

STORMWATER DRAINAGE DESIGN MANUAL



**CITY OF BROOKLAND
CRAIGHEAD COUNTY
ARKANSAS**

2023

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this manual is to establish standard principles and practices for the design and construction of storm water drainage facilities within Brookland, Arkansas. In addition floodplain compliance guidelines will be presented to insure base flood elevations will not rise because of the construction or modification of structures or land alteration within the floodplain. The design factors, formula, graphs, and procedures are intended for use as engineering guides in the solution of drainage problems involving determination of the quantity, rate of flow, and conveyance of storm water. The procedures defined herein shall be applied by experienced professional engineers licensed to practice in the State of Arkansas. Also, ultimate responsibility for the design of storm drainage structures lies with the engineer of record. As such, prudent engineering judgment should be used in the design of any facility within Brookland.

Methods of design other than those indicated herein may be considered in difficult cases where experience clearly indicates they are preferable. However, there should be no extensive variations from the practices established herein without express approval from the City of Brookland.

1.2 Scope

This manual presents various applications of accepted principles of surface drainage engineering and is a working supplement to the information obtained from standard drainage handbooks and other publications on drainage. It is presented in a format that gives logical development of solutions to problems of storm water drainage design and floodplain management.

This manual is intended to be used by the City of Brookland, consulting engineers contracted with the City, and for private development within the planning jurisdiction of the City. This manual applies to storm drainage conditions, which are generally relative to the City of Brookland and the immediate geographical area. Accepted engineering principles, applied to the City of Brookland's storm drainage requirements, are detailed within this manual.

1.3 Drainage Policy

The basic objective of the City of Brookland is to construct and maintain facilities intended to minimize the threat of flooding to all areas of the City and comply with the requirements of the National Flood Insurance Program. Drainage facilities are defined as all channels, pipes or other structures which handle public water. Additionally, it is the City's intent to insure that adequate facilities are constructed to accommodate new development such that existing property will not be subjected to additional flooding and so as not to increase the limits of the floodplains as shown on the flood insurance rate maps (FIRM's) for the City of Brookland and other entities (County, Levee Improvement Districts, and Municipal Utility Districts).

It is not economically feasible to construct storm sewer facilities, which are large enough to keep the street systems from becoming inundated during severe storm events. City policies as defined in the governing drainage ordinance and standards in this manual are

designed to minimize the impacts (depth and duration) of storm events and insure that the lowest floor elevation of any structures not used exclusively for storage, access, or parking are, at a minimum, twelve (12) inches above the 100-year flood elevation. The intent of this policy is that there should not be any street ponding for minor storm events, minor street ponding for larger events, and major ponding for the 100-year event storms but without water inundating building structures. Every attempt will be made to design major thoroughfares so that they are passable during severe storm events.

The City of Brookland has included in this manual criteria covering the design of storm water systems to serve both existing and new developments.

The criterion is considered a minimum for the City of Brookland. Approval from other applicable agencies may be required. Ultimate approval for any variance of the criteria contained in this manual must be given by the City of Brookland.

2.0 CONSTRUCTION PLAN PREPARATION

2.1 General

This section covers the preparation of drainage construction plans for the City of Brookland.

2.2 Design Phase

Plans shall be submitted in accordance with the City of Brookland's Checklist for Storm Drainage Plans. The first engineering plan set submission shall be complete, and in sufficient detail to allow review by the City of Brookland. All topographic surveys should be furnished to allow establishment of alignment, grades, and rights-of-way requirements.

The hydraulic design of the proposed facilities shall be accomplished based on the procedures and criteria outlined in this manual. Calculations shall be submitted as part of the plan set. These plans shall show the alignment, drainage areas, size of facilities, and grades.

Storm drainage plans shall include at a minimum, a drainage area map, plan-profile sheets, and channel cross-sections, if applicable.

Survey control performed for the project shall reference two reference marks established by the City of Brookland. A copy of the reference marks can be obtained from the City Engineer.

Survey control for the project shall conform to the following requirements:

- Vertical control will be NAVD 88, Third Order Vertical
- Horizontal control will be NAD 83, Third Order Class 1, Arkansas State Plane North Zone

2.3 Miscellaneous

All drawings shall be prepared on bond paper with a minimum sheet size of 24" x 36", to a standard engineering scale, and shall be clearly legible when sheets are reduced to half scale. All drawings shall be signed and sealed by a Professional Engineer registered in the State of Arkansas. After each review, all review comments shall be addressed, additional data incorporated, and drafting of plans completed. Each plan-profile sheet shall have a benchmark shown.

2.4 Design Guidelines and Checklists for Storm Drainage Plans

2.4.1 Drainage Area Map

The drainage area map shall be to a standard engineering scale, and show the street rights-of-way. Scale shall be selected to adequately depict drainage areas, flow paths, etc.

When calculating runoff, the drainage area map shall show the boundary of the drainage area contributing runoff into the proposed system. The area shall be further divided into sub-areas, sequentially numbered, to determine flow concentration points or inlet locations. The centerline of all streets will normally be a boundary of a drainage area, to insure that inlets are sized and positioned to fill the need without depending on storm water crossing over the street crown for proper drainage.

Direction of flow within streets, alleys, natural and man-made drainage ways, and at all system intersections, shall be clearly shown on the drainage area map and/or paving plans. Existing and proposed drainage inlets, storm sewer pipe systems, and drainage channels shall also be clearly shown and identified.

The following items/information shall be included:

- (1) Use design criteria as outlined in drainage regulations and prescribed in this manual;
- (2) Standard Engineering Scale. Show match lines between any two (2) or more maps. Show graphic bar scale;
- (3) Show drainage areas including acres, land use description, hydrologic soil group, and inlet time for each area;
- (4) Show existing sub-areas for alley, street, and off-site areas;
- (5) Indicate contours on map for on- and off-site, not to exceed two (2) foot contour. For large drainage areas show contours at intervals appropriate to indicate drainage patterns;
- (6) Location of all existing and proposed drainage structures on the project site;
- (7) Show local and FEMA designated SFHA and floodways if they exist. If not, note that none exists;
- (8) Indicate city zoning on drainage area. Identify land use for adjacent properties;
- (9) Show points of concentration and their designations;
- (10) Inlets, their size and location, the bypass flow for each, the direction of flow as indicated by flow arrows, the station for the centerline;
- (11) Indicate runoff at all inlets, dead-end streets and alleys, or to and from adjacent additions or acreage;
- (12) For cumulative runoff, show calculations;
- (13) Show north arrow. Orient sheet such that the direction of north is to top page or to the left;
- (14) Location of existing and proposed drainage structures;

- (15) A table depicting runoff computations;
- (16) Flow arrows to indicate all crests, sags, and street and alley intersections; and,
- (17) Street names shall be indicated.

2.4.2 Storm Sewer Design Guidelines

General guidelines for the design of closed conduit systems, storm sewers, are outlined below.

- (1) Diversion of flow from one natural drainage area to another will not be allowed;
- (2) Show plan and profile of all storm sewers;
- (3) Pipe Material in City rights-of-way or easements shall conform to the following minimum requirements:
 - Roadway Crossings
 - RCP Class III or Class IV
 - ASTM C-76
 - ASTM C-506
 - ASTM C-507
 - Box Culverts and Small Bridges
 - ASTM C-1433
 - ASTM C-507
 - Mains and Laterals
 - Aluminized Steel Type 2 Corrugated Steel Pipe
 - ASTM A-929
 - ASTM A-760
 - RCP Class III or Class IV
 - ASTM C-76
 - ASTM C-506
 - ASTM C-507
 - Box Culverts and Small Bridges
 - ASTM C-1433
 - ASTM C-507

Alternative pipe materials for use outside City rights-of-way or easements shall be approved by the City Engineer.

- (4) In areas where pipes cross beneath railroads, areas of deep fill and areas subjected to heavy loads the engineer shall select the pipe material that is adequate for the design load and provide documentation of such analysis;
- (5) The minimum allowable concrete strength for concrete pipe is 3,500 psi. Specify concrete strength for all structures;
- (6) Provide inlets where street capacity is exceeded. Provide inlets where addition of alley runoff to street exceeds intersecting street capacity;

- (7) Storm water flow from streets into alleys is to be avoided. The City Engineer may approve this type of drainage flow when it is not possible to direct flow anywhere else;
- (8) Maximum discharge velocity of eight (8) feet per second (fps) is allowed at the pipe outfall. Velocities that exceed 8 fps must be approved by the City Engineer and must include adequate provisions for erosion control considering the soil conditions at the outfall;
- (9) As it relates to erosion control, discharge flow lines of storm sewers shall be a maximum of two (2) feet above the natural flow line of the channel, unless channel lining is present. Energy dissipation shall be provided when specified by the City Engineer;
- (10) Where fill is proposed for trench cuts in creeks or outfall ditches, compaction shall be 95% of the maximum density as determined by ASTM D 698; and,
- (11) Any off-site drainage work or discharge to downstream property will require an easement. Easement shall be sized such that the developed flows can be conveyed within the easement.

2.4.3 Laterals

Laterals are defined as minor storm sewer lines that serve the purpose of connecting a single inlet to a larger storm sewer main line. The following is a list of requirements that apply to laterals.

- (1) Show laterals on trunk profile with stations;
- (2) Provide lateral profiles for laterals exceeding thirty (30) feet in length. Potential conflicts with existing utilities (i.e. sanitary sewer, etc.) should be shown in profile;
- (3) Laterals shall be placed in profile such that the hydraulic grade line is not less than one foot from the curb flow line, unless utilities or storm sewer depth requires otherwise;
- (4) Laterals shall not enter the corners or bottoms of inlets;
- (5) In general, the angle of confluence between main line and lateral shall not exceed ninety (90) degrees. Situations where angles exceed this requirement must be supported by calculations that show that the connection will not create adverse flow conditions in the connecting pipe;
- (6) Longitudinal centers should intersect;
- (7) At junction structures, downstream pipe crown elevations should not be above upstream pipe crown elevations; and,
- (8) Minimum pipe diameter within City rights-of-way or easements shall be twelve (12) inches unless otherwise approved by the City Engineer.

2.4.4 Inlets and Intakes

Inlets shall be provided at the following locations as a minimum:

- At locations on grade where the design flows exceeds the depth and spread criteria;
- At all low points (sag points) in gutters;
- Immediately upgrade of median breaks and street intersections;
- Immediately upgrade of roadway cross slope reversals;
- Upstream and downstream of bridge locations where applicable; and,
- Behind curbs and sidewalks as necessary to drain low areas

Inlets shall be given the same number designation as the area or sub-area contributing runoff to the inlet. The inlet number designation shall be shown opposite the inlet. At intersections, where possible, the end of the inlet shall be ten (10) feet from the curb return or Point of Tangency, and the inlet location shall also provide minimum interference with the use of adjacent property. Inlets in residential areas should be located in streets and alleys so that driveway access is not prohibited to the lots. Drainage from abutting properties shall not be impaired, and shall be designed into the storm drainage system.

Data opposite each inlet shall include paving or storm sewer stationing at centerline of inlet, size and type of inlet, number or designation, top of curb elevation and flow line of inlet as shown on the construction plans.

- (1) Indicate direction of flow and the design flow (Q) entering the inlet. Identify capacity of inlet and any bypass flow that may result;
- (2) On plan view, indicate inlet designation number, location of inlet (station and offset), size of inlet, sizes of pipes entering and exiting the inlet with associated flow lines, and top-of-curb elevations; and,
- (3) Use standard curb inlets in City rights-of-way or easements as presented in the City of Brookland Street Improvement Program Manual, latest edition.

2.4.5 Plan and Profile Sheets

In the plan view, the storm sewer designation, size of pipe, and length of each size pipe shall be shown adjacent to the storm sewer. The main line sewer plan shall be stationed at one hundred (100) feet intervals.

This data shall consist of pipe diameter in inches, the design storm discharge in cubic feet per second, slope of hydraulic gradient in percent, Manning capacity of the pipe flowing full in cubic feet per second, velocity in feet per second, and $V^2/2g$. Also, the head loss at each interception point shall be shown.

Stationing and flow line elevations shall also be shown at all pipe grade changes, pipe size changes, lateral connections, manholes, and wye connections. Crown elevations should conform to 2.4.3(7).

- (1) The recommended scale for storm sewer plan and profile sheets is 1" = 50' minimum and 1" = 100' maximum;
- (2) Indicate property lines and lot lines along storm sewers, and show easements with dimensions;
- (3) Provide separate plan and profile of storm sewers. The storm drain lines should also be shown on paving plans with a dashed line. Full pipe sections should be shown on sanitary sewer profiles at crossings;
- (4) Show pipe sizes in plan and profile;
- (5) Show hydraulics on each segment of pipe profile to include: Q (Design Flow), C (Manning full flow capacity); S (Slope), V (Velocity), $V^2/2g$ (Velocity Head);
- (6) Show all existing utilities in plan and profile. Show sanitary sewer profiles at all crossings of storm drain profiles;
- (7) Indicate existing and proposed ground line on all street, alley, and storm sewer profiles;
- (8) Show future streets and grades where applicable;
- (9) When connections are made to existing systems, computations must be provided to show the capacity of the existing system to accept flows. Hydrologic Grade Line (HGL) will be calculated from the outfall to the connection point including the designed flows of the added system;
- (10) Indicate flow line elevations of storm sewers on profile, show pipe slope (percent grade). Match pipe soffits at all junction boxes or inlets;
- (11) In general, the angle of confluence between main line and lateral shall not exceed ninety (90) degrees;
- (12) Show details of all non-standard structures such as junction boxes, headwalls, storm sewers, flumes, and manholes;
- (13) Pipe deflections for directional changes shall be placed at the manufacturers recommendations. Deflections exceeding the manufacturer's recommendation will not be tolerated;
- (14) Bends in pipes may be used in unusual circumstances with approval by the City. No bend at one location may exceed thirty (30) degrees;
- (15) Show water surface elevation of the outfall for design year event (i.e. Q_{25});

- (16) On all dead-end streets and alleys where water exits at the dead-end, show grade out to “daylight” for drainage on the profiles and provide erosion control when necessary. Show typical section and slope of “daylight” drainage;
- (17) At sags in pavement, provide a positive overflow (swale) to act as a safety path for failure of the storm drain system. Also, provide minimum lowest floor elevations along this overflow rout; and,
- (18) Provide sections for road, railroad, and other ditches with profiles. Show design water surface on profile.

The profile portion of the storm sewer plan-profile sheet shall include:

- (1) The existing and proposed ground profile along the centerline of the proposed sewer;
- (2) The hydraulic gradient of the sewer;
- (3) The profile of the proposed storm sewer line;
- (4) Profile view of utilities that cross the proposed sewer alignment;
- (5) Locations where laterals intersect the main line;
- (6) Text identifying the pipe size, elevations at 50’ intervals, physical grade in percent, stations where laterals intersect main line; and,
- (7) Hydraulic data for each length of storm sewer between interception points shall be shown on the profile.

2.4.6 Detention

- (1) Provide drainage area map and show all computations for runoff affecting the detention basin;
- (2) Provide a plot plan with existing and proposed contours for the detention basin and plan for structural measures;
- (3) Where earth embankment is proposed for impoundment, furnish a typical embankment section and specifications for fill including profile for the structural outflow structure and Geotechnical report;
- (4) Provide structural details and calculations for any item that is not a standard detail;
- (5) Provide detention basin volume calculations and elevation versus storage curve;
- (6) Provide detention calculations for volume by elevation-area, outflow using orifice and/or weir, and reservoir routing; and,

- (7) Provide SCS, Type II 24-hour distribution, determination of storage requirements, (permitted for areas of 100 acres or less). Areas greater than 100 acres shall use City of Brookland FEMA data (if available).

2.4.7 Bridges

- (1) Show Geotechnical soil boring information on plans;
- (2) Provide channel cross sections of the water surface elevations for the design storm immediately upstream and downstream of the structure;
- (3) Provide hydraulic calculations on all sections;
- (4) Provide structural/standard details and calculations;
- (5) Provide vertical and horizontal alignment;
- (6) Show soil erosion protection measures;
- (7) The pre- and post- construction SFHA and regulatory floodway if defined shall be delineated on the plans; and,
- (8) Additional requirements for Bridges may be found in Section 7.0 and Section 9.0.

2.4.8 Open Channels

- (1) Plan view of channel showing existing and proposed alignment including creek centerline stationing, north arrow, and scale;
- (2) Profile of existing and proposed creek centerline;
- (3) Profile of the 25-year and 100-year water surface elevation;
- (4) Typical cross sections showing dimensions, and the station limits for which they apply;
- (5) Velocities and discharges for the 25-year and 100-year storms;
- (6) Limits of temporary erosion protection associated with the construction of the channel needs to be indicated in plan view;
- (7) Indicate property lines and lot lines along with existing utilities and show easements with dimensions; and,
- (8) Include on the construction plans or as in a separate report, the computations performed in developing the water surface profile.

3.0 HYDROLOGY

3.1 General

The planning, design, and construction of drainage facilities are based on the determination of one or more aspects of storm runoff.

Continuous long-term records of rainfall and resulting storm runoff in an area provide the best data source from which to base the design of storm drainage and flood control systems in that area. However, it is not possible to obtain such records in sufficient quantities for all locations requiring storm runoff computations. Therefore, the accepted practice is to relate storm runoff to rainfall, thereby providing a means of estimating the rates, timing and volume of runoff expected within local watersheds at various recurrence intervals.

It is generally accepted that urban development has a pronounced effect on the rate and volume of runoff from a given rainfall. Urbanization generally alters the hydrology of a watershed by improving its hydraulic efficiency, reducing its surface infiltration, and reducing its storage capacity.

For certain small drainage areas (generally less than 100 acres in size), the widely used NRCS (formerly SCS) graphical peak discharge (TR55) provides a useful means of determining peak discharges. If the engineer wishes to use an alternative design technique, it is recommended that the City Engineer be consulted prior to design. If the area is larger than 100 acres and has FEMA hydrology determined for it, the FEMA hydrology model shall be used.

3.2 (Intentionally Deleted)

3.3 SCS, Type II 24-hour Distribution, TR-55 Hydrograph Method

The Soil Conservation Service (SCS now Natural Resources Conservation Service – NRCS) hydrologic method has been widely used by engineers and hydrologists for analyses of small urban watersheds.

This method results from extensive analytical work using a wide range of statistical data concerning storm patterns, rainfall-runoff characteristics and many hydrologic observations in the United States. The SCS method can be applied to urban drainage areas of any size. Major parameters required to calculate the hydrograph include the rainfall distribution, runoff curve numbers, time of concentration, and drainage area.

The runoff equation used by the SCS is a relationship between accumulated rainfall and accumulated runoff derived from experimental plots for numerous soils and vegetation. The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \quad (3.2)$$

Where

- Q = accumulated direct runoff, (in)
- P = accumulated rainfall (potential maximum runoff), (in)
- S = potential maximum retention after runoff begins, (in)
- I_a = initial abstraction (including surface storage, interception, and infiltration prior to runoff), (in)

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S \quad (3.3)$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation (3.3) into equation (3.2) gives:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \quad (3.4)$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10 \quad (3.5)$$

Graphical peak discharge was developed from TR-20. The peak discharge equation is

$$q_p = q_u A_m Q F_p \quad (3.6)$$

q_p = peak discharge, (cfs)

q_u = unit peak discharge, (cfs/sq mi/in)

A_m = drainage area, (mi²)

Q = runoff, (in)

F_p = pond and swamp adjustment factor (necessary if spread throughout the watershed and not considered in T_c computation)

The following are the steps necessary to use the SCS Method for peak discharge computations:

1. Determine the drainage area;
2. Determine the soil classification based on runoff potential (Group A, B, C, or D). See Section 3.3.3 for detailed information. One approach for a general classification is to determine the soil name and type from SCS (NRCS) soils map or report for Craighead County;
3. Determine the antecedent soil moisture conditions (AMC). For design purposes, the AMC will be "average" or II;
4. Classify cover type and hydrologic condition of the soil-cover complex as good, fair, or poor. For additional information see Tables 2-2a, b, and c in Appendix 1;

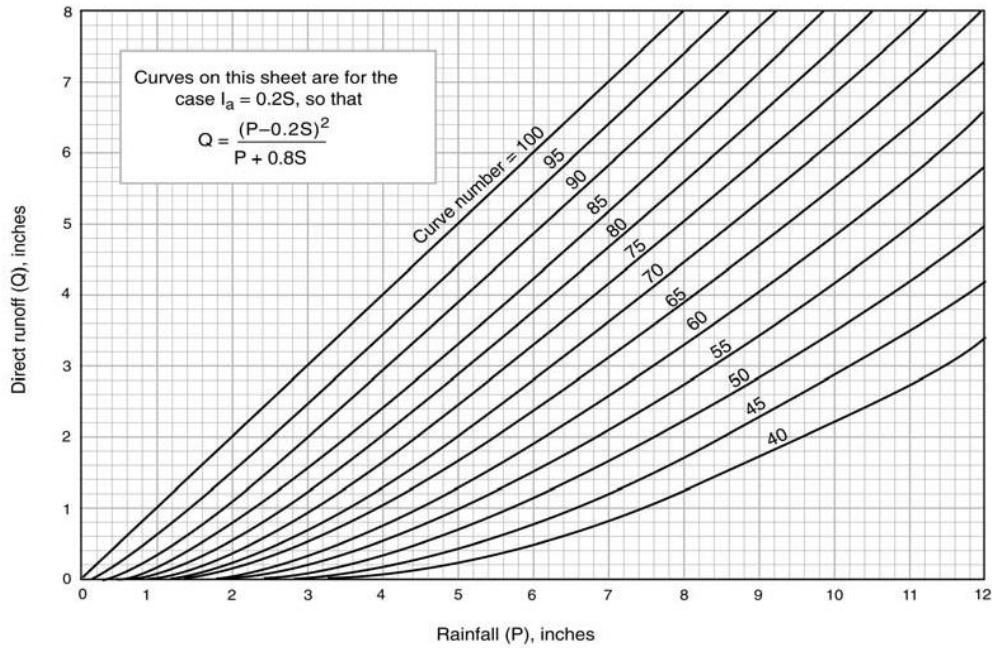
5. Determine the Curve Number (CN) for the AMC II soil classification. If necessary, determine a weighted value by dividing the sum of the products of the subarea sizes and CNs by the total area. (See Section 3.3.2 for details about CN);
6. Estimate the watershed time of concentration in hours (T_c) using TR-55 with max sheet flow of 100 ft.;
7. Determine the potential maximum storage (S). Use Equation 3.5 to calculate the potential maximum storage;
8. Determine the initial abstraction (I_a). Use CN to determine I_a using Table 4-1 from TR-55, as shown below. See if I_a is greater than P;

Table 4-1. I_a values for runoff curve numbers

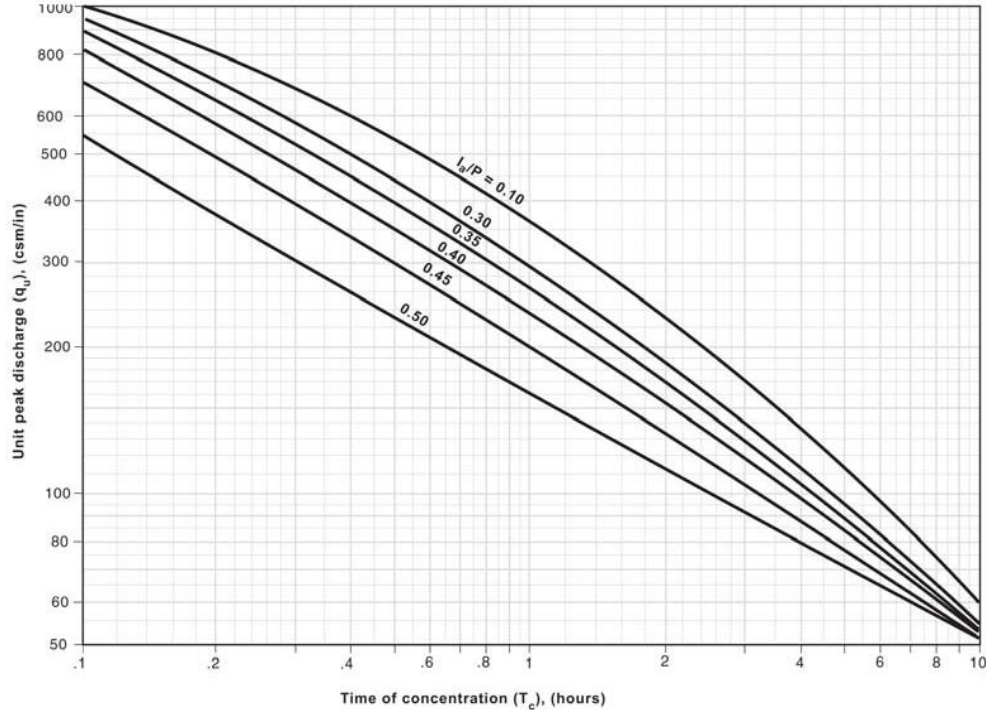
Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

9. Use information in Section 3.3.1 to determine the total rainfall for watershed for the design frequency;

- Determine the accumulated direct runoff (Q) using equation 3.4 (or solution of runoff equation TR-55 Figure 3.1);



- Determine I_a / P ratio;
- Using I_a / P ratio and T_c determine unit peak discharge (q_u). Use TR-55 Exhibit 4-II Unit peak discharge (q_u) for NRCS (SCS) type II rainfall distribution;



- Determine the unit peak discharge using graphical methods of the I_a/P ratio and the T_c (hours) and using Worksheet 4 in Appendix 1;
- Determine the pond and swamp adjustment factor (F_p); and,
- Compute peak discharge using equation 3.6

Appendix 1 has worksheets from the TR-55 manual to determine peak discharge.

3.3.1 Accumulated Rainfall (P) and Rainfall Distribution

Brookland is located in the SCS Type II hypothetical storm area. The design storm duration for drainage work is the 24-hour duration at the relevant frequency. The rainfall depth vs. frequency is shown in Table 3-1.

**Table 3-1. Rainfall Depth vs. Frequency for Brookland, AR
from TP-40 and HYDRO-35**

Frequency	24-hour
2-Year	3.88
10-Year	5.58
25-Year	6.35
50-Year	6.99
100-Year	7.70
500-Year	9.25

3.3.2 Curve Number (CN) Factors

The major factors affecting CN determination are hydrologic soil groups (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). The CN varies according to the factors below. Tables 2-2a, b and c in Appendix 1 provide details for CN selection. If a watershed subarea has multiple land uses, the CN can be weighted for the subarea.

3.3.3 Hydrologic Soil Groups

Soil properties influence the relationship between rainfall and runoff by affecting the rate of infiltration. NRCS divides soils into four hydrologic soil groups based on infiltration rates (Groups A-D). Urbanization also impacts soil groups as well.

Group A - Group A soils have low runoff potential due to high infiltration rates even when saturated. These soils primarily consist of deep sands, deep loess, and aggregated silts.

Group B - Group B soils have moderate infiltration rates when saturated. These soils primarily consist of moderately deep to deep, moderately well-drained to well-drained soils with moderately fine to moderately coarse textures (shallow loess, sandy loam).

Group C - Group C soils have slow infiltration rates and a moderately high runoff potential. These soils when saturated usually have a layer near the surface that impedes downward movement of water. These soils are moderately fine to fine in texture and examples include clay loams, shallow sandy loams, soils low in organic content, and soils usually high in clay.

Group D - Group D soils have high runoff potential (very slow infiltration rates) when saturated. These soils are predominantly clay soils with a high swelling potential, soils

with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material.

The SCS has published a county soil survey book for Craighead County. Use of the soil survey book and TR-55 table of soils and their hydrologic soil group is necessary to determine the Curve Number (CN).

3.3.4 Cover Type

Cover types can include vegetation, bare soil, and impervious surfaces. Cover type can be determined by reconnaissance, aerial photography, and land use maps. Tables 2-2a, b and c in Appendix 1, addresses most cover types.

3.3.5 Treatment

Treatment is a cover modifier that describes management of cultivated agricultural lands. Table 2-2b in Appendix 1 is used with agricultural areas that are cultivated.

3.3.6 Hydrologic Condition

Hydrologic condition is generally estimated from plant density and residue cover to account for the effects of cover and treatment in infiltration and runoff. Hydrologic condition only is a factor in CN for agricultural lands. Details about good, fair, and poor conditions are found in Table 2-2b and Table 2-2c in Appendix 1.

3.3.7 Antecedent Runoff Condition (ARC)

For design purposes, the antecedent runoff conditions (ARC) will be average, or Type II. The CN values assume medium ARC (or Type II) conditions.

3.3.8 Ponding and Swamp Adjustment Factor (F_p)

If ponds and swamp areas are spread throughout the watershed and not considered in the T_c computation, an adjustment is needed. Table 4-2 includes the adjustment factor for percent of area of the subbasin that is pond or swamp.

TR55-Table 4.2. Adjustment factor (F_p) for pond and swamp areas that are spread throughout the watershed

Percentage of pond and swamp areas	F _p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

3.4 Computer Hydrograph Methods

The Corps of Engineers have developed HEC-HMS for determining hydrology. For large areas, HEC-HMS provides flow estimates that can account for valley storage and routing which SCS methods do not. HEC-HMS can be obtained from the Corps of Engineers. It can be downloaded from their website at <http://www.hec.usace.army.mil/>. For a Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR), a FEMA approved hydrology model must be used. Currently (May 2006), HEC-HMS is approved by FEMA.

NRCS has also developed a computer version of TR-55. It can be downloaded from their website at <http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html> or <http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-wintr55.html>.

4.0 STORM DRAIN AND DRAINAGE APPURTENANCES

4.1 General

This section contains storm drainage design criteria and demonstrates the design procedures to be employed on drainage projects within the City of Brookland. All drainage design calculations and assumptions shall submitted with permit applications.

4.2 Design Frequencies

Table 7 in Appendix 1 shows the appropriate design frequencies to be used for storm drain designs in the City of Brookland.

4.3 Runoff Calculations

To begin design of a storm drainage system, it is necessary to compute the amount of runoff that accumulates upstream of the intake structures. For basins less than 100 acres, the SCS Method should be used for computing runoff. The equation is:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \quad (4.1)$$

where

- Q = runoff, (in)
- P = rainfall, (in)
- S = potential maximum retention after runoff begins, (in)

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10 \quad (4.2)$$

4.4 Street Flow

The next step in the design of the storm drain system is to calculate the flow within the streets.

4.4.1 Definitions

The following street classifications will provide clarity in discussing the requirements and methodology to calculate the flow in streets:

Principal Arterials: Serve the major centers of activity

Minor Arterials: Intended to provide land access

Collectors: Connect local streets in residential neighborhoods

Locals: Provide access to various public and private properties

The following descriptions relate to the shape of the cross section of the roadway:

Straight Crown - A constant slope from one gutter flow line across the street to the other gutter flow line.

Parabolic Crown - A pavement surface shaped in a parabolic from one gutter flow line to the other.

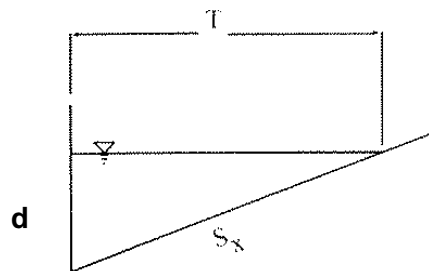
Vertical Displacement Between Gutter Flow Line - Due to topography, it will be necessary at times that the curbs on a street be placed at different elevations.

4.4.2 Calculation of Flow in Streets

The calculation of flow in streets is dependent on street width and shape. Generally, there are two shapes for streets: straight crown and parabolic crown. The straight crowned street can be further subdivided into two types of gutters: uniform and composite. The following discussion covers the methodology used to compute the flow in the street.

Table 7 in Appendix 1 shows the requirements for the design of the roadway drainage.

4.4.3 Uniform Gutter Sections



Uniform Road Section

The runoff in the gutter is generally treated as open channel flow. Therefore, Manning's Equation can be used to calculate the flow or spread in the road section. The following formula is a modified version of the Manning's Equation. It incorporates the geometry of the uniform roadway section.

$$Q = \frac{K_C}{n} S_X^{1.67} S_L^{0.5} T^{2.67} \quad (4.3)$$

Where:

$$K_C = 0.56$$

n = Manning's roughness coefficient (0.013 for concrete)

S_L = Longitudinal slope of road, (ft/ft)

S_x = Pavement (road) cross-slope, (ft/ft) = d/T

T = Total width of flow or spread

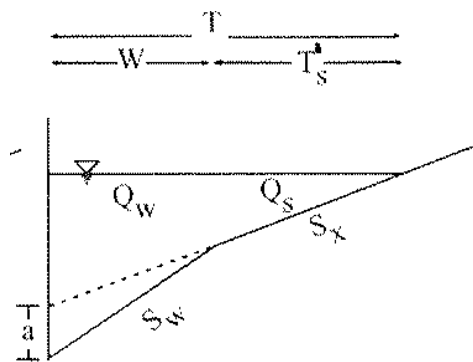
Q = Total discharge, (cfs)

S_L = Longitudinal slope of road

This equation assumes that the depth of flow, d , is small when compared to the overall spread and therefore the spread is assumed to be equal to the wetted perimeter. Also, the friction along the curb height is assumed to be negligible when compared to the friction along the spread.

The roadway should be designed such that the spread will be maximized just upstream of the inlet. See design spread criteria in Table 7 in Appendix 1.

4.4.4 Composite Gutter Sections



Composite Road Section

Where:

Q_w = Flow in depressed section, (ft³/s)

Q_s = Side flow, (cfs)

S_w = Gutter Cross Slope, (ft/ft)

S_x = Pavement (road) cross-slope, (ft/ft)

W = Width of depressed gutter, (ft)

T_s = Width of side flow, (ft)

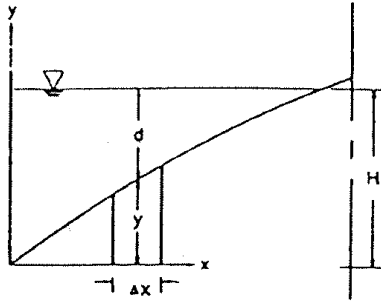
T = Total width of flow, (ft)

a = Continuous gutter depression, (in)

In order to calculate the flow in a composite section the ratio of frontal flow to total gutter flow, E_o , can be calculated using Formula (4.4) in conjunction with Formula (4.3).

$$E_o = \frac{1}{\left\{ 1 + \frac{S_w}{S_x} \left[\left(1 + \frac{S_w / S_x}{(T/W) - 1} \right)^{2.67} - 1 \right]^{-1} \right\}} = \frac{Q^w}{QTOTAL} \quad (4.4)$$

4.4.5 Parabolic Street Sections



c. Parabolic

For residential streets, parabolic sections are often used because they provide a flatter driving surface than uniform sections. However, the flow capacity is less for the parabolic section than the uniform section. The following formulas can be used to calculate the flows and associated spread in a parabolic section.

$$y = ((Q/S^{0.5})^{C2}) / C1 \quad (4.5)$$

$$Q = (y * C1)^{(1/C2)} * S^{0.5} \quad (4.6)$$

$$T = B - (C3 - C4y)^{0.5} \quad (4.7)$$

$$A = (T * y) / 3 \quad (4.8)$$

$$V = Q/A \quad (4.9)$$

Where:

- y = Flow depth in gutter for one side of street, (ft)
- Q = Gutter discharge for one side of the street, (cfs)
- T = Spread for one side of the street, (ft)
- A = Cross sectional area of flow, (ft²)
- V = Velocity of flow, (ft/s)
- B = 1/2 of the street width

Table 4.1: Parabolic Roadway Coefficients

	CROWN	C1	C2	C3	C4
	6"	9.2180	0.3405	169	338
26'	* 5"	9.9714	0.3404	169	405.6
	4"	10.9821	0.3404	169	507
	7"	9.1145	0.3418	225	385.7143
31'	6"	9.7396	0.3418	225	450
	* 5"	10.5346	0.3418	225	540
	8"	9.1888	0.3421	324	486
36'	7"	9.7317	0.3421	324	555.4286
	* 6"	10.4020	0.3422	324	648
44'	* 8"	9.9146	0.3433	484	726
	7"	10.4975	0.3433	484	829.7143
	6"	11.2173	0.3433	484	968
* These crown heights shall be used for new developments					
Note: These constants were derived for a Manning's n of 0.016.					

Alternatively, the nomographs included in Appendix 4 can be used as aids in designing parabolic roadway drainage.

4.5 Drainage Inlet Design

The hydraulic capacity of a storm drain inlet depends upon its geometry as well as the characteristics of the gutter flow. Inlet capacity governs both the rate of water removal from the gutter and the amount of water that can enter the storm drainage system. Inadequate inlet capacity or poor inlet location may cause flooding on the roadway resulting in a hazard to the traveling public.

In general inlets should be placed to meet the spread requirements summarized in Table 7 in Appendix 1. In addition, inlets should be spaced at a maximum distance of 600 feet apart or before intersecting street.

4.5.1 Inlet Types

Storm drain inlets are used to collect runoff and discharge it to an underground storm drainage system. Inlets are typically located in gutter sections, paved medians, and roadside and median ditches. Inlets used for the drainage of highway surfaces can be divided into the following three classes:

1. Grate inlets;
2. Curb-opening inlets; and,
3. Combination inlets

Grate inlets consist of an opening in the gutter or ditch covered by a grate. Curb-opening inlets are vertical openings in the curb covered by a top slab. Combination inlets consist of both a curb-opening inlet and a grate inlet placed in a side-by-side configuration, but the curb opening may be located in part upstream of the grate.

4.5.2 Interception Capacity of Inlets on Grade

Inlet interception capacity, Q_j , is the flow intercepted by an inlet under a given set of conditions. The efficiency of an inlet, E , is the percent of total flow that the inlet will intercept for those conditions. The efficiency of an inlet changes with changes in cross slope, longitudinal slope, total gutter flow, and, to a lesser extent, pavement roughness. In mathematical form, efficiency, E , is defined by the following equation:

$$E = \frac{Q_j}{Q} \quad (4.10)$$

Where:

E = Inlet Efficiency (ft³/s)
 Q = Total Gutter Flow
 Q_j = Intercepted Flow, (ft³/s)

Flow that is not intercepted by an inlet is termed carryover or bypass and is defined as follows:

$$Q_b = Q - Q_j \quad (4.11)$$

Where:

Q_b = bypass flow, (ft³/s)

In Appendix 4, design charts for inlets on grade and procedures for using the charts are presented for the various inlet configurations. Remember that for locally depressed inlets, the quantity of flow reaching the inlet would be dependent on the upstream gutter section geometry and not the depressed section geometry.

Charts for grate inlet interception have been made and are applicable to all grate inlets tested for the Federal Highway Administration. The chart for frontal flow interception is based on test results which show that grates intercept all of the frontal flow until a velocity is reached at which water begins to splash over the grate. At velocities greater than "Splash-over" velocity, grate efficiency in intercepting frontal flow is diminished. Grates also intercept a portion of the flow along the length of the grate, or the side flow. A chart in Appendix 4 is provided to determine side-flow interception. Chart 5B in Appendix 4 determines the "splash-over" velocity.

A procedure for determining the interception capacity of combination inlets is also presented.

4.5.2.1 Grate Inlets

Grate inlets perform satisfactory over a wide range of gutter grades. The capacity of an inlet depends on its geometry and the cross slope, longitudinal slope, total gutter flow, depth of flow and pavement roughness. The depth of water next to the curb is a major factor in the interception capacity of both gutter inlets and grate inlets. At low velocities all the water flowing in the gutter adjacent to a grate is intercepted. On steep slopes only a portion of the frontal flow will be intercepted if the velocity is high or the grate is short and splash over occurs. For grates less than two (2) feet long intercepted flow is small.

A parallel bar grate inlet is the most efficient type of curb inlet; however when crossbars are added for bicycle safety the efficiency is greatly reduced. Where bicycle traffic is a design consideration, the curved vane grate and tilt bar grate are recommended for both hydraulic features and safety.

Where debris is a problem, consideration should be given to debris handling efficiency rankings. Table 4-2 presents the results of tests for debris handling efficiency. This table should be used for relative comparisons only.

Table 4-2. Average Debris Handling Efficiencies of Grates Tested

Rank	Grate	Longitudinal Slope	
		0.005	0.04
1	Curved Vane	46	61
2	30° - 85 Tilt Bar	44	55
3	45° - 85 Tilt Bar	43	48
4	P - 50	32	32
5	P - 50x100	18	28
6	45° - 60 Tilt Bar	16	23
7	Reticuline	12	16
8	P-30	9	20

When the velocity approaching the grate is less than the “splash-over” velocity, the grate will intercept essentially all of the frontal flow. Conversely, when the gutter flow velocity exceeds the “splash-over” velocity for the grate, only part of the flow will be intercepted. A part of the flow along the side of the grate will be intercepted, dependent on the cross slope of the pavement, the length of the grate, and flow velocity.

The ratio of frontal flow to total gutter flow, E_o for a uniform cross slope is expressed by equation 4.12:

$$E_o = \frac{Q_w}{Q} = 1 - \left(1 - \frac{W}{T}\right)^{2.67} \quad (4.12)$$

Where:

Q= total gutter flow, (ft³/s)
 Q_w= flow in width W, (ft³/s)
 W= width of depressed gutter or grate, (ft)
 T= total spread of water, (ft)

Chart 2B in Appendix 4 provides solutions of E_o for either uniform cross slopes or composite gutter sections.

The ratio of side flow, Q_s, to total gutter flow is:

$$\frac{Q_s}{Q} = 1 - \frac{Q_w}{Q} = 1 - E_o \quad (4.13)$$

The ratio of frontal flow intercepted to total frontal flow, R_f, is expressed by equation 4.14:

$$R_f = 1 - K_u (V - V_o) \quad (4.14)$$

Where:

K_u= 0.09 in English Units
 V= velocity of flow in the gutter, (ft/s)
 V_o= gutter velocity where “splash-over” first occurs, (ft/s)
 (Note: R_f cannot exceed 1.0)

This ratio is equivalent to frontal flow interception efficiency. Chart 5B in Appendix 4 provides a solution for equation 4.14 which takes into account grate length, bar configuration, and gutter velocity at which splash-over occurs. The average gutter velocity (total gutter flow divided by the area of flow) is needed to use Chart 5B in Appendix 4. This velocity can also be obtained from Chart 4B in Appendix 4.

The ratio of side flow intercepted to total side flow, R_s, is side flow interception efficiency, is expressed by equation 4.15. Chart 6B in Appendix 4 provides a solution to equation 4.15.

$$R_s = 1 / \left(1 + \frac{K_u V^{1.8}}{S_x L^{2.3}} \right) \quad (4.15)$$

Where:

K_u = 0.15 in English Units
 L = length of grate along gutter, (ft)
 S_x = roadway cross slope
 V = velocity, (ft/s)

The efficiency, E , of a grate is expressed as provided in equation 4.16:

$$E = R_f E_o + R_s (1 - E_o) \quad (4.16)$$

The first term on the right side of equation 4.16 is the ratio of intercepted frontal flow to total gutter flow, and the second term is the ratio of intercepted side flow to total side flow. The second term is insignificant with high velocities and short grates.

The interception capacity of a grate inlet on grade is equal to the efficiency of the grate multiplied by the total gutter flow as represented in equation 4.17.

$$Q_i = E Q = Q [R_f E_o + R_s (1 - E_o)] \quad (4.17)$$

4.5.2.2. Curb-opening Inlets

Curb-opening inlets are most effective on flatter slopes, in sags, and with flows which typically carry significant amounts of floating debris. The interception capacity of curb-opening inlets decreases as the gutter grade increases. Consequently, the use of curb-opening inlets is recommended in sags and on grades less than 3%.

Curb-opening inlets are effective in the drainage of pavements where flow depth at the curb is sufficient for the inlet to perform efficiently. Curb openings are less susceptible to clogging and offer little interference to traffic operation. They are a viable alternative to grates on flatter grades where grates would be in traffic lanes or would be hazardous for pedestrians or bicyclists.

Curb opening heights vary in dimension; however, a typical maximum height is approximately 4 to 6 inches. The length of the curb-opening inlet required for total interception of gutter flow on a pavement section with a uniform cross slope is expressed by equation 4.18:

$$L_T = K_u Q^{0.42} S_L^{0.3} \left(\frac{1}{n S_x} \right)^{0.6} \quad (4.18)$$

Where:

K_u = 0.6 in English Units

n = Manning's Coefficient

S_x = roadway cross slope

L_T = curb opening length required to intercept 100 percent of the gutter flow, (ft)

S_L = longitudinal slope

Q = gutter flow, (ft³/s)

The efficiency of curb-opening inlets shorter than the length required for total interception is expressed by equation 4.19:

$$E = 1 - \left(1 - \frac{L}{L_T} \right)^{1.8} \quad (4.19)$$

Where:

L = curb-opening length, (ft);

L_t = curb opening length at 100% efficiency, (ft)

Chart 7B in Appendix 4 is a nomograph for the solution of equation 4.18 and Chart 8B In Appendix 4 provides a solution of equation 4.19.

The length of inlet required for total interception by depressed curb-opening inlets or curb-openings in depressed gutter sections can be found by the use of an equivalent cross slope, S_e , in equation 4.18 in place of S_x . S_e can be computed using equation 4.20.

$$S_e = S_x + S'_w E_o \quad (4.20)$$

Where:

S_x = roadway cross slope, (ft/ft);

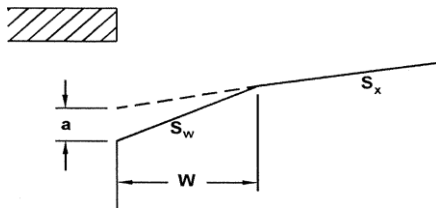
S'_w = cross slope of the gutter measured from the cross slope of the pavement,

S_x , (ft/ft) , ($S'_w = (a/[12 W])$, for W in ft) or = $S_w - S_x$);

a = gutter depression, (in);

E_o = ratio of flow in the depressed section to total gutter flow determined by the gutter configuration upstream of the inlet.

The following diagram shows the depressed curb inlet for equation 4.26, E_o is the same ratio as used to compute the frontal flow interception of a grate inlet.



As seen from Chart 7B in Appendix 4, the length of curb opening required for total interception can be significantly reduced by increasing the cross slope or the equivalent cross slope. The equivalent cross slope can be increased by use of a continuously depressed gutter section or a locally depressed gutter section.

Using the equivalent cross slope, S_e , equation 4.18 becomes:

$$L_T = K_T Q^{0.42} S_L^{0.3} \left(\frac{1}{nS_e} \right)^{0.6} \quad (4.21)$$

Where:

$K_T = 0.6$ in English Units

n = Manning's Coefficient

S_e = equivalent cross slope

L_T = curb opening length required to intercept 100 percent of the gutter flow, (ft)

S_L = longitudinal slope

Q = gutter flow, (ft³/s)

Equation 4.19 is applicable with either straight cross slopes or composite cross slopes. Charts 7B and 8B in Appendix 4 are applicable to depressed curb-opening inlets using S_e .

4.5.2.3. Combination Inlets

Combination inlets provide the advantages of both curb opening and grate inlets. This combination results in a high capacity inlet which offers the advantages of both grate and curb-opening inlets. When the curb opening extends upstream of the grate in a "sweeper" configuration, the interception capacity can be computed as the sum of the capacity of the curb opening upstream of the grate and the grate capacity. Used in a sag configuration, the "sweeper" inlet can have a curb opening on both sides of the grate.

The interception capacity of a combination inlet consisting of a curb opening and grate placed side-by-side is no greater than that of the grate alone. Capacity is computed by neglecting the curb opening. A combination inlet is sometimes used with a part of the curb opening placed upstream of the grate. The curb opening in such an installation intercepts debris which might otherwise clog the grate and is called a "sweeper" inlet. A sweeper combination inlet has an interception capacity equal to the sum of the curb opening upstream of the grate plus the grate capacity, except that the frontal flow and thus the interception capacity of the grate is reduced by interception by the curb opening.

4.5.3 Interception Capacity of Inlets in Sag Locations

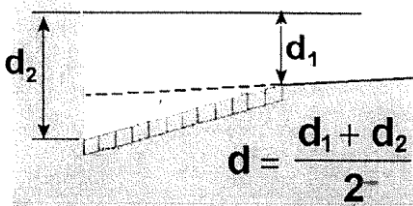
Inlets in sag locations operate as weirs under low head conditions and as orifices at greater depths. Orifice flow begins at depths dependent on the grate size, the curb opening height, or the slot width of the inlet. At depths between those at which weir flow definitely prevails and those at which orifice flow prevails, flow is in a transition stage. At

these depths, control is ill-defined and flow may fluctuate between weir and orifice control. Design procedures presented here are based on a conservation approach to estimating the capacity of inlets in sump locations.

