METEOROLOGY/CLIMATOLOGY INTERIM REPORT

This report gives a review of the meteorological operations program commenced in March, 1976 for environmental analysis of the Copper-Nickel Region (CNR) and results of the background climatological study of the region. The report covers activities during the period ending June 30, 1976. Many of the activities during this period centered around acquisition of the observational equipment.

The operations program was partially implemented during this period and the general background climatic study was completed. All meteorological operations are expected to be in full gear within 60 days following June 30, 1976, except for operation of the meteorological tower, which was delayed because the U.S. Forest Service tower on which instrumentation was to be placed was condemned by officials of the U.S. Occupational Safety and Health Administration (OSHA). The tower is expected to be operating in November, 1976.

An Operations Manual was drafted which specifies data reporting formats, instrument calibration and maintenance plans, and data handling methods.

The background climatic study was completed. However, work in this area will go on with detailed studies of historic data throughout the CNR.

OPERATIONAL PROGRAM

Figure 1 gives the location of the meteorological instrumentation in the region. A complete description of the type of observations made is given in the Operations Manual.

Up to June 30, some observations had not yet commenced because of lengthy procedures involved in purchasing equipment through the proper channels. Most importantly, the meteorological tower was not yet installed, and installation has been held up by the fact that the tower intended for use was condemned by officials of the U.S. Occupational Health and Safety Administration. Other observations not commenced until September, 1976 were hygrothermography observations because the sensors and their shelters had not arrived.

Surface Observations

Daily observations were commenced by Darrel Dowden on June 1 using a sling psychrometer, which does not require a shelter. Continuous hygrothermography readings are available from the Environmental Protection Agency (EPA) in Ely. Figure 2 shows the form that Dowden is using. Several copies of a manual were prepared which gives complete instructions for observation making.

Rain Gage Installation

Two automatic Fisher-Porter rain gages were installed during the period. One is at the mouth of the Isabella River by Bald Eagle Lake, the other near the junction of Stony River and Minnesota Route 1.

Acquisition of Data from other Sources

Data being taken by the National Weather Service, the Minnesota Department of Natural Resources, the EPA, AMAX, the U.S. Forest Service, and the Federal Aviation Agency are being acquired from June 1 forward. These include cooperative observer temperature, rainfall, snowfall, and evaporation data; temperature-humidity strip charts; radiosonde observations; and hourly surface weather observations at Hibbing. In addition, other available data include satellite data being stored for the National Weather Service and weather radar data when observations commence at the Duluth Airport in the fall of 1976.

The balloon-borne temperature sonde and winds aloft equipment were tested at Kawishiwi, but no data record readings were made prior to July 1.

As a footnote, all equipment and programs except the meteorological tower were operating by September. The tower is expected to be operating in November.

Survey Program

It is impractical to monitor meteorological variables over the entire CNR. However, by making temperature and humidity (atmospheric water vapor content, not necessarily relative humidity) readings along various routes over the variety of topographic and vegetative features that exist, it is possible to construct temperature, humidity and low-level inversion climatology of the entire CNR. Survey data can be related to other data that are taken continuously, and thus variations that exist in the atmospheric structure can be accounted for. Use of the data with a computer SYMAP program can facilitate quick climatology construction.

Surveying is being done by automobile along five standard routes for which landmarks have been established. Surveys are conducted on a continuing basis. Routes were selected for representitiveness of topographical and vegetative variability and road quality -- excessively bumpy roads impede the ability to read the thermometer and keep it in the ambient air stream. In addition, sampling will be done on other roads enough times to establish relationships with the standard routes.

Figure 3 gives the five routes and highway route numbers that form the standard route boundaries. The routes are named after water bodies within, except for the

Echo Trail route, which is not a circuit. Most frequent sampling is being done along the Shagawa and One Pine routes, which together contain essentially all of the topographic-vegetative features in the region. The size of the two routes enables several surveys to be made during one night.

Figure 4 gives the results of a survey made between 1:45 am and 2:25 am on the morning of September 11, 1976. Isotherms, in degrees Celius, are drawn according to the data, and topographic and vegetative features. Values varied from below zero degrees Celsius to over 12°C on this nearly clear night with really calm winds.

Figures 5 and 6 give the results of a survey made in and around Ely on the evening of May 12, 1976 with the help of Vermilion College students. The time of the survey was between 8:30 and 9:00 CDT (1930 - 2000 CST). There was a 5000-foot overcast at the time, with a bit of light drizzle around 8:55 CDT (1955 CST). Even with the cloudy weather, the Ely heat island -- warmth of the city as compared to the country -- shows up clearly.

BACKGROUND CLIMATOLOGICAL STUDY

Weather over the Year

Analyses performed during this work period permit insights being made into weather and climate systems over the year in the CNR.

Figure 7 presents average daily precipitation as observed in Tower, MN over 83 years (except for a few years when observations were not available). Figure 8 gives the average daily snowfall. Maximum precipitation occurs in late June (as compared with a maximum around June 10 over the southern half of Minnesota), with minimum precipitation in early February. The characteristic wet September and October of northeastern Minnesota is evident. Most maximum and minimum daily precipitation correspond to those from other parts of the Upper Midwest.

As the year begins, precipitation is not far above the February minimum. Winds are predominantly from the northwest, with occasional southeasterlies ahead of storms whose centers pass to the north. A small maximum occurs in late January, associated with an increase in northeasterly winds and decrease in southeasterlies as storm centers pass to the south. At this time, cold weather rules as the CNR is bathed in polar or arctic air before and after storm passages.

February is generally marked by lighter winds and less precipitation than January. High pressure to the northwest dominates, with strong, deep inversions in the CNR. This is a favorite time for potential high pollutant concentrations. Late February has somewhat higher average precipitation than the earlier part of the month. This is largely caused by a moisture increase in warmer air. An increasing percentage of this precipitation is in the form of liquid water as the month's end is approached. The last part of February is marked by more sunshine than the previous part of the winter. More sunshine combined with warmer temperatures creates a crust on the snow surface.

Early March brings a sharp increase in average daily precipitation, with 80 percent of the total still in the snow form through the first half of the month. Large, intense storms dominate the scene from the first few days of March through the first week of April. The northwesterly wind component loses its overwhelming dominance as the storms begin, with a good share of southeasterlies occurring. Associated wind speeds are higher. Increases in the southeastern wind component, as the end of the month is reached, is reflected in warmer temperatures, and rain and drizzle making up half the precipitation total.

