NOTE:

THE FOLLOWING DESIGN CRITERIA WILL BE FOLLOWED UNTIL THE CITY OF BLUE RIDGE COMPLETES AND IMPLEMENTS ITS OWN DESIGN CRITERIA STANDARDS. THIS CRITERIA SHALL BE FOLLOWED ALONG WITH ALL THE STANDARDS SET FORTH IN THE CITY OF BLUE RIDGE ORDINANCES. ANY DISCREPANCIES WILL BE HANDLED ON A CASE-BY-CASE BASIS. DEVELOPERS ARE ENCOURAGE TO KEEP TRACK OF THE LATEST REVISIONS TO THESE DESIGN CRITERIA AS WELL AS ANY OTHER CITY OF BLUE RIDGE STANDARDS.

CITY OF BLUE RIDGE

Storm Water Drainage Design Criteria

METHODOLOGY

For Design of Drainage Structures

II. Runoff Methods

A. Regional Regression Equations

1. Planning and Development

The year 2000 planning study (called City of Blue Ridge Master Drainage Plan) for all major corridors within the City of Blue Ridge used Regional Regression Equations to evaluate potential flood flows within the city. The information in the study[1] may be used by the owner or developer as a base for development. If the owner or developer wishes to optimize or further evaluate flows, the methodology in the following sections must be used.

[1] Note: the information from the latest update of the study at the time of preliminary plat must be used; however, if the timeframe between preliminary plat and final plat is more than one year, then the information from the latest update of the study from four months prior to submittal of the final plat must be used. For instance, if a final plat is submitted in May, then any updates to the study as of January of that year must be incorporated into the design. The City Engineer reserves the right to make additional comments or requirements at the time of preliminary plat for final plat submittals.

2. Blue Ridge Master Drainage Plan

The Blue Ridge Master Drainage Plan (BRMDP) was developed as a planning tool for major drainage corridors within the City of Blue Ridge. The BRMDP consists of two volumes (three bound reports) as follows:

- Volume I – Part I contains informational verbiage, hydrologic data, and the hydraulic data for ultimate conditions
- Volume I – Part II contains the hydraulic data for current conditions
- Volume II – Map Set (11x17 exhibit) contains all maps relating to the Master Drainage Plan

Information from the BRMDP can be obtained from the City Engineer. Use of the BRMDP is described in *Appendix A – Guidelines for development.*

3. Guide

A "step by step' guide is included in Appendix A to assist owners with developing their property in accordance with these drainage standards.

B. Rational Method

1. Methodology

Stormwater runoff for drainage areas less than 200 acres may be calculated using the Rational Method. The Rational Method is based on the principle that the maximum rate of runoff from a given drainage area occurs when all parts of the area are contributing to the flow at the point of discharge.

The modified Rational method shall be used, where a factor accounts for antecedent precipitation for various recurrence intervals of storm events. The formula for the modified Rational Method is:

$$Q = f * CIA \qquad (1)$$

Where

Q = maximum rate of discharge (cfs).

C = runoff coefficient based on topography, soil, land use and moisture content of the soil at the time the rainfall producing runoff occurs.

I = rainfall intensity in inches/hour for the time period it takes flow from the farthest point of the drainage area to reach the point of design.

A = the drainage area contributing to the runoff at the specified concentration point/outfall (acres).

f = antecedent precipitation factor, choose from the below table

	Factor
2 to 10-year storm event	1.0
25-year storm event	1.1
50-year storm event	1.2
100-year storm event	1.25

2. Runoff Coefficient "C"

a. The runoff coefficient "C" shall be based on the ultimate land use as recommended in the City of Sherman Master Plan.

b. For areas that a change in zoning has occurred the "C" value of the new zoning shall be used.

c. Runoff coefficient "C" values are based on topography and land use. The table entitled "Runoff Coefficient Values" included in *Appendix B – Hydrology Table and Figures* shall be used to determine "C" values.

3. Time of Concentration

Time of concentration is the longest time, without interruption of flow by detention devices, which a drop of water takes to flow from the farthest point of the drainage area to the point of concentration (i.e. the point of design).

a. The SCS methodology is recommended to determine the time of concentration (Tc), which is based on three types of flow: sheet flow, shallow concentrated flow, and open channel flow.

1) **Sheet Flow.** Sheet flow is flow over plane surfaces. It occurs in the uppermost area of the defined basin.

The time of concentration in minutes for sheet flow is determined using the following equation:

$$T_{C\ sheet\ flow} = 60\frac{D}{V} \quad (2)$$

where,

D = distance along the flow path (feet)
V = velocity (feet per second)
Tc = time of concentration (minutes)

Determine the longest flowpath for the water in each individual basin (begins at the uppermost part of the basin, not at the start of the major channel of the basin). Sheet flow length is measured along this flowpath from the uppermost part of the basin for a length no more than 300-feet. (At a maximum distance of 300-feet *sheet flow* changes *to shallow concentrated flow*).

A slope should be estimated along this length of flow. A velocity corresponding to this slope can be determined using the upland method graph found in *Appendix B – Hydrology Tables and Figures.*

2) **Shallow Concentrated Flow.** Shallow concentrated flow begins where sheet flow ends. A projected slope should be established along the flowline for the shallow concentrated flow length. A velocity corresponding to this slope can be determined from the shallow concentrated flow graph in *Appendix B – Hydrology Tables and Figures.* The time of concentration in minutes for shallow concentrated flow is determined by the following equation:

$$T_{c\ shallow concentrated\ flow} = 60\frac{D}{V} \quad (3)$$

where,

D = distance along the flow path (feet)
V = velocity (feet per second)
Tc = time of concentration (minutes)

3) **Open Channel Flow.** Open channel flow is applicable for large channel

sections. In most cases, it is not applicable for the rational methods (since large channels indicate large watersheds where a unit hydrograph method is applied in the City of Blue Ridge).

The time of concentration for open channel flow is determined using the following equations:

(4)

where,

D = distance along the flow path
V = velocity (feet per second)
Tc = time of concentration (minutes)

V is determined using a combination of the continuity equation and Manning's equation:

$$V = \frac{1.486}{n} (R)^{2/3} (S)^{1/2} \qquad (5)$$

where,

n = manning's n
R = A/P = hydraulic radius (feet)
A = area (square feet)
P = wetted perimeter (feet)
S = slope (ft/ft)

4) **Resulting Time of Concentration**. The time of concentration is the sum of the sheet flow, shallow flow, and open channel flow segments.

$$Tc = Tc_{\textit{sheet flow}} + Tc_{\textit{shallow concentrated flow}} + Tc_{\textit{channel flow}}$$

In no case shall a shorter time of concentration be used than;

i) 10 minutes for property zoned multiple family, churches, schools, local business, central business, commercial, or industrial.

ii) 15 minutes for property zoned for parks, cemeteries, agricultural, and single family residential.

4. Rainfall Intensity

Rainfall depths can be found from the City of Blue Ridge Intensity-Duration-Frequency (IDF) curve. A copy of the IDF curve is provided in *Appendix B – Hydrology Tables and Figures*.[1]

Design storm frequencies for various drainage structures are listed in *Appendix B – Hydrologic Tables and Figures.*

C. Unit Hydrograph Method

1. Methodology

A unit hydrograph method is required for drainage areas greater than 200 acres. The recommended unit hydrograph models are HEC-1 and HEC-HMS. These software packages are available from the Army Corps of Engineer's Hydrologic Engineering Center or various software companies. The Hydrologic Engineering Center's web site with many free engineering software downloads is www.wrc-hec.usace.army.mil

The City Engineer must approve other unit hydrograph methods.

2. Rainfall

Design storm frequency requirements are listed in *Appendix B – Hydrology Tables and Figures*. Rainfall values can be determined using the City of Blue Ridge IDF curve and corresponding table included in the same appendix.

For the HEC-1 hydrology model, a hypothetical storm distribution for rainfall amounts shall be coded into the model using the PH record.

3. Loss Rate

a. Methodology

The loss rate shall be determined using SCS Curve Numbers. A table of Curve Numbers corresponding to land use can be found in *Appendix B – Hydrology Tables and Figures.*

b. HEC-1

For the HEC-1 hydrology model, the LS card should be used to model the loss rate.

4. Time of Concentration

a. Methodology

The time of concentration shall be developed using SCS methods. The methodology is listed in section *A. Rational Method, 3. Time of Concentration.* The basic principle of the SCS methodology for estimating the time of concentration is

$$Tc_{total} = Tc_{sheet\,flow} + Tc_{shallow\,concentrated\,flow} + Tc_{open\,channel\,flow}$$

where the total time of concentration is equal to the sum of the time of concentrations along the flow path for sheet flow, shallow concentrated flow, and open channel flow.

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[1] For IDF Curve, Rainfall events greater than 60 minutes are from Reference 15 (TP-40); Rainfall events with durations of 5 to 60 minutes are from Reference 9 (Hydro-35).

b. HEC-1

The Clark Unit Hydrograph Method (UC card, time of concentration in hours) shall be used in the HEC-1 hydrology model.

5. Routing

a. Methodology

Routing shall be accomplished using normal depth storage (normal depth channel routing).

b. HEC-1

The RS, RC, RX, and RY records shall be used for routing in the HEC-1 hydrology model.

DESIGN CRITERIA

For Design of Drainage Structures

III. FEMA Criteria

The developer or owner is required to meet all FEMA regulations. When a submittal to FEMA is required, the submittal must be submitted to and approved by the City Engineer prior to submitting to FEMA. Conditional Letter of Map Revisions (CLOMRs) and Letter of Map Revisions (LOMRs) are required for any modifications to a floodplain or floodway.

A Certificate of Occupancy will not be issued by the City until a copy of the FEMA approval letter for the LOMR is sent to the City (if required for the site). In the typical development of a site, a CLOMR precedes site development, and a LOMR follows site development and is based on as-built conditions.

IV. City Criteria

A. General Requirements

1. Runoff calculations are required for development of property one acre (1 ac.) or greater, or any property that is platted as a part of an overall tract which is greater than one acre (1 ac.) in size, or where major streams (under FEMA Jurisdiction) are proposed to be modified. In cases where major streams are proposed to be modified, a CLOMR is required prior to construction, and a LOMR is required after construction is complete before an occupancy permit will be issued.
2. The Rational Method may be used to calculate runoff for situations in which the drainage area is less than 200 acres. A unit hydrograph method is required for drainage areas 200 acres and larger.
3. Runoff calculations must be based on the proposed lot grading for the development. Runoff contributed from off-site sources must be considered in the calculations. All off-site drainage must be calculated at the proposed ultimate land use (fully developed conditions in the watershed). Existing upstream detention can and shall be considered when analyzing the fully developed conditions of the watershed.
   There are many SCS Dams (detention) proposed within the City of BlueRidge ETJ limits that will affect ultimate flows in the watershed. The developer/land owner should contact the City Engineer to determine where new dams have been designed or are under construction (as these may not have been included in the Blue Ridge Master Drainage Plan analysis of fully developed conditions).
4. All drainage systems shall provide for positive overflow at all low points. Positive overflow means that when the inlets do not function properly or when the design capacity of the conduit is exceeded, the excess flow for the 100-year storm event can be conveyed overland.
5. Detention facilities are not required in the City of Blue Ridge when runoff from the site can be directly carried to a designated FEMA floodway that has adequate capacity. In cases

where there is not adequate capacity in the downstream system to safely convey water (i.e. without adversely impacting property downstream), detention shall be utilized.

Property shall be developed so that the rate of runoff created by the development as it leaves the property does not exceed the pre-developed rate of runoff.

In some cases where downstream facilities are planned ("future drainage facilities"), the City Engineer may allow a higher rate of runoff. However, this variance must be approved in writing by the City Engineer. Also, this rate of runoff must not at any time cause flooding to existing property until the future drainage facilities are in-place.

The intent of these detention standards is that in cases where there *is not adequate capacity* in the water course to carry ultimate developed flows and where no future drainage facilities are planned (as described above), the burden of detaining flows is spread out across all the land owners (rather than the last developed property needing to detain all flows due to the increase in flows from previous development).

Where there *is adequate capacity* to convey flows or when property is located adjacent to major watercourses in the City, no detention is necessary.

B. Open Channels

It is the City's desire for channels to remain in their natural vegetated state whenever possible. In cases where channels are improved, the following design criteria apply.

1. Design Criteria

a. General Criteria

1) In cases where the **entire channel section is contained within the limits of the developer/owner property boundaries**. The developer/owner shall;

i) Provide for an improved stabilized channel cross-section which reduces all velocities to 6.0 fps or below for vegetated channels. The channel improvements must meet all requirements of this ordinance.

ii) For vegetated channel sections with overbank velocities ranging from 6 to 8 fps, grade control structures must be constructed within the channel and overbank areas to prevent erosion. Grade control structures shall have a minimum effective depth of 3.0 feet below existing or proposed grades with an adequate number of structures to prevent less than 1 foot of degradation.

2) In cases where the **property boundary follows the centerline of the channel or incorporates only a portion of the channel cross-section**, the developer/owner shall;

i) Determine the design section required to provide for an improved stabilized channel cross-section which reduces all velocities to 6.0 fps or below for vegetated channels. The design channel section must meet all requirements of this ordinance.

ii) The design section may include vegetated channel sections with overbank velocities ranging from 6 to 8 fps, provided that grade control structures are included within the channel and overbank areas to prevent erosion. Grade control

structures shall have a minimum effective depth of 3.0 feet below existing or proposed grades with an adequate number of structures to prevent less than 1 foot of degradation.
iii) The developer/owner shall construct all improvements required on their property for the ultimate channel design.
iv) If grade control structures are incorporated into the design, the developer/owner shall coordinate with adjacent owners in order to construct these features in their entirety at the time of the channel improvements.
v) The developer/owner shall provide for a drainage easement and access/maintenance easement consistent with the improvements provided.

3) In cases where the developer/owner **owns property adjacent to channel or floodplain areas but does not own a portion of the channel or floodplain area**, the developer/owner shall;

i) Determine the channel improvement configuration necessary to reduce all velocities to 6.0 fps or below for vegetated channels.
ii) Shall provide a dedicated easement to the portion of this future improvement configuration, including necessary maintenance and access easement, which may include the developer/owner property.

b. Methodology

1) Models. Major channels or channels where backwater effects occur must be modeled using a standard backwater model. The U.S. Army Corps of Engineer's Hydraulic Engineering Center's model HEC-RAS is preferred. Other models that are acceptable are HEC-2 and WSPRO. Note that the model must meet FEMA and standard engineering criteria (in some cases other models must be used).

2) Manning's Equation. For collector channels and swales, Manning's equation can be used to determine water surface elevations and velocities since backwater affects are negligible. Manning's equation is included in *Appendix C – Hydraulic Equations*.

b. Hydraulic Criteria

1) Freeboard. Two feet of freeboard is required on all major channels, and one foot of freeboard on collector channels. In bends in the channel, the superelevation of the water must be estimated and added to the freeboard of the channel on the outside of the bend. An equation that can be used to determine the height of the superelevation of the water is included in *Appendix C – Hydraulic Equations*.

2) Flow Regime. All channels are to be designed to have subcritical flow with a Froude Number less than 0.86. Hydraulic jumps are to be avoided. An exception to this is at bridges and culverts. When a hydraulic jump is predicted at a bridge or culvert the channel bottom and side slopes must be protected from erosion. In addition, the worst case water surface elevation must be used for determining floodway impacts.

3) Channel Shape. It is preferred that channels and swales have a trapezoidal section for concrete lined or earth banks. The channel section should have adequate area to take care of the uncertainties in runoff estimates, changes in channel roughness coefficients, channel obstructions, and silt accumulations.

4) Bends. All channel radii are recommended to be a minimum of three times the top width of flow. An alignment with few horizontal curves or changes is desirable. If the natural channel radius is smaller than three times the top width, care should be provided in the design to protect any structures from channel migration or flooding.

5) Channel Side Slopes. Side slopes shall be;

i) 4 feet horizontal to 1-foot vertical for side slopes with grass or other ground cover

ii) 1.5 feet horizontal to 1-foot vertical for side slopes protected by rock or gabions

6) Channel Slopes and Velocities.

i) Minimum Slopes. Where practicable, all unpaved channels should have sufficient gradient to avoid ponding low flow conditions. A minimum slope of at least 0.30% is required for all unpaved channels and swales except those used as part of a wetlands area. A concrete pilot channel should be included in all improved major earthen channels.

ii) Maximum Velocity for Earthen Channels
Channels are encouraged to be left in their natural state provided that potential lateral migration or other conditions in the channel are safe and acceptable after development.

iii) Maximum Velocity for Improved Channels
The maximum velocity allowed in concrete lined channels is 15 feet per second or less.

c. **Channel Vegetation.** The developer/owner shall use low maintenance vegetation cover. The selection of materials shall comply with the existing ground cover listing for North Central Texas furnished through the Texas Agricultural Extension Service.

2. Erosion Prevention and Channel Maintenance

All channel sections must consider and account for channel stabilization in their design. This requirement pertains to all sections whether they are left in their natural condition or are modified in any manner. The design of all drainage channels and swales shall assure adequate capacity and minimum maintenance to overcome the result of erosion, silting, sloughing of bends or similar occurrences. Drop structures, ditch checks or paved spillways may be required to control erosion that results from the high velocities of large volumes of water on steep grades.

Lined channels are strictly discouraged. If the design velocity is greater than 6.0 feet per second, for earthen channels measures shall be used to reduce velocities. Erosion countermeasures such as concrete, rock walls, and gabions may be used upon approval of the City Engineer.

C. Bridges

1. Design Criteria

a. Freeboard. One foot of freeboard is required between the 100-year water surface elevation and the low chord of the bridge.

b. Skew. The skew of the bridge piers and abutments shall be oriented as close to the normal or flood direction of flow resulting in an angle of attack as close to 0 degrees as possible.

c. Model. Bridges shall be designed using standards methods. If the HEC-2 backwater model is used, the normal bridge option shall be used for bridges without interior bents (interior piers). The special bridge option in HEC-2 shall be used for bridges with interior bents, or where pressure flow or weir flow occurs.

2. Erosion Protection

Stream stability shall be assessed when designing the abutments and interior bents of the bridge. Scour shall be accounted for in the design. Refer to references 3 and 4 for more information.

D. Culverts

1. Design Criteria

a. **Freeboard.** One foot of freeboard is required between water surface elevation and the top of road elevation.

100 yr	Thoroughfare
50 yr	Collector
25 yr	Residential

b. Methods. Culverts must be designed using standard methods and engineering judgement. Standard charts are provided in *Appendix E – Hydraulic Figures*. In addition, numerous computer models are available. Culverts shall be designed in accordance with the latest edition of the State of Texas Department of Highways and Public Transportation Bridge Division Hydraulic Manual. Standards of the City of Blue Ridge will take precedence over the TxDOT manual in cases of conflict.

c. Skew. The culvert shall be skewed such that impacts due to the flood and normal flow angles of attack on the structure are minimized.

d. Erosion. Culverts can be designed in supercritical flow for hydraulic efficiency. However, the outlet of the culvert needs to be evaluated for erosion concerns, and the hydraulic jump must be forced at the outlet of the culvert, whether by design grades or an energy dissipater.

e. **Bends.** For long culverts, bends may sometimes be necessary. Culverts are recommended to be designed with maximum 15 degree bends on 50-foot intervals (Reference 5). When modeling culverts with bends, backwater models may need to be calibrated with other models to accurately estimate the losses in the culvert.

f. **Velocity.** The maximum discharge velocity of culverts shall be 15 feet per second.

2. Erosion Protection

Stream stability shall be assessed when determining the number of barrels, height and width of barrels, and culvert skew. Potential for scour shall be accounted for in the design. Refer to references 3 and 4 for more information.

Energy Dissipaters

Energy dissipaters shall be designed, where required, at exits to culverts, bridges, and in channels to convey flow safely. Design of these structures shall be according to standard methods (see References for additional sources). The City discourages the use of energy dissipaters except where hydraulically constrained (subcritical flow throughout the drainage system is preferred).

F. Levees

The use of levees is discouraged in the City of Blue Ridge, except in cases to meet freeboard requirements.

G. Buildings

The finished floor (FF) elevation of commercial buildings shall be 1 foot above the 100-year fully-developed water surface elevation (WSE) of the ultimate floodplain or 2 feet above existing FEMA flood deviations.

The FF elevation of residential buildings shall be 2 feet above the 100-year fully-developed WSE of the ultimate floodplain or 2 feet above existing FEMA flood elevation..

All buildings shall be located outside of the current 100-year floodway and floodplain. See *Appendix A – Guidelines for Development* for information on encroachment in the ultimate floodplain.

H. Detention Facilities

1. General

a. Detention Facilities are NOT required in the City of Blue Ridge when runoff from the site can be directly carried to a major channel or natural drainage-way that has adequate capacity. If the flows leaving the site cannot be conveyed to a designated FEMA Floodway without adversely impacting downstream property, then detention is required. The design requirements are listed in Section 2 below. In lieu of detention, the affected drainage system may be upgraded to provide the required capacity.

b. Detention facilities may be used for aesthetics and to control flooding, soil erosion, sedimentation and pollution control.

c. A maintenance plan, approved by the City Engineer, is required for all detention facilities and shall meet the standards given in this section.

d. All detention facilities must be designed to drain within 36 hours of the storm event.

e. Due to the relatively impermeable soils in this area retention facilities will not satisfy detention requirements for the City of Blue Ridge. Combination retention/detention facilities are acceptable. However, the retention portion of the facility may not be included in the calculations as satisfying detention volume requirements.
In addition, retention facilities shall be assumed to contain standing water and be designed with proper aeration (such as a fountain) so as not to promote odors, insect breeding, or other undesirable conditions.

2. Design Criteria

a. Design Storm Frequency

When required, detention facilities shall be designed for the 100-year event.

b. Maximum Discharge Rates

The discharge rate shall be limited to the pre-developed discharge rate. In cases where future downstream facilities or upstream detention (such as an SCS dam) are planned, the City Engineer may allow an exception (either by increasing the discharge rate allowed or not requiring detention). However, this variance must be approved by the City Engineer in writing.

c. Minimum Storage Volumes

A detention facility must be able to store the 100-year, 2 hour rainfall event for the site without exceeding the pre-developed discharge rate off the site.

d. Minimum Slope in Detention Facilities

A detention facility shall have enough gradient to ensure positive drainage to the outlet structures so as to avoid nuisance conditions such as standing water, odors, insects, and weeds. A minimum slope of 0.40% towards the outlet structure is required for all detention facilities.

e. Freeboard

All detention facilities shall have minimum of one foot (1 ft.) of freeboard above the water surface elevation of the required runoff storage.

f. Sediment Control Facilities

Detention facilities used as a sediment control device shall meet the following requirements:

1) The sediment control facility shall be designed with minimal velocities such that sediment is dropped and not picked up by flows at any time during the storm event.

2) The basin shall be designed with adequate sediment storage area so that sediment removal is not required more than twice a year.

3) Sediment control facilities cannot be used to meet detention requirements unless the volume of sediment is included in the calculations for the detention basin design.

g. **Flood Peak Consideration**

All detention facilities designs shall consider the timing of the flood peak in the main channel into which the detention facility drains. Delaying the peak from a site in lower portions of a watershed may result in a higher peak on the main channel.

3. Easements

Drainage easements shall be provided for all detention facilities. Easements shall include the outlet structure and associated outfall channel or conduits, detention facility and a 10-foot maintenance access strip around the facility.

4. Maintenance

a. Detention facilities must be properly maintained by the owner to ensure the facility functions properly.

1) **Mowing.** Facilities should be mowed as required and at least twice a year to control weeds and discourage woody growth.

2) **Debris Control.** Debris, litter and accumulated sediment should be removed from detention facilities at least twice a year. Particular attention should be given to removal of debris, litter and sediment around outlet structures.

3) **Sediment Removal for Basins Designed with Sediment Storage.** Detention basins designed for sediment removal shall be maintained as specified in the maintenance plan.

4) **Maintenance Plan.** Conformance with the maintenance plan is the responsibility of the owner of the detention facility.

5. Developments near Major Drainage Corridors or with downstream drainage corridors of sufficient capacity to carry ultimate flows

Detention is not required for these sites.

Major Drainage Corridors are those considered under the Jurisdiction of FEMA. Information is available for these corridors in the City of Blue Ridge Master Drainage Plan.

For the drainage watercourse between the site and the major drainage corridor (the area downstream of the site and upstream of the major waterways), a capacity analysis must be shown on the plans (or in a drainage report) showing that there is adequate capacity to safely convey flows in this area. Otherwise, detention is required.

6) Developments where downstream drainage corridors cannot convey ultimate flows

Detention is required for these sites. The following information is required on the drainage area map submittal or in a drainage report:

1) Calculations showing detention required

2) Allowable release (current flows)

3) Calculations showing release without detention (post-project before detention)

4) Calculations showing release with detention (post-project with detention)

5) Downstream capacity shall be considered adequate whenever the top of curb is not exceeded by the flows resulting from the new development.

6) A developer shall be responsible for detaining the increased flow solely from his development.

I. Storm Sewer Systems and Appurtenances

1. Storm Sewer Design

a. Storm Frequency

The design storm event for storm sewers shall be a minimum of 25-year, plus 100-year positive overflow at inlets in street low points.

b. Velocities and Grades in Storm Sewers

1) Minimum Velocity

The minimum velocity in a storm sewer conduit shall be 2.5 feet per second.

2) Recommended Slopes

The minimum slopes for various pipe sizes that will maintain the minimum velocity are given in *Appendix D – Hydraulic Tables*.

3) Maximum Velocity

i) Storm Sewer

The maximum velocity allowed within a storm sewer conduit is 12.5 feet per second or less.

ii) Outfall

The maximum discharge velocities in the pipe shall also not exceed the permitted velocity of the receiving channel or conduit at the outfall to prevent erosive conditions. The maximum outfall velocity of a conduit in partial flow shall be computed for partial depth and shall not exceed the maximum permissible velocity of the receiving channel unless controlled by an appropriate energy dissipater (e.g. stilling basins, impact basins, riprap protection).

c. Hydraulic Gradient of Storm Sewers

Conduits must be sized and slopes set such that runoff flows smoothly down the drainage system. To insure this smooth passage, the hydraulic gradient must be at the proper elevations. In storm drain systems flowing full, all losses of energy through resistance with flow in pipes, by changes of momentum or by interference with flow patterns at junctions, must be accounted for by accumulative head losses along the system from its initial upstream inlet to its outlet. The purpose of accurate determinations of head losses at junctions is to include these values in a progressive calculation of the hydraulic gradient along the storm drain system. In this way, it is possible to determine the water surface elevation, which will exist at each structure. The hydraulic grade line shall represent the rate of energy loss through the storm drain system.

1) The hydraulic grade line (HGL) shall be established for all storm drainage design and included in the profile of the storm sewer. In open channels, the HGL

is often controlled by the conditions of the sewer outfall. Therefore, the elevation of the tailwater pool must be known. The hydraulic gradient is constructed downstream from the upstream end, taking into account all of the head losses that may occur along the line. The gradient can then be adjusted to intersect at or above the gradient of the sewer outfall.

2) The friction head loss shall be determined by direct application of Manning's Equation. Minor losses due to turbulence at structures shall be determined.

3) The hydraulic grade line shall in no case be closer to the surface of the ground or street than 1 foot. Allowance of head must also be provided for future extensions of the storm drainage system.

d. Minor Losses

When establishing the hydraulic gradient of a storm sewer, minor head losses at points of turbulence shall be calculated and included in the computation of the hydraulic gradient. The following minor losses shall be accounted for in the storm sewer system design. Equations to determine these head losses are in *Appendix C: Hydraulic Equations*.

i) Entrance Losses

Entrance losses to a closed storm sewer system from an open channel or lake shall be calculated. The resulting hydraulic gradeline shall be compared to inlet control conditions for the storm sewer. The higher of the two values will be used as the controlling upstream hydraulic grade line.

ii) Expansion Losses

For locations within the storm sewer system where the pipe size increases expansion head loss shall be calculated.

iii) Manhole and Bend Losses

Head losses associated with manholes used for pipe direction changes and bends in pipes of equal diameter shall be calculated.

iv) Junction Losses

Head losses associated with wye connections or manholes with branch laterals entering the main line shall be calculated.

e. Open Channels and Conduits

Open channels may be used instead of enclosed systems when required flow is greater than 3-72" conduits. Open channels shall not be permitted when the flow is less than the capacity of 3-72" conduits.

2. Storm Sewer Laterals

Laterals for storm sewer systems shall be sized to control the flooding depth at the inlets. The depth shall not be closer to the surface of the ground or street than 1 foot. Calculation of the flooding depth shall be determined based on the addition of the velocity head of the lateral to the computed hydraulic grade line. See *Appendix C: Hydraulic Equations* for flooding depth equation for laterals.

3. Inlets

a. Inlet Placement

In cases where curbs are not used along paved streets, a drainage course must be provided to safely convey flows. Inlets are not required. The standards for permissible spread of water under Section J – Roads must be met.

1) Storm sewer inlets shall be built along paved streets at frequent enough intervals so that the 25-year storm does not exceed the top of curb.

2) Inlets shall be generally placed upstream of intersections. Surface drainage will be allowed to cross intersections of residential streets. However, only one street shall be crossed with surface drainage at any one intersection and this street shall be the lower classified street. Surface drainage must be intercepted prior to an intersection of collector or thoroughfare streets. No surface drainage will be permitted to cross a collector or thoroughfare street; therefore, valley gutters will not be permitted in collector or thoroughfare streets.

3) When an alley intersects a street, inlets shall be placed in the alley whenever flow down that alley would cause the capacity of the intersecting street to be exceeded.

4) When a driveway intersects a street, inlets shall be placed in the driveway whenever flow down that driveway would cause the capacity of the intersecting street to be exceeded.

5) An inlet shall be placed in the lowest corner of all backyard areas to remove storm flows from each residential lot.

b. Capacity and Size

1) The minimum inlet size shall be five-feet (5').

2) No more than 20 feet of inlets shall be placed along a gutter at any location.

3) Minimum lateral pipe size shall be eighteen-inches (18").

4) Where laterals tie into trunk lines, place the laterals on a sixty-degree (60°) angle with the trunk line. The lateral shall be connected to the trunk lines to match the soffet of the pipe.

Inlet sizing charts are provided in *Appendix E – Hydraulic Figures*.

c. Design

1) All storm drain inlets shall be designed in accordance with the latest State of Texas Department of Highways and Public Transportation Bridge Division Hydraulic Manual. Standards of the City of Blue Ridge will take precedence over the TxDOT manual in cases of conflict.

2) Recessed inlets shall be required on thoroughfare and collector streets.

3) A curb line inlet is to be used on all streets except thoroughfare and collectors.

4) Slotted drains, grate inlets will not be allowed unless approved by the City Engineer.

5) Combination inlets may be considered where physical geometry limits capacity and shall be appoved by the City Engineer.

6) Storm drains from streets that pass between houses to an outfall shall be designed to carry the 100-year flow.

4. Outfall

a. Flowline Elevations

The flow lines of storm sewer conduits that discharge into open channels shall match the flow line of the channel expect under the following conditions:

1) When a storm sewer discharges into a concrete-lined channel, the outlet must be below the top of the channel lining

2) When the outfall is submerged below the normal water surface of a lake or floodplain area. Under this condition, the storm sewer could discharge into a lined channel ditch that would convey runoff to the flow line of the channel without creating an erosive condition. Permissible velocities within the ditch will be based on the type of lining used and the velocities.

b. **Flumes.** Flumes to bring the discharge down to the flow line of earthen creeks shall not be permitted.

c. **Drop Structures.** Drop structures shall be allowed only upon the written approval of the City Engineer.

d. **Intersections with Creeks.**

1) The discharge pipe shall intersect minor creeks at an angle not to exceed 60-degrees, provided that channel banks are adequately protected from erosion concerns.

2) Pipes may intersect major creeks at an angle of 90-degrees, provided that the ratio of discharge in the creek versus the discharge in the pipe during the 100-year storm event is greater than 10. Erosion and safety concerns shall be incorporated into the design.

3) For all pipes intersecting major creeks, the design shall minimize erosion concerns and provide for the safety of citizens during storm events.

5. Manholes

a. Location

1) Manholes shall be located at intervals not to exceed 600 feet for pipe 24 inches in diameter or smaller.

2) Manholes shall preferably be located at street intersections, sewer junctions, and changes of grade and changes of alignment.

3) Manholes for sewers greater than 24 inches in diameter shall be located at points where design indicates entrance into the sewer is desirable; however, in no case should the distance between openings or entrances be greater than 1,200 feet.

b. Shape

Manholes shall be rectangular and as specified in the construction details of these standards.

6. Materials

Stormwater shall be carried in reinforced concrete pipe and shall be to the specifications given in *Appendix F – Material Specifications*. Other materials are not permitted unless prior approval is obtained from the City Engineer. *Appendix D –Hydraulic Tables* shows recommended roughness coefficients for various types of conduits. If, in the opinion of the design engineer, other values for the roughness coefficient should be used, the different value can be used with the permission of the City Engineer in writing. Appropriate notes showing the roughness coefficient shall be provided on the plans.

7. Installation

a. Storm Sewer Installation

1) Construction shall begin at downstream end of project and continue upstream with the pipe bell facing upstream. No upstream piping shall be installed before downstream piping unless approved by the City Engineer.

2) The amount of trench excavation shall not exceed 200 (two hundred) feet from the end of the pipe laying operations, and no more than 300 (three hundred) feet of total open trench will be allowed. At the end of each workday, all trench excavation shall be backfilled to the end of the pipe laying operation. Barricades and lights will be required around any open trench left overnight.

3) Approved plugs shall be installed at the open ends of the line at the end of each working day. All joints shall be assembled free of dirt and any foreign matter.

4) Water jetting of storm sewer trenches will only be allowed in sandy soils with the prior approval of the City Engineer. The jet pipe should be kept at least two (2) feet away from the pipeline to prevent the eroding of the embedment. Only that amount of water should be used which is necessary to consolidate the backfill. The jet ordinarily will consist of a pipe to which a two-inch diameter hose is attached at its upper end, utilizing conventional pipe fittings or swivel fittings. The jet pipe should not be less than 1-1/2 inch steel pipe and its length should be shorter than the depth of the lift of backfill to be compacted. It should be used with a continuous supply of water with a pressure sufficient to cause backfill displacement.

5) A density test shall be taken as required by the City Engineer. The density reports shall be submitted daily to the City's inspection division.

6) All density reports shall be completed and delivered to the City's inspector before paving is allowed to begin.

7) Concrete work for all structures shall conform to all requirements of ACI 301, Standard Specification for Structural Concrete, published by the American Concrete Institute, except as modified herein.

b. Extension Ring Installation

1) The number of extension ring sections shall be kept to a minimum (i.e. use 1-12" extension ring instead of 2-6" extension rings).

2) A 1" x 3-1/2" bitumastic gasket shall be used to seal the extension ring at both joints.

c. Storm Drainage Wyes

All storm sewer wyes shall be factory made unless authorized by the City Engineer or his representative.

J. Roads

1. Design Storm Frequencies

a. Urban Street Sections

Urban street sections must be designed to contain the 100-year storm event within the right-of-way. In cases where flooding will occur to existing buildings adjacent to the right-of-way or where traffic is severely impacted, the City reserves the right to require flows to be contained within the curb or at a level specified at the City Engineer's discretion.

b. Rural Street Sections

Rural street sections must be designed to contain the 25-year storm event in the borrow ditch and the 100-year event within the right-of-way.

2. Permissible Spread of Water

As water collects in the gutter and flows downhill, a certain portion of the roadway will be encroached by this flow. This spread of water on the roadway shall be limited to prevent the street from losing its effectiveness as a traffic carrier, which is an important concern in the case of emergency vehicles which may not be able to traverse an inundated roadway. The following table lists the allowable encroachment limits.

Street Classification	Allowable Encroachment
Residential	Maximum depth of 6 in. or top of curb (25-year storm). Limits of ROW (100-year storm).
Collector	One lane must remain open (100-year storm).
Thoroughfare	One lane of traffic in each direction must remain open (100-year storm).

3. Calculation of Flow in Gutters

The flow of stormwater in curb and gutter sections is classified as open channel flow. As such, the design calculations are based on a modified form of Manning's equation. A modification to the hydraulic radius term is required because the hydraulic radius is not suitable for describing the cross section. The modified Manning's equation to determine gutter discharge is included in *Appendix C – Hydraulic Equations.*

4. **Alleys**

a. The flow created by a 25-year storm shall be contained within the limits of pavement of all paved alleys. The 100-year storm flow shall be contained in the limits of the alley ROW.

b. Alleys shall be super-elevated as required at corners and curves to insure that flow remains in the paved alley section.

c. Design flow in alleys shall be calculated by using the same equation to calculate gutter flow for a straight crown calculated in two triangular sections.

K. Easements

1. Easements Required for Open Channels

a. General

1) Drainage and/or floodway easements for all open channels and flumes shall be dedicated to the City of Sherman.

2) No fences, buildings, or other structures which could impede flow shall be placed within this dedicated drainage easement. Existing fences shall be "grandfathered" (acceptable); however, once the fence is removed it cannot be replaced.

b. Minimum Widths.

1) Easements shall encompass all areas having a ground elevation below the higher of:
  a) one foot above the ultimate water surface elevation or
  b) the top of the high bank or channel edge.

This will allow the City access to all areas of the channel.

2) The easement shall also include at least a 10-foot wide maintenance strip along both sides of the channel or, if the City Engineer so allows, at least a 20-foot wide maintenance strip along one side of the channel. Streets, alleys, bike paths, etc., alongside the channel can serve as all or part of the maintenance easement.

3) Drainage easements for flumes shall be located with sufficient width to permit future maintenance accessibility, and in no case shall be less than 15 feet wide.

2. Easements for Enclosed Storm Sewers and Positive Overflow Areas

a. General

All storm sewer conduits are to be dedicated to the City of Sherman shall be located in an easement dedicated to the City at the time of final platting of the property.

b. Minimum Easement Widths

1) The easement shall be at least 15 feet wide for storm sewers or meet the

following requirements:

i) If the storm sewer line is less than 12-feet deep, the outside diameter of the storm sewer line shall be located a minimum distance of 6-feet from the edge of the easement, and if other utilities are located in the same easement., the outside diameter of the storm sewer line shall be located a minimum distance of 3-feet from the outside diameter of the other utilities.

ii) If the storm sewer line is greater than 12-feet deep, the outside diameter of the storm line shall be located a minimum distance of 9-feet from the edge of the easement. If other utilities are located in the same easement, the outside diameter of the storm sewer line shall be located a minimum distance of 6-feet from the outside diameter of the other utilities.

2) Special drainage easements on private property shall be a minimum of 10 feet wide or wider if the City Engineer requires it for maintenance or other purposes. No buildings or other structures and improvements shall be placed within these dedicated easements.

L. Utility Conflicts

With the hydraulic gradient established for a particular line, considerable latitude is available for the physical placement of the pipe flow line elevations. The inside top of the pipe must be on or below the hydraulic gradient, thus allowing the pipe to be lowered where necessary to maintain proper cover and to minimize grade conflicts with existing utilities.

a. **General.** In the design of a storm drainage system, the engineer is frequently confronted with the problem of intersections between the proposed storm drain and existing utilities such as water, gas and sanitary sewer lines.

b. **Water Lines.** All existing water lines in the immediate vicinity of the proposed storm drains shall be clearly indicated on both the plan and profile sheets. When design clearly indicates that an intersection of the storm drain line and the water main exists and the proposed storm drain cannot be economically relocated, then the existing water line shall be adjusted.

c. **Sanitary Sewers.** All existing or proposed sanitary sewers in the immediate vicinity of the proposed storm drains shall be clearly indicated on both plan and profile sheets. When design clearly indicates that an intersection of the storm drain line and the water main exists and the proposed storm drain cannot be economically relocated, then the existing sanitary sewer line shall be adjusted.

d. **Gas Lines and Other Utilities.** All existing gas lines and other utilities in the immediate vicinity of the proposed storm drain shall be clearly indicated on both the plan and profile sheets. Gas lines and other utilities, not controlled by elevation, shall be adjusted when the design clearly indicates that an intersection of the storm drain line and the utility exists and the proposed storm drain cannot be economically relocated.

V. Other Criteria

In addition to the requirements given in this standard, all other state and federal agency regulations, such as U.S. Army Corps of Engineers and TNRCC must be met. In some cases where channel areas are disturbed, mitigation may also be required.

SUBMITTALS

VI. Drainage Report Submittal

A. General

A Drainage Report is required to be submitted to the City Engineer for major channels and structures, or when all of the hydrologic and hydraulic calculations are not provided on the Construction Plans. A Drainage Report must be submitted to the City when a LOMR or CLOMR is required by FEMA.

B. Report Text

The report text shall include all methodology and references for all hydrologic and hydraulic calculations.

C. Report Appendix

The Appendix shall include all tables, figures, spreadsheets, and forms used in the analysis. The following are suggested appendices *as data is required* (some appendices may not apply) to assist with an efficient review:

Appendix A - General

- Vicinity Map
- Site Boundary

Appendix B - Hydrology

- Drainage Area Map
- Supporting Calculations and Figures for Current Conditions Hydrology (if required); for smaller drainage systems, hydrologic calculations may be submitted on plan sheets.
- Supporting Calculations and Figures for Post Project Conditions Hydrology
- Supporting Calculations and Figures for Ultimate Conditions Hydrology

Appendix C - Existing Hydraulics

- Figures and Tables
- Model Output (Current Conditions Hydrology – if required)
- Model Output (Post Project Conditions Hydrology)
- Model Output (Ultimate Conditions Hydrology)
- Profile Data
- Cross-Section Data

Appendix D - Post Project Hydraulics

- Figures and Tables
- Model Output (Post Project Conditions Hydrology)

- Model Output (Ultimate Conditions Hydrology)
- Profile Data
- Cross-Section Data

Appendix E – FEMA Information / Other

- FEMA Forms (if required)
- Other

Additional Appendices may be required, depending on site models required by FEMA (Duplicate Effective Models, Corrected Effective Models, Post Project Models)

VII. Specifications

A. Authority

For any specifications not covered by the City of Sherman's standards or specifications, the Standard Specifications for Public Works Construction, North Central Texas adopted by North Central Texas Council of Governments (NCTCOG) on February 24, 1983, with all amendments thereto, shall govern and shall constitute the City of Sherman's technical specifications except as herein amended or supplemented. They will be referred to as the Standard Specifications and will not be physically bound with the City's Design Criteria. Copies of the Standard Specifications may be obtained from the NCTCOG.

B. Submittal Specifications

Submittal specifications shall be submitted with construction plan sets for review by the City Engineer.

VIII. Construction Plans Submittals

A. General

The platting process consists of a Preliminary Plat Submittal and a Final Plat Submittal. Requirements for these submittals are as listed in the City Developer's Ordinance and approved before any private improvements are made.

After the platting process is complete, Construction Plans must be submitted to the City. The Final Plat may be submitted as part of the Construction Plans Submittal.

B. Construction Plans Submittal

The Construction Plans Submittal consists of Construction Plans and a Drainage Report. The plans and report shall be signed and sealed by a Licensed Professional Engineer in the State of Texas. The construction plans shall include the items given in this section.

1. Survey

Non-published survey data (i.e. new survey) shall by signed and sealed by a registered land surveyor (RLS). Benchmarks used in the survey shall be clearly listed in the plans. The signed and sealed copy of the survey data may be included in the Drainage Report instead of on the plans as part of the final submittal. All survey data used in floodplain delineation must meet FEMA requirements.

2. Roads

Drainage calculations for all roads must be provided on the plan sheets, or incorporated into the Drainage Report.

3. Drainage Area Map

a. General

1) A Drainage Area Map must be included in the plan set. Calculations for flow must be included in either the plan set or in the Drainage Report.

2) The Drainage Area Map must show the delineation of *on-site* basins, concentration points, and corresponding flows. *Off-site* basins must be shown in either the Drainage Report or in the Final Plans.

b. Rational Method Calculations

1) If the Rational Method is used to determine the flows, the plan sheet shall include a table that shows the following (or a note that references the Drainage Report name and date):

i) Drainage area designation (name) for each delineated basin

ii) Basin area, A

iii) Runoff coefficient, C (current and post-project conditions)

iv) Time of Concentration, Tc

v) Rainfall Intensity, I

vi) Discharge at each concentration point, Q (current and post-project conditions)

2) The plan sheet must show a concentration point for each basin and a flow arrow that depicts the direction of flow.

c. Developments near Major Drainage Corridors or with downstream drainage corridors of sufficient capacity to carry ultimate flows

Detention is not required for these sites.

Major Drainage Corridors are those considered under the Jurisdiction of FEMA. Information is available for these corridors in the City of Sherman Master Drainage Plan.

For the drainage watercourse between the site and the major drainage corridor (the area downstream of the site and upstream of the major waterways), a capacity analysis must be shown on the plans (or in a drainage report) showing that there is adequate capacity to safely convey flows in this area. Otherwise, detention is required.

d. Developments where downstream drainage corridors cannot convey ultimate flows

Detention is required for these sites. The following information is required on the drainage area map submittal or in a drainage report:

1) Calculations showing detention required

2) Allowable release (current flows)

3) Calculations showing release without detention (post-project before detention)

4) Calculations showing release with detention (post-project with detention)

5) Downstream capacity shall be considered adequate whenever the top of curb is not exceeded by the flows resulting from the new development.

6) A developer shall be responsible for detaining the increased flow solely from his development.

4. Culverts

The following information shall be submitted in either the Construction Plans or the Drainage Report for all culverts:

a. Profile of culvert
b. Culvert size
c. Required discharge
d. Design discharge
e. Headwater elevation
f. Tailwater surface elevation
g. Upstream invert
h. Downstream invert

5. Bridges

The following information shall be submitted in either the Construction Plans or the Drainage Report for all bridges:

a. Profile of culvert
b. Culvert size
c. Required discharge
d. Design discharge
e. Headwater elevation
f. Tailwater surface elevation
g. Upstream invert
h. Downstream invert

6. Open Channels

The following information shall be provided for each section of open channel in either the Construction Plans or the Drainage Report:

a. Description of segment location

b. Length of segment
c. Geometry of segment
d. Required discharge
e. Design discharge
f. Slope of hydraulic gradient
g. Upstream hydraulic gradient elevation
h. Downstream hydraulic gradient elevation
i. Velocity
j. Upstream invert
k. Downstream invert

7. Storm Sewer

The following information shall be submitted for storm sewers on the plan set:

a. Description of pipe location (i.e., from which manhole or inlet to which manhole or inlet)
b. Length of pipe
c. Required discharge
d. Pipe size
e. Slope of hydraulic gradient
f. Upstream hydraulic gradient elevation
g. Downstream hydraulic gradient elevation
h. Inflow velocity
i. Outflow velocity
j. Sum of minor losses through the pipe section
k. Hydraulic gradient elevation at design point
l. Incoming pipe invert elevation at design point
m. Outgoing pipe invert elevation at design point

8. Laterals

The following information shall be submitted for storm sewer laterals either on the plan set or with a note referencing the drainage report by name and date.

a. Description of pipe location (to what inlet)
b. length of pipe
c. required discharge
d. pipe size
e. slope of hydraulic gradient
f. upstream hydraulic gradient elevation
g. downstream hydraulic gradient elevation
h. upstream pipe invert elevation of lateral
i. downstream pipe invert elevation of lateral

9. Inlets

The following information shall be submitted for inlets on the plan set or with a note referencing the drainage report by name and date.

a. Inlet number
b. Description of inlet location (where along street)
c. Design storm frequency
d. Time of concentration (Tc)
e. Rainfall intensity (I)
f. Runoff coefficient (C)
g. Area contributing runoff (A)
h. Discharge at inlet
i. Carryover flow from upstream inlets
j. Street capacity
k. Gutter slope
l. Length of inlet
m. Inlet capacity per foot
n. Flow captured by inlet
o. Percent intercepted flow
p. Flow that passes by inlet
q. Pipe sizes in and out of inlet
r. Hydraulic gradient at inlet

s. Elevation of gutter at inlet

t. Elevation of top of curb

u. Upstream pipe invert elevation at inlet

v. Downstream pipe invert elevation at inlet

10. Outfall

The following information shall be submitted for storm sewer outfalls on the plan set or with a note referencing the drainage report by name and date.

a. Description of outfall location

b. 100 year water surface elevation at outfall

c. Description of outfall stream dimensions

d. Maximum allowable velocity of outfall stream

e. Maximum capacity of outfall stream

11. Materials

All material to be used in construction of the storm drain system shall be specified either in the General Notes of the Construction Plans or on the plan and profile sheets.

12. Easements

a. All utility easements and right-of-ways must be clearly identified on the plans.

b. The width of all easements and right-of-ways shall be clearly shown on the plans.

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APPENDICES

Appendix A

Step 1. preliminary work

The City has adopted these drainage standards to assist with the orderly and safe development of property within the city. These "Step by Step" guidelines are included to assist the owner or developer with complying with all City requirements.

Step 1a. Visit City offices and obtain the following:

- FEMA map for your property
- Copy of the drainage planning study called "The City of Sherman Drainage Master Plan" (original study adopted in early 2001). Please check for updates. The city engineer can assist you with this information.

Step 1b. Evaluate the FEMA information.

- For the FEMA map, determine if there are any FEMA floodplains on your property. There are some areas within the city where land is identified in a floodplain but the floodplain limits have not been determined (Zone A). The City is working with FEMA to get these areas mapped. If your property is within one of these areas, you have several options for development of your land, described in Step 2 below.

Step 1c. Evaluate the planning study information. The information from the study pertains to major drainage corridors within the city. For local site drainage, skip to "step 2 - design".

- From the Drainage master plan, determine the information relating to your property, including major corridor flows and the ultimate floodplain (if applicable).
- You will need to depict this information during the platting process.

Appendix A

Step 2. design

The detailed standards for design of drainage facilities within the City can be found in the preceding sections of this design manual. However, the following is provided to give a brief synopsis of the design guidelines within the city.

Step 2a. Identify drainage paths and major corridors. From step 1b (above), if the FEMA map shows part of your property in a floodplain, then you have a major corridor crossing your property. Go to step 2c. If you do not have a FEMA floodplain on your land, go to step 2b.

Step 2b. Read the following if you have NO FEMA floodplains on your property:

When it rains, if water comes onto your land from other property, you must quantify what this amount of water will be for a 100-year event at ultimate development and safely convey this water around any structures on your property.

If there is no water coming onto your property from any other property, then proceed directly to Step 2d.

The equation used to determine the amount of water from upstream land is called the Rational Equation (assuming the amount of land upstream is less than 200 acres at any one "infall" point). For directions on how to use the rational equation, see Section II - Runoff Methods of this design manual.

Since you are not in a mapped FEMA floodplain, runoff from other property onto your land will probably be relatively small. However, you must ensure that this water is safely conveyed throughout your property, and that you are not altering the historical path of the water.

Go to Step 2d.

Step 2c. If you DO have FEMA floodplains on your property, the following applies:

1) When developing your property, you must follow all FEMA requirements

2) The city has identified ultimate "projected" floodplain corridors in the master Drainage Plan study (originally dated August 2000). In developing your property, if you remain outside of the ultimate "projected" floodplain on your property, then you have met city requirements. The ultimate and current floodplains must be shown on the final plat submitted to the city for review and approval.

3) In some cases the property owner may wish to grade within the floodplain. As such, the city's standards are to allow development to occur within the ultimate floodplain, but not within the current floodplain (as defined by FEMA at the time of development).

In most cases the FEMA floodplain is identified within the city. If you fall within a zone where the land is identified as being in the floodplain, but the exact limits of the current floodplain have not been determined (for example, Zone A), then you have several choices:

- The city is currently working with FEMA to model the unstudied creeks within the city. This is a lengthy process, and guarantees cannot be made as to when all of the creeks within the city will be studied. As the property owner, you can wait to develop within the ultimate floodplain until the creek on your property is studied and the exact current floodplain limits are identified.

- A second option is to hire a civil engineer to map the limits of the current and ultimate floodplains (and to ensure Step 2d below).

Step 2d. In addition to all of the above, as a property owner you must do the following:

- In ALL CASES, if you are encroaching on the ultimate floodplain in any way, you **must show that the current floodplain is not impacted.** All FEMA requirements must be met. In addition, you must show that the ultimate water surface elevation is not increased after development. If you fill within the ultimate floodplain you will need to excavate in the overbanks of the current floodplain or within another portion of the ultimate floodplain. In some cases, the city will not allow excavation within the current floodplain (depending on safety or aesthetic concerns). If you modify the current floodplain you must submit a CLO:MR and LO:MR to FEMA. A plan must be submitted to the city engineer for approval.

- Convey water safely on your property (whether from upstream properties 111 any direction, or from onsite)

- Discharge the water from your site in the same "historical" locations as prior to development (unless there is a new "water corridor" identified by the city). A new corridor would be identified by the city in cases where there is an existing flooding problem, and the city has built a new corridor to help alleviate flooding problems.

