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TECHNICAL PAPER NO. 2

**Maximum Recorded
United States Point Rainfall
For 5 Minutes to 24 Hours at 296
First-Order Stations**

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for

**Engineering Division, Soil Conservation Service
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CONTENTS

	Page
Authority	1
Introduction	1
Maximum rainfall data	2
Representativeness of maximum rainfall data	3
Seasonal distribution	3
Daily distribution	5
Depth-duration characteristics	5
Acknowledgments	6
References	7

TABLES

1. Number of new maximum rainfalls recorded during the period 1947-1961 at 146 stations with records of at least 50 years	1
2. Percentage increase of new maxima over maxima prior to 1947	1
3. Comparison by states of maximum 24-hour rainfall amounts from first-order stations with those measured by cooperative or unofficial observers	4
4. Monthly distribution of maximum rainfall amounts	5
5. Number of occurrences of maximum depth-duration values in same storm	6
6. Maximum recorded U. S. Point Rainfall	8-28

ILLUSTRATIONS

1. Station locations	30-31
2. 5-minute maximum recorded precipitation	32-33
3. 10-minute maximum recorded precipitation	34-35
4. 15-minute maximum recorded precipitation	36-37
5. 30-minute maximum recorded precipitation	38-39
6. 60-minute maximum recorded precipitation	40-41
7. 2-hour maximum recorded precipitation	42-43
8. 3-hour maximum recorded precipitation	44-45
9. 6-hour maximum recorded precipitation	46-47
10. 12-hour maximum recorded precipitation	48-49
11. 24-hour maximum recorded precipitation	50-51
12. Maximum observed U. S. rainfalls	52
13. Daily and seasonal distribution of maximum rainfall occurrences	53
14. Predominating seasons of occurrence of maximum rainfalls	54
15. Percentages of excessive-rain occurrences per quarter day--annual and summer	55
16. Mean depth-duration curves of maximum 60-minute rainfalls	56

MAXIMUM RECORDED UNITED STATES POINT RAINFALL

for 5 Minutes to 24 Hours at 296 First-Order Stations

INTRODUCTION

This report, which is a revision of Technical Paper No. 2 17 originally published in 1947 in cooperation with the Corps of Engineers, was prepared for the Soil Conservation Service to provide rainfall information for planning and design purposes in connection with its Watershed Protection and Flood Prevention Program (authorization: P. L. 566, 83d Congress, and as amended.)

Many of the maximum rainfall values for the stations listed in the original Technical Paper No. 2 have been exceeded since its publication, some by large amounts. Table 1 lists, for stations with at least 50 years of record as of 1961, the number of maximum values exceeded each year during the 15-year period 1947-1961. A total of 338 new maxima out of a possible 1459 were observed in this period. New maxima were recorded in every year.

The relative differences between the new maxima and those prior to 1947 are shown in table 2. The largest percentage increases were found to be associated with durations of 3 hours and longer. The unusually high percentage increase shown for the 12-hour duration resulted from two outstanding percentages for Hartford, Conn., and Key West, Fla., 86 and 103 percent, respectively. If these two values were eliminated, the mean percentage increase for 12 hours would be 26.9. The mean percentage increase for 24 hours would be 31.8.

Table 1
NUMBER OF NEW MAXIMUM RAINFALLS RECORDED DURING THE PERIOD 1947-1961 AT 146 STATIONS WITH RECORDS OF AT LEAST 50 YEARS

Year	Duration												Number of new maxima	Number of stations	Bureau Technical Paper No. 2
	Minutes	5	10	15	30	60	2	3	6	12	24	Total			
1947	2	4	4	4	2	2	1	3	4	3	29	29	1459	296	17
1948	0	0	0	1	2	2	2	1	0	0	8	8	1459	296	17
1949	2	2	3	1	2	5	6	6	3	3	33	33	1459	296	17
1950	0	0	2	4	7	3	4	2	3	4	29	29	1459	296	17
1951	1	2	2	0	0	2	0	0	0	2	9	9	1459	296	17
1952	1	3	3	3	2	2	1	1	1	1	18	18	1459	296	17
1953	1	3	3	3	4	3	3	1	2	0	23	23	1459	296	17
1954	1	0	1	0	1	2	2	2	2	2	13	13	1459	296	17
1955	4	4	5	6	7	6	5	3	3	4	47	47	1459	296	17
1956	0	2	0	0	1	0	1	1	1	0	6	6	1459	296	17
1957	2	3	3	3	2	3	2	3	4	2	27	27	1459	296	17
1958	7	8	7	5	4	4	4	4	1	2	46	46	1459	296	17
1959	2	0	0	1	0	2	4	2	1	1	13	13	1459	296	17
1960	5	3	2	3	2	2	2	2	2	1	24	24	1459	296	17
1961	2	2	1	0	1	2	0	1	1	3	13	13	1459	296	17
Total	30	36	36	34	37	40	37	32	28	28	338	338	1459	296	17

Duration	Percent	PERCENTAGE INCREASE OF NEW MAXIMA OVER MAXIMA PRIOR TO 1947											
		5 min.	10 min.	15 min.	20 min.	30 min.	40 min.	60 min.	1 hr.	2 hr.	3 hr.	6 hr.	12 hr.
5 min.	17.2												
10 min.	15.7												
15 min.	15.2												
20 min.													
30 min.	20.3												
40 min.													
60 min.	16.4												
1 hr.													
2 hr.	20.2												
3 hr.	25.0												
6 hr.	24.6												
12 hr.	31.8												
24 hr.	23.8												

has been out of print and unavailable for several years. Since maximum rainfall rates are of great interest to meteorologists and hydrologists and there was no other published summary of these data, it appeared that a revision of Technical Paper No. 2 was in order.

MAXIMUM RAINFALL DATA

Maximum rainfall amounts for 5, 10, 15, 30 and 60 minutes and for 2, 3, 6, 12 and 24 hours at 296 stations (fig. 1) are shown in table 6 and on maps (figs. 2-11), one map for each duration. Maximum values were obtained by examination of precipitation data in published and unpublished tabulations and summaries /2-11/. Maxima were selected for all Weather Bureau first-order stations, active or discontinued, having published excessive rainfall tabulations (5 to 180 minutes) for at least a 5-year period. In the original study the minimum length of record was 10 years. The minimum was lowered to 5 years in order to include a relatively large number of stations that began measurements of excessive rainfalls for 5- to 180-minute durations about 1954.

Very few of the stations for which maximum rainfall amounts are listed in table 6 remained at the same location during the entire period of record given. The most important location changes occurred when official observations were moved from a city office to an airport station. In such cases, if the city office discontinued observations, its record was combined with that of the airport station. When observations were made by both the city office and airport station, the records were kept separate.

Practically all of the maximum amounts listed in table 6 are from automatic records. Their accuracy is subject to the instrumental limitations of recording gages and to imperfections of the compilation method. With tipping-bucket gages, intensities of the order of 1 inch in 5 minutes often produce so dense a packing of the trace that the actual intensity can be determined only indirectly by subtracting the totals for the periods of lower, more readable intensities from the total measured by stick. Also, the stick measurement often exceeds the automatically recorded amount for heavy rains because water continues to flow into the tipping bucket while it is tipping. Under these conditions, the automatic record may show maximum intensities that are about 5 percent too low /12/. The automatic record is corrected by distributing the difference in proportion to the recorded intensities.

In the case of weighing-type gages, unusual frictional effects in the mechanism may produce a trace indicating a lower intensity than the actual. On the other hand, a sudden freeing of the binding mechanism may result in an indicated intensity greater than the actual.

Some compilations of the excessive rainfall data prior to 1935 were based only upon successive 5-minute intervals of duration, beginning with the first indication of excessive rain /13/. The actual maximum intensity may then exceed the tabulated maximum by as much as 10 percent for 5 minutes. Longer durations show less error /14/.

Maximum amounts for 6 and 12 hours, which are not usually tabulated by Weather Bureau stations, were compiled from tabulations of hourly amounts by standard 1-hour clock intervals. Prior to 1936, when tabulations of excessive 180-minute rainfall amounts were inaugurated, 3-hour maxima were obtained from hourly data also. The effect of such compilation by 1-hour intervals rather than to the nearest minute is to increase the discrepancy between actual and tabulated maxima.

Maximum values from non-recording gages are mostly confined to 24-hour amounts, although a few maxima for durations as short as 2 hours were obtained from such gages. Such values have been used when already identified as official station maxima for a particular duration. The records are authentic but from a period of station operation antedating the installation of a recording gage. Use of these amounts required, in some cases, a change in the value of a maximum observed amount for a shorter duration, for example, when the 60-minute amount was less than one-third the 3-hour value. The amount for the shorter duration was adjusted to agree with a percentage depth-duration distribution determined from stations having values of corresponding magnitude. This method of adjustment was also applied in a few cases in which, for example, exactly half the 10-minute maximum was recorded as the 5-minute maximum because of the illegibility of the trace for the shorter duration. All adjusted amounts are so identified in the Notes of table 6.

REPRESENTATIVENESS OF MAXIMUM RAINFALL DATA

No isohyets have been drawn on the maps of figures 2-11 because no line connecting points of equal magnitude would necessarily be a line of equal observed maximum magnitude. Since records confined to the fewer than 300 stations constitute an obviously small sample, it is natural to question these values as representative of the maximum observed for the vicinity, no matter how "vicinity" is defined. Experience with values of this type indicates that first-order station maximum values are roughly doubled by maxima for cooperative stations or by unofficial but verifiable records (fig. 12). Naturally, such a rule is not applicable to all States nor to all records.

Table 3 lists both first-order and other 24-hour maxima for each of the contiguous 48 States. Connecticut is the only State where the maximum 24-hour amount measured by a first-order station exceeded the maximum obtained by either a cooperative observer or an unofficial measurement. The biggest difference listed is for Pennsylvania, where the unofficial measurement of 34.50 in. is more than three times the first-order station maximum of 10.42 in. The West Virginia unofficial maximum is also more than three times the first-order maximum, i.e., 19.00 in. vs. 5.60 in.

SEASONAL DISTRIBUTION

The monthly distribution of maximum observed rainfall amounts for stations with 20 or more years of record is shown in table 4. The highest percentage of occurrence for durations up to 6 hours is in July or August.

Table 3 COMPARISON BY STATE OF MAXIMUM 24-HOUR RAINFALL AMOUNTS (IN.) FROM FIRST-ORDER AND UNOFFICIAL STATIONS WITH THOSE MEASURED BY COOPERATIVE OR UNOFFICIAL OBSERVERS

State	First-Order		Coop. or Unofficial		State	First-Order		Coop. or Unofficial			
	Alabama	13.36	20.33	Nebraska	8.38	13.15	N. Carolina	14.93	22.22		
Arizona	5.20	5.95	3.30	4.37	Nevada	5.97	8.00	N. Dakota	5.58	7.70	
Arkansas	9.58	12.00	New Hampshire	9.21	14.81	Ohio	5.98	8.70	Oklahoma	7.87	19.75
California	9.31	26.12	New Jersey	5.65	11.28	Oregon	7.66	10.17	Oregon	7.66	10.17
Colorado	6.53	8.05	New Mexico	9.55	11.17	Pennsylvania	10.42	34.50	Pennsylvania	10.42	34.50
Connecticut	12.12	*	New York	14.93	22.22	Rhode Island	8.52	12.13	Rhode Island	8.52	12.13
Delaware	6.53	7.83	N. Carolina	14.93	22.22	S. Carolina	10.57	13.25	S. Carolina	10.57	13.25
Florida	19.88	38.70	N. Dakota	5.58	7.70	S. Dakota	7.52	8.00	S. Dakota	7.52	8.00
Georgia	11.44	18.00	Ohio	5.98	8.70	Tennessee	10.48	11.00	Tennessee	10.48	11.00
Idaho	2.72	7.17	Oklahoma	7.87	19.75	Texas	23.11	38.20	Texas	23.11	38.20
Illinois	7.56	14.25	Oregon	7.66	10.17	Utah	2.72	4.50	Utah	2.72	4.50
Indiana	6.94	10.50	Pennsylvania	10.42	34.50	Vermont	7.72	8.77	Vermont	7.72	8.77
Iowa	6.74	12.99	Rhode Island	8.52	12.13	Virginia	8.79	11.20	Virginia	8.79	11.20
Kansas	8.08	12.59	S. Carolina	10.57	13.25	Washington	5.91	12.00	Washington	5.91	12.00
Kentucky	8.06	10.40	S. Dakota	7.52	8.00	W. Virginia	5.60	19.00	W. Virginia	5.60	19.00
Louisiana	16.01	21.40	Tennessee	10.48	11.00	Wisconsin	7.23	11.72	Wisconsin	7.23	11.72
Maine	7.49	7.72	Texas	23.11	38.20	Wyoming	4.86	5.50	Wyoming	4.86	5.50
Maryland	8.35	14.75	Utah	2.72	4.50						
Massachusetts	8.40	11.14	Vermont	7.72	8.77						
Michigan	5.64	9.91	Virginia	8.79	11.20						
Minnesota	7.80	10.75	Washington	5.91	12.00						
Mississippi	9.97	12.35	W. Virginia	5.60	19.00						
Missouri	8.78	12.25	Wisconsin	7.23	11.72						
Montana	3.74	10.10	Wyoming	4.86	5.50						

* First-order station maximum exceeded all other measurements.

Well over half of the occurrences for these durations fall in the 3-month period, June through August. For the 12- and 24-hour durations, the highest monthly percentage of occurrence is in September. About half of the maxima for these longer durations occur in the 3-month period, July through September. There appears to be a slight tendency towards a more uniform seasonal distribution as duration increases.

The frequency distribution by seasons is shown in the lower portion of figure 13. Summer is obviously the predominating season for all durations, but the increase of autumn occurrences with duration is very noticeable. For the 24-hour duration, the summer occurrences only slightly exceed the fall.

There are geographic variations in the seasonal distribution of occurrences of maximum observed values. The frequency distributions indicated by table 4 and figure 13 are biased by the much larger number of stations in the eastern United States. The months of occurrence of maximum observed 24-hour amounts were therefore plotted on a map, and lines separating the various seasons were then drawn (fig. 14). A single storm could alter the picture appreciably. For example, a fall hurricane along the east coast might well change the predominating season in the coastal areas from summer to fall.

Another map (not shown) was prepared also to show the predominant seasons of occurrence of maximum observed 1-hour amounts. Summer predominated everywhere except for a narrow strip along the west coast where spring and winter were the predominating seasons.

Table 4

MONTHLY DISTRIBUTION (IN PERCENT) OF MAXIMUM RAINFALL AMOUNTS
(Based on 211 stations with 20 or more years of record)

Duration	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5 min.	0.9	2.4	3.8	4.2	11.7	16.8	22.9	26.6	7.0	1.4	1.8	0.5
10 min.	0	2.4	0.9	3.8	10.3	16.8	28.0	27.1	5.6	2.3	2.3	0.5
15 min.	0	1.4	0.9	3.3	8.9	17.2	29.9	27.1	4.7	3.3	2.8	0.5
30 min.	0.5	1.4	1.4	2.3	8.0	15.9	24.8	30.8	6.5	4.2	2.3	1.9
60 min.	0.8	1.6	1.2	2.4	5.1	19.8	26.6	25.0	10.3	4.0	3.2	0
2 hr.	0.4	1.2	1.6	3.2	5.5	19.0	25.8	22.6	12.7	5.2	2.8	0
3 hr.	0.8	1.2	1.6	3.2	6.4	16.7	24.3	19.9	14.7	8.0	2.4	0.8
6 hr.	1.2	0.4	1.2	2.4	6.0	18.8	20.8	16.8	18.4	8.4	4.0	1.6
12 hr.	2.8	0.4	2.8	2.4	4.8	15.9	15.5	15.9	20.3	11.6	4.0	3.6
24 hr.	3.2	0	3.6	4.3	7.5	12.8	12.4	14.2	19.9	11.4	5.7	5.0

DAILY DISTRIBUTION

Beginning in 1936, times of beginning and ending of rain were omitted from the tabulations of excessive precipitation. A new analysis of daily distribution would have required examination of the recording-gage charts, which were not readily available. The discussion and data presented in the remainder of this section are therefore practically the same as presented in the original Technical Paper No. 2.

