MINIMUM DRAINAGE STANDARDS

FOR THE

CITY OF VAN BUREN, ARKANSAS

MAY 1980

CITY OF VAN BUREN

MINIMUM STORM DRAINAGE STANDARDS

1. SCOPE

1\. a. Shall apply to all storm drainage facility, whether an enclosed structure, pipe, open channel, ditch or stream.

1\. b. These Minimum Storm Drainage Standards are those referred to in Ordinance No. 8-1963 as amended, (Sub-Division Regulations) Section IV, IMPROVEMENTS, c. Storm Drainage.

2. GENERAL DESIGN REQUIREMENTS AND DESIGN SUBMITTALS

2\. 1. A. All designs, plans and specifications submitted to the Planning Commission for approval shall be prepared by a registered professional engineer, licensed in the State of Arkansas.

B. Plan Requirements

Plans shall be submitted on 24" x 36" sheets.

The plans shall include:

-Locations of the project with respect to well-known roads, streets, subdivisions or survey lines on a key map of the entire project.

-Plans and profiles for each storm sewer line shall be provided which show location, size, flowline elevations, gradients, materials and any soil boring information. Plan profiles submitted shall have a verticle scale of not less than one inch equal to five feet.

- All easements, storm sewers (enclosed or open channel), utilities and facilities, both existing and proposed shall be shown.
- Elevations submitted shall use USGS Datum. Location and elevation of all benchmarks shall be indicated.
- The critical channel section and typical cross sections shall be shown.
- Details of drainage structures shall be provided.

C. DRAINAGE AREA MAP

An area map showing topography shall be furnished with the drainage basin and subareas outlined. Area map shall be of 1" : 100' scale and shall have a two (2) foot contour interval when required.

D. DESIGN CALCULATIONS

Storm drainage calculations shall be provided which support the drainage system shown on plan submittal. Calculations summarized in a form similar to Figure 1 and 2.

2.2. DESIGN FLOWS

A storm sewer system shall be designed to contain all run-off from a 10 year storm except in the following cases:

A. Arterial street drainage shall be designed such that curb flows are not to inundate the center two lanes of roadway with a 50-year storm. This shall include back water from storm sewers.

B. All lots adjacent to storm sewers or ditches or in low areas shall have a minimum finish floor slab elevation given on the final plat that will be one foot above the water level of the 100-year flood.

2.3. Flow Toward Streets

Any concentration of surface flow in excess of 6 c.f.s. shall be intercepted before crossing the curb (or curbline) and carried by enclosed storm sewers. No storm water concentration will be allowed to empty into the street except as stated above.

2.4. Methods of Conveying Water

A. All flows within the R/W of non-estate streets not carried in the gutter and side lot flows to drainage channels at the rear of lots shall be in storm sewers.

B. Storm flows in areas not listed in 2.4.A. may be carried in open channels as defined in Section 5.

C. Natural drainage channels (not relocated or channelized) may be used in new developments providing the channel will carry the storm runoff used in the design storm without erosion problems and sufficient land for a one foot (1') freeboard is included in a drainage easement.

2.5. System Discharge

All storm sewer systems shall be adequate to contain the design storm runoff to the discharge point at the down-stream property line. The point of storm water discharge from the developed property shall be the same as the pre-development discharge point. All reasonable effort should be taken to insure that storm water discharge volume and velocity would be limited to the pre-development discharge conditions.

2.6. Easements

All storm sewers shall be located in street right-of-way or in an easement dedicated to public use:

A. Enclosed drainage structures require a minimum easement width of 15' or the width of the drainage structure plus 10', whichever is greater.

B. Open channel easements shall be required to contain the entire channel design width including freeboard with the minimum width being 15'.

3. HYDROLOGY

3.1. Hydrologic Design Method

The Rational Method shall be used to determine storm water runoff characteristics for storm sewer design when tributary drainage area is 200 acres or less. When the tributary drainage area is over 200 acres, other methods such as the SCS Method, hydrographs, or computer models shall be used as approved. The Rational Method uses the basic formula $Q = CiA$ for estimating runoff from rainfall, where:

Q = Rate of runoff in cubic feet per second

i = Average rainfall intensity in inches per hour for the design storm having a duration equal to the time of concentration for the critical upstream drainage area.

C = Run off coefficient, which is the fraction of the rainfall which becomes runoff.

A = Tributary drainage area in acres

3.2. Rainfall and Intensity

The duration - intensity relationships are shown by the curves in Figure 3; and shall be used for all storm sewer design.

A. The time of concentration equals the overland flow time plus the time for the water to flow down the pipe or channel to the point in question. The overland flow time, T_t, may be figured from the following equation*:

$$T_t = \frac{L}{K\,Y^{0.5}}$$

Where: T_t = overland flow time, seconds;

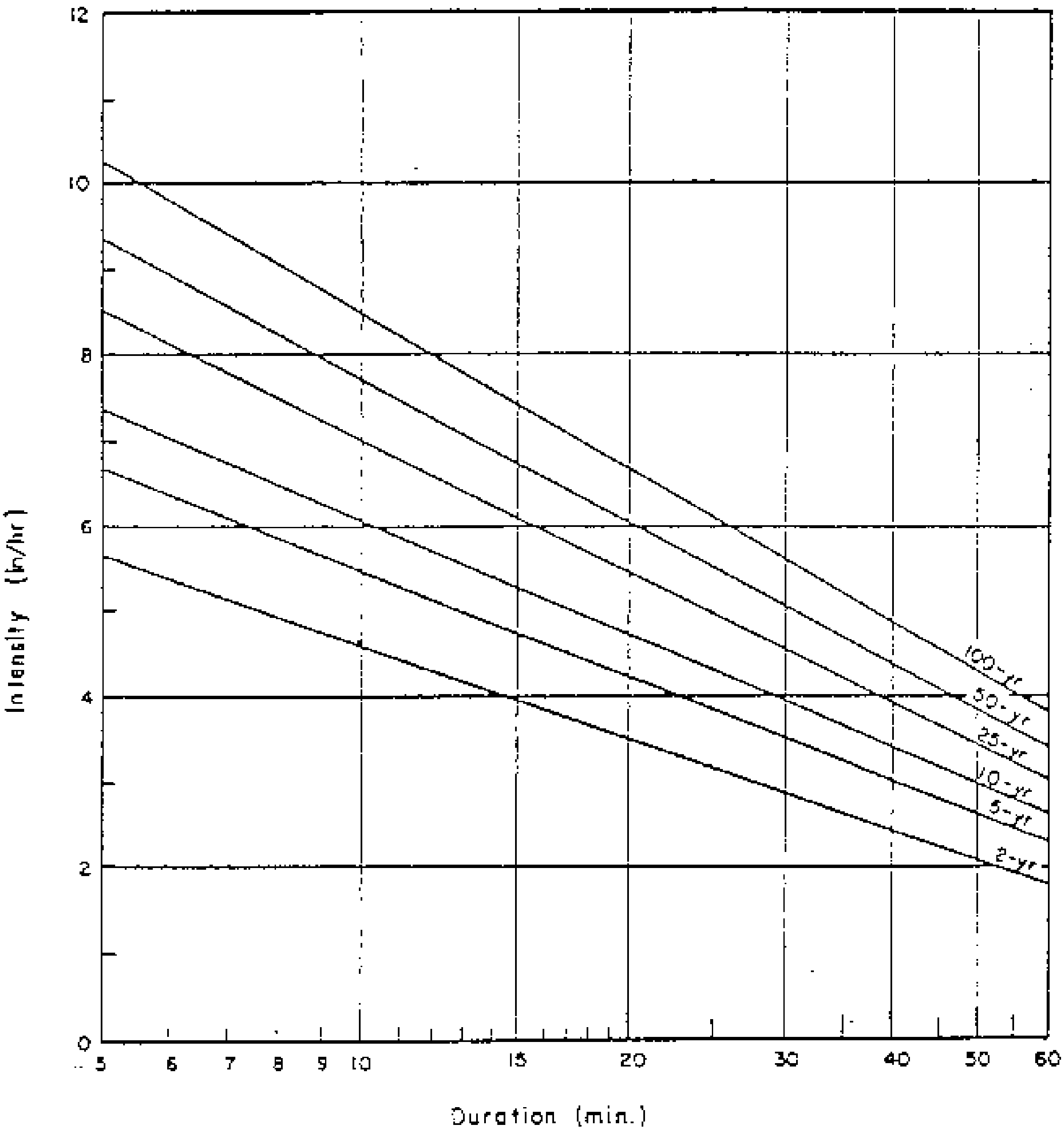
L = overland flow distance, feet;

K = conveyance factor which depends on ground cover;

Y = ground slope, percent.

K	Ground Cover
0.25	Forest With Heavy Ground Litter and Meadow
0.47	Fallow or Minimum Tillage Cultivation
0.71	Short Grass Pasture and Lawns
1.00	Nearly Bare Ground
1.52	Grassed Waterway
2.00	Paved Area (Sheet Flow) and Shallow Gutter Flow

* Adapted from Fig. 3-1 pp 3-2 of SCS TR-55, U. S. Dept. of Agriculture



RAINFALL DURATION - INTENSITY CURVES *

Figure 3

*Based on information presented in NOAA Tech. Memo. NWS HYDRO-35, "Five to 60 Minute Precipitation Frequency for the Eastern and Central United States", National Weather Service

B. Where a section of the storm sewer system is being designed in the middle or lower portion of a drainage basin, the designer shall design the system based on on the future development of the upland tributary area.

3.3. Runoff Coefficient

In selecting a runoff coefficient, the ultimate development of the drainage area must be considered. The following values should be used as a guide in selecting the runoff coefficient:

Description of Area	Runoff Coefficients
Residential	
Single-family	0.30 to 0.50
Multi-Units, detached	0.40 to 0.60
Multi-Units, attached	0.60 to 0.75
Residential (suburban)	
1 acre or more	0.25 to 0.40
Apartment	0.50 to 0.70
Industrial	
Light	0.50 to 0.80
Heavy	0.60 to 0.90
Parks, Cemeteries	0.10 to 0.25
Playgrounds	0.20 to 0.35
Railroad Yard	0.20 to 0.35
Unimproved	0.10 to 0.30

In some cases it may be necessary to develop a composite runoff coefficient, in which case the following value should be used.

Character of Surface	Runoff Coefficients
Pavement	
Asphalt and Concrete	0.70 to 0.95
Brick	0.70 to 0.85
Roofs	0.75 to 0.95
Lawns, sandy soil	
Flat, 2 percent	0.05 to 0.10
Average, 2 to 7 percent	0.10 to 0.15
Steep, above 7 percent	0.15 to 0.20
Lawns, heavy soil	
Flat, 2 percent	0.13 to 0.17
Average, 2 to 7 percent	0.18 to 0.22
Steep, above 7 percent	0.25 to 0.35

4. PIPES AND CULVERTS - GENERAL REQUIREMENTS AND DESIGN CRITERIA

4.1. Culvert Hydraulics

Culvert flow may be limited by conditions existing at either the inlet or the outlet of the pipe, when inlet control governs the cross sectional area of the barrel, the shape of the inlet and the amount of ponding (head-water) at the inlet are primary design considerations. Outlet control is dependent upon the depth of water in the outlet channel (tailwater), the slope of the barrel, type of culvert material and length of the barrel. The basis for all hydraulic design calculations will be Manning's Formula and the Continuity Equation:

$$V = \frac{1.486}{n} R^{0.67} S^{0.50}$$

$$Q = AV$$

where

V = mean velocity of flow in feet per second (fps)

n = Manning's coefficient of roughness

R = hydraulic radius (ft.)

S = slope (ft./ft.)

Q = discharge (cfs)

A = area of flow (sq.ft.)

A. Coefficients of Roughness

The coefficients of roughness to be used for culverts of the various kinds of pipe are as follows:

Portland Cement Concrete	n = 0.012-0.013
Corrugated Metal	n = 0.024
Corrugated Metal with Paved invert (25% paved)	n = 0.021
Smooth Flow Corrugated Metal	n = 0.013
Asbestos Cement	n = 0.013

B. Inlet Control

The size of a culvert operating with inlet control is determined by the size and shape of the inlet and the depth of ponding allowable (headwater) as shown in Figure 4.

Factors not affecting inlet control design are the barrel roughness, slope and length and the depth of tailwater.

The headwater (HW) depth for a culvert of a given diameter or height (D) for a given discharge can be determined by obtaining the HW/D value from Figure 6 to Figure 9. The elevation of adjacent facilities (i.e., buildings, etc.) must be examined to avoid flooding.

C. Outlet Control

A culvert will operate under outlet control when the depth of tailwater, the length, slope or roughness of the barrel act as the control on the quantity of water able to pass through a given culvert as shown in Figure 5. The energy head required for a culvert to operate under outlet control is comprised of velocity head (H_v), entrance loss (H_e) and friction loss (H_f). This energy head (H) is obtained from Figure 10 to Figure 13 and entrance loss coefficients from Table 1.

The headwater depth (HW) at the culvert entrance is calculated by the following formula:

$$HW = H + h_o - LS_o$$

Where:

H = energy head.

L = length of culvert (ft.)

S_o = slope of barrel (ft. per ft.)

