WEATHER BUREAU
Eastern Region Headquarters
Garden City, New York

June 1968

Washington Metropolitan Area Precipitation and Temperature Patterns

CLARENCE A. WOOLLUM
NORMAN L. CANFIELD

Technical Memorandum WBTM-ER-28

U.S. DEPARTMENT OF COMMERCE / ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

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U.S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
WEATHER BUREAU

Weather Bureau Technical Memorandum ER-28

WASHINGTON METROPOLITAN AREA PRECIPITATION AND TEMPERATURE PATTERNS

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Eastern Region
EASTERN REGION HEADQUARTERS
SCIENTIFIC SERVICES DIVISION
TECHNICAL MEMORANDUM NO. 28

GARDEN CITY, NEW YORK
June 1968

FOREWORD

In many cities it is necessary to rely on "official" observations from one observation site to represent the climatology for that specific urban area. This report by Woollum and Canfield is a fine contribution to urban climatology. It emphatically demonstrates the necessity for Metropolitan Climatological Networks if industry and the public are to have a proper understanding of the variations that exist in relatively short distances.

The charts in this report represent compilations and analyses of thousands of individual observations. Much valuable information that is available is not included due to lack of time and economic limitations. Maps showing variations in snowfall for individual storms, variations in precipitation during heavy rain situations and variations in temperature during extreme heat or cold have been furnished the Washington newspapers from time to time by Mr. Woollum. Publication of these by the press has helped in improving public understanding not only of the mesoclimatology but of the difficulty in issuing forecasts to indicate adequately some of these variations.

It is sincerely hoped that local climatological networks can eventually be established in most large urban areas in order to provide industry and the public with information important to their needs.

R. C. Schmidt
Meteorologist in Charge
Weather Bureau Forecast Center
Washington, D.C.

LIST OF FIGURES

WASHINGTON METROPOLITAN AREA PRECIPITATION AND TEMPERATURE PATTERNS

C. A. Woollum
Weather Bureau Forecast Center, Washington, D.C.

N. L. Canfield
Weather Bureau Eastern Region, Garden City, N.Y.

INTRODUCTION

The climate of cities is a subject that has evoked increasing interest in recent years. In the United States, symposia have been held and survey articles published, for example (6) and (4), respectively. Elsewhere, at least one book has been written on the subject (1) since the appearance of (3) and earlier works.

In several cities, small-scale variations of temperature have been measured over periods of a few days or weeks by sensors mounted on motor vehicles. The results of such experiments generally have verified the existence of an "urban heat island" in the absence of a sufficiently dense network of conventional fixed observational sites.

Around Washington, D.C., a systematic effort to map monthly data on a metropolitan-area basis began in January 1946. Plotted but unanalyzed maps showing average maximum and minimum temperature, and total heating degree days and precipitation, were published routinely in Monthly Climatological Summary,[1] Washington, D.C., from January 1946 through May 1949, and again from September 1949 through April 1950. Network coordination was transferred to the Weather Bureau Forecast Center in 1958 and analysis of monthly maps became routine by 1963.

PURPOSE

The purpose of this technical memorandum is to present an updated selection of very generalized patterns of Washington, D.C. metropolitan area precipitation and temperature data as drawn by Woollum. Seasonal and annual maps are based on 20 years of record, 1946 through 1965. A few of the monthly maps and one of the daily maps are based on 1966 or 1967 events that exceeded extremes for the basic 20-year period.

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[1]Predecessor of Local Climatological Data.

GENERAL DISCUSSION

Several of the maps update charts published in (12); this reference includes a map showing the general topography of the area and the network of stations as of July 1, 1964. At that time there were about 30 stations in the network. By early 1968, there were about 40 stations. For the 20-year period, there have been 13 to 19 stations in the network, of which about a dozen have been "official" stations. However, less than ten stations have provided virtually continuous measurements for the 20 years of record being considered.

The charts published in (12) also provided information for (2). Frederick's paper, along with (7), offers the most complete discussion of Washington climate that has appeared since (9), which is an out-of-print compendium based mainly on first-order station data from Washington weather records for the period 1871 through 1945. Although not as extensive, similar data compilations subsequently were published for other cities, such as (8). Trends in urban-rural temperature differences and urban warming, for Washington and other cities, are analyzed in (5).

The authors emphasize that the present maps show only very generalized patterns. We hope that observational completeness and representativeness, and network density and continuity, will continue to increase so that more precise analyses will be feasible in the future. In other words, these maps are far from representing the final mesoclimatological word for Washington, but the fact that even general pictures can be presented is a tribute to the cooperation and diligence of many volunteer observers. (A list of observers participating as of March 1968 is given at the end of this manuscript.)

THE MAPS

The figures that follow appear in three groups: Precipitation, Figures 1-8; Snow, Figures 9-14; Temperature, Figures 15-23. All figures are maps except for one graph showing smoothed probability of first significant snowfall, an event showing little areal variation over the long term.

PRECIPITATION

Figure 1 shows a relative minimum of annual precipitation extending upstream along the Potomac River while greater precipitation is associated with higher terrain to the west and north of the District of Columbia. The "network mean" for 1946 through 1965, 9 stations, was 41.4 in. The 20-year single-station means ranged from 39.1 in. at the National Airport to 43.5 in. at Brookdale, Md., northwest of the District of Columbia. The wettest of the 20 calendar years at all nine stations was 1948 (when 59.5 in. was recorded at the National Airport); the driest year at most stations was 1965 (when 26.9 in. was the National Airport total).

Figures 2-5, seasonal precipitation, each generally resembles the annual pattern. Spring and summer, Figures 3 and 4, account for up to 60 percent of the area's annual rainfall. Figure 5 indicates that the smallest range of precipitation across the metropolitan area occurs in the fall. October is often the driest month in the eastern U.S., but this fact tends to be lost in a 3-month grouping, because of the effects of occasional tropical cyclones, occasional heavy thunderstorms (early September), and occasional intense extratropical storms in November.

Figures 6 and 7 illustrate the effects of occasional tropical cyclones. Hurricanes Connie and Diane were the primary reasons for August 1955 being recorded as the wettest August since 1928. Connie caused the record 24-hour rainfall shown in Figure 7. The 20-station "network average" was 6.6 in. in 24 hours. 24-hour totals ranged from 4.3 in. at Rockville, Md. (northwest of the District) to 9.4 in. at Beltsville, Md. (northeast of the District).

A detailed description of excessive rains not caused by a tropical cyclone is given in (11).

Figure 8 shows the rainfall pattern for the driest month on record (1871 to date) in Washington, D.C. October 3 and 26, 1963 were the primary dates of measurable rainfall but, obviously, amounts were small. The total for the month amounted to a trace at both Washington National and Dulles International Airports.

SNOW

Figure 9 shows that the mean annual snowfall ranges from about 16 inches in the center of the city to nearly 22 inches over higher terrain in the northwestern and eastern suburbs of the metropolitan area. Normally, we look to temperature maps that follow for portrayal of the urban heat island. However, Figure 9 suggests that the phenomenon, along with elevation, is a factor in the pattern of long-term snowfall totals. The 20-year network mean amounts to 19.8 in. Annual totals at single stations ranged from 2.8 in. in 1959 at the U.S. Soldiers Home to 48.7 in. during 1961 at the National Arboretum. (The snowiest calendar year at most stations, however, was 1960 rather than 1961.)

The simple procedure of reading snow depth from a foot-rule or yardstick stuck in the snow is often complicated by the drifting of snow that falls in major storms. Natural variability and measurement difficulties cause considerable data variability and make the selection of a single snowiest month quite arbitrary. However, by any standard, it is quite clear that the snowfall during several winter months since December 1965 equals or exceeds monthly snowfalls during the preceding twenty years. The patterns of the recent snowy months also are more firmly documented by the larger network of observers now cooperating.

Figures 10, 11, and 12, respectively, show the snowiest December (1966), January (1966), and February (1967) on record since the end of World War II. The record from the National Airport indicates that these snowy months were due mainly to the effects of 3, 2, and 3 separate snowstorms, respectively. Even more recently, a single storm at the end of November 1967 also was a record-breaker for the month.

Despite all the recent monthly records, Figure 13 shows that the daily (24-hour) record occurred near the middle of the basic 20-year period. The February 1958 snowstorm began about 9 a.m. on the 15th and ended about 24 hours later. In terms of hours with measurable amounts, the February 15-16 storm was a 21-hour storm. The storm dumped 14.4 in. at the National Airport, the greatest since an identical amount fell on February 6-7, 1936.

Figure 14 presents a graphical analysis of the percentage probability of 1-inch (or greater) and 3-inch (or greater) snowfalls on or before any winter date. The curves are smoothed from data for the winters of 1945-46 through 1967-68. There were four winters in which no snowfalls of 3 in. or greater occurred. These winters (1949-50, 1952-53, 1955-56, and 1958-59) were excluded from the computations, in accord with common practice. Figure 14 shows that median (50-percent probability) dates approximately are as follows:

Snowfall	Median date
1 in. or more	December 13
3 in. or more	December 22

TEMPERATURE

The collection of nine temperature charts is comprised of eight maps with isotherms in degrees Fahrenheit for both maximum and minimum temperature, followed by a concluding last-spring-freeze map of probable interest to home gardeners and others. The eight isotherm maps, based on the 20-year period 1946-1965, all show maximum temperature by dashed lines and minimum temperature by solid lines.

Figures 15, 16, 17, and 18 show mean daily maximum and mean daily minimum temperature for each of the four seasons. In all seasons, the centers of the isotherm patterns are in similar locations. In early morning, as indicated by the mean daily minimum temperature, the center of the urban heat island is rather consistently found between the center of the District and the intersection of the Anacostia and Potomac Rivers, 2-4 miles to the southeast. In the afternoon, however, two heat centers are evident several miles upstream along each of the rivers. These features are common characteristics of individual maps that have been drawn monthly and occasionally daily over the last several years.

The gradients of maximum and minimum temperature from the center of the city to the suburbs seem to be similar in all seasons. All four maps show a 3- or 4-degree difference from the maximum-temperature centers to the edge of the analysis. The maps also show a 6- to 7-degree difference in minimum temperature prevailing between downtown Washington and the Prince Georges County suburbs to the northeast.

Figures 19 and 20 show the coldest month and day, respectively, observed during the basic 20-year period. The coldest month, January 1948, saw northerly winds and below-normal temperatures prevail during most of the last 18 days and all of the last 9 days of the month. The cold was aggravated by 1½-inch snowfalls on the 20th and 23rd and by an 8-inch snowfall accompanying the coldest day of the siege on the 24th.

Exactly fifteen years later, January 24, 1963 "nosed out" January 24, 1948 for the dubious distinction of being the coldest day of the 20-year period at the National Airport. Sixteen stations in the metropolitan network reported maxima ranging from 23 to 30 degrees and minima ranging from -5 to +5 degrees on January 24, 1963. Thus the network averages were about 27 degrees and zero for maximum and minimum temperature, respectively. At the National Airport, the official readings for the day were 24 and 3 degrees, respectively, which resulted in an average for the day that amounted to 23 degrees below normal.

Figure 21 shows the patterns of temperature for July 1955, the warmest month of record (1871 to date) in Washington, D.C. To begin to appreciate the implications of Figure 21, it must be remembered that the values reflect a continuous 31-day period of afternoon temperatures that averaged up to 93 degrees and of temperatures that stayed above 70 degrees throughout virtually every night. At the old "City Office" of the Weather Bureau, 24th and M Streets, N.W., the daily average temperature stayed below 81 degrees on only 5 of the 31 days; the maximum temperature reached 90 degrees or more on 22 days, breaking a record of 21 days that had stood since 1872.

Figure 22 shows the temperature patterns for July 3, 1966, a day in which the heat generally exceeded that for any individual day during the basic 1946-1965 period. Maxima exceeded 100 degrees and minima exceeded 70 degrees over most of the District. In addition to the usual centers or near-centers of high maximum temperature to the northeast and northwest, a third bulge in the maximum-temperature pattern appears to the southwest, possibly reflecting the extensive new construction that has transformed much of that area in recent years.

At the National Airport, the month of July 1966 exeeded July 1955 in terms of average daily maximum temperature (91.0° vs. 90.7°) and number of days with maximum temperature 90 degrees or above (20 vs. 18). However, in terms of overall average temperature for the month and in several other respects, July 1955 clearly retains the warmest-month title as outlined above.

Figure 23, an updating of a map in (12), is based on 19 years of record, 1947-1965. Although all analyses are subject to some oversimplification, togography and related factors may cause the real-life details of freeze-date patterns to be much more complex than the generalized patterns presented with this manuscript. However, the figure is included for the sake of a first general picture of the degree to which the presence of the urban heat island affects an average freeze date. Refinement of this and other maps should result as more data accumulates and further analysis is attempted.

ACKNOWLEDGMENTS

The presentation of these maps has been made possible by the dozens of voluntary observers who have served so faithfully over a large part or all of the last two decades. Some have been or are Weather Bureau employees, e.g. H. L. Choate, B. F. Dashiell, W. K. Shoun, and W. A. Wood. Many, of course, are not Weather Bureau employees, e.g. S. G. Ernst (Park Naturalist, Wheaton Regional Park, Md.), F. P. Eshbaugh (National Arboretum), and Mr. N. Groves (U.S. Soldiers Home). It is a particular pleasure to note the more recent contributions of a daughter and a son of Weather Bureau employees, Miss Sherry L. Snider and Donald C. House, Jr.

