CITY OF SAN DIEGO

DRAINAGE DESIGN MANUAL

APRIL • 1984

ADDENDUM
TO THE
DRAINAGE DESIGN MANUAL

(MARCH 1989)

A. On page 1, under 1-101.2, BASIC OBJECTIVES, paragraph A. shall read:

> A. Objectives are to collect, transmit, and discharge drainage in a manner to promote public health and safety, to provide for low maintenance, and to protect the environment by:

B. On page 2, under 1-101.3, BASIC POLICY ON DRAINAGE DESIGN, <u>Add</u>:

> Any drainage facility shall be designed for low maintenance and shall protect the environment.

C. On page 7, under 1-103.2, SERVICE LIFE, <u>Add</u> paragraph:

> B. Metal, polyethylene or PVC conduit shall not be used where 100-year service life is required.

D. On page 7, under 1-103.2, SERVICE LIFE, paragraph A., delete item 6.

E. On page 11, under 1-103.6, INLET DETAILS, D. (2) shall read:

> D. (2) Minimum pipe grade shall be five-tenths of one percent (0.5%).

F. On page 20, under 1-103.8, ANCHORAGE ON SLOPES / SLOPE DRAINS, <u>Add</u> under paragraph C:

> Under difficult installations situations, metal pipe may be used if it is encased with a minimum of six inches of concrete all around the pipe.

G. On page 25, 1-103.15, SPECIAL DESIGN CONDITIONS, under paragraph A., Case-in-Place Pipe, <u>Add</u> items (11) and (12):

> (11) "n" value = 0.015
>
> (12) The following conditions and restrictions shall apply to the use and design of cast-in-place pipe:

1. No abrasive materials in the flow.

Velocity (feet per second)	Additional Wall Thickness (inches)	Concrete Strength (pounds per square inch)
10	0	Standard
10 to 20	1/2	5,000
20	Cast-in-place pipe shall not be used.	

2. Abrasive materials in the flow.

Velocity (feet per second)	Additional Wall Thickness (inches)	Concrete Strength (pounds per square inch)
5	1/2	5,000
5 to 10	1	5,000
10 to 15	1-1/2	5,000
15 to 20	2	5,000
20	Cast-in-place pipe shall not be used.	

The above listed thicknesses are in addition to the standard or design thickness and shall apply to the lower 120 degrees of the conduit and shall be considered sacrificial and shall not be included in a structural analysis.

2. On page 27, items C. and C.(1) shall read:

C. Aluminum, Aluminized-Steel and Steel Pipes, Arches, etc.

(1) Aluminum, aluminized-steel and steel pipe shall be classified with the type of applied protective coatings and linings as follows:

Classification	Plan Designation	
	Aluminum	Metal
Plain	CAP	CMP
Polymer		PLC
Bituminous coated dipped	- -	CMPC
Fully Bituminous lined	- -	CMPL
Bituminous coated and lined	- -	CMPCL

Classification	Plan Designation	
	Aluminum	Metal
Paved Invert	- -	CMPI
Asbestos Bonded	- -	CMPB
Paved Invert, asbestos bonded	- -	CMPBI

NOTE: All CMP shall be hot-dipped galvanized. CMP means steel pipe. Metal refers to steel.

I. On page 28, items (2) and (3) at the top of the page shall read:

(2) All steel pip, arches, etc, shall be hot-dipped galvanized.

(3) Steel products shall be shipped and handled in such a manner as to prevent bruising, scaling or breaking of the galvanized surface or protective coating.

J. On page 28, under 1-103.17, SERVICE LIFE AND LIMITATION ON USE, paragraph A. shall read:

A. Corrugated and Spiral Rib Aluminum Conduit and Aluminized-Steel Conduit.

Item (7) shall read

(7) Maximum velocity shall be 5 fps.

K. On page 29, paragraph B. shall read:

B. Corrugated and Spiral Rib Steel Conduit

L. On page 29, under paragraph B., Corrugated and Spiral Rib Steel Conduit, item (3) shall read:

(3) Sixty (60) year minimum life- -not to be used where one hundred (100) year life is required.

M. On page 29 under paragraph B., Corrugated and Spiral Rib Steel Conduit, item (6) shall read:

(6) Maximum velocity shall be 5 fps.

N. On page 70, under 1-104.12, STREET DRAINAGE, paragraph D. shall read:

> D. The minimum street and gutter grade permitted is 0.6%.

O. On page 141, under paragraph 14, item d. shall read:

> d. Notation that all pipe openings are closed, and kept closed, for at least seven (7) days.

P. On page 7, 1-103.3, MINIMUM CONDUIT SIZE, shall read:

> 1-103.3 CONDUIT SIZE
>
> The minimum conduit size shall be the equivalent of an 18-inch circular pipe in cross-sectional area.
>
> Circular conduit shall be in 6-inch increments only (i.e., 18 inches, 24 inches, 30 inches, etc.). Conduits shall not have odd sizes such as 27 inches in diameter.

ACCEPTABLE PRODUCTS

I. Corrugated Polyethylene (CPEP) Pipe

Description - This specification covers the furnishing and placing of corrugated polyethylene storm drain pipe in nominal diameters 18 inches through 36 inches for storm drain projects.

Only CPEP, which has a smooth interior lining providing for increased hydraulics and additional stiffness, will be allowed.

Materials
Pipe: The pipe and fittings shall be manufactured in accordance with the following specifications:

AASHTO M-294 latest addition. Minimum stiffness at 5 percent deflection per ASTM D-2412 shall be as follows:

Diameter	Stiffness
18 inches	40
24 inches	34
30 inches	28
36 inches	22

Joints: The pipe shall have split couplings with nylon ties. Neoprene sponge gaskets mounted in the couplings shall be furnished by the pipe manufacturer. Maximum allowable deflection at joints shall be 5 degrees. Other joint systems must be approved by the engineer.

Installation - Corrugated polyethylene pipe may be exposed the rays of the sun.

The minimum allowable trench width is two feet wider than the outside diameter of the pipe, or if a soil/cement slurry is used, the minimum allowable trench width is six inches wider than the outside diameter of the pipe. The pipe shall be centered in the trench.

The minimum allowable cover is 24 inches to finished grade. The maximum allowable cover shall conform to the manufacturer's requirements.

II. Plastic Pipe

Plastic pipe culverts shall be either corrugated smooth-interior high density polyethylene (HDPE), ribbed smooth-interior polyvinyl chloride (PVC) or high density polyethylene (HDPE) smooth-interior pipe.

Corrugated smooth-interior HDPE plastic pipe culverts shall conform to AASHTO Designation M294 and ribbed smooth-interior PVC plastic pipe culverts shall conform to AASHTO Designation F794. The inside diameter and diameter tolerances shall conform to the requirements of AASHTO Designations M294 or F794.

The materials for HDPE pipe and fittings shall be virgin compounds which have a minimum cell classification of either 315412C, 334433C or 335434C and conform with the requirements of ASTM Designation D3350.

The materials for PVC pipe and fittings shall be virgin compounds which have a minimum cell classification of 12364C and conform with the requirements of ASTM Designation D1784.

III. Reinforced Thermosetting Resin (RTR) Coupling for Concrete Pipe

IV. Precast Cleanouts and Inlets

The design and specifications for these products, polyethylene pipe, plastic pipe, RTR coupling and precast cleanouts and inlets shall be shown and specified on the engineering plans.

City of San Diego
Drainage Design Manual

April 1984

Mayor

ROGER HEDGECOCK

City Council

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BILL CLEATOR	Second District
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ACKNOWLEDGMENTS

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State of California Department of Water Resources

Los Angeles County Flood Control District

City of Los Angeles

San Diego County Engineering Department

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DRAINAGE DESIGN (1-100)

BASIC POLICIES (1-101)

1-101.1 INTRODUCTION

The purpose of this section is to provide policies and procedures to attain reasonable standardization of drainage design throughout the City and coordination with procedures of the County and other local jurisdictions.

Adequate designs for each project should provide for removal of runoff from the roadway or the upstream end of any development, and for carrying runoff water from the upstream side to the downstream side. These functions should be accomplished without causing objectionable backwater, causing excessive or increased velocities, creating damages to downstream ownerships, or unduly affecting the safe operation of traffic on the roadway. Design criteria for drainage should be selected to provide for safe operation of vehicular and pedestrian traffic and to prevent damage to any adjacent property. The goal of drainage design is to provide optimum facilities considering function versus cost, rather than to design facilities that just meet arbitrary minimum standards.

1-101.2 BASIC OBJECTIVES

A. Objectives are to collect, transmit and discharge drainage in a manner to promote public safety and provide for low maintenance by:

   (1) Calculating the amount and frequency of storm runoff.

   (2) Determining the natural points of concentration and discharge and other hydraulic controls.

   (3) Determining the necessity for protection from floating trash and from debris moving under water.

   (4) Determining the requirements for energy dissipation and slope protections.

   (5) Analyzing the deleterious effects of corrosive soils and waters on drain pipe and structures.

   (6) Minimizing scour and siltation of natural stream beds, canyons and lagoons.

   (7) Preventing the diversion of drainage.

(8) Providing for public health and safety.

(9) Preventing property damage.

(10) Comparing and coordinating proposed design with existing structures and systems handling the same flows.

(11) Coordinating with other agencies the proposed designs for facilities.

(12) Providing access for maintenance operations.

(13) Providing for removal of detrimental amounts of subsurface water.

(14) Design of the most efficient drainage facilities consistent with good drainage practices and considering economic considerations, ease and economy of maintenance, safety, legal obligations and aesthetics.

1-101.3 BASIC POLICY ON DRAINAGE DESIGN

In drainage design, the basic consideration is to protect the roadway and property against damage from artificial, storm and subsurface waters, to provide for public health and safety, and taking into account the effect of the proposed improvement on traffic and property. Diversion of drainage is not permitted.

Private drainage is defined as drainage on or from private property. Private drainage can be sheet flow, open channel, or via an underground pipe system.

All concentrated private drainage from an area of one (1) acre or greater shall be taken to the gutter via a D-25 underdrain turned 30° to 45° with the gutter flow from property line. The use of the sidewalk underdrain pipe D-27 should be considered for any site development where small anticipated artificial or natural flows might cause a nuisance flow over the sidewalk area.

Public drainage is defined as drainage originating within the public right-of-way or drainage that is carried within a drainage system located within a drainage easement granted to the City. Private street drainage is not public drainage but is designed to public standards.

No pipe product unless formally approved herein, or by separate specific approval by the City Engineer, may be installed as a public drain. On occasion, short segments of new pipe products may be used with the specific review and written approval of the City Engineer.

1-101.4 POLICY ON COOPERATIVE DRAINAGE PROJECTS

The City may participate in cooperative projects for storm drains in accordance with Council Policy 800-4.

1-101.5 ECONOMICS OF DRAINAGE DESIGN

A. Economic comparisons of drainage designs, where a choice is available, should consider the following factors:

(1) Initial cost of construction and right-of-way.

(2) Extra cost for safety and aesthetics.

(3) Useful life and cost of replacement, lining or extensions.

(4) Cost effects of the facilities on property, such as a reduction in value, and particularly as to protection of City liability for personal injury or property damage.

(5) Cost to the traveling public of any delays or extra travel distance occasioned by road closures.

(6) Maintenance costs for cleaning, repair, traffic control and all other pertinent maintenance costs that may occur during the total life of the facilities.

(7) Justifiable extra costs for access or oversize to allow the use of maintenance equipment.

(8) Inlet and outlet control.

1-101.6 SUBMITTAL OF PRELIMINARY HYDRAULIC DATA TO THE CITY

Submittal of hydraulic data and preliminary plans for drainage structures to the City are required for approval.

A. Data to be provided with the plans may include:

(1) Hydrology studies, including design Q and frequency.

(2) Hydraulic design studies and reports.

(3) Hydraulic and/or energy grade lines.

(4) Inflow-outflow hydrographs.

(5) Stream velocities.

(6) Design water surface profiles.

(7) Slope protection limits.

(8) Subsurface investigations.

(9) Specifications, estimates.

(10) HEC II Computer run based on subcritical flow velocities (regardless if actual frequency flow is supercritical) for all projects within the Federal Emergency Management Agency (FEMA) regulation limits and any other one hundred (100) year frequency or greater storm flow requirements.

(11) Any other data necessary for adequate review.

(12) HEC II or FLUVIAL 11 Computer runs where appropriate for bridge construction in a watercourse.

1-101.7 REQUIREMENTS FOR DRAINAGE STUDIES

A. On-site drainage studies shall be made on 200 scale topo sheets or a scale readable and workable on one sheet. Off-site drainage studies may be made on other scales depending on the drainage area and necessary details for an appropriate and readable study.

B. Drainage studies must include:

(1) Quantity of flow at each inlet or intercepter.

(2) Quantity of flow and direction in street gutters within each street involved in the improvement and off-site as required to completely identify the flow received and discharged from the project.

(3) Topo sheets must show readable contours.

(4) All existing drainage systems involved, with quantity of flow shown.

(5) Entire proposed improvement plotted.

(6) All proposed drainage systems with quantities and velocities shown.

HYDROLOGY (1-102)

1-102.1 GENERAL

The design discharge depends upon many variables. Some of the more important are duration and intensity of rainfall, storm frequency, ground cover, the size, imperviousness and slope and shape of the drainage area.

1-102.2 DESIGN RUNOFF

Design runoff shall be based upon the following:

(1) Within floodplain and floodplain fringe areas as defined by the Federal Emergency Management Agency (FEMA), the runoff criteria shall be based upon a 100-year frequency storm.

(2) For all drainage channels and storm drain systems, which will convey drainage from a tributary area equal to and greater than one (1) square mile, the runoff criteria shall be based upon a 100-year frequency storm.

(3) For tributary areas under one (1) square mile:

  (a) The storm drain system shall be designed so that the combination of storm drain system capacity and overflow will be able to carry the 100-year frequency storm without damage to or flooding of adjacent existing buildings or potential building sites.

  (b) The runoff criteria for the underground storm drain system shall be based upon a 50-year frequency storm.

(4) Type D soil shall be used for all areas.

1-102.3 DESIGN RUNOFF METHODS

A. The designer should check with Floodplain Management/Beach Erosion Section, Transportation Design Division, Engineering and Development Department, to determine if there are established storm discharge flows.

B. If no established storm discharge flows are available, the applicable methods shown in Appendix 1, 2, or 3 shall be used.

(1) Storm discharge flows shall be based on:

(a) Watersheds less than 0.5 square mile - Rational Method. See Appendix 1.

(b) Watersheds 0.5 - 1 square mile - Modified Rational Method. See Appendix 2.

(c) Watersheds greater than 1 square mile - SCS Methods, tabular or computer, or U. S. Army Corps of Engineers - HEC I computer method. See Appendix 3.

(d) Design runoff for drainage and flood control facilities within the City shall be based upon full development of the watershed area in accordance with the land uses shown on the City of San Diego, Progress Guide and General Plan.

(e) When determining criteria for floodplain management and flood proofing, design runoff within the City shall be based upon existing conditions in accordance with the City Floodplain Management Requirements and the Federal Emergency Management Agency (FEMA) Regulations. Under City requirements, the minimum elevation of the finished, first floor elevation of any building is two (2) feet above the 100-year frequency flood elevation.

UNDERGROUND CONDUITS (1-103)

1-103.1 INTRODUCTION

Hydraulics, debris and detritus, maintenance, inlet conditions, outlet conditions, safety, the effects on traffic, property, economics and aesthetics shall be considered in the design of all underground conduits.

1-103.2 SERVICE LIFE

The minimum design service life for all underground conduits shall be sixty (60) years.

A. The service life for underground conduits shall be 100 years when:

   (1) The height of cover is in excess of fifteen feet (15').

   (2) The conduit is or may be located under a structure or the overhang of a structure.

   (3) Located within the traveled way of 4-lane collector, major and prime arterial streets.

   (4) Storm drains adjacent to or between structures which are located horizontally a distance equal to or less than the vertical pipe cover depth in feet from the structure to the center line of the pipe.

   (5) Any storm drain pipe under a pressure head.

   (6) ~~All slope drains.~~ B SEE ADDENDUM

1-103.3 MINIMUM CONDUIT SIZE

is 18" (ADDENDUM) 6" increments no odd size #27"

The minimum conduit size shall be the equivalent of an 18-inch circular pipe in cross-sectional area.

1-103.4 MINIMUM GRADIENT

The minimum gradient shall be governed by an 0.5 percent grade, or by a minimum velocity of four feet (4') per second with the pipe flowing one quarter full. Flatter grades may be approved where no other practical solution is available. Conduits shall be designed to flow full and free of pressure heads except for short runs where the grade changes and a small pressure head cannot be avoided. Where it is necessary to design for a pressure head in a system and it is approved by the City Engineer, pressure pipe with water-tight joints shall be used (100 year service life).

1-103.5 CLEANOUT DETAILS

For purposes of design, the definition of a cleanout under this section shall mean those structures designated as cleanout, curb inlet or catch basin in City of San Diego Standard Drawings.

A. Cleanout Spacing - The maximum length in feet between cleanouts for straight runs of conduit shall be as follows:

(1) Conduit under an equivalent diameter of 30", approximate maximum spacing of 300 feet.

(2) 30" to 41", 400 feet.

(3) 42" to 59", 600 feet.

(4) 60" and over, 800 feet.

(5) When a private storm drain system changes and becomes public, a cleanout shall be provided at the change to initiate the public system.

B. Cleanouts; Horizontal Curves or Angle Points

(1) Cleanouts should be installed near one end of all horizontal curves in the conduit where possible, and maintain the maximum spacing.

(2) A cleanout shall be installed near one end of a horizontal curve when radius is 100 feet or less.

(3) A cleanout shall be installed at the P.C.C. and/or P.R.C. of curves.

(4) A cleanout shall be installed at all horizontal angle points, except a single angle of 10° or less will be permitted between cleanouts provided:

(a) The angle point does not combine a horizontal and vertical curve.

(b) The angle point is located within forty feet (40') of a cleanout or outfall.

(c) Abrasive bed load materials, under relatively high velocities (15 F.P.S. or greater) will not occur.

C. Cleanouts; Vertical Curves or Angle Points

(1) Normally on sag vertical curves the cleanout should be located at the end connecting the flattest grade.

(2) A cleanout shall be installed at vertical angle points, except a single angle of 10° or less will be permitted between cleanouts provided:

(a) The angle point does not combine a horizontal and vertical curve.

(b) The angle point is located within ten feet (10') of a cleanout or outfall.

(c) Abrasive bed load materials under relatively high velocities (15 F.P.S. or greater) will not occur.

(3) An angle of deflection of 30° within ten feet (10') of an outfall may be approved, provided a factory manufactured elbow (10° max. angle points) is used. Should the conduit ever be extended from this outfall, a cleanout shall be provided at this point. Should the direction of the pipe change more than a total of 30° in the vertical or horizontal direction from the top of slope to bottom of slope, a cleanout is required at the bottom angle point.

When a pipe size or type is changed, make the change in a cleanout or inlet structure.

The design shall make sure that the energy gradient is six inches (6") lower than the bottom of the roof slab on a cleanout.

1-103.6 INLET DETAILS

A. Type of inlet to be used when an inlet shall be required as follows:

(1) Type "A" Curb Inlet - May only be used where there is no room behind the curb (due to existing conditions) to accommodate other curb inlets, or will provide the most efficient design for a particular problem.

(2) Type "B" Curb Inlet - To be used as the basic inlet to intercept street drainage.

(3) Type "C" Curb Inlet - Not permitted where street grade is less than five percent (5%). May be used to gain additional inlet capacity of two (2) C.F.S. maximum when a Type "B" curb inlet is slightly insufficient and combined with a street grade over five percent (5%).

(4) Type "D" Curb Inlet - Not permitted in the City of San Diego.

(5) Type "E" curb Inlet - Not permitted without special approval.

(6) Type "F" Catch Basin - To be used to intercept surface drainage from ditches or swales outside of traveled ways. Not permitted adjacent to sidewalks, bikeways or trails for public use.

(7) Type "G" Catch Basin - Not to be used, use Type "I" catch basin.

(8) Type "H" Curb Inlet - Not permitted in the public right-of-way (to be used in alleys, parking areas or similar paved areas).

(9) Type "I" Catch Basin - Only to be used under special conditions and with prior approval. May be used in alleys.

(10) Inlet aprons shall be limited to parking lanes only.

(11) Use curb inlet - Type "J" Median (D-45) for center median inlets (four feet (4') maximum opening L=5' Max.). Do not depress the gutter beyond the lip of the gutter i.e., not into the driving lane.

(12) Sidewalk Underdrains - Use Type "A" curb outlet (D-25) for 0.5 C.F.S. to 4.0 C.F.S.; sidewalk underdrains(s) D-27 for flows to 0.5 C.F.S. D-26 is not permitted in the City of San Diego.

(13) Minimum inlet opening length is four feet (4'), L = 5'.

(14) Maximum inlet opening length is twenty feet (20'), L = 21'.

(15) All drainage shall be intercepted and collected at superelevated roadway transition sections where concentrated flows are not permitted to cross traveled lanes under the design storm frequency for the street. Median inlets shall be designed and spaced so the lane adjacent to the median (number one lane or fast lane of traffic adjacent to the median) is free from drainage flow for the design storm frequency.

(16) At tee intersections, drainage from the terminating or side street shall be picked up in an inlet when the street grade exceeds five percent (5%) and for flatter grades when the gutter flow will encroach or overrun the cross gutter.

(17) The basic criteria for storm drain inlet design shall be that any inlet will be sized to accept one hundred percent (100%) of the drainage received without bypass for the design storm frequency required for the system. Storm flows in the public right-of-way should be picked up at subdivision boundaries.

(18) Any wing on an inlet shall be constructed on the upstream side.

B. Curb inlets under Section 1-103.6 Item A may be used at any approved location in the curb on grades up to five percent (5%). Grades in excess of five percent (5%) may necessitate the use of a concrete apron within the parking lane, additional inlets, or other special inlet design as approved by the City Engineer.

C. Inlet capacities may be determined by CHART 1-103.6A, CHART 1-103.6B, and CHART 1-103.6C.

D. Slotted drain pipe may be used in certain approved, select locations or to increase the capacity of curb inlets, where justified, providing it meets the following conditions:

(1) Minimum pipe size shall be eighteen inches (18").

(2) Minimum pipe grade shall be five percent ~~(5%)~~. 0.5%

(3) Minimum slot height shall be six inches (6").

(4) Pipe shall be 16 gage or heavier.

(5) Pipe shall conform to the minimum allowable service life for underground conduits (see 1-103.2).

(6) All drain pipes/conduits shall be designed to withstand an H-20 loading.

(7) Maximum length of any one run of slotted pipe shall be sixty feet (60').

(8) The slotted pipe trench shall be backfilled and encased from below the bottom of the pipe with 420 B 2500 concrete to the subgrade of the final surface course of the traveled way.

(9) Length of slotted pipe required may be determined from CHART 1-103.6D and CHART 1-103.6E.

(10) Use of slotted drain pipe should be discouraged in areas of heavy pedestrian traffic. Expanded wire mesh heel guards shall be attached across the top of the open slot when pipe is approved in pedestrian traffic areas.

(11) Slotted drain pipes shall be used parallel to concrete median barriers for drainage pickup. These shall be collected in a Type I inlet (grate must be anchored).

(12) A cleanout shall be installed at one end of a run of slotted drain pipe.

(13) Hot dipped galvanized protection is required for CMP slotted drain pipe.

E. All inlets shall be designed to make sure that the energy gradient is a minimum of six inches (6") lower than the gutter grade or grate, for grated inlets, whichever is lower.

CHART 1-103.6 A

CAPACITY OF CURB OPENING INLETS

ASSUMED 2% CROWN.

$$Q = 0.7L\ (A+Y)^{3/2}$$

*A = 0.33

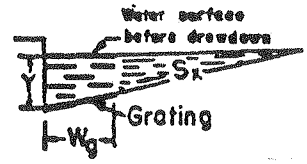
Y = HEIGHT OF WATER AT CURB FACE (0.4' MAXIMUM)
REFER TO CHART 1-104.12

L = LENGTH OF CLEAR OPENING OF INLET

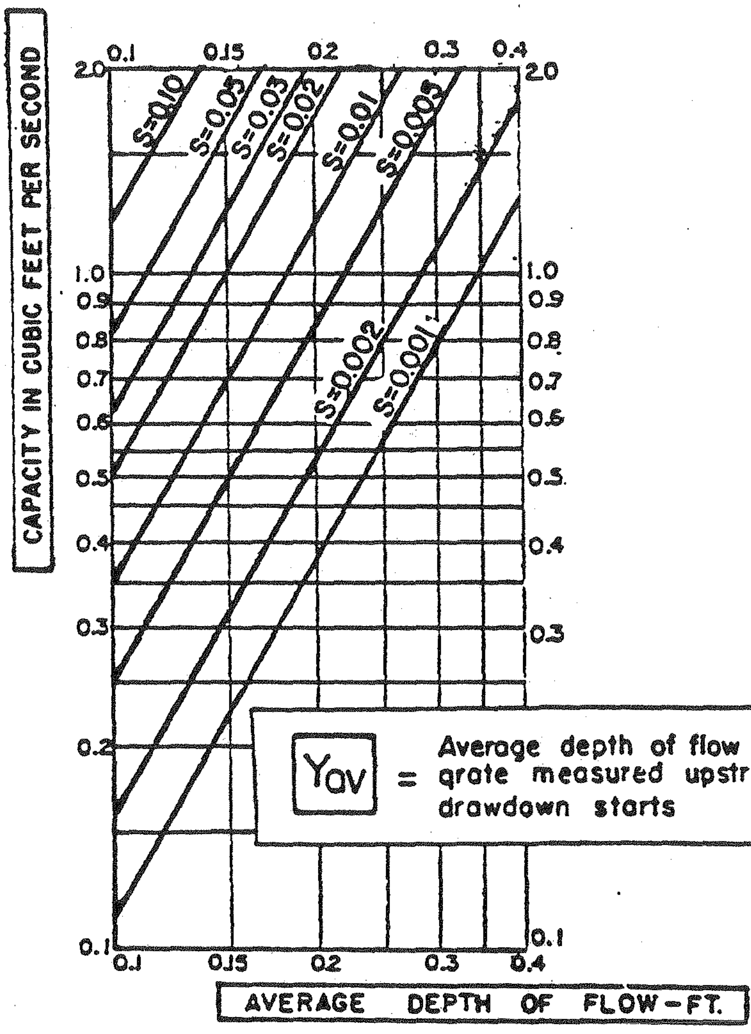
*Use A=0 when the inlet is adjacent to traffic; i.e., for a Type "J" median inlet or where the parking lane is removed.

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		CAPACITY OF CURB OPENING INLETS	

CHART I-103.6B



STANDARD GUTTER



$$Y_{av} = \text{Average depth of flow over the grate measured upstream before drawdown starts} = Y - \left(\frac{W_g S_x}{2}\right)$$

NOTES:

PARAMETERS

Y = Maximum depth at curb
S = Longitudinal slope – ft/ft.
S_x = Cross slope – ft./ft.

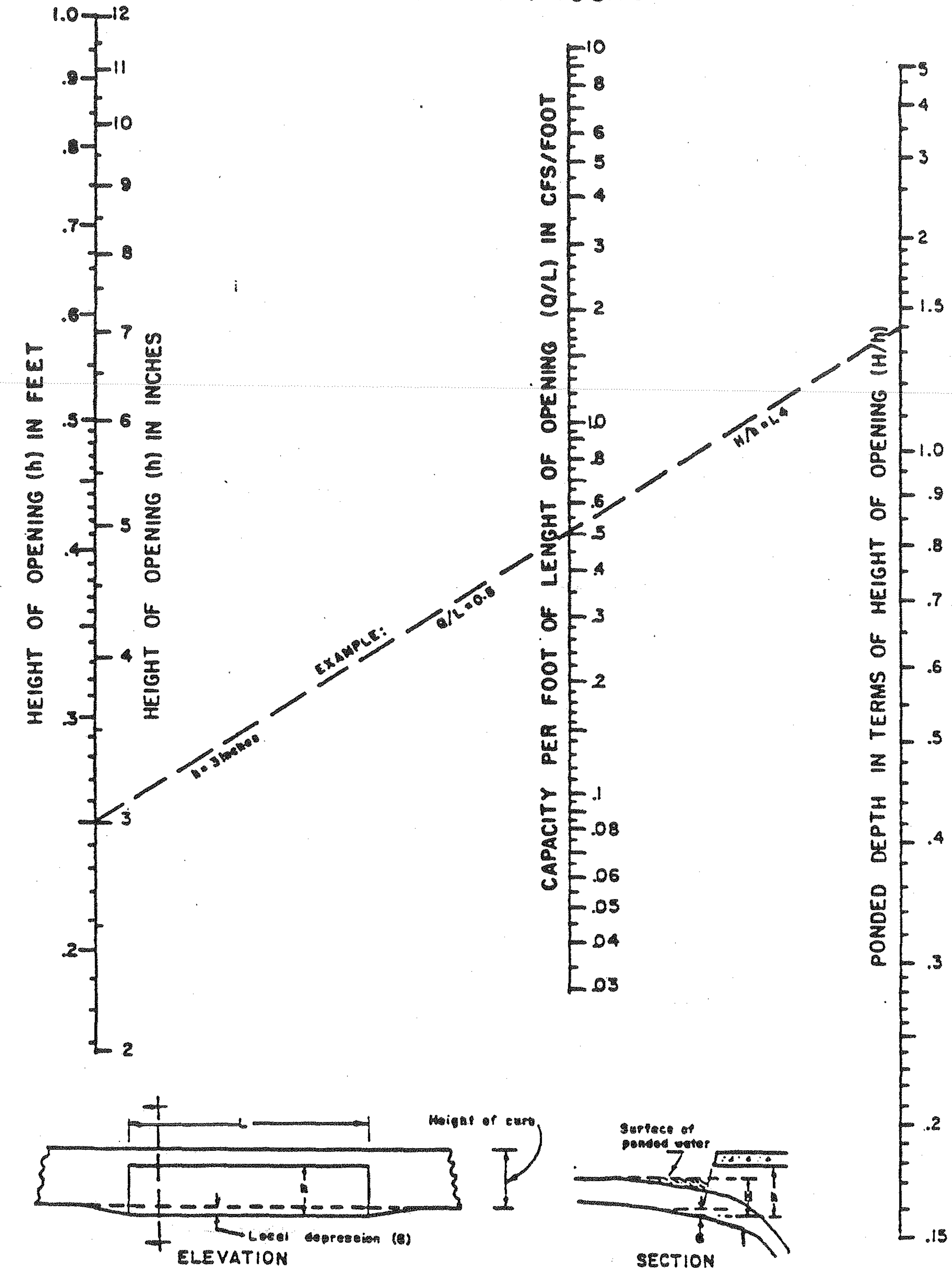
GRATE DATA

Clear length – 35 3/8"
Clear width (W_g) – 24"
Spacing between Bars – 1", 1 3/8" and 2"

NOTE: For grades of 10% or steeper - no capacity credit is allowed.

SHT. NO.	CITY OF SAN DIEGO - DESIGN GUIDE	REV.	
	CAPACITY CURVES FOR GRATING INLETS For complete interception over the grate, All Bar Spacings		

CHART I-103.6C



REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		NOMOGRAM—CAPACITY, CURB INLET AT SAG	

CHART I-103.6D

FOR SLOT ON INDICATED GRADE IN CURB AND GUTTER INSTALLATION

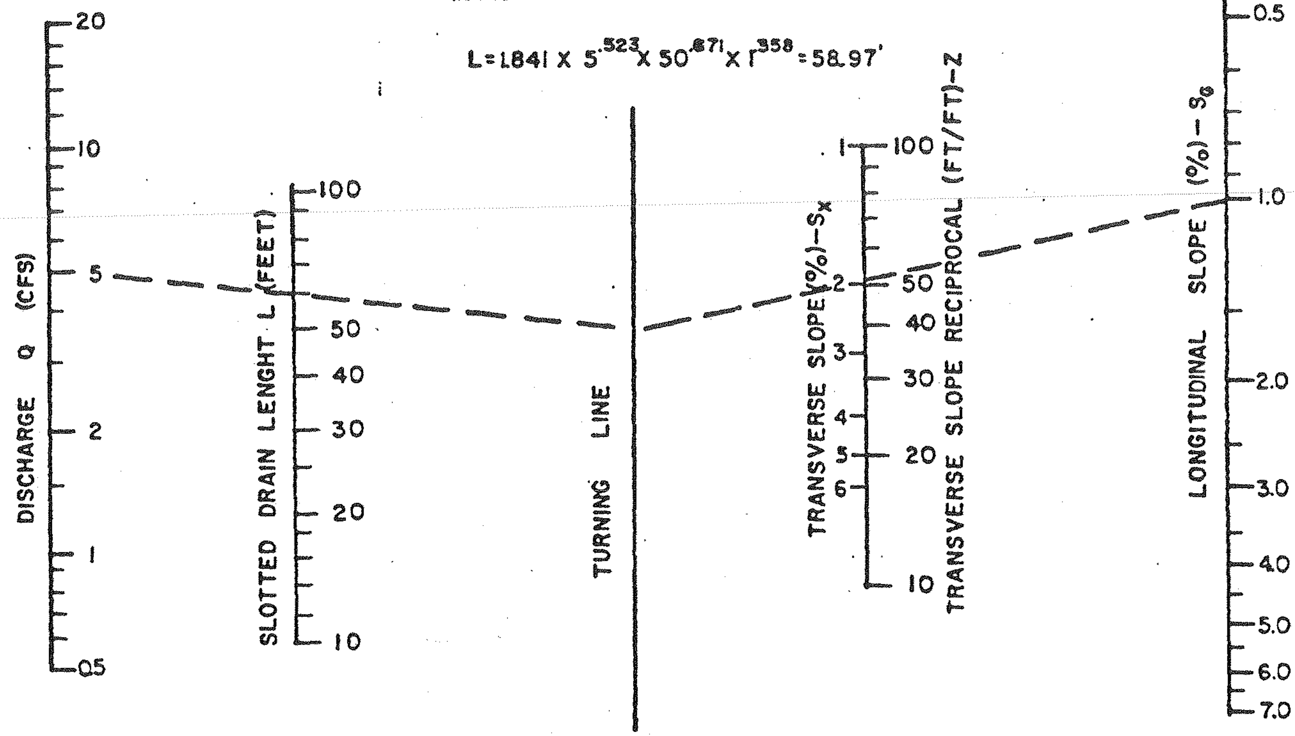
EXAMPLE

Given: $S_G = 1\%$
$S_x = 2\%$
$Q = 5$ CFS

SOLUTION

1. Connect points from S_G and S_X with line to turning point.
2. Connect point from Q to turning point.
3. Read required lenght — 59'.
4. Calculate from formula.

$$L = 1.841 \times 5^{.523} \times 50^{.871} \times 1^{.358} = 58.97'$$

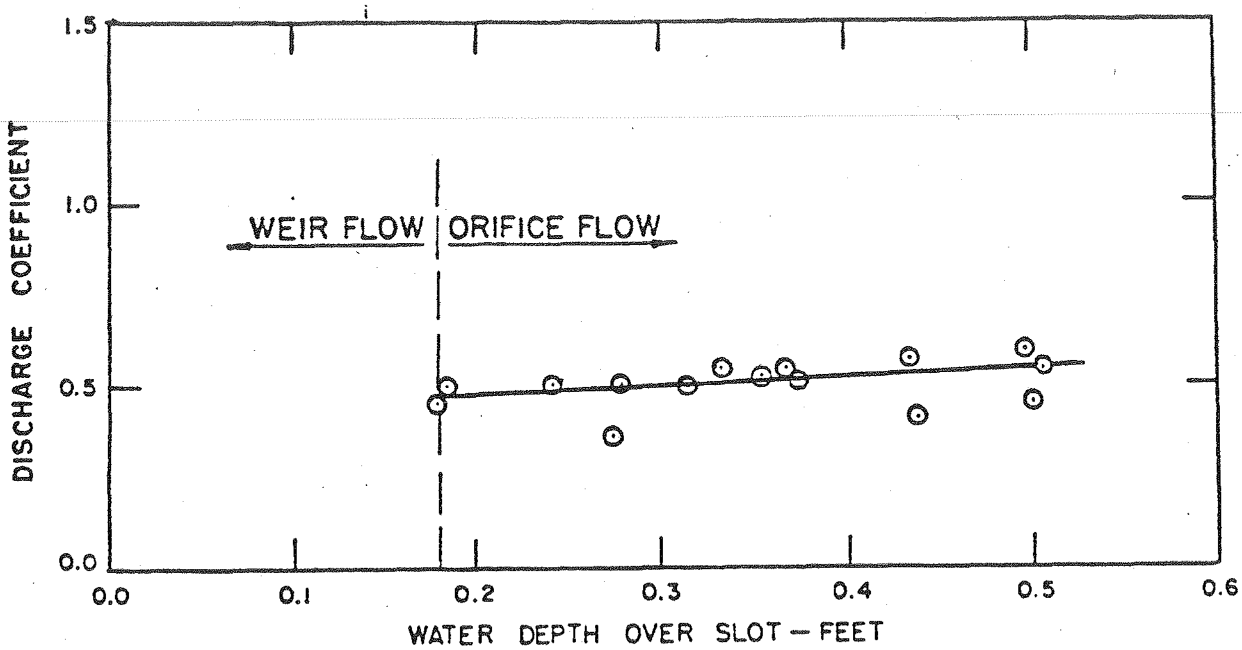


S_G — Longitudinal Slope — %
S_X — Transverse Slope — %
Z — Transverse Slope Reciprocal — ft./ft.
d — Depth of Flow — ft.
L — Length of Slot — ft.
Q — Discharge — CFS
g — Gravity — 32.3 ft./sec./sec.
W — Width of open Slot (use 1.75 ÷ 12 ft.)
C_{Do} — Orifice Discharge Coefficient from CHART I-103.6E

SHT. NO.	CITY OF SAN DIEGO - DESIGN GUIDE	REV.	
	NOMOGRAPH — DESIGN LENGTH OF SLOT OPENING — SLOTTED DRAIN PIPE		

CHART 1-103.6E

FOR FLATTER GRADES THAN THOSE SHOWN
IN CHART 1-103.6D OR FOR OTHER THAN
CURB AND GUTTER INSTALLATIONS



Length of Grate = Q ÷ $C_{DW} d^{3/2}$ where $C_{DW} = 3.125$
(For weir flow, d ≦ 18 ft)

Length of Grate = Q ÷ CDO w $\sqrt{2 gd}$
(For orifice flow, d > 18 ft)

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		ORIFICE DISCHARGE COEFFICIENT C_{Do}	

1-103.7 CONDUIT CURVATURES

A. Reinforced Concrete Pipe (R.C.P.)

(1) Horizontal radii and deflections shall conform with the requirements as shown on Table 1-103.7A and Table 1-103.7B.

(2) Vertical curves shall be circular curves, not parabolic curves and shall be designed so that angle points fall at a pipe joint. Minimum spacing of angle points shall be four feet (4'). Maximum angle at any joint shall be 10°. Vertical deflections shall conform with the deflection requirements as shown on Table 1-103.7A and Table 1-103.7B.

(3) The simultaneous combination of horizontal and vertical curves is not permitted.

(4) Care shall be taken to prevent horizontal and vertical curves within the same run of pipe. Same run of pipe is defined here as any run between two structures or between a structure and the end of the pipe. Should this combination become necessary for a proper design, the proposed design shall be submitted for prior approval by the City Engineer.

(5) RCP installed on slopes over forty percent (40%) shall have water tight joints, reinforced masonry or reinforced cast in place Portland Cement Concrete (PCC) cutoff walls (and velocity rings when required).

B. Asbestos - Cement Pipe (A.C.P.)
(This pipe product is not currently readily available.)

(1) A.C.P. may be used for relatively straight runs of pipe. Curves in the alignment shall be of reinforced concrete pipe and shall be connected with a concrete pipe collar.

(2) If angle points in alignment of A.C.P. are permitted, the maximum angle point permitted will be 10°. The angle point must be a factory-manufactured joint. Any angle point greater than 10° will require a cleanout structure or the use of R.C.P.

(3) Horizontal radii and deflections shall conform with the requirements as shown on Table 1-103.7A.

(4) The above conditions apply to vertical curves and all angle points.

(5) The simultaneous combination of horizontal and vertical curves is not permitted.

TABLE 1-103.7A

RADII FOR VARIOUS PIPE SIZES				
PIPE SIZE	8' LENGTHS 5° BEVEL ONE END	8' LENGTHS 5° BEVEL BOTH ENDS	4' LENGTHS 5° BEVEL ONE END	4' LENGTHS 5° BEVEL BOTH ENDS
12°	91.5'	45.5'	45.0'	22.5'
15°	91.0'	45.0'	45.0'	22.5'
18°	91.0'	45.0'	44.5'	22.5'
21°	91.0'	45.0'	44.0'	22.0'
24°	91.0'	45.0'	44.0'	22.0'
27°	90.5'	44.5'	44.0'	22.0'
30°	90.5	44.5'	44.0'	22.0'
33°	90.5'	44.5'	43.5'	22.0'
36°	90.0'	44.5'	43.5'	22.0'
39°	90.0'	44.0'	43.5'	22.0'
42°	90.0'	44.0'	43.0'	21.5'
45°	89.5'	44.0'	43.0'	21.5'
48°	89.5'	43.5'	42.0'	21.0'
51°	87.5	41.5'	41.0'	20.5'
54°	87.5'	41.5'	40.5'	20.5'
57°	89.0'	43.0'	42.5'	21.5'
60°	87.0'	40.0'	39.5'	20.0'
63°	87.0'	40.5'	40.5'	20.5'
66°	86.5'	41.0'	40.0'	20.0'
69°	86.5'	41.0'	40.0'	20.0'
72°	85.5'	39.5'	39.0'	19.5'
75°	86.0'	40.5'	39.5'	20.0'
78°	86.0'	40.5'	40.0'	20.0'
81'	86.5'	40.0'	39.5'	20.0'

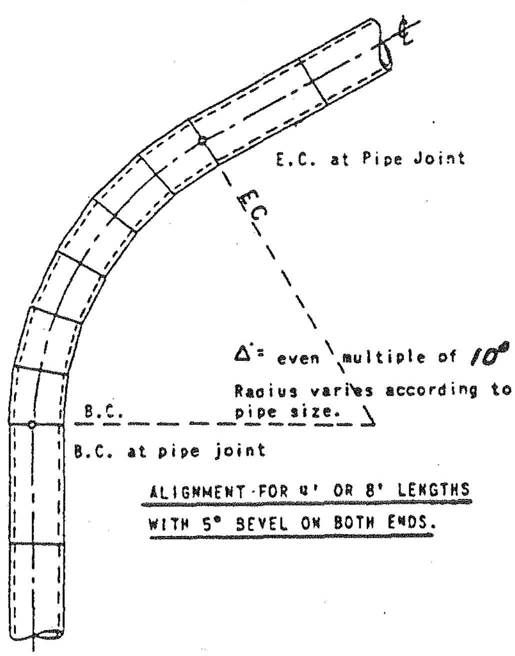
B.C. denotes Beginning of Curve

E.C. denotes End of Curve.

