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DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

VARIATION IN REFLECTANCE OF VEGETATION AND SOILS CAUSED BY AN UNDERGROUND NUCLEAR EXPLOSION

FINAL TECHNICAL REPORT

1 November 1962

U S Army Engineer Research And Development Laboratories

FORT BELVOIR, VIRGINIA

VARIATION IN REFLECTANCE OF VEGETATION AND SOILS CAUSED BY AN UNDERGROUND NUCLEAR EXPLOSION

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1 November 1962

Submitted in Accordance with Requirements of
Program Vela/Uniform T/182
(Air Force Technical Applications Center Project 7.7)

Mine Detection Branch

U. S. Army Engineer Research and Development Laboratories
Fort Belvoir, Virginia

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FIGURES

REFLECTANCE STUDIES

I INTRODUCTION

1. Objective - To obtain vegetation reflectance data from 250 to 2000 millimicrons in order to determine the effect of underground nuclear explosions on vegetation.

2. Background - Reports on nuclear detonations in operation Hard Tack II at the Nevada Test Site indicated that one of the effects was the death of vegetation over a large area. An investigation of aerial photography as a means for detecting this vegetation damage was undertaken. It was anticipated that this type of detection might serve as an on-site inspection technique. Information on reflectance data was needed in order to select film filter combinations which would exploit spectral regions where there were reflectance differences between disturbed and undisturbed vegetation. These reflectance differences would show up as contrast differences on aerial photographs.

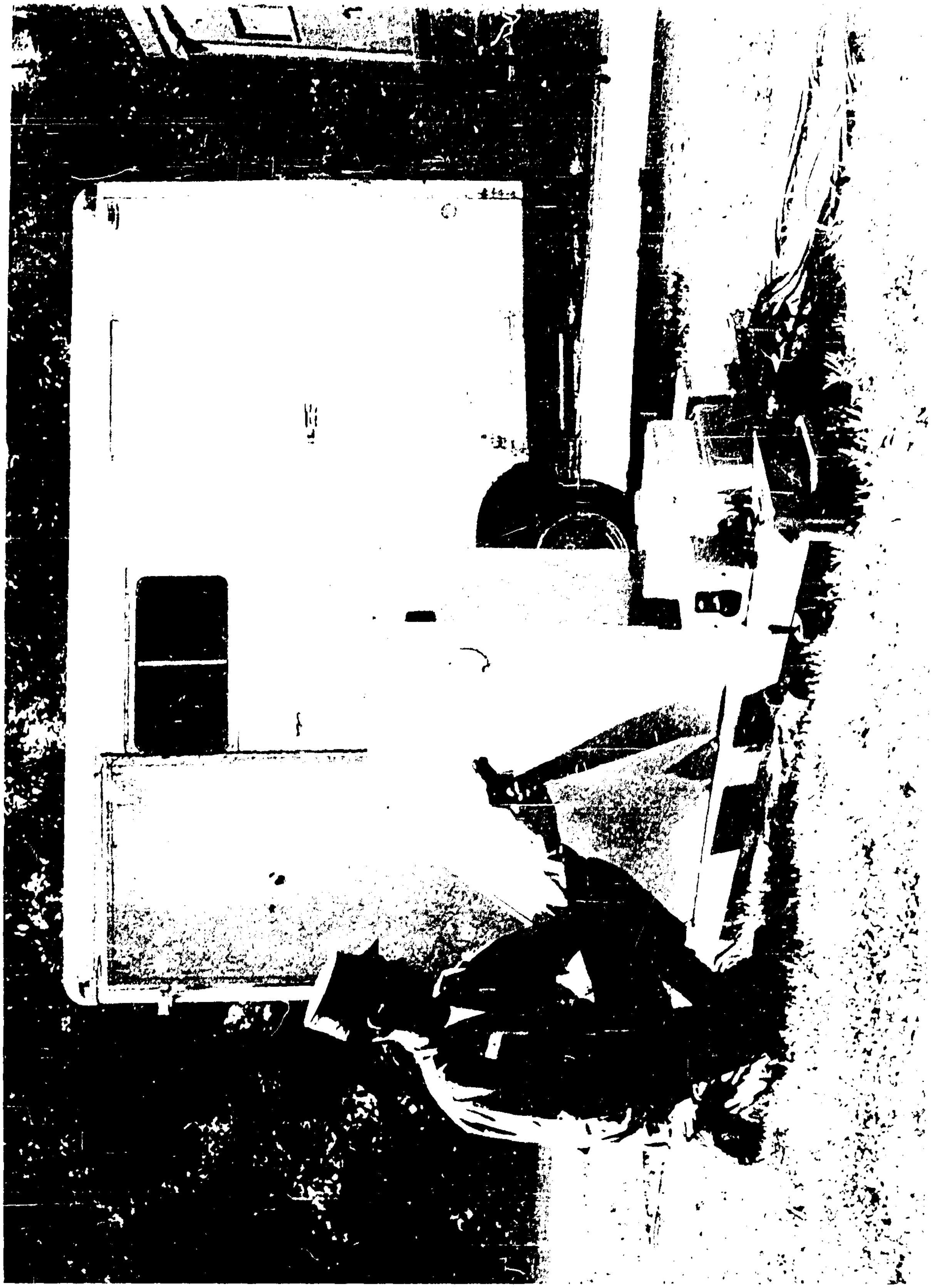
In order to determine the optimum film filter combinations, basic reflectance data was collected at the Nevada Test Site during 23 February - 9 March, 20 - 28 June, and 7 - 14 November 1961. Additional data was collected in connection with Operation Gnome, of the Plowshare Program, at Carlsbad, New Mexico during 17 November, 6 - 22 December 1961 and 30 April - 4 May 1962.

II INVESTIGATION

3. Theory - Damage to root systems of vegetation, whatever the cause, affects the health and vigor of the plants and causes changes in reflectance characteristics. These changes will be manifested within a few days to several weeks and can be measured on-site with a reflectance spectrophotometer. From such reflectance data, film-filter combinations can be chosen that will utilize the spectral region providing optimum tonal contrast on aerial photographs.

4. Instrumentation - The USAERDL portable reflectance spectrophotometer, developed by the Perkin-Elmer Corporation, is shown in Fig. 1. The power supply, amplifier and recorder are installed in the trailer. In the foreground is the basic unit containing an illuminating source, collecting optics, monochrometer, visible and infrared detectors, and a moveable thermometer glass standard reflectance target. The instrument operates over the 250-2000 millimicron region, with a resolution of at least 50 mu in any region. The resolution varies over the spectrum because of slit width adjustments required to give a satisfactory signal level.

The basic unit weighs 150 pounds and can be raised to a height of 5 feet for data collection over tall vegetation. Electrical power



is supplied by a 5 KW engine-generator mounted on the trailer.

The majority of the reflectance data discussed in this report was collected using a Xenon arc lamp to illuminate the sample. This provided light in the ultra violet portion of the spectrum (out to 250 mu). Analysis of the data revealed that there was no significant information available in the ultra violet, so an incandescent lamp (much more rugged and simple to operate) was substituted for the Xenon lamp. Reflectance data collected 30 April - 4 May 1962 at Carlsbad, New Mexico were obtained with the incandescent light source.

5. Procedure -

a. Nevada Test Site: A reconnaissance of the Orchid Test Area, in February 1961, indicated that data could be collected in three quadrants with respect to ground zero. Reflectance data collection sites (fig. 2) were chosen on the basis of vegetation population and location with reference to ground zero. Each sample site was marked with stakes driven into the ground so that the instrument could always be placed in the same position for future collection of data. The sites were also fenced with engineer's tape.

Each sample site was assigned a four term identification number. For example, 0-260-III-3 indicates "0" for Orchid; "260" for 260 yards from ground zero; "III" for third quadrant with reference to ground zero; "3" for the sample number. Based upon observations of the effect of the "Blanca" explosion, the 410 yard sample site was considered to be outside the area which the "Orchid" detonation would influence. Thus a comparison of vegetation and soil reflectance in disturbed and undisturbed area could be made at some future date. Fig. 3 is a panoramic photograph of the test area. Soil samples were collected at each site and vegetation identifications were made by personnel from the New Mexico Highlands University.

An effort was made at each data collection site to obtain reflectance curves of representative samples. However, this was not possible when the vegetation was more than 5 feet tall because the instrument could not be raised above this height. (The instrument provided parallel light illumination of sample area.) When Juniper and Pinyon trees were more than 5 feet tall, the crown on a limb was removed and placed in a water filled hole in the ground. Data collection was begun within two minutes of the time that the cut was made and completed within 20 minutes, the time required for the spectrophotometer to complete its scan. Dead limbs for comparison with their healthy counterparts were obtained from trees in the "Blanca" test area, where a previous underground nuclear explosion had killed off much of the vegetation.

Preliminary data reduction was completed in the field immediately after collection of data, so that unusual responses could be rechecked. This preliminary reduction involved conversion of raw data, which was

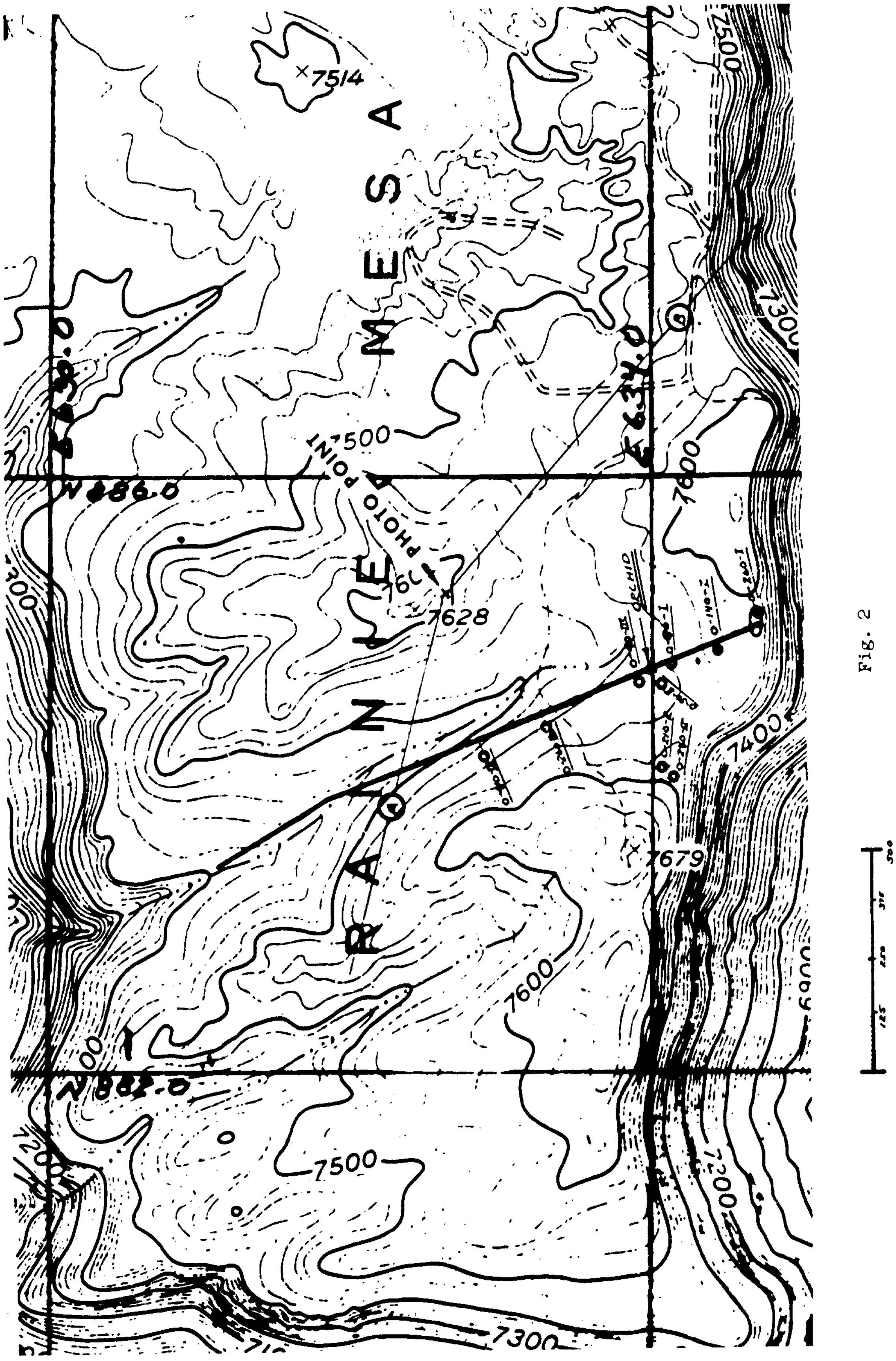
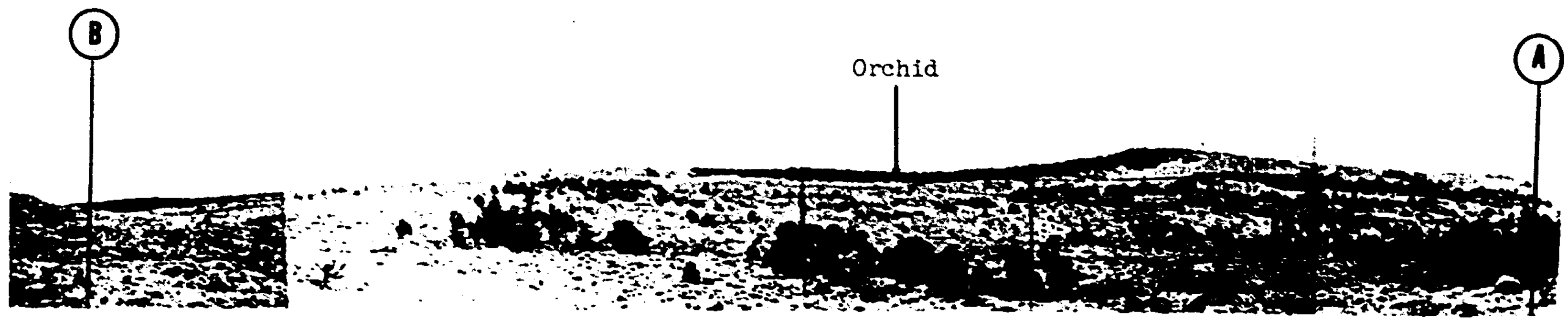