A complete list of stations and observers, as of March 1968, is given in the Appendix. We wish to acknowledge the contributions of all of these observers and, where applicable, their predecessors.

We also wish to acknowledge the valuable technical assistance rendered by W. J. Moyer, ESSA State Climatologist for Maryland and Delaware, and by the Weather Bureau staff at the Washington National Airport. Credit for carrying out the initial set-up of the network is due W. A. Mattice and J. L. Baldwin. Finally, the continued support of Mr. R. C. Schmidt, Meteorologist in Charge, Weather Bureau Forecast Center, was essential and is especially appreciated.

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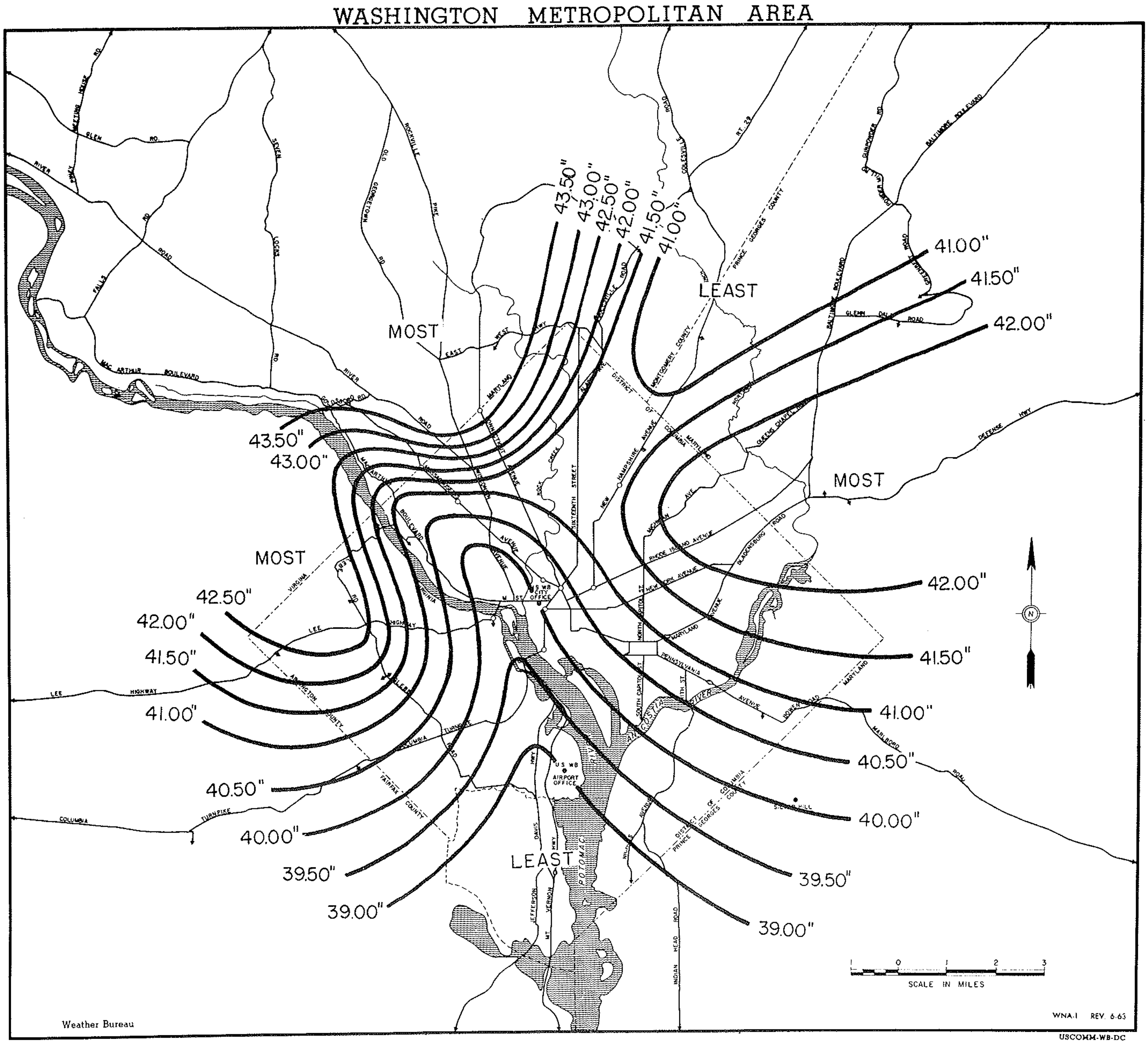


Figure 1. Mean Annual Precipitation, in.

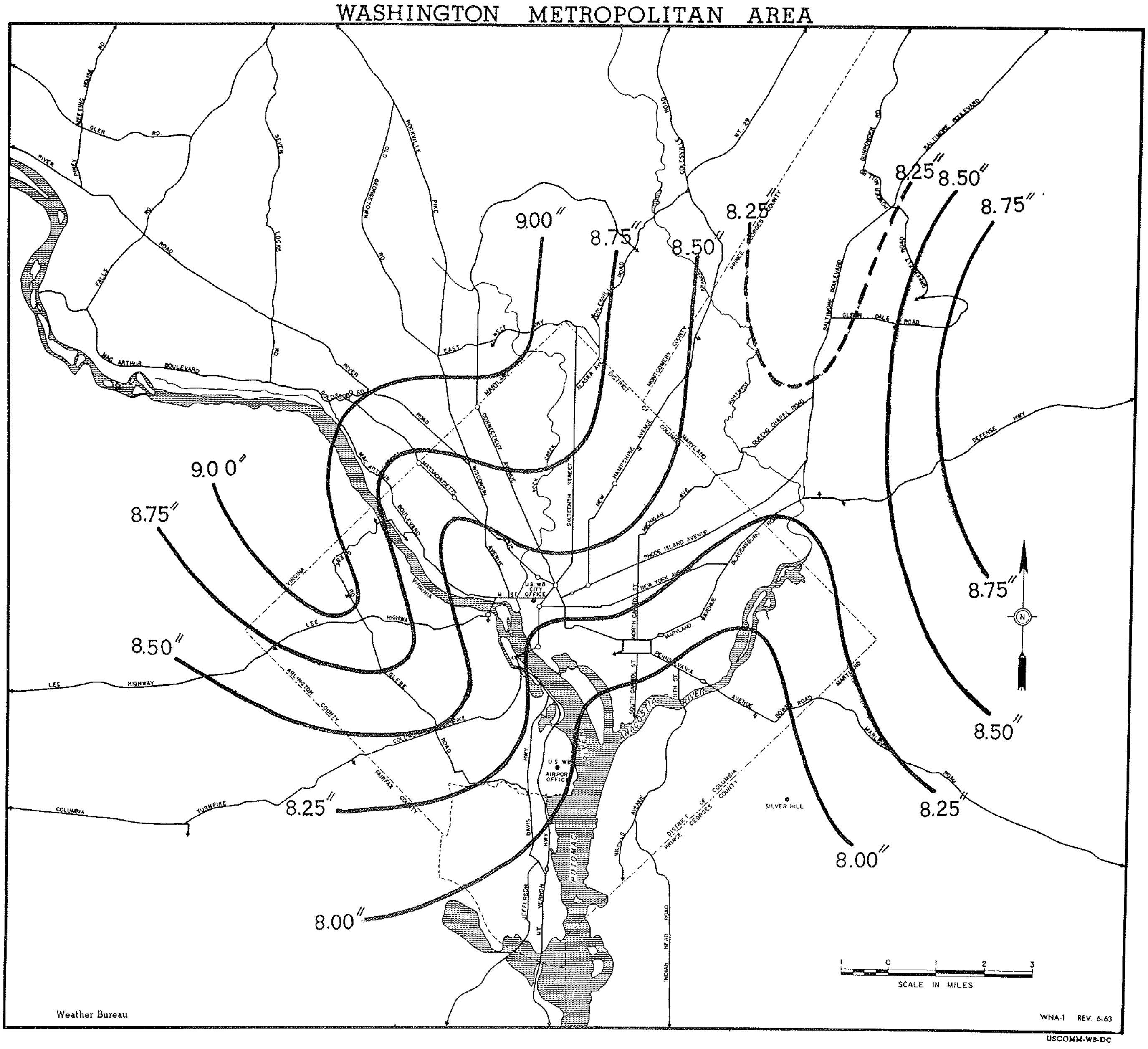


Figure 2. Mean Winter (Dec., Jan., Feb.) Precipitation, in.

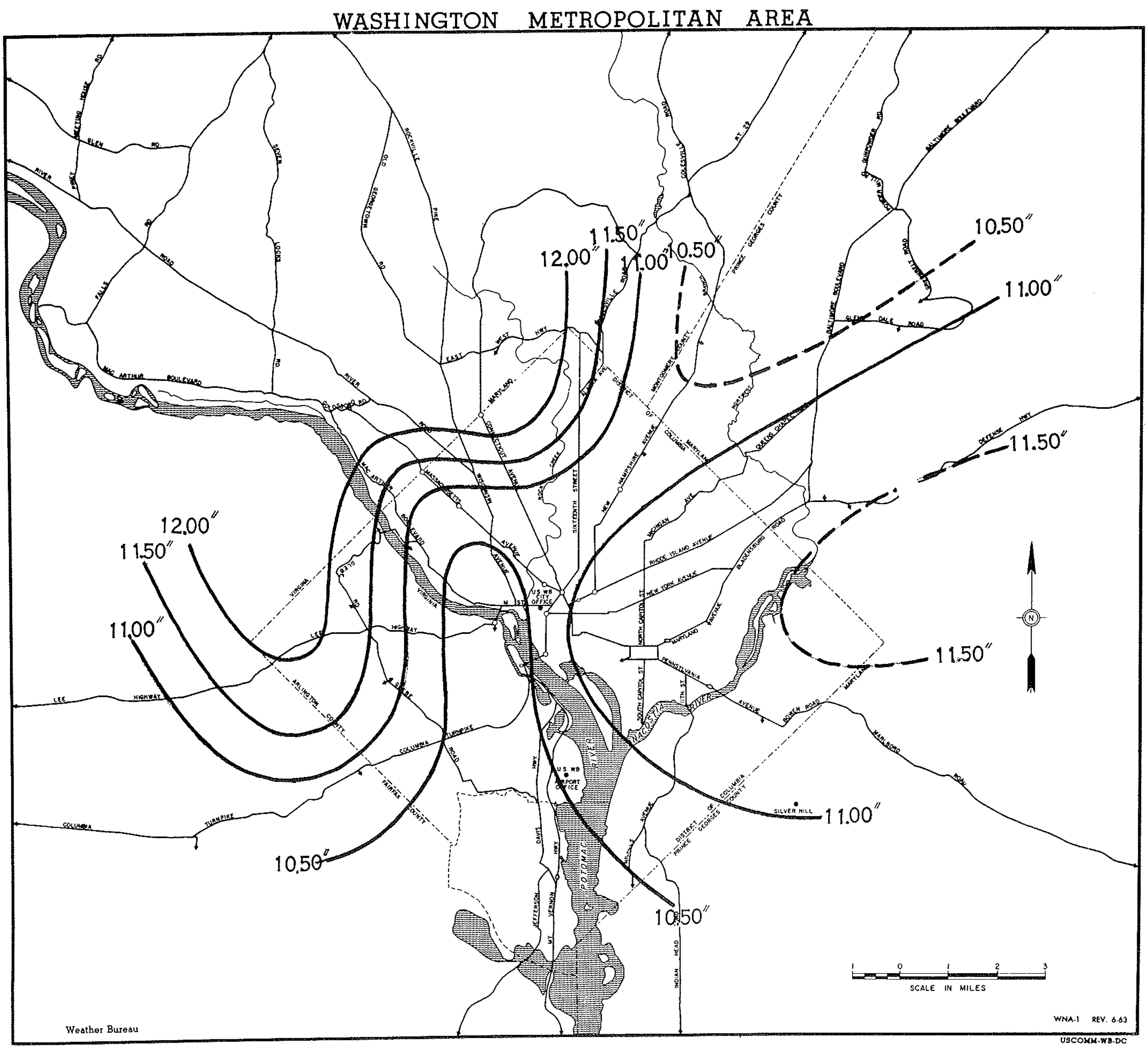


Figure 3. Mean Spring (Mar., Apr., May) Precipitation, in.