April 10 marks the ending time for big storms. Pressure pattern shifts bring easterly winds over the middle third of the month. Around the 20th, the "rainy season" begins as invasions of air aloft from the Gulf of Mexico reach the CNR. By this time 80 percent of the precipitation total is from rain rather than snow. However, occurrence of snow at this time is entirely possible. On the average, as much snow falls during the third week of April as during the third week of February. Snow is important in the CNR throughout the entire month of April, and by no means the rarity that it is in the southern half of Minnesota. Much of the snow falling from April into early May is in the form of passing flurries from daytime cumulus clouds -- the type that bring rain showers further south. It is common for a large storm to pass over the CNR during the first week of May, usually accompanied by brisk winds. This results in a rainfall maximum at this time. The rest of May is marked by passing afternoon rain showers and thunderstorms.

From this time through the rest of the summer, prevailing winds are pretty much evenly split between northwesterlies and southeasterlies, with a smattering of other directions. The rainy season peak is around June 20, with June being the wettest month of the year. A weaker maximum occurs around July 10, which does not occur further south in Minnesota. The peak is probably associated with frequent passage of a storm at this time. The last half of July is marked by the season's characteristic dry period which occurs throughout the Upper Midwest. This is a warm time of the year. Southwesterly winds in the CNR show their greatest inclination to blow at this time, although their relative frequency is far less than in southern Minnesota.

A strong rainfall maximum occurs during the first week of August. This maximum occurs throughout the Upper Midwest, and is associated with the prevalence of a storm or two. The mid-August dry period, found over the Upper Midwest, is well developed in the CNR. A rainy period is well defined in the CNR from August 20 to mid-September. This period of rain is well developed over eastern portions of Minnesota, northern Wisconsin, and Upper Michigan.

Rainfall drops sharply after mid-September, although the drop is not as sharp as in southern Minnesota. There is a resurgence of rain in early October, which is a feature of the Lake Superior region. The "rainy season" ends abruptly around October 12. By October 20, the winter pattern establishes itself, and prevailing northwesterly winds dominate the scene. At this time, snow becomes an important precipitation form.

Minor precipitation maxima occur in the region around November 2, 11 and 20; and December 6 and 25, as they do elsewhere in Minnesota. These are associated with favored storm passage times. Snow becomes the predominant precipitation form by November 12. By October 31 there is an average of one-half inch snow cover on the ground. However, there usually is not a snow cover more than half of the time until November 12. November is a month of considerable storminess; but not as much as is March. December is a time of very little high wind; storms are generally weak; and snowfalls are gentle. It is almost unknown to get a blizzard in December.

Snow Depth

The accumulation of snow on the ground is 0.1 inches or greater from October 15 to May 1, with the maximum occurring on February 8, according to records made over a 35-year period at Babbitt. Figure 9 illustrates the average snow cover over the year.

Average snow cover on the February 8 peak is 17 inches, which is, for comparison, three times the maximum average snow cover in the Minneapolis-St. Paul area. The decrease in snow cover after February 8 is associated with the outbreak of generally fine weather during the latter part of February. The decrease also results from a lack of precipitation and melting due to sunshine. Deceleration in snow cover shrinkage can be seen during the first 10 days of March because of frequent storm occurrences.

Upper Air Climatology

Figure 10 gives International Falls' average temperatures over the year, measured to a height of 6,250 meters (slightly over 20,000 feet). The graph is based on monthly averages of observations made at 6:00 AM and 6:00 PM Central Standard Time, taken over a 10-year period.

The data show the presence of an inversion year-round except in November. The inversion is even present in June, despite short nights and the fact that June observations are made about two hours after sunrise and two hours before sunset. The data differ from radiosonde data at St. Cloud, where there is no mean inversion between May and September. The reason for the inversion's presence is that at the time of the 6:00 AM observation, solar heating occurring in the first two hours after sunrise has not been strong enough to overcome the inversion that forms at night-time. At the 6:00 PM observation, when an adiabatic lapse rate is usually present, the deficit still exists, because atmospheric turnover results when the lapse rate becomes even slightly superadiabatic (temperature in the lowest few hundred meters above ground cannot be more than a few degrees cooler than at the ground).

From December through February the inversion is about one kilometer deep. The data suggest that the inversion is usually present throughout the winter day, because the short day and low sun cannot result in breaking up such a deep layer, except when a low pressure system is near the station.

In November, lack of the inversion suggests that the air is usually moving and air temperature is usually colder than the surface (bare or snow-covered) temperature, resulting in a prevailing condition of local instability.

Wind

Wind variation with season has been previously described under variation of weather over the year. Figure 11 gives the annual wind rose for Hibbing, based on a 10-year observation from 1964 to 1973 inclusive.

Bruce Watson
November 24, 1976

Note:
Originally submitted to MEQC in August 1976.