The frequency distribution by quarter days of maximum rainfall amounts is shown in the top portion of figure 13. Beginning times of rain were used as times of occurrence, e.g., a 24-hour maximum beginning at 11 p.m. would have its time of occurrence classified in the fourth quarter.

Although the third period (1200 to 1800, local standard time) is generally predominant, its frequencies are approximately equaled or exceeded by the frequencies in the fourth period for durations longer than 60 minutes.

There are geographic variations in the distribution of quarter-day frequencies. The frequency distribution of figure 13 is biased by the large number of eastern stations. The original Technical Paper No. 2 did not present any map showing the distribution of quarter-day frequencies of maximum rainfall amounts, but it referred to a similar map in Hydrometeorological Report No. 5 [15]. This map (fig. 15) was based on all values of excessive precipitation, not merely the maximum values. It shows the distribution by quarter days in summer and for the year as a whole. The map is practically identical with the geographic distribution of percentage frequencies of thunderstorm occurrences, the Midwest region of nocturnal thunderstorms being prominent in both.

DEPTH-DURATION CHARACTERISTICS

In examining the depth-duration characteristics of the maximum observed rainfall amounts of table 6, a distinction was made between maxima observed within the same storm and those observed among all storms. In other words, some of the maxima observed at a station for the various durations sometimes were from the same storm and some were from different storms. Table 5, for example, shows that out of 115 maximum observed 5-minute rainfall amounts,

Table 5
NUMBER OF OCCURRENCES OF MAXIMUM DEPTH-DURATION VALUES IN SAME STORM
(Based on stations with at least 50 years of record for all durations)

Duration	No. of Stations	Minutes						Hours					
		10	15	30	60	2	3	6	12	24	48	72	96
5 min.	115	62	42	26	20	11	9	8	7	4	2	1	0
10 min.	115		77	37	22	16	11	8	6	4	2	1	0
15 min.	115			53	31	22	17	11	6	5	2	1	0
30 min.	116				60	36	23	17	7	4	2	1	0
60 min.	125					62	43	33	17	16	7	3	1
2 hr.	126						80	55	33	29	14	7	2
3 hr.	128							71	45	38	22	11	3
6 hr.	130								72	54	32	16	4
12 hr.	136									86	46	23	5

INDIVIDUAL STORMS

only 62 occurred in the same storms that yielded the 10-minute maxima. The number of within-storm occurrences drops off rapidly as the difference between durations is increased. Thus, for example, of 115 observations of 5-minute maxima only 4 occurred in the same storms yielding the 24-hour maxima. In general, table 5 indicates that roughly half of the maxima for a specific duration were observed in the same storm yielding the maxima for double the duration.

Most of the maxima listed in table 6 for durations up to 60 minutes were associated with thunderstorms. In order to portray the depth-duration characteristics of such rainfalls, two sets of curves were prepared showing the maxima for various durations in terms of 60-minute maxima of various magnitudes (fig. 16). Only stations having at least 20 years of record were used. Maximum short-duration amounts within storms producing the maximum 60-minute amounts listed in table 6 provided the basis for the dashed curves. In most cases, these short-duration maxima were less than the maxima of record shown in the table. The solid curves are based on the values of table 6, regardless of whether or not the short-duration maxima were from the same storm producing the 60-minute maxima. The solid curves naturally show higher percentage values than the dashed within-storm curves, the differences being greatest for the shorter durations.

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Table 6
MAXIMUM RECORDED U.S. POINT RAINFALL (INCHES)

	MINUTES						HOURS					
	5	10	15	30	60	120	2	3	6	12	24	
WYOMING (cont.)												
Sheridan*	0.49	0.91	1.11	1.30	1.53	2.74	2.94	3.85	3.90	4.41		
Month, Day	7/2	7/2	7/2	6/25	7/23	7/22	7/22	7/22	7/22	7/22		
Year	1912	1939	1939	1932	1923	1923	1923	1923	1923	1923		
Period	1908-1961						1904-1940					
Yellowstone Park	0.24	0.36	0.39	0.51	0.63	0.74	0.80		1.60	2.34		
Month, Day	7/16	7/16	7/16	8/14	8/14	8/14	8/14		10/14	10/14		
Year	1935	1935	1935	1915	1915	1915	1915		1908	1908		
Period	1904-1940						1904-1940					

* NOTES

- ALABAMA: Mobile: Amounts for 1891-1905 from special observations
- ARIZONA: Tucson: No record 1884-1890, and 1896-1922
- ARKANSAS: Bentonville: 2- to 12-hr. amounts from special observations
Fort Smith: 5-min. amount also on 6/8/51
- CALIFORNIA: Burbank: 5- and 10-min. amounts also on 2/11/59
Eureka: 5-min. amount also on 9/9/52 and 12/6/52
Mt. Shasta: 5- to 60-min. amounts partly estimated
Mt. Tamalpais: 3-hr. amount also on 2/19/17
Sacramento: 6.35 in. in 16 hr. on 4/21/80
San Francisco AP: 30-min. amount also on 3/20/58
- COLORADO: Grand Junction: 2-hr. amount also on 9/2/38
Wagon Wheel Gap: 5-min. amount also on 7/17/14 and 7/29/17
- CONNECTICUT: Bridgeport: 5-min. amount also on 8/29/59
- FLORIDA: Daytona Beach: 10-min. amount also on 8/26/61
Jupiter: 24-hr. amount partly estimated
Orlando: 10-min. amount adjusted to be at least 1/2 of the 20-min. amount for the same date
- GEORGIA: Savannah: 15-min. amount also on 6/17/46
- HAWAII: Honolulu: 5-min. amount also on 4/21/24
- ILLINOIS: Chicago: 30-min. amount of 2.03 in. at Chicago University on 7/7/21
Moline: No record 1936-37
- IOWA: Des Moines: Station journal states 6/24/79: "2.50 in. fell in 20 minutes, from 3:10 p.m. to 3:30 p.m."
Sioux City: 15-min. amount also on 6/13/30
- KANSAS: Dodge City: 2-, 3- and 6-hr. amounts partly estimated
Goodland: 5-min. amount also on 7/11/51
- LOUISIANA: Baton Rouge: 5-min. amount also on 4/21/59 and 2/17/61
- MASSACHUSETTS: Pittsfield: 10-min. amount also on 6/5/60
- MICHIGAN: Detroit Willow Run AP: 10-min. amount also on 9/1/61
Grand Rapids: 10-min. amount also on 6/26/09 and 15-min. amount also on 8/30/47
Houghton: 3-hr. amount also on 7/3/29
Muskegon: 10-min. amount also on 8/20/58
Sault Ste. Marie: 5-min. amount also on 9/23/59 and 15-min. amount also on 8/22/42
- MISSISSIPPI: Jackson: 15-min. amount also on 7/1/59
- MISSOURI: St. Joseph: 5-min. amount also on 10/29/61
- NEBRASKA: Grand Island: 5-, 10- and 15-min. amounts partly estimated
North Platte: 5-min. amount also on 7/5/49
- NEVADA: Elko: 5-min. amount also on 7/5/49
Reno: 10-min. amount also on 8/2/12
Tonopah: 5-min. amount also on 9/22/18, 5/28/19, and 9/12/23. 12-hr. amount also on 8/23/55
Winnemucca: 10-min. amount also on 6/16/23
- NEW MEXICO: Albuquerque: 5-min. amount also on 10/19/57
- NEW YORK: Binghamton: 30-min. to 3-hr. amounts interpolated. 6-hr. amount also on 6/17/60
Oswego: 30-min. amount also on 6/11/11
- OKLAHOMA: Tulsa: 10-min. amount adjusted to be at least 1/2 of 20-min. amount for the same date
- OREGON: Burns: 10-min. amount also on 8/1/49
Portland: 4.36 in. in 13 hours, 7 a.m. to 8 p.m., 12/13/82
- PENNSYLVANIA: Allentown: 5-min. amount also on 5/23/55 and 6/12/55
- PUERTO RICO: San Juan AP: 30-min. amount also on 5/29/60

Table 6
MAXIMUM RECORDED U.S. POINT RAINFALL (INCHES)

* NOTES (cont.)

RHODE ISLAND:	Providence: Airport station recorded 5.92 in. in 12 hours, 8/7/46
SOUTH CAROLINA:	Columbia: 5-min. amount also on 8/19/04
	Spartanburg: 5-min. amount also on 4/6/56. 30-min. amount also on 8/5/61
SOUTH DAKOTA:	Huron: 1-hr. amount also on 7/2/58
	Pierre: Breaks in record
TENNESSEE:	Bristol: 5-min. amount also on 6/13/54. 15-min. amount also on 6/23/57
TEXAS:	El Paso: 5-min. to 1-hr. amounts estimated on basis of percentage depth-duration analysis of like 2-hr. amounts
	Midland: 2- and 3-hr. amounts interpolated
	Taylor: 5- and 10-min. amounts estimated on basis of percentage depth-duration analysis of like 15-min. amounts
	Victoria: 10-min. amount also on 7/18/60. 15-min. amount also on 3/31/57
UTAH:	Salt Lake City: 6-hr. amount also on 1/14/53
WASHINGTON:	Tatoosh Island: 10-min. amount also on 10/9/55
WEST VIRGINIA:	Charleston: 10-minute amount also on 7/19/61
	Elkins: 10-min. amount also on 6/23/07. 15-min. amount also on 8/3/02
WYOMING:	Huntington: 5-min. amount also on 6/18/56 and 7/27/59
	Sheridan: 5- and 15-min. amounts also on 5/20/56

