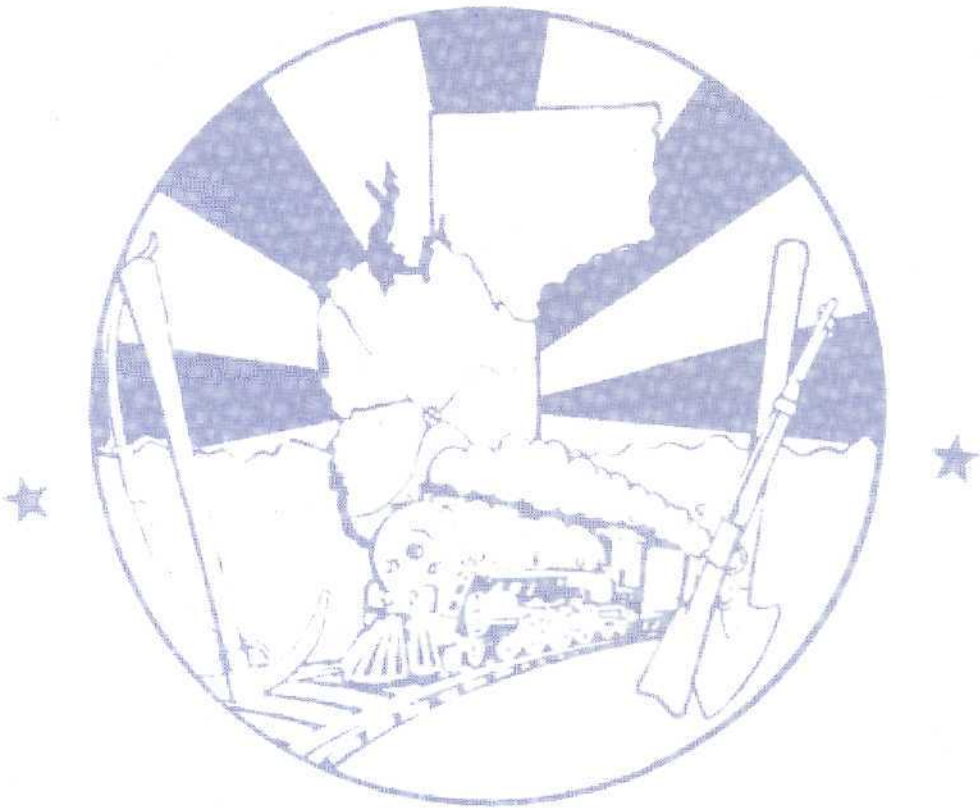
KINGMAN AREA
MASTER DRAINAGE PLAN

DESIGN AND ADMINISTRATIVE MANUAL

June 1988



BOYLE ENGINEERING CORPORATION

consulting engineers / architects

PREFACE

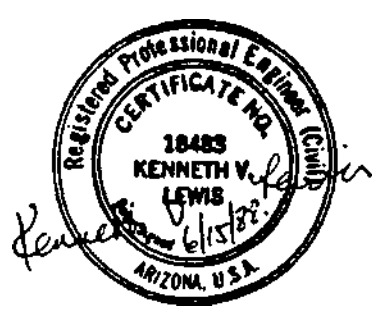
In March 1987 the City of Kingman contracted with Boyle Engineering Corporation to prepare a Master Drainage Plan for the greater Kingman Area. The work was to include a Drainage Design and Administrative Manual, A Master Drainage Plan, a more detailed analysis of the Bull Mountain Drainage Basin, and an Executive Summary of the entire project.

The results of the study are presented in the following documents:

Executive Summary	
Master Drainage Plan	
Appendices - Volume 1	Hydrology/Hydraulic Details
Appendices - Volume 2	Bull Mountain Basin Southeast Area Drainage

Design and Administrative Manual

This document is the Design and Administrative Manual.



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1. INTRODUCTION

This Design and Administrative Manual has been prepared to fill a need for a uniform basis of design for urban stormwater drainage systems in the City of Kingman and surrounding environs.

Adoption of these standards and procedures by the City of Kingman and Mohave County will result, in the long term, in a common standard of drainage amenity.

Their adoption by members of the private sector will result in time and effort being saved by both designers and government review staff, due to the reduction in the necessity for amendments to submitted drainage proposals and designs.

There may be circumstances where departure from these standards may be justified, but in the case of the private sector, concurrence for any such departure shall be obtained from the relevant jurisdiction's Engineering Department (ENGINEER) before design is commenced.

2. DRAINAGE POLICIES

The policies established herein express the approach to drainage management by the jurisdictional agencies in the City of Kingman and surrounding environs in Mohave County. The policies are divided into four categories:

Planning
Conveyance
Storage
Administrative.

The policies are intended to direct planning and design of improvements within individual developments. Adherence to the policies is desirable regardless of the size, location or extent of the area being planned. The major drainageways, addressed in the Kingman Area Master Drainage Plan, have been planned with these policies as a guideline. Minor drainageways, which collect and convey storm runoff to major drainageways, should also be planned in accordance with these policies.

2.1 PLANNING

1. The City of Kingman and Mohave County shall establish and publish criteria for drainage planning and design and shall adopt criteria relevant to all public and private drainage interests.

2. All storm drainage facilities shall be planned and designed in accordance with the criteria set forth in this Drainage Design and Administrative Manual. The criteria contained herein may periodically be revised or amended as new technology is developed and/or experience gained in the use of this document.

3. All persons proposing to modify or impact drainageways through land use changes or developments shall prepare and implement corrective drainage plans which shall mitigate existing or anticipated drainage problems. Such plans shall be coordinated with the comprehensive Master Drainage Plan and with stated planning goals and objectives, and shall consider a combination of structural and non-structural measures.

4. Drainage planning shall involve concerned publics.

5. Drainage planning for developments shall be carried out in the earliest stages of the planning process. The proposed methods of managing drainage and associated land use shall be reviewed by the City or County early in the process.

6. Storm drainage shall be considered a sub-system of the overall urban system and storm drainage planning for all developments shall include the allocation of space for drainage facilities.

7. Multiple use of drainage works is encouraged, provided the use does not adversely impact the functional design of the system.

8. Drainage plans shall include a full range of preventive and corrective approaches, in accordance with stated comprehensive planning goals and objectives, including the following:

Maintaining the integrity of existing drainage patterns;

Establishment of selected major drainage routes by the use of purchase, dedication, development rights, and easements;

Design of adequately-sized conveyance systems for the minor and major storms;

Storage and attenuation of stormwater runoff; and

Construction of drainage works.

The combination of strategies shall balance engineering, economic, environmental, and social factors in relationship to stated comprehensive planning goals and objectives.

2.2 CONVEYANCE

1. Drainage systems shall be designed to convey nuisance runoff from the more frequent minor storm of 10 years and to minimize major damage from the 100 year storm event.

2. Drainage planning and design shall be based on the principle of not increasing or transferring detrimental drainage effects to other areas. Inter-basin transfer of storm drainage runoff is to be avoided and the historic drainage path should be maintained within the basin.

3. Maintenance access shall be provided to all storm drainage facilities to assure continuous operational capability of the drainage facilities including inlets, pipes, culverts, channels, ditches, hydraulic structures, and detention basins located on private land.

2.3 STORAGE

1. To eliminate adverse impacts on downstream properties from upstream development, stormwater detention facilities may be necessary as a component of an overall drainage system.

2. When storage is utilized, the facilities shall be sized to limit downstream flows for the 10 and 100 year storms, to the greater of historic levels, or the capacity of the downstream conveyance system.

3. Offsite flows shall not be routed through the storage facilities without proper consideration of its impacts on the operation of the facility. All plans proposing routing of offsite flows through storage facilities shall be approved by the ENGINEER.

4. Wherever possible, storage facilities shall be located In parks or other recreational facilities to offset the cost of open space and to encourage improved maintenance.

2.4 ADMINISTRATIVE

1. All plans developed for the collection, conveyance or detention of storm water runoff within the City of Kingman and surrounding environs shall be reviewed and approved by the ENGINEER.

2. A Drainage Report shall be submitted to the ENGINEER for all proposed developments. For the purpose of this document, developments shall include all parcels of land for which a plat (preliminary or final) is being submitted. If, during the Pre-Preliminary Plan Meeting, the ENGINEER determines that there is no significant impact on drainage resulting from the proposed development, he may waive the requirement for a Drainage Report.

3. The responsibility for the planning, design, construction and maintenance of major and minor drainageways shall be as follows:

Table 2.1 Drainage Responsibility

Element	Within City Limits	Outside City Limits
MAJOR DRAINAGEWAYS		
Planning	City	County
Design	City	County
Construction	City/Developer	County/Developer
Maintenance	City	County
MINOR DRAINAGEWAYS		
Planning	City/Developer	County/Developer
Design	City/Developer	County/Developer
Construction	City/Developer	County/Developer
Maintenance	City	County

4. Major drainageways shall be designated on the Kingman Area Master Drainage Plan.

3. DRAINAGE PLANNING

Drainage planning is for the purpose of minimizing inconvenience and reducing flood damage and potential loss of life. The benefits of planning reduce overall public and private costs, while providing a drainage infrastructure that will account for the implementation of long-term development goals.

Drainage planning helps to achieve orderly, efficient, pleasant and diverse development of a community. Accomplishment of the comprehensive goals and objectives can be assisted by a broad drainage planning process. Such a process should be considered within the context of the total environmental system and should be compatible with comprehensive regional plans.

All developments within the community should proceed with drainage planning at the earliest possible opportunity during the development process. Storm drainage occurs regardless of the level of drainage planning, however, costs and impacts to the developer and the community can be minimized with proper planning. The identification of unified drainage policies, as presented in the preceding chapter, provides the necessary direction.

It is vitally important that planning precede development for the following reasons: to ensure drainage problems are not transferred from one location to another; multiple use opportunities are not lost, and the cost for overall drainage facilities are kept to a minimum.

The major elements in planning include:

Master Planning
Site Planning

3.1 MASTER PLANNING

A Master Drainage Plan for the Kingman Area has been prepared for the City and County and published as a separate document The master drainage plan describes the recommended plan for major drainage and the course of action for implementation in terms of priorities. It shows sizes, types and location of major drainage facilities on maps in sufficient detail to allow for planning new development. The Drainage Design and Administrative Manual is intended to be an adjunct to the Kingman Area Master Drainage Plan.

The Master Plan developed for the Kingman Area addresses major drainageways and does not explicitly address minor drainageways. The planning and design of improvements along minor drainageways should be accomplished in accordance with this Drainage Design and Administrative Manual.

The intent of the Master Plan is to provide a plan for the conveyance of flood waters along major drainageways with a minimum disruption to the community. The plan includes the identification of improvements consisting of combinations of channels, pipes, culverts, natural drainages and retention which balance all the conflicting needs of the community. In many cases the immediate implementation of the Master Plan recommendations is not feasible, therefore estimates of required rights-of-way have been made to provide corridors for future construction.

The recurrence interval which Master Planning is to consider is the 100-year flood (major). This is generally accomplished by sizing systems which convey the entire flood flows; however, in areas of intense existing development this may consist of systems designed to convey the ten-year flood (minor) with some additional provisions such as flood proofing or levees to minimize impacts associated with a major event.

3.2 SITE PLANNING

Planning of drainage for individual developments is to be consistent with the intent of the Master Drainage Plan and with the requirements presented in this Drainage Design and Administrative Manual. The intent of the on-site planning effort is to provide a system which conveys storm flows from their point of origin to the major drainageway in a controlled fashion.

The on-site drainage system may consist of a combination of conveyance and storage components. Conveyance components may include open channels, pipes, culverts or natural drainageways which control flooding for the minor storm and minimize damage from the major storm. Storage components may consist of basins sized as needed to eliminate adverse impacts downstream for the 10 and 100-year storm with an appropriately sized spillway to pass events in excess of the 100-year flood without damage.

The planning of drainage facilities shall encourage the use of facilities for multiple purposes. In this way the competing demands for land and open space can best be satisfied. Drainage facilities can be used for other purposes and facilities not designed specifically for drainage can provide drainage benefits if properly designed.

Planning and design of drainage systems shall include consideration of impacts on upstream and downstream properties and/or existing drainage systems. Adverse impacts shall be eliminated wherever possible. Specifically, the diversion of storm runoff from one drainage area to another introduces significant legal, social and technical problems and shall be avoided unless specific reasons justify such a transfer. All diversions shall be approved by the ENGINEER.

The planning of drainage facilities shall include consideration of the right-of-way requirements. Rights-of-way shall be dedicated at the time of platting for all facilities not planned within streets or other dedicated public rights-of-way. Easements will not be acceptable for uses other than maintenance access.

The results of site drainage planning shall be contained in a Drainage Report, sealed by a civil engineer registered as a professional engineer in the State of Arizona.

4. BASIS OF DESIGN

4.1 DRAINAGE CLASSIFICATION

All drainageways within the Kingman Area shall be classified as either "major" or "minor" drainageways. These drainageways are so designated based on their tributary drainage area and general hazard and interest.

Major Drainageways generally serve areas greater than 150 acres. For the Kingman Area the major drainageways have been identified in the Kingman Area Master Drainage Plan.

