TECHNICAL PAPER NO. 40

RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

for Durations from 30 Minutes to 24 Hours and
Return Periods from 1 to 100 Years

Prepared by
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Cooperative Studies Section, Hydrologic Services Division
for
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U.S. Department of Agriculture

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*Out of print.*
This publication is intended as a convenient summary of empirical relationships, working guides, and maps, useful in practical problems requiring application of the ideas and results in earlier papers. This work has been supported and financed by the Soil Conservation Service, Department of Agriculture, to provide material for use in developing planning and design criteria for the Watershed Protection and Flood Prevention program (P.L. 566, 86th Congress and as amended).

The paper is divided into two parts. The first part presents the rainfall analyses. Included are measures of the quality of the various relationships, comparisons with previous works of a similar nature, numerical examples, discussions of the limitations of the results, transformation from point to areal frequency, and seasonal variation. The second part presents 48 rainfall frequency maps based on a comprehensive and integrated collection of up-to-date statistics; several related maps, and seasonal variation diagrams. The rainfall frequency (isopluvial) maps are for selected return periods from 10 minutes to 24 hours and return periods from 1 to 100 years.

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20. 100-year 6-hour rainfall
21. 5-year 12-hour rainfall
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26. 5-year 24-hour rainfall
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31. 5-year 30-minute rainfall
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33. 25-year 30-minute rainfall
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36. 5-year 60-minute rainfall
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41. 1-hour rainfall
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44. 12-hour rainfall
45. 24-hour rainfall
46. 30-minute rainfall
47. 60-minute rainfall
48. 10-minute rainfall
49. 15-minute rainfall
50. 30-minute rainfall
51. 10-minute rainfall
52. 15-minute rainfall

This study was prepared in the Cooperative Studies Section (Joseph L. H. Paulson, Chief) of Hydrologic Services Division, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C. Assistance in the study was received from several people. In particular, the author wishes to acknowledge the help of William E. Miller who prepared the rainfall frequency and duration functions and supervised the processing of all the data; Norman S. Foa, who supervised the collection of the basic data; Howard Thompson who prepared the maps for analysis; Walter T. Wilson, a former colleague, who was associated with the development of a large portion of the material presented here; Max A. Kuehler, A. L. Haines, and Leonard L. Weiss, of the Weather Bureau, and V. Marko and R. A. Andreis, of the Soil Conservation Service, who reviewed the manuscript and made many helpful suggestions. Carol W. Gardner prepared the drafting.

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INTRODUCTION

Historical review

About 1963, economic and engineering design requiring rainfall frequency data was based largely on Yarnell's paper [1] which contains a series of generalized maps for several combinations of durations and return periods. Yarnell's maps are based on data from about 200 first-order Weather Bureau stations which maintains complete recording-gage records. In 1949, about 5 years after Yarnell's paper was published, a hydrologic network of recording gages was installed to supplement both the Weather Bureau recording gages and the relatively large number of nonrecording gages. The additional recording gages have subsequently increased the amount of short-duration data by a factor of 20.

Weather Bureau Technical Paper No. 48, Parts I and II [2], prepared for the Corps of Engineers in connection with their military construction program, contained the first studies covering an extensive area which exploited the hydrologic network data. The results of this work showed the importance of the additional data in defining the short-duration rainfall frequency regime in the mountainous regions of the West. In many instances, the differences between Technical Paper No. 48 and Yarnell reach a factor of three, with the former generally being larger. Relationships developed and knowledge gained from these studies in the United States were then used to prepare similar reports for the contiguous United States [3] and several Arctic regions [4] where recording-gage data were lacking.

Cooperation between the Weather Bureau and the Soil Conservation Service began in 1950 for the purpose of defining the depth-duration-frequency curves in the United States. Technical Paper No. 88 [5], which was partly a by-product of previous work performed for the Corps of Engineers, was the first paper published under the sponsorship of the Soil Conservation Service. This paper contains a series of rainfall intensity-duration-frequency curves for 200 first-order Weather Bureau stations. This was followed by Technical Paper No. 87 [6], which is an expansion of Technical Paper No. 48 to longer return periods and durations. Next to be published were the first parts of Technical Paper No. 89 Series [7], which cover the region east of 90° W. Included in this series are seasonal variations on a frequency basis and area-depth curves so that the point frequency values can be transformed to area frequency. Except for the region between 90° W. and 105° W., the contiguous United States has been covered by generalized rainfall frequency studies prepared by the Weather Bureau since 1953.