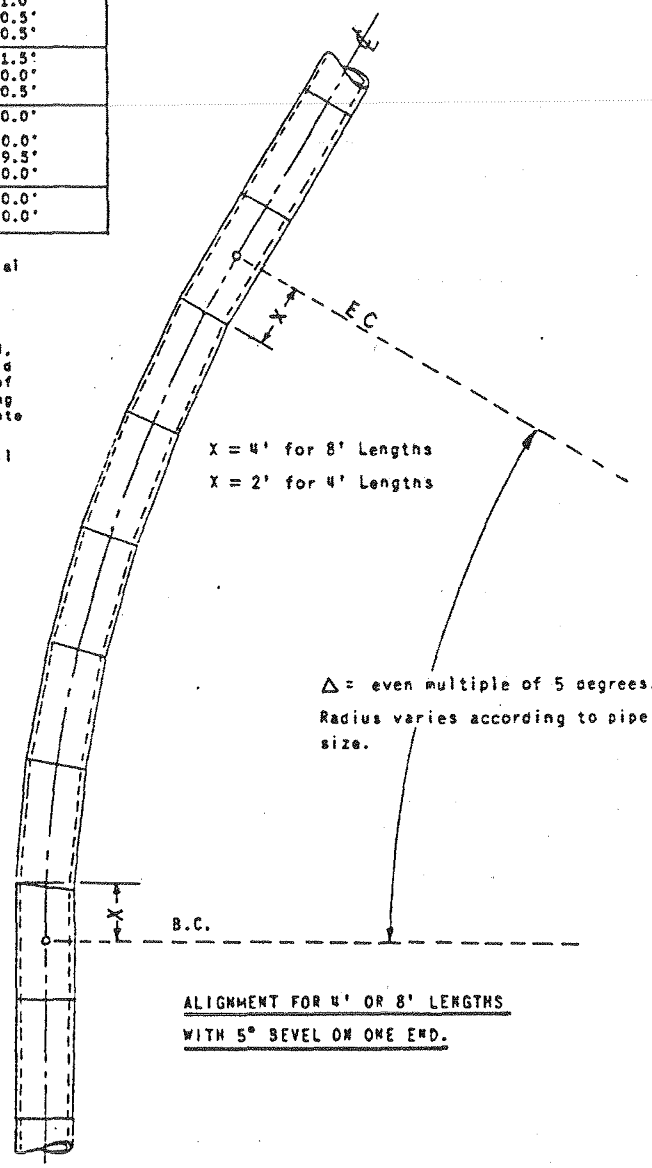
CURVE DESIGN DATA

The center line lengths of beveled end pipes may vary by several inches from nominal 4 foot and 8 foot lengths causing pipe to fail to lay to nominal radii. The above table, based on pipe lengths as shown gives radii to be used. Before placing pipe around curves, measure the center line lengths of the pipes delivered to the job and from the average length so determined, compute a new curve radius and relocate the B.C and E.C. Should the first or last bevel joint fail to fall within six inches of the position with respect to B.C and E.C. shown on this drawing the pipe shall be cut to fit and the joint encased in a concrete pipe collar.

The maximum joint spread allowed to obtain pipe alignment shall be one inch measured on the outside of the joint.



ALIGNMENT FOR 4' OR 8' LENGTHS WITH 5° BEVEL ON BOTH ENDS.

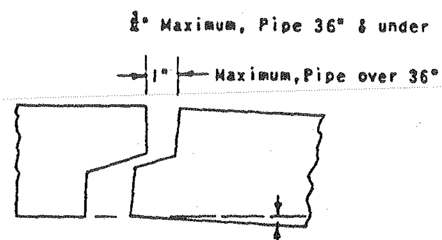


ALIGNMENT FOR 4' OR 8' LENGTHS WITH 5° BEVEL ON ONE END.

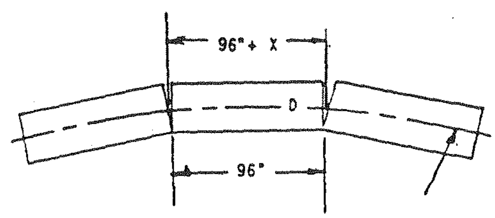
REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		DEFLECTION AND RADII BEVEL STORM DRAIN PIPE	

TABLE 1-103.7B

SIZE INCH	WALL INCH	O.D. PIPE INCH	DEPTH BELL INCH	JOINT OPENING INCH	RADIUS FEET	DEFL. ° - '
12	2	16	11/16	5/8	206	2 14
15	2	19	1	3/4	204	2 16
18	2-1/4	22-1/2	15/16	3/4	242	1 55
21	2-3/8	25-3/4	1-5/8	3/4	277	1 40
24	2-1/2	29	1-5/8	3/4	311	1 29
27	2-5/8	32-1/4	1-5/8	3/4	346	1 20
30	2-3/4	35-1/2	1-3/4	3/4	381	1 13
33	2-7/8	38-3/4	1-3/4	3/4	417	1 07
36	3-1/8	42-1/4	1-3/4	3/4	454	1 01
39	3-1/2	46	1-7/8	1	370	1 15
42	3-3/4	49-1/2	1-7/8	1	398	1 10
45	3-7/8	52-3/4	1-7/8	1	424	1 05
48	4-1/8	56-1/4	2	1	452	1 01
51	4-1/4	59-1/2	2	1	478	0 58
54	4-1/2	63	2	1	507	0 55
57	4-3/4	66-1/2	2	1	535	0 52
60	5	70	2	1	563	0 49
63	5-1/4	73-1/2	2	1	591	0 47
66	5-1/2	77	2	1	619	0 45
69	5-3/4	80-1/2	2	1	647	0 43
72	6	84	2-5/8	1	675	0 41
75	6-1/4	87-1/2	2-5/8	1	704	0 39
78	6-1/2	91	2-5/8	1	731	0 37
81	6-3/4	94-1/2	2-5/8	1	760	0 35
84	7	98	2-3/4	1	788	0 34
87	7-1/4	101-1/2	3	1	816	0 33
90	7-1/2	105	3	1	844	0 32
93	7-3/4	108-1/2	3	1	872	0 31
96	8	112	3	1	900	0 30



Sketch: Joint spread or opened 1" from normal



$$X = \frac{192D}{2RrD}$$

X = opening between pipe in inches

D = O.D. or I.D. of pipe in feet (see note)

R = center line radius of curve in feet

Note: If I.D. of pipe is used, X will be opening at inside surface of pipe. If O.D. is used, X will be opening of outside surface

Note: The radius column indicates a minimum radius for pipe line curves to be laid with straight 8 foot sections of centrifugal concrete pipe. Proportional for 4 foot pipe sections. For shorter radii, use beveled pipe.

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		DEFLECTION AND RADII STORM DRAIN PIPE	

C. Cast-in-Place Concrete Pipe (C.I.P.C.P.)

The minimum radius of curvature for C.I.P.C.P. shall be thirty (30) times the nominal internal pipe diameter, No Exceptions.

D. Corrugated Aluminum Pipe (C.A.P.) and Corrugated Metal Pipe (C.M.P.)

(1) The minimum centerline radius for C.A.P. and C.M.P. shall be twenty-five feet (25').

(2) Angle points will be permitted with no one angle point being more than 10° in horizontal or vertical alignment.

(3) Any angle point greater than 10° will require a cleanout structure.

(4) All angles shall be factory manufactured. C.M.P. shall be hot dipped galvanized after factory joint welding.

(5) Horizontal radii and deflections shall conform with the requirements as shown on Table 1-103.7A.

(6) The simultaneous combination of horizontal and vertical curves is not permitted.

E. Corrugated Plate Conduit and Arches

(1) Considered a special design, must have prior approval of the City Engineer. Generally, previous criteria will apply where applicable (100 year service life normally required).

(2) The simultaneous combination of horizontal and vertical curves is not permitted.

F. Rectangular Conduits

(1) Normally a minimum centerline radius of fifty feet (50') shall be used.

(2) The simultaneous combination of horizontal and vertical curves in not permitted. This combination is permitted for reinforced cast in place concrete structures.

(3) Masonry structures are not permitted.

1-103.8 ANCHORAGE ON SLOPES/SLOPE DRAINS

A slope drain is defined as a conduit constructed on a grade of 5:1 (20%) or greater and does not fall within a traveled way. Slope drains are normally located within cut or fill slopes.

A. Slope drains may be permanent installations or temporary drains for a future extension of a permanent installation, above or below ground.

B. Any slope drain which would be conspicuous or placed in landscaped areas shall be concealed by burial or other means.

C. In general, slope drains shall have a 100 year service life where slopes are 2-1/2:1 (40%) or steeper.

D. All slope drains shall have positive water-tight joint connections.

E. Slope drain pipe shall conform to the minimum allowable service life for underground conduits. (see 1-103.2).

F. Adequate anchorage or cutoff walls shall be installed at intervals up to a maximum of thirty feet (30') for all conduit pipe placed on or within slopes 3:1 or steeper. Metal or fiberglass cutoff walls are not permitted.

G. Cutoff walls shall be installed at intervals up to a maximum of thirty feet (30') (horizontally) for all pipes placed in slopes where there is the possibility of erosion of the pipe trench on the slope. Metal or fiberglass cutoff walls are not permitted.

H. All above ground pipes must have special approval and shall be temporary.

I. Reinforced masonry or reinforced cast in place concrete cutoff walls are required.

1-103.9 ANGLE OF CONFLUENCE

A. In no case shall a component of lateral velocity oppose the mainline velocity by an angle of confluence.

B. The angle of confluence shall be 90° or less.

C. The angle of confluence shall be determined by the following:

(1) If the lateral measures an equivalent of thirty-six inches (36") in diameter or more, the angle of confluence shall be 60° or less.

(2) The change in energy gradient in the cleanout or juncture shall not exceed three feet (3').

(3) In no case shall the energy gradient exceed the elevation of six inches (6") below the gutter grade on inlets, grate for grated inlets, or six inches (6") below the bottom of the roof slab on cleanouts.

D. A concrete lug will be allowed at the junction if:

(1) The criteria for cleanout locations in both lines is satisfied.

(2) If the connecting pipe is in conformance with the following:

Main Line	Connector
24"	18" max.*
27"	18" max.*
30"	21" max.*
36"	24" max.
42"	30" max.
48"	30" max.
54" or larger	36" max.**

*A cleanout at that connection will be required if there is no cleanout within fifty feet (50') of the connection.

**A cleanout will be required when connector pipe exceeds thirty-six inches (36").

(3) That the lug has a maximum depth of cover of fifteen feet (15').

(4) No more than one lug is allowed for a lateral connection in any nominal section length of conduit.

(5) Lugs are only permitted with R.C.P. to R.C.P. or the pipe which is receiving the lugged pipe is R.C.P. or a reinforced concrete box structure. A.C.P. is not permitted to be used in any lug condition.

E. Lugs are not permitted when either pipe is C.I.P.C.P.

1-103.10 HEADWALLS AND CURTAIN WALLS

A. Headwalls are to be installed at all inlets and outlets. A curtain wall may be used in place of a headwall where an extension downstream of the conduit is likely to occur prior to the next rainy season and no fill is to be retained at the wall.

B. Flared end sections may be approved with proper details, if it is unlikely the conduit will be extended in the near future.

C. Perimeter fences may be required at the inlet and outlet ends of the conduit to reduce hazardous conditions at such points. To provide for maintenance, access gates may be required in the perimeter fences.

D. Outfalls may require energy dissipators, the minimum allowed shall be per Standard Drawing D-40.

1-103.11 CONDUIT ENTRANCES

A. Entrances shall be rounded, beveled or expanded, whichever is appropriate, to increase the capacity of the conduit, whether the outlet is free or submerged and whether the slope is above or below critical.

B. Flared inlets should be considered for efficient design when the conduit flows under inlet control, except when extension of the conduit upstream is imminent.

C. Inlet aprons shall be used as transitions between the conduit and an improved approach channel, and may be used between the conduit and a natural approach channel. These should be designed to prevent grade cutting of natural channels and/or to provide for a more efficient entrance condition.

1-103.12 DEBRIS AND SILT CONTROL FACILITIES

A. Where flows are likely to carry floating debris or rock in sufficient size to block or obstruct the conduit/channel inlet/entrance, a trash fence/rack, or deflector is required. Vehicular maintenance access is also required. These facilities shall be constructed upstream of the inlet/entrance so they will not obstruct the entrance.

B. Should drainage flows be transporting silt, a temporary desilting basin shall be required to prevent silting of the conduit or the area downstream from the conduit or project. (See an example of a desilting basin in the Appendix). These basins are to be maintained by the developer.

1-103.13 OUTLET DISSIPATOR

A. Where conduits discharge into an unimproved or natural channel, and the quantities and velocities exceed those permissable for the material involved, a suitable energy dissipator is to be installed to reduce discharge to non-erodable velocities.

B. Drop manholes or cleanouts shall not be used for energy dissipators unless, for a special condition, a special structural design is approved. These should be very rare installations.

1-103.14 DESIGN CRITERIA

A. Cast-in-Place concrete pipe shall not be used in streets with existing underground utilities, such as existing water services, sewer laterals, gas services, underground electric services, etc.

B. Only metal pipe shall be used for above ground installations when required for downdrains.

C. Minimum D-Loads (H-20 Loading):

Reinforced Concrete Pipe	1350-D*
Asbestos Cement Pipe	2000-D**
Cast-in-Place Concrete Pipe	Requires Special Design**
Other Classifications	H-20 Loading**

*Lateral loading on the pipe will require special circular reinforcing.

**R.C.P. shall be used for all pipes with, or having the potential of, having lateral loads.

D. No conduit shall be reduced in cross-sectional area downstream in any storm drain system.

E. Where the conduit size increases downstream in storm drain systems, the inside top slopes of the conduits shall be continuous in elevation, rather than the flow lines. Change in conduit sizes shall be accomplished in a reinforced concrete storm drain cleanout structure only.

F. All pipes/conduits on a grade of twenty percent (20%) or greater shall have water-tight joints.

G. All pipes/conduits in the storm drain system shall have D-loads or gauge thickness for metal pipes, as appropriate, and shall be indicated in the profiles on the plans. C.I.P.C.P. shall show the wall thickness.

H. Quantities of flow shall be shown in the profile of the conduit at all entrances and pipe runs, and quantities with storm frequency noted and velocities of flow at all outfalls. Outfalls of pipes/culverts and ditches, including brow ditches, must show the quantity of flow "Q" and velocity "V" on the plans. The velocity shall be calculated in the steeper reach; i.e., not in the short pipe segment adjacent to an outfall unless backwater curves for the outfall are submitted for the pipe flowing, 1/4,1/2,3/4 and full. The outfall shall be designed for the greatest flow and velocity of the four noted conditions.

I. Storm drain stationing shall run upgrade from the lower end of the drain. When a storm drain runs longitudinally in a street, the stationing may be the street stationing.

J. Storm drain outfalls shall extend to the nearest well-defined natural drainage channel which can adequately convey the discharge. Downstream conditions shall be investigated to verify the appropriateness of the point of discharge. This may require offsite storm drains or channel stabilization measures.

K. All outfalls from a sump condition in the public right-of-way which cross through private property via a drainage easement to the storm drain outfall shall be designed to convey a 100-year frequency storm.

L. When the pipe is expected to carry a large amount of abrasive material, such as rocks and boulders, a special design to protect the full length of invert area (the lower 90°) and walls within curves to the spring line will be required.

M. Drainage must be picked up prior to reversing superelevation sections to prevent cross flows from one side of the street to the other or median.

N. Storm drains shall not be constructed parallel to and within the slope face. Provide a flat access area over all public storm drains. All storm drains within the slope shall be aligned perpendicular to all slope faces.

O. Storm drains shall be limited to a maximum cover depth of fifteen feet (15'). Approval of the City Engineer is required for drains with more than fifteen feet (15') of cover.

P. Drainage alignment priority shall be given to the larger of any two connecting storm drain systems. All pipes larger than thirty-six inches (36") shall not run into and out of storm drain inlets in lieu of cleanouts without a specially designed inlet structure. This should be avoided whenever possible.

Q. Cross gutters are not permitted across any four-lane collector, major or prime arterial roadways, or at signalized intersections.

R. Provide the hydraulic calculations when the flow changes from supercritical to subcritical flow.

S. Storm drains with twenty-five feet (25') of cover or more shall meet the following requirements:

(1) 100-year minimum life.

(2) Sized to allow a future metal plate liner installation which will carry the design storm and retain full structural strength.

(3) Pipe runs shall be straight -- no curves or angle points.

(4) Depth of cover over fifteen feet (15') shall be allowed by necessity only. All drains shall utilize every possible means to minimize excessive cover. This may require offsite reconstruction or filling of upstream low areas. Larger pipe sizes to reduce pipe depth shall be used.

T. A metal band coupling connection of CMP to CAP or CAP to CMP is not permitted.

U. Diversion of drainage is not permitted.

V. All landscaped medians shall have storm drain systems which prevent storm and irrigation water from entering the paved roadway. These median drains are to be maintained by the same entity charged with median maintenance. A Portland Cement Concrete paved area on both sides of the landscaped median is required for a maintenance access area.

W. The 50 year frequency storm shall be contained between the curbs (within the public right-of-way) with maximum flows permitted in the curb/gutter controlled by Chart 1-104.12.

1-103.15 SPECIAL DESIGN CONDITIONS

A. Cast-in-Place Concrete Pipe

(1) Refer to the City of San Diego Standard Specification and Special Provisions for additional C.I.P.C.P. installation requirements (Not listed herein).

(2) Maximum height of cover over pipe - fifteen feet (15').

(3) Minimum Wall thickness:

Diameter (Inches)	Min. Wall Thickness (Inches)
30	3
36	3-1/2
42	4
48	5
54	5-1/2
60	6
66	6-1/2
72	7
84	8-1/2
96	10

(4) Minimum pipe diameter - thirty inches (30").
Maximum pipe diameter - ninety-six inches (96").

(5) Maximum pipe grade - ten percent (10%).
Minimum pipe grade - one-half of one percent (0.5%).

(6) The minimum earth cover for the pipe is three feet (3'). However, for an eighty-four inch (84") diameter pipe

constructed under a traveled roadway, it must have a minimum earth cover of four feet (4'), and for a ninety-six inch (96") diameter pipe under a traveled roadway it must have a minimum earth cover of five feet (5').

(7) Minimum width of undisturbed ground between trenches of other utilities, existing and proposed, and the cast-in-place pipe trench shall be five feet (5').

(8) Construction plans shall show normal pipe dimensions plus the minimum pipe wall thickness.

(9) Where cast-in-place pipe crosses over an existing utility, R.C.P. will be required for the pipe crossing as shown on the plans.

(10) Lugs are not permitted in C.I.P.C.P. A cleanout, inlet or similar type of reinforced concrete structure must be used for a storm drain connection or lateral connection.

The following specification requirements shall be adheard to during the design and installation of a C.I.P.C.P. storm drain and the Department Instruction 3930-002 in the appendix:

I. The material in which the pipe is to be constructed must be stable and unyielding when saturated.

II. A Soils Engineer shall verify that the material in which the pipe is to be constructed must be able to stand vertically from the bottom of the trench to three feet (3') above the top of the pipe without sloughing.

III. C.I.P.C.P. will be permitted for use only in materials which are at a minimum relative compaction of ninety percent (90%).

IV. Where structures are to be constructed in the drain, the pipe shall be constructed continuous through the structure location, then cut away while the concrete is fresh to the neat inside lines of the structure. No structure is to be supported by the pipe. Standard reinforced concrete structures are required of cast-in-place concrete pipe.

V. C.I.P.C.P. requires a minimum 28-day concrete strength of 4,000 p.s.i.

VI. No backfill of C.I.P.C.P. is permitted until 4,000 p.s.i. strength has been verified by laboratory tests.

VII. C.I.P.C.P. repaired sections shall utilize R.C.P. with an appropriate D-load design.

VIII. A Soils Engineer shall certify that the water table in the trench(es) is below the bottom of the trench, or that the trench can be adequately dewatered to allow construction and curing and that the water table maximum elevation is low enough to preclude future damage to the C.I.P.C.P. Storm water shall not enter the pipe until the 28 day strength is reached and the trench is backfilled.

IX. The removal of concrete to bring high points to flow line grade shall be permitted providing the minimum wall thickness is maintained.

B. Asbestos-Cement Pipe

(1) Maximum height of cover over pipe - fifteen feet (15'), minimum cover - three feet (3').

(2) Couplings shall be asbestos cement sleeves with two (2) sealing rings suitable for connecting lengths of pipe. The couplings shall be specified on the construction plans.

C. Aluminum and Metal Pipes, Arches, etc.

(1) Corrugated aluminum pipe and corrugated metal pipe shall be classified in accordance with the type of applied protective coatings and linings as follows:

Classification	Plan Designation	
	Aluminum	Metal*
Plain	CAP	CMP
Bituminous coated dipped	--	CMPC
Fully Bituminous lined	--	CMPL
Bituminous coated and lined	--	CMPCL
Paved Invert	--	CMPI
Asbestos Bonded	--	CMPB
Paved Invert, Asbestos Bonded	--	CMPBI

*All CMP shall be Hot-Dipped Galvanized.

(2) All corrugated metal pipe, arches, etc., shall be hot-dipped galvanized.

(3) Corrugated metal products shall be shipped and handled in such a manner as to prevent bruising, scaling or breaking of the galvanized surface or protective coating.

(4) Minimum cover over pipe shall be two feet (2') or a minimum of one foot (1') below pavement subgrade, whichever is greater.

1-103.16 SOIL TESTS FOR METAL DRAINAGE CONDUITS

A. Use of any particular metal drainage conduit will require reports covering any or all of the following:

(1) Watershed soil resistivity and pH valves along the proposed drain location.

(2) pH of site water and resistivity at low flows.

(3) Imported backfill soil resistivity and pH.

(4) History and present condition of existing conduits in the watershed area, if any.

B. Resistivity soil tests and pH shall be made by a City-approved testing laboratory, which shall determine the minimum resistivity and pH values.

1-103.17 SERVICE LIFE AND LIMITATION ON USE

A. Corrugated Aluminum Conduit

(1) Aluminum alloy conduit may be used where the minimum resistivity of the soil, backfill and effluent is above 500 ohm-cm and where pH of the water and soil falls within the range of five and one half (5.5) to eight and one half (8.5) or a minimum of 1500 ohm-cm where pH of the water and soil falls between a range of five (5.0) to five and one half (5.5) and between eight and one half (8.5) to nine (9.0).
(2) Minimum cover permitted is two feet (2') or one foot (1') below pavement subgrade, whichever is greater.
(3) Maximum cover permitted is fifteen feet (15').
(4) Minimum pipe thickness shall be 14 ga.
(5) This pipe is recommended for use in sea water. Use the next heavier gage above normal.

(6) The CAP Neopreme gasket shall conform to ASTM D 1506.

(7) CAP service life - refer to CHART 1-103.17A.

(8) CAP should not normally be used when excessive wear from mild abrasives are present or expected in the flow.

B. Corrugated Metal Conduit

(1) The predicted service life of the conduit shall be determined from CHART 1-103-17A (Minimum 14 gage).

(2) TABLE 1-103-17B may be used for anticipating additional service life by bituminous coating, etc.

(3) Sixty year (60) maximum life - not to be used where one hundred year (100) life is required.

(4) Minimum cover over pipe shall be two feet (2') or a minimum of one foot (1') below pavement subgrade, whichever is greater.

(5) This conduit is not suitable for sea water exposure.

(6) Severe abrasion usually occurs when the flow velocity exceeds 15 fps and contains a bedload. When this condition is anticipated, or severe abrasion may be combined with corrosion, additional metal thickness shall be provided.

C. Concrete and Asbestos - Cement Conduit

(1) The predicted service life of the conduit shall be 100 years and must conform to the conditions as shown on TABLE 1-103.17C and TABLE 1.103.17D.

(2) The type of cement, as shown on TABLE 1-103.17D, shall conform with the following:

(a) Type II portland cement shall conform to the specifications of ASTM Designation: C150, with the following modifications:

1. The cement shall not contain more than 0.60 percent by weight of alkalies calculated at the percentage of Na_2O plus 0.658 times the percentage of K_2O, when determined by either direct intensity flame photometry or by the atomic absorption method. The instrument and procedure used shall be qualified as to precisions and accuracy in accordance with the requirements of ASTM Designation: C114.

2. The autoclave expansion shall not exceed 0.50 percent.

3. Mortar containing the portland cement to be used and Ottawa sand, shall not expand in water more than 0.010 percent and shall not contract in air more than 0.048 percent.

(b) Type V Portland cement shall conform to the specification in ASTM Designation: C150, and the modifications listed above for Type II portland cement.

(3) Soluble sulphate content of proposed backfill, watershed soil or runoff. This information shall be submitted to the City Engineer in all instances when the soil resistivity measures less than 3000 ohm-cm.

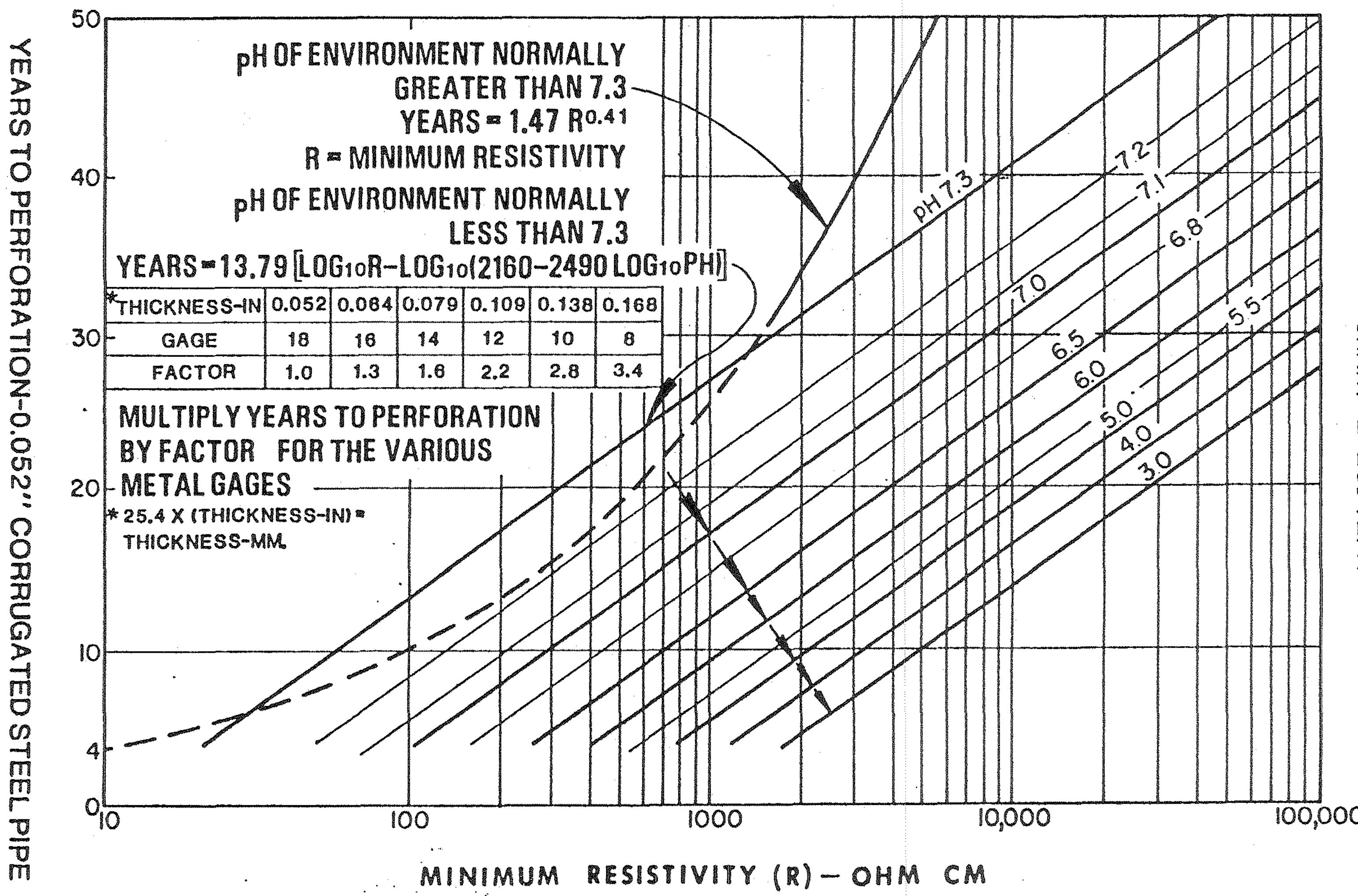
REV.

CITY OF SAN DIEGO - DESIGN GUIDE

ESTIMATED YEARS TO PERFORATION OF METAL CULVERTS

SHT. NO.

CHART 1-103.17A



*THICKNESS-IN	0.052	0.064	0.079	0.109	0.138	0.168
GAGE	18	16	14	12	10	8
FACTOR	1.0	1.3	1.6	2.2	2.8	3.4

TABLE 1-103.17B

ENVIRONMENT		PROBABLE FLOW VELOCITY, Q_{10}		CMPC[3] CAPC[3]	CMPCI[4] CAPCI[4]	CMPBCI[5]
LOCATION	PROBABLE SLOPE OF CHANNEL	(FEET PER SECOND)	CHANNEL[1] MATERIALS	(YEARS)	(YEARS)	(YEARS)
VALLEY	LESS THAN 2%	LESS THAN 5	ABRASIVE	6	15	20
			NON ABRASIVE	8	15	20
FOOTHILL	APPROXIMATELY 3%	5-7 (INCL)	ABRASIVE	6	12	20
			NON ABRASIVE	8	15	20
MOUNTAINS	GREATER THAN 4%	GREATER THAN 7	ABRASIVE	0	5	8
			NON ABRASIVE	2	10	20

-NOTES-

1. Channel Materials: If there is no existing culvert, it may be assumed that channel is potentially abrasive to culvert if sand and/or rocks are present.

   Presence of silt, clay, or heavy vegetation may indicate a non abrasive flow.

   For continuous flow, the years of invert protection can be expected to be one-half of that shown.
2. Any bituminous coating may add up to 20 years of service on the backfill side of the culvert.
3. CMPC - Bituminous coating.
4. CMPCI - Bituminous coating and paved invert.
5. CMPBCI - Asbestos bonded, bituminous coating and paved invert.

SHT. NO.	CITY OF SAN DIEGO - DESIGN GUIDE	REV.	
	GUIDE FOR ANTICIPATED SERVICE LIFE ADDED TO STEEL PIPES BY BITUMINOUS COATINGS[2]		

TABLE 1-103.17C

Limitation on Use of Concrete and Asbestos Cement Pipe by Acidity of Soil and Water

Acidity pH	Remarks
6.5 or less	Use of porous concrete pipe with shell thickness of 1" or less is not advisable
5.5 or less	Use of reinforced concrete or asbestos cement pipe without a protective coating not advisable(1)

NOTE:

(1) Subject to approval, coal tar or coal tar epoxy may be used for protective measures.

TABLE 1-103.17D

Guide for Sulfate Resisting Concrete Pipe and Other Concrete Drainage Structures(2)

Water-Soluble Sulfate in Soil Sample(1) (Percent)	Sulfate in Water Sample(1) (Parts per Million	Type of Cement	Cement Factor
0-0.20	0-2000	II	Minimum required by Specifications
0.20-0.50	2000-5000	V	Minimum required by Specifications
		or II	7 Sacks
0.50-1.50	5000-15000	V	Minimum required by Specifications
		or II	7 Sacks
Over 1.50	Over 15000	V	7 Sacks

NOTES:

(1) Reported as SO_4

(2) Recommended measures for type and amount of cement based on analysis of soil and water for sulfate content

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		TABLE 1-103.17C AND TABLE 1-103.17D	

1-103.18 SUBSURFACE DRAINAGE

A. Seepage Collector Lines

(1) When there is a local seepage problem in an established neighborhood, City will provide a seepage line (pending fund availability) in the public right-of-way to convey seepage away from the private property, provided the property owner(s) install(s) an acceptable underground drain system on their property to the point of connection in the public right of way (Refer to 1-103.18A). These seepage lines shall be in conformance with Council Policy 800-4.

(2) The minimum size of a seepage collector line within the public right-of-way shall be eight inches (8").

(3) Allowable alternate conduit for seepage collector lines within a public right-of-way shall be asbestos-cement pipe, polyvinyl chloride pipe, acrylonitrile - butadiene - styrene (ABS) composite pipe per ASTM designation: D 2680 (couplings to be Type SC), or vitrified clay pipe.

(4) A suitable cleanout or manhole shall be located in the seepage collector line on a 350 foot spacing for straight runs of pipe, and at each break in alignment or grade.

(5) All seepage lines and sump pump discharge outlets for new construction on existing lots or newly developed lots shall be taken to the nearest existing underground public storm drain system at the property owners expense.

B. Subsurface Drainage

(1) Refer to the City's Geotechnical Guidelines Manual

(2) When required:

(a) Cut and fill slopes shall be provided with approved subsurface drainage as necessary for stability and protection of adjacent properties from the influence of groundwater. The design of such facilities shall be contained in the approved initial pre-grading geo-technical report and/or shall appear on the approved grading plan pursuant to the approval of the Soils Engineer and/or the Engineering Geologist.

(b) Specifically, subsurface drainage facilities shall be installed where natural and/or artificially introduced groundwater (i.e., derived from meteroic and/or landscape irrigation and similar sources, respectively), affects or is likely to affect the project in a potentially unstable, hazardous or otherwise deleterious manner.

(3) Seepage Statement in Soil Reports and Geological Reports

(a) All Soils Reports and Geological reports submitted for development shall have a statement about the possibility of ground water seepage. This statement shall contain the following items:

1. Sufficient geologic mapping of graded areas to evaluate and comment on anticipated ground water conditions.

2. Location of any springs or seeps.

3. Permeability characteristics of on-site earth materials.

4. Subgrade flow along natural drainage proposed for fillings.

(b) In addition, in those developments where seepage has been identified as a possible problem, the final compaction reports submitted to the City shall contain a discussion of geologic conditions encountered during the grading operation as they relate to the ground water regime of the project and mitigative steps taken to prevent ground water build-up.

(4) The minimum size for subsurface drains shall be four inch (4") diameter pipe unless otherwise specified by the Soils Engineer.

(5) Surface drainage will not be permitted to discharge into a subsurface drain. The discharge from a subsurface drain into a storm drain will be permitted if the subsurface drain outfall is not under hydrostatic pressure.

(6) Cleanouts. Location and spacing as specified by the Soils Engineer or as required by the City Engineer.

(7) Grade Requirements. In general, the minimum allowable grade shall be 0.5 percent. If conditions require flatter grades, approval of the plan by the City Engineer is required.

(8) Depth and spacing of Underdrains: The depth of the underdrain will depend upon the permeability of the soil, the elevation of the water table, and the amount of drawdown needed to insure stability. Whenever practicable, an underdrain pipe should be set in the impervious zone below the aquifer.

(9) Allowable alternate conduit for subsurface drains shall be perforated asbestos-cement pipe, perforated aluminum pipe, perforated clay pipe, acrylonitrile - butadiene - styrene (ABS) composite sewer pipe or perforated polyvinyl chloride pipe.

(10) Subsurface drains shall be carried to a public storm drain system or to a natural well defined drainage channel. Subsurface drains are not permitted to be outfalled into the gutter.

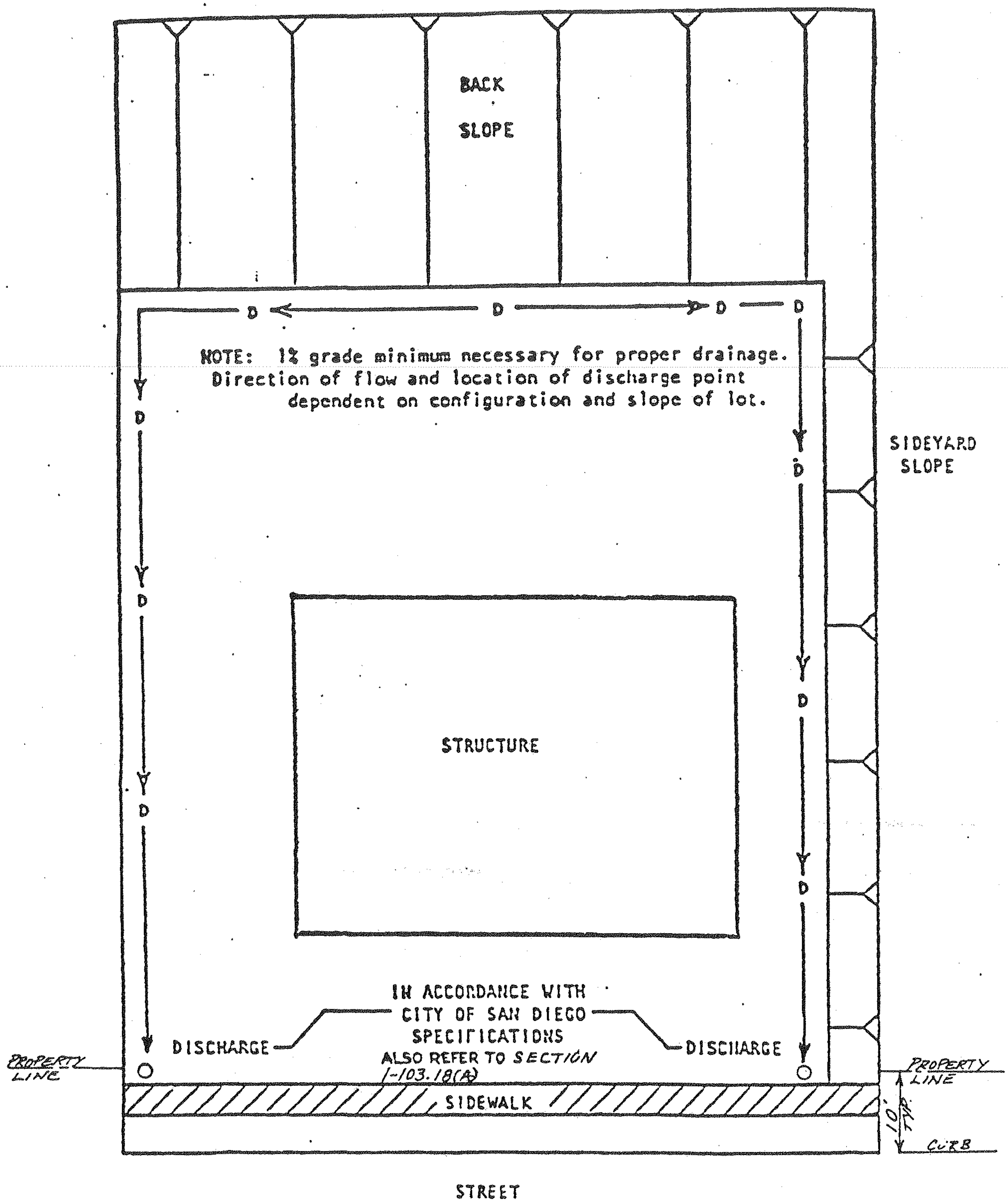
(11) Sump pumps and well points must be discharged in the same manner as stated in (10) above.

(12) Details:

FIGURE 1-103.18A Plan View of Typical Subdrain Layout

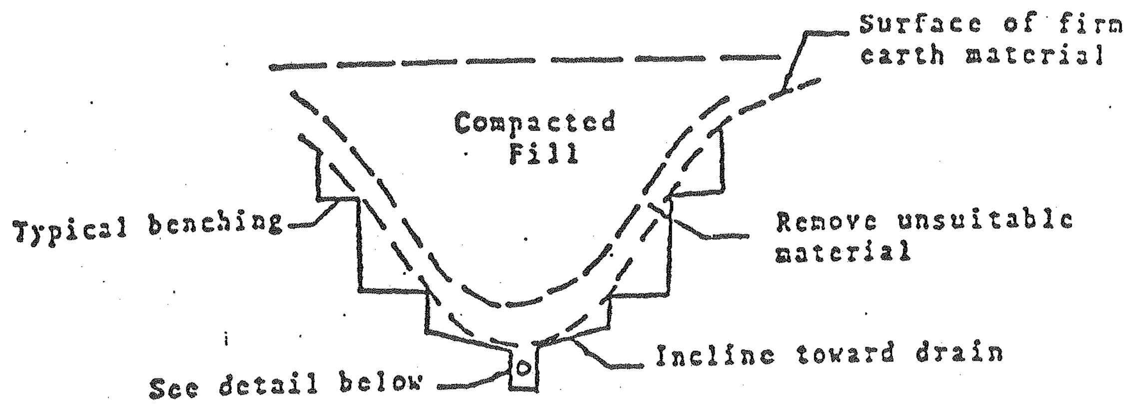
FIGURE 1-103.18B Typical Subdrain Cross-Section Details

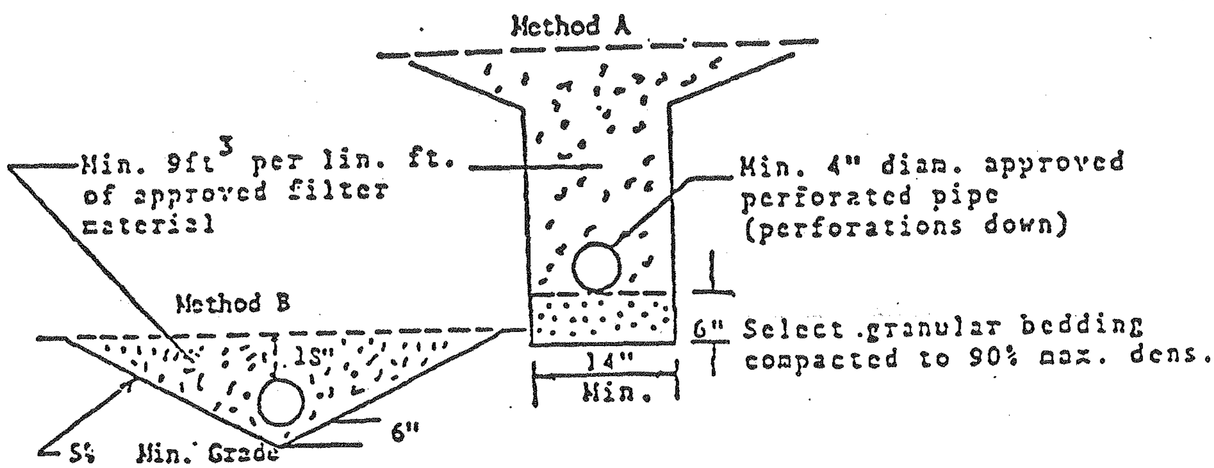
FIGURE 1-103.18A



REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		PLAN VIEW OF TYPICAL SUBDRAIN LAYOUT	

FIGURE I-103.188





DETAIL

Filter material to meet following specification or approved equal:

Sieve Size	Percentage Passing
1"	100
3/4"	90-100
3/8"	40-100
No.4	25-40
No.8	18-33
No.30	5-15
No.50	0-7
No.200	0-3

SHT. NO.	CITY OF SAN DIEGO - DESIGN GUIDE	REV.
	TYPICAL SUBDRAIN CROSS-SECTION DETAILS	

1-103.19 CONDUIT DESIGNATIONS ON THE PLANS

The following legend indicates the conduit designations which shall be used on improvement plans.

LEGEND

Designation	Conduit
ABS	Acrylonitrile - Butadiene - Styrene Composite Sewer Pipe**
ACP	Asbestos-Cement Pipe
CAP	Corrugated Aluminum Pipe
CAPA	Corrugated Aluminum Pipe Arch
CASP	Corrugated Aluminized Steel Pipe*
CIPCP	Cast-in-Place Concrete Pipe
CMP	Corrugated Metal Pipe
CMPA	Corrugated Metal Pipe Arch
CMPB	Corrugated Metal Pipe Asbestos Bonded
CMPC	Corrugated Metal Pipe Bituminous Coated (dipped)
CMPCL	Corrugated Metal Pipe Bituminous Coated and Lined
CMPI	Corrugated Metal Pipe Paved Invert
CMPL	Corrugated Metal Pipe Fully Bituminous Coated
PACP	Perforated Asbestos-Cement Pipe**
PAP	Perforated Aluminum Pipe**
PCLP	Perforated Clay Pipe**
PPVCP	Perforated Polyvinyl Chloride Pipe**
PVCP	Polyvinyl Chloride Pipe*,**
RCA	Reinforced Concrete Arch
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
RCPA	Reinforced Concrete Pipe Arch
SPIRAL RIB	SPIRAL RIB*
SSPA	Structural Steel Plate Arch
SSPP	Structural Steel Plate Pipe
SSPPA	Structural Steel Plate Pipe Arch
TECHITE	TECHITE*
VCP	Vitrified Clay Pipe*

*These conduits are not City approved drain products. Their use as public storm drains shall be limited to short experimental installations and shall have prior written approval of the City Engineer.