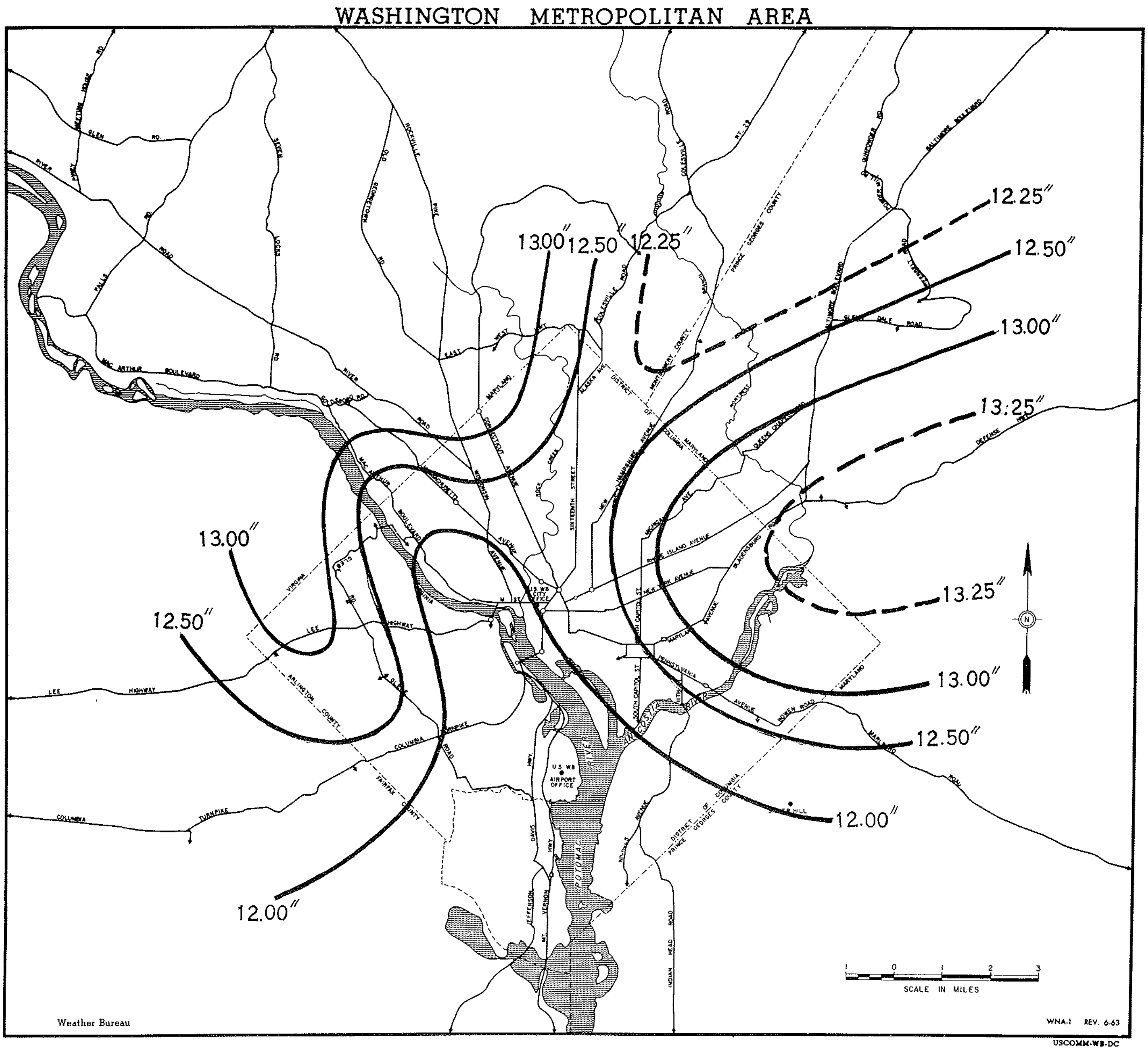


Figure 4. Mean Summer (June, July, Aug.) Precipitation, in.

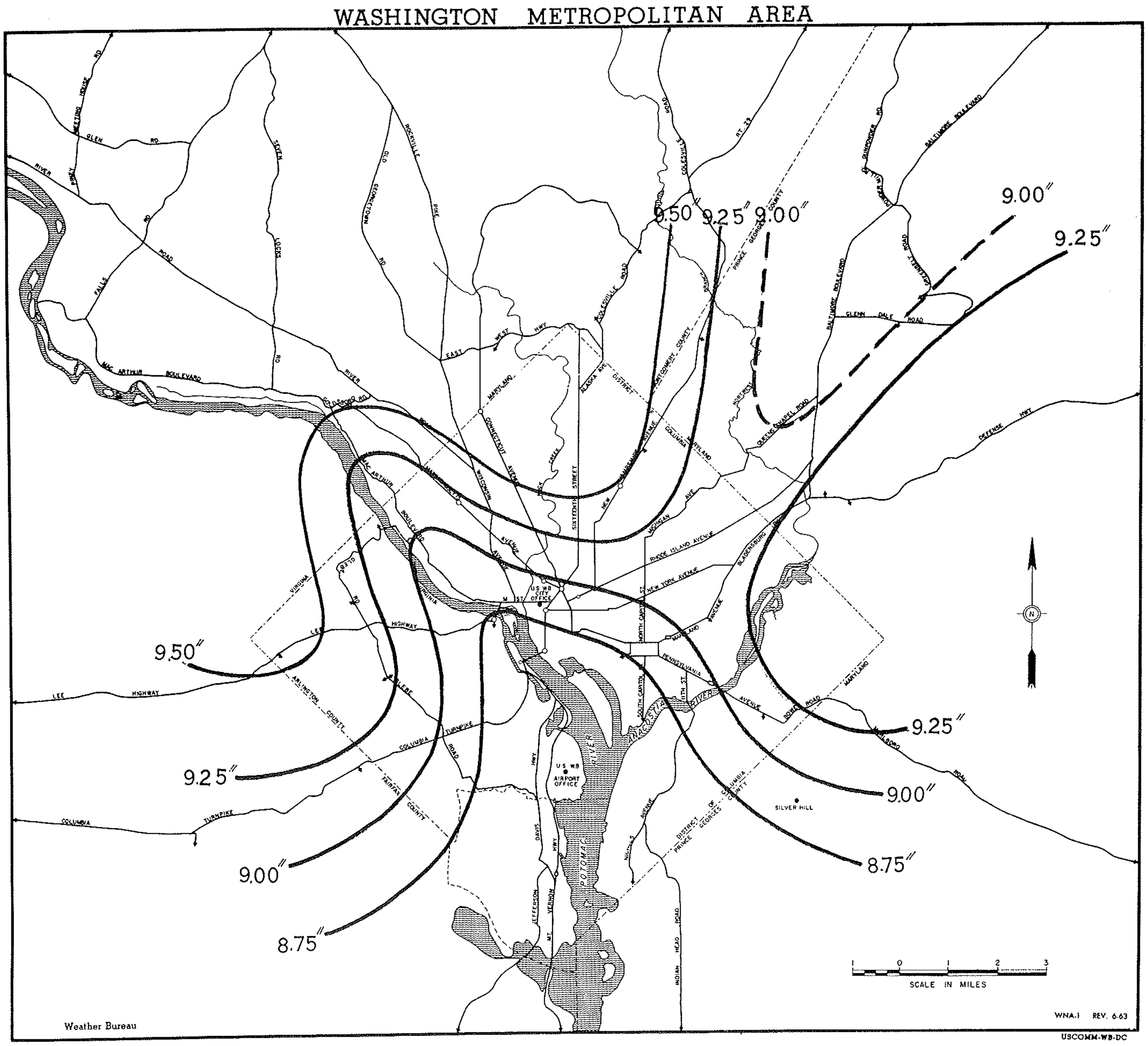


Figure 5. Mean Autumn (Sept., Oct., Nov.) Precipitation, in.

WASHINGTON METROPOLITAN AREA

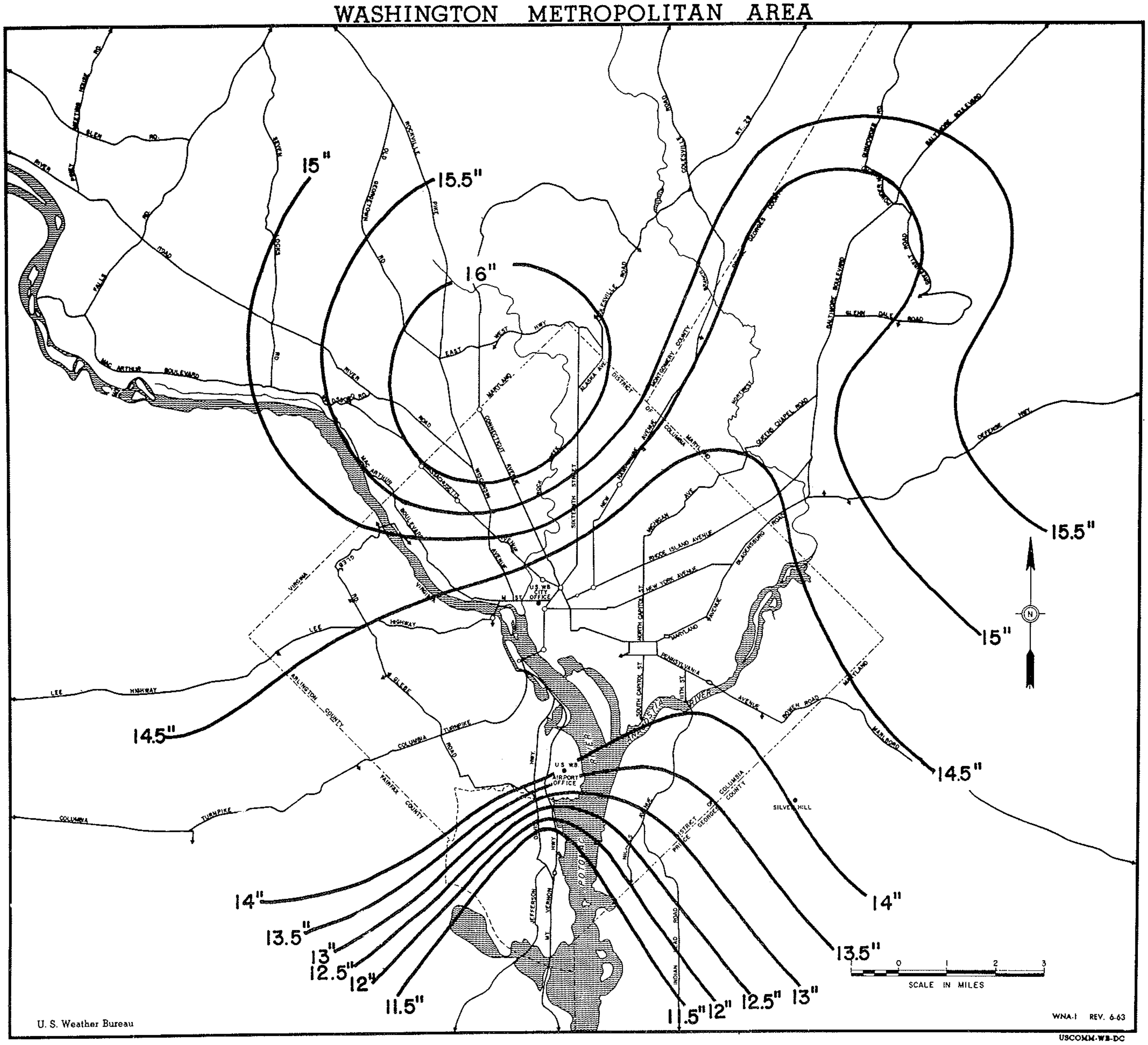


Figure 6. Total Precipitation, in., Wettest Month (Aug. 1955)

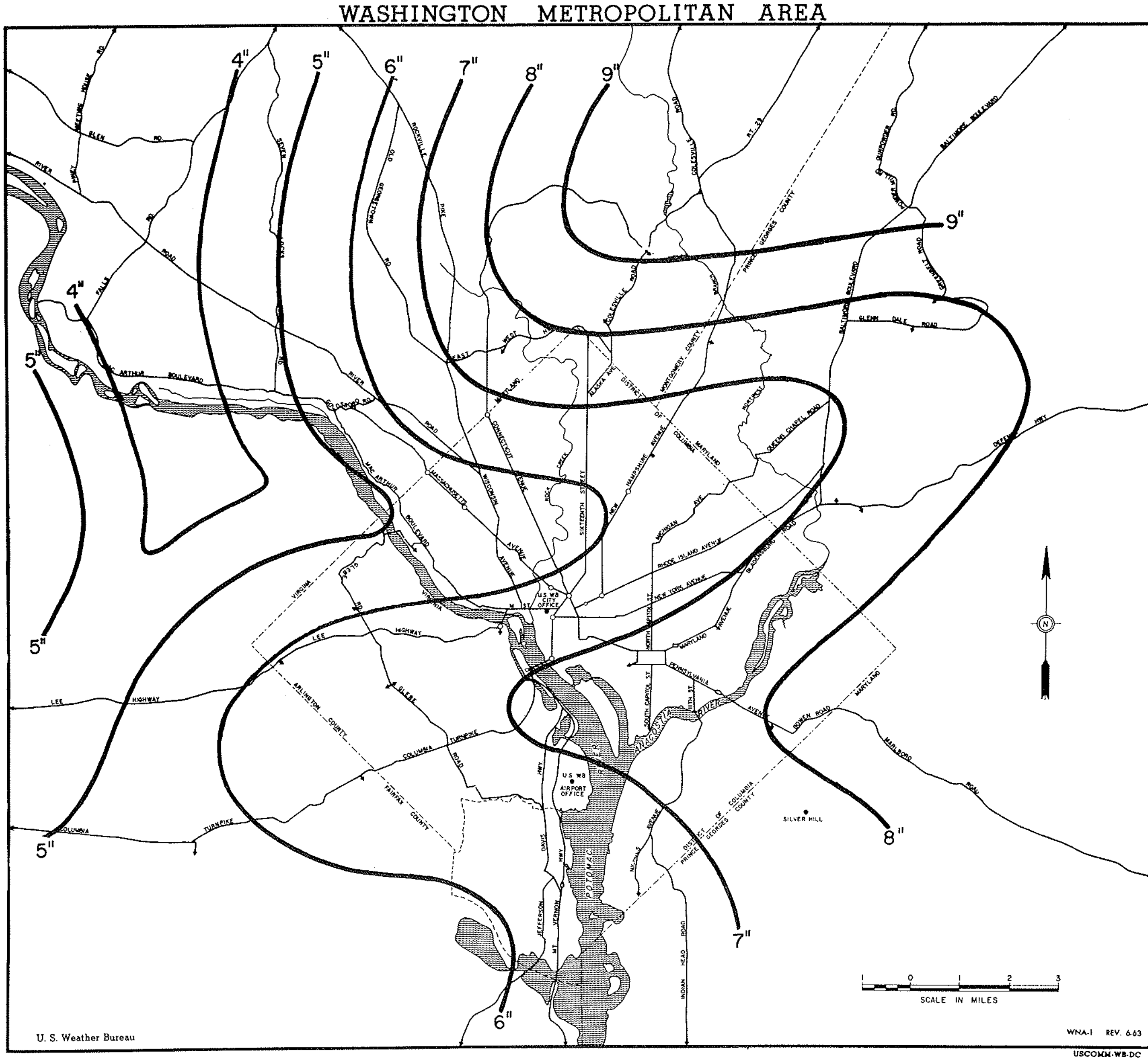


Figure 7. Total Precipitation, in., Greatest in 24 hours (Aug. 12-13, 1955)