General approach

The approach followed in the present study is basically that utilized in [6] and [7]. In these references, simplified duration and return-period relationships and several key maps were used to determine additional combinations of return periods and durations. In this study, four key maps provided the basis for these two relationships which were programmed to permit digital computer computations for a 1000-point grid on each of 45 additional maps.

PART I: ANALYSES

Basic data

Types of data.—The data used in this study are divided into three categories. First, there are the recording-gage data from the long-record first-order Weather Bureau stations. There are 200 such stations with records long enough to provide adequate results within the ranges of return periods of this paper. These data are for the 6-hour period containing the maximum rainfall. Second, there are the recording-gage data of the hydrologic network which are published for clock-hour intervals. These data were processed for the 24 consecutive clock-hour intervals containing the maximum rainfall—not calendar-day. Finally, there is the very large amount of nonrecording-gage data with observations made once daily. Use was made of these data to help define both the 24-hour rainfall regime and the shorter duration regimes through applications of empirical relationships.

Station data.—The sources of data are indicated in table 1. The data from the 200 long-record Weather Bureau stations were used to develop most of the relationships which will be described later. Long records from more than 1000 stations were analyzed to define the relationships for the rarer frequencies (return periods), and statistics from short periods of the record from about 2000 stations were used as an aid in defining the regional pattern for the 2-year return period. Several thousand additional stations were considered but not plotted where the station density was adjudged to be inadequate.

Period and length of record.—The nonrecording short-record data were compiled for the period 1938-1957 and long-record data from the earliest year available through 1957. The recording-gage data cover the period 1940-1958. Data from the long-record Weather Bureau stations were processed through 1958. No record of less than five years was used to estimate the 2-year value.


for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years

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Table 1.—Source of point-record data

<table>
<thead>
<tr>
<th>Duration</th>
<th>No. of stations</th>
<th>Average length of record (yr.)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 min.</td>
<td>50-200</td>
<td>40</td>
<td>8, 9, 10</td>
</tr>
<tr>
<td>Daily</td>
<td>160</td>
<td>14</td>
<td>11, 12</td>
</tr>
<tr>
<td>Monthly</td>
<td>143</td>
<td>12</td>
<td>11, 13</td>
</tr>
<tr>
<td>Annual</td>
<td>73</td>
<td>47</td>
<td>13</td>
</tr>
</tbody>
</table>

FIGURE 1.—Relation between 3-year 60-minute rainfall and 2-year clock-hour rainfall; relation between 3-year 1440-minute rainfall and 2-year observational-day rainfall.
Duration analysis

A generalized duration relationship was developed with which the rainfall depth for a selected return period can be computed for any duration between 1 and 24 hours, when the 1- and 24-hour values for that particular return period are given (see fig. 2). This generalization was obtained empirically from data for the 300 Weather Bureau first-order stations. To use this diagram, a straightedge is laid across the values given for 1 and 24 hours and the values for other durations are read at the proper intersections. The quality of this relationship for the 2- and 6-hour durations is illustrated in figures 3 and 4 for stations with a wide range in rainfall magnitude.

Relationship between 30-minute and 60-minute rainfall.—If a 30-minute ordinate is positioned to the left of the 60-minute ordinate on the duration interpolation diagram of figure 2, acceptable estimates can be made of the 30-minute rainfall. This relationship was used in several previous studies. However, tests showed that better results can be obtained by simply multiplying the 60-minute rainfall by the average 30- to 60-minute ratio. The empirical relationship used for estimating the 30-minute rainfall is 0.79 times the 60-minute rainfall. The quality of this relationship is illustrated in figure 5.

Frequency analysis

Two types of series.—This discussion requires consideration of two methods of selecting and analyzing intense rainfall data. One method, using the partial-duration series, included all the high values. The other uses the annual series which consists only of the highest value for each year. The highest value of record, of course, is the top value of each series, but at lower frequency levels (shorter return periods) the two series diverge. The partial-duration series, having the highest values regardless of the year in which they occur, recognizes that the second highest of some year occasionally exceeds the highest of some other year. The purposes to be served by the series require that the results be expressed in terms of partial-duration frequencies. In order to avoid laborious processing of partial-duration data, the annual series were collected, analyzed, and the resulting statistics transformed to partial-duration statistics.

