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HEADQUARTERS
QUARTERMASTER RESEARCH & ENGINEERING COM
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TECHNICAL REPORT
EP-62

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BAG

HANDBOOK OF
THE QUARTERMASTER RESEARCH & ENGINEERING
ENVIRONMENT AND CLIMATIC TEST FACILITIES



QUARTERMASTER RESEARCH & ENGINEERING CENT
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

SEPTEMBER 1957

NATICK, MASSACHUSETTS

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HEADQUARTERS QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
Quartermaster Research & Engineering Center
Natick, Massachusetts

ENVIRONMENTAL PROTECTION RESEARCH DIVISION

Technical Report

EP-62

HANDBOOK OF THE QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENT AND CLIMATIC TEST FACILITIES

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FOREWORD

This report provides information on the environment and the environmental research facilities of the Quartermaster Research and Engineering Center, Hatick, Massachusetts, and its surrounding area. To aid in the planning, timing, and evaluation of scientific studies and tests conducted at the Center, a description is given of the climate with its changing seasons, the ground and vegetation characteristics of the outdoor testing areas, the Climatic Research Laboratory, and other climatic test facilities. Where possible, information has been presented graphically to facilitate use.

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C. 16f

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ABSTRACT

The Quartermaster Research and Engineering Center at Natick, Massachusetts, provides facilities for conducting research and development in many fields of science. Both indoor and outdoor climatic facilities for research and testing are available at the Center. These facilities include wind tunnels for simulating extreme climates and a solar furnace for testing materials designed to protect soldiers against thermal radiation.

A comprehensive weather recording and observing program is conducted at the Center by personnel of the Army Signal Corps. Topoclimatic stations are located in representative areas, and microclimatological measurements are made to determine the vertical distribution of weather elements as well as the physical processes involved.

The climate of the area is one of moderately cold, moist winters and warm, moist summers. January, the coldest month, has a mean temperature of 26.5°F, and minimum temperatures at or below freezing on an average of 29 days. July, the warmest month, has a mean temperature of 70.8°F and an average of 6 days with temperatures at or above 90°F. Mean annual precipitation totals 47.77 inches and is evenly distributed throughout the year. November, the wettest month, receives an average of 4.76 inches, and October and July, the driest months, both have a mean of 3.36 inches. Snowfall may occur during all months from November through April, but significant amounts are likely only during December, January, February, and March.

The Natick area, like all of New England, was influenced by intensive glaciation, and the landforms in evidence today were caused chiefly by the last glacier to cover the region. Most lakes and ponds, including Lake Cochituate, owe their origin to glaciers. Soils of the area, derived from glacial material, tend to be acid and coarse.

Natick lies within the northeastern hardwood forest. Trees, which are all second or later growth, include American elm, gray birch, red maple, several species of oak, and some white pine. Marshy areas consist mainly of sedges, cat-tail, and small willows.

HANDBOOK OF
THE QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENT AND CLIMATIC TEST FACILITIES

1. Introduction

The Quartermaster Corps has been responsible for providing food, clothing, equipment, and other needs of the United States Army since 1776. The problems of developing these items are manifold, and for years have been investigated at laboratories at various places throughout the country. The Quartermaster Research and Development Center* was established in 1953 to consolidate Quartermaster research and development activities. The Center provides facilities in which the efforts of scientists and technologists in many fields of science and industry can be coordinated for developing and improving the many thousands of items for which the Quartermaster Corps has responsibility. For example, between 1947 and 1954 the Quartermaster Corps introduced nearly 500 new line items or materials into supply, and, in addition, during this period more than 800 standard items of issue were modified to improve functional characteristics (Calloway, 1954).

The Quartermaster Research and Engineering Center is in the town of Natick, Massachusetts, at $42^{\circ} 17' N.$ latitude and $71^{\circ} 22' W.$ longitude (Fig. 1), on a peninsula on the east side of Lake Cochituate.

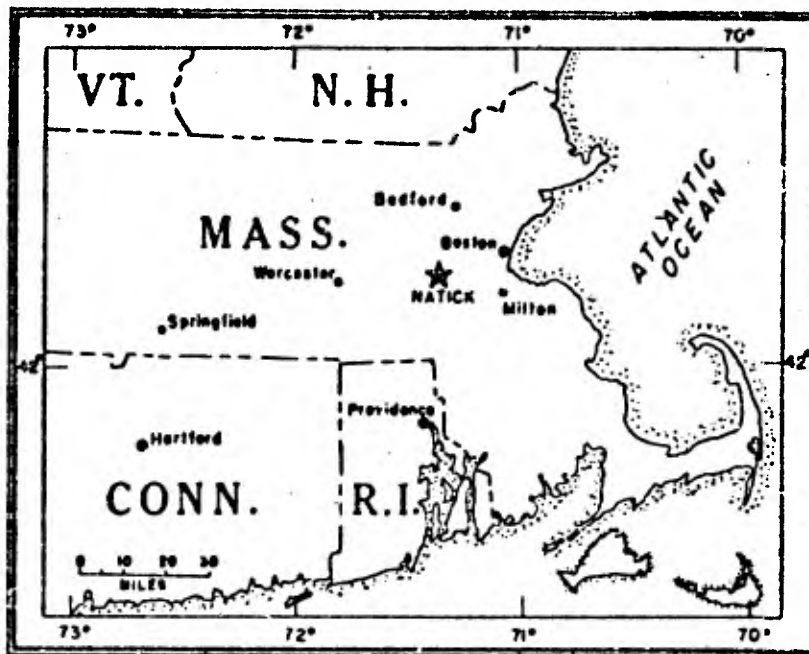


Figure 1: Location of Natick, Massachusetts.

*Redesignated Quartermaster Research and Engineering Center
QMC Circular 57, 7 May 1957

The Center is approximately 20 miles west of the center of Boston and 5 miles east of the town of Framingham. Natick is accessible from all points by major highways and by the Boston and Albany Railroad. Framingham is the nearest station stop for through trains. The nearest commercial airport is Logan Field, the municipal airport for Boston, 23 miles from the Center. The nearest military airport is Hanscom Air Force Base, near Bedford, Massachusetts, 17 miles from the Center.

Laboratories in the buildings shown on Figure 50 (following Appendix) are used for conducting research and development in chemicals and plastics, environmental protection, mechanical engineering, pioneering research, and textiles, clothing, and footwear.*

2. Climatic Test Facilities

Both indoor and outdoor facilities are available for testing items during their development. Location of buildings and test areas is shown on Figure 50.

a. Climatic Research Laboratory

Among the more important facilities are the wind tunnels in the Climatic Research Laboratory. A floor plan of this building is shown in Figure 2. The wind tunnels simulate conditions that occur in various environments. They were designed, and are used primarily, to determine physiological and psychological reactions of troops under controlled conditions, but they may also be used to test items of equipment. Scientists conducting tests in the wind tunnels can observe and direct - from an observation room - the activities of test subjects and record their reactions (Figure 3). A two-way communications system is provided between the tunnels and observation room. The Arctic and Tropic wind tunnels are discussed in greater detail below.

(1) The Arctic Wind Tunnel (Figure 4) occupies a total area of 900 square feet (60 ft. by 15 ft.), with height ranging from 8 ft. 8 in. at the sides to 11 ft. 3 in. at the center, and includes two treadmills (each 4.5 ft. by 8 ft.) that may be adjusted from a level position to a 12 percent grade. These treadmills are designed to carry 4 fully equipped men at speeds adjustable from 1.5 to 15 mph (+ 0.1 mph).

This wind tunnel is designed to provide and maintain dry-bulb temperatures within the limits -70°F to 70°F ($\pm 1\text{F}^{\circ}$). With dry-bulb

*Quartermaster research on food processing and packaging is conducted by the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Ill. Field tests of newly developed Quartermaster items are conducted by the Field Evaluation Agency, Fort Lee, Virginia. These two installations, with Quartermaster Radiation Planning Agency, Washington, D. C., and the Center at Natick, comprise the Quartermaster Research and Engineering Command.

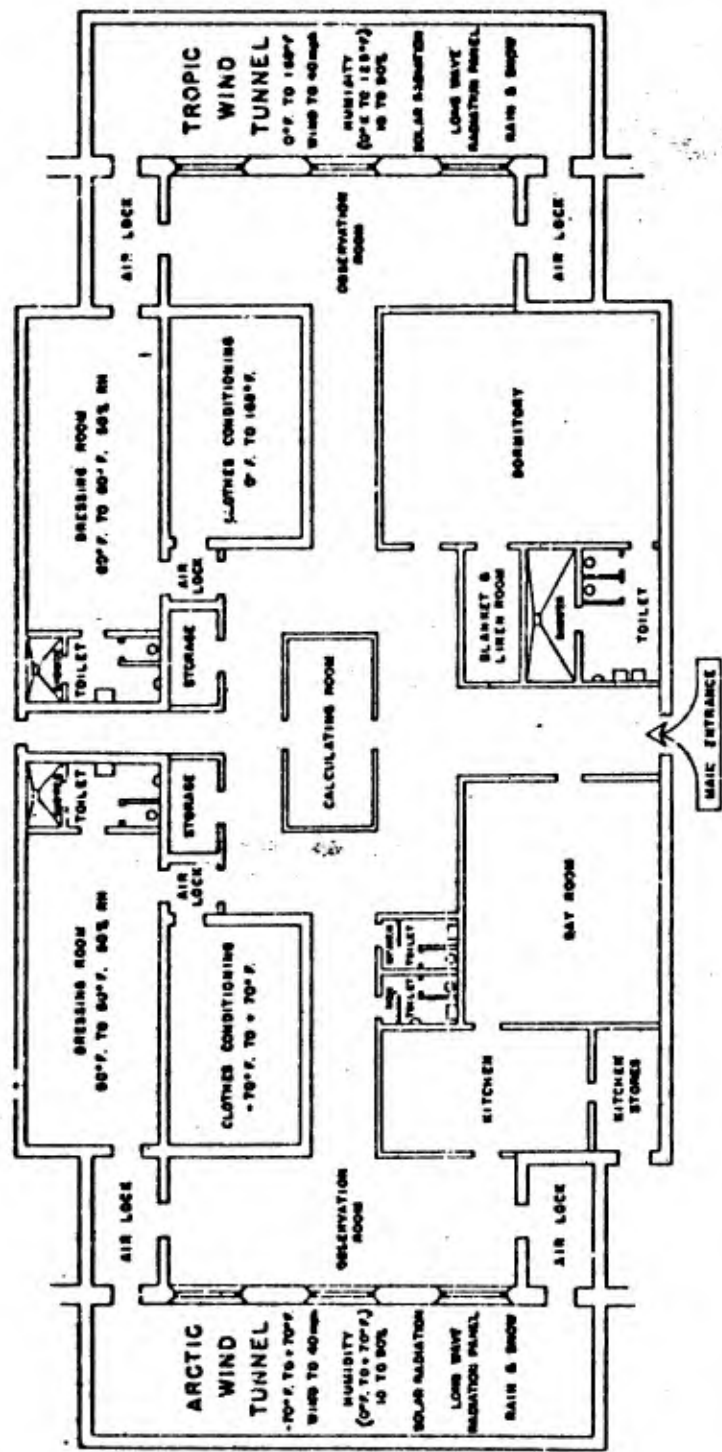


Figure 2: Climatic Research Laboratory floor plan.

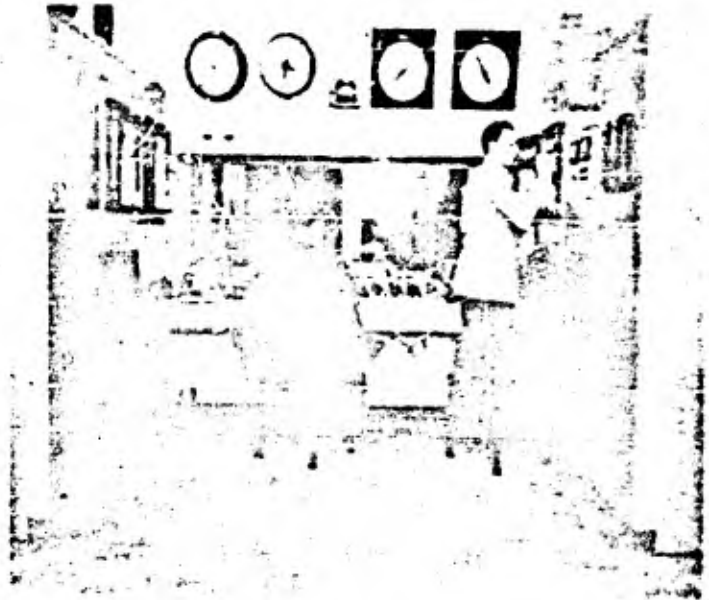


Figure 3: Instrument and observation area used by scientists conducting studies in the Arctic Wind Tunnel.

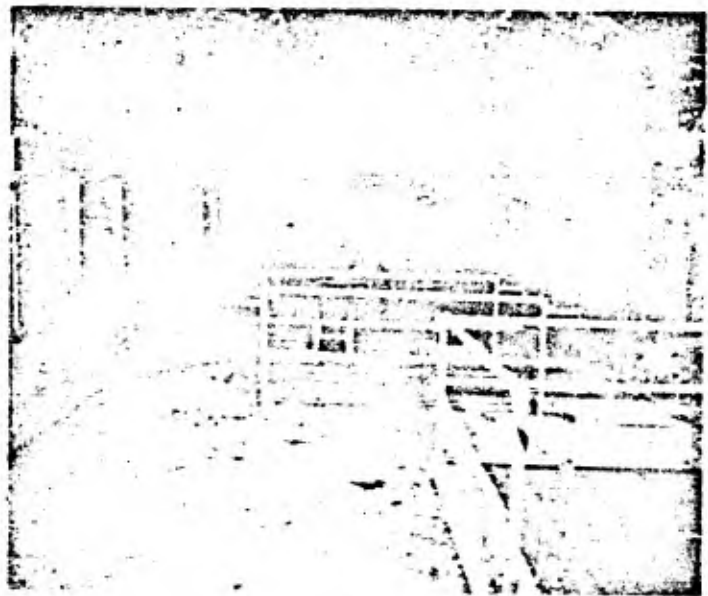


Figure 4: Interior of Arctic Wind Tunnel with study in progress. Wires lead to thermocouples which are attached to skin of test subjects.

temperatures 0°F to 70°F the chamber is designed to maintain dewpoint temperature from -40°F to 67.5°F within a 1°F limit, giving relative humidities from 10% to 90%. There is no control of humidity at dry-bulb temperatures ranging from 0°F to -70°F . Wind speed can be controlled within limits as follows:

| Windspeed (mph) | at Temperature ($^{\circ}\text{F}$) |
|--------------------|--|
| 2 to 5 | -70 |
| 2 to 10 | -60 |
| 2 to 28 | -50 |
| 2 to 40 | -40 to 70 |

The area to be used for simulating rainfall is 15 by 20 feet. Up to 4 inches of rainfall per hour will be produced, and snow-making and distributing equipment will be provided to operate when ambient air temperatures in the wind tunnel are below 32°F . Estimated completion dates are winter 1957-58 for the rain facility and 1959-60 for snow-making equipment.

In the Arctic dressing room (15 by 35 ft.) (Fig. 5), temperatures can be maintained at any temperature between 60°F and 80°F , with a relative humidity of 50%. In the Arctic clothing conditioning room (15 by 26 ft.), temperatures can be maintained at any point between -70°F and 70°F .

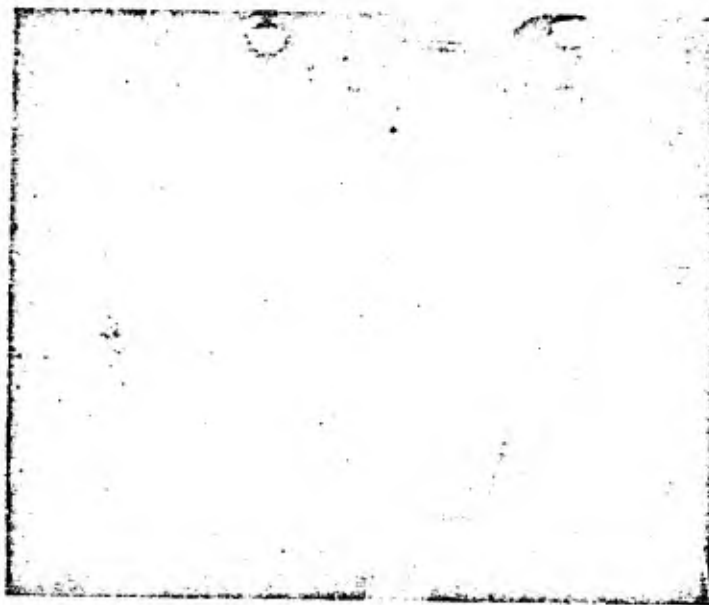


Figure 5: Arctic dressing room showing test subjects engaged in study.

Low temperature radiation panels which can be heated or cooled will be provided in the Arctic Wind Tunnel during 1957 or 1958. These panels will be mounted on the ceiling and sides for a length of 20 feet, and will be movable and demountable. In addition, ultraviolet and infrared radiation will be provided in a section of this wind tunnel.

(2) The Tropic Wind Tunnel is designed to maintain temperatures from 0°F to 165°F (+1°F). For temperatures from 125°F to 165°F there is no control of humidity. With dry-bulb temperatures from 0°F to 125°F, however, the tunnel is designed to provide dewpoint temperatures from -40°F to 120°F (+1°F), which give relative humidities from 10% to 90%. Windspeeds can be controlled within limits as follows:

| <u>Windspeed</u> <u>(mph)</u> | <u>at Temperature</u> <u>(°F)</u> |
|----------------------------------|--------------------------------------|
| 2 to 5 | 140 to 165 |
| 2 to 20 | 130 |
| 2 to 30 | 120 |
| 2 to 40 | 0 to 110 |

The facilities of the Tropic Wind Tunnel are similar to those of the Arctic Wind Tunnel. Treadmills are of the same dimensions and capabilities, and rain, snow, and radiation will also be produced in the same way as in the Arctic Wind Tunnel. The tropical clothing conditioning room is designed to maintain room temperatures between 0°F and 165°F, but there is no control of humidity. The tropical dressing room temperatures can be maintained between 60°F and 80°F at 50% relative humidity.

b. Solar Furnace

Construction of a large solar furnace was begun in February 1957, at a location west of the boiler house on the shore of Lake Cochituate, and will be completed in 1958. It is to be the largest solar furnace in the United States, and will be used to test material designed to protect soldiers against thermal radiation. Reliance upon atomic tests in field trials will be necessary only for final evaluation.

The installation, which is over 100 feet long, will use simple optical principles to achieve a concentration of solar radiation. The direct radiation from the sun is reflected from a large array of flat mirrors, the heliostat, to another array of concave mirrors, the concentrator. The concentrator produces a convergent beam which is focused on a target position. An image (about 1/4 inches in diameter) of the sun is formed. A water-cooled protective shutter and a fast-acting exposure shutter control the projection of this image

on samples placed at the target position. An automatic positioning system drives the heliostat to keep it at the correct angle with the sun. The directly reflected rays illuminate the concentrator during daylight hours, regardless of the time of day or year. It is hoped that irradiances greater than 60 calories/cm²/sec can be obtained frequently in research studies on thermal protection.

c. Raintower

Simulated rain can be produced not only in the climatic wind tunnels but also in the Engineering Building, which contains a 40-foot raintower capable of producing a maximum rainfall of 8 to 9 inches per hour. The height of the tower allows drops to reach terminal velocity similar to that attained by raindrops in nature.

d. Outdoor Test Areas

Facilities are also available to a limited extent at the Center for conducting outdoor tests. Outdoor test areas include the gravel pit and Point area (Figure 50). These areas can be used for studying the effect of exposure on materials, for conducting development tests on mechanical equipment and clothing, and for physiological measurements.

The gravel pit (Fig. 6) has a level surface, part of which (about 25%) is surfaced with asphalt. Power (110 volt, 60 cycle, single-phase, and 220 volt, single cycle, three-phase), telephone connection, and water supply are available at the pit.



Figure 6: Gravel pit, view facing northwest.

The Point area (Fig. 7) is provided with power (110 volt, 60 cycle, single-phase, and 220 volt, single cycle, three-phase), telephone connections, water supply, and a fuel dump for storing fuel required during certain tests.



Figure 7: Point area showing test in progress

On the west side of the peninsula, some 60 feet of shore has been cleared. A 40-foot pier, which may be used during immersion tests of items, extends from this cleared strip into the lake (Fig. 8). The water at the end of the pier is only 3 to 4 feet deep, but a large part of the lake, several hundred feet from the pier, is 60 feet deep (Dept. of Natural Resources, Comm. of Mass., 1952).

e. Meteorological Stations and Observations

A comprehensive weather recording and observing program is in operation at the Center. The observations and measurements provide meteorological and climatological data required by research scientists and test planners in all Divisions at the Center. Weather conditions influencing tests and studies are recorded in detail.

A primary weather station is located on the lawn near the south end of the Administration Building (Fig. 9). This station is equipped with a standard instrument shelter, containing a hygrothermograph, maxima and minima thermometers, psychrometer, and the sensing element of a Foxboro dewcell. A standard 8-inch rain gauge, a recording weighing rain gauge, net exchange radiometer, and a soil-heat transfer plate are also installed at this station (Fig. 10). Wind recording



Figure 8: Pier used in immersion tests, on west side of peninsula.

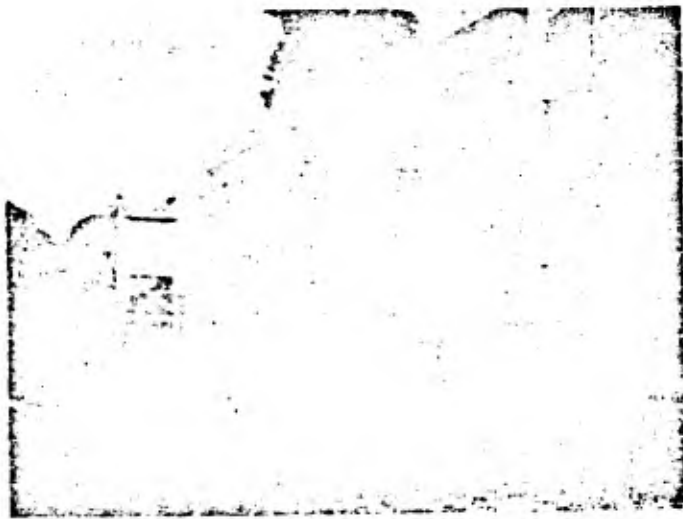


Figure 9: Primary weather station, showing rain gauge, net exchange radiometer, and instrument shelter.

instruments, a recording tipping-bucket rain gauge, an Eppley pyrheliometer (for measuring solar radiation), and a total hemispheric radiometer are mounted on the roof of the Research Building (Fig. 11).

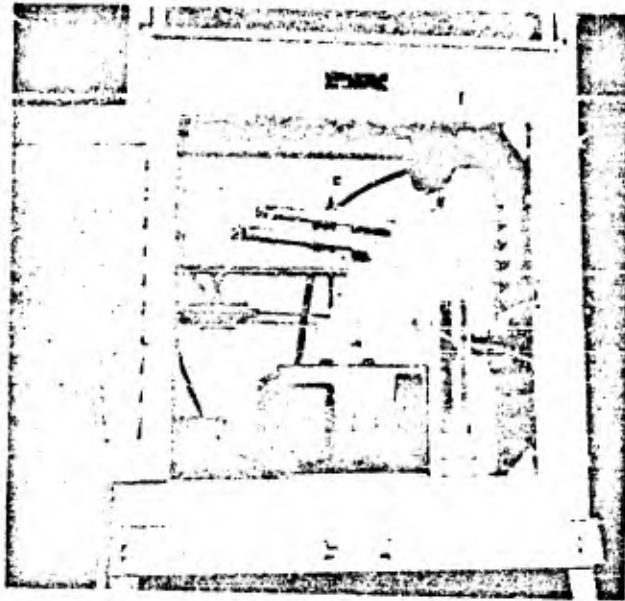


Figure 10: Interior of instrument shelter at primary weather station showing arrangement of instruments

Recorders for electrical instruments are located in the Research Building and the Administration Building. Visual observations include visibility; time of beginning and ending, and type of precipitation; amount, type, height, direction of movement, and speed of clouds; ground conditions; and snow cover and depth.



Figure 11: Roof of Research Building, showing meteorological instruments.

Additional weather stations have been installed in the Point area (Fig. 12), in the gravel pit (Fig. 13), in the wooded area south of the Climatic Research Laboratory (Fig. 14), and on the bluff on the west side of the peninsula (Fig. 15). Each station is equipped with a rain gauge and an instrument shelter containing a thermograph and maximum and minimum thermometers.



Figure 12: Topoclimatic Station, Point area.



Figure 13: Topoclimatic Station, gravel pit.



Figure 14: Topoclimatic Station, woods south of Climatic Research Laboratory.



Figure 15: Topoclimatic Station, bluff on west side of peninsula.

Locations of these topoclimatic stations are shown on Figure 50.

3. Climate

New England, lying in the middle latitudes, comes under the influence of frequent conflicts between cold, dry air masses flowing out of the great subpolar region to the northwest and the warmer moisture-bearing, tropical maritime air masses from the south (Hessmith, 1941). The Natick area has moderately cold, moist winters and warm, moist summers. Occasional oceanic influences reach the area and reduce the frequency of extreme high or low temperatures. Precipitation is moderately abundant in all seasons of the year, although considerable variation in amount and distribution may occur from year to year. Winter precipitation is generally in the form of snow. Once or twice a year, storms with freezing rain (glaze) occur, forming ice accumulations on exposed surfaces and causing widespread damage (Bennett, 1957).