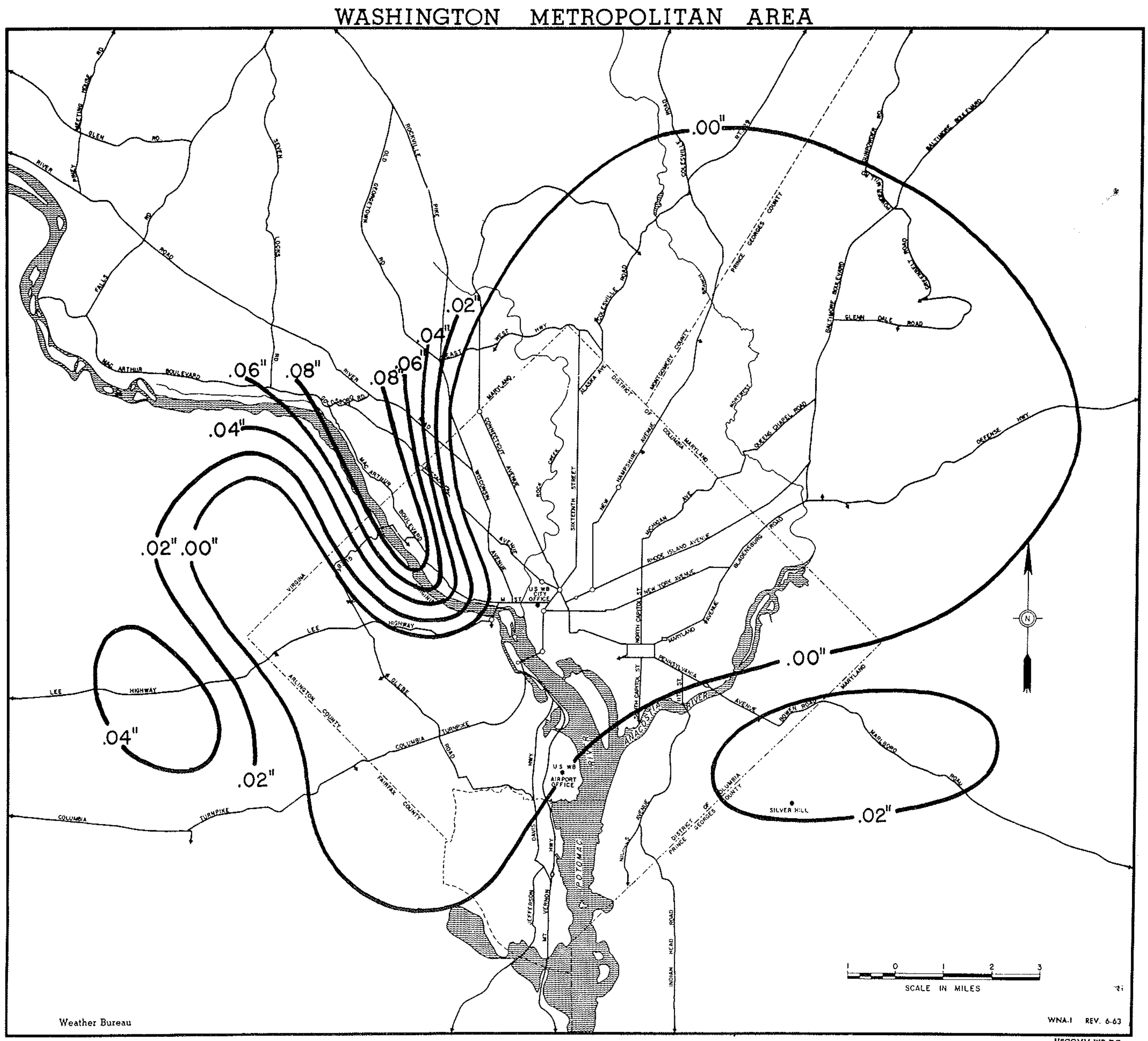


Figure 8. Total Precipitation, in., Driest Month (Oct. 1963)

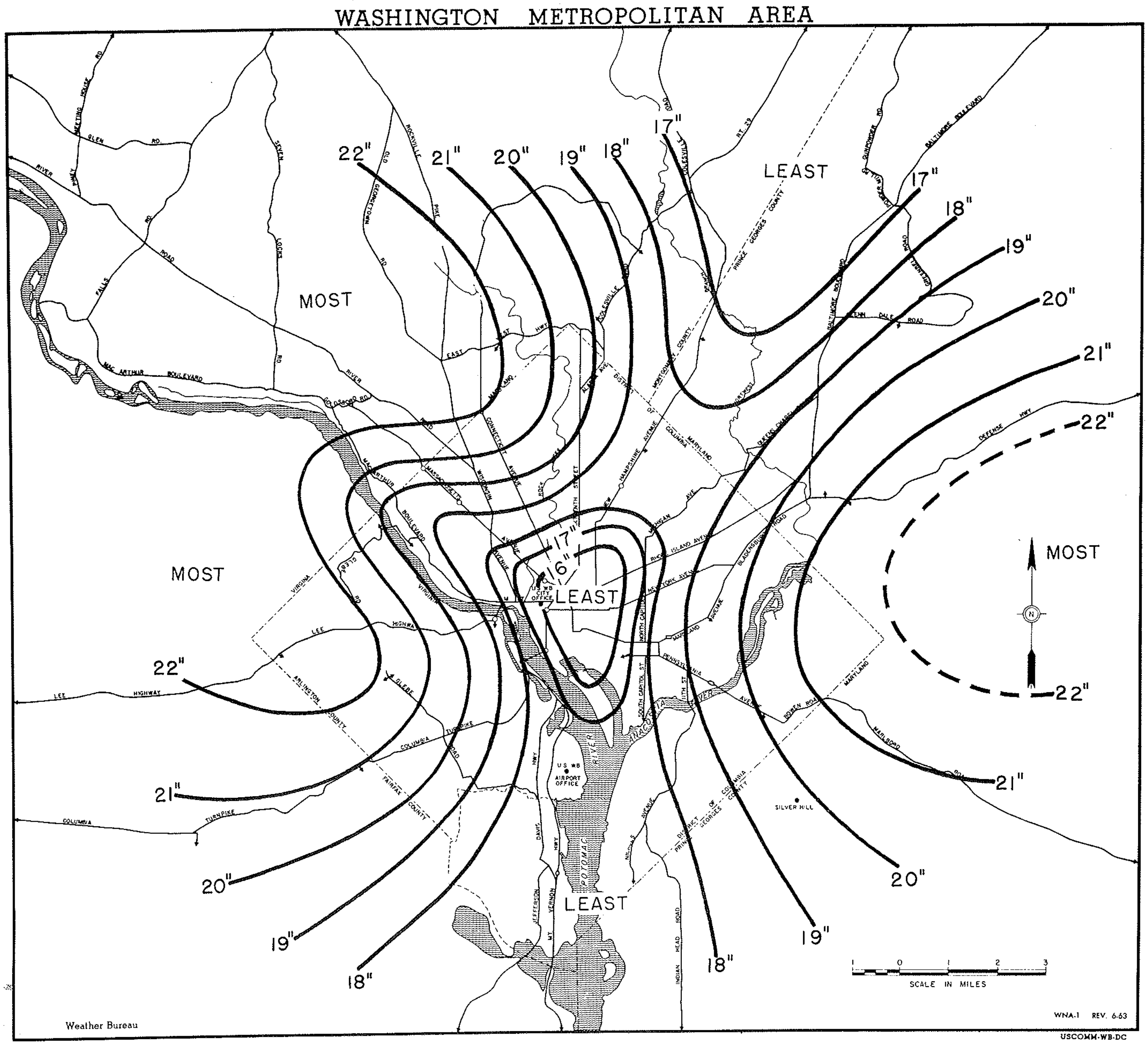


Figure 9. Mean Annual Snowfall, in.

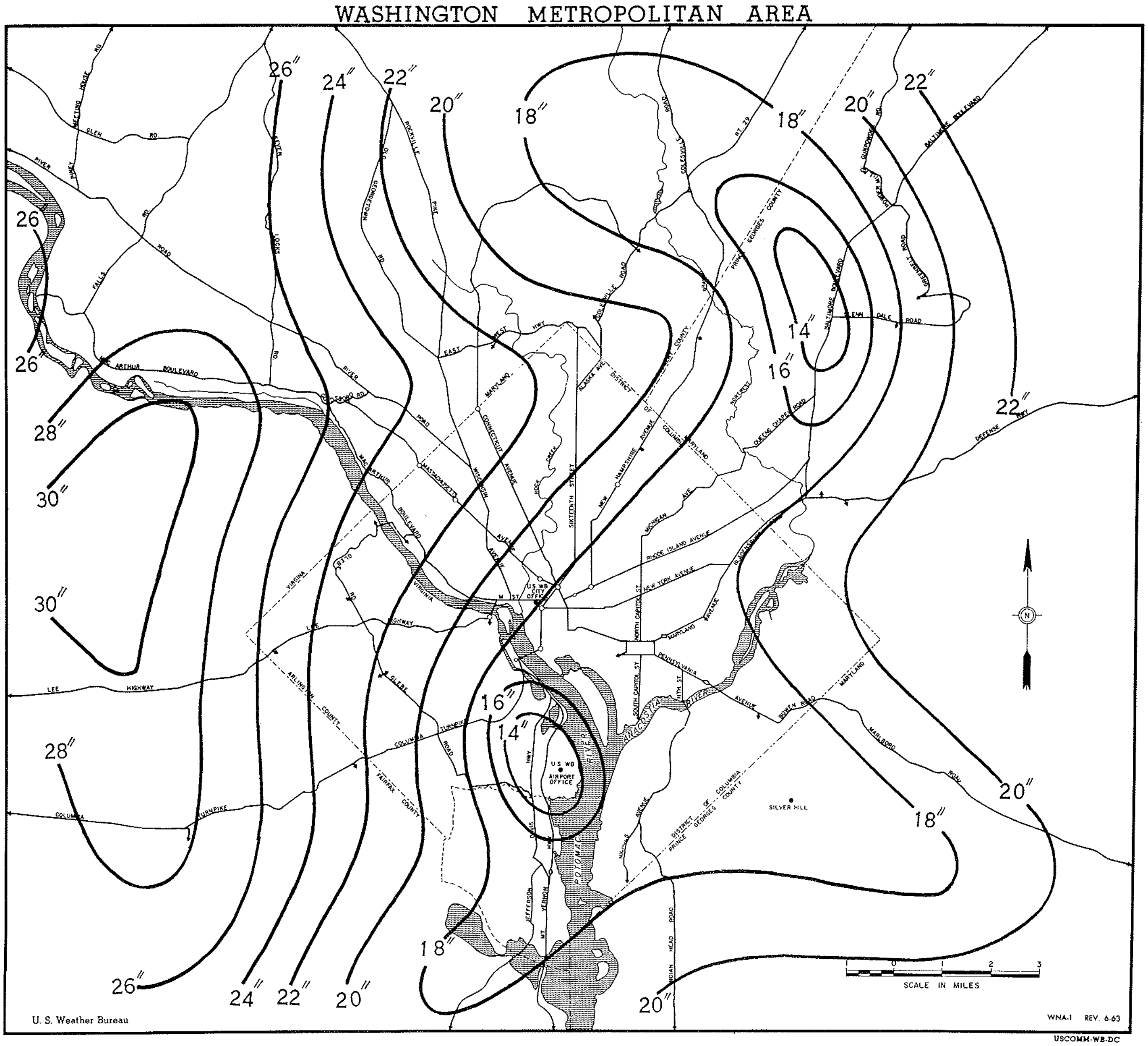


Figure 10. Total Snowfall, in., Snowiest December (1966)

