	48150								
TRENCH WIDTH AT TOP OF PIPE	18.5							_			24150							36090							45210							54710	
TRE	-	-			_	_				21770						29960		33830		36310		38740	39930		39330 42260	454 0	42440 45660	46760	47850	4,030	40000	51030	
	16,5	_	** **	11560	13210													31550							39330	40000					70404	46400	44550 48300
	15.0"	8069	8414	11320	12650	13950	15240	16500	17750	18980	20200	21390	22570	23730	24870	26000	27110	00707	30350	31390	32420	33440	34440	35430	36400	2000	39240	40160	4 1 0 60	4 105	7 00 7	42830	44550
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TRAN	SITION	WIDTH 14'- 5"	14'- 9'	15'- 5"	15'- 9"		.991			17: 6"				19 0"	19'- 5"	19'-10"	20'- 3"	21'. 1"	21'- 5"	21'- 7'	21:- 8"	21'-11"			22 - 3			22.10.	22.13	22'- 0"	3 6	22-	23. 4.
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H																		0900	44600	46620	48580	50540		54020 54440	555/0 56390	57 100 56320 58620 60360	50120 6221	81600 64150		345 10 68	040101010	2 0	68740 7
OF PIPE		O- 22															37180	42064	43600 44600	45 150 46620	46680 48580	48200 50540	49690 52490	54020	52620 55570 563	54060 57 100 5636	60120	58280 61600 64150		59650 63000 58	61000 65040 60	2 0	68740
T TOP OF PIPE		0.72 0.12													32580	34850	36750 37180	42064	41230 43600 44600	42690 45150 46620	44120 46680 48580	45540 48200 50540	49690 52490	51160 54020	49680 52620 55570 563	5360 55480 58630 6036	53670 56890 60120 6221	54960 58280	50650 63060	52500 64000 64510 68	57 300 8 1000 843 19 88	2 0	61180 64960 68740
TH AT TOP OF PIPE		0.22 0-02 0-61											28240		31790			38090 38270 39380	38870 41230 43600 4460	40230 42690 45 150 46620	41570 44120 46680 48580	42890 45540 48200 50540	44 190 46940 49690 52490	45480 48320 51160 54020	46/50 49680 52620 555/0 563	48000 31030 34080 37 100 3832	50450 52300 55450 55550 5551 55130 5231	51650 54960 58280	51830 34300 38280 81800	52840 36240 39630 63060 64010 68	54010 37300 61000 043 10 00	2 0	61180 64960 68740
H WIDTH AT TOP OF PIPE		0-27 0-17 0-81 0-81							20290	22190	24150	25710	27130	28530	29910 31790	31270	32600	33920 38090 38270 33380	36510 38870 41230 43600 4460	37770 40230 42690 45150 4662 0	39020 41570 44120 46680	40240 42890 45540 48200 50540	44 190 46940 49690 52490	45480 48320 51160 54020	43820 46750 49680 52620 55570 563	44980 48000 5 1030 54060 57 100 3636	47250 50450 53670 56890 60120 6221	51650 54960 58280	46360 51630 34300 38260 61600	60530 54010 57500 61000 64510 68	30330 340 10 37 300 8 1000 643 1	51590 55160 58740 62340 65940 52640 56300 59870 63660 67350	53670 57420 61180 64960 68740
RENCH WIDTH AT TOP OF PIPE	17.0.1 18.0.1 10.0.1 20.0.1 22.0.1 22.0.1	0 22 0 12 0 02 0 61 0 61 0 61				14900		18440	20040	21420	22790	24130 25710	25450 27130	26750 28530	28030 29910 31790	29290 31270	30530 32600	31/60 33920 36090 362/0 39360	34150 36510 38870 41230 43600 4460	37770 40230 42690 45150 4662 0	39020 41570 44120 46680	37600 40240 42890 45540 48200	38720 41450 44190 46940 49690 52490	39820 42650 45480 48320 51160 54020	140900 43820 46750 49680 52620 55570 563	1419/0 44980 46000 31030 34060 37100 3636	744050 47250 50450 52500 55450 50521	51650 54960 58280	45070 46360 51630 54300 5650 61060	47060 50530 54040 57500 61000 64510 68	30330 340 10 37 300 8 1000 643 1	51590 55160 58740 62340 65940 52640 56300 59870 63660 67350	53670 57420 61180 64960 68740
TRENCH WIDTH AT TOP OF PIPE		0.52 0.12 0.02 0.81 0.81 0.91 0.91	9900		<u> </u>	14770	16120	17440 18440	18750 20040	20030 21420	21300 22790	22540 24130 25710	23770 25450 27130	24970 26750 28530	26150 28030 29910 31790	27320 29290 31270	28470 30530 32600	29000 31700 33920 30090 38270 39380	31800 34150 36510 38870 41230 43600 4460	32870 35320 37770 40230 42690 45150 4662 0	33930 36470 39020 41570 44120 46680	34970 37600 40240 42890 45540 48200	35990 38720 41450 44190 46940 49690 52490	37000 39820 42650 45480 48320 51160 54020	0 37990 40900 43820 46750 49680 52620 55570 563	38890 41970 44880 46000 51030 54060 57100 3636	33920 43020 45120 49240 52300 53400 50520 02500 0050000 0050000 0050000 0050000 0050000 005000000	51650 54960 58280	41000 43070 46300 31030 34300 36200 81000	42610 46070 49430 32640 36240 39630 63080	30330 340 10 37 300 8 1000 643 1	51590 55160 58740 62340 65940 52640 56300 59870 63660 67350	53670 57420 61180 64960 68740
TRENCH WIDTH AT TOP OF PIPE	17.0.1 18.0.1 10.0.1 20.0.1 22.0.1 22.0.1	1950 15 0 15 0 16 0 16 0 16 0 16 0 16 0 16	6 8414 2 0887 0066	112001	12500	14770	16120	16250 17440 18440	20040	21420	22790	22540 24130 25710	25450 27130	26750 28530	28030 29910 31790	25350 27320 29290 31270	26400 28470 30530 32600	31/60 33920 36090 362/0 39360	29450 31800 34150 36510 38870 41230 43600 4460	30430 32870 35320 37770 40230 42690 45150 4662 0	31400 33930 36470 39020 41570 44120 46680	32340 34970 37600 40240 42890 45540 48200	33270 35990 38720 41450 44190 46940 49690 52490	34190 37000 39820 42650 45480 48320 51160 54020	35090 37990 40900 43820 46750 49680 52620 55570	31 339/0 38960 419/0 44980 48000 31030 34060 3/100 3832	37700 40870 44050 47250 50450 53670 56890	38640 41800 46070 48260 51650 54060 58380	26340 41600 43070 46300 31630 34300 36260 61600	400/0 49430 32640 36240 39630 63000	40 170 430 10 47000 30330 340 10 37300 6 1000 643 1	2 0	42520 46220 49940 53670 57420 61180 64960 68740

* For backfill weighing 110 pounds per cubic foot, increase loads 10%, for 120 pounds per cubic foot, increase 20%; etc. A Transition loads (**bold type**) and widths based on Kµ-0.19, r_{sd}p-0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-29