The efficiency of inlets in passing debris is critical in sag locations because all runoff which enters the sag must be passed through the inlet. Total or partial clogging of inlets in these locations can result in hazardous ponded conditions. Grate inlets alone are not recommended for use in sag locations because of the tendencies of grates to become clogged. Combination inlets or curb-opening inlets are recommended for use in these locations.

4.5.3.1 Grate Inlets in Sags

A grate inlet in a sag location operates as a weir to depths dependent on the size of the grate and as an orifice at greater depths. Grates of larger dimension will operate as weirs to greater depths than smaller grates.



The capacity of grate inlets operating as weirs is:

$$Q_j = C_w P d^{1.5} \quad (4.22)$$

Where:

P = perimeter of the grate in (ft) disregarding the side against the curb

C_w = 3.0 in English Units

d = average depth across the grate; $0.5 (d_1 + d_2)$, (ft)

The capacity of a grate inlet operating as an orifice is:

$$Q_j = C_o A_g (2 g d)^{0.5} \quad (4.23)$$

Where:

C_o = orifice coefficient = 0.67

A_g = clear opening area of the grate, (ft²)

g = 32.2 ft/s²

Use of equation 4.23 required the clear area of opening of the grate. Opening ratios for the grates are given on Chart 9B in Appendix 4.

Chart 9B in Appendix 4 is a plot of equation 4.22 and 4.23 for various grate sizes. The chart indicates the effect of the grate size on the depth at which it operates as an orifice. The transition from weir to orifice flow results in an interception capacity less than that computed by either the weir or the orifice equation. This capacity can be approximated by drawing in a curve between the lines representing the perimeter and net area of the grate to be used.

4.5.3.2 Curb-Opening Inlets

The capacity of a curb-opening inlet in a sag depends on water depth at the curb, the curb opening length, and the height of the curb opening. The inlet operates as a weir to depths equal to the curb opening height and as an orifice at depths greater than 1.4 times the opening height. At depths between 1.0 and 1.4 times the opening height, flow is in a transition stage.

Spread on the pavement is the usual criterion for judging the adequacy of a pavement drainage inlet design. It is also convenient and practical in the laboratory to measure depth at the curb upstream of the inlet at the point of maximum spread on the pavement. Therefore, depths at the curb measurements from experiments coincide with the depth at curb of interest to designers. The weir coefficient for a curb-opening inlet is less than the usual weir coefficient for several reasons. The most obvious of which is that depth measurements from experimental tests were not taken at the weir, and drawdown occurs between the point where measurements were made and the weir.

The weir location for a depressed curb-opening inlet is at the edge of the gutter, and the effective weir length is dependent on the width of the depressed gutter and the length of the curb opening. The weir location for a curb-opening inlet that is not depressed is at the lip of the curb opening, and its length is equal to that of the inlet, as shown in Chart 10B in Appendix 4.

The equation for the interception capacity of a depressed curb-opening inlet operating as a weir as:

$$Q_j = (L + 1.8 W)d^{0.5} \quad (4.24)$$

Where:

$$C_w = 2.3$$

L = length of curb opening, (ft)

W = lateral width of depression, (ft)

d = depth at curb measured from the normal cross slop, (ft), i.e., $d = T S_x$

The weir equation is applicable to depths at the curb approximately equal to the height of the opening plus the depth of the depression. Thus, the limitation on the use of equation 4.24 for a depressed curb-opening inlet is:

$$d \leq h + a/12, \text{ in English Units} \quad (4.25)$$

Where:

- h= height of curb-opening inlet, (ft)
- a= depth of depression, (in)

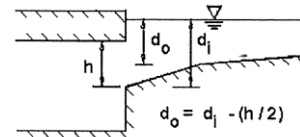
The weir equation for curb-opening inlets without depression becomes:

$$Q_j = C_w L d^{1.5} \tag{4.26}$$

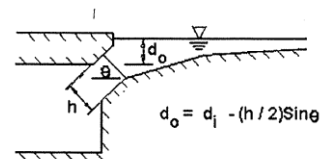
Without depression of the gutter section, the weir coefficient, C_w , becomes 3.0, English system. The depth limitation for operation as a weir becomes $d \leq h$.

At curb-opening lengths greater than 12 feet, equation 4.26 for non-depressed inlet produces intercepted flows which exceed the values for depressed inlets computed using equation 4.25. Since depressed inlets will perform at least as well as non-depressed inlets of the same length, equation 4.26 should be used for all curb-opening inlets having lengths greater than 12 feet.

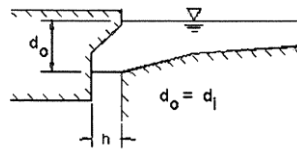
Curb-opening inlets operate as orifices at depths greater than approximately 1.4 times the opening height. The interception capacity can be computed by equation 4.27a and equation 4.27b. These equations are applicable to depressed and undepressed curb-opening inlets. The depth at the inlet includes any gutter depression.



a. Horizontal Throat



b. Inclined Throat



$$Q_j = C_o h L (2 g d_o)^{0.5} \tag{4.27a}$$

Or

$$Q_j = C_o A_g \left[2g \left(d_i - \frac{h}{2} \right) \right]^{0.5} \tag{4.27b}$$

Where:

- C_o = orifice coefficient (0.67)
- d_o = effective head on the center of the orifice throat, (ft)
- L = length of orifice opening, (ft)
- A_g = clear area of opening, (ft²)
- d_i = depth at lip of curb-opening, (ft)
- h = height of curb-opening orifice, (ft)
- g = gravitational constant (32.2 ft/s²)

The height of the orifice in equations 4.27a and 4.27b assumes a vertical orifice opening. As illustrated in the adjacent figure, other orifice throat locations can change the effective depth on the orifice and the dimension ($d_j - h/2$). A limited throat width could reduce the capacity of the curb-opening inlet by causing the inlet to go into orifice flow at depths less than the height of the opening.

For curb-opening inlets with other than vertical faces, equation 4.27a can be used with:

h = orifice throat width, (ft)

d_o = effective head on the center of the orifice throat, (ft)

Chart 10B in Appendix 4 provides solutions for equations 4.24 and 4.27 for depressed curb-opening inlets, and Chart 11B in Appendix 4 provides solutions for equations 4.26 and 4.27 for curb-opening inlets without depression. Chart 12B in Appendix 4 is provided for use for curb-openings with other than vertical orifice openings.

4.5.3.3 Combination Inlets

Combination inlets consisting of a grate and a curb opening are considered advisable for use in sags where hazardous ponding can occur. Equal length inlets refer to a grate inlet placed along side a curb-opening inlet, both of which have the same length. A “sweeper” inlet refers to a grate inlet placed at the downstream end of a curb-opening inlet. The curb-opening inlet is longer than the grate inlet and intercepts the flow before the flow reaches the grate. The “sweeper” inlet is more efficient than the equal length combination inlet and the curb-opening has the ability to intercept any debris which may clog the grate inlet. The interception capacity of the equal length combination inlet is essentially equal to that of a grate alone in weir flow. In orifice flow, the capacity of the equal combination inlet is equal to the capacity of the grate plus the capacity of the curb-opening.

Equation 4.22 and Chart 9B in Appendix 4 can be used for grates in weir flow or combination inlets in sag locations. Equations 4.24, 4.25, and 4.26 as well as Charts 10B, 11B, and 12B in Appendix 4 for curb-opening inlets are applicable assuming that the grate is completely clogged.

Where depth at the curb is such that orifice flow occurs, the interception capacity of the inlet is computed by adding equations 4.23 and 4.27 are as follows:

$$Q_i = 0.67 A_g (2 g d)^{0.5} + 0.67 h L (2 g d_o)^{0.5} \quad (4.28)$$

Where:

A_g = clear area of the grate, (ft²)

g = gravitational constant (ft/s²)

d = average depth over the grate, (ft)

h = height of curb-opening orifice (ft)

L = length of curb-opening, (ft)

d_o = effective depth at the center of the curb opening orifice, (ft)

Trial and error solutions are necessary for determining the depth at the curb for a given flow rate using Charts 9B, 10B, and 11B in Appendix 4 for orifice flow. Different assumptions for clogging of the grate can also be examined using these charts.

4.5.4 Inlet Locations

4.5.4.1 Geometric Controls

There are a number of locations where inlets may be necessary with little regard to contributing drainage area. These locations should be marked on the plans prior to any computations regarding discharge, water spread, inlet capacity, or flow bypass. Examples of such locations as follows:

- At locations on grade where the design flows exceeds the depth and spread criteria;
- At all low points (sag points) in gutters;
- Immediately upgrade of median breaks and street intersections;
- Immediately upgrade of roadway cross slope reversals;
- Upstream and downstream of bridge locations, where applicable;
- Behind curbs and sidewalks as necessary to drain low areas; and,
- At the end of channels in cut sections.

In addition to the areas identified above, runoff from areas draining towards the highway pavement should be intercepted by roadside channels or inlets before it reaches the roadway. This applies to drainage from cut slopes, side streets, and other areas alongside the pavement. Curbed pavement sections and pavement drainage inlets are inefficient means for handling extraneous drainage.

4.5.4.2 Inlet Spacing on Continuous Grades

Design spread is the criterion used for locating storm drain inlets between those required by geometric or other controls. Design spread criteria is presented in Table 7 in Appendix 1. The interception capacity of the upstream inlet will define the initial spread. As flow is contributed to the gutter section in the downstream direction, spread increases. The next downstream inlet is located at the point where the spread in the gutter reaches the design spread. Therefore, the spacing of inlets on a continuous grade is a function of the amount of upstream bypass flow, the tributary drainage area, and the gutter geometry. However, the inlets shall not be spaced any more than 600 feet apart.

For a continuous slope, the designer may establish the uniform design spacing between inlets of a given design if the drainage area consists of pavement only or has reasonably uniform runoff characteristics and is rectangular in shape. In this case, the time of concentration is assumed to be the same for all inlets.

4.6 HYDRAULIC DESIGN OF CLOSED CONDUITS

All closed conduits shall be hydraulically designed through the application of Manning's Equation, (non critical flows) expressed as follows:

$$Q = A V \quad (4.29)$$

$$Q = \frac{1.486}{n} A R^{2/3} S_f^{1/2} \quad (4.30)$$

$$R = \frac{A}{P} \quad (4.31)$$

Where:

Q = flow (ft³/s)

A = cross sectional area, (ft²)

V = velocity of flow in the conduit, (ft/s)

n = roughness coefficient of the conduit

R = hydraulic radius which is the area of flow divided by the wetted perimeter, (ft)

S_f = channel slope of the conduit in (ft/ft)

P = wetted perimeter, (ft)

4.6.1 Velocity in Closed Conduits

Storm sewers should operate within certain velocity limits to prevent excessive deposition of solids due to low velocities, and to prevent invert erosion and undesirable and hazardous outlet conditions due to excessively high velocity. Minimum and maximum velocities for closed conduits are provided in Table 6 in Appendix 1. In extreme conditions where the maximum velocity must be exceeded, prior approval must be obtained from the City Engineer.

4.6.2 Roughness Coefficients for Closed Conduits

Roughness coefficients are directly related to construction procedures. When alignment is poor and joints have not been properly assembled, extreme head losses will occur. Coefficients used in this matter are related to construction procedures, and assume that the pipe will be manufactured with a consistently smooth surface. Recommended roughness coefficients are provided in Table 2 in Appendix 1.

4.6.3 Minor Head Losses in Closed Conduits

Head losses at structures shall be determined for manholes, junction boxes, wye branches, bends, curves, and changes in pipe sizes in the design of closed conduits. Minimum head loss used at any structure shall be 0.10 feet. Properly designed curves may have zero losses.

- A. Head losses and gains for wyes and pipe size changes will be calculated by the following formulas:

Where $V_1 < V_2$:

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

Where $V_1 > V_2$:

$$\frac{V_2^2}{4g} - \frac{V_1^2}{4g} = HL \quad (4.32)$$

and V_1 is upstream velocity and V_2 is downstream velocity. It should be noted that new storm sewer design shall be designed where the receiving pipe velocity increases going downstream. Otherwise, a hydraulic jump may occur. Deviations to this requirement shall be handled on a case by case basis by the City Engineer.

- B. Head losses and gains for manholes, bends, curves and junction boxes will be calculated as shown in Table 5A and Table 5B in Appendix 1.

- 1) The basic equation for most cases where there is both upstream and downstream velocity, takes the form as set forth below with the various conditions of the coefficient "Kj" shown in Table 5A in Appendix 1.

$$hj = \frac{V_2^2}{2g} - Kj \frac{V_1^2}{2g} \quad (4.33)$$

Where:

Hj = junction or structure head loss, (ft)

V_1 = velocity in upstream pipe, (ft/s)

V_2 = velocity in downstream pipe, (ft/s)

K = junction or structure coefficient of loss

- 2) In the case where the inlet is at the very beginning of a line, or the line is laid with bends or obstructions, the equation is revised as follows, without any approach velocity.

$$hj = Kj \frac{V_2^2}{2g} \quad (4.34)$$

5.0 OPEN CHANNELS

5.1 General

This section describes the criteria for the design of drainage channels. The minimum slope for all proposed channels shall be 0.25%, unless otherwise approved by the City Engineer.

The hydraulic characteristics of improved channels are to be determined through the application of Manning's Equation. In lieu of Manning's Equation, HEC-RAS can be used to determine the water surface profile. According to the complexity of the system, the City Engineer may require the use of the HEC-RAS Computer Program.

5.2 Cross Sections

Figure 2 in Appendix 2, contains typical sections that are to be used in the design of open channels.

All improved channels shall be designed to carry the 25-year flow plus one foot of freeboard. Adjacent building structures finish floor elevations shall be at least one foot above the 100-year water surface elevation.

A dedicated drainage easement shall be provided to the City of Brookland for open channels. The easement width shall be no less than the minimum width required to convey the 100-year frequency runoff or 15 feet, whichever is greater.

Unlined improved channels that contain bends shall be designed such that erosion at the bends is minimized. Erosion protection at bends shall be determined based on the velocity along the outside of the channel bend. Unlined improved channels shall have side slopes no steeper than 3:1 and lined channels shall have side slopes no steeper than 2:1, unless authorized by the City Engineer. A soil analysis shall be performed to determine the maximum slope that the soil, at the channel improvement site, can sustain without failure.

5.3 Roughness Coefficients

The roughness coefficients that are to be used are shown in Table 4 in Appendix 1. Variations from that which is shown must be approved by the City Engineer.

5.4 Velocity Requirements

The velocity limits for open-channel flow are given in Table 4 in Appendix 1. The channels for which the velocity exceeds these limits shall be protected by appropriate erosion protection or energy dissipater or both.

5.5 Channel Drop Structures

The function of a drop structure is to reduce channel velocities by allowing flatter upstream and downstream channel slopes. Sloping channel drops and vertical channel drops are two commonly used drop structures.

The flow velocities in the channel upstream and downstream of the drop structure need to satisfy the permissible velocities allowed for channels in Table 4 in Appendix 1. The velocities shall be checked for flows produced by the 10-, 50- and 100-year frequency events.

An apron shall be constructed immediately upstream of the chute to protect against the increasing velocities and turbulence which result as the water approaches the drop structure. The apron shall extend at least five (5) feet upstream of the point where flow becomes supercritical. In no case shall the length of the upstream apron be less than ten (10) feet.

An apron shall be constructed immediately downstream of the chute or stilling basin to protect against erosion due to the occurrence of the hydraulic jump. The apron shall extend a minimum of ten (10) feet beyond the anticipated location of the hydraulic jump.

The design of drop structures is based on the height of the drop, the normal depths upstream and downstream of the drop structure and discharge.

5.5.1 Vertical Drop Structures

The approximate height of the drop required to stabilize the hydraulic jump should be determined.

The drop length and the hydraulic jump length of the drop structure should be calculated to determine the length of the downstream apron required to prevent erosion.

5.5.2 Sloping Drop Structures

The location of the hydraulic jump should be determined based on the upstream and downstream flow depths and channel slopes.

The length of the hydraulic jump should be calculated to determine the length of the downstream apron required to prevent erosion.

6.0 CULVERTS

6.1 General

The design theory outlined herein is a modification of the method used in the hydraulic design of concrete box and pipe culverts, as discussed in the Federal Highway Administration's Hydraulic Design Series Number 5 entitled "*Hydraulic Design of Highway Culverts*".

The hydraulic capacity of culverts is computed using various factors and formulas. Laboratory tests and field observations indicate that culvert flow may be controlled either at the inlet or outlet. Inlet control involves the culvert cross-sectional area, the ponding of headwater at the entrance, and the inlet geometry. Outlet control involves the tailwater elevation in the outlet channel, the slope of the culvert, the roughness of the surface and length of the culvert barrel.

6.2 Culverts Flowing with Inlet Control

Inlet control means that the discharge capacity of a culvert is controlled at the culvert entrance by the depth of the headwater and entrance geometry, including the barrel shape and cross-sectional area, and the type of inlet edge.

Nomographs for determining culvert capacity for inlet control are shown in Appendix 5. These nomographs were developed by the Division of Hydraulic Research, Bureau of Public Roads, from analysis of laboratory research reported in the National Bureau of Standards Report No. 444, entitled "*Hydraulic Characteristics of Commonly Used Pipe Entrances*", by John L. French, and "*Hydraulics of Conventional Highway Culverts*" by H. G. Bossy. Experimental data for box culverts with headwalls and wingwalls were obtained from an unpublished report of the U.S. Geological Survey.

6.3 Culverts Flowing with Outlet Control

The culvert is designed so that the depth of headwater, which is the vertical distance from the upstream culvert flow line to the elevation of the ponded water surface, does not encroach on the allowable freeboard during the design storm.

Headwater depth, HW, can be expressed by a common equation for all outlet control conditions:

$$HW = H + h_o - L (S_o) \quad (6.1)$$

HW = headwater depth in feet from the flow line of the culvert, (ft)

H = head or energy required to pass a given discharge through a culvert, (ft)

h_o = vertical distance from the downstream culvert flow line to the elevation from which H is measured, (ft)

L = length of culvert, (ft)

S_o = culvert barrel slope, (ft)

The head, H, is made up of three parts: including the velocity head, exist loss (H_v) and entrance loss (H_e), and a friction loss (H_f). This energy is obtained from the ponding of water at the entrance and is expressed as:

$$H = H_v + H_e + H_f \quad (6.2)$$

H = head or energy in feet of water

$$H_v = \frac{V^2}{2g} \quad \text{where } V \text{ is average velocity in culvert or } \frac{Q}{A}$$

$$H_e = K_e \frac{V^2}{2g} \quad \text{where } K_e \text{ is the entrance loss coefficient Table 8 in Appendix 1}$$

H_f = the energy required to overcome the friction of the culvert barrel and expressed as:

$$H_f = \left[\frac{29.2n^2L}{R^{1.33}} \right] \frac{V^2}{2g} \quad (6.3)$$

Where:

n = coefficient of roughness

L = length of culvert barrel, (ft)

V = average velocity in the culvert, (ft/s)

g = gravitational acceleration (32.2 ft/s²)

R = hydraulic radius (Area / Wetted Perimeter, ft)

Substituting into the previous equation:

$$H = \frac{V^2}{2g} + K_e \frac{V^2}{2g} + \left[\frac{29.2n^2L}{R^{1.33}} \right] \frac{V^2}{2g} \quad (6.4)$$

and simplifying:

$$H = \left[1 + K_e + \frac{29.2n^2L}{R^{1.33}} \right] \left[\frac{V^2}{2g} \right] \quad \text{for full flow} \quad (6.5)$$

For various conditions of outlet control flow, h_o is calculated differently. When the elevation of the water surface in the outlet channel is equal to or above the elevation of the top of the culvert opening at the outlet, h_o is equal to the tailwater depth or:

$$h_o = TW$$

If the tailwater elevation is below the top of the culvert opening at the outlet, h_o is the greater of two values: (1) Tailwater, TW, as defined above, or (2) $(d_c + D) / 2$, where d_c = critical depth. The critical depth, d_c , for box culverts may be obtained from Appendix 5 or may be calculated from the formula:

$$d_c = 0.315 \left[\frac{Q}{B} \right]^{2/3} \quad (6.6)$$

Where:

d_c =critical depth for box culvert, (ft)

Q =discharge, (ft³/s)

B =bottom width of box culvert, (ft)

The critical depth for circular pipes may be obtained from Appendix 5, or may be calculated by trial and error. Charts developed by the Bureau of Public Roads may be used for determining the critical depth. Utilize values of D , A and d_c , which will satisfy the equation:

$$\frac{Q^2}{g} = \frac{A^3}{D} \quad (6.7)$$

Where:

d_c = critical depth for culvert, (ft)

Q = discharge, (ft³/s)

g = gravitational constant (32.2 ft/s²)

A = cross-sectional area, (ft²)

The equation is also applicable for trapezoidal or irregular channels, in which instances "D" becomes the channel top width in feet.

7.0 BRIDGES

Once a design discharge and depth of flow have been established, the size of the bridge opening may be determined. The bridge opening shall be designed so that it is in compliance with Section 5.0 and Section 9.0 of this manual and meets all FEMA requirements.

The bridge opening shall be designed utilizing the latest version of HEC-RAS computer software.

Input and output data from the software shall be included within the storm drainage calculations as required by Section 2.0 of this manual.

8.0 DETENTION POND DESIGN

8.1 General

The purpose of stormwater detention is to protect downstream properties from flood increases due to upstream development. Stormwater detention is required to control peak flow at the outlet of a site such that post-development peak flows are equal to or less than pre-development peak flows for the 2-year through 100-year design storms.

8.2 No Adverse Impact Policy

The City of Brookland has adopted the policy that runoff from new development will not adversely affect downstream properties.

The City of Brookland retains the right to require detention in areas of known flooding when detention will not exacerbate downstream flooding. Detention systems must be constructed during the first phase of major developments to eliminate damage to adjacent properties during construction. In this regard, the detention systems shall be designed to function as sediment traps and cleaned out to proper volumes before completion. If siltation has occurred, detention systems must be restored to their design dimensions after construction is complete and certified as part of the as-built submittal.

8.3 Detention Reservoir Routing

The peak flow reduction obtained by a stormwater detention system can be evaluated by performing reservoir routing calculations, usually as a trial and error process. The use of the Storage Indication Method relationship is as follows:

- a. Inflow Hydrograph
- b. Stage-storage curve
- c. Stage-discharge curve

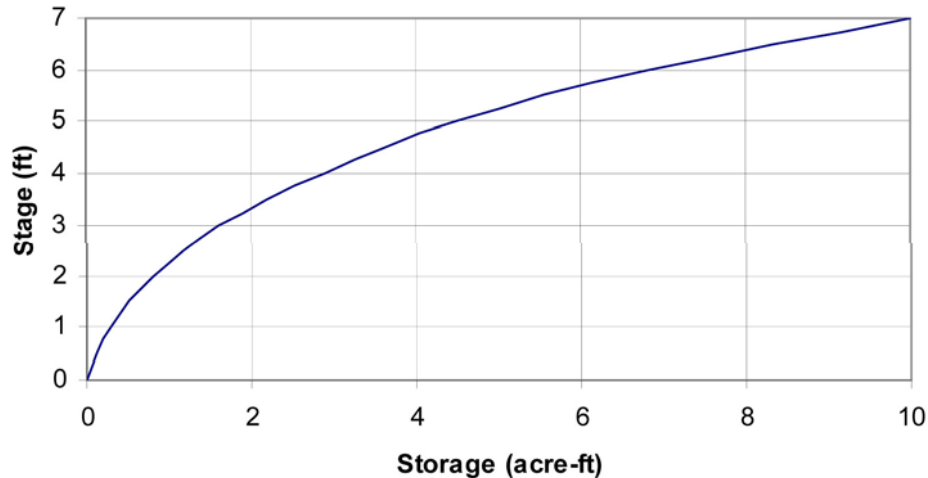
Development of each of these relationships should be based on site-specific data.

8.3.1 Inflow Hydrograph

Fundamentals for the development of an inflow hydrograph for design flood conditions presented in Section 3.

8.3.2 Stage-Storage Curve

A stage-storage curve defines the relationship between the depth of water and storage volume in a reservoir. An example of a stage-storage curve is shown below.



8.3.2.1 Stage-Storage Calculations

Bottom Area

The volume is computed by treating it as a trapezoidal basin where:

$$V = LWD + (L+W)Z D^2 + \frac{4}{3} Z^2 D^3 \quad (8.1)$$

Where:

- V = Storage at stage D (cu-ft)
- D = Stage or depth (ft)
- L = Bottom length (ft)
- W = Bottom width (ft)
- Z = Side slope, (Z:1) (H:V)

Pipe Storage

$$V = \frac{L}{6} (A_1 + 4M + A_2) \quad (8.2)$$

Where:

- V = Storage (cu-ft)
- L = Pipe length (ft)
- A₁ = Cross-sectional area of depth at downstream end
- A₂ = Cross-sectional area of depth at upstream end
- M = Cross-sectional area of depth at midsection

When the pipe slope is zero, Volume = LA₁

Contours

The average-end-area method may be applied vertically or the Conic method. The conic method uses the following equation:

$$V = d \left(\frac{A_1 + \sqrt{A_1 A_2} + A_2}{3} \right) \quad (8.3)$$

Where:

V = Storage (cu-ft)

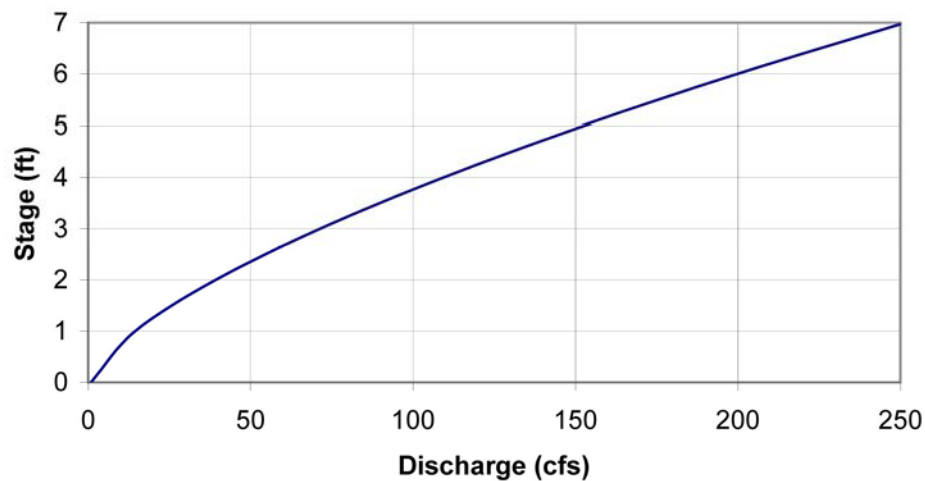
d = Change in elevation between points 1 and 2

A₁ = Surface area at elevation 1 (sq-ft)

A₂ = Surface area at elevation 2 (sq-ft)

8.3.3 Stage-Discharge Curve

A stage-discharge curve defines the relationship between the depth of water and the discharge or outflow from a storage basin. An example of a stage-discharge curve is shown below.



A typical stormwater storage basin has two spillways: principal and emergency. The principal spillway is usually designed with a capacity sufficient to convey the design storm without allowing flow to enter the emergency spillway. The emergency spillway is sized to provide a bypass for stormwater during a storm that exceeds the design capacity of the principal spillway.

8.3.3.1 Stage-Discharge Calculations

Culverts/Orifices

The equation used for culvert/orifice structures is:

$$Q = C_o A \sqrt{\frac{2gh}{k}} \times Nb \quad (8.4)$$

Under Inlet Control

Q = Discharge, (cfs)

A = Culvert area, (sq-ft)

h = Distance between the water surface and the centroid of the culvert barrel (1/2 flow depth during partial flow), (ft)

N_b = Number of barrels

C_o = Orifice coefficient

k = 1

Under Outlet Control

Q = Discharge, (cfs)

A = Culvert area, (sq-ft)

h = Distance between the upstream and downstream water surface

N_b = Number of barrels

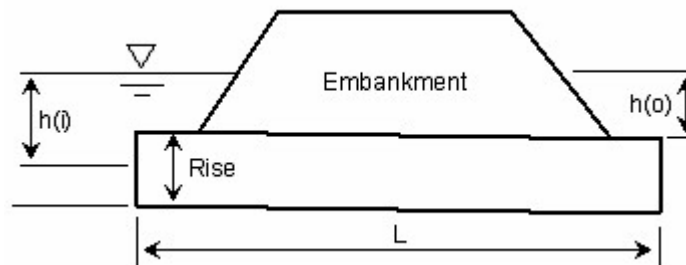
C_o = 1

k = 1.5 + [(20n²L)/R^{1.33}]

n = Manning's n-value

L = Culvert length, (ft)

R = Area/wetted perimeter, (ft)



Profile of typical culvert

h(i) is the head under inlet control. H(o) under outlet control.

Weirs

The basic equations used to calculate weir flow are:

Rectangular, Cipoletti, Broad Crested & Riser

$$Q = C_W LH^{1.5} \quad (8.5)$$

Where:

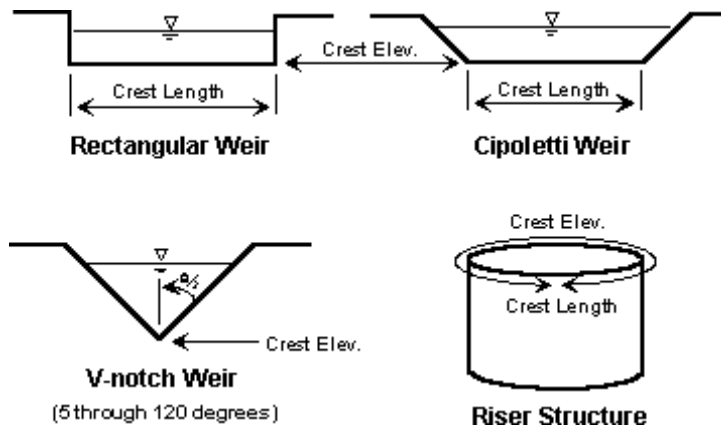
- Q = Discharge over weir, (cfs)
- L = Length of the weir crest, (ft)
- H = Distance between water surface and the crest, (ft)
- C_w = Weir coefficient, typically 3.33

V-notch

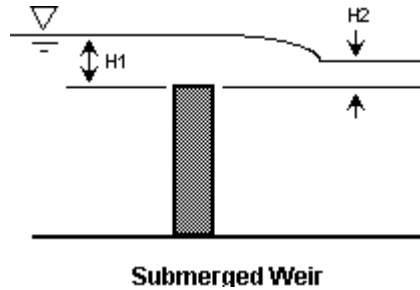
$$Q = 1.38T \tan\left(\frac{\theta}{2}\right) H^{2.5} \quad (8.6)$$

Where:

- Q = Discharge over weir, (cfs)
- θ = Angle of v-notch, (deg)
- H = Head on apex of v-notch, (ft)

**Adjustment for Submerged Weirs**

Rectangular, V-notch, and Cipoletti weirs are affected by submergence when the tailwater rises above the crest, as shown below. The result will be that the discharge over the weir will be reduced.



The equation for the reduction in flow is:

$$Q_s = Q_r \left(1 - \left(\frac{H_2}{H_1} \right)^{1.5} \right)^{0.385} \quad (8.7)$$

Where:

- Q_s = Submerged flow, (cfs)
- Q_r = Unsubmerged flow from standard weir equations
- H_1 = Upstream head above crest, (ft)
- H_2 = Downstream head above crest, (ft)

Routing fundamentals

Reservoir routing is the process of passing a flood hydrograph through a storage reservoir or detention pond. This process changes the pattern of flow with respect to time but conserves volume. The purpose of reservoir routing is usually to reduce the peak flow to a predetermined level or to delay the peak. The routing procedure is known as the Storage Indication Method and begins with a stage/storage/discharge relationship, an inflow hydrograph and is based entirely on the continuity equation.

$$I - O = \frac{ds}{dt} \quad (8.8)$$

Where:

- I = Inflow;
- O = Outflow;
- ds/dt = change in storage

Limitations

The most common type of detention routing problem requires knowing the design storm period or inflow hydrograph and peak outflow or allowable discharge from the detention basin. A trial and error procedure is used to calculate the storage volume required.

A less common routing problem involves preventing storage basin overflow during the design for a given basin size and return period. In such a case, the magnitude of the peak flow reduction is fixed. A trial and error procedure will be required to find a solution, as only the stage-storage curve is known explicitly.

8.3.4 Dry Reservoirs (Ponds)

Wet weather ponds or dry reservoirs shall be designed with proper safety, stability, and ease of maintenance. Maximum side slopes for grass reservoirs shall not exceed one (1) foot vertical for three (3) feet horizontal (3:1) unless adequate measures are included to provide for the above noted features. In no case shall the limits of the maximum water surface elevation be less than one (1) foot vertically below the lowest floor elevation of any adjacent structure.

The entire reservoir area shall be seeded, fertilized, mulched, sodded or paved as required for acceptance by the City Engineer. Overflow areas shall be protected against erosive velocities.

8.3.5 Open Channels

Normally permitted open channels may be used as detention areas provided that the limits of the maximum design water surface elevation are not less than one (1) foot below the lowest floor elevation of any adjacent structure. No detention will be permitted within public road rights-of-way unless approval is given by the City of Brookland.

8.3.6 Wet Reservoirs (Ponds)

Permanent lakes with fluctuating volume controls may be used as retention areas provided that the limits of the maximum water surface elevation are not less than one (1) foot below the lowest floor elevation of any adjacent structure.

Maximum side slopes for the fluctuating area of permanent lakes shall be one (1) foot vertical to three (3) feet horizontal (3:1) unless provisions are included for safety, stability, and ease of maintenance.

Special consideration shall be given to safety and accessibility in design of permanent lakes in residential areas. Typical items to be considered are: tops with grate openings on riser structures, 6' to 10' wide safety ledges at no greater than 2'-3' below normal pool elevation, trash and/or safety racks on pipe inlets and outlets, danger/warning signs, fencing, etc.

An analysis shall be furnished of any proposed earthen dam construction soil. A boring of the foundation for the earthen dam may be requested by the City Engineer. Earthen dam structures shall be designed by a licensed Professional Engineer in the State of Arkansas.

8.3.7 Parking Lots

Detention in parking lots is not permitted except in those instances where the parking serves lot serves as overflow storage for those storms above the 10-year storm event. In this instance detention is permitted to a maximum depth of six (6) inches. In no case should the maximum limits or storage be designed closer than ten (10) feet from a building unless waterproofing of the building and pedestrian accessibility are properly documented and approved. The maximum design water surface elevation should be no less than one (1) foot below the lowest floor of any adjacent structure.

8.3.8 Control Structures

The 100-year frequency storm is to be used to determine the volume of detention storage required. In addition, the outlet structure shall be designed such that peak discharges for the fully urbanized development are not increased for the pre-developed storm frequencies of the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year storm events.

Detention facilities shall be provided with obvious and effective control structures. Plan view and sections of the structure with adequate details shall be included in plans.

The maximum discharge shall be designed to take place under total anticipated design-head conditions.

Sizing of the low-flow pipe shall be by inlet control, hydrologic control, and hydrologic gradient requirements. Low-flow pipes shall not be smaller than twelve (12) inches in diameter to minimize maintenance and operating problems except in parking lot and roof retention where minimum size of openings shall be designed specifically for each condition. A bar-screen on a minimum (3:1) slope to reduce blockage by debris is suggested on the flow-pipe.

Where the outflow structure conveys flow through the embankment in a conduit, the conduit shall be reinforced concrete or an approved alternate designed to withstand external loads. The conduit is to withstand the internal hydraulic pressure without leakage under full external load or settlement, and must convey water at the design velocity without damage to the interior surface of the conduit.

The outflow structure shall discharge flows into the natural stream or unlined channels at a non-erosive rate in accordance with the requirements of this design manual.

Earth embankments used to impound required detention volume shall be constructed according to specifications for fill based on a Geotechnical Investigation of the site. The Geotechnical investigation shall be performed by a registered Professional Engineer in the State of Arkansas, who has an emphasis in geotechnical analysis and shall include, as a minimum, the type of material to be used, water content, liquid limit, plasticity index, and desired compaction.

8.3.9 Emergency Spillways

An emergency spillway or overflow area shall be provided at the maximum 100-year pool level. Spillways shall be designed for the 500-year design storm. This design criteria shall apply to all dams with normal storage greater than or equal to one (1) acre-ft or have a dam height of five (5) feet or greater, that are exempt from Title VII "*Rules Governing Design and Operation of Dams*" that are regulated by the Arkansas Natural Resource Commission.

9.0 FLOODPLAIN GUIDELINES

9.1 General Standards

The following standards apply to all developments in Special Flood Hazard Areas, regardless of the type of proposed development or the Risk Zone of the proposed site:

- (1) All new and substantial construction or substantial improvements shall be designed (or modified) and adequately anchored to prevent flotation, collapse or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy;
- (2) All new construction or substantial improvements shall be constructed by methods and practices that minimize flood damage;
- (3) All new construction or substantial improvements shall be constructed with materials resistant to flood damage;
- (4) All critical facilities constructed or substantially improved in Special Flood Hazard Areas (SFHA) must be constructed or modified to exceed 500-year flood protection standards or located outside the SFHA;
- (5) The placement or construction of all new structures must be in full compliance with the provisions of this Code;
- (6) For the purposes of this Code, all mixed-use structures are subject to the more stringent requirements of residential structures;
- (7) A substantial improvement or substantial damage to an existing structure triggers a requirement to bring the entire structure into full compliance with the provisions of this Code. The existing structure, as well as any reconstruction, rehabilitation, addition, or other improvement, must meet the standards of new construction in this Code;
- (8) Any improvement to an existing structure that is less than a substantial improvement requires the improvement, but not the existing structure, to be in full compliance with the provisions of this Code;
- (9) All manufactured homes to be placed within a Special Flood Hazard Area on a community's FIRM shall be installed using methods and practices which minimize flood damage. For the purposes of this requirement, manufactured homes must be elevated and anchored to resist flotation, collapse, or lateral movement. Methods of anchoring may include, but are not limited to, use of over-the-top or frame ties to ground anchors. This requirement is in addition to applicable State and local anchoring requirements for resisting wind forces. Screw augers or expanding anchors will not satisfy the requirement of this provision;
- (10) The design or location of electrical, heating, ventilation, plumbing, and air conditioning equipment for new structures, or for any improvements to an

existing structure, must be elevated one (1) foot above the Base Flood Elevation (BFE); (Ord. No. 10:099, § 1, 01-18-2011)

- (11) The design of all new and replacement water supply systems must minimize or eliminate infiltration of floodwaters into the system during base flood events;
- (12) The design of all new and replacement sanitary sewage systems must minimize or eliminate infiltration of floodwaters into the system during flooding events, and must prevent sewage discharge from the systems into floodwaters;
- (13) The placement of on-site waste disposal systems must avoid impairment to, or contamination from, the disposal system during base flood events;
- (14) Construction of basement foundations in any Special Flood Hazard Area is prohibited;
- (15) New construction and substantial improvements, with fully enclosed areas (such as garages and crawlspaces) below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are below the base flood elevation shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria:
 - (a) A minimum of two (2) openings on separate walls having a total net area of not less than one (1) square inch for every square foot of enclosed area subject to flooding shall be provided;
 - (b) The bottom of all openings shall be no higher than one (1) foot above grade;
 - (c) Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of floodwaters.
- (16) The placement of recreational vehicles (RV) in Special Flood Hazard Areas must either:
 - (a) Be temporary, as demonstrated by the RV being fully licensed, being on wheels or a jacking system, attached to the site only by quick disconnect type utilities and security devices, having no permanently attached additions, and being immobile for no more than 180 consecutive days; or else
 - (b) Meet all provisions of this Code applicable to manufactured home structures.
- (17) All proposals for the development of a residential subdivision, commercial business park or manufactured home park/subdivision must have public utilities

and facilities such as sewer, gas, electrical and water systems located and constructed to minimize or eliminate flood damage;

- (18) All proposals for the development of a residential subdivision, commercial business park or a manufactured home park/subdivision must include an adequate drainage plan to reduce exposure to flood hazards; and,
- (19) All proposals for the development of a commercial business park or a manufactured home park/subdivision must include an adequate evacuation plan for the escape of citizens from affected nonresidential structures during flooding events.
- (20) A minimum of a ten (10) foot buffer shall be placed between any structure and the floodway.
- (21) The cost of any reconstruction, remodeling, addition or improvement to a structure in a Special Flood Hazard Area in the preceding three (3) years shall be considered as part of the current improvement costs in the substantial improvement determination, unless the specific improvements are otherwise excluded by definition. (Ord. No. 11:013, §1, 02-15-2011)

9.2 RISK ZONE SPECIFIC STANDARDS

In addition to the General Standards, the following standards apply to specific development types in specific Risk Zones. Risk Zones listed in this Code that do not appear on the current FIRM are not applicable.

- (1) **In AE Risk Zones:** Special Flood Hazard Areas with base floods determined
 - (a) For Residential Structures in Zone AE:
 1. For all new residential structures, the top surface of the lowest floor must have an elevation (1 foot or more) above the published BFE. This elevation must be documented on an Elevation Certificate properly completed by a Professional Engineer, Surveyor, or Architect licensed to practice in the State of Arkansas.
 2. For all substantial improvements or substantial damage to existing residential structures, the entire structure becomes subject to the requirements of a new residential structure.
 3. For any reconstruction, rehabilitation, addition, or other improvement to an existing residential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new residential structure.

- (b) For Nonresidential Structures in Zone AE:
1. All new commercial, industrial or other nonresidential structures must either:
 - a. have the lowest floor (including basement) elevated (1 feet or more) above the base flood level or
 - b. be floodproofed such that, together with attendant utility and sanitary facilities, be designed so that below (an elevation of 2 feet above) the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy. (Ord. No. 11:059, §1, 09-20-2011)
 - c. a registered professional engineer or architect shall develop and/or review structural design, specifications, and plans for the construction, and shall certify on a Floodproofing Certificate that the design and methods of construction are in accordance with accepted standards of practice as outlined in this subsection. A record of such certification which includes the specific elevation (in relation to mean sea level) to which such structures are floodproofed shall be maintained by the Floodplain Administrator.
 2. For all substantial improvements or substantial damage to existing commercial, industrial or other nonresidential structures the entire structure becomes subject to the requirements of a new nonresidential structure.
 3. For any reconstruction, rehabilitation, addition, or other improvement to an existing nonresidential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new nonresidential structure.
- (c) For Manufactured Homes in Zone AE:
1. All manufactured homes that are placed or substantially improved on sites:
 - a. outside of a manufactured home park or subdivision,
 - b. in a new manufactured home park or subdivision,
 - c. in an expansion to an existing manufactured home park or subdivision, or
 - d. in an existing manufactured home park or subdivision on which a manufactured home has incurred "substantial damage" as a result of a flood, be elevated on a permanent foundation such that the lowest floor of the

manufactured home is elevated (1 foot or more) above the base flood elevation and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.

2. Require that manufactured homes be placed or substantially improved on sites in an existing manufactured home park or subdivision on the community's FIRM that are not subject to the provisions of paragraph (1.) of this section be elevated so that either:
 - a. the lowest floor of the manufactured home is (1 foot or more) above the base flood elevation, or
 - b. the manufactured home chassis is supported by reinforced piers or other foundation elements of at least equivalent strength that are no less than 36 inches in height above grade and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.
3. For all substantial improvements or substantial damage to existing manufactured home, the entire structure becomes subject to the requirements of a new manufactured home.
4. For any reconstruction, rehabilitation, addition, or other improvement to an existing manufactured home that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new manufactured home.

(d) Where FEMA has not established a regulatory floodway in Zone AE, no Floodplain Development Permit may be issued unless a detailed engineering analysis is submitted along with the application that demonstrates the increase in base floodwater elevation due to the proposed development and all cumulative developments since the publication of the current FIRM will be less than 1 foot.

(2) **Floodways** - High risk areas of stream channel and adjacent floodplain

- a) Developments in regulatory floodways are prohibited, unless:
 1. A No-Rise Certificate, signed and stamped by a Professional Engineer licensed to practice in the State of Arkansas, is submitted to demonstrate through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed development would not result in any increase in flood levels within the community during the occurrence of a base flood event; or
 2. All requirements of 44 CFR §65.12 are first met.

- b) No Manufactured Home may be placed in a regulatory floodway, regardless of elevation height, anchoring methods, or No-Rise Certification.

(3) **In AH or AO Risk Zones:** Special Flood Hazard Areas of shallow flooding

(a) For Residential Structures in Zones AH or AO:

1. All new residential structures must be constructed with the top surface of the lowest floor elevated (1 foot or more) above the published BFE, or (2 feet or more) above the highest adjacent grade in addition to the depth number specified (at least 2 feet if no depth number is specified) on the community's FIRM. This elevation must be documented on an Elevation Certificate properly completed by a Professional Engineer, Surveyor or Architect licensed to practice in the State of Arkansas.
2. For all substantial improvements or substantial damage to existing residential structures the entire structure becomes subject to the requirements of a new residential structure.
3. For any reconstruction, rehabilitation, addition, or other improvement to an existing residential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new residential structure

(b) For Nonresidential Structures in Zones AH or AO:

1. All new commercial, industrial or other nonresidential structure must either:
 - a. have the top surface of the lowest floor elevated (1 foot or more) above the published BFE, or (2 feet or more) above the highest adjacent grade in addition to the depth number specified (at least 2 feet if no depth number is specified) on the community's FIRM, with documentation on an Elevation Certificate properly completed by a Professional Engineer, Surveyor or Architect licensed to practice in the State of Arkansas; or
 - b. be floodproofed such that the structure, together with attendant utility and sanitary facilities be designed so that below (2 feet or more) above the published BFE in Zone AH, or (2 feet or more) above the base specified flood depth in an AO Zone, the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads of effects of buoyancy. (Ord. No. 11:059, § 1, 09-20-2011)

2. For all substantial improvements or substantial damage to existing commercial, industrial or other nonresidential structures the entire structure becomes subject to the requirements of a new nonresidential structure.
 3. For any reconstruction, rehabilitation, addition, or other improvement to an existing nonresidential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new nonresidential structure.
- (c) For Manufactured Homes in Zones AH or AO:
1. All manufactured homes that are placed or substantially improved on sites:
 - a. outside of a manufactured home park or subdivision,
 - b. in a new manufactured home park or subdivision,
 - c. in an expansion to an existing manufactured home park or subdivision, or
 - d. in an existing manufactured home park or subdivision on which a manufactured home has incurred "substantial damage" as a result of a flood, be elevated on a permanent foundation such that the lowest floor of the manufactured home is elevated (1 feet or more) above the published BFE, or (2 feet or more) above the highest adjacent grade in addition to the depth number specified (at least 2 feet if no depth number is specified) on the community's FIRM, and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.
 2. Require that manufactured homes be placed or substantially improved on sites in an existing manufactured home park or subdivision on the community's FIRM that are not subject to the provisions of paragraph 1. of this section be elevated so that either:
 - a. the lowest floor of the manufactured home meets the elevation standard of paragraph 1., or
 - b. the manufactured home chassis is supported by reinforced piers or other foundation elements of at least equivalent strength that are no less than 36 inches in height above grade and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.
 3. For all substantial improvements or substantial damage to existing manufactured home, the entire structure becomes subject to the requirements of a new manufactured home.