MESA
PHOTO POINT
7514
7500
7628
7679
7600
7400
7300
7200
YARDS

Fig. 2

Top of Rainier Mesa



General Terrain Conditions

referenced to monochrometer drum turns, into reflected energy versus spectral wavelength. A comparison of reflected energy with the thermometer glass standard was then made.

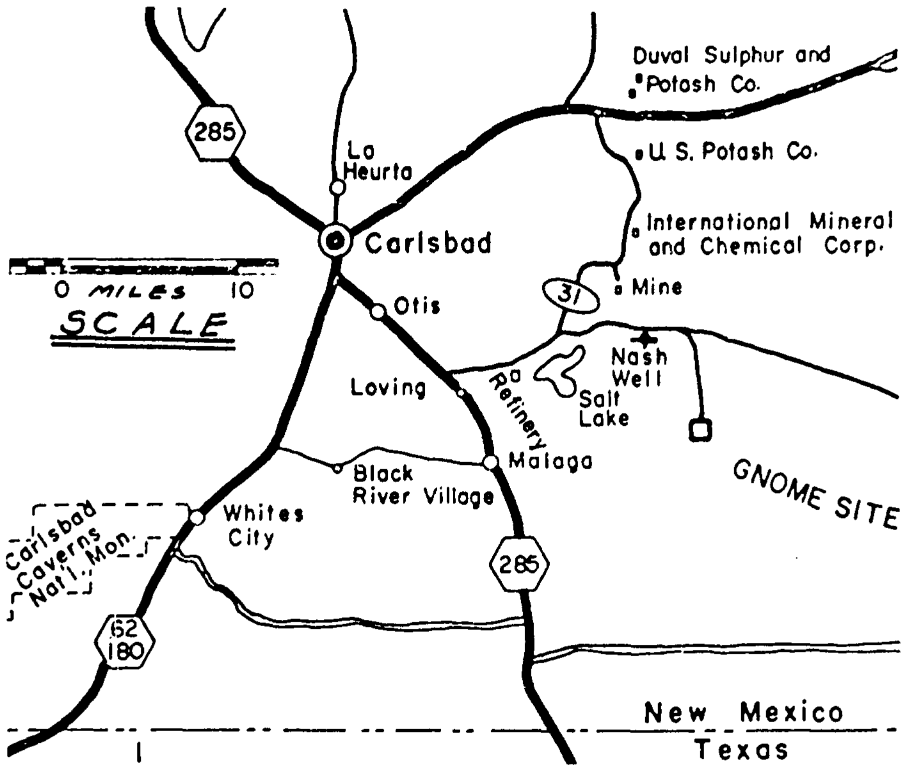
Work in the Antler area, 7 - 14 November 1961, consisted of collecting only post-shot vegetation reflectance data. No pre-shot data was collected at Antler because the explosion took place prior to the scheduled arrival time of the spectrophotometer crew. In lieu of the Antler pre-shot data, sample sites were located in the orchid area which contained similar soil and vegetation conditions. The Antler data was collected at 6 sites along a straight line beginning at 50 yards from ground zero and continuing out to 300 yards.

b. Carlsbad, New Mexico: A reconnaissance of the Gnome test area (Fig. 4) indicated that suitable sites for reflectance data collection existed along a North-South line of horizontal motion targets. The line was one of 3 that started at ground zero and went out to 800 meters. Unimproved roads in the vicinity offered relatively easy access to the target line. The line also presented a means of fairly precise location of sample sites with respect to ground zero. Actual sample locations were selected both on the basis of vegetation present and distance from ground zero. Pre- and post-shot vegetation reflectance were collected at 60, 95, 140, 160 and 285 meters distance from ground zero. Samples of vegetation were also located approximately one mile north of ground zero; it was believed that these samples would be outside the area influenced by the blast and would thus afford a standard against which suspect vegetation reflectances could be measured. All sample sites were staked and fenced in the same manner as those at the Nevada Test Site.

6. Results

a. Nevada Test Site: A list of relfectance samples by data site is given in Appendix I and the corresponding reflectance curves for both the Orchid and Antler areas are contained in Appendix II. If one examines Figs. 5 and 6, one notes that there are 4 regions of the spectrum where there is significant reflectance difference between living and dead Pinyon foliage, and 3 regions of significant difference between living and dead Juniper foliage. The reflectance of the undisturbed soil background (Fig. 8) is shown for estimation of possible photographic contrast of the healthy tree against its background. There must not only be a difference in reflectance between living and dead vegetation, but also a difference in reflectance between such vegetation and its background in order to achieve photographic detection of damaged vegetation.

Fig. 7 shows reflectance characteristics of living oak, sagebrush, pinyon and juniper. The samples chosen for comparison represent samples of thick density, except in the case of the oak, when only one sample was available.



Duval Sulphur and Potash Co.
U. S. Potash Co.
International Mineral and Chemical Corp.
Mine
285
La Heurta
Carlsbad
0 MILES 10
SCALE
Otis
31
Nash Well
Loving
Refinery
Salt Lake
Malaga
Black River Village
GNOME SITE
Carlsbad Caverns Nat'l. Mon.
Whites City
285
62
180
New Mexico
Texas

Fig. 4

Fig. 8 shows reflectance characteristics of weathered tuff bedrock, fresh fractured tuff, and desert soil. The fresh fractured sample was obtained by collecting an undisturbed sample and cracking it. The weathered sample was obtained from exposed bedrock at the surface of the soil.

Fig. 9 shows the variation of reflectance as a function of sample density (thin, medium and thick living juniper).

b. Carlsbad, New Mexico: Pre-shot data were obtained for samples of scrub oak, mesquite, sagebrush and yucca. Because of severe frost spells prior to the Gnome detonation, only sagebrush and yucca were utilized for post-shot data. A comparison of reflectance curves reveals that there may have been a change in vegetation reflectance in the infrared that persisted for 8 or 9 days after the detonation. After this period, reflectance values once again become normal (Figures 10 and 11). The samples a mile away from the blast did not exhibit this change.

During April 1961 supplemental data was gathered for scrub,oak, mesquite, yucca and sagebrush. A comparison with the earlier set of curves reveals a difference in the visible portion of the spectrum. This difference may be a result of (1) seasonal changes (2) instrument variations (3) vegetation damage, or a combination of these factors. The possibilities are discussed in detail in the following section. Figures 12-15 are composite curves for various samples, comparing pre-shot, post-shot and spring reflectances.

III DISCUSSION

7. Nevada Test Site

a. Living and Dead Pinyon: Figure No. 5 shows four regions of the spectrum where there is a sufficient difference in reflectance to offer identification of living and dead pinyon foliage: 0.3-0.5; 0.55-0.75; 0.8-1.2; and 1.3-2.0 microns. These regions are similar to those of the March 1961 data. The 0.3-0.5 micron region can be photographed with Kodak Class 103-O film without filter; and the 0.55-0.75 micron region, with Kodak Class 103 a-u film with a Wratten 29 filter; and the 0.78-1.28 micron region, with Kodak Class I-A hypersensitized film with a Wratten 89B filter. The 1.28-2.0 micron region is beyond the photographic range, but can be observed with a thermograph.

b. Living and Dead Juniper: Figure No. 6 shows three regions of the spectrum where there is a sufficient difference in reflectance to offer identification of living and dead juniper foliage: 0.55-0.8; 0.85-1.2 and 1.2-2.0 microns. It is interesting to note that the

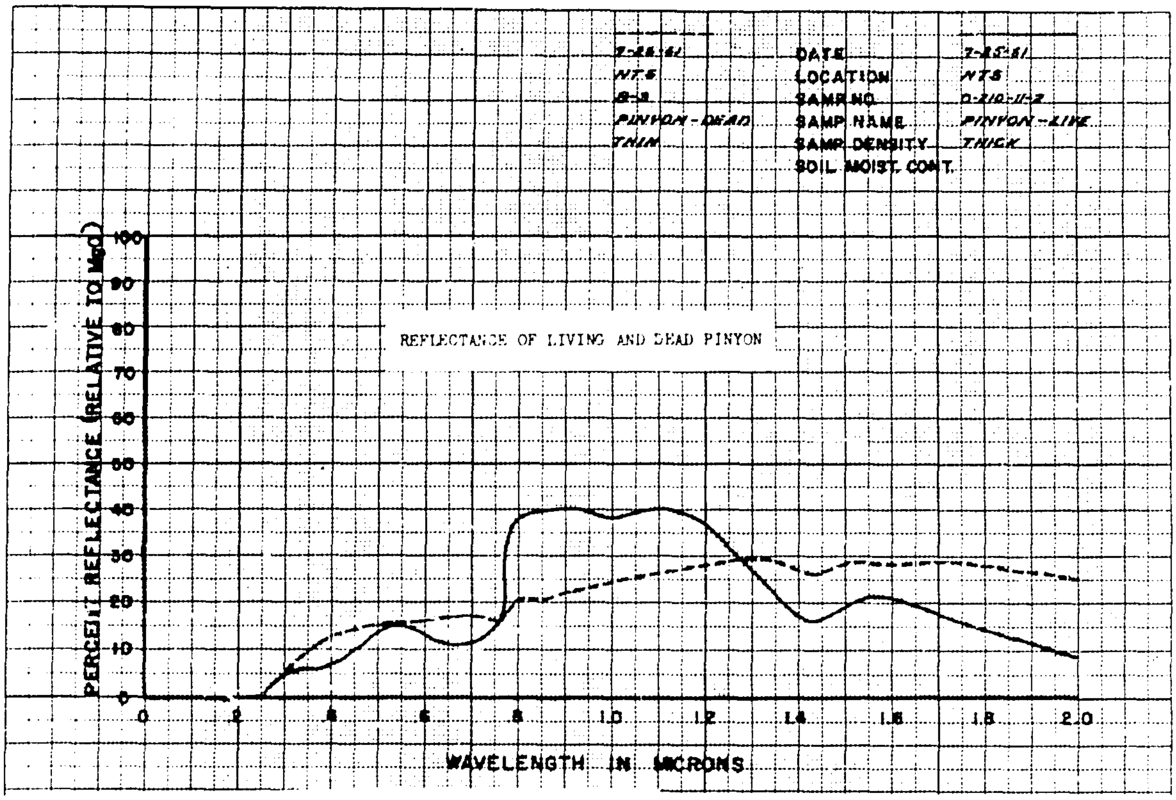

NTS
PINYON - DEAD
THIN
DATE
LOCATION
SAMP NO.
SAMP NAME
SAMP DENSITY
SOIL MOIST. CONT.
7-25-61
NTS
D-210-11-2
PINYON - LIVE
THICK
REFLECTANCE OF LIVING AND DEAD PINYON
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

