TECHNICAL PUBLICATION SJ 88-3

RAINFALL ANALYSIS FOR NORTHEAST FLORIDA

PART VI: 24-HOUR TO 96-HOUR MAXIMUM RAINFALL FOR RETURN PERIODS 10 YEARS, 25 YEARS, AND 100 YEARS

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INTRODUCTION

Rainfall data is an essential element of basic data input to many hydrologic and engineering studies. Peak rainfall data are used in designing stormwater management systems and in determining the flooding potential of various storm events. Daily or hourly data are required in continuous hydrologic simulation procedures. Monthly and seasonal data are used in determining supplementary irrigation water requirements, and in engineering studies related to storage analyses, water supply, and reservoir management. The St. Johns River Water Management District (Figure 1) is responsible for management of the water resources of the District, which includes all or parts of nineteen counties in northeast Florida. The District makes extensive use of rainfall data in its consumptive use and MSSW (Management and Storage of Surface Waters) permit activities and in its hydrologic and engineering studies related to the preparation of surface water basin management plans. For example, in the District's consumptive use program, agricultural withdrawals are permitted based on certain monthly and/or seasonal drought conditions. With regard to the management and storage of surface waters permitting program, when certain thresholds are exceeded, various developments are required to satisfy certain conditions based on the 10- and 25-year maximum storm discharges and the 100-year flood elevation.

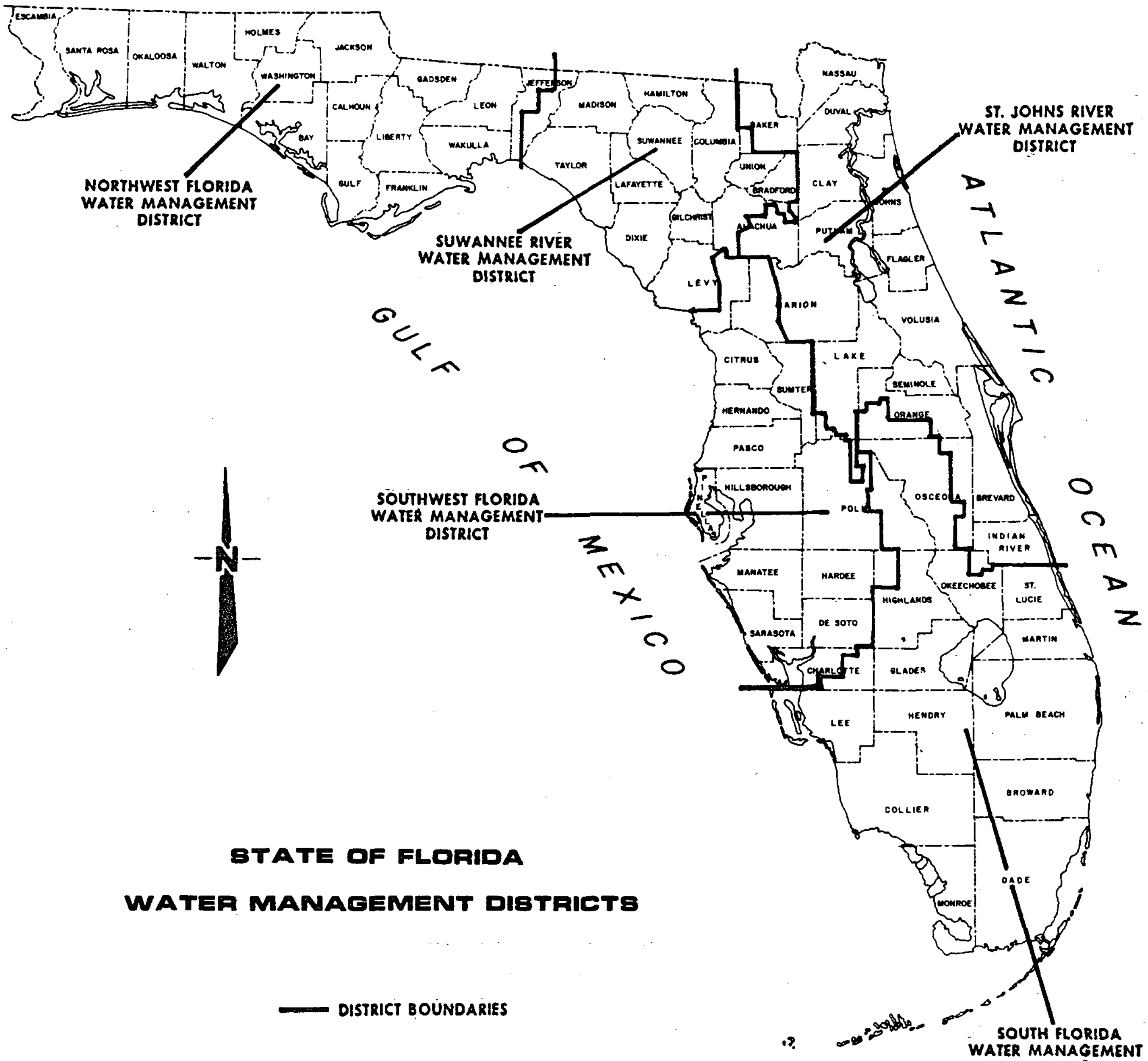

Figure 1: State of Florida Water Management Districts

This project, "Rainfall Analysis for Northeast Florida," has been undertaken to fulfill the needs of the District and to provide the same information to interested organizations and individuals. The project objective is the production of a series of reports, each based on the collection and detailed analyses of rainfall data and directed at a specific hydrologic/engineering study goal. The series consists of six reports. They are: (Part I) 24-Hour to Ten-Day Maximum Rainfall Data; (Part II) Summary of Monthly and Annual Rainfall Data; (Part III) Seasonal Rainfall Data; (Part IV) Frequency Analysis of Summer and Winter Rainfalls; (Part V) Frequency Analysis of Wet Season and Dry Season Rainfalls; and (Part VI) 24-Hour to 96-Hour Maximum Rainfall for Return Periods 10 Years, 25 Years, and 100 Years. The first three reports present basic rainfall data of specific nature, and the final three reports include the results of specific analyses. This report is Part VI of the series. (NOTE: Completion of Parts III, IV and V is scheduled for a future date. Therefore, these reports are not available at this time).

The National Oceanic and Atmospheric Administration, NOAA [formerly the U.S. Weather Bureau (through 1965) and the Environmental Sciences Services Administration (1965-1970)] has produced several publications presenting the results of regional and nationwide rainfall analyses. The publications widely used for obtaining maximum rainfall depths for different return periods are:

1. Technical Paper No. 40 (TP-40), "Rainfall Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 years (1961)";
2. Technical Paper No. 49 (TP-49), "Two-to Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States (1964)"; and
3. NOAA Technical Memorandum NWS HYDRO-35, "Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States (1977)."

Considerable additional rainfall data have accumulated since the publication of TP-40 and TP-49. Also, several new weather stations have been established throughout the District. This expanded data base can provide improved estimates of maximum rainfall depths compared to those obtained through TP-40 and TP-49. In this study, using the rainfall data currently available, generalized maximum rainfall charts are developed for northeast Florida. The durations and frequencies selected for the study are those which need to be evaluated in various permitting programs administered by the District.

MAXIMUM RAINFALL DATA

Part I of this rainfall analysis series (Technical Publication SJ 86-3) has presented annual maximum rainfall data for durations from 24 hours to 10 days for 46 six stations located in northeast Florida and southeast Georgia (Table 1,

Table 1. List of Principal Rain Gage Stations.

PRINCIPAL STATION AND COUNTY	NOAA NUMBER	SUPPLEMENTARY STATIONS
AVON PARK (HIGHLANDS)	0369	DESOTA CITY (S)
BARTOW (POLK)	0478	
BITHLO (ORANGE)	0758	CHRISTMAS (C)
BUSHNELL 2E. (SUMTER)	1163	
CLERMONT (LAKE)	1641	EVA (S)
CRESCENT CITY (PUTNAM)	1978	
DAYTONA BEACH AIRPORT (VOLUSIA)	2158	DAYTONA BCH (C,S), NEW SMYRNA BCH (S)
DELAND (VOLUSIA)	2229	ORANGE CITY (S)
FEDERAL POINT (PUTNAM)	2915	HASTINGS (S)
FELLSMERE (INDIAN RIVER)	2936	
FERNANDINA BCH (NASSAU)	2944	
FORT DRUM (OKEECHOBEE)	3137	
FT. PIERCE (ST.LUCIE)	3207	
GAINESVILLE (ALACHUA)	3321	GAINESVILLE UNIVERSITY (C,S), GAINESVILLE (NOAA 3326)(S)
GLEN ST. MARY (BAKER)	3470	
HART LAKE (ORANGE)	3840	
HIGH SPRINGS (ALACHUA)	3956	
INVERNESS (CITRUS)	4289	
ISLEWORTH (ORANGE)	4332	LAKE HIAWASSEE (S)
JACKSONVILLE AIRPORT (DUVAL)	4358	JACKSONVILLE CITY (C,S)
JACKSONVILLE BCH. (DUVAL)	4366	
JASPER (HAMILTON)	4394	
KISSIMMEE (OSCEOLA)	4625	KISSIMMEE FIELD STATION (C)
LAKE ALFRED EXP.STA. (POLK)	4707	WINTER HAVEN (S)
LAKE CITY (COLUMBIA)	4731	
LAKELAND WSO CI (POLK)	4797	
LISBON (LAKE)	5076	EUSTIS (C), LEESBURG (S)
LYNNE (MARION)	5237	
MARINELAND (FLAGLER)	5391	
MELBOURNE (BREVARD)	5612	
MOUNTAIN LAKE (POLK)	5973	BABSON PARK (S)
NITTAW (OSCEOLA)	6251	KENANSVILLE FORESTRY TOWER (C)*, HOLOPAW (S)
OCALA (MARION)	6414	OCALA AIRPORT (S)
OKEECHOBEE (OKEECHOBEE)	6485	OKEECHOBEE 9W (S)
ORLANDO WSO MCCOY (ORANGE)	6628	ORLANDO (C), ORLANDO WATER PLANT (S)
PALATKA (PUTNAM)	6753	
RAIFORD ST. PRISON (BRADFORD)	7440	
ST. AUGUSTINE R.TWR (ST.JOHNS)	7826	ST. AUGUSTINE (C,S)
SANFORD EXP. STA. (SEMINOLE)	7982	SANFORD (C)
STARKE (BRADFORD)	8527	CAMP BLANDING (C)
STUART INLET (MARTIN)	8620	
TITUSVILLE (BREVARD)	8942	MERRITT ISLAND (S)
USHER TOWER (LEVY)	9120	
VERO BCH. (INDIAN RIVER)	9219	VERO BEACH AIRPORT (C)
GEORGIA STATIONS		
BRUNSWICK	1340	BRUNSWICK FAA AP (S)
FOLKSTON 9SW	3465	HILLIARD (C,S), FOLKSTON 3SW (S)

(C) - DATA COMBINED WITH PRINCIPAL STATION DATA
(S) - PRINCIPAL STATION MAXIMUM RAINFALL WAS SUBSTITUTED BY THE SUPPLEMENTARY STATION MAXIMUM RAINFALL IF THE LATTER WAS GREATER
* - MAINTAINED BY THE FLORIDA STATE DIVISION OF FORESTRY