4. For any reconstruction, rehabilitation, addition, or other improvement to an existing manufactured home that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new manufactured home.
 - (d) Where FEMA has not established a regulatory floodway in Zones AH or AO, no Floodplain Development Permit may be issued unless a detailed engineering analysis is submitted along with the application that demonstrates the increase in base floodwater elevation due to the proposed development and all cumulative developments since the publication of the current FIRM will be less than 1 foot.
 - (e) Require adequate drainage paths around structures on slopes, to guide flood waters around and away from proposed structures.
- (4) **In “A” Risk Zones:** Special Flood Hazard Areas with no base flood elevations determined
 - (a) In Zone A, The applicant or the applicant’s agent must determine a base flood elevation prior to construction. The BFE will be based on a source or method approved by the local Floodplain Administrator.
 - (b) For Residential Structures in Zone A:
 1. For all new residential structures, the top surface of the lowest floor must have an elevation (1 feet or more) above the BFE. This elevation must be documented on an Elevation Certificate properly completed by a Professional Engineer, Surveyor or Architect licensed to practice in the State of Arkansas.
 2. For all substantial improvements or substantial damage to existing residential structures, the entire structure becomes subject to the requirements of a new residential structure.
 3. For any reconstruction, rehabilitation, addition, or other improvement to an existing residential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new residential structure.
 - (c) For Nonresidential Structures in Zone A:
 1. All new commercial, industrial or other nonresidential structures must either:
 - a. have the lowest floor (including basement) elevated (1 feet or more) above the base flood level or
 - a. be floodproofed such that, together with attendant utility and sanitary facilities, be designed so that below (an elevation of 2 feet above)the base flood level the structure

is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy. (Ord. No. 11:059, § 1, 09-20-2011)

- c. A registered professional engineer or architect shall develop and/or review structural design, specifications, and plans for the construction, and shall certify on a Floodproofing Certificate that the design and methods of construction are in accordance with accepted standards of practice as outlined in this subsection. A record of such certification which includes the specific elevation (in relation to mean sea level) to which such structures are floodproofed shall be maintained by the Floodplain Administrator.
 2. For all substantial improvements or substantial damage to existing commercial, industrial or other nonresidential structures the entire structure becomes subject to the requirements of a new nonresidential structure.
 3. For any reconstruction, rehabilitation, addition, or other improvement to an existing nonresidential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new nonresidential structure.
- (d) For Manufactured Homes in Zone A:
1. All manufactured homes that are placed or substantially improved on sites:
 - a. outside of a manufactured home park or subdivision,
 - b. in a new manufactured home park or subdivision,
 - c. in an expansion to an existing manufactured home park or subdivision, or
 - d. in an existing manufactured home park or subdivision on which a manufactured home has incurred "substantial damage" as a result of a flood, be elevated on a permanent foundation such that the lowest floor of the manufactured home is elevated (1 feet or more) above the base flood elevation and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.
 2. Require that manufactured homes be placed or substantially improved on sites in an existing manufactured home park or subdivision on the community's FIRM that are not subject to the provisions of paragraph (1.) of this section be elevated so that either:

- a. the lowest floor of the manufactured home is (1 foot or more) above the base flood elevation, or
 - b. the manufactured home chassis is supported by reinforced piers or other foundation elements of at least equivalent strength that are no less than 36 inches in height above grade and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.
3. For all substantial improvements or substantial damage to existing manufactured home, the entire structure becomes subject to the requirements of a new manufactured home.
 4. For any reconstruction, rehabilitation, addition, or other improvement to an existing manufactured home that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new manufactured home.
- (e) Base flood elevation data and a regulatory floodway, utilizing accepted engineering practices, shall be generated for subdivision proposals and other proposed development including the placement of manufactured home parks and subdivisions which is greater than 50 lots or 5 acres, whichever is lesser, if not otherwise provided.

9.3 Hydrology

Any hydrologic study performed within the City of Brookland must comply with the guidelines set forth in this manual. This includes submitting a hydrologic work map that includes watershed boundaries, and all other hydrologic parameters. If the Design Engineer wishes to use an alternative hydrologic analysis methodology, the City Engineer shall be consulted prior to the start of the analysis. In locations where FEMA hydrology exists, the FEMA hydrology model shall be used. FEMA models shall be updated, as deemed necessary, by the City Engineer to simulate current development within the drainage basin.

9.4 Hydraulics

Any modification to a floodway or floodplain where no floodway has been determined within the City of Brookland requires a hydraulic study, performed by a Professional Engineer licensed in the State of Arkansas. All hydraulic studies along water courses must comply with FEMA's guidelines.

The Corps of Engineers HEC-RAS computer program shall be used to compute the water surface elevation. To do so, cross sections along the watercourse must be no greater than 400 ft. apart for tangent sections of channel and no greater than 200 ft. apart for curvilinear sections of channel unless otherwise approved by the City Engineer. Roughness values shall be determined based on values in Table 4 in Appendix 1. A printout of the computer model as well as an electronic copy of the HEC-RAS files shall be submitted with the Hydraulic Report for any work proposed in the floodplain. All hydraulic models shall conform to survey control requirement of Section 2.2.

Table 4 in Appendix 1, shows the maximum permissible velocities that are to be allowed in the channel. Velocities above that which are shown in this table, must be reduced or approved by the City Engineer.

9.5 SFHA Submittals

(1) Elevation Certificates

(b) Minimum requirements for all elevation certificate submittals are as follows:

1. Submit two original copies of all elevation certificates with permit applications;
2. The basis for all base flood elevations in Zone AE areas shall be determined using the FIS Profiles, not scaled off the FIRM;
3. Provide at least two site pictures and a vicinity map with all submittals (includes pre-construction elevation certificates). The vicinity map shall depict, at a minimum, the following:
 - a. Location of floodplain and floodway (where floodway is applicable);
 - b. Property Lines (Plat of Survey);
 - c. Spot elevation for all pertinent data to include all utilities servicing the building;
 - d. Adjacent waterway name;
 - e. Surrounding street names;
 - f. Location of utilized benchmark;
 - g. Dimensioned location of building on property;
 - h. North arrow; and,
 - i. Scale

(2) Letter of Map Change

(a) For letters of map change, submit all FEMA requirements and forms requested included in the MT-1, MT-2, and MT-EZ standard application packs;

(b) As-built or topographic surveys are required for all LOMR-F submittals. These surveys shall depict, at a minimum, the following:

1. Location of floodplain and floodway (where floodway is applicable),
2. Adjacent waterway name;
3. Surrounding street names;
4. Location of utilized benchmark;
5. Location of property and buildings;
6. Spot elevations;
7. Natural ground contours (maximum one foot contour interval);
8. North arrow; and,

9. Scale

All SFHA submittals must comply with all guidelines set forth in this manual and all utilized survey control must be based on state or federal published benchmarks.

10.0 EROSION CONTROL

10.1 General

Any development within the City of Brookland Planning jurisdiction must comply with the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended, Ark. Code Ann. 8-4-101 et seq.) and the Clean Water Act (33 U.S.C. 1251 et seq.), and shall obtain authorization to discharge storm water associated with construction activity under the National Pollutant Discharge Elimination System (NPDES) permit program administered by the Arkansas Department of Environmental Quality (ADEQ). Eligibility and permit requirements for this program are provided in Appendix 7.

In addition to the Federal and State requirements, any development within the City of Brookland Planning jurisdiction shall comply with the provisions of Section 2.3, 2.6 (B)(3), and Section 3.3 of the Stormwater Management Regulations.

10.2 Environmental Protection Agency BMP's

In 1996, under a cooperative agreement between the [American Society of Civil Engineers \(ASCE\)](#) and the [U.S. Environmental Protection Agency \(USEPA\)](#) the International Stormwater Best Management Practices (BMP) Database was developed monitoring the performance of BMP techniques. All BMP studies, performance analysis results, tools for use in BMP performance studies, monitoring guidance and other study-related publications can be found at www.bmpdatabase.org. This website provides scientifically sound information to improve the design, selection and performance of BMPs. Designers shall utilize appropriate BMP's as they relate to each specific project.

APPENDIX 1
LIST OF TABLES

Appendix 1

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2	Roughness Coefficients for Closed Conduits
2-1	TR-55 Runoff Depth for Selected CN's and Rainfall Amounts
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4	Roughness Coefficients for Open Channels
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7	Design Criteria for the Design of Roads, Culverts, and Channels
8	Entrance Loss Coefficients for Culverts

**TABLE 1
(Intentionally Deleted)**

TABLE 2
Roughness Coefficients for Closed Conduits*

Material of New Construction	Recommended Roughness Coefficient, n
Concrete Pipe Storm Sewer	0.013
Corru`gated Metal Pipe Culverts	0.024

Material of Existing Systems	Recommended Roughness Coefficient, n
Concrete Pipe Storm Sewer	
Fair Alignment, Ordinary Joints	0.015
Poor Alignment, Poor Joints	0.017
Concrete Pipe Culverts	0.012
Corrugated Metal Pipe Culverts	0.030

****Note: For materials other than those listed here, use manufacturer's suggestion and/or City Engineers recommendations.***

Table 2-1 Runoff depth for selected CN's and rainfall amounts ^{1/}

Rainfall	Runoff depth for curve number of—												
	40	45	50	55	60	65	70	75	80	85	90	95	98
	inches												
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.15	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
2.0	.00	.00	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
2.5	.00	.00	.02	.08	.17	.30	.46	.65	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	.71	.96	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	1.01	1.30	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	.24	.44	.69	.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	.50	.80	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.56	6.22	6.88	7.52	8.16	8.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.81	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.71	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

^{1/} Interpolate the values shown to obtain runoff depths for CN's or rainfall amounts not shown.

Table 2-2a Runoff curve numbers for urban areas ^{1/}

Cover description	Average percent impervious area ^{2/}	Curve numbers for hydrologic soil group			
		A	B	C	D
<i>Fully developed urban areas (vegetation established)</i>					
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
<i>Developing urban areas</i>					
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.

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
		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 Hydraulic condition is based on combination 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, (d) percent of residue cover on the land surface (good $\geq 20\%$), 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.

Table 2-2c Runoff curve numbers for other agricultural lands ^{1/}

Cover description ----- Cover type	Hydrologic condition	Curve numbers for ----- hydrologic soil group -----			
		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	30 ^{4/}	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	30 ^{4/}	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.

Worksheet 2: Runoff curve number and runoff

Project	By	Date
Location	Checked	Date

Check one: Present Developed

1. Runoff curve number

Soil name and hydrologic group <small>(appendix A)</small>	Cover description <small>(cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)</small>	CN ¹			Area <input type="checkbox"/> acres <input type="checkbox"/> mi ² <input type="checkbox"/> %	Product of CN x area
		Table 2-2	Figure 2-3	Figure 2-4		

¹ Use only one CN source per line

Totals ➡

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = _____ = _____ ; **Use CN** ➡

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency..... yr			
Rainfall, P (24-hour) in			
Runoff, Q..... in			
<small>(Use P and CN with table 2-1, figure 2-1, or equations 2-3 and 2-4)</small>			

Worksheet 4: Graphical Peak Discharge method

Project	By	Date
Location	Checked	Date

Check one: Present Developed

1. Data

Drainage area $A_m =$ _____ mi^2 (acres/640)

Runoff curve number $CN =$ _____ (From worksheet 2)

Time of concentration $T_c =$ _____ hr (From worksheet 3)

Rainfall distribution = _____ (I, IA, II III)

Pond and swamp areas spread throughout watershed = _____ percent of A_m (_____ acres or mi^2 covered)

	Storm #1	Storm #2	Storm #3
2. Frequency yr			
3. Rainfall, P (24-hour)..... in			
4. Initial abstraction, I_a in (Use CN with table 4-1)			
5. Compute I_a/P			
6. Unit peak discharge, q_u csm/in (Use T_c and I_a/P with exhibit 4- _____)			
7. Runoff, Q in (From worksheet 2) Figure 2-6			
8. Pond and swamp adjustment factor, F_p (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)			
9. Peak discharge, q_p ft^3/s (Where $q_p = q_u A_m Q F_p$)			

TABLE 4
Roughness Coefficients for Open Channels*

Channel Description	Recommended Roughness Coefficients			Maximum Velocity (ft/s)
	Minimum	Normal	Maximum	
Minor Natural Streams				
Moderately Well Defined Channel				
Grass and Weeds, Little Brush	0.025	0.030	0.033	8
Dense Weeds, Little Brush	0.030	0.035	0.040	8
Weeds, Light Brush on Banks	0.030	0.035	0.040	8
Weeds, Heavy Brush on Banks	0.035	0.050	0.060	8
Weeds, Dense Willow on Banks	0.040	0.060	0.080	8
Irregular Channel With Pools and Meanders				
Grass and Weeds, Little Brush	0.030	0.036	0.042	8
Dense Weeds, Little Brush	0.036	0.042	0.048	8
Weeds, Light Brush on Banks	0.036	0.042	0.048	8
Weeds, Heavy Brush on Banks	0.042	0.060	0.072	8
Weeds, Dense Willow on Banks	0.048	0.072	0.096	8
Floodplain, Pasture				
Short Grass, No Brush	0.030	0.035	0.040	8
Tall Grass, No Brush	0.035	0.040	0.050	8
Floodplain, Cultivated				
No Crops	0.030	0.035	0.040	8
Mature Crops	0.035	0.045	0.050	8
Floodplain, Uncleared				
Heavy Weeds, Light Brush	0.050	0.060	0.070	8
Medium to Dense Brush	0.070	0.100	0.160	8
Trees with Flood Stage below Branches	0.080	0.100	0.120	8

TABLE 4
Roughness Coefficients for Open Channels*

Channel Description	Recommended Roughness Coefficients			Maximum Velocity (ft/s)
	Minimum	Normal	Maximum	
Major Natural Streams				
<i>The roughness coefficient is less than that for minor streams of similar description because banks offer less effective resistance.</i>				
Moderately Well Defined Channel	0.025		0.060	8
Irregular Channel	0.035		0.100	8
Unlined Vegetated Channels				
Mowed Grass, Clay Soil	0.025	0.030	0.035	8
Mowed Grass, Sandy Soil	0.025	0.030	0.035	6
Unlined Non-Vegetated Channels				
Clean Gravel Section	0.022	0.025	0.030	8
Shale	0.025	0.030	0.035	10
Smooth Rock	0.025	0.030	0.035	15
Earth Lined, Sandy	0.028	0.035	0.040	6
Earth Lined, Clay	0.028	0.035	0.040	8
Lined Channels				
Smooth Finished Concrete	0.013	0.015	0.020	15
Riprap (rubble)	0.030	0.040	0.050	12
Gabion	0.028	0.032	0.035	15
Pavement				
Concrete	-	0.015	-	-
Asphalt	-	0.017	-	-

***Note: Deviations from these values must be approved by the City Engineer for Brookland.**

TABLE 5A
Velocity Head Loss Coefficients for Closed Conduits

Description of Conditions	Kj
Inlet on Main Line	0.5
Inlet on Main Line with Branch Lateral	0.25
Manhole on Main Line with bend at:	
90 degrees	0.25
60 degrees	0.35
45 degrees	0.5
22.5 degrees	0.95
Wye Connection or Cut In	
60 degrees	0.6
45 degrees	0.75
22.5 degrees	0.95
Inlet or Manhole at the Beginning of Line	1.25
Conduit Curves for 90 degrees*	
Curve Radius	
2 to 8 times the diameter **	0.4
8 to 20 times the diameter	0.25
Greater than 20 times the diameter	0
Bends where the radius is equal to the Diameter	
90 degree bend	0.05
60 degree bend	0.43
45 degree bend	0.35
22.5 degree bend	0.2

The values of the coefficient "Kj" for determining the loss of head due to obstructions in pipes are shown in Table 6-B and the coefficients are used in the following equation to calculate the head loss at the obstruction:

$$H_j = K_j (V^2/2g)$$

* Where deflection other than 90 degrees are used, the 90 degree deflection coefficient can be used with the following percentage factors:

60 degree bend = 0.85

45 degree bend = 0.70

22.5 degree bend = 0.40

**The diameter is the inside diameter of the pipe.

TABLE 5B
Head Loss Coefficients Due to
Sudden Enlargements and
Contractions

D2/D1*	Sudden Enlargements, Kj	Sudden Contractions, Kj
1.2	0.1	0.08
1.4	0.23	0.18
1.6	0.35	0.25
1.8	0.44	0.33
2	0.52	0.36
2.5	0.65	0.4
3	0.72	0.42
4	0.8	0.44
5	0.84	0.45
10	0.89	0.46
> then 10	0.91	0.47

***D2/D1 = Ratio of larger to smaller diameter**

TABLE 6
Velocity Requirements for Closed Conduits*

Material of New Construction	Velocity	
	Minimum	Maximum
Storm Sewers	2.000	8
Inlet Laterals	2.000	8
Culverts	2.000	8

Note: Velocities that exceed 8 fps must be approved by the City Engineer.

For velocity requirements in Open Channels see Table 4. Storm Sewers shall discharge into open channels at a maximum velocity of 8 feet per second.

**TABLE 7
Design Criteria for the Design of Roads, Culverts, and Channels***

Road Classification	Design Return Period	Design Spreads
Major Thoroughfare		
6 Lane Divided	10-Year	Two Lanes Open Ea. Direction
	100-Year	Top of Curb
4 Lane Divided	10-Year	One Lane Open Ea. Direction
	100-Year	Top of Curb
4 Lane Undivided	10-Year	One Lane Open Ea. Direction
	100-Year	Top of Curb
Collector	10-Year	Allow 1 Lane Open
	100-Year	Top of Curb
Residential Streets	10-Year	Top of Curb
	100-Year	Contained within the Right of Way
Rural Road w/ Bar Ditches	10-Year	One Foot Below Pavement
	100-Year	Contained within the Right of Way

Other Drainage Structures***	Design Return Period
Enclosed Storm Sewer System	10-Year
Culvert or Bridge Along a Creek, River, or other Watercourse	25-Year
Culvert or Bridge not Located on a Creek River or other Watercourse	10-Year
Channel Improvements	25-Year**

***Note:** The City Engineer may reserve the right to require more stringent requirements depending on the location of a specific project. All deviations from what is shown must be approved by the City Engineer.

****Note:** For Channel Improvements the 25-year storm should be contained within the channel. Adjacent structures and lots must be a minimum of one foot above the 100-year water surface elevation.

*****Note:** All improvements in SFMA shall meet requirements of Section 9 in this manual

APPENDIX 2
FIGURES

APPENDIX 2
FIGURES

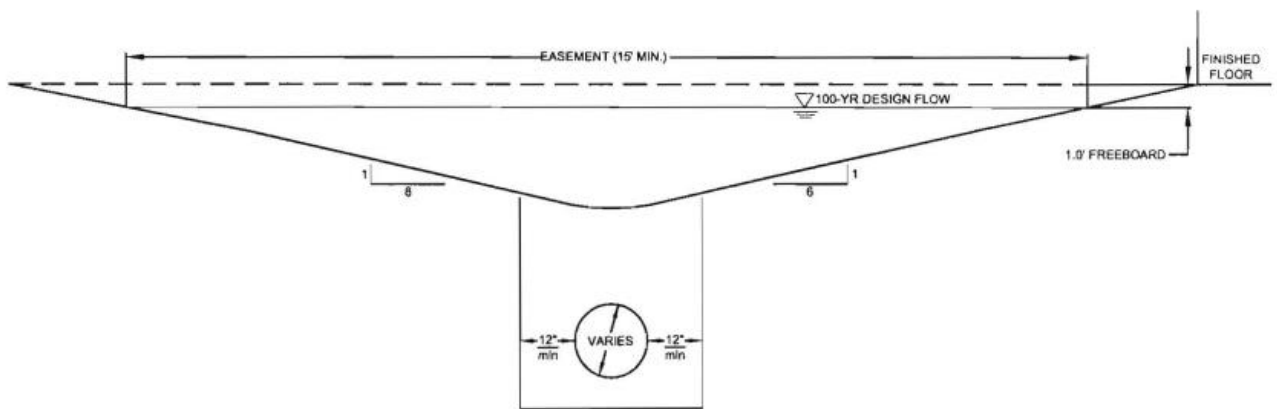
Appendix 2

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Figure Number	Title
1	Piped Flow Types
2	Open Channel Types

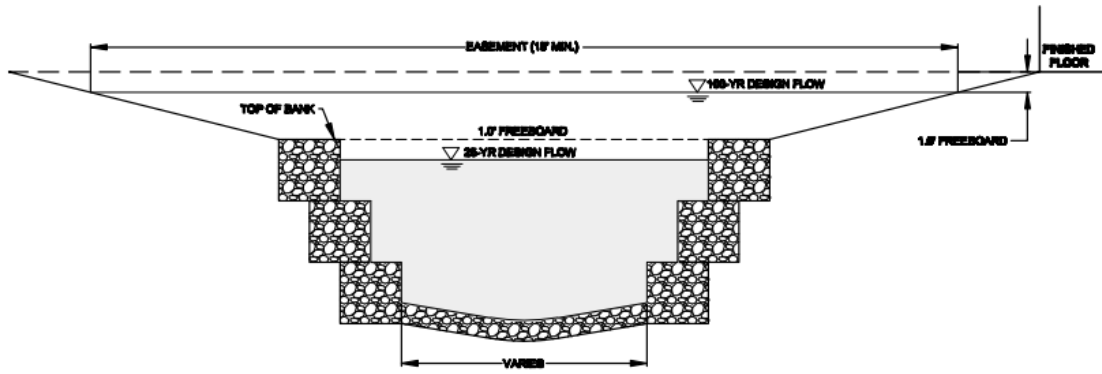
TYPICAL DRAINAGE PIPE/SWALE
SECTION

Figure 1. Piped Flow Types

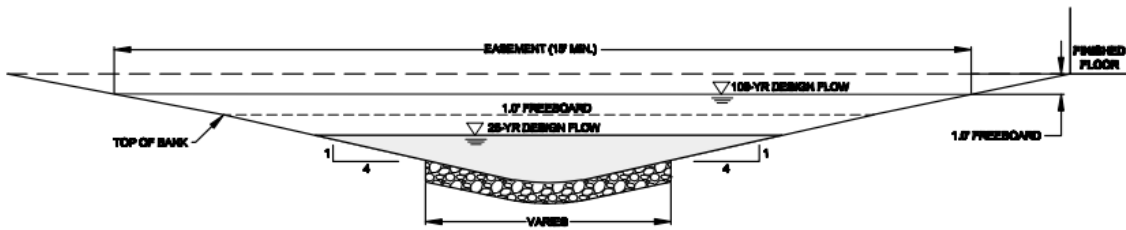


TYPICAL DRAINAGE PIPE/SWALE SECTION

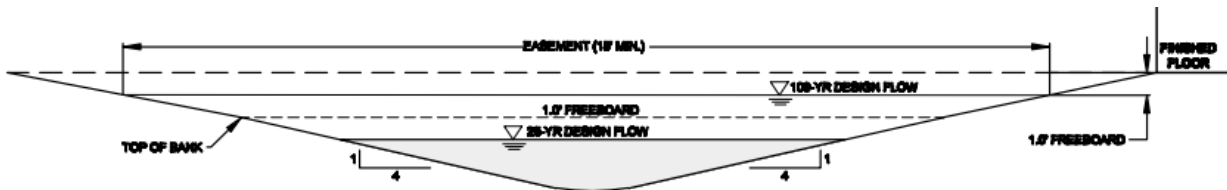
Figure 2. Open Channel Types



**TYPICAL CHANNEL IMPROVEMENT
W/ GABION LINING**



**TYPICAL IMPROVED CHANNEL IMPROVEMENT
W/ ROCK CHANNEL LINING**



TYPICAL IMPROVED UNLINED CHANNEL SECTION

**Figure 2
Appendix 2**

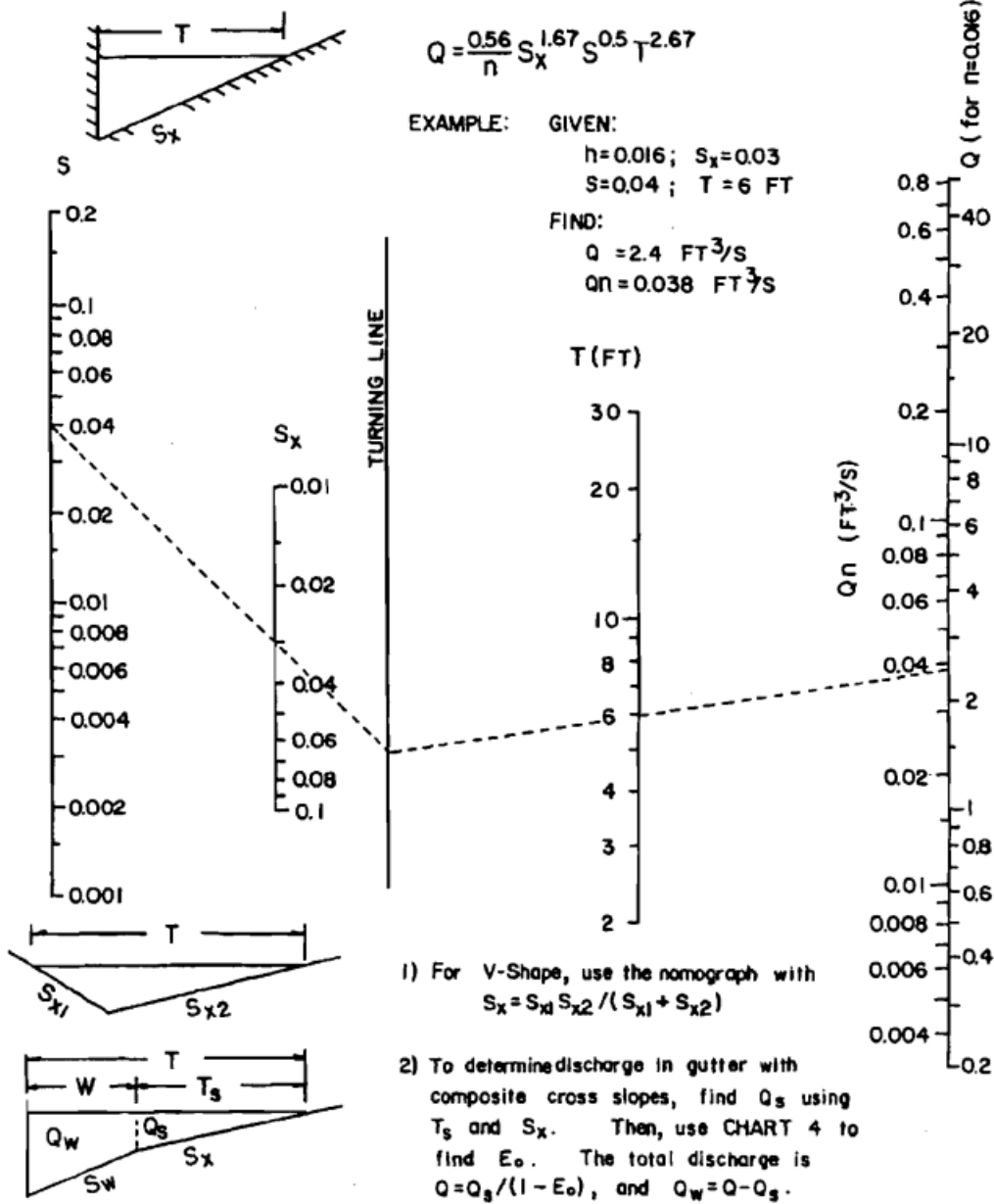
***APPENDIX 3
INTENTIONALLY DELETED***

APPENDIX 4
STREET CAPACITY NOMOGRAPHS

Appendix 4**Table of Contents**

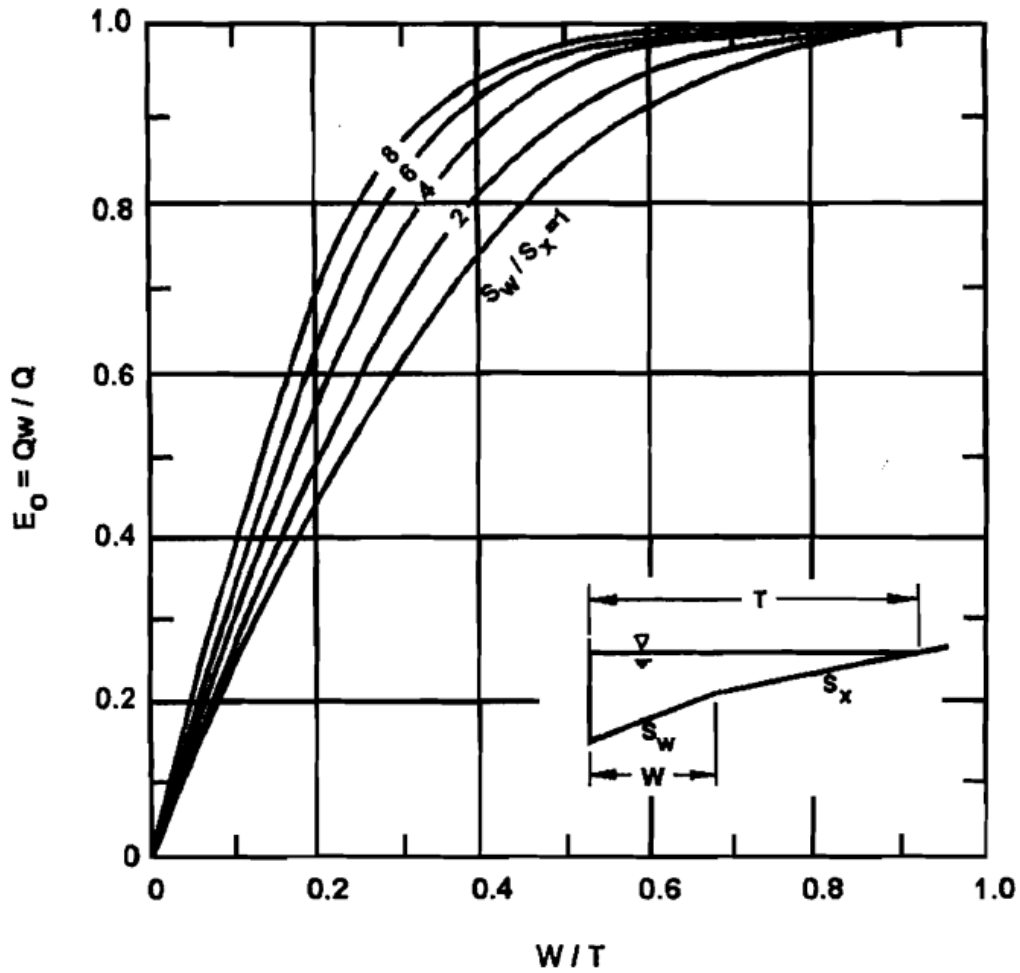
Chart Number	Title
1B	Flow in Triangular Gutter Sections
2B	Ratio of Frontal Flow to Total Gutter Flow
3B	Conveyance in Circular Channels
4B	Velocity in Triangular Gutter Sections
5B	Grate Inlet Frontal Flow Interception Efficiency
6B	Grate Inlet Side Flow Intercept Efficiency
7B	Curb-opening and Slotted Drain Inlet Length for Total Interception
8B	Curb-opening and Slotted Drain Inlet Interception Efficiency
9B	Grate Inlet Capacity in Sump Conditions
10B	Depressed Curb-opening Inlet Capacity in Sump Locations
11B	Undepressed Curb-opening Inlet Capacity in Sump Locations
12B	Curb-opening Inlet Orifice Capacity for Inclined and Vertical Orifice Throats

CHART1B



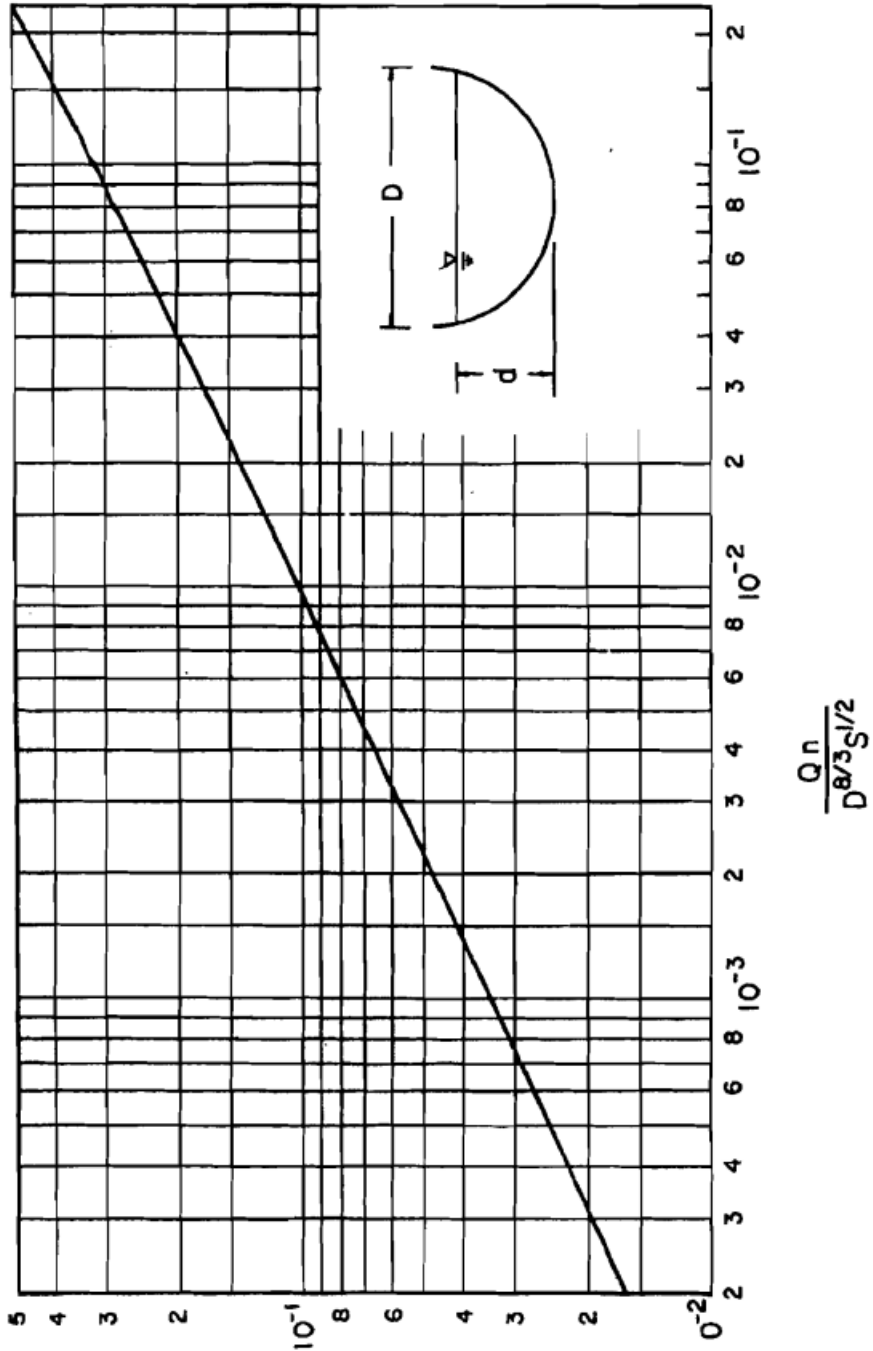
Flow in Triangular Gutter Sections - English Units

CHART 2B



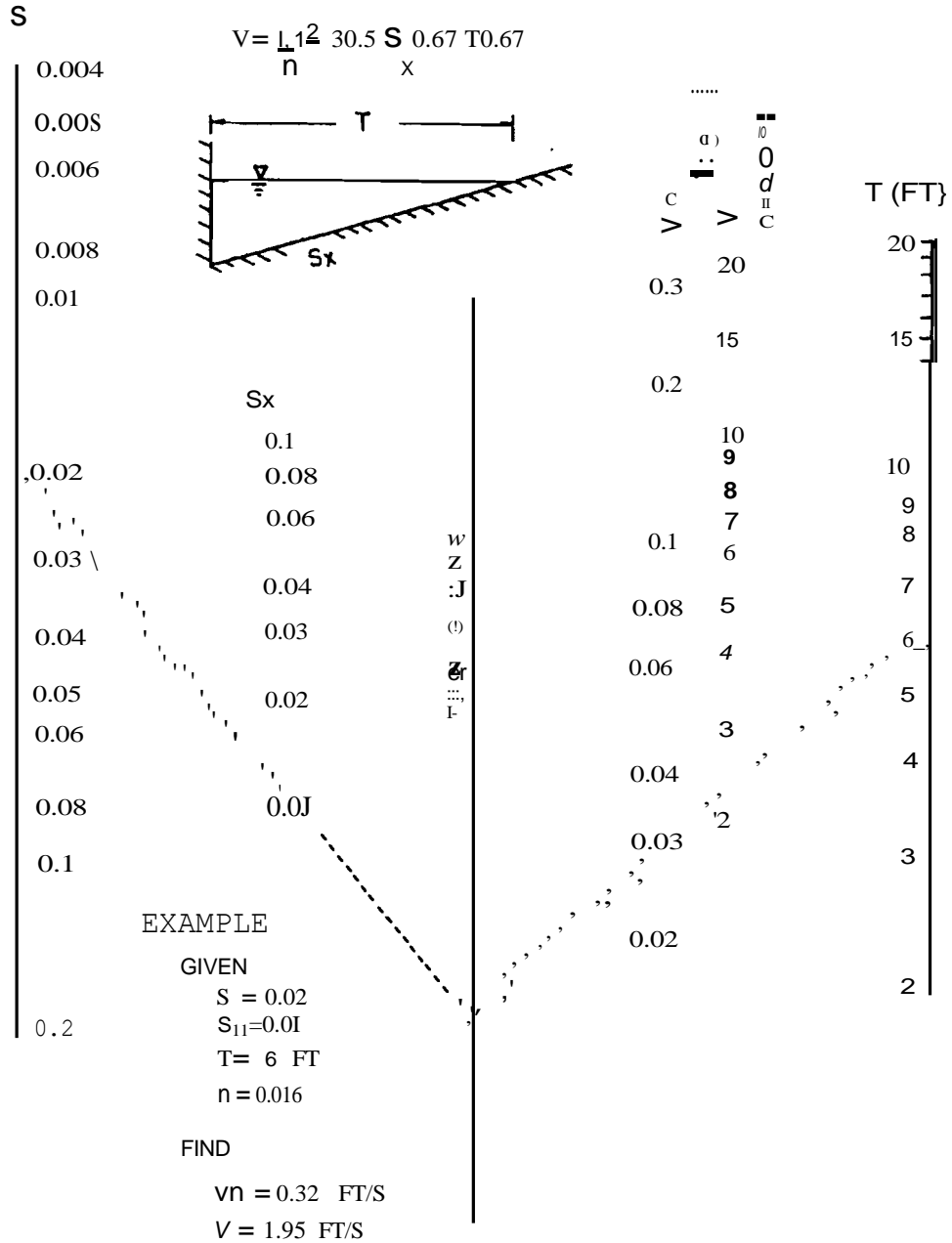
Ratio of Frontal Flow to Total Gutter Flow

CHART3B



Conveyance in Circular Channels - English Units

CHART4B



Velocity in Triangular Gutter Sections - English Units

CHART 5B

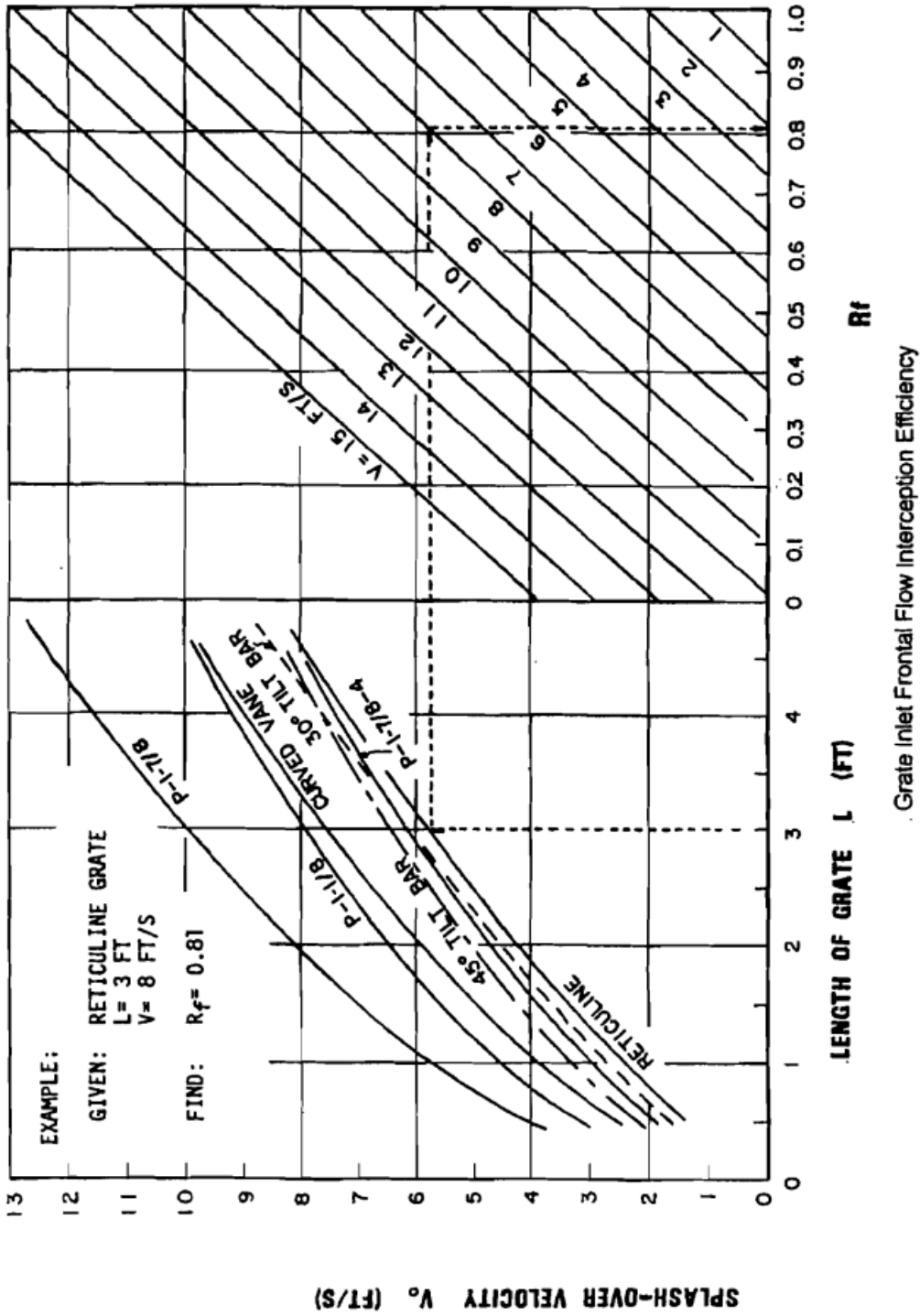
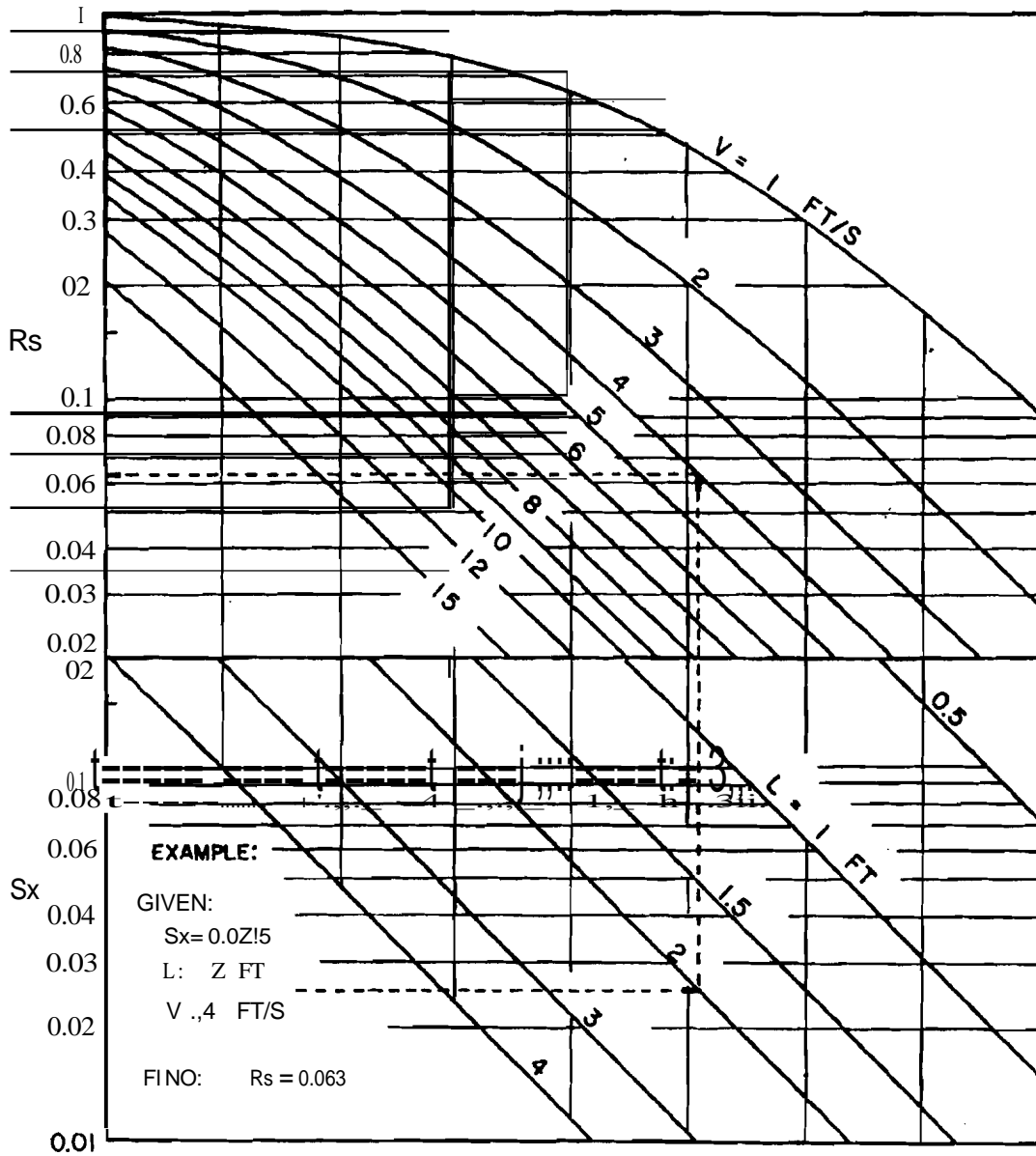


CHART6B



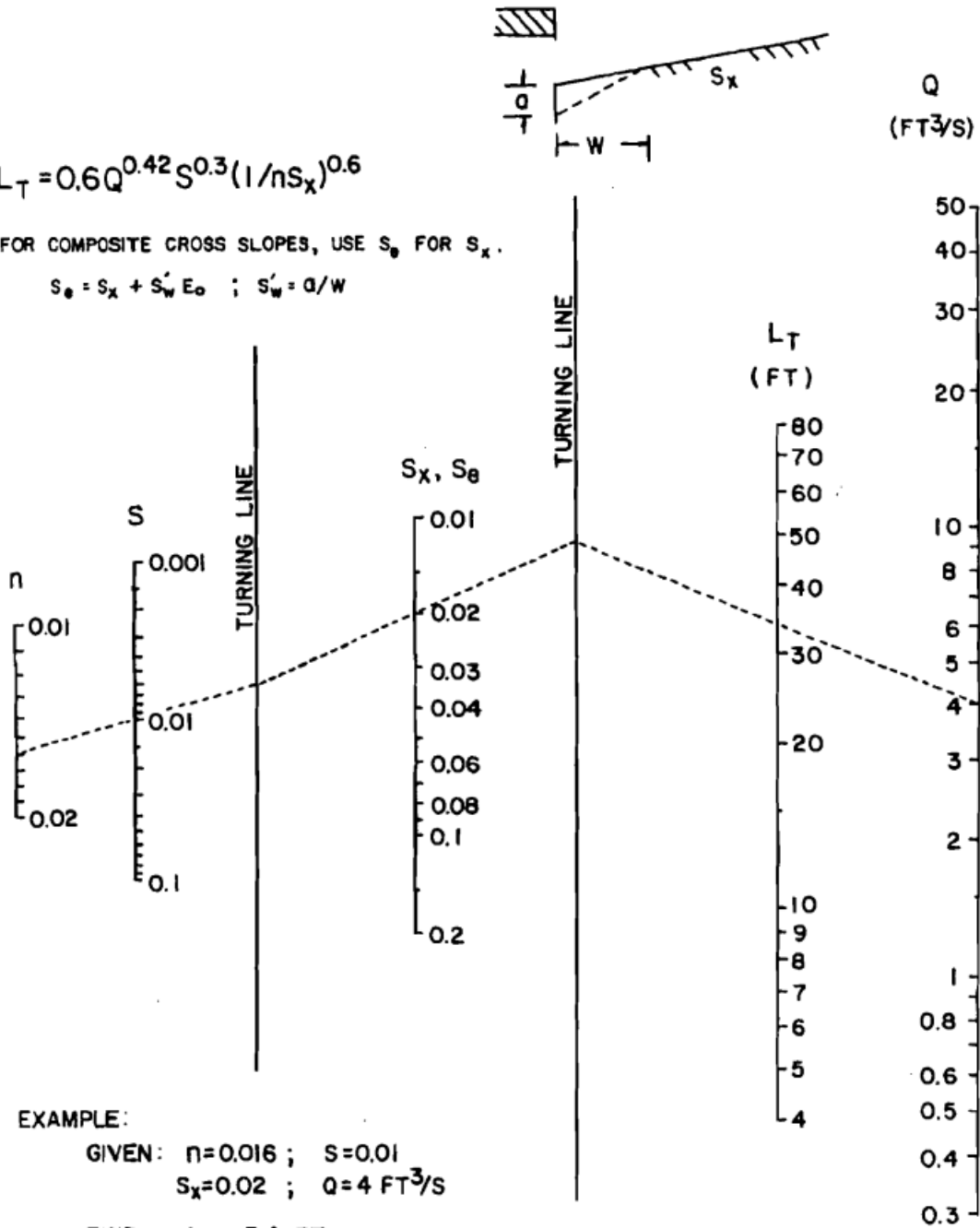
Grate Inlet Side Flow Intercept Efficiency