$h_o = \frac{d_c + D}{2}$ or TW, whichever is greater

d_c = critical depth of flow in barrel. Critical depth may be determined by using Figure 14 through 16.

D = height of pipe or box

TW = tailwater depth

The maximum desirable headwater depth for culverts operating under outlet control shall be the same as described in Section 4.1.B.

4.2. Computation Format

Figure 2 is to be used to present culvert design calculations. Design methods utilizing computers may be used with prior approval.

The procedures to follow in determining culvert size are:

1. List all design data.
2. Select a trial culvert size.
3. Determine the headwater depth for the trial size.
    a. Headwater for inlet control
    b. Headwater for outlet control
    c. Compare headwaters and use higher value
4. Compare this headwater with the allowable limit

a. If headwater is within allowable limit, proceed to Step 5.

b. If headwater is above allowable limit, repeat Steps 2 through 4 until allowable limits are reached.

5. Compute outlet velocity to determine need for channel protection.

4.3. Culvert Types and Sizes

The permissible types of culverts under all roadways and embankments are concrete box, round pipe and pipe arch. All corrugated metal pipe placed with street right-of-ways shall be asphalt coated. The minimum size of pipe for all culverts shall be 15 inches (15") or the equivalent sized pipe arch. Box culverts may be constructed in sizes equal to or larger than 4' x 3' (span vs. height).

4.4. Velocity

All storm drainage pipes and culverts shall be designed to maintain a minimum velocity of 2.0 feet per second and a maximum velocity of 15 feet per second when flowing full.

4.5. Velocity Head

Large quantities or masses of water flowing at a high rate of speed contain a large amount of kinetic energy which is defined as velocity head, $\frac{V^2}{2g}$: Any change in cross section, restrictions in pipes or inlets shall be considered energy losses and shall be taken into consideration in the design of the system.

4.6. Structural Considerations

The minimum allowable fill or cover for structures (RCP, CMP, concrete culverts) under roadways shall be one foot or a minimum clearance of six inches from top of structures to the bottom of pavement base, except for a special box culvert designed to carry traffic on the top slab. Structural protection, such as special bedding, shall be provided where adequate cover cannot be attained. Maximum fill shall be determined on the basis of structural strength of pipe and design loads. Outside of street right-of-ways, a minimum cover of twelve (12) inches is considered desirable for purposed of growth of vegetation and protection against unusual loading.

5. OPEN CHANNELS - GENERAL REQUIREMENTS AND DESIGN CRITERIA

5.1. Open Channels

Shall be designed using the Manning Formula and "n" values shown.

CHANNEL LINING	"n"
Grass	0.03-0.05
Concrete	0.013-0.015
Riprap	0.017-0.03

All open channels shall have a minimum of one foot (1') of freeboard.

5.2. Open Channels (Unpaved)

Unpaved channels may be used where the velocities of a 10-year storm runoff are not greater than 3 ft/second. The sides shall have a slope ratio not steeper than 3:1. All unpaved channels shall be seeded, plugged, or sodded immediately after their construction and adequate measures taken to prevent erosion.

5.3. Open Channel (Paved)

Where velocities are greater than 3 feet per second, the channel section shall be paved with concrete. The paved ditch may have either vertical sides with a maximum height of 24" or sloped sidewalls with a maximum slope of 1 to 1. The minimum flat bottom width shall be three (3) feet.

5.4. Open Channel Erosion Protection

Special protection such as headwalls, riprap, or concrete lining will be required in places such as bends, junctions, and inlets and outlets for storm sewers where erosion is likely.

6. CURB INLETS - GENERAL REQUIREMENTS AND DESIGN CRITERIA

6.1. Curb Inlets

Curb inlets will be required at low points of streets and at all other locations where water is removed from street gutters.

6.2. Areas of Potential High Pedestrian Volume

Inlets may be required near intersections to keep cross-walks free of storm water.

6.3. Arterial Streets

Curb inlets shall be located on arterial streets so that the center two lanes are free from water during runoff from a 50-year storm.

6.4. Minor and Collector Streets

Curb inlets shall be located on streets so that depth of runoff from a 10-year storm shall not exceed the top of standard 6" curbs. Curb inlet capacity shall be determined as shown in Figure 17.

6.5. Swales

6.5.1. No swales shall be permitted across through streets.

6.5.2. All swales on "non-through" streets shall be of concrete construction.

ENTRANCE LOSS COEFFICIENTS	
TYPE OF STRUCTURE AND DESIGN OF ENTRANCE	COEFFICIENT K_e
Pipe, Concrete	
Projecting from fill, socket end	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe	0.2
Square-edge	0.5
Rounded (Radius = ½D)	0.2
Mitered to conform to fill slope	0.7
End-section conforming to fill slope*	0.5
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls	
Square-edge	0.5
Mitered to conform to fill slope	0.7
End-section conforming to fill slope*	0.5
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12	
Barrel dimension	0.2
Wingwalls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12	
Barrel dimension	0.2
Wingwalls at 10° to 25° to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7

* Standard sections are commonly available from manufacturers

Table 1.

DRAINAGE CALCULATIONS FOR ____________________

PIPE CODE	STRUCTURE			DRAINAGE AREA			RUNOFF COEFFICIENT				TIME		DISCHARGE		PIPE AND CHANNEL DESIGN							REMARKS
	CODE	LOCATION	TYPE	ΔA Acres	ΣΔA Acres	ΣA Acres	C	ΔCA	ΣΔCA	WtC	ΔT (Min.)	ΣT (Min.)	I (in/hr)	Q (cfs)	DIA. (in.)	L (feet)	SLOPE (%)	VEL. (fps)	CAP. (cfs)	FLOW LINE EL. Upper	FLOW LINE EL. Lower	

Figure 1.

PROJECT ____________________

DESIGNER ____________________

DATE ____________________

HYDROLOGIC AND CHANNEL INFORMATION	SKETCH

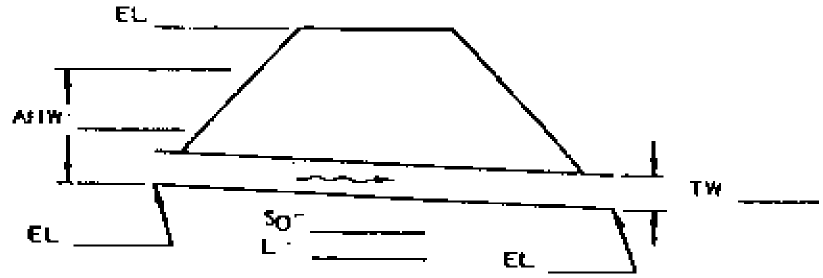
Q_1: ____________ TW_1: ____________

Q_2: ____________ TW_2: ____________

Q_1 = DESIGN DISCHARGE
Q_2 = CHECK DISCHARGE

SKETCH

STATION ____________



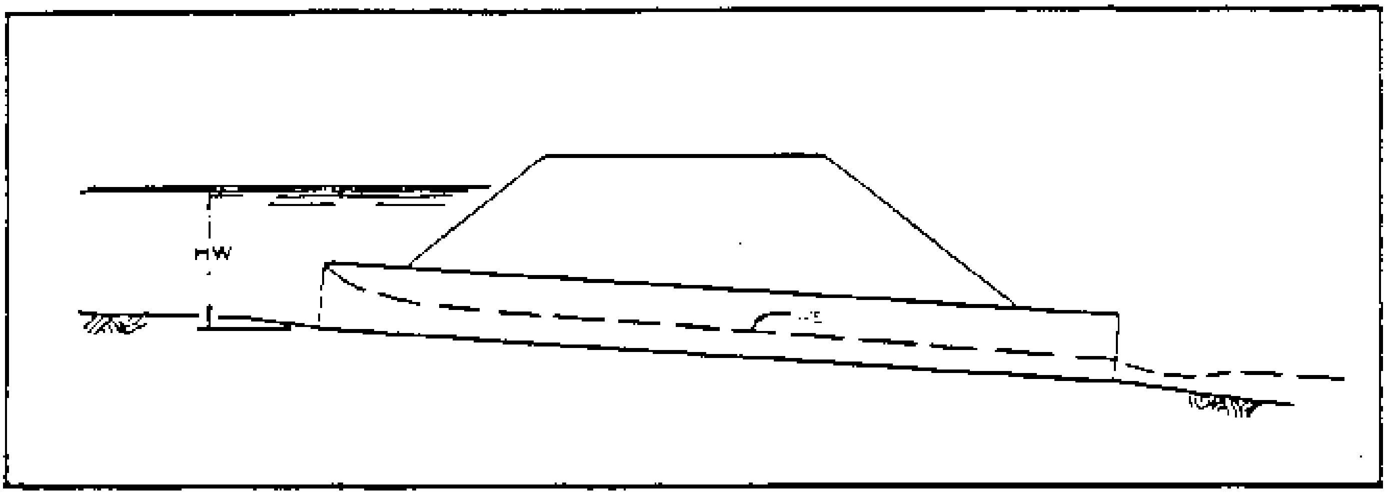
MEAN STREAM VELOCITY ____________

MAX. STREAM VELOCITY ____________

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION										CONTROLLING HW	OUTLET VELOCITY	COMMENTS
			INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$										
			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW			

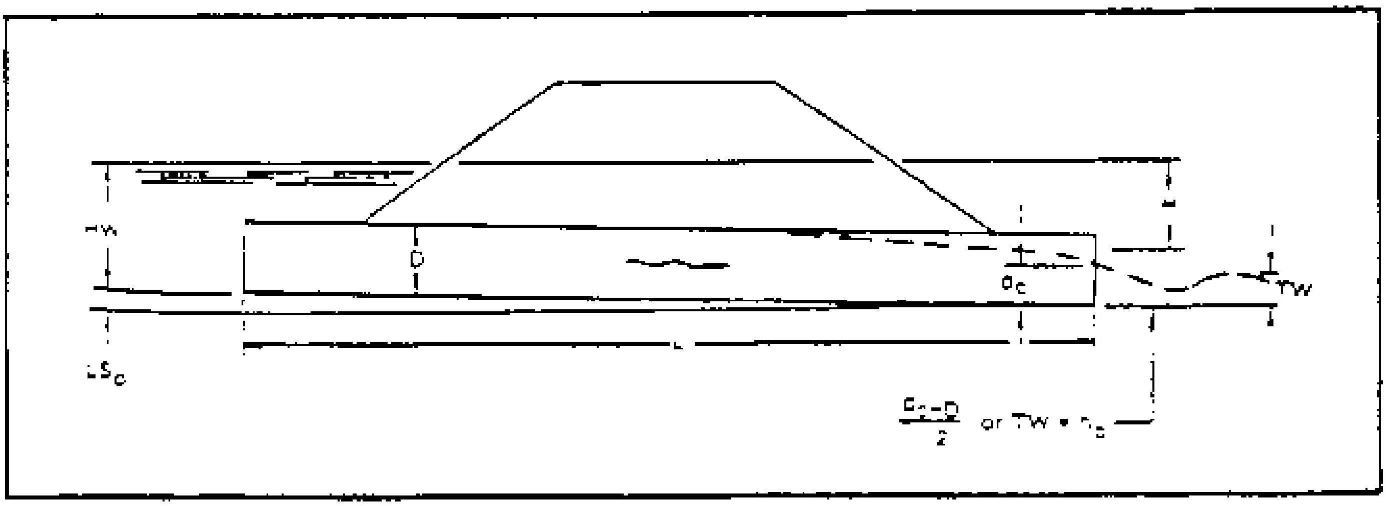
SUMMARY & RECOMMENDATIONS:

Figure 2.



