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Frequency Distributions of Heavy Rainstorms in Illinois

by FLOYD A. HUFF and JAMES R. ANGEL

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Frequency Distributions of Heavy Rainstorms in Illinois

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Title: Frequency Distributions of Heavy Rainstorms in Illinois.

Abstract: This publication represents a condensed version of an extensive report on the distributions of heavy rainstorms in Illinois, based on data for 61 precipitation stations operated during 1901-1983. Shown are annual frequency distributions of point rainfall for periods ranging from 5 minutes to 10 days and for recurrence intervals varying from 2 months to 100 years. Results are presented in two forms: mean relations for ten regions of approximately homogeneous precipitation climate, and statewide isohyetal maps based on the 61 -station data The report also discusses the results of a special investigation pertaining to Chicago and the surrounding six counties subject to urban influences on the precipitation distribution. The final section of the report provides information on the urban influences on the two Illinois counties adjacent to St. Louis.

Reference: Huff, Floyd A., and James R. Angel. Frequency Distributions of Heavy Rainstorms in Illinois. Illinois State Water Survey, Champaign, Circular 172, 1989.

Indexing Terms: Climatology, heavy rainstorms, hydroclimatology, hydrometeorology, Illinois, rainfall.

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by Floyd A. Huff and James R. Angel

INTRODUCTION

The statewide frequency relations provided in this document have been abstracted from a comprehensive report on the frequency distributions and hydroclimatic characteristics of heavy rainstorms in Illinois (Huff and Angel, 1989). The relations are those most commonly used by hydrologists, soil scientists, and others who need information on extreme rainfalls, and they are presented in a convenient form for application. The user is referred to the Huff-Angel report for details (if desired) on the methods and techniques used in the research that led to the results shown here. The Huff-Angel publication also addresses other aspects of Illinois extreme rain events, including climatic trends in heavy rainfall frequencies, urban effects on the distribution of heavy rainfall, sampling variability within regions of similar rainfall climate, the seasonal distribution of heavy rainfall events, and other pertinent spatial and temporal characteristics of heavy rainstorms.

The frequency relations presented here represent both an updating and an expansion of those previously published by Huff and Neill (1959), Hershfield (1961), and Ackermann (1970). Their use is strongly recommended in preference to existing relations, since they were based on longer periods of record, more observational stations, consideration of climatic trends, and evaluation of urban and topographic influences on heavy rainfall distributions.

All results have been expressed in the English system of units; that is, inches as opposed to the metric system's use of millimeters or centimeters. The frequency relations were derived from the partial-duration system of ranking rainfall events, which is considered most appropriate for hydrologic and most other applications. As opposed to the annual-maxima method of frequency analysis, which incorporates only the highest values for each year, this system incorporates all of the highest values regardless of the year in which they occur. Thus more than one value used in a frequency distribution can occur in a single year.

Acknowledgments

This report was prepared under the direction of Richard G. Semonin, Chief of the Illinois State Water Survey, and with the general guidance of Peter J. Lamb, Head of the Water Survey's Climate and Meteorology Section. The research was partially supported by the Illinois Department of Transportation, Division of Water Resources. John Vogel directed the initial research for this project. John Brother, Linda Riggin, and Lynn Weiss prepared the illlustrations, and Gail Taylor edited the report.

PART 1: FREQUENCY OF HEAVY RAINFALL EVENTS

Frequency distributions were determined for rain periods ranging from 5 minutes to 10 days and for recurrence intervals varying from 2 months to 100 years. Analyses were based on carefully edited daily data from 61 Illinois precipitation-reporting stations in operation during 1901-1983 (figure 1) and 55 recording-gage stations operated in and near Illinois during 1948-1983 (figure 2).

The state was divided into ten sections of approximately homogeneous precipitation climate with respect to the distribution of heavy rainstorm events (figure 1). This division was based on assessment of the 83-year sample of heavy rainstorms and on consideration of pertinent meteorological and climatological factors. Both sectional mean and point rainfall frequency distributions were derived, after adjusting for the climatic trend found in the 83-year sample. Sectional mean relationships were developed because this approach lessens the effects of natural and human-induced variability (undetected measurement and computational errors) between points in an area of approximately homogeneous precipitation climate. However, some users prefer to use individual point relationships; these are included in the Huff-Angel report (1989), but not in this abbreviated version.

The sectional relations are presented in table 1. In this table, the first column (storm code) refers to the storm (rain) period. The codes are numbered consecutively from 1 to 15, with code 1 representing 10-day storm periods and code 15 representing 5-minute periods. The second column (zone code) refers to the ten climatic sections. Thus zone 1 is the northwestern section, zone 2 is northeastern, and so on, as indicated in the code explanations included with the table.

For each storm period, rainfall amounts are shown for each climatic section for each recurrence interval from 2 months to 100 years. For example, assume a user wishes to know the 10-year frequency of 24-hour rainfall in the central section. First, move to storm code 5 (24-hour rainfall). In the code 5 grouping, move to zone 4 (central section) and continue across the page to the column labeled "10-year." At this point (storm code 5, zone 4) the rainfall amount is 4.45 inches, which is the 24-hour rainfall to be expected, *on the average,* once in 10 years at any given point in the central section.

Figures 3 through 11 are isohyetal maps for selected storm periods and recurrence intervals, based on point rainfall frequencies derived for each of the 61 long-term stations (1901-1983). Isohyetal presentations are preferred over sectional means by some hydrologists, especially when interpolation between adjoining basins is involved. Therefore, isohyetal maps are shown for storm periods ranging from 30 minutes to 72 hours and for recurrence intervals of 2 to 100 years, which are the storm periods and recurrence intervals most commonly used in hydrologic design problems. The six-county cutoff in northeastern Illinois in these figures was the subject of a special study. This study is summarized in part 2 of this report and is discussed in detail by Huff and Angel (1989).

Figure 1. Precipitation-reporting stations and climatic sections used in developing Illinois frequency relations

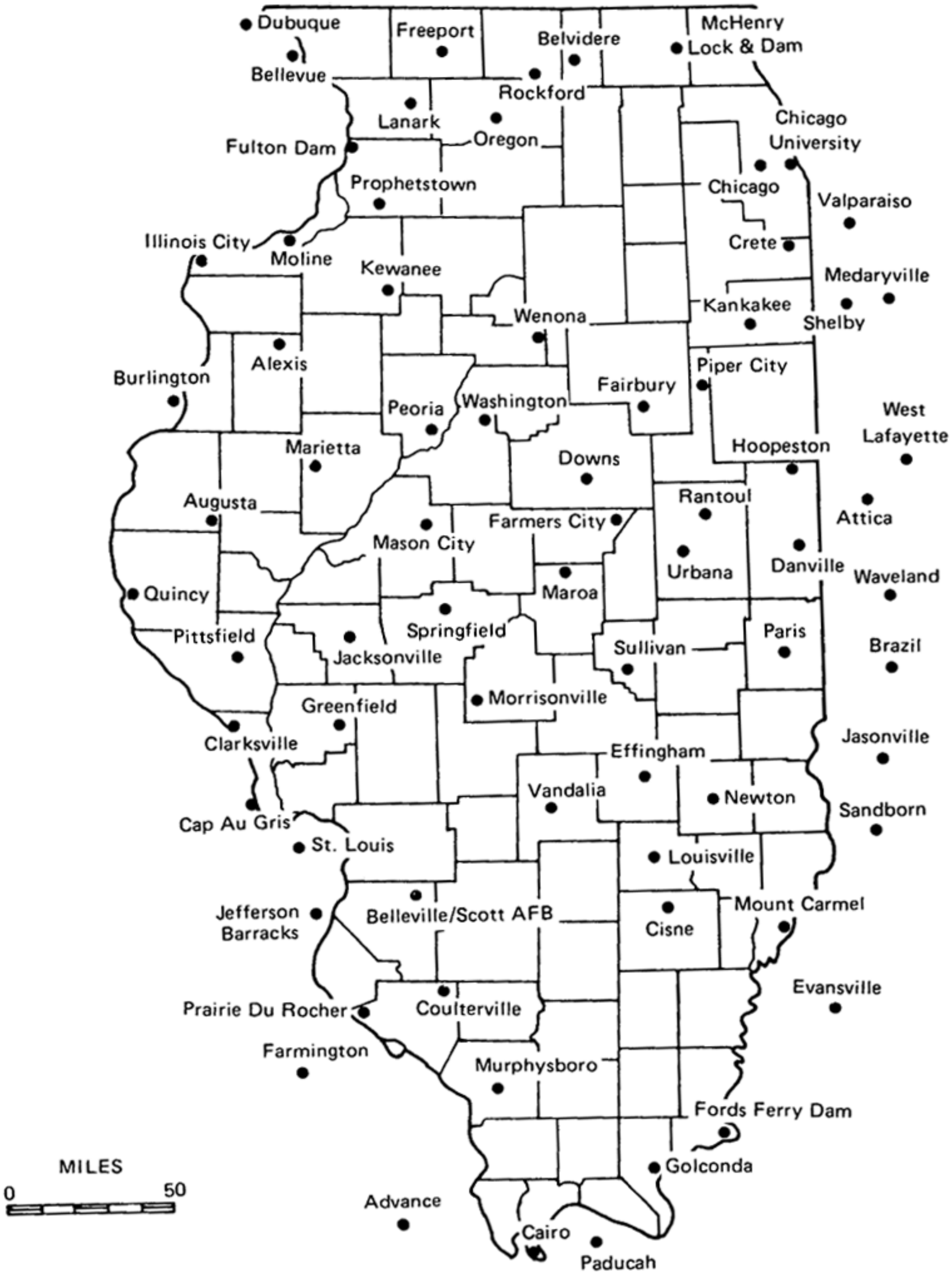


Figure 2. Locations of recording-gage stations

Table 1. Sectional Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Months to 100 Years

Storm codes		*Sectional (zone) codes*
1 - 10 days	9 - 3 hours	1 – Northwest
2 - 5 days	10 - 2 hours	2 - Northeast
3 - 72 hours	11 - 1hour	3 – West
4 - 48 hours	12 - 30 minutes	4 - Central
5 - 24 hours	13 - 15 minutes	5 – East
6 - 18 hours	14 - 10 minutes	6 – West Southwest
7 - 12 hours	15 - 5 minutes	7 – East Southeast
8 - 6 hours		8 - Southwest
		9 - Southeast
		10 - South

Rainfall (inches) for given recurrence interval

Storm code	*Zone code*	*2-month*	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
1	1	2.14	2.60	2.97	3.50	4.02	4.37	5.23	6.30	7.14	8.39	9.64	11.09
1	2	2.02	2.48	2.80	3.30	3.79	4.12	4.95	6.04	6.89	8.18	9.38	11.14
1	3	2.27	2.78	3.13	3.68	4.23	4.60	5.60	6.91	7.89	9.24	10.36	11.90
1	4	2.10	2.58	2.92	3.43	3.93	4.29	5.12	6.27	7.10	8.19	9.10	10.18
1	5	2.13	2.62	2.96	3.48	4.00	4.35	5.15	6.21	6.97	8.04	8.90	9.92
1	6	2.16	2.65	2.99	3.52	4.05	4.40	5.35	6.62	7.45	8.66	9.79	11.26
1	7	2.30	2.80	3.16	3.70	4.27	4.64	5.58	6.80	7.61	8.66	9.70	10.87
1	8	2.22	2.74	3.09	3.63	4.18	4.54	5.54	6.80	7.80	9.20	10.44	11.81
1	9	2.30	2.88	3.23	3.80	4.33	4.75	5.74	7.09	8.07	9.54	10.68	11.79
1	10	2.55	3.15	3.58	4.21	4.84	5.26	6.36	7.81	8.90	10.34	11.36	12.50
2	1	1.76	2.12	2.38	2.76	3.17	3.45	4.13	5.10	5.91	7.21	8.36	9.97
2	2	1.66	1.98	2.24	2.60	2.99	3.25	3.93	4.91	5.70	6.93	8.04	9.96
2	3	1.92	2.30	2.56	2.97	3.41	3.71	4.57	5.80	6.65	7.90	8.95	10.50
2	4	1.77	2.12	2.37	2.78	3.20	3.48	4.17	5.11	5,84	6.96	7.98	9.21
2	5	1.75	2.10	2.37	2.75	3.15	3.42	4.12	4.96	5.67	6.76	7.65	8.78
2	6	1.77	2.13	2.39	2.78	3.19	3.47	4.19	5.32	6.20	7.44	8.53	9.93
2	7	1.85	2.22	2.50	2.90	3.31	3.63	4.34	5.33	6.11	7.28	8.37	9.65
2	8	1.85	2.21	2.49	2.90	3.31	3.62	4.40	5.46	6.34	7.68	8.88	10.68
2	9	1.90	2.29	2.59	3.00	3.45	3.75	4.48	5.57	6.50	7.91	9.16	10.57
2	10	2.09	2.52	2.83	3.29	3.77	4.10	4.99	6.20	7.21	8.45	9.45	10.82
3	1	1.58	1.90	2.11	2.45	2.82	3.06	3.73	4.67	5.42	6.59	7.64	8.87
3	2	1.53	1.83	2.02	2.34	2.70	2.93	3.55	4.44	5.18	6.32	7.41	8.78
3	3	1.72	2.05	2.28	2.64	3.02	3.30	4.08	5.11	5.87	6.97	7.95	9.48
3	4	1.59	1.91	2.12	2.44	2.80	3.05	3.70	4.55	5.26	6.15	7.25	8.16
3	5	1.61	1.93	2.16	2.48	2.85	3.10	3.71	4.57	5.20	6.17	6.97	7.83
3	6	1.63	1.95	2.16	2.50	2.88	3.13	3.81	4.85	5.68	6.84	7.76	8.92
3	7	1.62	1.90	2.15	2.50	2.87	3.12	3.73	4.64	5.32	6.39	7.35	8.54
3	8	1.67	1.97	2.20	2.54	2.93	3.22	3.94	4.92	5.74	6.97	8.12	9.55
3	9	1.73	2.02	2.25	2.62	3.00	3.27	3.92	4.92	5.75	7.05	8.23	9.40
3	10	1.88	2.25	2.49	2.87	3.30	3.59	4.36	5.48	6.34	7.53	8.54	9.52
4	1	1.47	1.74	1.93	2.24	2.58	2.80	3.42	4.28	4.96	6.07	7.02	8.07
4	2	1.44	1.70	1.90	2.18	2.49	2.70	3.30	4.09	4.81	5.88	6.84	8.16
4	3	1.61	1.88	2.09	2.42	2.76	3.01	3.68	4.56	5.50	6.45	7.56	8.80
4	4	1.48	1.76	1.95	2.25	2.58	2.81	3.38	4.19	4.86	5.78	6.62	7.51
4	5	1.51	1.77	1.95	2.26	2.57	2.82	3.40	4.16	4.77	5.66	6.40	7.16
4	6	1.52	1.81	2.00	2.30	2.64	2.87	3.49	4.45	5.21	6.28	7.12	8.19
4	7	1.52	1.78	1.98	2.30	2.64	2.87	3.42	4.26	4.88	5.84	6.75	8.00
4	8	1.57	1.85	2.06	2.38	2.75	2.97	3.59	4.52	5.26	6.43	7.36	8.81
4	9	1.59	1.87	2.07	2.40	2.76	3.00	3.60	4.52	5.28	6.48	7.58	8.62
4	10	1.75	2.08	2.31	2.65	3.02	3.30	4.00	5.03	5.80	6.93	7.86	8.79
5	1	1.40	1.64	1.80	2.08	2.36	2.57	3.11	3.95	4.63	5.60	6.53	7.36
5	2	1.38	1.61	1.76	2.03	2.31	2.51	3.04	3.80	4.47	5.51	6.46	7.58
5	3	1.53	1.77	1.95	2.24	2.56	2.79	3.45	4.29	4.93	6.07	7.04	8.20
5	4	1.39	1.63	1.80	2.04	2.32	2.52	3.02	3.76	4.45	5.32	6.08	6.92
5	5	1.36	1.58	1.75	2.00	2.27	2.47	3.01	3.71	4.26	5.04	5.83	6.61
5	6	1.42	1.66	1.84	2.10	2.38	2.59	3.11	3.93	4.65	5.57	6.46	7.45
5	7	1.40	1.63	1.78	2.07	2.35	2.55	3.03	3.80	4.44	5.37	6.23	7.41
5	8	1.49	1.73	1.90	2.20	2.48	2.71	3.28	4.13	4.76	6.02	7.07	8.21
5	9	1.44	1.68	1.85	2.12	2.41	2.62	3.16	4.00	4.62	5.79	6.71	7.73
5	10	1.63	1.91	2.10	2.41	2.74	2.97	3.62	4.51	5.21	6.23	7.11	8.27