Fig. 5

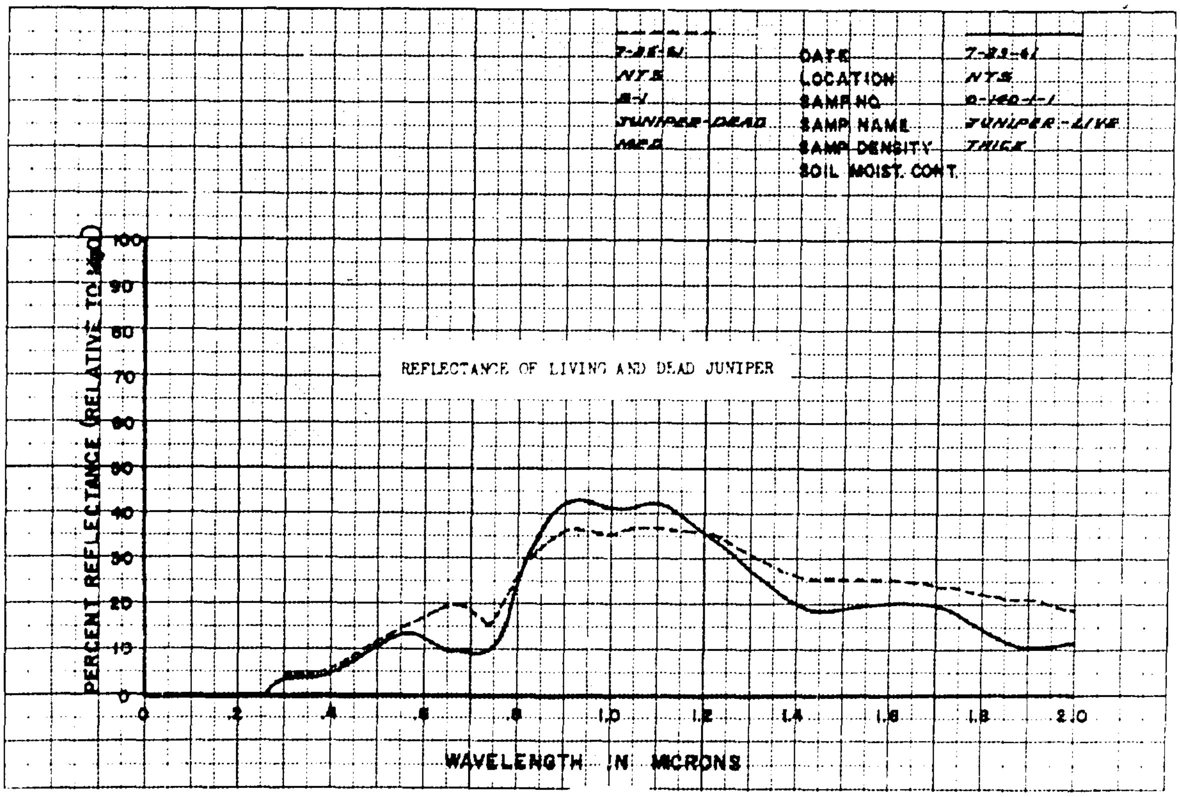
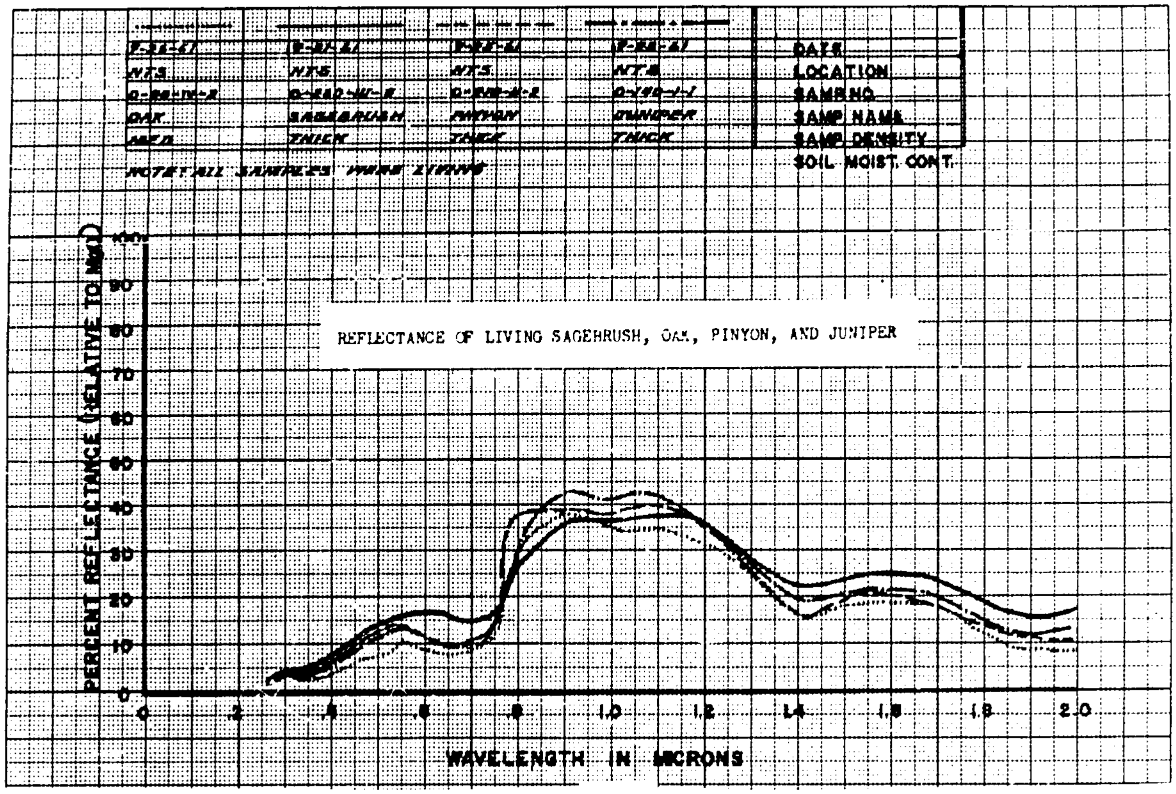
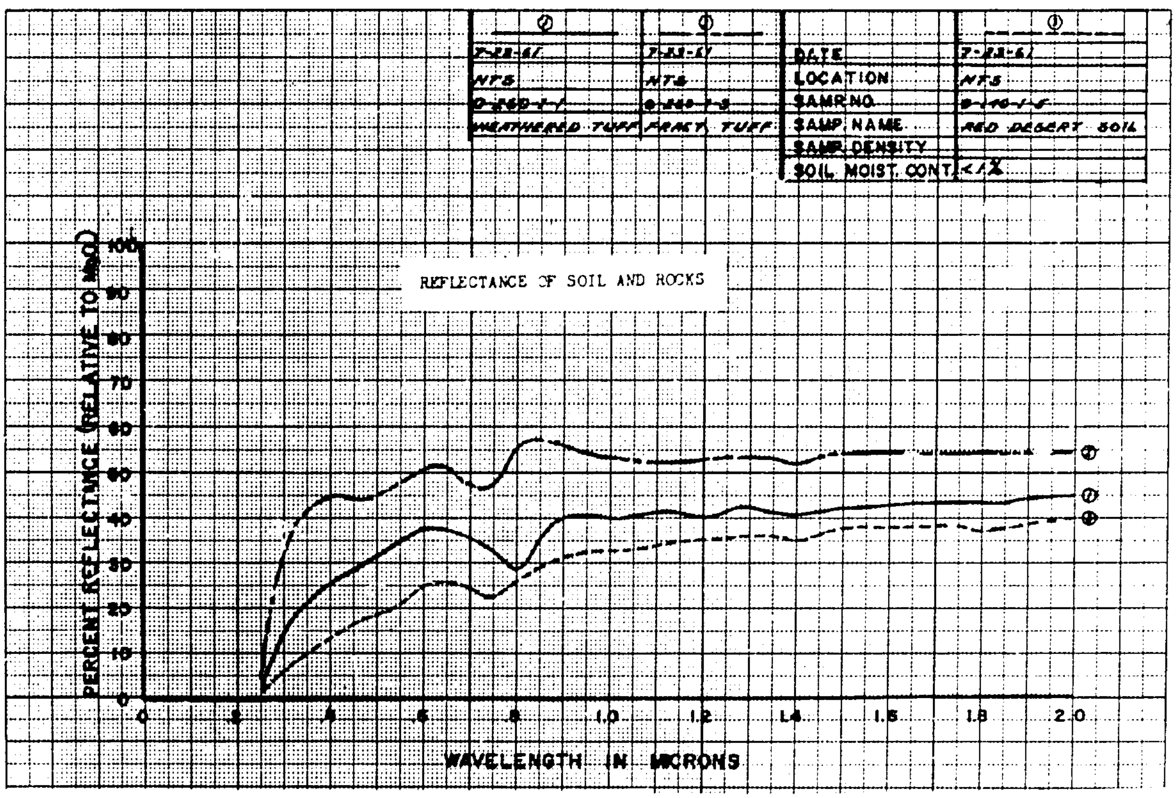

NTS
JUNIPER-DEAD
MED
DATE
LOCATION
SAMP NO.
SAMP NAME
SAMP DENSITY
SOIL MOIST. CONT.
NTS
JUNIPER - LIVE
THICK
REFLECTANCE OF LIVING AND DEAD JUNIPER
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

Fig. 6



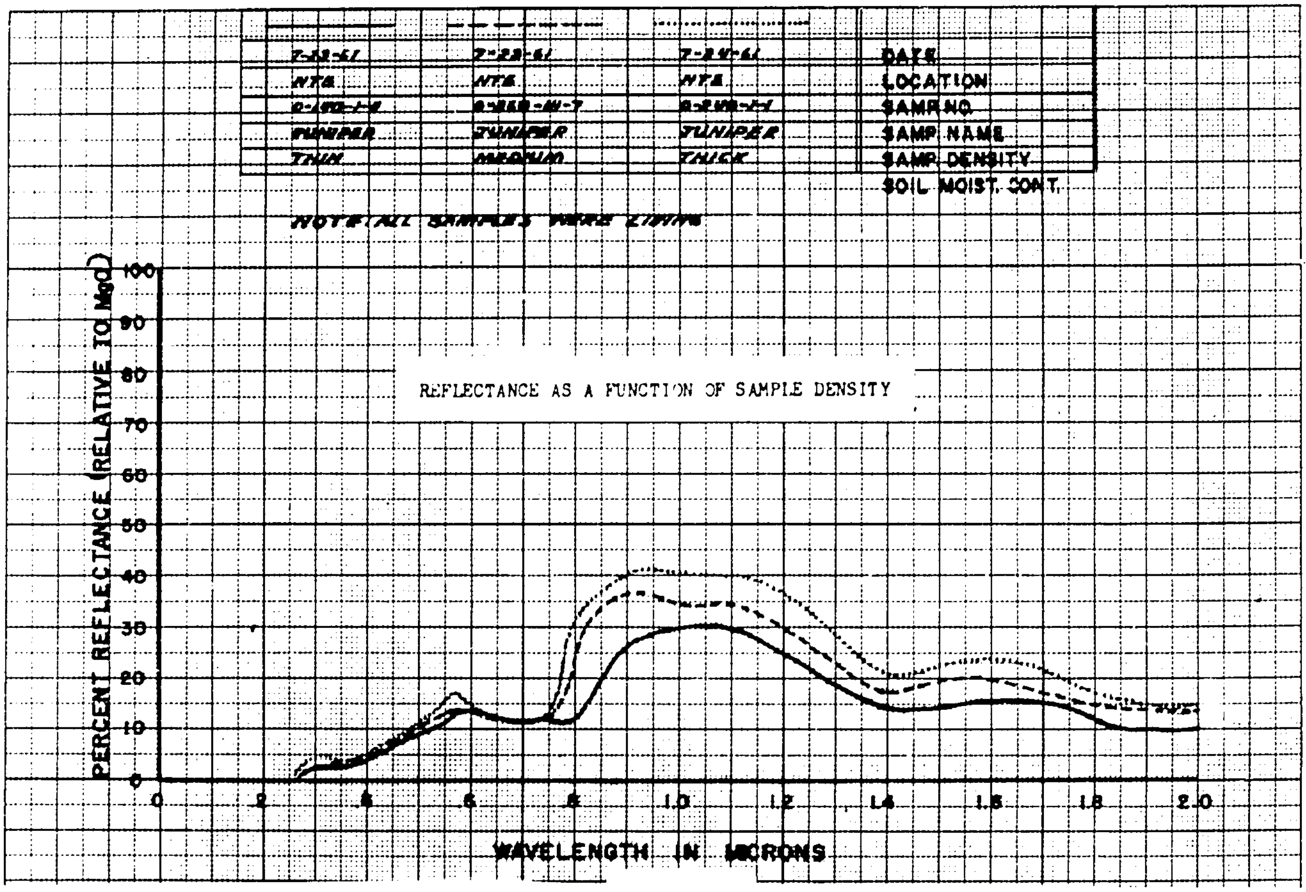
DATE
LOCATION
SAMP NO.
SAMP NAME
SAMP DENSITY
SOIL MOIST. CONT.
NTS
OAK
SAGEBRUSH
PINYON
JUNIPER
THICK
REFLECTANCE OF LIVING SAGEBRUSH, OAK, PINYON, AND JUNIPER
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