Because of their designation as major drainageways in the Master Plan, improvements along these channels have been planned. Design, construction and maintenance of Major Drainageways will be the responsibility of the relevant jurisdiction as shown in Table 2.1. When public funds are unavailable, private developers may design and construct drainageway improvements following review and approval by the ENGINEER.

Minor Drainageways are defined as all drains which collect storm runoff and convey it to major drainageways. These drains are normally associated with subdivision development and are to be designed and constructed by developers subject to the review and approval of the ENGINEER. Maintenance of these facilities is generally by the local jurisdiction unless special arrangements have been made between the developer and the City or County.

4.2 RUNOFF COMPUTATION

Runoff for areas less than 150 acres may be established using either the Rational Method or the SCS Method. Runoff from areas greater than 150 acres shall use the SCS method. The data for these two procedures is presented in Section 5 of this Manual.

4.3 HYDRAULIC DESIGN

All hydraulic calculations used in the design and analysis of channels and storm sewers shall be based on the principles of continuity and conservation of energy. Friction losses for channels and pipes shall be determined using Manning's equation. Brief descriptions and necessary data for the more common elements in urban drainage design are given in Section 6 of this Manual.

4.4 DESIGN RECURRENCE INTERVALS

Drainage systems shall be designed to convey nuisance runoff from the more frequent minor storm of 10 years and to minimize major damage from the 100 year storm event.

Runoff from the 10 year storm shall be contained within the street section with no curb overtopping. Where no curb exists, the maximum depth of water shall be 0.5 feet over the crown. Runoff from the 100 year storm shall not enter buildings and when flowing along streets, shall be contained within the street right-of-way.

5. FLOOD ESTIMATION

A hydrologic study shall be performed for each proposed development unless in the opinion of the ENGINEER it is not required. When a study is required it shall define peak flows and volumes necessary for designing the minor and major drainage system. Peak flows and volumes shall be estimated using one of the following methods:

1) Rational
2) SCS
3) Hydrograph Method

For large basins it may be necessary to perform more sophisticated analyses which generate flood hydrographs. At the Pre-Preliminary Plan Meeting, the ENGINEER will determine the need for more detailed analyses.

5.1 RATIONAL METHOD

The rational method may be used to determine peak flows and runoff volumes for areas less than 150 acres. The Rational Equation relates rainfall intensity, a runoff coefficient and drainage area size to the direct runoff from the drainage area. This relationship is expressed by the equation:

$$Q - C\ I\ A$$

where: Q — the runoff in cubic feet per second (cfs) from a given area.
C - a coefficient representing the ratio of runoff to rainfall.
I - the rainfall intensity in inches per hour.
A — the drainage area in acres.

5.1.1 Runoff Coefficient C

The runoff coefficient C represents the cumulative effects of infiltration, evaporation, surface retention, flow routing, surface cover and roughness, ground slope and interception on peak runoff. The range of coefficients, with respect to land use are given in Table 5.1.

Table 5.1 Rational Method Runoff Coefficients

Roofs and Pavements		0.90			
Commercial/Industrial		0.80			
Residential (More than 8 units/acre)		0.70			
Residential (4 to 8 units/acre)		0.60			
Residential (1 to 4 units/acre)		0.50			
Mobile Home Parks		0.55			
Improved Open Space		0.30			
Unimproved Open Space		Hydrologic Soil Group			
		A	B	C	D
Flat:	0 - 2 %	0.04	0.16	0.32	0.48
Average:	2 - 6 %	0.07	0.28	0.50	0.63
Steep:	Over 6%	0.21	0.45	0.64	0.77

5.1.2 Rainfall Intensity I

The rainfall intensity I is the average rainfall intensity in inches per hour for a duration equal to the time of concentration of the basin. For urban storm water basins, the time of concentration (t_c) consists of the time required for runoff to flow over the ground surface to the nearest point of concentration (t_o), and the time for concentrated flow to reach the point under consideration (t_d).

$$t_c = t_o + t_d$$

Figure 5.1 can be used for estimating t_o. The maximum overland flow length used in the determination of t_o shall not exceed 500 feet.

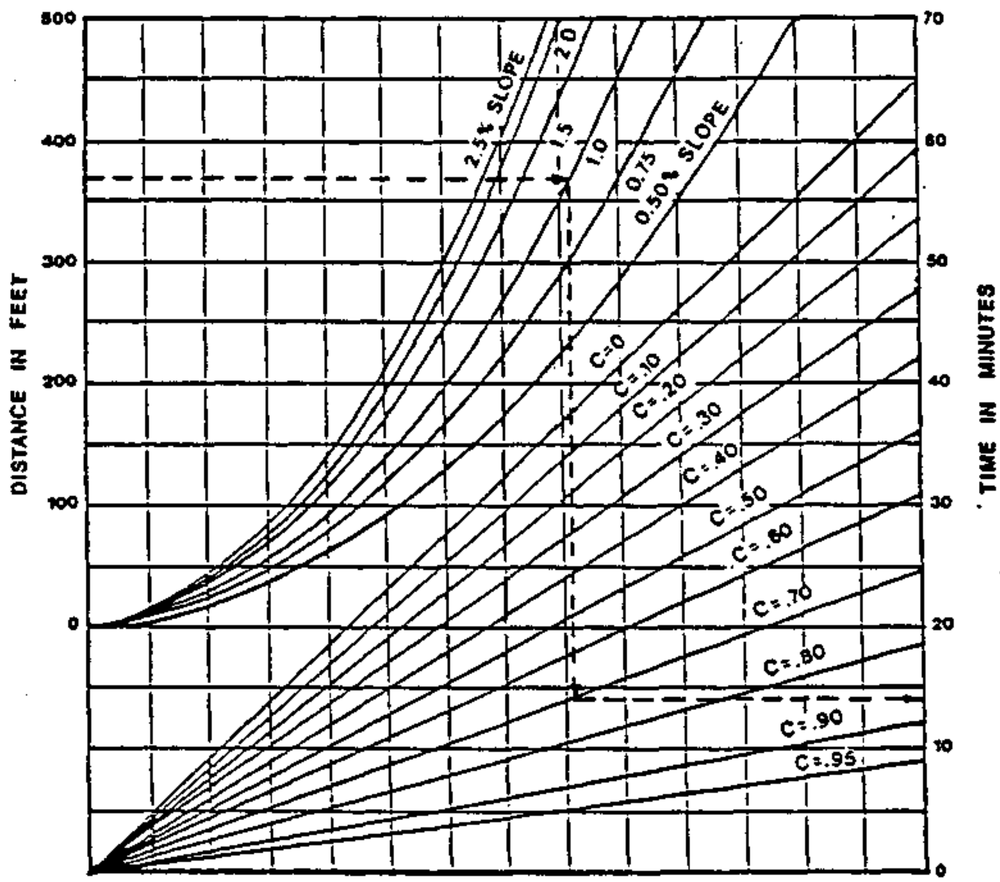


Figure 5.1 Overland Time of Flow Curves

The t_d can be estimated by determining the length from the point where flows first concentrate to the point under consideration and dividing this flow length by the average velocity in the channel. The average velocity can be determined from Table 5.2.

Table 5.2 Approximate Channel Velocities

Average Slope of Channel (Percent)	Average Velocity (feet/second)
1-2	2.0
2-4	3.0
4-6	4.0
6-10	5.0
10-15	8.0

Using the time of concentration (t_c) established above, the rainfall intensity can be established from Figure 5.2.

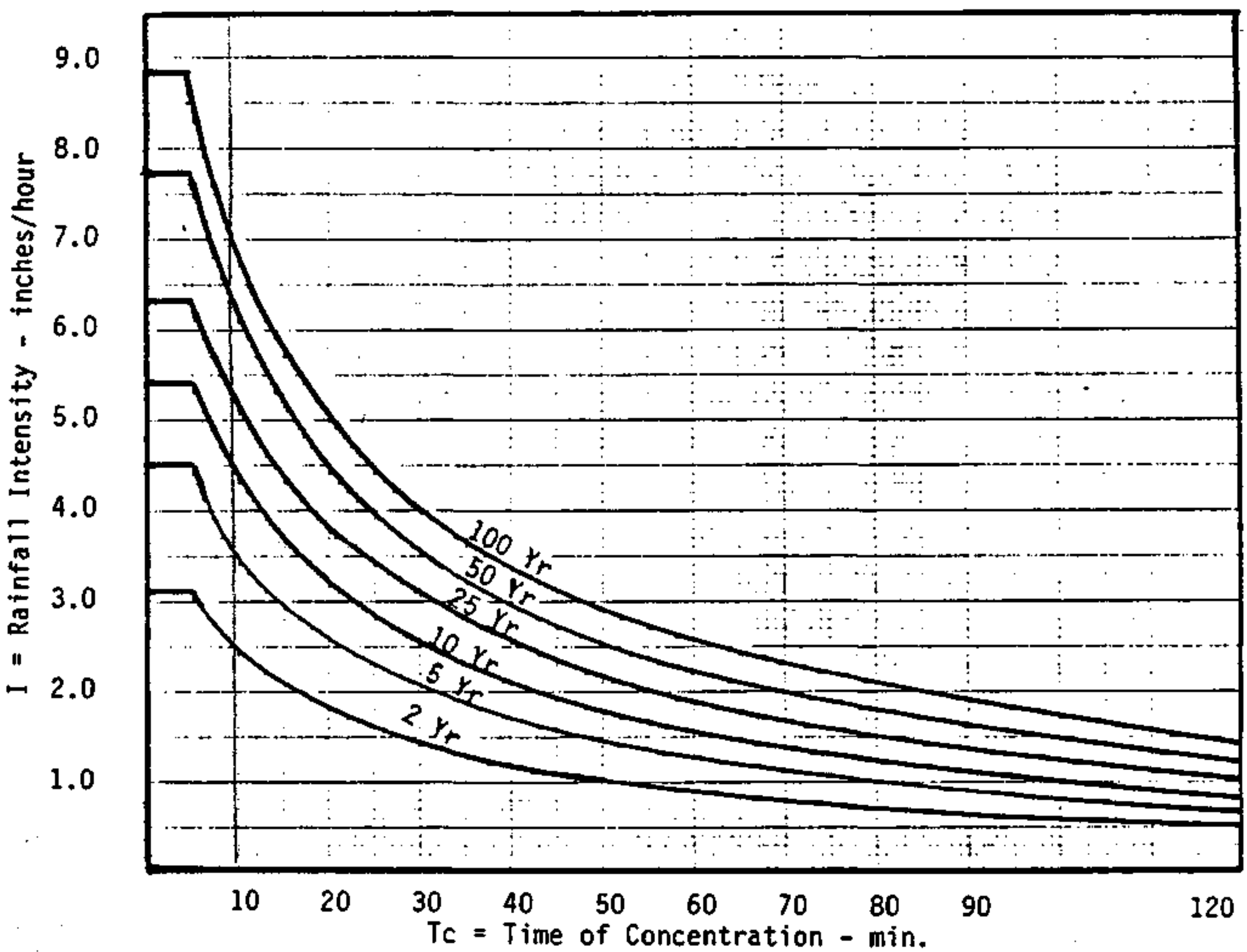


Figure 5.2 Kingman Area Frequency-Duration-Intensity Curves

5.2 SCS METHOD

The SCS method may be used for all basin areas less than 10-square miles to determine peak flows. A detailed description is provided in Technical Release No. 55 "Urban Hydrology for Small Watersheds" (TR-55). The application of this methodology within the Kingman area should be consistent with TR-55.

5.2.1 Precipitation

When using the methodology for determining peak flows presented in TR-55, the total 24-hour rainfall depth should be used. For the Kingman area, the appropriate depths for various recurrence intervals are presented in Table 5.3.

Table 5.3 Rainfall Depth - Inches

Duration (hours)	Recurrance Interval (Years) 2	5	10	25	50	100
24	1.50	2.l9	2.63	3.22	3.68	4.15

5.2.2 Curve Number Determination

The curve number (CN) is a function of soil type and cover. The soil types are grouped by hydrologic soil classifications ranging from A (low runoff potential) to D (high runoff potential). Figure 5.3 presents the hydrologic soil group classification within the greater Kingman area. A typical land use may be assigned an appropriate CN or a composite CN can be developed by analyzing the various components individually and developing a weighted CN. Table 5.4 provides the CN values by land use and soil group for the Kingman area. These may differ from those presented in other references; however, these shall be used in all studies to be reviewed by the ENGINEER.

Table 5.4 SCS **Curve** Numbers by Land Use

Land Use	Hydrologic Soil Group A	B	C	D
Roofs and Pavements	98	98	98	98
Commercial/Industrial	81	88	91	93
Residential (More than 8 units/acre)	78	86	90	92
Residential (4 to 8 units/acre)	69	80	87	90
Residential (1 to 4 units/acre)	56	71	81	86
Mobile Home Parks	73	82	88	90
Improved Open Space	44	65	77	82
Unimproved Open Space				
Flat: 0 - 2%	51	68	79	84
Average: 2 - 6 %	59	74	83	88
Steep: Over 6%	68	79	86	89

5.3 HYDROGRAPH METHOD

Numerous hydrograph methods exist which can be used to determine peak flows and volumes for planning and design purposes. The specific methodology to be used shall be reviewed by the ENGINEER. Specific parameters used in the methodology shall be consistent with those presented herein.

