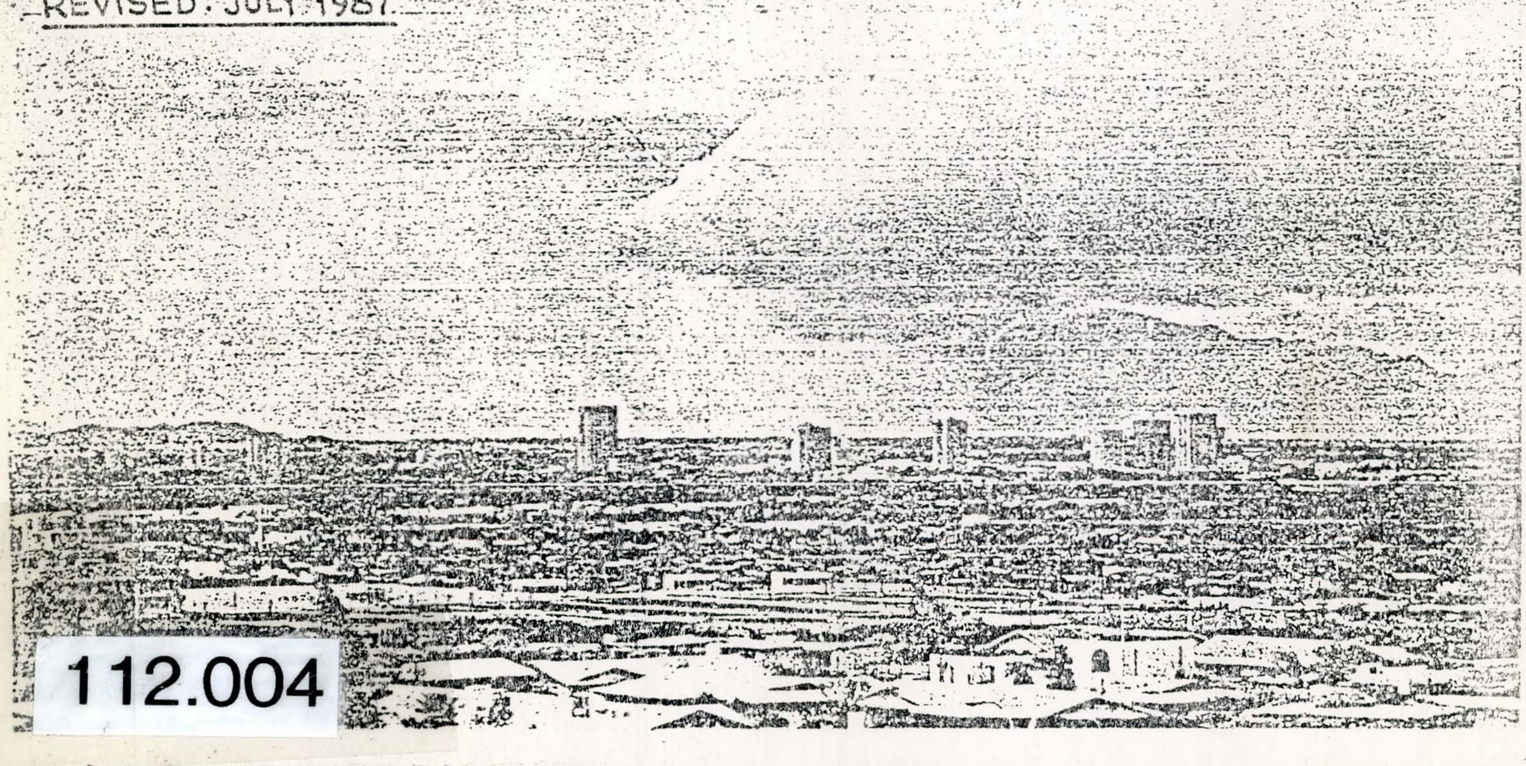
STORM DRAIN DESIGN MANUAL

Storm Drains With Paving Of Major Streets

CITY of PHOENIX

Engineering Department
James E. Attebery
City Engineer
August 1975
REVISED: JULY 1987



City of Phoenix
Engineering Department

All Major Street Paving Design
Engineering Consultants

MISCELLANEOUS INFORMATION AND
CLARIFICATIONS CONCERNING STORM
DRAIN LATERAL AND CATCH BASIN
CONNECTOR PIPE DESIGN
AND PLAN SUBMITTALS

As an interim update to the Storm Drain Design Manual for Storm Drains with Paving of Major Streets, the following information is being sent:

1. Storm Drain Design Manual Changes, dated 7/8/87.

2. Storm Drain Plans and Design Guidelines, dated 7/8/87.

3. Latest Storm Drain Check List and Information Details, dated 7/8/87.

Currently, the City is engaged in a storm drain pipe study which may change some criteria in the manual. Also, the Arizona Department of Transportation has indicated a need for other information and some design changes for Federal-aid projects which are currently not contained within the manual. When these matter are settled, the Storm Drain Manual will be formally revised in its entirety.

Very truly yours,

J. E. ATTEBERY, P.E., City Engineer

Robert J. Bortfeld

ROBERT J. BORTFELD, P.E.
Engineering Supervisor

LDE:ps/LDE04

Enclosure

125 East Washington Street, Phoenix, Arizona 85004-2342

STORM DRAIN DESIGN MANUAL CHANGES
DATED 7/8/87

Throughout the manual references are made to catch basin types which have been changed to new letter designations per the current City of Phoenix Standard Details.

These changes are:

OLD DESIGNATION	NEW DESIGNATION	COMMENTS
"D" (7') - "G" (14')	"J" - P-1566	"Apron type" - not to be used on Major Streets - OK on Residential Streets
"H" (7') - "K" (14')	"K" - P-1567	Combination Curb and Grate
"L"	"L" - P-1568	No change - curb and parkway openings
"A" - 3'6" curb opening "B" - 5'6" " " "C" - 8' " "	"M" - P-1569	Most popular use in City of Phoenix with mild slopes
"E" & "F"	"N" - P-1570	Grate only
None	"P" - P-1571	New - Double curb openings for frontage roads
None	"Q" - P-1572 uses large type 1 Detail P-1565 grate	Combination curb and grate - used when you need to clear utilities back of curb
None	"R" - P-1573	Same as "Q" except it uses a small type 2 Detail P-1565 grate

In addition to the above current standard catch basins, there are two additional Special Detail Catch Basins:

Type "M" Modified - has an offset towards the back of sidewalk in order to clear existing utilities near the curb line.

Type "R" Modified - this is a combination curb and grate opening with the basin and wings offset towards the street.

The above Special Details are available by request through the Major Streets Design Section.

Other changes are:

1. Page 2, under "Hydrology" - the pervious area (Ap) part of the modified rational formula can usually be neglected for built up residential areas on flat slopes for storms of the one and two-year recurrence intervals. When ground slopes are relatively steep (2% or greater) or for other reasons applicable, the pervious area should be taken into account and the straight C.I.A. Formula with an appropriate weighted "C" Factor should be used.

2. Page 3, under "Brief Outline for Design of Storm Drain System" - 4. Should be amended to read, "Complete design and spacing of catch basins, maintaining one dry lane, 12-foot wide in each direction" but not to exceed 660 feet (more or less) between catch basins.

3. Page 4, paragraph 10 - the storm drain lateral should be designed for the two-year storm event for its entire length not for the first 1/2 mile then only for the one-year event for the last 1/2 mile. This is mainly applicable for all laterals which have outlets into major storm drain trunk lines which have outfalls designed after 1978.

4. Page 5, under "Lateral Design Policy" - add Item 5 - minimum lateral size is 18 inches circular or equivalent.

5. Page 36, third paragraph last sentence - "Gage thickness of CMP to be used is shown in Standard Detail 215." should read, "Gage thickness of CMP to be used is shown in Standard Detail 510 (minimum gage is 14 gage).

   D-load requirements shall be determined using an earth loading of 140 pcf for major street lateral and connector pipes. (Chart attached)

   Tenth paragraph - Detail #524 replaces Detail #213 Special Detail 621 (available through Major Streets Design Section) is to be used when the outside diameter of the connecting pipe is greater than 1/2 the inside diameter of the existing main. Concrete pipe is to be rubber gasketed up to 36" diameter (changed from 48") where private irrigation crosses streets only rubber gasketed reinforced concrete pipe is to be used.

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE
POSITIVE PROJECTION CONDITION
(140 P.C.F. EARTH LOAD)

PIPE SIZE	H (COVER IN FEET) 1	1.25	1.5	1.75	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
12	-	2000	1700	1500					1200				1400	1700									
15		1750																				2750	
18	2250												1350										
21		1500																					
24							1000				1250		1500		1750		2000		2250		2500		
27	2000			1250																			
30																							
33	1750																						
36																							
39	1500	1200	1100																				
42	1400																						
45	1300	1100																					
48	1200										1100			1400		1700	1800	1900		2200	2300	2400	2500
51	1100																						
54																							
57																							
60												1200											
63	900																		2000				
66	850												1300		1500								
69				800																	2250		
72																							
75																							
78									850	950	1000			1350		1600	1750	1850		2100		2350	2450
81																							
84																							
87												1150											
90																					2200		
93																			1950				
96																							

STRUCTURAL NOTES:

1. Ku = 0.1924
2. FOR H ≦ 10, P=1.0, He/Bc = 1.7
3. FOR H > 10, P=0.5, He/Bc = 1.4
4. DEAD LOAD FACTOR = 1.9
5. SAFETY FACTOR = 1.0
6. EARTH LOADING = 140 pcf (MARSTON'S FORMULA)
7. LIVE LOADING: H-20, S-16 TRUCK, AASHO IMPACT

EXAMPLES			
CONN. PIPE SIZE	DEPTH TO TOP MIN	MAX	"D" LOAD
15"	2'	13'	1750
15"	2.1'	13.1	2000

NEW, NOVEMBER, 1982

MAJOR STREET STORM DRAIN PLANS AND DESIGN GUIDELINES

7/8/87

STORM DRAIN PIPE QUANTITIES

Do not show storm drain pipe, main or connector, on the "Roadway Summary" sheet. Do add a note to this sheet mentioning that this data may be found on the "Alternate Pipe Chart". Total lengths of pipe shown on the proposal in the specifications should be the same as totals on the Alternate Pipe Chart.

UNDERGROUND TELEPHONE FACILITIES

All the underground telephones shall be labeled according to type. In no case will the letter (T) be acceptable on the plans. If underground cable, spell out cable, if underground conduit, give all details such as number of ducts and whether or not encased in concrete. The engineer shall contact Mountain Bell if any questions arise about types or locations of underground facilities.

HYDRAULIC AND ENERGY GRADE LINE

We require a plot of the hydraulic and energy grade lines for all main line storm drain pipe designed by the engineer. The grade lines shall be submitted on a separate sheet and turned in with the design data sheet for preliminary plan review. Included with the grade lines shall be:

a) The finished street elevation over the pipe.

b) The pipe profile and size shown.

c) The Q's in the pipe.

d) The velocity in the pipe.

e) Appropriate stationing.

A sample hydraulic profile is attached as a guide.

SANITARY SEWER MANHOLES (EXISTING)

On the storm drain plan sheets, the engineer shall show the rim and invert elevations at all existing sewer manholes.

WATERLINE VALVE NUT ELEVATIONS

The engineer shall take nut elevations and all water valves on the project.

These nut elevations shall be shown on the plan view beside the water valve and called out.

STORM SEWER PLANS

The following items shall be shown in the right-hand column of the storm sewer plan sheets as pay items:

1. New Storm Sewer Pipe
2. Manholes
3. Catch Basins
4. Connector Pipe
5. Pipe Collars When 24" or Over in Diameter
6. Prefabricated Tees
7. Other Drainage Appurtenances

If the storm sewer is existing and no separate storm sewer plans are required, the above mentioned items shall be shown as pay items in the right-hand column of the paving plans.

PIPE INFORMATION

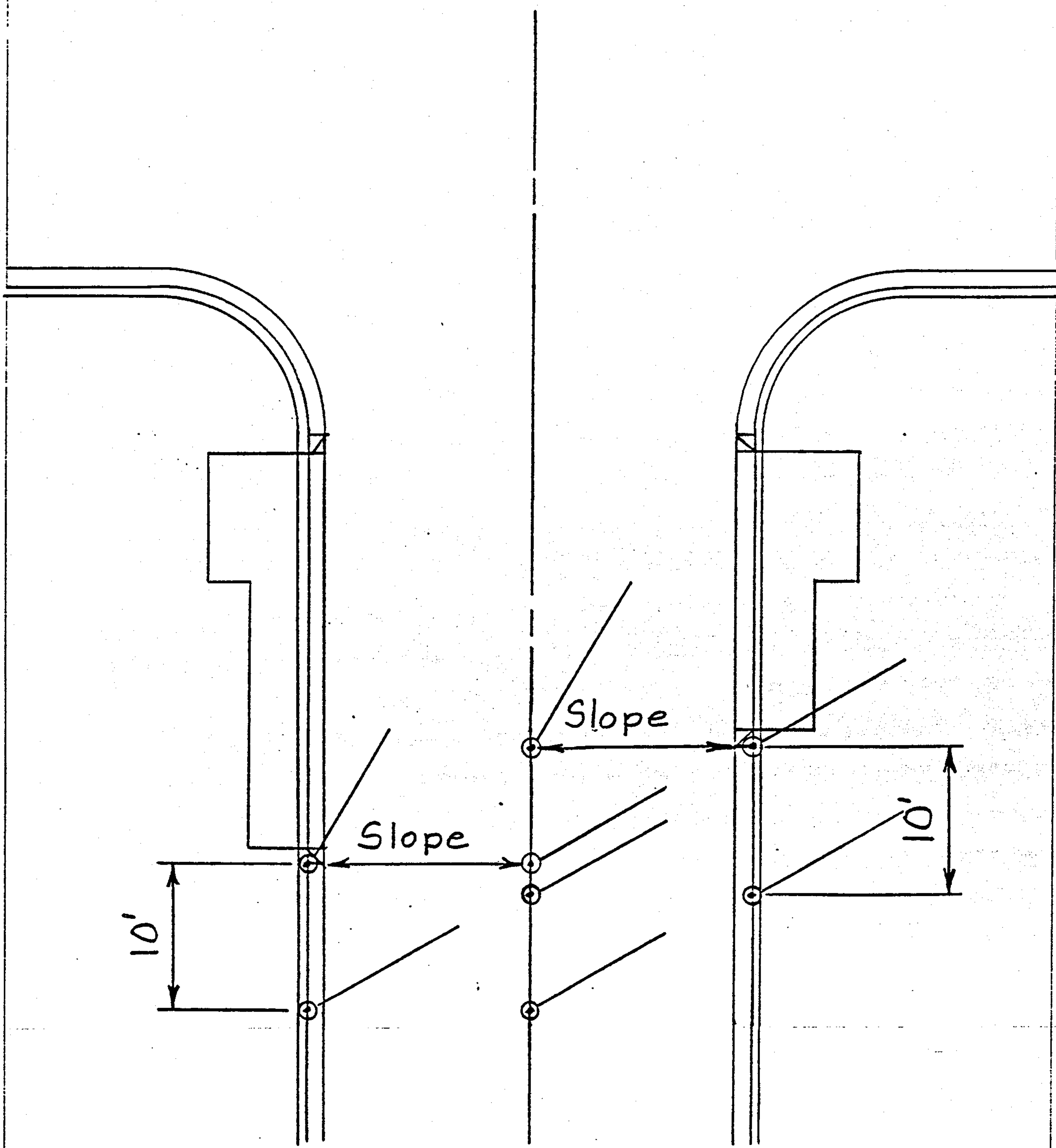
Minimum strength for non-reinforced concrete pipe is the "D" load times 1.5 times the diameter of the pipe in feet.

The minimum gauge for CMP is 14 gauge (to obtain design life requirements).

Minimum thickness, in inches, for cast-in-place concrete pipe is equal to the inside diameter of the pipe (in feet) + 1/2" with the minimum thickness being 2.5".

SIDE STREET ELEVATIONS

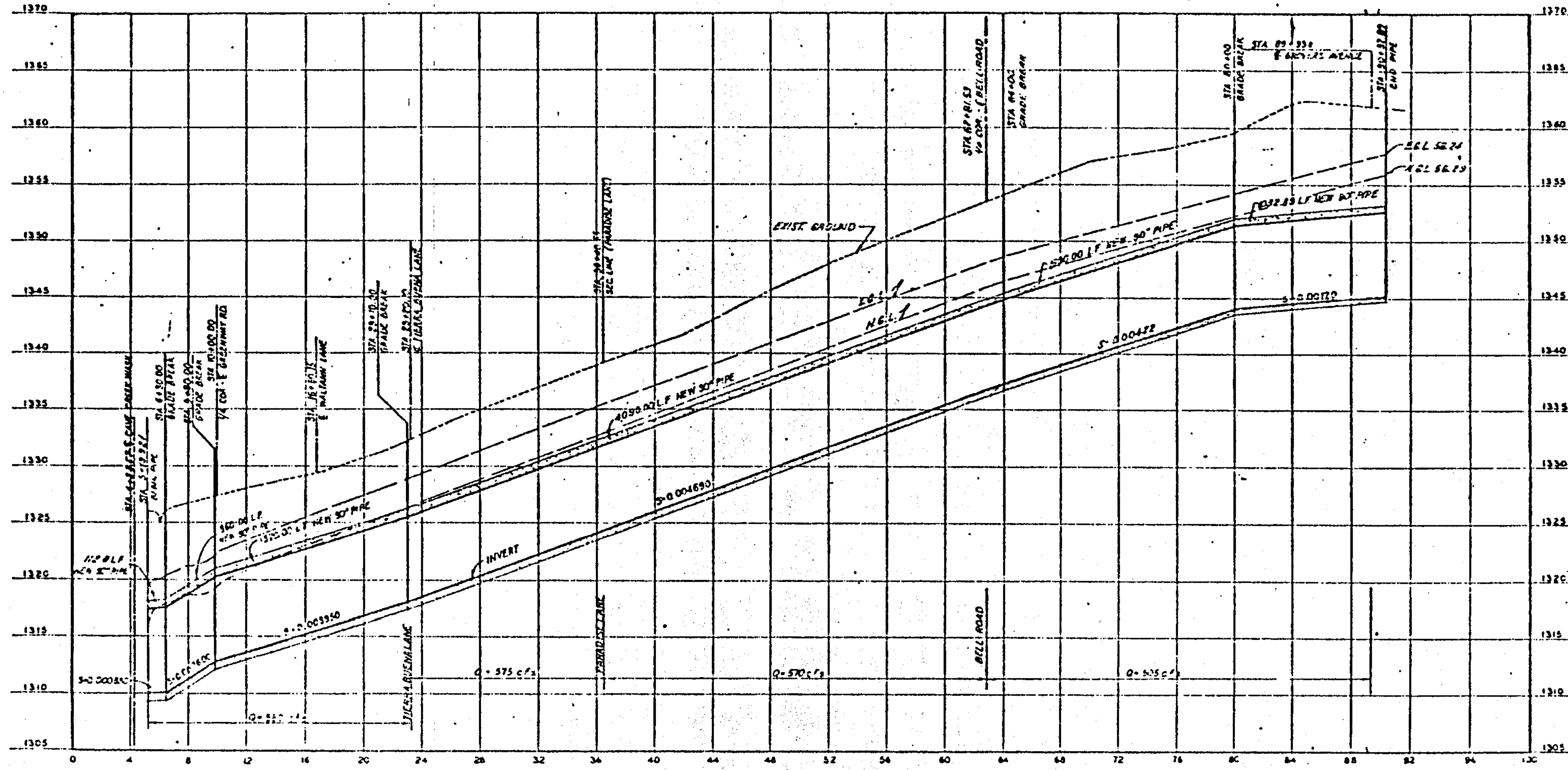
(see attachments)



ELEVATIONS NEEDED ON INTERSECTING STREETS WHICH DRAIN ONTO PROJECT

The engineer shall supply elevations at the locations represented by dots on the above sketch. This shall be done at all streets intersecting the project which drain onto the project.

(4)



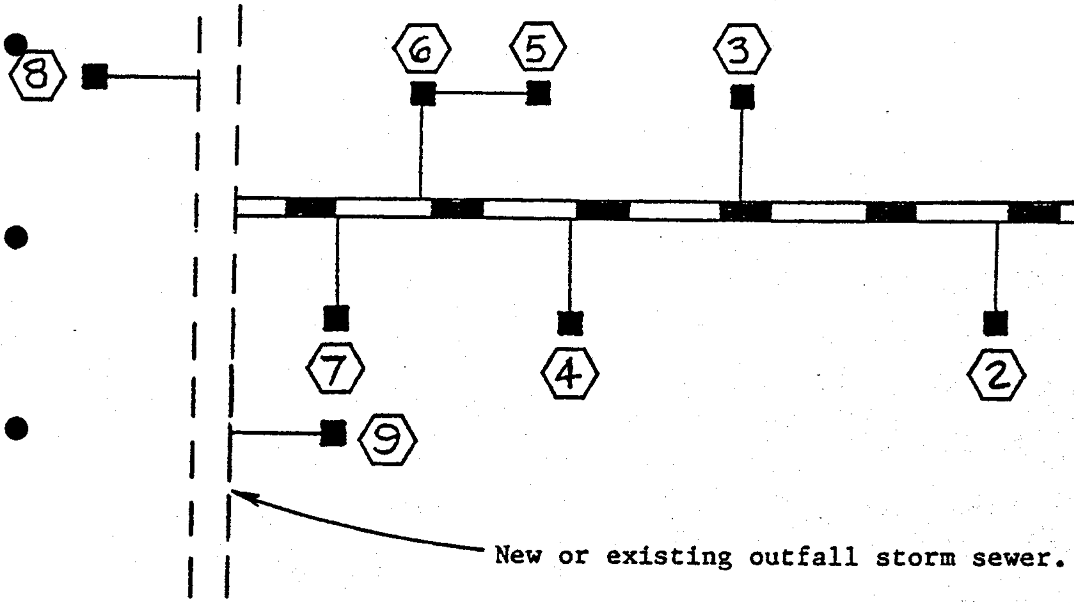
PROJECT HYDRAULIC PROFILE
(SAMPLE)

ENGINEER'S MAJOR STREET
STORM DRAIN CHECK LIST
INFORMATION DETAILS

Status		Item
______	1.	Soil borings requires at a minimum of 1320' intervals and as near to the proposed pipe centerline as possible if, trench is 10' or over in depth when street profile is finalized or as otherwise required per design contract.
______	2.	Soil boring sheet information per A.P. #13 and its addendums (include "responsibility note").
______	3.	Check for old concrete underlay.
______	4.	Check if storm drain will be too close to existing utilities or existing backfilled trenches to give proper stability. Use 45° slope between storm drain and the utility (especially waterlines).
______	5.	Are water and sewer taps shown?
______	6.	Top of S.S. manhole and invert elevations should be shown on the paving and storm drain plan sheets.
______	7.	Have all pertinent water valve nut elevations been noted? When pertinent water valves are not found or need to be uncovered, they should be so noted on the preliminary plans and a request made through Major Streets to have these located and/or uncovered.
______	8.	"Major Street Storm Drain Design Summary Sheet" submitted on a 24" x 36" print.
______	9.	Sealed Hydraulic and Energy Grade Line Profile submitted.
______	10.	All underground telephone called out on the plans as to type, number of ducts and whether or not encased in concrete. The symbol "T" alone will not be accepted.
______	11.	Telephone ducts shown per configuration and size on S.D. profiles.
______	12.	Utility "as-built" plans submitted to Major Streets with Preliminary Plans.
______	13.	Letter and location map requesting potholing of pertinent utilities (with) preliminary plans submittal.
______	14.	Check to see if upstream building's finished floor elevations are a minimum of .5' above crown. Should be plotted on paving profile sheets.
______	15.	Check for need of pipe supports on sanitary sewer crossings over storm drain mains. Specify Std. Detail 403 where needed.
______	16.	Check for potential problems with existing waterline kick blocks.
______	17.	Check main design - minimum 5' cover. Minimum velocity 5 F.P.S. Flowing Full.
______	18.	Typical Section to be shown on each profile sheet of main.
______	19.	A completed Drainage Area Map containing the following:
______		a) Done to scale (no less than 1" = 200')
______		b) Each individual area colored to delineate it from adjacent areas.
______		c) Show drainage directional arrows on all streets, parking lots, paved areas and vacant land.
______		d) Show the zoning on each parcel.
______		e) Show all catch basins (dot existing catch basins).
______		f) Each area number shall correspond to the number of catch basin to which it contributes (i.e., Area 1 contributes to Catch Basin 1, Areas 3, 3a and 3b contribute to Catch Basin 3 etc.

