

U. S. DEPARTMENT OF COMMERCE

WEATHER BUREAU

TECHNICAL PAPER NO. 25

# **Rainfall Intensity-Duration-Frequency Curves**

**For Selected Stations in the  
United States, Alaska, Hawaiian Islands, and Puerto Rico**

U. S. DEPARTMENT OF COMMERCE

SINCLAIR WEEKS, *Secretary*

WEATHER BUREAU

F. W. REICHELDERFER, *Chief*

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For Selected Stations in the  
United States, Alaska, Hawaiian Islands, and Puerto Rico

HYDROLOGIC SERVICES DIVISION  
COOPERATIVE STUDIES SECTION

In cooperation with

CORPS OF ENGINEERS, U. S. ARMY

and

U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE



WASHINGTON, D. C.

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INTRODUCTION

This paper presents a set of rainfall intensity-duration curves for durations of 5 minutes to 24 hours, and return periods of 2, 5, 10, 25, 50 and 100 years for each of 203 U. S. Weather Bureau stations.

Much of the data analysed for these curves is a by-product of work done on transfer of funds from the military construction investigational program of the Corps of Engineers, and Watershed Improvement and Flood Prevention program of the Soil Conservation Service. The project was conducted under the supervision of J. L. Paulhus and Walter T. Wilson, former and present Chiefs of the Cooperative Studies Section of the Hydrologic Services Division, W. E. Hiatt, Chief. David M. Hershfield was project leader, assisted by N. M. Kauffman, L. L. Weiss, and A. R. Pagan. Computations and other work were done by Annie Laurie Criss, Lillian C. Langdon, Edith E. Marlowe and Bonnie R. True, drafting by C. W. Gardner. Max A. Kohler, A. L. Shands and H. C. S. Thom acted as consultants.

The data are almost entirely from tipping-bucket gages, with some data from weighing-recorders. No evaluation was made of gage exposures, or changes in gage exposure at the stations. The 60-minute data are not for clock-hour, but for the 60 consecutive minutes having the maximum total precipitation each year, and similarly for other durations. Some of the curves, particularly for those stations with relatively short records, have been smoothed slightly.

The curves in the diagrams are spaced according to the Fisher-Tippett Type I (Gumbel) distribution<sup>1</sup>. For discussion of other distributions, and transformations among them, reference is made to the bibliography appearing in a paper by Chow<sup>2</sup>.

The curves in this paper are from the annual series (maximum value for each year) which for many applications is less appropriate than the partial-duration series<sup>3</sup>. The partial-duration series includes all the high values and recog-

nizes that the second-highest of some year might exceed the highest of some other year. For the partial-duration series a distribution could be fitted and extrapolated, as for the annual series, but the processing of partial-duration data is very laborious.

On the basis of a selected sample of 50 precipitation stations, empirical factors have been found for transforming the annual series to the partial-duration series. To transform values from the curves in this paper to corresponding partial-duration values, multiply them by the following factors:

2-year return period, 1.13  
 5-year return period, 1.04  
 10-year return period, 1.01

For longer return periods the differences between the two series are regarded as insignificant.

When rainfall intensity-frequency data are needed at a point an appreciable distance from the nearest long-record station, it is usually better to use local data than to interpolate solely among the sparse first-order stations. Local data will usually include a few station-years of recorder data and some long records of daily data. These local data can be exploited by relating the local short-record rainfall intensity data to the corresponding longer record data from nearby first-order stations, and relating the local values of daily rainfall to the characteristic intensity-duration curves of the nearby first-order stations. These methods are illustrated in Weather Bureau Technical Paper No. 24, Parts I and II of which cover the United States from Denver west<sup>4,5</sup>.

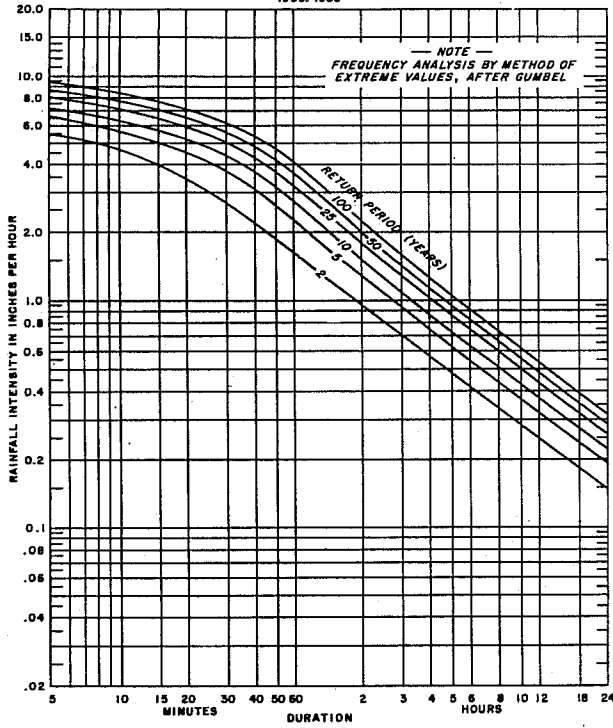
Comparison of data from Technical Paper No. 24 with data in this paper will show differences in most instances because the data in Technical Paper No. 24 are based on the partial-duration series, with the results subjected to considerable areal generalization and smoothing of the relationships.

## REFERENCES

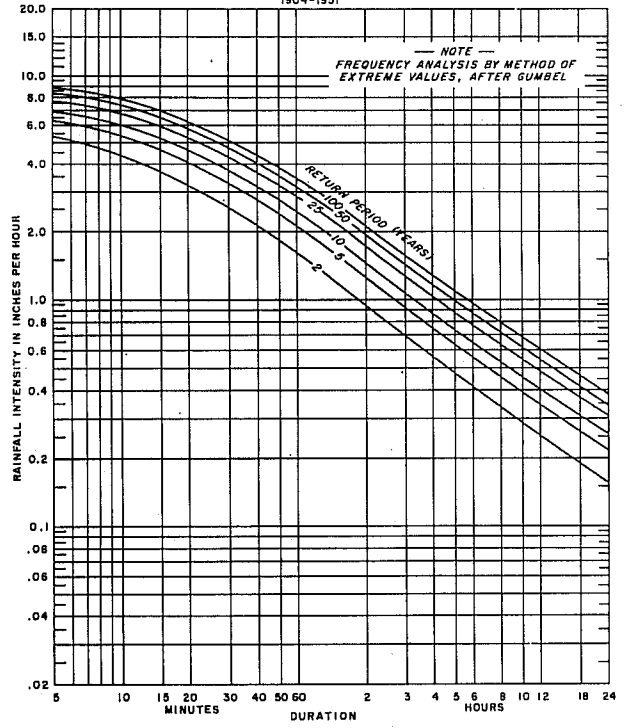
1. E. J. Gumbel, "The return period of flood flows," The Annals of Mathematical Statistics, vol. XII, June 1941, pp. 163-190.
2. Ven Te Chow, "The log-probability law and its engineering applications," Proceedings, American Society Civil Engineers, Separate No. 536, vol. 80, November 1954.
3. W.B. Langbein, "Annual floods and the partial-duration series," Transactions American Geophysical Union, vol. 30, no. 6, 1949, pp. 879-881.
4. U. S. Weather Bureau, "Rainfall intensities for local drainage design in the United States, Part I, West of the 115th Meridian," Technical Paper No. 24, Washington, D. C., August 1953. (Revised February 1955).
5. U. S. Weather Bureau, "Rainfall intensities for local drainage design in the United States, Part II: Between 105°W and 115°W," Technical Paper No. 24, Washington, D. C., August 1954.

# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

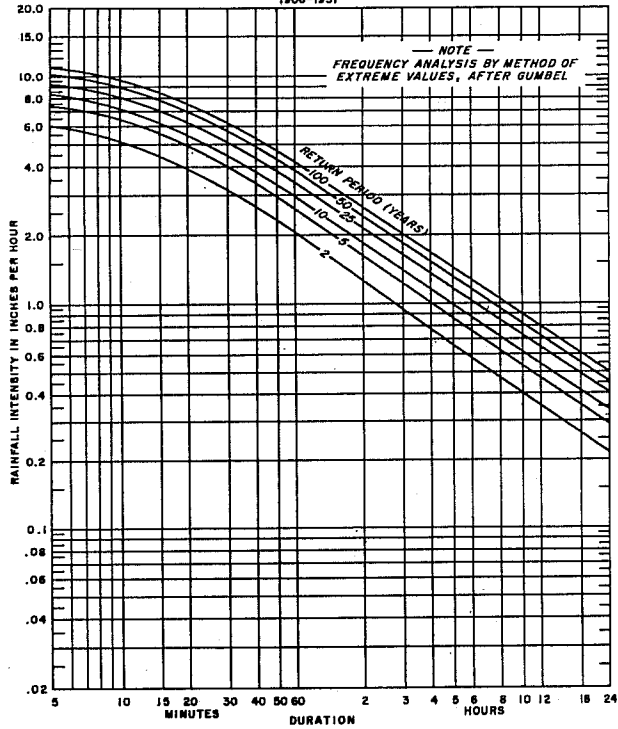
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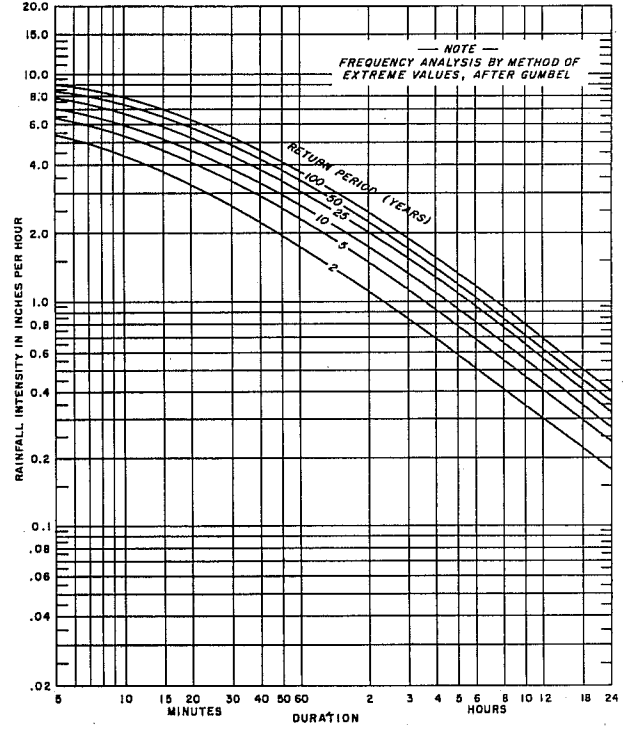
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1904-1951



**MOBILE, ALABAMA**  
1906-1951



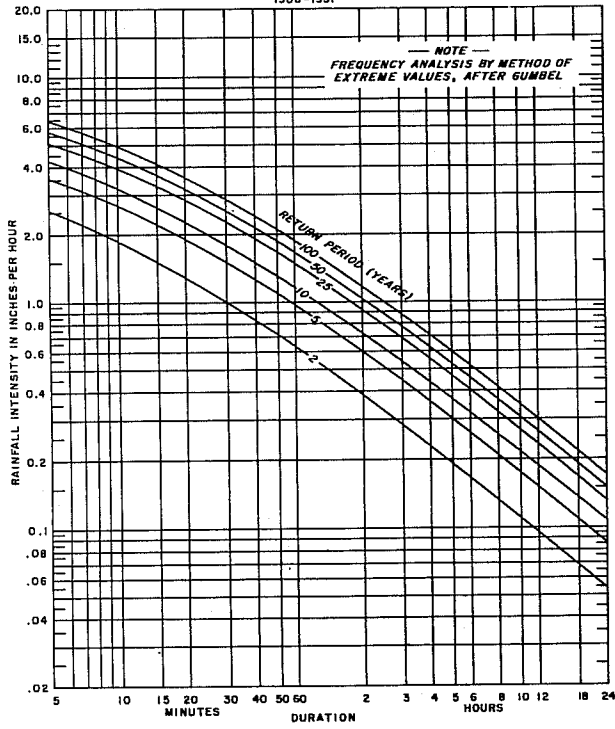
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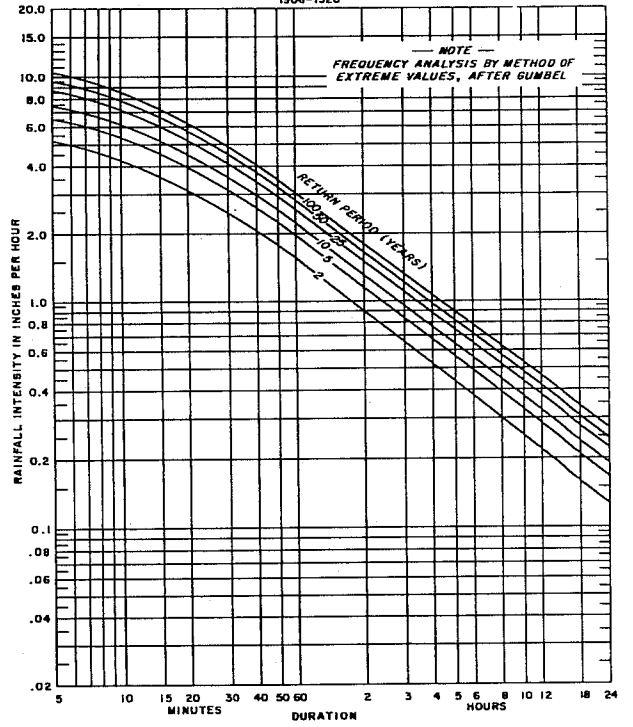


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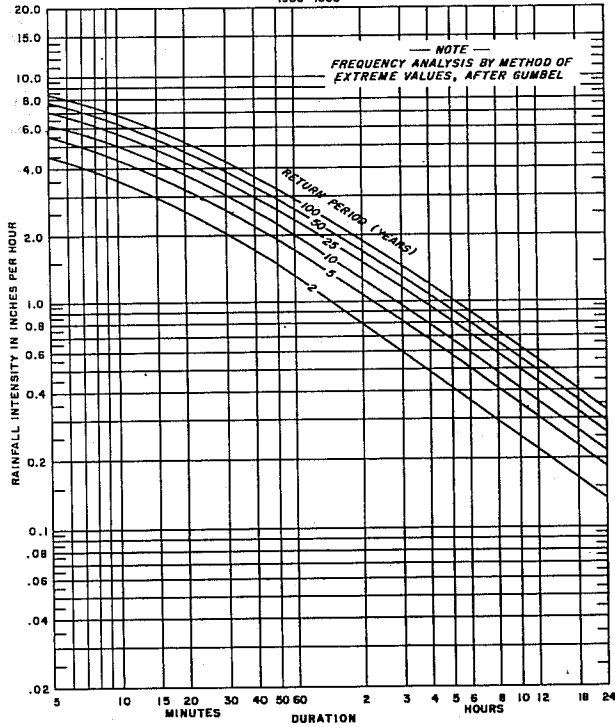
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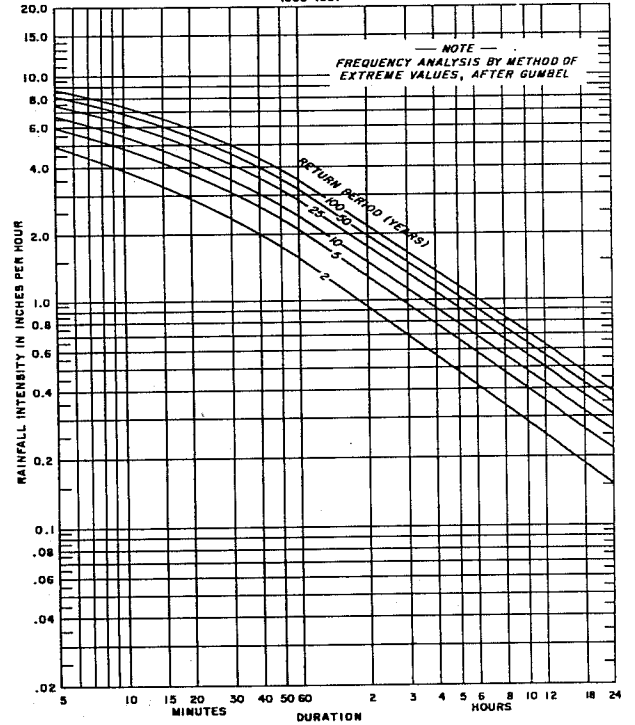
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1906-1920



FORT SMITH, ARKANSAS  
1903-1950

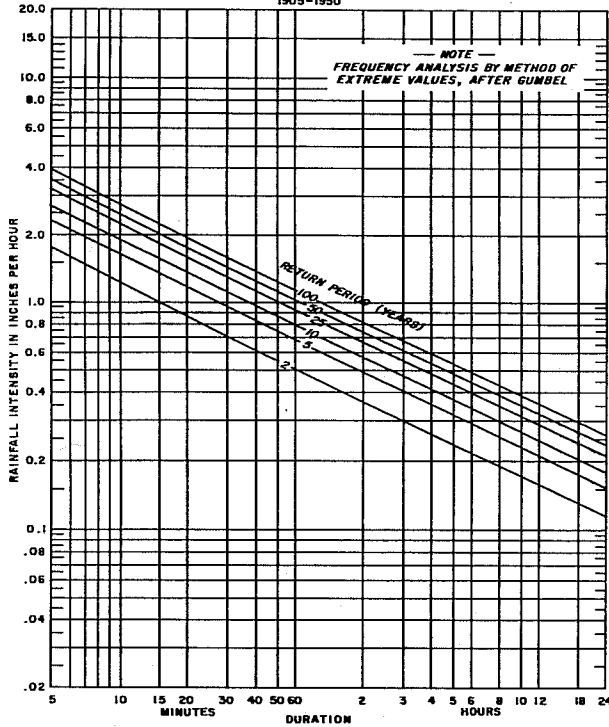


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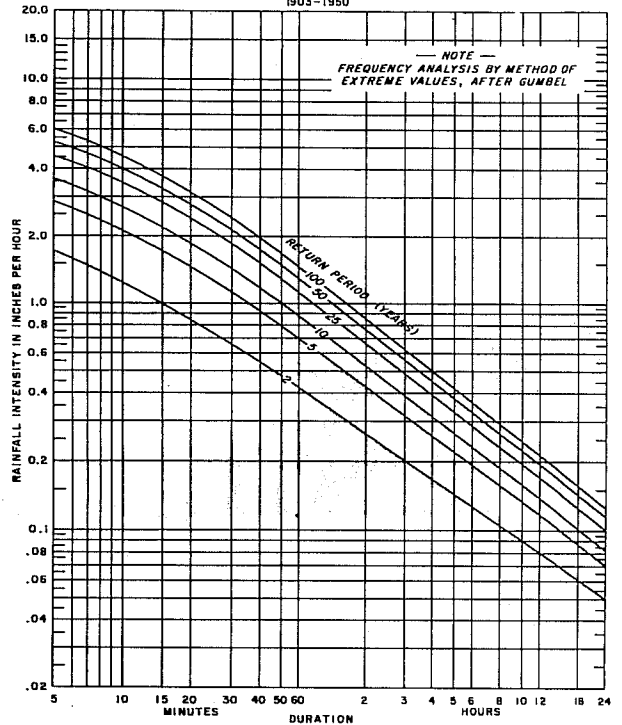


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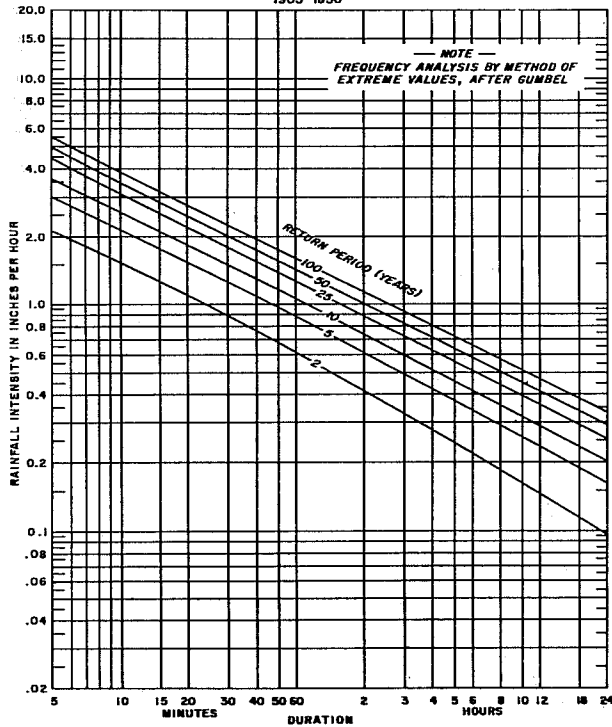
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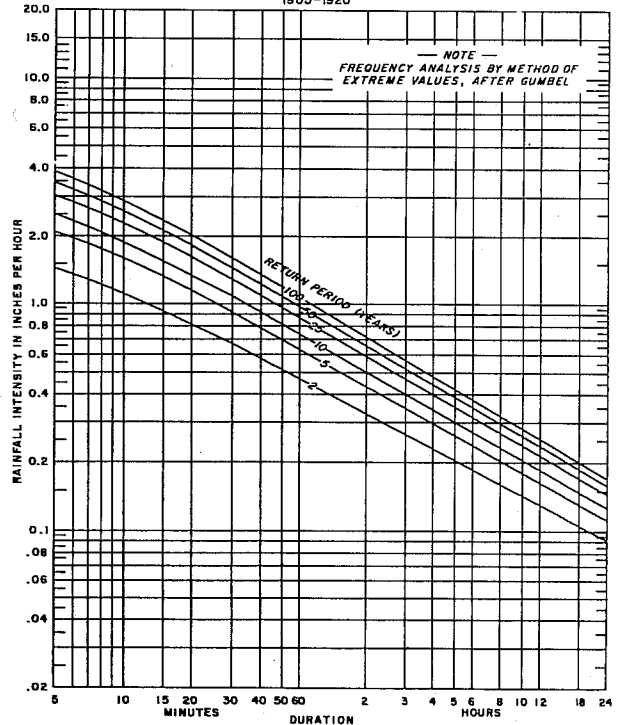
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1903-1950



**LOS ANGELES, CALIFORNIA**  
1903-1950

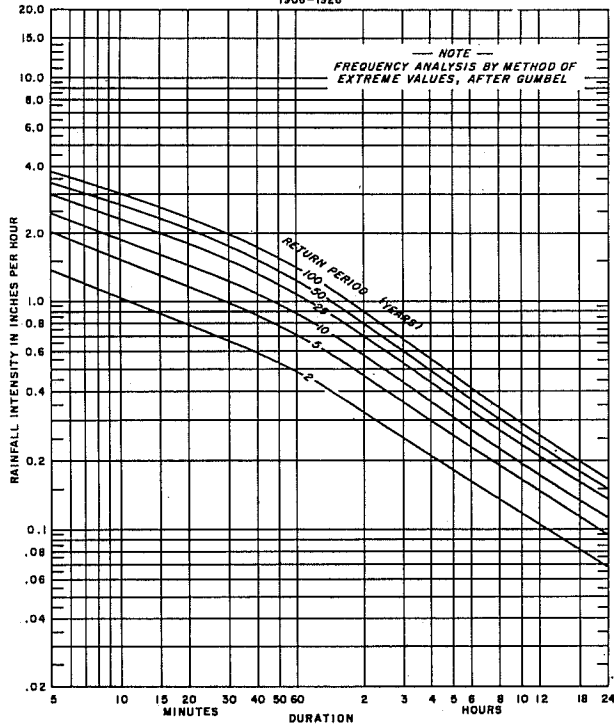


**MT. TAMALPAIS, CALIFORNIA**  
1905-1920

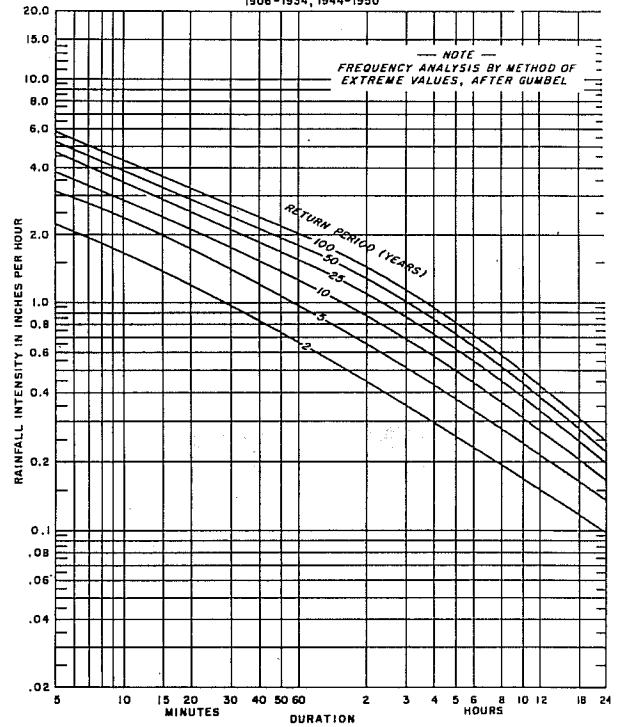


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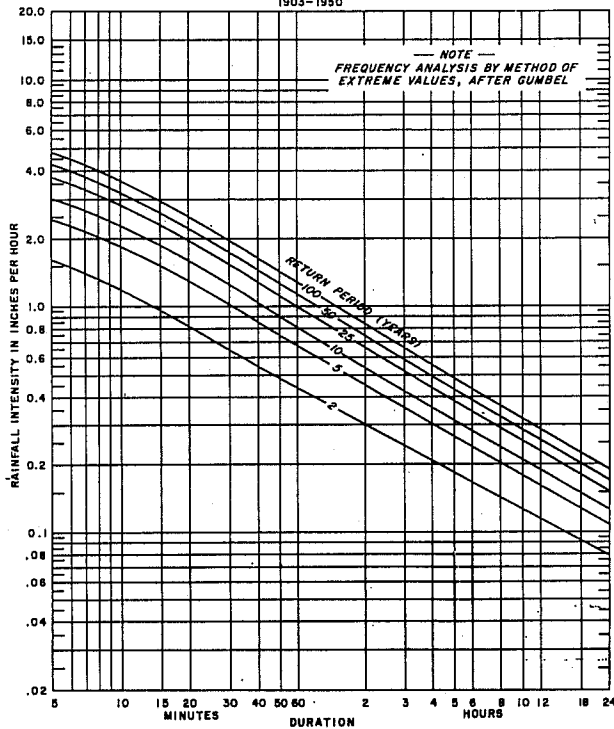
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1906-1926



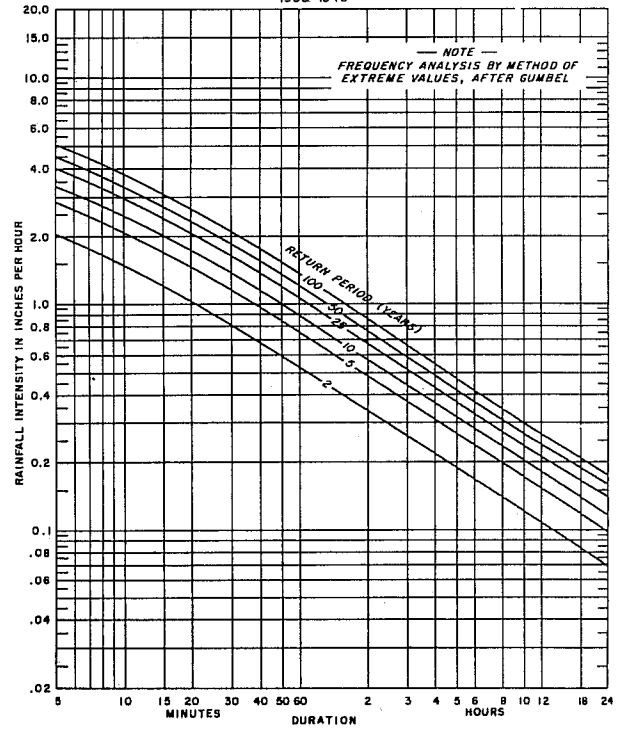
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**SACRAMENTO, CALIFORNIA**  
1903-1950

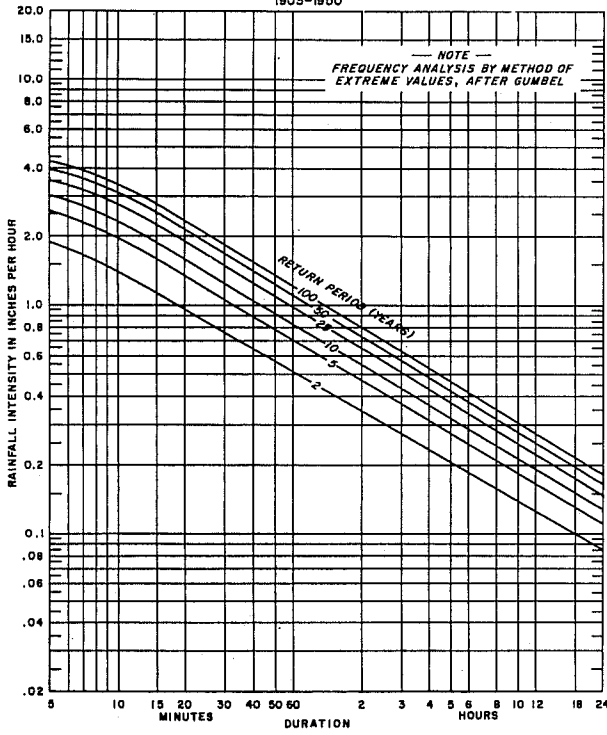


**SAN DIEGO, CALIFORNIA**  
1903-1949

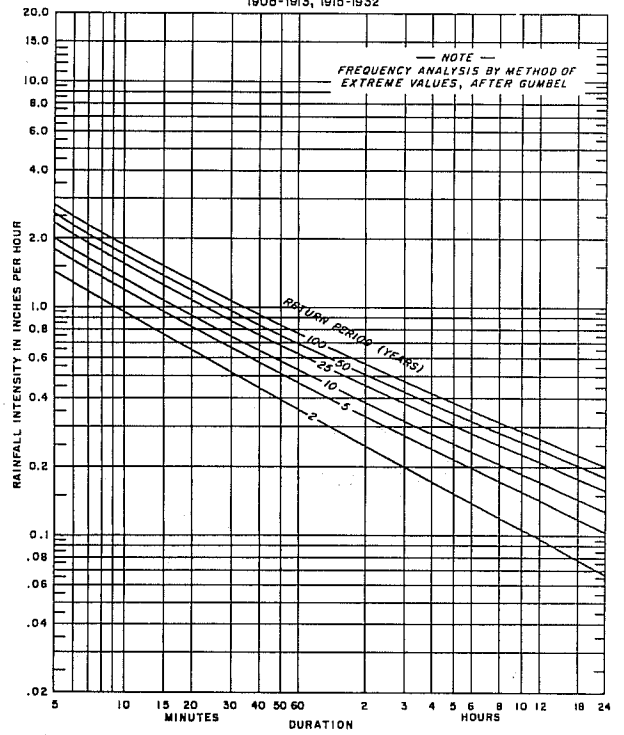


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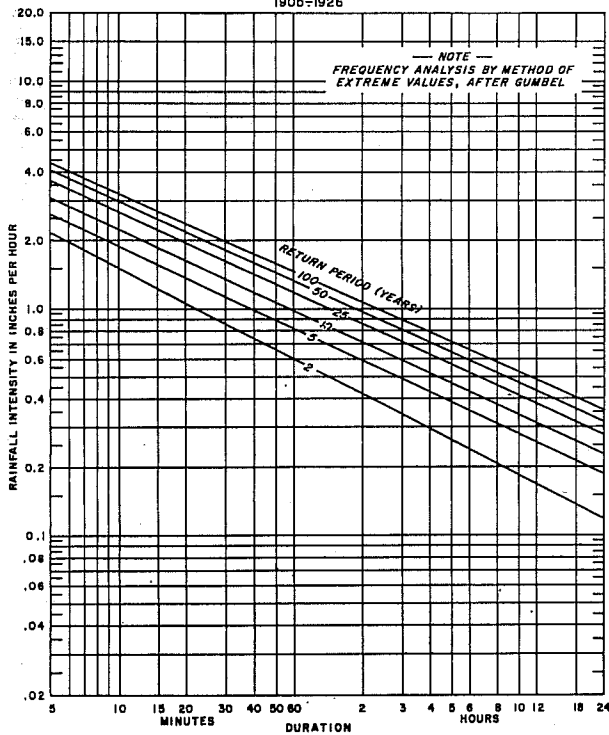
SAN FRANCISCO, CALIFORNIA  
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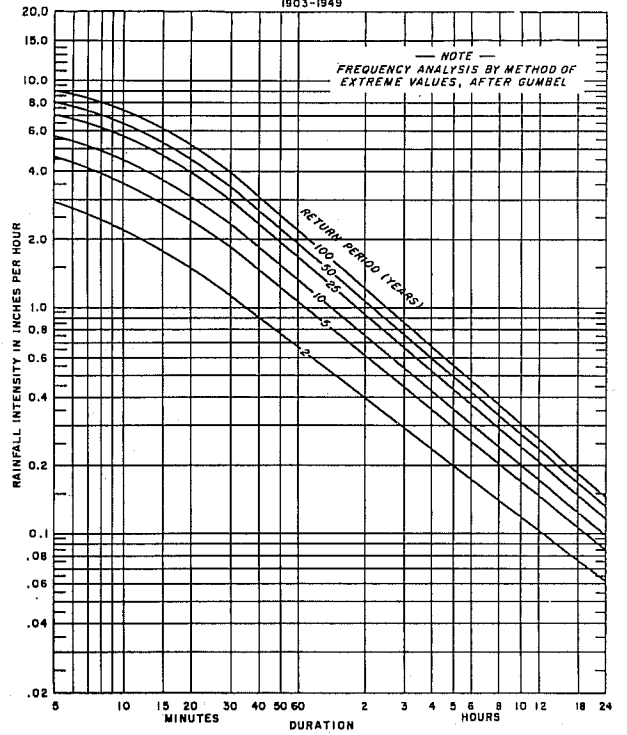
SAN JOSE, CALIFORNIA  
1908-1913, 1915-1932



SAN LUIS OBISPO, CALIFORNIA  
1905-1926

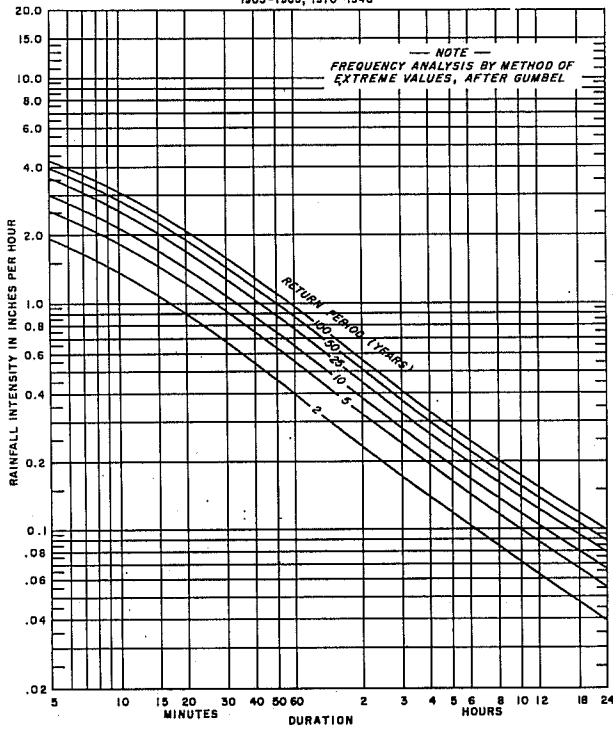


DENVER, COLORADO  
1903-1949

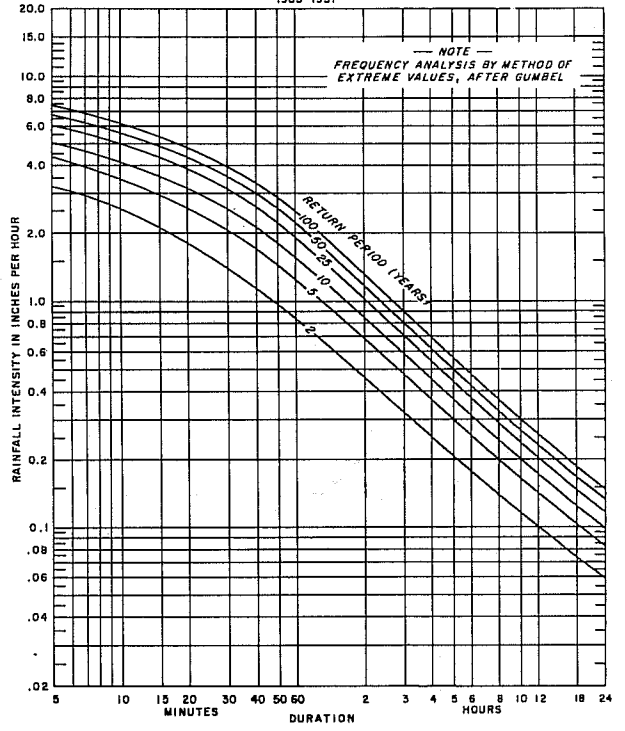


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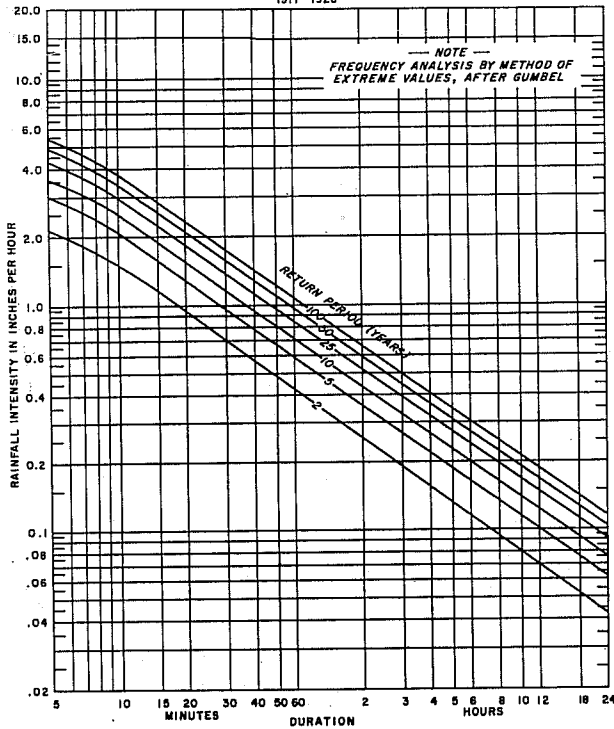
**GRAND JUNCTION, COLORADO**  
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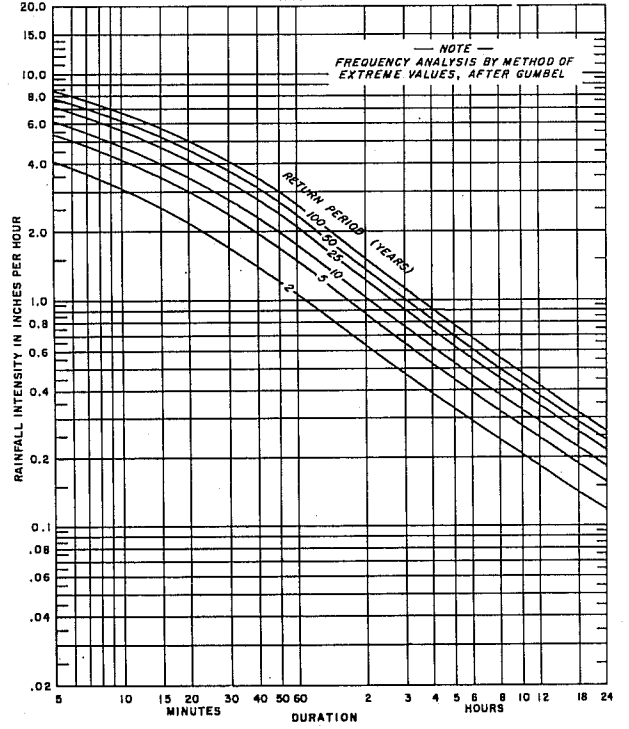
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1903-1951