**Subsurface seepage drainage only.

Other conduit products not listed above are not approved for public storm drains.

1-103.20 EASEMENTS

A. Minimum Widths

The following table is a general guide for establishing minimum easement widths, although special conditions, such as deep locations, may require additional widths.

Pipe Dia. or Equivalent (inches)	Minimum Width (feet)
18-35	10
36-60	15
61-84	20
85-108	25
Over 108	30

B. Storm drains and easements are to be placed on one side of lot ownership lines in new development and in existing developments where conditions will permit.

C. Generally storm drain easements are to be established exclusively for drainage facilities. Joint use easements will be permitted, such as sewer, water, etc. where necessary, except each line shall be separated by a minimum of five feet (5') horizontally.

D. Access Easements. Physical access shall be provided to all storm drain easements. Should special access to storm drain easement be required because of grade differential, a minimum access easement of fifteen feet (15') shall be established. A minimum access road shall be provided in the access easement, twelve feet (12') wide, with a maximum grade of fifteen percent (15%). Maintenance vehicle access to the channel is required every 1500 feet or more often as needed.

E. In areas to be improved over a storm drain easement, only at-grade parking lots or fences may be constructed. This construction must be approved by the city, and the owner must execute an Encroachment Maintenance and Removal Agreement to the City. In general, structures are not permitted over or within storm drain easements.

F. Storm drain easements for pipes with fifteen feet (15') to twenty-five feet (25') of cover shall require an increased easement width based on two (2) additional feet of easement for every foot of cover over fifteen feet (15').

Example: 18" pipe with 20' of cover

Minimum easement width	=	10'
Additional easement 2 x 5	=	10'
TOTAL EASEMENT WIDTH	=	20'

G. Special easement widths will be determined based on a specific project basis for all storm drains with cover in excess of twenty-five feet (25').

H. All pipes twenty-four inches (24") in diameter and larger, enlarge easement on one side at structures (inlets, cleanouts, etc.) to twenty feet (20') for maintenance access.

I. For all pipes forty-eight inches (48") in diameter and larger:

(1) Provide a twelve foot (12') graded access road (fifteen percent (15%) maximum) to upstream inlet;

(2) Easements to downstream outlets must be twenty feet (20') minimum width for maintenance access.

1-103.21 DESIGN TABLES AND CRITERIA

A. TABLE 1-103.21A Design Values for Manning Roughness Coefficient (n)

B. TABLE 1-103.21B D-load Requirements for Reinforced Concrete Pipe

*C. TABLE 1-103.21C Maximum Height of Cover for Corrugated Steel Pipe - 2-2/3" x 1/2" Corrugations

*D. TABLE 1-103.21D Maximum Height of Cover for Corrugated Steel Pipe - 3" x 1" Corrugations

*E. TABLE 1-103.21E Maximum Height of Cover for Structural Steel Plate Circular Pipe - 6" x 2" Corrugations

*F. TABLE 1-103.21F Maximum Height of Cover for Steel Pipe Arches-2-2/3" x 1/2" Corrugations

*G. TABLE 1-103.21G Maximum height of Cover for Structural Steel Plate Pipe Arches -6" x 2" Corrugations

*H. TABLE 1-103.21H Maximum Height of Cover for Corrugated Aluminum Pipe 2-2/3" x 1/2" Corrugations

*I. TABLE 1-103.21I Maximum Height of Cover for Aluminum Pipe Arches - 2-2/3" x 1/2" Corrugations

J. TABLE 1-103.21J Suggested Depth and Spacing of Underdrains for Various Soil Types

* Refer to the Special Requirements Under Section 1-103.14 O.

TABLE 1-103.21A

DESIGN VALUES FOR MANNINGS ROUGHNESS COEFFICIENT (n)

TYPE OF CONDUIT	n Value
*Metal Pipe and Pipe Arches (2-2/3" x 1/2" Corrugations)	0.024
NOTE: NO reduction in n Value is permitted for Lining of metal pipes.	0.000
*Metal Pipe (3" x 1" Corrugations)	0.027
*Metal Pipe and Pipe Arches (6" x 2" Corrugations)	0.032
Reinforced Concrete Pipe	0.013
Concrete Boxes and Arches	0.015
Cast-in-Place Concrete Pipe	0.015
Clay Sewer Pipe	0.013
Asbestos - Cement Pipe	0.013
CAP Helical	0.022

*CMP and CAP ANNULAR

TABLE I-103.21B

D-load requirements: ordinary bedding, dead load factor 1.50

Cover in feet		Pipe diameter in inches—D-load in pounds per foot														
		12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
2.0	Dead Load	350	309	286	267	254	243	234	227	255	250	244	238	234	230	226
	Live Load	1393	1323	1306	1281	1262	1248	1236	1226	1219	1125	1044	975	914	860	812
	Total	1743	1632	1592	1549	1516	1491	1471	1454	1474	1375	1289	1213	1148	1090	1039
2.5	Dead Load	426	377	349	327	311	298	288	280	315	308	301	295	289	284	280
	Live Load	817	776	766	751	740	732	725	719	719	723	722	715	670	631	595
	Total	1243	1153	1115	1079	1052	1031	1014	1000	1034	1031	1024	1010	960	915	876
3.0	Dead Load	497	441	410	385	366	352	340	331	373	365	358	349	344	337	333
	Live Load	515	490	483	474	467	462	457	454	454	456	456	453	453	451	451
	Total	1013	931	893	859	834	814	798	785	827	822	814	803	797	789	784
4.0	Dead Load	629	560	523	493	470	453	439	427	485	475	466	456	448	441	435
	Live Load	312	296	293	287	283	280	277	275	275	276	276	274	274	273	273
	Total	942	857	816	780	753	733	716	703	760	752	742	730	723	714	709
5.0	Dead Load	747	668	626	592	566	546	531	518	590	580	569	557	549	539	533
	Live Load	220	209	206	202	199	197	195	194	193	194	194	193	193	192	192
	Total	968	878	832	794	766	744	726	712	784	775	763	751	742	732	726
6.0	Dead Load	853	765	720	682	655	633	616	603	690	679	667	654	644	634	627
	Live Load	164	155	153	150	148	147	145	144	144	145	145	144	144	143	143
	Total	1017	921	874	833	803	780	762	747	835	824	812	798	789	778	771
7.0	Dead Load	947	853	805	766	736	714	696	682	785	773	760	746	736	725	717
	Live Load	127	120	119	117	115	113	112	112	111	112	112	111	111	111	111
	Total	1074	974	924	883	852	828	809	794	897	886	872	858	848	836	829
8.0	Dead Load	1031	932	883	842	812	789	771	756	875	863	849	834	824	812	804
	Live Load	101	96	95	93	92	91	90	89	89	89	89	89	89	88	88
	Total	1132	1029	978	935	904	880	861	846	964	953	939	923	913	901	893
9.0		1194	1087	1036	993	961	937	918	903	1037	1025	1011	995	985	972	964
10.0		1250	1141	1090	1047	1015	992	973	959	1108	1096	1082	1065	1055	1042	1034
11.0		1301	1191	1141	1098	1067	1043	1026	1012	1177	1165	1151	1134	1123	1110	1103
12.0		1347	1236	1187	1145	1115	1092	1075	1062	1242	1231	1217	1200	1190	1177	1170
14.0		1426	1315	1269	1229	1201	1181	1166	1155	1365	1356	1343	1326	1317	1304	1297
16.0		1490	1380	1338	1301	1276	1259	1247	1239	1477	1470	1458	1442	1434	1422	1417
18.0		1541	1433	1396	1363	1341	1327	1318	1312	1578	1574	1564	1549	1543	1532	1528
20.0		1582	1477	1445	1415	1397	1386	1380	1378	1670	1669	1661	1647	1643	1633	1631
24.0		1642	1542	1519	1496	1485	1482	1483	1486	1828	1833	1830	1819	1820	1813	1816
28.0		1679	1585	1570	1554	1550	1553	1560	1571	1955	1967	1969	1963	1969	1966	1973
32.0		1703	1613	1605	1595	1597	1606	1619	1635	2058	2077	2085	2083	2094	2095	2107
36.0		1718	1632	1629	1624	1631	1646	1664	1686	2141	2166	2180	2183	2198	2204	2220
40.0		1727	1644	1645	1644	1656	1675	1698	1724	2208	2240	2258	2265	2286	2296	2317

Design criteria

General—D-load values given in the table indicate greater accuracy than warranted in field installation, thus, when specifying, pipe should be classified in 50-D increments; for example, 800-D, 850-D.

Bedding—The above table is based on installations with ordinary bedding[1] and should not be used for other conditions, except as noted. D-loads given in the table are based on a load factor of 1.50. For classes of bedding with load factors other than 1.50, the corrected dead load may be obtained by multiplying the table's dead load by 1.50 and dividing by the desired dead load factor.

Backfill[2]—Based on Marston's curve for saturated topsoil, when $K\mu = 0.150$, the table is conservative for sands, gravels and cohesionless materials. The D-load should be recomputed for clay backfills, when $K\mu > 0.150$, using the correct coefficient. The table has been computed using materials with a unit weight of 110 pounds per cubic foot. For materials having a unit weight other than 110 pounds per cubic foot, the correct dead load can be calculated by multiplying the dead load shown in the table by the desired unit weight and dividing by 110.

Trench width—D-loads given in the table are based on trench widths (at top of pipe) of pipe OD plus 16 inches for pipe diameters 33 inches or less; and pipe OD plus 24 inches for pipe diameters greater than 33 inches. Pipe ODs are based on wall thicknesses given in the dimensional data table for Wall A pipe through 96-inch diameter, and on wall thicknesses given in table for large diameter pipe with 102- and 108-inch diameters. Thicker wall designs may require a slightly higher D-load classification.

For earth covers of two to eight feet the tabulated dead load D-loads approach the maximum loads that occur at the transition trench width. The difference in dead load for wider trench widths or the projecting conduit conditions may be a small value and the pipe may safely withstand the increase. For assurance it will be

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		D-LOAD REQUIREMENTS REINFORCED CONCRETE PIPE	

TABLE I-103.21B

Pipe diameter in inches—D-load in pounds per foot

57	60	63	66	69	72	75	78	81	84	87	90	93	96	102	108	Cover in feet
223	221	218	216	214	212	211	209	208	206	205	204	203	202	203	201	
769	731	696	664	636	609	585	562	541	522	504	487	471	457	430	406	2.0
993	952	915	881	850	822	796	772	749	729	710	692	675	659	633	607	
277	273	271	268	266	263	261	259	258	256	255	253	252	251	252	250	
564	536	510	487	466	446	429	412	397	383	369	357	346	335	315	297	2.5
841	810	781	756	732	710	690	672	655	639	625	611	598	586	568	548	
329	325	322	319	316	314	311	309	307	305	304	302	300	299	401	298	
427	406	386	369	353	338	325	312	300	290	280	270	262	253	239	225	3.0
756	731	709	688	669	652	636	622	608	596	584	573	563	553	540	524	
430	426	421	418	414	411	409	406	404	401	399	397	395	394	396	393	
273	273	273	273	273	273	262	252	243	234	226	218	211	205	193	182	4.0
704	699	695	691	688	685	671	658	647	636	626	616	607	599	589	576	
527	522	518	513	510	506	503	500	497	495	492	490	488	486	490	486	
192	192	192	192	192	192	192	192	192	192	192	192	186	180	170	160	5.0
720	715	710	706	702	699	696	693	690	687	685	683	675	667	660	647	
621	615	610	606	601	598	594	591	588	585	583	580	578	576	581	577	
143	143	143	143	143	143	143	143	143	143	143	143	143	143	143	143	6.0
765	759	753	749	745	741	738	735	732	729	726	724	722	719	727	720	
711	705	700	695	690	686	682	679	676	673	670	668	665	663	669	665	
111	111	111	111	111	111	111	111	111	111	111	111	111	111	113	113	7.0
822	816	811	806	802	798	794	790	787	784	782	779	777	775	782	778	
797	791	786	781	776	772	76[illegible]	765	761	758	756	753	751	748	756	752	
88	88	88	88	88	88	88	88	88	88	88	88	88	88	90	90	8.0
886	880	874	869	865	861	857	853	850	847	845	842	840	837	848	842	
957	951	945	940	936	932	928	924	921	918	915	913	911	908	918	914	9.0
1027	1021	1016	1011	1006	1002	998	995	992	989	986	984	982	979	991	987	10.0
1096	1090	1085	1080	1076	1072	1068	1065	1062	1059	1057	1054	1052	1050	1063	1059	11.0
1163	1157	1152	1148	1144	1140	1137	1134	1131	1128	1126	1124	1122	1120	1135	1131	12.0
1292	1287	1283	1279	1275	1272	1270	1267	1265	1263	1262	1260	1258	1257	1275	1272	14.0
1412	1409	1405	1403	1400	1398	1397	1395	1394	1393	1392	1391	1390	1389	1411	1409	16.0
1525	1523	1521	1519	1518	1517	1517	1516	1516	1516	1516	1516	1516	1516	1542	1542	18.0
1630	1629	1629	1629	1629	1630	1631	1631	1632	1633	1634	1635	1636	1637	1668	1669	20.0
1818	1821	1825	1828	1832	1835	1839	1842	1846	1850	1853	1857	1860	1863	1903	1908	24.0
1980	1987	1994	2002	2009	2016	2032	2030	2037	2043	2050	2056	2062	2068	2118	2126	28.0
2118	2130	2142	2153	2164	2175	2186	2196	2206	2216	2226	2235	2244	2253	2313	2326	32.0
2237	2253	2269	2285	2300	2315	2329	2343	2357	2371	2383	2396	2408	2420	2490	2509	36.0
2338	2359	2379	2399	2418	2437	2456	2474	2491	2508	2524	2540	2556	2571	2651	2675	40.0

necessary to recompute the D-loads for any installation change at any depth of cover.

Safety factor—A safety factor of 1.0 against the occurrence of the 0.01-inch crack is assumed in the calculations. If a factor different than 1.0 is desired, corrected D-loads can be obtained by multiplying loads shown in the table by the desired safety factor.

Live loads—Live load distribution is calculated from AASHTO HS-20 for truck loads[3]. For different wheel loadings, correct live loads can be obtained by multiplying live loads shown in the table by the desired maximum wheel load in kips and dividing by 16. This table is limited to AASHTO live load distributions (a square at backfill depth, H, whose sides equal 1.75H) for single truck loading with impact factors based on depth. A live load factor of 1.50, recommended in Iowa State College Bulletin 112 by Spangler for ordinary bedding or better, is used. For covers nine feet and greater, live loads are included in the indicated D-loads.

References

1. "Soil Engineering," Spangler, M. G. and Handy, R. L.; Intext Educational Publishers, third edition, 1973.
2. "Loads on Underground Conduits," Engineering Library 1-2, Ameron, 1973.
3. "Standard Specification for Highway Bridges," American Association of State Highway and Transportation Officials (AASHTO), twelfth edition, 1973.

MAXIMUM HEIGHT OF COVER FOR CORRUGATED STEEL PIPE

2-2/3" x 1/2" Corrugations

Diameter inches	Maximum Height of Cover (feet) — 5/16" Rivets: 18 gage .042"	16 gage .064"	14 gage .079"	Maximum Height of Cover (feet) — 3/8" Rivets: 12 gage .109"	10 gage .138"	8 gage .168"
SINGLE RIVETED						
12	63	63	83			
15	50	50	66			
18	42	42	55	84		
21	36	36	47	72		
24	32	32	42	61	75	
30		25	33	49	60	74
36		21	28	41	50	62
DOUBLE RIVETED						
42		40	43	72	76	80
48		35	38	63	67	70
54			34	56	59	63
60				50	53	56
66				46	49	51
72					45	47
78					43	44
84					40	40

Note: Seams may be riveted, welded or helical lock seam.

California Division of Highways

TABLE 1-103.21C

REV.

CITY OF SAN DIEGO - DESIGN GUIDE

MAXIMUM COVER FOR CORRUGATED STEEL PIPE
2-2/3" X 1/2" CORRUGATIONS

SHT. NO.

TABLE 1-103.21D

MAXIMUM HEIGHT OF COVER FOR CORRUGATED STEEL PIPE

3" x 1" Corrugations

Diameter inches	Maximum Height of Cover (feet)		
	Double 3/8" Rivets		Double 7/16" Rivets
	16 gage .064"	14 gage .079"	12 gage .109"
54	29	38	59
60	26	34	53
66	23	31	48
72	22	29	44
78	20	26	41
84		25	38
90		23	35
96			33
102			31
108			29
114			28
120			26

California Division of Highways.

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		MAXIMUM COVER FOR CORRUGATED STEEL PIPE 3"X1" CORRUGATIONS	

TABLE I-103.21E

Maximum Height of Cover for Structural Steel Plate Circular Pipe with 6" x 2" Corrugations

Diameter (inches)	Maximum Height of Cover (Feet)						
	4-Bolt Seams						
	METAL THICKNESS IN INCHES						
	0.109	0.138	0.168	0.188	0.218	0.249	0.280
60	67	87					
66	61	79	96				
72	56	72	88	99			
78	52	67	81	91			
84	48	62	76	85	99		
90	45	58	71	79	92		
96	42	54	66	74	87	99	
102	39	51	62	70	81	93	
108	37	48	59	66	77	88	99
114	35	45	56	62	73	83	94
120	33	43	53	59	69	79	89
126	32	41	50	56	66	75	85
132	30	39	48	54	63	72	81
138	29	37	46	51	60	69	77
144	28	36	44	49	58	66	74
150	27	34	42	47	55	63	71
156	26	33	40	45	53	61	68
162	25	32	39	44	51	58	66
168	24	31	38	42	49	56	64
174	23	30	36	41	48	54	61
180	22	29	35	39	46	52	59
186	21	28	34	38	44	51	57
192		27	33	37	43	49	56
198		26	32	36	42	48	54
204		25	31	35	40	46	52
210		24	30	34	39	45	51
216			29	33	38	44	49
222			28	32	37	42	48
228			28	31	36	41	47
234			27	30	35	40	45
240				29	34	39	44
246				29	33	38	43
252					33	37	42

NOTE

When flow velocities with full culvert at entrance exceeds 5 fps, thicker metal invert plates shall be for values left of heavy broken lines.

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		MAXIMUM COVER FOR STRUCTURAL STEEL PLATE CIRCULAR PIPE —6" X 2" CORRUGATIONS	

TABLE 1-103.21F

Maximum Height of Cover for Steel Pipe Arches with 2 2/3" x 1/2" Corrugations (Annular or Helical)

Span–Rise (inches)	Minimum Corner Radius	Maximum Height of Cover (Feet) (2)		
		5/16" Rivets	3/8" Rivets	
		METAL THICKNESS IN INCHES (3)		
		0.079	0.109	0.138
		Single Riveted (1)		
21 x 15	3	9	9	
24 x 18	3	8	8	
28 x 20	3	6	6	6
35 x 24	3	5	5	5
42 x 29	3½	5	5	5
		Double Riveted (1)		
49 x 33	4	5	5	5
57 x 38	5	6	5	5
64 x 43	6	6	6	6
71 x 47	7		6	6
77 x 52	8		6	6
83 x 57	9			7

NOTES:

(1) Annular and longitudinal seams may be riveted or spot welded. Helical seams may be continuous lock seam or continuous welded.

(2) Cover limited by corner pressure of 2 ton per sq. ft.

(3) When flow velocity with full culvert at entrance exceeds 5 fps under abrasive conditions, thicker metal shall be provided for values left of heavy broken line.

TABLE 1-103.21G

Maximum Height of Cover for Structural Steel Plate Pipe Arches With 6" x 2" Corrugations (1)

Span	Rise	Maximum Height of Cover (Feet) (3)							
		Corner soil bearing 1½ tons per square foot				Corner soil bearing 3 tons per square foot			
		METAL THICKNESS IN INCHES (2)							
		.109	.138	.168	.188	.109	.138	.168	.188
		18" CORNER RADIUS (4)							
6'-1"	4'-7"	10				20			
7'-0"	5'-1"	9				18			
7'-11"	5'-7"	8				16			
8'-10"	6'-1"	7				14			
9'-9"	6'-7"	6				12			
10'-11"	7'-1"	6				12			
12'-10"	8'-4"	6				12			
14'-1"	8'-9"	5				10			
15'-4"	9'-3"	5				10			
15'-10"	9'-10"	5				10			
16'-7"	10'-1"	5				10			
		31" CORNER RADIUS (5)							
13'-3"	9'-4"	8					16		
14'-2"	9'-10"	8					16		
15'-4"	10'-4"	7					14		
16'-3"	10'-10"		6				12		
17'-2"	11'-4"		6				12		
18'-1"	11'-10"			6				12	
19'-3"	12'-4"			5				10	
19'-11"	12'-10"			5				10	
20'-7"	13'-2"				5				10

NOTES:

(1) 6" x 2" corrugations fabricated with bolted seams.

(2) When flow velocities with full culvert at entrance exceeds 5 fps under abrasive conditions, thicker metal invert plates shall be provided.

(3) For intermediate sizes, the depth of cover shall be interpolated.

(4) Specify that the 18" corner radius plate shall be fabricated from plate that is 0.138 inch thick.

(4) and (5) 31" corner radius pipe arch should be specified in preference to the 18" corner radius pipe arch when conditions will permit its use.

TABLE 1-103.21H

Maximum Height of Cover for Corrugated Aluminum Pipe with 2 2/3" x 1/2" Annular & Helical Corrugations

Diameter (Inches)	Maximum Height of Cover (Feet)				
	METAL THICKNESS IN INCHES (2)				
	5/16" Rivets		3/8" Rivets		
	.060	.075	.105	0.135	0.164
	Single Riveted (1)				
12	91	99			
15	73	91	99		
18	60	76	99		
21	52	65	91		
24	45	57	79	99	
30		45	63	82	
36		38	53	68	
	Double Riveted (1)				
42			45	58	
48			39	51	62
54				41	51
60				33	42
66					34
72					26

NOTES:

(1) Seams may be annular riveted or helical lock seam only.

TABLE 1-103.21I

Maximum Height of Cover for Aluminum Pipe Arches with 2 2/3" x 1/2" Annular and Helical Corrugations

Span & Rise (Inches)	Minimum Corner Radius (Inches)	Maximum Height of Cover (Feet) (2)				
		METAL THICKNESS IN INCHES (3)				
		5/16" Rivets		3/8" Rivets		
		0.060	0.075	0.105	0.135	0.164
		Single Riveted (1)				
17 x 13	3	8				
21 x 16	3	8				
24 x 18	3	8				
28 x 20	3		6			
35 x 24	3		5			
42 x 29	3 1/2			5		
		Double Riveted (1)				
49 x 33	4			5		
57 x 38	5				5	
64 x 43	6				6	
71 x 47	7					6
77 x 52	7					5
83 x 57	7					6

NOTES:

(1) Seams may be annular riveted or helical lock seam only.

(2) Cover is limited by corner soil bearing pressure of 2 tons per square foot.

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		TABLE 1-103.21H AND TABLE 1-103.21I	

TABLE I-103.21J

Suggested Depth and Spacing of Underdrains for Various Soil Types

Soil Classes	Soil Composition			Drain Spacing (Feet)			
	Percent Sand	Percent Silt	Percent Clay	3 Ft. Deep	4 Ft. Deep	5 Ft. Deep	6 Ft. Deep
Clean Sand	80-100	0-20	0-20	110-150	150-200		
Sandy Loam	50-80	0-50	0-20	50-100	100-150		
Loam	30-50	30-50	0-20	30-60	40-80	50-100	60-120
Clay Loam	20-50	20-50	20-30	20-40	25-50	30-60	40-80
Sandy Clay	50-70	0-20	30-50	15-30	20-40	25-50	30-60
Silty Clay	0-20	50-70	30-50	10-25	15-30	20-40	25-50
Clay	0-50	0-50	30-100	15 (max.)	20 (max.)	25 (max.)	40 (max.)

NOTE: Depth is measured to invert of pipe.

California Division of Highways.

SHT. NO.

CITY OF SAN DIEGO - DESIGN GUIDE

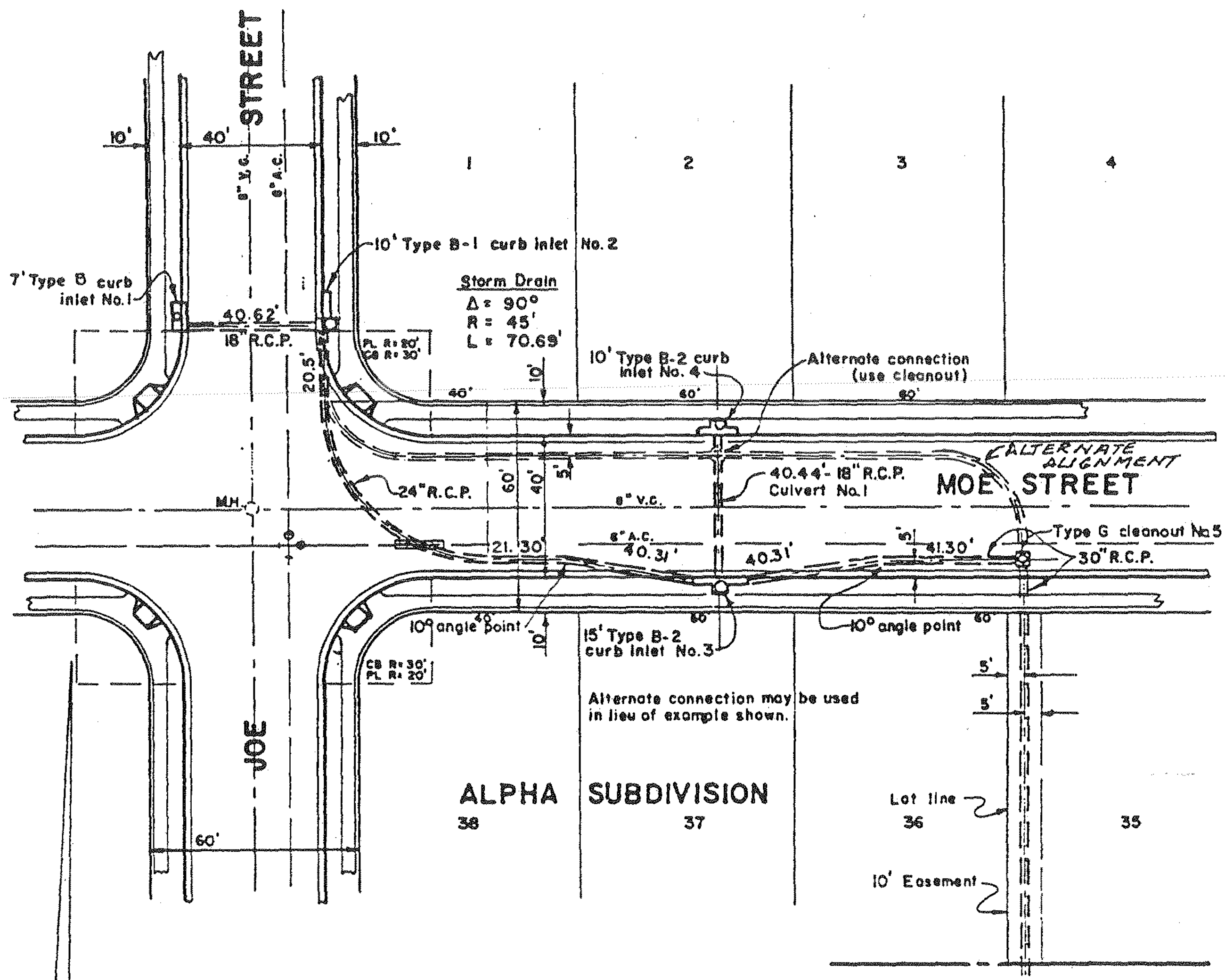
DEPTH AND SPACING OF UNDERDRAINS FOR VARIOUS SOIL TYPES

REV.

1-103.22 DESIGN GUIDES

A.	FIGURE 1-103.22A	Typical Plan in Improved Street (Flat Grades)
B.	FIGURE 1-103.22B	Typical Profile in Improved Streets (Flat Grades)
C.	FIGURE 1-103.22C	Typical Plan in Easement (Steep Grades)
D.	FIGURE 1-103.22D	Typical Profile in Easement (Steep Grades)
E.	FIGURE 1-103.22E	Typical Plan - Combination of Flat and Steep Grades with Curved Alignment and Profile.
F.	FIGURE 1-103.22F	Typical Profile - Combination of Flat and Steep Grades with Curved Alignment and Profile.
G.	FIGURE 1-103.22G	Typical Plan in Easement with Complex Alignment on Fill Slope.
H.	FIGURE 1-103.22H	Typical Profile in Easement with Complex Alignment on Fill Slope.

FIGURE 1-103.22A



NOTE: For Profile See Figure 1-103.22B

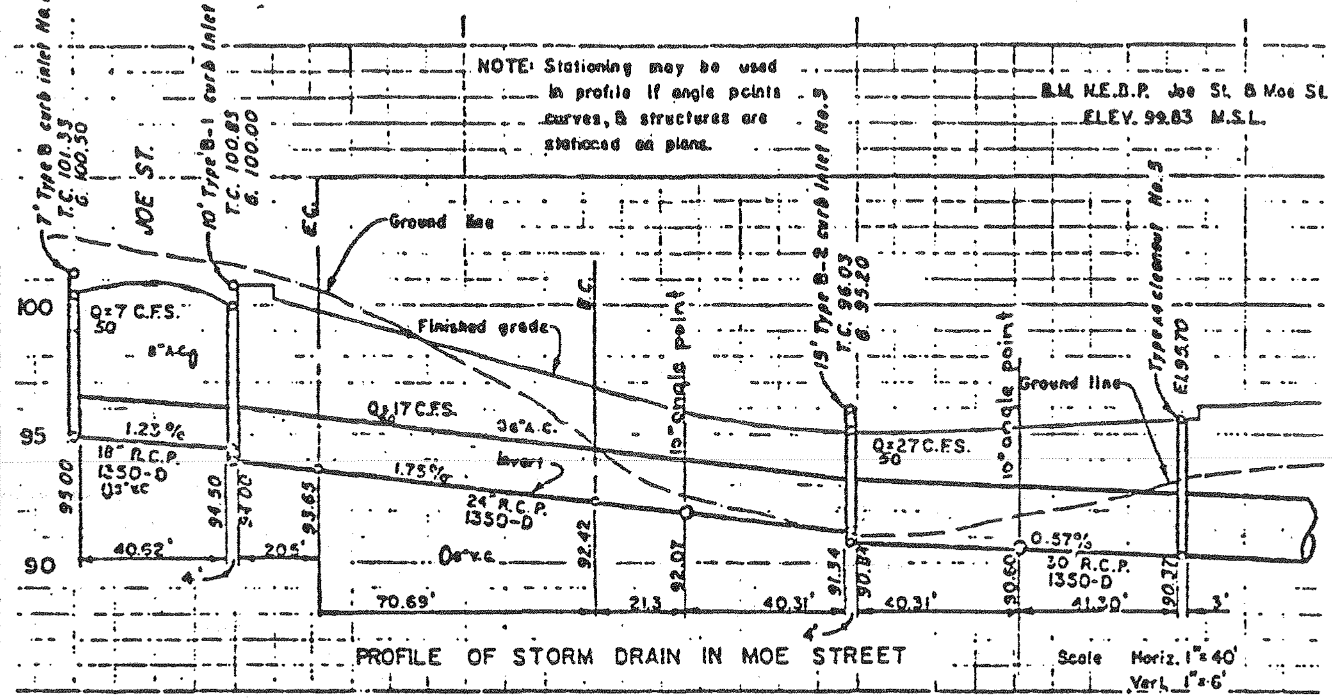
Conditions beyond this point are as shown on other Guide Sheets.

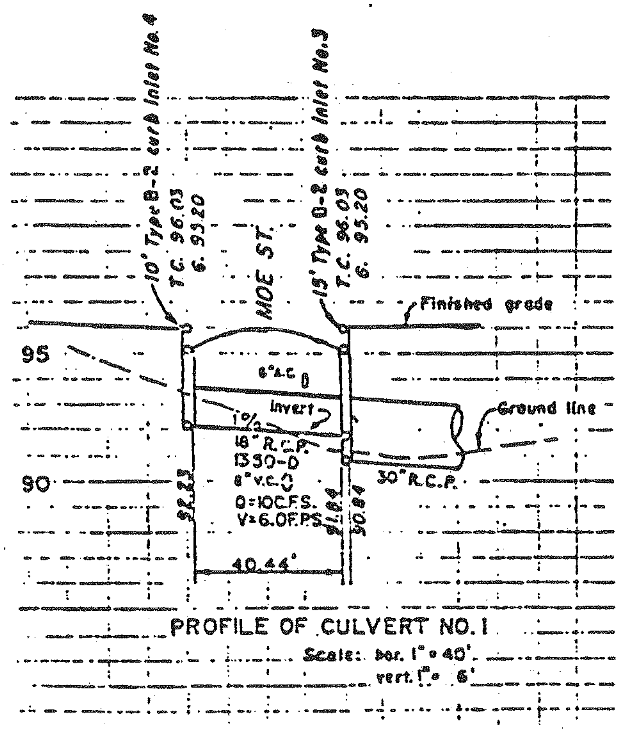
N

SCALE: 1"=40'

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		TYPICAL PLAN IN IMPROVED STREETS (FLAT GRADES)	

FIGURE I-103.22B

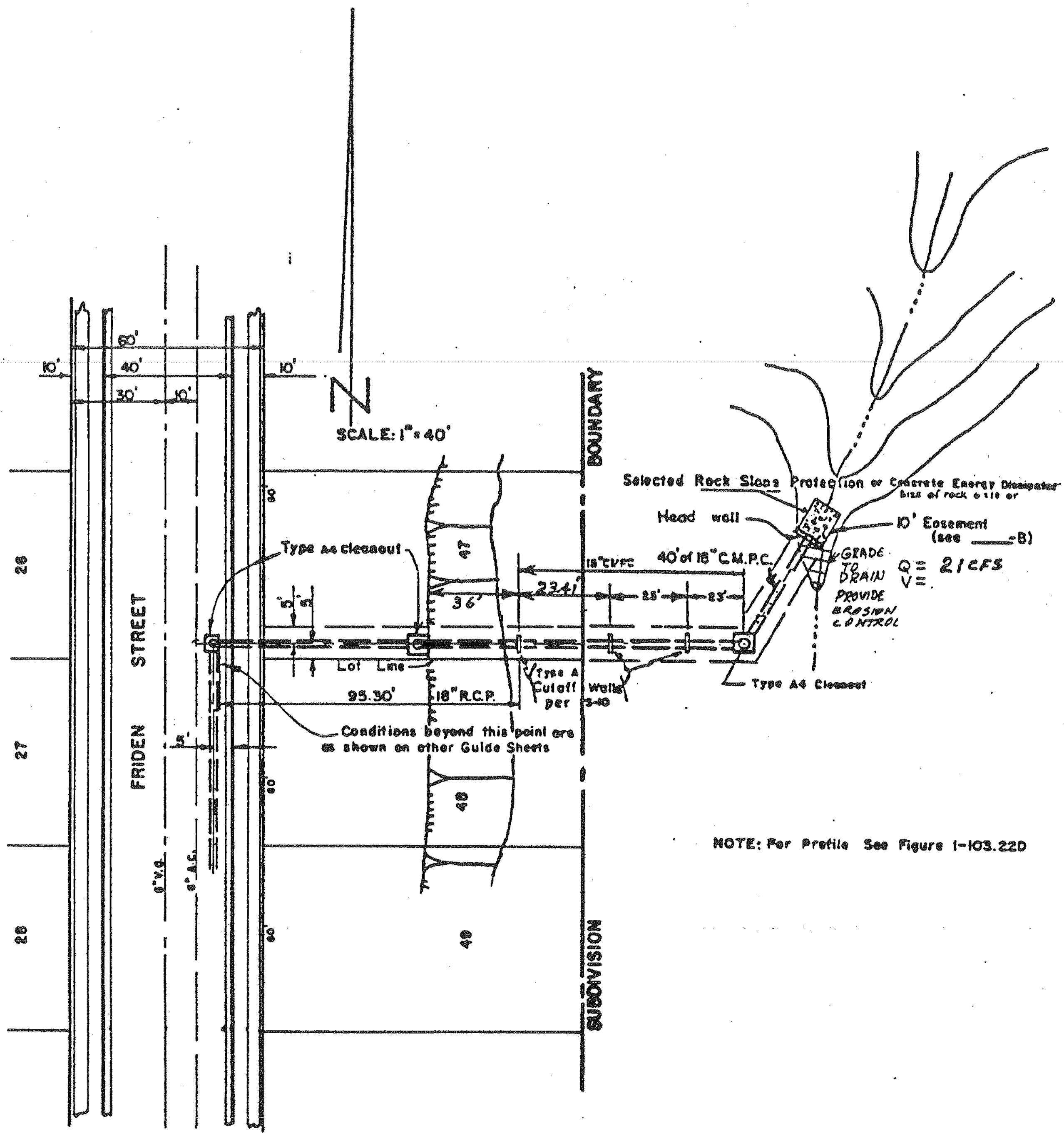




NOTE: For Plan See Figure I-103.22A

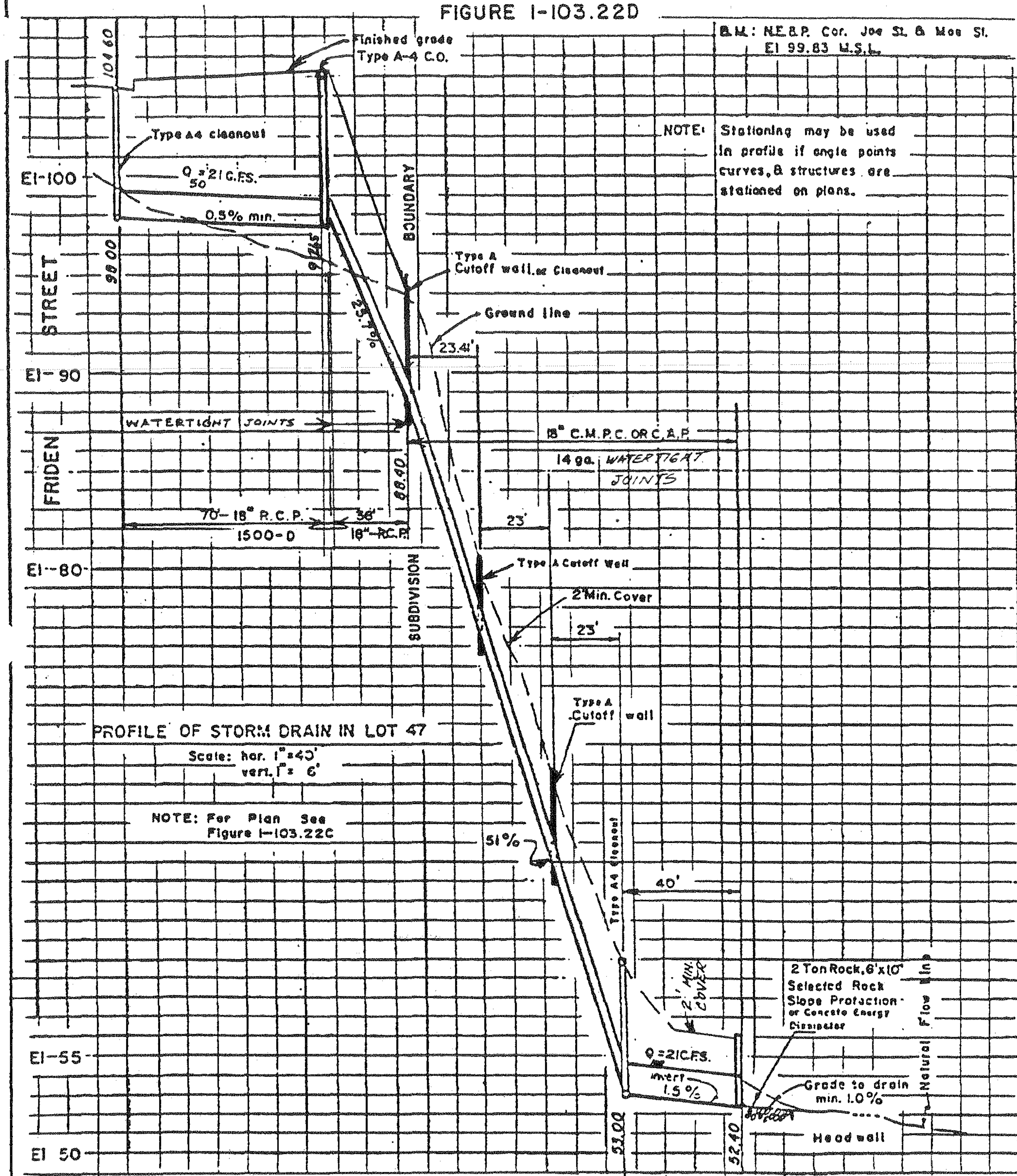
SHT. NO.	CITY OF SAN DIEGO - DESIGN GUIDE	REV.	
	TYPICAL PROFILE IN IMPROVED STREETS (FLAT GRADES)		

FIGURE 1-103.22C



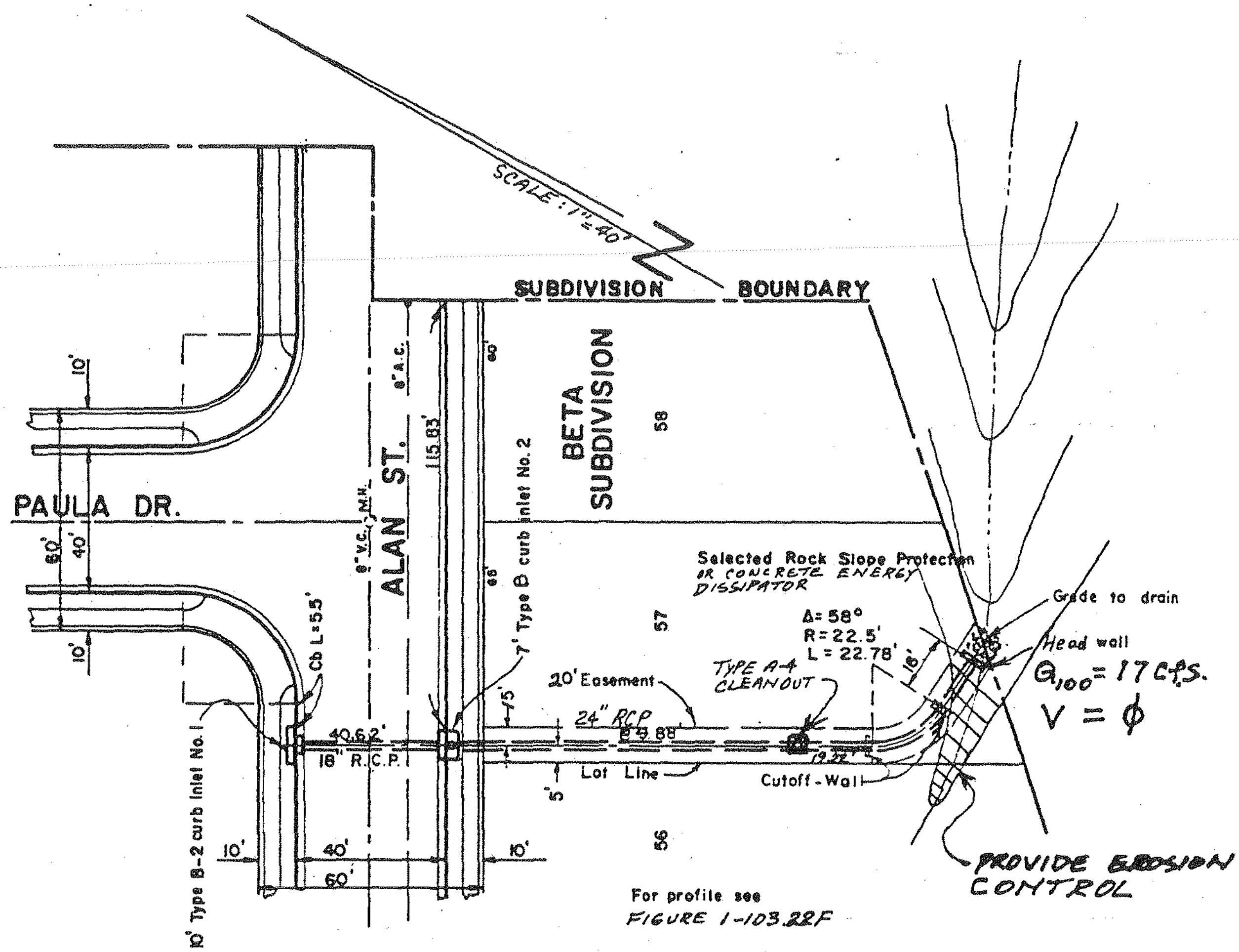
REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		TYPICAL PLAN IN EASEMENT (STEEP GRADES)	