19. (cont'd)

_________ g) Begin the catch basin numbering system by assigning the first catch basin at the upstream end of the storm drain the number 1. Assign the next catch basin, which contributes to the storm drain, the number 2, etc. (see example below).



On the "DESIGN SUMMARY SHEET" begin at the top with catch basin No. 1.

MAJOR STREET STORM DRAIN DESIGN SUMMARY SHEET

AREA NO.	C.B. NO.	
1	1	
2	2	
3	3	
4	4	
5	5	
6	6	
7	7	
8	8	
9	9	

Catch basins 8 & 9 should be separated since they have nothing to do with the design of the lateral storm drain.

_________ h) On the Storm Drain and/or Paving Plans assign the same number to each catch basin as used on Design Summary Sheet and area map (i.e., don't number catch basins beginning with number one on each sheet) Use a hexagon symbol (⟨8⟩) to number each catch basin on both the Plans and the Drainage Area Map

______ 20. Previous Drainage Studies Checked.
______ 21. Potential ponding behind sidewalks checked.
______ 22. Alternate Pipe Chart included. Use 140 lbs/ft^3 "D" Load Chart.
______ 23. SRP design requested (copy to Major Streets).
______ 24. SRP Preliminary Plans approved.
______ 25. SRP mylars submitted.
______ 26. Submit private irrigation design and calculations.
______ 27. Check condition and amount of cover of existing SRP and RID irrigation.
______ 28. a) Check to see if private irrigation is deep enough for pipe to have minimum of 1' of cover after subgrade excavation from structural section. If not, cap the pipe.

b) Street crossings (check D-load under side street crossings), cap if necessary.

c) Use Class 2 RGNRCP behind sidewalk and use RCP of proper D-load under streets or driveways when minimum of 1.5' of cover cannot be maintained.

d) Check with SRP for amount of delivery - water master of concerned area.

e) Check that eyesores are not created and that the systems operation is as good, if not better, than original.

f) If an existing irrigation service is being deleted, a letter of authorization to delete this service must be obtained from the property owner or his agent. Check SRP records for history of deliveries to first determine if irrigation is or is not being used. Begin your investigation at the most downstream delivery point.

29. Show existing ground in connecting pipe profiles.
______ 30. Don't use M-1, L=17" catch basins (or greater) unless flows are in the magnitude of 10 C.F.S.±.
______ 31. Check side crown breakover where sump is needed - maximum 2-1/2%.
32. Set elevation at 1/4 pts. where necessary.
______ 33. Check that one 12' dry lane each way is maintained in catch basin design.
______ 34. Sufficient intersecting street elevations to determine flow velocities and street capacities.
35. Driveway/catch Basin Conflicts checked.
______ 36. Major Street Storm Drain Runoff Factors:

a) If retention (10-year or 100-year) exists on an area or a grading and drainage plan for the area has been submitted to the City for approval, no runoff will be calculated from the area.

b) If contributory land is vacant and no grading and drainage plans have been submitted to the City of Phoenix Plans Review Section for review, use a 25% impervious runoff factor for these areas.

c) When land has already been developed without on-site retention, use the runoff factors according to the existing zoning per page 20 of the Major Street Storm Drain Design Manual.

d) Zoning is assumed to extend to the monument line at the boundaries of the areas being considered.

37. Maximum spacing between catch basin = 660 feet ±.
______ 38. Reproducible S.D. Summary Sheet (updated) and Master Drainage Area Map (updated) submitted to City of Phoenix. Both are to be sealed.

Revised
7/8/87

PROJECT NAME________________________

____

INDEX NO. P-________________________

ENGINEER'S MAJOR STREET STORM DRAIN CHECK LIST

Submit copy with each Storm Drain plan submitted to Major Streets.
NOTE - Complete all items or be subject to return of plans for non-completeness.

STATUS	ITEM
1.________	Soil Boring Taken.
2.________	Soil Borings Sheet Completed.
3.________	Exist Concrete Pavement Underlay.
4.________	S.D. Conflicts with Other Utilities.
5.________	Water and Sewer Service Taps Shown.
6.________	S.S. Manhole Rim and Invert Elevations on Plans.
7.________	Top of Water Valve Nut Elevations Noted on S.D. Plan View.
8.________	Storm Drain Design Summary Sheet Completed (36"x24").
9.________	Hydraulic Energy Grade Line Profile Submitted.
10.________	Tel. Identified Properly - If Conduit, Need Number of Ducts.
11.________	Tel. Ducts Plotted in Correct Scale on All Profiles.
12.________	Utility As-Builts Submitted to *COP (with Preliminary Plans).
13.________	Pothole Request Letter to *COP (with Preliminary Plans).
14.________	Upstream Floor Elevs. Minimum of .5' Above Street Crown.
15.________	Pipe Supports for S.S. Above Main Storm Drain.
16.________	Waterline Kick Block Conflicts.
17.________	Main S.D. Minimum 5' Cover and Minimum Velocity 5 f.p.s. flowing full.
18.________	Typical X-Sections for Each S.D. Main Profile Sheet.
19.________	A completed Drainage Area Map Containing the Following:
________	a) Done to scale (no less than 1"=200').
________	b) Each area colored.
________	c) Directional drainage arrows on all streets, parking lots, paved areas, and vacant land.
________	d) Zoning shown on each parcel.
________	e) Catch basins shown (existing catch basins dotted).
________	f) Each catch basin number corresponds to the number of the area which contributes to it.
________	g) Catch basins numbered beginning with number 1 being the first catch basin contributing to the storm drain at the upstream end. The next catch basin contributing being number 2, etc.
________	h) On the Storm Drain and/or Paving Plans the same number has been assigned to each catch basin as used on Design Summary Sheet and Area Map. A hexagon symbol (⟨8⟩) has been used to number each catch basin on both the Plans and the Drainage Area Map.
20.________	Previous Drainage Studies Checked.
21.________	Potential Ponding Behind Sidewalks Checked.
22.________	Alternate Pipe Chart, Use 140 lbs/ft^3 "D" Load Chart.
23.________	**SRP Design Requested (copy to *COP). Profile Sheet.
24.________	SRP Preliminary Plans Approved (copy to *COP).
25.________	SRP Mylars Submitted.
26.________	Private Irrigation Design and Calculations Submitted.
27.________	Condition and Amount of Cover for SRP and ***RID Pipes Checked.
28.________	a) Check to see if private irrigation is deep enough for pipe to have minimum of 1' of cover after subgrade excavation from structural section. If not, cap the pipe.

_________ b) Street crossings (check D-Load under side street crossings), cap if necessary.

_________ c) Use Class 2 RGNRCP behind sidewalk and use RCP of proper D-Load under streets or driveways when minimum of 1.5' of cover cannot be maintained.

_________ d) Check with SRP for amount of delivery - water master of concerned area.

_________ e) Check that eyesores are not created and that the systems operation is as good, if not better, than original.

_________ f) If an existing irrigation service is being deleted, a letter of authorization to delete this service must be obtained from the property owner or his agent. Check SRP records for history of deliveries to first determine if irrigation is or is not being used. Begin your investigation at the most downstream delivery point.

29._________ Existing Ground Shown on All Connector Pipe Profiles.

30._________ Use M-1, L+17 or Greater Only When Flows are 10 cfs±.

31._________ Max. Side Street Crown Breakover is 2-1/2%.

32._________ 1/4 Point Elevs. Set Where Necessary.

33._________ 12' Wide Dry Lane in Each Direction.

34._________ Sufficient Intersecting Street Elevations Noted.

35._________ Driveway/Catch Basin Conflicts Checked.

36._________ Major Street Storm Drain Runoff Factors:

_________ a) If retention (10-year or 100-year) exists on an area or a grading and drainage plan for the area has been submitted to the City for approval, no runoff will be calculated from the area.

_________ b) If contributory land is vacant and no grading and drainage plans have been submitted to the City of Phoenix Plans Review Section for review, use a 25% impervious runoff factor for these areas.

_________ c) When land has already been developed without on-site retention, use the runoff factors according to the existing zoning per page 20 of the Major Street Storm Drain Design Manual.

_________ d) Zoning is assumed to extend to the monument line at the boundaries of the areas being considered.

37._________ Max. Catch Basin Spacing = 660±.

38._________ S.D. Summary Sheet Original (updated) and Master Drainage Area Map (updated) submitted. Both are to be sealed.

*COP - City of Phoenix Major Streets Attn: Project Manager
SRP - Salt River Project * - Roosevelt Irrigation District.

General

Procedures outlined in this manual are intended to provide guidance for hydrologic & hydraulic design of storm drains and inlets to be installed with the paving of Major streets in the City of Phoenix, Arizona. They are based on hydrology developed in two reports on storm drainage done by Yost and Gardner Engineers. Derivation of the hydrology is explained in detail in the 1956 report on storm drainage for the City of Phoenix and referred to in the 1970 report on storm drainage for the Maricopa Association of Governments.

INDEX SHEET

A — Area - acre
Ai — Impervious area - acre
Ap — Pervious area - acre
a_1 — Cross sectional area of C.B. connector pipe - sq. ft.
c — Co efficient of discharge for submerged orfices
C — Constant in runoff formula
C.B. — Catch Basin
d — Diam. of connector pipe see fig.13 on page 33 - ft. or in.
d_1 — Diam. of connector pipe between 1st and 2nd C.B. see fig.13 on page 33 - ft. or in.
d_2 — Diam. of connector pipe for 2nd C.B. see fig.13 on page 33 - ft. or in.
fc — Infiltration rate - In./Hour
G — Fall (between inlets or 2 points) - ft.
H — Head loss — $\frac{Q^2}{2ga^2c^2}$ - ft.
h — Height of C.B. inlet opening (Type A.B.C.D. & E.) - In. or Ft.
I — Intensity of rainfall - In./hour
L — Length of C.B. inlet opening - ft.
n — Manning's roughness co-efficient
Q — Quantity of flow - cu. ft./sec.
S — Slope (longitudinal slope of the street) - ft./1,000 ft.
S_C — Cross slope of street - ft./1,000 ft.
tc — Time of concentration - min.
v_1 or v_2 — Velocity of flow in the connecter pipe
V_1 — Depth of 1st inlet see Fig. 13 on page 33 - ft.
V_2 — Depth of 2nd inlet see Fig. 13 on page 33 - ft.
v — Velocity - ft./sec.
W — Spread - ft.
yg — Depth of water in gutter at upstream side of C.B. - ft.
Z — $1/S_C$

CITY OF PHOENIX DESIGN POLICIES

The policies are general in nature and applicable to areas where no recognizable natural water courses exist, urbanization is probable and the general slope of the terrain is less than 2%. For areas that will not be developed and are steeper than 2%, use Soil Conservation Service method for determining runoff.

Main Spacing

1. Generally, at one mile intervals on section lines north and south, designed for run off from 1-year storm - 1 mile wide. Future mains at 1/2 mile intervals north and south, designed for 2-year storm 1/2 mile wide.

Lateral Spacing

1. Generally, at one-mile intervals on section line streets aligned east and west sized for runoff from the two-year storm. ~~for upstream half mile and balance of storm drain designed for runoff from whole mile for one-year storm.~~
2. Laterals to be added at 1/2 mile intervals in the future, sized for two-year storm.

Hydrology

1. The runoff formula as developed in the Phoenix Storm Drain Report of 1956, shall be the basis for design for storm drain trunks and laterals. This formula is:
   $Q = 0.8 (I - fc) Ap + 0.9 (I - 0.2) Ai$, Where:
   Q = Discharge in cubic feet per second
   I = Intensity of rainfall for the appropriate time of concentration and frequency. From the chart on page 24, if the outfall design basis was TP #40, if TP #25 was used, the graph on page 23 is to be used.
   fc = Infiltration rate in inches per hour. (From the map on page 22)
   Ap = Pervious area in acres
   Ai = Impervious area in acres
2. Intensities of rainfall shall be from the rainfall curve on page 23 or page 24.
3. Time of Concentration
   (a.) Time of concentration from impervious areas should be computed using average gutter velocities from the graph on page 26 and average pipe velocities from the graph on page 25.
   (b.) An investigation of the gutter velocity chart reveals velocity is relatively insensative to variations in Q and cross-slope, **The chart on page 26 may be entered with a Q of 3 cfs** and the average longitudinal slope of the area. The velocity obtained by this procedure may be used for the average velocity in computing times of concentration.
   (c.) Time of concentration for runoff from commercial areas shall be computed summing flow times over asphalt, in the gutter, and in the pipe.
   (d.) For purposes of lateral sizing, time of concentration is computed at the upstream termination of the lateral and pipe flow time is added at each inlet downstream. If the maximum runoff to any individual catch basin is greater than the accumulated runoff to that point using the accumulated time of concentration, the Q for the catch basin shall be used to size the main at that point.

Drainage Areas

4. Drainage Areas
   (a.) Laterals and inlets are sized for runoff from impervious areas and pervious areas except as noted hereinafter.

(b.) Percentages of total areas that are impervious will be computed using existing zoning and the table giving % impervious on page 20.

(c.) In irrigated areas it is reasonable to assume no runoff from the irrigated sump or from any pervious or imprevious area draining into the irrigated sump for storms of the one or two-year magnitude.

(d.) In single family residential areas, impervious areas that drain to pervious areas (rooftops, etc.) are not considered in determining peak runoff for sizing storm drain laterals of inlets.

(e.) The above exceptions are accounted for in arriving at the % impervious table on page 20.

(f.) No runoff is assumed from lawns that are relatively flat and grassy when one and two year design storms are used.

5. Rainfall Intensities

(a.) Intensities for the design of laterals whose outfall is a trunkline designed in accordance with rainfall intensities from the rainfall curve based on Weather Bureau Technical Paper #25 shall be from the curve reproduced on page 23.

(b.) Intensities for the design of laterals whose outfall is a trunkline designed in accordance with rainfall curves based on Weather Bureau Technical Paper #40 shall be from the curve on page 24.

Street Design Policies

1. In no instance shall the elevation of the crown of the street exceed an elevation of 0.5' below the floor elevation of buildings on the upstream side of the street.
2. Laterals shall extend to the point at which one 12' wide traffic lane in each direction remains above water for the 2-year storm.
3. Future developments shall not be allowed to introduce runoff into arterial streets in excess of street capacity as defined by the one lane in each direction above water criteria.
4. Streets shall be designed so as not to disturb natural drainage patterns for flows in excess of street plus storm drain capacity to top of curb.
5. Care shall be taken to ensure that street design does not increase runoff onto private property.
6. Spread into the street shall be computed by dividing depth of flow in the gutter by street cross-slope.

Brief Outline for Design of Storm Drain System (Federal-Aid Street)

1. Obtain aerial contours and/or street as-builts to determine pattern of runoff and limits of drainage areas.
2. Obtain zoning map of area to provide basis for using runoff factors.
3. Start at upper end of project and size areas for Q's contributary to catch basins that are compatible with the most economical location of catch basins.
   Data necessary to determine capacity of catch basins at any given location is as follows:
   (a) Cross slope of street at catch basin location
   (b) Average longitudinal slope of street
   (c) Sump or flow-by situation
   (d) Time of concentration contributary to each catch basin (average slope and distance)
   Adjust size of contributary area to catch basin to obtain a Q of run-off and flow-by from catch basin upstream that is compatible with a Q from attached charts for capacity of streets and catch basins, if catch basin location is not fixed by other considerations. Design catch basin for 2-year storm.
4. Complete design and spacing of catch basins, maintaining one dry lane, 12' wide, in each direction.
5. Use areas from catch basin design to size main storm drain preliminarily. Use runoff formula $Q = .9\ (I - .2'')\ Ai + .8\ (I - fc)\ Ap$. The pervious portion of formula can be ignored if pervious areas are irrigated or are relatively flat lawns. Use new time of concentration for storm

drain. Set preliminary grade at average slope of ground. If a north-south main is being designed, depths must be maintained to accommodate future laterals at their respective pickup points. Maintain minimum silt carrying velocity of 5 f.p.s. if possible. Generally, maintain minimum cover on storm drain sufficient to allow sewer taps to pass over storm drain.

6. Investigate underground utility conflicts using as-builts and exposing of utilities, if necessary, to set final grade for main storm drain.
7. Determine hydraulic grade line of main storm drain.
8. Determine head for each connecting pipe. Head = vertical distance from .5' below lip of gutter to hydraulic grade line of main storm drain. Size connecting pipe using chart from this Manual. Minimum sized connecting pipe to be 15" diameter for cleaning purposes.
9. Determine depth of catch basin using chart or formula from this Manual.
10. A complete storm drain system with storm drains on the section lines north and south and and laterals on section lines east and west is the primary goal. The ultimate system will have storm drains on the half section lines north and south and on half section lines east and west also, and will be designed to handle a two-year storm event. The initial storm drain lateral will be designed for the two-year storm for the upstream half mile and then the remaining half mile is designed for the one-year storm using areas from the total mile reach. This design is then checked to see that the downstream half mile will accommodate the two-year storm event for the downstream half mile contributary area when the half mile north-south mains are installed at some future date. The largest sized pipe required by either design at any location is the size used in the final design for that location. These general directions apply except where modified by special studies.

Inlet Design

1. Considerations for inlet design and spacing are the draining of intersections, low points and areas where spread into the roadway is such that one lane of traffic in each direction would not remain above water.
2. Inlets are spaced using the modified rational formula $Q = .9\,(I - .2'')\,A_i + .8\,(I - fc)\,Ap$, and the intensities for a two-year storm, to conform with the ultimate plan.
3. Inlet capacities are computed using the graphs on pages 28, 29, and 30 of this manual, or using equations developed by the Bureau of Public Roads.

   For curb opening inlets, the theoretical length needed to capture all the gutter flow is determined from the formula. $\frac{Q_a}{L_a} = 0.7\,(a+Y)^{3/2}\left[1-\left(1-\frac{Y}{a+Y}\right)^{3/2}\right]$ or on the graph shown on page 28 at 12a.

   The interception capacity of a given length of curb opening is then determined by the formula:

   $\frac{Q}{Q_a} = \frac{\left(\frac{a}{Y}+1\right)^{3/2} - \left(\frac{a}{Y}+1-\frac{L}{L_a}\right)^{3/2}}{\left(\frac{a}{Y}+1\right)^{3/2} - \left(\frac{a}{Y}\right)^{3/2}}$ or from the graph shown on page 28 as "12b".

   Definitions of terms are as follows:

   La = Required length of curb opening to intercept entire flow
   a = Depth of catch basin depression in feet
   y = Depth of flow in approach gutter in feet
   L = Length of clear curb opening in feet
   Qa = Discharge in approach gutter in cubic feet per second
   Q = Discharge intercepted by catch basin in cubic feet per second

   Depth of flow in the gutter is determined by using the nomograph developed by the Bureau of Public Roads and reproduced on page 27.
5. The graph on page 30 may be used for the capacity of grated inlets in sumps. For grated inlets on a continuous grade the rationale is as follows:

A grated inlet placed in a sloping gutter will provide optimum interception of flow if the bars are placed parallel to the direction of flow, if the openings total at least 50 percent of the width of the grate (i.e. normal to the direction of flow), and if the unobstructed opening is long enough (parallel to the direction of flow) that the water falling through will clear the downstream end of the opening.

The minimum length of clear opening required depends on the depth and velocity of flow in the approach gutter and the thickness of the grate at the end of the slot. This minimum length may be estimated by the partly emperical formula.

$$L = \frac{v}{2}\sqrt{y + d}$$

where L = minimum length of slot in feet

v = average velocity of flow in the approach gutter in feet per second
y = depth of water at curb in approach gutter in feet
d = thickness of grate at downstream end of slot in feet

A rectangular grated inlet in a gutter on a continuous grade can be expected to intercept all the water flowing in that part of the gutter cross section that is occupied by the grating, plus an amount that will flow in along the exposed sides. However, unless the grate is over 3 feet long or is greatly depressed (but extreme warping of the pavement is seldom permissible), any water flowing outside the grate width can be considered to bypass the inlet. The quantity of flow in the prism intercepted by such a grate can be computed by using the graph on sheet 27 and the design chart 12b on page 28 to determine interception rates.

6. Manning's "n" for street flow is .015.
7. A summary of inlet design calculations should be submitted in the format shown on page 39.
8. If there is flow-by, past an inlet, this Q is to be added to the design Q for the next inlet downstream without adjustment to tc.
9. Many variables effect catch basin depths (utilities, placement of the main line, etc.). Minimum depth of catch basins will be calculated using the method shown on pages 31 to 34.
10. The diameter of catch basin connector pipe and pipe connecting catch basins in series will be computed using the LACFCD procedure shown on page 31 to 34. Minimum diameter in all cases shall be 15 inches.