Conversion factors for two series.—Table 2, based on a sample of a number of widely scattered Weather Bureau first-order stations, gives the empirical factors for converting the partial-duration series to the annual series.
The quality of the relationship between the mean of the partial-duration series and the mean of the annual series data for the 1-, 6-, and 24-hour durations is illustrated in figure 6. The means for both series are equivalent to the 2.3-year return period. Tests with samples of record length from 10 to 50 years indicate that the factors of table 2 are independent of record length.

The 2-year value is a measure of the first moment—the central tendency of the distribution. The relationship of the 2-year to the 100-year value is a measure of the second moment—the dispersion of the distribution. These two parameters, 2-year and 100-year rainfall, are used in conjunction with the return-period diagram of figure 7 for estimating values for other return periods.

Use of diagram.—The two intercepts needed for the frequency relation in the diagram of figure 7 are the 2-year values obtained from the 2-year maps and the 100-year values from the 100-year maps. Thus, the given rainfall values for both 2- and 100-year return periods, values for other return periods are functionally related and may be determined from the frequency diagram which is entered with the 2- and 100-year values.

General applicability of return-period relationships.—Tests have shown that within the range of the data and the purpose of this paper, the return-period relationship is independent of duration. In other words, for 30 minutes, or 24 hours, or any other duration within the range of this report, the 2-year and 100-year values define the values for other return periods in a consistent manner. Studies have disclosed no regional pattern that would improve the return-period diagram.

Stationary trend.—The use of short-record data introduces the question of possible secular trend and biased sample. Routine tests with subsamples of equal size from different periods of record for the same station showed no appreciable trend, indicating that the direct use of the relatively recent short-record data is legitimate.

EXAMPLE. If the 5-, 6- and 10-year partial-duration series values estimated from the maps as a particular point are 3.00, 3.75, and 4.31 inches, respectively, what are the annual series values for corresponding return periods? Multiplying by the appropriate conversion factors of table 2 gives 3.64, 3.90, and 4.17 inches.

The transition was smoothed subjectively between 10- and 20-year return periods. If rainfall values for return periods between 5 and 100 years are taken from the return-period diagram of figure 7, converted to annual series values by applying the factors of table 2, and plotted on either Gumbel or log-normal paper, the points will very nearly approximate a straight line.

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Bureau stations. The spacing of the vertical lines on the diagram exists between the hydrologic characteristics of hurricane or tropical storm rainfall and those of rainfall from other types of storms. The conventional procedure of analyzing the annual maxima without regard to storm type is to be preferred because it avoids non-systematic sampling. It also eliminates having to attach a storm type label to the rainfall, which in some cases of intermediate storm type (as when a tropical storm becomes extratropical) is arbitrary.

Predictive value of theoretical distribution.—Estimation of return periods requires an assumption concerning the parametric form of the distribution function. Since less than 10 percent of the more than 6000 stations used in this study have records for 60 years or longer, this raises the question of the predictive value of the results particularly, for the longer return periods. As indicated previously,

Trend table 2 gives 2.64, 3.60, and 4.17 inches.
and the 1- and 24-hour duration. In order to minimize the exaggerated effect that an outlier (nonstationary event) from a short record has on the magnitude of the 100-year value, only the data from stations with minimum record lengths of 18 years for the 1-hour and 40 years for the 24-hour were used in this analysis. As a result of the large sampling errors associated with these ratios, it is not possible to find a station with a ratio of 2.0 located near a 3.0 ratio even in regions where geographic influence on the rainfall regime are absent. As a group, the stations’ ratios mask out the stations-to-station dispersions and provide a more reliable indication of the direction of distribution than the individual station data. A mean-transformation revealed that some systematic geographical variation was present which would justify the construction of smoothed ratio maps with a small range. The loessil patterns constructed for the two maps are not identical but the ratios on both maps range from about 2.0 to 3.0. The average ratio is about 2.5 for the 24-hour duration and 2.2 for the 1-hour.

100-year 1-hour and 24-hour maps. The 100-year values which were computed for 3000 selected points (fig. 10) are the product of the values from the 2-year maps and the 100-year to 2-year ratio maps. Good definition of the complexity of pattern and steepness of gradient of the 2-year and 100-year maps determined the geographically balanced grid density of figure 10.