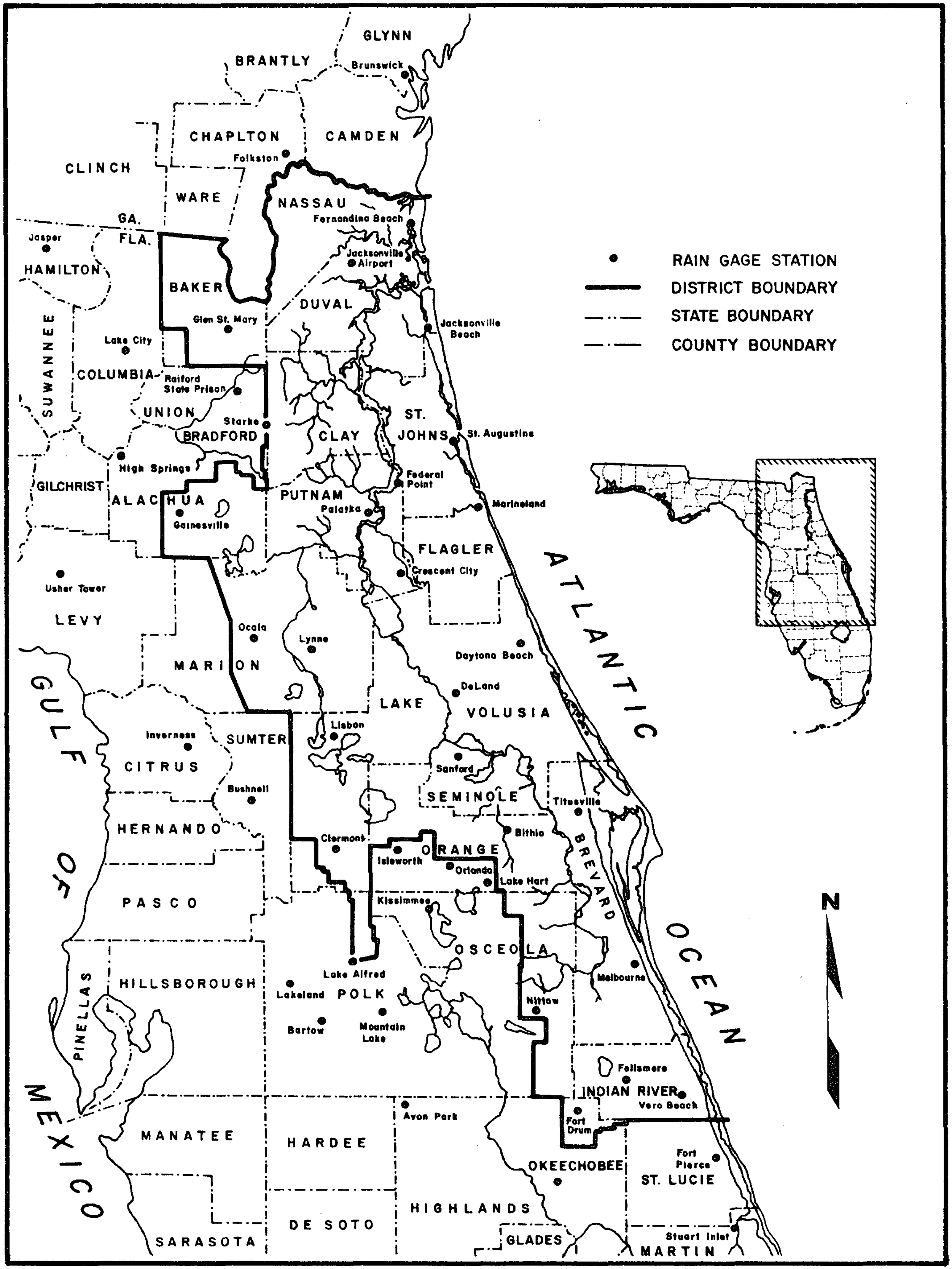

Figure 2. Location of Principal Rain Gage Stations.

Figure 2). Two stations from southeast Georgia are included in the study to facilitate smoother extension of isopluvial lines (lines representing equal rainfall values). In compiling this data, 77 rain gage stations in operation in this region between 1931 and 1983 were originally considered. The forty-six stations mentioned were identified as principal stations. Other stations were omitted because either they had short records or were discontinued. However, data from these stations also were used to supplement and/or extend data at a nearby principal station. Details of various adjustments made to the data and procedures used in evaluating maximum rainfall data appear in Technical Publication SJ 86-3 (Rao and Clapp, 1986). Table 2 presents maximum observed rainfall (since 1914) at principal rain gage stations.

FREQUENCY ANALYSIS

The estimates of maximum rainfall depths for different return periods (T) are obtatined by the statistical technique of frequency analysis. If P is the annual exceedance probability of a maximum event, the return period for the event is given by T = 1/P. Thus, the analysis consists of determining maximum rainfall depths associated with several P values of interest. The common technique consists of choosing an appropriate probability distribution and fitting it to sample data by one of the available statistical procedures. The sample data in this type of analysis consists of the annual series of maximum rainfall

Table 2. Maximum Observed Rainfall at Principal Rain Gage Stations.

PRINCIPAL STATION AND COUNTY	NOAA NUMBER	RAINFALL DURATION 24 HR	48 HR	72 HR	96 HR	5 DAY	10 DAY
AVON PARK (HIGHLANDS)	0369	10.15	10.66	10.79	14.49	15.17	16.74
BARTOW (POLK)	0478	12.91	14.13	14.71	15.21	15.37	15.63
BITHLO (ORANGE)	0758	12.05	12.81	13.45	13.54	13.54	15.36
BUSHNELL 2E. (SUMTER)	1163	11.68	13.96	14.66	14.92	14.94	16.32
CLERMONT (LAKE)	1641	14.77	17.57	17.75	17.75	17.78	18.46
CRESCENT CITY (PUTNAM)	1978	10.34a	11.60a	12.53a	12.92a	13.06a	15.37a
DAYTONA BEACH AIRPORT (VOLUSIA)	2158	21.98b	23.53b	23.80b	26.50b	29.33b	36.45b
DELAND (VOLUSIA)	2229	9.25	11.89a	13.49a	14.92a	15.74a	19.04a
FEDERAL POINT (PUTNAM)	2915	8.21c	10.28d	11.10d	11.58d	11.85d	12.33d
FELLSMERE (INDIAN RIVER)	2936	12.83	14.66	14.78	14.98	15.45	16.74
FERNANDINA BCH (NASSAU)	2944	22.22	22.50	22.63	22.65	23.57	27.22
FORT DRUM (OKEECHOBEE)	3137	9.85	11.69	13.82	14.75	15.34	16.11
FT. PIERCE (ST.LUCIE)	3207	10.16	10.42	10.60	12.06	12.76	14.51
GAINESVILLE (ALACHUA)	3321	7.55	9.82	10.92	11.22	11.30	12.73
GLEN ST. MARY (BAKER)	3470	9.27	11.82	13.86	14.25	14.29	14.29
HART LAKE (ORANGE)	3840	10.58	11.28	12.95	14.60	14.65	15.45
HIGH SPRINGS (ALACHUA)	3956	7.67	9.81	11.37	12.15	12.38	14.68
INVERNESS (CITRUS)	4289	11.10	14.33	15.44	15.66	15.78	16.64
ISLEWORTH (ORANGE)	4332	10.25	11.05	11.31	12.01	12.01	13.03
JACKSONVILLE AIRPORT (DUVAL)	4358	10.75	13.25	14.87	15.28	15.35	16.81
JACKSONVILLE BCH. (DUVAL)	4366	10.79	13.80	14.83	15.31	15.39	16.14
JASPER (HAMILTON)	4394	10.38	10.50	11.71	14.69	15.59	18.25
KISSIMMEE (OSCEOLA)	4625	15.23	16.26	16.28	16.38	16.44	16.96
LAKE ALFRED EXP.STA. (POLK)	4707	12.45	13.95	14.92	16.15	16.51	17.79
LAKE CITY (COLUMBIA)	4731	7.02	10.33	11.90	12.08	12.10	12.45
LAKELAND WSO CI (POLK)	4797	10.42	12.26	12.77	12.97	12.98	13.31
LISBON (LAKE)	5076	9.18	11.99	13.01	13.31	13.37	13.94
LYNNE (MARION)	5237	12.35	13.99	15.41	15.63	15.63	15.63
MARINELAND (FLAGLER)	5391	14.63	15.45	15.55	15.55	15.55	17.84
MELBOURNE (BREVARD)	5612	8.28	10.99	12.24	12.84	13.04	13.34
MOUNTAIN LAKE (POLK)	5973	12.78e	13.66e	14.30e	14.46	14.57	17.81
NITTAW (OSCEOLA)	6251	12.72	13.60	13.67	13.67	13.67	16.52
OCALA (MARION)	6414	11.74	13.71	15.38	15.62	15.62	15.62
OKEECHOBEE (OKEECHOBEE)	6485	9.55	10.11	11.28	11.95	12.03	12.77
ORLANDO WSO MCCOY (ORANGE)	6628	9.41	12.63	14.01	14.19	14.19	14.20
PALATKA (PUTNAM)	6753	11.86	14.58	16.81	18.24	18.38	18.62
RAIFORD ST. PRISON (BRADFORD)	7440	9.21	10.45	13.01	13.75	13.75	13.75
ST. AUGUSTINE R.TWR (ST.JOHNS)	7826	14.34d	18.43d	19.64d	20.25d	20.67d	21.79d
SANFORD EXP. STA. (SEMINOLE)	7982	9.12	9.52a	9.82	10.00	11.58	13.37
STARKE (BRADFORD)	8527	6.89	10.80	12.49	12.72	12.77	13.15
STUART INLET (MARTIN)	8620	12.92	15.47	15.53	15.57	15.57	15.57
TITUSVILLE (BREVARD)	8942	11.99	13.30	14.35	15.05	16.62f	18.78f
USHER TOWER (LEVY)	9120	12.25	14.41	15.27	15.42	15.42	15.89
VERO BCH. (INDIAN RIVER)	9219	9.45	10.83	11.55	12.14	12.23	15.26
GEORGIA STATIONS							
BRUNSWICK (GLYNN)	1340	12.44	15.53	16.24	16.45	16.50	21.02
FOLKSTON 9SW (CHAPLTON)	3465	9.74	11.48	12.88	13.49	14.14	15.62

a - OCT 1924; b - NEW SMYRNA BEACH, OCT 1924; c - HASTINGS, 1929; d - 1920; e - 1928; f - MERRITT ISLAND, OCT 1924.

values, i.e., the largest single events occurred within each reference year (calendar year, water year, or any other consecutive 12-month period).

Frequency analysis also may be conducted using partial-duration series data, i.e., all values above a base (normally the smallest maximum annual event) regardless of how many occur in the same year provided they are independent. This analysis, however, is laborious and more complex. As a result, most investigators prefer performing their analyses using annual series data (e.g., TP-40, TP-49, and NWS HYDRO-35). Results equivalent to partial-duration series are then obtained by conversion factors. For maximum rainfall events, Hershfield (1961) derived the following factors for converting annual series to equivalent partial-duration series.

Return Period (yr)	Factor
2	1.13
5	1.04
10	1.01
25	1.00
100	1.00

The preceding factors show that the two series of data provide practically equivalent results for T = 10 yr or greater. If a facility has to be designed for more frequent rainfall events (T = 2 yr or 5 yr) partial-duration series will give a conservative (higher) design estimate. In this study annual series data presented in publication SJ 86-3 are used for frequency analysis.

Several probability distributions have been used to determine the frequencies of hydrologic variables (Chow, 1964; Markovic, 1965; Matalas, 1963). These vary in complexity from the simple two-parameter Gumbel distribution (1958) to the five-parameter Wakeby distribution (Houghton, 1978). A distribution widely used in precipitation analysis is the extreme value type I distribution using a fitting procedure suggested by Gumbel (the Gumbel Method). This distribution, however, has some properties which are not hydrologically appealing. It inherently has a constant skewness coefficient (CS = 1.14) and its lower bound extends to $-\infty$. Several rainfall samples can be found with CS substantially different from 1.14. Further, extension of the Gumbel density curve to $-\infty$ implies the existence of negative data. Investigations have shown that these unconformities between real data and the data from the Gumbel distribution lead to biased results when the Gumbel distribution is used to predict precipitation events (Rao, 1981). Gumbel's suggested fitting procedure was also found to be misleading. Therefore, the use of the method was discouraged by Lettenmaier and Burges (1982).

The Log Pearson type 3 distribution, a more flexible (three-parameter) distribution than the Gumbel, is selected for this study. For each station, the estimates of 10 yr, 25 yr and 100 yr maximum rainfall depths for different durations are obtained by fitting the Log Pearson Type 3 distribution to data by the logarithmic moments method and the Method of Mixed Moments-I (MXM1). Reliance is placed on the results given by MXM1 because this method has been found to possess superior statistical properties (Rao, 1980, 1983).

For some stations the highest observed value is found to be an outlier, i.e., a value markedly different in magnitude from the remaining data (e.g., Daytona Beach Airport and Fernandina Beach, Table 1). In such cases, the available daily and all monthly records prior to the period of analysis (1931-1983) were examined to determine if that value was the largest event in a much longer period than the period of analysis. For example, records at Fernandina Beach started in 1902. The highest monthly rainfall recorded prior to 1931 was 20.2 inches. From this it is inferred that the values shown in Table 1 are the maximum events since 1902 for Fernandina Beach. Based on such information the log Pearson type 3 frequency curve is historically adjusted as described in Bulletin #17B of the Hydrology Subcommittee, Interagency Advisory Committee on Water Data (Reference No.3, 1982).

As mentioned in Part I of this series (Technical Publication SJ 86-3), data prior to 1931 were not included in compiling the annual series of data because of the voluminous task involved. However, data on all major storm events which occurred during 1914-1930 are included in the analysis. These data are obtained from the Weather Bureau climatological data publications available through the University of Florida. The analysis is similar to the historic frequency curve adjustment mentioned in the foregoing paragraph. Assume that major storm events occurred in four years during 1914-1930 at a certain station. Data for these four years are added to the existing sample (1931-1983). The largest value in the combined sample is compared with monthly data prior to 1914. Suppose, the largest value exceeded all monthly values for 1895-1913. Then, depending on the magnitudes, one to three highest values from the combined sample are regarded as the highest during the historic period of 1895-1983 and the frequency curve is adjusted accordingly. Appendix A presents the estimates of 10 yr, 25 yr, and 100 yr maximum rainfall depths for the 46 rain gage stations selected for this study. These results are presented for information only. The design T-year values should be obtained from (or selected in conjunction with) the isopluvial maps presented in this publication.