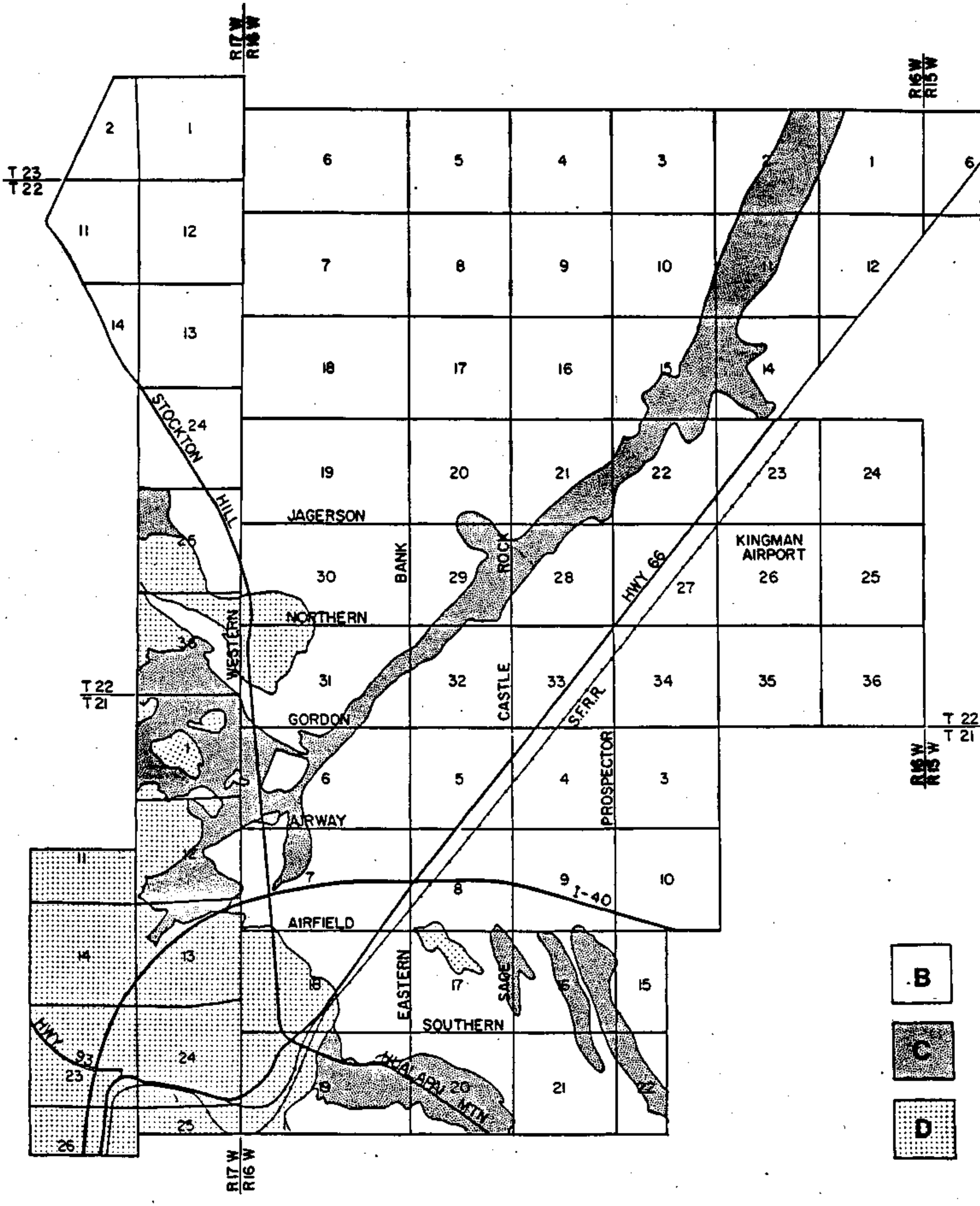


Figure 5.3 Hydrologic Soil Groups - Kingman

6. HYDRAULIC DESIGN

The collection and conveyance of storm runoff is generally a combination of street and gutter systems, storm sewer systems, and open channels. The hydraulic analysis of these component parts is all based on the fundamental principles of continuity and conservation of energy.

Hydraulic analysis of open channel or pipe systems is a complex topic to which many books have been devoted. The information presented in this Drainage Design Manual is intended to repeat the basic equations used in most storm drainage system analyses. Because of the dynamic nature of storm flows, other methodologies must frequently be employed to accurately represent the system mathematically. It is the engineer's responsibility to assess the anticipated hydraulic conditions of the storm sewer and to apply the appropriate theory and computational techniques.

6.1 HYDRAULIC COMPUTATIONS

All hydraulic calculations used in the design and analysis of channels and storm sewers shall be based on the principles of continuity and conservation of energy. The continuity equation states:

$$Q = A\,V$$

where: Q — discharge in cubic feet per second
A - area in square feet
V - velocity in feet per second

The conservation of energy principle states that energy between sections must be accounted for. This is generally done using Bernoulli's equation with a head loss term.

$$d_1 + z_1 + \frac{V_1^2}{2g} = d_2 + z_2 + \frac{V_2^2}{2g} + h_1$$

where: d - depth of flow in feet
z - elevation of invert in feet
v - velocity of section in feet per second
g - acceleration due to gravity in feet per second squared
h_1 - head losses due to friction and turbulence in feet

Friction losses shall be determined using Manning's equation:

$$Q = \frac{1.49}{n} A\,R^{2/3}\,S_f^{1/2}$$

where: Q - discharge in cubic feet per second
n - Manning's roughness coefficient
A - area in square feet
R - hydraulic radius in feet
S_F - slope of the energy grade line in feet per foot

Uniform flow occurs in a channel when the water surface is parallel to the channel bottom. Non-uniform flow occurs in a channel when the water surface is not parallel to the channel bottom.

The Manning equation is sufficient to describe uniform flow. However, the Bernoulli equation must be used to describe non-uniform flow. It is necessary to recognize which type of flow condition prevails. Uniform flow generally occurs in long channel reaches of constant or nearly constant properties.

When non-uniform flow occurs, the designer should recognize "controls", and draw a generalized flow profile. Controls are channel cross sections for which the depth and velocity are known or can accurately be estimated.

Manning's roughness coefficient "n" used in hydraulic computations shall be in accordance with Table 6.1.

Table 6.1 Manning's n Coefficients

Material		Manning's n
Reinforced Concrete Box and Pipe		.012
Corrugated Metal Pipe		.024
Corrugated Metal Pipe (Multiplate)		.035
Asphalt Lined Corrugated Metal Pipe		.012
Asphalt Lined Channels		.016
Concrete Lined Channels		.015
Curb and Gutter		.015
Soil (Sand-Silt) Channels		.030
Rip-Rap Channels		.040
Grass Channels		.035
Natural Channel	- Sand/Silt	.030
	- Clump Grasses	.033
	- Turf Grasses (maintained)	.035
	- Unmaintained Grasses	.040
Floodplain	- Native Vegetation	.055
	- Developed	.070

6.2 STORM SEWERS

The capacity of the storm sewer system should be such that a combination of pipes and streets can convey the 10-year flows at acceptable levels of inundation. Using preliminary street grades and cross sections, calculate the allowable carrying capacity for the streets. Beginning at the upper end of the basin, calculate the quantity of flow in the street until the point is reached at which the allowable carrying capacity of the street matches the design runoff. The storm sewer system starts at this point. The allowable street capacity plus the storm sewer capacity must equal or exceed the design flow.

The hydraulic design of a storm sewer system should be based on the procedures set forth in this Manual. A Manning's n value should be determined and applied as necessary, treating the conduits as either open channels or pipes flowing full. The energy grade line and the hydraulic grade line should be calculated. Mannings equation shall be the basis for pipe friction losses with junction and transition losses as shown in Figure 6.1.

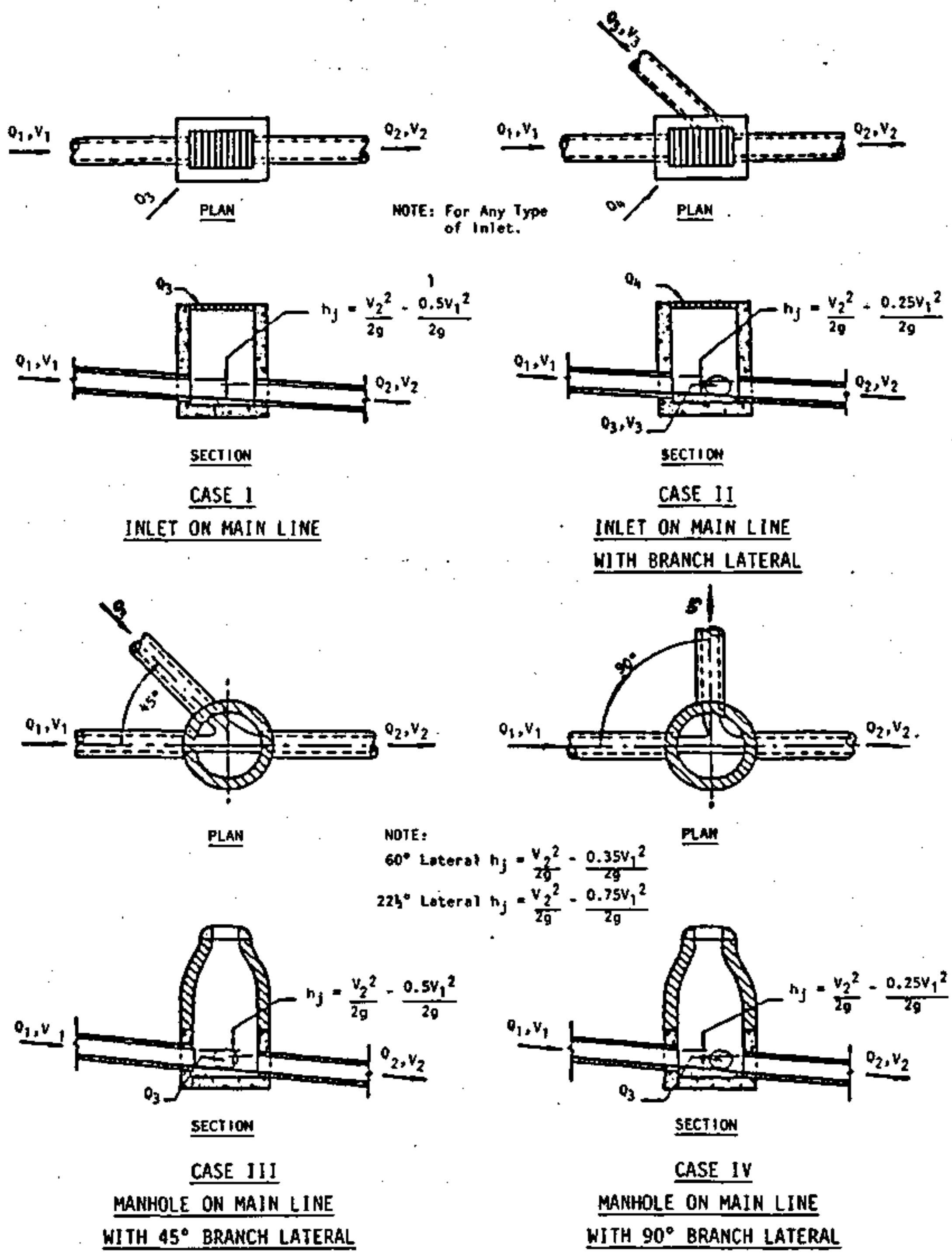
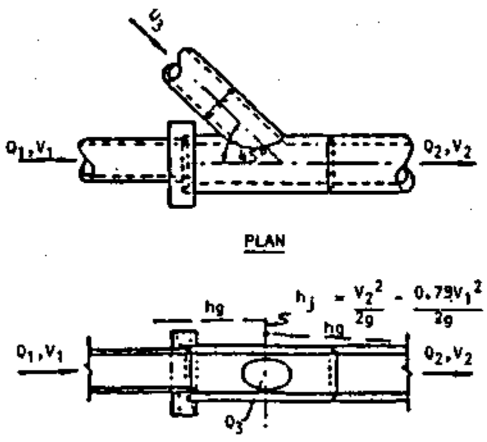
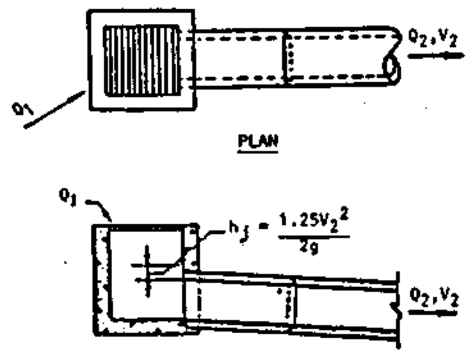


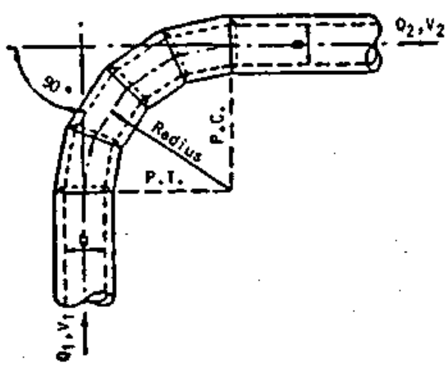
Figure 6.1 Minor Losses at Structures



CASE V
45° WYE CONNECTION
OR CUT IN



CASE VI
INLET OR MANHOLE AT
BEGINNING OF LINE



CASE VII
CONDUIT ON 90° CURVES*

NOTE: Headloss applied at P.C. for length of curve.