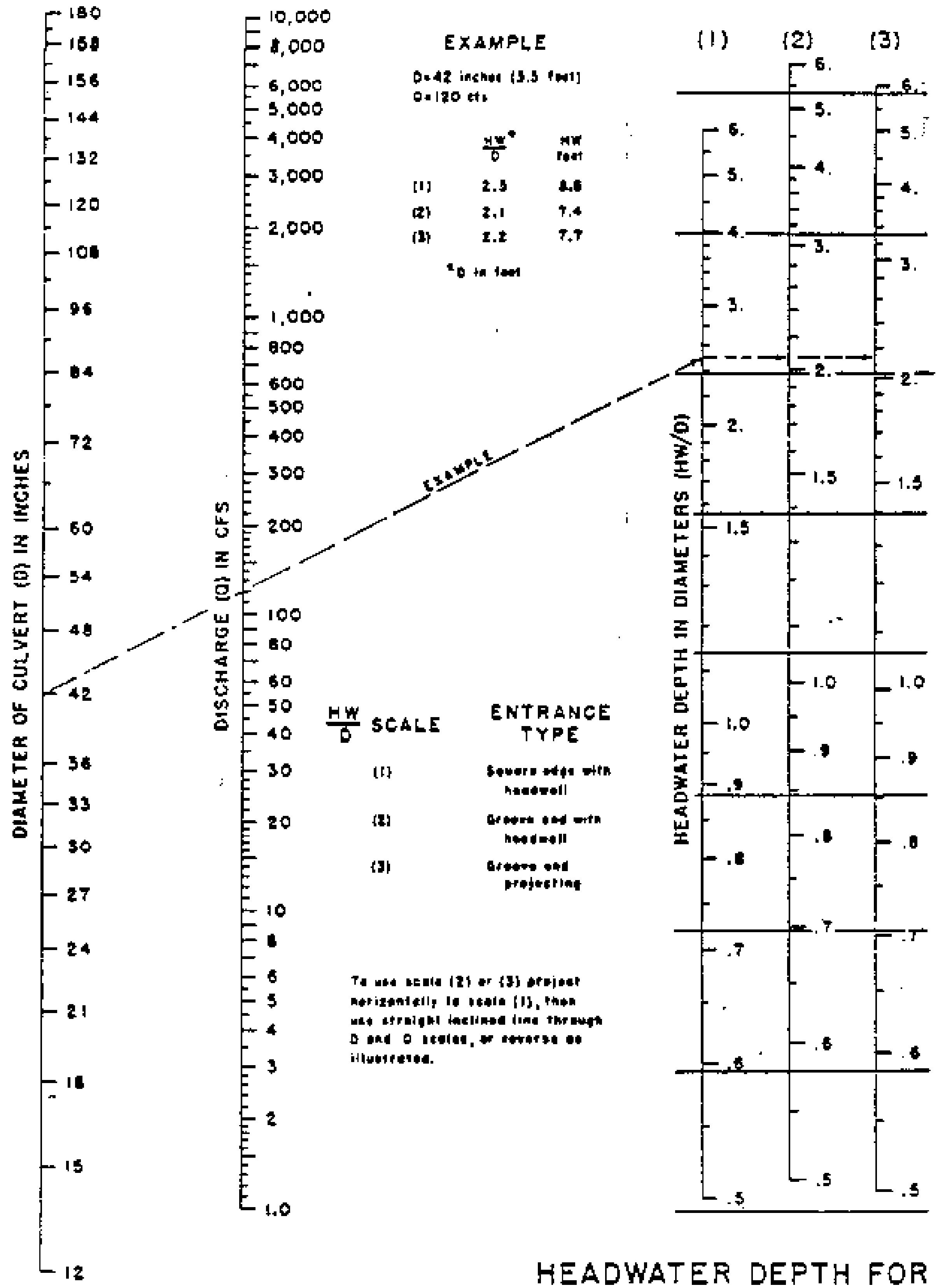
INLET CONTROL

Figure 4.



OUTLET CONTROL

Figure 5.



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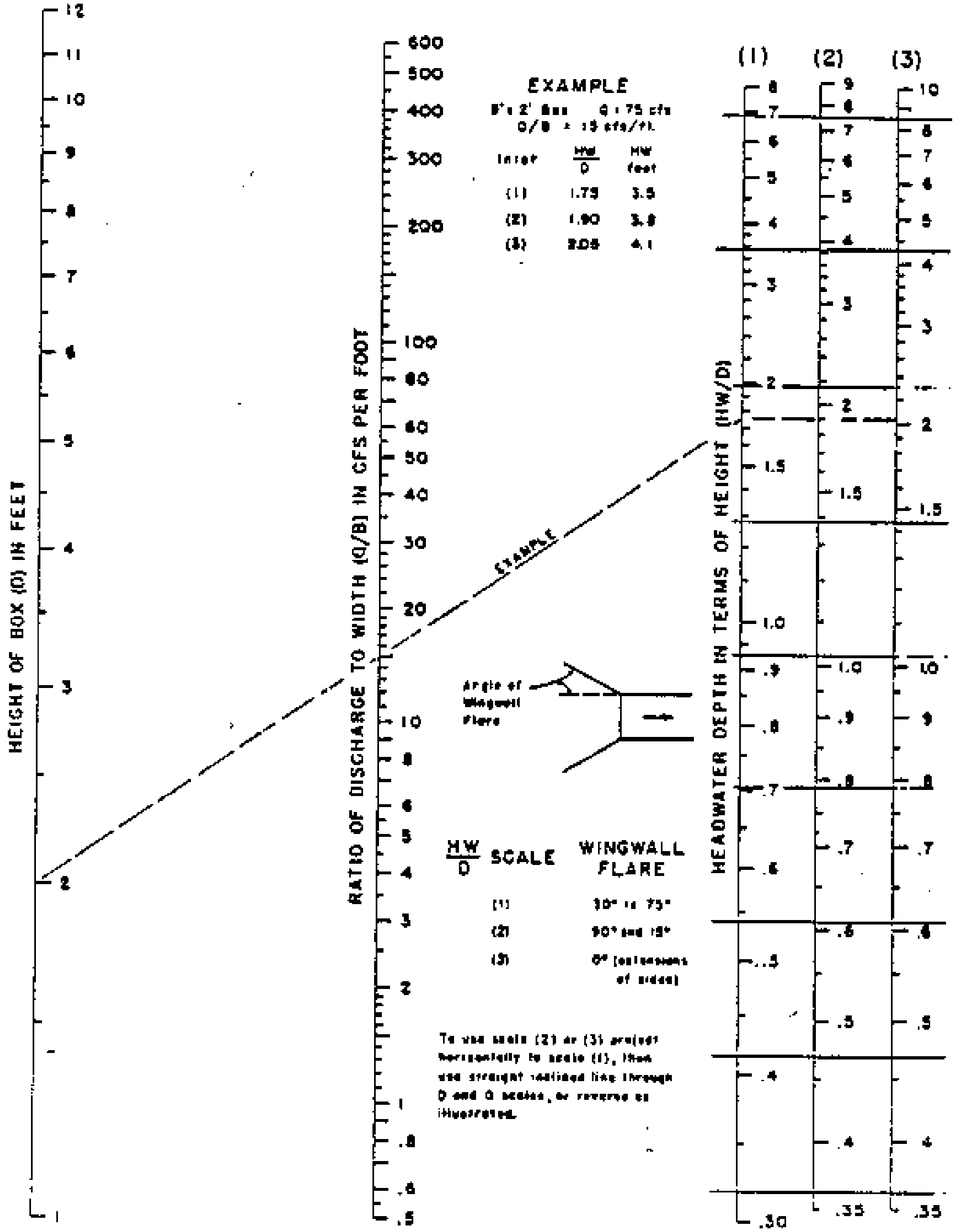
HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

Figure 7



HEADWATER DEPTH
FOR BOX CULVERTS
WITH INLET CONTROL

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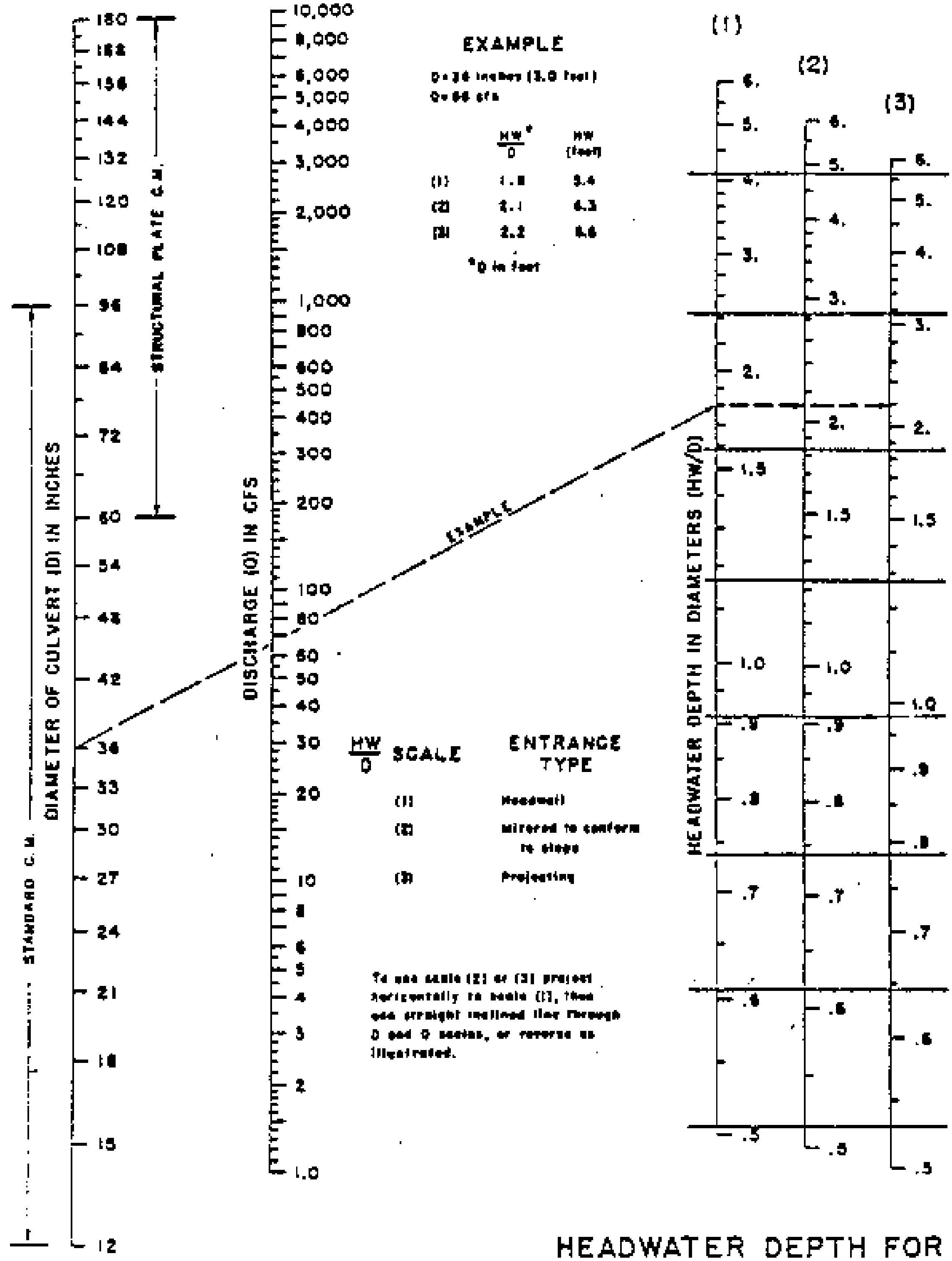
Figure 6



HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

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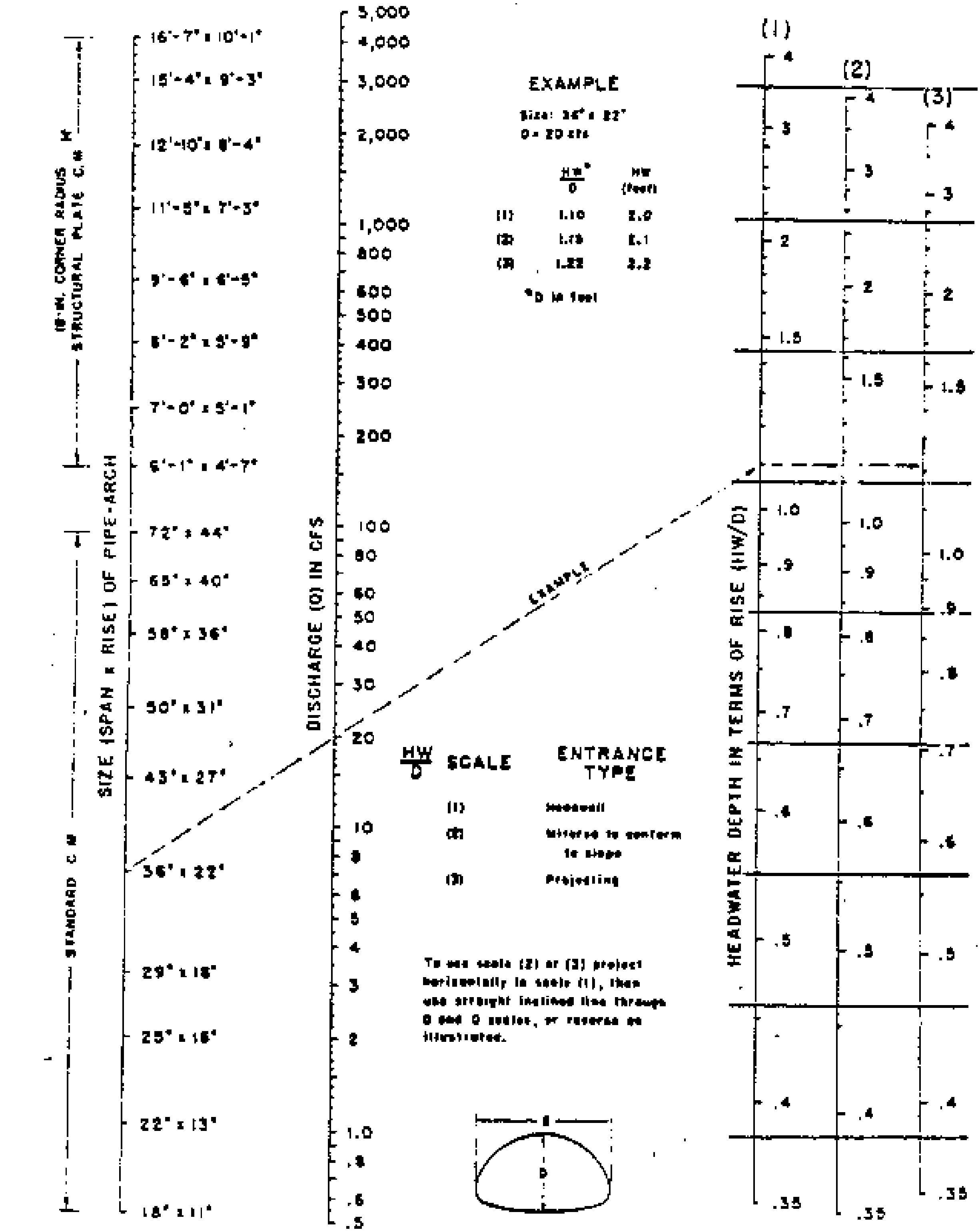
Figure 8



