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TECHNICAL REPORT
EP-8

HANDBOOK OF DEVILS LAKE ENVIRONMENT



QUARtermaster RESEARCH & DEVELOPMENT CENTER
ENVIRONMENTAL PROTECTION DIVISION

APRIL 1955

NATICK, MASSACHUSETTS

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Quartermaster Research & Development Center, US Army
Natick, Massachusetts

ENVIRONMENTAL PROTECTION DIVISION

Technical Report
EP-8

HANDBOOK OF DEVILS LAKE, NORTH DAKOTA, ENVIRONMENT

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Geographer

ENVIRONMENTAL RESEARCH BRANCH

Project Reference:
7-83-03-008B

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Foreword

This report is one of a series of studies designed to provide pertinent information concerning environmental conditions at Army testing sites. Inaugurated in August, 1952, at the request of the Test Coordinator, Research and Development Division, Office of The Quartermaster General, the program of test site studies was undertaken to enable test planners to select optimal conditions for scheduling performance tests of Quartermaster equipment at selected testing installations. By request of the Office of the Assistant Chief of Staff, G-4, environmental studies for Dugway Proving Ground, Utah, (Environmental Protection Division Report No. 227), and Devils Lake, North Dakota, were included in the site study program to complete the coverage of installations presently in use by all concerned agencies within the Department of the Army.

This test site study will serve as a convenient reference for those who require information concerning the climate, terrain, and vegetation at Devils Lake, North Dakota.

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ABSTRACT

The Devils Lake Test Site, situated in the northeastern part of North Dakota, in the same latitude as Vienna and Stalingrad, is an area of severe winters. Temperature averages and extremes are among the lowest in the United States, although extreme cold is rarely long-lasting. The lowest recorded temperature was -46°F and temperatures below -25°F occur several times during an average winter. Summers are mild with high temperatures rarely exceeding 100°F . Precipitation averages about 18 inches per year and occurs mostly in summer. Snowfall, averaging 33 inches for the year, is to be expected from early November through early April.

Terrain varies from flat and marshy lake beds to fairly rugged low hills. The hills are largely morainal with infrequent bedrock cores deeply buried under the glacial till. The entire region lies within the Central Plains Drift Region. Soils are immature, with textures ranging from clay size rock flour to fairly heavy gravels. Rock outcrops are limited to glacial erratics and are spotty in their occurrence.

Vegetation is typically subhumid in type with forest growth occurring in moist depressions and in the upland. Trees are generally small, averaging between 20 and 30 feet high, and the predominate types are burr oak, box elder, Eastern cottonwood, American elm, and green ash. Undergrowth is dense and varied in type. Vegetation on former lake beds is principally weed and swamp grass. Brush and forest surround most lakes and lake beds. The drift plains are largely in cultivated grasses and grains.

Summer insects are abundant around lakes and former lake beds. The most prevalent of these are mosquitoes, deer flies, and horse flies.

HANDBOOK OF DEVILS LAKE ENVIRONMENT

1. Introduction

The Devils Lake Test Site is located in northeastern North Dakota about 80 miles west of the Minnesota border and 70 miles south of the Canadian border (Fig. 1). Devils Lake, the principal town within the Test Area, (population 6,419 in 1950) was at one time an important lake port in an extensive lake system. At the present time it is considerably removed from the lake shore and serves as a market and rail center for a large farm region.

Devils Lake is served by two major railroad lines, the Great Northern and Minneapolis, St. Paul, and Sault Ste. Marie. A large number of sidings and a roundhouse are maintained in the town of Devils Lake and existing facilities are adequate for military needs.

Highways include a network of asphalt and gravel roads, all of which are maintained for all-weather traffic. A municipal airport is located just west of the town. Runways, though unsurfaced, are long and firm enough to receive four-motored planes. No scheduled commercial airlines serve the area.

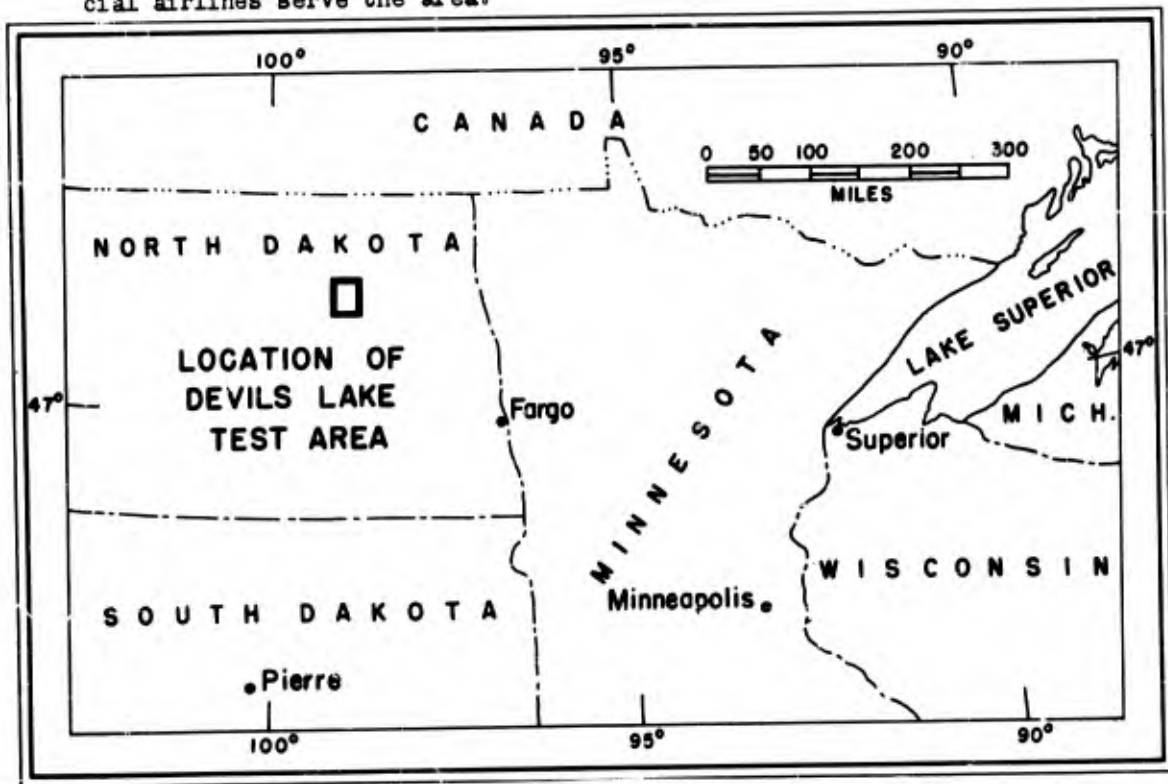


Figure 1 Location of Test Area

The earliest military activity associated with the Test Site occurred in 1867, when Fort Totten, which later became Fort Totten Indian Agency, was established on the southern shore of the lake. Its chief purpose was to maintain order and give protection to the territorial settlers and also to receive the Indians of the area on a permanent reservation.

Camp Grafton, on the north shore of the lake, just south of the town of Devils Lake, was established in 1904 as the field training site of the North Dakota National Guard. The camp covers 6 of the 180 square miles once included in the original Rock Island Military Reservation which was established before North Dakota became a state. (See Fig. 2). The United States still maintains ownership and leases the camp to North Dakota for the state National Guard. National Guard maneuvers are usually held for two weeks in early June. Two units, composed of a total of about 1,100 men, normally participate in the activities.

In 1942 an Army Ordnance unit was stationed for a short time at Camp Grafton and in the same year Mexican nationals from the Mexican Army were housed there while aiding in the harvests under the auspices of the War Food Administration. In 1949 the camp was used as a training site for the Civilian Air Cadet Corps from Ogden, Utah. Runways were established on the meadows in the northeast portion of the camp and float planes were landed in the lake to the west of the camp.

In 1943 the Army became interested in the Camp Grafton-Devils Lake area as a possible site for the Army Service Forces Winter Proving Ground. A survey to determine the suitability of the site for winter testing was conducted under the direction of the Corps of Engineers. After studying the Engineers' report, interested Army agencies rejected the area as an Arctic Test Station. It was established that while the Devils Lake area is one of the more suitable sites in the continental United States, the climate is not consistently severe enough for arctic testing. It was not until 1949 that the area was used as a test site. In that year the Army Ordnance Climatic Test Detachment began winter tests of vehicles and equipment in and around Camp Grafton. This program has continued every winter up to the time covered by this report (winter 1952-53).

The support and maintenance of Camp Grafton is a joint operation: the United States Army provides a caretaker with civilian crews, and a full time National Guard maintenance unit aids in the operation of the camp.

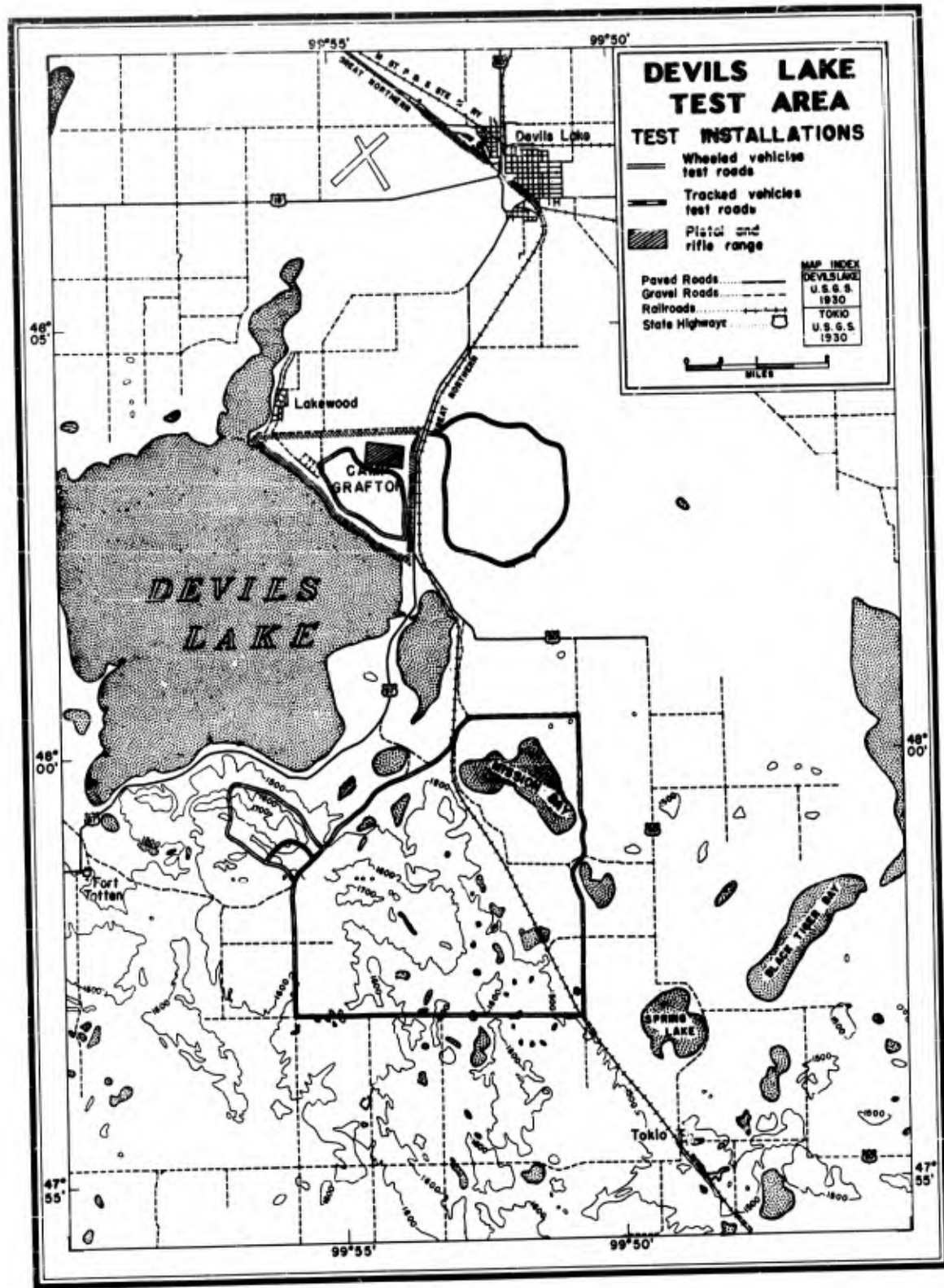


Figure 2

2. Climate

a. General

As its position in the center of the North American interior plains indicates, the Devils Lake Test Area has a typically continental climate, characterized by marked seasonal changes. Winters are generally cold and dry and summers are warm and moderately moist. Climatic conditions similar to those of the test area exist in various parts of the USSR and northern China. Kazan and Chklov, in the upper Volga River Basin, Barnaul, in south central Siberia, and Harbin, in central Manchuria, all have temperature and precipitation regimes similar to those of Devils Lake, as Table I indicates.

TABLE I: CLIMATIC COMPARISONS BETWEEN CITIES OF UUSR AND CHINA, AND DEVILS LAKE, NORTH DAKOTA

	<u>Mean Temperature</u> (°F)												<u>Annual Mean</u>
	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	
Devils Lake	3	7	22	39	52	62	68	66	56	43	25	10	38
Kazin, USSR	7	10	20	38	54	63	68	63	51	39	25	11	37
Chklov, USSR	3	6	17	38	58	66	73	67	55	39	24	11	38
Barnaul, USSR	0	3	14	34	52	63	68	62	51	35	17	6	33
Harbin, China	-2	5	24	42	56	66	72	69	58	40	21	3	38

	<u>Mean Precipitation</u> (inches)												
	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	
Devils Lake	0.4	0.4	0.7	1.3	2.1	3.2	2.6	2.3	1.9	1.1	0.7	0.5	17
Kazan, USSR	0.5	0.4	0.6	0.9	1.6	2.2	2.4	2.4	1.6	1.1	1.0	0.7	15
Chklov, USSR	1.1	0.8	1.0	0.9	1.4	2.0	1.7	1.3	1.2	1.2	1.2	1.2	15
Barnaul, USSR	0.8	0.6	0.6	0.6	1.3	1.7	2.2	1.8	1.1	1.3	1.1	1.1	14
Harbin, China	0.1	0.2	0.4	0.9	1.7	3.8	4.5	4.1	1.8	1.3	0.3	0.2	19

Although Devils Lake experiences some of the coldest weather in the United States, it cannot be considered an ideal arctic or subarctic station. Winter weather is very changeable and extremely low temperatures are normally of short duration. Considerable time may elapse between periods of typical test conditions. Climatic conditions are summarized in Table II, and in the graphs comprising Appendix A.

b. Temperatures

Mean monthly temperatures at Devils Lake range from a January low of 3°F to a July high of 68°F. Even more significant than the monthly mean temperatures - for purposes of testing - are the extremes experienced.

each year. An absolute minimum of -46°F has been recorded, and temperatures below -25°F may be expected on an average of 7 days each winter. Below-zero temperatures may be expected on 14 days in December, 20 days in January, 16 days in February, and less frequently in November, March and April. Because of the low absolute humidity of the air, extreme winter cold is not too uncomfortable for men adequately clothed, except when it is accompanied by strong winds. Fortunately, winds are nearly always light when temperature is below -25°F .

Variability in temperature from year to year is considerable. In the 20-year period from 1931 through 1950, January mean temperatures ranged between -13°F and 19°F , and the standard deviation is about 8°F . This marked variability makes it difficult to anticipate temperatures that may be expected in a given season.

Although an absolute maximum of 112°F has been recorded, temperatures over 100°F do not occur frequently. (They were recorded 23 times in the period 1933 through 1952). An average of 55 days annually have temperatures exceeding 80°F . The average frost-free period begins May 15th and ends September 24th, providing an average growing season of 132 days. The latest date that a killing spring frost ever occurred in the 47-year period of record was June 4, and the earliest recorded autumn frost was August 22.

c. Precipitation.

Precipitation at Devils Lake shows marked seasonal difference and considerable year-to-year fluctuations. The mean annual total is 17.31 inches, varying from 10.29 inches to 25.37 inches. Normally, almost half of the annual precipitation occurs in June, July, and August, and most of it falls in showers and thunderstorms in late afternoon and early evening. On an average, 30 thunderstorms occur each year, mostly in the summer. Eight thunderstorms may be expected in July, 7 in June and August, and they occur less frequently during spring and autumn months. The average monthly precipitation ranges from 0.42 inch in January and February to 3.22 inches in June. The greatest precipitation recorded in one month was 8.34 inches in September; and the least, a trace in May. While as much as 4.82 inches of precipitation has been recorded in a 24-hour period, small daily amounts, which may occur as intense rainfall for a short period, are characteristic of the test area. There are only about 5 days from June through August (the period of maximum rainfall) when there is more than one-half inch of rain.

Snowfall averages 33.3 inches annually, occurring mostly between early November and early April. More than 5 inches of snow falls in each month from November through March, in the form of very small and dry flakes and crystals. Water equivalent of winter snow is very low owing to the low temperature. The ground is usually frozen and snow-covered from about mid-November to the end of March.

d. Relative Humidity.

In general, relative humidity is low. Humidities are highest at the early morning readings (0630 hours), averaging 82 percent for the year. The 0630 reading in July, August, and September, the most humid months, averages near 86 percent. Noon readings are lower, with lowest readings (between 50 and 55 percent) recorded during May, July, August, and September. During winter, when the temperatures average far below freezing, the high relative humidities may be misleading, since the absolute moisture content of the air is very low.

e. Cloudiness.

The Devils Lake region is cloudy, although it has little precipitation. More than 8/10 cloud cover may be expected on 141 days each year, or about 38 percent of all days. The cloudiest months are November and December, when 8/10 or more cover may be expected on about 50 percent of all days. The clearest skies occur during summer (July, August, and September) when less than 3/10 cover is to be expected on more than 35 percent of all days. July, one of the rainiest months, is also the least cloudy month, with clear skies expected on about 45 percent of all day.

f. Solar Radiation*

Solar radiation at Devils Lake, as at all high latitude stations, varies tremendously from summer to winter. Readings may be expected to range from 80 langleys per day in December to 540 langleys per day in July.

g. Possible Sunshine.

More than 50 percent of the sunshine possible at the latitude may be expected in all months except November and December, which average about 45 percent. July, the sunniest month, averages 71 percent, and all months from April through August average more than 60 percent of the possible sunshine.

h. Wind.

Mean hourly wind speeds at Devils Lake average about 10 mph, varying from 8.7 mph in July to 11.4 mph in April. There is little seasonal difference in wind speed, either mean or extreme. The highest wind speed recorded was 56 mph, in July. In all months, maximum wind speeds have exceeded 40 mph. While average wind speeds are moderate, occasional strong winds

*Solar radiation data were not available from Devils Lake; approximate values were interpolated by Air Weather Service, from monthly maps giving the average solar radiation for the United States. Langley = 1 gm. cal/square meter.