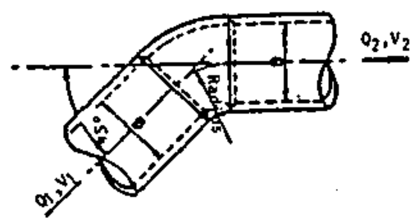
Radius = Diameter of Pipe $h_j = 0.50 \frac{V_2^2}{2g}$

Radius = (2-8) Dia. of Pipe $h_j = 0.25 \frac{V_2^2}{2g}$

Radius = (8-20) Dia. of Pipe $h_j = 0.40 \frac{V_2^2}{2g}$

Radius = Greater than 20 Dia. of Pipe $h_j = 0$

*When curves other than 90° are used, apply the following factors to 90° curves.
60° curve 85%
45° curve 70%
22½° curve 40%



CASE VIII
BENDS WHERE RADIUS IS
EQUAL TO DIAMETER OF PIPE

NOTE: Headloss applied at beginning of bend

90° Bend $h_j = 0.50 \frac{V_2^2}{2g}$

60° Bend $h_j = 0.43 \frac{V_2^2}{2g}$

45° Bend $h_j = 0.35 \frac{V_2^2}{2g}$

22½° Bend $h_j = 0.20 \frac{V_2^2}{2g}$

Figure 6.1 (cont'd) Minor Losses at Structures

In addition to the hydraulic design of pipe systems as presented herein, some practical guidelines should also be adhered to.

Table 6.2 Storm Sever Miscellaneous Design Criteria

MANHOLES			
Minimum drop		through manhole	0.1'
		one lateral	0.2'
		laterals	0.3'
Maximum spacing	-	less than 36" Dia.	400'
		greater than 36" Dia.	500'
PIPELINES			
Minimum size	-	main	18"
		inlet lateral	15"

6.3 OPEN CHANNELS

Open channels are frequently used for the conveyance of large flows. Costs are generally less than pipe systems and the need for elaborate inlet systems is reduced. Channels are often described as natural or artificial. Natural channels include all water courses that have occurred naturally by the erosion process, while artificial channels are those constructed or developed by human effort.

The hydraulic properties of natural channels vary along the channel reach and can be either controlled to the extent desired or altered to meet given requirements. Natural channels must frequently be protected from erosion due to high velocity flows or protected from excessive silt deposition due to low velocities. If a natural channel is to be used for carrying storm runoff from an urbanized area, the altered nature of the runoff peaks and volumes from urban development may cause additional erosion. Detailed hydraulic analysis will be required for natural channels to identify the erosion tendencies.

Artificial channels are created to convey flows in a controlled environment. Frequently it is necessary to stabilize the body of the channel, protect the soil mass of the bed and banks, and control the movement of particles along the channel bottom. This may be accomplished by providing a hardened lining of concrete, soil cement or rock, providing a vegetative lining which protects the surface and bonds the soil particles together, or by controlling velocities to a range which results in neither aggradation nor degradation. The hydraulic analysis of open channels often requires an analysis of rapidly varied flow or sediment transport capacity. In critical channel sections, the ENGINEER shall determine the appropriate level of analysis required to review the design.

The principles of continuity and conservation of energy apply to open channel flow in both natural and artificial channels. Manning's equation shall be used with appropriate values of n. Head losses associated with transitions and other changes in channel geometry shall be estimated using the following equation and coefficients given in Table 6.5

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

where:

h_e	= head loss due to geometry in feet
K_t	= loss coefficient due to expansion or contraction
$\frac{V_1^2}{2g} - \frac{V_2^2}{2g}$	= absolute difference in velocity head

Table 6.3 Transition Loss Coefficients K_t

Transition Type	Severity	K_t
Expansion	Abrupt	.5
Expansion	Gradual	.2
Contraction	Abrupt	.3
Contraction	Gradual	.1

Additional design criteria for open channels is given in Table 6.4.

Table 6.4 Open Channel Miscellaneous Design Criteria

FREEBOARD		
Subcritical Flow (Froude Number less than 0.8)		$0.5' + \frac{V^2}{2g}$
Supercritical Flow (Froude Number greater than 1.2)		Conjugate depth + 1'
Minimum		1.0'
VELOCITY (Unlined Channels)		
Minimum	- 10 year	2 fps
Maximum *	- 10 year	7 fps
	- 100 year	10 fps

* When hardened linings are used this value may reach 20 fps

6.4 CULVERTS

Culverts are used to convey flow beneath roadways crossing the drainageway. They typically extend from one side of the road to the other connecting natural drainageways or open channels. In some poorly defined washes they merely provide a mechanism for flows from one side to reach the other without overtopping the roadway.

For this discussion, culverts include concrete pipes, corrugated metal (CM.) pipe and arch sections, and concrete box culverts. All such culverts have a uniform barrel cross section throughout. The culvert inlet may consist of the culvert barrel projected from the roadway fill or mitered to the embankment slope. Sometimes inlets have headwalls, wingwalls and apron slabs, or standard end sections of concrete or metal.

There are two major types of culvert flow: flow with inlet control and flow with outlet control. For each type of control, different factors and formulas are used to compute the hydraulic capacity of a culvert. Under inlet control, the cross-sectional area of the culvert barrel, the inlet geometry and the amount of headwater or ponding at the entrance are of primary importance. Outlet control involves the additional consideration of the elevation of the tailwater in the outlet channel and the slope, roughness and length of the culvert barrel.

6.4.1 Inlet Control

Inlet control means that the discharge capacity of a culvert is controlled at the culvert entrance by the depth of headwater (HW) and the entrance geometry, including the area, shape and type of inlet edge. With inlet control, the roughness and length of the culvert barrel and outlet conditions (including depth of tailwater) are not factors in determining culvert capacity. The barrel slope has some effect on discharge, but any adjustment for slope is considered minor and can be neglected. Figures 6.2 to 6.5 give headwater-discharge relationships for culverts flowing under inlet control.

6.4.2 Outlet Control

Outlet control in a culvert implies that the flow through the culvert is controlled by downstream parameters. The total head required to force flow through the culvert is composed of velocity head and friction and entrance losses. This head must be added to the elevation of the downstream water surface elevation and subtracting the change in invert elevation through the pipe to determine the required headwater.

Figures 6.6 to 6.9 have been included to directly determine the total head required without solving for the individual component parts of the total head. Figure 6.10 will assist in the determination of the type of control and the governing head.