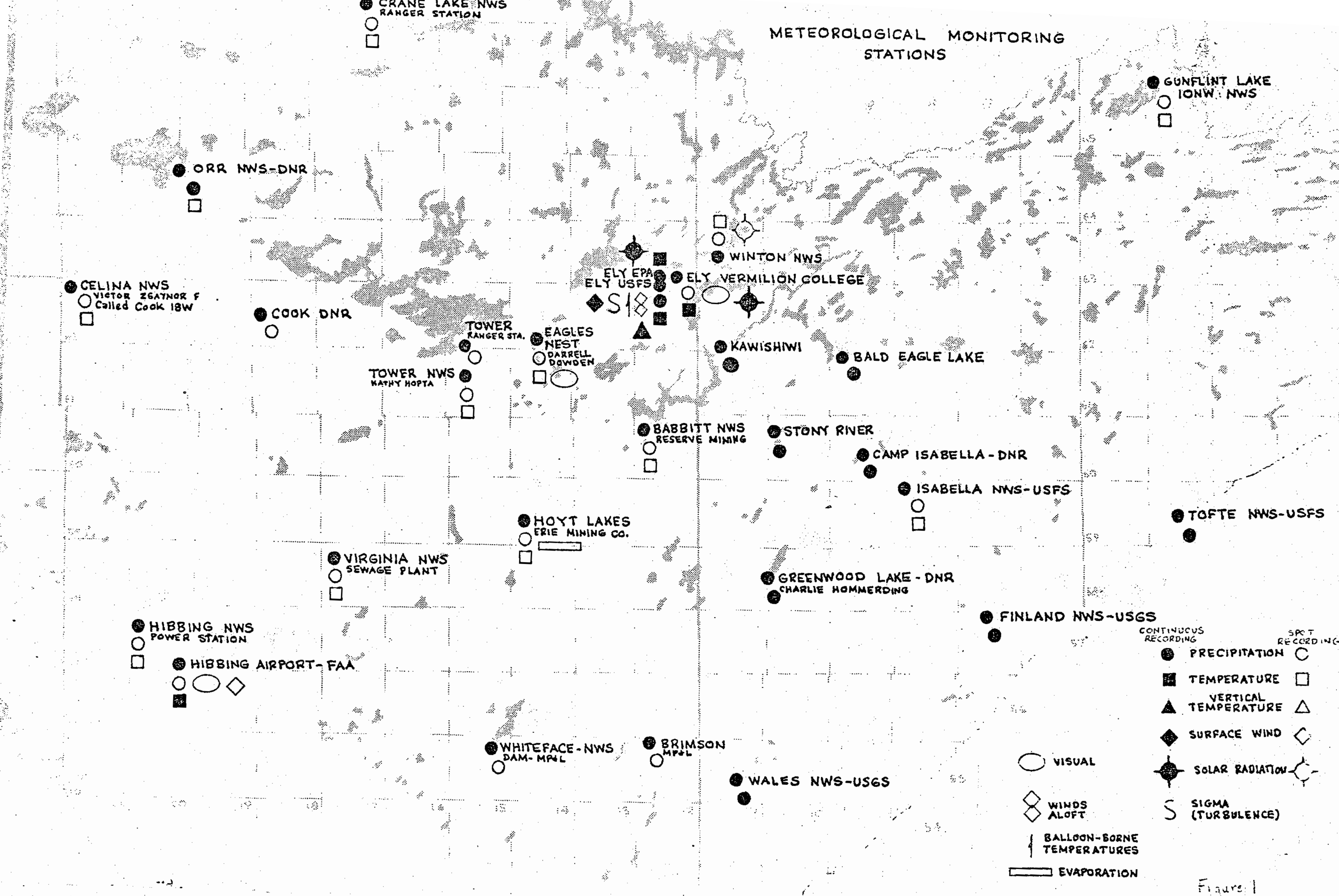

METEOROLOGICAL MONITORING STATIONS
CRANE LAKE NWS
RANGER STATION
GUNFLINT LAKE
IONW NWS
ORR NWS-DNR
WINTON NWS
ELY EPA
ELY USFS
ELY VERMILION COLLEGE
CELINA NWS
VICTOR ZGAYNOR F
Called Cook 18W
COOK DNR
TOWER
RANGER STA.
EAGLES NEST
DARRELL DOWDEN
KAWISHIWI
BALD EAGLE LAKE
TOWER NWS
KATHY HOPTA
BABBITT NWS
RESERVE MINING
STONY RIVER
CAMP ISABELLA - DNR
ISABELLA NWS-USFS
TOFTE NWS-USFS
HOYT LAKES
ERIE MINING CO.
VIRGINIA NWS
SEWAGE PLANT
GREENWOOD LAKE - DNR
CHARLIE HOMMERDING
FINLAND NWS-USGS
HIBBING NWS
POWER STATION
HIBBING AIRPORT-FAA
WHITEFACE-NWS
DAM-MP&L
BRIMSON
MP&L
WALES NWS-USGS
CONTINUOUS RECORDING
SPOT RECORDING
PRECIPITATION
TEMPERATURE
VERTICAL TEMPERATURE
SURFACE WIND
SOLAR RADIATION
VISUAL
WINDS ALOFT
SIGMA (TURBULENCE)
BALLOON-BORNE TEMPERATURES
EVAPORATION

Figure 1

Figure 2

SURFACE WEATHER OBSERVATIONS

STATION ____________

MONTH ____________ DAY ______ YEAR ______

LAT. ____________ LONG. ____________

TYPE (1)	TIME (l.s.t.) (2)	CEILING (hundreds of feet) AND SKY (3)	VISIBILITY (miles) (4)	WEATHER AND OBSTRUCTIONS TO VISION (5)	REL. HUMIDITY (%) (20)	TEMP. (°F) (7)	DEW PT. (°F) (8)	WIND DIRECTION (9)	WIND SPEED (knots) (10A)	WIND CHARACTER AND GUSTS (11)	ALTIMETER SET. (in.) (12)	REMARKS AND SUPPLEMENTAL CODED DATA (13)	(14A)	(14B)

DESCRIPTION OF DAY

PRECIP. AND THDRSTM. (82)	BEGAN (83)	ENDED (84)	DUR. (85) hr.	DUR. (85) min.	OBSTR. TO VIS. (86)	BEGAN (87)	ENDED (88)	DUR. (89) hr.	DUR. (89) min.

24-HOUR MAX. TEMP. (°F) (66)	24-HOUR MIN. TEMP. (°F) (67)	24-HOUR PRECIP. WATER EQUIV. (in.) (68)	24-HOUR SNOW FALL UNMLTD. (in.) (69)	SNOW DEPTH (in.) (70)