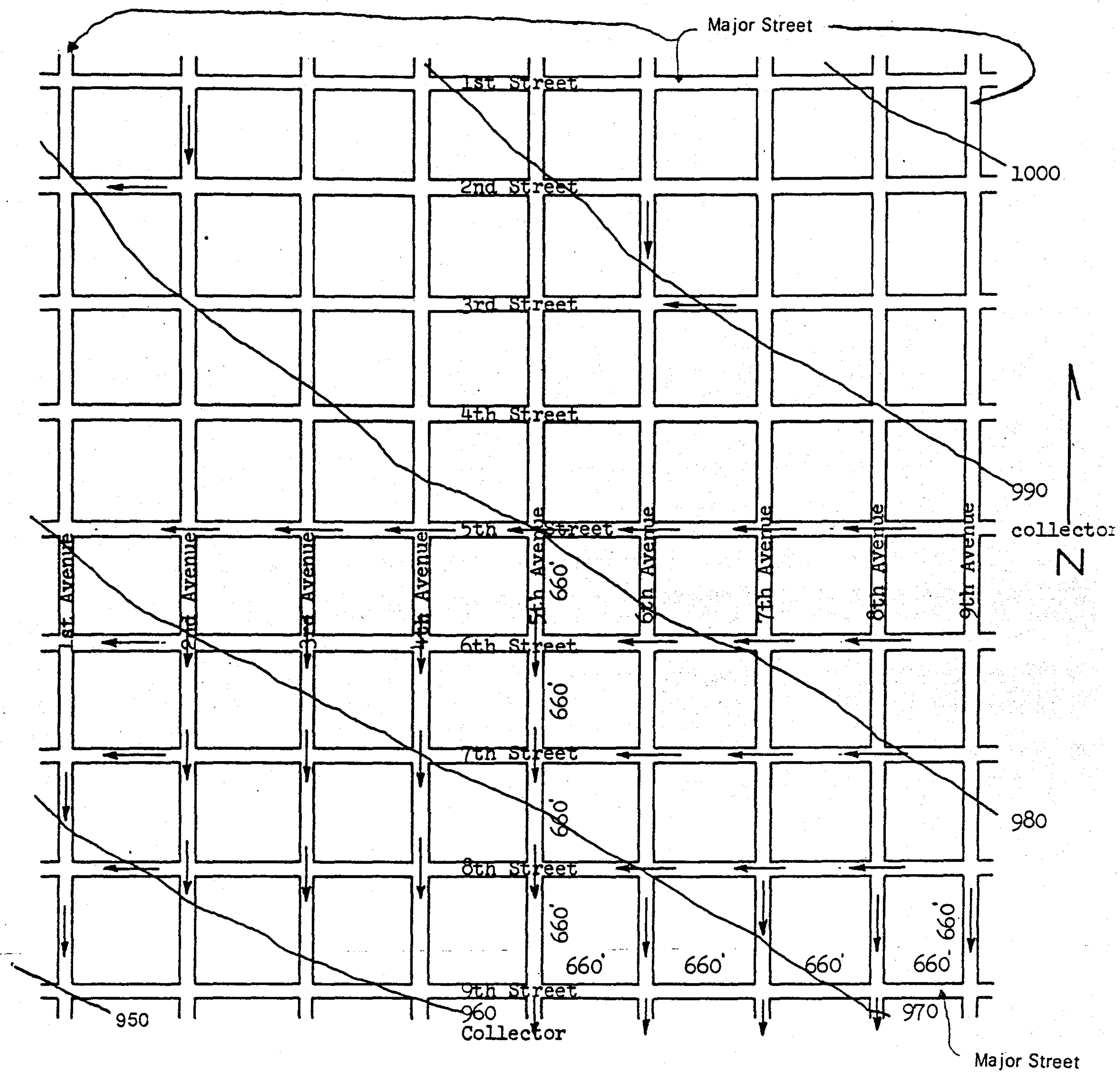
Lateral Design Policy

1. Minimum design velocity is 5 fps - small variations from this velocity are to be expected
2. The hydraulic grade line for the storm drains shall remain within the pipe except for local variations.
3. Pipe capacities shall be determined using the graph on page 25.
4. Manholes shall be spaced as follows:
   For pipe diameters of 30" or less every 330 feet
   For pipe diameters of 33" to 45" every 440 feet
   For pipe diameters of 48" and greater every 660 feet

Items Required for Submittal of Storm Drain Design for Major Street Project

(Federal-Aid Street) **(In duplicate)**

1. Discussion of storm drain design for the project.
2. Contours of area and/or street flow pattern.
3. Map showing drainage areas contributing to catch basins.
4. Zoning map of area of project used in determining impervious areas.
5. Tabulated design data for storm drain system.
6. One set of prints of plans of subject project for storm drain review.



PROBLEM: Design the lateral for 9th Street.

DESIGN DATA: Zoning R1-6, non-irrigated, trunklines in 1st and 9th Avenue, long-range plans for a lateral in 5th Street and a trunk in 5th Avenue, a commercial strip 220' wide along 9th Street, 1st Ave, and 9th Ave. Assume 1st Ave. has an existing main designed with intensities from page 23.

Figure 1

Initial Layout For Storm Drain Lateral In 9th Street

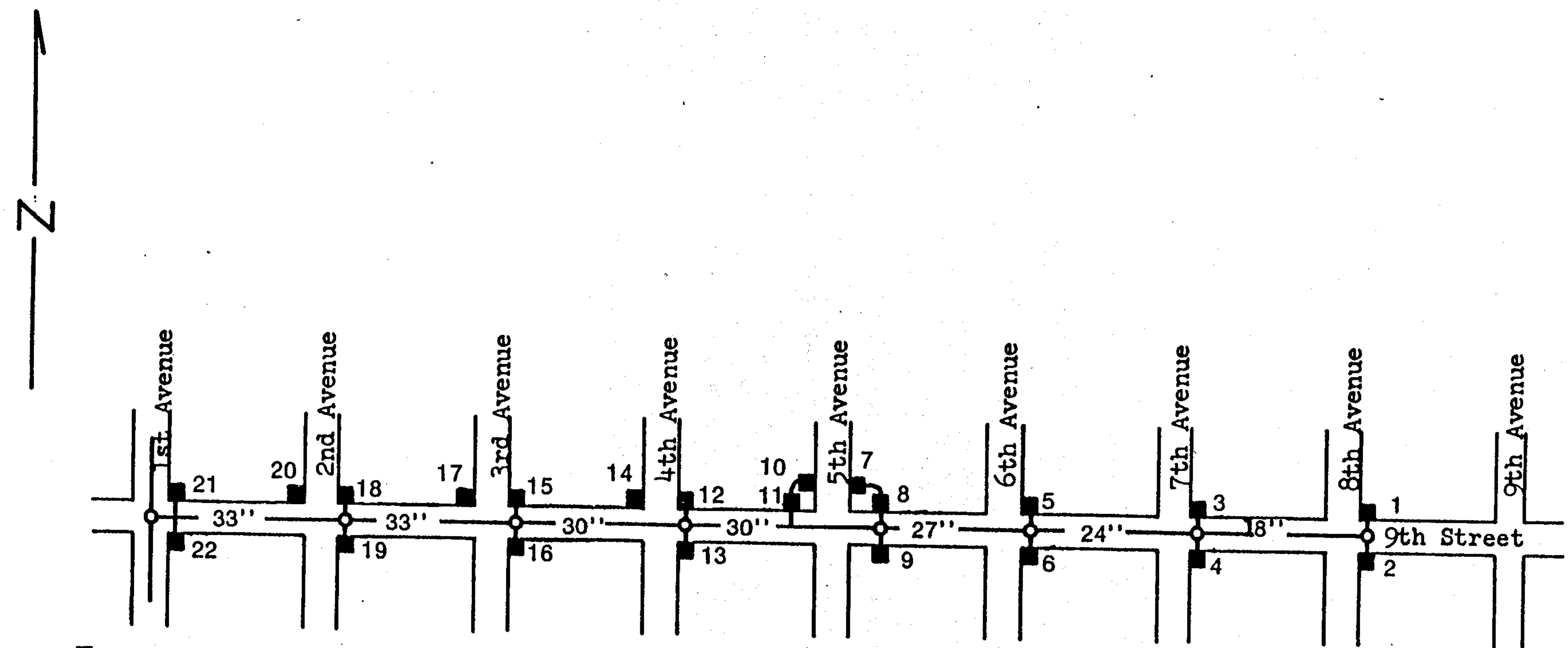


Figure 2

The first step in the solution of this problem is to determine the point where surface drainage is no longer acceptable. Valley gutters on minor streets intersecting major streets are not desirableand will not be used for collector-major, and major-major intersections. Surface drainage is allowable until spread in the roadway becomes such that one lane in each direction is not above the water's surface, or until a sump situation is encountered. Valley gutters across major streets are unacceptable.

For this example, valley gutters will be assumed unacceptable and the lateral will extend from 1st Avenue to 8th Avenue.

Now compute times of concentration and drainage areas for each inlet.

Average slope of the drainage area = 53/2 (5280) = 0.0050, N – S slope = .005, E – W slope = .005

Entering the Chart on page 26 Gutter velocity (v) is read as follows:
A Q = 3 cfs, v = 2.3 fps.

The minimum tc used would be 10 minutes, in ten minutes the distance traveled by a water particle = 10 (2.3) (60) = 1380'. The entire area contributes to inlet #1 @ tc = 10 min.

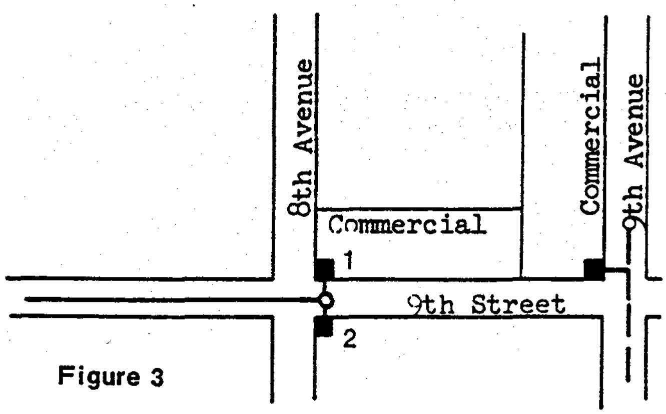


Figure 3

The Commercial strip along 9th Avenue drains to the 9th Avenue storm drain

In sizing laterals times of concentration are quite short and only the impervious area need be considered as contributing.

At 8th Avenue Inlets #1 & #2

Area contributing to inlet #1 & #2 (Zoning is assumed to extend to monument line at boundaries of area being considered).

Ai = (.85) comm. strip 440 (220) /43560 + 440 (440) (0.25) table on p. 20 /43560 = 1.9 + 1.1 = 3.0

First half mile of lateral will be designed for 2-year storm intensities from page 24, as future 5th Avenue storm drain will be designed using these intensities.

I = 2.7 from page 24
Q = .9 (I - .2) Ai
Q = 0.9 (3.0) (2.7 - 0.2) = 6.75 c.f.s.

So total Q at 8th Avenue inlets = 6.75 c.f.s.

Assume the inlets pick up all the Q and size the pipe
Try pipe slope = 0.005

From the chart on page 25 to achieve a velocity of 5 fps use 18" pipe (18" min. size main) now investigate the corner at 7th Avenue.
Flow time in pipe = 660/5(60) = 2.2 minutes
So tc at 7th Avenue = 10 + 2.2 = 12.2 minutes

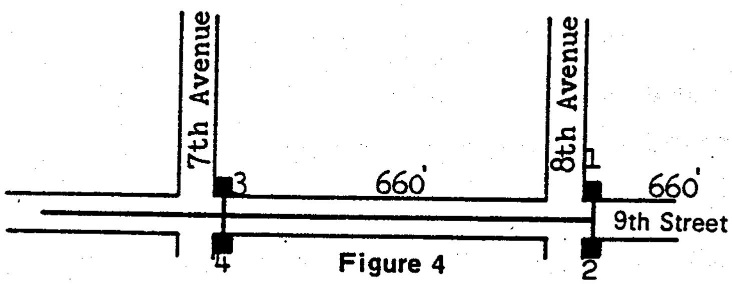


Figure 4

At inlets #3 and #4, Ai = 3.0 + 2.8 + 1.67 = 7.5 acres
Then for tc = 12.2, I = 2.5
Q = .9 (I - .2) Ai
Then 7.5 (2.5 - .2) = 16.6 cfs
Total Q at 7th Avenue inlets = 16.6 cfs
Enter the chart on page 25 with slope = 0.005 & v = 5 fps
Use a 24" pipe
At 6th Avenue the process is repreated for inlets #5 & #6
Pipe flow time = 2.2 min. from 7th Avenue to 6th Avenue so tc = 14.4 min.
from chart on page 24 find I = 2.3 in./hr.

Area at inlets #5 and #6, Ai = 2(4.5) + 3.0 = 12 acres
Q = 0.9(2.3 - .2) (12) = 23.6 cfs

So total Q to 6th Avenue inlets = 23.6 cfs
Enter chart on page 25 with S = .005, v = 5.0 fps use a 27" pipe

At inlets #8 and #9, Ai = 3(4.5) + 3 = 16.5 acres
Pipe flow time = 2.2 min. from 6th Avenue to 5th Avenue

So tc = 16.6 min. I = 2.1 in./hr.

Q = .9 (I - .2) Ai

So Q = .9(2.1 - .2) 16.5 = 28.2 cfs

Enter chart on page 25 with slope = 0.005 & v = 6 fps
Use a 30" pipe up to inlets 8 and 9.

From this point on the lateral will be sized using a one-year design storm using total accumulated impervious area and intensities from page 23. After this is done the last half mile will be checked to be sure that the designed size will accommodate a 2-year storm for the last half mile wide area only.

Assume gutter velocity = 2.3 fps

Max distance a water particle must travel to arrive at inlet #7 is 5280, (see initial layout page 7).

tc = 5280/2.3 (60) = 38.3 minutes
Ai total = 16.5 + 0.25 (110) = 44.0 acres
From chart on page 23 for tc = 38 min. I = 0.76 in./hr.
Q = 0.9 (I - .2) Ai = 0.9(.76 - .2)48.5 = 24.4 cfs

So size for lateral at inlet #7 is 30" since 24.4 cfs less than 28.2 cfs from above.
Pipe flow time of 4th Avenue = 660/6(60) = 1.83 min.
So use 40 minutes for the tc at 4th Avenue

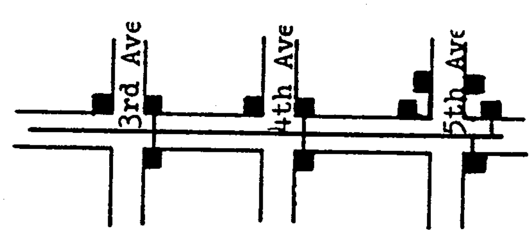


Figure 5

Area contributing at inlets #12 and #13

Ai 44 + (3.3 x .85) + (40 - 3.3) .25 = 44 + 2.8 + 9.2 = 56 acres
I = .71
At inlet = 12 Q = .9(.71 - .2) 56 = 25.7 cfs
25.7 is less than 28.2 Use 30'' pipe

At Third Avenue inlets #15 and #16
Ai = 56 (from #12 and #13) + (36.66 x .25) +(3.33 x .85) = 68 acres
Flow time is 1.83 minutes so tc at inlets #15 and #16 is 41.8 min.
I = 0.69
Q total = .9(I - .2)Ai = .9(.69-.2) 68 = 30 cfs
Pipe Size (from chart on page 31 S = .005) = 30''

At 2nd Avenue inlets #18 and #19

Flow time at 6 fps = 1.83 so tc = 43.6 minutes

Ai = 68 + 9.2 + 2.8 = 80 acres

I from chart = .67

Q = .9(I - .2) Ai = .9(.67 - .2) 80 = 34 cfs

Pipe size (from chart page 25 S = .005) = 33''

At 1st Avenue inlets #21 and #22

As there is a trunk storm drain (with inlets at every intersection from 5th St. to 9th St.) in 1st Avenue, drainage that would have eventually found its way to inlets #21 and #22 is intercepted by the main line.

Ai at inlets #21 and #22 = 80 + 3.33(.85) + 6,66(.25) = 85 acres

Flow time = 1.83 minutes so tc = 45.4 min.

I = .66 in./hr.

Q = .9(I - .2) Ai = .9(.66 - .2)85 = 35 cfs

Pipe size = 33''

The foregoing computations are listed on the Cal. Sheet on page 39

INLET AND CONNECTOR DESIGN

The next step in lateral design is to space and size inlets, keeping in mind the following criteria:

Criteria

1. Governing considerations shall be the draining of intersections and low points.
2. In some instances, long blocks on a continuous grade may be encountered and spread into the roadway may become a problem. Spread for the two-year storm shall not exceed the point at which one lane in each direction remains above the gutter flow.
3. Inlets in sumps are generally much more efficient and economically justifiable than inlets on a continuous grade, so the street designer should strive to adjust grades, when practical, to provide sumps for inlets. A sump is created at each intersection of a side street with a major street where the crown of the side street is extended at least to the quarter point of of the major street. This provides an efficient pick up point. However, on the downstream side of the side street, incoming storm drainage will tend to flow on down the major street and by pass a catch basin. (See Fig. 6) Therefore, where conditions permit, the side street may be depressed for a short distance upstream from the curb return to provide a second efficient pick up point, if the side street is bringing in a large volume of runoff.

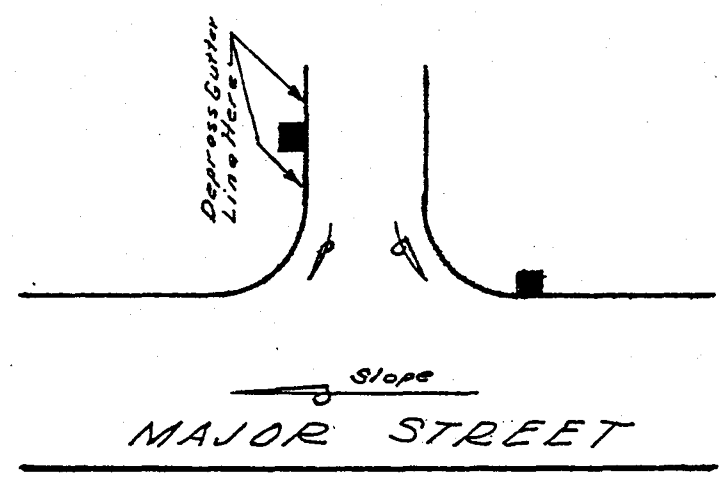


Figure 6

Other alternatives are a Type G or multiple catch basins to intercept the excessive runoff. The most economical alternative shall be used.

4. Computed Inlet Capacities shall be reduced as follows to allow for clogging and future pavement overlays:

Grates

1. Sump Conditions: ([illegible] per chart on page 30)
   a. Orifice Flow Actual Area = 2.0 x required area (orifice flow,.8' depth and over)
   b. Weir Flow : Actual Perimeter = 2.0 x required perimeter
2. Continuous grade conditions:
   a. Actual width of opening perpindicular to flow = 2.0 x required width or greater

Curb Opening Inlets

1. Sump Conditions or Continuous grade
   a. Actual length of opening = 1.2X x required length or greater

Combination Grate and Curb Opening: (Where length of curb opening = Length of grate)

1. Sump Conditions and Continuous Grade Conditions
   a. 1.0 x capacity of grate only

City of Phoenix Type D

1. 1.0 x capacity of grate + (.8) capacity of curb opening upstream from grate

HYDROLOGY FOR INLET SPACING

Proceeding with the inlet spacing design for our example problem:
First an initial layout for the system is required: From inspection of the drainage pattern for the example problem note the following:

1. Relatively little area contributers runoff to inlets on 6th, 7th, and 8th Avenues. Experience would indicate that type ''C'' & ''B'' inlets on the northeast and southeast corner respectively of each intersection would be adequate so this will be the initial assumption for these streets. Note: The inlets on the southeast corners are difficult to justify economically, however, the legal implications of increasing the runoff, to the south are such that it is prudent to place inlets on these corners.

2. At 5th Avenue, a considerable area is drained so an inlet pattern as shown below will probable be required.

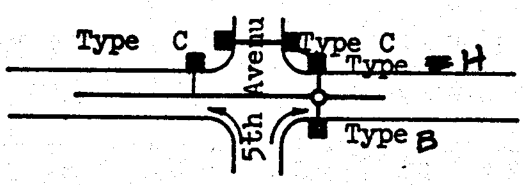


Figure 7

Note: If possible, street grades should be adjusted so the major street does not drain to a residential street.

