SECTION 9
STORM DRAINAGE DESIGN

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SECTION 9
STORM DRAINAGE DESIGN

9-1 COUNTY POLICY AND REQUIREMENTS:

A. The planning, design and construction of drainage facilities and other related appurtenances to be owned, operated and maintained by the County of Sacramento shall comply with these standards herein referred to as the "Standards."

B. In addition to these Storm Drain Design Standards, other specific requirements for the improvement and construction of drainage facilities are set forth in the Sacramento County Water Agency Drainage Ordinance, the County of Sacramento Standard Construction Specifications, the Sacramento City/County Drainage Manual, the Sacramento County Water Agency Code Titles I and II, the Sacramento County Floodplain Management and Interim Floodplain Development Policies, the Guidance Manual for On-Site Storm Water Quality Control Measures, and the Sacramento County Floodplain Management Ordinance.

C. All submitted plans shall be signed by a registered Civil Engineer prior to approval and all work shall be in accordance with these design standards and good engineering practice.

D. The Director shall decide all questions of interpretation of "good engineering practice," guided by the standards and manuals of the discipline in question.

E. All drainage facilities shall be located within the County's right-of-way unless otherwise approved by the Director. Adequate access for maintenance (including removal and replacement) of the system shall be provided.

F. All public roads shall be protected from the design storm event (Figure 2-1).

G. All new structures shall be protected from the 100-year (1%) flood event. Certified pad elevations shall be set at least one and two tenths foot (1.2') above all sources of 100-year flooding.

H. The design of a new storm drain system shall include consideration of the downstream creek or storm drain. The consulting engineer shall show that the existing storm water system can convey the proposed drainage without adverse flooding, erosion or other water quality impacts to upstream, downstream or adjacent facilities or areas; or that such facilities or areas are being improved or protected to the point where the drainage can be conveyed without adverse impacts.

I. Private storm drain systems shall be clearly noted on the plans and maintenance responsibilities recorded in the covenants conditions and restrictions for each parcel.

J. Storm water quality treatment facilities shall be provided for new and redevelopment projects in accordance with these Standards.

9-2 STORMWATER UTILITY: The County maintains public drainage facilities within the Sacramento County Storm Water Utility service area. New development in areas outside the existing Sacramento County Storm Water Utility service area will be required to annex or form a benefit assessment district for storm drain maintenance as required by the Director.

9-3 DEFINITIONS: The following terms, abbreviations or definitions shall apply and the intent and meaning shall be interpreted as stated herein wherever they are encountered in these Standards or in any documents or instruments referenced by these standards unless otherwise approved by the Director.

ASTM	American Society for Testing and Materials.
Base Flood	100-year (1%) flood event pursuant to the County Floodplain Management ordinance or any source of 100-year flooding as determined by Department of Water Resources.
Certified Pad Elevation	As defined in the Grading Section of these Standards
CLOMA/LOMA	Conditional Letter Of Map Amendment / Letter Of Map Amendment.
CLOMR/LOMR	Conditional Letter Of Map Revision / Letter Of Map Revision.
Credit Agreement	An agreement between the SCWA and developer identifying eligible reimbursement costs.
County	The County of Sacramento and incorporated cities who have adopted these Standards.
Design Storm	The design runoff (for pipe design) per acre as indicated on Standard Specifications Drawings 9-2 through 9-5.
Director	Director of Sacramento County Department of Water Resources, or designee.

Drainage Easement	A strip of land dedicated, condemned or reserved for drainage use.
FEMA	Federal Emergency Management Agency.
Interim	A temporary facility- constructed and maintained by the developer.
NFIP	National Flood Insurance Program.
Nolte Method	Pipe design flows (Figures 2-4 to 2-10)
100-Year Storm	A hydrograph created using the Sacramento Method indicating runoff over time for a storm with a one-percent statistical probability of annual recurrence.
Overland Release Path	An alignment that allows the passage of floodwater through a development without damaging structures.
Right-of-Way	A strip of land dedicated, condemned or reserved for public use.
SACCALC	The Sacramento calculator for determining design flows and HEC-1 hydrographs using the Nolte Method and the Sacramento County Hydrology Standards. This is a Windows based software available for free download.
SACPRE	Sacramento preprocessor software for developing runoff flows.
SCDWR	Sacramento County Department of Water Resources.
SCWA	Sacramento County Water Agency, a political subdivision of the State of California
Specifications	County of Sacramento Municipal Services Agency Standard Construction Specifications, latest version.
Standards	These storm drain design standards.
Ten-Year Storm	A hydrograph created using the Sacramento Method indicating runoff over time for a storm with a ten-percent statistical probability of annual recurrence.
Trunk Drainage	Mainline drainage from an area over 30 acres.
Volume 2	Volume 2 of the Sacramento City/County Hydrology Standards.

9-4 FEDERAL FLOOD PROGRAM:

A. The County of Sacramento is a participant in the National Flood Insurance Program and all development in the County shall comply with the regulations of the Federal Emergency Management Agency (FEMA) and the County's Floodplain Management ordinance. Amendments or revisions of FEMA flood maps will be required for all commercial and subdivision development located in a federal flood zone. Petitions for a Conditional Letter of Map Amendment (CLOMA) or Conditional Letter of Map Revision (CLOMR), including any fee required by FEMA, shall be submitted to the Department of Water Resources and approved by FEMA before improvement plan approval.

B. Petitions for a Letter of Map Amendment (LOMA) or Letter of Map Revision (LOMR), including any fee required by FEMA, shall be submitted to the Department of Water Resources and approved by FEMA before building permit issuance.

C. Fill for the removal of land from the FEMA 100-year floodplain of a watercourse, where building pads will be created, must be compacted to 95 percent (95%) of the maximum density obtainable with the standard proctor test method (ASTM Standard D-698) or an equivalent test method acceptable to FEMA.

D. These regulations do not preclude the County from requiring additional standards to protect the public from projected flood runoff.

9-5 DRAINAGE FEES AND CREDITS: All developments in Zones 11A, 11B and 11C and all future sub-zones, of the Sacramento County Water Agency are subject to payment of a drainage fee. The Sacramento County Water Agency administers said fees for the construction of trunk drainage facilities. The Sacramento County Water Agency will reimburse second parties for the construction of trunk drainage facilities, where the County requires such work, according to a predetermined credit schedule. The fee and credit schedule is shown in the Sacramento County Water Agency Code, Titles 1 and 2, and is revised annually. Credit agreements shall be signed by the developer, and notarized, before approval of improvement plans.

9-6 DRAINAGE DIVERSIONS: All drainage must enter and leave the project area at its existing line and grade, unless otherwise approved by the Director.

9-7 DRAINAGE EASEMENTS:

A. Install storm drain facilities in easements only where the topography makes it necessary to install storm systems outside of the road right-of-way. Such easements must be wide enough to accommodate normal construction equipment and shall be easily accessible to such equipment as necessary to construct, operate, maintain and reconstruct the facility. The easement shall be dedicated to the County of Sacramento, SCWA, or to the Incorporated City where applicable. Easements shall not be split along property lines unless otherwise approved by the Director.

B. Where improvements outfall on to an adjacent property (such as day-lighting ditch profiles) drainage easements shall be required. Exceptions may be granted, on a case-by-case basis, by the Director.

C. In the event necessary permanent offsite easements cannot be acquired through negotiation, the County may condemn necessary rights-of-way providing the person, firm, or corporation requesting such condemnation enters into a written agreement to pay all costs and expenses of the condemnation. The agreement shall require a cash deposit that will consist of the estimated cost of condemnation plus 25%. It shall require payment of all costs and expenses of the deposit as specified by the County. Any unspent funds will be returned.

D. Acquisition and maintenance of temporary construction easements outside of the limits of the subdivision shall be the sub-divider's responsibility.

E. Easements for closed conduits shall meet the following width criteria:

1. All easements for closed conduits shall have a minimum width equal to the greater of fifteen feet (15') or the required trench width according to the standard detail for pipe bedding and initial backfill (Drawing 9-1, Specifications) plus two feet (2') of additional width for every foot of depth as measured from the bottom of the pipe to finished grade. Exceptions to the minimum width require approval by the Director.

2. All conduits shall be centered within their easements.

3. Drainage easements for open channels shall have sufficient width to contain the ultimate channel; as well as, fencing and a twenty-foot (20') service road (where required). Additional width shall be provided to allow equipment to safely negotiate the service road for the purposes of construction, operations and maintenance activities. Exceptions may be made on a case-by-case basis depending on the layout of adjoining roadways and recreational paths, with approval from the Director.

4. Easements shall not be split along property lines unless otherwise approved by the Director.

9-8 DRAINAGE CAPACITY / DESIGN:

A. All drainage systems shall be designed to accommodate the ultimate development of the entire upstream watershed. The Sacramento County Municipal Services Agency Design Runoff (Figures 2-4 to 2-10) shall be used in the design of closed conduit drainage systems. All open channel drainage systems shall be designed to carry the 100-year frequency design storm, using the worst case duration, with freeboard greater than one-foot. Freeboard and roughness requirements shall be determined by the Director on a plan-by-plan basis.

B. Design criteria for Class "C" subdivisions shall be determined on an individual basis.

C. The consulting engineer shall design an overland release path and show its incorporation in the grading plan. See Section 9-16 of these Standards.

9-9 DESIGN COMPUTATION: The design computations for drainage shall include the following information that shall be submitted before the plans will be accepted for preliminary review:

A. Topographic map showing existing and proposed ground elevations.
B. Shed map including on-site and off-site watershed boundaries draining onto the site. It shall also include land uses, total and sub-shed areas in acres.
C. Quantity of flow (cfs) to each drainage inlet structure with corresponding area and land uses that generates the quantity.
D. Quantity of flow (cfs) in each pipe.
E. Flow line elevation of each manhole or junction structure.
F. Top of structure rim elevation.
G. Hydraulic grade line
H. Pipe size, material type, class, length and slope.
I. Channel dimensions, flow and water surface profile computations.
J. Overland Release hydraulic computations for street and non-street releases (including fence/wall openings).

9-10 DESIGN STORM: Use of three design methods, Nolte, Sacramento and Sato for runoff calculations in the County of Sacramento are described in Volume 2 of the City/County Drainage Manual, Hydrology Standards. SACCALC is a Windows based software, available for free download, for assistance with these calculations.

Other methods may be used for special situations where above methods are not applicable, upon approval of the Director of the Department of Water Resources.

The required design methods, their appropriate applications and design tools are summarized in Table 9-1.

A. Under 160 acres

1. The runoff used in storm drain pipe design for drainage area 160 acres and smaller shall be computed from the drainage zone chart and the accompanying design runoff graphs shown on Drawings 9-2 through 9-5. The selection of the appropriate chart will be based on the County General Plan.

2. In drainage areas that contain multiple zoning, the runoff shall be computed from the following formula:

$$Q_{Design} = Q_r + (Q_m - Q_r)\, A_m/A_t + (Q_c - Q_r)\, A_c/A_t$$

Where: Q_r = Flow from residential curve using total area of watershed.
Q_m = Flow from multiple family formula using total area of watershed.
Q_c = Flow from commercial curve using total area of watershed.
A_m = Area of multiple family zoning.
A_c = Area of commercial zoning.
A_t = Area in total.

3. Residential runoff curves shall be used for those areas zoned AR-2 to RD-5, inclusive. Multiple family runoff shall be computed for those areas zoned RD-7 to RD-30, inclusive. Commercial runoff curves shall be used for those areas zoned RD-40, industrial and commercial uses.

4. At sag points where approaching gutter profile slope exceeds 2%, the inlets shall be designed to account for upstream bypass flows of at least 0.7 cfs/acre runoff.

B. Over 160 acres

The runoff to be used in drainage channel and channel/bridge design for watersheds exceeding the capacity of a 72" pipe, typically over 160 acres, shall be determined using the Sacramento Method, Volume 2 Hydrology Standards.

Table 9-1 Minimum Design Methods

Application	Hydrology Calculation	Method	Design Tools
Design of: · street drainage · storm sewers · culverts (driveway)	Flow from Charts	Design Runoff	Design Charts (Dwg. 9-2 to 9-5)
Special Design Case*: · street drainage · storm sewers · culverts	Peak Flow and/or 100-year Volume	Sacramento	Design Charts, HEC-1 and SACPRE
Design of overland release, culverts, and bridges**:	Peak Flow and/or 100-year Volume	Sacramento	Design Charts, HEC-1 and SACPRE
Master Plans Design of: · open channels · bridges · detention facilities	Peak Flow and Volume	Sacramento	HEC-1and SACPRE
Water Quality Detention Basins	Volume	Sato	Design Chart

*Special design cases include: streets designated for emergency evacuation (refer also to the Sacramento County Disaster Mitigation Plan), high use public areas, areas with potential loss of life, areas with potential high property damages, areas with limited overland release, and areas lower than surrounding elevations.
**Overland release flows may be determined from Figures 2-11 and 2-18 thru 2-23 of the Volume 2 Hydrology Standards for shed areas less than 160 acres.

9-11 HYDRAULICS:

A. Hydraulic Grade Line

1. Hydraulic grade line calculations for pipe storm drain systems shall begin at the worst case existing ultimate 10-year channel or basin water surface elevation. For the design storm, the hydraulic grade line shall be a minimum one-half foot (0.5') below the elevation of all inlet grates and a minimum one foot (1') below the elevation of manhole covers.

2. The hydraulic grade line shall be shown on the plans wherever the hydraulic grade line is above the soffit of the pipe.

3. A note shall be made on the plans indicating stationing where the hydraulic grade line is below the soffit of the pipe.

4. For open channel systems, the hydraulic grade line shall be shown for the 10-year and 100-year flood events.

5. In adjacent unimproved areas with no current development plans, the future gutter flow line is assumed one and one-half feet (1.5') lower than the natural ground elevation, for purposes of pipe hydraulics calculations.

B. Hydraulic Gradient

In order to analyze the drainage system to determine if design flows can be accommodated without causing flooding at some locations or causing flows to exit the system at locations where this is unacceptable, the consulting engineer shall analyze the hydraulic gradient. The Manning's Formula shall be used to compute capacities of all open and closed conduits other than driveway- and cross-culverts.

C. Friction Losses

Friction losses can be calculated two ways. These methods cannot be interchanged for design of the pipe system. One method shall be used throughout the analysis. The first method uses a conservative Manning's "n" value to account for minor losses.

Method 1 – Friction Losses

The Manning's formula shall be used to compute capacities of all open and closed conduits and all cross culverts which will become a part of the closed conduit system.

The minimum 'n' values to be used in the Manning's formula shall conform to the following:

Precast Concrete Pipe	0.015
High Density Polyethylene Pipe	0.015
Polyvinylchloride Pipe	0.015
Concrete Box Culvert - (within a closed conduit system)	0.016
Ribbed Metal Pipe	0.015
Concrete Cast-In-Place Pipe	0.015
Pavement Surfaces	0.016
Open Channel Fully Lined	0.018
Corrugated Metal Pipe 2-2/3" x ½" Corrugations	0.024
Corrugated Metal Pipe 3" x 1" or 5" x 1" Corrugations	0.028
Open Channel with Lined Bottom, Clean Sides	0.035

Earth Channel with Clean and Uniform Sides	0.060
Earth Channel with natural bottom and sides or higher	0.080

Using Method 1 does not require the analysis of other minor losses. Pipes that are designed with inlet control shall account for losses associated with inlet control.