The area is subject to storms in both summer and winter, due to the frequent passage of frontal systems. Frontal and convectional thunderstorms, with gusty winds, are frequent in summer. Adverse weather conditions of longest duration experienced in summer usually are due to warm fronts or stationary fronts to the south. These frontal systems cause extended periods of cloudiness, drizzle, and low visibility in the area. Cold front weather in winter is usually more severe than that which occurs in summer. There is usually continuous snow ahead of the cold front, lasting up to two hours after the frontal passage, after which time there is a general improvement in the weather conditions. In winter, warm fronts which form in, or pass by, the vicinity of Long Island, New York, cause precipitation in the form of rain or freezing rain in the Natick area.

In late summer or early fall (August and September) the weather is sometimes influenced by hurricanes. Most of these storms do not pass directly over the area, but at times cause considerable precipitation and strong winds. The area has been affected by hurricanes about 17 times in the past 55 years, but not more than 7 of these storms were severe enough to cause extensive damage.

Climatic data are presented in detail in the graphs and tables in the Appendix, and discussed below.

a. Data Sources

Few weather observations have been taken in Natick proper, and climatic information used in this study is based on records obtained from weather stations located between 3 and 15 miles from the Laboratory site.

Temperature values were computed from data obtained from 25 years of weather records at the Lake Cochituate observing station, maintained by the Metropolitan District Commission (Water Division, 1954). Twenty-seven years of records from this station were used in determining

the precipitation regime. The Lake Cochituate station is located on Route 30 on the west shore of Lake Cochituate, approximately 3 miles north of the Center, at 148 feet above mean sea level.

Radiation and sunshine data cited are from observations at the Harvard Elm Hill Meteorological Observatory (elevation 640 ft.) in Milton, Massachusetts, about 14 miles east-southeast of Natick (U. S. Weather Bureau, 1953). Mean monthly radiation data are for a 7-to 9-year period, but mean weekly values are presented for a period of 15 years (Hand, 1949). Sunshine data are for a 69-year period. Comparison of the data from Elm Hill with nearby areas indicates no significant differences in the radiation and sunshine received, and it may be assumed that the data are also representative of Natick.

Data for wind, snow depth, visibility, sky condition, and ceiling height were obtained from the U. S. Air Force weather station at Hanscom Air Force Base (elevation 135 ft.) at Bedford, Massachusetts, 17 miles north of the Center (USAF, 1954). These data were obtained for periods of record varying from 5 to 11 years. Owing to differences in topography, vegetation, and land-water relationships at the two sites, some differences must be inferred between conditions observed at Bedford and those occurring during comparable periods at Natick, particularly with respect to visibility, and wind speed and direction frequencies. Such differences presumably would be small with regard to visibility but significant with regard to wind direction at lower values of wind speed.

b. Temperature

Mean temperatures (Fig. 18 and Table I) in the Natick area are moderately high in summer. July, the warmest month, has a mean temperature of 70.3° and mean daily maximum and minimum temperatures of 83.7° and 57.9°, respectively, for the period 1929 to 1953. The highest temperature recorded in July was 101.0°. The absolute maximum temperature observed during the entire period of record was 103.0°, recorded in September 1953. The absolute minimum temperature for July is 39.0°.

Temperatures at or above 90°F may be expected about 3 days in June, 5 days in July, 4 in August, and 1 day each in May and September (Figs. 23 through 27). Temperatures at or above 80° normally occur about 16 days in June, 24 days in July, and 20 days in August.

January is the coldest month. For the Lake Cochituate weather station, the mean January temperature for the period 1929 to 1953 is 26.5°F, and the mean daily minimum temperature, 15.0°F. The absolute minimum temperature of -28°F has been recorded in both January and February, but not in the same year. The mean daily maximum temperature in January is 38.1°F, and the absolute maximum, 70°F.

Temperatures at or below freezing (32°F) may be expected on more than 25 days each month from December through March (Figs. 19,

20, 21, and 30). Temperatures at or below 0°F normally occur on less than 1 day in November, 2 days in December, 4 days each in January and February, and 1 day in March.

Table I, Appendix, lists the standard deviations from the mean, mean daily maximum, and mean daily minimum temperatures. The values presented indicate the variability of temperatures in the area. As is evident from the figures, the warmer months of the year have the least variability. This is especially true of September, which has standard deviations of only 1.8°F, 1.6°F, and 2.3°F for the mean daily maximum, mean, and mean daily minimum temperatures, respectively. January, the month of greatest variability, has standard deviations of more than 5°F for the mean daily maximum, mean, and mean daily minimum temperatures. In other words, monthly temperatures in January can be expected to be more than 5°F above or below the mean in 2 out of 3 years.

c. Precipitation

The mean annual precipitation at the Lake Cochituate station is 47.77 inches. On the average, precipitation is evenly distributed throughout the year (Fig. 31 and Table II). The mean precipitation for July and October, the driest months, is 3.36 inches; and for March and November, the wettest months, 4.68 and 4.76 inches, respectively. In summer, precipitation is generally associated with convective activity. It usually occurs in thunderstorms, and is of short duration but relatively high intensity. Winter precipitation is usually of low intensity, but lasts for periods of one to several days, and is most commonly associated with the passage of slowly moving low pressure systems.

The maximum amount of precipitation received in one month at Lake Cochituate station was 15.35 inches recorded in August; the minimum amount, 0.44 inch, occurred in October. The greatest amount in 24 hours, 6.90 inches, was recorded in September 1954, during a hurricane.

Snowfall has been recorded in all months from November through April, but significant amounts may be expected only during December, January, February, and March; these months have average values of 8.2, 13.7, 13.8, and 6.8 inches, respectively (Fig. 32 and Tables III and IV). The greatest amount recorded in one month, 46.1 inches, occurred in March 1956.

The frequency of precipitation amounts (rain and water equivalent of snow) is shown in Figures 33 through 44. In January, about 7 days may be expected to have 0.10 inch or more, and 3 days 0.50 inch or more. In July, 0.10 inch or more may be expected on 6 days of the month, and 1.00 inch or more on 1 day.

Monthly precipitation, and especially snowfall, varies considerably from year to year. In January, which has a mean precipitation of 4.13 inches and a mean snowfall of 13.7 inches, the standard deviations are 1.72 and 10.2 inches, respectively. Values for other months are shown in Table IV.

d. Wind

Winds are usually light to moderate through the year in the Hatick area. At Hanscom Air Force Base, winds of 25 mph or greater are most frequent from November through April, with the maximum occurrence of about 5% in February (Fig. 45, and Tables V, VI, and VII). Calm conditions prevail an average of 27% of the time in August, which has the greatest amount of calm weather, and an average of about 15% of the time in March, the month with least frequent calm conditions. Wind speeds of 75 mph or greater are experienced very infrequently; they are usually associated with the passage of a hurricane.

e. Cloudiness

Late spring and early summer (May, June, and July) have the greatest amount of cloudy weather. At Hanscom Air Force Base, during these months, approximately 85%, 85%, and 83% of the days, respectively, have some cloud cover (Fig. 46 and Table VIII). Low overcast sky conditions are least frequent during the period from June through October, when only 17% to 24% of the days have this sky cover. From August through April, approximately one-quarter to one-third of the days are clear.

Ceilings above 9,500 feet occur more than 50% of the time in all months, but are most frequent in summer (July, 71.7%). January, with 14.4%, has the greatest number of days with ceilings 900 feet or less. July, with 7.9%, has the least number of days with ceilings of 900 feet or less (Table IX).

f. Sunshine and Radiation

The hours of possible daily sunshine vary during the year from a minimum of about 9 hours in December to a maximum of 15½ hours in June. The amount of sunshine actually received in each month is only about one-half the hours possible (Fig. 47).

Radiation varies from a minimum daily average of 125 and 135 langleys, respectively, during December and January, to maximum values between 530 and 540 langleys during June and July (Fig. 48). The greatest weekly mean values of daily total solar and sky radiation occur from about the middle of June to the middle of July (Fig. 49).

g. Visibility

Visibility in the Hatick area is good. Visibilities of 10 miles or more, as recorded at Hanscom Air Force Base, normally occur 43.0% of the time in August, the month with most frequent restricted visibilities, and 63.3% of the time in April, the month with the best visibility conditions (Table VIII). The chief restrictions to visibility are fog and precipitation. Visibilities of one mile or less are least frequent in April and June (average occurrence, 2.9% and 3.0% of the time, respectively).

h. Humidity

Humidity data (Table X), obtained from the records of the Signal Corps Meteorological Team at the Center, are for a period of only one year. Data for a longer period were available only from a source distant from the Center, and are not included in the study, since it was expected that the Center, bordered on three sides by water, might have higher humidities than Hanscom Air Force Base or Blue Hill Observatory.

Mean monthly maximum relative humidities are above 75% during all months. Due to the differences of the hours of observations (February through September observations were taken only from 0730 hours to 1930 hours; October through January observations were taken 24 hours each day), it is not possible to determine accurately the months having highest relative humidities. During summer especially, when observations did not begin until 0730 hours, it is likely that maximum relative humidities occurred too early in the morning to have been recorded.

Minimum relative humidities usually occur in the early afternoon, and mean monthly minimums varied from a low value of 40.0% in May to a high value of 57.9% in December.

Additional data, covering a longer period, are required before reliable information concerning the annual regime of relative humidity can be provided. It is intended that a supplement to this report will be issued when sufficient humidity and other climatic data have been compiled at the weather station at the Center.

4. Topography

a. General

The Natick area lies within the Seaboard Lowland of the New England Province as defined by Fenneman (1938). Although New England was glaciated several times, the landforms evidenced today were caused by the last glacier to cover the region (an estimated 10,000 years ago), which also destroyed most evidences of earlier glaciation.

The surface character of the New England Province is described as follows by Wright (1934):

"Much of New England is a country of ancient, worn-down mountains, a land of extremely complex rock structure. The ceaseless forces of erosion have etched out a pattern of valleys below the general levels to which the mountains were reduced far back in geological times, and the complexity of relief reflects the complexity of the underlying rocks. The invasions and retreats

of the continental ice sheets did much to accentuate the diversified quality of the surface. The ice scraped the earth and carried away pieces of rock from countless hillsides; it dropped its load in moraines, damming streams and impounding the waters in lakes and ponds. It turned rivers aside from their older channels. It scattered boulders and gravel far and wide. Its melting waters gathered along the ice fronts in lakes, now vanished. On the floors of these lakes, sand and mud were laid down, and these deposits today form little plains, often terraced by post-glacial streams."

The Hattick area strongly reflects this influence of glacial activity. All conspicuous landforms in the area are either directly or indirectly the result of glaciers or their associated meltwaters, and subsequent action of the forces of erosion and weathering. Ground moraine, or glacial till, forms a stony mantle over the bedrock in much of the region, and outwash plains are common. Stones of all sizes make agriculture difficult, and account for one of New England's traditional landmarks - the stone fence. Glacial erratics brought from a distance are common, but for every one of these there are thousands of stones derived from the local bedrock.

The effects of glaciers in altering relief, reflected in the drumlins, eskers, knobs and kettles, kames and terraces of various types, have probably been less than their influence on drainage. Most lakes and ponds, including Lake Cochituate, owe their origin to glaciers. Many have become swamps or meadows. Others have been modified by man through drainage or damming. Stream patterns and drainage are complex because they have been entirely reformed. Deposition by glaciers forced streams to find new channels, and often no trace can be found of old channels.

b. Quartermaster R&E Center

The Quartermaster Research and Engineering Center is located on a pitted outwash plain which forms a peninsula extending into Lake Cochituate. This plain, which has an average elevation of 165 feet above mean sea level, and about 30 feet above the lake surface, is believed to be composed in large part of stratified drift, a mixture of sand and gravel deposited by running water. Pits, or kettles, were formed when ice remnants, buried or partly buried in the drift, melted, and slumping took place. Much of the site has been leveled and filled during construction, but at least one glacial pit can be seen in the woods directly north of the water tower. The pit is about 200 feet in diameter and 15 feet deep.

The west shore of the peninsula, possibly a kame terrace, may have been formed in the following manner: during the retreat of the glaciers at the end of the Ice Age (Pleistocene), a large block

of ice became separated from the main glacier in the area now occupied by Lake Cochituate. This block of stagnant ice melted slowly, and a lake (Lake Cochituate) was formed between the ice and accumulated deposits around it. Sediments deposited by streams flowing into the lake formed lacustrine beds. At a later date, when the ice was completely melted and the surface of the lake had lowered, these beds of stratified lacustrine material collapsed or slumped. Still later, these beds became visible, probably through the actions of weathering and erosion, and some may now be seen at places along the west banks of the peninsula bordering Lake Cochituate. The steep bank, rising 25 feet in places, exposes the horizontal beds of sedimentary material that form the immediate substratum of the site upon which the Center is built. The top 15 to 18 inches consists of soil cover and wind-deposited silt. Below is found about 10 feet of alluvial material, which grades from a medium coarse sand to a gravelly cobble, and below this the remaining portion consists of silty lacustrine deposits. The depth to which these lacustrine beds extend below the lake level is not known.

c. Lake Cochituate

This lake, formed by the glacial processes described above, drains north into the Sudbury River through Cochituate Brook. It has been considerably modified during the period of settlement. The original surface of the lake covered about 450 acres. This was increased to over 650 acres when the lake was converted to a reservoir of the water supply system for Boston. At present, Lake Cochituate is administered by the Massachusetts Department of Natural Resources and is no longer a part of the water supply system. The surface area is now 591 acres. The lake is approximately $3\frac{1}{4}$ miles long, and averages 22.6 feet in depth. Deeper parts of the middle and upper lake adjacent to the Center average 69.7 feet in depth. The lower lake, to the north, has 7 or 8 acres with depths of 70 feet, and one small spot has a maximum depth of 80 feet (Department of Natural Resources, Commonwealth of Mass., 1952).

The water of Lake Cochituate is slightly turbid, and visibility is usually about 8 feet. The bottom is three-quarters muck and the remainder largely sand and rubble. More than one-half of the shoreline is wooded, and there is relatively little aquatic vegetation.

The source of water for Lake Cochituate is mainly subsurface springs. A few streams, such as Beavertan, Course, and Snake Brook, flow into the lake but contribute little to the total volume*.

d. Soils

Most of the soils of southern New England are derived from

*Personal communication from Mr. Carl Lydiard, Superintendent of Lake Cochituate State Park, Massachusetts Department of Natural Resources.

glacial material. Nearly all have been podsolized^{*} to some degree and are acidic. In the northern parts of New England true podzols occur, but in the central and southern parts of the region (including Massachusetts) most of the soils may be classed as brown or gray-brown podsollic soils. Gray-brown podzols have a thin mat of partly decayed leaves over a very thin dark grayish-brown humus-mineral soil. These soils are developed under deciduous or mixed deciduous and coniferous forest in temperate or cool-temperate humid regions. In eastern Massachusetts, where the forest cover is either mixed (coniferous-deciduous) or predominantly deciduous, soils are less acid than those of the true podzols farther north.

The soils in the Natick region are of the Gloucester-Plymouth Association (USDA Yearbook, 1939), which is found widely scattered over rolling land from the Maine coast to Connecticut. The Gloucester series predominates in the Natick area. It develops under cool temperate conditions from parent materials of glacial till and outwash materials, mainly from granite and gneiss. Much of the land covered by this association is very stony and forested, though there are many areas of farmed land and pastures.

Where forested, Gloucester loam has a surface covering of leaf mold about 1 inch thick. This rests on dark-brown light loam, 1 or 2 inches thick, which grades into light-brown loam or heavy fine sandy loam which continues downward for 2 or 3 inches before it grades into the subsoil. In cleared areas the soil, to a depth of 6 or 8 inches, is dark-brown light loam or heavy fine sandy loam underlaid by yellowish-brown, friable, medium-textured loam. At a depth of 18 or 20 inches, the subsoil grades downward into yellow, slightly compact loam or sandy loam. Some gravel, small stones, and boulders are scattered on the surface and throughout the soil (Lattier and Lemphear, 1924). Many of these loose stones are piled into fences that surround the fields.

5. Vegetation

Natick lies within the northeastern hardwood forest (Shantz and Zon, 1924). The original composition of the stands has been considerably altered during a long period of settlement. Trees within the Center are mostly second or later growth, with few, if any, exceeding 75 years in age. The diversity of physical conditions gives rise to a corresponding variety in the character of the vegetation.

During construction of the Center, a large percentage of the land was cleared, spread with silt topsoil, filled, and leveled. A few

^{*}Podzols are soils having an organic mat and a very thin organic-mineral layer above a gray leached layer which rests upon a dark-brown layer into which the leached material has been deposited (illuvial layer). It is developed under the coniferous or mixed forest in a temperate to cold moist climate (USDA Yearbook, 1939).

scattered trees and small patches of woods were left as landscaping. Most of the cleared area not used for buildings and roads is seeded in lawn. A former gravel pit, north of the main part of the center, has been leveled, partly surfaced with asphalt, and the wide slopes planted in grass.

The western edge of the peninsula and the land south of the Research Building and Climatic Research Laboratory still retain a natural vegetation cover, although in some places the understory of shrubs has been cleared away (Fig. 16). This vegetation consists primarily of various species of oak, including black, white, and red oak. Other hardwoods scattered throughout the woods are red maple, American elm, and gray birch. Conifers are represented by a stand of white pine in the low-lying area along the southwest shore of the peninsula, and by young white pines interspersed among the hardwoods. In addition to the white pines, a few pitch pines grow on the site.



Figure 16: Woods on western edge of peninsula.
Note lack of undergrowth.

Most of the deciduous species lose their leaves in October or November, but the dry leaves of the white and black oak persist through the winter. Leafing out usually begins in early May, and is well advanced by June. Pines lose some leaves (needles) in winter, but their greatest loss of old needles occurs in spring and fall, when new foliage appears.

The marshes along the shores of the eastern bay and along the edges of the small pond to the north of Kansas Street consist largely of

marsh sedges, cat-tail, and occasional small willows and other shrubs (Fig. 17).



Figure 17: Marsh on eastern shore of the peninsula.

6. Acknowledgments

Appreciation is expressed to Dr. Charles F. Brooks, Mr. Charles Cuniff, and other members of the Harvard Blue Hill Observatory, for data and advice relating to radiation and sunshine; to personnel of the Framingham Office, Metropolitan Water Works, Massachusetts District Commission, for making available records of temperature and precipitation for the Lake Cochituate station; to Dr. Joseph Hartshorn, U. S. Geological Survey, for conducting a brief field study of the geology and geomorphology of Natick and vicinity; to Mr. Carl Lydiard, Massachusetts Dept. of Natural Resources, for providing data and information related to Lake Cochituate; to the Directorate of Climatology, Air Weather Service, USAF, for providing climatic statistics for Hanscom Air Force Base; to Mr. Gerald MacDonald, Chief, and Dr. Ernest Kenyon, Testing Office, QM DAK Command, for providing information on test facilities; to Mr. Eugene S. Cotton for information concerning the solar furnace; to Mr. Benjamin Malin and Mr. Edwin Zelezny for information pertaining to the Rain Tower and Climatic Research Laboratory; to FTC George Barth for assisting in the field study of geology and geomorphology and in the preparation of the section on topography; to Mr. Owen Parrels for assisting with statistical computations; to Mr. Jameson D. MacFarland, Miss Elizabeth Nason, Mr. Roland Frolich, and Mr. Donald Cox for preparing graphs, charts, and maps included in this report.

7. References

- Bassett, Iven. 1957. Glass: Its Meteorology and Climatology, Geographical Distribution, and Economic Effects. QM R&E Ctr., Natick, Mass. (unpub. tech. rpt.).
- Callaway, Charles G. 1954. Research in the Quartermaster Corps. Address presented to Lowell Technological Institute, Lowell, Mass.
- Collins, J. F., and H. W. Preston. 1912. Illustrated Key to the Wild and Commonly Cultivated Trees of Northeastern United States and Adjacent Canada. Henry Holt and Co., New York.
- Conrad, V., and L. W. Pollak. 1950. Methods in Climatology. Harvard University Press, Cambridge, Mass.
- Eme, L. L., and F. S. Collins. 1888. Flora of Middlesex County, Massachusetts. Malden Middlesex Institute, Malden, Mass.
- Dept. of Natural Resources, Commonwealth of Massachusetts. 1952. SONAR Depth Study of Lake Cochituate. (unpub. rpt.).
- Fenneman, Nevin M. 1938. Physiography of Eastern United States. McGraw-Hill Book Co., New York.
- Flint, Richard F. 1947. Glacial Geology and the Pleistocene Epoch. John Wiley & Sons, Inc., New York.
- Had, I. F. 1949. Weekly Mean Values of Daily Total Solar and Sky Radiation. Tech. Paper No. 11, Weather Bureau, Dept. of Commerce, Washington, D. C.
- Jarvis, R. T. 1949. Framingham-Natick, a Comparative Study. Department of Geography, Harvard University, Cambridge, Mass. (unpub. rpt.)
- Lattimer, W. J. and H. O. Lamphear. 1924. Soil Survey of Middlesex County, Massachusetts. Pub. No. 26, Bureau of Chemistry and Soils, U. S. Dept. Agric., Washington, D. C.
- Lea, H. J., and R. F. Chandler, Jr. 1946. Forest Soils. John Wiley & Sons, Inc., New York.
- Natick Federal Savings and Loan Association. 1948. The Story of Natick. Natick, Mass.
- Smith, Mark T. 1941. Supplementary Climatic Notes for New England. Climate and Man, U. S. Dept. Agric. Yearbook, Washington, D. C.
- Quartermaster R&D Command. 1956. Solar Furnace. Pioneering Research Division, Pioneering Newsletter, Vol. 1, No. 8, 26 Nov.

- Shantz, H. L. and R. Zon. 1930. Natural Vegetation of the United States. Atlas of American Agriculture, U. S. Dept. Agric., Washington, D. C.
- Sudbury Section, Water Division, Metropolitan District Commission. 1954. Temperature and Precipitation Data, 1928-1953, Lake Cochituate Station, Framingham, Mass.
- Tannehill, I. R. 1942. Hurricanes. Princeton Univ. Press, Princeton, New Jersey.
- _____. 1956. The Hurricane. Tech Pub., Weather Bureau, U. S. Dept. of Commerce, Washington, D. C.
- Thompson, J. H. and E. C. Higbee. 1952. New England Excursion Guide-book, 17th International Geographical Congress, International Geographical Union, Washington, D. C.
- Thornbury, W. D. 1954. Principles of Geomorphology. John Wiley & Sons, Inc., New York.
- U. S. Air Force. 1954. Surface weather observations, Hanscom AFB Bedford, Massachusetts, February 1943-September 1953. Data Control Division, Air Weather Service, National Weather Records Center, Asheville, N. C.
- U. S. Department of Agriculture. 1939. Soils and Men. Yearbook of Agriculture, Washington, D. C.
- Visher, S. S. 1954. Climatic Atlas of the United States. Harvard Univ. Press, Cambridge, Mass.
- Ward, Robert DeC. 1925. The Climates of the United States. Ginn & Co., New York.
- Weather Bureau, U. S. Dept. of Commerce. 1953. Local Climatological Data, 1953. Blue Hill Meteorological Observatory of Harvard University, Milton, Mass.
- Williams, R. L. 1947. Natick, A Field Study. Department of Geography Harvard University, Cambridge, Mass. (unpub. rpt.)
- Wright J. K. 1933. Regions and Landscapes in New England. In New England's Prospects, 1933. Spec. Pub. No. 16, American Geographical Society, New York.