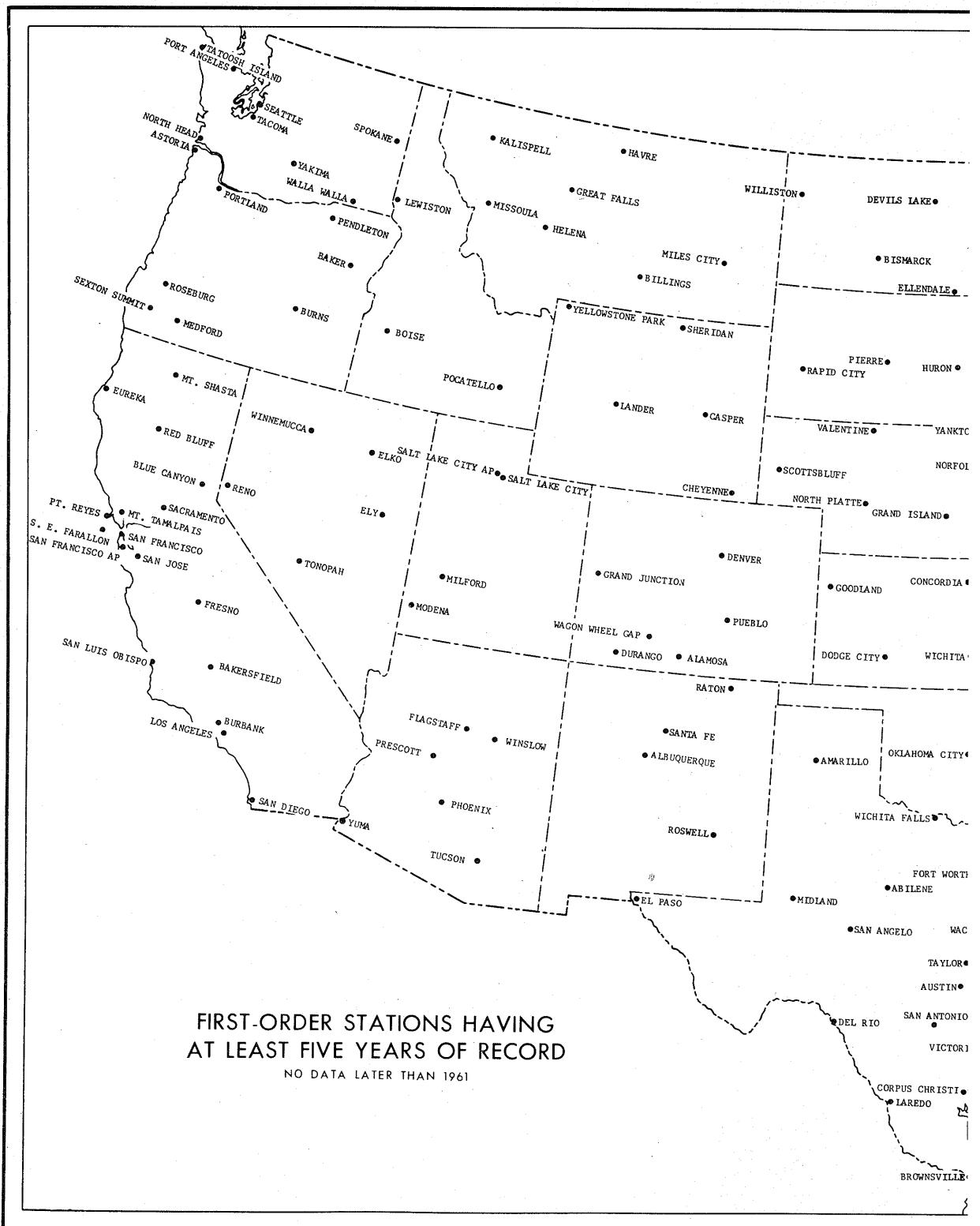


Figure 1

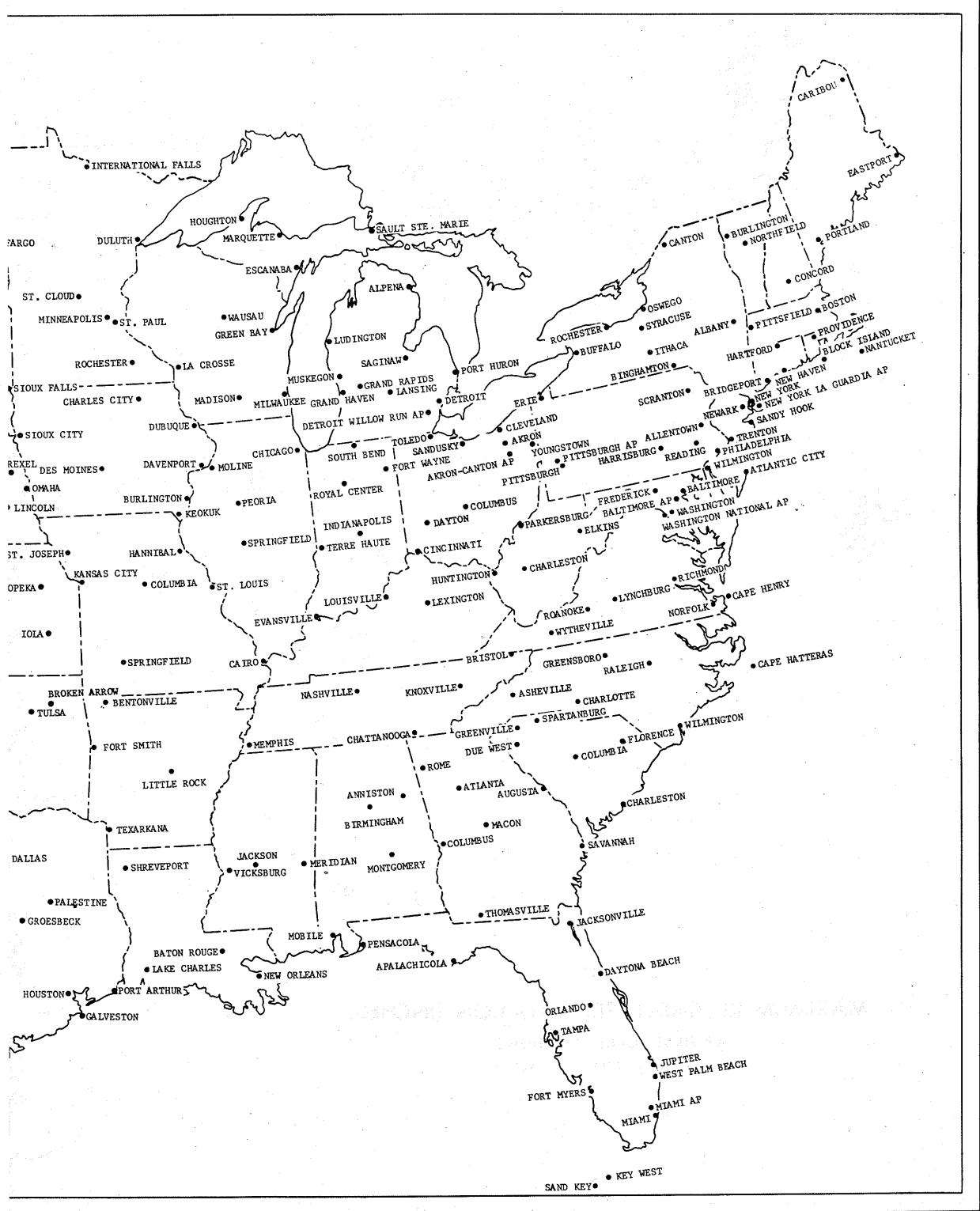


Figure 1

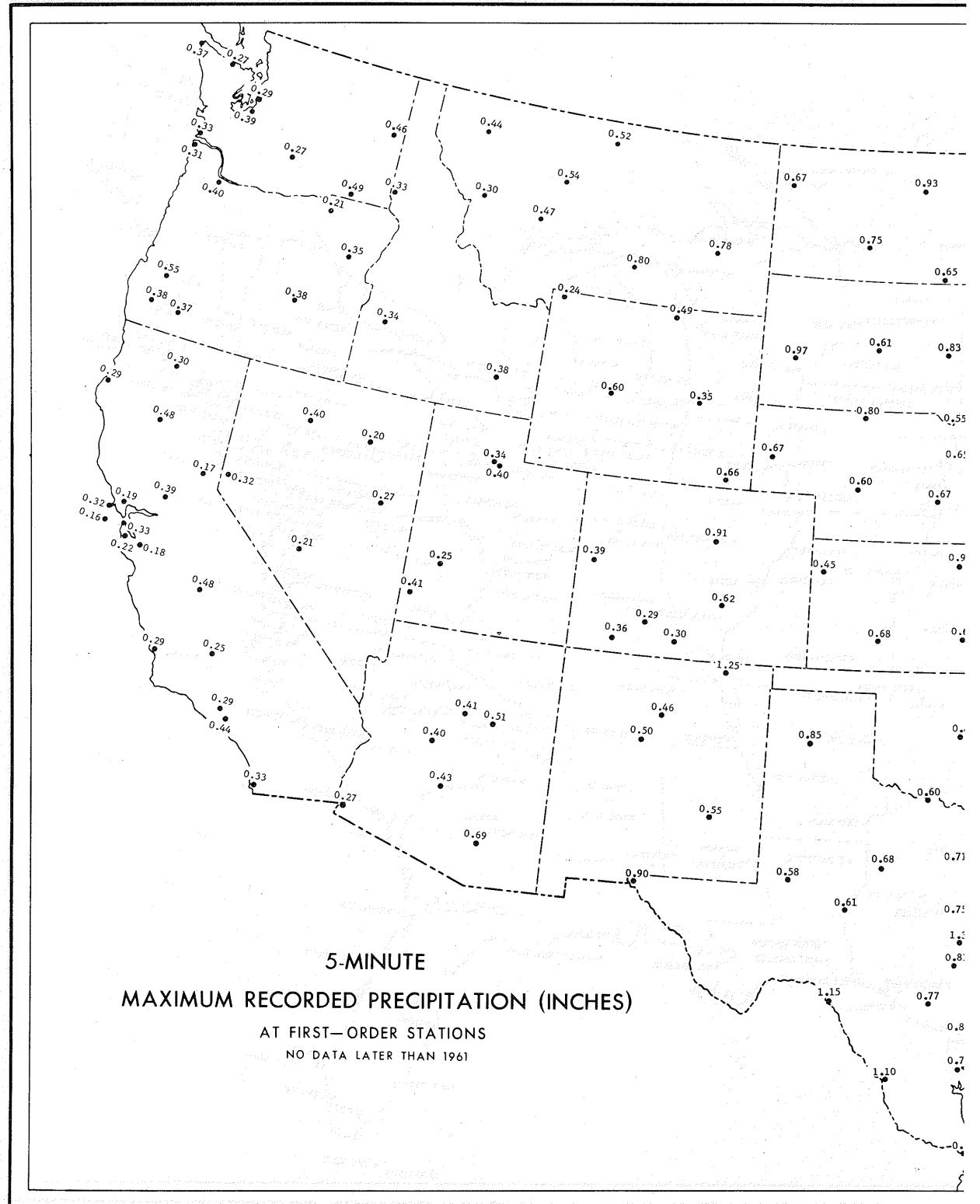


Figure 2

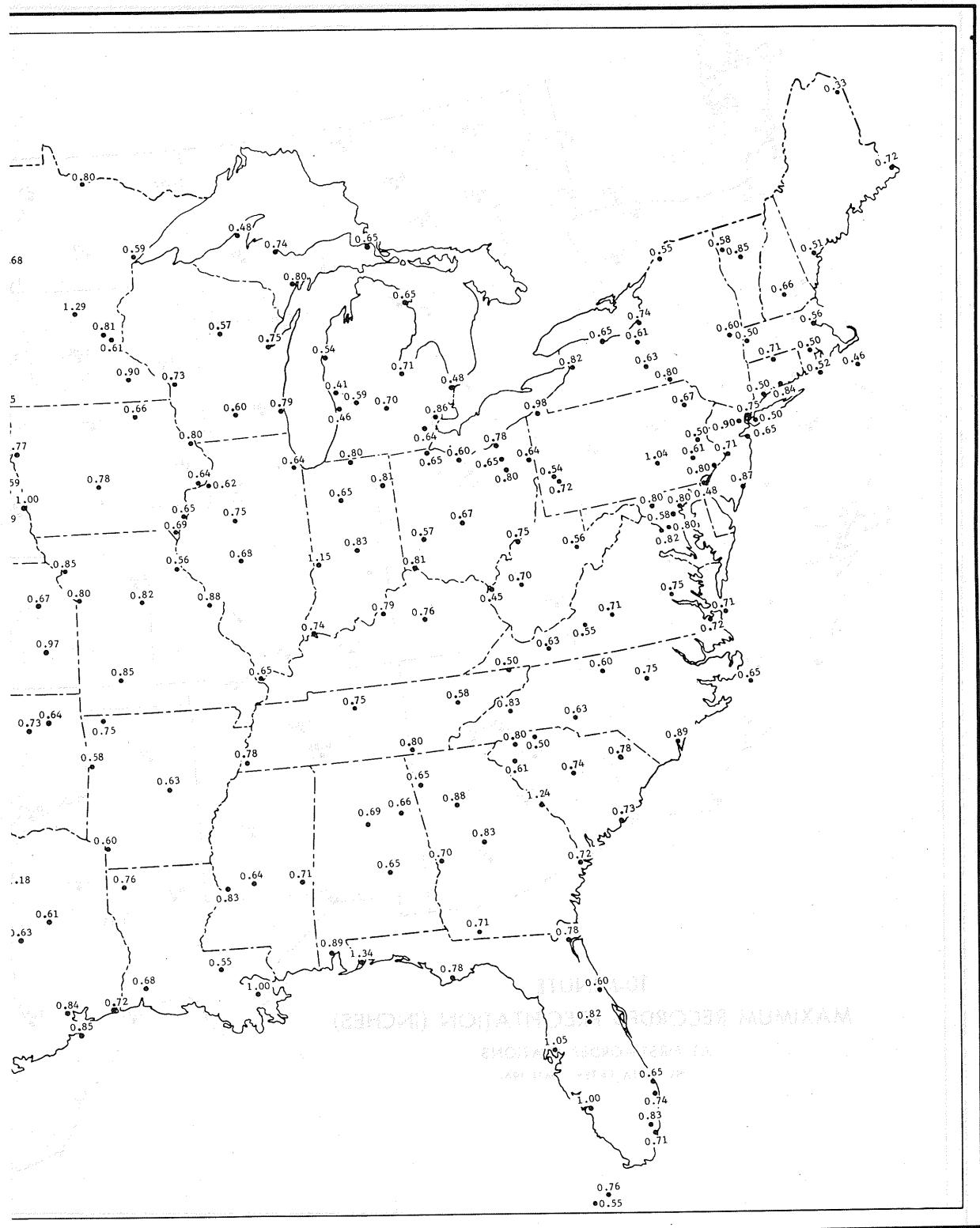


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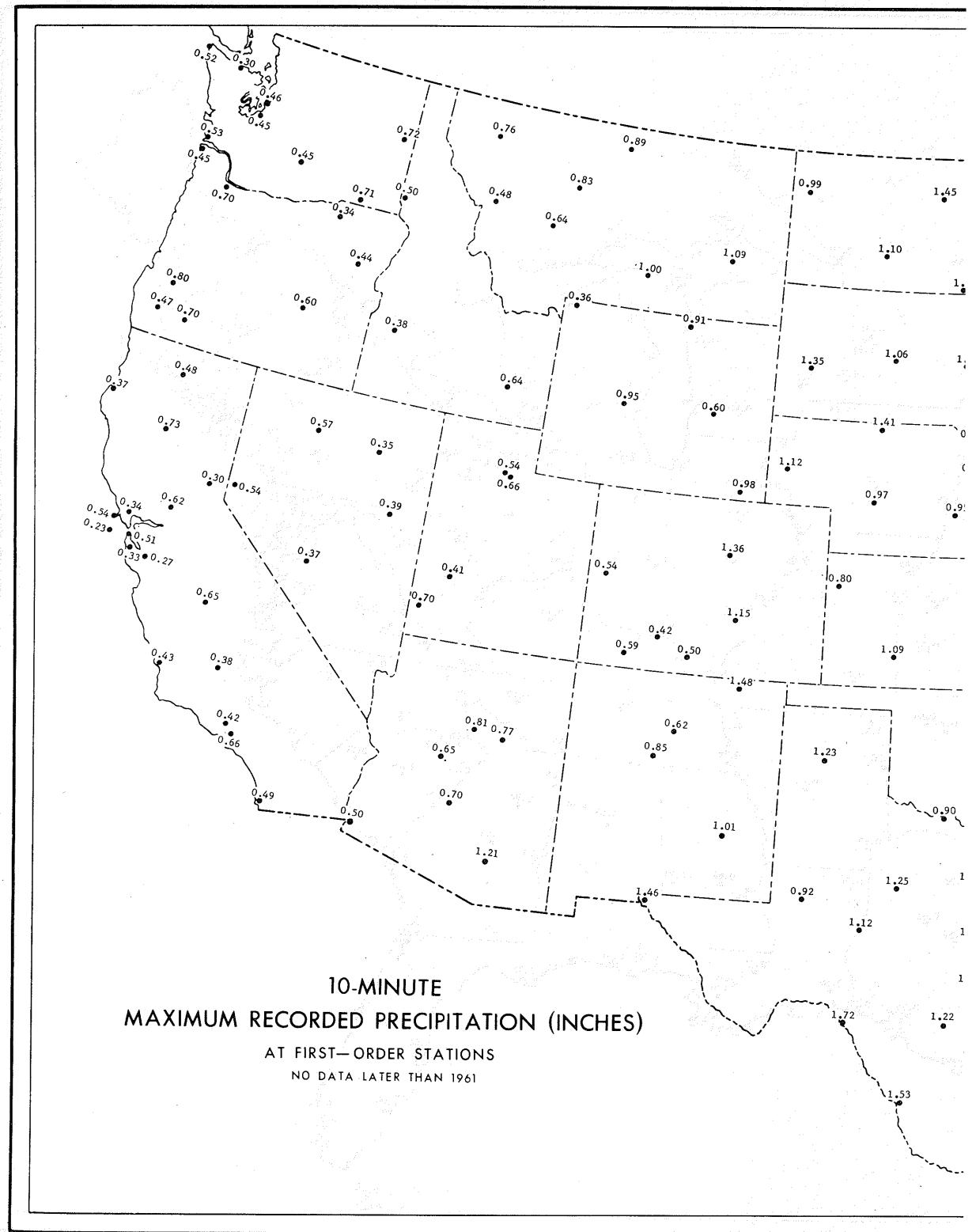


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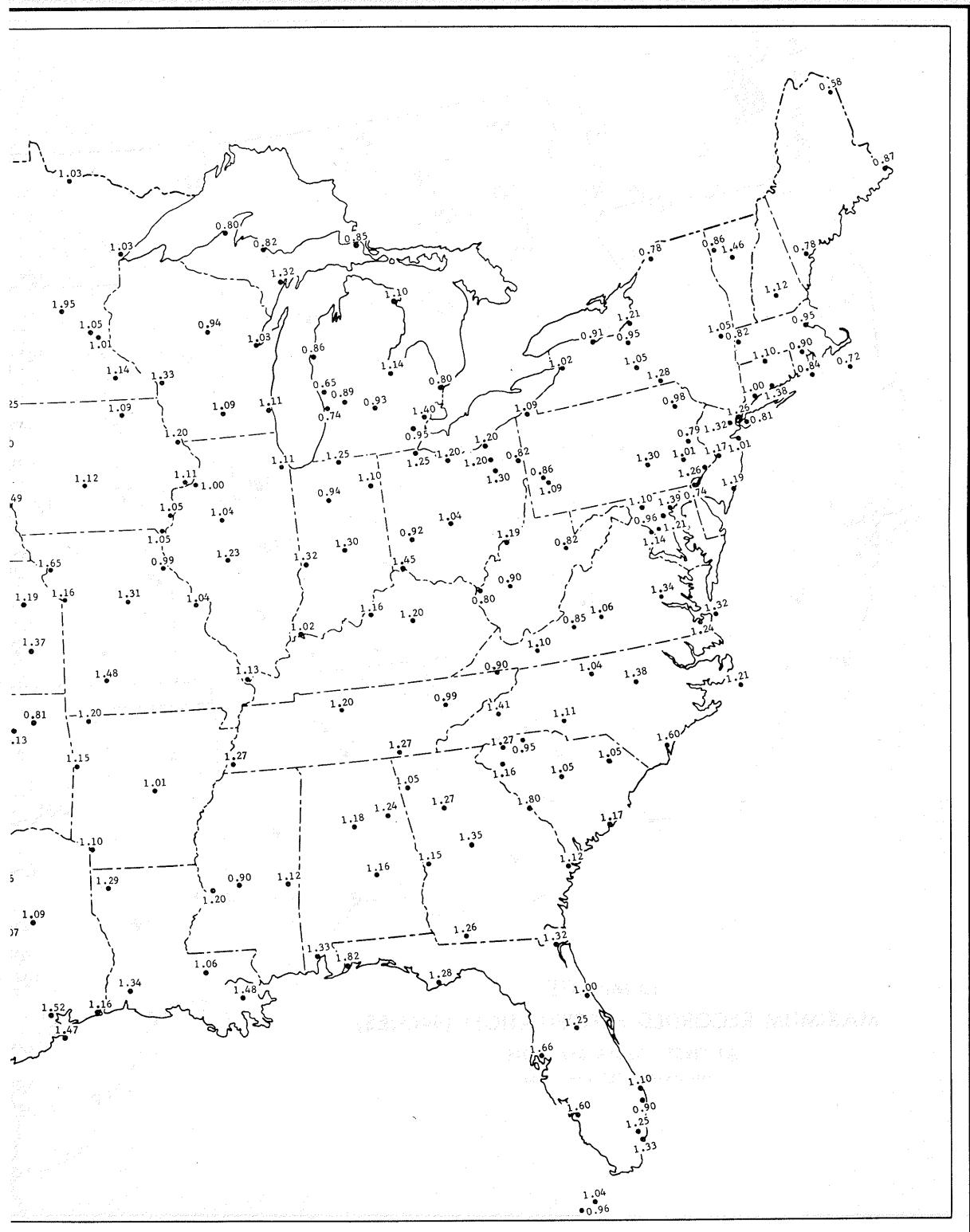