Method 2 – Minor Losses

Calculation of minor losses more accurately models the system. Energy losses from pipe friction shall be determined by the following:

$S_f = [Qn/1.486\ AR^{2/3}]^2$
Where:
S_f = friction slope, ft/ft
Q = flow rate, ft^3/s
n = Manning's coefficient
A = area, ft^2
R = hydraulic radius

The head loss due to friction is determined by the formula:

$H_f = S_f L$
Where:
H_f = friction head loss, ft
L = length of outflow pipe, ft

The minimum "n" value used in Manning's formula shall conform to the following:

Precast Concrete Pipe	0.012
High Density Polyethylene Pipe	0.012
Polyvinylchloride Pipe	0.012
Concrete Box Culvert - (within a closed conduit system)	0.013
Ribbed Metal Pipe	0.013
Concrete Cast-In-Place Pipe	0.014
Pavement Surfaces	0.016
Open Channel Fully Lined	0.018
Corrugated Metal Pipe 2-2/3" x ½" Corrugations	0.024
Corrugated Metal Pipe 3" x 1" or 5" x 1" Corrugations	0.028
Open Channel with Lined Bottom, Clean Sides	0.035
Earth Channel (Clean, Uniform Sides) or Natural Channel	0.060
Earth Channel with natural bottom and sides or higher	0.080

Velocity Head Losses

Analysis methods must account for all minor losses.

Minor head loss is usually written as:

$H_L = K_c (V^2/2g)$
Where:
H_L = the minor head loss
K_c = the sum of minor loss coefficients
$V^2/2g$ = the velocity head

The loss coefficient and the form of the equation are different depending on the type of loss, whether flow is open channel or pressure flow, and at times, whether flow is sub-critical or supercritical. Full discussion and values of coefficients are given in several references (Chow *Open Channel Hydraulics*; Brater and King *Handbook of Hydraulics*; Rouse *Fluid Mechanics for Hydraulic Engineers*; Hendrickson *Hydraulics of Culverts*). The following are minor head loss formulas for hydraulic structures commonly found in storm drain systems and open channels.

Entrance Losses -- Entrance losses to box culverts and pipes of various materials can be estimated by using the entrance loss coefficients listed in Table 9-2 in conjunction with the minor head loss equation.

Manhole and Junction Losses -- Junctions are locations where two or more pipes join together to form another pipe or channel.

Multiple pipes or channels coming together at a junction should flow together smoothly to avoid high head losses. Items that promote turbulent flow and high losses include a large angle between the two (>60°), a large vertical difference between the two (greater than 6 inches (6") between the two inverts), and absence of a semicircular channel or benching at the bottom of the junction box in the case of pipes. Special problems arise when smaller pipes join a larger one at a junction.

Straight Through Manhole -- In a straight through manhole where there is no change in pipe size, the minor loss shall be calculated by:

$$H_m = 0.05 (V^2/2g)$$

Incoming Opposing Flows -- The head loss at a junction, H_{j1}, for two almost equal and opposing flows meeting head-on with the outlet direction perpendicular to both incoming directions is considered as the total velocity head of outgoing flow.

$$H_{j1} = V^2/2g$$

Changes in Direction of Flow -- When main storm drainpipes or lateral lines meet in a junction, velocity is reduced within the chamber and specific head increases to develop the velocity needed in the outlet pipe. The sharper the bend (approaching 90°) the more severe the energy loss becomes. When the outlet conduit is sized, determine the velocity and compute head loss in the chamber by the minor head loss formula in conjunction with the following:

K	Degree of Turn (In Junction)
0.19	15
0.35	30
0.47	45
0.56	60
0.64	75
0.70	90 and greater

Any degrees of turn greater than 90 degrees requires the approval of the Director. For a graphic solution to other degree of turns, refer to drawing 9-6.

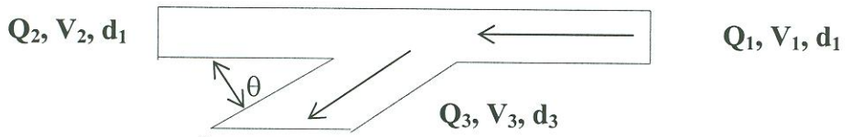
Table 9-2 Entrance Loss Coefficients for Culverts (FHWA 1985) Outlet Control, Full or Partly Full Entrance Head Loss.

$H_e = k_e (V^2/2g)$

Type of *Structure and Design of Entrance*	*Coefficient* k_e
Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square Edge	0.5
Rounded (radius = 1/12D)	0.2
Mitered to conform to fill slope	0.7
*End-section conforming to fill slope	0.5
Beveled edges, 33.78 or 458 bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
*End-section conforming to fill slope	0.5
Beveled edges, 33.78 or 458 bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 308 to 758 to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of ½ barrel dimension, or beveled top edge	0.2
Wingwalls at 108to 258to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

*Note: "End-section conforming to fill slope," made of either metal, concrete or HDPE are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both *inlet* and *outlet* control. Some end sections, incorporating a *closed* taper in their design, have a superior hydraulic performance.

The following equation may be used to determine the loss in head in cases where it may be necessary to split or branch the flow into another drain.



$H_{br} = cV_1^2/2g$

Divergence Angle - θ	$Q_3/Q_1 = 0.3$	$Q_3/Q_1 = 0.5$	$Q_3/Q_1 = 0.7$
90°	c = 0.76	0.74	0.80
60°	c = 0.59	0.54	0.52
45°	c = 0.35	0.32	0.30

Several Entering Flows - The computation of losses in a junction with several entering flows utilizes the principle of conservation of energy, involving both position energy (elevation of water surface) and momentum energy (mass times velocity head). Thus, for a junction with several entering flows, the energy content of the inflows is equal to the energy content of the outflows plus additional energy required by the collision and turbulence of flows passing through the junction. In addition, when two nearly equal flows enter the junction from opposing directions, head loss is considered as the total velocity head of the outgoing flow.

For example, the total junction losses at the sketched intersection is as follows:

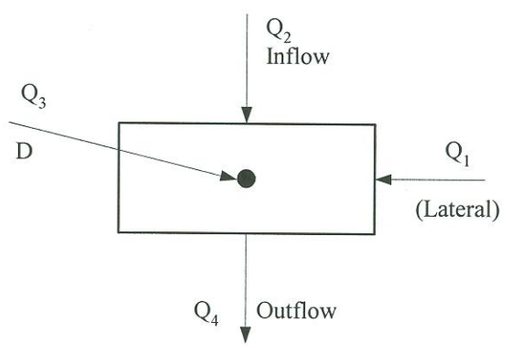


Figure 9-1

$Hj_2 = [(Q_4V_4^2) - (Q_1V_1^2) - (Q_2V_2^2) + (KQ_1V_1^2)] / (2gQ_4)$

Where:
Hj_2 = junction losses, ft
Q = discharges, cfs
V = horizontal velocities ft/s

V_3 = is assumed to be zero
K = bend loss factor

Subscript nomenclature for the equation is as follows:
Q_1 = 90 ° lateral, cfs
Q_2 = straight through inflow, cfs
Q_3 = vertical dropped-in flow, from an inlet, cfs
Q_4 = main outfall = total computed discharge, cfs

V_1, V_2, V_3, V_4 are the horizontal velocities of foregoing flows, respectively in feet per second

Also assume: $H_b = K (V_1^2)/2g$ for change in direction. No velocity head of an incoming line is greater than the velocity head of the outgoing line. Water surface of inflow and outflow pipes in junction to be level.

When losses are computed for any junction condition for the same or a lesser number of inflows, the above equation will be used with zero quantities for those conditions not present. If more directions or quantities are at the junction, additional terms will be inserted with consideration given to the relative magnitudes of flow and the coefficient of velocity head for directions other than straight through.

E. Bend Loss -- Bend losses shall be calculated from the following equations:

$$H_b = K_b (V^2/2g)$$

Where:
$K_b = 0.20 (\Delta/90°)^{0.5}$
Δ = Central angle of bend in degrees.

Bend losses should be included for all closed conduits, those flowing partially full as well as those flowing full.

F. Trash-rack Head Loss -- The head loss through a stationary trash-rack is commonly determined from the following equation:

$$H_{TR} = K_{TR} (V^2_n/2g)$$

$$K_{TR} = 1.45 - 0.45 A_n/A_g - (A_n/A_g)^2$$

Where:
K_{TR} = Trash-rack coefficient
A_n = Net area through bars, in ft^2
A_g = Gross area of trash-rack and supports (water area without trash-rack in place), in ft^2
V_n = Average velocity through the rack openings (Q/A_n), in ft/sec

For design, assume that the rack is clogged, thereby reducing the value of A_n by 50%.

9-12 CLOSED CONDUITS: The specific type of pipe or alternate pipe to be used in the development shall be shown on the profile sheets. If the Consulting Engineer or contractor proposes to use any type of pipe not shown on the approved plans, the plans shall be resubmitted to the County for approval. The minimum inside diameter for pipes shall be no less than twelve inches (12"). No storm drain conduit shall have a diameter less than that of the conduit immediately upstream of it. Use of plastic, polyvinyl chloride or high density polyethylene pipes at channel or detention basin outfall shall not be allowed unless otherwise approved by the Director.

A. Material - Publicly maintained drainage systems shall be constructed of the following materials and installed consistent with the latest edition of County of Sacramento Standard Construction Specifications:

1. Reinforced Concrete Pipe -- Class of pipe shall be based upon depth as detailed in the Standard Drawings. Pipe shall conform to ASTM C76, latest revision. The consultant shall specify on the plans that the assembly of joints shall be in accordance with the pipe manufacturer's recommendations and the requirements of ASTM C443.

2. Concrete Cast-In-Place-Pipe

   a. Where Concrete Cast-In-Place-Pipe is to be used, a soil report is required for the project that addresses placement of Concrete Cast-In-Place-Pipe.
   b. The Consulting Engineer shall provide details on the plans for connection of the concrete cast-in-place-pipe to the different piping materials being used.

3. Polyvinyl Chloride Pipe -- Polyvinyl Chloride (PVC) Pipe may be used conforming to the Construction Specifications.

4. High Density Polyethylene Pipe

   a. Use of High Density Polyethylene Pipe downstream of the last manhole or junction structure to open channels, detention facilities or to a daylight condition is not allowed. This condition does not preclude the use of HDPE for driveway culverts, pursuant to the Specifications.

   b. Unless otherwise authorized by the Director, there shall be no HDPE pipe used for storm drain **inlet laterals in**

roadway intersections, defined as outside curb return to outside curb return.

5. Metal Pipe

a. Metal pipe shall be corrugated steel, corrugated aluminum, corrugated aluminized steel Type II, ribbed steel, ribbed aluminized steel Type II or ribbed aluminum.

b. Metal pipe shall be designed for a minimum maintenance free service life of fifty (50) years in accordance with the methods specified in Section 854.3 and 854.4 of the California Department of Transportation Highway Design Manual (a copy of Figure 854.3B may be found in the back of in these Drainage Standards). To assure that the service life is achieved, alternative metal pipe may require added thickness and/or protective coatings. The Consulting Engineer shall provide certified copies of the laboratory report giving the results of pH and resistivity tests. The report shall also include a map showing the location of each site and depth where samples were taken.

c. Unless otherwise specified by the Director, a minimum of two soil samples shall be taken for the first 1,000 lineal feet of pipe or fraction thereof on a project with a minimum of one additional sample being required for each additional 1,000 lineal feet of pipe or fraction thereof. The samples shall be taken along the approximate alignment and at the approximate depth of the pipe to be installed. Priority in sampling shall be given to trunk facilities.

B. Cover Requirements - At locations where the minimum cover requirements cannot feasibly be obtained, the conduit shall be provided with a concrete cover or other methods of pipe protection as approved by the Director. Cover shall be measured from the top of a rigid Portland cement concrete pavement or the bottom of a flexible asphalt concrete pavement.

1. Minimum Cover -- The minimum cover requirements shall be per Table 9-3.

Table 9-3 Minimum Pipe Cover Requirements

Pipe Material Type and Location	Minimum Cover Requirement
High Density Polyethylene (HDPE) – non traffic areas	Eighteen inches (18") – top of pipe to top of grade
High Density Polyethylene (HDPE) – for dia. to 36" in traffic areas	Eighteen inches (18") – top of pipe to bottom of roadway structural section (AC & AB)
High Density Polyethylene (HDPE) – dia. 42" to 60" in traffic areas	Eighteen inches (18") – top of pipe to bottom of roadway structural section (AC & AB)
Corrugated Metal	Span/8 but not less than twelve inches (12")
Spiral Rib – Steel	Span/3 but not less than twelve inches (12")
Spiral Rib – Aluminum with spans less than or equal to 72"	Span/2 but not less than twelve inches (12")
Spiral Rib – Aluminum with spans greater than 72"	Span/3 but not less than thirty inches (30")
Reinforced Concrete in unpaved areas	1/8 the diameter or rise (the greater of) but not less than twelve inches (12")
Reinforced Concrete under flexible pavements (Class IV and V)	1/8 the diameter or rise (the greater of) but not less than twelve inches (12")
Reinforced Concrete under flexible pavements (Class I, II, and III)	1/8 the diameter or rise (the greater of) but not less than twenty-four inches (24")
Reinforced Concrete under rigid pavements	A nine-inch (9") space between top of pipe and bottom of slab consisting of compacted granular fill shall be maintained at a minimum.
Cast-in-Place-Concrete-Pipes in paved areas	The structural section (AC & AB) plus twenty-four inches (24")
Cast-in-Place-Concrete-Pipes in unpaved areas	Twenty-four inches (24")
Polyvinyl Chloride – C900 and C905	Twelve inches (12")
Polyvinyl Chloride – D2241 and D3034	Twenty-four inches (24")

Note: All depths shown are for a minimum trench width equal to the outside diameter of the pipe plus sixteen inches (16") measured at the top of the pipe.

2. Maximum Cover -- Maximum height of cover shall be per Tables 9-4a and b.

Table 9-4a Maximum Pipe Cover Requirements - Concrete and Plastic Pipe
Measured to bottom of trench in feet

DIA.	RCP Class					Cast In Place	PVC	HDPE
	I	II	III	IV	V			
12	Not Permitted	8	12	30	No Limit	No Limit	14	49
15		10	15	35			14	45
18		11	16	38			14	43
21		12	17	39			14	
24		12	18	39			14	43
27		13	19	39			14	
30		14	19	38			Not Permitted	34
33		14	20	38				
36		13	17	27	69			45
42		14	18	29	62	38		46
48		15	19	30	60	30		41
54		16	20	31	58	26		
60	14	16	21	31	57	24		48
66	15	17	22	32	56	21		
72	15	18	23	33	56	21		

Note: All depths shown are for a minimum trench width equal to the outside diameter of the pipe plus sixteen inches (16") measured at the top of the pipe.

Table 9-4b Maximum Pipe Cover Requirements - Metal Pipes
Measured to bottom of trench in feet

DIA.	CMP ** Thickness – inches					Ribbed Steel Pipe Thickness - inches			Ribbed Aluminum Pipe Thickness inches			
	0.064	0.079	0.109	0.138	0.168	0.064	0.079	0.109	0.060	0.075	0.105	0.135
12	99	No Limits										
15	99											
18	99											
21	99	99										
24	93	99				36	50	67	21	29	49	64
30	74	93	99			30	40	56	17	24	40	51
36	62	78	99	99		26	35	48	14	21	34	44
42	53	66	93	99		21	31	41	13	18	30	37
48	46	58	81	99	99	20	28	38	12	17	26	34
54	47	52	72	93	99	19	26	34		15	25	31
60	43	53	65	84	99		25	32		14	23	28
66	39	48	68	76	93		22	30			21	26
72	35	42	62	70	85		22	28			20	25

Note: 1) All depths shown are for a minimum trench width equal to the outside diameter of the pipe plus sixteen inches (16") measured at the top of the pipe.

2) ** Normal pipe corrugation profile is 2 2/3" x ½". The corrugation of the pipes within the shaded box area shall have profile of 3" x 1" or 5" x 1".

3) When flow velocity exceeds five (5) feet per second, the next thicker gauge shall be used for CMP pipe.

