LAKE COUNTY

HYDROLOGY DESIGN STANDARDS

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Water Resources Division
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These Standards provide design criteria and the methodology used to estimate peak flows for drainages within Lake County.

These Standards are based on information provided by the National Weather Service, the USDA Natural Resources Conservation Service, the California Department of Water Resources, and the California Department of Transportation.

It is the intent that these Standards be utilized for estimating flows in minor waterways (drainage areas less than one square mile) with time of concentrations of less than two hours. For larger drainage areas, we recommend the use of more detailed calculations and/or models, such as TR20, TR-55, HEC-1 and HEC-HMS.

WATERWAY DESIGN CRITERIA

A "waterway" is defined as being a natural or artificial channel or depression in the surface of the earth or an underground conduit system that conveys storm water runoff.

For the purposes of design criteria contained herein, waterways are divided into three classifications:

1. Major Waterways: having a tributary drainage area of four square miles or more; shall require a design frequency of re-occurrence of one in 100 years. This frequency would only apply to design in urban and suburban areas and not, for instance, agricultural channel design.
2. Secondary Waterways: having a tributary drainage area of between one and four square miles; shall require a design frequency of re-occurrence of once in 25 years.
3. Minor Waterways: having a tributary drainage area less than one square mile; shall require a design frequency of re-occurrence of once in 10 years.

Commercial sites, industrial sites, residential subdivisions, and manufactured home parks or subdivisions shall be designed to carry the 10-year storm in the storm drain system, and the 100-year storm within the confines of the streets. Secondary and major waterways passing through the site shall be designed to their respective design flows. All new building pads should be designed such that they are not inundated by a 100-year flood event from local drainage facilities. Flooding from regional sources will be considered on a case-by-case basis.

Best Management Practices (BMPs), such as filter strips and sedimentation basins, are usually designed for the 2-year event. BMP's designed for the 2-year event will properly treat over 90% of the flow during its life. Design criteria, such as included in the California Storm Water Best Management Practice Handbooks should be used.

Open channels should be designed with a minimum of six inches of freeboard at the design flow. Closed conduit systems should be designed with no surcharging at the design flow. Culvert inlets may be surcharged to efficiently use the culvert. To reduce routine maintenance, facilities should be designed with a self-cleansing velocity of 3 feet per second. Erosive velocities in unlined channels and culvert outlets should be minimized, or erosion resistant lining provided.

ROADWAY DESIGN CRITERIA

Roadway drainage design is a matter of properly balancing technical principles and data with the environment giving due consideration to other factors such as safety and economics. Drainage features to remove runoff from the roadway and to convey surface and stream waters originating upstream of the roadway to the downstream side should be designed to accomplish these functions without causing objectionable backwater, excessive velocities or unduly affecting traffic safety. Chapters 800 to 890 of the CALTRANS Highway Design Manual should be used for drainage design of public roadways within Lake County. The following minimum design standards apply to Lake County:

Bridges/Major Culverts: Design in conformance with Chapter 820 of the Highway Design Manual. For Major Waterways and streams that are included in the Flood Insurance Study (FIS), a 100-year flood should be used for design purposes. Bridges over streams included in the FIS may not increase the base flood elevation more than one foot. If a floodway is present, the bridge may not encroach on the floodway or must be designed with no increase the base flood elevation.

Arterial and Collector Roadways: Cross culverts should be designed for a 25-year flood event with headwater six inches below the edge of the traveled way. A 100-year event should be used if the drainage is defined as a Major Waterway.

Drainage along the roadway, i.e. gutter flow, should be designed for a 25-year event with flow contained within the shoulder or parking lane. Roadside ditches should be designed for a 25-year flood event with six inches of freeboard. The 100-year event should be contained within the roadway.

Local Roadways: Cross culverts must be designed for a 10-year flood event with headwater six inches below the edge of the traveled way. Secondary and Major Waterways should be designed for the corresponding recurrence interval.

Drainage along the roadway, i.e. gutter flow, should be designed for a 10-year event with flow contained within the shoulder or parking lane. Roadside ditches should be designed for a 10-year flood event with six inches of freeboard. The 100-year event should be contained within the roadway.

In the event of sheet flooding occurring in the area of a bridge or culvert, exceptions to the above standards will be considered on a case-by-case basis.

HYDROLOGIC DESIGN

Estimation of flood flows from minor waterways and for drainage areas that have significant areas of urban development should be through use of the Rational Formula. Secondary and major waterways should have the flood flows estimated from detailed calculations and/or models. Design shall be based on the assumption that all upstream areas are fully developed, consistent with zoning at the time of project approval.