3. For 2nd 3rd and 4th Avenues, an initial layout as shown below will probably be required.

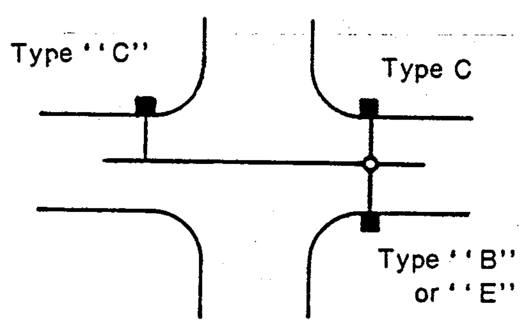
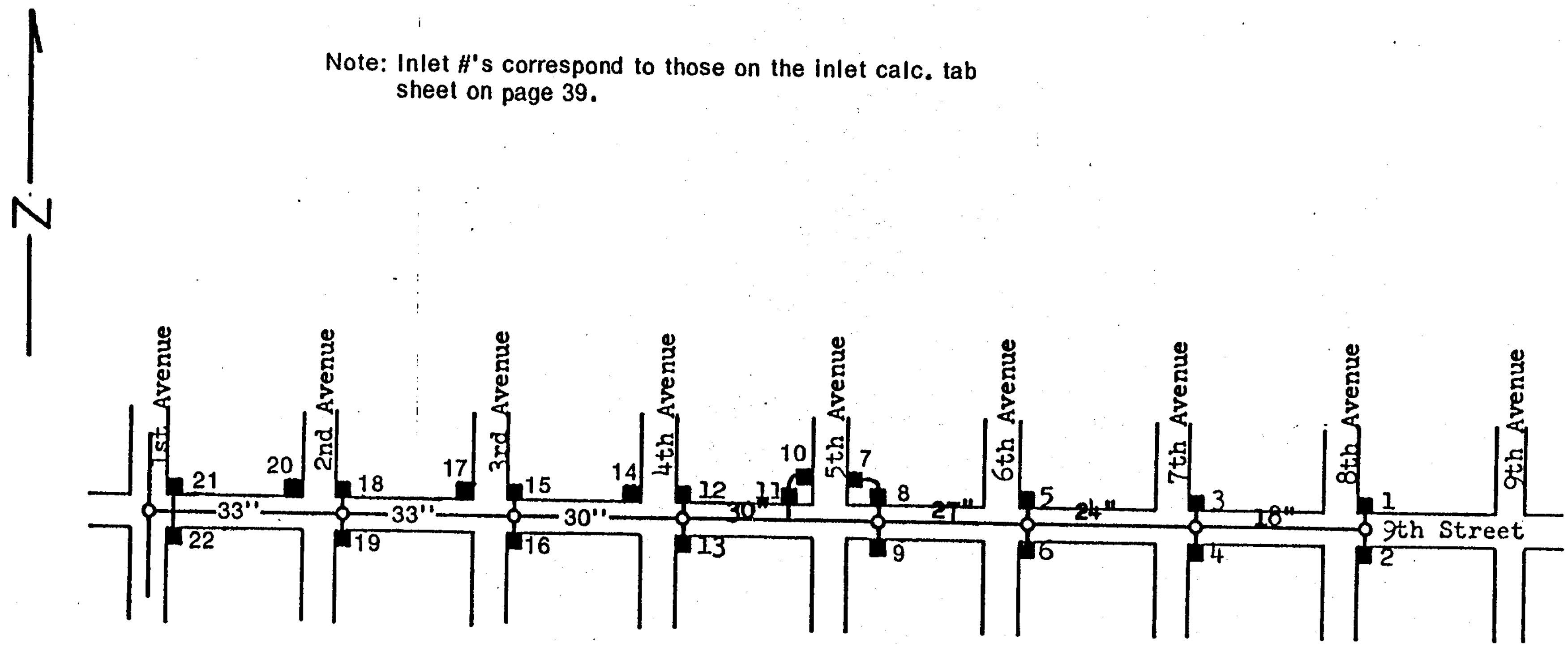


Figure 8

Preliminary Layout For Storm Drain Lateral in 9th Street

Note: Inlet #'s correspond to those on the inlet calc. tab sheet on page 39.



Catch basin types
#3, 5, 8, 12, 15, 18, 21 are type ''[redacted]'' "H" or "K"
#1, 7, 10, 11, 14, 17, 20 are type ''C''
#2, 4, 6, 9, 13, 16, 19, 22 are type ''B''

Figure 9

Calculations for 8th Avenue are as follows:

Ai contributing to inlet #1 at 8th Avenue = 2.4 acres at a time of concentration of 10 minutes.

And I = 2.7 (from the graph on page 24 for the 2-year frequency)

Q = .9 (2.7 - .2)2.4 = 5.4 cfs

Since this inlet is located in a sump and is a type ''C'' which is a curb opening inlet, the graph on page 29 is used to determine the depth the water must pond to in order that sufficient capacity is developed.

Assume gutter Yo = 0.4', then capacity from page 29 = .85 cfs per ft. of curb opening
The opening for a type ''C'' inlet is 8 ft. So inlet capacity .85 x 8 = 6.8 cfs
Clogging factor .8 capacity, .8(6.8) = 5.4 cfs
This is greater than the flow to the inlet. Now check spread into the roadway.

Cross-slope (from street cross-section) = .02, 0.4/.02 = 20', O.K.

With a 64' street and 12' lanes spread can be 20' so the inlet is O.K. for the two-year storm.

Since inlets #3 and #5 have identical contributing areas the following calculations apply to both.

Ai = (6.66 x .25) + (3.33 x .85) = 4.5 acres
Tc = 10 min.
I = 2.7 Q = .9(I - .2)Ai
Q = .9(2.7 - .2)4.5 = 10.13

Check spread: From page 27 get y = .38'
Spread = $\frac{.38}{.02}$ = 19' spread

.4 sumps are created at intersections at 6th and 7th Avenues
From GRAPH find "K" catch basin capacity in .4' sump equals 11.2 cfs

For all inlets on the south side of 9th Street up to 5th Avenue
Ai = 0.6 acres, I = 2.7 inches/1 hour
Q = .9(2.7 - .2).6 = 1.35 cfs

To find inlet capacity it is first necessary to determine Yg, the depth of flow in the gutter and spread.

To determine Yg at an inlet on a continuous grade, it is necessary to use the BPR nomograph for flow in triangular channels on page 27. It is entered with a Z/n number, where Z is the reciprocal of the cross-slope (Sc) and n is Manning's n = 0.015 for Asphalt surface courses.

If Sc = .02 then Z = 1/.02 = 50
Z/n = 50/.015 = 3300

If the longitudinal slope of the street (S) = .005 & Q = 1.35 cfs then from the nomograph Yg = 0.19
Spread w = Yg(Z) = 40(19) = 7.6

The Phoenix Type ''B'' catch basin is a 5.5' catch basin on a continuous grade.

Enter the chart on page 28 with a y = .19 and a depression depth = .16 and get $\frac{Qa}{La}$ = .13, min. size curb opening inlet type "B" has 5.5 curb opening.

Qa = 1.35, La = 10.4, $\frac{L}{La} = \frac{5.5}{10.4}$ = [redacted] 53%, $\frac{a}{y} = \frac{.16}{.19}$ = .84, $\frac{Q}{Qa}$ = [redacted] 67%, 1.35 x [redacted] 67% = [redacted] .90 cfs, X .8 clogging factor = 0.72 cfs

1.35 - [redacted] .72 = [redacted] .63 cfs flowby

These computations are done for all inlets on the south side of 9th Street and entered in the summary sheet shown on page 39.

The inlets on the northwest corners of 6th Avenue and 7th Avenue are checked as discussed previously.

Calculations for inlet capacities at 5th Avenue. Inlets shall be designed for 1-year storm and a contributing area without 5th Avenue storm drain in place as this Q will control over contributing Q with 5th Avenue storm drain in place.

Earlier it was determined that an inlet layout as shown in Figure 10 would probably be required.

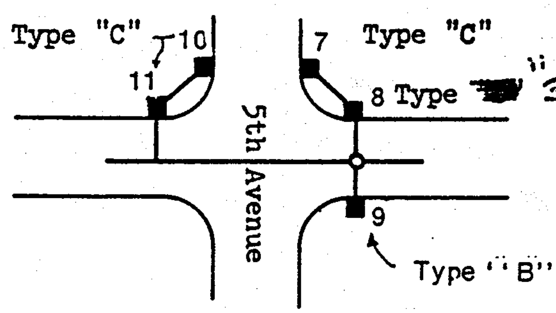


Figure 10

Area contributing to inlet #10 in Figure 10
A = 90 + (3 x 6.66) = 110 acres Ai = 110 x .25 = 27.5 acres

Use v = 2.3 ft./sec. for velocity, tc = $\frac{7 \times 660}{2.3 \times 60}$ = 33.5 minutes, I from the chart on page 23, is .8 in/hr. Q = .9 (8 - .2) 27.5 = 14.85 cfs

Inlets #7 and #10 are on a continuous grade of .005 and the cross-slope of 5th Avenue Sc = .025
Z = 1/.125 = 4 O,Z/n = 40/.015 = 2,667.0

1/.025 = 40 $\frac{Z}{n} = \frac{40}{.015}$ =

Since the crown of the street is only 0.38' water will cross the crown of 5th Avenue and each gutter will be carrying 7.42 cfs. The nomograph gives a y of .37 for this Q.

Use type ''C'' inlets for both #10 and #7 and enter the charts on page 28 to determine capacity.

Flow intercepted by inlets #10 and #7
From chart on page 28 with Yg = .37 ft. $\frac{Qa}{La} = \frac{7.42}{La} = .25$, La = 30, $\frac{L}{La} = \frac{8}{30} = .27$, $\frac{a}{y} = .43$

Q/Q80 = .140   .16/.37

Q intercepted = 40%
Q x 40 = 7.42(.40) = 3 cfs

Flow by - past inlet #7 to inlet #8 and past inlet #10 to #11
Q = 7.42 - 3 = 4.42 cfs
Flow on the street to inlet #8 computed as follows:
Ai = 4.5   tc = 10 min., I = 2.7
Q = .9 (2.7 - .2) 4.5 = 10.1 cfs
So total Q = 4.42 + 10.1 = 14.52 cfs
At .4 sump depth, capacity of [redacted] equals [redacted] +.8(20 x .85) = [redacted] 13.6 cfs
ADOT C.B. C-15.03 (L=17') ≅ M-1, L=17'
Use Type '[redacted]' catch basin for inlet #8

Flowby from inlet #8 to #11 = 14.52 - [redacted] 13.6 = [redacted] .92 cfs

Flowby from inlet #10 to #11 = 4.42

Total Q at inlet #11 = 4.42 + [redacted] .92 += [redacted] 5.34 cfs

Z = 1/.02 = 50, Z/n = 50/.015 = 3,300
Yg = 0.29, spread w = .29/.025 = 14.5 so O.K. at inlet #11 use type ''C''

From page 28 flowby intercepted at inlet #11 = 4.84 x 47% = 2.27 cfs. Flowby = 4.84 - 2.27 = 2.57
Quite a bit of flow comes down 4th Avenue so use an arrangement as shown in Figure 10 to limit flowby to inlet #12

Flowby to 4th Avenue = 2.57 cfs
For the inlets at 2nd, 3rd, and 4th Avenue a layout as shown in Fig. 11 will probably be required.

Flow on street to inlet #12
Ai = (36.6).25 + 3.33(.85) = 12
tc = $\frac{2640}{2.3 \times 60}$ = 19 min.
I = 1.5 in./hr.

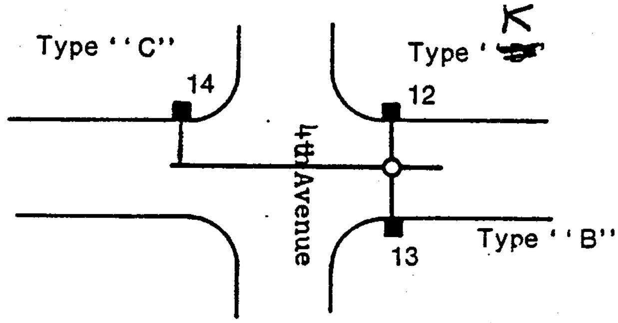


Figure 11

Q = .9(1.5 - .2) 12 = 14 cfs. With crown of .33' in residential street 4th Avenue, each half of street will carry 7 cfs.
Total flow to #12 is 7 + 2.57 = 9.57 cfs
Capacity of type "K" at Yg = 0.4 = 11.2 cfs O.K. for .4 sump
Check spread = 0.4/.02 = 20.0' O.K. Use type "K" catch basins.
Then Q at inlet #14 = 7 cfs From p. 28 Q intercepted by #14 = 7 x 39% = 2.73 cfs
Flowby from inlet #14 to #15 = 7 - 2.73 = 4.27 cfs
Total Q at inlet #15 = 7 + 4.27 = 11.27 cfs
At 2nd and 3rd Avenue situation is repeated and Type "K" inlet in 4' sump will intercept all the flow.

Use Type "K" catch basin.

The next step is to determine minimum depths of catch basins and the size of connector pipe required. The minimum size to be used is 15", for maintenance purposes.

Minimum catch basin depth is calculated by the method explained on page 33 of this manual for single catch basins. For example: The inlet at 8th Avenue receives a flow of 5.4 cfs. Using the chart on page 31 we find that the connector pipe diameter required is less than 15" if H-5'. (For this example assume the hydraulic grade line is 5.5 feet below gutter elevation.)

Minimum catch basin depth is then:

$$DCB = 1.17' + 1.5 \frac{V_1^2}{2g} + d$$

v_1 is the velocity of flow in the connector pipe
$v_1 = Q/a$
Area for a 15" pipe a = 1.227 ft^2
$v_1^2 = Q/a = 5.4/1.23 = 4.4$ fps

$v_1^2/2g = 19.3/64.4 = .3$
Depth required = 2.42 + 1.5 (.3) = 2.87 ft.
Go to page 25 to find hydraulic slope of pipe needed, S = .006 for pipe flowing full.
Head needed for pipe is 32' x .006 = .20'. Total H needed is .45 + .2 = .65'
Available H = 5' O.K.

Minimum depth per standard Type "C" basin is 4' - 0" from top of curb so use 4.0 feet minimum. Therefore, 15" pipe will be sufficient for inlet #1.

For inlets in series, such as those at 5th Avenue, the method outlined on page 31 is used to determine catch basin depth and connector pipe size. Q intercepted at inlet #7 is 3 cfs, at #8 it is 14.1 cfs. The hydraulic grade line is 5.5 feet below the gutter elevation of inlet #7 so available head is 5'. The fall from inlet #7 to inlet #8 is 0.3' difference in gutter elevations. Assume 15" connector pipe will be required.

Minimum depth for #7 inlet
$v_1 = Q/a = 3/1.23 = 2.5$ fps from page 25 hydraulic slope of pipe needed, S = .008
$v_1 = 1.17 + 1.5\frac{v_1^2}{2g} + d = 2.40 + 1.5\ (.1) = 2.55$ feet. Minimum depth per std.
detail is 4 feet, use 4.0 feet minimum depth.

$H_1 = .15 + (20' \times .008) = .3'$

Total Q in pipe out of inlet #8 is 17.1 cfs.
$v_2 = Q/a = 17.1/1.767 = 9.7$ fps. Hydraulic slope of 18" pipe required is $S = .025$, $L = 32'$. Head loss in pipe = 32 x .025 = .8'

$\frac{v_2^2}{2g} = (9.7)^2/64.4 = 1.45$ $H_2 = 1.5\ (1.45) + .8 = 3'$

$V_2 = 1.17 + 1.5(1.45) + 1.5 = 4.87'$ Check on page 32. $V_2 = 4.8'$ O.K.

Now using the available Head, $H_2 = 5.0 - .3' = 4.7$ ft. and the total Q for the connector pipe from inlet #8 enter the nomograph on page 31 to find the minimum connector pipe allowable is 18" so our selection of 18" is okay.

Utility conflicts may cause catch basin minimum depth to vary considerably from this value. In no instance shall the minimum depth be less than as specified on the Standard Details or as calculated using this procedure.

This process is repeated for the remainder of the connector pipes on the project and the results entered in the tabular summary on page 39.

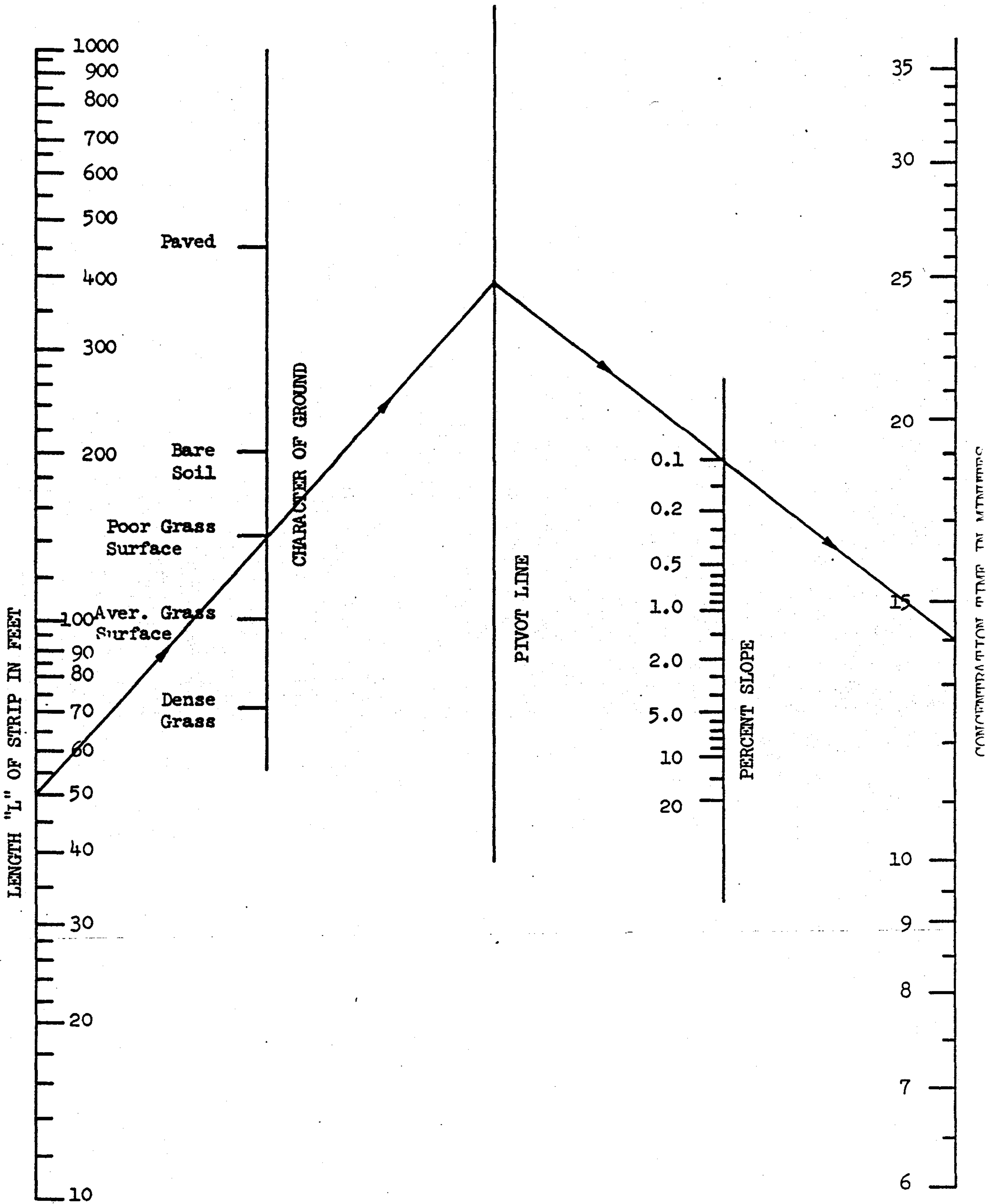
With the initial layout established, surveys and an exhaustive utilities search must be undertaken to establish final alignment depth and slope of the pipe. The desired minimum velocity in the laterals is 5 fps, and slopes must be reconciled with utility conflicts to obtain this velocity when possible. If slopes differ from the preliminary layout due to utility conflict, or for some other reason, it may be necessary to recompute pipe sizes.

Inlets may have to be rearranged slightly due to utilities, driveways, etc., and grades may be altered slightly without significant effect on the computations since spread is usually not the governing factor for inlet locations.

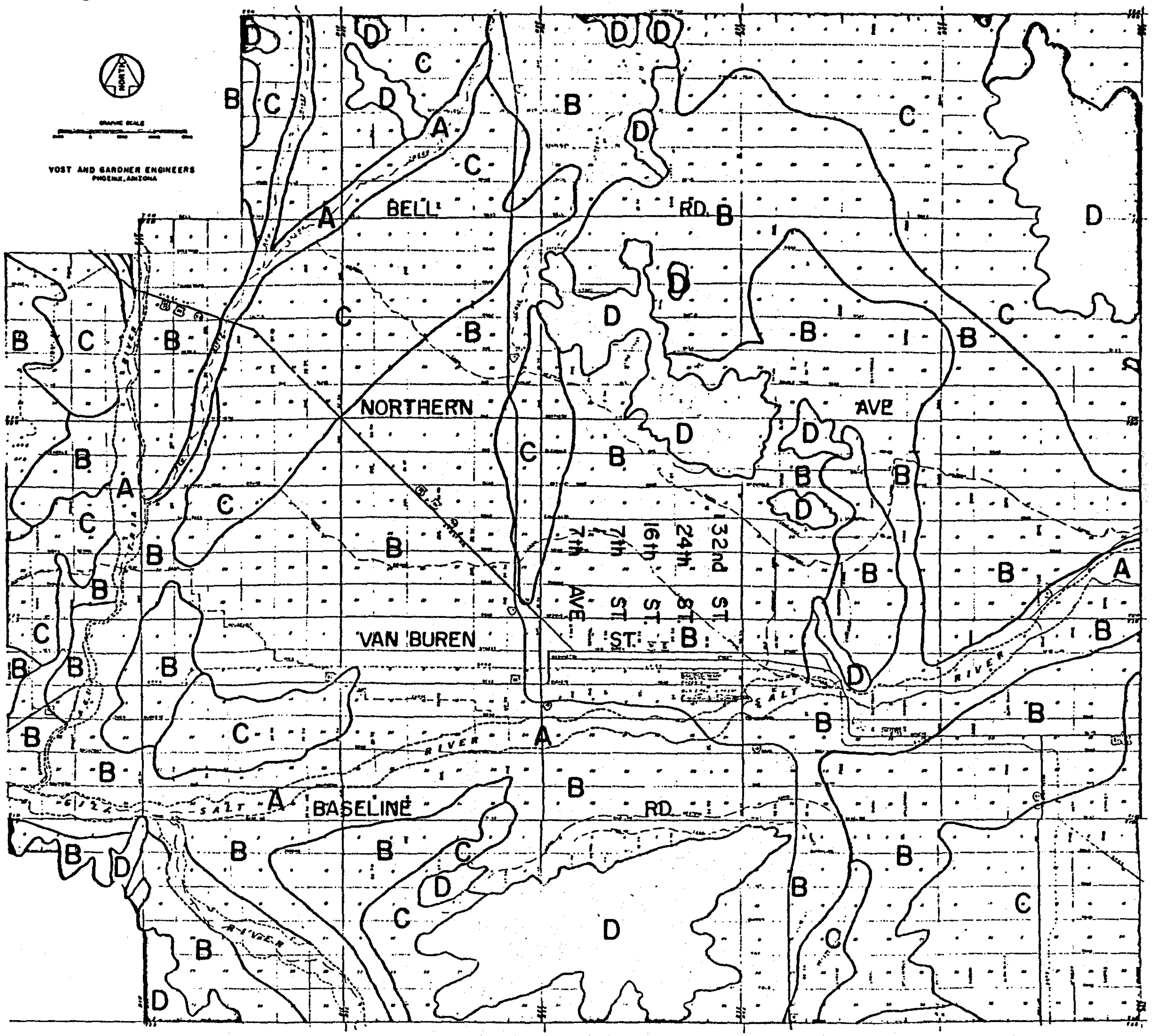
The intent of this manual is to provide a logical, sequential approach to storm drain design in conformance with local conditions. It should in no way be considered a substitute for experience and judgement on the part of a designer.

When in the opinion of the designer, conditions are such that procedures previously outlined do not apply, the proper solution in his judgement should be presented.

