Appendix A.1. Temporal distributions of heavy precipitation associated with NOAA Atlas 14 Volume 3

1. Introduction

Temporal distributions of heavy precipitation are provided for use with precipitation frequency estimates from NOAA Atlas 14 Volume 3 for 1-, 6-, 12-, 24- and 96-hour durations covering Puerto Rico and the U.S. Virgin Islands. The temporal distributions are expressed in probabilistic terms as cumulative percentages of precipitation and duration at various percentiles. The starting time of precipitation accumulation was defined in the same fashion as it was for precipitation frequency estimates for consistency.

Temporal distributions for each duration are presented in Figure A.1.1. The data were also subdivided into quartiles based on where in the distribution the most precipitation occurred in order to provide more specific information on the varying distributions that were observed. Figures A.1.2 through A.1.6 depict temporal distributions for each quartile for the five durations. Digital data to generate the temporal distributions are available at http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_temporal.html. Table A.1.1 lists the number and proportion of cases in each quartile for each duration.

2. Methodology

This project largely followed the methodology used by the Illinois State Water Survey (Huff, 1990) except in the definition of the precipitation accumulation. This project computed precipitation accumulations for specific (1-, 6-, 12-, 24- and 96-hour) time periods as opposed to single events or storms in order to be consistent with the way duration was defined in the associated precipitation frequency project. As a result, the accumulation cases may contain parts of one, or more than one precipitation event. Accumulation computations were made moving from earlier to later in time resulting in an expected bias towards front loaded distributions when compared with distributions for single storm events.

For every precipitation observing station in the project area that recorded precipitation at least once an hour, the three largest precipitation accumulations were selected for each month in the entire period of record for the 12-, 24- and 96-hour durations. For the 1- and 6-hour durations, 15-minute data were accumulated in the same manner. Therefore, the 1-hour distribution contains only four data points while the 6-hour distribution contains twenty-four points. A minimum threshold was applied to make sure only heavier precipitation cases were being captured. Precipitation with an average recurrence interval (ARI) of 2 years at each observing station for each duration was used as the minimum threshold at that station.

A minimum threshold of 25-year ARI was tested. It was found to produce results similar to using a 2-year ARI minimum threshold. The 25-year ARI threshold was rejected because it reduced the number of samples sufficiently to cause concern for the stability of the distributions.

To determine whether distributions varied appreciably across the project area, temporal distributions based on data from each hourly region were computed separately, and compared to the distributions computed for the project area as a whole. The distributions were nearly identical, although there was more noise in the distributions from the separate regions due to smaller sample size. As a result the temporal distributions presented here were based on the entire project area because of the larger sample size and because the distributions varied so little by region.

Each of the accumulations was converted into a ratio of the cumulative hourly (or 15-minute) precipitation to the total precipitation for that duration, and a ratio of the cumulative time to the total time. Thus, the last value of the summation ratios always had a value of 100%. The data were combined, cumulative deciles of precipitation were computed at each time step, and then results were plotted to provide the graphs presented in Figure A.1.1. The data were also separated into categories by the quartile in which the greatest percentage of the total precipitation occurred and the procedure was repeated for each quartile category to produce the graphs shown in Figures A.1.2 through A.1.6. A moving window weighted average smoothing technique was performed on each curve.

Consideration was given to a temporal distribution in which a majority of the rain fell symmetrically about the center hours of the distribution. However, after dividing the distributions into smaller time segments and reviewing the distributions in more temporal detail, most cases did not occur around the center regardless of duration or average recurrence interval. Therefore, we have not produced a center-loaded time distribution.

3. Interpreting the Results

Figure A.1.1 presents cumulative probability plots of temporal distributions for the 1-, 6-, 12-, 24- and 96-hour durations for the project area. Figures A.1.2 through A.1.6 present the same information but for categories based on the quartile of most precipitation. The x-axis is the cumulative percentage of the time period. The y-axis is the cumulative percentage of total precipitation.