FIGURE 1-103.22D



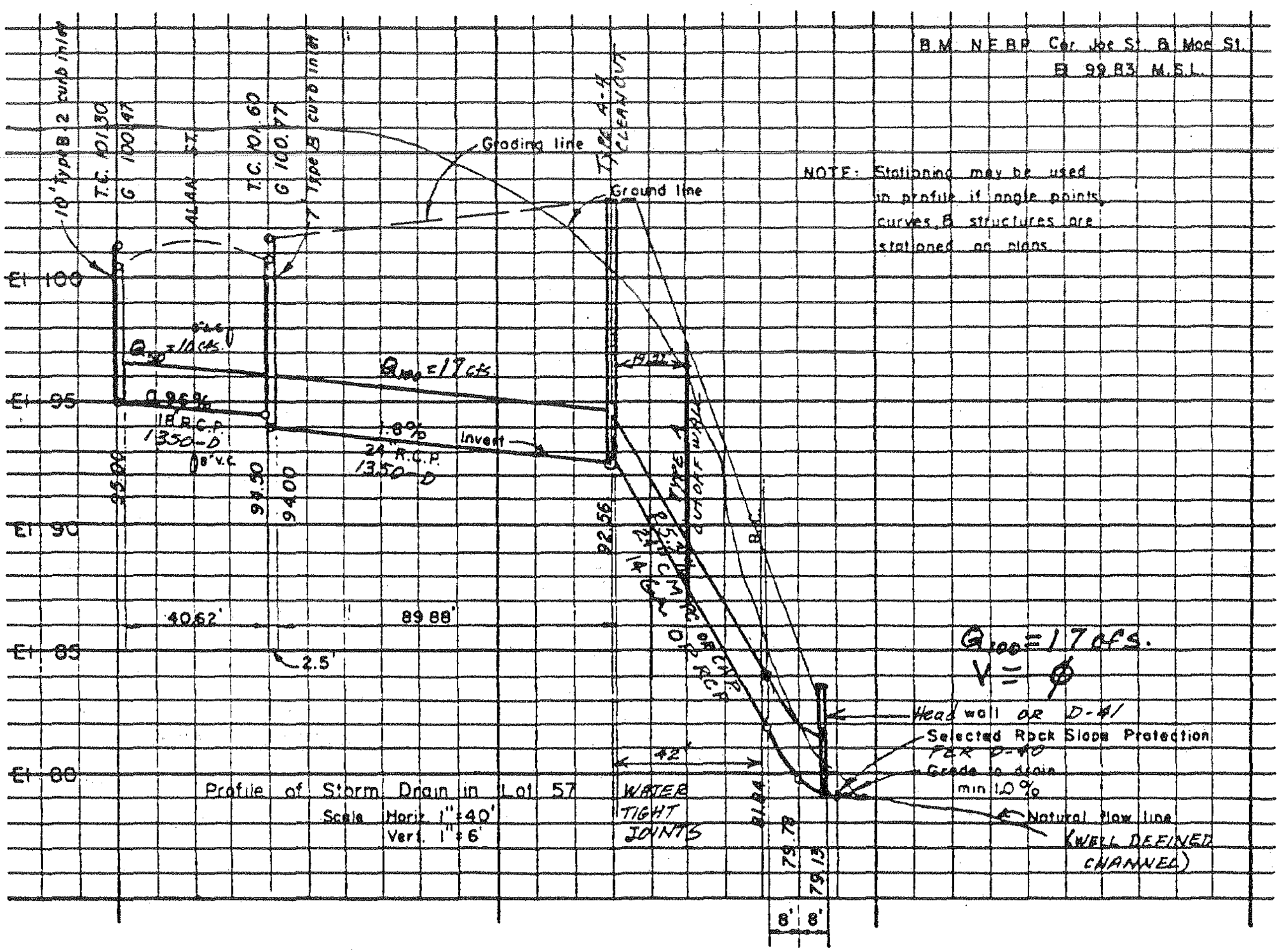
SHT. NO.	CITY OF SAN DIEGO - DESIGN GUIDE	REV.
	TYPICAL PROFILE IN EASEMENT (STEEP GRADES)	

FIGURE 1-103.22E



REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		TYPICAL PLAN COMBINATION OF FLAT AND STEEP GRADES WITH CURVED ALIGNMENT AND PROFILE	

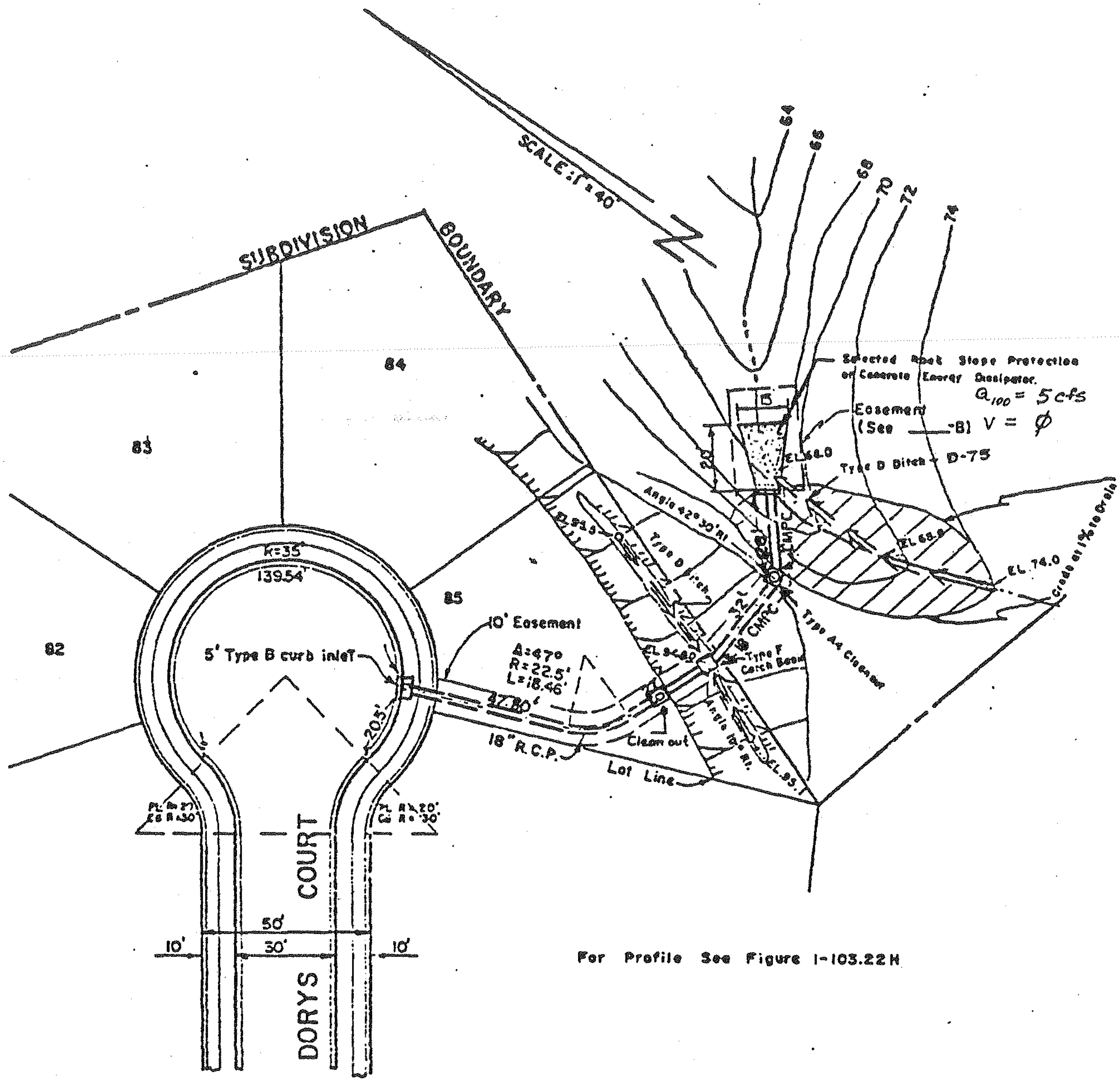
FIGURE 1-103.22F



For Plan See Figure 1-103.22E

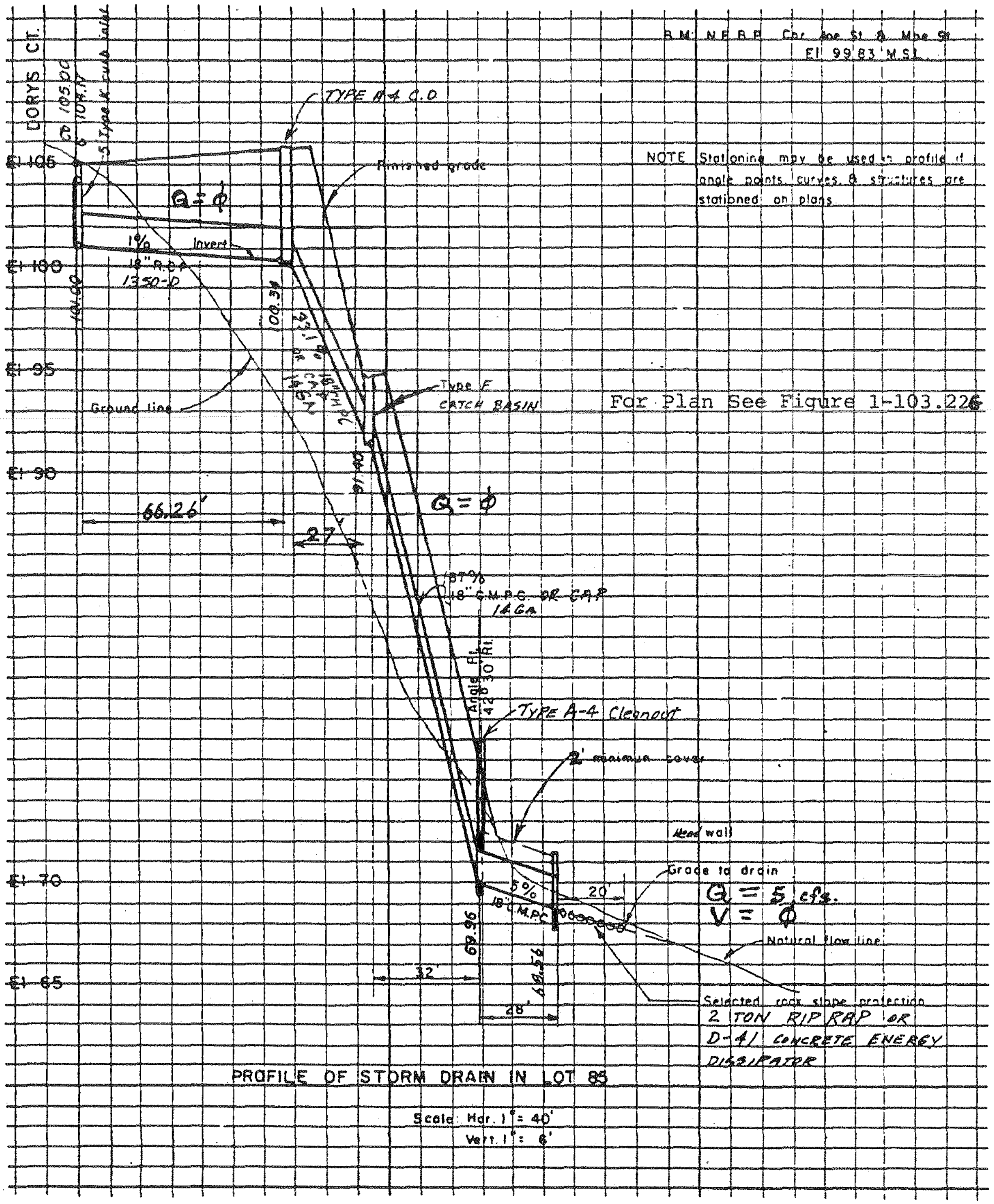
REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		TYPICAL PROFILE COMBINATION OF FLAT AND STEEP GRADES WITH CURVED ALIGNMENT AND PROFILE	

FIGURE 1-103.22G



REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		TYPICAL PLAN	
		IN EASEMENT WITH COMPLEX ALIGNMENT ON FILL SLOPE	

FIGURE 1-103.22H



REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		TYPICAL PROFILE IN EASEMENT WITH COMPLEX ALIGNMENT ON FILL SLOPE	

OPEN CHANNELS (1-104)

1-104.1 INTRODUCTION

A. An open channel is any waterway in which water flows with a free surface. The term shall be applied to streams, canals, channels, ditches, improved streets, and other conduits with no overhead restriction. It shall also include any conduit flowing partially full.

B. The design of open channels consists of computing a channel section which will carry the design discharge under the controlling conditions, adding two feet (2') minimum freeboard for projects under the Federal Emergency Management Administration Regulations. All other channels require one foot (1') of freeboard above the energy gradeline for all other channels and 0.5 feet of freeboard above the energy gradeline for all brow ditches. Appropriate control shall be provided.

1-104.2 MINIMUM CHANNEL GRADIENT

Generally, the minimum gradient shall be 0.5 percent, provided this gradient is adequate to carry low flows. A flatter gradient may be approved where special provisions are made to provide for low flows.

1-104.3 CHANNEL ALIGNMENT

A. A bend in channel alignment should be located where the velocity is lowest and the change in direction should be as small as is practicable.

B. The minimum radius of curvature of the centerline of a channel shall be at least three times the width of a rectangular channel or three times the bottom width of a trapezodial channel to minimize development of spiral flow.

1-104.4 CHANNEL SUPERELEVATION

A. All horizontal curves shall be superelevated in drainage channels in accordance with Chart 1-104.4.

B. Superelevation of a channel shall be located as follows:

(1) In accordance with the formulae that follow, begin at a point 5 Lw downstream from the point of tangent of the curve with no allowance.

(2) Taper uniformly to full superelevation at a point 3 Lw downstream from the point of tangent on both blanks.

(3) Carry full superelevation to upstream end of curve on both banks.

(4) Continue top of bank elevation level from the upstream end of curve to its intersection with the normal top of bank.

(5) Superelevation Formulae

$Lw = 2T\sqrt{F^2 - 1}$ when $F \geqq 1$

$Lw = 2T$ when $F < 1$

F=Froude Number = $\dfrac{Q/A}{\sqrt{gA/T}}$

Lw = Wave length

T = Top width of water surface (feet)

C. Trapezodial channels with curved alignment under supercritical flow conditions will require special design considerations.

D. Transition Curves

Transition curves shall be used upstream and downstream from horizontal curves in rectangular channels for supercritical velocities where one of the following conditions exists:

(1) When the freeboard, above superelevated water surface (as calculated for the channel curve) is less than one foot (1').

(2) In reverse curves or on alignments where curves follow one another closely.

(3) For any case where it appears desirable to eliminate crosswave distrubances.

The radius of the transition curve shall be twice the radius of the central curve.

The central angle of the transition curve shall be determined by the formula:

$$\tan \varnothing_t = \frac{T}{2rc \tan Bo}$$

Bo = wave angle at entrance

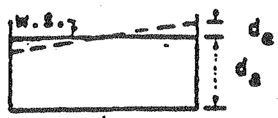
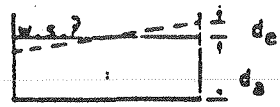
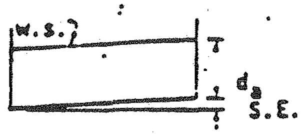
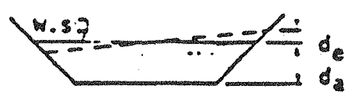
$\sin Bo = 1/F_1$

F_1 = Froude number of flow in approach channel

T = normal top width of channel

rc = radius of central curve

CHART I-104.4

Depth > dc (TRANQUIL FLOW)	SECTION	Depth < d_c (RAPID FLOW)
$d_e = \frac{V^2 T}{2gR}$	 HORIZONTAL INVERT NO SPIRAL	$d'_e = \frac{V^2 T}{gR}$
$d_e = \frac{V^2 T}{2gR}$	 HORIZONTAL INVERT SPIRAL TRANSITION	$d'_e = \frac{V^2 T}{2gR}$
$S.E. = \frac{V^2 T}{gR}$	 SUPERELEVATED INVERT SPIRAL TRANSITION	$S.E. = \frac{V^2 T}{gR}$
$d_e = \frac{V^2 T}{2gR}$	 HORIZONTAL INVERT WITH OR WITHOUT SPIRAL TRANSITION	$d'_e = C\frac{V^2 T}{gR}$ C=1.3 WITH NO SPIRAL C=1.0 WITH SPIRAL TRANSITION

d_a = DEPTH INCLUDING AIR
d_e = RISE ABOVE d_a DUE TO CENTRIFUGAL FORCE
d'e = RISE ABOVE d_a DUE TO CENTRIFUGAL FORCE AND TRANSVERSE WAVES
S.E. = DIFFERENCE IN ELEVATION OF WATER SURFACE BETWEEN WALLS
T = TOP WIDTH AT WATER SURFACE
R = RADIUS OF CURVATURE, ℄ OF CHANNEL
C = CONSTANT

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		FORMULAE FOR CHANNEL SUPERELEVATION	

1-104.5 CHANNEL TRANSITIONS

A. Transitions between two different shaped channels shall be designed to produce a smooth, low-head-loss transfer of flow. The design shall consider flow-rate changes, wall roughness, and channel shape and slope.

The water surface level of the downstream channel must be set below the water surface level of the upstream channel by at least the sum of the increase in velocity head, plus transition and friction losses.

B. Conduit to channel or channel to conduit transitions shall conform to the conditions set forth in Item A. The channel downstream of a conduit shall have a water surface far enough below the conduit to prevent a submerged outlet for a design storm.

C. The maximum angle of deviation in any transition shall be 12.5°.

1-104.6 ANGLE OF CONFLUENCE

A. Generally, the angle of confluence shall be determined by the downstream flow characteristics. It shall be designed to produce a smooth, low-head-loss transfer of flow and shall consider flow-rate changes, roughness, and shape and slope.

B. In no case shall a component of lateral velocity oppose the mainline velocity by an angle of confluence.

C. A conduit connection to a channel shall be made at an elevation as near the top of the channel water surface as possible and the angle of confluence shall be such as to produce a smooth low-head-loss transfer of flow.

1-104.7 CUT-OFF WALLS

A. Lined channels shall have a cut-off wall constructed at each end of the lining along the full width of section.

B. Graded, unlined channels, or channels with rock slope protection shall have a rock or other type of suitable cut-off wall at each end along the full width or section.

1-104.8 DEBRIS AND SILT CONTROL FACILITIES

A. Where flows into a channel are likely to carry floating debris and/or rocks in any quantity, a trash fence or rack, or deflector may be required up stream of the channel. This facility shall be designed and located to prevent an obstruction or blockage of the channel entrance. Maintenance access is required to all of these debris/rock collectors. The channel entrance and upstream area should be designed in such a way to provide for overtopping of the trash fence/rack without overtopping of the channel or damage to adjacent property.

B. Should the flows be transporting significant quantities of silt, a temporary or permanent silt basin may be required to prevent silting in the channel or downstream from the channel.

1-104.9 OUTLET DISSIPATOR

A. A suitable energy dissipator for all open channel flow is to be installed to reduce velocities to pre-improved conditions as follows:

(1) Where all channels discharge into an unimproved or natural channel and the velocities exceed those permissable for the material involved.

(2) At the end of street improvements where the street gutters discharge onto natural ground with velocities exceeding those permissable for the material involved.

1-104.10 CHANNEL TYPES

A. Unlined and Soft Bottom Channels

Such channels may be appropriate where the following conditions exist:

(1) A fully improved channel section is determined to be economically unfeasible.

(2) Adequate bank protection, where necessary, is to be installed for alignment control and for safeguarding adjacent property.

(3) Channel work will not significantly alter the watercourse or cause detrimental effects on adjacent property.

(4) Will conform to the permissible velocities as shown on TABLE 1-104.10A.

(5) A low flow channel may be required should the main channel grade be determined to be so flat that drainage water will pond through the reach of the channel.

B. Grass-Lined Channels

(1) Grass-lined channels may be approved where the channel area is planned for open space use, is properly designed, and provisions are made to guarantee perpetual maintenance.

(2) Channel must conform to the permissible velocities as shown on TABLE 1-104.10B.

C. Paved Channels

(1) Trapezodial channels shall conform to the City of San Diego Standard Drawings.

(2) Other channel sections must be designed to withstand all loads to which they will be subjected. The following factors should be considered: hydrostatic uplift, lateral earth pressures, velocities and debris loads, truck surcharge, and possible wheel loads.

(3) Particular attention must be given to the subdrainage system which must be so chosen as to assure that upward pressure will be less than the weight of the lining.

D. Masonry Wall Drainage Structures

(1) The use of masonry walls for drainage structures is not permitted.

(2) The use of masonry walls for box culverts is not permitted.

TABLE I-104.10A

Recommended Permissible Velocities for Unlined Channels

Type of Material in Excavation Section	Permissible Velocity (Feet per Second)	
	Intermittent Flow	Sustained Flow
Fine Sand (Noncolloidal)	2.5	2.5
Sandy Loam (Noncolloidal)	2.5	2.5
Silt Loam (Noncolloidal)	3.0	3.0
Fine Loam	3.5	3.5
Volcanic Ash	4.0	3.5
Fine Gravel	5.0	4.0
Stiff Clay (Colloidal)	6.0	4.5
Graded Material (Noncolloidal)		
Loam to Gravel	6.5	5.0
Silt to Gravel	7.0	5.5
Gravel	7.5	6.0
Coarse Gravel	8.0	6.5
Gravel to Cobbles (Under 6 Inches)	9.0	7.0
Gravel and Cobbles (Over 8 Inches)	10.0	8.0

TABLE I-104.10 B

PERMISSIBLE VELOCITIES WITH GRASS COVERS [1,2]

Cover	Slope range	Permissible velocity on Erosion resistant soils	Permissible velocity on Easily eroded soils
	Percent	f.p.s.	f.p.s.
Bermudagrass	0-5	8	6
	5-10	7	5
	Over 10	6	4
Buffalograss, Kentucky bluegrass, Smooth brome, Blue gamma	0-5	7	5
	5-10	6	4
	Over 10	5	3
Grass mixture	0-5	5	4
	5-10	4	3
Lespedeza sericea, Weeping lovegrass, Yellow bluestem, Kudzu, Alfalfa, Crabgrass	0-5	3.5	2.5
Common lespedeza [3], Sudangrass [3]	[4] 0-5	3.5	2.5

[1] From Handbook of Channel Design for Soil and Water Conservation, U. S. Soil Conservation Service

[2] Use velocities over 5 f.p.s. only where good covers and proper maintenance can be obtained.

[3] Annuals, used on mild slopes or as temporary protection until permanent covers are established.

[4] Use on slopes steeper than 5 percent is not recommended.

SHT. NO.	CITY OF SAN DIEGO - DESIGN GUIDE	REV.
	PERMISSABLE VELOCITIES FOR GRASS-LINED CHANNELS	

1-104.11 DRAINAGE DITCHES

Generally, the classification for ditch under this manual shall be an open conduit which conveys less than 15 c.f.s. of public drainage. The applicable requirements for channels shall apply to drainage ditches.

A. Brow and Terrace Ditches

(1) Minimum grade shall be two percent (2%) or a grade which will produce a minimum velocity of 6 f.p.s. when flowing full, 4 f.p.s when one quarter full.

(2) Minimum freeboard shall be 0.5 foot. Where energy gradients necessitate, more freeboard will be required.

(3) The maximum angle of confluence on any ditch connection shall be 60°. Connections at any angle of confluence may require some means to contain the drainage flow within the ditches (splash aprons, splash walls, etc.)

(4) Downdrains may be either ditch or pipe. Special considerations must be made to insure that all drainage flow in an open ditch downdrain is totally contained within the ditch.

(5) Brow ditch drainage must outfall either into the paved street section, inlet or a well defined natural channel. An energy dissipator will be required at the outfall in a natural channel.

(6) Single lot brow ditches may terminate at the toe of the slope within the lot, with an adequate energy dissipator.

(7) Spot elevations shall be shown every 100 feet (100') on center, or more often if conditions require, for clarity or by the City Engineer.

(8) All D-75 brow ditches shall be reinforced.

(9) If drainage is carried in a brow ditch, then:

(a) Drainage must be continued to the gutter (Refer to 1-101.3), an inlet, or to a well defined natural drainage channel in a brow ditch or pipe.

(b) Brow ditch down-drain for each lot is permitted providing that only 100 feet (100') beyond the lot line is picked up in the brow ditch and NO natural drainage channel is intercepted (even sheet flow only). These ditches may be terminated at the toe of slope in an adequate rip rap energy dissipator.

B. Toe Ditches

(1) Toe ditches shall be required at the toe of fill slopes where any drainage is directed toward or along the slope.

(2) Brow and/or terrace ditch sections may be used as toe ditches if they have adequate capacity for the drainage flow.

1-104.12 STREET DRAINAGE

A. Maximum allowable drainage on any street section shall be as indicated on CHART 1-104.12.

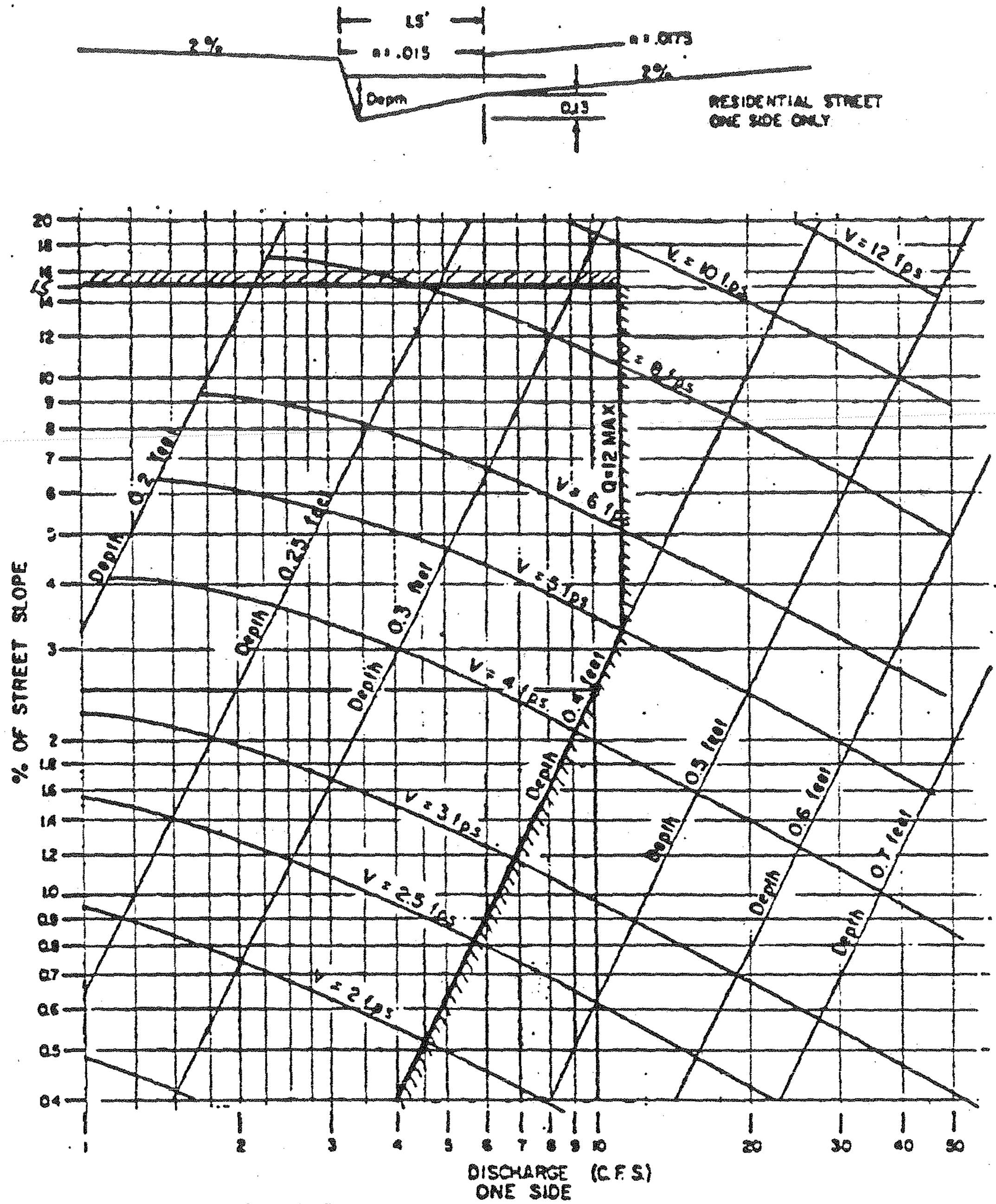
B. Street drainage shall be intercepted with an underground storm drain prior to any street grade of ten percent (10%) or greater, wherever possible.

C. Design for drainage on any 4-lane or 6-lane street section shall require retention of the drainage flows in such a manner that two (2) lanes will be clear of flow at all times for 50-year incidence storm.

D. The minimum street and gutter grade permitted is 0.75%. 0.6%

E. All streets shall have a nominal two (2%) percent crown unless superelevated.

CHART I-104.12



EXAMPLE:

Given: Q = 10 S = 2.5%
Chart gives: Depth = 0.4, Velocity = 4.4 f.p.s.

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		GUTTER AND ROADWAY DISCHARGE - VELOCITY CHART	

1-104.13 CHANNEL EASEMENTS

A. All easements shall be wide enough to provide for the channel structure and adequate maintenance access.

(1) For channels thirty feet (30') or more in top width, a minimum access road width of twelve feet (12') shall be provided on each side of the channel.

(2) For channels with a top width of less than thirty feet (30'), a minimum access road width of twelve feet (12') shall be provided on one side of the channel and four feet (4') on the opposite side.

(3) The minimum width of any channel easement shall be the top width of channel plus four feet (4') on each side of the channel.

B. Access Easements

When the lack of a service road is not considered detrimental to the maintenance and integrity of the channel, the twelve foot (12') access can be omitted under the following conditions:

(1) Intermediate channels with a minimum bottom width of eight feet (8').

Provide suitable exit-entry ramps at street crossings and at other approved needed locations to facilitate travel of maintenance and emergency vehicles in the channel bottom. At a minimum one access ramp must be provided at each end of a channel.

(2) Small channels with a bottom width of less than eight feet (8'). Provide vehicular access to the channel on a maximum spacing of 1,000 feet and at other approved, needed locations.

(3) A minimum access road shall be provided in the access easement, twelve feet (12') wide, with a maximum grade of fifteen percent (15%).

C. Easement Location

Easements shall be placed on one side of lot or ownership lines in new developments and in existing development where conditions permit.

D. Fencing

(1) Fencing is required for all channels abutting residential developments, schools, parks and pedestrian walkways as follows:

(a) Fencing is required for all concrete lined or rip rapped channels where the design frequency storm provides a velocity which exceed 5 feet per second and two feet (2') in depth or a combination thereof for a factor of ten (10). (This does not include brow ditches).

(b) Fencing is required for all unlined channels steeper than 4:1 where the design frequency storm provides a velocity which exceeds five feet (5') per second and two feet (2') in depth or a combination thereof for a factor of ten (10).

(2) Six foot (6') high chain link fence shall be installed on both sides of the channel easement, with gate openings at all access points. (Twenty foot (20') gates - 1,000 feet on center; four-foot (4') gates - 500 feet on center or portion thereof for maintenance or emergency access.

(3) Fencing shall be located a minimum of six inches (6") inside the easement boundary lines unless otherwise approved.

(4) Fencing Material:

(a) All new fences shall be chain link, a minimum of six feet (6') in height with a top rail. (Steel fence must be galvanized).

(b) Existing five foot (5') high chain link fences may remain if they are in good condition. (No rust).

(c) Existing four foot (4') high fences shall be replaced with six foot (6') high chain link fences.

(5) All bridge crossings shall be fenced.

1-104.14 MANNINGS ROUGHNESS COEFFICIENTS

A. TABLE 1-104.14A Design values for Mannings Roughness Coefficient (n)

B. CHART 1-104.14B Nomograph for Solution of Manning Equation

TABLE 1-104.14A

DESIGN VALUES FOR MANNINGS ROUGHNESS COEFFICIENT (n)

TYPE OF CHANNEL	N VALUE
Unlined Channels:	
Clay Loam	0.023
Sand	0.020
Gravel	0.030
Rock	0.040
Lined Channels:	
Portland Cement Concrete	0.015
Air Blown Mortar	0.018
Asphalt Concrete	0.018
Grass Lined Channels: (Shallow depths)	
2 inch length	0.050
4 - 6 inch length	0.060
6 - 12 inch length	0.120
12 - 24 inch + length	0.200
Pavement and Gutters:	
Concrete	0.015
Asphalt Concrete	0.018
Natural Streams: (Less than 100 feet wide at flood stage)	
1. Regular section	
a. Some grass and weeds, little or no brush	0.030
b. Dense growth of weeds, depth of flow substantially greater than weed height	0.040
c. Some weeds, light brush on bank	0.040
d. Some weeds, heavy brush on banks	0.060
e. With trees in channel, branches submerged at flood stage, increase above values by	0.015

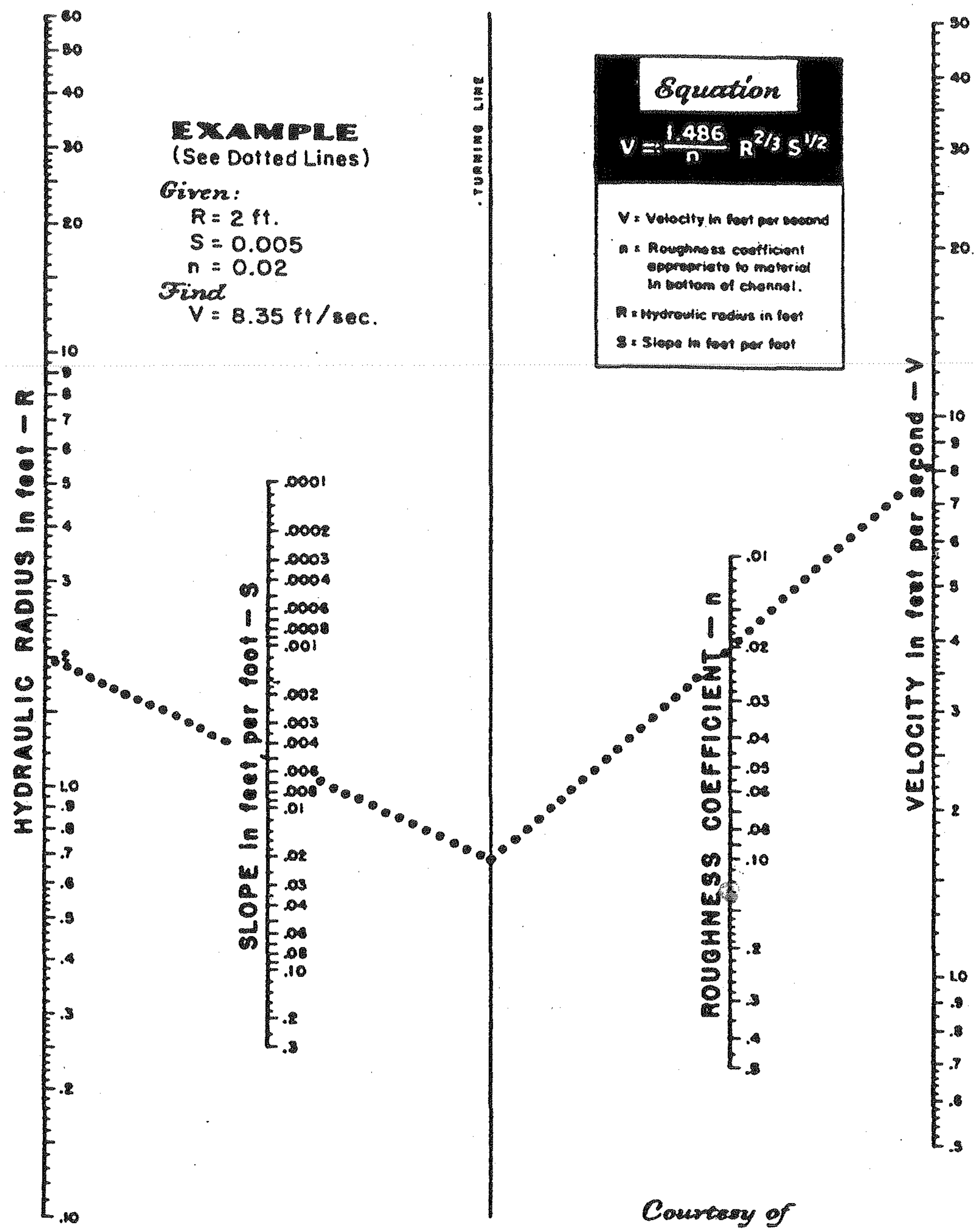
TABLE 1-104.14A (Continued)

2.	Irregular section, with pools, slight channel meander increase all values listed in 1. Regular Section, by	0.015

Flood Plains: (adjacent to natural streams)

1.	Pasture, no brush		
	a.	Short grass	0.030
	b.	High grass	0.040
2.	Cultivated areas		
	a.	No crop	0.040
	b.	Mature row crops	0.040
	c.	Mature field crops	0.050
3.	Heavy weeds, scattered brush		0.050
4.	Light brush and trees		0.060
5.	Medium to dense brush		0.090
6.	Dense willows		0.170
7.	Cleared land with tree stumps, 100-150 per acre		0.060
8.	Heavy stand of timer, little undergrowth		
	a.	Flood depth below branches	0.110
	b.	Flood depth reaches branches	0.140

CHART I-104.14B



Courtesy of
FEDERAL HIGHWAY ADMINISTRATION
AUGUST 1951

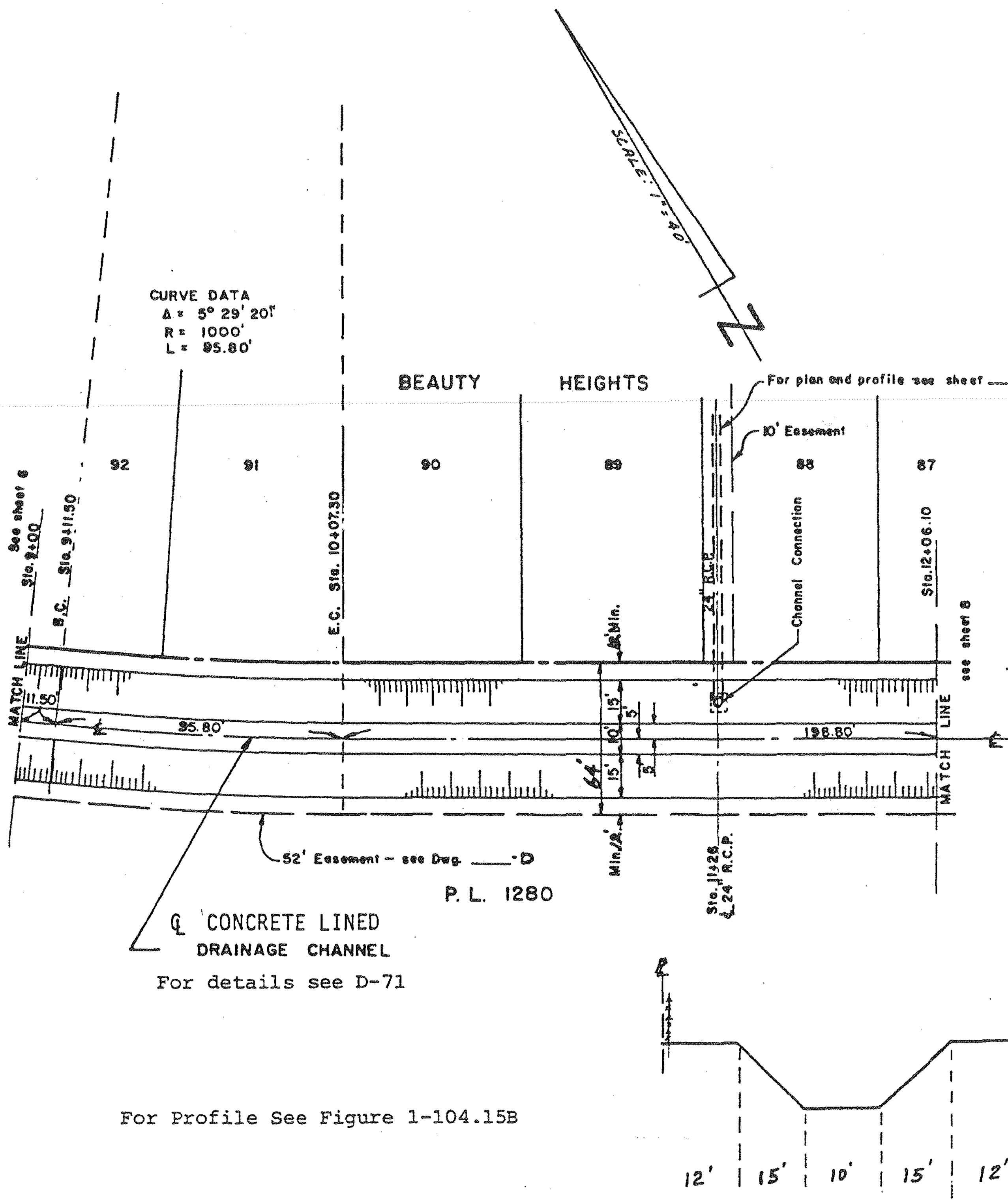
REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		NOMOGRAPH FOR SOLUTION OF MANNING EQUATION	

1-104.15 DESIGN GUIDES

A. FIGURES 1-104.15A Typical Channel Plan

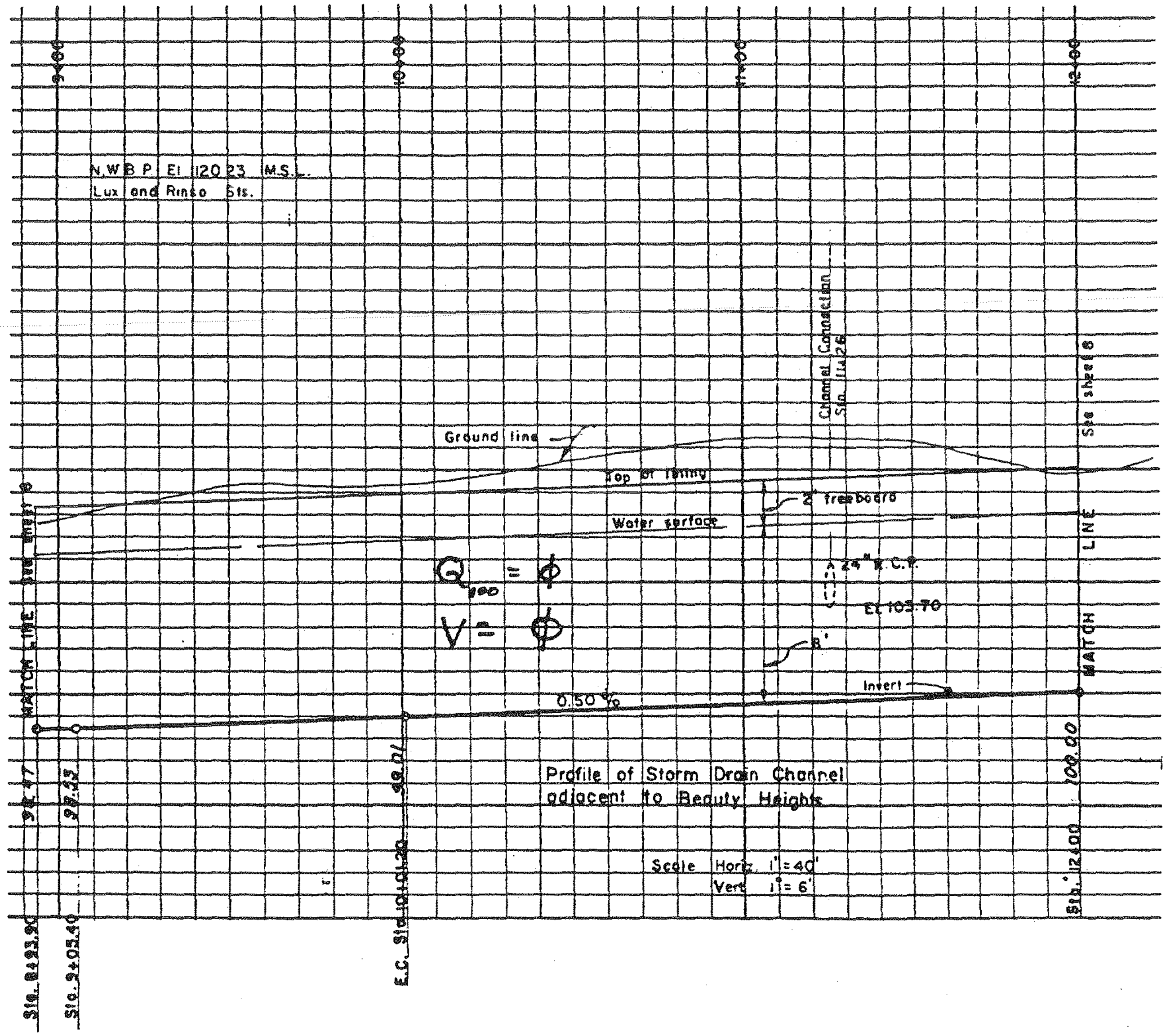
B. FIGURES 1-104.15B Typical Channel Profile

FIGURE 1-104.15A



REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		TYPICAL CHANNEL PLAN	

FIGURE 1-104.15B



For Plan See Figure 1-104.15A

REV.		CITY OF SAN DIEGO - DESIGN GUIDE	SHT. NO.
		TYPICAL CHANNEL PROFILE	

APPENDIX I

RATIONAL METHOD

Watersheds Less than 0.5 Square Mile

Method of Computing Runoff

Use the Rational Formula Q = CIA where:

Q is the peak rate of flow in cubic feet per second.