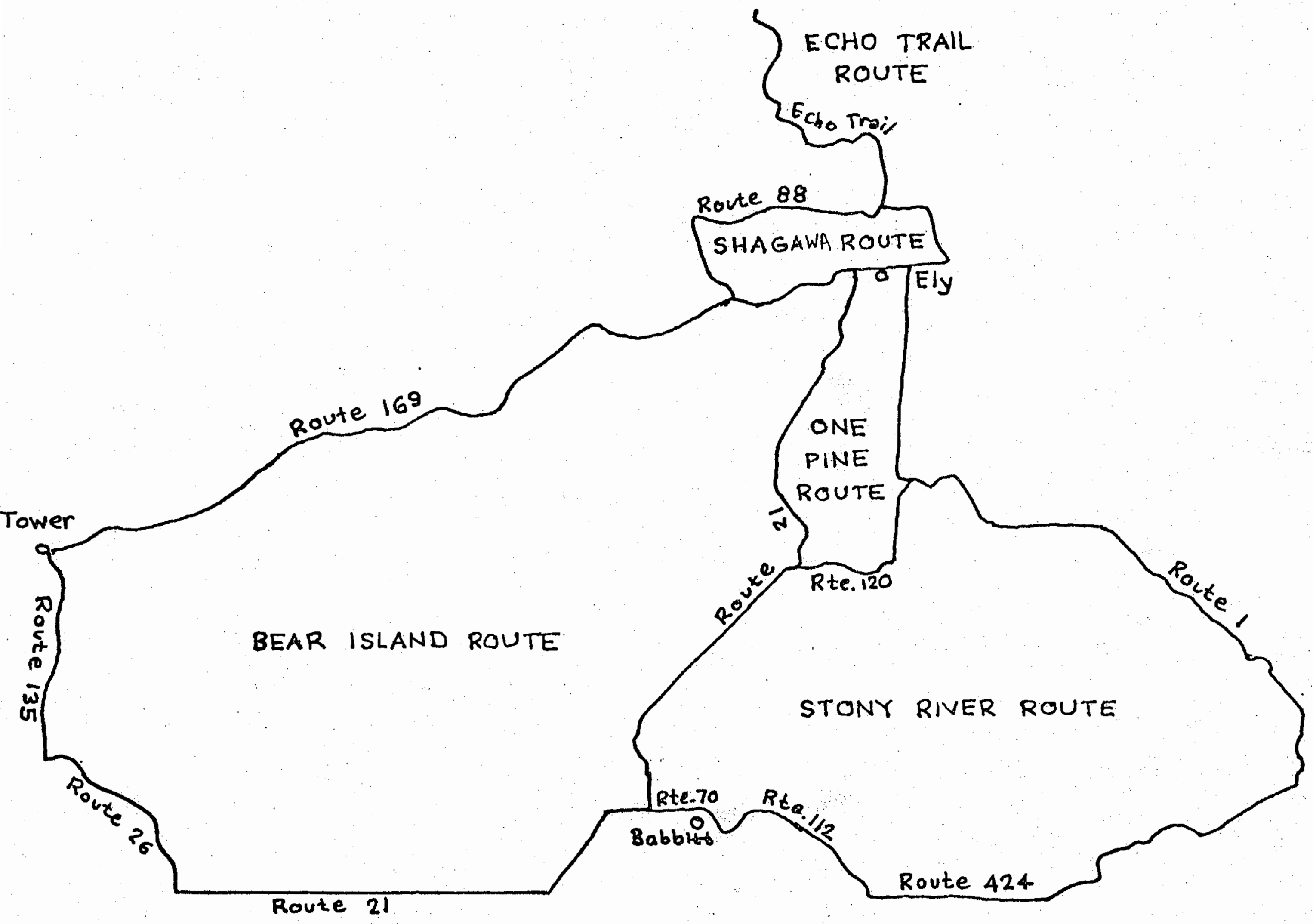


FIGURE 3

METEOROLOGICAL SURVEY ROUTES

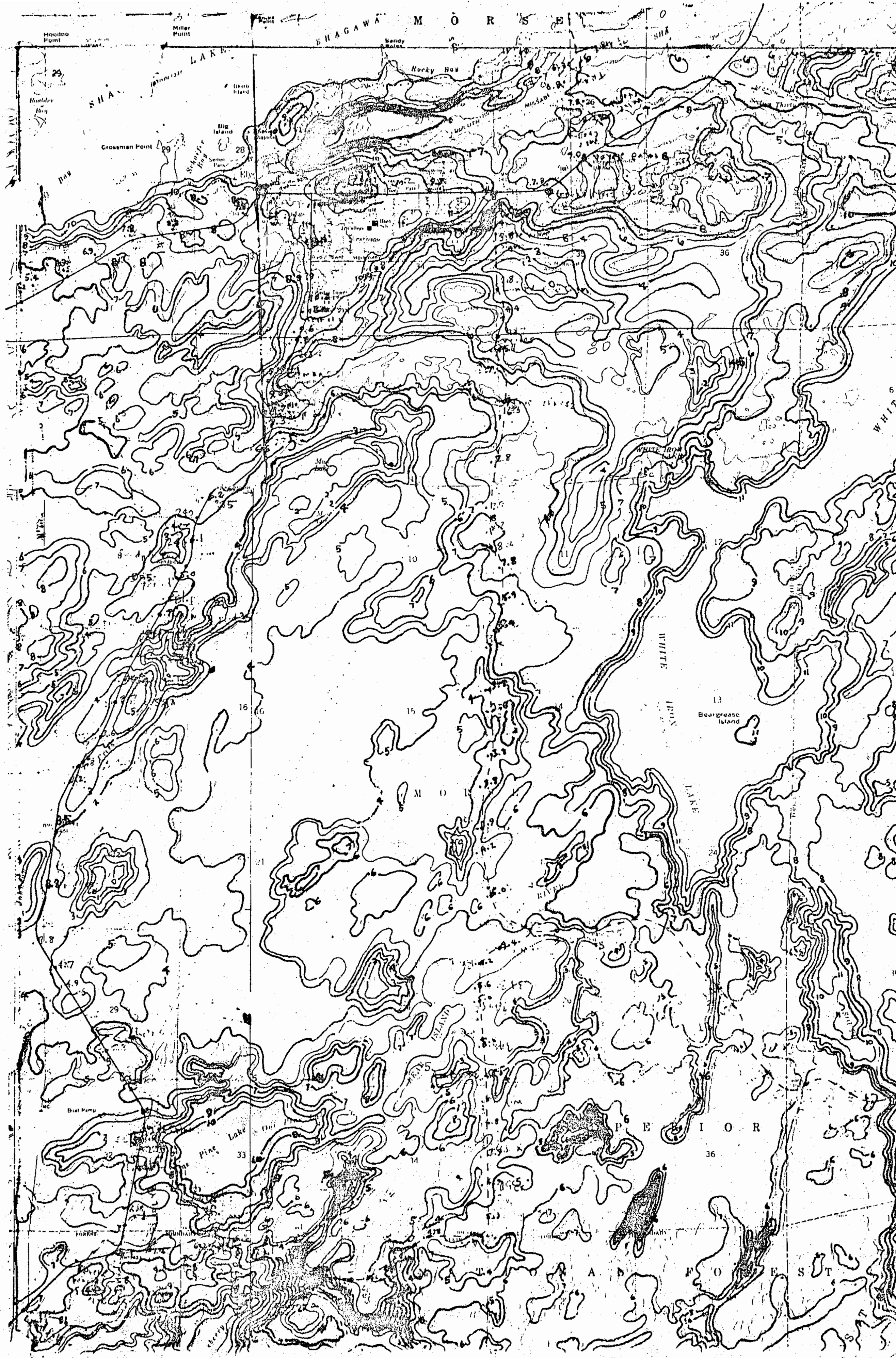

Hoodoo Point
Miller Point
SHAGAWA
MORSE
Sandy Point
Rocky Bay
Big Island
Crossman Point
WHITE