Note to the property owner: Texas water law states that you cannot develop your property such that it floods downstream property that was not previously flooded (or increase the flooding problem on a property that is already being flooded). As such, you must either discharge into a waterway that can handle your increase in flows from your property, or detain the water that is "increased" by development of your property. It is the city's primary goal regarding drainage to minimize the risk of flooding throughout the city. It is the owner's responsibility to ensure that water is safely conveyed throughout their property. These drainage standards are provided as a 'level of standard' within the city; however, they do not ensure that a property will not be flooded during a certain rainstorm event.

Appendix A

Step 3. submittals

There are three possible submittal requirements, depending on the "level" of drainage on the site:

- Drainage Study
- Specifications
- Construction Plans

Drainage Study

A drainage study is a text bound report that must be submitted if the information regarding drainage for the site cannot be displayed in it's entirety on the construction plans. In most cases, this would pertain to a site where a FEMA floodplain exists and modifications are proposed in the ultimate floodplain.

Specifications

Specifications are bound in a report and consist of line items pertaining to construction items. These are required to be submitted to the City if you are receiving construction bids for your development or renovation.

Construction Plans

Construction plans are submitted to the City:

A simplified form of construction plans may be submitted for homeowners who are performing their own drainage work. The intent is for the City to understand how the water is conveyed on the property and to ensure that it is carried in a safe manner.

Appendix A

Step 4. approval process

The City Engineer shall coordinate the review process. The City encourages landowners, developers, and engineers to meet with the City prior and after submittals. The City believes these meetings will help expedite reviews and facilitate communication between the parties. The City is committed to completing reviews in a timely process and looks forward to working with its citizens as the city continues to develop.

Step 5. construction

The city assigns inspectors during the construction process. For more information regarding requirements and working with the City, contact the Office of Public Works and Engineering.

Appendix B: Hydrology Tables and Figures

Design Storm Frequencies

Rational Method, Runoff Coefficient "C"

Tc Graph for Sheet Flow (Upland Method)

Tc Graph for Shallow Concentrated Flow

City of Sherman IDF Curve

SCS Curve Numbers

Appendix B

Design Storm Frequencies

The design storm frequencies for various drainage structures are given below:

Drainage Facility	Minimum Design Recurrence Interval
Street - Urban sections	100-year within the ROW
Street - Rural sections	25-year in the borrow ditch and 100-year within the right-of-way
Closed storm sewer systems	25-year, plus 100-year positive overflow and inlets at a street low point or swale assuming no conveyance from the sump storm sewer or such that requirements are not for the street.
Culverts and bridges	100, 50, 25-year depending on street classification
Channels	100-year

The City requires that sites be developed to the 100-year ultimate conditions. FEMA requires that models be submitted that represent current or post-project conditions.

The design storm frequencies for storm sewers is a minimum of 25-year, plus 100-year positive overflow and inlets at a street low point.

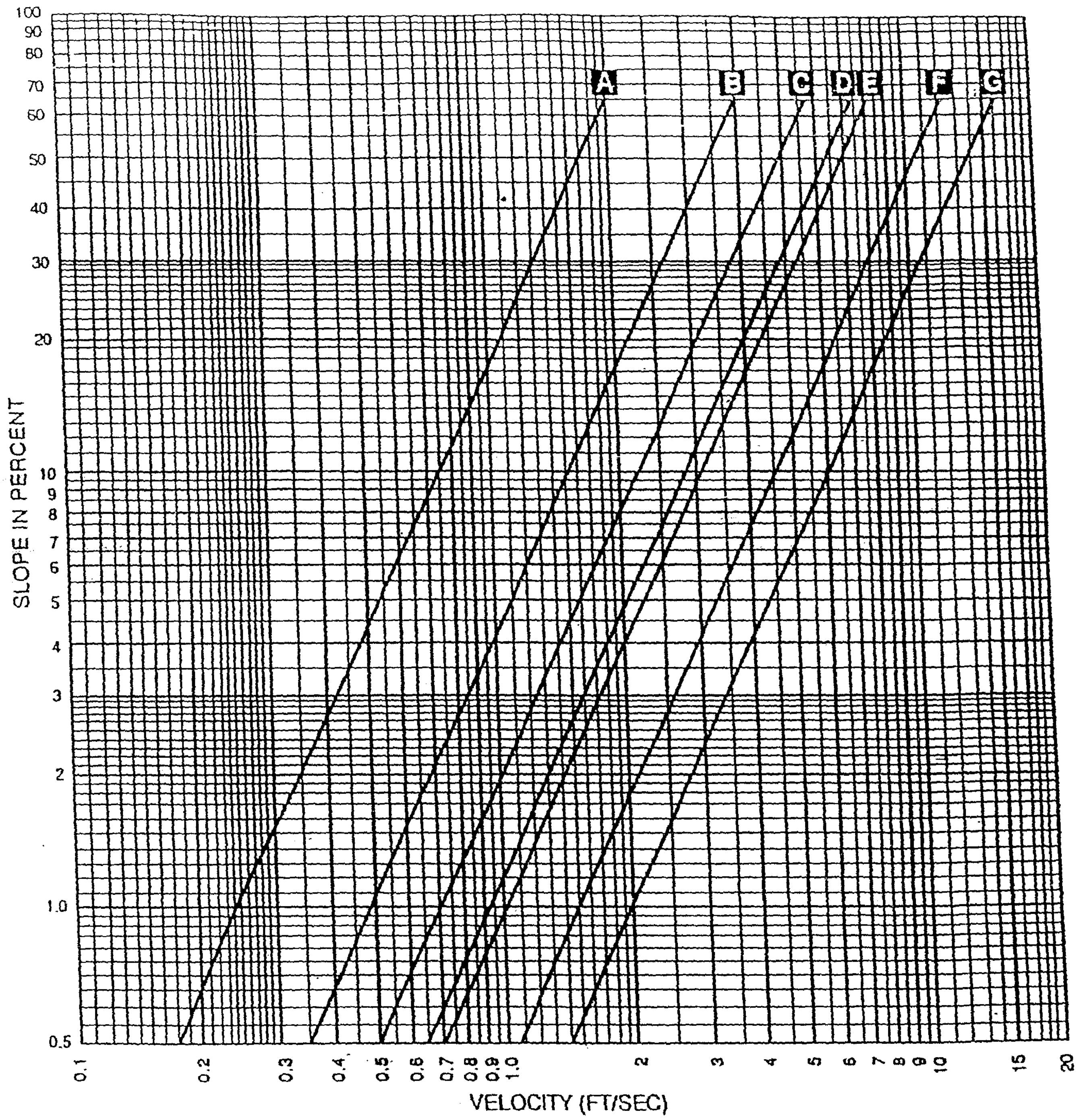
In urban sections, the depth of flow in the streets shall not exceed the limits of the ROW for the 100-year storm.

Appendix B

Runoff Coefficient Values for "C"

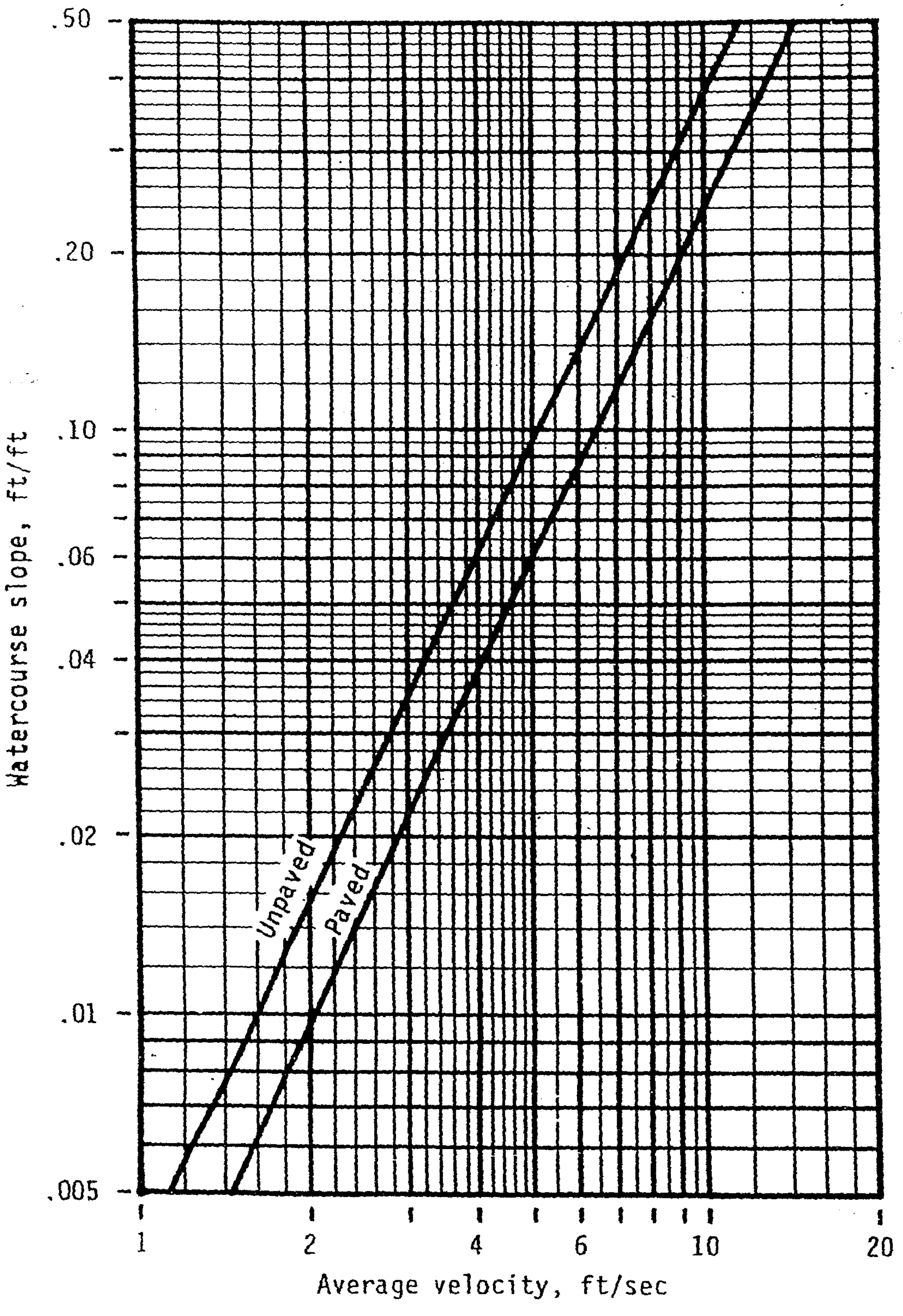
Runoff coefficients shall be applied to current and developed conditions as outlined below. Interpretation of "C" values for a questionable zoning or land use application is at the discretion of the City Engineer.

Land Use	Runoff Coefficient
Park areas - No developed land	0.30
Developed park sites	0.40
Single family residential	0.55
Duplex	0.60
Multiple family	0.70
Schools	0.70
Churches	0.75
Local Business	0.75
Central Business	0.85
Commercial	0.85
Industrial	0.85



A Forest with heavy ground litter & hay meadow (overland flow)
B Trash fallow or minimum tillage cultivation; contour or strip cropped & woodland (overland flow)
C Short grass pasture (overland flow)
D Cultivated, straight row (overland flow)
E Nearly bare and untilled (overland flow); alluvial fans western mountain regions
F Grassed waterway
G Paved area (sheet flow); small upland gullies

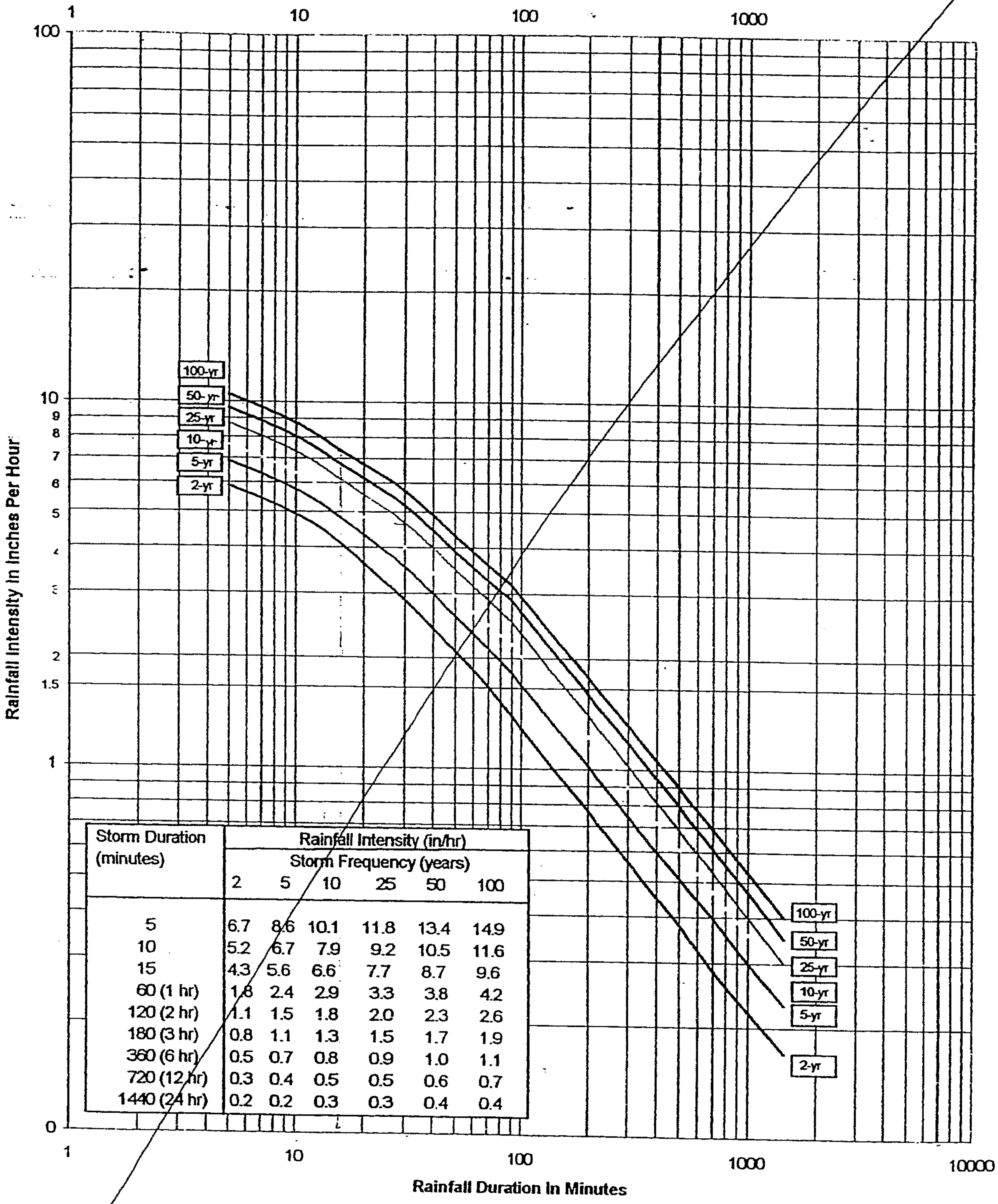
Overland Flow Velocities for Upland Method of Estimating T



–Average velocities for estimating travel time for shallow concentrated flow.

Do not use

Appendix A
Intensity - Duration - Frequency Curve
City of Sherman



Storm Duration (minutes)	Rainfall Intensity (in/hr)					
	Storm Frequency (years)					
	2	5	10	25	50	100
5	6.7	8.6	10.1	11.8	13.4	14.9
10	5.2	6.7	7.9	9.2	10.5	11.6
15	4.3	5.6	6.6	7.7	8.7	9.6
60 (1 hr)	1.8	2.4	2.9	3.3	3.8	4.2
120 (2 hr)	1.1	1.5	1.8	2.0	2.3	2.6
180 (3 hr)	0.8	1.1	1.3	1.5	1.7	1.9
360 (6 hr)	0.5	0.7	0.8	0.9	1.0	1.1
720 (12 hr)	0.3	0.4	0.5	0.5	0.6	0.7
1440 (24 hr)	0.2	0.2	0.3	0.3	0.4	0.4

SCS Curve Numbers

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

---

[1] Average runoff condition, and I_a = 0.2S.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

SCS Curve Numbers

Table 2-2b.—Runoff curve numbers for cultivated agricultural lands[1]

Cover description			Curve numbers for hydrologic soil group—			
Cover type	Treatment[2]	Hydrologic condition[3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

---

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Crop residue cover* applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydrologic condition is based on combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

SCS Curve Numbers

Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	[4]30	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	[4]30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

[3] *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4] Actual curve number is less than 30; use CN = 30 for runoff computations.

[5] CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6] *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Appendix C: Hydraulic Equations

Manning's & Continuity Equations

Superelevation of Water

Gutter Discharge

Weir Equations

Minor Headloss Equations

Lateral Flooding Depth

Froude Number

Note: The following equations will assist in calculations required in storm sewer and open channel design. In addition to these equations there are numerous computer programs that may be used to do the calculations required for designing storm sewer systems.

Appendix C

Manning's Equation

Following is Manning's Equation:

$$Q = \frac{1.486}{n} A R^{2/3} S_f^{1/2} \qquad (6)$$

where,
Q = Total discharge (cfs)
n = Coefficient of roughness (Manning's n)
A = Cross-section area of channel (sq.ft.)
$R = A/P$ = Hydraulic radius of channel (ft)
P = Wetted perimeter (ft)
S_f = Slope of the frictional gradient (ft/ft)

Continuity Equation

Following is the Continuity Equation:

$$Q = V A \qquad (7)$$

where,
Q = Total discharge (cfs)
V = Velocity (ft/s)
A = Cross-section area of channel (sq.ft.)

Combined Manning's Equation and Continuity Equation

The two equations can be combined to solve for Velocity:

$$V = \frac{1.486}{n} R^{2/3} S_f^{1/2} \qquad (5)$$

Appendix C

Height of Superelevation of Water In a Bend

An equation that can be used to determine the height of the superelevation of the water (Reference 13) is:

$$H_s = \frac{c\,V^2\,w}{g\,r}$$

where

H_s = height of superelevation of the water around the bend (ft)
c = coefficient, see table below
V = velocity around the bend (ft/s)
w = top width of flow (ft)
g = gravity constant, (32.2 ft/s^2)
r = radius of the bend (ft)

Table for Coefficient, c

Flow type	Channel Cross-section	Type of Curve	Value of c
Tranquil	Rectangular	Simple circular	0.5
Tranquil	Trapezoidal	Simple circular	0.5
Rapid	Rectangular	Simple circular	1.0
Rapid	Trapezoidal	Simple circular	1.0
Rapid	Rectangular	Spiral transitions	0.5
Rapid	Trapezoidal	Spiral transitions	1.0
Rapid	Rectangular	Spiral banked	0.5

Appendix C

Gutter Discharge

For streets with straight crowns, the gutter section will resemble a triangular channel. The equation to determine gutter discharge is as follows:

$$Q = 0.56\left(Z/n\right)(S^{1/2})(Y^{8/3})$$

Where:

Q = gutter discharge (cfs)
Z = reciprocal of the crown slope (ft/ft)
S = longitudinal street or gutter slope (ft/ft)
n = roughness coefficient
Y = depth of flow at curb (ft)

Manning's n for Gutters

The following table includes various values for the roughness coefficient ("n" values) for use in the gutter discharge equation.

Type of Gutter	**Manning's n**
Concrete gutter with asphalt pavement rough	0.015
Concrete pavement broom finish	0.016

Appendix C

Weir Equations

Broad Crested Weirs

Discharge over broad-crested weirs can be expressed by the equation:

$$Q = C_B L H^{3/2}$$

where

Q = discharge, cfs

C_B = coefficient, below

L = length of weir, ft

H = height of water over weir, ft

Broad Crested Weir Coefficient C_B

Measured head in feet, H	Breadth of crest of weir in feet										
	0.5	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	10	15
0.2	2.80	2.75	2.69	2.62	2.54	2.48	2.44	2.38	2.34	2.49	2.68
0.4	2.92	2.80	2.72	2.64	2.61	2.60	2.58	2.54	2.50	2.56	2.70
0.6	3.08	2.89	2.72	2.64	2.61	2.60	2.68	2.69	2.70	2.70	2.07
0.8	3.30	3.04	2.85	2.68	2.60	2.67	2.68	2.68	2.68	2.69	2.64
1.0	3.32	3.14	2.98	2.75	2.66	2.64	2.65	2.67	2.68	2.68	2.63
1.2	3.32	3.20	3.08	2.86	2.70	2.65	2.64	2.67	2.66	2.69	2.6
1.4	3.32	3.26	3.20	2.92	2.77	2.68	2.64	2.65	2.65	2.67	2.64
1.6	3.32	3.29	3.28	3.07	2.89	2.75	2.68	2.66	2.65	2.64	2.63
1.8	3.32	3.32	3.31	3.07	2.88	2.74	2.68	2.66	2.65	2.64	2.63
2.0	3.32	3.31	3.30	3.03	2.85	2.76	2.72	2.68	2.65	2.64	2.63
2.5	3.32	3.32	3.31	3.28	3.07	2.89	2.81	2.72	2.67	2.64	2.63
3.0	3.32	3.32	3.32	3.32	3.20	3.05	2.92	2.73	2.66	2.64	2.63
3.5	3.32	3.32	3.32	3.32	3.32	8.19	2.97	2.76	2.68	2.64	2.63
4.0	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.70	2.64	2.63
4.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	2.88	2.74	2.64	2.63
5.0	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.64	2.63
5.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	2.88	2.64	2.63

Appendix C

V-Notch Weirs

Discharge over a V-notch weir can be expressed by the equation

$$Q = C_1 \tan \frac{\theta}{2} H^{5/2}$$

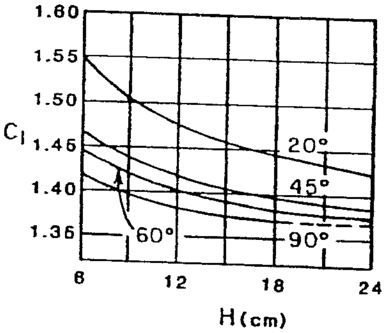
where,

Q = discharge, cfs

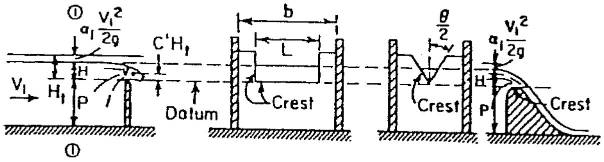
C_1= coefficient, see graph below

θ = Vertex

H = height of water over weir



Coefficients, V-notch sharp-crested weirs.



(*a*) Section through sharp-crested weir

(*b*) Horizontal crested weir L/b < 1

(*c*) V-notch weir

(*d*) Round-crested weir

Appendix C

Lateral Flooding Depth

The flooding depth for lateral shall be based on the following equation;

$$ELEV = HGL + \frac{V_2}{2g} + L\left(\frac{nV}{(1.486)R^{2/3}}\right)^2$$

Where: ELEV = Flooding depth for storm sewer lateral (ft)

HGL = Hydraulic grade line elevation for inlet at downstream end of lateral (ft)

V = Velocity in lateral (ft/s)

g = Gravitational constant (32.2 ft/s^2)

n = Roughness coefficient

R = Hydraulic radius (ft)

L = Length of lateral (ft)

Appendix C

Froude Number

The Froude Number can be calculated using the following equation

$$Fr = \frac{V}{(gy)1/2}$$

Where:

Fr = Froude Number

V = Velocity (ft/s)

g = Gravitational constant (32.2 ft/s^2)

y = Depth of flow (ft)

The Froude Number is used to define the flow regime. The following table gives regime type based on Froude Number and range for design purposes.

Flow Regime	Fr	Fr for design
Subcritical	Fr<1	Fr<0.86
Critical	Fr=1	NA
Supercritical	Fr>1	Fr Number as great as possible (to avoid hydraulic jump); Designing channels within supercritical flow is to be avoided whenever possible.

Appendix D: Hydraulic Tables

Manning's n

Minimum Slopes for Concrete Pipes

Maximum Permissible Velocities in Conduits Flowing Full and Channels

Entrance Loss Coefficients

Junction or Structure Loss Coefficients

Headloss Coefficients due to Sudden Expansions and Contractions

Appendix D

Manning's n for Channels

Reference Source: 2

Channel Description	Coefficient of Roughness "n"
MINOR NATURAL STREAMS	
Fairly regular section	
Some grass and weeds; little or no brush	0.030
Dense growth of weeds, depth of flow materially greater than weed height	0.035
Some weeds, light brush on banks	0.035
Some weeds, heavy brush on banks	0.050
Some weeds, dense willows on banks	0.060
For trees within channels with branches submerged at high stage, increase all values above by	0.010
Irregular section with pools, slight channel meander, use A1 to A5 above, increase all values by	0.010
Flood Plain - Pasture	
Short grass	0.030
Tall grass	0.035
Flood Plain - Cultivated Areas	
No crop	0.030
Mature row crops	0.035
Mature field crops	0.040
Flood Plain - Uncleared	
Heavy weeds, scattered	0.050
Wooded	0.120

Appendix D

Manning's n for Channels

Channel Description	Coefficient of Roughness "n"
MAJOR NATURAL STREAMS	
Roughness coefficient is usually less for major streams than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of "n" for larger streams of mostly regular Sections, with no boulders or brush may be in the range from	0.028 to 0.033
UNLINED VEGETATED CHANNELS	
Clays (Bermuda Grass)	0.035
Sandy and Silty Soils (Bermuda Grass)	0.035
UNLINED NON-VEGETATED CHANNELS	
Sandy Soils	0.030
Silts	0.030
Sandy Silts	0.030
Clays	0.030
Coarse Gravel	0.030
Shale	0.030
Rock	0.025
LINED CHANNELS	
Neat Concrete	0.015
Riprap (Broken Concrete & Rubble)	0.030

Appendix D

Manning's n for Conduits

Concrete Pipe Storm Sewer	.013
Concrete Pipe Culverts	.013
Monolithic Concrete Culverts	.013
Corrugated Metal	.024
Corrugated Metal Pipe (Smooth Lined)	.013

Appendix D

MINIMUM SLOPES FOR CONCRETE PIPES

to produce a velocity of 2.5 fps or greater

Pipe Diameter (inches)	Slope (Feet/100 Feet)	Pipe Diameter (inches)	Slope (Feet/100 Feet)
18	.180	42	.056
21	.150	45	.052
24	.120	48	.048
27	.110	51	.045
30	.090	54	.041
33	.080	60	.036
36	.070	66	.032
39	.062	72	.028

Appendix D

MAXIMUM VELOCITIES IN CONDUITS FLOWING FULL AND CHANNELS

	Maximum Flow Velocity (fps)
Culverts	15
Inlet Laterals	10
Storm Sewers	12.5
Earthern Channels	6
Concrete Channels	15

Appendix D

ENTRANCE LOSS COEFFICIENTS

$$\text{Entrance head loss } HL = K_e \frac{V_1^2}{2g}$$

Type of Structure and Design of Entrance	Coefficient K_e
Concrete Pipe	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, square cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radius = 1/12D)	0.2
Metered to conform to fill slope	0.7
End-section conforming to fill slope	0.5
Beveled edges, 33.7 or 45 bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe or Pipe-Arch Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edged	0.5
Metered to conform to fill slope, paved or unpaved slope	0.7
End-section conforming to fill slope	0.5
Beveled edges. 33.7 or 45 bevels	0.2
Side- or slope-tapered inlet	0.2
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 or beveled on 3 sides	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 dimension, or beveled top edge	0.2
Wingwall at 10 to 25 to barrel	
Square-edged at crown	0.5
Wingwall parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

Appendix D

Junction or Structure Loss Coefficients

Description of Condition	K_j
Inlet on Main Line	0.50
Inlet on Main Line with Lateral	0.25
Manhole on Main Line with 22-1/2° Lateral	0.75
Manhole on Main Line with 45° Lateral	0.50
Manhole on Main Line with 60° Lateral	0.35
Manhole on Main Line with 90° Lateral	0.25
45° Wye Connection or Cut-in	0.75
Inlet or Manhole at Beginning of Line	1.25

The following head loss coefficients for bends in storm sewers are for pipes with diameters of 48-inches or less. For storm sewers with diameters greater than 48-inches the momentum equation should be used to determine head loss.

Conduit on Curves	K_b Radius of Pipe Bend			
	90°	60°	45°	22.5°
Pipe radius = diameter	0.50	0.43	0.35	0.20
Pipe radius = 2 to 8 diameter	0.25	0.21	0.18	0.10
Pipe radius = 8 to 20 diameter	0.40	0.34	0.28	0.16

Appendix D

Head Loss Coefficients Due To Sudden Enlargements and Contractions

D_2/D_1*	Sudden Contractions K_j
1.2	0.08
1.4	0.18
1.6	0.25
1.8	0.33
2.0	0.36
2.5	0.40
3.0	0.42
4.0	0.44
5.0	0.45
10.0	0.46
∞	0.47

*D_2/D_1 = Ratio of larger to smaller diameter.

The values of the coefficient "K_j" for determining the loss of head due to obstructions in pipes are shown below and the coefficient is used in the following equation to calculate the head loss at the obstruction:

$$HL = K_j \frac{{}^{V}2^{2}}{2g}$$

Head Loss Coefficients Due To Obstructions

A/A_o*	K_j	A/A_o*	K_j
1.0	0.10	3.0	15.0
1.0	0.21	4.0	27.3
1.2	0.50	5.0	42.0
1.4	1.15	6.0	57.0
1.6	2.40	7.0	72.5
1.8	4.00	8.0	88.0
2.0	5.55	9.0	104.0
2.2	7.05	10.0	121.0
2.5	9.70		

* A/A_o Ratio of area of pipe to area of opening at obstruction.

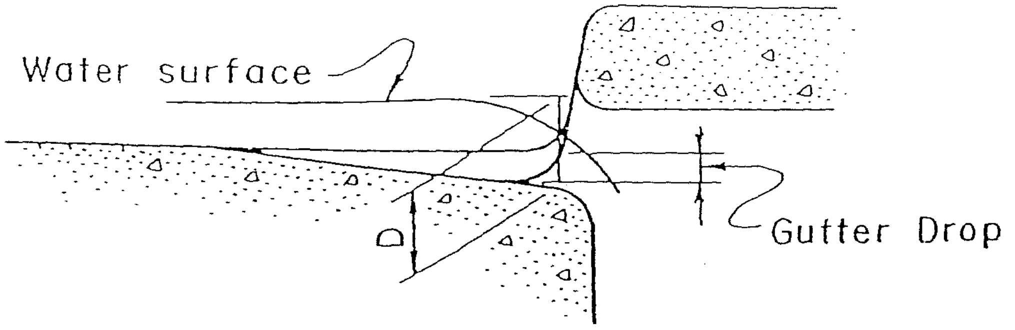
Appendix E: Hydraulic Figures

Inlet Capacity for Low Point Inlets

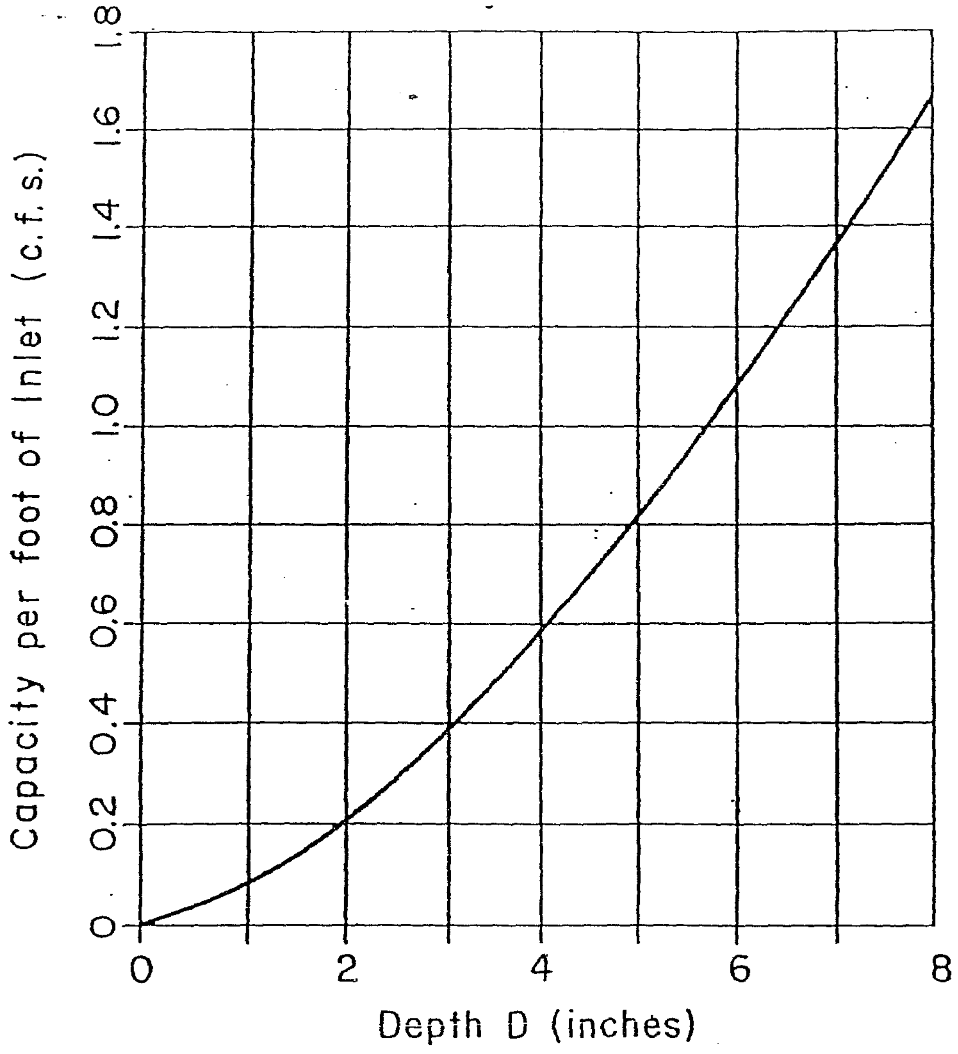
Inlet Capacity for On-Grade Inlets

Ratio of Intercepted to Total Flow Inlets on Grade

Culvert Design Charts



SECTION



INLET CAPACITY
FOR
LOW POINT INLETS

Figure 11

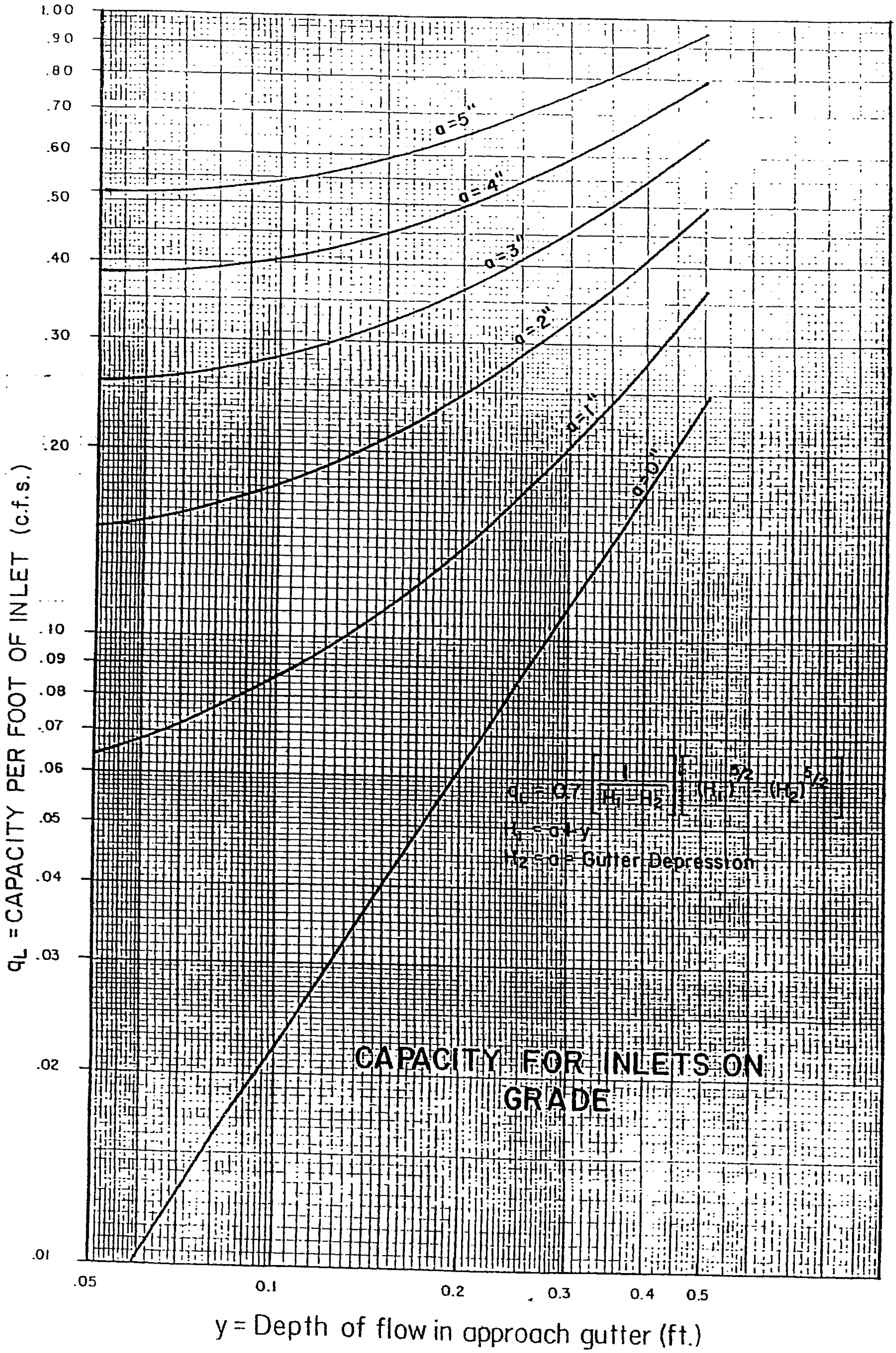

CAPACITY FOR INLETS ON GRADE
$q_L = 0.7 \left[\frac{1}{H_1 - H_2}\right]\left[(H_1)^{5/2} - (H_2)^{5/2}\right]$
$H_1 = a + y$
$H_2 = a$ = Gutter Depression
a=5"
a=4"
a=3"
a=2"
a=1"
a=0"
q_L = CAPACITY PER FOOT OF INLET (c.f.s.)
y = Depth of flow in approach gutter (ft.)
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
.05
0.1
0.2
0.3
0.4
0.5

Figure 9

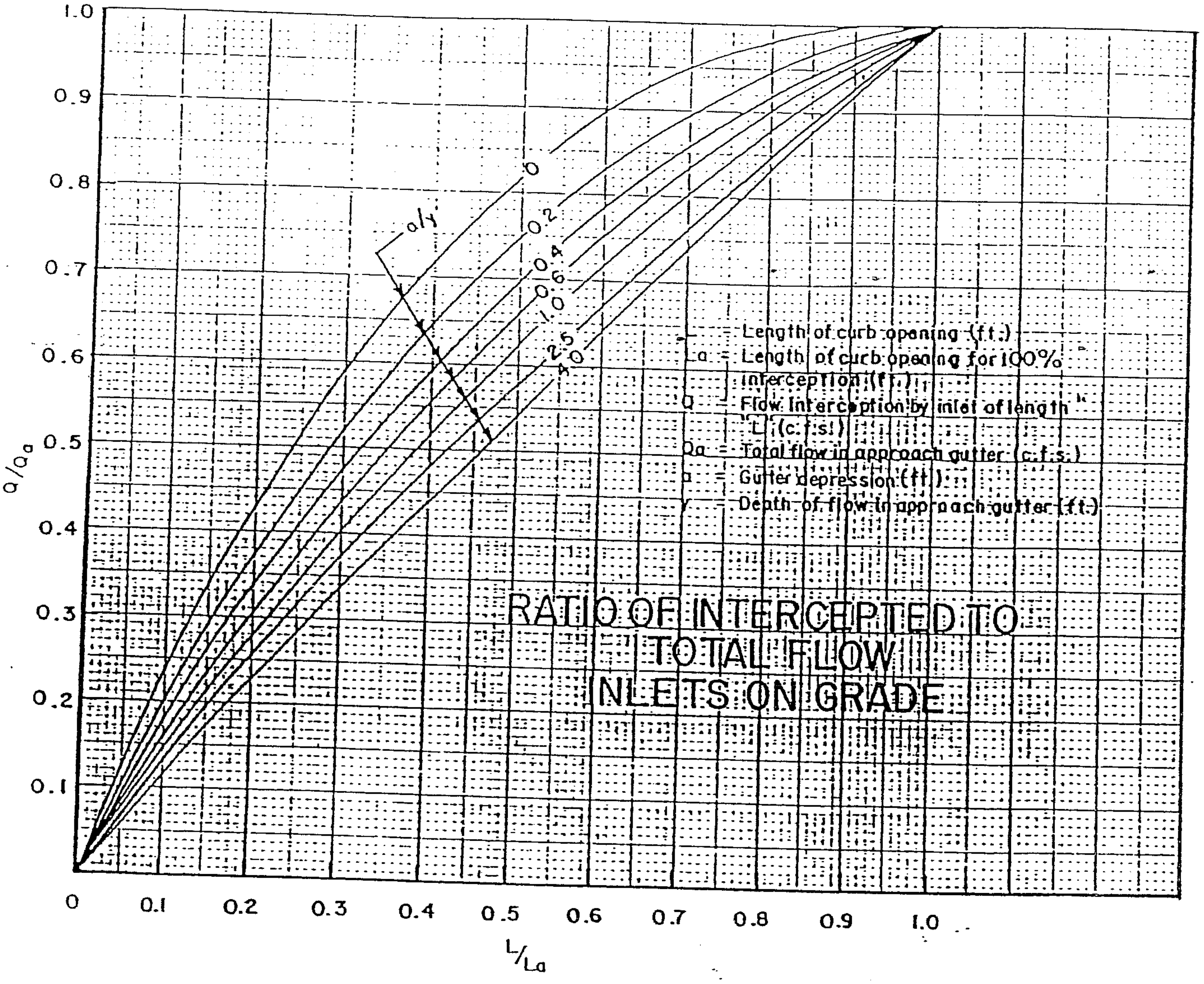
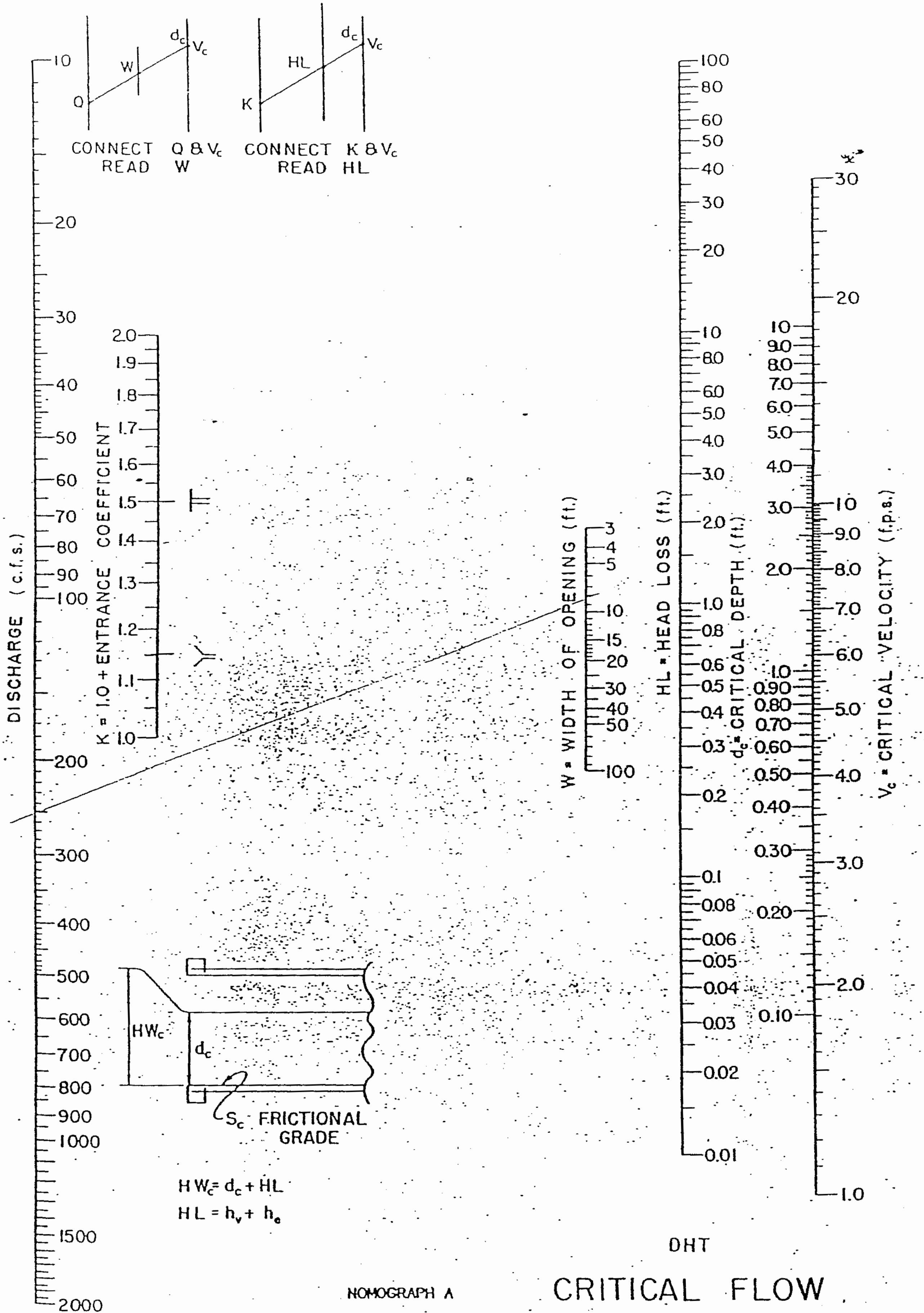

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Q/Qa
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
L/La
a/y
0
0.2
0.4
0.6
1.0
2.5
4.0
L = Length of curb opening (ft.)
La = Length of curb opening for 100% interception (ft.)
Q = Flow interception by inlet of length "L" (c.f.s.)
Qa = Total flow in approach gutter (c.f.s.)
a = Gutter depression (ft.)
y = Depth of flow in approach gutter (ft.)
RATIO OF INTERCEPTED TO
TOTAL FLOW
INLETS ON GRADE

Figure 10



$HW_c = d_c + HL$

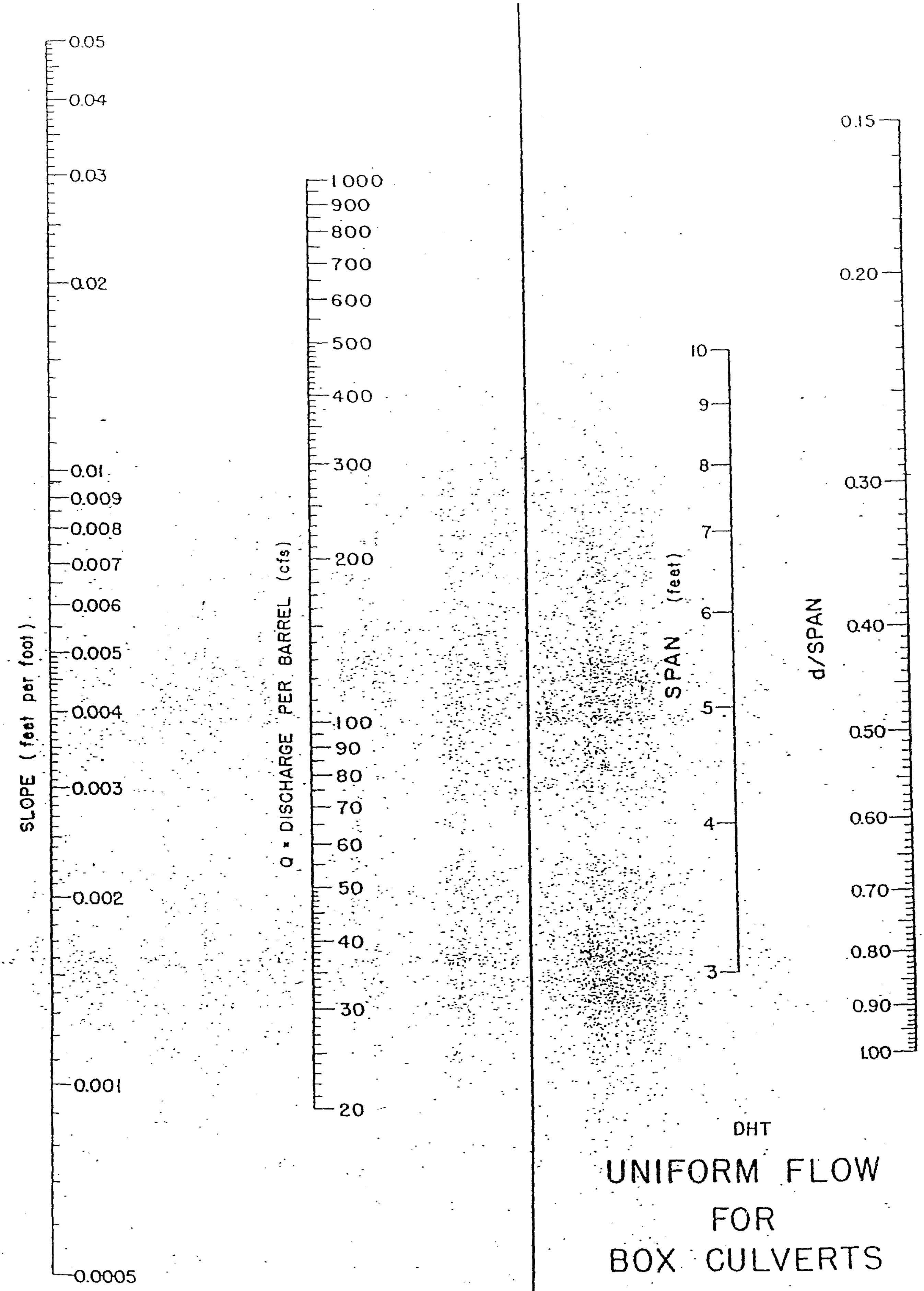
$HL = h_v + h_e$

DHT

NOMOGRAPH A

CRITICAL FLOW FOR BOX CULVERTS

$n = 0.012$

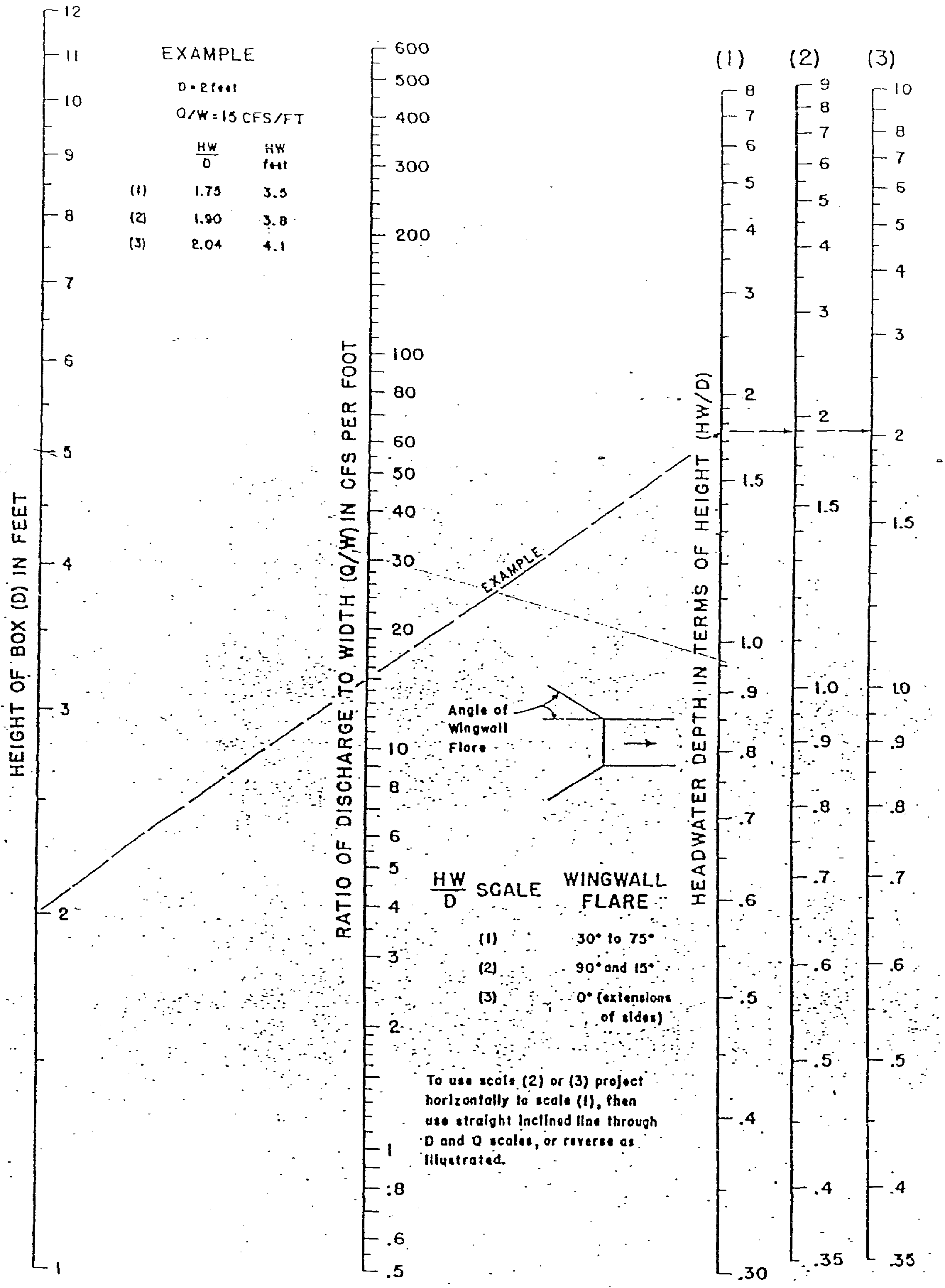


DHT

UNIFORM FLOW
FOR
BOX CULVERTS
$n = 0.012$

3 Sides Wetted

NOMOGRAPH B



EXAMPLE

D = 2 feet

Q/W = 15 CFS/FT

	$\frac{HW}{D}$	HW feet
(1)	1.75	3.5
(2)	1.90	3.8
(3)	2.04	4.1

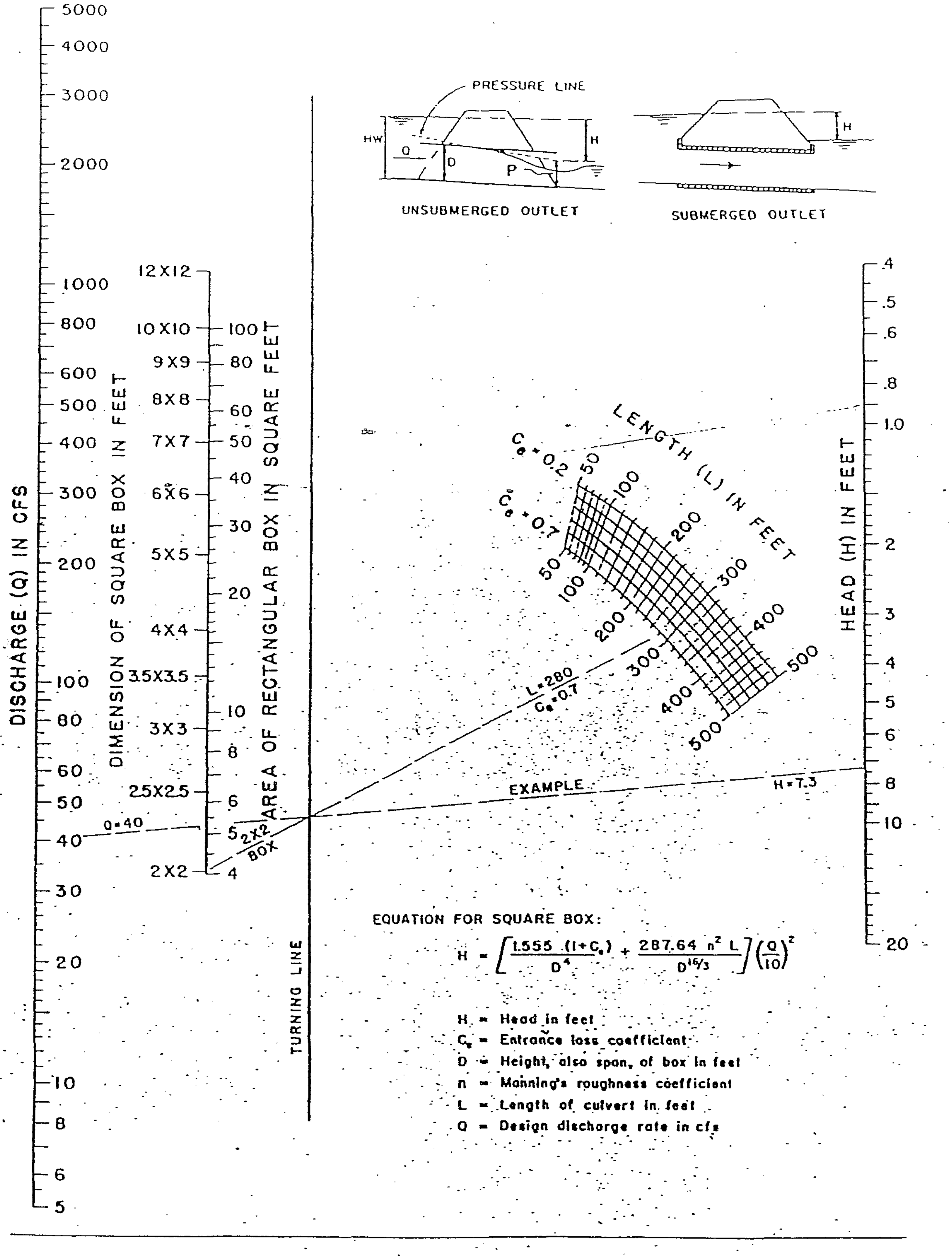
$\frac{HW}{D}$ SCALE	WINGWALL FLARE
(1)	30° to 75°
(2)	90° and 15°
(3)	0° (extensions of sides)

To use scale (2) or (3) project horizontally to scale (1), then use straight inclined line through D and Q scales, or reverse as illustrated.