C is a runoff coefficient expressed as that percentage of rainfall which becomes surface runoff.

I is the average rainfall intensity in inches per hour for a storm duration equal to the time of concentration (T_c) of the contributing drainage area.

A is the drainage area in acres tributary to design point.

(1) Runoff Coefficient, C

Appendix I-A lists the estimated coefficients for urban areas.

For urban areas select an appropriate coefficient for each type of land use from Table, 2, Appendix I-A. Multiply this coefficient by the percentage of the total area included in that class. The sum of the products for all land uses in San Diego County is the weighted runoff coefficient.

(2) Rainfall Intensity, I

Intensity - duration - frequency curves applicable to all areas within San Diego County are given in Appendix I-B.

(3) Time of Concentration, Tc

The time of concentration is the time required for runoff to flow from the most remote part of the watershed to the outlet point under consideration.

Methods of calculation differ for natural watersheds (non-urbanized) and for urban drainage systems. Also, when designing storm drain systems, the designer must consider the possibility that an existing natural watershed may become urbanized during the useful life of the storm drain system.

(a) Natural watersheds: Obtain T_c from Appendices I-C and I-D.

(b) Urban drainage systems: In the case of urban drainage systems, the time of concentration at any point within the drainage area is given by:

$$T_c = T_i + T_f \text{ where}$$

T_i is the inlet time or the time required for the storm water to flow to the first inlet in thesystem. It is the sum of time in overland flow across lots and in the street gutter.

T_f is the travel time or the time required for the storm water to flow in the storm drain from the most upstream inlet to the point in question.

Travel Time, T_f, is computed by dividing the length of storm drain by the computed flow velocity. Since the velocity normally changes at each inlet because of changes in flow rate or slope, total travel time must be computed as the sum of the travel times for each section of the storm drain.

The overland flow component of inlet time, T_i, may be estimated by the use of the chart shown in Appendix I-E. Use Appendix I-F to estimate time of travel for street gutter flow.

TABLE 2

RUNOFF COEFFICIENTS (RATIONAL METHOD)

DEVELOPED AREAS (URBAN)

Land Use	Coefficient, C Soil Type (1)
Residential:	D
Single Family	.55
Multi-Units	.70
Mobile Homes	.65
Rural (lots greater than 1/2 acre)	.45
Commercial (2) 80% Impervious	.85
Industrial (2) 90% Impervious	.95

NOTES:

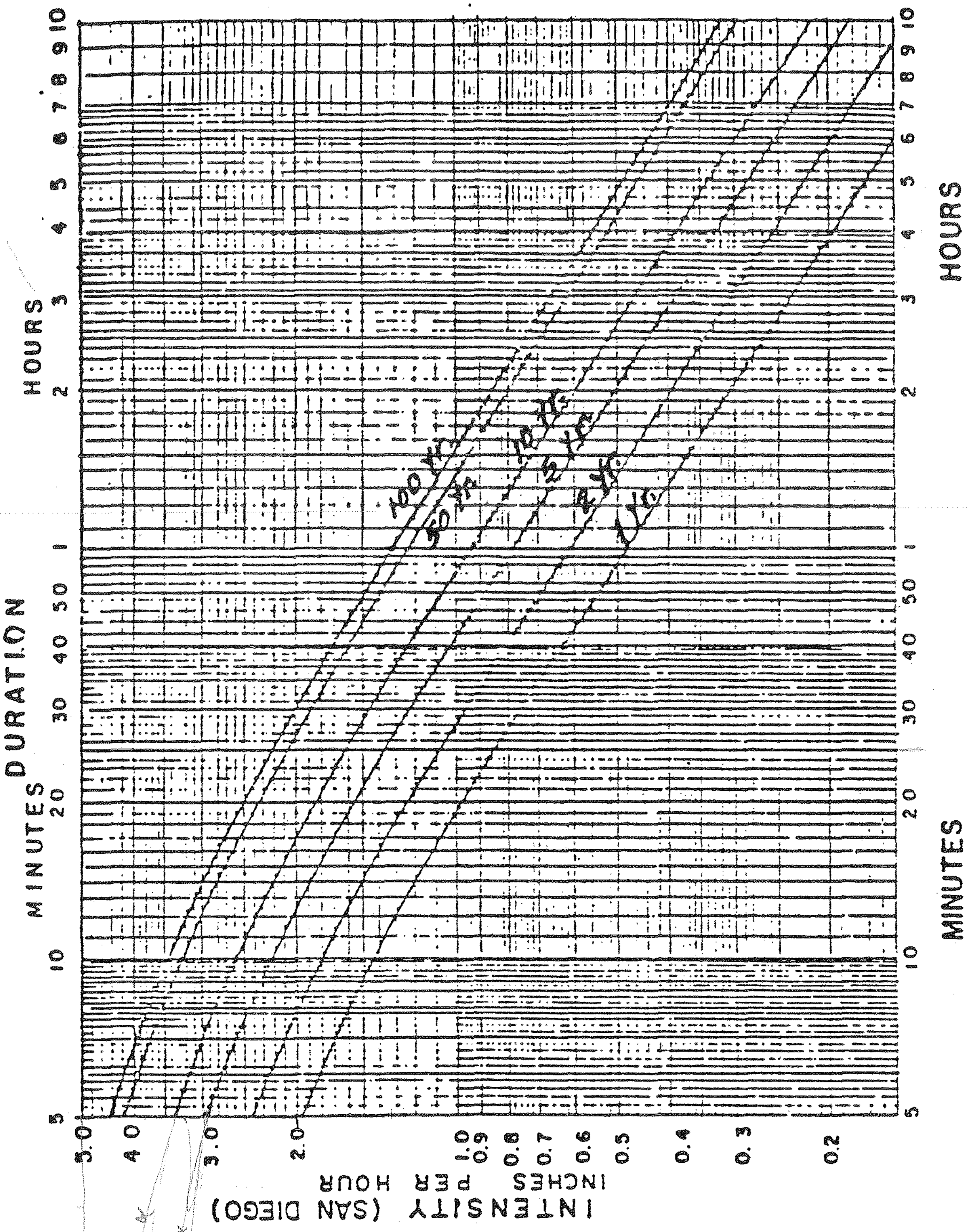
(1) Type D soil to be used for all areas.

(2) Where actual conditions deviate significantly from the tabulated imperviousness values of 80% or 90%, the values given for coefficient C, may be revised by multiplying 80% or 90% by the ratio of actual imperviousness to the tabulated imperviousness. However, in no case shall the final coefficient be less than 0.50. For example: Consider commercial property on D soil.

Actual imperviousness = 50%

Tabulated imperviousness = 80%

$$\text{Revised C} = \frac{50}{80} \times 0.85 = 0.53$$

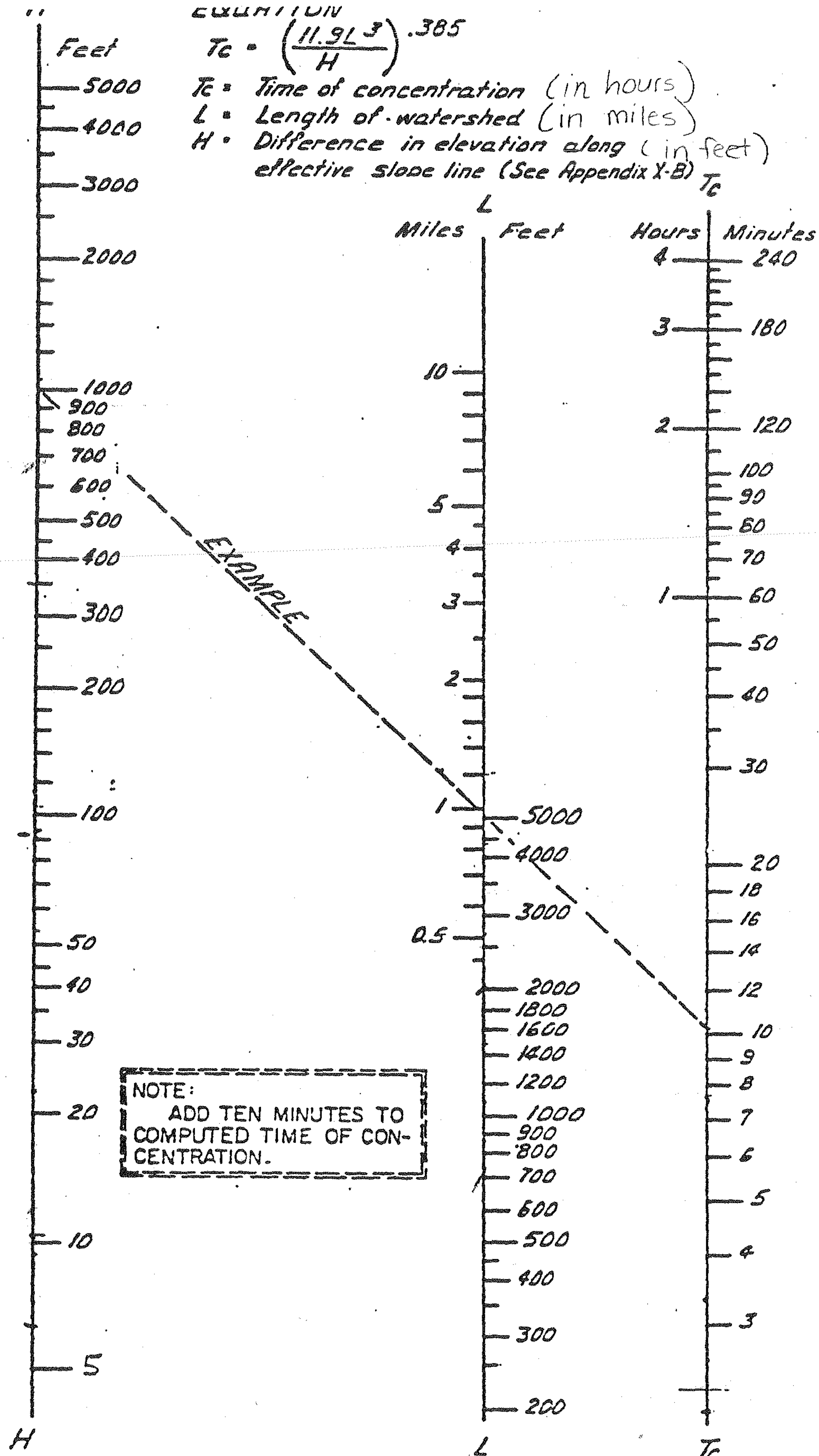


ELEV.	FACTOR
0–1500	1.00
1500–3000	1.25
3000–4000	1.42
4000–5000	1.60
5000–6000	1.70
DESERT	1.25

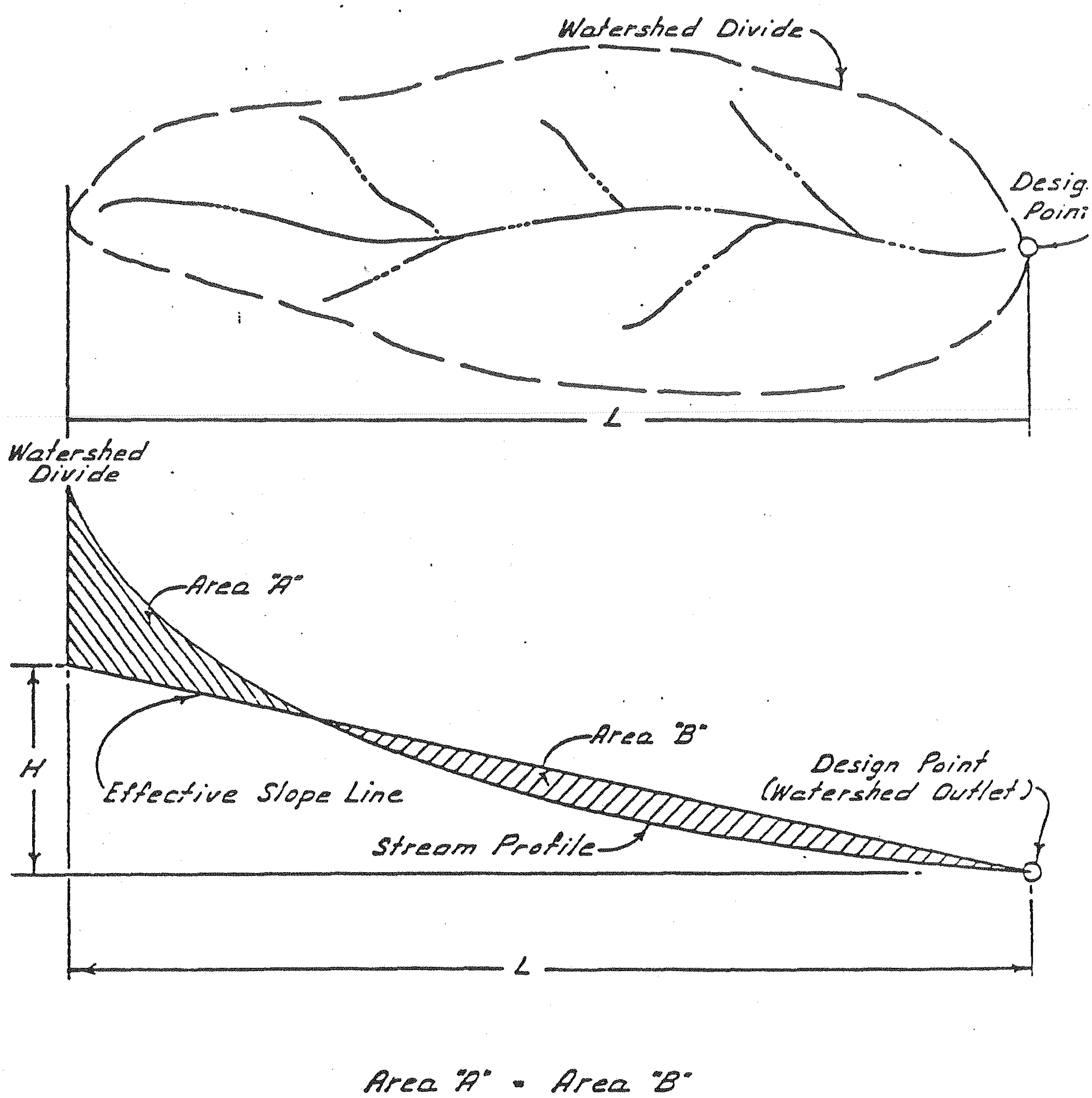
To obtain correct intensity, multiply intensity on chart by factor for design elevation.

RAINFALL INTENSITY – DURATION – FREQUENC
CURVES
for
COUNTY OF SAN DIEGO

APPENDIX I

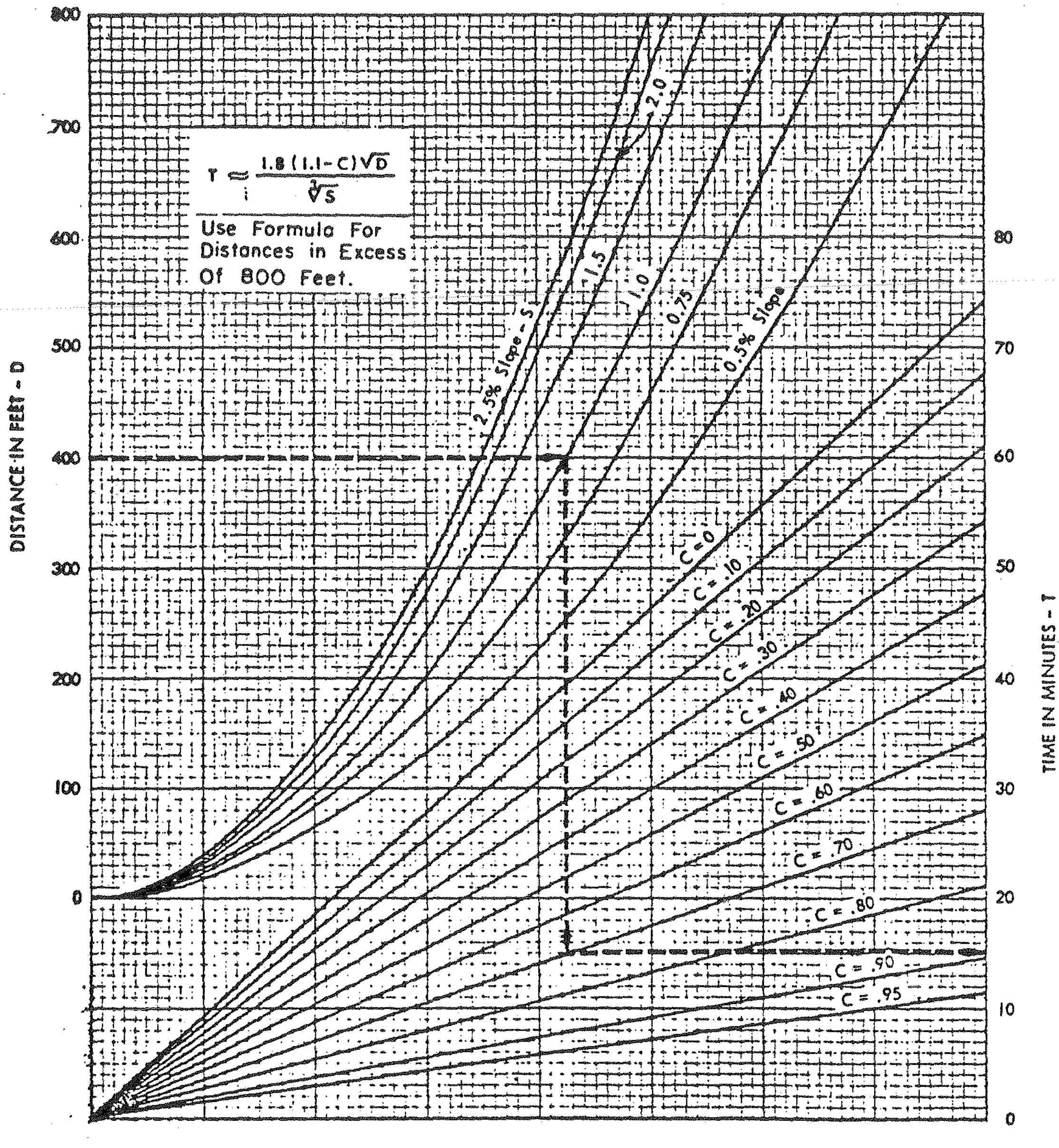


SAN DIEGO COUNTY DEPARTMENT OF SPECIAL DISTRICT SERVICES DESIGN MANUAL	NOMOGRAPH FOR DETERMINATION OF TIME OF CONCENTRATION (Tc) FOR NATURAL WATERSHEDS	
APPROVED [signature]	DATE ______	APPENDIX



SAN DIEGO COUNTY DEPARTMENT OF SPECIAL DISTRICT SERVICES DESIGN MANUAL APPROVED [illegible]	COMPUTATION OF EFFECTIVE SLOPE FOR NATURAL WATERSHEDS	
	DATE [illegible]	APPENDIX

URBAN AREAS OVERLAND TIME OF FLOW CURVES



Surface Flow Time Curves

EXAMPLE:

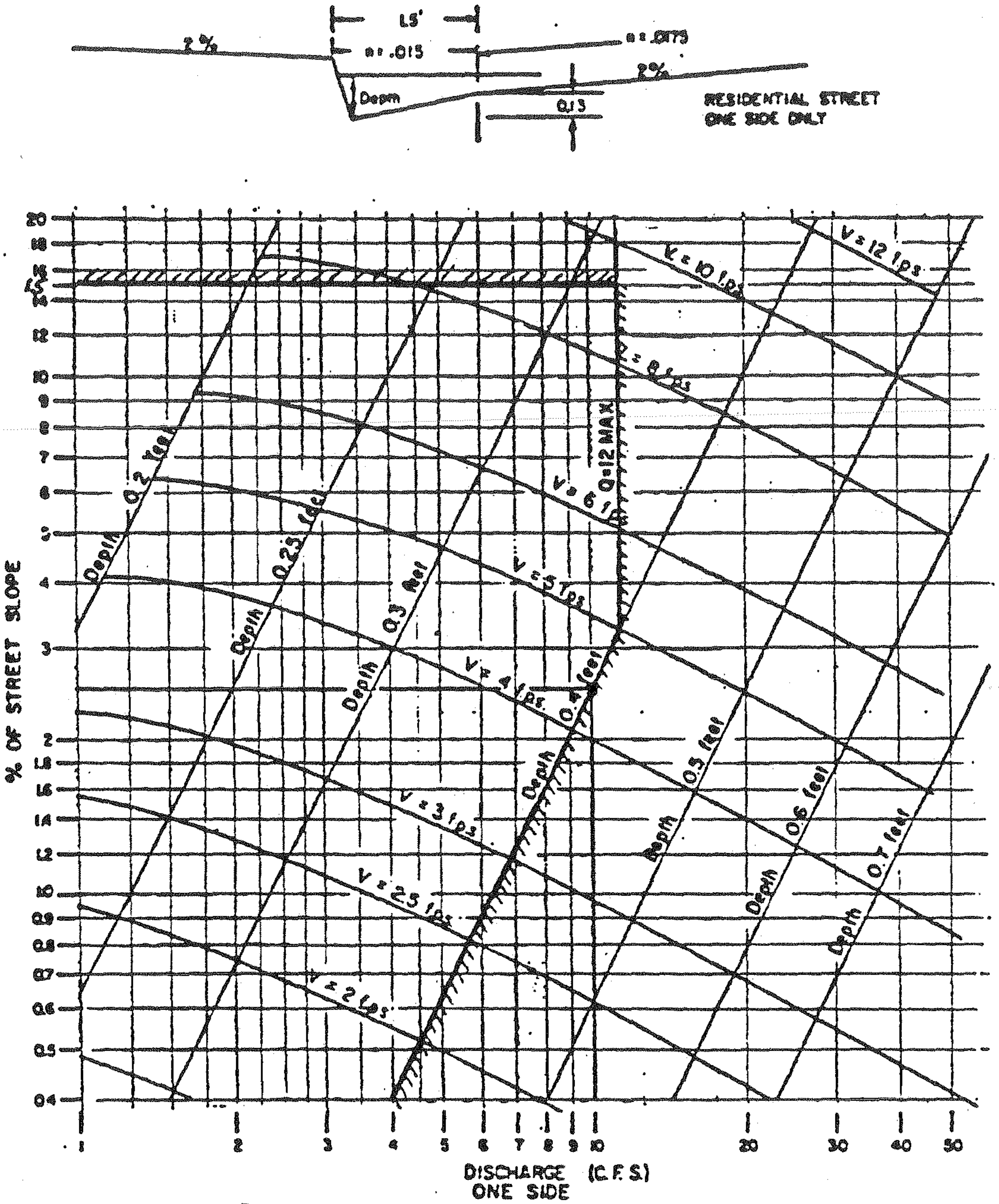
GIVEN: LENGTH OF FLOW = 400 FT.

SLOPE = 1.0 %

COEFFICIENT OF RUNOFF C = .70

READ: OVERLAND FLOWTIME = 15 MINUTES

CHART 1-104.12



EXAMPLE:

Given: Q = 10 S = 2.5%
Chart gives: Depth = 0.4, Velocity = 4.4 f.p.s.

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		GUTTER AND ROADWAY DISCHARGE - VELOCITY CHART	

APPENDIX II

MODIFIED RATIONAL METHOD

1. Divide drainage area into subareas of from 20 to 100 acres. These divisions should, if possible, be based on the topography, soil type, and the land development. The size of the initial area should be chosen such that the length of travel for the water from the most remote point to the point of concentration should not exceed 1,000 ft., and if possible be near 500 ft.

2. Determine the quantity of water for the initial area.

   (a) Estimate the initial time of concentration using Appendix X-A and X–B for rural areas, and Appendix X–C for urban areas. (See attached sheets).

   (b) Obtain the intensity from Appendix XI (also attached). Frequency of the design storm shall be in accordance with 1–102.2 Design Runoff.

   (c) Obtain coefficient C from Appendix IX–B.

   (d) Determine Area A in acres.

   (e) Calculate the discharge Q using rational formula Q = CIA.

   (f) Estimate the travel time to the next point of concentration.

   (g) Add this time to the initial Tc to obtain a new time of concentration.

   (h) Calculate a new Q for the second sub area by using this new Tc and continuing with 2. (b) above. Continue adding sub areas along the main line until a junction with a tributary is reached.

3. When a junction is reached, start at the upper end of the tributary area and calculate its Q as was done before, down to the junction.

   (a) Compute the peak Q at each junction. Let Q_A, T_A, I_A correspond to the tributary area with the longer time of concentration. Let Q_B, T_B, I_B correspond to the tributary area with the shorter time of concentration and Q_p, T_p correspond to the peak Q and time of concentration when the peak flow occurs.

   (b) If the tributary areas have the same time of concentration, the tributary q's are added to obtain the peak Q.

$$Q_p = Q_A + Q_B \qquad T_p = T_A = T_B$$

(c) If the tributary areas have different time of concentration, the smaller of the tributary Q's must be corrected as follows:

(1) The usual case is where the tributary area with the longer time of concentration has the larger Q. In this case, the smaller Q is corrected by a ratio of the intensities and added to the larger Q to obtain the peak Q. The tabling is then continued downstream using the longer time of concentration.

$$Q_p = Q_A + Q_B \frac{I_A}{I_B} \qquad T_p = T_A$$

(2) In some cases, the tributary area with the shorter time of concentration has the larger Q. In this case, the smaller Q is corrected by a ratio of the times of concentration and added to the larger Q to obtain the peak Q. The tabling is then continued downstream using the shorter time of concentration.

$$Q_p = Q_B + Q_A \frac{T_B}{T_A} \qquad T_p = T_B$$

DRAINAGE STUDY

(Example of Modified Rational Method)

AREA	ACRES	Σ A	"C"	CA	Σ CA
A-1	198	198	.55	109	109
A-2	52	250	.55	29	138
A-3	137	387	.55	75	213
A-4	86	473	.55	47	260
A-5	76	549	.6	46	306

INITIAL AREA A-1:

$A = 198$ acres, $L = 5000'$, $\Delta H = 1127 - 680 = 447'$, $T_c = 10 + 14 = 24$ min,

$i_{50} = 2.1$ in/hr., $Q_{50} = 109 \times 2.1 = 229$ cfs, Length of next reach = 1700',

slope = 40'/1700' = .0235

Say 2.5% max., max velocity in improved section: assume future channel extension to this point (6' bottom 1.5: 1 sides)

$b^{8/3} = 119\ S^{\frac{1}{2}} = 0.158$, $K' = \frac{229 \times .014}{119 \times .158} = 0.17$, $D/b = .256$, $D = 6 \times .256 = 1.5$, $A = 8.25 \times 1.5 = 12.4\ ft^2$, $V = 229/12.4 = 18.5$ ft/sec

Time in reach $= \frac{1700}{60 \times 18.5} = 1.5$ min.

AREA A-2:

$\Sigma CA = 138$, Adjusted Time = 24 + 1.5 = 25.5 min.

$i_{50} = 2.05$ in/hr, $Q_{50} = 138 \times 2.05 = 283$ cfs

Length of next reach = 1600', Slope $= \frac{40}{1600} = 2.5\%$, Use 3% max (assume future improved 6' bottom 1.5:1 concrete section) $K' = \frac{283 \times .014}{119 \times .17} = .196$, $D/b = .276$, $D = .276 \times 6 = 1.66'$ $A = 8.49 \times 1.66 = 14.1\ ft^2$, $V = \frac{283}{14.1} = 20.1$ ft/sec,

Time in reach $= \frac{1600}{60 \times 20.1} = 1.3$ min.

AREA A-3:

$\Sigma CA = 213$, Adjusted Time = 25.5 + 1.3 = 26.8 min, $i_{50} = 2.0$ in/hr,

$Q_{50} = 2 \times 213 = 426$ cfs, Length of next reach = 1800', slope = 175/1800 = 9.7%, Say 10%, use 6' bottom 1.5:1 concrete section, $K' = \frac{426.014}{119x.32} = .16$,

$D/b = .25$, $D = 6 \times .25 = 1.5'$, $8.25 \times 1.5 = 12.38\ ft^2$

$V = 426/12.38 = 34.4$ ft/sec, Time in reach $= \frac{1800}{34.4x60} = .87$ min

AREA A-4.

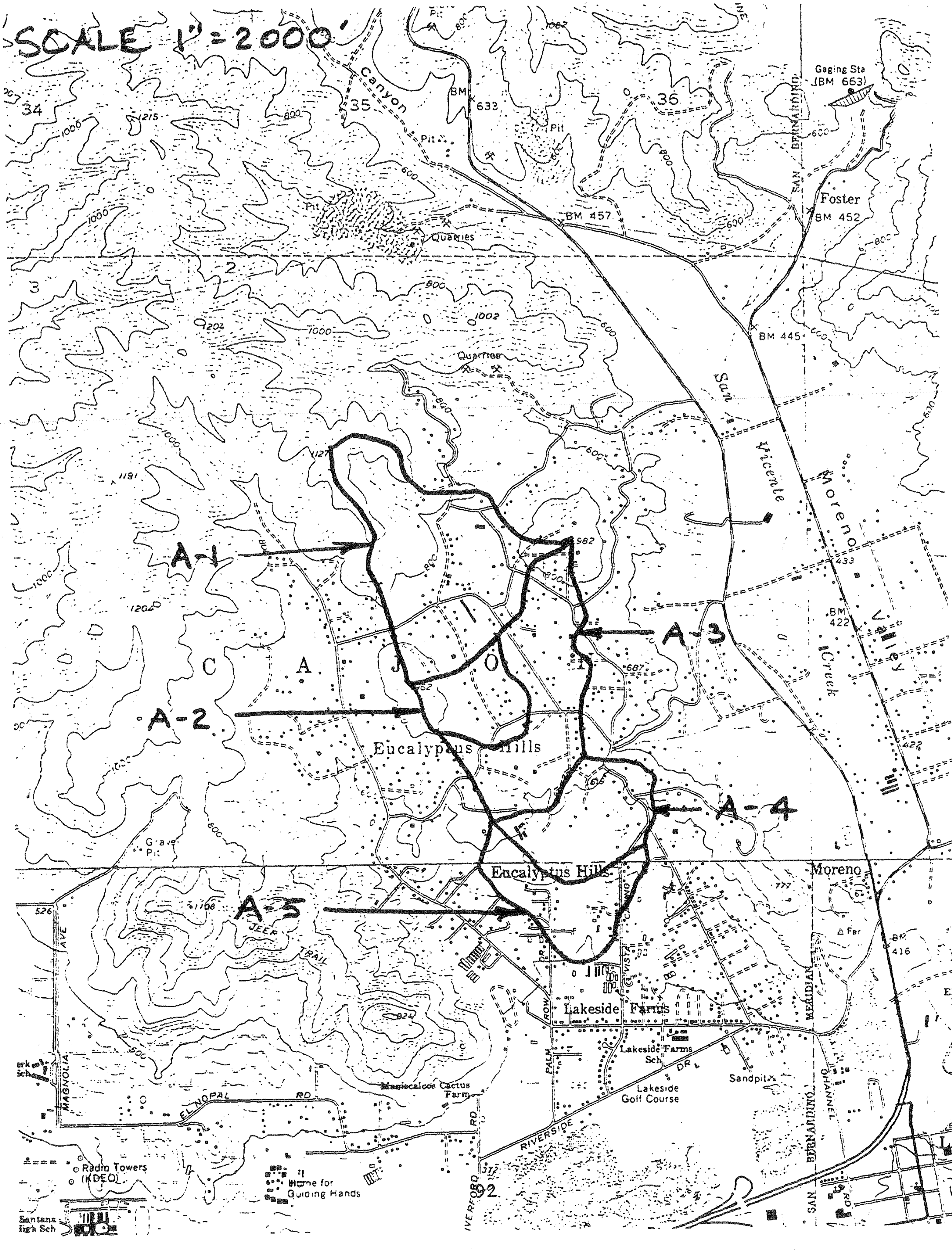
$\Sigma CA = 260$, Adjusted Time = 26.8 + .9 = 27.7 min, $i_{50} = 1.98$ in/hr,

$Q_{50} = 1.98 \times 260 = 515$ cfs, Length of next reach = 1400', Slope = $\frac{20'}{1400'} = 1.4\%$, Say 1.5%, $S^{1/2} = .12$, 10' bottom, $b^{8/3} = 464$, $K' = \frac{515x.014}{464x.12} = .13$, $D/b = .22$, $D = 2.2$, $A = 13.3 \times 2.2 = 27.3\ ft^2$,

$V = 515/27.3 = 18.9$ ft/sec, Time in reach $= \frac{1400}{18.9x60} = 1.2$ min.

AREA A-5

$\Sigma CA = 306$, Adjusted Time = 28.9 min, $i_{50} = 1.9$ in/hr, $Q_{50} = 1.93 \times 306 =$ 590 cfs



SCALE 1" = 2000'
A-1
A-2
A-3
A-4
A-5
Canyon
Gaging Sta (BM 663)
Foster
BM 452
BM 457
BM 445
BM 633
Quarries
Pit
San Vicente
Moreno Valley
Creek
C A J O N
Eucalyptus Hills
Eucalyptus Hills
Moreno
Gravel Pit
JEEP TRAIL
Lakeside Farms
Lakeside Farms Sch
Lakeside Golf Course
Sandpit
EL NOPAL RD
RIVERSIDE DR
MAGNOLIA AVE
MERIDIAN
SAN BERNARDINO
CHANNEL
Radio Towers (KDEO)
Home for Guiding Hands
Santana High Sch
Mamiscalcos Cactus Farm
VERFORD RD
BM 416
BM 422

APPENDIX III

SCS METHOD

Procedure for Calculation of Runoff Curve Number (CN)

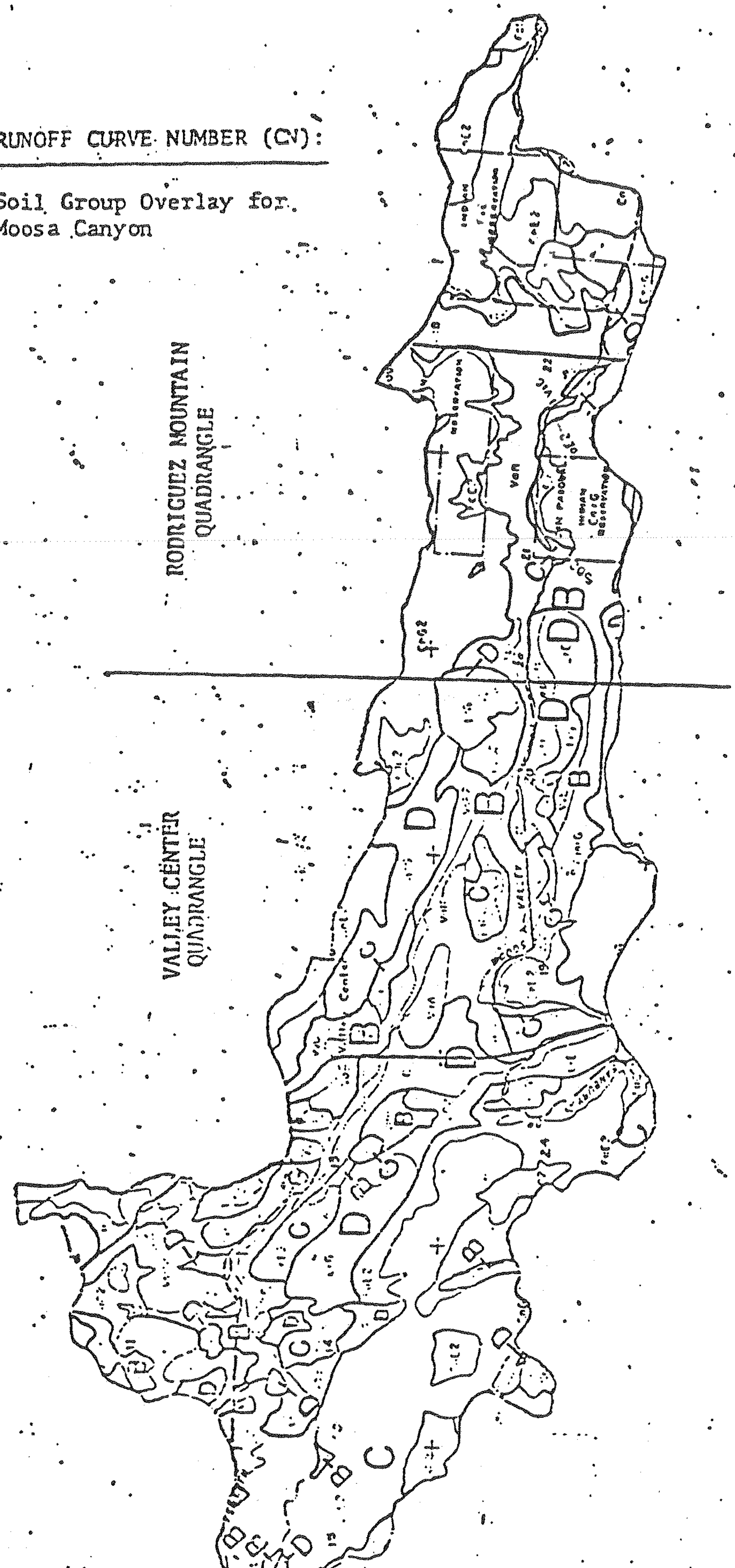
Reference in Hydrology Manual	Procedure Step No.		Refer to Example on Page
p. I-A-3	1.	Locate basin on 1:2000 scale USGS topographic map(s).	APP-B-11
	2.	Using a 1/2-inch or 1-inch grid (1/2-inch for areas less than 5 square miles) on a translucent overlay sheet, trace the basin boundary and other significant information from the topographic maps.	APP-B-7
	3.	Locate basin on 1:2000 scale Soil Conservation Service (SCS) hydrologic ground cover and soil group maps available at the offices of the Department of Sanitation and Flood Control.	APP-B-5 APP-B-6
	4.	Overlay the grid sheet onto the ground cover and soil group maps; for each map record appropriate group cover (OB, NC, DL, etc.) and soil group (A, B, C, or D) at each grid intersection within the basin.	APP-B-7
	5.	For each combination of ground cover/soil group (OB/A, NC/B, NC/D, etc.) count and record the number of grid intersections where that combination occurs.	APP-B-7
	6.	Compute the total number of grid intersections within the basin. For a 1-inch grid, each intersection represents 1 square inch on the maps, and the total area of the basin is found by scale conversion; for 1/2-inch grid, each intersection is 1/4 square inch. Compute the total area of the basin.	APP-B-7
p. I-A-14	7.	By field inspection, determine the hydrologic conditions which exist in the basin for each type of ground cover.	APP-B-8 APP-B-9 Col. 2

Procedure for Calculation of Runoff Curve Number (CN)
(Continued)

Reference in Hydrology Manual	Procedure Step No.		Refer to Example on Page
p. I-A-14	8.	For each ground cover/soil group combination compute the fraction of the total area represented by that combination by the ratio of the number of grid intersections counted in Step 5 to the total number of grid intersections counted in Step 6.	APP-B-9 Col. 5
p. I-A-6 p. I-A-7	9.	For each ground cover/soil group/hydrologic condition combination, select the appropriate runoff curve number for antecedent moisture Condition 2 (CN_2).	APP-B-9 Col. 4
	10.	Compute the partial CN_2 for each ground cover/soil group combination by the product of area fraction of each combination from Step 8 and the selected CN_2's from Step 9.	APP-B-9 Col. 6
	11.	Sum the partial CN_2's from Step 10 to obtain the CN_2 for the entire basin.	
	12.	For future land uses modify existing ground cover designations and use same procedures.	
p. I-A-17 to p. I-A-25	13.	If stream bed is alluvial fill with deep group "A" soils (sands and gravels), the CN adjustment procedure should be considered.	