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

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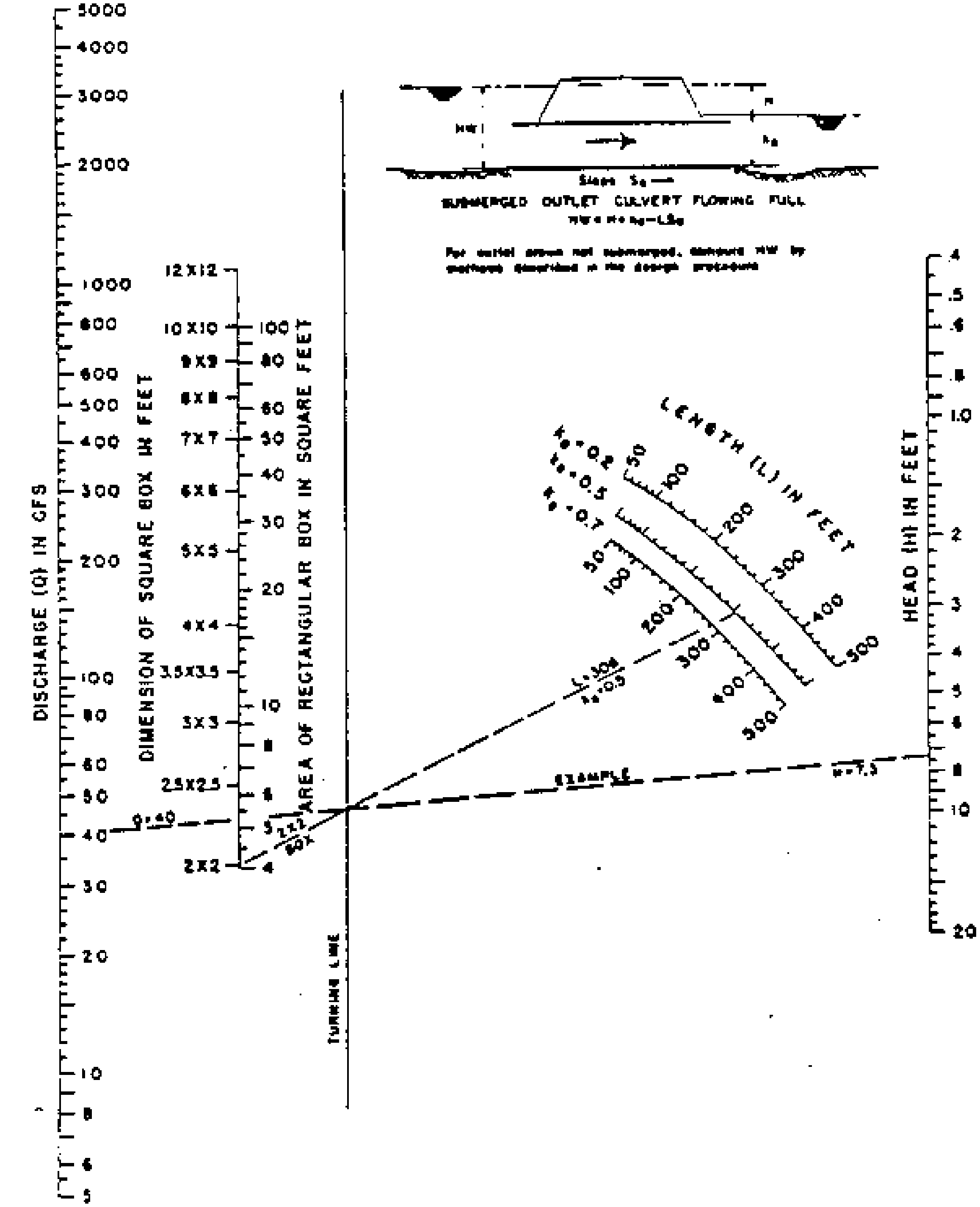
HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

Figure 9



HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
$n = 0.012$

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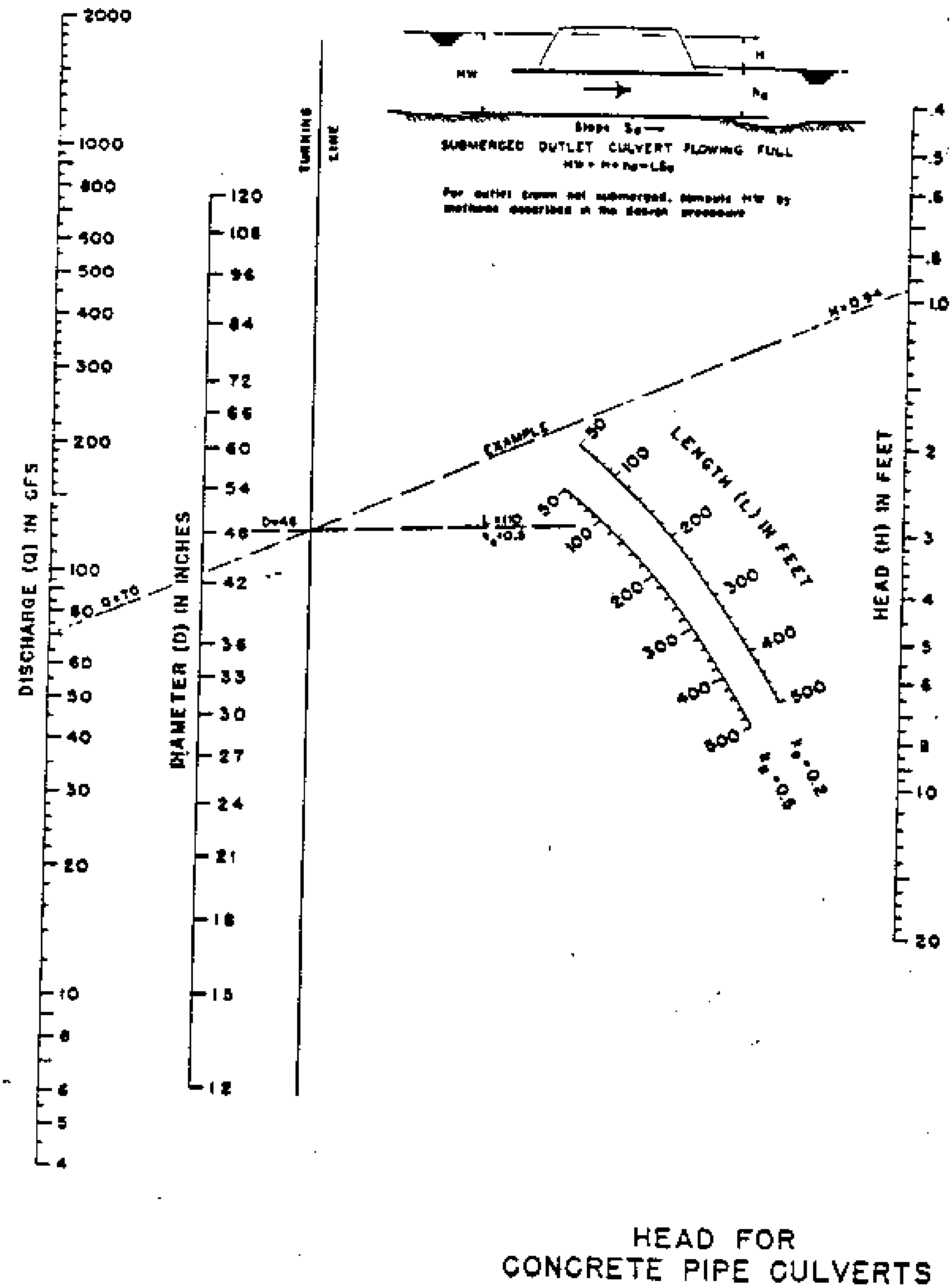
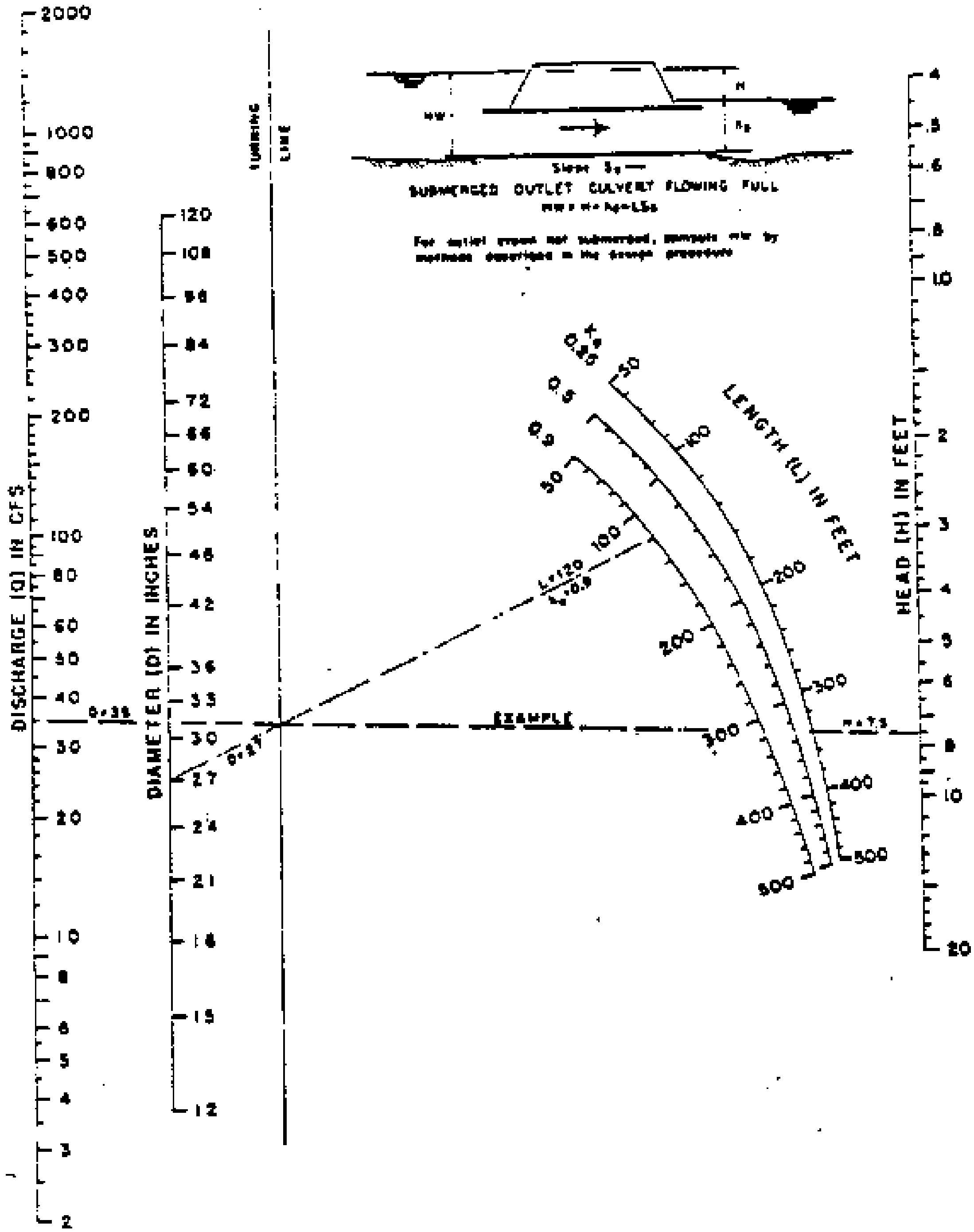
Figure 10



HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

Figure 11



HEAD FOR
STANDARD
C. M. PIPE CULVERTS
FLOWING FULL
n = 0.024

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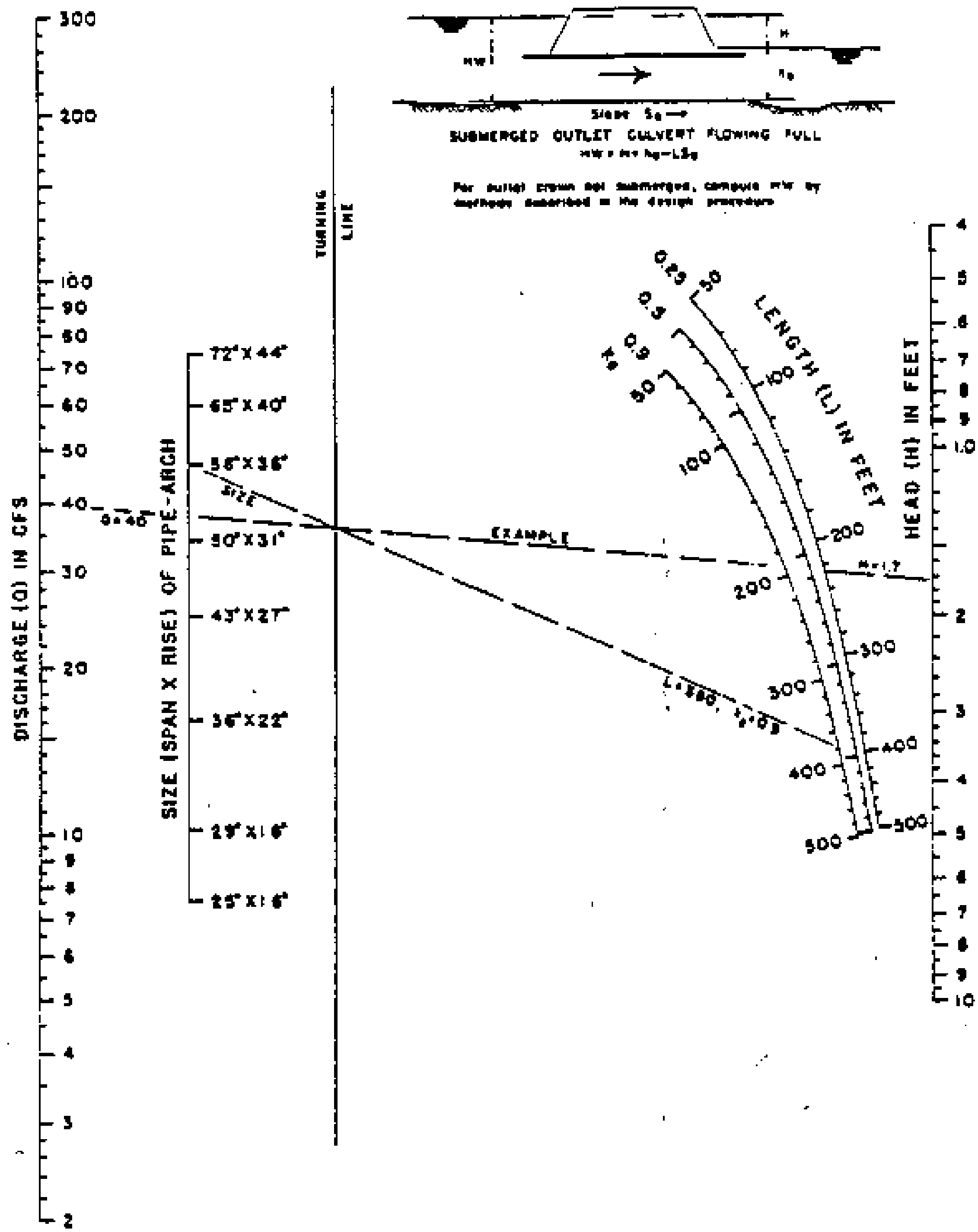
Figure 12



HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n=0.024

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Figure 13

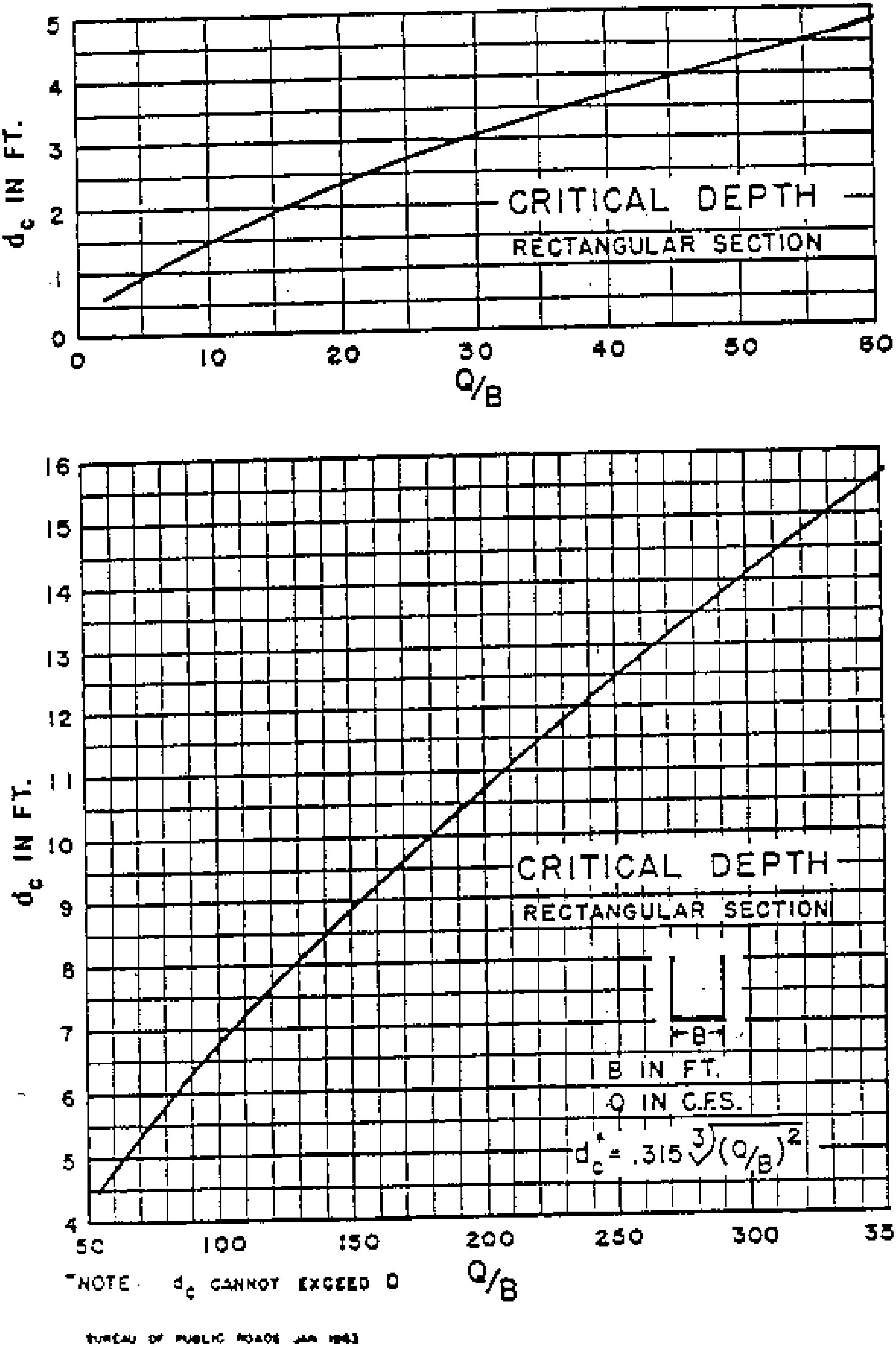
CRITICAL DEPTH
RECTANGULAR SECTION
dc IN FT.
Q/B
0
10
20
30
40
50
60
1
2
3
4
5
CRITICAL DEPTH
RECTANGULAR SECTION
B IN FT.
Q IN C.F.S.
dc* = .315 ∛(Q/B)²
dc IN FT.
Q/B
50
100
150
200
250
300
350
4
5
6
7
8
9
10
11
12
13
14
15
16
*NOTE dc CANNOT EXCEED D
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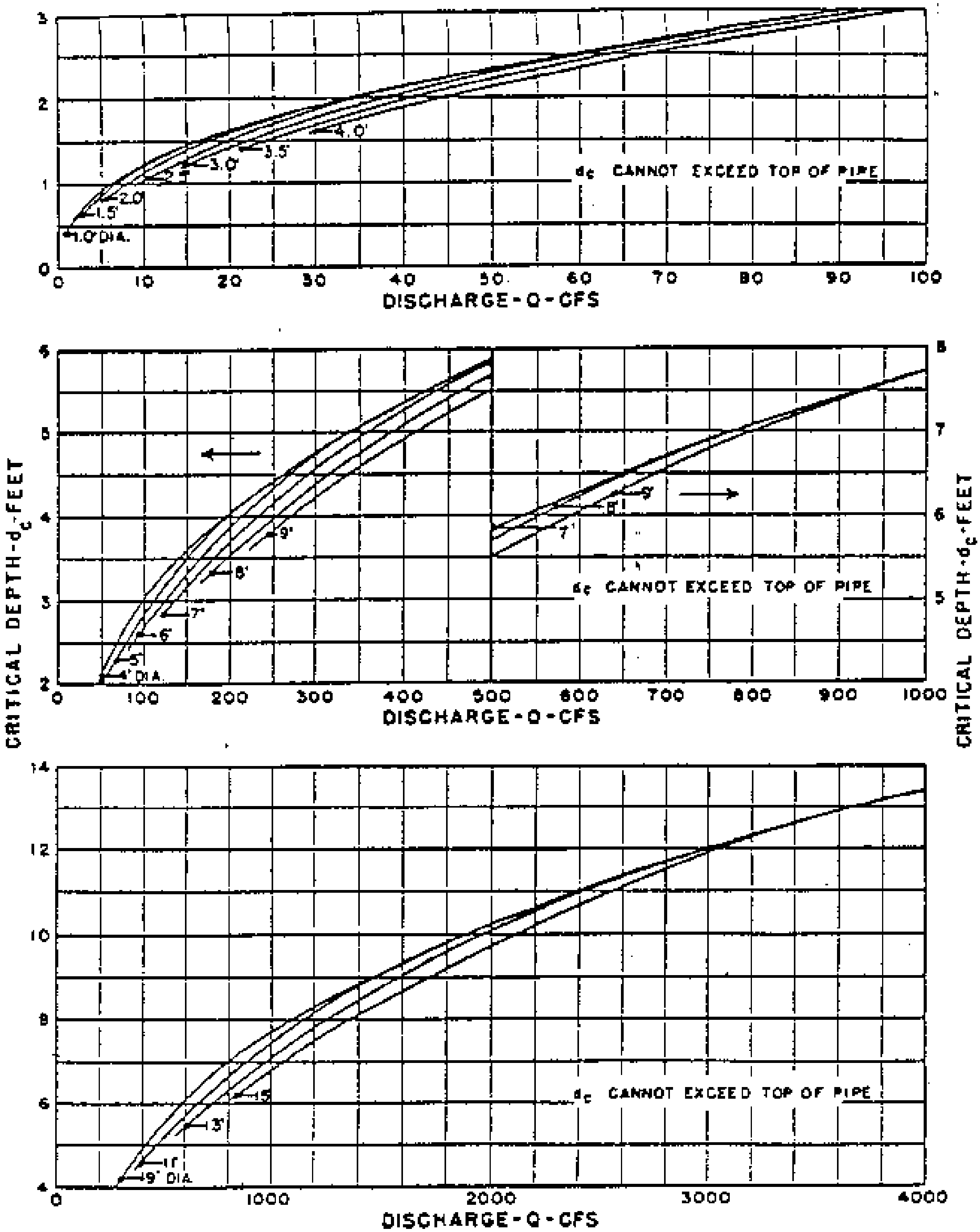
Figure 14



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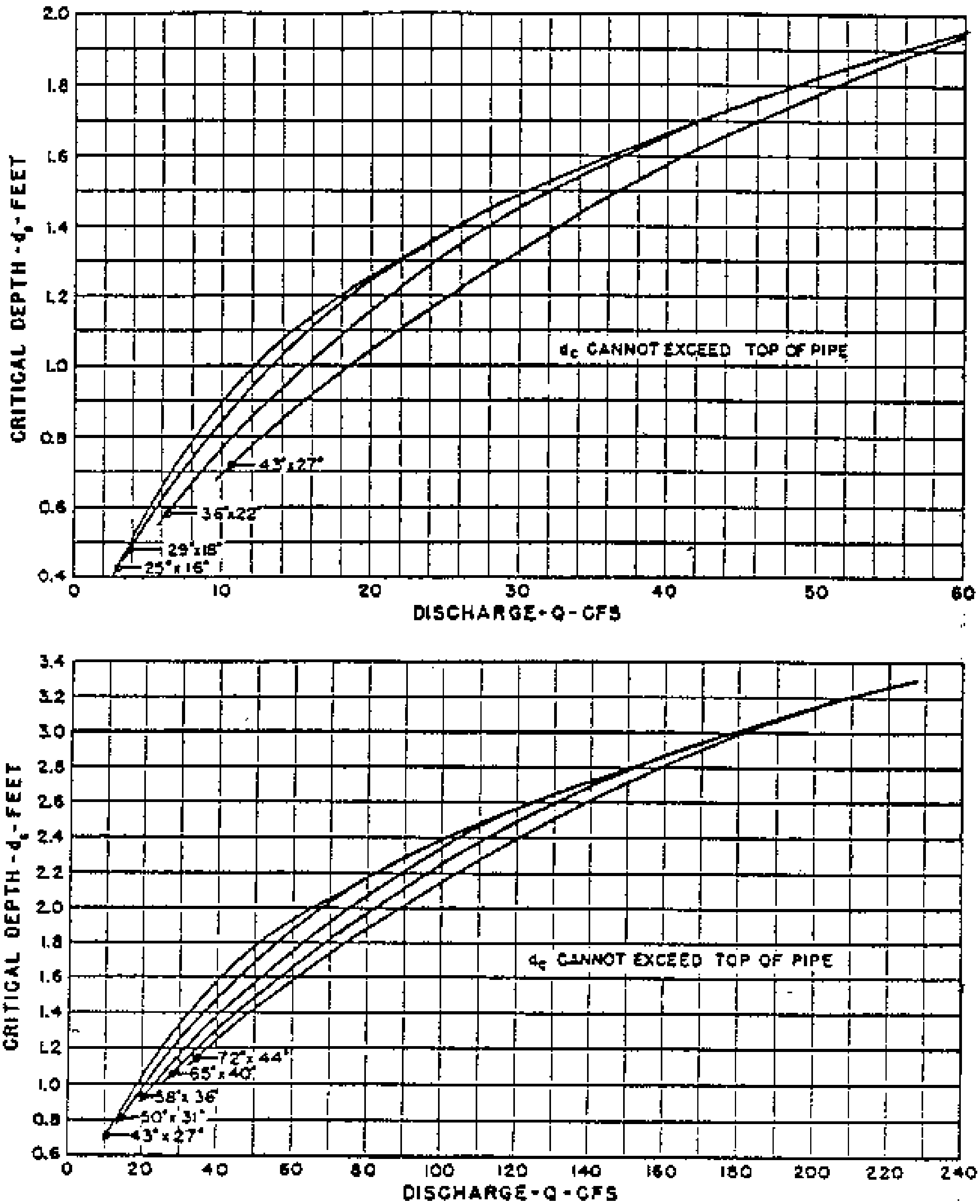
JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