Figure 3

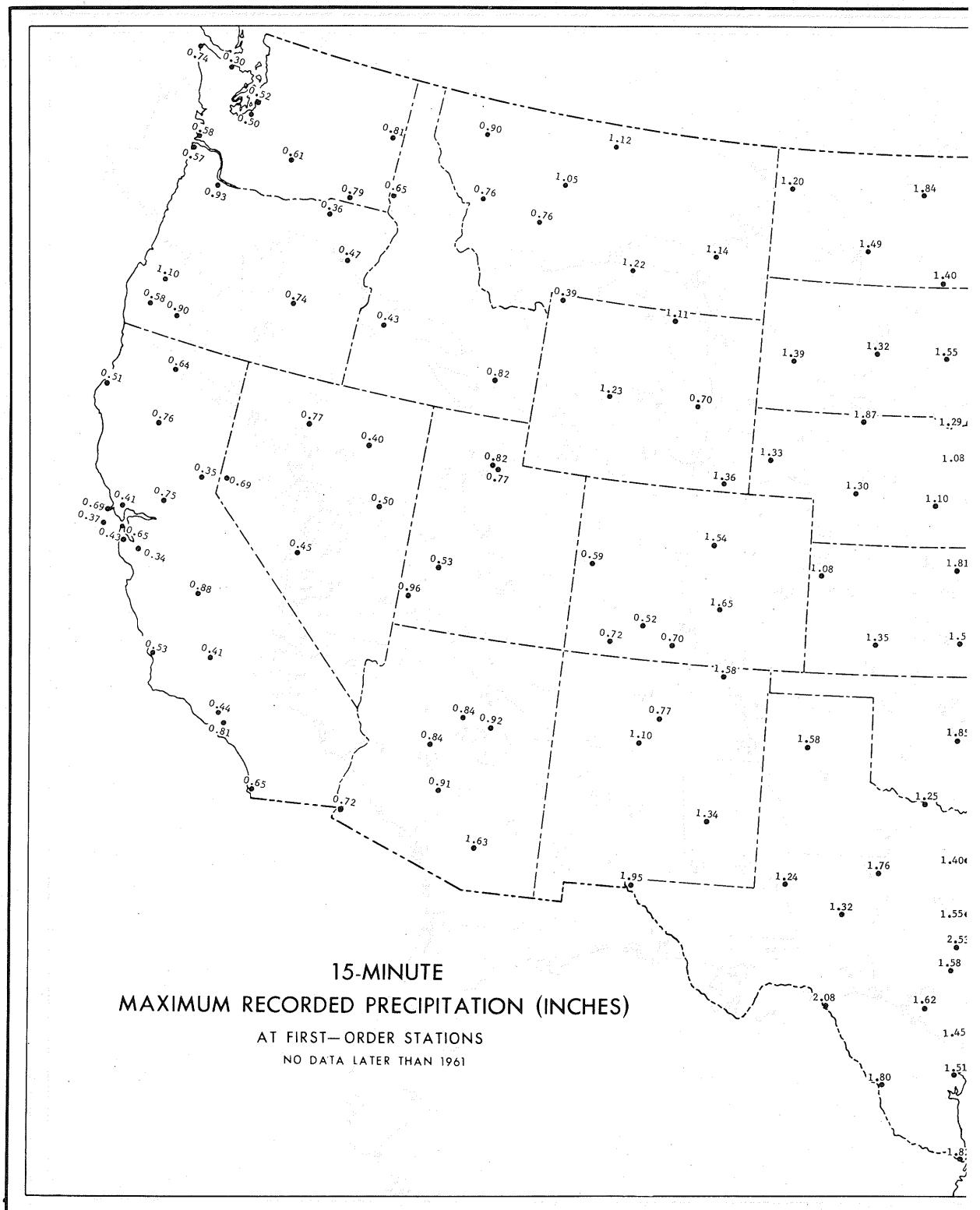


Figure 4

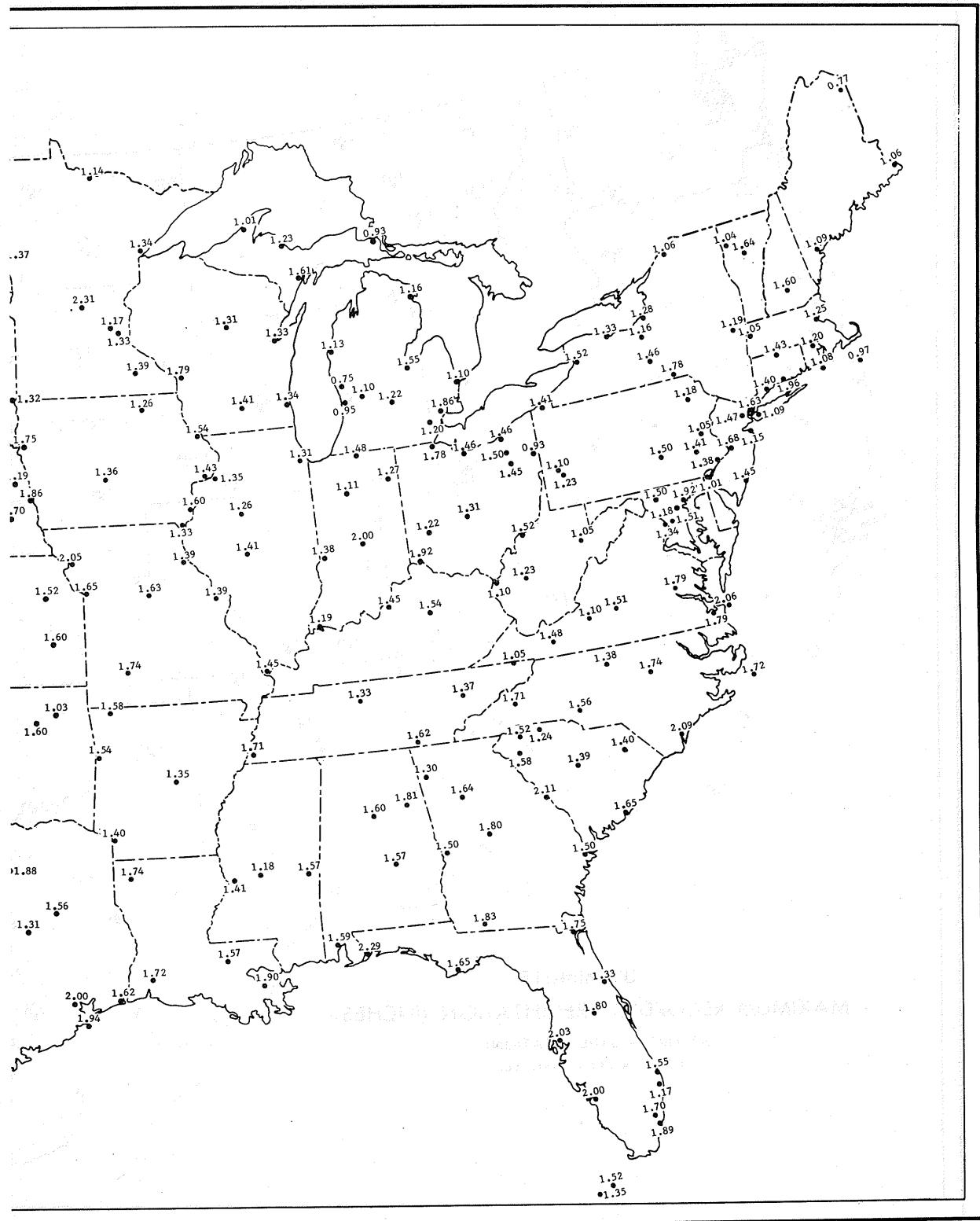


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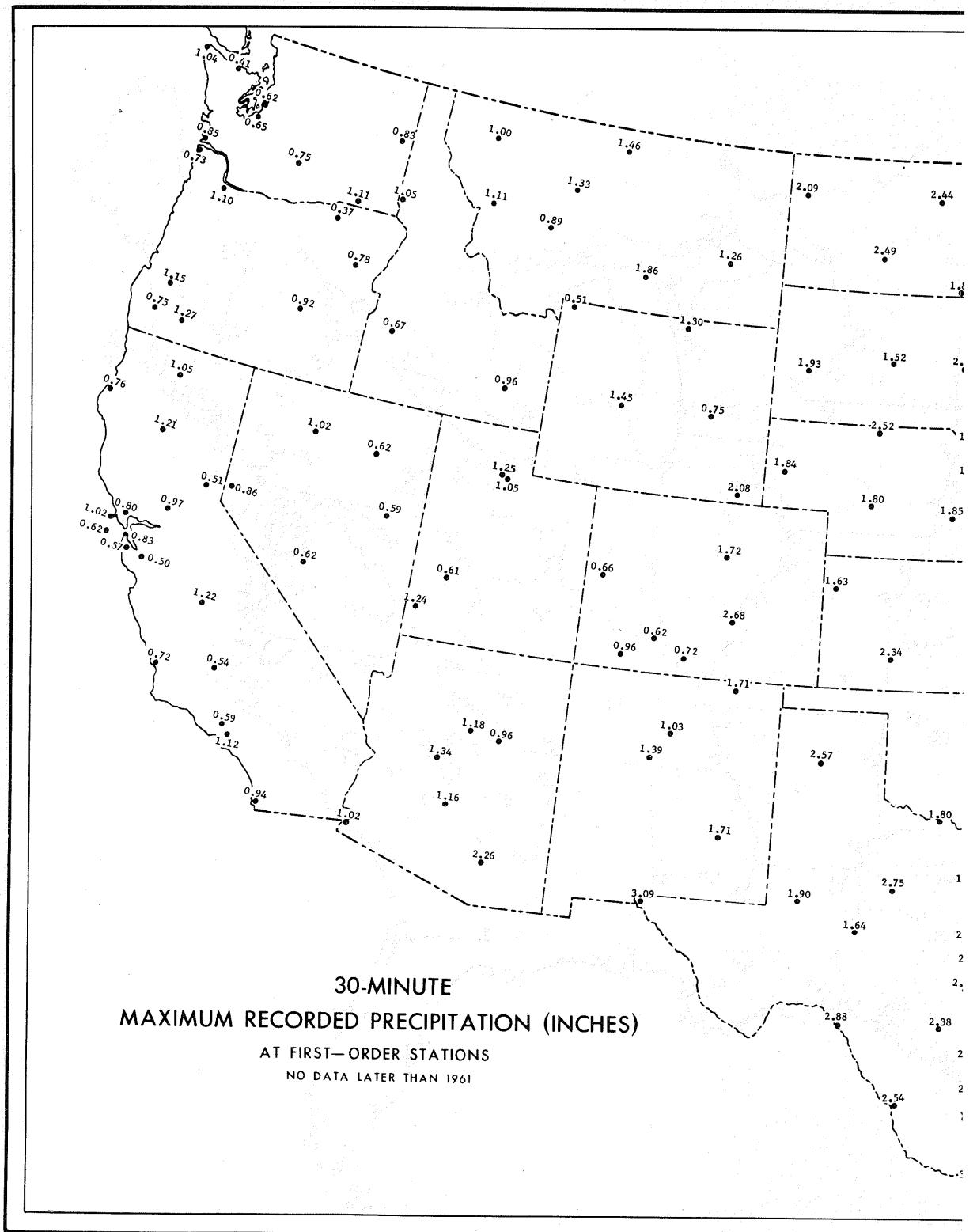