RUNOFF CURVE NUMBER (CN):

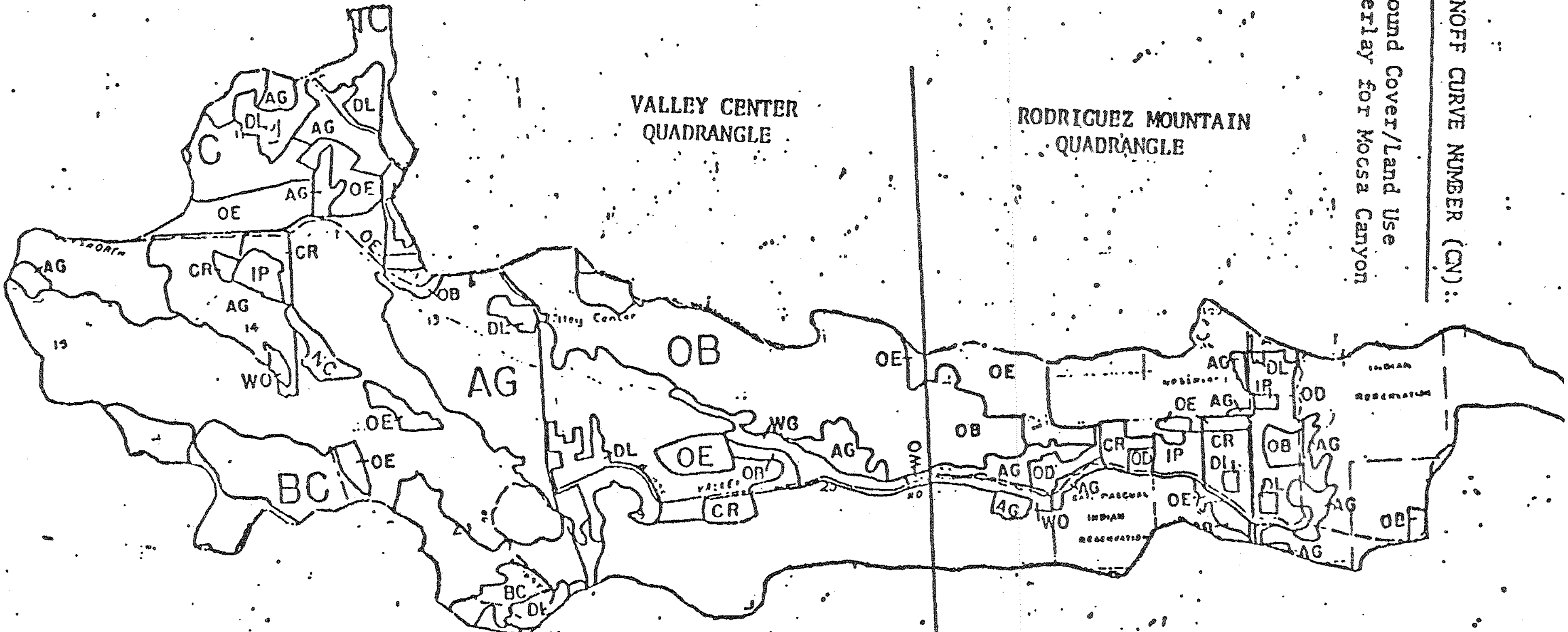
Soil Group Overlay for Moosa Canyon



SOIL GROUPS - Moosa Canyon

RUNOFF CURVE NUMBER (CN):

Ground Cover/Land Use Overlay for Moosa Canyon



HYDROLOGIC GROUND COVER - LAND USE - Moosa Canyon

RUNOFF CURVE NUMBER (CN):

Tabulation of Ground Cover/Land Use and Soil Group designations for 1" grid on 1:2000 scale map:

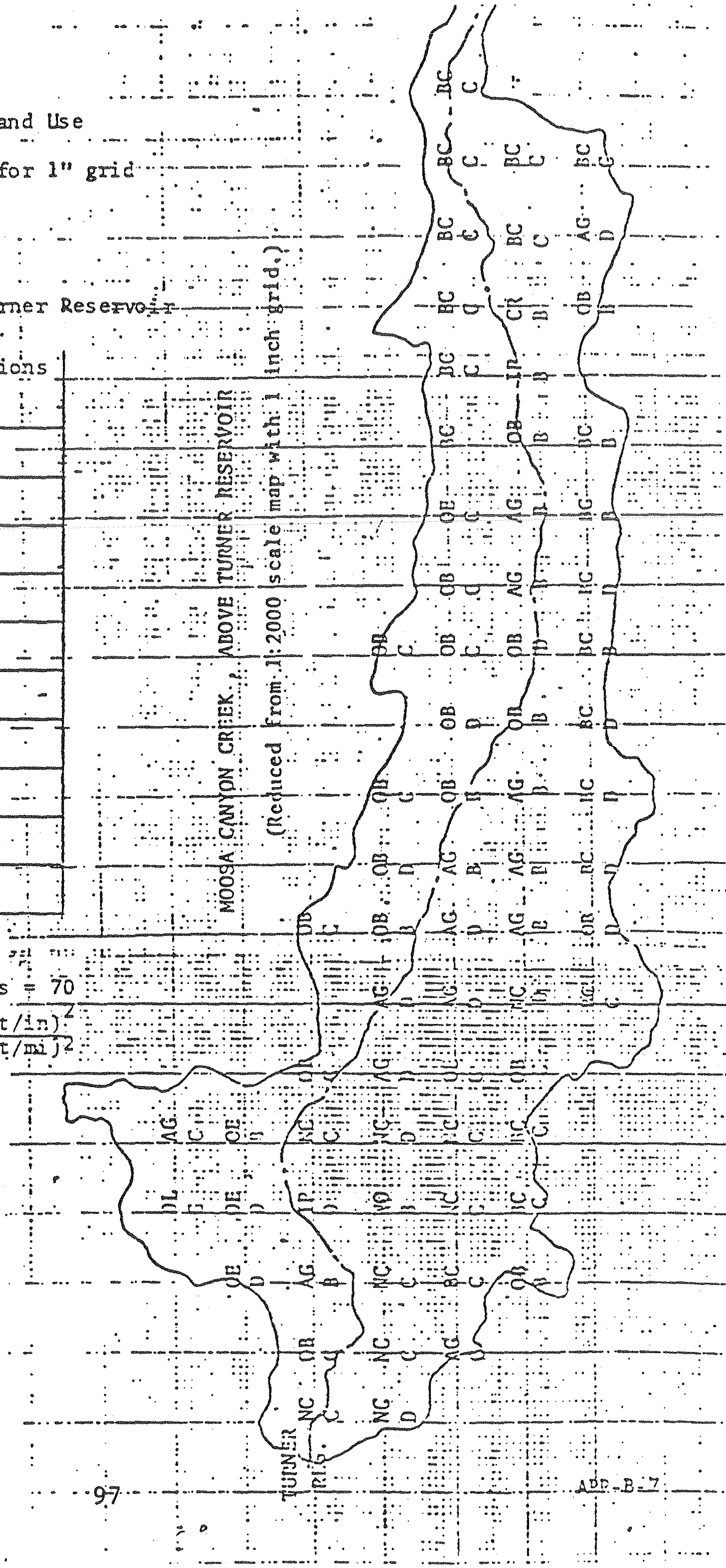
Moosa Canyon Creek, Above Turner Reservoir

Ground Cover/ Land Use	Number of intersections for each Soil Group			
	A	B	C	D
CR		1		
IP		1		1
OE		1	2	2
DL			1	
AG		7	2	5
BC		3	12	4
NC			6	3
OB		6	8	4
WO		1		

Total number of intersections = 70

$$\text{Area} = (70 \text{ sq.in.}) \times \frac{(2000 \text{ ft/in})^2}{(5280 \text{ ft/mi})^2}$$

Area = 10.0 sq. miles



RIVER NAME: PAGE OF

DATE BY		LAND USE CODE	HYDROLOGIC CONDITION GOOD 3				FAIR 2				POOR 1			
			A	B	C	D	A	B	C	D	A	B	C	D
FALLOW STRAIGHT ROW	CR	1												
ROW CROPS STRAIGHT ROW	CR	2												
ROW CROPS CONTOURED	CR	3												
SMALL GRAIN STRAIGHT ROW	CR	4												
SMALL GRAIN CONTOURED	CR	5												
CLOSE SEEDED STRAIGHT	CR	6												
CLOSE SEEDED CONTOURED	CR	7												
IRRIGATED PASTURE	IP	8												
WATER SURFACES (DURING FLOODS)	WA	9												
ORCHARDS EVERGREEN	OE	10												
URBAN LOW DENSITY	DL	12												
URBAN MEDIUM DENSITY	DL	13												
URBAN HIGH DENSITY	DL	14												
COMMERCIAL INDUSTRIAL	DL	15												
ANNUAL GRASS	AG	16												
BROADLEAF CHAPARRAL	BC	17												
MEADOW	ME	18												
NARROWLEAF CHAPARRAL	NC	20												
OPEN BRUSH	OB	20												
PERENNIAL GRASS	PG	21												
WOODLAND GRASS	WG	22												
WOODS	WO	23												
BARREN	BA	24												
TURF	TU	25												
FARMSTEADS	FS	26												
ROADS (DIRT)	RD	27												
ROADS (HARD SURFACE)	RD	28												

RUNOFF CURVE NUMBER (for Antecedent Moisture Condition 2) CN_2:

COLUMN 1 GROUND COVER/ LAND	COLUMN 2 HYDRO-LOGIC CONDI-TION (field inspec.)	COLUMN 3 SOIL GROUP	COLUMN 4 CN_2 From Hydrology Manual pp.I-A-6,7	COLUMN 5 FRACTION OF AREA A_1/A	COLUMN 6 PARTIAL CN_2 $CN_2 \times \frac{A_1}{A}$
CR - Row Crops Straight Row	Good	B	78	0.014	1.092
IP - Irrigated Pasture	Good	B	58	0.014	0.812
		D	79	0.014	1.106
OE - Orchards Evergreen	Good	B	58	0.014	0.812
		C	72	0.028	2.016
		D	79	0.028	2.212
DL - Urban Low Density	Fair	C	84	0.014	1.176
AD - Annual Grass	Good	B	61	0.100	6.100
		C	74	0.028	2.072
		D	80	0.071	5.680
BC - Broadleaf Chaparral	Good	B	57	0.043	2.451
		C	71	0.171	12.141
		D	78	0.058	4.524
NC Narrowleaf Chaparral	Fair	C	81	0.087	7.047
		D	86	0.043	3.698
OB - Open Brush	Good	B	63	0.087	5.481
		C	75	0.114	8.550
		D	81	0.058	4.698
WO - Woodland	Good	B	55	0.014	0.770
			Sums =	1.000	72.438

For entire basin $CN_2 = 72$

Procedure for Calculation of Lag Time and Time to Peak (See p. APP-B-11)

Reference in Hydrology Manual	Procedure Step Number		Computed Value
	1.	Locate basin boundary on 1' = 2000' scale topographic map.	
p. I-B-1	2.	Compute:	
		a. Drainage area, A, square miles. (See p. APP-B-7)	$A = 10.0 \text{ mi.}^2$
		b. Length of longest watercourse, L, in miles.	L = 9.45 mil.
		c. L_c, length along longest watercourse in miles, measured upstream to point opposite center of area.	L_c = 4.1 mi.
p. I-B-1	3.	Compute overall slope, S:	
		a. E_h = elevation of most remote point on watercourse.	E_h = 2140 ft.
		b. E_1 = elevation at outlet.	E_1 = 1000 ft.
		c. $S = \dfrac{E_h - E_1}{L} = \dfrac{2100\text{-}100}{9.45} = 121 \text{ ft per mi.}$	S = 121 ft/mi.
p. I-B-1,2	4.	By field inspection select basin $\bar{n}$ factor, the average of the Manning's $\bar{n}$ values of the watercourse and tributaries.	$\bar{n} = 0.050$
p. I-B-1	5.	Compute Lag time: $\text{Lag} = 24\,\bar{n}\left(\dfrac{L \times L_c}{S}\right)^{.38} = (24)(.050)\left(\dfrac{(9.45)(4.1)}{121}\right)^{.38}$ Lag = 1.94 hr.	Lag = 1.94 hr.
p. I-C-10	6.	If no unit hydrograph has been developed for the basin based on recorded rainfall-runoff data, use Soil Conservation Service (SCS) dimensionless unit hydrograph for which the time to peak is: $T_p = 0.862 \text{ Lag} = (0.862)(1.94) = 1.67 \text{ hr.}$	T_p = 1.67 hr.

Most remote pt.
(elevation 2140)

A = drainage area = 10.0 sq. miles

L = length of reach = 9.45 miles

L_c = distance from outlet to point along longest watercourse opposite center of area = 4.1 mi.

E_h = 2140 ft.

E_1 = 1000 ft.

S = effective slope = $\frac{2140 - 1000}{9.45}$

= 121 feet per mile

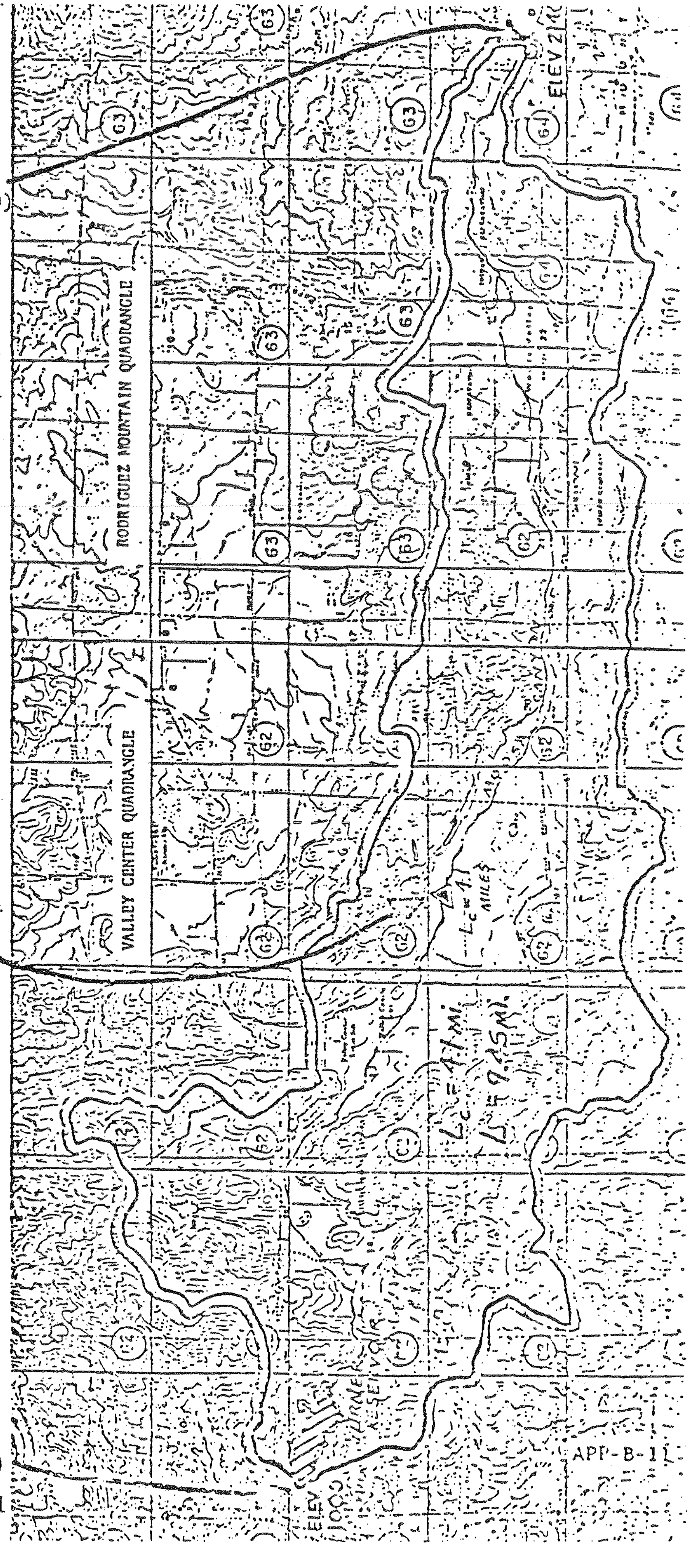
$\bar{n}$ = 0.050

$$Lag = 24\bar{n}\left[\frac{L \times L_c}{\sqrt{S}}\right]^{.38} = 1.94 \text{ hr.}$$

T_p = 0.862 Lag = (.862)(1.94) = 1.67

Center of area

Outlet
(elevation 1000)



Procedure for Using Peak Flow Charts to Compute Peak Flow
(Refer to Example on Worksheet)

Reference in Hydrology Manual	Procedure Step No.	
p. IV-A-1	1.	Determine design recurrence interval (frequency).
p. I-A-23	2.	Determine the precipitation zone number (PZN) of the center of the basin on the map of Figure I-A-2.
p. II-B-1	3.	Determine the antecedent moisture condition (AMC) from Table II-B-1 for the appropriate PZN. Interpolation, if necessary, is linear.
p. I-A-16	4.	Adjust basin CN_2 for antecedent moisture condition calculated in Step 3. CN_2 and CN_3 values are given in Table I-A-5 and interpolation is linear.
Sec. II-A	5.	From the precipitation maps, select the 6 and 24-hour precipitation amounts for the design frequency for the center of the basin.
p. II-B-4	6.	If the basin area is greater than 10 square files from Figure II-B-2a, determine the area rainfall reduction ratio and reduce the point precipitation amounts from Step 5 by that ratio.
Sec. I-B Sec. I-C	7.	Determine the time to peak (T_p) and check if it is in the range covered by the Peak Flow Charts. (0.4 T_p 4.0)
	8.	Select from the Peak Flow Charts times to peak (T_{pa} and T_{pb}) which bracket the computer basin T_p, if no chart is available for the exact basin T_p. For the adjusted CN from Step 4 and the precipitation amounts from Steps 5 and 6, select flows Q_{a6} and Q_{b6}.
	9.	Using the formulas on the worksheet, interpolate Q'_6 between Q_{a6} and Q_{b6}, and Q'_{24} between Q_{a24} and Q_{b24}.
	10.	Select the greater of Q'_6 and Q'_{24}.
	11.	Compute the ratio of the actual area of the basin to 10 square miles (R_a).
	12.	Compute the peak flow from the basin by the product of the basin area ratio from Step 11 and the flow from Step 10.
	13.	Record a summary of the computations: a. The computed peak flow from Step 12. b. The design frequency from Step 1. c. The duration of the controlling storm (6-hour or 24-hour) from Step 10.

Computed By ______________________________ Date: __________

DEPARTMENT OF SANITATION AND FLOOD CONTROL — SAN DIEGO COUNTY

PEAK FLOW COMPUTATION WORKSHEET

(For use with Peak Flow Charts; Western Drainage, Precipitation Zones 1.0 to 3.5 only).

Reference In Hydrology Manual	
	Basin Name ____________________
	Geographic location of center of basin: Long. ______ Lat. ______
1. Sec. IV-A	Storm Frequency ______ year. Basin Area ______ square miles.
2. Fig. I-A-2, p. I-A-23	Precipitation Zone Number (PZN) PZN = ______
3. Sec. II-B	Antecedent Moisture Condition AMC (5-35 yr.) = ______ (Interpolate basin AMC for basin PZN) AMC (35-150 yr.) = ______
4. Sec. I-A, p. I-A-16	Runoff Curve Numbers (interpolate basin CN for basin AMC; CN_2 and CN_3 are for AMC's = 2 and 3) CN_2 ______ CN ______ CN_3 ______
5. Sec. II-A	Precipitation for Storm Duration: 6 hr. (P_6) ______ inches 24 hr. (P_{24}) ______ inches
6. Fig. II-B-2a, p. II-B-4	Area Rainfall Reduction Ratio (R_r) ______ (for areas greater than 10 square miles) $P_6 \times R_r$ = ______ inches $P_{24} \times R_r$ = ______ inches
7. Sec. I-B, Sec. I-C	Time to Peak (T_p) ______ hours ($T_p = 0.862 \times$ Lag Time) $\bar{n}$ = ______ L = ______ mi. L_c = ______ mi. S = ______ ft/mi.

8. Enter Peak Flow Charts with T_p, CN, P_6 and P_{24}; select two nearest T_p's available:

(For T_{pa} T_{pb}): 6 hr storm 24 hr storm

8a. From Peak Flow Charts: T_{pa} ______ hr Q_{a6} ______ cfs Q_{a24} ______ cfs

For 10 sq. mile basin: T_p ______ hr Q'_6 ______ cfs Q'_{24} ______ cfs

8b. From Peak Flow Charts: T_{pb} ______ hr Q_{b6} ______ cfs Q_{b24} ______ cfs

9. $$Q'_6 = Q_{b6} + (Q_{a6} - Q_{b6}) \frac{T_{pb} - T_p}{T_{pb} - T_{pa}}$$

$$Q'_{24} = Q_{b24} + (Q_{a24} - Q_{b24}) \frac{T_{pb} - T_p}{T_{pb} - T_{pa}}$$

10. Greater of Q'_6 and Q'_{24}, for 10 sq. mile basin, (Q') = ______________ cfs'

11. Basin Area Ratio (R_a) = (basin area) (10 sq. miles) = ______________

12. Peak Flow (Q_p) = (Q'_{24}) x (R_a) = ______________ cfs

13. SUMMARY: PEAK FLOW ______ cfs, FREQUENCY ______ year, DURATION ______ hr

EXAMPLE 2: **Proctor Valley above Upper Otay Reservoir**

This example problem further illustrates use of the Peak Flow Charts using parameters previously computed. The procedures are the same as desribed in Example 1. Since this basin is greater than 10 square miles in area, special attention should be paid to Steps 6, 11, and 12 of the worksheet which involve adjustments for areas other than 10 square miles.

Computed By ______ Date: ______

DEPARTMENT OF SANITATION AND FLOOD CONTROL — SAN DIEGO COUNTY

PEAK FLOW COMPUTATION WORKSHEET

(For use with Peak Flow Charts; Western Drainage, Precipitation Zones 1.0 to 3.5 only).

Reference In Hydrology Manual	
	Basin Name ______
	Geographic location of center of basin: Long. ______ Lat. ______
1. Sec. IV-A	Storm Frequency ______ year. Basin Area ______ square miles.
2. Fig. I-A-2, p. I-A-23	Precipitation Zone Number (PZN) PZN = ______
3. Sec. II-B	Antecedent Moisture Condition AMC (5-35 yr.) = ______ (Interpolate basin AMC for basin PZN) AMC (35-150 yr.) = ______
4. Sec. I-A, p. I-A-16	Runoff Curve Numbers (interpolate basin CN for basin AMC; CN_2 and CN_3 are for AMC's = 2 and 3) CN_2 ______ CN ______ CN_3 ______
5. Sec. II-A	Precipitation for Storm Duration: 6 hr. (P_6) ______ inches 24 hr. (P_{24}) ______ inches
6. Fig. II-B-2a, p. II-B-4	Area Rainfall Reduction Ratio (R_r) ______ (for areas greater than 10 square miles) $P_6 \times R_r$ = ______ inches $P_{24} \times R_r$ = ______ inches
7. Sec. I-B, Sec. I-C	Time to Peak (T_p) ______ hours (T_p = 0.862 x Lag Time) $\bar{n}$ = ______ L = ______ mi. L_c = ______ mi. S = ______ ft/mi.

8. Enter Peak Flow Charts with T_p, CN, P_6 and P_{24}; select two nearest T_p's available:

(For T_{pa} T_{pb}):		6 hr storm	24 hr storm
8a. From Peak Flow Charts:	T_{pa} ______ hr	Q_{a6} ______ cfs	Q_{a24} ______ cfs
For 10 sq. mile basin:	T_p ______ hr	Q'_6 ______ cfs	Q'_{24} ______ cfs
8b. From Peak Flow Charts:	T_{pb} ______ hr	Q_{b6} ______ cfs	Q_{b24} ______ cfs

9. $$Q'_6 = Q_{b6} + (Q_{a6} - Q_{b6}) \frac{T_{pb} - T_p}{T_{pb} - T_{pa}}$$

$$Q'_{24} = Q_{b24} + (Q_{a24} - Q_{b24}) \frac{T_{pb} - T_p}{T_{pb} - T_{pa}}$$

10. Greater of Q'_6 and Q'_{24}, for 10 sq. mile basin, (Q') = ______ cfs'

11. Basin Area Ratio (R_a) = (basin area) (10 sq. miles) = ______

12. Peak Flow (Q_p) = (Q'_{24}) x (R_a) = ______ cfs

13. SUMMARY: PEAK FLOW ______ cfs, FREQUENCY ______ year, DURATION ______ hr

RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL-COVER COMPLEXES (CN)

TABLE I-A-1

AMC 2

Ia = 0.2S

Cover			Hydrologic Soil Groups			
Land Use	Treatment or Practice[3]	Hydrologic Condition[4]	A	B	C	D
Water Surfaces (During floods)			97	98	99	99
Urban						
Commercial-industrial			89	90	91	92
High density residential			75	82	88	90
Medium density residential			73	80	86	88
Low density residential			70	78	84	87
Baren			78	86	91	93
Fallow	Straight row		76	85	90	90
Vineyards	(see accompanying land-use description					
	Disked		76	85	90	92
	Annual grass or legume cover	Poor	65	78	85	89
		Fair	50	69	79	84
		Good	38	61	74	80
Roads[5] (hard surface)			74	84	90	92
	(dirt)		72	82	87	89
Row crops	Straight row	Poor	72	81	88	91
		Good	67	78	85	89
	Contoured	Poor	70	79	84	88
		Good	65	75	82	86
Narrowleaf chaparral		Poor	71	82	88	91
		Fair	55	72	81	86

RUNOFF CURVE NUMBERS (CN)
AMC 2

Cover			Hydrologic Soil Groups			
Land Use	Treatment or Practice[3]	Hydrologic Condition[4]	A	B	C	D
Perennial grass		Poor	67	79	86	89
		Fair	50	69	79	84
		Good	38	61	74	80
Annual grass		Poor	67	78	86	89
		Fair	50	69	79	84
		Good	38	61	74	80
Close-seeded legumes or rotated pasture	Straight row	Poor	66	77	85	89
		Good	58	72	81	85
	Contoured	Poor	64	75	83	85
		Good	55	69	78	83
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
Meadow		Poor	63	77	85	88
		Fair	51	70	80	84
		Good	30	58	72	78
Open brush		Poor	62	76	84	88
		Fair	46	66	77	83
		Good	41	63	75	81
Farmsteads			59	74	82	86
Irrigated pasture		Poor	58	74	83	87
		Fair	44	65	77	82
		Good	33	58	72	79

RUNOFF CURVE NUMBERS (CN)

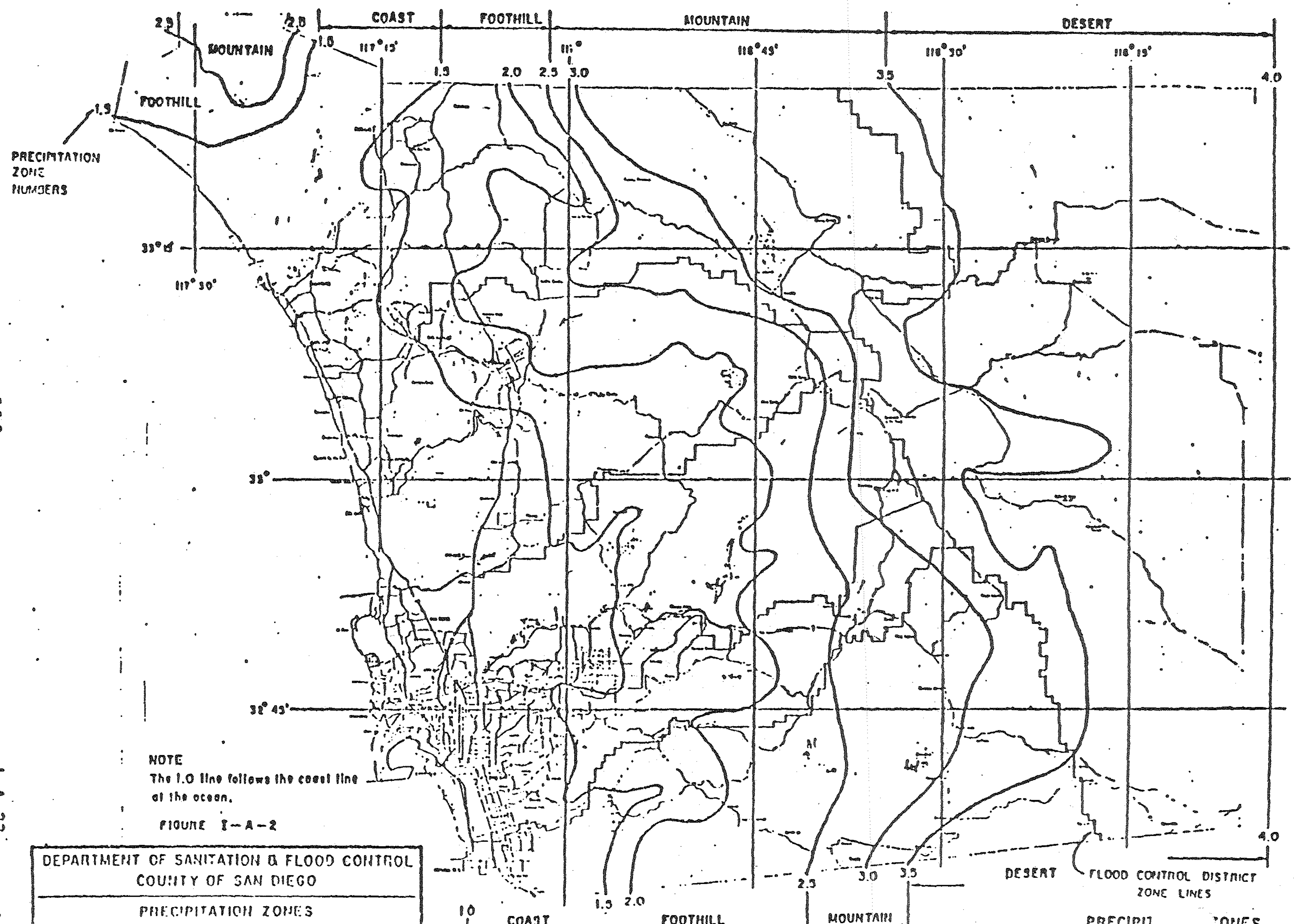
AMC 2

Cover			Hydrologic Soil Groups			
Land Use	Treatment or Practice[3]	Hydrologic Condition[4]	A	B	C	D
Turf[6]		Poor	58	74	83	87
		Fair	44	65	77	82
		Good	33	58	72	79
Woodland-grass		Poor	57	73	82	86
		Fair	44	65	77	82
		Good	33	58	72	79
Orchards (deciduous)		(See accompanying land-use description)				
Orchards (evergreen)		Poor	57	73	82	86
		Fair	44	65	77	82
		Good	33	58	72	79
Broadleaf chaparral		Poor	53	70	80	85
		Fair	40	63	75	81
		Good	31	57	71	78
Woods (woodland)		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	28	55	70	77

Table I-A-5 Curve Numbers (CN) and Constants for the Case $I_a = 0.2\ S$

1	2	3	4	5	1	2	3	4	5
CN for condition II	CN for conditions I	III	S Values*	Curve* starts where P =	CN for condition II	CN for conditions I	III	S Values*	Curve* starts where P =
			(inches)	(inches)				(inches)	(inches)
100	100	100	0	0	60	40	78	6.67	1.33
99	97	100	.101	.02	59	39	77	9.95	1.39
98	94	99	.204	.04	58	38	76	7.24	1.45
97	91	99	.309	.06	57	37	75	7.54	1.51
96	89	99	.417	.08	57	36	75	7.86	1.57
95	87	98	.526	.11	55	35	74	8.88	1.64
94	85	98	.638	.13	54	34	73	8.52	1.70
93	83	98	.753	.15	53	33	72	8.87	1.77
92	81	97	.870	.17	52	32	71	9.23	1.85
91	80	97	.989	.20	51	31	70	9.61	1.92
90	78	96	1.11	.22	50	31	70	10.0	2.00
89	76	96	1.24	.25	49	30	69	10.4	2.08
88	75	95	1.36	.27	48	29	68	10.8	2.16
87	73	95	1.49	.30	47	28	67	11.3	2.26
86	72	94	1.36	.33	46	27	66	11.7	2.34
85	70	94	1.76	.35	45	26	65	12.2	2.44
84	68	93	1.90	.38	44	25	64	12.7	2.54
83	67	93	2.05	.41	43	25	63	13.2	2.64
82	66	92	2.20	.44	42	24	62	13.8	2.76
81	64	92	2.34	.47	41	23	61	14.4	2.88
80	63	92	2.50	.50	40	22	60	15.0	3.00
79	62	91	2.66	.53	39	21	59	15.6	3.12
78	60	90	2.82	.56	38	21	58	16.3	3.26
77	59	89	2.99	.60	37	20	57	17.0	3.40
76	58	89	3.16	.63	36	19	56	17.8	3.56
75	57	88	3.33	.67	35	18	55	18.6	3.72
74	55	88	3.51	.70	34	18	54	19.4	3.88
73	54	87	3.70	.74	33	17	53	20.3	4.06
72	53	86	3.89	.78	32	16	52	21.2	4.24
71	52	86	4.09	.82	31	16	51	22.2	4.44
70	51	85	4.28	.86	30	15	50	23.3	4.66
69	50	84	4.49	.90					
68	48	84	4.70	.90	25	12	43	30.0	6.00
67	47	83	4.92	.98	20	9	37	40.0	8.00
66	46	82	5.15	1.03	15	6	30	56.7	11.34
65	45	82	5.38	1.08	10	4	22	90.0	18.00
64	44	81	5.62	1.12	5	2	13	190.0	38.00
63	43	80	5.87	1.17	0	0	0	infinity	infinity
62	42	79	6.13	1.23					
61	41	78	6.39	1.28					

*For CN in Column 1.



NOTE
The 1.0 line follows the coast line of the ocean.

FIGURE I-A-2

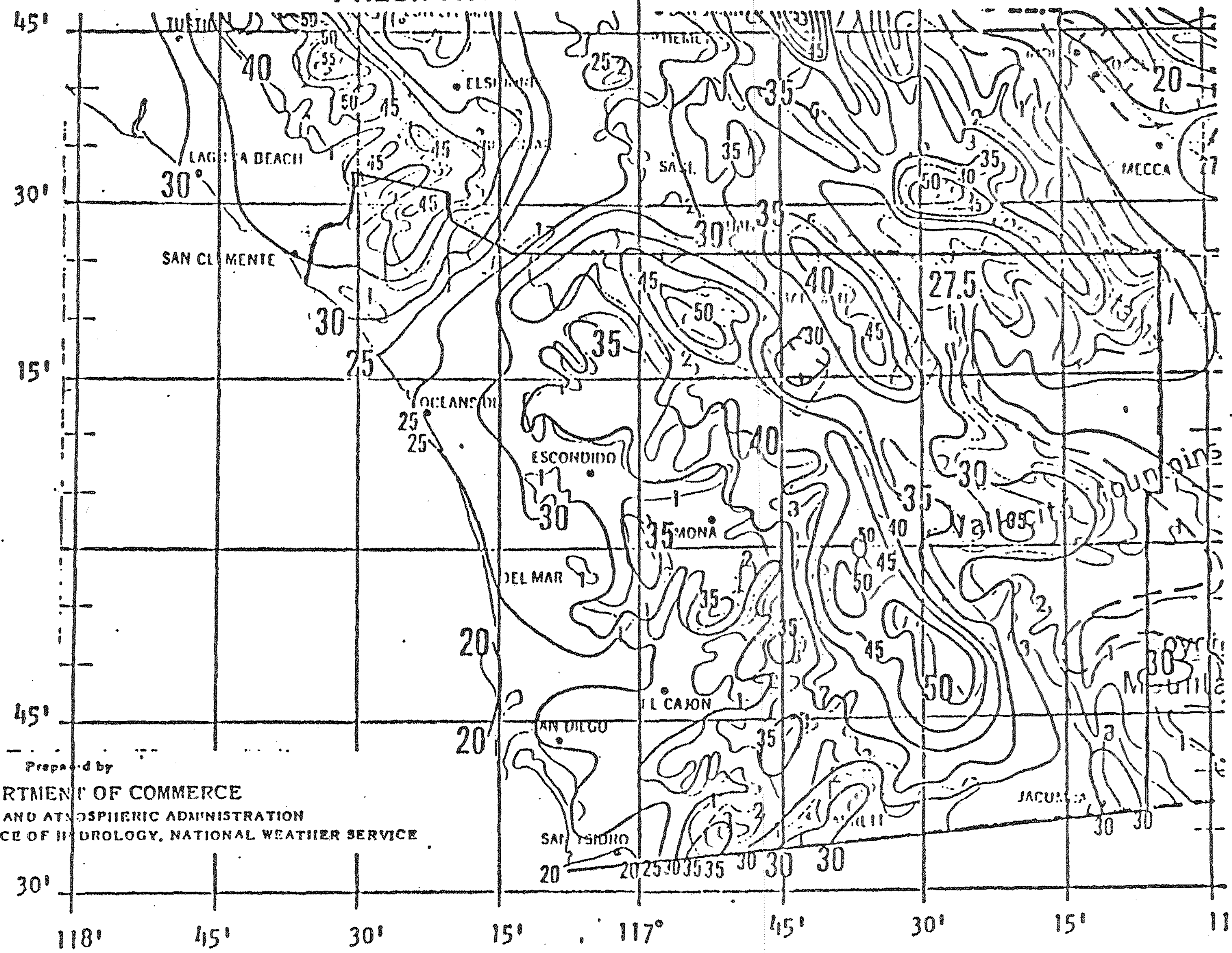
DEPARTMENT OF SANITATION & FLOOD CONTROL
COUNTY OF SAN DIEGO

PRECIPITATION ZONES

JITY OF SAN DIEGO
DEPARTMENT OF SANITATION &
FLOOD CONTROL

100-YEAR 6-HOUR PRECIPITATION

20 ISOPLUVIALS OF 100-YEAR 6-HOUR PRECIPITATION IN TENTHS OF AN INCH

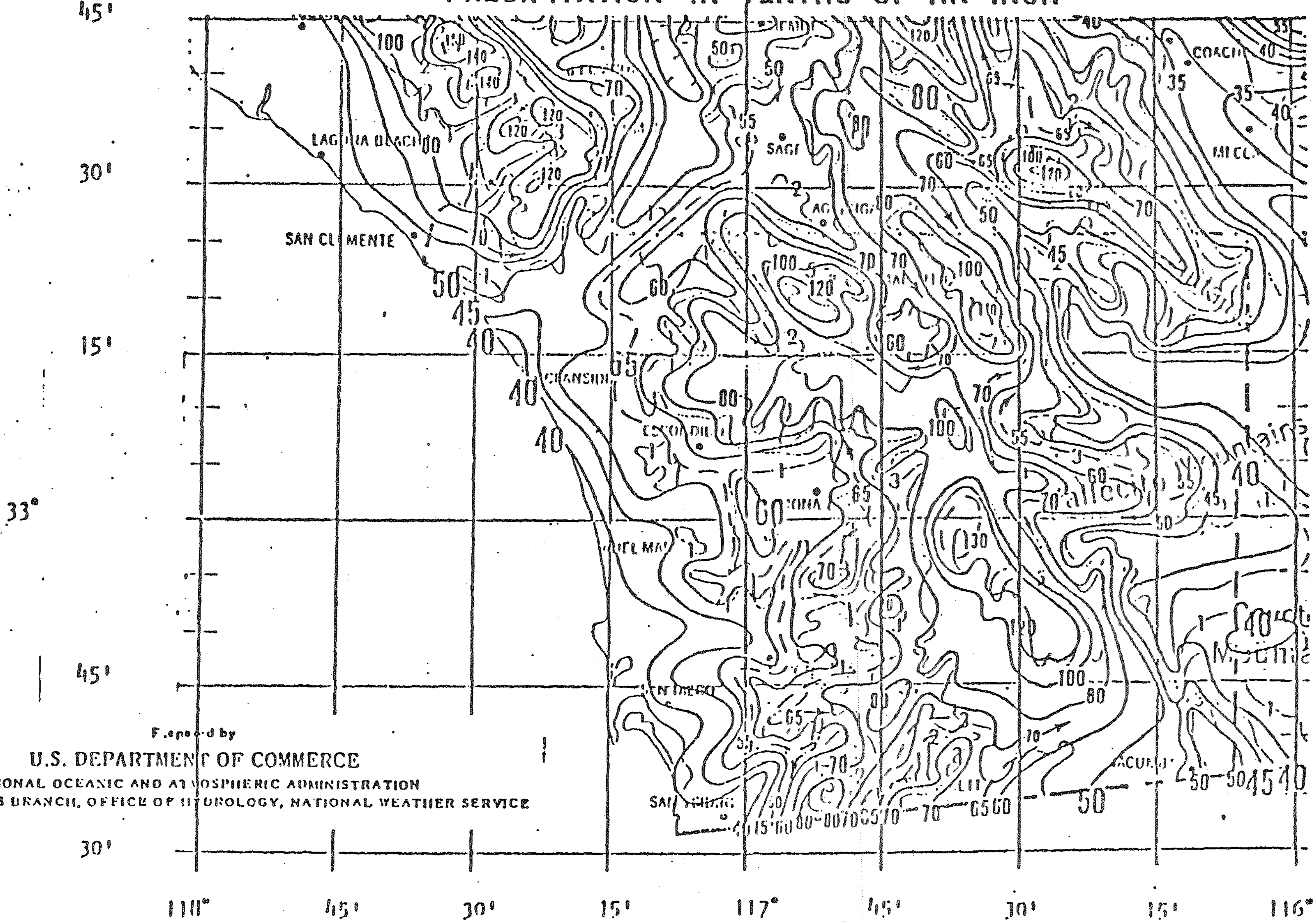


Prepared by
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
SPECIAL STUDIES BRANCH, OFFICE OF HYDROLOGY, NATIONAL WEATHER SERVICE

COUNTY OF SAN DIEGO
DEPARTMENT OF SANITATION &
FLOOD CONTROL

100-YEAR 24-HOUR PRECIPITATION

20 ISOPLUVIALS OF 100-YEAR 24-HOUR PRECIPITATION IN TENTHS OF AN INCH



Prepared by
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
SPECIAL STUDIES BRANCH, OFFICE OF HYDROLOGY, NATIONAL WEATHER SERVICE

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SECTION II-B

The County is divided into two main drainages. The westerly drainage area (about two-thirds of the County) drains toward the Pacific Ocean. The remaining portion of the County drains easterly to the desert.

WESTERN DRAINAGE

The Type B distribution (Figure II-B-1 and Table II-B-2) supersedes Type 1 for 24-hour duration storms and is to be used in San Diego County. The effect of using Type B instead of Type 1 is to lower peak flows for smaller basins. The 6-hour Type B distribution (Figure II-B-2) controls for certain smaller basins (depending upon area, time to peak, CN, frequency, etc.), producing greater flows than derived from 24-hour Type B, and the larger peak flow should be used.

The antecedent moisture condition (AMC) to be used for flood flow computations is given in Table II-B-1 below:

TABLE II-B-1

Storm Frequency	Coast (PZN=1.0)*	Foothills (PZN=2.0)	Mountains (PZN=3.0	Desert (PZN=4.0)
5 to 35 years	1.5	2.5	2.0	1.5
35 to 150 years	2.0	3.0	3.0	2.0

The Pacific Coast Climate area reduction ratio given in Figure II-B-2 should be used.

EASTERN (DESERT) WATERSHED

A 6-hour storm of Distribution C shall be used for flood flow computations. The Arid and Semi-arid Climate area reduction factor is given in Figure II-B-2 should be used.