**WAGON WHEEL GAP, COLORADO**  
1911-1926

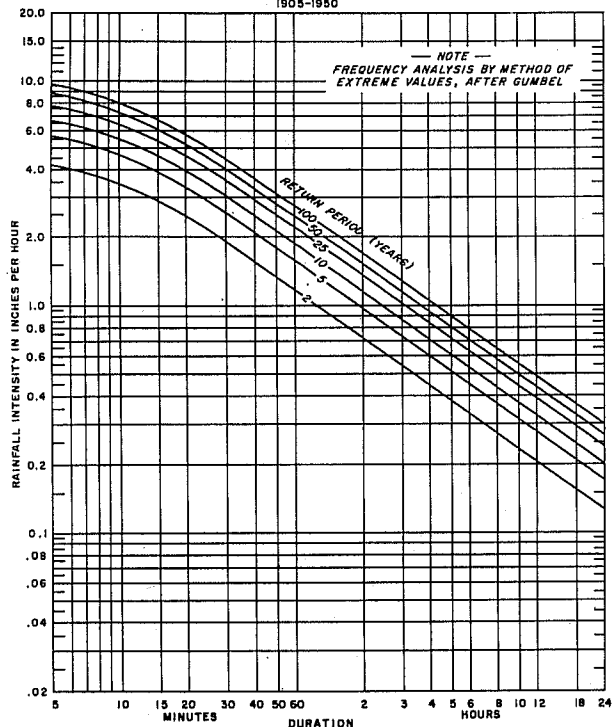


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1905-1951

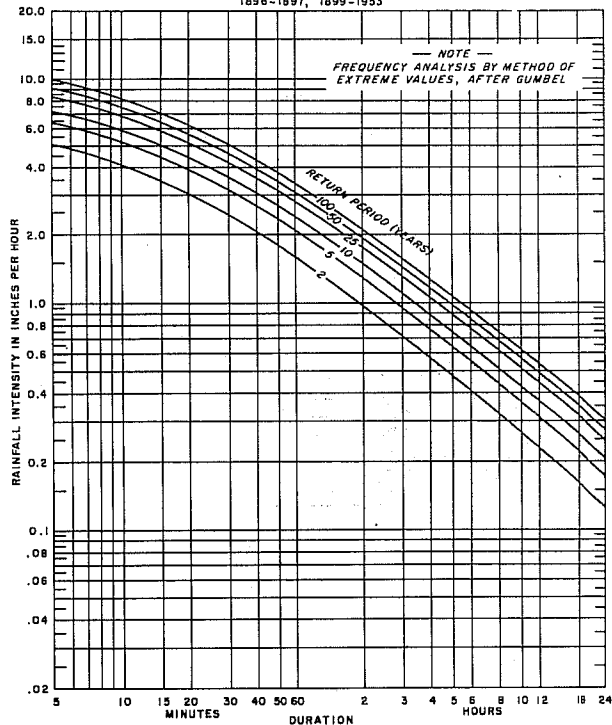


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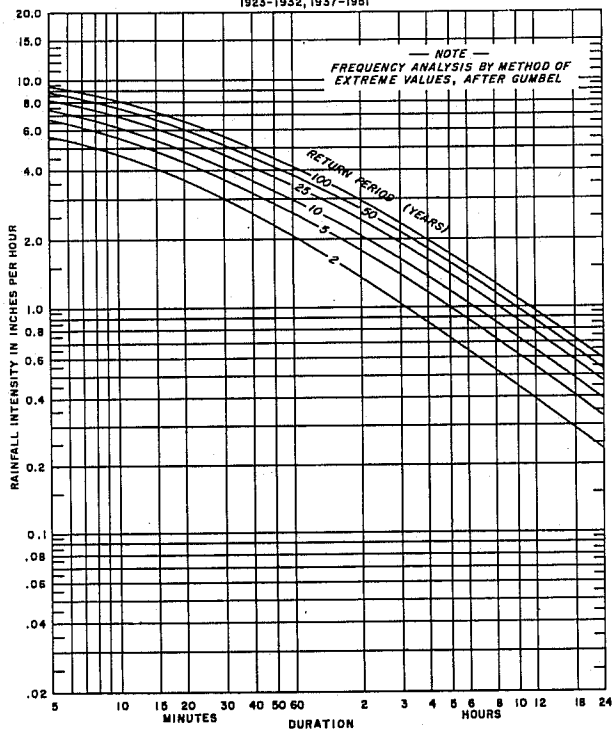
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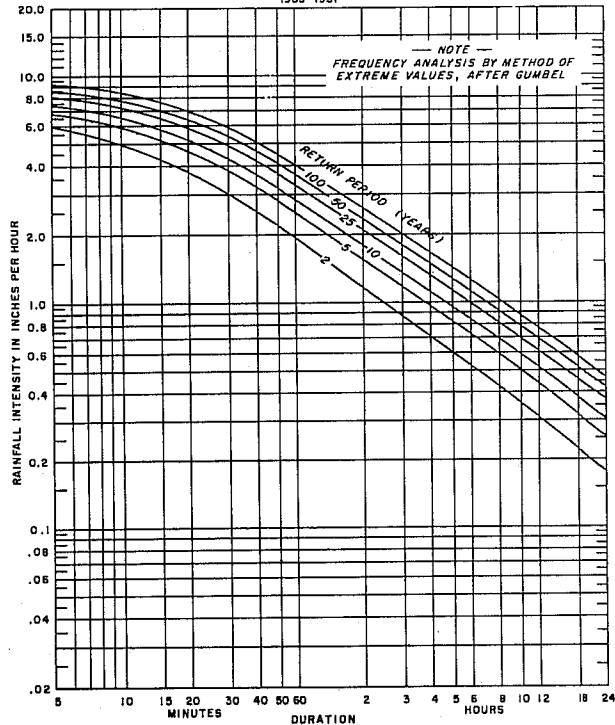
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1896-1897, 1899-1953



**APALACHICOLA, FLORIDA**  
1923-1932, 1937-1951

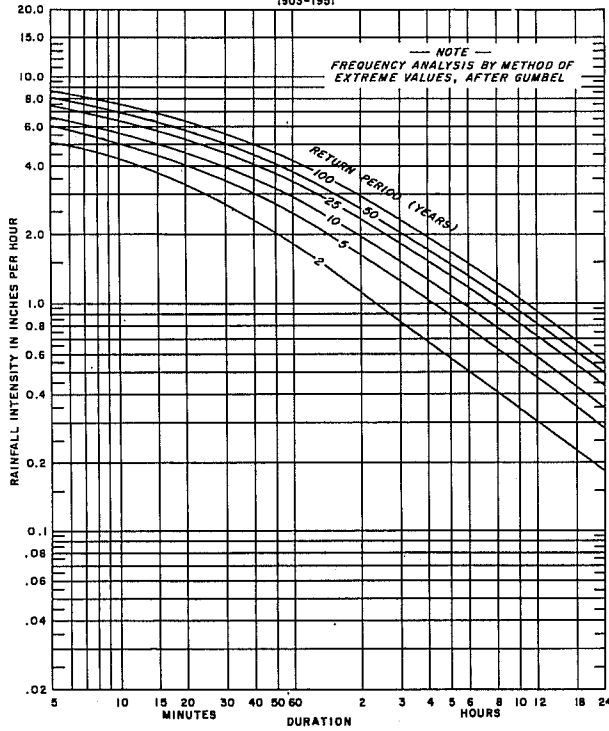


**JACKSONVILLE, FLORIDA**  
1903-1951

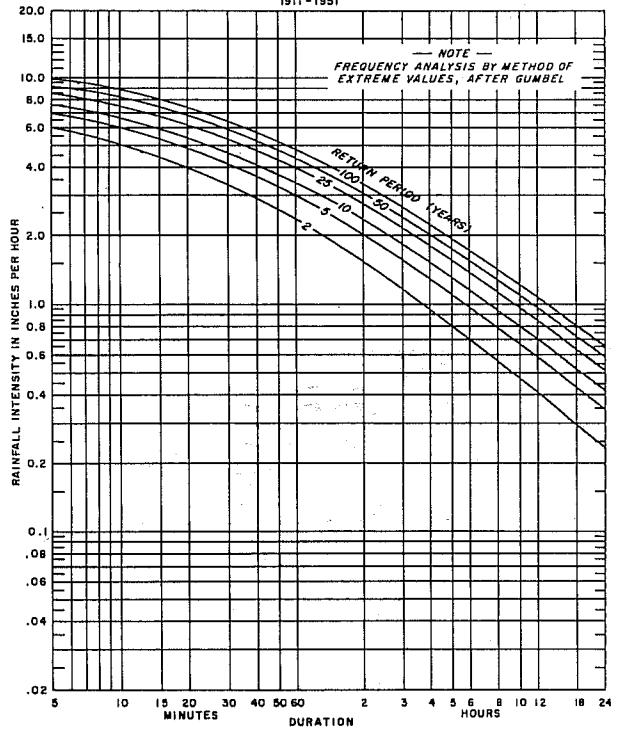


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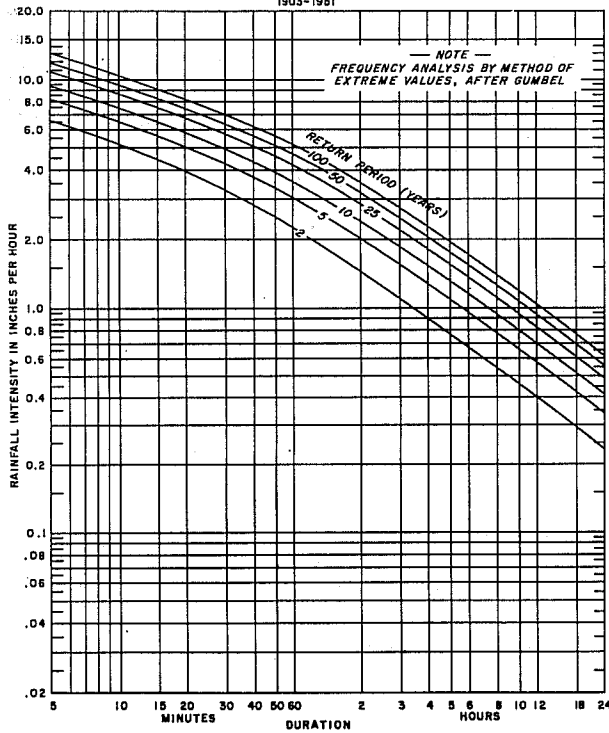
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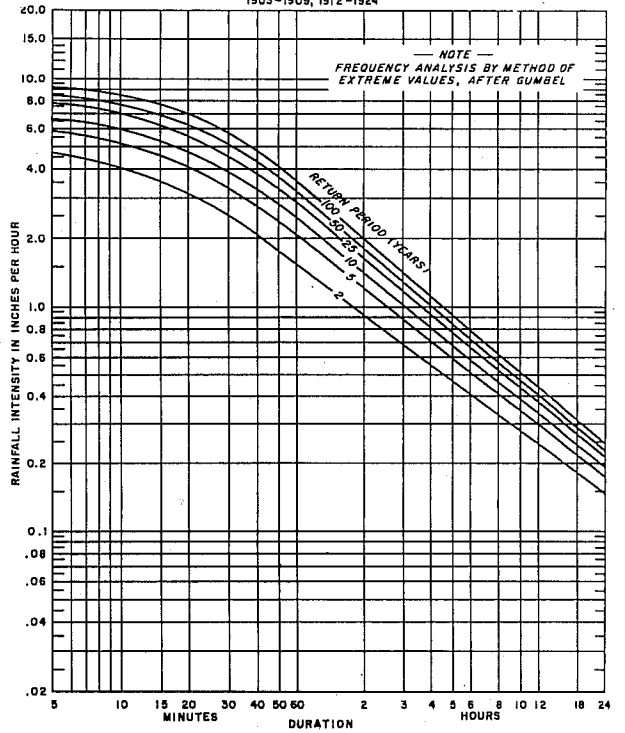
MIAMI, FLORIDA  
1911-1951



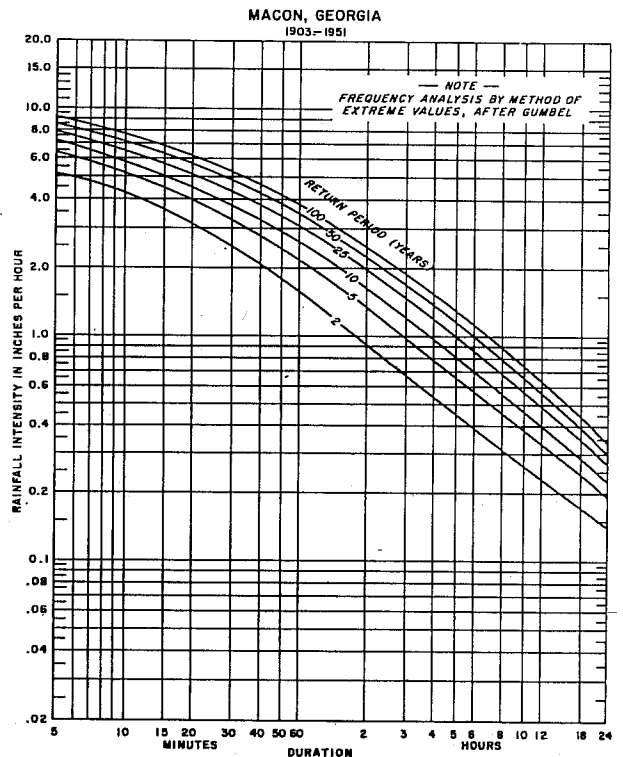
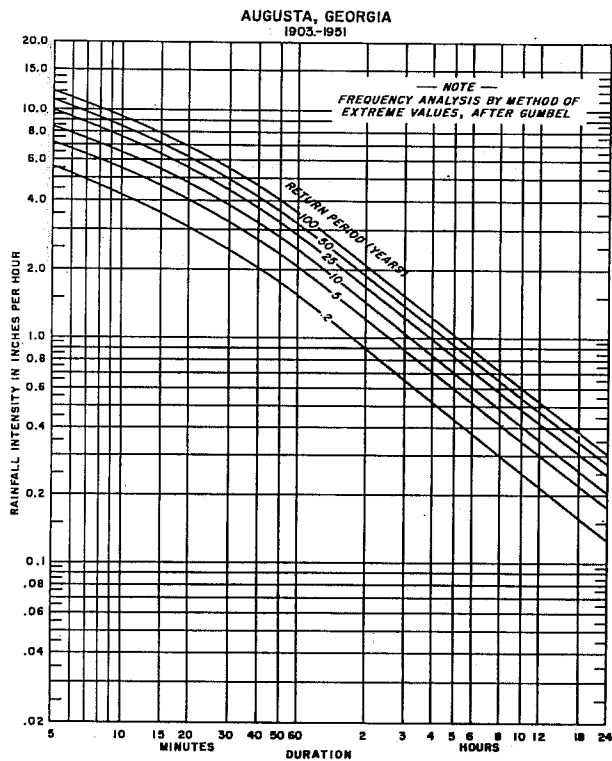
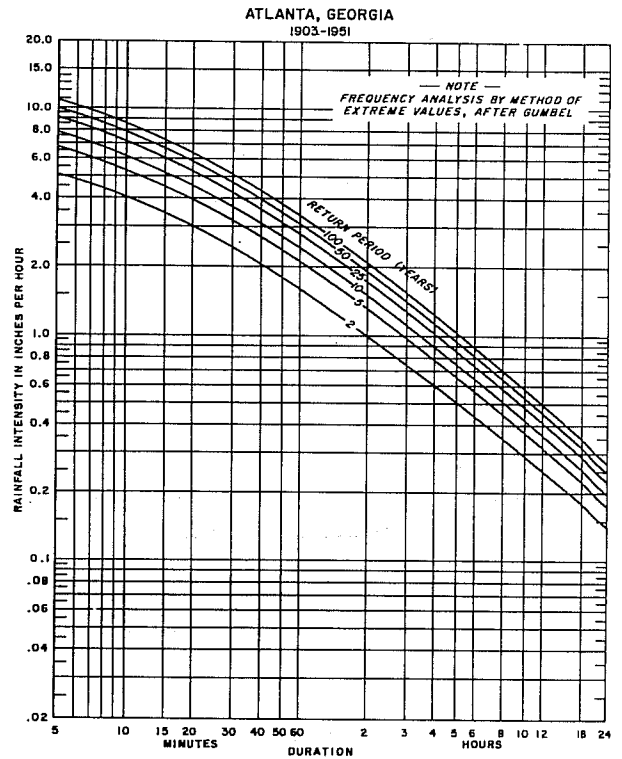
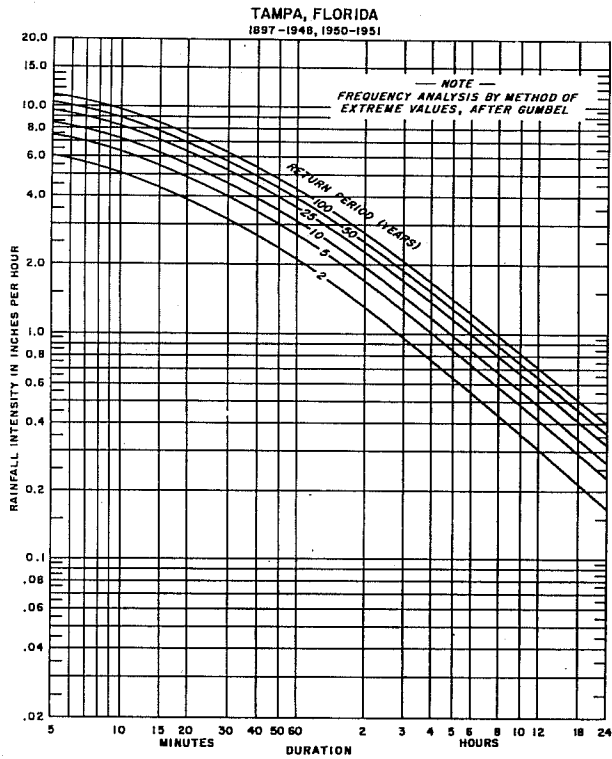
PENSACOLA, FLORIDA  
1903-1951



SAND KEY, FLORIDA  
1903-1909, 1912-1924



# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

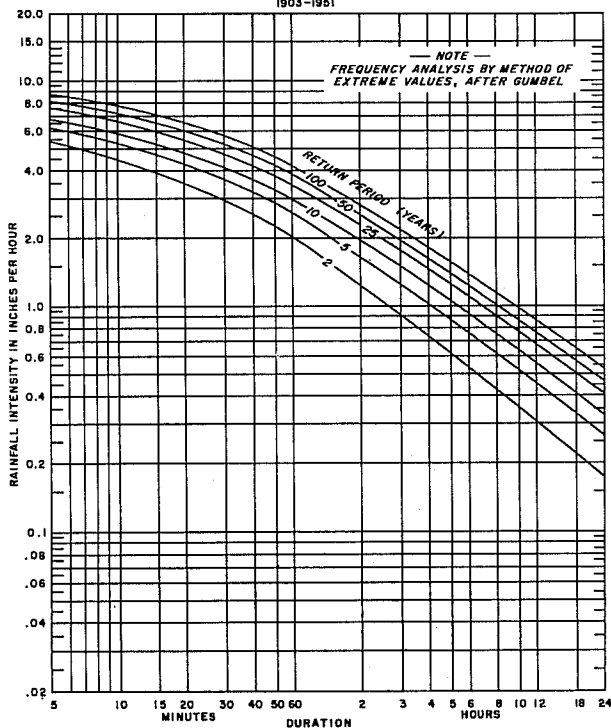


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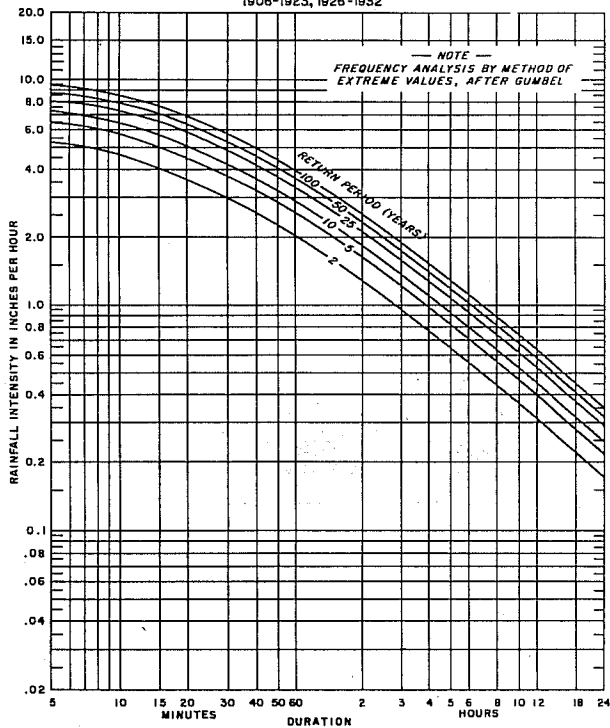


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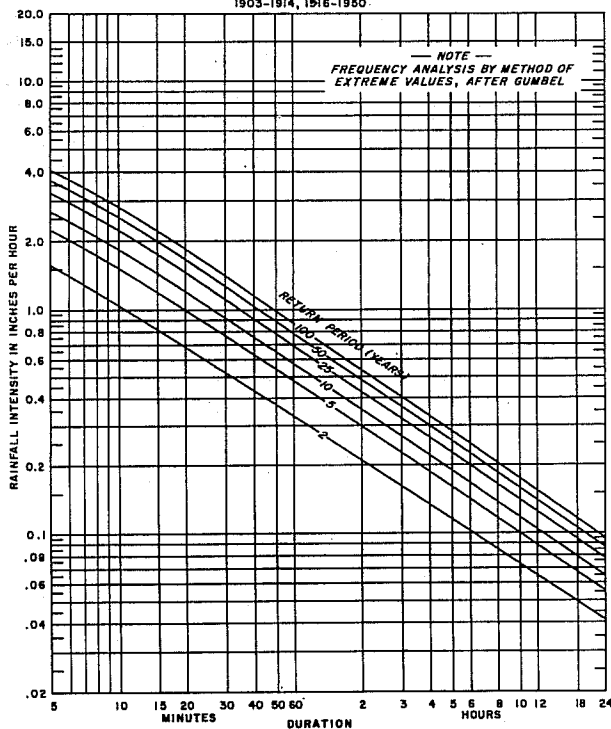
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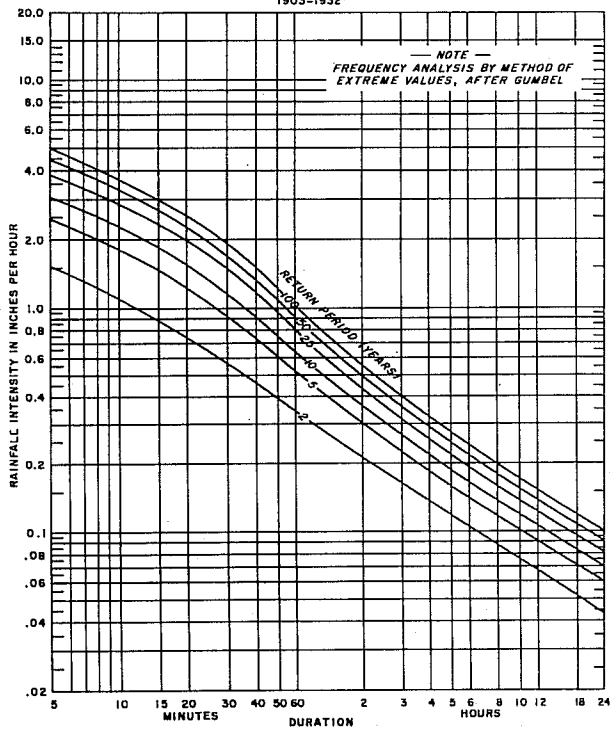
**THOMASVILLE, GEORGIA**  
1906-1923, 1926-1932



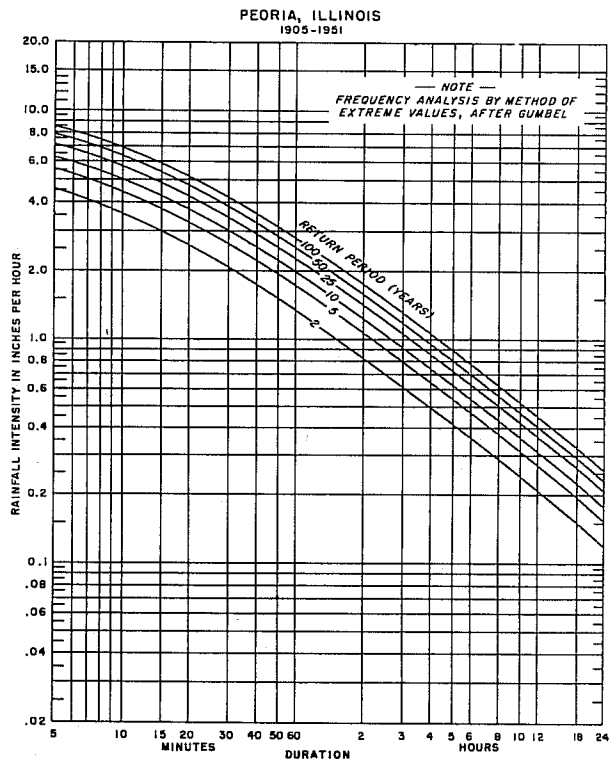
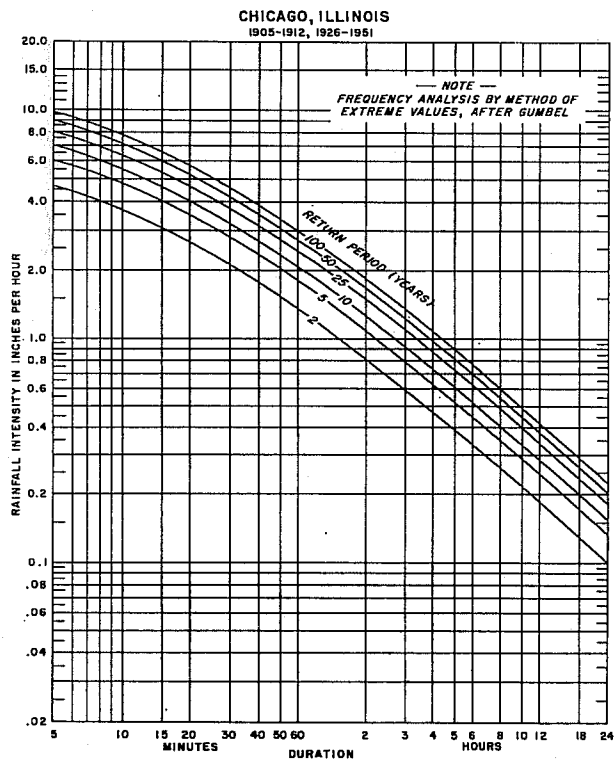
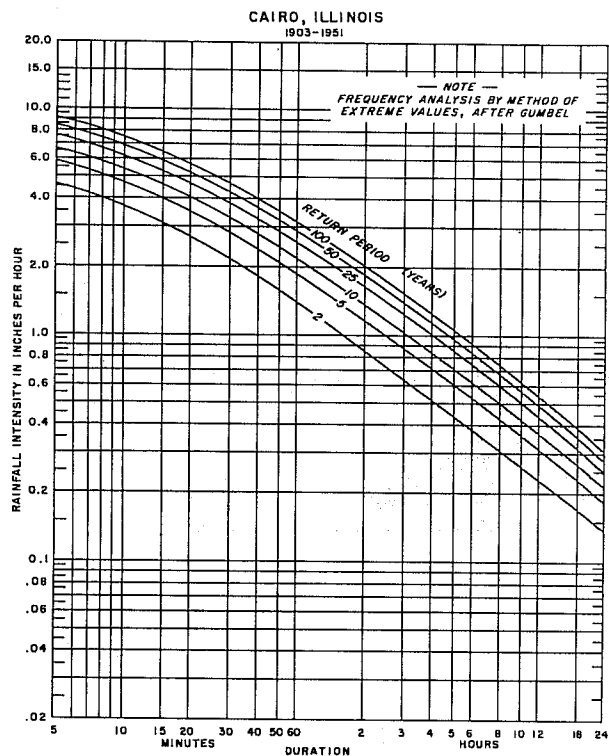
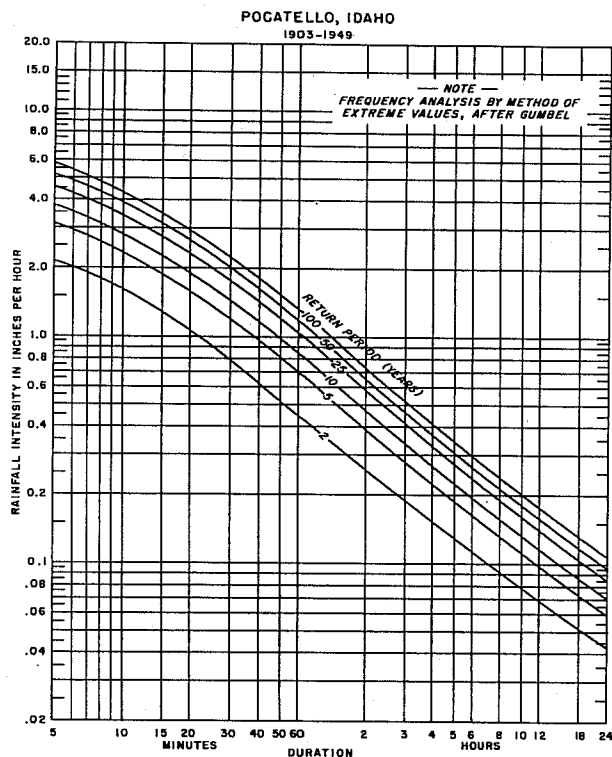
**BOISE, IDAHO**  
1903-1914, 1916-1960



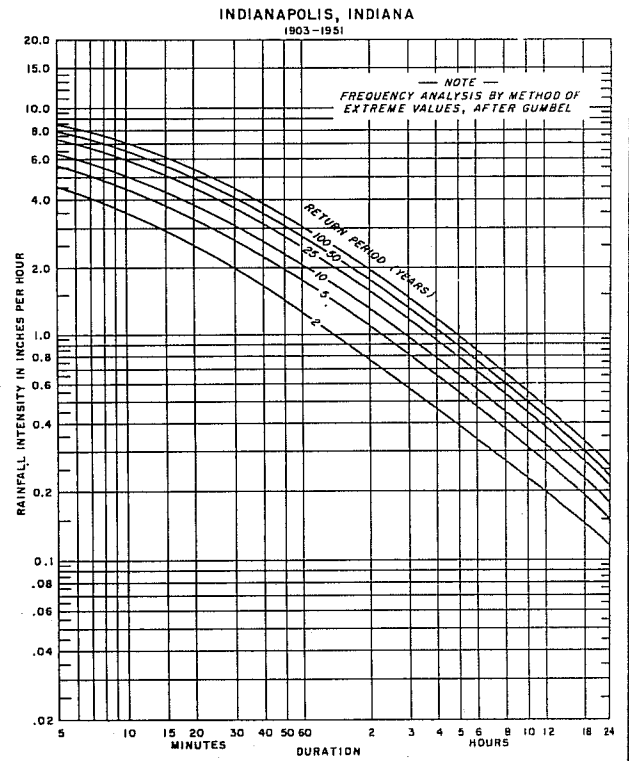
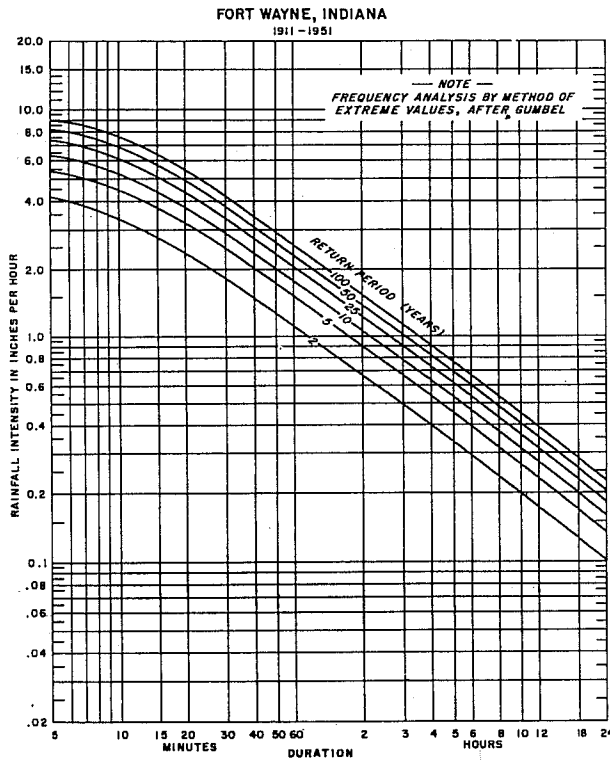
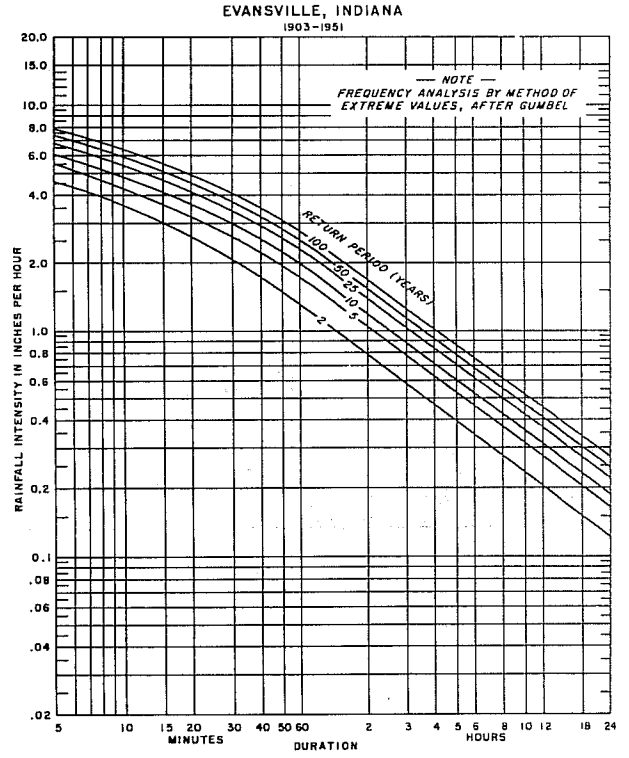
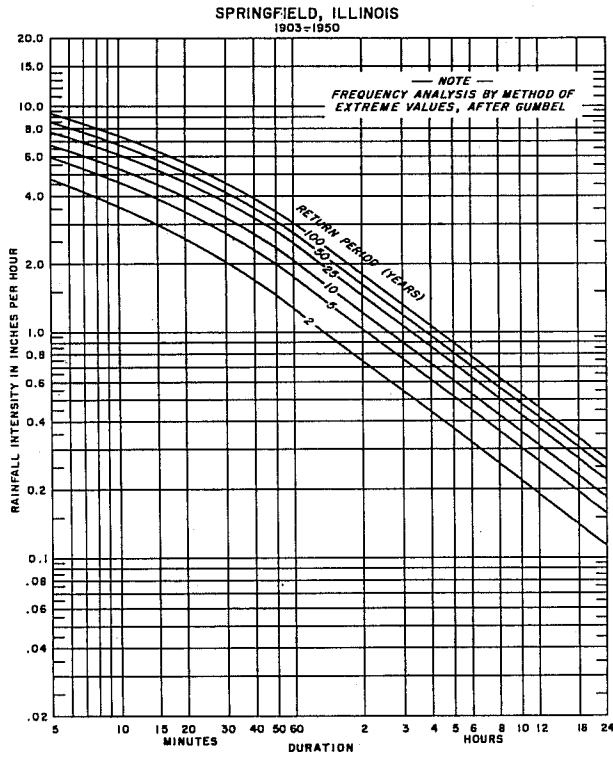
**LEWISTON, IDAHO**  
1903-1932