TABLE II: CLIMATIC SUMMARY FOR DEVILS LAKE, NORTH DAKOTA*
(Elevation 1,471 Feet)

Month	TEMPERATURE (°F)									
	Mean		Mean		Number of Days					
	Daily Max.	Record Highest	Daily Min.	Record Lowest	Maximum			Minimum		
				≥90°	≥50°	≤32°	≤32°	≤0°		
Jan	13	51	-6	-44	0	0	27	31	20	
Feb	17	56	-2	-46	0	0	24	28	16	
Mar	32	85	13	-32	0	2	16	29	6	
Apr	51	87	29	-4	0	15	3	19	<1	
May	64	106	40	6	1	28	<1	4	0	
Jun	73	103	51	29	1	30	0	<1	0	
Jul	81	112	56	37	46	31	0	0	0	
Aug	79	103	53	31	45	31	0	<1	0	
Sep	68	103	44	15	1	28	0	2	0	
Oct	54	89	32	-1	0	21	1	14	<1	
Nov	34	69	17	-21	0	4	16	29	14	
Dec	20	64	2	-37	0	<1	24	31	14	

Month	PRECIPITATION (inches)									
	Mean Monthly	Max. in Month	Min. in Month	Max. in Day	Snowfall (inches)			Number of Days		
					Mean Monthly	Max. in Month	Max. in Day	≥.01 in.	≥1.0 in.	
Jan	0.42	1.67	0.04	0.59	5.3	17.3	5.9	9	2	
Feb	0.43	2.20	0.01	0.80	5.2	18.2	7.8	7	2	
Mar	0.67	2.14	0.09	1.22	5.4	16.8	7.8	8	2	
Apr	1.34	4.96	0.10	2.43	3.0	9.6	8.6	8	<1	
May	2.09	5.18	T	2.86	0.7	7.3	6.0	10	1	
Jun	3.22	5.84	0.96	4.08	T	T	T	12	0	
Jul	2.68	7.44	0.67	4.82	0.0	0.0	0.0	10	0	
Aug	2.26	6.55	0.27	4.53	0.0	0.0	0.0	9	0	
Sep	1.90	8.34	0.02	4.55	T	1.5	1.5	8	<1	
Oct	1.11	3.94	0.01	2.14	1.7	10.2	9.2	7	<1	
Nov	0.69	2.59	0.08	1.73	5.5	19.9	9.4	7	2	
Dec	0.50	1.55	0.06	0.72	6.5	20.1	9.5	8	2	

Month	RELATIVE HUMIDITY(%)		WIND (mph)			CLOUDINESS (days)			SUNSHINE	
	Mean At		Mean	Prev.	Fastest	Partly			Amt. Possible	
	0630 hrs.	1230 hrs.	Speed	Dir.	Mile	Clear	Cloudy	Cloudy	(hrs.)	(%)
Jan	88	81	10.1	NW	41	8	9	14	8h 44m	52
Feb	90	81	10.3	NW	54	8	8	12	10h 08m	58
Mar	90	74	10.9	NW	54	8	10	13	11h 53m	59
Apr	84	57	11.4	NW	47	9	9	12	13h 41m	60
May	81	52	11.0	NE	50	9	10	12	15h 16m	60
Jun	85	57	9.8	SE	49	9	11	10	16h 08m	62
Jul	87	53	8.7	SE	56	14	11	6	15h 45m	71
Aug	86	51	8.8	SE	47	13	10	8	14h 22m	67
Sep	86	52	9.5	SE	46	11	9	10	12h 38m	58
Oct	82	54	10.1	NW	46	10	8	13	10h 50m	54
Nov	86	75	10.3	NW	47	7	8	15	9h 13m	44
Dec	86	78	9.5	NW	42	8	8	15	8h 17m	45

*Fog and thunderstorm (Table, p. 51)

and dry weather create dust storms which sharply reduce visibility and may cause sand and blowing dust to penetrate instruments and machines. In winter, visibility is reduced by blowing snow, and resulting drifts are a hazard to transportation.

1. Sleet and Hail.

Complete records are not available concerning the occurrence of sleet and hail. A one-year record (1942) shows the occurrence of sleet on 10 days in January, February, March, November, and December. During this period, only one hail storm occurred, in September.

3. Terrain

a. General.

The Camp Grafton Military Reservation and the associated test sites of the Ordnance Climatic Test Detachment are located in the Central Plains Drift Region of North America. The terrain in general is gently rolling to hilly, with glaciation responsible for the formation of terrain features. Scattered groups of low, well-rounded hills rise above the plains, but they are so deeply covered with glacial drift that only their form suggests a bedrock core. More numerous and more important from a military point of view are the long lines of hills and ridges that cross the test area from southeast to northwest and which reach their greatest elevation just south of Devils Lake. While the higher of these probably have a bedrock core, they are for the most part recessional moraines, formed at the heads of glaciers during pauses in their retreat.

The northern part of the test area occupies the southwestern portion of a large interior drainage basin which empties into the Devils Lake system. The terrain has a gentle but constant slope southward and is unmarked by drainage lines except for a few winding coulees which were formerly glacial stream channels or connecting links between lakes at a time when they were at a somewhat higher level. The land rises sharply in the hills south of the lakes, then slopes more gently southward toward the valley of the Sheyenne River.

b. Swamps and Marshlands.

Devils Lake occupies an old glacial valley which is partially filled with glacial drift. It once covered an area of 142 square miles, had a surface level of 1,435 feet, and was drained southward by a tributary of the Sheyenne River. Within recorded time, however, it has had no outlet, and with cultivation of the land during the past century the level of the lake dropped still further until very little of it remained after the drought years of 1934 and 1936. It has made some recovery since that time, but in 1953 it was still less than 30 square miles in extent and the surface

elevation was only about 1,400 feet. The lake is rather shallow, the deeper parts ranging between 50 and 75 feet in depth.

In addition to the Devils Lake system, many smaller lakes occupy depressions throughout the test area. All are bordered by weeds and brush and most are being filled by silt and vegetation. A shallow beach borders most of the lakes, and is usually covered by a crusty white layer of alkali salts. Movement on foot over the lake margins is very hazardous in summer, and almost impossible for wheeled and heavy tracked vehicles. Beach slopes are gentle, ranging between one and three degrees. Water in most lakes is strongly saline and unsuitable for drinking.

A large part of the bed of the original Devils Lake and of many smaller lakes has dried sufficiently for coarse grass and weeds to dominate. The surface materials consist of a moderately thick layer of silty clay or muck, dark in color and very soft in wet weather. Surface boulders up to 3 feet in diameter occur, and when hidden by thick grass and weeds form a considerable hazard for vehicular movement. In many places, ponds and swampy sloughs remain throughout the summer season and add to the difficulty of movement. While foot travel is relatively easy in dry weather, the entire lake bed may be hazardous in rainy weather. During winter, when the ground is frozen and snow-covered, movement is relatively easy. Winter vehicle testing, both wheeled and tracked, is conducted over much of the former lake bed east of Camp Grafton.

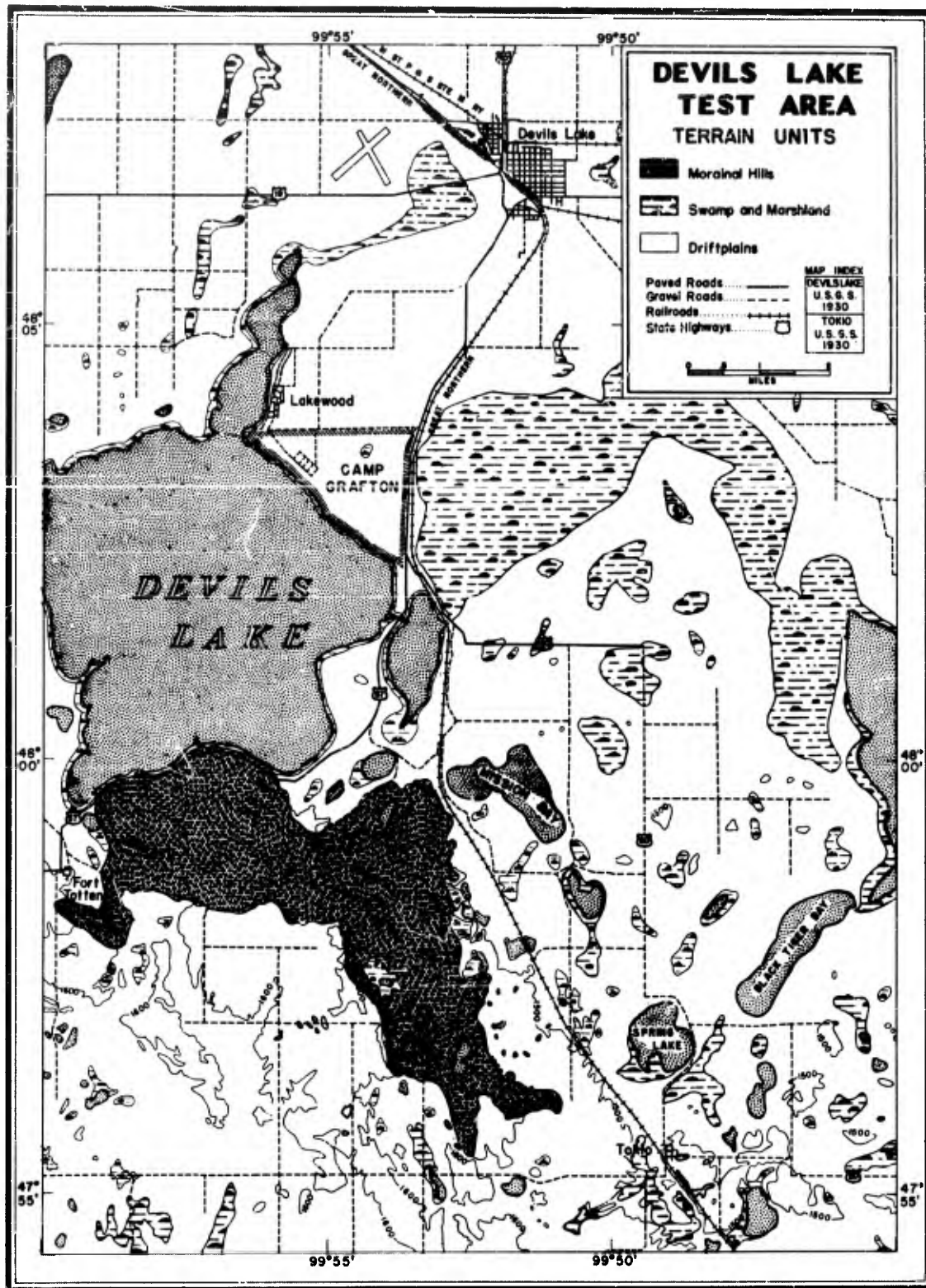
c. Morainal Hills.

To the south of Devils Lake is a group of rugged morainal hills. They rise to over 1,700 feet (300 feet above the surface of the lake) and form the divide between the interior drainage of the Devils Lake System and that of the Sheyenne River, a southeast-flowing tributary of the Red River of the North. Hills are mostly forested and the rough terrain offers many excellent testing areas.

These hills, following roughly a northwest-southeast alignment, reach their greatest elevation (over 1,740 feet) along the southwest margin of the lake. Broad coulees (now grassed over) wind between the hills in many places. Water flows in them only during periods of heavy rain and during the spring thaw. One of the courses used by the Ordnance Corps for testing vehicles on steep hills is within this hill belt.

The steepest slopes overlook Devils Lake from the south. Slopes up to 45 degrees occur, though the average slope is much less steep. There is a general flattening toward the south and southeast, where the hills merge with the roughly undulating till plain.

Surface materials throughout the hill section range from sandy loam to gravel. The soils are well drained and offer excellent support in dry weather and fairly good support in wet weather. The occasional heavy winter snow combined with steep slopes provides good conditions for vehicular testing.



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Figure 3

TABLE III: SUMMARY OF TERRAIN AND GROUND CONDITIONS IN DEVILS LAKE TEST AREA

<u>Terrain Types</u>	<u>Slope and Elevation</u>	<u>Ground Conditions and Surface Materials</u>	<u>Vegetation</u>	<u>Remarks</u>
SWAMPS AND MARSHLANDS (Figs 36 and 38)	0-3° Slope. 1400-1500 feet above sea level.	Lake shallow with silty clay bottom overlying gravelly till. Exposed lake beds have silty clay and muck surface overlying gravelly till. Infrequent boulder outcrops. Surface marshy in wet weather but generally firm in dry weather. White alkali deposit found on recently exposed beds.	Swamp grass and weeds bordering lakes and covering dry lake beds. Brush or stunted forest at outer margin of lake shore.	Good vehicle support over dry lake bed in dry weather. Hazardous in wet weather. Drainage poor. Frozen and snow-covered mid-November through March.
MORAINAL HILLS (Fig 39)	10-45° Slope. Elevations between 1500 and 1750 feet.	Surface materials vary from a sandy loam to gravel. Rock and boulder outcrops are infrequent. Very steep slopes in places but no cliff exposures. Very few marshy spots in valleys and depressions.	Deciduous forest types. Fairly dense undergrowth. Thick weedy vegetation in open areas.	Firm ground offering good support even in wet weather. Drainage excellent. Frozen and snow-covered mid-November through March.
DRIFTPLAINS	0-10° Slope. Elevation from 1400 feet.	Smooth to roughly undulating driftplain surface. Surface materials range from silty clays to heavy gravels. Many small boggy depressions and marshy conlees. Infrequent exposures of glacial boulders	Domestic and native wild grasses and weeds; cultivated grains such as wheat; many wooded shelter belts.	Firm ground and good support in most areas. Generally good drainage even though there are many small boggy depressions and marshy conlees. Frozen and snow-covered from mid-November through March.

Accentuating the ruggedness of the terrain are occasional outcrops of glacial boulders. No cliffs were noted within the test area. While very steep slopes encircle most of higher summits, large stretches of almost flat land are found along the crests of the higher hills.

d. Driftplains.

The driftplains are the most extensive of the terrain units within the test area, occupying most of the nearly flat land north of Devils Lake. South and east of the hill belt the plains tend to be somewhat rougher in appearance, and most of the land slopes perceptibly. The topography is "kame and kettle", with numerous low rises and shallow depressions. The plains are dotted with permanent lakes and many more wet-weather ponds and swamp areas. Areas of swamp or marsh, while common, are not extensive enough to present any great problem for military operations. Soils in most areas have permeable, moderately heavy, and very dark upper zones, with a large admixture of gravels in the subsoil. Glacial boulders, while not abundant, outcrop at intervals throughout the plains area. In a few places they are numerous enough to present a problem for military operations.

Broad coulees break the undulating character of the plains in many places. These are essentially flat and are usually covered by a thick grass turf. In places, drainage is poor, and in wet weather standing water is frequently found. However, permanent streams are lacking and distinct stream channels are not evident anywhere within the test area. Coulee banks, while quite pronounced, have an average slope of only eight to ten degrees, and present no barrier to movement.

e. Terrain Data.

Terrain units are shown in Figure 3, and summarized in Table III.

4. Vegetation

a. General.

North Dakota is almost exclusively a prairie state, and the Devils Lake Test Area is located in the transition zone between the semi-arid west and the more humid east. This is a zone of variable rainfall, which accounts in part for the presence of both humid and semi-arid types of vegetation. Large parts of the lowland adjacent to the Devils Lake system and most of the upland south of the lake is thickly forested, although the trees are generally small (less than 30 feet tall). Of all the species of plants found within the Test Area, those introduced constitute only about 15 percent of the total, but this figure is rising every year, as shelter belts of introduced plants are constantly being planted.

Three main vegetation types are discernible: (1) Woodland; (2) Marshland; and (3) Grasslands and Grainfields.

b. Woodland.

The state of North Dakota has only about 600 square miles of woodland and one of the areas having many groves is near Devils Lake. Continuous stands of forest are found in the hills and ridges south of the lake, in some lowland areas where there is sufficient moisture and no agriculture, and along the Devils Lake shore.

The principal trees making up the forests are oak, box elder, basswood, ash, elm, and cottonwood. The most conspicuous of these are the box elder, oak, and the cottonwood. Underbrush is usually dense, forming almost impenetrable thickets in many places. The principal shrub species include chokeberry, buckthorn, buffalo berry, sumac, dwarf willow, sand cherry, juneberry, wild plum, currant, silverberry, and young growth of the larger trees. Weed and vine plants are abundant and include thistle, cocklebur, marsh elder, foxtail, morning glory, honeysuckle, goldenrod, burdock, plantain, wild rose, grapevine, and many others. Undergrowth is thickest and most difficult to walk through at the forest margins and wherever the tree stand is somewhat open. Another conspicuous shrub found throughout the area, especially in shelter belts, is the Russian olive. It is a bushy shrub that forms dense thickets, which are ideal for windbreaks.

Forest growth, while not generally tall, is high enough to provide fairly complete cover for individual movement, but, because of the close spacing of the trees and the thick shrub and weed growth, walking is difficult. In winter, foot travel is also hampered by snow in deep drifts that frequently accumulates along the forest margins and by the half hidden shrub growth. Since practically all trees are deciduous and many of the weeds mixed with the undergrowth are annuals, visibility in the forest is far better in winter than in summer.

Along the margins of the lakes and in moist depressions, brush stands are common. These are usually not continuous enough to constitute a problem, although individual stands are frequently thick.

c. Marshland.

The area of Devils Lake was at one time approximately 142 square miles but is now only about 30 square miles. During recent decades, much of the land formerly submerged has been put under cultivation. Many such areas are found near the town of Devils Lake. Many smaller abandoned lake beds are found throughout the area and many of the existing lakes are drying up. Bush vegetation usually surrounds these and the beds themselves are being invaded by swamp grass and weeds.

In summer, the former lake beds are swampy and at all times have small ponds of standing water, but in winter they are frozen over. Vegetation consists of a combination of coarse swamp grass and a growth of weeds which includes Russian thistle, pigeon grass, salt grass, mustard,



M-O A SEPT 1933

Figure 4

TABLE IV: VEGETATION TYPES IN THE DEVILS LAKE TEST AREA

<u>Vegetation Types</u>	<u>Habitat</u>	<u>Principal Species</u>	<u>Size and Density</u>	<u>Color</u>
WOODLAND (Figs 37, 39, 40)	Throughout hill portion of test area and lowland adjacent to lakes. In shelterbelts on plains. Well drained soil.	Oak, box elder, basswood, ash, elm, cottonwood. Underbrush includes chokeberry, buckthorn, buffalo berry, dwarf willow, sand cherry, juneberry, wild plum, currant, wild rose, silver berry, thistle, honeysuckle, grapevine, cocklebur, sumac, etc	Tree tops average about 20 feet - maximum heights up to 55 or 45 feet. Thick stands with closed canopy over most of area.	Many shades of green in summer. Short, multi-colored in autumn with shades of green, yellow, and brown dominant. In winter, grey-brown tone of bare trees on white cover of snow.
MARSHLAND (Figs 36, 38)	Marsky, heavy black clay or muck soils. Essentially flat land.	Reed, swamp grass, Russian thistle, pigeon grass, salt grass, burdock, marsh elder, foxtail, wild oats, and many other weeds.	Grass and weed growth 2 to 3 feet high. Stand appears continuous, but on close inspection is found to be bunchy.	Varying shades of green, brown, and yellow during spring, summer, and early fall. Fields snow-covered in winter.
GRASSLANDS AND GRAINFIELDS	Level to roughly undulating plains. Generally well drained, permeable soils ranging from heavy loams or clays to gravels.	Grasses: buffalo grass, smooth brome, wheat grasses, blue stem, grama, oat grass, needle grass. Grains: wheat, barley, oats, and flax. Weed growth similar to that found in the marshland area.	Heavy turf of grasses up to 16 inches high. Grains in spring and summer may reach 2-1/2 feet. Dead grass and stubble in winter.	Various shades of green, brown and yellow in rectangular plots during spring, summer, and early fall. In winter, fields are largely snow-covered.

burdock, wild oats, foxtail, reeds, and many others. This plant cover generally disappears in winter, but in summer may constitute a problem to vehicular movement by concealing boulders, small sloughs, and open holes. Foot movement is unaffected by the vegetation in either summer or winter.

d. Grasslands and Grainfields.

North of Camp Grafton and east and south of the hill lands are large areas of farmland. Vegetation consists primarily of pasture grasses, meadows, and domestic grain fields. Among the more common grasses used for pasture and meadow are smooth brome, crested wheat, slender wheat, buffalo grass, blue stem, grama, oat grass, and needle grass. The most extensive pasturelands and meadows are in the roughly undulating land just south of the hills. North of Camp Grafton, cultivated grain fields occupy a much larger percentage of the land than they do farther south. The grains are largely spring sown and are harvested in late July and August. Of the grains almost 50 percent of the area is in spring wheat and about 25 percent in barley. Oats and flax make up most of the remaining crop land.

Agricultural land, if not properly cared for, will be invaded by weed growth within a very short time. Among the more common weeds are gumweed, foxtail, sage, yellow corn flower, wild barley, creeping jenny, cocklebur and plantain.

e. Vegetation Data.

Types of vegetation are shown on Figure 4 and summarized in Table IV.

5. Animal Life

The Devils Lake area is ideal for many forms of animal life - large and small. The Sullys hill region is set aside as a game preserve, but hunting is now allowed on the Camp Grafton Military Reservation. Deer are very numerous and should continue to be, since sportsmen are allowed to hunt only one day each year. Rabbits are numerous and so are other small animals such as squirrels. The lakes, especially those south of the hill belt, attract huge flocks of ducks, geese, and other water birds, and the grain fields provide food for large numbers of pheasant and quail.

Swarms of insects are found near the lake and in the surrounding marshy lowlands. Mosquitoes, while most numerous in the moist lowland surrounding the lake and in the dry lake bed, are found throughout the test area even in the higher parts of the hill lands. These, together with horse flies and deer flies, are annoying, especially in late afternoon and early evening. Of all the localities in the test area, the most insect-afflicted spot is the center of the large dry lake bed east

of Camp Grafton.