Figure 5

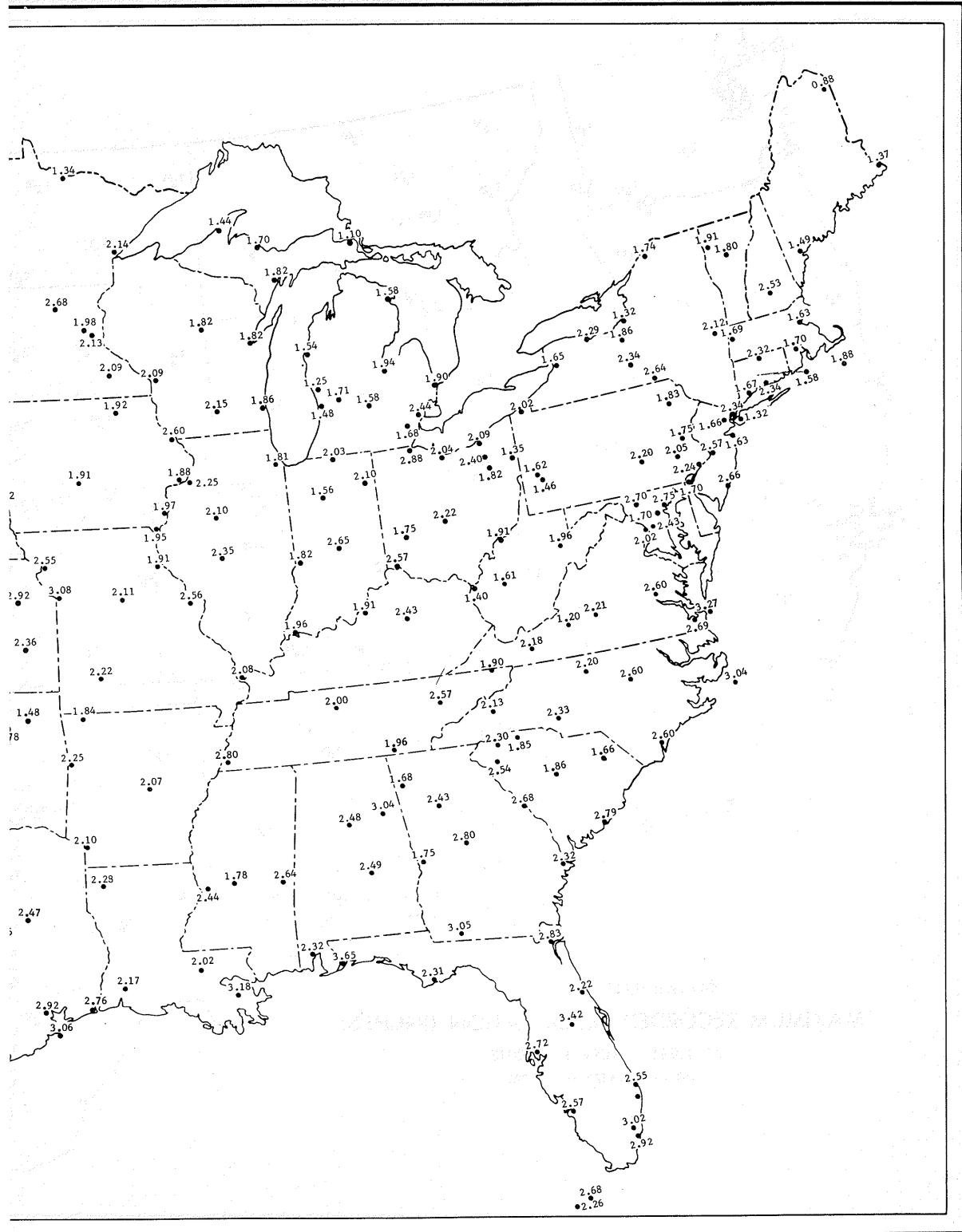


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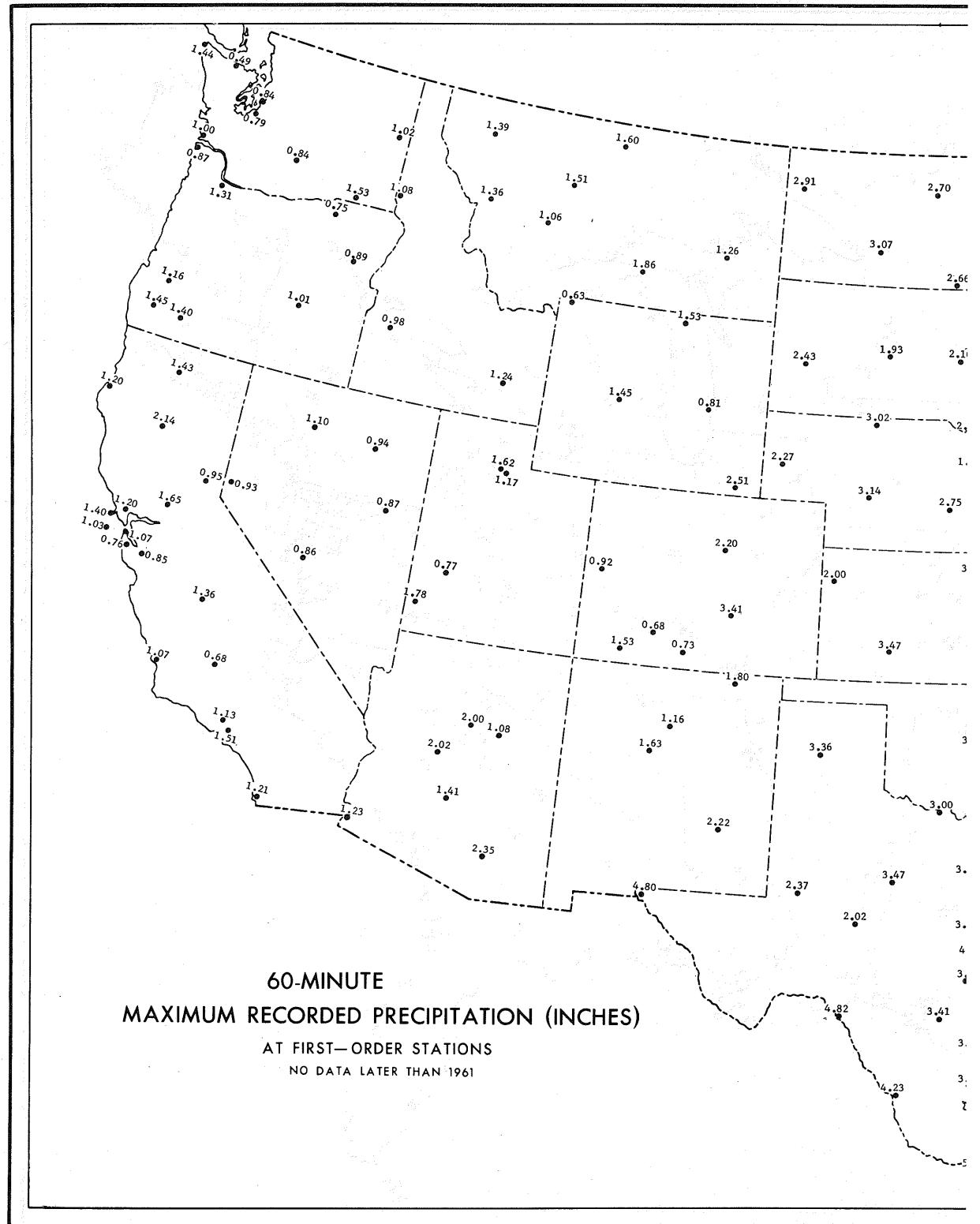


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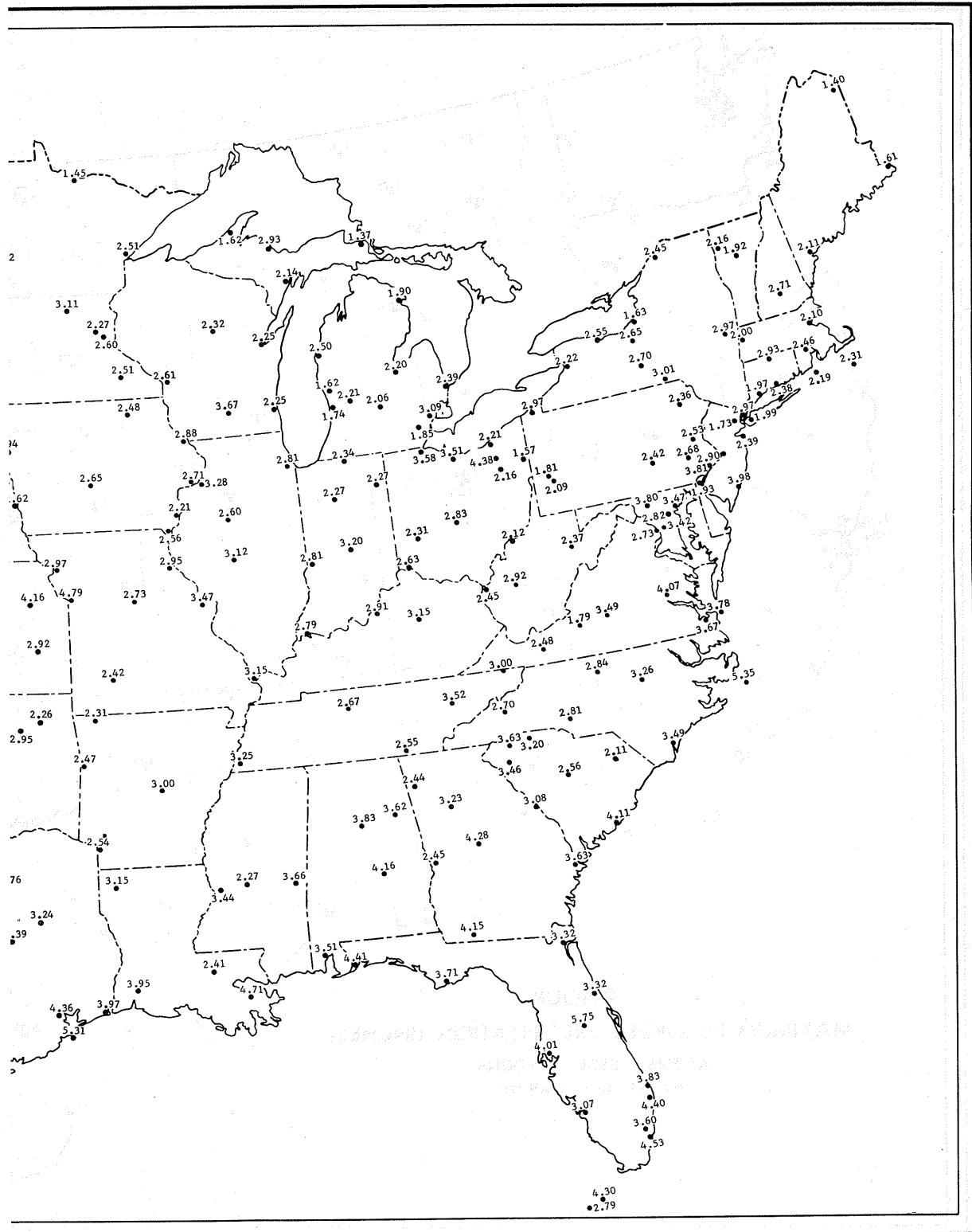


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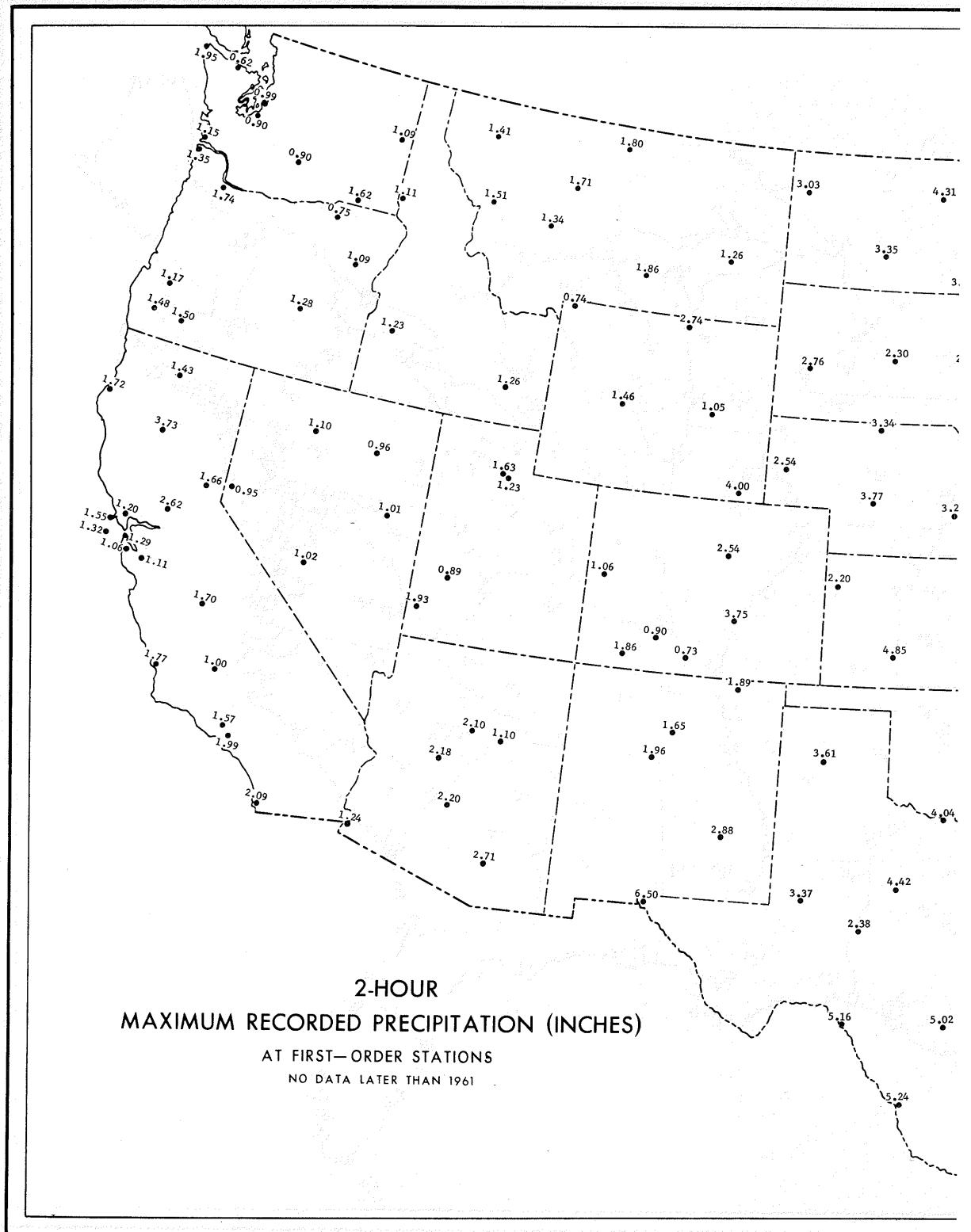


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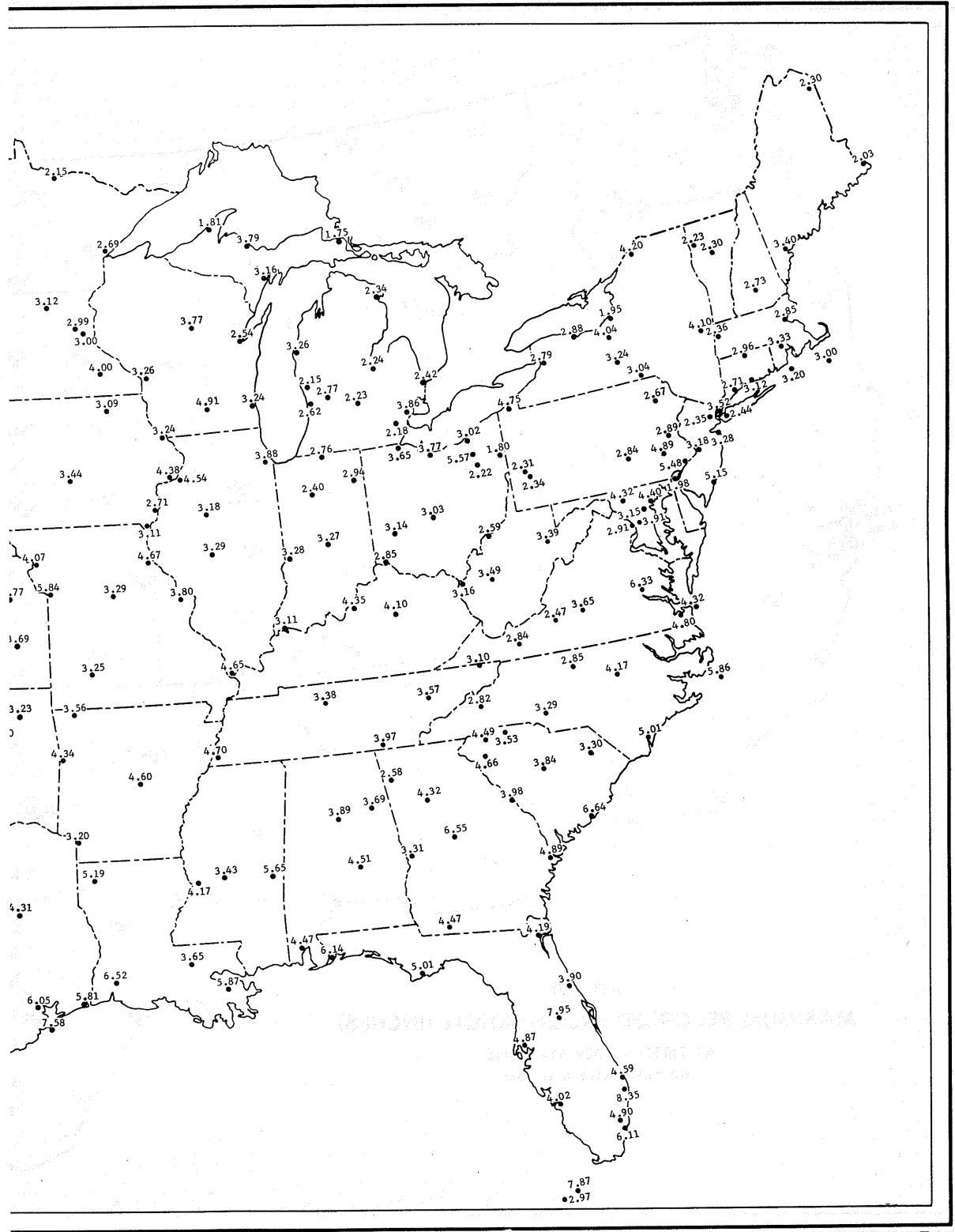