The data on the graph represent the average of many events illustrating the cumulative probability of occurrence at 10% increments. For example, the 30% of cases in which precipitation is concentrated closest to the beginning of the time period will have distributions that fall above and to the left of the 30% curve. At the other end of the spectrum, only 10% of cases are likely to have a temporal distribution falling to the right and below the 90% curve. In these latter cases the bulk of the precipitation falls toward the end of the time period. The 50% curve represents the median temporal distribution on each graph.

First-quartile graphs consist of cases where the greatest percentage of the total precipitation fell during the first quarter of the time period, i.e., the first 90 minutes of a 6-hour period, the first 3 hours of a 12-hour period, etc. The second, third and fourth quartile plots, similarly are for cases where the most precipitation fell in the second, third or fourth quarter of the time period.

The time distributions consistently show a greater spread, and therefore greater variation, between the 10% and 90% probabilities as the duration increases. Longer durations are more likely to have captured more than one event separated by drier periods; however, this has not been objectively tested as the cause of the greater variation at longer durations.

The following is an example of how to interpret the results using Figure A.1.5a and Table A.1.1. Of the 392 cases of the 24-hour duration, 126 of them were first-quartile events:

- In 10% of these cases, 50% of the total rainfall (y-axis) fell in the first 1.8 hours of event time (7.5% on the x-axis). By the 9th hour (37% on the x-axis), all of the precipitation (100% on the y-axis) had fallen and it was dry for the rest of the 24-hour period.
- A median case of this type will drop half of its total rain (50% on the y-axis) in 5.3 hours (22% on the x-axis).
- In 90 percent of these cases, 50% of the total precipitation fell by 9.6 hours (40% on the x-axis).

4. Application of Results

Care should be taken in the use of these data. The data are presented in order to show the range of possibilities and to show that the range can be broad. The data should be used in a way that reflects the goals of the user. For example while all cases represented in the data will preserve volume, there will be a broad range of peak flow that could be computed. In those instances where peak flow is a critical design criterion, users should consider temporal distributions likely to produce higher peaks rather than the 50th percentile or median cases, for example. In addition, users should consider whether using results from one of the quartiles rather than from the "all cases" sample might achieve more appropriate results for their situation.

5. Summary and General Findings

The results presented here can be used for determining temporal distributions of heavy precipitation at particular durations and at particular levels of probability. The results are designed for use with precipitation frequency estimates and may not be the same as the temporal distributions of single storms or single precipitation events. The time distributions show a greater spread between the percentiles with increasing duration. At the 6-, 12-, and 24-hour durations a majority of the cases analyzed were first quartile with fewer cases falling into each subsequent quartile category. At the 96-hour duration, however, the number of cases was nearly evenly distributed between all four quartile categories. The majority of the cases by far at the 1-hour duration were second quartile.

Table A.1.1. Numbers and proportion of cases in each quartile for each duration and temporal distribution associated with NOAA Atlas 14 Volume 3.

	1st Quartile	**2nd Quartile**	**3rd Quartile**	**4th Quartile**	**Total number of cases**
1-hour	81 (18%)	186 (42%)	123 (29%)	51 (11%)	441
6-hour	159 (40%)	107 (27%)	85 (21%)	49 (12%)	400
12-hour	138 (34%)	132 (33%)	79 (20%)	54 (13%)	403
24-hour	126 (32%)	106 (27%)	85 (22%)	75 (19%)	392
96-hour	112 (27%)	92 (22%)	108 (25%)	109 (26%)	421