6. Acknowledgements

The maps and graphs in this handbook were drafted by Mr. Donald Cox and Miss Gertrude Barry. Appreciation is expressed to Mr. Sigmund Falkowski and Mr. William Robison for their review and suggestions for the sections on climate, terrain, and vegetation. Acknowledgement is also made to military personnel at Devils Lake for their assistance during the field surveys.

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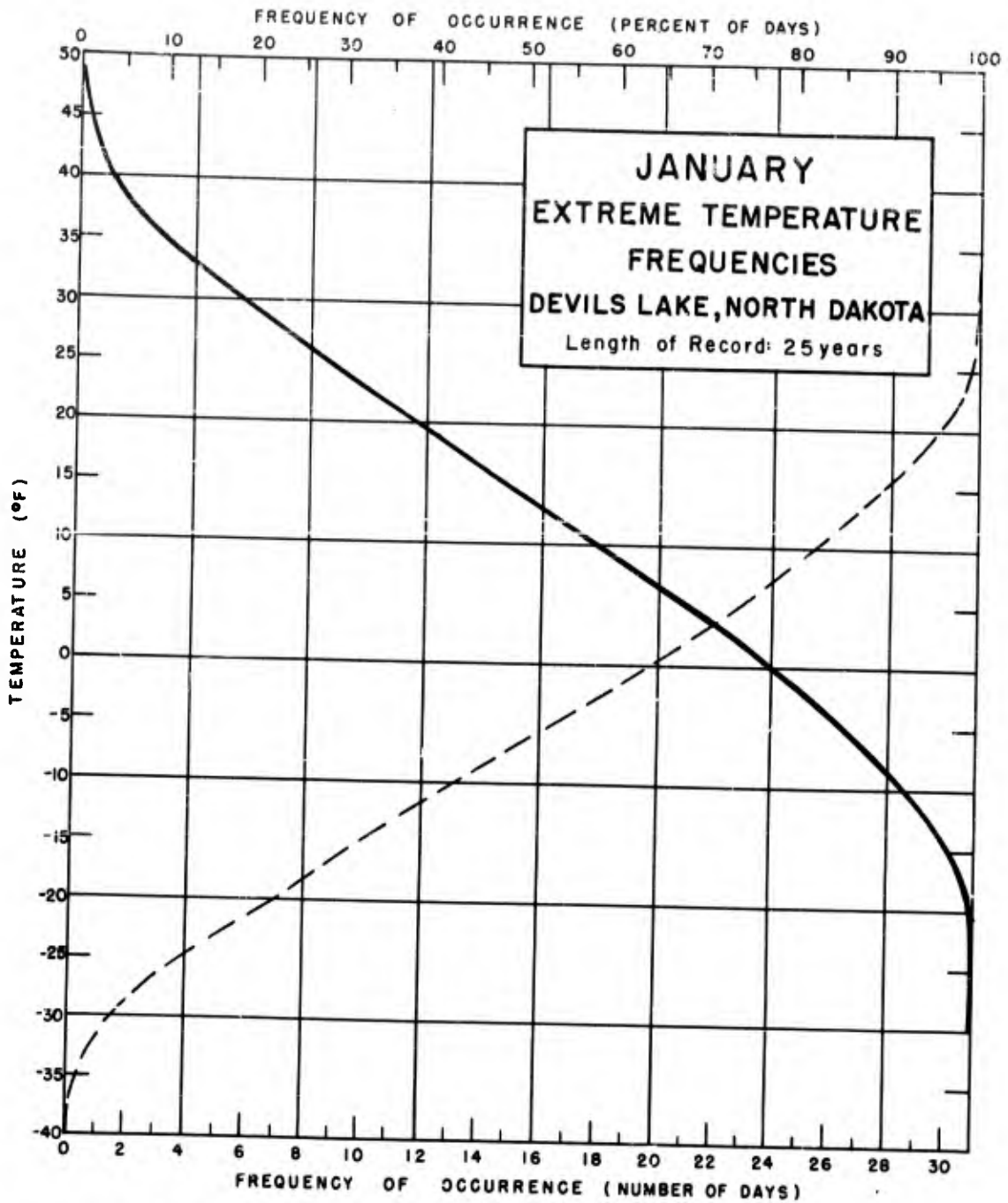
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APPENDIX A
CLIMATIC GRAPHS

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Temperature regime	32
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Precipitation regime	45
Sky cover	46
Amount of sunshine	47
Surface winds (table)	48
Relative humidity	49
Monthly snowfall	50
Thunderstorms and heavy fog (table)	51

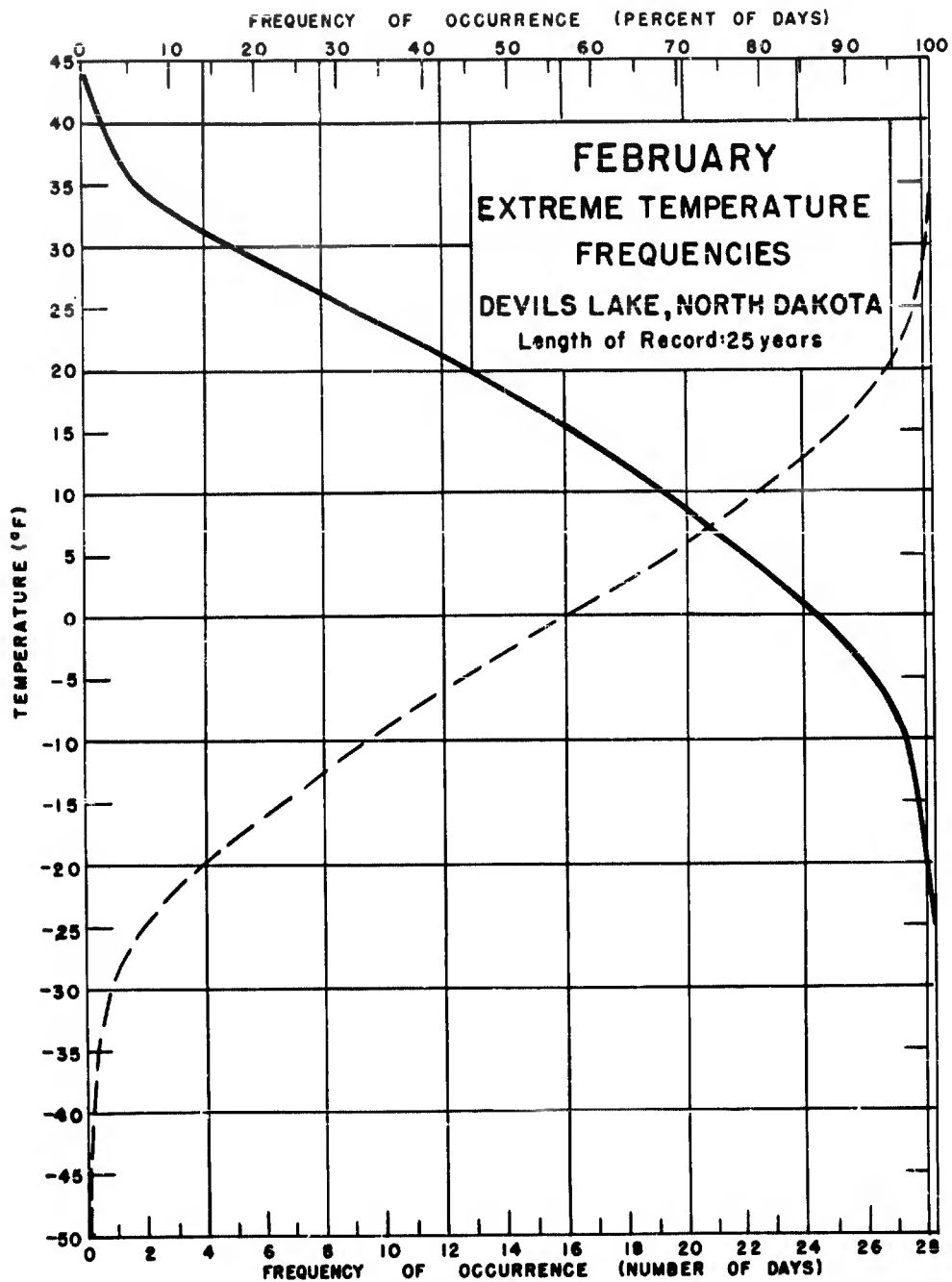
SOURCES OF DATA

The climatic data utilized in preparing the graphs comprising Appendix A were obtained from United States Weather Bureau records for Devils Lake, North Dakota. Temperature and precipitation frequency graphs are based on a 25-year record (1928 to 1952, inclusive). The remainder of the data presented in the graphs and tables have periods of record of from 1 year for wind to 12 years for relative humidity, 45 years for precipitation, sky cover, sunshine and snowfall, and 47 years for temperature.



- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

FIGURE 5

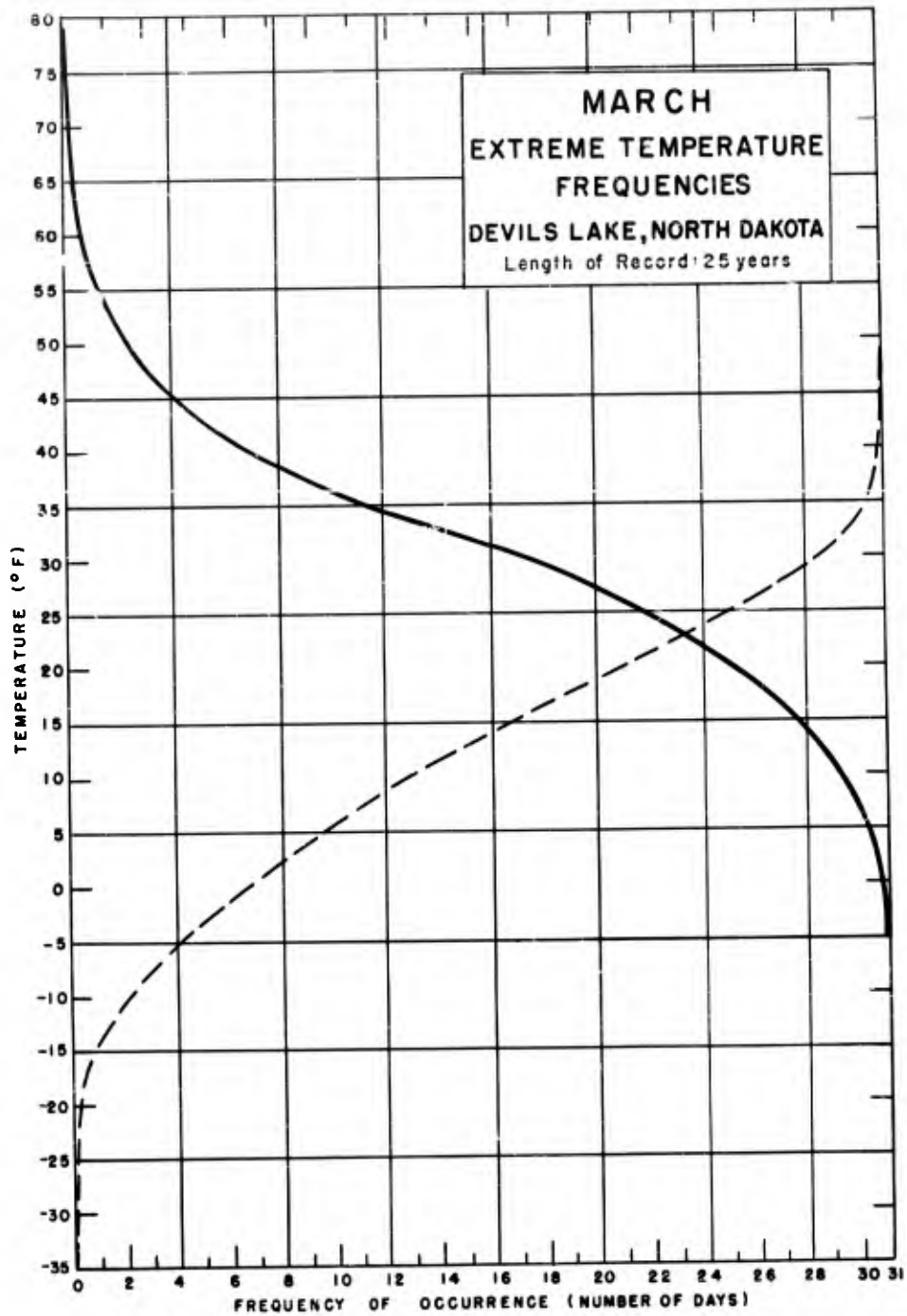


— Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.

--- Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

FIGURE 6

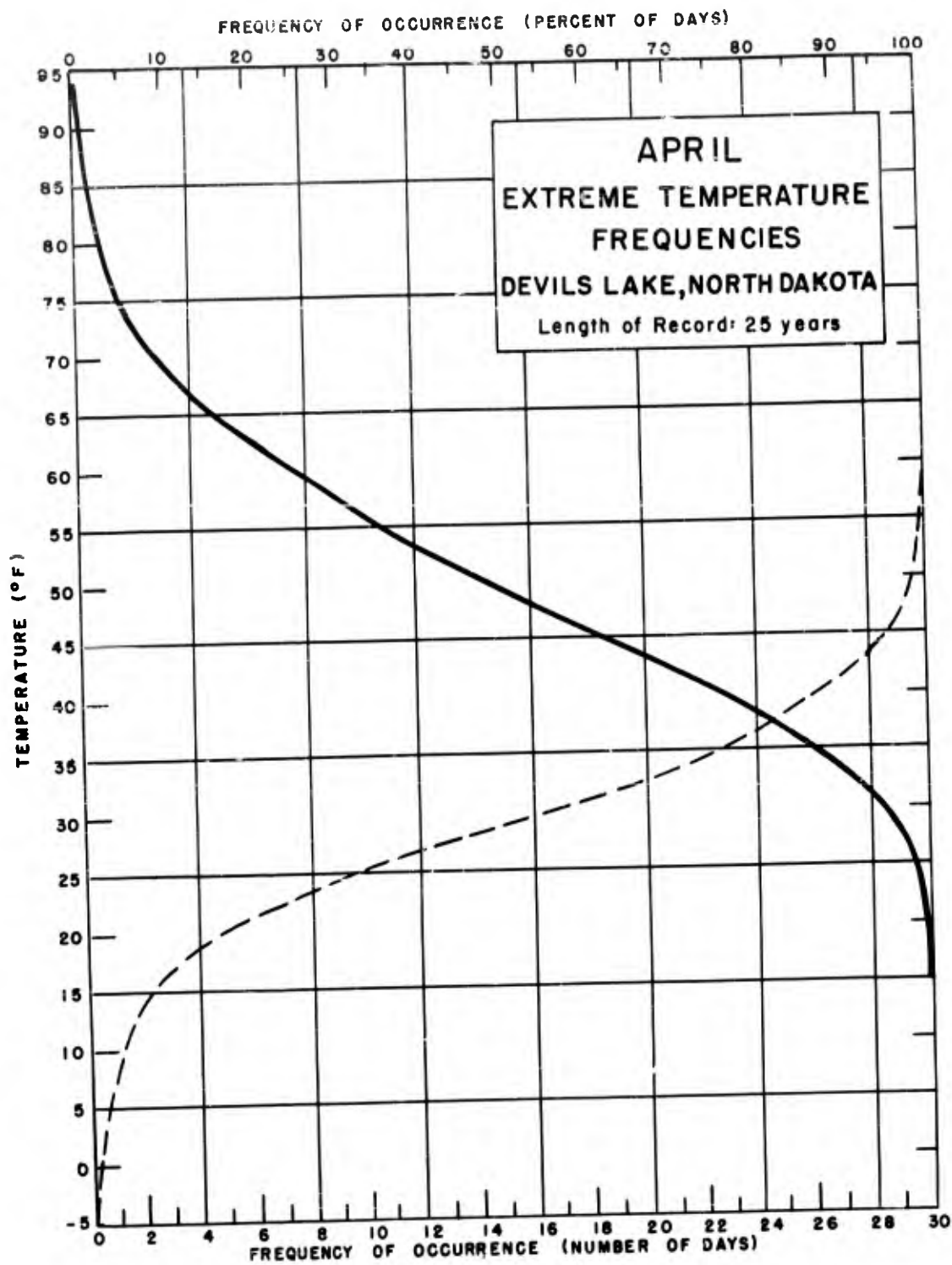
FREQUENCY OF OCCURRENCE (PERCENT OF DAYS)



— Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.

- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

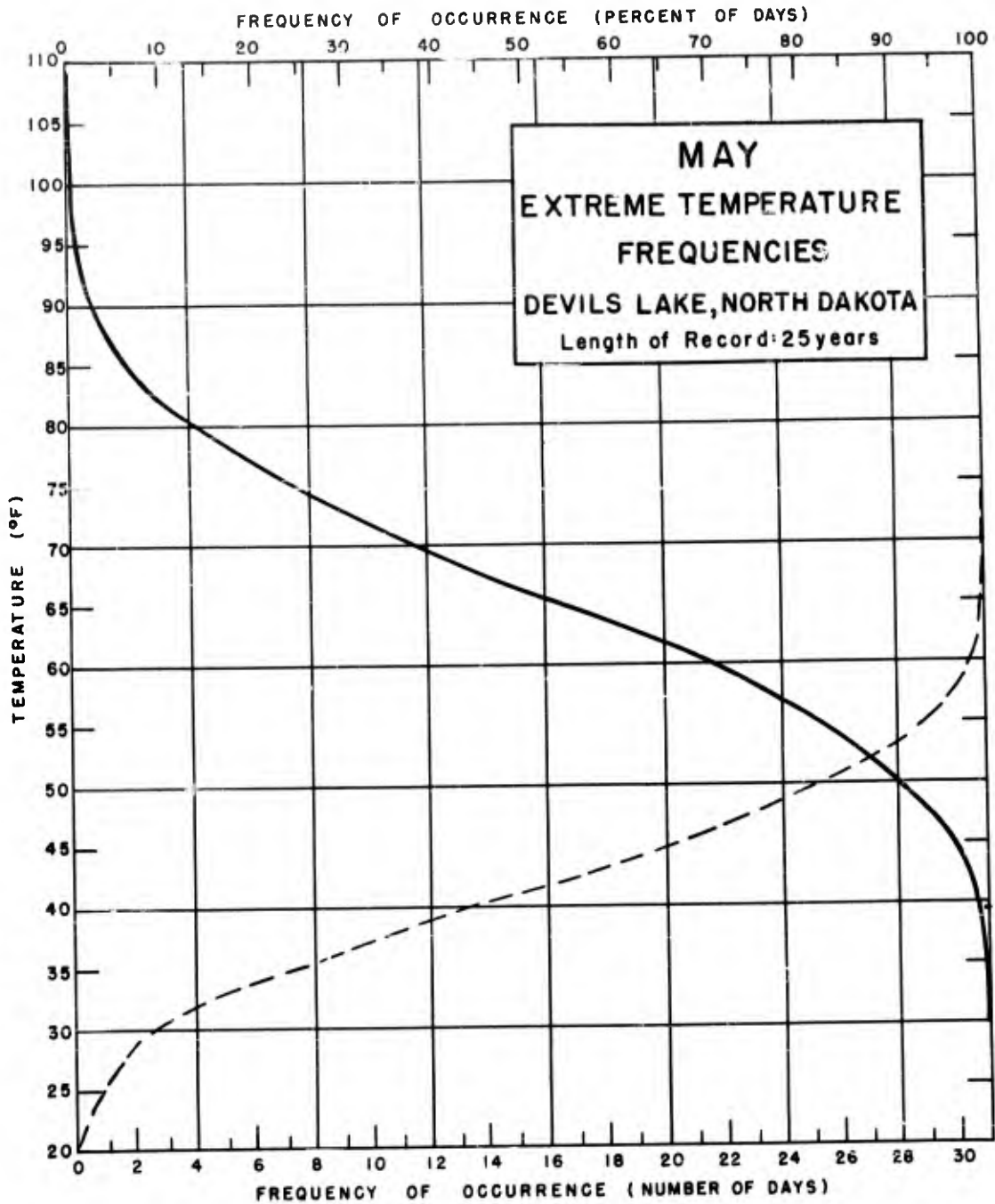
FIGURE 7



— Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.