Additional maps. The 4500-grid point grid of figure 12 was also used to depict the isoline patterns of the 45 additional maps. Four values—one from each of the four key maps—were read for each grid point. Programming of the duration and return period relationships plus the four values for each point permitted digital computer computation for the 45 additional maps. The isolines were positioned by interpolation with reference to numbers at the grid points. This was necessary to maintain the internal consistency of the series of maps. Pronounced “highs” and “lows” are positioned in consistent locations on all maps. Where the 1- to 24-hour ratio for a particular area is small, the 24-hour value has the greatest influence on the pattern of the intermediate duration maps. Where the 1- to 24-hour ratio is large, the 1-hour value appears to have the most influence on the intermediate duration pattern.

Reliability of results. The term reliability is used here in the statistical sense to refer to the degree of confidence that can be placed in the accuracy of the results. The reliability of results is influenced by sampling error in time, sampling error in space, and by the manner in which the maps were constructed. Sampling error in space is a result of the two factors: (1) the chance occurrence of an anomalous storm which has a disproportionate effect on one station’s statistics but not on the statistics of a nearby station, and (2) the geographical distribution of stations. Where stations are farther apart along the dense networks studied for this project, stations may experience rainfalls that are nonrepresentative of their vicinity, or may completely miss rainfalls that are representative. Similarly, sampling error in time results from rainfalls not occurring according to their average regime during a brief record. A brief record of precipitation may include some nonrepresentative large storms, or may miss important storms that occurred before or after the period of record so a given station. In evaluating the effects of spatial sampling errors, it is pertinent to look for and to evaluate bias and consistency in the rainfall distribution.

Spatial sampling error. In developing the area-depth relations, it was necessary to estimate data from several dense networks. Some of these dense networks were in regions where the physiography could have little or no effect on the rainfall regime. Examination of these data showed that the variability in area-depth relations beyond the physical differences is generally minor. The 1- and 24-hour isopluvials were deliberately drawn so that the average ratio is about 2.5 for the 24-hour duration and 2.2 for the 1-hour.

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smoothed isopluvials is about 0.2 inch. Since there are no assignable causes for these discrepancies, they must be regarded as a residual error in sampling the relatively small amounts of extreme-value data available for each station.

The geographical distribution of the stations used in the analysis is portrayed on the dot maps of figures 8 and 9. Even this relatively coarse network cannot reveal very accurately the fine structure of the isopluvial patterns in the mountainous regions of the West. A measure of the sampling error is provided by a comparison of a 2-year 1-hour generalized map for Los Angeles County (400 square miles) based on 30 stations with one based on 110 stations. The average difference for values from randomly selected points from both maps was found to be approximately 20 percent.

Sampling error in time—Sampling error in time is present because the data at individual stations are intended to represent a mean condition that would hold over a long period of time. Daily data from 300 geographically dispersed long-record stations were analyzed for short- and long-record returns to determine the reliability or level of confidence that should be placed on the results from the short-record data. The diagram of figure 11 shows the scatter of the means of the extreme-value distributions for the two different lengths of record. The slight bias which is exhibited is a result of the skewness of the extreme-value distribution. Accordingly, more weight has been given to smoothing the isopluvials.

Internal consistency—Numerous statistical maps were made in an effort to refine the maps presented here. However, tests have shown that the use of these parameters would result in no improvement in the rainfall-frequency patterns because of the sampling and other error inherent in values obtained for each station.

Evaluation.—In general, the standard error of estimate ranges from 2 to 100 years from the same point on all the maps on either a flat region of one of the 2-year maps to 25 years of additional data, the differences are negligible.
of additional stations were used in this study, the differences between the two papers in the eastern national data are now available. For example, the results of this paper with those previous rainfall frequency studies.

**Comparisons with previous rainfall frequency studies**

The technical paper No. 85 [3] contains a series of rainfall intensity-duration-frequency curves for the 200 Weather Bureau stations. The curves were developed from each station's data with no consideration given to anomalous events or series of rainfall intensity-duration-frequency curves for the West, the enlarged inventory of data now available has had a profound effect on the isopluvial pattern. In general, the results from this paper are larger in the West with the differences occasionally reaching a factor of two.

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**Technical Paper No. 85, Parts I and II, Technical Paper No. 28**—The differences in refinement between Technical Paper No. 85 [3] and Technical Paper No. 89 [4] on the one hand and this paper on the other do not, however, seem to influence the end results to an important degree. Inspection of the values in several rugged areas, as well as in flat areas, reveals disparities which average about 10 percent. This is attributable to the much larger amount of data (both longer records and more stations) and the greater areal generalization used in this paper.