Curb-opening & Slotted Drain Inlet Length for Total Interception - English Units

$$L_T = 0.6Q^{0.42} S^{0.3} (1/nS_x)^{0.6}$$

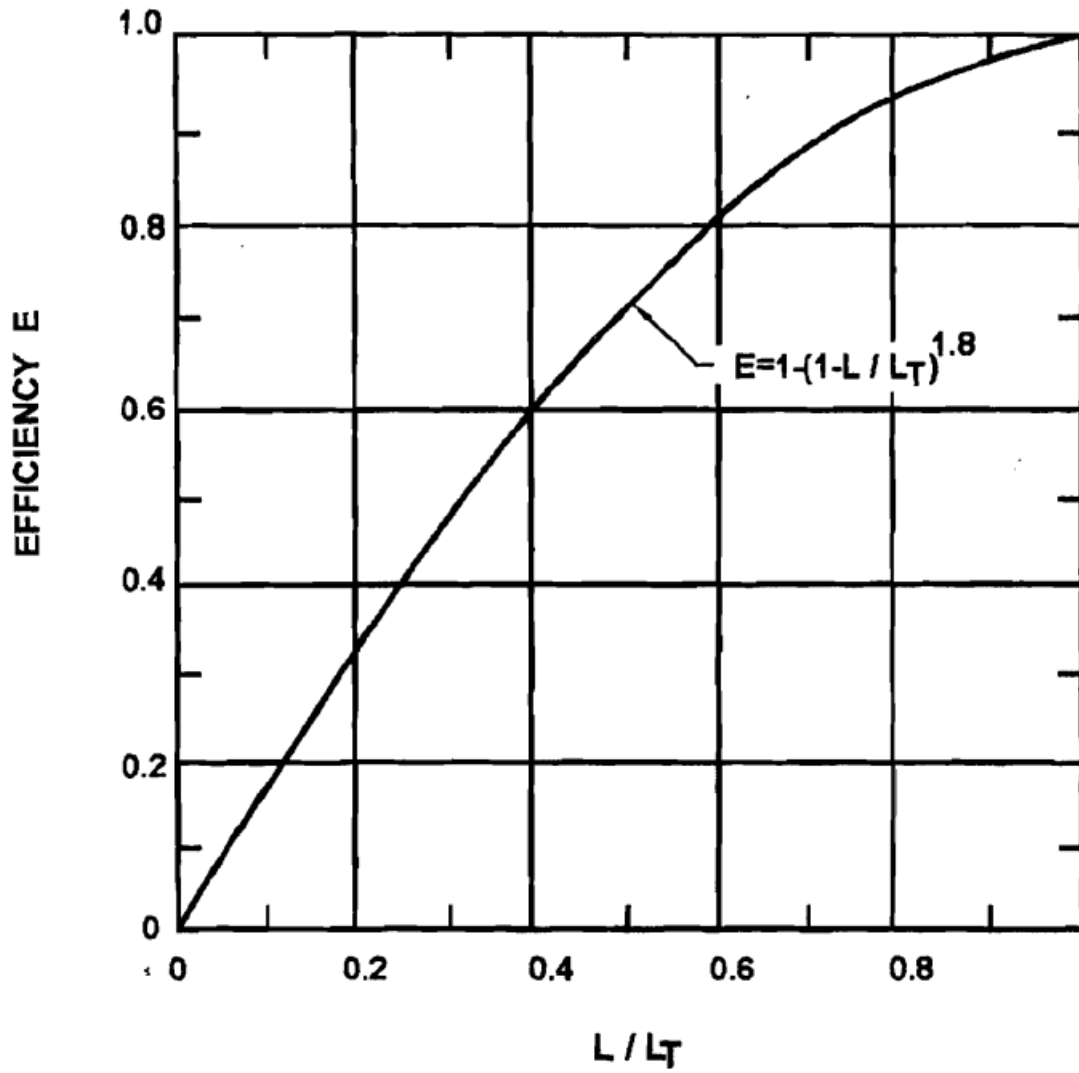
FOR COMPOSITE CROSS SLOPES, USE S_e FOR S_x .

$$S_e = S_x + S'_w E_o ; S'_w = a/W$$



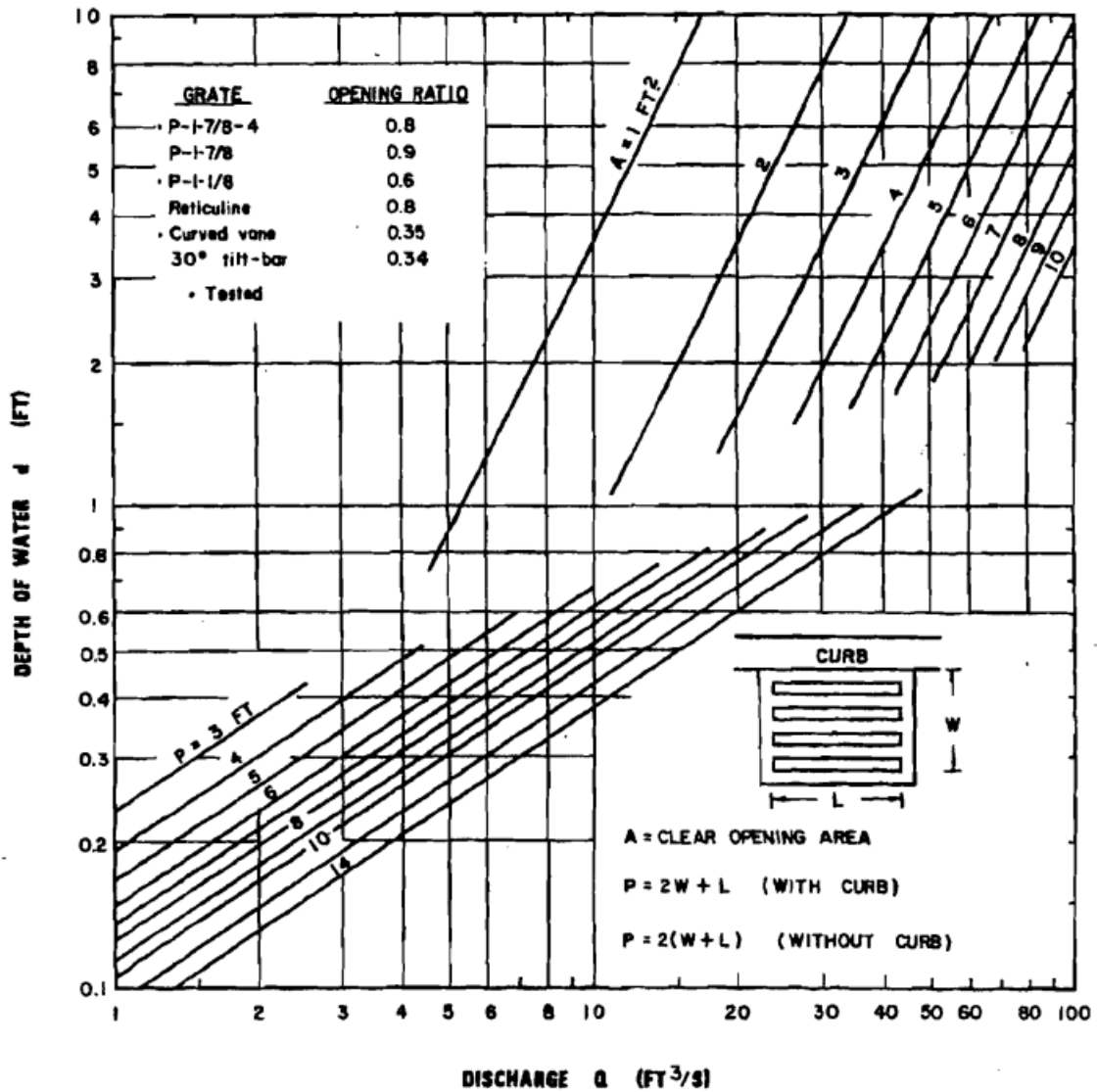
Curb-opening & Slotted Drain Inlet Length for Total Interception - English Units

CHART 8B



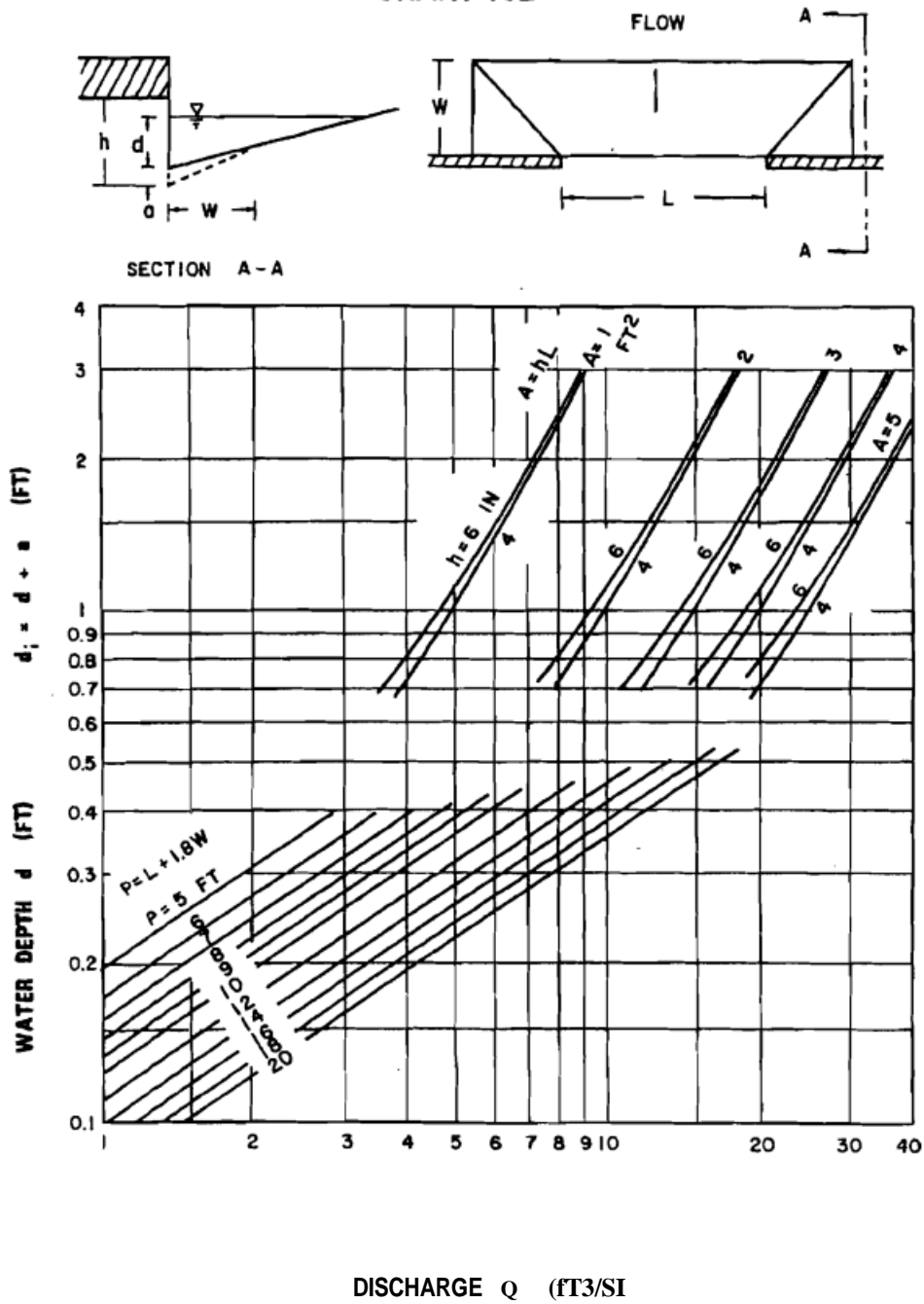
Curb-opening and Slotted Drain Inlet Interception Efficiency.

CHART 9B



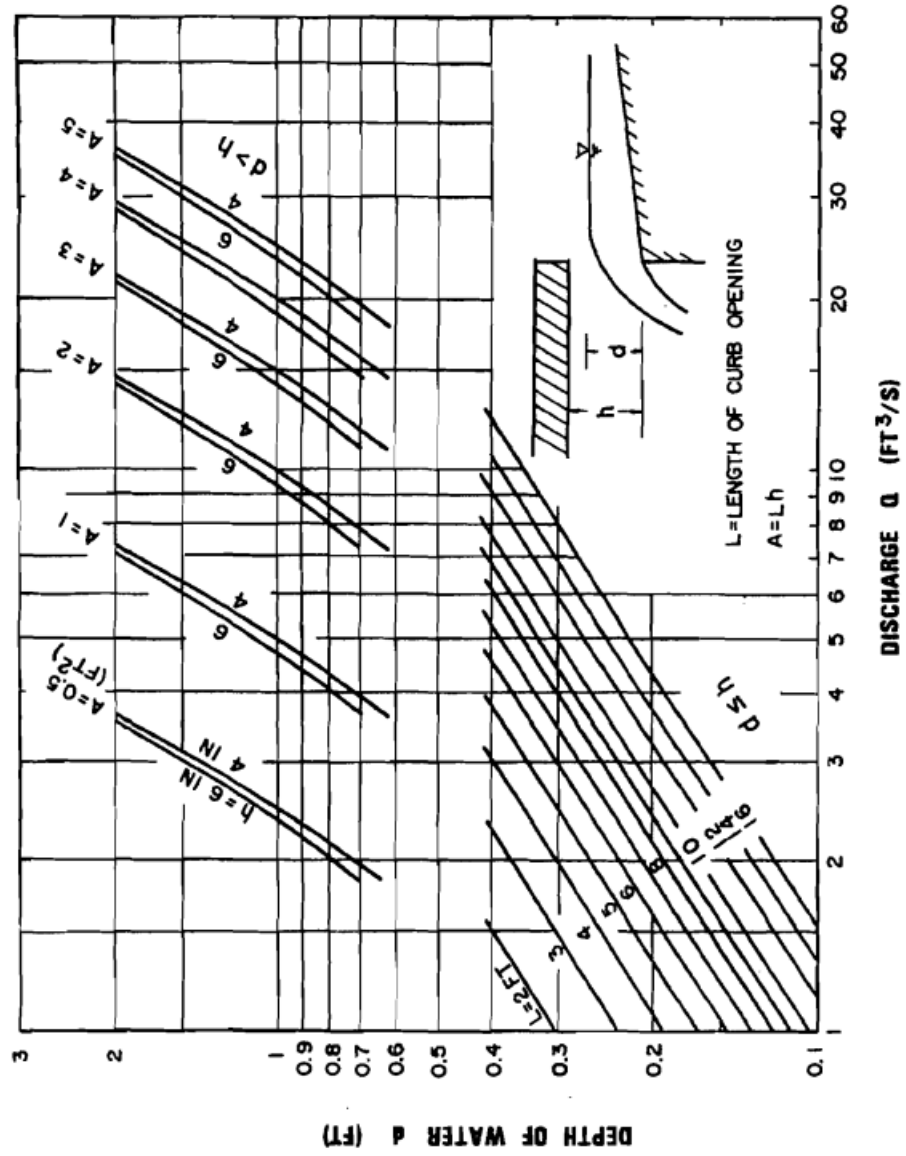
Grate Inlet Capacity in Sump Conditions - English Units

CHART 10B



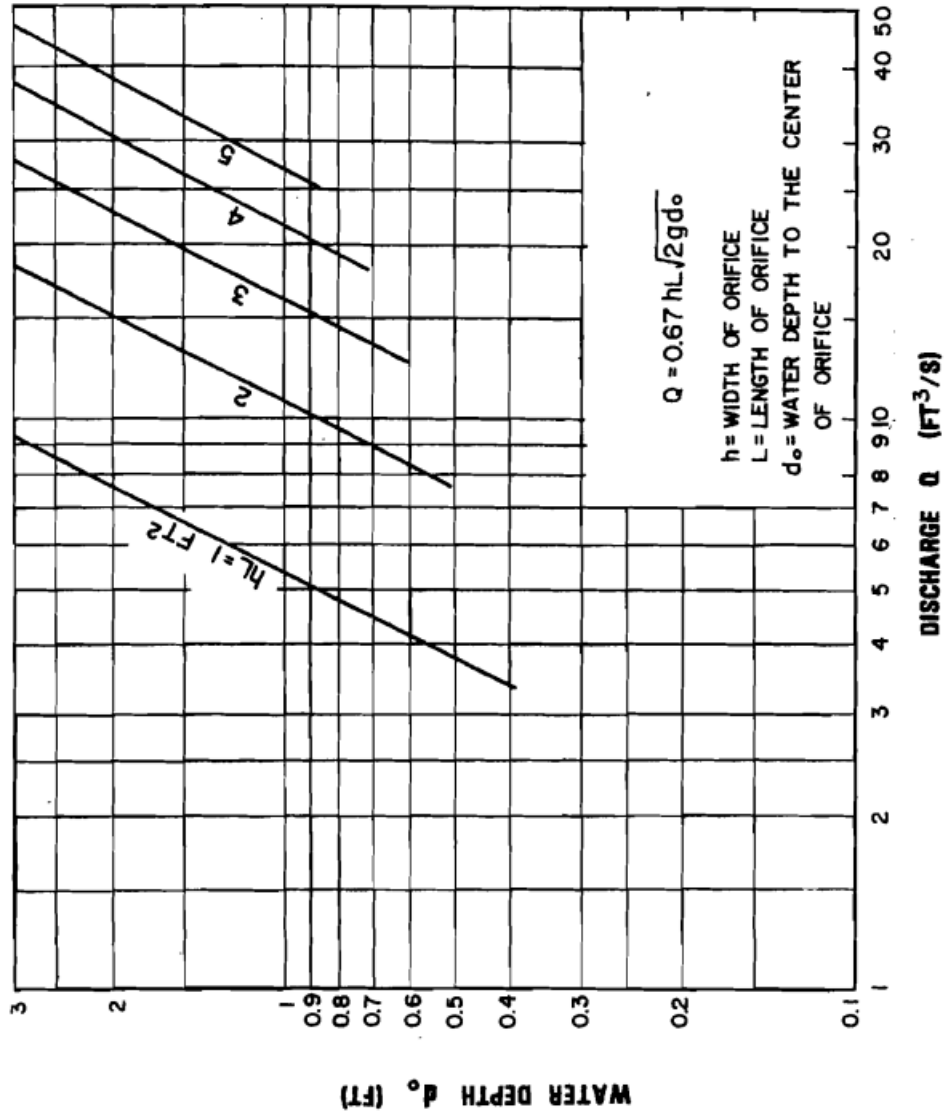
DISCHARGE Q (ft³/s)
Depressed Curb-opening Inlet Capacity in Sump Locations - English Units

CHART 11B



Undepressed Curb-opening Inlet Capacity in Sump Locations - English Units

CHART 12B



Curb-opening Inlet Orifice Capacity for Inclined and Vertical Orifice Throats - English Units

**APPENDIX 5
CULVERT NOMOGRAPHS**

Appendix 5

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Chart

Circular Culverts

1B	Headwater Depth for Concrete Pipe Culverts with Inlet Control
2B	Headwater Depth for C. M. Pipe with Inlet Control
3B	Headwater Depth for Circular Pipe Culverts with Beveled Ring Control
4B	Critical Depth - Circular Pipe
5B	Head for Concrete Pipe Culverts Flowing Full, $n = 0.012$
6B	Head for Standard C.M. Pipe Culverts Flowing Full, $n = 0.0245$
7B	Head for Structural Plate Corrugated Metal Pipe Culverts Flowing Full, $n = 0.0328$ to 0.302

Concrete Box Culverts

8B	Headwater Depth for Box Culverts with Inlet Control
9B – 27B	Headwater Depth for Inlet Control Rectangular Box Culverts, Flared Wingwalls 18° to 33.7° and 45°
28B	Head for Corrugated Metal Box Culverts Flowing Full with Corrugated Bottom Rise/Span > 0.5

Elliptical Culverts

29B	Headwater for Oval Concrete Pipe Culverts Long Axis Horizontal with Inlet Control
30B	Headwater Depth for Oval Concrete Pipe Culverts Long Axis Vertical with Inlet Control
31B	Critical Depth -Oval Concrete Pipe Long Axis Horizontal
32B	Critical Depth -Oval Concrete Pipe Long Axis Vertical
33B	Head for Oval Concrete Pipe Culverts Long Axis Horizontal or Vertical Flowing Full, $n = 0.012$

Pipe/Arch Culverts

34B	Headwater Depth for C.M. Pipe-Arch Culverts with Inlet Control
35B	Headwater Depth for Inlet Control Structural Plate Pipe-Arch Culverts, 35A -457 mm (18-inch -35B) Radius Corner Plate, Projecting or Headwall Inlet, Headwall with or without Edge Bevel
36B	Headwater Depth for Inlet Control Structural Plate Pipe-Arch Culverts, 787 mm (Chart 36A (31-inch -Chart 36B) Radius Corner Plate, Projecting or Headwall Inlet, Headwall with or without Edge Bevel
37B	Critical Depth -Standard Corrugated Metal Pipe-Arch
38B	Critical Depth -Structural Plate Corrugated Metal Pipe-Arch
39B	Head for Standard C.M. Pipe-Arch Culverts Flowing Full, $n = 0.024$
40B – 54B	Head for Structural Plate Corrugated Metal Pipe-Arch Culverts, 457 mm -40A (18-inch -40B) Corner Radius Flowing Full, $n = 0.0327$ - 0.0306

Circular Tapered Inlet

55B	Throat Control for Side-Tapered Inlets to Pipe Culvert (Circular Section Only)
56B	Face Control for Side-Tapered Inlets to Pipe Culverts (Non-Rectangular Section Only)

Chart

Rectangular Tapered Inlets

57B	Throat Control for Box Culverts with Tapered Inlets
58B	Face Control for Box Culverts with Side-Tapered Inlets
59B	Face Control for Box Culverts with Slope-Tapered Inlets

CHART 1B

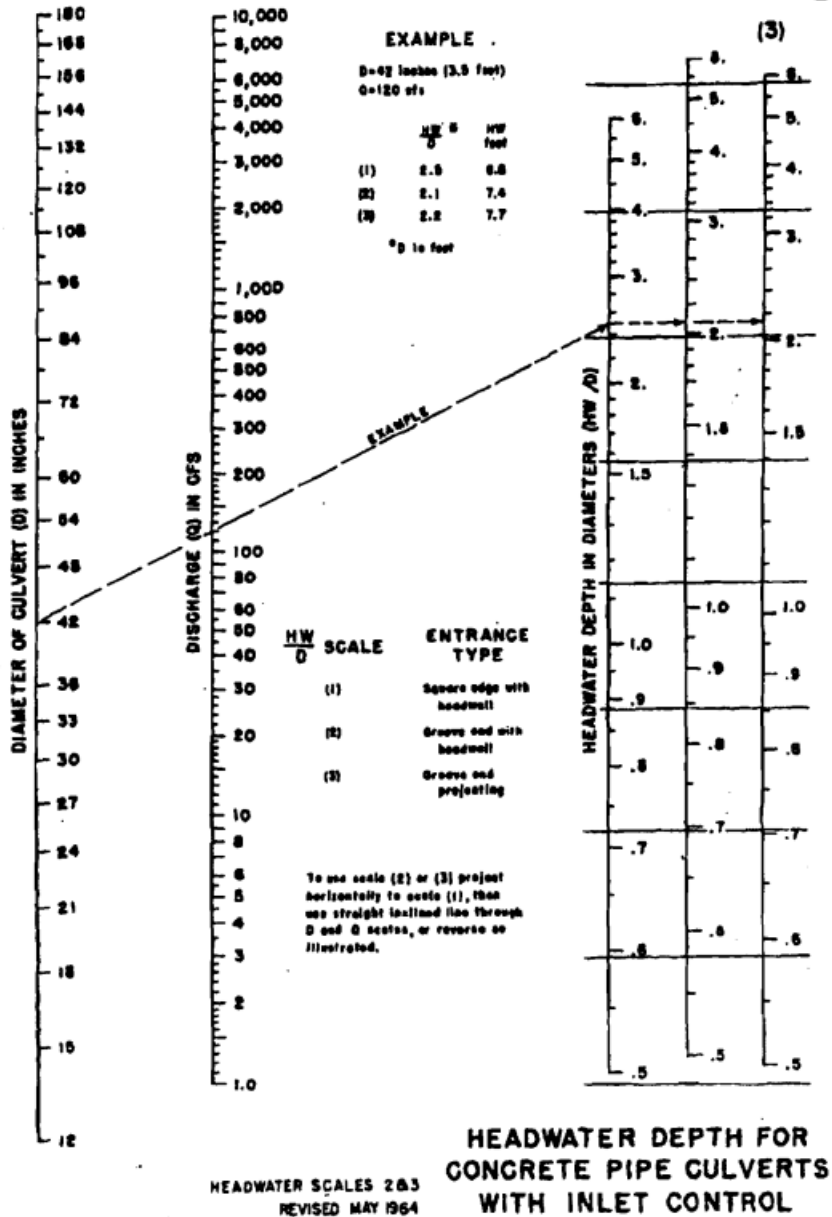
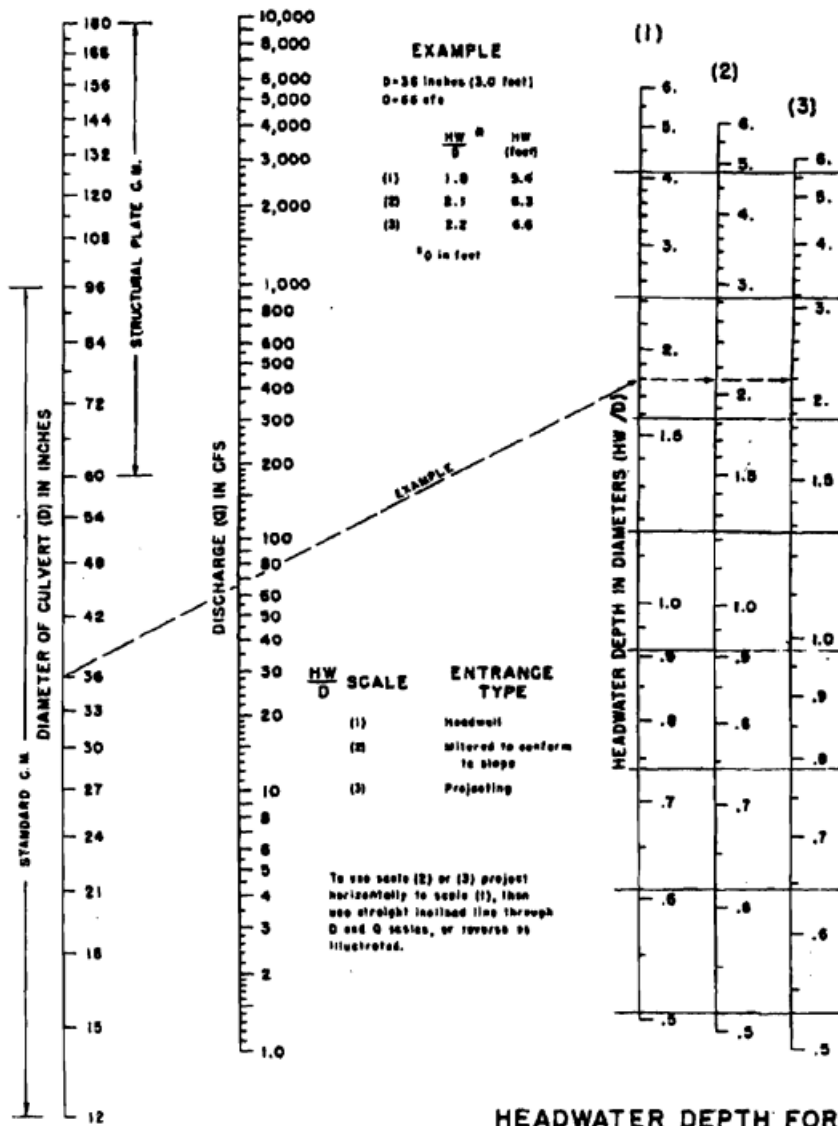


CHART 2B



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

CHART 3B

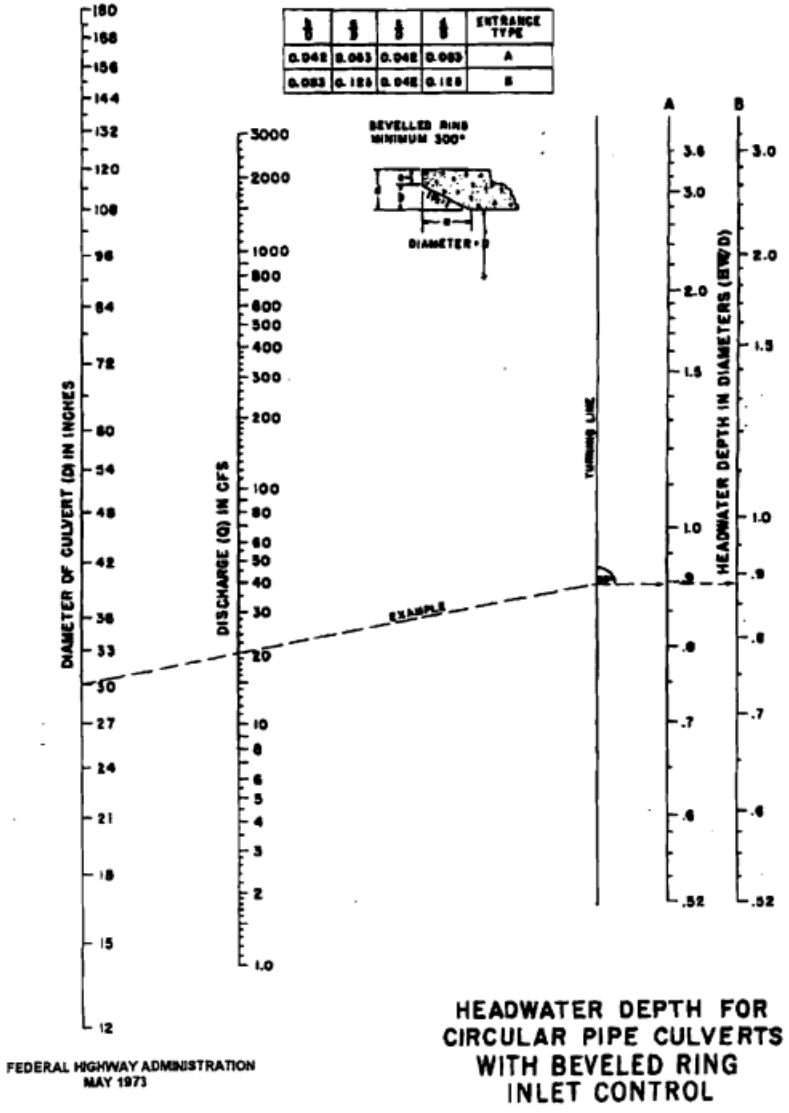
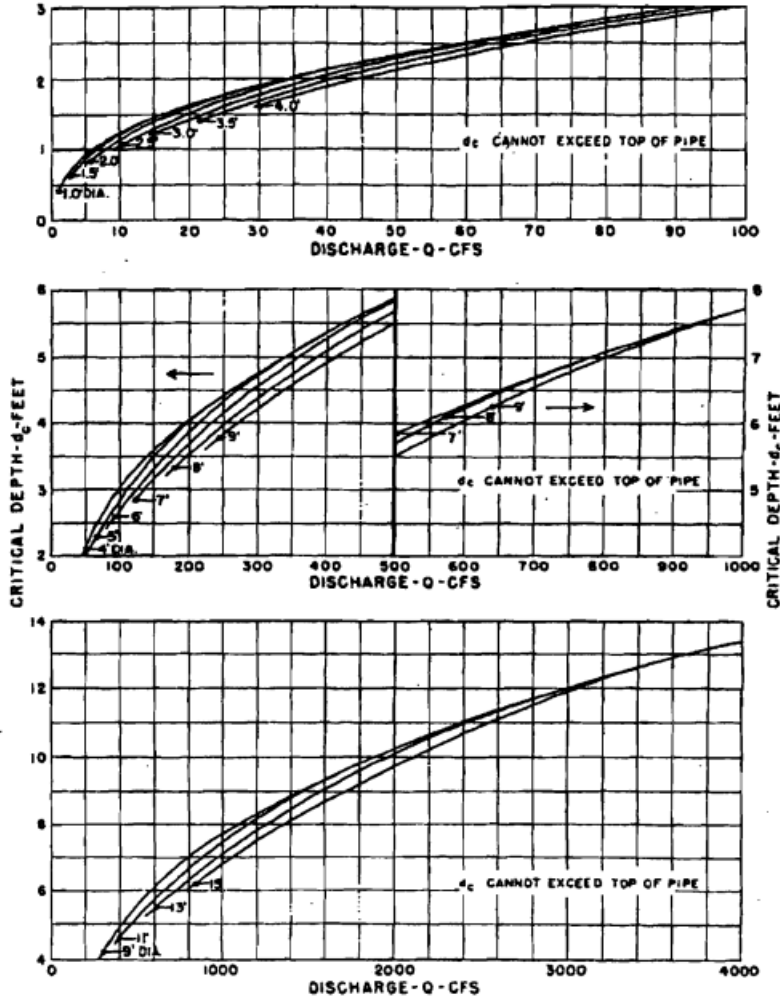


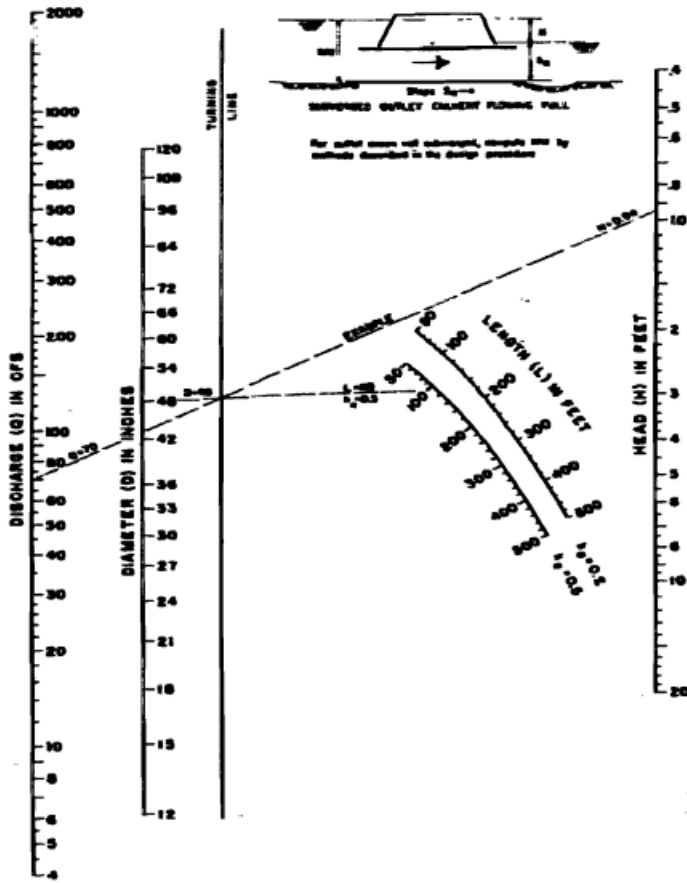
CHART 4B



BUREAU OF PUBLIC ROADS
JAN. 1964

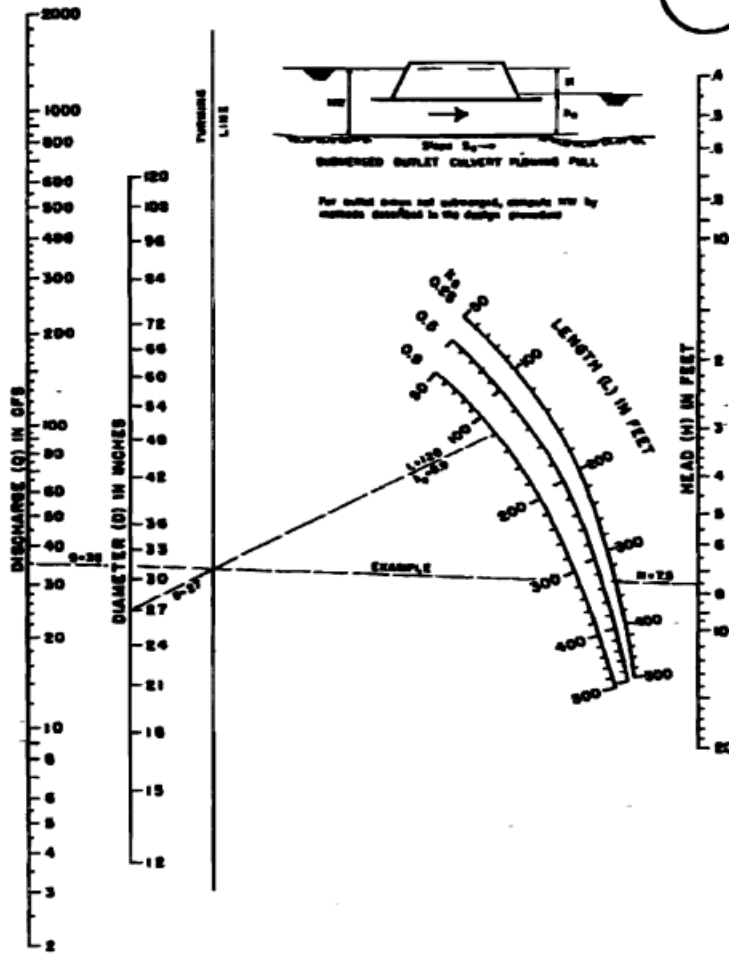
CRITICAL DEPTH
CIRCULAR PIPE

CHART 5B



**HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n=0.012**

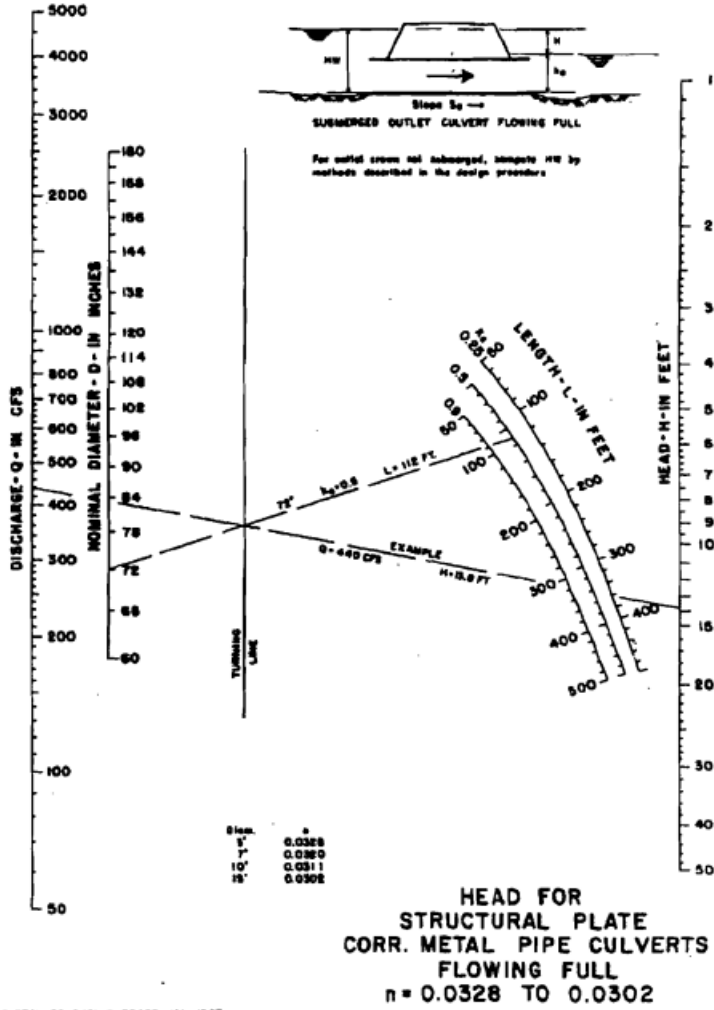
CHART 6B



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

BUREAU OF PUBLIC ROADS JAN 1953

CHART 7B



BUREAU OF PUBLIC ROADS JAN. 1963

CHART 8B

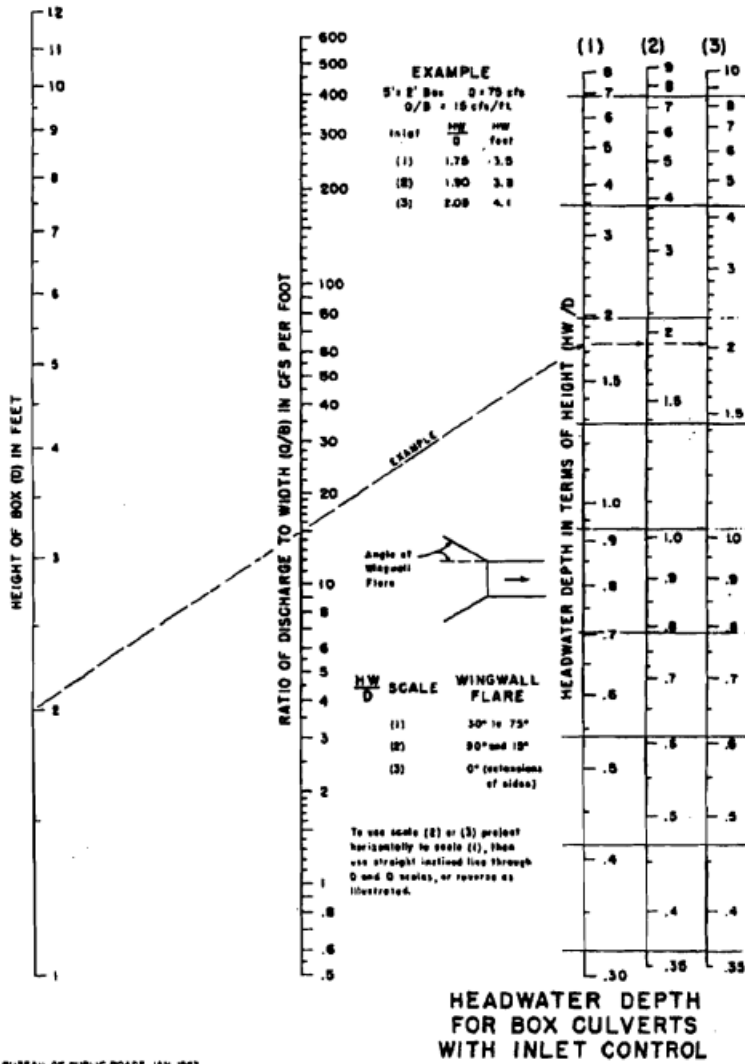


CHART 9B

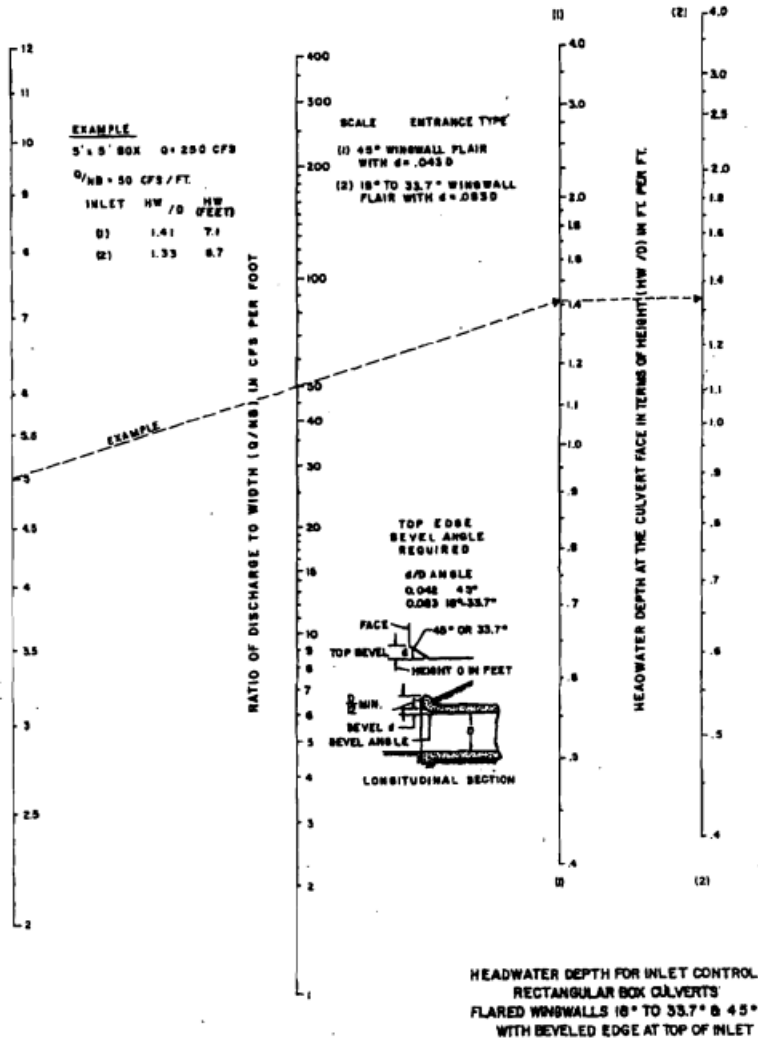
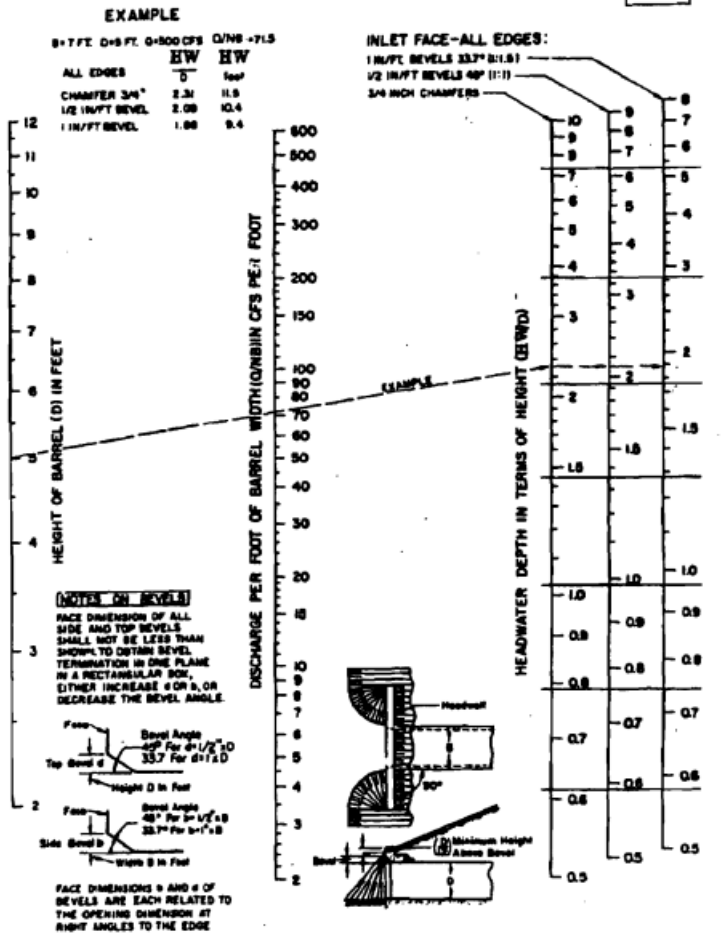