Table 1. Continued

		Rainfall (inches) for given recurrence interval											
Storm code	*Zone code*	*2-month*	*3-month*	*4 month*	*6 month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
6	1	1.30	1.52	1.66	1.92	2.18	2.37	2.86	3.63	4.26	5.15	6.01	6.92
6	2	1.26	1.47	1.61	1.86	2.12	2.30	2.79	3.50	4.11	5.06	5.95	6.97
6	3	1.41	1.64	1.80	2.07	2.36	2.57	3.18	3.95	4.53	5.59	6.47	7.55
6	4	1.27	1.51	1.66	1.88	2.12	2.28	2.75	3.46	4.09	4.90	5.59	6.37
6	5	1.25	1.47	1.62	1.84	2.09	2.27	2.77	3.41	3.92	4.63	5.37	6.08
6	6	1.31	1.53	1.68	1.93	2.19	2.38	2.86	3.61	4.28	5.12	5.95	6.85
6	7	1.29	1.50	1.64	1.90	2.16	2.35	2.79	3.49	4.08	4.94	5.73	6.81
6	8	1.35	1.59	1.74	2.00	2.29	2.49	3.02	3.80	4.38	5.54	6.51	7.55
6	9	1.33	1.55	1.71	1.95	2.22	2.41	2.91	3.68	4.25	5.33	6.17	7.11
6	10	1.51	1.77	1.95	2.22	2.52	2.74	3.33	4.15	4.79	5.74	6.54	7.61
7	1	1.23	1.43	1.57	1.81	2.06	2.24	2.71	3.43	4.03	4.88	5.66	6.51
7	2	1.20	1.40	1.53	1.77	2.01	2.18	2.64	3.31	3.89	4.79	5.62	6.59
7	3	1.34	1.56	1.70	1.94	2.22	2.43	2.98	3.73	4.29	5.28	6.13	7.14
7	4	1.19	1.40	1.53	1.77	2.01	2.17	2.62	3.27	3.87	4.63	5.29	6.02
7	5	1.18	1.38	1.53	1.74	1.98	2.15	2.62	3.23	3.71	4.38	5.08	5.75
7	6	1.24	1.44	1.57	1.82	2.07	2.25	2.71	3.39	3.97	4.84	5.62	6.48
7	7	1.21	1.42	1.55	1.80	2.04	2.22	2.63	3.30	3.86	4.67	5.42	6.45
7	8	1.28	1.50	1.64	1.88	2.15	2.35	2.86	3.60	4.14	5.24	6.15	7.14
7	9	1.25	1.46	1.60	1.85	2.10	2.28	2.75	3.48	4.02	5.04	5.84	6.72
7	10	1.42	1.66	1.83	2.10	2.38	2.59	3.15	3.93	4.53	5.42	6.19	7.20
8	1	1.06	1.24	1.37	1.56	1.77	1.93	2.33	2.96	3.48	4.20	4.90	5.69
8	2	1.03	1.21	1.32	1.52	1.74	1.88	2.28	2.85	3.35	4.13	4.85	5.68
8	3	1.15	1.34	1.47	1.67	1.91	2.10	2.58	3.22	3.70	4.55	5.28	6.15
8	4	1.03	1.21	1.34	1.53	1.74	1.89	2.26	2.82	3.33	3.99	4.56	5.19
8	5	1.00	1.18	1.32	1.49	1.70	1.85	2.26	2.78	3.20	3.78	4.38	4.96
8	6	1.07	1.24	1.37	1.57	1.78	1.94	2.33	2.95	3.48	4.18	4.85	5.59
8	7	1.06	1.23	1.37	1.55	1.74	1.87	2.27	2.85	3.33	4.03	4.67	5.56
8	8	1.12	1.30	1.44	1.64	1.87	2.03	2.45	3.10	3.57	4.52	5.30	6.16
8	9	1.08	1.27	1.41	1.60	1.81	1.97	2.37	3.00	3.47	4.34	5.03	5.80
8	10	1.23	1.44	1.58	1.71	2.05	2.23	2.73	3.39	3.91	4.68	5.31	6.21
9	1	0.91	1.06	1.16	1.33	1.52	1.65	1.99	2.53	2.97	3.59	4.18	4.90
9	2	0.88	1.02	1.13	1.30	1.47	1.60	1.94	2.43	2.86	3.53	4.14	4.85
9	3	0.98	1.15	1.26	1.44	1.65	1.79	2.21	2.75	3.15	3.89	4.51	5.25
9	4	0.89	1.03	1.13	1.30	1.47	1.61	1.93	2.41	2.85	3.41	3.89	4.43
9	5	0.87	1.02	1.12	1.28	1.46	1.58	1.93	2.37	2.73	3.22	3.74	4.23
9	6	0.91	1.07	1.18	1.34	1.52	1.66	1.99	2.51	2.98	3.56	4.14	4.77
9	7	0.89	1.05	1.15	1.32	1.50	1.63	1.94	2.43	2.84	3.44	3.99	4.74
9	8	0.95	1.12	1.22	1.40	1.59	1.73	2.10	2.63	3.08	3.86	4.52	5.25
9	9	0.92	1.08	1.21	1.37	1.55	1.68	2.02	2.56	2.96	3.71	4.29	4.95
9	10	1.06	1.23	1.35	1.54	1.75	1.90	2.32	2.89	3.33	3.99	4.55	5.29
10	1	0.84	0.97	1.06	1.23	1.40	1.52	1.83	2.33	2.74	3.31	3.86	4.47
10	2	0.81	0.95	1.05	1.20	1.36	1.48	1.79	2.24	2.64	3.25	3.82	4.47
10	3	0.91	1.06	1.17	1.32	1.50	1.65	2.02	2.53	2.91	3.58	4.15	4.84
10	4	0.82	0.95	1.04	1.19	1.37	1.48	1.78	2.22	2.62	3.14	3.59	4.08
10	5	0.79	0.93	1.03	1.17	1.34	1.46	1.78	2.19	2.52	2.97	3.44	3.90
10	6	0.84	0.98	1.08	1.24	1.41	1.53	1.84	2.32	2.74	3.28	3.81	4.39
10	7	0.83	0.97	1.07	1.22	1.38	1.50	1.79	2.24	2.62	3.17	3.67	4.39
10	8	0.88	1.02	1.13	1.28	1.47	1.60	1.94	2.44	2.87	3.55	4.20	4.84
10	9	0.85	1.00	1.12	1.26	1.43	1.55	1.85	2.36	2.72	3.41	3.96	4.56
10	10	0.97	1.13	1.25	1.43	1.62	1.76	2.14	2.66	3.07	3.68	4.20	4.88

Table 1. Concluded

Storm code	Zone code	Rainfall (inches) for given recurrence interval											
		2-month	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
11	1	0.67	0.78	0.86	0.98	1.11	1.21	1.46	1.86	2.18	2.63	3.07	3.51
11	2	0.65	0.76	0.84	0.96	1.09	1.18	1.43	1.79	2.10	2.59	3.04	3.56
11	3	0.72	0.84	0.92	1.06	1.21	1.31	1.60	2.02	2.32	2.86	3.31	3.85
11	4	0.65	0.76	0.83	0.95	1.09	1.18	1.42	1.77	2.09	2.50	2.86	3.25
11	5	0.64	0.74	0.81	0.93	1.07	1.16	1.41	1.74	2.00	2.39	2.74	3.11
11	6	0.67	0.79	0.87	0.99	1.12	1.21	1.46	1.85	2.19	2.62	3.04	3.50
11	7	0.66	0.77	0.85	0.97	1.10	1.20	1.42	1.78	2.09	2.52	2.93	3.48
11	8	0.70	0.81	0.89	1.02	1.15	1.26	1.54	1.93	2.27	2.84	3.32	3.86
11	9	0.68	0.79	0.88	1.00	1.13	1.23	1.49	1.88	2.20	2.72	3.15	3.63
11	10	0.77	0.90	0.99	1.13	1.29	1.40	1.70	2.12	2.45	2.93	3.34	3.89
12	1	0.52	0.61	0.68	0.77	0.87	0.95	1.15	1.46	1.71	2.07	2.42	2.77
12	2	0.51	0.60	0.65	0.75	0.86	0.93	1.12	1.41	1.65	2.04	2.39	2.80
12	3	0.57	0.66	0.73	0.83	0.95	1.03	1.27	1.59	1.82	2.25	2.61	3.03
12	4	0.52	0.60	0.66	0.75	0.86	0.93	1.12	1.39	1.64	1.97	2.25	2.56
12	5	0.50	0.58	0.64	0.74	0.84	0.91	1.11	1.37	1.57	1.87	2.16	2.45
12	6	0.53	0.61	0.68	0.78	0.88	0.96	1.15	1.46	1.72	2.06	2.39	2.75
12	7	0.52	0.60	0.66	0.76	0.86	0.93	1.12	1.41	1.64	1.99	2.31	2.74
12	8	0.55	0.64	0.71	0.81	0.92	1.00	1.22	1.53	1.78	2.25	2.62	3.03
12	9	0.53	0.62	0.68	0.78	0.89	0.97	1.17	1.47	1.73	2.14	2.48	2.86
12	10	0.61	0.70	0.77	0.89	1.01	1.10	1.34	1.66	1.93	2.31	2.63	3.06
13	1	0.38	0.45	0.50	0.57	0.64	0.70	0.84	1.07	1.25	1.51	1.76	1.99
13	2	0.37	0.44	0.48	0.55	0.63	0.68	0.82	1.03	1.21	1.49	1.75	2.05
13	3	0.41	0.48	0.53	0.61	0.69	0.75	0.91	1.16	1.33	1.64	1.90	2.21
13	4	0.37	0.44	0.49	0.56	0.63	0.68	0.81	1.02	1.20	1.44	1.64	1.87
13	5	0.37	0.43	0.47	0.54	0.62	0.67	0.81	1.00	1.14	1.37	1.60	1.85
13	6	0.38	0.45	O.49	0.57	0.64	0.70	0.84	1.06	1.26	1.52	1.75	2.01
13	7	0.38	0.44	0.49	0.56	0.63	0.69	0.82	1.03	1.20	1.45	1.68	2.00
13	8	0.40	0.47	0.52	0.59	0.67	0.73	0.89	1.12	1.29	1.63	1.91	2.22
13	9	0.39	0.46	0.50	0.58	0.65	0.71	0.85	1.08	1.25	1.56	1.81	2.09
13	10	0.43	0.51	0.56	0.65	0.74	0.80	0.98	1.22	1.41	1.68	1.92	2.23
14	1	0.31	0.36	0.40	0.46	0.52	0.57	0.68	0.87	1.02	1.23	1.44	1.62
14	2	0.30	0.35	0.39	0.45	0.51	0.55	0.67	0.84	0.98	1.21	1.42	1.67
14	3	0.34	0.39	0.43	0.49	0.56	0.61	0.74	0.94	1.08	1.33	1.55	1.81
14	4	0.30	0.35	0.39	0.45	0.50	0.55	0.66	0.83	0.98	1.17	1.34	1.52
14	5	0.30	0.35	0.38	0.43	0.49	0.54	0.66	0.81	0.94	1.12	1.28	1.46
14	6	0.31	0.36	0.40	0.46	0.52	0.57	0.68	0.87	1.02	1.22	1.42	1.64
14	7	0.31	0.36	0.40	0.45	0.51	0.56	0.66	0.83	0.98	1.18	1.37	1.63
14	8	0.33	0.38	0.42	0.49	0.55	0.60	0.72	0.91	1.05	1.32	1.55	1.81
14	9	0.32	0.37	0.41	0.47	0.53	0.58	0.70	0.88	1.02	1.27	1.48	1.70
14	10	0.36	0.42	0.46	0.53	0.60	0.65	0.80	0.99	1.14	1.37	1.56	1.82
15	1	0.17	0.20	0.22	0.25	0.29	0.31	0.37	0.47	0.56	0.67	0.78	0.89
15	2	0.17	0.19	0.21	0.24	0.28	0.30	0.36	0.46	0.54	0.66	0.78	0.91
15	3	0.18	0.21	0.23	0.26	0.30	0.33	0.40	0.51	0.59	0.73	0.84	0.98
15	4	0.17	0.19	0.21	0.24	0.28	0.30	0.36	0.45	0.53	0.64	0.73	0.83
15	5	0.17	0.19	0.21	0.24	0.28	0.30	0.36	0.44	0.51	0.61	0.70	0.79
15	6	0.17	0.20	0.22	0.25	0.29	0.31	0.37	0.47	0.56	0.67	0.78	0.89
15	7	0.17	0.20	0.22	0.25	0.29	0.31	0.36	0.46	0.54	0.64	0.75	0.89
15	8	0.18	0.21	0.23	0.26	0.30	0.33	0.40	0.50	0.58	0.72	0.85	0.99
15	9	0.18	0.20	0.22	0.26	0.29	0.32	0.38	0.48	0.55	0.69	0.81	0.93
15	10	0.20	0.23	0.25	0.29	0.33	0.36	0.43	0.54	0.62	0.75	0.85	0.99

Note: For Madison County, see the discussion in part 3 of this report.