**Technical Paper No. 85, Parts I through A**—The salient feature of the comparison of Technical Paper No. 89 [4] with this paper is the very small disparities between the four key maps and the slightly larger disparities between the intermediate maps. The average difference areas of the order of magnitudes of 10 and 20 percent, respectively. The larger difference between the intermediate maps is attributable to the smoothing of these maps in a consistent manner.

**Probability considerations**

**General**—The analysis presented thus far has been mainly concerned with attaching a probability to a particular magnitude of rainfall at a particular location. Once this probability has been determined, consideration must also be given to the conditional question: What is the probability that the n-year event will occur at least once in the next n years?

From elementary probability theory it is known that there is a good chance that the n-year event will occur at least once before 2 years have elapsed. For example, if an event has the probability 1/6 of occurring in a particular year (assume the annual series is being used), where n is 10 or greater, the probability, P, of the event occurring at least once among n observations (or years) is

\[ P = 1 - (1 - 0.1)^n = 1 - 0.63 \]

Thus, for example, the probability that the 10-year event will occur at least once in the next 10 years is 0.63, or about 2 chances out of 3.

**Relationship between design return period, T years, design period, Tn, and probability of not being exceeded in Tn years**—Figure 14, prepared from theoretical computations, shows the relationship between the design return period, T, years, design period, Tn, and probability of not being exceeded in Tn years (10).

**EXAMPLE**—What design return period should the engineer use to be approximately 90 percent certain that it will not be exceeded in the next 10 years? Entering the design period coordinate at 10 years, the probability of not being exceeded is 2.5 percent larger than the 100-year value.

**Probable maximum precipitation (PMP)**

The 6-hour PMP and its relationship to the 100-year 6-hour rainfall—Opposed to the probability method of rainfall estimation presented in this paper is the probable maximum precipitation (PMP) method which uses a combination of physical model and several estimated meteorological parameters. The main purpose of the PMP method is to provide complete-safety design criteria in cases where structure failure would be disastrous. The 6-hour PMP map of Chart 28 is based on the 10-year values of Hydro meteorological Report No. 88 [26] for the region east of 105° W. and on Weather Bureau Technical Paper No. 88 [27] for the West. Chart 51 presents the ratios of the PMP values to the 10-year point rainfall values of this paper. Examination of this map shows that the ratios vary from less than 2 to about 5. These ratios must be considered merely indicative of the order of magnitude of extremely rare rainfall.
Area-depth relationships

**General.**—For drainage areas larger than a few square miles consideration must be given not only to point rainfall, but to the average depth of rainfall over the entire drainage area. The average area-depth relationship, as a percent of the point value, has been determined for 20 dense networks up to 400 square miles from various regions in the United States [1].

The area-depth curve of figure 15 must be viewed operationally. The operation is related to the purpose and application. In application the process is to select a point value from an isoplethic map. This point value is the average depth for the location concerned, for a given frequency and duration. It is a composite. The area-depth curve relates this average point value, for a given frequency and duration within a given area, to the average depth over that area for the corresponding duration and frequency.

The data used to develop the area-depth curves of figure 15 are based on groups of stations. Generally情况 best for the mountainous region west of smoothed isopleths of those presented previously in the regional discontinuities between curves of adjacent subregions can be smoothed locally for all practical purposes. No seasonal variation because there is no conclusive method of determining whether this comes from seasonal distribution curves constructed based on groups of stations. It is tentatively accepted that storm magnitude (or return period) length of record to

**EXAMPLE.**—Determine the probability of occurrence of a 1-year 1-hour rainfall for the region May through August for the point at 48° N, 80° W. From Chart I, the probability for each month is estimated. For each month the probability of occurrence of a 1-year 1-hour rainfall is in May of any particular year is 1 percent; for June, 2 percent; and so forth. (Additional examples are given in all five parts of Technical Paper No. 88.)

**Seasonal variation**

**Introduction.**—To this point, the frequency analysis has followed the conventional procedures of using only the annual maxima or the n-maximum events for monthly or seasonal distributions. However, the average 1-hour depth for various regions of the United States is not the major parameter. None of the dense networks had sufficient length of record to evaluate the effect of magnitude (or return period) on the area-depth relationship. For areas up to 400 square miles, it is tentatively accepted that storm magnitude (or return period) is not a parameter in the area-depth relationship. The reliability of this relationship appears to be best for the longer durations.