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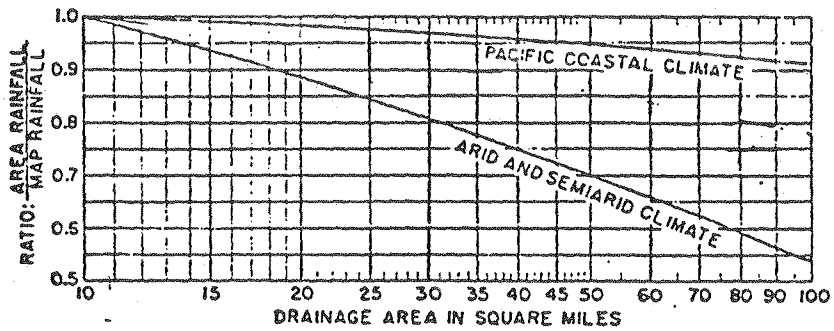
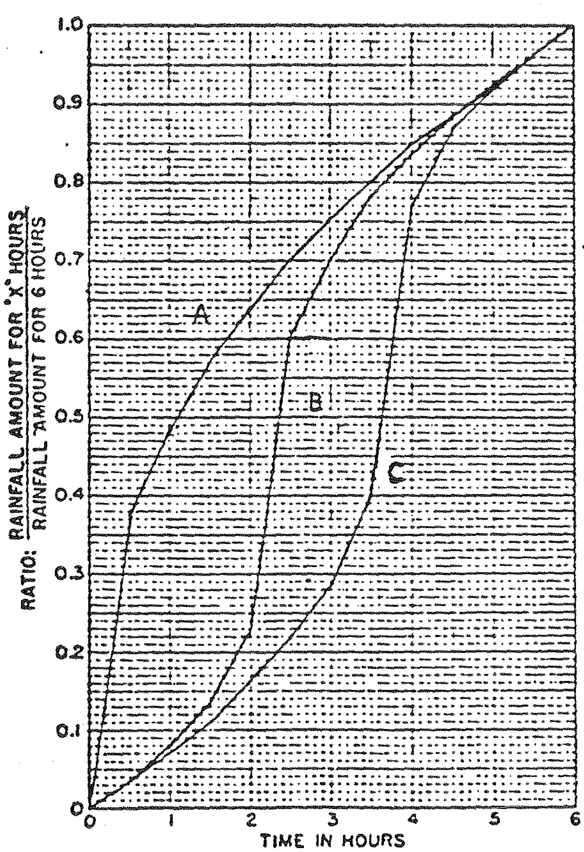
*PZN is the Precipitation Zone Number (see Figure I-A-2, Page I-A-23).

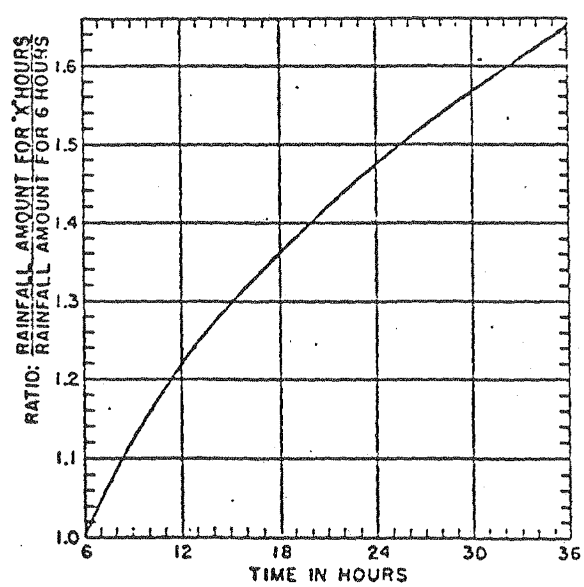
HYDROLOGY: CRITERIA FOR DESIGN STORMS



(a) RAINFALL RATIOS FOR DRAINAGE AREAS OF 10 TO 100 SQUARE MILES



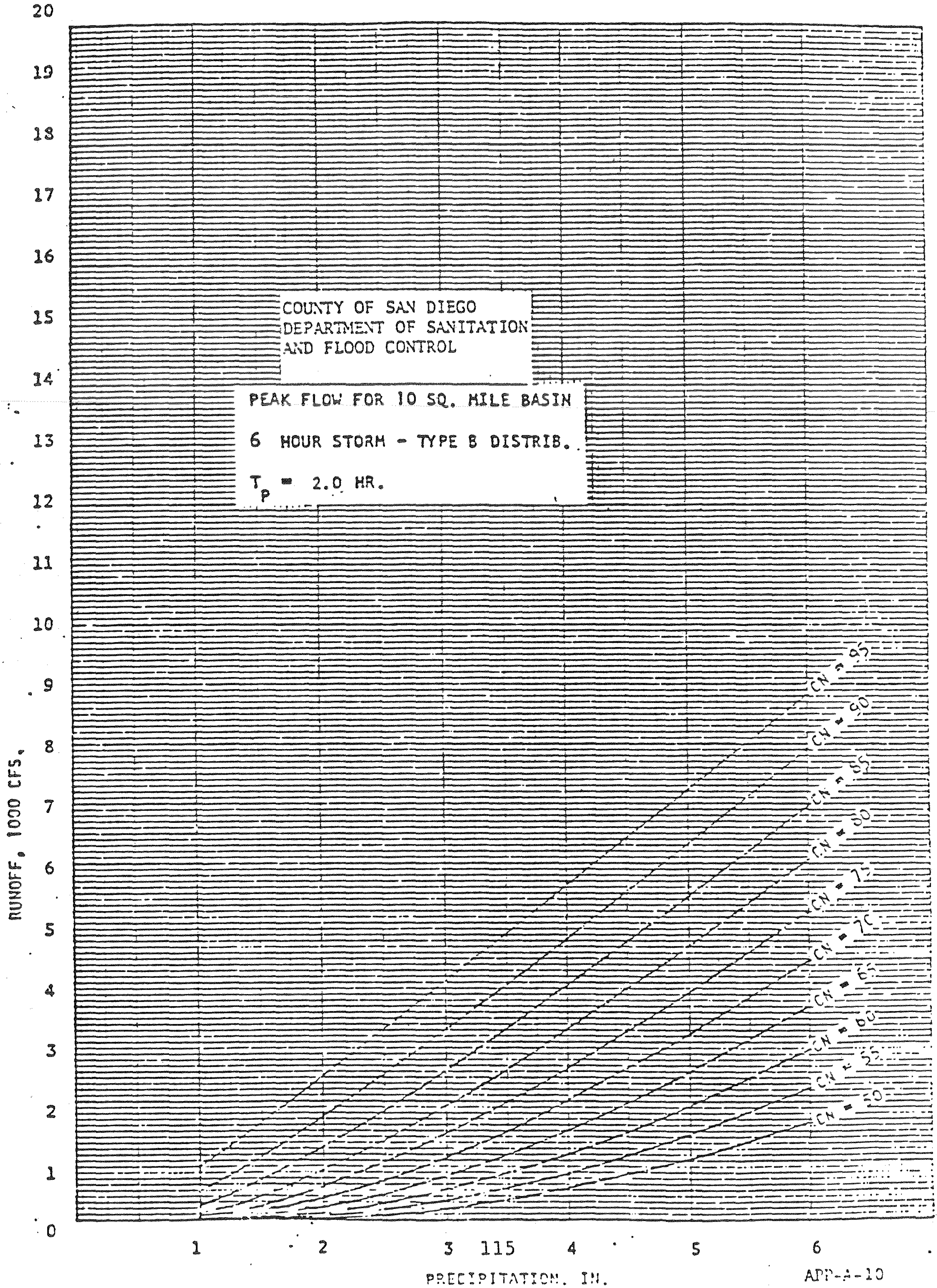
(b) SIX HOUR DESIGN STORM DISTRIBUTION

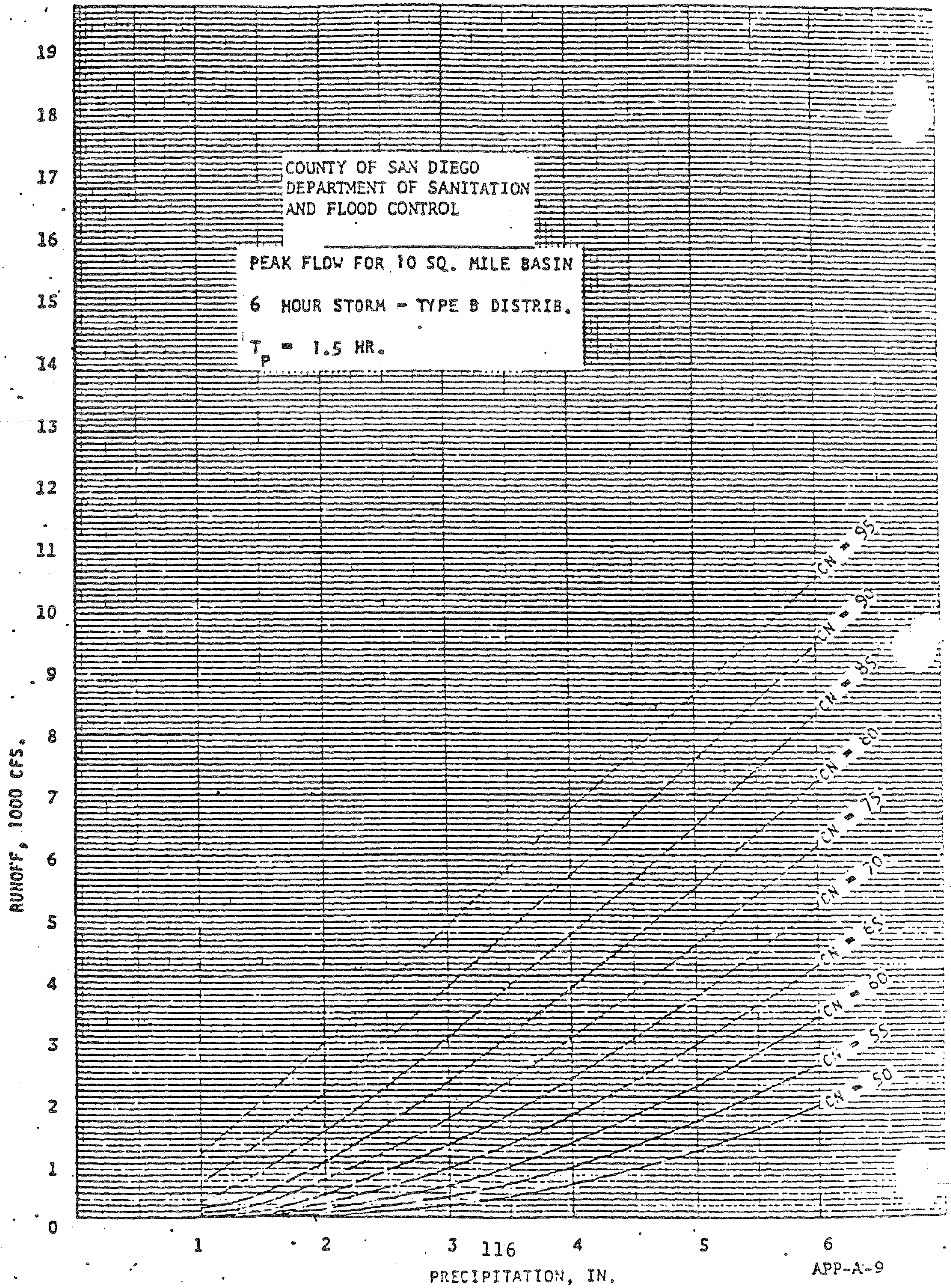


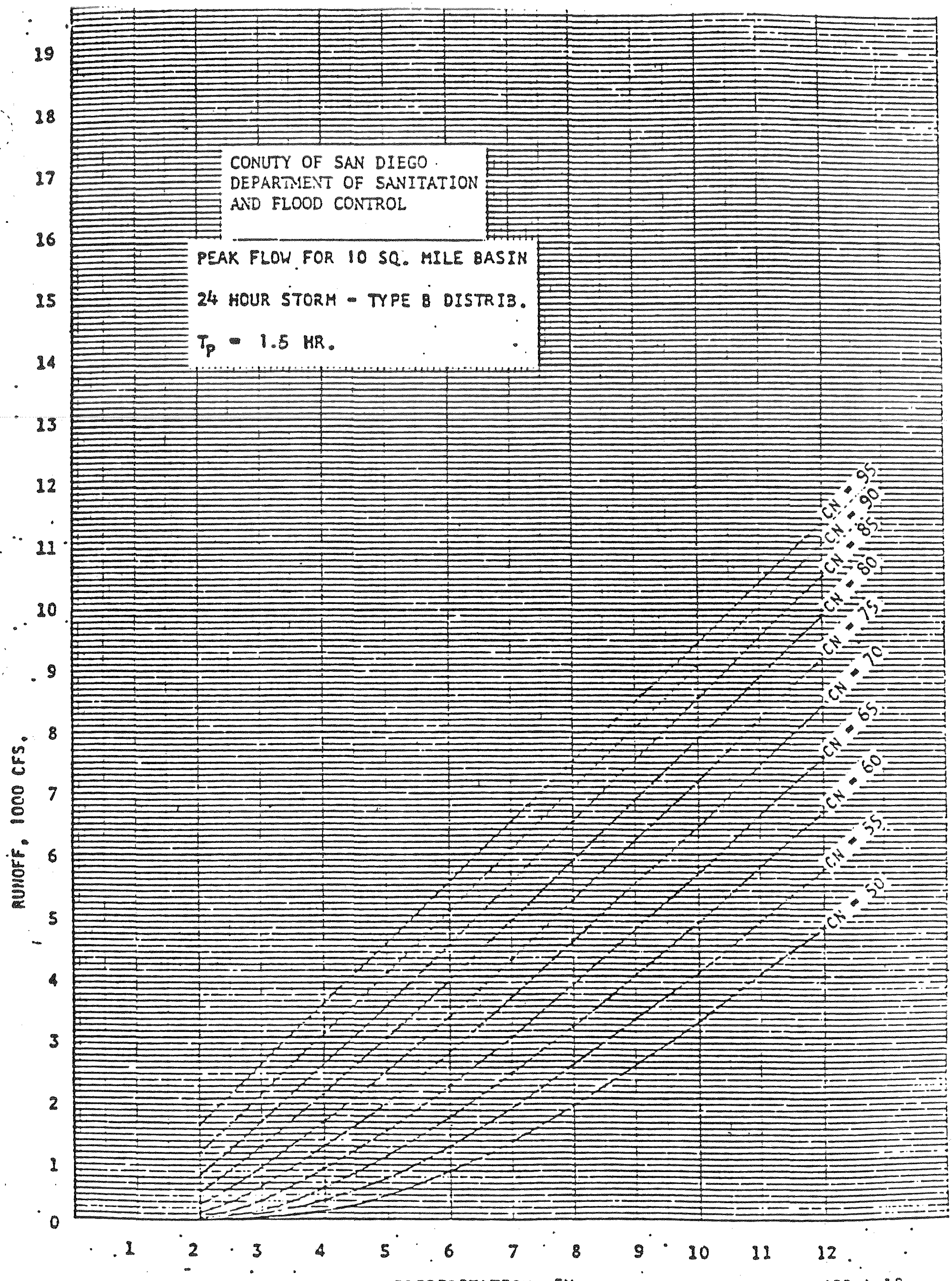
(c) RELATIVE INCREASE IN RAINFALL AMOUNT FOR STORM DURATIONS OVER SIX HOURS

REFERENCE
U.S. Department of Agriculture
Soil Conservation Service
Engineering Division

COUNTY OF SAN DIEGO
DEPARTMENT OF SANITATION AND
FLOOD CONTROL

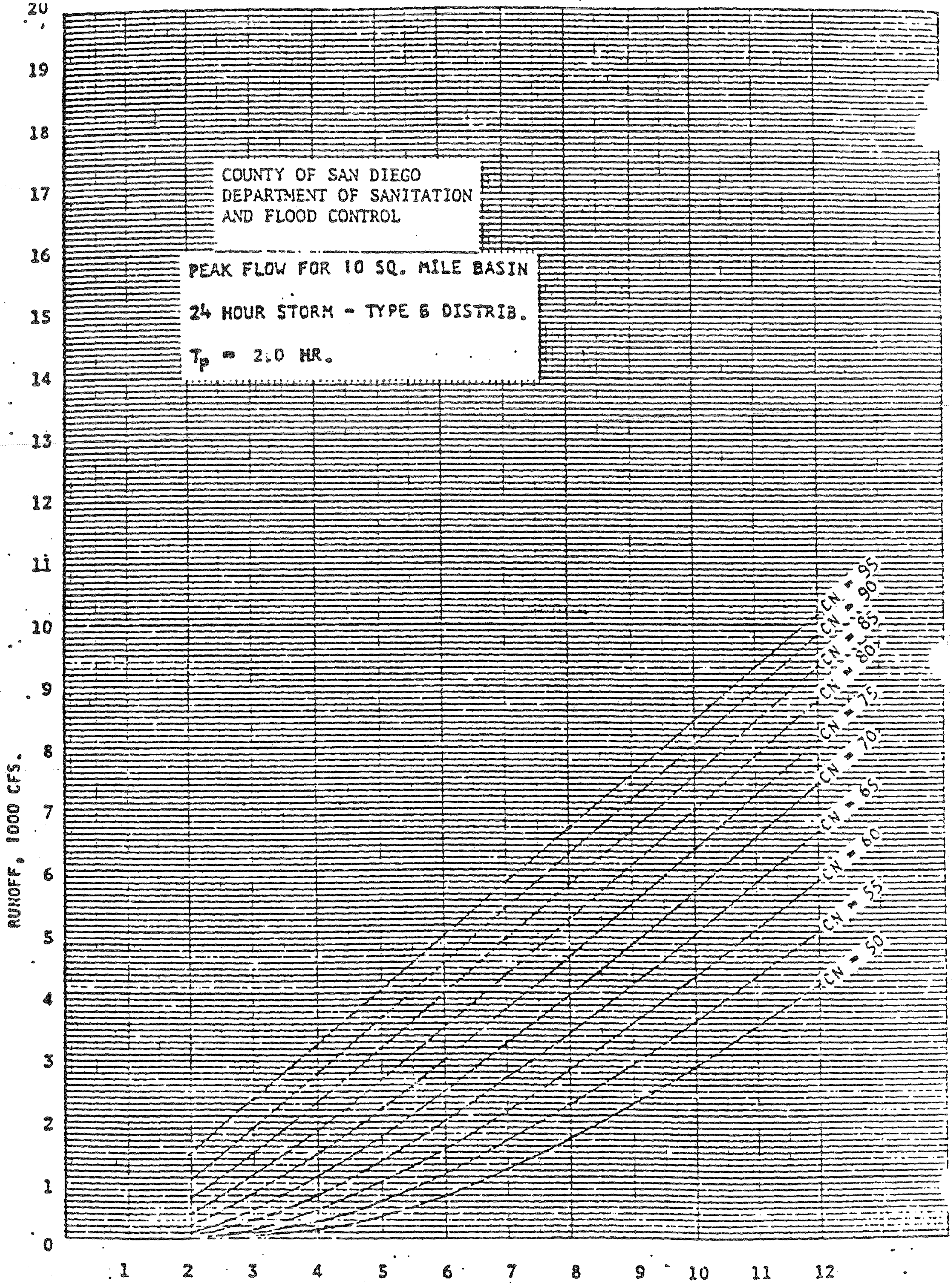

COUNTY OF SAN DIEGO
DEPARTMENT OF SANITATION
AND FLOOD CONTROL
PEAK FLOW FOR 10 SQ. MILE BASIN
6 HOUR STORM - TYPE B DISTRIB.
T_p = 2.0 HR.
RUNOFF, 1000 CFS.
PRECIPITATION, IN.
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
1
2
3
4
5
6
115
CN = 95
CN = 90
CN = 85
CN = 80
CN = 75
CN = 70
CN = 65
CN = 60
CN = 55
CN = 50


COUNTY OF SAN DIEGO
DEPARTMENT OF SANITATION
AND FLOOD CONTROL
PEAK FLOW FOR 10 SQ. MILE BASIN
6 HOUR STORM - TYPE B DISTRIB.
T_p = 1.5 HR.
RUNOFF, 1000 CFS.
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
CN = 95
CN = 90
CN = 85
CN = 80
CN = 75
CN = 70
CN = 65
CN = 60
CN = 55
CN = 50
1
2
3
4
5
6
PRECIPITATION, IN.



CONUTY OF SAN DIEGO
DEPARTMENT OF SANITATION
AND FLOOD CONTROL
PEAK FLOW FOR 10 SQ. MILE BASIN
24 HOUR STORM - TYPE B DISTRIB.
T_p = 1.5 HR.
CN = 95
CN = 90
CN = 85
CN = 80
CN = 75
CN = 70
CN = 65
CN = 60
CN = 55
CN = 50
RUNOFF, 1000 CFS.
PRECIPITATION, IN.
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

APP-A-15


COUNTY OF SAN DIEGO
DEPARTMENT OF SANITATION
AND FLOOD CONTROL
PEAK FLOW FOR 10 SQ. MILE BASIN
24 HOUR STORM - TYPE B DISTRIB.
Tp = 2.0 HR.
CN = 95
CN = 90
CN = 85
CN = 80
CN = 75
CN = 70
CN = 65
CN = 60
CN = 55
CN = 50
RUNOFF, 1000 CFS.
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
PRECIPITATION, IN.

WEIR, SPILLWAY, AND CHANNEL DIMENSIONS - DESILTING BASIN

AREA (acres)	Q (cfs)	WIDTH L or b (feet)	HEIGHT H (Feet)		
			WEIR	SPILLWAY	CHANNEL
10	32	6.0 4.0 3.0	1.5 2.0 2.5	1.5 1.5 2.0	1.0 1.2 1.5
15	46	8.5 5.5 4.0	1.5 2.0 2.5	1.5 1.5 2.0	1.0 1.2 1.5
20	60	11.0 7.5 5.5	1.5 2.0 2.5	1.5 1.5 2.0	1.0 1.2 1.5
40	113	20.5 13.5 9.5	1.5 2.0 2.5	1.5 1.5 2.0	1.0 1.2 1.5
80	204	24.0 17.0	2.0 2.5	1.5 2.0	1.2 1.5
100	246	29.0 21.0	2.0 2.5	1.5 2.0	1.2 1.5
150	343	29.0	2.5	2.0	1.5
200	429	36.0	2.5	2.0	1.5
RUNOFF FOR 5-YEAR STORM FREQUENCY. FLOW IS SUPERCRITICAL THROUGHOUT.					

*For unusual shaped drainage areas 40 acres or larger, compare tabled Q with Q labeled hereon.

SEDIMENT DETENTION BASIN

1. A sediment detention basin is a reservoir which retains high flows sufficiently to cause deposition of transported sediment. Sediment basins may be either temporary or permanent structures which prevent off-site transportation of sediment generated from construction activities. See Figure 36.

DESIGN CONSIDERATIONS

1. The design of the sediment basin shall be based on the total drainage area lying upstream and on the future use of such lands.

2. The spillway overflow from a debris basin should not increase the down stream sediment loads.

3. Vegetation should be planted on slopes of embankments composed of erodible soil.

4. Beyond certain limitations on the height of the dam and the storage capacity of the reservoir, the design of the sediment basin will come under the jurisdiction of the California Division of Safety of Dams (See Table 23).

5. For basins which also serve as permanent water storage consideration should be given to the prevention of "algae bloom" which is aesthetically unsightly.

STORAGE

1. The site should be selected to provide adequate storage.

2. Storage capacity shall be the volume below the pipe spillway crest or emergency spillway crest.

3. Consideration should be given toplan for periodic cleanout in order to maintain the capacity requirements.

4. The maximum allowable level of deposited sediment before cleanout shall be determined and given in the design data as a distance below the top of the riser.

PIPE SPILLWAY

1. The combined capacity of the pipe and emergency spillways will be designed to handle the design flood.

2. Runoff will be figured by an acceptable hydrologic procedure, and should be based on drainage area conditions expected to prevail during the anticipated effective life of the structure.

3. The pipe spillway will consist of a perforated vertical pipe or box-type riser joined to a horizontal pipe conduit (barrel) which will extend beyond the downstream toe of the embankment.

4. The horizontal pipe conduit (barrel) will be a minimum of twelve inches (12") in diameter.

5. The riser is a minimum of thirty inches (30") in diameter and has a cross-sectional area of at least 1.5 times the cross-sectional area of horizontal pipe conduit.

6. The crest elevation of the riser shall be such that full flow will be generated before there is discharge through emergency spillway and at least one foot below crest of emergency spillway.

7. If no emergency spillway is provided, the crest elevation of riser must be at least three feet below crest of emergency spillway.

8. The upper half to two-thirds of the riser shall be perforated with one and one-half to four inch (1-1/2" - 4") holes, 10 to 12 inches on center and staggered.

9. The antivortex device can increase volume of discharge by as much as fifty percent (50%).

10. An approved antivortex device is a thin, vertical plate normal to the centerline of the dam and firmly attached to the top of the riser. The plate dimensions are:

    Height = diameter of barrel

    Length = diameter of riser plus twelves inches (12")

11. The riser shall have a base attached with a watertight connection and shall have sufficient weight to prevent floatation of the riser. Three recommended methods are:

    a. A square concrete base eighteen inches (18") thick with the riser embedded six inches (6") in the base. Each side of base will be diameter of standpipe plus twenty-four inches (24").

    b. A one-quarter inch (1/4") minimum thickness steel plate welded all around the base of the riser to form a watertight connection. The plate shall be square with each side equal to two times the riser diameter. The plate shall have two feet of stone, gravel or tamped earth placed on it to prevent floatation.

    c. Properly anchored guy wires may be substituted for the anchor block.

12. The trash rack consisting of #4 bars, 6 inches on center shall be welded across the top of riser.

13. At least one seepage ring is required and each ring shall be rectangular with each side a minimum of barrel diameter plus 24 inches.

EMERGENCY SPILLWAY

1. The emergency spillway should be designed for 1.5 maximum design flow. Two recommended designs are:

   a. Discharge over top of dam or embankment. Spillway must be lined with 3 inch thick gunite or 4 inch concrete reinforced with 6 X 6 - 10/10 wire mesh, extending to a minimum of 3 feet down the upstream face of embankment. Spillway will be minimum of 18 inches deep with 1-1/2:1 side slopes.

   b. Earth spillways must be installed on undisturbed soil (not on fill) by grading. Side slopes will not be steeper than 2:1. Embankment and spillway channel must be protected by vegetation, rock riprap, etc. The maximum allowable velocity in exit channel shall be 6 feet per second.

FREEBOARD

1. Freeboard is the vertical distance between the elevation of the water surface in the pond when spillway is discharging at designed depth and the elevation of the top of the dam after all settlement has taken place.

2. Minimum freeboard shall be 1.0 foot for sediment basins where the maximum length of pond is less than 660 feet.

EMBANKMENT

1. The embankment shall have top widths based on the following:

Height of Dams	Top Width
Under 10'	8'
10' - 15'	10'
15' - 20'	12'
20' - 25'	14'

2. Slide shall be no steeper than 2:1.

CONSTRUCTION

SITE PREPARATION

1. The foundation area reservoir area shall be cleared of all trees, stumps, roots, brush, boulders, sod, and debris.

2. All topsoil containing excessive amounts of organic matter shall be removed.

BORROW AREAS

1. All borrow areas outside the pool shall be graded, seeded, and left in such a manner that they are well drained and protected from erosion.

EMBANKMENT

1. The embankment material shall be taken from borrow areas as stated on plans.

2. The material shall be free of all sod, roots, woody vegetation, large rock (exceeding 6 inches in diameter,) and other debris.

3. The embankment should be constructed to an elevation which provides for anticipated settlement to design elevation (allow 10% for settlement).

4. The foundations for embankment shall be scarified prior to placement of fill.

5. Placement of fill material shall be started at the lowest point of the foundation and shall be placed in 6 inch maximum lifts which are to be continuous over entire length of fill and approximately horizontal.

6. The satisfactory compaction is usually achieved when the entire surface of the fill is traversed by at least one pass of the load hauling equipment or through use of a roller.

PIPE SPILLWAY

1. The barrel shall be placed on a firm foundation to the lines and grades shown on the plans.

2. Backfill material shall be placed around the barrel in 4 inch layers and each layer shall be thoroughly compacted with suitable hand-operated equipment to at least 2 feet above the top of the pipe and seepage rings before heavy equipment is operated over it.

VEGETATIVE PROTECTION

1. A protective cover shall be established on all exposed surfaces of the embankment, spillway, and borrow area to the extent practical.

PROTECTION OF SPILLWAY DISCHARGE AREA

1. All areas subject to discharges from pipe spillway and emergency spillway must be protected with vegetation, rock, riprap, etc.

SEDIMENT CLEANOUT AND DISPOSAL

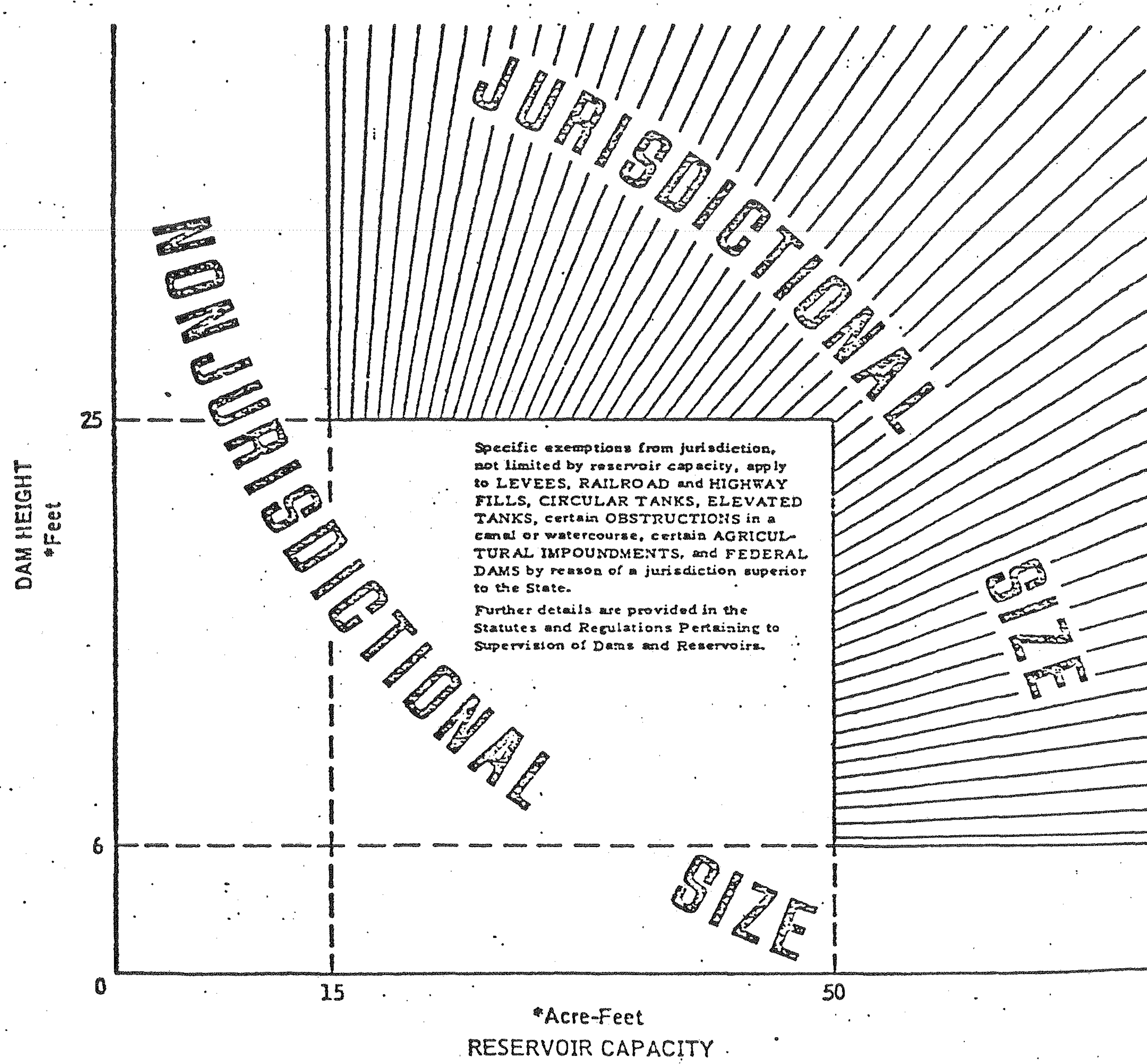
1. The sediment should be removed whenever the storage capacity has been reduced to unsafe, improperly functioning levels.

2. The sediment must be disposed of in such a manner that will prevent its return to the sediment basin or movement into downstream areas during subsequent runoff.

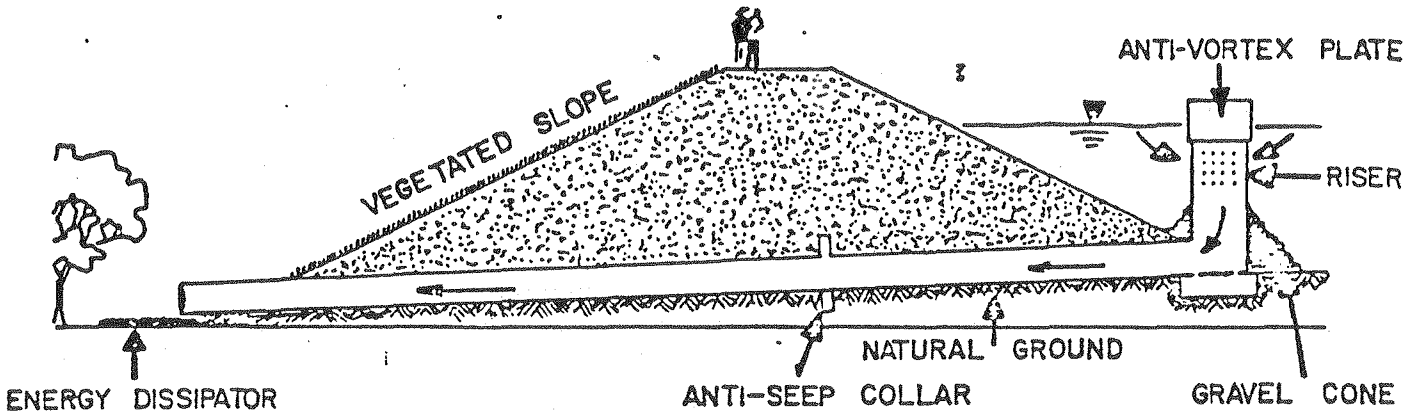
TABLE 23. DESIGN LIMITATIONS AND JURISDICTION OF DAMS IN CALIFORNIA.

Condition	DESIGN HEIGHT (ft)	DESIGN STORAGE (acre-ft)	USE OF DAM	Jurisdiction by the California Division of Safety of Dams
1	≤ 6	No limit	Impound or divert water.	No (sec. 6003)
2	No limit	≤ 15	Impound or divert water.	No (sec. 6003)
3	≤ 15	No limit	Underground percolation.	No (sec. 6004)
4	≥ 25	≥ 15	Impound or divert water.	Yes (sec. 6002a)
5	No limit	≥ 50	Impound or divert water.	Yes (sec. 6002b)

PROVISIONS OF DIVISION 3 OF THE CALIFORNIA WATER CODE AFFECTING JURISDICTION OVER DAMS AND RESERVOIRS



*Metric units not specified in the Water Code are:
1.83 metres = 6 feet   18.50 megalitres = 15 acre-feet
7.62 metres = 25 feet   61.68 megalitres = 50 acre-feet



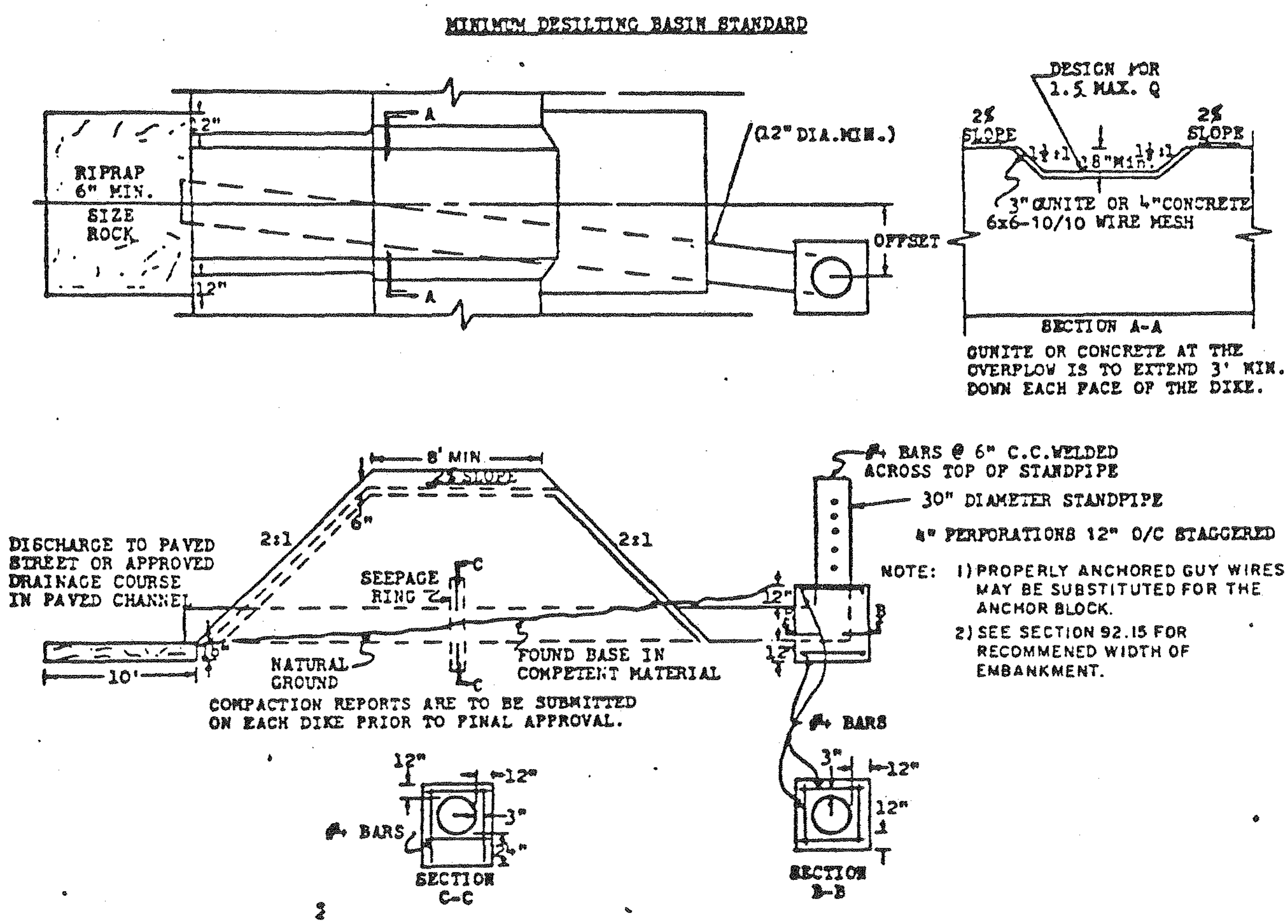


Figure 36. Schematic Design of Sediment Detention Basins. [20] [56]

DESILTING BASIN CAPACITY TABLE

ESTIMATED QUANTITIES OF SILT AND DEBRIS

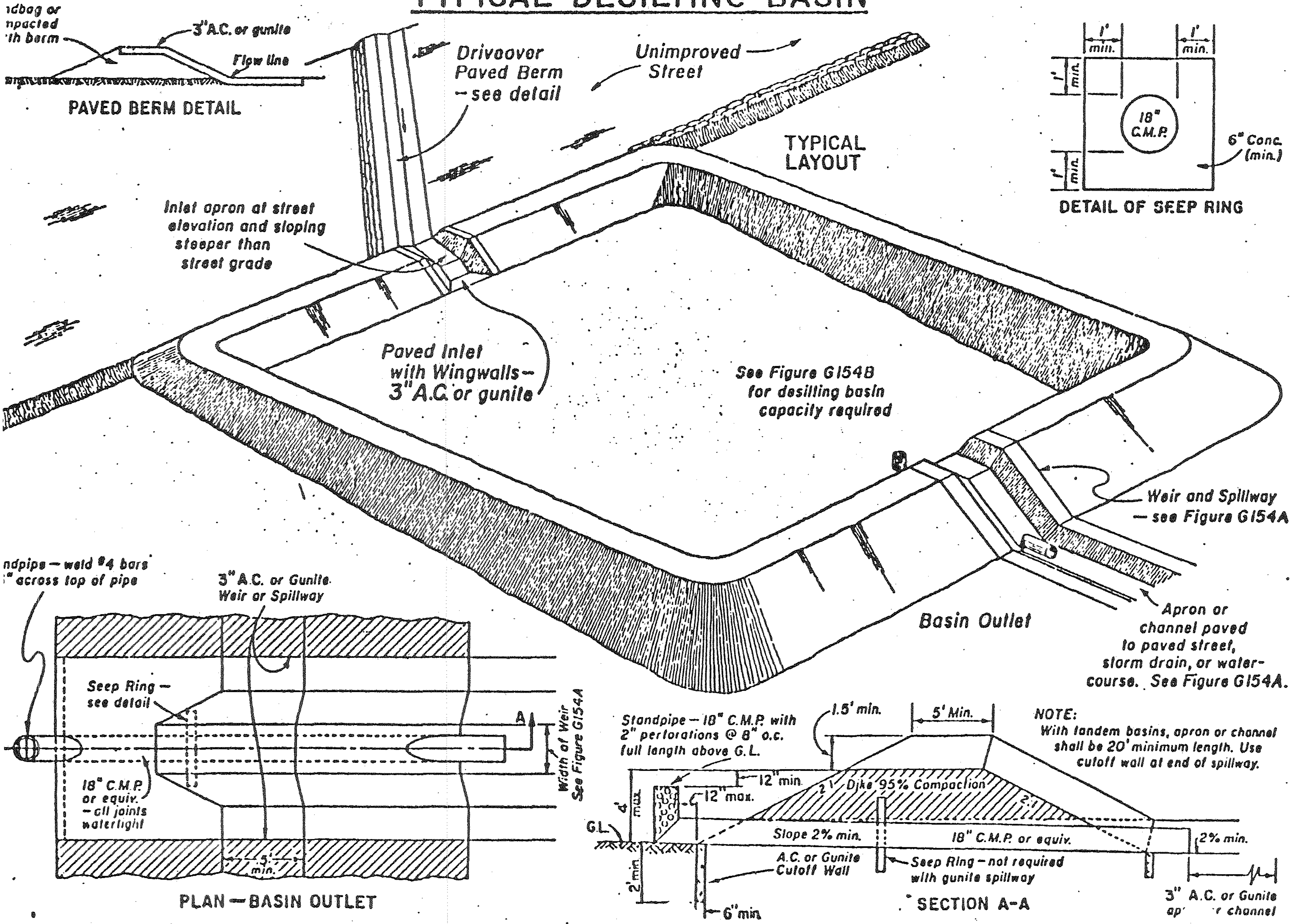
(Cubic Yards)

DRAINAGE TRACT AREA (Acres)	SOIL CONDITIONS	AVERAGE STREET SLOPE					
		2%	5%	8%	10%	12%	15%
10	Loose Granular	270	350	370	400	450	500
	Compacted	100	270	200	240	270	300
15	Loose Granular	400	420	460	600	675	750
	Compacted	150	255	300	360	400	450
20	Loose Granular	540	700	740	800	900	1000
	Compacted	200	340	400	480	540	600
40	Loose Granular	1080	1400	1480	1600	1800	2000
	Compacted	400	680	800	960	1080	1200
80	Loose Granular	2160	2800	2960	3200	3600	4000
	Compacted	800	1360	1600	1920	2160	2400
100	Loose Granular	2700	3500	3700	4000	4500	5000
	Compacted	1000	1700	2000	2400	2700	3000
150	Loose Granular	4000	4200	4600	6000	6750	7500
	Compacted	1500	2550	3000	3600	4000	4500
200	Loose Granular	5400	7000	7400	8000	9000	10000
	Compacted	2000	3400	4000	4800	5400	6000

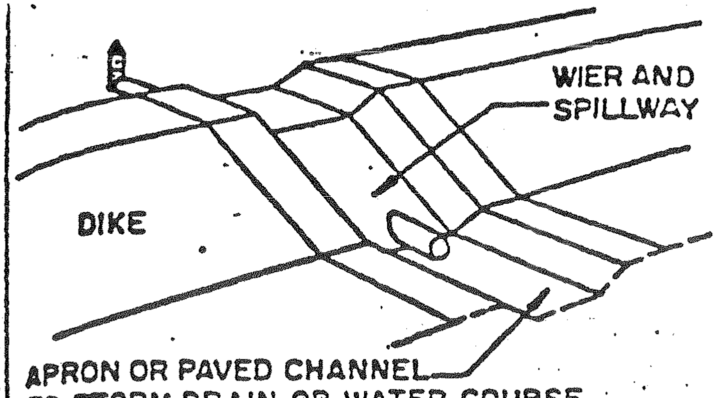
NOTE: Always use the value for granular material unless the project is finished and the utility trenches are filled with soil which has been compacted to 90% relative compaction.