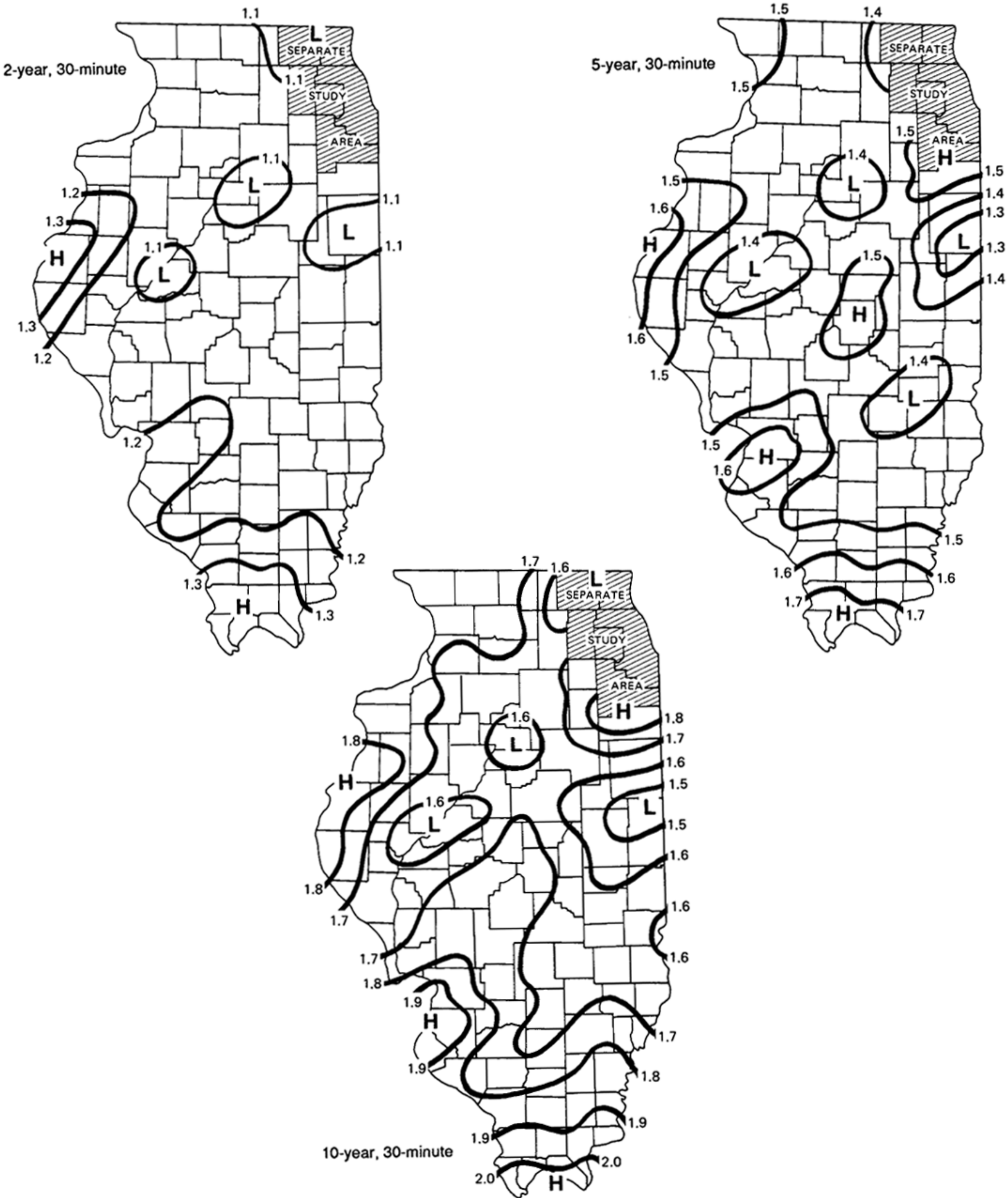


Figure 3. Spatial distributions of 30-minute rainfall (inches)

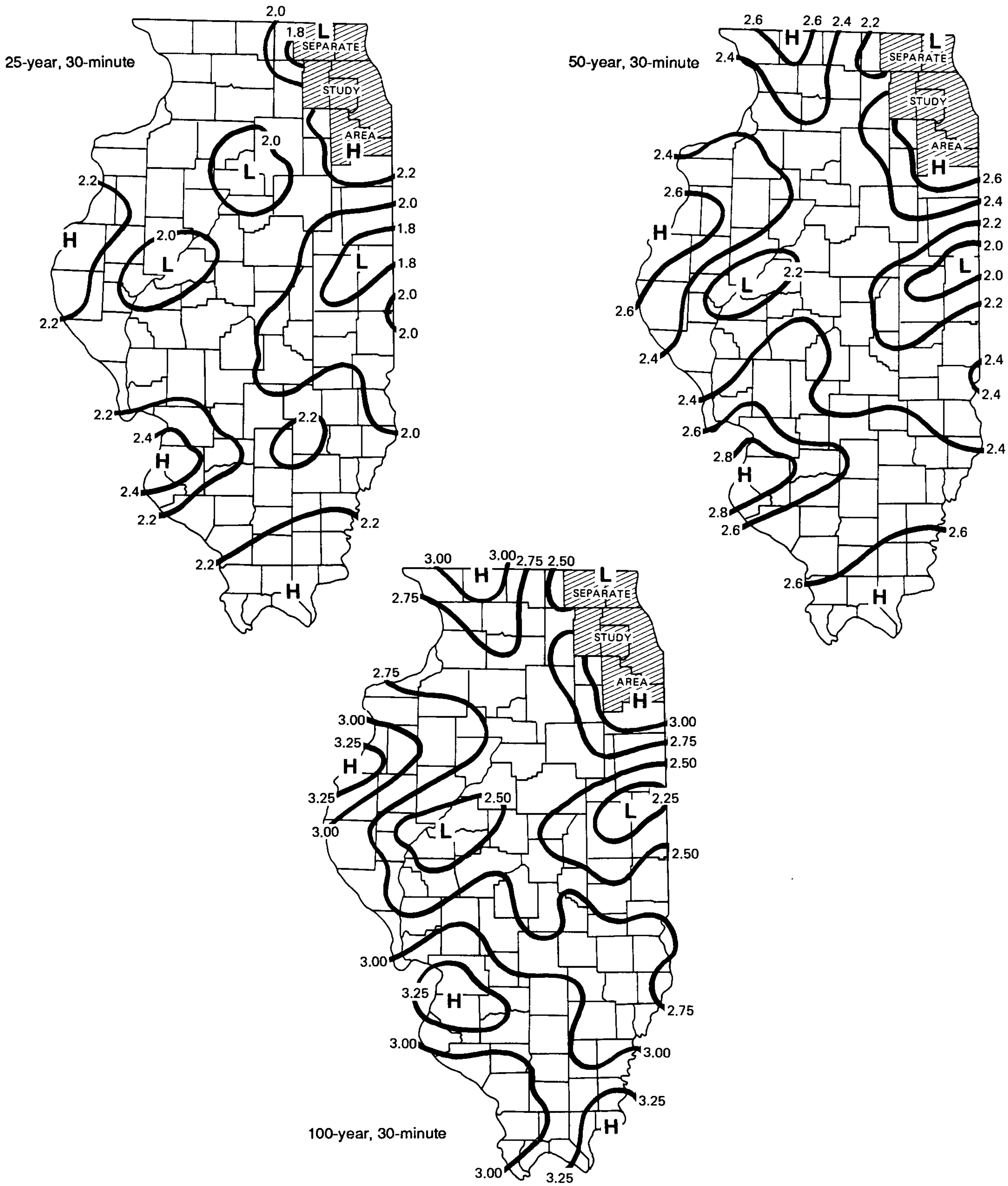


Figure 3. Concluded

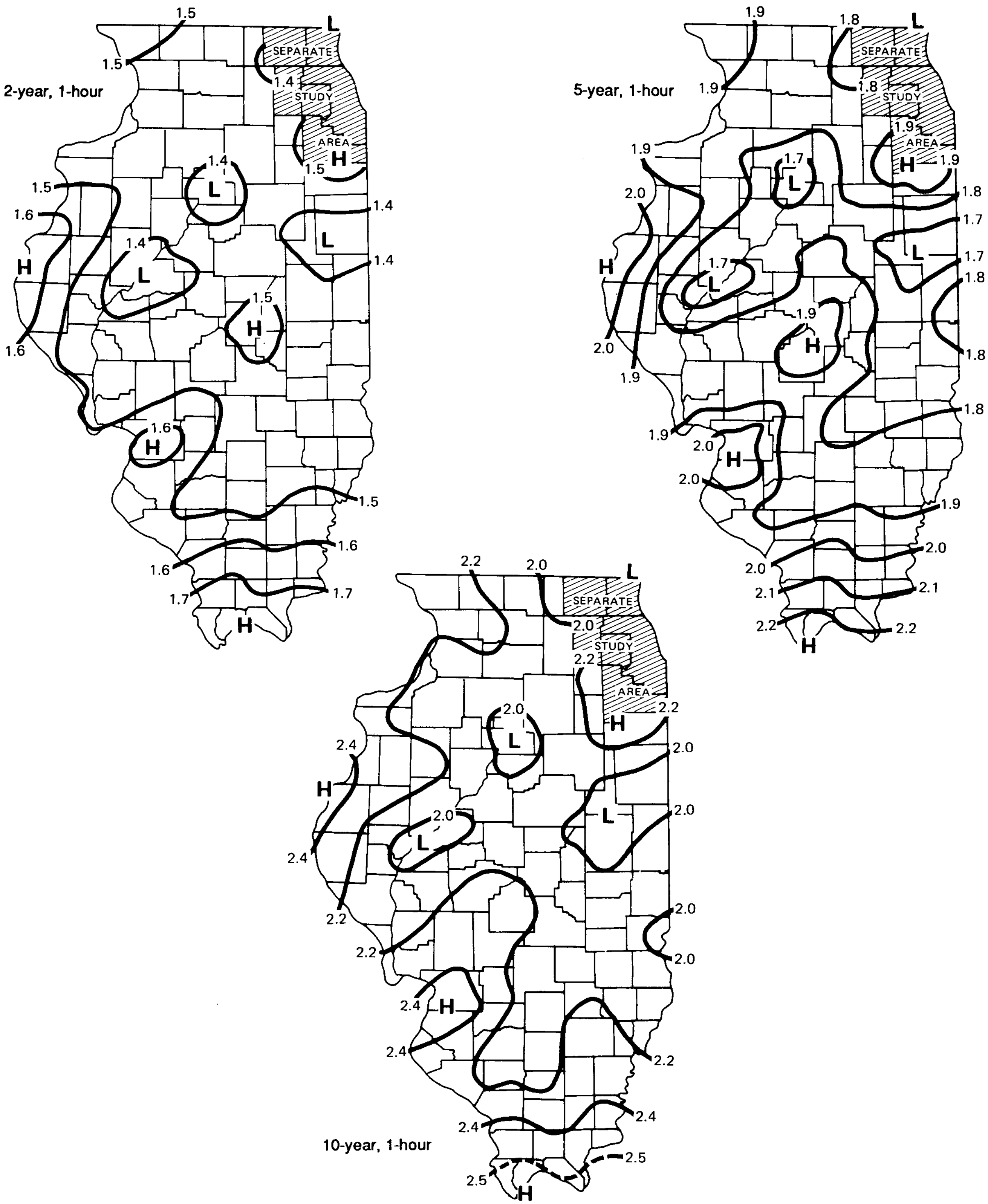
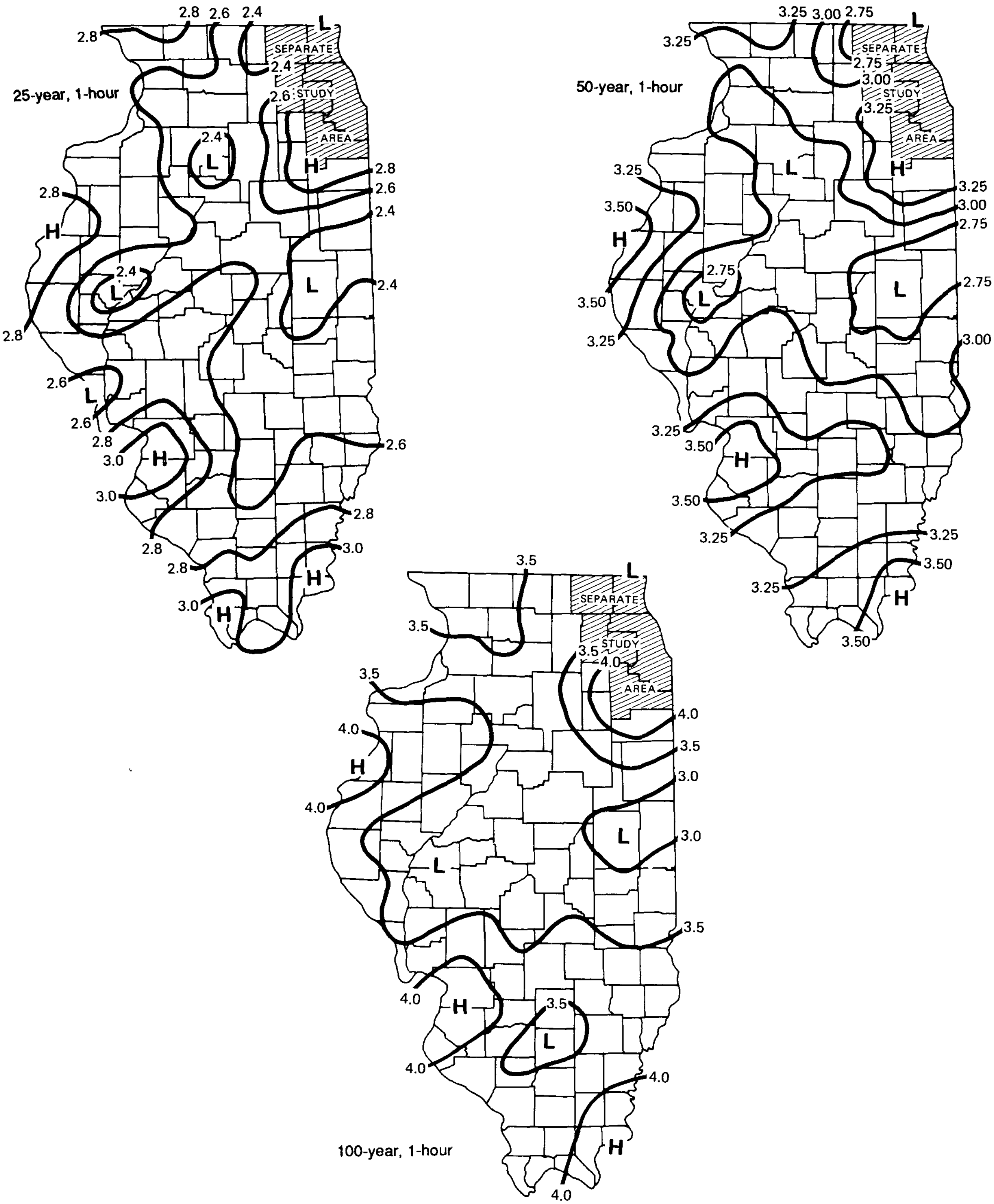


Figure 4. Spatial distributions of 1-hour rainfall (inches)