FHWA

HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

NOMOGRAPH C



EQUATION FOR SQUARE BOX:

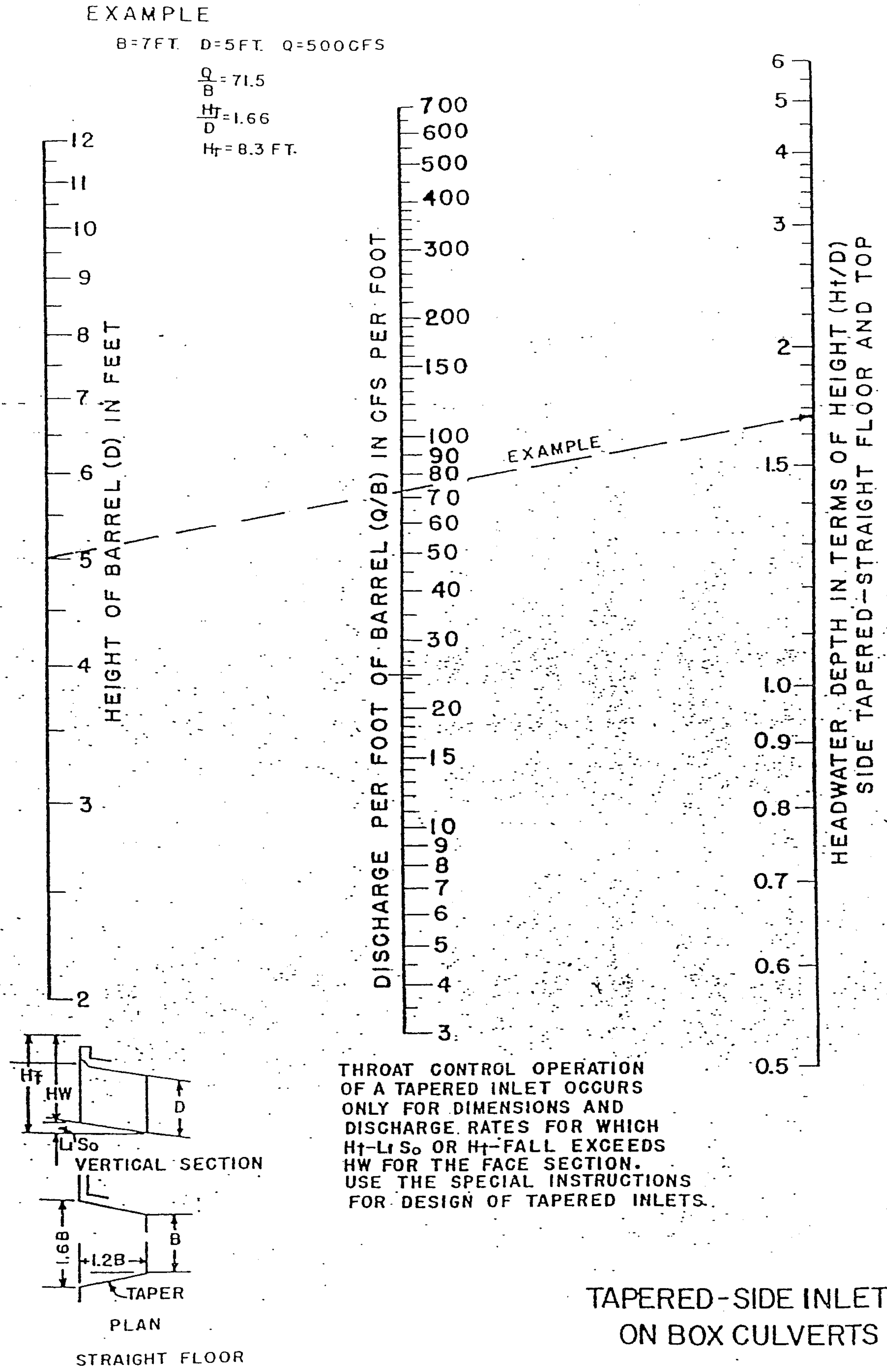
$$H = \left[\frac{1.555\ (1+C_e)}{D^4} + \frac{287.64\ n^2\ L}{D^{16/3}}\right]\left(\frac{Q}{10}\right)^2$$

H = Head in feet
C_e = Entrance loss coefficient
D = Height, also span, of box in feet
n = Manning's roughness coefficient
L = Length of culvert in feet
Q = Design discharge rate in cfs

HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

FHWA

NOMOGRAPH D

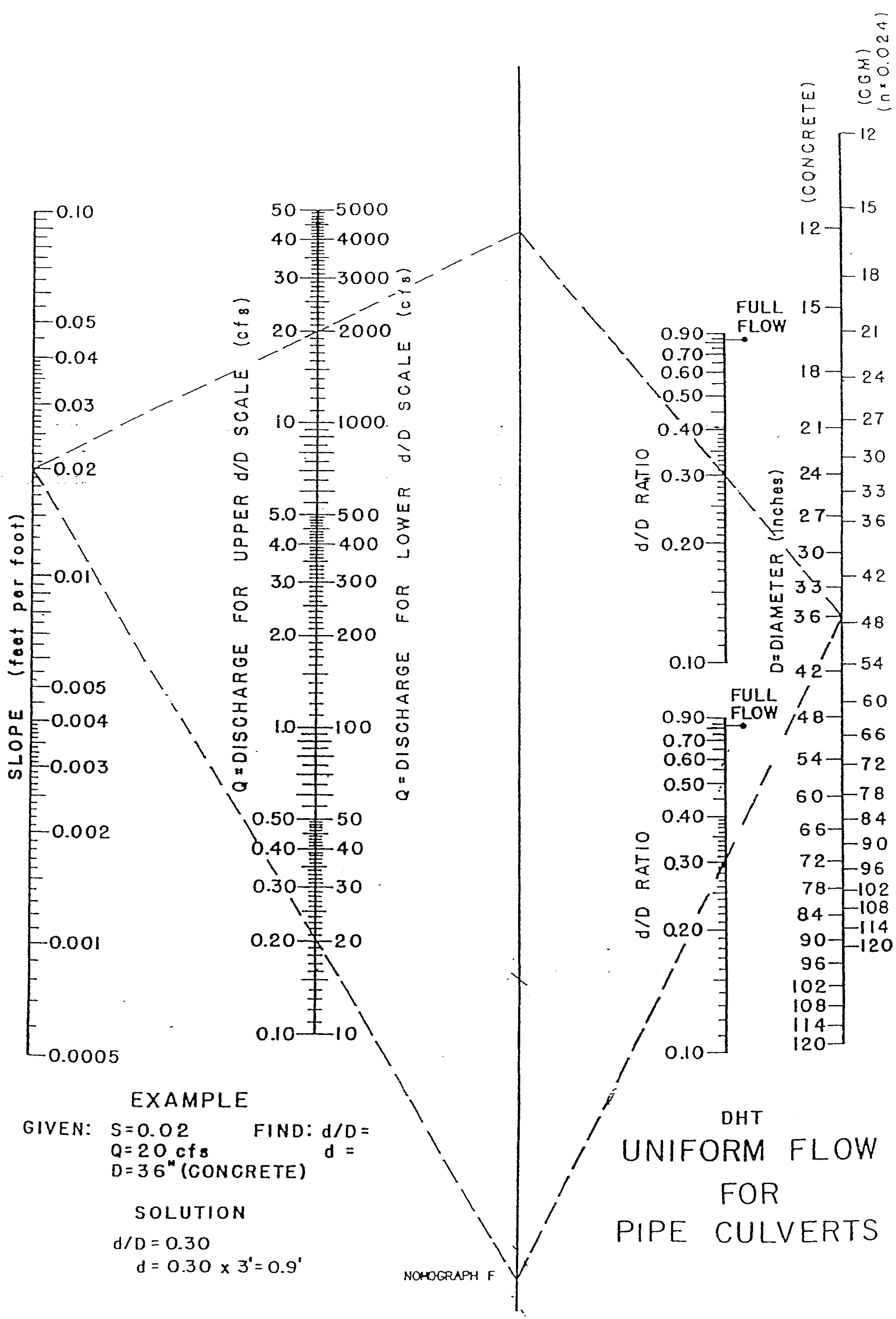


THROAT CONTROL OPERATION OF A TAPERED INLET OCCURS ONLY FOR DIMENSIONS AND DISCHARGE RATES FOR WHICH $H_t - L_i S_o$ OR H_t-FALL EXCEEDS HW FOR THE FACE SECTION. USE THE SPECIAL INSTRUCTIONS FOR DESIGN OF TAPERED INLETS.

TAPERED-SIDE INLETS ON BOX CULVERTS

(FHWA)

NOMOGRAPH E



EXAMPLE

GIVEN: S=0.02 FIND: d/D=
Q=20 cfs d =
D=36" (CONCRETE)

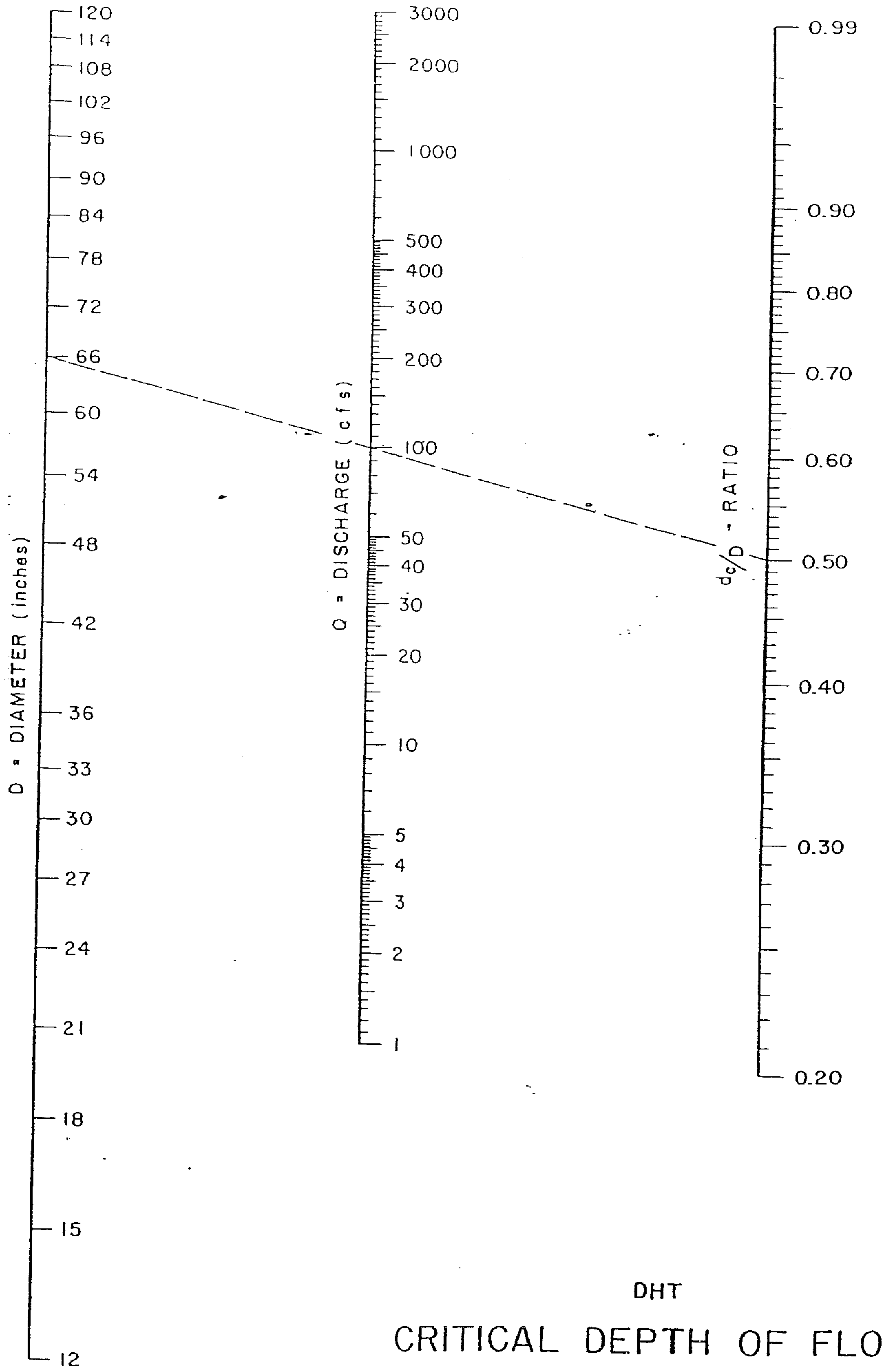
SOLUTION

d/D = 0.30
d = 0.30 x 3' = 0.9'

NOMOGRAPH F

DHT

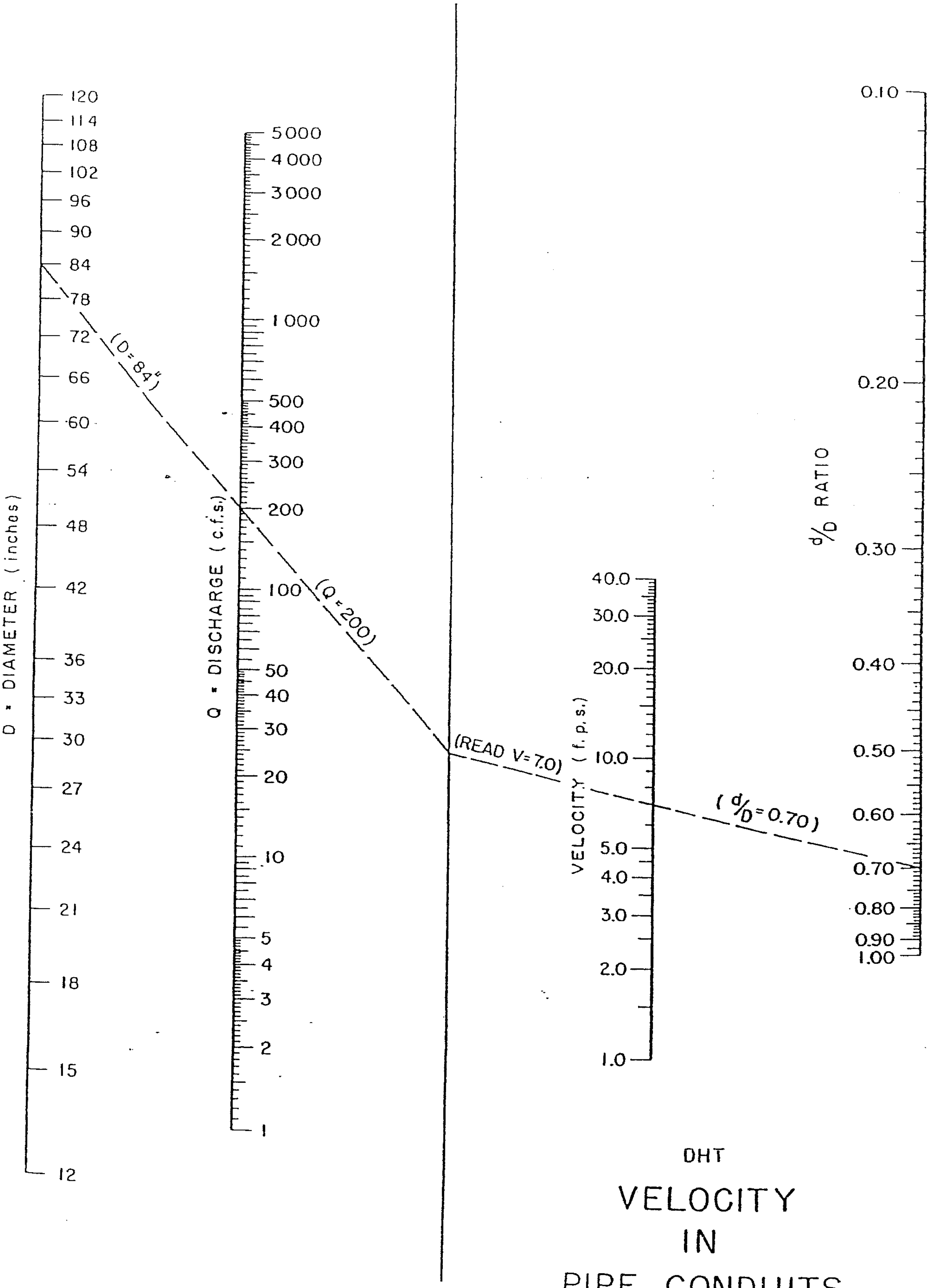
UNIFORM FLOW FOR PIPE CULVERTS



DHT

CRITICAL DEPTH OF FLOW FOR CIRCULAR CONDUITS

NOMOGRAPH G

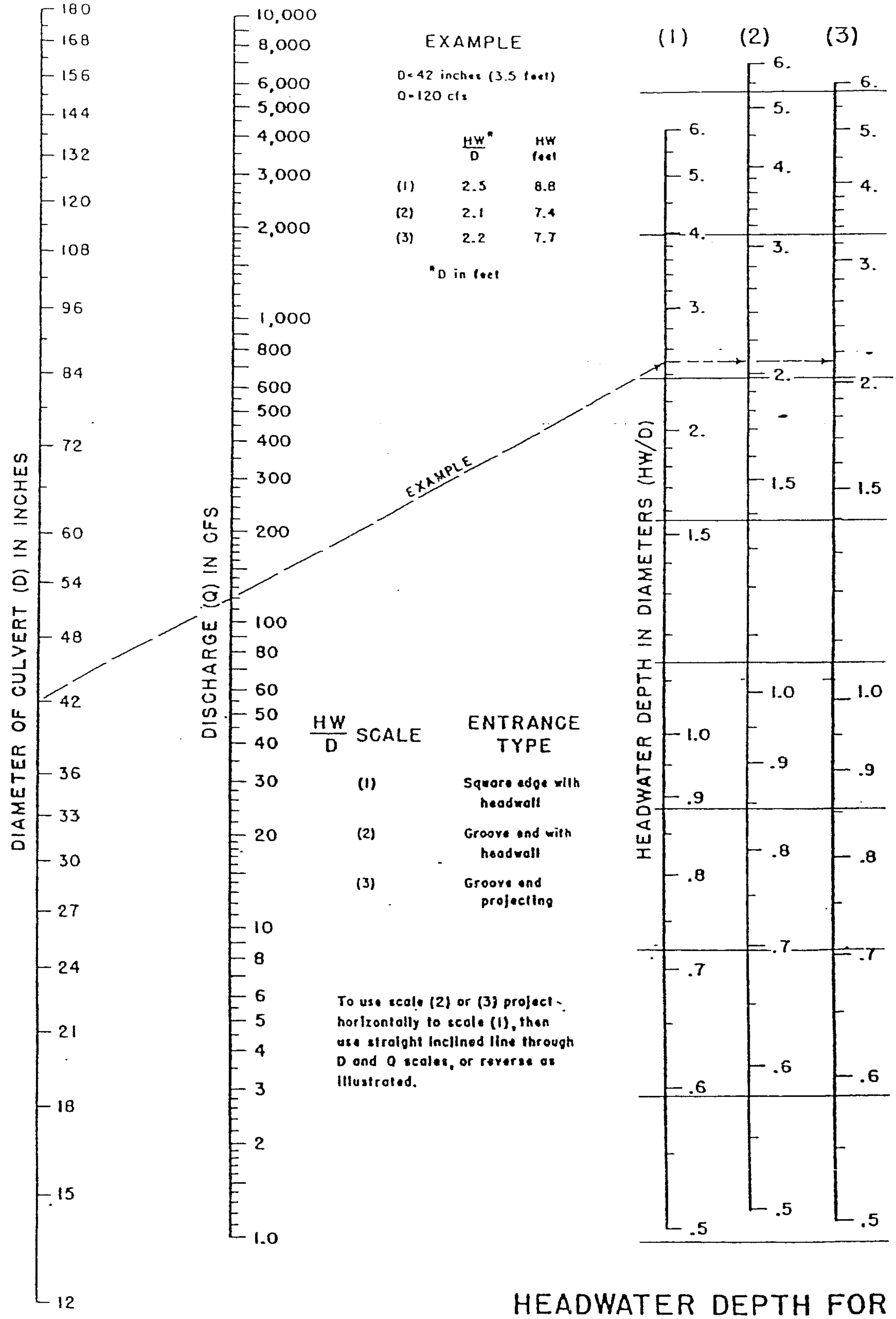


DHT

VELOCITY
IN
PIPE CONDUITS

BASED ON
Q = VA

NOMOGRAPH H



EXAMPLE

D=42 inches (3.5 feet)
Q=120 cfs

	$\frac{HW}{D}$*	HW feet
(1)	2.5	8.8
(2)	2.1	7.4
(3)	2.2	7.7

*D in feet

$\frac{HW}{D}$ SCALE	ENTRANCE TYPE
(1)	Square edge with headwall
(2)	Groove end with headwall
(3)	Groove end projecting

To use scale (2) or (3) project horizontally to scale (1), then use straight inclined line through D and Q scales, or reverse as illustrated.

FHWA

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

NOMOGRAPH I

Appendix F: Material Specification

Appendix F

This appendix provides material specification and standards for storm sewer products that will be used in the City of Sherman. The City Engineer before installation must approve all materials or products that do not meet these minimum standards.

A. Culverts

1. **Reinforced Concrete Box**
    - a. **Precast.** Precast reinforced concrete box shall conform to ASTM C789 or C850.
    - b. **Cast-in-place.** Cast-in-place concrete box shall be designed in a Licensed Professional Engineer in the State of Texas.

2. **Concrete Pipe.** Pipe used for culverts shall be able to handle HS-20 traffic loading and conform to the standards for storm sewer conduits.

B. Storm Sewer Conduits

1. **Storm Sewer (Reinforced Concrete)** pipe shall confirm to the following ASTM Designations:
    - a. Circular Pipe – ASTM Designation C76; Wall "B".
    - b. Arch Pipe ASTM – Designation C506.
    - c. Elliptical Pipe ASTM – Designation C507.
    - d. Other Pipe Material – Such as metal and high-density polyethylene pipe, will not be allowed unless approved by the City Engineer.

2. **Fittings**

    The design and manufacture of all special fittings shall be governed by the same requirements as the connecting pipe.

3. **Joint Materials:**
    - a. Gasket Material – ASTM C443. The polymer shall be synthetic rubber; natural rubber will not be acceptable.
    - b. Flexible Joint Sealant – Preformed butyl rubber sealant; Hamilton-Kent "Kent Seal No. 2", Press-Seal, Gasket "E-Z Stik", or K.T. Snyder "RUB'R-NEK".
    - c. Mastic – Trowel grade sewer sealing compound; J.P. Petroleum Products "Tex-Mastic 726" or Grahn "Anchor-Tite Plastic Mastic".

Appendix F (continued)

This appendix provides material specification and standards for storm sewer products that will be used in the City of Sherman. The City Engineer before installation must approve all materials or products that do not meet these minimum standards.

C. Manholes

1. Manhole Materials

a. **Manhole Covers** – All manhole covers shall conform to the Standard Specifications for Grey Iron Castings, ASTM A-48, Class 30 B.

b. **Installation**

1) All manhole covers shall be 24-inch in diameter
2) All manhole covers shall have two integrally cast pick bars.
3) Manhole covers shall weigh approximately 134 lbs. 300 x 24 assembly.

c. **Manufactures**

1) Bass and Hays
2) Vulcan
3) or Equal

2. Manhole Frames

a. All manhole frames shall conform to the Standard Specifications for Grey Iron Castings, ASTM A-48, Class 30 B.

b. **Installation**

1) All manhole frames shall provide a 24-1/4" opening to assure proper fit of the manhole cover.
2) Manhole rings shall weigh approximately 170 lbs.

c. **Manufacturers**

1) Bass and Hays
2) Vulcan
3) or Equal

3. Extension Ring Materials

a.. All precast reinforced concrete extension rings shall conform to ASTM C-478.

b. The number of extension ring sections shall be kept to a minimum (i.e. use 1-1/2" extension ring instead of 2-6" extension rings).

c. A 1" x 3-1/2" bitumastic gasket shall be used to seal the extension ring at both joints.

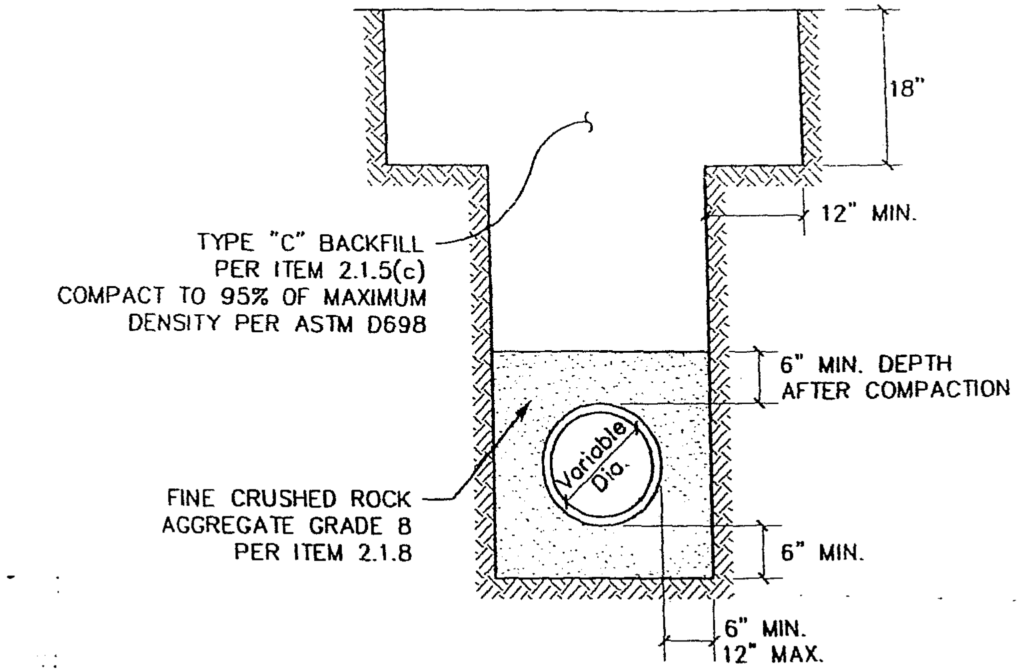
d. Manufacturers

1) Hydro-Conduit
2) or Equal

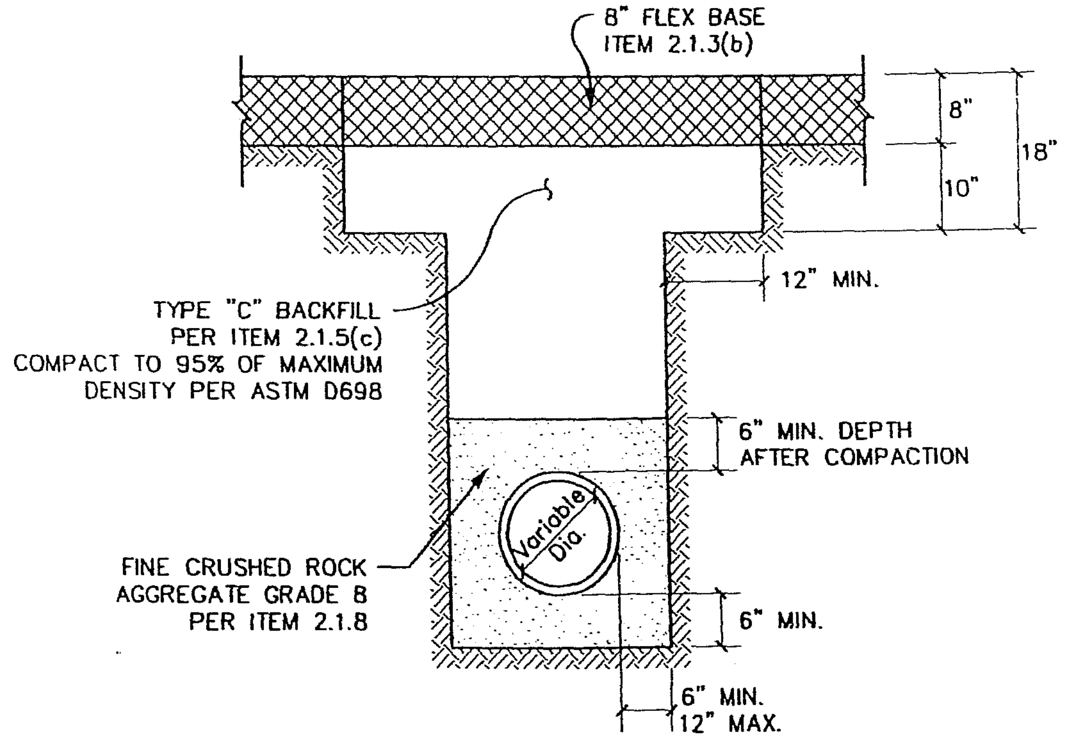
Appendix G: Standard Details

Storm Water Drainage Improvements Details

Title	Detail No.	Sheet No.	Revision Date
Embedment and Backfill	D-1	1, 2, 3	April, 2000
Subsurface Drain	D-2	1	April, 2000
Inlet General Notes	D-3	1	April, 2000
Curb Inlet	D-3	2, 3	April, 2000
Curb Inlet Recessed	D-3	4, 5	April, 2000
Drop Inlet	D-3	6	April, 2000
Storm Drain Manhole	D-4	1	April, 2000
Manholes 1 - 7	D-4	2	April, 2000
Reinforced Concrete Collar	D-5	1	April, 2000
Curbed Flume & Pilot Channels	D-6	1	April, 2000
Concrete Riprap	D-7	1	April, 2000
Sloping Headwall	D-8	1	April, 2000
Vertical Headwall	D-8	2	April, 2000
Culvert W/Safety End Treatments	D-9	1	April, 2000
Concrete Headwalls For Pipe Culverts	CH-11	1	April, 2000
Concrete Headwalls for Pipe Culverts 12-72" Dia.	CH-11-B-15°	1	April, 2000
Concrete Headwalls For Pipe Culverts 12-72" Dia.	CH-11-B-30°	1	April, 2000
Parallel Wings-Normal For Single Box Culverts	PW-N	1	April, 2000
Parallel Wings-15° For Single Box Culverts	PW-15°	1	April, 2000
Parallel Wings 30° Skew For Single Box Culverts	PW-30°	1	April, 2000
Flared Wings - Normal For Single Box Culverts	FW-N	1	April, 2000
Flared Wings - 15° Skew For Single Box Culverts	FW-15°	1	April, 2000
Flared Wings - 30° Skew For Single Box Culverts	FW-30°	1	April, 2000



UNPAVED AND FUTURE PAVED AREAS



EXISTING FLEXBASE SURFACE

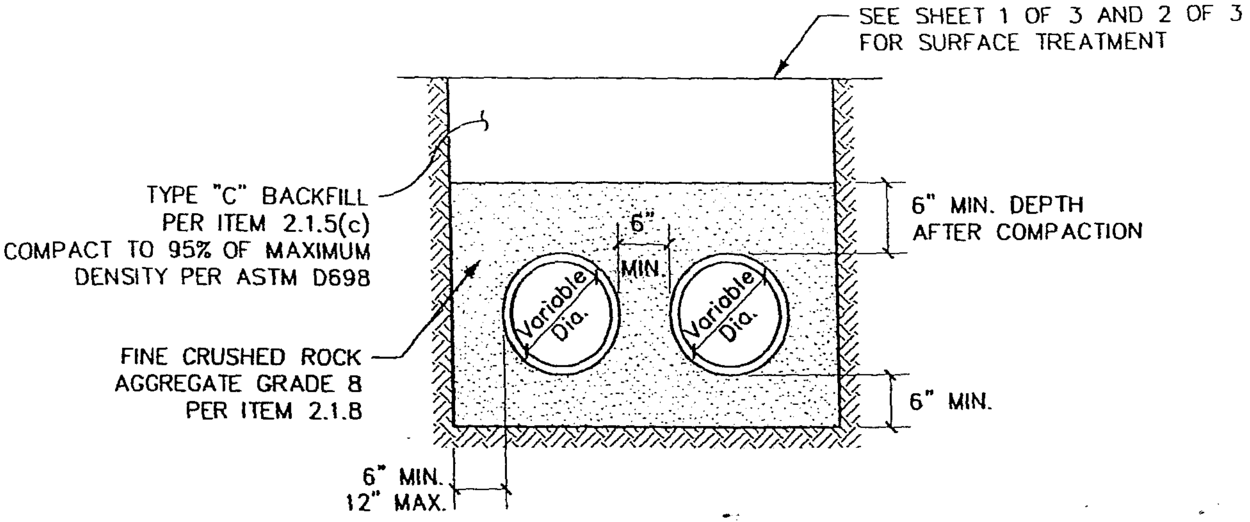
NOTES:

1. AT THE END OF EACH WORK DAY, ALL SPOILS SHALL BE REMOVED FROM THE TOWN R.O.W. UNLESS PRIOR WRITTEN PERMISSION IS OBTAINED FROM THE TOWN TO STORE SPOILS IN DESIGNATED SPOIL STORAGE AREAS THAT DO NOT OBSTRUCT AUTOMOBILE OR PEDESTRIAN TRAFFIC.
2. A MAXIMUM OF 300-FT OF OPEN TRENCH WILL BE ALLOWED AT ANY TIME, UNLESS APPROVED BY THE TOWN ENGINEER.
3. ALL PAVEMENT PATCHES SHALL BE REMOVED ALONG NEAT SAW CUT LINES PER ITEM 8.8.
4. IN SANDY SOILS THE CRUSHED ROCK EMBEDMENT SHALL BE WRAPPED IN A FILTER FABRIC.

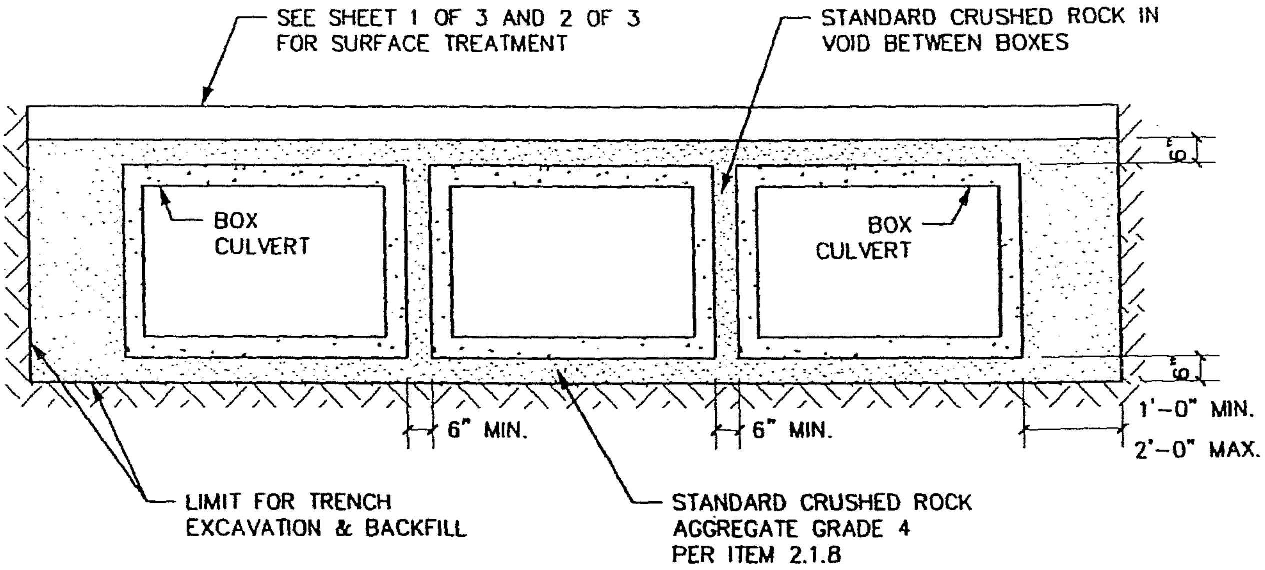
SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER

DATE: 04/13/00
SHEET 1 OF 3
SHEET: D-1



MULTIPLE PIPE EMBEDMENT



MULTIPLE BOX EMBEDMENT

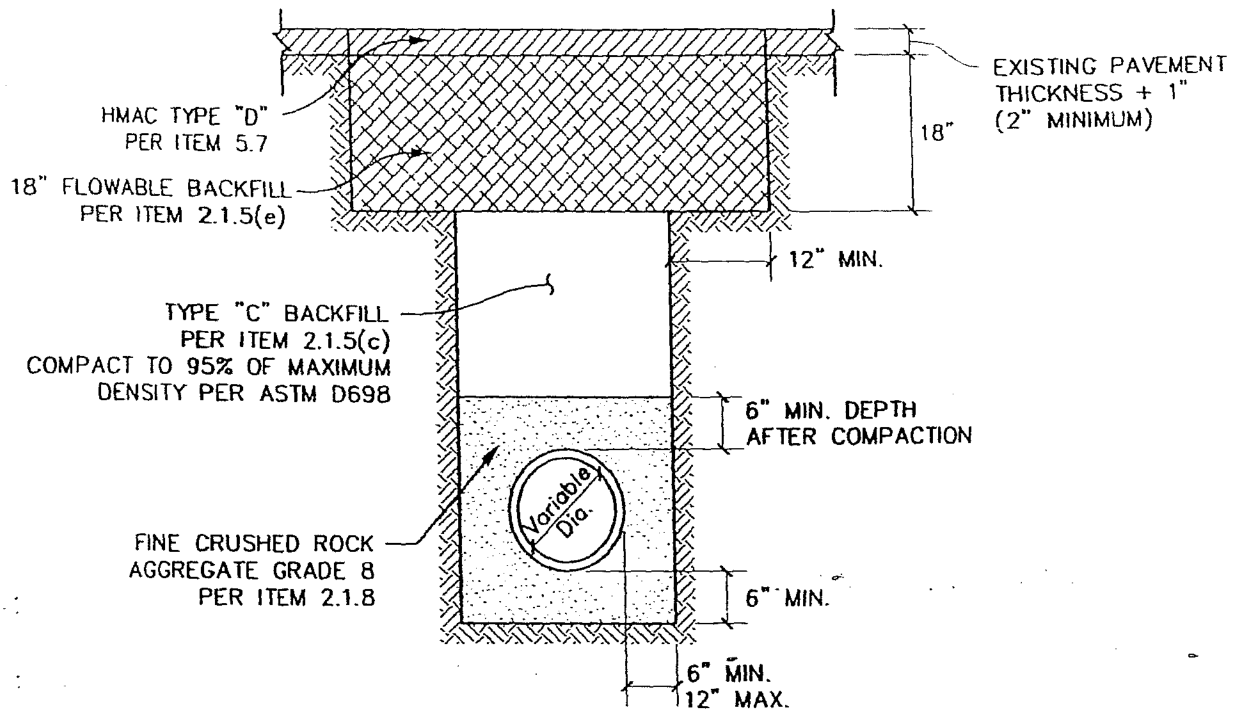
NOTES:

1. AT THE END OF EACH WORK DAY, ALL SPOILS SHALL BE REMOVED FROM THE TOWN R.O.W. UNLESS PRIOR WRITTEN PERMISSION IS OBTAINED FROM THE TOWN TO STORE SPOILS IN DESIGNATED SPOIL STORAGE AREAS THAT DO NOT OBSTRUCT AUTOMOBILE OR PEDESTRIAN TRAFFIC.
2. A MAXIMUM OF 300-FT OF OPEN TRENCH WILL BE ALLOWED AT ANY TIME, UNLESS APPROVED BY THE TOWN ENGINEER.
3. ALL PAVEMENT PATCHES SHALL BE REMOVED ALONG NEAT SAW CUT LINES PER ITEM 8.8.
4. IN SANDY SOILS THE CRUSHED ROCK EMBEDMENT SHALL BE WRAPPED IN A FILTER FABRIC.
5. NATIVE MATERIALS ARE <u>NOT</u> ACCEPTABLE FOR USE IN A FLOWABLE BACKFILL MIX.

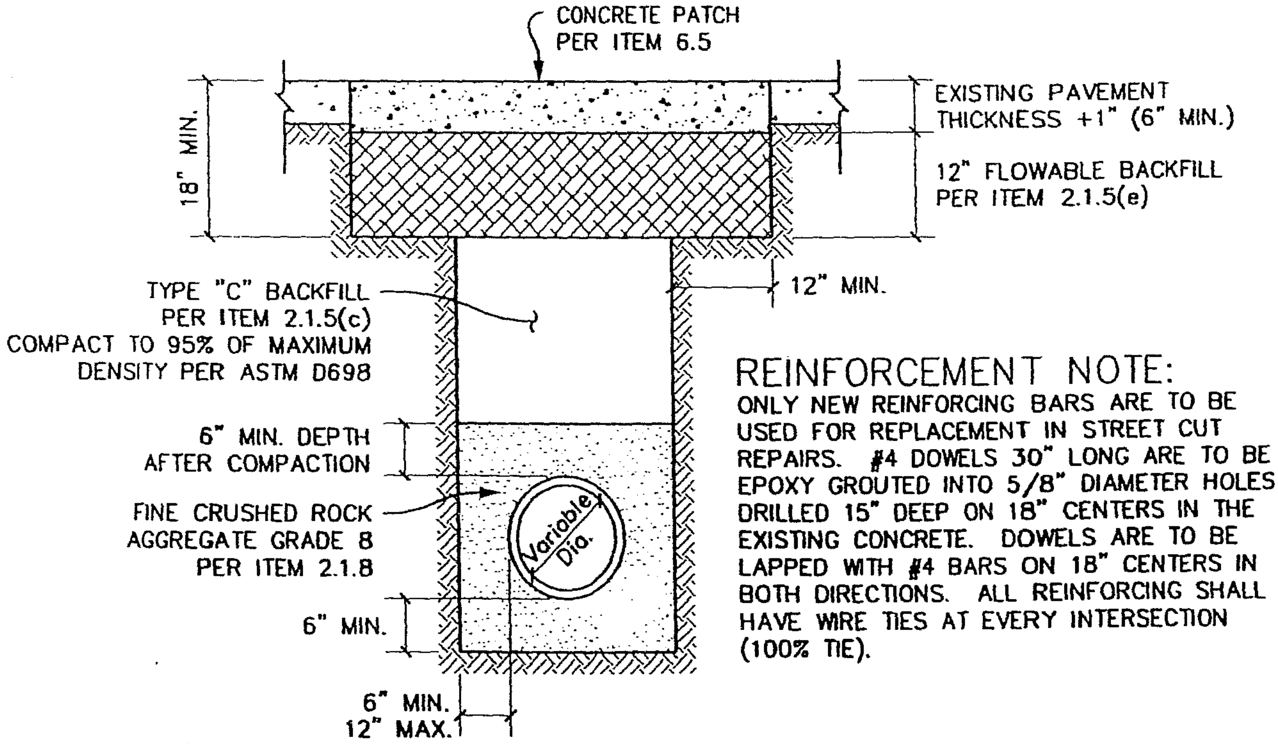
SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
EMBEDMENT

DATE: 04/13/00
SHEET 3 OF 3



EXISTING ASPHALT PAVEMENT



REINFORCEMENT NOTE:

ONLY NEW REINFORCING BARS ARE TO BE USED FOR REPLACEMENT IN STREET CUT REPAIRS. #4 DOWELS 30" LONG ARE TO BE EPOXY GROUTED INTO 5/8" DIAMETER HOLES DRILLED 15" DEEP ON 18" CENTERS IN THE EXISTING CONCRETE. DOWELS ARE TO BE LAPPED WITH #4 BARS ON 18" CENTERS IN BOTH DIRECTIONS. ALL REINFORCING SHALL HAVE WIRE TIES AT EVERY INTERSECTION (100% TIE).

EXISTING CONCRETE PAVEMENT

NOTES:

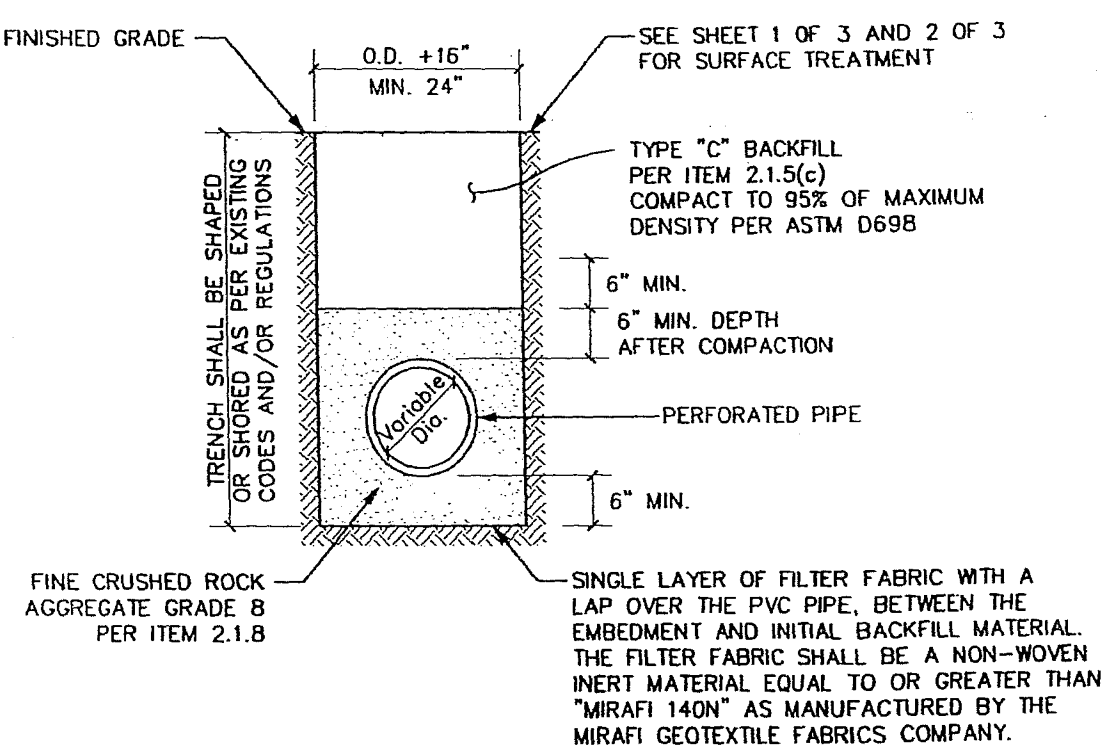
1. AT THE END OF EACH WORK DAY, ALL SPOILS SHALL BE REMOVED FROM THE TOWN R.O.W. UNLESS PRIOR WRITTEN PERMISSION IS OBTAINED FROM THE TOWN TO STORE SPOILS IN DESIGNATED SPOIL STORAGE AREAS THAT DO NOT OBSTRUCT AUTOMOBILE OR PEDESTRIAN TRAFFIC.
2. ALL PAVEMENT SHALL BE REMOVED ALONG NEAT SAW CUT LINES PER ITEM 8.8.
3. A MAXIMUM OF 300-FT OF OPEN TRENCH WILL BE ALLOWED AT ANY TIME, UNLESS APPROVED BY THE TOWN ENGINEER.
4. NATIVE MATERIALS ARE <u>NOT</u> ACCEPTABLE FOR USE IN FLOWABLE BACKFILL MIX.
5. IN SANDY SOILS THE CRUSHED ROCK EMBEDMENT SHALL BE WRAPPED IN A FILTER FABRIC.