The capacity required by the above table shall be in a pit or basin. At the lower end of the basin there shall be constructed an outlet dike with dimensions as per instructions. The size of the desilting basin may be reduced by constructing more than one basin. However, the total volume of basins constructed shall be equal to the estimated volume of runoff solids.

TYPICAL DESILTING BASIN



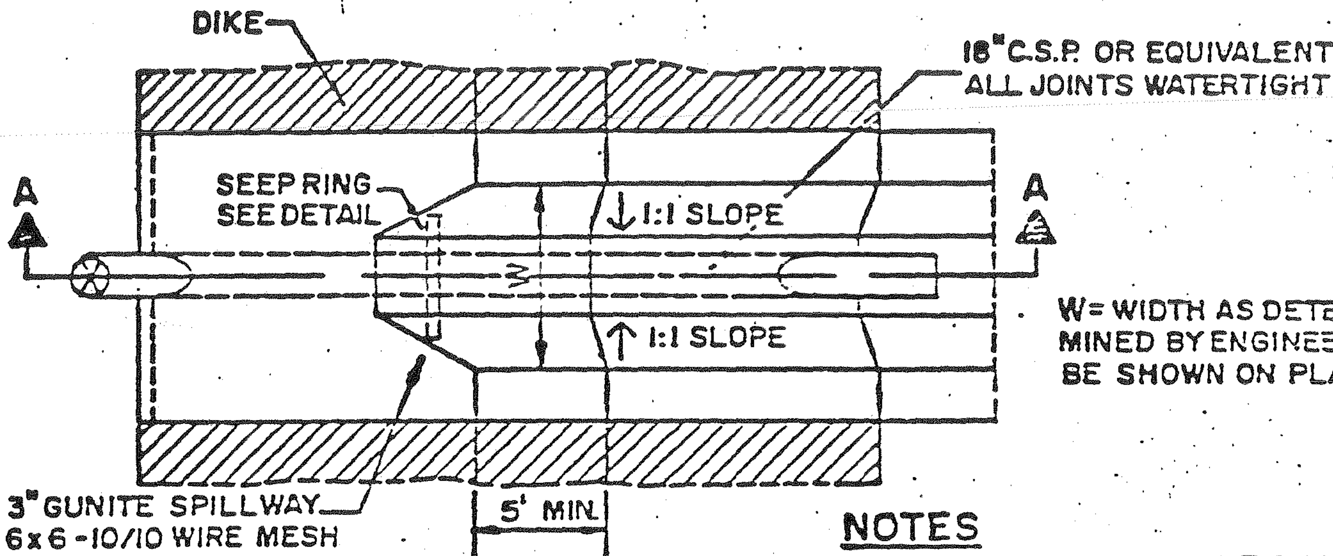
Note: Desiltin[illegible] ins built on lots adjacent to dwellings shall be completely lined with. [illegible] or gunite.



OBLIQUE VIEW

BASIN CAPACITY TABLE
(IN CUBIC YARDS)

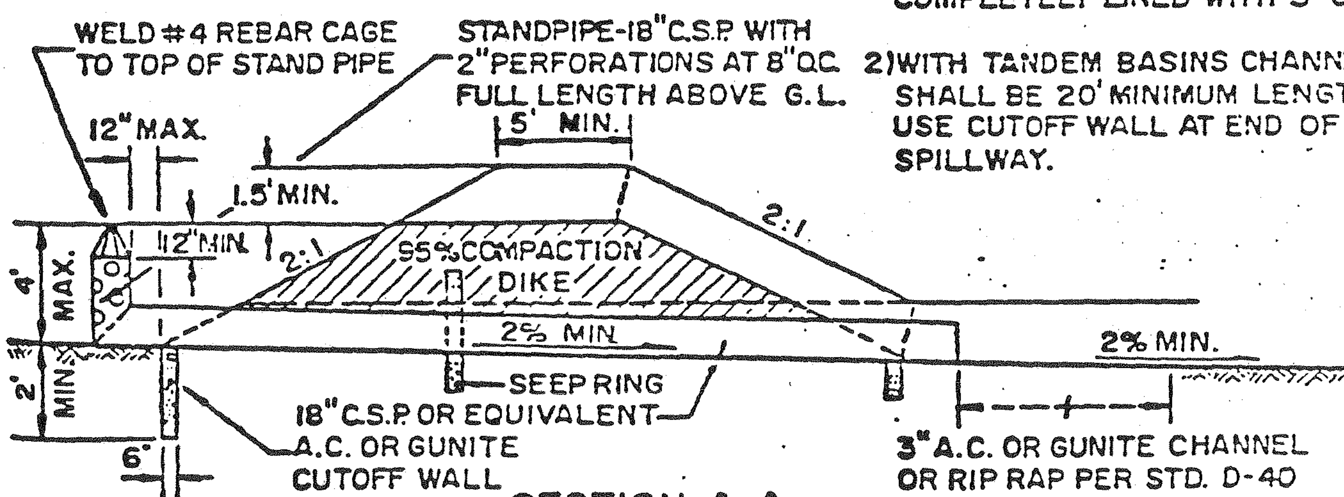
TRACT AREA (ACRES)	AVERAGE SLOPES					
	2%	5%	8%	10%	12%	15%
10	270	350	370	400	450	[illegible]
15	400	420	460	600	675	750
20	540	700	740	800	900	1000
40	1080	1400	1480	1600	1800	2000
80	2160	2800	2960	3200	3600	4000
100	2700	3500	3700	4000	4500	5000
150	4000	4200	4600	6000	6750	7500
200	5400	7000	7400	8000	9000	10000



W= WIDTH AS DETERMINED BY ENGINEER TO BE SHOWN ON PLANS

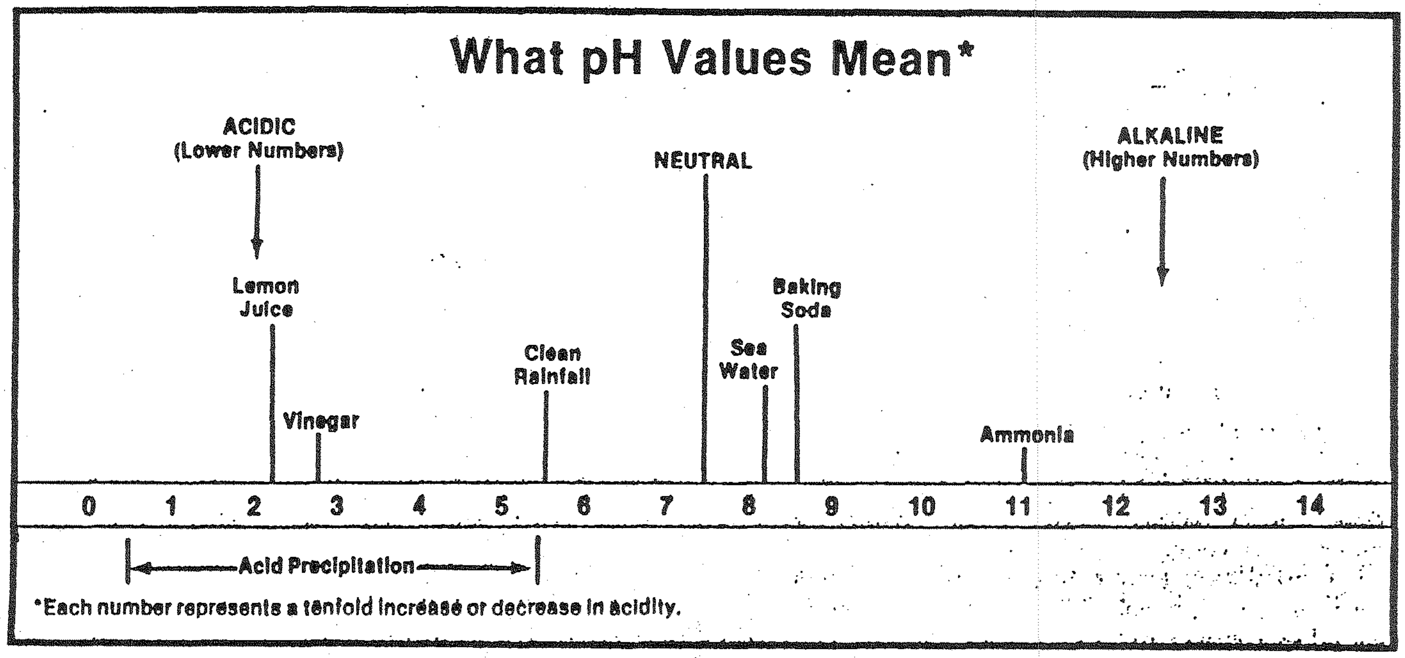
PLAN

NOTES
1) DESILTATION BASINS BUILT ON LOTS ADJACENT TO DWELLINGS SHALL BE COMPLETELY LINED WITH 3" GUNITE
2) WITH TANDEM BASINS CHANNEL SHALL BE 20' MINIMUM LENGTH. USE CUTOFF WALL AT END OF SPILLWAY.



SECTION A-A

REV.	APPROVED	DATE	CITY OF CARLSBAD	L. Evans 10. CITY ENGINEER
			DESILTATION BASIN OUTLET AND CAPACITY TABLE	SUPPLEMENTAL STANDARD NO. DS-3


What pH Values Mean*
ACIDIC
(Lower Numbers)
NEUTRAL
ALKALINE
(Higher Numbers)
Lemon
Juice
Vinegar
Clean
Rainfall
Sea
Water
Baking
Soda
Ammonia
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Acid Precipitation
*Each number represents a tenfold increase or decrease in acidity.

Glossary of Drainage Terms (7–881)

The definitions in this Glossary are for use with this Manual and the references cited. They are not necessarily definitions as established by case or statutory law.

Accretion—Outward growth of bank or shore by sedimentation. Increase or extension of boundaries of land by action of natural forces.

Acre–Foot—A unit of measurement for volume of water. It is equal to the quantity of water required to cover one acre to a depth of one foot and is equal to 43,560 cubic feet or 325,851 gallons. The term is commonly used in measuring volumes of water used or stored.

Aggradation—Upgrading of a stream bed by sedimentation. Modification of the earth's surface in the direction of uniformity of grade, or slope, by deposition as in a river bed.

Aggressive—Refers to the corrosive properties of soil and water.

Alluvium—Stream–borne materials deposited in and along a channel.

Apron—A lining of the bed of the channel upstream or downstream from a lined or restricted waterway. A floor or lining of concrete, timber, etc., to protect a surface from erosion such as the pavement below chutes, spillways, at the toes of dams, or along the toe of bank protection.

Aqueduct—(1) a major conduit. (2) The entire transmission main for a municipal water supply which may consist of a succession of canals, pipes, tunnels, etc. (3) Any conduit for water; especially one for a large quantity of flowing water. (4) A structure for conveying a canal over a river or hollow.

Aquifer—Water-bearing geologic formations that permit the movement of ground water.

Artesian Waters—Percolating waters confined below impermeable formations with sufficient pressure to spring or well up to the surface.

Avulsion—(1) A forcible separation; also, a part torn off. (2) The sudden removal of land from the estate of one man to that of another, as by a sudden change in a river, the property thus separated continuing in the original owner. (A sudden shift in location of channel.)

Backwater—An unnaturally high stage in stream caused by obstruction or confinement of flow, as by a dam, a bridge, or a levee. Its measure is the excess of unnatural over natural stage, not the difference in stage upstream and downstream from its cause.

Bank—The lateral boundary of a stream confining water flow. The bank on the left side of a channel looking downstream is called the left bank, etc.

Bank Protection—Revetment—or other armor protecting a bank of a stream from erosion—include devices used to deflect the forces of erosion away from the bank.

Bedding—The foundation under a drainage structure.

Bedload—That solid material which is heavier than water and is transported by the flowing water along or close to the bed. May consist of silt, sand and rocks.

Bulking—The increase in volume of flow due to air entrainment, debris, bedload, or sediment in suspension.

Camber—An upward adjustment of the profile of a drainage facility under a heavy loading (usually a high embankment) and poor soil conditions, so that as the drainage facility settles it approaches the design profile.

Capacity—The effective carrying ability of a drainage structure. Generally measured in cubic feet per second.

Capillarity—The attraction between water and soil particles which causes water to move in any direction through the soil mass regardless of gravitational forces.

Capillary Water—Water which clings to soil particles by capillary action. It is normally associated with fine sand, silt, or clay, but not normally with coarse sand and gravel.

Catch Basin—A drainage structure which collects water. May be either a structure where water enters from the side or through a grating.

Check Dam—A small dam generally placed in steep ditches for the purpose of reducing the velocity in the ditch.

Cienega—A swamp formed by water rising to the surface at a fault.

Cleanout—An access opening to a roadway drainage system. Usually consists of a manhole shaft, a special chamber or an opening into a shallow culvert or drain.

Coefficient of Runoff—Percentage of gross rainfall which appears as runoff.

Concentrated Flow—Flowing water that has been accumulated into a single fairly narrow stream.

Concentration—In addition to its general sense, means the unnatural collection or convergence of waters so as to discharge in a narrower width, and at greater depth or velocity.

Conduit—Any pipe, arch, box or drain tile through which water is conveyed.

Control—A natural constriction of the channel, a long reach of the channel, a stretch of rapids, or an artificial structure downstream from a gaging station that determines the stage–discharge relation at the ~ge. That section which determines the flow for a ꞁticular reach of a drainage system.

Cradle—A concrete base generally constructed to fit the shape of a structure which is to be forced through earthen material by a jacking operation. The cradle is constructed to line and grade. Then the pipe rides on the cradle as it is worked through the given material by jacking and tunneling methods. Also serves as bedding for pipes in trenches in special conditions.

Critical Depth—(Depth at which specific energy is a minimum)—The depth of water in a conduit at which under certain other conditions the maximum flow will occur. These other conditions are the conduit is on the critical slope with the water flowing at its critical velocity and there is an adequate supply of water. The depth of water flowing in an open channel or a conduit partially filled, for which the velocity head equals one–half the hydraulic mean depth.

Critical Flow—A condition which exists at the critical depth. Under this condition, the sum of the velocity head and static head is a minimum.

Critical Slope—That slope at which the maximum flow will occur at the minimum velocity. The slope or grade that is exactly equal to the loss of head per foot resulting from flow at a depth that will give uniform flow at critical depth; the slope of a conduit which will produce critical flow.

Critical Velocity—Mean velocity of flow when flow is at critical depth.

Culvert—A closed conduit, other than a bridge, which allows water to pass under a highway. A culvert has a span of less than 20 feet, or if multispan, the individual spans are ten feet or less.

Cutoff Wall—A wall at the end of a drainage structure, the top of which is an integral part of the drainage structure, while the actual cutoff wall extends a specified depth below the structure. This wall is usually buried and its function is to prevent undermining of the drainage structure if the natural material at the outlet of the structure is dug out by the water discharging from the end of the structure. Cutoff walls are sometimes used at the upstream end of a structure when there is a possibility of erosion at this point.

Debris—Solid matter carried by storm waters. May consist of limbs, sticks, orchard prunings, rubbish, logs, trees, or a mixture of clay, silt, sand, gravel and rock.

Debris Barrier—A deflector placed at the entrance of a culvert upstream, which tends to deflect heavy floating debris or boulders away from the culvert entrance during high–velocity flow.

Debris Basin—Any area upstream from a drainage structure utilized for the purpose of retaining debris in order to prevent clogging of drainage structures downstream.

Debris Rack—A straight barrier placed across the stream channel which tends to separate light and medium floating debris from stream flow and prevent the debris from reaching the culvert entrance.

Degradation—The lowering of the bed of a stream or channel.

Design Discharge—The quantity of flow that is expected at a certain point as a result of a design storm. Usually expressed as a rate of flow in cubic feet per second.

Design Frequency—The recurrence interval for hydrologic events used for design purposes. As an example, a design frequency of 50 years means a storm of a magnitude that would be expected to recur on the average of once every 50 years.

Design Storm—That particular storm which contributes runoff which the drainage facilities were designed to handle. This storm is selected for design on the basis of its probable recurrence, i.e.—a 50–year design storm would be a storm for which its maximum runoff would occur on the average of once every 50 years.

Detritus—Rock, gravel, sand and silt carried by a flowing stream.

Dike—Usually an earthen bank alongside and parallel with a river or open channel or an A.C. dike along the edge of shoulder.

Discharge—A volume of water flowing out of a drainage structure or facility. Measured in cubic feet per second.

Diversion—The change in character, location, direction, or quantity of flow of a natural drainage course. A deflection of flood water is not diversion.

D–Load (Cracking D–Load)—A term used in expressing the strength of concrete pipe. The cracking D–load represents the test load required to produce a 0.01 inch crack for a length of one foot.

Downdrain—A prefabricated drainage facility assembled and installed in the field for the purpose of transporting water down steep slopes.

Drainage—(1) The process of removing surplus ground or surface water by artificial means. (2) The system by which the waters of an area are removed. (3) The area from which waters are drained; a drainage basin.

Drainage Area (Drainage Basin) (Basin)—That portion of the earth's surface upon which falling precipitation flows to a given location. With respect to a highway, this location may be either a culvert, the furthest point of a channel, or an inlet to a roadway drainage system.

Drainage Course—Any path along which water flows when acted upon by gravitational forces.

Drainage Divide—The rim of a drainage basin. A series of high points from which water flows in two directions, to the basin and away from the basin.

Drainage Easement—(See "Easement")

Drainage System—Usually a system of underground conduits and collector structures which flow to a single point of discharge.

Dry Weather Flows—A small amount of water which flows almost continually due to lawn watering, irrigation or springs.

Easement—Right to use the land of others.

Eddy Loss—The energy lost (converted into heat) by swirls, eddies, and impact, as distinguished from friction loss.

Endwall—A wall placed at the end of a culvert. It may serve three purposes—one, to hold the embankment away from the pipe and prevent sloughing into the pipe outlet channel; two, to provide a wall which will prevent erosion of the roadway fill; and three, to prevent flotation of the pipe.

Energy Dissipator—A structure for the purpose of slowing the flow of water and reducing the erosive forces present in any rapidly flowing body of water.

Energy Grade Line—A hydraulic term used to define a line representing the total amount of energy available at any point along a water course, pipe, or drainage structure. Where the water is motionless, the water surface would coincide with the point or the energy grade line. As the flow of water is accelerated the water surface drops further away from the energy grade line. If the flow is stopped at any point the water surface jumps back to the energy grade line.

Energy Head—The elevation of the hydraulic grade line at any section plus the velocity head of the mean velocity of the water in that section.

Entrance Head—The head required to cause flow into a conduit or other structure; it includes both entrance loss and velocity head.

Entrance Loss—The head lost in eddies and friction at the inlet to a conduit or structure.

Equalizer—A drainage structure similar to a culvert but different in that it is not intended to pass a design flow in a given direction. Instead it is often placed level so as to permit passage of water in either direction. It is generally used where there is no place for the water to go. Its purpose is to maintain the same water surface elevation on both sides of the highway embankment.

Erosion—The wearing away of a surface by some external force. In the case of drainage terminology, this term generally refers to the wearing away of the earth's surface by flowing water. It can also refer to the wear on a structural surface by flowing water and the material carried therein. *Erosion* and *Scour* are cutting or wearing away by the forces of water of the banks and bed of a channel in horizontal and vertical directions, respectively.

Erosion and Accretion—Loss and gain of land, respectively, by the gradual action of a stream in shifting its channel by cutting one bank while it builds on the opposite bank. Property is lost by erosion and gained by accretion but not by *avulsion* when the shift from one channel to another is sudden. Property is gained by *reliction* when a lake recedes.

Evaporation—A process whereby water as a liquid is changed into water vapor through heat supplied from the sun.

Fan—A portion of a cone, but sometimes used to emphasize definition of radial channels. Also reference to spreading out of water or soils associated with waters leaving a confined channel.

Flap Gate—This is a form of valve that is designed so that a minimum force is required to push it open but when a greater water pressure is present on the outside of the valve, it remains shut so as to prevent water from flowing in the wrong direction. Construction is simple with a metal cover hanging from an overhead rod or pinion at the end of a culvert or drain.

Flood Plain—Strip of land adjacent to a river or channel which has a history of overflow.

Flood Plane—The position occupied by the water surface of a stream during a particular flood. Also loosely, the elevation of the water surface at various points along the stream during a particular flood.

Flood Stage—The elevation at which overflow of the natural banks of a stream begins to cause damage in the reach in which the elevation is measured.

Flood Waters—Former stream waters which have escaped from a watercourse (and its overflow channel) and flow or stand over adjoining lands. They remain as such until they disappear from the surface by infiltration, evaporation, or return to a natural watercourse. They do not become surface waters by mingling with such waters, nor stream waters by eroding a temporary channel.

Flow—A term used to define the movement of water, silt, sand, etc.; discharge; total quantity carried by a stream.

Flow Line—A term used to describe the line connecting the low points in a watercourse.

Freeboard—The distance between the normal operating level and the top of the sides of an open conduit; the crest of a dam, etc., designed to allow for wave action, floating debris, or any other condition or emergency, without overtopping the structure.

Free Outlet—A condition under which water discharges with no interference such as a pipe discharging into open air.

Free Water—Water which can move through the soil by force of gravity.

French Drain—A trench loosely backfilled with stones, the largest stones being placed in the bottom with the size of stones decreasing towards the top. The interstices between the stones serve as a passageway for water.

Grade to Drain—A construction note often inserted on a plan for the purpose of directing the Contractor to slope a certain area in a specific direction, so that the storm waters will flow to a designated location.

Gradient (Slope)—The rate of ascent or descent—expressed as a percent or as a decimal as determined by the ratio of the change in elevation to the length.

Ground Water—That water which is present under the earth's surface. Ground water is that situated below the surface of the land, irrespective of its source and transient status. Subterranean streams are flows of ground waters parallel to and adjoining stream waters, and usually determined to be integral parts of the visible streams.

Head—When used as a hydraulic term, this represents an available force equivalent to a certain depth of water. This is the motivating force in effecting the movement of water. The height of water above any point or plane of reference. Used also in various compound expressions, such as energy head, entrance head, friction head, static head, pressure head, lost head, etc.

Hydraulic Gradient—A line which represents the relative force available due to the potential energy available. This is a combination of energy due to the height of the water and the internal pressure. In any open channel, this line corresponds to the water surface. In a closed conduit, if several openings were placed along the top of the pipe and open tubes inserted, a line connecting the water surface in each of these tubes would represent the hydraulic grade line.

Hydraulic Jump (or Jump)—Transition of flow from the rapid to the tranquil state. A varied flow phenomenon producing a rise in elevation of water surface. A sudden transition from supercritical flow to the complementary subcritical flow, conserving momentum and dissipating energy.

Hydraulic Mean Depth—The area of the flow cross section divided by the water surface width.

Hydraulic Radius—The cross sectional area of a stream of water divided by the length of that part of its periphery in contact with its containing conduit; the ratio of area to wetted perimeter.

Hydrograph—A graph showing stage, flow, velocity, or other property of water with respect to time.

Hydrography—Water Surveys. The art of measuring, recording, and analyzing the flow of water; and of measuring and mapping watercourses, shore lines, and navigable waters.

Hydrology—The science dealing with the occurence and movement of water upon and beneath the land areas of the earth. Overlaps and includes portions of other sciences such as meteorology and geology. The particular branch of Hydrology that a Drainage Section is generally interested in is surface runoff which is the result of excessive precipitation.

Hyetograph—Graphical representation of rainfall intensity against time.

Infiltration—The passage of water through the soil surface into the ground.

Inlet Time—The time required for storm runoff to flow from the most remote point, in flow time, of a drainage area to the point where it enters a drain or culvert.

Inlet Transition—A specially shaped entrance to a box or pipe culvert. It is shaped in such a manner that in passing from one flow condition to another, the minimum turbulence or interference with flow is permitted.

Invert—The bottom of a drainage facility along which the lowest flows would pass.

Invert Paving—Generally applies to metallic pipes where it is desirable to improve flow characteristics or prevent corrosion at low flows. The bottom portion of the pipe is paved with an asphaltic material, concrete, or air-blown mortar.

Inverted Siphon—A pipe for conducting water beneath a depressed place. A true inverted siphon is a culvert which has the middle portion at a lower elevation than either the inlet or the outlet and in which a vacuum is created at some point in the pipe. A sag culvert is similar, but the vacuum is not essential to its operation.

Isohyetal Line—A line drawn on a map or chart joining points that receive the same amount of precipitation.

Isohyetal Map—A map containing isohyetal lines and showing rainfall intensities.

Isovel—Line on a diagram of a channel connecting points of equal velocity.

Jack (or Jack Straw)—Bank protection element consisting of wire or cable strung on three mutually perpendicular struts connected at their centers.

Jacking Operations—A means of constructing a pipeline under a highway without open excavation. A cutting edge is placed on the first section of pipe and the pipe is forced ahead by hydraulic jacks. As the leading edge pushes ahead, the material inside the pipe is dug out and transported outside the pipe for disposal.

Jetty—An elongated, artifical obstruction projecting into a stream or the sea from bank or shore to control shoaling and scour by deflection of strength of currents and waves.

Lag—Variously defined as time from beginning (or center of mass) of rainfall to peak (or center of mass) of runoff.

Laminar Flow—That type of flow in which each particle moves in a direction parallel to every other particle and in which the head loss is approximately proportional to the velocity (as opposed to turbulent flow).

Lateral—In a roadway drainage system, a drainage conduit transporting water from inlet points to the main drain trunk line.

Levee—An embankment to prevent inundation.

Local Depression—A low area in the pavement or in the gutter established for the special purpose of collecting surface waters on a street and directing these waters into a drainage inlet.

Mean Velocity—Average velocity within a cross section.

Mud Flow—A well-mixed mass of water and alluvium which, because of its high viscosity, and low fluidity as compared with water, moves at a much slower rate, usually piling up and spreading out like a sheet of wet mortar or concrete.

Navigable Waters—Those stream waters lawfully declared or actually used as such. *Navigable waters of the State of California* are those declared to be such by Statute. *Navigable waters of the United States* are those determined by the Corps of Engineers or the U.S. Coast Guard to be so used in interstate or international commerce. Other streams have been held navigable by courts under the common law that navigability in fact is navigability in law.

Negative Projecting Conduit—A structure installed in a trench with the top below the top of trench, then covered with backfill and embankment. See Positive Projecting Conduit.

Normal Depth—The depth at which flow is steady and hydraulic characteristics are uniform.

Off-Site Drainage—The handling of that water which originates outside the highway right of way.

On-Site Drainage—The handling of that water which originates inside the highway right of way.

Open Channel—A drainage course which has no restrictive top. It is open to the atmosphere and may or may not permit surface flow to pass over its edge and into the channel in an unrestricted manner. In many cases where dikes or berms are constructed to increase the channel capacity, entrance of surface waters is necessarily controlled.

Outfall—Discharge or point of discharge of a culvert or other closed conduit.

Outwash—Debris transported from a restricted channel to an unrestricted area where it is deposited to form an alluvial or debris cone or fan.

Overflow—That portion of the runoff which is excess of the capacity of a stream or channel at given point and which leaves the stream or channel at that point and either flows errantly across the surface or enters into an adjacent stream or channel.

Overflow Channel—A natural or artificial channel which accomodates excess waters from the primary watercourse.

Overland Flow—Flow of surface waters before reaching a natural watercourse.

Peak Flow—Maximum momentary stage or discharge of a stream in flood. Design Discharge.

Perched Water—Ground water located above the level of the water table and separated from it by a zone of impermeable material.

Percolating Waters—Waters which have infiltrated the surface of the land and move slowly downward and outward through devious channels (aquifers) unrelated to stream waters, until they reach an underground lake or regain and spring from the land surface at a lower point.

Permeability—The property of soils which permits the passage of any fluid. Permeability depends on grain size, void ratio, shape and arrangement of pores.

Point of Concentration—That point at which the water flowing from a given drainage area concentrates. With reference to a highway, this would generally be either a culvert entrance or some point in a roadway drainage system.

Positive Projecting Conduit—A structure installed in shallow trench with the top of the conduit projecting above the top of the trench and then covered with embankment. See Negative Projecting Conduit.

Potamology—The hydrology of streams.

Precipitation—Rainfall, snow, sleet, fog, hail, dew and frost.

Prescriptive Rights—The operation of the law whereby rights might be established by long exercise of their corresponding powers or extinguished by prolonged failure to exercise such powers.

Pumping Plant—A complete pumping installation including a storage box, pump or pumps, standby pumps, connecting pipes, electrical equipment, pumphouse and outlet chamber.

Rainfall—*Point Precipitation:* That which registers at a single gauge. *Area Precipitation:* Adjusted point rainfall for area size.

Rainwash—The creep of soil lubricated by rain.

Rainfall Method—A means of estimating the amount of storm water arriving at a given point. See Index No. 7-811.2

Reach—The length of a channel uniform with re spect to discharge, depth, area, and slope. More generally, any length of a river or drainage course.

Regimen—The characteristic behavior of a stream during ordinary cycles of flow.

Reliction—Pertaining to being left behind. For example: that area of land is left behind by reliction when the water surface of a lake is lowered.

Retarding Basin—Either a natural or man made basin with the specific function of delaying the flow of water from one point to another. This tends to increase the time that it takes all the water falling on the extremities of the drainage basin to reach a common point, resulting in a reduced peak flow at that point.

Retrogression—Reversal of stream grading, i.e., aggradation after degradation, or vice versa.

Revetment—Bank protection to prevent erosion. May be pipe and wire, rip rap, concrete, asphalt, rail and wire, etc.

Riparian—Pertaining to the banks of a stream.

Rip-Rap—Protection against erosion consisting of broken concrete, sacked concrete, rock, etc.

Riser—In mountainous terrain where much debris is encountered, the entrance to a culvert sometimes becomes easily clogged. Therefore, a corrugated metal pipe or a structure made of timber or concrete with small perforations, called a riser, is installed vertically to permit entry of water and prohibit the entry of mud and debris. The riser may be increased in height as the need occurs.

Rounded Inlet—The edges of a culvert entrance that are rounded for smooth transition which reduces turbulence and increases capacity.

Runoff—The portion of precipitation that appears as flow in streams. Drainage or flood discharge which leaves an area as surface flow or a pipeline flow, having reached a channel or pipeline by either surface or subsurface routes, and includes underflow in some cases.

Saltation—Bed load transport by leaps or bounds.

Sag Culvert (or Sag Pipe)—A pipeline with a dip in its grade line crossing over a depression or under a highway, railroad, canal, etc. The term inverted siphon is common but inappropriate as no siphonic action is involved. The term "sag pipe" is suggested as a substitute.

Scour—Wearing of the bed of the stream by entrainment of alluvium and erosion of native rock. Also caused by excessive velocities at the entrance of a concentrated stream of water onto unstable material. Wearing away by abrasive action.

Sedimentation—Gravitational deposit of transported material in flowing or standing water.

Sheet Flow—Any flow spread out and not confined, i.e, flow across a flat open field.

Shoaling—Process of creating a shallow region made in flowing or standing water, especially if made shallow by deposition.

Silt—(1) *Water-Borne Sediment.* Detritus carried in suspension or deposited by flowing water, ranging in diameter from .0002 to .002 inches. The term is generally confined to fine earth, sand, or mud, but is sometimes both suspended and bedload. (2) *Deposits of Water-Borne Material.* As in a reservoir, on a delta, or on flood plains.

Skew—When a drainage structure is not normal (perpendicular) to the longitudinal axis of the highway, it is said to be on a skew. The skew angle is the smallest angle between the perpendicular and the axis of the structure.

Slide—Gravitational movement of an unstable mass of earth from its natural position.

Slip Out—Gravitational movement of an unstable mass of earth from its constructed position. Applied to embankments and other man-made earthworks.

Slope—(1) Gradient of a stream. (2) Inclination of the face of an embankment, expressed as the ratio of horizontal to vertical projection; or (3) the face of an inclined embankment or cut slope. In hydraulics it is expressed as percent or in decimal form.

Slough—(1) Pronounced *SLU.* A side or overflow channel in which water is continually present. It is stagnant or slack; also a waterway in a tidal marsh. (2) Pronounced *SLUFF.* Slide or slipout of a thin mantle of earth, especially in a series of small movements.

Slugflow—Flow in culvert or drainage structure which alternates between full and partly full. Pulsating flow—mixed water and air.

Soffit—The bottom of the top—(1) With reference to a bridge, the low point on the underside of the suspended portion of the structure. (2) In a culvert, the uppermost point on the inside of the structure.

Specific Energy—The energy of a stream referred to its bed; namely, depth plus velocity head of mean velocity.

Stage—The elevation of a water surface above its minimum; also above or below an established "low water" plane; hence above or below any datum of reference; gage height.

Storage—Detention, or retention of water for future flow, naturally in channel and marginal soils or artificially in reservoirs.

Storage Basin—Space for detention or retention of water for future flow, naturally in channel and marginal soils, or artificially in reservoirs.

Storm—A disturbance of the ordinary, average conditions of the atmosphere which, unless specifically qualified, may include any or all meterological disturbances, such as wind, rain, snow, hail, or thunder.

Stream Waters—Former surface waters which have entered and now flow in a well defined natural watercourse, together with other waters reaching the stream by direct precipitation or rising from springs in bed or banks of the watercourse. They continue as stream waters as long as they flow in the watercourse, including overflow and multiple channels as well as the ordinary or low–water channel.

Strutting—Elongation of the vertical axis of pipe prior to installing in a trench. After the backfill has been placed around the pipe and compacted the wires or rods holding the pipe in its distorted shape are removed. Greater side support from the earth is developed when the pipe tends to return to its original shape. Generally used on pipes which because of size or thinness of the metal would tend to deform during construction operations. Arches are strutted diagonally per standard or special plan.

Subcritical Flow—Flow with a velocity head less than half the hydraulic mean depth of water.

Subdrain—A conduit for collecting and disposing of underground water. It generally consists of a pipe, with perforations in the bottom through which water can enter.

Sump—In drainage, any low area which does not permit the escape of water by gravity flow.

Supercritical Flow—Flow with a velocity head more than half the hydraulic mean depth of the water.

Surface Runoff—The movement of water on earth's surface, whether flow is over surface of ground or in channels.

Surface Waters—Surface waters are those which have been precipitated on the land from the sky or forced to the surface in springs, and which have then spread over the surface of the ground without being collected into a definite body or channel. They appear as puddles, sheet or overland flow, and rills, and continue to be surface waters until they disappear from the surface by infiltration or evaporation, or until by overland or vagrant flow they reach well–defined watercourses or standing bodies of water like lakes or seas.

Swale—A shallow, gentle depression in the earth's surface. This tends to collect the waters to some extent and is considered in a sense as a drainage course, although waters in a swale are not considered stream waters.

Tapered Inlet—A transition to direct the flow of water into a channel or culvert. A smooth transition to increase hydraulic efficiency of an inlet structure.

Time of Concentration—The time required for storm runoff to flow from the most remote point, in flow time, of a drainage area to the point under consideration. It is usually associated with the design storm.

Trash Rack—A grid or screen across a stream designed to catch floating debris.

Trunk (or Trunk Line)—In a roadway drainage system, the main conduit for transporting the storm waters. This main line is generally quite deep in the ground so that laterals coming from fairly long distances can drain by gravity into the trunk line.

Turbulence—A state of flow wherein the water is agitated by cross–currents and eddies; opposed to a condition of flow that is quiet and laminar.

Turbulent Flow—That type of flow in which any particle may move in any direction with respect to any other particle, and in which the head loss is approximately proportional to the square of the velocity.

Undercut—Erosion of the low part of a steep bank so as to compromise stability of the upper part.

Underflow—The downstream flow of water through the permeable deposits that underlie a stream. (1) Movement of water through a pervious sub–surface stratum, the flow of percolating water; or water under ice, or under a structure. (2) The rate of flow or discharge of subsurface water.

Velocity Head—A term used in hydraulics to represent the kinetic energy of flowing water. This "head" is represented by a column of standing water equivalent in potential energy to the kinetic energy of the moving water calculated as $(V^2/2g)$ where the "V" represents the velocity in feet per second and "g" represents the potential acceleration due to gravity, in feet per second per second.

Watercourse—A definite channel with bed and banks within which water flows, either continuously or in season. A watercourse is continuous in the direction of flow and may extend laterally beyond the definite banks to include overflow channels contiguous to the ordinary channel. The term does not include artificial channels such as canals and drains, except natural channels trained or restrained by the works of man. Neither does it include depressions or swales through which surface or errant waters pass.

Watershed—The area drained by a stream or stream system.

Water Table—The surface of the ground water below which the void spaces are completely saturated.

Waterway—That portion of a watercourse which is actually occupied by water.

Weephole—A hole in a wall, invert, apron, lining or other solid structure to relieve the pressure of ground water.

Weir—A low overflow dam or sill for measuring, diverting, or checking flow.

CITY OF SAN DIEGO, CALIFORNIA DEPARTMENT INSTRUCTION	NUMBER DI. 3930-002	DEPARTMENT ENGINEERING & DEVELOPMENT
SUBJECT CONSTRUCTION INSPECTION OF CAST-IN-PLACE CONCRETE PIPE (C.I.P.C.P.)	PAGE 1 OF 4	EFFECTIVE DATE March 30, 1984
	SUPERSEDES DI- 3930-002 PAGES	DATED December 14, 1981

PURPOSE

To establish quality control and procedures for the inspection and acceptance of the construction of C.I.P.C.P., within the City's jurisdiction.

BACKGROUND

It has been determined that quality control and continuous inspection is imperative for this type of installation. It is therefore necessary to require full conformance to standard specification of C.I.P.C.P. installations.

POLICY

It is the policy of the Engineering and Development Department to assure that the City receives full value in public improvements from any construction project within City's jurisdiction.

DEFINITIONS

1. C.I.P.C.P. - Cast-in-place Concrete Pipe.

2. Inspector - City's Staff Inspector or City Registered Special Inspector of Concrete.

PROCEDURE

The construction of C.I.P.C.P. shall be in strict conformance with Section 306-4, Standard Specifications for Public Works Construction, and the following supplemental and additional provisions and conditions:

1. Construction plans must show normal pipe dimensions plus pipe thickness and the 28-day concrete strength requirement of 4,000 p.s.i. If these conditions are not met on any C.I.P.C.P. plan, the inspector shall require a construction change to meet them before allowing any construction to begin.

2. On all subdivision and permit projects, which include the construction of C.I.P.C.P., a full time, City Registered Special Inspector of Concrete, employed by a City approved Testing Lab and under direct supervision of a Registered Civil Engineer, will be required for continuous inspection of the construction of the pipe. The inspector will be required to certify the construction, including the thickness of the pipe, placement and curing. The City Registered Special Inspector of concrete is subject to City approval on each separate project.

3. All City projects will be inspected by City staff with the same requirements for continuous inspection of the construction of C.I.P.C.P. as in Item 2.

4. On all subdivision and permit projects, which include construction of C.I.P.C.P., a soils engineer must verify by tests to ensure 90% minimum compaction in the pipe support area of the trench, to ensure the integrity of the trench bottom and to approve the stability of the vertical trench walls. The trench walls must stand vertically from bottom of trench to three feet above top of pipe.

PROCEDURE (Continued)

City staff will provide this function on City projects.

5. The contractor shall obtain approval of the Inspector for any equipment proposed to be used for the construction of C.I.P.C.P. and the contractor may be required to furnish evidence of successful operation on prior work. Equipment not suitable to produce the quality for the pipeline will not be permitted to operate on the contract.

6. C.I.P.C.P. shall be constructed only in the presence of the Inspector.

7. The minimum size of C.I.P.C.P. shall be 30-inch I.D. and the maximum size shall be 96-inch I.D.

8. a. Minimum cover, all pipe sizes is (3) three feet.

   b. Minimum cover for 84-inch pipe in a travelled roadway is (4) four feet.

   c. Minimum cover for 96-inch pipe in a travelled roadway is (5) five feet.

9. A minimum of (3) three concrete cylinders shall be molded for each (100) one hundred cubic yards of concrete used for the C.I.C.P.C. and this work shall be done by City's Materials and Testing Laboratory.

10. Slump tests shall be made in accordance with ASTM C143. Slump shall not exceed (2) two inches. City's Materials and Testing Laboratory shall make a slump test for each set of (3) three test cylinders. The Inspector shall make slump tests as deemed necessary to maintain proper consistency of the concrete delivered to the site.

11. The supplier of transit-mixed concrete for use in C.I.P.C.P. shall deliver to the Inspector a certificate with each load of concrete. The certificate shall contain the following information:

    a. A certificate identification number.

    b. The name of the vendor.

    c. The name of the contractor.

    d. The number of cubic yards in the batch.

    e. The amount of water added at the plant.

    f. The job site location.

    g. The batch/mix design number of the weights of the aggragate.

11. (Continued)

h. The amount of water added at the job.

i. The cement type.

j. The brand and amount of admixture used.

k. The time and date of batching.

l. The time of discharging.

m. The revolution count (start and stop)

Two gallons of water per cubic yard of concrete shall be withheld from each load so that additional water can be added at the job site and mixed into the load for a minimum mixing time of three (3) minutes before discharging.

Concrete shall be delivered and deposited in its final position within a period of 90-minutes after the addition of mixing water at the batch plant. Concrete that is too wet or has taken a partial set will be rejected by the Inspector.

The temperature of the fresh concrete shall not be more than 90-degrees F° and not less than 50-degrees F°. The Inspector shall check the loads for temperature.

12. The thickness of C.I.P.C.P. shall be measured after construction at the top, at the bottom, and at points 45-degrees each side of top and bottom. Test holes for measuring thickness shall be at the rate of one set of holes for each 50-feet, or fraction thereof, of pipe placed.

13. The Inspector shall remain on the job site until all initial concrete curing operations have been accomplished.

14. During construction of the C.I.P.C.P., a daily Inspection Report will be required of the Inspector and shall be submitted to the City's Construction Engineer. The Inspection Report shall include:

a. Trench conditions, such as, in cut or fill, % compaction, and stability of bottom and sides.

b. Observed alignment and grade tolerances of pipe.

c. Method of curing of the concrete.

d. Notation that all pipe openings are closed, and kept closed for at least ~~5~~-days.
7 (seven)

e. Repairing of pipe in accordance with specifications.

f. Location, width, and length of any cracking in the pipe.

g. Log of test cylinders taken and truck ticket number samples taken from.

h. Slump tests and truck ticket number from which tests were taken.

i. Location and actual thickness of pipe at test sites for top, bottom, and 45-degrees each side of top and bottom.

j. Location and actual thickness of any concrete cores when required.

k. Location and results of any required load bearing test.

15. Storm water shall not enter the pipe until the 28 day strength is reached and the trench is backfilled.

16. After construction of the C.I.P.C.P. is complete, and Inspection Report by the Inspector shall be submitted to the Construction Engineer of any sampling or testing on the C.I.P.C.P. within one week of any such sampling or testing.

17. The Inspector shall gather all testing data and shall submit a final Inspection Report to the Construction Engineer certifying that the pipe was constructed in conformance with the specifications and has satisfactorily passed all tests.

J.P. Casey
Director

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