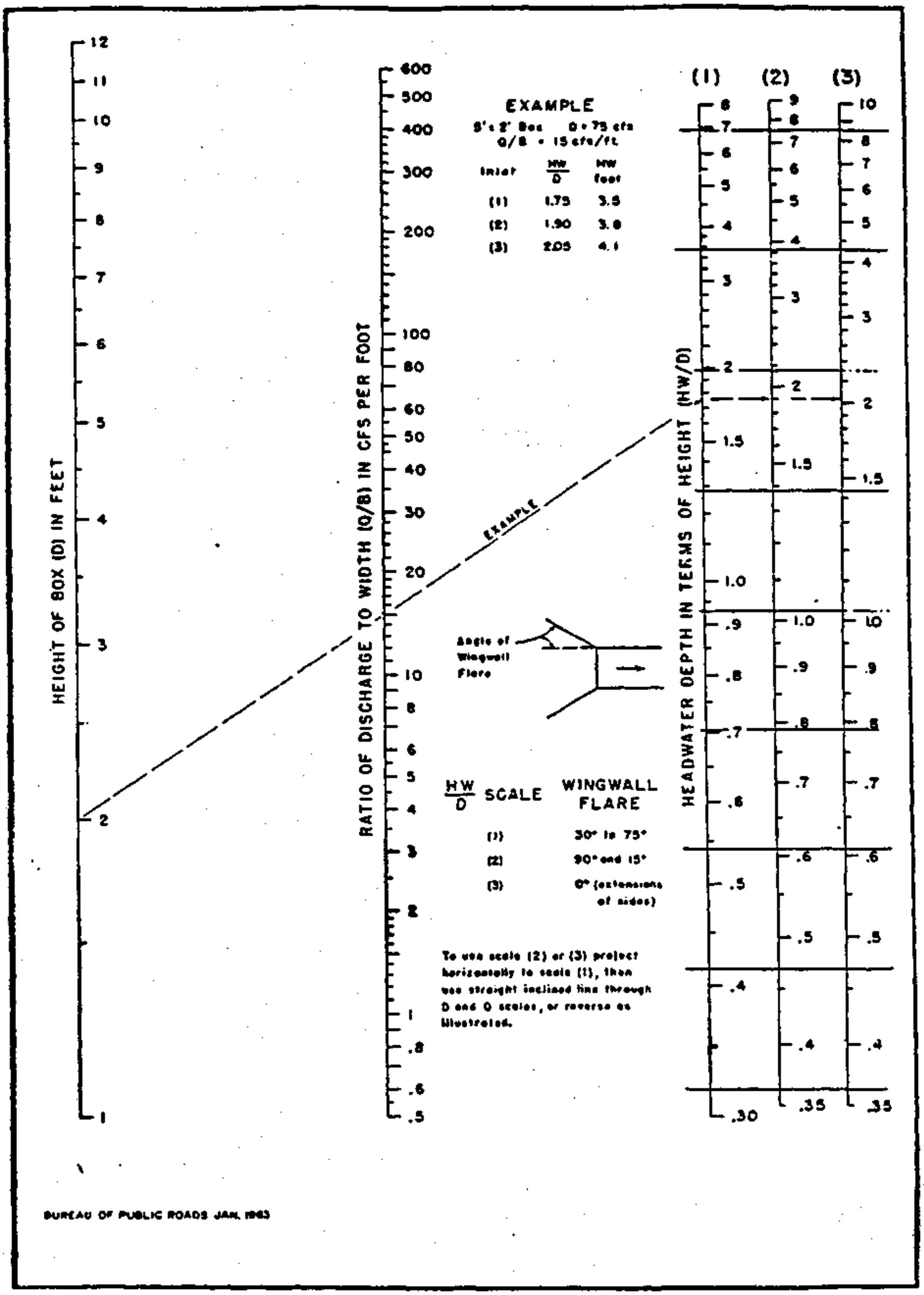


Figure 6.2 Headwater Depth for Box Culverts - Inlet Control

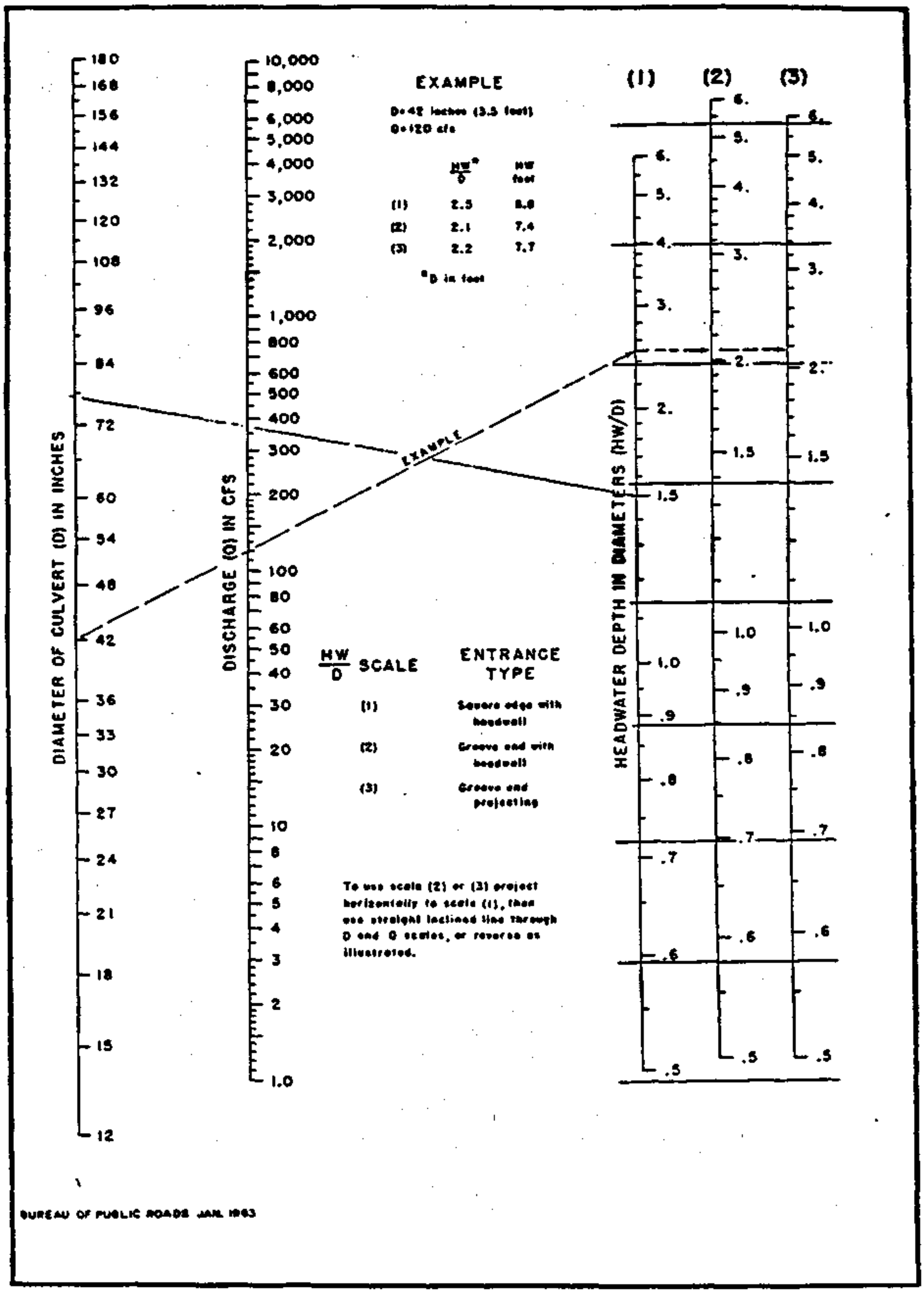


Figure 6.3 Headwater Depth for Concrete Pipe Culverts - Inlet Control

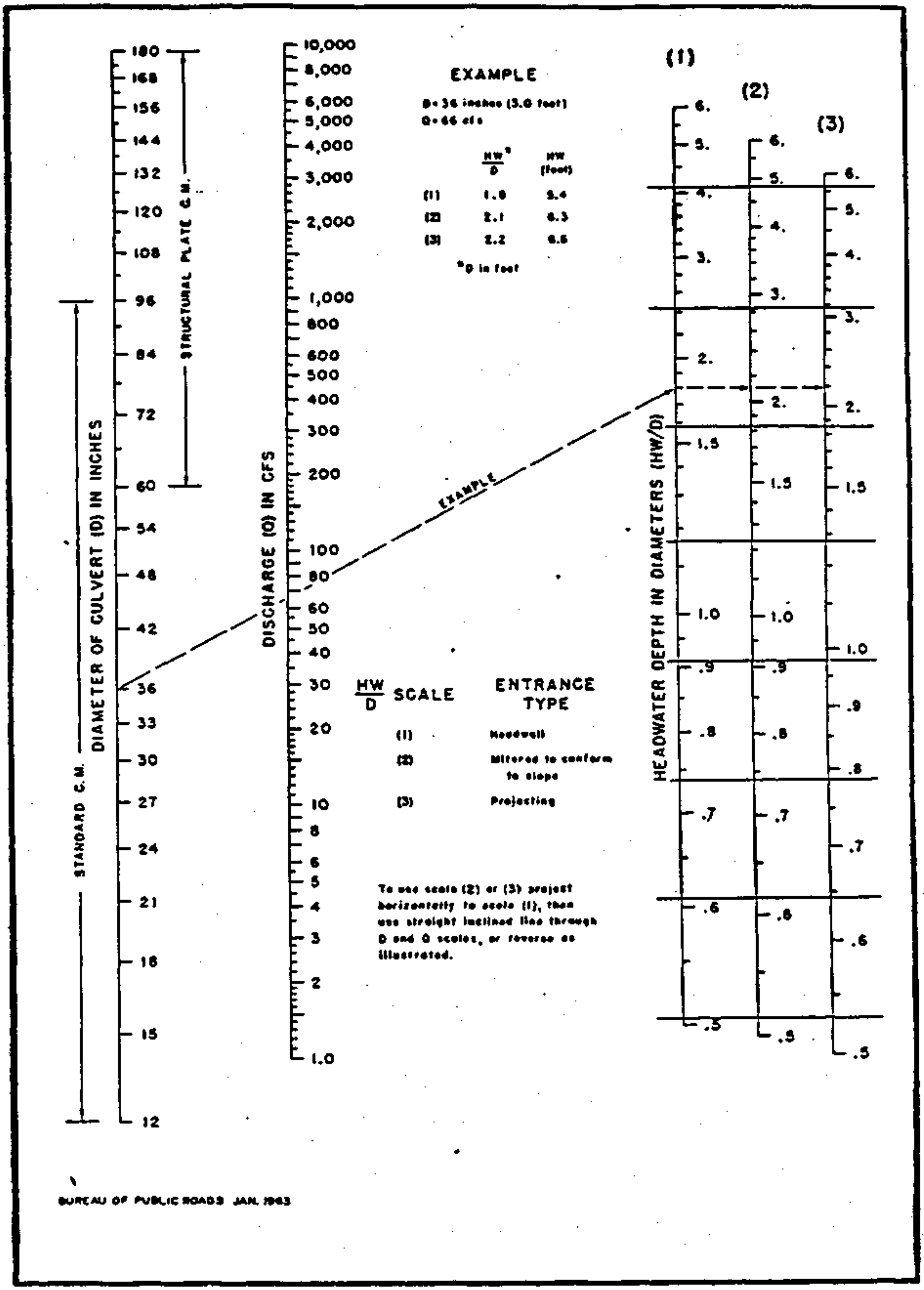


Figure 6.4 Headwater Depth for C M Pipe Culverts - Inlet Control

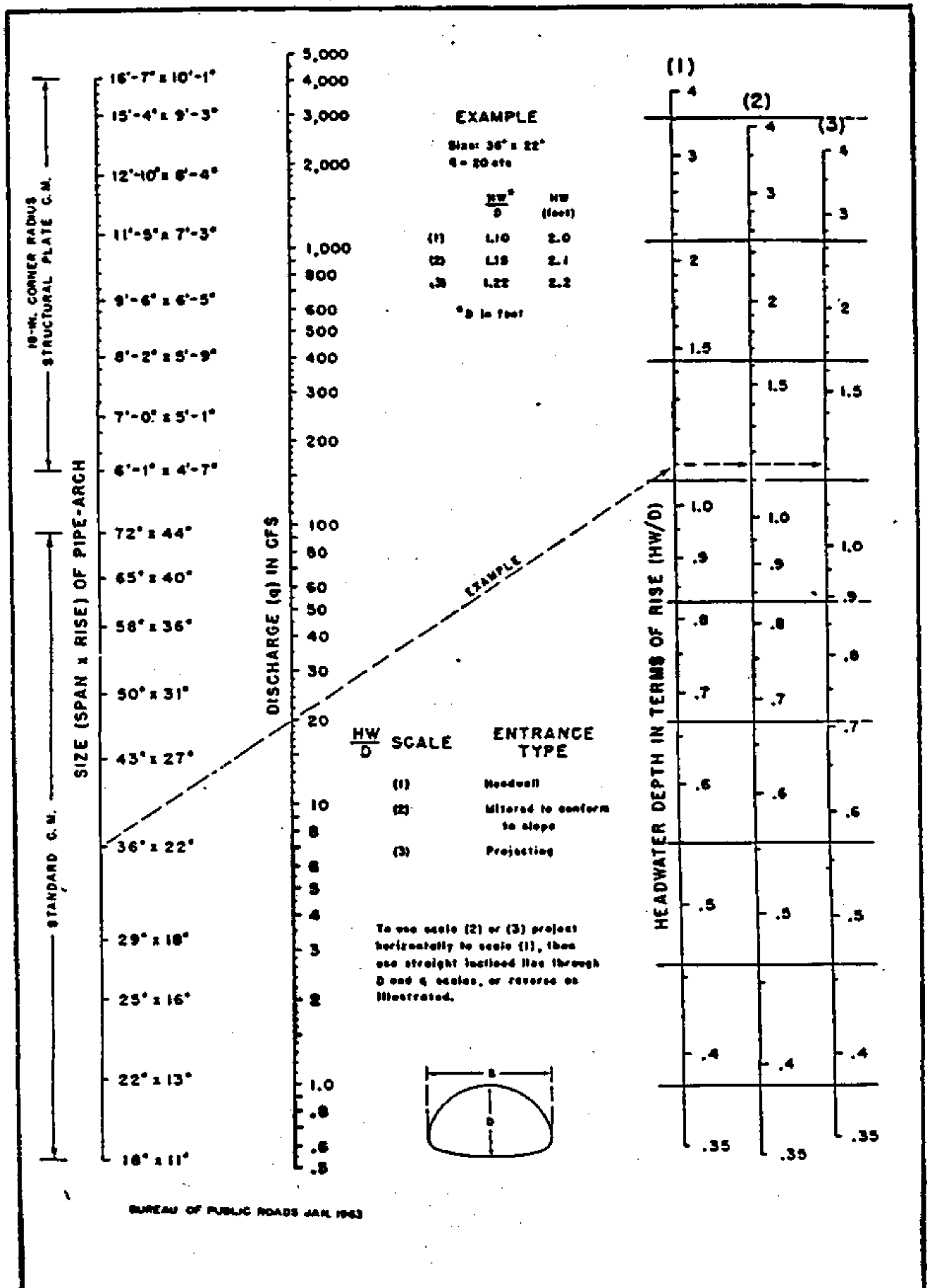


Figure 6.5 Headwater Depth for C M Pipe Arch Culverts - Inlet Control

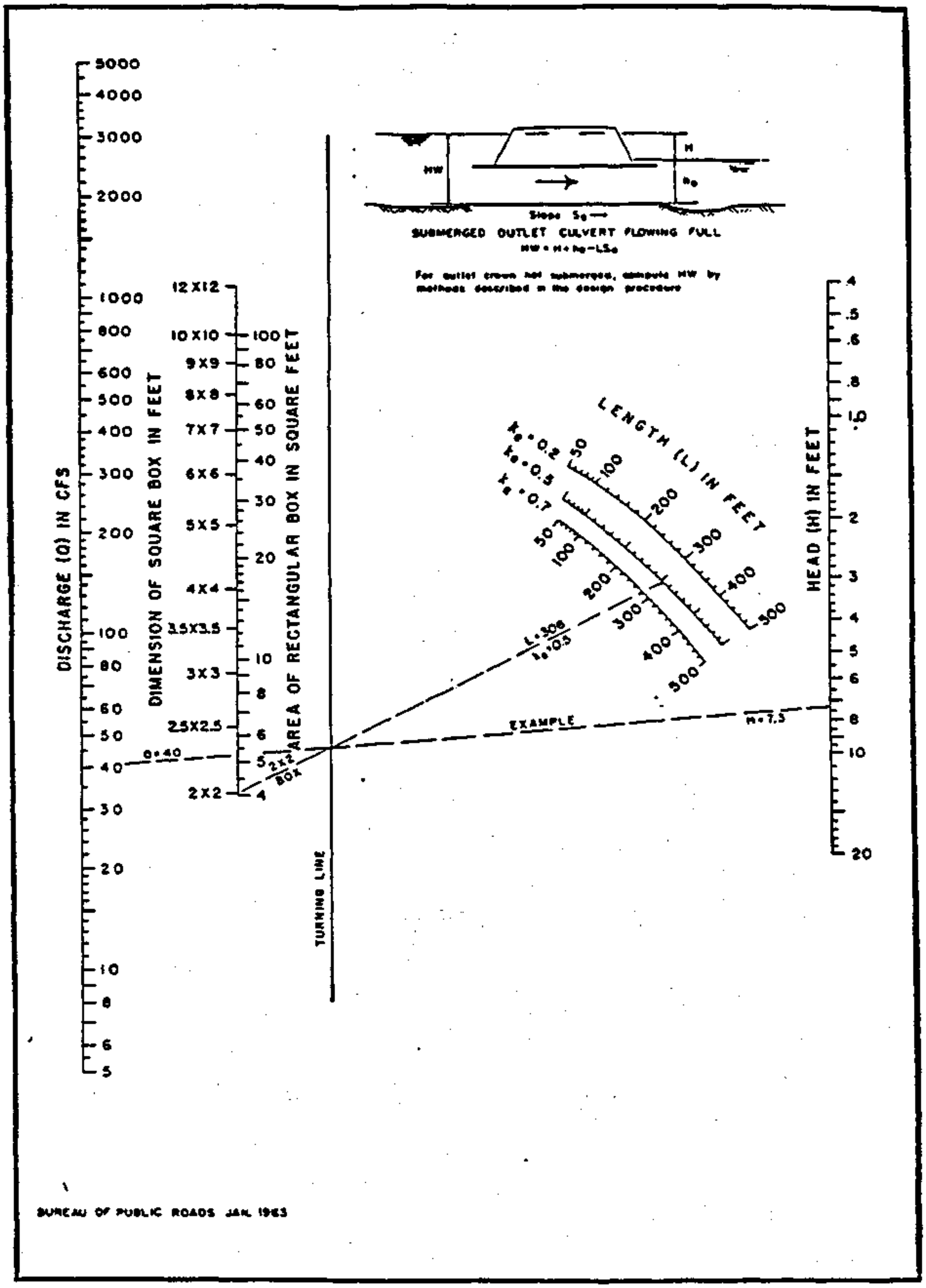


Figure 6.6 Head for Concrete Box Culverts - Flowing Full n - 0.012

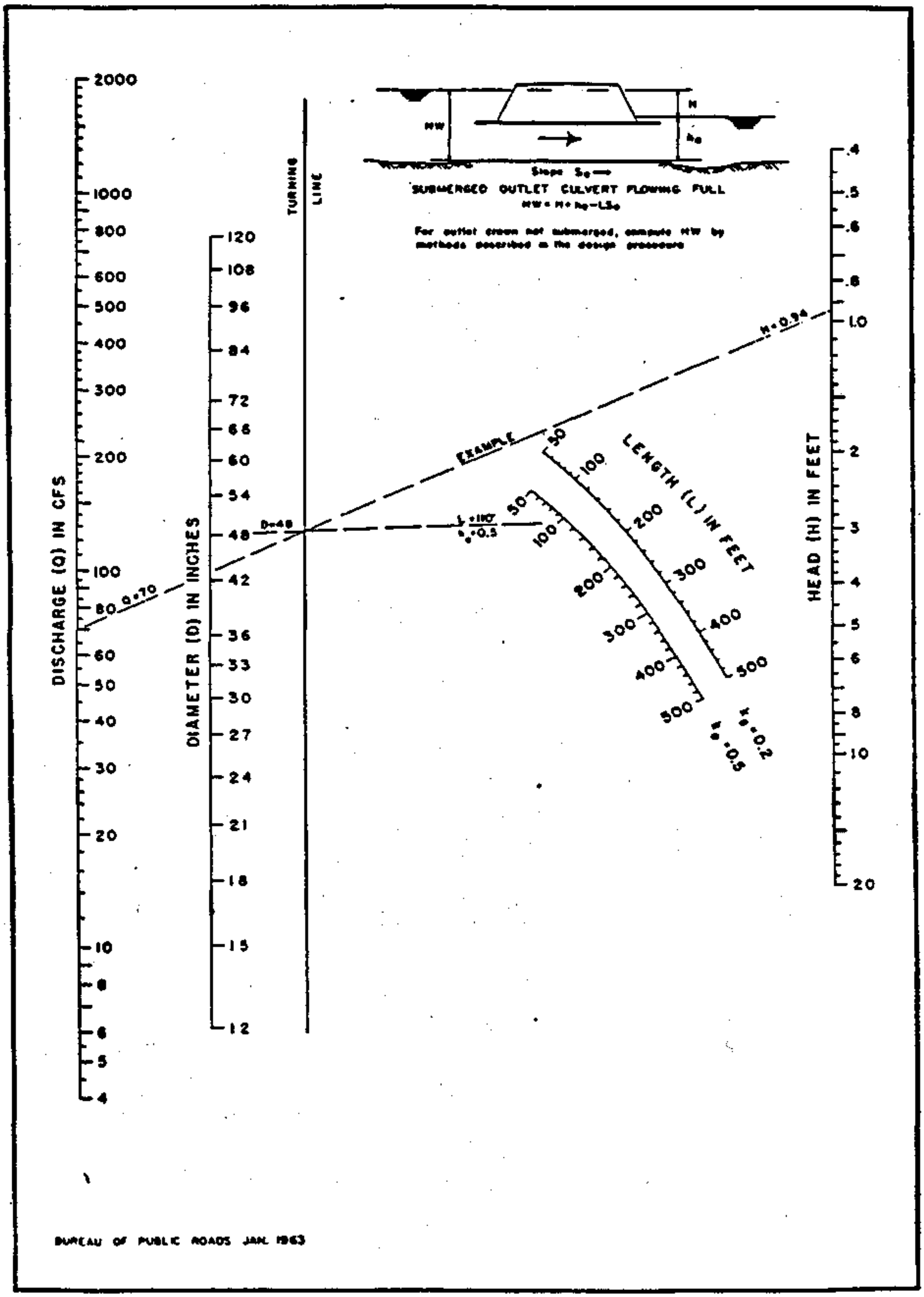


Figure 6.7 Head for Concrete Pipe Culverts - Flowing Full n - 0.012

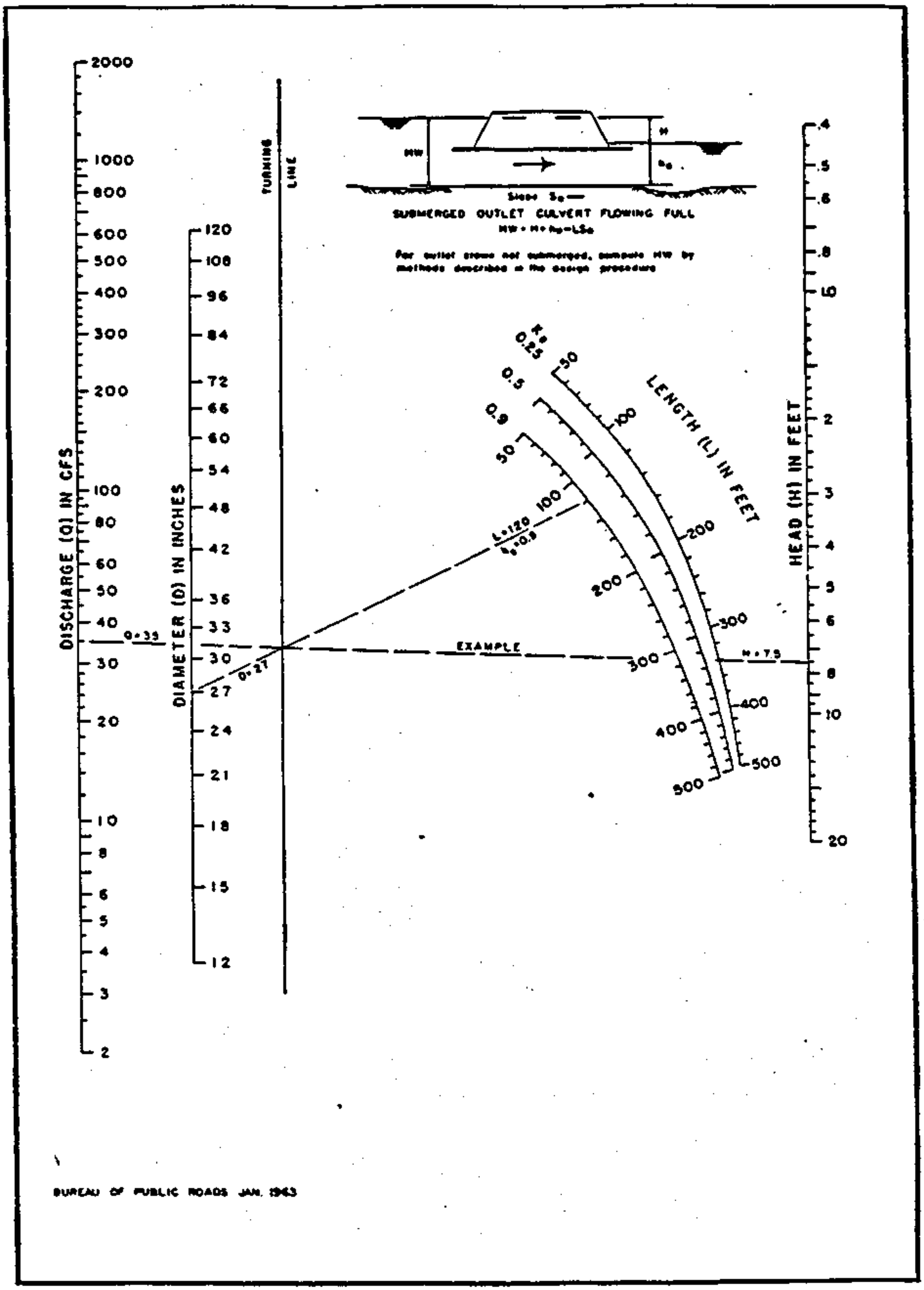


Figure 6.8 Head for Standard C M Pipe Culverts - Flowing Full n - 0.024

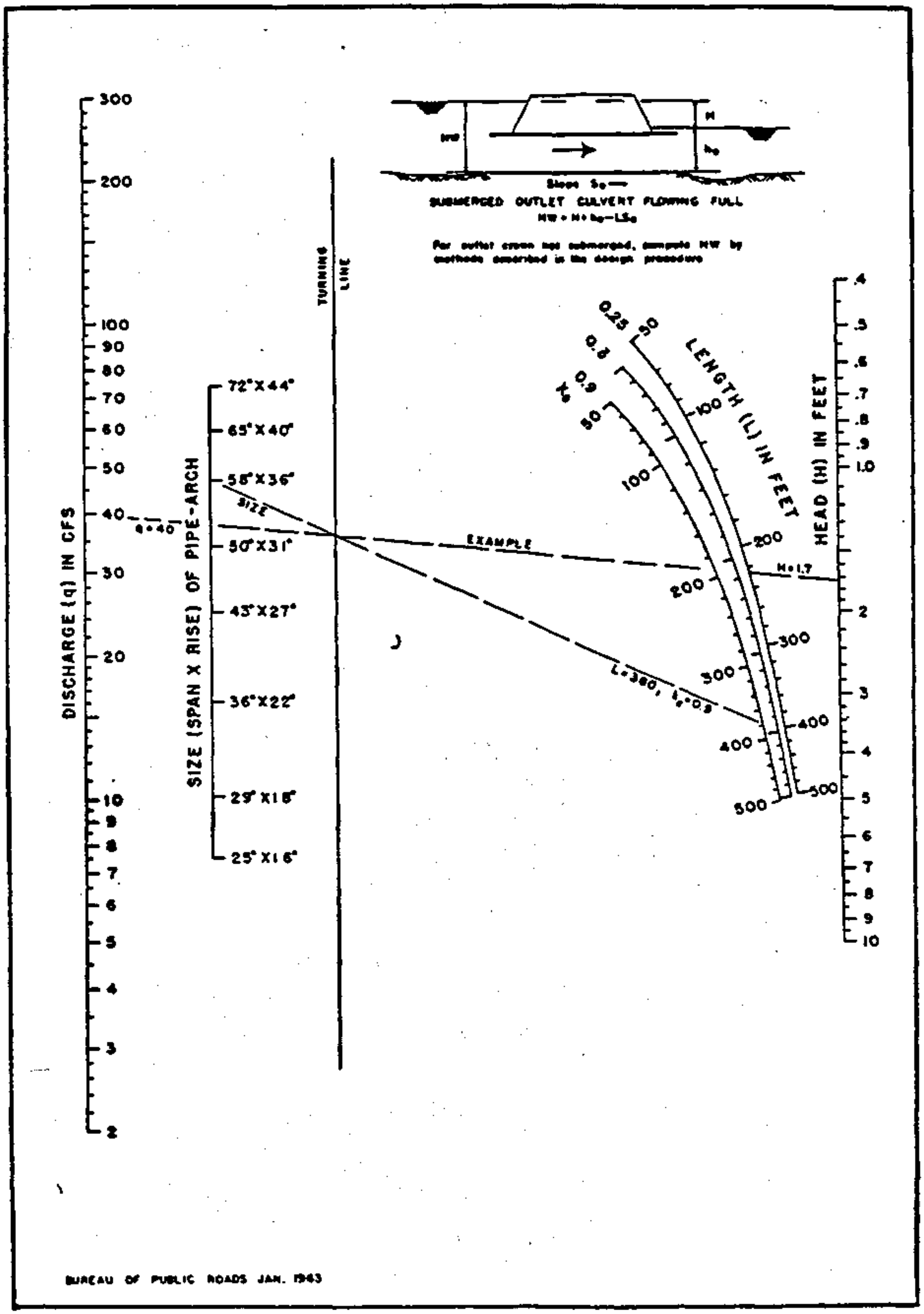


Figure 6.9 Head for C M Pipe Arch Culverts - Flowing Full n - 0.024