ZONING TYPES		% IMPERVIOUS
RE-43	Single Family Res. 43560 S. F. Lots Minimum	15.
RE-35	" " " 35000 S. F. Lots Minimum	15.
RE-24	" " " 24000 S. F. Lots Minimum	18.
RI-18	" " " 18000 S. F. Lots Minimum	18.
RI-14	" " " 14000 S. F. Lots Minimum	20.
RI-10	" " " 10000 S. F. Lots Minimum	25.
RI-8	" " " 8000 S. F. Lots Minimum	25.
RI-6	" " " 6000 S. F. Lots Minimum	25.
R-3	Multi-Family Res. 1-Unit For Each 3000 S. F.	60.
R-4	" " " " " " 1500 S. F.	65.
R-4A	" " " " " " 1000 S. F.	70.
R-5	" " " " " " 1000 S. F.	70.
C-0	Commericial Office District - Restricted Commercial	75.
HR	High Rise District	90.
PSC	Planned Shopping Center	90.
C-1	Neighborhood Commercial	85.
C-2	Intermediate Commercial	85.
C-3	General Commercial	85.
P-1	Parking (Open)	85.
P-2	Parking (Structures	85.
IND. PARK	Industrial Park	75.
A-1	Light Industrial	75.
A-2	Heavy Industrial	75.
P.A.D.	Planned Area Development	85.
D.G.	Dwelling Group	85.
RIGHT OF WAY (R.O.W.)		100.



OVERLAND FLOW TIME



GROUP "A" - 2" per hour & over
Undifferentiated sandy alluvial soils subject to overflow

Torrifluvents - recent alluvial soil
Calciorthids - high calcium soils
GROUP "B" 0.15" to 0.30" per hour & over

GROUP "C" - 0.05" to 0.15" per hour & over
Haplargids - stratified clay soils

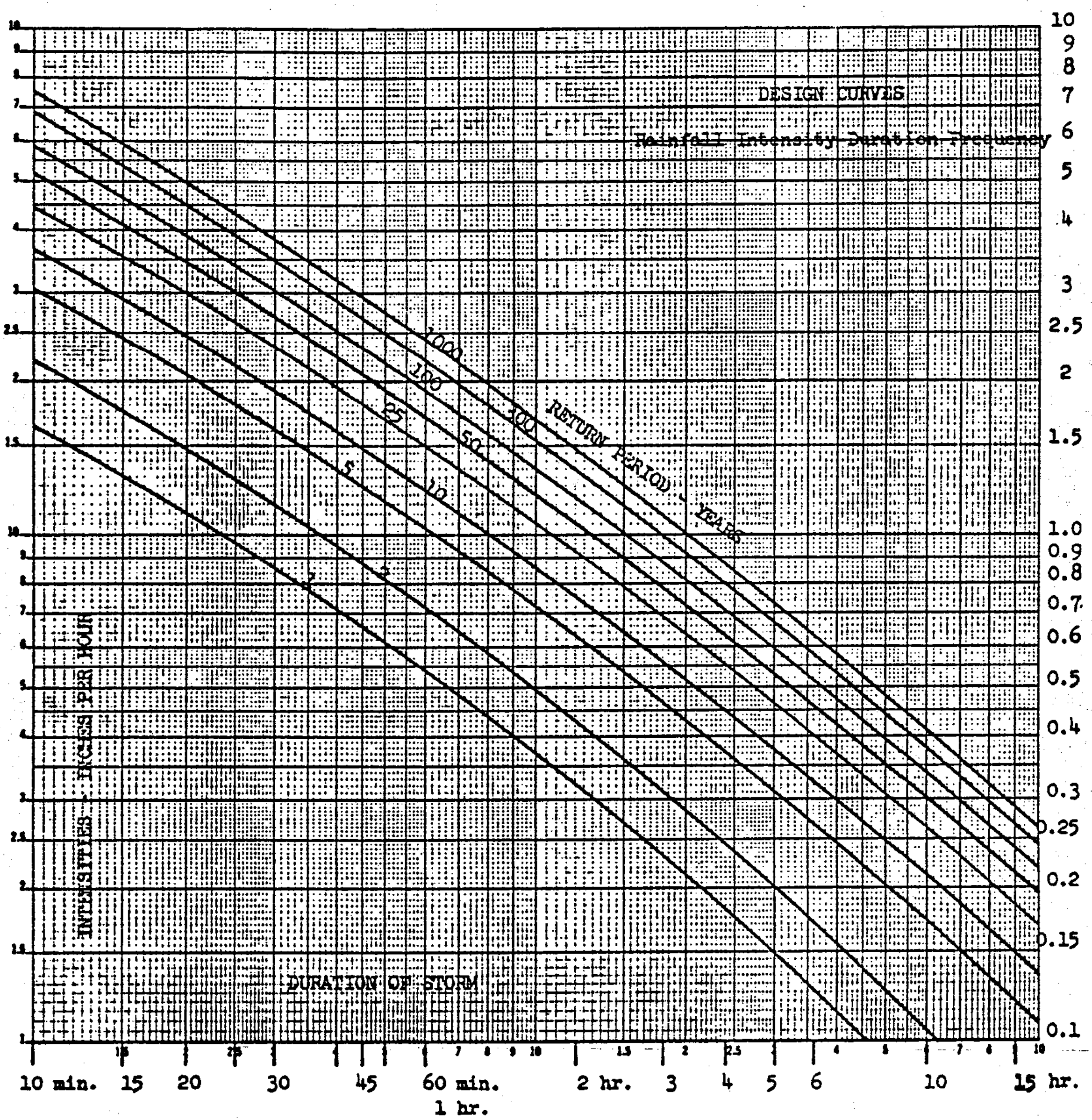
GROUP "D" - Less than 0.05" per hour
Rock outcropings - stony mountainous soils on steep slopes

NOTE: Minimum infiltration rates shown are from "WATER" - The Yearbook of Agriculture (1955) U.S. Department of Agriculture - pg. 157

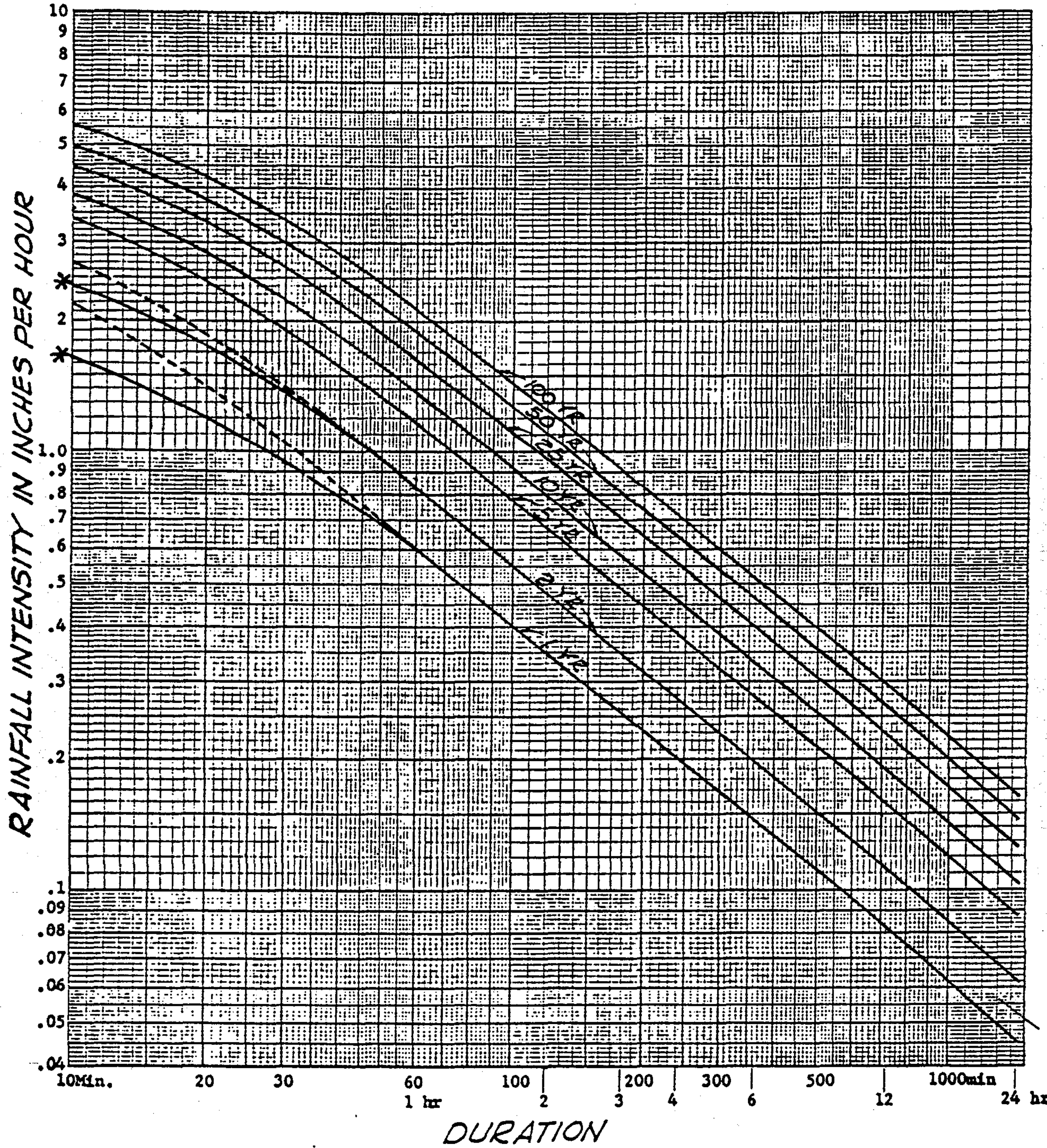
SOIL TYPES

FROM "GENERAL SOIL MAP OF MARICOPA COUNTY"
U S Department of Agriculture, Soil Conservation Service

THE PREPARATION OF THIS REPORT WAS FINANCED IN PART THROUGH AN URBAN PLANNING GRANT FROM THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED.



RAINFALL INTENSITY, DURATION, FREQUENCY (use only when trunk storm drain was designed for the one year return period.)
USWB Tech Paper 25

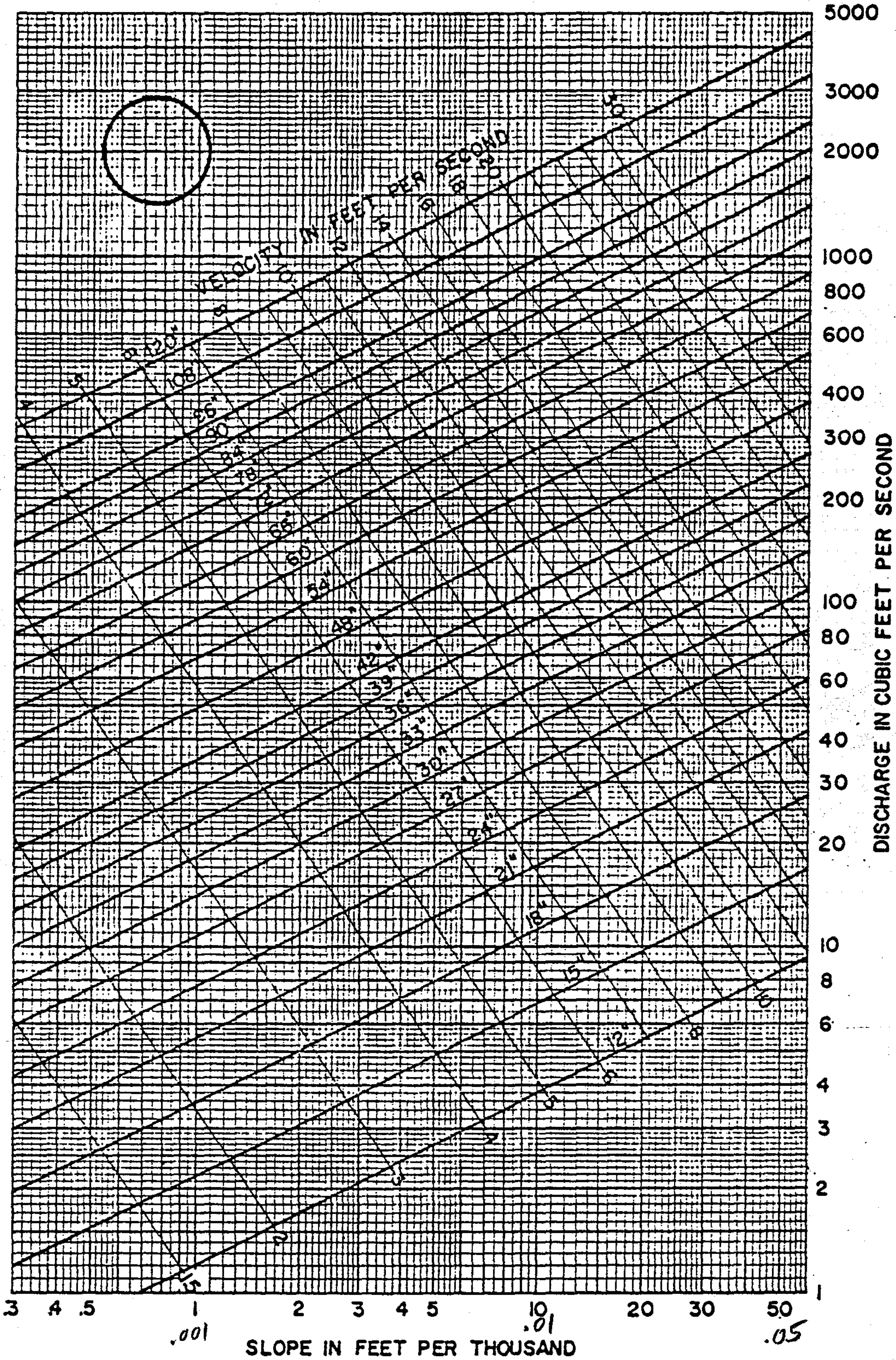


RAINFALL INTENSITY-DURATION-FREQUENCY RELATION
FOR PHOENIX, ARIZONA
(Partial Duration Series)

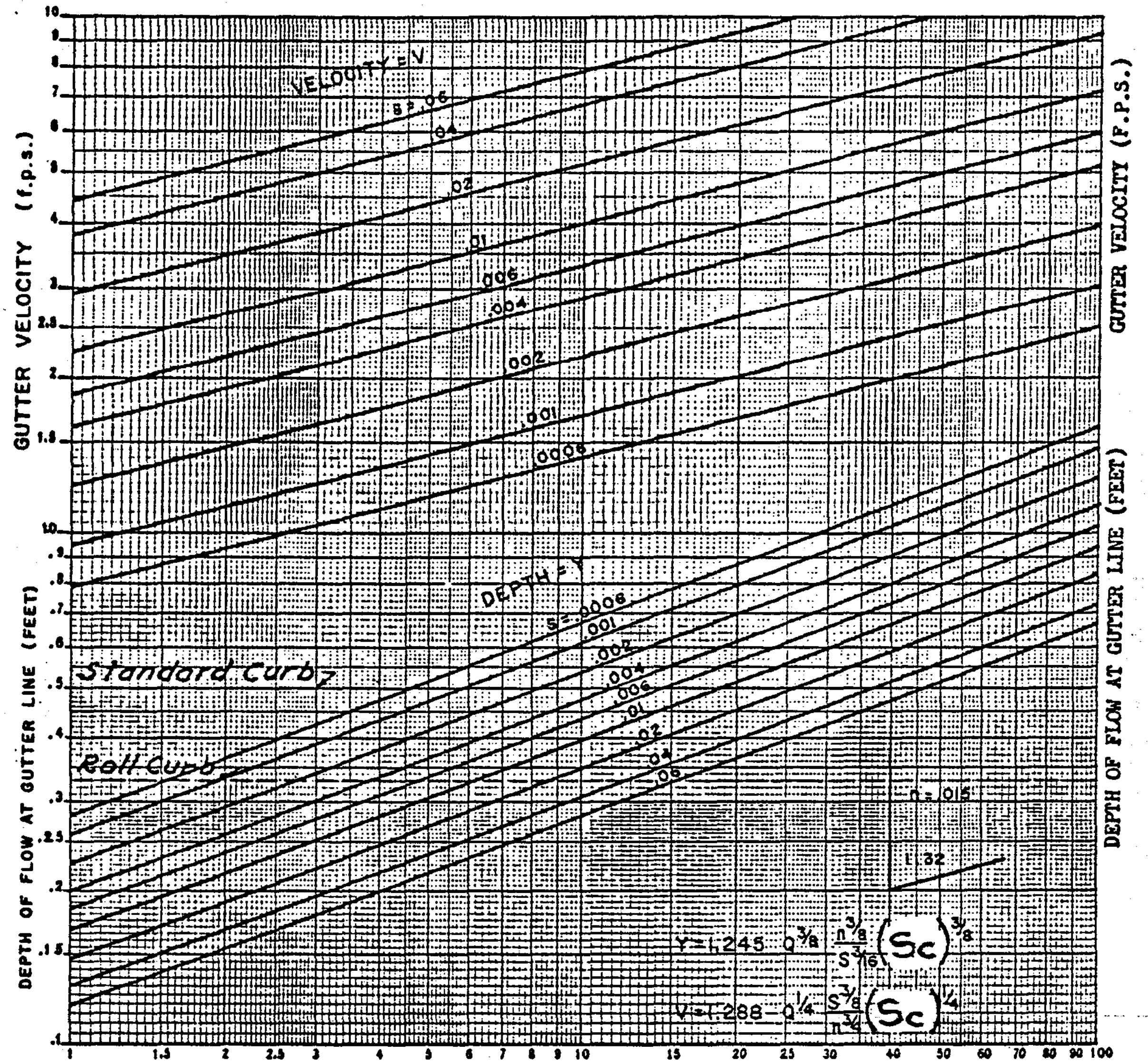
Curves are based on methods of U.S. Weather Bureau Technical Papers Nos. 28 and 40 and rainfall data prepared by U.S. Weather Bureau Office of Hydrology for the Soil Conservation Service, March 1967

* Curves revised June 1975 to reflect new information from WR-44.

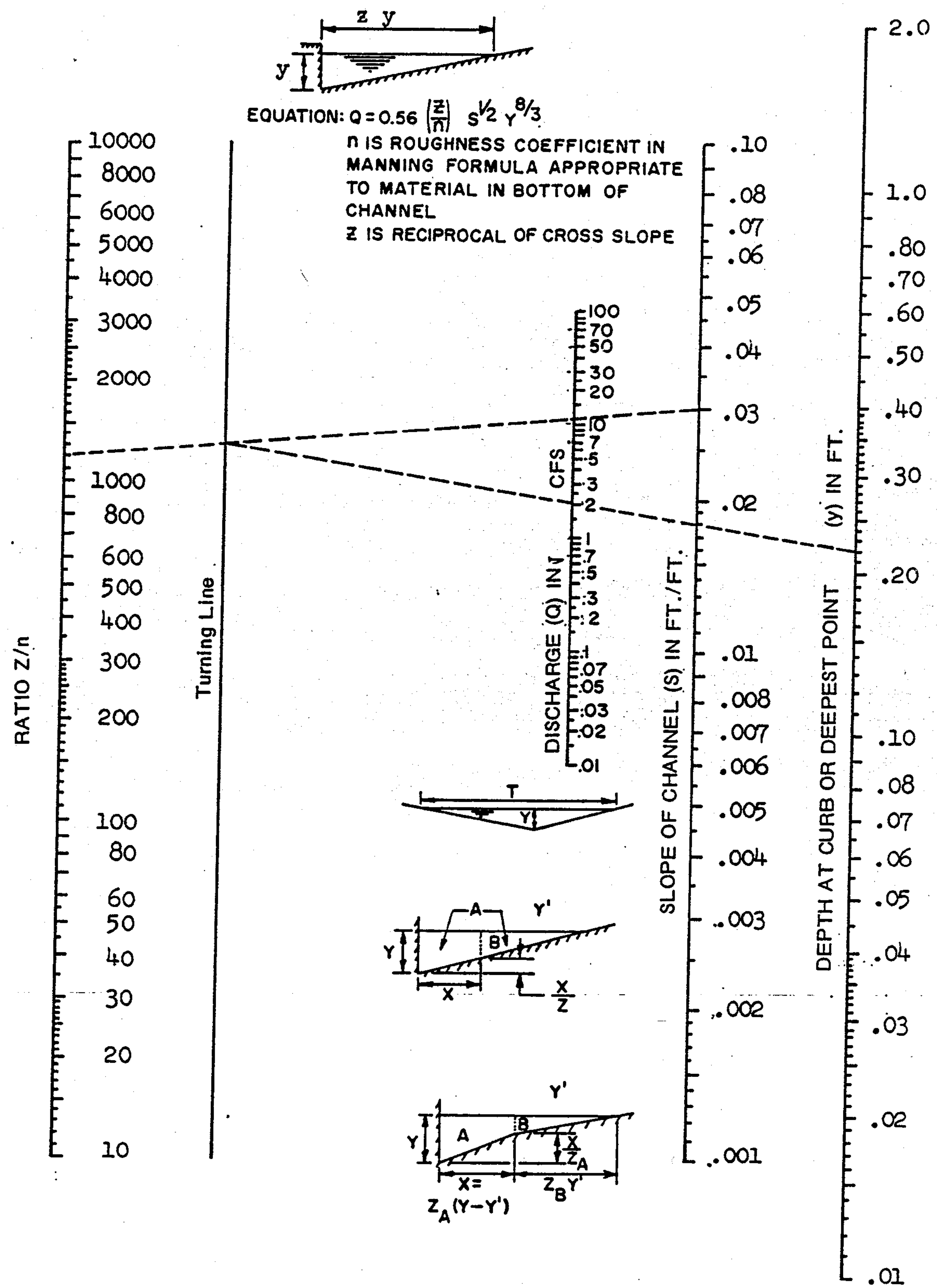
COMPUTED FROM MANNING'S FORMULA
n=0.012



PIPE CAPACITIES FLOWING FULL



GUTTER FLOW = Q (C.F.S.)