Fig. 7



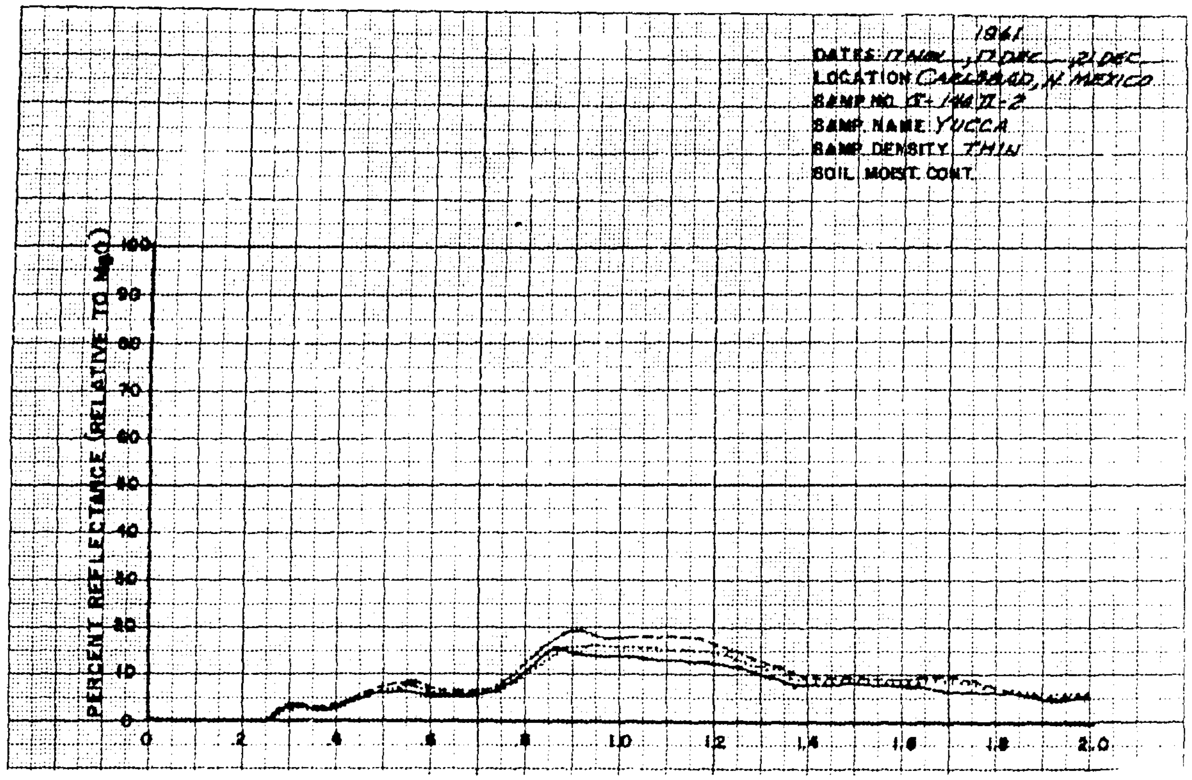
DATE
LOCATION
SAMP NO.
SAMP NAME
SAMP DENSITY
SOIL MOIST. CONT.
NTS
WEATHERED TUFF
FRACT. TUFF
RED DESERT SOIL
REFLECTANCE OF SOIL AND ROCKS
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

Fig. 8



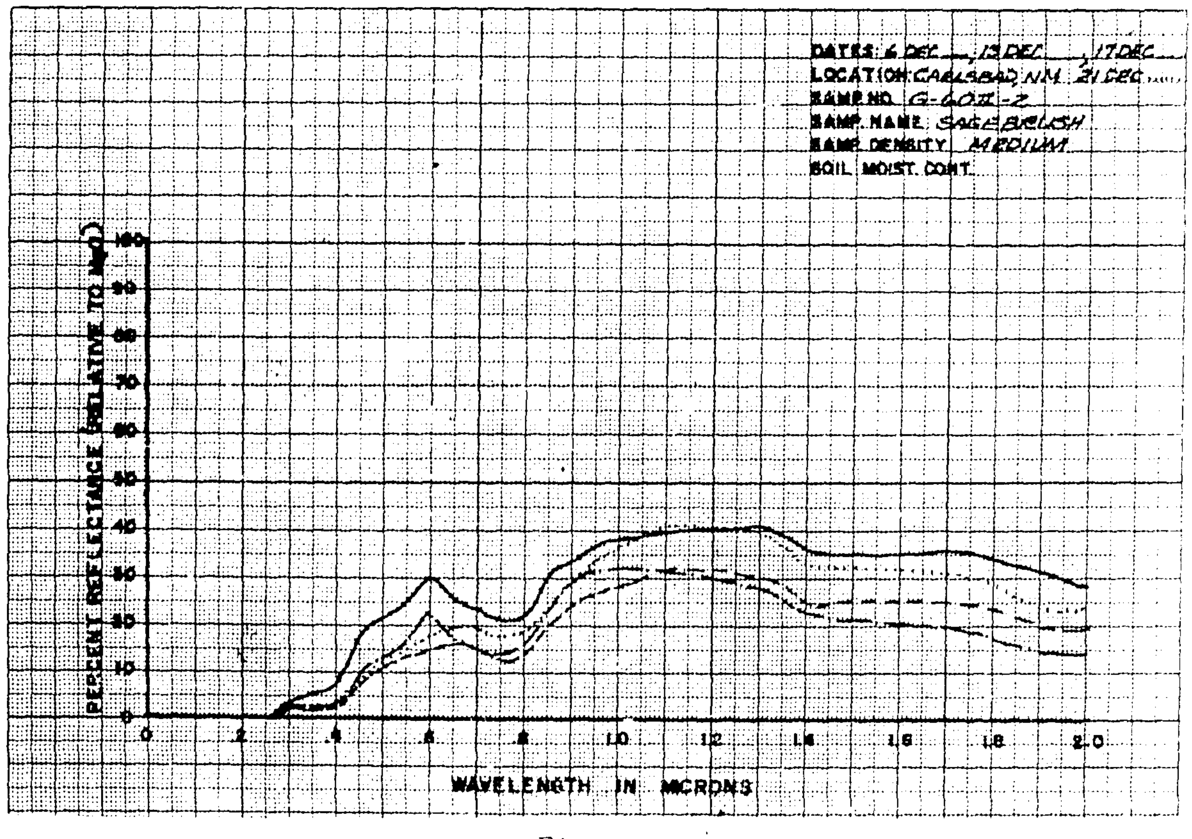
NTS
NTS
NTS
JUNIPER
JUNIPER
THIN
MEDIUM
THICK
DATE
LOCATION
SAMP NO.
SAMP NAME
SAMP DENSITY
SOIL MOIST. CONT.
REFLECTANCE AS A FUNCTION OF SAMPLE DENSITY
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

Fig. 9



1961
DATES: 17 NOV, 17 DEC, 21 DEC
LOCATION CARLSBAD, N. MEXICO
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0 .2 .4 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0

Fig. 10



DATES: 6 DEC, 13 DEC, 17 DEC
LOCATION: CARLSBAD, N.M. 21 DEC
SAMP. NO. G-60II-2
SAMP. NAME SAGEBRUSH
SAMP. DENSITY MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0 .2 .4 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0
WAVELENGTH IN MICRONS

Fig. 11

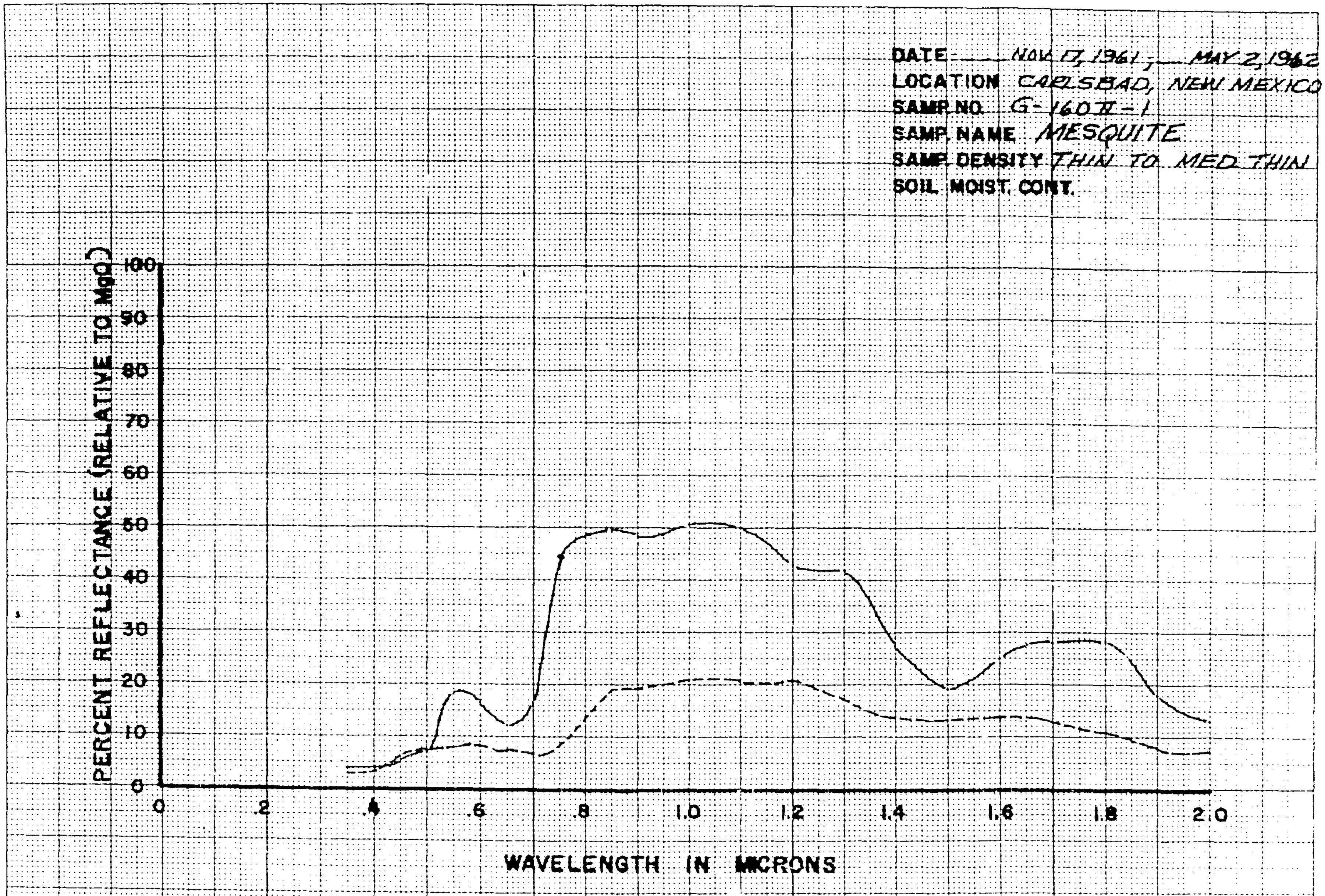

DATE NOV 17, 1961; MAY 2, 1962
LOCATION CARLSBAD, NEW MEXICO
SAMP. NO. G-160 II-1
SAMP. NAME MESQUITE
SAMP. DENSITY THIN TO MED THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