PROJECT: ____________ DESIGNER: ____________

DATE: ____________

HYDROLOGIC AND CHANNEL INFORMATION

Q_1 = ______ TW_1 = ______

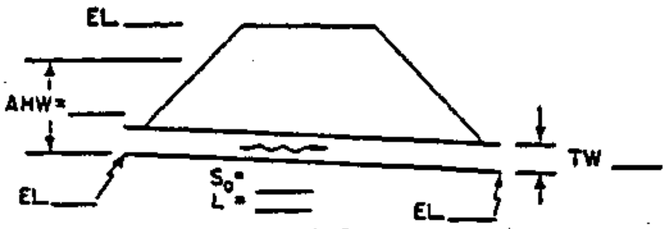
Q_2 = ______ TW_2 = ______

Q_1 = DESIGN DISCHARGE,

Q_2 = CHECK DISCHARGE,

SKETCH

STATION: ____________



MEAN STREAM VELOCITY= ______

MAX. STREAM VELOCITY= ______

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

SUMMARY & RECOMMENDATIONS:

Figure 6.10 Culvert Design Form

7. STREET DRAINAGE

7.1 ALLOWABLE INUNDATION OF STREETS

Design standards for the collection and conveying of runoff water on public streets is based on an acceptable frequency of traffic interference. That is, depending on the width (and hence classification) of the street, certain traffic lanes can be fully inundated after exceeding the design storm frequency.

Street drainage shall be governed by Table 7.1.

