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Technical Report 106

NOVEMBER, 1964

Ground Temperature Observations Gulkana, Alaska

CONDUCTED FOR

CORPS OF ENGINEERS, U.S. ARMY

BY

U.S. ARMY MATERIEL COMMAND

COLD REGIONS RESEARCH & ENGINEERING LABORATORY

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PREFACE

Collection of the data presented herein was authorized in July 1946 by the Chief of Engineers in "Instructions and Outline on Meteorological Data Study". The program was initiated by the Permafrost Division, St. Paul District, and continued by the Arctic Construction and Frost Effects Laboratory (ACFEL), U. S. Army Engineer Division, New England. It was carried out for the Civil Engineering Branch, Engineering Division, Military Construction, Office, Chief of Engineers. In February 1961 ACFEL was merged with the U. S. Army Snow Ice and Permafrost Research Establishment to form the U. S. Army Cold Regions Research and Engineering Laboratory (USA CRREL).

The program included the collection of data at 20 stations in Alaska and one in Canada. This report summarizes the data obtained at one of these stations. The data obtained at the other stations in this program will be presented in separate reports.

The investigation was a cooperative venture of the Corps of Engineers, the United States Weather Bureau, and the Federal Aviation Agency (formerly Civil Aeronautics Administration). Substantial support and assistance in the investigation were provided by personnel of the Alaska Field Station, CRREL (formerly Arctic Construction Investigations Area) at Fairbanks, Alaska, under the direction of Mr. F. F. Kitze, Chief. Personnel from the AFS installed and maintained the ground-temperature-measuring equipment and rendered technical assistance to the operating personnel of the U. S. Weather Bureau and Federal Aviation Agency.

This report was prepared by the Construction Engineering Branch (Mr. E. F. Lobacz, Chief) as a project of the Experimental Engineering Division (Mr. K. A. Linell, Chief).

Construction Engineering Branch personnel actively engaged in this project have been Messrs. George W. Aitken, C. W. Fulwider, and Spc R. W. Huck. Mr. J. F. Haley, formerly Assistant Chief, ACFEL, Mr. Harry Carlson, formerly Chief, Permafrost Division, and many others of these organizations contributed substantially in this investigation. Mr. Aitken and Mr. Fulwider analyzed the project data and prepared the basic format for the report series.

Commanding Officer of USA CRREL during the preparation of this report was Colonel William L. Nungesser. Technical Director was Mr. W. K. Boyd.

This report has been reviewed and approved for publication by the Office of the Chief of Engineers, U. S. Army.

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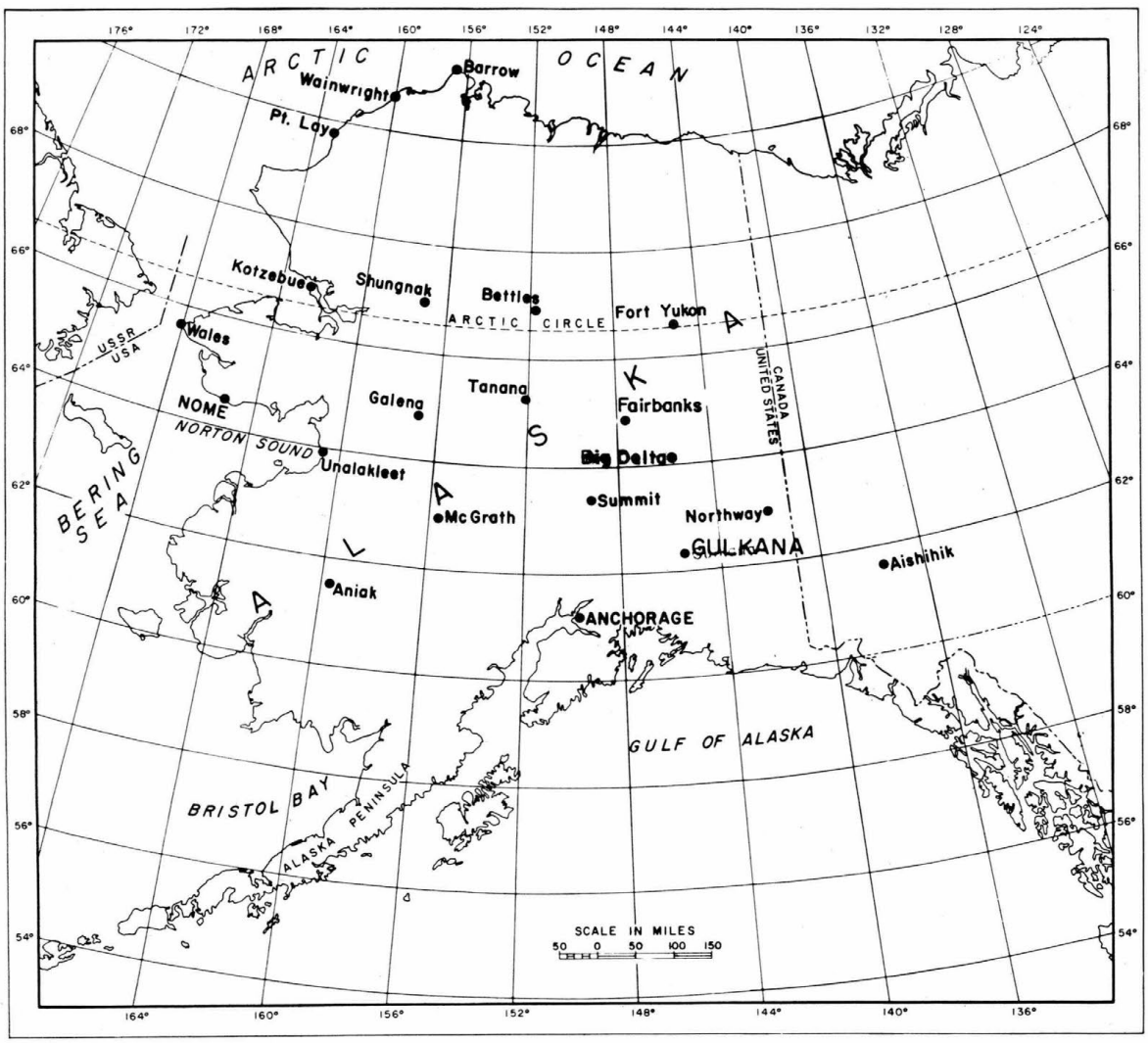
SUMMARY

This report summarizes climatological, ground-temperature, and soil data obtained at Gulkana, Alaska. The climatological data were obtained from U. S. Weather Bureau records. Various periods-of-record were used, the minimum being 10 years unless otherwise noted in the report. The ground-temperature data presented were obtained from daily observations during the years 1952 to 1958, and the soil data were obtained from samples taken while drilling two holes; one in June 1946 and the other in February 1955.