z y
y
EQUATION: $Q = 0.56 \left(\frac{z}{n}\right) S^{1/2} Y^{8/3}$
n IS ROUGHNESS COEFFICIENT IN MANNING FORMULA APPROPRIATE TO MATERIAL IN BOTTOM OF CHANNEL
z IS RECIPROCAL OF CROSS SLOPE
RATIO Z/n
10000
8000
6000
5000
4000
3000
2000
1000
800
600
500
400
300
200
100
80
60
50
40
30
20
10
Turning Line
DISCHARGE (Q) IN CFS
100
70
50
30
20
10
7
5
3
2
1
.7
.5
.3
.2
.1
.07
.05
.03
.02
.01
SLOPE OF CHANNEL (S) IN FT./FT.
.10
.08
.07
.06
.05
.04
.03
.02
.01
.008
.007
.006
.005
.004
.003
.002
.001
DEPTH AT CURB OR DEEPEST POINT (y) IN FT.
2.0
1.0
.80
.70
.60
.50
.40
.30
.20
.10
.08
.07
.06
.05
.04
.03
.02
.01
T
Y
A
Y'
B
Y
X
X/Z
Y'
Y
A
B
X/Z_A
X= Z_A(Y−Y')
Z_BY'

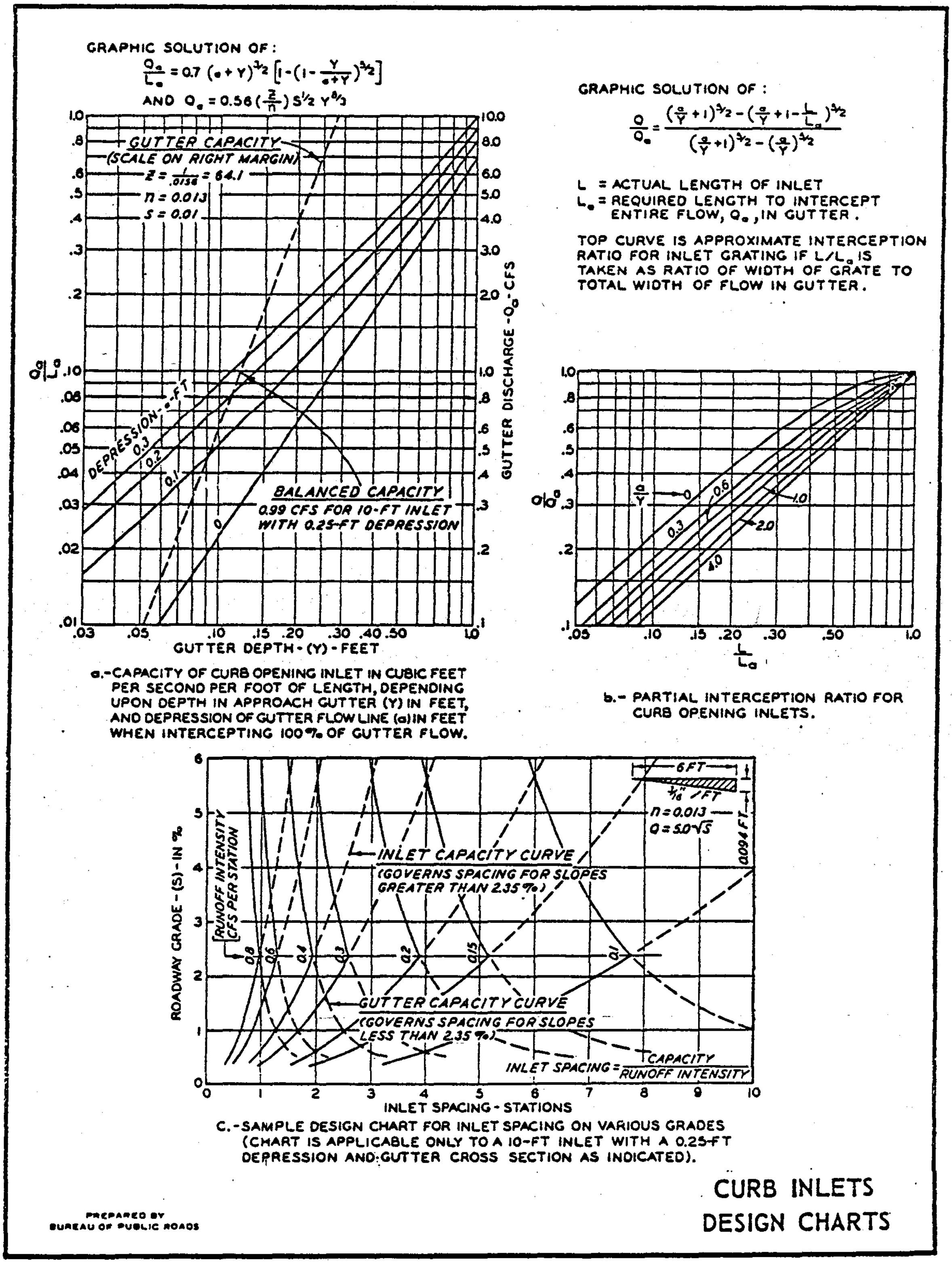
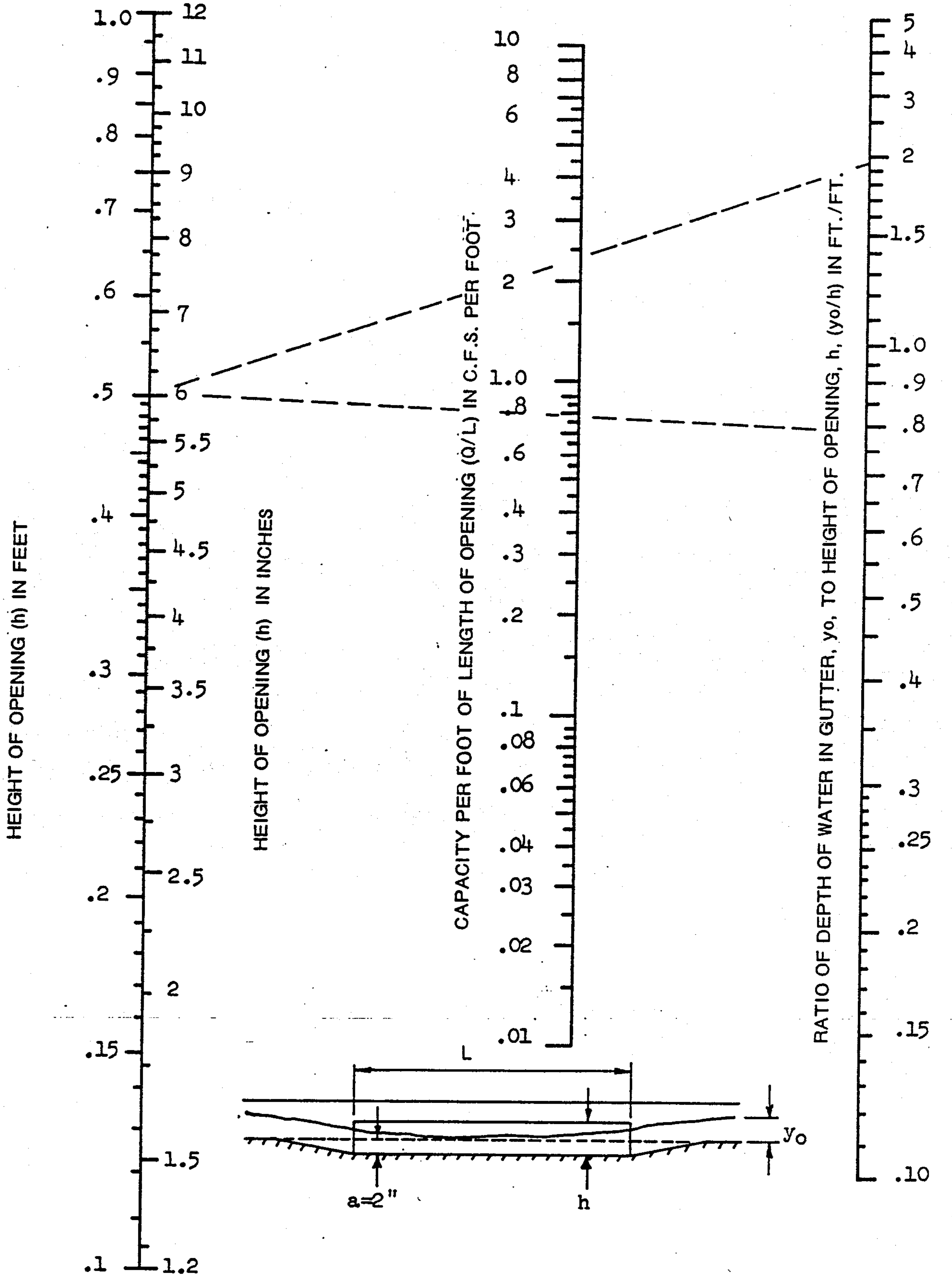
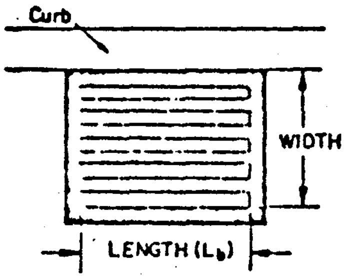

GRAPHIC SOLUTION OF:
$\frac{Q_a}{L_a} = 0.7\,(a+Y)^{3/2}\left[1-\left(1-\frac{Y}{a+Y}\right)^{3/2}\right]$
AND $Q_a = 0.56\,(\frac{z}{n})\,S^{1/2}\,Y^{8/3}$
GUTTER CAPACITY
(SCALE ON RIGHT MARGIN)
$z = \frac{1}{.0156} = 64.1$
$n = 0.013$
$S = 0.01$
DEPRESSION-a-FT
BALANCED CAPACITY
0.99 CFS FOR 10-FT INLET WITH 0.25-FT DEPRESSION
GUTTER DISCHARGE - Q_a - CFS
GUTTER DEPTH - (Y) - FEET
a.-CAPACITY OF CURB OPENING INLET IN CUBIC FEET PER SECOND PER FOOT OF LENGTH, DEPENDING UPON DEPTH IN APPROACH GUTTER (Y) IN FEET, AND DEPRESSION OF GUTTER FLOW LINE (a) IN FEET WHEN INTERCEPTING 100% OF GUTTER FLOW.
GRAPHIC SOLUTION OF:
$\frac{Q}{Q_a} = \frac{(\frac{a}{Y}+1)^{5/2} - (\frac{a}{Y}+1-\frac{L}{L_a})^{5/2}}{(\frac{a}{Y}+1)^{5/2} - (\frac{a}{Y})^{5/2}}$
L = ACTUAL LENGTH OF INLET
L_a = REQUIRED LENGTH TO INTERCEPT ENTIRE FLOW, Q_a, IN GUTTER.
TOP CURVE IS APPROXIMATE INTERCEPTION RATIO FOR INLET GRATING IF L/L_a IS TAKEN AS RATIO OF WIDTH OF GRATE TO TOTAL WIDTH OF FLOW IN GUTTER.
b.- PARTIAL INTERCEPTION RATIO FOR CURB OPENING INLETS.
6 FT
3/4" / FT
0.094 FT
$n = 0.013$
$Q = 5.0\sqrt{S}$
INLET CAPACITY CURVE
(GOVERNS SPACING FOR SLOPES GREATER THAN 2.35%)
GUTTER CAPACITY CURVE
(GOVERNS SPACING FOR SLOPES LESS THAN 2.35%)
RUNOFF INTENSITY CFS PER STATION
INLET SPACING = CAPACITY / RUNOFF INTENSITY
ROADWAY GRADE - (S) - IN %
INLET SPACING - STATIONS
C.-SAMPLE DESIGN CHART FOR INLET SPACING ON VARIOUS GRADES (CHART IS APPLICABLE ONLY TO A 10-FT INLET WITH A 0.25-FT DEPRESSION AND GUTTER CROSS SECTION AS INDICATED).
PREPARED BY BUREAU OF PUBLIC ROADS
CURB INLETS
DESIGN CHARTS

Figure 12



NOMOGRAPH FOR CAPACITY OF CURB OPENING
INLETS IN SUMPS, DEPRESSION DEPTH 2"

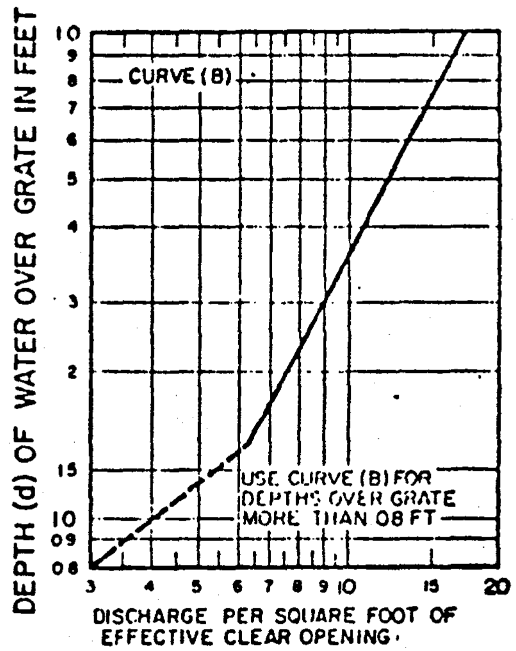


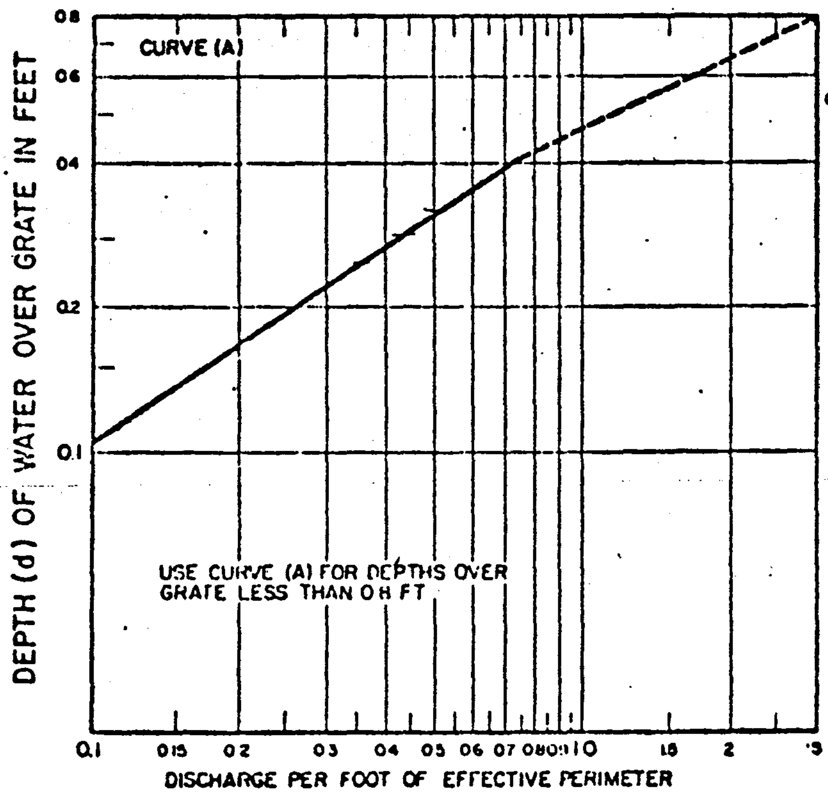
$P = 2B + L_b$

A = AREA OF CLEAR OPENING IN GRATE

TO ALLOW FOR CLOGGING DIVIDE P OR A BY 2 BEFORE OBTAINING d.

WITHOUT CURB $P = 2(B + L_b)$



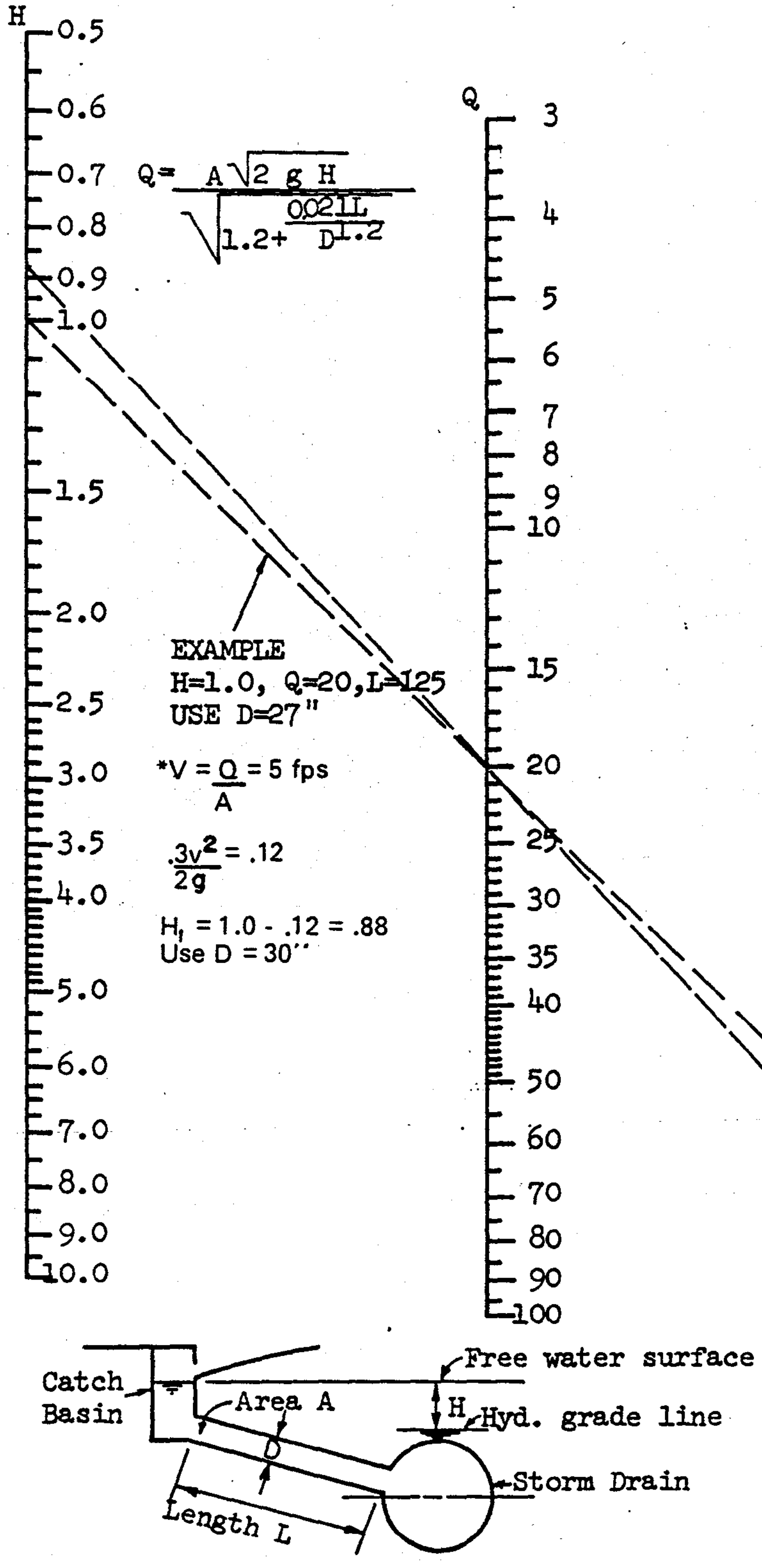


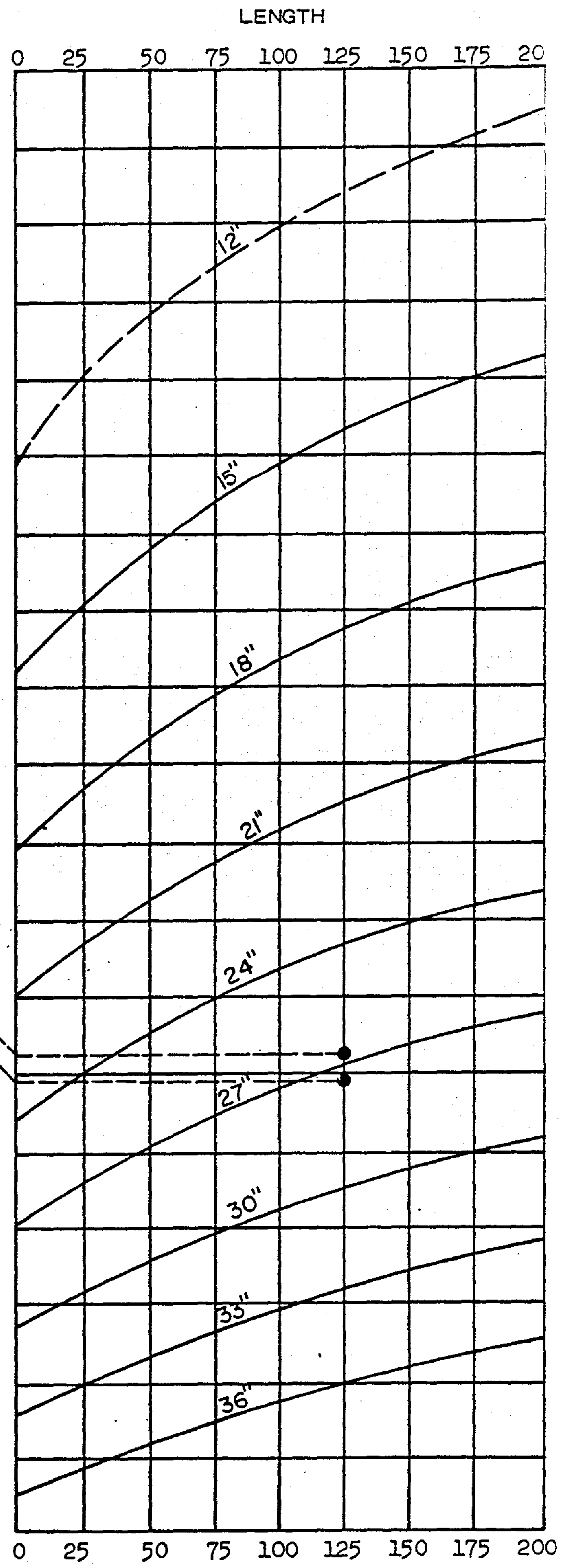
GRATE TYPE	AREA	P
1	3.78	10.66
2	2.56	9.41