APPENDIX

TABLES AND GRAPHS OF CLIMATIC DATA

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TEMPERATURE REGIME
 Lake Cochichewick Station
 Notick, Massachusetts
 Length of Record: 25 years

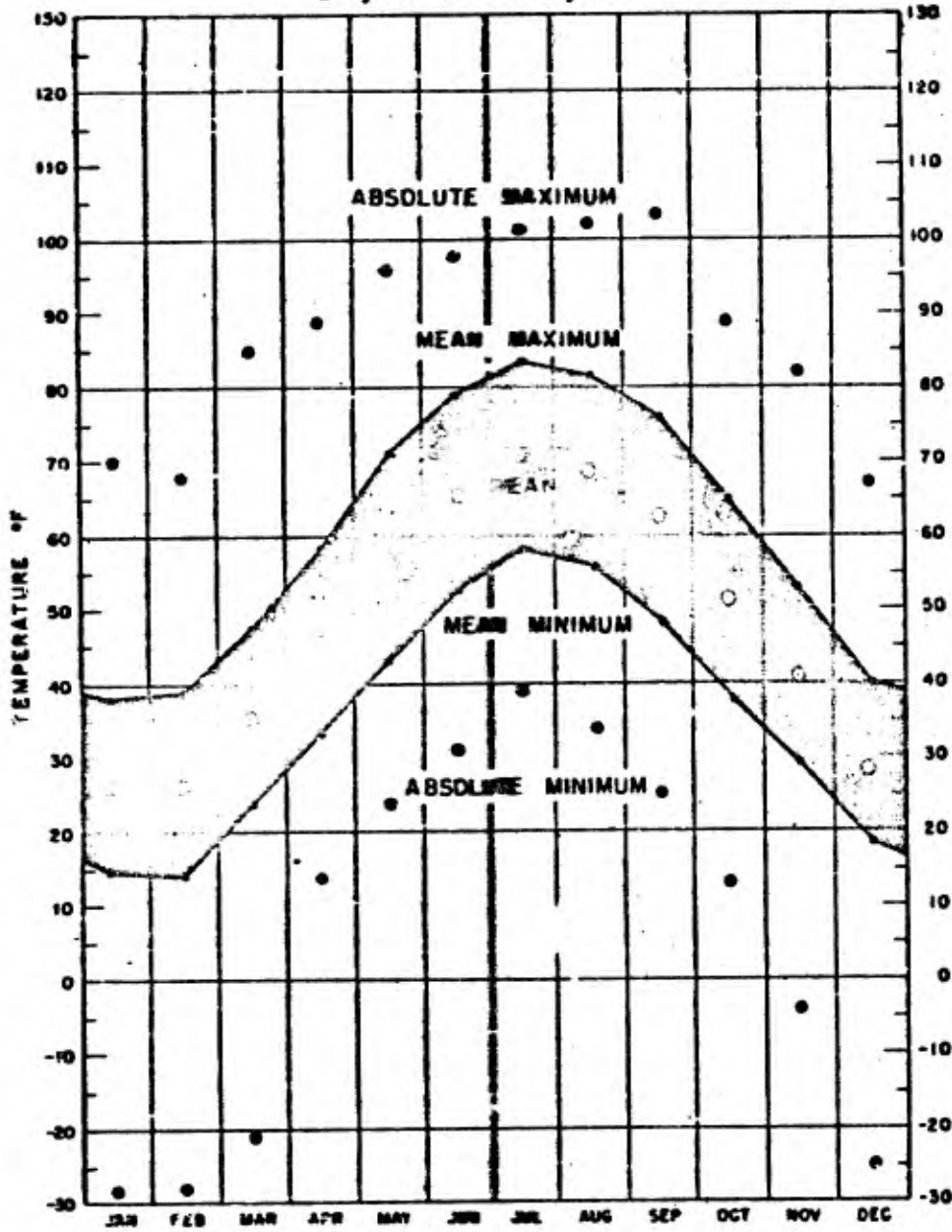
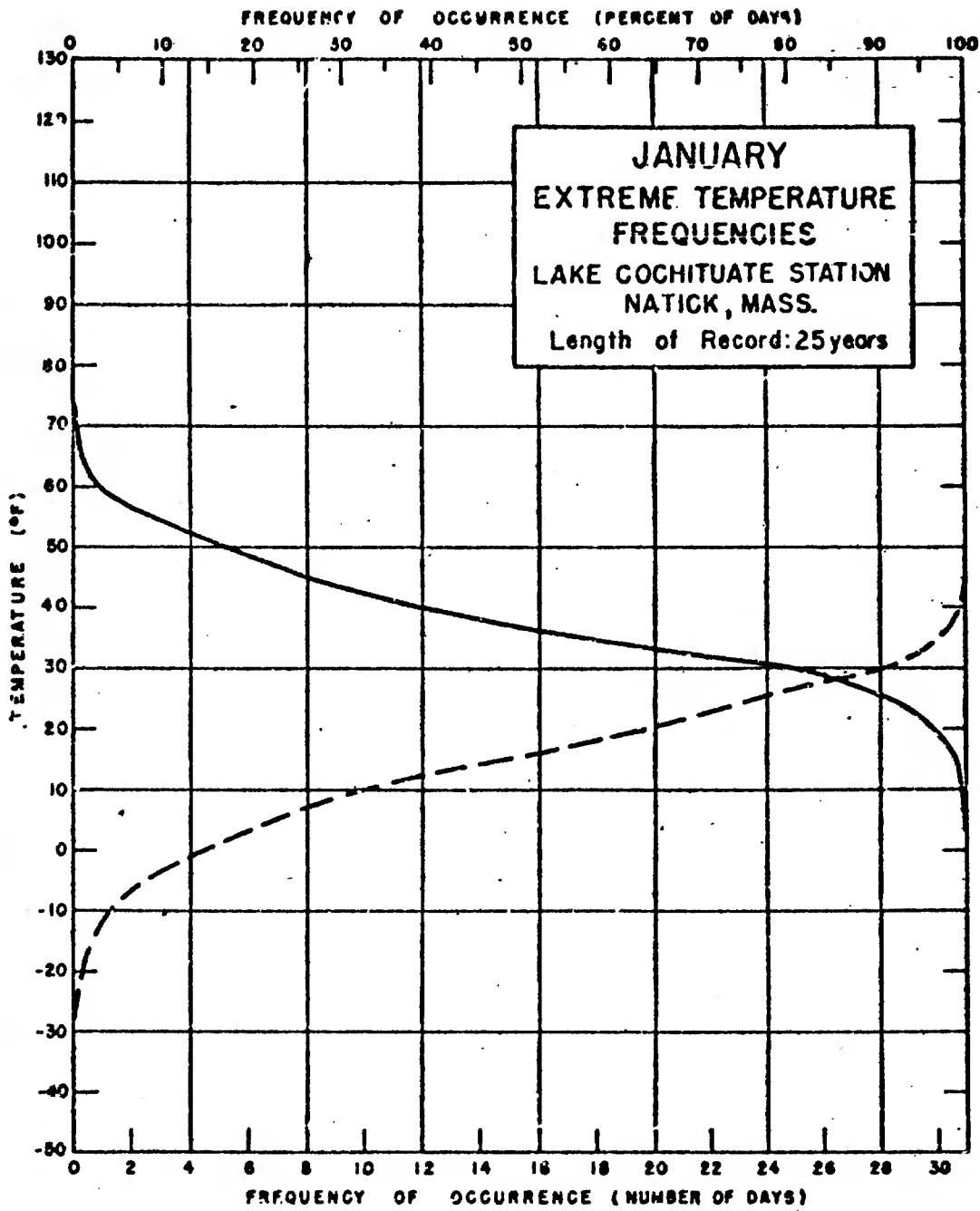
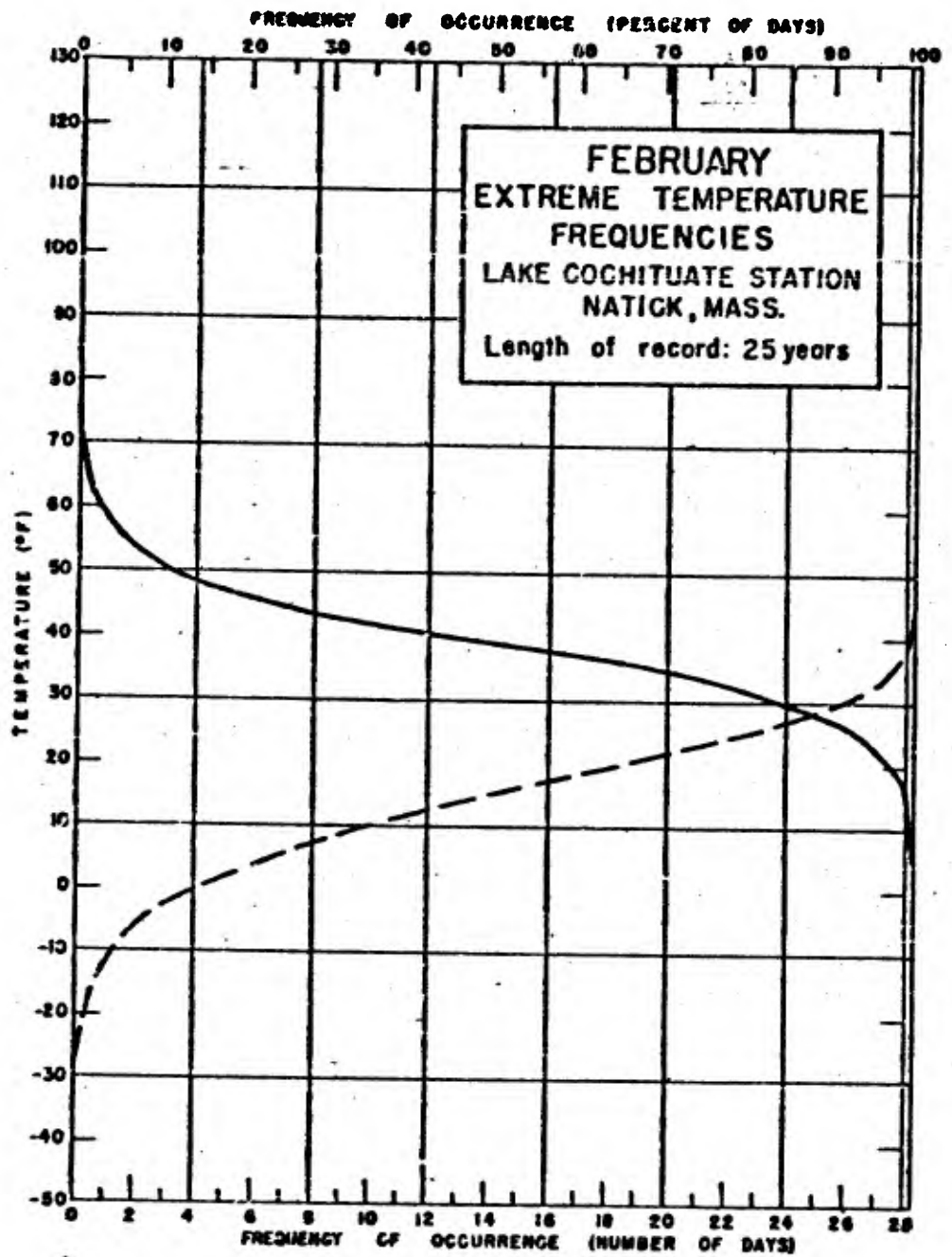


Figure 18



- 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.

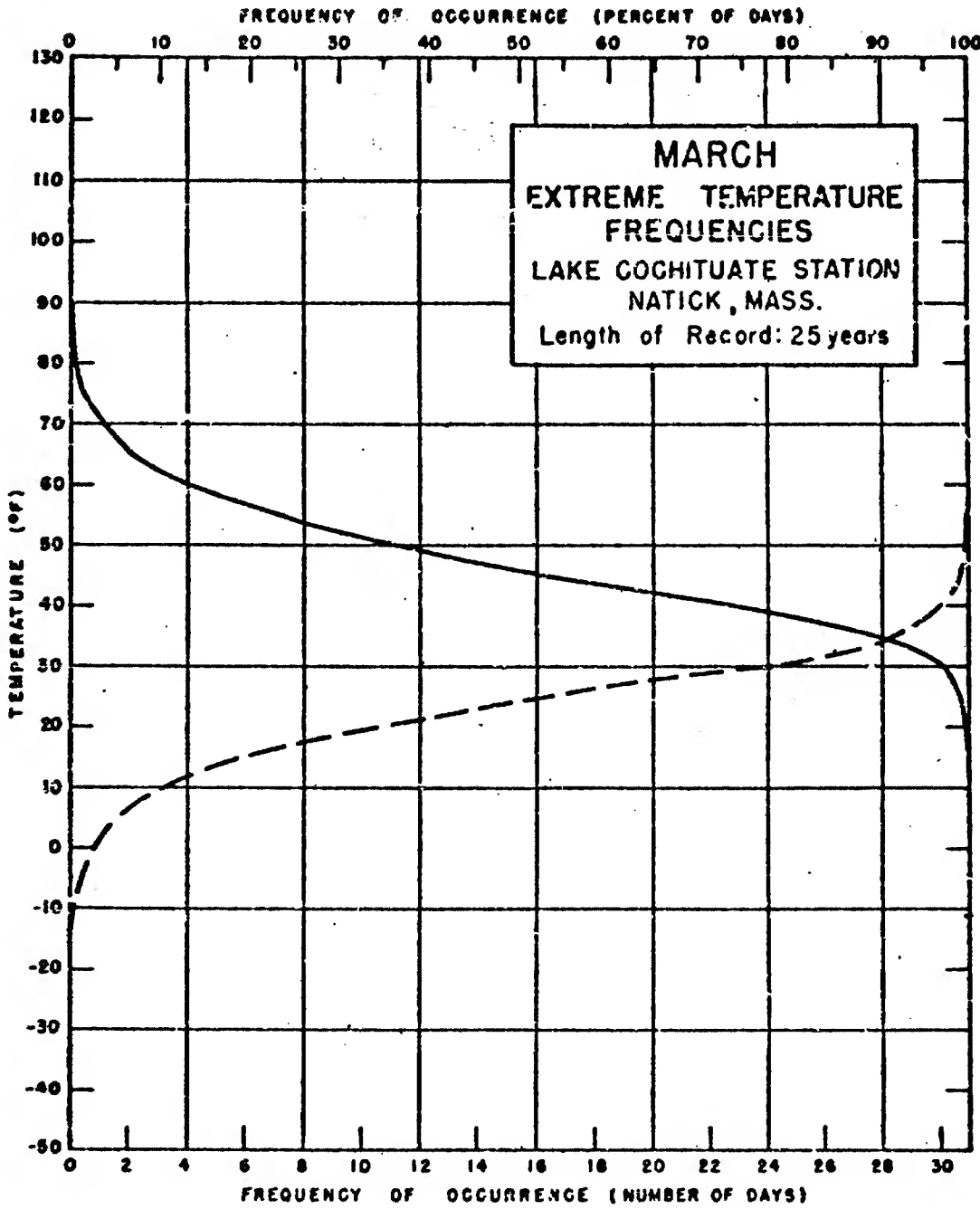
Figure 19



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

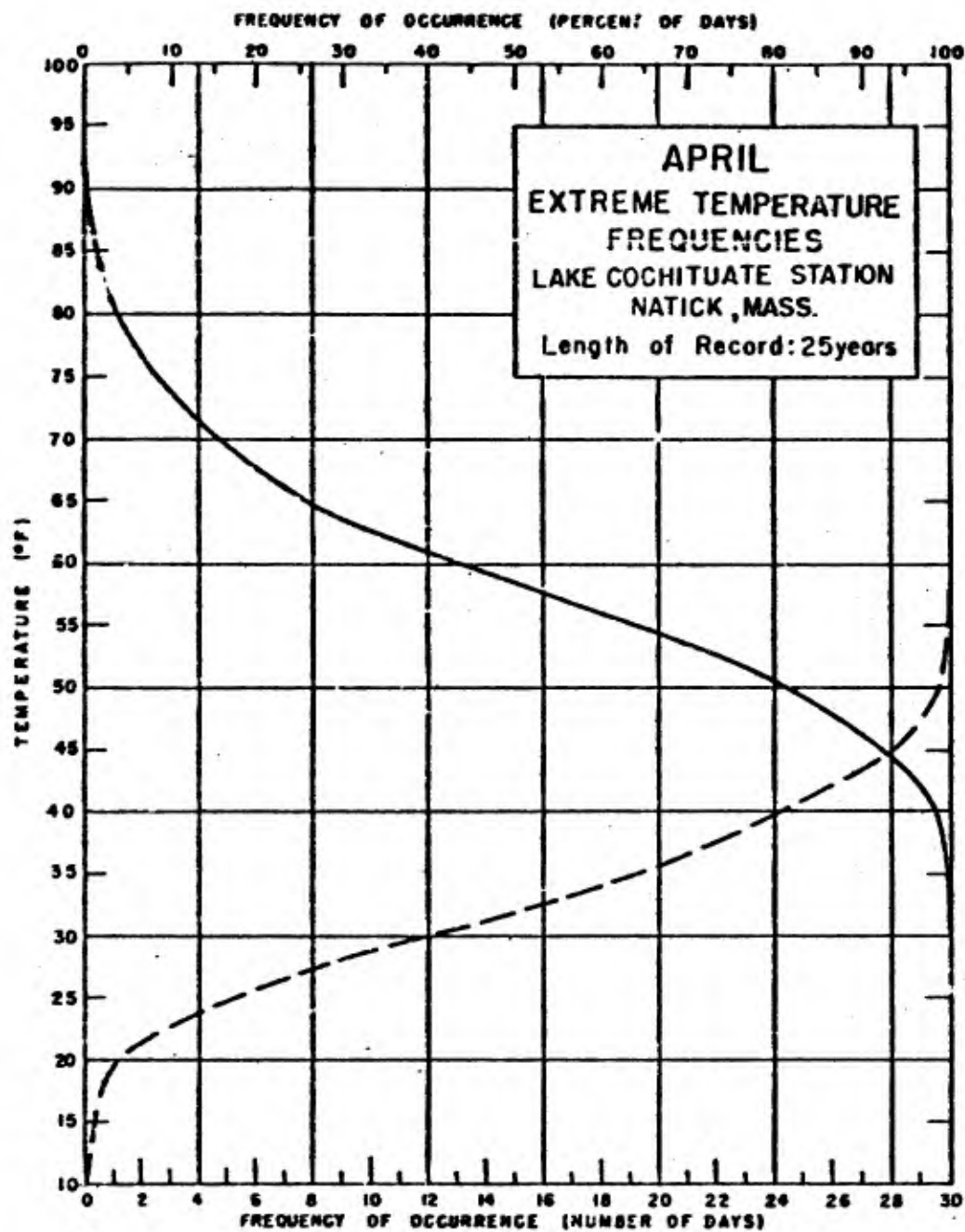
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

Figure 20



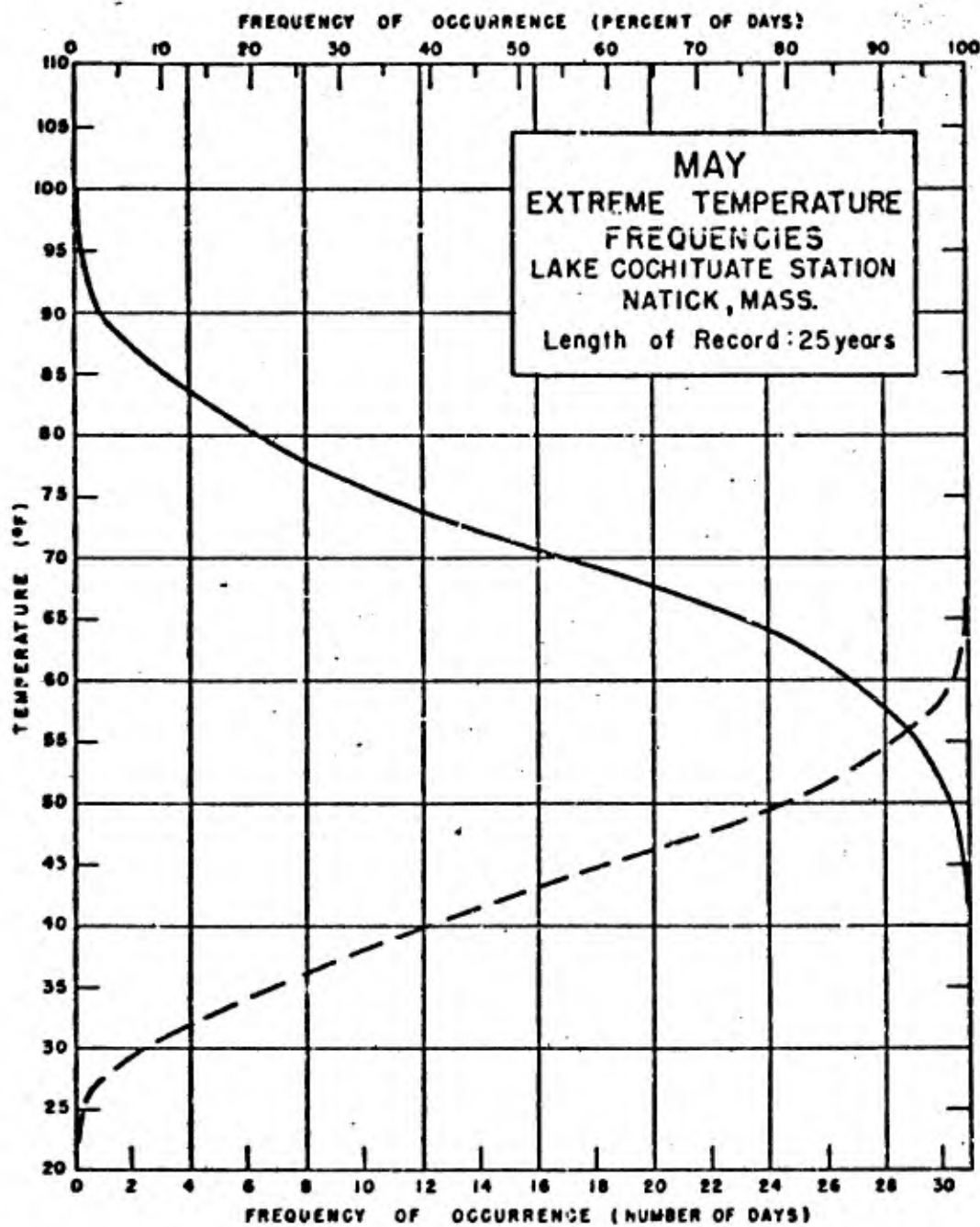
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

Figure 21



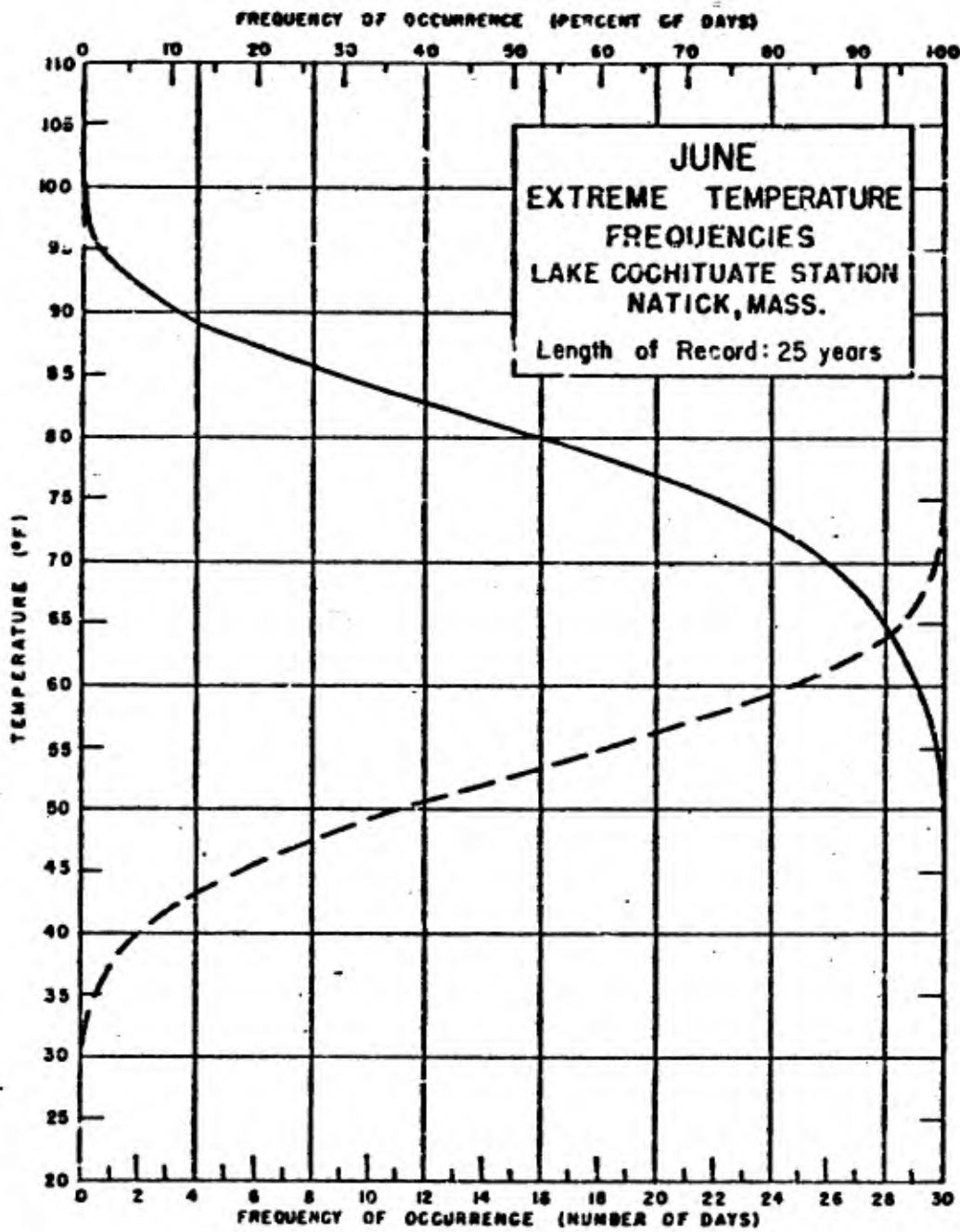
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