CHART 10B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
90° HEADWALL
CHAMFERED OR BEVELED INLET EDGES

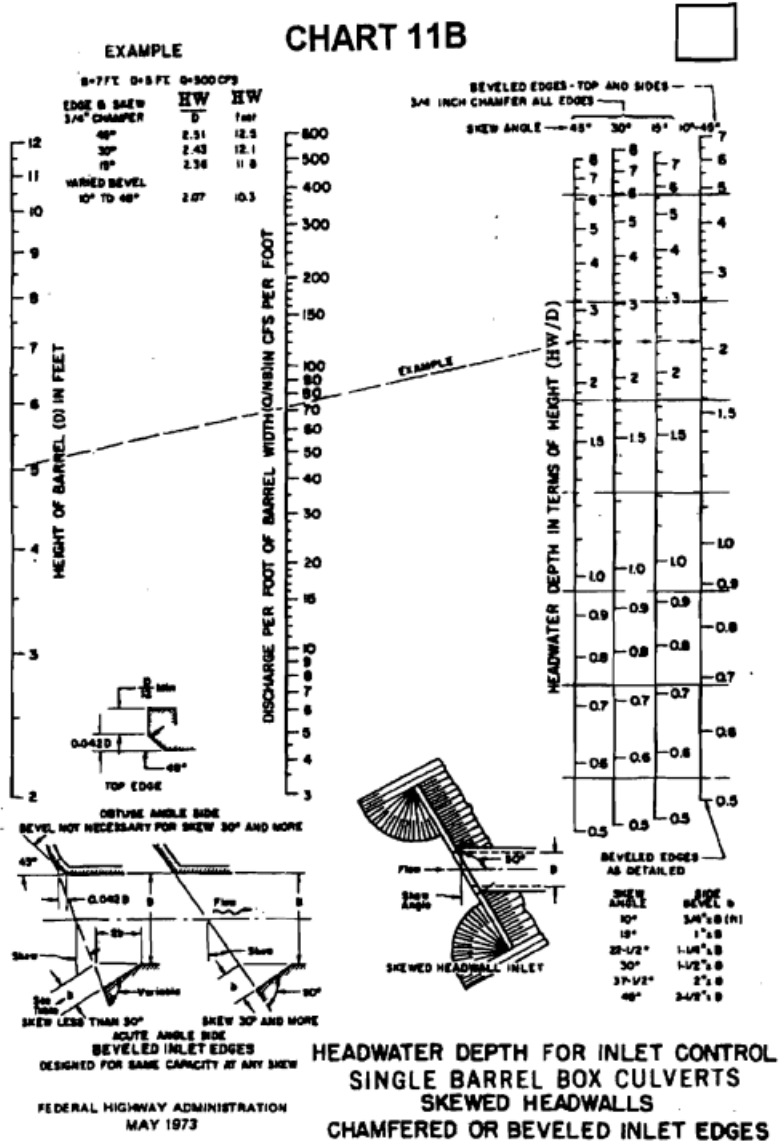
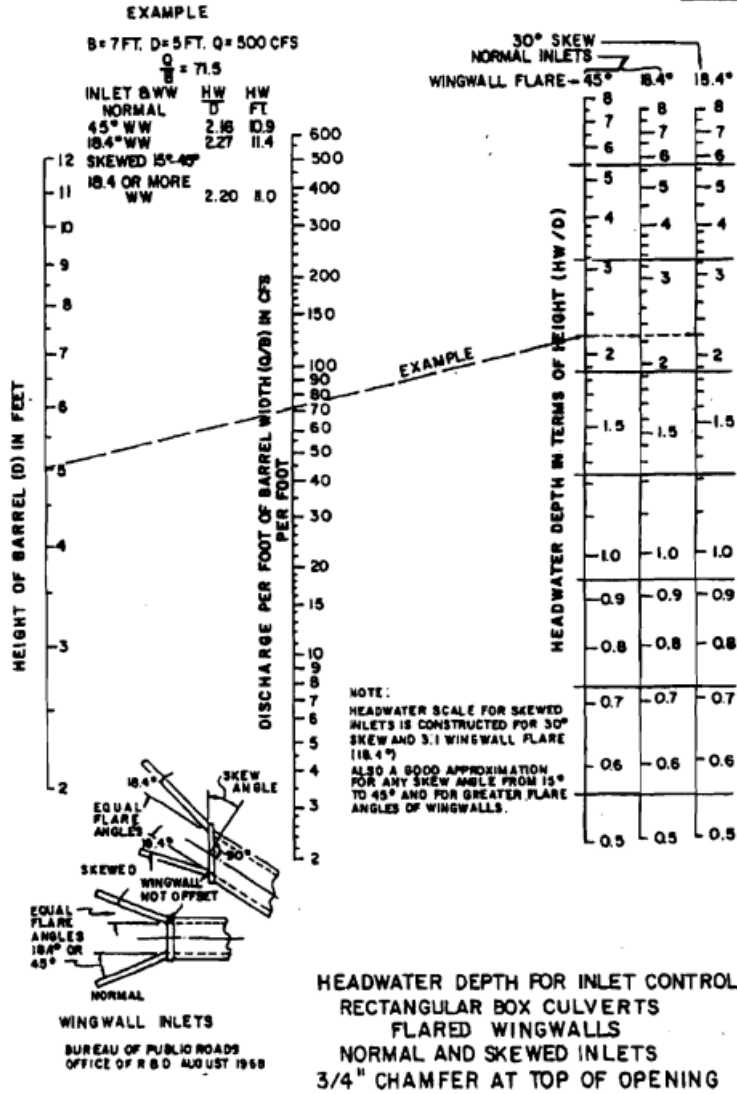


CHART 12B



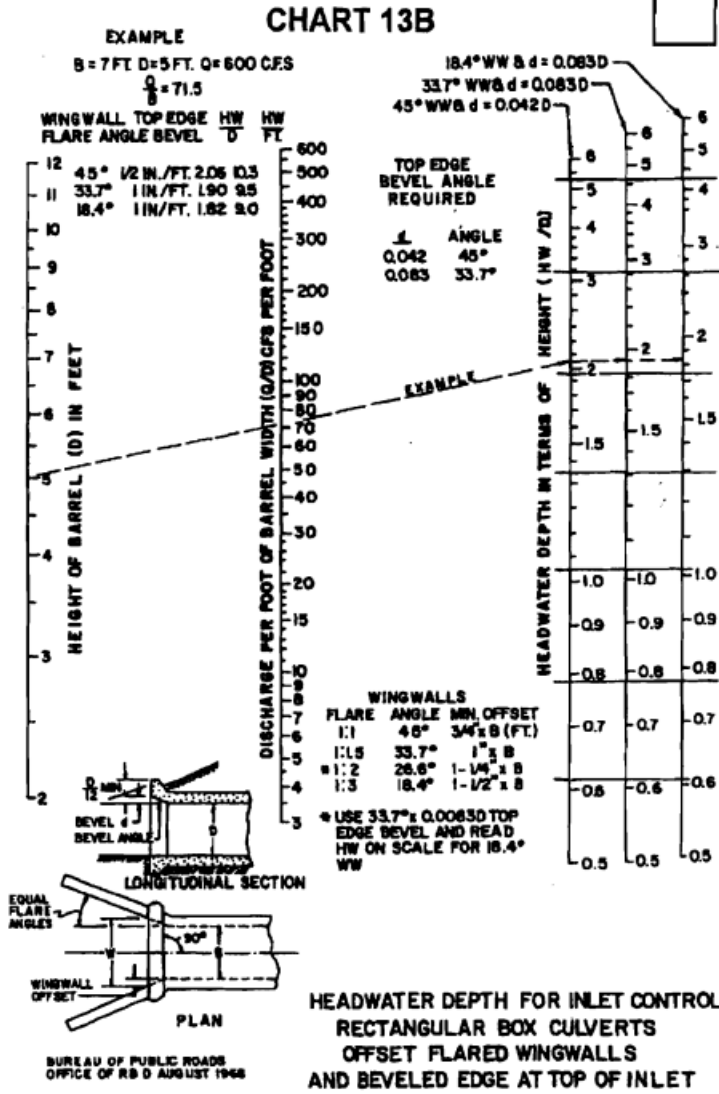
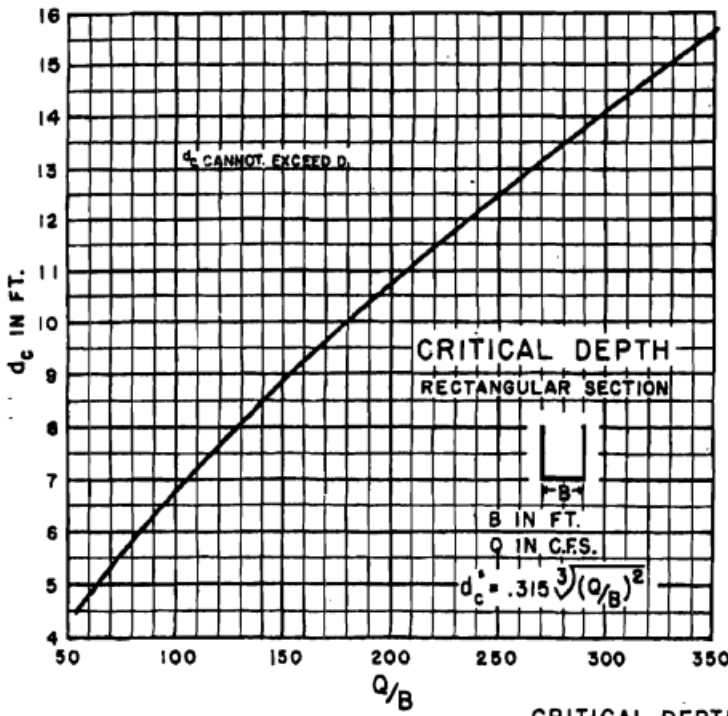
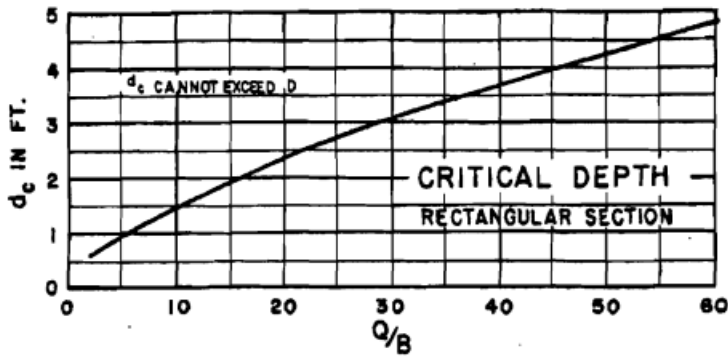


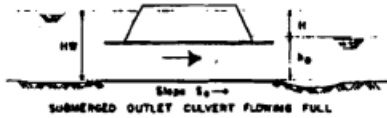
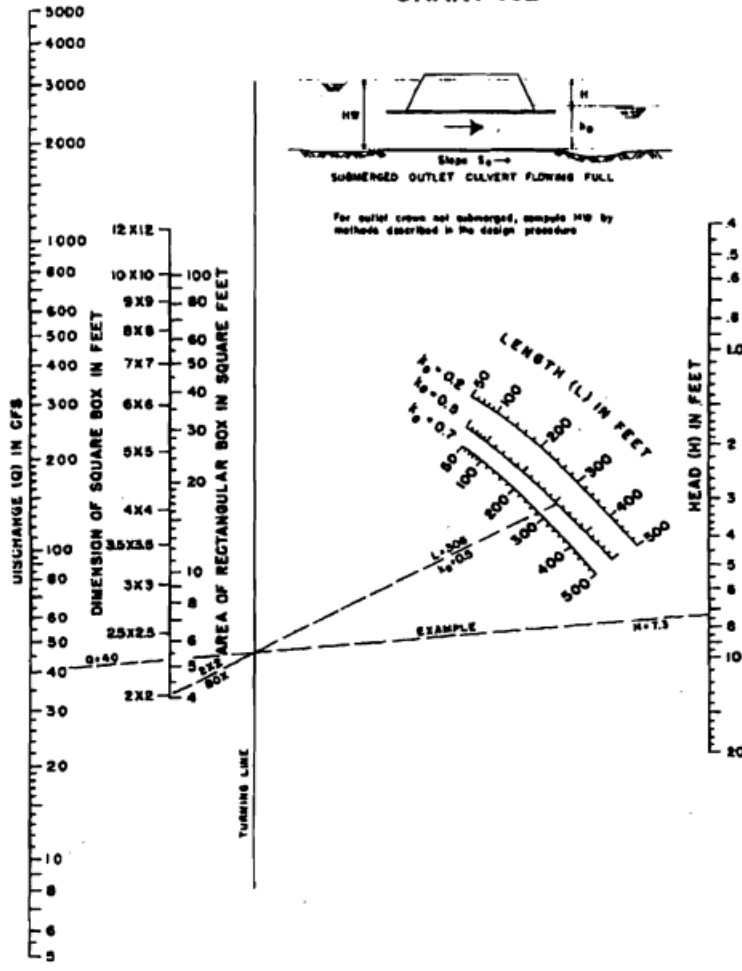
CHART 14B



BUREAU OF PUBLIC ROADS JAN 1963

CRITICAL DEPTH
RECTANGULAR SECTION

CHART 15B



For outlet crown not submerged, compute H_0 by methods described in the design procedure

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

CHART 16B

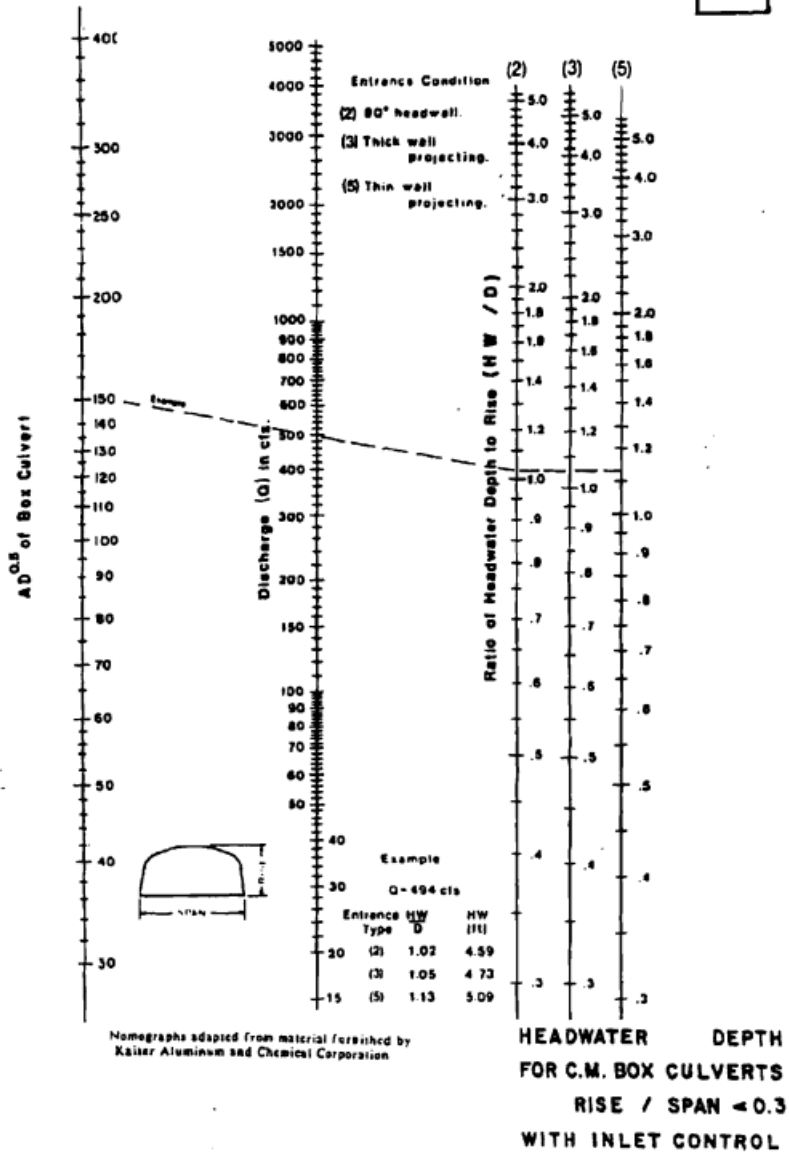
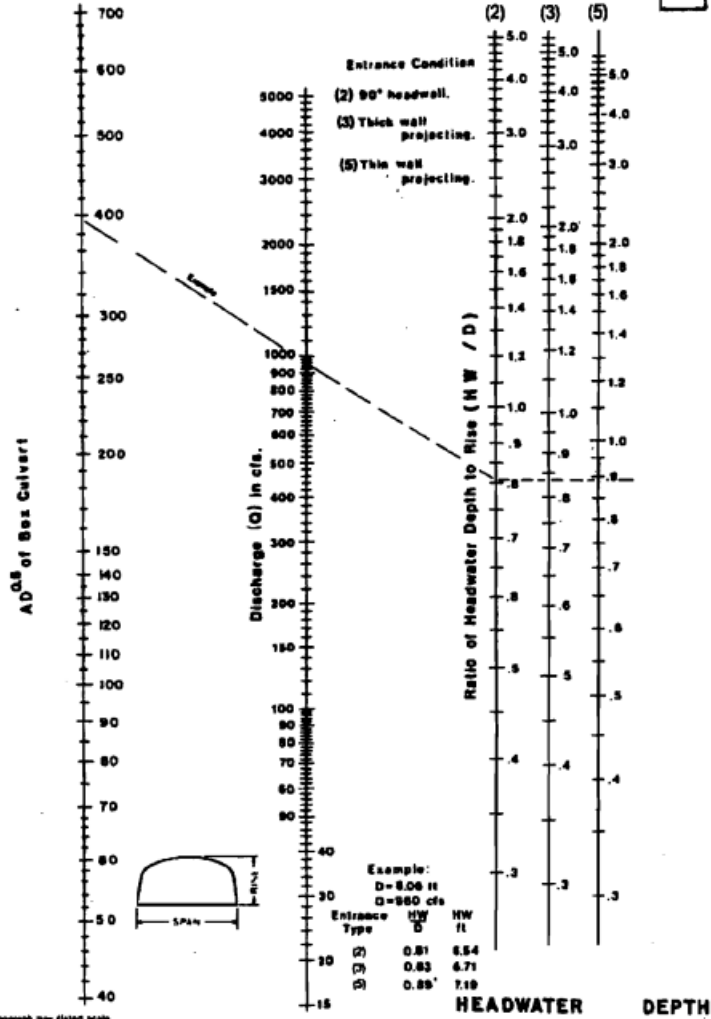


CHART 17B



Duplication of this nomograph may distort scale

Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

CHART 18B

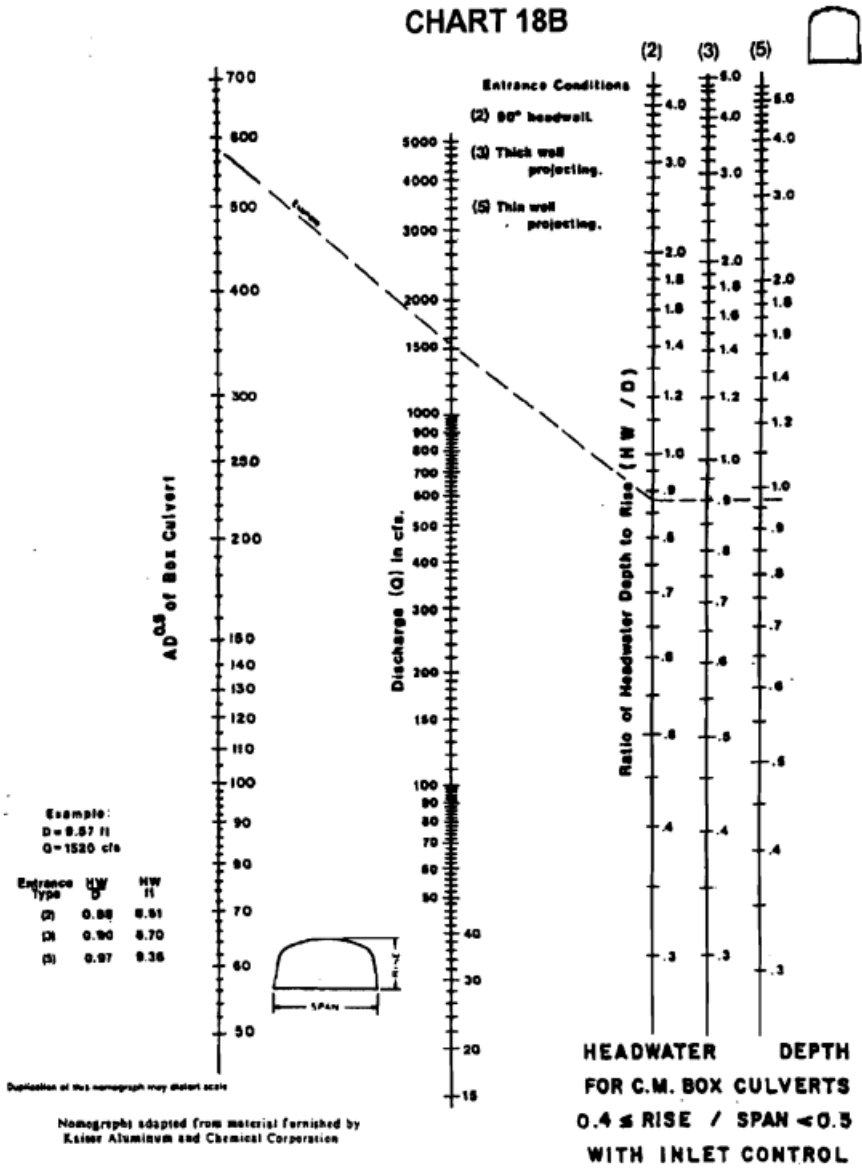
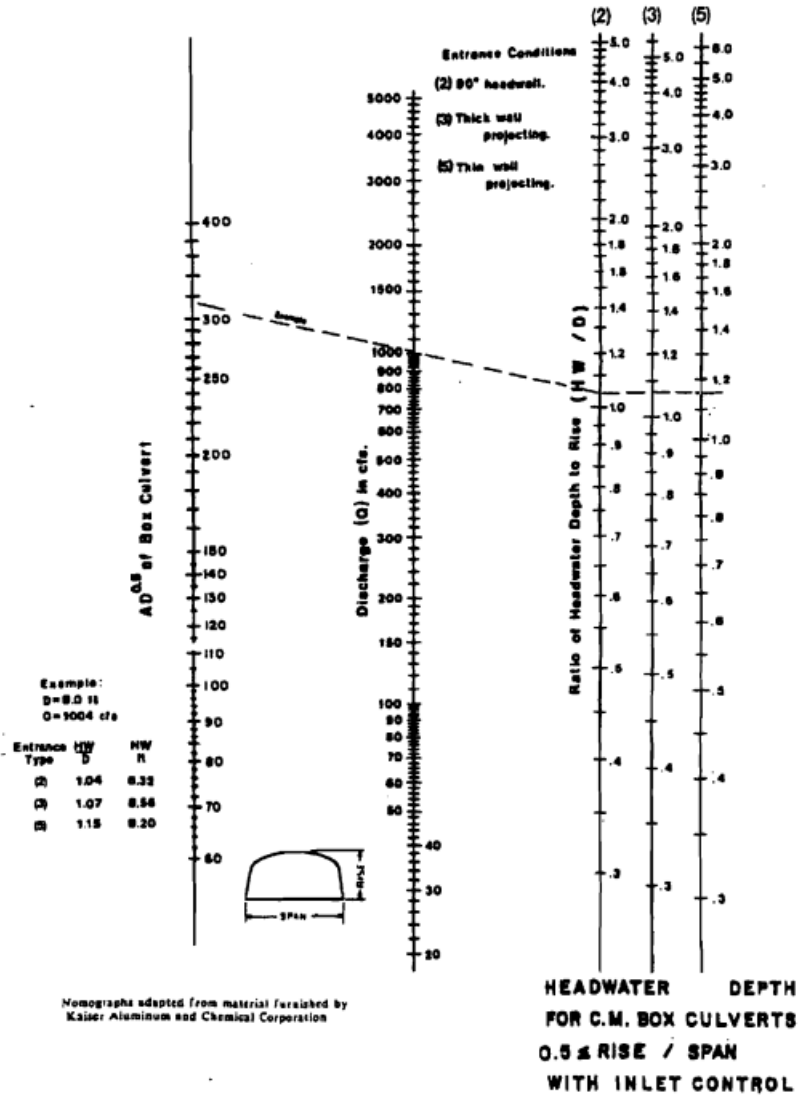


CHART 19B



Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

CHART 20B

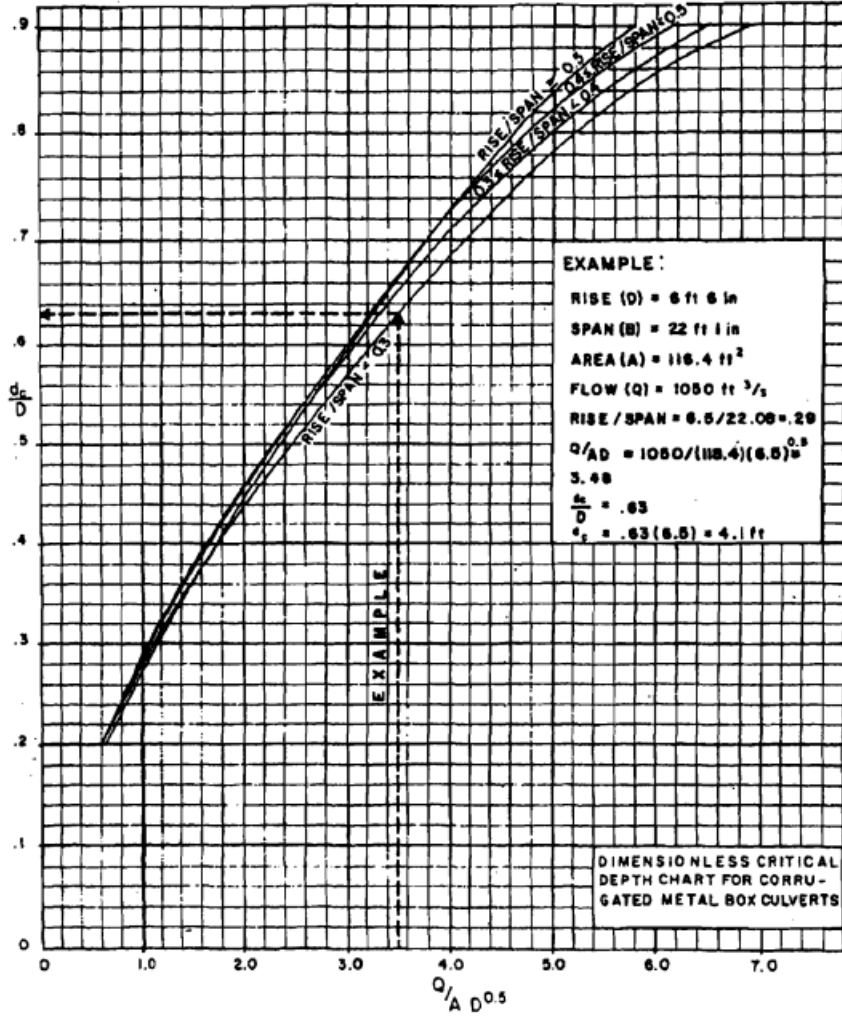
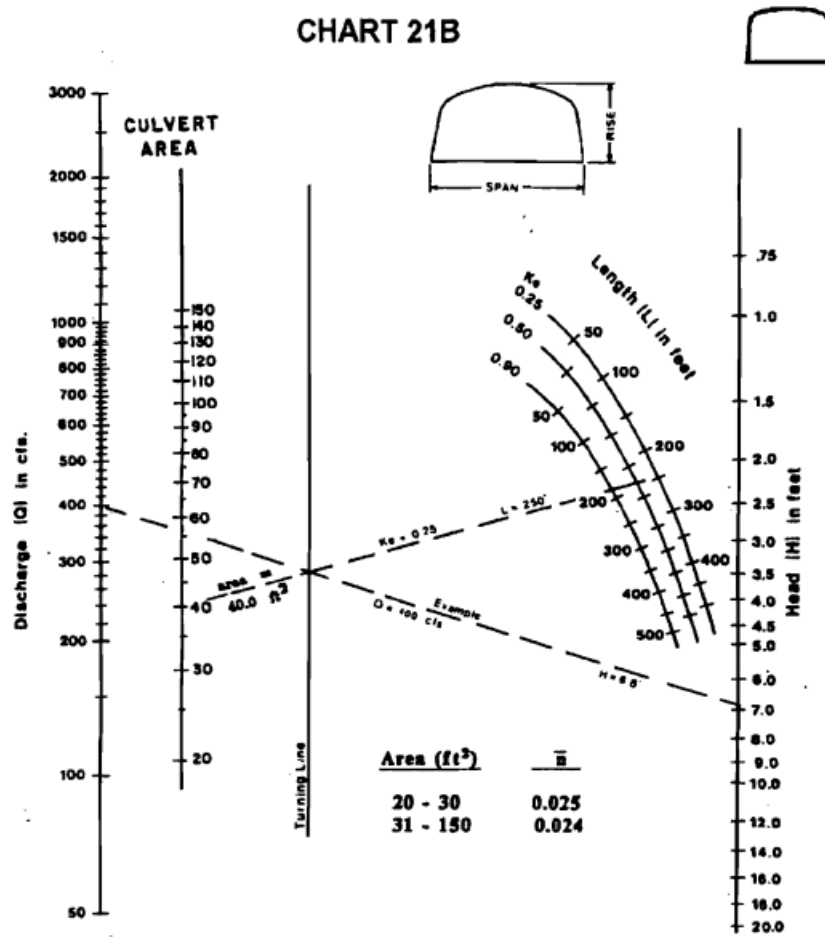


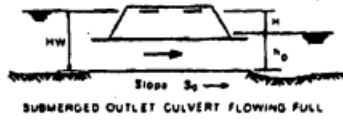
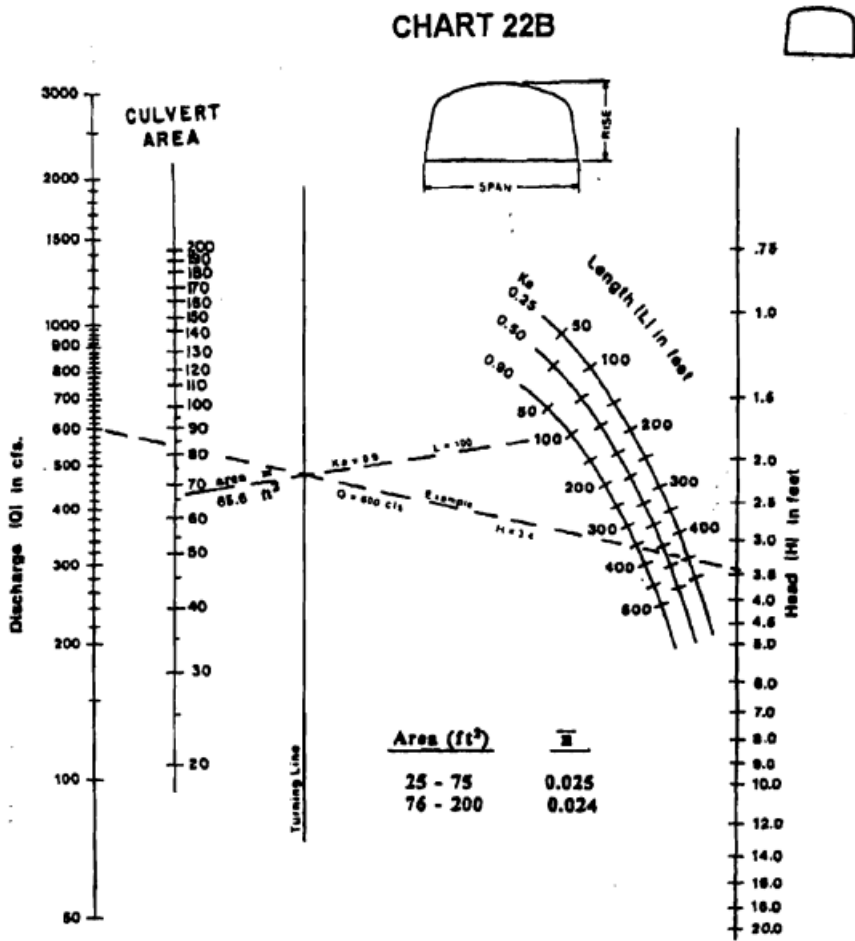
CHART 21B



Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 22B

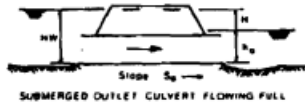
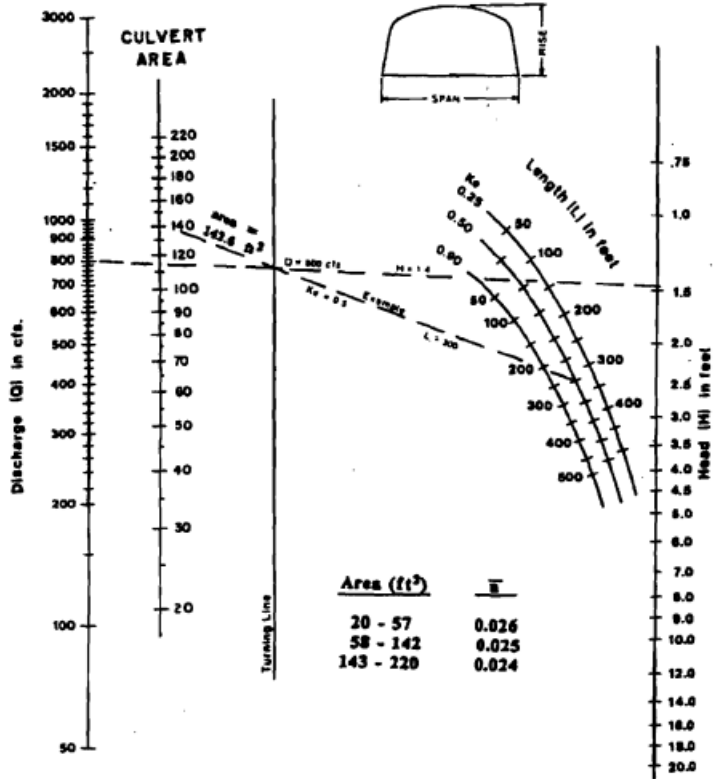


HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CONCRETE BOTTOM
 $0.3 \leq \text{RISE} / \text{SPAN} \leq 0.4$

Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

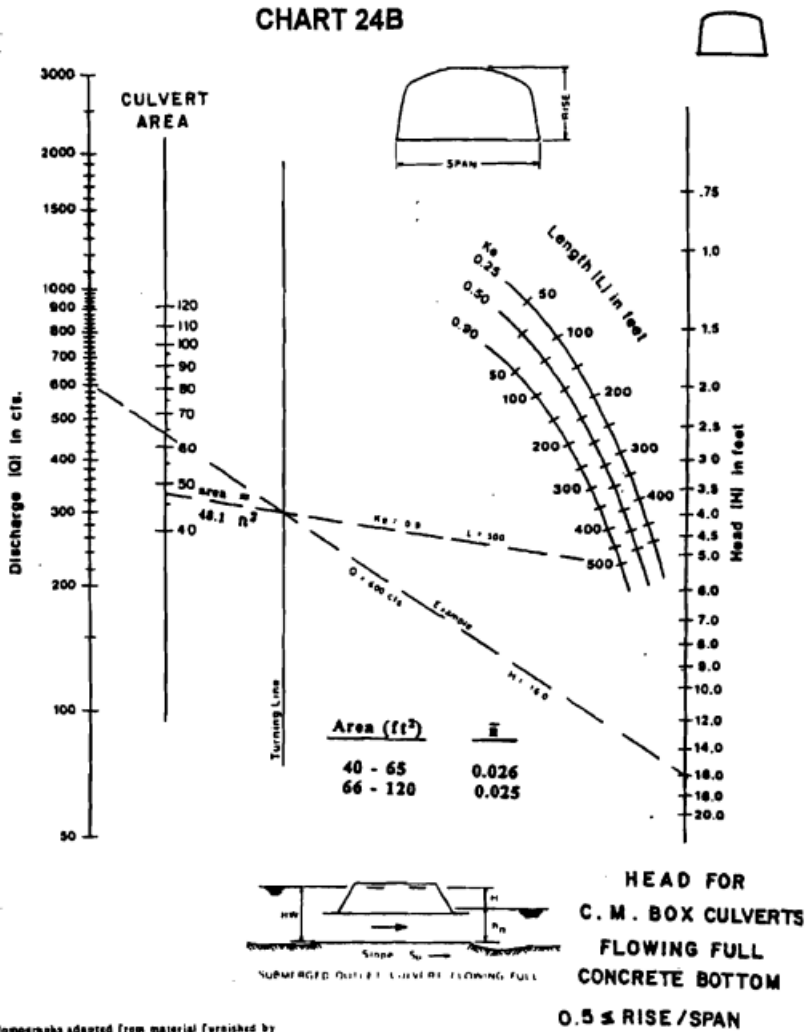
CHART 23B



HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CONCRETE BOTTOM
 $0.4 \leq \text{RISE} / \text{SPAN} < 0.5$

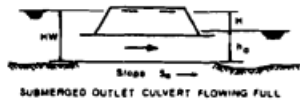
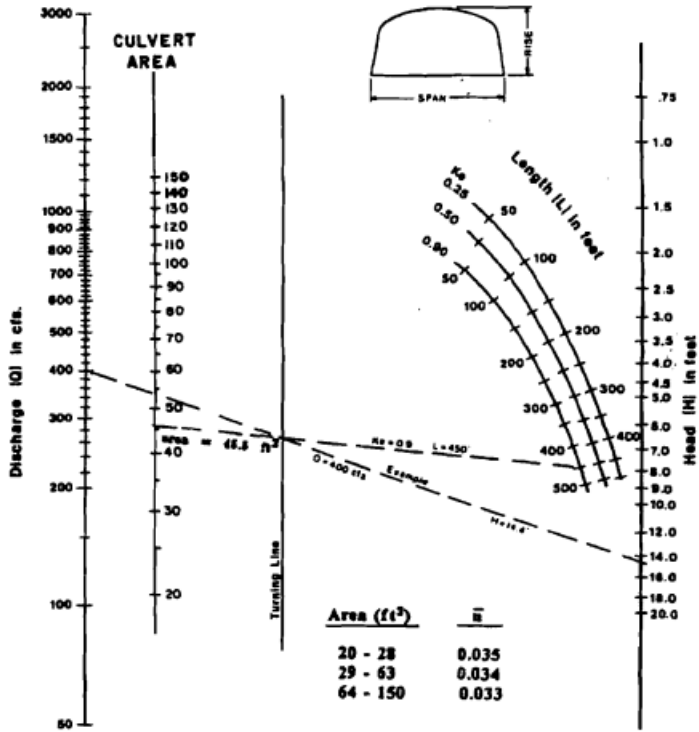
Nomograph adapted from material furnished by
Kaiser Aluminum and Chemical Corporation
Duplication of this nomograph may distort scale

CHART 24B



Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation
Duplication of this nomograph may distort scale

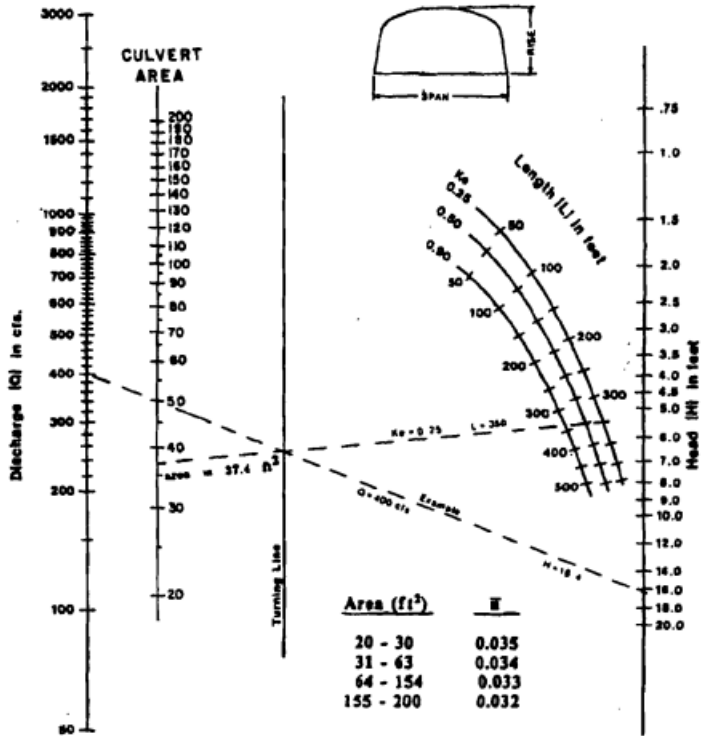
CHART 25B



HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CORRUGATED METAL BOTTOM
RISE / SPAN \leq 0.3

Nomograph adapted from material furnished by
Kaiser Aluminum and Chemical Corporation
Duplication of this nomograph may distort scale

CHART 26B



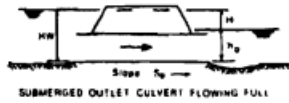
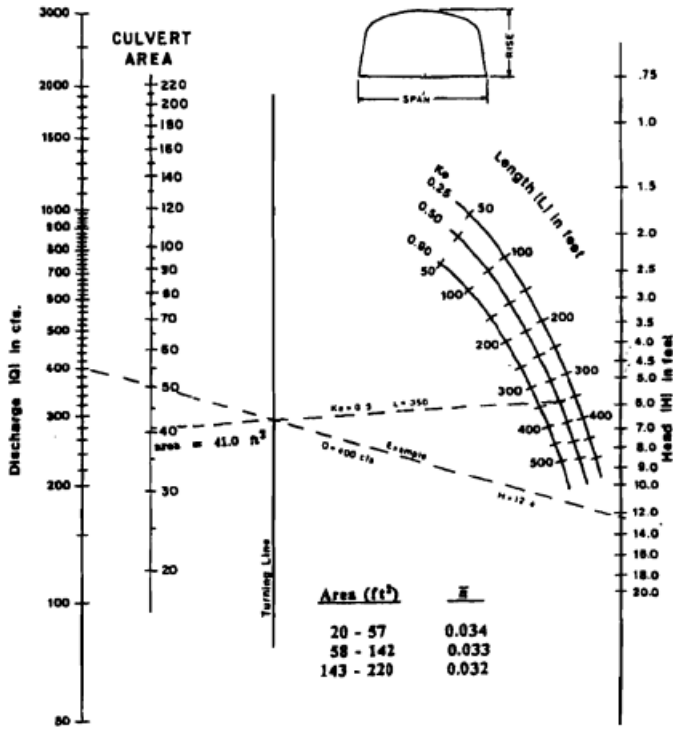
SUBMERGED OUTLET CULVERT FLOWING FULL

HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CORRUGATED METAL BOTTOM
 $0.3 \leq \text{RISE} / \text{SPAN} \leq 0.4$

Nomograph adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Distortion of this nomograph may distort scale

CHART 27B

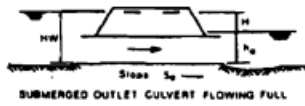
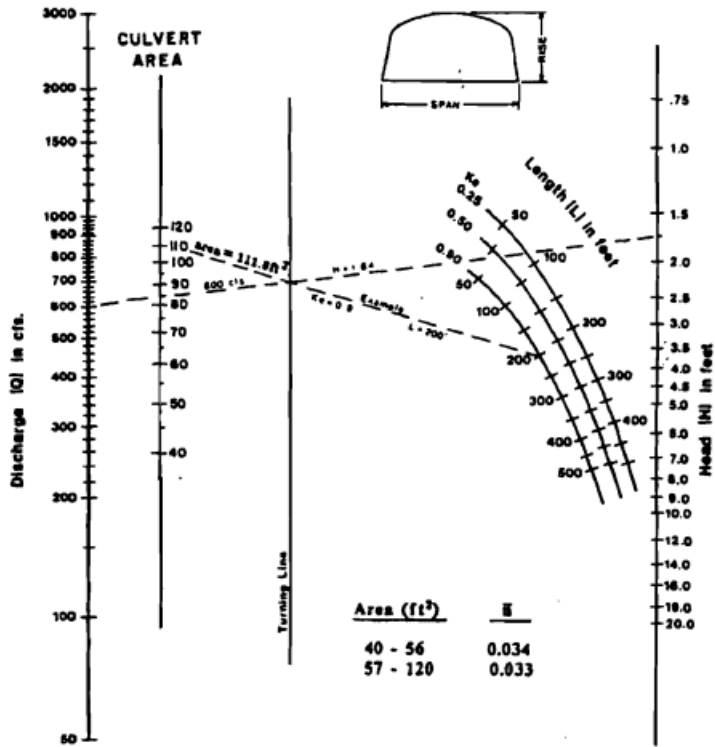


HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CORRUGATED METAL BOTTOM
 $0.4 \leq \text{RISE} / \text{SPAN} < 0.5$

Homograph adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplication of this homograph may distort scale

CHART 28B



HEAD FOR
C. M. BOX CULVERTS
FLOWING FULL
CORRUGATED METAL BOTTOM
0.5 ≤ RISE / SPAN

Nomographs adapted from material furnished by
Keiser Aluminum and Chemical Corporation