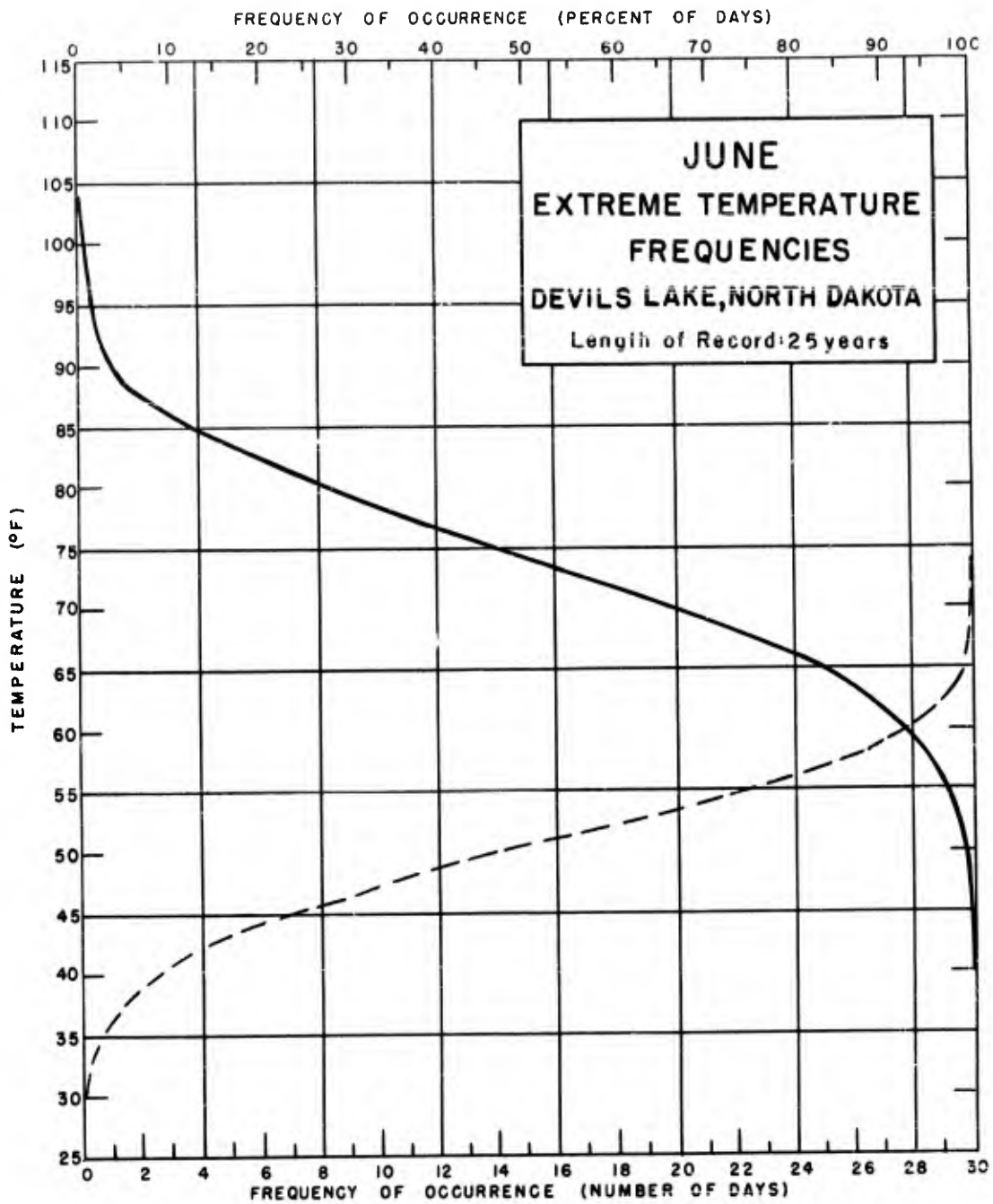
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

FIGURE 8



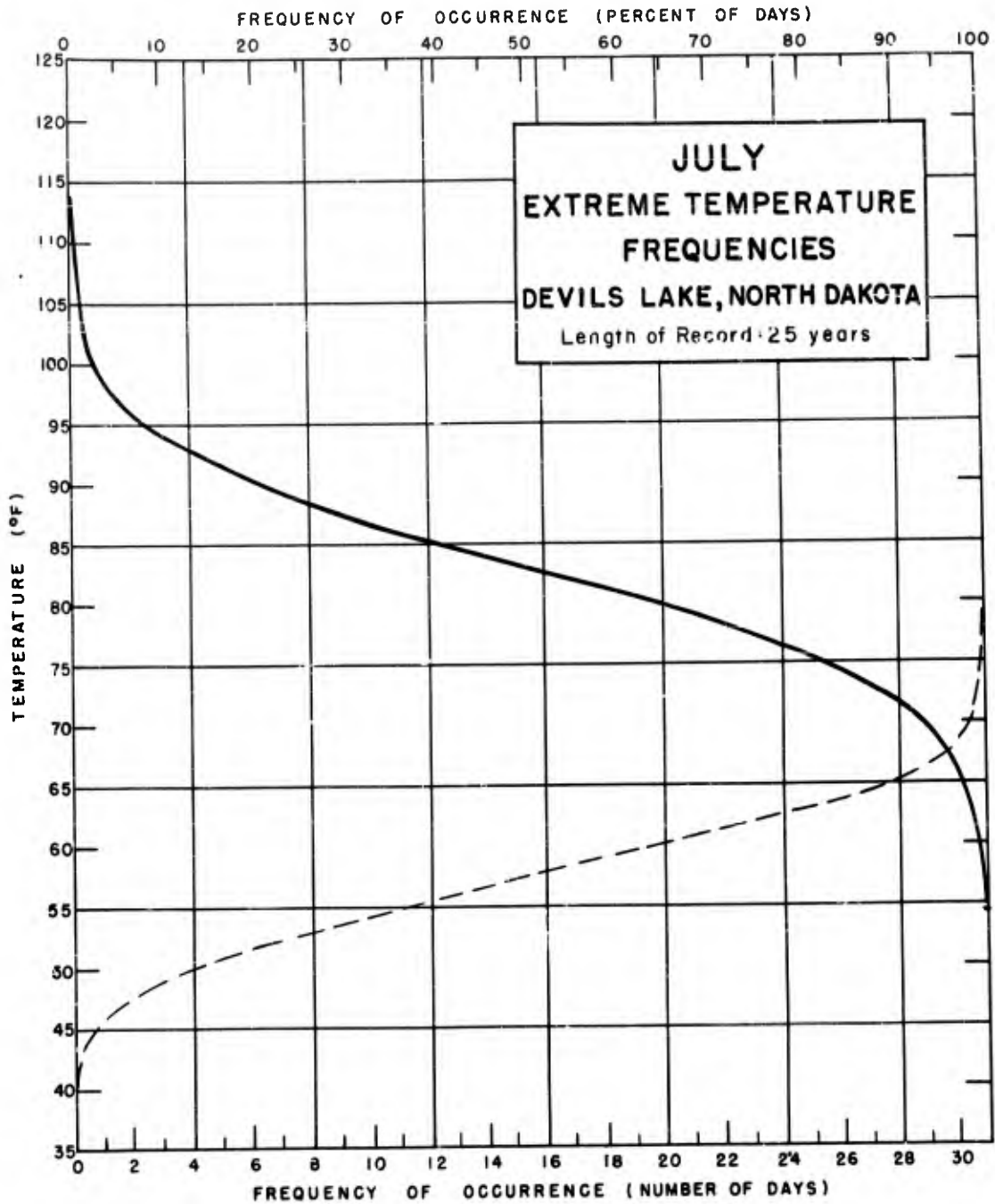
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

FIGURE 9



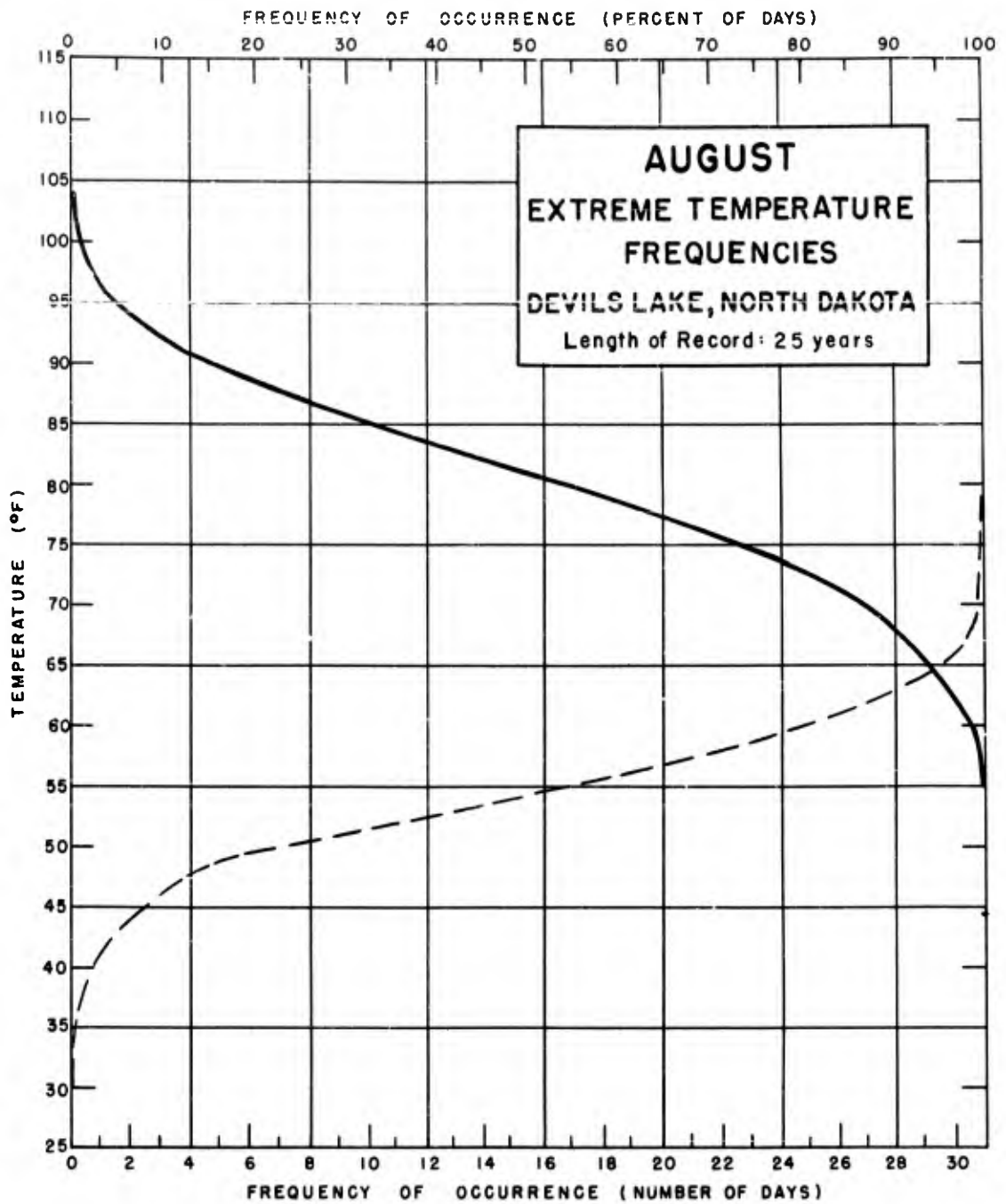
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

FIGURE 10



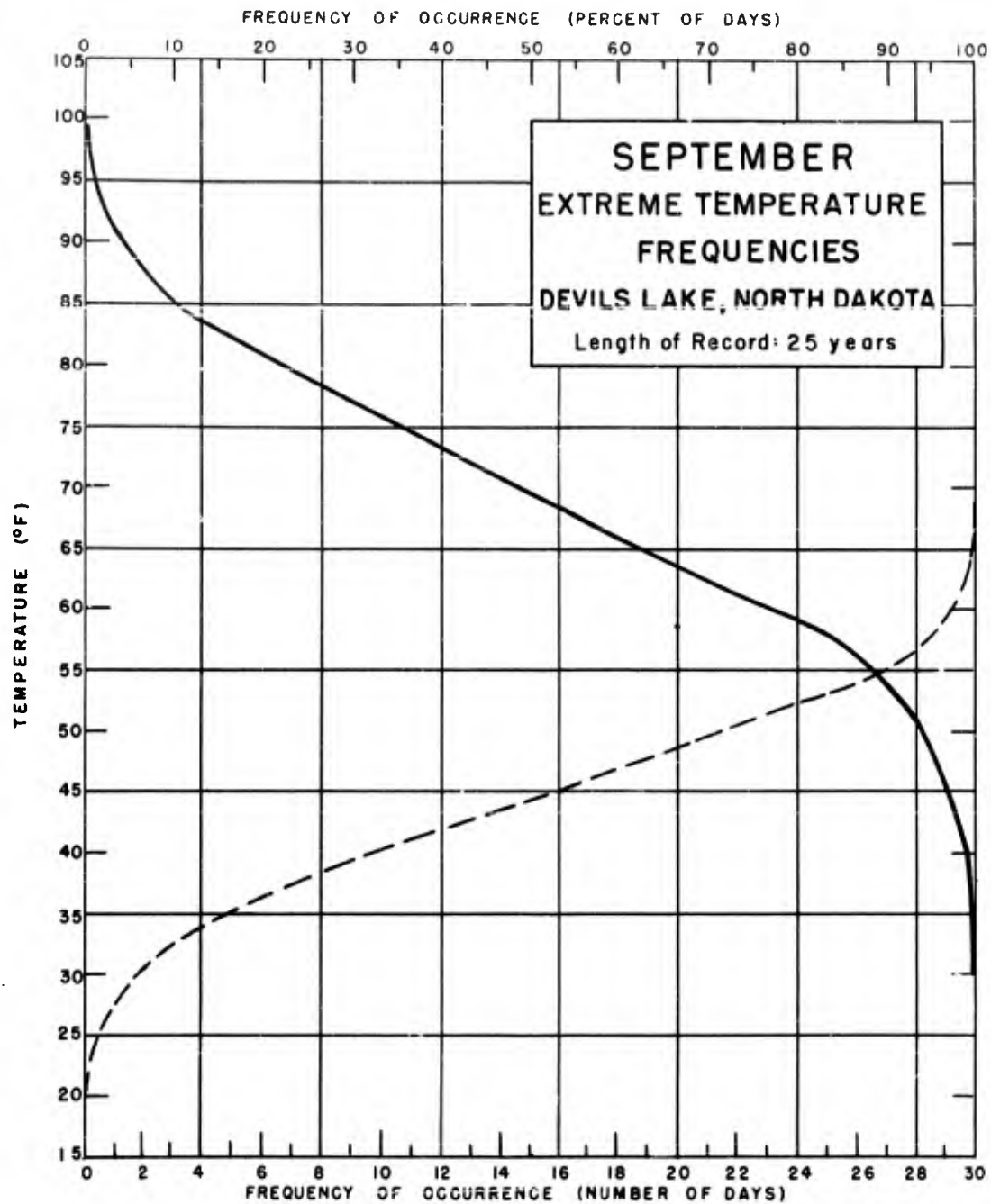
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

FIGURE 11



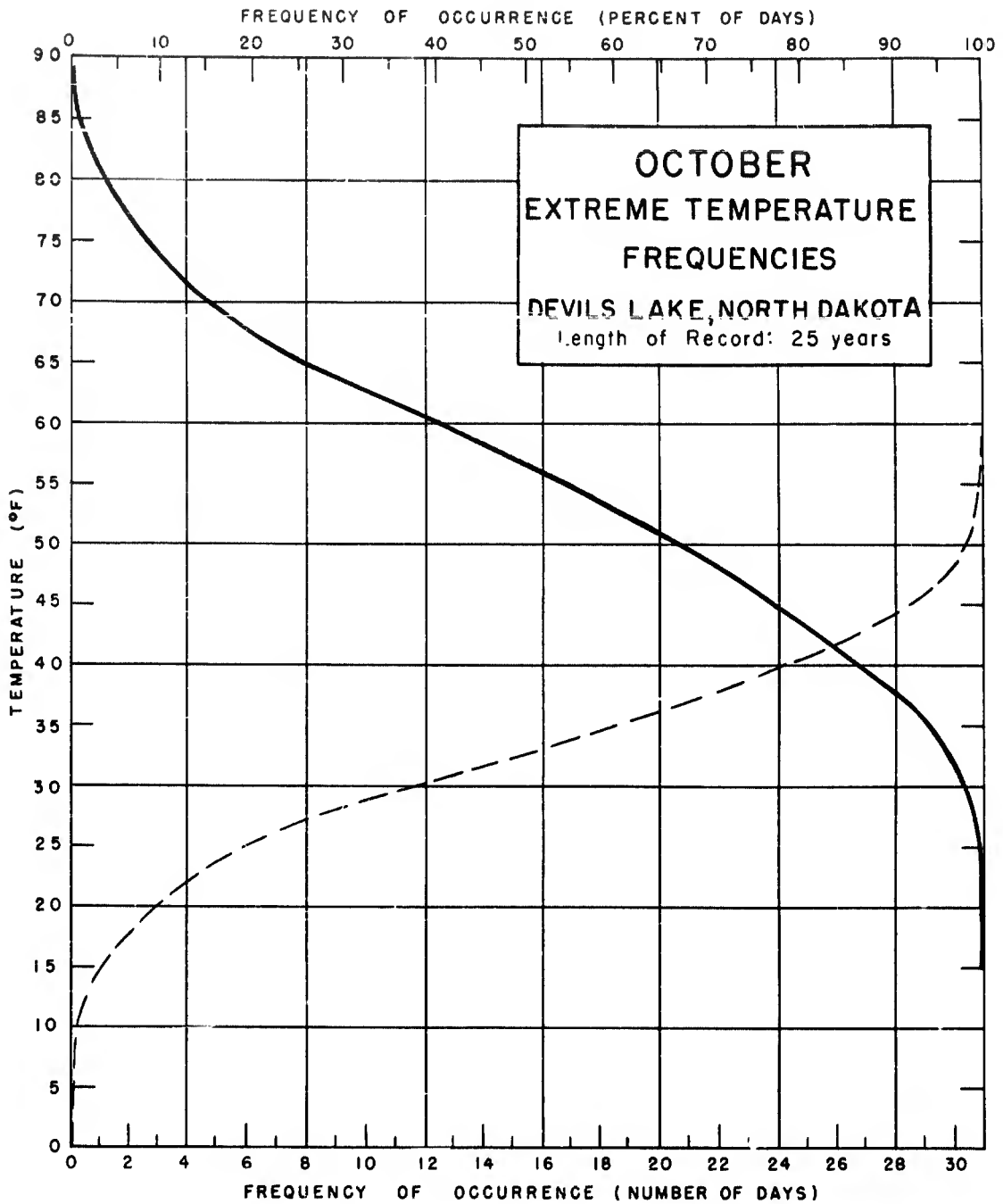
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

FIGURE 12



- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

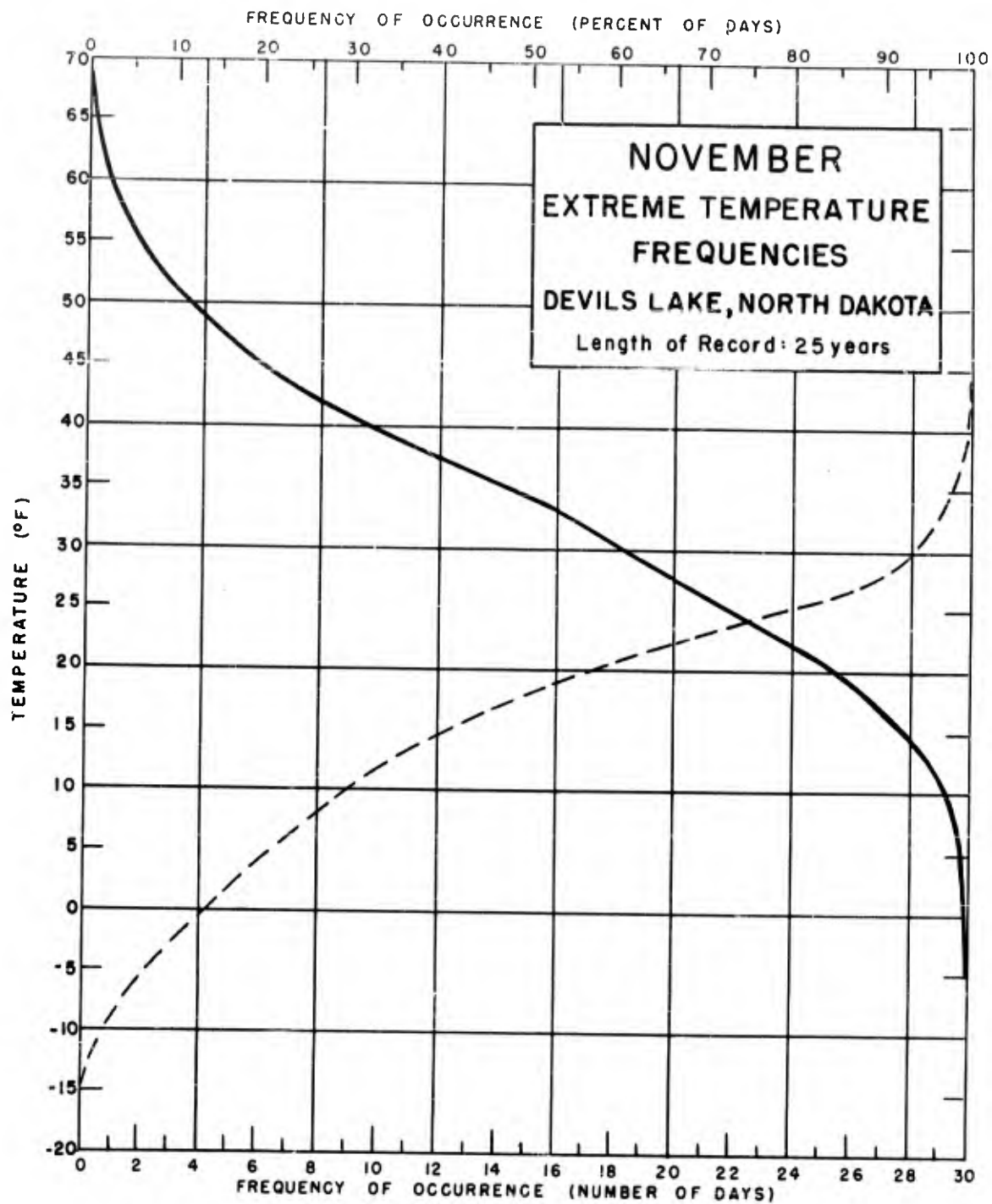
FIGURE 13



— Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.