	l						ł	ΗE	IC	ìΗ	IT	0	F	В	A(CK	FI	LL	. F	1 /	۱B	Ю	VE	Ξ 7	ГО	P	0	F	ΡI	PE	Ξ,	FE	ΞE	T			
_	<u> </u>		Ω.	9	_	∞	6	10	Ξ	12	13	4	15	16	17	<u>~</u>	19	20	21	22	23	24	25	26	27	28	59	9	31	32	8	34	35	8	37	38	& 4
~	ATRAN-	WIDTH	5'- 1"	.9 -,51	15'-10"	16'- 2"	16. 7"	16'-11"	17:- 3"	17:- 7"	18. 0.	18'- 4"	18'- 9"	19'- 1"	19 6"	19'-11"	20'- 3"	20'- 8"	21'- 2"	21'- 6"	21'-11"	22'- 4"	22'- 9"	23'- 0"	23'- 2"	23'- 3"	23'- 6"		23'- 9"	23'-10"	24'- 1"	24'- 2"	24'- 4"	5.	24'- 6"	24'- 9"	24'-10" 24'-11"
138″	•		15	15	5	9	16	9	=	1	2	<u>~</u>	28	₽	- 6	19	8	2	7	2	2	55	52	8	23	8	8	23	23					0 24			
-		260																														67010	6904	7106	7309	7510	77.13 79.15
		24.0."																							52750	54800	56850	58890	0920	2940	64900	66480	68040 69040	9580	71100 73090	72600 75100	75550 79150
150	Ⅱ	230 5									_								-			8	82	_				00	920 e				30 6	9 080			
0.	F P	23.																	0	0	0	0 458	0 486	0 507	0 52340	0 536	0 555	0 57100	0 586	0 60	0 6 16	0 631	0 646	0 660	0 675	0 685	0 703 0 716
O S Y	OP C	22.0												L					38320	4077	4328	45030 45860	4660	4816	49690	51200 53950	52700 55540	54170	5562	57050 60170 62940	58460 61680	59860 63160	61230 64630	6229	6392	6524	6654 6783
LAT EAR SOII	1	21:-0" 22:-0"															33630	35940	8100	9640	1170	2670	4150	5610	47040	48460	49860	51240	2600	3940	55260	6560	57840	9100	0320	1580	3990
P LIN	H	200 2												27070	29200	31380	33060 3	34560 3	36030 38100	37480 39640 40770	38900 41170 43280	40310 42670	390 4	900 4	44400 4	730 4	47030 4	48320 5	980	330	52060 5	53270 56560	54460 5	330 5	56790 60350 63920 67500	930 6	9 09
NS PE	WID	20,				_						0	0							0 374		040	0 416	0 430	0 444	0 457	0 470	0 483	0 495	0 206		0 532	0 544	0 556	0 567	0 579	0 590
E PATE	Ş	19.°C										22990	25000	26860	28330	29770	31190	32580	3396	3531	3664	3796	3924	4052	41770	4300	4421	45400	4658	4773	4887	4999	5109	5217	53240	5429	5533 5634
N TRENCH INSTALLATION LOADS IN POUNDS PER LINEAR FOOT SATURATED TOP SOIL Kµ'—0.150	TRENCH WIDTH AT TOP OF PIPE	180" 190"							17280	19130	21030	22480	23890	25280	26650	27990	29310	30610	31890 33960	33150 35310	34390 36640	35600 37960	36800 39240 41690 44150 46600 48520	37980 40520 43060 45610 48160 50700	39140	37560 40270 43000 45730	41390 44210	42490	3580	4640	42520 45690 48870	46720 49990	44390 47730 51090	45300 48730 52170 55630 59100 62590 66080 69580 71060	49710	0670	51620 55330 59050 62790 66540 70310 52550 56340 60160 63990 67830 71680
TRI		17:-0				12030	13730	_				21090 2	22400 2	23700 2	24970 2	26220 2		28650 3	29830 3	30990	32140 3	33260 3		35450 3	365 10 3	560 4	38590 4	39600 4	590 4	560 4	520 4	43460 4	390	300 4	46190 4	070	330 780 5
Z ³		-	20	22				$\overline{}$								10 26				<u>8</u> 04								39	37620 40590 43580 46580 49580 52600 55620 58650 60920	38500 41560 44640 47730 50830 53940	0 42	0 43		30 45;	90 46	43480 47070 50670 54290 57930 61580 65240 68920	44260 47930 51620 55330 59050 62790 66540 70310 45020 48780 52550 56340 60160 63990 67830 71680
PE A B		16.0"	7202	8767	10380	11890	13250	14590	15900	17190	18460	19700	20920	22120	23290	24440	25570	26680	27770	28840	29890	30920	31930	32920	33900	34850	35790	36710	32/62	3850	39370	40220	41060	41880	42690	4348	4426
AR F																																					
	ATRAN-	WIDTH	ო				ģ			6	Š	ò	18'-11"	4	ò	-	. 7	0	21'- 4"	21'-10"		22 7"	+	آ. پ	. 0	8	ģ	1	'n	ŝ	Š	ė	à		<u>.</u>	÷.	, in
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IRCL ACKFIL	T-0		15'-	15.	12	-9	16.	17.	17	17	-8	-8	-82	19.	19'-	20	50.	21.	21,	21.	22.	55.	23.	23,	23,	53,	23,		20 24	24	24'-	24	24'-	60 24'-10"			30 25 50 25:-
N CIRCL OT BACKFIL	T.¶	.092	15	15	15.	16,	16.	17.	17′-	17	-8	18.	18.	19.	19.	20	50.	21	21,	21.	22,									24	64970 24'-	24	24'-				
S ON CIRCL C FOOT BACKFIL	TA		15	15.	15.	16,	19.	14.	17	17	18.		18.	19.	-61	50	50.	21	21,	21.	22,									24	64970 24'-	24	24'-				73840 77130
ADS ON CIRCI CUBIC FOOT BACKFIL 65		240" 26'-0"	15	15.		16.	16:	17.	17.	17'-	-18.	18.	18.	19.	19.	50	50.	21	21.				48520		52750	54800	56850	58890	60580 60920	62130 62940 24'-	63670 64970 24'-	24	24'-				73840 79150
LOADS ON CIRCULAR PIF PER CUBIC FOOT BACKFILL MATERIAL -0.165	PIPE	23'-0" 24'-0" 26'-0"	15	15.	15.		16.	17.	17	17'-	-18.	18.	18.	19.	19.	20.	50.				43280		48320 48520	49910 50700	52750	54800	54560 56850	58890	60580 60920	59020 62130 62940 24 -	63670 64970 24'-	24	24'-				73840 79150
FILL LOADS ON CIRCI UNDS PER CUBIC FOOT BACKFIL. Ky'-0.165	PIPE	22'-0" 23'-0" 24'-0" 26'-0"	15.	15.	12	16.	16.	17.	17	17	18.		18.	19.	19.						43280		48320 48520	49910 50700	52750	54800	51730 54560 56850	58890	54540 57550 60580 60920	55910 59020 62130 62940 24 -	57260 60460 63670 64970 24'-	58590 61880 65180 67010 24-	24'-				64960 68700 72450 77130 66170 70000 73840 79150
CKFILL LOADS ON CIRCI OPOUNDS PER CUBIC FOOT BACKFIL VEL KJV'—0.165	PIPE	23'-0" 24'-0" 26'-0"	15.	15.	12.	16.		17.	17	17'-	-18		18.	19.	19.						43280		48320 48520	49910 50700	52750	54800	51730 54560 56850	58890	54540 57550 60580 60920	55910 59020 62130 62940 24 -	57260 60460 63670 64970 24'-	58590 61880 65180 67010 24-	24'-				64960 68700 72450 77130 66170 70000 73840 79150
$\cap \sim \neg$	PIPE	21'-0" 22'-0" 23'-0" 24'-0" 26'-0"	15.	15.		16.	16.	17:	17	17	-18	18.	18.								43280		48320 48520	49910 50700	52750	54800	51730 54560 56850	58890	54540 57550 60580 60920	55910 59020 62130 62940 24 -	57260 60460 63670 64970 24'-	58590 61880 65180 67010 24-	24'-				64960 68700 72450 77130 66170 70000 73840 79150
BACKFILL LOADS ON CIRCI *100 POUNDS PER CUBIC FOOT BACKFIL IND GRAVEL Kµ'—0.165	PIPE	20'-0" 21'-0" 22'-0" 23'-0" 24'-0" 26'-0"	15.	15.			16.	17:	17	17'-	-18			27070	29200						43280		48320 48520	49910 50700	52750	54800	51730 54560 56850	58890	54540 57550 60580 60920	55910 59020 62130 62940 24 -	57260 60460 63670 64970 24'-	58590 61880 65180 67010 24-	24'-				5/520 61230 64960 68/00 /2450 /7130 58560 62360 66170 70000 73840 79150
BACKFILL LOADS ON CIRCI *100 POUNDS PER CUBIC FOOT BACKFIL ND AND GRAVEL Kµ'-0.165	PIPE	19.0" 20.0" 21.0" 22.0" 23.0" 24.0" 26.0"	15:	15:		16.				17	21030 18'-		25000	26540 27070	27970 29200		30750 32620 33630				43280		48320 48520	49910 50700	52750	54800	51730 54560 56850	58890	54540 57550 60580 60920	55910 59020 62130 62940 24 -	57260 60460 63670 64970 24'-	58590 61880 65180 67010 24-	24'-				5/520 61230 64960 68/00 /2450 /7130 58560 62360 66170 70000 73840 79150
BACKFILL LOADS ON CIRCL *100POUNDS PER CUBIC FOOT BACKFIL SAND AND GRAVEL Kµ'—0.165		20'-0" 21'-0" 22'-0" 23'-0" 24'-0" 26'-0"	15.	15:	72	-16.		15480	17280	19130	21030 18'-	22220 22990	23600 25000	26540 27070	29200		30750 32620 33630				43280		48320 48520	49910 50700	52750	54800	40490 43290 46100 48910 51730 54560 56850	58890	54540 57550 60580 60920	55910 59020 62130 62940 24 -	57260 60460 63670 64970 24'-	58590 61880 65180 67010 24-	24'-				5/520 61230 64960 68/00 /2450 /7130 58560 62360 66170 70000 73840 79150
BACKFILL LOADS ON CIRCL *100 POUNDS PER CUBIC FOOT BACKFIL SAND AND GRAVEL Kµ'—0.165	PIPE	18.0" 19.0" 20.0" 21.0" 22.0" 23.0" 24.0" 26.0"	15.	15:				15480	17280	19130	20820 21030 18'-	22220 22990	23600 25000	24960 26540 27070	26290 27970 29200		28880 30750 32620 33630				33780 36030 38280 40530 42790 43280	34950 37290 39640 41990 44340 45860	48320 48520	49910 50700	52750	54800	40490 43290 46100 48910 51730 54560 56850	58890	54540 57550 60580 60920	55910 59020 62130 62940 24 -	57260 60460 63670 64970 24'-	58590 61880 65180 67010 24-	24'-				5/520 61230 64960 68/00 /2450 /7130 58560 62360 66170 70000 73840 79150
BACKFILL LOADS ON CIRCL *100 ON CIRCL *100 POUNDS PER CUBIC FOOT BACKFIL SAND AND GRAVEL Kµ'—0.165	PIPE	17.0" 18.0" 19.0" 20.0" 21.0" 22.0" 23.0" 24.0" 26.0"						15480	17280	19130	20820 21030 18'-	22220 22990	22120 23600 25000	24960 26540 27070	26290 27970 29200		27010 28880 30750 32620 33630	28180 30140 32100 34070 35940	29320 31370 33430 35500 37560 38320		33780 36030 38280 40530 42790 43280	32610 34950 37290 39640 41990 44340 45860	33670 36100 38530 40970 43420 45860 48320 48520	49910 50700	35720 38330 40950 43580 46210 48840 51480 52750	36720 39420 42130 44840 47570 50300 53040 54800	37700 40490 43290 46100 48910 51730 54560 56850	38660 41540 44420 47320 50230 53150 56070 58890	39600 42560 45540 48530 51530 54540 57550 60580 60920	55910 59020 62130 62940 24 -	57260 60460 63670 64970 24'-	58590 61880 65180 67010 24-	24'-				5/520 61230 64960 68/00 /2450 /7130 58560 62360 66170 70000 73840 79150
### BACKFILL LOADS ON CIRCL ************************************	PIPE	18.0" 19.0" 20.0" 21.0" 22.0" 23.0" 24.0" 26.0"	7202	8767	10380	11800 12031	13140 13730	14460 15450 15480	15750 16840 17280	17010 18200 19130	18240 19530 20820 21030	19460 20840 22220 22290	20640 22120 23600 25000	21800 23380 24960 26540 27070	27970 29200	18 24060 25820 27600 29370 31150 31380 20 -	25150 27010 28880 30750 32620 33630	26220 28180 30140 32100 34070 35940	27270 29320 31370 33430 35500 37560 38320	28300 30440 32590 34740 36900 39060 40770	29300 31540 33780 36030 38280 40530 42790 43280	30290 32610 34950 37290 39640 41990 44340 45860	31250 33670 36100 38530 40970 43420 45860 48320 48520	32200 34710 37220 39750 42280 44820 47360 49910 50700	33120 35720 38330 40950 43580 46210 48840 51480 52750	34030 36720 39420 42130 44840 47570 50300 53040 54800	34920 37700 40490 43290 46100 48910 51730 54560 56850	35790 38660 41540 44420 47320 50230 53150 56070 58890	36640 39600 42560 45540 48530 51530 54540 57550 60580 60920	37480 40520 43580 44640 49720 52810 55910 59020 62130 62940 24	38300 41420 44570 47720 50890 54070 57260 60460 63670 64970 24 °-	39100 42310 45540 48780 52040 55310 58590 61880 65180 67010 24-	39890 43180 46500 49830 53180 56530 59900 63280 66670 69040 24'-	40660 44040 47440 50850 54290 57740 61200 64670 68150 71060	41410 44870 48360 51860 55380 58920 62470 66030 69600 73090	42150 45690 49260 52850 56460 60080 63720 67370 71030 75100	5/520 61230 64960 68700 72450 77130 58560 62360 66170 70000 73840 79150