IRON
LAKE
13
Beargrease Island
RIVER
Boat Ramp
Pine Lake
33
36
PERIOR

Figure 4

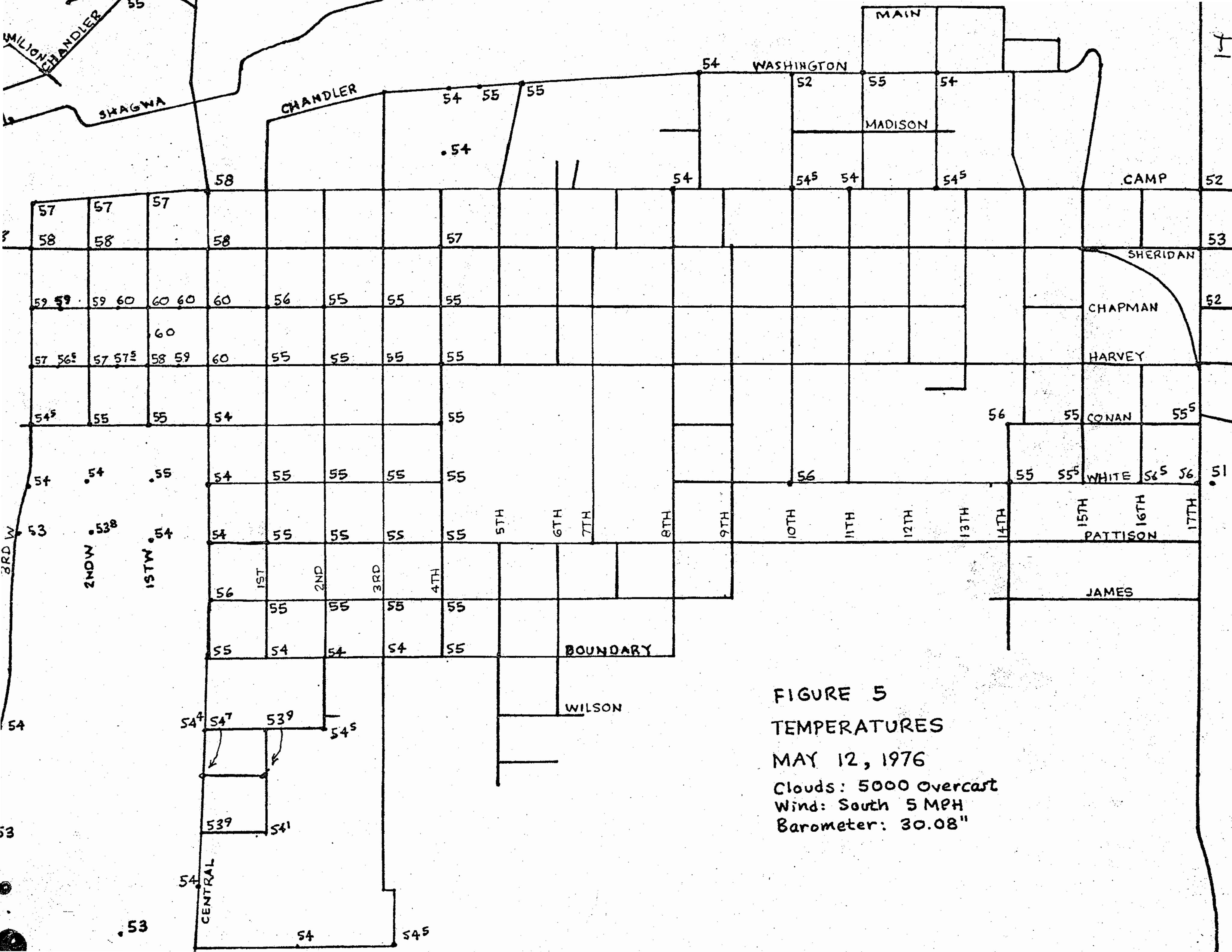


FIGURE 5
TEMPERATURES
MAY 12, 1976
Clouds: 5000 Overcast
Wind: South 5 MPH
Barometer: 30.08"