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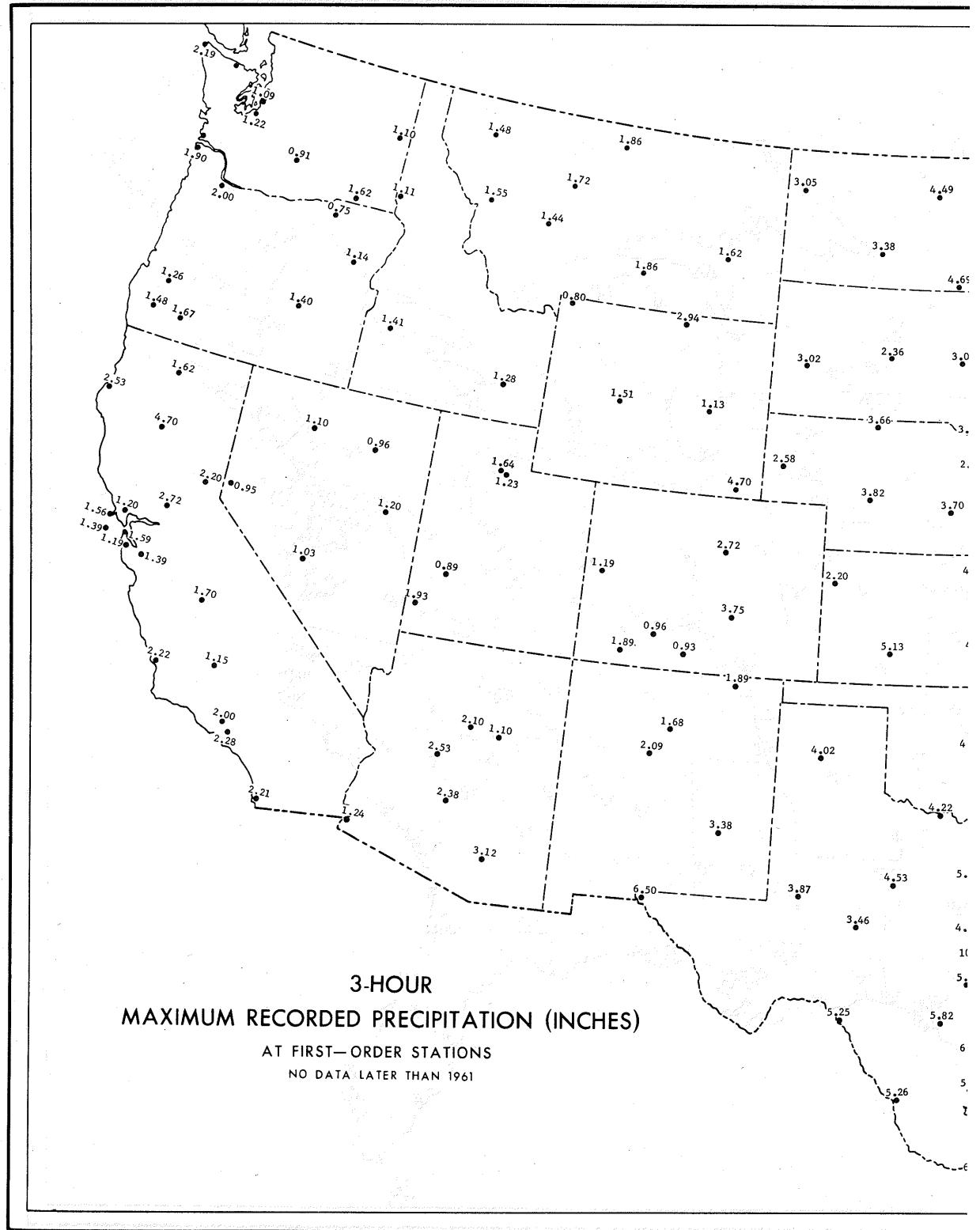


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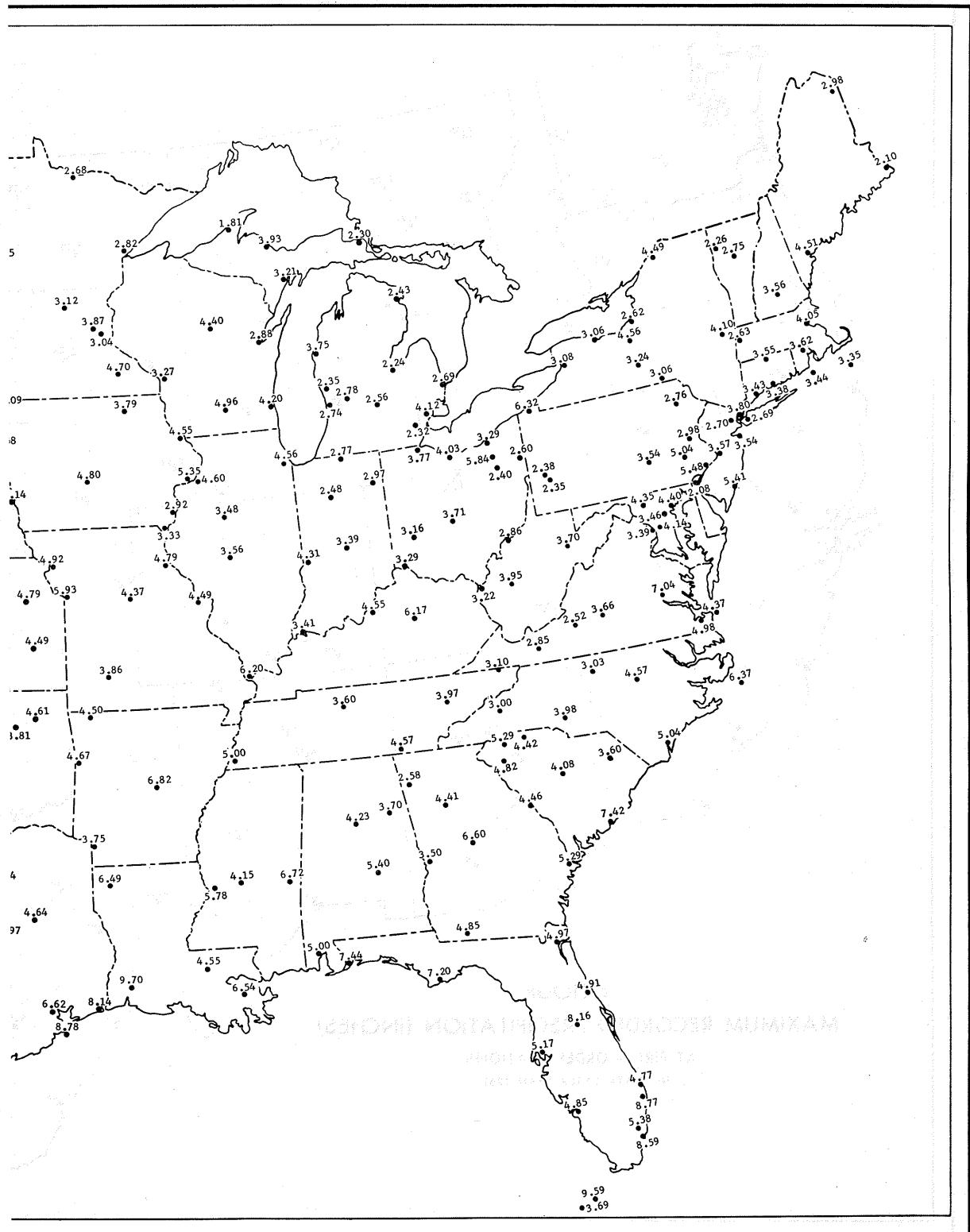


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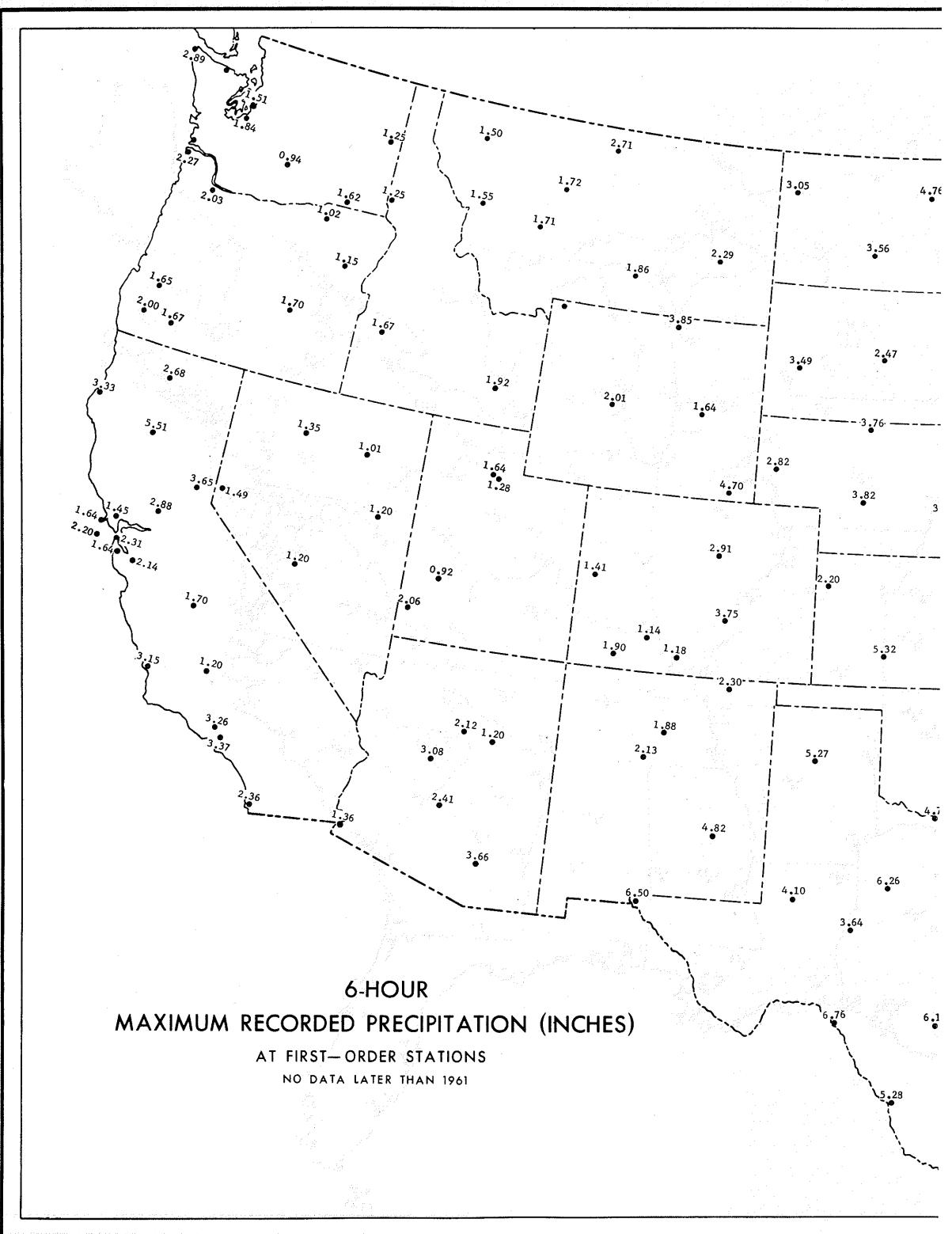