Ground-temperature observation sites.

GROUND TEMPERATURE OBSERVATIONS
GULKANA, ALASKA

by

G. W. Aitken

INTRODUCTION

Purpose

The Gulkana, Alaska, data summarized in this report were obtained in connection with an investigation to evaluate the relationship between climatic conditions, soil conditions, and ground temperatures in arctic and subarctic areas. These data could be used by agencies requiring general knowledge of this area for such purposes as site selection or as a guide in more detailed investigational efforts.

Scope

The investigational program involved the collection of climatological, ground-temperature, and soil data from 20 stations in Alaska and one in Canada.

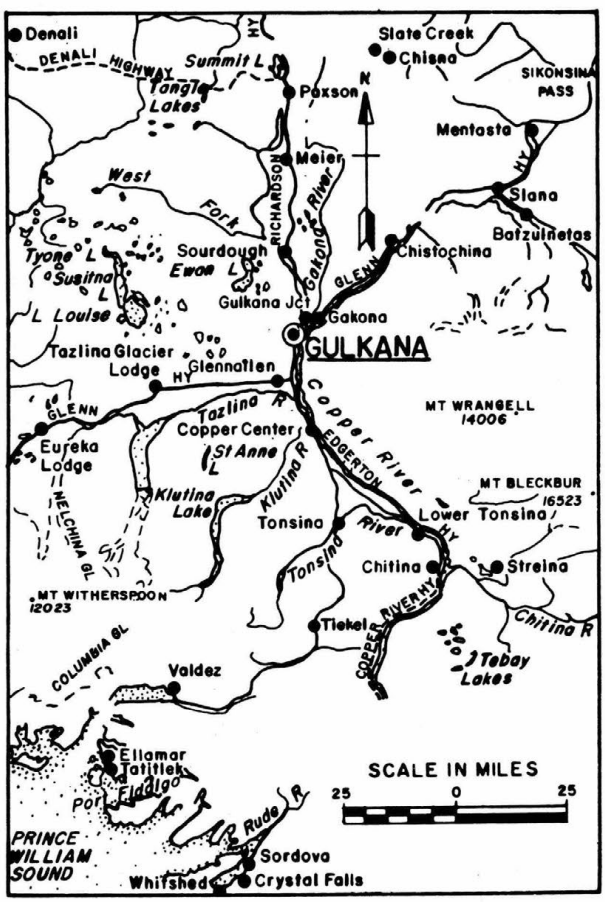


Figure 1. Vicinity map.

The climatological data for Gulkana, Alaska, were obtained from U. S. Weather Bureau records. Ground-temperature observations were obtained on a daily basis from 1947 to 1958 by the U. S. Weather Bureau for the Arctic Construction and Frost Effects Laboratory, U. S. Army Engineer Division, New England. Soil data were obtained from samples taken during the drilling of two holes, one in June 1946 and the other in February 1955.

DESCRIPTION OF SITE

Location

The Federal Aviation Agency's (FAA) Gulkana airfield is in south-eastern Alaska. It is located 8 miles south of the village of Gulkana at 62° 09' north latitude and 145°28' west longitude (Fig. 1). The airfield is situated east of and adjacent to the Richardson Highway, approximately 2 miles west of the Copper River and consists of two asphalt-surfaced runways, one 5200 feet long, the other 3600 feet long (Fig. 2).

Terrain

Gulkana airfield is located on a gently sloping alluvial plain between Dry Creek and the Copper River. The area is bordered on the east by the Wrangell Mountains with elevations up to 16,000 feet and on the northwest by the Alaska Range.

Climate

Climatological data for Gulkana, Alaska are given in Table I and Figures 3 and 4.

Table I gives air temperatures, precipitation, amounts of snowfall and snow cover, and the freezing and thawing indexes. The air temperatures were obtained in accordance with standard Weather Bureau procedures. The snow cover measurements are believed to be representative of the area where the ground-temperature assembly is located.

Figure 3, a climograph (also called a hythergraph), shows mean monthly values of precipitation versus temperature; direction and force of prevailing winds; cloud cover; number of days of precipitation (rain and/or snow); and fog data for the area.

Figure 4 presents meteorological data and ground isotherms for a typical year. The meteorological data include average daily air temperatures, degree-days of thaw and freeze (cumulative on the last day of each month), daily precipitation (rain and/or snow), and depth of snow on the ground.

Figure 2. Aerial view of Gulkana looking north.

Table I. Gulkana, Alaska climatological data.

Air temperature - °F		
Mean annual		27.0
Recorded high	7/25/53	91
Recorded low	2/3/47	-65
Precipitation - inches		
Mean annual		11.7
Max. annual	(1943)	16.4
Max. monthly	(Sept 1951)	4.3
Snowfall - inches		
Mean annual		50.9
Max. annual	(1955)	72.8
Max. monthly	(Dec 1955)	30.0
Freezing index (degree-days F below 32)		
Average	(1947-1958)	4802
Minimum	(Oct 57 - Mar 58)	3832
Maximum	(Oct 58 - Apr 59)	6833
Thawing index (degree-days F above 32)		
Average	(1947-1958)	2881
Minimum	(Apr 49 - Oct 49)	2597
Maximum	(Apr 53 - Oct 53)	3272
Average date start freeze season		12 Oct
Average date start thaw season		18 Apr
Average length of freeze season (days)		188
Average length of thaw season (days)		172

Snow cover in inches
first day of month for 1952-1958.

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Maximum recorded	0	T	5	14	22	25	25	16	3	0
Minimum recorded	0	0	T	2	4	6	9	3	0	0
7-year average	0	0	3	7	12	14	15	10	T	0