3. Temporary Construction Vehicle Loading

a. A note shall be made on the plans stating the minimum cover requirements during construction for temporary heavy construction vehicle loading, such as scraper or truck haul routes.

b. For flexible pipes, place at least four feet (4') of cover over the top of the pipe.

c. For rigid pipes, place at least three feet (3') of cover over the top of the pipe.

C. Trench Requirements

1. Trenches shall be excavated with full depth and vertical sides whenever possible.

2. The minimum trench width shall not be less than the outside diameter of the pipe barrel plus sixteen inches (16"), measured at the top of the pipe. Where conditions require side sloping of trenches, the minimum vertical trench shall be from the bottom of the trench to one foot (1') over the top of the pipe.

3. In fill areas, or in areas with poor soil conditions where it is anticipated that a good, firm, vertical-walled trench cannot be constructed, the consulting engineer shall design the pipe structural requirements in accordance with good engineering practice. A note shall be placed on the plans directing the contractor to place the proper strength pipe if trench conditions encountered differ from the design trench.

D. Spacing Requirements - When multiple adjacent pipe lines are used, they shall be spaced so that the sides of the pipes shall be no closer than two feet (2'), or for parallel pipes larger than forty-eight inch (48") the spacing shall be no closer than one half (1/2) the nominal diameter. This is to permit adequate compaction of backfill material. Special bedding and backfill considerations shall be taken when depths of parallel pipes vary.

E. Alignment Requirements

1. The location of storm drainage pipes in new streets shall be typically six feet (6') north or west of and parallel to the centerline of the street. In special situations, pipelines may be placed in alternative locations, including under curb and gutter, as approved by the Director.

2. All new storm drain mains shall be placed a minimum of one hundred feet (100') from existing and proposed water wells. Encroachments less than one hundred feet (100') require approval of the Environmental Management Department and the water purveyor prior to plan approval.

3. Avoid unnecessary meandering and angular changes of pipelines. Angular changes, when necessary, shall not exceed 90 degrees unless approved by the Director. No angular changes in direction are allowed for concrete cast-in-place-pipe other than on a radius.

4. Pipeline Radius Criteria: All pipe placed on curves shall meet manufacturer's recommendations for curved alignment. All curves, radii, length of pipe joints, and types of pipe shall be shown on the plans. The minimum radius of curvature for concrete cast-in-place-pipe shall be determined by the formula R = 30D where R = radius of curvature, and D = nominal internal pipe diameter, with R and D expressed in the same units.

5. Pipelines shall be laid straight in both horizontal and vertical planes between manholes unless otherwise approved by the Director.

6. Where storm drain pipelines of different diameter join, the invert elevations shall be adjusted to maintain a uniform energy gradient.

F. Velocity

1. The minimum full flow velocity shall be no less than two (2) feet per second. The maximum velocity, at maximum pipe system capacity, shall be less than the critical velocity ($V_c = (gd)^{.50}$, where critical velocity in ft/sec equals the square root of the product of the gravitational constant 32ft/sec/sec times the depth of flow in feet).

2. When full-flowing pipelines produce supercritical velocity, special provisions shall be taken to prevent erosion, pipe displacement, and manhole lid surcharge.

G. Entrances and Exits

1. Headwalls, flared end section and other structures at entrances shall be designed to increase hydraulic efficiency, prevent erosion adjacent to the conduit and provide a counterweight to prevent flotation. Headwalls or flared end sections should be used at discharge ends of culverts and pipes.

2. Where drainage systems discharge into a channel, standard headwalls should be installed per standard drawings of the latest

edition of County of Sacramento Standard Construction Specifications.

3. The vertical face of the headwall shall be set back a sufficient distance from the channel side slope to accommodate flap-gates (when needed) in a fully opened position without encroachment of the flap past the channel side slope face.

4. Energy dissipation shall be designed at outlets into earthen channels.

H. Water and Soil Tight System

1. All storm drain pipe, manholes, and fitting connections, including drain inlet laterals shall be water and soil tight and tested in conformance with Section 38-10 of the Specifications.

2. A note shall be placed on the improvement plans stating these requirements and that the contractor is responsible for providing equipment and labor for performing tests and making measurements when directed to do so by the County's inspector.

I. Bored and Jacked Pipe -- All casing pipes shall be sealed at both ends in such a manner as to provide water resistant seal.

J. Backfill Seepage -- A concrete filled cutoff barrier shall be required at inlets and outlets where water may penetrate pipe backfill material. This shall be detailed on the improvement plans.

9-13 Manholes & Junction boxes: Requirements for manholes are as follows:

A. Standard pre-cast concrete or saddle type manholes shall be used except where special manholes or junction boxes are required. The design of special manholes and junction boxes must be submitted to the Director for approval. Cast-in-place manholes shall conform to standard drawings of the latest edition of County of Sacramento Standard Construction Specifications.

A. In no case will junction boxes or manholes be allowed which are smaller than twenty-four inches (24") inside dimension.

C. Manholes shall be sized to provide a minimum of nine inches (9") wall spacing between annular cutout edges of pipe openings.

D. Manholes shall be located at junction points, angle points greater than 15 degrees, and changes in pipe size or materials. On curved pipes with radii of 200-feet to 400-feet, manholes shall be placed at the beginning and end of curve and on 300-feet maximum intervals along the curve. On curves

with radii exceeding 400-feet, manholes shall be placed at the beginning and end of curves and on 400 feet maximum intervals along the curve for pipes twenty-four inches (24") and less in diameter and 500-feet maximum intervals along the curve for pipes greater than twenty-four inches (24") in diameter. Manhole spacing on curves with radii less than 200-feet will be determined on an individual basis. Exceptions to these calculated manhole placement shall be allowed if the resulting manholes are within 100 feet of existing or proposed manhole.

E. Spacing of manhole, junction boxes (or inlets of such size as to be accessible for maintenance) shall not exceed 400-feet for drains fifteen inches (15") and smaller in diameter, 500-feet for drains between eighteen inches (18") and thirty-six inches (36") in diameter, and 600-feet for pipes greater than forty-two inches (42") in diameter.

F. All manholes and junction boxes other than inlets shall have standard manhole frames and covers as shown in the Specifications. Manholes will not be allowed in the gutter flow line except as approved by the Director.

G. A reinforced flat top forty-eight inch (48") diameter (no cone) concrete lid as shown in the Construction Specifications shall be required when any pipe would enter the manhole above any portion of the base of a manhole cone. Maximum twenty-four inch (24") diameter riser (chimney) height shall be less than or equal to eighteen inches (18").

H. Use grated manhole covers (Drawing 9-11) to pick up minor drainage in non-traffic areas only if debris clogging is not a concern.

I. Improvement plans shall include a special detail for all manholes at junction points where there is a change in pipe direction for pipe diameters exceeding forty-eight inches (48").

J. Resilient connectors, in conformance with Section 39-2.02 of the Specifications, are required between pre-cast manhole/box and pipe, and between pre-cast drop inlet and pipe. Water stops are required for pipe to cast-in-place manhole/drop inlet connections. Use non-shrinking/non-expansive grout for making connections of pipe and water stop to structure walls.

K. Stations of manholes/boxes shown on project drawings apply at center line of shaft.

L. Manhole/box lids shall be bolted to frame where lids are prone to surcharging when the storm drain system is at maximum capacity. A pressure manhole design may be required by the Director.

M. Storm drain manholes/boxes shall be tested in conformance with Section 39-4.02 of the Specifications.

N. There shall be no sumps in manholes outside of the public right-of-way.

O. Drop inlets shall not be used as junction boxes, unless approved by the Director.

P. Junction boxes shall be constructed of pre-cast or cast in place reinforced concrete with minimum wall thickness of six inches (6"). The consulting engineer shall submit calculations indicating the junction box is designed to withstand H-20 loading

Q. The inside vertical dimension of junction boxes shall be such as to provide a minimum of three-inch (3") clearance on the outside diameter of the largest pipe in each face. Junction boxes shall have a minimum horizontal inside dimension of forty-eight inches (48").

R. All junction boxes shall be rectangular unless otherwise approved by the Director.

S. Pipes adjacent to junctions shall have tight, impermeable joints subject to testing requirements of Section 39-4.02 of the Specifications.

T. Junction boxes larger than ten feet (10') in any dimension shall have two manhole access points.

9-14 Inlets: All inlet design curves in these Standards assume clean inlets. The Consulting Engineer shall assume a 50% clogging factor when determining the number and location of inlets.

A. Additional inlets are required at sump locations per Section 9-10A of these Standards.

B. Type B inlets are typically used for streets with concrete curbs and gutters. See Standard Drawing 9-12, of these Standards, for flow capacity.

C. Always use grated inlets when the longitudinal slope of the street exceeds 4% where due to the high velocities it is difficult to direct the flows into the curb opening.

D. Type F inlets may be used in roadside ditches, swales, unimproved medians, and outside of the road right-of-way. Figure 9-1 provides design capacity for one two-foot wide window of a Type F inlet, clear of debris.

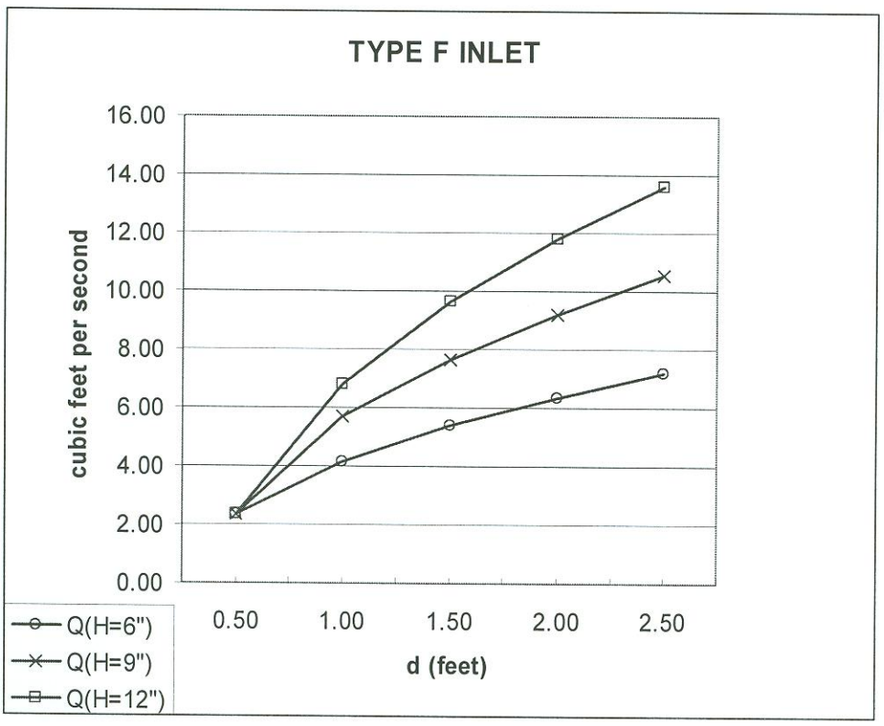
E. Curb opening catch basins with grating(s) and debris skimmers (Drawings 300,301,308,309 in the Specifications) may be used in locations where additional inlet capacity, beyond a single Type B inlet, is needed, or as where directed by the Director. The inlet width may vary from seven feet

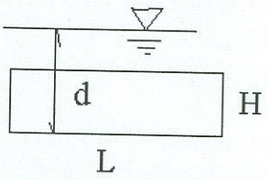
(7') to twenty-eight feet (28'). The H dimension is the gutter depression depth and shall be a standard two inches (2"). When more than one grate is required, use Drawing 9-16 for support assembly. Assure that the lateral is sized to serve the increased inlet capacity. Flow capacity for the 300 and 301 inlets is calculated using the methods found in the Federal Highway Administration (FHWA) Urban Drainage Design Manual Hydraulic Engineering Circular No. 22.

F. Inlets in Class "A" and "B" streets shall be placed at lot lines in residential subdivisions and at the curb return of intersections. Inlets shall be placed so that the length of flow does not exceed 500 feet, unless otherwise approved by the Director. Inlets at curb returns shall be constructed so that they are not in conflict with the Americans with Disabilities Act requirements for ramps.

G. All new and replacement storm drain inlets on public rights-of-way, private property and drainage easements shall include a "No Dumping- Drains to Creek" concrete stamp or other approved epoxy affixed permanent marker on the curb adjacent to the drainage inlet in accordance with Drawing 9-35, of these Standards.

H. Type F inlets shall be designed based on the following chart and Figure 9-1. The chart assumes clean openings, so some clogging shall be accounted for by adding a grated lid or increasing the window opening(s).





$$Q_{weir} = 3.33 L d^{1.5} \qquad (d<H)$$

$$Q_{weir} = 0.60(2gd)^{0.50} \qquad (d>H)$$

FIGURE 9-1

9-15 OVERLAND RELEASE: Piped storm drain systems are not designed to convey peak flow from infrequent high intensity storm events. When the pipes and inlets are clogged or overwhelmed, surface runoff will pond in low areas and flow overland along designed overland release routes. The improvement plans shall include overland release routing and the consulting engineer shall provide back up calculations. Risk of flood damage shall be reduced by insuring that the 100-year storm runoff ponds and flows through the proposed development with appropriate freeboard protecting existing and proposed structures, pursuant to Section 9-1 of these Standards. Unless otherwise authorized by the Director, 100-year depth in streets shall be limited to no more than eight inches over back of walk.

A. For the purposes of determining overland release flows, the 100-year runoff may be obtained from Figures 2-18 through 2-23 of Volume 2. Certain collector streets will require dry lanes in the 100-year storm, as determined by the Sacramento County Department of Transportation.

For purposes of design, assume the storm drain pipes are flowing full capacity into 100-year backwater.

B. Overland flow passing over street vertical curves shall not exceed a depth of six inches (6") over the back of walk.

D. Where overland release leaves the right-of-way, concrete improvements shall include a stamp in concrete or epoxy affixed message *"EMERGENCY DRAINAGE RELEASE PATH – DO NOT BLOCK"*.

C. The overland release, outside of the street right-of-way, shall be a concrete mow strip, gutter or other permanent flow line. Grouted cobbles are not a suitable construction material for overland release paths.

D. Streets, parking lots, playgrounds, pedestrian areas, pedestrian walkways, utility easements and other open space areas may be considered compatible uses for the overland release routing.

Equation 1

The US Department of Transportation recommends, in Hydraulic Engineering Circular Number 22, the use of the following equation when the depth at the gutter is less than one fortieth (1/40) the width of flow. It is a variation of the Manning's formula because the hydraulic radius does not adequately describe the gutter cross section. The compound gutter and rolled curb are considered negligible and are ignored.

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

Where:

Q = flow rate (ft^3/sec)

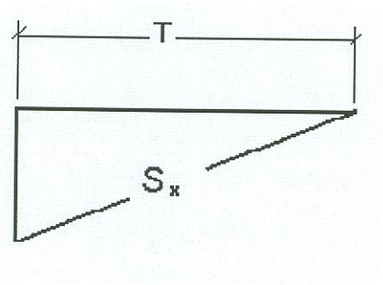
K_C = 0.56 (English units)

n = Manning's coefficient (use 0.016 for paved street)

T = width of flow or spread (ft)

S_X = cross slope, typically 0.020 (ft/ft)

S_L = longitudinal slope (ft/ft)



Depth at gutter = TSx

9-16 **PIPE STUBS:** The criteria for pipe stubs shall be as follows:

A. A headwall or flared end and trash rack shall be required where the upstream pipe ends at a park or open field, and the site shall be graded toward the inlet.

B. Temporary pipe stubs shall be as deep as possible to provide for future extension, and raised to grade using a type F, type H, or type I inlet or other appropriate catchments. Type H Inlets shall be sized two (2) sizes larger than the connecting pipe or pipe stub.