Rational Formula

Design discharge for minor waterways and urban areas shall be determined by use of the rational formula:

$$Q = C\ I\ A\ K$$

Where:
Q = design discharge in cubic feet per second, cfs
C = runoff coefficient based on full development
I = rainfall intensity in inches per hour
A = drainage area in acres
K = coefficient of intensity

Runoff Coefficient:

The runoff coefficient for undeveloped areas is selected from Table 1. For developed areas, the runoff coefficient is calculated based on the runoff coefficient from Table 1 and the percentage of area that is covered by impermeable surfaces. Table 2 provides some typical ranges for the area covered by impermeable surfaces for different levels of development. Table 3 provides some typical runoff coefficients for different types of development. The runoff coefficient is calculated as follows:

$$Ct = (Ap/At)(Cp) + (Av/At)(Cv)$$

Where:
Ap = area covered by impermeable surfaces, such as paving and buildings
Av = area planted or vegetated
At = total area
Cp = coefficient of runoff of paved area, usually 0.95
Cv = coefficient of runoff for planted or vegetated areas, from Table 1
Ct = coefficient adjusted for vegetated area

Rainfall Intensity:

Rainfall Duration-Intensity Curves are included in Figure 1. Proper determination of the time of concentration has the greatest effect on the rainfall intensity. The time of concentration is the time required for water from the most remote point of the drainage area to travel to the point of interest. Because the flow velocity is dependent on the characteristics of the flow route, the route should be divided into segments where the route characteristics change (i.e. roughness, slope, wetted perimeter, channel slope, etc.) and the individual times added together to get the time of concentration. Figure 2 provides a relationship of slope, cover type and overland flow velocity. The flow velocities for natural channels can be estimated using Manning's equation. Because the depth of flow increases with higher intensity rainfall, the time of concentration will decrease as the storm intensity increases. Add 10 minutes initial time of concentration to the calculated time of travel to obtain the total time of concentration for the design rainfall intensity.

K: The "K" factor is used to adjust for variations in rainfall intensities throughout the County. "K" is determined by obtaining the mean annual precipitation for the drainage basin from Figure 3, and dividing it by 35 inches per year.

General:

The Rational Method is based on the following assumptions:

1. All areas of the drainage basin contribute to the peak flow.

2. Rainfall falls at a uniform rate over the entire drainage basin.

3. The runoff coefficient is the same for storms of various frequencies.

4. The runoff coefficient is the same for all storms in a given watershed.

5. The frequency of peak discharge is the same as that of the rainfall intensity for the given time of concentration.

6. The base flow is negligible compared to the flood flow.

Because of these assumptions, use of the Rational Formula should be limited to small, simple watersheds, generally less than 640 acres. Diverse watersheds should be divided into homogenous subareas and the resultant flows accumulated based on the entire watershed's time of concentration. If a large amount of storage exists within the basin, development of a hydrograph and flood routing may be required.

Table 1: Runoff Coefficients For Undeveloped Areas

	Watershed Types			
	Extreme	**High**	**Normal**	**Low**
Relief	0.28-0.35 Steep Rugged terrain with average slopes above 30%	0.20-0.28 Hilly, with average slopes of 10 to 30%	0.14-0.20 Rolling with average slopes of 5 to 10%	0.08-0.14 Relatively flat land, with average slopes of 0 to 5%
Soil infiltration	0.12-0.16 No effective soil cover, either rock or thin soil mantle of negligible infiltration capacity	0.08-0.12 Slow to take up water, clay or shallow loam soils of low soil infiltration capacity, imperfectly or poorly drained	0.06-0.08 Normal, well drained light or medium textured soils, sandy loams, silt and silt loams	0.04-0.06 High, deep sand or other soil that takes up water readily, very light well drained soils
Vegetal Cover	0.12-0.16 No effective plant cover, bare or very sparse cover	0.08-0.12 Poor to fair; clean cultivation crops, or poor natural cover, less than 20% of drainage area over good cover	0.06-0.08 Fair to good; about 50% of area in good grassland or woodland, not more than 50% of area in cultivated crops	0.04-0.06 Good to excellent; about 90% of drainage area in good grassland, woodland or equivalent cover
Surface Storage	0.10-0.12 Negligible surface storage, depressions few and shallow; drainageways steep and small, no marshes	0.08-0.10 Low; well defined system of small drainageways; no ponds or marshes	0.06-0.08 Normal; considerable surface depression storage; lakes and pond marshes	0.04-0.06 High; surface storage high; drainage system not sharply defined; large floodplain storage or large number of ponds and marshes
Given: An undeveloped watershed consisting of 1) rolling terrain with average slopes of 5%, 2) clay type soils, 3) good grassland area, and 4) normal surface depressions Find: The runoff coefficient, C, for the above watershed			Solution: Relief 0.14 Soil Infiltration 0.08 Vegetal Cover 0.04 Surface Storage 0.06 C = 0.32	