T = Trace

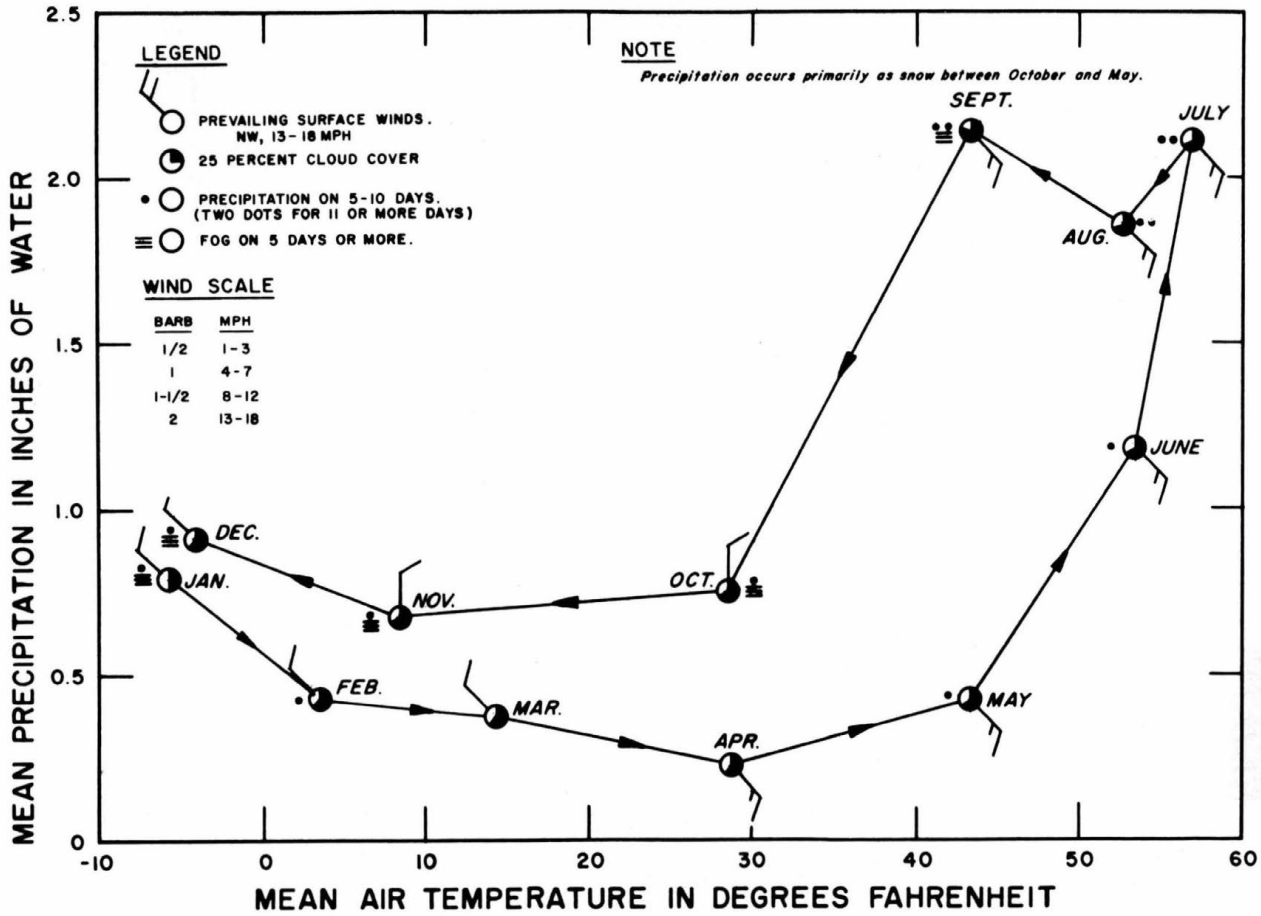


Figure 3. Climograph.

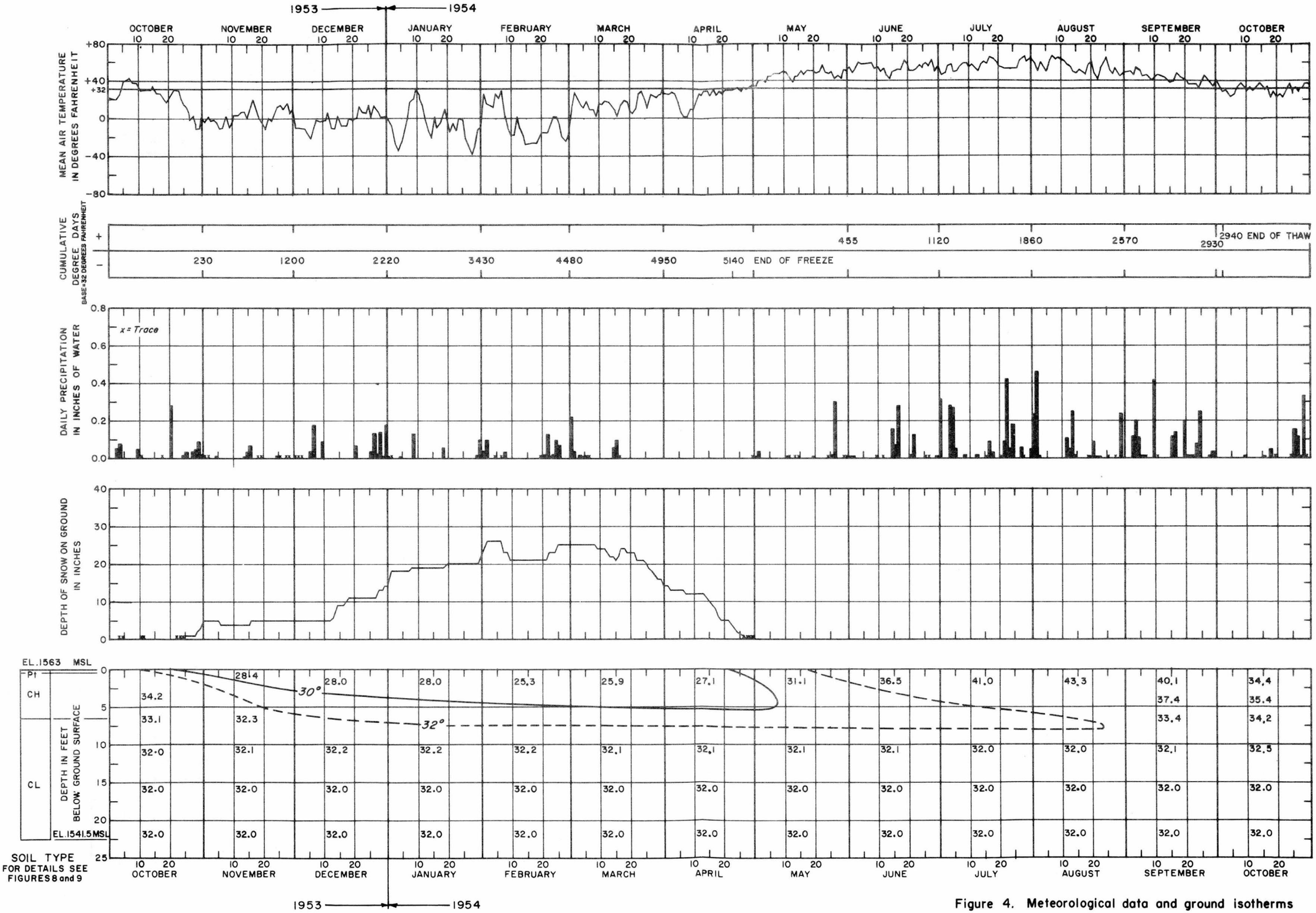


Figure 4. Meteorological data and ground isotherms

GROUND-TEMPERATURE ASSEMBLY

Location

The ground-temperature assembly at Gulkana, Alaska was installed 166 feet west of the FAA control building (Fig. 5).