Table B-29 Continued

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	ATRAN-	5 ₹	14'-11 15'- 3	15'- 7'	15.	16.	<u>.</u>	16.	17	17'-	17.	₩.	- - - -	18,-1	19'-	19'-	5 0	-,02	20.	21,	21.	21.	55.	22.	22.	22.	22	25.	22'-1	23.	23	33,	23.	23,-	23.	23.	33,	
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		24'-0"																													67010	69040	7106	7309	75100	77130	79150	
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	P C	22'-0"																		43280	45860	48520	50370	52060	53730	55380	57020	58640	60250	61840	63410 66760	64970	66510	68040	69550	71050	72530	
SATURATED CLAY Kµ'-0.110	TRENCH WIDTH AT TOP OF PIPE	21'-0"																38320	40770	42920	44560		,800	49390	50960	52520	54060	280	57100	58590	60070	61530	59450 62980	60790 64410	65830	67230	68620	
2	H)" [-				_	_		0	0	9		<u>8</u>			0 46	45220 47800	20 45	<u>20</u>		00 54	10 25	0 57	99 09	<u>00</u>		29 OS	90 64	20 65	20 67	39 03	
ED.	/IDT	20:-0													31380	33630	35940	37500	39080	40640	42190	43710	4522	46720	48200		51100	5255	53950	55350	56730	58100	5945	3209	62120	63420	64720	
RAT	≯ I	19:-0"										25000	27070	29200	30870	32400	33920	35420	36900	38360	39810	41240	0997	41390 44060	42680 45440	43950 46800	3150	490	47670 50810	110	53400	54670	930	53580 57180	54710 58410	59630	60830	
ATU	NC							_	0	0	2											70 41	30 42	30 44	30 45	50 46	10 48	50 46	70	48880 52110	<u>22</u>	30 54	52420 55930	30 57	10 58		20 00	etc.
Ś	TRE	180							19130	21030	22990	24670	26160	27630	29080	30520	31940	33340	34720	36090	37440	38770	4006		4268	4396	452	464	4767		50080	51260		5358		55840	56950	20%;
		02				13730	15480	17280	18890	20340	21770	23180	24570	25940	27300	28640	29960	31260	32550	33820	35070	36310	37530 40090 42660	38740	39930	41100	42260 45210 48150	3410	1540	45660	46760	47850	3920	49980	51030	52060	53080	ase
			32	. 8				_								<u>80</u>							30 37			30 4	30 4;	40380 43410 46450 49490 52530 55590	41420 44540				45430 48920					incre
۵		160	7202	10380	12030	13540	14950	16330	17700	19050	20380	21690	22980	24250	25510	26750	27980	29180	30370	31550	32710	33850	34980	36090	37180	38260	39330	403	414	42440	43450	44450	454	46400	47360	48300	49230	foot, ion
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	ATRAN-	WIDTH	15'- 0" 15'- 4"							17 9"	18'- 1"	18'- 6"	18'-10"	19'- 3"	19'- 7"	20'- 0"	20'- 5"	20 9	21'- 2"	21'- 6"	21'-11"	22 5"	22'- 7"	22'- 8"	22'-11"	23'- 0"	23'- 1"	23'- 3"	23'- 4"	23 6"	23 8"	23 9"	23'-10"	23'-11"	24 - 1"	24'- 3"	24'- 4"	ınds per ankment
	ATRAN-	_									18'- 1"	18'- 6"	18'-10"	19'- 3"	19'- 7"	20,- 0		20:- 9"	21'- 2"	21'- 6"	21:-11"	22 5"	22'- 7"	22 8"	22'-11"	23 0"	23 1"	23 3"	23 4"	23 6"	23 8"	23'- 9"	23'-10"	23'-11"		24′-	24'-	0 pounds per embankment
	ATRAN-	.092									18'- 1"	18'- 6"	18'-10"	19'- 3"	19'- 7"	20,- 0		20 9.	21 2"	21'- 6"	21:-11	22 5"	22'- 7"	22'- 8"	22'-11"	23 0.		23	23	23	23	23			75100	77130 24'-	24'-	or 120 pounds per n the embankment
	ATRAN-	240" 26:-0"									18'- 1"	18 6"	18'-10"	19'- 3"	19'- 7"	20 0		.602	21 2"	21'- 6"	21'-11"	22 5"	22'- 7"	22'- 8"	22:-11.	23'- 0"	58890	23	62940 23'-	64970 23'-	23	69040 23'-	71060		75100	76340 77130 24'-	77900 79150 24'-	0%; for 120 pounds per 0.5 in the embankment is
		240" 26:-0"									18'- 1"	18'- 6"	18'-10"	19'- 3"	19'- 7"	20,- 0		20 9	21'- 2"		21:-11"	22	22			23	58890	23	62940 23'-	64970 23'-	23	69040 23'-	71060		75100	76340 77130 24'-	77900 79150 24'-	ads 10%; for 120 pounds per sdp—0.5 in the embankment widths
130		230" 240" 26:-0"									18'- 1"	18'- 6"	18,-10	19'- 3"	19'- 7"	20 0		20 9.	21			48520 22	50700 22'-	52750	54800	56850 23'-	58520 58890	60150 60920 23'-	61760 62940 23'-	63350 64970 23'-	64920 67010 23'-	66480 69040 23'-	68020 71060	69540 73090	71050 74760 75100	72540 76340 77130 24'-	74010 77900 79150 24 "-	se loads 10%; for 120 pounds per cubic foo 19, f _{Sd} p—0.5 in the embankment equation ench widths
-0.130	OF PIPE	22'-0" 23'-0" 24'-0" 26'-0"									18'- 1"	18'- 6"	18'-10"	19'- 3"	19'- 7"	20 0		70 9	40770 21'-	43280	45860	47620 48520 22'-	49250 50700 22'-	50860 52750	52440 54800	54020 56850 23'-	55570 58520 58890	57100 60150 60920 23'-	58620 61760 62940 23'-	60120 63350 64970 23-	61600 64920 67010 23'-	63060 66480 69040 23'-	68020 71060	69540 73090	71050 74760 75100	68740 72540 76340 77130 24'-	70120 74010 77900 79150 24 -	crease loads 10%; for 120 pounds per µ-0.19, r _S dp-0.5 in the embankment for trench widths
Кµ.—0.130	OF PIPE	22'-0" 23'-0" 24'-0" 26'-0"									18: 1:	18'- 6"	18,-10.	19'- 3"	19'- 7"		- 50	- 50	40770 21'-	43280	45860	47620 48520 22'-	49250 50700 22'-	50860 52750	52440 54800	54020 56850 23'-	55570 58520 58890	57100 60150 60920 23'-	58620 61760 62940 23'-	60120 63350 64970 23-	61600 64920 67010 23'-	63060 66480 69040 23'-	68020 71060	69540 73090	71050 74760 75100	68740 72540 76340 77130 24'-	70120 74010 77900 79150 24 -	ot, increase loads 10%; for 120 pounds per on Kµ—0.19, r _{sd} p—0.5 in the embankment and/or trench widths
LAY Kµ'-0.130	OF PIPE	210" 22'-0" 23'-0" 24'-0" 26'-0"									18'- 1"	18'- 6"	18:-10"	19'-		- 50,-	35940 20'-	- 50	40770 21'-	43280	45860	47620 48520 22'-	49250 50700 22'-	50860 52750	52440 54800	54020 56850 23'-	55570 58520 58890	57100 60150 60920 23'-	58620 61760 62940 23'-	60120 63350 64970 23-	61600 64920 67010 23'-	59650 63060 66480 69040 23'-	61000 64510 68020 71060	69540 73090	71050 74760 75100	64980 68740 72540 76340 77130 24'-	66250 70120 74010 77900 79150 24 -	bic foot, increase loads 10%; for 120 pounds per ased on Kμ-0.19, f _{Sd} p-0.5 in the embankment ackfill and/or trench widths
Y CLAY Kµ'-0.130	OF PIPE	200" 210" 220" 230" 240" 26:-0"										18.		29200 19'-	31380	33630 20'-	35220 35940 20'-	36750 38320 20:-	38270 40440 40770 21'-	39760 42030 43280	41230 43600 45860	42690 45150 47620 48520 22	14120 46680 49250 50700	45540 48200 50860 52750	46940 49690 52440 54800	54020 56850 23'-	55570 58520 58890	57100 60150 60920 23'-	52360 55480 58620 61760 62940 23'-	53670 56890 60120 63350 64970 23'-	61600 64920 67010 23'-	59650 63060 66480 69040 23'-	61000 64510 68020 71060	69540 73090	71050 74760 75100	61180 64980 68740 72540 76340 77130 24'-	62380 66250 70120 74010 77900 79150 24 -	ar cubic foot, increase loads 10%; for 120 pounds per ths based on $K\mu$ –0.19, $f_{sd}p$ –0.5 in the embankment of backfill and/or trench widths
VARY CLAY Kμ'-0.130	OF PIPE	200" 210" 220" 230" 240" 26:-0"										18.		29200 19'-	31380	33630 20'-	35220 35940 20'-	36750 38320 20:-	38270 40440 40770 21'-	39760 42030 43280	41230 43600 45860	42690 45150 47620 48520 22	14120 46680 49250 50700	45540 48200 50860 52750	46940 49690 52440 54800	54020 56850 23'-	55570 58520 58890	57100 60150 60920 23'-	52360 55480 58620 61760 62940 23'-	53670 56890 60120 63350 64970 23'-	61600 64920 67010 23'-	59650 63060 66480 69040 23'-	61000 64510 68020 71060	69540 73090	71050 74760 75100	61180 64980 68740 72540 76340 77130 24'-	62380 66250 70120 74010 77900 79150 24 -	ds per cubic foot, increase loads 10%; for 120 pounds per 1 widths based on Kµ-0.19, r _{Sd} p-0.5 in the embankment inhis of backfill and/or trench widths
3DINARY CLAY Kµ'-0.130	OF PIPE	190" 200" 210" 220" 230" 240" 260"							17	-12.	22990	25000 18'-		28820 29200 19'-	80310 31380	31790 33630 20'-	33240 35220 35940 20 -	34680 36750 38320 20'-	36090 38270 40440 40770 21'-	37490 39760 42030 43280	38870 41230 43600 45860	42690 45150 47620 48520 22	14120 46680 49250 50700	45540 48200 50860 52750	46940 49690 52440 54800	54020 56850 23'-	55570 58520 58890	57100 60150 60920 23'-	52360 55480 58620 61760 62940 23'-	53670 56890 60120 63350 64970 23'-	61600 64920 67010 23'-	52840 56240 59650 63060 66480 69040 23'-	61000 64510 68020 71060	69540 73090	71050 74760 75100	61180 64980 68740 72540 76340 77130 24'-	58530 62380 66250 70120 74010 77900 79150 24 '-	pounds per cubic foot, increase loads 10%; for 120 pounds per θ) and widths based on $K\mu$ –0.19, $r_{SQ}p$ –0.5 in the embankment in heights of backfill and/or trench widths
ORDINARY CLAY Kµ'-0.130	OF PIPE	180" 190" 200" 210" 220" 230" 240" 260"				-16:	16'-	117	19130 17'-	21030 17'-	22820 22990	24280 25000 18'-	25710 27070	27130 28820 29200 19'-	28530 80310 31380	29910 31790 33630 20'-	31270 33240 35220 35940 20'-	32600 34680 36750 38320	33920 36090 38270 40440 40770	35220 37490 39760 42030 43280	36510 38870 41230 43600 45860	37770 40230 42690 45150 47620 48520 22	39020 41570 14120 46680 49250 50700	40240 42890 45540 48200 50860 52750	41450 44190 46940 49690 52440 54800	42650 45480 48320 51160 54020 56850 23 '-	43820 46750 49680 52620 55570 58520 58890	57100 60150 60920 23'-	52360 55480 58620 61760 62940 23'-	53670 56890 60120 63350 64970 23'-	48360 51650 54960 58280 61600 64920 67010 23'-	49450 52840 56240 59650 63060 66480 69040 23 '-	61000 64510 68020 71060	69540 73090	71050 74760 75100	61180 64980 68740 72540 76340 77130 24'-	54690 58530 62380 66250 70120 74010 77900 79150 24 '-	110 pounds per cubic foot, increase loads 10%; for 120 pounds per $ $ type) and widths based on $K\mu$ –0.19, $f_{sd}p$ –0.5 in the embankment exists heights of backfill and/or trench widths
ORDINARY CLAY Kµ'-0.130		180" 190" 200" 210" 220" 230" 240" 260"				-16:	16'-	117	19130 17'-	21030 17'-	22820 22990	24280 25000 18'-	25710 27070	27130 28820 29200 19'-	28530 80310 31380	29910 31790 33630 20'-	31270 33240 35220 35940 20'-	32600 34680 36750 38320	33920 36090 38270 40440 40770	35220 37490 39760 42030 43280	36510 38870 41230 43600 45860	37770 40230 42690 45150 47620 48520 22	39020 41570 14120 46680 49250 50700	40240 42890 45540 48200 50860 52750	41450 44190 46940 49690 52440 54800	42650 45480 48320 51160 54020 56850 23 '-	43820 46750 49680 52620 55570 58520 58890	57100 60150 60920 23'-	52360 55480 58620 61760 62940 23'-	53670 56890 60120 63350 64970 23'-	48360 51650 54960 58280 61600 64920 67010 23'-	49450 52840 56240 59650 63060 66480 69040 23 '-	61000 64510 68020 71060	69540 73090	71050 74760 75100	61180 64980 68740 72540 76340 77130 24'-	54690 58530 62380 66250 70120 74010 77900 79150 24 '-	thing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per (bold type) and widths based on Kµ—0.19, r _{Sd} p—0.5 in the embankment remediate heichts of backfill and/or trench widths
ORDINARY CLAY Kµ'-0.130	OF PIPE	17'-0" 18'-0" 19'-0" 20'-0" 21'-0" 22'-0" 23'-0" 24'-0" 26'-0"	15.	15.	-191	13730 16:-	15480	117	18640 19130 17'-	20040 21030 17'-	21420 22820 22990	22790 24280 25000 18'-	24130 25710 27070	25450 27130 28820 29200 19'-	26750 28530 80310 31380	28030 29910 31790 33630 20'-	29290 31270 33240 35220 35940 20'-	30530 32600 34680 36750 38320	31760 33920 36090 38270 40440 40770	32960 35220 37490 39760 42030 43280	34150 36510 38870 41230 43600 45860	35320 37770 40230 42690 45150 47620 48520 22	39020 41570 14120 46680 49250 50700	37600 40240 42890 45540 48200 50860 52750	38720 41450 44190 46940 49690 52440 54800	39820 42650 45480 48320 51160 54020 56850 23 '-	40900 43820 46750 49680 52620 55570 58520 58890	57100 60150 60920 23'-	52360 55480 58620 61760 62940 23'-	53670 56890 60120 63350 64970 23'-	48360 51650 54960 58280 61600 64920 67010 23'-	46070 49450 52840 56240 59650 63060 66480 69040 23 '-	61000 64510 68020 71060	69540 73090	71050 74760 75100	61180 64980 68740 72540 76340 77130 24'-	54690 58530 62380 66250 70120 74010 77900 79150 24 '-	weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per oads (bold type) and widths based on $K\mu$ –0.19, $r_{Sd}p$ –0.5 in the embankment for intermediate heights of backfill and/or trench widths
ORDINARY CLAY Kµ'-0.130	OF PIPE	180" 190" 200" 210" 220" 230" 240" 260"	7202 15	10380	12030 16'-	13400 13730 16:-	14770 15480 16'-		17440 18640 19130	18750 20040 21030	20030 21420 22820 22990	21300 22790 24280 25000 18'-	22540 24130 25710 27070	23770 25450 27130 28820 29200	24970 26750 28530 80310 31380	26150 28030 29910 31790 33630 20°-	27320 29290 31270 33240 35220 35940	28470 30530 32600 34680 36750 38320	29600 31760 33920 36090 38270 40440 40770	30700 32960 35220 37490 39760 42030 43280	31800 34150 36510 38870 41230 43600 45860	32870 35320 37770 40230 42690 45150 47620 48520 22-	33930 36470 39020 41570 14120 46680 49250 50700 22 '-	34970 37600 40240 42890 45540 48200 50860 52750	35990 38720 41450 44190 46940 49690 52440 54800	37000 39820 42650 45480 48320 51160 54020 56850	37990 40900 43820 46750 49680 52620 55570 58520 58890	38960 41970 44980 48000 51030 54060 57100 60150 60920 23-	39920 43020 46120 49240 52360 55480 58620 61760 62940 23:-	40870 44050 47250 50450 53670 56890 60120 63350 64970 23:-	41800 45070 48360 51650 54960 58280 61600 64920 67010 23 '-	42710 46070 49450 52840 56240 59650 63060 66480 69040 23'-	43610 47060 50530 54010 57500 61000 64510 68020 71060	44490 48030 51590 55160 58740 62340 65940 69540 73090	45360 48990 52640 56300 59970 63660 67350 71050 74760 75100	46220 49940 53670 57420 61180 64980 68740 72540 76340 77130 24'-	47060 50860 54690 58530 62380 66250 70120 74010 77900 79150 24 .	ickfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per tion loads (bold type) and widths based on $K\mu$ –0.19, $f_{sd}p$ –0.5 in the embankment plate for intermediate heights of backfill and/or trench widths
C ORDINARY CLAY Kµ'—0.130	OF PIPE	17'-0" 18'-0" 19'-0" 20'-0" 21'-0" 22'-0" 23'-0" 24'-0" 26'-0"	15.	10380	-191	13730 16:-	15480	117	12 17440 18640 19130 17'-	13 18750 20040 21030	14 20030 21420 22820 22990	22790 24280 25000 18'-	16 [22540 [24130 [25710 27070]	17 23770 25450 27130 28820 29200	18 24970 26750 28530 80310 31380	19 26150 28030 29910 31790 33630	20 27320 29290 31270 33240 35220 35940 20'-	21 28470 30530 32600 34680 36750 38320	22 29600 31760 33920 36090 38270 40440 40770	23 30700 32960 35220 37490 39760 42030 43280	24 31800 34150 36510 38870 41230 43600 45860	25 32870 35320 37770 40230 42690 45150 47620 48520 22 .	26 33930 36470 39020 41570 14120 46680 49250 50700 22	27 34970 37600 40240 42890 45540 48200 50860 52750	28 35990 38720 41450 44190 46940 49690 52440 54800	29 37000 39820 42650 45480 48320 51160 54020 56850 23 '-	30 37990 40900 43820 46750 49680 52620 55570 58520 58890	31 38960 41970 44980 48000 51030 54060 57100 60150 60920 23-	32 39920 43020 46120 49240 52360 55480 58620 61760 62940 23 :	53670 56890 60120 63350 64970 23'-	34 41800 45070 48360 51650 54960 58280 61600 64920 67010 23 '-	35 42710 46070 49450 52840 56240 59650 63060 66480 69040 23 '-	36 43610 47060 50530 54010 57500 61000 64510 68020 71060	69540 73090	45360 48990 52640 56300 59970 63660 67350 71050 74760 75100	61180 64980 68740 72540 76340 77130 24'-	47060 50860 54690 58530 62380 66250 70120 74010 77900 79150 24 .	* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%, etc. ▲Transition loads (bold type) and widths based on Kµ-0.19, r _S dp-0.5 in the embankment equation Intervolate for intermediate heights of backfill and/or trench widths