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
EMBEDMENT AND BACKFILL

DATE: 04/13/00

SHEET 2 OF 3



NOTES:

1. WHERE THE CONTRACTOR ENCOUNTERS UNDERGROUND WATER, A SUBSURFACE DRAINAGE SYSTEM SHALL BE INSTALLED, WITH THE DISCHARGE IF SAID SYSTEM BEING CARRIED TO THE NEAREST STORM DRAIN SYSTEM OR NATURAL WATER SHED SYSTEM.
2. THE SUBSURFACE DRAINAGE SYSTEM SHALL BE CONSTRUCTED WITH A MINIMUM SIZE OF SIX (6) INCH DIAMETER TYPE PS-46 PVC PIPE, OR APPROVED EQUAL. THE PIPE SHALL MEET ALL CURRENT ASTM F758 REQUIREMENTS, AND SHALL HAVE GASKET TYPE JOINTS. THE PERFORATED AND CONDUCTING PIPES SHALL BE WHITE IN COLOR.
3. IN SANDY SOILS THE CRUSHED ROCK EMBEDMENT SHALL BE WRAPPED IN FILTER FABRIC.
4. CLEANOUTS SHALL BE INSTALLED AT THE END OF EACH PIPING SYSTEM.
5. FRENCH DRAINS SHALL BE SHOWN ON ALL AS-BUILT PLANS.

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER

DATE: 04/13/00

SHEET 1 OF 1

GENERAL NOTES:

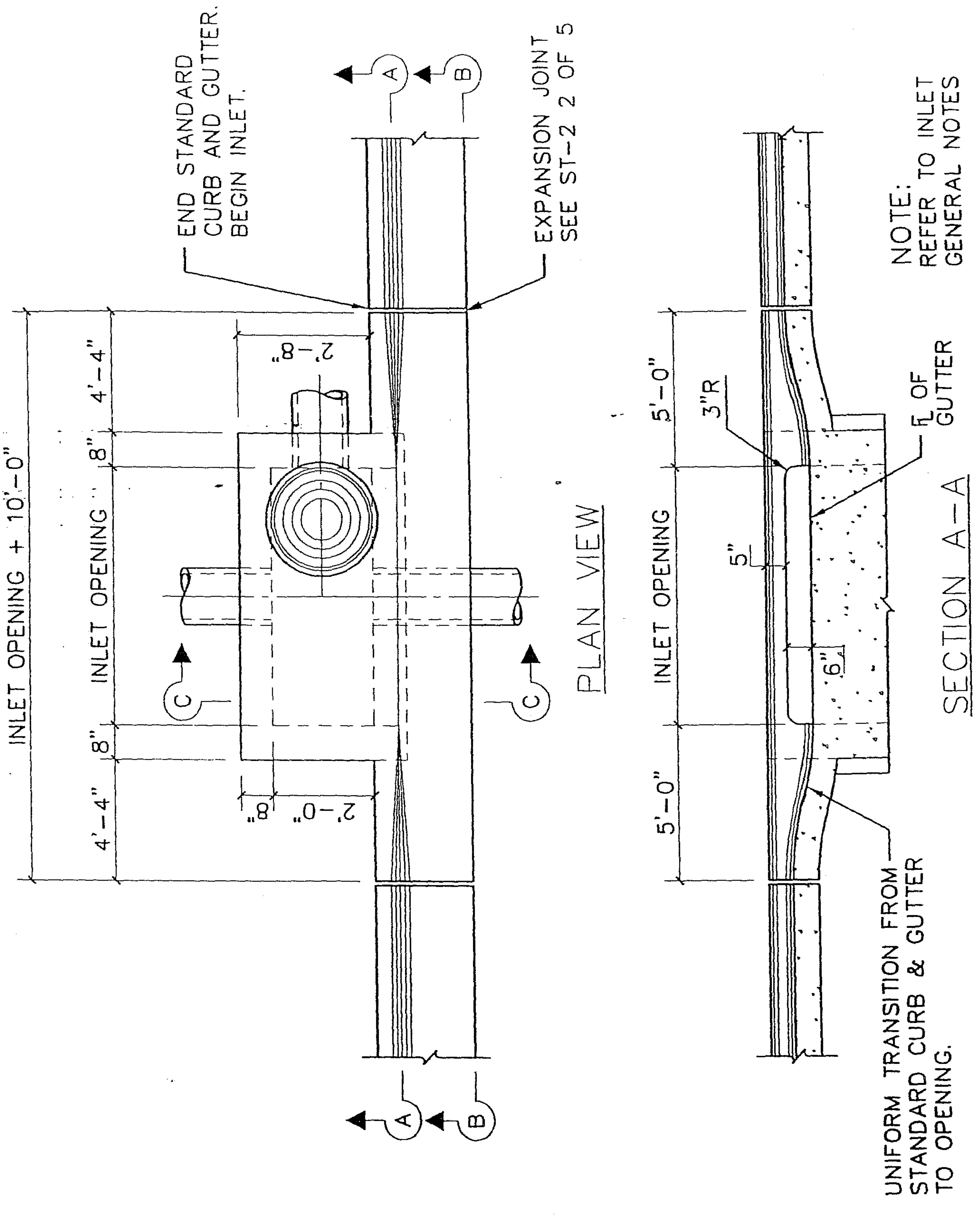
1. IN GENERAL, INLET REINFORCING STEEL SHALL BE #4 BARS ON 12" CENTERS BOTH WAYS FOR GUTTER, BOTTOM SLAB ENDS, FRONT AND BACK WALLS, AND #4 BARS ON 6" CENTERS BOTH WAYS FOR TOP SLAB. AN ADDITIONAL #6 BAR SHALL BE PLACED IN THE FRONT EDGE OF THE TOP SLAB IN THE INLETS AND ADDITIONAL REINFORCING STEEL SHALL BE PLACED AROUND MANHOLES AS SHOWN.
2. ALL REINFORCING STEEL SHALL BE GRADE 60.
3. ALL CONCRETE SHALL BE CLASS "A". ALL EXPOSED CORNERS SHALL BE CHAMFERED 3/4".
4. ALL REINFORCING STEEL SHALL HAVE A MINIMUM COVER OF 2" TO THE CENTERS OF THE BARS.
5. 10'-0" OF EXISTING CURB AND GUTTER UPSTREAM AND 10'-0" OF EXISTING CURB AND GUTTER DOWNSTREAM SHALL BE REMOVED AND REPOURED INTEGRALLY WITH EACH INLET.
6. ALL BACK FILLING SHALL BE IN ACCORDANCE WITH ITEM 6.2.9 TO 95% STANDARD PROCTOR DENSITY.
7. CENTER BEAM IS REQUIRED FOR ALL INLET OPENINGS GREATER THAN 10'-0".
8. TWO MANHOLE FRAMES AND COVERS ARE REQUIRED WHEN INLET OPENING IS GREATER THAN 10'-0".
9. ALL INLET FLOORS ARE TO HAVE A 2% SLOPE TOWARDS THE OUTLET PIPE.
10. MINIMUM INLET OPENING SIZE IS 8'-0".
11. MAXIMUM INLET OPENING SIZE IS 20'-0".
12. OUTLET PIPE TO BE PLACED AT LOWEST END OF FLOOR INLET. MANHOLE COVER TO BE PLACED OVER OUTLET END OF INLET.
13. MANHOLE FRAME AND COVER SHALL BE CAST IRON, VULCAN V-1874 OR APPROVED EQUAL.

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER

DATE: 04/13/00

SHEET 1 OF 6

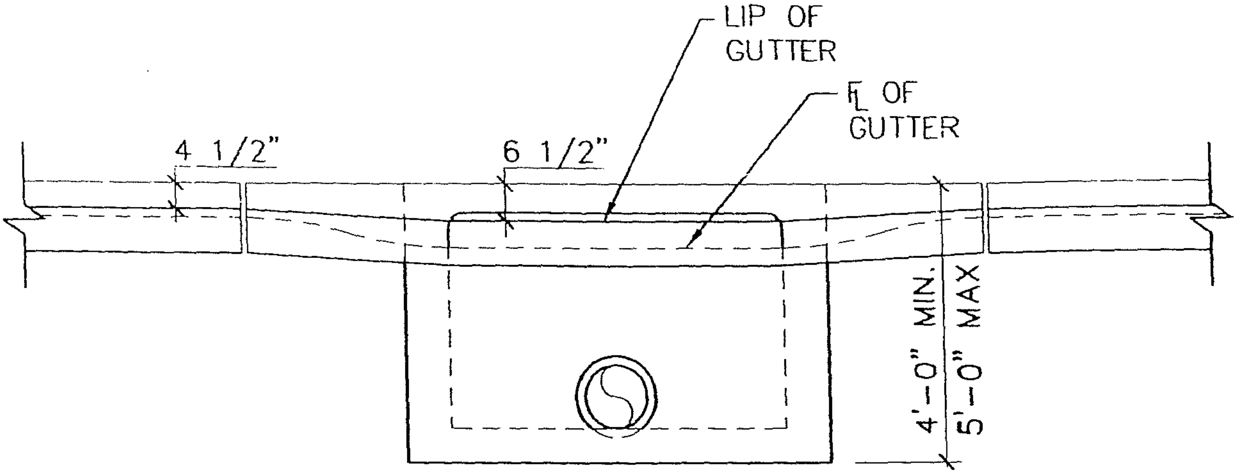


NOTE:
REFER TO INLET GENERAL NOTES

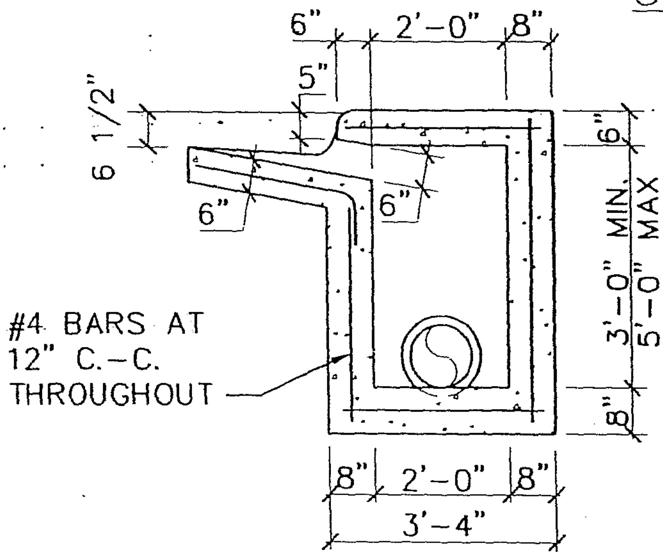
SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER

DATE: 04/13/00
SHEET 2 OF 6

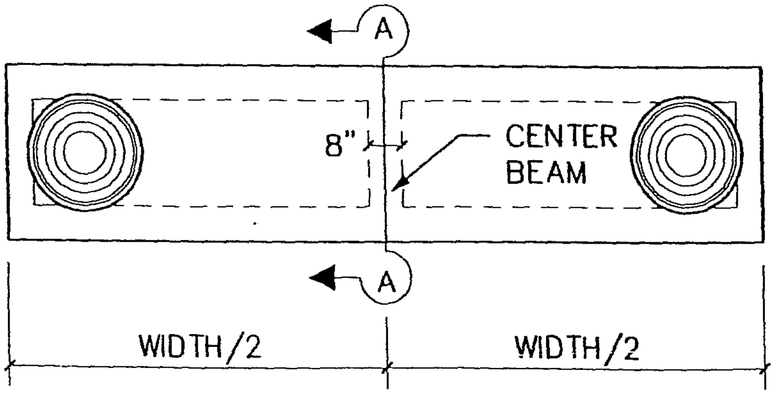


SECTION B-B

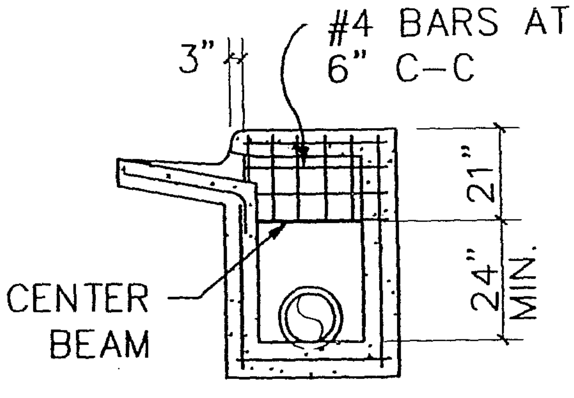


SECTION C-C

NOTE:
REFER TO INLET GENERAL NOTES



PLAN VIEW



SECTION A-A

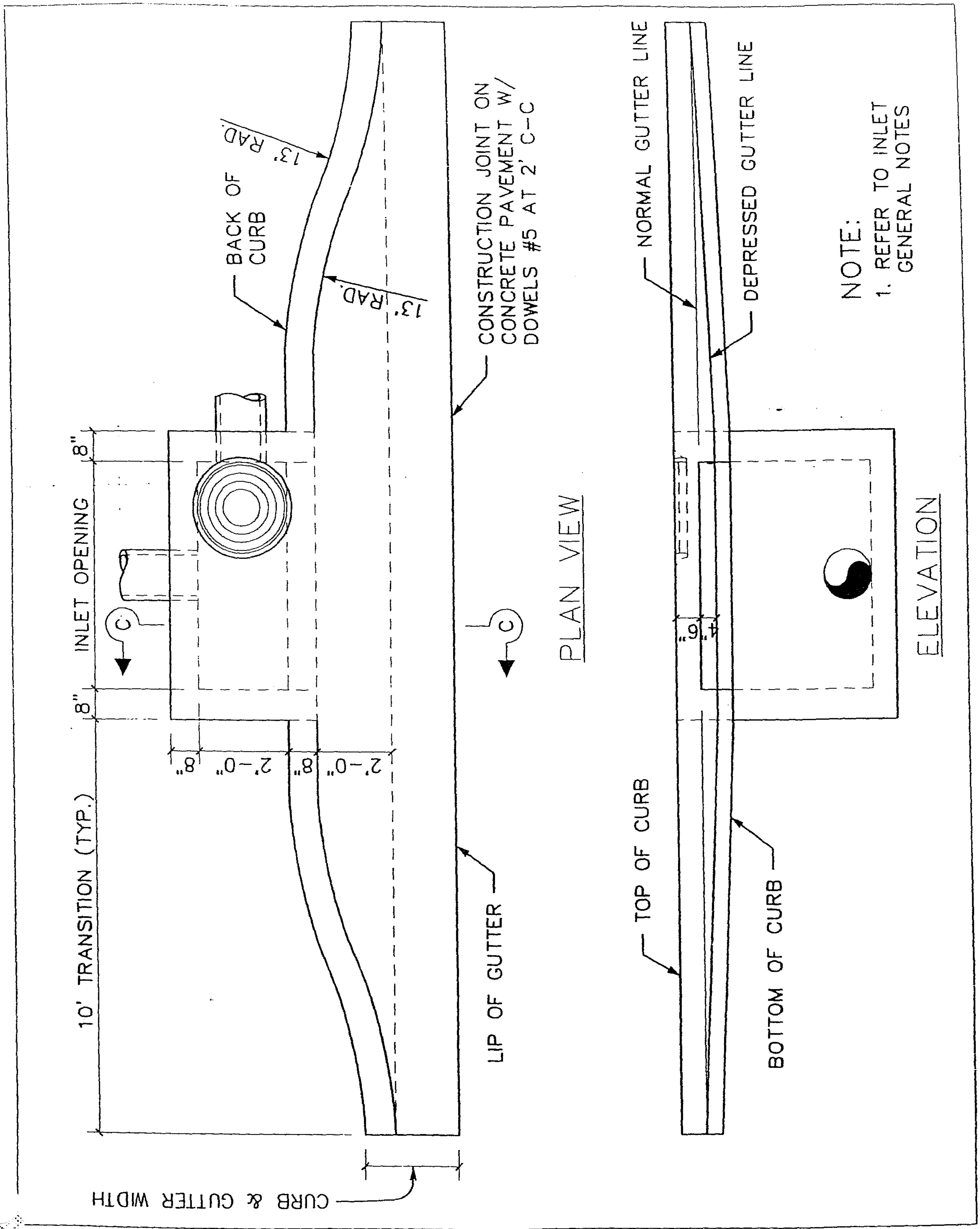
CENTER BEAM DETAIL

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER

DATE: 04/13/00

SHEET 3 OF 6



NOTE:

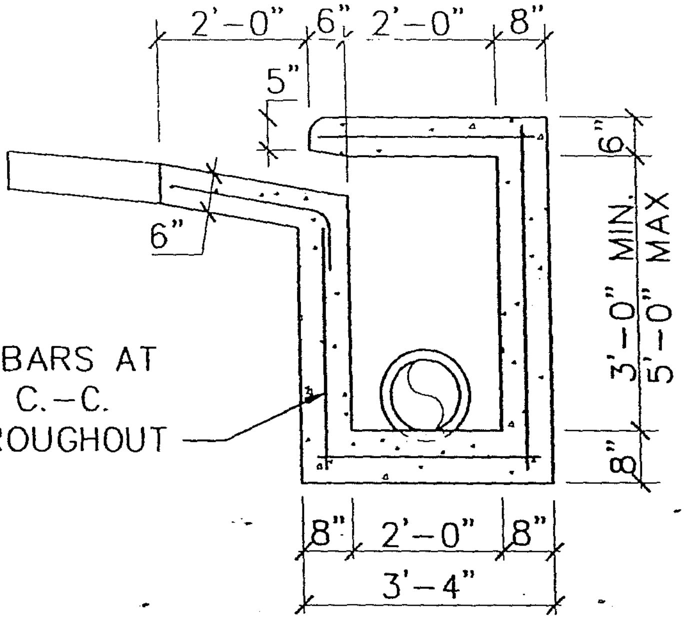
1. REFER TO INLET GENERAL NOTES

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
CURB INLET RECESSED

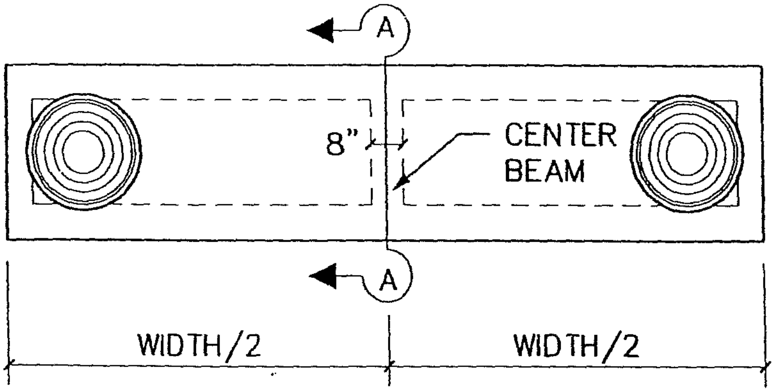
DATE: 04/13/00

SHEET 4 OF 6

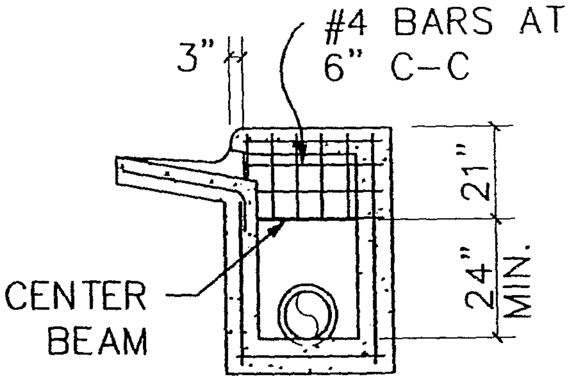


SECTION C-C

NOTE:
1. REFER TO INLET GENERAL NOTES



PLAN VIEW



SECTION A-A

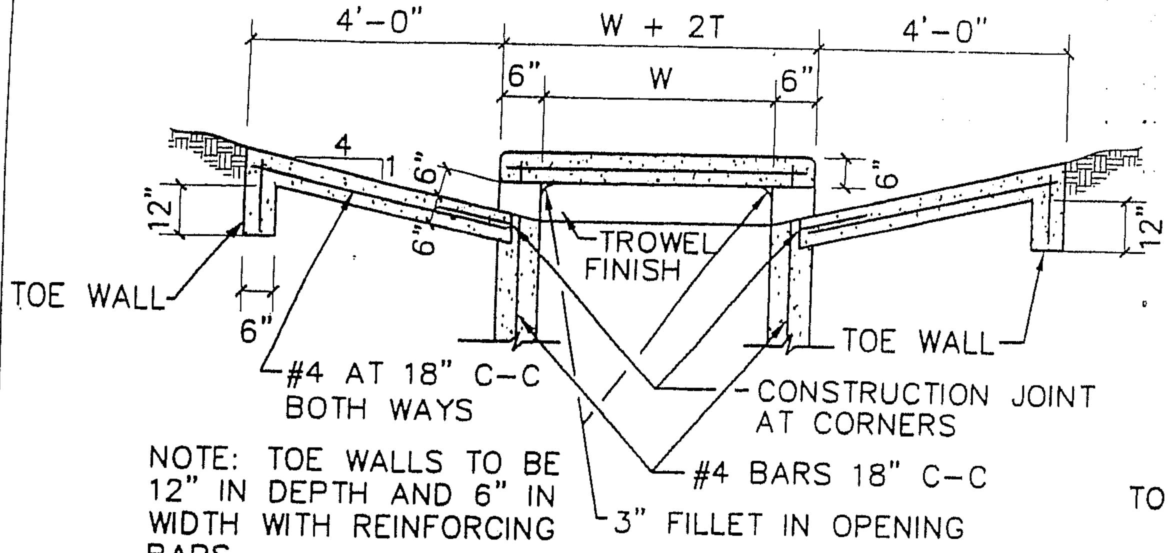
CENTER BEAM DETAIL

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
CURB INLET

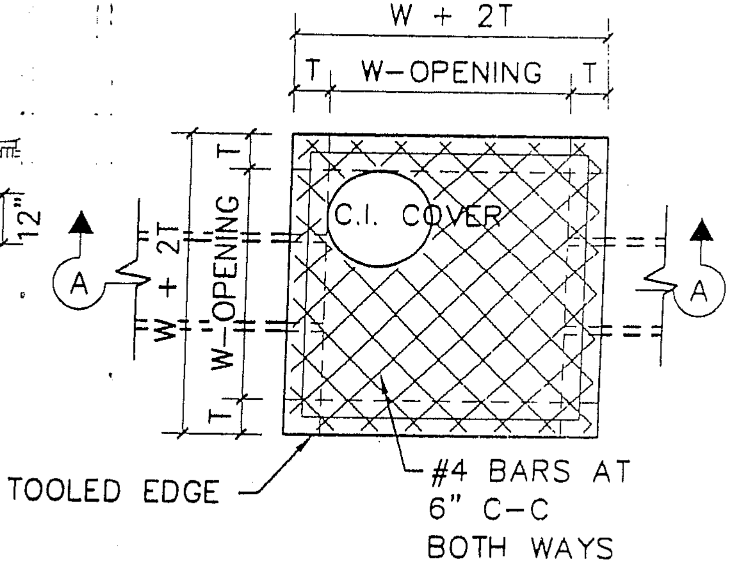
DATE: 04/13/00

SHEET 5 OF 6



NOTE: TOE WALLS TO BE 12" IN DEPTH AND 6" IN WIDTH WITH REINFORCING BARS.

SECTION A-A
N.T.S.



PLAN VIEW
N.T.S.

NOTES:

1. MATERIAL AND WORKMANSHIP SHALL CONFORM WITH THE REQUIREMENTS OF STANDARD SPECIFICATIONS FOR STANDARD CONCRETE MANHOLES.
2. FOR DETAILS OF REINFORCING TO LOWER PORTIONS OF INLET SEE APPROPRIATE SQUARE MANHOLE DETAILS.
3. DEPTH OF DROP INLET FROM FINISHED GRADE TO FLOW LINE OF INLET IS VARIABLE. APPROXIMATE DEPTH WILL BE SHOWN ON PLANS AT LOCATION OF INLET.
4. ALL STANDARD DROP INLETS SHALL HAVE ONE OPENING ON EACH SIDE UNLESS SHOWN ON PLANS.
5. DECK MAY BE REINFORCED SAME AS STANDARD SQUARE STORM DRAIN MANHOLE.
6. MANHOLE FRAME AND COVER SHALL BE CAST IRON, VULCAN V-1874 OR APPROVED EQUAL.

INLET SIZE	T	W
2' SQUARE	7"	2'-0"
4' SQUARE	7"	4'-0"
5' SQUARE	8"	5'-0"
6' SQUARE	9"	6'-0"
7' SQUARE	9"	7'-0"
8' SQUARE	9"	8'-0"

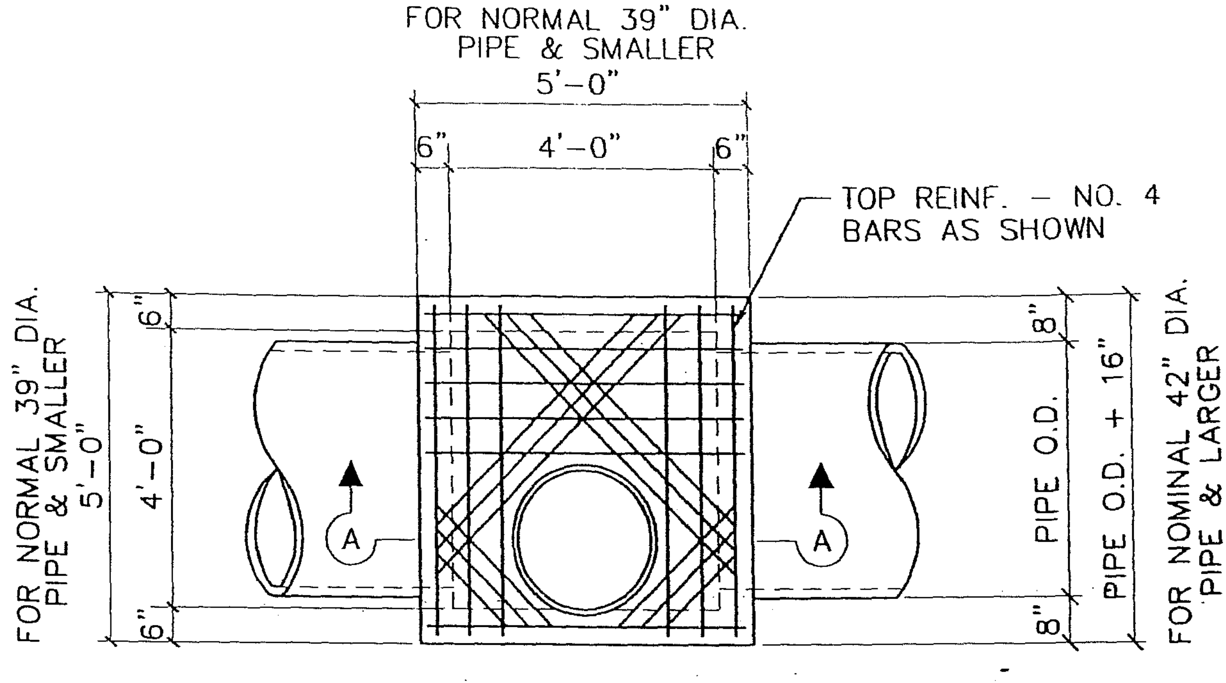
FOR LOWER PORTION OF 2' SQUARE DROP INLET USE REINF. STEEL DETAILS OF 4' SQUARE MANHOLE AND ELIMINATE INLET RING AND COVER.

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
DROP INLET

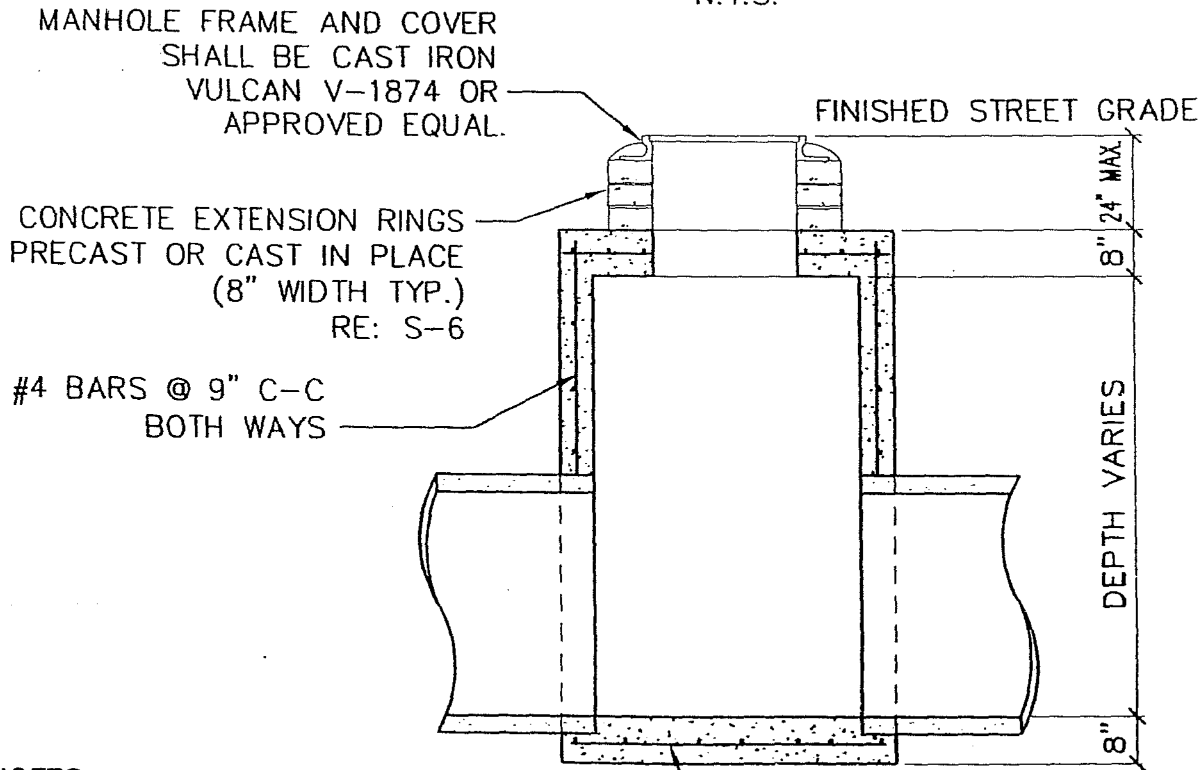
DATE: 04/13/00

SHEET 6 OF 6



PLAN VIEW

N.T.S.



NOTES:
1. LARGER J-BOXES SHALL BE DESIGNED BY THE ENGINEER AND SUBMITTED TO THE TOWN ENGINEER FOR REVIEW.

SECTION A-A

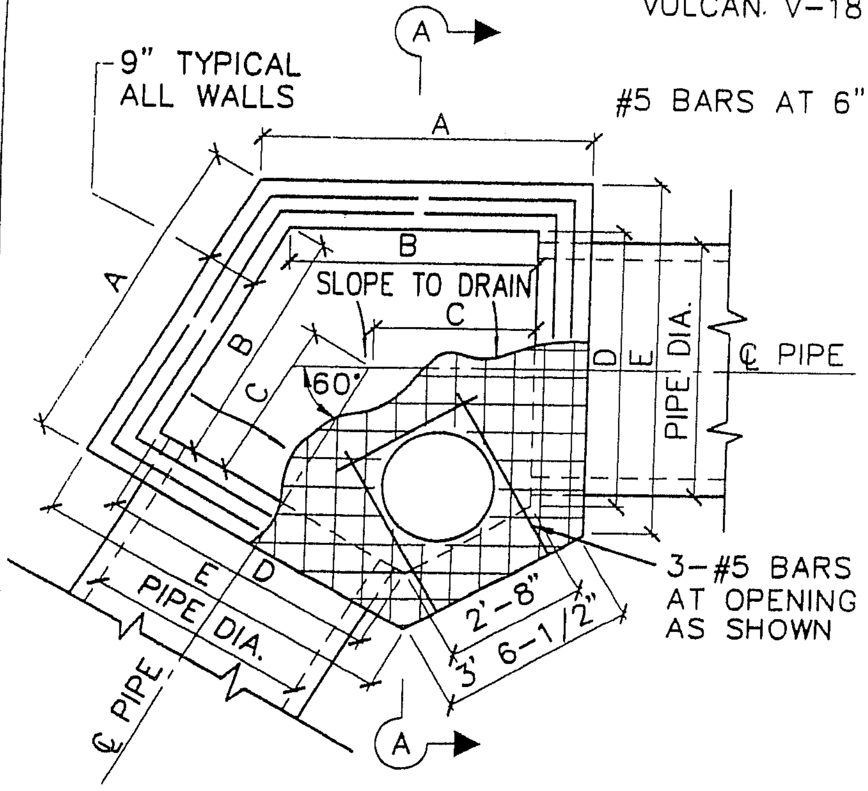
N.T.S.

SHERMAN

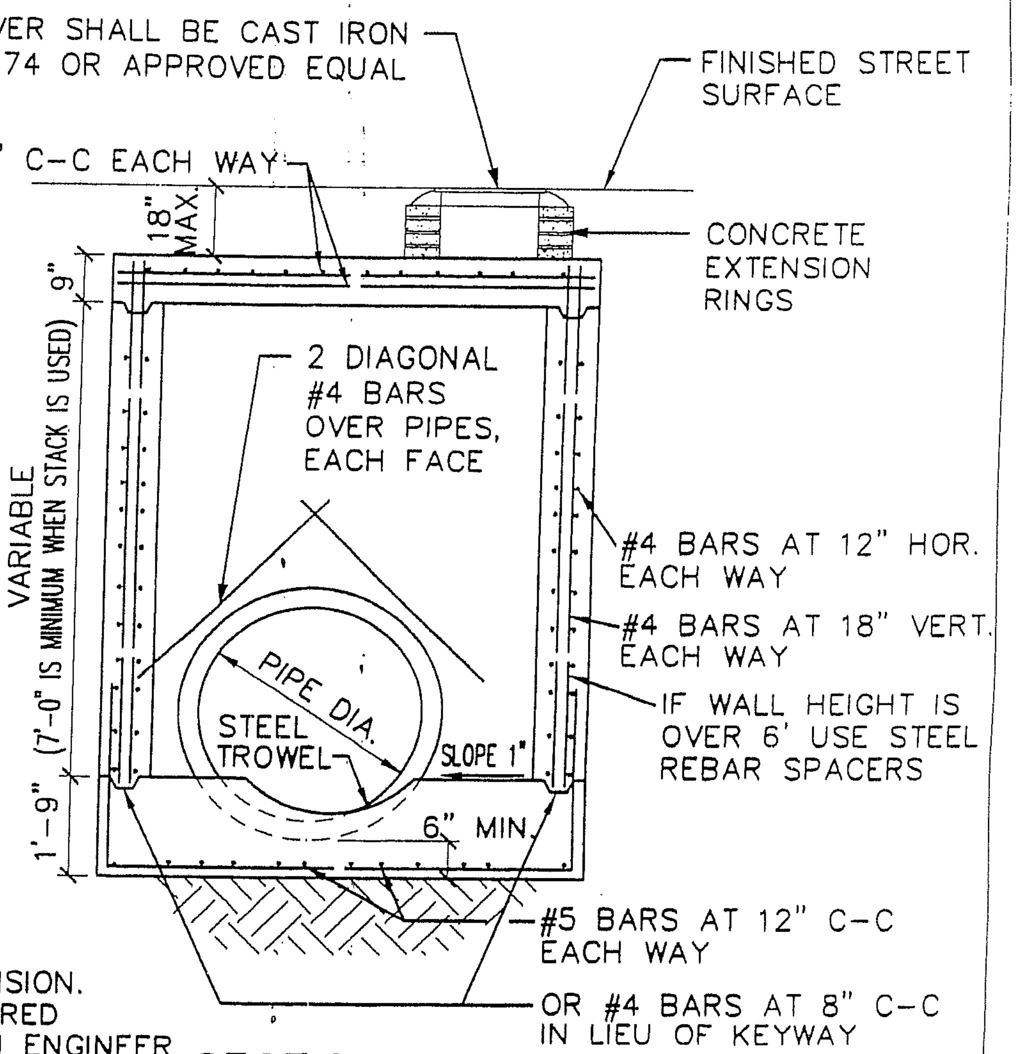
DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
STORM DRAIN MANHOLE

DATE: 04/13/00

SHEET 1 OF 2



PLAN VIEW



SECTION A-A

NOTE:

1. 2'-8" DIMENSION SHALL BE THE CONTROL DIMENSION. ANY DEVIATION IN OTHER DIMENSIONS ENCOUNTERED IN THE FIELD SHALL BE ADJUSTED BY THE TOWN ENGINEER.
2. ALL BACK FILLING SHALL BE IN ACCORDANCE WITH ITEM 6.2.9.

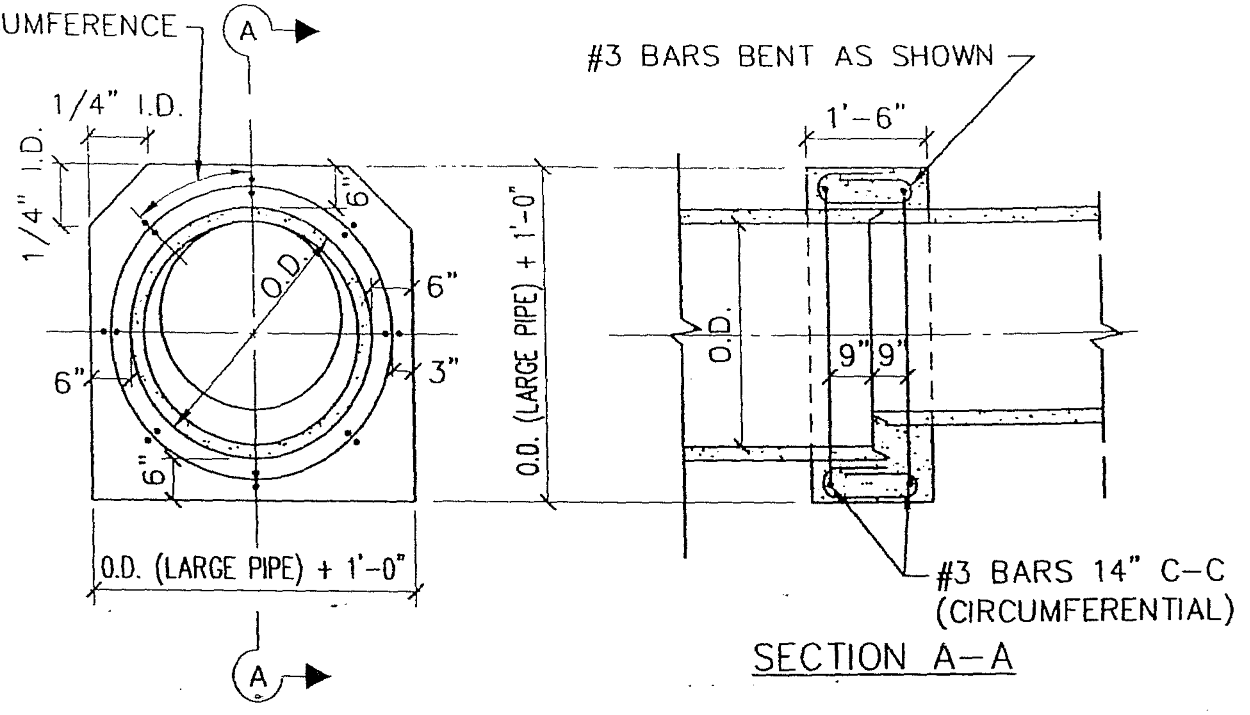
	MANHOLE TYPE						
	1	2	3	4	5	6	7
PIPE DIA.	18" TO 24 "	27" TO 33"	36" TO 42"	48" TO 54"	60" TO 66"	72" TO 78"	84" TO 96"
A	4' 5-1/2"	4' 11-5/8"	5' 5-5/8"	6' 1-3/4"	6' 9-7/8"	7' 6"	8' 6-1/8"
B	3' 3-5/16"	3' 9-3/8"	4' 3-7/16"	4' 11-1/2"	5' 7-5/8"	6' 3-3/4"	7' 3-7/8"
C	2' 5"	2' 8"	2' 11"	3' 3"	3' 7"	3' 11"	4' 5-1/8"
D	3' 0"	3' 10-1/2"	4' 9"	5' 11."	7' 1"	8' 3"	10' 0"
E	4' 2"	5' 1"	5' 11-1/4"	7' 1-1/4"	8' 3-1/4"	9' 5-1/4"	11' 2-1/4"

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
MANHOLES 1-7

DATE: 04/13/00

SHEET 2 OF 2



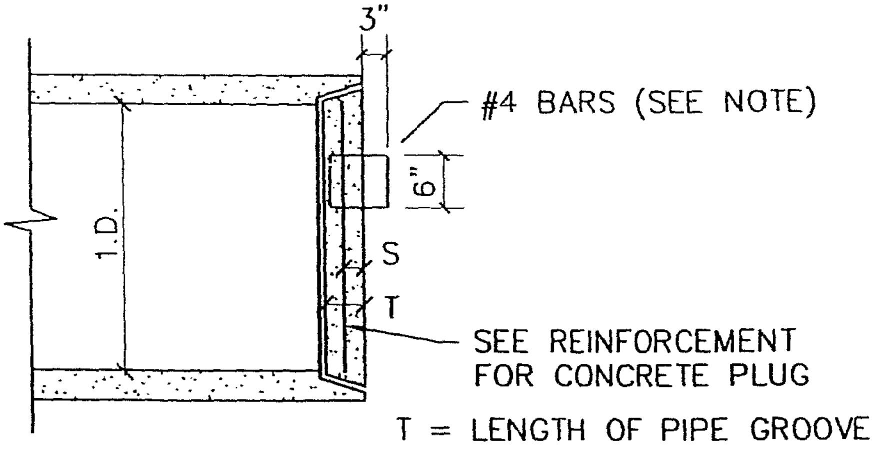
SECTION A-A

REINFORCED CONCRETE COLLAR

N.T.S.

NOTE:

COLLARS MAY ONLY BE USED TO REDUCE THE DIAMETER ONE PIPE SIZE.
A JUNCTION BOX IS REQUIRED FOR REDUCING MORE THAN ONE PIPE SIZE.



T = LENGTH OF PIPE GROOVE

REINFORCED CONCRETE PIPE PLUG

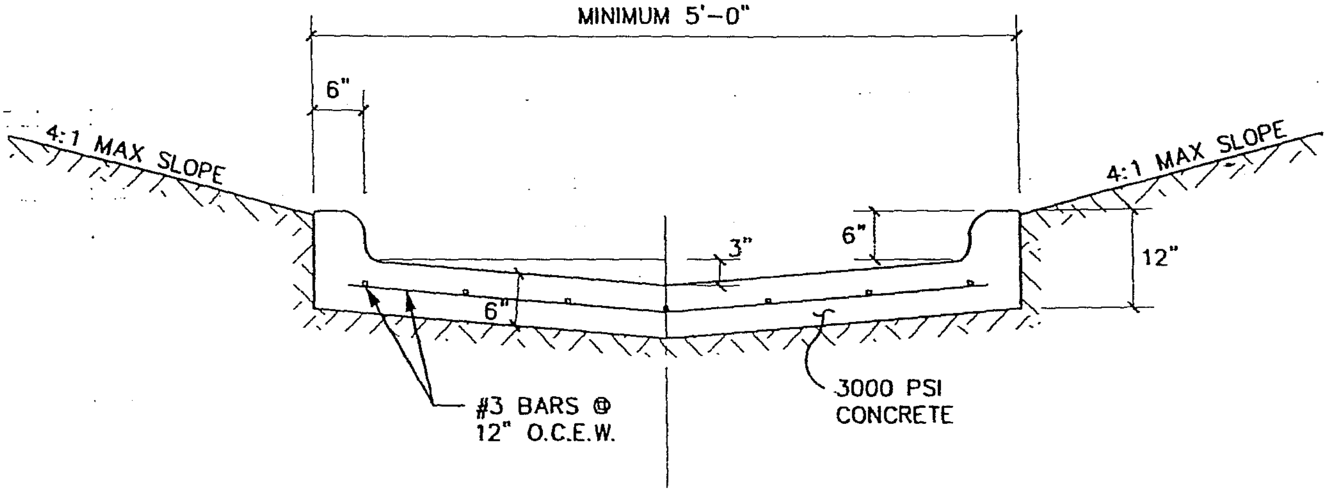
N.T.S.

PIPE SIZE	REINF. BAR	DISTANCE C-C BOTH WAYS	S
18"-33"	# 2	12"	1/2 T
36"-54"	# 3	12"	1/3 T
60"	# 4	12"	1/4 T

NOTE:

STEEL HANDLE FOR REINFORCED CONCRETE PIPE PLUG SHALL BE LOCATED 1/4 I.D. ABOVE CENTER POINT OF PLUG. TWO (2) STEEL HANDLES WILL BE REQUIRED ON PLUGS OF 36" DIA. PIPES OR LARGER AND SHALL BE PLACED 1/4 I.D. APART AND 1/4 I.D ABOVE CENTER OF PLUG.

SHERMAN	DRAINAGE SYSTEM CONSTRUCTION DETAILS STANDARD STORM SEWER REINFORCED CONCRETE COLLAR	DATE: 04/13/00 SHEET 1 OF 1



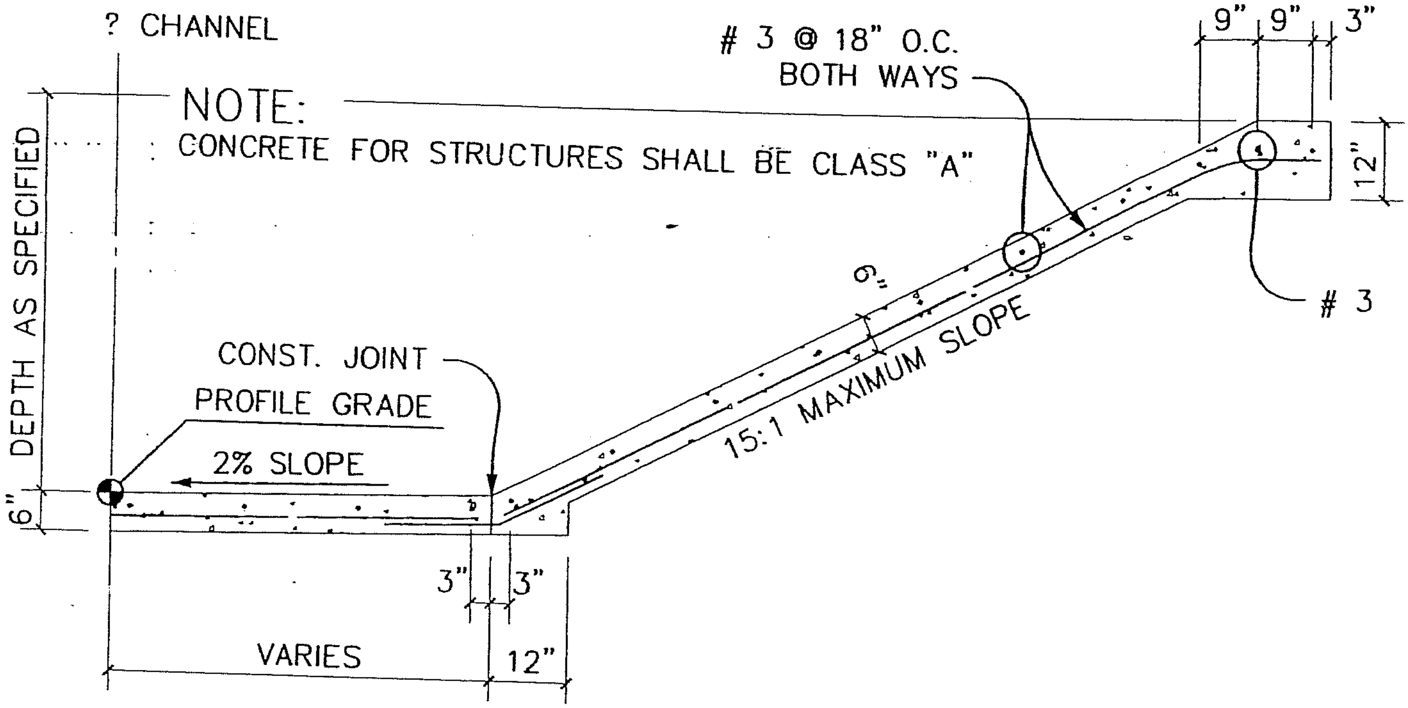
NOTES:

1. IF FLUME IS 7' OR WIDER, USE PIPE BOLLARDS
   7' x 6" DIA., AND FILL WITH CONCRETE
   PLACE AT BOTH START AND END OF FLUME
   BURY TO 4' DEPTH
2. SIDE SLOPES TO BE HYDROMULCHED.

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
CURBED FLUME & PILOT CHANNELS

DATE: 04/13/00

SHEET 1 OF 1



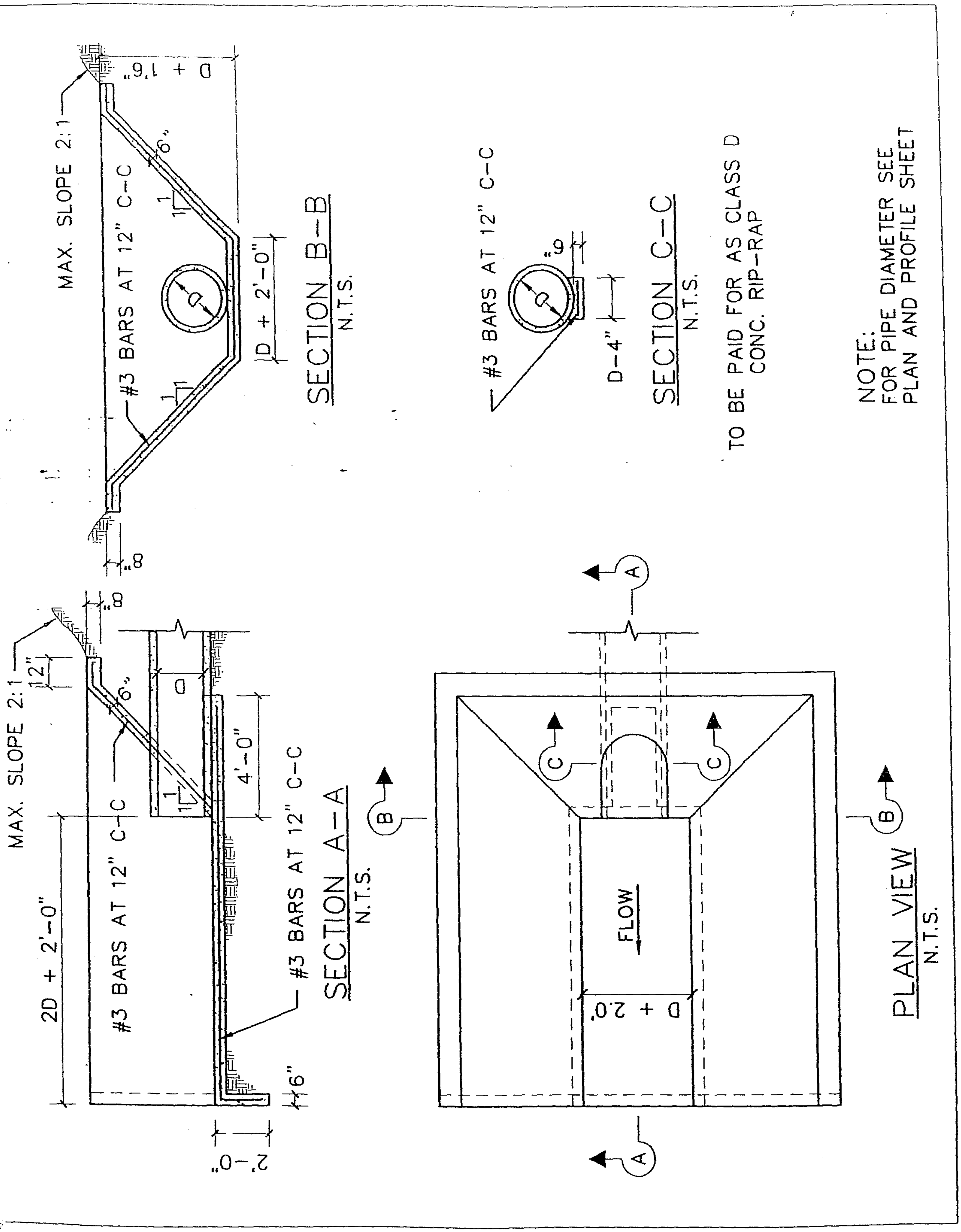
NOTE:
CONCRETE FOR STRUCTURES SHALL BE CLASS "A"

NOTE:
RIPRAP TO BE FORMED ON UNDISTURBED SOIL CUT TO GRADE. IF TO BE PLACED ON FILL, ALL FILL SHALL BE PLACED ON BENCHES CUT IN UNDISTURBED SOIL AND FILLED IN 8" LOOSE LIFTS, EACH COMPACTED TO 95% STANDARD PROCTOR DENSITY. THE FILL SO COMPACTED SHALL THEN BE CUT TO GRADE.