The location of the temperature assembly in such close proximity to the asphalt runway and other developed areas of Gulkana Airfield should be considered when interpreting the ground-temperature data as it is possible that ground temperatures will vary considerably as the distance from developed areas increases.

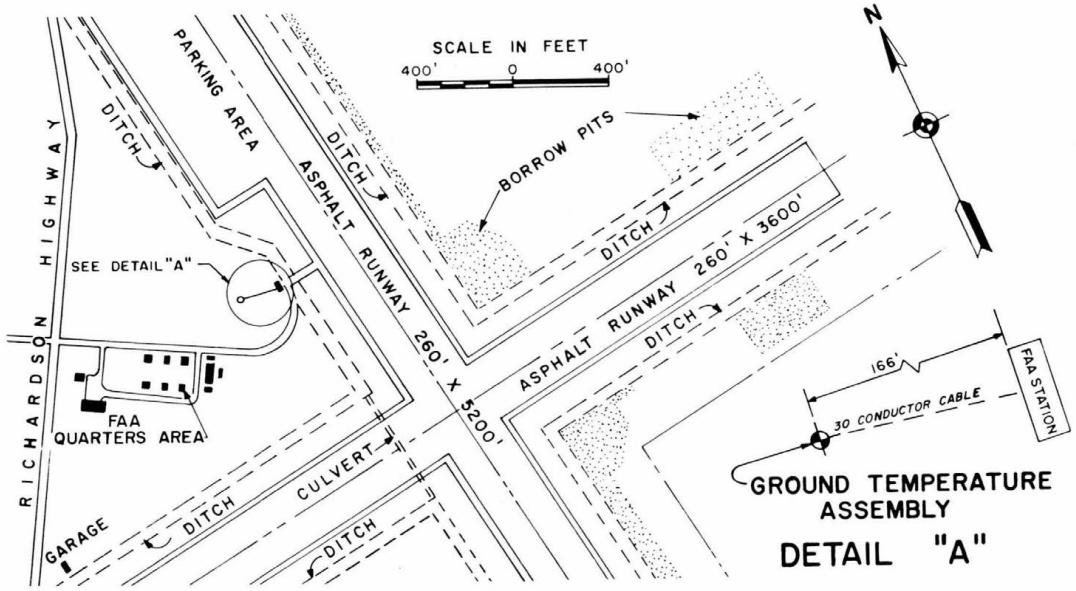


Figure 5. Site location.

Drainage and vegetation

The terrain surrounding the ground-temperature installation slopes gently from west to east. The surface drainage is from a westerly direction toward the Copper River. The subsurface drainage of this area is poor.

The area immediately to the east of the ground-temperature installation is covered by a low grassy swale, and during the observational period the vegetation in the general area consisted of a sparse growth of grass (Fig. 6).

Temperature-well drilling

Drilling operations began on 20 June 1946. The first six holes that were started had to be abandoned because of large rocks and boulders which the available drilling equipment could not penetrate. On 22 June 1946, a 22.5-ft deep temperature well was completed using a combination of driving and water jetting.

Instrumentation

The ground-temperature measuring equipment installed at Gulkana consisted of nine copper resistance thermometers (thermohms) with the top three thermohms encased in $\frac{3}{4}$-in. diam tubing and the other six thermohms suspended in a 2-in. diam oil-filled pipe. The top three thermohms were replaced by thermohms placed directly in the ground in the summer of 1950 when the original ones became inoperative due to water freezing in the tubing. The thermohms extended from 0.0 to 22.0 feet below the ground surface, spaced as shown in Figure 7. It should be noted that the 0.0-ft thermohm is actually $\frac{1}{8}$ to $\frac{1}{4}$-inch below ground surface.

Figure 6. Surface cover in area of ground-temperature assembly.

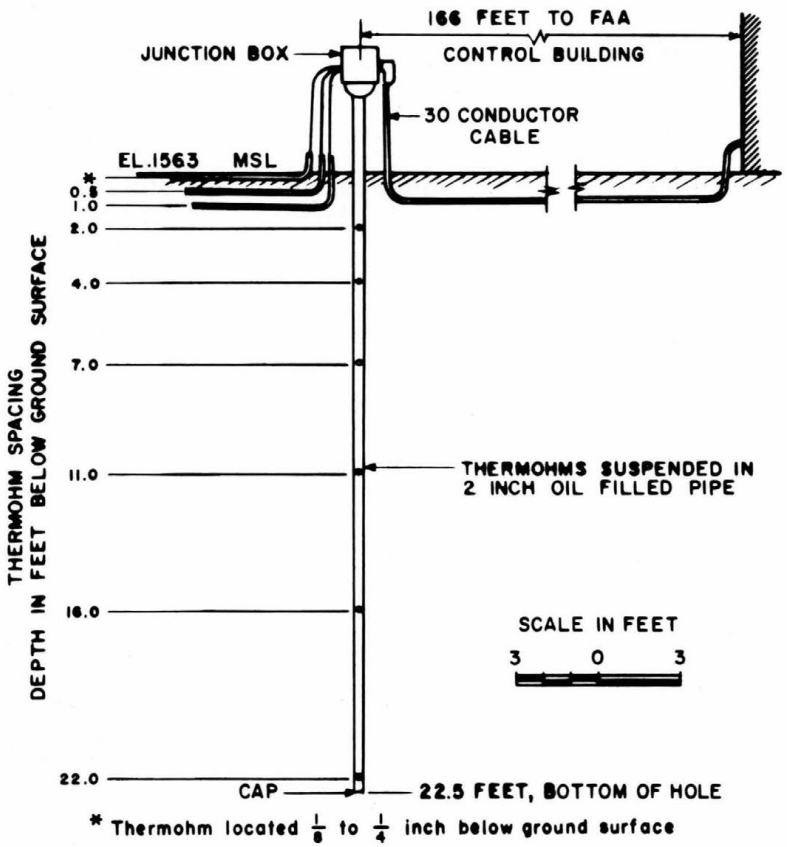


Figure 7. Resistance thermometer installations.

GROUND TEMPERATURE OBSERVATIONS

Temperature observations were made with a Leeds and Northrup Model 8015-S temperature indicator; it was a double range, Wheatstone-bridge type with one scale range of -50 to -5C and one of -15 to + 30C.

Resistance thermometers were used because similar instrumentation had previously been used by the U. S. Weather Bureau and station personnel were familiar with the observational procedure involved.