BUREAU OF PUBLIC ROADS
REV. AUG. 1968

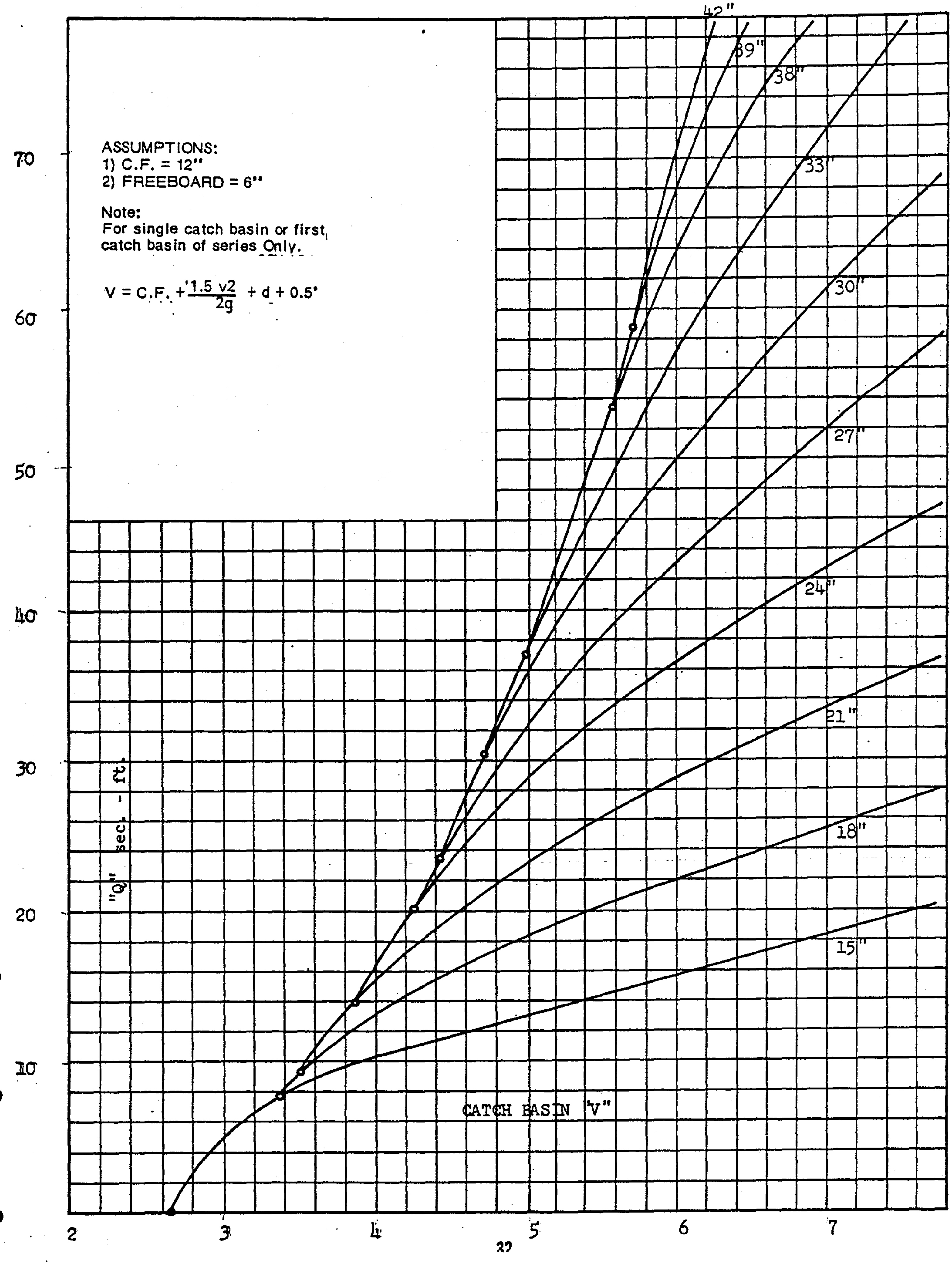
HYDRAULIC CAPACITY OF GRATE INLET IN SUMP

DESIGN OF SPUN CONCRETE CONNECTOR PIPES FLOWING FULL





*Since City of Phoenix Inlets have higher entrance losses than allowed for in this chart the available head is adjusted as shown.


ASSUMPTIONS:
1) C.F. = 12"
2) FREEBOARD = 6"
Note:
For single catch basin or first catch basin of series Only.
V = C.F. + 1.5 v2 / 2g + d + 0.5'
"Q" sec. - ft.
CATCH BASIN "V"
42"
39"
38"
33"
30"
27"
24"
21"
18"
15"
70
60
50
40
30
20
10
2
3
4
5
6
7

11. Catch Basins in Series

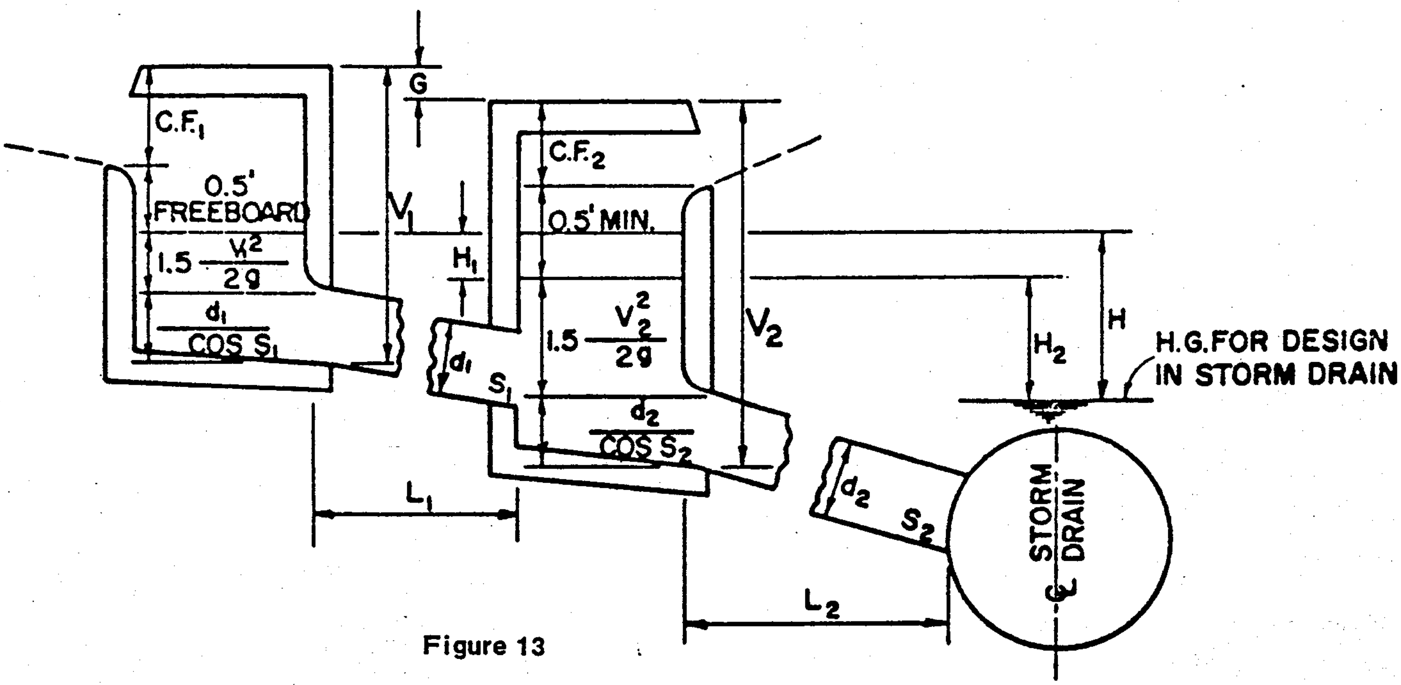


Figure 13

a. Connector Pipes -

1. Determine the available head (H) as shown in figure 13,

2. Compute head loss for each catch basin and connector pipe in the series by culvert equation. The sum of head losses in the series must be less than or equal to the available head.
(i.e. $H_1 + H_2 = \ldots\ldots + H_n \quad H$)

b. Minimum Catch Basin Depth - V -

1. The first catch basin depth is the same as for a single catch basin.

$$V1 = 1.16 + 1.5 \frac{v_1^2}{2g} + d1$$

2. The second catch basin depth may be determined as follows:
Referring to Figure 13.

$$V_2 = C.F._1 + 0.5 + H_1 + 1.5 \frac{V_2^2}{2g} + \frac{d_2}{\cos s_2} - G$$

Assuming $C.F._1 = 0.66$
$\cos s_2 = 1$

II. Catch Basins in Series - continued.

$$V = 1.16 + H + 1.5 \frac{v_2^2}{2g} + d_2 - G$$

*3. Check the freeboard provided for the second catch basin.

4. Succeeding catch basin depths in the series may be determined by similar computations.

III. Where especially "tight" conditions prevail, the o.5' freeboard may be omitted and the difference between gutter elevation and storm drain soffit elevation may be accepted as the available head (H).

C.F. = Curb face assumed to equal 1.0'

V = Catch basin depth measured from invert of connector pipe to top of curb.

v = Velocity in connector pipe.

d = Diameter of connector pipe.

s = Slope of connector pipe.

L = Length of connector pipe.

H = Available head

$H_1, H_2, \ldots H_n$ = Lost head.

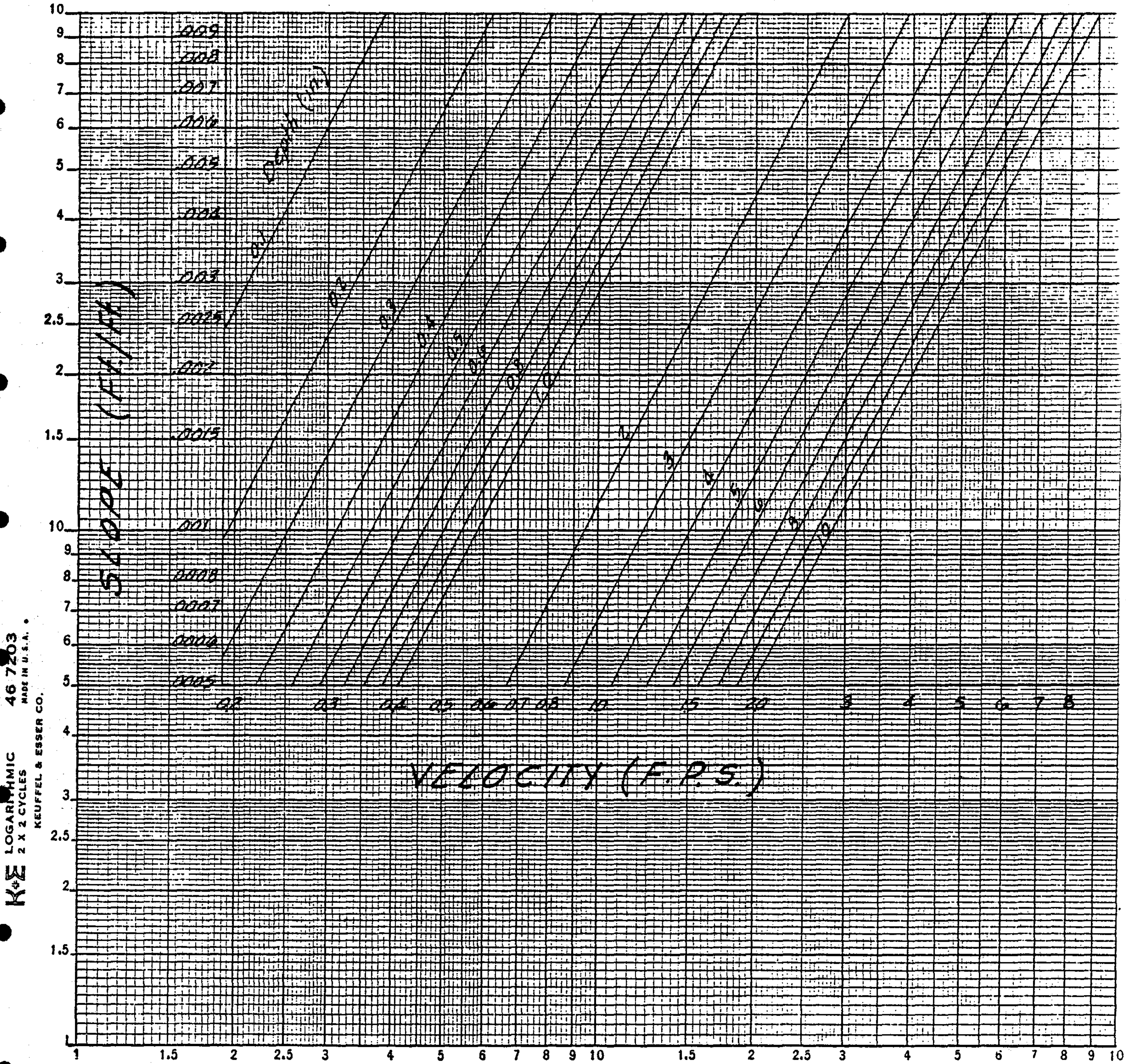
G = Difference in elevation of top of curb.

$$\text{*Freeboard2} = \frac{V_2 - d_2}{\cos s_2} - 1.5 \frac{v_2^2}{2g} - \text{C.F.2}$$

Assuming $C.F._2 = 0.67$ & $\cos s = 1$

$$\text{Freeboard2} = V_2 - d_2 - 1.5 \frac{v_2^2}{2g} - .66 \geq V1 \geq 0 \quad 0.5' \text{ Min.}$$

FINAL CHECK FOR ADVERSE SLOPE: $V_2 + G > V_i + 0.5'$



Sheet Flow on Asphalt

$n = .015$

PRESENTATION OF STORM DRAIN IN PLANS

A table is to be made giving the alternate pipe information shown in the sample table on page 38.

On storm drain mains that have more than ten-foot depth of trench, soil boring information and soil resistivity is to be provided and shown on the plans by the Consulting Engineer. Information shall be provided as per Administrative Procedure #13. From this information it will be determined if C.I.P.P. is a feasible alternate. If the soil will not stand, C.I.P.P. will not be considered as an alternate material. Also if too many utility interferences are involved, C.I.P.P. will not be used.

Corrugated metal pipe will be Type D on the main storm drain and Type A for connecting pipes. Type "D", corrugated metal pipe, is asphalt coated outside and smooth flow asphalt inside with N = .012. For mains over 54" diameter, either 2⅔ x ½ or 3" x 1" corrugations may be used. Type "A" corrugated metal pipe is asphalt coated inside and out, but not smooth flow, with N = .024 for 2⅔ x ½ corrugations. Gage thickness of C.M.P. to be used is shown in Standard Detail 215.

The diameter of the main storm drain will be the same for all alternates. This diameter is to be shown on plans in profile without reference to type of material. For Federal Aid projects, pipes into manholes shall match crowns.

Connecting pipe to be shown in cross sections by diameter of reinforced concrete pipe alternate, but without reference to type of material.

Manholes are to be spaced as follows:

For pipe diameters of 30" or less every 330'
For pipe diameters of 33" to 45" every 440'
For pipe diameters of 48" and greater every 660'

D-Load requirements shall be determined using a 140 p.c.f. earth load. In ordinary soil conditions, positive projected condition shall be used up to 10' of cover. Trench condition shall be used for deeper trenches in ordinary soil conditions. If the soil information indicates unstable soil, positive projected condition shall be used exclusively in determining D-Load requirements.

Complete Specifications on pipe alternates are included in Uniform Standard Specifications of Maricopa Association of Governments.

Prefabricated tees are to be used on all connections to the [redacted] main storm drains where a new main is being installed and connection is not at a manhole location.

On projects where the storm drain main is existing, connections are to be made with Detail 524 if the outside diameter of the connecting pipe is less than ½ the inside diameter of the main. Where the outside diameter of the connecting pipe is greater than ½ the inside diameter of the existing main, special detail 621 is to be used.

The concrete pipe is to be rubber gasketed up to 48" diameter.

Storm drain catch basins, connecting pipe, and mains are to be shown in plan view of paving sheets of plans and storm drain sheets.

Quantities of catch basins, connecting pipes, and mains are to be shown on storm drain sheets only.

Where private irrigation crosses streets, only rubber gasketed concrete pipe is to be used.

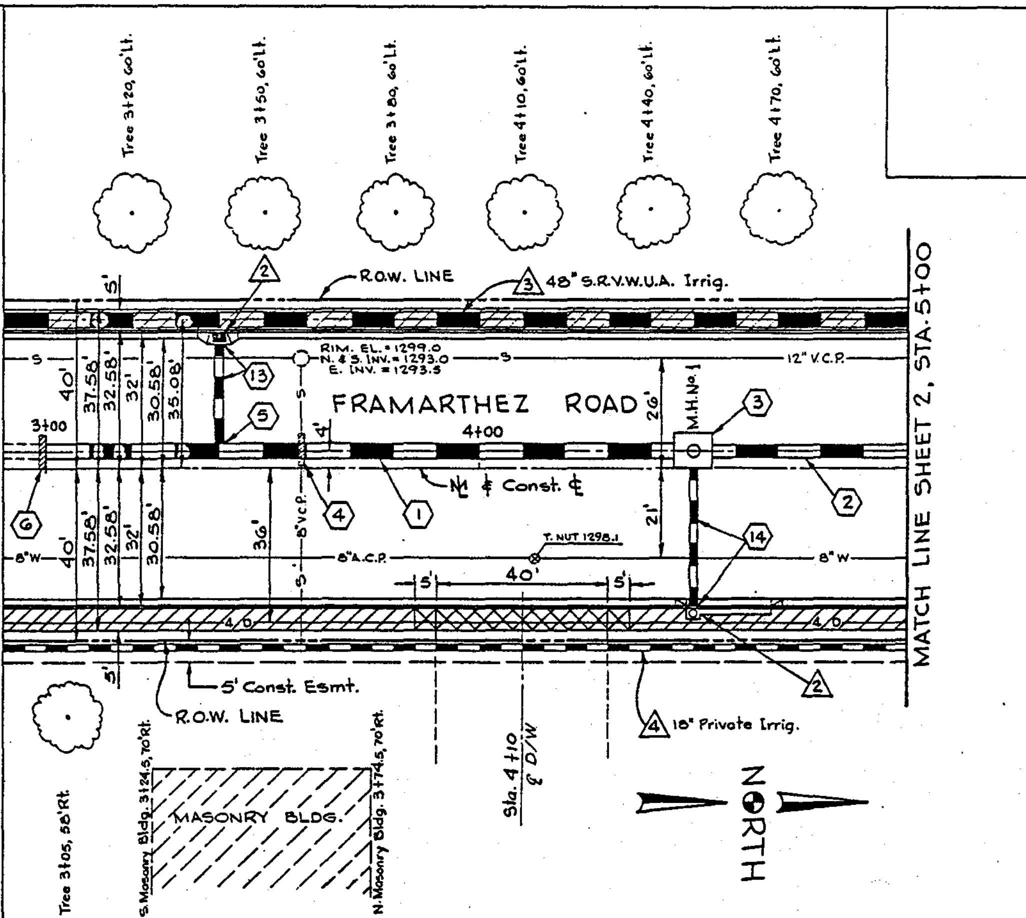
Crown elevation of side streets at curb alignment of major streets is to be shown in plan and profile of paving plans.

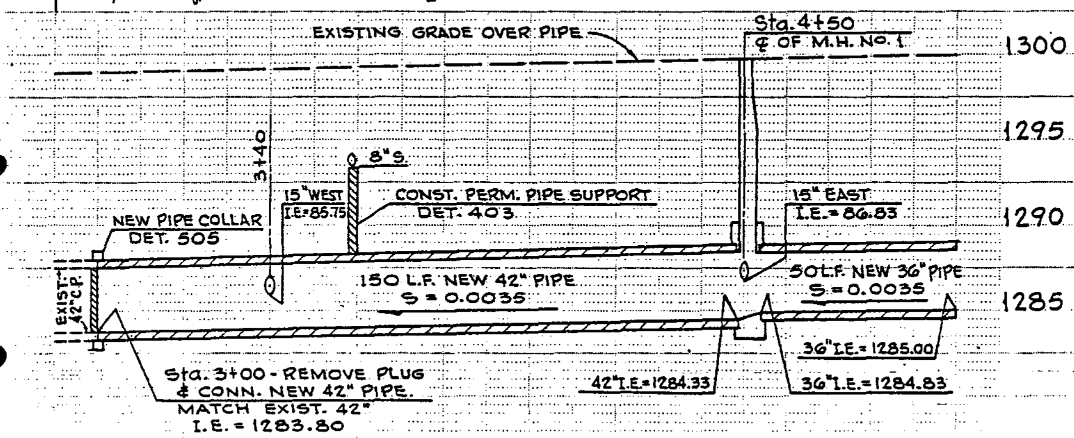
The consulting engineer must seal the hydraulic calculations.

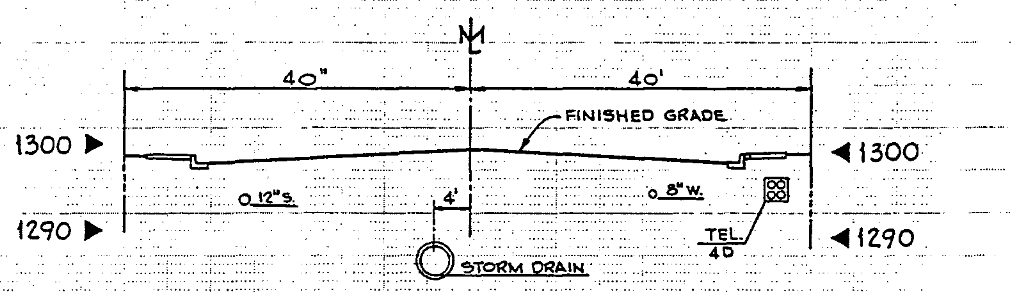
F.H.W.A. REGION	STATE	PROJ. NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ				

CONSULTING ENGINEER

DES | DR | CK | DATE







SECTION AT STA. 4+00

SCALE: 1" = 10' HORIZ. & VERT.

STORM DRAIN PIPE			
NO.	STA. TO STA.	L.F.	SIZE
1	3+00 TO 4+50	150	42"
2	4+50 TO 5+00	50	36"

STORM DRAIN MANHOLE			
NO.	STATION	SHAFT	BASE
3	4+50	MAG 522	MAG 520

PERMANENT PIPE SUPPORTS		
NO.	STATION	STD. DET.
4	3+60 ±	MAG 403

PRE FABRICATED TEES		
NO.	STATION	SIZE
5	3+40	42"x 42"x 15"

CONCRETE PIPE COLLARS (24" & LARGER)			
NO.	STATION	SIZE	DETAIL
6	3+00	42"	MAG 505

CONC. CATCH BASINS & CONNECTOR PIPE						
NO.	STATION	INLET TYPE	DETAIL	CONN.	L.F.	SIZE
*13	3+40 Lt.	'C' Single	P-1572	PREFAB TEE	26	15"
*14	4+50 Rt.	M-1, L=17	P-1569	M.H.	26	15"

NOTE:
* CATCH BASIN NUMBERS SHOULD BE THE SAME NUMBERS AS THEIR CONTRIBUTARY DRAINAGE AREA.

For Paving See Sheet 2.