Figure A.1.1
Temporal Distribution: All Cases

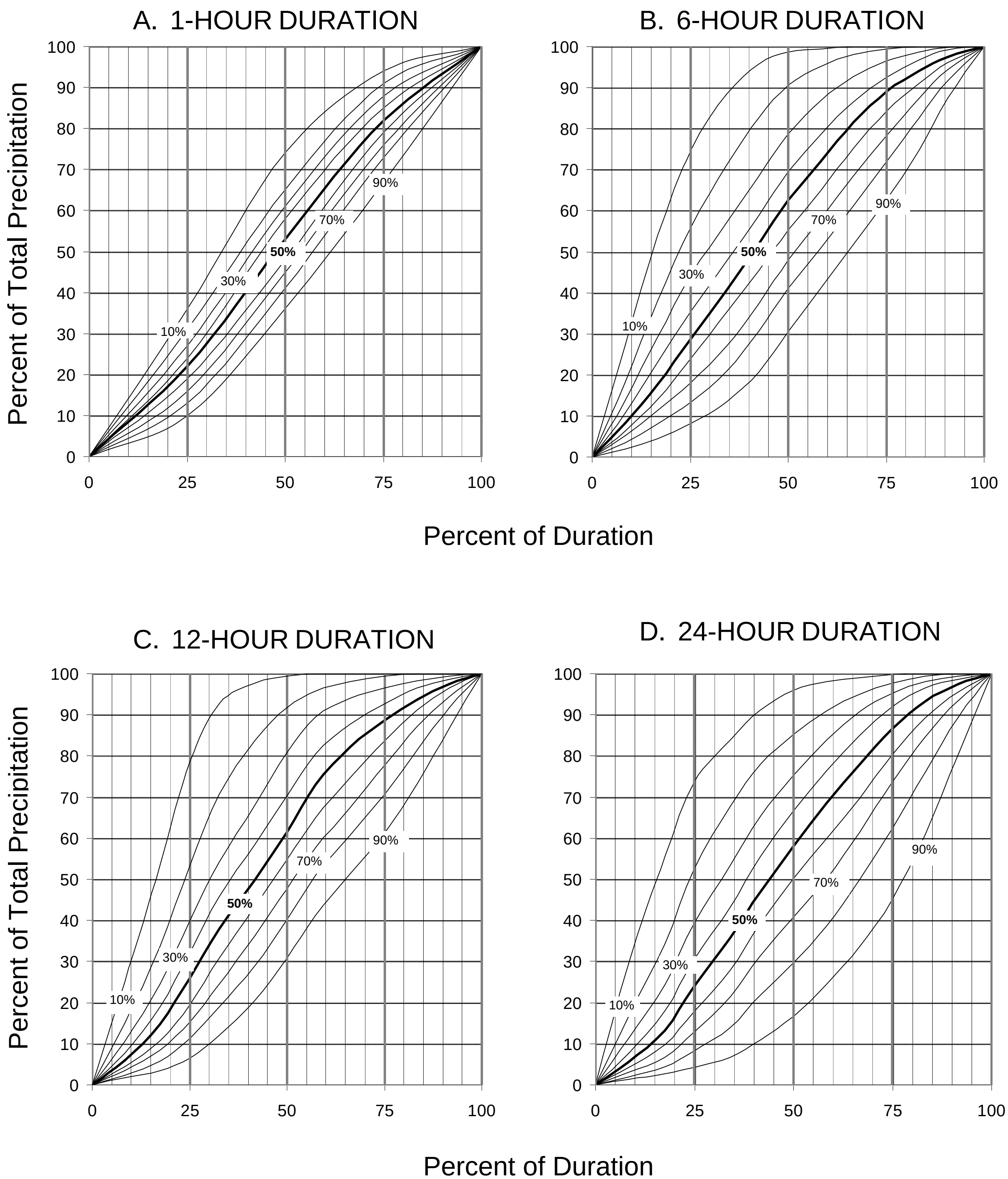

FIGURE A.1.1 (CONTINUED)