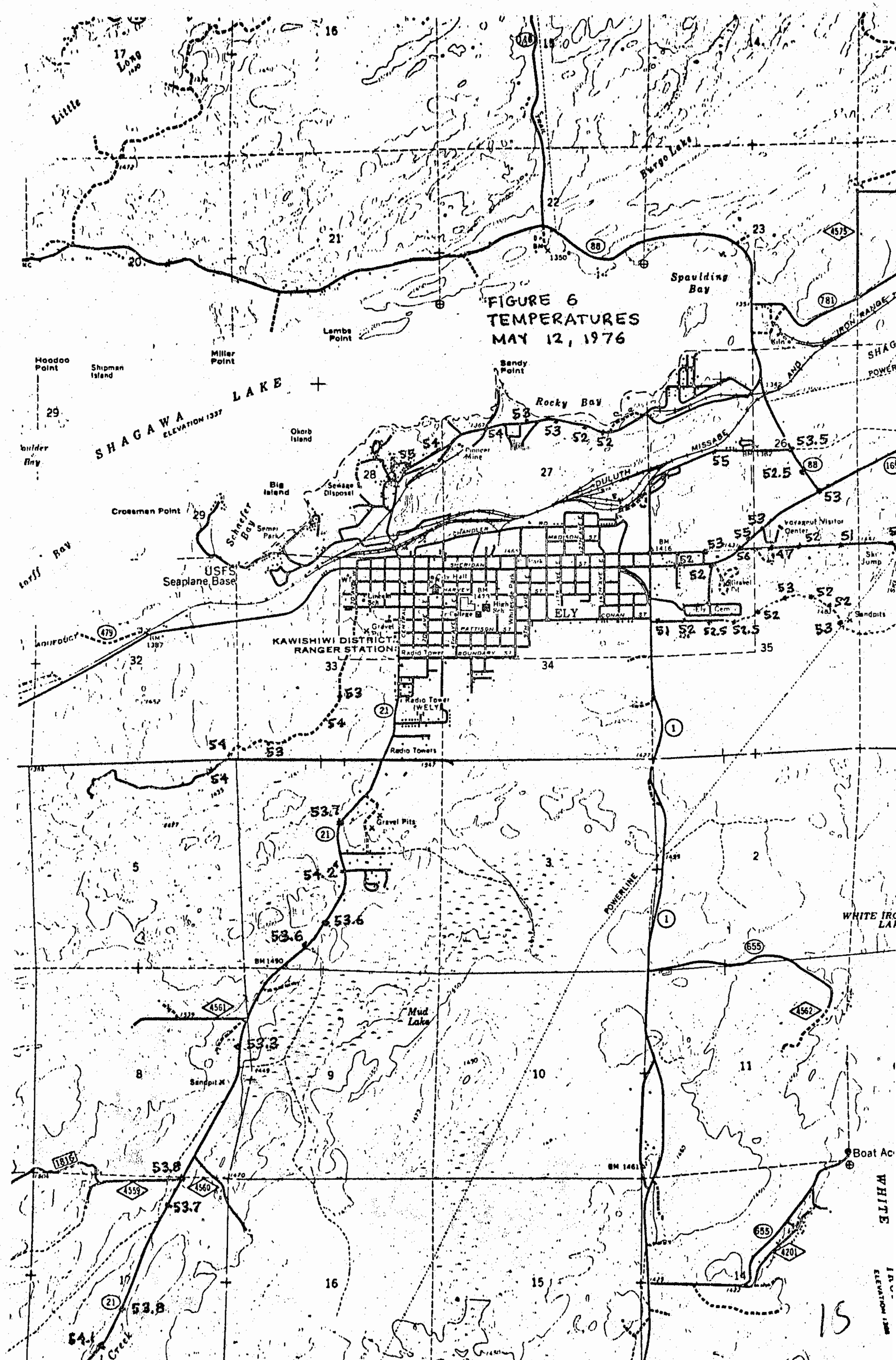
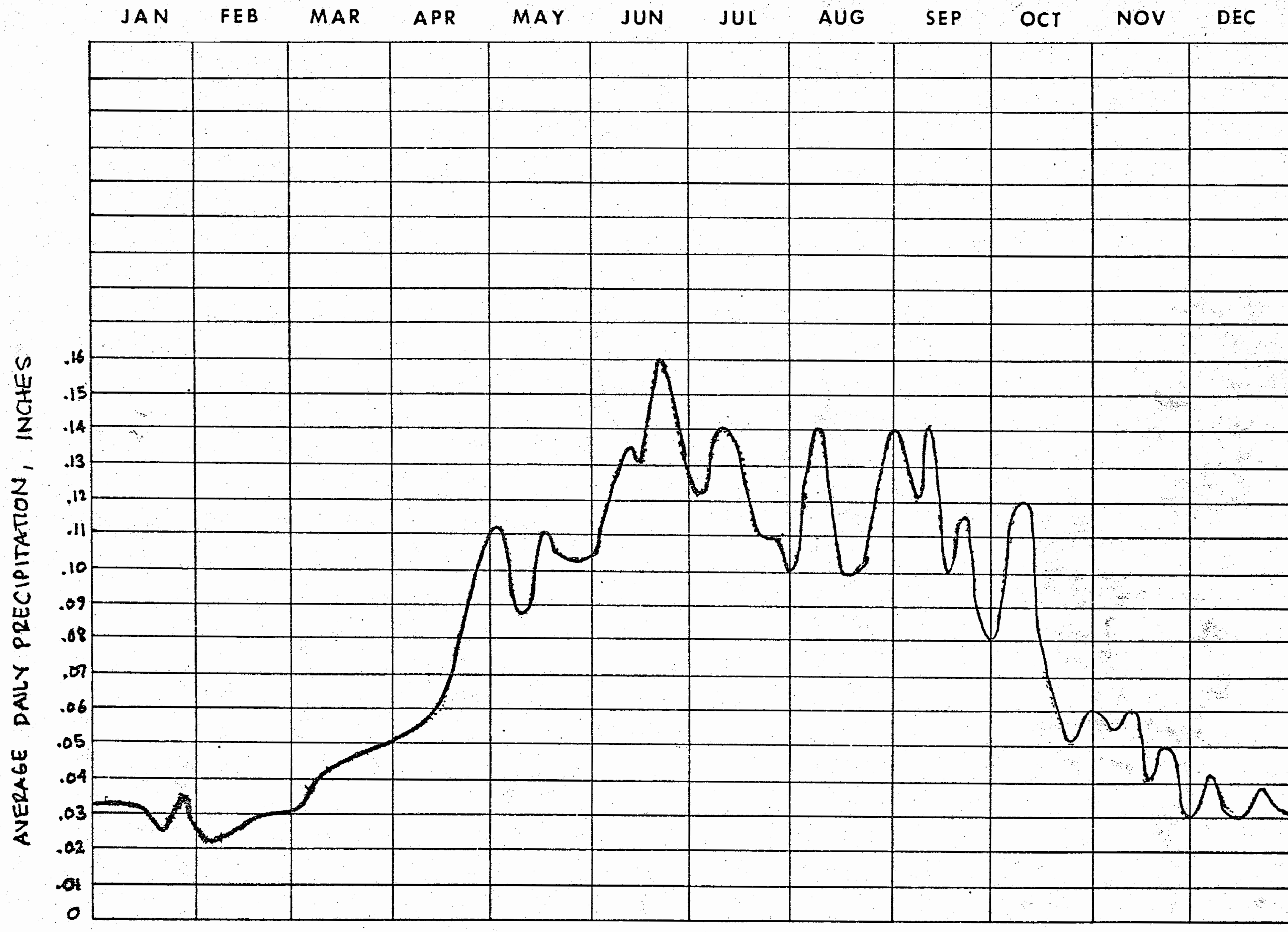