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
CONCRETE RIPRAP

DATE: 04/13/00
SHEET 1 OF 1
SHEET D-7



TO BE PAID FOR AS CLASS D CONC. RIP-RAP

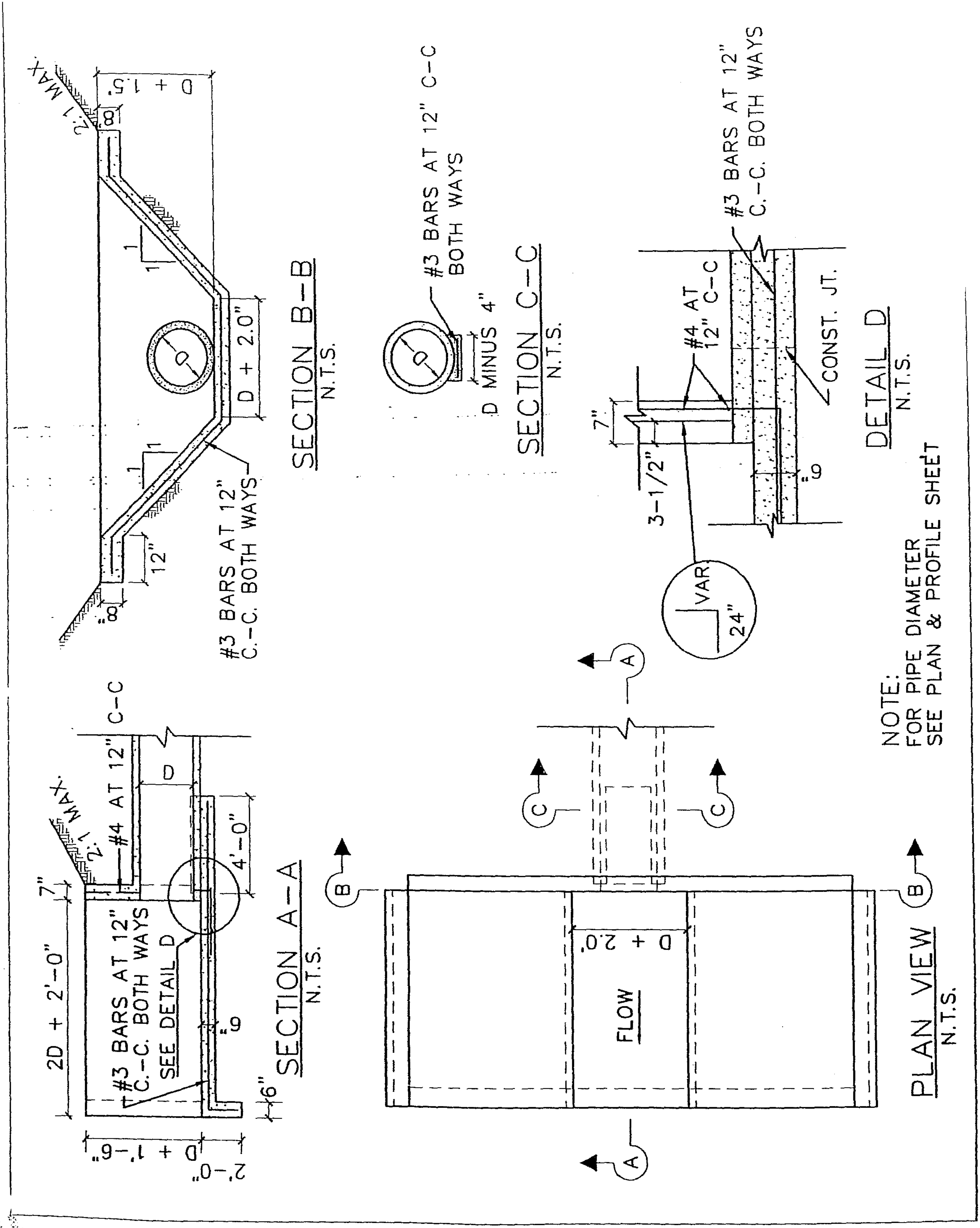
NOTE:
FOR PIPE DIAMETER SEE PLAN AND PROFILE SHEET

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER

DATE: 04/13/00

SHEET 1 OF 2



NOTE:
FOR PIPE DIAMETER
SEE PLAN & PROFILE SHEET

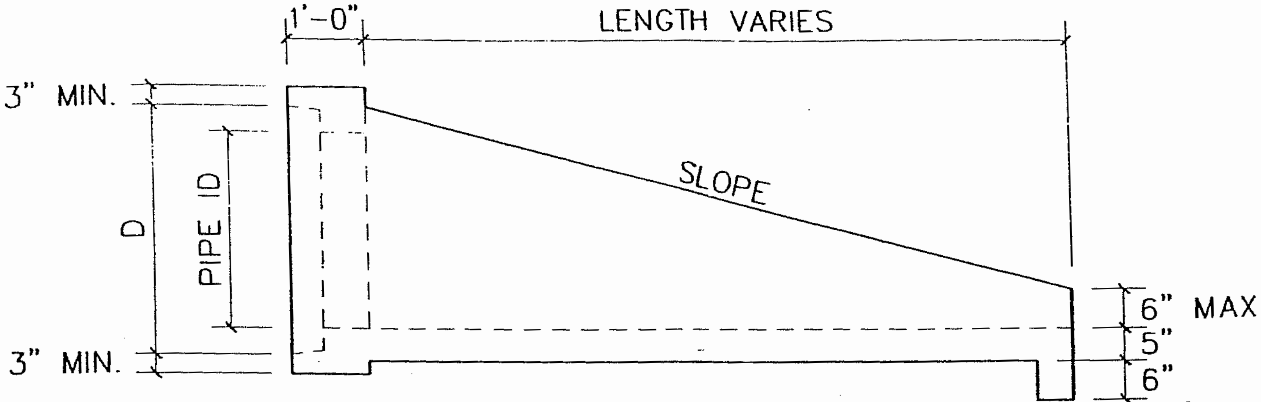
SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
VERTICAL HEADWALL

DATE: 04/13/00

SHEET 2 OF 2

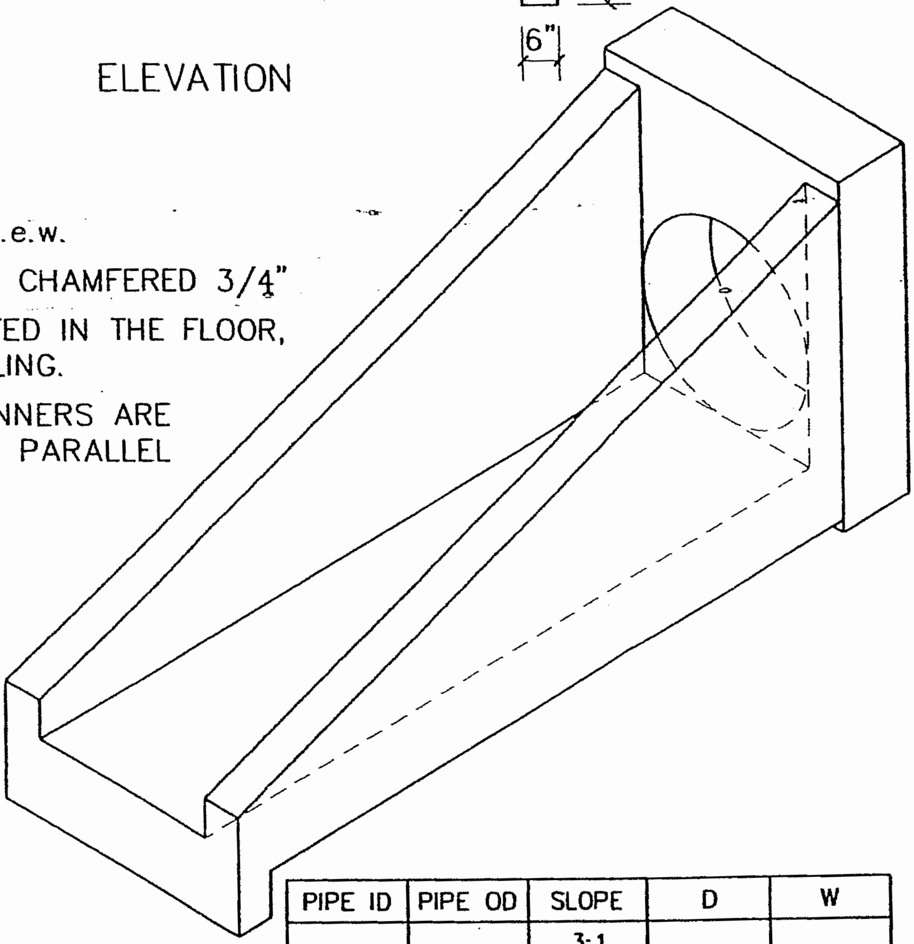
SHEET: D–8

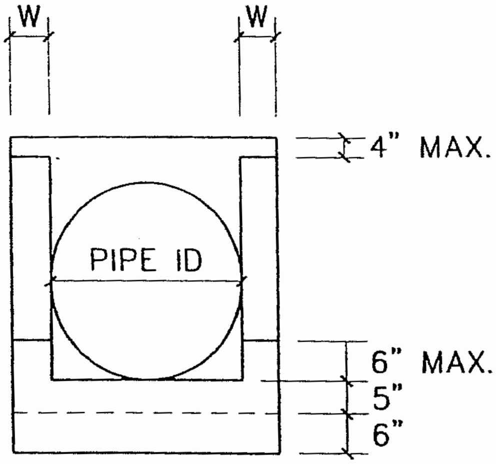


ELEVATION

NOTES:

1. 4500 PSI CONCRETE
2. #4 GRADE 60 REBAR 9" o.c.e.w.
3. ALL EXPOSED CORNERS ARE CHAMFERED 3/4"
4. SWIFT LIFT ANCHORS, LOCATED IN THE FLOOR, SHALL BE USED FOR HANDLING.
5. GALVANIZED STEEL PIPE RUNNERS ARE AVAILABLE FOR CROSS AND PARALLEL DRAINAGE APPLICATIONS.





FRONT ELEVATION

PIPE ID	PIPE OD	SLOPE	D	W
18"	23"	3:1	24"	5"
		4:1		
		6:1		
24"	30"	3:1	31"	5"
		4:1		
		6:1		

PIPE ID	PIPE OD	SLOPE	D	W
30"	37"	3:1	38"	6"
		4:1		
		6:1		
36"	44"	3:1	45-1/2"	6"
		4:1		
		6:1		
42"	51"	3:1	52-3/4"	8"
		4:1		
		6:1		
48"	58"	3:1	60"	8"
		4:1		
54"	65"	3:1	67"	8"

SHERMAN

DRAINAGE SYSTEM CONSTRUCTION DETAILS
STANDARD STORM SEWER
CULVERT W/SAFETY END TREATMENTS

DATE: 04/13/00

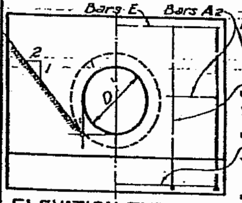
SHEET 1 OF 1

TABLE OF DIMENSIONS AND QUANTITIES FOR TWO TYPE A HEADWALLS

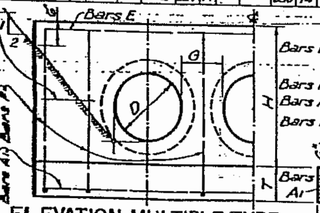
NO. OF PIPES	DIAM. OF PIPES	TABLE OF DIMENSIONS G	K	T	E	H	W	REINF. STEEL FOR TWO HEADWALLS: BARS A1 4-#3 Lgth	Wt.	BARS A2 #3 @ 18"± No.	Lgth	Wt.	BARS E 4-#5 Lgth	Wt.	BARS F1 @ 12"± No.	Size	Lgth	Wt.	BARS F2 @ 12"± No.	Size	Lgth	Wt.	TOTAL QUANTITIES STEEL LBS.	CONC. C.Y.
1	12"	~	12"	9"	1'-9"	2'-6"	7'-0"	6'-8"	10	8	2'-6"	8	6'-8"	28	12	#4	2'-11"	23	12	#4	3'-8"	29	98	1.48
2	"	10"	"	"	"	"	8'-10"	8'-6"	13	"	"	"	8'-6"	35	14	"	"	27	14	"	"	34	117	1.81
3	"	"	"	"	"	"	10'-8"	10'-4"	16	"	"	"	10'-4"	43	16	"	"	31	16	"	"	39	137	2.15
4	"	"	"	"	"	"	12'-6"	12'-2"	18	"	"	"	12'-2"	51	18	"	"	35	18	"	"	44	156	2.48
1	15"	~	12"	9"	1'-9"	2'-9"	8'-3"	7'-11"	12	8	3'-0"	9	7'-11"	33	12	#4	3'-2"	25	12	#4	3'-11"	31	110	1.82
2	"	1'-0"	"	"	"	"	10'-6"	10'-2"	15	"	"	"	10'-2"	42	14	"	"	30	14	"	"	37	133	2.24
3	"	"	"	"	"	"	12'-9"	12'-5"	19	"	"	"	12'-5"	52	16	"	"	34	16	"	"	42	156	2.66
4	"	"	"	"	"	"	15'-0"	14'-8"	22	"	"	"	14'-8"	61	18	"	"	38	18	"	"	47	177	3.09
1	18"	~	12"	9"	1'-9"	3'-0"	9'-6"	9'-2"	14	8	3'-0"	11	9'-2"	38	20	#4	3'-5"	46	20	#4	4'-2"	56	165	2.19
2	"	1'-2"	"	"	"	"	12'-2"	11'-10"	18	"	"	"	11'-10"	49	22	"	"	50	22	"	"	61	189	2.70
3	"	"	"	"	"	"	14'-10"	14'-6"	22	"	"	"	14'-6"	60	24	"	"	55	24	"	"	67	215	3.21
4	"	"	"	"	"	"	17'-6"	17'-2"	26	"	"	"	17'-2"	72	26	"	"	59	26	"	"	72	240	3.73
1	24"	~	12"	9"	2'-0"	3'-6"	12'-0"	11'-8"	18	8	4'-6"	14	11'-8"	49	24	#4	3'-11"	63	24	#4	4'-11"	79	223	3.17
2	"	1'-5"	"	"	"	"	15'-5"	15'-1"	23	"	"	"	15'-1"	63	26	"	"	68	26	"	"	85	253	3.89
3	"	"	"	"	"	"	18'-10"	18'-6"	28	"	"	"	18'-6"	77	28	"	"	73	28	"	"	92	284	4.62
4	"	"	"	"	"	"	22'-3"	21'-11"	33	"	"	"	21'-11"	91	30	"	"	79	30	"	"	99	316	5.35
1	30"	~	12"	9"	2'-3"	4'-0"	14'-6"	14'-2"	21	16	5'-6"	33	14'-2"	59	28	#4	4'-5"	83	28	#4	5'-8"	106	302	4.31
2	"	1'-8"	"	"	"	"	18'-8"	18'-4"	28	"	"	"	18'-4"	76	32	"	"	94	32	"	"	121	352	5.28
3	"	"	"	"	"	"	22'-10"	22'-6"	34	"	"	"	22'-6"	94	36	"	"	108	36	"	"	136	403	6.26
4	"	"	"	"	"	"	27'-0"	26'-8"	40	"	"	"	26'-8"	111	40	"	"	118	40	"	"	152	454	7.24
1	36"	~	12"	12"	2'-6"	4'-6"	17'-0"	16'-8"	25	16	6'-6"	39	16'-8"	70	32	#4	5'-2"	111	32	#4	6'-8"	143	388	6.40
2	"	1'-11"	"	"	"	"	21'-11"	21'-7"	32	"	"	"	21'-7"	90	36	"	"	124	36	"	"	160	445	7.89
3	"	"	"	"	"	"	26'-10"	26'-6"	40	"	"	"	26'-6"	111	40	"	"	138	40	"	"	178	506	9.37
4	"	"	"	"	"	"	31'-9"	31'-5"	47	"	"	"	31'-5"	131	44	"	"	152	44	"	"	196	565	10.85
1	42"	~	12"	12"	2'-9"	5'-0"	19'-6"	19'-2"	29	16	7'-6"	45	19'-2"	80	36	#4	5'-8"	136	36	#4	7'-5"	178	468	8.10
2	"	2'-2"	"	"	"	"	25'-2"	24'-10"	37	"	"	"	24'-10"	104	40	"	"	152	40	"	"	198	536	9.96
3	"	"	"	"	"	"	30'-10"	30'-6"	46	"	"	"	30'-6"	127	44	"	"	167	44	"	"	218	603	11.80
4	"	"	"	"	"	"	36'-6"	36'-2"	54	"	"	"	36'-2"	151	48	"	"	182	48	"	"	238	670	13.68
1	48"	~	15"	12"	3'-0"	5'-9"	23'-0"	22'-8"	34	24	8'-9"	79	22'-8"	95	40	#5	6'-5"	288	40	#5	8'-5"	351	827	10.74
2	"	2'-5"	"	"	"	"	29'-5"	29'-1"	44	"	"	"	29'-1"	121	44	"	"	295	44	"	"	386	925	13.08
3	"	"	"	"	"	"	35'-10"	35'-6"	53	"	"	"	35'-6"	148	48	"	"	321	48	"	"	422	1023	15.43
4	"	"	"	"	"	"	42'-3"	41'-11"	63	"	"	"	41'-11"	175	52	"	"	348	52	"	"	457	1122	17.77
1	54"	~	15"	12"	3'-3"	6'-3"	25'-6"	25'-2"	38	24	9'-9"	88	25'-2"	105	44	#5	6'-11"	318	44	#5	9'-2"	421	970	12.87
2	"	2'-10"	"	"	"	"	32'-10"	32'-6"	49	"	"	"	32'-6"	136	50	"	"	361	50	"	"	478	1112	15.77
3	"	"	"	"	"	"	40'-2"	39'-10"	60	"	"	"	39'-10"	166	56	"	"	404	56	"	"	536	1254	18.66
4	"	"	"	"	"	"	47'-6"	47'-2"	71	"	"	"	47'-2"	197	62	"	"	447	62	"	"	593	1396	21.55
1	60"	~	15"	12"	3'-6"	6'-9"	28'-0"	27'-8"	42	24	10'-9"	97	27'-8"	115	48	#5	7'-5"	371	48	#5	9'-11"	497	1122	15.20
2	"	3'-0"	"	"	"	"	36'-0"	35'-8"	54	"	"	"	35'-8"	149	54	"	"	418	54	"	"	559	1277	18.55
3	"	"	"	"	"	"	44'-0"	43'-8"	66	"	"	"	43'-8"	182	60	"	"	464	60	"	"	621	1430	21.89
4	"	"	"	"	"	"	52'-0"	51'-8"	78	"	"	"	51'-8"	216	66	"	"	511	66	"	"	683	1585	25.24
1	66"	~	15"	12"	3'-9"	7'-3"	30'-6"	30'-2"	45	32	11'-9"	141	30'-2"	126	52	#5	7'-11"	430	52	#5	10'-8"	579	1321	17.72
2	"	3'-1"	"	"	"	"	39'-1"	38'-9"	58	"	"	"	38'-9"	162	58	"	"	479	58	"	"	645	1485	21.49
3	"	"	"	"	"	"	47'-8"	47'-4"	78	"	"	"	47'-4"	198	64	"	"	529	64	"	"	712	1651	25.27
4	"	"	"	"	"	"	56'-3"	55'-11"	84	"	"	"	55'-11"	235	70	"	"	578	70	"	"	779	1815	29.05
1	72"	~	15"	12"	4'-0"	7'-9"	33'-0"	32'-8"	49	32	12'-9"	153	32'-8"	136	56	#5	8'-5"	492	56	#5	11'-5"	687	1497	20.42
2	"	3'-2"	"	"	"	"	42'-2"	41'-10"	63	"	"	"	41'-10"	175	62	"	"	544	62	"	"	738	1673	24.66
3	"	"	"	"	"	"	51'-4"	51'-0"	77	"	"	"	51'-0"	213	68	"	"	597	68	"	"	810	1850	28.89
4	"	"	"	"	"	"	60'-6"	60'-2"	90	"	"	"	60'-2"	251	74	"	"	650	74	"	"	881	2025	33.12

TABLE OF DIMENSIONS AND QUANTITIES FOR TWO TYPE B HEADWALLS

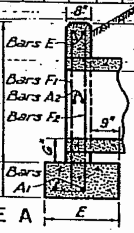
NO. OF PIPES	DIAM. OF PIPES	TABLE OF DIMENSIONS G	K	X	H	Y	W	REINFORCING STEEL AND QUANTITIES FOR TWO HEADWALLS: BARS A1-Ax #4 @ 12"± No.	Av. Lgth	Wt.	BARS B #3 @ 18"± No.	Lgth	Wt.	BARS B1-Bx #3 @ 18"± No.	Av. Lgth	Wt.	C=2'-0" #4 @ 12"± No.	Wt.	BARS D1-Dx #3 @ 12"± No.	Av. Lgth	Wt.	BARS E 8-#5 Lgth	Wt.	BARS F No.	Size	Lgth	Wt.	BARS G 4-#3 Lgth	Wt.	BARS S 12-#4 Lgth	Wt.	BARS V1-Vx #4 @ 12"± No.	Av. Lgth	Wt.	BARS W 4-#5 Lgth	Wt.	*TOTAL QUANTITIES STEEL LBS.	CONC. C.Y.
1	12"	~	12"	2'-4"	2'-0"	1'-0"	2'-4"	2	2'-8"	4	6	2'-6"	6	—	—	—	4	5	—	—	—	2'-0"	17	8	#4	2'-2"	12	2'-8"	4	8"	5	4	2'-11"	8	1'-8"	7	68	.52
2	"	10"	"	4'-2"	"	"	4'-2"	"	4'-6"	6	8	"	8	—	—	—	"	"	—	—	—	3'-10"	32	12	"	"	17	4'-6"	7	"	"	"	"	"	"	"	95	.82
3	"	"	"	6'-0"	"	"	6'-0"	"	6'-4"	8	10	"	9	—	—	—	"	"	—	—	—	5'-8"	47	16	"	"	23	6'-4"	10	"	"	"	"	"	"	"	122	1.11
4	"	"	"	7'-10"	"	"	7'-10"	"	8'-2"	11	12	"	11	—	—	—	"	"	—	—	—	7'-6"	63	20	"	"	29	8'-2"	12	"	"	"	"	"	"	"	151	1.40
1	15"	~	12"	2'-7½"	2'-3"	1'-6"	3'-2⅝"	4	3'-0"	8	6	3'-0"	7	4	1'-10"	3	8	11	—	—		2'-3"	19	8	#4	2'-5"	13	3'-7"	5	1'-3"	10	8	3'-0"	16	2'-3"	9	101	.75
2	"	1'-0"	"	4'-10½"	"	"	5'-5⅝"	"	5'-3"	14	8	"	9	"	"	"	"	"	—	—		4'-6"	38	12	"	"	19	5'-10"	9	"	"	"	"	"	"	"	138	1.16
3	"	"	"	7'-1½"	"	"	7'-8⅝"	"	7'-6"	20	10	"	11	"	"	"	"	"	—	—		6'-9"	56	16	"	"	26	8'-1"	12	"	"	"	"	"	"	"	174	1.57
4	"	"	"	9'-4½"	"	"	9'-11⅝"	"	9'-9"	26	14	"	16	"	"	"	"	"	—	—		9'-0"	75	20	"	"	32	10'-4"	16	"	"	"	"	"	"	"	214	1.98
1	18"	~	12"	2'-11"	2'-6"	2'-0"	4'-0⅜"	4	3'-10"	10	6	3'-6"	8	4	1'-10"	3	8	11	4	1'-0"	2	2'-7"	22	8	#4	2'-8"	14	4'-5"	7	1'-10"	15	12	3'-2"	25	2'-11"	12	129	1.00
2	"	1'-2"	"	5'-7"	"	"	6'-8⅜"	"	6'-6"	17	8	"	11	"	"	"	"	"	"	"	"	5'-3"	44	12	"	"	21	7'-1"	11	"	"	"	"	"	"	"	172	1.55
3	"	"	"	8'-3"	"	"	9'-4⅜"	"	9'-2"	25	12	"	16	"	"	"	"	"	"	"	"	7'-11"	66	16	"	"	29	9'-9"	15	"	"	"	"	"	"	"	219	2.11
4	"	"	"	10'-11"	"	"	12'-0⅜"	"	11'-10"	32	16	"	21	"	"	"	"	"	"	"	"	10'-7"	88	20	"	"	36	12'-5"	19	"	"	"	"	"	"	"	264	2.65
1	24"	~	12"	3'-6"	3'-0"	3'-0"	5'-9¾"	6	5'-0"	20	6	4'-6"	10	4	1'-10"	3	8	11	4	1'-0"	2	3'-2"	26	8	#4	3'-2"	17	6'-2"	9	3'-0"	24	16	3'-5"	37	4'-2"	17	176	1.62
2	"	1'-5"	"	6'-11"	"	"	9'-2¾"	"	8'-5"	34	10	"	17	"	"	"	"	"	"	"	"	6'-7"	55	12	"	"	25	9'-7"	14	"	"	"	"	"	"	"	239	2.46
3	"	"	"	10'-4"	"	"	12'-7¾"	"	11'-10"	47	16	"	27	"	"	"	"	"	"	"	"	9'-10"	82	16	"	"	34	13'-0"	20	"	"	"	"	"	"	"	304	3.32
4	"	"	"	13'-9"	"	"	16'-0¾"	"	15'-3"	61	20	"	34	"	"	"	"	"	"	"	"	13'-5"	112	20	"	"	42	16'-5"	25	"	"	"	"	"	"	"	368	4.18
1	30"	~	12"	4'-1"	3'-6"	4'-0"	7'-6⅝"	8	6'-2"	33	6	5'-6"	12	8	3'-1"	9	12	16	8	2'-2"	7	3'-9"	31	8	#4	3'-8"	20	7'-11"	12	4'-2"	33	20	3'-8"	49	5'-5"	23	245	2.34
2	"	1'-8"	"	8'-3"	"	"	11'-8⅝"	"	10'-4"	55	12	"	25	"	"	"	"	"	"	"	"	7'-11"	56	16	"	"	39	12'-1"	18	"	"	"	"	"	"	"	340	3.58
3	"	"	"	12'-5"	"	"	15'-10⅝"	"	14'-6"	77	18	"	37	"	"	"	"	"	"	"	"	12'-1"	101	24	"	"	59	16'-3"	24	"	"	"	"	"	"	"	435	4.80
4	"	"	"	16'-7"	"	"	20'-0⅝"	"	18'-8"	100	24	"	50	"	"	"	"	"	"	"	"	16'-3"	136	32	"	"	78	20'-5"	31	"	"	"	"	"	"	"	532	6.04
1	36"	~	12"	4'-8"	4'-0"	5'-0"	9'-3⅜"	10	7'-4"	49	8	6'-6"	20	8	3'-1"	9	12	16	8	2'-2"	7	4'-4"	36	8	#4	4'-2"	22	9'-8"	15	5'-4"	43	24	3'-11"	63	6'-8"	28	308	3.23
2	"	1'-11"	"	9'-7"	"	"	14'-2⅜"	"	12'-3"	82	14	"	34	"	"	"	"	"	"	"	"	9'-3"	77	16	"	"	45	14'-7"	22	"	"	"	"	"	"	"	426	4.89
3	"	"		14'-6"	"	"	19'-1⅜"	"	17'-2"	115	20	"	49	"	"	"	"	"	"	"	"	14'-2"	118	24	"	"	67	19'-6"	29	"	"	"	"	"	"	"	544	6.55
4	"	"		19'-5"	"	"	24'-0⅜"	"	22'-1"	147	28	"	68	"	"	"	"	"	"	"	"	19'-1"	159	32	"	"	89	24'-5"	37	"	"	"	"	"	"	"	666	8.22
1	42"	~	12"	5'-3"	4'-6"	6'-0"	11'-0¼"	12	8'-6"	68	8	7'-6"	23	12	4'-5"	20	16	21	12	3'-3"	15	4'-11"	41	8	#4	4'-8"	25	11'-5"	17	6'-5"	51	28	4'-2"	78	7'-11"	33	392	4.23
2	"	2'-2"	"	10'-11"	"	"	16'-8¼"	"	14'-2"	114	16	"	45	"	"	"	"	"	"	"	"	10'-7"	88	16	"	"	50	17'-1"	26	"	"	"	"	"	"	"	541	6.40
3	"	"	"	16'-7"	"	"	22'-4¼"	"	19'-10"	159	24	"	68	"	"	"	"	"	"	"	"	16'-3"	136	24	"	"	75	22'-9"	34	"	"	"	"	"	"	"	690	8.56
4	"	"	"	22'-3"	"	"	28'-0¼"	"	25'-6"	204	32	"	90	"	"	"	"	"	"	"	"	21'-11"	183	32	"	"	100	28'-5"	43	"	"	"	"	"	"	"	838	10.74
1	48"	~	15"	5'-10"	5'-3"	7'-0"	12'-9⅛"	14	9'-8"	90	10	8'-6"	32	12	4'-5"	20	16	21	12	3'-4"	15	5'-6"	46	8	#5	5'-5"	45	13'-2"	20	7'-7"	61	32	4'-5"	94	9'-3"	39	483	5.43
2	"	2'-5"	"	12'-3"	"	"	19'-2⅛"	"	16'-1"	150	18	"	58	"	"	"	"	"	"	"	"	11'-11"	99	16	"	"	90	19'-7"	29	"	"	"	"	"	"	"	676	8.25
3	"	"	"	18'-8"	"	"	25'-7⅛"	"	22'-6"	210	26	"	83	"	"	"	"	"	"	"	"	18'-4"	153	24	"	"	136	26'-0"	39	"	"	"	"	"	"	"	871	11.07
4	"	"	"	25'-1"	"	"	32'-0⅛"	"	28'-11"	270	36	"	115	"	"	"	"	"	"	"	"	24'-9"	207	32	"	"	181	32'-5"	49	"	"	"	"	"	"	"	1072	13.89
1	54"	~	15"	6'-5"	5'-9"	8'-0"	14'-6"	16	10'-10"	116	10	9'-6"	36	12	4'-5"	20	20	27	16	4'-5"	27	6'-1"	51	8	#5	5'-11"	49	14'-10"	22	8'-9"	70	40	4'-8"	125	10'-5"	43	586	6.71
2	"	2'-10"	"	13'-9"	"	"	21'-10"	"	18'-2"	194	20	"	71	"	"	"	"	"	"	"	"	13'-5"	112	20	"	"	123	22'-2"	33	"	"	"	"	"	"	"	845	10.28
3	"	"	"	21'-1"	"	"	29'-2"	"	25'-6"	273	30	"	107	"	"	"	"	"	"	"	"	20'-9"	173	32	"	"	198	29'-6"	44	"	"	"	"	"	"	"	1107	13.84
4	"	"	"	28'-5"	"	"	36'-6"	"	32'-10"	351	40	"	143	"	"	"	"	"	"	"	"	28'-1"	234	44	"	"	272	36'-10"	55	"	"	"	"	"	"	"	1367	17.42
1	60"	~	15"	7'-0"	6'-3"	9'-0"	16'-2⅞"	18	12'-0"	144	10	10'-6"	39	16	5'-9"	35	20	27	16	4'-5"	27	6'-8"	56	8	#5	6'-5"	54	16'-7"	25	9'-11"	80	44	4'-11"	145	11'-8"	49	681	8.11
2	"	3'-0"	"	15'-0"	"	"	24'-2⅞"	"	20'-0"	240	22	"	87	"	"	"	"	"	"	"	"	14'-8"	122	20	"	"	134	25'-7"	38	"	"	"	"	"	"	"	984	12.34
3	"	"	"	23'-0"	"	"	32'-2⅞"	"	28'-0"	337	32	"	126	"	"	"	"	"	"	"	"	22'-8"	189	32	"	"	214	32'-7"	49	"	"	"	"	"	"	"	1278	16.57
4	"	"	"	31'-0"	"	"	40'-2⅞"	"	36'-5"	438	44	"	174	"	"	"	"	"	"	"	"	30'-8"	256	44	"	"	295	40'-8"	61	"	"	"	"	"	"	"	1587	20.82
1	66"	~	15"	7'-7"	6'-9"	10'-0"	17'-11¾"	20	13'-2"	176	12	11'-6"	52	16	5'-9"	35	24	32	20	5'-7"	42	7'-3"	60	8	#5	6'-11"	58	18'-4"	28	11'-1"	89	48	5'-2"	166	13'-0"	54	792	9.65
2	"	3'-1"	"	16'-2"	"	"	26'-6¾"	"	21'-9"	291	24	"	104	"	"	"	"	"	"	"	"	15'-10"	132	20	"	"	144	26'-11"	40	"	"	"	"	"	"	"	1129	14.54
3	"	"	"	24'-9"	"	"	35'-1¾"	"	30'-4"	405	34	"	147	"	"	"	"	"	"	"	"	24'-5"	204	32	"	"	231	35'-6"	53	"	"	"	"	"	"	"	1458	19.42
4	"	"	"	33'-4"	"	"	43'-8¾"	"	39'-8"	530	46	"	199	"	"	"	"	"	"	"	"	33'-0"	275	44	"	"	318	44'-2"	67	"	"	"	"	"	"	"	1807	24.31
1	72"	~	15"	8'-2"	7'-3"	11'-0"	19'-8⅝"	22	14'-4"	211	12	12'-6"	56	16	5'-9"	35	24	32	20	5'-7"	42	7'-10"	65	8	#5	7'-5"	62	20'-1"	30	12'-3"	98	52	5'-5"	188	14'-3"	59	878	11.32
2	"	3'-2"	"	17'-4"	"	"	28'-10⅝"	"	23'-6"	345	24	"	113	"	"	"	"	"	"	"	"	17'-0"	142	20	"	"	155	29'-3"	44	"	"	"	"	"	"	"	1253	16.91
3	"	"	"	26'-6"	"	"	38'-0⅝"	"	32'-10"	482	38	"	179	"	"	"	"	"	"	"	"	26'-2"	218	32	"	"	248	38'-5"	58	"	"	"	"	"	"	"	1639	22.52
4	"	"	"	35'-8"	"	"	47'-2⅝"	"	41'-10"	615	50	"	235	"	"	"	"	"	"	"	"	35'-4"	295	44	"	"	341	47'-8"	72	"	"	"	"	"	"	"	2017	28.11



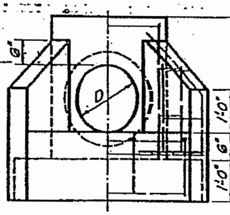
ELEVATION TYPE A



ELEVATION MULTIPLE TYPE A



℄ SECTION



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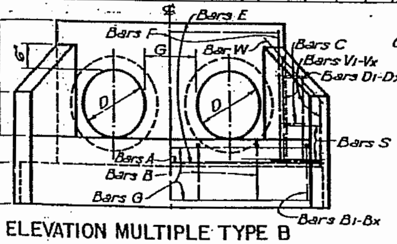

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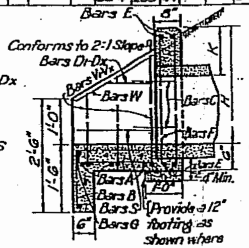
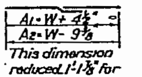


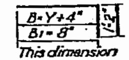
required to maintain 4"Min. cover for pipes. Concrete for footing shall be added to Total Quantities shown.

TYPICAL WING ELEVATION



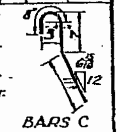
This dimension reduced 1'-1⅞" for each successive bar.

BARS A1-Ax



This dimension increased 2'-7" for each successive bar.

BARS B & B1-Bx

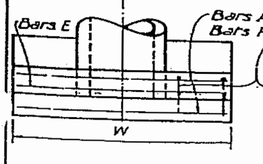


BARS C

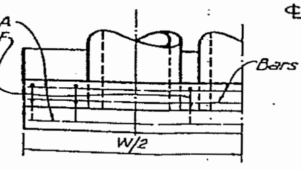
GENERAL NOTES :-

All exposed corners shall be chamfered ¾".

Reinforcing steel shall be placed with the center of the outside layer of bars 2" from the surface of the concrete. Total Quantities include one 20 diameter lap for all bars over 60'-0" in length.



PLAN TYPE A



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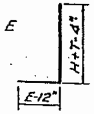
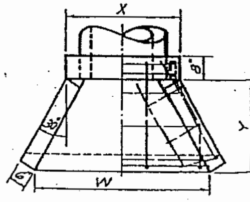
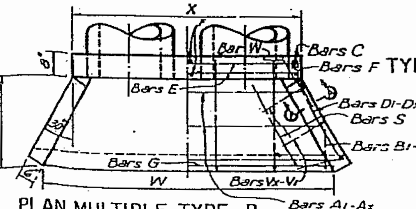


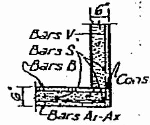
BARS F2



PLAN TYPE B



PLAN MULTIPLE TYPE B



SEC. A-A

*Concrete Quantities increase slightly for metal pipe installations

TEXAS HIGHWAY DEPARTMENT

CONCRETE HEADWALLS FOR PIPE CULVERTS

12 TO 72 INCHES IN DIAMETER

CH-11

DN.	T.H.D.	DRAWING	DATE
CK. DN.	T.H.D.	Original	Feb. 1950
DW.	H.D.A.		
CK. DW.	K.M.A.	Rev. 11-57 Concrete	
TR.	D.C.K.		
CK. TR.	H.D.A.		

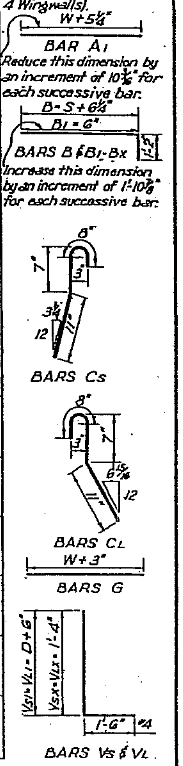
TABLE OF DIMENSIONS / BILL OF REINFORCING STEEL FOR TWO COMPLETE HEADWALLS

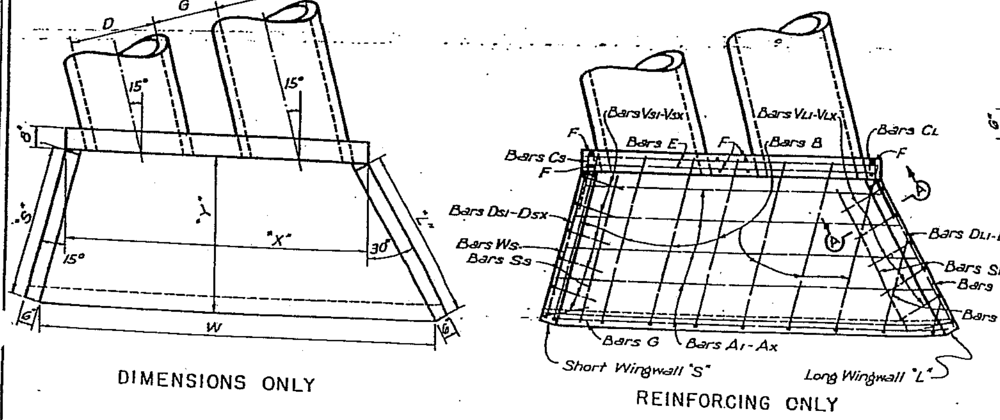
NO. OF PIPES	PIPE DIAM. D	G	K	X	H	Y	W	S	L	BARS A_1-A_x #4 @ 12"±			BARS B #3 @18"±			BARS B_1-B_x #3 @ 18"			C_S = 2'-0" #4 @12"±		C_L = 2'-0" #4 @12"±		BARS D_{S1}-D_{SX} #3 @ 12"±			BARS D_{L1}-D_{LX} #3 @ 12"±		
										No.	Av.Lgth.	Wt.	No.	Lgth.	Wt.	No.	Av.Lgth.	Wt.	No.	Wt.	No.	Wt.	No.	Av.Lgth.	Wt.	No.	Av.Lgth.	Wt.
1	12"	~	12"	2'-5⅞"	2'-0"	1'-0"	2'-2⅛"	10⅝"	10⅝"	2	2'-8"	4	4	2'-7"	4	—	—	—	2	3	2	3	—	—	—	—	—	—
2	"	10"	"	4'-5⅝"	"	"	4'-2⅛"	"	"	"	4'-8"	6	6	"	6	—	—	—	"	"	"	"	—	—	—	—	—	—
3	"	"	"	6'-4⅜"	"	"	6'-1¼"	"	"	"	6'-7"	9	10	"	10	—	—	—	"	"	"	"	—	—	—	—	—	—
4	"	"	"	8'-3"	"	"	8'-0"	"	"	"	8'-5"	11	12	"	12	—	—	—	"	"	"	"	—	—	—	—	—	—
1	15"	—	12"	2'-10⅜"	2'-3"	1'-6"	3'-0⅝"	1'-5"	1'-5⅝"	4	3'-1"	8	4	3'-1"	5	2	1'-8"	1	4	5	4	5	—	—	—	—	—	—
2	"	1'-0"	"	5'-2¼"	"	"	5'-4⅜"	"	"	"	5'-5"	14	8	"	9	"	"	"	"	"	"	"	—	—	—	—	—	—
3	"	"	"	7'-6¼"	"	"	7'-8⅜"	"	"	"	7'-9"	21	10	"	12	"	"	"	"	"	"	"	—	—	—	—	—	—
4	"	"	"	9'-10¼"	"	"	10'-0⅛"	"	"	"	10'-1"	27	16	"	19	"	"	"	"	"	"	"	—	—	—	—	—	—
1	18"	~	12"	3'-2"	2'-6"	2'-0"	3'-9⅝"	1'-11⅝"	2'-0¼"	4	3'-9"	10	4	3'-7"	5	2	1'-8"	1	4	5	4	5	2	11"	1	2	1'-0"	1
2	"	1'-2"	"	5'-11⅝"	"	"	6'-6⅝"	"	"	"	6'-6"	17	8	"	11	"	"	"	"	"	"	"	"	"	"	"	"	"
3	"	"	"	8'-8⅝"	"	"	9'-3⅝"	"	"	"	9'-4"	25	12	"	16	"	"	"	"	"	"	"	"	"	"	"	"	"
4	"	"	"	11'-5⅞"	"	"	12'-0½"	"	"	"	12'-1"	32	16	"	22	"	"	"	"	"	"	"	"	"	"	"	"	"
1	24"	~	12"	3'-9⅜"	3'-0"	3'-0"	5'-2⅞"	2'-11⅝"	3'-2⅝"	6	4'-10"	19	6	4'-8"	11	2	1'-8"	1	4	5	4	5	2	1'-0"	1	2	1'-0"	1
2	"	1'-5"	"	7'-3⅜"	"	"	8'-9"	"	"	"	8'-4"	33	10	"	18	"	"	"	"	"	"	"	"	"	"	"	"	"
3	"	"	"	10'-10⅝"	"	"	12'-3⅜"	"	"	"	11'-11"	48	16	"	28	"	"	"	"	"	"	"	"	"	"	"	"	"
4	"	"	"	14'-4½"	"	"	15'-9⅜"	"	"	"	15'-5"	62	20	"	35	"	"	"	"	"	"	"	"	"	"	"	"	"
1	30"	~	12"	4'-4⅝"	3'-6"	4'-0"	6'-7⅛"	4'-0⅝"	4'-4"	8	5'-10"	31	6	5'-8"	13	4	2'-7"	4	6	8	6	8	4	2'-0"	3	4	2'-2"	3
2	"	1'-8"	"	8'-8¼"	"	"	10'-11⅝"	"	"	"	10'-2"	54	12	"	26	"	"	"	"	"	"	"	"	"	"	"	"	"
3	"	"	"	13'-0"	"	"	15'-3⅜"	"	"	"	14'-6"	77	18	"	38	"	"	"	"	"	"	"	"	"	"	"	"	"
4	"	"	"	17'-3¾"	"	"	19'-7⅜"	"	"	"	18'-9"	100	24	"	51	"	"	"	"	"	"	"	"	"	"	"	"	"
1	36"	~	12"	4'-11¾"	4'-0"	5'-0"	8'-1¼"	5'-0½"	5'-5⅝"	10	6'-10"	46	8	6'-9"	20	4	2'-7"	4	6	8	6	8	4	2'-0"	3	4	2'-2"	3
2	"	1'-11"	"	10'-0⅜"	"	"	13'-2⅝"	"	"	"	11'-11"	80	14	"	36	"	"	"	"	"	"	"	"	"	"	"	"	"
3	"	"	"	15'-1⅞"	"	"	18'-3½"	"	"	"	17'-0"	114	20	"	51	"	"	"	"	"	"	"	"	"	"	"	"	"
4	"	"	"	20'-3"	"	"	23'-4½"	"	"	"	22'-2"	148	26	"	66	"	"	"	"	"	"	"	"	"	"	"	"	"
1	42"	~	12"	5'-7"	4'-6"	6'-0"	9'-6⅝"	6'-0⅝"	6'-7⅝"	12	7'-11"	63	8	7'-9"	23	6	3'-7"	8	8	11	8	11	6	3'-0"	7	6	3'-3"	7
2	"	2'-2"	"	11'-5⅜"	"	"	15'-5⅝"	"	"	"	13'-9"	110	16	"	47	"	"	"	"	"	"	"	"	"	"	"	"	"
3	"	"	"	17'-3⅜"	"	"	21'-3½"	"	"	"	19'-8"	158	24	"	70	"	"	"	"	"	"	"	"	"	"	"	"	"
4	"	"	"	23'-2⅝"	"	"	27'-1⅜"	"	"	"	25'-6"	204	32	"	93	"	"	"	"	"	"	"	"	"	"	"	"	"
1	48"	~	15"	6'-2¼"	5'-3"	7'-0"	11'-0"	7'-1⅜"	7'-9½"	14	8'-11"	83	8	8'-10"	27	8	4'-6"	14	8	11	8	11	6	3'-0"	7	6	3'-4"	8
2	"	2'-5"	"	12'-9⅞"	"	"	17'-7¾"	"	"	"	15'-7"	146	18	"	60	"	"	"	"	"	"	"	"	"	"	"	"	"
3	"	"	"	19'-5⅝"	"	"	24'-3½"	"	"	"	22'-3"	208	26	"	86	"	"	"	"	"	"	"	"	"	"	"	"	"
4	"	"	"	26'-1⅜"	"	"	30'-11¼"	"	"	"	28'-10"	270	34	"	113	"	"	"	"	"	"	"	"	"	"	"	"	"
1	54"	~	15"	6'-9½"	5'-9"	8'-0"	12'-5½"	8'-1¼"	8'-11⅝"	16	9'-11"	106	10	9'-10"	37	8	4'-6"	14	10	13	10	13	8	4'-0"	12	8	4'-5"	13
2	"	2'-10"		14'-4⅝"	"	"	20'-0½"	"	"	"	17'-6"	187	20	"	74	"	"	"	"	"	"	"	"	"	"	"	"	"
3	"	"		21'-11⅝"	"	"	27'-7⅜"	"	"	"	25'-2"	269	30	"	111	"	"	"	"	"	"	"	"	"	"	"	"	"
4	"	"		29'-6⅞"	"	"	35'-2¼"	"	"	"	29'-9"	318	40	"	148	"	"	"	"	"	"	"	"	"	"	"	"	"
1	60"	~	15"	7'-4⅜"	6'-3"	9'-0"	13'-10⅛"	9'-2¼"	10'-1¼"	18	11'-0"	132	10	10'-10"	41	10	5'-5"	20	10	13	10	13	8	4'-0"	12	8	4'-5"	13
2	"	3'-0"	"	15'-8⅝"	"	"	22'-2¼"	"	"	"	19'-3"	231	22	"	90	"	"	"	"	"	"	"	"	"	"	"	"	"
3	"	"	"	23'-11½"	"	"	30'-5⅝"	"	"	"	27'-6"	331	32	"	130	"	"	"	"	"	"	"	"	"	"	"	"	"
4	"	"	"	32'-2⅜"	"	"	38'-9"	"	"	"	35'-10"	431	42	"	171	"	"	"	"	"	"	"	"	"	"	"	"	"
1	66"	~	15"	7'-11⅞"	6'-9"	10'-0"	15'-4¼"	10'-2⅝"	11'-3⅜"	20	12'-0"	160	12	11'-11"	54	10	5'-5"	20	12	16	12	16	10	5'-1"	19	10	5'-7"	21
2	"	3'-1"	"	16'-10⅜"	"	"	24'-2⅞"	"	"	"	20'-11"	279	22	"	99	"	"	"	"	"	"	"	"	"	"	"	"	"
3	"	"	"	25'-9¼"	"	"	33'-1⅝"	"	"	"	29'-9"	397	34	"	152	"	"	"	"	"	"	"	"	"	"	"	"	"
4	"	"	"	34'-7⅞"	"	"	42'-0⅝"	"	"	"	38'-11"	520	46	"	206	"	"	"	"	"	"	"	"	"	"	"	"	"
1	72"	~	15"	8'-7⅝"	7'-3"	11'-0"	16'-9⅞"	11'-3"	12'-5"	22	13'-0"	191	12	12'-11"	58	12	6'-5"	29	12	16	12	16	10	5'-1"	19	10	5'-7"	21
2	"	3'-2"	"	18'-1⅛"	"	"	26'-3⅜"	"	"	"	22'-6"	331	24	"	117	"	"	"	"	"	"	"	"	"	"	"	"	"
3	"	"	"	27'-7"	"	"	35'-9⅝"	"	"	"	32'-0"	470	36	"	175	"	"	"	"	"	"	"	"	"	"	"	"	"
4	"	"	"	37'-0⅝"	"	"	45'-3¼"	"	"	"	42'-0"	617	48	"	233	"	"	"	"	"	"	"	"	"	"	"	"	"

NO. OF PIPES	PIPE DIAM. D	BARS E 8-#5		BARS F				BARS G 4-#3		BARS S_S 6-#4		BARS S_L 6-#4		BARS V_{S1}-V_{SX} #4 @ 12"±			BARS V_{L1}-V_{LX} #4 @12"±			BARS W_S 2-#5		BARS W_L 2-#5		*TOTAL** QUANTITIES STEEL	CONC.
		Lgth.	Wt.	No.	Size	Lgth.	Wt.	Lgth.	Wt.	Lgth.	Wt.	Lgth.	Wt.	No.	Av.Lgth.	Wt.	No.	Av.Lgth.	Wt.	Lgth.	Wt.	Lgth.	Wt.	LBS.	C.Y.
1	12"	2'-3"	19	8	#4	2'-2"	12	2'-5"	4	0'-8"	3	0'-8"	3	2	2'-11"	4	2	2'-11"	4	1'-7"	3	1'-8"	3	69	.54
2	"	4'-2"	35	12	"	"	17	4'-5"	7	"	"	"	"	"	"	"	"	"	"	"	"	"	"	97	.86
3	"	6'-1"	51	16	"	"	23	6'-4"	10	"	"	"	"	"	"	"	"	"	"	"	"	"	"	129	1.18
4	"	8'-0"	67	20	"	"	29	8'-3"	12	"	"	"	"	"	"	"	"	"	"	"	"	"	"	157	1.47
1	15"	2'-7"	22	8	#4	2'-5"	13	3'-3"	5	1'-3"	5	1'-3"	5	4	3'-0"	8	4	3'-0"	8	2'-2"	5	2'-3"	5	100	.77
2	"	4'-11"	41	12	"		19	5'-7"	8	"	"	"	"	"	"	"	"	"	"	"	"	"	"	138	1.20
3	"	7'-3"	61	16	"		26	7'-11"	12	"	"	"	"	"	"	"	"	"	"	"	"	"	"	179	1.62
4	"	9'-7"	80	20	"		32	10'-3"	15	"	"	"	"	"	"	"	"	"	"	"	"	"	"	220	2.05
1	18"	2'-11"	24	8	#4	2'-8"	14	4'-0"	6	1'-9"	7	1'-10"	7	6	3'-2"	13	6	3'-2"	13	2'-8"	6	2'-11"	6	124	1.01
2	"	5'-8"	47	12	"	"	21	6'-9"	10	"	"	"	"	"	"	"	"	"	"	"	"	"	"	171	1.58
3	"	8'-5"	70	18	"	"	29	9'-6"	14	"	"	"	"	"	"	"	"	"	"	"	"	"	"	219	2.15
4	"	11'-2"	93	20	"	"	36	12'-3"	18	"	"	"	"	"	"	"	"	"	"	"	"	"	"	266	2.72
1	24"	3'-6"	29	8	#4	3'-2"	17	5'-5"	8	2'-9"	11	3'-0"	12	8	3'-5"	18	8	3'-5"	18	3'-10"	8	4'-2"	9	173	1.59
2	"	7'-0"	58	12	"	"	25	9'-0"	14	"	"	"	"	"	"	"	"	"	"	"	"	"	"	237	2.48
3	"	10'-7"	88	16	"	"	34	12'-6"	19	"	"	"	"	"	"	"	"	"	"	"	"	"	"	306	3.36
4	"	14'-1"	117	20	"	"	42	16'-1"	24	"	"	"	"	"	"	"	"	"	"	"	"	"	"	369	4.25
1	30"	4'-1"	34	8	#4	3'-8"	20	6'-11"	10	3'-10"	15	4'-2"	17	10	3'-8"	25	10	3'-8"	25	5'-0"	10	5'-5"	11	237	2.29
2	"	8'-5"	70	16	"	"	39	11'-3"	17	"	"	"	"	"	"	"	"	"	"	"	"	"	"	335	3.56
3	"	12'-9"	106	24	"	"	59	15'-6"	23	"	"	"	"	"	"	"	"	"	"	"	"	"	"	432	4.83
4	"	17'-1"	143	32	"	"	78	19'-10"	30	"	"	"	"	"	"	"	"	"	"	"	"	"	"	531	6.10
1	36"	4'-9"	40	8	#4	4'-2"	22	8'-4"	13	4'-10"	19	5'-4"	21	12	3'-11"	31	12	3'-11"	31	6'-2"	13	6'-8"	14	296	3.11
2	"	9'-10"	82	16	"	"	45	13'-5"	20	"	"	"	"	"	"	"	"	"	"	"	"	"	"	418	4.83
3	"	14'-11"	124	24	"	"	67	18'-6"	28	"	"	"	"	"	"	"	"	"	"	"	"	"	"	539	6.55
4	"	20'-0"	167	32	"	"	89	23'-7"	35	"	"	"	"	"	"	"	"	"	"	"	"	"	"	660	8.27
1	42"	5'-4"	44	8	#4	4'-8"	25	9'-10"	15	5'-11"	24	6'-5"	26	14	4'-2"	39	14	4'-2"	39	7'-3"	15	7'-11"	17	374	4.04
2	"	11'-2"	93	16	"	"	50	15'-8"	24	"	"	"	"	"	"	"	"	"	"	"	"	"	"	528	6.29
3	"	17'-1"	143	24	"	"	75	21'-6"	32	"	"	"	"	"	"	"	"	"	"	"	"	"	"	682	8.53
4	"	22'-11"	191	32	"	"	100	27'-5"	41	"	"	"	"	"	"	"	"	"	"	"	"	"	"	833	10.78
1	48"	5'-11"	49	8	#5	5'-5"	45	11'-3"	17	6'-11"	28	7'-7"	30	16	4'-5"	47	16	4'-5"	47	8'-5"	18	9'-3"	19	461	5.17
2	"	12'-7"	105	16	"	"	90	17'-11"	27	"	"	"	"	"	"	"	"	"	"	"	"	"		668	8.09
3	"	19'-3"	161	24	"	"	136	24'-6"	37	"	"	"	"	"	"	"	"	"	"	"	"	"		868	11.01
4	"	25'-10"	210	32	"	"	181	31'-2"	47	"	"	"	"	"	"	"	"	"	"	"	"	"		1067	13.92
1	54"	6'-6"	54	8	#5	5'-11"	49	12'-8"	19	8'-0"	32	8'-9"	35	18	4'-8"	56	20	4'-8"	62	9'-7"	20	10'-5"	22	557	6.35
2	"	14'-1"	117	20	"	"	123	20'-3"	30	"	"	"	"	"	"	"	"	"	"	"	"	"	"	823	10.05
3	"	21'-9"	181	32	"	"	198	27'-11"	42	"	"	"	"	"	"	"	"	"	"	"	"	"	"	1093	13.75
4	"	29'-4"	245	44	"	"	272	35'-6"	53	"	"	"	"	"	"	"	"	"	"	"	"	"	"	1328	17.44
1	60"	7'-2"	60	8	#5	6'-5"	54	14'-2"	21	9'-0"	36	9'-11"	40	20	4'-11"	66	22	4'-11"	72	10'-9"	22	11'-8"	24	639	7.65
2	"	15'-5"	129	20	"	"	134	22'-5"	34	"	"	"	"	"	"	"	"	"	"	"	"	"	"	949	12.04
3	"	23'-8"	198	32	"	"	214	30'-9"	46	"	"	"	"	"	"	"	"	"	"	"	"	"	"	1250	16.42
4	"	32'-0"	267	44	"	"	295	39'-0"	59	"	"	"	"	"	"	"	"	"	"	"	"	"	"	1554	20.81
1	66"	7'-9"	65	8	#5	6'-11"	58	15'-7"	23	10'-0"	40	11'-1"	44	22	5'-2"	76	24	5'-2"	83	11'-11"	25	13'-0"	27	747	9.07
2	"	16'-8"	139	20	"	"	144	24'-6"	37	"	"	"	"	"	"	"	"	"	"	"	"	"	"	1085	14.14
3	"	25'-6"	213	32	"	"	231	33'-4"	50	"	"	"	"	"	"	"	"	"	"	"	"	"	"	1430	19.20
4	"	34'-5"	287	44	"	"	318	42'-3"	64	"	"	"	"	"	"	"	"	"	"	"	"	"	"	1782	24.26
1	72"	8'-4"	70	8	#5	7'-5"	62	17'-1"	26	11'-1"	44	12'-3"	49	24	5'-5"	87	26	5'-5"	94	13'-0"	27	14'-3"	30	839	10.61
2	"	17'-10"	149	20	"	"	155	26'-6"	40	"	"	"	"	"	"	"	"	"	"	"	"	"	"	1224	16.40
3	"	27'-4"	228	32	"	"	248	36'-0"	54	"	"	"	"	"	"	"	"	"	"	"	"	"	"	1607	22.19
4	"	36'-10"	307	44	"	"	341	45'-8"	68	"	"	"	"	"	"	"	"	"	"	"	"	"	"	1998	27.98

*These Total Quantities are for (2 Aprons, 2 Headwalls & 4 Wingwalls).