TEMPORAL DISTRIBUTION: ALL CASES

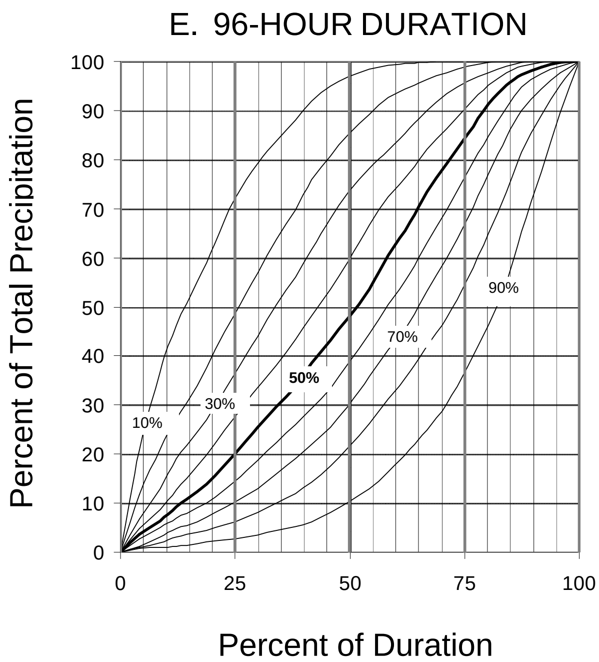

Figure A.1.2
Temporal Distribution: 1-Hour Duration