Figure 22



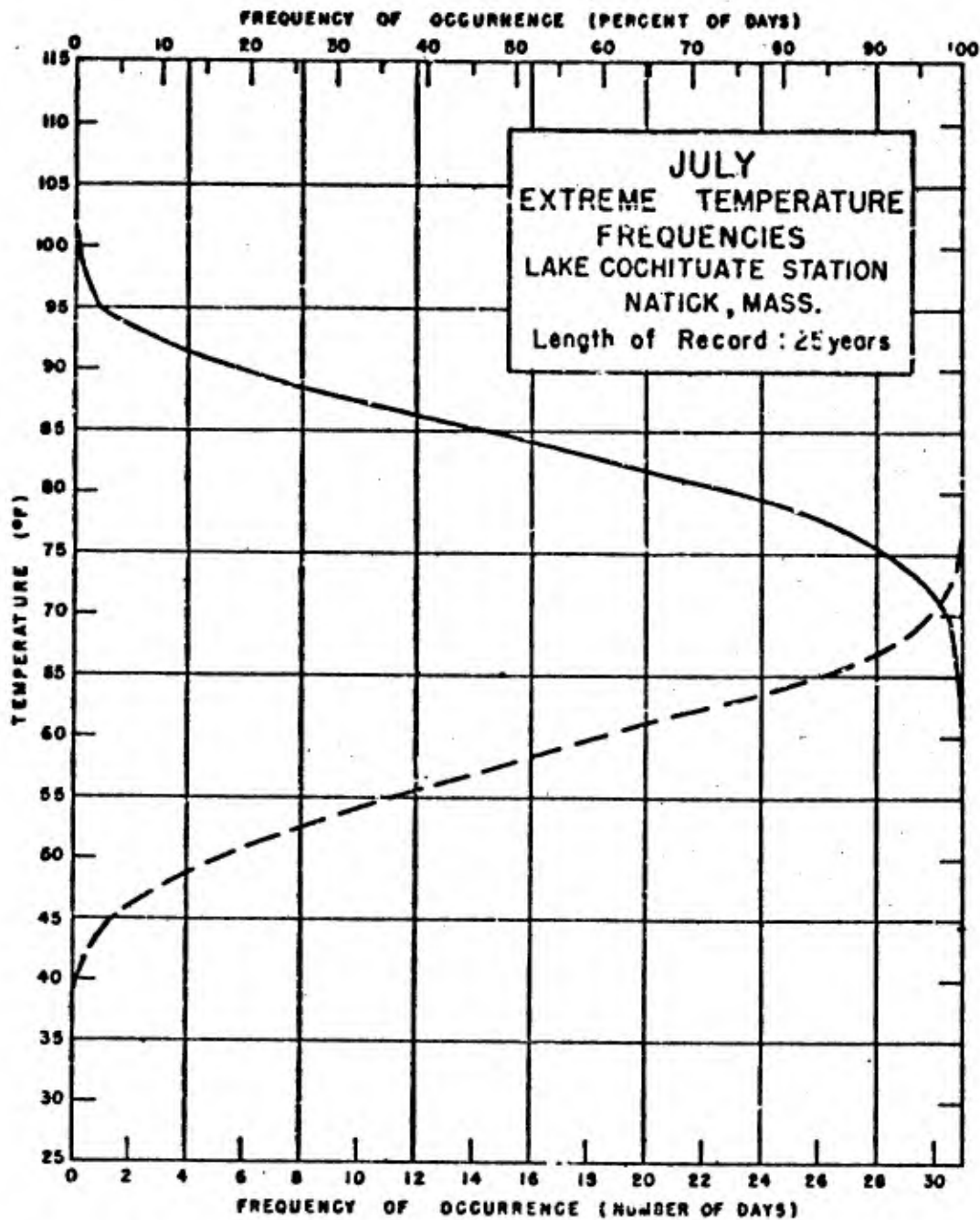
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

Figure 23



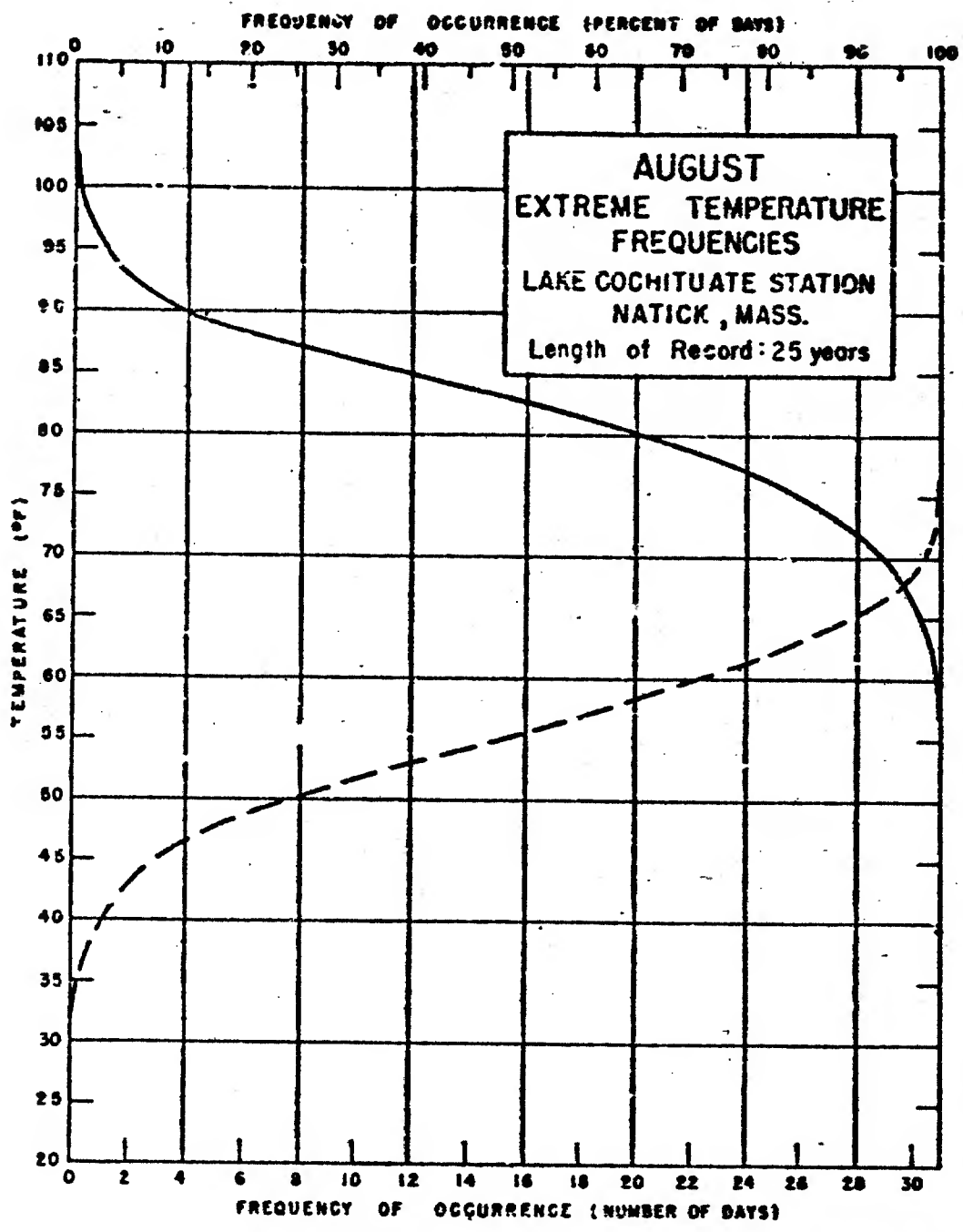
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

Figure 2h



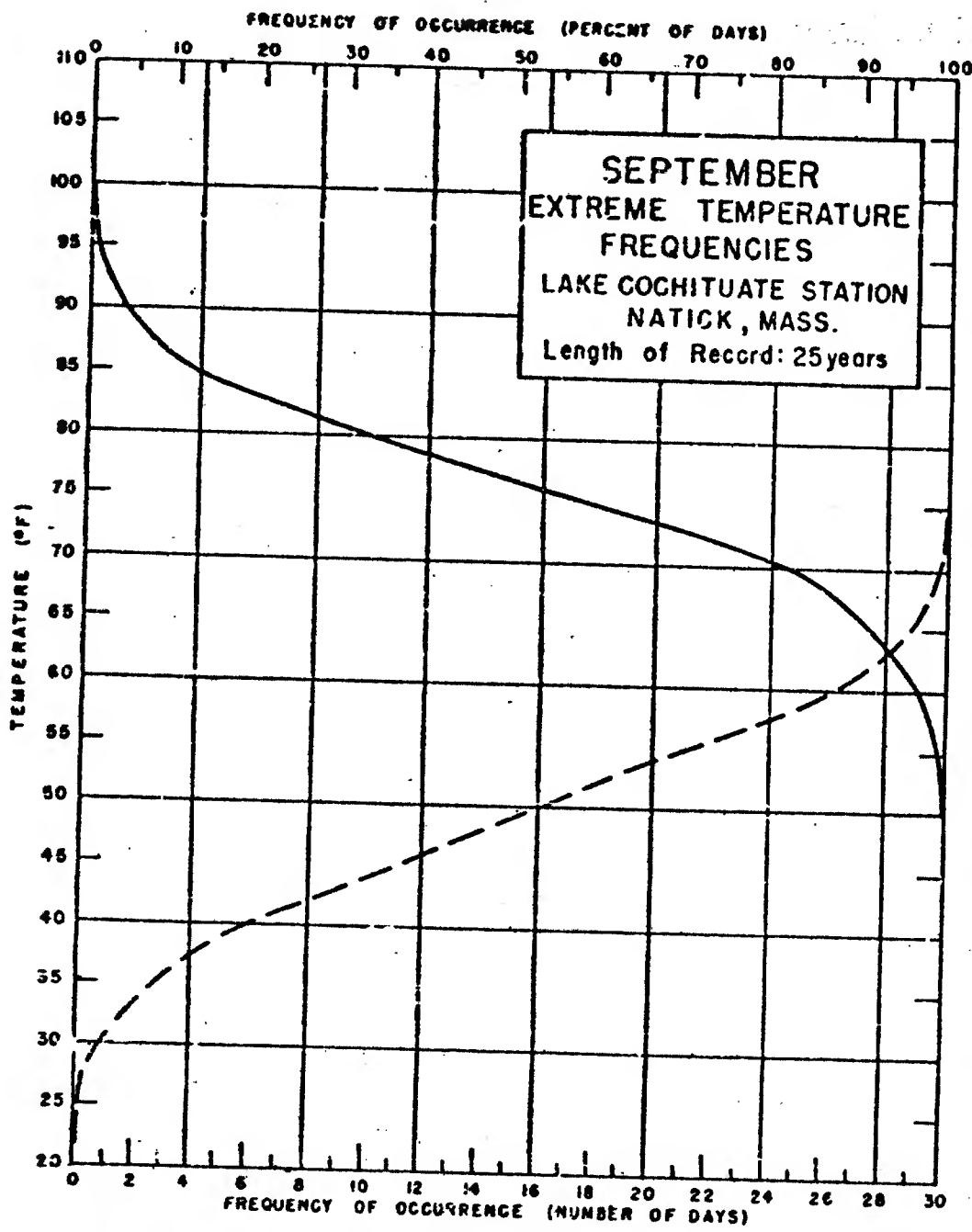
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

Figure 25



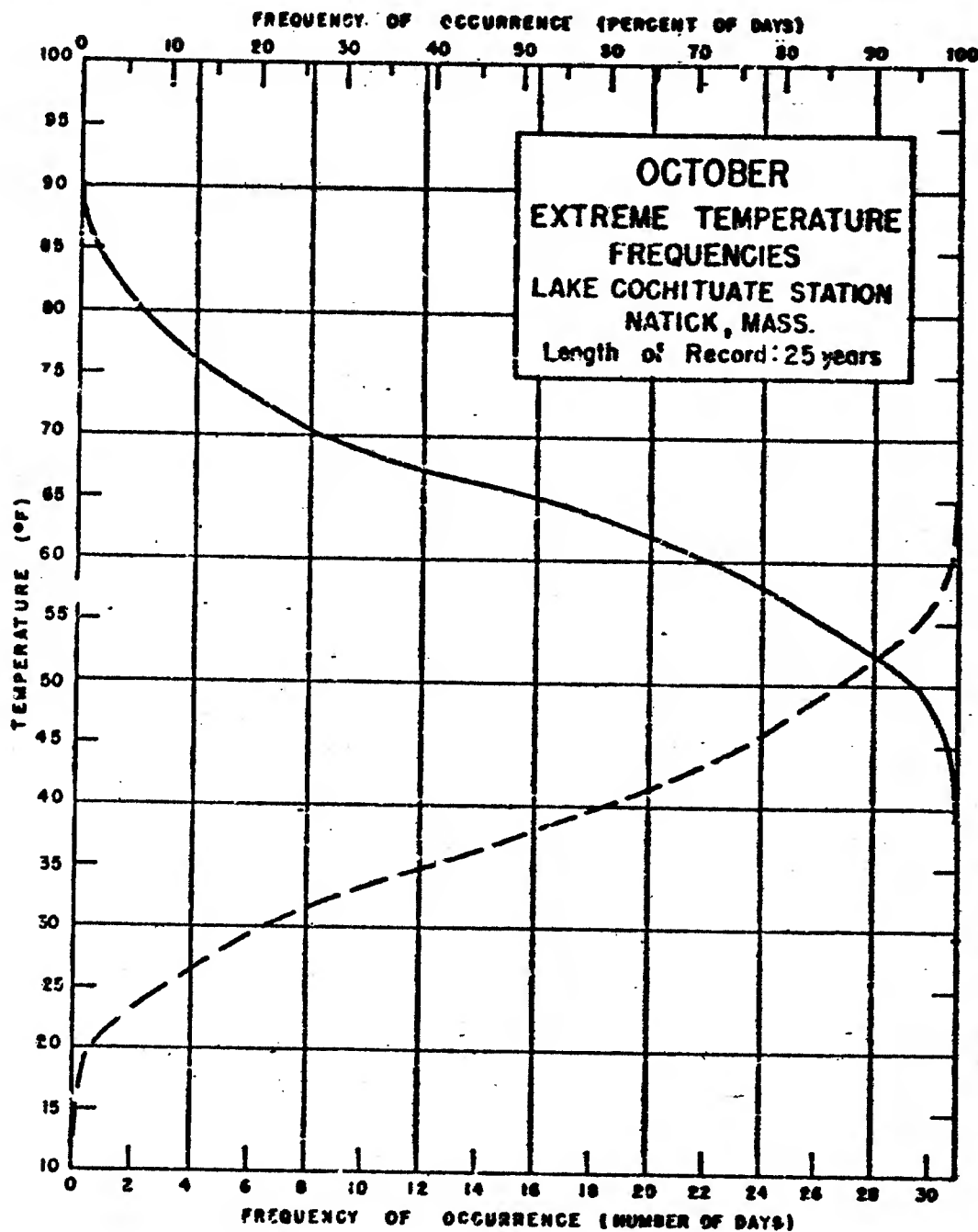
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

Figure 26



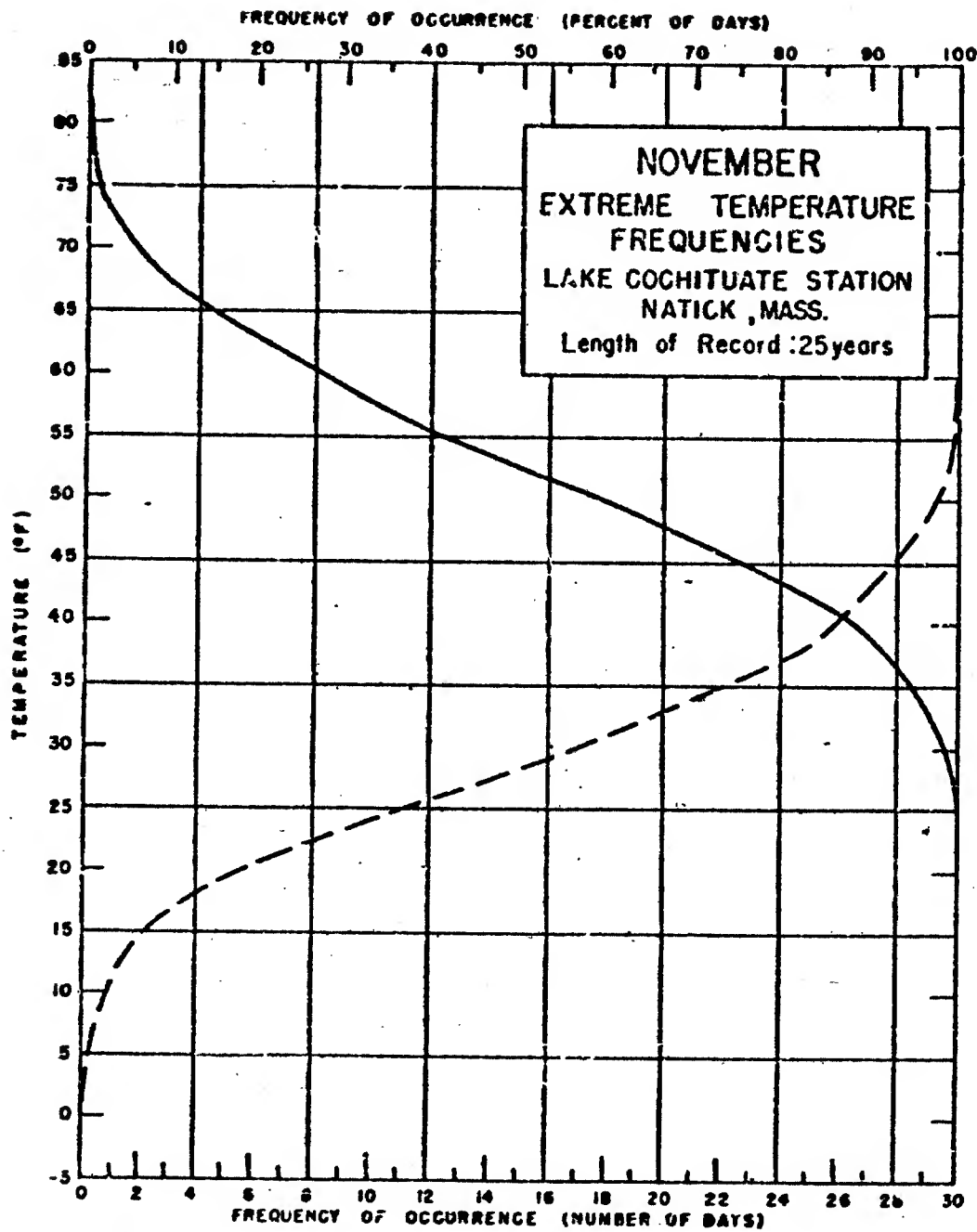
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

Figure 27



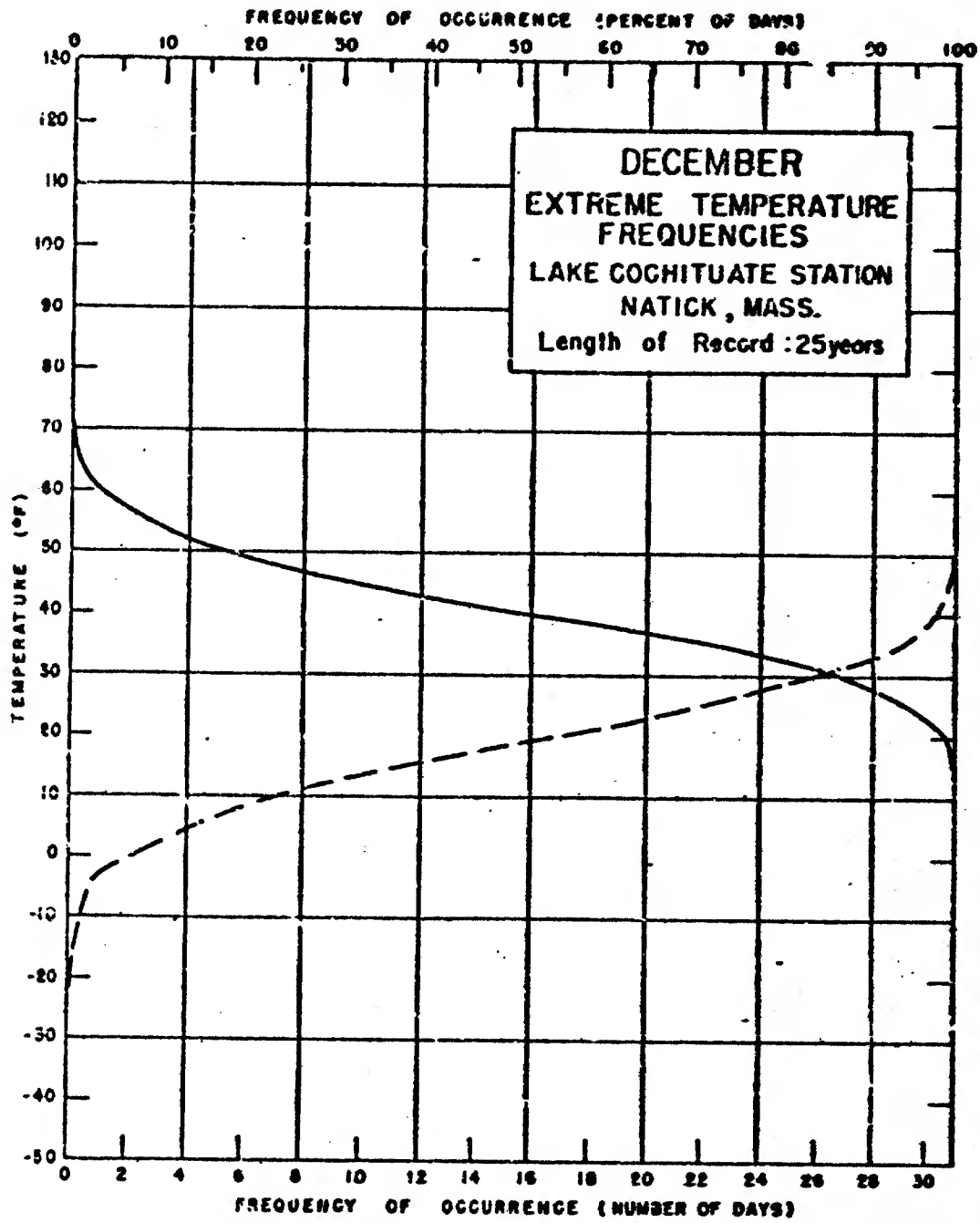
- Number of days (or percent of days) the daily maximum temperature may be expected to equal or be greater than a particular temperature.
- - - Number of days (or percent of days) the daily minimum temperature may be expected to equal or be less than a particular temperature.