Distortion of this nomograph may distort scale

CHART 29B

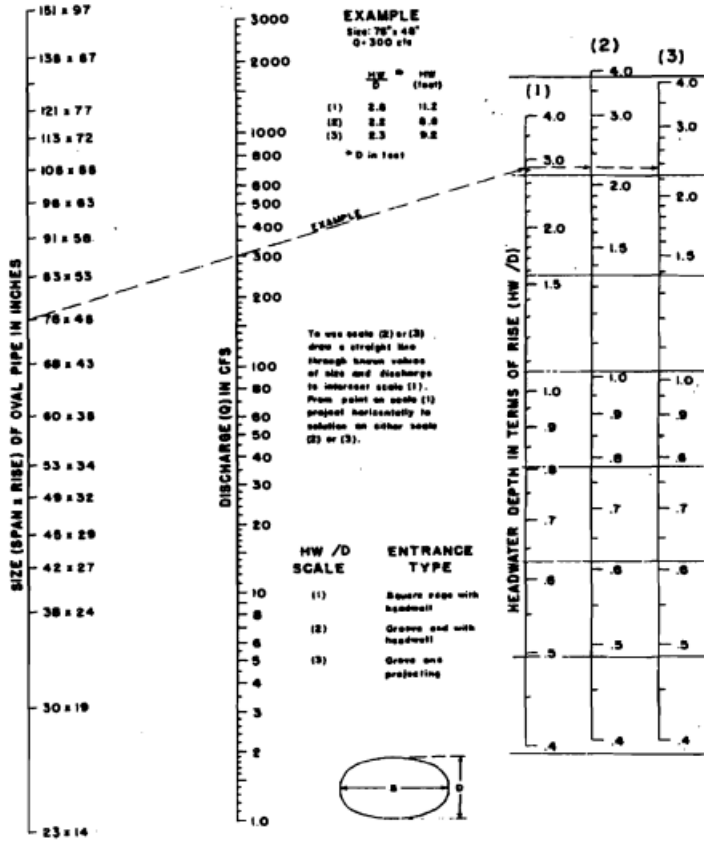
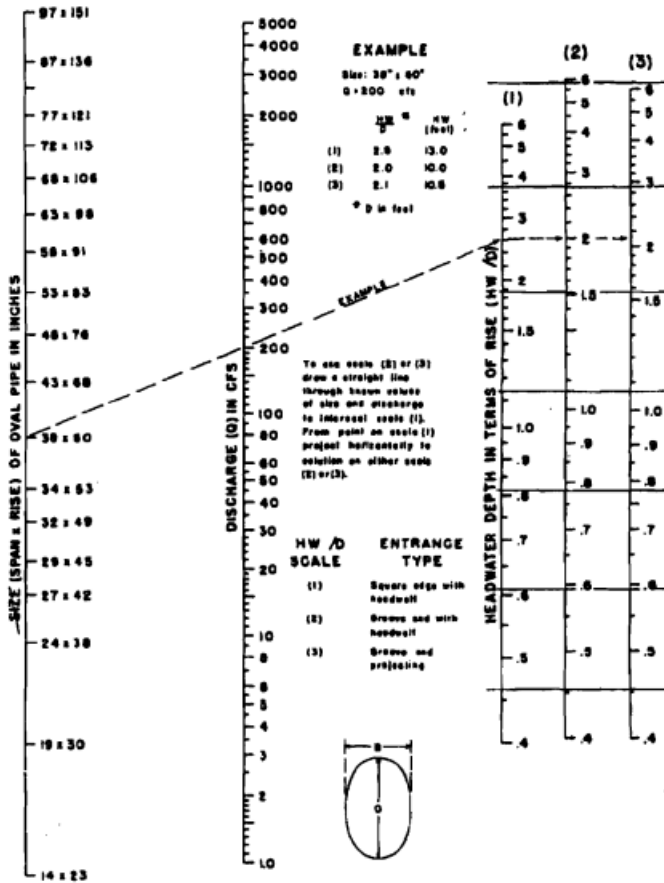
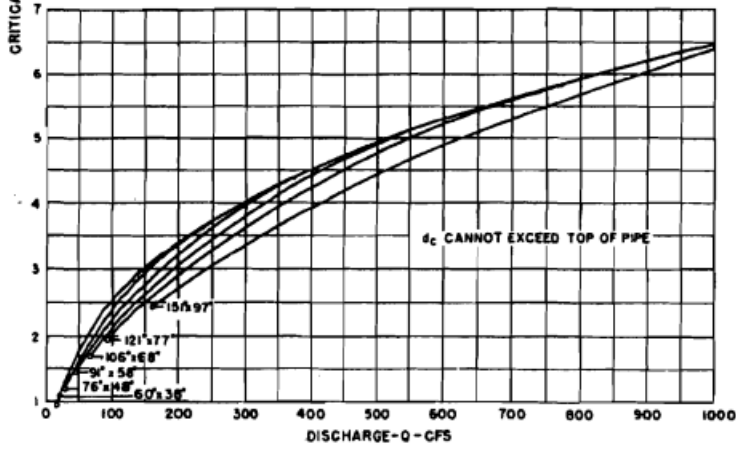
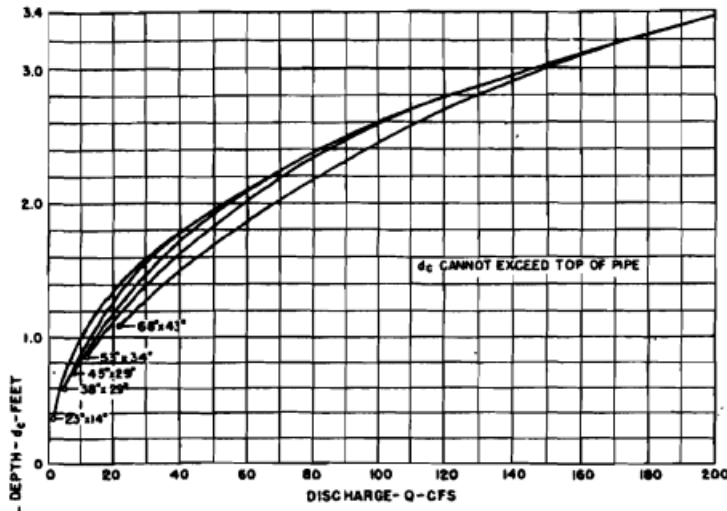


CHART 30B



HEADWATER DEPTH FOR
OVAL CONCRETE PIPE CULVERTS
LONG AXIS VERTICAL
WITH INLET CONTROL

CHART 31B

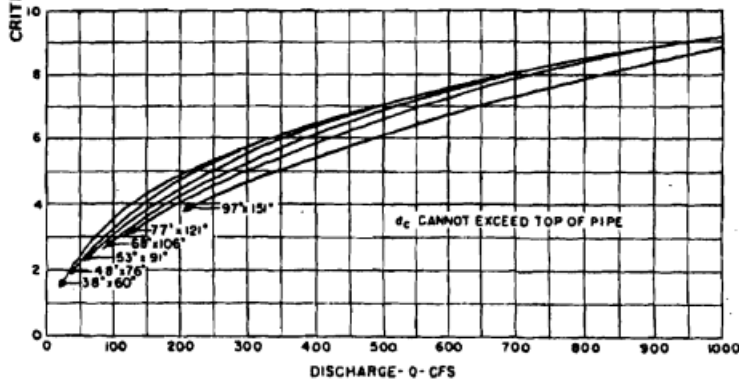
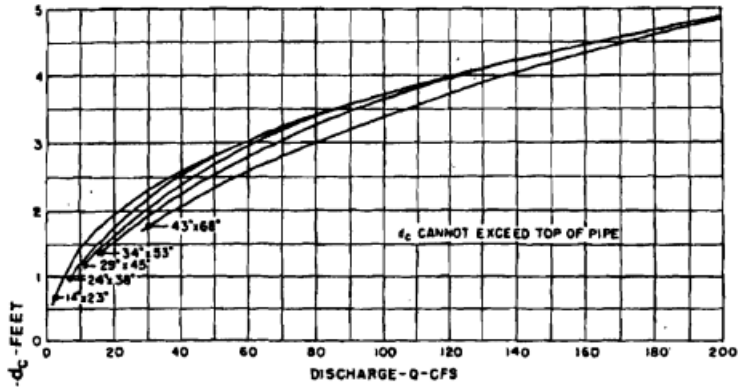


BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
OVAL CONCRETE PIPE
LONG AXIS HORIZONTAL

0

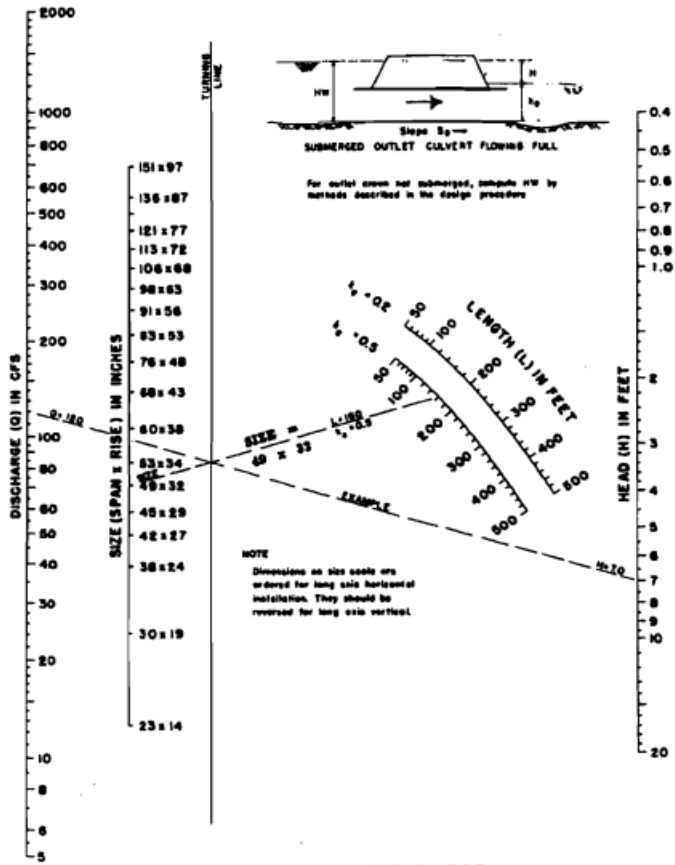
CHART 32B



BUREAU OF PUBLIC ROADS
JAN 1964

CRITICAL DEPTH
OVAL CONCRETE PIPE
LONG AXIS VERTICAL

CHART 33B



HEAD FOR
OVAL CONCRETE PIPE CULVERTS
LONG AXIS HORIZONTAL OR VERTICAL
FLOWING FULL
 $n = 0.012$

CHART 34B

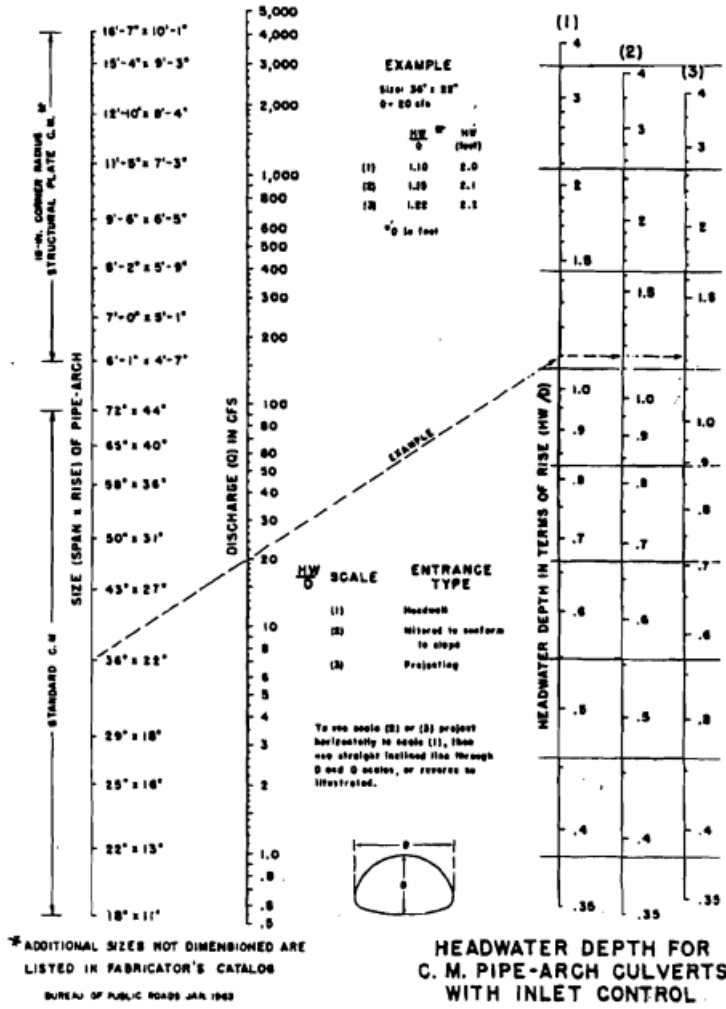


CHART 35B

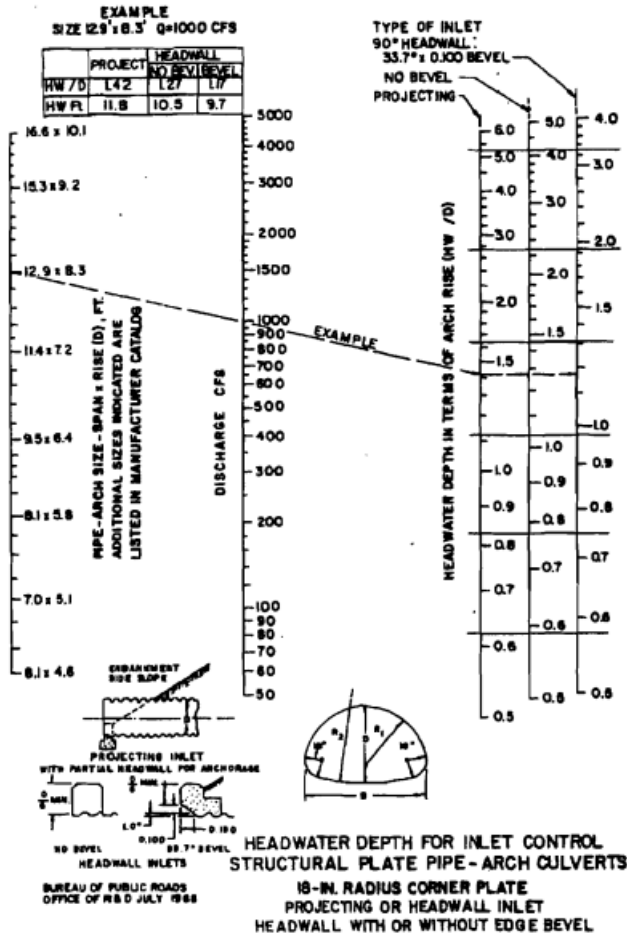


CHART 36B

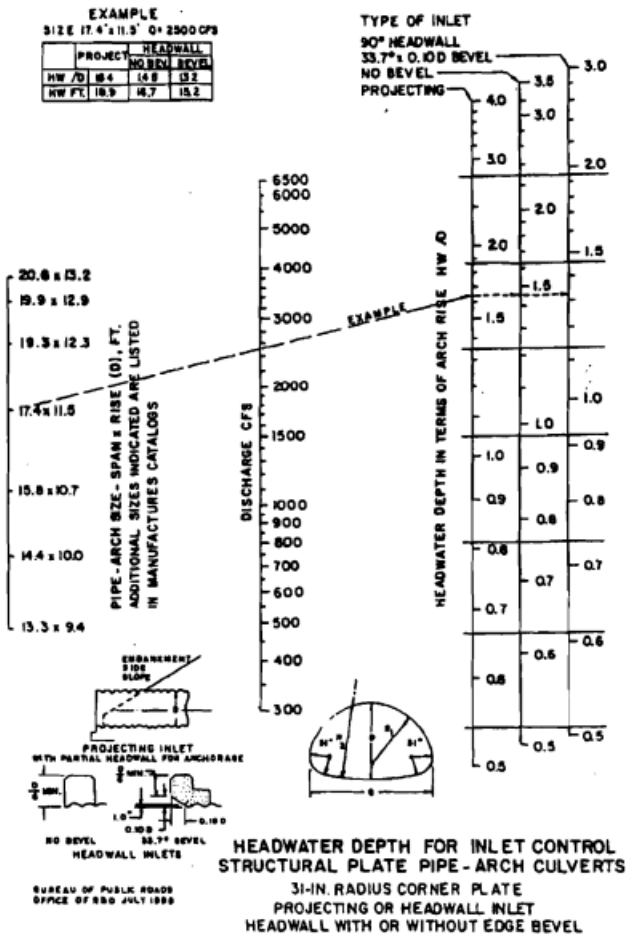
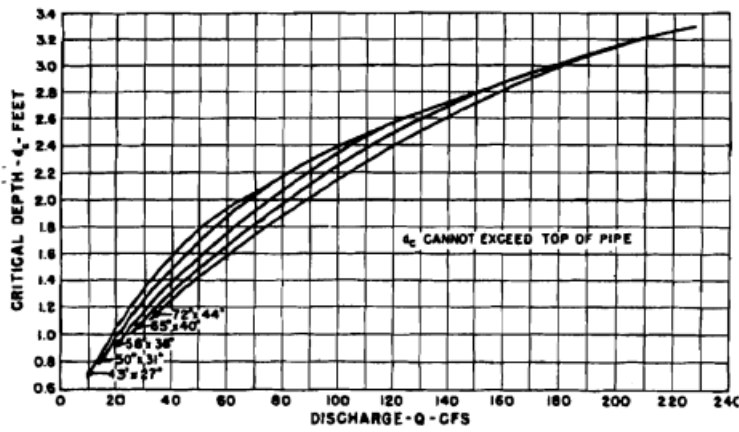
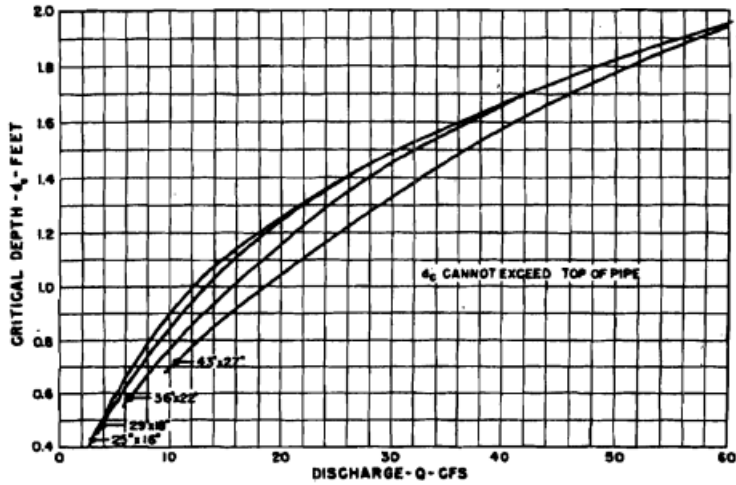


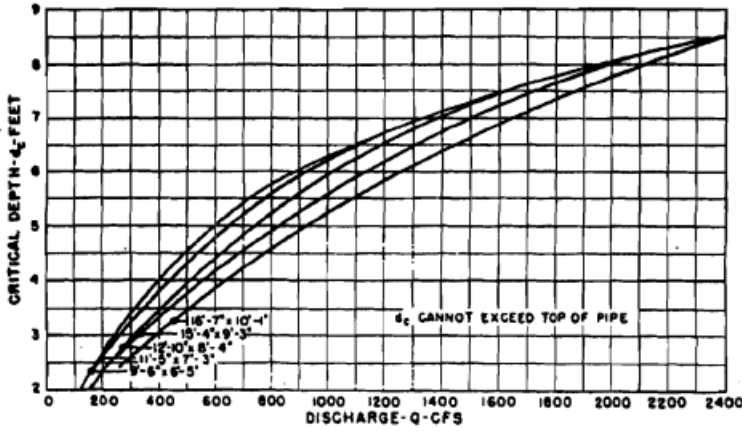
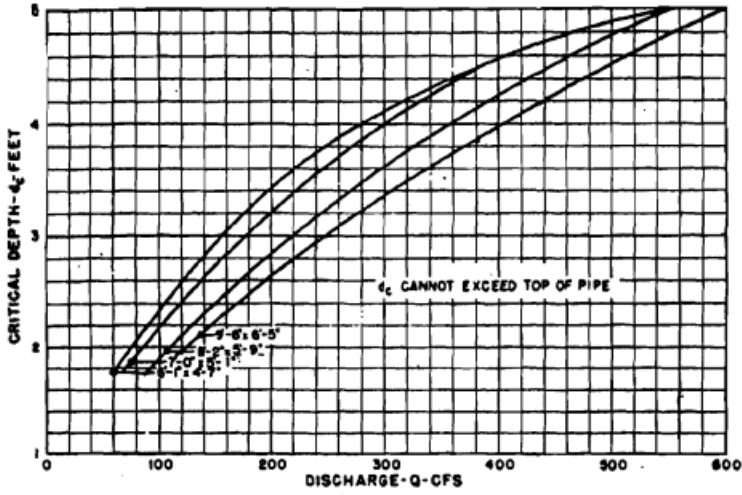
CHART 37B



BUREAU OF PUBLIC ROADS
JAN 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

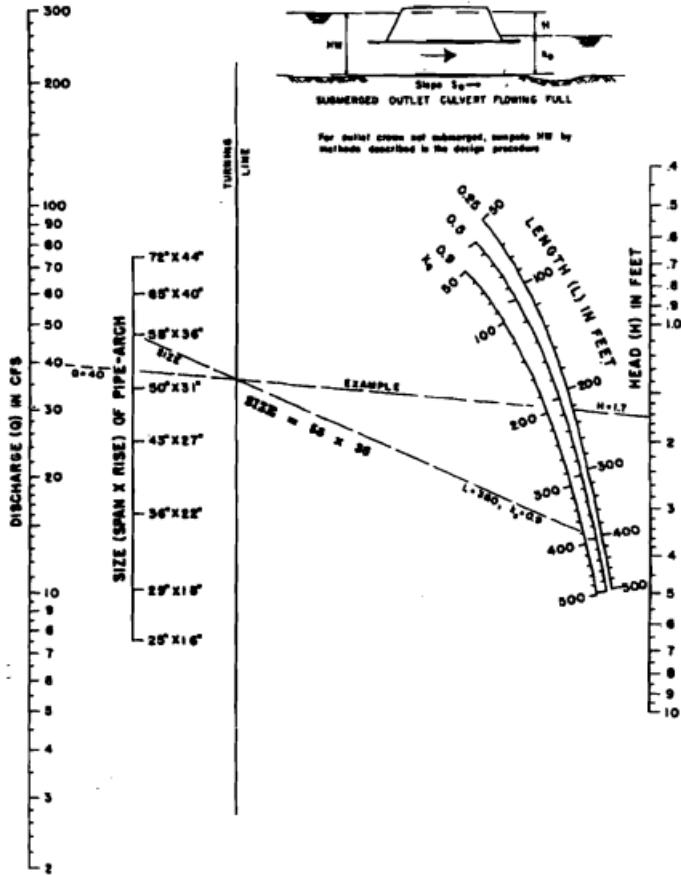
CHART 38B



BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
STRUCTURAL PLATE
C. M. PIPE - ARCH
18 INCH CORNER RADIUS

CHART 39B



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

CHART 40B

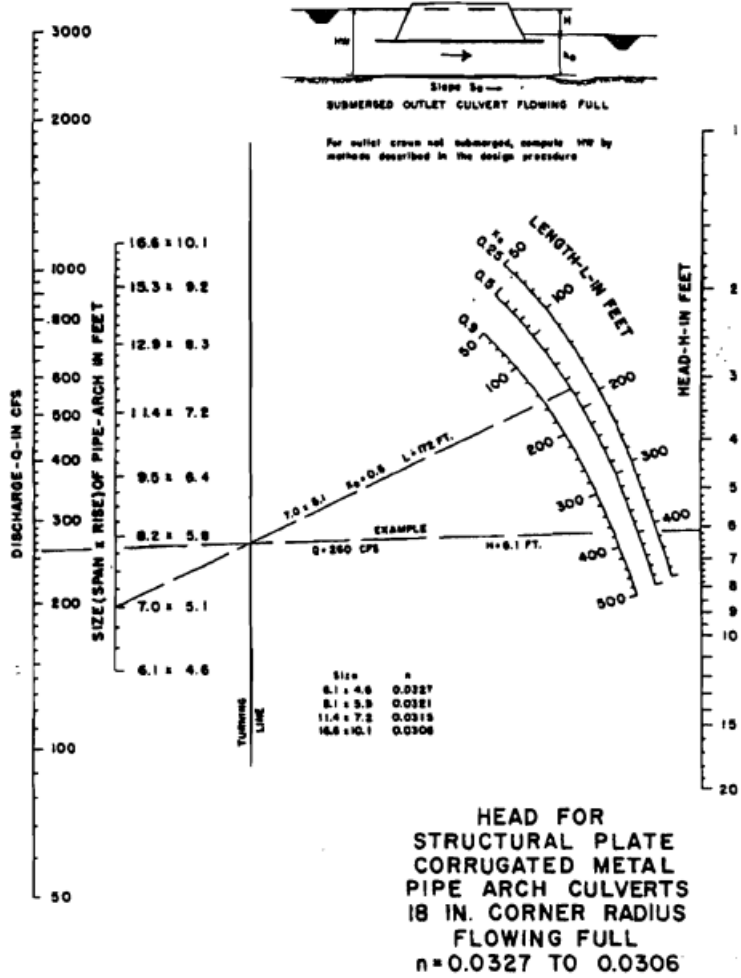


CHART 41B

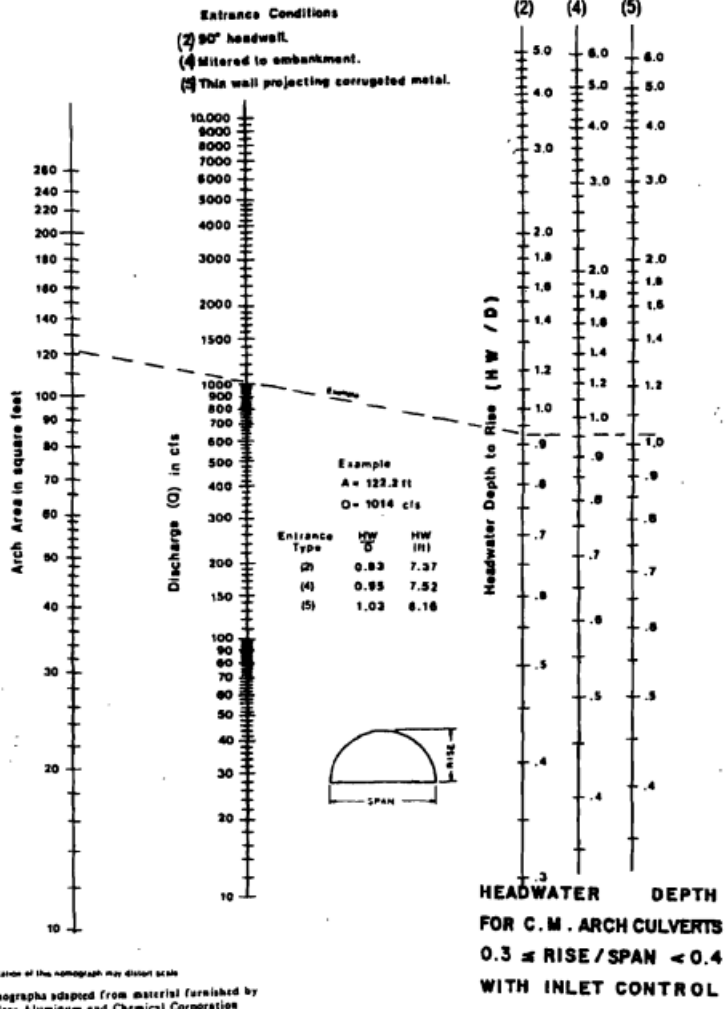




CHART 42B

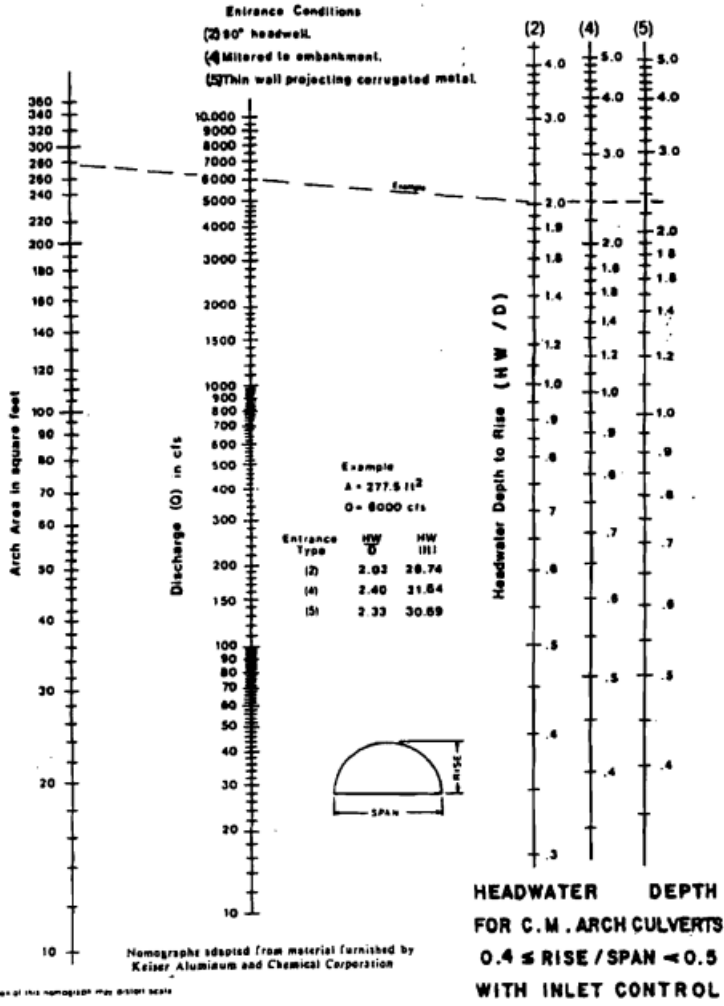


CHART 43B

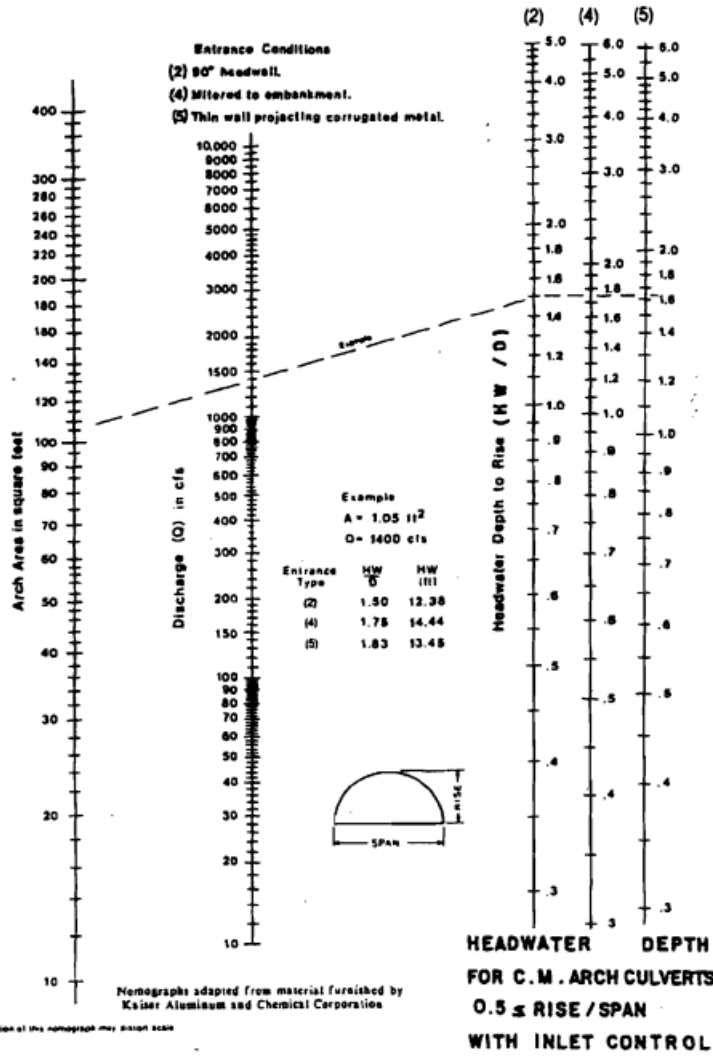




CHART 44B

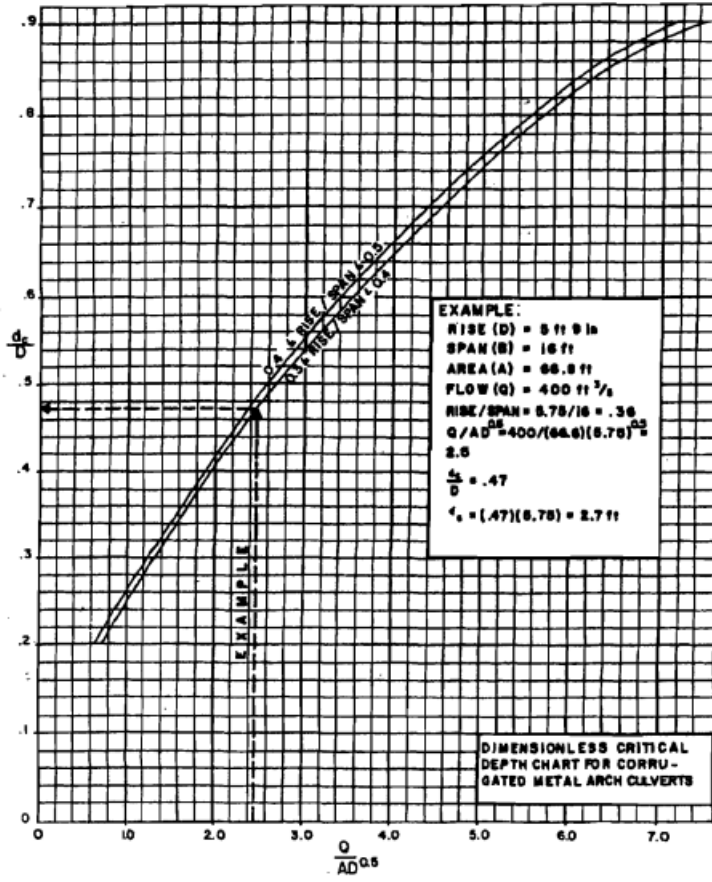
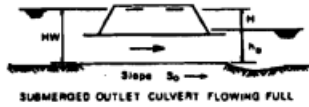
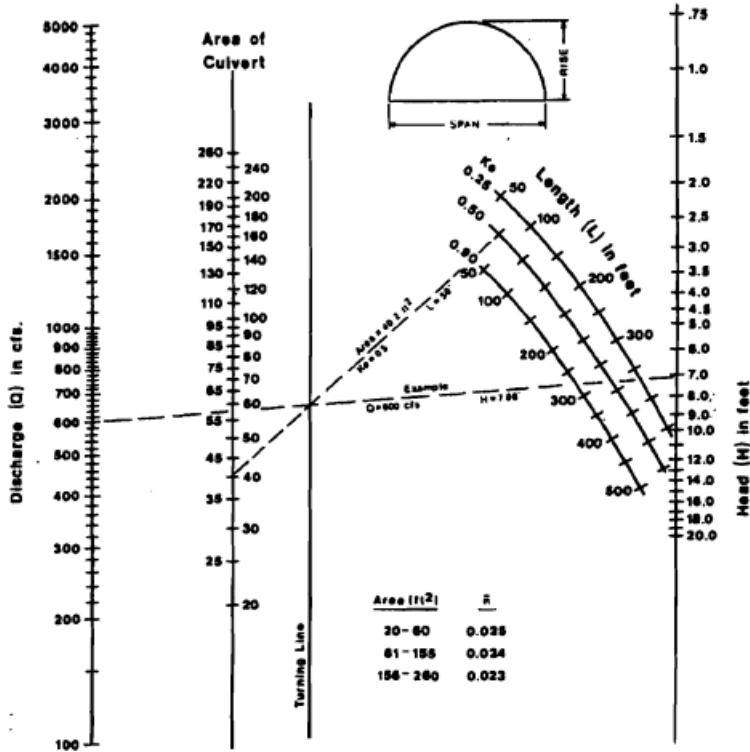


CHART 45B

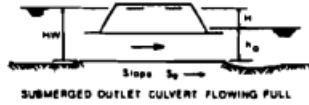
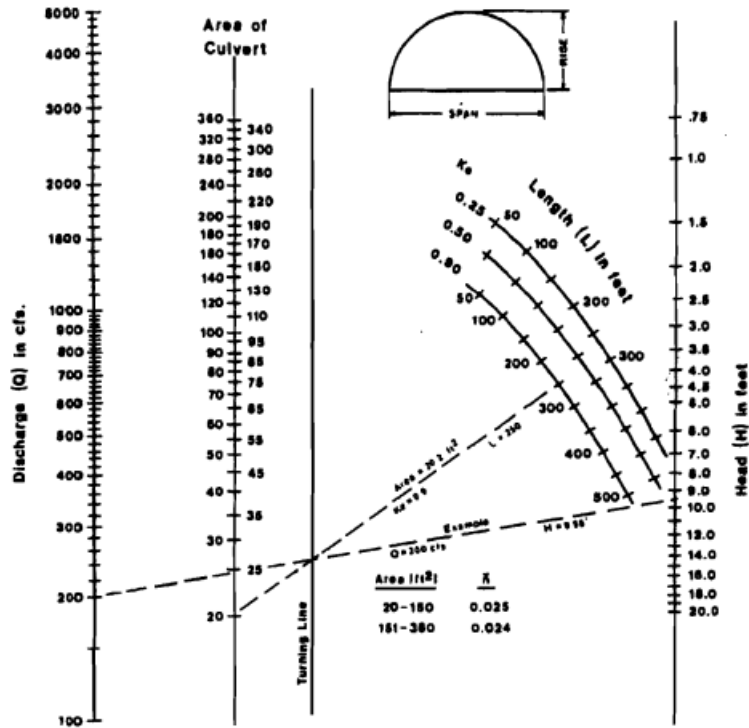


**HEAD FOR
C. M. ARCH CULVERTS
FLOWING FULL
CONCRETE BOTTOM
0.3 ≤ RISE / SPAN ≤ 0.4**

Nomograph adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 46B



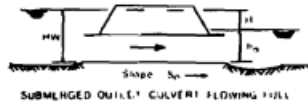
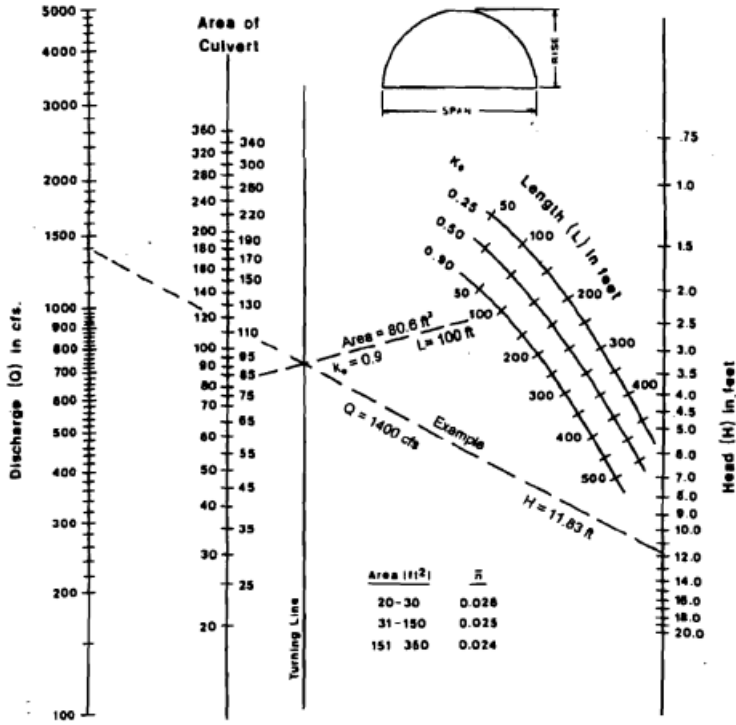
HEAD FOR
C.M. ARCH CULVERTS
FLOWING FULL
CONCRETE BOTTOM
 $0.4 \leq \text{RISE} / \text{SPAN} \leq 0.5$

Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplication of this nomogram may distort scale



CHART 47B

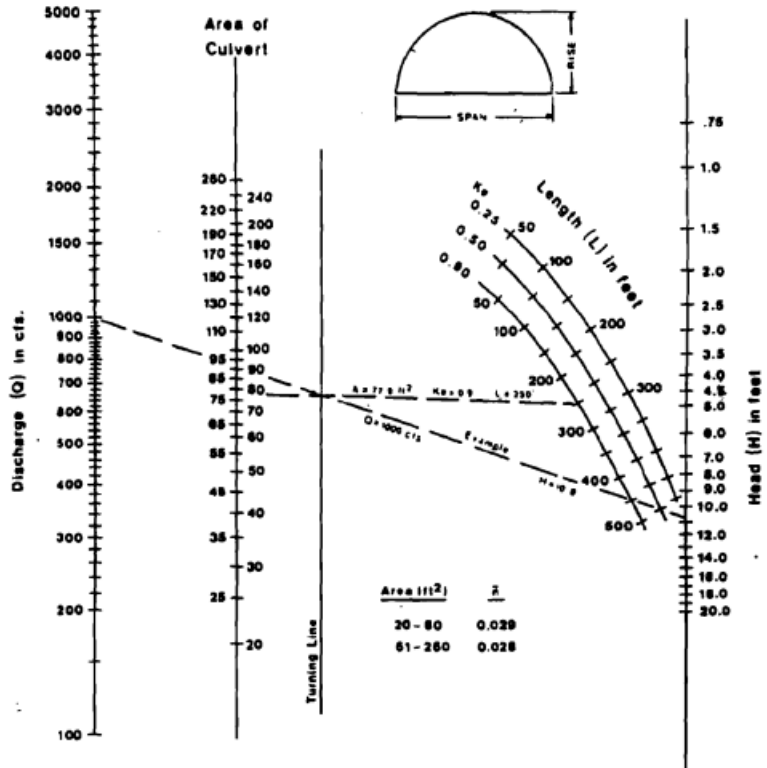


HEAD FOR
C.M. ARCH CULVERTS
FLOWING FULL
CONCRETE BOTTOM
0.5 ≤ RISE / SPAN

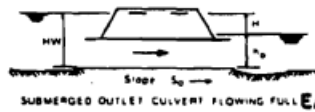
Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplicate of the nomograph may be used.

CHART 48B



Area (ft ²)	\bar{x}
20 - 80	0.028
81 - 260	0.028

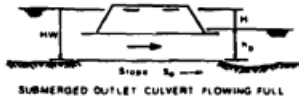
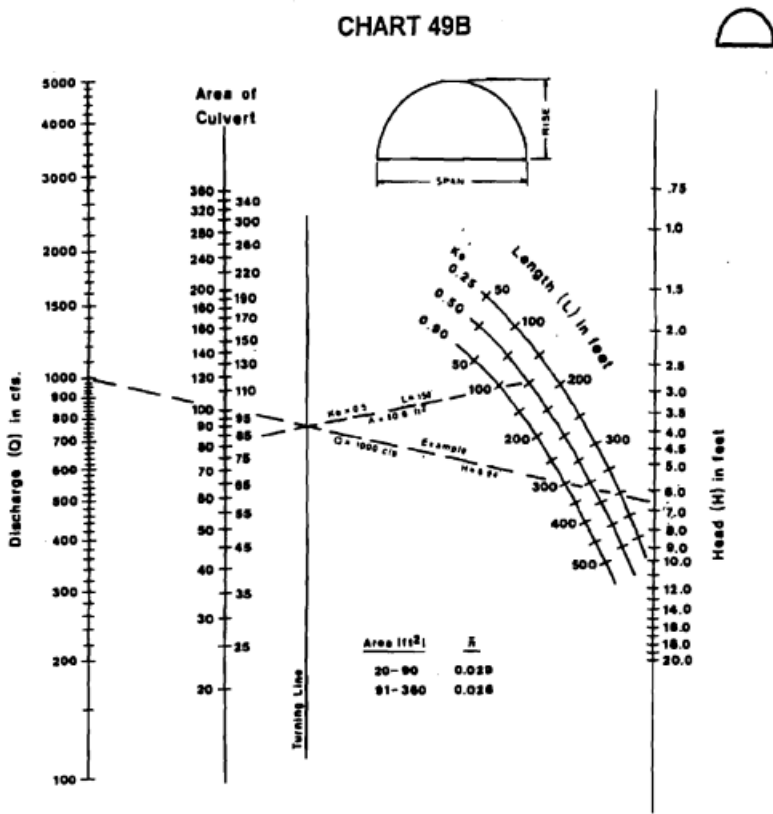


**HEAD FOR
C.M. ARCH CULVERTS
FLOWING FULL
EARTH BOTTOM ($n_b = 0.022$)
 $0.3 \leq \text{RISE} / \text{SPAN} \leq 0.4$**

Nomeographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 49B



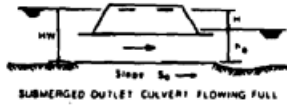
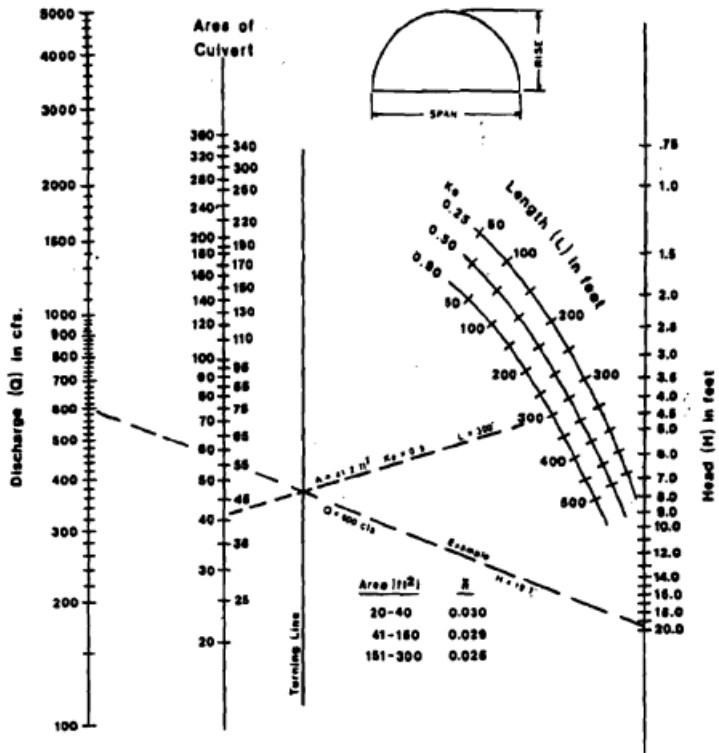
HEAD FOR
C. M. ARCH CULVERTS
FLOWING FULL
EARTH BOTTOM ($n_b = 0.022$)
 $0.4 \leq \text{RISE} / \text{SPAN} < 0.5$

Nonographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplication of this nonograph may distort scale



CHART 50B

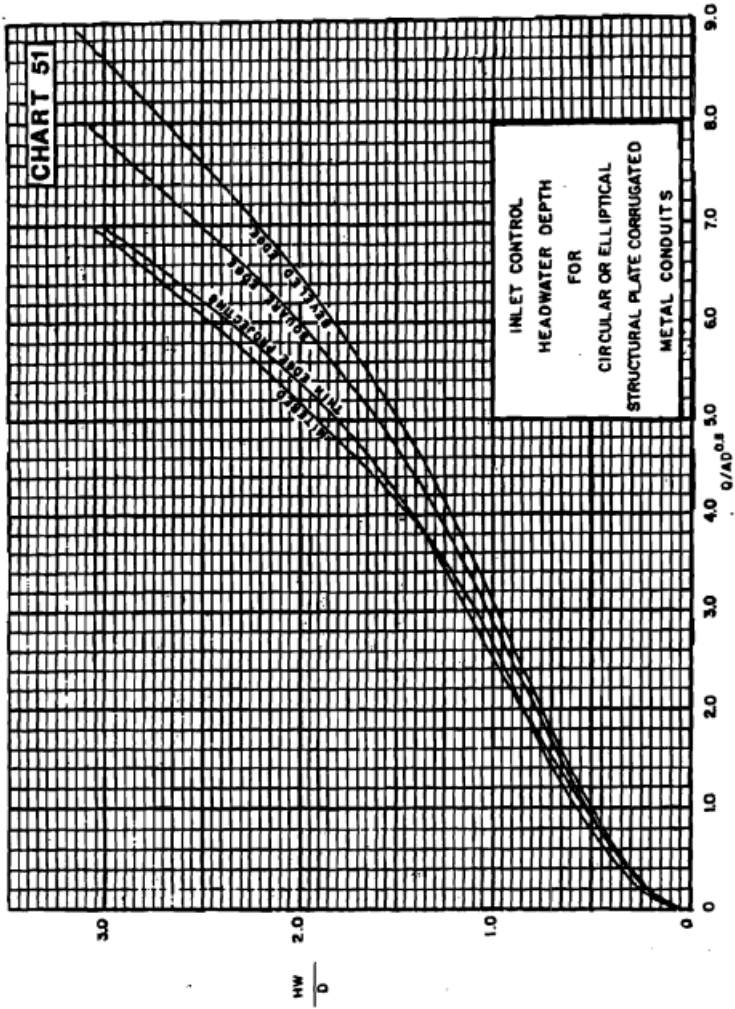


HEAD FOR
C.M. ARCH CULVERTS
FLOWING FULL
EARTH BOTTOM ($n_b = 0.022$)
 $0.5 \leq \text{RISE} / \text{SPAN}$

Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

CHART 51B
(English Units)



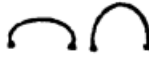


CHART 52B
(English Units)