ISOPLUVIAL MAPS

Drawing isopluvial lines through a field of rainfall frequency data is similar to, but not exactly same as drawing contour maps for a land surface area from topographic survey data. Using data from all individual stations will give rise to a complicated pattern of several local minima and maxima which is an incorrect way of interpreting rainfall data. Individual station T-year values are derived from a small sample of rainfall population. When the orographic influence is absent, as in the present study area, the occurrence of heavy rainfall has a random component and the estimated T-year values at individual stations are subject to sampling errors. Within the same climatic cell (conceptually a few square miles to several square miles) some areas are expected to experience more extreme events than others during the data period. As a result, all precipitation-frequency maps are constructed through use of space-averaging techniques (Frederick et al., 1977).

In the present study two approaches are tried to construct isopluvial maps. In the first method, a computer program is developed to average spatially distributed values by the inverse distance square principle. The study region is divided into a grid at 0.25 degree latitude and longitude intervals. The program generates rainfall values for each grid point from the values at the specified number of nearest rain gage stations using the inverse distance square principle. Three sets of data were generated for the grid points by averaging rainfall from the nearest, 2 stations, 4 stations, and 6 stations. Isopluvial maps are drawn from these data by the District developed MCONTOUR program. In general, these maps greatly obscured the general maximum rainfall trends which are apparent from an inspection of the station data plots. The major contributing factor for this over-smoothing of results appears to be an uneven distribution of rain gage stations. Some of these stations appear as clusters while there are areas where the station distribution is very sparse (Fig. 2). Isopluvial plots produced by this method are discarded since they are found to be unsatisfactory.

In the second method simple areal averaging is done for groups of stations. Stations which are closely located to each other are grouped together (e.g., Isleworth, Orlando, Lake Hart, and Kissimmee, Fig. 2). In addition, if the average T-year rainfall for stations forming a polygon appear to be realistic representations of rainfall for the area covered by the polygon then those stations also are grouped together. Jacksonville Beach, Jacksonville Airport, Fernandina Beach, and Brunswick (Fig. 2) are stations grouped this way. The arithmetic average of T-year rainfall for the group is computed and assigned to one of the stations in the group. This approach provided twenty well distributed rainfall locations for northeast Florida.

Isopluvial lines are initially drawn by a Tektronics plotter using the MCONTOUR program mentioned earlier. The Tektronix plots are manually smoothed and extended/adjusted where necessary to produce the final isopluvial maps. Figures 3 through 14 present these maps for mean annual, 10 yr, 25 yr, and 100 yr maximum rainfall for durations 24 hr, 48 hr and 96 hr.

COMPARISON WITH TP-40 AND TP-49

Appendix B presents selected isopluvial maps for Florida extracted from TP-40 and TP-49. These maps indicate an increasing trend in rainfall maximums from the interior peninsular Florida to the coastal areas. The pan-handle, the Tampa Bay area and southeastern Florida are subject to heavy rainfall. On the eastern half of peninsular Florida rainfall maximums progressively increase in the southeastern direction. While these rainfall trends are generally preserved in the present study, the southeastern portion of the District, i.e., the region south of Titusville, is in some contrast with TP-40/TP-49 trends. This result occurred because of the greater resolution provided by this study (to rainfall trends). While the coastal stations from

Brunswick to Titusville experienced similar heavy rainfall incidence, the stations south of Titusville (within and close to the District) experienced lower incidence. These local minima are obscured by the general trends developed in TP-40/TP-49.

For 25 yr and 100 yr return periods, the rainfall depths given by the isopluvial maps presented in this publication are higher compared to TP-40/TP-49 for most of the study area. The occurrence of several severe storm events in the region since the completion of TP-40/TP-49 studies, which are based on rainfall data through 1957/1958, may be the major contributing factor for the revision in the maximum rainfall depths.

DESIGN STORM DISTRIBUTION

The rainfall values provided in this publication are total depths for 24 hr, 48 hr, and 96 hr durations. For application in various storm water management analyses a knowledge of time distribution of this rainfall within the total storm duration is essential and will be discussed in a separate report.

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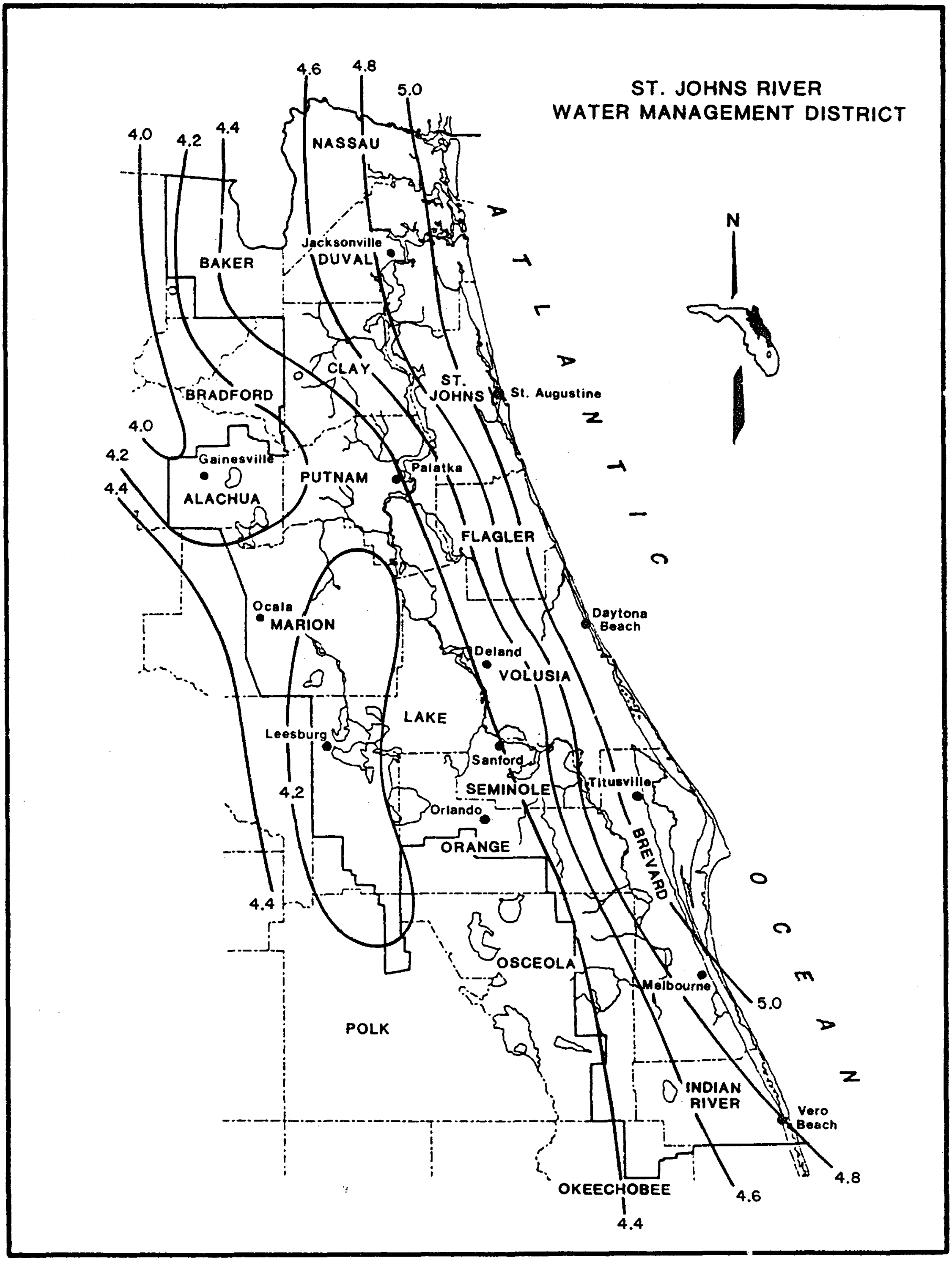


Figure 3. Mean Annual 24-Hour Maximum Rainfall for Northeast Florida, Inches.

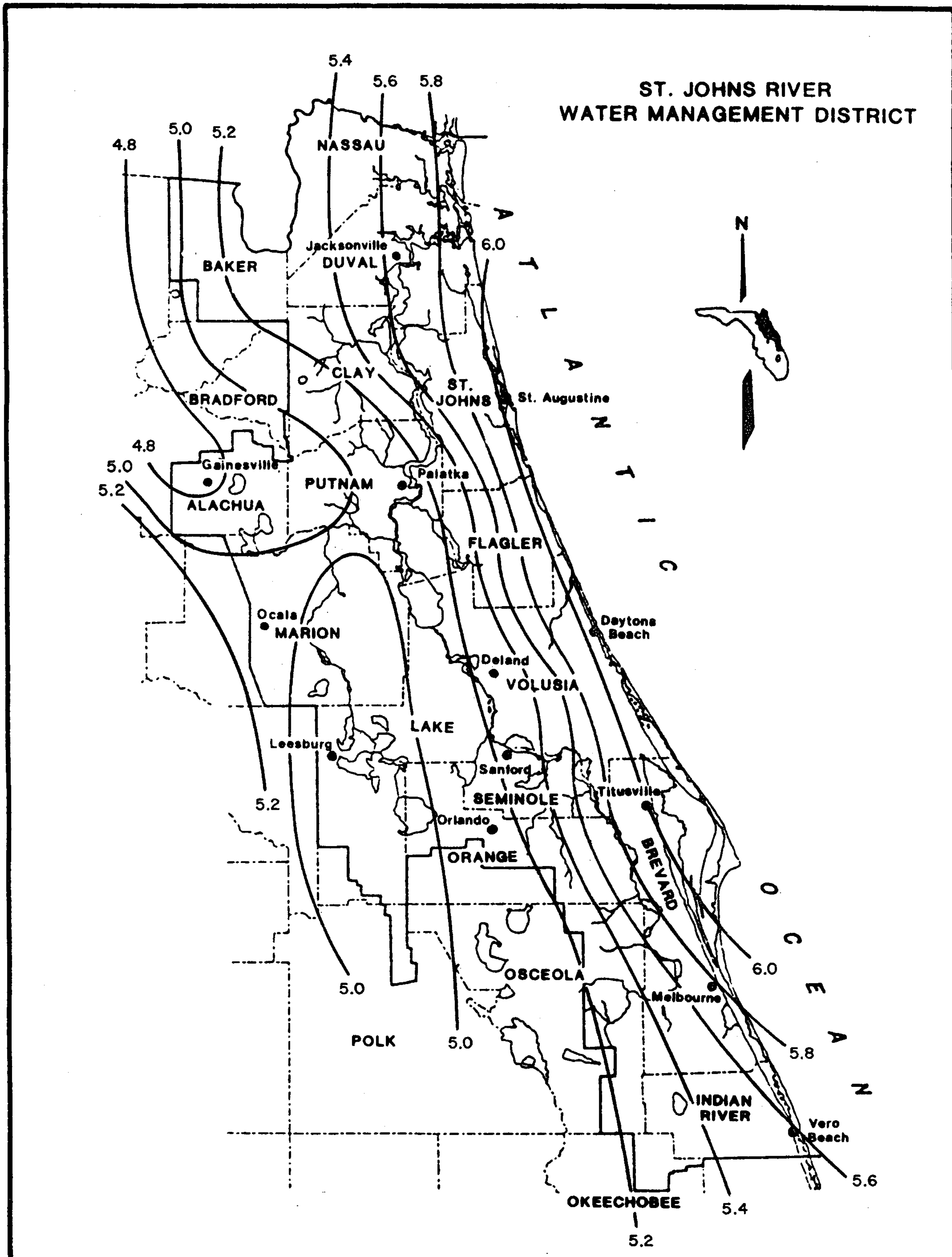


Figure 4. Mean Annual 48-Hour Maximum Rainfall for Northeast Florida, Inches.