Figure 15



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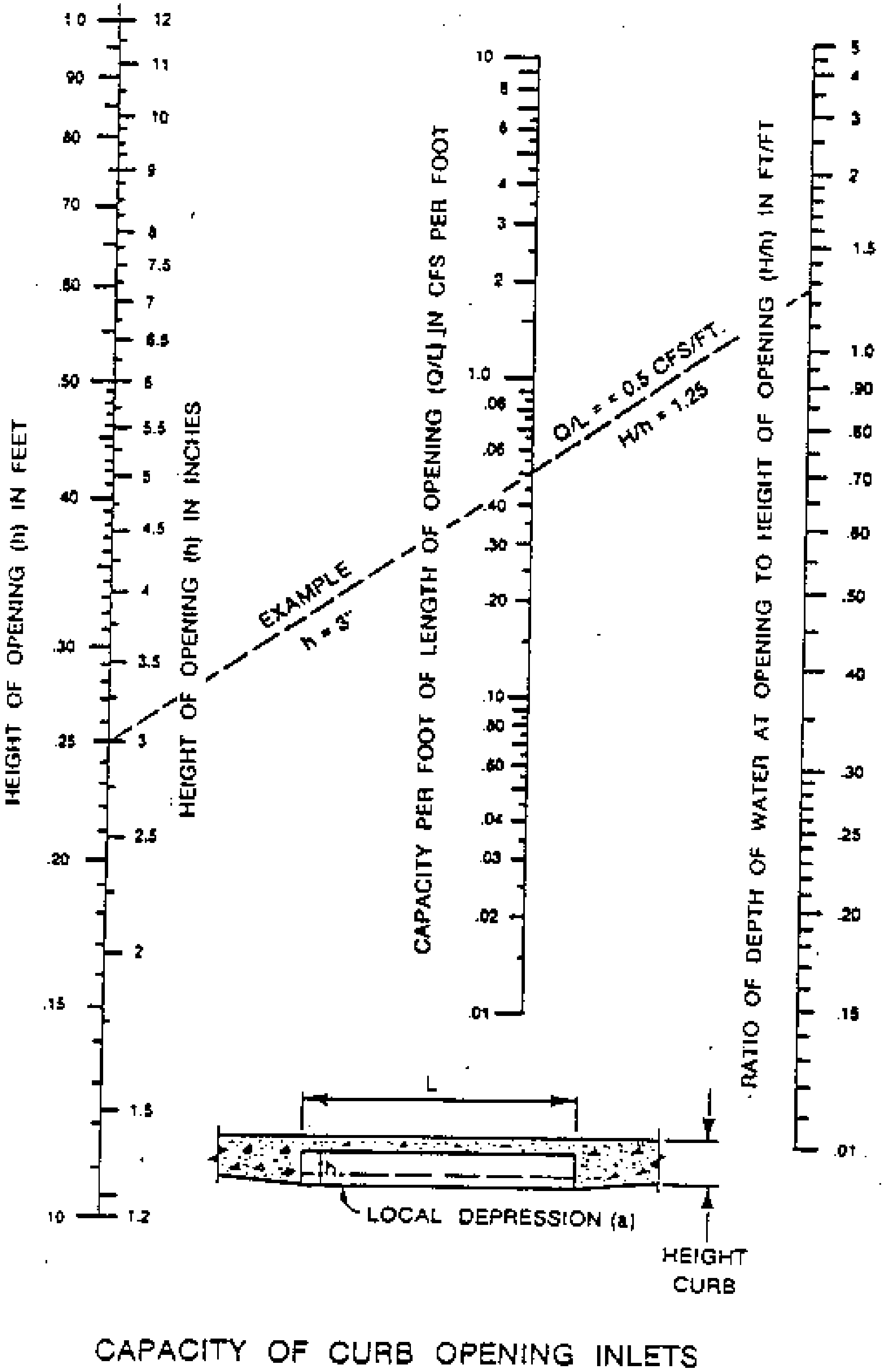
JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