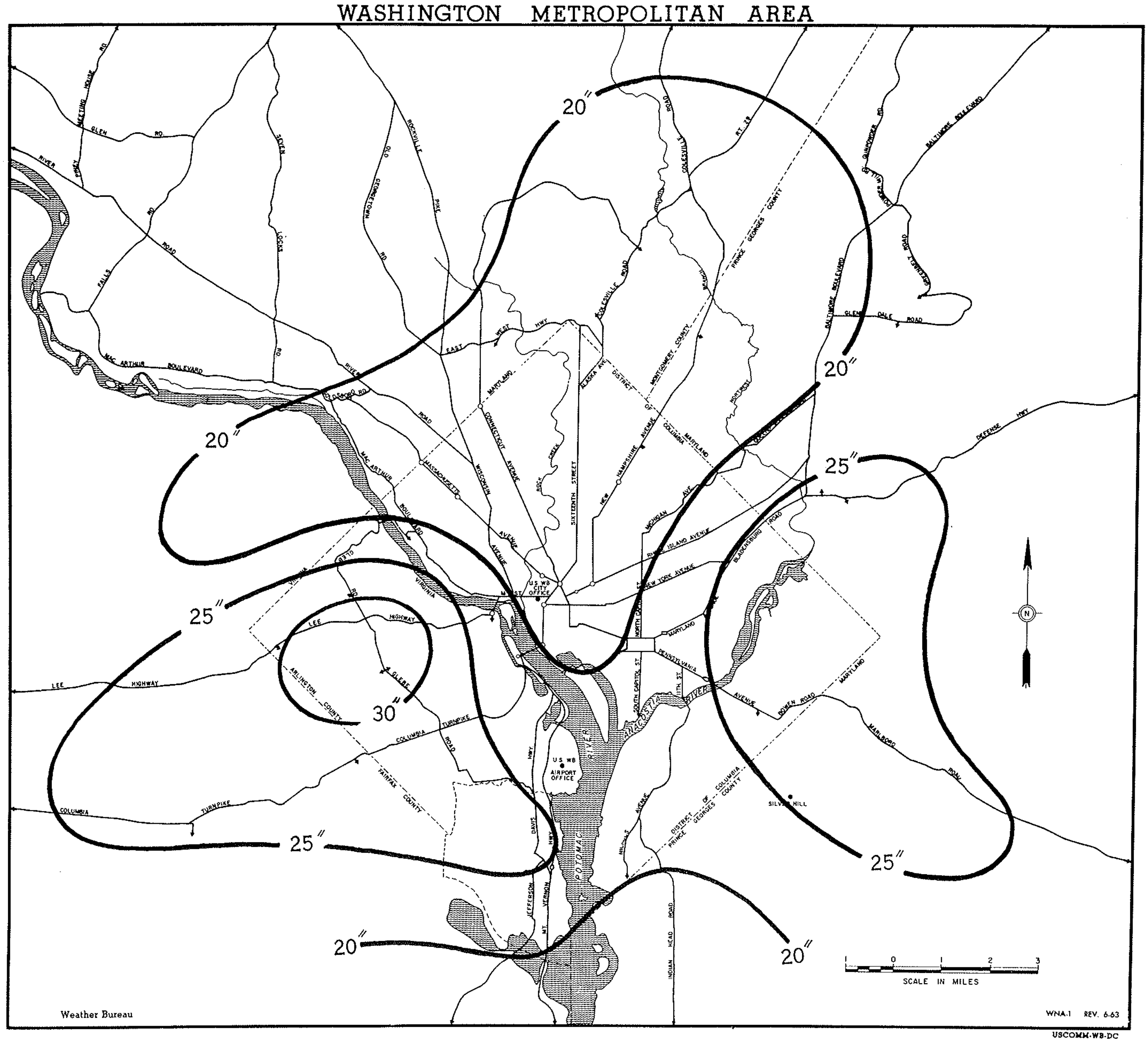


Figure 11. Total Snowfall, in., Snowiest January (1966)

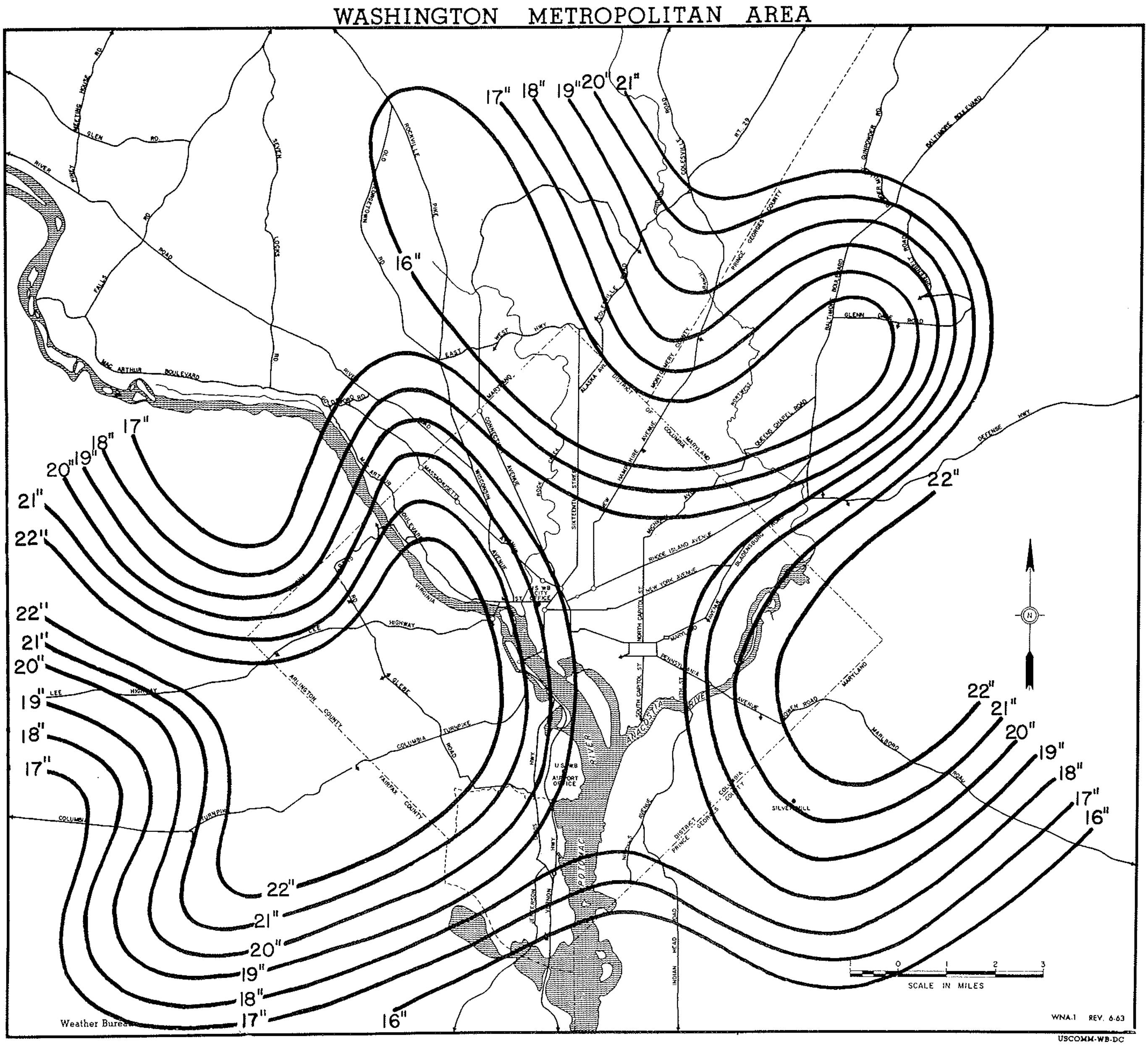


Figure 12. Total Snowfall, in., Snowiest February (1967)

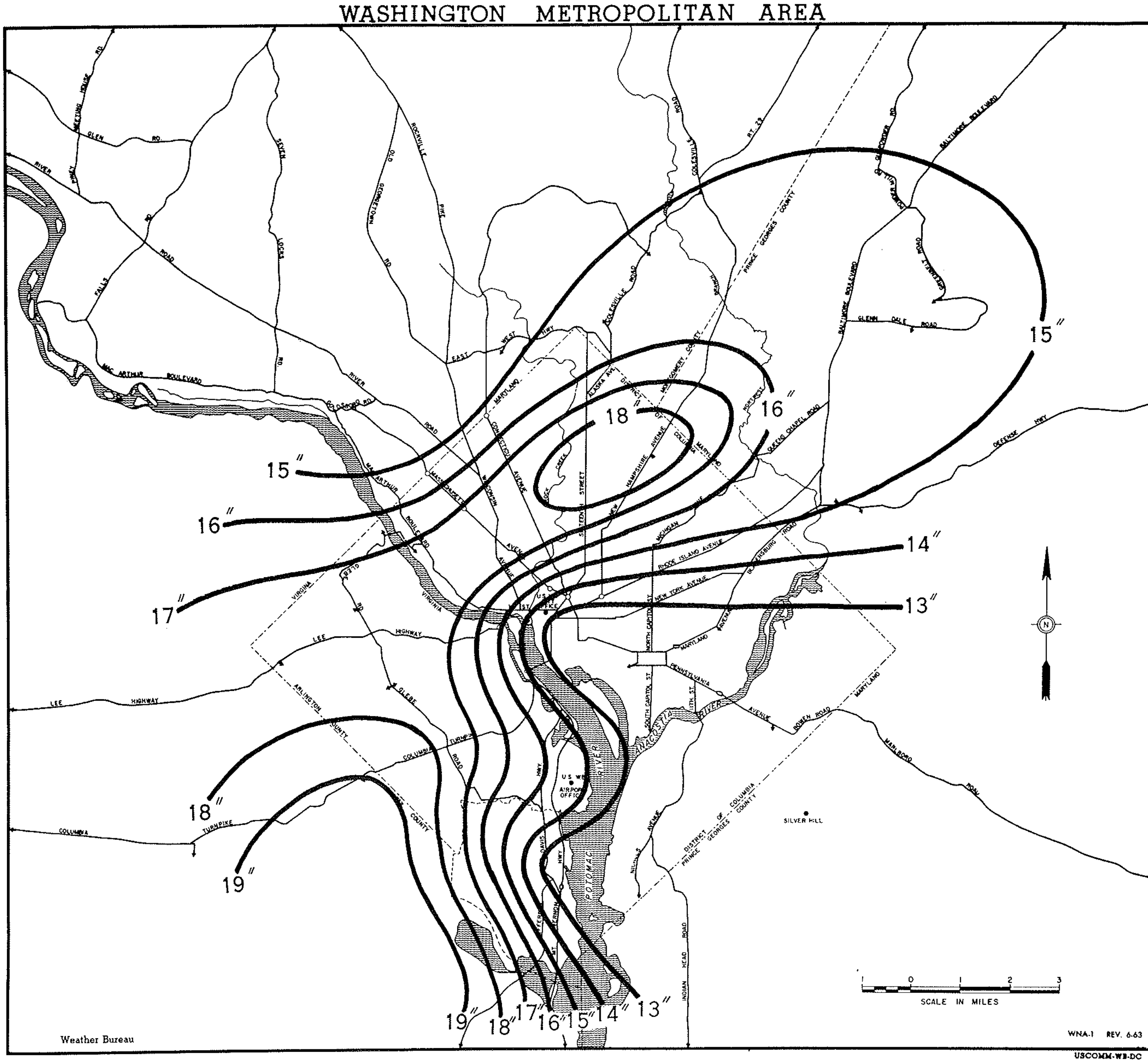


Figure 13. Total Snowfall, in., Greatest in 24 hours
(Feb. 15-16, 1958)

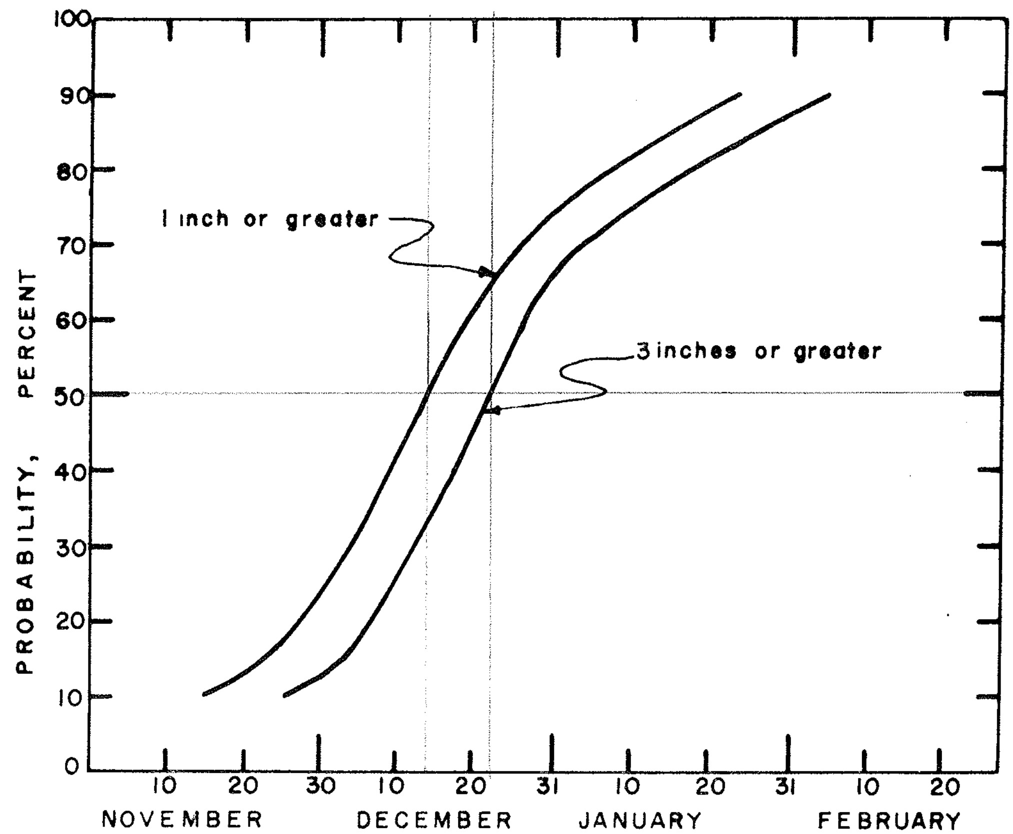


Figure 14. Probability, percent, of first 1-inch and 3-inch Snowfalls occurring by any winter date.