9-17 HEADWALLS AND RACKS: The requirements for headwalls, wing-walls, end walls, trash racks, access control racks and railings are as follows:

A. All headwalls, wing-walls and end walls shall be considered individually and in general shall be designed in accordance with the Standards and Specifications of the California Department of Transportation.

B. Erosion control is of high importance where storm drain pipes discharge to natural channels. Energy dissipating structures shall be detailed on the improvement plans.

C. Trash racks will be provided on all open end inlets to pipes to prevent clogging. Trash racks shall be designed such that the ratio of trash rack open area to drain opening is at a minimum four to one (4:1).

D. Access control racks shall be required on pipes twenty-four inches (24") or larger, unless otherwise approved by the Director, and shall be designed such that the ratio of access control rack open area to drain opening is at a minimum four to one (4:1). They shall hinge at the top to allow them to open should debris and hydraulic forces provide pressure.

E. Both trash racks and access control racks on pipe outfalls 37 to 66-inch diameter shall be constructed as two separate hinged sections. For pipe outfalls greater than 66-inch diameter, the racks shall be split into three sections.

F. Public safety may require metal beam guardrail or wrought iron fencing at culverts, headwalls, box culverts, and on steep side slopes, unless otherwise approved by the Director. Installation shall be in accordance with the Specifications.

G. Slopes around headwalls, wingwalls, end walls, trash racks and other concrete structures shall be protected from erosion in accordance with Section 11 – Erosion and Sediment Control.

9-18 DRAINAGE PUMPS: Drainage pumping plants shall be designed in accordance with the latest edition of the Hydraulic Institute Standards and as specified by the Director.

9-19 DETENTION SYSTEMS: Flood control detention system designs require the approval of the Director.

9-20 OPEN CHANNELS: Open channels are to be designed pursuant to the drainage study provided by the consulting engineer and to the satisfaction of the Director. Each project has unique hydraulic constraints and storm water quality requirements; therefore, the following should be deemed guidelines.

A. Open channels are required whenever one or more of the following applies:

1. The design flow rate exceeds the capacity of a seventy-two inch (72") pipe.

2. The outfall is at an elevation such that minimum cover cannot be obtained over the pipe.

3. County, State or Federal Government policies require that the channel remain natural.

B. Open channels shall consist of vegetated earth channels. Concrete lining may only be allowed with approval by the Director.

C. Criteria for open channels shall be as follows:

1. Open channel design shall include a water surface profile analysis using the Army Corps of Engineers HEC-RAS computer program, UNET program or other hydraulic program, approved by the Director.

2. ii. Open channels shall be designed to convey the 100-year flood event with a minimum one foot (1') of freeboard. Greater freeboard may be required depending on the sensitivity of the model, obstructions, and surrounding property.

3. 3. There is no minimum velocity for open channels. The maximum velocity shall be as follows:

A. Earth channels, six (6) ft/s
B. Lined channels, ten (10) ft/s
C. Bottom-lined channels, eight (8) ft/s

4. Super elevating the outside bank on bends may be required to maintain specified freeboard.

5. The centerline curve radius of an open channel shall be equal to the greater of twice the bottom width or thirty-five feet (35').

6. Earth channels and the side slopes of bottom lined channels shall be vegetated with native grasses or other permanent vegetative cover. All vegetation shall be approved by the Director. Vegetation shall

be established prior to the wet season (October 1). Hydro-seeding conducted during the wet season (October 1 – April 30) shall include additional appropriate soil stabilization materials to prevent erosion, in accordance with Section 11 of the Improvement Standards. A note shall be added to improvement plans stating "Vegetated open channels shall not be accepted by the County until 70% of the vegetation is established."

7. Channels, deeper than three feet, shall be constructed to a typical cross section with 3 horizontal to 1 vertical (3:1) or flatter side slopes. Exceptions require approval of the Director.

8. All lined channels shall have a minimum bottom width of six feet (6') and shall have access ramps for maintenance equipment, see Drawing 9-24 and 9-25 of the Specifications.

9. Access ramps are required to allow access for emergency and periodic maintenance. The minimum width shall be ten feet (10') at a maximum slope of ten percent (10%). Ramps may be constructed of concrete (colored to blend with the surroundings) or other durable material. Detail the ramps on the improvement plans, attention to both aesthetics and serviceability is required.

10. When a paved public street or bicycle path are not adjacent to the top of bank, a twenty foot (20') service road shall be provided having a sixteen foot (16') improved surface and two foot (2') shoulders on each side. Curve radii shall be a minimum of forty-two feet (42'). Turnouts shall be placed as dictated by horizontal sight distance, or no greater than one-thousand feet (1000'). The service road shall be constructed of aggregate base rock unless otherwise determined by the Director.

11. Erosion protection shall be placed at the top of the cut or bank where deemed necessary to prevent erosion (see Standard Drawings in the Specifications).

12. For all channels, either improved or natural, the following items shall be shown on improvement plans in addition to information heretofore required:

    A. Typical sections and cross-sections.

    B. Profile of the existing channel and top of bank profile including enough of the existing channel each side of the development to establish an average profile grade through the development.

C. Ten and one-hundred year water surface elevations.

D. Road crossings with road profile indicating overland release.

9-21 OUTFALL DESIGN: Requirements for outfall design are as follows:

A. All permanent and temporary drainage outfalls shall be shown in both plan and profile on the improvement plans for a distance until a definite "daylight" condition is established.

B. The profiles shall include ditch flow-line and left and right top of bank elevations.

C. When improvements have more than one unit or phase, the drainage outfall shall be shown as extending to the property boundary and beyond, if required, although it may not be constructed with the current unit development.

9-22 FENCING REQUIREMENTS: The requirements for fencing shall be as follows, variations are subject to the approval of the Director:

A. Improved channels and detention basins exceeding three feet (3') in depth and with side slopes steeper than 3:1 shall be fenced with six foot (6') wrought iron fencing or black vinyl coated chain link, located six inches (6") inside of right of way or easement. Green vinyl coated chain link shall be used where basins or channels are adjacent to landscape area. On culverts with headwalls or parapets, wrought iron fencing shall be used and shall wrap around along the channel for a distance of at least 150 feet.

B. Walk gates shall be four feet (4') wide

C. Drive gates shall be two eight-foot gates with a total opening of sixteen feet (16') wide. They shall be set a minimum of twenty feet (20') back from the edge of pavement to allow for a safe parking area off of the traveled way while opening and closing the gates. Gates must swing away from road right-of-way. A concrete driveway shall be provided at vertical curb locations. Asphalt concrete paving shall be provided between the traveled way and drive gate. Design the paving per Section 4, Streets of these Standards.

D. The gate access shall be marked no parking.

9-23 CROSS CULVERT CRITERIA: The following standards apply when the 100-year water surface elevation is not freely spanned by a bridge:

A. Cross culverts for minor sheds shall be designed in accordance with procedures outlined in the U.S. Department of Transportation "Hydraulic

Design of Highway Culverts," Hydraulic Design Series No. 5, September, 1985. For shed areas greater than 160 acres, use HEC-RAS or other software approved by the Director.

B. Cross culverts shall be checked against 100-year runoff to assure that no adverse effect will occur upstream or downstream.

C. Cross culvert profile will be determined by an examination of the overall profile of the channel for a minimum distance of 500 feet on each side of the installation, assuring that freeboard requirements are met.

D. Where no overland release is possible, cross culverts shall be oversized by at least twenty five percent (25 %).

E. Where roads are not to be overtopped, for public safety or physical constraints, the box culvert soffit shall have one-foot (1') of freeboard over the 100-year water surface elevation.

F. Culverts shall include a headwall or flared end section at both the upstream and downstream end.

9-24 DRAINAGE ALONG CLASS "C" Streets: The criteria for design of drainage along Class "C" streets are as follows, unless otherwise approved by the Director:

A. Roadside ditches shall be sized to convey design runoff per Drawings 9-2 through 9-5 of these Standards. Analysis of 100-year flows shall be considered per Section 9-1. Analysis shall include culverts. The 10-year and 100-year hydraulic grade lines shall be shown on the profile.

B. If the roadside ditch extends beyond the dedicated right-of-way, the right-of way shall be extended or a drainage easement shall be dedicated over the portion of the ditch outside the right-of-way.

C. To prevent end of pipe distortion Driveway culverts for subdivision improvement plans shall include a flared end section at the upstream and downstream ends or place a six inch (6") thick concrete collar and headwall.

9-25 STORMDRAIN SYSTEMS IN PRIVATE STREETS:

A. Private storm drain systems that connect to County maintained drainage facilities shall have a manhole immediately upstream of the connection within the public easement or right-of-way.

B. It shall be made clear on the plans which facilities are private.

C. Private storm drain pipes serving more than two parcels shall be built according to the Improvement Standards.

9-26 STORMWATER QUALITY: Water quality measures shall be incorporated into new and redevelopment projects in order to reduce the amount of pollution discharged to the storm drain system and local waterways from urban areas. This requirement is necessary to ensure compliance with the County's National Pollutant Discharge Elimination System (NPDES) Municipal Storm Water Permit.

Water quality may be treated through regional facilities, on-site measures, or a combination. Typically, water quality facilities shall be located off-line to receive the first flush of runoff from a storm event, with provisions for high flow bypass. Some facilities, such as detention basins and channels, may be designed as on-line, dual-purpose facilities (flood control and water quality), subject to the approval of the Director. In no cases will water quality treatment be allowed within natural creeks, tributaries and rivers considered by the State to be "Waters of the State," unless approval of the design is granted in advance by the Central Valley Regional Water Quality Control Board.

Storm Water Quality
Control Measure Decision Matrix
TABLE 9-5

<table>
<tr><td>LAND USE</td><td colspan="5">POST-CONSTRUCTION CONTROL MEASURES</td></tr>
<tr><td></td><td>WITH REGIONAL CONTROLS [6]</td><td colspan="4">WITHOUT REGIONAL CONTROLS[6]</td></tr>
<tr><td></td><td></td><td><1 acre [4]</td><td>1-5 acres [4]</td><td>5-100 acres [4]</td><td>>100 acres [4]</td></tr>
<tr><td>Residential - Single Family [1]</td><td>Source Control Measures</td><td colspan="3">Source Control Measures [8]</td><td>Regional Control</td></tr>
<tr><td>Residential - Multi-family [1]</td><td>Source Control Measures</td><td>Source Control Measures</td><td colspan="3">Source Control and Treatment Control Measures</td></tr>
<tr><td>Commercial [2][3][5]</td><td>Source Control Measures [7]</td><td>Source Control Measures</td><td colspan="3">Source Control and Treatment Control Measures</td></tr>
<tr><td>Industrial [3][5]</td><td>Source Control Measures and General Permit [7]</td><td colspan="4">Source Control and Treatment Control Measures and General Permit</td></tr>
</table>

(1) Based on gross acres.
(2) Includes churches.
(3) Includes school sites.
(4) May be subject to State of California NPDES General Permit for Construction Activities during construction.
(5) May be subject to State of California NPDES General Permit for Industrial Activities.
(6) Regional control measures are watershed or drainage basin-wide controls.
(7) Director may require additional treatment control measures.

(8) Director may require additional treatment control measures or regional control measures.

Regional Water Quality Facilities -- Regional Water Quality Detention Basins and Water Quality Channels shall be designed in accordance with the City of Sacramento Department of Utilities Procedures Manual, Section 11.6 (Regional Water Quality Control). These procedures incorporate the Sato Method from Volume 2 of the City/County Drainage Manual (Hydrology Standards) for sizing of detention basins. The final design shall be subject to the approval of the Director. The Consulting Engineer is encouraged to present conceptual design approaches to the County as soon as possible in the earliest possible planning stages of the project.

On-Site Water Quality Control Measures -- Table 9-5 indicates projects that are required to include on-site treatment and/or source control water quality control measures. Treatment measures are intended to remove pollutants from runoff, whereas source control measures are structural and non-structural measures designed to stop pollution at its source, before the pollutants can enter site runoff. Guidance for the selection, design, installation and maintenance of on-site water quality control measures is provided in "Guidance Manual for On Site Storm water Quality Control Measures", prepared jointly by the City and County of Sacramento. Other devices and methods not contained in the guidance manual may be presented to the County for consideration, but additional time should be allowed in the design process. Due to the rapidly evolving nature of water quality treatment, the Consulting Engineer is encouraged to present conceptual design approaches to the County in the earliest possible planning stages of the project.

Maintenance of Storm Water Quality Facilities -- Routine inspection and maintenance is required for all storm water quality facilities in order to continue to ensure optimum pollutant removal performance. A note shall be included on improvement plans where regional storm water facilities are specified stating "A written maintenance plan shall be required for all regional storm water quality facilities before the County will accept the facilities. The maintenance plan shall include procedures and a schedule for vegetation establishment and maintenance, as applicable. The developer shall be responsible for vegetation maintenance on regional storm water quality facilities until vegetation is established to the approval of the Director." If on-site facilities are specified, a note shall be included on the improvement plans stating "A maintenance agreement is required for all on-site storm water quality facilities. The project will not be accepted by the County until the maintenance agreement has been signed by the Developer/Property Owner."

9-27 EASEMENTS: Use the following sample language in preparing drainage easement documents for notary witnessed signature and recordation:

A. EASEMENT FOR DRAINAGE CANAL OR DITCH
Undersigned do(es) hereby grant to the COUNTY OF SACRAMENTO, a political subdivision of the State of California, for the purpose of digging, constructing, reconstructing, repairing and forever maintaining thereon, a drainage canal or ditch of such dimensions as Grantee shall deem necessary

for drainage purposes, together with the spoil banks and appurtenant structures thereof, a drainage easement over that certain real property in the County of Sacramento, State of California, bounded and described as follows, to-wit: [refer to attached legal description exhibit]. Together with the perpetual right and privilege of flowing water in, through, and along said canal or ditch in such amounts and at such times as necessary, and the perpetual right of ingress to and egress from said property, for the purpose of exercising and performing all of the rights and privileges herein granted.