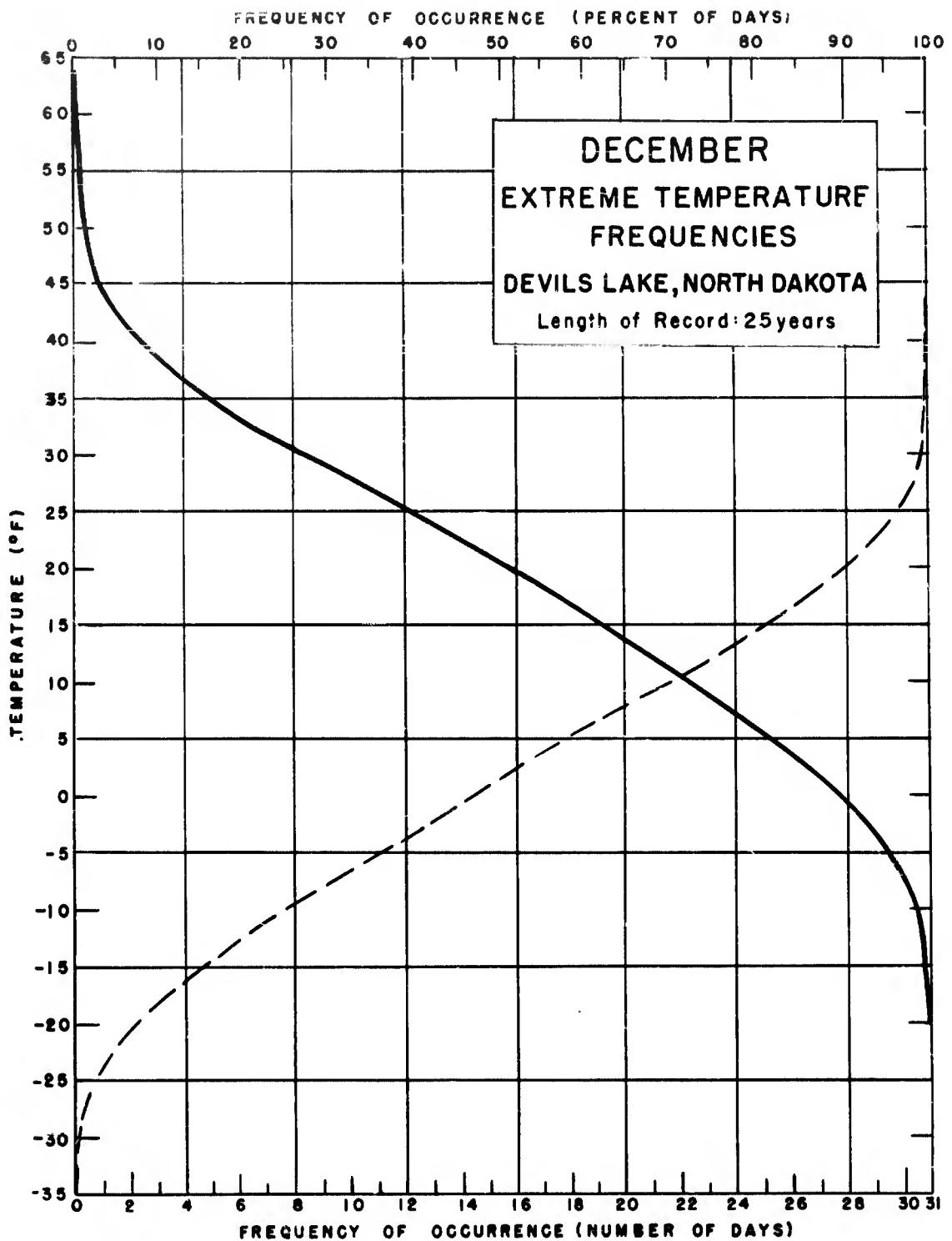
- - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

FIGURE 14



- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

FIGURE 15



- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

FIGURE 16

TEMPERATURE REGIME

DEVILS LAKE, NORTH DAKOTA

Length of Record: 47 years

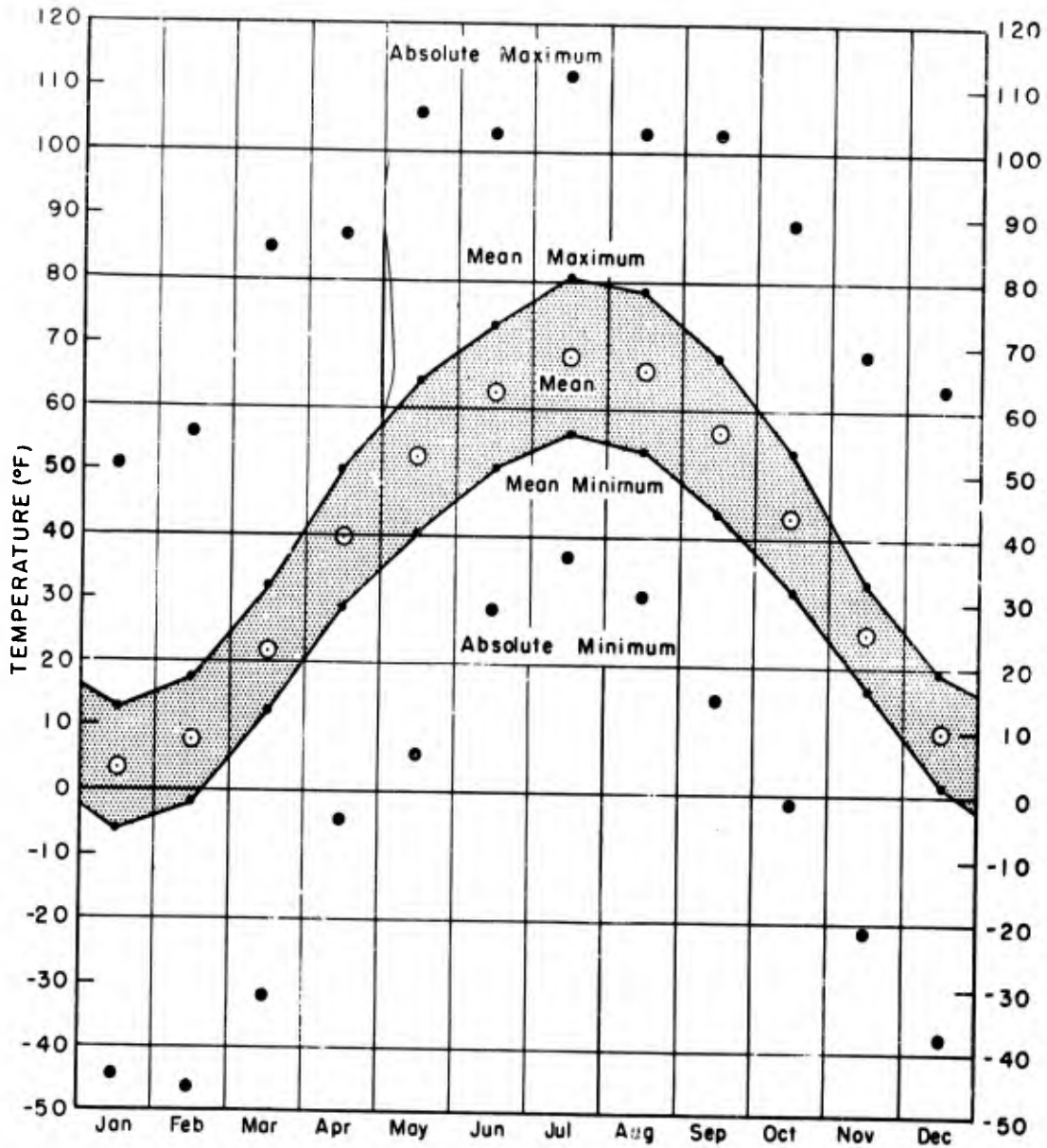
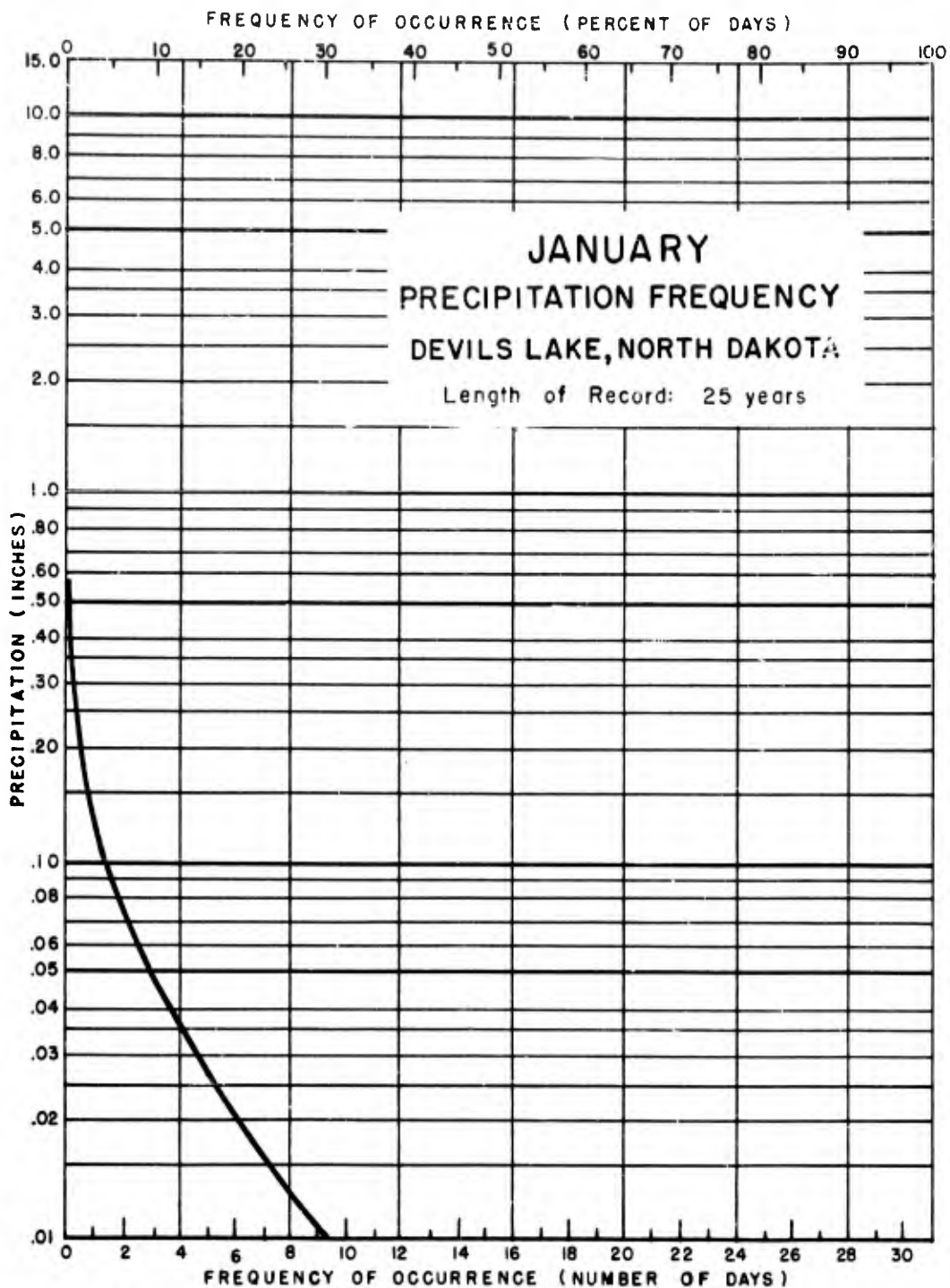


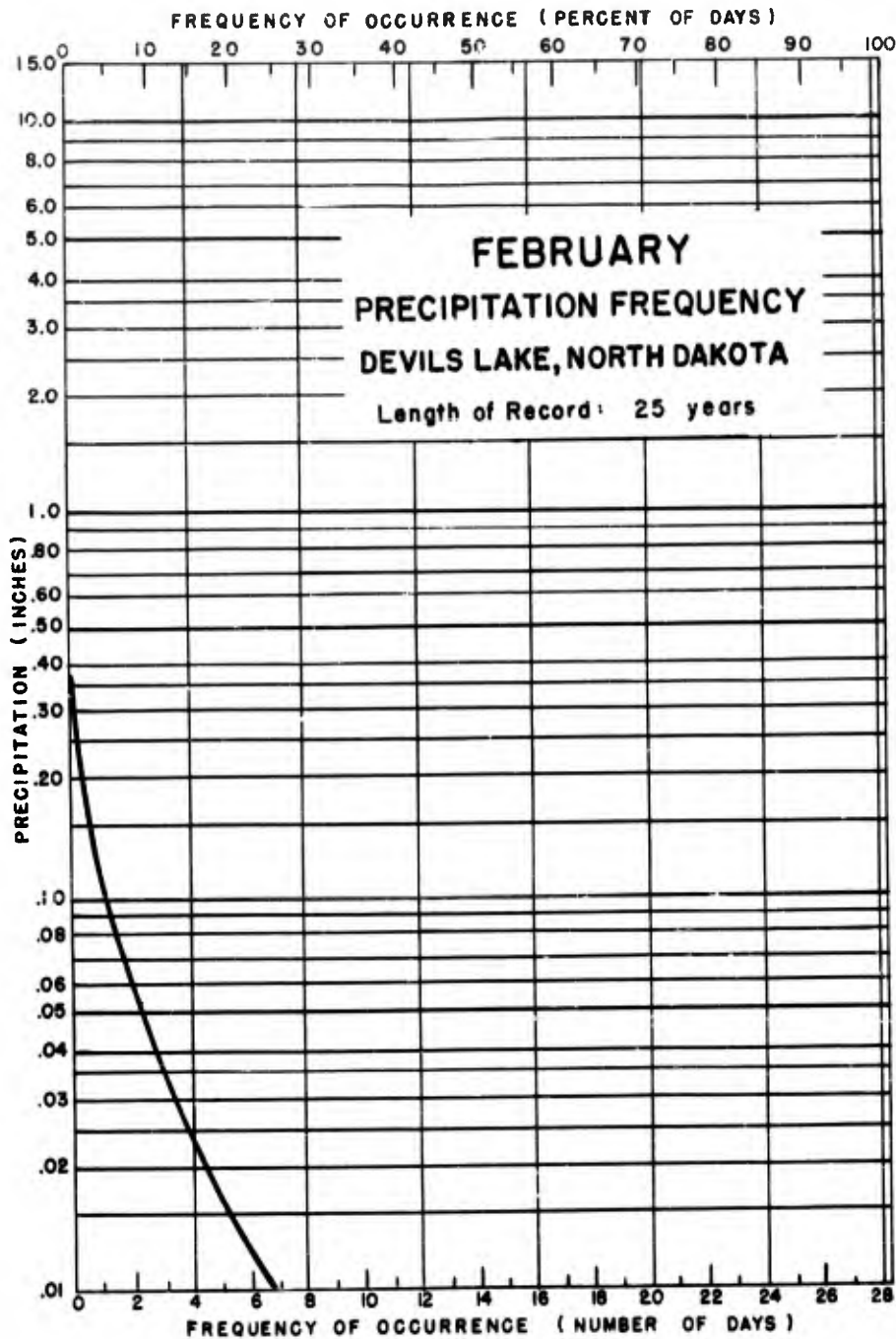
FIGURE 17



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .02 inches or more precipitation may be expected to occur 6 days during January (or approximately 19 percent of the days).

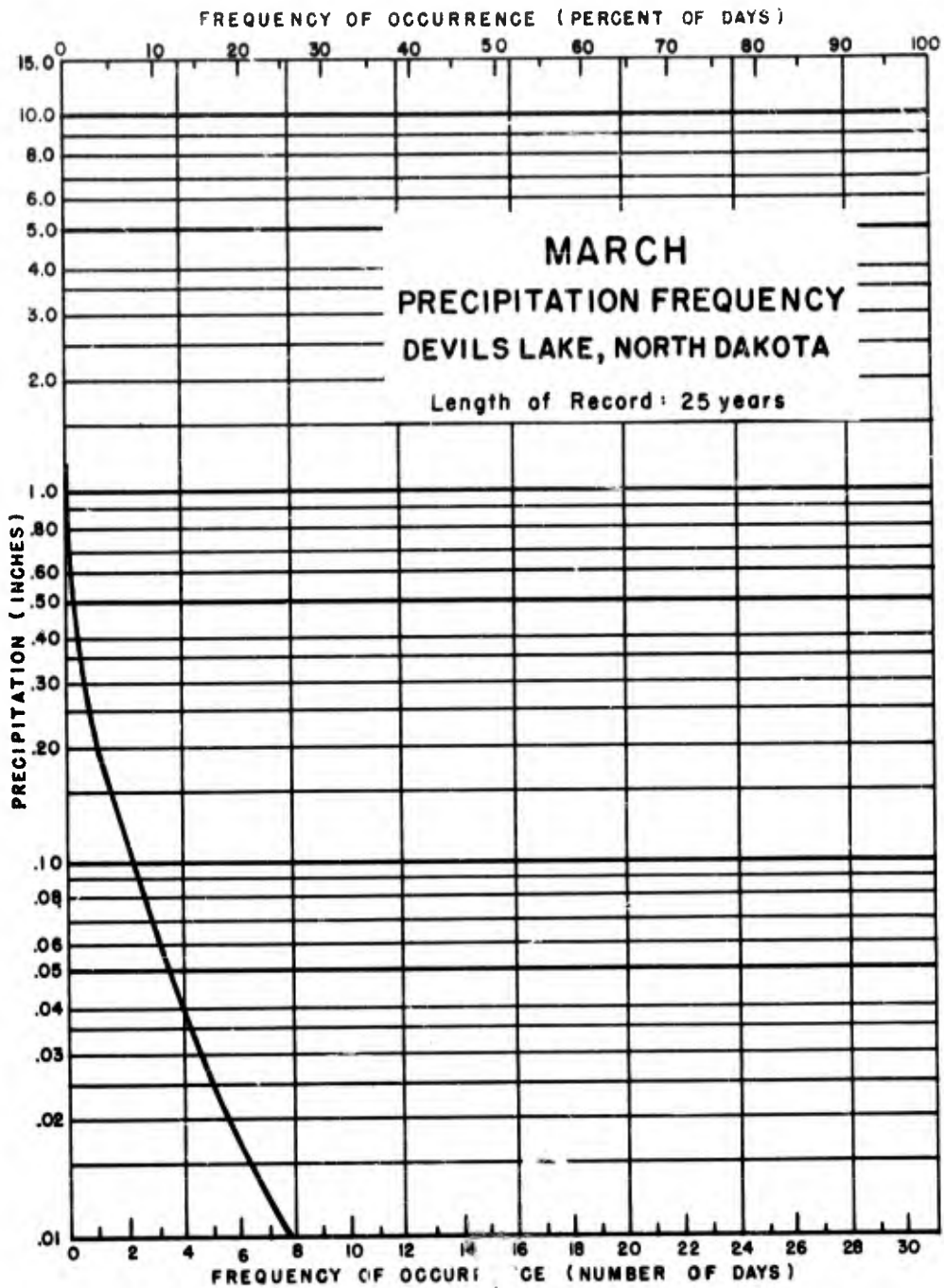
FIGURE 18



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .06 inches or more precipitation may be expected to occur 2 days during February (or approximately 7 percent of the days).