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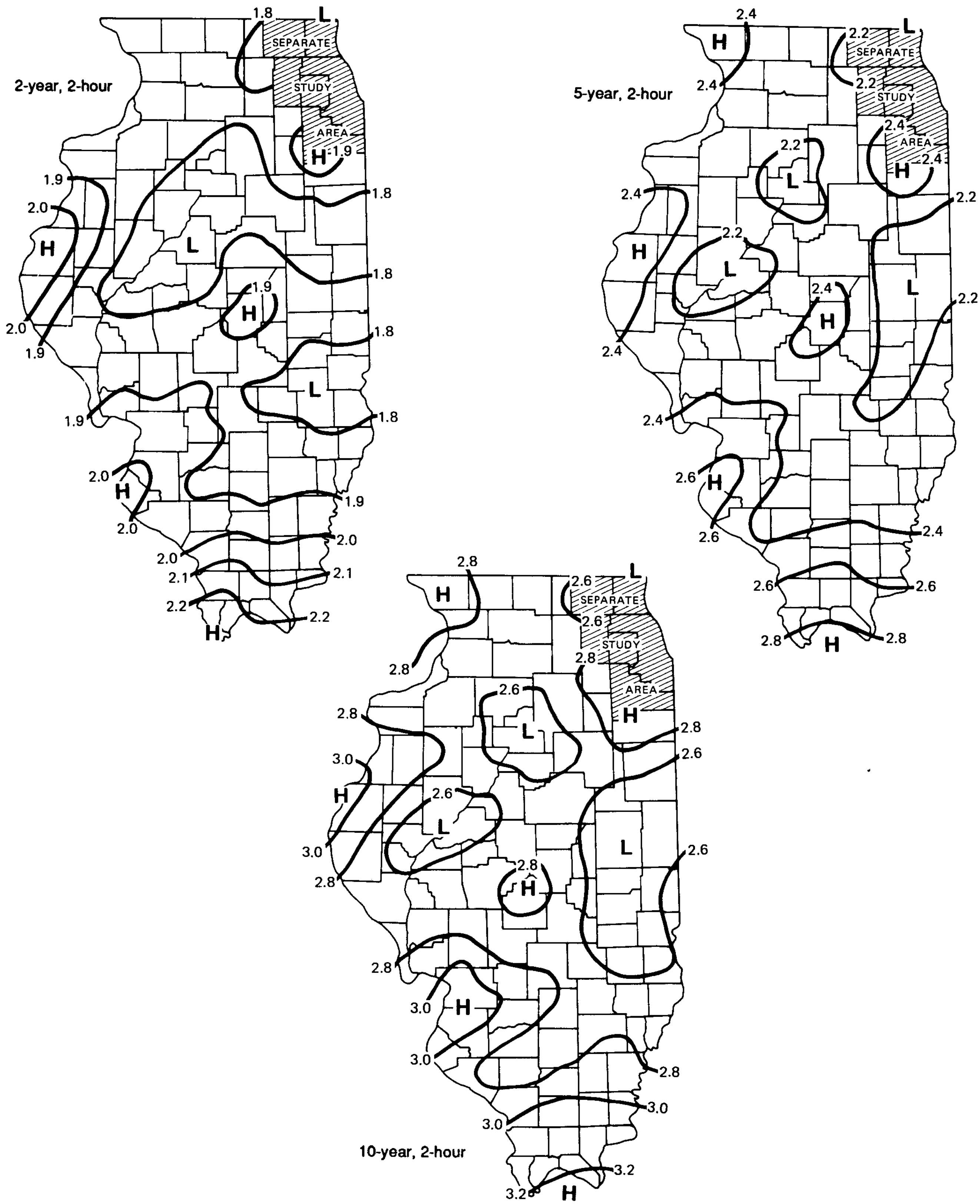
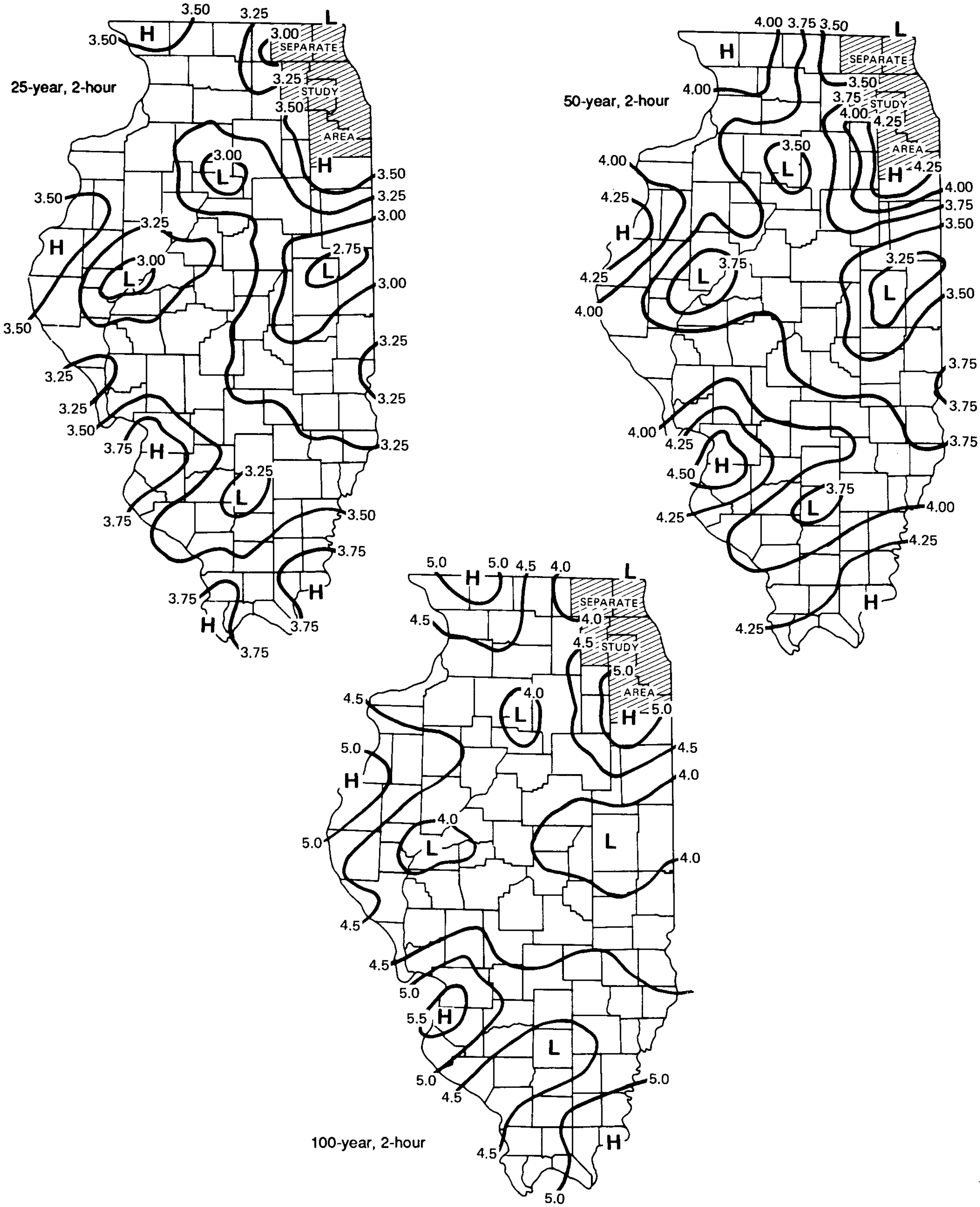


Figure 5. Spatial distributions of 2-hour rainfall (inches)



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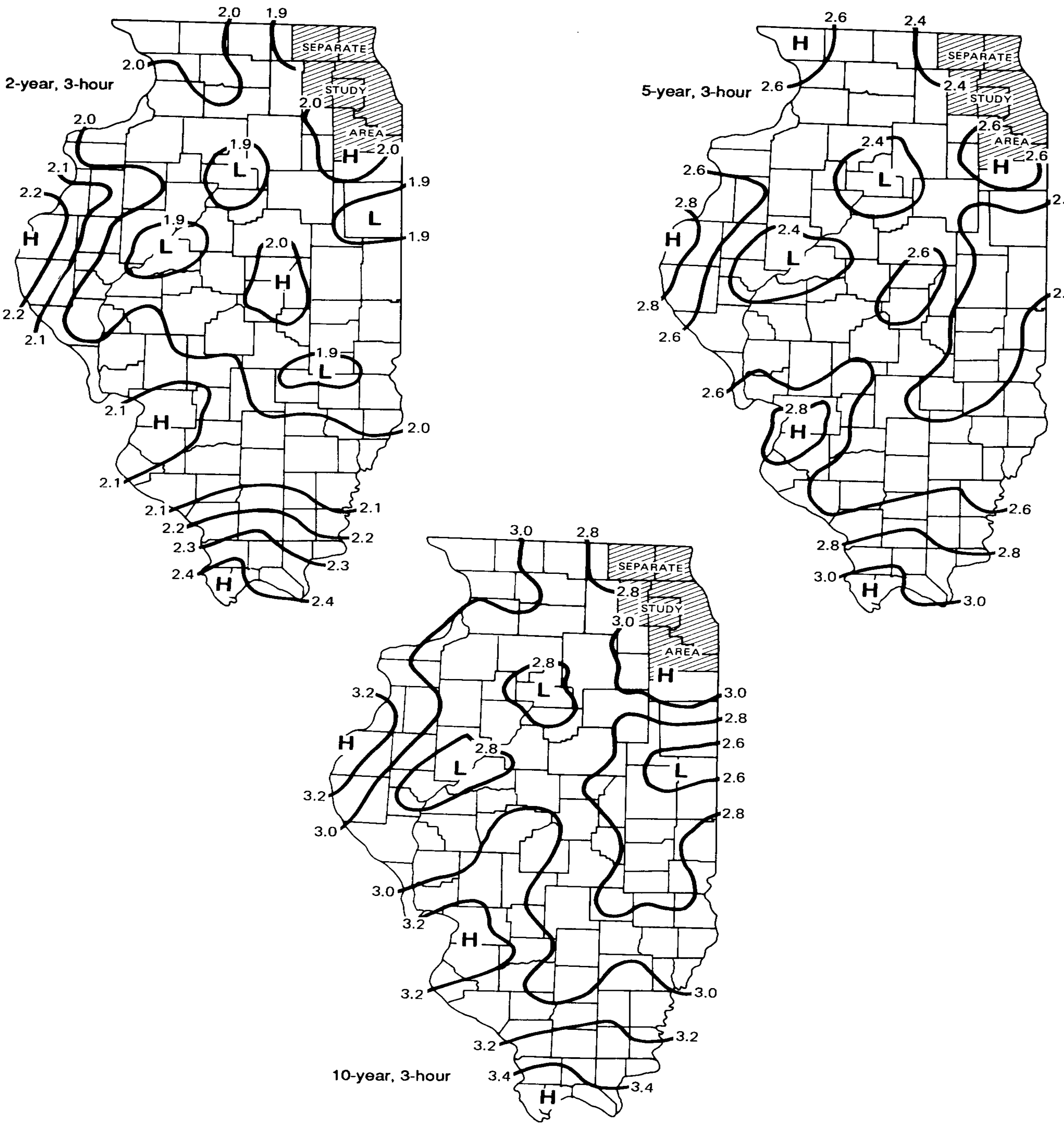
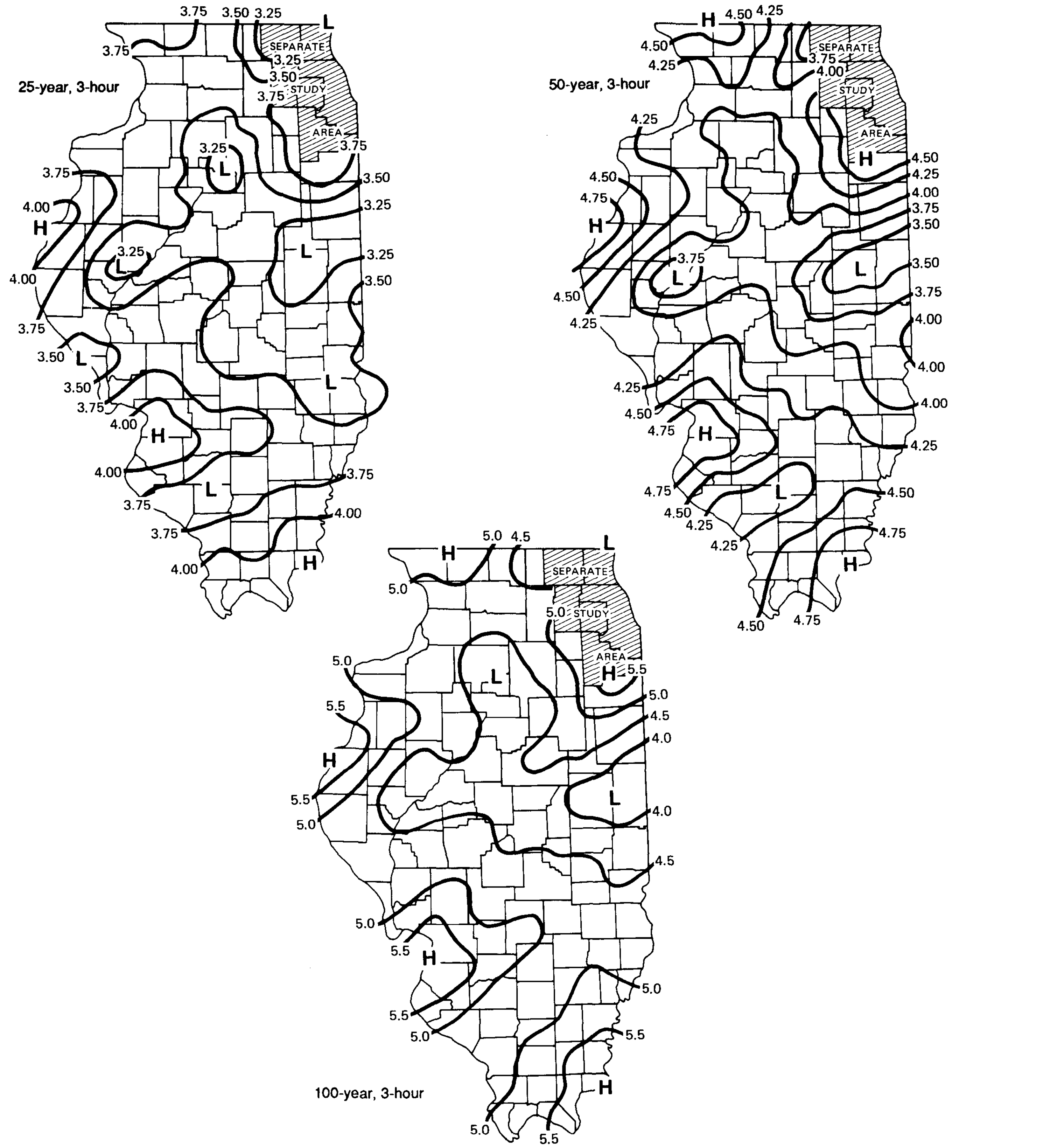


Figure 6. Spatial distributions of 3-hour rainfall (inches)