SOIL INVESTIGATIONS

Exploration

In conjunction with drilling operations for the temperature well, representative soil samples were obtained with a 4-in. hand auger after each drill run. A 22-ft deep exploratory hole was drilled 3 feet northwest of the temperature well in February 1955. The exploratory drilling was performed by drive sampling with a churn drill. A 3-in. diam hardened steel drive tube was used to obtain continuous samples for the full depth of the hole.

Soil data

Laboratory tests were performed to identify and classify the soil samples obtained, with moisture content and density tests made on suitable representative samples. The boring log and soil data for the temperature well (1946) are shown in Figure 8, and the log and soil data for the exploratory (1955) hole in Figure 9.

GROUND TEMPERATURES

Observed ground temperatures

Ground temperatures were recorded daily at Gulkana for 12 years (1947-1958). A careful review of the ground-temperature observations obtained during the period 1947-1952 showed that these data did not at all times accurately reflect the actual conditions existing at the site (such as depth to permafrost) because of periodic instrumentation malfunctions and inadequate observational techniques. The data presented in this report are for the period 1952-1958 only and are considered to be representative of the actual conditions at the Gulkana site within the limitations noted in the preceding discussion relative to location of the ground-temperature assembly.

The maximum, minimum, and the average of the temperatures as recorded the first day of each month for the 1952-1958 period are shown in Table II. The actual ground temperatures recorded the first day of each month are presented in Table III.

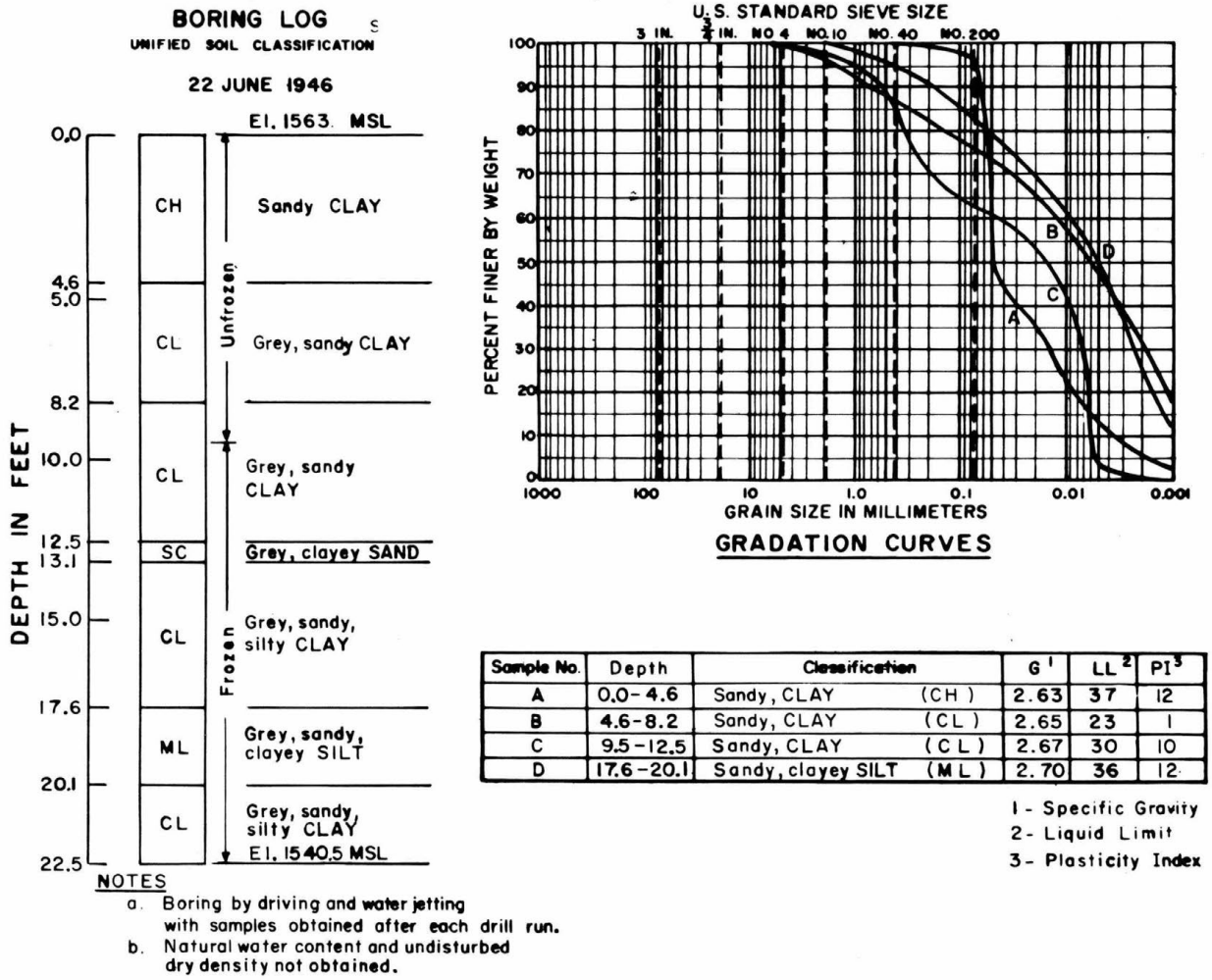
Ground-temperature gradients and maximum-minimum curves

Ground-temperature gradients for a typical thaw and freeze season (1952-53) at Gulkana, Alaska are shown in Figure 10. Gradients were plotted for the start of freeze, middle-of-freeze, end of freeze, and middle of thaw. The maximum and minimum ground temperatures recorded during the period of record at each depth are also presented. It should be noted that the maximum and minimum temperatures shown for the various depths do not represent the 1952-53 season as do the gradients; rather, they are the maximum and minimum temperatures recorded at each depth during the years 1952 to 1958.

Depth to permafrost

The seasonal depth of freeze at Gulkana varied slightly from year to year; the average seasonal depth of freeze observed during the 1952-1958 period of observations was about 7.5 feet below the ground surface.