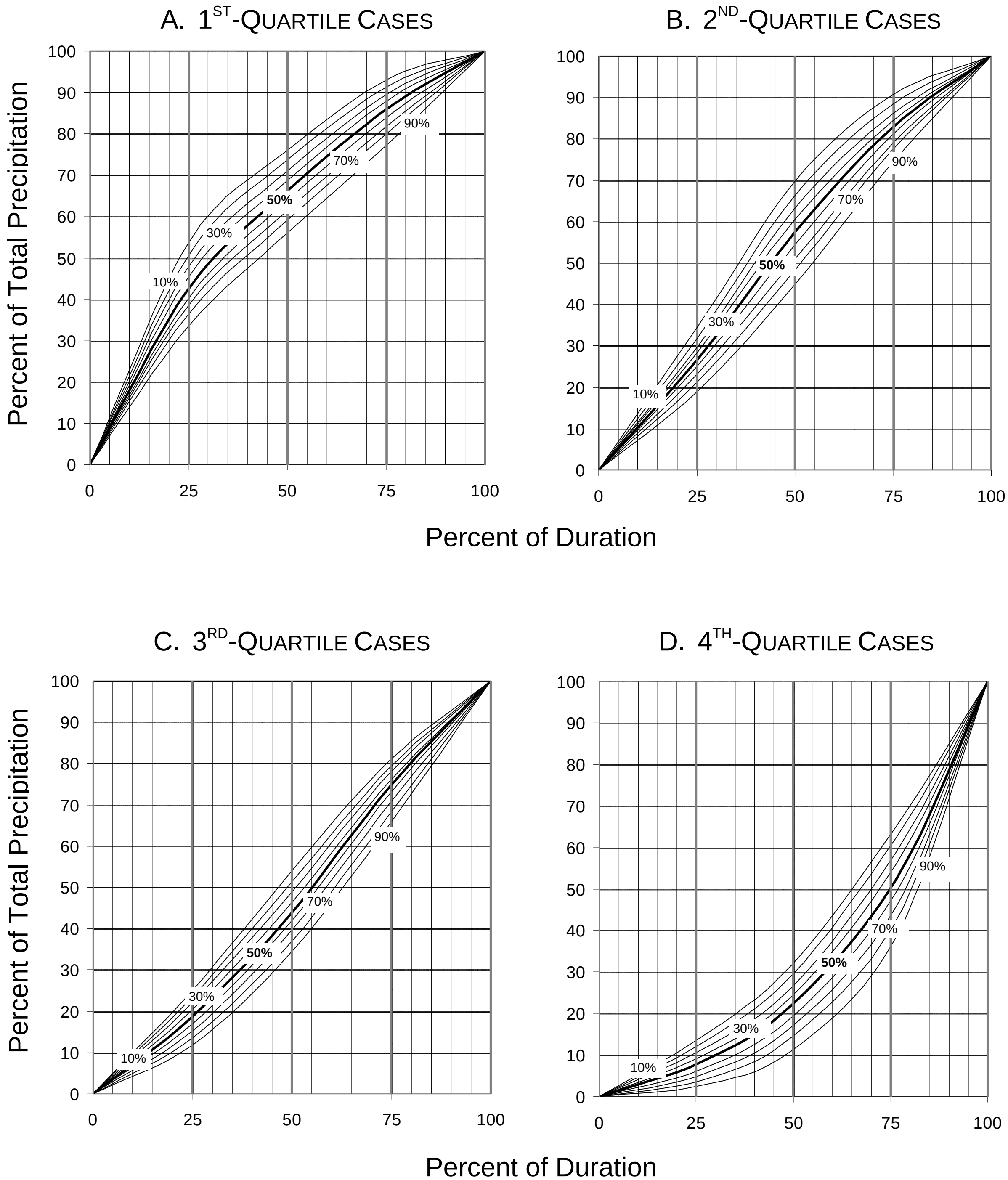

FIGURE A.1.3
TEMPORAL DISTRIBUTION: 6-HOUR DURATION

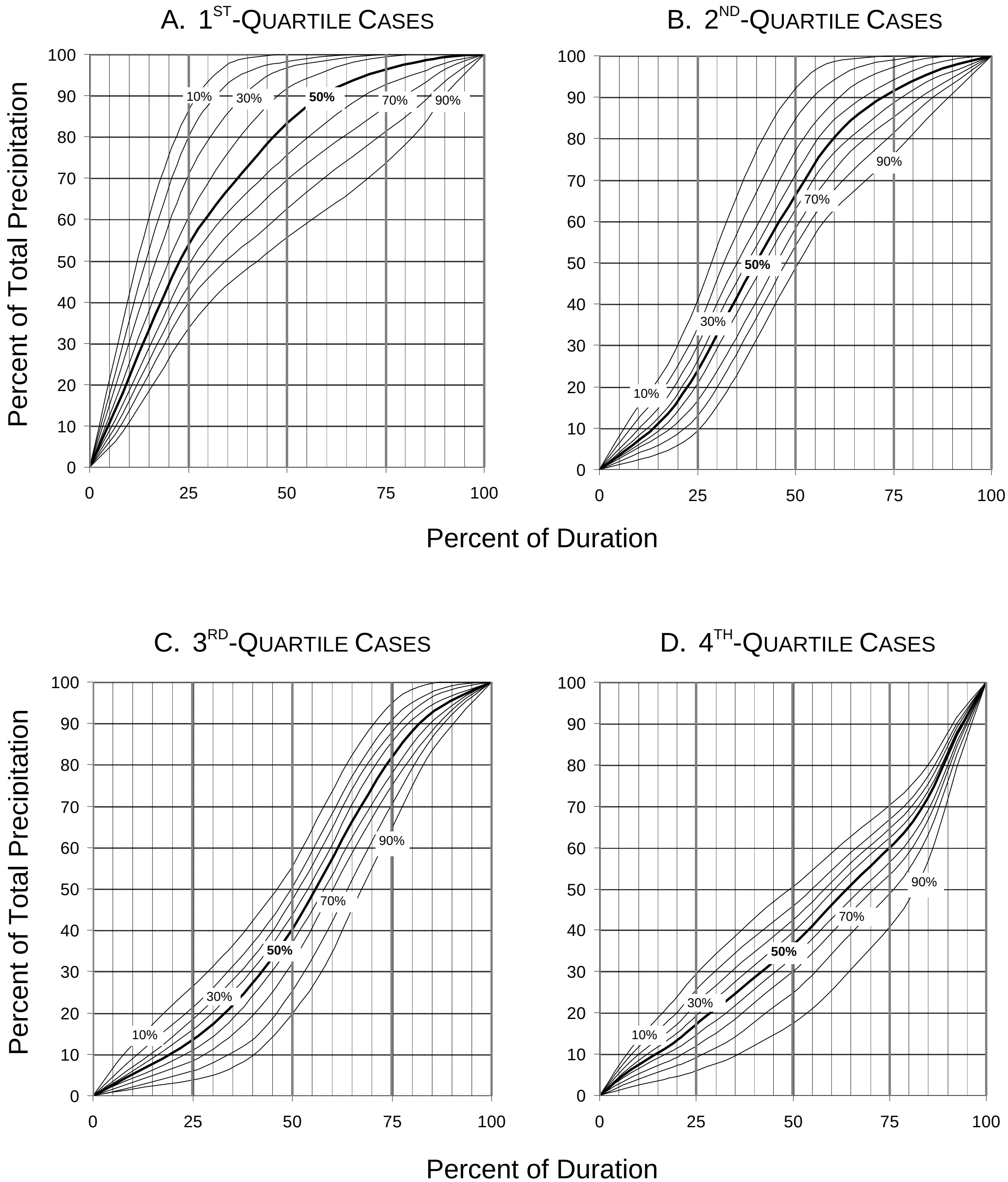