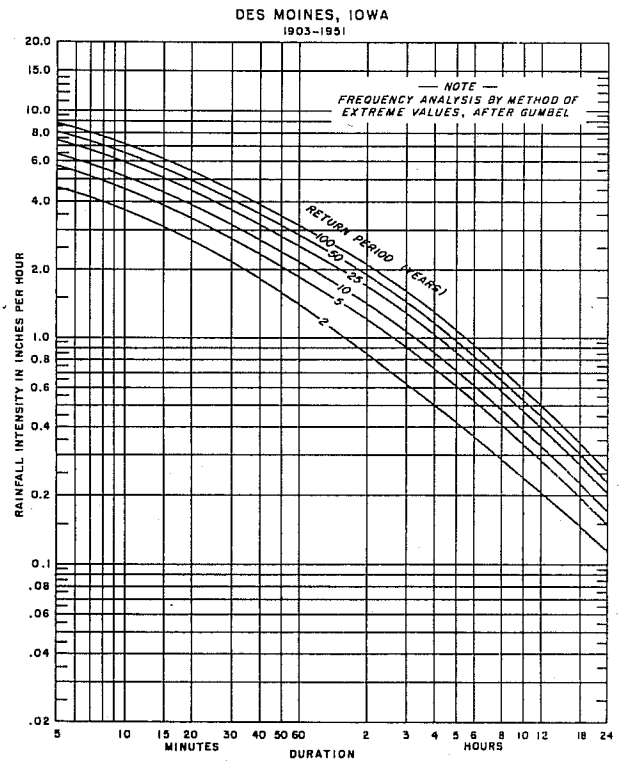
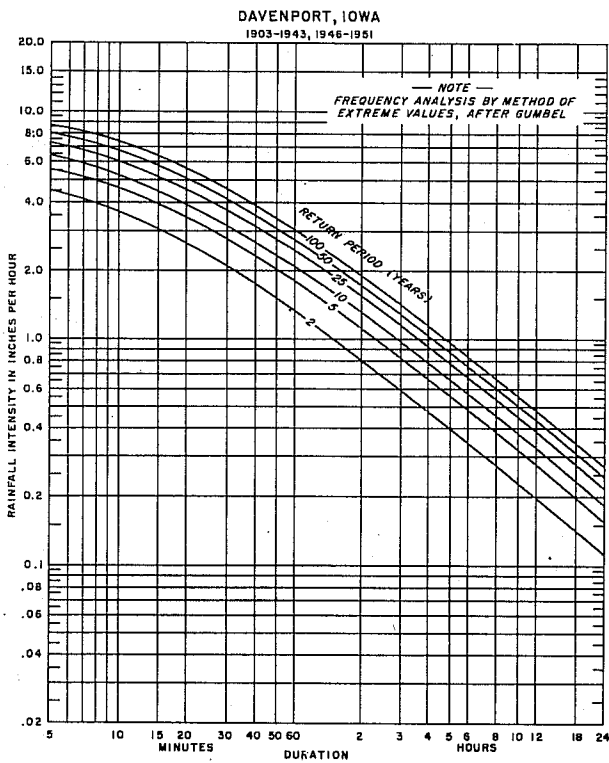
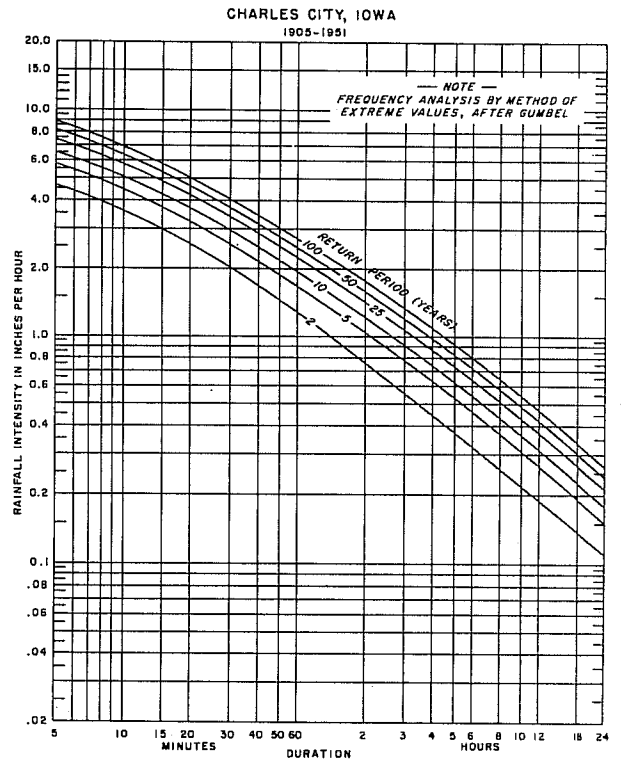
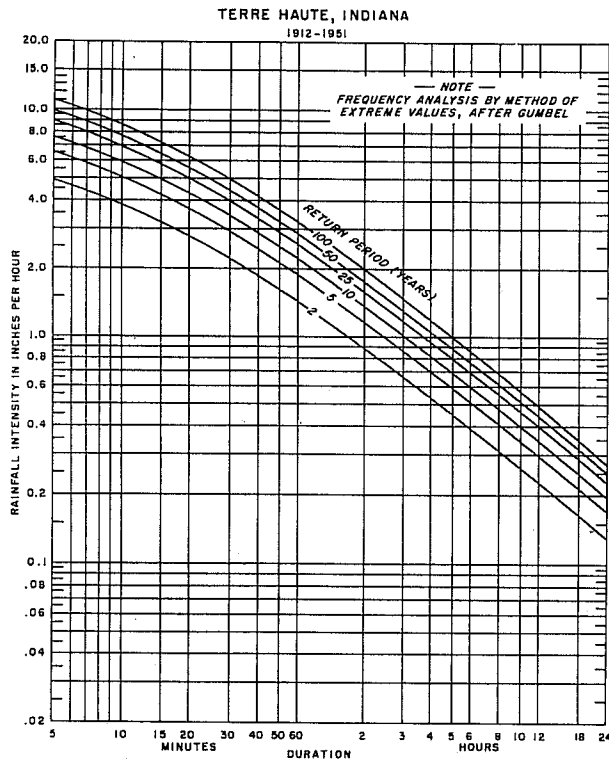
# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES



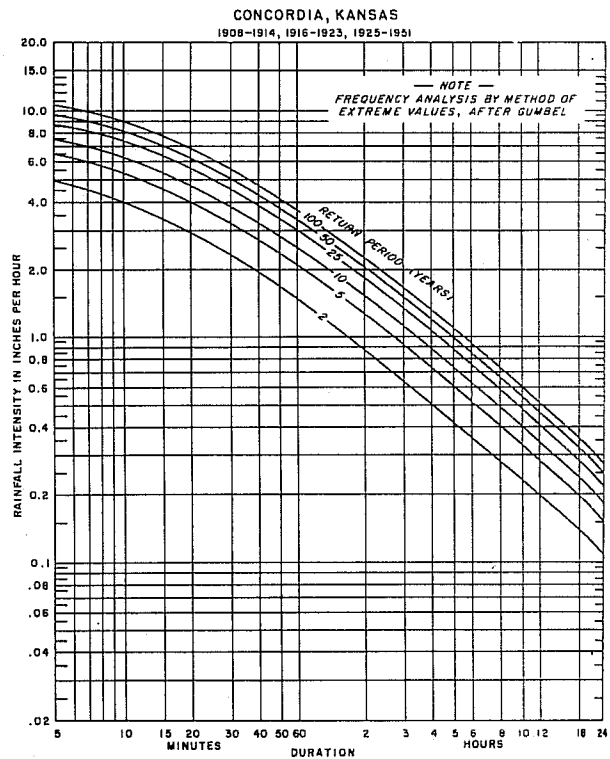
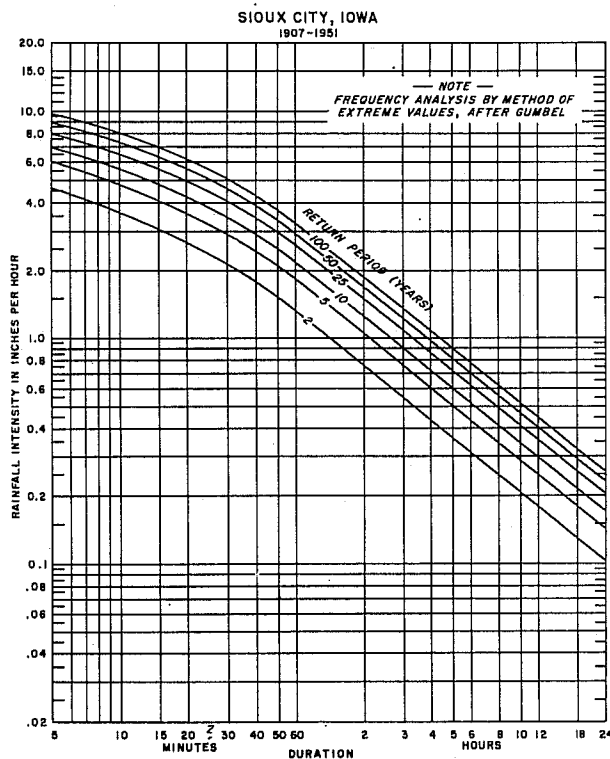
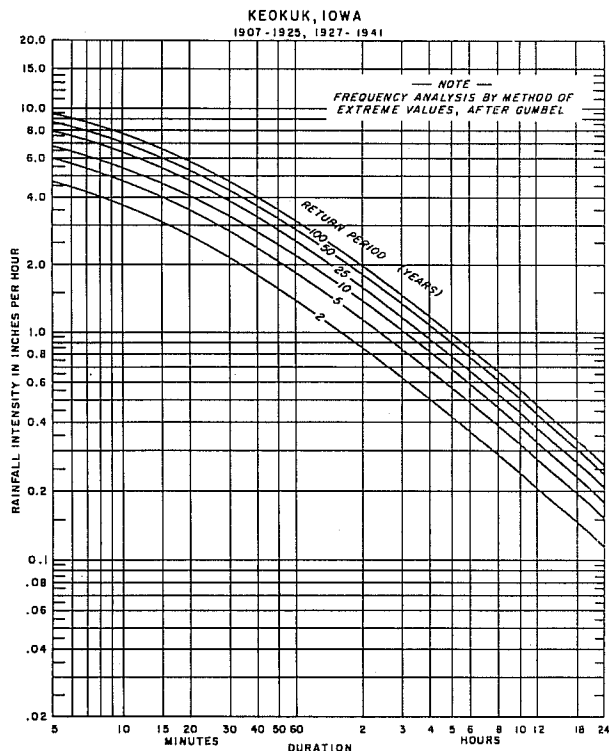
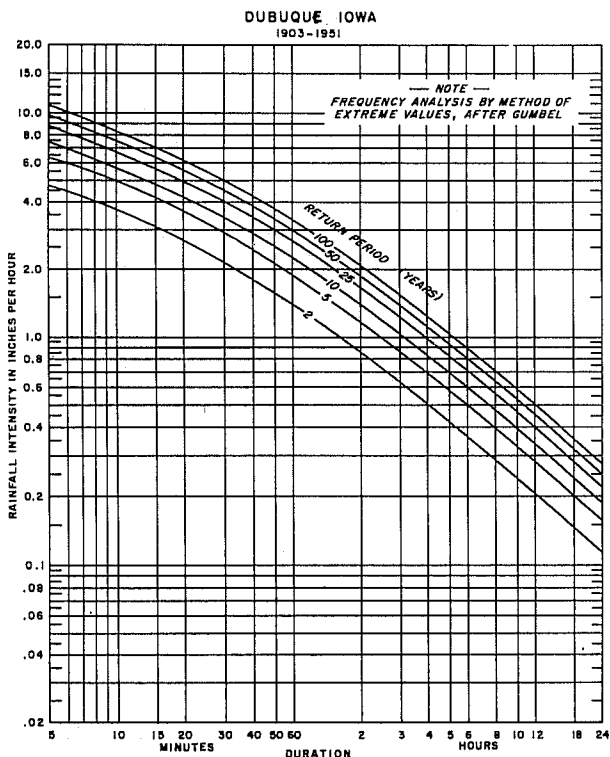
# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES



# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

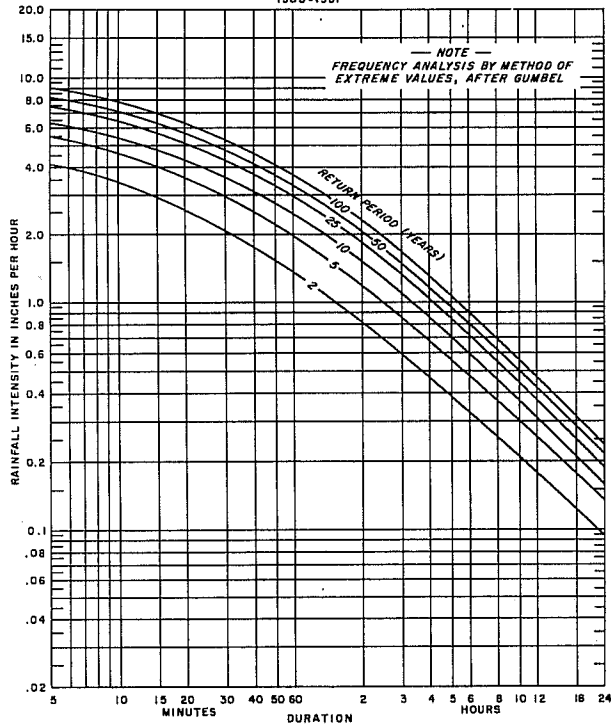


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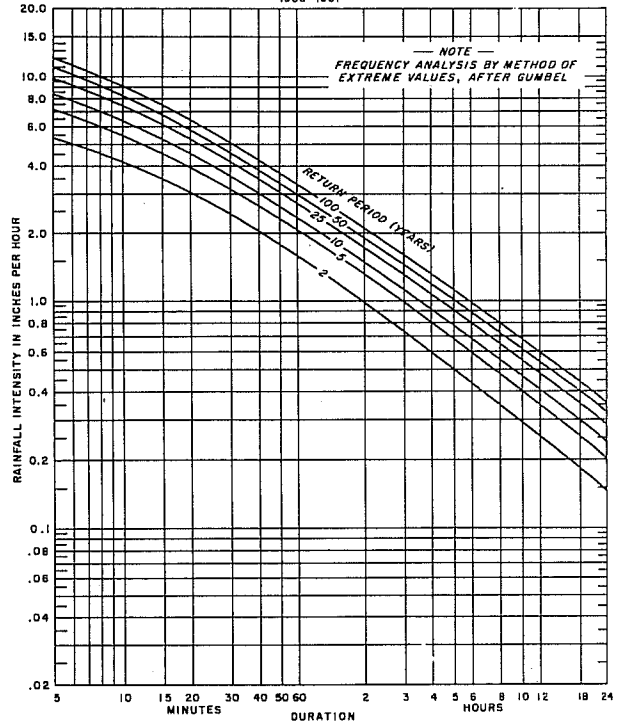


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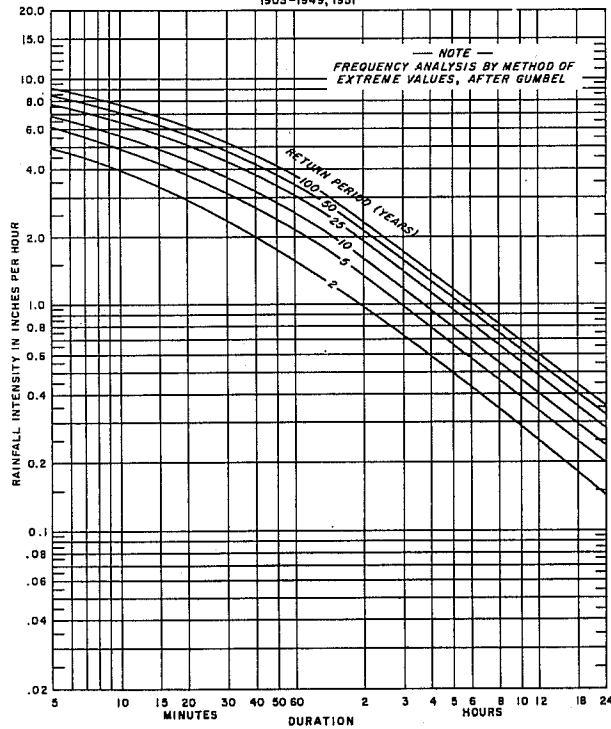
**DODGE CITY, KANSAS**  
1905-1951



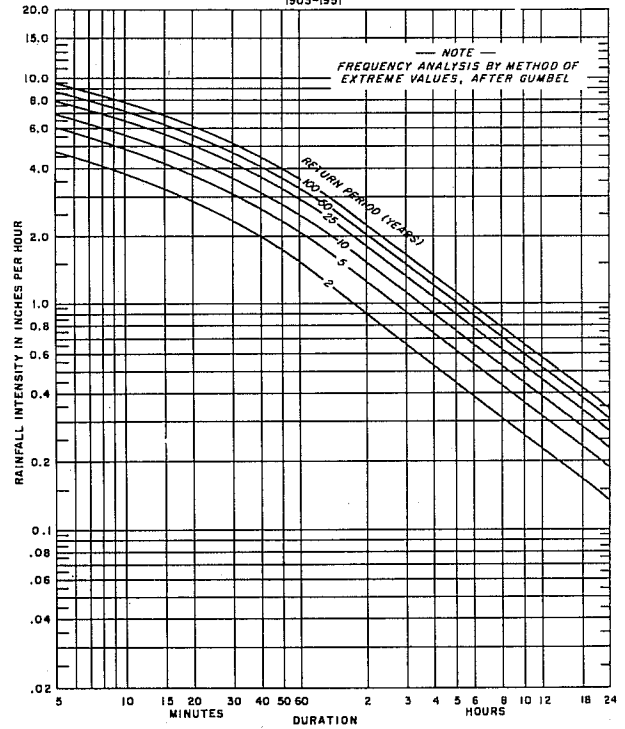
**IOLA, KANSAS**  
1906-1931



**TOPEKA, KANSAS**  
1903-1949, 1951

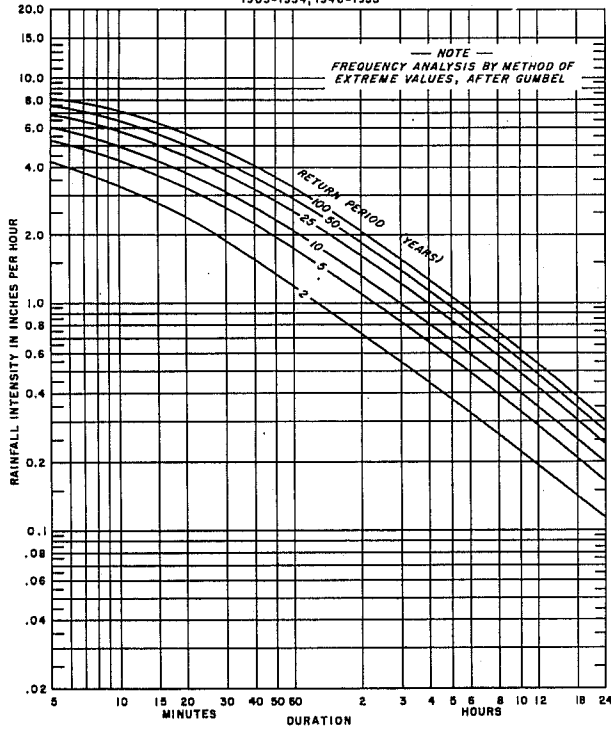


**WICHITA, KANSAS**  
1903-1951

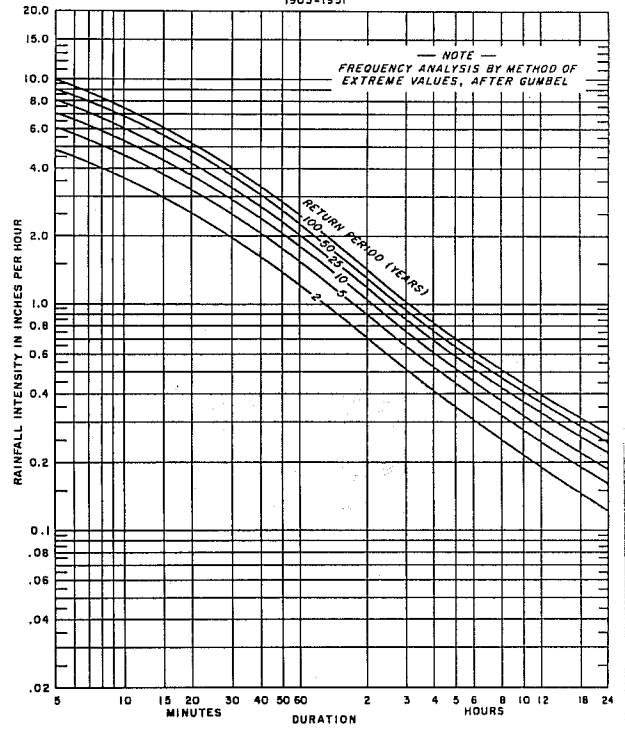


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

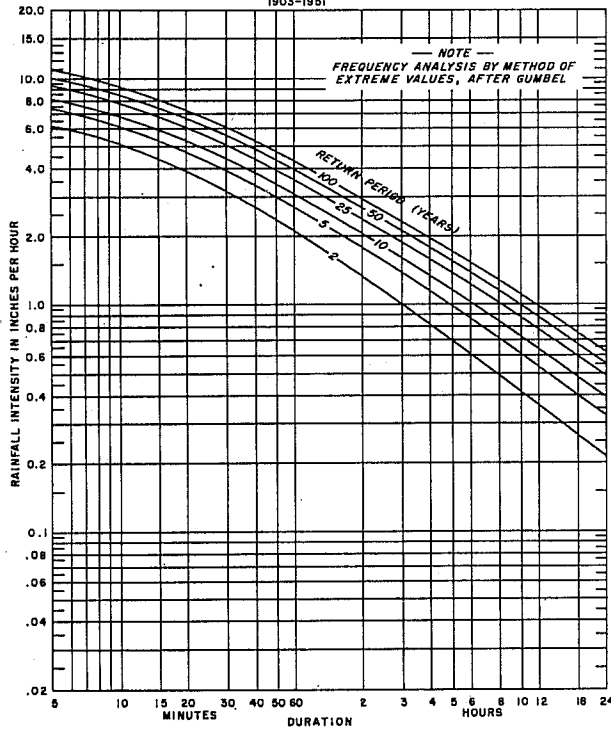
**LEXINGTON, KENTUCKY**  
1903-1934, 1946-1953



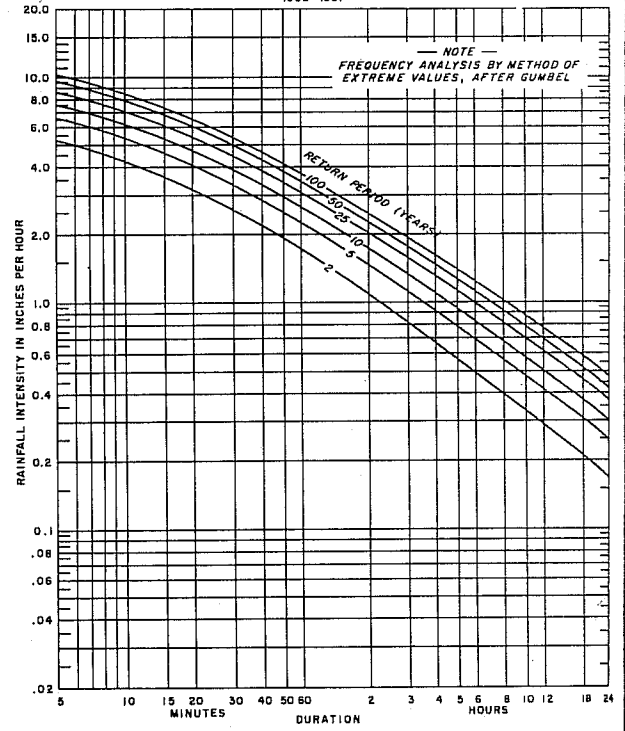
**LOUISVILLE, KENTUCKY**  
1903-1951



**NEW ORLEANS, LOUISIANA**  
1903-1951

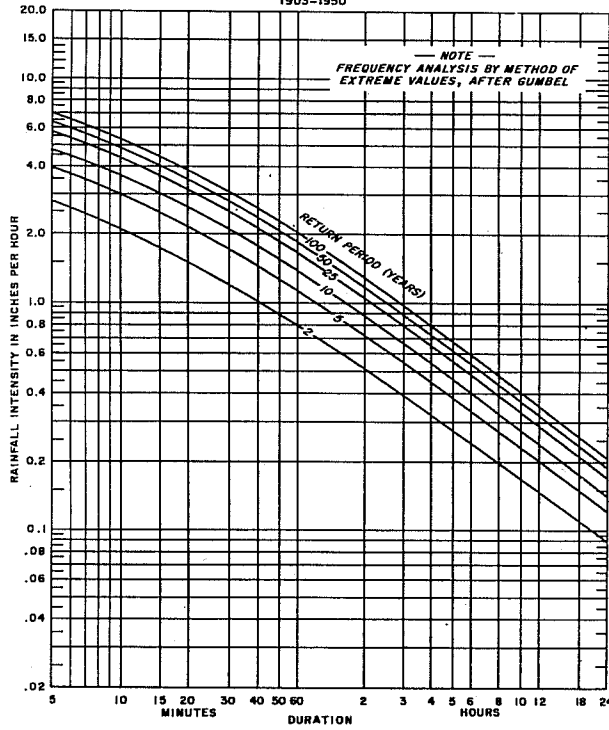


**SHREVEPORT, LOUISIANA**  
1903-1951

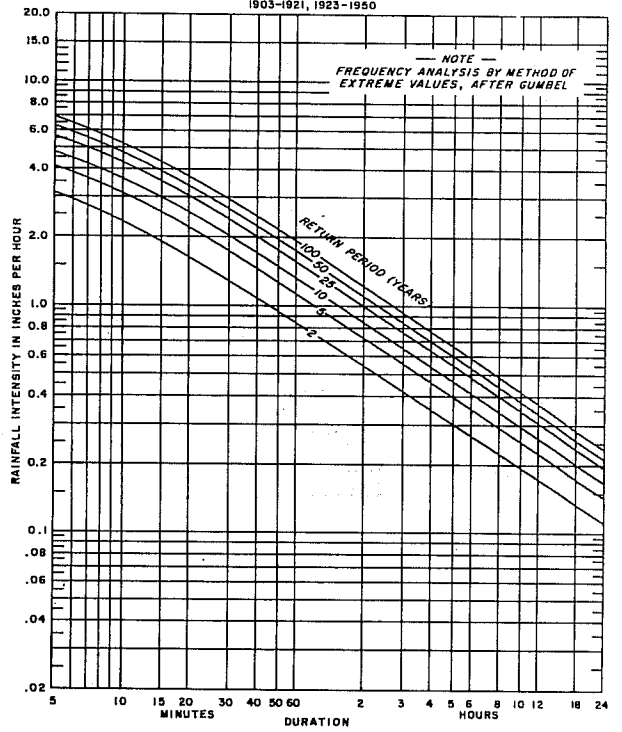


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

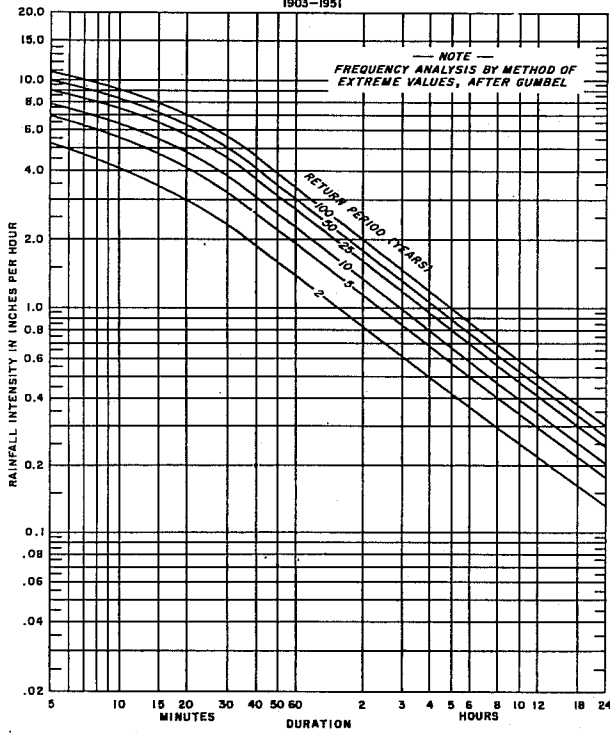
**EASTPORT, MAINE**  
1903-1950



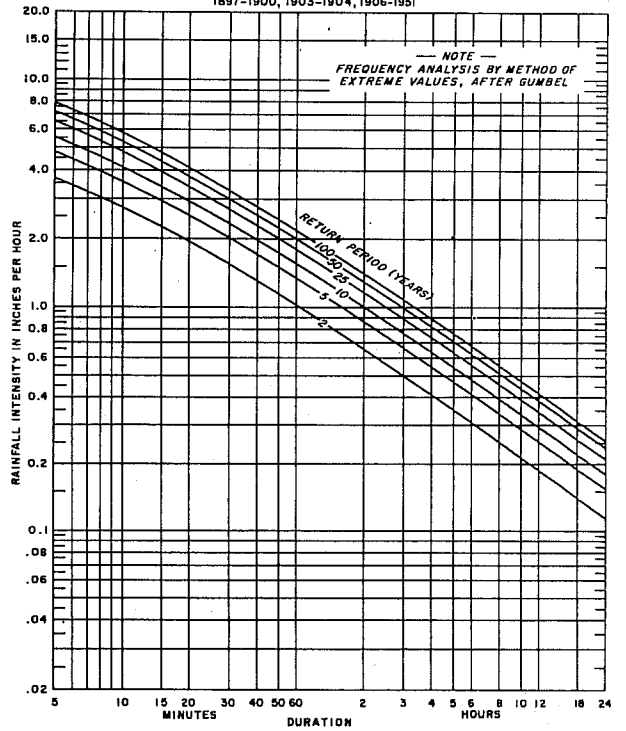
**PORTLAND, MAINE**  
1903-1921, 1923-1950



**BALTIMORE, MARYLAND**  
1903-1951

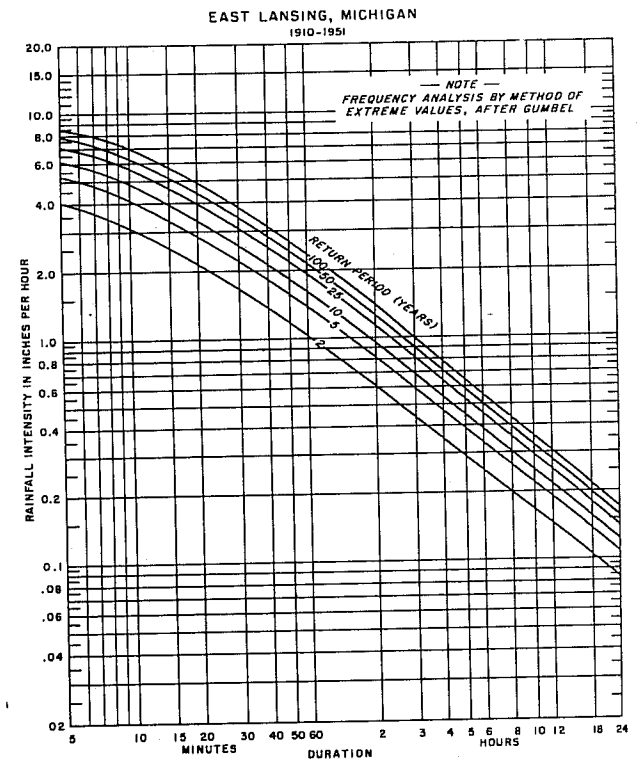
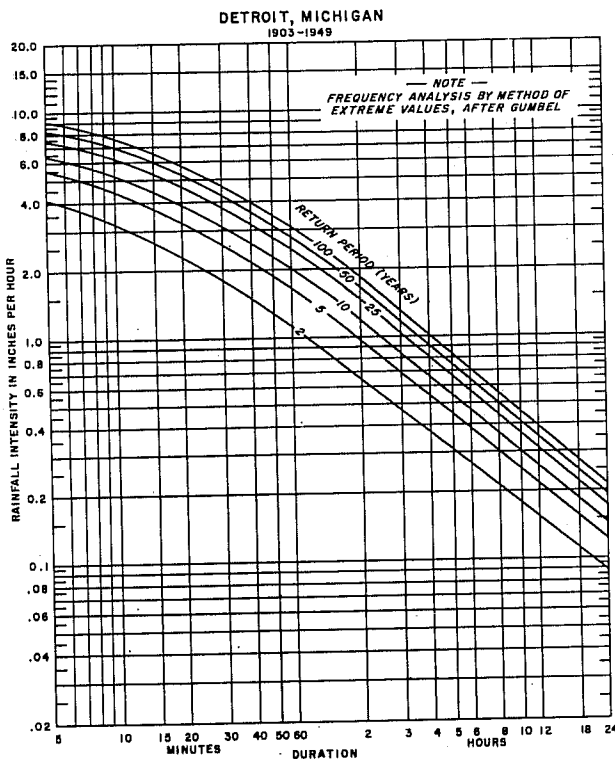
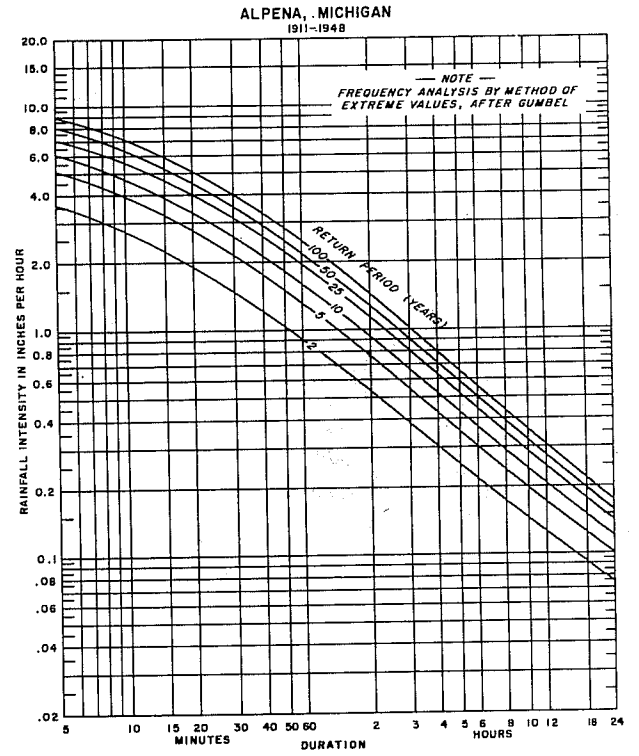
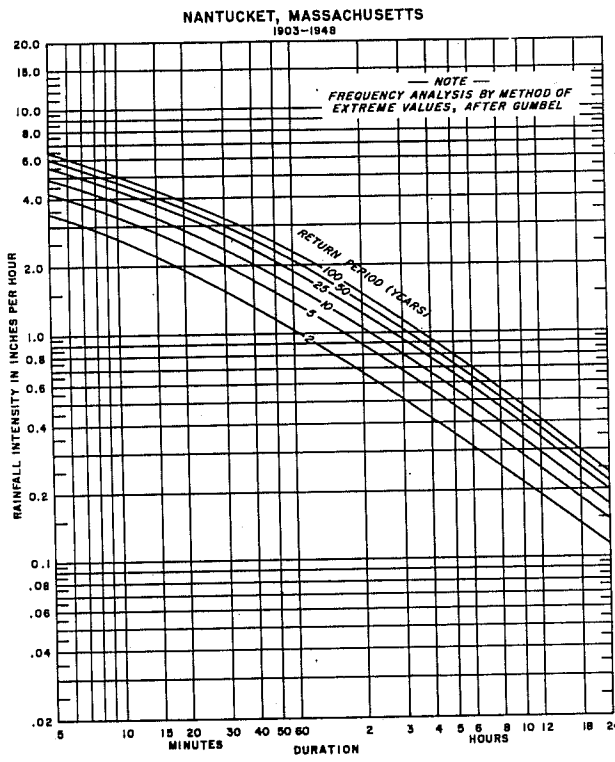


**BOSTON, MASSACHUSETTS**  
1897-1900, 1903-1904, 1906-1951



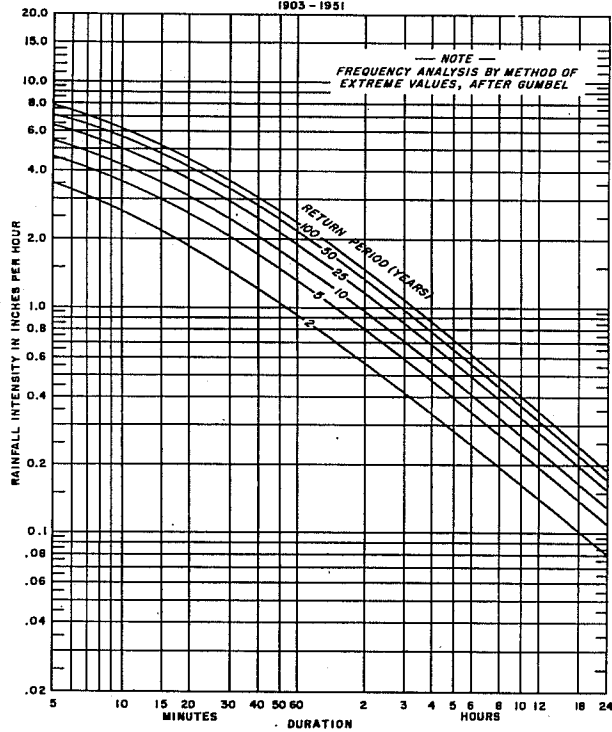


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

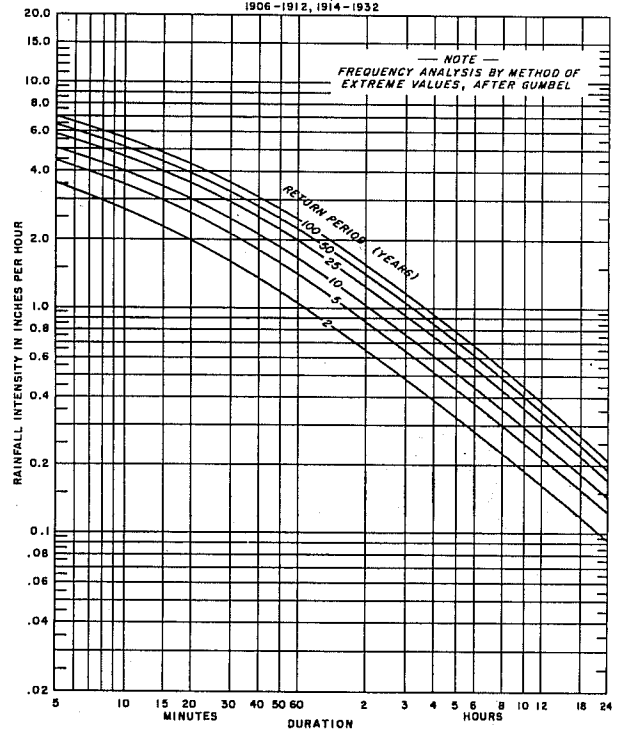


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

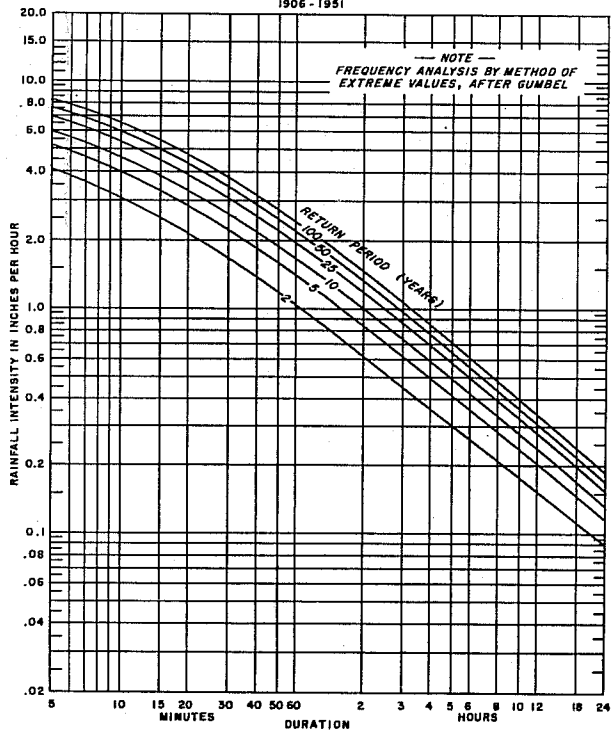
ESCANABA, MICHIGAN  
1903 - 1951



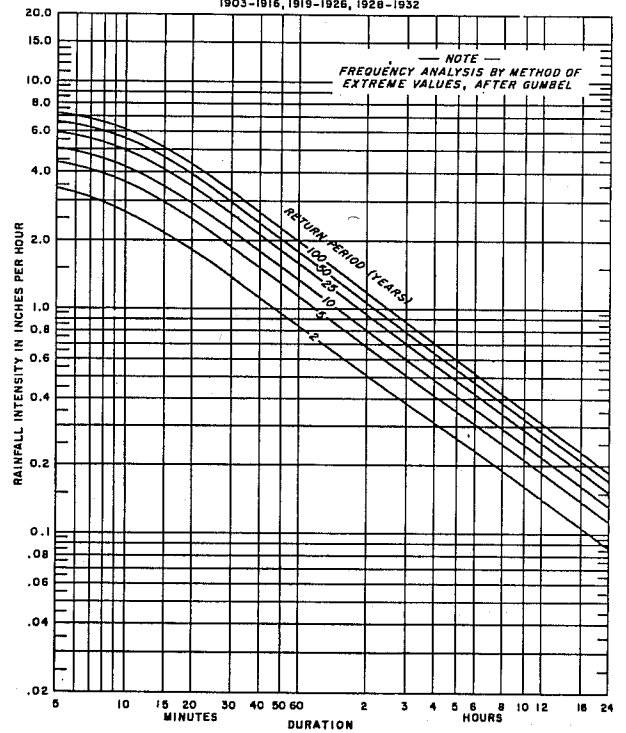
GRAND HAVEN, MICHIGAN  
1906 - 1912, 1914 - 1932