FIG. 12

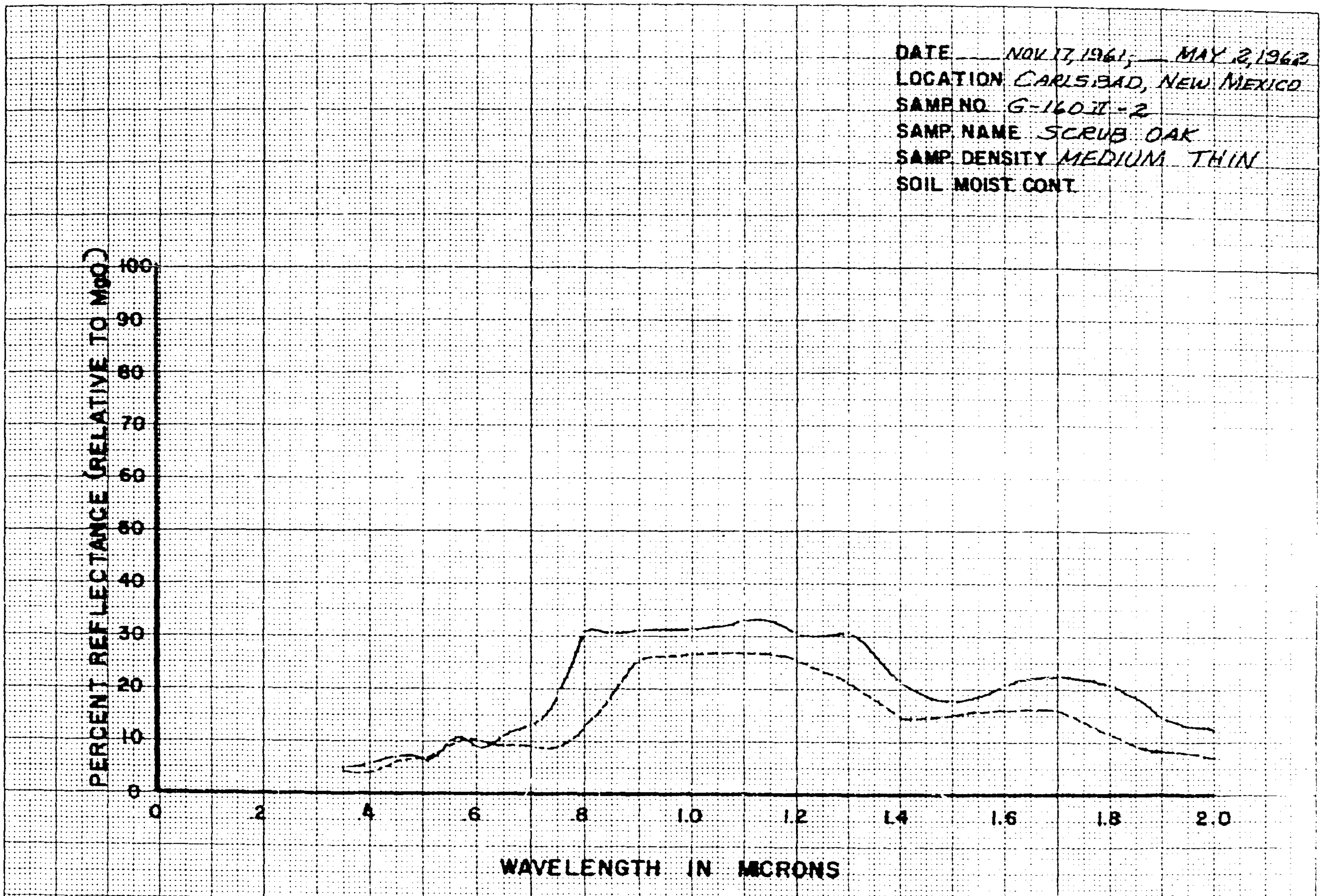
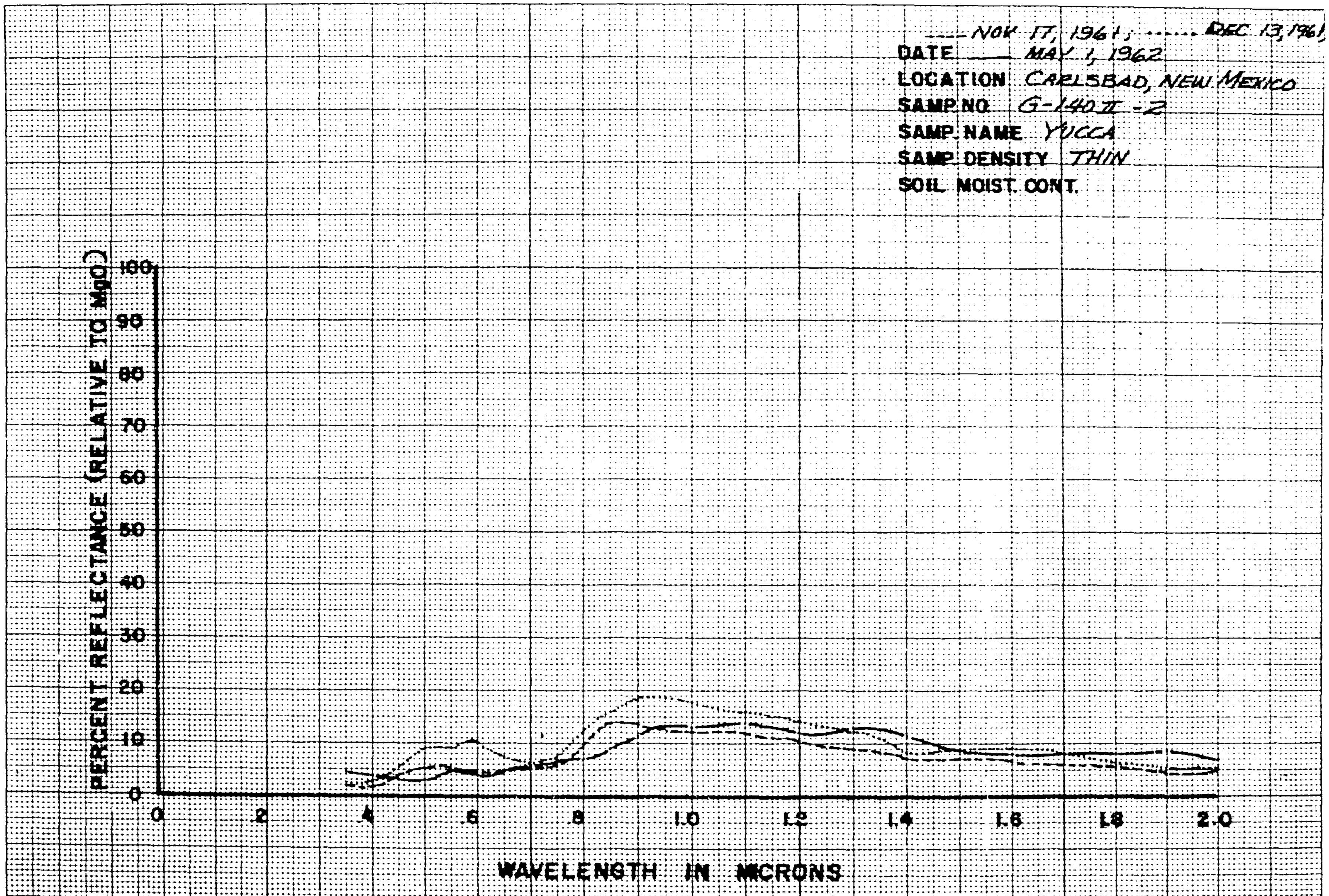

DATE NOV 17, 1961; MAY 2, 1962
LOCATION CARLSBAD, NEW MEXICO
SAMP NO. G-160 II - 2
SAMP. NAME SCRUB OAK
SAMP. DENSITY MEDIUM THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

FIG. 13



—— NOV 17, 1961; ······ DEC 13, 1961
DATE —— MAY 1, 1962
LOCATION CARLSBAD, NEW MEXICO
SAMP. NO. G-140 II -2
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

FIG. 14

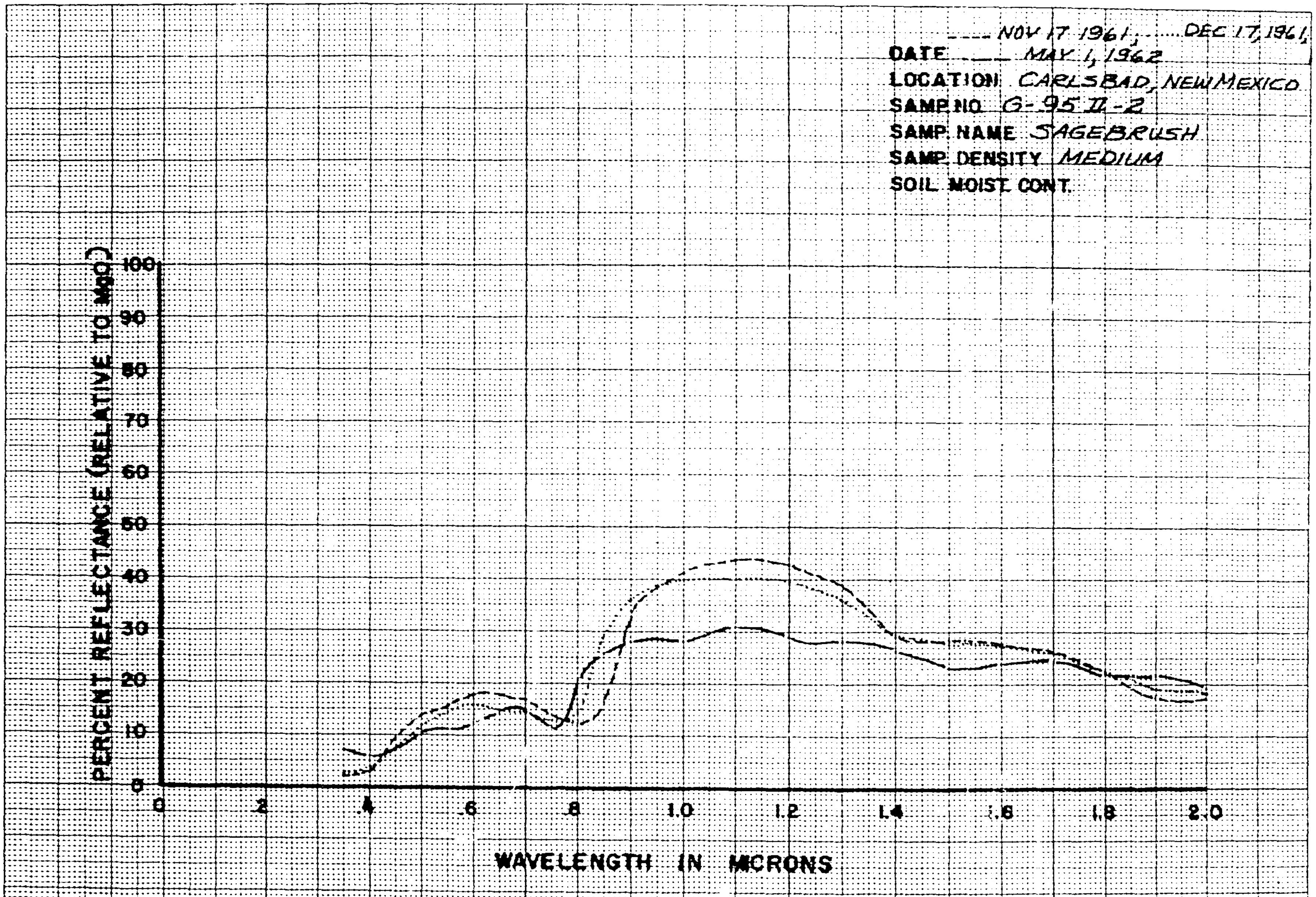

---- NOV 17 1961; ...... DEC 17, 1961;
DATE ___ MAY 1, 1962
LOCATION CARLSBAD, NEW MEXICO
SAMP. NO. G-95 II-2
SAMP. NAME SAGEBRUSH
SAMP. DENSITY MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

FIG. 15

cross-over point of living and dead pinyon and juniper are very close to each other, i.e., approximately 0.55, 0.77 and 1.2 microns. This is significant when the total number of film-filter combinations potentially usable are considered for detection in areas where the vegetation has not been pre-determined. If the cross-over points for most other types of vegetation occur in generally the same region of the spectrum, then only a few film-filter combinations will be required. Also, pre-determined vegetation occurrence or identification of vegetation by photo-interpretation becomes an unnecessary task.

c. Reflectance of Living Sagebrush, Oak, Pinyon and Juniper: Figure No. 7 shows that the reflectance properties of these four vegetation types do not vary greatly. With the exception of sagebrush, at a given wavelength, about a 20% difference in reflectance between the various types of vegetation occurs throughout the entire spectrum. The minimum difference occurs in about the same regions of the cross-over for living and dead pinyon and juniper. Each curve has a green peak, a distinct red dip, a high plateau in the near infrared with a slight dip near 1 micron, a sharp dip at 1.4 microns, and a gradually decrease into the longer wavelength infrared.

d. Reflectance of Soils and Rocks: Figure No. 8 shows that each curve sharply rises (as compared to vegetation) in the ultra-violet, peaks in the red, has a sharp dip between 0.8 and 0.9, then gradually rises out to 2.0 microns. The soil sample contained less than 1% moisture; a sample with greater moisture would probably have a lower reflectance. The weathered tuff has a lower reflectance because its surface had become mottled and dull.

e. Reflectance as a Function of Sample Density: Figure No. 9 shows the variation in reflectance of living juniper that can occur by variation in the sample density. Density in this case relates to the quantity of reflecting material in the sample surface. A semi-quantitative system of designation was used throughout these tests. This system was based upon amount of coverage of the sampled area (a six-inch diameter circle); a thin sample occupied about 70%; a medium sample, about 80%; and a thick sample, about 90% of the sample area. With the exception of the green region, where there is about an 18% difference, there is little difference in reflectance between 0.2 to 0.75 microns. Between 0.75 and 2.0 microns, a direct relationship exists between reflectance and density. A 25% difference occurs between the dense and the thin sample in the 1.0 micron plateau, while there is a 33% difference in the region of the 1.4 micron water absorption band.

f. Reflectance of Antler Samples: A comparison of the Antler reflectance curves with those of healthy vegetation from the Orchid area reveals a great deal of similarity between the two sets of data. Apparently the Antler underground blast did not cause any appreciable vegetation damage.