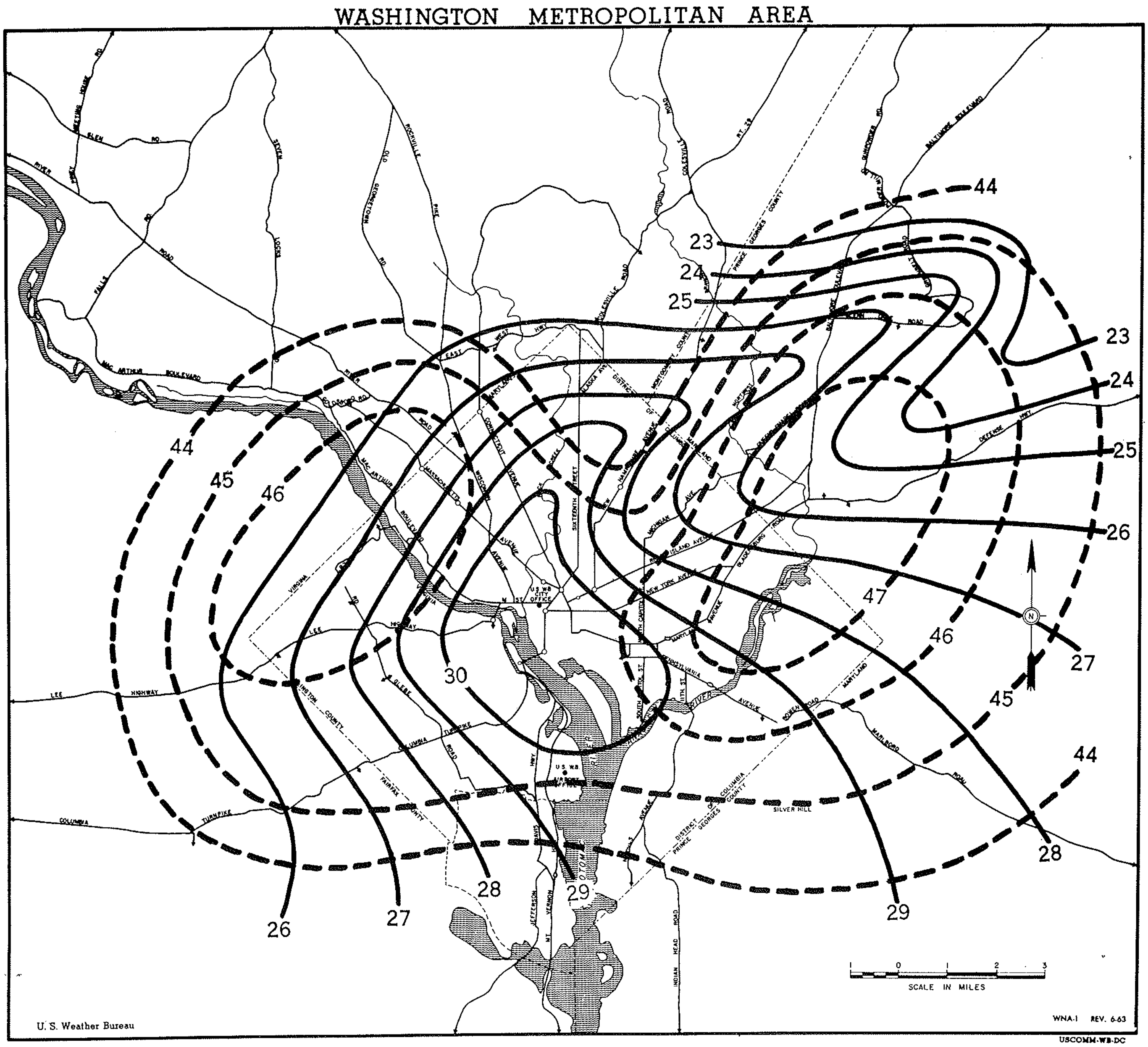
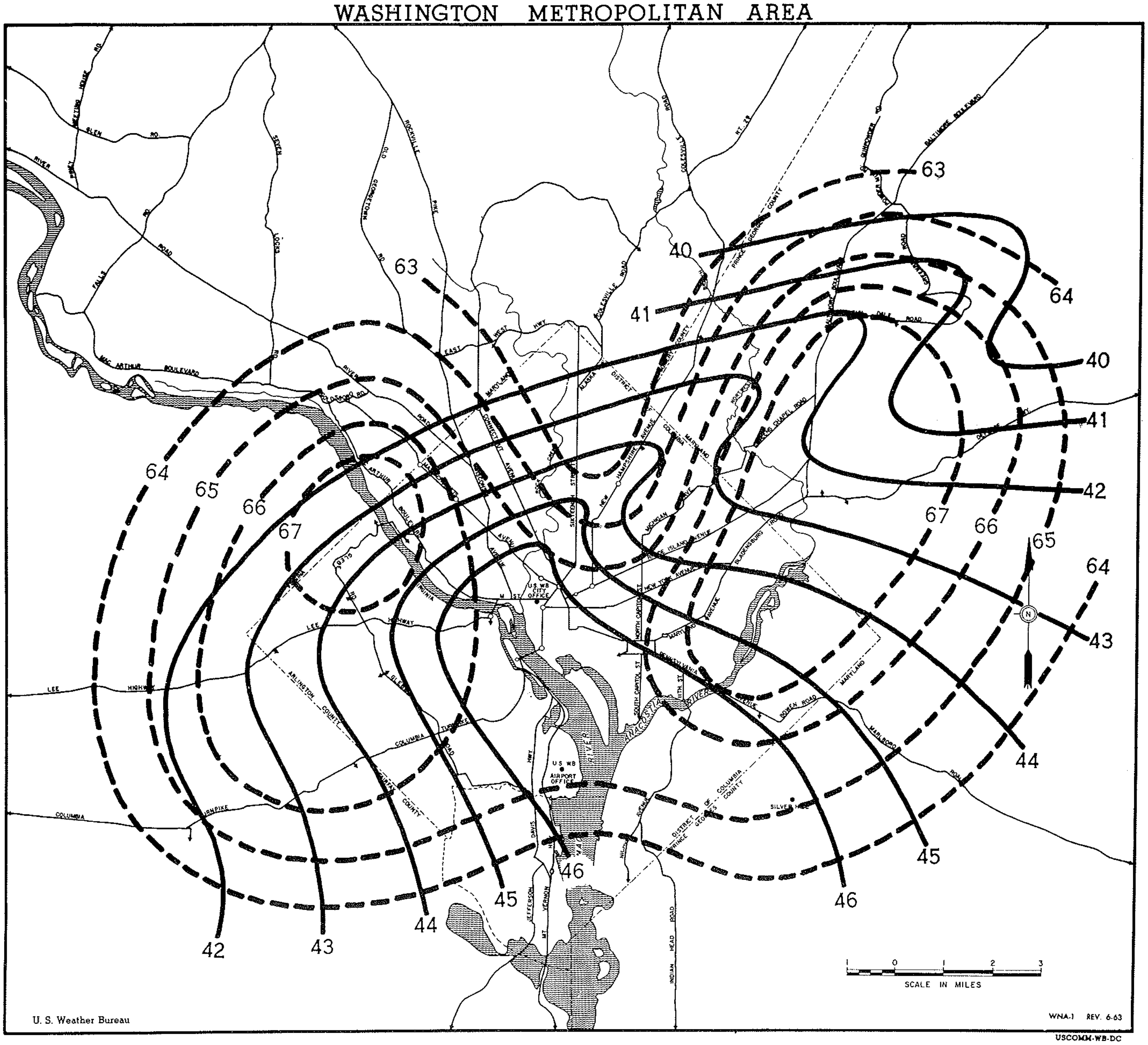


Figure 15. Mean Winter (Dec., Jan., Feb.) Temperature, °F.



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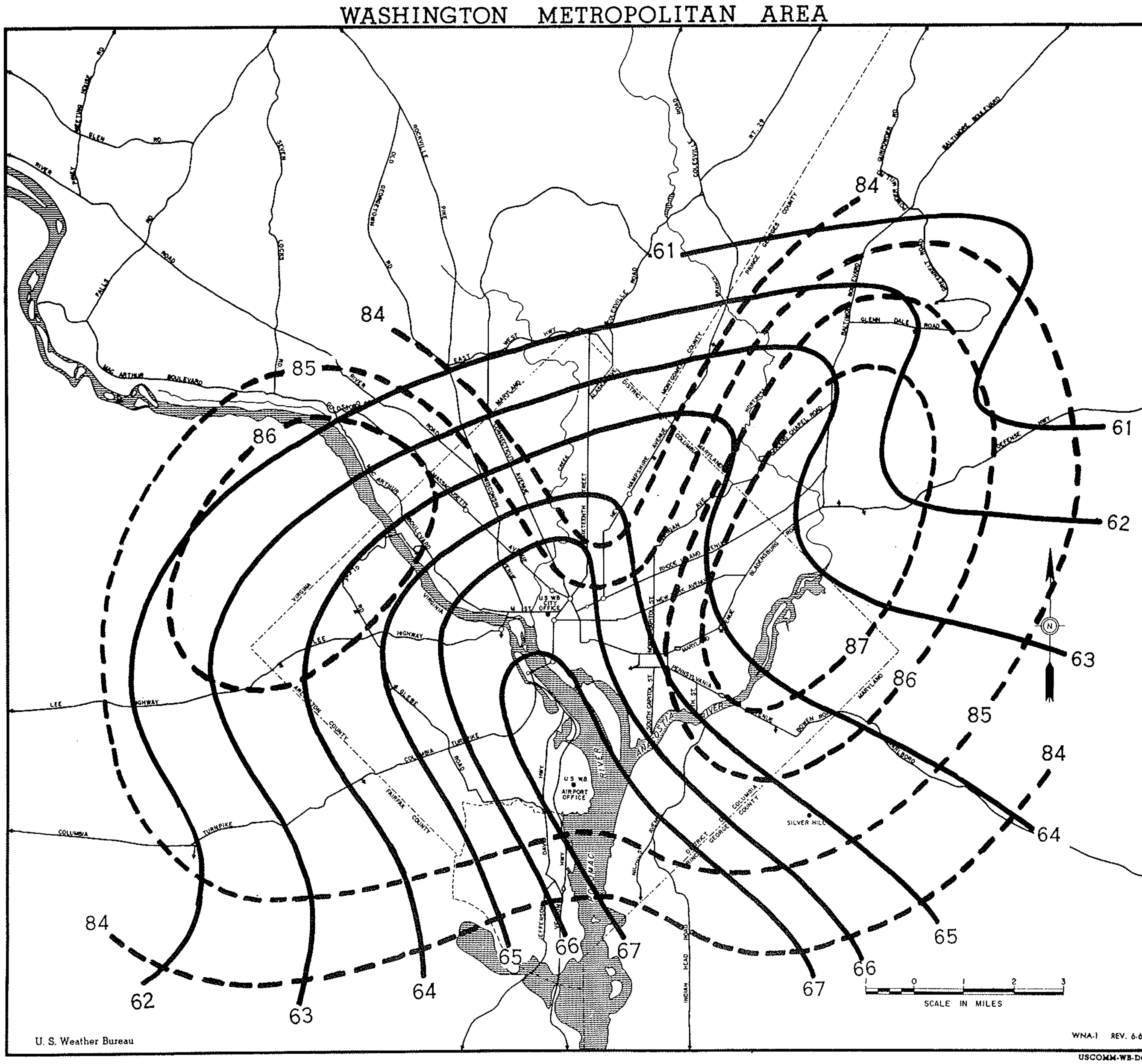

Figure 17. Mean Summer (June, July, Aug.) Temperature, °F.