B. EASEMENT FOR SECONDARY FLOWAGE

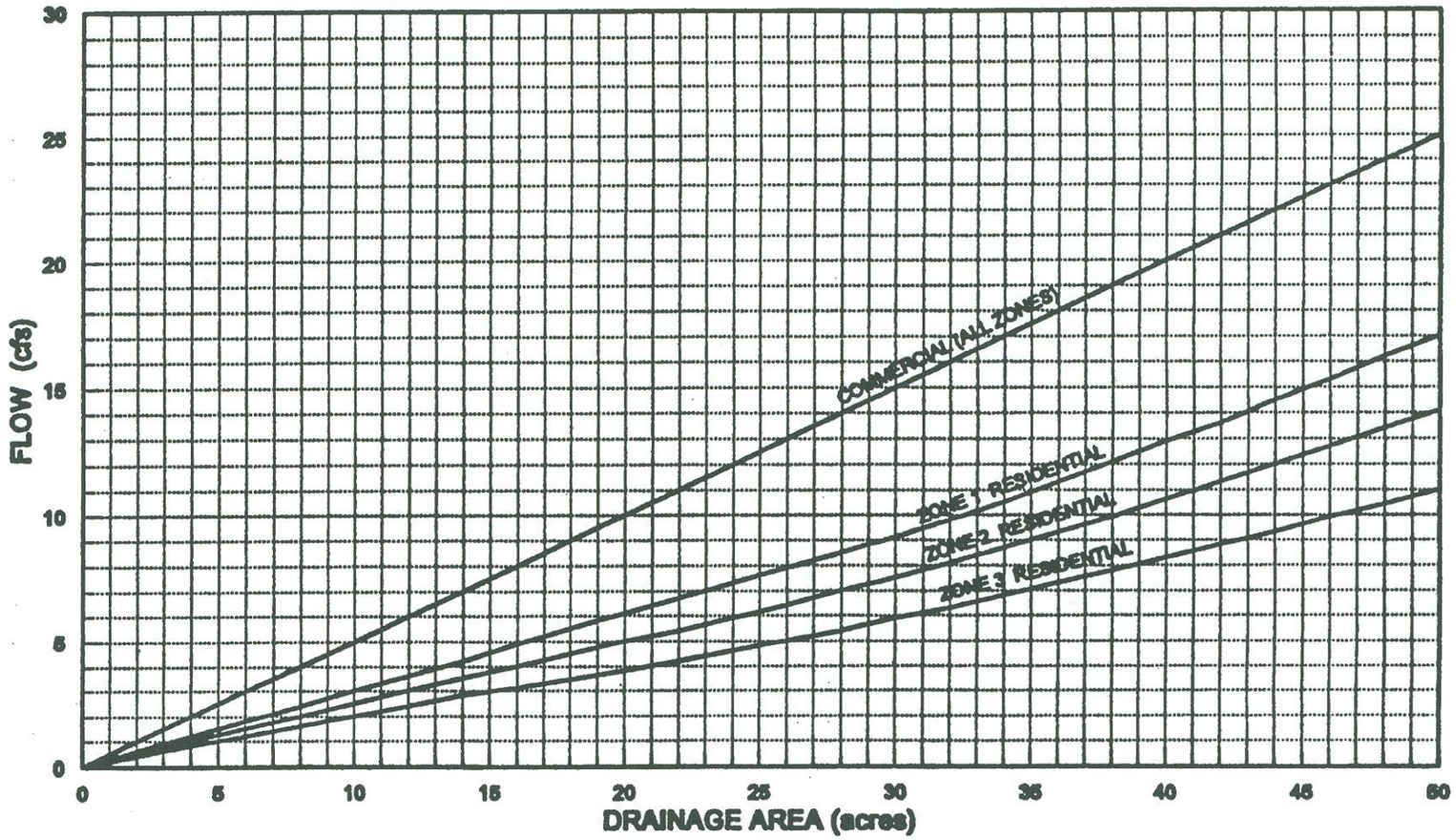
Undersigned do(es) hereby consent to the recording of this indenture to the County of Sacramento for the purpose of designating the hereafter described property as subject to flooding, to-wit: [refer to attached legal description exhibit]. Together with the perpetual right and privilege to flow water in, through and over the subject land during periods of storm water runoff. This is not to exclude the owner from any and all inherent uses or privileges of the subject property.

C. EASEMENT FOR DRAINAGE PIPELINE

Undersigned do(es) hereby grant to the COUNTY OF SACRAMENTO, a political subdivision of the State of California, for the purpose of digging, constructing, reconstructing, repairing and forever maintaining thereon, a drainage pipeline of such dimensions as Grantee shall deem necessary for drainage purposes, a drainage easement over that certain real property in the County of Sacramento, State of California, bounded and described as follows, to-wit: [refer to attached legal description exhibit]. Together with the perpetual right and privilege of flowing water in, through, and along said pipeline in such amounts and at such times as necessary, and the perpetual right of ingress to and egress from said property, for the purpose of exercising and performing all of the rights and privileges herein granted.

D. EASEMENT FOR FLOODPLAIN

Undersigned do(es) hereby consent to the recording of this indenture to the County of Sacramento for the purpose of designating the hereafter described property as subject to flooding, to-wit: [refer to attached legal description exhibit]. Together with the perpetual right and privilege to flow water in, through and over the subject land during periods of flooding. This is not to exclude the owner from any and all inherent uses or privileges of the subject property, subject to applicable County codes, policies, and ordinances.



NOTE: Design runoff for multiple family development shall be based on the following formula:

$Qm = Qr + (Qc - Qr)(I-50)/40$

Where:

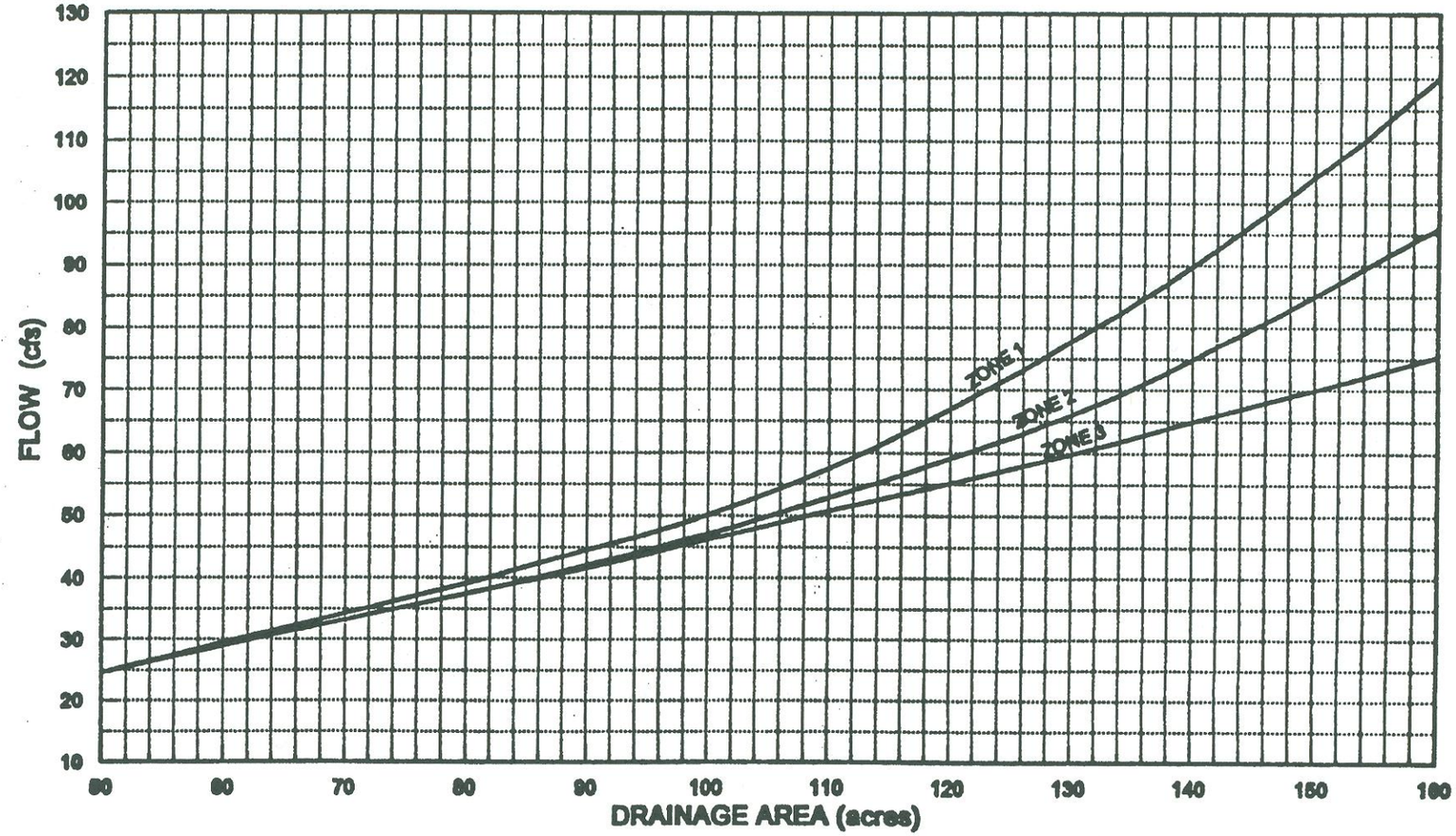
RD- 7	I = 60
RD-10	I = 70
RD-20	I = 80
RD-30	I = 90

Source: County of Sacramento Master Drainage Plan, Part 1, County-wide Hydrology, Nolte and Assoc.

Design Runoff Nolte Method Drainage Areas, <50 Acres

Date December 1996

Figure 2-5

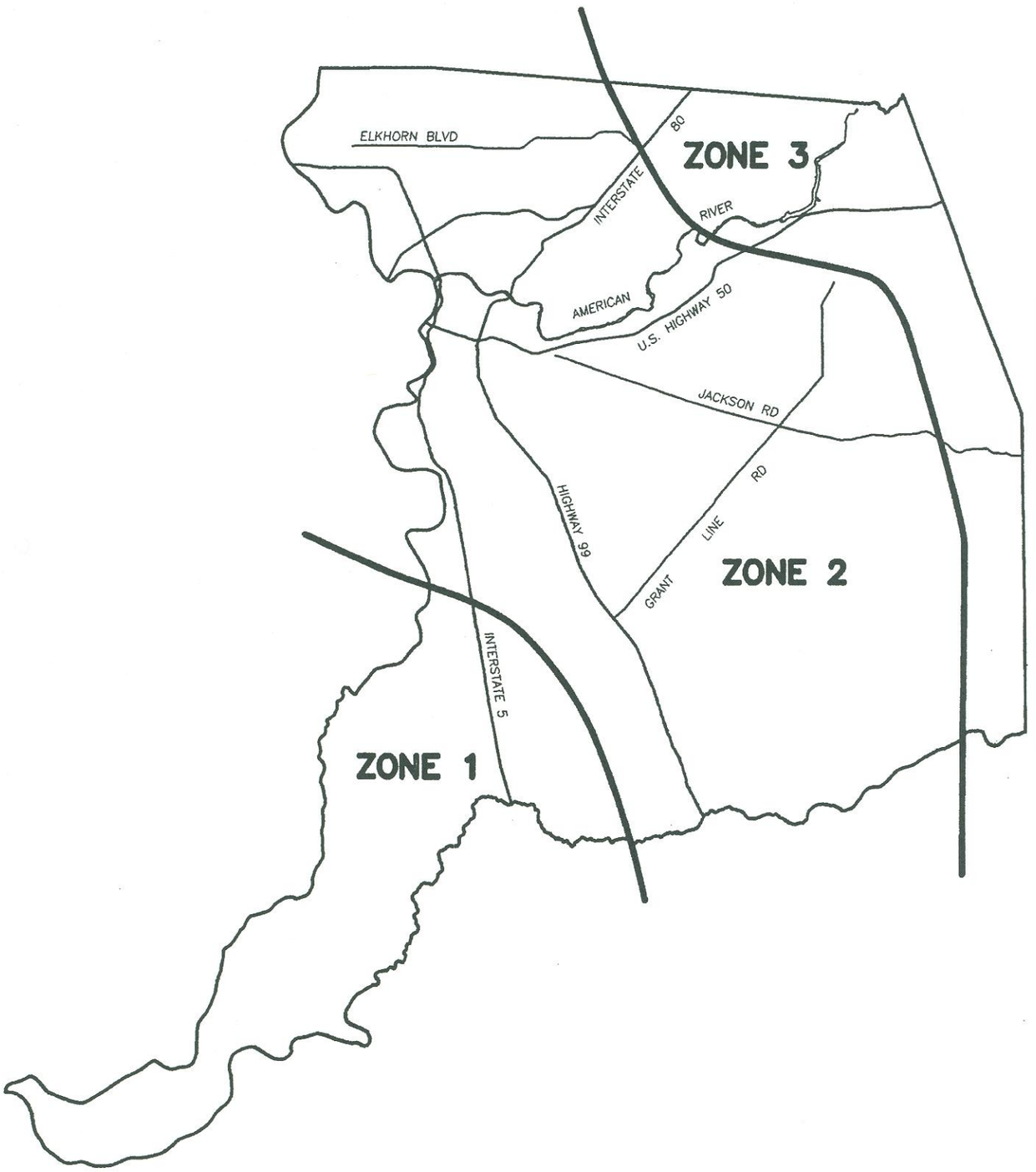


Source: County of Sacramento Master Drainage Plan, Part 1, County-wide Hydrology, Nolte and Assoc.

Design Runoff Nolte Method
Commercial Areas
50–160 Acres

Date: December 1996

Figure 2–7

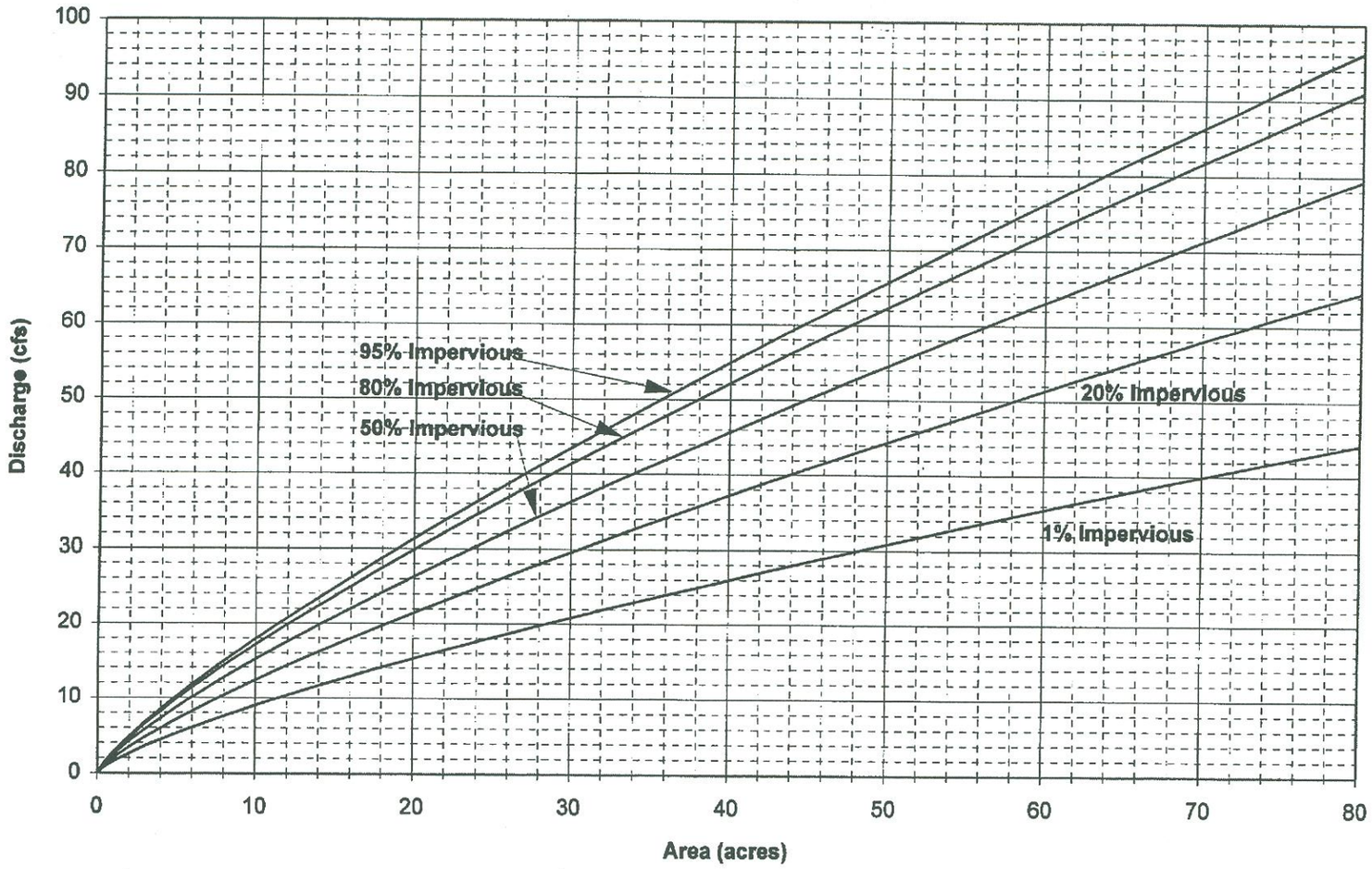


Note : See foldout map in the back of Hydrology Standards for larger scale map of Rainfall Zones.