Table 7.1 Design Storm Frequencies for Street Drainage (Years)

LONGITUDINAL STREET FLOW	
No curb overtopping * (For 4 or more laned streets at least 1 traffic lane free of water in each direction.)	10
Flow to be calculated assuming contained in right-of-way with top water elevation within 1 foot of lowest finished floors.	100
CROSS STREET FLOW	
No flow across streets **	10
1.0 feet of depth at crown	100

* Where no curb exists, maximum depth to be 0.5 feet over crown
** Except at designated dip crossings.

Regardless of the size of the culvert, bridge or dipped section, the street crossing is to be designed to convey the 100-year storm runoff under and/or over the road to an area downstream of the crossing to which the flow would have gone in the absence of the street crossing.

For flows crossing broad shallow washes where the construction of a culvert is not practical or desirable, the road should be dipped to allow the entire flow across the road. The pavement through the dip should have a one way slope and curbing and medians must not be raised. For these situations approval is to be obtained from the ENGINEER.

7.2 GUTTER FLOW

Longitudinal street flow for events less than the 10 year recurrence interval will frequently be contained within the street section by the curb and gutter. The calculation of a theoretical gutter capacity can be performed using Manning's equation as previously presented. Because splashing,waves from traffic and cars parked in the gutter frequently reduce the actual gutter capacity, a reduction factor must be applied to theoretical flow to determine actual gutter capacity. Figure 7-1 presents a nomograph for allowable gutter capacity and already includes a reduction factor.

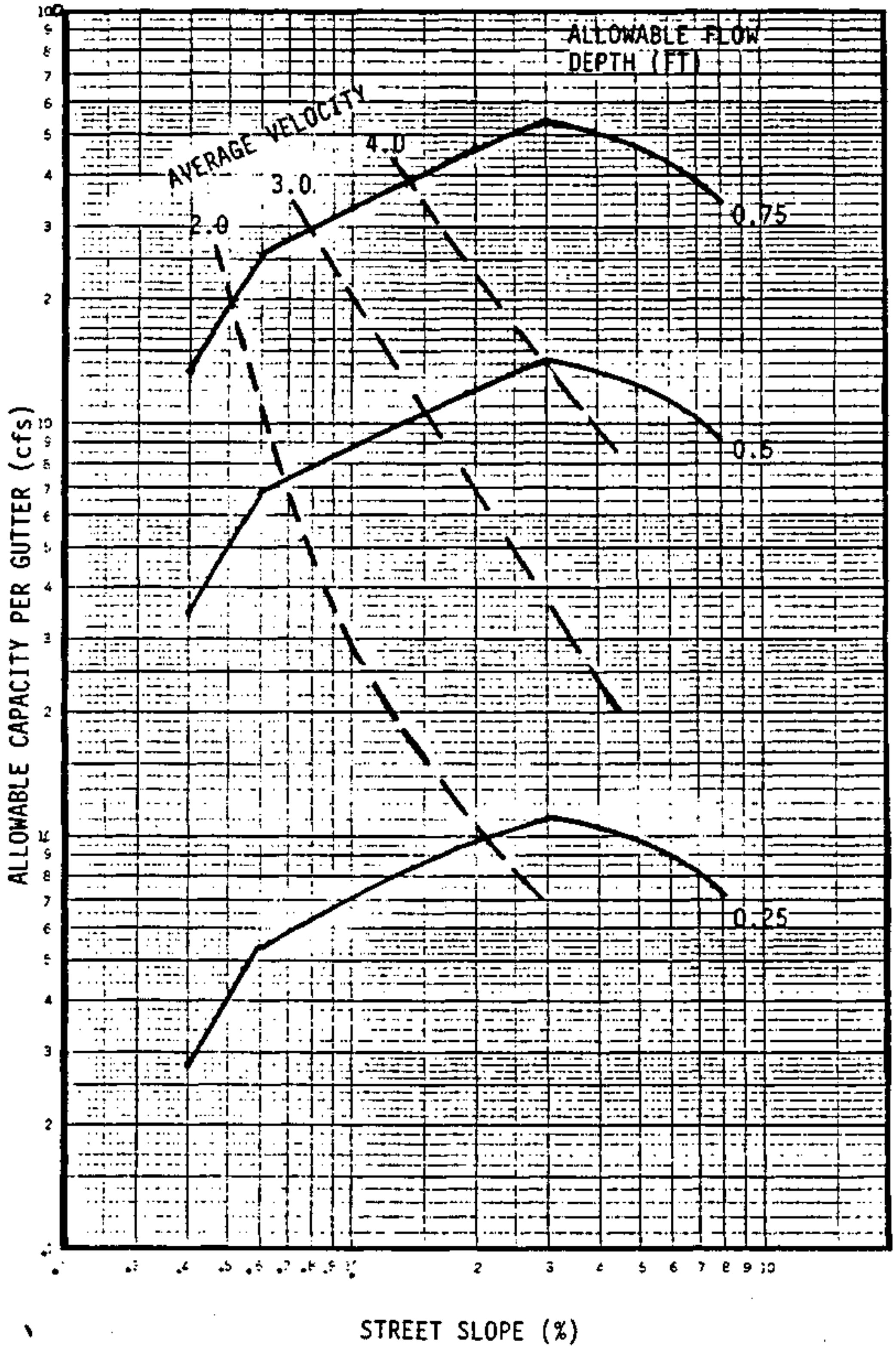


Figure 7.1 Allowable Gutter Capacity

7.3 INLETS

Inlets provide the opening for stormwater to enter the storm sewer system. The inlets must be sized to intercept flows from the streets before exceeding the capacity of the street section and without surcharging storm sewer pipes.

There are three types of inlets allowed in the Kingman area:

- Curb Inlet
- Grated Inlet
- Combination Inlet

Inlets are further classified as being on a continuous grade or in a sump. The term continuous grade refers to inlets located where the grade of the street has a continuous slope past the inlet and, therefore, ponding does not occur. The sump condition exists whenever water ponds at the inlet. A sump condition can occur at a change in grade of the street from positive to negative, or at an intersection due to the crown slope of a cross street.

The capacity of inlets is dependent upon depth of flow in the gutter, area of inlet opening, gutter and cross street slope and inlet depression. The capacity must be reduced to reflect actual conditions which may include debris accumulation and street overlays.

7.3.1 Continuous Grade

For the continuous grade condition, the capacity of the inlet is dependent upon many factors including gutter slope, depth of flow in the gutter, height and length of curb opening, street cross slope, and the amount of depression at the inlet. In addition, all of the gutter flow will not be intercepted and some flow will continue past (carryover) the inlet area.

The capacity of the standard inlets has been prepared in nomograph form and is shown on Figure 7.2 (curb opening) and 7.3 (combination). The values represent allowable capacity for curb opening and combination inlets on continuous grade. Grated inlets alone are not recommended on continuous grades because of their hydraulic inefficiencies and their tendency to trap debris.

7.3.2 Sump Condition

The capacity of the inlet in a sump condition is dependent on the depth of ponding above the inlet. Typically, the number and length of inlets or depth of flow required to intercept a given flow amount must be calculated. Figure 7.3 relates depth of ponding to inlet capacity for various inlet types.

7.3.3 Inlet Spacing

The optimum spacing of storm inlets on continuous grade is dependent upon several factors including traffic requirements, contributing land use, street slope, and distance to the nearest outfall system. The suggested sizing and spacing of the inlets is based upon the interception rate of 70% to 80%. This spacing has been found to be more efficient than a spacing using 100% interception rate. Using the suggested spacing, only the most downstream inlet in a development would be designed to intercept 100% of the flow.