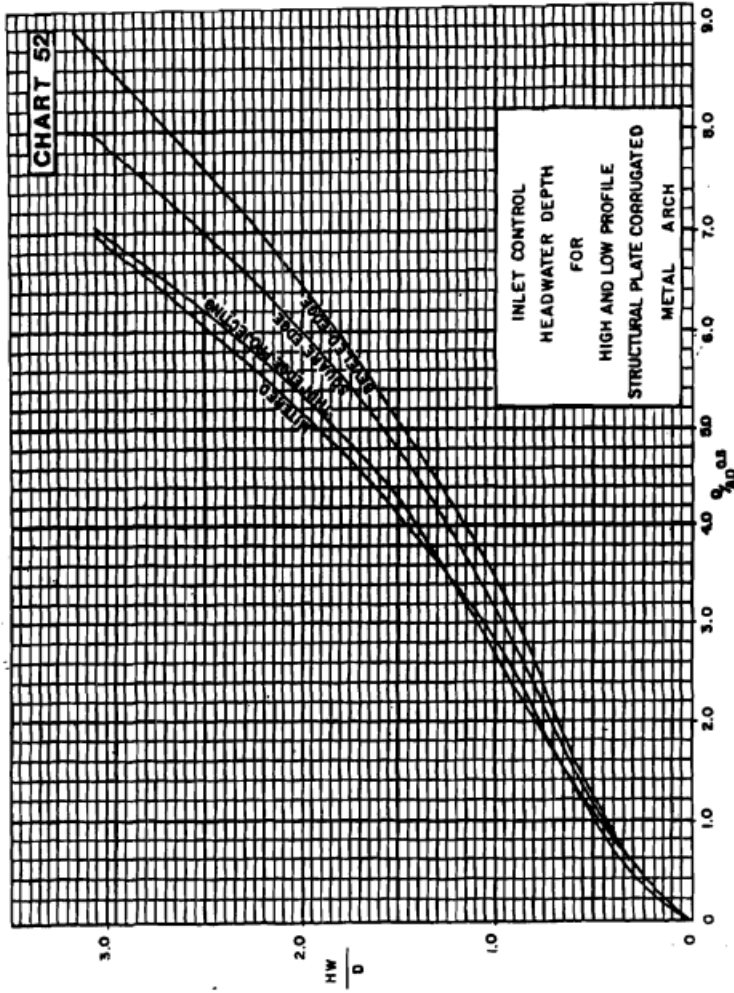


CHART 53B

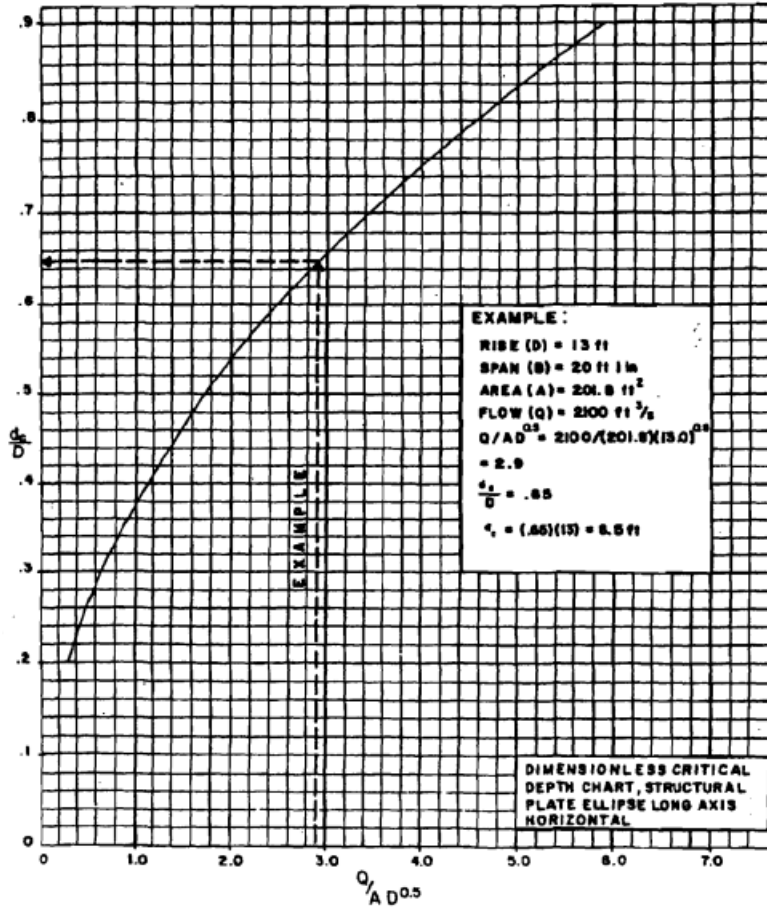


CHART 54B

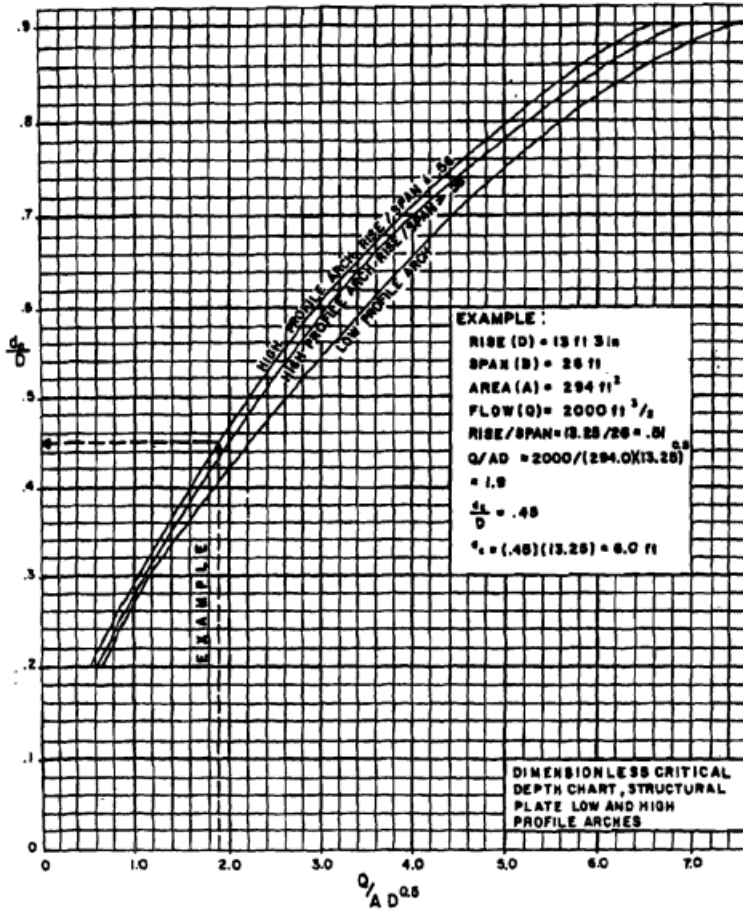
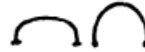
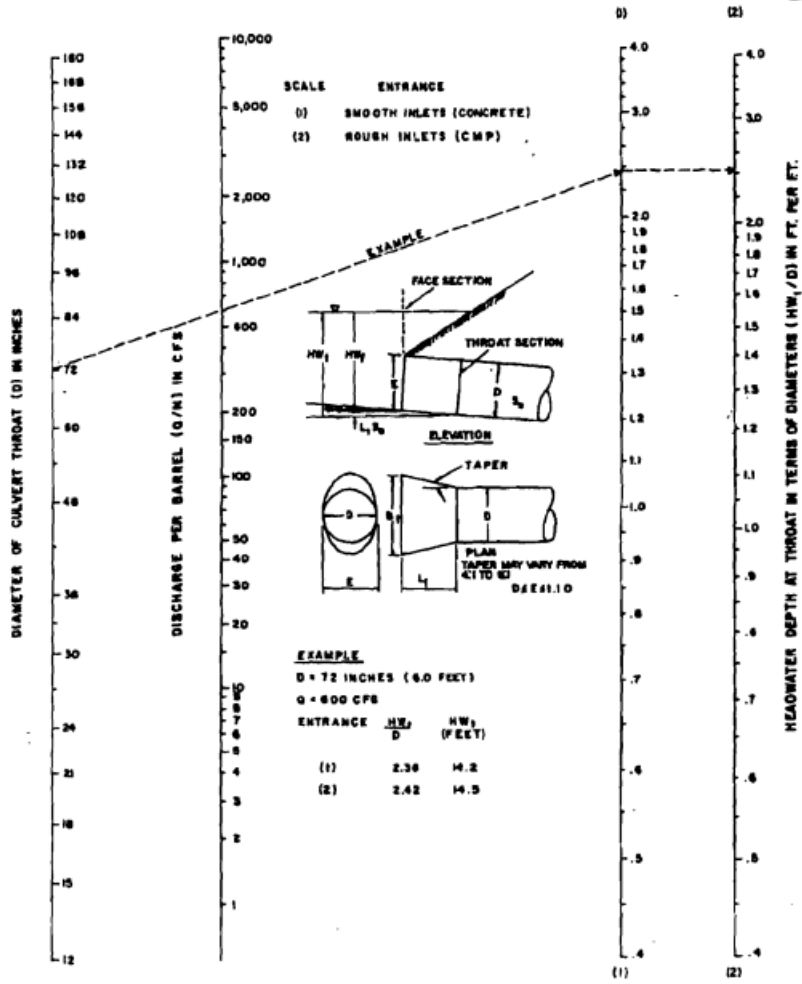
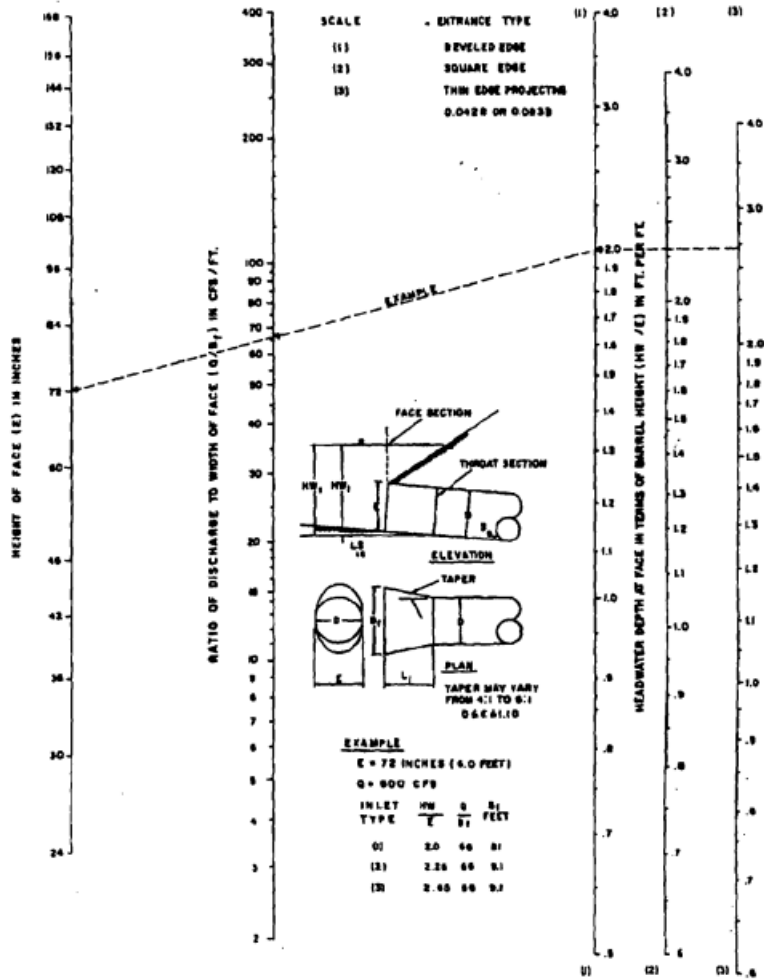


CHART 55B



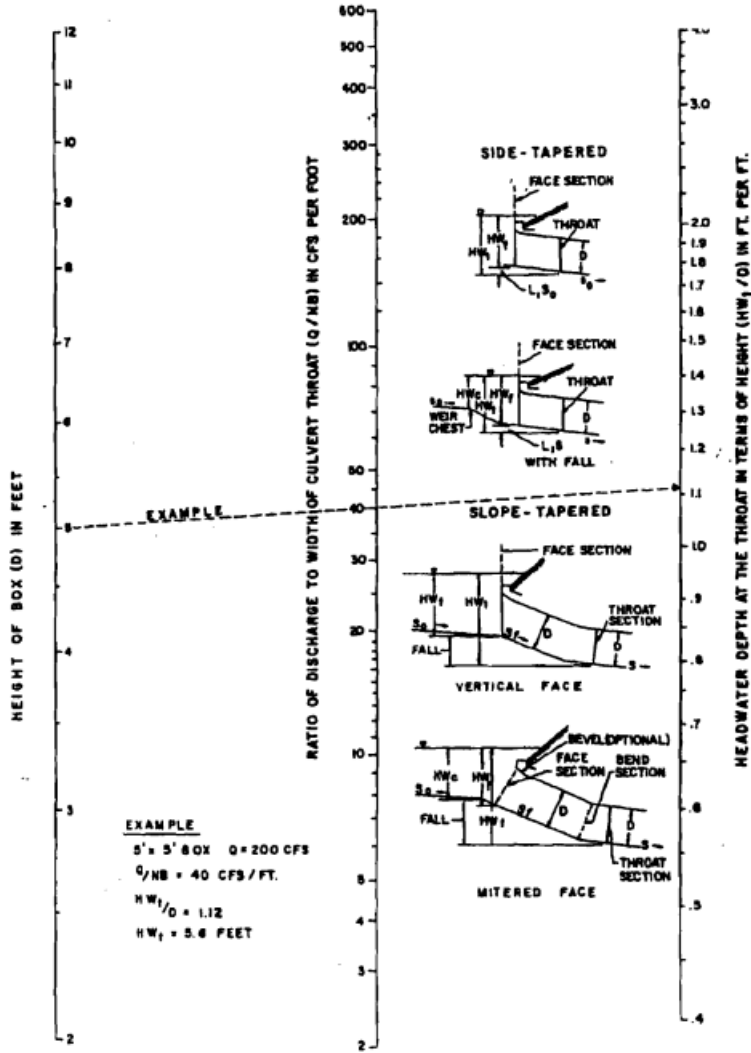
THROAT CONTROL
FOR SIDE-TAPERED INLETS TO PIPE CULVERT
(CIRCULAR SECTION ONLY)

CHART 56B



FACE CONTROL FOR SIDE-TAPERED
INLETS TO PIPE CULVERTS
(NON-RECTANGULAR SECTIONS ONLY)

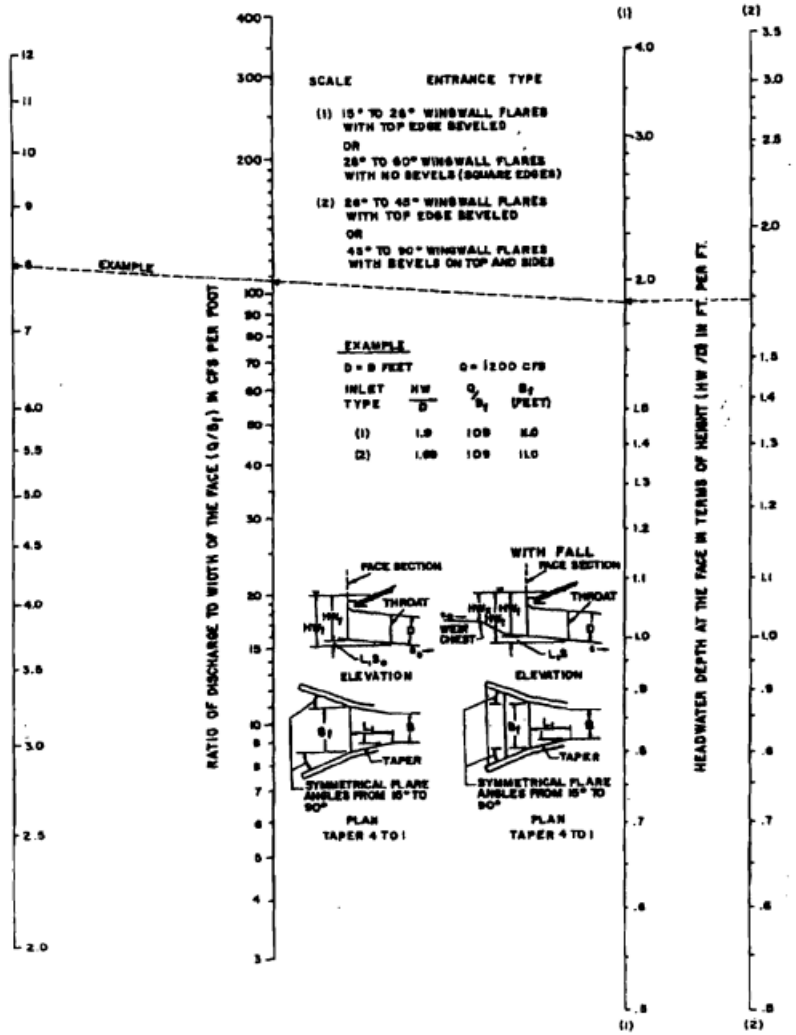
CHART 57B



EXAMPLE
 $3' \times 3' \text{ BOX } Q = 200 \text{ CFS}$
 $Q/NB = 40 \text{ CFS/FT.}$
 $HW_1/D = 1.12$
 $HW_1 = 3.6 \text{ FEET}$

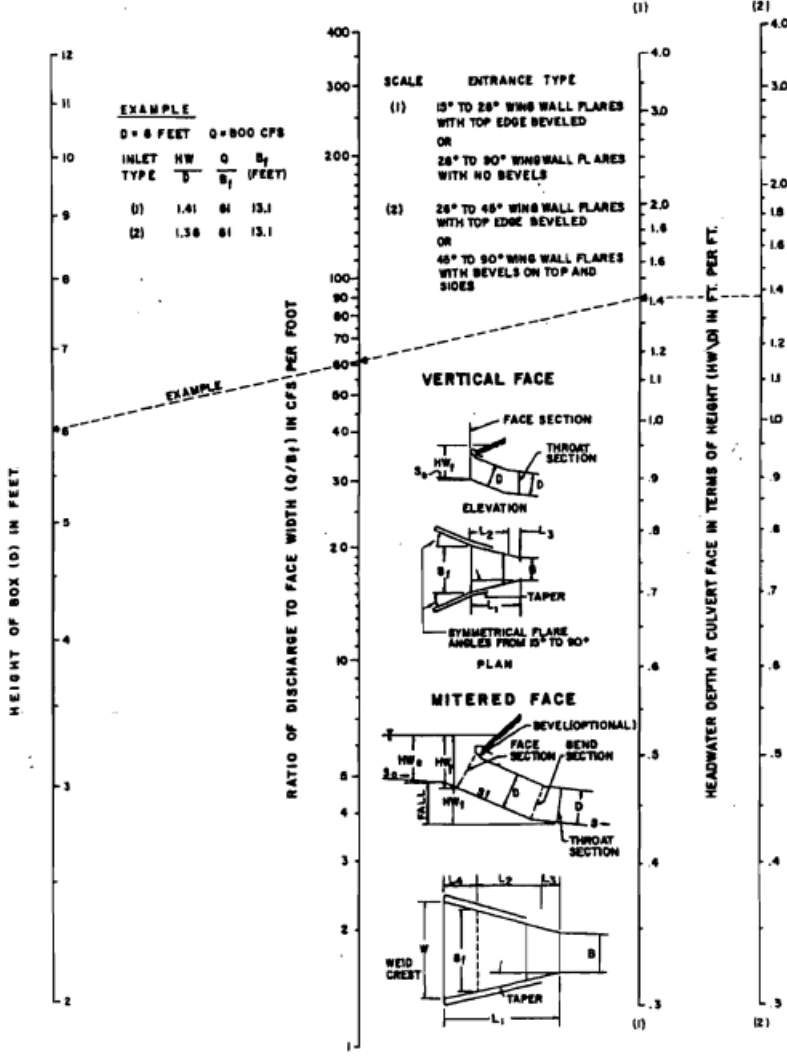
THROAT CONTROL FOR BOX
CULVERTS WITH TAPERED
INLETS

CHART 58B



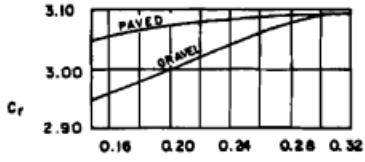
FACE CONTROL FOR BOX CULVERTS
WITH SIDE TAPERED INLETS

CHART 59B

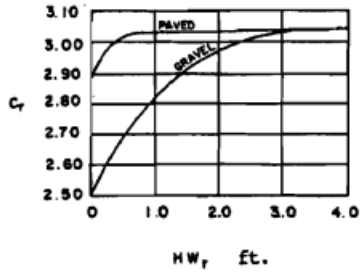


FACE CONTROL FOR BOX
CULVERTS WITH SLOPE
TAPERED INLETS

CHART 60B



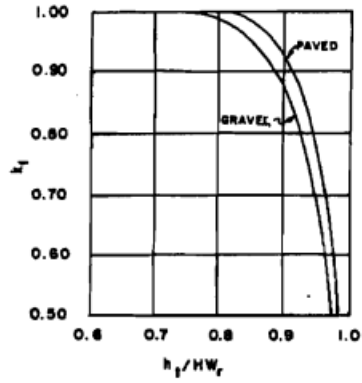
A) DISCHARGE COEFFICIENT FOR
 $HW_r/L_r > 0.15$



B) DISCHARGE COEFFICIENT FOR
 $HW_r/L_r \leq 0.15$

$$C_d = k_f C_r$$

$$Q_r = C_d L H W_r^{1.5}$$



C) SUBMERGENCE FACTOR

English Discharge Coefficients
for Roadway Overtopping

S

*t
o
r
m*

*W
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*D
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APPENDIX 6
GIS DATABASE SUBMITTALS

Appendix 6

GIS Database Submittals

All storm drainage infrastructures in any dedicated easement or street rights of way shall be submitted in accordance with all provisions herein. This includes all vertical and horizontal alignments for all constructed street centerlines and detention/retention pond finished contours, outlet structures, and emergency spillways. Survey control shall conform to Section 2.2 of this manual.

All data shall be provided to the City of Brookland in ESRI shapefile and PDF formats.

For all shapefiles, a separate spatial data file should be used for each structure and specific attributes should be recorded on site at the time of collection. The following table should be used for recording these attributes along with all feature attribute input criteria.

Table 1. Attribute Fields

	Field Name	Data Type	Length	Precision	Scale
Inlet	DATE	Date			
	BASIN	Text	1		
	NUMBER	Long Integer		6	
	DEPTH	Double		12	1
	TYPE	Text	12		
	WIDTH	Short Integer		2	
	LENGTH	Short Integer		2	
	COMMENT	Text	80		
Circular Pipe	DATE	Date			
	BASIN	Text	1		
	NUMBER	Long Integer		6	
	SIZE	Short Integer		2	
	MATERIAL	Text	20		
	PROTECTION	Text	21		
	COMMENT	Text	80		
	INVERT	Float		6	2
Elliptical Pipe	DATE	Date			
	BASIN	Text	1		
	NUMBER	Long Integer		6	
	DIMENSION	Text	5		
	MATERIAL	Text	20		
	PROTECTION	Text	21		
	COMMENT	Text	80		
	INVERT	Float		6	2

	Field Name	Data Type	Length	Precision	Scale
Arch Pipe	DATE	Date			
	BASIN	Text	1		
	NUMBER	Long Integer		6	
	DIMENSION	Text	5		
	MATERIAL	Text	20		
	PROTECTION	Text	21		
	COMMENT	Text	80		
	INVERT	Float		6	2
Box Culvert	DATE	Date			
	BASIN	Text	1		
	NUMBER	Long Integer		6	
	WIDTH	Short Integer		2	
	HEIGHT	Short Integer		2	
	MATERIAL	Text	8		
	COMMENT	Text	80		
	INVERT	Float		6	2
Outfall	DATE	Date			
	BASIN	Text	1		
	NUMBER	Long Integer		6	
	SIZE	Short Integer		2	
	FLOWDIRECT	Text	1		
	ODOR	Short Integer		4	
	FLOWQUANT	Short Integer		3	
	COLOR	Text	11		
	POLLUTANT	Text	10		
	COMMENT	Text	80		
	INVERT	Float		6	2
Bridge	DATE	Date			
	BASIN	Text	1		
	NUMBER	Long Integer		6	
	DECK TO BEAM	Float		4	1
	PIERSHAPE	Text	8		
	PIERSIZE	Short Integer		2	
	COMMENT	Text	80		

(Ord. No. 09:008, §2, 02-17-2009)

ANY FEATURE WITH THESE ATTRIBUTES

BASIN: C = Cache
L = Languille
S = St Francis

MATERIAL: Concrete
Corrugated metal
Non corrugated metal
Plastic
Clay

PROTECTION: None
Flared end section
Headwall
Headwall and Wingwall

INVERT: 2 decimal places in the measurement

ARCH PIPE

DIMENSION: 11x18
14x22
18x29
23x36
27x44
31x51
36x59
40x65
45x73
54x88

BOX CULVERT

WIDTH & HEIGHT: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

BRIDGE

PIERSHAPE: Circular
Square

PIERSIZE: 12, 18, 24, 30, 36, 42, 48

DECKTOBEAM: one decimal place in the measurement

CIRCULAR PIPE

SIZE: 12, 15, 18, 24, 30, 36, 42, 48, 54, 60, 72

ELLIPTICAL PIPE

DIMENSION: 12x18
14x23
19x30
22x34
24x38
29x45
34x53
38x60
43x68
48x76
53x83

INLET

TYPE: Area
Combination
Curb
Grate
Junction box
Other

WIDTH & LENGTH: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

DEPTH: one decimal place in the measurement

OUTFALL

SIZE: 12, 15, 18, 24, 30, 36, 42, 48, 54, 60, 72

FLOWDIRECT: N, S, E, W

FLOWQUANT: 0, 25, 50, 75, 100

COLOR: Clear
Black
Dark brown
Light brown
Red
Other

POLLUTANT: None
Oil
Oil sheen

For each structure, a digital photograph shall be taken and submitted, providing visual documentation of the structure's condition. Each image file shall be named to identify it based on drainage area, structure type, and number.

As a post processing step, all appropriate drainage structure location points shall be connected to create line work representing the storm drainage network. Care should be taken to tie the new drainage structures to the existing structures or to the appropriate drainage channel. At a minimum, structure diameter and length (in feet) should be added to the attribute table at the time of creation.

APPENDIX 7
ADEQ PERMIT NO. ARR150000

**AUTHORIZATION TO DISCHARGE STORMWATER UNDER
THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM AND THE
ARKANSAS WATER AND AIR POLLUTION CONTROL ACT**

In accordance with the provisions of the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended, Ark. Code Ann. 8-4-101 et seq.), and the Clean Water Act (33 U.S.C. 1251 et seq.),

Operator of Facilities with Stormwater Discharges Associated With Construction Activity

is authorized to discharge to all receiving waters except as stated in Part I.B.11 (Exclusions).

For facilities that are eligible for coverage under this General Permit (GP), the Department sends a cover letter (Notice of Coverage with tracking permit number which starts with ARR15) and a copy of the permit to the facility. The cover letter includes the Department's determination that a facility is covered under the GP and may specify alternate requirements outlined in the permit.

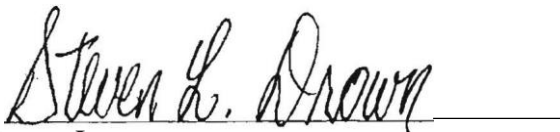
The responses to comments related to this permit are available as a separate document on the Department's website.

; 1

Issue Date: October 31, 2008

Effective Date: November 1, 2008

Expiration Date: October 31, 2011



Steven L. Drown
Chief, Water Division
Arkansas Department of Environmental Quality

PART I PERMIT REQUIREMENTS

Information in **Part I** is organized as follows:

Section A: Definitions

Section B: Coverage Under this Permit:

1. Permitted Area
2. Eligibility
3. Responsibilities of the Operator
4. Where to submit
5. Requirements for Qualifying Local Program (QLP)
6. Requirements for Coverage
7. Notice of Intent (NOI) Requirements
8. Posting Notice of Coverage (NOC)
9. Applicable Federal, State or Local Requirements
10. Allowable Non-Stormwater Discharges
11. Limitations on Coverage (Exclusions)
12. Trench and Ground Water Control
13. Buffer Zones
14. Waivers from Permit Coverage
15. Continuation of the Expired General Permit
16. Notice of Termination (NOT)
17. Responsibilities of the Operator of a Larger Common Plan of Development for a Subdivision
18. Change in Operator
19. Late Notifications
20. Failure to Notify
21. Maintenance
22. Releases in Excess of Reportable Quantities
23. Attainment of Water Quality Standards

SECTION A: DEFINITIONS

1. **"ADEO" or "Department"** is referencing the Arkansas Department of Environmental Quality. The Department is the governing authority for the National Pollutant Discharge Elimination System program in the state of Arkansas.
2. **"Arkansas Pollution Control and Ecology Commission"** shall be referred to as APCEC throughout this permit.
3. **"Automatic Coverage"** indicates those sites that are defined as a small construction site or a site that is less than five (5) acres but part of a larger common plan.
4. **"Best Management Practices (BMPs)"** schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. According to the EPA BMP manual the use of hay bales in concentrated flow areas is not recommended as a best management practice.
5. **"Commencement of Construction"** the initial disturbance of soils associated with clearing, grading, or excavating activities or other construction activities.
6. **"Contaminated"** means a substance the entry of which into the MS4, Waters of the State, or Waters of the United States may cause or contribute to a violation of Arkansas water quality standards.
7. **"Control Measure"** as used in this permit, refers to any Best Management Practice or other method used to prevent or reduce the discharge of pollutants to waters of the State.
8. **"Construction Site"** an area upon which one or more land disturbing construction activities occur that in total will disturb one acre or more of land, including areas that are part of a larger common plan of development or sale where multiple separate and distinct land disturbing construction activities may be taking place at different times on different schedules but under one plan such that the total disturbed area is one acre or more.
9. **"CWA"** the Clean Water Act or the Federal Water Pollution Control Act.
10. **"Dedicated Portable Asphalt Plant"** a portable asphalt plant that is located on or contiguous to a construction site that provides asphalt only to the construction site on which the plant is located or adjacent to. The term does not include facilities that are subject to the asphalt emulsion effluent guideline limitations at 40 CFR Part 443.
11. **"Dedicated Portable Concrete Plant"** is a portable concrete plant that is located on or contiguous to a construction site and that provides concrete only to the construction site on which the plant is located on or adjacent to.
12. **"Detention Basin"** a detention basin is an area where excess stormwater is stored or held temporarily and then slowly drains when water levels in the receiving channel recede. In essence, the water in a detention basin is temporarily detained until additional room becomes available in the receiving channel.
13. **"Director"** the Director, Arkansas Department of Environmental Quality, or a designated representative.
14. **"Discharge"** when used without qualification means the "discharge of a pollutant".
15. **"Discharge of Stormwater Associated with Construction Activity"** as used in this permit, refers to a discharge of

pollutants in stormwater runoff from areas where soil disturbing activities (e.g., clearing, grading, or excavation), construction materials or equipment storage or maintenance (e.g., fill I piles, borrow area, concrete truck washout, fueling), or other industrial stormwater directly related to the construction process (e.g., concrete or asphalt batch plants) are located.

16. **"Discharge-Related Activities"** as used in this permit, include: activities that cause, contribute to, or result in stormwater point source pollutant discharges, including but not limited to: excavation, site development, grading and other surface disturbance activities; management of solid waste and debris; and measures to control stormwater including the construction and operation of BMPs to control, reduce or prevent stormwater pollution.

17. **"Disturbed area"** the total area of the site where any construction activity is expected to disturb the ground surface. This includes any activity that could increase the rate of erosion, including, but not limited to, clearing, grubbing, grading, excavation, demolition activities, haul roads, and areas used for staging. Also included, are stockpiles of topsoil, fill material and any other stockpiles with a potential to create additional runoff.

18. **"Eligible"** qualified for authorization to discharge stormwater under this general permit.

19. **"Erosion"** the process by which the land's surface is worn away by the action of wind, water, ice or gravity.

20. **"Facility" or "Activity"** any NPDES "point source" or any other facility or activity (including land or appurtenances thereto) that is subject to regulation under the NPDES program.

21. **"Final Stabilization":**

A. All soil disturbing activities at the site have been completed and either of the two following criteria are met:

- 1) A uniform (e.g., evenly distributed, without large bare areas) perennial vegetative cover with a density of 80% of the native background vegetative cover for the area has been established on all unpaved areas and areas not covered by permanent structures, or
- 2) Equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed.

B. When background native vegetation will cover less than 100% of the ground (e.g., arid areas, beaches), the 80% coverage criteria is adjusted as follows: if the native vegetation covers 50% of the ground, 80% of 50% ($0.80 \times 0.50 = 0.40$) would require 40% total cover for final stabilization. On a beach with no natural vegetation, no stabilization is required.

C. For individual lots in residential construction, final stabilization means that either:

- 1) The homebuilder has completed final stabilization as specified above, or
- 2) The homebuilder has established temporary stabilization including perimeter controls for an individual lot prior to occupation of the home by the homeowner and informing the homeowner of the need for, and benefits of, final stabilization.

D. For construction projects on land used for agricultural purposes (e.g., pipelines across crop or range land, staging areas for highway construction, etc.), final stabilization may be accomplished by returning the disturbed land to its pre-construction agricultural use. Areas disturbed that were not previously used for agricultural activities, such as buffer.

strips immediately adjacent to "water of the United States", and areas which are not being returned to their pre-construction agricultural use must meet the final stabilization criteria in A, B, or C above.

22. **"Infrastructure"** streets, drainage, curbs, utilities, etc.
23. **"Impaired Water"** a water body listed in the current, approved Arkansas 303(d) list.
24. **"Landscaping"** improving the natural beauty of a piece of land (i.e. entrance of subdivision) through plantings or altering the contours of the ground.
25. **"Large and Medium Municipal Separate Storm Sewer System"** all municipal separate storm sewer systems that are either:
 - A. Located in an incorporated place with a population of 100,000 or more as determined by the latest Decennial Census by the Bureau of Census; or
 8. Located in the counties with unincorporated urbanized populations of 100,000 or more, except municipal, separate storm sewers that are located in the incorporated places, townships or towns within such counties; or
 - C. Owned or operated by a municipality other than those described in paragraphs (i) or (ii) and that are designated by the Director as part of the large or medium municipal separate storm sewer system.
26. **"Large Construction Site"** Construction activity includes clearing, grading and excavation, **except** operations that result in the disturbance of less than five acres of total land area. Construction activity also includes the disturbance of less than five acres of total land area that is a part of a larger common plan of development or sale if the larger common plan will ultimately disturb five acres. (Please see Part I.B.14 for partial waivers.)
27. **"Larger Common Plan of Development"** a contiguous (sharing a boundary or edge; adjacent; touching) area where multiple and distinct construction activities may be taking place at different times on different schedules under one plan. Such a plan might consist of many small projects (e.g. a common plan of development for a residential subdivision might lay out the streets, house lots, and areas for parks, schools and commercial development that the developer plans to build or sell to others for development.) All these areas would remain part of the common plan of development or sale. The following items can be used as guidance for deciding what might or might not be considered a "Common Plan of Development or Sale." The "plan" in a common plan of development or sale is broadly defined as any announcement or piece of documentation (including a sign, public notice or hearing, sales pitch, advertisement, drawing, permit application, zoning request, computer design, etc.) or physical demarcation (including boundary signs, lot stakes, surveyor markings, etc.) indicating construction activities may occur on a specific plot. You must still meet the definition of operator in order to be required to get permit coverage, regardless of the acreage you personally disturb.

If a smaller project (i.e., less than 1 acre) is part of a large common plan of development or sale (e.g., you are building a residential home on a 1/2 acre lot in a 40 acre subdivision or are putting in a fast food restaurant on a 3/4 acre pad that is part of a 20 acre retail center) permit coverage is required. Under 40 CFR 122.26(b)(2)(vi), smaller parts of a larger common plan of development are automatically authorized under this general permit and should follow the conditions of a site with automatic coverage set forth in this permit (see Part I.8.6.A).
28. **"NOC"** Notice of Coverage
29. **"NOI"** Notice of Intent to be covered by this permit.

30. **"NOT"** Notice of Termination.

31. **"Operator"** for the purpose of this permit and in the context of stormwater associated with construction activity, means any person (an individual, association, partnership, corporation, municipality, state or federal agency) who has the primary management and ultimate decision-making responsibility over the operation of a facility or activity. The operator is responsible for ensuring compliance with all applicable environmental regulations and conditions.

In addition, for the purposes of this permit and determining who is an operator, "owner" refers to the party that owns the structure being built. Ownership of the land where construction is occurring does not necessarily imply the property owner is an operator (e.g., a landowner whose property is being disturbed by construction of a gas pipeline or a landowner who allows a mining company to remove dirt, shale, clay, sand, gravel, etc. from a portion of his property). Likewise, if the erection of a structure has been contracted for, but possession of the title or lease to the land or structure is not to occur until after construction, the would-be owner may not be considered an operator (e.g., having a house built by a residential homebuilder).

32. **"Outfall"** a point source where stormwater leaves the construction site.

33. **"Owner"** the owner or operator of any "facility or activity" subject to regulation under the NPDES program. In addition, for purposes of this permit and determining who is an operator, "owner" refers to the party that owns the structure being built. Ownership of the land where construction is occurring does not necessarily imply the property owner is an operator (e.g., a landowner whose property is being disturbed by construction of a gas pipeline). Likewise, if the erection of a structure has been contracted for, but possession of the title or lease to the land or structure is not to occur until after construction, the would-be owner may not be considered an operator (e.g. having a house built by a residential homebuilder).

34. **"Physically Interconnected"** that one municipal separate storm sewer system is connected to a second municipal separate storm sewer system in such a way that it allows for direct discharges into the second system.

35. **"Point Source"** any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

36. **"Qualified Local Program"** is a municipal program for stormwater discharges associated with construction sites that has been formally approved by the Department.

37. **"Qualified personnel"** a person knowledgeable in the principles and practice of erosion and sediment controls who possesses the skills to assess conditions at the construction site that could impact stormwater quality and to assess the effectiveness of any sediment and erosion control measures selected to control the quality of stormwater discharges from the construction activity.

38. **"Regulated Small Municipal Separate Storm Sewer System"** all municipal separate storm sewer systems that are either:

- A. Located within the boundaries of an "urbanized area" with a population of 50,000 or more as determined by the latest Decennial Census by the Bureau of Census; or
- B. Owned or operated by a municipality other than those described in paragraph A and that serve a jurisdiction with a population of at least 10,000 and a population density of at least 1,000 people per square mile; or
- C. Owned or operated by a municipality other than those described in paragraphs A and B and that contributes substantially to the pollutant loadings of a "physically interconnected" municipal separate storm sewer system.

39. **"Retention Basin"** a basin that is designed to hold the stormwater from a rain event and allow the water to infiltrate through the bottom of the basin. A retention basin also stores stormwater, but the storage of the stormwater would be on a more permanent basis. In fact, water often remains in a retention basin indefinitely, with the exception of the volume lost to evaporation and the volume absorbed into the soils. This differs greatly from a detention basin, which typically drains after the peak of the storm flow has passed, sometimes while it is still raining.
40. **"Runoff Coefficient"** the fraction of total rainfall that will appear at the conveyance as runoff.
41. **"Sediment"** material that settles to the bottom of a liquid.
42. **"Sediment Basin"** a basin that is designed to maintain a 10 year-24 hour storm event for a minimum of 24-hours in order to allow sediment to **settle** out of the water.
43. **"Small Construction Site"** Construction activities including clearing, grading, and excavating that result in land disturbance of equal to or greater than one acre and less than five acres. Small construction activity also includes the disturbance of less than one acre of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb equal to or greater than one and less than five acres. Small construction activity does not include routine maintenance.
44. **"Stormwater"** stormwater runoff from rainfall, snow melt runoff, and surface runoff and drainage.
45. **"Stormwater Associated with Construction Activity"** the discharge from any conveyance which is used for collecting and conveying stormwater, and which is directly related to construction activity.
46. **"Stormwater Pollution Prevention Plan (SWPPP or SWP3)"** a plan that includes site map(s), an identification of construction/contractor, activities that could cause pollutants in the stormwater, and a description of measures or practices to control these pollutants (BMPs).
47. **"Temporary Sediment Controls"** controls that are installed to control sediment runoff from the site. These could be silt fencing, rock check dams, etc.
48. **"Total Maximum Daily Load" or "TMDL"** the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for non-point sources and natural background. If receiving water has only one point source discharger, the TMDL is the sum of that point source WLA plus the LAs for any non-point sources of pollution and natural background sources, tributaries, or adjacent segments. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure.
49. **"Uncontaminated"** can not exceed the water quality standards as set forth in APCEC Regulation 2.
50. **"Urbanized Area"** the areas of urban population density delineated by the Bureau of the Census for statistical purposes and generally consisting of the land area comprising one or more central place(s) and the adjacent densely settled surrounding area that together have a residential population of at least 50,000 and an overall population density of at least 1,000 people per square mile as determined by the latest Decennial Census by the Bureau of Census.

SECTION B: COVERAGE UNDER THIS PERMIT

Introduction

This Construction General Permit (CGP) authorizes stormwater discharges from large and small construction activities that result in a total land disturbance of equal to or greater than one acre, where those discharges enter surface waters of the State or a municipal separate storm sewer system (MS4) leading to surface waters of the State subject to the conditions set forth in this permit. This permit also authorizes storm water discharges from any other construction activity designated by ADEQ where ADEQ makes that designation based on the potential for contribution to an excursion of a water quality standard or for significant contribution of pollutants to waters of the State. This permit replaces the permit issued in 2003. The goal of this permit is to minimize the discharge of storm water pollutants from construction activity. The Operator should make sure to read and understand the conditions of the permit. A copy of the General Stormwater Construction Permit is available on the ADEQ web site at http://www.adeg.state.ar.us/water/branch_npdes/stormwater/construction/construction.htm. You may also obtain a hard copy by contacting the ADEQ's General Permits Section at (501) 682-0623.

1. **Permitted Area.** If a large or small construction activity is located within the State of Arkansas, the operator may be eligible to obtain coverage under this permit.

2. **Eligibility.** Permit eligibility is limited to discharges from "large" and "small" construction activity, or as otherwise designated by ADEQ. This general permit contains eligibility restrictions, as well as permit conditions and requirements. You may have to take certain actions to be eligible for coverage under this permit. In such cases, you must continue to satisfy those eligibility provisions to maintain permit authorization. If you do not meet the requirements that are a pre-condition to eligibility, then resulting discharges constitute unpermitted discharges. By contrast, if you are eligible for coverage under this permit and do not comply with the requirements of the general permit, you may be in violation of the general permit for your otherwise eligible discharges.
 - A. This general permit authorizes discharges from construction activities as defined in 40 CFR 122.26(a), 40 CFR 122.26(b)(14)(x), and 40 CFR 122.26(b)(15)(i).

 - B. This permit also authorizes stormwater discharges from support activities (e.g., concrete or asphalt batch plants, equipment staging yards, materials storage areas, excavated material disposal areas, borrow areas) provided:
 - 1) The support activity is directly related to a specific construction site that is required to have NPDES permit coverage for discharges of stormwater associated with the construction activity;
 - 2) The support activity is not a commercial operation serving multiple unrelated construction projects by different operators, and does not operate beyond the completion of the construction activity at the last construction project it supports;
 - 3) Pollutant discharges from support activity areas are minimized in compliance with conditions of this permit; and
 - 4) discharges from the support activity areas must be identified in a stormwater pollution prevention plan stating appropriate controls and measures for the area.

 - C. Other activities may be considered for this permit at the discretion of the Director as defined in 40 CFR 122.26(b)(15)(ii).

3. **Responsibilities of the Operator.** Permittees with operational control are responsible for compliance with all applicable terms and conditions of this permit as it relates to their activities on the construction site, including protection of endangered species and implementation of BMPs and other controls required by the SWPPP. Receipt of this general

pennit does not relieve any operator of the responsibility to comply with any other applicable federal, state or local statute, ordinance or regulation.

4. **Where to submit.** The operator shall submit a complete and signed NOI and SWPPP to the Department at the following address:

Arkansas Department of Environmental Quality
Discharge Pennits Section
5301 Northshore Drive
North Little Rock, AR 72118-5317

Or by electronic mail (Complete documents (NOI and SWPPP) must be submitted in PDF format) to:

Water-pennit-application@adeq.state.ar.us ;

NOTE: Notice of Coverage (NOC) will **NOT** be issued until payment has been received by ADEQ.

5. **Requirements for Qualifying Local Program (QLP).** The Department reviews and approves the QLP programs to ensure that they meet or supersede both state and federal requirements outlined in this permit and 40 CFR 122.44(s). ADEQ will review the QLP program at least every 5 years for recertification. If the Department approves a QLP, then the QLP requirements must at the minimum meet the Department's requirements. This would include all templates and forms.

If the small construction site is within the jurisdiction of a QLP, the operator of the small construction site is authorized to discharge stormwater associated with construction activity under QLP permit requirements only.

List of Qualifying Local Programs: A list of municipalities with Qualifying Local Programs is available at http://www.adeq.state.ar.us/water/branch_npdes/stonwater/ms4.htm. At this time only the City of Hot Springs is meeting the ADEQ minimum requirements.

6. **Requirements for Coverage.**

- A. **Automatic Coverage.** An operator of each site with automatic coverage may discharge under this general permit without submitting a NOI, SWPPP and fee. Please note that all the permit conditions set forth must be followed. The Operator is responsible for ensuring that the site is in compliance with any changes or updates of this general permit, by either contacting ADEQ or reviewing the ADEQ website

http://www.adeq.state.ar.us/water/branch_npdes/stormwater/construction/construction.htm .

- B. **Large Construction Sites.** An operator of a large construction site discharging under this general permit must submit the following items at least two weeks prior to commencement of construction:

- 1) A Notice of Intent (NOi) in accordance with the requirements of Part I.B.7 of this permit.
- 2) A complete Stormwater Pollution Prevention Plan (SWPPP) in accordance with the requirements of Part II.A of this permit.
- 3) An initial pennit fee must accompany the NOI under the provisions of APCEC Regulation No. 9. Subsequent annual fees will be billed by the Department until the operator has requested a termination of coverage by submitting a Notice of Termination (NOT). Failure to remit the required permit fee may be grounds for the Director to deny coverage under this general permit.
- 4) Per Part I.B.14 of the permit, any single lot that are less than five (5) acres but part of a larger common plan

greater than five (5) acres, are waived from the requirements of a large site and may be permitted under automatic coverage.

Permitted Ongoing Project:

If you previously did receive authorization to discharge for your project under the 2003 CGP and you wish to obtain coverage under this permit, you must submit only an NOI within 60 days of the issuance date of this permit and update the existing SWPPP in accordance with Part II of this permit.

C. Coverage within a OLP

An operator of a site with automatic coverage, as defined in this permit, shall comply with the requirements of the QLP which has jurisdiction over the site.

7. Notice of Intent (NOD Requirements)

- A. **NOI Form.** Large Construction site operators who intend to seek coverage for stormwater discharge under this general permit must submit a complete and accurate ADEQ NOI form to the Department at least two weeks prior to coverage under this permit. The NOI form **must** be the current version obtained from the stormwater webpage indicated above in Part IB.

If the NOI is deemed incomplete, the Department will notify the applicant with regard to the deficiencies by a letter, email, or phone within ten (10) business days of receipt of NOI. If the operator does not receive a notification of deficiencies from ADEQ's receipt of the NOI, the NOIs deemed complete. If the applicant does not provide the Department with the requested deficiencies within the deadline set by the Department, then the Department will return the NOI, fee and SWPPP back to the applicant.

- B. **Contents of the NOI.** The NOI form contains, at a minimum, the following information:

- 1) Operator (Permittee) information (name, address, telephone and fax numbers, E-mail address)
- 2) Whether the operator is a federal, state, private, public, corporation, or other entity
- 3) Application Type: New or renewal
- 4) Invoice mailing information (name, address, and telephone and fax numbers)
- 5) Project Construction site information (name, county, address, contact person, direction to site, latitude and longitude for the entrance of the site or the endpoints for linear project (in degrees, minutes, and seconds), estimated construction start date and completion date through site final stabilization, estimate of the total project acreage and the acreage to be disturbed by the operator submitting the NOI, type of the project (subdivision, school, etc), whether the project is part of a larger common plan of development.)
- 6) Discharge information (name of the receiving stream, ultimate receiving stream, name of municipal storm sewer system)
- 7) Endangered Species information
- 8) Previous/Current permit information
- 9) The Certification statement and signature of a qualified signatory person in accordance with 40 CFR 122.22, as adopted by reference in APCEC Regulation No. 6
- 10) The certification of the facility corporation
- 11) Other information (location of the SWPPP).

C. **Notice of Coverage (NOC).** Unless notified by the Director to the contrary, dischargers who submit a NOI in accordance with the requirements of this permit are authorized to discharge stormwater from construction sites under the terms and conditions of this permit two weeks after the date the NOI is deemed complete by ADEQ. If the NOC has not been received by the permittee two weeks after the date the NOI is deemed complete by ADEQ, the NOI should be posted until the NOC is received. Upon review of the NOI and other available information, the Director may deny coverage under this permit and require submittal of an application for an individual NPDES permit.

8. Posting Notice of Coverage (NOC).

A. **Large Sites: NOC Posting for Large Construction Sites.** The posting for large construction sites shall be obtained from the Department only after the permittee has met the NOI, permit fee and complete SWPPP submittal to the Department for the coverage.