Sacramento City and County
Rainfall Zones
Sacramento Method

Date **December 1996**

Figure **2–11**

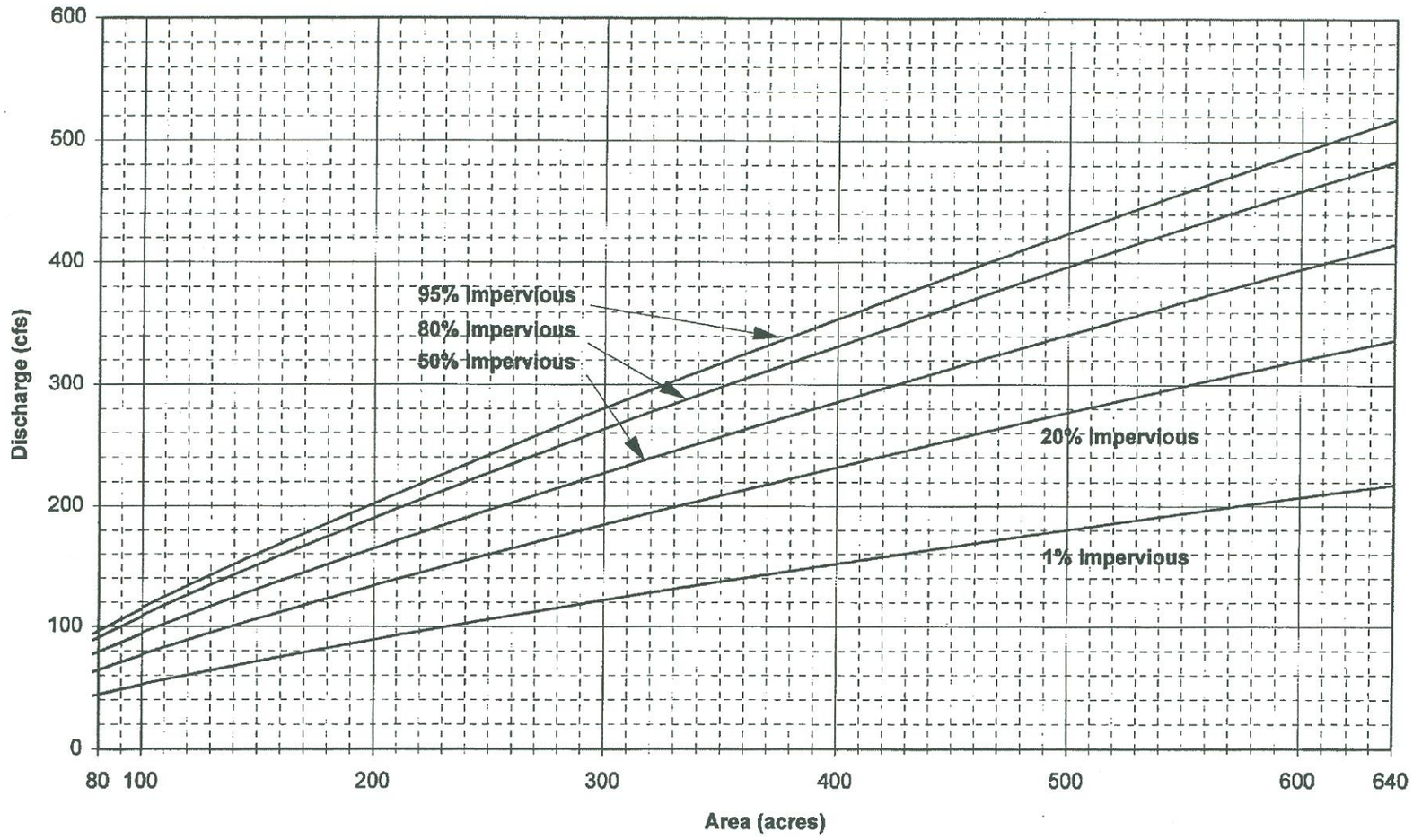


Note: Refer to accompanying disk for assumptions made in deriving this figure.

100–Year Peak Flow Sacramento Method Rainfall Zone 1, <80 Acres

Date: December 1996

Figure: 2–18

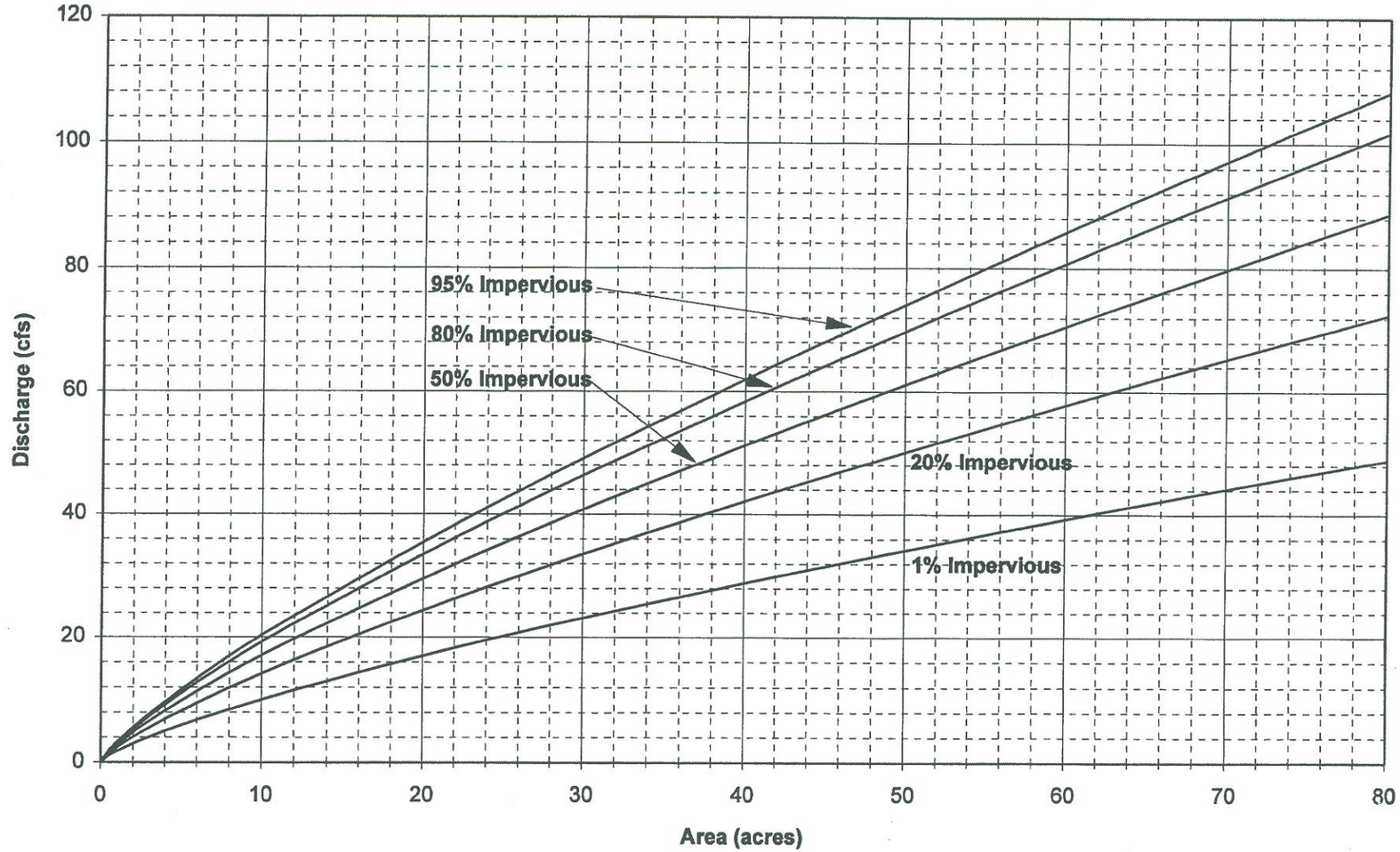


Note: Refer to accompanying disk for assumptions made in deriving this figure.

100–Year Peak Flow
Sacramento Method
Rainfall Zone 1, 80–640 Acres

Date: December 1996

Figure 2–19

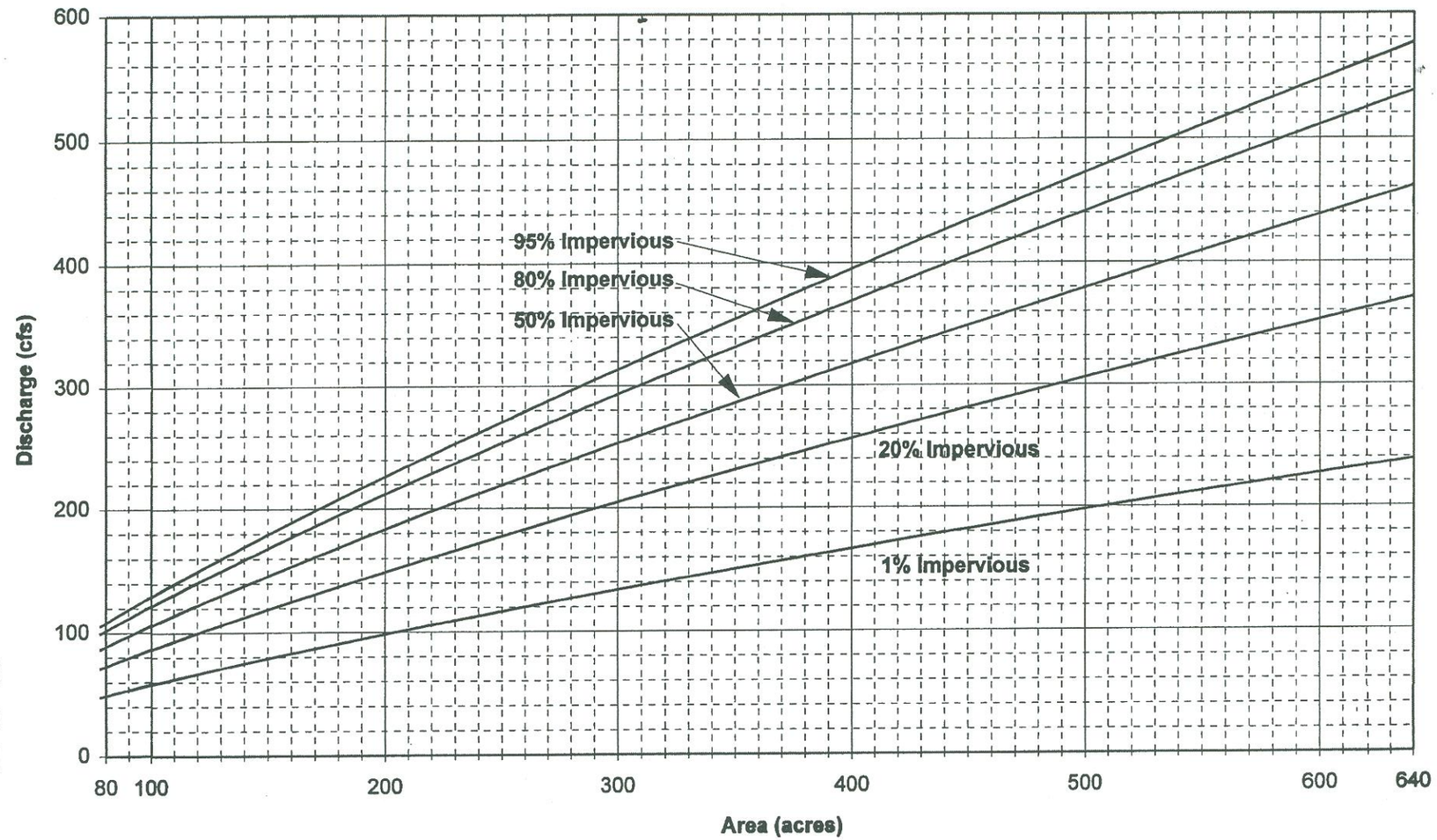


Note: Refer to accompanying disk for assumptions made in deriving this figure.

100–Year Peak Flow
Sacramento Method
Rainfall Zone 2, <80 Acres

Date: December 1996

Figure 2–20

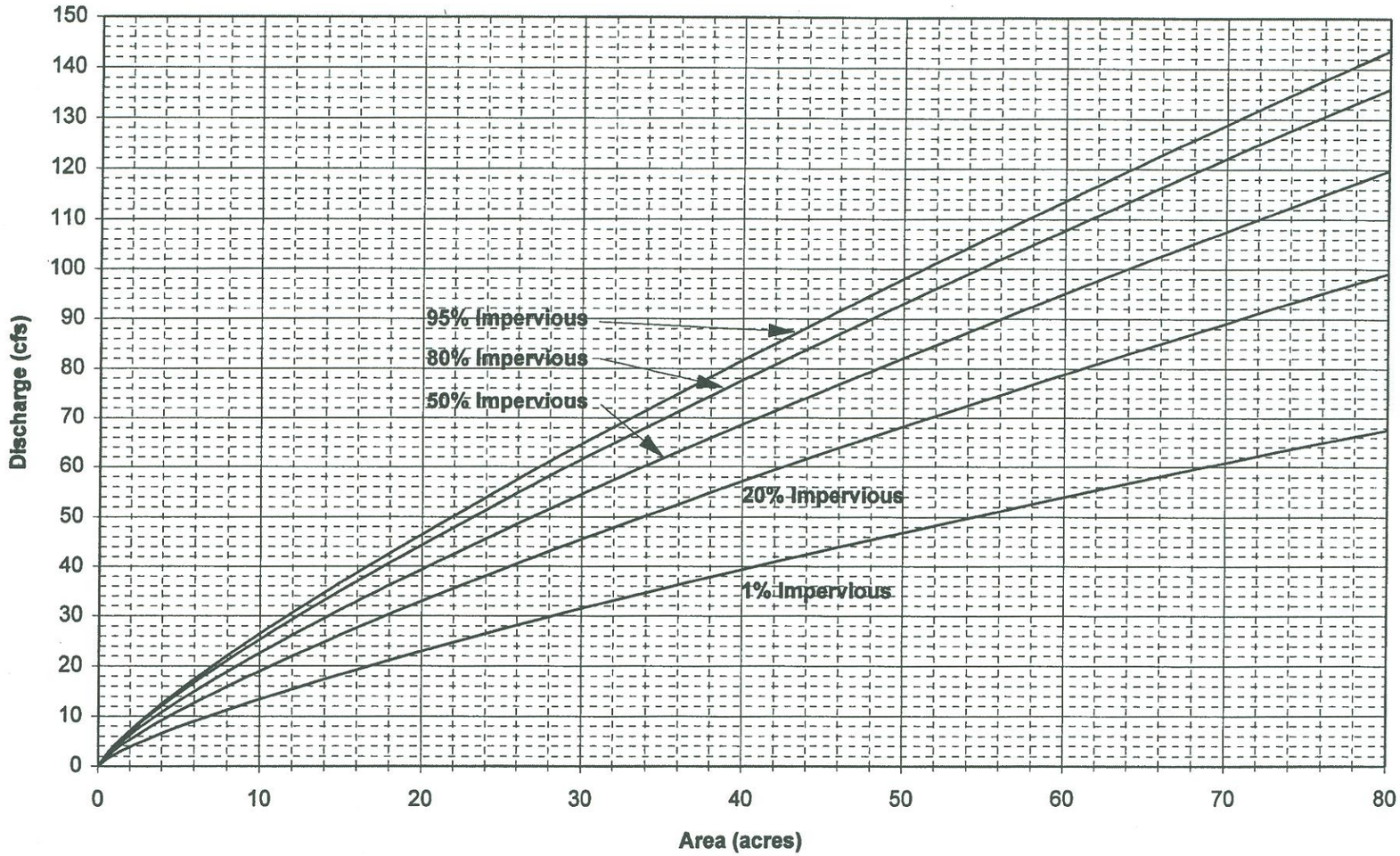


Note: Refer to accompanying disk for assumptions made in deriving this figure.