Figure 9

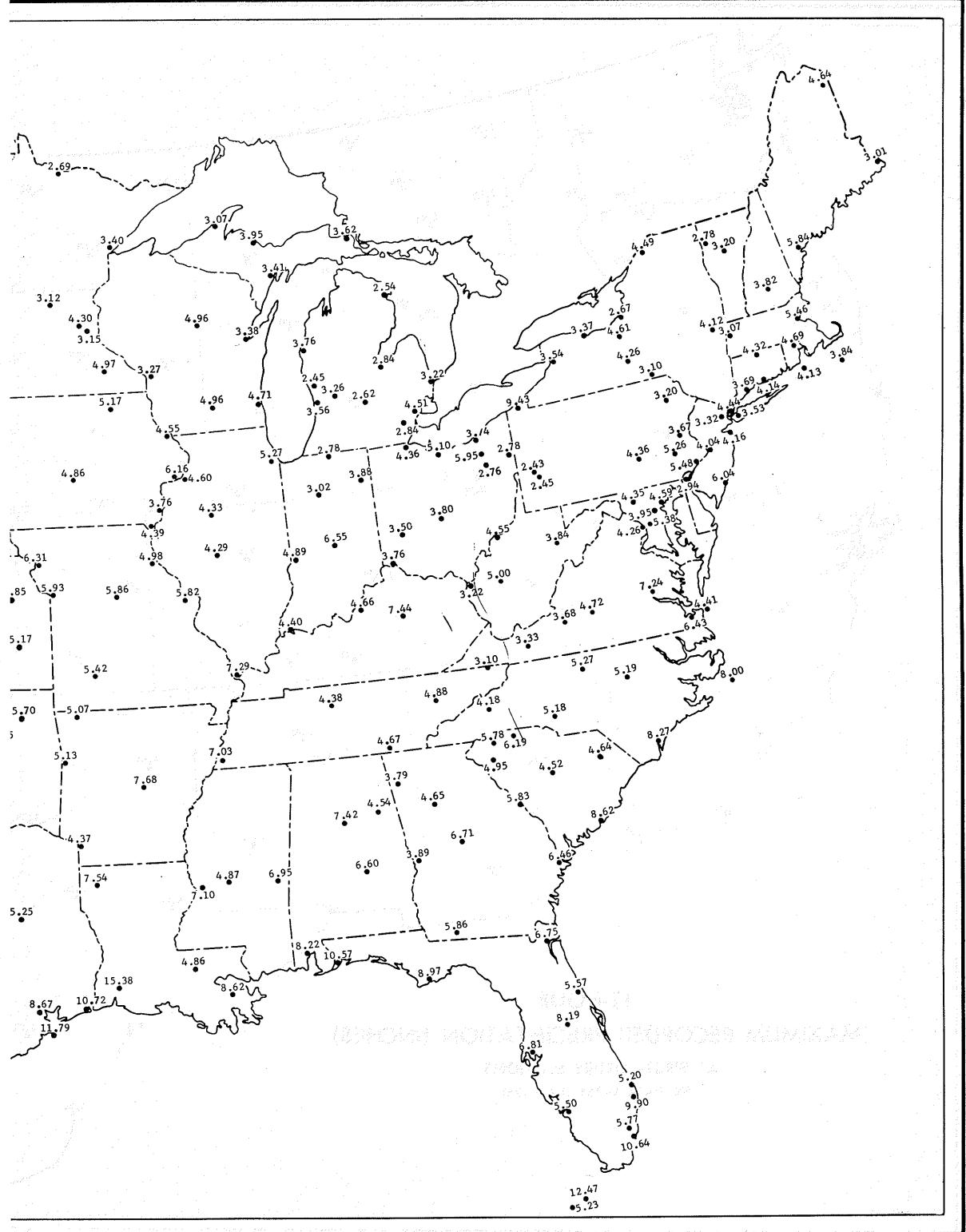


Figure 9

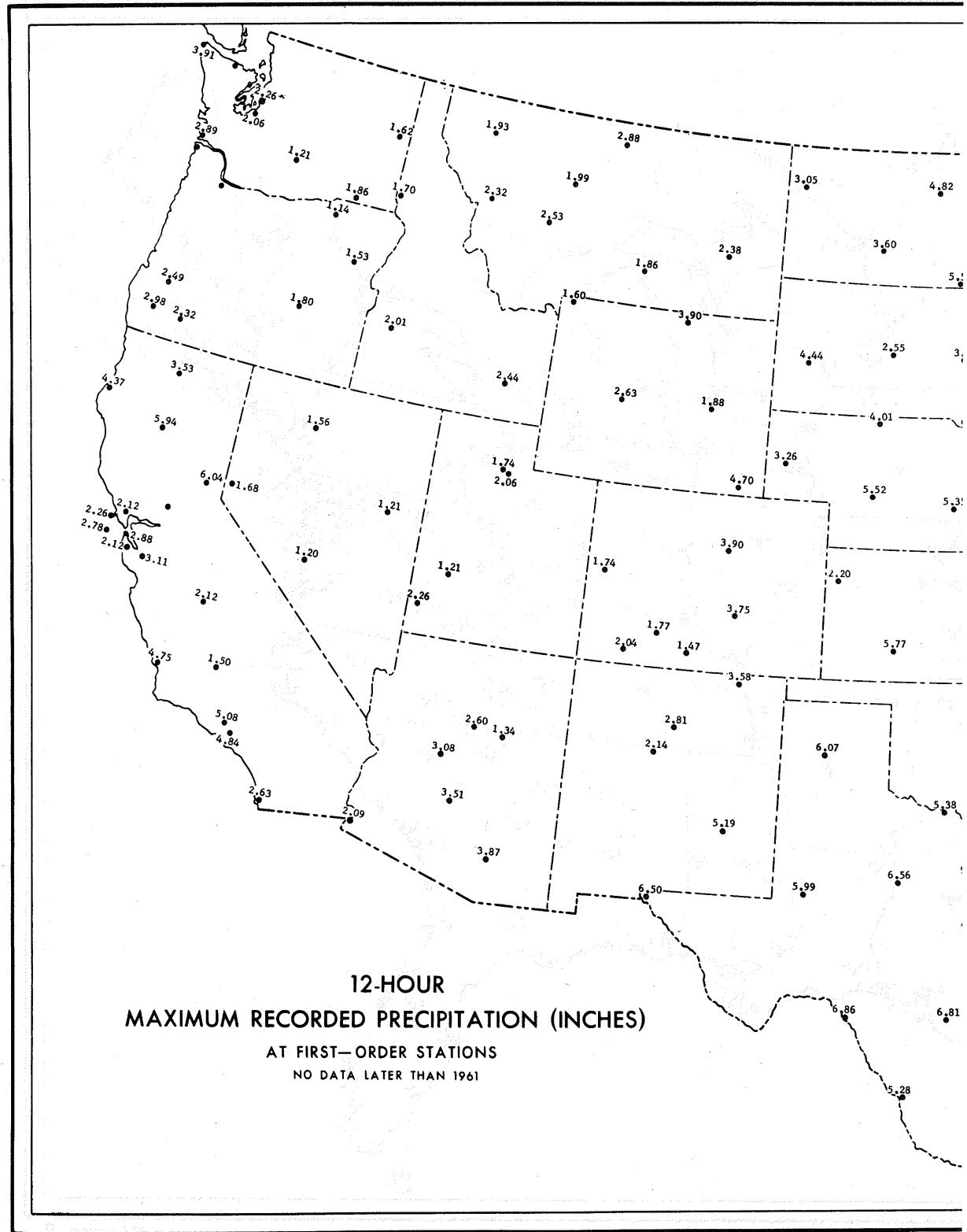


Figure 10

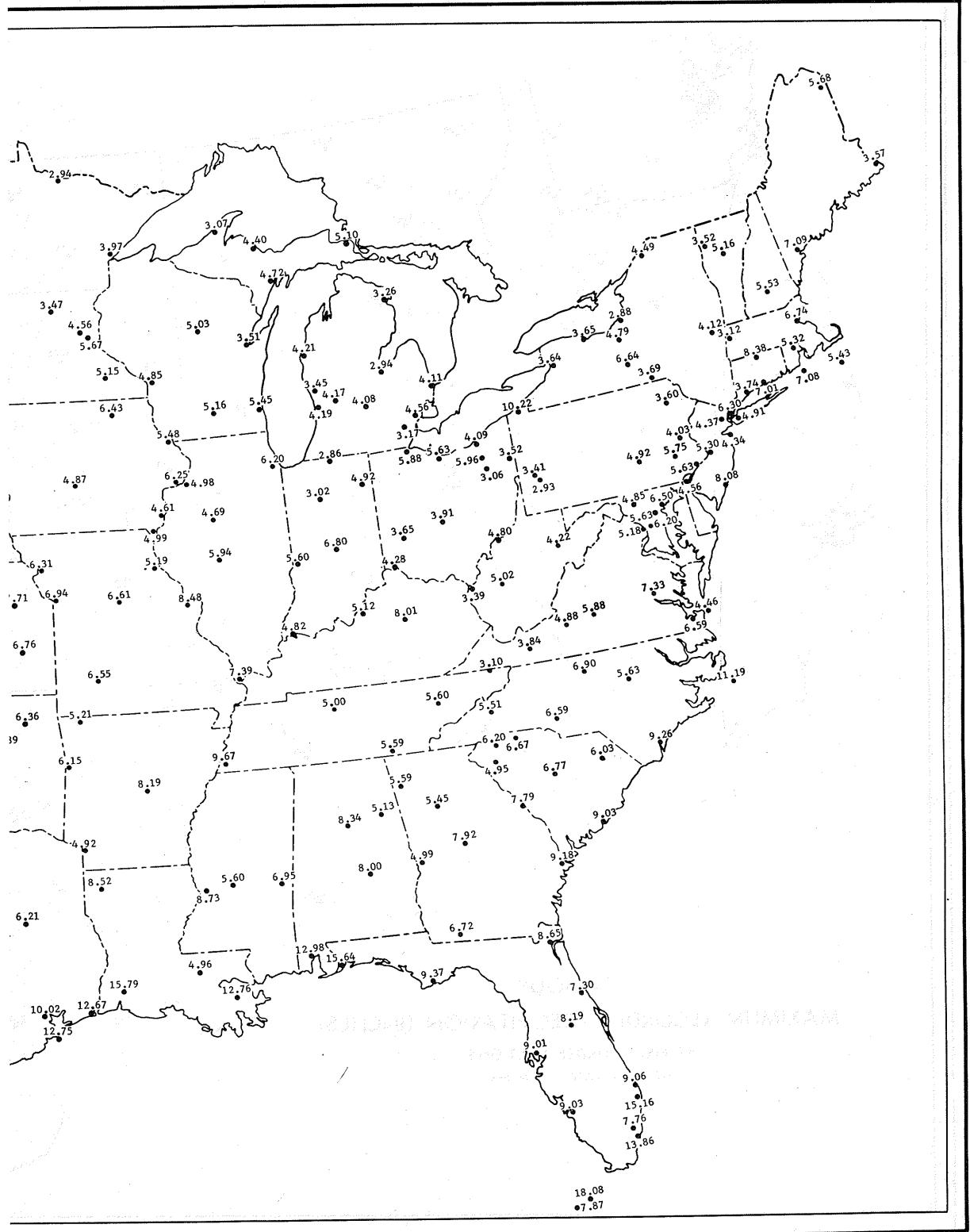


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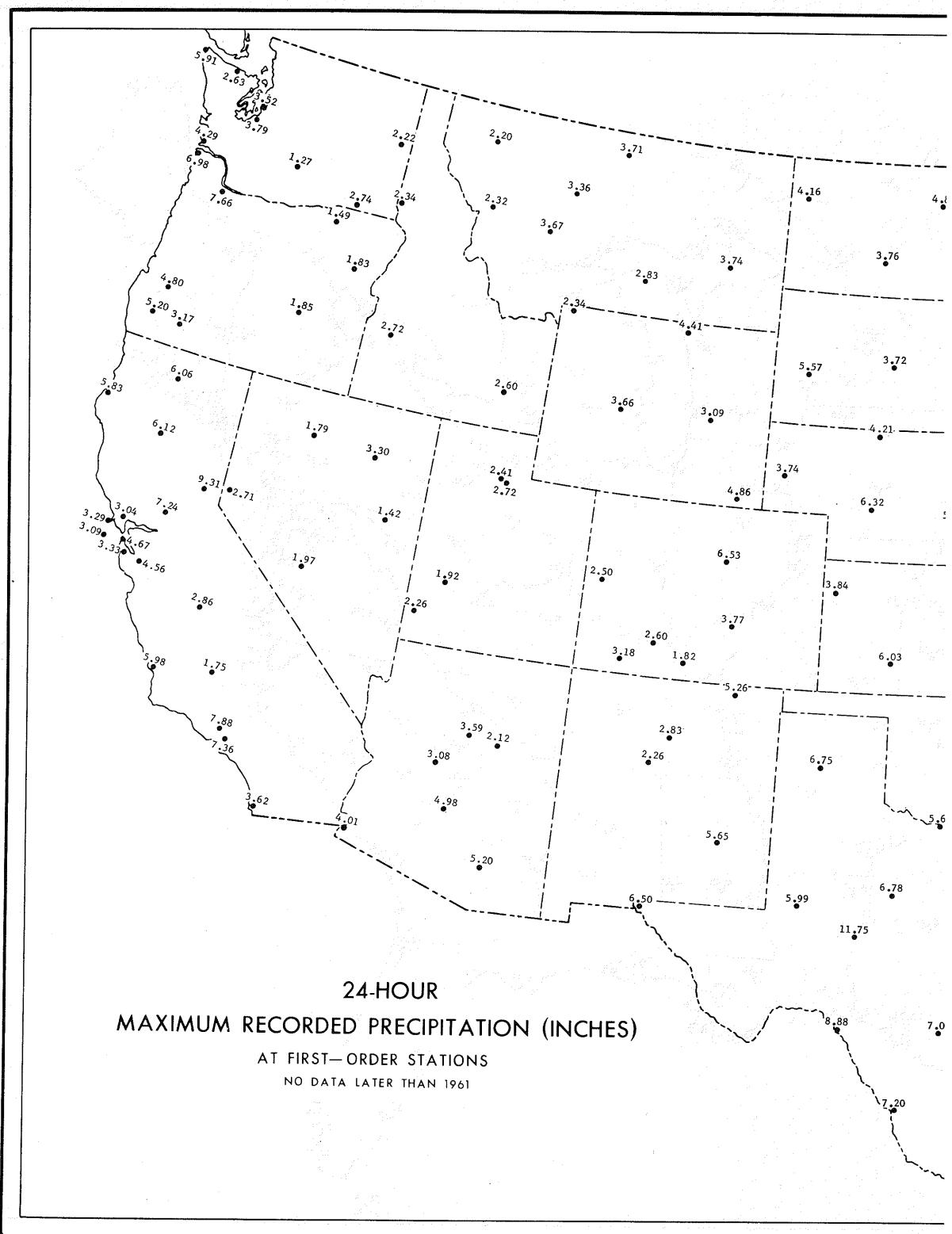