Table 2: Typical Ranges of Impermeable Area

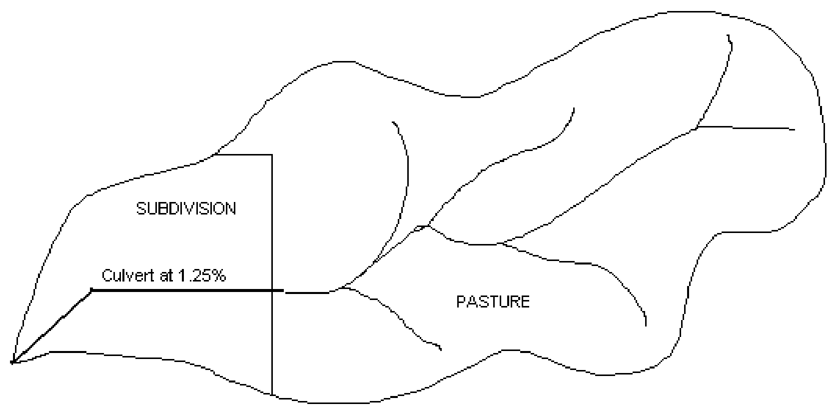
Development Type	Low, %	High, %
Suburban Residential (SR)	5	15
Single-Family Residential (R1)	45	65
Two-Family Residential (R2)	50	70
Multi-Family Residential (R3)	50	75
Commercial	50	100

Table 3: Typical Runoff Coefficients for Developed Areas

Type of Drainage Area	Runoff Coefficient	Type of Drainage Area	Runoff Coefficient
Business:		Residential	
Downtown Areas	0.70-0.95	Single Family Areas	0.30-0.50
Neighborhood Areas	0.50-0.70	Multi-units, detached	0.40-0.60
Industrial		Multi-units, attached	0.60-0.75
Light industrial areas	0.50-0.80	Suburban	0.25-0.40
Heavy industrial areas	0.60-0.90	Apartment dwelling areas	0.50-0.70
Parks, cemeteries	0.10-0.25	Playgrounds	0.20-0.40

Example:

Calculate the design flow for a subdivision in Kelseyville which has flow from 35 acres of adjacent, rolling, pasture land (zoned AG) and 15 acres of subdivision (zoned R1). The average slope of the agricultural land is 8 percent. The average slope within the subdivision is 3 percent. The soil is a normal Lake County loam.



Estimate Cv from Table 1:

Cv, Pasture:	Slope of 8%	0.18
	Loam Soil	0.07
	Good grassland	0.04
	Well defined drainage	<u>0.09</u>
		0.38
Cv, Subdivision:	Slope of 3%	0.12
	Loam Soil	0.07
	Good grassland	0.04
	Well defined drainage	<u>0.09</u>
		0.32

Calculate Ct

Subdivision

Estimate 55% of subdivision will be under impermeable surfaces

Ct = (0.55)(0.95) + (0.45)(0.32)

Ct = 0.67

Entire Drainage:

Ct = (0.38)(35/50) + (0.67)(15/50)

Ct = 0.47

Calculate I:

The drainage area is less than 1 square mile, therefore, design for the 10-year event, check for 100-year event to avoid flooding

Tc = 10 minutes + Overland Flow time + Channel Flow time

<u>10-year Event</u>

Overland Flow: Pasture; 500 feet, slope of 10%, good grass cover

From Figure 2, the flow velocity is 0.8 feet per second

Tof = (500/0.8)/60 = 10.4 minutes

Channel Flow: Pasture: 1200 feet of natural channel at 1.5%

Use Manning's equation to estimate velocity

$V = (1.49/n)(R)^{2/3} \times (S)^{1/2}$

$V = (1.49/0.035)(0.5)^{2/3} \times (0.015)^{1/2}$

V = 3.3 fps

Tch = (1200/3.3)/60 = 6.1 minutes

Subdivision: 800 feet of culvert at 1.25 %

$V = (1.49/0.013)(0.5)^{2/3} \times (.0125)^{1/2}$

V = 8 fps

Tch = (800/8)/60 = 1.7 minutes

Design Time of Concentration

Tc = 10 + 10.4 + 6.1 + 1.7 = 28.2 minutes, Use 30 minutes

Using Figure 1 for the 10-year event, the rainfall intensity is 0.96 inches/hour

<u>100-year Event</u>

Estimate flow velocities at 110% of 10-year flow velocities

Overland Flow

Tof = (500/0.88)/60 = 9.5 minutes

Channel Flow:

Pasture: Tch = (1200/3.6)/60 = 5.6 minutes

Subdivision: Tch = (800/8.8)/60 = 1.5 minutes

Design Time of Concentration

Tc = 10 + 9.5 + 5.6 + 1.5 = 26.6 minutes, Use 27 minutes

Using Figure 1 for the 100-year event, the rainfall intensity is 1.45 inches/hour

Determine K

Using Figure 3, the average annual precipitation for Kelseyville is 26 inches/year

K = 26/35 = 0.74

$Q_{10} = (0.47)(0.96)(50)(0.74) = 16.7$ cfs

$Q_{100} = (0.47)(1.45)(50)(0.74) = 25.2$ cfs

Design Drainage Facilities for 17 cfs, and check for flooding at 25 cfs

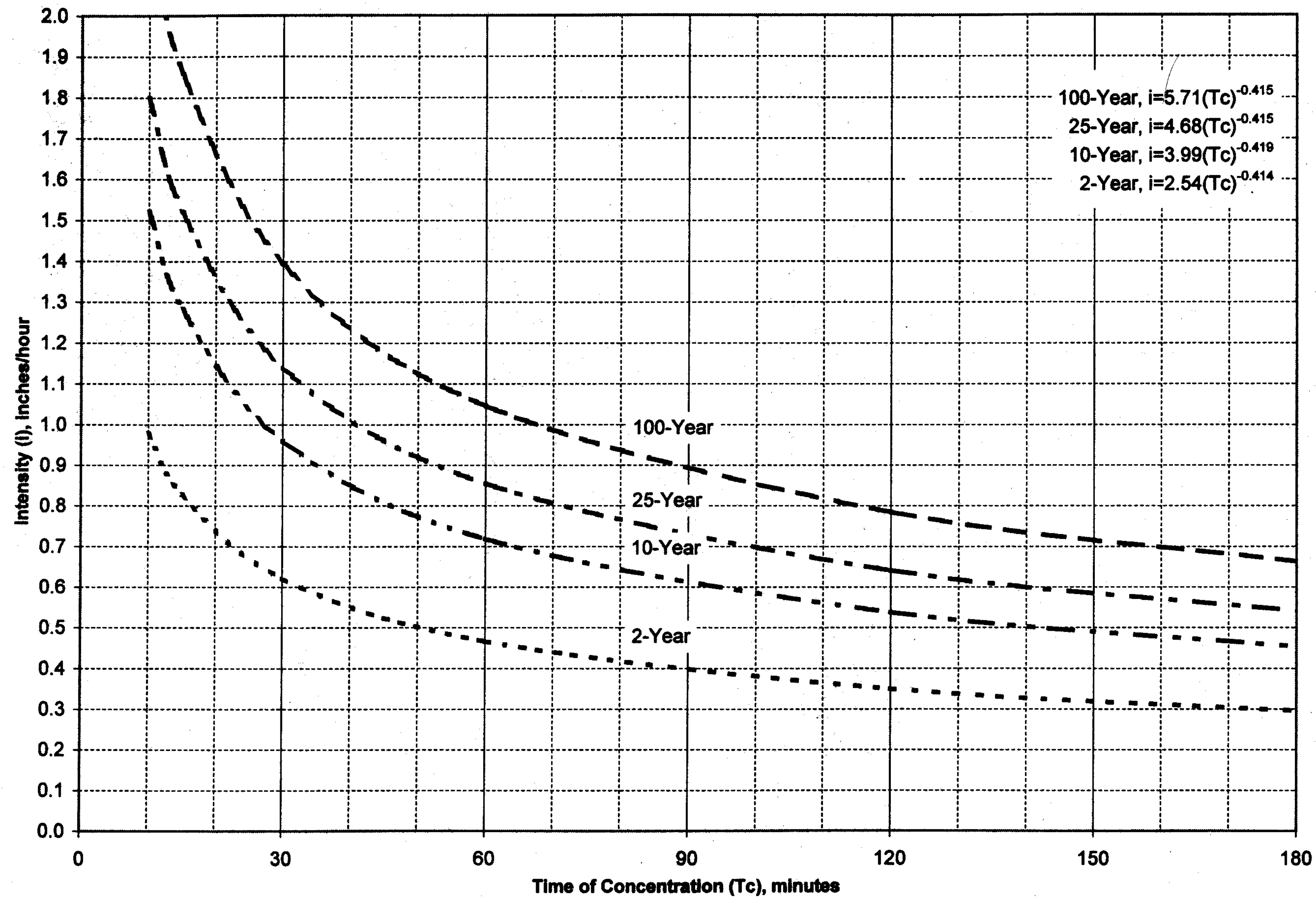


Figure 1: Rainfall Duration-Intensity Curves

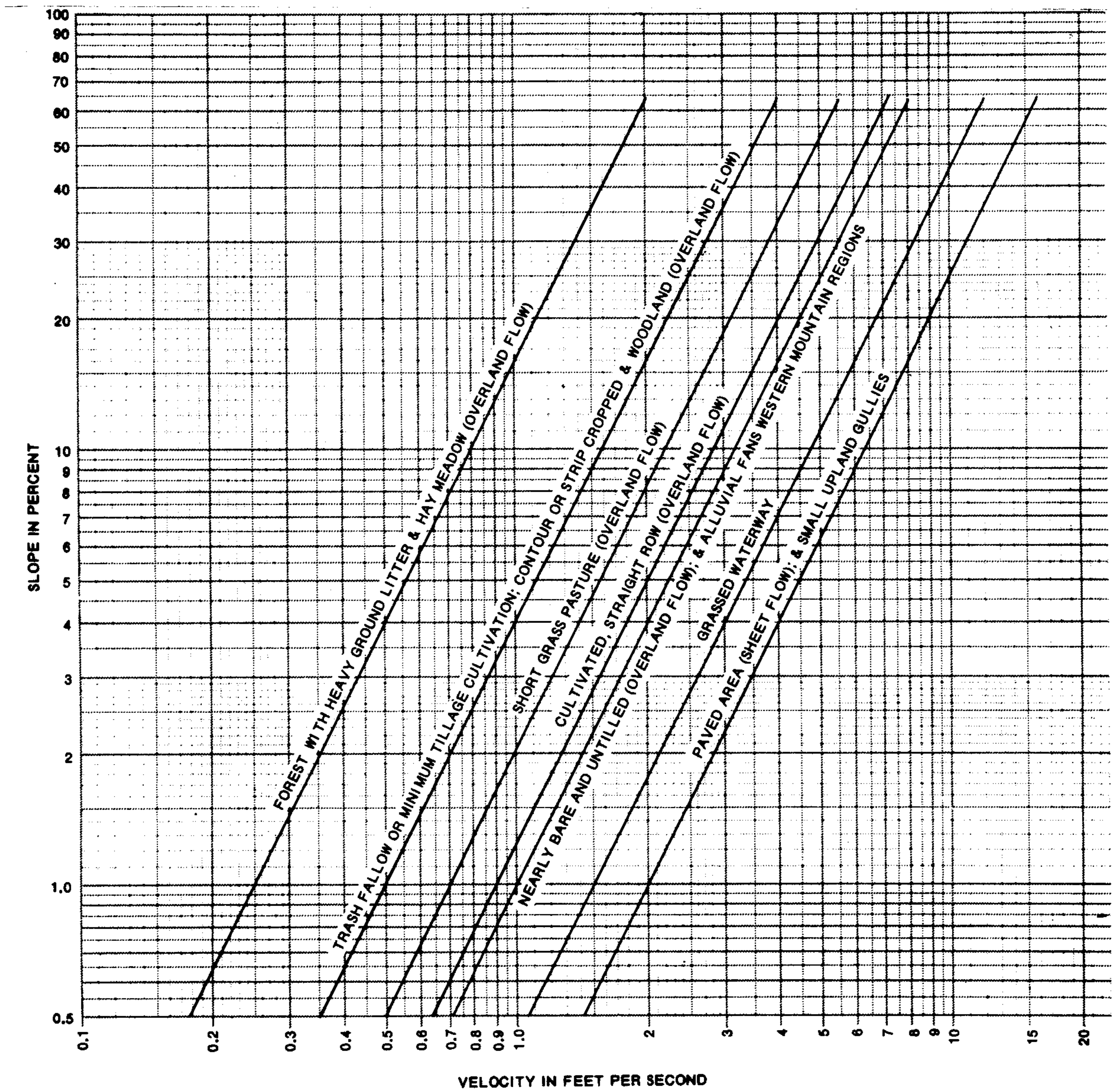


Figure 2: Overland Flow Velocities

From: USDA Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, March 1985, p. 15-8