**Concrete quantities increase slightly for metal pipe installations.

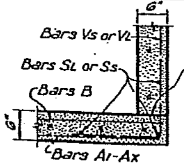




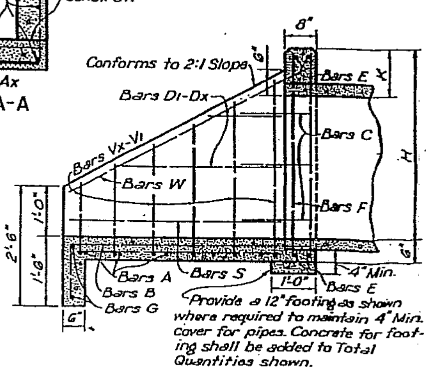
DIMENSIONS ONLY

REINFORCING ONLY

PLANS



SEC. A-A



Provide a 12" footing as shown where required to maintain 4" Min. cover for pipes. Concrete for footing shall be added to Total Quantities shown.

TYPICAL WING ELEVATION

GENERAL NOTES:-

Dimensions relating to reinforcing steel are to centers of bars.

Steel cover to be 2" from center of outside layer of steel to face of concrete.

Subscripts "s" & "L" for bar markings designate short wingwall (s) and long wingwall (L).

Chamfer all exposed corners ¾".

TEXAS HIGHWAY DEPARTMENT

CONCRETE HEADWALLS FOR PIPE CULVERTS

12 TO 72 INCHES IN DIAMETER

CH-11-B-15°

DN. T.H.D.	DRAWING	DATE		STATE	FEDERAL AID PROJECT NO.	SHEET NO.
CK.DN. T.H.D.	Original	Feb 1950				
DW. M.D.A.			6	TEXAS		
CK.DW. K.M.					COUNTY	

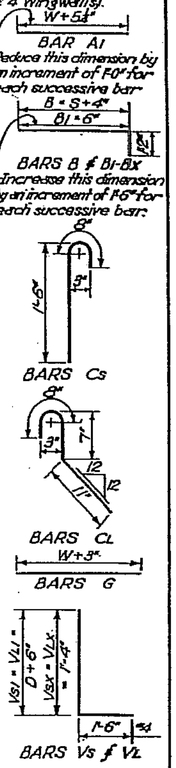
NO. OF PIPES	PIPE DIAM.	TABLE OF DIMENSIONS							
	D	G	K	X	H	Y	W	S	L
1	12"	~	12"	3'-1⅜"	2'-0"	1'-0"	2'-10⅝"	1'-0"	11"
2	·	10"	·	5'-2½"	·	·	5'-0"	·	·
3	·	·	·	7'-3⅝"	·	·	7'-1⅝"	·	·
4	·	·	·	9'-5¼"	·	·	9'-2⅞"	·	·
1	15"	~	12"	3'-5⅞"	2'-3"	1'-6"	3'-8⅝"	1'-6"	1'-7½"
2	·	1'-0"	·	6'-0⅛"	·	·	6'-3⅞"	·	·
3	·	·	·	8'-7½"	·	·	8'-11"	·	·
4	·	·	·	11'-2⅜"	·	·	11'-6⅛"	·	·
1	18"	~	12"	3'-9⅞"	2'-6"	2'-0"	4'-6⅜"	2'-0"	2'-4"
2	·	1'-2"	·	6'-10⅛"	·	·	7'-7⅝"	·	·
3	·	·	·	9'-11⅛"	·	·	10'-8⅝"	·	·
4	·	·	·	13'-0"	·	·	13'-9½"	·	·
1	24"	~	12"	4'-5¾"	3'-0"	3'-0"	6'-2¼"	3'-0"	3'-8⅝"
2	·	1'-5"	·	8'-4⅝"	·	·	10'-2⅜"	·	·
3	·	·	·	12'-4"	·	·	14'-1½"	·	·
4	·	·	·	16'-3⅜"	·	·	18'-0⅝"	·	·
1	30"	~	12"	5'-1⅛"	3'-6"	4'-0"	7'-10⅝"	4'-0"	5'-4⅞"
2	·	1'-8"	·	9'-4⅝"	·	·	12'-8⅝"	·	·
3	·	·	·	14'-8⅛"	·	·	17'-6⅝"	·	·
4	·	·	·	19'-6⅝"	·	·	22'-4⅝"	·	·
1	36"	~	12"	5'-9⅜"	4'-0"	5'-0"	9'-7"	5'-0"	6'-6⅝"
2	·	1'-11"	·	11'-5⅜"	·	·	15'-9⅜"	·	·
3	·	·	·	17'-1⅜"	·	·	20'-11⅜"	·	·
4	·	·	·	22'-9⅜"	·	·	26'-7⅜"	·	·
1	42"	~	12"	6'-5½"	4'-6"	6'-0"	11'-3"	6'-0"	7'-4⅛"
2	·	2'-2"	·	13'-0"	·	·	17'-9½"	·	·
3	·	·	·	19'-6½"	·	·	24'-4⅛"	·	·
4	·	·	·	25'-1⅛"	·	·	30'-10⅝"	·	·
1	48"	~	15"	7'-1⅝"	5'-5"	7'-0"	12'-11⅛"	7'-0"	9'-4⅜"
2	·	2'-5"	·	14'-6¼"	·	·	20'-4"	·	·
3	·	·	·	21'-11⅛"	·	·	27'-8⅞"	·	·
4	·	·	·	29'-4⅛"	·	·	35'-1⅞"	·	·
1	54"	~	15"	7'-9¾"	5'-9"	8'-0"	14'-7¼"	8'-0"	10'-9⅝"
2	·	2'-10"	·	16'-3¼"	·	·	23'-0⅝"	·	·
3	·	·	·	24'-8⅝"	·	·	31'-6⅝"	·	·
4	·	·	·	33'-2⅛"	·	·	40'-0"	·	·
1	60"	~	15"	8'-5⅜"	6'-3"	9'-0"	16'-3¼"	9'-0"	12'-2¾"
2	·	3'-0"	·	17'-8⅜"	·	·	25'-6⅝"	·	·
3	·	·	·	26'-11½"	·	·	34'-9"	·	·
4	·	·	·	36'-2⅜"	·	·	43'-11⅞"	·	·
1	66"	~	15"	9'-4⅜"	6'-9"	10'-0"	17'-11⅛"	10'-0"	13'-7⅝"
2	·	3'-4"	·	19'-0⅝"	·	·	27'-10⅛"	·	·
3	·	·	·	28'-11⅛"	·	·	37'-9¼"	·	·
4	·	·	·	38'-10⅝"	·	·	47'-8⅛"	·	·
1	72"	~	15"	9'-9⅜"	7'-3"	11'-0"	19'-7½"	11'-0"	15'-0⅝"
2	·	3'-2"	·	20'-5"	·	·	30'-2½"	·	·
3	·	·	·	31'-0"	·	·	40'-9½"	·	·
4	·	·	·	41'-7"	·	·	51'-4½"	·	·

BILL OF REINFORCING STEEL FOR TWO COMPLETE HEADWALLS

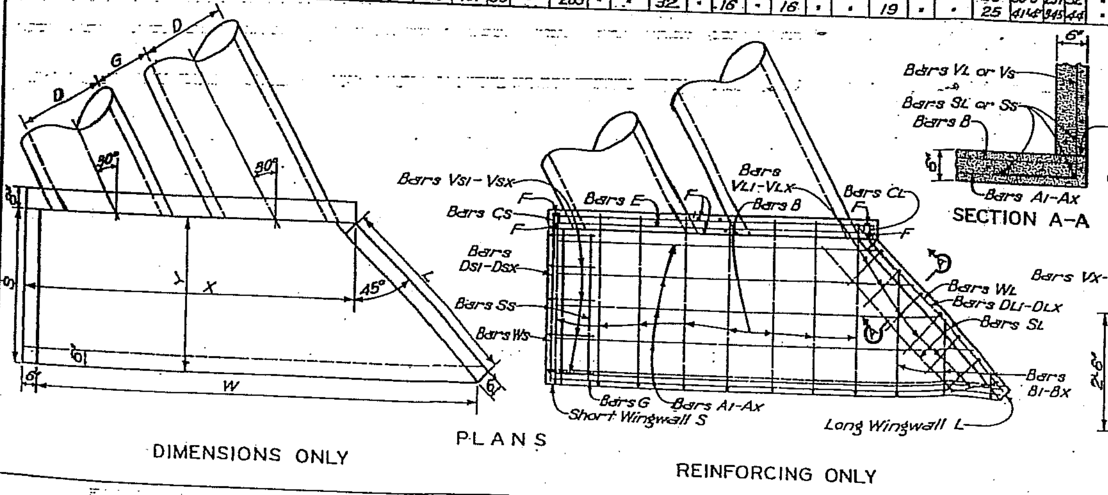
NO. OF PIPES	PIPE DIAM.	BARS A1-Ax #4 @ 12"±			BARS B #3 @ 18"±			BARS B1-Bx #3 @ 18"			Cs~2'-0" #4 @ 12"±		Cl~2'-0" #4 @ 12"±		BARS Ds1-Dsx #3 @ 12"±			BARS DL1-DLx #3 @ 12"±			BARS E 8~#5	
	D	No.	Av.Lgth.	Wt.	No.	Lgth.	Wt.	No.	Av.Lgth.	Wt.	No.	Wt.	No.	Wt.	No.	Av.Lgth.	Wt.	No.	Av.Lgth.	Wt.	Lgth.	Wt.
1	12"	2	3'-2"	4	6	2'-6"	6	–	–	–	2	3	2	3	–	–	–	–	–	–	2'-10"	24
2	·	·	5'-4"	7	8	·	8	–	–	–	·	3	·	3	–	–	–	–	–	–	4'-11"	41
3	·	·	7'-5"	10	10	·	9	–	–	–	·	3	·	3	–	–	–	–	–	–	7'-1"	59
4	·	·	9'-6"	13	14	·	13	–	–	–	·	3	·	3	–	–	–	–	–	–	9'-2"	77
1	15"	4	3'-8"	10	6	3'-0"	7	2	1'-8"	1	4	5	4	5	–	–	–	–	–	–	3'-2"	26
2	·	·	6'-4"	17	8	·	9	·	·	1	·	5	·	5	–	–	–	–	–	–	5'-9"	48
3	·	·	8'-11"	24	12	·	14	·	·	1	·	5	·	5	–	–	–	–	–	–	8'-4"	70
4	·	·	11'-6"	31	16	·	18	·	·	1	·	5	·	5	–	–	–	–	–	–	10'-11"	91
1	18"	4	4'-6"	12	6	3'-6"	8	2	1'-8"	1	4	5	4	5	2	1'-0"	1	2	1'-2"	1	3'-6"	29
2	·	·	7'-7"	20	10	·	13	·	·	1	·	5	·	5	·	·	1	·	·	1	6'-7"	55
3	·	·	10'-8"	29	14	·	18	·	·	1	·	5	·	5	·	·	1	·	·	1	9'-8"	81
4	·	·	13'-9"	37	18	·	24	·	·	1	·	5	·	5	·	·	1	·	·	1	12'-9"	106
1	24"	6	5'-8"	23	6	4'-6"	10	4	2'-5"	4	4	5	4	5	2	1'-0"	1	2	1'-3"	1	4'-2"	35
2	·	·	9'-8"	39	12	·	20	·	·	4	·	5	·	5	·	·	1	·	·	1	8'-1"	67
3	·	·	13'-7"	54	18	·	30	·	·	4	·	5	·	5	·	·	1	·	·	1	12'-1"	101
4	·	·	17'-7"	70	22	·	37	·	·	4	·	5	·	5	·	·	1	·	·	1	16'-0"	134
1	30"	8	6'-11"	37	8	5'-6"	17	4	2'-5"	4	6	8	6	8	4	2'-0"	3	4	2'-8"	4	4'-10"	40
2	·	·	11'-7"	62	14	·	29	·	·	4	·	8	·	8	·	·	3	·	·	4	9'-8"	81
3	·	·	16'-6"	88	20	·	41	·	·	4	·	8	·	8	·	·	3	·	·	4	14'-6"	121
4	·	·	21'-4"	114	28	·	58	·	·	4	·	8	·	8	·	·	3	·	·	4	19'-5"	161
1	36"	10	8'-1"	54	8	6'-6"	20	6	3'-2"	7	6	8	6	8	4	2'-0"	3	4	2'-8"	4	5'-6"	46
2	·	·	13'-9"	92	16	·	39	·	·	7	·	8	·	8	·	·	3	·	·	4	11'-2"	93
3	·	·	19'-5"	130	24	·	59	·	·	7	·	8	·	8	·	·	3	·	·	4	16'-10"	140
4	·	·	25'-4"	168	32	·	78	·	·	7	·	8	·	8	·	·	3	·	·	4	22'-7"	188
1	42"	12	9'-3"	74	10	7'-6"	28	8	3'-11"	12	8	11	8	11	6	3'-0"	7	6	4'-0"	9	6'-2"	51
2	·	·	15'-9"	126	18	·	51	·	·	12	·	11	·	11	·	·	7	·	·	9	12'-9"	106
3	·	·	22'-4"	179	28	·	79	·	·	12	·	11	·	11	·	·	7	·	·	9	19'-3"	161
4	·	·	28'-10"	231	36	·	102	·	·	12	·	11	·	11	·	·	7	·	·	9	25'-10"	216
1	48"	14	10'-5"	97	10	8'-6"	32	8	3'-11"	12	8	11	8	11	6	3'-0"	7	6	4'-0"	9	6'-10"	57
2	·	·	17'-10"	167	20	·	64	·	·	12	·	11	·	11	·	·	7	·	·	9	14'-3"	119
3	·	·	25'-3"	236	30	·	96	·	·	12	·	11	·	11	·	·	7	·	·	9	21'-8"	181
4	·	·	32'-8"	306	40	·	128	·	·	12	·	11	·	11	·	·	7	·	·	9	29'-1"	243
1	54"	16	11'-7"	124	12	9'-6"	43	10	4'-8"	18	10	13	10	13	8	4'-0"	12	8	5'-6"	17	7'-6"	63
2	·	·	20'-6"	214	22	·	79	·	·	18	·	13	·	13	·	·	12	·	·	17	16'-0"	134
3	·	·	28'-6"	305	34	·	121	·	·	18	·	13	·	13	·	·	12	·	·	17	24'-6"	204
4	·	·	37'-1"	396	46	·	164	·	·	18	·	13	·	13	·	·	12	·	·	17	32'-11"	275
1	60"	18	12'-9"	153	12	10'-6"	47	12	5'-5"	24	10	13	10	13	8	4'-0"	12	8	5'-6"	17	8'-3"	69
2	·	·	22'-0"	265	24	·	95	·	·	24	·	13	·	13	·	·	12	·	·	17	17'-5"	145
3	·	·	31'-3"	376	36	·	142	·	·	24	·	13	·	13	·	·	12	·	·	17	26'-8"	223
4	·	·	40'-4"	492	50	·	197	·	·	24	·	13	·	13	·	·	12	·	·	17	35'-11"	300
1	66"	20	13'-11"	186	14	11'-6"	61	12	5'-5"	24	12	16	12	16	10	5'-0"	19	10	6'-9"	25	8'-11"	74
2	·	·	23'-10"	318	26	·	112	·	·	24	·	16	·	16	·	·	19	·	·	25	18'-10"	157
3	·	·	33'-9"	451	40	·	173	·	·	24	·	16	·	16	·	·	19	·	·	25	28'-9"	240
4	·	·	44'-5"	593	52	·	225	·	·	24	·	16	·	16	·	·	19	·	·	25	38'-7"	322
1	72"	22	15'-1"	222	14	12'-6"	66	14	6'-2"	32	12	16	12	16	10	5'-0"	19	10	6'-9"	25	9'-7"	80
2	·	·	25'-8"	377	28	·	132	·	·	32	·	16	·	16	·	·	19	·	·	25	20'-2"	168
3	·	·	36'-5"	535	42	·	197	·	·	32	·	16	·	16	·	·	19	·	·	25	30'-9"	257
4	·	·	47'-8"	701	56	·	263	·	·	32	·	16	·	16	·	·	19	·	·	25	41'-4"	345

NO. OF PIPES	PIPE DIAM.	BARS F				BARS G 4~#3		BARS Ss 6~#4		BARS SL 6~#4		BARS Vs1-Vsx #4 @ 12"±			BARS VL1-VLx #4 @ 12"±			BARS Ws 2~#5		BARS WL 2~#5		* TOTAL** QUANTITIES	
																						STEEL	CONC.
	D	No.	Size	Lgth.	Wt.	Lgth.	Wt.	Lgth.	Wt.	Lgth.	Wt.	No.	Av.Lgth.	Wt.	No.	Av.Lgth.	Wt.	Lgth.	Wt.	Lgth.	Wt.	LBS.	C.Y.
1	12"	8	#4	2'-2"	12	3'-2"	5	10"	3	9"	3	2	2'-11"	4	2	2'-11"	4	1'-7"	3	1'-11"	4	78	0.67
2	·	12	·	·	17	5'-3"	8	·	·	·	·	·	·	·	·	·	·	·	·	·	·	108	1.00
3	·	16	·	·	23	7'-4"	11	·	·	·	·	·	·	·	·	·	·	·	·	·	·	139	1.34
4	·	20	·	·	29	9'-6"	14	·	·	·	·	·	·	·	·	·	·	·	·	·	·	173	1.68
1	15"	8	#4	2'-5"	13	4'-0"	6	1'-4"	5	1'-5"	6	4	3'-0"	8	4	3'-0"	8	2'-2"	5	2'-8"	6	111	0.91
2	·	12	·	·	19	6'-7"	10	·	·	·	·	·	·	·	·	·	·	·	·	·	·	152	1.39
3	·	16	·	·	26	9'-2"	14	·	·	·	·	·	·	·	·	·	·	·	·	·	·	197	1.86
4	·	20	·	·	32	11'-9"	18	·	·	·	·	·	·	·	·	·	·	·	·	·	·	239	2.34
1	18"	8	#4	2'-8"	14	4'-10"	7	1'-10"	7	2'-2"	9	6	3'-2"	13	6	3'-2"	13	2'-8"	6	3'-5"	7	138	1.20
2	·	12	·	·	21	7'-11"	12	·	·	·	·	·	·	·	·	·	·	·	·	·	·	189	1.83
3	·	16	·	·	29	11'-0"	17	·	·	·	·	·	·	·	·	·	·	·	·	·	·	242	2.46
4	·	20	·	·	36	14'-0"	21	·	·	·	·	·	·	·	·	·	·	·	·	·	·	292	3.10
1	24"	8	#4	3'-2"	17	6'-6"	10	2'-10"	11	3'-7"	14	8	3'-5"	18	8	3'-5"	13	3'-10"	8	4'-11"	10	190	1.86
2	·	12	·	·	25	10'-5"	16	·	·	·	·	·	·	·	·	·	·	·	·	·	·	262	2.85
3	·	16	·	·	34	14'-4"	22	·	·	·	·	·	·	·	·	·	·	·	·	·	·	336	3.83
4	·	20	·	·	42	18'-4"	28	·	·	·	·	·	·	·	·	·	·	·	·	·	·	406	4.82
1	30"	8	#4	3'-8"	20	8'-2"	12	3'-10"	15	5'-0"	20	10	3'-8"	25	12	3'-8"	29	4'-11"	10	6'-5"	13	265	2.66
2	·	16	·	·	39	13'-0"	20	·	·	·	·	·	·	·	·	·	·	·	·	·	·	370	4.08
3	·	24	·	·	59	17'-9"	27	·	·	·	·	·	·	·	·	·	·	·	·	·	·	475	5.49
4	·	32	·	·	78	22'-7"	34	·	·	·	·	·	·	·	·	·	·	·	·	·	·	584	6.91
1	36"	8	#4	4'-2"	22	9'-10"	15	4'-10"	19	6'-5"	26	12	3'-11"	31	14	3'-11"	37	6'-0"	13	7'-11"	17	330	3.59
2	·	16	·	·	45	15'-6"	23	·	·	·	·	·	·	·	·	·	·	·	·	·	·	465	5.51
3	·	24	·	·	67	21'-2"	32	·	·	·	·	·	·	·	·	·	·	·	·	·	·	601	7.44
4	·	32	·	·	89	26'-10"	40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	736	9.36
1	42"	8	#4	4'-8"	25	11'-6"	17	5'-10"	23	7'-10"	31	14	4'-2"	39	16	4'-2"	45	7'-2"	15	9'-5"	20	418	4.66
2	·	16	·	·	50	18'-0"	27	·	·	·	·	·	·	·	·	·	·	·	·	·	·	583	7.16
3	·	24	·	·	75	24'-7"	37	·	·	·	·	·	·	·	·	·	·	·	·	·	·	754	9.67
4	·	32	·	·	100	31'-1"	47	·	·	·	·	·	·	·	·	·	·	·	·	·	·	919	12.17
1	48"	8	#5	5'-5"	45	13'-2"	20	6'-10"	27	9'-3"	37	16	4'-5"	47	20	4'-5"	59	8'-9"	17	10'-10"	23	511	5.95
2	·	16	·	·	90	20'-7"	31	·	·	·	·	·	·	·	·	·	·	·	·	·	·	731	9.20
3	·	24	·	·	136	28'-0"	42	·	·	·	·	·	·	·	·	·	·	·	·	·	·	951	12.46
4	·	32	·	·	181	35'-5"	53	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1171	15.71
1	54"	8	#5	5'-11"	49	14'-10"	22	7'-10"	31	10'-8"	43	18	4'-8"	56	22	4'-8"	69	9'-5"	20	12'-5"	26	619	7.30
2	·	20	·	·	125	23'-4"	35	·	·	·	·	·	·	·	·	·	·	·	·	·	·	905	11.42
3	·	32	·	·	198	31'-9"	48	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1194	15.54
4	·	44	·	·	272	40'-2"	60	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1477	19.67
1	60"	8	#5	6'-5"	54	16'-6"	25	8'-10"	35	12'-1"	48	20	4'-11"	66	26	4'-11"	85	10'-6"	22	13'-10"	29	772	8.77
2	·	20	·	·	134	25'-9"	39	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1042	13.66
3	·	32	·	·	214	35'-0"	53	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1372	18.55
4	·	44	·	·	295	44'-2"	66	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1706	23.44
1	66"	8	#5	6'-11"	58	18'-2"	27	9'-10"	39	13'-6"	54	22	5'-2"	76	28	5'-2"	97	11'-8"	24	15'-5"	32	828	10.39
2	·	20	·	·	144	28'-1"	42	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1195	16.04
3	·	32	·	·	231	38'-0"	57	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1574	21.68
4	·	44	·	·	318	47'-10"	72	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1947	27.33
1	72"	8	#5	7'-5"	62	19'-10"	30	10'-10"	43	14'-11"	60	24	5'-5"	87	32	5'-5"	116	12'-9"	27	16'-11"	35	936	12.14
2	·	20	·	·	155	30'-5"	46	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1354	18.59
3	·	32	·	·	248	41'-0"	62	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1767	25.05
4	·	44	·	·	341	51'-7"	78	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2204	31.51

*These Total Quantities are for (2 Aprons, 2 Headwalls & 4 Wingwalls).



** Concrete quantities increase slightly for metal pipe installations.

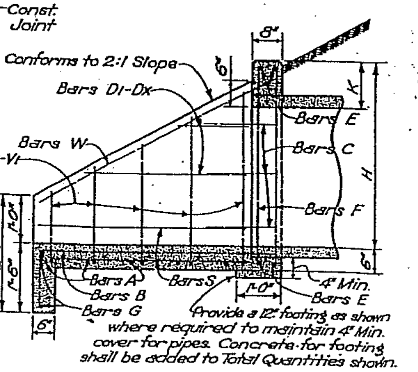


SECTION A-A

PLANS

DIMENSIONS ONLY

REINFORCING ONLY



Provide a 12" footing as shown where required to maintain 4" Min. cover for pipes. Concrete for footing shall be added to Total Quantities shown.

TYPICAL WING ELEVATION

GENERAL NOTES:-

Dimensions relating to reinforcing steel are to centers of bars.

Steel cover to be 2" from center of outside layer of steel to face of concrete.

Quantities of reinforcing steel shown hereon include one 20 diameter lap for all bars exceeding 60'-0" in length.

Subscripts "s" & "L" for bar markings designate short wingwall (S) and long wingwall (L).

Chamfer all exposed corners ¾".

TEXAS HIGHWAY DEPARTMENT

CONCRETE HEADWALLS
FOR
PIPE CULVERTS
12 TO 72 INCHES IN DIAMETER
CH-11-B-30°

DRAWING	ORIGINAL	DATE	FEB. 1950	TEXAS

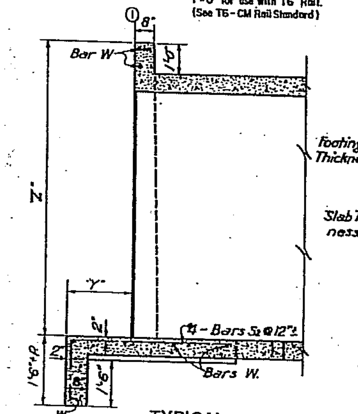
Rev. 11-67 Concrete

CULVERT SIZE	SLAB DEPTH	MAX FILL	WING HEIGHT	WING LENGTH	TOTAL QUANT. 4 WINGWALLS		TABLE OF DIMENSIONS				
S H	"T"	FT	"Z"	"L"	CONC. C.Y.	REINF. LB.	"R"	"W"	"V"	"D"	"Y"
3×2	6"	14'	3'-6"	5'-3"	4.10	558	6½"	2'-6"	8"	10"	1'-0"
3×3	6"	14'	4'-6"	6'-9"	6.11	818	7"	2'-10"	8"	1'-2"	1'-0"
4×2	6"	12'	3'-6"	5'-3"	4.21	564	6½"	2'-6"	8"	10"	1'-0"
4×3	6"	12'	4'-6"	6'-9"	6.23	824	7"	2'-10"	8"	1'-2"	1'-0"
4×4	6"	12'	5'-6"	8'-3"	8.75	1322	7"	3'-5"	8"	1'-7"	1'-2"
5×2	6"	8'	3'-6"	5'-3"	4.33	569	7"	2'-6"	8"	10"	1'-0"
5×3	6"	8'	4'-6"	6'-9"	6.34	829	7"	2'-10"	8"	1'-2"	1'-0"
5×4	6"	8'	5'-6"	8'-3"	8.87	1328	7"	3'-5"	8"	1'-7"	1'-2"
5×5	6"	8'	6'-6"	9'-9"	11.86	1876	7"	4'-0"	8"	2'-0"	1'-4"
6×3	6"	8'	4'-6"	6'-9"	6.46	835	7"	2'-10"	8"	1'-2"	1'-0"
6×4	6"	8'	5'-6"	8'-3"	8.90	1336	7"	3'-5"	8"	1'-7"	1'-2"
6×5	6"	8'	6'-6"	9'-9"	11.99	1883	7"	4'-0"	8"	2'-0"	1'-4"
6×6	6"	8'	7'-6"	11'-3"	15.56	2616	7"	4'-8"	8"	2'-3"	1'-9"
7×3	6½"	8'	4'-6½"	6'-10"	6.68	841	7"	2'-10"	8"	1'-2"	1'-0"
7×4	6½"	8'	5'-6½"	8'-4"	9.24	1341	7"	3'-5"	8"	1'-7"	1'-2"
7×5	6½"	8'	6'-6½"	9'-10"	12.27	1890	7"	4'-0"	8"	2'-0"	1'-4"
7×6	6½"	8'	7'-6½"	11'-4"	15.89	2624	7"	4'-8"	8"	2'-3"	1'-9"
7×7	6½"	8'	8'-6½"	12'-10"	21.55	3650	8"	5'-2"	9½"	2'-6½"	1'-10"
8×4	6½"	4'	5'-6½"	8'-4"	9.36	1347	7"	3'-5"	8"	1'-7"	1'-2"
8×5	6½"	4'	6'-6½"	9'-10"	12.40	1887	7"	4'-0"	8"	2'-0"	1'-4"
8×6	6½"	4'	7'-6½"	11'-4"	16.03	2632	7"	4'-8"	8"	2'-3"	1'-9"
8×7	6½"	4'	8'-6½"	12'-10"	21.70	3659	8"	5'-2"	9½"	2'-6½"	1'-10"
8×8	6½"	4'	9'-6½"	14'-4"	28.49	5222	9"	5'-9"	10½"	2'-8½"	2'-2"
8×4	7"	6'	5'-7"	8'-4"	9.41	1347	7"	3'-5"	8"	1'-7"	1'-2"
8×5	7"	6'	6'-7"	9'-10"	12.46	1887	7"	4'-0"	8"	2'-0"	1'-4"
8×6	7"	6'	7'-7"	11'-4"	16.11	2632	7"	4'-8"	8"	2'-3"	1'-9"
8×7	7"	6'	8'-7"	12'-10"	21.79	3659	8"	5'-2"	9½"	2'-6½"	1'-10"
8×8	7"	6'	9'-7"	14'-4"	28.60	5222	9"	5'-9"	10½"	2'-8½"	2'-2"
8×4	7½"	8'	5'-7½"	8'-5"	9.54	1347	7"	3'-5"	8"	1'-7"	1'-2"
8×5	7½"	8'	6'-7½"	9'-11"	12.61	1887	7"	4'-0"	8"	2'-0"	1'-4"
8×6	7½"	8'	7'-7½"	11'-5"	16.30	2632	7"	4'-8"	8"	2'-3"	1'-9"
8×7	7½"	8'	8'-7½"	12'-11"	22.02	3659	8"	5'-2"	9½"	2'-6½"	1'-10"
8×8	7½"	8'	9'-7½"	14'-5"	28.88	5222	9"	5'-9"	10½"	2'-8½"	2'-2"
9×5	7"	6'	6'-7"	9'-10"	12.59	1904	7"	4'-0"	8"	2'-0"	1'-4"
9×6	7"	6'	7'-7"	11'-4"	16.26	2640	7"	4'-8"	8"	2'-3"	1'-9"
9×7	7"	6'	8'-7"	12'-10"	21.95	3668	8"	5'-2"	9½"	2'-6½"	1'-10"
9×8	7"	6'	9'-7"	14'-4"	28.78	5232	9"	5'-9"	10½"	2'-8½"	2'-2"
9×9	7"	6'	10'-7"	15'-10"	37.26	6904	9½"	6'-4"	12½"	2'-10½"	2'-5"
9×5	8"	8'	6'-8"	10'-0"	12.90	1904	7"	4'-0"	8"	2'-0"	1'-4"
9×6	8"	8'	7'-8"	11'-6"	17.35	2640	7½"	4'-9"	8½"	2'-3½"	1'-9"
9×7	8"	8'	8'-8"	13'-0"	23.11	3668	8½"	5'-4"	9½"	2'-7½"	1'-11"
9×8	8"	8'	9'-8"	14'-6"	30.73	5232	9½"	6'-0"	11"	2'-11"	2'-2"
9×9	8"	8'	10'-8"	16'-0"	38.93	6904	10"	6'-6"	12½"	2'-11½"	2'-6"
10×5	7"	4'	6'-7"	9'-10"	12.72	1911	7"	4'-0"	8"	2'-0"	1'-4"
10×6	7"	4'	7'-7"	11'-4"	16.41	2648	7"	4'-8"	8"	2'-3"	1'-9"
10×7	7"	4'	8'-7"	12'-10"	22.11	3677	8"	5'-2"	9½"	2'-6½"	1'-10"
10×8	7"	4'	9'-7"	14'-4"	28.96	5241	9"	5'-9"	10½"	2'-8½"	2'-2"
10×9	7"	4'	10'-7"	15'-10"	37.45	6895	9½"	6'-4"	12½"	2'-10½"	2'-5"
10×10	7"	4'	11'-7"	17'-4"	48.02	8740	11"	7'-0"	13½"	3'-2½"	2'-8"
10×5	8"	6'	6'-8"	10'-0"	13.04	1911	7"	4'-0"	8"	2'-0"	1'-4"
10×6	8"	6'	7'-8"	11'-6"	17.51	2648	7½"	4'-9"	8½"	2'-3½"	1'-9"
10×7	8"	6'	8'-8"	13'-0"	23.28	3677	8½"	5'-4"	9½"	2'-7½"	1'-11"
10×8	8"	6'	9'-8"	14'-6"	30.91	5241	9½"	6'-0"	11"	2'-11"	2'-2"
10×9	8"	6'	10'-8"	16'-0"	39.14	6895	10"	6'-6"	12½"	2'-11½"	2'-6"
10×10	8"	6'	11'-8"	17'-6"	48.80	8740	11"	7'-0"	13½"	3'-2½"	2'-8"
10×5	8½"	8'	6'-8½"	10'-1"	13.20	1911	7"	4'-0"	8"	2'-0"	1'-4"
10×6	8½"	8'	7'-8½"	11'-7"	17.71	2648	7½"	4'-9"	8½"	2'-3½"	1'-9"
10×7	8½"	8'	8'-8½"	13'-1"	23.52	3677	8½"	5'-4"	9½"	2'-7½"	1'-11"
10×8	8½"	8'	9'-8½"	14'-7"	31.20	5241	9½"	6'-0"	11"	2'-11"	2'-2"
10×9	8½"	8'	10'-8½"	16'-1"	39.50	6895	10"	6'-6"	12½"	2'-11½"	2'-6"
10×10	8½"	8'	11'-8½"	17'-7"	49.18	8740	11"	7'-0"	13½"	3'-2½"	2'-8"

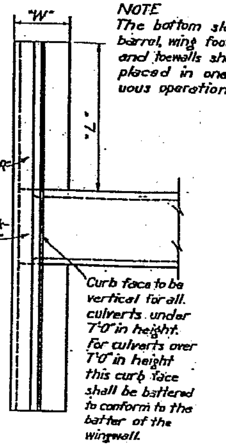
TABLE OF REINFORCING STEEL FOR 4 WING WALLS

WING SIZE		BARS R					BARS S1					#4 BARS T1 @18"±			#4 BARS T2 @12"±			BARS U					#4 Bars P @18"cc			#4 BARS W @12"±			TOTAL
"Z"	"L"	NO	SIZE	SPAC	LENGTH	WEIGHT	NO	SIZE	SPAC	LENGTH	WEIGHT	NO	LENGTH	WEIGHT	NO	LENGTH	WEIGHT	NO	SIZE	SPAC	LENGTH	WEIGHT	SPAC	LENGTH	WEIGHT	NO	LENGTH	WEIGHT	WEIGHT
3'-6"	5'-3"	24	#4	12"	5'-1"	81	24	#4	12"	3'-11"	63	16	5'-0"	53	8	5'-0"	27	16	#5	18"	6'-0"	100	20	3'-9"	50	28	8'-9"	164	538
4'-6"	6'-9"	32	#4	11"	6'-1"	130	32	#4	11"	4'-3"	91	24	6'-6"	104	8	6'-6"	35	24	#5	18"	6'-0"	150	24	4'-9"	76	28	11'-3"	210	796
5'-6"	8'-3"	60	#4	7"	7'-3"	291	60	#4	7"	4'-10"	194	32	8'-0"	171	8	8'-0	43	32	#5	18"	6'-0"	200	28	5'-9"	108	32	13'-3"	283	1290
6'-6"	9'-9"	56	#5	8½"	8'-5"	492	60	#5	8"	5'-5"	339	32	9'-6"	203	12	9'-6"	76	32	#5	18"	6'-0"	200	32	6'-9"	144	36	15'-9"	379	1833
7'-6"	11'-3"	80	#5	7"	9'-10"	820	80	#5	7"	6'-1"	507	40	11'-0"	294	12	11'-0"	88	40	#5	18"	6'-0"	250	36	7'-9"	186	36	17'-3"	415	2560
8'-6½"	12'-10"	112	#5	5½"	11'-4"	1324	104	#5	6"	6'-7"	714	48	12'-7"	403	12	12'-7"	101	48	#5	18"	6'-0"	300	40	8'-9"	234	40	18'-11"	505	3581
9'-6½"	14'-4"	108	#6	6½"	12'-9"	2,068	116	#6	6"	7'-4"	1277	48	14'-1"	452	16	14'-1"	150	48	#5	18"	6'-0"	300	44	9'-9"	287	44	20'-6"	603	5137
10'-7"	15'-10"	140	#6	5½"	14'-4"	3,013	140	#6	5½"	7'-11"	1665	56	15'-7"	583	16	15'-7"	167	56	#5	18"	6'-0"	350	48	10'-10"	347	44	22'-0"	647	6772
11'-7"	17'-4"	168	#8	5"	15'-9"	3 974	168	#6	5"	8'-7"	2165	64	17'-1"	730	16	17'-1"	183	64	#5	18"	6'-0"	401	52	11'-10"	411	48	23'-6"	754	8618

① Curb width must be increased to 1'-0" for use with T6 Rail. (See T6-CM Rail Standard)



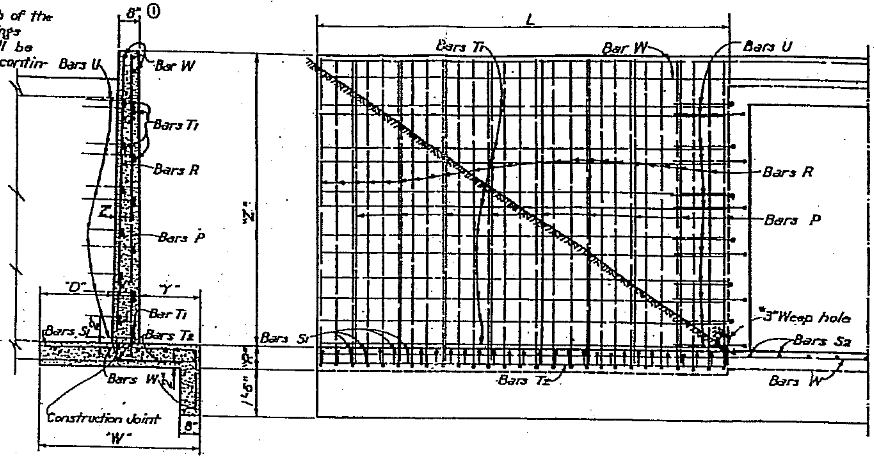
TYPICAL
LONGITUDINAL SECTION THRU BOX
SHOWING DETAIL OF APRON



Curb face to be vertical for all culverts under 7'0" in height. For culverts over 7'0" in height this curb face shall be battered to conform to the batter of the wingwall.

PLAN VIEW OF
WING WALL

NOTE
The bottom slab of the barrel, wing footings and toewalls shall be placed in one continuous operation.



SECTION

HALF ELEVATION

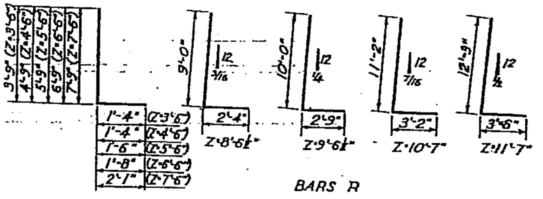
DETAIL OF WING WALL

* Place one weep hole per wing at approximate earth line as shown. Fill around inlet of drains with broken stone or coarse gravel to permit free passage of water. Weep holes required for Z=6'-6" and greater.

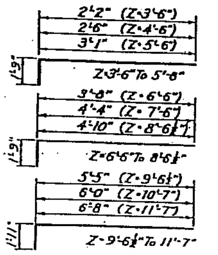
GENERAL NOTES:

Chamfer all exposed corners ¾" unless specified otherwise.

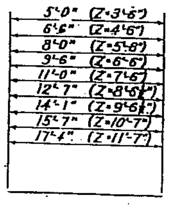
All dimensions relating to reinforcing steel are to centers of bars.