FIGURE 6
TEMPERATURES
MAY 12, 1976

TOWER, MINNESOTA



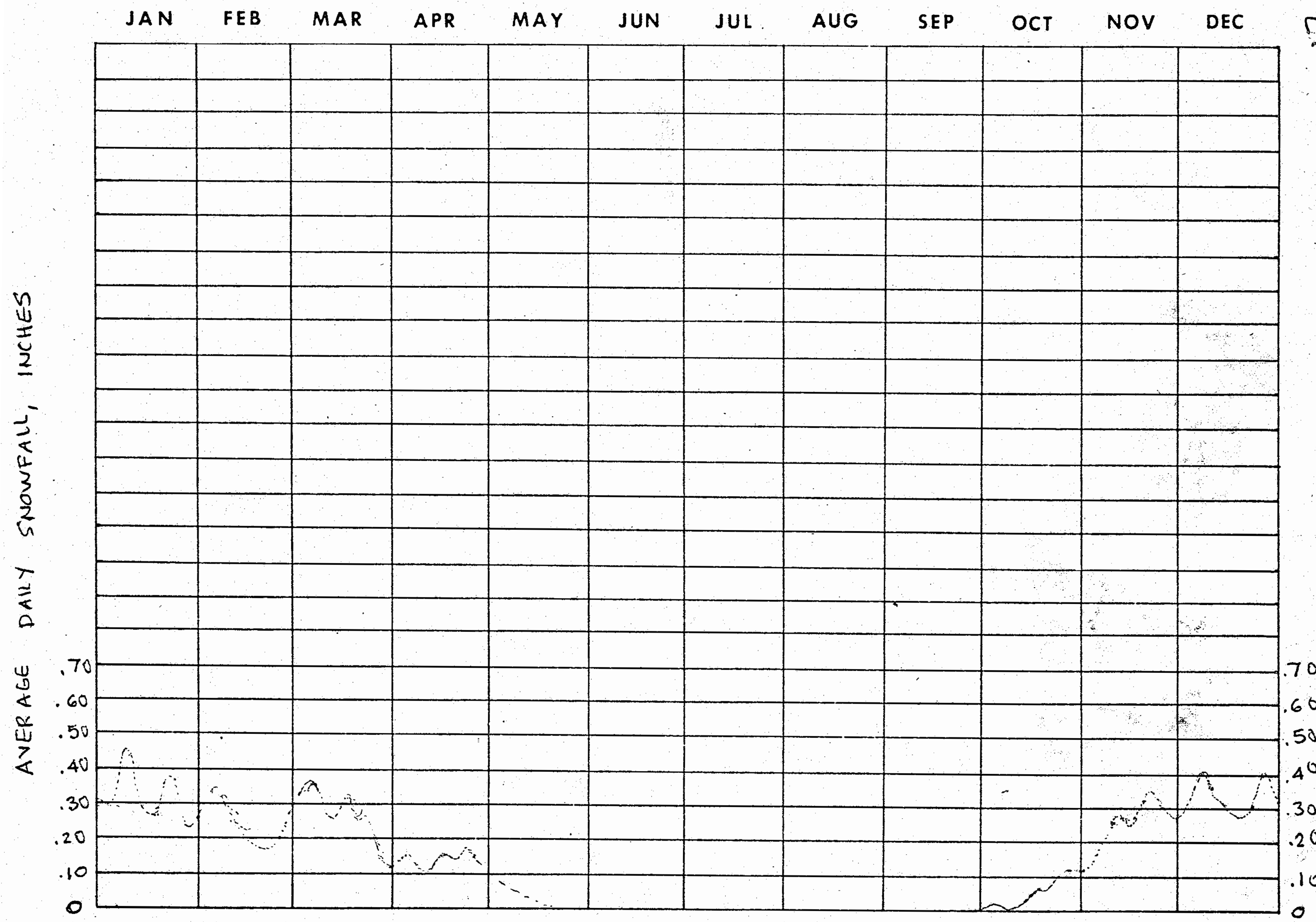


FIGURE 8. AVERAGE SNOW FALL
BABBITT, MINNESOTA

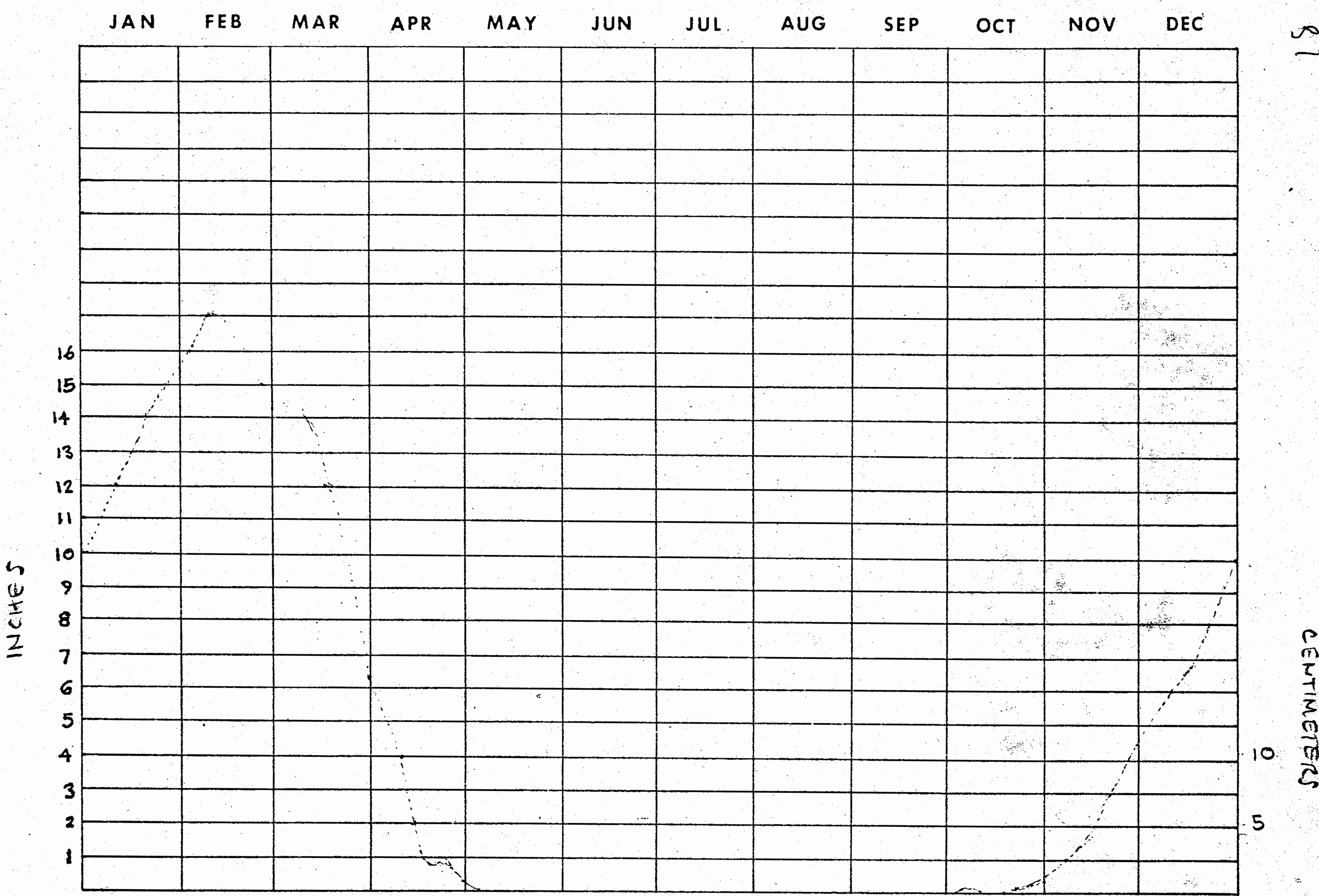