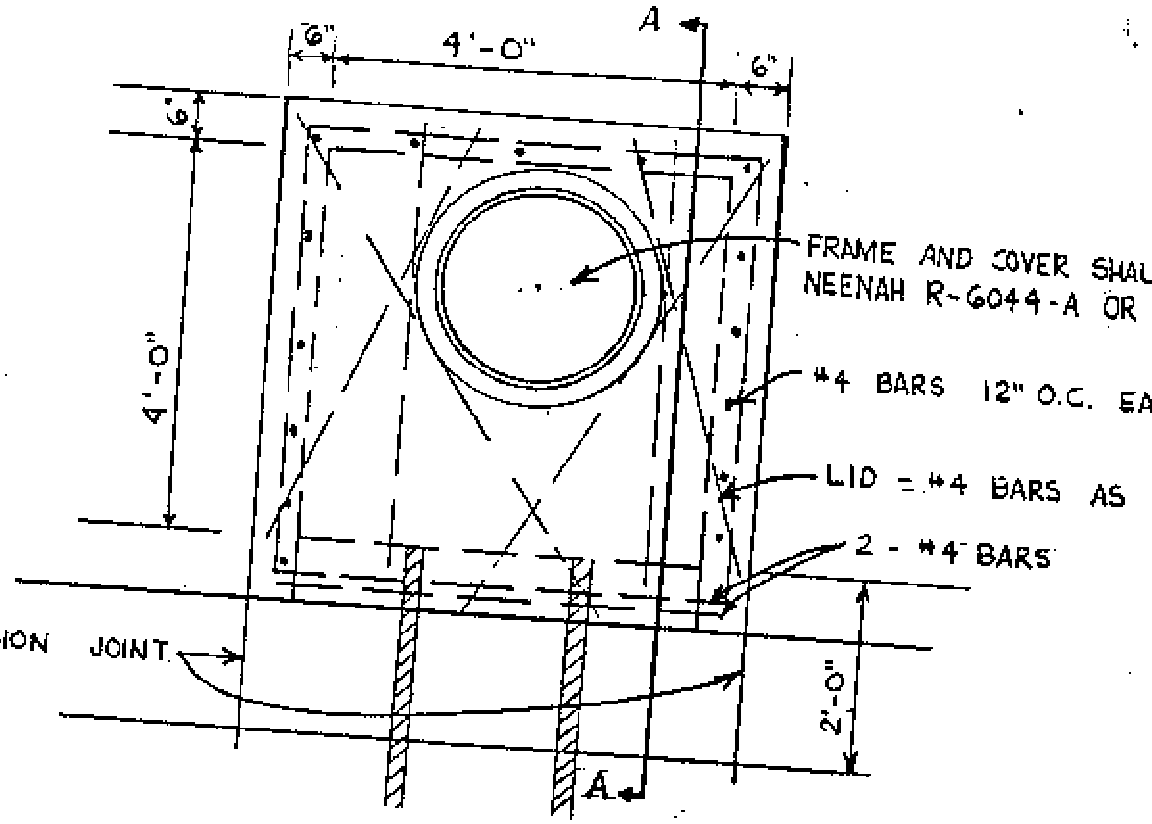
Figure 16



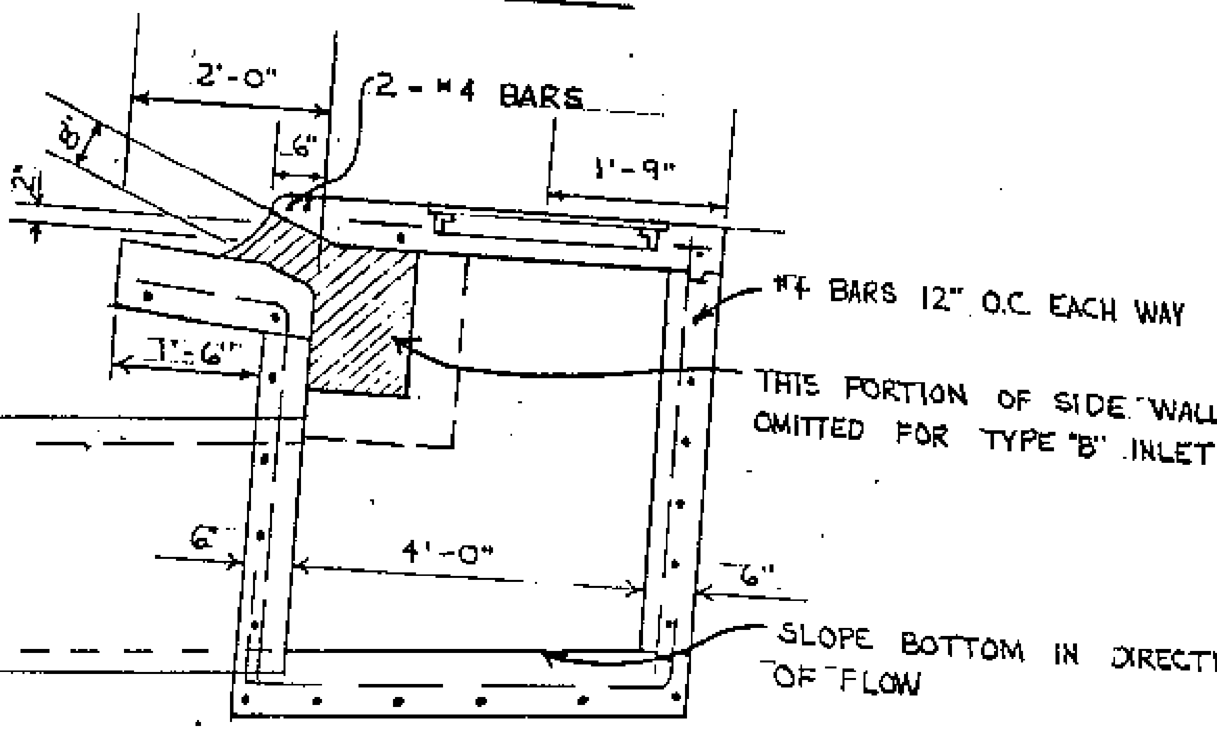
CAPACITY OF CURB OPENING INLETS

AT LOW POINT

Figure 17

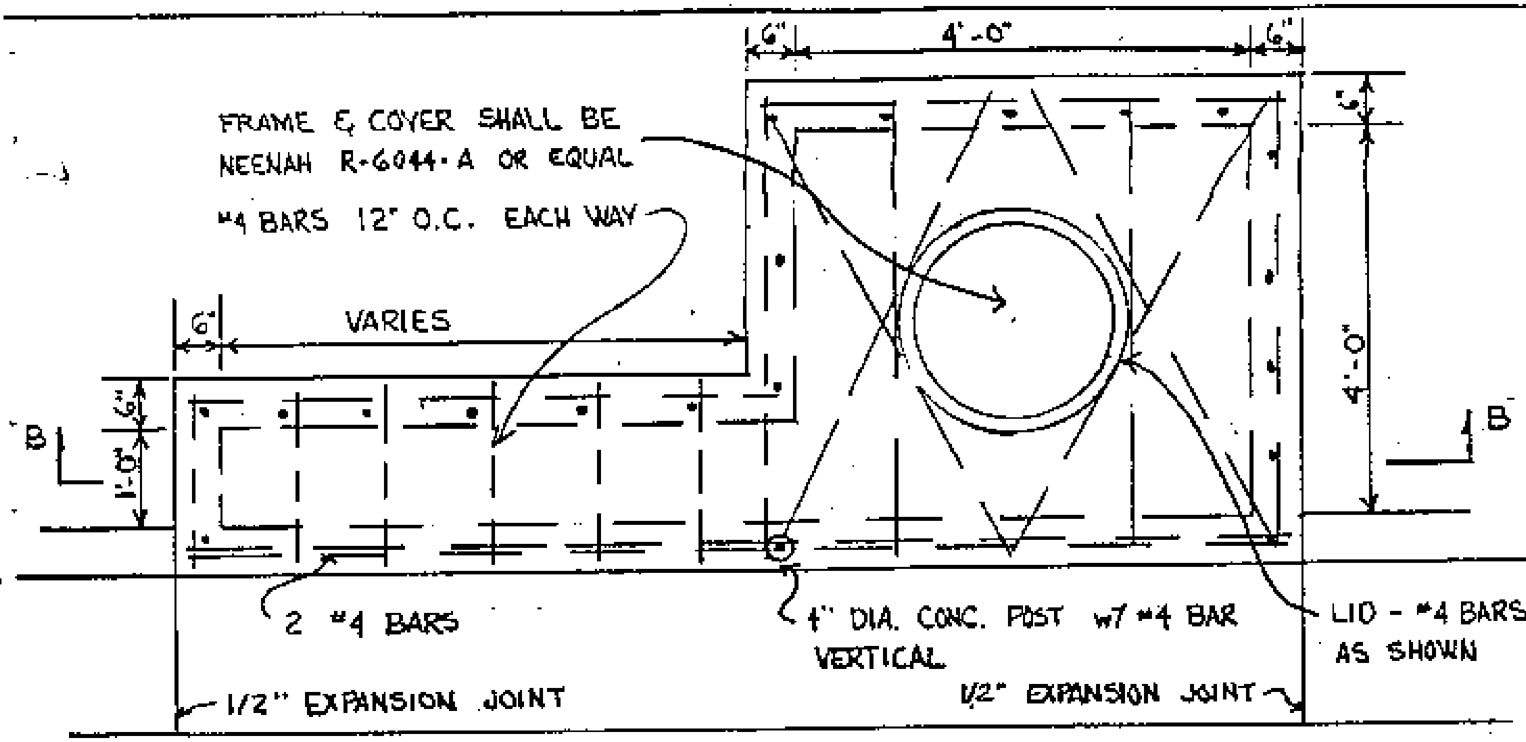


PLAN

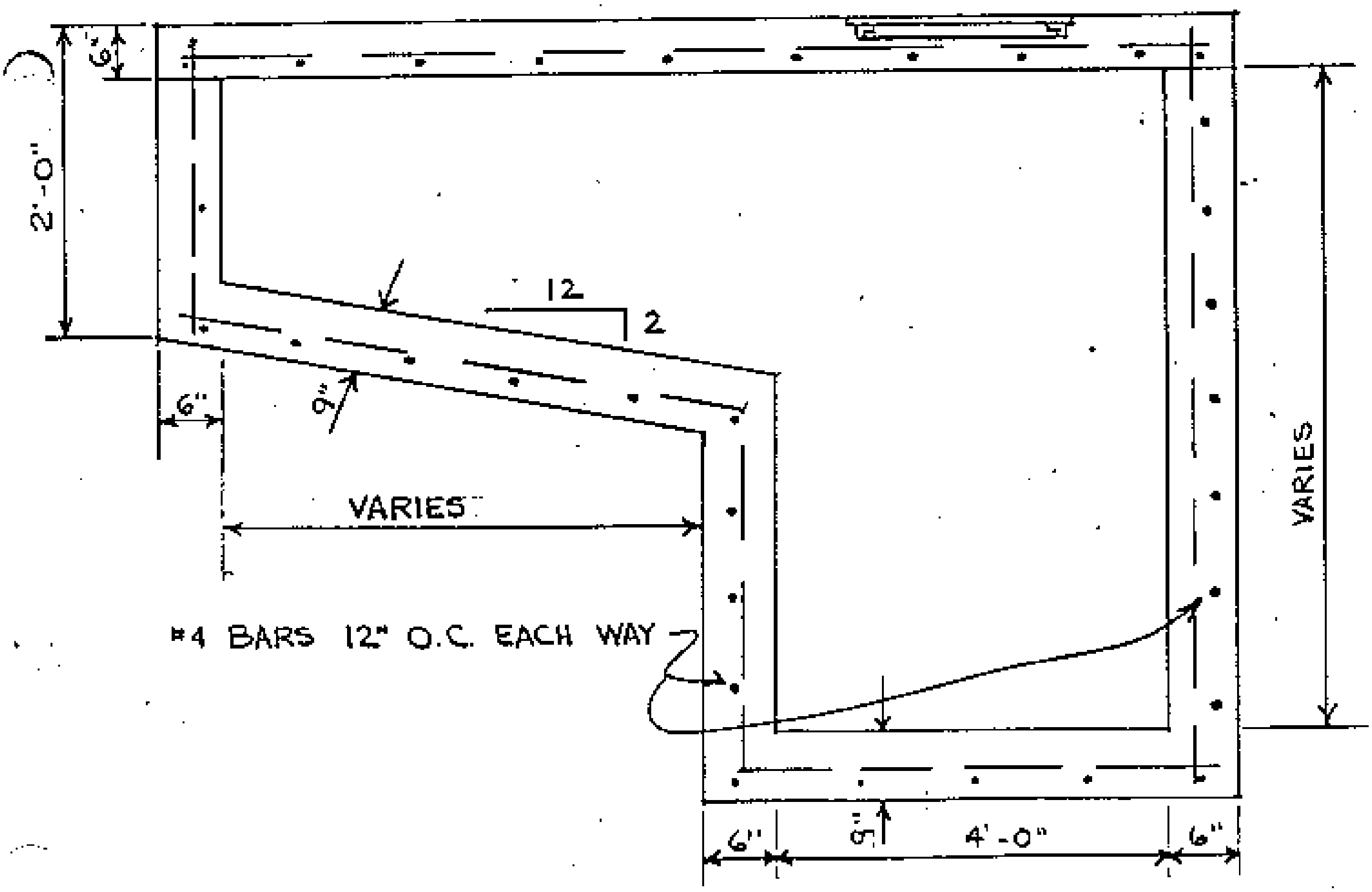


SECTION "A-A"
(INLET TYPE "B" SIMILAR)
INLET TYPE "A" = SIDE INLET

FIG. 18



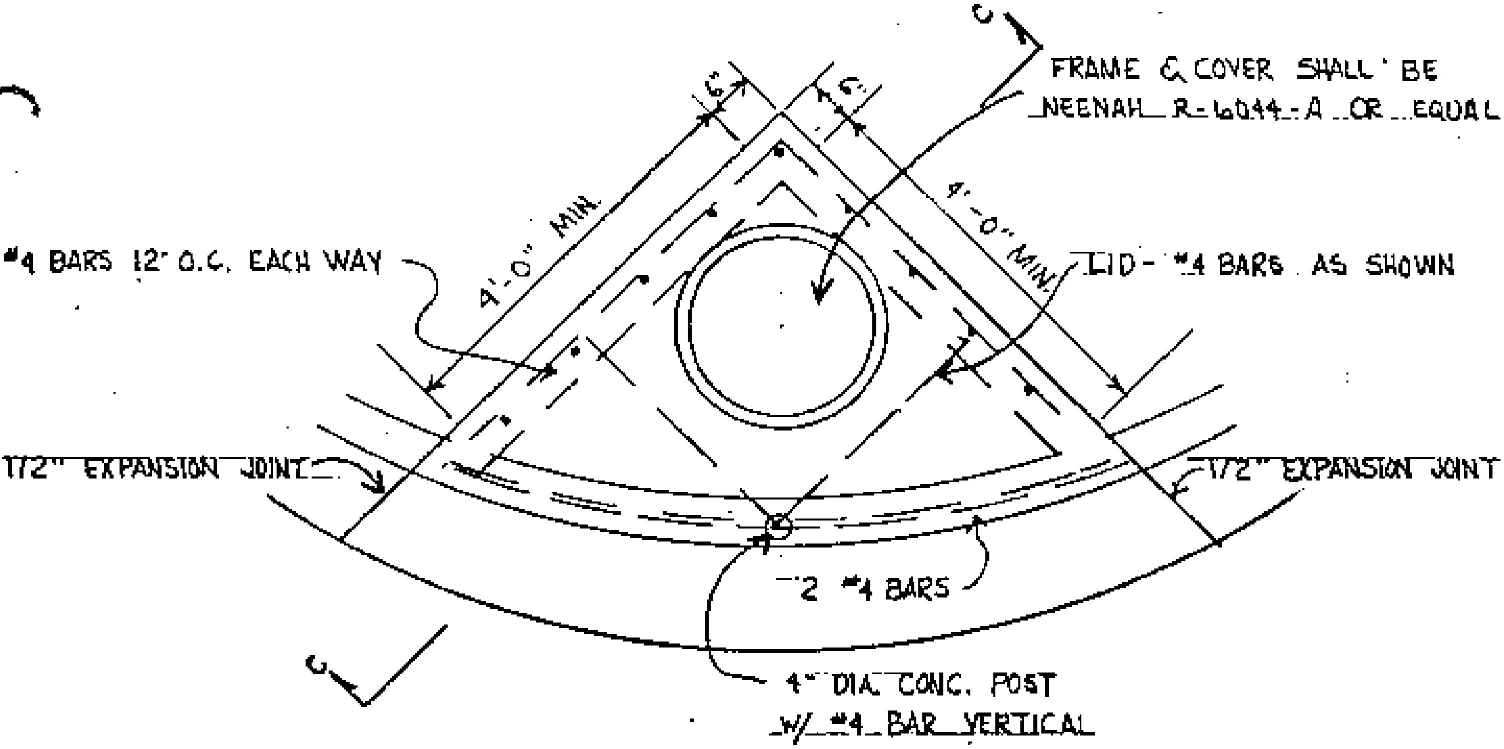
PLAN



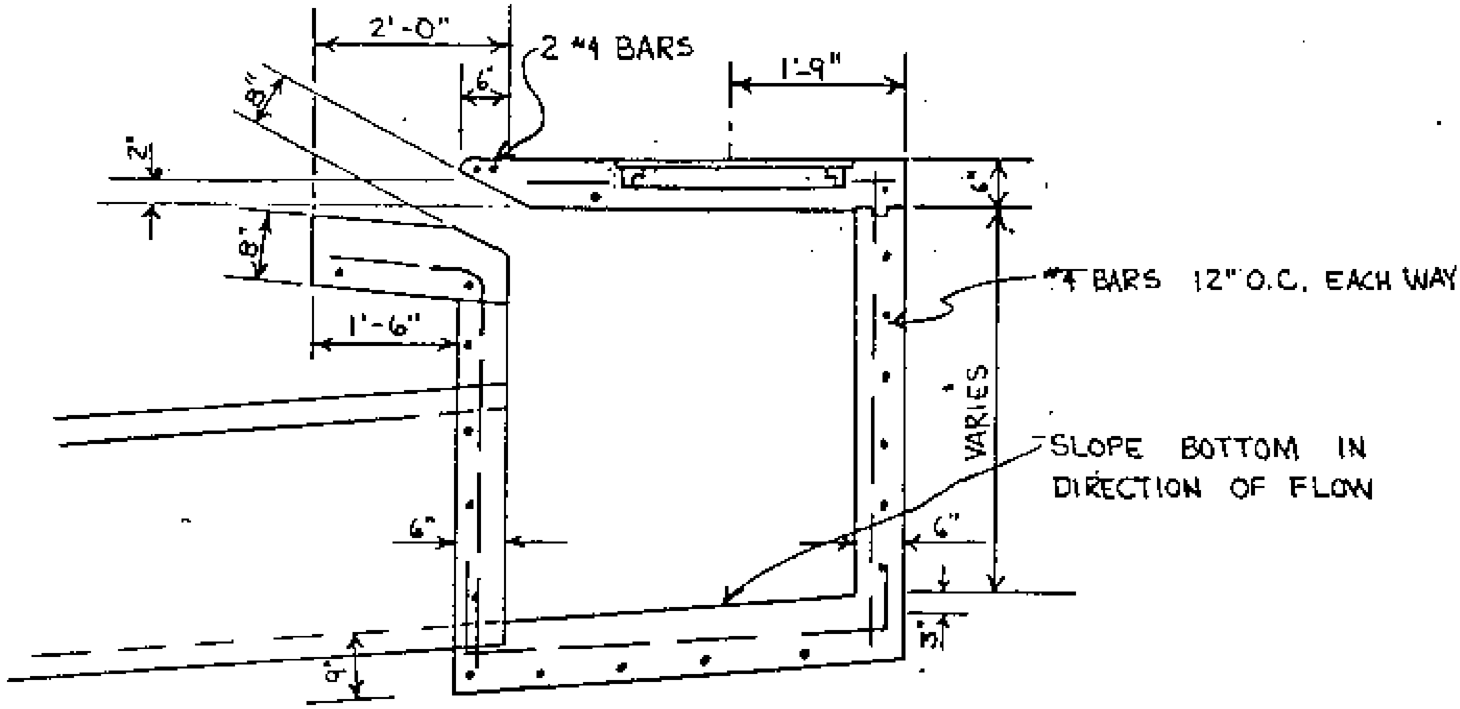
SECTION "B-B"