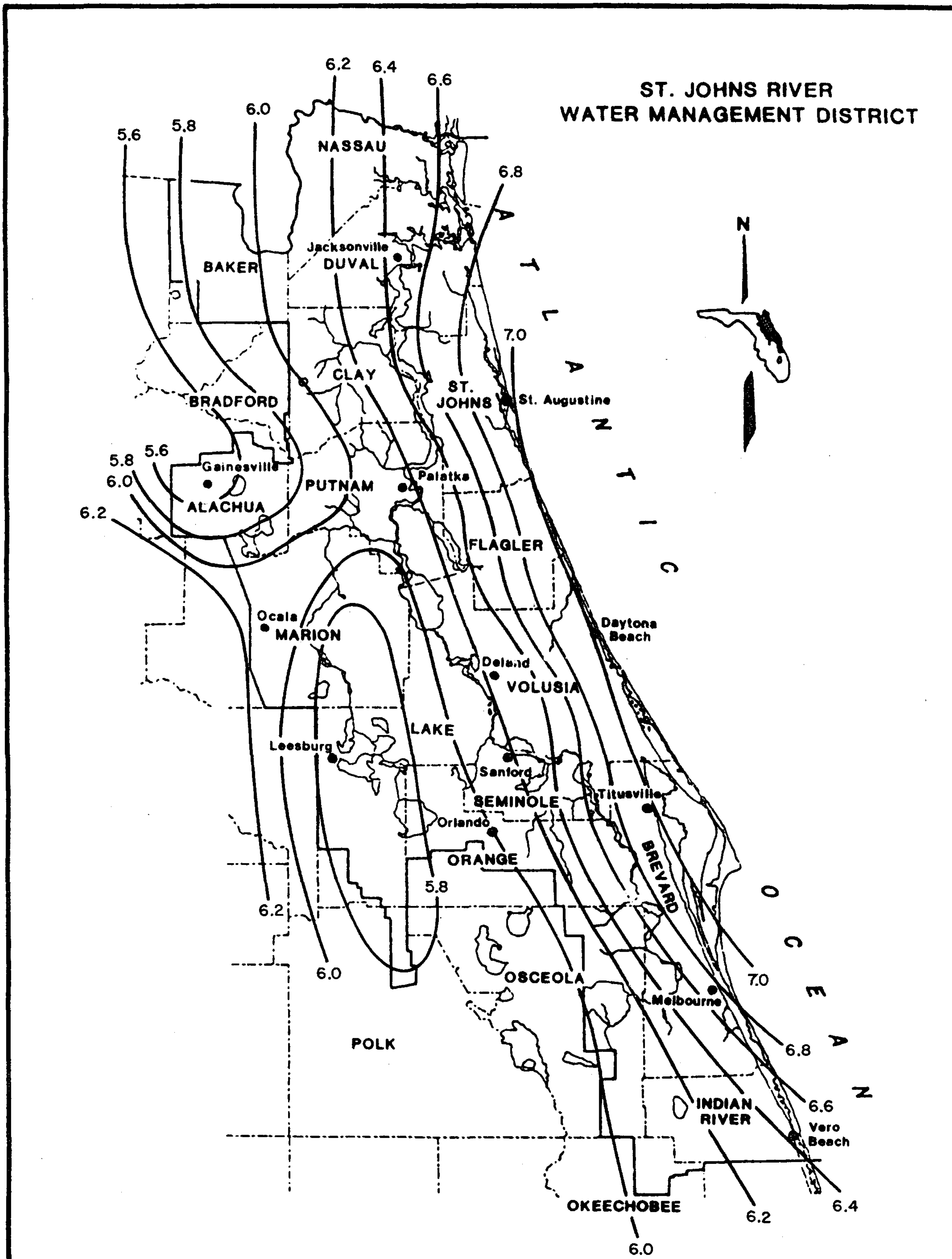


Figure 5. Mean Annual 96-Hour Maximum Rainfall for Northeast Florida, Inches.

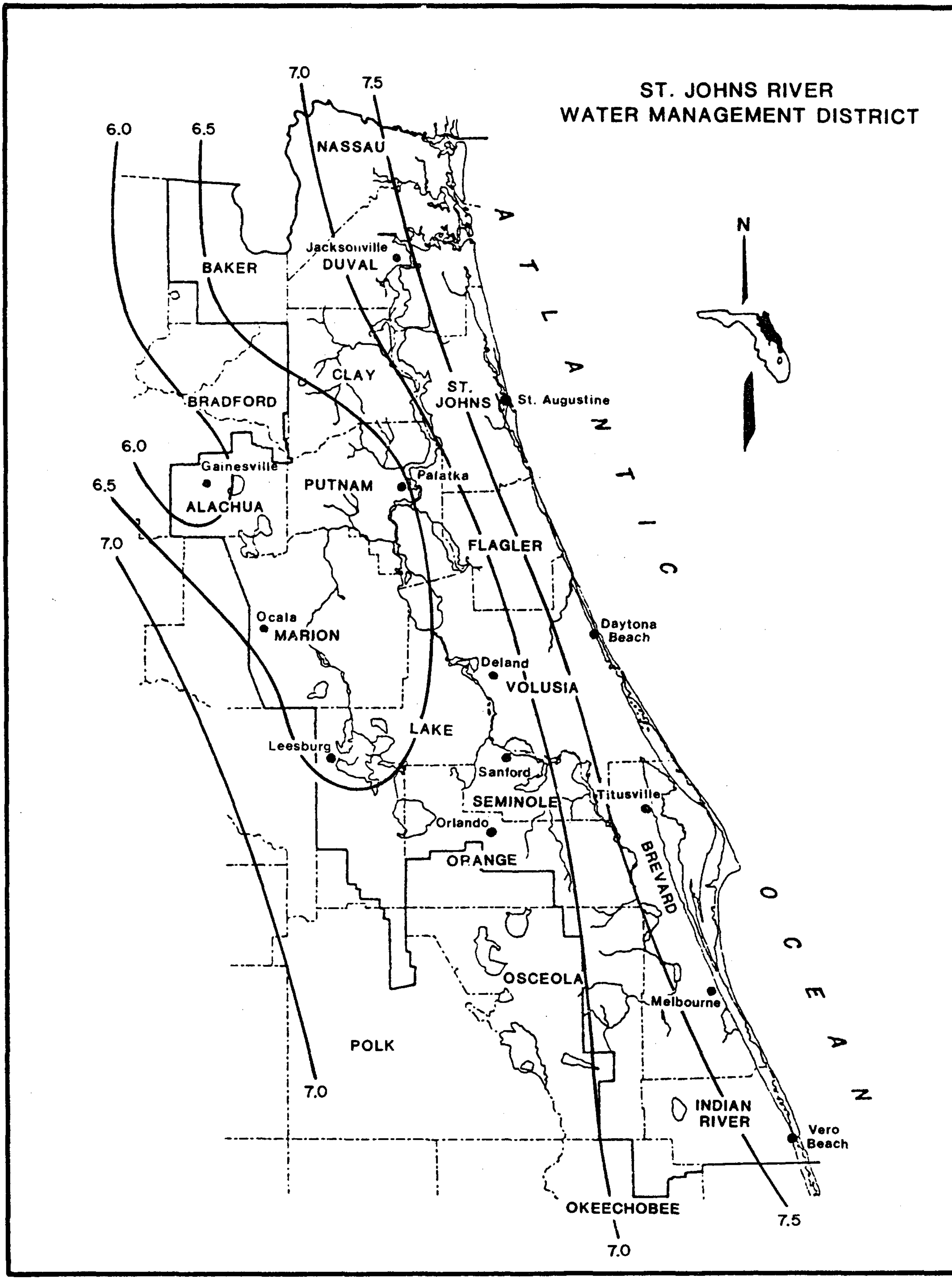


Figure 6. 10-Year 24-Hour Maximum Rainfall for Northeast Florida, Inches.

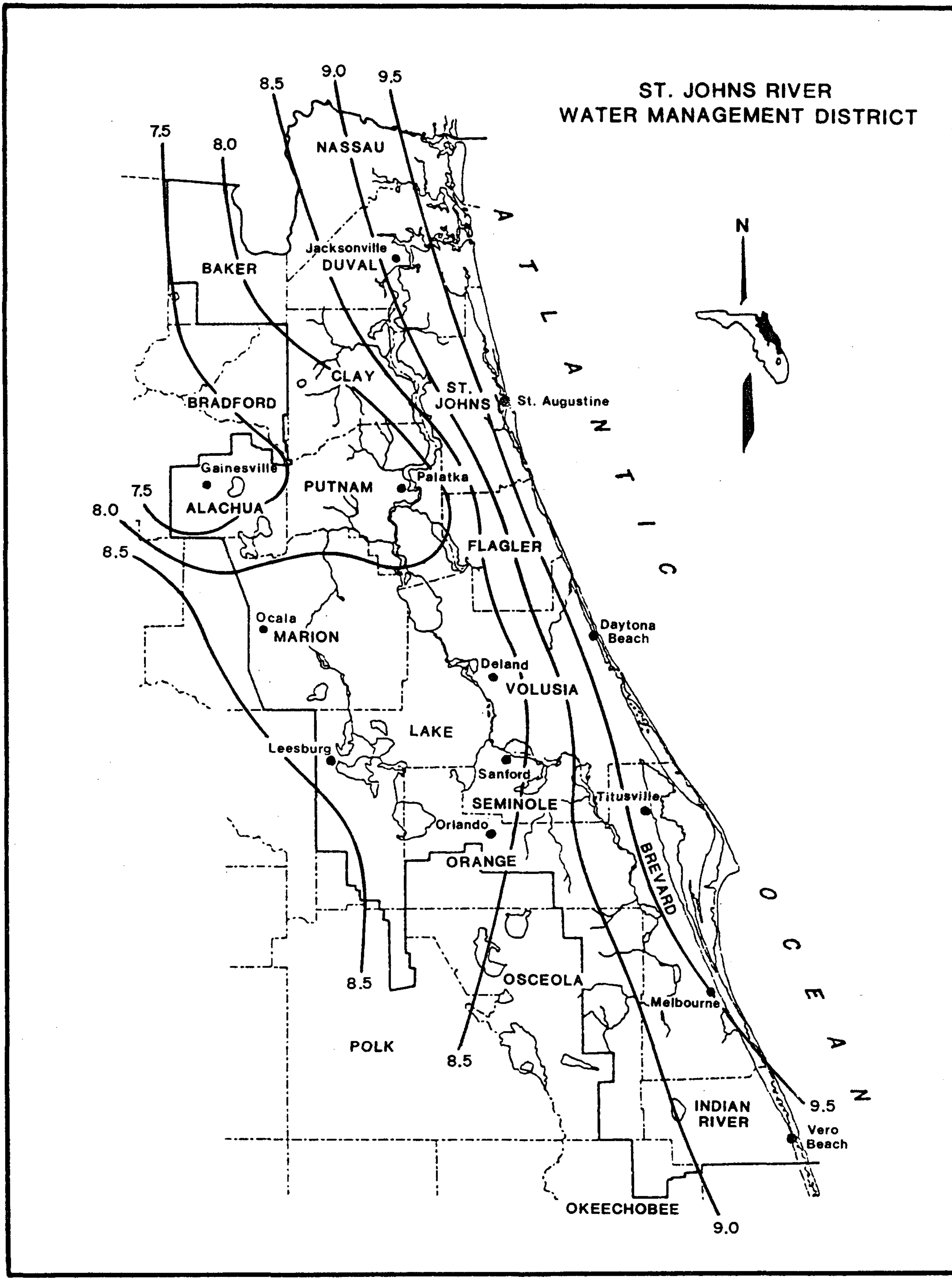


Figure 7. 25-Year 24-Hour Maximum Rainfall for Northeast Florida, Inches.

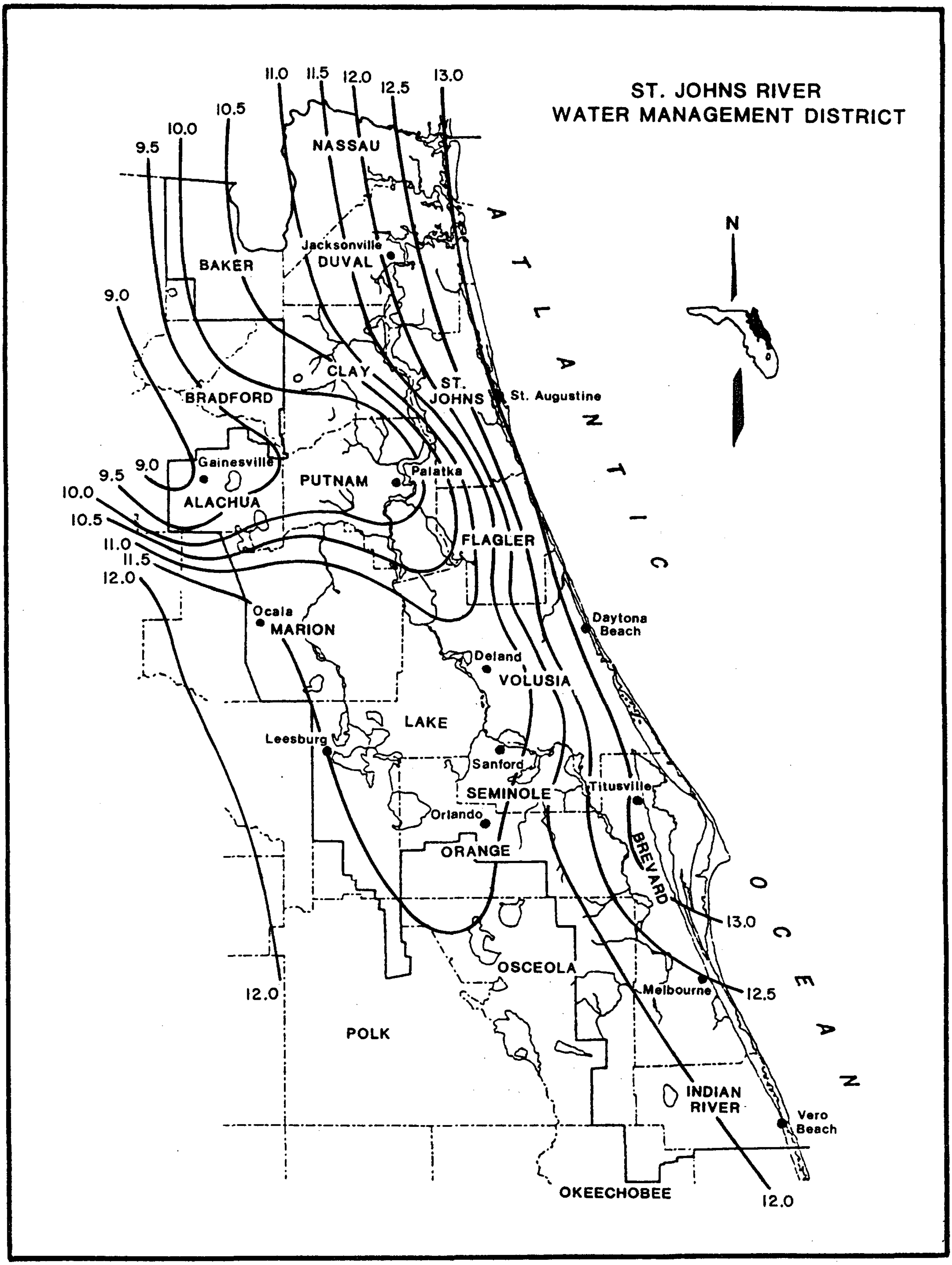


Figure 8. 100-Year 24-Hour Maximum Rainfall for Northeast Florida, Inches.