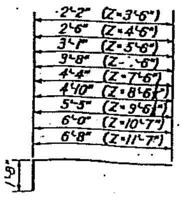
BARS R



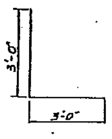
BARS S1



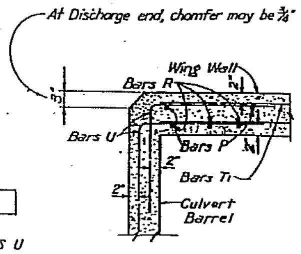
BARS T1



BARS S2
(Culvert Apron)



BARS U



ARRANGEMENT OF
WING WALL REINF.
AT CULVERT WALL

BILL OF #4 BARS S2 @12"± FOR 2 CULVERT APRONS

"Z"	SPAN	NO	LGTH	WEIGHT	"Z"	SPAN	NO	LGTH	WEIGHT
3'-6"	3'-0"	8	3'-10"	20	6'-6"	9'-0"	20	5'-4"	71
	4'-0"	10	3'-10"	26		10'-0"	22	5'-4"	78
	5'-0"	12	3'-10"	31	7'-6"	6'-0"	14	6'-0"	56
4'-6"	3'-0"	8	4'-2"	22		7'-0"	16	6'-0"	64
	4'-0"	10	4'-2"	28		8'-0"	18	6'-0"	72
	5'-0"	12	4'-2"	33		9'-0"	20	6'-0"	80
	6'-0"	14	4'-2"	39		10'-0"	22	6'-0"	88
	7'-0"	16	4'-2"	45	8'-6½"	7'-0"	16	6'-6"	69
5'-6"	4'-0"	10	4'-9"	32		8'-0"	18	6'-6"	78
	5'-0"	12	4'-9"	38		9'-0"	20	6'-6"	87
	6'-0"	14	4'-9"	44		10'-0"	22	6'-6"	96
	7'-0"	16	4'-9"	51	9'-6½"	8'-0"	18	7'-1"	85
	8'-0	18	4'-9"	57		9'-0"	20	7'-1"	95
6'-6"	5'-0"	12	5'-4"	43		10'-0"	22	7'-1"	104
	6'-0"	14	5'-4"	50	10'-7"	9'-0"	20	7'-8"	102
	7'-0"	16	5'-4"	57		10'-0"	22	7'-8"	113
	8'-0"	18	5'-4"	64	11'-7"	10'-0"	22	8'-4"	122

TEXAS HIGHWAY DEPARTMENT

PARALLEL WINGS-NORMAL

FOR SINGLE BOX CULVERTS
3 X 2 TO 10 X 10

PW-N

Dn. CFS/JHH	Original	June 1946
Ck. Dn. WH		
Dn. ABL	Rev. 8-74	
Ck. Dn. WH	Rev. 7-95 (note ①)	
Tr. AOB		

STATE: TEXAS
6

TABLE OF DIMENSIONS

	CULVERT SIZE	MAX FILL	SLAB	WING							* TOTAL QUANT.	
	S × H	FT.	T	Z	L	R	W	V	D	Y	CONC C.Y.	REINF. LB.
SC-15°A, SC-15°B & SC-15°C	3 × 2	14'	6"	3'-6"	5'-5"	6½"	2'-6"	8"	10"	1'-0"	4.23	562
	3 × 3	14'	6"	4'-6"	7'-0"	7"	2'-10"	8"	1'-2"	1'-0"	6.34	836
	4 × 2	12'	6"	3'-6"	5'-5"	6½"	2'-6"	8"	10"	1'-0"	4.35	567
	4 × 3	12'	6"	4'-6"	7'-0"	7"	2'-10"	8"	1'-2"	1'-0"	6.46	841
	4 × 4	12'	6"	5'-6"	8'-6"	7"	3'-5"	8"	1'-7"	1'-2"	9.02	1334
	5 × 2	8'	6"	3'-6"	5'-5"	7"	2'-6"	8"	10"	1'-0"	4.56	572
	5 × 3	8'	6"	4'-6"	7'-0"	7"	2'-10"	8"	1'-2"	1'-0"	6.58	847
	5 × 4	8'	6"	5'-6"	8'-6"	7"	3'-5"	8"	1'-7"	1'-2"	9.14	1341
	5 × 5	8'	6"	6'-6"	10'-1"	7"	4'-0"	8"	2'-0"	1'-4"	12.27	1394
	6 × 3	8'	6"	4'-6"	7'-0"	7"	2'-10"	8"	1'-2"	1'-0"	6.70	853
	6 × 4	8'	6"	5'-6"	8'-6"	7"	3'-5"	8"	1'-7"	1'-2"	9.27	1347
	6 × 5	8'	6"	6'-6"	10'-1"	7"	4'-0"	8"	2'-0"	1'-4"	12.40	2002
	6 × 6	8'	6"	7'-6"	11'-8"	7"	4'-8"	8"	2'-3"	1'-9"	16.14	2648
	7 × 3	8'	6½"	4'-6½"	7'-1"	7"	2'-10"	8"	1'-2"	1'-0"	6.92	858
	7 × 4	8'	6½"	5'-6½"	8'-7"	7"	3'-5"	8"	1'-7"	1'-2"	9.52	1354
	7 × 5	8'	6½"	6'-6½"	10'-2"	7"	4'-0"	8"	2'-0"	1'-4"	12.69	2009
	7 × 6	8'	6½"	7'-6½"	11'-9"	7"	4'-8"	8"	2'-3"	1'-9"	16.47	2656
	7 × 7	8'	6½"	8'-6½"	13'-3"	8"	5'-2"	9½"	2'-6½"	1'-10"	22.25	3811
SC-15°A	8 × 4	4'	6½"	5'-6½"	8'-7"	7"	3'-5"	8"	1'-7"	1'-2"	9.65	1360
	8 × 5	4'	6½"	6'-6½"	10'-2"	7"	4'-0"	8"	2'-0"	1'-4"	12.82	2016
	8 × 6	4'	6½"	7'-6½"	11'-9"	7"	4'-8"	8"	2'-3"	1'-9"	16.62	2664
	8 × 7	4'	6½"	8'-6½"	13'-3"	8"	5'-2"	9½"	2'-6½"	1'-10"	22.41	3820
	8 × 8	4'	6½"	9'-6½"	14'-10"	9"	5'-9"	10½"	2'-8½"	2'-2"	29.49	5562
SC-15°B	8 × 4	6'	7"	5'-7"	8'-8"	7"	3'-5"	8"	1'-7"	1'-2"	9.78	1360
	8 × 5	6'	7"	6'-7"	10'-3"	7"	4'-0"	8"	2'-0"	1'-4"	12.98	2016
	8 × 6	6'	7"	7'-7"	11'-9"	7"	4'-8"	8"	2'-3"	1'-9"	16.70	2664
	8 × 7	6'	7"	8'-7"	13'-4"	8"	5'-2"	9½"	2'-6½"	1'-10"	22.64	3820
	8 × 8	6'	7"	9'-7"	14'-11"	9"	5'-9"	10½"	2'-8½"	2'-2"	29.76	5562
SC-15°C	8 × 4	8'	7½"	5'-7½"	8'-9"	7"	3'-5"	8"	1'-7"	1'-2"	9.92	1360
	8 × 5	8'	7½"	6'-7½"	10'-3"	7"	4'-0"	8"	2'-0"	1'-4"	13.04	2016
	8 × 6	8'	7½"	7'-7½"	11'-10"	7"	4'-8"	8"	2'-3"	1'-9"	16.89	2664
	8 × 7	8'	7½"	8'-7½"	13'-5"	8"	5'-2"	9½"	2'-6½"	1'-10"	22.86	3820
	8 × 8	8'	7½"	9'-7½"	14'-11"	9"	5'-9"	10½"	2'-8½"	2'-2"	29.88	5562
SC-15°A & SC-15°B	9 × 5	6'	7"	6'-7"	10'-3"	7"	4'-0"	8"	2'-0"	1'-4"	13.11	2023
	9 × 6	6'	7"	7'-7"	11'-9"	7"	4'-8"	8"	2'-3"	1'-9"	16.86	2672
	9 × 7	6'	7"	8'-7"	13'-4"	8"	5'-2"	9½"	2'-6½"	1'-10"	22.80	3829
	9 × 8	6'	7"	9'-7"	14'-11"	9"	5'-9"	10½"	2'-8½"	2'-2"	29.95	5572
	9 × 9	6'	7"	10'-7"	16'-5"	9½"	6'-4"	12½"	2'-10½"	2'-5"	38.63	7085
SC-15°C	9 × 5	8'	8"	6'-8"	10'-4"	7"	4'-0"	8"	2'-0"	1'-4"	13.29	2023
	9 × 6	8'	8"	7'-8"	11'-11"	7½"	4'-9"	8½"	2'-3½"	1'-9"	17.98	2672
	9 × 7	8'	8"	8'-8"	13'-5"	8½"	5'-4"	9½"	2'-7½"	1'-11"	23.86	3829
	9 × 8	8'	8"	9'-8"	15'-0"	9½"	6'-0"	11"	2'-11"	2'-2"	31.79	5572
	9 × 9	8'	8"	10'-8"	16'-7"	10"	6'-6"	12½"	2'-11½"	2'-6"	40.35	7085
SC-15°A	10 × 5	4'	7"	6'-7"	10'-3"	7"	4'-0"	8"	2'-0"	1'-4"	13.25	2031
	10 × 6	4'	7"	7'-7"	11'-9"	7"	4'-8"	8"	2'-3"	1'-9"	17.01	2680
	10 × 7	4'	7"	8'-7"	13'-4"	8"	5'-2"	9½"	2'-6½"	1'-10"	22.96	3838
	10 × 8	4'	7"	9'-7"	14'-11"	9"	5'-9"	10½"	2'-8½"	2'-2"	30.13	5581
	10 × 9	4'	7"	10'-7"	16'-5"	9½"	6'-4"	12½"	2'-10½"	2'-5"	38.83	7095
	10 × 10	4'	7"	11'-7"	18'-0"	11"	7'-0"	13½"	3'-2½"	2'-8"	49.86	8976
SC-15°B	10 × 5	6'	8"	6'-8"	10'-4"	7"	4'-0"	8"	2'-0"	1'-4"	13.48	2031
	10 × 6	6'	8"	7'-8"	11'-11"	7½"	4'-9"	8½"	2'-3½"	1'-9"	18.14	2680
	10 × 7	6'	8"	8'-8"	13'-5"	8½"	5'-4"	9½"	2'-7½"	1'-11"	24.03	3838
	10 × 8	6'	8"	9'-8"	15'-0"	9½"	6'-0"	11"	2'-11"	2'-2"	31.98	[illegible]
	10 × 9	6'	8"	10'-8"	16'-7"	10"	6'-6"	12½"	2'-11½"	2'-6"	40.56	7095
	10 × 10	6'	8"	11'-8"	18'-1"	11"	7'-0"	13½"	3'-2½"	2'-8"	50.43	8976
SC-15°C	10 × 5	8'	8½"	6'-8½"	10'-5"	7"	4'-0"	8"	2'-0"	1'-4"	13.64	[illegible]
	10 × 6	8'	8½"	7'-8½"	12'-0"	7½"	4'-9"	8½"	2'-3½"	1'-9"	18.35	2680
	10 × 7	8'	8½"	8'-8½"	13'-6"	8½"	5'-4"	9½"	2'-7½"	1'-11"	24.27	3838
	10 × 8	8'	8½"	9'-8½"	15'-1"	9½"	6'-0"	11"	2'-11"	2'-2"	32.28	[illegible]
	10 × 9	8'	8½"	10'-8½"	16'-8"	10"	6'-6"	12½"	2'-11½"	2'-6"	40.91	7095
	10 × 10	8'	8½"	11'-8½"	18'-2"	11"	7'-0"	13½"	3'-2½"	2'-8"	50.82	8976

BILL OF #4 BARS S2 @12"± FOR 2 CULVERT APRONS

H	SPAN	NO.	LGTH.	WT.	H	SPAN	NO.	LGTH.	WT.
2'-0"	3'-0"	8	3'-11"	21	5'-0"	9'-0"	20	5'-5"	72
	4'-0"	10	3'-11"	26		10'-0"	22	5'-5"	80
	5'-0"	12	3'-11"	31	6'-0"	6'-0"	14	6'-1"	57
3'-0"	3'-0"	8	4'-3"	23		7'-0"	16	6'-1"	65
	4'-0"	10	4'-3"	28		8'-0"	18	6'-1"	73
	5'-0"	12	4'-3"	34		9'-0"	20	6'-1"	81
	6'-0"	14	4'-3"	40		10'-0"	22	6'-1"	89
	7'-0	16	4'-3"	45	7'-0"	7'-0"	16	6'-7"	70
4'-0"	4'-0"	10	4'-10"	32		8'-0"	18	6'-7"	79
	5'-0"	12	4'-10"	39		9'-0"	20	6'-7"	88
	6'-0"	14	4'-10"	45		10'-0"	22	6'-7"	97
	7'-0"	16	4'-10"	52	8'-0"	8'-0"	18	7'-2"	86
	8'-0"	18	4'-10"	58		9'-0"	20	7'-2"	96
5'-0"	5'-0"	12	5'-5"	43		10'-0"	22	7'-2"	105
	6'-0"	14	5'-5"	51	9'-0"	9'-0"	20	7'-9"	104
	7'-0"	16	5'-5"	58		10'-0"	22	7'-9"	114
	8'-0"	18	5'-5"	65	10'-0"	10'-0"	22	8'-5"	124

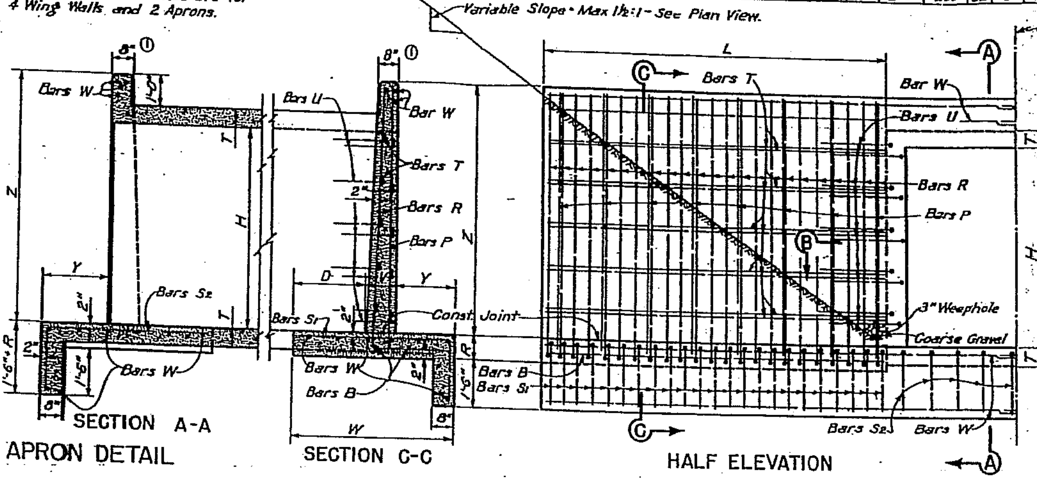
TABLE OF REINFORCING STEEL FOR 4 WINGWALLS

WING SIZE		#4 BARS B @12"±			BARS R					BARS S1				
H	L	NO.	LGTH.	WT.	NO.	SIZE	SPAC.	LGTH.	WT.	NO.	SIZE	SPAC.	LGTH.	WT.
2'-0"	5'-5"	8	5'-0"	27	24	#4	12"	5'-1"	81	24	#4	12"	3'-11"	63
3'-0"	7'-0"	8	6'-7"	35	32	#4	11"	6'-1"	130	32	#4	11"	4'-3"	91
4'-0"	8'-6"	8	8'-1"	43	60	#4	7"	7'-3"	291	60	#4	7"	4'-10"	194
5'-0"	10'-1"	12	9'-8"	78	64	#5	8"	8'-5"	562	64	#5	8"	5'-5"	362
6'-0"	11'-8"	12	11'-3"	90	80	#5	7"	9'-10"	820	80	#5	7"	6'-1"	507
7'-0"	13'-3"	12	12'-10"	103	116	#5	5½"	11'-4"	1371	116	#5	5½"	6'-7"	796
8'-0"	14'-10"	16	14'-5"	154	120	#6	6"	12'-9"	2298	120	#6	6"	7'-4"	1321
9'-0"	16'-5"	16	16'-0"	171	144	#6	5½"	14'-4"	3099	144	#6	5½"	7'-11"	1713
10'-0"	18'-0"	16	17'-7"	188	172	#6	5"	15'-9"	4069	172	#6	5"	8'-7"	2217

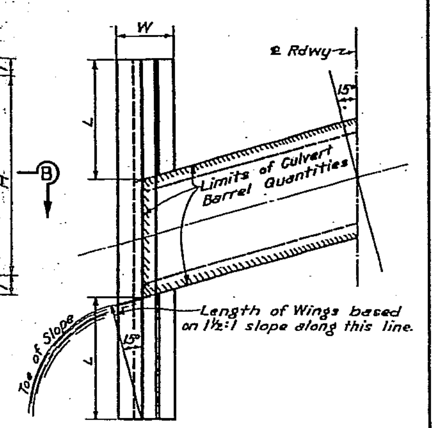
WING SIZE		#4 BARS T1 @18"±			#4 BARS T2 @18"±			BARS U1 @18"±				BARS U2 @18"±				#4 BARS W @12"±			#4 Bars P @18" c.c.			TOTAL WEIGHT
H	L	NO.	LGTH.	WT.	NO.	LGTH.	WT.	NO.	SIZE	LGTH.	WT.	NO.	SIZE	LGTH.	WT.	NO.	LGTH.	WT.	NO.	LGTH.	WT.	
2'-0"	5'-5"	8	5'-0"	27	8	5'-2"	28	8	#5	6'-0"	50	8	#5	6'-0"	50	28	8'-10"	165	20	3'-9"	50	541
3'-0"	7'-0"	12	6'-7"	53	12	6'-9"	54	12	#5	6'-0"	75	12	#5	6'-0"	75	28	12'-0"	224	24	4'-9"	76	813
4'-0"	8'-6"	16	8'-1"	86	16	8'-3"	88	16	#5	6'-0"	100	16	#5	6'-0"	100	32	13'-8"	292	28	5'-9"	108	1302
5'-0"	10'-1"	16	9'-8"	103	16	9'-10"	105	16	#5	6'-0"	100	16	#5	6'-0"	100	36	16'-6"	397	32	6'-9"	144	1951
6'-0"	11'-8"	20	11'-3"	150	20	11'-5"	153	20	#5	6'-0"	125	20	[illegible]	6'-0"	125	36	18'-1"	435	36	7'-9"	186	2591
7'-0"	13'-3"	24	12'-10"	206	24	13'-0"	208	24	#5	6'-0"	150	24	[illegible]	6'-0"	150	40	19'-7"	523	40	8'-9"	234	3741
8'-0"	14'-10"	24	14'-5"	231	24	14'-7"	234	24	#5	6'-0"	150	24	#5	6'-0"	150	44	21'-3"	625	48	9'-9"	313	5476
9'-0"	16'-5"	28	16'-0"	299	28	16'-2"	302	28	#5	6'-0"	175	28	#5	6'-0"	175	44	22'-10"	671	52	10'-10"	376	6981
10'-0"	18'-0"	32	17'-7"	376	32	17'-9"	379	32	#5	6'-0"	200	32	#5	6'-0"	200	48	24'-4"	780	56	11'-10"	445	8852

* These Total Quantities are for 4 Wing Walls and 2 Aprons.

① Curb width must be increased to 1'-0" for use with T6 Rail. (See T6-CM Rail Standard)



DETAIL OF WINGWALL



PLAN VIEW OF WINGWALL

GENERAL NOTES:

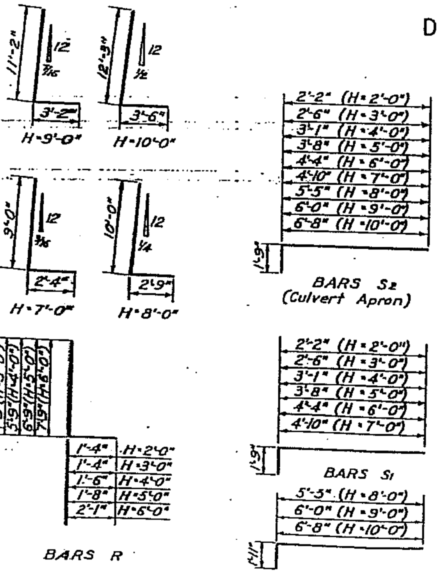
Chamfer all exposed corners ¾".

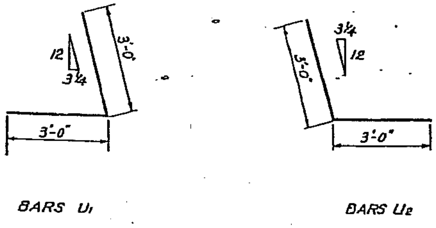
All dimensions relating to reinforcing steel are to centers of bars.

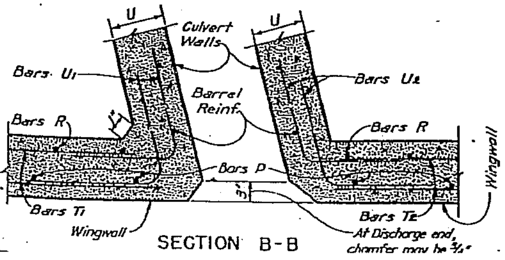
Provide weepholes for H=5'-0" and greater.

The bottom slab of the barrel, wing footings and toe walls shall be placed in one continuous operation.

Wings shall be constructed monolithic with the barrel. If construction joints are used near the top of the barrel walls these joints shall continue through the wings.







SECTION B-B

TEXAS HIGHWAY DEPARTMENT

PARALLEL WINGS-15° SKEW

FOR SINGLE BOX CULVERTS
SIZES 3'x2' TO 10'x10'

PW-15°

DES.	DRAWING	DATE
CK. DES. W.H.	ORIGINAL	DEC. 1949
DW. MHDA	Rev. 6-74	
CK. DWG. KM	Rev. 7-95 (note ①)	

FED. RD. DIV. NO.	STATE	FEDERAL AID PROJECT NO.	SHEET NO.
8	TEXAS		

TABLE OF DIMENSIONS

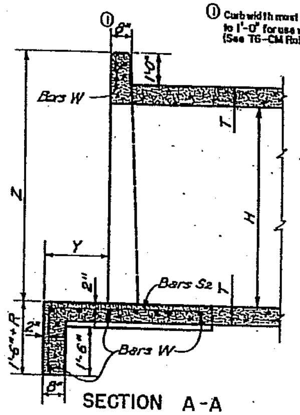
	CULVERT SIZE	MAX FILL	SLAB	WING							* TOTAL QUANT.	
	S H	FT	T	Z	L	R	W	V	D	Y	CONC. C.Y.	REINF. LBS.
SC-30°A, SC-30°B & SC-30°C	3 x 2	14'	6"	3'-6"	6'-1"	6½"	2'-6"	8"	10"	1'-0"	4.75	618
	3 x 3	14'	6"	4'-6"	7'-10"	7"	2'-10"	8"	1'-2"	1'-0"	7.09	912
	4 x 2	12'	6"	3'-6"	6'-1"	6½"	2'-6"	8"	10"	1'-0"	4.88	623
	4 x 3	12'	6"	4'-6"	7'-10"	7"	2'-10"	8"	1'-2"	1'-0"	7.23	918
	4 x 4	12'	6"	5'-6"	9'-6"	7"	3'-5"	8"	1'-7"	1'-2"	10.08	1480
	5 x 2	8'	6"	3'-6"	6'-1"	7"	2'-6"	8"	10"	1'-0"	5.12	629
	5 x 3	8'	6"	4'-6"	7'-10"	7"	2'-10"	8"	1'-2"	1'-0"	7.36	924
	5 x 4	8'	6"	5'-6"	9'-6"	7"	3'-5"	8"	1'-7"	1'-2"	10.22	1486
	5 x 5	8'	6"	6'-6"	11'-3"	7"	4'-0"	8"	2'-0"	1'-4"	13.69	2154
	6 x 3	8'	6"	4'-6"	7'-10"	7"	2'-10"	8"	1'-2"	1'-0"	7.49	929
	6 x 4	8'	6"	5'-6"	9'-6"	7"	3'-5"	8"	1'-7"	1'-2"	10.36	1493
	6 x 5	8'	6"	6'-6"	11'-3"	7"	4'-0"	8"	2'-0"	1'-4"	13.83	2161
	6 x 6	8'	6"	7'-6"	13'-0"	7"	4'-8"	8"	2'-3"	1'-9"	17.98	2970
	7 x 3	8'	6½"	4'-6½"	7'-10"	7"	2'-10"	8"	1'-2"	1'-0"	7.67	935
	7 x 4	8'	6½"	5'-6½"	9'-7"	7"	3'-5"	8"	1'-7"	1'-2"	10.63	1493
	7 x 5	8'	6½"	6'-6½"	11'-4"	7"	4'-0"	8"	2'-0"	1'-4"	14.14	2168
	7 x 6	8'	6½"	7'-6½"	13'-1"	7"	4'-8"	8"	2'-3"	1'-9"	18.34	2978
	7 x 7	8'	6½"	8'-6½"	14'-10"	8"	5'-2"	9½"	2'-6½"	1'-10"	24.90	4263
SC-30°A	8 x 4	4'	6½"	5'-6½"	9'-7"	7"	3'-5"	8"	1'-7"	1'-2"	10.77	1506
	8 x 5	4'	6½"	6'-6½"	11'-4"	7"	4'-0"	8"	2'-0"	1'-4"	14.29	2175
	8 x 6	4'	6½"	7'-6½"	13'-1"	7"	4'-8"	8"	2'-3"	1'-9"	18.51	2986
	8 x 7	4'	6½"	8'-6½"	14'-10"	8"	5'-2"	9½"	2'-6½"	1'-10"	25.08	4272
	8 x 8	4'	6½"	9'-6½"	16'-6"	9"	5'-9"	10½"	2'-8½"	2'-2"	32.81	6074
SC-30°B	8 x 4	6'	7"	5'-7"	9'-8"	7"	3'-5"	8"	1'-7"	1'-2"	10.91	1506
	8 x 5	6'	7"	6'-7"	11'-5"	7"	4'-0"	8"	2'-0"	1'-4"	14.46	2175
	8 x 6	6'	7"	7'-7"	13'-2"	7"	4'-8"	8"	2'-3"	1'-9"	18.71	2986
	8 x 7	6'	7"	8'-7"	14'-10"	8"	5'-2"	9½"	2'-6½"	1'-10"	25.19	4272
	8 x 8	6'	7"	9'-7"	16'-7"	9"	5'-9"	10½"	2'-8½"	2'-2"	33.10	6074
SC-30°C	8 x 4	8'	7½"	5'-7½"	9'-9"	7"	3'-5"	8"	1'-7"	1'-2"	11.05	1506
	8 x 5	8'	7½"	6'-7½"	11'-6"	7"	4'-0"	8"	2'-0"	1'-4"	14.62	2175
	8 x 6	8'	7½"	7'-7½"	13'-2"	7"	4'-8"	8"	2'-3"	1'-9"	18.80	2986
	8 x 7	8'	7½"	8'-7½"	14'-11"	8"	5'-2"	9½"	2'-6½"	1'-10"	25.43	4272
	8 x 8	8'	7½"	9'-7½"	16'-8"	9"	5'-9"	10½"	2'-8½"	2'-2"	33.38	6074
SC-30°A & SC-30°B	9 x 5	6'	7"	6'-7"	11'-5"	7"	4'-0"	8"	2'-0"	1'-4"	14.61	2190
	9 x 6	6'	7"	7'-7"	13'-2"	7"	4'-8"	8"	2'-3"	1'-9"	18.88	3002
	9 x 7	6'	7"	8'-7"	14'-10"	8"	5'-2"	9½"	2'-6½"	1'-10"	25.37	4289
	9 x 8	6'	7"	9'-7"	16'-7"	9"	5'-9"	10½"	2'-8½"	2'-2"	33.30	6093
	9 x 9	6'	7"	10'-7"	18'-4"	9½"	6'-4"	12½"	2'-10½"	2'-5"	43.14	7836
SC-30°C	9 x 5	8'	8"	6'-8"	11'-7"	7"	4'-0"	8"	2'-0"	1'-4"	14.89	2190
	9 x 6	8'	8"	7'-8"	13'-3"	7½"	4'-9"	8½"	2'-3½"	1'-9"	20.00	3002
	9 x 7	8'	8"	8'-8"	15'-0"	8½"	5'-4"	9½"	2'-7½"	1'-11"	26.67	4289
	9 x 8	8'	8"	9'-8"	16'-9"	9½"	6'-0"	11"	2'-11"	2'-2"	35.50	6093
	9 x 9	8'	8"	10'-8"	18'-6"	10"	6'-6"	12½"	2'-11½"	2'-6"	45.01	7836
SC-30°A	10 x 5	4'	7"	6'-7"	11'-5"	7"	4'-0"	8"	2'-0"	1'-4"	14.76	2197
	10 x 6	4'	7"	7'-7"	13'-2"	7"	4'-8"	8"	2'-3"	1'-9"	19.05	3011
	10 x 7	4'	7"	8'-7"	14'-10"	8"	5'-2"	9½"	2'-6½"	1'-10"	25.55	4298
	10 x 8	4'	7"	9'-7"	16'-7"	9"	5'-9"	10½"	2'-8½"	2'-2"	33.50	6103
	10 x 9	4'	7"	10'-7"	18'-4"	9½"	6'-4"	12½"	2'-10½"	2'-5"	43.36	7847
	10 x 10	4'	7"	11'-7"	20'-1"	11"	7'-0"	13½"	3'-2½"	2'-8"	55.63	9957
SC-30°B	10 x 5	6'	8"	6'-8"	11'-7"	7"	4'-0"	8"	2'-0"	1'-4"	15.10	2197
	10 x 6	6'	8"	7'-8"	13'-3"	7½"	4'-9"	8½"	2'-3½"	1'-9"	20.18	3011
	10 x 7	6'	8"	8'-8"	15'-0"	8½"	5'-4"	9½"	2'-7½"	1'-11"	26.86	4298
	10 x 8	6'	8"	9'-8"	16'-9"	9½"	6'-0"	11"	2'-11"	2'-2"	35.71	6103
	10 x 9	6'	8"	10'-8"	18'-6"	10"	6'-6"	12½"	2'-11½"	2'-6"	45.25	7847
	10 x 10	6'	8"	11'-8"	20'-2"	11"	7'-0"	13½"	3'-2½"	2'-8"	56.24	9957
SC-30°C	10 x 5	8'	8½"	6'-8½"	11'-7"	7"	4'-0"	8"	2'-0"	1'-4"	15.17	2197
	10 x 6	8'	8½"	7'-8½"	13'-4"	7½"	4'-9"	8½"	2'-3½"	1'-9"	20.39	3011
	10 x 7	8'	8½"	8'-8½"	15'-1"	8½"	5'-4"	9½"	2'-7½"	1'-11"	27.12	4298
	10 x 8	8'	8½"	9'-8½"	16'-10"	9½"	6'-0"	11"	2'-11"	2'-2"	36.02	6103
	10 x 9	8'	8½"	10'-8½"	18'-7"	10"	6'-6"	12½"	2'-11½"	2'-6"	45.62	7847
	10 x 10	8'	8½"	11'-8½"	20'-3"	11"	7'-0"	13½"	3'-2½"	2'-8"	56.65	9957

TABLE OF REINFORCING STEEL FOR 4 WINGWALLS

WING SIZE		#4 BARS B@12"±			BARS R					BARS S1					#4-BARS T1@18"±			#4 BARS T2@18"±			BARS U1 @ 18"±				BARS U2 @ 18"±				#4 BARS W@12"±			#4 Bars P @ 18"cc			TOTAL
H	L	NO.	LGTH.	WT.	NO.	SIZE	SPAC.	LGTH.	WT.	NO.	SIZE	SPAC.	LGTH.	WT.	NO.	LGTH.	WT.	NO.	LGTH.	WT.	NO.	SIZE	LGTH.	WT.	NO.	SIZE	LGTH.	WT.	NO.	LGTH.	WT.	No.	LGTH.	WT.	WEIGHT
2'-0"	6'-1"	8	5'-6"	29	28	#4	12"	5'-4"	95	28	#4	12"	3'-11"	73	8	5'-6"	29	8	6'-0"	32	8	#5	6'-0"	50	8	#5	6'-0"	50	28	9'-10"	184	20	3'-9"	50	592
3'-0"	7'-10"	8	7'-3"	39	36	#4	11"	6'-4"	146	36	#4	11"	4'-3"	102	12	7'-3"	58	12	7'-9"	62	12	#5	6'-0"	75	12	#5	6'-0"	75	28	12'-9"	238	28	4'-9"	89	884
4'-0"	9'-6"	8	8'-11"	48	68	#4	7"	7'-3"	329	68	#4	7"	4'-10"	219	16	8'-11"	95	16	9'-5"	101	16	#5	6'-0"	100	16	#5	6'-0"	100	32	15'-3"	326	32	5'-9"	123	1441
5'-0"	11'-3"	12	10'-8"	86	68	#5	8"	8'-5"	597	68	#5	8"	5'-5"	384	16	10'-8"	114	16	11'-2"	119	16	#5	6'-0"	100	16	#5	6'-0"	100	36	18'-4"	441	36	6'-9"	162	2103
6'-0"	13'-0"	12	12'-5"	100	92	#5	7"	9'-10"	943	92	#5	7"	6'-1"	583	20	12'-5"	166	20	12'-11"	173	20	#5	6'-0"	125	20	5	6'-0"	125	36	20'-1"	483	40	7'-9"	207	2905
7'-0"	14'-10"	12	14'-3"	114	132	#5	5½"	11'-4"	1560	132	#5	5½"	6'-7"	906	24	14'-3"	228	24	14'-9"	236	24	#5	6'-0"	150	24	#5	6'-0"	150	40	21'-10"	583	44	8'-9"	257	4184
8'-0"	16'-6"	16	15'-11"	170	132	#6	6"	12'-9"	2528	132	#6	6"	7'-4"	1453	24	15'-11"	255	24	16'-5"	263	24	#5	6'-0"	150	24	#5	6'-0"	150	44	23'-8"	696	48	9'-9"	313	5978
9'-0"	18'-4"	16	17'-9"	190	160	#6	5½"	14'-4"	3444	160	#6	5½"	7'-11"	1903	28	17'-9"	332	28	18'-3"	341	28	#5	6'-0"	175	28	5	6'-0"	175	44	25'-5"	747	56	10'-10"	405	7712
10'-0"	20'-1"	16	19'-6"	208	192	#6	5"	15'-9"	4542	192	#6	5"	8'-7"	2474	32	19'-6"	417	32	20'-0"	428	32	#5	6'-0"	200	32	5	6'-0"	200	48	27'-1"	868	60	11'-10"	474	9811

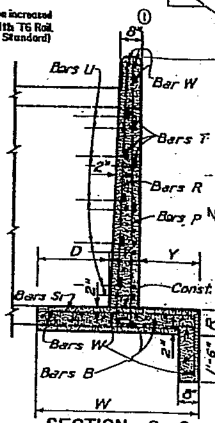
*These Total Quantities are for 4 Wing Walls and 2 Aprons.

① Curb width must be increased to 1'-0" for use with T6 Rail. (See T6-CM Rail Standard)

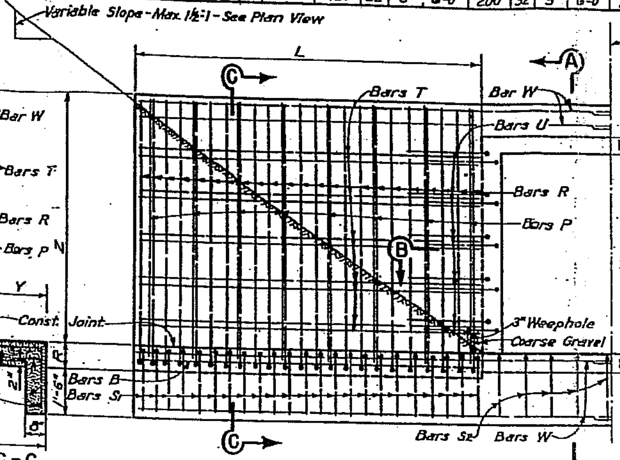


SECTION A-A

APRON DETAIL

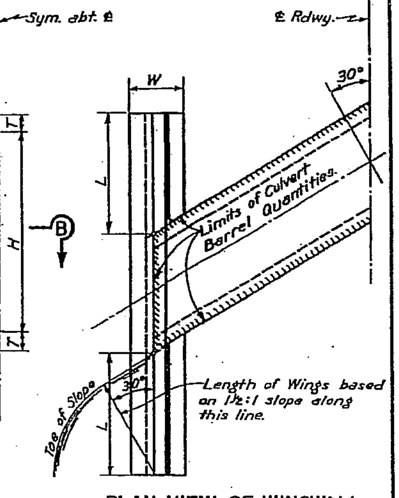


SECTION C-C



HALF ELEVATION

DETAIL OF WINGWALL



PLAN VIEW OF WINGWALL

GENERAL NOTES:

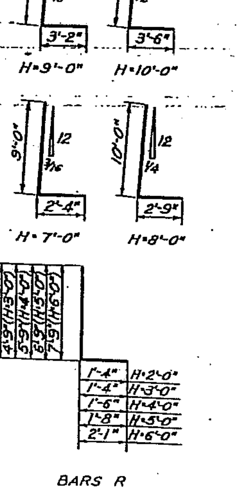
Chamfer all exposed corners ¾".

All dimensions relating to reinforcing steel are to centers of bars.

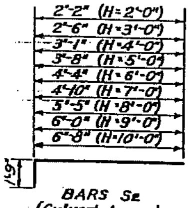
Provide weepholes for H=5'-0" and greater.

The bottom slab of the barrel, wing footings and toe walls shall be placed in one continuous operation.

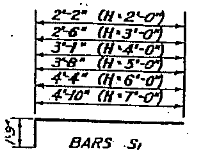
Wings shall be constructed monolithic with the barrel. If construction joints are used near the top of the barrel walls these joints shall continue through the wings.



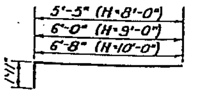
BARS R



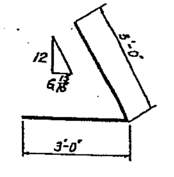
BARS S2
(Culvert Apron)



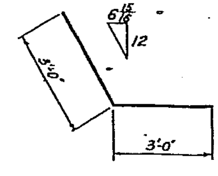
BARS S1



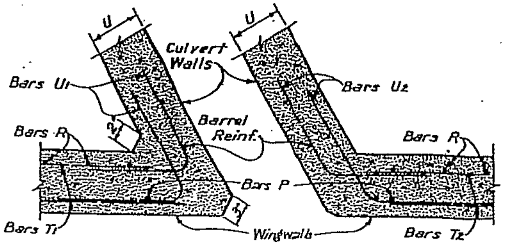
BARS S1



BARS U1



BARS U2



SECTION B-B

BILL OF #4 BARS S2 @ 12"± FOR 2 CULVERT-APRONS

H	SPAN	NO.	LGTH.	WT.	H	SPAN	NO.	LGTH.	WT.
2'-0"	3'-0"	10	3'-11"	26	5'-0"	9'-0"	24	5'-5"	87
	4'-0"	12	3'-11"	31		10'-0"	26	5'-5"	94
	5'-0"	14	3'-11"	37	6'-0"	6'-0"	16	6'-1"	65
3'-0"	3'-0"	10	4'-3"	28		7'-0"	18	6'-1"	73
	4'-0"	12	4'-3"	34		8'-0"	20	6'-1"	81
	5'-0"	14	4'-3"	40		9'-0"	24	6'-1"	97
	6'-0"	16	4'-3"	45		10'-0"	26	6'-1"	106
	7'-0"	18	4'-3"	51	7'-0"	7'-0"	18	6'-7"	79
4'-0"	4'-0"	12	4'-10"	39		8'-0"	20	6'-7"	88
	5'-0"	14	4'-10"	45		9'-0"	24	6'-7"	105
	6'-0"	16	4'-10"	52		10'-0"	26	6'-7"	114
	7'-0"	18	4'-10"	58	8'-0"	8'-0"	20	7'-2"	96
	8'-0"	20	4'-10"	65		9'-0"	24	7'-2"	115
5'-0"	5'-0"	14	5'-5"	51		10'-0"	26	7'-2"	125
	6'-0"	16	5'-5"	58	9'-0"	9'-0"	24	7'-9"	124
	7'-0"	18	5'-5"	65		10'-0"	26	7'-9"	135
	8'-0"	20	5'-5"	72	10'-0"	10'-0"	26	8'-5"	146

TEXAS HIGHWAY DEPARTMENT

PARALLEL WINGS 30° SKEW

FOR SINGLE BOX CULVERTS
SIZES 3'x2' TO 10'x10"

PW-30°

	DRAWING	DATE		STATE	FEDERAL AID PROJECT NO.	
DR. ~CZS~ (RKH)						
CK. DWG. HH	ORIGINAL	JAN 1950	8	TEXAS		
DES. MDA	Rev. 11-67					
CK. DES. KM	Rev. 7-93 (note ①)					
TR. A.O.G						
CK. TR. MDA						

TABLE OF DIMENSIONS

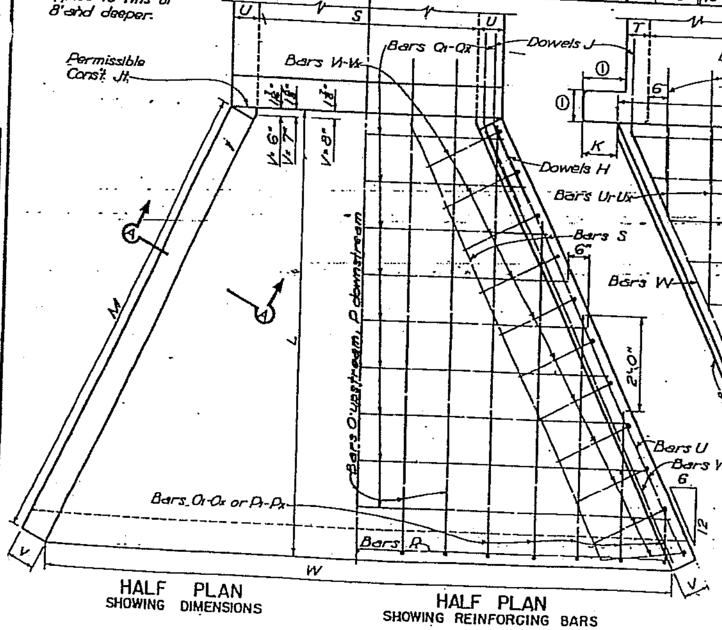
CULVERT SIZE								MAX FILL 4'	MAX FILL 6'	MAX FILL 8'*	TOTAL QUANTITIES Conc	TOTAL QUANTITIES Steel
S × H	L	M	V	W	C	D	T_A	K	K	K	Cu Yds	Lbs
3 × 2	3'-6¼"	3'-8⅜"	6"	6'-5¼"	1'-0"	2'-8"	6"	-	-	10"	1.73	241
3 × 3	5'-6¾"	5'-11⅛"	6"	8'-5¾"	1'-0"	3'-8"	6"	-	-	10"	3.03	371
4 × 2	3'-6¼"	3'-8⅜"	6"	7'-5¼"	1'-0"	2'-8"	6"	-	-	10"	1.93	256
4 × 3	5'-6¾"	5'-11⅛"	6"	9'-5¾"	1'-0"	3'-8"	6"	-	-	10"	3.29	390
4 × 4	7'-6¾"	8'-2⅞"	6"	11'-5¾"	1'-0"	4'-8"	6"	-	-	10"	4.98	558
5 × 2	3'-6¼"	3'-8⅜"	6"	8'-5¼"	1'-0"	2'-8"	6"	-	-	10"	2.12	271
5 × 3	5'-6¾"	5'-11⅛"	6"	10'-5¾"	1'-0"	3'-8"	6"	-	-	10"	3.56	410
5 × 4	7'-6¾"	8'-2⅞"	6"	12'-5¾"	1'-0"	4'-8"	6"	-	-	10"	5.32	583
5 × 5	8'-7⅝"	9'-3⅞"	7"	13'-5½"	1'-6"	5'-8"	6"	-	-	10"	7.17	728
6 × 3	5'-6¾"	5'-11⅛"	6"	11'-5¾"	1'-0"	3'-8"	6"	-	10"	10"	3.88	432
6 × 4	7'-6¾"	8'-2⅞"	6"	13'-5¾"	1'-0"	4'-8"	6"	-	10"	10"	5.66	610
6 × 5	8'-7⅝"	9'-3⅞"	7	14'-5½"	1'-6"	5'-8"	6"	-	10"	10"	7.55	757
6 × 6	10'-7⅝"	11'-6⅞"	7"	16'-5⅜"	1'-6"	6'-8"	6"	-	10"	10"	10.13	972
7 × 3	5'-7¾"	6'-0⅞"	6"	12'-6¾"	1'-0"	3'-8½"	6½"	10"	10"	10"	4.36	465
7 × 4	7'-7¾"	8'-3⅞"	6"	14'-6¾"	1'-0"	4'-8½"	6½"	10"	10"	10"	6.37	642
7 × 5	8'-8⅝"	9'-4⅞"	7"	15'-6½"	1'-6"	5'-8½"	6½"	10"	10"	10"	8.37	792
7 × 6	10'-8⅝"	11'-7⅞"	7"	17'-6½"	1'-6"	6'-8½"	6½"	10"	10"	10"	11.15	1014
7 × 7	12'-8⅝"	13'-10⅞"	7"	19'-6½"	1'-6"	7'-8½"	6½"	10"	10"	10"	14.28	1372
8 × 4	7'-8¾"	8'-4⅞"	6"	15'-7¼"	1'-0"	4'-9"	7"	9½"	10"	10½"	7.14	671
8 × 5	8'-9⅝"	9'-6"	7"	16'-7½"	1'-6"	5'-9"	7"	9½"	10"	10½"	9.26	828
8 × 6	10'-9⅝"	11'-8⅞"	7"	18'-7½"	1'-6"	6'-9"	7"	9½"	10"	10½"	12.25	1053
8 × 7	12'-9⅝"	13'-11⅞"	7"	20'-7½"	1'-6"	7'-9"	7"	9½"	10"	10½"	15.60	1385
8 × 8	13'-9⅝"	15'-1⅞"	8"	21'-7¾"	2'-0"	8'-9"	7"	9½"	10"	10½"	19.25	1818
9 × 5	8'-10⅝"	9'-7⅞"	7"	17'-8½"	1'-6"	5'-9½"	7"	9½"	9½"	10"	9.82	858
9 × 6	10'-10⅝"	11'-10"	7"	19'-8½"	1'-6"	6'-9½"	7"	9½"	9½"	10"	12.91	1106
9 × 7	12'-10⅝"	14'-0⅞"	7"	21'-8½"	1'-6"	7'-9½"	7"	9½"	9½"	10"	16.36	1428
9 × 8	13'-10⅝"	15'-2⅞"	8"	22'-8¾"	2'-0"	8'-9½"	7"	9½"	9½"	10"	20.09	1894
9 × 9	15'-10⅝"	17'-5⅞"	8"	24'-8¾"	2'-0"	9'-9½"	7"	9½"	9½"	10"	24.47	2563
10 × 5	8'-11⅝"	9'-8⅞"	7"	18'-9½"	1'-6"	5'-10"	7½"	9"	10"	10½"	10.82	894
10 × 6	10'-11⅝"	11'-11⅞"	7"	20'-9½"	1'-6"	6'-10"	7½"	9"	10"	10½"	14.14	1149
10 × 7	12'-11⅝"	14'-1⅞"	7"	22'-9½"	1'-6"	7'-10"	7½"	9"	10"	10½"	17.84	1479
10 × 8	13'-11⅝"	15'-3⅞"	8"	23'-9¾"	2'-0"	8'-10"	7½"	9"	10"	10½"	21.72	1849
10 × 9	15'-11⅝"	17'-6⅞"	8"	25'-9¾"	2'-0"	9'-10"	7½"	9"	10"	10½"	26.36	2626
10 × 10	17'-11⅝"	19'-9"	8"	27'-9¾"	2'-0"	10'-10"	7½"	9"	10"	10½"	31.41	3744

* Applies to fills of 8' and deeper.

TABLE OF REINFORCING STEEL FOR 2 WINGS

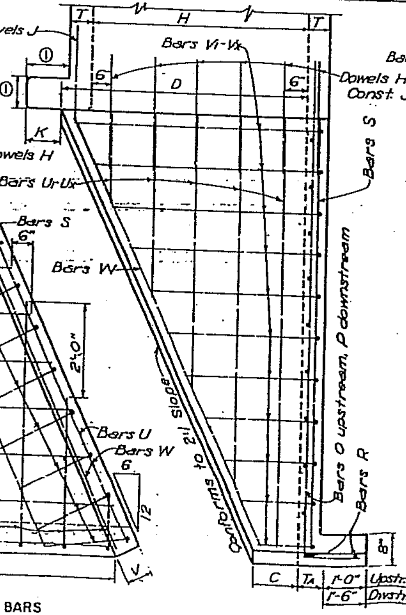
CULVERT SIZE	Bars H-#4 2'-6" Long @12"		Bars J-#6 4'-0" Long		Bars O #4 @12"			Bars O1-Ox #4 @12"			Bars P #4 @12"			Bars P1-Px #4 @12"		
S × H	No	Wt	No	Wt	No	Lgth	Wt	No	Av Lgth	Wt	No	Lgth	Wt	No	Av Lgth	Wt
3 × 2	12	20	8	48	3	5'-11"	12	4	3'-6"	9	3	6'-5"	13	4	4'-0"	11
3 × 3	16	27	8	48	3	7'-11"	16	6	4'-6"	18	3	8'-5"	17	6	5'-0"	20
4 × 2	12	20	8	48	4	5'-11"	16	4	3'-6"	9	4	6'-5"	17	4	4'-0"	11
4 × 3	16	27	8	48	4	7'-11"	21	6	4'-6"	18	4	8'-5"	22	6	5'-0"	20
4 × 4	20	33	8	48	4	9'-11"	26	8	5'-6"	29	4	10'-5"	28	8	6'-0"	32
5 × 2	12	20	8	48	5	5'-11"	20	4	3'-6"	9	5	6'-5"	21	4	4'-0"	11
5 × 3	16	27	8	48	5	7'-11"	26	6	4'-6"	18	5	8'-5"	28	6	5'-0"	20
5 × 4	20	33	8	48	5	9'-11"	33	8	5'-6"	29	5	10'-5"	35	8	6'-0"	32
5 × 5	24	40	8	48	5	10'-11"	36	8	6'-6"	35	5	11'-5"	38	8	7'-0"	37
6 × 3	16	27	8	48	6	7'-11"	32	6	4'-6"	18	6	8'-5"	34	6	5'-0"	20
6 × 4	20	33	8	48	6	9'-11"	40	8	5'-6"	29	6	10'-5"	42	8	6'-0"	32
6 × 5	24	40	8	48	6	10'-11"	44	8	6'-6"	35	6	11'-5"	46	8	7'-0"	37
6 × 6	28	47	8	48	6	12'-11"	52	10	7'-6"	50	6	13'-5"	54	10	8'-0"	53
7 × 3	16	27	8	48	7	8'-0"	37	6	4'-7"	18	7	8'-6"	40	6	5'-1"	20
7 × 4	20	33	8	48	7	10'-0"	47	8	5'-7"	30	7	10'-6"	49	8	6'-1"	33
7 × 5	24	40	8	48	7	11'-0"	51	8	6'-7"	35	7	11'-6"	54	8	7'-1"	38
7 × 6	28	47	8	48	7	13'-0"	61	10	7'-7"	51	7	13'-6"	63	10	8'-1"	54
7 × 7	32	53	8	48	7	15'-0"	70	12	8'-7"	69	7	15'-6"	72	12	9'-1"	73
8 × 4	20	33	8	48	8	10'-1"	54	8	5'-8"	30	8	10'-7"	57	8	6'-2"	33
8 × 5	24	40	8	48	8	11'-1"	59	8	6'-8"	36	8	11'-7"	62	8	7'-2"	38
8 × 6	28	47	8	48	8	13'-1"	70	10	7'-8"	51	8	13'-7"	73	10	8'-2"	55
8 × 7	32	53	8	48	8	15'-1"	81	12	8'-8"	69	8	15'-7"	83	12	9'-2"	73
8 × 8	36	60	8	48	8	16'-2"	86	12	9'-9"	78	8	16'-8"	89	12	10'-3"	82
9 × 5	24	40	8	48	9	11'-2"	67	8	6'-9"	36	9	11'-8"	70	8	7'-3"	39
9 × 6	28	47	8	48	9	13'-2"	79	10	7'-9"	52	9	13'-8"	82	10	8'-3"	55
9 × 7	32	53	8	48	9	15'-2"	91	12	8'-9"	70	9	15'-8"	94	12	9'-3"	74
9 × 8	36	60	8	48	9	16'-3"	98	14	8'-10"	83	9	16'-9"	101	14	9'-4"	87
9 × 9	40	67	8	48	9	18'-3"	110	16	9'-10"	105	9	18'-5"	113	16	10'-4"	110
10 × 5	24	40	8	48	10	11'-3"	75	8	6'-10"	37	10	11'-9"	78	8	7'-4"	39
10 × 6	28	47	8	48	10	13'-3"	89	10	7'-10"	52	10	13'-9"	92	10	8'-4"	56
10 × 7	32	53	8	48	10	15'-3"	102	12	8'-10"	71	10	15'-9"	105	12	9'-4"	75
10 × 8	36	60	8	48	10	16'-4"	109	14	8'-11"	83	10	16'-10"	112	14	9'-5"	88
10 × 9	40	67	8	48	10	18'-4"	122	16	9'-11"	106	10	18'-10"	126	16	10'-5"	111
10 × 10	44	73	8	48	10	20'-4"	136	18	10'-11"	131	10	20'-10"	139	18	11'-5"	137

CULVERT SIZE	Bars Q1-Qx #4 @12"			Bars R 4-#4		Bars S 8-#4		Bars U #4			Bars V1-Vx					8 Bars W		
S × H	No	Av Lgth	Wt	Lgth	Wt	Lgth	Wt	No	Av Lgth	Wt	No	Size	Spac	Av Lgth	Wt	Size	Lgth	Wt
3 × 2	6	5'-0"	20	6'-6"	17	3'-5"	18	8	3'-1"	16	16	#4	12"	3'-6"	37	#4	3'-9"	20
3 × 3	10	6'-0"	40	8'-6"	23	5'-8"	30	12	4'-4"	35	24	#4	12"	4'-0"	64	#4	6'-3"	33
4 × 2	6	6'-0"	24	7'-6"	20	3'-5"	18	8	3'-1"	16	16	#4	12"	3'-6"	37	#4	3'-9"	20
4 × 3	10	7'-0"	47	9'-6"	25	5'-8"	30	12	4'-4"	35	24	#4	12"	4'-0"	64	#4	6'-3"	33
4 × 4	14	8'-0"	75	11'-6"	31	7'-10"	42	16	5'-7"	60	36	#4	12"	4'-6"	108	#4	8'-7"	46
5 × 2	6	7'-0"	28	8'-6"	23	3'-5"	18	8	3'-1"	16	16	#4	12"	3'-6"	37	#4	3'-9"	20
5 × 3	10	8'-0"	53	10'-6"	28	5'-8"	30	12	4'-4"	35	24	#4	12"	4'-0"	64	#4	6'-3"	33
5 × 4	14	9'-0"	84	12'-6"	33	7'-10"	42	16	5'-7"	60	36	#4	12"	4'-6"	108	#4	8'-7"	46
5 × 5	16	9'-6"	102	13'-6"	36	9'-0"	48	20	6'-6"	87	40	#4	12"	5'-3"	140	#5	9'-8"	81
6 × 3	10	9'-0"	60	11'-6"	31	5'-8"	30	12	4'-4"	35	24	#4	12"	4'-0"	64	#4	6'-3"	33
6 × 4	14	10'-0"	94	13'-6"	36	7'-10"	42	16	5'-7"	60	36	#4	12"	4'-6"	108	#4	8'-7"	46
6 × 5	16	10'-6"	112	14'-6"	39	9'-0"	48	20	6'-6"	87	40	#4	12"	5'-3"	140	#5	9'-8"	81
6 × 6	20	11'-6"	154	16'-6"	44	11'-3"	60	24	7'-8"	123	48	#4	12"	5'-9"	184	#5	12'-4"	103
7 × 3	10	10'-0"	67	12'-7"	34	5'-8"	30	12	4'-4"	35	28	#4	1	4'-1"	76	#4	6'-3"	33
7 × 4	14	11'-0"	103	14'-7"	39	8'-0"	43	16	5'-7"	60	36	#4	1	4'-7"	110	#4	8'-9"	47
7 × 5	16	11'-6"	123	15'-7"	42	9'-1"	49	20	6'-6"	87	40	#4	12"	5'-4"	142	#5	9'-11"	83
7 × 6	20	12'-6"	167	17'-7"	47	11'-4"	61	24	7'-9"	124	48	#4	12"	5'-10"	187	#5	12'-5"	104
7 × 7	24	13'-6"	216	19'-7"	52	13'-7"	73	28	8'-11"	167	84	#4	8"	6'-4"	355	#5	14'-11"	124
8 × 4	14	12'-0"	112	15'-8"	42	8'-1"	43	16	5'-7"	60	36	#4	12"	4'-8"	112	#4	8'-10"	47
8 × 5	16	12'-6"	134	16'-8"	45	9'-2"	49	20	6'-7"	88	40	#4	12"	5'-5"	145	#5	10'-1"	84
8 × 6	20	13'-6"	180	18'-8"	50	11'-5"	61	24	7'-9"	124	48	#4	12"	5'-11"	190	#5	12'-6"	104
8 × 7	24	14'-6"	232	20'-8"	55	13'-8"	73	28	8'-11"	167	76	#4	9"	6'-5"	326	#5	15'-0"	125
8 × 8	26	15'-0"	261	21'-8"	58	14'-9"	79	32	9'-9"	208	120	#4	6"	7'-2"	575	#6	16'-2"	194
9 × 5	16	13'-6"	144	17'-9"	47	9'-3"	49	20	6'-7"	88	40	#4	12"	5'-5"	145	#5	10'-2"	85
9 × 6	20	14'-6"	194	19'-9"	53	11'-6"	61	24	7'-9"	124	52	#4	12"	5'-11"	206	#5	12'-7"	103
9 × 7	24	15'-6"	248	21'-9"	58	13'-9"	73	28	8'-11"	167	76	#4	9"	6'-5"	326	#5	15'-1"	126
9 × 8	26	16'-0"	278	22'-9"	61	14'-10"	79	32	9'-10"	210	124	#4	6"	7'-2"	594	#6	16'-3"	195
9 × 9	30	17'-0"	341	24'-9"	66	17'-1"	91	36	11'-0"	265	120	#5	7"	8'-2"	1022	#6	18'-9"	225
10 × 5	16	14'-6"	155	18'-10"	50	9'-4"	50	20	6'-8"	89	40	#4	12"	5'-6"	147	#5	10'-3"	86
10 × 6	20	15'-6"	207	20'-10"	56	11'-7"	62	24	7'-10"	126	52	#4	12"	6'-0"	208	#5	12'-8"	106
10 × 7	24	16'-6"	265	22'-10"	61	13'-10"	74	28	9'-0"	168	76	#4	9"	6'-6"	330	#5	15'-2"	127
10 × 8	26	17'-0"	295	23'-10"	64	14'-11"	80	32	9'-10"	210	104	#4	7"	7'-3"	504	#6	16'-4"	196
10 × 9	30	18'-0"	361	25'-10"	69	17'-2"	92	36	11'-0"	265	120	#5	7"	8'-3"	1033	#6	18'-10"	226
10 × 10	34	19'-0"	432	27'-10"	74	19'-5"	104	40	12'-2"	325	136	#6	7"	9'-3"	1890	#6	21'-3"	255

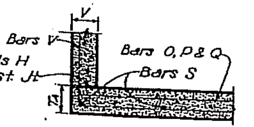


HALF PLAN
SHOWING DIMENSIONS

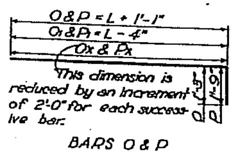
HALF PLAN
SHOWING REINFORCING BARS



ELEVATION
PARALLEL TO BARREL

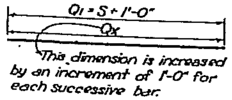


SECTION A-A



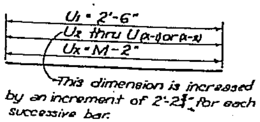
This dimension is reduced by an increment of 2'-0" for each successive bar.