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Table B-30

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130		240' 250" 260"						17. 8"	18 0	18'- 4"	18 8"	19'- 1"	19'- 5"	19'-10"	20 2"	20'- 7"	21:- 0"	21'- 3"	21'- 8'			221	52580 23	54910 23	57050 23'-	23-	24	24	24'-	24	24	69910 71930	71540 74050 24'-	73160 76160 24'-	74760 78280 25'-	76340 80150 80380	77900 81810 82500 25-
-0.130		230" 240' 250" 260"						17. 8"	18 0	18'- 4"	18'- 8"	19 1.	19 5"	19'-10"	20'- 2"	20'- 7"	21 0			44490		221	52580 23	54910 23	57050 23'-	23-	24	24	24'-	24	24	69910 71930	71540 74050 24'-	73160 76160 24'-	74760 78280 25'-	76340 80150 80380	77900 81810 82500 25-
′ Kµ′—0.130		230" 240' 250" 260"						17 8"	18 0.	18'- 4"	18 8"	19'- 1"	19:- 5"	1910"	20,- 2"	20'- 7"	21 0"			44490		221	52580 23	54910 23	57050 23'-	23-	24	24	24'-	24	24	69910 71930	71540 74050 24'-	73160 76160 24'-	74760 78280 25'-	76340 80150 80380	77900 81810 82500 25-
SLAY Kµ'—0.130		220" 230" 240' 250" 26:-0"						17. 8"	18: 0"	18'- 4"	18, 8"	19'- 1"	19 5."	19:-10			21'-	39450	41940	44300 44490	45970 47120	47620 49810 22'-1	49250 51810 52580 23-	50860 53520 54910 23-	52440 55200 57050 23'-	54020 56870 59190 23'-	55570 58520 61320 24-	57100 60150 63200 63440 24-	58620 61760 64900 65580 24'-	60120 63350 66590 67690 24-	61600 64920 68260 69810 24-	63060 66480 69910 71930	71540 74050 24'-	73160 76160 24'-	67350 71050 74760 78280 25 -	76340 80150 80380	77900 81810 82500 25-
RY CLAY Kµ'-0.130		21.0" 22.0" 23.0" 24.0' 25.0" 26.0"						17: 8"	18 0.	18'- 4"	18'- 8"	19.	19.		32370		21'-	39450	41940	44300 44490	45970 47120	47620 49810 22'-1	49250 51810 52580 23-	50860 53520 54910 23-	52440 55200 57050 23'-	54020 56870 59190 23'-	55570 58520 61320 24-	57100 60150 63200 63440 24-	58620 61760 64900 65580 24'-	60120 63350 66590 67690 24-	61600 64920 68260 69810 24-	63060 66480 69910 71930	71540 74050 24'-	73160 76160 24'-	67350 71050 74760 78280 25 -	76340 80150 80380	77900 81810 82500 25-
JINARY CLAY Kµ'-0.130		20'-0" 21'-0" 22'-0" 23'-0" 24'-0' 25'-0" 26'-0"						17'- 8"	18 0.	18,-	18.	25840 19'-	19.		32100 32370		35220 37030 21'-	39450	38270 40440 41940	44300 44490	45970 47120	47620 49810 22'-1	49250 51810 52580 23-	50860 53520 54910 23-	52440 55200 57050 23'-	54020 56870 59190 23'-	49680 52620 55570 58520 61320 24-	57100 60150 63200 63440 24-	52360 55480 58620 61760 64900 65580 24 *-	53670 56890 60120 63350 66590 67690 24-	54960 58280 61600 64920 68260 69810 24'-	56240 59650 63060 66480 69910 71930	71540 74050 24'-	73160 76160 24'-	67350 71050 74760 78280 25 -	76340 80150 80380	77900 81810 82500 25-
ORDINARY CLAY Kµ'-0.130		21.0" 22.0" 23.0" 24.0' 25.0" 26.0"						17'- 8"	18 0"	18,-	18.	25840 19'-	19.		32100 32370		35220 37030 21'-	39450	38270 40440 41940	44300 44490	45970 47120	47620 49810 22'-1	49250 51810 52580 23-	50860 53520 54910 23-	52440 55200 57050 23'-	54020 56870 59190 23'-	49680 52620 55570 58520 61320 24-	57100 60150 63200 63440 24-	52360 55480 58620 61760 64900 65580 24 *-	53670 56890 60120 63350 66590 67690 24-	54960 58280 61600 64920 68260 69810 24'-	63060 66480 69910 71930	71540 74050 24'-	73160 76160 24'-	67350 71050 74760 78280 25 -	76340 80150 80380	77900 81810 82500 25-
ORDINARY CLAY Kµ'-0.130	TRENCH WIDTH AT TOP OF PIPE	19.0" 20.0" 21.0" 22.0" 23.0" 24.0' 25.0" 26.0"					17:	-,11	18.	21770 18	18.	25840 19'-	19.		32100 32370		35220 37030 21'-	39450	38270 40440 41940	44300 44490	45970 47120	47620 49810 22'-1	49250 51810 52580 23-	50860 53520 54910 23-	52440 55200 57050 23'-	54020 56870 59190 23'-	49680 52620 55570 58520 61320 24-	57100 60150 63200 63440 24-	52360 55480 58620 61760 64900 65580 24 *-	53670 56890 60120 63350 66590 67690 24-	54960 58280 61600 64920 68260 69810 24'-	52840 56240 59650 63060 66480 69910 71930	71540 74050 24'-	73160 76160 24'-	67350 71050 74760 78280 25 -	76340 80150 80380	77900 81810 82500 25-
ORDINARY CLAY Kµ'-0.130		18-0" 19-0" 20-0" 21-0" 22-0" 23-0" 24-0' 25-0" 26-0"	15.	19.	19.	- 91	16050	-,11	18.	21330 21770	22820 23780 18:-	24280 25760 25840 19-	19.		28530 30310 32100 32370		31270 33240 35220 37030 21'-	39450	38270 40440 41940	44300 44490	45970 47120	47620 49810 22'-1	49250 51810 52580 23-	50860 53520 54910 23-	52440 55200 57050 23'-	54020 56870 59190 23'-	43820 46750 49680 52620 55570 58520 61320 24-	57100 60150 63200 63440 24-	52360 55480 58620 61760 64900 65580 24 *-	53670 56890 60120 63350 66590 67690 24-	54960 58280 61600 64920 68260 69810 24'-	49450 52840 56240 59650 63060 66480 69910 71930	71540 74050 24'-	51590 55160 58740 62340 65940 69540 73160 76160	67350 71050 74760 78280 25 -	76340 80150 80380	54690 58530 62380 66250 70120 74010 77900 81810 82500 25.
ORDINARY CLAY Kµ'-0.130		19.0" 20.0" 21.0" 22.0" 23.0" 24.0' 25.0" 26.0"	7491 15'-	9113	10780	12490	15760 16050	17210 17910	18640 19810	20040 21330 21770	21420 22820 23780 18:-	22790 24280 25760 25840	24130 25710 27300 27960 19-	25450 27130 28820 30140	26750 28530 30310 32100 32370	28030 29910 31790 33670 34670	29290 31270 33240 35220 37030 21 ⁻	30530 32600 34680 36750 38830 39450	31760 33920 36090 38270 40440 41940	32960 35220 37490 39760 42030 44300 44490	34150 36510 38870 41230 43600 45970 47120	35320 37770 40230 42690 45150 47620 49810	36470 39020 41570 44120 46680 49250 51810 52580 23-	37600 40240 42890 45540 48200 50860 53520 54910 23·	38720 41450 44190 46940 49690 52440 55200 57050 23 -	39820 42650 45480 48320 51160 54020 56870 59190 23-	40900 43820 46750 49680 52620 55570 58520 61320	41970 44980 48000 51030 54060 57100 60150 63200 63440 24-	43020 46120 49240 52360 55480 58620 61760 64900 65580 24 *-	44050 47250 50450 53670 56890 60120 63350 66590 67690 24 '-	45070 48360 51650 54960 58280 61600 64920 68260 69810 24 '-	46070 49450 52840 56240 59650 63060 66480 69910 71930	47060 50530 54010 57500 61000 64510 68020 71540 74050 24 .	48030 51590 55160 58740 62340 65940 69540 73160 76160	48990 52640 56300 59970 63660 67350 71050 74760 78280	49940 53670 57420 61180 64960 68740 72540 76340 80150 80380	50860 54690 58530 62380 66250 70120 74010 77900 81810 82500 25.
C ORDINARY CLAY Kµ'—0.130		18-0" 19-0" 20-0" 21-0" 22-0" 23-0" 24-0' 25-0" 26-0"	7491 15'-	9113	10780	12490	16050	17210 17910	12 18640 19810	20040 21330 21770	14 21420 22820 23780 18 -	15 22790 24280 25760 25840 19 -	16 24130 25710 27300 27960	17 25450 27130 28820 30140	18 26750 28530 30310 32100 32370	19 28030 29910 31790 33670 34670	20 29290 31270 33240 35220 37030 21-	21 30530 32600 34680 36750 38830 39450	22 31760 33920 36090 38270 40440 41940	23 32960 35220 37490 39760 42030 44300 44490	24 34150 36510 38870 41230 43600 45970 47120	25 35320 37770 40230 42690 45150 47620 49810 22:-1	26 36470 39020 41570 44120 46680 49250 51810 52580 23.	27 37600 40240 42890 45540 48200 50860 53520 54910 23·	28 38720 41450 44190 46940 49690 52440 55200 57050 23 -	29 39820 42650 45480 48320 51160 54020 56870 59190 23 -	40900 43820 46750 49680 52620 55570 58520 61320	31 41970 44980 48000 51030 54060 57100 60150 63200 63440 24 -	32 43020 46120 49240 52360 55480 58620 61760 64900 65580 24 *-	33 44050 47250 50450 53670 56890 60120 63350 66590 67690 24 .	54960 58280 61600 64920 68260 69810 24'-	35 46070 49450 52840 56240 59650 63060 66480 69910 71930	36 47060 50530 54010 57500 61000 64510 68020 71540 74050 24 .	51590 55160 58740 62340 65940 69540 73160 76160	48990 52640 56300 59970 63660 67350 71050 74760 78280	76340 80150 80380	54690 58530 62380 66250 70120 74010 77900 81810 82500 25.