GRAND RAPIDS, MICHIGAN  
1906 - 1951

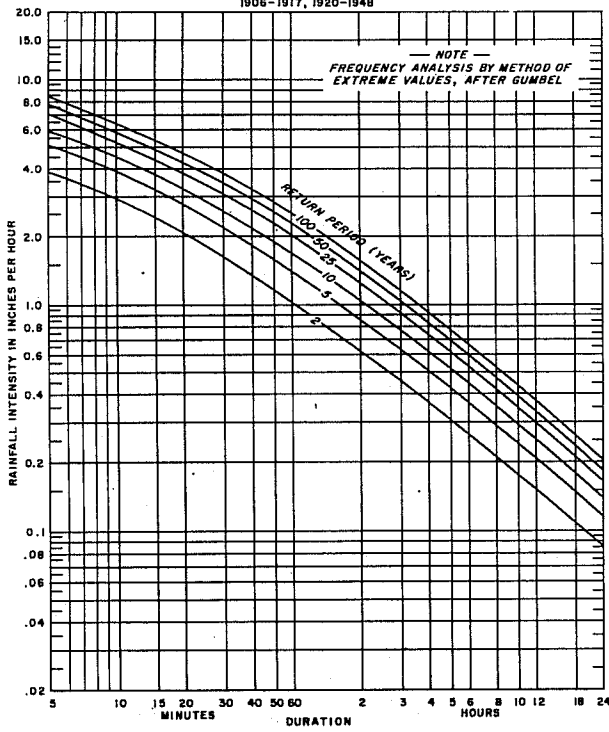


HOUGHTON, MICHIGAN  
1903 - 1916, 1919 - 1926, 1928 - 1932

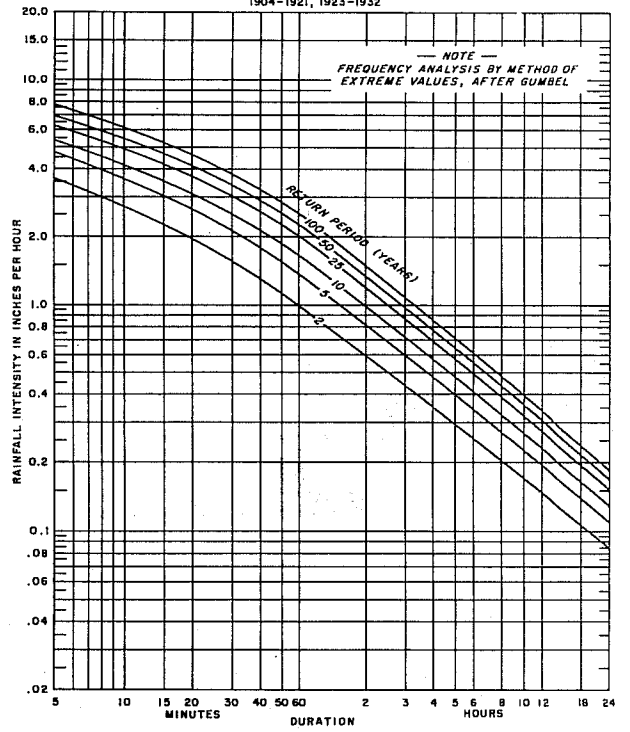


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

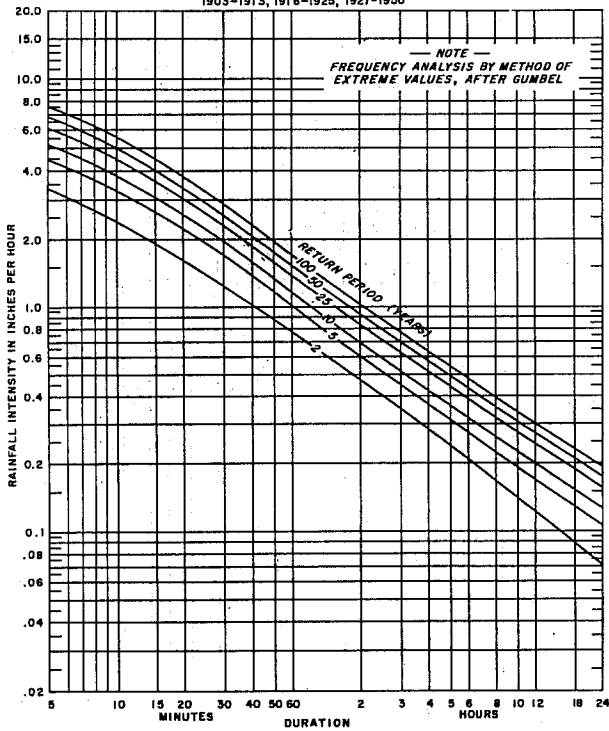
**MARQUETTE, MICHIGAN**  
1906-1917, 1920-1948



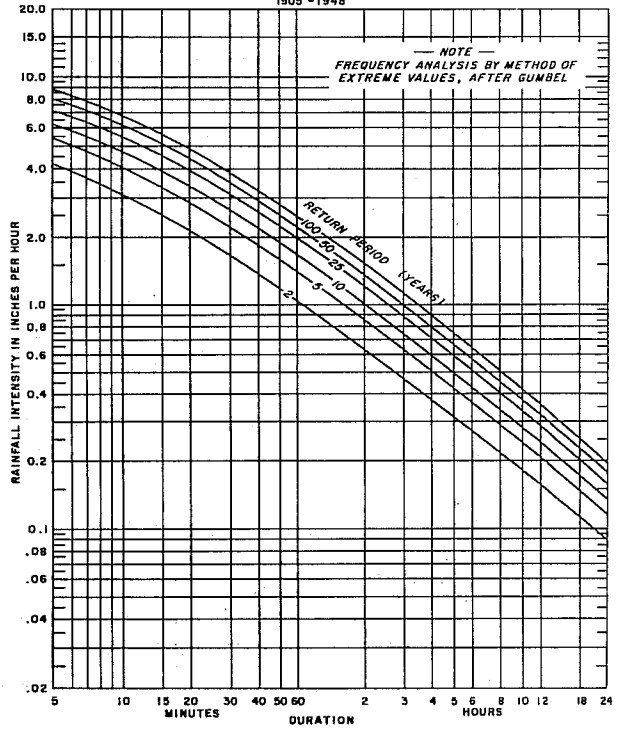
**PORT HURON, MICHIGAN**  
1904-1921, 1923-1932



**SAULT STE. MARIE, MICHIGAN**  
1903-1913, 1916-1925, 1927-1950

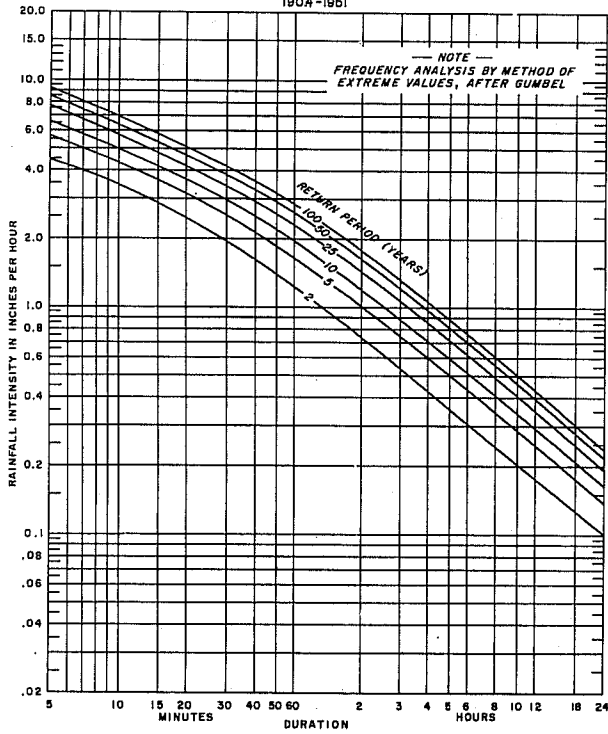


**DULUTH, MINNESOTA**  
1905-1948

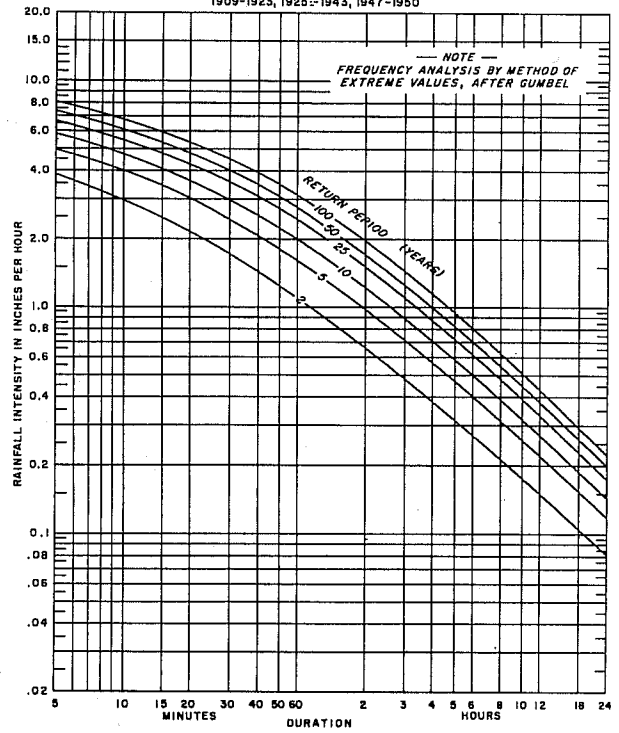


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

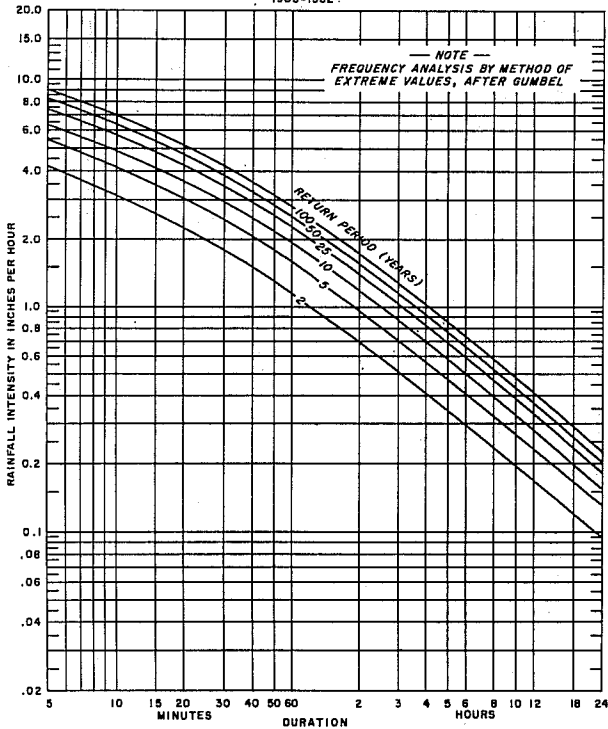
MINNEAPOLIS, MINNESOTA  
1904-1951



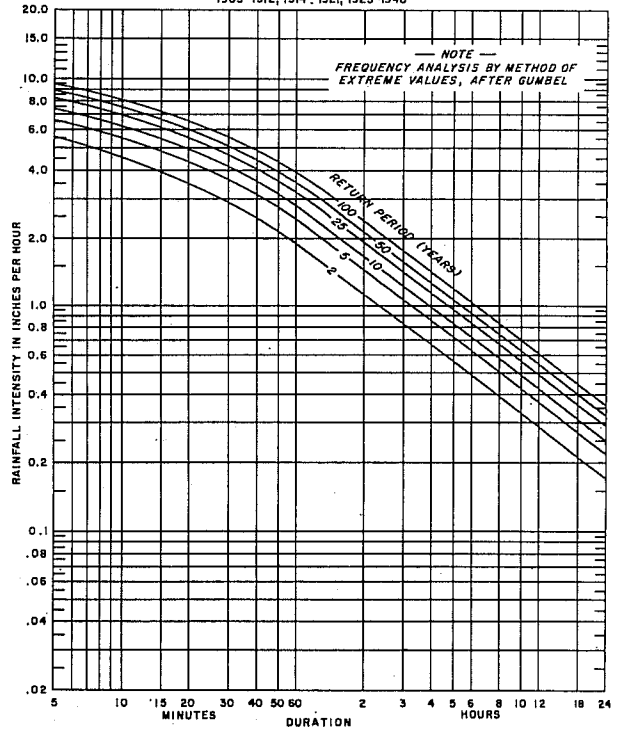
MOORHEAD, MINNESOTA  
1909-1923, 1925-1943, 1947-1950



ST. PAUL, MINNESOTA  
1903-1932

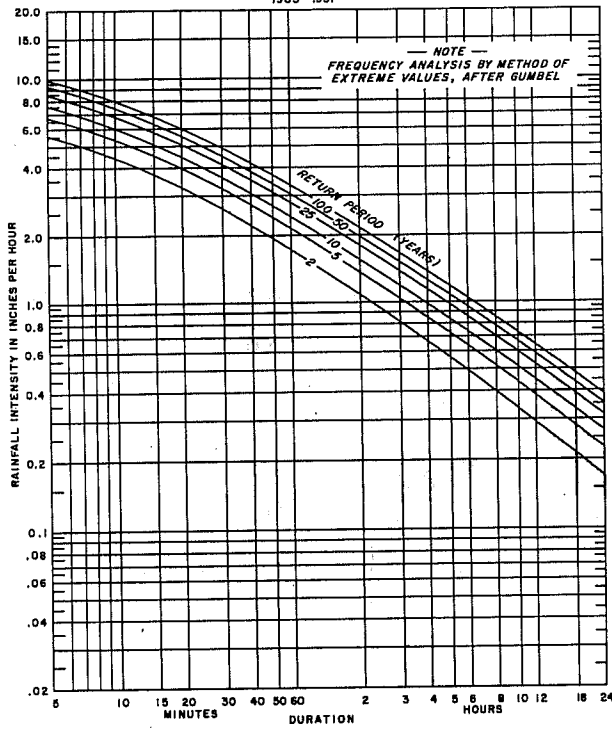


MERIDIAN, MISSISSIPPI  
1903-1912, 1914-1921, 1923-1948

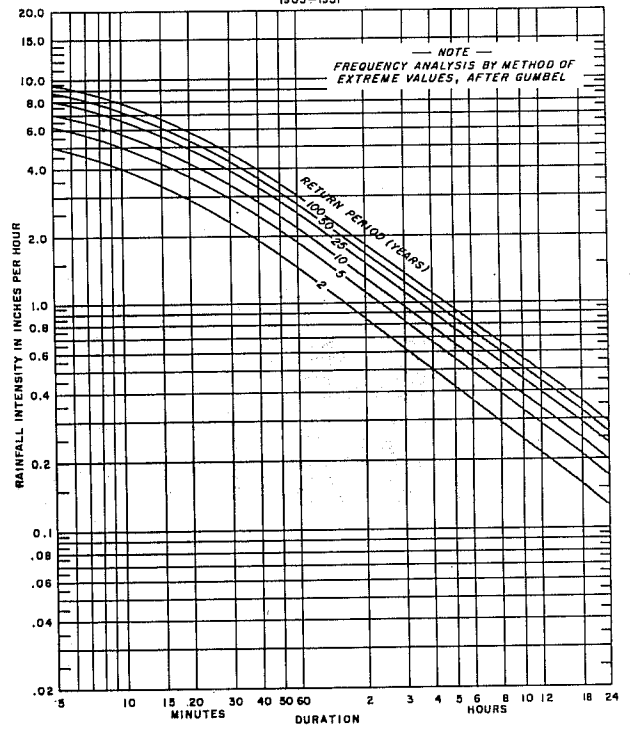


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

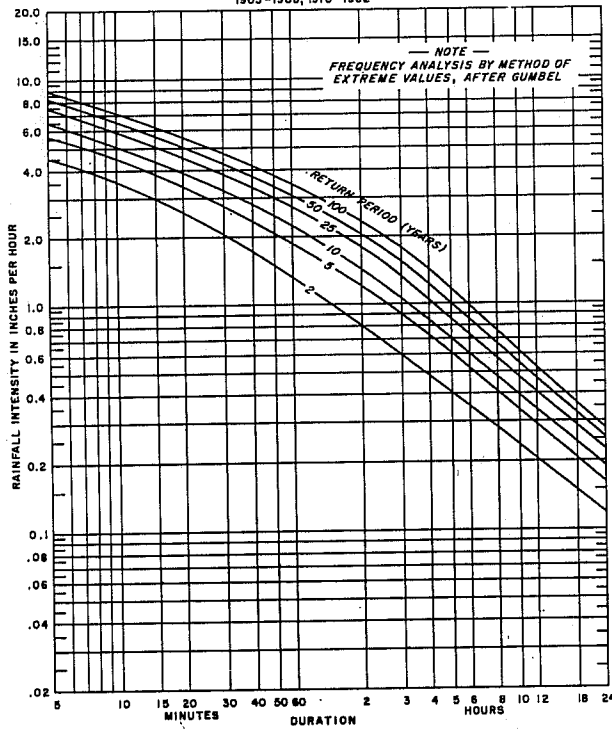
**VICKSBURG, MISSISSIPPI**  
1903-1951



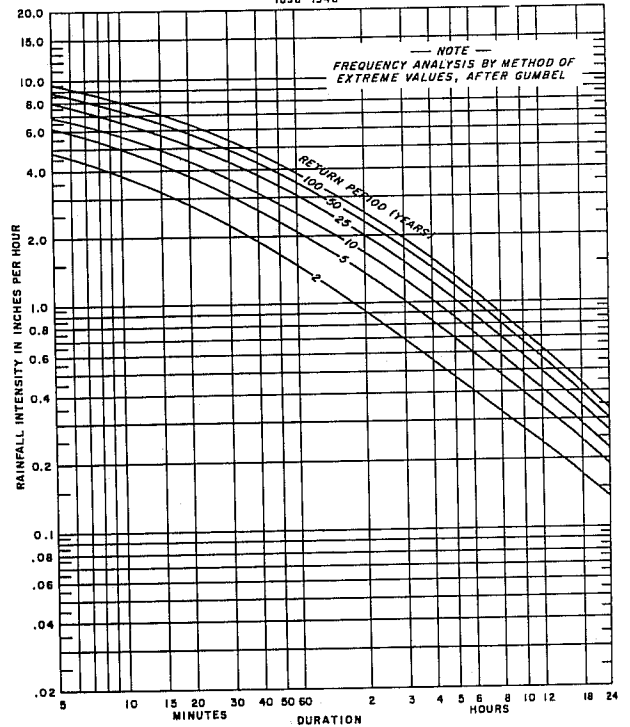
**COLUMBIA, MISSOURI**  
1903-1951



**HANNIBAL, MISSOURI**  
1903-1908, 1910-1932

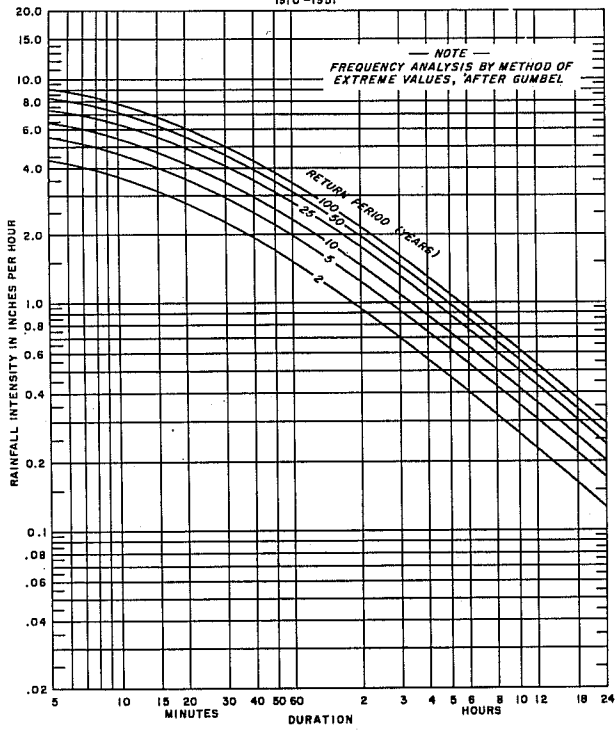


**KANSAS CITY, MISSOURI**  
1896-1948

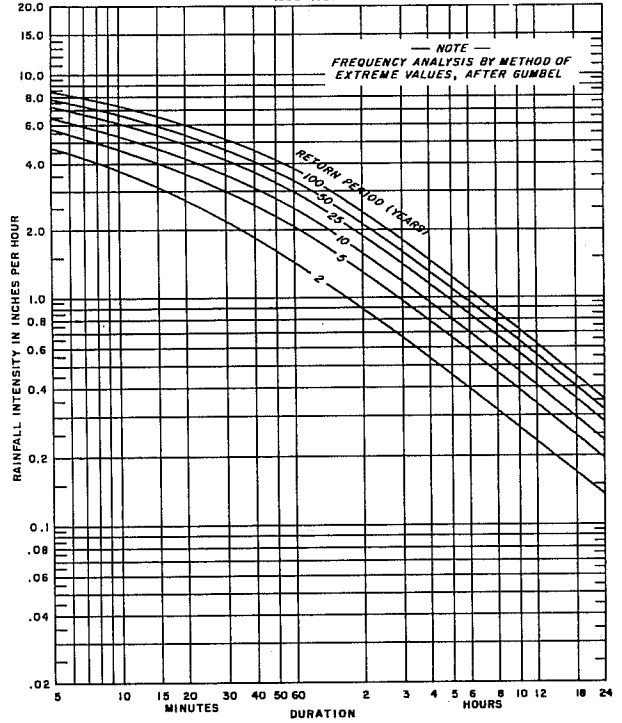


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

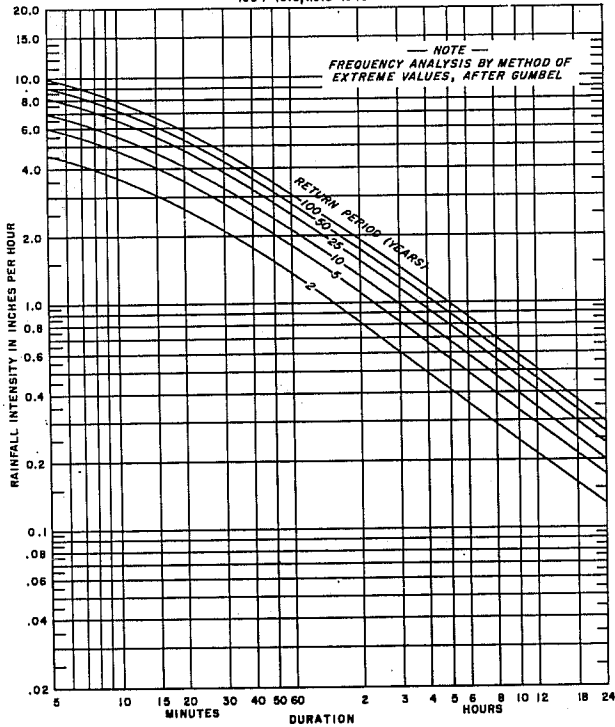
**ST JOSEPH, MISSOURI**  
1910-1951



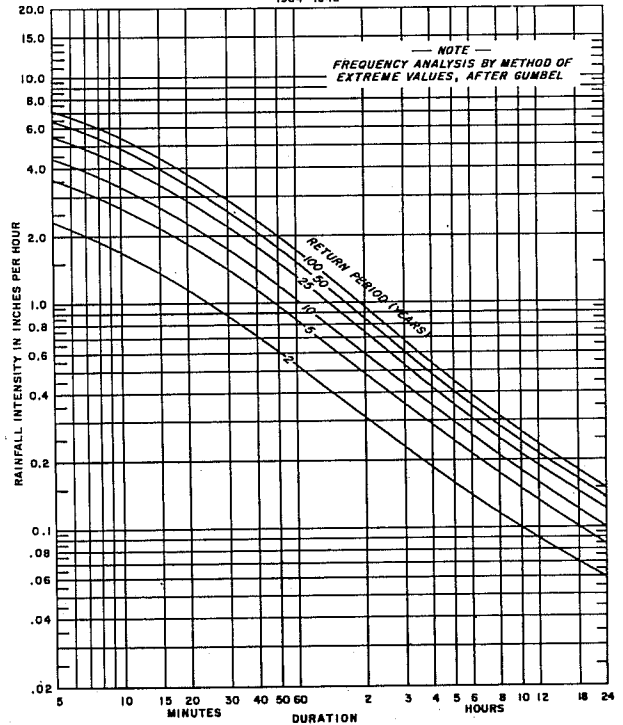
**ST. LOUIS, MISSOURI**  
1903-1951



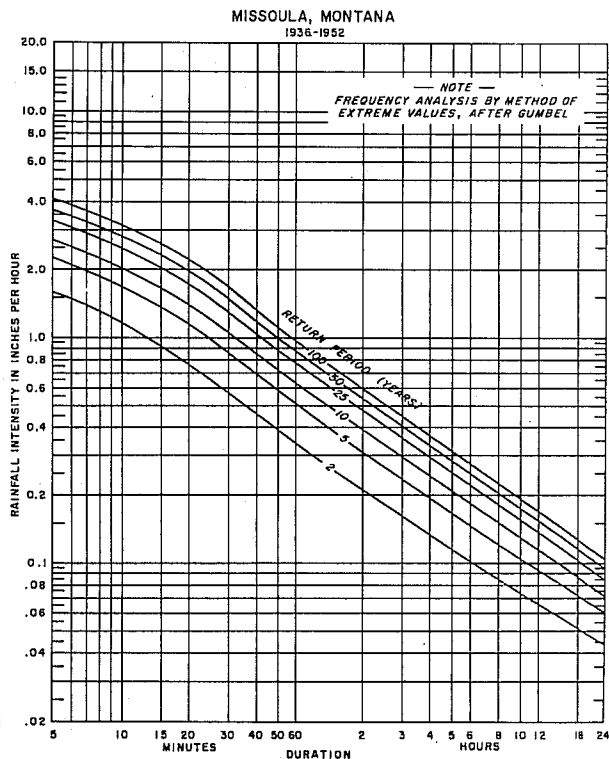
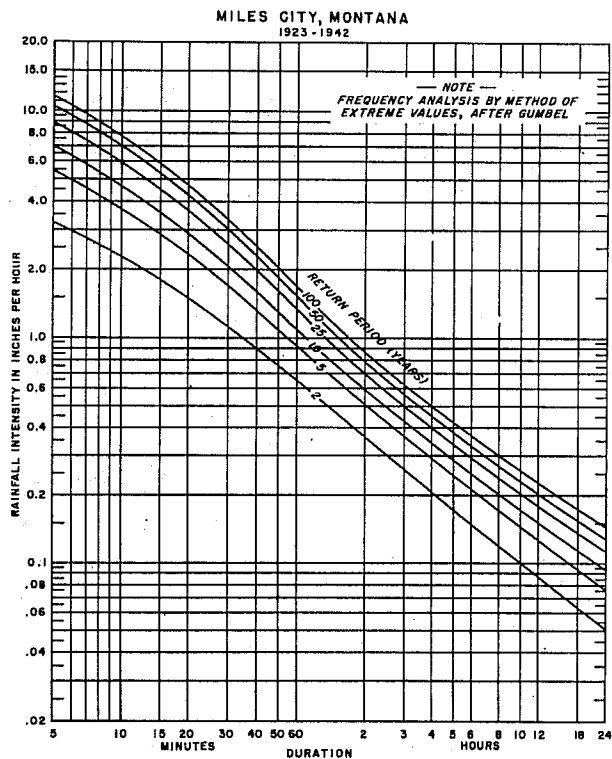
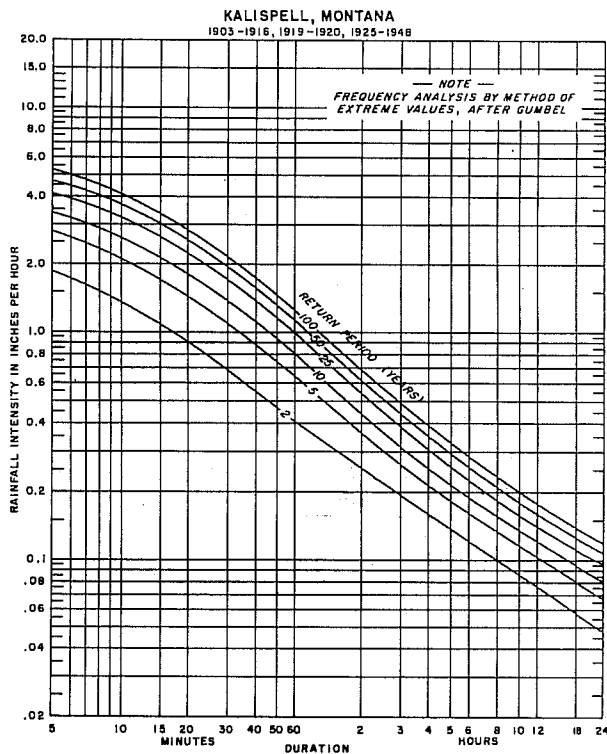
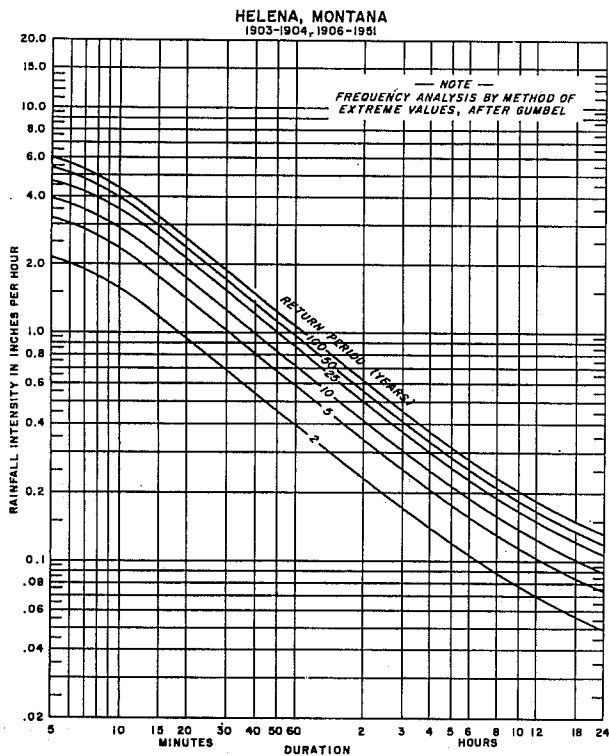
**SPRINGFIELD, MISSOURI**  
1904-1913, 1915-1948



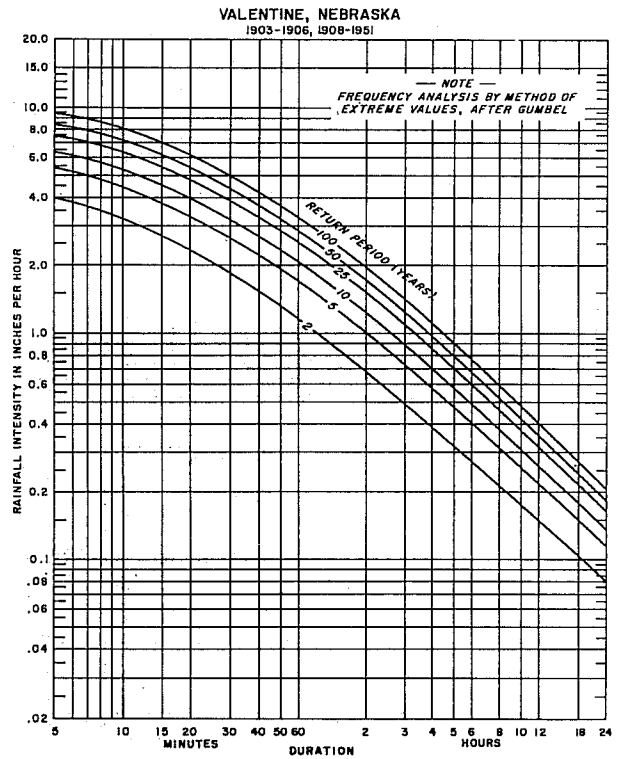
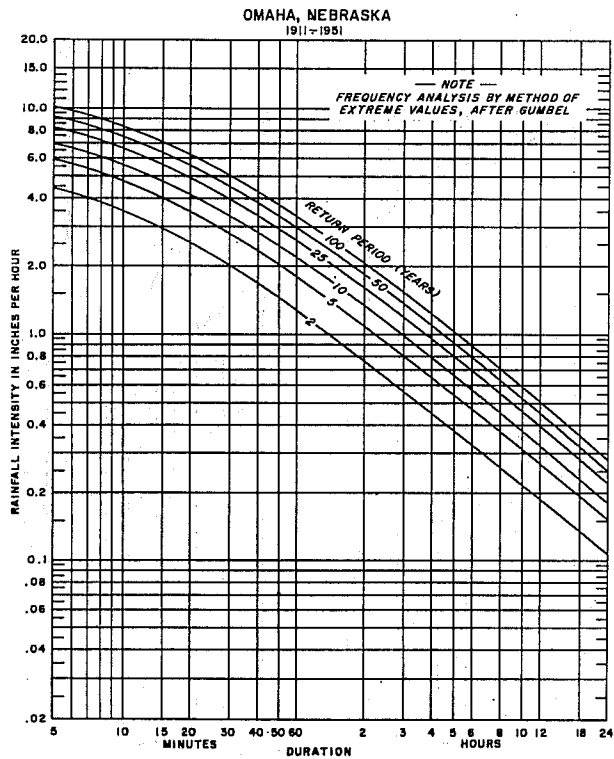
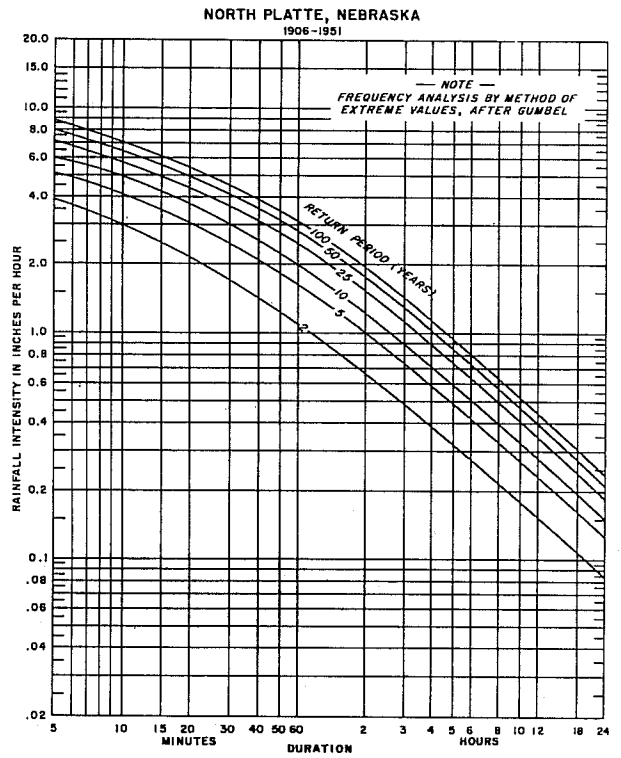
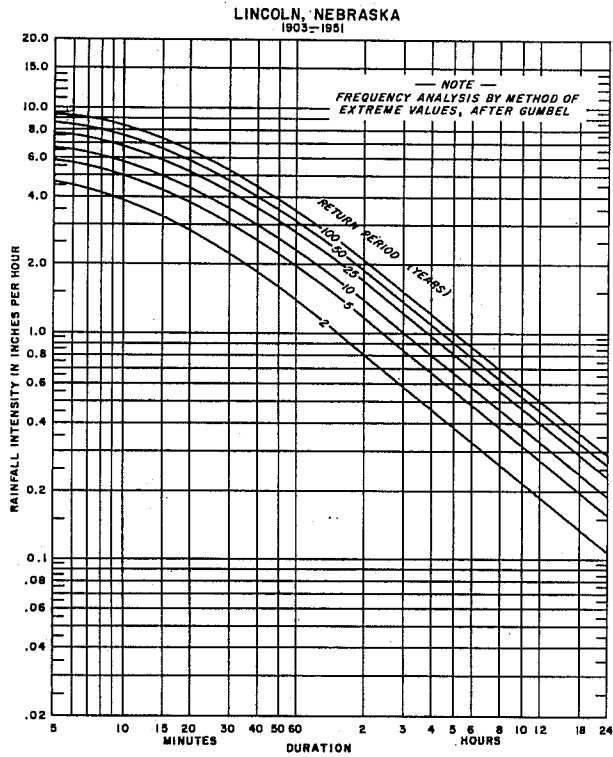
**HAVRE, MONTANA**  
1904-1948



# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

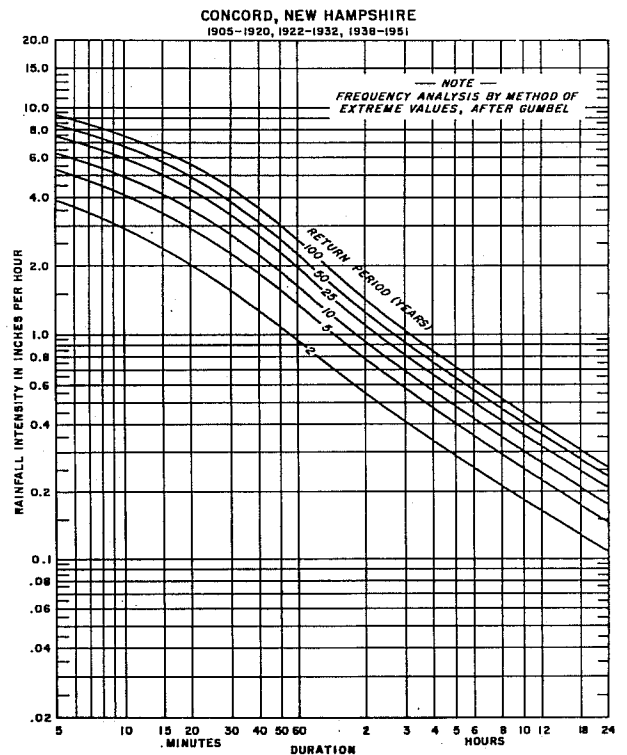
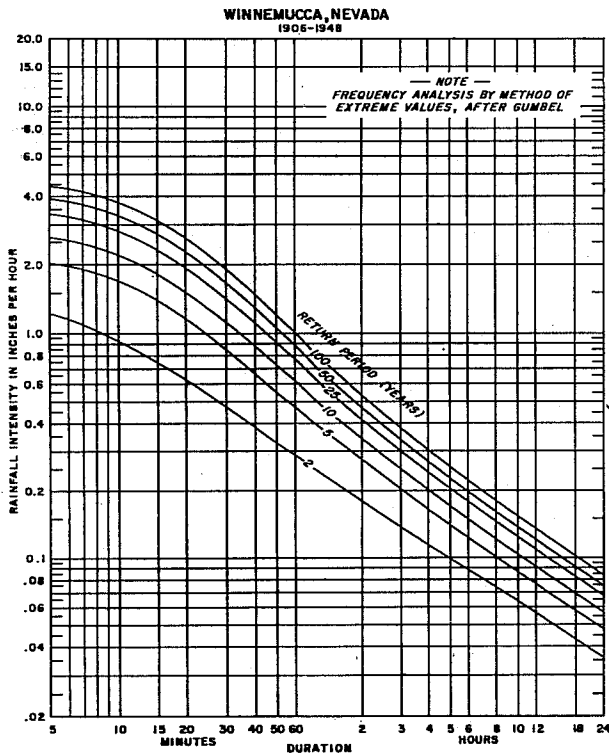
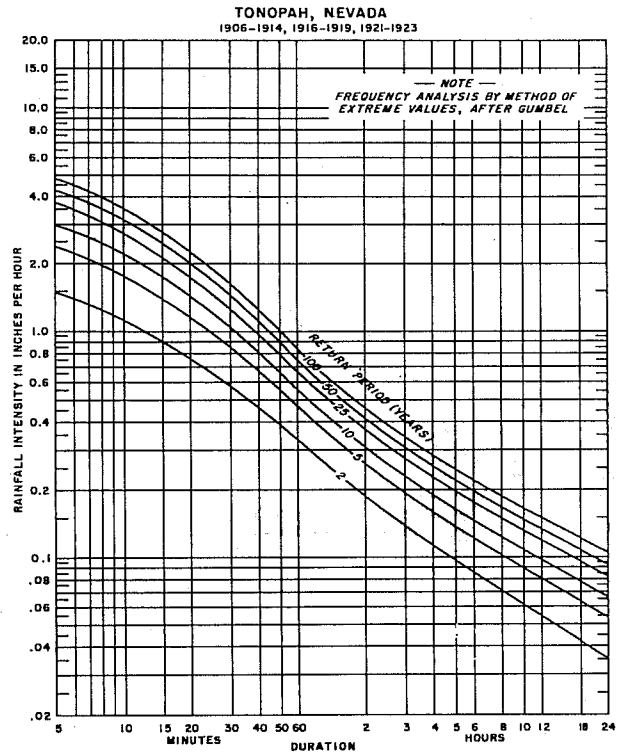
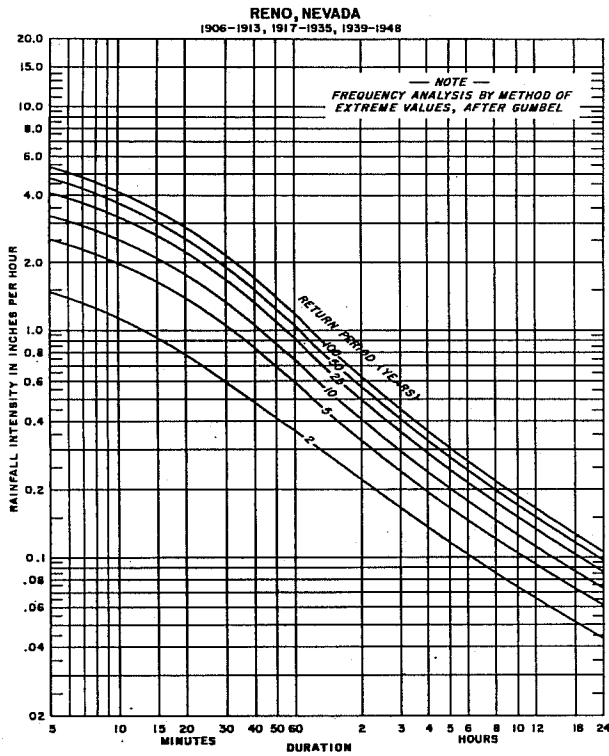


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES



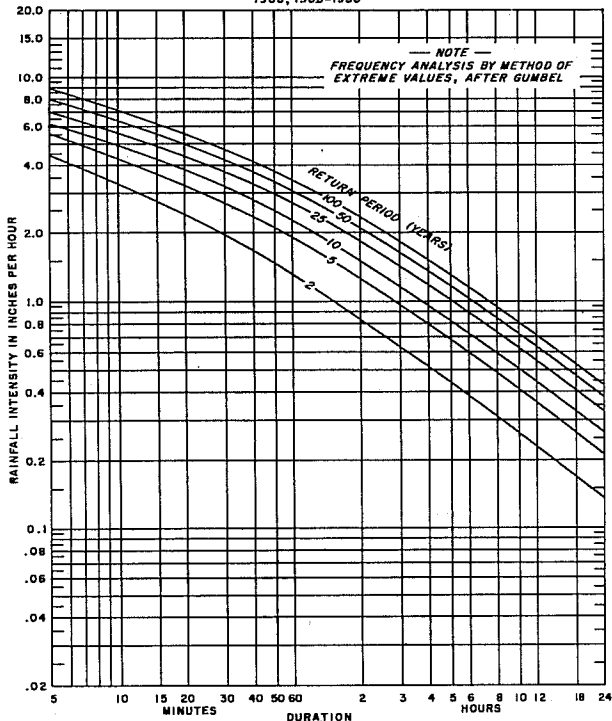


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

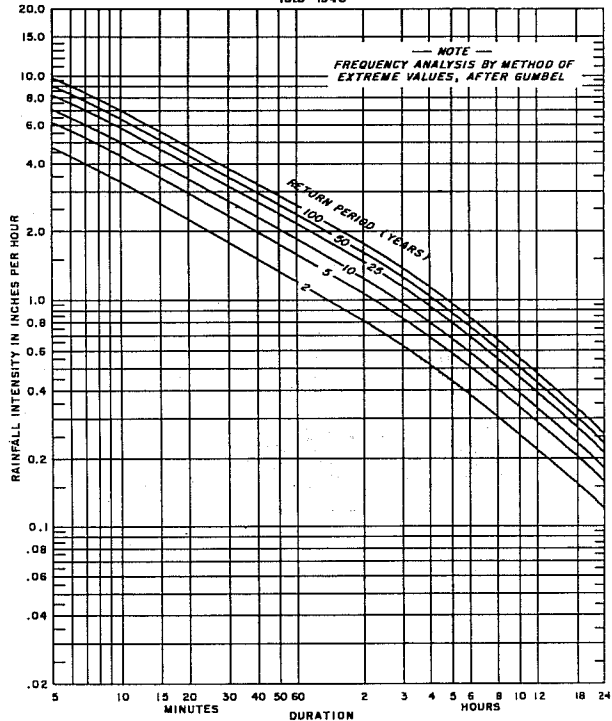


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

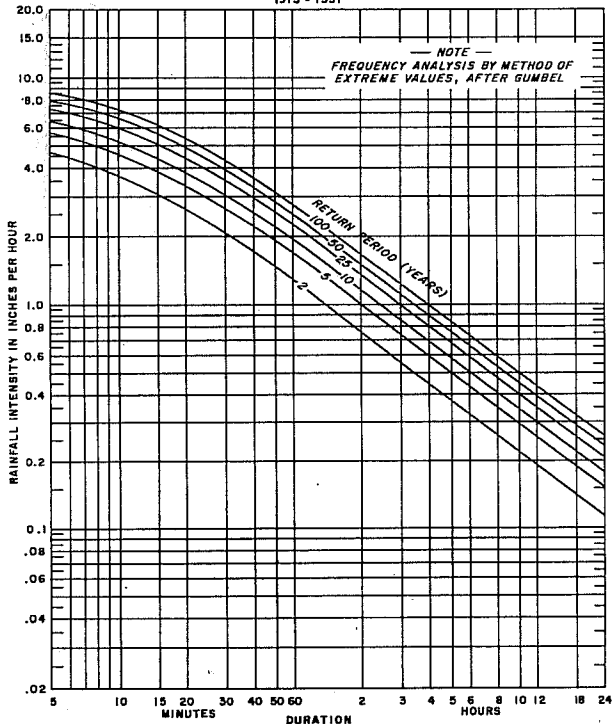
**ATLANTIC CITY, NEW JERSEY**  
1903, 1905-1950



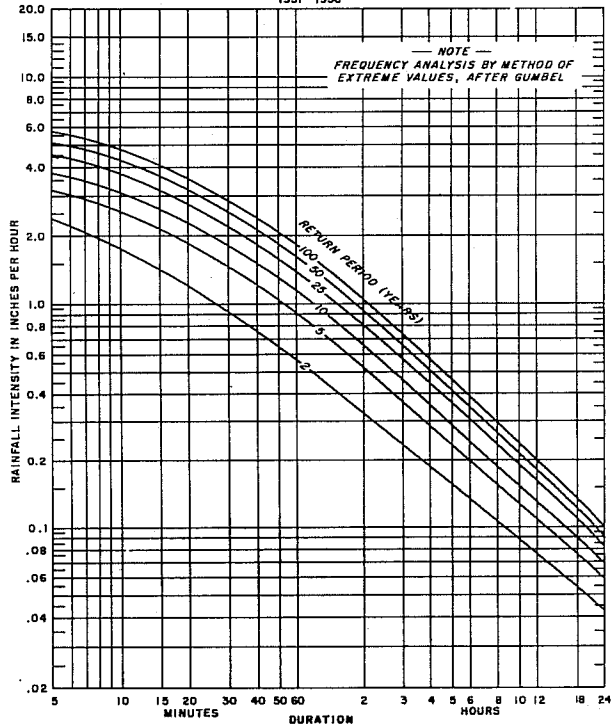
**SANDY HOOK, NEW JERSEY**  
1915-1940



**TRENTON, NEW JERSEY**  
1913-1951

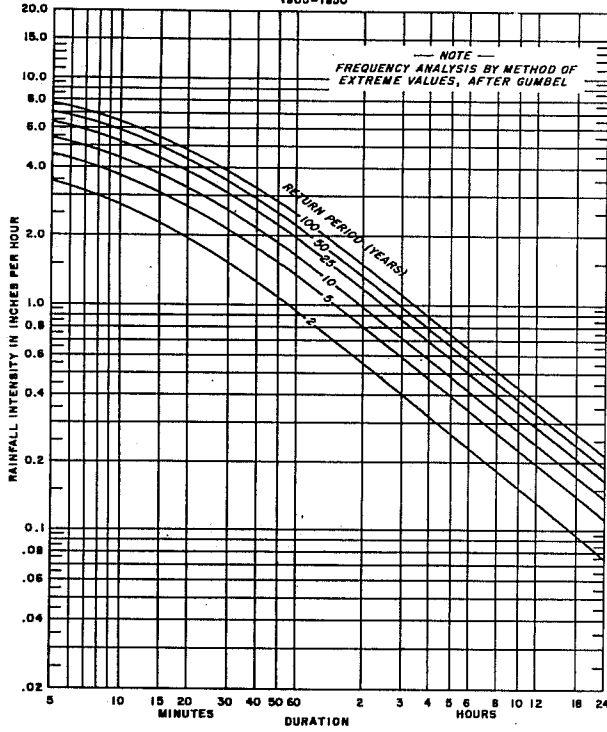


**ALBUQUERQUE, NEW MEXICO**  
1931-1950

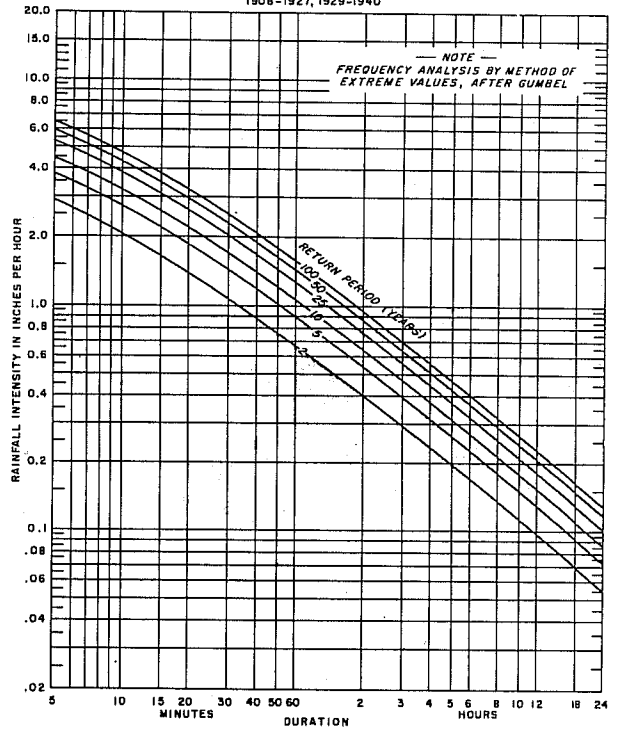


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

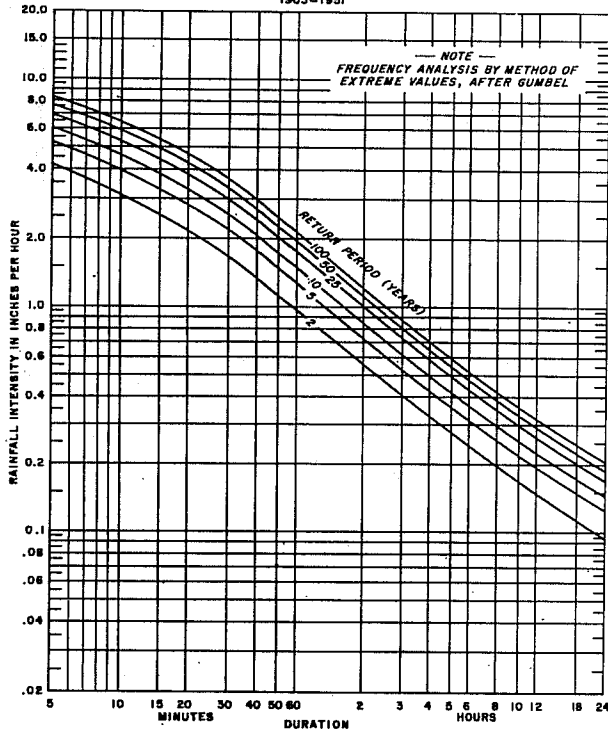
**ROSWELL, NEW MEXICO**  
1906-1980



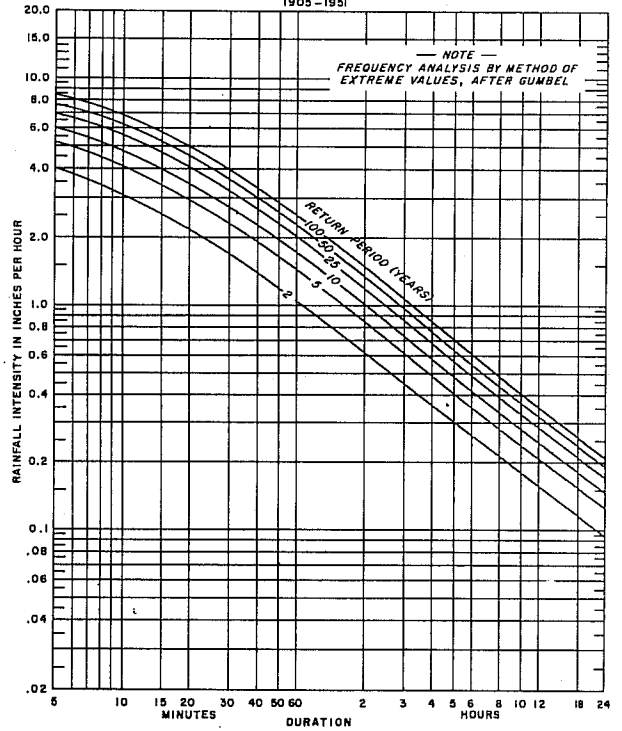
**SANTA FE, NEW MEXICO**  
1908-1927, 1929-1940



**ALBANY, NEW YORK**  
1903-1951

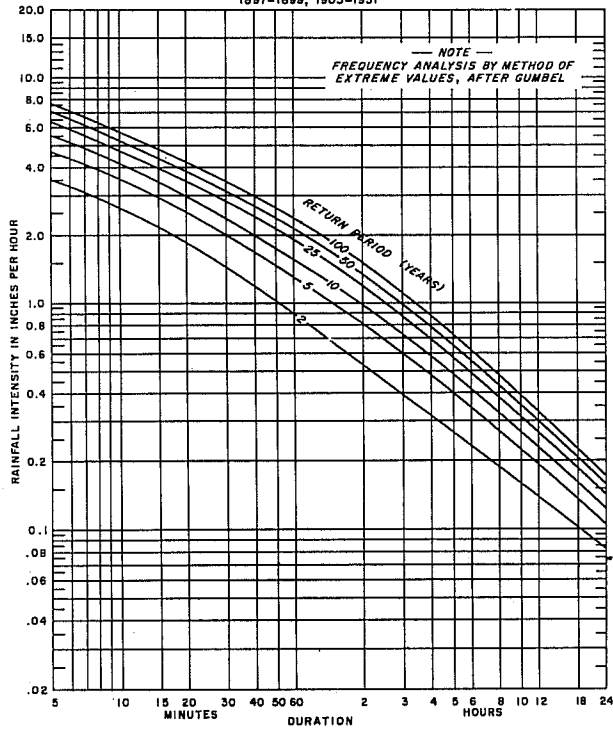


**BINGHAMTON, NEW YORK**  
1901-1951

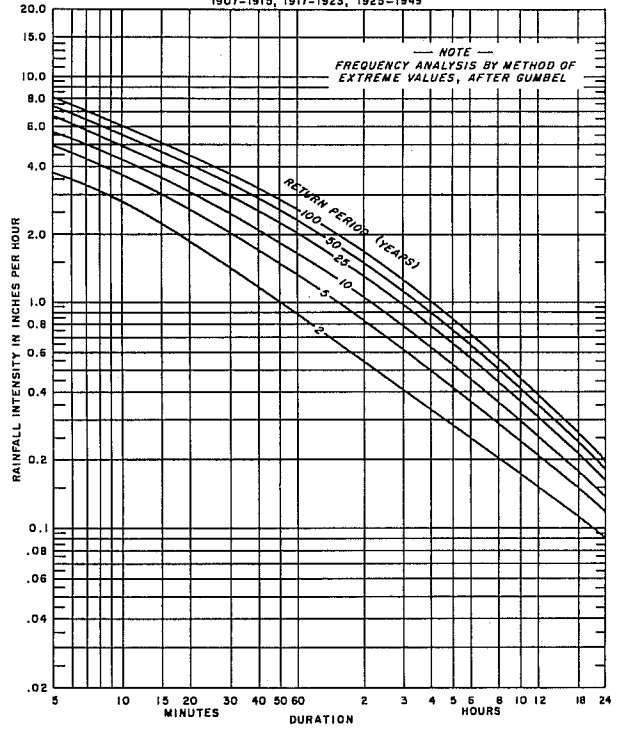


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

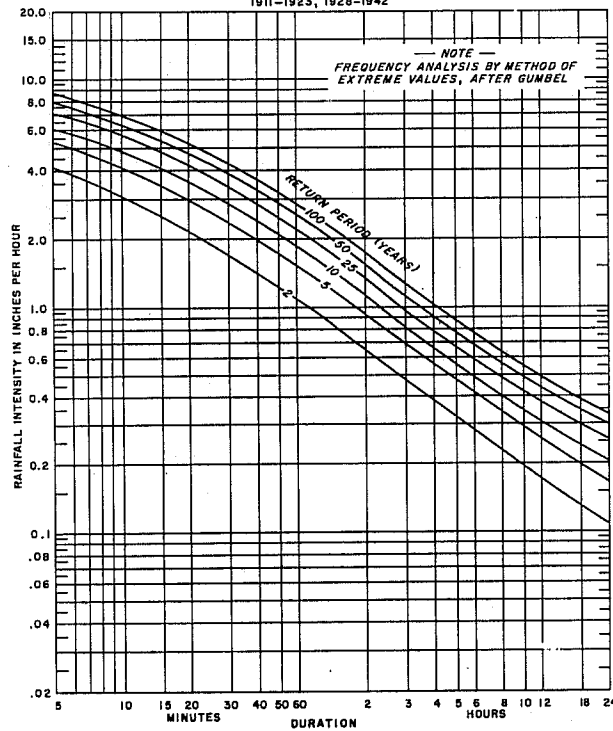
**BUFFALO, NEW YORK**  
1897-1899, 1903-1951



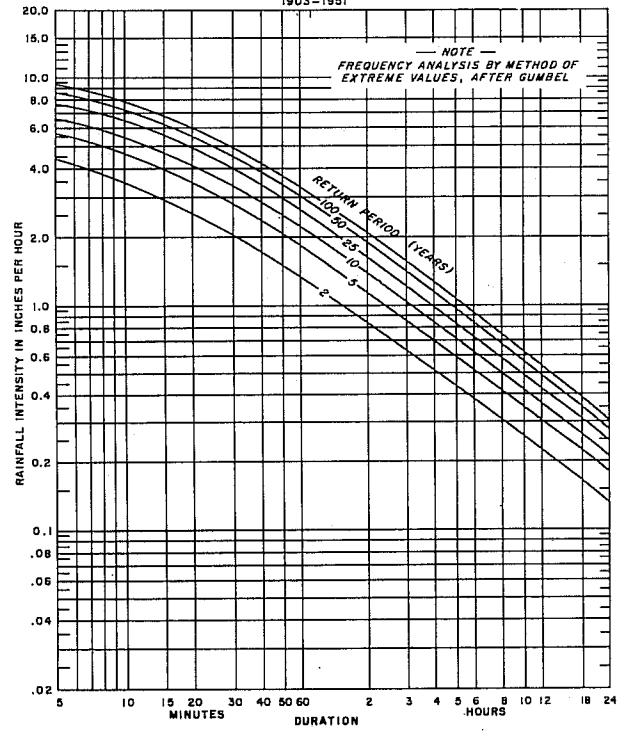
**CANTON, NEW YORK**  
1907-1913, 1917-1923, 1925-1949



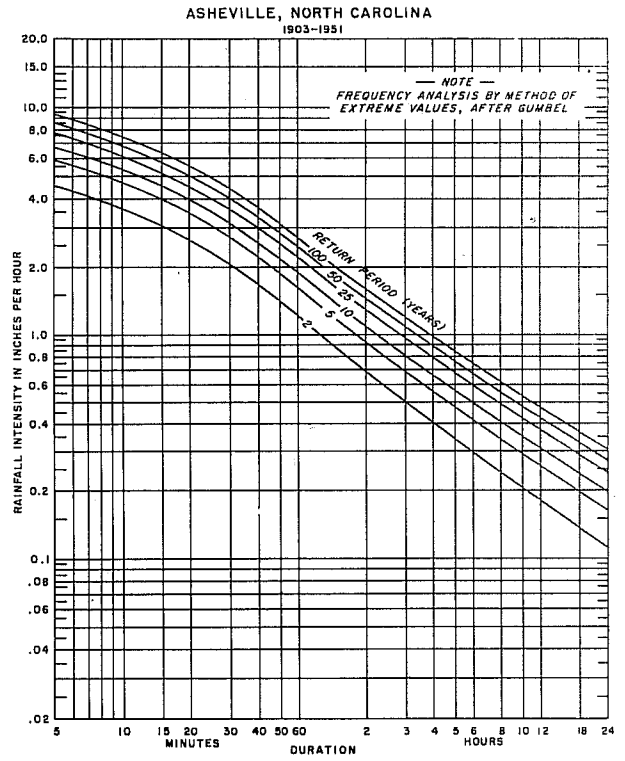
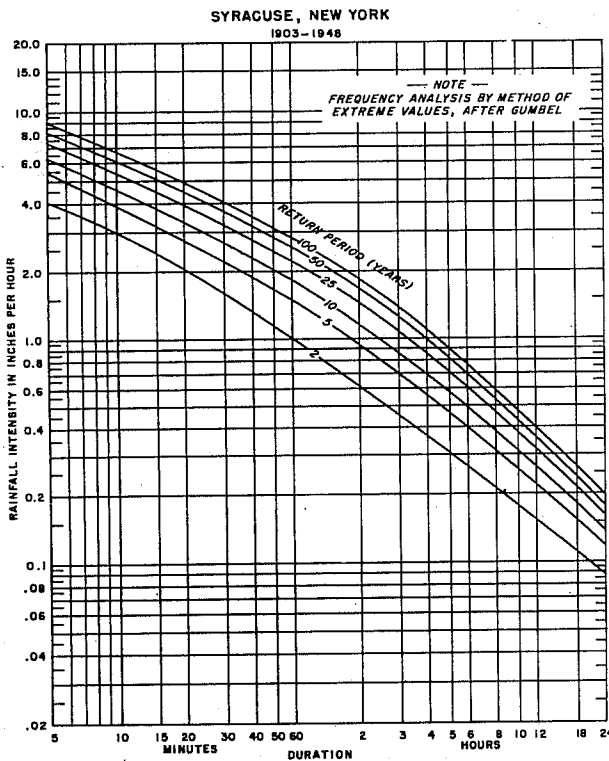
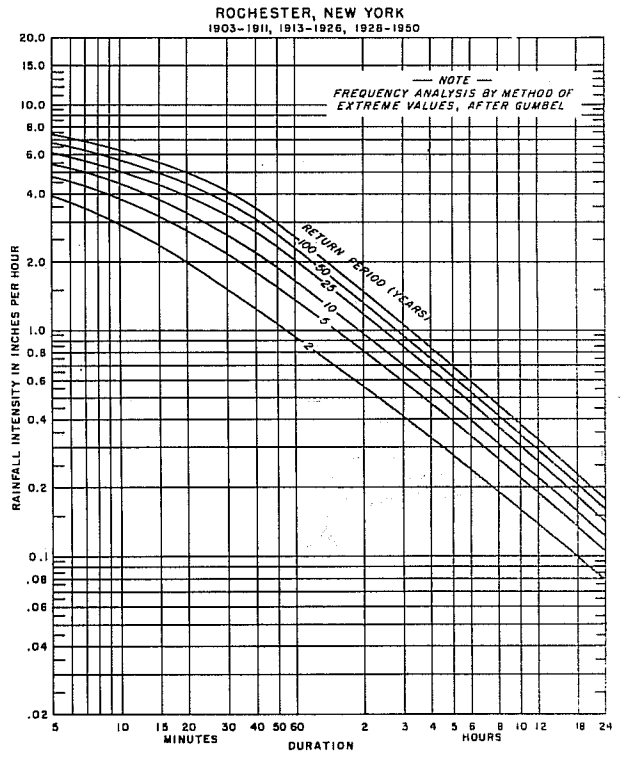
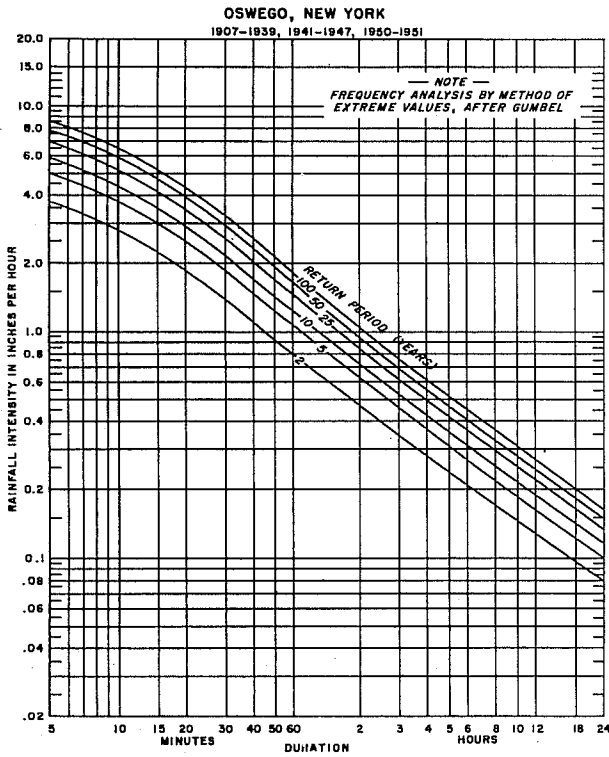
**ITHACA, NEW YORK**  
1911-1923, 1928-1942



**NEW YORK, NEW YORK**  
1903-1951

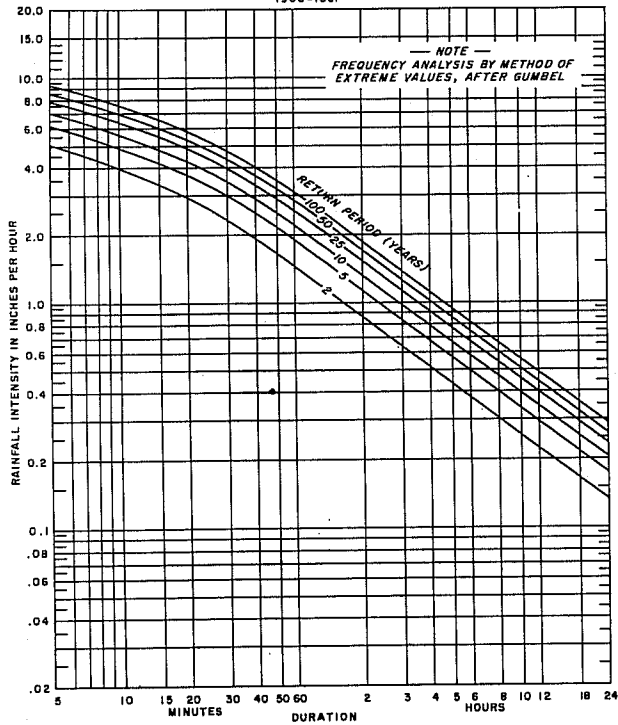


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

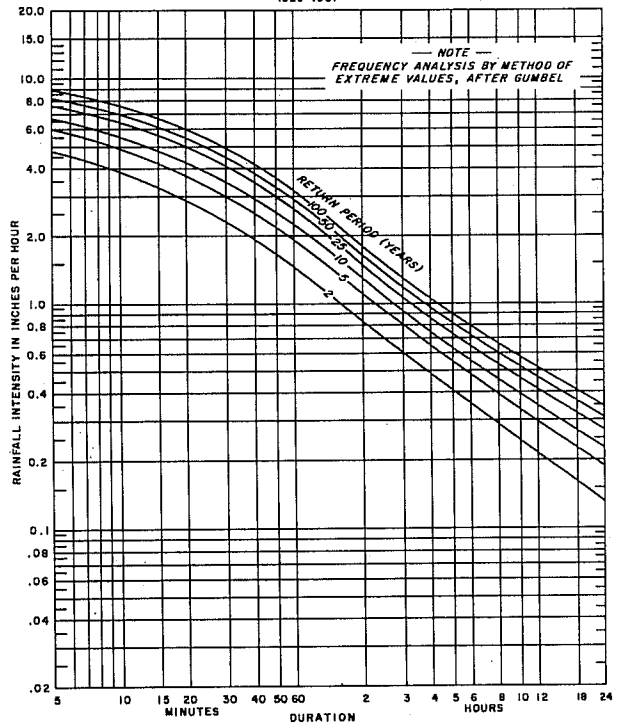


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

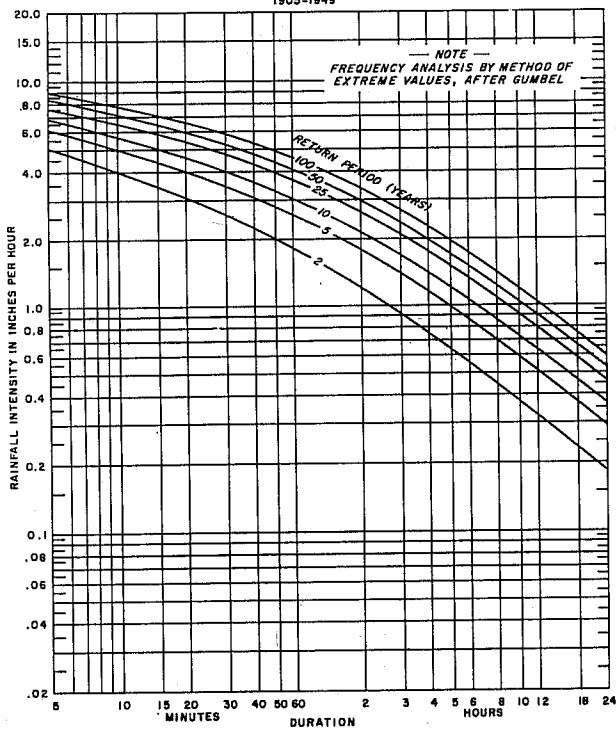
**CHARLOTTE, NORTH CAROLINA**  
1903-1951



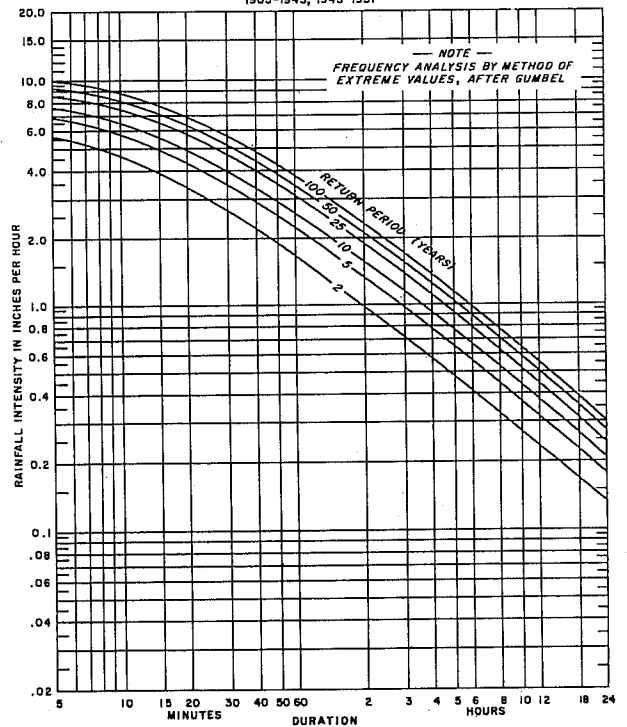
**GREENSBORO, NORTH CAROLINA**  
1929-1951