Figure 28



- 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 29



- 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 30
38

TABLE I: STANDARD DEVIATIONS FROM MEAN TEMPERATURES (F°)
 LAKE OCCITUATE STATION
 Natick, Mass.
 Length of Records 25 Years

| | Mean Daily Maximum | | Mean | | Mean Daily Minimum | |
|-----------|--------------------|-----|-------|-----|--------------------|-----|
| | Temp. | SD | Temp. | SD | Temp. | SD |
| January | 38.1 | 5.3 | 26.5 | 5.5 | 15.0 | 5.9 |
| February | 39.0 | 4.0 | 26.5 | 4.4 | 14.1 | 5.4 |
| March | 47.5 | 4.9 | 35.7 | 4.0 | 23.8 | 3.4 |
| April | 58.4 | 3.6 | 45.7 | 2.8 | 33.1 | 2.7 |
| May | 71.0 | 3.7 | 57.2 | 2.4 | 43.4 | 2.0 |
| June | 79.3 | 3.3 | 65.9 | 2.3 | 52.5 | 1.9 |
| July | 83.7 | 2.4 | 70.8 | 1.7 | 57.9 | 2.1 |
| August | 81.9 | 3.3 | 68.9 | 2.7 | 55.9 | 2.5 |
| September | 76.1 | 1.8 | 62.5 | 1.6 | 48.9 | 2.3 |
| October | 65.0 | 3.4 | 51.6 | 2.5 | 38.2 | 2.3 |
| November | 52.8 | 4.1 | 41.1 | 2.9 | 29.3 | 2.8 |
| December | 40.2 | 4.8 | 29.4 | 3.6 | 18.6 | 3.2 |

PRECIPITATION REGIME
 Lake Cochituate Station
 Natick, Massachusetts
 Length of Record: 27 years

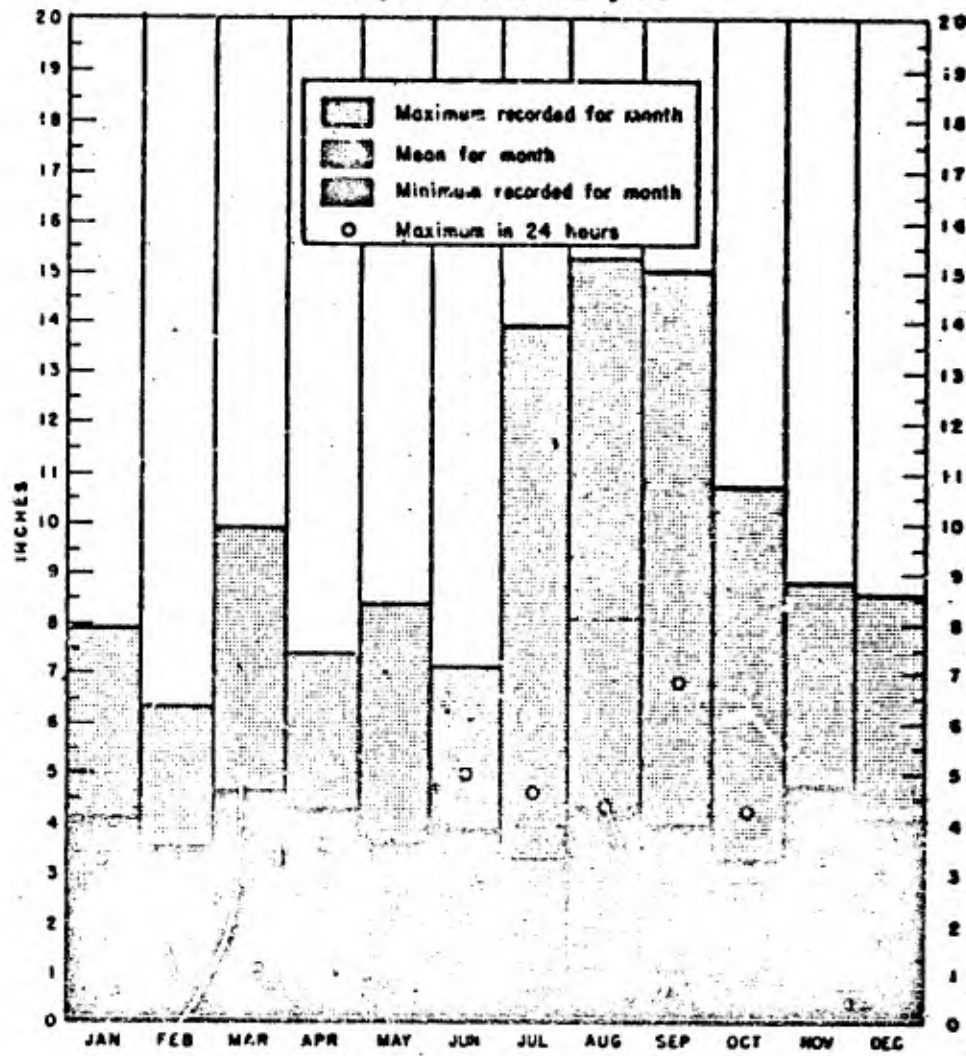


Figure 31

TABLE II: PRECIPITATION MEANS AND EXTREMES (inches)
 LAKE COCHITUATE STATION
 Natick, Mass.
 Length of Records: 27 Years

| | Mean in Month | Max. in Month | Min. in Month | Max. in Day | No. of Days ≥ 0.01 | Mean Snowfall |
|-----------|---------------------|---------------------|---------------------|-------------------|-----------------------|------------------|
| January | 4.13 | 7.91 | 0.82 | 3.27 | 10 | 13.7 |
| February | 3.50 | 6.38 | 1.46 | 2.47 | 8 | 13.8 |
| March | 4.68 | 9.63 | 1.92 | 3.80 | 10 | 6.8 |
| April | 4.18 | 7.40 | 1.47 | 3.57 | 10 | 1.2 |
| May | 3.62 | 8.44 | 0.91 | 2.35 | 10 | 0.0 |
| June | 3.83 | 7.11 | 1.09 | 4.98 | 9 | 0.0 |
| July | 3.36 | 13.91 | 0.72 | 4.64 | 9 | 0.0 |
| August | 4.21 | 15.35 | 1.17 | 5.40 | 8 | 0.0 |
| September | 4.01 | 15.02 | 0.60 | 6.90 | 8 | 0.0 |
| October | 3.36 | 10.71 | 0.44 | 4.28 | 8 | 0.0 |
| November | 4.76 | 8.81 | 0.95 | 3.88 | 9 | 2.5 |
| December | 4.13 | 8.64 | 1.09 | 3.77 | 8 | 8.2 |
| TOTAL | 47.77 | | | | | 46.2 |

MONTHLY SNOWFALL
 Lake Cochituate Station
 Natick, Massachusetts
 Length of Record: 25 years

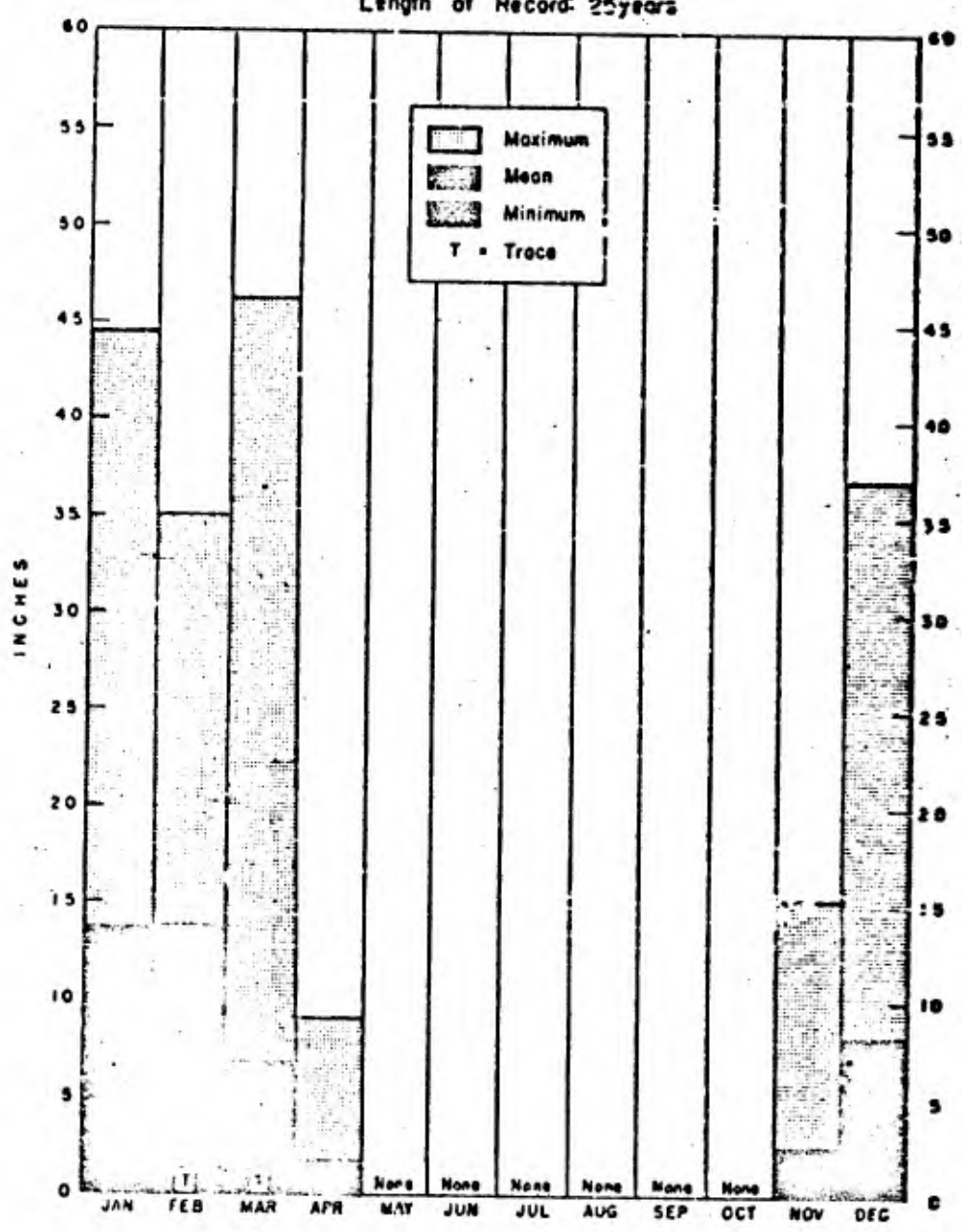


Figure 32

TABLE III: SNOW DEPTH
Hanscom AFB
Bedford, Mass.

Period of Records 1946 - 1953*

| Month | None Trace | Frequency of Occurrence (days) | | | | | | | | | | Total Days | Mean No. of Days With Measure. Anka. |
|-----------|------------|--------------------------------|-------|-------|---------|----------|-----------|-----------|-----------|---|-----|------------|--------------------------------------|
| | | 1 in. | 2 in. | 3 in. | 4-6 in. | 7-12 in. | 13-24 in. | 25-36 in. | 37-48 in. | | | | |
| January | 92 | 22 | 14 | 11 | 12 | 35 | 27 | 21 | 8 | 3 | 248 | 15.4 | |
| February | 83 | 17 | 17 | 17 | 20 | 27 | 29 | 9 | 7 | 0 | 226 | 15.6 | |
| March | 181 | 12 | 15 | 5 | 5 | 17 | 8 | 3 | 0 | 0 | 248 | 6.9 | |
| April | 234 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 239 | 0.5 | |
| May | 247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 247 | 0.0 | |
| June | 240 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 240 | 0.0 | |
| July | 248 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 248 | 0.0 | |
| August | 248 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 248 | 0.0 | |
| September | 240 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 240 | 0.0 | |
| October | 217 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 217 | 0.0 | |
| November | 201 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 209 | 0.9 | |
| December | 141 | 14 | 15 | 12 | 6 | 14 | 6 | 5 | 3 | 0 | 216 | 8.0 | |

*Snow depth observations taken at 0030 GMT (1930 LST) through June 1952, and at 1230 GMT (0730 LST), from July 1952 to September 1953.

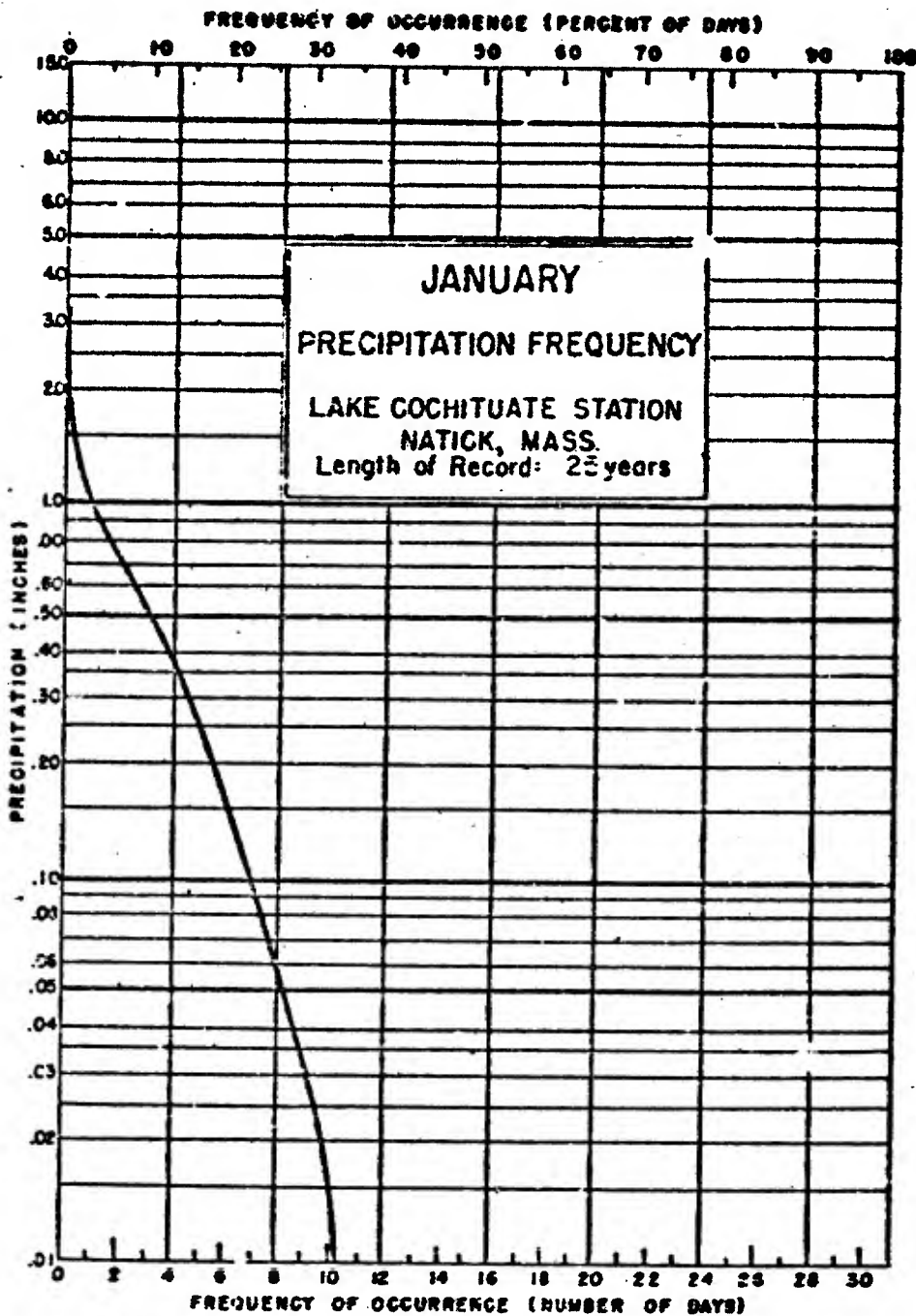
TABLE 17: STANDARD DEVIATIONS FROM MEAN
PRECIPITATION* AND SNOWFALL

Lake Cochituate Station
Natick, Mass.

Length of records: 27 years for precipitation
25 years for snowfall

| Month | Precipitation (inches) | | Snowfall (inches) | |
|-----------|------------------------|------|-------------------|------|
| | Mean | SD | Mean | SD |
| January | 4.13 | 1.72 | 13.7 | 10.2 |
| February | 3.50 | 1.08 | 13.8 | 7.8 |
| March | 4.68 | 1.99 | 6.8 | 6.1 |
| April | 4.18 | 1.63 | 1.2 | 2.7 |
| May | 3.62 | 1.78 | 0.0 | 0.0 |
| June | 3.83 | 1.74 | 0.0 | 0.0 |
| July | 3.36 | 2.69 | 0.0 | 0.0 |
| August | 4.21 | 3.04 | 0.0 | 0.0 |
| September | 4.01 | 3.55 | 0.0 | 0.0 |
| October | 3.36 | 2.30 | 0.0 | 0.0 |
| November | 4.76 | 2.53 | 2.5 | 4.3 |
| December | 4.13 | 1.92 | 8.2 | 9.3 |

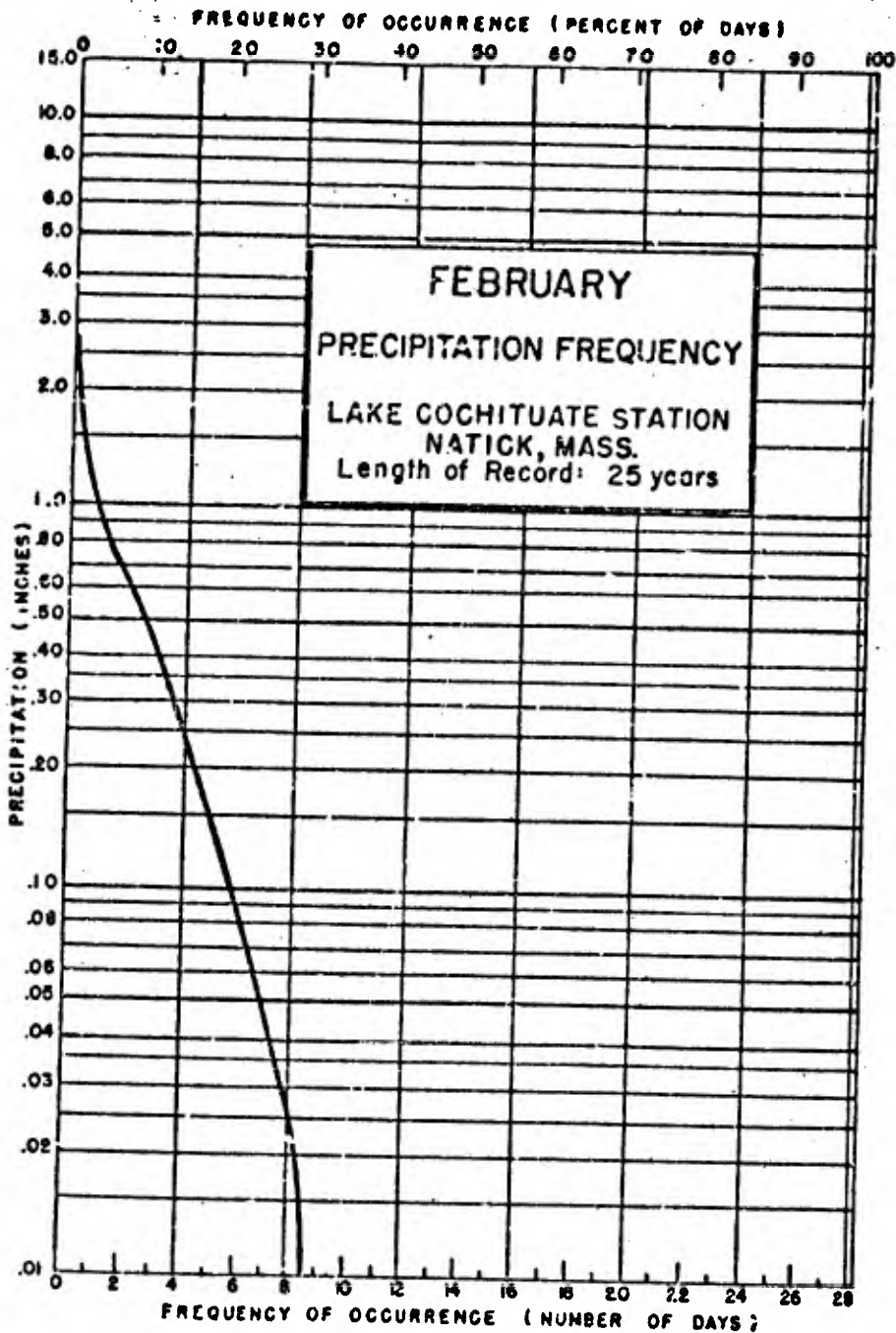
*Includes snowfall, water equivalent



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

Example: 0.06 inches or more precipitation may be expected to occur 8 days during January (or approximately 26 percent of the days).

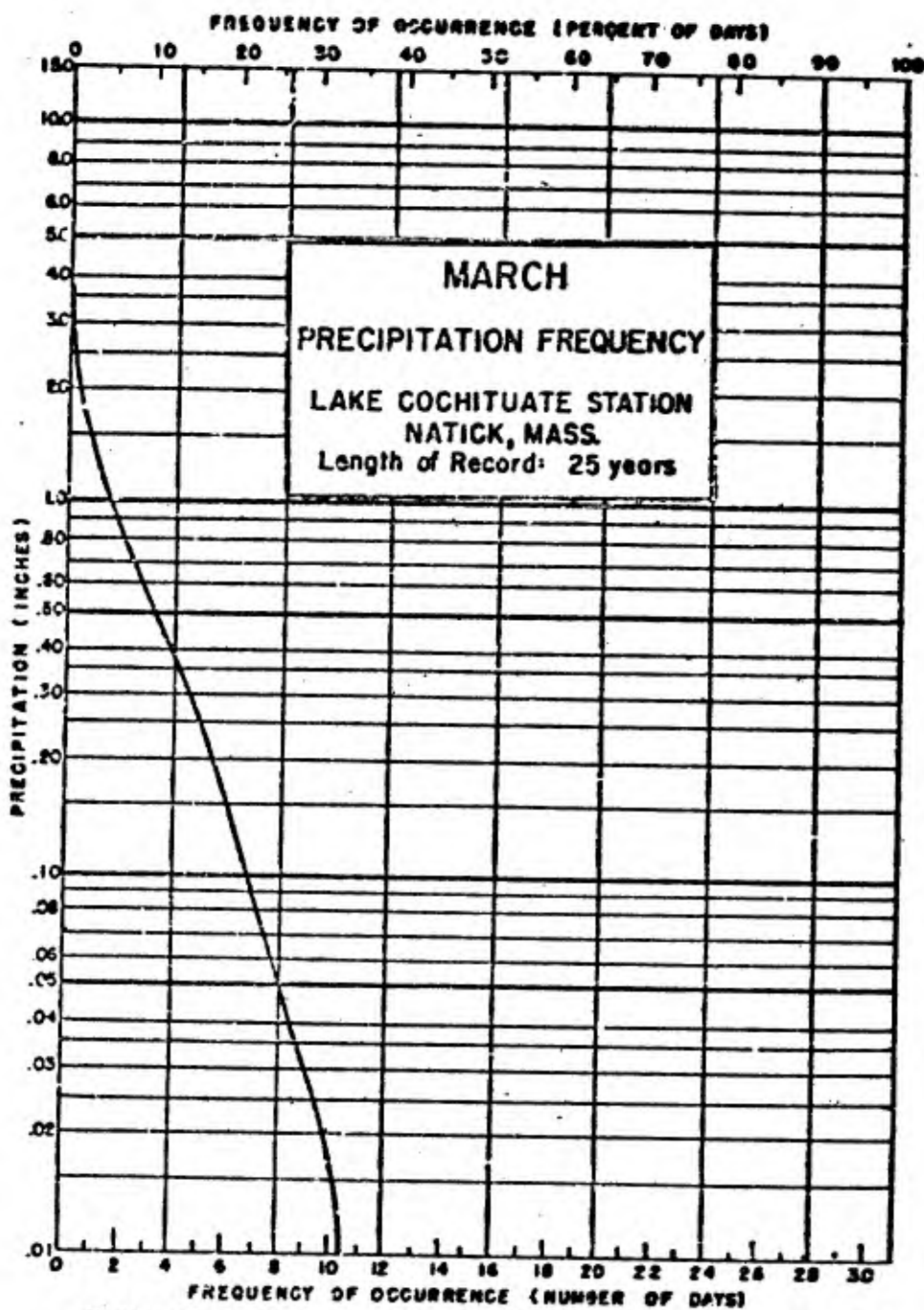
Figure 33



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

Example: 0.26 inches or more precipitation may be expected to occur 4 days during February (or approximately 15 percent of the days).

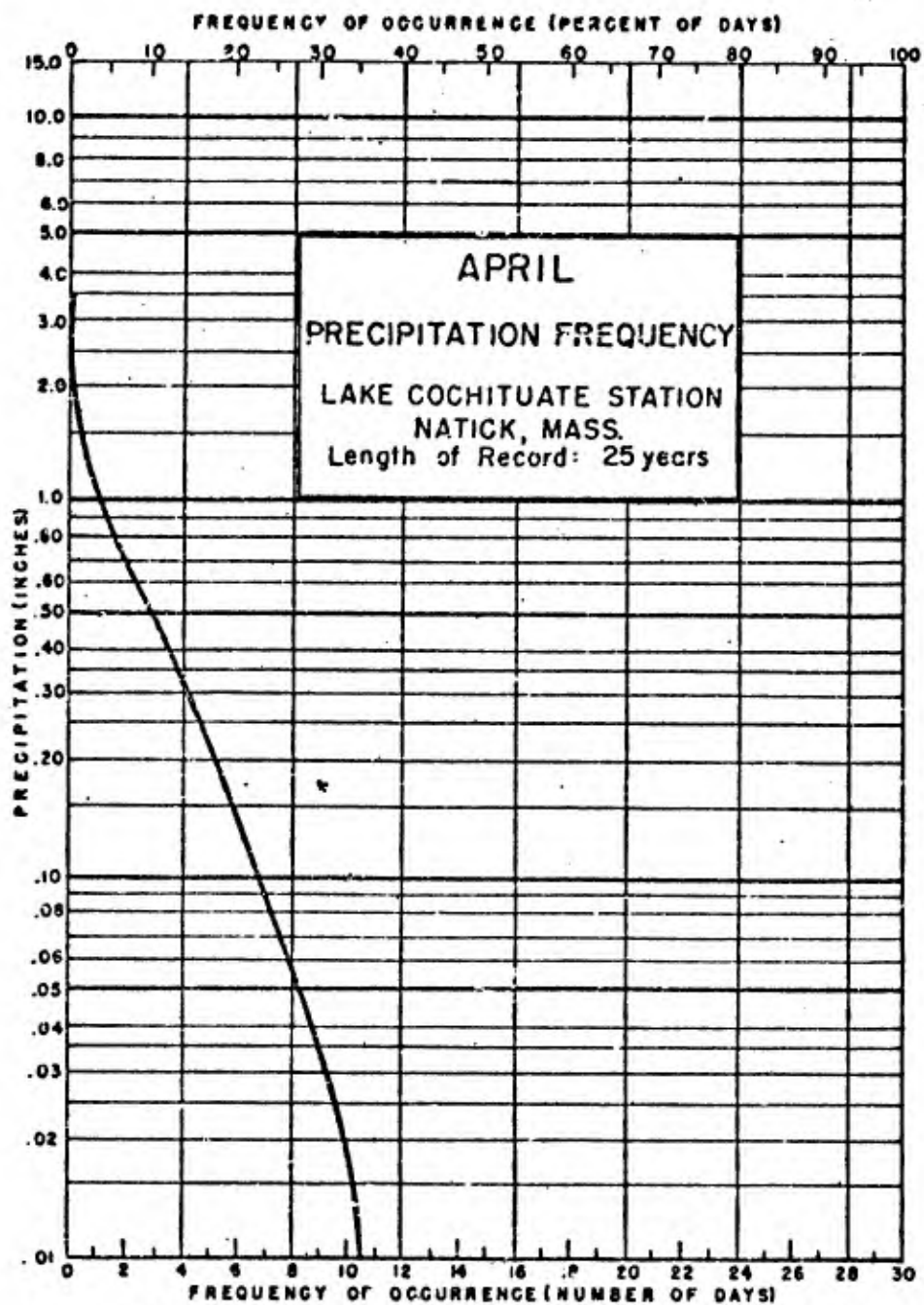
Figure 34



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

Example: 0.02 inches or more precipitation may be expected to occur 9.8 days during March (or approximately 32 percent of the days).