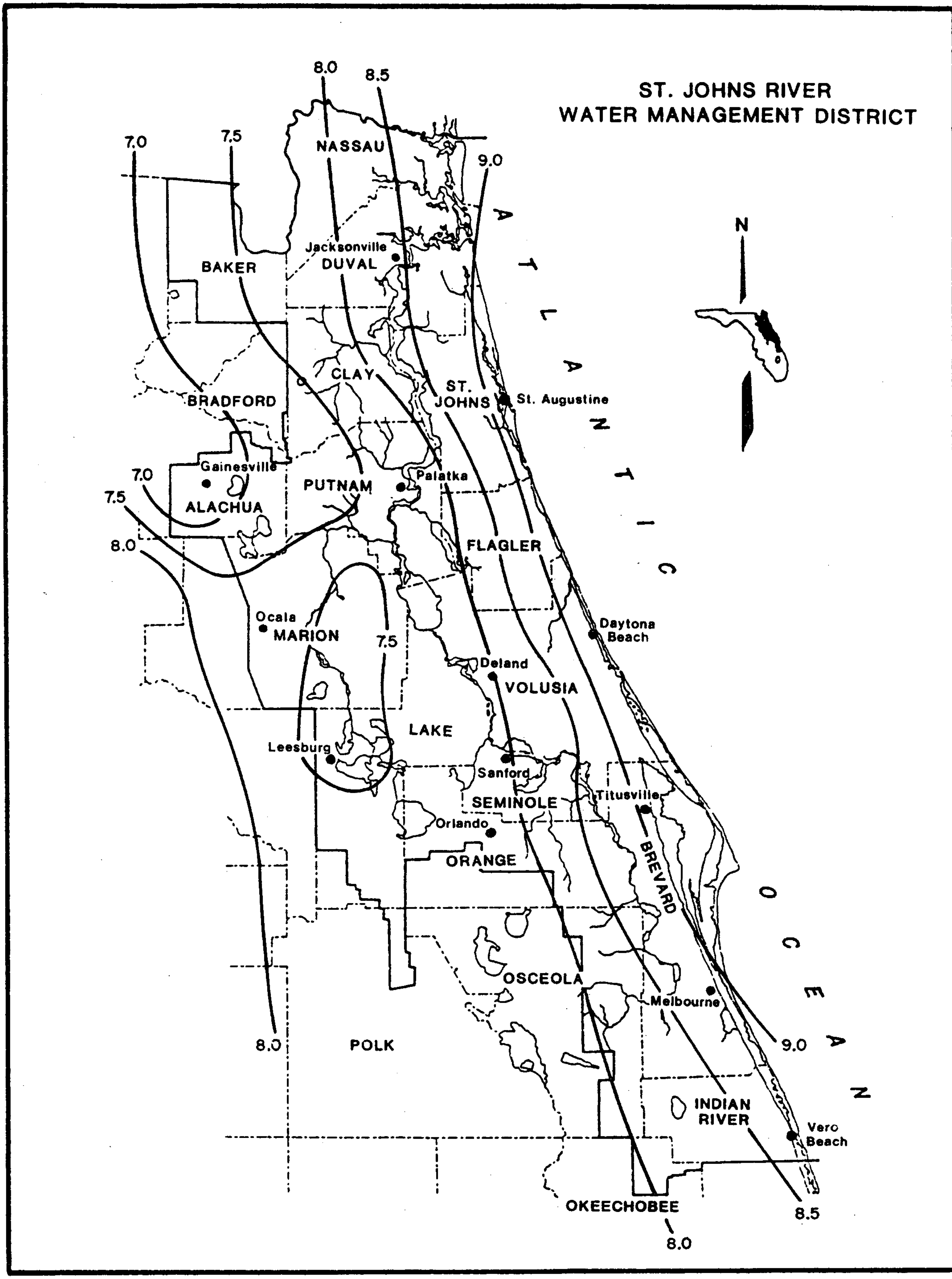


Figure 9. 10-Year 48-Hour Maximum Rainfall for Northeast Florida, Inches.

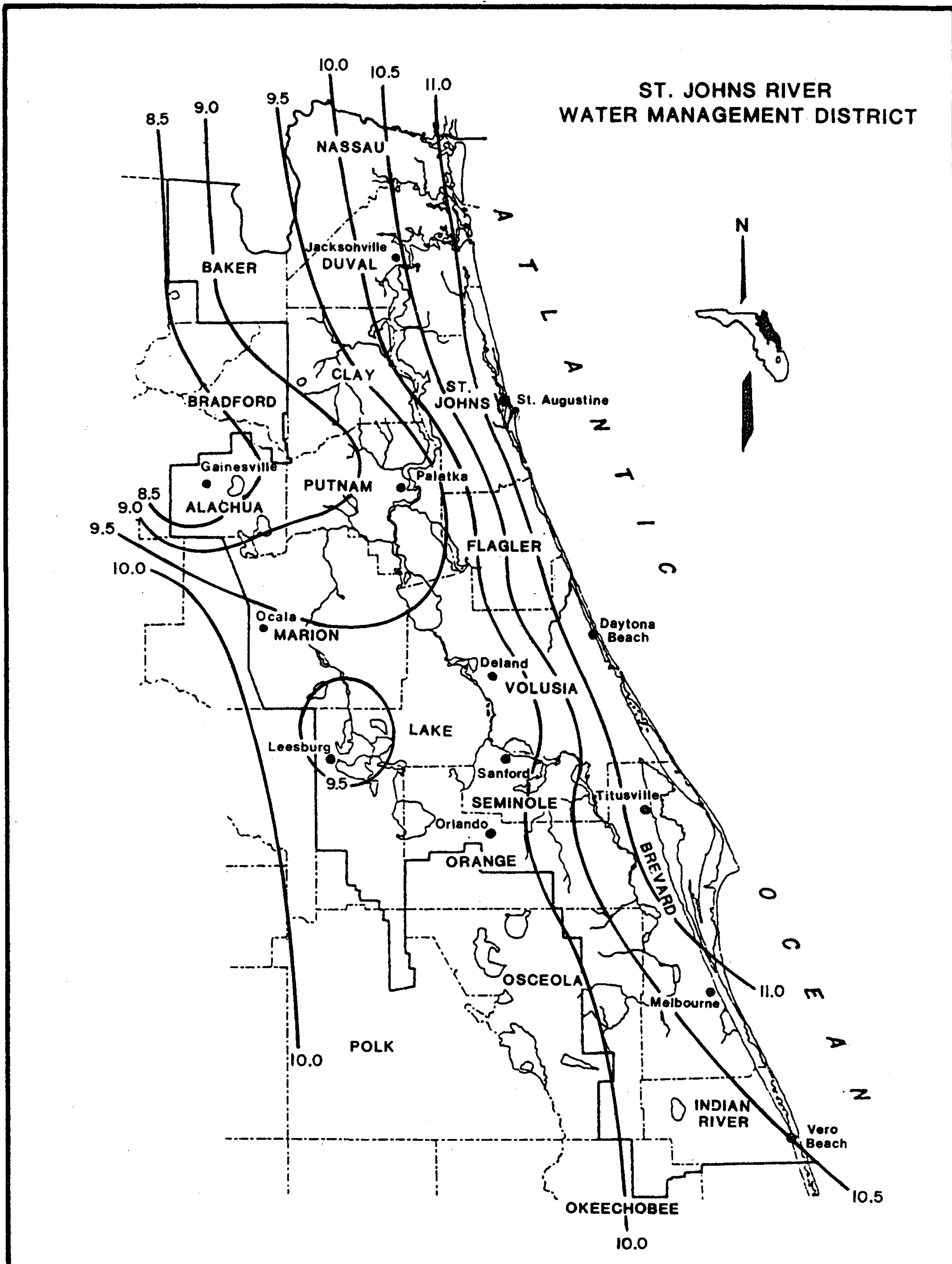


Figure 10. 25-Year 48-Hour Maximum Rainfall for Northeast Florida, Inches.

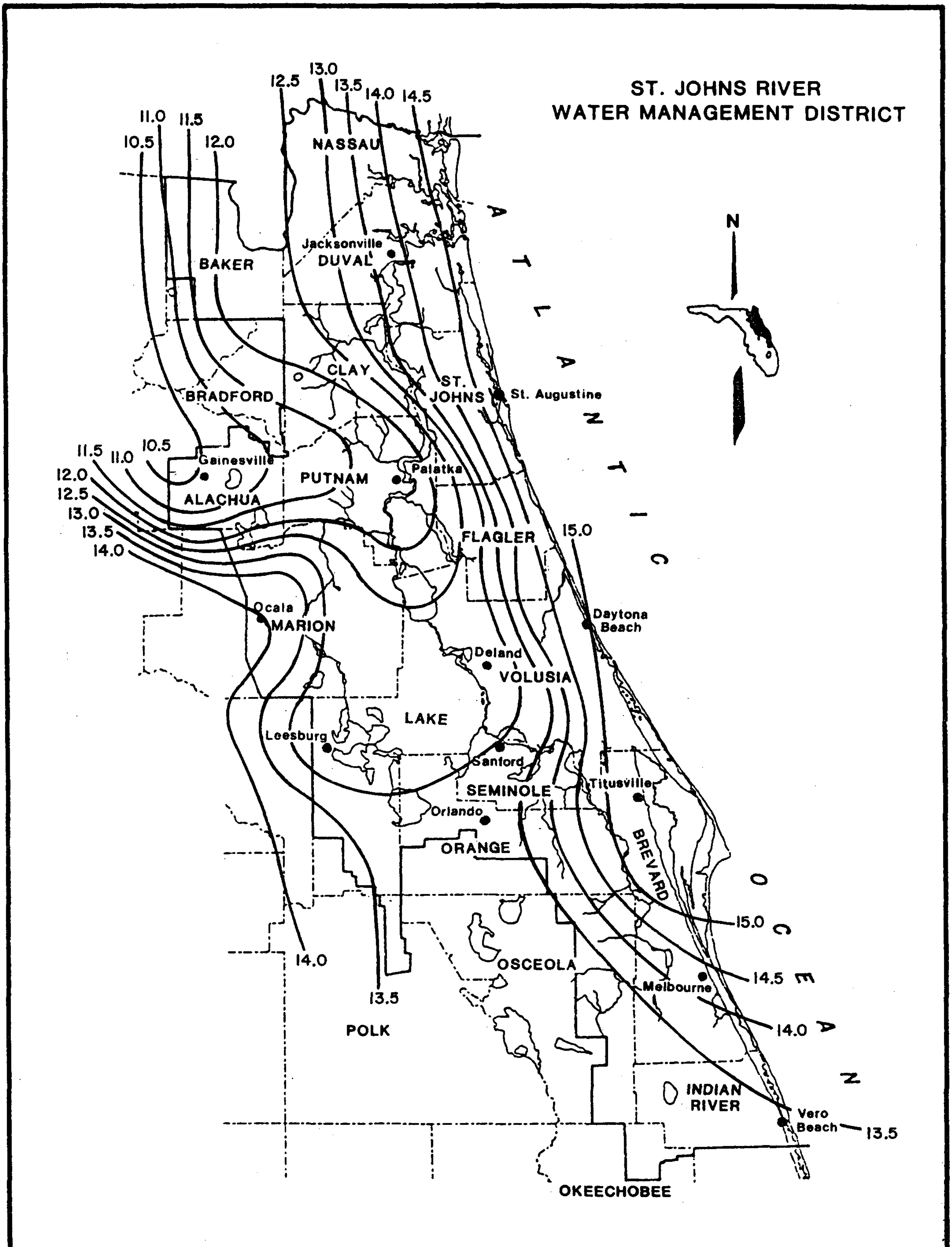


Figure 11. 100-Year 48-Hour Maximum Rainfall for Northeast Florida, Inches.