BARS O & P

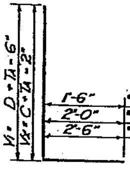


This dimension is increased by an increment of 1'-0" for each successive bar.

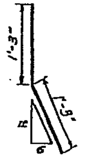
BARS Q



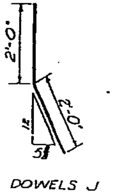
This dimension is increased by an increment of 2'-2¼" for each successive bar.



BARS V



DOWELS H



DOWELS J

GENERAL NOTES -

Dimensions relating to reinforcing steel are to centers of bars.

Steel cover to be 2" from center of outside layer of steel to face of concrete.

Chamfer exposed corners ¾" except as otherwise noted.

① See Box Culvert Standards for dimensions.

TEXAS HIGHWAY DEPARTMENT

FLARED WINGS - NORMAL
FOR SINGLE BOX CULVERTS

SIZES 3×2 to 10×10

FW-N

Dn. RMM	DRAWING	DATE
Ck. Dn. V.H.	Original	April, 1944
Dn. RMM	Rev. 11-67	
Ck. Dn. A.B.L.	Rev. 7-55 (note ①)	
Tr. ABP		
Ck. Tr. RMM		

STATE TEXAS

TABLE OF DIMENSIONS

CULVERT SIZE S	H	Ta	V	L	M	N	W	C	D	TYPE A K	TYPE B K	TYPE C K	TOTAL QUANT. 2 WINGS Conc. Cu.Yds.	Steel Lbs.
3x	2	6"	6"	5'-6¾"	3'-9⅞"	3'-6⅝"	6'-0⅜"	1'-0"	2'-8"	-	-	10"	1.68	243
	3	6"	6"	5'-6¾"	6'-1⅝"	5'-7½"	7'-9"	1'-0"	3'-8"	-	-	10"	2.89	376
4x	2	6"	6"	5'-6¾"	3'-9⅞"	3'-6⅝"	7'-1⅞"	1'-0"	2'-8"	-	-	10"	1.88	235
	3	6"	6"	5'-6¾"	6'-1⅝"	5'-7½"	8'-9⅞"	1'-0"	3'-8"	-	-	10"	3.17	396
	4	6"	6"	7'-6¾"	8'-5⅝"	7'-8⅜"	10'-5⅞"	1'-0"	4'-8"	-	-	10"	4.76	542
5x	2	6"	6"	5'-6¾"	3'-9⅞"	3'-6⅝"	8'-1½"	1'-0"	2'-8"	-	-	10"	2.08	273
	3	6"	6"	5'-6¾"	6'-1⅝"	5'-7½"	9'-9⅝"	1'-0"	3'-8"	-	-	10"	3.45	416
	4	6"	6"	7'-6¾"	8'-5⅝"	7'-8⅜"	11'-6⅝"	1'-0"	4'-8"	-	-	10"	5.11	568
	5	6"	7"	8'-7⅛"	9'-7"	8'-8⅜"	12'-4⅞"	1'-6"	5'-8"	-	-	10"	6.89	715
6x	3	6"	6"	5'-6¾"	6'-1⅝"	5'-7½"	10'-10¼"	1'-0"	3'-8"	-	-	10"	3.73	438
	4	6"	6"	7'-6¾"	8'-5⅝"	7'-8⅜"	12'-6½"	1'-0"	4'-8"	-	10"	10"	5.46	594
	5	6"	7"	8'-7⅛"	9'-7"	8'-8⅜"	8'-4⅞"	1'-6"	5'-8"	-	10"	10"	7.28	745
	6	6"	7"	10'-7⅛"	11'-10¾"	10'-9⅜"	15'-1⅞"	1'-6"	6'-8"	-	10"	10"	9.71	961
7x	3	6½"	6"	5'-7¾"	6'-2¼"	5'-8½"	11'-11½"	1'-0"	3'-8½"	-	10"	10"	4.26	463
	4	6½"	6"	7'-7¾"	8'-6½"	7'-9⅜"	13'-7¼"	1'-0"	4'-8½"	10"	10"	10"	6.10	624
	5	6½"	7"	8'-8⅛"	9'-8¾"	8'-9⅜"	14'-6⅝"	1'-6"	5'-8½"	10"	10"	10"	8.10	780
	6	6½"	7"	10'-8⅛"	11'-11⅞"	10'-10⅜"	16'-2⅜"	1'-6"	6'-8½"	10"	10"	10"	10.72	1009
	7	6½"	7"	12'-8⅛"	14'-3⅝"	12'-11⅝"	17'-10¼"	1'-6"	7'-8½"	10"	10"	10"	13.67	1294
8x	4	7"	6"	7'-8¾"	8'-7⅝"	7'-10⅞"	14'-9¼"	1'-0"	4'-9"	10"	10"	10"	6.94	674
	5	7"	7"	8'-9⅛"	9'-9⅝"	8'-11"	15'-7⅞"	1'-6"	5'-9"	9½"	10"	10½"	8.98	822
	6	7"	7"	10'-9⅛"	12'-4"	10'-11⅜"	17'-3⅜"	1'-6"	6'-9"	9½"	10"	10½"	11.81	1044
	7	7"	7"	12'-9⅛"	14'-4⅝"	13'-0⅝"	19'-0"	1'-6"	7'-9"	9½"	10"	10½"	14.98	1371
	8	7"	8"	13'-9⅝"	15'-6⅝"	14'-1⅞"	19'-10⅜"	2'-0"	8'-9"	9½"	10"	10½"	18.50	1787
9x	5	7"	7"	8'-10⅛"	9'-10½"	9'-0"	16'-8⅜"	1'-6"	5'-9½"	9½"	10"	10½"	9.55	860
	6	7"	7"	10'-10⅛"	12'-2¾"	11'-0⅞"	18'-5"	1'-6"	6'-9½"	9½"	9½"	10"	12.49	1092
	7	7"	7"	12'-10⅛"	14'-5⅞"	13'-1⅞"	20'-1⅞"	1'-6"	7'-9½"	9½"	9½"	10"	15.76	1415
	8	7"	8"	13'-10⅝"	15'-7⅞"	14'-2⅜"	20'-11⅝"	2'-0"	8'-9½"	9½"	9½"	10"	19.35	1857
	9	7"	8"	15'-10⅝"	17'-11½"	16'-3¼"	22'-8"	2'-0"	9'-9½"	9½"	9½"	10"	23.49	2509
10x	5	7½"	7"	8'-11⅛"	9'-11¾"	9'-1"	17'-10"	1'-6"	5'-10"	9½"	9½"	10"	10.55	897
	6	7½"	7"	10'-11⅛"	12'-3⅛"	11'-1⅞"	19'-6⅞"	1'-6"	6'-10"	9"	10"	10½"	13.72	1132
	7	7½"	7"	12'-11⅛"	14'-7⅛"	13'-2⅛"	21'-2½"	1'-6"	7'-10"	9"	10"	10½"	17.23	1473
	8	7½"	8"	13'-11⅝"	15'-8⅞"	14'-3⅜"	22'-1"	2'-0"	8'-10"	9"	10"	10½"	20.96	1838
	9	7½"	8"	15'-11⅝"	18'-0⅞"	16'-4¼"	23'-9⅝"	2'-0"	9'-10"	9"	10"	10½"	25.36	2574
	10	7½"	8"	17'-11⅝"	20'-4⅞"	18'-5⅜"	25'-5⅝"	2'-0"	10'-10"	9"	10"	10½"	30.13	3682

TABLE OF REINFORCING STEEL FOR TWO WINGS

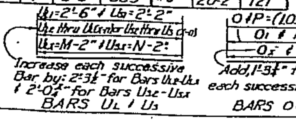
S	H	Bars HL-#4 2'-6" Long @ 12" No.	Weight	Bars JL-#6 4'-0" Long No.	Weight	Bars O #4 @ 12" No.	Length	Wt.	Bars O1-Ox #4 @ 12" No.	Av.Lgth.	Wt.	Bars P #4 @ 12" No.	Length	Wt.	Bars P1-Px #4 @ 12" No.	Av.Lgth.	Wt.	Bars Q1-Qx #4 @ 12" No.	Av.Lgth.	Wt.
3x	2	6	10	4	24	4	6'-0"	16	3	3'-2"	6	4	6'-6"	17	3	3'-8"	7	6	4'-11"	20
	3	8	13	4	24	4	8'-1"	22	5	4'-5"	15	4	8'-7"	23	5	4'-11"	16	10	5'-9"	38
4x	2	6	10	4	24	5	6'-0"	20	3	3'-2"	6	5	6'-6"	22	3	3'-8"	7	6	4'-11"	20
	3	8	13	4	24	5	8'-1"	27	5	4'-5"	15	5	8'-7"	29	5	4'-11"	16	10	6'-9"	45
	4	10	17	4	24	5	10'-2"	34	6	5'-1"	20	5	10'-8"	36	6	5'-7"	22	14	7'-8"	72
5x	2	6	10	4	24	6	6'-0"	24	3	3'-2"	6	6	6'-6"	26	3	3'-8"	7	6	7'-0"	28
	3	8	13	4	24	6	8'-1"	32	5	4'-5"	15	6	8'-7"	34	5	4'-11"	16	10	7'-10"	52
	4	10	17	4	24	6	10'-2"	41	6	5'-1"	20	6	10'-8"	43	6	5'-7"	22	14	8'-8"	81
	5	12	20	4	24	6	11'-3"	45	7	5'-9"	27	6	11'-9"	47	7	6'-3"	29	18	9'-3"	99
6x	3	8	13	4	24	7	8'-1"	38	5	4'-5"	15	7	8'-7"	40	5	4'-11"	16	10	8'-10"	59
	4	10	17	4	24	7	10'-2"	48	6	5'-1"	20	7	10'-8"	50	6	5'-7"	22	14	9'-9"	91
	5	12	20	4	24	7	11'-3"	53	7	5'-9"	27	7	11'-9"	55	7	6'-3"	29	16	10'-9"	110
	6	14	23	4	24	7	13'-4"	62	9	7'-0"	42	7	13'-10"	64	9	7'-6"	45	20	11'-1"	148
7x	3	8	13	4	24	8	8'-2"	44	5	4'-5"	15	8	8'-8"	46	5	4'-11"	16	10	10'-0"	67
	4	10	17	4	24	8	10'-3"	55	6	5'-1"	20	8	10'-9"	57	6	5'-7"	22	14	10'-10"	101
	5	12	20	4	24	8	11'-4"	61	7	5'-9"	27	8	11'-10"	63	7	6'-3"	29	16	11'-4"	121
	6	14	23	4	24	8	13'-5"	72	9	7'-0"	42	8	13'-11"	74	9	7'-6"	45	20	12'-3"	164
	7	16	27	4	24	8	15'-6"	83	10	7'-8"	51	8	16'-0"	86	10	8'-2"	55	24	13'-1"	210
8x	4	10	17	4	24	9	10'-4"	62	7	5'-9"	27	9	10'-10"	65	7	6'-3"	29	14	11'-11"	111
	5	12	20	4	24	9	11'-5"	69	7	5'-9"	27	9	11'-11"	72	7	6'-3"	29	16	12'-6"	134
	6	14	23	4	24	9	13'-6"	81	9	7'-0"	42	9	14'-0"	84	9	7'-6"	45	20	13'-4"	178
	7	16	27	4	24	9	15'-7"	94	11	8'-3"	61	9	16'-1"	97	11	8'-9"	64	24	14'-2"	227
	8	18	30	4	24	9	16'-8"	100	11	8'-3"	61	9	17'-2"	103	11	8'-9"	64	26	14'-10"	258
9x	5	12	20	4	24	10	11'-6"	77	7	5'-9"	27	10	12'-0"	80	7	6'-3"	29	16	13'-7"	145
	6	14	23	4	24	10	13'-7"	91	9	7'-0"	42	10	14'-1"	94	9	7'-6"	45	20	14'-5"	193
	7	16	27	4	24	10	15'-8"	105	11	8'-3"	61	10	16'-2"	108	11	8'-9"	64	24	15'-4"	246
	8	18	30	4	24	10	16'-9"	112	12	8'-11"	72	10	17'-3"	115	12	9'-5"	76	26	15'-11"	276
	9	20	33	4	24	10	18'-9"	125	13	9'-6"	82	10	19'-3"	129	13	10'-0"	87	30	16'-9"	335
10x	5	12	20	4	24	11	11'-7"	85	7	5'-9"	29	11	12'-1"	89	7	6'-3"	29	16	14'-8"	157
	6	14	23	4	24	11	13'-8"	100	9	7'-0"	42	11	14'-2"	104	9	7'-6"	45	20	15'-7"	208
	7	16	27	4	24	11	15'-9"	116	11	8'-3"	61	11	18'-3"	119	11	8'-9"	64	24	16'-5"	263
	8	18	30	4	24	11	16'-10"	124	12	8'-11"	72	11	17'-4"	127	12	9'-5"	72	26	17'-0"	295
	9	20	33	4	24	11	18'-10"	138	13	9'-6"	82	11	19'-4"	142	13	10'-0"	87	30	17'-11"	359
	10	22	37	4	24	11	20'-11"	154	15	10'-10"	109	11	21'-5"	157	15	11'-4"	114	34	18'-9"	426

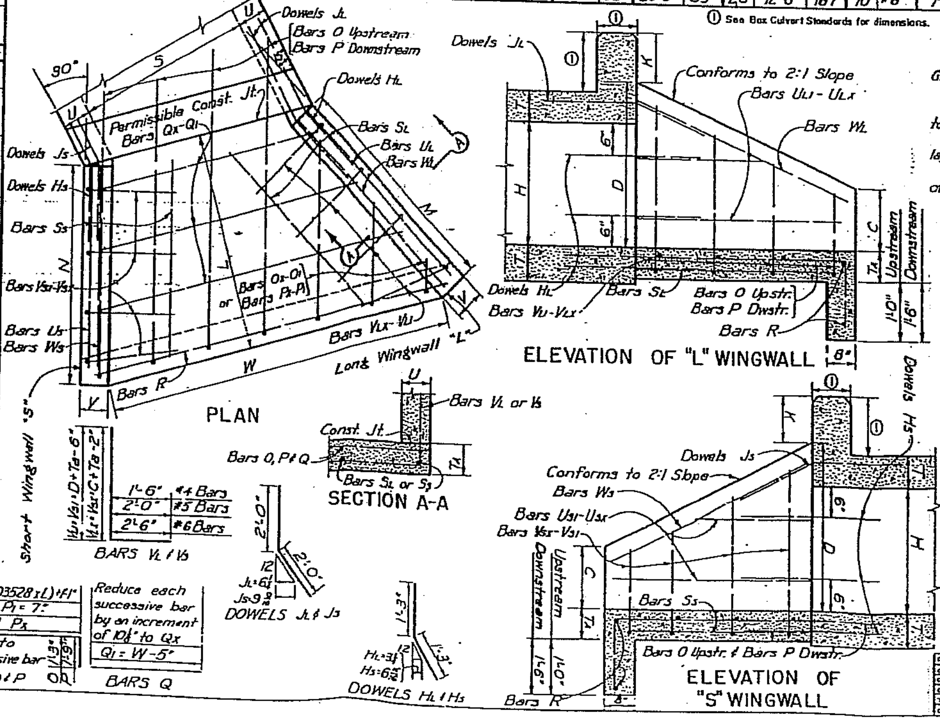
S	H	Bars R 4-#4 Length	Wt.	Bars SL 4-#4 Length	Wt.	Bars UL1-ULx #4 No.	Av.Lgth.	Wt.	Bars VL1-VLx No.	Size	Spa.	Av.Lgth.	Weight	4 Bars WL Size	Length	Wt.	Bars Hs-#4 2'-6" Long @ 12" No.	Weight	Bars Js-#6 4'-0" Long No.	Weight
3x	2	6'-5"	17	3'-6"	9	4	3'-1"	8	8	#4	12"	3'-6"	19	#4	3'-10"	10	6	10	4	24
	3	8'-1"	22	5'-10"	16	6	4'-5"	18	14	#4	12"	4'-0"	37	#4	6'-4"	17	8	13	4	24
4x	2	7'-5"	20	3'-6"	9	4	3'-1"	8	8	#4	12"	3'-6"	19	#4	3'-10"	10	6	10	4	24
	3	9'-1"	24	5'-10"	16	6	4'-5"	18	14	#4	12"	4'-0"	37	#4	6'-4"	17	8	13	4	24
	4	10'-10"	29	8'-1"	22	8	5'-8"	30	18	#4	12"	4'-6"	54	#4	8'-10"	24	10	17	4	24
5x	2	8'-5"	22	3'-6"	9	4	3'-1"	8	8	#4	12"	3'-6"	19	#4	3'-10"	10	6	10	4	24
	3	10'-2"	27	5'-10"	16	6	4'-5"	18	14	#4	12"	4'-0"	37	#4	6'-4"	17	8	13	4	24
	4	11'-10"	32	8'-1"	22	8	5'-8"	30	18	#4	12"	4'-6"	54	#4	8'-10"	24	10	17	4	24
	5	12'-8"	34	9'-3"	25	10	6'-8"	45	20	#4	12"	5'-5"	70	#5	10'-1"	42	12	20	4	24
6x	3	11'-2"	30	5'-10"	16	6	4'-5"	18	14	#4	12"	4'-0"	37	#4	6'-4"	17	8	13	4	24
	4	12'-10"	34	8'-1"	22	8	5'-8"	30	18	#4	12"	4'-8"	54	#4	8'-10"	24	10	17	4	24
	5	13'-9"	37	9'-3"	25	10	6'-8"	45	20	#4	12"	5'-3"	70	#5	10'-1"	42	12	20	4	24
	6	15'-5"	41	11'-7"	31	12	7'-11"	63	26	#4	12"+	5'-9"	100	#5	12'-8"	53	14	23	4	24
7x	3	12'-5"	33	5'-11"	16	6	4'-6"	18	14	#4	12"+	4'-1"	38	#4	6'-5"	17	8	13	4	24
	4	14'-0"	37	8'-3"	22	8	5'-9"	31	18	#4	12"	4'-7"	55	#4	9'-0"	24	10	17	4	24
	5	14'-10"	40	9'-4"	25	10	6'-8"	45	20	#4	12"	5'-4"	71	#5	10'-3"	43	12	20	4	24
	6	16'-6"	44	11'-8"	31	12	7'-11"	63	26	#4	12"-	5'-10"	101	#5	12'-9"	53	14	23	4	24
	7	18'-2"	49	14'-0"	37	14	9'-1"	85	42	#4	8"+	6'-4"	176	#5	15'-3"	64	16	27	4	24
8x	4	13'-1"	40	8'-4"	22	8	5'-8"	30	18	#4	12"	4'-8"	36	#4	9'-1"	24	10	17	4	24
	5	15'-11"	43	9'-5"	25	10	6'-8"	45	20	#4	12"	5'-5"	72	#5	10'-4"	43	12	20	4	24
	6	17'-7"	47	11'-9"	31	12	7'-11"	63	24	#4	12"	5'-11"	95	#5	12'-10"	54	14	23	4	24
	7	19'-4"	52	14'-1"	38	14	9'-2"	86	38	#4	9"	6'-5"	163	#5	15'-4"	64	16	27	4	24
	8	20'-2"	54	15'-3"	41	16	10'-0"	108	62	#4	6"	7'-2"	297	#6	16'-7"	100	18	30	4	24
9x	5	17'-0"	45	9'-7"	26	10	6'-9"	45	22	#4	12"	5'-5"	80	#5	10'-5"	43	12	20	4	24
	6	18'-9"	50	11'-10"	32	12	7'-11"	63	26	#4	12"	5'-11"	103	#5	12'-11"	54	14	23	4	24
	7	20'-5"	55	14'-2"	38	14	9'-2"	86	38	#4	9"	6'-5"	163	#5	15'-5"	64	16	27	4	24
	8	21'-4"	57	15'-4"	41	16	10'-1"	108	62	#4	6"	7'-2"	297	#6	16'-9"	101	18	30	4	24
	9	23'-0"	61	17'-8"	47	18	11'-4"	136	62	#5	7"	8'-2"	528	#6	19'-3"	116	20	33	4	24
10x	5	18'-2"	49	9'-8"	26	10	6'-9"	45	22	#4	12"+	5'-6"	81	#5	10'-6"	44	12	20	4	24
	6	19'-10"	53	11'-11"	32	12	7'-11"	63	26	#4	12"-	6'-0"	114	#5	13'-1"	55	14	23	4	24
	7	21'-7"	58	14'-3"	38	14	9'-2"	86	40	#4	9"	6'-6"	174	#5	15'-7"	65	16	27	4	24
	8	22'-5"	60	15'-5"	41	16	10'-1"	108	54	#4	7"	7'-3"	282	#6	16'-10"	101	18	30	4	24
	9	24'-1"	64	17'-8"	47	18	11'-6"	138	62	#5	7"-	8'-3"	534	#6	19'-4"	118	20	33	4	24
	10	25'-9"	69	20'-0"	53	20	12'-6"	167	70	#6	7"	9'-3"	973	#6	21'-10"	131	22	37	4	24

① See Box Culvert Standards for dimensions.

TABLE OF REINFORCING STEEL - Continued

CULVERT SIZE S	H	Bars Ss 4-#4 Length	Wt.	Bars Us1-Usx #4 No.	Av.Lgth.	Wt.	Bars Vs1 - Vsx No.	Size	Spa.	Av.Lgth.	Weight	4 Bars Ws Size	Length	Weight
3x	2	3'-3"	9	4	2'-10"	8	8	#4	12"	3'-6"	19	#4	3'-7"	10
	3	5'-4"	14	6	4'-0"	16	12	#4	12"	4'-0"	32	#4	5'-11"	16
4x	2	3'-3"	9	4	2'-10"	8	8	#4	12"	3'-6"	19	#4	3'-7"	10
	3	5'-4"	14	6	4'-0"	16	12	#4	12"	4'-0"	32	#4	5'-11"	16
	4	7'-4"	20	8	5'-3"	27	16	#4	12"	4'-6"	48	#4	8'-3"	22
5x	2	3'-3"	9	4	2'-10"	8	8	#4	12"	3'-6"	19	#4	3'-7"	10
	3	5'-4"	14	6	4'-0"	16	12	#4	12"	4'-0"	32	#4	5'-11"	16
	4	7'-4"	20	8	5'-1"	27	16	#4	12"	4'-6"	48	#4	8'-3"	22
	5	8'-5"	22	10	5'-11"	40	18	#4	12"+	5'-3"	63	#5	9'-4"	39
6x	3	5'-4"	14	6	4'-0"	16	12	#4	12"	4'-0"	32	#4	6'-0"	16
	4	7'-4"	20	8	5'-1"	27	16	#4	12"	4'-6"	48	#4	8'-4"	22
	5	8'-5"	22	10	5'-11"	40	18	#4	12"+	5'-3"	83	#5	9'-6"	39
	6	10'-6"	28	12	7'-0"	56	22	#4	12"+	5'-9"	85	#5	11'-9"	49
7x	3	5'-5"	14	6	4'-0"	16	12	#4	12"	4'-1"	33	#4	6'-0"	16
	4	7'-6"	20	8	5'-1"	27	16	#4	12"	4'-7"	49	#4	8'-4"	22
	5	8'-6"	23	10	5'-11"	40	18	#4	12"	5'-4"	64	#5	9'-6"	40
	6	10'-7"	28	12	7'-0"	56	24	#4	12"-	5'-10"	93	#5	11'-9"	49
	7	12'-8"	34	14	8'-1"	76	30	#4	8"-	6'-4"	127	#5	14'-1"	59
8x	4	7'-6"	20	8	5'-1"	27	18	#4	12"	4'-8"	56	#4	8'-5"	22
	5	8'-7"	23	10	6'-0"	40	20	#4	12"	5'-5"	72	#5	9'-7"	40
	6	10'-8"	29	12	7'-1"	57	24	#4	12"	5'-11"	95	#5	11'-10"	49
	7	12'-8"	34	14	8'-1"	76	36	#4	9"	6'-5"	154	#5	14'-2"	59
	8	13'-10"	37	16	9'-0"	96	56	#4	6"	7'-2"	268	#6	15'-4"	92
9x	5	8'-8"	23	10	6'-0"	40	20	#4	12"+	5'-5"	72	#5	9'-8"	40
	6	10'-9"	29	12	7'-1"	57	24	#4	12"+	5'-11"	95	#5	12'-0"	50
	7	12'-10"	34	14	8'-2"	76	36	#4	9"	6'-5"	154	#5	14'-3"	59
	8	13'-11"	37	16	9'-0"	96	56	#4	6"	7'-2"	268	#6	15'-5"	93
	9	16'-0"	43	18	10'-1"	121	56	#5	7"	8'-2"	477	#6	17'-9"	107
10x	5	8'-9"	23	10	6'-0"	40	20	#4	12"+	5'-6"	73	#5	9'-9"	41
	6	10'-10"	29	12	7'-1"	57	24	#4	12"-	6'-0"	96	#5	12'-1"	50
	7	12'-11"	35	14	8'-2"	76	36	#4	9"	6'-6"	156	#5	14'-4"	60
	8	13'-11"	37	16	9'-0"	96	50	#4	7"	7'-3"	242	#6	15'-6"	93
	9	16'-0"	43	18	10'-1"	121	56	#5	7"	8'-3"	482	#6	17'-10"	107
	10	18'-1"	48	20	11'-2"	149	64	#6	7"-	9'-3"	889	#6	20'-2"	121





GENERAL NOTES:-

Dimensions relating to reinforcing steel are to centers of bars.

Steel cover to be 2" from center of outside layer of steel to face of concrete.

Chamfer exposed corners ¾" except as otherwise noted.

TEXAS HIGHWAY DEPARTMENT

FLARED WINGS-15° SKEW
FOR
SINGLE BOX CULVERTS

SIZES 3 x 2 TO 10 x 10

FW-15°

Dn.: R.M.M.	Original	April 1949	
Sp. Dn.: W.H.	Rev. 11-67		
Dn.: M.D.A.	Rev. 7-95 (note ①)		
Ck. Dn.: R.M.			
Tr.: C.W.W.			
Ck. Tr.: M.D.A.			

6	TEXAS		

TABLE OF DIMENSIONS

CULVERT SIZE S	H	TA	V	L	M	N	W	C	D	TYPE A K	TYPE B K	TYPE C K	TOTAL QUANT. 2 WINGS Conc. Cu. Yd.	TOTAL QUANT. 2 WINGS Steel Lbs.
3	2	6"	6"	3'-6½"	4'-6½"	3'-6½"	6'-11½"	1'-0"	2'-8"	-	-	10"	1.88	265
	3	6"	6"	5'-6½"	7'-4½"	5'-6½"	8'-11½"	1'-0"	3'-8"	-	-	10"	3.20	404
4	2	6"	6"	3'-6½"	4'-6½"	3'-6½"	8'-1½"	1'-0"	2'-8"	-	-	10"	2.11	280
	3	6"	8"	5'-6½"	7'-4½"	5'-6½"	10'-1½"	1'-0"	3'-8"	-	-	10"	3.57	425
	4	6"	6"	7'-6½"	10'-2½"	7'-6½"	12'-1½"	1'-0"	4'-8"	-	-	10"	5.17	596
5	2	6"	6"	3'-6½"	4'-6½"	3'-6½"	9'-3½"	1'-0"	2'-8"	-	-	10"	2.33	297
	3	6"	6"	5'-6½"	7'-4½"	5'-6½"	11'-3½"	1'-0"	3'-8"	-	-	10"	3.88	448
	4	6"	6"	7'-6½"	10'-2½"	7'-6½"	13'-3½"	1'-0"	4'-8"	-	-	10"	5.76	624
	5	6"	7"	8'-7½"	11'-6½"	8'-7½"	14'-3½"	1'-6"	5'-8"	-	-	10"	7.74	790
6	3	6"	6"	5'-6½"	7'-4½"	5'-6½"	12'-5½"	1'-0"	3'-8"	-	10"	10"	4.15	480
	4	6"	6"	7'-6½"	10'-2½"	7'-6½"	14'-5½"	1'-0"	4'-8"	-	10"	10"	6.15	664
	5	6"	7"	8'-7½"	11'-6½"	8'-7½"	15'-5½"	1'-6"	5'-8"	-	10"	10"	8.11	836
	6	6"	7"	10'-7½"	14'-4½"	10'-7½"	17'-5½"	1'-6"	6'-8"	-	10"	10"	10.85	1070
7	3	6½"	6"	5'-7½"	7'-5½"	5'-7½"	13'-8½"	1'-0"	3'-8½"	10"	10"	10"	4.79	510
	4	6½"	6"	7'-7½"	10'-3½"	7'-7½"	15'-8½"	1'-0"	4'-8½"	10"	10"	10"	6.89	705
	5	6½"	7"	8'-8½"	11'-6½"	8'-8½"	16'-8½"	1'-6"	5'-8½"	10"	10"	10"	9.10	878
	6	6½"	7"	10'-8½"	14'-6½"	10'-8½"	18'-8½"	1'-6"	6'-8½"	10"	10"	10"	12.06	1115
	7	6½"	7"	12'-8½"	17'-4½"	12'-8½"	20'-8½"	1'-6"	7'-8½"	10"	10"	10"	15.42	1506
8	4	7"	6"	7'-8½"	10'-5½"	7'-8½"	16'-11"	1'-0"	4'-9"	9½"	10"	10½"	7.81	740
	5	7"	7"	8'-9½"	11'-9½"	8'-9½"	17'-11½"	1'-6"	5'-9"	9½"	10"	10½"	10.10	915
	6	7"	7"	10'-9½"	14'-7½"	10'-9½"	19'-11½"	1'-6"	6'-9"	9½"	10"	10½"	13.29	1164
	7	7"	7"	12'-9½"	17'-5½"	12'-9½"	21'-11½"	1'-6"	7'-9"	9½"	10"	10½"	16.87	1518
	8	7"	8"	13'-9½"	18'-10½"	13'-9½"	22'-11½"	2'-0"	8'-9"	9½"	10"	10½"	20.80	1992
9	5	7"	7"	8'-10½"	11'-10½"	8'-10½"	19'-2½"	1'-6"	5'-9½"	9½"	9½"	10"	10.67	952
	6	7"	7"	10'-10½"	14'-9"	10'-10½"	21'-2½"	1'-6"	6'-9½"	9½"	9½"	10"	14.05	1208
	7	7"	7"	12'-10½"	17'-7"	12'-10½"	23'-2½"	1'-6"	7'-9½"	9½"	9½"	10"	17.74	1564
	8	7"	8"	13'-10½"	18'-10½"	13'-10½"	24'-2½"	2'-0"	8'-9½"	9½"	9½"	10"	21.74	2044
	9	7"	8"	15'-10½"	21'-9½"	15'-10½"	26'-2½"	2'-0"	9'-9½"	9½"	9½"	10"	26.42	2795
10	5	7½"	7"	8'-11½"	12'-0½"	8'-11½"	20'-5"	1'-6"	5'-10"	9"	10"	10½"	11.87	1003
	6	7½"	7"	10'-11½"	14'-10½"	10'-11½"	22'-5"	1'-6"	6'-10"	9"	10"	10½"	15.43	1267
	7	7½"	7"	12'-11½"	17'-8½"	12'-11½"	24'-5"	1'-6"	7'-10"	9"	10"	10½"	19.39	1634
	8	7½"	8"	13'-11½"	19'-1"	13'-11½"	25'-5½"	2'-0"	8'-10"	9"	10"	10½"	25.56	2034
	9	7½"	8"	15'-11½"	21'-11"	15'-11½"	27'-5½"	2'-0"	9'-10"	9"	10"	10½"	28.53	2888
	10	7½"	8"	17'-11½"	24'-9"	17'-11½"	29'-5½"	2'-0"	10'-10"	9"	10"	10½"	33.91	4088

TABLE OF REINFORCING STEEL FOR TWO WINGS

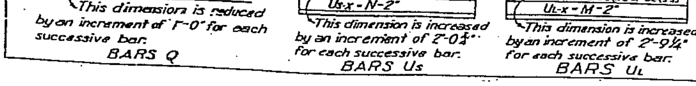
CULVERT SIZE S	H	Bars Hs-#4 2'-6" Long @12" No.	Wt.	Bars HL-#4 2'-6" Long @12" No.	Wt.	Bars Js-#6 4'-0" Long No.	Wt.	Bars JL-#6 4'-0" Long No.	Wt.	Bars O #4 @12" No.	Lgth.	Wt.	Bars O1-Ox #4 @12" No.	Av. Lgth.	Wt.	Bars P #4 @12" No.	Lgth.	Wt.	Bars P1-Px #4 @12" No.	Av. Lgth.	Wt.
3	2	6	10	6	10	4	24	4	24	4	5'-11"	16	4	3'-3"	9	4	6'-5"	17	4	3'-9"	10
	3	8	13	8	13	4	24	4	24	4	7'-11"	21	6	4'-3"	17	4	8'-5"	22	6	4'-9"	19
4	2	6	10	6	10	4	24	4	24	5	5'-11"	20	4	3'-3"	9	5	6'-5"	21	4	3'-9"	10
	3	8	13	8	13	4	24	4	24	5	7'-11"	26	6	4'-3"	17	5	8'-5"	28	6	4'-9"	19
	4	10	17	10	17	4	24	4	24	5	9'-11"	33	8	5'-3"	28	5	10'-5"	35	8	5'-9"	31
5	2	6	10	6	10	4	24	4	24	6	5'-11"	24	4	3'-3"	9	6	6'-5"	26	4	3'-9"	10
	3	8	13	8	13	4	24	4	24	6	7'-11"	32	6	4'-3"	17	6	8'-5"	34	6	4'-9"	19
	4	10	17	10	17	4	24	4	24	6	9'-11"	40	8	5'-3"	28	6	10'-5"	42	8	5'-9"	31
	5	12	20	12	20	4	24	4	24	6	10'-11"	44	9	5'-10"	35	6	11'-5"	46	9	6'-4"	38
6	3	8	13	8	13	4	24	4	24	7	7'-11"	37	7	4'-9"	22	7	8'-5"	39	7	5'-3"	25
	4	10	17	10	17	4	24	4	24	7	9'-11"	46	9	5'-9"	35	7	10'-5"	49	9	6'-3"	38
	5	12	20	12	20	4	24	4	24	8	10'-11"	58	9	5'-10"	35	8	11'-5"	61	9	6'-4"	38
	6	14	23	14	23	4	24	4	24	8	12'-11"	69	11	6'-10"	50	8	13'-5"	72	11	7'-4"	54
7	3	8	13	8	13	4	24	4	24	9	8'-0"	48	6	4'-3"	17	9	8'-6"	51	6	4'-9"	19
	4	10	17	10	17	4	24	4	24	9	10'-0"	60	8	5'-3"	28	9	10'-6"	63	8	5'-9"	31
	5	12	20	12	20	4	24	4	24	9	11'-0"	66	9	5'-10"	35	9	11'-6"	69	9	6'-4"	38
	6	14	23	14	23	4	24	4	24	9	13'-0"	78	11	6'-10"	50	9	13'-6"	81	11	7'-4"	54
	7	16	27	16	27	4	24	4	24	9	15'-0"	90	13	7'-10"	68	9	15'-6"	93	13	8'-4"	72
8	4	10	17	10	17	4	24	4	24	10	10'-1"	67	8	5'-3"	28	10	10'-7"	71	8	5'-9"	31
	5	12	20	12	20	4	24	4	24	10	11'-1"	74	9	5'-10"	35	10	11'-7"	77	9	6'-4"	38
	6	14	23	14	23	4	24	4	24	10	13'-1"	87	11	6'-10"	50	10	13'-7"	91	11	7'-4"	54
	7	16	27	16	27	4	24	4	24	10	15'-4"	101	13	7'-10"	68	10	15'-7"	104	13	8'-4"	72
	8	18	30	18	30	4	24	4	24	10	16'-2"	108	14	8'-5"	79	10	16'-8"	111	14	8'-11"	83
9	5	12	20	12	20	4	24	4	24	11	11'-2"	82	9	5'-10"	35	11	11'-8"	86	9	6'-4"	38
	6	14	23	14	23	4	24	4	24	11	13'-2"	97	11	6'-10"	50	11	13'-8"	100	11	7'-4"	54
	7	16	27	16	27	4	24	4	24	11	15'-2"	111	13	7'-10"	68	11	15'-8"	115	13	8'-4"	72
	8	18	30	18	20	4	24	4	24	11	16'-3"	119	14	8'-5"	79	11	16'-9"	125	14	8'-11"	83
	9	20	33	20	33	4	24	4	24	11	18'-3"	134	16	9'-5"	101	11	18'-9"	138	16	9'-11"	106
10	5	12	20	12	20	4	24	4	24	12	11'-3"	90	10	6'-4"	42	12	11'-9"	94	10	6'-10"	46
	6	14	23	14	23	4	24	4	24	12	13'-3"	106	12	7'-4"	59	12	13'-9"	110	12	7'-10"	63
	7	16	27	16	27	4	24	4	24	12	15'-3"	122	14	8'-4"	78	12	15'-9"	126	14	8'-10"	83
	8	18	30	18	30	4	24	4	24	12	16'-4"	131	15	8'-11"	89	12	16'-10"	135	15	9'-5"	94
	9	20	33	20	33	4	24	4	24	12	18'-4"	147	17	9'-11"	113	12	18'-10"	151	17	10'-5"	118
	10	22	37	22	37	4	24	4	24	12	20'-4"	163	19	10'-11"	139	12	20'-10"	167	19	11'-5"	145

CULVERT SIZE S	H	Bars Q1-Qx #4 @12" No.	Av. Lgth.	Wt.	Bars R 4-#4 Lgth.	Wt.	Bars Ss 4-#4 Lgth.	Wt.	Bars SL 4-#4 Lgth.	Wt.	Bars Us-1-Us-x #4 No.	Av. Lgth.	Wt.	Bars UL-1-UL-x #4 No.	Av. Lgth.	Wt.
3	2	6	5'-8"	23	7'-4"	20	3'-3"	9	4'-3"	11	4	2'-10"	8	4	3'-9"	10
	3	10	6'-8"	45	9'-4"	25	5'-3"	14	7'-0"	19	6	3'-11"	16	6	5'-4"	21
4	2	6	6'-10"	27	8'-6"	23	3'-3"	9	4'-3"	11	4	2'-10"	8	4	3'-9"	10
	3	10	7'-10"	52	10'-6"	28	5'-3"	14	7'-0"	19	6	3'-11"	16	6	5'-4"	21
	4	14	8'-10"	83	12'-6"	33	7'-3"	19	9'-10"	26	8	5'-0"	27	8	6'-10"	36
5	2	6	8'-0"	32	9'-7"	26	3'-3"	9	4'-3"	11	4	2'-10"	8	4	3'-9"	10
	3	10	9'-0"	60	11'-7"	31	5'-3"	14	7'-0"	19	6	3'-11"	16	6	5'-4"	21
	4	14	10'-0"	94	13'-7"	36	7'-3"	19	9'-10"	26	8	5'-0"	27	8	6'-10"	36
	5	16	10'-7"	113	14'-9"	39	8'-3"	22	11'-3"	30	10	5'-11"	40	10	8'-0"	53
6	3	10	10'-2"	68	12'-9"	34	5'-3"	14	7'-0"	19	6	3'-11"	16	6	5'-4"	21
	4	14	11'-2"	104	14'-9"	39	7'-3"	19	9'-10"	26	8	5'-0"	27	8	6'-10"	36
	5	16	11'-9"	126	15'-11"	43	8'-3"	22	11'-3"	30	10	5'-11"	40	10	8'-0"	53
	6	20	12'-9"	170	17'-11"	48	10'-3"	27	14'-0"	37	12	7'-0"	56	12	9'-6"	76
7	3	10	11'-5"	76	14'-0"	37	5'-4"	14	7'-2"	19	6	4'-0"	16	6	5'-4"	21
	4	14	12'-5"	116	16'-0"	43	7'-4"	20	10'-0"	27	8	5'-1"	27	8	6'-10"	36
	5	16	12'-11"	138	17'-1"	46	8'-4"	22	11'-4"	30	10	5'-11"	40	10	8'-0"	53
	6	20	13'-11"	186	19'-1"	51	10'-4"	28	14'-2"	38	12	7'-0"	56	12	9'-6"	76
	7	24	14'-11"	259	21'-1"	56	12'-4"	33	17'-0"	45	14	8'-1"	76	14	11'-0"	103
8	4	14	13'-8"	128	17'-3"	46	7'-5"	20	10'-4"	27	8	5'-1"	27	8	6'-11"	37
	5	16	14'-2"	151	18'-4"	49	8'-5"	22	11'-6"	31	10	5'-11"	40	10	8'-1"	54
	6	20	15'-2"	203	20'-4"	54	10'-5"	28	14'-4"	38	12	7'-0"	58	12	9'-6"	76
	7	24	16'-2"	259	22'-4"	60	12'-5"	33	17'-1"	46	14	8'-1"	76	14	11'-0"	103
	8	26	16'-9"	291	23'-6"	63	13'-6"	36	18'-6"	49	16	8'-11"	95	16	12'-1"	129
9	5	18	15'-6"	166	19'-7"	52	8'-6"	23	11'-7"	31	10	5'-11"	40	10	8'-1"	54
	6	20	16'-6"	220	21'-7"	58	10'-6"	28	14'-5"	39	12	7'-0"	58	12	9'-7"	77
	7	24	17'-6"	281	23'-7"	63	12'-6"	33	17'-5"	46	14	8'-1"	76	14	11'-0"	103
	8	26	18'-0"	313	24'-9"	66	13'-7"	36	18'-8"	50	16	8'-11"	95	16	12'-2"	130
	9	30	19'-0"	381	26'-9"	71	15'-7"	42	21'-6"	57	18	10'-0"	120	18	13'-7"	163
10	5	16	16'-8"	178	20'-10"	56	8'-7"	23	11'-8"	31	10	6'-0"	40	10	8'-1"	54
	6	20	17'-8"	236	22'-10"	61	10'-7"	28	14'-6"	39	12	7'-1"	57	12	9'-7"	77
	7	24	18'-8"	299	24'-10"	66	12'-7"	34	17'-4"	46	14	8'-1"	76	14	11'-0"	103
	8	26	19'-2"	333	25'-11"	69	13'-8"	37	18'-9"	50	16	8'-11"	95	16	12'-2"	130
	9	30	20'-2"	404	27'-11"	75	15'-8"	42	21'-7"	58	18	10'-1"	121	18	13'-8"	164
	10	34	21'-2"	481	29'-11"	80	17'-8"	47	24'-5"	65	20	11'-1"	146	20	15'-1"	201

① See Box Culvert Standards for dimensions.

TABLE OF REINFORCING STEEL ~ Continued

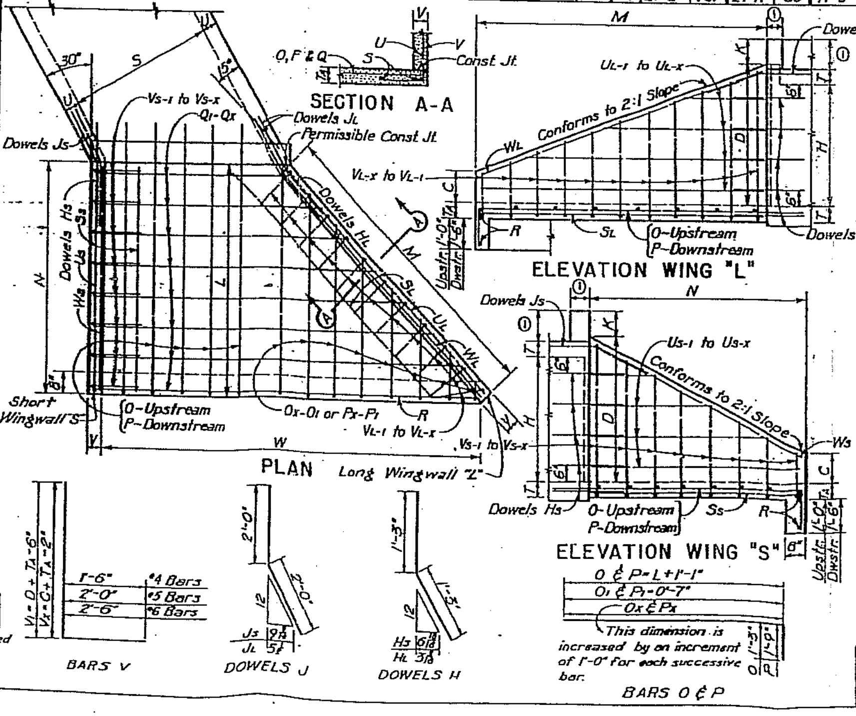
CULVERT SIZE S	H	Bars Vs-1-Vs-x Na.	Size	Spac.	Av. Lgth.	Weight	Bars VL-1-VL-x Na.	Size	Spac.	Av. Lgth.	Weight	4 Bars Ws Size	Length	Wt.	4 Bars WL Size	Length	Wt.
3	2	8	#4	12"	3'-6"	19	10	#4	12"	3'-6"	23	#4	3'-7"	10	#4	4'-6"	12
	3	12	#4	12"	4'-0"	32	16	#4	12"	4'-0"	43	#4	5'-10"	16	#4	7'-6"	20
4	2	8	#4	12"	3'-6"	19	10	#4	12"	3'-6"	23	#4	3'-7"	10	#4	4'-6"	12
	3	12	#4	12"	4'-0"	32	16	#4	12"	4'-0"	43	#4	5'-10"	16	#4	7'-6"	20
	4	16	#4	12"	4'-6"	48	22	#4	12"	4'-6"	66	#4	8'-0"	21	#4	10'-6"	28
5	2	8	#4	12"	3'-6"	19	10	#4	12"	3'-6"	23	#4	3'-7"	10	#4	4'-6"	12
	3	12	#4	12"	4'-0"	32	16	#4	12"	4'-0"	43	#4	5'-10"	16	#4	7'-6"	20
	4	16	#4	12"	4'-6"	48	22	#4	12"	4'-6"	66	#4	8'-0"	21	#4	10'-6"	28
	5	20	#4	12"	5'-3"	70	24	#4	12"	5'-3"	84	#5	9'-2"	38	#5	11'-11"	50
6	3	12	#4	12"	4'-0"	32	16	#4	12"	4'-0"	43	#4	5'-10"	16	#4	7'-6"	20
	4	16	#4	12"	4'-6"	48	22	#4	12"	4'-6"	66	#4	8'-0"	21	#4	10'-6"	28
	5	20	#4	12"	5'-3"	70	24	#4	12"	5'-3"	84	#5	9'-2"	38	#5	11'-11"	50
	6	24	#4	12"	5'-9"	92	30	#4	12"	5'-9"	115	#5	11'-5"	48	#5	14'-10"	62
7	3	14	#4	12"	4'-1"	38	16	#4	12"	4'-1"	44	#4	5'-11"	16	#4	7'-7"	20
	4	18	#4	12"	4'-7"	55	22	#4	12"	4'-7"	67	#4	8'-2"	22	#4	10'-7"	28
	5	20	#4	12"	5'-4"	71	26	#4	12"	5'-4"	93	#5	9'-3"	39	#5	12'-1"	50
	6	24	#4	12"	5'-10"	93	30	#4	12"	5'-10"	117	#5	11'-6"	48	#5	15'-1"	63
	7	40	#4	6"	6'-4"	169	54	#4	6"	6'-4"	228	#5	13'-9"	57	#5	18'-1"	75
8	4	16	#4	12"	4'-8"	56	22	#4	12"	4'-8"	69	#4	8'-5"	22	#4	10'-9"	29
	5	20	#4	12"	5'-5"	72	26	#4	12"	5'-5"	94	#5	9'-4"	39	#5	12'-2"	51
	6	24	#4	12"	5'-11"	95	32	#4	12"	5'-11"	127	#5	11'-7"	48	#5	15'-2"	63
	7	36	#4	9"	6'-5"	154	48	#4	9"	6'-5"	208	#5	13'-10"	58	#5	18'-2"	76
	8	56	#4	6"	7'-2"	268	76	#4	6"	7'-2"	364	#6	15'-0"	90	#6	19'-8"	118
9	5	20	#4	12"	5'-5"	72	26	#4	12"	5'-5"	94	#5	9'-6"	40	#5	12'-4"	51
	6	24	#4	12"	5'-11"	95	32	#4	12"	5'-11"	127	#5	11'-8"	49	#5	15'-4"	64
	7	36	#4	9"	6'-5"	154	48	#4	9"	6'-5"	206	#5	14'-0"	58	#5	18'-4"	76
	8	56	#4	6"	7'-2"	268	78	#4	6"	7'-2"	364	#6	15'-1"	91	#6	19'-10"	119
	9	56	#6	7"	8'-2"	477	76	#5	7"	8'-2"	648	#6	17'-3"	104	#6	22'-10"	137
10	5	20	#4	12"	5'-6"	73	26	#4	12"	5'-6"	96	#5	9'-7"	40	#5	12'-5"	52
	6	24	#4	12"	6'-0"	96	32	#4	12"	6'-0"	128	#5	11'-10"	49	#5	15'-5"	64
	7	36	#4	9"	6'-8"	156	48	#4	9"	6'-8"	208	#5	14'-0"	58	#5	18'-5"	77
	8	48	#4	7"	7'-3"	232	66	#4	7"	7'-3"	320	#6	15'-2"	91	#6	19'-11"	120
	9	56	#5	7"	8'-5"	482	76	#5	7"	8'-5"	654	#6	17'-5"	105	#6	22'-11"	138
	10	62	#6	7"	9'-5"	861	88	#6	7"	9'-3"	1195	#6	19'-8"	118	#6	25'-11"	156



This dimension is reduced by an increment of 1'-0" for each successive bar.
BARS Q

This dimension is increased by an increment of 2'-0¼" for each successive bar.
BARS Us

This dimension is increased by an increment of 2'-9¼" for each successive bar.
BARS UL



GENERAL NOTES:

Dimensions relating to reinforcing steel are to centers of bars.

Steel cover to be 2" from center of outside layer of steel to face of concrete.

Chamfer exposed corners ¾" except as otherwise noted.

TEXAS HIGHWAY DEPARTMENT

FLARED WINGS ~ 30° SKEW FOR SINGLE BOX CULVERTS

SIZES 3'x2' TO 10'x10'

FW-30°

		DRAWING	DATE
Dn.:	RHM	Original	April, 1949
Ck.Dn.:	W.H.	Rev. 8-67	
Dn.:	K.M.	Rev. 7-95 (note ①)	
Ck.Dn.:	H.L.G.		
Tr.:	E.J.T.		
Ck.Tr.:	K.M.		

Appendix C

Minor Head Loss Equations

Entrance Losses

$$HL = K_e \frac{(V_1)^2}{2g}$$

where,

HL = Head loss (feet)

V_1 = Velocity in the downstream pipe (feet per second)

K_e = Head loss coefficient

g = Gravitational constant (32.2 ft/s^2)

Expansion Losses

$$HL = \left(1 - \frac{(D_1)^2}{(D_2)^2}\right)^2 \frac{V_1^2}{2g}$$

where: HL = Head loss (feet)

V_1 = Upstream velocity (feet per second)

D_1 = Upstream pipe diameter

D_2 = Downstream pipe diameter (feet)

g = Gravitational constant (32.2 ft/s^2)

Appendix C

Bend Losses

Head losses associated with bends in pipes of equal diameter shall be calculated using:

$$HL = K_b \frac{(V_2)^2}{2g}$$

Where: HL = Head loss (feet)

V_2 = Velocity in the downstream pipe (feet per second)

K_b = Head loss coefficient

g = Gravitational constant (32.2 ft/s^2)

Junction Losses

$$HL = \frac{(V_2)^2}{2g} - K_j \frac{(V_1)^2}{2g}$$

Where: HL = Head loss (feet)

V_1 = Velocity in the upstream pipe (feet per second)

V_2 = Velocity in the downstream pipe (feet per second)

K_j = Head loss coefficient

g = Gravitational constant (32.2 ft/s^2)