FIGURE A.1.4
TEMPORAL DISTRIBUTION: 12-HOUR DURATION

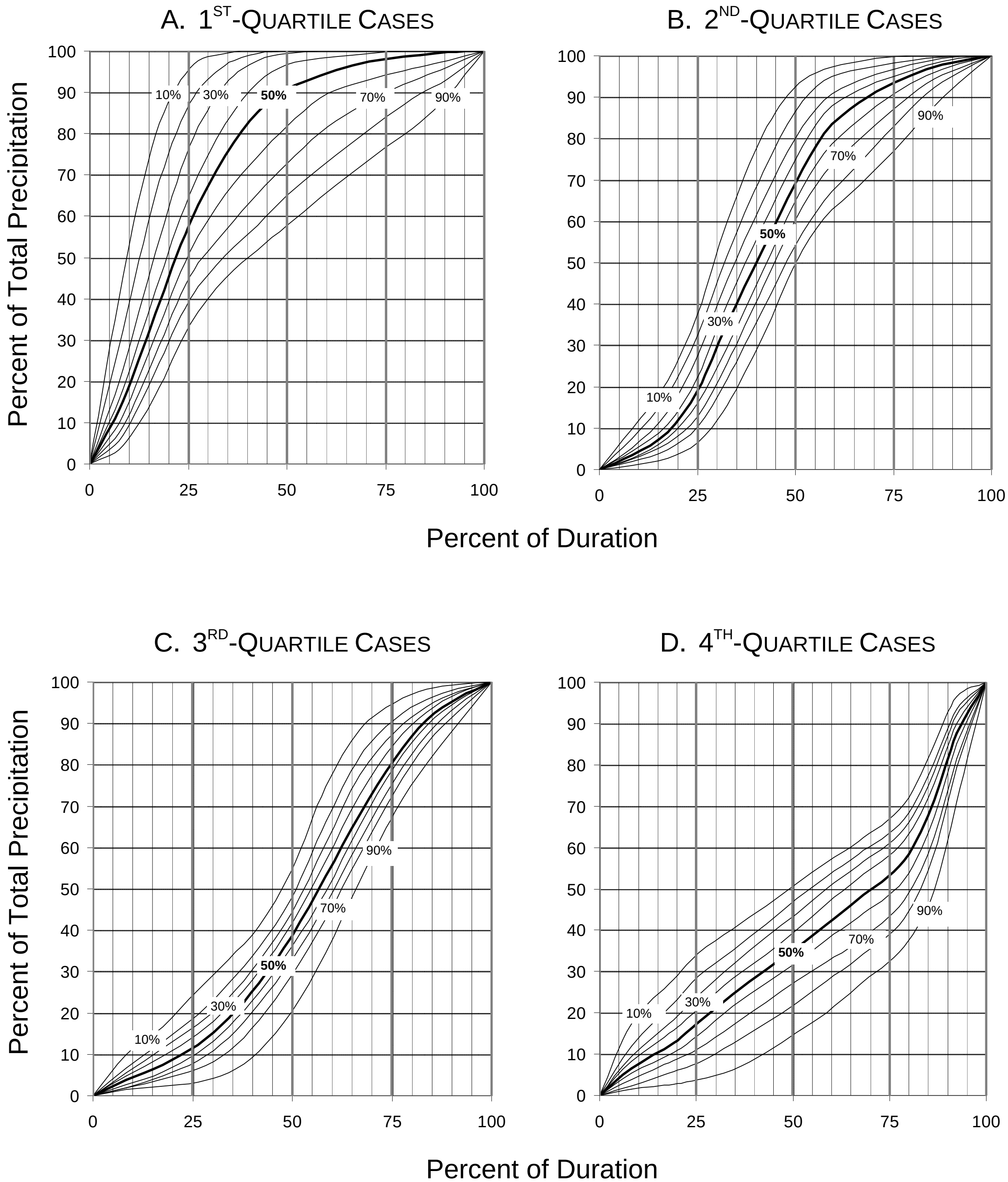

FIGURE A.1.5