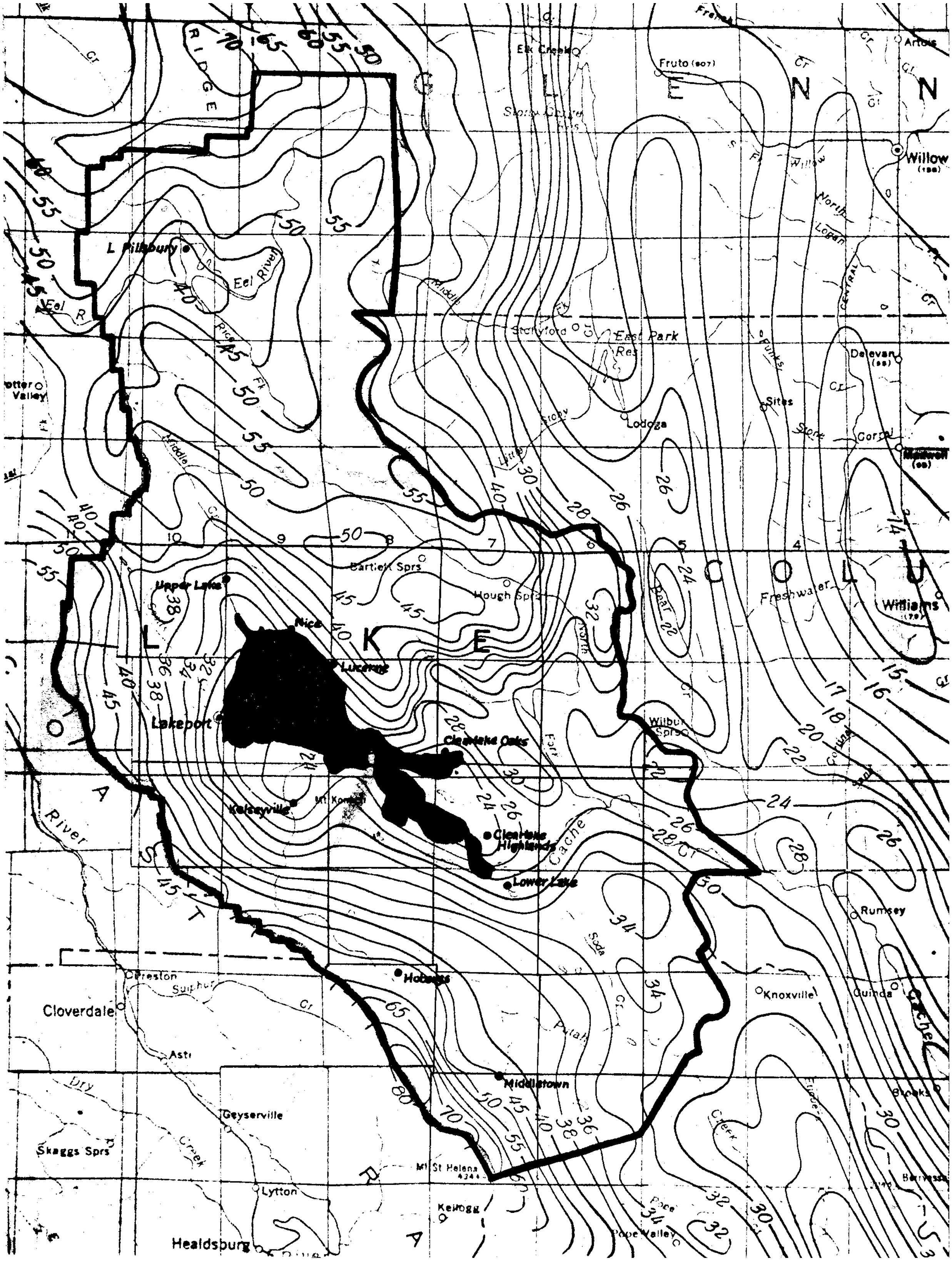


Figure 3: Average Annual Precipitation for Lake County

From: Calif. Department of Water Resources, Lines of Average Yearly Precipitation in the Central Valley, April 1966

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