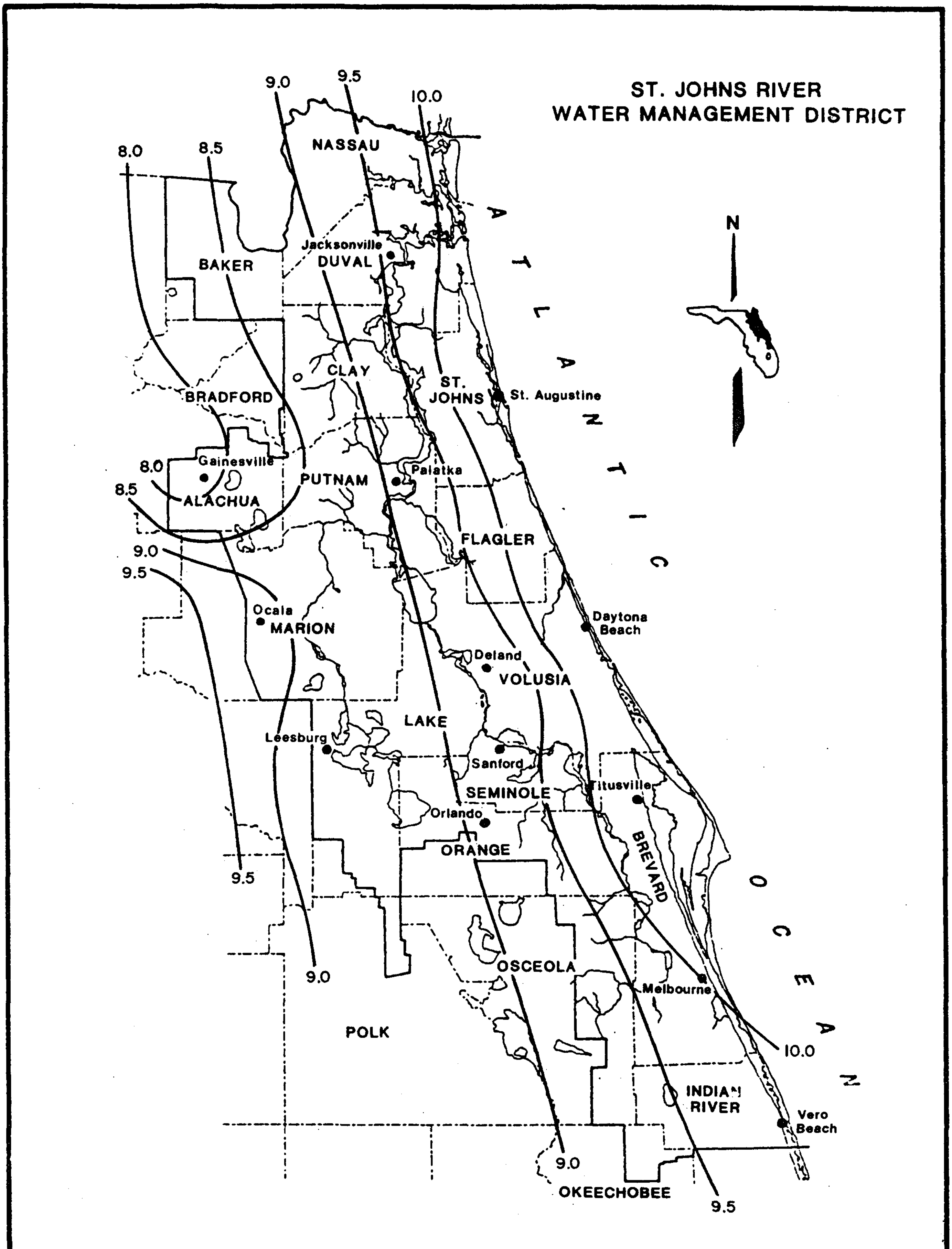


Figure 12. 10-Year 96-Hour Maximum Rainfall for Northeast Florida, Inches.

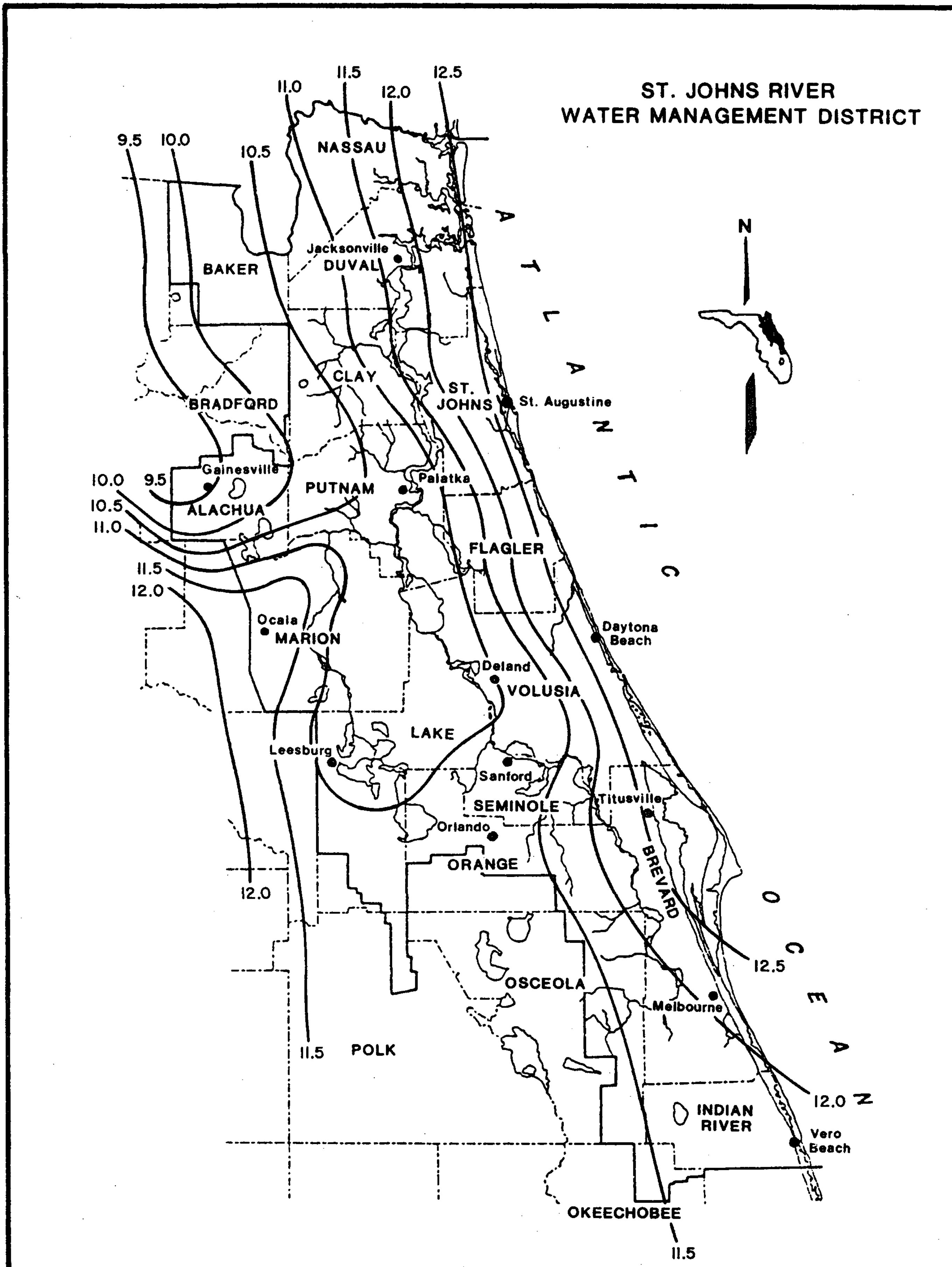


Figure 13. 25-Year 96-Hour Maximum Rainfall for Northeast Florida, Inches.

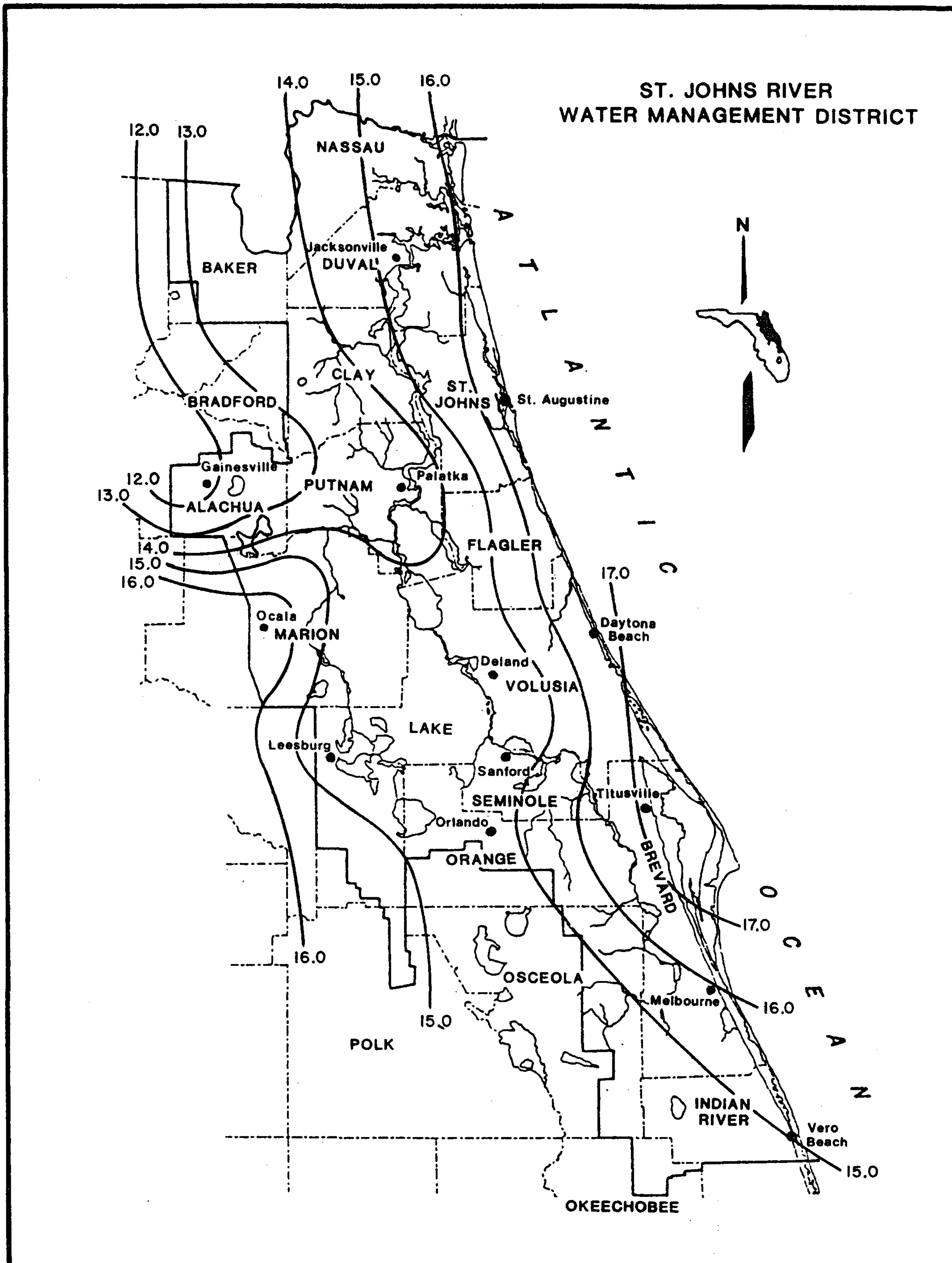


Figure 14. 100-Year 96-Hour Maximum Rainfall for Northeast Florida, Inches.

APPENDIX A

ESTIMATES OF 10 YR, 25 YR, AND 100 YR MAXIMUM RAINFALL DEPTHS FOR PRINCIPAL RAIN GAGE STATIONS

Table A-1: Maximum Rainfall Depths for Avon Park, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest observed	Mean Annual	10 yr	25 yr	100 yr
24	10.15*	4.49	6.9	8.4	10.8
48	10.66*	5.26	7.8	9.3	11.7
96	14.49*	6.26	9.0	10.9	13.9

* Highest during 1914-1983. Log Pearson frequency curve historically adjusted.