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc. A Transition loads (**bold type**) and widths based on Kµ-0.19, r_{sd}p-0.5 in the embankment equation Interpolate for intermediate heights of backfill and/or trench widths

Table B-31

DESIGN VALUES OF SETTLEMENT RATIO

	Settlem Ratio	
Installation and Foundation Condition	Usual Range	Design Value
Positive Projecting	0.0 to +1.0	
Rock or Unyielding Soil	+1.0	+1.0
*Ordinary Soil	+0.5 to +0.8	+0.7
Yielding Soil	0.0 to +0.5	+0.3
Zero Projecting		0.0
Negative Projecting	-1.0 to 0.0	
p' = 0.5		-0.1
p' = 1.0		-0.3
p' = 1.5		-0.5
p' = 2.0		-1.0
Induced Trench	-2.0 to 0.0	
p' = 0.5		-0.5
p' = 1.0		-0.7
p' = 1.5		-1.0
p' = 2.0		-2.0

^{*}The value of the settlement ratio depends on the degree of compaction of the fill material adjacent to the sides of the pipe. With good construction methods resulting in proper compaction of bedding and sidefill materials, a settlement ratio design value of +0.5 is recommended.

Table B-32

BEDDING FACTORS FOR CIRCULAR PIPE POSITIVE PROJECTING EMBANKMENT INSTALLATIONS

H B _c			ASS A				ASS B DDING			
					p = 0.9	· · · · · · · · · · · · · · · · · · ·				
	rsd p = 0	0.1	0.3	0.5	1.0	$r_{sd} p = 0$	0.1	0.3	0.5	1.0
0.5	5.09	5.09	5.09	5.09	5.09	2.92	2.92	2.92	2.92	2.92
1.0	5.09	5.09	5.09	5.09	5.09	2.92	2.92	2.92	2.92	2.92
1.5	5.09	4.83	4.47	4.47	4.47	2.92	2.83	2.71	2.71	2.71
2.0	5.09	4.49	4.35	4.19	4.19	2.92	2.77	2.67	2.61	2.61
3.0	5.09	4.50	4.21	4.06	3.88	2.92	2.72	2.62	2.56	2.50
5.0	4.97	4.37	4.11	3.97	3.81	2.88	2.67	2.58	2.52	2.46
10.0	4.82	4.28	4.04	3.90	3.76	2.83	2.64	2.55	2.50	2.44
15.0	4.77	4.25	4.01	3.88	3.74	2.81	2.63	2.54	2.49	2.43
	· · · · · · · · · · · · · · · · · · ·				p = 0.7			····		T
	$r_{sd} p = 0$	0.1	0.3	0.5	1.0	$r_{sd} p = 0$	0.1	0.3	0.5	1.0
0.5	6.03	6.03	6.03	6.03	6.03	2.80	2.80	2.80	2.80	2.87
1.0	5.61	4.79	4.79	4.79	4.79	2.73	2.58	2.58	2.58	2.58
1.5	5.17	4.46	4.19	4.19	4.19	2.65	2.50	2.44	2.44	2.44
2.0	4.98	4.35	4.11	3.99	3.98	2.61	2.48	2.42	2.39	2.39
3.0	4.80	4.25	4.02	3.90	3.75	2.58	2.45	2.40	2.36	2.32
5.0	4.66	4.18	3.95	3.84	3.70	2.55	2.43	2.38	2.35	2.31
10.0	4.57	4.12	3.91	3.79	3.66	2.53	2.42	2.36	2.33	2.30
15.0	4.53	4.09	3.89	3.77	3.65	2.52	2.41	2.36	2.33	2.29
					P = 0.5		r	· · · · · · · · · · · · · · · · · · ·	I	1
	$r_{sd} p = 0$	0.1	0.3	0.5	1.0	$r_{sd} p = 0$	0.1	0.3	0.5	1.0
0.5	4.84	4.54	4.55	4.55	4.55	2.37	2.33	2.33	2.33	2.33
1.0	4.33	3.97	3.97	3.97	3.97	2.31	2.25	2.25	2.25	2.25
1.5	4.18	3.83	3.68	3.68	3.68	2.28	2.23	2.20	2.20	2.20
2.0	4.11	3.79	3.65	3.58	3.58	2.27	2.22	2.20	2.19	2.18
3.0	4.04	3.75	3.62	3.54	3.45	2.26	2.22	2.19	2.18	2.16
5.0	3.99	3.72	3.58	3.51	3.43	2.26	2.21	2.19	2.17	2.16
10.0 15.0	3.95 3.94	3.69 3.68	3.56 3.56	3.49 3.48	3.41 3.40	2.25 2.25	2.20 2.20	2.18 2.18	2.17 2.17	2.15 2.15
10.0	0.01	0.00	0.00	0.10	p = 0.3					
	$r_{sd} p = 0$	0.1	0.3	0.5	1.0	$r_{sd} p = 0$	0.1	0.3	0.5	1.0
0.5	3.49	3.41	3.41	3.41	3.41	2.11	2.10	2.10	2.10	2.10
1.0	3.40	3.28	3.28	3.28	3.28	2.10	2.08	2.08	2.08	2.08
1.5	3.40	3.25	3.20	3.20	3.20	2.10	2.08	2.07	2.07	2.07
2.0	3.35	3.24	3.20	3.16	3.16	2.09	2.08	2.07	2.07	2.07
3.0	3.34	3.23	3.18	3.15	3.11	2.09	2.08	2.07	2.07	2.06
5.0	3.33	3.22	3.17	3.14	3.11	2.09	2.08	2.07	2.07	2.06
10.0	3.32	3.22	3.17	3.14	3.10	2.09	2.08	2.07	2.07	2.06
15.0	3.32	3.22	3.17	3.14	3.10	2.09	2.08	2.07	2.07	2.06
	1	i	·	ZERO	PROJE	CTING		1	L	<u> </u>
			2.83					2.02		
L	L					L				