INLET TYPE "B" - SIDE INLET W/ THROAT EXTENSION

FIG. 19



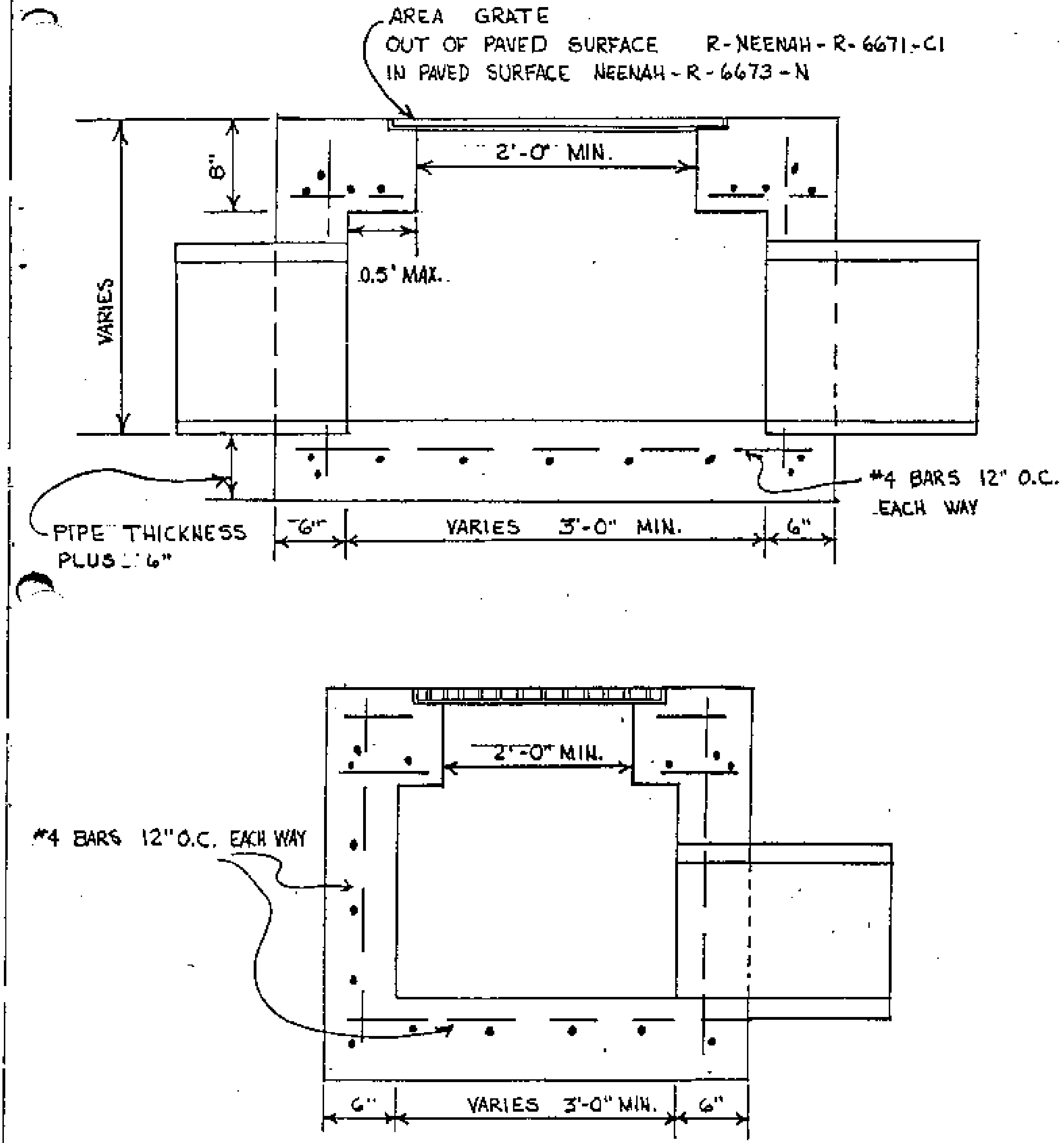
PLAN



SECTION "C-C"

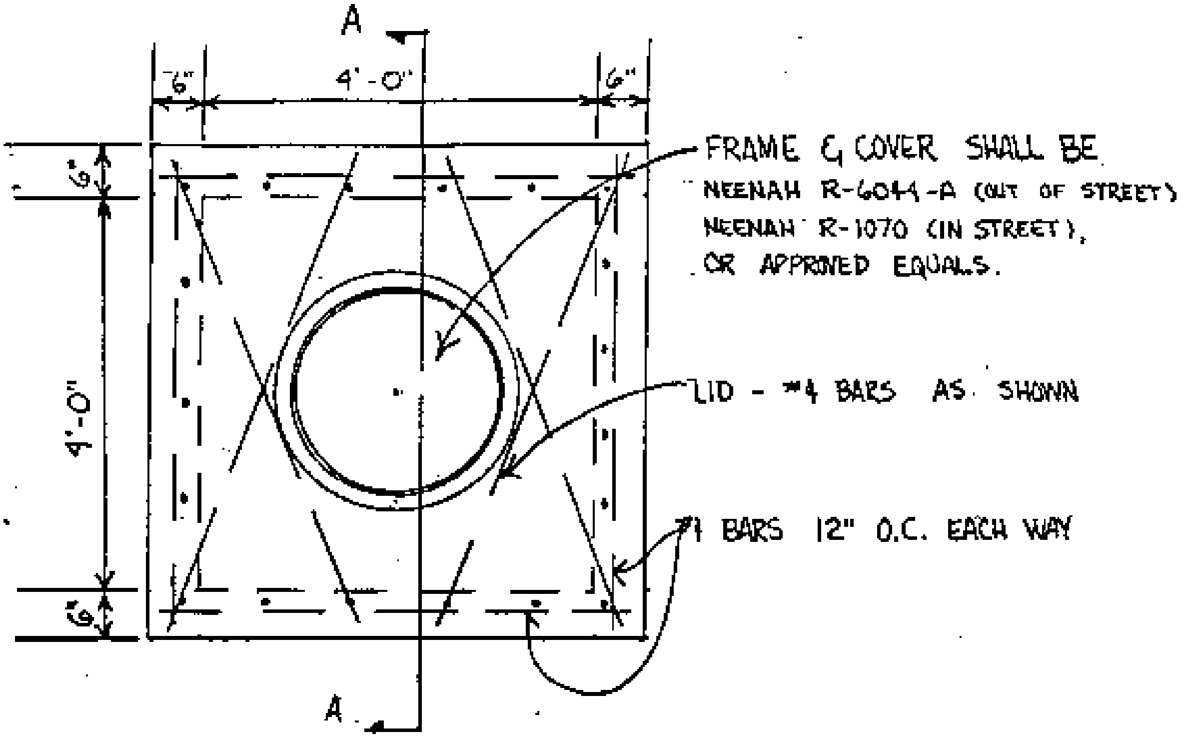
INLET TYPE "C" - CORNER INLET

FIG. 20

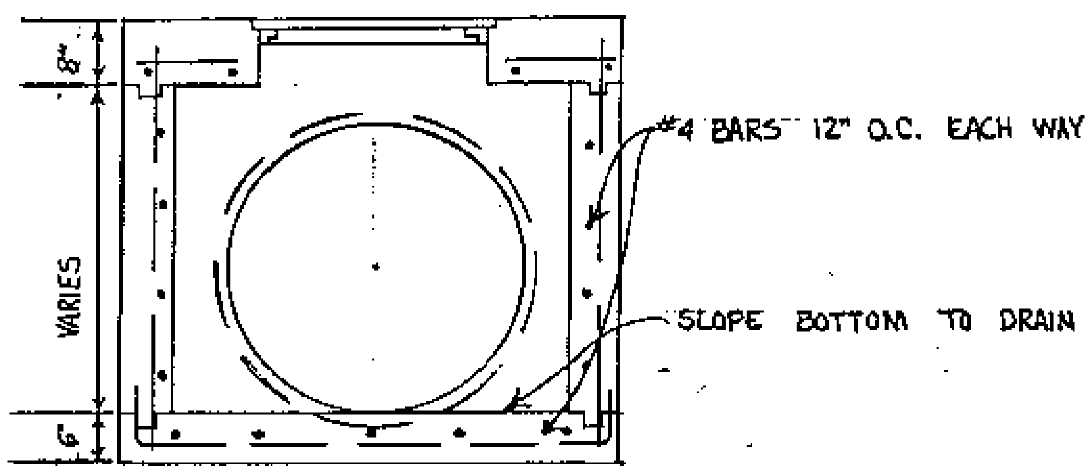


INLET TYPE "D" - GRATED AREA INLET

FIG. 21



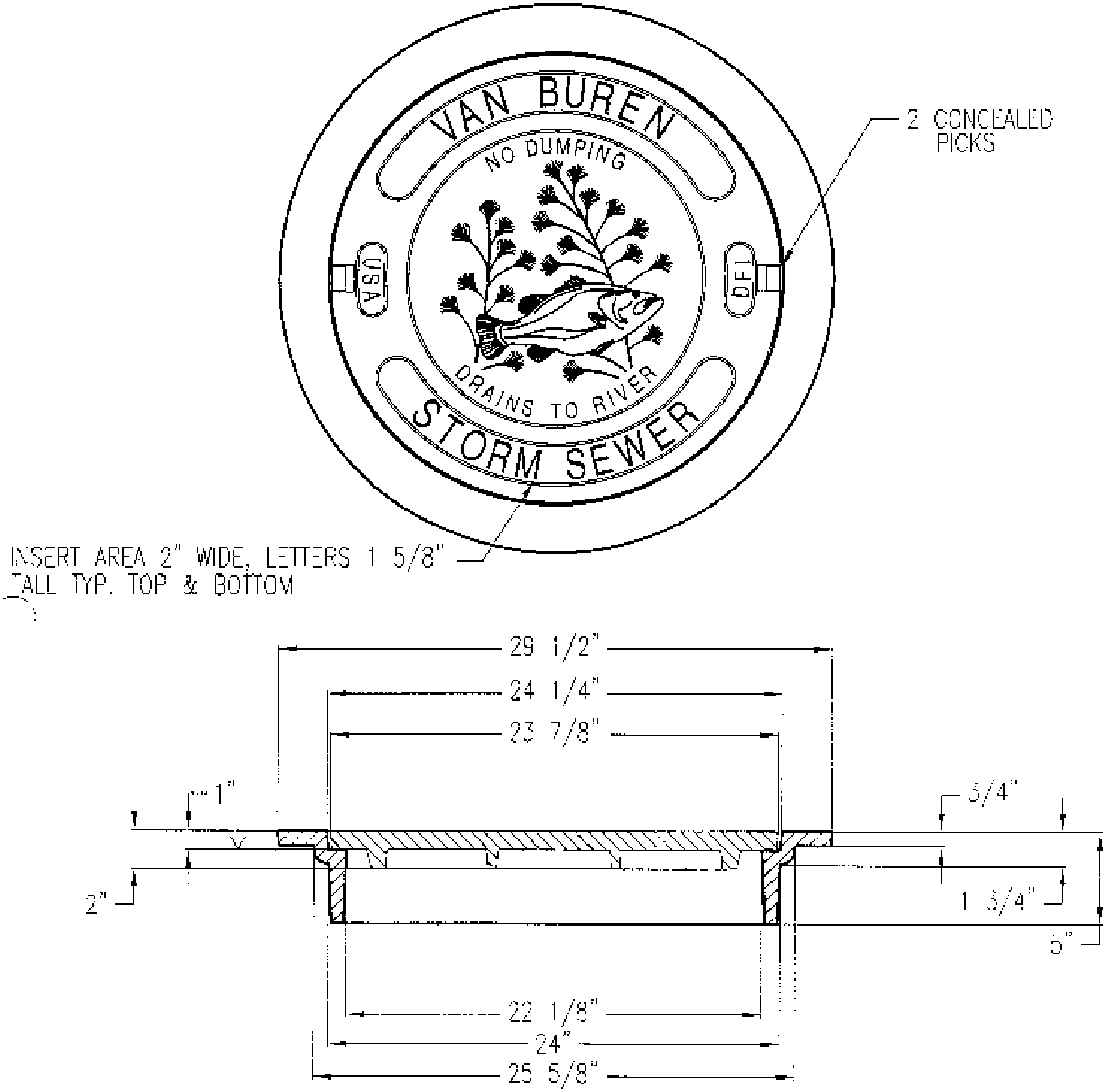
PLAN



SECTION "A-A".

JUNCTION BOX

FIG. 22



NOTE:
1. FURNISHED WITH MACHINED HORIZONTAL BEARING SURFACES.

CONCEPTUAL DRAWING

MATERIAL:	CAST GRAY IRON ASTM A-48, CLASS 35B
FINISH:	NO PAINT
WEIGHT:	COVER 140 LBS. FRAME 133 LBS.

CAD DWG. REF. 2018A-01\LAYER: ALL\SCALE: .125

Deeter Foundry, Inc.

5945 NORTH 70th STREET
LINCOLN, NEBRASKA 68529

2018-A MANHOLE RING & COVER

Date:	Drawn by	Scale:
03 JAN 96	RON	1/8
DRAWING NO. 01-2018A-01	Revised by: KRH	Date: 27 FEB 02