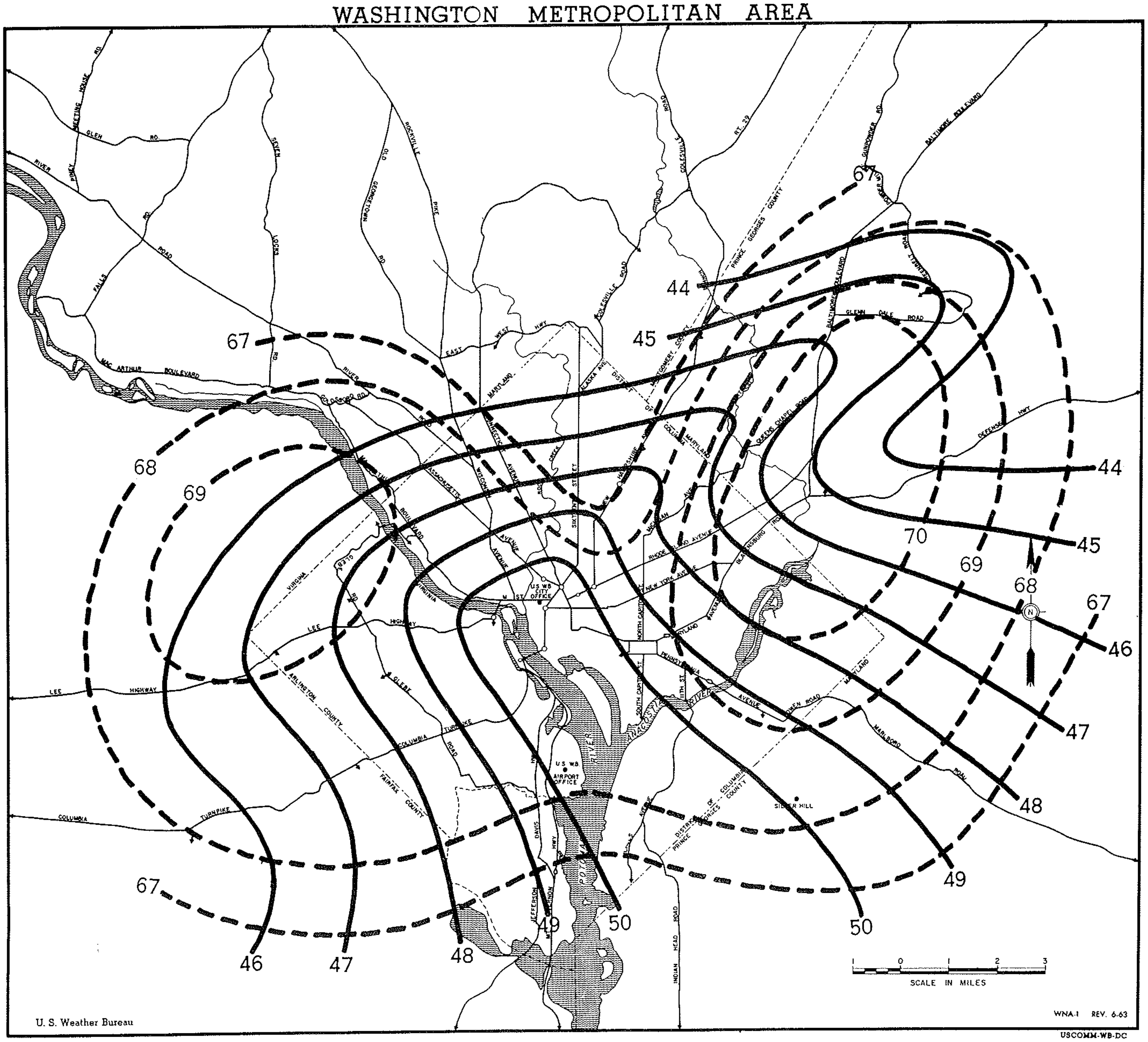

Figure 18. Mean Autumn (Sept., Oct., Nov.) Temperature, °F.

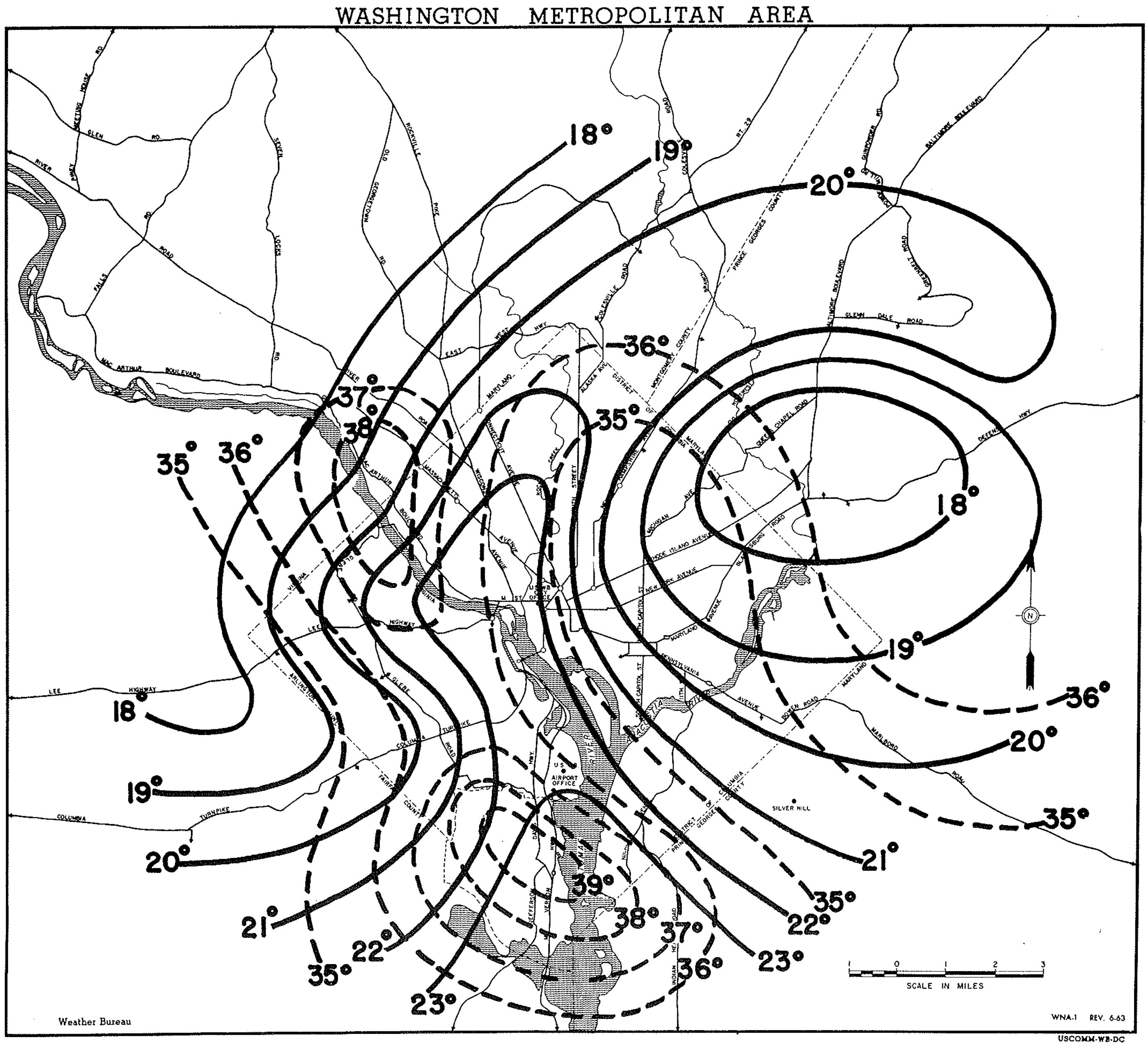

Figure 19. Temperature, °F., Coldest Month (Jan. 1948)

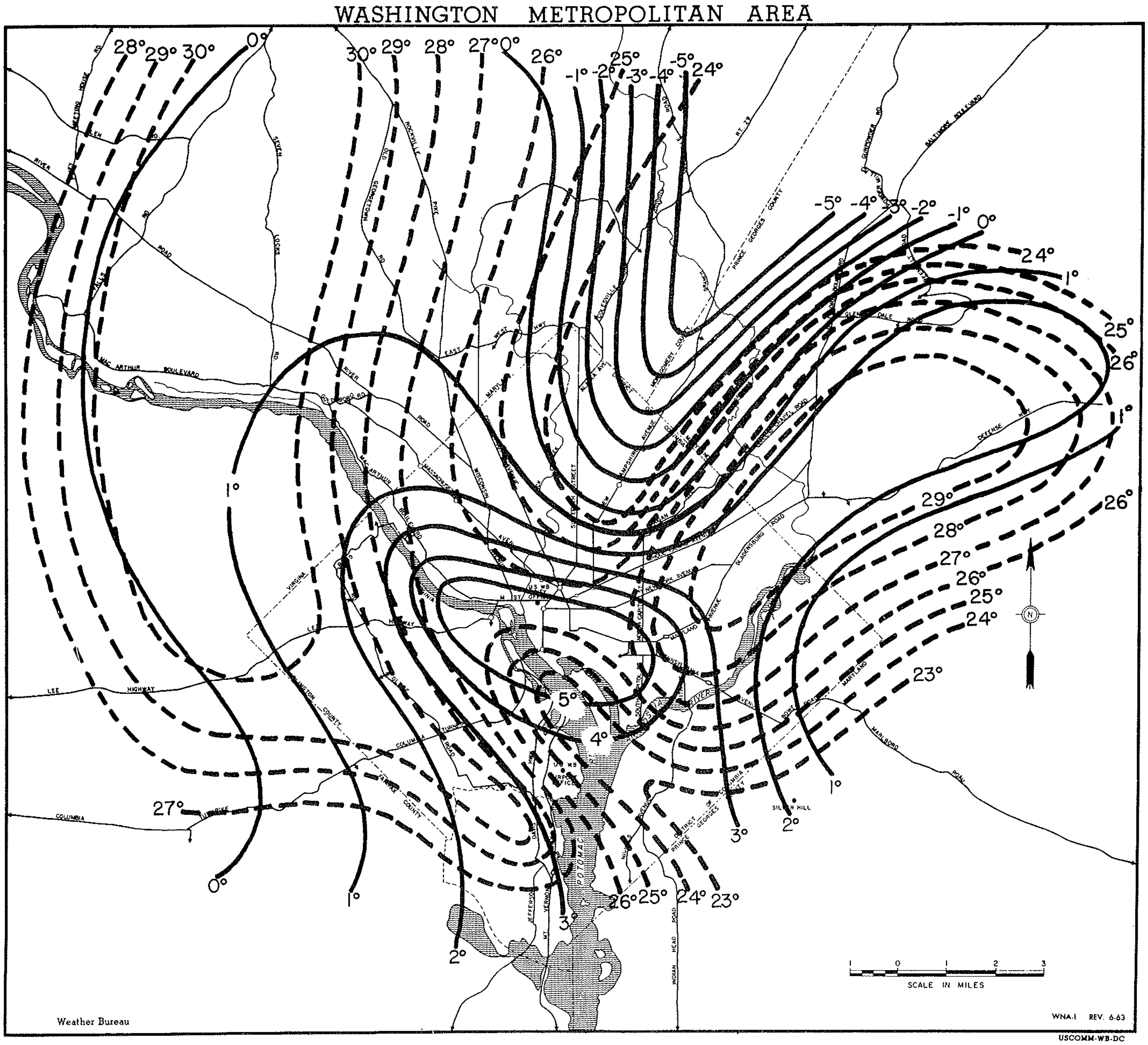

Figure 20. Temperature, °F., Coldest Day (Jan. 24, 1963)

WASHINGTON METROPOLITAN AREA

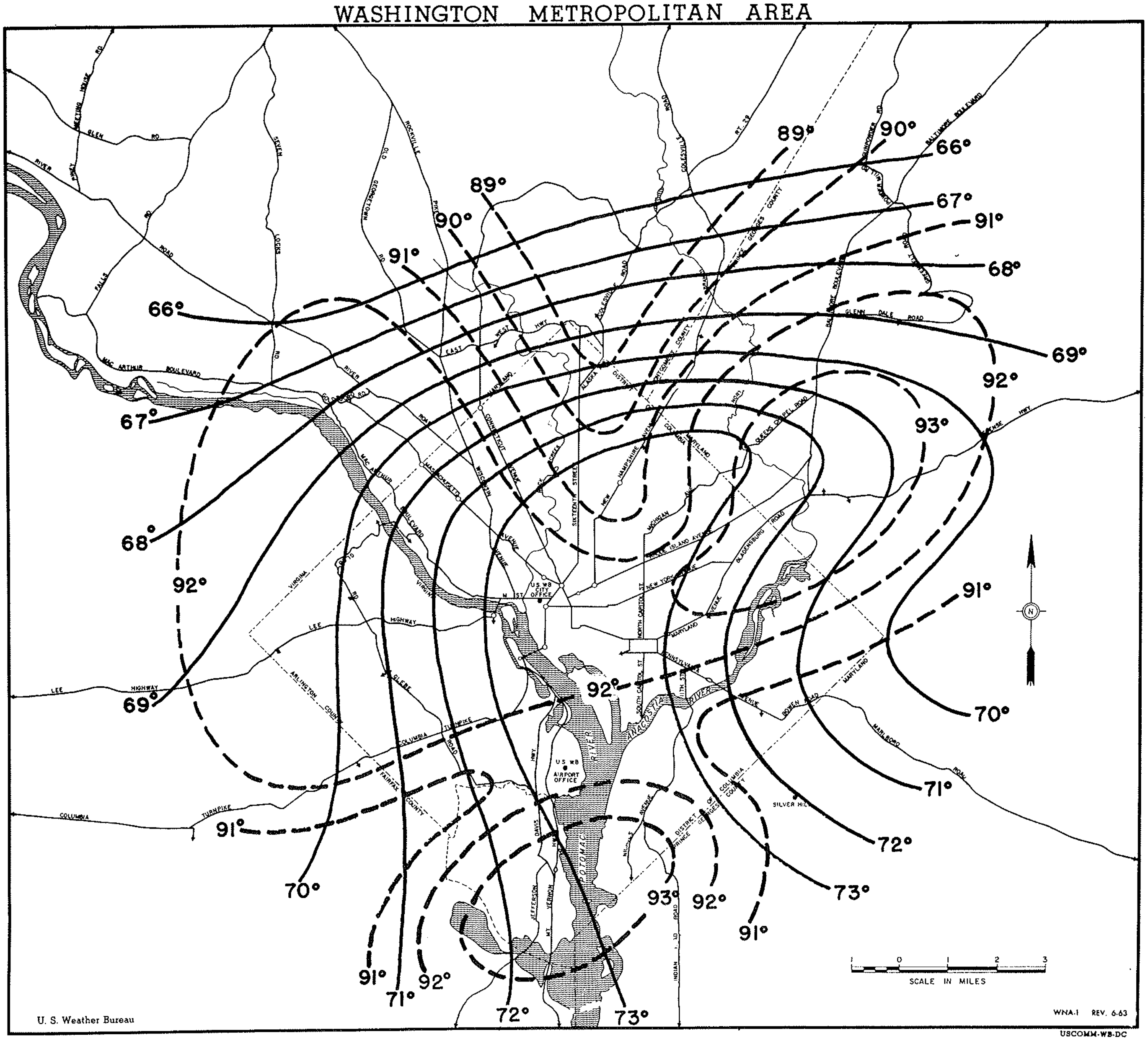

Figure 21. Temperature, °F., Warmest Month (July 1955)