FIGURE 9. AVERAGE SNOW DEPTH
BABBITT MINNESOTA

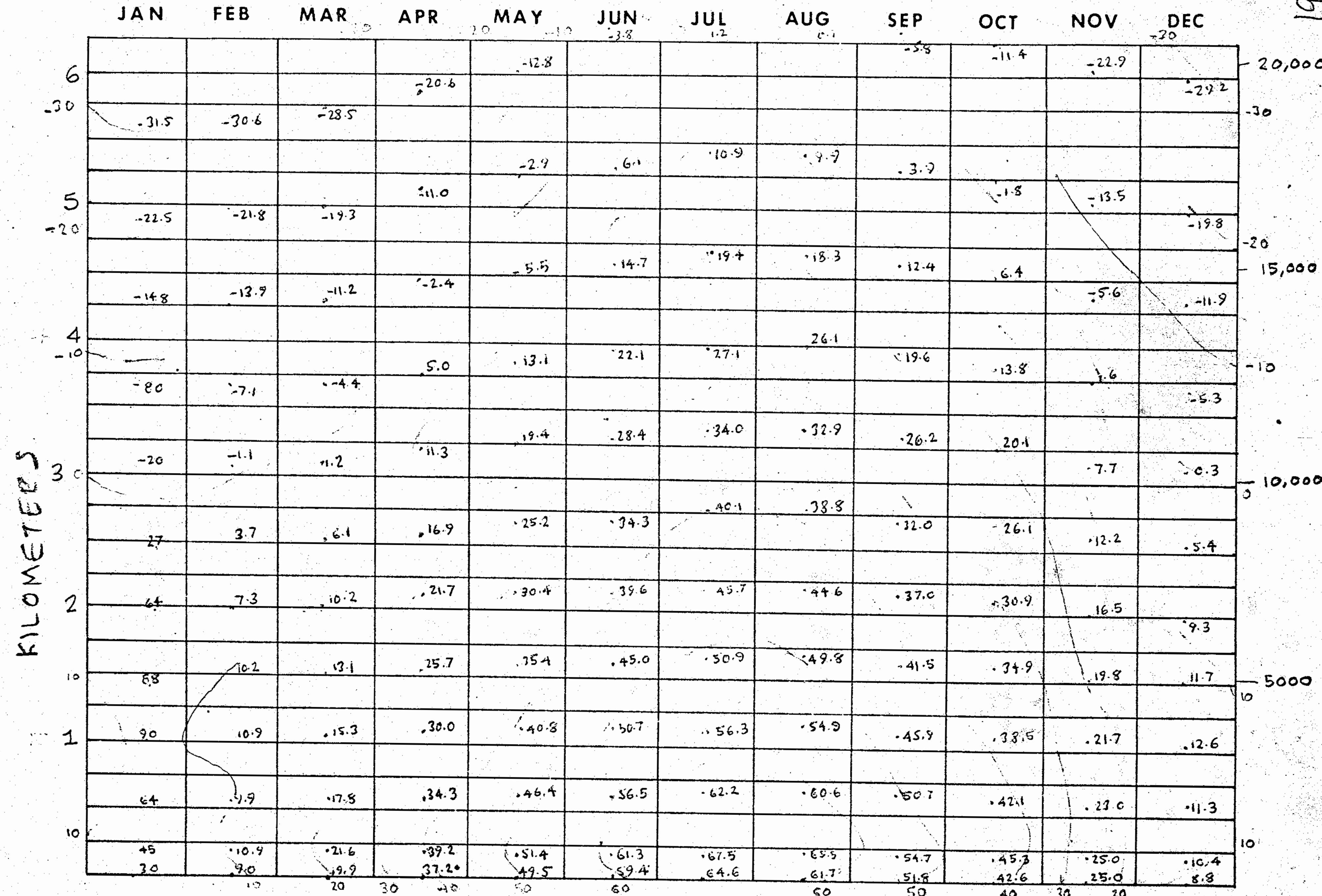


FIGURE 10, AVERAGE TEMPERATURES ALOFT AT INTERNATIONAL FALLS

FIGURE 11

HIBBING WIND ROSE

% FREQUENCY BY OCTANTS