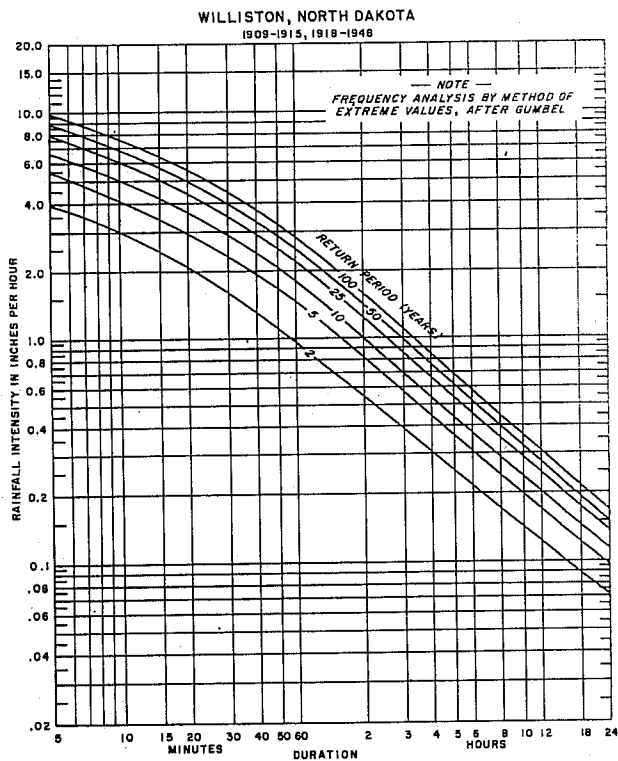
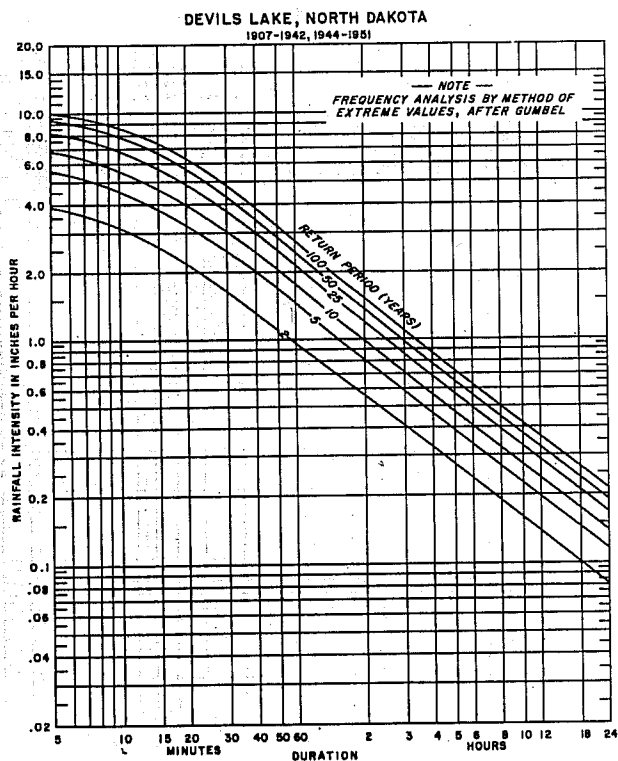
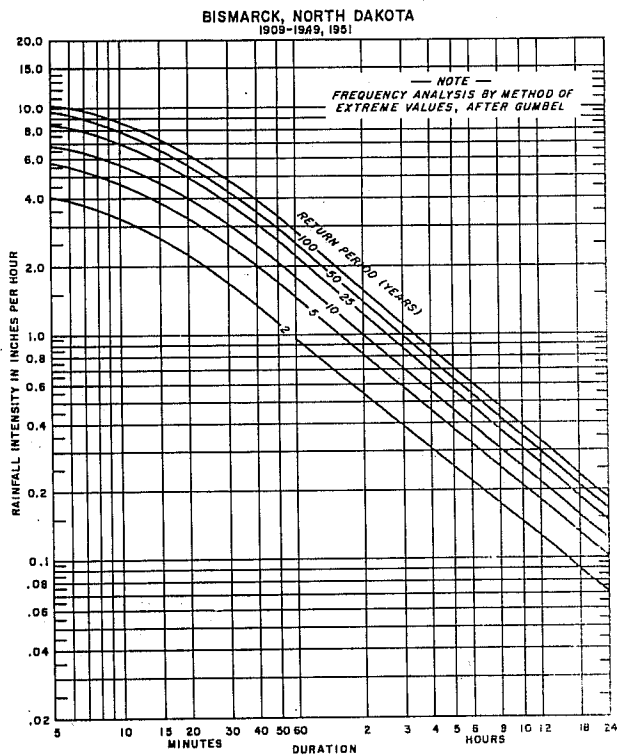
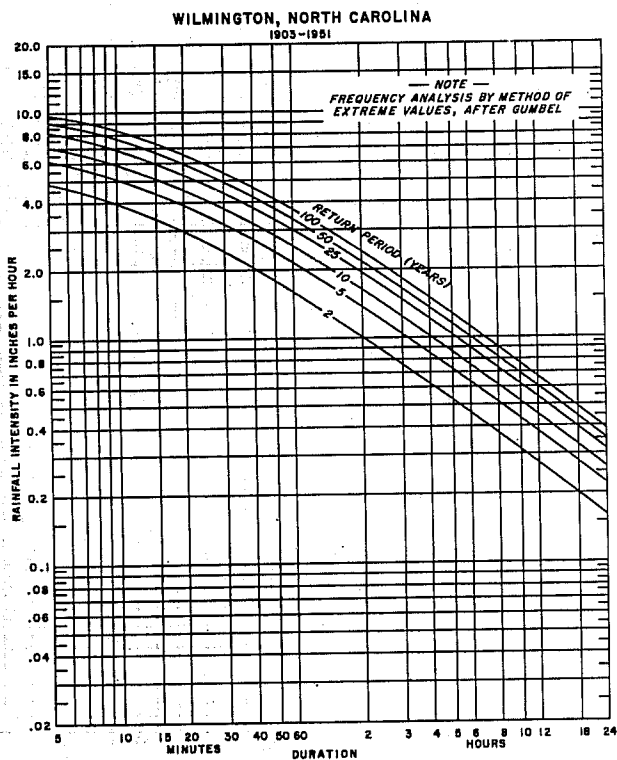
**HATTERAS, NORTH CAROLINA**  
1905-1949



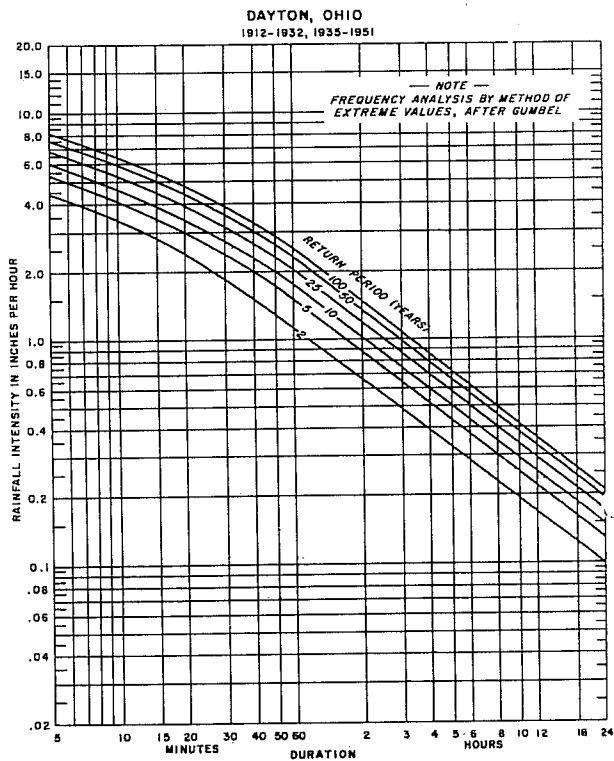
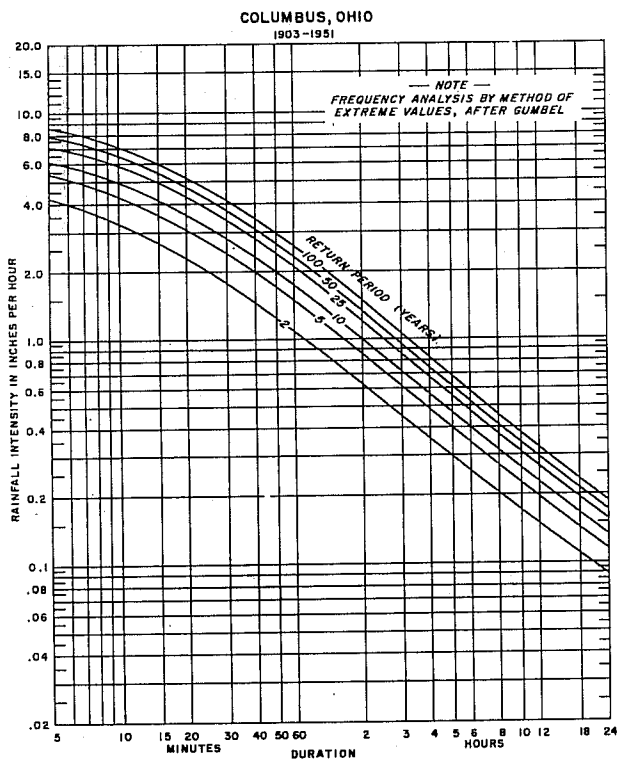
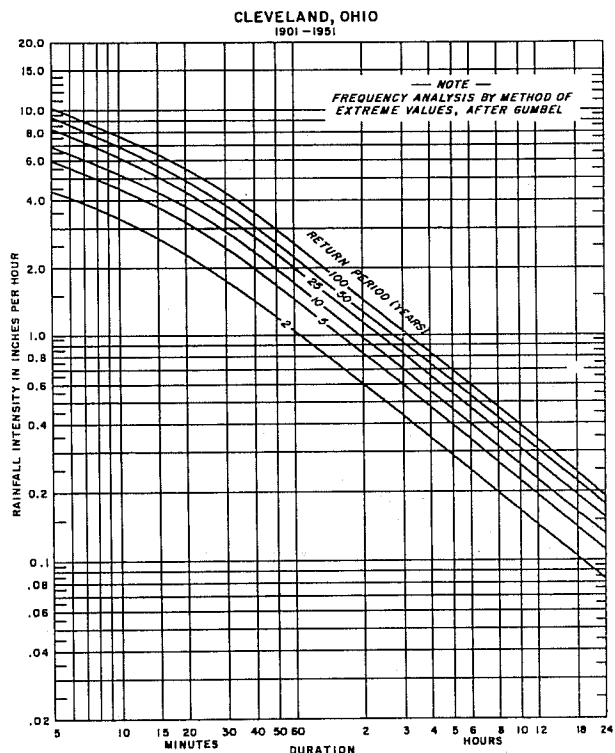
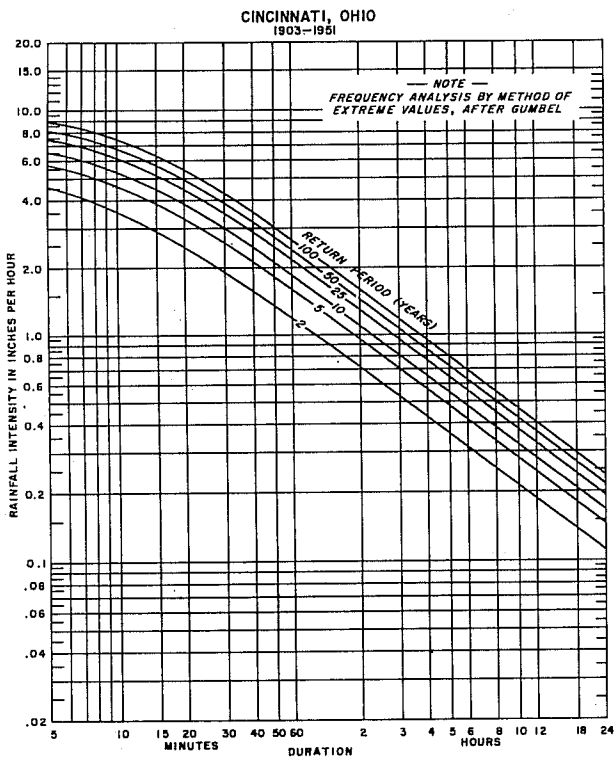
**RALEIGH, NORTH CAROLINA**  
1903-1943, 1945-1951



# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

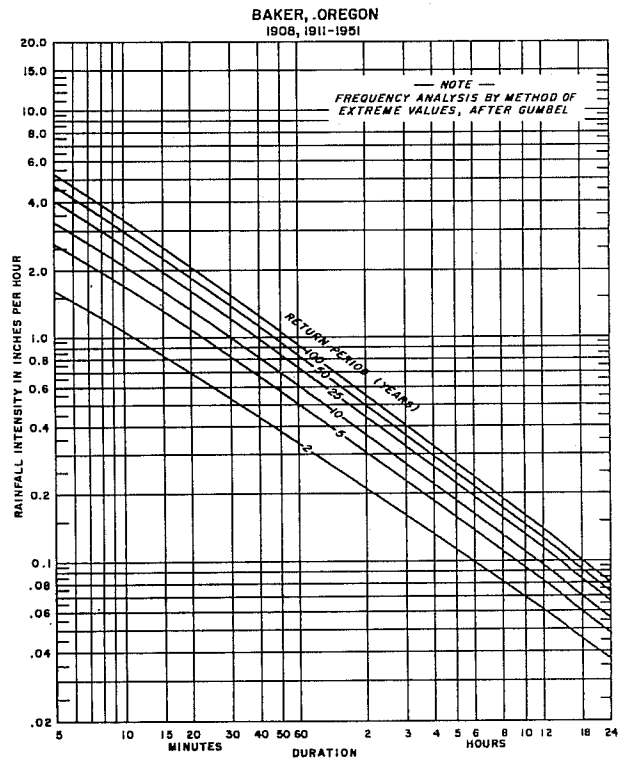
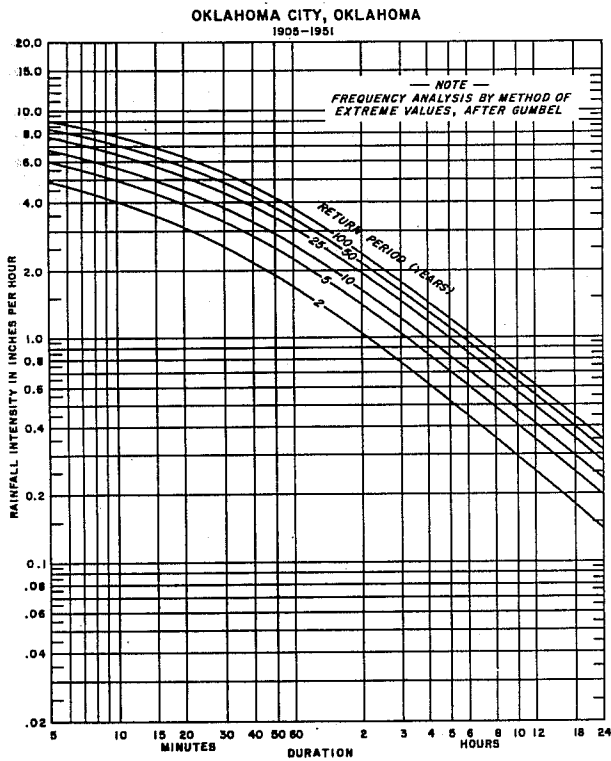
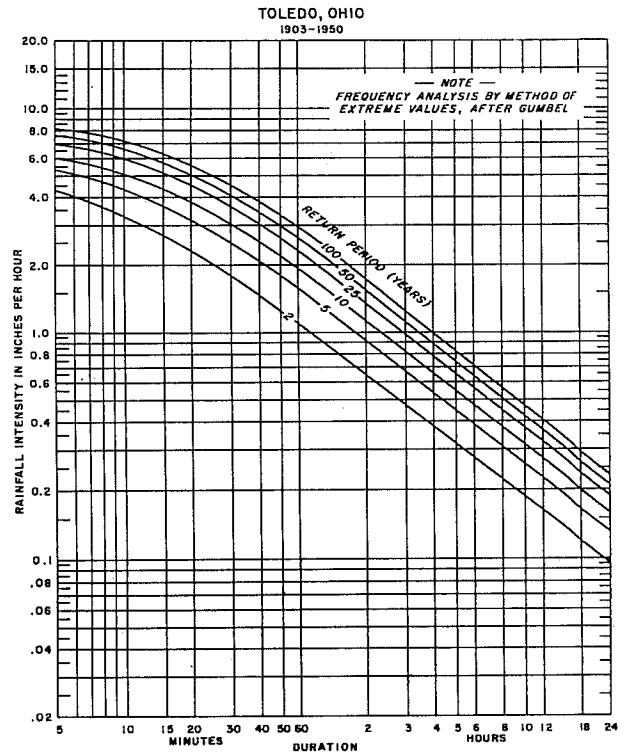
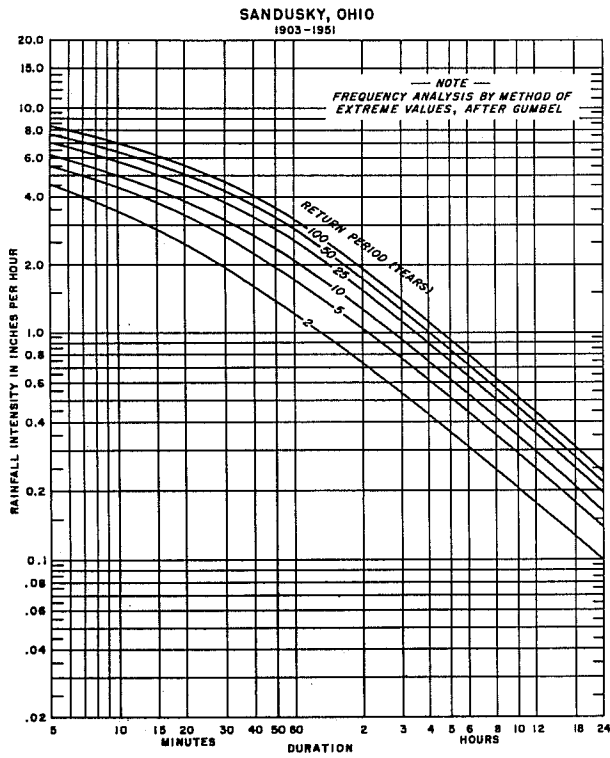


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES



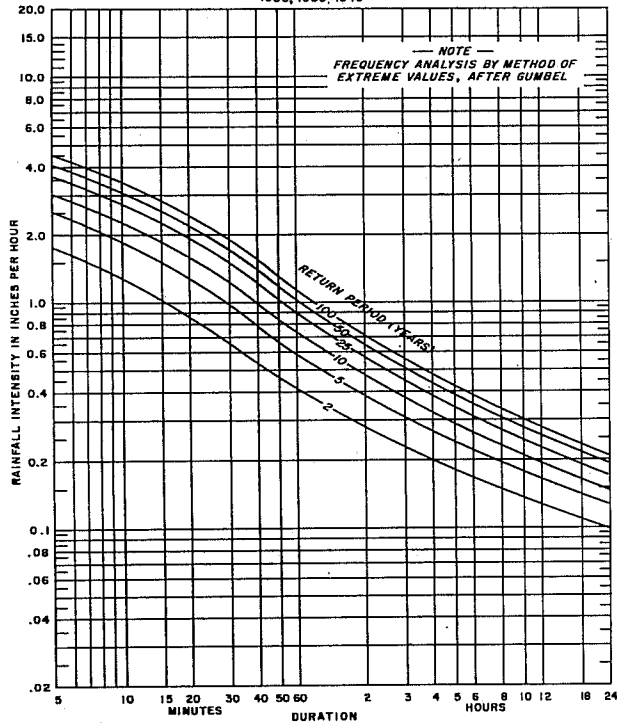


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

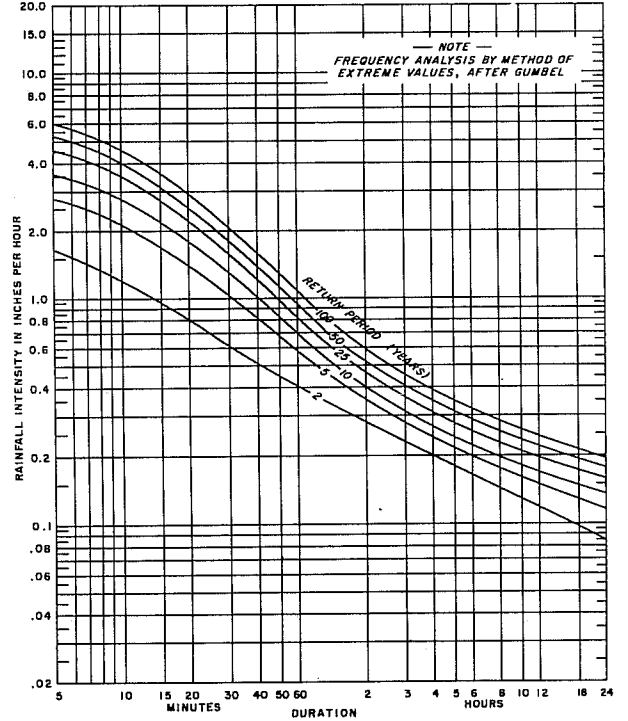


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

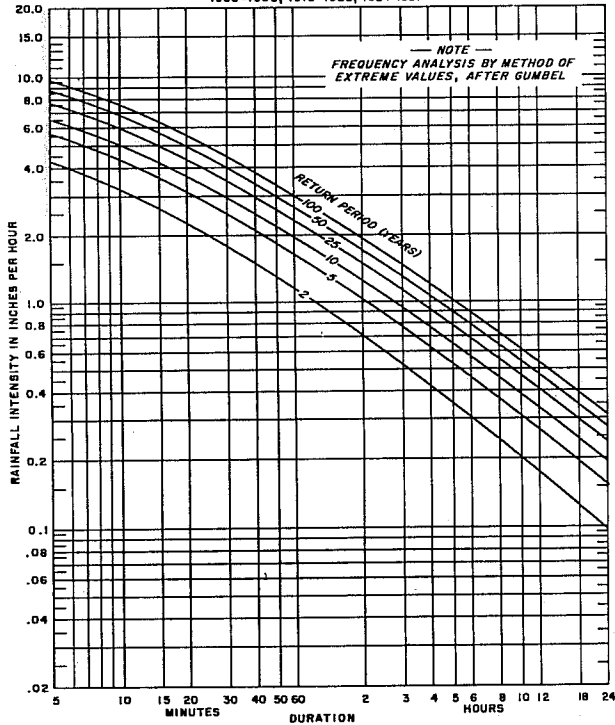
**PORTLAND, OREGON**  
1900, 1903-1949



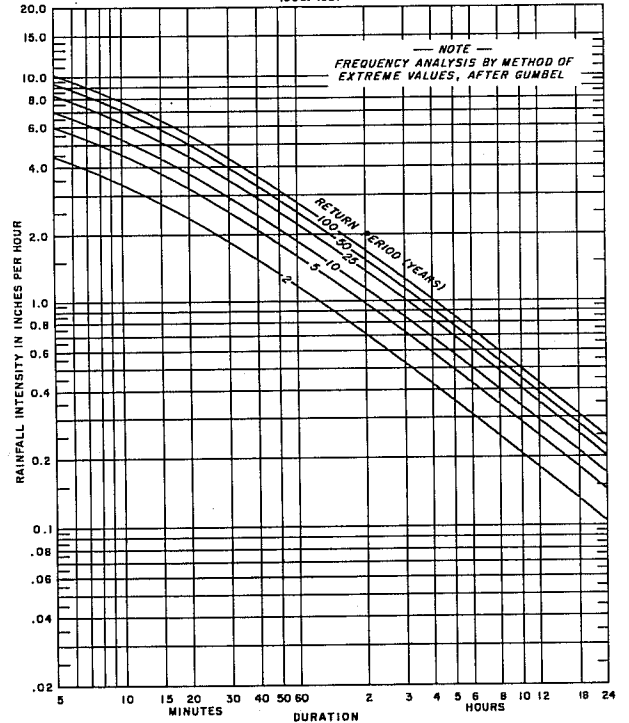
**ROSEBURG, OREGON**  
1905-1948



**ERIE, PENNSYLVANIA**  
1903-1908, 1910-1922, 1924-1951

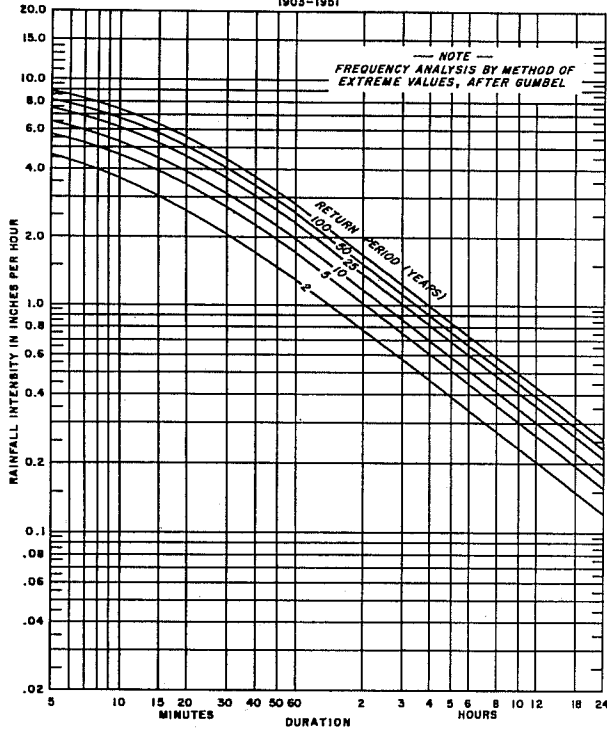


**HARRISBURG, PENNSYLVANIA**  
1903-1951

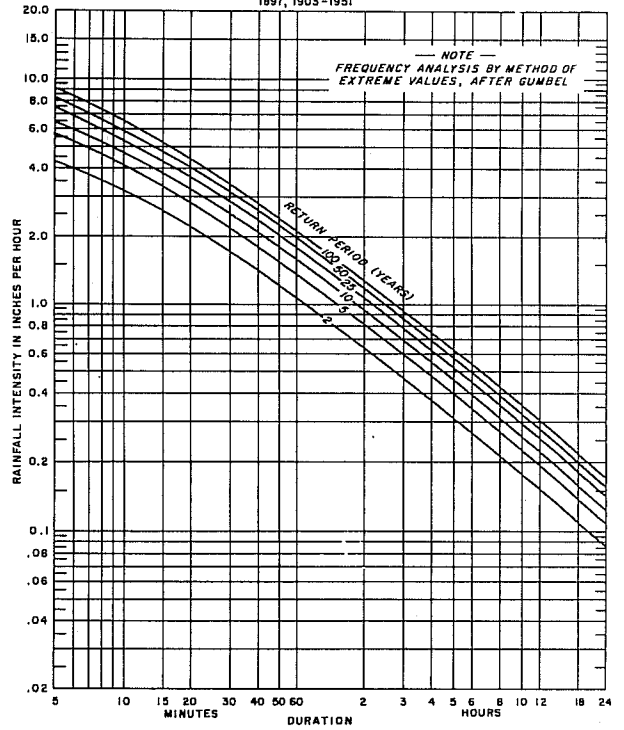


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

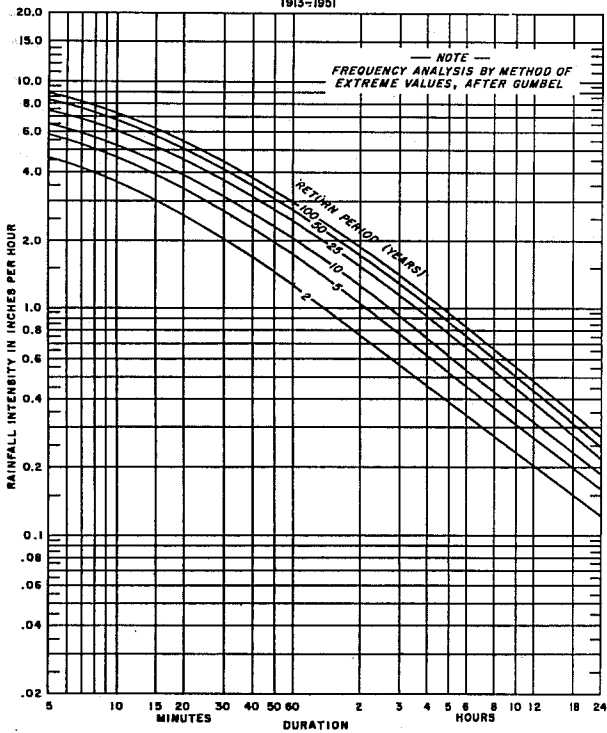
**PHILADELPHIA, PENNSYLVANIA**  
1903-1951



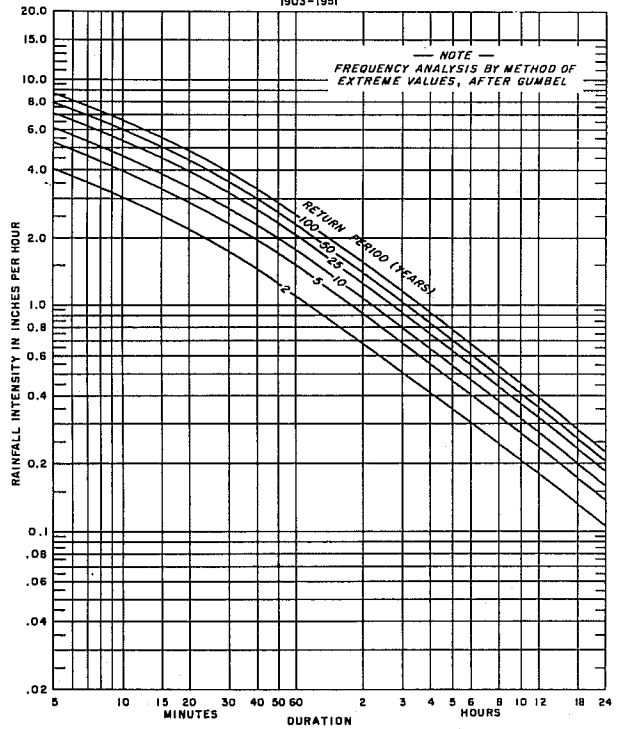
**PITTSBURGH, PENNSYLVANIA**  
1897, 1903-1951



**READING, PENNSYLVANIA**  
1913-1951

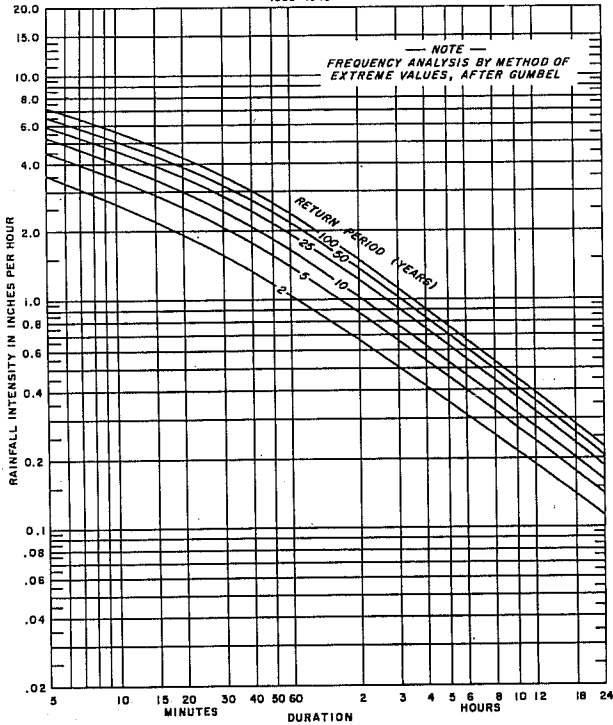


**SCRANTON, PENNSYLVANIA**  
1903-1951

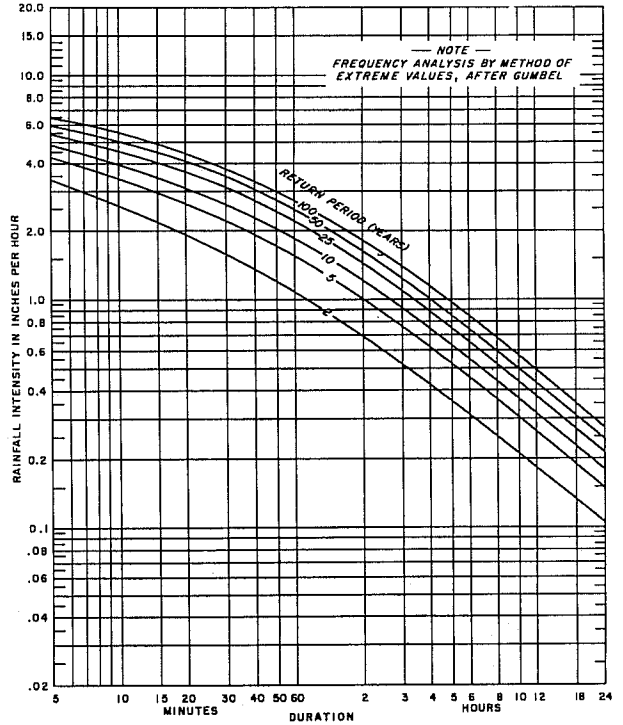


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

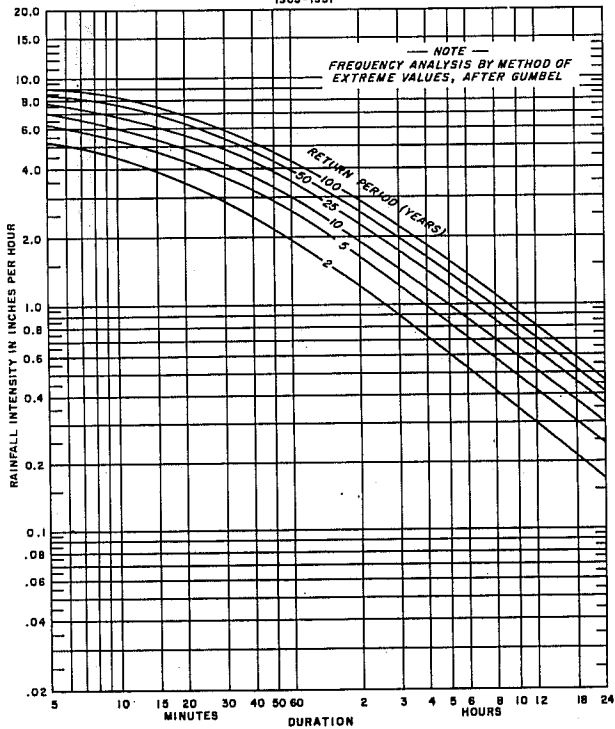
**BLOCK ISLAND, RHODE ISLAND**  
1903-1948



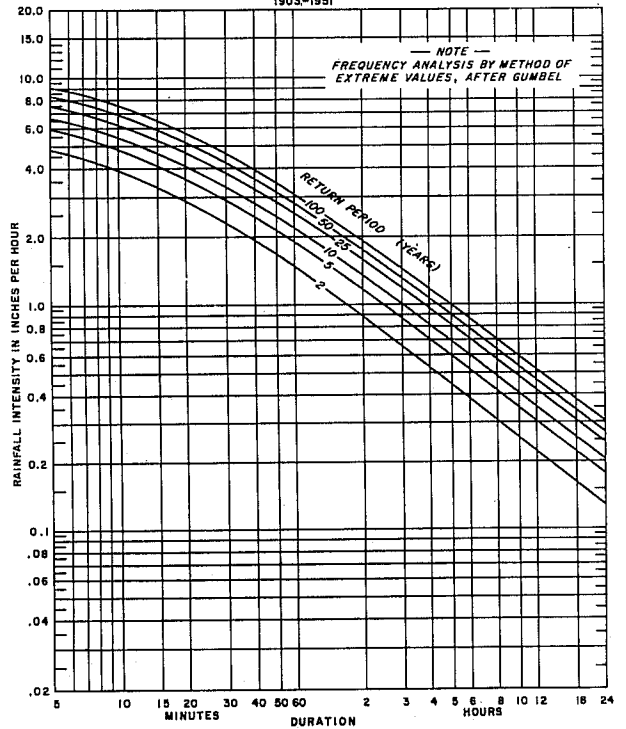
**PROVIDENCE, RHODE ISLAND**  
1903-1951



**CHARLESTON, SOUTH CAROLINA**  
1903-1951

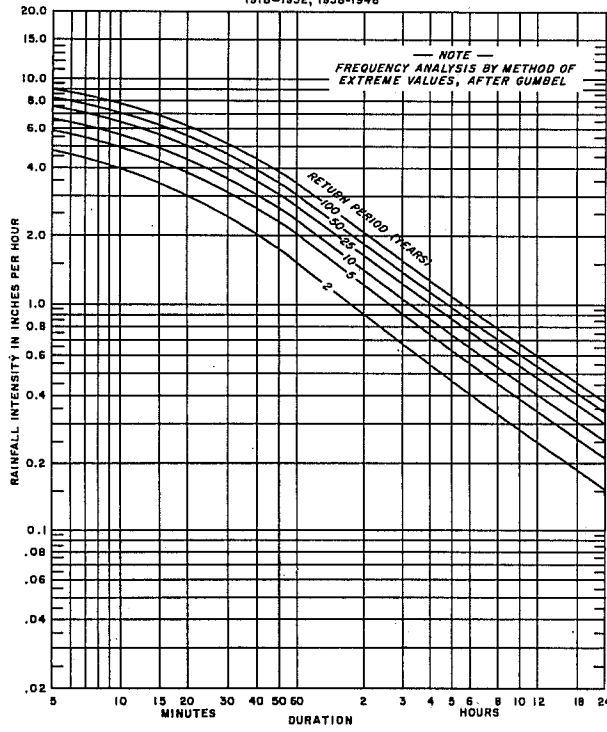


**COLUMBIA, SOUTH CAROLINA**  
1903-1951

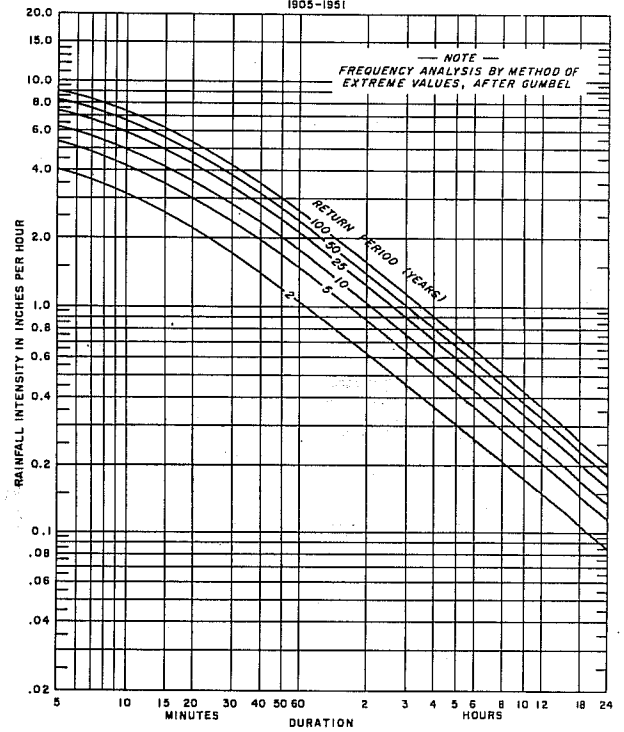


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

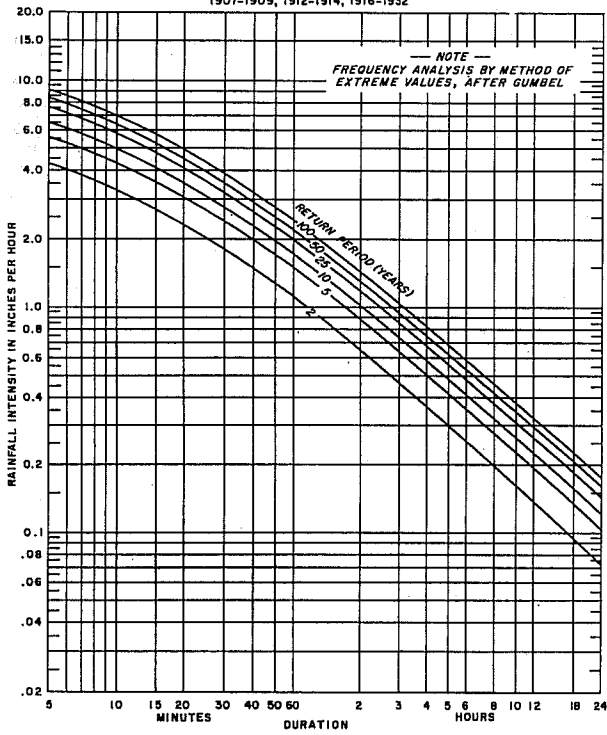
**GREENVILLE, SOUTH CAROLINA**  
1918-1922, 1938-1948