△2 - For Catch Basin X-Sections - See Sheet 10.
△3 - For Salt River Project Plans - See Sheet 15.
△4 - For Private Irrigation - See Sheet 20.

STORM DRAIN

CITY OF PHOENIX, ARIZONA
ENGINEERING DEPARTMENT

FRAMARTHEZ ROAD
NORTHWEST AVE. TO SOUTHEAST ST.
PROJECT NO. P-192771

DES	DR F.L.Z.	CK L.E.	SHEET NO.	TOTAL SHEETS	AS BUILT
DATE	DATE 7-87	DATE 7-87	5	60	

SCALE 1" = ——— HORIZONTAL / ——— VERTICAL

THUNDERBIRD ROAD - MAJOR STREET
PHOENIX STREETS MARICOPA CO.
32ND STREET TO 40TH STREET

* RUBBER GASKET PIPE REQUIRED FOR 36" DIAMETER OR SMALLER AND IS OPTIONAL FOR GREATER THAN 36" DIAMETER.

ALTERNATE PIPE MATERIAL FOR CONNECTING PIPES

STATION RT. OR LT.	LENGTH	DEPTH TO TOP OF PIPE MAX.	DEPTH TO TOP OF PIPE MIN.	R.C.P. OR N.R.C.P. SIZE	R.C.P. (A.S.T.M. C-76) * REQUIRED "D" LOAD TO PRODUCE A 0.01" CRACK	N.R.C.P. * A.S.T.M. C-14 CLASS	C.M.P., TYPE A 14 GAUGE 2⅔ x ½ CORR. SIZE
22+50 Rt.	9'	5.5'	2.5'	15"	1000	1	15"
24+90 Lt. (?)	27'	7'	2'	15"	1250	2	15"
25+45.35 Lt.	43'	7.5'	2'	15"	1750	N/A	15"
31+48.75 Rt.	28'	5'	2'	15"	1250	2	15"
32+05 Lt.	38'	4'	2'	15"	1250	2	15"
36+63.84 Lt.	44'	6.5'	2.5'	15"	1000	1	15"
36+83.29 Rt.	33'	8.5'	2'	15"	1250	2	15"
38+27.18 Lt.	28'	11'	2'	15"	1500	3	15"
38+68.29 Lt.	37'	12'	2.5'	15"	1750	N/A	15"
47+00 Lt.	37'	3'	2'	15"	1750	N/A	15"
47+25 Rt.	28'	9'	1.5'	15"	1750	N/A	15"
Sta 48+52.38 (?) Lateral in 37th Pl.	79'	9'	5.5	27"	1250	3	27"
55+00 Lt.	36'	6'	2.5'	15"	1000	1	15"
56+00 Lt.	36'	5.5'	2'	15"	1250	2	15"
55+05 Rt.	27'	6.5'	2'	15"	1250	2	15"
57+04 Lt.	36'	5.5'	2.5'	15"	1000	1	15"
* 47+93.59 Lt.	25'	8'	2'	15"	1250	2	15"
** 40+52.59 Lt.	33'	8'	2'	15"	1250	2	15"
20+36.25 Lt.	38'	3'	1.5'	15"	1750	N/A	15"

* Connects to 27" Lateral in 37th Place @ 30' Lt. of Thunderbird Rd.
** Connects to 27" Lateral in 37th Place @ 35.12' Lt. of Thunderbird Rd.

ALTERNATE PIPE MATERIAL FOR MAIN LINE

STATION FROM	STATION TO	LENGTH	DEPTH TO TOP OF PIPE MAX.	DEPTH TO TOP OF PIPE MIN.	R.C.P., N.R.C.P., C.M.P. & C.I.P.P. SIZE	R.C.P. (A.S.T.M. C-76) * REQUIRED "D" LOAD TO PRODUCE A 0.01" CRACK	N.R.C.P. * A.S.T.M. C-14 CLASS	CMP, TYPE D 2⅔ x ½ CORR. GAUGE	CMP, TYPE D 3 x 1 CORR. GAUGE	C.I.P.P. MIN. WALL THICK.
22+40	24+90	258'	8'	6.5'	24"	1250	3	14	N/A	2½"
24+90	32+05	715'	8'	5'	18"	1260	2	14	N/A	2½"
36+63.84	37+63.03	99'	14'	7'	18"	2000	N/A	14	N/A	2½"
37+63.03	48+19.09	1056'	12.6'	7'	48"	1700	N/A	14	N/A	4½"
48+19.09	57+04	885'	8.5'	4.5'	36"	1250	N/A	14	N/A	3½"

REVISION BY CITY OF PHOENIX

38

STORM DRAIN
ALTERNATE PIPE CHART

CITY OF PHOENIX, ARIZONA
ENGINEERING DEPARTMENT
THUNDERBIRD RD.
32ND ST. TO 40TH ST.
PROJECT NO. P-845750

SHEET NO. 72 TOTAL SHEETS 37

[redacted]

GREENWAY ROAD
PHOENIX STREETS MARICOPA CO.
35TH AVE. TO BLACK CANYON FREEWAY

MAJOR STREETS STORM DRAIN DESIGN SUMMARY SHEET

P-851246
MANN AND JOHNSON ENGINEERS, INC.
CONSULTING ENGINEER

Storm Drainage Design Data Paving Project M - P-851246 Location

Area No.	Inlet No.	Inlet Sta.	Total Area Acres	Zoning Factor	Imperv. Area Ai	Infiltration in/hr Ic	Street Slope ft/ft	Max. Dist.	Tc Min.	Inlet i	Pervious Q=.8(I-Ic)Ap	Impervious Q=.8(I-.2)Ai	Q	Average Upstream Gutter Slope ft/ft	Cross Slope At Inlet ft/ft	Flowby To This Catch Basin	Flowby + Runoff (Q)	Depth Of Water In Upstream Gutter	Width Of Water In Street	Gutter Velocity	Depth Of Sump @ Sump	Inlet Type	Q Accepted By C.B.	Flowby	To Inlet No.	Tc2 Main Storm Drain CONT Area Imper	Tc2 Main Storm Drain Tc (Min.)	Main Storm Drain i	Main Storm Drain Q2	Slope Main Storm Drain ft/ft	Size Main Storm Drain	Velocity Main Storm Drain f.p.s.	Length Main Storm Drain	ΔTc2 Min.	Elevation Crown Inlet	Elevation Crown Outlet	H.G.L. Sf ft/ft	H.G.L. HL ft	H.G.L. Elevation Inlet	H.G.L. Elevation Outlet	Head Between 0.8' Below Lip Gutter To H.G. Main	Length Conn. Pipe	Dia. Conn. Pipe	Depth Catch Basin
(1)a	(1)a	14+88.4 Rt.	0.41	1.00	0.41		0.0019	555	10.0	2.40		0.81	0.81	0.00184	0.0262	0	0.81	0.20	7.54	1.1		M.H. [illegible]	0.81	—	—	To Exist. 72"			35th	Ave. See	Bottom	of Summary Sheet												
(1)b	(1)b	(6)	1.68	0.25	0.42		0.0020	555	10.0	2.40		0.83	0.83	0.002	0.0133	0	0.83	0.15	11.43	1.0			0.83	—	—	0.83	30.3	1.4	66.71	Ex. 0.00453	Exist. 42"				89.11	89.10			[illegible]	90.80	4.61	36'	15"	4'-0"
																													65.55	↓	↓	6.81	21.3	0.1			0.00362	0.06						
(2)	(2)	15+09.7 Lt.	0.35	1.00	0.35		0.0015	426	10.0	2.40		0.69	0.69	0.00149	0.0261	0	0.69	0.17	7.39	1.0		P	0.69	—	—	0.35	30.2	1.4								89.69			92.55	90.52	4.83	2'	15"	4'-0"
	MH	17+60																									28.6		65.06	0.00316	New 42"	6.76	250.3	0.6		89.88	0.00357	0.89	91.47	91.08	Top Of MH 3.3			
(3)a	(3)a	19+36.3 Lt.	0.22	1.00	0.22		0.0015	300	10.0	2.40		0.44	0.44	0.0015	0.0200	0	0.44	0.15	7.38	0.8		P	0.44	—	—				65.06			6.76	176.3	0.4			0.00357	0.62						
(3)b	(3)b		0.12	1.00	0.12		0.0017	300	10.0	2.40		0.24	0.24	0.0017	0.0015	0.24	0.48	0.13	10.0	0.8			0.48	—	—	0.34	29.2	1.4								90.44			92.12	92.09	3.90	28'	15"	4'-0"
(4)a	(4)a	20+60.0 Rt.	0.33	1.00	0.33		0.0022	580	10.0	2.40		0.65	0.65	0.0022	0.0227	0	0.65	0.17	7.35	1.1		P	0.65	—	—				64.58			6.71	113.7	0.3			0.00351	0.43						
(4)b	(4)b		1.43	0.25	0.36		0.002	580	10.0	2.40		0.71	0.71	0.002	0.0206	0	0.71	0.17	8.21	1.0			0.71	—	—	0.69	28.9	1.4								90.80			92.63	92.35	3.52	36'	15"	4'-0"
																													63.61			6.61	195.0	0.5			0.00344	0.63						
	MH	22+45.0																									28.4									91.41			93.76	93.22	Top Of MH 4.20			
																													63.61			6.61	57.4	0.1			0.00341	0.19						
(5)	(5)	22+65.9 Lt.	1.85	0.25	0.46		0.008	790	10.0	2.40		0.91	0.91	0.0036	0.0307	1.48(4)	2.39	0.29	9.77	1.7		M-1 L=10'	2.39	—	—	0.46	Incl. w/		#6											[illegible]	1.65(4)	32'	15"	3'-0"
(6)	(6)	23+02.4 Lt.	33.24	0.25	8.31		0.005	3310	26.5	1.55		10.10	10.10	0.0026	0.030	0	8.62(6)	0.46	15.93	2.3		M-1 L=17'	8.62	1.48	5	8.77	28.5	1.4								91.59			93.9[illegible]	93.05	3.06	91'	18"	5'-0"
																													51.98			5.40	24.6	0.1			0.00228	0.05						
(7)a	(7)a	23+27.0 Lt.	0.21	1.00	0.21		0.0028	343	10.0	2.40		0.42	0.42	0.0028	0.0219	0	0.42	0.13	6.10	1.0		P	0.42	—	—																			
(7)b	(7)b		1.38	0.25	0.35		0.0028	343	10.0	2.40		0.69	0.69	0.0028	0.006	0	0.69	0.10	14.90	0.9			0.45	0.24	3b	0.56	28.2	1.4								91.67			93.97	93.93	2.64	28'	15"	4'-5"
																													51.20			5.32	348.0	1.1			0.00221	0.76						
(8)a	(8)a	26+75.0 Rt.	0.54	1.00	0.54		0.0028	740	10.0	2.40		1.07	1.07	0.0028	0.0190	0	1.01	0.18	9.46	1.3		M-1 L=3.5'	1.01	—	—																			
(8)b	(8)b		2.03	0.25	0.51		0.0028	740	10.0	2.40		1.01	1.01	0.0028	0.0174	0	1.07	0.17	9.70	1.2			1.07	—	—	1.70	27.1	1.4								92.73					2.82	35'	15"	4'-0"
MH	(8)c	26+75.0 Lt.																																					94.94	94.75				
(8)c	(8)c	26+75.0 Lt.	0.38	1.00	0.38		0.0028	455	10.0	2.40		0.75	0.75	0.0028		0	0.75	0.17	7.58	1.2		M-1 L=3.5'	0.75	—	—																2.96	28'	15"	4'-0"
(8)d	(8)d		1.38	0.25	0.35		0.0028	400	10.0	2.40		0.69	0.69	0.0028		1.56+0.16	2.25	0.22	14.44	1.4			2.25	—	—	0.78	Incl. in		#8a	↓	↓													
(9)a	(9)a	30+70.7 Lt.	0.16	1.00	0.16		0.0031	270	10.0	2.40		0.32	0.32	0.0031	0.0292	0	0.32	0.13	4.51	1.1		M-1 L=3'	0.32	—	—	0.16	Incl. in		#9b												3.38	19'	15"	4'-0"
MH	(9)	30+93.8 Lt.																											48.78			5.07	418.2	1.4			0.00200	0.83	95.[illegible]	95.67	HL=0.32	107'	18"	
(9)b	(9)b	31+07.5 Lt.	15.61	0.25	3.90		0.005	2020	15.0	2.00		6.32	6.32	0.0025	0.0261	0	6.32	0.40	15.82	2.0		M-1 L=17'	4.90	1.42	8d	4.06	25.7	1.5		0.00316	New 36"				93.6[illegible]	94.10					3.43	11'	15"	4'-0"
																													42.78			6.05	39.0	0.1			0.00350	0.13						
(10)a	(10)a	31+32.2 Lt.	0.50	1.00	0.50		0.0037	680	10.0	2.40		0.99	0.99	0.0037	0.0238	0.16	1.15	0.19	8.02	1.5		M-1 L=3.5'	1.15	—	—																			
(10)b	(10)b		4.00	0.25	1.00		0.004	910	10.0	2.40		1.98	1.98	0.004	0.0111	0	1.98	0.17	15.64	1.5			1.84	0.14	8d	1.50	25.6	1.5								93.72			95.95	95.77	2.51	28'	15"	4'-0"
																													39.14			5.54	306.1	0.9			0.00394	0.90						
(11)	(11)	34+38.3 Rt.	1.03	0.92	0.94		0.005	610	10.0	2.40		1.86	1.86	0.0032	0.0188	0	1.86	0.22	11.45	1.5		M-1 L=10'	1.50	0.36	[illegible]	0.94	24.7	1.6								94.68			96.87	96.85	3.95	35'	15"	4'-0"
																													38.64			5.07	368.4	1.1			0.00286	1.05						
(12)a	(12)a	38+06.7 Lt.	0.41	1.00	0.41		0.005	500	10.0	2.40		0.81	0.81	0.0057	0.0234	2.41	3.27	0.26	11.3	1.2		P	1.74	1.48	10a																			
(12)b	(12)b		0.80	0.25	0.20		0.0046	245	10.0	2.40		0.40	0.40	0.0046	0.0200	0	0.40	0.12	6.54	1.6			0.40	—	—	0.61	23.6	1.6								95.85			97.97	97.92	3.46	26'	15"	3'-6"
—	(12)c	39+96.8 Lt.	—	—	—		—	—	—	—		—	—	0.0057	0.025	8.03	8.03	0.37	14.8	3.0		M-1 L=17'	5.62	2.41	12		22.8	1.6	37.66(10)			5.33	190.0	0.59		96.45	0.002714	0.52	98.7[illegible]	98.50	3.55	26'	15"	4'-0"
(13)	(13)	40+49.7 Lt.	5.98	0.25	1.50		0.005	2160	16.0	1.95		2.36	2.36	0.0027	0.0230	13.76(12)	18.32	0.57	23.52	2.3		M-8 L=17'	14.11	4.21	12c	1.50	22.8	1.6	29.63			4.19	53.0	0.21		96.62	0.001577	0.09	97.53	98.88	3.89	83'	18"	5'-0"
																													(9)			2.20	57.8	—			0.00046	0.03						
(14)	(14)	41+07.5 Lt.	75.87	0.36(7)	27.09		0.005	3080	22.8	1.60		34.13	34.13	0.0024	0.0243	0	18.17(13)	0.60	23.48	2.4		M-2 L=17'	14.35	3.82(13)	12c	27.09	22.8	1.0	15.52		(13)					96.80			99.56	99.56	3.75	83	18"	5'-0"
																													1.17	↓	↓	0.17	14.4	1.4			0.000003	0.00						
(15)	(15)	41+21.9 Rt.	0.22	1.00	0.22		0.0069	240	10.0	2.40		0.44	0.44	0.0069	0.0203	0	0.44	0.10	5.1	1.7		M-1 L=6'	0.44	—	—	0.22	22.8	1.6								96.84			99.56	99.56	4.34	36'	15"	4'-0"
																													0.82			0.12	18.3	2.5			0.000001	0.00						
	(16)	41+40.2 Lt.	0.54	1.00	0.54	Freeway	Drainage	Channel	10.0	2.40		1.07	1.07			0	1.07					Drop Inlet	1.07	—	—	0.54	22.8	1.5		0.00316	New 36"				96.40	96.90				99.56	[illegible]	35'	30"	
	(1)	14+88.4(2) 34+88.4					Continued	From Above																		ΣAi=37.72	30.3								89.11	89.10				90.40	From Top Of Sheet			
The	Starting H.G.L.	Below	Is Based on	Data	Taken	From the	"Drainage	Design	Report (35th Ave - Thunderbird to Greenway)"													C.O.P. #P-78008	Dated	May	1975				66.71	Ex. 0.0045	Ex. 42"	6.97	11.4				0.00375	0.04						
	22	34+77																																					90.36					
835	Sta.	20+48.6																											72.84 (Ave.)	Ex. 0.0045	Ex. 42"		1828.4				0.00445	6.36	8[illegible].30(3)					

(1) A Max. Q Of 44.0 cfs Will Enter This Drop Inlet From The Freeway Pumps & D.A. East Of The Freeway, But Will Not Be Used To Compute The H.G.L. For Connector Pipe Purposes.

(2) 14+88.4 + 20100.0 (@ 35th Ave): 34+88.4

(3) Crown of 72" Pipe in 35th Ave. & Greenway Rd.

(4) H_L Per Page 33 COP Storm Drain Design Manual.

(5)

(6) a&c: For Street Side; b&d: For Frontage Road Side } Except #9.

(7) From Drainage Area Composites, Pg. 5 DP Report

(8) Same As Tc For D.A. #14

(9) Qz = C.B. Accepted Q (14.35) + 1.17 cfs = 15.52

(10) Qz = 14.35 + 1.17 + 14.11 + 8.03 = 37.66

(11) Cont. Area Is The Drainage Area That Contributes To The Runoff At The Tc Shown.

(12) ½ Street Flow Capacity

(13) Over the Crown Flow Due to Excessive ½ Street Capacity

NOTE: The N.W. Drainage Study Shows A Q Of 53.0 c.f.s. At Greenway Rd & 35th Ave.

(14) 30" ⌀ Pipe extended to collect Q from Freeway Pumps & D.A. East of I-17 for Tc. (See Note 1)

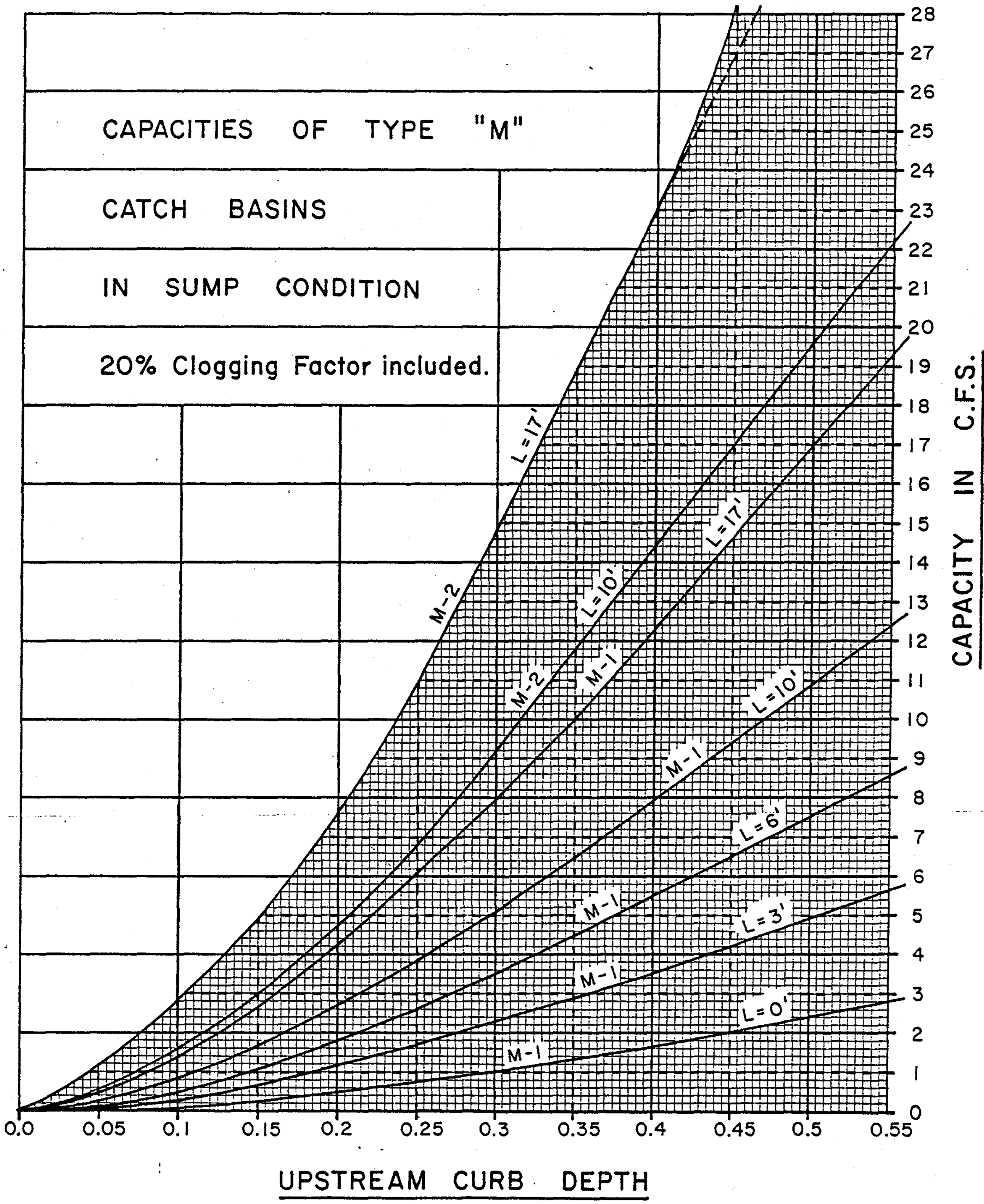
CITY OF PHOENIX, ARIZONA
ENGINEERING DEPARTMENT
GREENWAY ROAD P-851246
35TH AVENUE TO
BLACK CANYON FREEWAY

REVISED JAN. 18, 1984 FLZ

FIG. 2

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 .0 .1 .2 .3 .4 .5 .6 .7 .8

CAPACITY IN C.F.S.


CAPACITIES OF TYPE "M"
CATCH BASINS
IN SUMP CONDITION
20% Clogging Factor included.
M-2
L=17'
M-2
L=10'
M-1
L=17'
M-1
L=10'
M-1
L=6'
M-1
L=3'
M-1
L=0'
0.0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
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CAPACITY IN C.F.S.
UPSTREAM CURB DEPTH