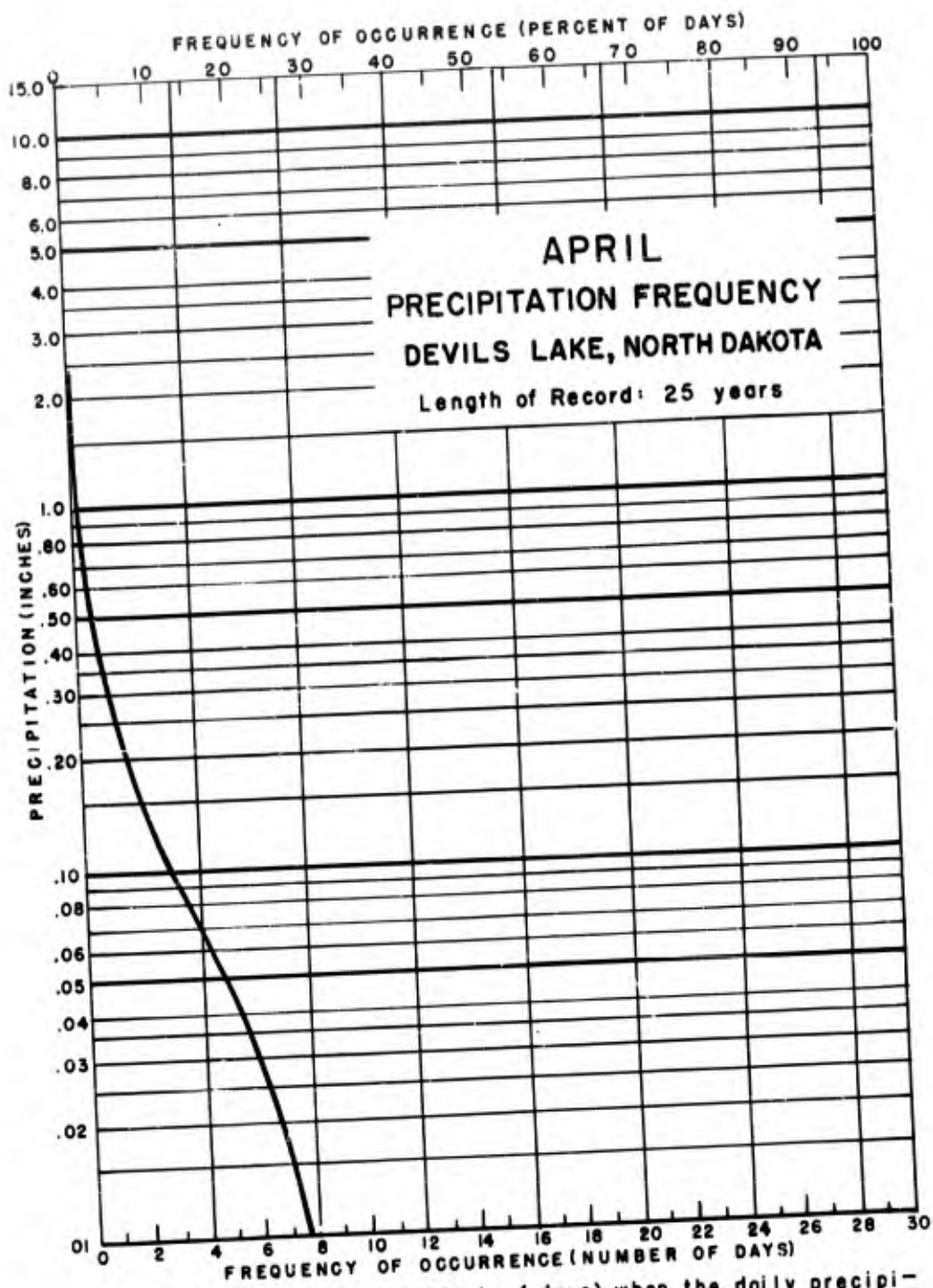
FIGURE 19



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .04 inches or more precipitation may be expected to occur 4 days during March (or approximately 13 percent of the days).

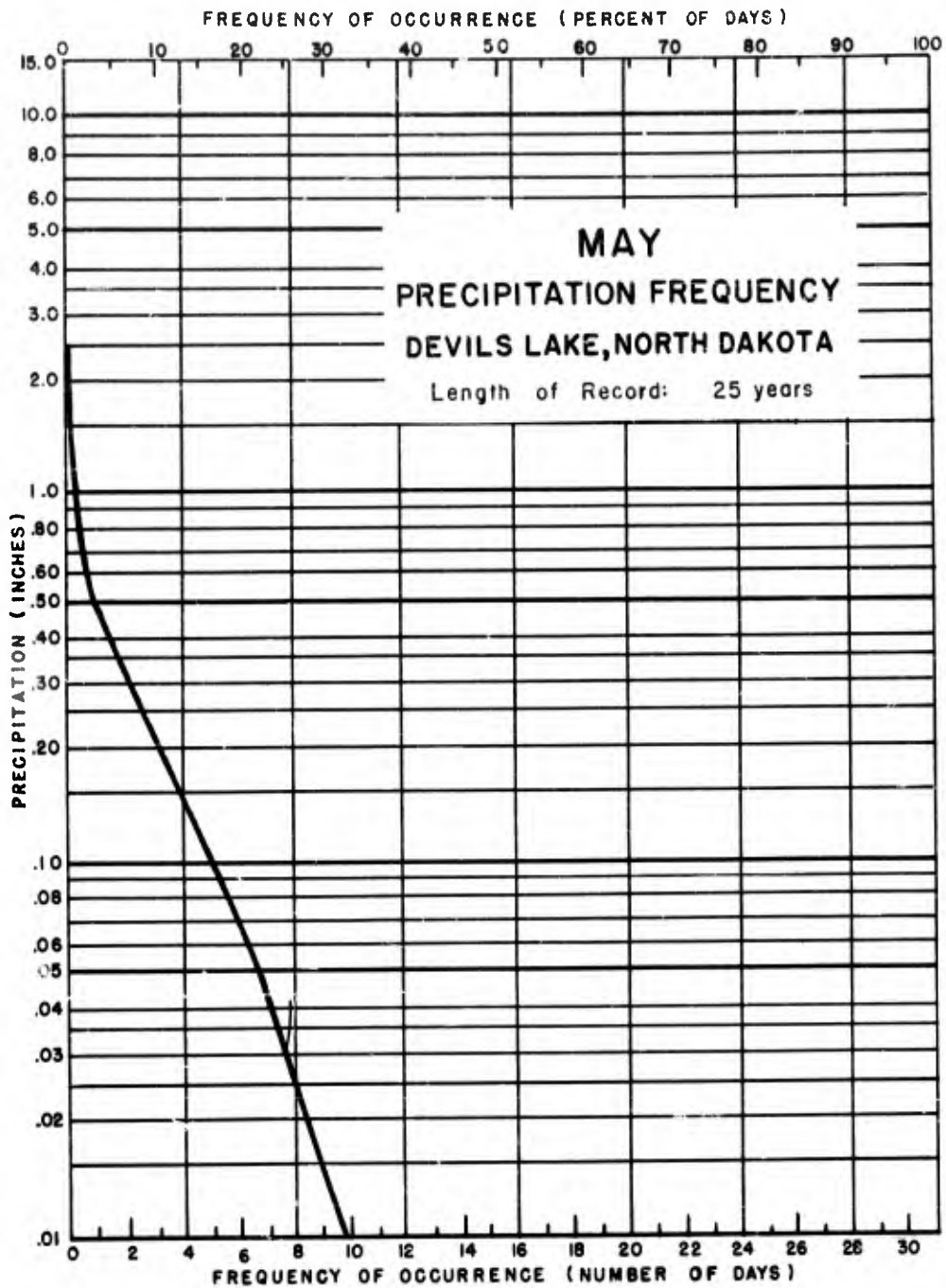
FIGURE 20



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .05 inches or more precipitation may be expected to occur 5 days during April (or approximately 17 percent of the days).

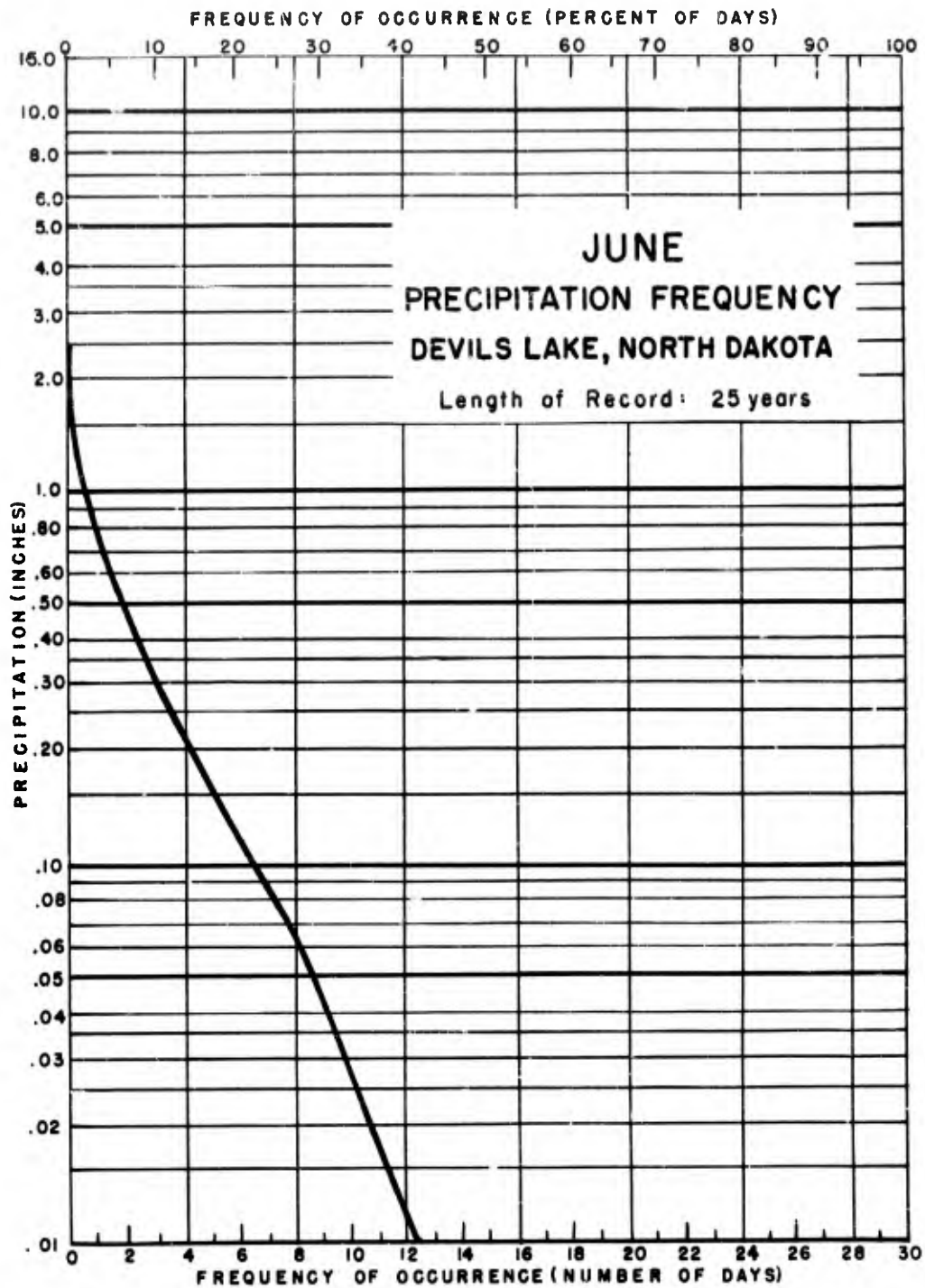
FIGURE 21
36



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .04 inches or more precipitation may be expected to occur 7 days during May (or approximately 23 percent of the days).

FIGURE 22

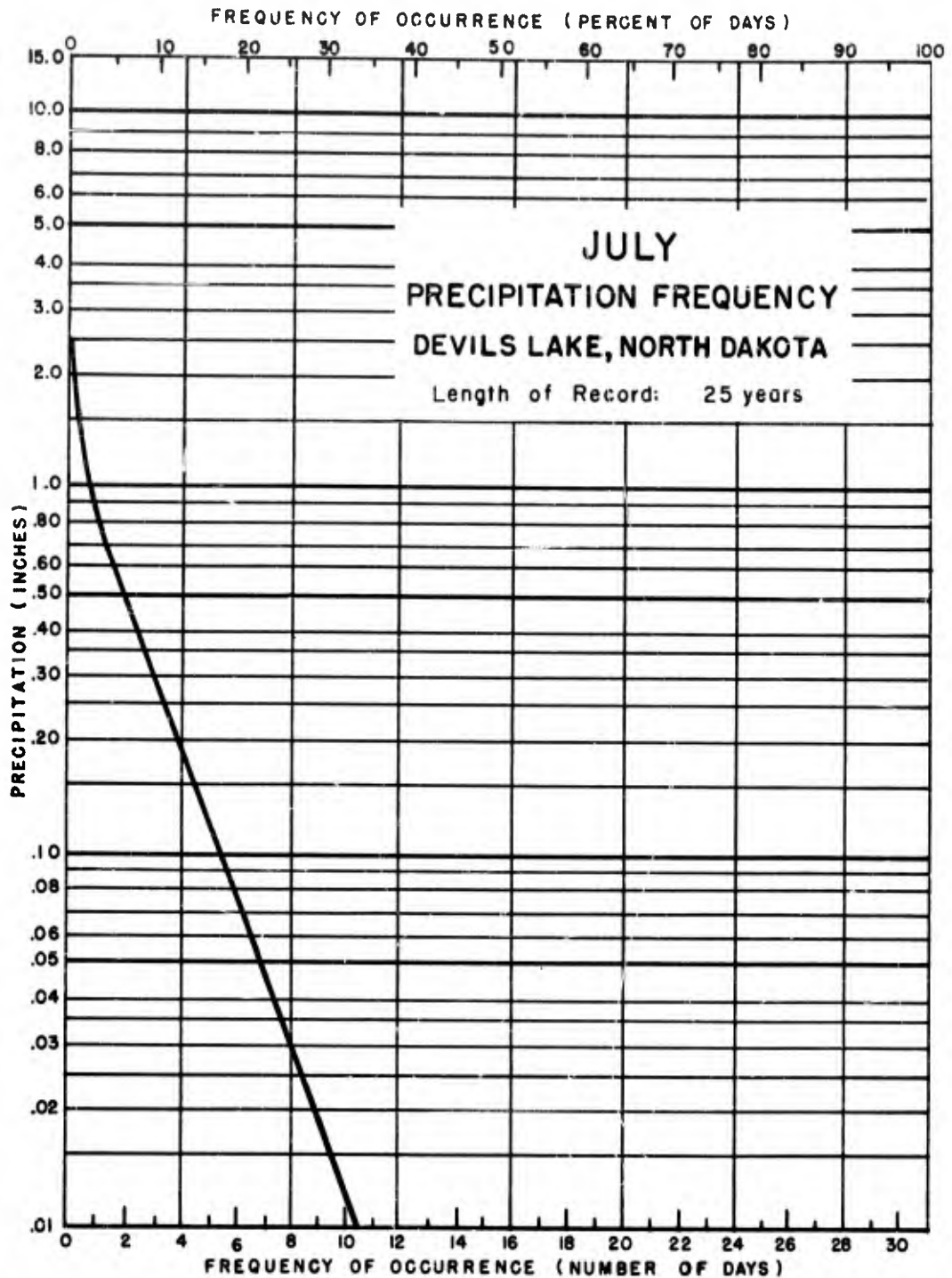


Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .06 inches or more precipitation may be expected to occur 8 days during June (or approximately 27 percent of the days).

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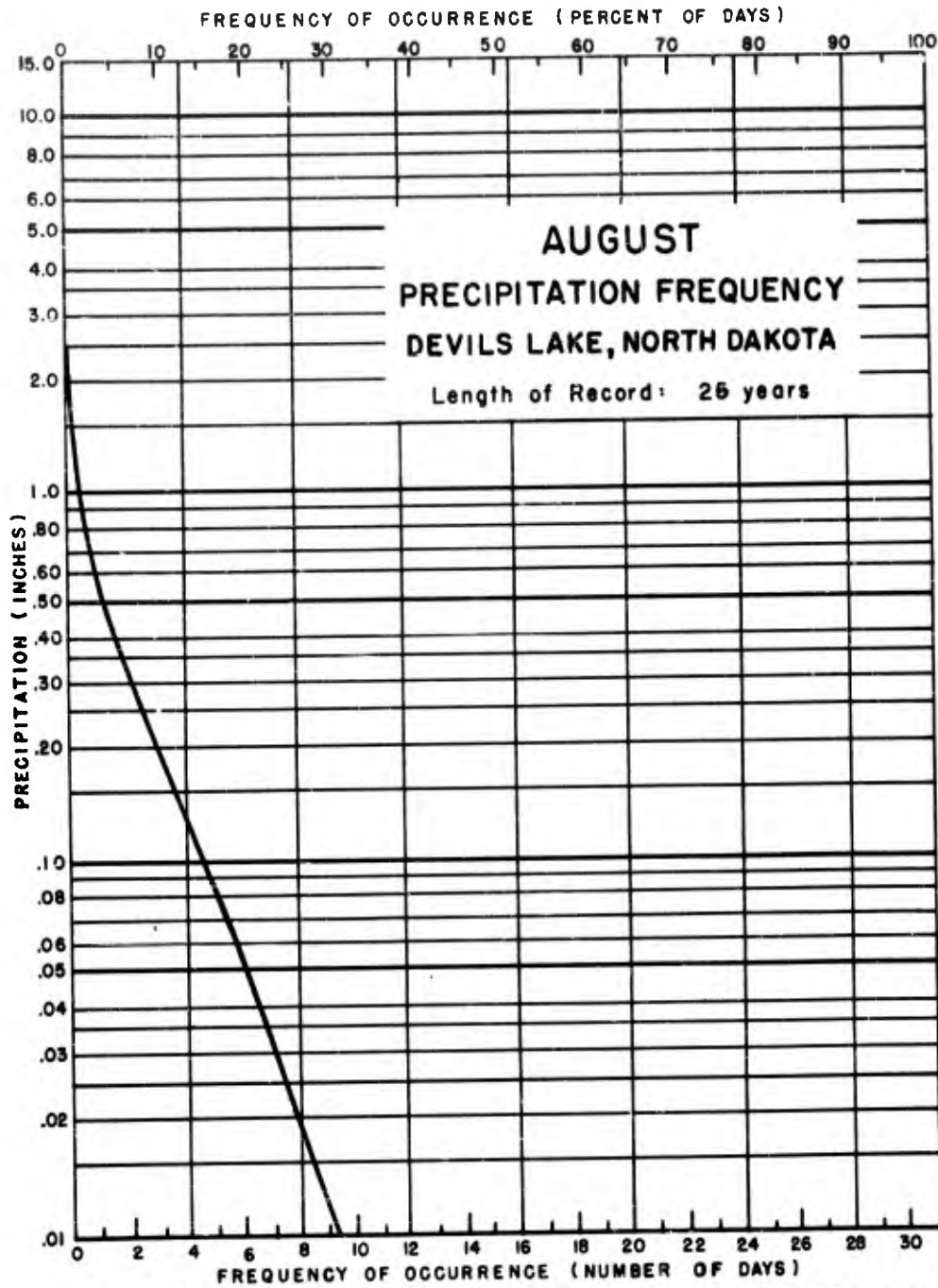
FIGURE 23



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .03 inches or more precipitation may be expected to occur 8 days during July (or approximately 26 percent of the days).