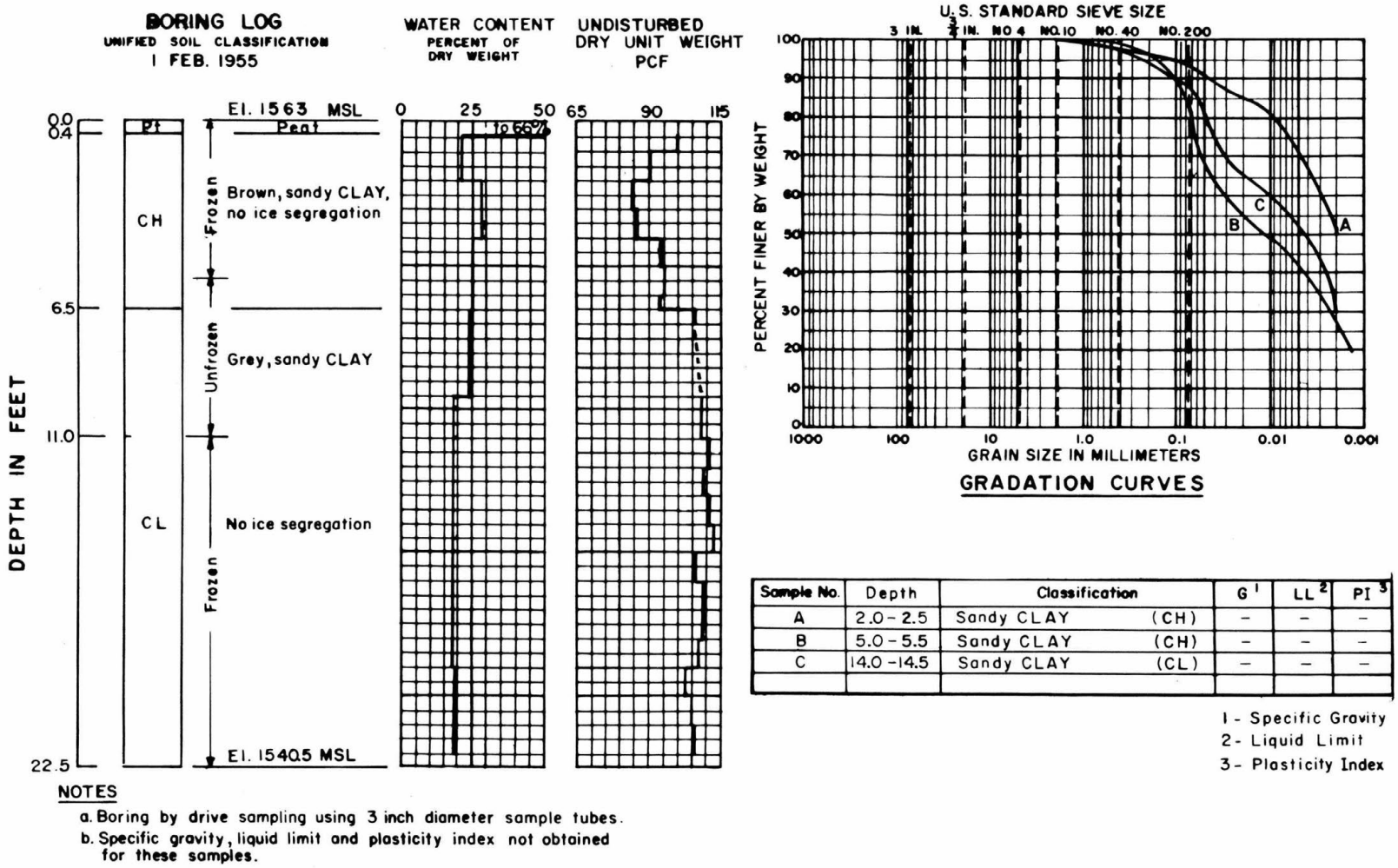
When the ground-temperature well was drilled on 22 June 1946, frozen ground (permafrost) was encountered at a depth of 9 feet (Fig. 8). On 1 February 1955 an exploration hole was drilled as close as was physically possible (3 feet northwest) to the ground-temperature assembly, and frozen ground was encountered at 11 feet below the ground surface. These depths to permafrost are corroborated by the ground-temperature data for the 1952-1958 period.



Sample No.	Depth	Classification		G [1]	LL [2]	PI [3]
A	0.0-4.6	Sandy, CLAY	(CH)	2.63	37	12
B	4.6-8.2	Sandy, CLAY	(CL)	2.65	23	1
C	9.5-12.5	Sandy, CLAY	(CL)	2.67	30	10
D	17.6-20.1	Sandy, clayey SILT	(ML)	2.70	36	12

1 - Specific Gravity
2 - Liquid Limit
3 - Plasticity Index

Figure 8. Boring log and soil data, ground-temperature well.



Sample No.	Depth	Classification		G [1]	LL [2]	PI [3]
A	2.0 - 2.5	Sandy CLAY	(CH)	-	-	-
B	5.0 - 5.5	Sandy CLAY	(CH)	-	-	-
C	14.0 -14.5	Sandy CLAY	(CL)	-	-	-

1 - Specific Gravity
2 - Liquid Limit
3 - Plasticity Index

NOTES

a. Boring by drive sampling using 3 inch diameter sample tubes.
b. Specific gravity, liquid limit and plasticity index not obtained for these samples.

Figure 9. Boring log and soil data, exploratory drilling.