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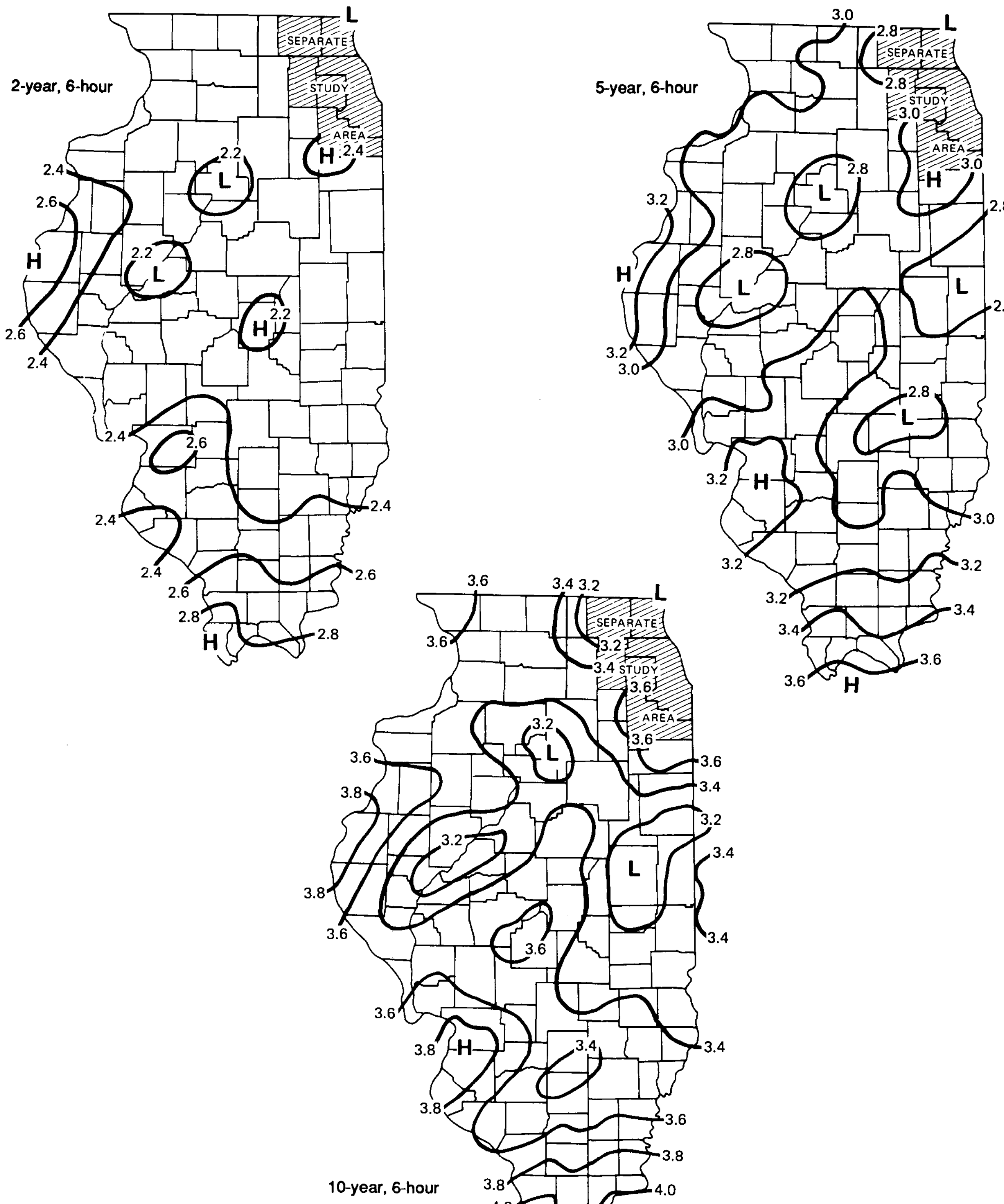
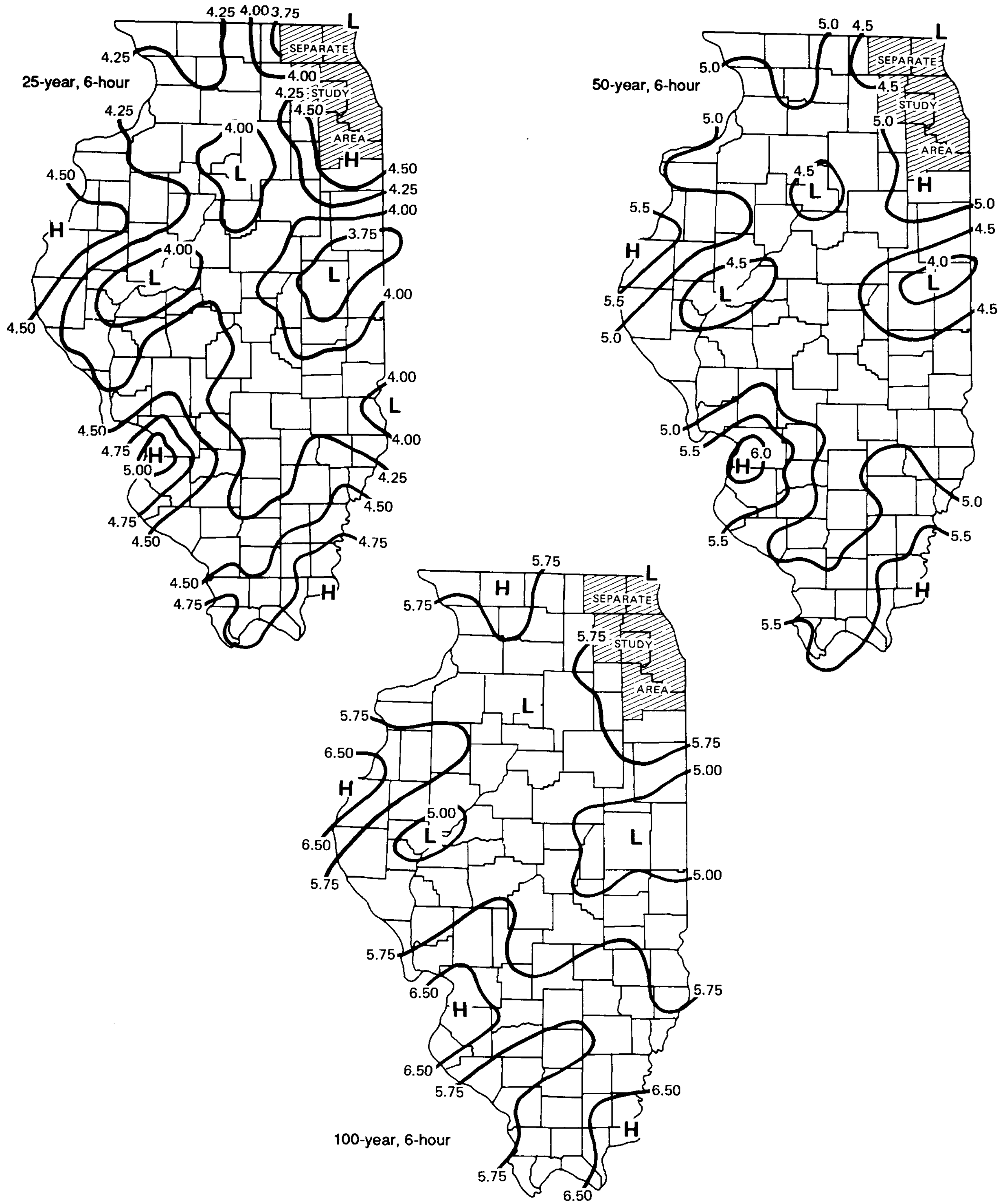


Figure 7. Spatial distributions of 6-hour rainfall (inches)



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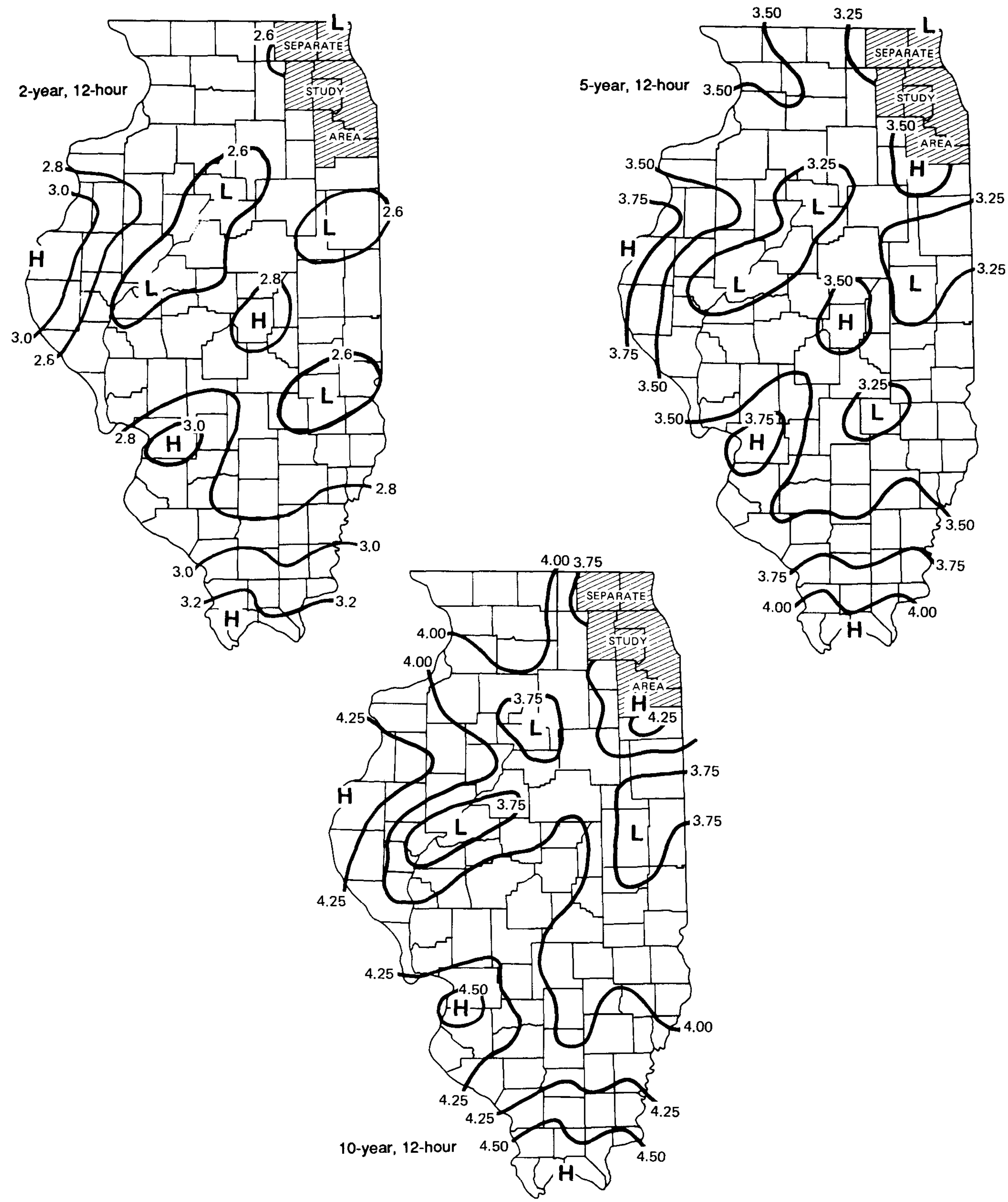
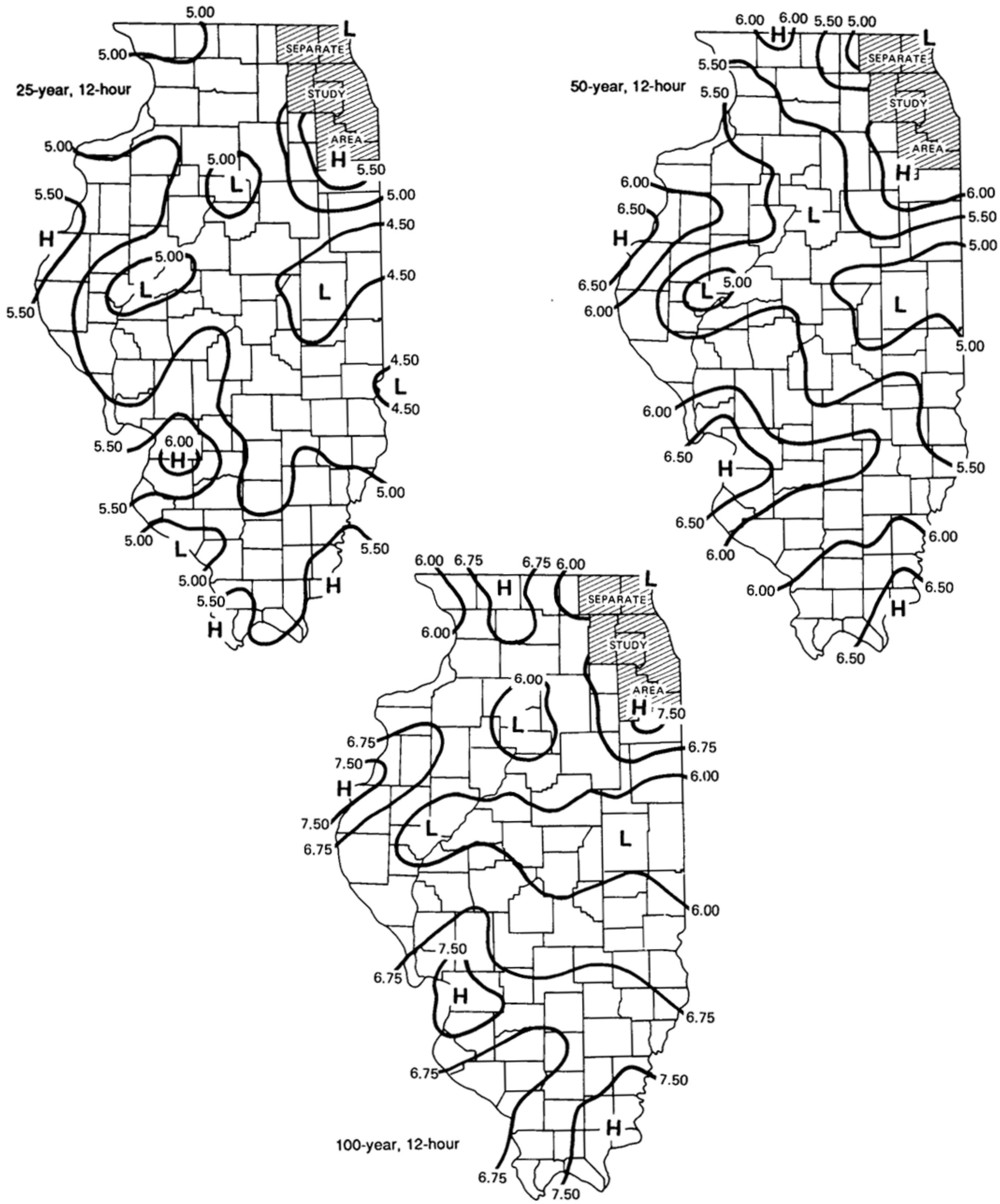


Figure 8. Spatial distributions of 12-hour rainfall (inches)



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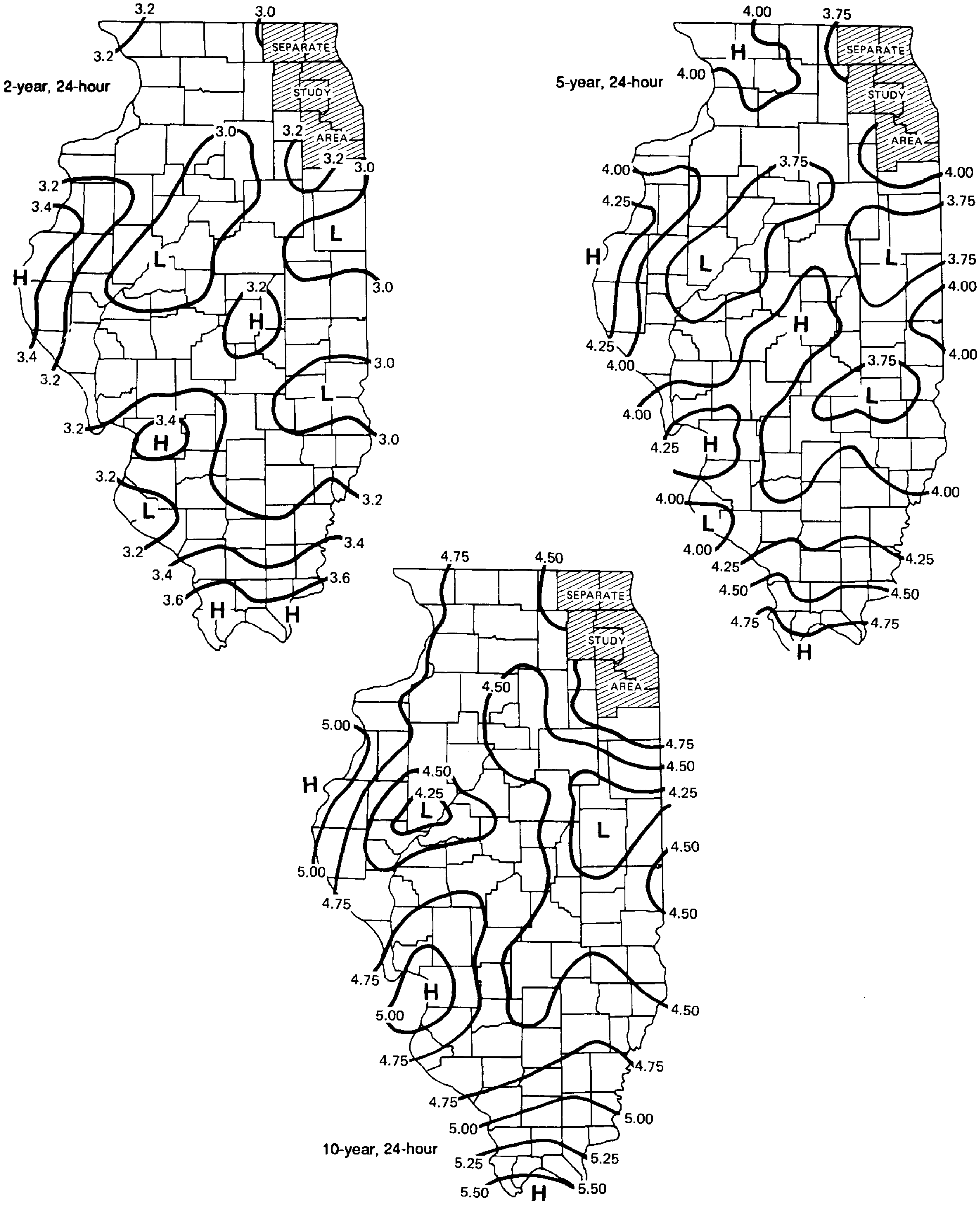


Figure 9. Spatial distributions of 24-hour rainfall (inches)