TEMPORAL DISTRIBUTION: 24-HOUR DURATION

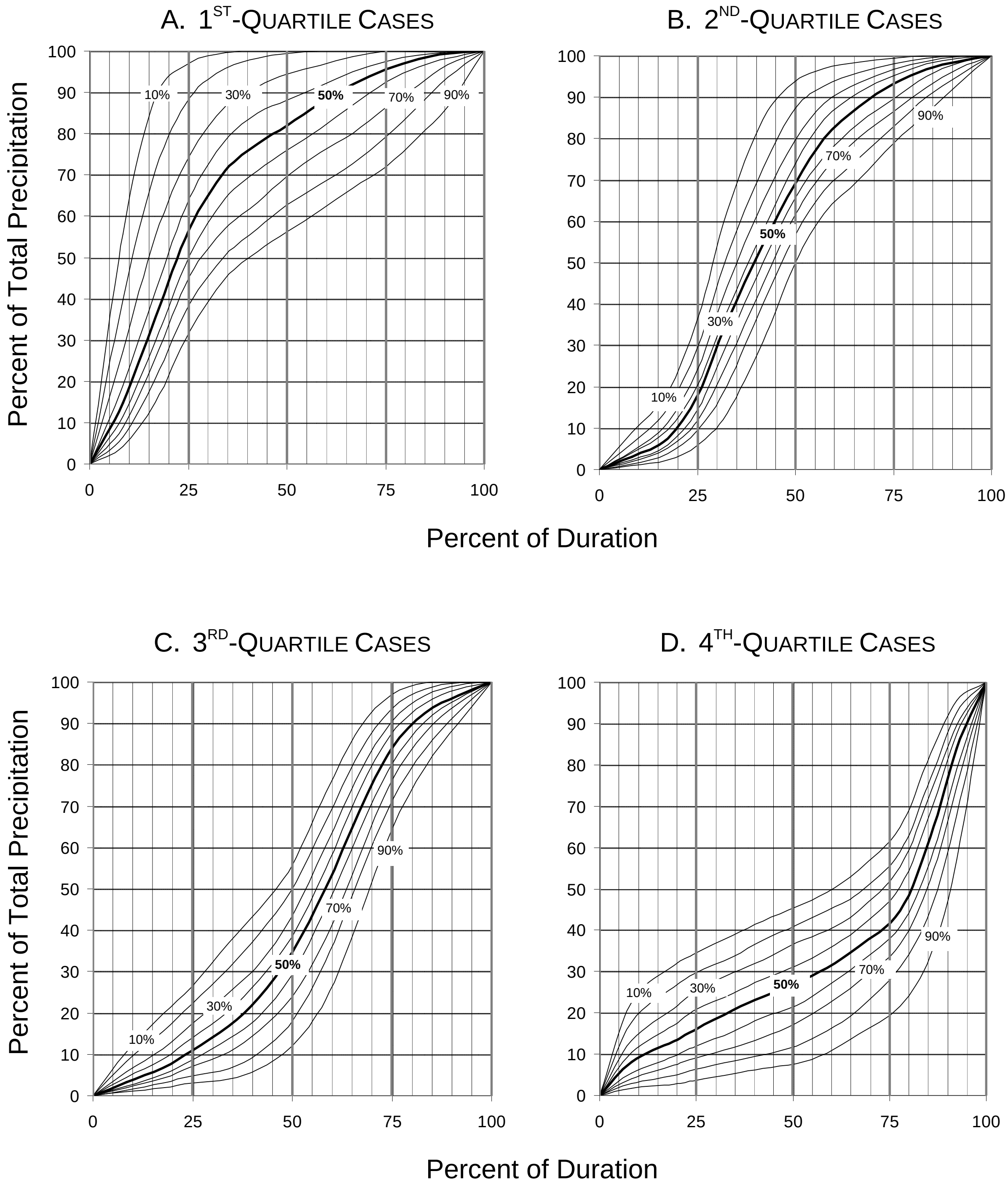

FIGURE A.1.6
TEMPORAL DISTRIBUTION: 96-HOUR DURATION