POSITIVE PROJECTING EMBANKMENT INSTALLATIONS

Table B-33

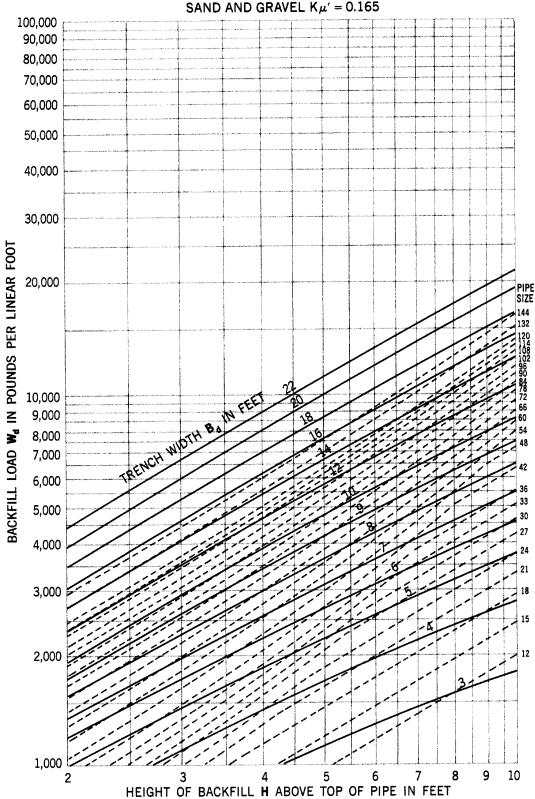
BEDDING FACTORS FOR CIRCULAR PIPE

H _{B_c}			ASS C DDING					ASS D DDING		
					P= 0.9	· · · · · · · · · · · · · · · · · · ·				
	$r_{sd} p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0
0.5	2.29	2.29	2.29	2.29	2.29	1.31	1.31	1.31	1.31	1.31
1.0	2.29	2.29	2.29	2.29	2.29	1.31	1.31	1.31	1.31	1.31
1.5	2.29	2.26	2.16	2.16	2.16	1.31	1.29	1.27	1.27	1.27
2.0	2.29	2.20	2.14	2.10	2.10	1.31	1.28	1.26	1.24	1.24
3.0	2.29	2.17	2.10	2.07	2.02	1.31	1.27	1.24	1.23	1.22
5.0	2.27	2.14	2.08	2.04	2.00	1.30	1.26	1.24	1.22	1.21
10.0	2.24	2.12	2.06	2.03	1.99	1.29	1.25	1.23	1.22	1.20
15.0	2.23	2.10	2.05	2.02	1.98	1.29	1.25	1.23	1.21	1.20
		,			p = 0.7					
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	rsdp = 0	0.1	0.3	0.5	1.0
0.5	2.22	2.22	2.22	2.22	2.22	1.28	1.28	1.28	1.28	1.28
1.0	2.18	2.08	2.08	2.08	2.08	1.27	1.24	1.24	1.24	1.24
1.5	2.13	2.03	1.99	1.99	1.99	1.25	1.22	1.20	1.20	1.20
2.0	2.10	2.01	1.97	1.95	1.95	1.24	1.21	1.20	1.19	1.19
3.0	2.08	2.00	1.96	1.94	1.91	1.24	1.21	1.19	1.18	1.17
5.0	2.06	1.98	1.95	1.93	1.90	1.23	1.20	1.19	1.18	1.17
10.0	2.05	1.98	1.94	1.92	1.89	1.22	1.20	1.18	1.18	1.17
15.0	2.04	1.97	1.94	1.91	1.89	1.22	1.20	1.18	1.18	1.17
					p = 0.5					
	$r_{sd} p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0
0.5	1.94	1.92	1.92	1.92	1.92	1.19	1.18	1.18	1.18	1.18
1.0	1.90	1.86	1.86	1.86	1.86	1.17	1.16	1.16	1.16	1.16
1.5	1.88	1.85	1.83	1.83	1.83	1.16	1.15	1.14	1.14	1.14
2.0	1.88	1.84	1.83	1.82	1.82	1.16	1.15	1.14	1.14	1.14
3.0	1.87	1.84	1.82	1.81	1.80	1.16	1.15	1.14	1.14	1.13
5.0	1.86	1.83	1.82	1.81	1.80	1.16	1.14	1.14	1.13	1.13
10.0	1.86	1.83	1.81	1.80	1.79	1.15	1.14	1.14	1.13	1.13
15.0	1.86	1.83	1.81	1.80	1.79	1.15	1.14	1.14	1.13	1.13
					p= 0.3					·
	$r_{sd}p = 0$	0.1	0.3	0.5	1.0	$r_{sd}p = 0$	0.1	0.3	0.5	1.0
0.5	1.76	1.76	1.76	1.76	1.76	1.12	1.11	1.11	1.11	1.11
1.0	1.76	1.75	1.75	1.75	1.75	1.11	1.11	1.11	1.11	1.11
1.5	1.75	1.74	1.74	1.74	1.74	1.11	1.11	1.11	1.11	1.11
2.0	1.75	1.74	1.74	1.74	1.74	1.11	1.11	1.11	1.11	1.11
3.0	1.75	1.74	1.74	1.73	1.73	1.11	1.11	1.11	1.11	1.10
5.0	1.75	1.74	1.74	1.73	1.73	1.11	1.11	1.11	1.11	1.10
10.0	1.75	1.74	1.74	1.73	1.73	1.11	1.11	1.11	1.10	1.10
15.0	1.75	1.74	1.74	1.73	1.73	1.11	1.11	1.11	1.10	1.10
		I	·	ZERO	PROJE	CTING		±		•
			1.70					1.10		
<u></u>	<u> </u>					I				

Figure B-1



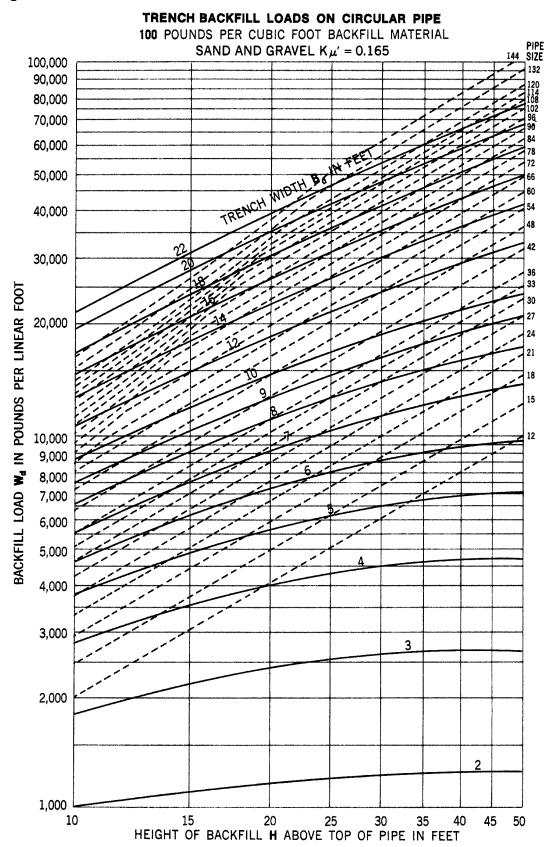
100 POUNDS PER CUBIC FOOT BACKFILL MATERIAL SAND AND GRAVEL Ku' = 0.165



For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and $\rho=0.7$ in the embankment equation

Figure B-2

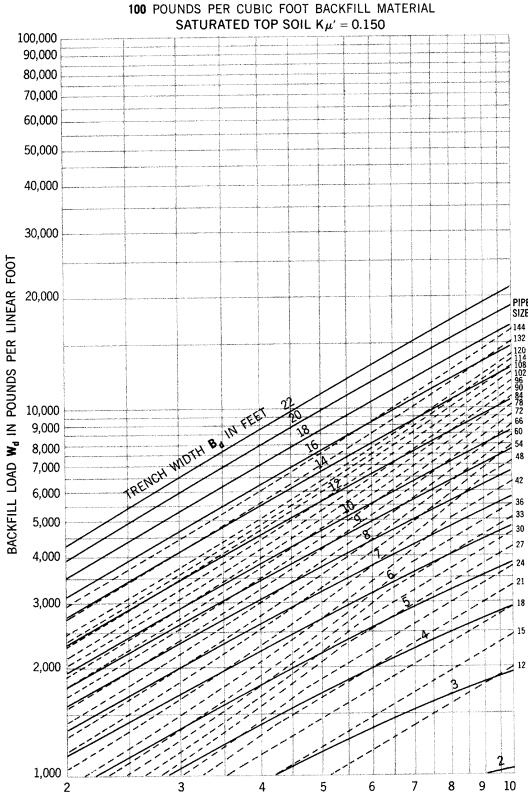


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on K_{μ} = 0.19, $r_{\rm sd}$ = 0.7 and ρ = 0.7 in the embankment equation

Figure B-3



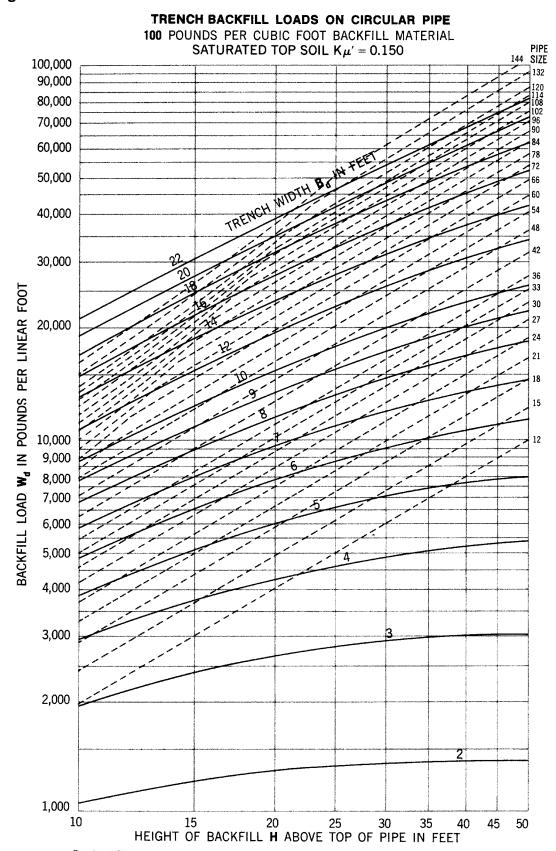


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE IN FEET

Transition loads and widths based on K_{μ} = 0.19, r_{sd} = 0.7 and p = 0.7 in the embankment equation

Figure B-4

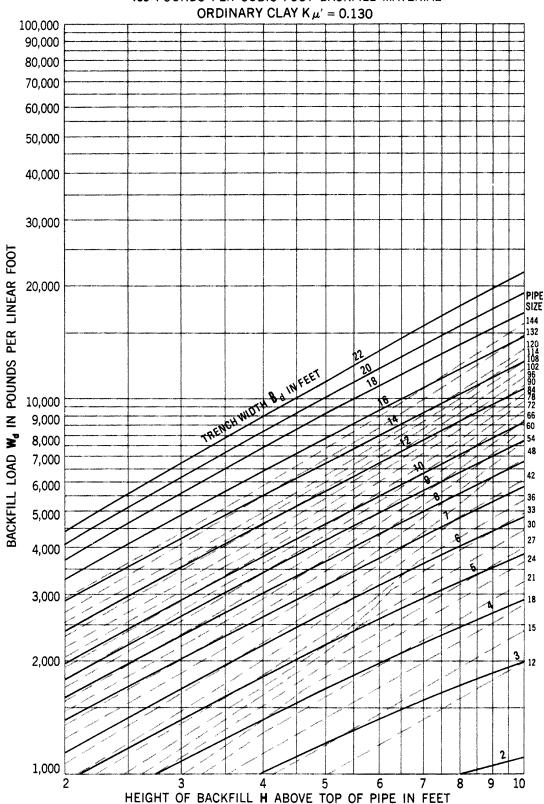


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on K $_{\mu}$ = 0.19, $r_{\rm sd}$ = 0.7 and p = 0.7 in the embankment equation

Figure B-5

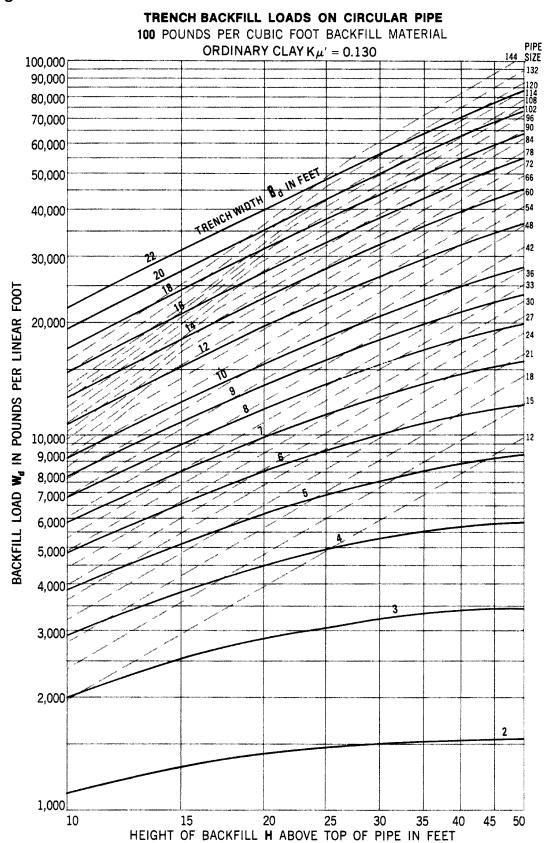




For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{sd}=0.7$ and p=0.7 in the embankment equation