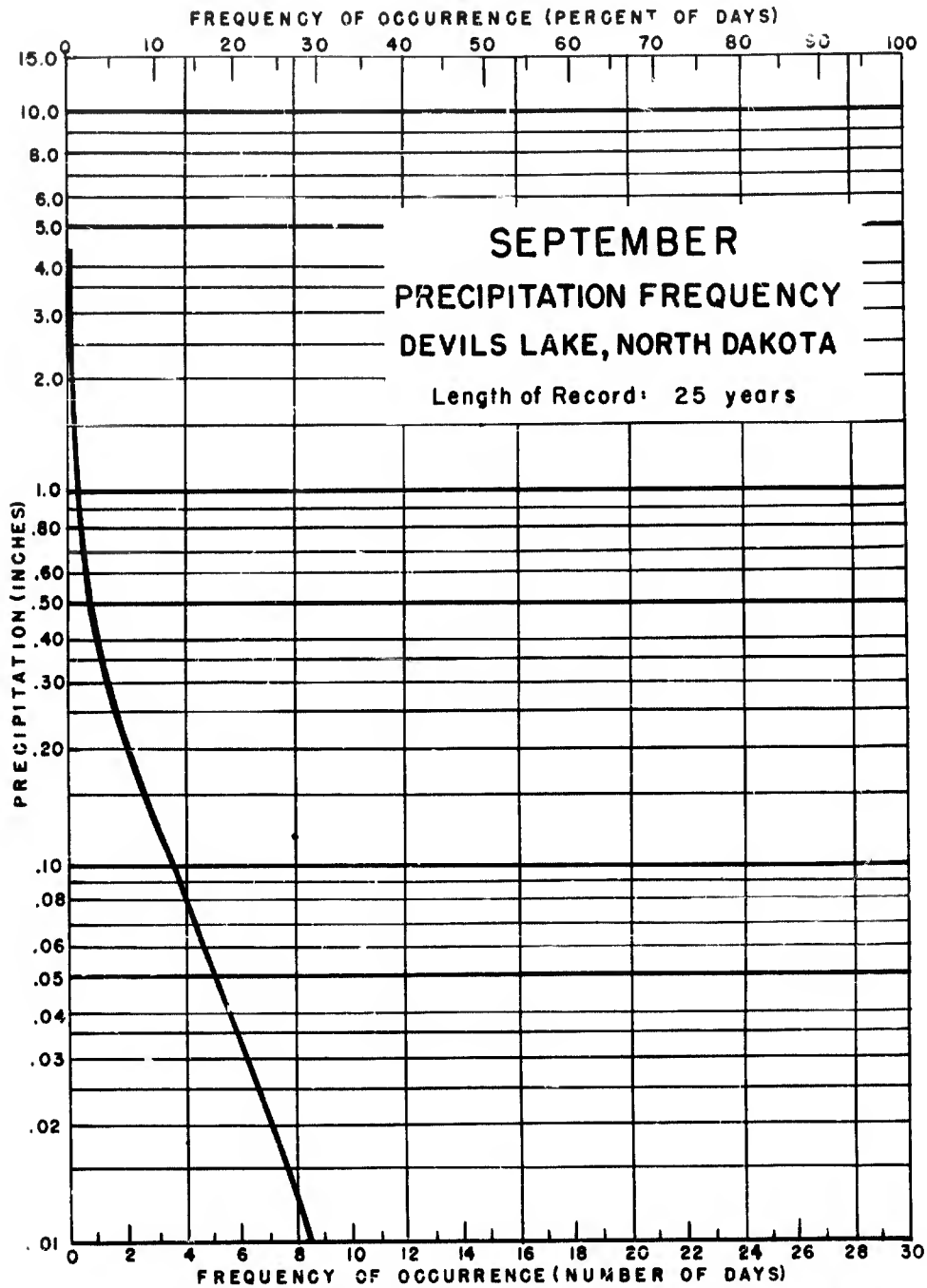
FIGURE 24



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .05 inches or more precipitation may be expected to occur 6 days during August (or approximately 19 percent of the days).

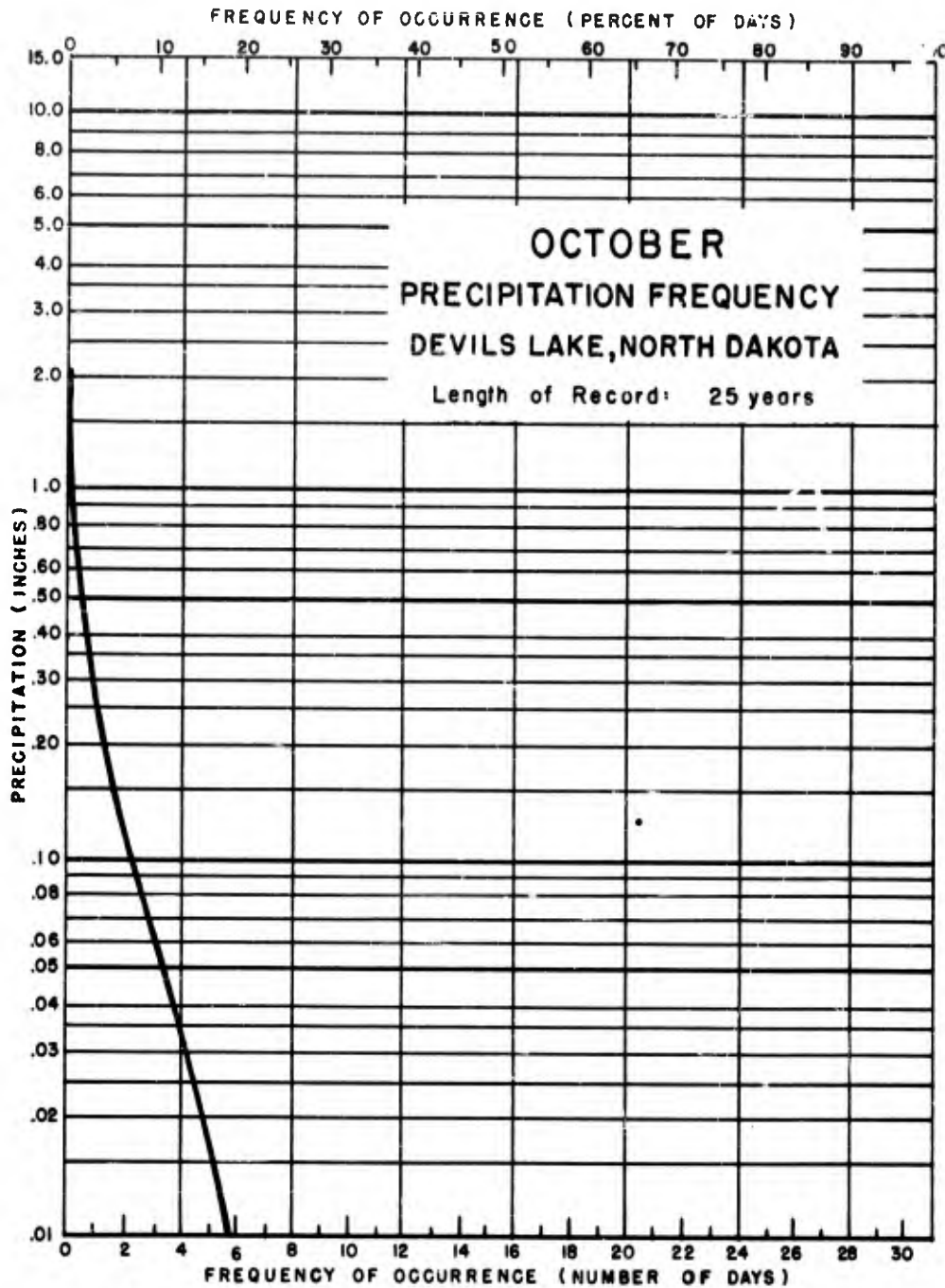
FIGURE 25
40



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .09 inches or more precipitation may be expected to occur 4 days during September (or approximately 13 percent of the days).

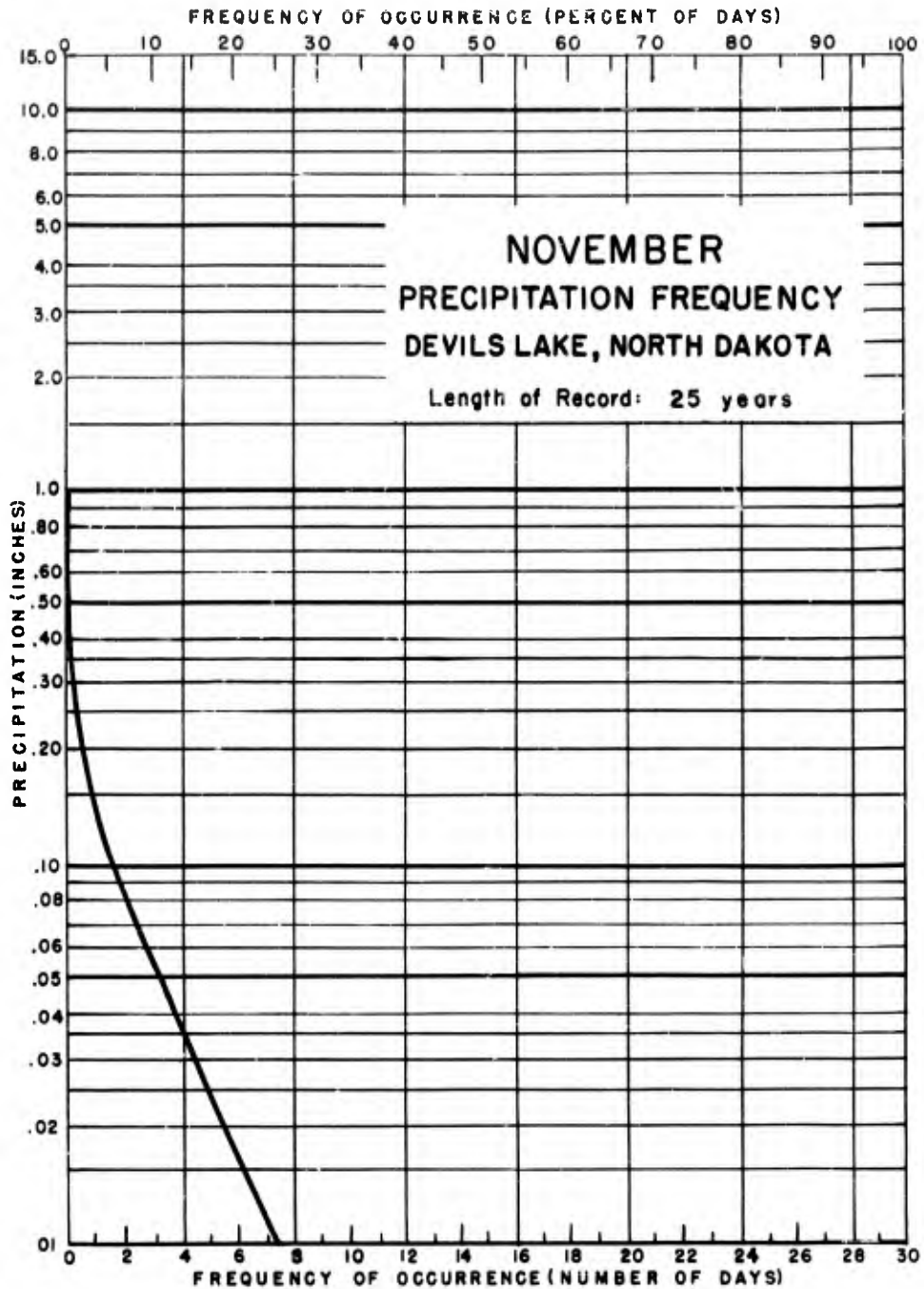
FIGURE 26



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .05 inches or more precipitation may be expected to occur 20 days during October (or approximately 66 percent of the days).

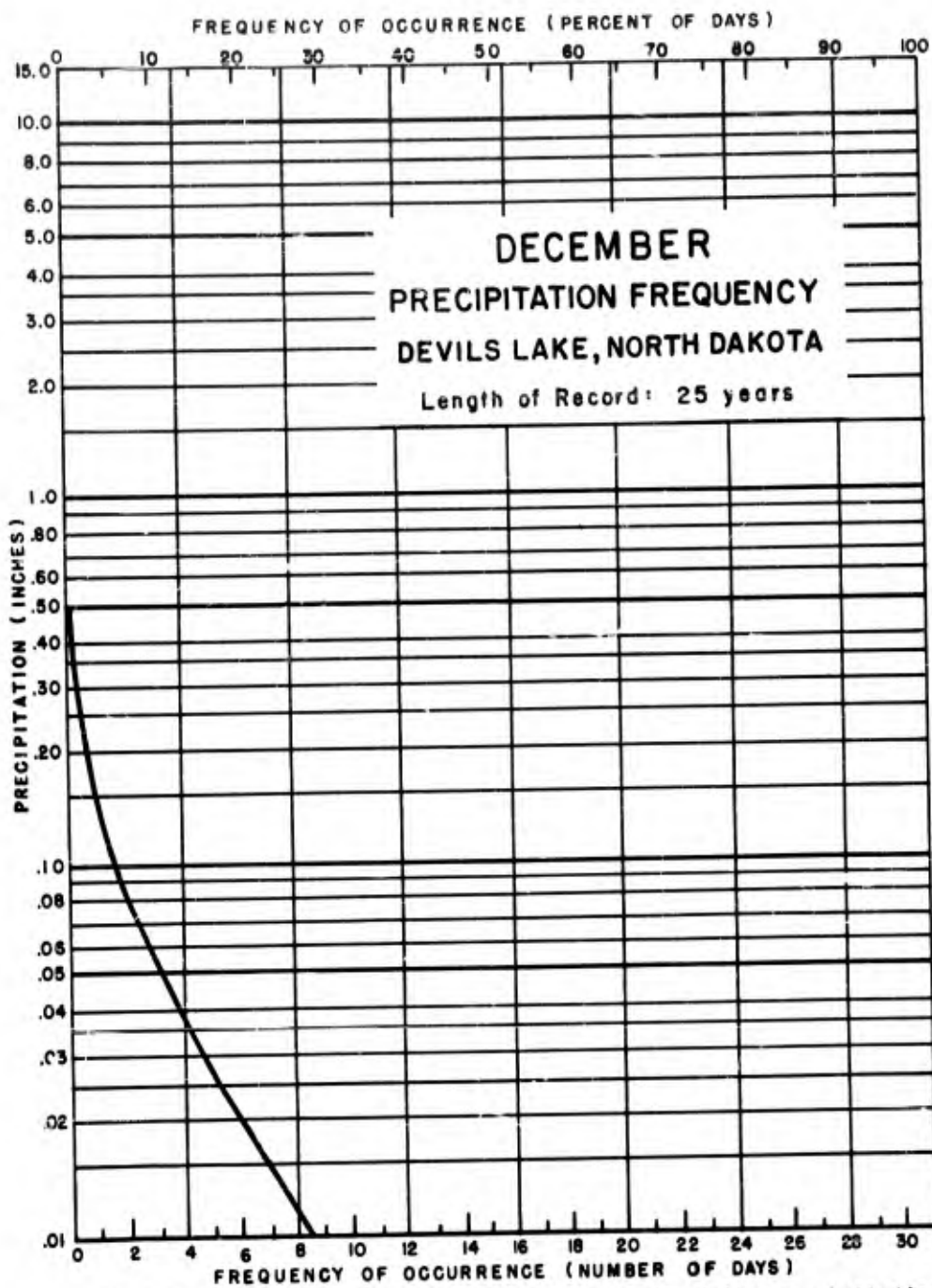
FIGURE 27



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .05 inches or more precipitation may be expected to occur 3 days during November (or approximately 10 percent of the days).

FIGURE 28



Number of days (or percent of days) when the daily precipitation may be expected to be the indicated amount or greater.

Example: .05 inches or more precipitation may be expected to occur 3 days during December (or approximately 10 percent of the days).