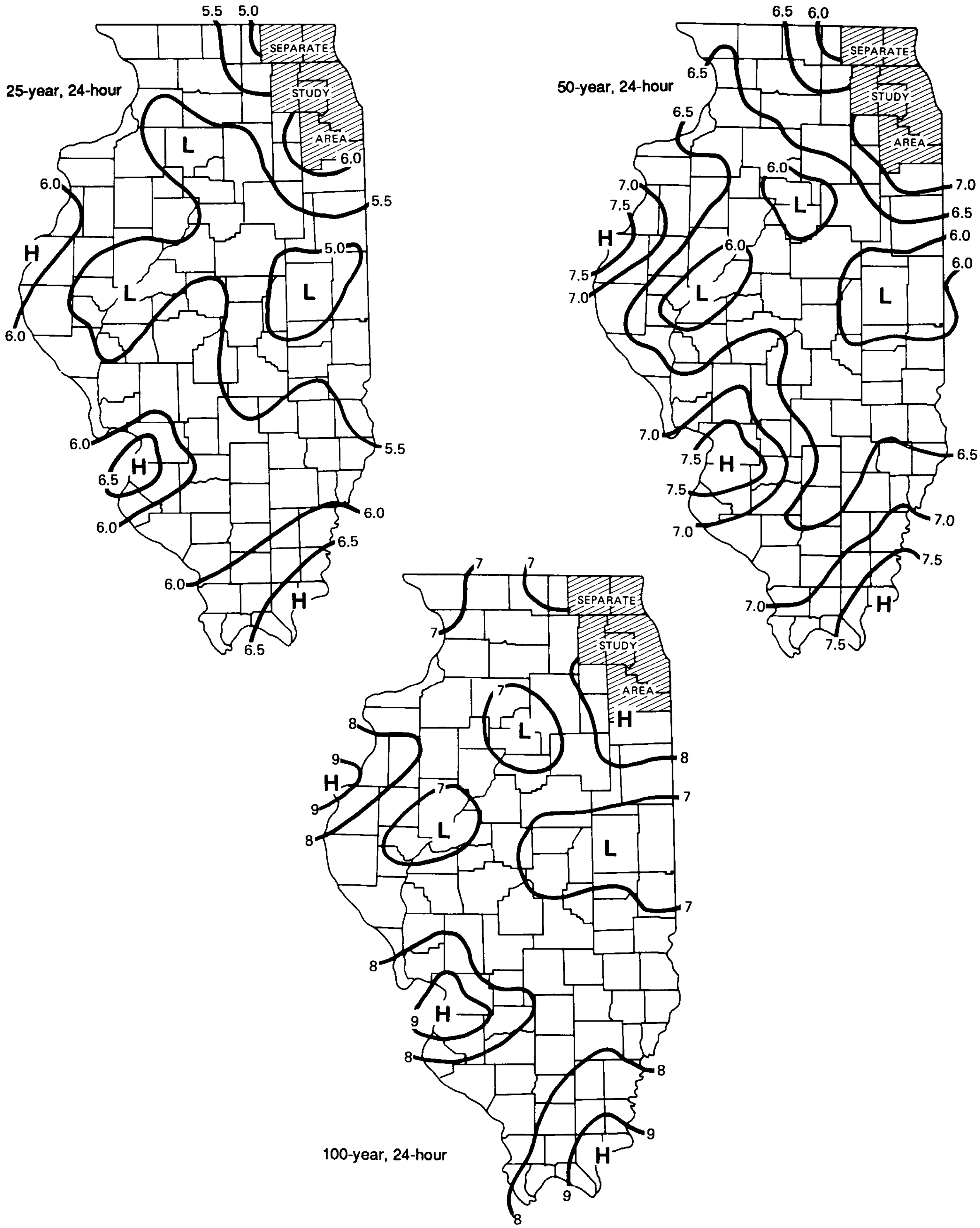


Figure 9. Concluded

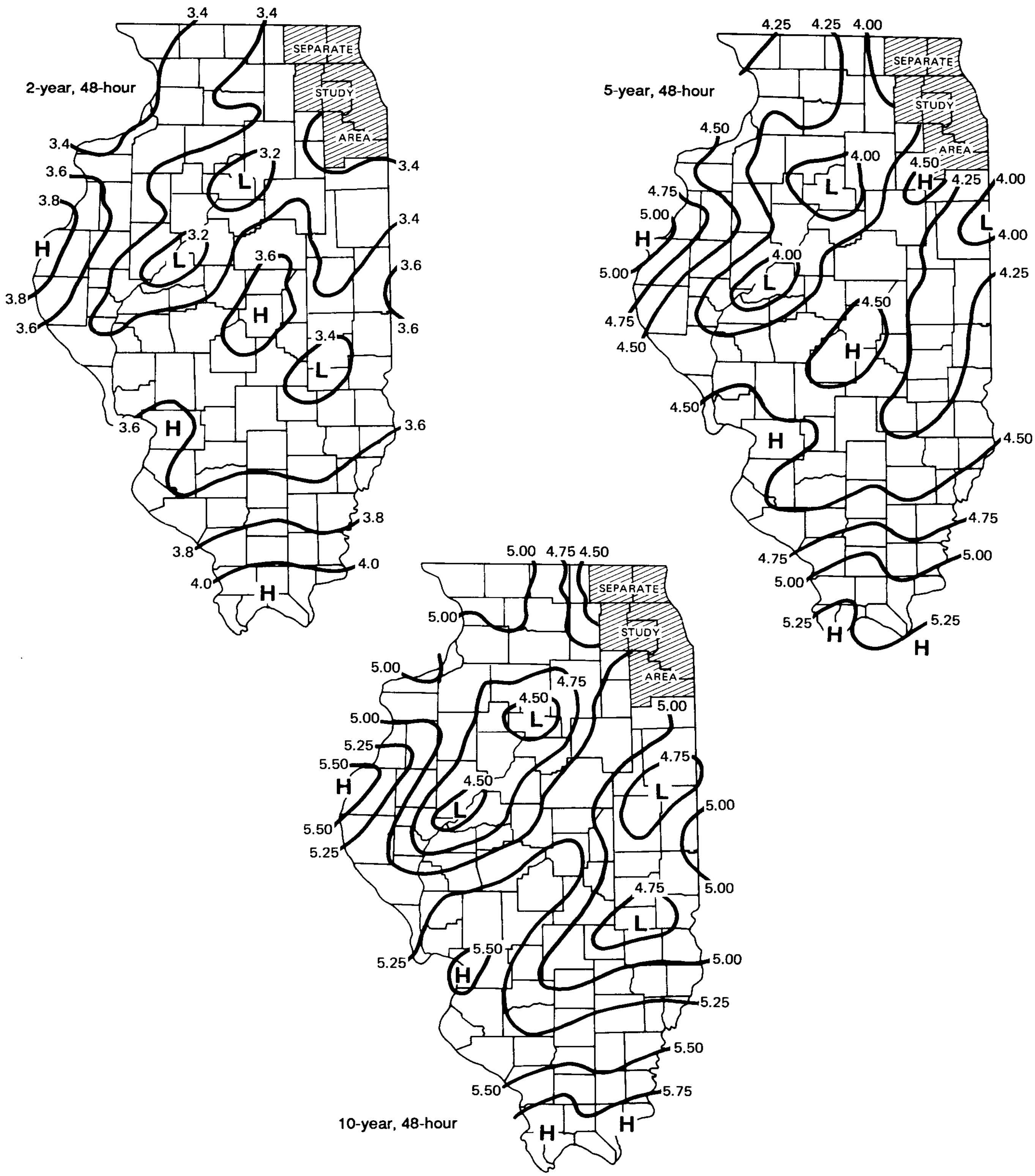


Figure 10. Spatial distributions of 48-hour rainfall (inches)

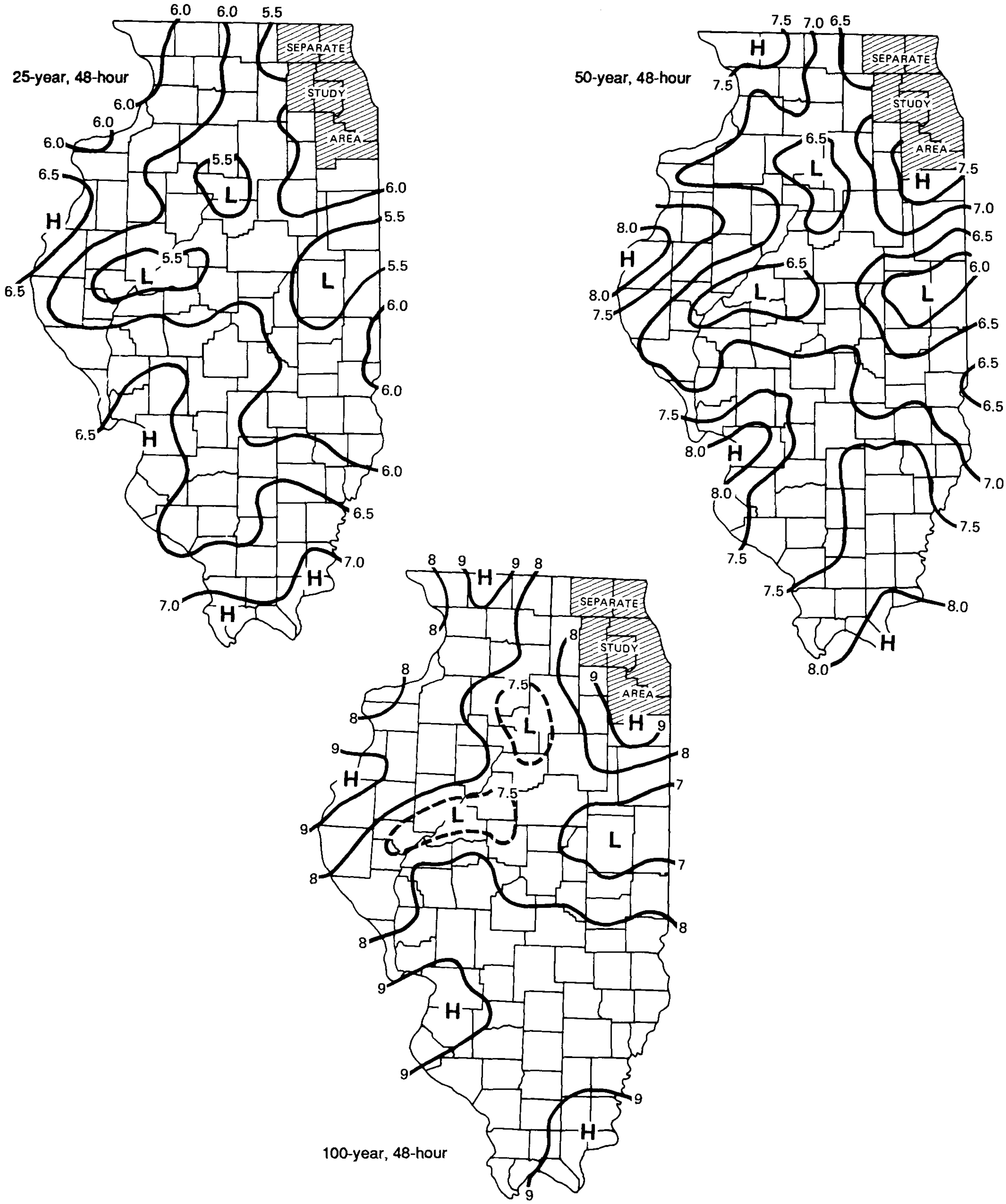


Figure 10. Concluded

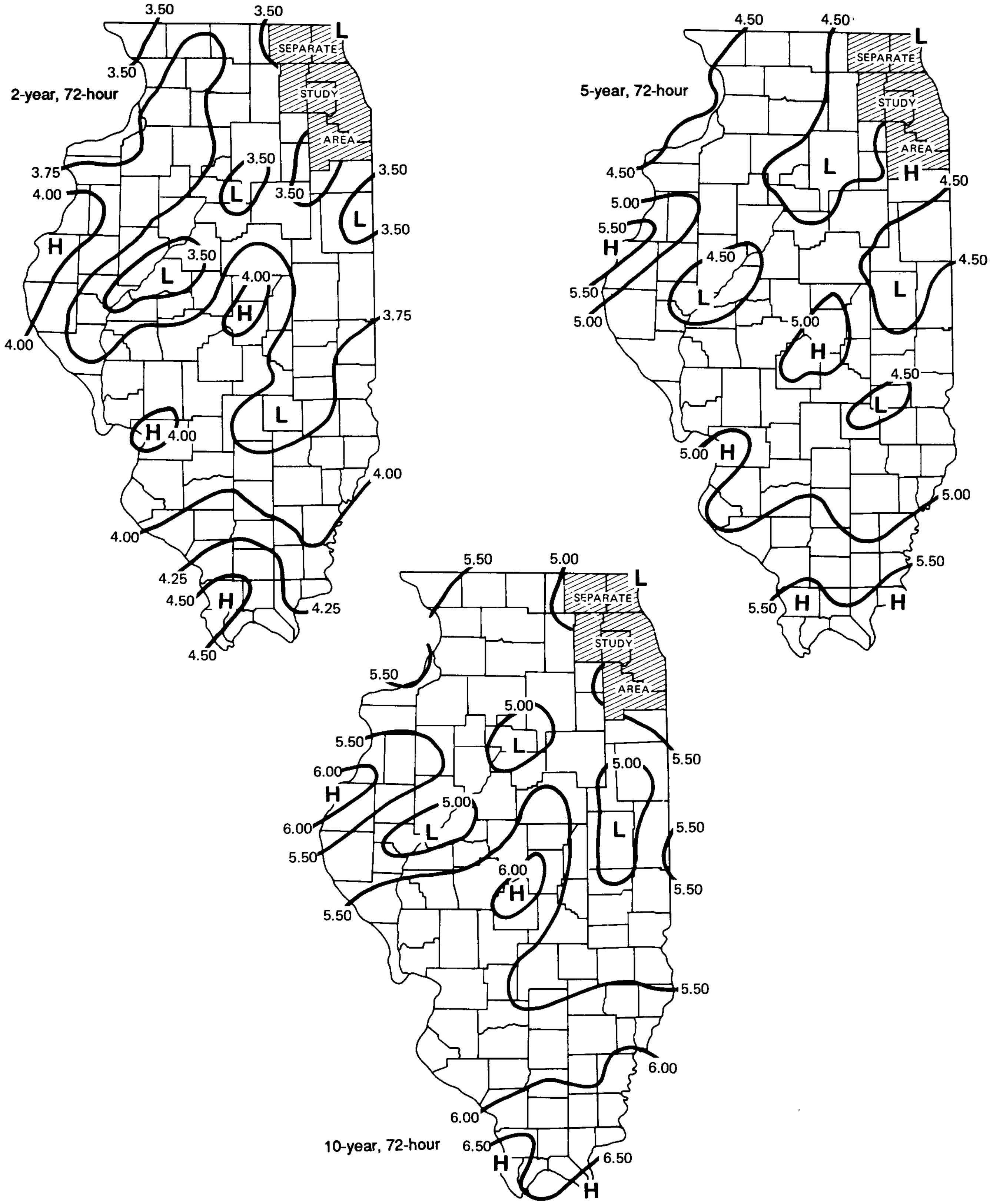


Figure 11. Spatial distributions of 72-hour rainfall (inches)