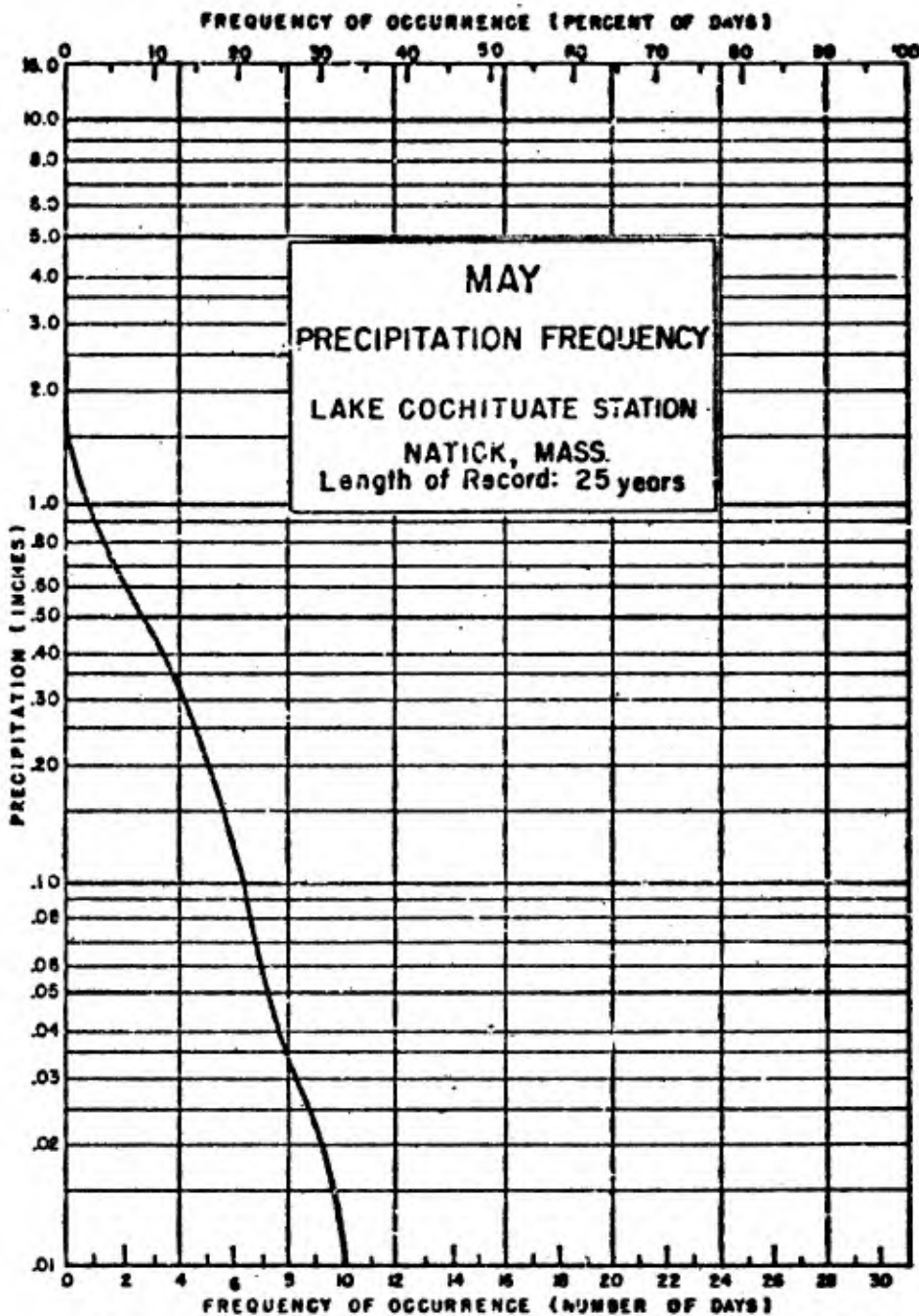
Figure 35



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

Example: 0.11 inches or more precipitation may be expected to occur 6.2 days during April (or approximately 23 percent of the days).

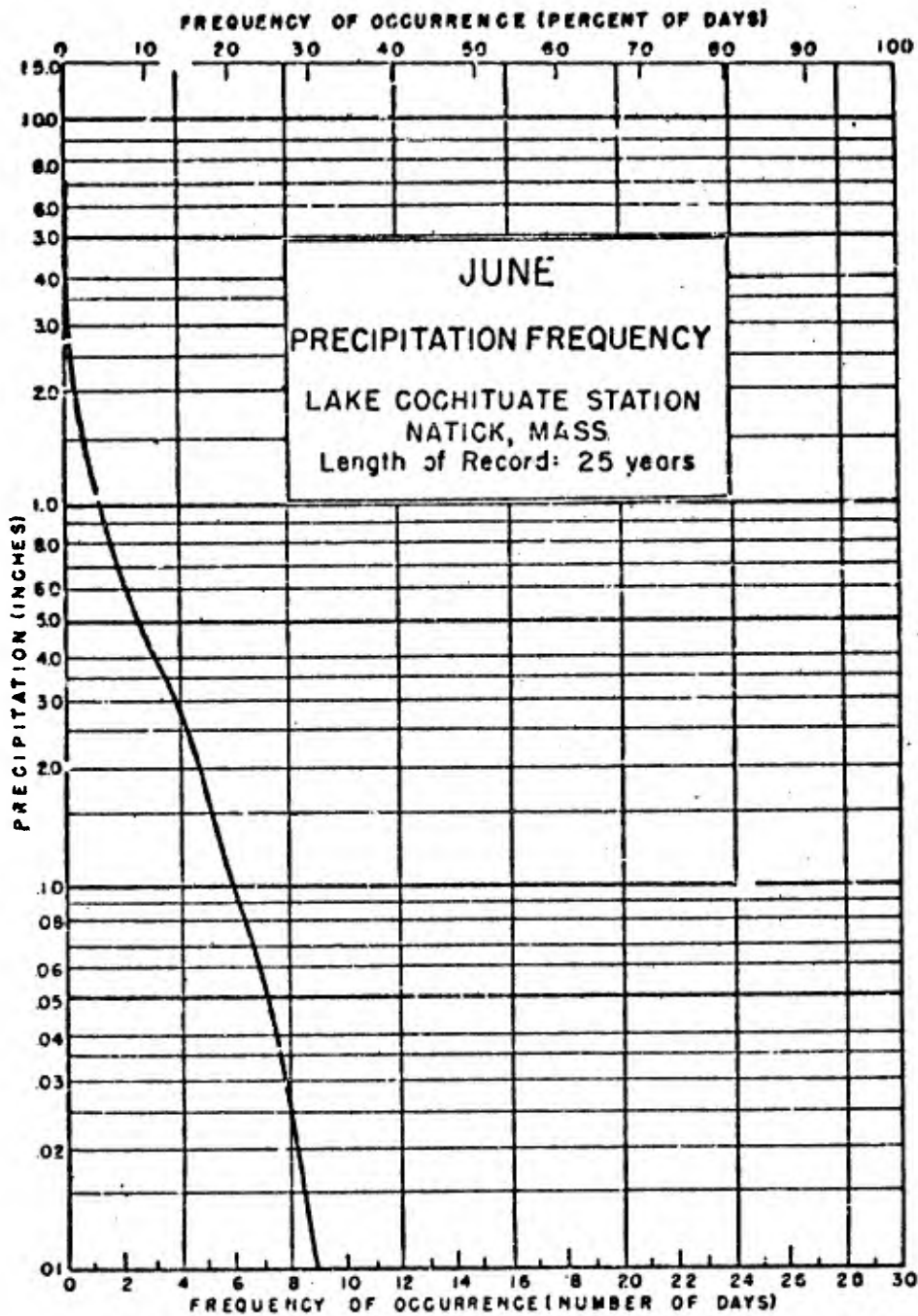
Figure 36



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

Example: 0.02 inches or more precipitation may be expected to occur 9 days during May (or approximately 29 percent of the days).

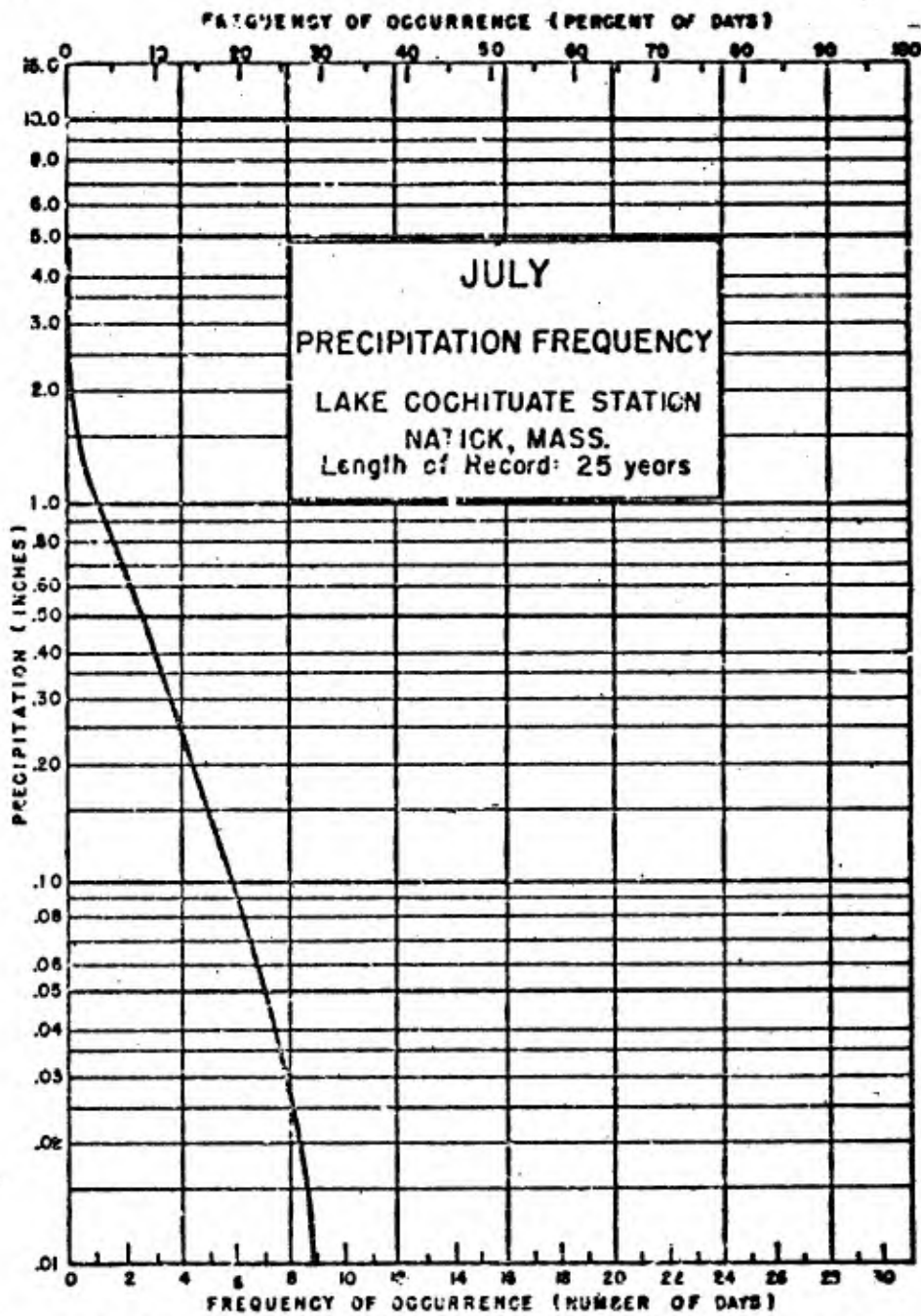
Figure 37



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

Example: 0.26 inches or more precipitation may be expected to occur 4.2 days during June (or approximately 15 percent of the days).

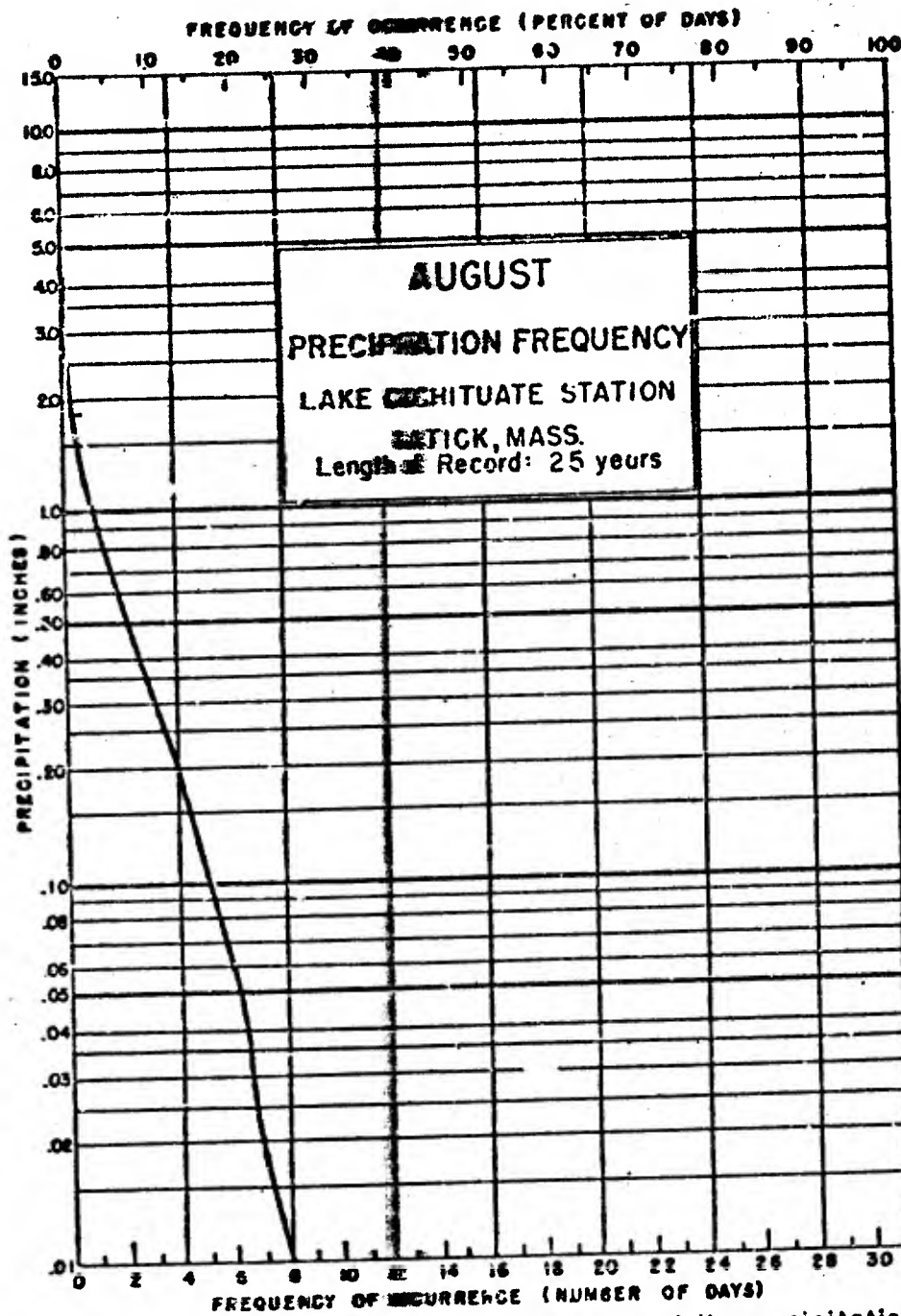
Figure 30



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

Example: 0.1 inches or more precipitation may be expected to occur 5.7 days during July (or approximately 17 percent of the days).

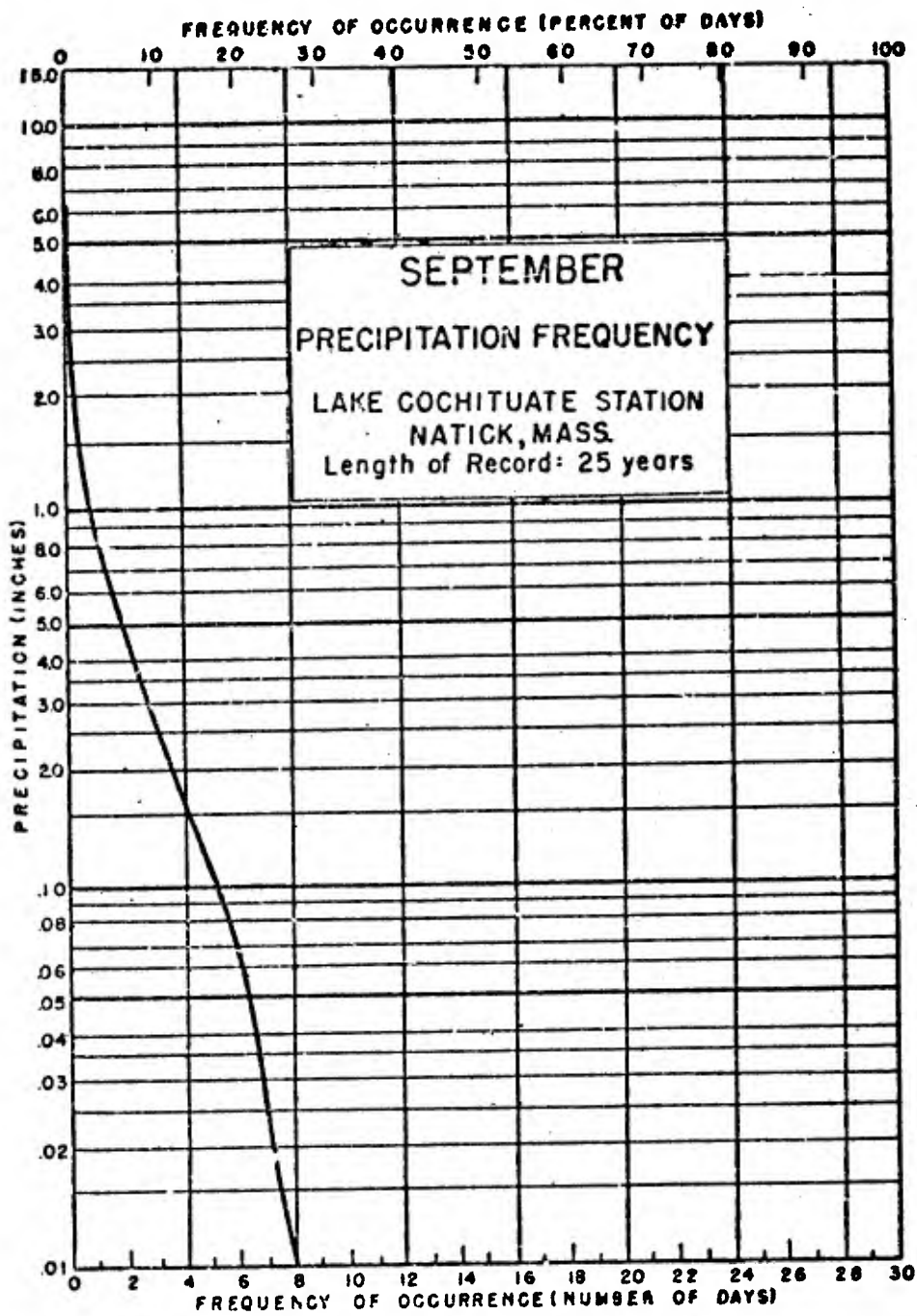
Figure 39



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

Example: 0.06 inches or more precipitation may be expected to occur 6 days during August (or approximately 19 percent of the month).

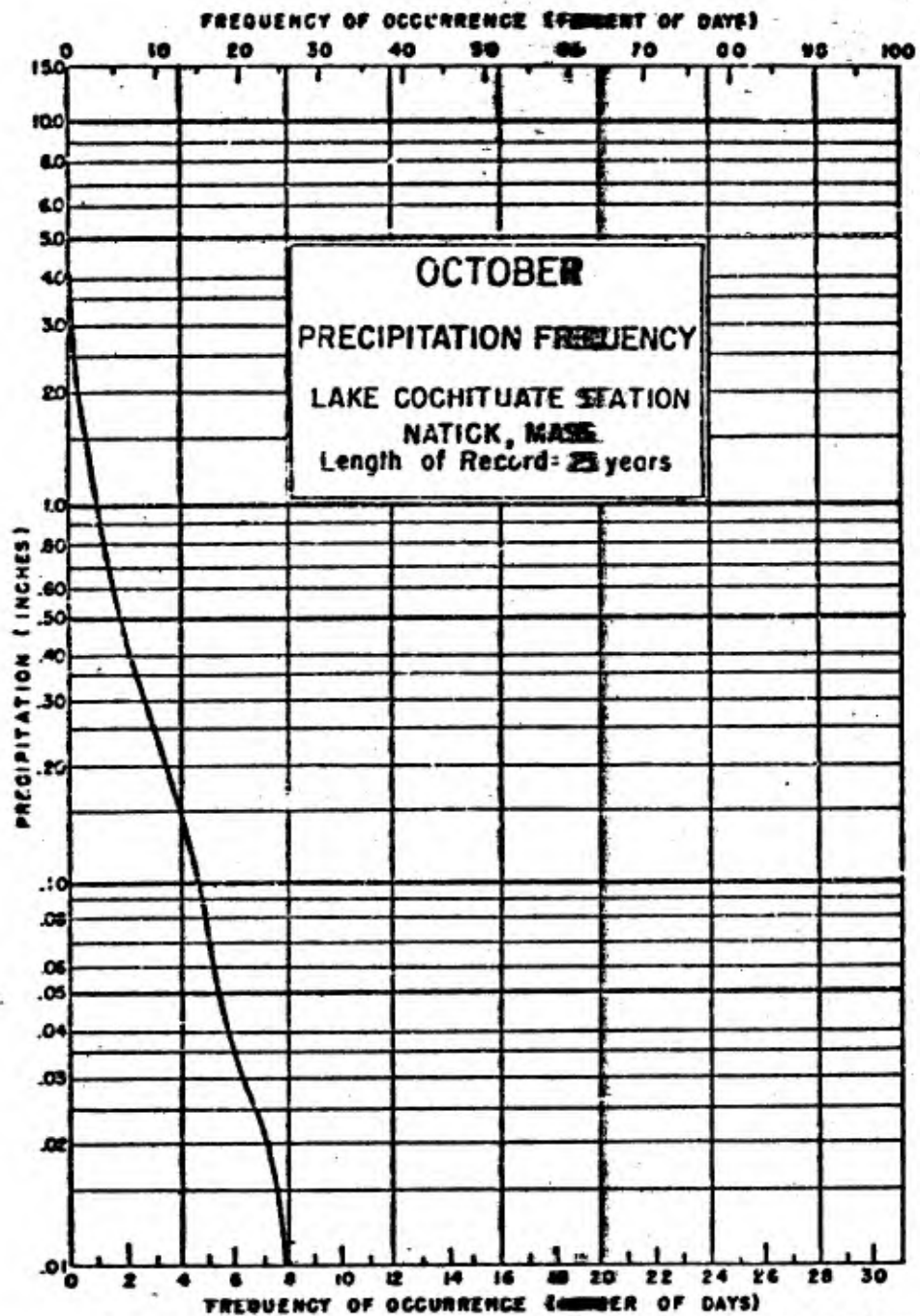
Figure 40



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

Example: 0.11 inches or more precipitation may be expected to occur 4.9 days during September (or approximately 17 percent of the days).

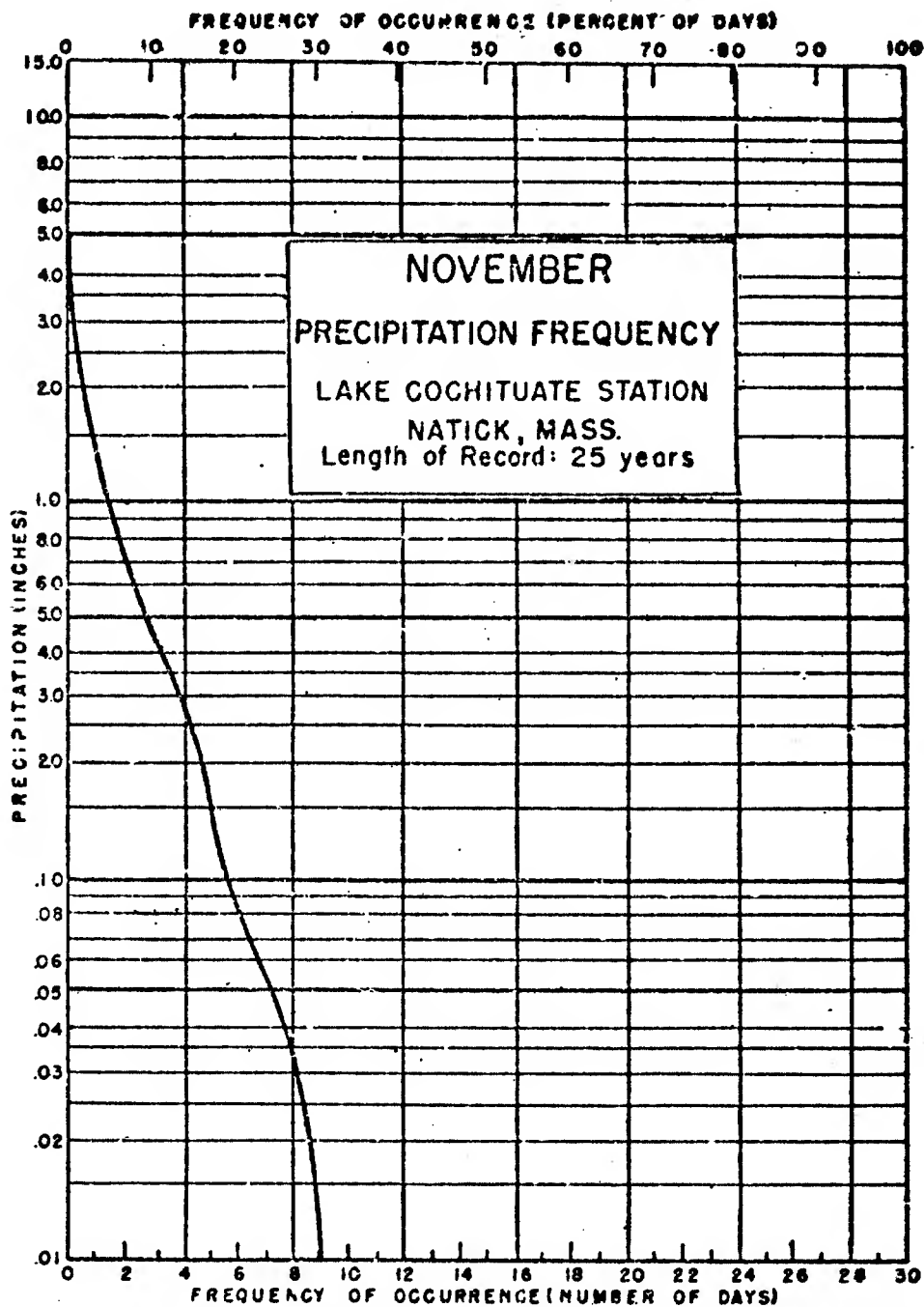
Figure h1



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

Example: 0.26 inches or more precipitation may be expected to occur 3.0 days during October for approximately 16 percent of the days.