**EXAMPLE.**—What is the average depth of 5-year 3-hour rainfall for a 200-square-mile drainage area in the vicinity of 20° N, 80° W? From the 5-year 3-hour map, 0.1 inches is estimated as the average depth for points in the area. However, the average 3-hour depth over the given subregion will be different for each specific month. Referring to figure 15, it is seen that the 3-hour curve anomaly is a constant value. The 5-year average depth over 200 square miles is 0.8 times 2, or 1.6 inches.

**Seasonal probability diagrams.**—A total of 24 seasonal probability diagrams are presented in Charts 32, 50, and 24 for the 1-, 6-, and 24-hour durations for 8 subregions of the United States east of 105° W. The 15 diagrams covering the region east of 105° W are identical to those presented previously in Technical Paper No. 88 [2]. The smoothed slope of a diagram for a particular duration is based on the average relationship from approximately 15 stations in each subregion. Some variations exist from station to station, suggesting a slight subregional pattern, but no attempt was made to define it because there is no conclusive method of determining whether this pattern is a climatic fact or an accident of sampling. The slight regional discontinuities between curves of adjacent subregions can be smoothed locally for all practical purposes. No seasonal variation relationships are presented for the mountainous region west of 105° W, because of the influence of local climatic and topographic conditions. This would call for seasonal distribution curves constructed from each station's data instead of average and more reliable curves based on groups of stations.

**Application to areal rainfall.**—The analysis of a limited amount of areal rainfall data in the same manner as the point data gave seasonal variations which exhibited no substantial difference from those of the point data. This lends some confidence in using these diagrams as a guide for small areas.

| Charts 1-7 | Illuspluvial maps. |
| Charts 50-51 | The 6-hour probable maximum precipitation and its relationship to the 100-year 6-hour rainfall. |
| Charts 82-84 | Diagrams of seasonal probability of intense rainfall, for 1-, 6-, and 24-hour durations. |
1-YEAR 30-MINUTE RAINFALL (INCHES)
2-YEAR 2-HOUR RAINFALL (INCHES)
10-YEAR 6-HOUR RAINFALL (INCHES)
50-YEAR 6-HOUR RAINFALL (INCHES)
100-YEAR 6-HOUR RAINFALL (INCHES)
1-YEAR 12-HOUR RAINFALL (INCHES)
5-YEAR 12-HOUR RAINFALL (INCHES)
25-YEAR 12-HOUR RAINFALL (INCHES)
10-YEAR 24-HOUR RAINFALL (INCHES)
RATIO OF PROBABLE MAXIMUM 6-HOUR PRECIPITATION FOR 10 SQUARE MILES TO 100-YEAR 6-HOUR RAINFALL
SEASONAL PROBABILITY OF INTENSE 1-HOUR RAINFALL

Chart 52

RETURN PERIOD IN YEARS

PART 1

PART 2

PART 3

PART 4

PART 5

PART 6

PART 7

PART 8

PROBABILITY IN PERCENT OF OBTAINING A RAINFALL IN ANY MONTH OF A PARTICULAR YEAR EQUAL TO OR EXCEEDING THE RETURN PERIOD VALUES TAKEN FROM THE ISOPLUVIAL MAPS.
SEASONAL PROBABILITY OF INTENSE 6-HOUR RAINFALL

PART 1

PART 2

PART 3

PART 4

PART 5

PART 6

PART 7

PART 8

RETURN PERIOD IN YEARS

J F M A M J J A S O N D

RETURN PERIOD IN YEARS

J F M A M J J A S O N D

RETURN PERIOD IN YEARS

J F M A M J J A S O N D

RETURN PERIOD IN YEARS

J F M A M J J A S O N D

PROBABILITY IN PERCENT OF OBTAINING A RAINFALL IN ANY MONTH OF A PARTICULAR YEAR EQUAL TO OR EXCEEDING THE RETURN PERIOD VALUES TAKEN FROM THE ISOLUVIAL MAPS.
SEASONAL PROBABILITY OF INTENSE 24-HOUR RAINFALL

PROBABILITY IN PERCENT OF OBTAINING A RAINFALL IN ANY MONTH OF A PARTICULAR YEAR EQUAL TO OR EXCEEDING THE RETURN PERIOD VALUES-TAKEN FROM THE ISOPLUVIAL MAPS.