8. Carlsbad, New Mexico- Although a variety of vegetation was sampled during the pre-shot activities, only two types of plants were utilized in post-shot collection of reflectance data. This decision was based upon seasonal changes which adversely affected the scrub oak and mesquite. The two types of plants investigated where a sagebrush which was not identified, and a species of yucca (Yucca glauca). Of these, the sagebrush was probably in a semi-dormant state, and only the yucca showed signs of growth activity.

Study of the reflectance curves indicates that a slight change in reflectance may have occurred after the blast and persisted until D+8 days. After this period the reflectances tended to regain their original values. The yucca shows an increase of 3% to 8% in the region from 850 to 1400 millimicrons. The sagebrush shows a decrease of 2% to 15% from 850 to 2000 millimicrons. The samples located one mile from ground zero do not exhibit these trends, so the changes are probably due to the blast. Post-shot samples also show a decrease in reflectance of 3% to 10% in the visible. However, the "control" samples also exhibit this decrease. It is thus more probable that this change is a seasonal one, rather than being artificially induced. If these changes were indeed a result of the detonation, they appear to be quite transient and indicate a very short time period within which aerial detection would be feasible.

The intent of the supplemental reflectance work performed in April-May 1962 was to examine the spring vegetation of the test site. The healthy vegetation should be in bloom during this period, and vegetation that was injured by the underground nuclear explosion should show traces of this damage. The contrast between healthy and damaged vegetation would be more evident in the spring than in the early winter when the Gnome detonation occured.

A visual examination of vegetation around the Gnome site disclosed that the various types of plants were apparently healthy, with two exceptions. Oneof these exceptions was the mesquite, which was dead, or at least dormant, in the valleys and low areas, but quite flourishing on the hill tops and other points of moderate height. This situation was prevalent not only in the test area proper, but throughout the region as a whole. It is therefore likely that the cause of the phenomenon is to be correlated with moisture availability as a function of relief, rather than as a result of the Gnome event, since the "dead" mesquite was not confined to the test area alone but was characteristic of a very large area.

The other exception was the sagebrush. This plant still bore its winter aspect and appeared to be quite dormant. It was impossible to tell if the Gnome detonation had truly affected it. Like the mesquite, its dormant aspect was not confined to the vicinity of the Gnome event, but was characteristic of a very large area.

In general, the reflectance curves bear out the impressions derived by visual inspection. The healthy mesquite curve differs considerably from those obtained in November, 1961; this is best explained by the difference in seasons. This case is, in fact, illustrative of the problems encountered in comparing this later post-shot data with the pre-shot data. There are no truly comparable pre-shot reflectance curves available. One really should compare this spring's reflectance curves with curves taken during the spring of 1961. Unfortunately, such early pre-shot data is non-existent.

The comments concerning the mesquite are also applicable to the scrub oak. The curves seem valid; the shift of the peak reflectance towards the green region of the spectrum is especially noticeable.

The yucca curves of the spring of 1962 match those of November and December, 1961, except in the visible region. The visible portion of the reflectance curves is lower in the spring 1962 and also peaks more in the green. This difference is probably seasonal, since the plants appear healthy.

The sagebrush presents a somewhat different problem. The spring 1962 curves do not match the earlier set at all, either in the visible, where not only amplitude but shape varies, or in the infra-red.where the shape of the curves is similar but the amplitude varies.

It is interesting to note that the sample (sagebrush) located a mile from ground zero is no different in this respect, except that the shape of the latest reflectance curve also deviates considerably from the curves of the other two spring samples.

To the naked eye, the sagebrush appeared even more lifeless than it did in December, 1961. This observation was not limited, however, to the test site proper. Nowhere in the area for miles around the test site was the sagebrush in any other than this dormant condition.

Weighing all the evidence, it appears most probable that the difference between the December 1961 and May 1962 sagebrush curves is a result of natural causes. The curves reflect differences in the degree of dormancy achieved in December as opposed to early May. The fact that the sagebrush had a uniform appearance over a very large area inclines one to this belief, rather than that the sagebrush was damaged by the Gnome event. The real difficulty is that there is no healthy sagebrush curve available for comparison to either the December 1961 or May 1962 curves.

IV CONCLUSIONS

9. Nevada Test Site

a. There are four regions of the spectrum that offer a possibility of discriminating between living and dead pinyon trees: namely 0.3 to 0.5, 0.55 to 0.75, 0.8 to 1.2, and 1.3 to 2.0 microns (Reference Figure 5.)

b. There are three regions of the spectrum that offer a possibility of discriminating between living and dead juniper: namely 0.55 to 0.8, 0.85 to 1.2 and 1.2 to 2 microns. (Reference Figure 6.)

c. The Antler underground explosion had little, if any, effect upon vegetation in the test area.

10. Carlsbad, New Mexico

a. There are changes in vegetation reflectance in the infrared portion of the spectrum that are attributed to the Gnome Event. These reflectance changes persist for no more than 9 days following the event.

b. Reflectance changes occurring in the visible portion of the spectrum during December 1961 are attributed to seasonal causes only and offer no capability for detection of underground expolsions by photography. With the possible exception of the sagebrush, there was no permanent vegetation damage evident in the visible region of the spectrum as a result of the Gnome event.

APPENDIX I

SAMPLES BY SITE

NEVADA TEST SITE

Orchid Area

0-40-III-1		Soil
	2	Bunch Grass (stipa speciosa)
	3	Bed rock, tuff, weathered
	4	Big Sagebrush (artemisia tridentata)
	5	Morman Tea (ephedra vividis)*
	6	Horsebrush (tetradymia conescens)
	7	Rabitbrush (chrysothomnus nauseosus)*
0-260-III-1		Soil
	2	Bunch Grass
	3	Rabbitbrush
	4	Horsebrush, without leaves
	5	Sagebrush, with leaves
	6	Pinyon, 4 ft. tall undisturbed (pinus monophylla)
	7	Juniper, cut branch, (juniperus ostersperma)
	8	Pinyon, 10 foot, cut-branch
	9	Sagebrush, without leaves
0-410-III-1		Soil
	2	Sagebrush, without leaves
	3	Sagebrush, with leaves*
	4	Pinyon, 15', cut-branch
	5	Pinyon, 3', undisturbed
0-50-I-	1	Pinyon, 3', undisturbed
	2	Pinyon, 15', cut-branch
	3	Bed rock, fresh fractured, tuff
0-140-I-	1	Juniper, 15', cut-branch
	2	Pinyon, 20', cut-branch
	3	Pinyon, 3', undistrubed
	4	Juniper, 3', undisturbed
	5	Soil
0-240-I-	1	Juniper, 15', cut crown
	2	Pinyon, 20', cut crown
0-260-I-	1	Bed rock, weathered tuff
	2	Soil
	3	Bed rock, fresh fractured tuff
	4	Pinyon, 3', undisturbed
	5	Juniper, 3', undisturbed

0-50-II- 1 Pinyon, 5', undisturbed
2 Pinyon, 15', limb cut from side

0-210-II- 1 Pinyon, 4', undisturbed
2 Pinyon, 20', cut crown

B-1 Juniper, 15', cut branch from dead tree in Blanca area, 1820 ft. north of orchid ground zero.

B-2 Juniper, 20', cut crown from dead tree in Blanca area, 1820 ft. north of orchid ground zero.

B-3 Pinyon, 20', cut crown from dead tree in Blanca area, 1820 ft. north of orchid ground zero.

B-4 Pinyon, 15', cut limb from dead tree in Blanca area, + 1820 ft. north of orchid ground zero.

0-90-IV- 2 Gambel oak (quercus gambelii) 4' tall, undisturbed. +

NOTE: * not sampled during 20-28 June 1961
+ not sampled during 23 February-9March 1961