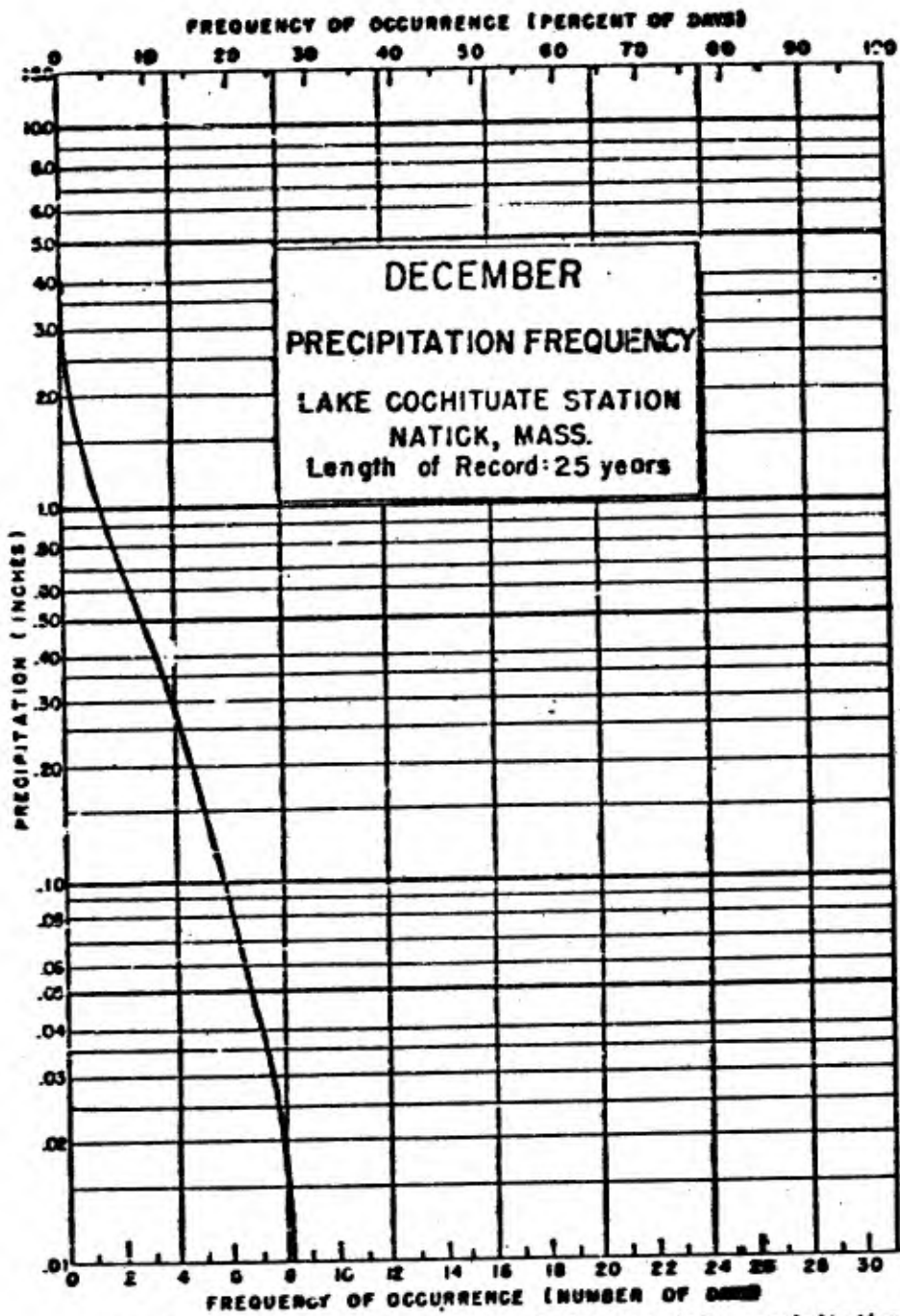
Figure k2



Numbe. of days (or percent of days) when the daily precipi-
tation may be expected to be the indicated amount or greater.

Example: 0.11 inches or more precipitation may be expected to
occur 5.5 days during November (or approximately 18
percent of the days).

Figure 13



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

Example: 0.11 inches or more precipitation may be expected to occur 5.6 days during December (or approximately 18 percent of the days).

Figure 4h

PERCENTAGE OF WIND SPEEDS BY GROUPS

Hanscom AFB
Bedford, Massachusetts

Length of Record: 10-11 years

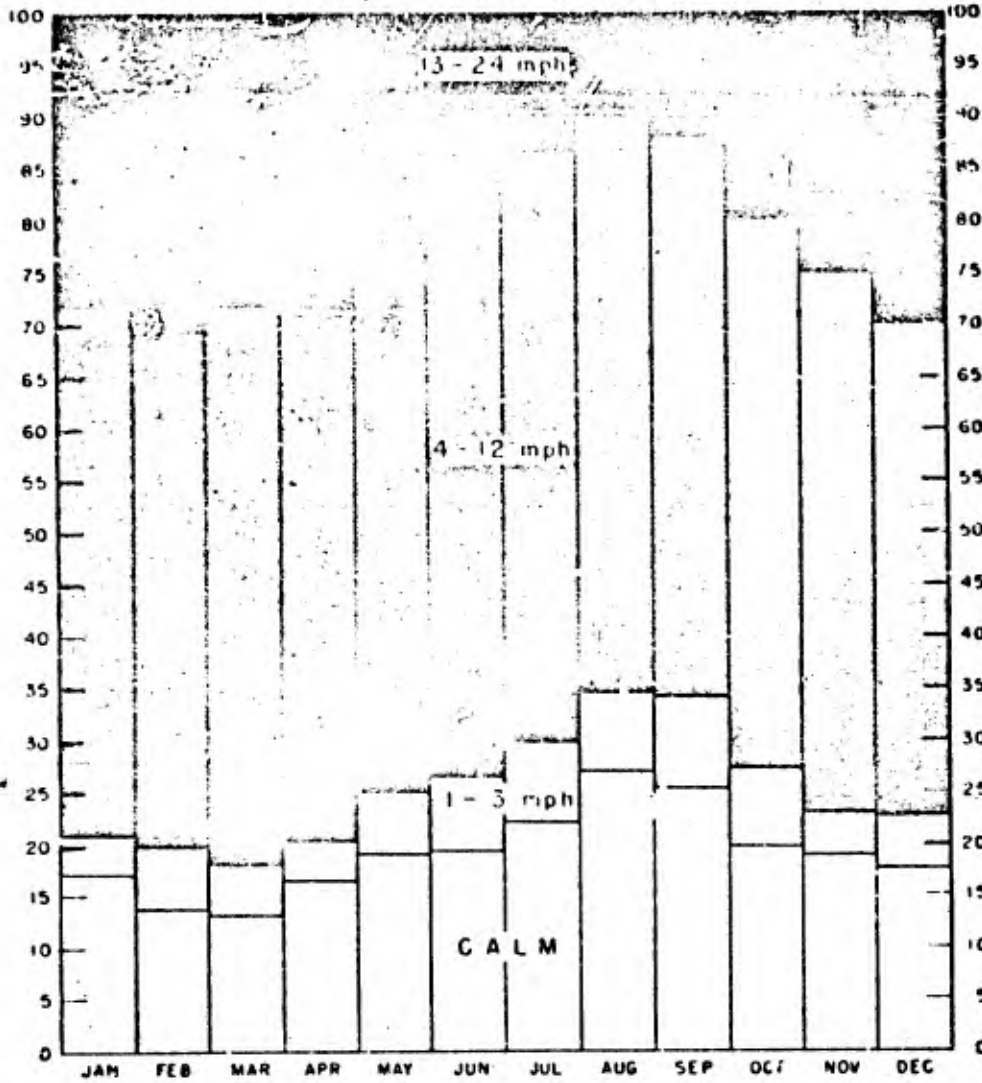


Figure 45

TABLE V: FREQUENCY OF OCCURRENCE OF WIND SPEEDS
(Percent of observations)
Hanscom AFB
Bedford, Mass.

Period of Records: Feb. 1943 - Sept. 1953

| Speed (mph) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Calm | 17.2 | 13.9 | 13.3 | 16.7 | 19.1 | 19.5 | 22.3 | 27.1 | 25.5 | 19.9 | 19.0 | 17.6 |
| 1-3 | 3.8 | 6.0 | 4.9 | 3.8 | 6.0 | 7.1 | 7.5 | 7.6 | 8.8 | 7.5 | 4.0 | 5.3 |
| 4-12 | 50.8 | 49.5 | 53.7 | 50.7 | 53.0 | 55.2 | 57.2 | 55.7 | 54.0 | 52.9 | 52.2 | 47.5 |
| 13-24 | 25.1 | 25.8 | 25.0 | 24.9 | 20.8 | 17.7 | 12.9 | 9.5 | 11.1 | 18.4 | 22.5 | 25.3 |
| 25-31 | 2.5 | 4.0 | 2.7 | 3.5 | 1.1 | 0.5 | 0.1 | 0.1 | 0.3 | 1.3 | 1.9 | 3.6 |
| 32-46 | 0.5 | 0.8 | 0.5 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.5 | 0.7 |

TABLE VI: FREQUENCY OF OCCURRENCE OF WIND DIRECTIONS
(Percent of observations)
Hanscom AFB
Bedford, Mass.

Period of Records: Feb. 1943 - Sept. 1953

| Direction | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| N | 5.8 | 5.9 | 5.0 | 3.5 | 2.5 | 2.4 | 2.2 | 2.9 | 4.2 | 4.3 | 5.0 | 4.8 |
| NNE | 5.4 | 4.5 | 5.0 | 3.6 | 3.2 | 2.7 | 2.6 | 3.4 | 3.0 | 3.9 | 3.7 | 3.7 |
| NE | 4.3 | 3.7 | 4.1 | 3.3 | 4.4 | 3.0 | 2.4 | 3.3 | 4.2 | 5.3 | 4.2 | 3.0 |
| ENE | 2.0 | 2.1 | 4.2 | 3.7 | 5.0 | 3.0 | 1.7 | 3.2 | 3.0 | 3.6 | 2.7 | 1.1 |
| E | 1.3 | 1.6 | 3.0 | 3.1 | 4.6 | 2.8 | 2.0 | 2.6 | 2.4 | 2.1 | 2.3 | 1.0 |
| ESE | 1.0 | 1.3 | 2.5 | 3.5 | 4.6 | 3.0 | 2.9 | 2.7 | 2.5 | 1.8 | 1.8 | 1.2 |
| SE | 1.2 | 2.0 | 2.4 | 3.4 | 4.1 | 3.0 | 2.6 | 2.3 | 2.3 | 2.4 | 1.6 | 1.1 |
| SSE | 1.9 | 2.7 | 2.8 | 2.5 | 3.4 | 2.4 | 2.9 | 2.3 | 3.4 | 1.9 | 2.2 | 1.6 |
| S | 3.2 | 3.3 | 3.2 | 3.2 | 3.7 | 3.5 | 5.1 | 5.0 | 5.6 | 4.4 | 4.3 | 2.6 |
| SSW | 5.5 | 4.9 | 6.8 | 6.1 | 6.9 | 10.2 | 11.2 | 7.6 | 7.3 | 7.0 | 6.2 | 3.9 |
| SW | 6.8 | 6.9 | 8.0 | 8.1 | 7.5 | 11.5 | 12.4 | 9.9 | 9.0 | 11.3 | 6.9 | 6.9 |
| WSW | 7.8 | 8.7 | 7.3 | 7.0 | 7.7 | 11.6 | 10.3 | 8.7 | 6.2 | 8.7 | 6.7 | 10.7 |
| W | 10.8 | 9.4 | 7.3 | 8.7 | 7.4 | 7.8 | 7.6 | 6.9 | 6.8 | 8.4 | 10.0 | 12.7 |
| WNW | 9.3 | 11.4 | 8.4 | 9.4 | 6.2 | 5.6 | 5.8 | 4.5 | 4.7 | 4.9 | 7.9 | 10.3 |
| WW | 9.4 | 10.9 | 7.6 | 7.6 | 5.2 | 3.8 | 3.0 | 3.8 | 5.2 | 5.8 | 9.3 | 10.8 |
| WNW | 7.1 | 7.0 | 9.2 | 6.6 | 4.4 | 4.0 | 3.1 | 3.9 | 4.8 | 4.3 | 6.4 | 7.8 |
| Calm | 17.2 | 13.9 | 13.3 | 16.7 | 19.1 | 19.5 | 22.3 | 27.1 | 25.5 | 19.9 | 19.0 | 17.6 |
| Total obsv. | 7,402 | 7,042 | 8,133 | 7,918 | 8,179 | 7,918 | 8,178 | 8,181 | 7,909 | 7,430 | 7,180 | 7,437 |

TABLE VII: FREQUENCY OF OCCURRENCE OF WIND SPEEDS BY DIRECTION
Hanscom AFB
Bedford, Mass.

Period of Record: Feb. 1943 - Sept. 1953

| Direction | Percentage Frequency of Occurrence | | | | | Total No. of Observations | | Mean Wind Speed (mph) |
|-----------|------------------------------------|----------|-----------|-----------|-----------|---------------------------|--------|-----------------------|
| | 1-3 mph | 4-12 mph | 13-24 mph | 25-31 mph | 32-46 mph | % | Obs. | |
| N | 0.3 | 2.8 | 0.9 | 0.1 | 0.0 | 4.0 | 3,718 | 8.6 |
| NNE | 0.3 | 2.7 | 0.7 | 0.0 | 0.0 | 3.7 | 3,443 | 9.1 |
| NE | 0.4 | 2.6 | 0.7 | 0.0 | 0.0 | 3.7 | 3,482 | 8.7 |
| ENE | 0.3 | 2.2 | 0.5 | 0.0 | 0.0 | 3.0 | 2,753 | 8.7 |
| E | 0.3 | 1.8 | 0.3 | 0.0 | 0.0 | 2.4 | 2,255 | 8.1 |
| ESE | 0.2 | 1.8 | 0.4 | 0.0 | 0.0 | 2.5 | 2,278 | 8.6 |
| SE | 0.2 | 1.9 | 0.3 | 0.0 | 0.0 | 2.4 | 2,225 | 7.9 |
| SSE | 0.3 | 1.9 | 0.3 | 0.0 | 0.0 | 2.5 | 2,326 | 8.0 |
| S | 0.5 | 3.0 | 0.5 | 0.0 | 0.0 | 3.9 | 3,632 | 7.7 |
| SSW | 0.5 | 4.9 | 1.5 | 0.1 | 0.0 | 7.0 | 6,526 | 9.5 |
| SW | 0.5 | 5.9 | 2.2 | 0.1 | 0.0 | 8.8 | 8,198 | 10.1 |
| WSW | 0.5 | 5.4 | 2.4 | 0.2 | 0.0 | 8.5 | 7,852 | 10.5 |
| W | 0.6 | 5.5 | 2.1 | 0.3 | 0.0 | 8.6 | 7,979 | 10.4 |
| WNW | 0.4 | 3.8 | 2.7 | 0.4 | 0.1 | 7.3 | 6,791 | 12.5 |
| NW | 0.4 | 3.6 | 2.4 | 0.4 | 0.1 | 6.8 | 6,283 | 12.6 |
| NNW | 0.3 | 3.0 | 2.0 | 0.2 | 0.0 | 5.6 | 5,208 | 12.0 |
| Calm | | | | | | 19.3 | 17,958 | |

TYPES OF SKY CONDITIONS
 Hanscom AFB
 Bedford, Massachusetts
 Length of Record: 5 years

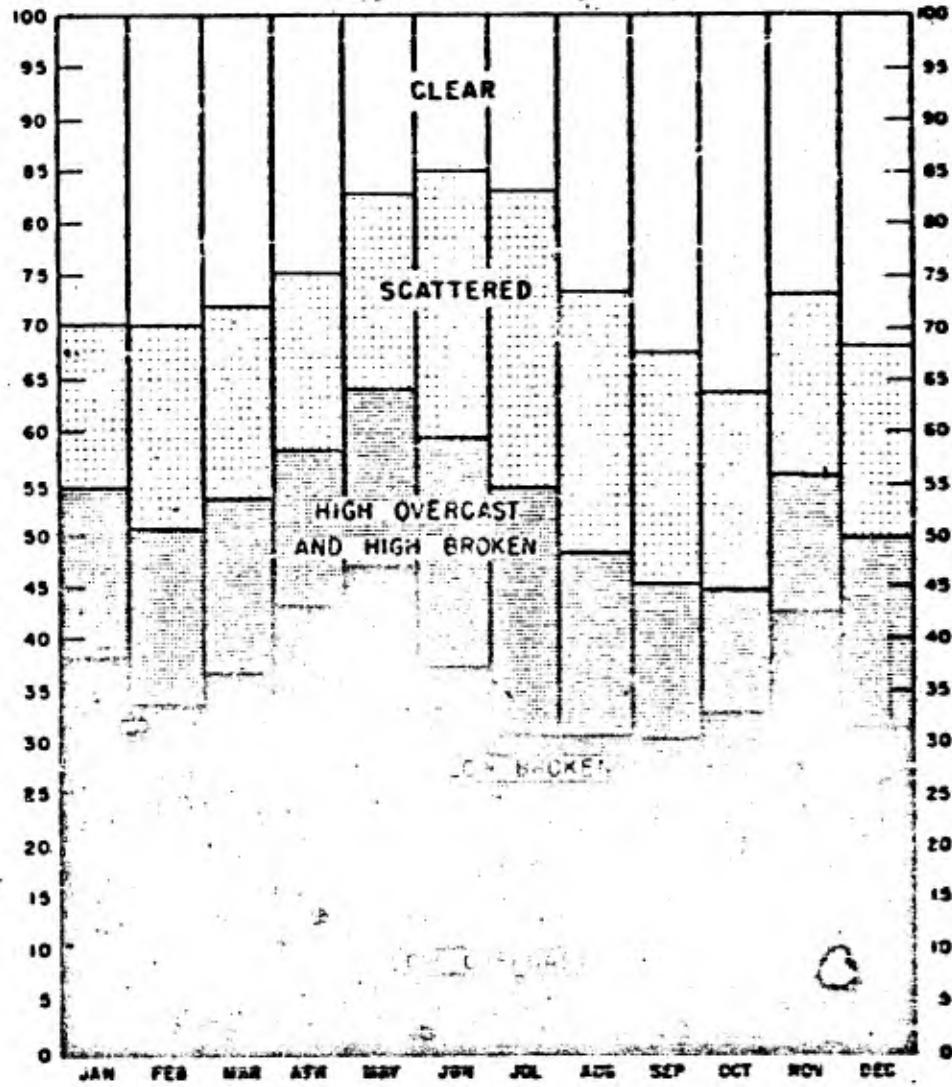


Figure 16

TABLE VIII: VISIBILITY AND SKY CONDITIONS
(Percent of Observations)
Hanscom AFB
Bedford, Mass.

Length of Records: 6 - 11 Years

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|--------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| <u>Obstructions to vision</u> | | | | | | | | | | | | |
| Fog | 4.6 | 2.9 | 3.5 | 2.7 | 4.9 | 2.9 | 3.1 | 3.3 | 4.8 | 6.3 | 3.8 | 2.2 |
| Smoke and/or haze | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.1 | 0.3 | 0.1 |
| Blowing snow and/or dust | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 |
| Precipitation | 2.8 | 2.5 | 1.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.1 | 0.7 | 1.8 |
| Total obs. \leq 1 mile | 7.5 | 5.8 | 4.3 | 2.9 | 5.1 | 3.0 | 3.2 | 3.7 | 5.1 | 6.5 | 4.9 | 4.2 |
| <u>Visibility (miles)</u> | | | | | | | | | | | | |
| 0 - 1/8 | 1.6 | 1.0 | 1.2 | 0.7 | 1.3 | 0.8 | 0.8 | 1.3 | 1.8 | 2.3 | 1.2 | 1.0 |
| 3/16 - 1/4 | 1.2 | 1.0 | 0.7 | 0.2 | 0.8 | 0.5 | 0.6 | 0.5 | 0.7 | 1.1 | 0.7 | 0.7 |
| 5/16 - 1/2 | 2.7 | 1.7 | 1.4 | 0.7 | 1.5 | 1.1 | 1.1 | 1.2 | 1.3 | 1.8 | 1.7 | 1.3 |
| 3/8 - 3/4 | 2.1 | 2.2 | 1.6 | 1.3 | 1.4 | 0.6 | 0.7 | 0.7 | 1.2 | 1.3 | 1.3 | 1.2 |
| 1 - 2 1/4 | 8.6 | 8.3 | 8.4 | 6.7 | 9.0 | 7.1 | 7.4 | 9.4 | 8.1 | 8.3 | 9.1 | 6.5 |
| 2 1/2 | 0.9 | 1.3 | 1.2 | 0.7 | 0.9 | 0.5 | 0.8 | 1.4 | 0.9 | 0.9 | 0.9 | 1.0 |
| 3 - 6 | 19.3 | 17.8 | 16.8 | 16.8 | 21.4 | 20.8 | 23.6 | 31.1 | 25.9 | 21.9 | 18.8 | 21.3 |
| 7 - 9 | 12.2 | 10.4 | 10.8 | 9.6 | 11.5 | 12.2 | 14.4 | 11.5 | 12.9 | 13.6 | 13.5 | 11.4 |
| 10 and over | 51.5 | 56.4 | 57.9 | 63.3 | 52.1 | 56.4 | 50.6 | 43.0 | 47.1 | 48.8 | 52.7 | 55.6 |
| <u>Sky conditions*</u> | | | | | | | | | | | | |
| Clear | 29.7 | 29.8 | 28.1 | 25.0 | 17.1 | 14.9 | 16.7 | 26.5 | 32.4 | 36.1 | 26.7 | 31.9 |
| Scattered | 15.6 | 19.6 | 18.5 | 17.0 | 18.9 | 25.7 | 28.7 | 25.1 | 22.2 | 19.1 | 17.5 | 18.5 |
| High broken or high overcast** | 16.6 | 16.9 | 16.8 | 14.9 | 17.1 | 22.0 | 23.7 | 17.5 | 14.9 | 11.8 | 13.3 | 18.3 |
| Low broken | 5.1 | 6.9 | 8.7 | 12.4 | 11.6 | 13.7 | 12.7 | 13.8 | 9.2 | 9.8 | 8.9 | 6.7 |
| Low overcast | 32.0 | 26.8 | 28.0 | 30.8 | 35.3 | 23.7 | 18.2 | 17.1 | 21.3 | 23.1 | 33.6 | 24.6 |

*Low clouds are those below 10,000 feet. High clouds are those at or above 10,000 feet
**With scattered or no low clouds

TABLE IX: FREQUENCY OF OCCURRENCE OF CEILING HEIGHTS
 (Percent of Observations)
 Hanscom AFB
 Bedford, Mass.