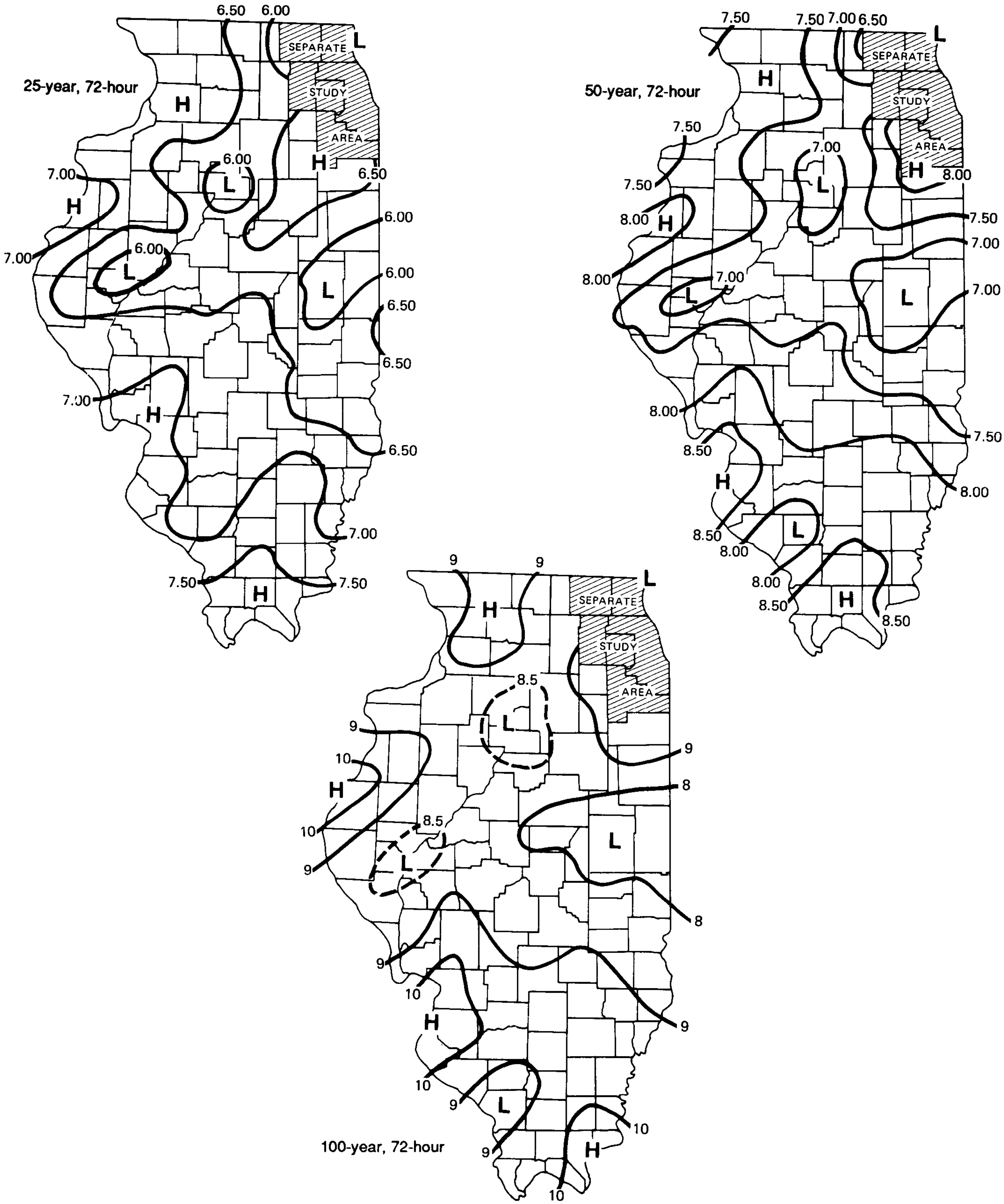


Figure 11. Concluded

PART 2: UPDATE OF HEAVY RAINFALL RELATIONS IN CHICAGO AND NORTHEASTERN ILLINOIS

Heavy rainfall frequency relations developed by Huff and Angel (1989) were used to update and adjust the relations presented in Water Survey Report of Investigation 82 (Huff and Vogel, 1976). Analyses showed that only minor adjustments were required in the Chicago urban area of 430 square miles (figure 12). However, substantial adjustments were needed in the western, southwestern, and southern areas of the six-county surrounding area (figure 12), based on the long-term data (1901-1983).

The 1901-1983 frequency relations at Aurora (west of Chicago) and Joliet (southwest of the urban area) showed a greater frequency of heavy rainstorms than indicated by the 1949-1974 data used by Huff and Vogel in their 1976 study. Differ-

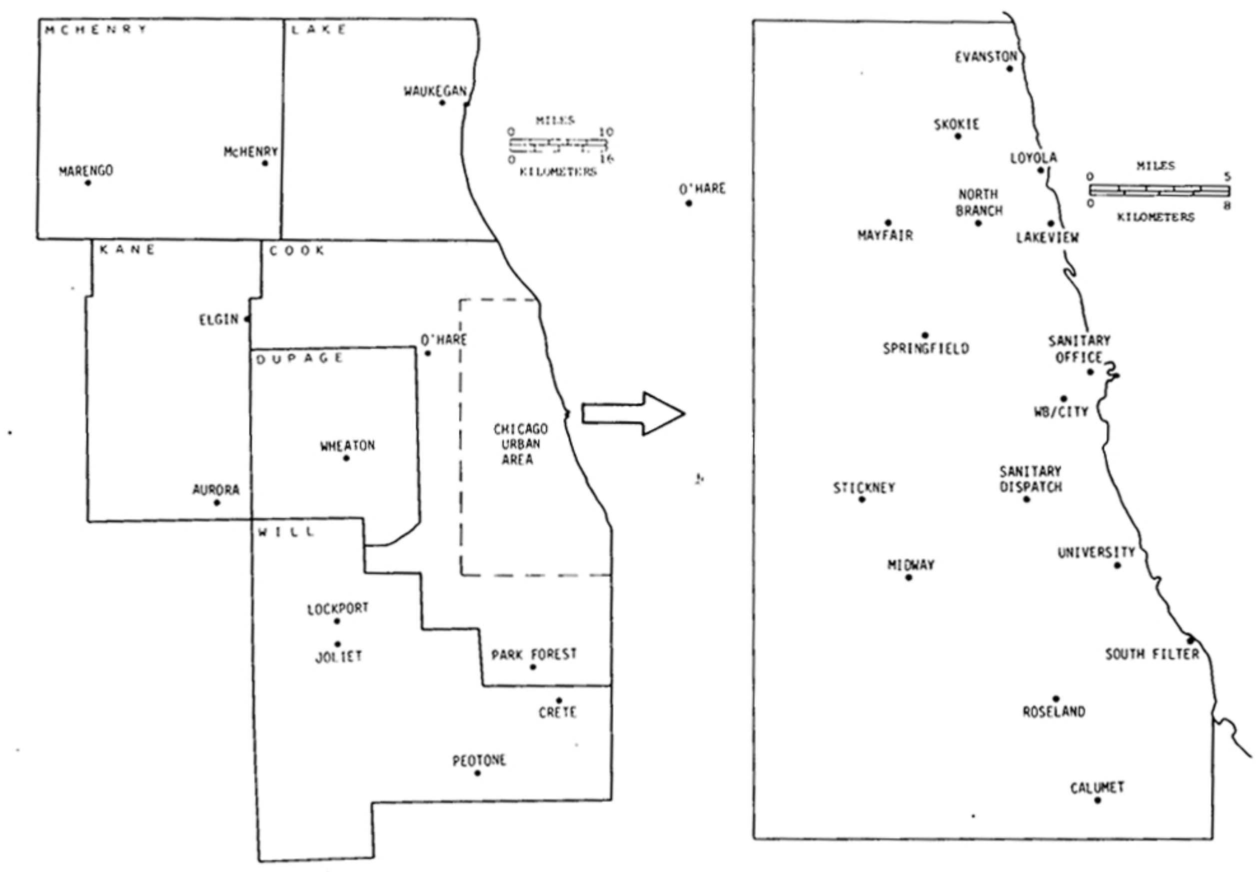


Figure 12. Location maps for northeast Illinois study

ences between the 1976 and 1989 studies were on the order of 5% in the urban area. However, differences increased from approximately 10% at 2-year recurrences to more than 20% for 100-year events west and southwest of the urban area. These relatively large differences resulted partly from a climatic adjustment integrated into the 1901-1983 analyses to account for an identified increase in the intensity of extreme rainfall events. This trend enveloped most of Illinois and maximized in the northeastern part of the state in the region encompassing Aurora, Joliet, and Kankakee (Huff and Angel, 1989).

Adjustments to Report of Investigation 82 (Huff and Vogel, 1976)

Figure 13 shows the frequency distribution of 24-hour maximum rainfall for the Chicago urban area for recurrence intervals ranging from 1 to 100 years. These maps replace the 24-hour isohyetal patterns in Water Survey Report of Investigation 82 (Huff and Vogel, 1976). The new maps incorporate the climatic trend adjustments derived from the 1901-1983 data. Figure 14 shows the adjusted 24-hour isohyetal pattern for the six-county area shown in figure 12.

Various Water Survey studies have shown that isohyetal patterns remain essentially the same for the various storm periods and recurrence intervals addressed here (Huff and Neill, 1959; Huff and Vogel, 1976; Huff and Angel, 1989). Thus, although the rainfall amount increases greatly for a given storm period between the 2-year and 100-year recurrences, the pattern characteristics remain essentially the same. For example, highs and lows in all the isohyetal maps of figures 13 and 14 are in approximately the same locations. Also, comparisons of the Huff-Vogel 1976 patterns with the adjusted patterns of Huff and Angel (1989) show nearly the same spatial distribution characteristics. Only the isohyetal amounts change significantly.

In view of the above findings, adjusted isohyetal relations for the Chicago urban area and the six-county area were derived by using the 24-hour isohyetal patterns of figures 13 and 14 as a base, and expressing all other frequency values for other storm periods and recurrence intervals as a function of the 24-hour values. This greatly reduces the cost that would be involved in revising and republishing Report of Investigation 82.

A simple computational method for deriving frequency relations for storm periods of 5 minutes to 72 hours and recurrence intervals of 2 months to 100 years is provided by using figures 13 and 14 in conjunction with tables 2 and 3. Frequency relations can easily be calculated for any point or area of interest through use of the above combination of base maps and tables, as illustrated by the following examples.

Table 2 shows the average ratio of x-hour to 24-hour rainfall (base period) in Illinois, as determined by Huff and Angel (1989). Thus if one wishes to determine the 5-year, 72-hour rainfall expected to occur at a given point, simply multiply the 24-hour value from the appropriate isohyetal map (figure 13 or 14) by 1.16. If the 3-hour value is needed, multiply by 0.64.

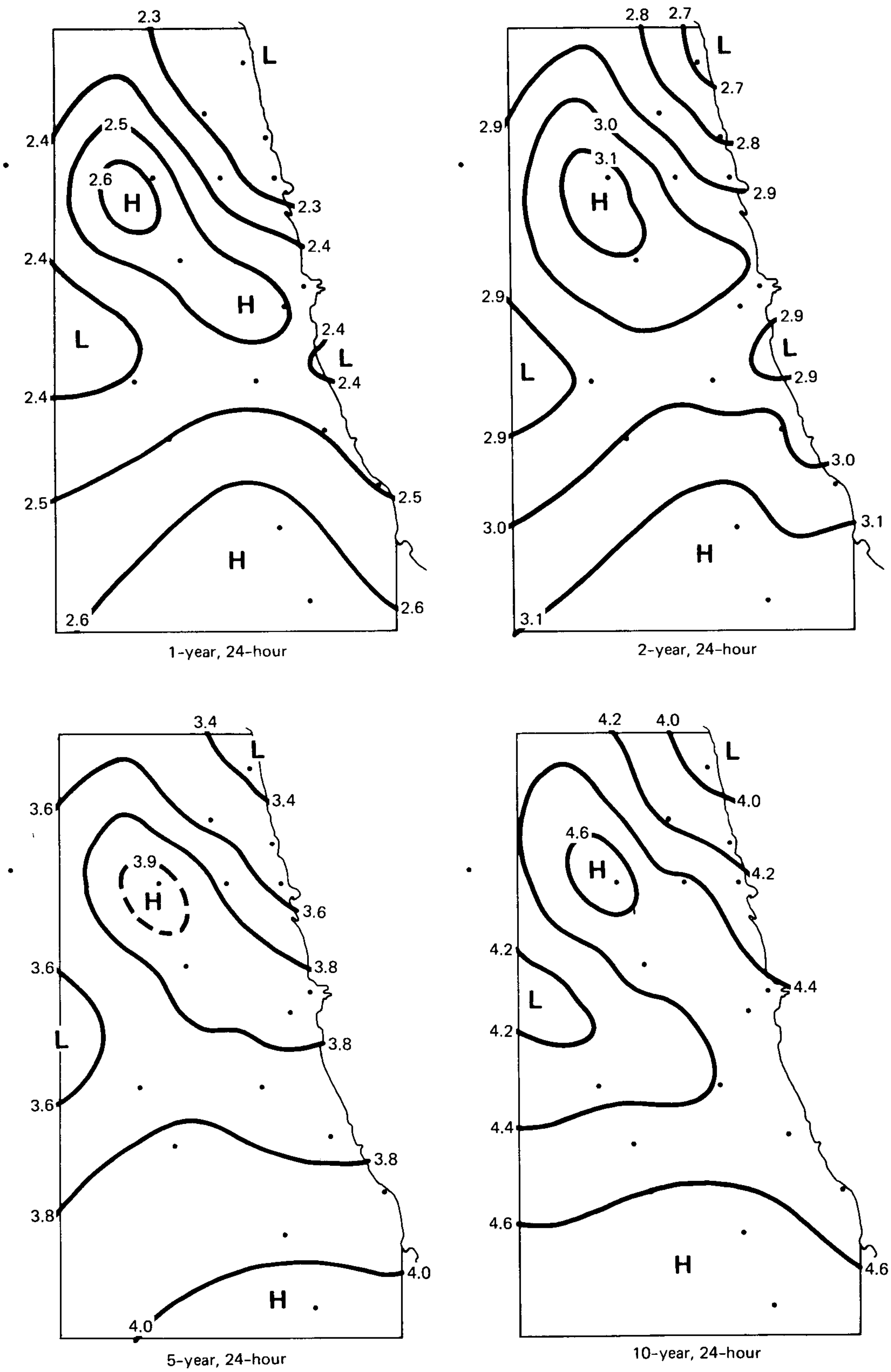


Figure 13. Frequency distribution of 24-hour maximum rainfall (inches), Chicago urban area (adjusted)