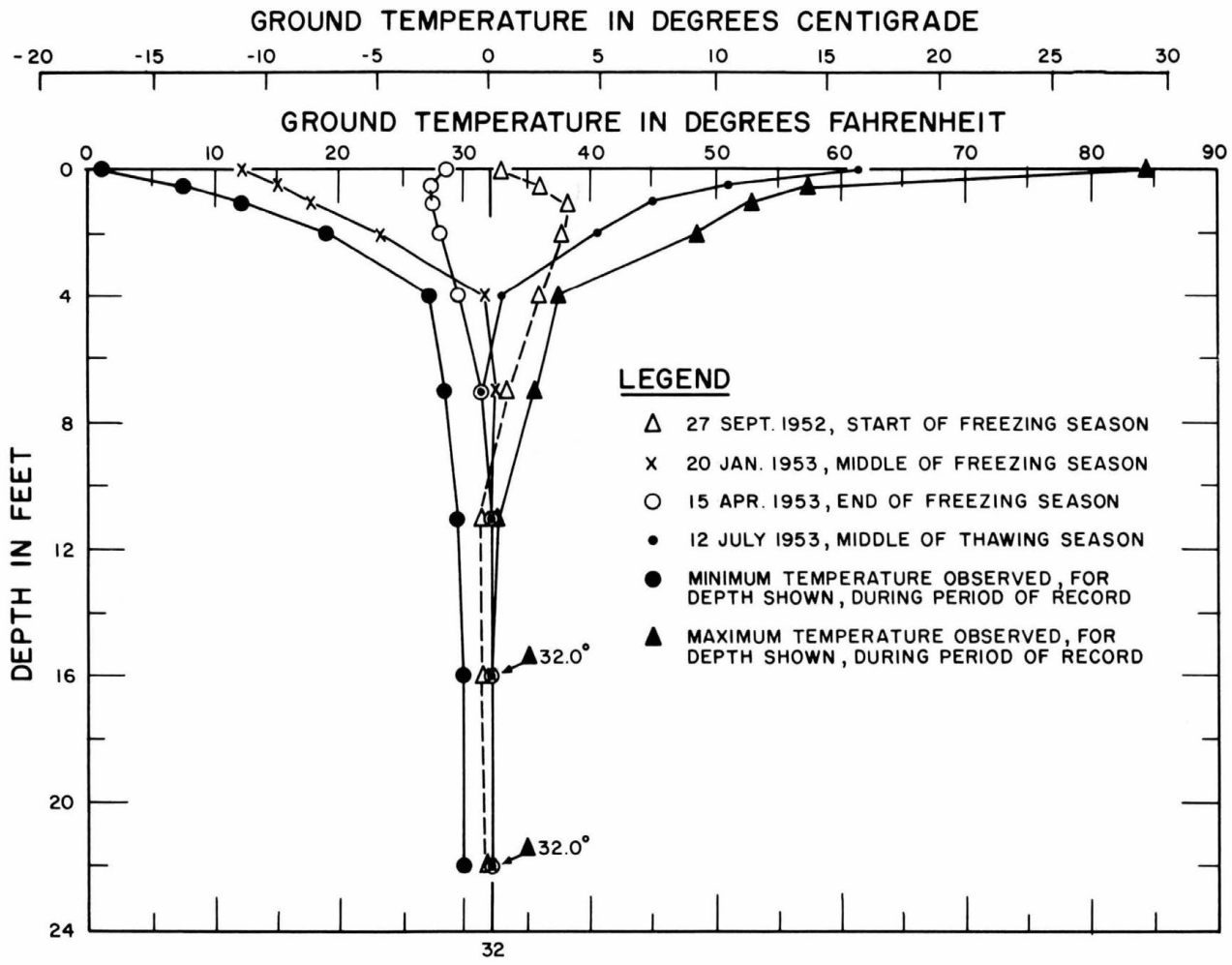


Figure 10. Ground-temperature gradients and maximum-minimum curves.

Table II. Ground temperatures, °F, maximum, minimum and average recorded first day of month, 1952-1958.

DEPTH IN FEET	MONTH																	
	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE		
	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
0.0*	25.5	18.0	22.5	23.0	15.4	19.7	24.8	18.3	21.4	25.9	20.7	23.1	49.5	27.9	36.6	65.5	47.0	53.8
0.5	26.6	20.8	24.2	24.8	8.0	19.3	25.4	19.4	22.6	26.4	21.6	24.2	33.4	30.4	32.0	43.2	36.6	40.4
1.0	27.4	22.6	25.4	25.7	12.4	20.8	26.2	19.8	23.3	26.8	22.3	24.7	31.3	30.2	30.8	41.9	33.4	37.2
2.0	29.4	21.8	27.4	28.4	20.0	24.7	27.7	23.0	25.5	28.6	24.6	26.5	30.4	28.0	29.1	34.1	31.3	32.7
4.0	32.2	30.4	31.3	32.0	29.2	30.8	32.0	28.2	29.9	31.8	28.0	29.7	31.1	28.8	30.0	31.8	30.0	30.9
7.0	32.5	31.5	31.8	32.2	31.3	31.8	32.5	31.3	31.8	31.8	30.6	31.3	31.8	30.6	31.3	32.2	30.4	31.2
11.0	32.0	31.5	31.8	32.2	31.6	32.0	32.2	31.6	32.0	32.0	30.6	31.7	32.0	31.5	31.7	32.0	31.5	31.8
16.0	32.0	31.6	31.8	32.0	31.6	32.0	32.0	31.6	32.0	32.0	30.6	31.6	32.0	31.1	31.7	32.0	31.1	31.7
22.0	32.0	31.5	31.8	32.0	31.6	32.0	32.0	31.8	32.0	32.0	30.6	31.7	32.0	31.3	31.7	32.0	31.3	31.8

DEPTH IN FEET	MONTH																	
	JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
0.0*	53.0	68.0	59.4	63.3	51.7	56.8	55.8	44.4	49.6	51.9	27.7	35.2	31.8	19.0	26.0	31.5	19.6	25.0
0.5	50.4	47.1	48.2	54.0	47.7	49.7	49.0	43.5	44.8	48.2	32.7	37.8	32.0	24.4	29.7	31.5	23.4	27.5
1.0	49.3	42.8	45.2	50.4	39.3	46.1	47.2	43.0	44.6	46.5	33.4	38.2	32.0	27.0	30.7	31.3	24.8	28.6
2.0	39.7	37.0	38.4	45.4	38.8	41.6	43.6	40.1	41.3	43.3	35.2	37.9	33.0	31.0	32.0	31.0	28.6	30.2
4.0	32.2	31.0	31.7	35.2	31.6	33.3	36.9	31.6	35.7	36.9	31.5	35.4	34.1	32.5	33.1	32.5	27.2	30.8
7.0	32.5	30.4	31.4	31.6	30.4	31.1	32.7	31.5	32.0	34.5	31.5	33.4	33.7	32.2	33.0	33.0	28.0	31.2
11.0	32.0	30.4	31.6	32.0	30.4	31.5	32.0	31.5	31.7	32.0	31.5	31.8	32.2	31.5	32.1	32.0	29.8	31.4
16.0	32.0	31.1	31.7	32.0	30.4	31.4	32.0	31.1	31.6	32.0	30.6	31.5	32.0	31.1	31.7	32.0	31.5	31.8
22.0	32.0	31.3	31.8	32.0	30.4	31.6	32.0	31.5	31.8	32.0	31.0	31.7	32.0	30.3	31.6	32.0	31.3	31.8

*Thermohm installed $\frac{1}{8}$ inch to $\frac{1}{4}$ inch below ground surface.

GROUND TEMPERATURE OBSERVATIONS

Table III. Ground temperatures, °F, recorded first day of month, 1952-1958.