Period of Record: Feb. 1943 - Sep. 1953

| Month | Frequency of Occurrence | | | | | | | | | | Total No. Obs. | | |
|-------|-------------------------|-------------------|---------------------|-------------------------|-------------------------|-------------------------|-----------|------|------|------|-------------------|------|-------|
| | 0 to 400 ft. | 500 to 900 ft. | 1000 to 2000 ft. | 2000 ft. to 3000 ft. | 3000 ft. to 5000 ft. | 5000 ft. to 9500 ft. | Unlimited | | | | | | |
| Jan | 6.9 | 7.5 | 8.6 | 5.7 | 7.3 | 7.1 | 56.6 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7,410 |
| Feb | 4.5 | 7.6 | 8.0 | 5.9 | 6.5 | 6.5 | 61.0 | 6.5 | 6.5 | 6.5 | 6.5 | 61.0 | 7,046 |
| Mar | 4.9 | 6.5 | 9.1 | 5.4 | 8.2 | 7.4 | 58.5 | 7.4 | 7.4 | 7.4 | 7.4 | 58.5 | 8,139 |
| Apr | 3.3 | 6.5 | 8.2 | 4.8 | 10.8 | 10.8 | 55.6 | 10.8 | 10.8 | 10.8 | 10.8 | 55.6 | 7,920 |
| May | 6.3 | 8.8 | 8.3 | 4.5 | 7.7 | 9.4 | 55.0 | 9.4 | 9.4 | 9.4 | 9.4 | 55.0 | 9,183 |
| Jun | 3.5 | 5.3 | 5.7 | 3.1 | 7.2 | 8.2 | 66.9 | 8.2 | 8.2 | 8.2 | 8.2 | 66.9 | 7,920 |
| Jul | 2.8 | 5.1 | 6.4 | 2.9 | 5.3 | 5.8 | 71.7 | 5.8 | 5.8 | 5.8 | 5.8 | 71.7 | 8,178 |
| Aug | 3.3 | 5.1 | 7.0 | 3.6 | 6.3 | 5.8 | 68.9 | 5.8 | 5.8 | 5.8 | 5.8 | 68.9 | 8,183 |
| Sep | 4.6 | 5.0 | 7.3 | 3.9 | 5.8 | 5.0 | 68.5 | 5.0 | 5.0 | 5.0 | 5.0 | 68.5 | 7,913 |
| Oct | 5.9 | 5.6 | 5.9 | 3.4 | 6.3 | 5.4 | 67.5 | 5.4 | 5.4 | 5.4 | 5.4 | 67.5 | 7,433 |
| Nov | 5.3 | 6.6 | 9.8 | 4.9 | 7.8 | 7.9 | 57.7 | 7.9 | 7.9 | 7.9 | 7.9 | 57.7 | 7,195 |
| Dec | 3.9 | 5.1 | 7.4 | 5.2 | 6.5 | 6.9 | 65.0 | 6.9 | 6.9 | 6.9 | 6.9 | 65.0 | 7,440 |

AMOUNT OF SUNSHINE
 Blue Hill Observatory.
 Milton, Massachusetts
 Length of Record: 69 years

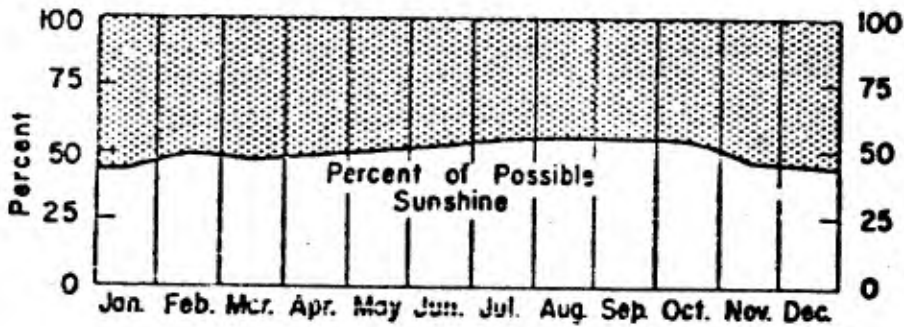
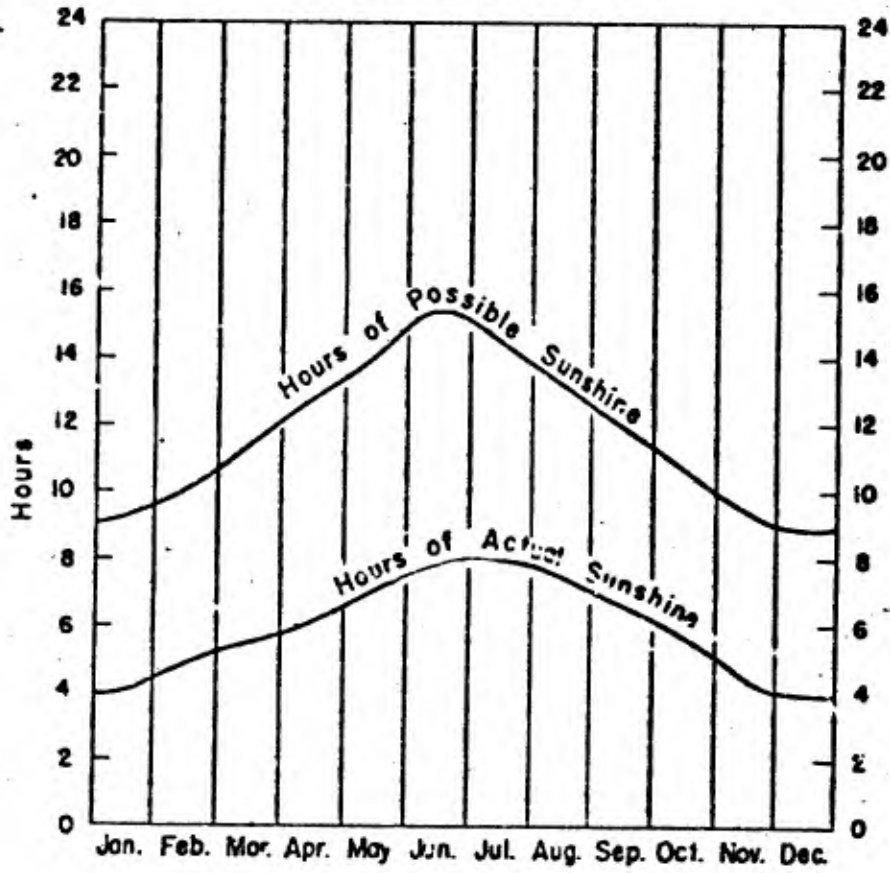


Figure 47

MONTHLY MEAN TOTAL SOLAR AND SKY RADIATION

Blue Hill Observatory
Milton, Massachusetts

Length of Record: 7-9 years

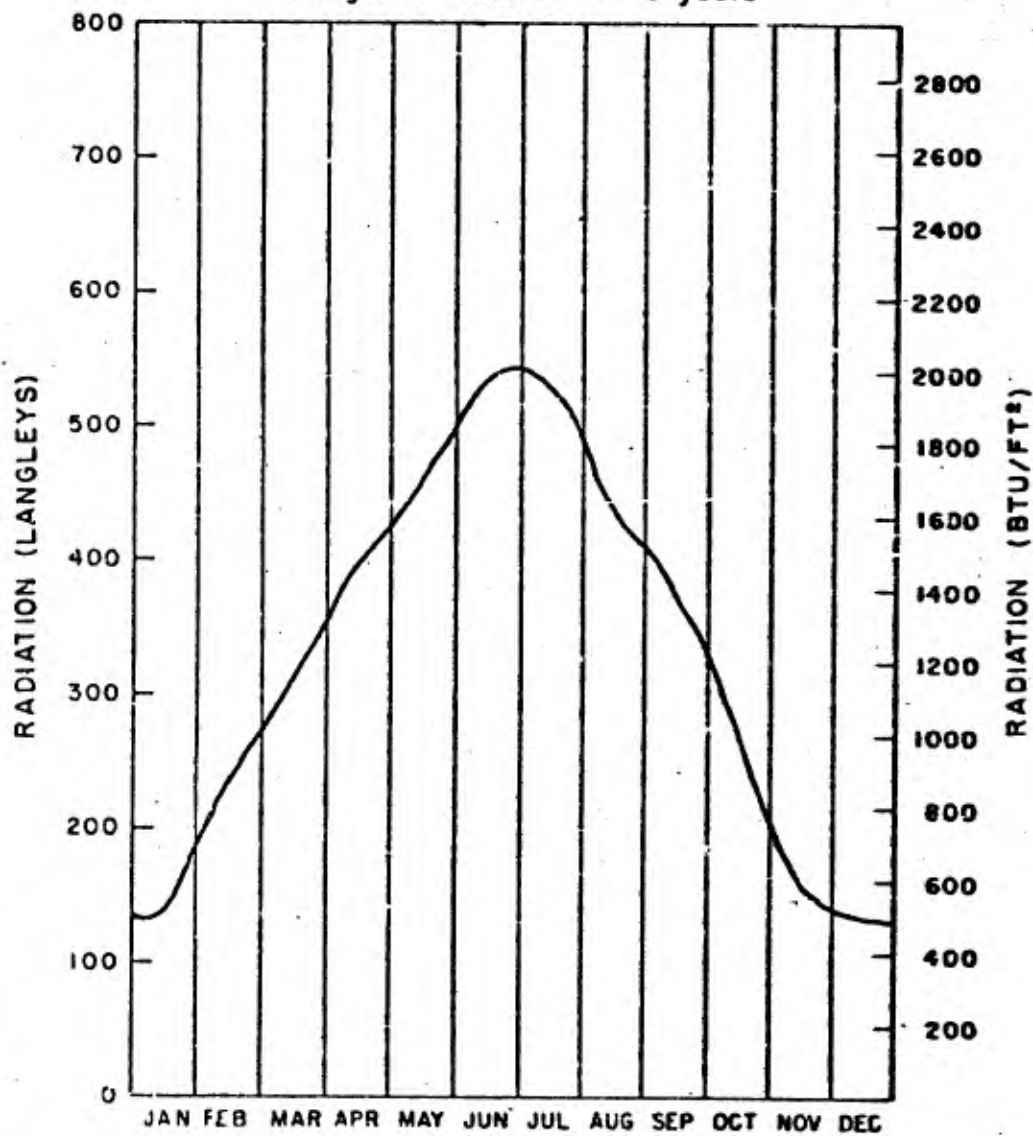
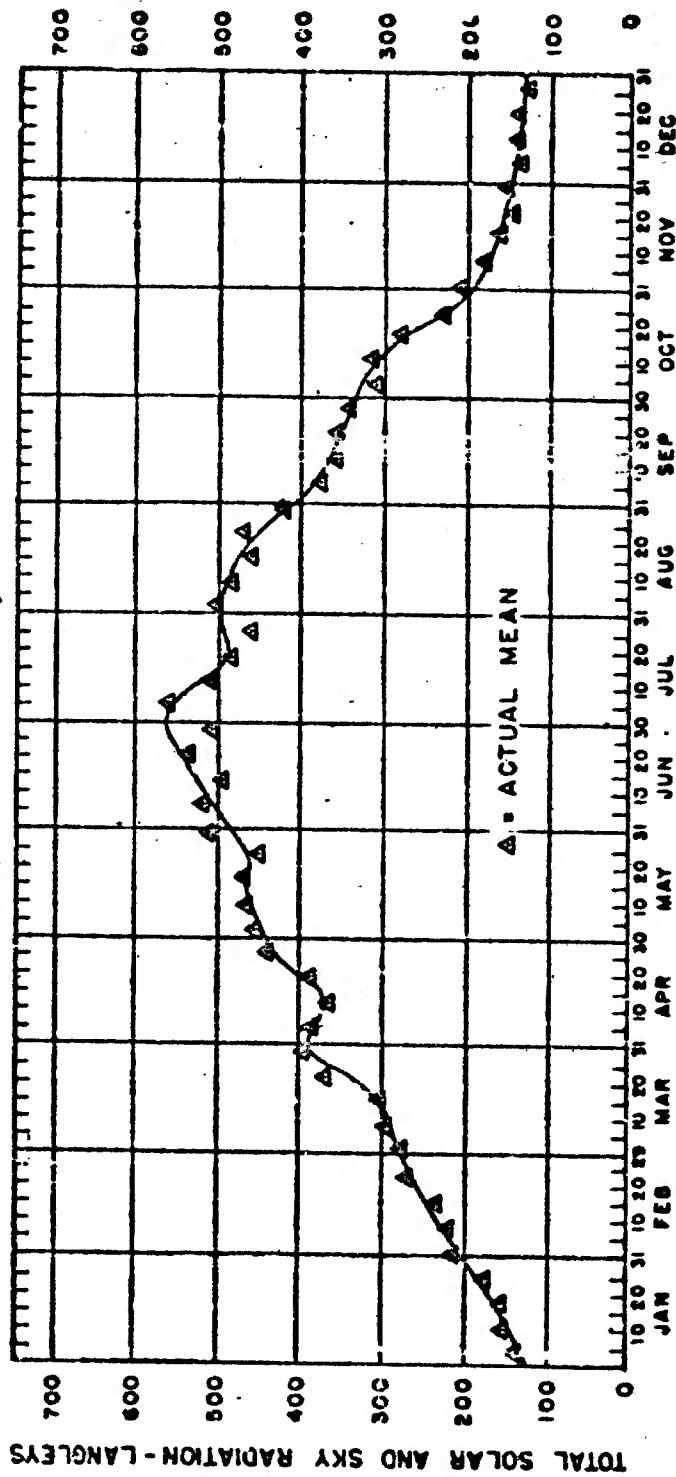


Figure 48

WEEKLY MEAN VALUES OF DAILY TOTAL SOLAR AND SKY RADIATION

Blue Hill Observatory
Milton, Massachusetts

Length of Record: 15 years



Taken from I.F. Hand, Technical Paper No. 11, U.S. Department of Commerce, 1949, p. 8

Figure 49

TABLE I: MEAN MONTHLY MAXIMUM AND MINIMUM RELATIVE HUMIDITY (in %)*

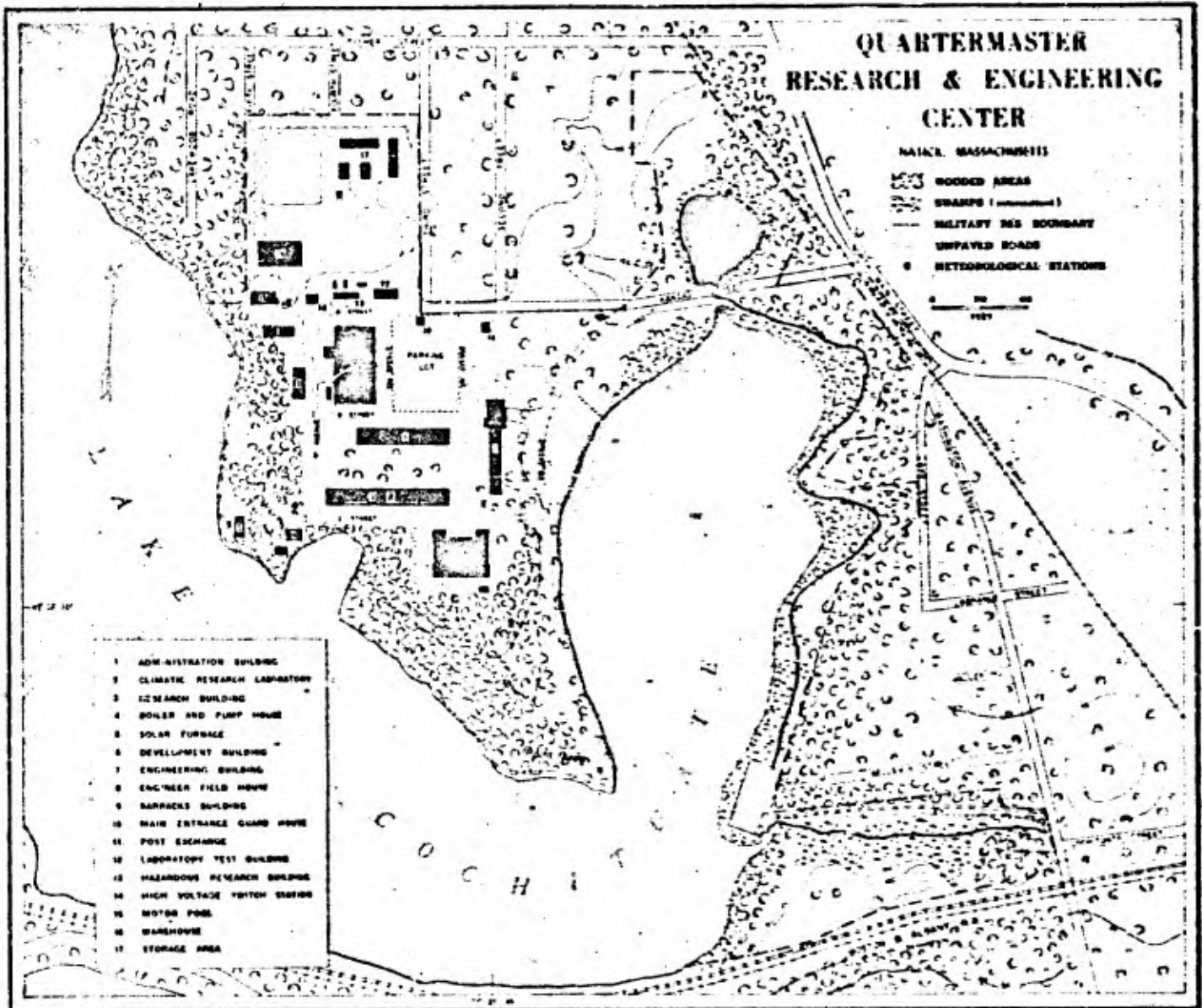
Quartermaster Research & Engineering Center
Natick, Massachusetts

(Period of Record: Feb. 1956 - Jan. 1957)

| <u>Month</u> | <u>Mean Maximum</u> | <u>Mean Minimum</u> |
|--------------|-------------------------|-------------------------|
| January | 91.2 | 46.6 |
| February | 74.4 | 48.2 |
| March | 78.4 | 46.5 |
| April | 76.1 | 46.2 |
| May | 76.7 | 40.0 |
| June | 76.2 | 47.1 |
| July | 78.4 | 50.6 |
| August | 78.5 | 46.3 |
| September | 86.3 | 53.6 |
| October | 97.1 | 42.7 |
| November | 90.4 | 47.5 |
| December | 96.1 | 57.9 |

*Data for the months of February through September were obtained from hourly observations taken from 0730 to 1930 each day. During these months it is probable that daily maximum values occurred earlier than 0730 and as a result mean monthly values are too low. This also explains the higher values for October through January, when twenty-four hourly observations were taken.

Figure 50



XXXXXXXXXXXX

ARMY

- 10 The Quartermaster General
Department of the Army
Washington 25, D. C.
- 2 Commanding General
Philadelphia Jt Depot
2700 South 20th St.
Philadelphia, Pa.
- 3 Commandant
JA Food & Container Institute
1819 N. Forsyth St.
Chicago, Illinois
- 1 Commanding General
Bgt., Jt Training Command
Attn: Jt Library
Ft. Lee, Virginia
- 2 Commanding Officer
of New Field Evaluation Agency
Ft. Lee, Virginia
- 2 Jt Liaison Officer, ACOL-8
Flight Air Development Center
Wright-Patterson AFB
Dayton, Ohio
- 1 U.S. Technical Representative
Directorate of Inter Service Dev.
2200 Washington St.
Ottawa, Canada
- 6 Jt Representative
US Army Standardization Group, US
Box 67, USA 100, WFO
New York, New York
- 1 Commandant
The Jt School, Ft. Lee, Va.
- 1 Commanding General
Princeton Arsenal, Philadelphia 37, Pa.
Attn: Engr. Psychology Div. (L2)
- 3 Ltj., Army Electronic Proving Ground
Ft. Huachuca, Arizona
Attn: Aviation & Meteorological Dept.
Tech. Information Br.
Deputy Chief for Meteorology
- 1 Commanding Officer
Artistic at Branch
Continental Army Command
APO 723, Seattle, Wash.

GENERAL STAFF

- 1 Deputy Chief of Staff for Logistics
Department of the Army
Washington 25, D. C.
- 1 Deputy Chief of Staff for Personnel
Department of the Army
Washington 25, D. C.
- 1 Deputy Chief of Staff for Military
Operations, Department of the Army,
Washington 25, D. C.
- 1 Chief of Research & Development
Department of the Army
Washington 25, D. C.

TECHNICAL SERVICES

- 2 Commanding General
The Engineer Center
Ft. Belvoir, Va.
- 1 Chief of Ordnance
Department of the Army
Washington 25, D. C.
Attn: Chief, Lab Div.

TECHNICAL SERVICES

- 2 Commanding General
Abnason Proving Ground
Aberdeen, Maryland
- 2 Chief Signal Officer
Department of the Army
Washington 25, D. C.
Attn: Res. & Dev. Div.
- 1 Commanding Officer
Signal Corps Engr. Lab.
Ft. Monmouth, N. J.
- 1 Office of Chief of Engineers
Department of the Army
Yam. Bldg. 1-7, Gravelly Point
Washington 25, D. C.
Attn: Research & Dev. Div.
- 2 CD, Chemical Corps
Chem. Radiological Lab.
Army Chemical Center, Maryland
Attn: Technical Library
- 1 Chief Chemical Officer
Department of the Army
Bldg. 1-7, Gravelly Point
Washington 25, D. C.
Attn: Res. & Dev. Div.
- 2 The Surgeon General
Department of the Army
P.O. Box 1142, Wash. 25, D. C.
(1-AMC Div., 1-Techn Liaison Offr)
- 1 The Armed Forces Medical Library
714 Independence Ave., S. W.
Washington 25, D. C.
- 3 Commanding Officer
Army Med. Res. Lab., Ft. Detrick, Md.
- 2 CD, Engr. Medical Nutrition Lab.
Fitzsimons Army Hospital
Denver, Colorado
(1-Dr. Friedman)
- 1 Armed Forces Institute of Pathology
Washington 25, D. C.
- 1 Chief, Armed Services Medical
Procurement Agency
Attn: Property Officer
Method: Reg. DUNS (ISA)
- 1 Chief of Transportation
Department of the Army
Temp Bldg. 1-7, Gravelly Point
Washington 25, D. C.
- 2 Commanding Officer
Transportation Res & Dev Command
Ft. Belts, Va.

ARMY MEDICAL AND DENTAL COMMAND

- 1 C.O., U.S. Continental Army Command
Ft. Monro, Va.
- 1 President, OASAC Board No. 1
Ft. Sill, Okla.
- 1 President, OASAC Board No. 2
Ft. Lee, Va.
- 1 President, OASAC Board No. 3
Ft. Benning, Ga.
- 1 President, OASAC Board No. 4
Ft. Hise, Tenn.
- 1 President, OASAC Board No. 5
Ft. Bragg, N. C.
- 1 President, OASAC Board No. 6
Camp Beaver, Alabama

AIR FORCE

- 2 Department of Air Force
Res., USAF, Room 25, S. C.
(1 OC/3 Material, 3 SC/3 Res.)
- 1 Commander
Air University
Maxwell AFB, Alabama
- 1 Commandant
NAF School of Aviation Medicine
Hendricks AF Base
Hendricks Field, Va.
- 2 Commander, Arctic Aeromedical Lab.
APO 723, Seattle, Washington
- 1 Commander
Air Res & Dev Command, P.O. Box 3399
Baltimore, Maryland
- 1 Commander
Aviation Air Development Center
Wright Patterson AFB, Ohio
Attn: Tech Library
- 1 Commander
Strategic Air Command
Offutt AFB, Nebraska
- 1 Chief, Nutrition Div.
Air Development Center
Aero-Medical Lab.
Wright Patterson AFB, Ohio
Attn: Dr. Harry K. Ryan
- 2 Commander
AF Cambridge Research Center
Air Research & Development Div.
Lawrence G. Brewster Field
Bedford, Mass.
Attn: CRDITY-2

NAVY

- 2 Director
Naval Research Laboratory
433 Choptank St., S. E.
Washington 25, D. C.
- 1 Chief, Bureau of Ordnance
Department of the Navy
Washington 25, D. C.
Attn: 603 Div.
- 1 Naval Medical Research Institute
641 Naval Res. Dev. Center
Bethesda, Md.
- 2 Chief of Naval Research
Washington 25, D. C.
Attn: Code 608
- 1 Chief, Bureau of Ships
Department of the Navy
Washington 25, D. C.
Attn: Code 228
- 1 Chief, Bureau of Naval Armaments
Department of the Navy,
Washington 25, D. C.
Attn: Code 33
- 1 Commander, U.S. Naval Res. Dev.
Station, China Lake, Calif.
Attn: Code 723
- 1 Chief, Bureau of Aeronautics
Dept. of the Navy, Wash 25, D. C.
Attn: Code 45 53
- 2 Chief, Bureau of Supplies & Accounts
Department of the Navy
Washington 25, D. C.

ARMY & AIR FORCE

- 1 Army Committee on Environment
Chief, Research & Development
Washington, D. C.
- 1 Army Com. on Impact and Subject Control
Office, Deputy Chief of Staff for Logistics
Washington, D. C.
- 1 Army Research Committee
Chief, Research & Development
Washington, D. C.

EDUCATION

- 1 The Army Library
Postage Bldg., Washington 25, D. C.
- 1 Commandant, National War College
Ft. Belts, Washington 25, D. C.
- 1 Commandant, Command & General Staff School
Ft. Leavenworth, Kansas
- 1 Commandant, U.S. Military Academy
West Point, New York
- 2 National Research Council
2201 Constitution Ave., Washington, D. C.
Attn: Advisory Bd. on Jt R&D
- 2 Armed Services Technical Information Agency
Research Service Center
South Building, Dayton 2, Ohio
Attn: SAC-23
- 1 Commanding Officer, Detroit Arsenal
2201 4th Ave. N., Detroit, Mich.
Attn: Res & Dev. Div.
- 1 U. S. Department of Commerce
Nathan S. Hartley Library,
Washington, D. C.
- 2 Commanding Officer
Engr., Research and Cold Weather Testing Command
Fort Carson, Colorado
- 2 General Intelligence Agency
Collection & Dissemination
2201 E St., S. E.
Washington 25, D. C.
- 2 Marine Corps Equipment Board
Naval Development Center
Marine Corps School
Quantico, Va.
- 1 Office of Technical Services
U. S. Department of Commerce
Washington, D. C.
Attn: Tech Serv Sec (7500 0302)
- 2 U. S. Department of Agriculture Library
Washington 25, D. C.
- 2 Commandant
Industrial College of the Armed Forces
Ft. Belts, Washington 25, D. C.