Antler Area

A-1 Pinyon - small 50 yards west of antler ground zero

A-2 Pinyon - medium 50 yards west of antler ground zero

A-3 Pinyon - medium 100 yards west of antler ground zero

A-4 Scrub Juniper - 100 yards west of antler ground zero

A-5 Pinyon - small 150 yards west of antler ground zero

A-6 Pinyon - large 300 yards west of antler ground zero

A-7 Pinyon - limb off half-dead tree 300 yards west of antler ground zero

CARLSBAD, NEW MEXICO SITE

G-60II- 1 Yucca (Yucca glanca)*
2 Sagebrush*

G-95II- 1 Mesquite*
2 Sagebrush

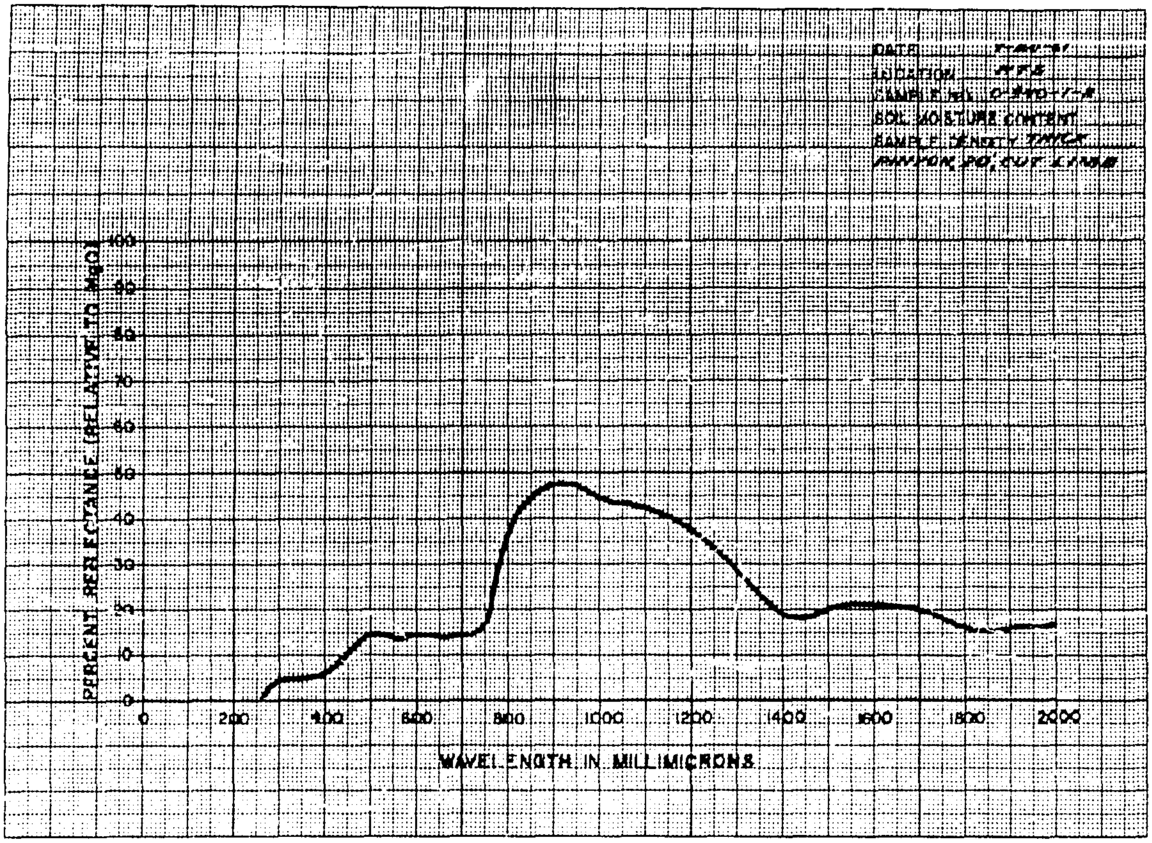
G-140II-1 Scrub oak*
2 Yucca

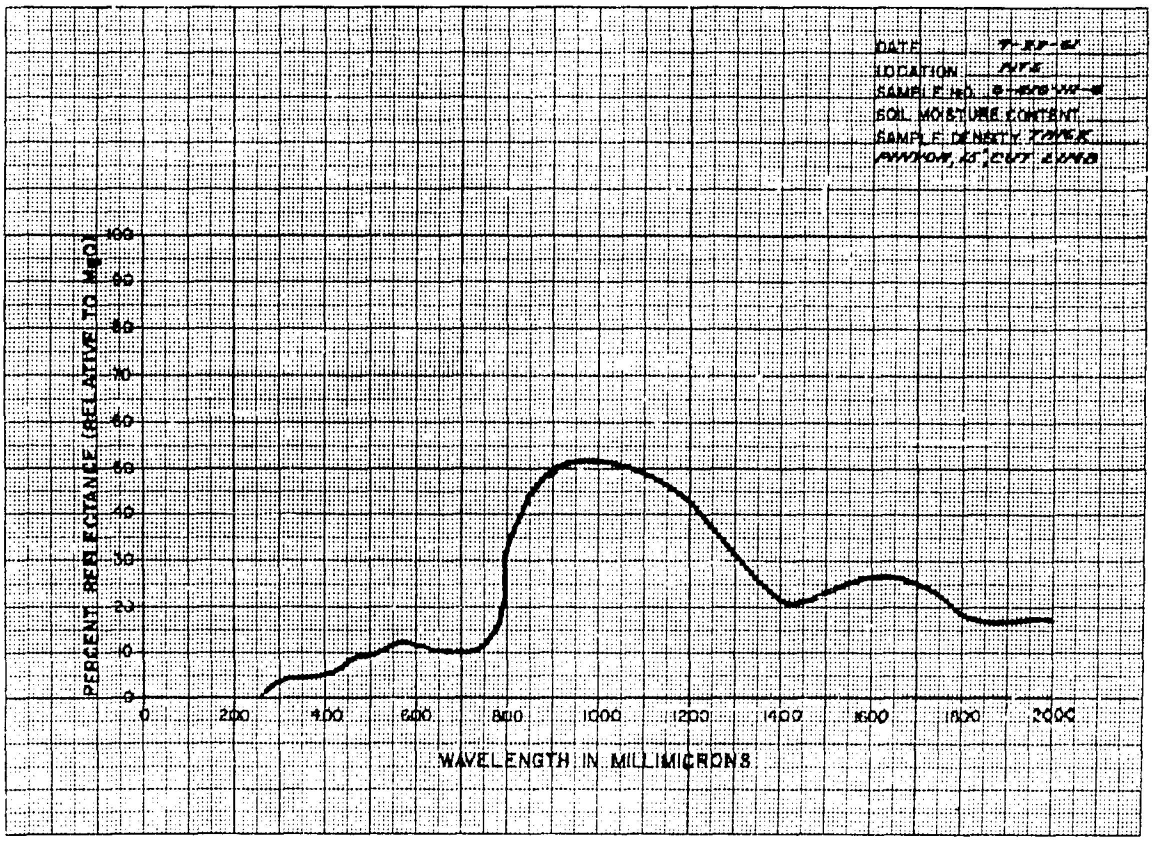
G-160II-1	Mesquite*	
2	Scrub oak✯	
G-285II-1	Sagebrush	
2	Yucca	
G-1 mile-1	Sagebrush	
2	Yucca	

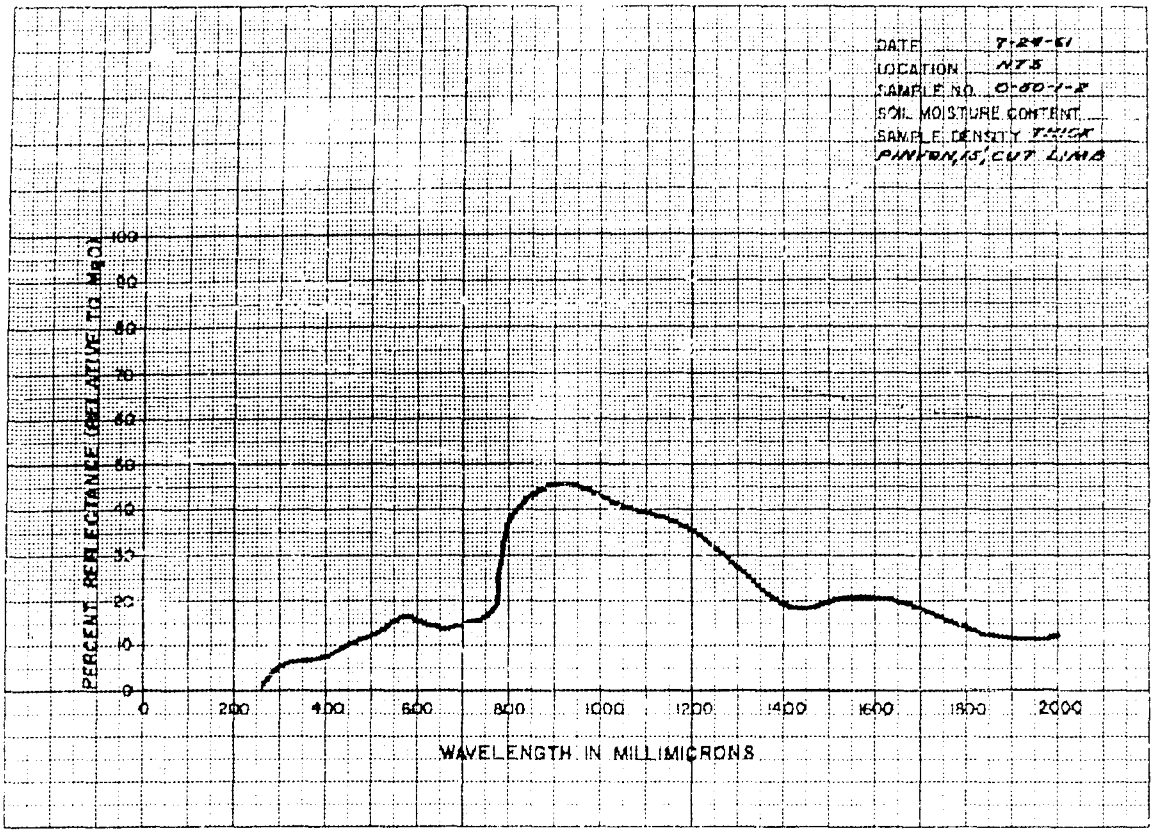
* not sampled during December 1961

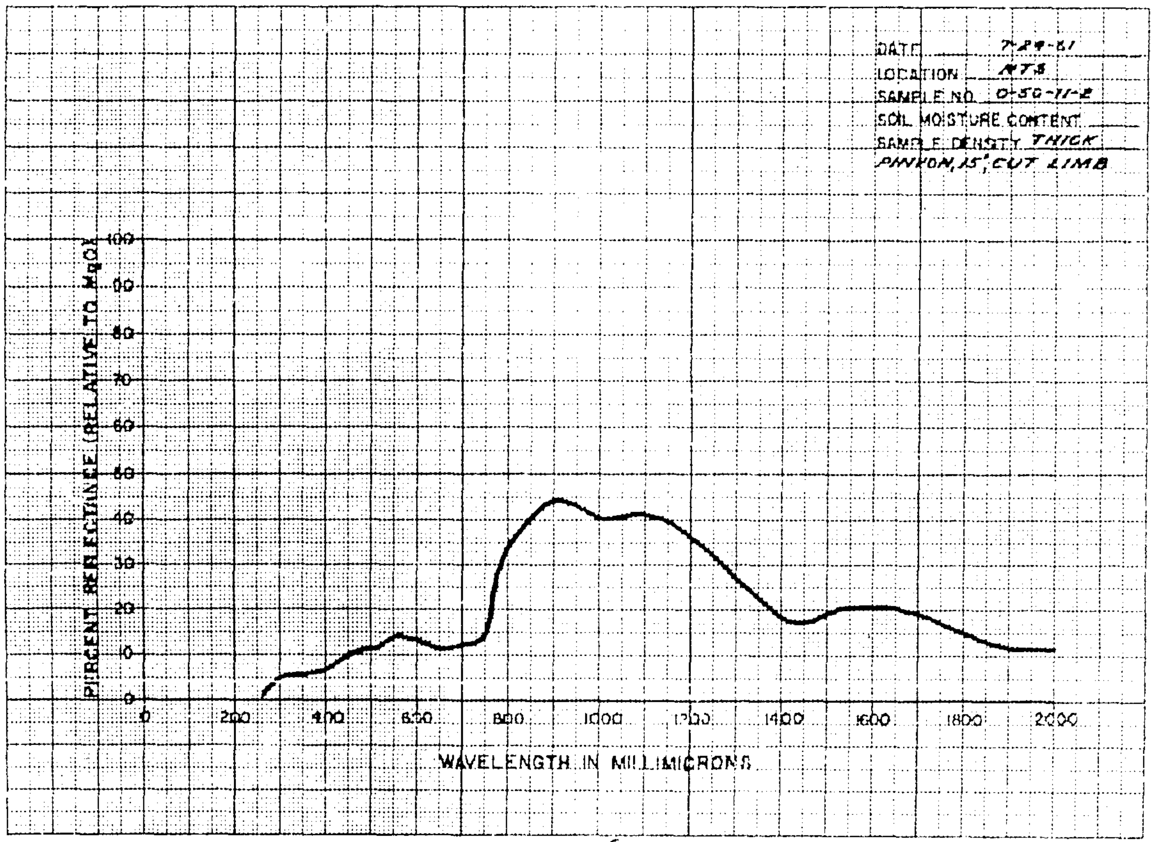
✯ sample site eventually obliterated by post-shot activities