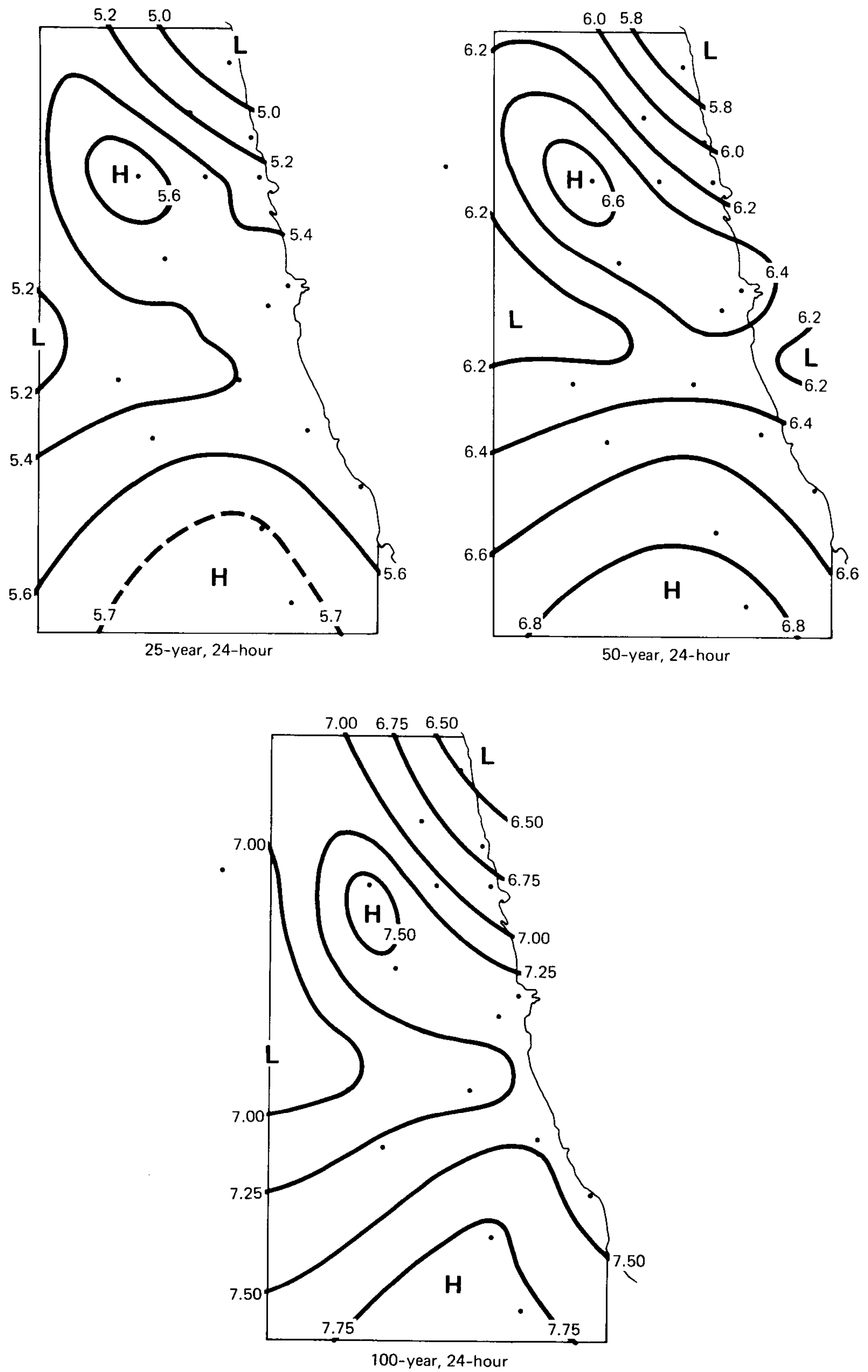


Figure 13. Concluded

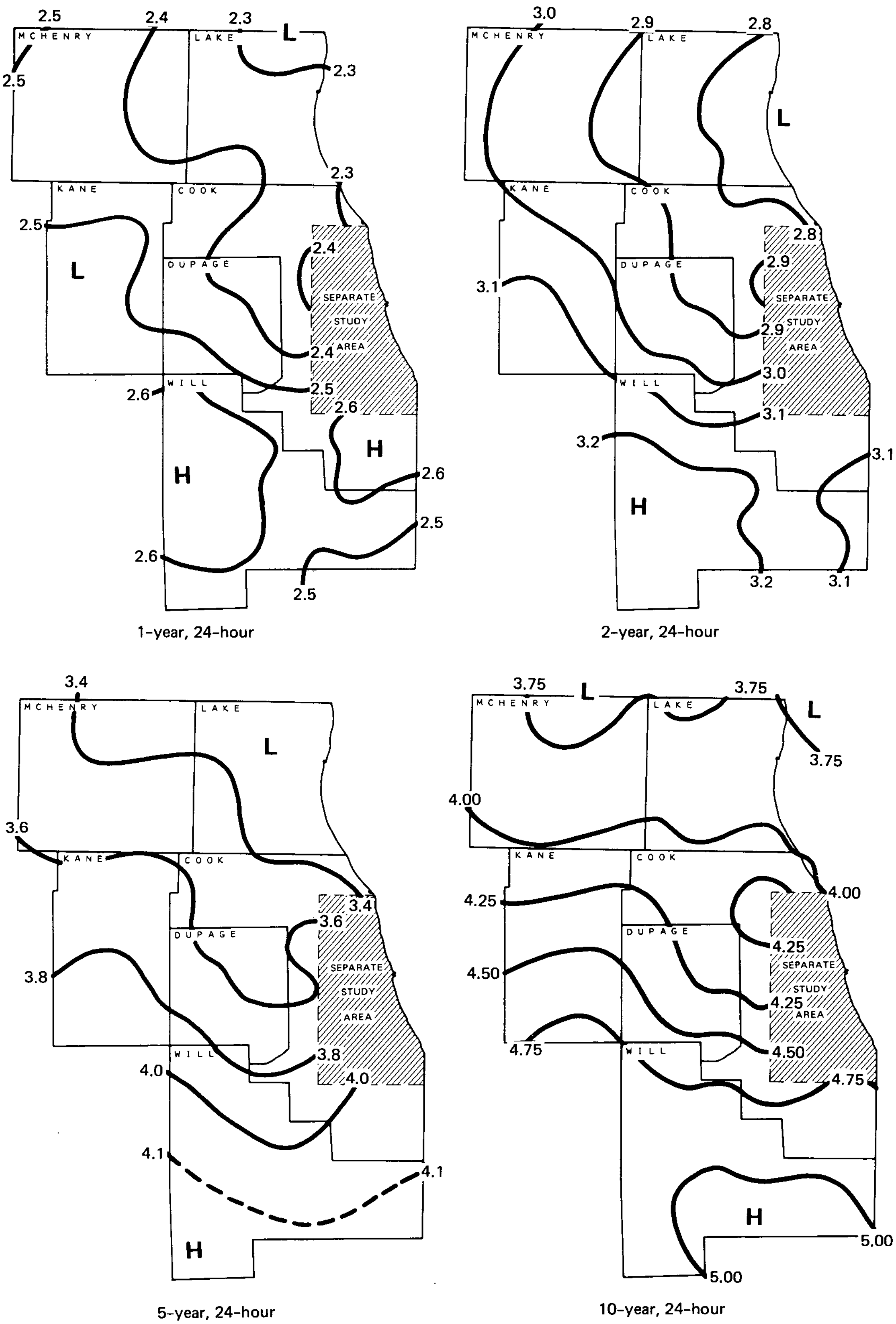
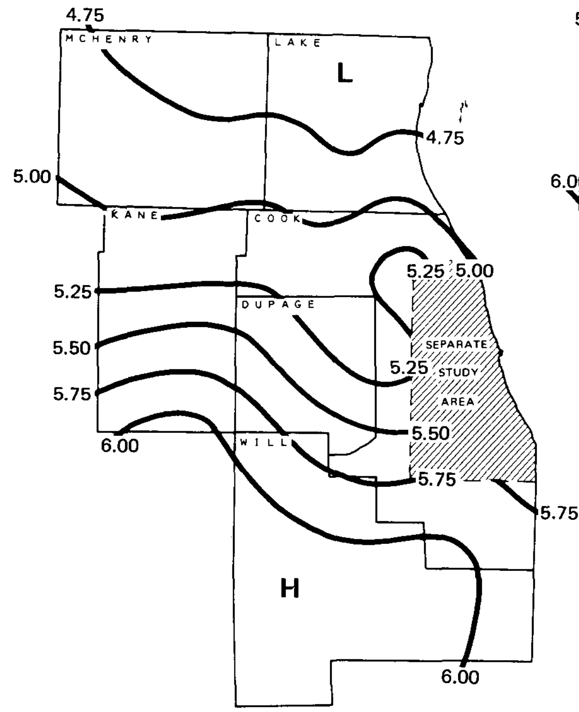
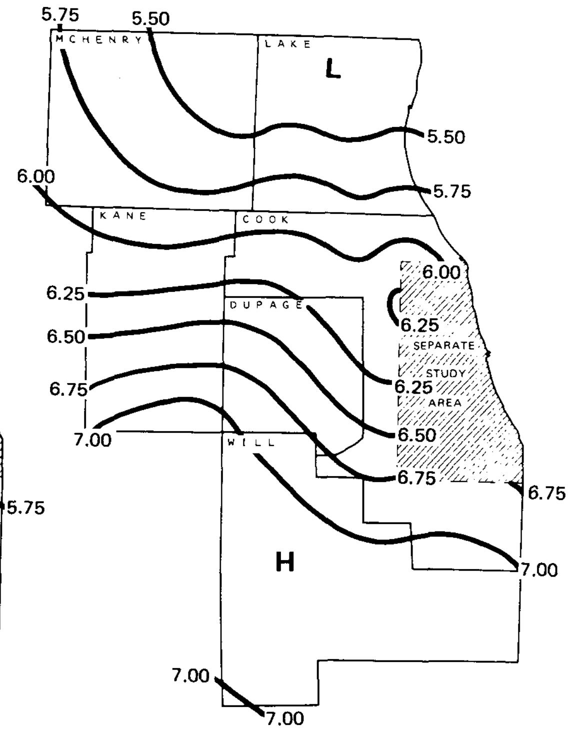


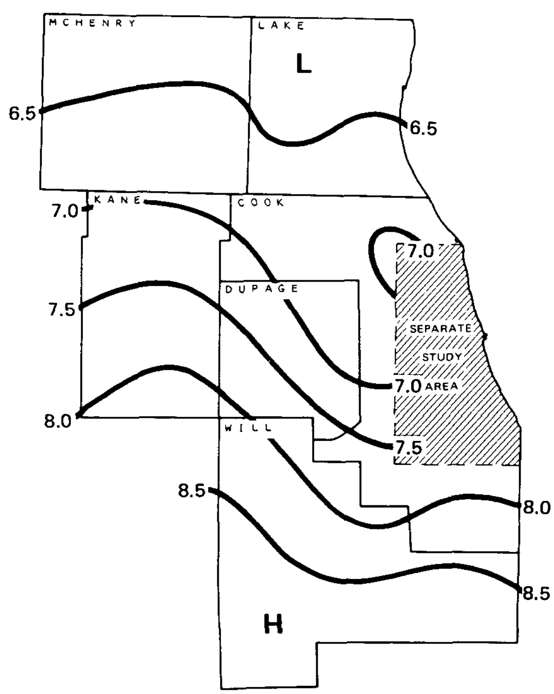
Figure 14. Frequency distribution of 24-hour maximum rainfall (inches), six-county area (adjusted)



25-year, 24-hour



50-year, 24-hour



100-year, 24-hour

Figure 14. Concluded

Table 2. Average Ratios of X-Hour/24-Hour Rainfall for Illinois

Storm period (hours)	*Ratio, x-hr/24-hr*
0.08 (5 min.)	0.12
0.17 (10 min.)	0.21
0.25	0.27
0.50	0.37
1	0.47
2	0.58
3	0.64
6	0.75
12	0.87
18	0.94
24	1.00
48	1.08
72	1.16

Table 3. Ratios of Illinois Rainfall Amounts for Recurrence Intervals of Less than 1 Year to Rainfall Amounts for Recurrence Intervals of 1 Year, for Various Rainstorm Periods

	Ratio, x-month to 12-month rainfall amount for given rainstorm period				
Storm period	*2 months*	*3 months*	*4 months*	*6 months*	*9 months*
≤24 hours	0.55	0.64	0.70	0.81	0.92
48 hours	0.53	0.62	0.69	0.80	0.92
72 hours	0.52	0.61	0.69	0.80	0.92

Table 3 shows the relationship between l-year and shorter-interval frequency values for various rain periods (Huff and Angel, 1989). Table 3 can be used if one desires recurrence-interval values for 2 to 9 months.

The following examples illustrate how to use figure 13 or 14 in conjunction with tables 2 and 3 to calculate frequency values for any given situation. Assume that a user wishes to calculate the maximum 6-hour rainfall expected to occur, on the average, once in 25 years at Aurora (figure 12). The 24-hour map for a 25-year recurrence (figure 14) shows a value of 6.00 inches at Aurora. Table 2 shows that the 6-hour/24-hour ratio is 0.75. Multiplying 6.00 by 0.75 gives a value of 4.50 inches for the 6-hour, 25-year storm.

Now assume further that the user wishes to determine the 6-hour rainfall to be expected once in 6 months, on the average. Figure 14 shows that the l-year, 24-hour storm value at Aurora is 2.55 inches. The l-year, 6-hour value is obtained by multiplying 2.55 by 0.75, which gives 1.91 inches. Table 3 indicates that the average 6-month value is 81% (0.81) of the l-year amount. Then 1.91 multiplied by 0.81 yields 1.55 inches for the 6-month, 6-hour amount.

Next, assume that a user wishes to obtain frequency values for a rain period other than 24 hours for an area within or between basins. This can be done quite readily by replacing the 24-hour values for each isohyet with the computed value for any rain period of interest. For example, assume that the user wants to determine the frequency distribution of 12-hour rainfall having a 5-year recurrence in DuPage County. Turning to the 5-year, 24-hour map in figure 14, multiply each isohyetal value by 0.87, the 12-hour/24-hour ratio in table 2. Then the 3.4-inch isohyet of figure 14 becomes 2.96 inches, and the 3.6-, 3.8-, and 4.0-inch isohyets convert to 3.13, 3.31, and 3.48 inches, respectively.

PART 3: THE ST. LOUIS ANOMALY

Previous Water Survey studies (Huff and Changnon, 1972; Changnon et al., 1977) have shown that inadvertent weather modification by the St. Louis urban environment substantially increases rainfall downwind of the city, and the urban enhancement tends to be largest in relatively heavy rainstorms. The anomaly is largely contained within a 25-mile radius extending northeast, east, and southeast of central St. Louis, and no significant effect has been identified beyond 50 miles. The effect is most pronounced in spring and summer, when the majority of the excessive rainstorms occur, particularly those producing 25-year to 100-year events.

Results of the St. Louis METROMEX studies indicate that in Illinois, only St. Clair and Madison Counties are significantly affected by the urban anomaly. The effect should be most pronounced in Madison County northeast and east of the city. Of the stations used in the present study of Illinois frequency distributions, only St. Louis (Lambert Field) and Mascoutah-Belleville could incorporate any of the potential urban effect on the natural rainfall distribution. Furthermore, Lambert Field is usually upwind of the major urban area.

According to the METROMEX research, the urban effect is most prominent in storms with relatively short durations (Changnon et al., 1977). Except during the METROMEX research in 1971-1975, there has been no raingage network of sufficient density, such as the Chicago urban network used in the northeastern Illinois study, to identify and define the intensity and areal extent of the St. Louis anomaly.

According to the St. Louis research, the effect is limited largely to storms of 24 hours or less. Maximum effect was indicated in excessive storm periods of 3 hours or less. For the larger, more intense storms producing amounts expected to occur only on the average of once in 10 years or longer, the urban effect appears to be minimal in comparison with the natural precipitation output generated by the controlling synoptic storm systems. It appears that these storm systems strongly suppress or eliminate urban influences on the natural precipitation processes.

No adjustment is recommended for St. Clair County, because the Mascoutah-Belleville data for 1901-1983 appear to have accounted adequately for the urban anomaly in that region. For Madison County, which lies within the southwest section, the values appearing in table 1 for that section may be used with the adjustments shown in table 4 and discussed below.

Table 4 shows adjusted frequency values for Madison County, based on findings in the METROMEX research and other urban studies of inadvertent weather modification. The estimates provided in this table indicate urban-induced increases of 20-25% for storm periods of 3 hours or less and recurrence intervals less than 5 years. These changes decrease gradually as the storm period and recurrence interval increase. Thus, for a storm period of 12 hours and a recurrence interval of 10 years, the urban effect decreases to 12-15%. It becomes insignificant at recurrence intervals of 25 years and longer and storm periods of 48 hours and longer.

Table 4. Frequency Relations for Madison County, Adjusted for St. Louis Urban Effect

	Rainfall (inches) for given recurrence interval								
Storm period (hours)	*3-month*	*6-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
0.5	0.65	0.84	1.05	1.20	1.61	1.83	2.22	2.61	3.03
1	0.97	1.22	1.52	1.89	2.34	2.65	2.92	3.35	3.88
2	1.23	1.54	1.92	2.35	2.87	3.26	3.60	4.20	4.85
3	1.33	1.66	2.08	2.52	3.14	3.50	3.88	4.52	5.25
6	1.53	1.91	2.39	2.90	3.62	4.10	4.58	5.30	6.16
12	1.67	2.16	2.70	3.25	4.05	4.60	5.25	6.15	7.14
24	1.77	2.28	2.85	3.45	4.35	4.95	6.02	7.07	8.21

Table 4 is an addition to Bulletin 70 (Huff and Angel, 1989) and presents results of further evaluation of the urban effect. The user should recognize that the adjustments are estimates based on information presently available on the subject and may be modified in the future as more information is accumulated.

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