FIGURE 29

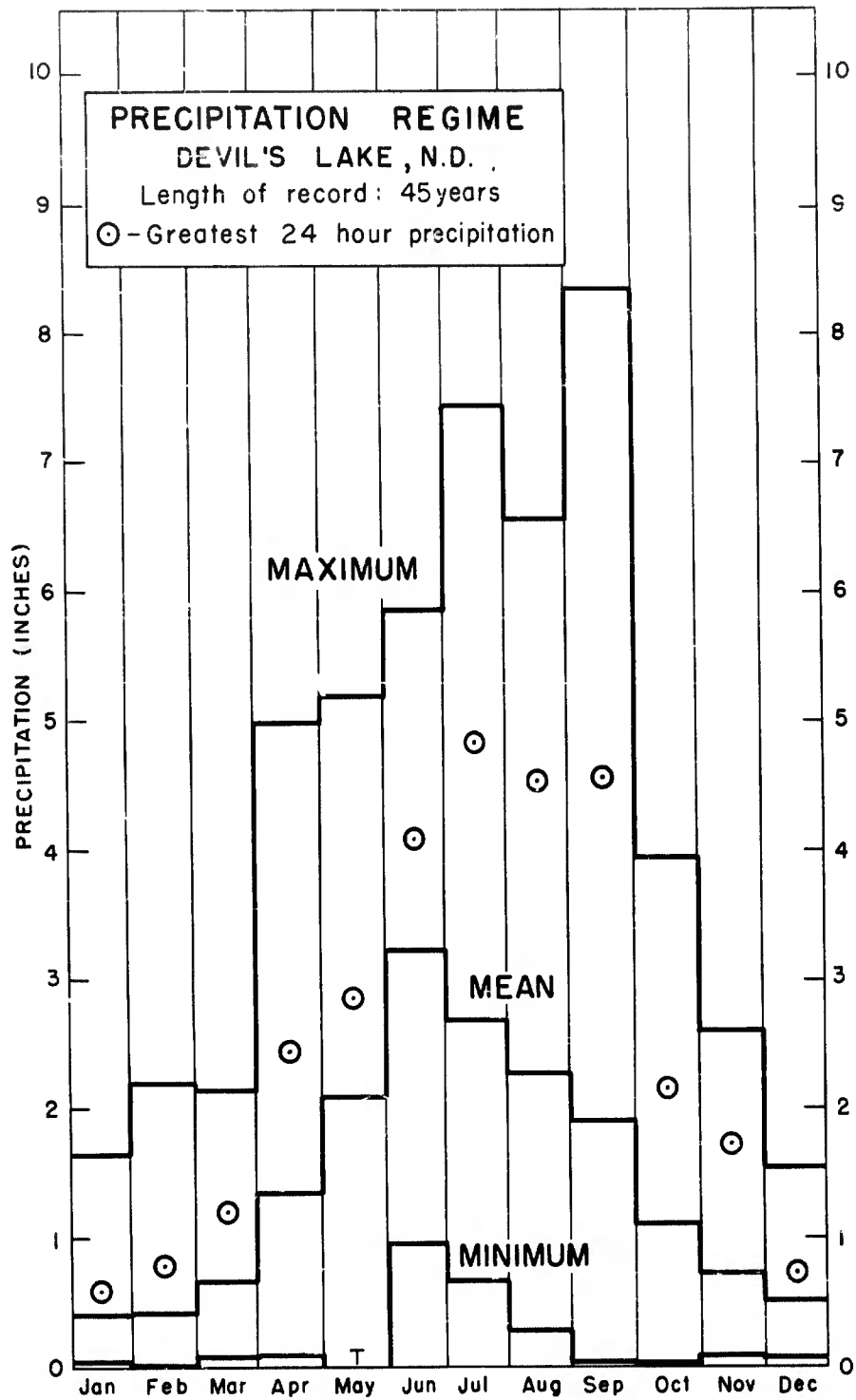


FIGURE 30

SKY COVER (SUNRISE TO SUNSET)
 DEVILS LAKE, N. D.
 Length of record: 45 years

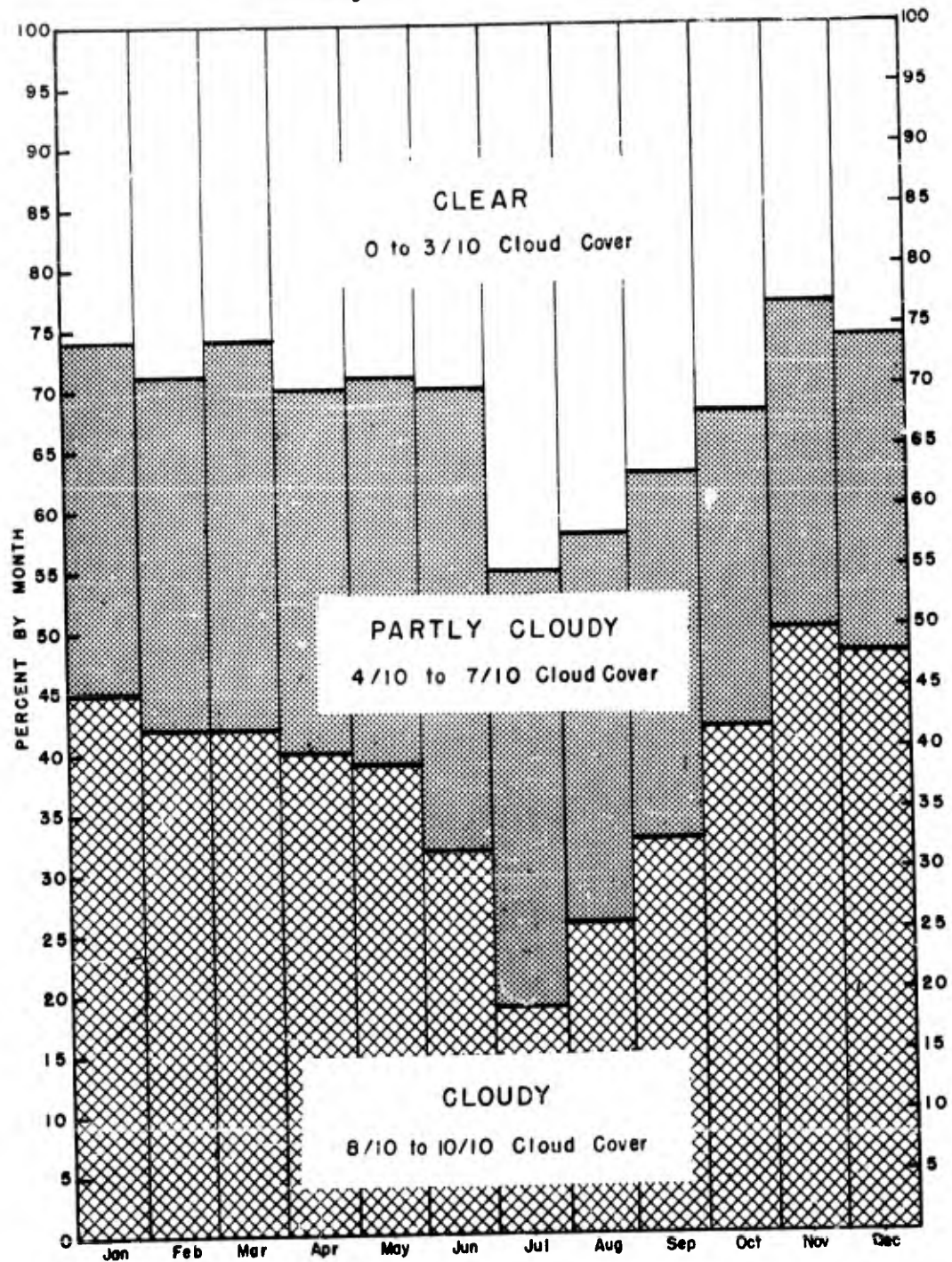
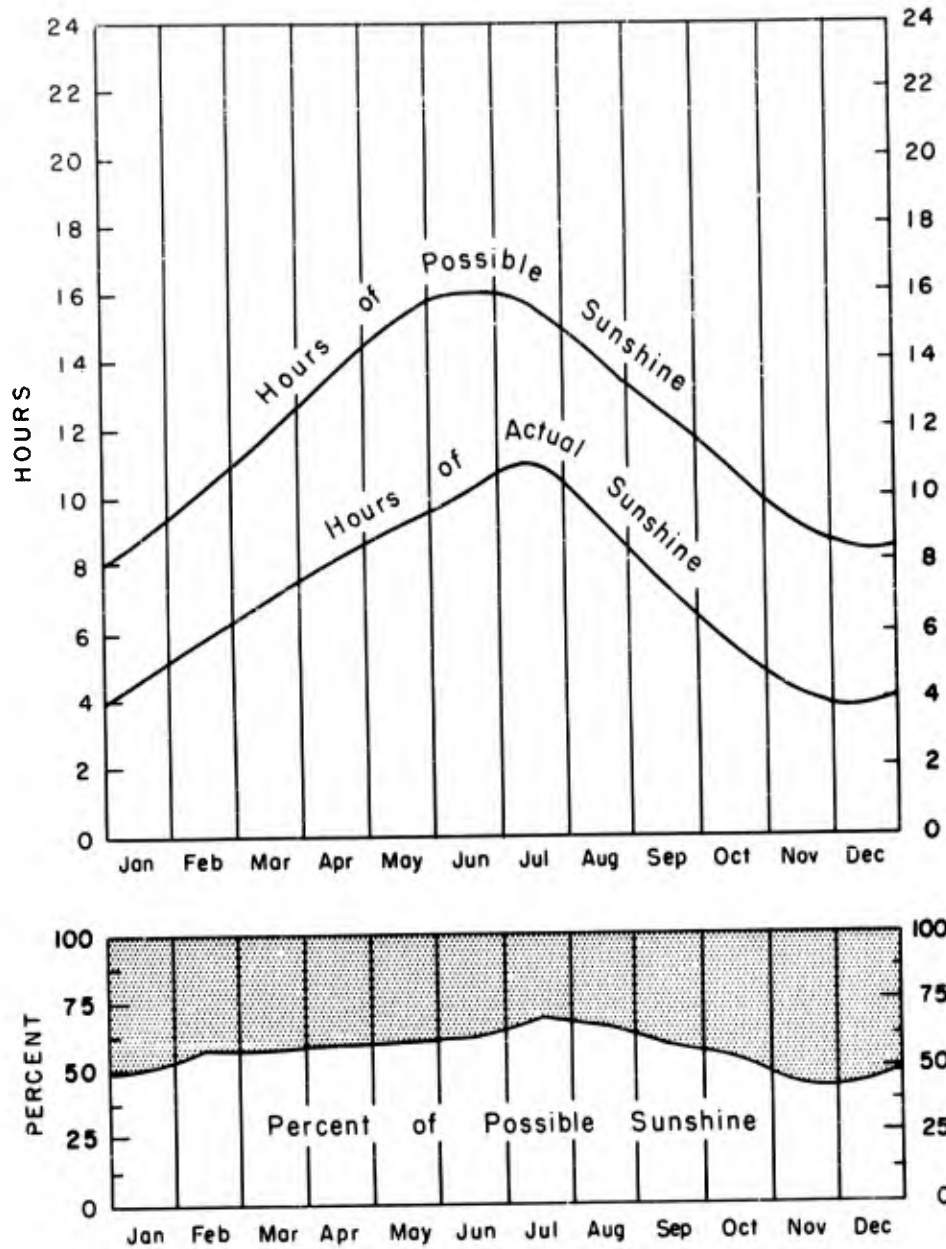


FIGURE 31

AMOUNT OF SUNSHINE

DEVILS LAKE, N.D.

Length of Record: 45 years



Hours of possible sunshine were computed for the sixteenth day of the month for thirty-one day months, the fifteenth day of the month for thirty day months, and on the fourteenth day of the month of February for latitude $48^{\circ} 42' N$. Hours of actual sunshine were computed by multiplying the total hours of possible sunshine by the percent of possible sunshine. (recorded between sunrise and sunset and averaged for 45 years)

FIGURE 32

TABLE V: PERCENTAGE FREQUENCY AND MEAN SPEED OF SURFACE WINDS BY DIRECTION, DEVILS LAKE, N. D. *
(Period of Record: 1 Year)

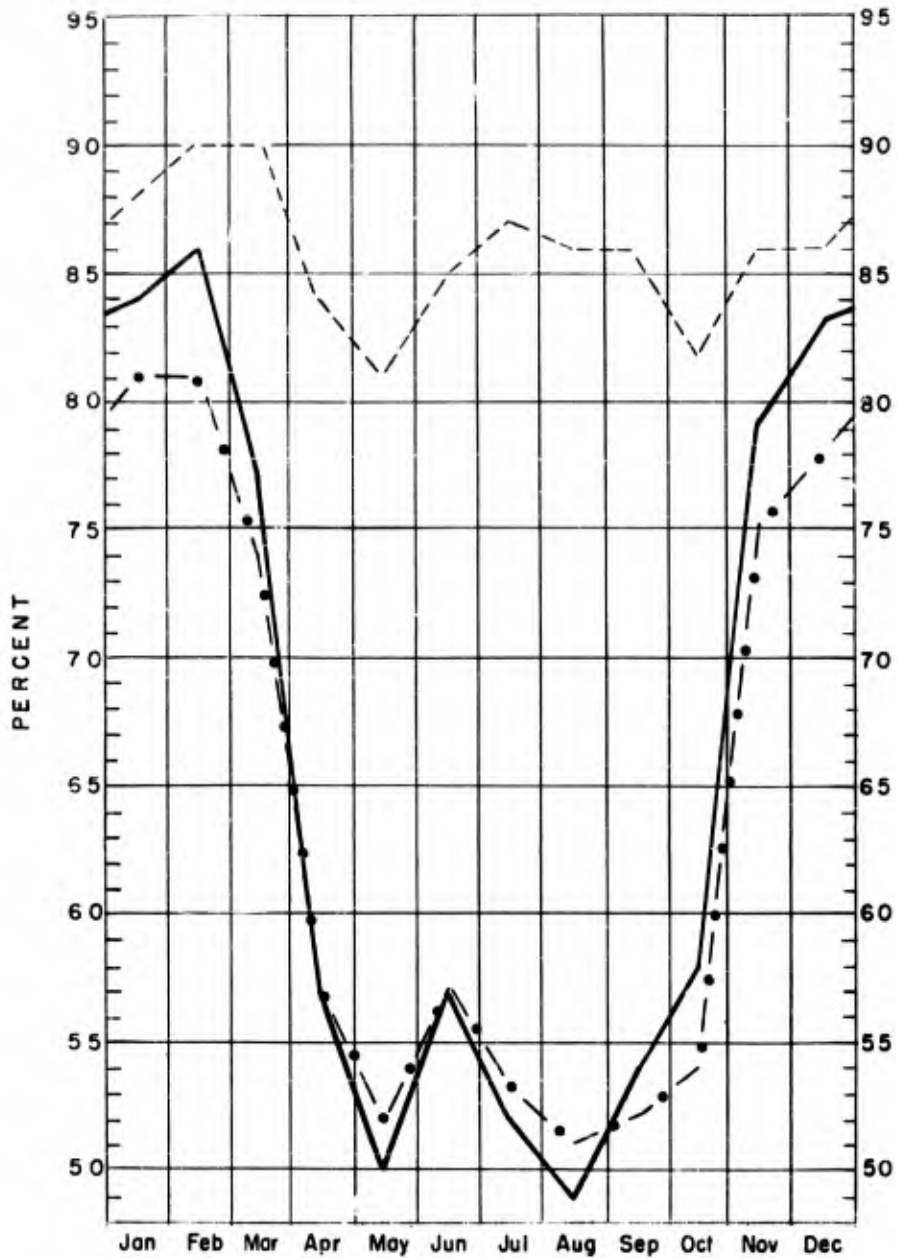
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM
Jan %	11.8		2.1		1.0		12.9		11.9		18.3		10.8	3.2	23.7	4.3	
mph	8.7		5.3		1.7		8.2		9.3		7.0		8.4	12.0	10.3	13.5	
Feb %	6.9	1.1	0.2		11.5		21.8		5.7		10.3	2.3	18.3	1.1	10.3		1.1
mph	11.8	6.7	13.3		8.8		10.0		7.9		7.3	5.0	8.3	2.7	11.3		
Mar %	10.8	16.1			6.5		4.3	2.1	15.0		14.0		18.3	1.0	9.7	1.0	
mph	9.0	13.5			11.0		5.2	5.7	6.6		7.8		6.5	3.7	10.1	4.0	
Apr %	7.8	2.2	13.3	1.1	8.9	4.5	20.0		4.5	1.1	4.4	1.1	11.1	5.6	14.4		
mph	11.0	11.0	13.2	2.3	12.3	10.2	11.3		8.3	5.0	7.2	4.0	7.4	14.8	10.6		
May %	11.9	5.3	15.1	3.2	12.9	3.2	8.6	2.1	9.7	1.1	9.7	4.3	3.2	2.2	4.3		2.2
mph	11.0	13.2	10.6	9.3	10.2	5.2	14.3	7.7	10.4	3.0	5.8	10.5	3.7	7.7	5.2		
Jun %	10.0		20.0	2.2	4.4	1.1	12.2	2.2	8.9	2.2	8.9		10.0	2.2	11.1	4.4	
mph	8.7		9.2	5.7	4.9	2.3	5.6	2.3	8.6	7.0	7.0		7.3	7.7	12.2	7.0	
Jul %	8.6		6.5	4.3	6.5	3.2	16.1	2.1	10.8		8.6	1.1	9.7	6.5	14.0	2.1	
mph	5.9		7.8	11.2	10.3	6.2	8.5	5.7	6.4		7.1	3.7	5.0	14.4	10.7	2.8	
Aug %	7.5		8.6		8.6	1.1	26.9	6.5	11.9		5.4		7.6	1.1	13.7	1.1	
mph	5.4		6.8		10.3	2.0	8.4	11.9	7.5		4.2		8.4	5.7	9.0	3.3	
Sep %	10.0	2.2	2.2	1.1	6.7		20.0	10.0	12.2		6.7	2.2	8.9	2.2	14.4	1.1	
mph	7.7	3.5	6.3	2.7	8.4		10.3	9.8	6.8		6.1	2.8	5.9	8.0	8.4	3.3	
Oct %	5.4		2.2		4.3		16.1	10.8	9.7		5.4	3.2	9.7	2.2	36.1	1.1	
mph	8.5		3.3		9.3		9.2	12.8	8.0		5.8	4.7	6.7	6.0	10.1	4.7	
Nov %	11.1	2.2	10.0		5.5	1.1	5.6	2.2	8.9	1.1	6.7	1.1	23.3	4.5	12.2	4.4	
mph	8.0	4.3	11.0		9.7	3.3	9.7	7.3	8.2	1.3	5.2	5.3	7.3	10.3	10.9	9.7	
Dec %	9.7		10.8		4.3		6.5	1.1	9.7	1.1	23.7		8.5	2.2	20.4	2.1	
mph	7.8		10.8		10.1		10.7	3.7	8.6	3.7	7.3		7.5	3.0	13.8	11.7	

*Computed from 0700, 1300, and 1900 hrs. observations. Values taken to nearest even tenth.

MEAN RELATIVE HUMIDITY AT SPECIFIED HOURS

DEVILS LAKE, N. D.

Length of Record : 12 years



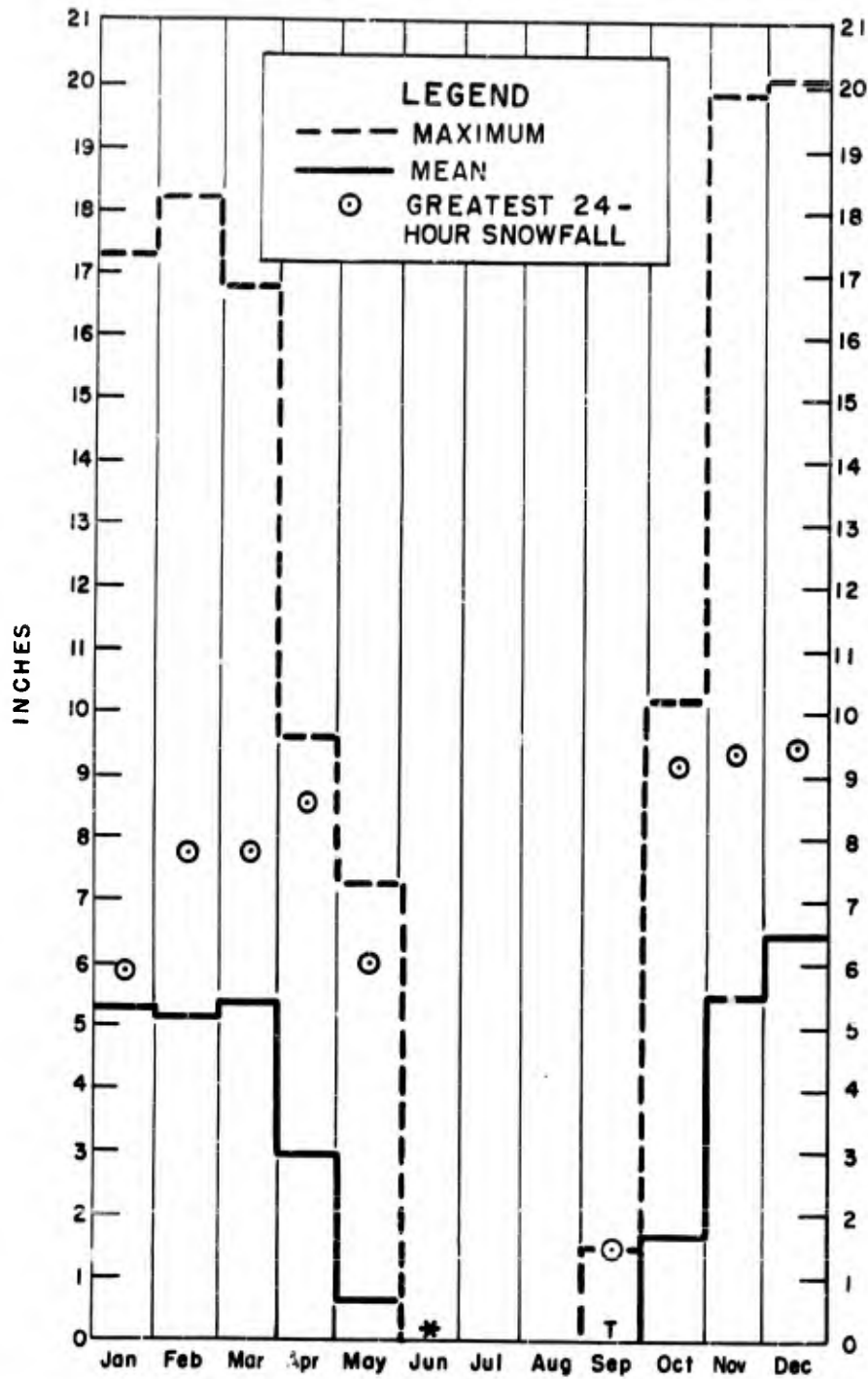
- Mean Relative Humidity at 0630
- Mean Relative Humidity at 1230
- Mean Relative Humidity at 1830

FIGURE 33

MONTHLY SNOWFALL

DEVILS LAKE, N. D.

Length of Record 45 years



*-Trace for mean total, maximum monthly and greatest 24 hour snowfall

T-Trace for mean Minimum not shown

FIGURE 34

TABLE VI: AVERAGE NUMBER OF DAYS WITH FOG AND THUNDERSTORMS AT DEVILS LAKE, N. D.

Length of Record: 45 years

Heavy Fog: One day each month of year

Thunderstorms:

Jan	0	May	3	Sep	3
Feb	0	Jun	7	Oct	1
Mar	1	Jul	8	Nov	1
Apr	1	Aug	7	Dec	0

APPENDIX B
PHOTOGRAPHS



Fig. 35-Transition zone between grasses and weeds near lake shore, and scrub timber in higher areas.



Fig. 36-View northwest looking over tracked vehicle course. In background is forest of elm, oak, box elder, and some cottonwood and basswood.



Fig. 37-View northeast from tracked vehicle course. Coarse weed growth dominates dried portion of the lake area.



Fig. 38-Summer view of forest south of Devils Lake. Principal trees are oak, box elder, and cottonwood. Shrub growth is dominated by sumac, junberry, and chokeberry.



Fig. 39-Winter view of forest of birch, cottonwood, box elder, and ash near Devils Lake.

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