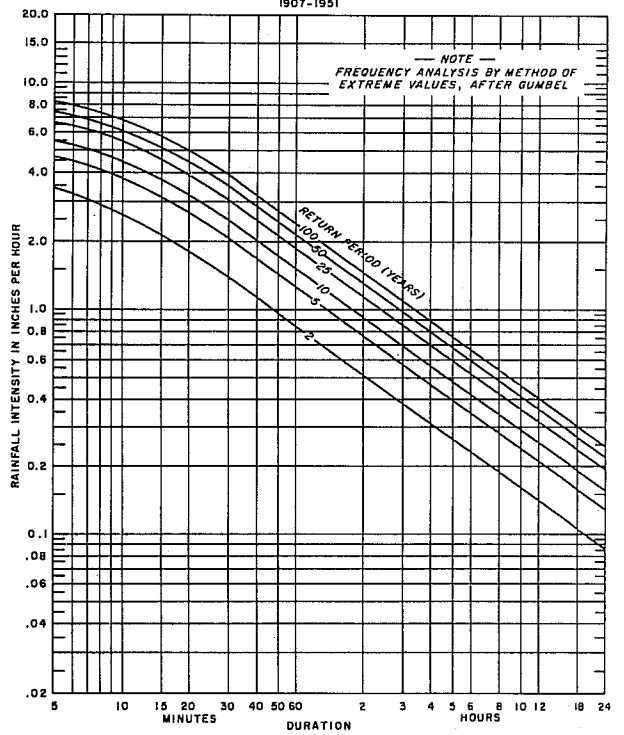
**HURON, SOUTH DAKOTA**  
1905-1951



**PIERRE, SOUTH DAKOTA**  
1907-1909, 1912-1914, 1916-1932

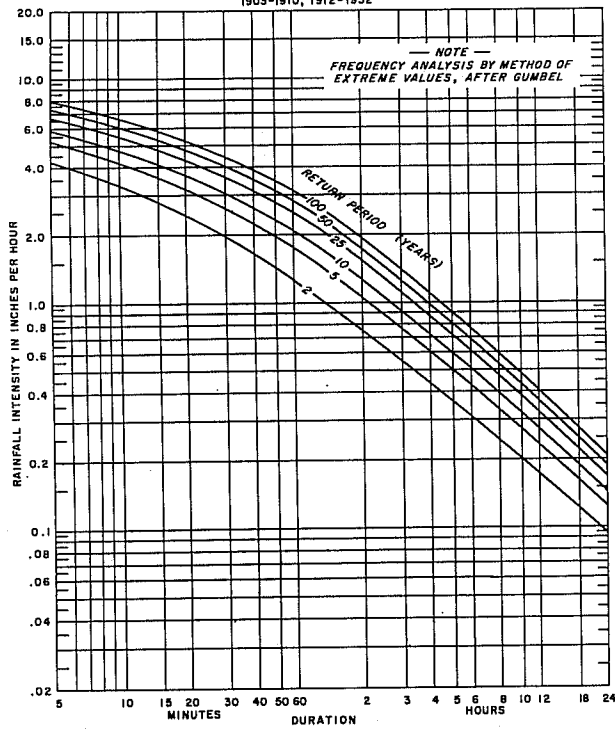


**RAPID CITY, SOUTH DAKOTA**  
1907-1951

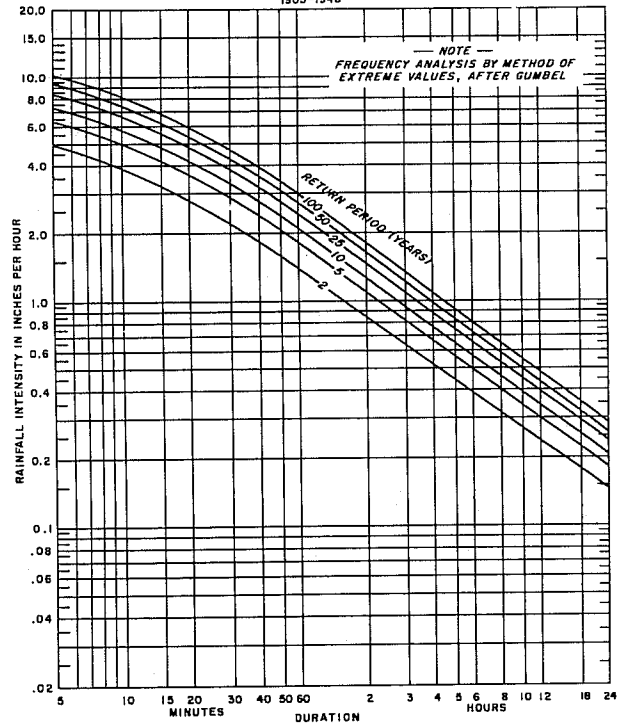


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

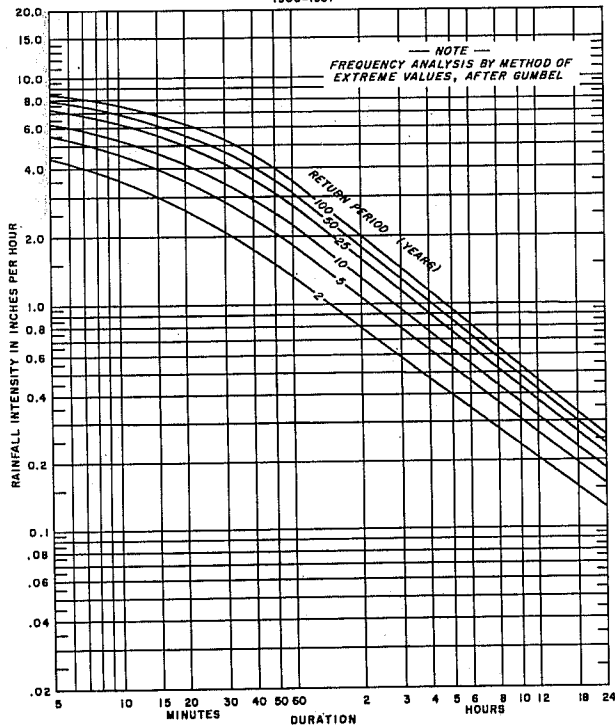
**YANKTON, SOUTH DAKOTA**  
1903-1910, 1912-1932



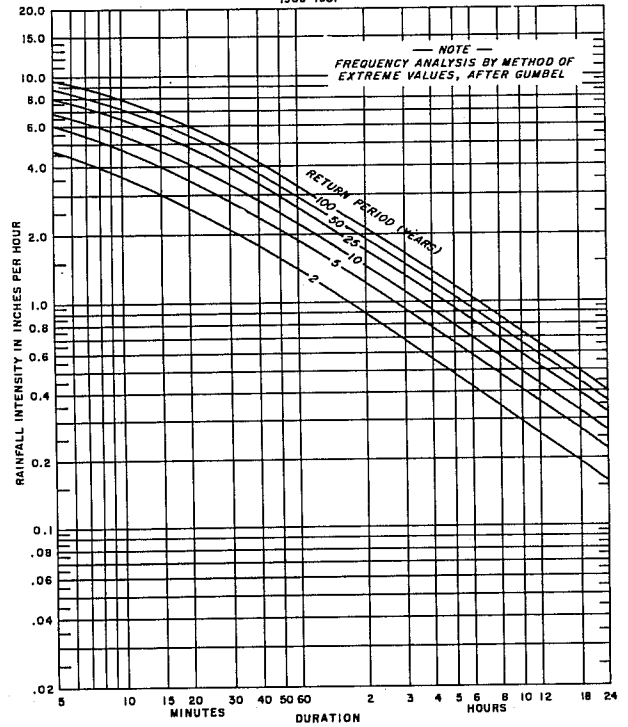
**CHATTANOOGA, TENNESSEE**  
1903-1948



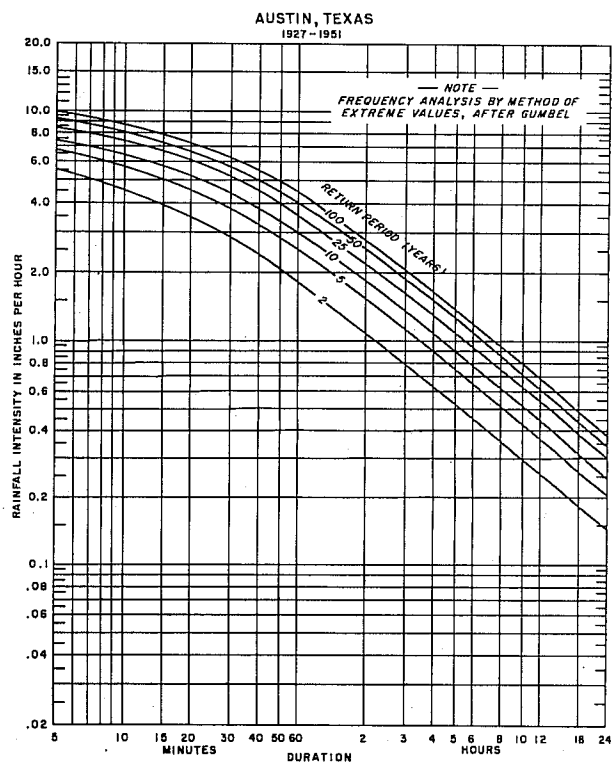
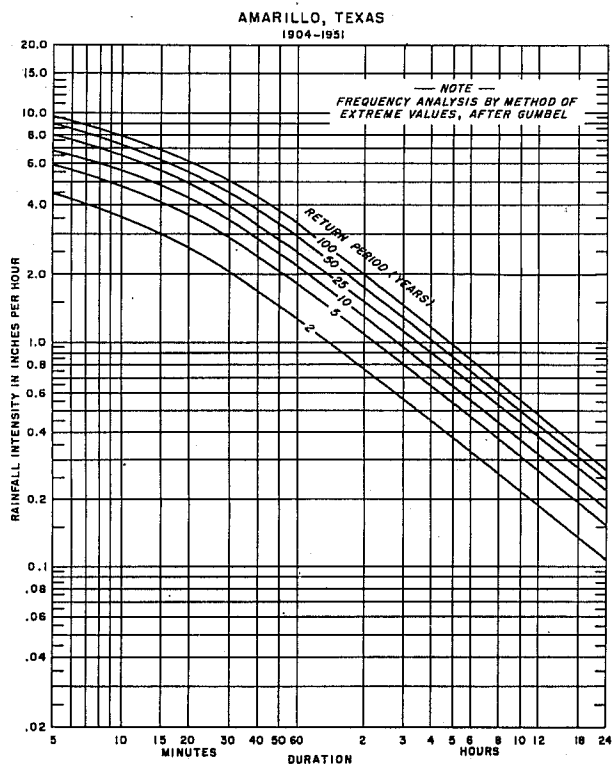
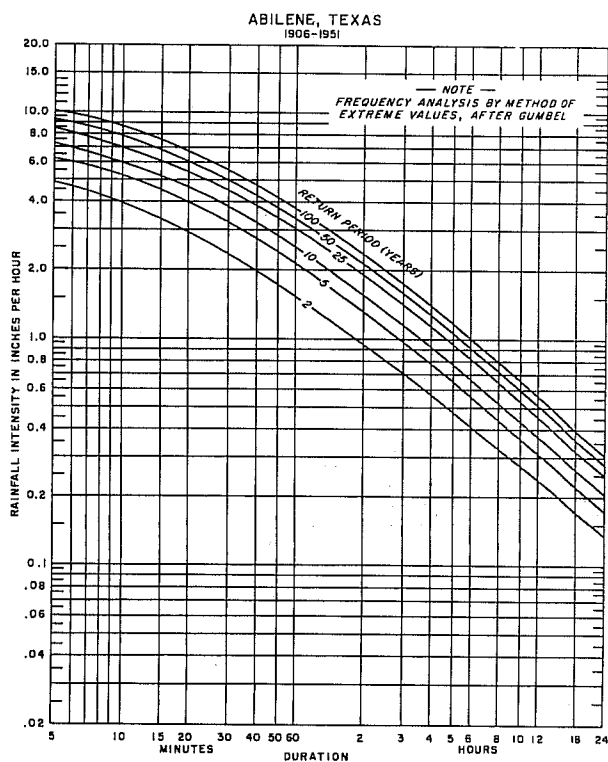
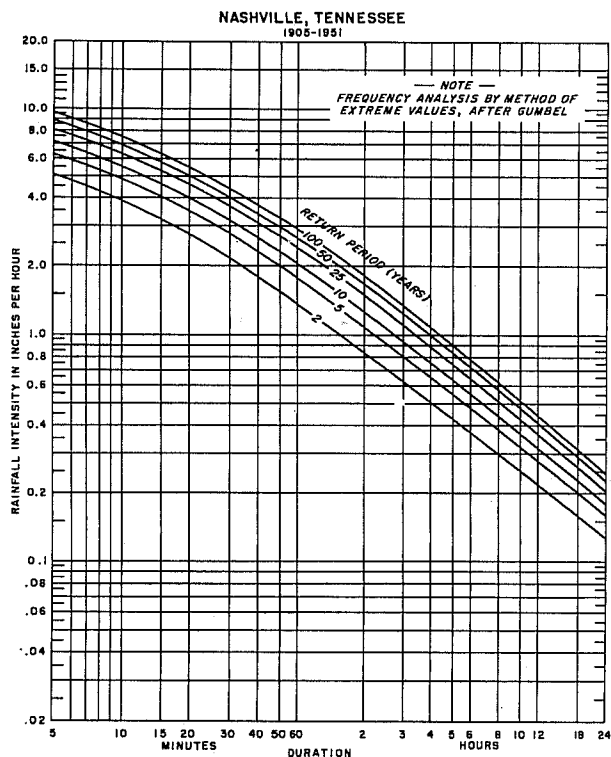
**KNOXVILLE, TENNESSEE**  
1903-1951



**MEMPHIS, TENNESSEE**  
1903-1951

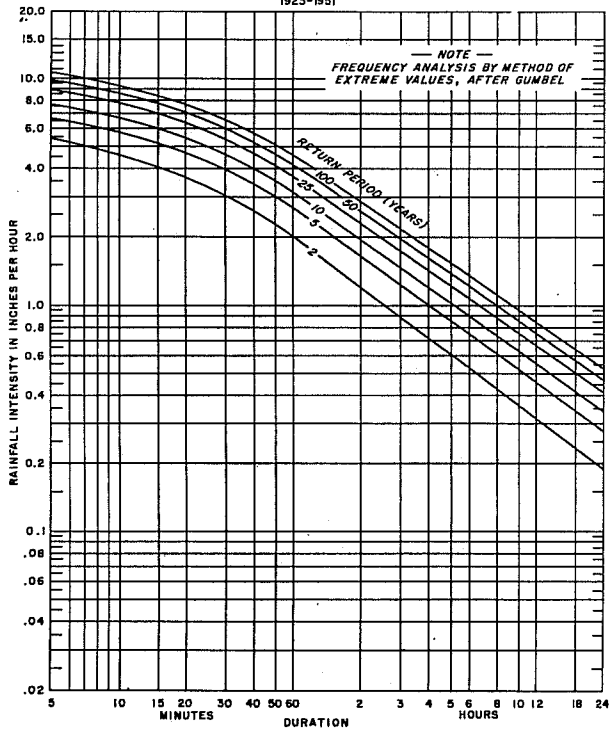


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

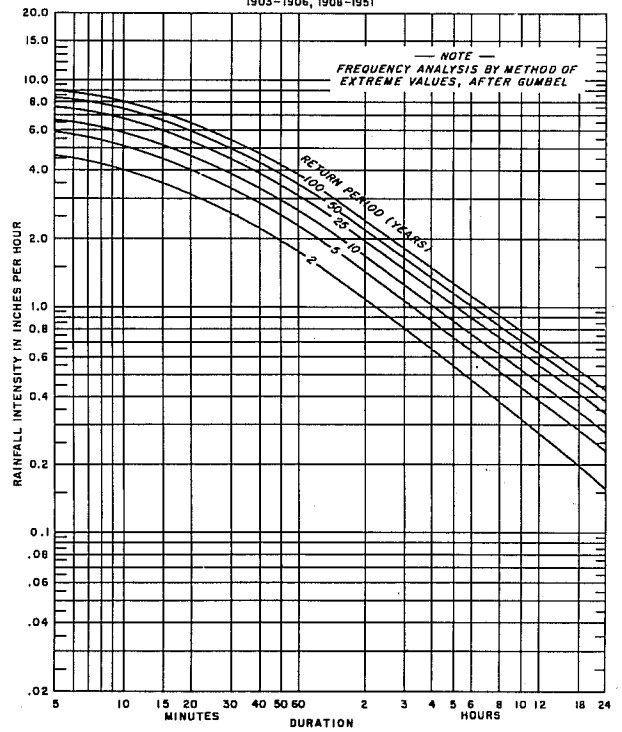


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

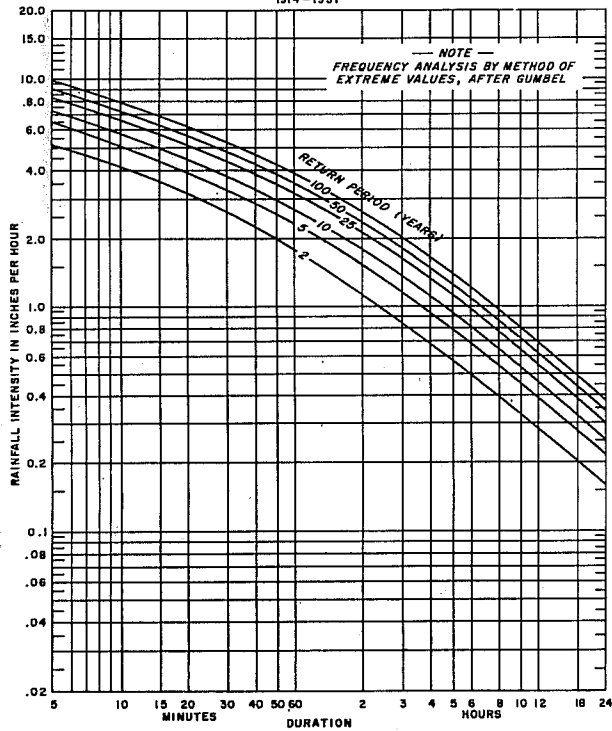
**BROWNSVILLE, TEXAS**  
1923-1951



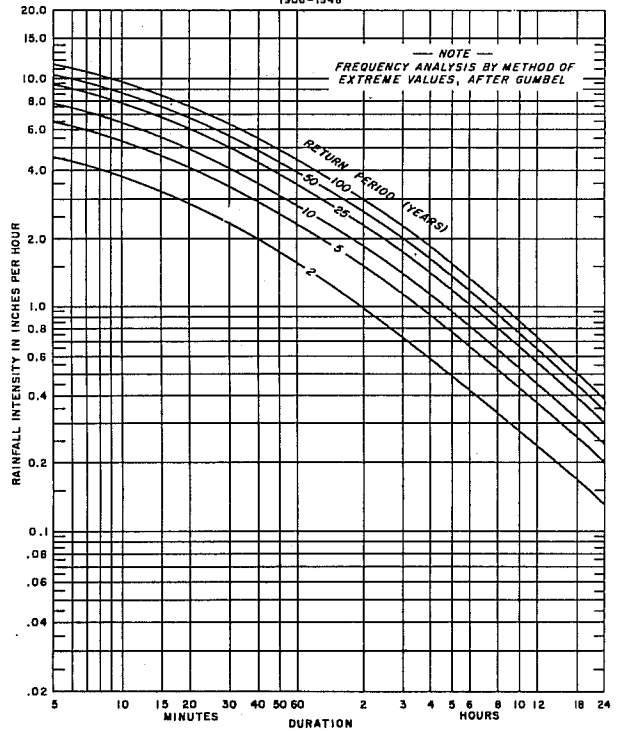
**CORPUS CHRISTI, TEXAS**  
1903-1906, 1908-1951



**DALLAS, TEXAS**  
1914-1951



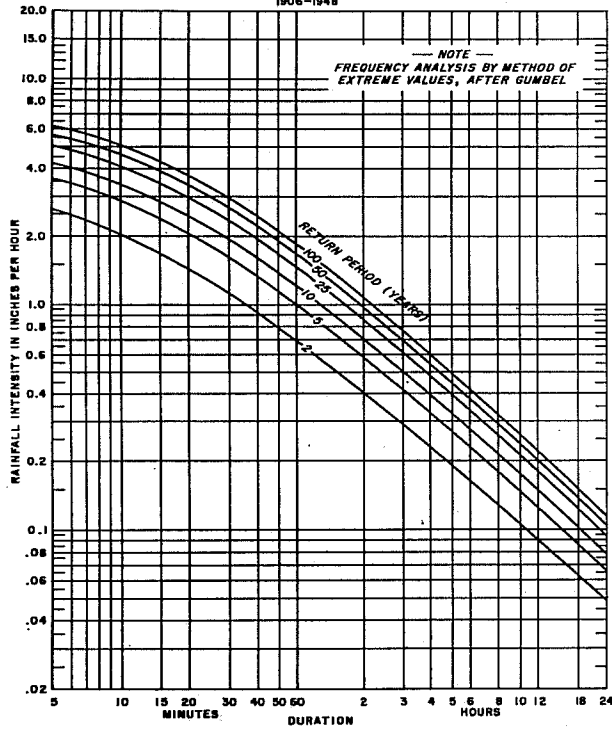
**DEL RIO, TEXAS**  
1906-1948



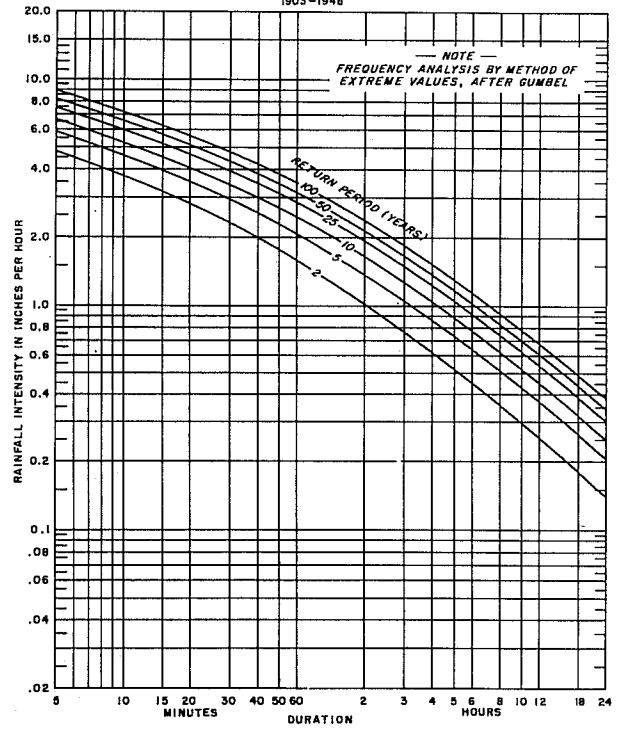


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

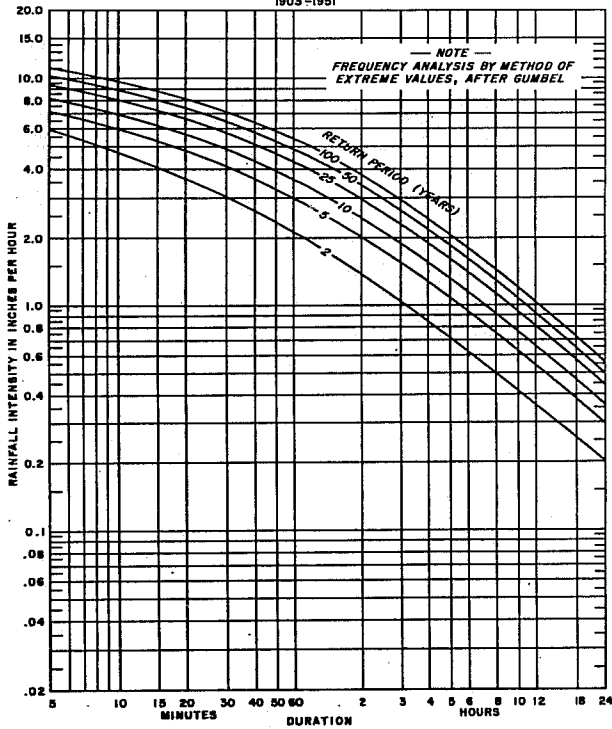
**EL PASO, TEXAS**  
1906-1948



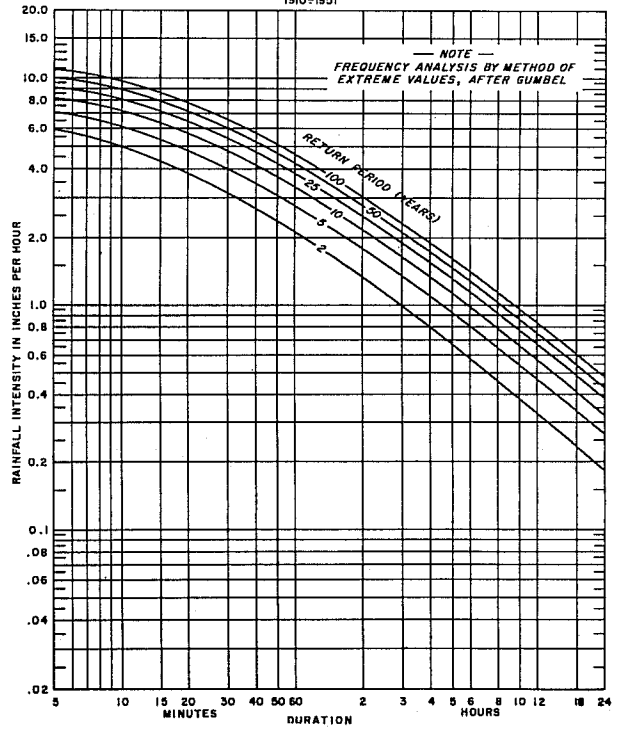
**FORT WORTH, TEXAS**  
1903-1948



**GALVESTON, TEXAS**  
1903-1951

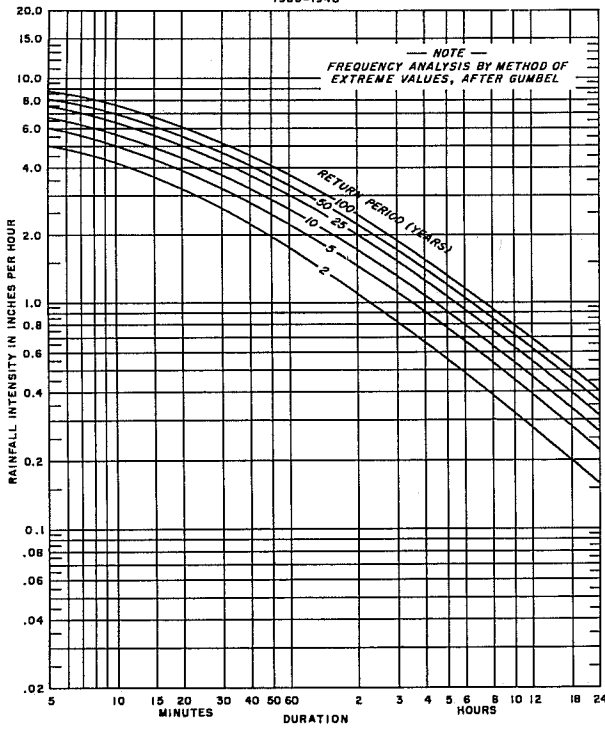


**HOUSTON, TEXAS**  
1910-1951

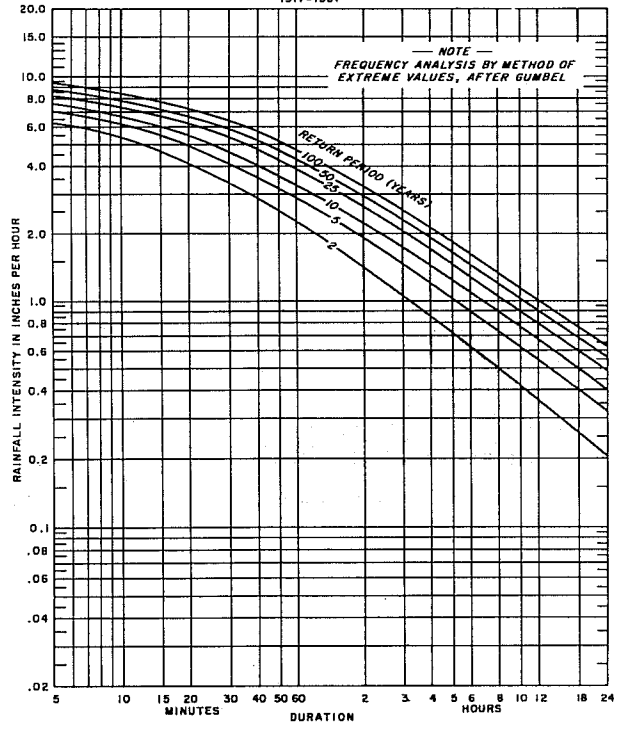


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

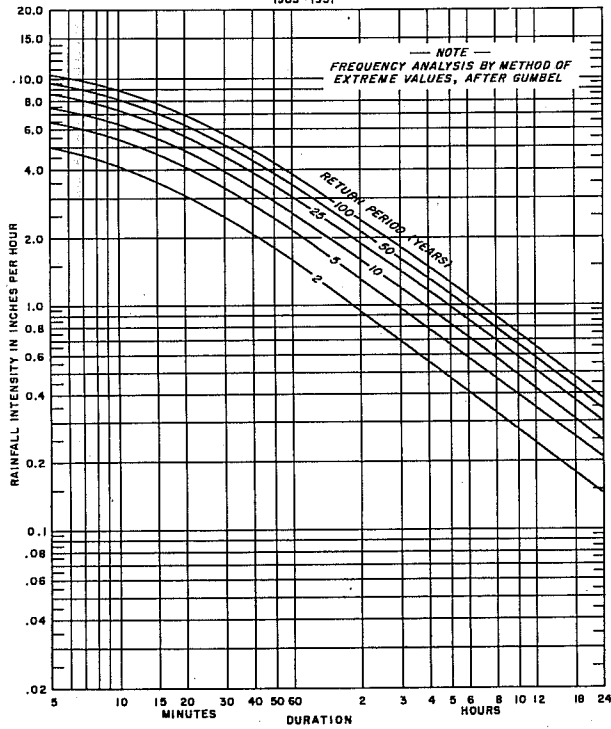
**PALESTINE, TEXAS**  
1905-1948



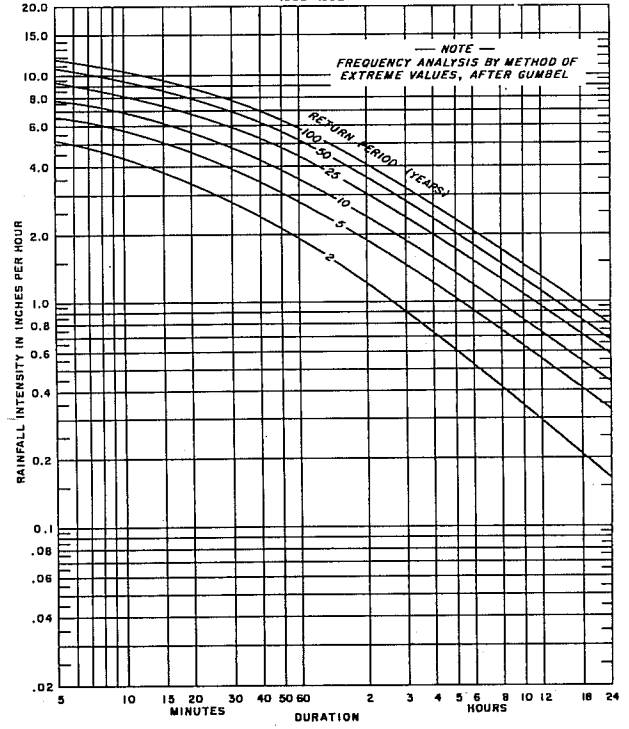
**PORT ARTHUR, TEXAS**  
1917-1951



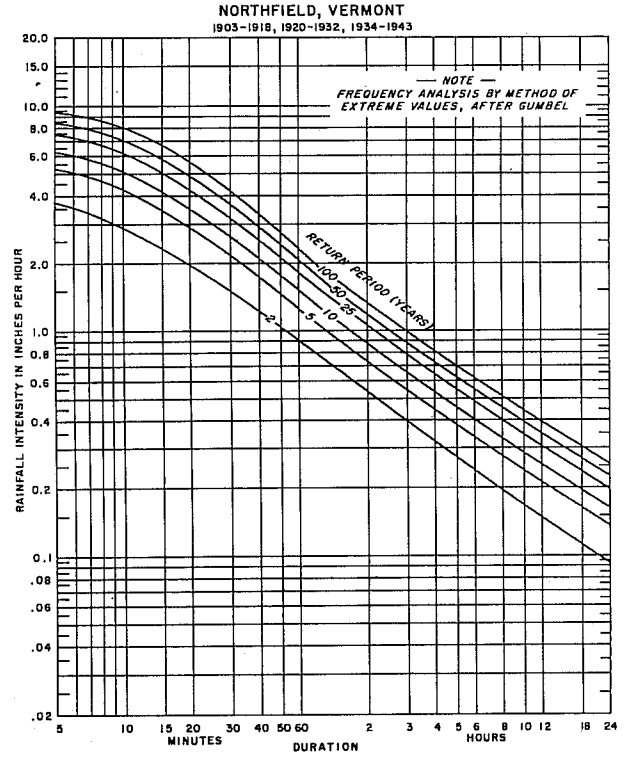
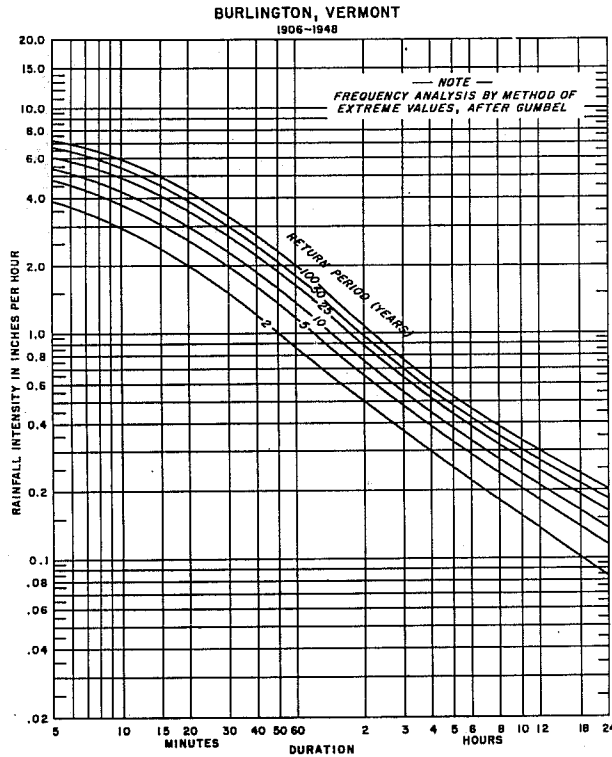
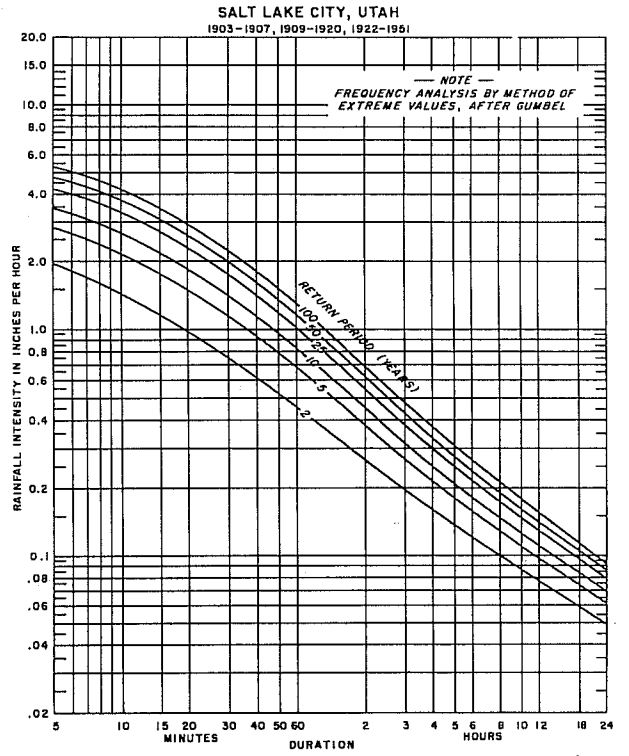
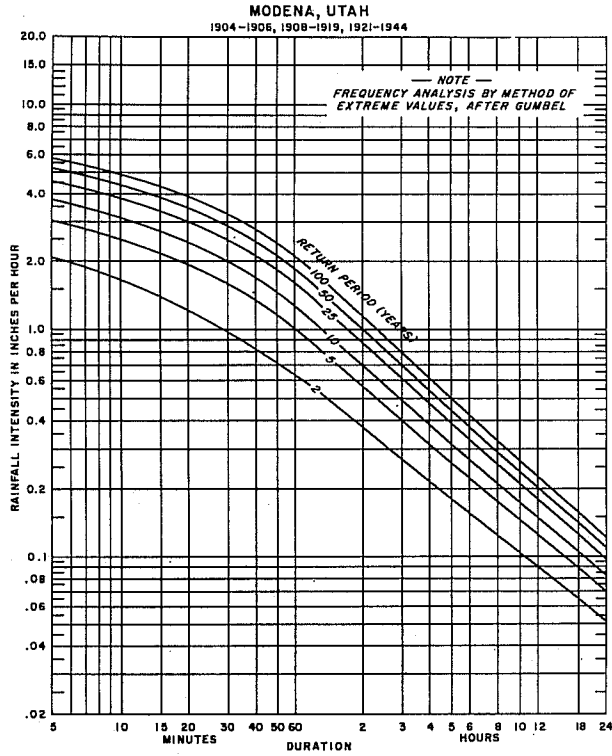
**SAN ANTONIO, TEXAS**  
1903-1951