Table A-2: Maximum Rainfall Depths for Bartow, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	12.91*	4.03	5.9	7.6	10.8
48	14.13*	4.72	7.0	8.8	12.3
96	15.21*	5.71	8.4	10.4	14.1

* Highest during 1913-1983- Log Pearson frequency curve historically adjusted.

Table A-3: Maximum Rainfall Depths for Bithlo, inches (Period of data analyzed = 1948-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	12.05	4.51	6.8	8.8	12.6
48	12.81	5.29	8.1	10.1	14.1
96	13.54	6.25	9.5	11.8	15.8

Table A-4: Maximum Rainfall Depths for Bushnell, inches (Period of data analyzed = 1937-1983)

Duration Hours	Highest observed	Mean Annual	10 yr	25 yr	100 yr
24	11.68	4.17	6.5	8.2	11.5
48	13.96	4.99	7.6	9.5	13.2
96	14.92	6.04	9.0	11.0	15.0

Table A-5: Maximum Rainfall Depths for Clermont, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	14.77*	4.17	6.9	9.0	12.5
48	17.57*	4.86	7.8	10.0	14.0
96	17.75*	5.70	8.8	11.2	15.5

* Highest during 1913-1983- Log Pearson frequency curve historically adjusted.

Table A-6: Maximum Rainfall Depths for Crescent City, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	10.34*	4.16	6.2	7.4	9.6
48	11.60*	5.03	7.4	8.7	10.9
96	12.92*	6.03	8.7	10.2	12.4

* Highest during 1911-1983 - Log Pearson Frequncy curve historically adjusted.

Table A-7: Maximum Rainfall Depths for Daytona Beach, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	21.98*	5.34	7.7	9.5	12.4
48	23.53*	6.30	9.0	10.9	14.0
96	26.50*	7.26	10.1	12.3	15.9

* Highest during 1871-1983 for New Smyrna Beach/Daytona Beach-Log Pearson frequency curve historically adjusted.

Table A-8: Maximum Rainfall Depths for Deland, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	9.25*	4.57	7.1	8.4	10.4
48	11.89*	5.54	8.4	10.1	12.5
96	14.92*	6.61	9.7	11.8	15.1

* Highest during 1913-1983. Log Pearson frequency curve historically adjusted.

Table A-9: Maximum Rainfall Depths for Federal Point, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	8.21*	4.57	6.6	7.8	9.6
48	10.28*	5.01	7.7	9.2	11.4
96	11.58*	6.19	8.9	10.6	13.1

* Highest during 1913-1983. Log Pearson frequency curve historically adjusted.

Table A-10: Maximum Rainfall Depths for Fellsmere, inches (Period of data analyzed = 1931-1979)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	12.83	4.58	7.4	9.1	12.0
48	14.66	5.38	8.4	10.4	13.6
96	14.98	6.17	9.7	12.0	15.6

Table A-11: Maximum Rainfall Depths for Fernandina Beach, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	22.22*	5.24	7.9	10.2	14.3
48	22.50*	5.91	8.9	11.3	15.6
96	22.65*	6.82	10.2	12.4	16.1

* Highest during 1902-1983. Log Pearson frequency curve historically adjusted.

Table A-12: Maximum Rainfall Depths for Fort Drum, inches (Period of data analyzed = 1956-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	9.85	3.97	6.1	7.8	10.5
48	11.69	4.54	7.4	9.3	12.5
96	14.75	5.69	8.9	11.2	14.9

Table A-13: Maximum Rainfall Depths for Fort Pierce, inches
(Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	10.16	4.32	6.5	7.7	9.5
48	10.42	5.18	7.6	8.8	10.7
96	12.06	6.20	8.8	10.2	12.2

Table A-14: Maximum Rainfall Depths for Gainesville, inches
(Period of data analyzed = 1903-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	7.55	3.91	5.6	6.9	8.5
48	9.82	4.67	6.5	7.8	9.9
96	11.22	5.48	7.6	8.9	10.9

Table A-15: Maximum Rainfall Depths for Glen St. Mary, inches
(Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	9.27	4.45	6.6	8.0	10.5
48	11.82	5.22	7.5	9.1	12.2
96	14.25	5.98	8.5	10.3	13.5

Table A-16: Maximum Rainfall Depths for Hart Lake, inches
(Period of data analyzed = 1943-1979)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	10.58	4.18	6.7	8.5	11.5
48	11.28	5.13	7.9	10.0	13.5
96	14.60	6.02	9.5	11.9	16.0

Table A-17: Maximum Rainfall Depths for High Springs, inches
(Period of data analyzed = 1945-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	7.67	4.15	6.3	7.5	9.0
48	9.81	5.08	7.3	8.6	10.6
96	12.15	5.84	8.3	9.8	11.9

Table A-18: Maximum Rainfall Depths for Inverness, inches
(Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	11.63	4.63	7.0	8.6	11.5
48	14.33	5.53	8.1	10.2	14.3
96	15.66	6.40	9.6	12.2	17.0

Table A-19: Maximum Rainfall Depths for Isleworth, inches (Period of data analyzed = 1931-1982)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	10.25	4.28	6.5	8.0	10.5
48	11.05	4.94	7.5	9.2	12.0
96	12.01	5.73	8.5	10.4	13.0

Table A-20: Maximum Rainfall Depths for Jacksonville Airport, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	10.75	5.04	8.0	9.6	12.5
48	13.25	5.78	9.0	11.0	14.6
96	15.28	6.53	10.0	12.4	16.1

Table A-21: Maximum Rainfall Depths for Jacksonville Beach, inches, (Period of data analyzed = 1945-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	10.79	4.67	7.5	9.0	12.0
48	13.80	5.55	8.6	10.8	14.0
96	15.31	6.35	9.8	12.1	15.7

Table A-22: Maximum Rainfall Depths for Jasper, inches (Period of data analyzed = 1953-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	10.38	4.39	6.9	8.5	11.2
48	10.50	5.11	7.9	9.8	13.1
96	14.69	5.86	9.1	11.4	15.5

Table A-23: Maximum Rainfall Depths for Kissimmee, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	15.23*	4.45	7.0	9.1	12.8
48	16.26*	5.19	8.1	10.3	14.5
96	16.38*	6.08	9.4	11.7	15.6

* Highest during 1892-1983. Log Pearson frequency curve historically adjusted.

Table A-24: Maximum Rainfall Depths for Lake Alfred Experimental Station, inches (Period of data analyzed = 1925-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	12.45	4.57	7.1	9.1	13.0
48	13.95	5.32	8.2	10.5	14.6
96	16.15	6.16	9.5	12.0	16.4

Table A-25: Maximum Rainfall Depths for Lake City, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	7.02	3.93	6.0	7.1	9.0
48	10.33	4.78	6.9	8.1	10.2
96	12.08	5.60	7.9	9.3	11.8

Table A-26: Maximum Rainfall Depths for Lakeland, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	10.42	4.04	6.3	8.0	11.0
48	12.26	4.71	7.3	9.1	12.5
96	12.97	5.56	8.4	10.4	13.7

Table A-27: Maximum Rainfall Depths for Lisbon, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	9.18	4.15	6.4	8.2	11.1
48	11.99	4.94	7.4	9.4	12.5
96	13.31	5.67	8.6	10.8	14.2

Table A-28: Maximum Rainfall Depths for Lynne, inches (Period of data analyzed = 1942-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	12.35	4.04	6.3	8.3	11.4
48	13.99	4.87	7.4	9.5	12.9
96	15.63	5.75	8.8	10.9	14.7

Table A-29: Maximum Rainfall Depths for Marineland, inches (Period of data analyzed = 1942-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	14.63	4.46	7.3	9.6	13.8
48	15.45	5.16	8.4	10.8	15.0
96	15.55	6.06	9.6	12.1	16.2

Table A-30: Maximum Rainfall Depths for Melbourne, inches (Period of data analyzed = 1939-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	8.28	4.57	7.1	8.7	11.7
48	10.99	5.31	8.1	10.0	13.0
96	12.84	6.04	9.2	11.3	14.6

Table A-31: Maximum Rainfall Depths for Mountain Lake, inches (Period of data analyzed = 1935-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	11.78*	4.43	6.9	8.7	11.9
48	13.66*	5.18	7.9	9.9	13.6
96	14.46*	5.97	8.7	10.7	14.2

* Highest during 1922-1983. Log Pearson frequency curve historically adjusted.

Table A-32: Maximum Rainfall Depths for Nittaw, inches (Period of data analyzed = 1942-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	12.72	4.82	8.0	10.3	13.5
48	13.60	5.46	9.0	11.2	14.5
96	13.67	6.38	10.2	12.3	15.3

Table A-33: Maximum Rainfall Depths of Ocala, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	11.74*	4.29	6.5	8.3	11.6
48	13.71*	5.05	7.7	9.9	14.0
96	15.62*	6.16	9.2	11.8	16.4

* Highest during 1907-1983. Log Pearson frequency curve historically adjusted.

Table A-34: Maximum Rainfall Depths for Okeechobee, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	9.55	4.07	6.7	8.1	10.0
48	10.11	4.73	7.5	9.0	11.2
96	11.95	5.58	8.6	10.2	12.4

Table A-35: Maximum Rainfall Depths for Orlando, inches (Period of data analyzed - 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	9.89	4.26	6.6	8.2	11.0
48	12.633	5.10	7.6	9.8	13.2
96	14.19	5.93	8.8	11.0	14.7

Table A-36: Maximum Rainfall Depths of Palatka, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	11.86*	4.46	6.6	8.1	10.3
48	14.58*	5.32	7.8	9.5	12.1
96	18.24*	6.31	9.3	11.3	14.4

* Highest during 1923-1983. Log Pearson frequency curve historically adjusted.

Table A-37: Maximum Rainfall Depths for Raiford State Prison, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	9.21	4.02	6.0	7.3	9.5
48	10.45	4.67	6.8	8.4	11.1
96	13.75	5.38	7.8	9.6	13.0

Table A-38: Maximum Rainfall Depths for St. Augustine, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	14.34*	5.00	7.9	9.7	12.7
48	18.43*	5.80	8.9	11.1	14.8
96	20.25*	6.72	9.9	12.5	16.8

* Highest during 1877-1983. Log Pearson frequency curve historically adjusted.

Table A-39: Maximum Rainfall Depths for Sanford, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	9.12*	4.26	6.3	7.8	10.5
48	9.52*	5.08	7.6	9.2	11.8
96	10.00*	5.92	8.6	10.2	12.7

* Highest during 1913-1983. Log Pearson frequency curve historically adjusted.

Table A-40: Maximum Rainfall Depths for Starke, inches (Period of data analyzed = 1942-1982)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	6.89	4.01	5.8	6.9	9.0
48	10.80	4.68	6.7	8.0	10.2
96	12.72	5.45	7.7	9.2	11.6

Table A-41: Maximum Rainfall Depths for Stuart Inlet, inches

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	12.92	4.36	6.7	8.6	11.9
48	15.47	5.30	7.9	9.9	13.5
96	15.57	6.39	9.6	11.6	14.7

Table A-42: Maximum Rainfall Depths for Titusville, inches (Period of data analyzed = 1931-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	11.99*	4.95	7.5	9.5	13.0
48	13.30*	5.93	9.1	11.5	15.5
96	15.05*	6.96	10.6	13.1	17.2

* Highest during 1913-1983. Log Pearson frequency curve historically adjusted.