100–Year Peak Flow
Sacramento Method
Rainfall Zone 2, 80–640 Acres

Date: December 1996

Figure 2–21

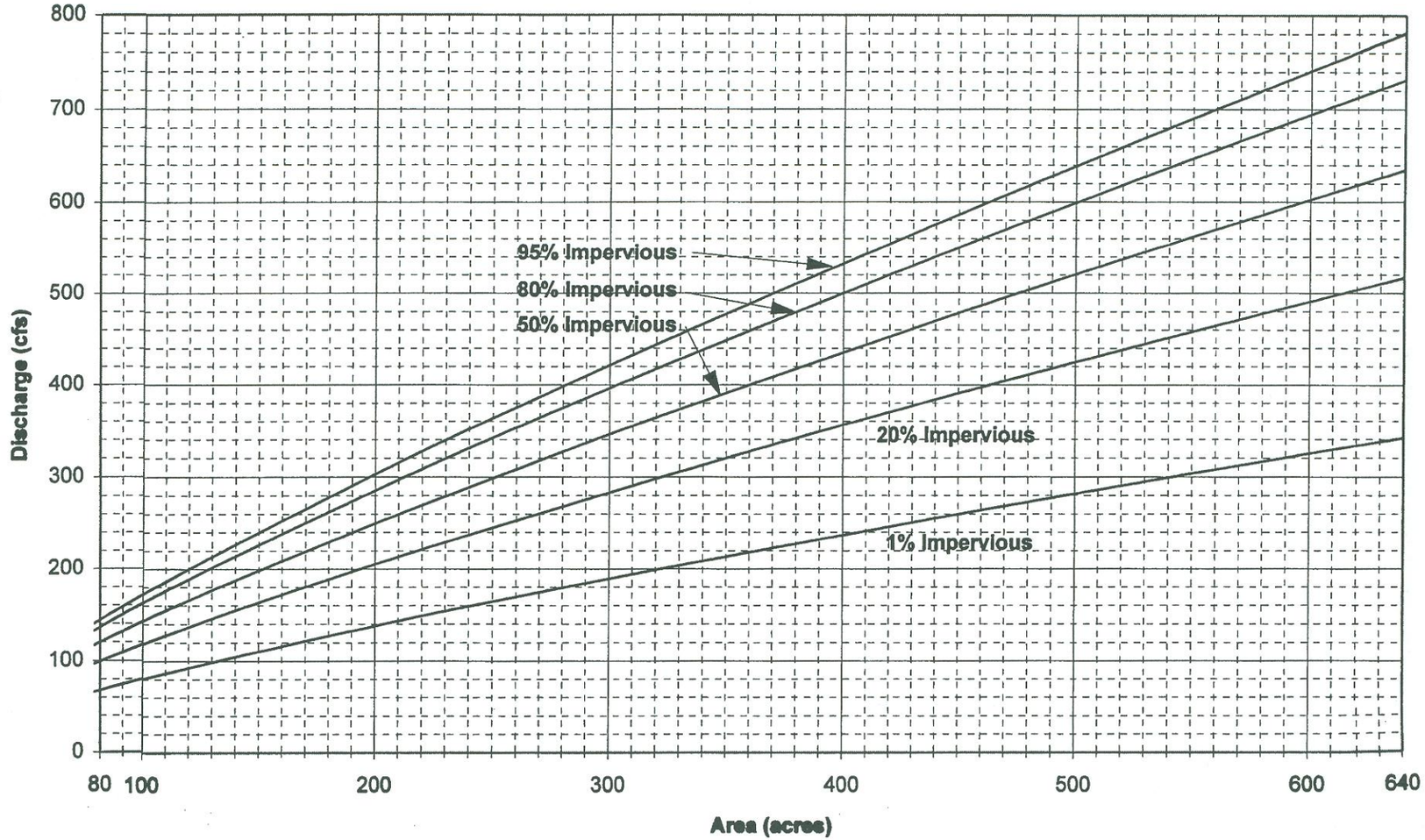


Note: Refer to accompanying disk for assumptions made in deriving this figure.

100–Year Peak Flow Sacramento Method Rainfall Zone 3, <80 Acres

Date December 1996

Figure 2–22

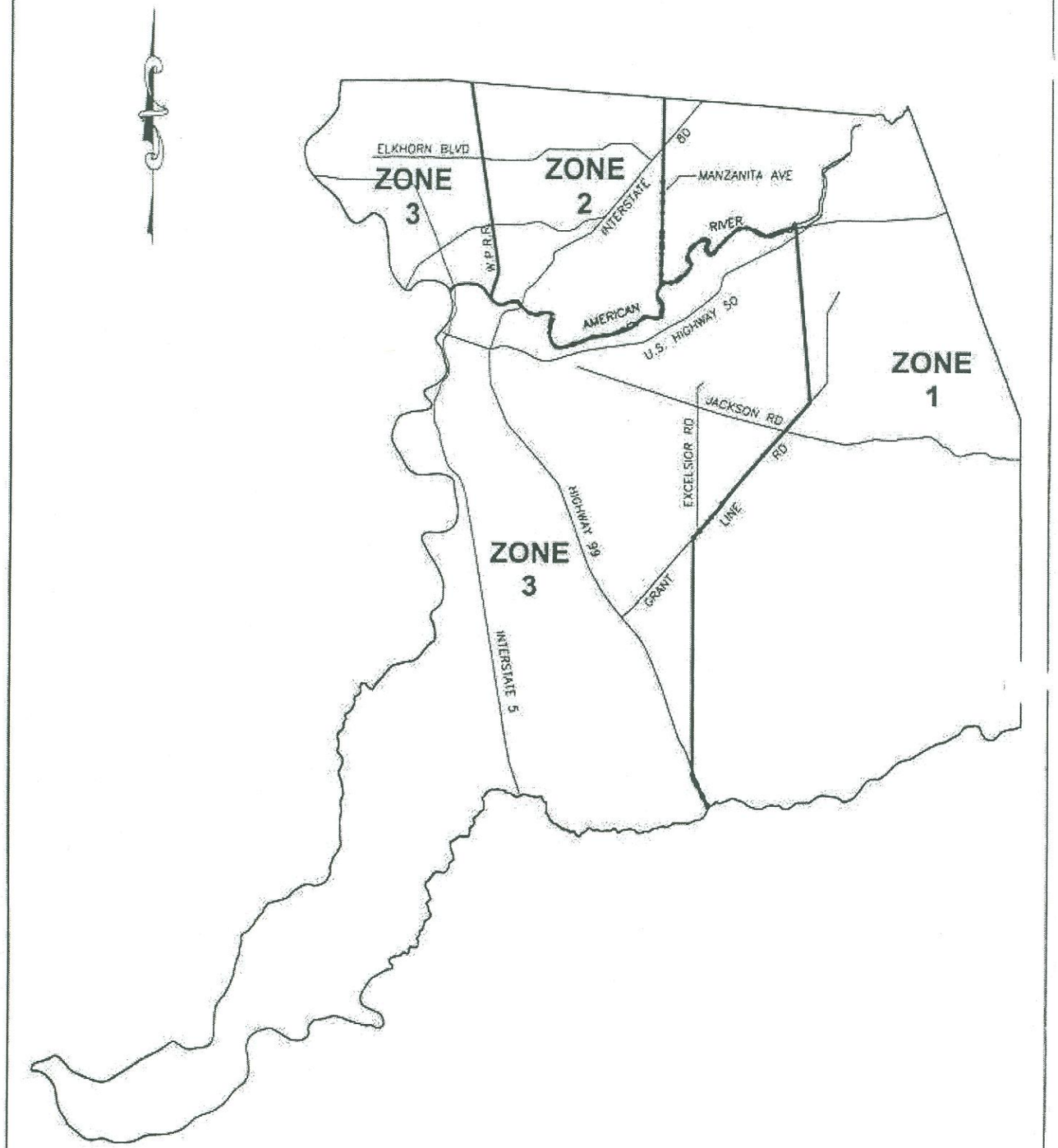


Note: Refer to accompanying disk for assumptions made in deriving this figure.

100–Year Peak Flow
Sacramento Method
Rainfall Zone 3, 80–640 Acres

Date: December 1996

Figure 2–23



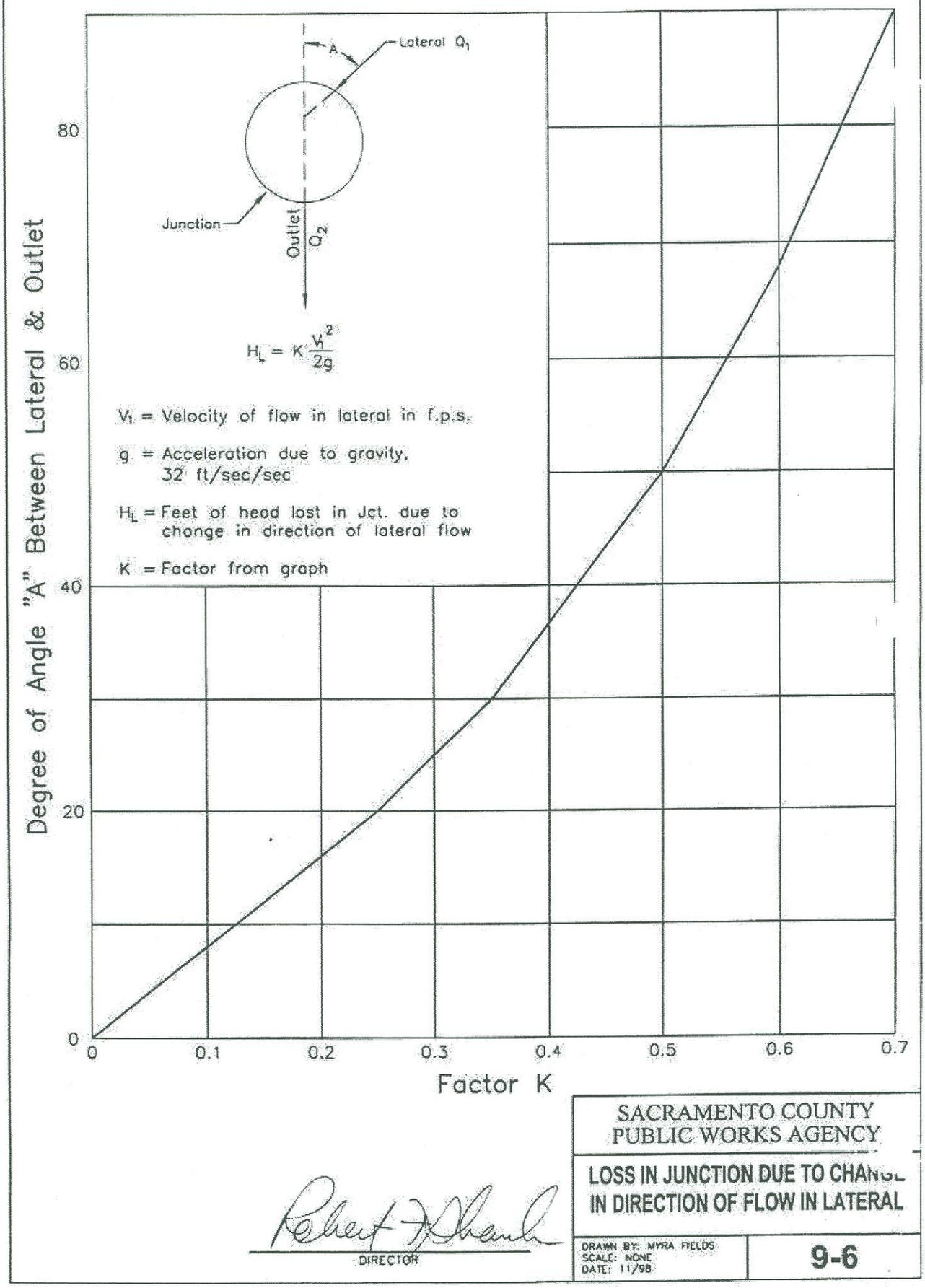
SACRAMENTO COUNTY
PUBLIC WORKS AGENCY

DRAINAGE ZONES

DRAWN BY: HEIDI HUBER
SCALE: NONE
DATE: 11/98

9-2

DIRECTOR



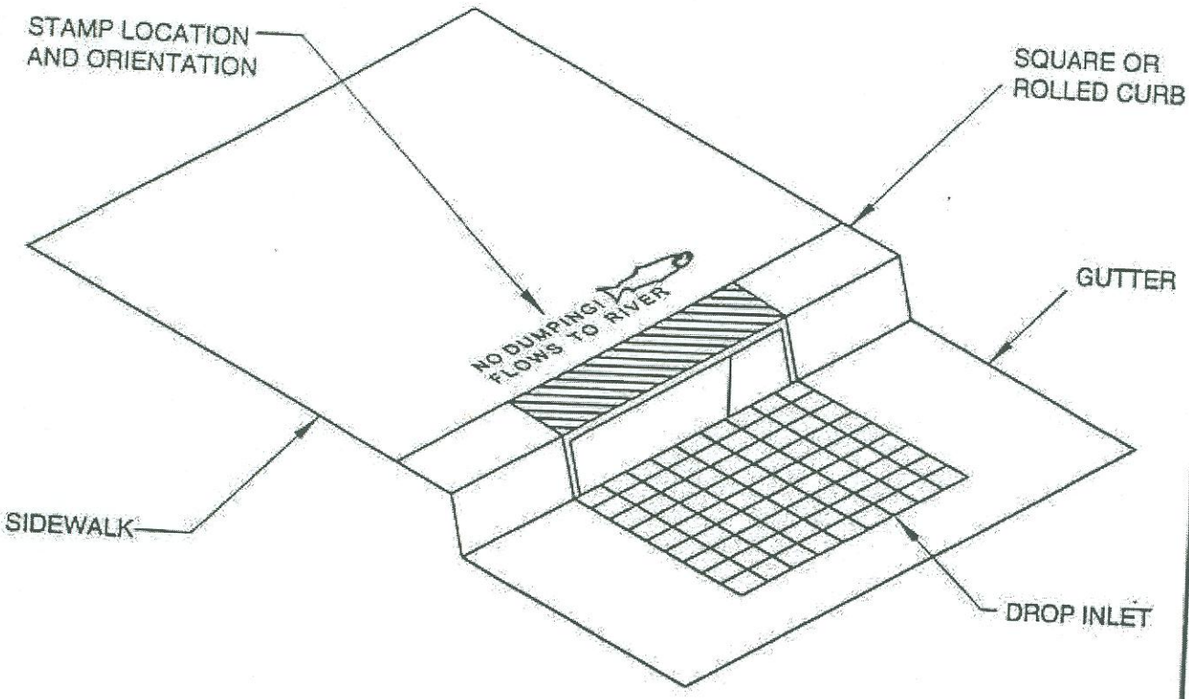
SACRAMENTO COUNTY
PUBLIC WORKS AGENCY

LOSS IN JUNCTION DUE TO CHANGE IN DIRECTION OF FLOW IN LATERAL

DIRECTOR

DRAWN BY: MYRA FIELDS
SCALE: NONE
DATE: 11/98

9-6



NOTES

1. MESSAGE AND SYMBOL SHALL BE AS SHOWN ON EC-10B OR AS APPROVED BY THE DIRECTOR.
2. LETTERS SHALL BE 1.5 INCHES (38 MM) IN HEIGHT. THE MESSAGE SHALL BE CENTERED ON THE BACK OF THE INLET.
3. CONCRETE SHALL BE STAMPED IN SUCH A WAY AS TO PROVIDE FOR A CLEAR AND LEGIBLE IMAGE. (APPROXIMATE DEPTH OF .25 INCH OR 6MM.)
4. ALL STAMPS SHALL BE APPROVED BY THE DIRECTOR BEFORE BEING USED.