DEPTH IN FEET	1952											
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
0.0	24.4	15.4	21.6	22.1	31.6	47.0	59.0	58.0	49.8	27.7	29.7	27.7
0.5	26.2	17.6	23.0	24.1	31.6	36.6	48.2	48.5	44.2	37.4	32.0	30.0
1.0	27.0	19.8	24.3	25.1	30.6	33.4	44.2	39.3	43.0	37.7	32.5	31.3
2.0	29.4	24.3	26.0	27.0	29.8	31.3	37.7	41.5	40.6	37.5	33.0	31.0
4.0	31.0	31.5	30.3	30.0	30.2	31.0	31.6	31.6	36.2	36.1	34.1	30.6
7.0	31.6	32.2	32.0	31.8	31.3	31.5	31.6	31.1	32.0	33.2	33.7	32.6
11.0	32.0	32.0	32.0	32.0	31.8	32.0	32.0	31.8	32.0	32.0	32.0	32.0
16.0	32.0	32.0	32.0	32.0	31.8	31.6	31.8	31.5	31.8	31.8	32.0	32.0
22.0	31.5	32.0	32.0	32.0	31.8	31.8	32.0	31.8	32.0	32.0	32.0	32.0

DEPTH IN FEET	1953											
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
0.0	21.6	-	24.3	24.3	49.5	58.2	65.5	63.3	51.0	31.0	26.4	19.6
0.5	24.5	8.0	24.3	24.5	33.4	42.4	47.1	54.0	44.1	33.8	29.4	23.6
1.0	26.2	12.4	24.6	24.3	31.0	37.9	43.8	49.5	43.6	35.4	31.1	26.2
2.0	28.8	20.0	26.4	25.7	30.0	34.1	39.7	45.4	41.0	36.2	31.3	28.8
4.0	32.0	30.8	29.7	29.2	30.2	31.0	32.0	35.2	36.2	36.0	32.7	27.2
7.0	32.5	32.2	31.6	31.6	31.5	31.2	31.5	31.5	31.6	33.3	32.7	28.0
11.0	32.0	32.0	32.2	32.0	32.0	32.0	32.0	32.0	32.0	31.8	32.2	31.3
16.0	32.0	32.0	32.0	32.0	32.0	32.0	31.8	31.8	31.8	31.8	31.6	32.0
22.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	31.8	32.0	32.0	32.0

DEPTH IN FEET	1954											
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
0.0	25.5	20.1	19.4	24.1	36.7	65.5	53.0	53.0	47.7	32.7	31.8	26.9
0.5	26.6	2[illegible].4	21.2	25.4	32.0	43.2	47.9	47.7	43.6	37.8	32.0	28.4
1.0	27.4	22.8	22.5	25.7	30.4	37.8	43.7	43.9	43.8	38.0	32.0	30.0
2.0	28.6	25.7	24.6	27.0	29.7	34.0	38.8	38.8	41.6	37.8	32.7	30.8
4.0	31.6	31.0	29.8	29.7	30.6	31.0	32.0	32.0	36.9	36.2	33.6	32.5
7.0	32.0	31.8	31.6	31.6	31.3	31.3	32.5	31.6	32.4	34.2	33.4	33.0
11.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	31.8	32.0	32.2	32.2
16.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	31.8	32.0	32.0
22.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0

DEPTH IN FEET	1955											
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
0.0	18.0	22.1	23.2	24.7	32.5	49.7	62.1	56.9	49.2	36.7	19.0	20.6
0.5	20.8	24.1	24.8	25.9	32.7	38.5	47.7	49.0	44.6	36.7	25.9	23.4
1.0	24.5	25.7	26.2	26.8	31.3	35.0	42.8	46.4	-	38.3	29.7	24.8
2.0	27.1	27.5	27.7	28.6	30.4	32.7	38.0	42.4	40.1	37.4	31.3	28.6
4.0	32.2	31.1	31.6	31.8	31.1	31.8	32.2	34.3	36.9	36.9	33.4	31.6
7.0	32.2	31.6	32.5	31.0	31.8	32.2	32.2	31.3	32.7	34.5	33.7	31.3
11.0	32.0	32.2	32.2	30.6	31.5	32.0	32.0	31.5	31.5	32.0	32.0	31.1
16.0	32.0	32.0	32.0	30.6	31.5	32.0	32.0	31.3	31.3	31.6	32.0	32.0
22.0	32.0	32.0	32.0	30.6	31.3	32.0	32.0	31.6	31.5	31.6	31.6	31.6

Table III. (Cont'd) Ground temperatures, °F, recorded first day of month, 1952-1958.

DEPTH IN FEET	1956											
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
0.0	25.4	20.5	18.3	21.4	41.6	50.4	53.3	51.7	44.4	31.3	19.2	31.5
0.5	25.7	20.8	19.9	21.8	32.2	38.5	47.7	47.9	43.5	32.7	24.4	31.5
1.0	26.2	21.0	20.7	22.3	31.1	37.2	47.2	47.7	44.2	33.4	27.0	31.1
2.0	27.7	24.6	23.6	24.6	28.6	31.8	37.0	40.6	40.7	35.2	31.0	30.8
4.0	31.0	30.4	29.0	28.4	29.2	30.4	31.0	32.7	36.2	35.6	32.5	31.6
7.0	31.5	31.8	31.5	31.0	30.6	30.4	30.4	30.4	31.5	33.4	32.5	31.8
11.0	31.5	32.0	32.0	31.6	31.6	31.5	30.4	30.4	31.5	31.6	32.2	32.0
16.0	31.6	32.0	32.0	31.6	31.6	31.5	31.3	30.4	31.3	31.3	31.6	31.5
22.0	31.6	32.0	32.0	31.6	31.6	31.5	31.3	30.4	31.6	31.6	31.6	31.6

DEPTH IN FEET	1957,											
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
0.0	21.2	17.3	18.5	20.7	27.9	52.1	63.7	57.8	55.8	51.9	29.7	23.8
0.5	22.3	18.7	19.4	21.6	30.4	43.2	50.4	51.0	49.0	48.2	31.5	28.0
1.0	22.6	18.7	19.8	22.7	30.2	41.9	49.3	50.4	47.2	46.5	32.0	28.0
2.0	21.8	22.7	23.0	24.6	28.0	32.4	39.4	41.2	43.6	43.3	32.4	31.0
4.0	30.8	29.2	28.2	28.0	28.8	30.0	31.6	33.8	31.6	31.5	32.5	31.0
7.0	31.6	31.3	31.3	30.6	31.5	30.6	30.4	30.8	31.8	31.5	32.2	30.4
11.0	31.8	31.6	31.6	31.6	31.5	31.5	31.5	31.3	31.5	31.5	31.5	29.8
16.0	31.6	31.6	31.6	31.1	31.1	31.1	31.1	31.1	31.1	30.6	31.1	31.0
22.0	31.6	31.6	31.6	31.5	31.6	31.6	31.6	31.5	31.6	31.0	30.3	31.3

DEPTH IN FEET	1958											
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
0.0	21.6	23.0	24.8	24.5								
0.5	23.6	24.8	25.4	26.4								
1.0	24.1	25.2	25.2	26.2								
2.0	28.4	28.4	27.5	27.9								
4.0	30.4	32.0	30.6	31.0								
7.0	31.5	31.8	31.8	31.8								
11.0	31.5	32.0	32.0	32.0								
16.0	31.6	31.8	31.8	32.0								
22.0	31.6	32.0	32.0	32.0								

DEPTH IN FEET												
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
0.0												
0.5												
1.0												
2.0												
4.0												
7.0												
11.0												
16.0												
22.0												