Table A-43: Maximum Rainfall Depths for Usher Tower, inches (Period of data analyzed = 1957-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	12.25	5.08	7.6	9.5	12.6
48	14.41	6.29	9.2	11.5	15.4
96	15.42	7.36	10.9	13.3	17.3

Table A- 44: Maximum Rainfall Depths for Vero Beach, inches (Period of data analyzes = 1942-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	9.45	4.74	7.3	8.7	11.0
48	10.83	5.56	8.3	9.9	12.3
96	12.14	6.32	9.4	11.2	13.8

Table A-45: Maximum Rainfall Depths for Brunswick, Georgia, inches (1930-1983)

Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	12.44	5.35	8.3	10.3	13.1
48	15.53	6.13	9.3	11.5	15.0
96	16.45	6.93	10.5	12.9	16.5

Table A-46: Maximum Rainfall Depths for Folkston, Georgia, (Period of data analyzed = 1931-1983)

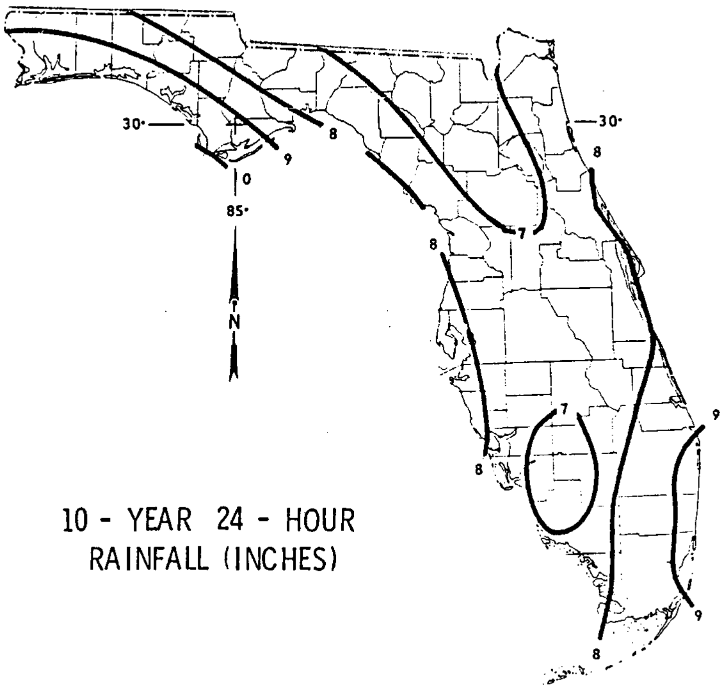
Duration Hours	Highest Observed	Mean Annual	10 yr	25 yr	100 yr
24	9.74	4.34	6.7	8.4	10.8
48	11.45	5.04	17.7	9.5	12.2
96	13.49	5.90	8.9	10.8	13.8

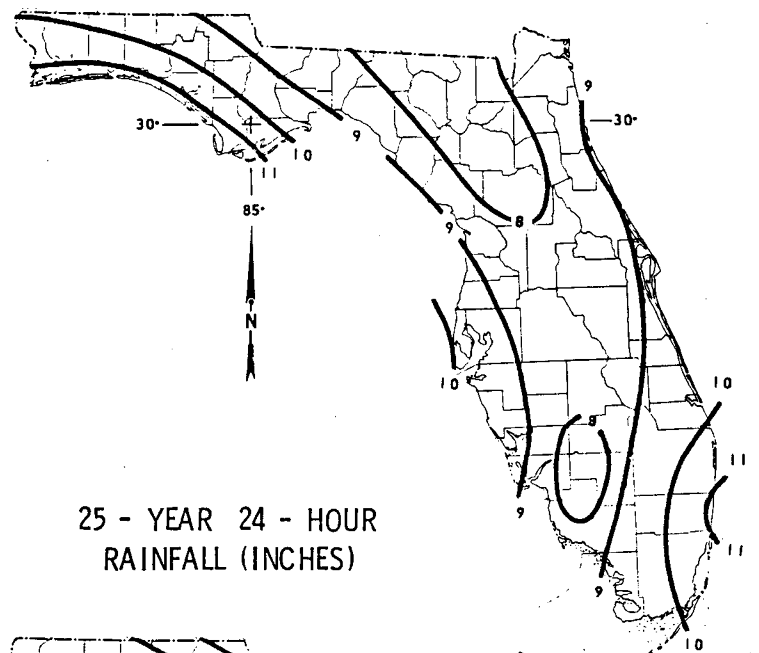
APPENDIX B

SELECTED ISOPLUVIAL MAPS

FROM

TP-40 AND TP-49





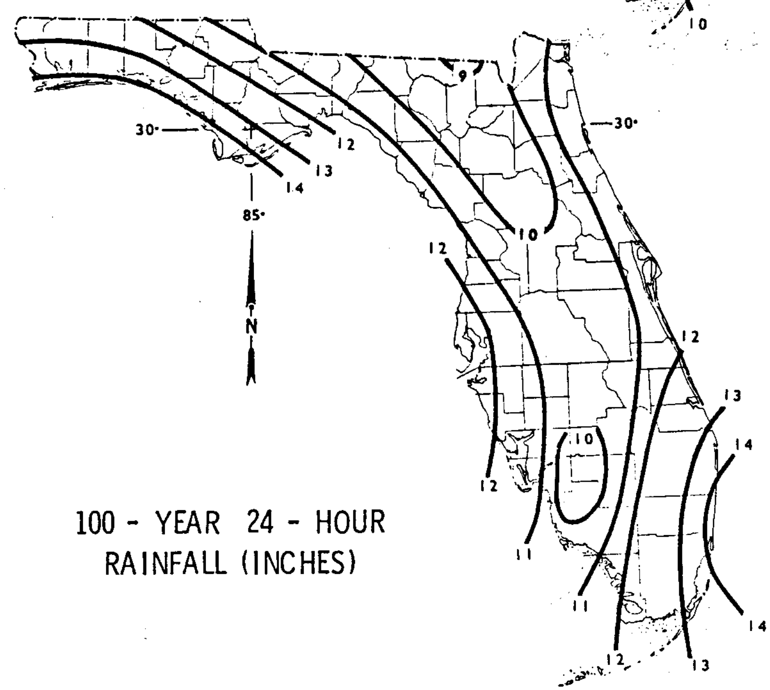
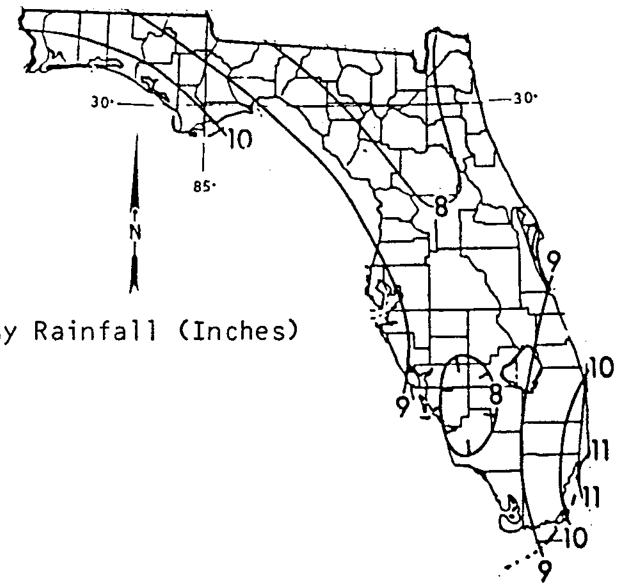
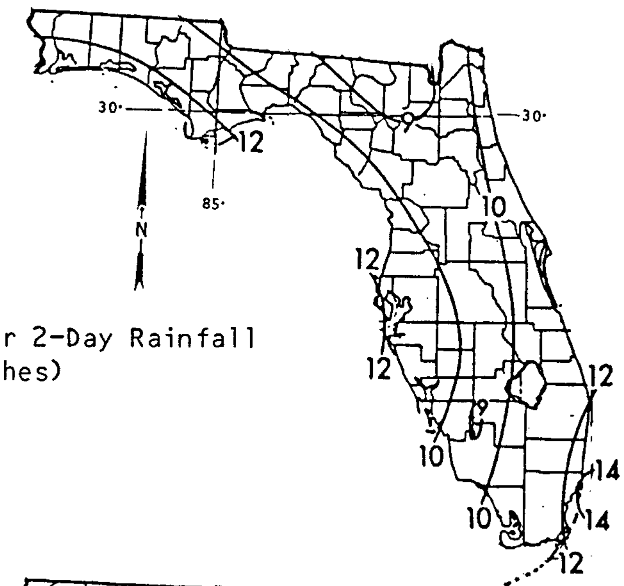


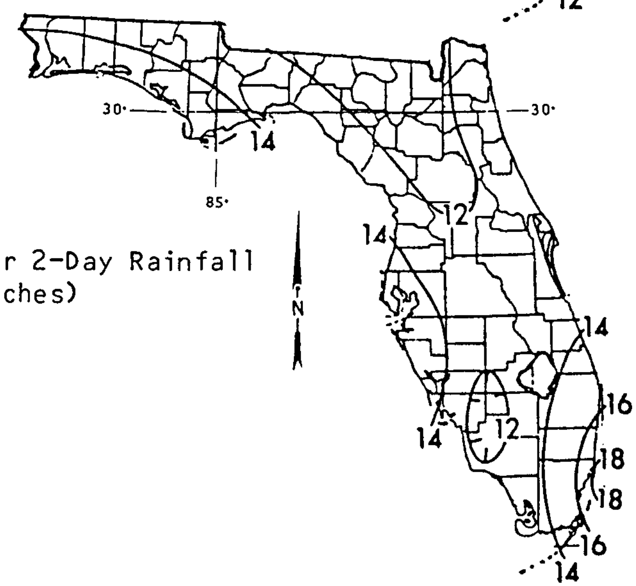
Figure B-1. 10-Yr, 25-Yr, and 100-Yr Maximum Rainfall for 24-Hour Duration for Florida. (Source: TP-40)



10-Year 2-Day Rainfall (Inches)

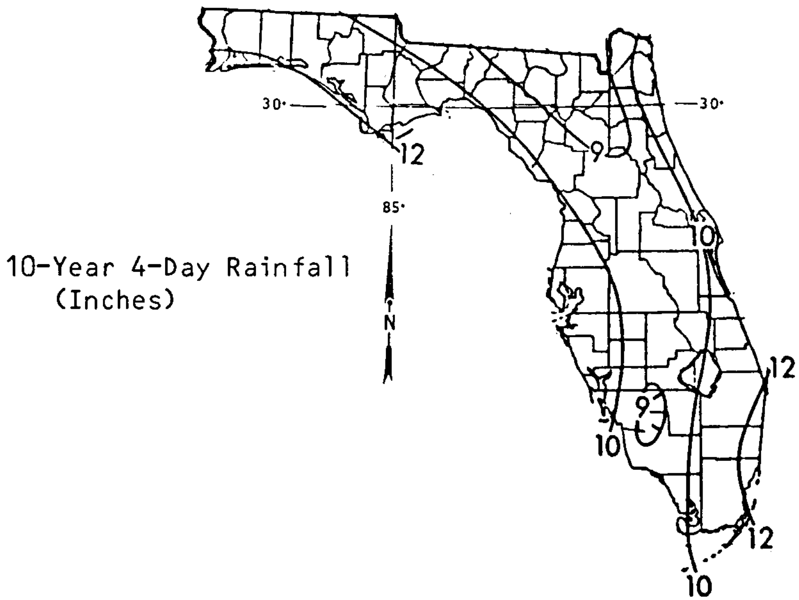


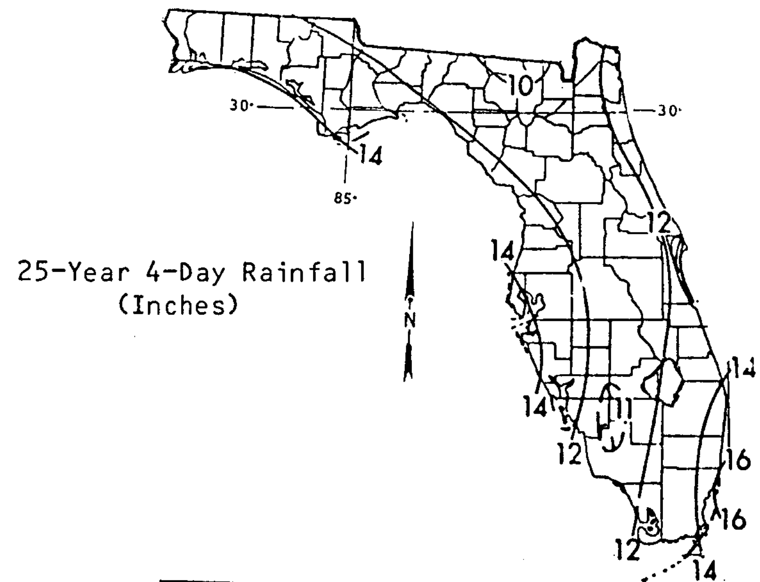
25-Year 2-Day Rainfall
(inches)



100-Year 2-Day Rainfall
(Inches)

Figure B-2. 10-Yr, 25-Yr, and 100-Yr Maximum Rainfall for 2-Day Duration for Florida (Source: TP-49)





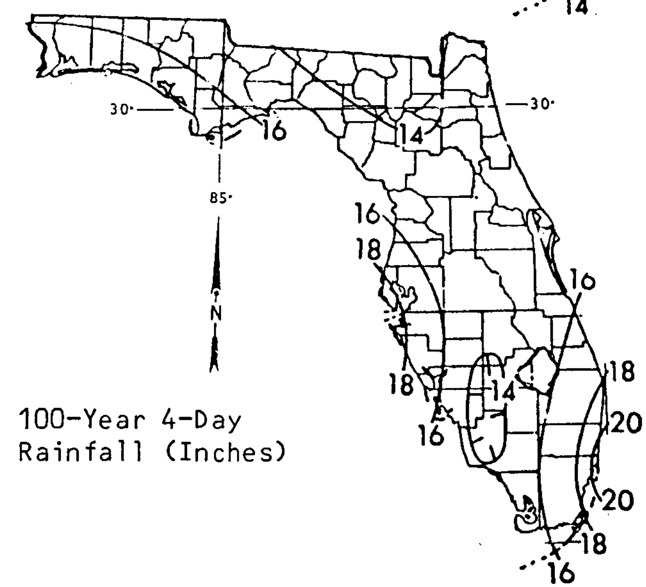


Figure B-3. 10-Yr, 25-Yr, and 100-Yr Maximum Rainfall for 4-Day Duration for Florida (Source: TP-49)