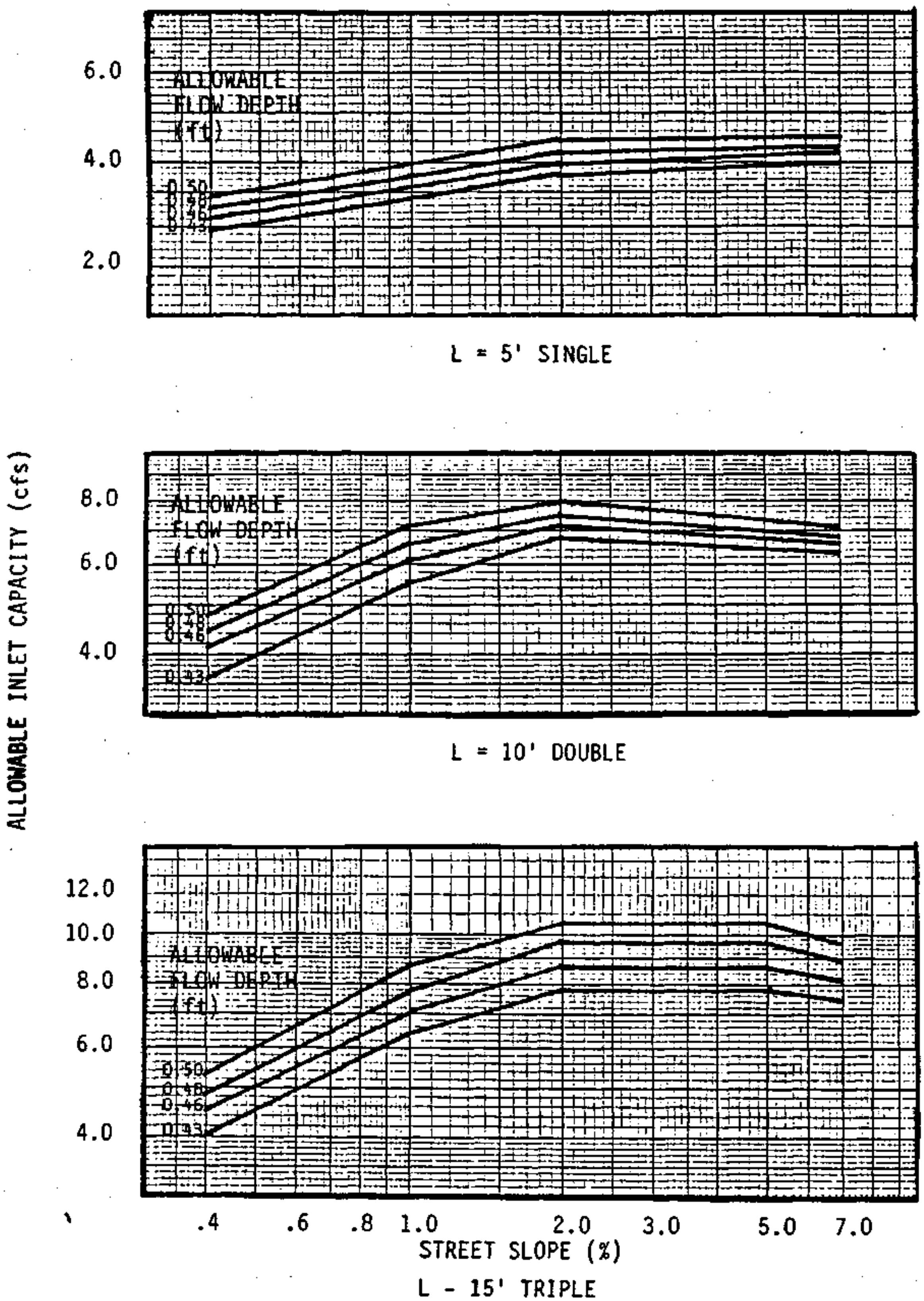


Figure 7.2 Allowable Inlet Capacity
Curb Opening on a Continuous Grade

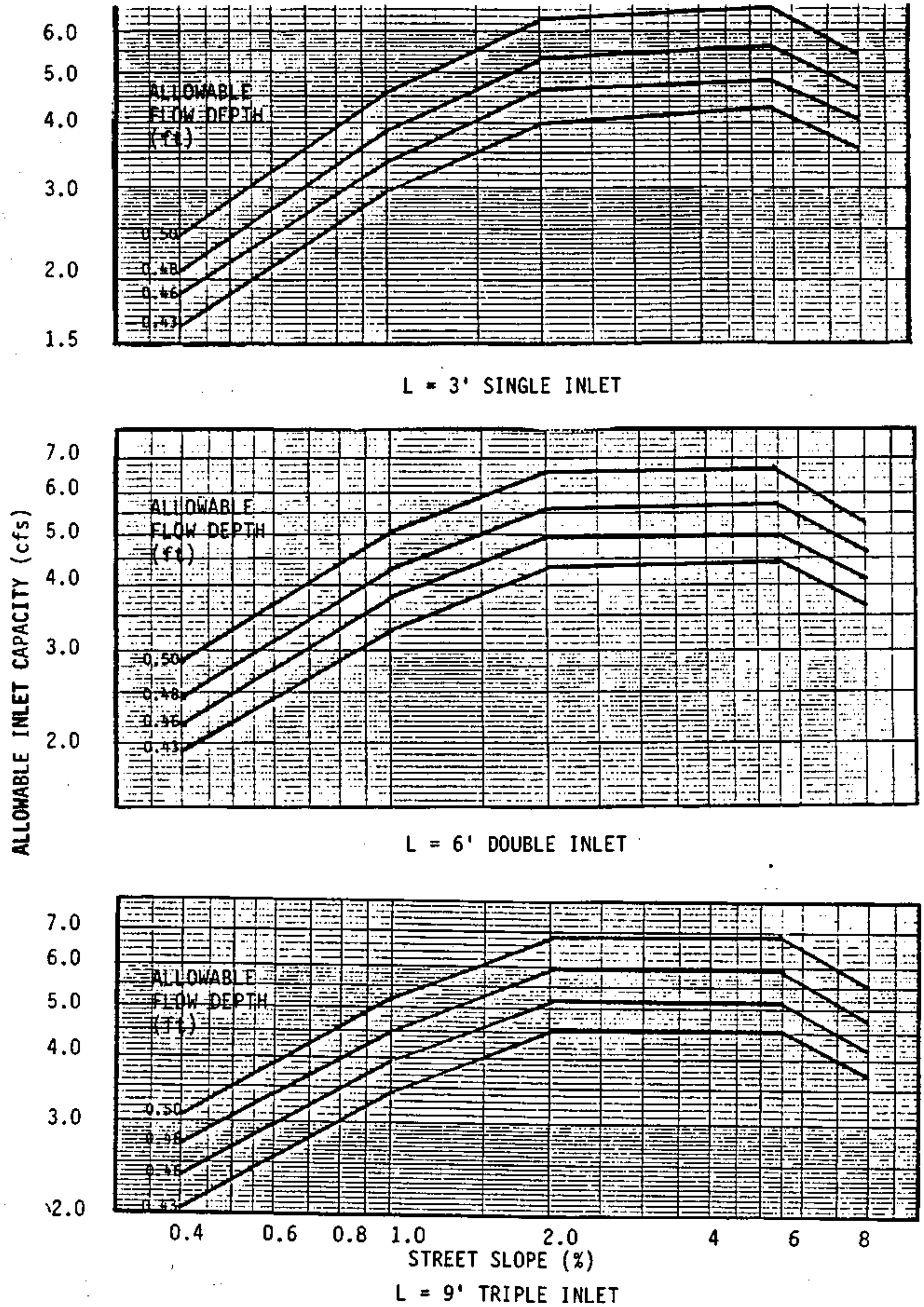


Figure 7.3 Allowable Inlet Capacity
Combination on a Continuous Grade

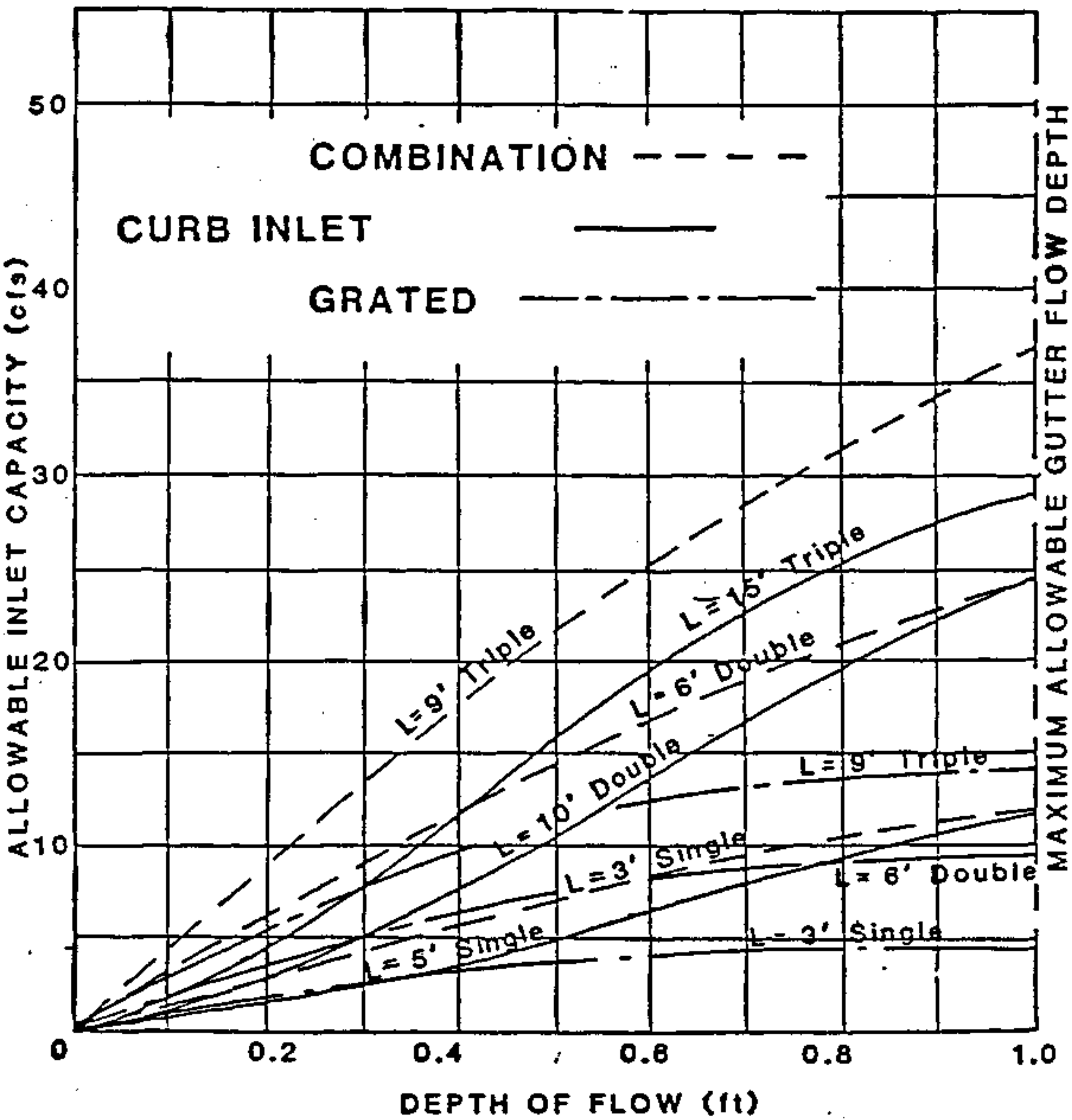


Figure 7.4 Allowable Inlet Capacity
Sump Conditions - All Inlets

8. STORAGE BASINS

When storage is proposed as an element of the overall drainage system, the storage facility shall be sized to limit downstream flows to historic levels for the 10-year and 100-year storms or to the capacity of the downstream conveyance facilities assuming full basin development, whichever is greater.

8.1 VOLUME REQUIREMENTS

The volume required for detention storage shall be developed utilizing the methodologies presented in TR-55.

8.2 BASIN DISCHARGE

Storage facilities, when proposed, shall be designed to limit the discharge from the facility during the 10-year and 100-year storms to historic levels or to a level which, when combined with fully-developed, undetained flows in the remainder of the watershed, does not exceed the capacity of the most restricted conveyance facility downstream. In no case is this discharge required to be less than the historic flow rates.

An emergency spillway, or other approved mechanism, shall be provided which is capable of conveying flows in excess of the storage capacity of the facility through the retention facility. The capacity of the overflow shall be based on the size of the retention facility and the potential downstream hazard, but shall have a minimum capacity of the peak 100-year discharge.

8.3 DESIGN CONSIDERATIONS

The design of storage facilities involves many considerations. The following list presents some additional standards which are to be imposed on the design of the facility.

Freeboard - There shall be a 1-1/2 foot freeboard from the water surface elevation of the design storage volume to the lowest building elevation.

Bottom Slope - The bottom of all basins shall be sloped toward the discharge points. The minimum bottom slope shall be 1.0 percent.

Side Slopes - Side slopes shall conform to the following:

Side slopes adjacent to public rights-of-way, or when there is pedestrian access to that portion of the basin, shall have a minimum side slope of 4:1.

Retaining walls (i.e. vertical slopes) may be used in areas adjacent to permanent walls, fences, etc., which restrict access.

Parking Lot Retention - The maximum depth of ponding in parking lots shall not exceed one foot, nor shall it exceed 0.15 feet at the midpoint of any parking space. All dedicated streets shall remain free from ponded water resulting from retention.

In addition to the design standards set forth above, aesthetic improvements are suggested. It is intended that storage basins present an aesthetically pleasing appearance. The Design Engineer should endeavor to "contour" the sides and bottom of the basin to enhance appearance through varied slopes. Curvilinear sides may be used in lieu of long stretches of straight lines. Side slopes may be varied (i.e. start with 4:1 then change to 6-7:1 or more and with appropriate use of landscaping, side slopes may even be reduced to 3:1. Bottom areas may be contoured to varying depths.

9. ADMINISTRATIVE PROCEDURES

The City of Kingman and Mohave County have established administrative procedures to direct the preparation and submission of drainage reports and improvement plans. The procedures supplement the Subdivision Application Procedure and Approval Process as stated in the subdivision regulations.

9.1 PRELIMINARY MEETING

Before preparing the preliminary plan for a subdivision, the applicant should discuss with the Planning Director the procedure for processing a subdivision plat and the requirements as to general layout of streets and for reservations of land, street improvements, drainage, sewerage, fire protection, zoning, and similar matters, as well as the availability of existing services. The Planning Director shall also advise the applicant, where appropriate, to discuss the proposed subdivision with those officials who must eventually approve the aspects of the subdivision plat coming under their jurisdiction.

9.2 PRELIMINARY DRAINAGE REPORT

A preliminary drainage report, prepared by an engineer registered to practice in the State of Arizona, covering the details of flood conditions and the specific effects of floods on the area being subdivided, shall be submitted with the preliminary plan. This report shall include a discussion of historic drainage conditions, the proposed drainage system, impacts from upstream flows on the project, and impacts of the project on downstream properties.

A Pre-Preliminary Planning meeting with the City or County Engineering Department is recommended prior to preparing the preliminary drainage report. This is to familiarize the Engineering Department with the proposed project and to facilitate discussions regarding potential drainage problems. At this meeting the ENGINEER may waive the need for a drainage report.

The preliminary drainage report shall be typed and five (5) copies shall be submitted. An outline of the preliminary report is given in Table 9.1.

9.3 FINAL DRAINAGE REPORT

A Final Drainage Report shall be submitted as part of the Final Plat package. This detailed drainage report, prepared by an engineer registered to practice in the State of Arizona, shall expand upon and modify the Preliminary Drainage Report. The contents of the Final Drainage Report shall support the designs presented in the Improvement Plans submitted as part of the Final Plat package. The Final Drainage Report shall be typed and bound and five (5) copies shall be submitted. The outline of the report is the same as for the Preliminary Drainage Report.

Table 9.1 Drainage Report Outline

1. TITLE **PAGE**
- a. Type of Report
- b. Project name
- c. Preparer name, firm, date
- d. P.E. seal of preparer
- e. Jurisdiction

2. INTRODUCTION
- a. Site location/description
- c. Project description
- d. Relevant existing flood hazard and drainage studies

3. HISTORIC DRAINAGE SYSTEM
- a. Major basin description
- b. Sub-basin and site drainage

4. PROPOSED (DEVELOPED) DRAINAGE SYSTEM
- a. Size of basin and subbasins
- b. Developed flow rates and paths (10-year and 100-Year)
- c. Storage volumes, depths, release rates and method
- d. Streets depth and velocity of flow for 10 and 100-year storms
- e. Open channels type of lining, depth and velocity
- f. Storm sewers, culverts and inlets design flows and capacities

5. CONCLUSIONS
- a. Discuss impact of development
- b. Compliance with applicable criteria
- C. Compliance with floodplain management regulation ordinance

Calculations shall be submitted as an appendix to the preliminary drainage report. The calculations need not be typed but shall be legible and orderly.

A Site Map and Drainage Plan shall be submitted together with the report with a size no larger than 24"x36". The map and plan shall include:

SITE LOCATION MAP
- a. Project name, scale, north arrow
- b. Site location
- c. Major drainage and sub-basin boundaries

SITE DRAINAGE PLAN
- a. Project name, scale, north arrow
- b. Existing and proposed contours to USGS datum
  - . 0-2% 2 foot
  - . 2-15% 5 foot
  - \ . Above 15% 10 foot
- c. Location and elevation of benchmarks
- d. Street names and grades.
- e. Existing and proposed property lines, drainage easements
- f. Existing and proposed flood plains, major channels and storm sewers
- g. Storage pond location
- h. Seal by professional engineer licensed to practice in Arizona.

9.4 **FINAL DRAINAGE PLAN** CHECKLIST

As part of the review of the submitted improvement plans, a Final Drainage Plan Checklist shall be prepared by the ENGINEER during the review of the Preliminary Drainage Report. This checklist will identify components of the drainage plan which are proposed during the planning stage and assure that they are included in the final Drainage Report and Improvement Plans. Table 9.2 presents the checklist.

Table 9.2 Final Drainage Plan Checklist

	Final Drainage Report	Improvement Plans
1. Title Page Project Name Professional Engineer Seal		
2. Site Boundary Map (Vicinity Map)		
3. Historic Drainage System Sketch		N/A
4. Proposed Drainage System Sketch		N/A
5. Detailed Drainage Plans	H/A	
6. Sub-basin area delineation		N/A
7. 10 and 100-year flow calculations		N/A
8. Storm Sewer Pipe Sizes/Capacities Culvert Sizes/Capacities Inlet Sizes/Capacities		
9. Storage (if proposed) Volume Calculations Release Rate and Method Overflow Method		
10. Unique Features Identified in Drainage Report 1. 2. 3. 4.		