Figure B-6

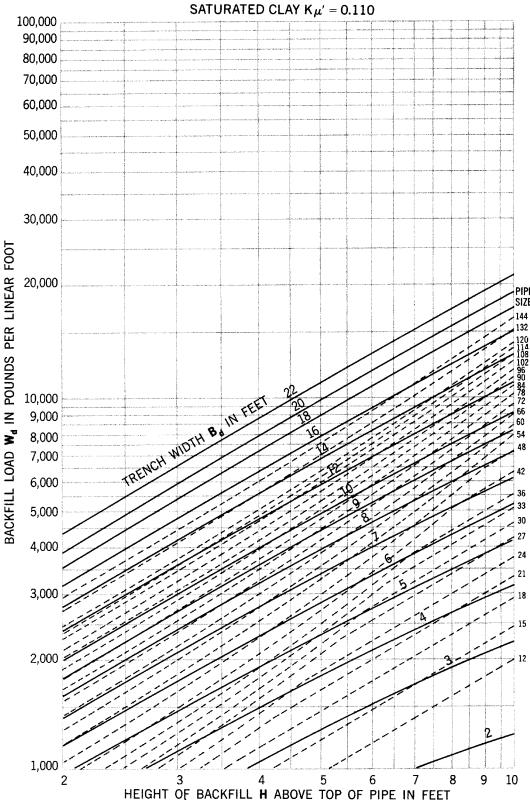


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu$ = 0.19, r_{sd} = 0.7 and p = 0.7 in the embankment equation

Figure B-7

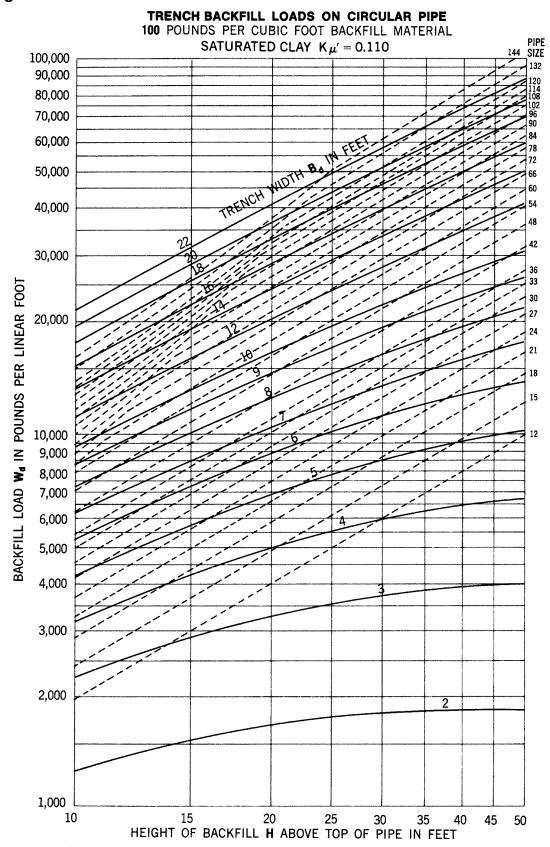




For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on $K\mu=0.19$, $r_{so}=0.7$ and $\rho=0.7$ in the embankment equation

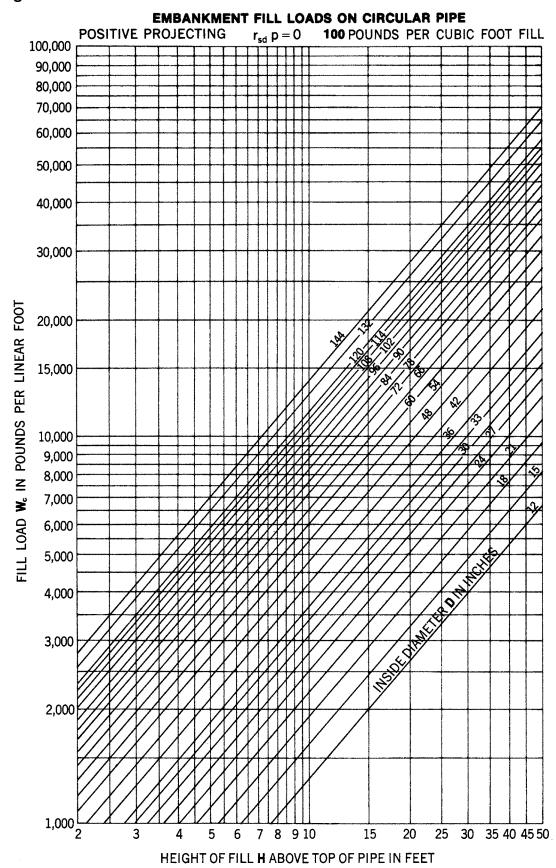
Figure B-8

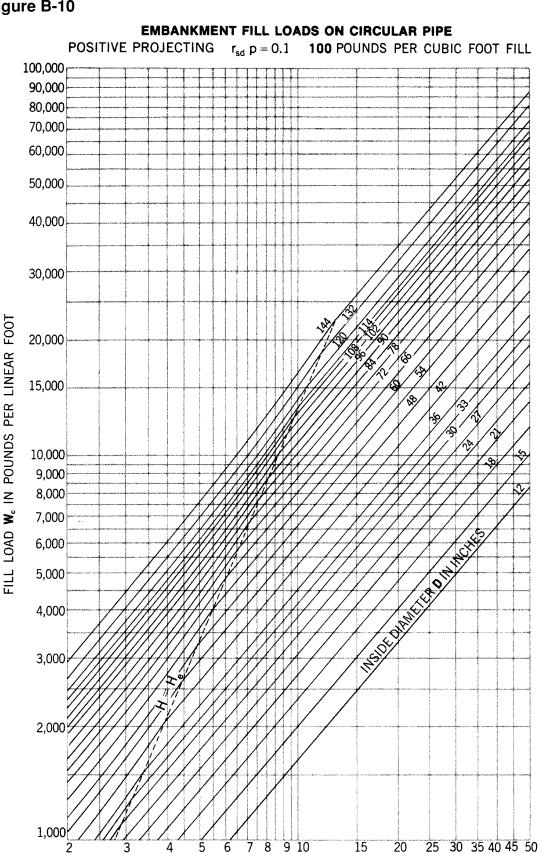


For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.

Transition loads and widths based on K $_{\mu}$ = 0.19, $r_{\rm sd}$ = 0.7 and ρ = 0.7 in the embankment equation

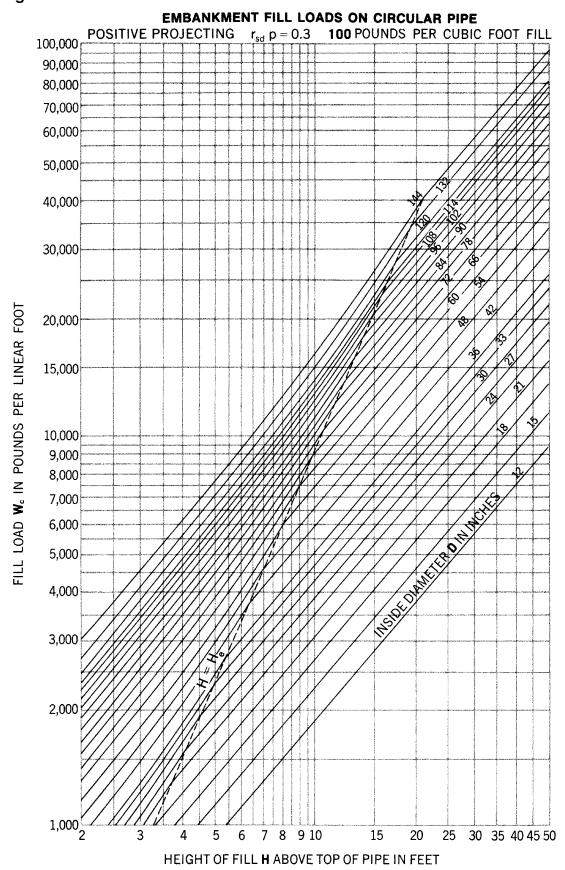
Figure B-9





For fill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds increase 20%, etc. Interpolate for intermediate pipe sizes.

HEIGHT OF FILL H ABOVE TOP OF PIPE IN FEET



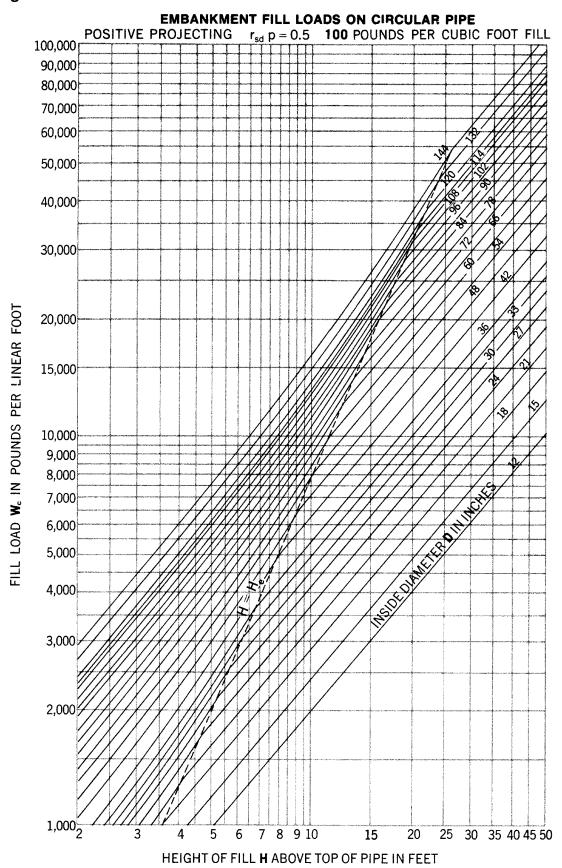
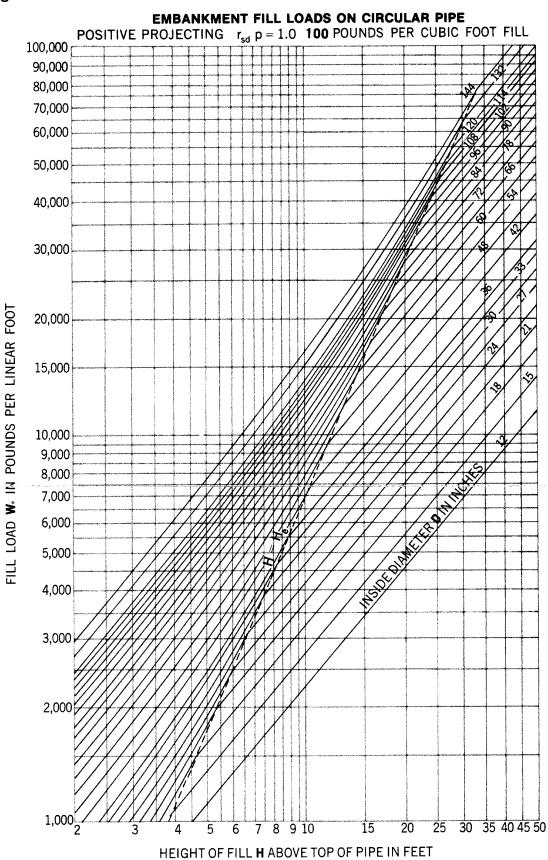