B. **Automatic Coverage Sites.** The Automatic Coverage NOC for small sites and a single site less than five (5) acres but part of a larger common plan, as defined in Part I.A, can be obtained from the Water Division's Construction Stormwater webpage. Posting a NOC without a SWPPP is a violation of this permit.

C. **Linear Projects.** If the construction project is a linear construction project (e.g., pipeline, highway, etc.), the notice must be placed in a publicly accessible location near where construction is actively underway and moved as necessary.

Please note, this permit does not provide the public with any right to trespass on a construction site for any reason, including inspection of a site; nor does this permit require that the permittee allow members of the public access to a construction site.

9. **Applicable Federal, State or Local Requirements.** The operator must ensure that the stormwater controls implemented at the site are consistent with all applicable federal, state, or local requirements. Additionally, an operator who is operating under approved local erosion and sediment plans, grading plans, local stormwater permits, or storm water management plans shall submit signed copies of the Notice of Intent to the local agency (or authority) upon the local agency's request.

10. Allowable Non-Stormwater Discharges.

- A. The following non-stormwater discharges that are combined with stormwater during construction may be authorized by this permit. Non-stormwater discharges must be addressed in the stormwater pollution prevention plan.
- 1) Fire fighting activities;
 - 2) Fire hydrant flushings;
 - 3) Water used to wash vehicles (where detergents or other chemicals are not used) or control dust in accordance with Part II.A.4.I.2;
 - 4) Potable water sources including uncontaminated waterline flushings;
 - 5) Landscape Irrigation ;
 - 6) Routine external building wash down which does not use detergents or other chemicals;
 - 7) Pavement wash waters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled materials have been removed) and where detergents or other chemicals are not used;
 - 8) Uncontaminated air conditioning, compressor condensate (See Part I.B.12 of this permit);
 - 9) Uncontaminated springs, excavation dewatering and groundwater (See Part I.B.12 of this permit);
 - 10) Foundation or footing drains where flows are not contaminated with process materials such as solvents (See Part I.B.12 of this permit);

- 11. Limitations on Coverage (Exclusions).** The following stormwater discharges associated with construction activity are not covered by this permit:
- A. **Post Construction Discharge.** Stormwater discharges associated with construction activities that originate from the site after construction activities have been completed, the site has undergone final stabilization, and the permit has been terminated.
 - B. **Discharges Mixed with Non-Stormwater.** Stormwater discharges that are mixed with sources of non-stormwater other than those identified in Part I.B.10.
 - C. **Discharges Covered by another Permit.** Stormwater discharges associated with construction activity that are covered under an individual or an alternative general permit may be authorized by this permit after an existing permit expires provided the expired permit did not establish numeric effluent limitations for such discharges.
 - D. **Discharges into Receiving Waters with an Approved TVIDL.** Discharges from a site into receiving waters for which there is an established total maximum daily load (TMDL) allocation (www.adeg.state.ar.us/water/branch_planning/default.htm) for Turbidity, Oil & Grease, and/or other pollutants at the discretion of the Director are not eligible for coverage under this permit unless the permittee develops and certifies a stormwater pollution prevention plan (SWPPP) that is consistent with the assumptions and requirements in the approved TMDL. To be eligible for coverage under this general permit, operators must incorporate into their SWPPP any conditions applicable to their discharges necessary for consistency with the assumptions and requirements of the TMDL within any timeframes established in the TMDL. If a specific numeric waste load allocation has been established that would apply to the project's discharges, the operator must incorporate that allocation into its SWPPP and implement necessary steps to meet that allocation. Please note that the Department will be reviewing this information. If it is determined that the project will discharge to a TMDL, then the Department may require additional BMPs.
 - E. **Discharges into Impaired Receiving Waters (303(d) List).** Discharges from a site into a receiving waters listed as impaired under Section 303(d) of the Clean Water Act (www.adeg.state.ar.us/water/branch_planning/default.htm) for Turbidity, Oil & Grease and/or other pollutants at the discretion of the Director, should incorporate into the SWPPP any additional BMPs needed to sufficiently protect water quality. The SWPPP should include a proposal for monitoring to determine if the BMPs and controls are effective. Please note that the Department will be reviewing this information. If it is determined that the project will discharge to an impaired water body, then the Department may require additional BMPs.
 - F. **Endangered and Threatened Species and Critical Habitat Protection.** Stormwater discharges from construction sites that are likely to adversely affect a listed endangered or threatened species or its critical habitat must contact the U.S. Fish and Wildlife Service (USFWS) at (501) 513-4470 or www.fws.gov/arkansas-es. Discharges which are not in compliance with the Endangered Species Act (ESA) cannot be covered under this permit.

In order to obtain coverage, the applicant must follow the process required by the USFWS in order to determine the project's compliance with the ESA. This automatic process can be found on the USFWS website at the following address: www.fws.gov/arkansas-es. The certification provided by the process must be included in the project's Stormwater Pollution Prevention Plan. If at some point during the process, the submittal of information to the USFWS is required, then the incomplete checklist should be submitted to the Department along with the letter of correspondence that was submitted to the USFWS.

12. Trench and Ground Water Control. There shall be no turbid discharges to surface waters of the state resulting from dewatering activities. If trench or ground waters contain sediment, it must pass through a sediment settling pond or other equally effective sediment control device, prior to being discharged from the construction site. Alternatively, sediment may be removed by settling in place or by dewatering into a sump pit, filter bag, or comparable practice. Ground water dewatering which does not contain sediment or other pollutants is not required to be treated prior to discharge. However, care must be taken when discharging ground water to ensure that it does not become pollutant-laden by traversing over disturbed soils or other pollutant sources.

13. Buffer Zones.

An undisturbed buffer zone as stated below shall be maintained at all times. Exceptions from this requirement for areas, such as water crossings, limited water access, and restoration of the buffer are allowed if the permittee fully documents in the SWPPP the circumstances and reasons for the buffer zone encroachment. Additionally, this requirement is not intended to interfere with any other ordinance, rule or regulation, statute or other provision of law.

- A. For construction projects where clearing and grading activities will occur, the SWPPP must provide at least twenty-five (25) feet of buffer zone, as measured horizontally from the top of the bank to the disturbed area, from any named or unnamed streams, creeks, rivers, lakes or other water bodies.
- B. The Department may also require up to fifty (50) feet of buffer zone, as measured from the top of the bank to the disturbed area, from established TMDL water bodies, streams listed on the 303 (d)-list, an Extraordinary Resource Water (ERW), Ecologically Sensitive Waterbody (ESW), Natural and Scenic Waterway (NSW), and/or any other uses at the discretion of the Director.
- C. Linear projects will be evaluated individually by the Department to determine buffer zone setbacks.

14. Waivers from Permit Coverage. The Director may waive the otherwise applicable requirements of this general permit for stormwater discharges from construction activities under the terms and conditions described in this section.

- A. Waiver Applicability and Coverage. Based upon 40 CFR Part 122.26.b. 1 5.i.A, operators of small construction activities may apply for and receive a waiver from the requirements to obtain this permit.
- B. No Stormwater Leaving the Site. If all of the stormwater from the construction activity is captured on-site under any size storm event and allowed to evaporate, soak into the ground on-site, or is used for irrigation, a permit is not needed.
- C. TMDL Waivers. This waiver is available for sites with automatic coverage if the ADEQ has established or approved a TMDL that addresses the pollutant(s) of concern and has determined that controls on stormwater discharges from small construction activity are not needed to protect water quality. The pollutant(s) of concern include sediment (such as total suspended solids, turbidity or siltation) and any other pollutant that has been identified as a cause of impairment of any water body that will receive a discharge from the construction activity. Information on TMDLs that have been established or approved by ADEQ is available from ADEQ online at www.adeg.state.ar.us/water/branch_planning/default.htm.
- D. Discharges into Impaired Receiving Waters (303(d) List). This waiver is available for sites with automatic coverage if the ADEQ has listed the waters in 303(d) list that addresses the pollutant(s) of concern and has determined that controls on stormwater discharges from small construction activity are not needed to protect water quality. The pollutant(s) of concern include sediment (such as total suspended solids, turbidity, or siltation) and any other pollutant.

that has been identified as a cause of impairment of any water body that will receive a discharge from the construction activity. Information on 303(d) that have been established by ADEQ is available from ADEQ online at www.adeg.state.ar.us/water/branch_planning/default.htm

- E. Sites part of the Larger Common Plan. Any single lot less than 5 acres that is part of larger common plan may be considered as a small construction site. As long as the operator has complied with all conditions of this permit without submitting an NOI in accordance with 40 CFR 122.28(b)(2)(v). This waiver is applicable if the operator has only one lot in the larger common plan or multiple lots in which construction will not begin within 24 months of the prior construction.

15. Continuation of the Expired General Permit. If this permit is not reissued or replaced prior to the expiration date, it will be administratively continued in accordance with the Administrative Procedure Act and remain in force and effect. If you were granted pennit coverage prior to the expiration date, you will automatically remain covered by the continued pennit until the earliest of:

- Reissuance or replacement of this permit, at which time the operator must comply with the conditions of the new pennit to maintain authorization to discharge and, the operator is required to notify the Department of his/her intent to be covered under this permit within 60 days after the effective date of the renewal permit; or
- Submittal of a Notice of Termination; or
- Issuance of an individual permit for the project's discharges; or
- A formal permit decision by ADEQ to not reissue this general permit, at which time you must seek coverage under an alternative general permit or an individual permit

Small site Operators are responsible for ensuring that the site is in compliance with any changes or updates of this general pennit, by reviewing the ADEQ website at:

http://www.adeg.state.ar.us/water/branch_npdes/stormwater/construction/construction.htm

16. Notice of Termination (NOT). All construction activities that disturbed soil are complete, the site has reached final effective stabilization (100% stabilization with 80% density), all stonnwater discharges from construction activities authorized by this permit are eliminated and all temporary sediment controls are removed and properly disposed, the operator of the facility may submit a complete Notice of Termination (NOT) to the Director. Along with the NOT, pictures that represent the entire site should be submitted for review. Final stabilization is not required if the land is returned to its pre-construction agriculture use. Operators of small construction sites are not required to submit NOTs for their construction sites. However, final stabilization is required on all sites. If a Notice of Termination is not submitted when the project is completed, the operator will be responsible for annual fees.

17. Responsibilities of the Operator of a Larger Common Plan of Development for a Subdivision.

- A. The operator is ultimately responsible for the runoff from the perimeter of the entire development. Regardless of the reason of the runoff, the operator is responsible for ensuring sufficient overall controls of the development.
- B. The operator shall not terminate the permit coverage until the following conditions have been met:
- 1) After all construction including landscaping and lot development has been completed; and
 - 2) All lots are sold and developed.

The following exceptions to this requirement can apply:

- a. less than 100% sold and developed at the discretion of the Director, or
 - b. Separation of the larger common plan if twenty-four (24) months have passed with no construction activity.
 - c. All lots are developed and there are no temporary common controls for subdivision outfalls, i.e. sediment basins, large sediment traps, check dams, etc.
- 3) If lots are sold then re-sold to a third party then permit coverage needs to be obtained by each of the operators while they have ownership of the lots. The second owner is responsible to obtain the same certification from the third owner, i.e.. the certification must pass from owner to owner.
- C. The operator shall not terminate permit coverage until the operators of all the individual lots within the larger common plan are notified of their permitting requirements under this general permit. In this case, the signed certification statements from each operator of individual lots must be maintained in the stormwater pollution prevention plan for the large common plan. A copy of the signed certifications must be submitted to ADEQ with the NOT. The certification shall be as follows:

"I, _____, operator of an individual lot #____, block ~~##~~ -- of _____ subdivision, certify under penalty of law that I was notified by the operator of the larger common plan of the stormwater permitting requirements for my construction site(s). I understand prior to commencement of any construction activity I have to prepare and comply with a SWPPP and post the Construction Site Notice. I understand that prior to the sale of this lot to another party; I must notify the new owner of ADEQ requirements and obtain this certification from the new owner."

Signature _____

- D. The following examples are provided as clarification:
- 1) If a small portion of the original common plan of development remains undeveloped and there has been a period of time (i.e., more than 24 months) where there are no ongoing construction activities (i.e., all areas are either undisturbed or have been finally stabilized), you may re-evaluate the original project based on the acreage remaining from the original "common plan." If less than five but more than one acre remains to build out the original "common plan", coverage under the large permit may not be required. However, you will need to comply with the terms and conditions for Small Construction Sites in the Construction General Permit. If less than one acre remains of the original common plan, your individual project may be treated as a part of a less than one acre development and no permit would be required.
 - 2) If you have a long-range master plan of development where some portions of the master plan are conceptual rather than a specific plan of future development and the future construction activities would, if they occur at all, happen over an extended period of time (i.e., more than 24 months), you may consider the "conceptual" phases of development to be separate "common plans" provided the periods of construction for the physically interconnected phases will not overlap.
 - 3) Where discrete construction projects within a larger common plan of development or sale are located ¼ mile or more apart and the area between the projects is not being disturbed, each individual project can be treated as a separate plan of development or sale provided any interconnecting road, pipeline or utility project that is part of the same "common plan" is not concurrently being disturbed. For example, an interconnecting access road or pipeline were under construction at the same time, they would generally be considered as a part of a single "common plan" for permitting purposes.
 - 4) If the operator sells all the lots in the subdivision to one or more multi-lot homebuilder(s), provisions must be made to obtain stormwater permit coverage by one of the following options:
 - a. The permit may be transferred from the first "operator" to the new/second "operator".

b. A new, separate permit may be obtained by the second "operator".

NOTE: If a new permit is to be obtained, then it must be obtained before the first/original permit is terminated.

- 5) If the operator retains ownership of any lots in the subdivision, the operator shall maintain permit coverage for those lots under the original permit. The operator shall modify the Stormwater Pollution Prevention Plan (SWPPP) by stating which lots are owned and marking the lots on the site map. If there **are** one (1) or two (2) lots remaining and the total acreage is less than five (5) acres, the original permit could be terminated and those lots could be covered as a small site.

18. Change in Operator. For stormwater discharges from large construction sites where the operator changes, including instances where an operator is added after the initial NOI has been submitted, the new operator must ensure that a permit transfer form is received by the Department at least two (2) weeks prior to the operator beginning work at the site.

19. Late Notifications. A discharger is not precluded from submitting an NOI in accordance with the requirements of this part after the dates provided in Part I.B.6 of this permit. In such instances, the Director may bring an enforcement action for failure to submit an NOI in a timely manner or for any unauthorized discharges of stormwater associated with construction activity that have occurred on or after the dates specified in this permit.

20. Failure to Notify. The operator of a construction site who fails to notify the Director of their intent to be covered under this permit, and who potentially discharges pollutants (sediment, debris, etc.) to waters of the State without an NPDES permit, is in violation of the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended).

21. Maintenance. Determination of the acreage of disturbance does not typically include disturbance for routine maintenance activities on existing roads where the line and grade of the road is not being altered, nor does it include the paving of existing roads. Maintenance activities (returning to original conditions) are not regulated under this permit unless one or more acres of underlying and/or surrounding soil are cleared, graded, or excavated as part of the operation.

22. Releases in Excess of Reportable Quantities.

A. The discharge of hazardous substances or oil in the stormwater discharge(s) from a facility shall be prevented or minimized in accordance with the applicable storm water pollution prevention plan for the facility. This permit does not relieve the operator of the reporting requirements of 40 CFR Parts 110, 117 and 302. Where a release containing a hazardous substance or oil in an amount equal to or in excess of a reporting quantity established under either 40 CFR 110, 40 CFR 117, or 40 CFR 302, occurs during a 24-hour period, the following action shall be taken:

- 1) Any person in charge of the facility is required to notify the National Response Center (NRC) (800-424-8802) in accordance with the requirements of 40 CFR 110, 40 CFR 117, or 40 CFR 302 as soon as he/she has knowledge of the discharge;
- 2) The operator shall submit within five (5) calendar days of knowledge of the release a written description of the release (including the type and estimate of the amount of material released), the date that such release occurred, and the circumstances leading to the release, and steps to be taken in accordance with Part II.B.13 of this permit to the ADEQ.
- 3) The stormwater pollution prevention plan described in Part II.A of this permit must be modified within fourteen (14) calendar days of knowledge of the release to:
 - a. Provide a description of the release and the circumstances leading to the release; and

b. The date of the release;

¹ Additionally, the plan must be reviewed to identify measures to prevent the reoccurrence of such releases and to respond to such releases, and the plan must be modified where appropriate.

B. Spills. This permit does not authorize the discharge of hazardous substances or oil resulting from an on-site spill.

23. Attainment of Water Quality Standards

The operator must select, install, implement and maintain control measures at the construction site that minimize the discharge of turbidity and/or oil and grease and/or other pollutants at the discretion of the Director as necessary to protect water quality. In general, except in situations explained in below, the stormwater controls developed, implemented, and updated to be considered stringent enough to ensure that your discharges do not cause or contribute to an excursion above any applicable water quality standard.

At any time after authorization, the ADEQ may determine that the stormwater discharges may cause, have reasonable potential to cause, or contribute to an excursion above any applicable water quality standard. If such a determination is made, ADEQ will require the permittee to:

- A. Develop a supplemental BMP action plan describing SWPPP modifications to address adequately the identified water quality concerns and submit valid and verifiable data and information that are representative of ambient conditions and indicate that the receiving water is attaining water quality standards; or
- B. Cease discharges of pollutants from construction activity and submit an individual permit application.

All written responses required under this part must include a signed certification consistent with Part II.B.9.

PART II **STANDARD CONDITIONS**

Information in **Part II** is organized as follows:

Section A: Stormwater Pollution Prevention Plans:

1. Deadlines for Plan Preparation and Compliance
2. Signature, Plan Review, Plan Availability, and NOC
3. Keeping Plans Current
4. Contents of Stormwater Pollution Prevention Plan
5. Contractors
6. Inspectors
7. Plan Certification

Section B: Standard Permit Conditions:

1. Retention of Records
2. Duty to Comply
3. Penalties for Violations of Permit Conditions
4. Continuance of Expired General Permit
5. Need to Halt or Reduce Activity Not a Defense
6. Duty to Mitigate
7. Duty to Provide Information
8. Other Information
9. Signatory Requirements
10. Certification
11. Penalties for Falsification of Reports
12. Penalties for Tampering
13. Oil and Hazardous Substance Liability
14. Property Rights
15. Severability
16. Transfers
17. Proper Operation and Maintenance
- 18.** Inspection and Entry
19. Permit Actions
20. Re-Opener Clause
21. Local Requirements

SECTION A: STORMWATER POLLUTION PREVENTION PLANS (SWPPP).

The operator must prepare a stormwater pollution prevention plan (the plan/SWPPP) before permit coverage. At least one SWPPP must be developed for each construction project or site covered by this permit. The SWPPP must follow the order outlined in Part II.A.4-7 below. This basic ADEQ format is available through the Department's website http://www.adeg.state.ar.us/water/branch_npdes/stormwater/construction/construction.htm . Other formats may be used at the discretion of the Director **if** the format has been approved by the Department prior to use. The operator must implement the SWPPP as written from initial commencement of construction activity until final stabilization is complete, with changes being made as deemed necessary by the permittee, local, state or federal officials. The plan shall be prepared in accordance with good engineering practices, by qualified personnel and must:

- Identify potential sources of pollution which may reasonably be expected to affect the quality of stormwater discharges from the construction.
- Identify, describe and ensure the implementation of Best Management Practices (BMPs), with emphasis on initial site stabilization, which are to be used to reduce pollutants in stormwater discharges from the construction site;
- Be site specific to what is taking place on a particular construction site;
- Ensure compliance with the terms and conditions of this permit; and
- Identify the responsible party for on-site SWPPP implementation.

1. Deadlines for Plan Preparation and Compliance.

A. Large Construction Sites

The plan shall be completed and submitted for review, along with a NOI and initial permit fee 2 weeks prior to commencement of construction activities. Submittals of updates to the plan during the construction process are required only if requested by the Director.

B. Automatic Coverage Sites

The plan shall be completed prior to the commencement of construction activities and updated as appropriate. Submittal of NOI, permit fee and SWPPP is not required.

C. Existing Permittees

Existing permittees, that were permitted prior to the issuance of this renewal permit, are required to update their plan as appropriate to come into compliance with the requirements contained in Part 11.A.4 within **sixty (60) days** from the effective date of this permit.

2. Signature, Plan Review, Plan Availability and NOC.

- A. The plan shall be signed by the operator in accordance with Part 11.B.9 and be retained on-site at the construction site during normal business hours (8:00 A.M. - 5:00 P.M.). The operator shall keep the complete updated SWPPP on-site.
- B. The operator shall make plans available, upon request, to the Director, the EPA, or a State or local agency reviewing sediment and erosion plans, grading plans, or stormwater management plans, or, in the case of a stormwater discharge associated with construction activity which discharges through a municipal separate storm sewer system with an NPDES permit, to the municipal operator of the system.

- C. The Director, or authorized representative, may notify the operator at any time that the plan does not meet one or more of the minimum requirements of this Part. Within seven (7) business days of such notification from the Director, (or as otherwise provided by the Director), or authorized representative, the operator shall make the required changes to the plan and submit to the Director a written certification that the requested changes have been made. The Department may request re-submittal of the SWPPP to confirm that all deficiencies have been adequately addressed. The Department may also take appropriate enforcement action for the period of time the operator was operating under a plan that did not meet the minimum requirements of this permit.
- D. The operator must post the NOC near the main entrance of the construction site and visible to the public. The NOC will indicate the location of the SWPPP.
3. **Keeping Plans Current.** The operator shall amend the plan within seven (7) business days or whenever there is a change in design, construction, operation, or maintenance at the construction site which has a significant effect on the potential for the discharge of pollutants to the Waters of the State that has not been previously addressed in the SWPPP. The plan should also be modified if a determination has been made through inspections, monitoring (if required), *or* investigation by the operator, local, state, or federal officials that the discharges are causing or contributing to water quality violation or the plan proves to be ineffective in eliminating or significantly minimizing pollutants from sources identified in stormwater discharges from the construction site.
4. **Contents of the Stormwater Pollution Prevention Plan.** The stormwater pollution prevention plan shall include the following items:
- A. **Site Description.** Each plan shall provide a description of the following:
- 1) Pre-construction topographic view;
 - 2) A description of the nature of the construction activity and its intended use after the NOT is filed (i.e., residential subdivision, shopping mall, etc.);
 - 3) A description of the intended sequence of major activities which disturb soils for major portions of the site (e.g. grubbing, excavation, grading, infrastructure installation, etc.);
 - 4) Estimates of the total area of the site (including off-site borrow and fill areas) and the total area of the site that is expected to be disturbed by excavation, grading or other activities; and
 - 5) An estimate of the runoff coefficient of the site for pre- and post-construction activities and existing data describing the soil or the quality of any discharge from the site.
- B. **Responsible Parties.** The SWPPP must identify (as soon as this information is known) all parties (i.e., General Contractors, Landscapers, Project Designers, and Inspectors) responsible for particular services they provide to the operator to comply with the requirements of the SWPPP for the project site, and areas over which each party has control. If these parties change over the life of the permit, or new parties are added, then the SWPPP should be updated to reflect these changes.
- C. **Receiving Waters.** The SWPPP must identify the nearest receiving water(s), or if the discharge is to a municipal separate storm sewer, the name of the operator of the municipal system, the ultimate receiving water(s)
- D. **Documentation of Permit Eligibility Related to the 303 (d) list and Total Maximum Daily Loads (TMDL).** The SWPPP should include information on whether or not the stormwater discharges from the site enter a water body that is on the most recent 303 (d) list or with an approved TMDL. If the stormwater discharge does enter a water body that is on the most recent 303(d) list or with an approved TMDL, then the SWPPP should address the following items:
- 1) Identification of the pollutants that the 303 (d) list or TMDL addresses, specifically whether the 303 (d) list or

TMDL addresses sediment or a parameter that addresses sediment (such as total suspended solids, turbidity, or siltation);

- 2) Identification of whether the operator's discharge is identified, either specifically or generally, on the 303 (d) list or any associated assumptions and allocations identified in the TMDL for the discharge; and
- 3) Measures taken by the operator to ensure that its discharge of pollutants from the site is consistent with the assumptions and allocations of the TMDL.

If the Department determines during the review process that the proposed project will be discharging to a receiving water that is on the most recent 303 (d) list or with an approved TMDL, then the Department will notify the applicant to include additional Best Management Practices in the SWPPP.

E. Attainment of Water Quality Standards After Authorization.

- 1) The permittee must select, install, implement, and maintain BMPs at the construction site that minimize pollutants in the discharge as necessary to meet applicable water quality standards. In general, except in situations explained below, the SWPPP developed, implemented, and updated to be considered as stringent as necessary to ensure that the discharges do not cause or contribute to an excursion above any applicable water quality standard.
- 2) At any time after authorization, the Department may determine that the stormwater discharges may cause, have reasonable potential to cause, or contribute to an excursion above any applicable water quality standard. If such a determination is made, the Department will require the permittee to:
 - a. Develop a supplemental BMP action plan describing SWPPP modifications to address adequately the identified water quality concerns and submit valid and verifiable data and information that are representative of ambient conditions and indicate that the receiving water is attaining water quality standards; or
 - b. Cease discharges of pollutants from construction activity and submit an individual permit application.
- 3) All written responses required under this part must include a signed certification (Part II.B.10)

F. Endangered Species. The SWPPP must contain information on endangered and threatened species, including whether any endangered species are in proximity of the stormwater discharge and BMP's to be constructed to control stormwater runoff. The letter of consent from the USF&W, as stated in Part I.B.11.F must be included with the SWPPP along with the name and telephone number of the person or agency which was contacted to obtain the information.

G. Site Map. The SWPPP must contain a legible site map complete to scale, showing the entire site, that identifies, at a minimum, the following:

- 1) Direction of storm water flow (i.e., use arrows to show which direction stormwater will flow) and approximate slopes anticipated after major grading activities;
- 2) Delineate on the site map areas of soil disturbance and areas that will not be disturbed under the coverage of this permit;
- 3) Location of major structural and nonstructural controls identified in the plan;
- 4) Location of main construction entrance and exit;
- 5) Location where stabilization practices are expected to occur;
- 6) Locations of off-site materials, waste, borrow area, or equipment storage area;
- 7) Location of areas used for concrete wash-out;
- 8) Location of all surface water bodies (including wetlands);

- 9) Locations where stormwater is discharged to a surface water and/or municipal separate storm sewer system if applicable,
- 10) Locations where stormwater is discharged off-site (should be continuously updated);
- 11) Areas where final stabilization has been accomplished and no further construction phase permit requirements apply.

H. Stormwater Controls. Each plan shall include a description of appropriate controls and measures that will be implemented at the construction site. The plan will clearly describe for each major activity identified in the project description control measures associated with the activity and the schedule during the construction process that the measures will be implemented. Perimeter controls for the site must be installed after the clearing and grubbing necessary for installation of the measure, but before the clearing and grubbing for the remaining portions of the site. Perimeter controls must be actively maintained until final stabilization of those portions of the site upward of the perimeter control. Temporary perimeter controls must be removed after final stabilization and properly disposed. The description and implementation of controls shall address the following minimum components:

- 1) Initial Site Stabilization, Erosion, and Sediment Controls. The SWPPP must address, at a minimum, the following:
 - a. For larger common plans, only streets, drainage, utility areas, areas needed for initial construction of streets (e.g., borrow pits, parking areas, etc.) and areas needed for stormwater structures may be disturbed initially. Upon stabilization of the initial areas, additional areas may be disturbed.
 - b. The construction-phase erosion (such as site stabilization) and sediment controls (such as check dams) should be designed to retain sediment on-site to the extent practicable.
 - c. All control measures must be properly selected, installed, and maintained in accordance with the manufacturer's specifications, good engineering, and construction practices. If periodic inspections or other information indicates a control has been used inappropriately or incorrectly, the permittee must replace or modify the control for site situations.
 - d. If sediment escapes the construction site, off-site accumulations of sediment must be removed at a frequency sufficient to minimize off-site impacts (e.g., fugitive sediment in street could be washed into storm sewers by the next rain and/or pose a safety hazard to users of public streets). This permit does not give the authority to trespass onto other property; therefore this condition should be carried out along with the permission of neighboring land owners to remove sediment.
 - e. Sediment must be removed from sediment traps (if used please specify what type) or sedimentation ponds when design capacity has been reduced by 50%.
 - f. Litter, construction debris, and construction chemicals exposed to stormwater shall be prevented from becoming a pollutant source for stormwater discharges (e.g., screening outfalls picked up daily).
 - g. Off-site material storage areas (also including overburden and stockpiles of dirt, borrow areas, etc.) used solely by the permitted project are considered a part of the project and shall be addressed in the SWPPP.
- 2) Stabilization practices. The SWPPP must include, at a minimum, the following information:
 - a. Description and Schedule: A description of initial, interim, and permanent stabilization practices, including site-specific scheduling of the implementation of the practices. Site plans should ensure that existing vegetation is preserved where attainable and that disturbed areas are stabilized. Stabilization practices may include: mulching, temporary seeding, permanent seeding, geotextiles, sod stabilization, vegetative buffer strips, protection of trees, and preservation of mature vegetation and other appropriate measures.
 - b. Description of buffer areas: The Department requires that a buffer zone be established between the top of stream bank and the disturbed area. The SWPPP must contain a description of how the site will maintain

buffer zones. For construction projects where clearing and grading activities will occur, SWPPP must provide at least twenty-five (25) feet of buffer zone from any named or unnamed streams, creeks, rivers, lakes or other water bodies. The plan must also provide at least fifty (50) feet of buffer zone from established TMDL water bodies, streams listed on the 303 (d)-list, an Extraordinary Resource Water (ERW), Ecologically Sensitive Waterbody (ESW), Natural and Scenic Waterway (NSW), and/or other uses at the discretion of the Director. If the site will be disturbed within the recommended buffer zone, then the buffer zone area must be stabilized as soon as possible. Exceptions from this requirement for *areas*, such as water crossings, limited water access, and restoration of the buffer are allowed if the permittee fully documents in the SWPPP the circumstances and reasons for the buffer zone encroachment. Additionally, this requirement is not intended to interfere with any other ordinance, rule or regulation, statute or other provision of law. Please note that above-grade clearing that does not disturb the soil in the buffer zone area does not have to comply with buffer zone requirements.

- c. Records of Stabilization: A record of the dates when major grading activities occur, when construction activities temporarily or permanently cease on a portion of the site, and when stabilization measures are initiated shall be included in the plan.
- d. Deadlines for Stabilization: Stabilization measures shall be initiated as soon as practicable in portions of the site where construction activities have temporarily or permanently ceased, but in no case more than fourteen (14) days after the construction activity in that portion of the site has temporarily or permanently ceased, except:
 - (1) Where the initiation of stabilization measures by the fourteenth (14th) day after construction activity temporarily or permanently ceases is precluded by snow cover, stabilization measures shall be initiated as soon as practicable.
 - (2) Where construction activity will resume on a portion of the site within twenty-one (21) days from when activities ceased (e.g. the total time period that construction activity is temporarily ceased is less than twenty-one (21) days), then stabilization measures do not have to be initiated on that portion of the site by the fourteenth (14th) day after construction activity temporarily ceased.

- 3) Structural Practices. A description of structural practices to divert flows from exposed soils, store flows, or otherwise limit runoff and the discharge of pollutants from exposed areas of the site to the degree attainable. Structural practices should be placed on upland soils to the degree attainable. The installation of these devices may be subject to Section 404 of the Clean Water Act. Such practices may include but are not limited to:

- silt fences (installed and maintained)
- earthen dikes to prevent run-on
- drainage swales to prevent run-on
- check dams
- subsurface drains
- pipe slope drains
- storm drain inlet protection
- rock outlet protection
- sediment traps
- reinforced soil retaining systems
- gabions
- temporary or permanent sediment basins.

A combination of erosion and sediment control measures is encouraged to achieve maximum pollutant removal. Adequate spillway cross-sectional area and re-enforcement must be provided for check dams, sediment traps, and sediment basins.

a. Sediment Basins.

- (1) For common drainage locations that serve an area with ten (10) or more acres (including run-on from other areas) draining to a common point, a temporary or permanent sediment basin that provides storage based on either the smaller of 3600 cubic feet per acre, or a size based on the runoff volume of a 10 year, 24 hour storm, shall be provided where attainable (so as not to adversely impact water quality) until final stabilization of the site. In determining whether installing a sediment basin is attainable, the operator may consider factors such as site soils, slope, available area on site, etc. Proper hydraulic design of the outlet is critical to achieving the desired performance of the basin. The outlet should be designed to drain the basin within twenty-four (24) to seventy-two (72) hours. (A rule of thumb is one square foot per acre for a spillway design.) The 24-hour limit is specified to provide adequate settling time; the seventy-two (72)-hour limit is specified to mitigate vector control concerns. If a pipe outlet design is chosen for the outfall, then an emergency spillway is required. If "non-attainability" is claimed, then an explanation of non-attainability shall be included in the SWPPP. Where a sediment basin is not attainable, smaller sediment basins and/or sediment traps shall be used. Where a sediment basin is un-attainable, vegetative buffer strips or other suitable controls which are effective are required for all side slopes and down slope boundaries of the construction area. The plans for removal of the sediment basin should also be included with the description of the basin in the SWPPP.
- (2) For drainage locations serving an area less than ten (10.0) acres, sediment traps, silt fences, or equivalent sediment controls are required for all side slope and down slope boundaries of the construction area unless a sediment basin providing storage based on either the smaller of 3,600 cubic feet per acre, or a size based on the runoff volume of a 10 year, 24 hour storm is provided. (A rule of thumb is one square foot per acre for a spillway.) However, in order to protect the waters of the state, the Director, at their discretion, may require a sediment basin for any drainage areas draining to a common point.

b. Velocity Dissipation Devices.

Velocity dissipation devices must be placed at discharge locations, within concentrated flow areas serving two or more acres, and along the length of any outfall channel to provide a non-erosive flow velocity from the structure to a water course so that the natural physical and biological characteristics and functions are maintained and protected (i.e., no significant changes in the hydrological regime of the receiving water). Please note that the use of hay-bales is not recommended in areas of concentrated flow.

I. Other Controls.

- 1) No solid materials, including building materials, shall be discharged to waters of the State.
- 2) Off-site vehicle tracking of sediments and the generation of dust shall be minimized through the use of a stabilized construction entrance and exit and/or vehicle tire washing.
- 3) For lots that are less than one (1) acre in size an alternative method may be used in addition to a stabilized construction entrance. An example of an alternative method could be daily street sweeping. This could allow for the shortening of the construction entrance.
- 4) The plan shall ensure and demonstrate compliance with applicable State or local waste disposal, temporary and permanent sanitary sewer or septic system regulations.
- 5) No liquid concrete waste shall be discharged to waters of the State. Appropriate controls to prevent the discharge of concrete washout waters must be implemented if concrete washout will occur on-site.
- 6) No contaminants from fuel storage areas, hazardous waste storage and truck wash areas shall be discharged to

waters of the State. Methods for protecting these areas shall be identified and implemented. These areas should not be located near a water body, if there is a water body on or near the project.

- J. Non-stormwater discharges. Sources of non-stormwater listed in Part LB. IO of this permit that are combined with stormwater discharges associated with construction activity must be identified in the plan. This list should be site specific non-stormwater discharges.
- K. Post-Construction Stormwater Management. The operator is required to provide a description of measures that will be installed during the construction process to control pollutants in stormwater discharges that will occur after construction operations have been completed. Structural measures should be placed on upland soils to the degree attainable. The installation of these devices may be subject to Section 404 (Corps of Engineers) of the Clean Water Act. This permit only addresses the installation of stormwater management measures, and not the ultimate operation and maintenance of such structures after the construction activities have been completed and the site has undergone final stabilization. However, post-construction stormwater BMPs that discharge pollutants from a point source once construction is completed may need authorization under a separate ADEQ NPDES permit. Such practices may include but are not limited to:

- infiltration of runoff onsite
- flow attenuation by use of open vegetated swales and natural depressions
- stormwater retention structures
- stormwater detention structures (including wet ponds)
- sequential systems, which combine several practices

A goal of at least 80 % removal of total suspended solids from these flows which exceed predevelopment levels should be used in designing and installing stormwater management controls (where practicable). Where this goal is not met, the operator shall provide justification for rejecting each practice listed above based on site conditions.

- L. Applicable State or Local Programs. The SWPPP must be updated as necessary to reflect any revisions to applicable federal, state, or local requirements that affect the stormwater controls you implement at your site.
- M. Inspections.

Inspections should be conducted by qualified personnel (provided by the operator). Inspections must include all areas of the site disturbed by construction activity and areas used for storage of materials that are exposed to precipitation. Inspectors must look for evidence of, or the potential for, pollutants entering the stormwater conveyance system. Erosion and sedimentation control measures must be observed to ensure proper operation. Discharge locations must be inspected to determine whether erosion control measures are effective in preventing significant impacts to waters of the State, where accessible. Where discharge locations are inaccessible, nearby downstream locations must be inspected to the extent that such inspections are practicable. Locations where vehicles enter or exit the site must be inspected for evidence of off-site sediment tracking. Inspections may not be required if the lot(s) within a larger common plan is/are sufficiently stabilized. The operator must ensure that no sediment will leave the lot(s) that are stabilized. These lots must be identified within the SWPPP and show what date they were stabilized. If the operator is unable to ensure this, then inspections must continue.

I) **Inspection Frequency.** Inspections must be conducted in accordance with one of the following schedules listed below. The schedule **must be specified** in the Stormwater Pollution Prevention Plan (SWPPP).

- a. At least once every 7 calendar days, or
- b. At least once every 14 calendar days and within 24 hours of the end of a storm event of 0.5 inches or greater (a

rain gauge must be maintained on-site).

- 2) **Inspection Form.** The ADEQ inspection form should be used for all inspections. The inspection form should include any erosion/sediment controls that are being used on the site. The form is available on the Departments website www.adeg.state.ar.us. If a different form is used it must at a minimum contain the following information:
 - a. Inspector Name and Title
 - b. Date of Inspection
 - c. Amount of Rainfall and Days Since Last Rain Event (only applicable to Part 11.A.4.M.1.b)
 - d. BMPs used on-site
 - e. If the BMPs are in working order and if Maintenance is required (when scheduled and completed)
 - f. Location and Dates When Major Construction Activities Begin, Occur or Cease
 - g. Report Signature of Inspector

Additional information may be added to the inspection report at the permittees discretion.

- 3) **Inspection Records.** The report shall be retained as part of the stormwater pollution prevention plan for at least three (3) years from the date the site is finally stabilized. The report shall be signed and have a certification statement in accordance with the requirements of this permit.
 - 4) **Winter Conditions.** Inspections will not be required at construction sites where snow cover exists over the entire site for an extended period, and melting conditions do not exist. Regular inspections, as required by this permit, are required at all other times as specified in this permit.
- N. **Maintenance.** A description of procedures to maintain vegetation, erosion and sediment control measures and other protective measures in good, effective operating condition shall be outlined in the plan. Any repairs that are needed based on an inspection shall be completed within three (3) business days of discovery or as otherwise directed by state or local officials. However, if conditions do not permit large equipment to be used, a longer time frame is allowed if the condition is thoroughly documented on the inspection form. Maintenance for manufactured controls must be done at a minimum of the manufacture's specifications. Maintenance for non-manufactured controls, i.e. check dams, sediment traps, must be done upon 50% capacity.

5. **Contractors.**

For each measure identified in the plan, the stormwater pollution prevention plan must clearly identify the contractor(s) that will implement the measure. If additional contractors are added to the project, then the list of contractors should be updated accordingly in the SWPPP.

6. **Inspectors.**

The stormwater pollution prevention plan must clearly identify the person or persons that will be conducting the inspections of all stormwater controls. If additional inspectors are added to the project, then the list of inspectors should be updated accordingly in the SWPPP.

7. **Plan Certification.**

The Stormwater Pollution Prevention Plan (SWPPP) Certification must be signed by either the operator or the cognizant official identified on the Notice of Intent. All documents required by the permit and other information requested by the Director shall be signed by operator or by a duly authorized representative of the operator (Please see Part 11.B.10 below

for certification).

SECTION B: STANDARD PERMIT CONDITIONS

1. Retention of Records.

- A. The operator shall retain records of all stormwater pollution prevention plans, all inspection reports required by this permit, and records of all data used to complete the Notice of Intent to be covered by this permit for a period of at least three years from the date the Notice of Termination letter is signed by the Department. This period may be extended by request of the Director at any time.
- B. The operator shall retain a signed copy of the stormwater pollution prevention plan required by this permit at the construction site from the date of project initiation to the date of final stabilization.

2. Duty to Comply. The operator must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the federal Clean Water Act and the Arkansas Water and Air Pollution Control Act and is grounds for: enforcement action; permit termination, revocation and re-issuance, or modification; or denial of a permit renewal application.

3. Penalties for Violations of Permit Conditions. The Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended) provides that any person who violates any provisions of a permit issued under the Act shall be guilty of a misdemeanor and upon conviction thereof shall be subject to imprisonment for not more than one (1) year, or a criminal penalty of not more than twenty five thousand dollars (\$25,000) or by both such fine and imprisonment for each day of such violation. Any person who violates any provision of a permit issued under the Act may also be subject to civil penalty in such amount as the court shall find appropriate, not to exceed ten thousand dollars (\$ 10,000) for each day of such violation. The fact that any such violation may constitute a misdemeanor shall not be a bar to the maintenance of such civil action.

4. Continuance of the Expired General Permit An expired general permit continues in force and effect until a new general permit is issued. If this permit is not re-issued or replaced prior to the expiration date, it will be administratively continued in accordance with the Administrative Procedure Act and remain in force and effect. If you were granted permit coverage prior to the expiration date, you will automatically remain covered by the continued permit until the earliest of:

- A. Re-issuance or replacement of this permit, at which time you must comply with the conditions of the new permit, within 60 days after issuance, to maintain authorization to discharge; or
- B. Your submittal of a Notice of Termination; or
- C. Issuance of an individual permit for the project's discharges; or
- D. A formal permit decision by the ADEQ to not re-issue this general permit, at which time you must seek coverage under an individual permit.

5. Need to Halt or Reduce Activity Not a Defense. It shall not be a defense for an operator in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

6. Duty to Mitigate. The operator shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has reasonable likelihood of adversely affecting human health or the environment.

7. Duty to Provide Information. The operator shall furnish to the Director, an authorized representative of the Director, the

EPA, a State or local agency reviewing sediment and erosion plans, grading plans, or storm water management plans, or in the case of a stormwater discharge associated with industrial activity which discharges through a municipal separate storm sewer system with an NPDES permit, to the municipal operator of the system, within a reasonable time, any information which is requested to determine compliance with this permit.

8. **Other Information.** When the operator becomes aware that he or she failed to submit any relevant facts or submitted incorrect information in the Notice of Intent or in any other report to the Director, he or she shall promptly submit such facts or information.

9. **Signatory Requirements.** All Notices of Intent, reports, or information submitted to the Director or the operator of a regulated small, medium, or large municipal separate storm sewer system shall be signed and certified.

A. All Notices of Intent shall be signed as follows:

1) For a corporation: by a responsible corporate officer. For purposes of this section, a responsible corporate officer means:

- a. A president, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation; or
- b. The manager of one or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

2) For a partnership or sole proprietorship: by a general partner or the proprietor, respectively;

3) For a municipality, State, Federal or other public agency: By either a principal executive or ranking elected official. For purposes of this section, a principal executive officer of a Federal agency includes:

- a. The chief executive officer of the agency; or
- b. A senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency.

B. All reports required by the permit and other information requested by the Director shall be signed by a person described above or by a **duly authorized** representative of that person. A person is a duly authorized representative only if:

1) The authorization is made in writing by a person described above and submitted to the Director;

2) The authorization specifies either an individual or a person having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a well or a well field, superintendent, or position of equivalent responsibility, or position of equivalent responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position); and

- 3) **Changes to authorization.** If an authorization under this Part is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the above requirements must be submitted to the Director prior to or together with any reports, information, or applications to be signed by an authorized representative.

10. Certification. Any person signing a document under this section shall make the following certification:

"I certify under penalty of law that this document and all attachments such as Inspection Form were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Note: For this pennit only, "this document" refers to the Stormwater Pollution Prevention Plan, "attachments" refers to the site map and inspection forms, and "system" is referencing the project site.

- 11. Penalties for Falsification of Reports.** The Arkansas Water and Air Pollution Control Act provides that any person who knowingly makes any false statement, representation, or certification in any application, record, report, plan or other document filed or required to be maintained under this permit shall be subject to civil penalties specified in Part 11.B.3 of this pennit and/or criminal penalties under the authority of the Arkansas Water and Air Pollution Control Act (Act472 of 1949, as amended).
- 12. Penalties for Tamperine.** The Arkansas Water and Air Pollution Control act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under the Act shall be guilty of a misdemeanor and upon conviction thereof shall be subject to imprisonment for not more than one (1) year or a fine of not more than twenty five thousand dollars (\$25,000) or by both such fine and imprisonment.
- 13. Oil and Hazardous Substance Liability.** Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the operator from any responsibilities, liabilities, or penalties to which the operator is or may be subject under Section 311 of the Clean Water Act or Section I06 of CERCLA.
- 14. Property Rights.** The issuance of this permit does not convey any property rights of any sort or any exclusive privileges, nor does it authorize any injury to private property, any invasion of personal rights, or any infringement of Federal, State, or local laws or regulations.
- 15. Severability.** The provisions of this permit are severable. If any provisions of this permit or the application of any provision of this pennit to any circumstance is held invalid, the application of such provisions to other circumstances and the remainder of this permit shall not be affected thereby.
- 16. Transfers.** This permit is not transferable to any person except after notice to the Director. A transfer form must be submitted to ADEQ as required by this permit.
- 17. Proper Operation and Maintenance.** The operator shall at all times:
- A. Properly operate and maintain all control (and related appurtenances) which are installed or used by the operator to achieve compliance with the conditions of this permit. This provision requires the operation of backup or auxiliary facilities or similar systems which are installed by an operator only when the operation is necessary to achieve compliance with the conditions of the permit.

- B. Provide an adequate operating staff which is duly qualified to carry out operation, inspection, maintenance, and testing functions required to insure compliance with the conditions of this permit.

18. Inspection and Entry. The operator shall allow the Director, the EPA, or an authorized representative, or, in the case of a construction site which discharges to a municipal separate storm sewer, an authorized representative of the municipal operator of the separate sewer system receiving the discharge, upon the presentation of credentials and other documents as may be required by law, to:

- A. Enter upon the operator's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;
- B. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;
- C. Inspect at reasonable times any facilities or equipment (including monitoring and control equipment);

19. Permit Actions. This permit may be modified, revoked and reissued, or terminated for cause including, but not limited to, the following;

- A. Violation of any terms or conditions of this permit;
- B. Obtaining this permit by misrepresentation or failure to fully disclose all relevant facts;
- C. A change in any conditions that requires either a temporary or permanent reduction or elimination of the authorized discharge;
- D. A determination that the permitted activity endangers human health or the environment and can only be regulated to acceptable levels by permit modification or termination; or
- E. Failure of the operator to comply with the provisions of ADEQ Regulation No. 9 (Fee Regulation). Failure to promptly remit all required fees shall be grounds for the Director to initiate action to terminate this permit under the provisions of 40 CFR 122.64 and 124.5(d), as adopted by reference in ADEQ Regulation No. 6, and the provisions of ADEQ Regulation No. 8.

20. Re-Opener Clause.

- A. If there is evidence indicating potential or realized impacts on water quality due to any stormwater discharge associated with industrial activity covered by this permit, the operator of such discharge may be required to obtain an individual permit or an alternative general permit in accordance with Part I.B.22 of this permit, or the permit may be modified to include different limitations and/or requirements.
- B. Permit modification or revocation will be conducted in accordance with the provisions of 40 CFR 122.62, 122.63, 122.64 and 124.5, as adopted by reference in ADEQ Regulation No. 6.

21. Local Requirements. All dischargers must comply with the lawful requirements of municipalities, counties, drainage districts, and other local agencies regarding any discharges of storm water to storm drain systems or other water sources under their jurisdiction, including applicable requirements in municipal storm water management programs developed to comply with the ADEQ permits. Dischargers must comply with local storm water management requirements, policies, or guidelines including erosion and sediment control.

***APPENDIX 8
BIBLIOGRAPHY***

Appendix 8

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