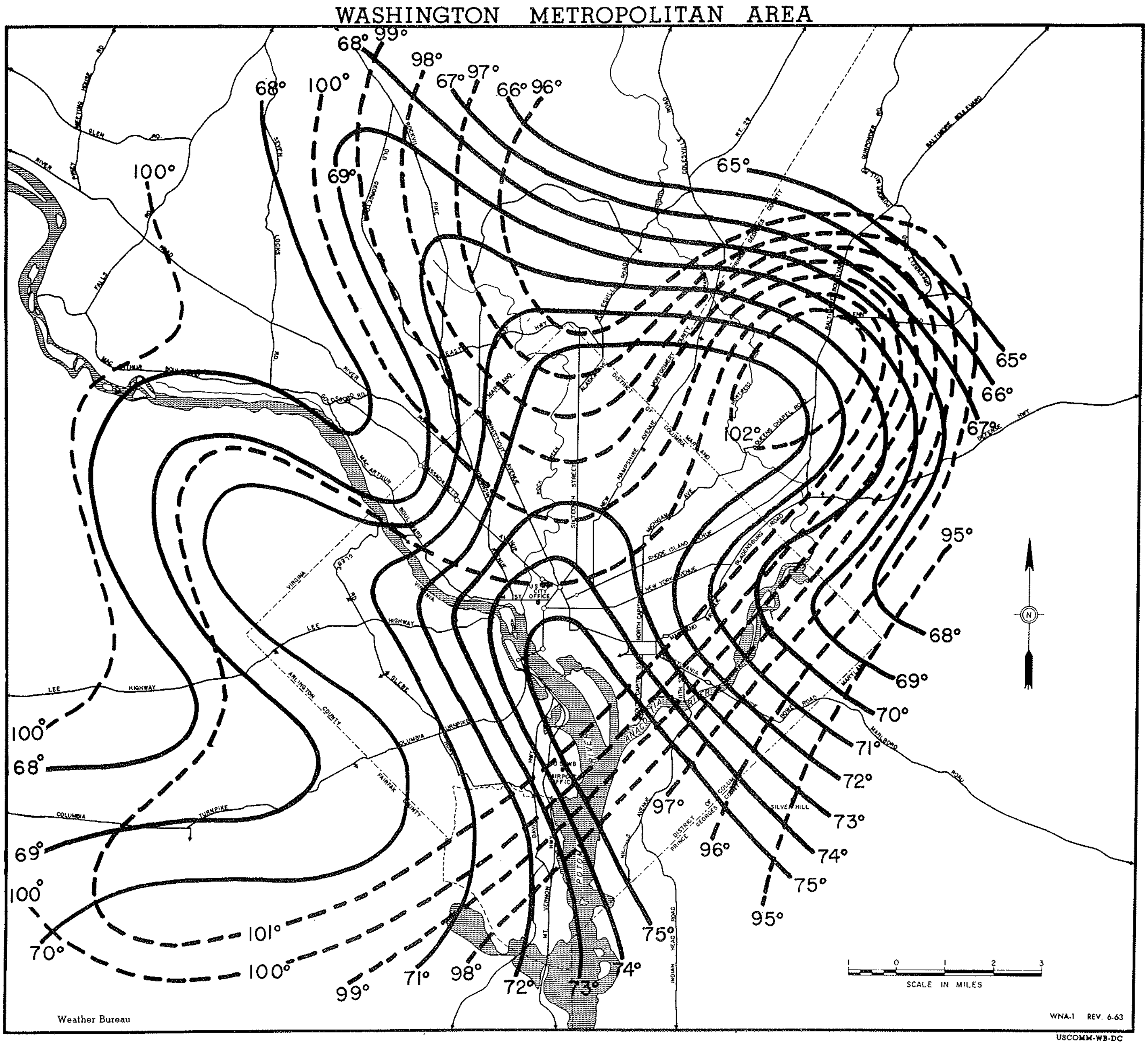

Figure 22. Temperature, °F., Warmest Day (July 3, 1966)

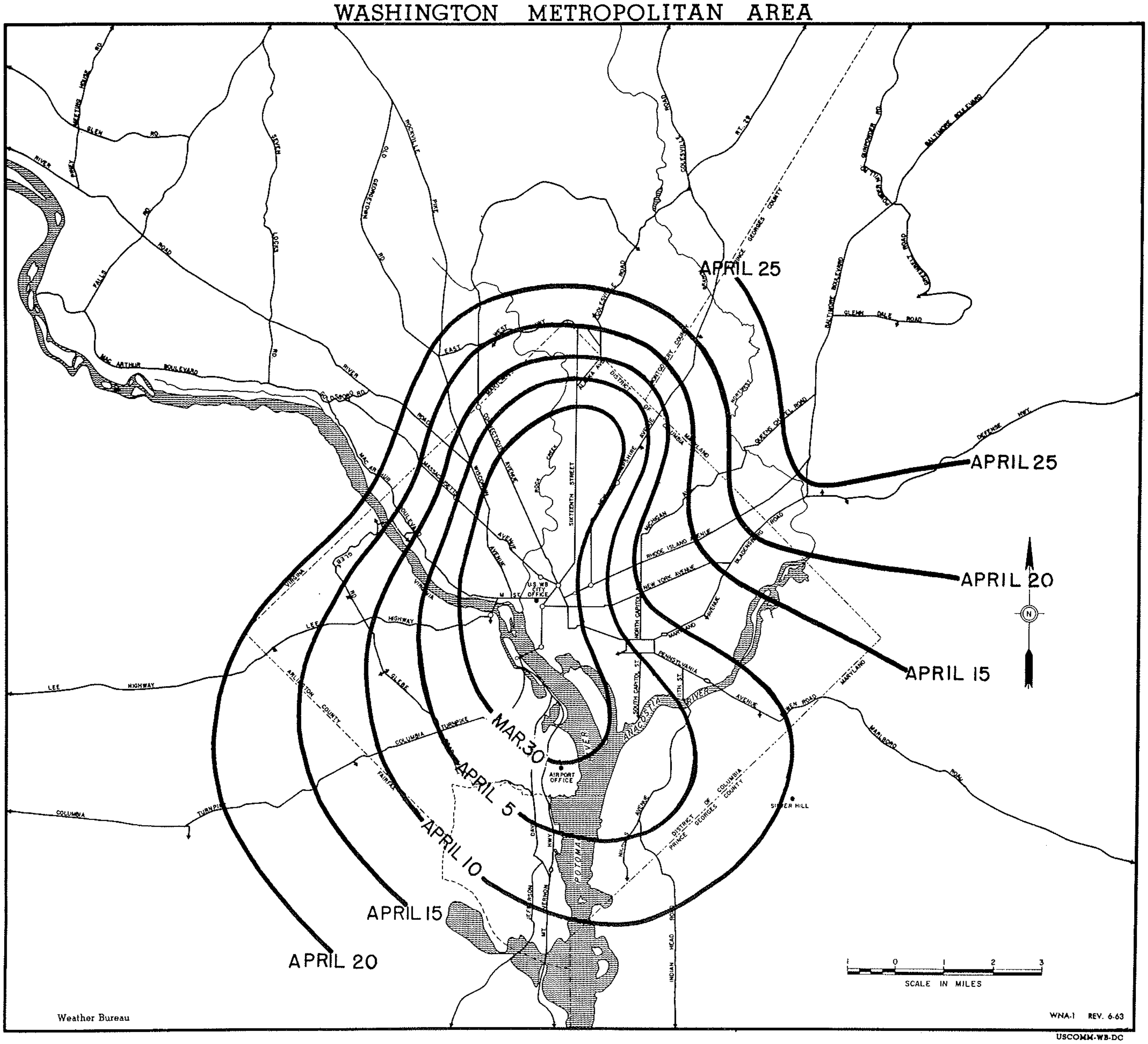

Figure 23. Average Date of Last Freezing Temperature in Spring

APPENDIX

WASHINGTON METROPOLITAN NETWORK STATIONS AND OBSERVERS MARCH 1968

Temperature and Precipitation Stations	Years Record	Name of Present Observer	Identification of Observer
Alexandria City Garage	20	Mr. F. R. Dishman	Employed by City of Alexandria
Alexandria Luray	14+	Mr. T. H. Lucas	Private Industry Employee
Andrews Air Force Base	20+	SSgt. H. J. Maille	U.S. Air Force Staff Sgt.
Arlington Club Manor	<2	C. H. Pals, DVM	Retired-Dept. of Agriculture
Bethesda	2+	Mr. W. A. Hass	ESSA-WB Employee
College Park	22+	Employee of USGS	U.S. Geological Survey
Dalecarlia Reservoir	22	Operator on Duty	U.S. Corps of Engineers- Filteration Plant
Fairfax	4	Mr. J. J. Herrmann	Student-Son of FAA Employee
Falls Church	22	Mr. W. K. Shoun	ESSA-WB Employee
Forest Glen	2+	Mr. D. M. Gales	ESSA-WB Employee
Greenbelt	21	Miss Sherry Snider	Student-Daughter of WB Employee
Langley	<2	Dr. J. M. Mitchell, Jr.	ESSA-EDS Employee
Lanham	10+	Mr. L. I. Benedict	Employed by Dept. of Agriculture
McLean	5+	Mr. R. A. Allen	ESSA-WB Employee
Melpar	<2	Mr. R. M. Whiting	Employed by Melpar Inc.
National Arboretum	22	Mr. F. P. Eshbaugh	Dept. of Agriculture, Nat'l Arboretum
Rockville, Woodley Gardens	2+	Mr. D. C. House, Jr.	Student-Son of ESSA-WB Employee
Silver Spring	<2	Dr. A. R. Barwick	Retired Prof. of Geology
Soldiers Home	23+	Mr. M. N. Groves	U.S. Soldier's Home Employee
Suitland	6+	Mr. W. H. Bartlett	ESSA-WB Employee
Viers Mill	<2	Mr. D. J. Foat	ESSA-WB Employee
Waverly Mills*	22+	Mr. & Mrs. H.L. Choate	Mr. Choate-Retired WB Employee
Washington Nat'l Airport	26+	Observer on Duty	ESSA-WB Official Synoptic Statio
Wheaton Park	7	Mr. S. G. Ernst	Park Naturalist-Md. Nat'l Capital Park & Planning Commission
<u>Precipitation Only</u>			
Alexandria Hemlock	<2	Mr. C. A. Woollum	ESSA-WB Employee
Annandale	<2	Mr. J. C. Hunter	ESSA-WB Employee
Ardmore	<2	Mr. D. G. Liddy	ESSA-WB Employee
Baileys X-Roads	<2	Mr. R. C. Schmidt	ESSA-WB Employee
Brookdale	21+	Mr. B. F. Dashiell	Retired-ESSA-WB Employee
Great Falls	<2	Mr. R. M. Denis	Owner Thistle Hill Nursery
Groveton	17+	Mr. W. A. Wood	ESSA-WB Employee
North Forestville	<2	Mr. K. W. Shaver	ESSA-WB Employee
Old Tilden Farm	<2	Dr. G. P. Cressman	Director-ESSA Weather Bureau
Oxon Hill	<2	Mr. C. L. Conway	ESSA-WB Employee
Temple Hills	<2	Mr. W. J. Moyer	ESSA-WB Employee
University Park	<2	Mr. G. C. Allen	ESSA-WB Employee
Vienna	<2	Mr. M. O. Swenson	Retired-ESSA WB Employee

*Closed 10/31/67

LIST OF EASTERN REGION TECHNICAL MEMORANDA
(Continued from inside front cover)

No. 25 Average Mixing Depths and Transport Wind Speeds Over Eastern United States in 1965. Marvin E. Miller. August 1967.

No. 26 The Sleet Bright Band. Donald Marier. October 1967.

No. 27 A Study of Areas of Maximum Echo Tops in the Washington, D.C. Area During the Spring and Fall Months. Marie Fellechner. April 1968.