Figure B-13



TRENCH BEDDINGS CIRCULAR PIPE

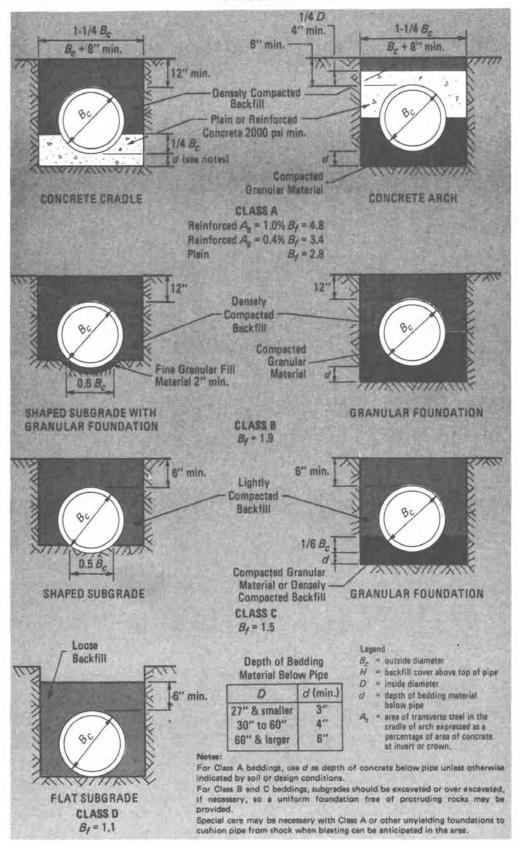
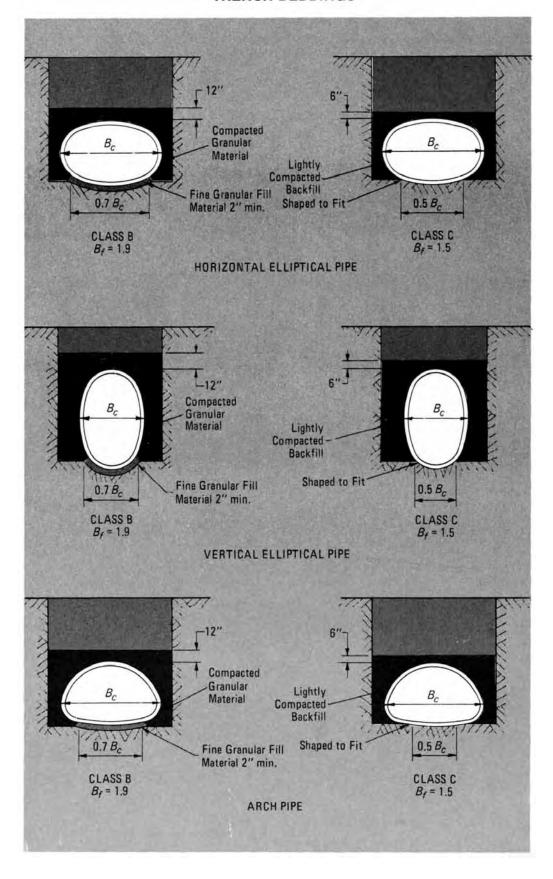


Figure B-15

TRENCH BEDDINGS



EMBANKMENT BEDDINGS CIRCULAR PIPE

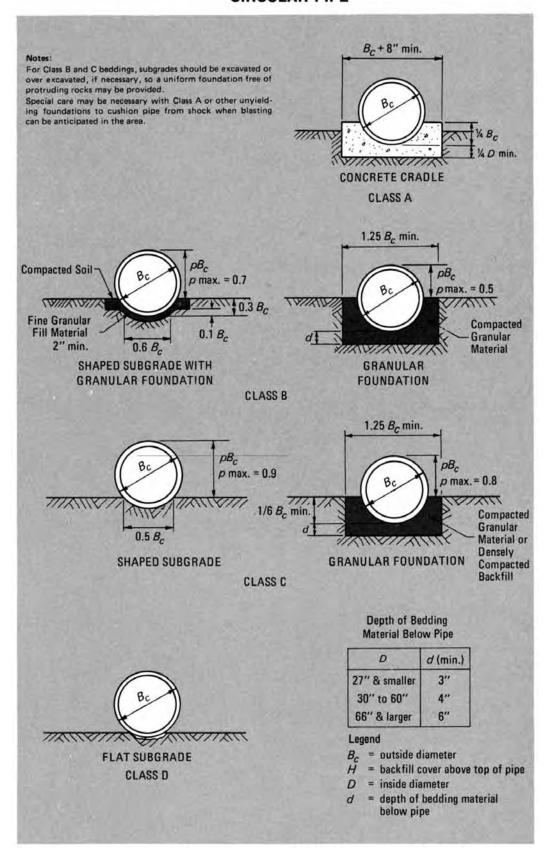
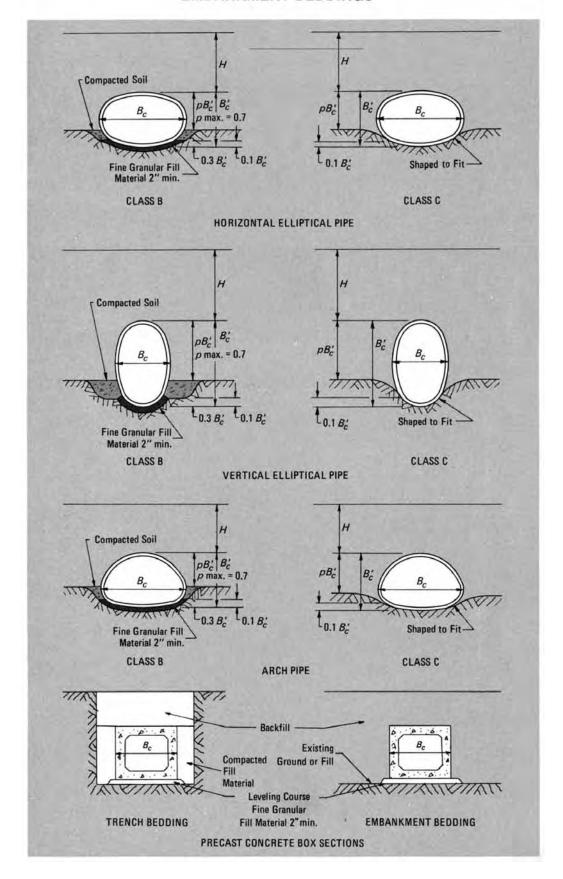


Figure B-17

EMBANKMENT BEDDINGS



Glossary of Terms

GLOSSARY OF HYDRAULIC TERMS (Chapters 2 and 3)

Across-sectional area of flow, square feet
Adrainage area, acres
AHWallowable headwater depth at culvert entrance, feet
Ccoefficient of runoff which is a function of the characteristics of the drainage area
C1constant in Manning's Formula for full flow
Dheight of culvert opening or diameter of pipe, inches or feet
dccritical depth, feet
Hhead loss, feet (the difference between the elevation of the entrance pool surface and the outlet tailwater surface)
HWheadwater depth at culvert inlet measured from invert of pipe, feet
hovertical distance between the culvert invert at the outlet and the hydraulic grade line, feet
keentrance head loss coefficient
irainfall intensity, inches per hour
Llength of culvert, feet
nManning's coefficient of roughness
Qflow in sewer or culvert discharge, cubic feet per second
Rhydraulic radius, equals area of flow divided by wetted perimeter, feet
Rinside vertical rise of elliptical, arch pipe, or boxes, feet or inches
Sinside horizontal span of elliptical, arch pipe, or boxes, feet or inches
Sslope of sewer, feet per foot
Soslope of culvert, feet per foot
TWtailwater depth at culvert outlet measured from invert of pipe, feet
Vvelocity, feet per second
GLOSSARY OF LOAD TERMS (Chapter 4 and Appendix B)
Aa constant corresponding to the shape of the pipe
A_{LL} distributed live load area on subsoil plane at outside top of pipe, square feet
A_s area of transverse steel in a cradle expressed as a percentage of the area of concrete in the cradle at the invert
B_c outside horizontal span of the pipe, feet
B_c' outside vertical height of the pipe, feet
B_a width of trench at top of pipe, feet
B_{dt} transition width at top of pipe, feet
B _r bedding factor
B _{fe} bedding factor, embankment
B _{fLL} bedding factor for live load
B _{fo} minimum bedding factor, trench
$B_{_{f_{V}}}$ variable bedding factor, trench
B_r maximum width of excavation ahead of pipe or tunnel, feet

Cpressure coefficient for live loads
Ccload coefficient for positive projecting embankment installations
Cdload coefficient for trench installations
Cnload coefficient for negative projecting embankment installations
Ctload coefficient for jacked or tunneled installations
cthickness of concrete cover over the inner reinforcement, inches
ccoefficient of cohesion of undisturbed soil, pounds per square foot
Diinside diameter of pipe, inches
Dooutside diameter of pipe, inches
Dinside diameter of circular pipe, feet or inches
D-loadthe supporting strength of a pipe loaded under three-edge-bearing test conditions expressed in pounds per linear foot per foot of inside diameter or horizontal span
Do.01the maximum three-edge-bearing test load supported by a concrete pipe before a crack occurs having a width of 0.01 inch measured at close intervals throughout a length of at least 1 foot, expressed as D-Load.
DultThe maximum three-edge-bearing test load supported by a pipe, expressed as D-load.
ddepth of bedding material below pipe, inches
dcdeflection of the vertical height of the pipe
Emodulus of elasticity of concrete, pounds per square inch (4,000,000 psi)
ebase of natural logarithms (2.718)
F.Sfactor of safety
Hheight of backfill or fill material above top of pipe, feet
HAFhorizontal arching factor, dimensionless
Heheight of the plane of equal settlement above top of pipe, feet
hthickness of rigid pavement
Ifimpact factor for live loads
Kratio of active lateral unit pressure to vertical unit pressure
kmodulus of subgrade reaction, pounds per cubic inch
Llength of ALL parallel to longitudinal axis of pipe, feet
Leeffective live load supporting length of pipe, feet
MFImoment at the invert under field loading, inch-pounds/ft
MFIELD maximum moment in pipe wall under field loads, inch-pounds/ft
MTESTmaximum moment in pipe wall under three-edge bearing test load, inch-pounds/ft
μ coefficient of internal friction of fill material
μ^{\prime} coefficient of sliding friction between the backfill material and the trench walls
Na parameter which is a function of the distribution of the vertical load and vertical reaction
NFIaxial thrust at the invert under field loads, pounds per foot
NFSaxial thrust at the springline under a three-edge bearing test load, pounds per foot
N'a parameter which is a function of the distribution of the vertical load and the vertical reaction for the concrete cradle method of bedding

PLprism load, weight of the column of earth cover over the pipe outside diameter, pounds per linear foot
pwheel load, pounds
pprojection ratio for positive projecting embankment installation; equals vertical distance between the top of the pipe and the natural ground surface divided by the outside vertical height of the pipe
p'projection ratio for negative projecting installations; equals vertical distance between the top of the pipe and the top of the trench divided by the trench width
polive load pressure at the surface, pounds per square inch or pounds per square foot
P(H,X)pressure intensity at any vertical distance, H, and horizontal distance, X, pounds per square inch or pounds per square foot
σ3.1416
qthe ratio of total lateral pressure to the total vertical load
Rinside vertical rise of elliptical, arch pipe, or boxes feet or inches
Rsradius of stiffness of the concrete pavement, inches or feet
rradius of the circle of pressure at the surface, inches
rsdsettlement ratio
Sinside horizontal span of elliptical, arch pipe, or boxes feet or inches
$\it SL$ outside horizontal span of pipe ($\it B_{\rm C}$) or width of $\it A_{\rm LL}$ transverse to longitudinal axis of pipe, whichever is less, feet
sd compression of the fill material in the trench within the height p'B $_{\rm d}$ for negative projecting embankment installations
stsettlement of the pipe into its bedding foundation
sgsettlement of the natural ground or compacted fill surface adjacent to the pipe
T.E.Bthree-edge bearing strength, pounds per linear foot
tpipe wall thickness, inches
uPoisson's ratio of concrete (0.15)
VAFvertical arching factor, dimensionless
Wcfill load for positive projecting embankment installations, pounds per linear foot
Wdbackfill load for trench installations, pounds per linear foot
WEearth load, pounds per linear foot
WLlive load on pipe, pounds per linear foot
Wnfill load for negative projecting embankment installations, pounds per linear foot
Wpweight of pavement, pounds per linear foot
$W\tau$ total live load on pipe, pounds
Wtearth load for jacked or tunneled installations, pounds per linear foot
wunit weight of backfill or fill material, pounds per cubic foot
wLaverage pressure intensity of live load on subsoil plane at outside top of pipe, pounds per square foot
xa parameter which is a function of the area of the vertical projection of the pipe over which active lateral pressure is effective
x'a parameter which is a function of the effective lateral support provided by the concrete cradle method of bedding

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