Figure 11

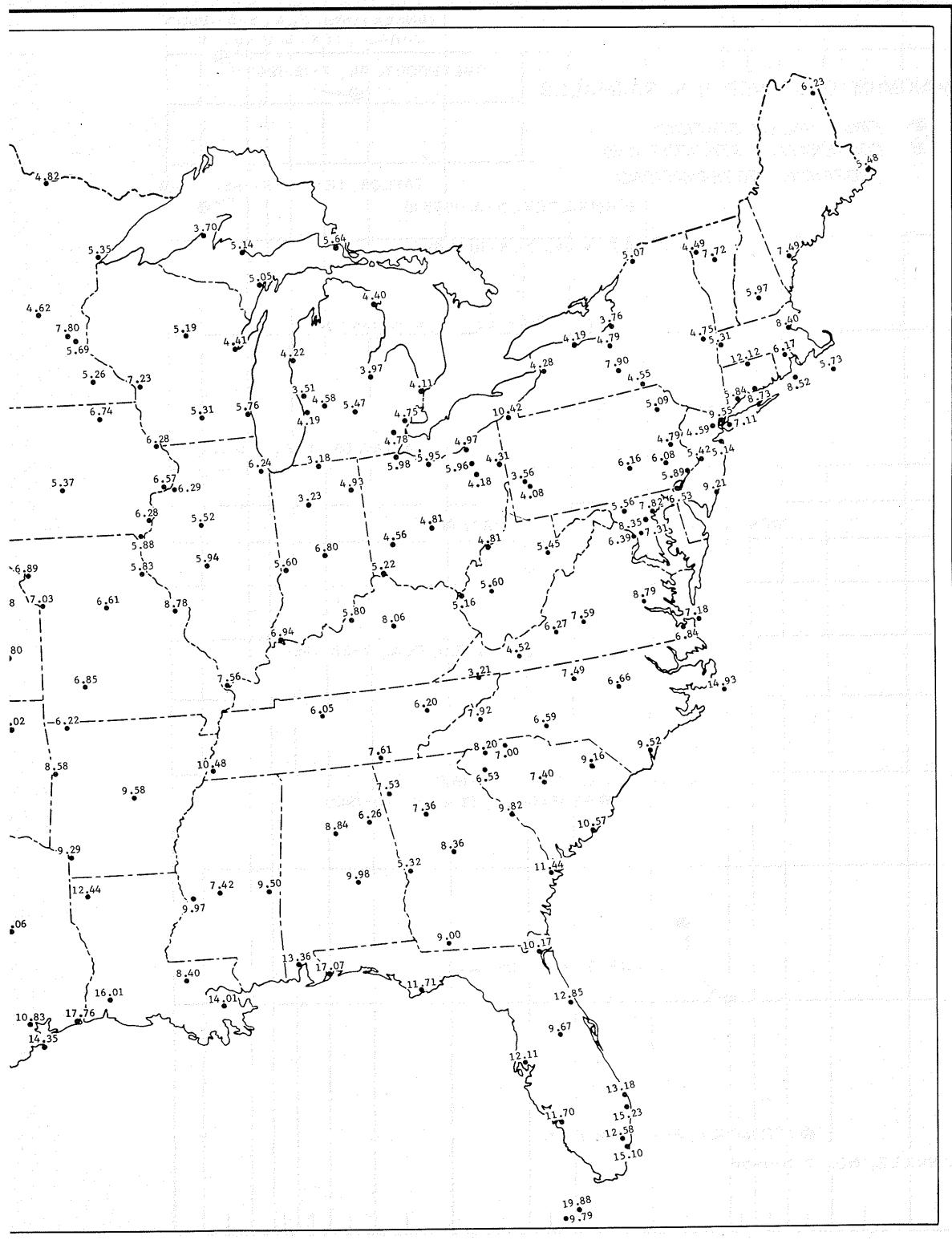


Figure 11

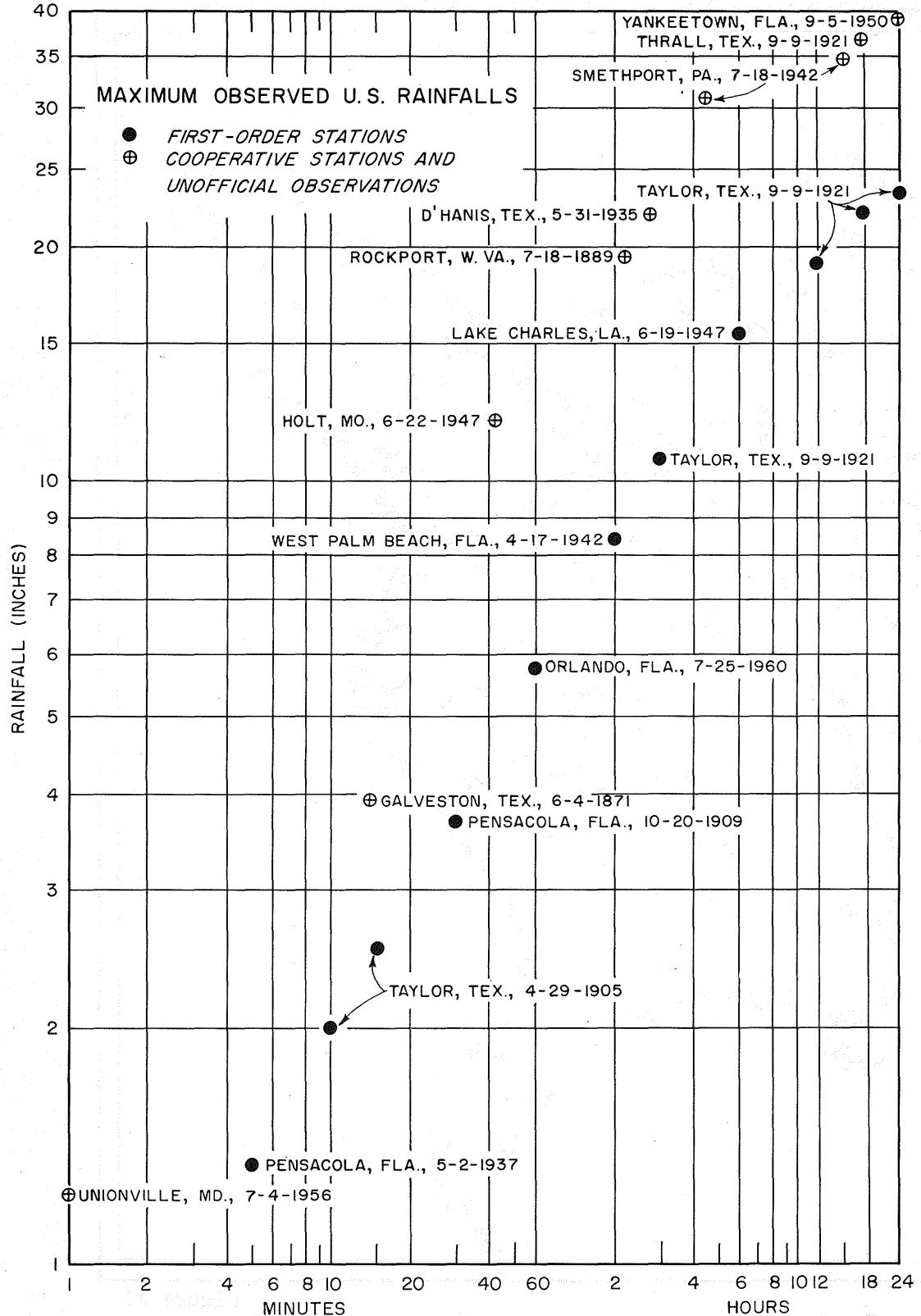


Figure 12.- Maximum observed rainfalls in the United States

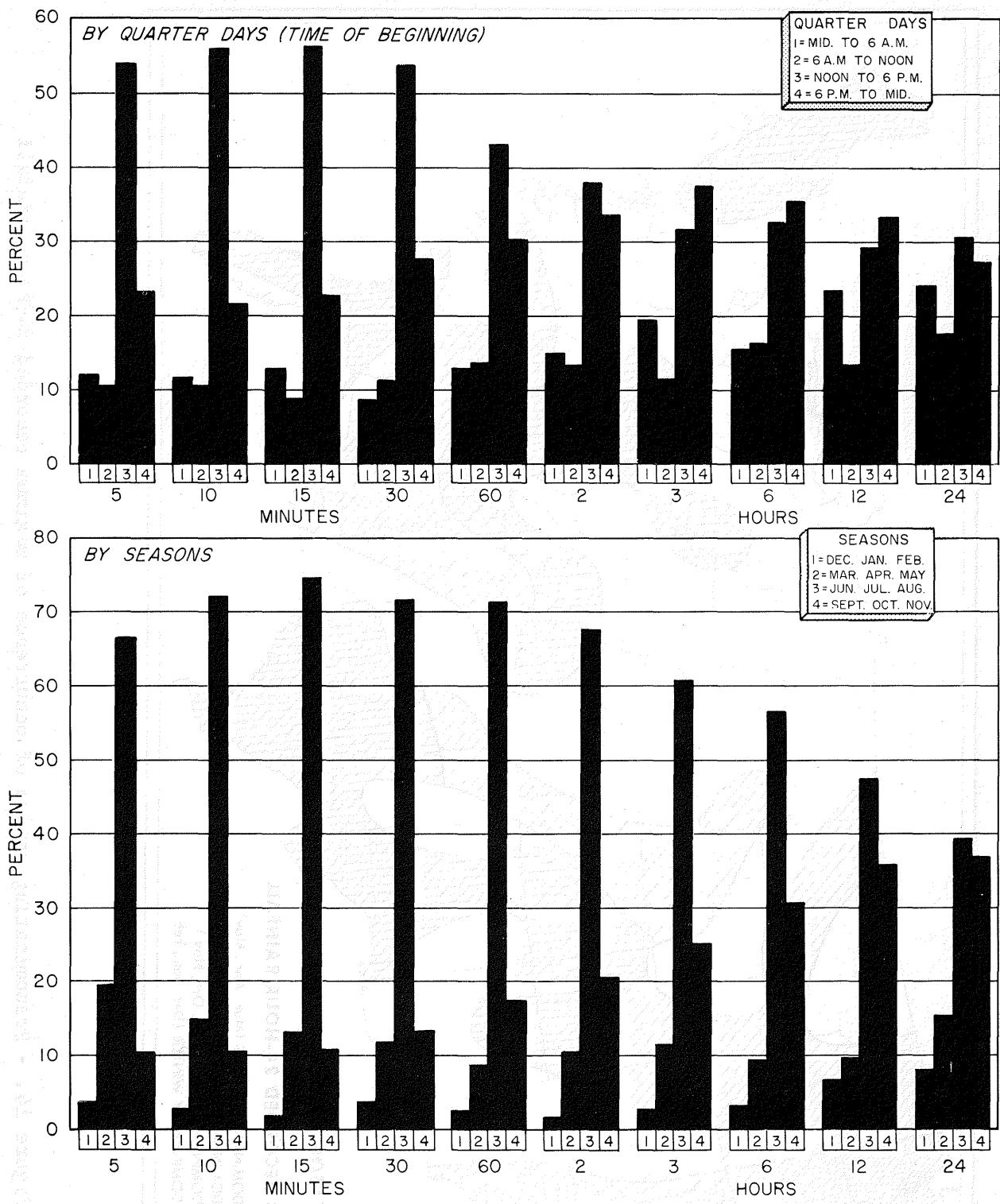


Figure 13. - Daily and seasonal distribution of maximum rainfall occurrences

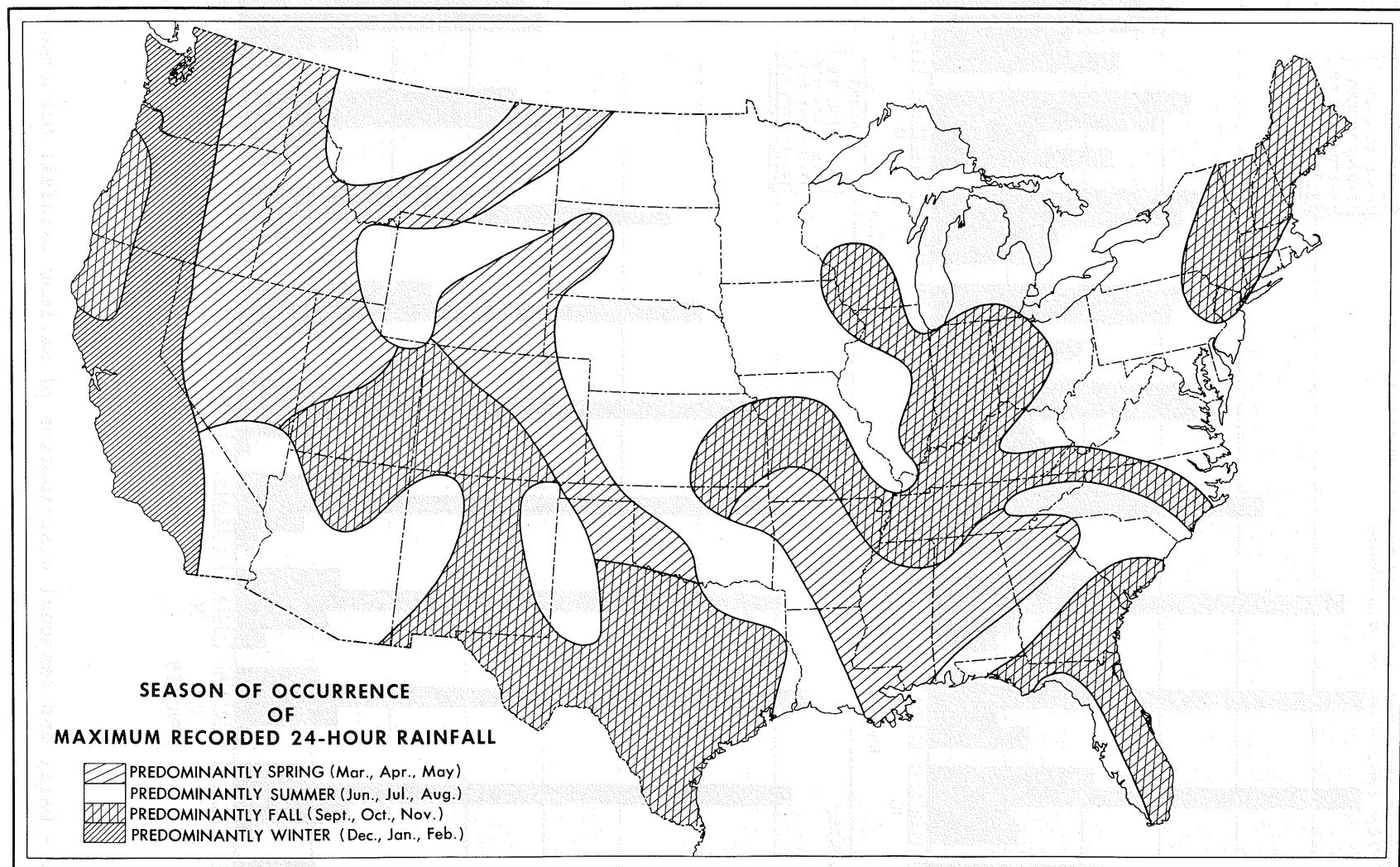


Figure 14. - Predominating season of occurrence of maximum recorded 24-hour rainfall

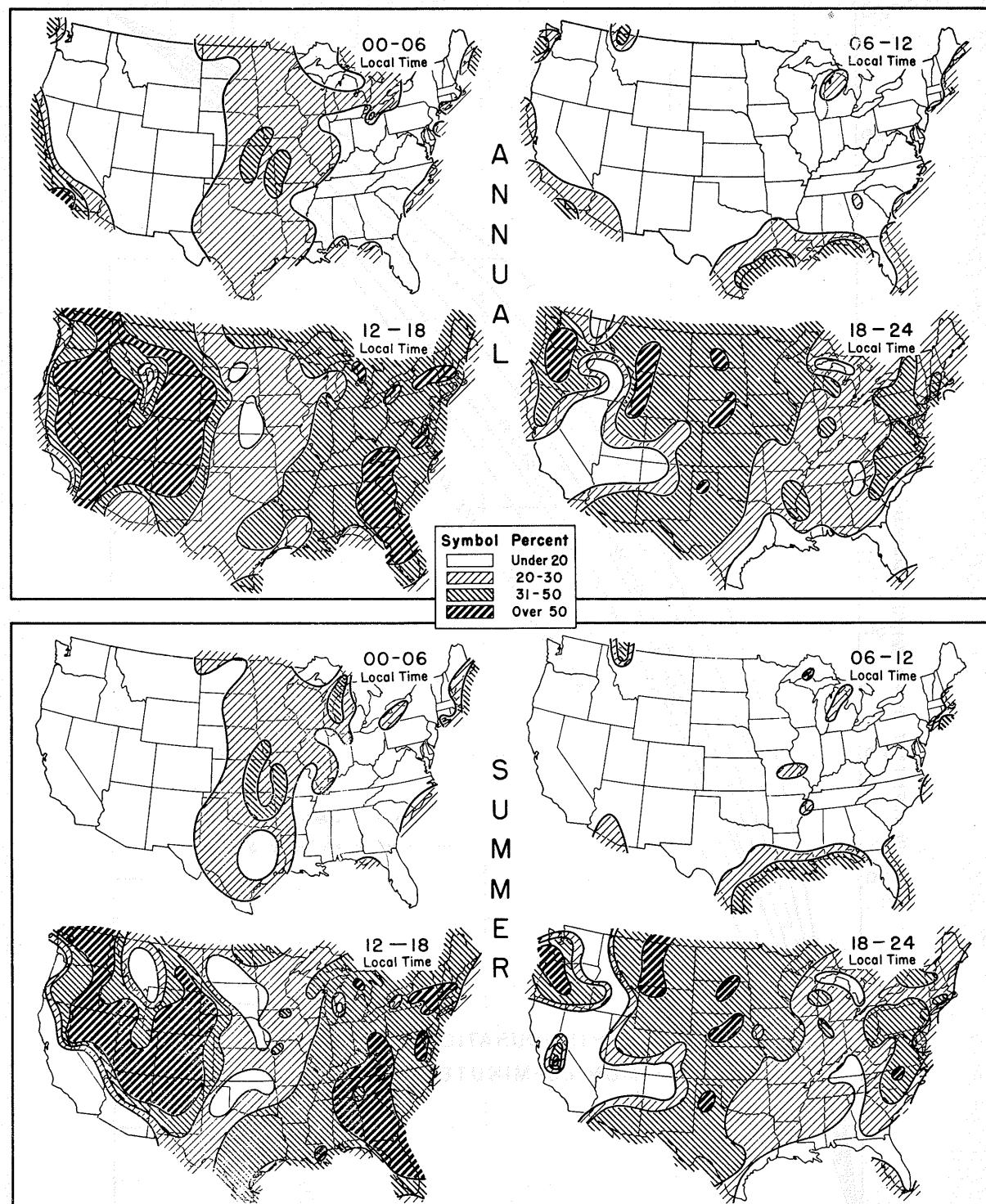


Figure 15. - Percentages of excessive rain occurrences per quarter day, 1904-33.
(from 157.)

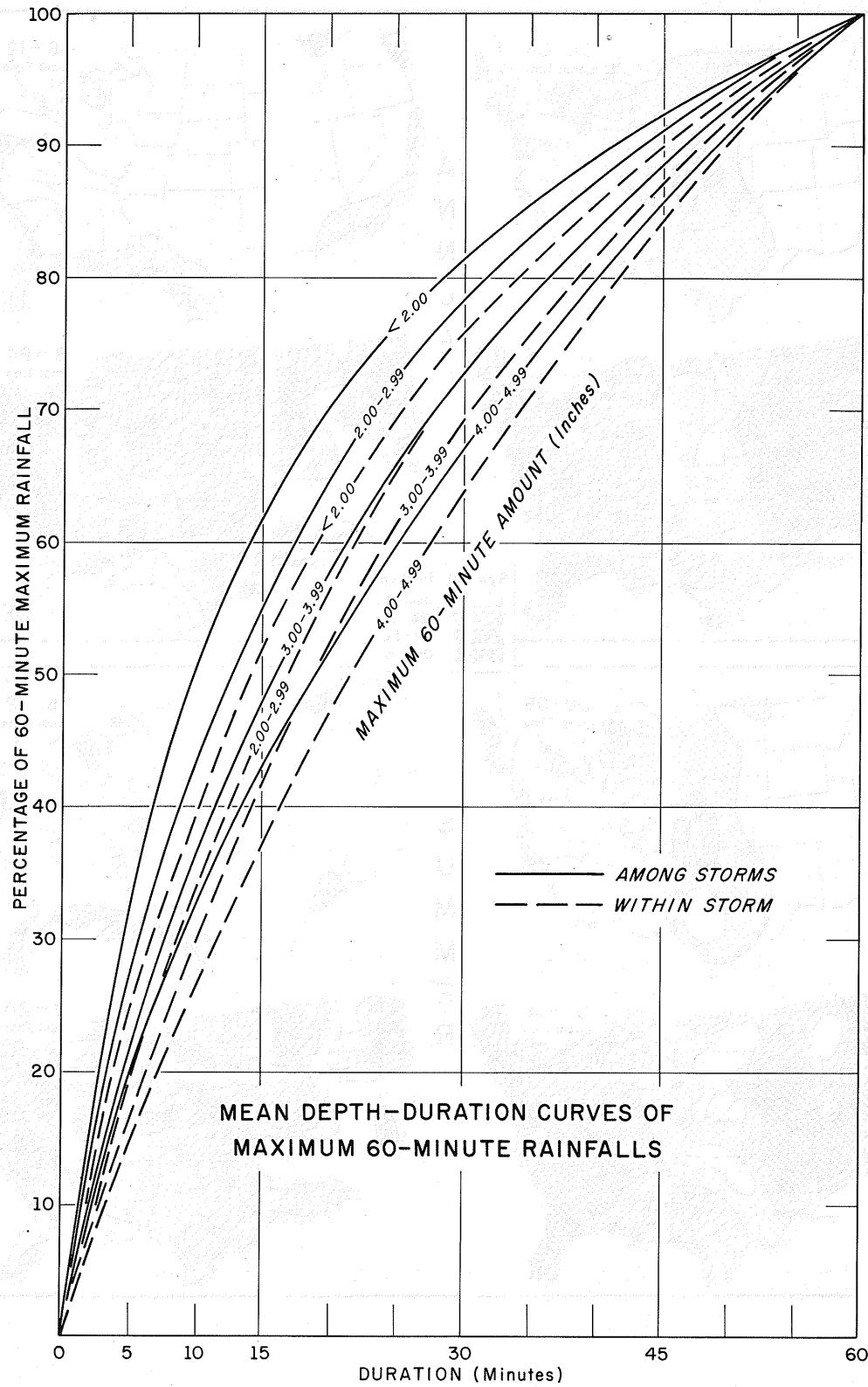


Figure 16. - Mean depth-duration curves of maximum 60-minute rainfalls.