**TAYLOR, TEXAS**  
1903-1932

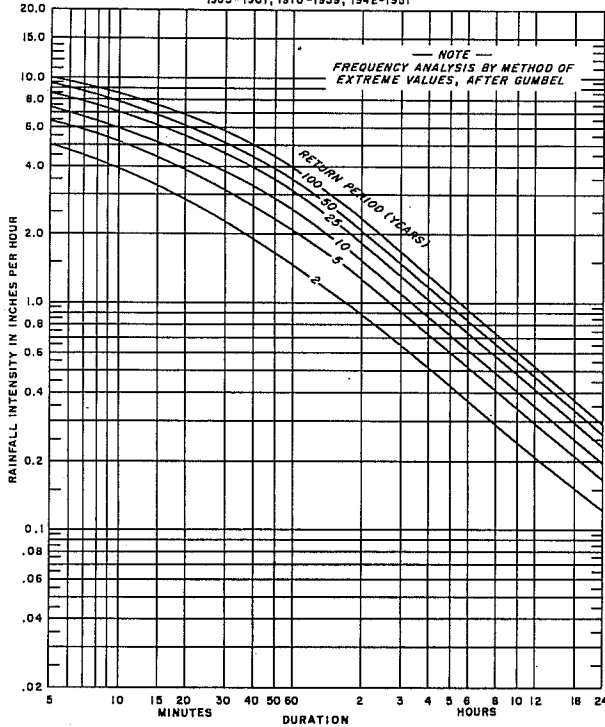


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

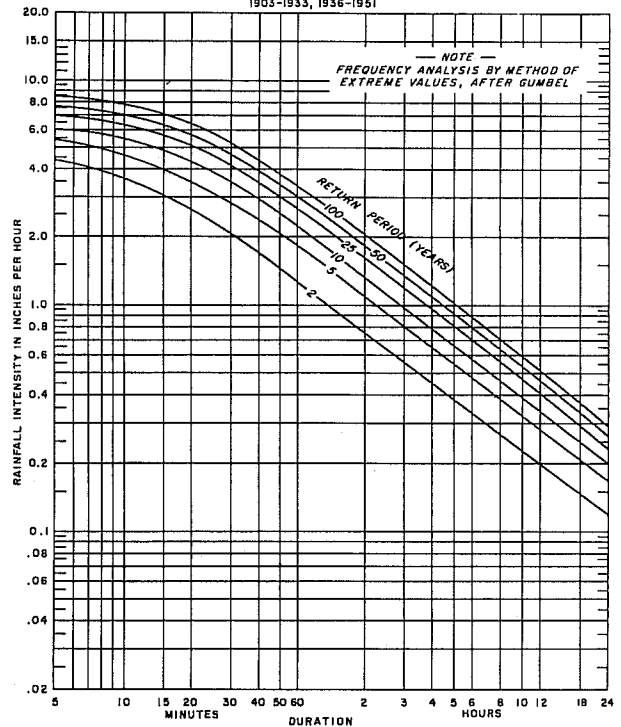


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

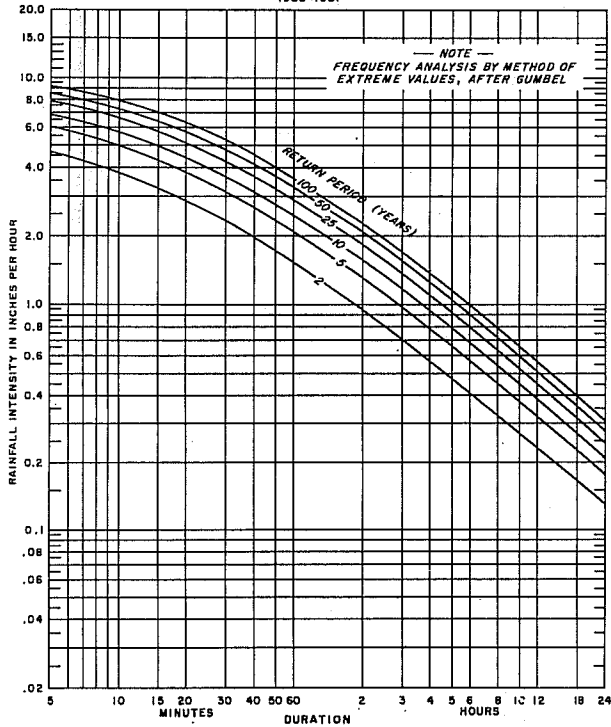
**CAPE HENRY, VIRGINIA**  
1903-1907, 1910-1939, 1942-1951



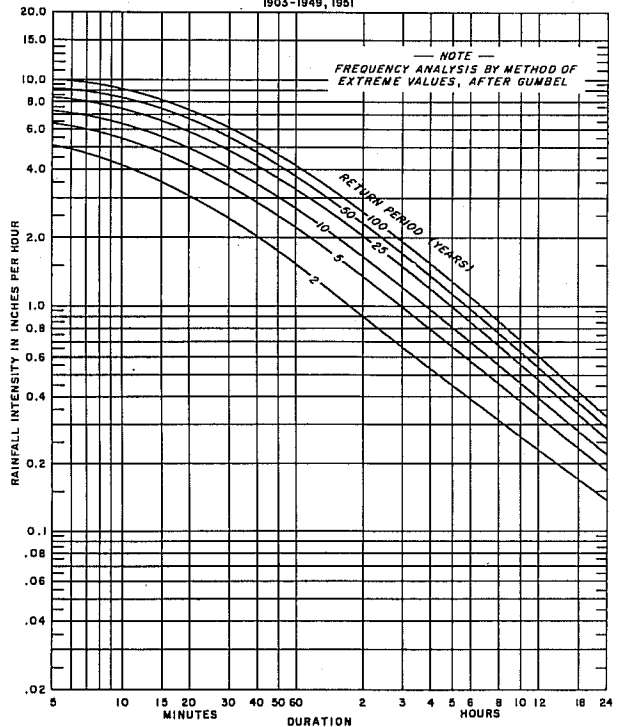
**LYNCHBURG, VIRGINIA**  
1903-1933, 1936-1951



**NORFOLK, VIRGINIA**  
1903-1951

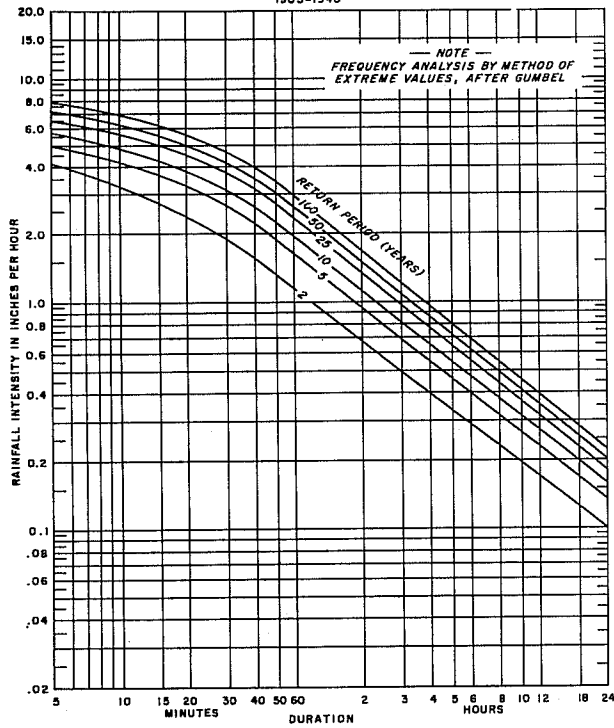


**RICHMOND, VIRGINIA**  
1903-1949, 1951

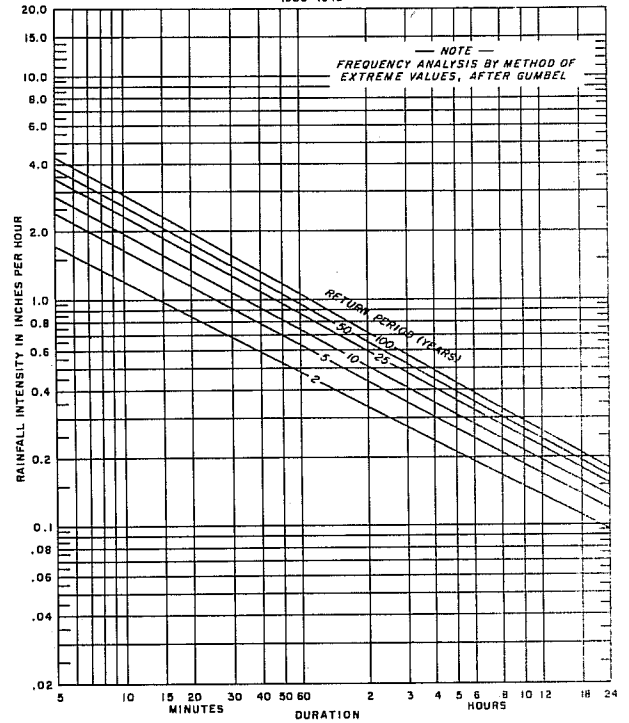


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

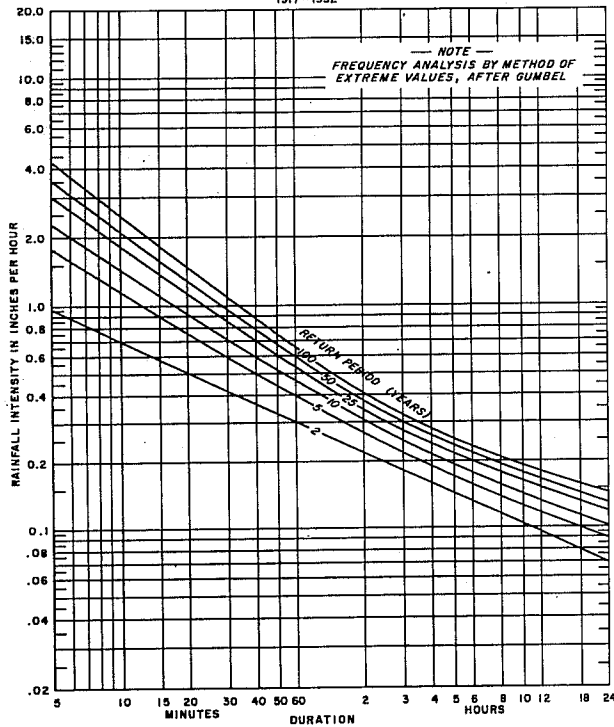
**WYTHEVILLE, VIRGINIA**  
1903-1940



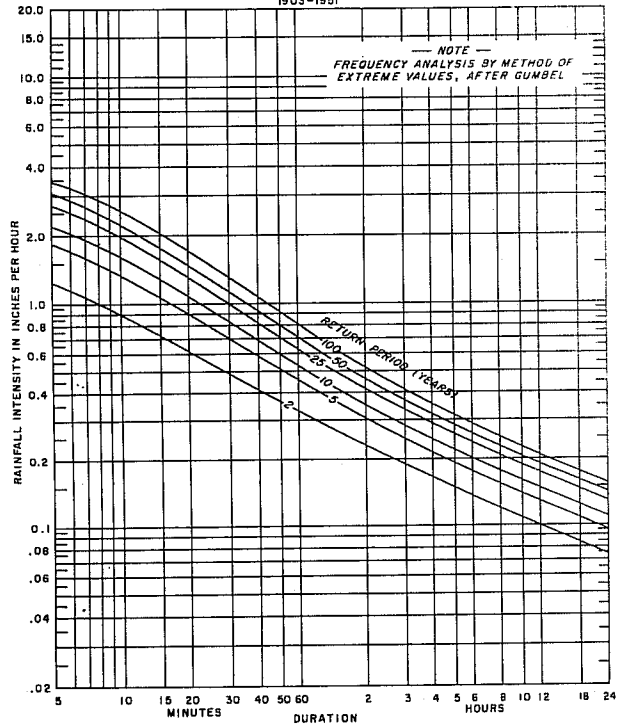
**NORTH HEAD, WASHINGTON**  
1903-1948



**PORT ANGELES, WASHINGTON**  
1917-1932

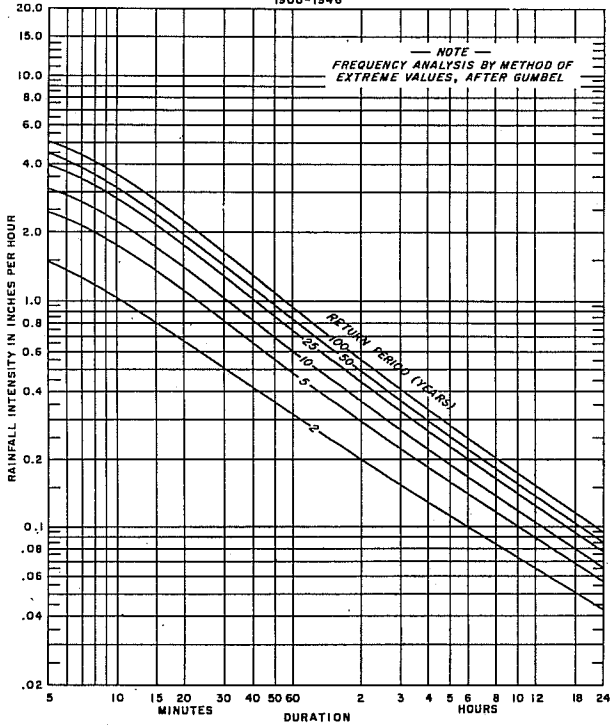


**SEATTLE, WASHINGTON**  
1903-1951

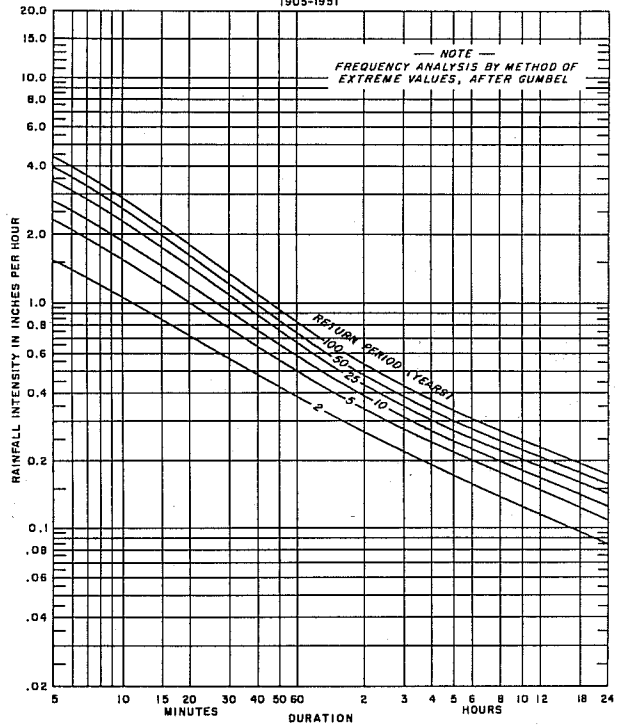


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

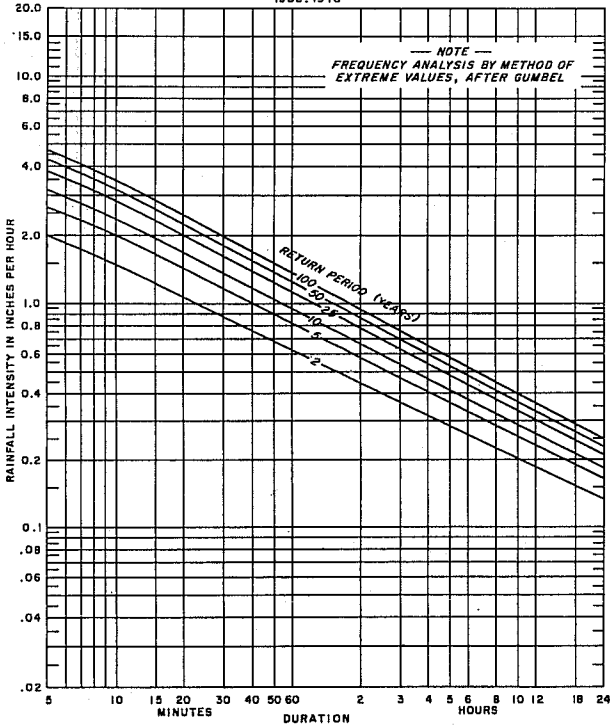
SPOKANE, WASHINGTON  
1900-1946



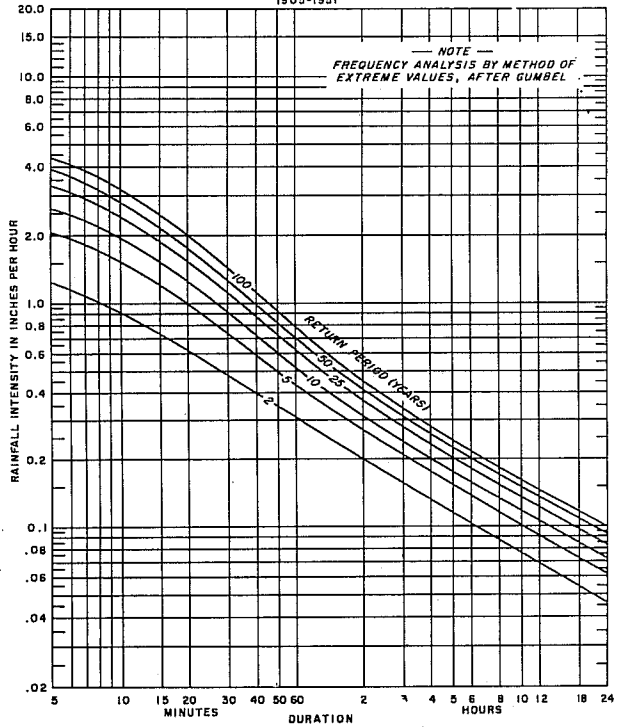
TACOMA, WASHINGTON  
1905-1951



TATOOSH ISLAND, WASHINGTON  
1903-1948

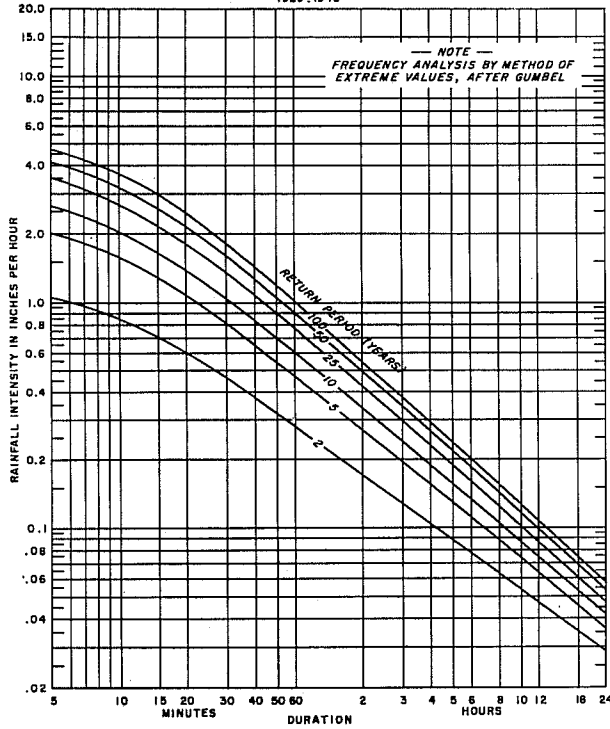


WALLA WALLA, WASHINGTON  
1905-1951

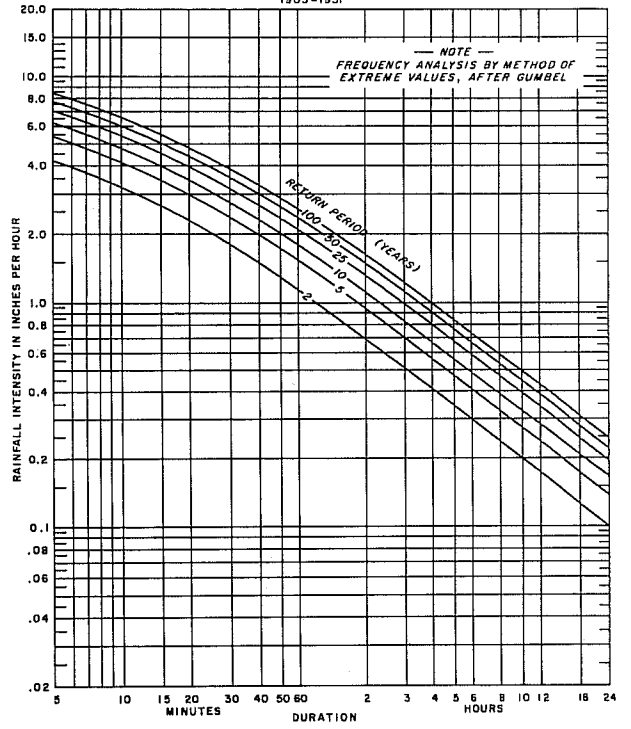


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

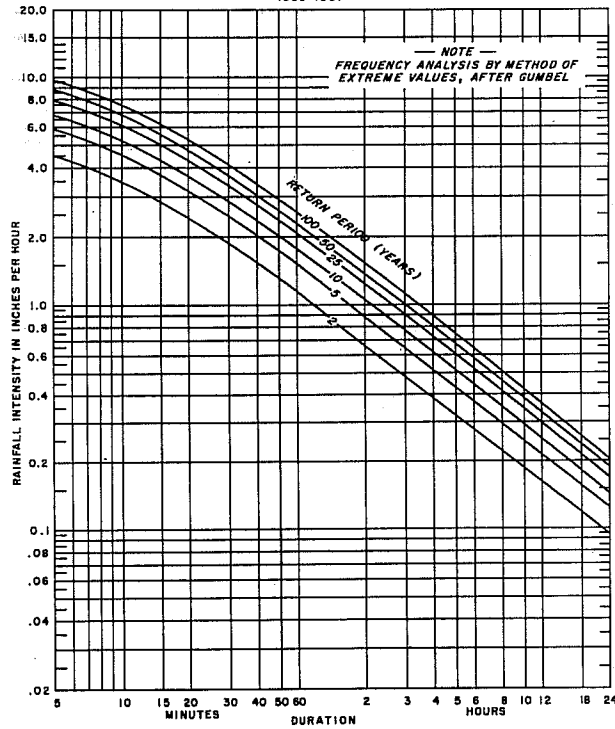
**YAKIMA, WASHINGTON**  
1929-1948



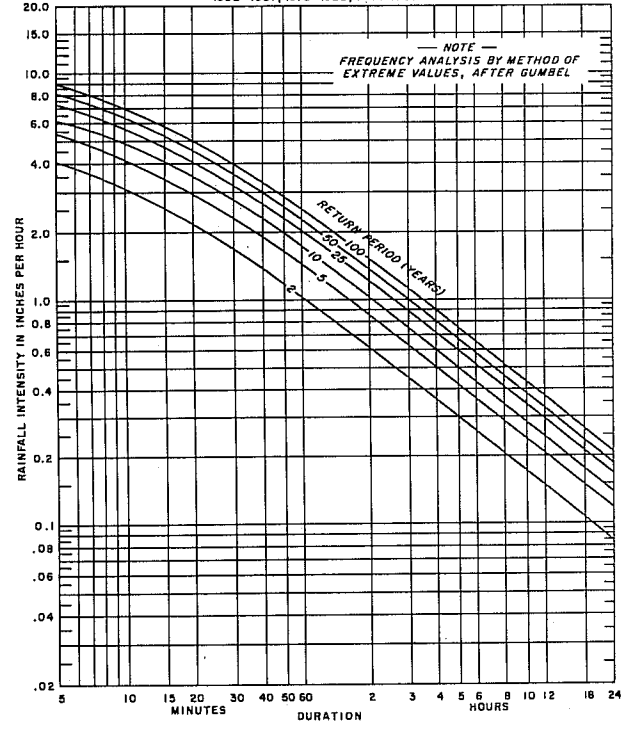
**ELKINS, WEST VIRGINIA**  
1903-1951



**PARKERSBURG, WEST VIRGINIA**  
1903-1951

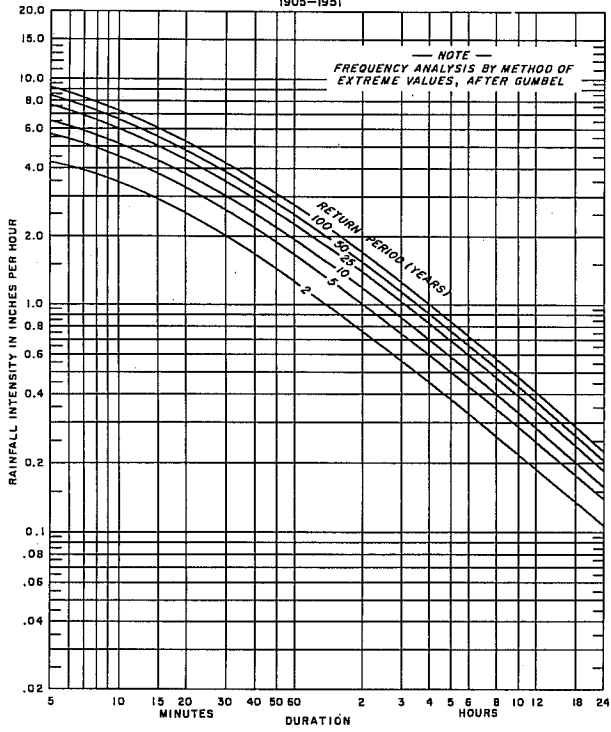


**GREEN BAY, WISCONSIN**  
1902-1907, 1910-1922, 1944-1951

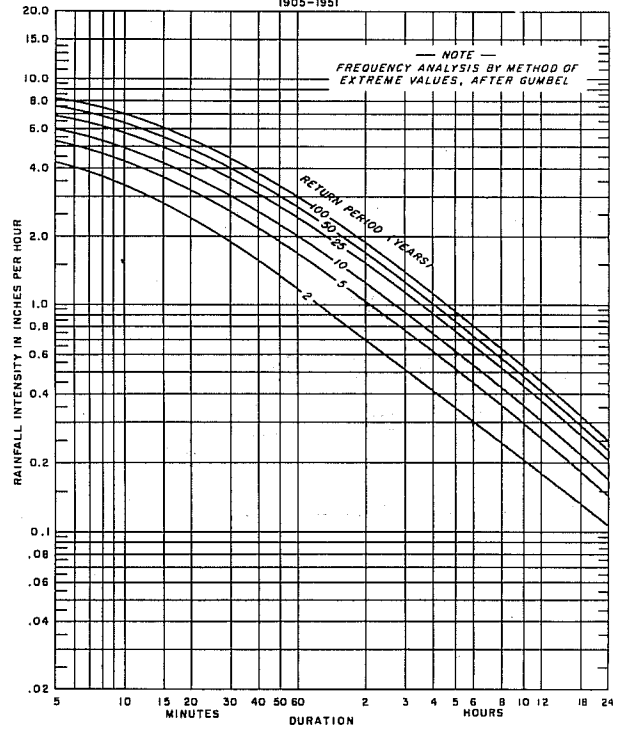


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

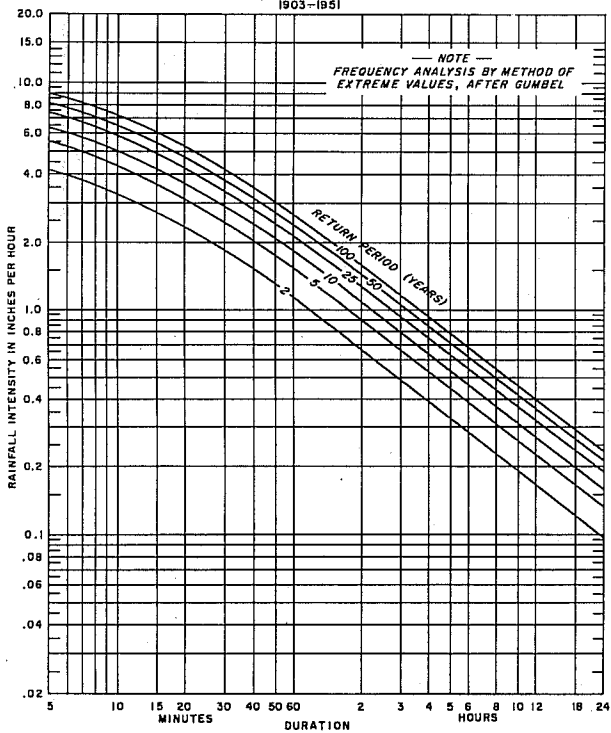
**LA CROSSE, WISCONSIN**  
1905-1951



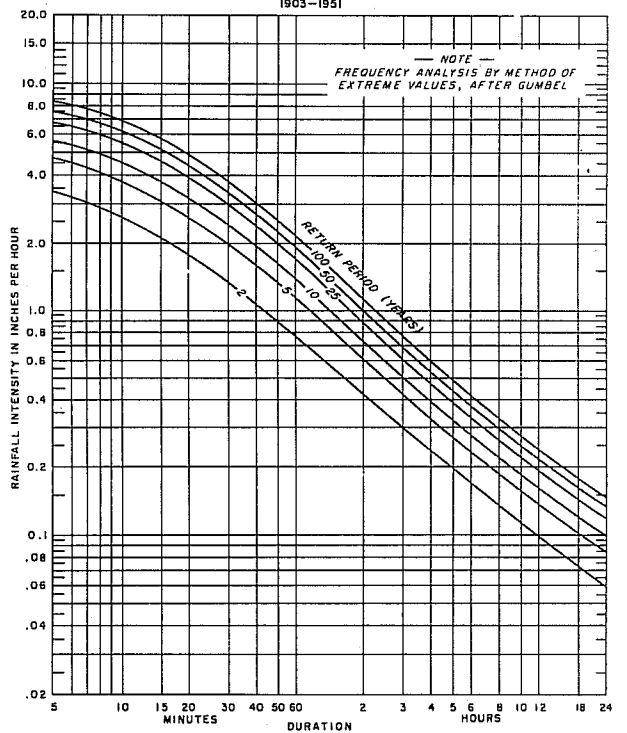
**MADISON, WISCONSIN**  
1905-1951



**MILWAUKEE, WISCONSIN**  
1903-1951



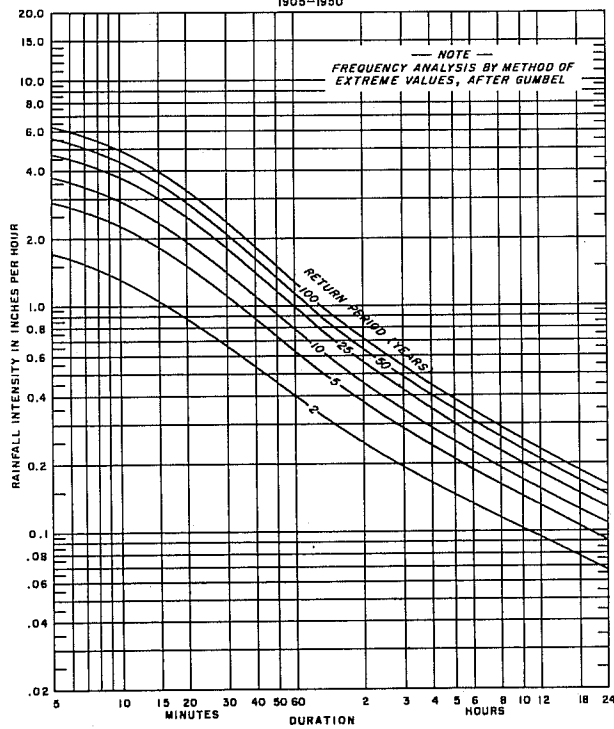
**CHEYENNE, WYOMING**  
1903-1951



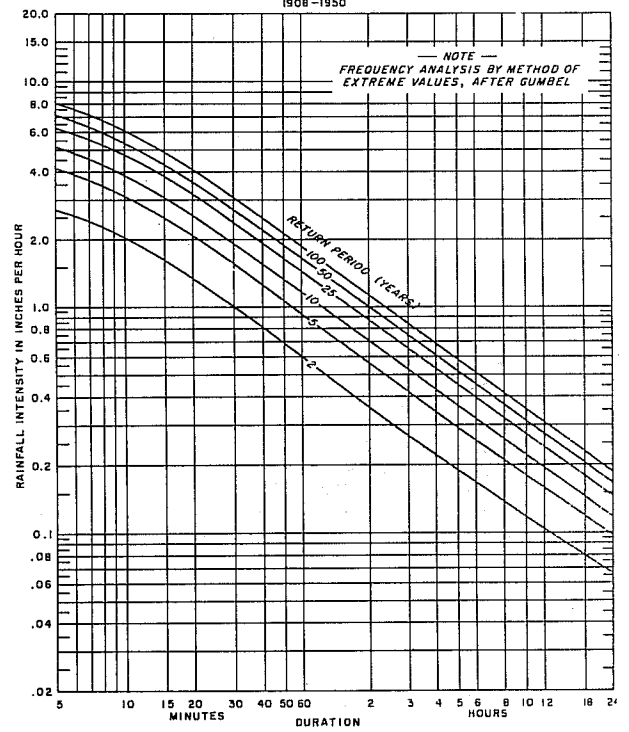


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

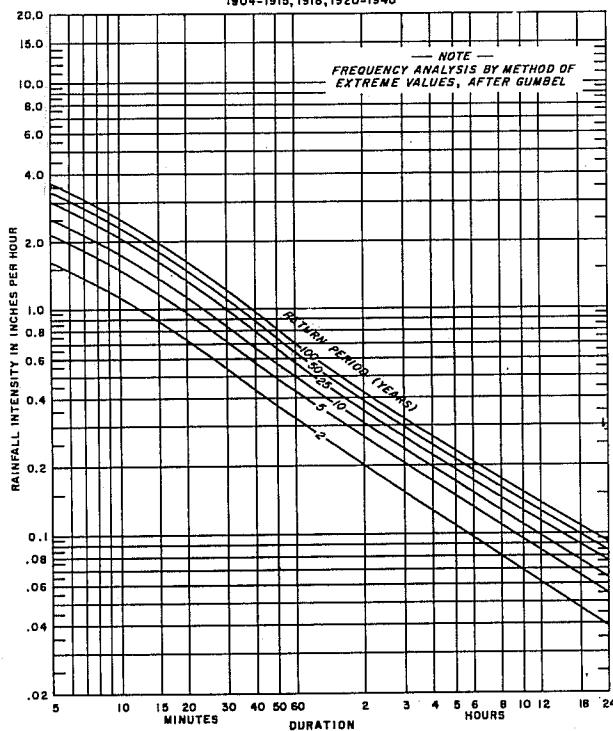
LANDER, WYOMING  
1905-1950



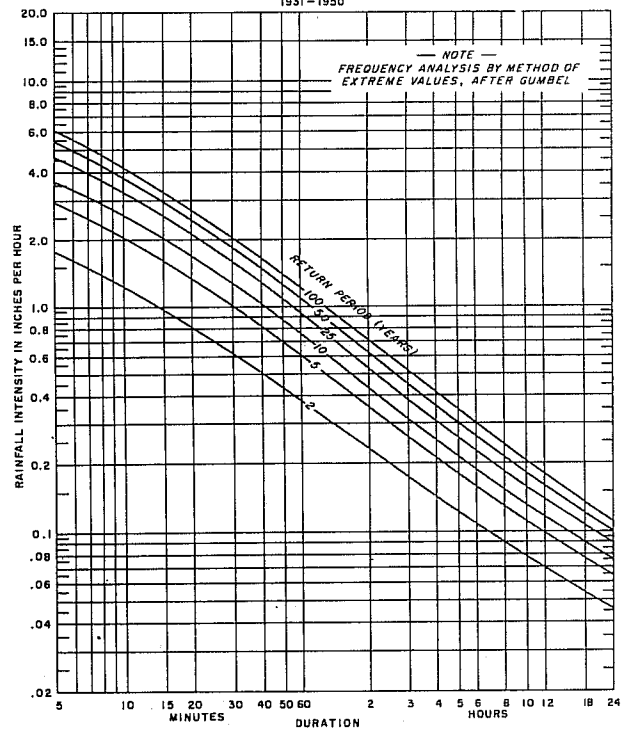
SHERIDAN, WYOMING  
1908-1950



YELLOWSTONE PARK, WYOMING  
1904-1915, 1918, 1920-1940

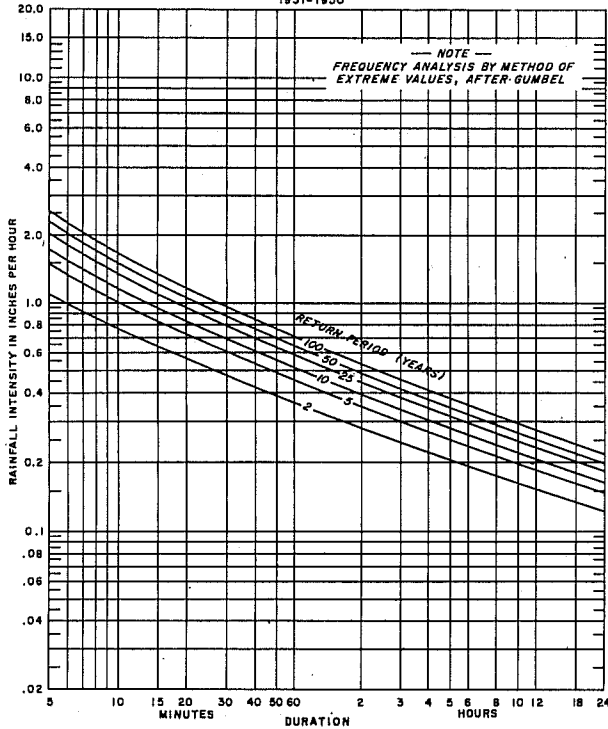


FAIRBANKS, ALASKA  
1931-1950

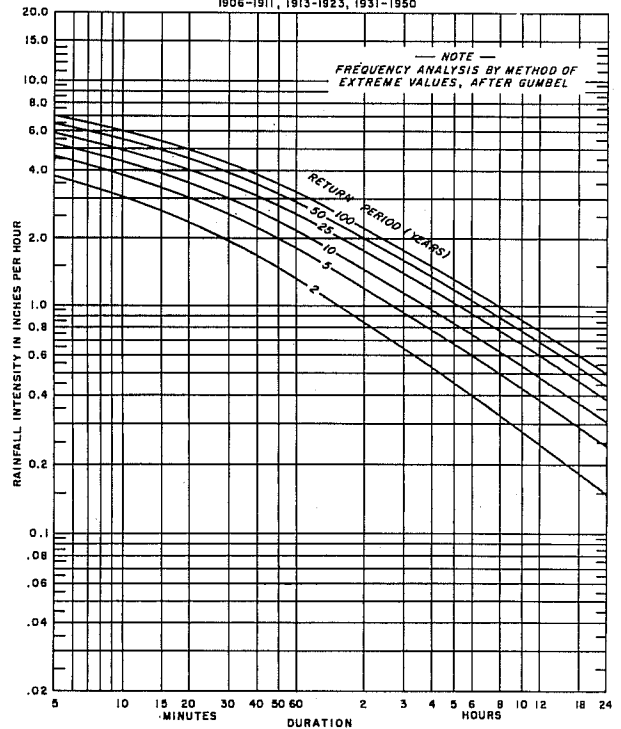


# RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

JUNEAU, ALASKA  
1931-1950



HONOLULU, T. H.  
1906-1911, 1913-1923, 1931-1950



SAN JUAN, PUERTO RICO  
1931-1950