DIRECTOR

SACRAMENTO COUNTY PUBLIC WORKS AGENCY	
STORMWATER QUALITY DROP INLET CONCRETE STAMP	
SCALE: NONE DATE: JANUARY 5, 1995 DRAWN BY: SLP	11-10A

STAMP MESSAGES AND SYMBOLS

DIMENSIONS MAY VARY AMONG THE STAMP DESIGNS SHOWN BELOW, BUT SHALL NOT EXCEED THE MAXIMUM DIMENSIONS.

30 INCHES MAXIMUM
(762 MM)

12 INCHES MAX.
(305 MM)

NO DUMPING!
FLOWS TO CREEK

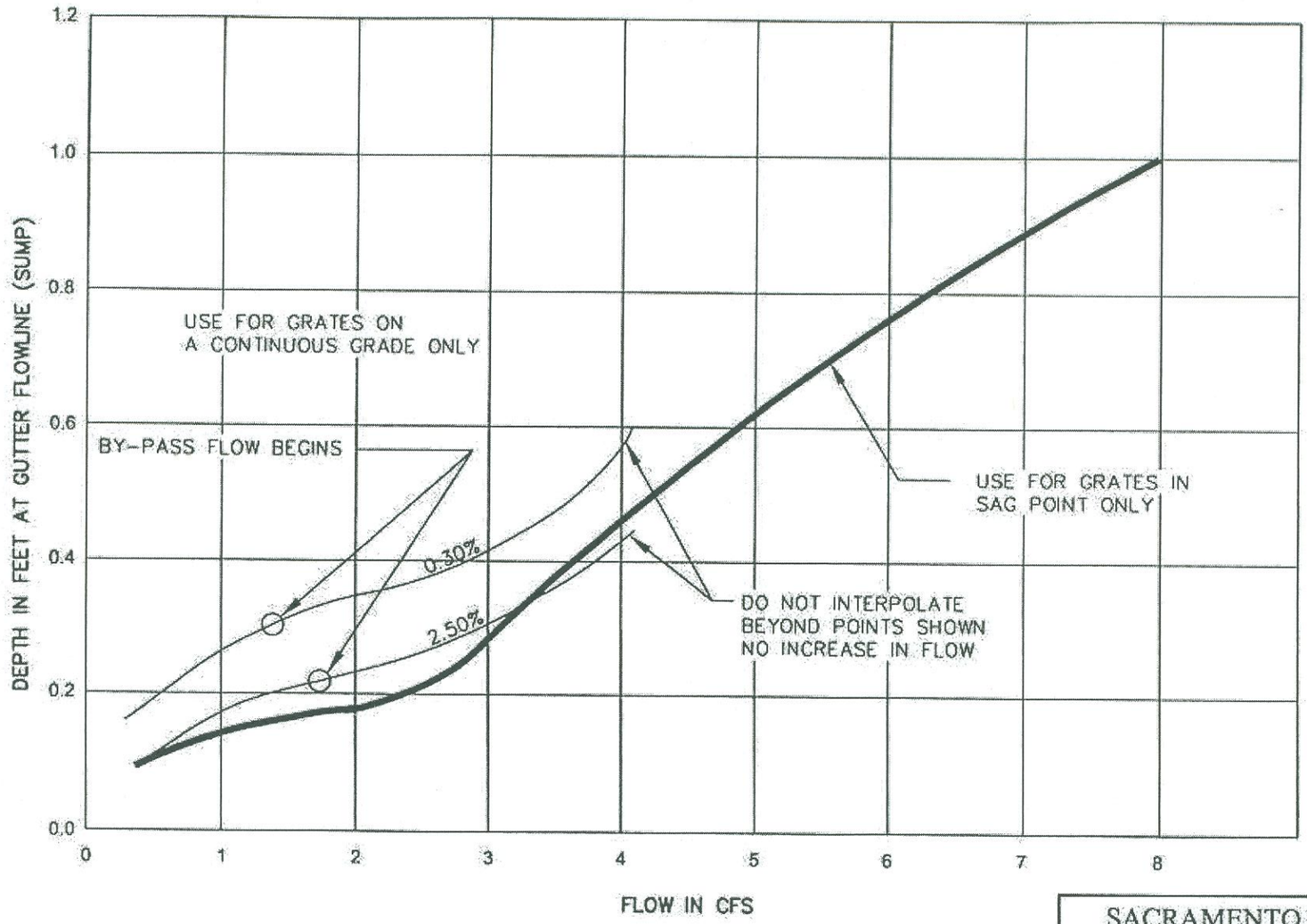
NO DUMPING

I LIVE DOWNSTREAM

NO DUMPING!
FLOWS TO RIVER

DIRECTOR

SACRAMENTO COUNTY PUBLIC WORKS AGENCY	
STORMWATER QUALITY DROP INLET CONCRETE STAMP	
SCALE: NONE DATE: JANUARY 5, 1995 DRAWN BY: SLP	11-10B



DIRECTOR

SACRAMENTO COUNTY
PUBLIC WORKS AGENCY

FLOW CAPACITY
TYPE B GRATE

DRAWN BY: TRU PHAN
SCALE: NONE
DATE: 7/98

9-12

LIST OF DRAWINGS

Title
Drawing

DESIGN RUNOFF CRITERIA FOR ALL DEVELOPMENT 2-1

NOLTE METHOD HYDROLOGY ZONE MAP 2-4

DESIGN RUNOFF NOLTE METHOD CURVES ..... 2-5 TO 2-10

LOSS IN JUNCTION DUE TO CHANGE IN DIRECTION OF FLOW IN LATERAL 9-6

FLOW CAPACITY TYPE B GRATE 9-12

TYPICAL RAMP AND TRANSITION DETAIL 9-25

STORMWATER QUALITY DROP INLET CONCRETE STAMP 11-10A

STORMWATER QUALITY DROP INLET CONCRETE STAMP 11-10B

SACRAMENTO CITY AND COUNTY RAINFALL ZONES SACRAMENTO METHOD 2-11

100-YEAR PEAK FLOW SACRAMENTO METHOD RAINFALL ZONE 1 <80 ACRES 2-18

100-YEAR PEAK FLOW SACRAMENTO METHOD RAINFALL ZONE 1 80-640 ACRES 2-19

100-YEAR PEAK FLOW SACRAMENTO METHOD RAINFALL ZONE 2 <80 ACRES 2-20

100-YEAR PEAK FLOW SACRAMENTO METHOD RAINFALL ZONE 2 80-640 ACRES 2-21

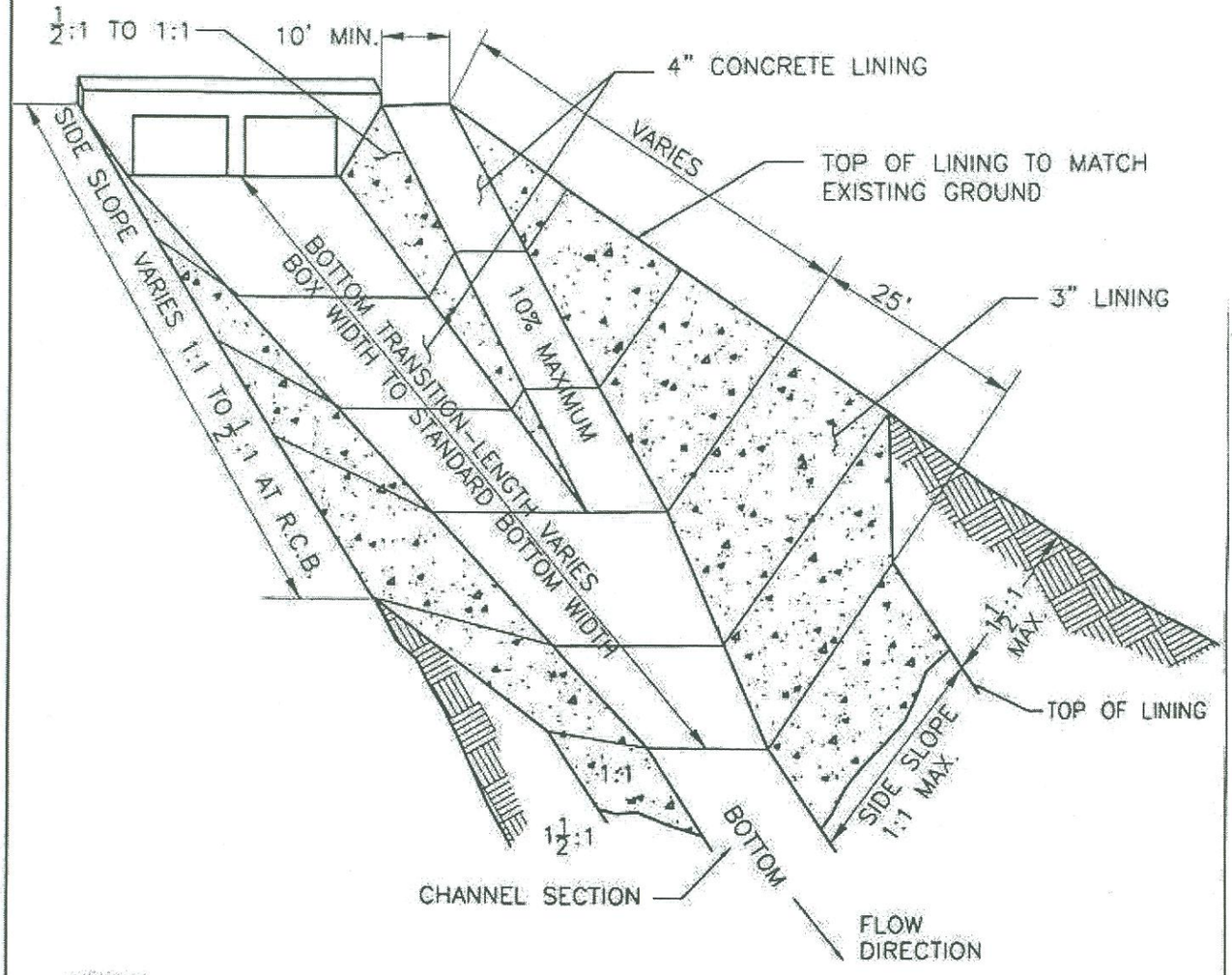
100-YEAR PEAK FLOW SACRAMENTO METHOD RAINFALL ZONE 3 <80 ACRES 2-22

100-YEAR PEAK FLOW SACRAMENTO METHOD RAINFALL ZONE 3 80-640 ACRES 2-23

MIN. THICKNESS OF METAL PIPE FOR 50-YR SERVICE LIFE ..... FIGURE 854.3B

NOTES: THE CONSTRUCTION SPECIFICATIONS CONTAIN DRAWINGS NOT INCLUDED IN THESE STANDARDS.

Drawings numbers beginning with "2" are from the Hydrology Standards.



NOTES:

1. BOTTOM TRANSITION 25' MINIMUM LENGTH WITH NO RAMP.
2. WEEP HOLES AND JOINTS AS REQUIRED FOR ALL LINED CHANNEL SECTIONS.
3. LOW SIDE OF CHANNEL TO BE OPPOSITE RAMP.
4. SIDE SLOPE LINING MAY BE DELETED ON CHANNELS WITH BOTTOM LINING ONLY.

DIRECTOR

SACRAMENTO COUNTY
PUBLIC WORKS AGENCY

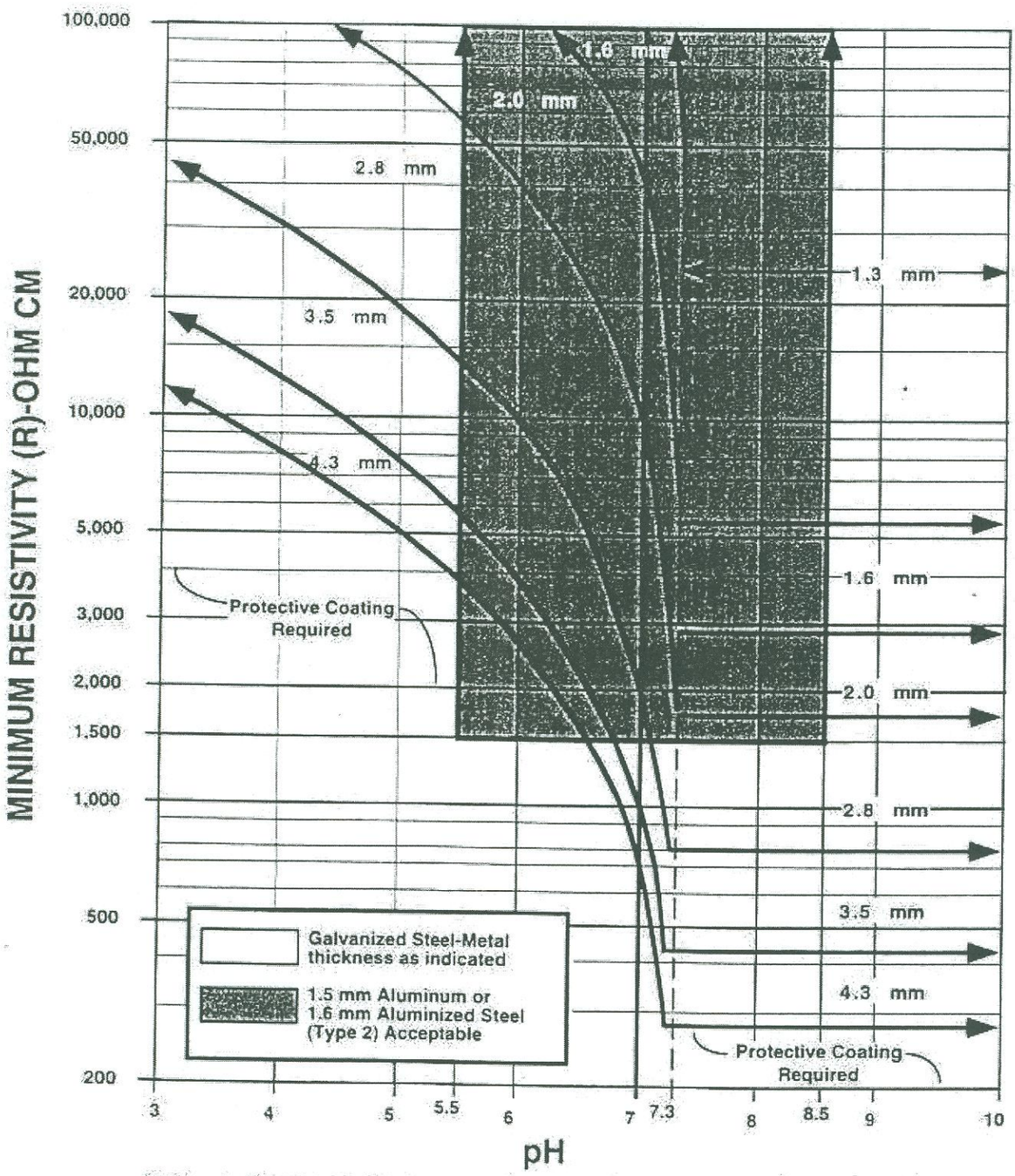
TYPICAL RAMP & TRANSITION DETAIL

DRAWN BY: TRU PHAN
SCALE: NONE
DATE: 11/98

9-25

Figure 854.3B

Minimum Thickness of Metal Pipe for 50 Year Maintenance Free Service Life



Notes: 1. For pH and minimum resistivity levels not shown refer to California Test 643.

2. Refer to CULVERT 3 computer program for service life estimate due to various corrosive conditions.