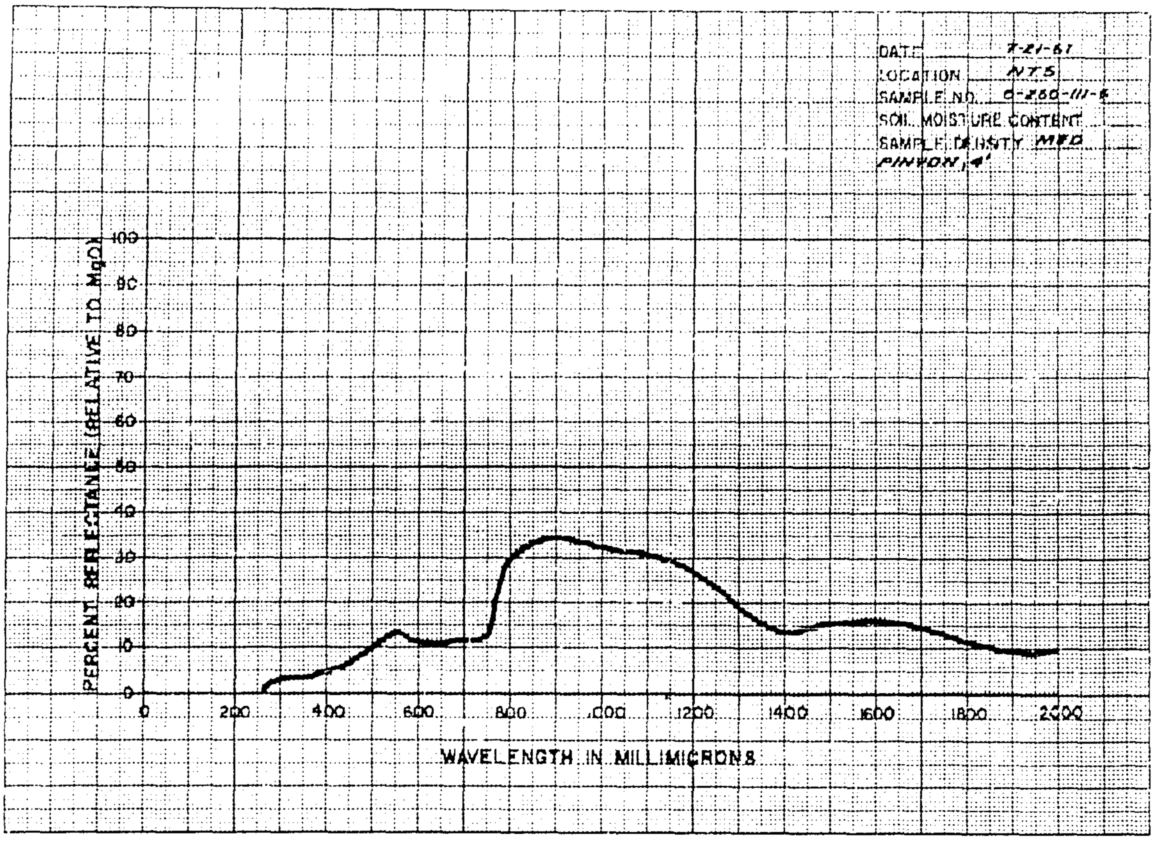
APPENDIX II

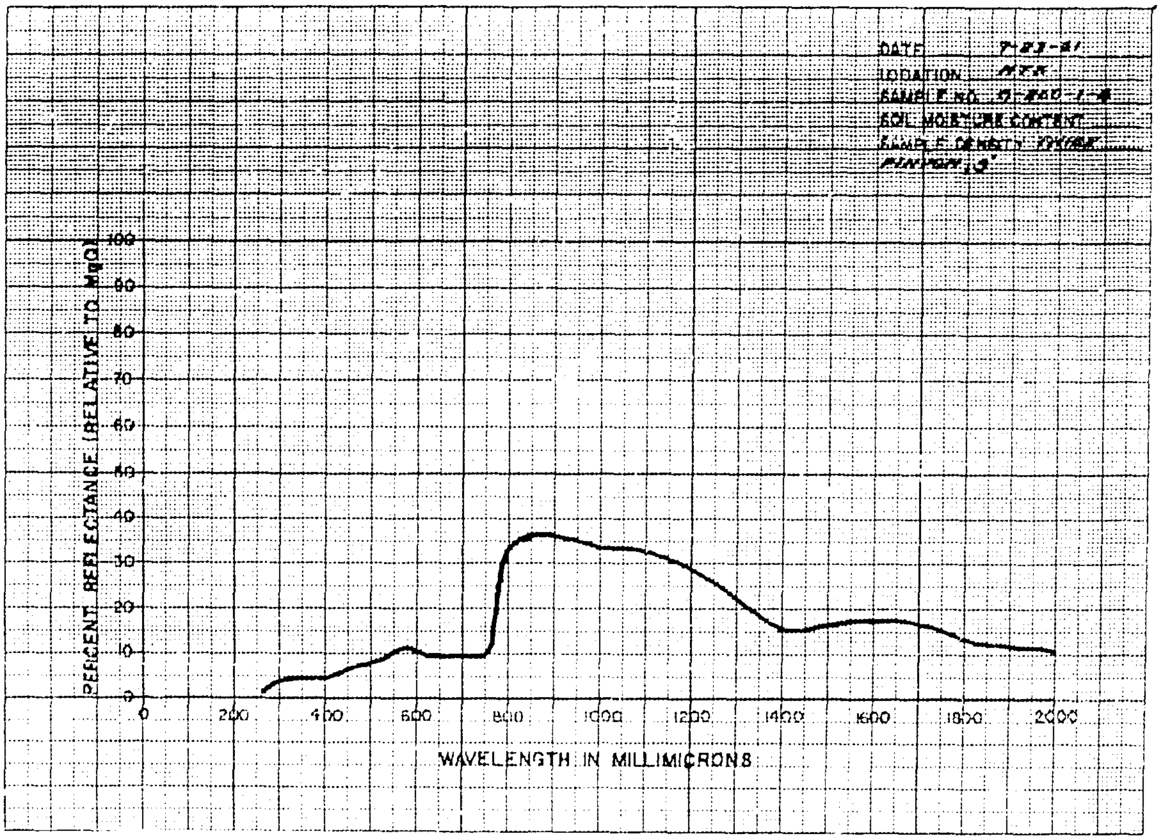

DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY THICK
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

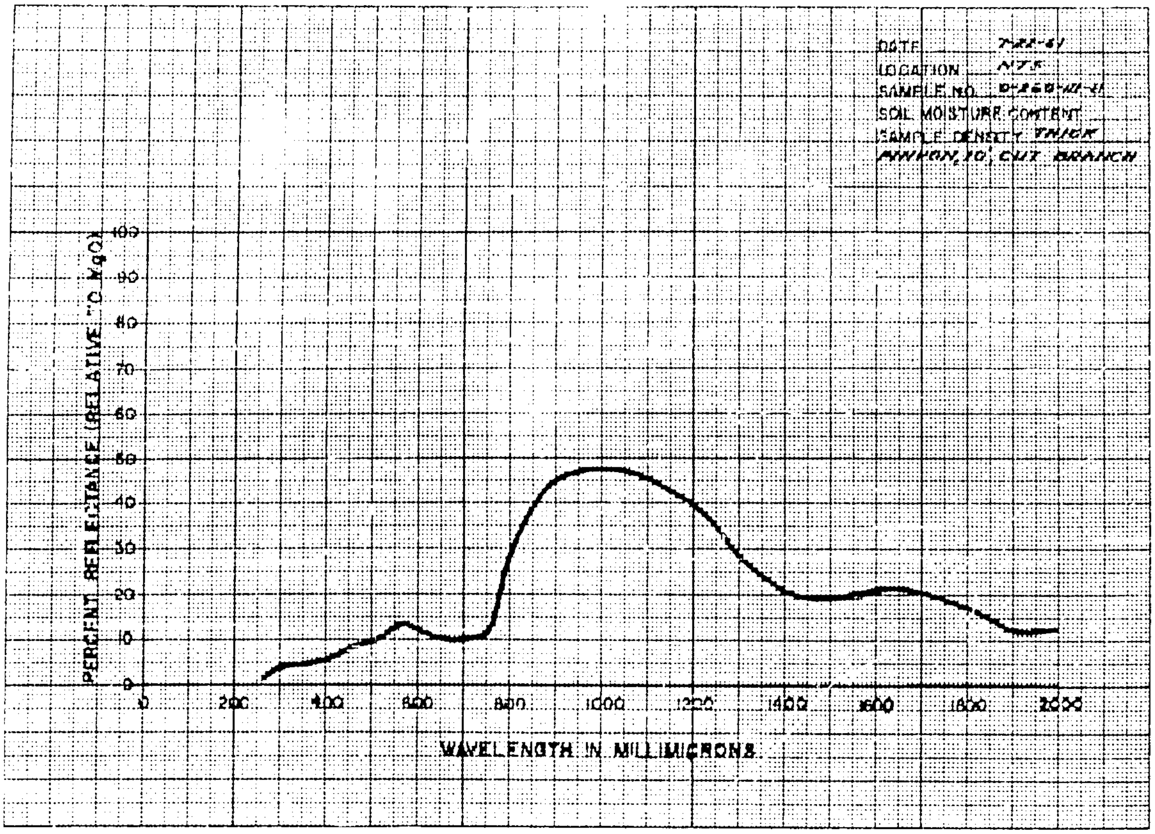

DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY THICK
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

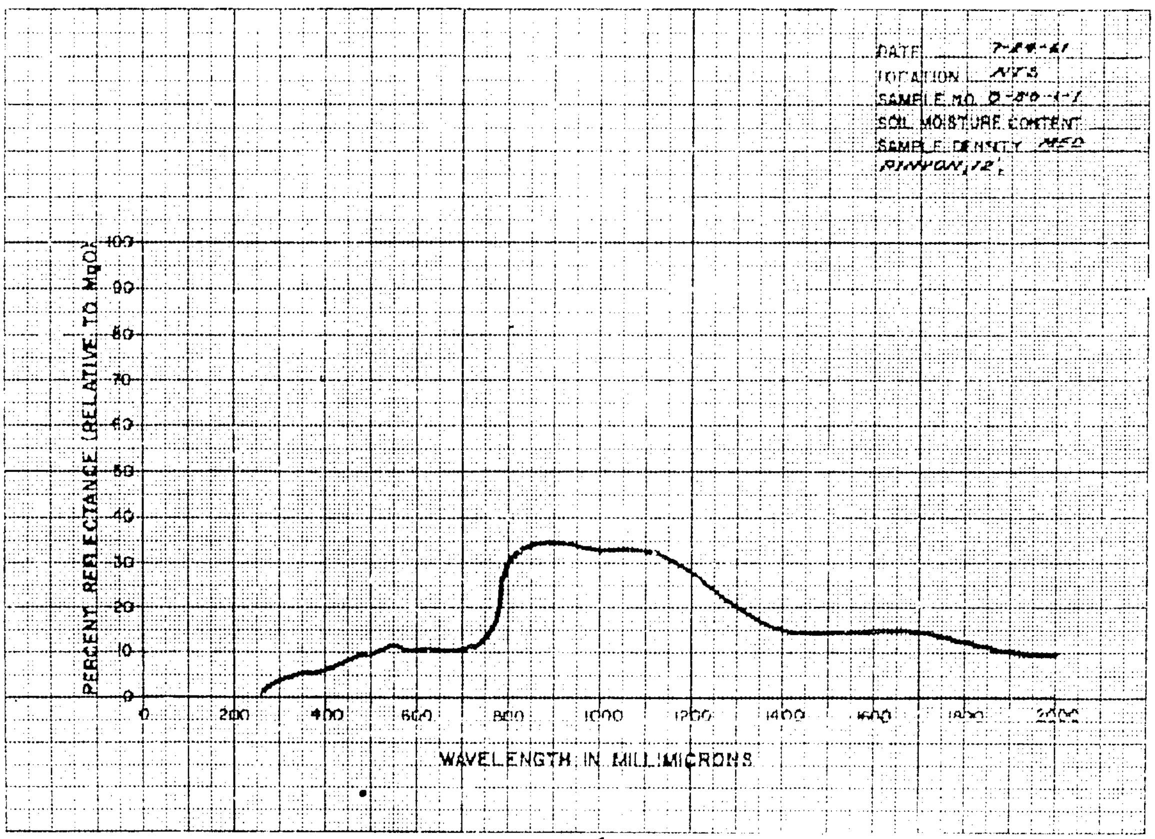

DATE 7-24-61
LOCATION NTS
SAMPLE NO. O-60-1-2
SOIL MOISTURE CONTENT
SAMPLE DENSITY THICK
PINYON, 15', CUT LIMB
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MILLIMICRONS

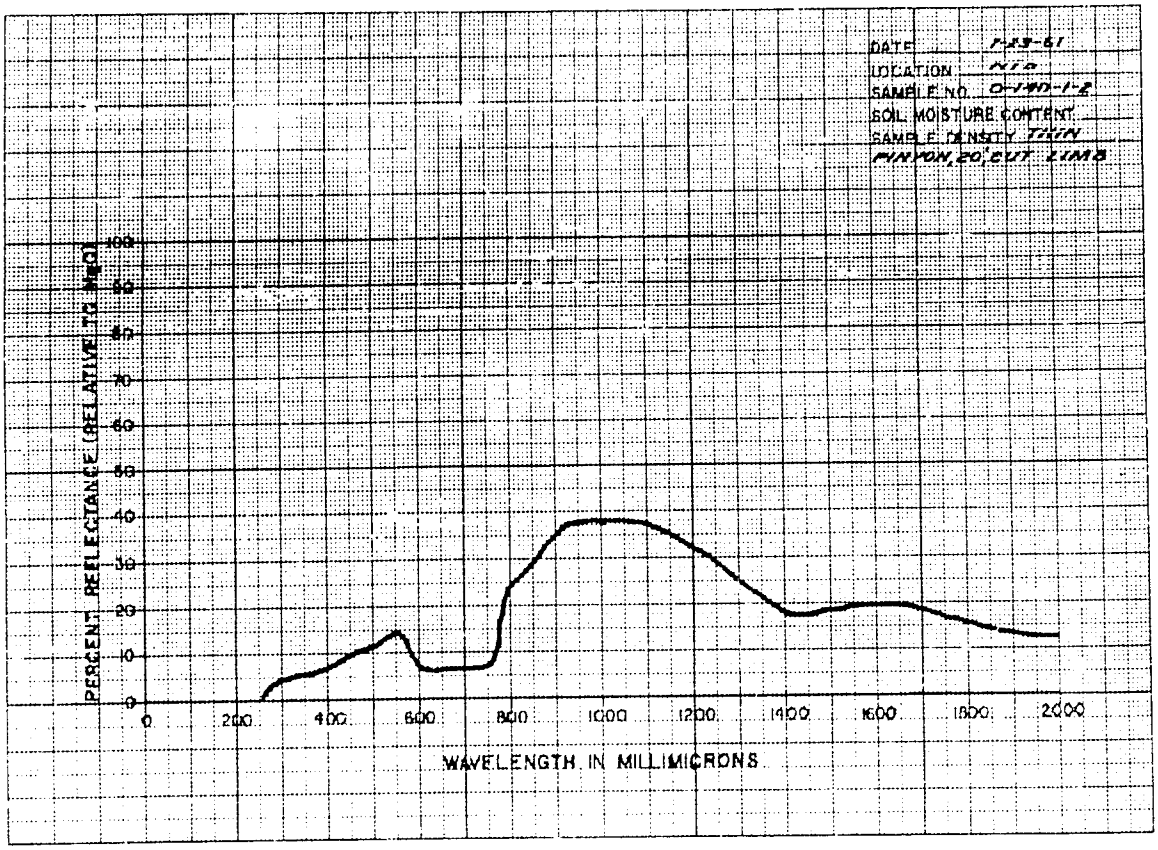

DATE 7-24-61
LOCATION NTS
SAMPLE NO. O-50-11-2
SOIL MOISTURE CONTENT
SAMPLE DENSITY THICK
PINYON, 15', CUT LIMB
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MILLIMICRONS

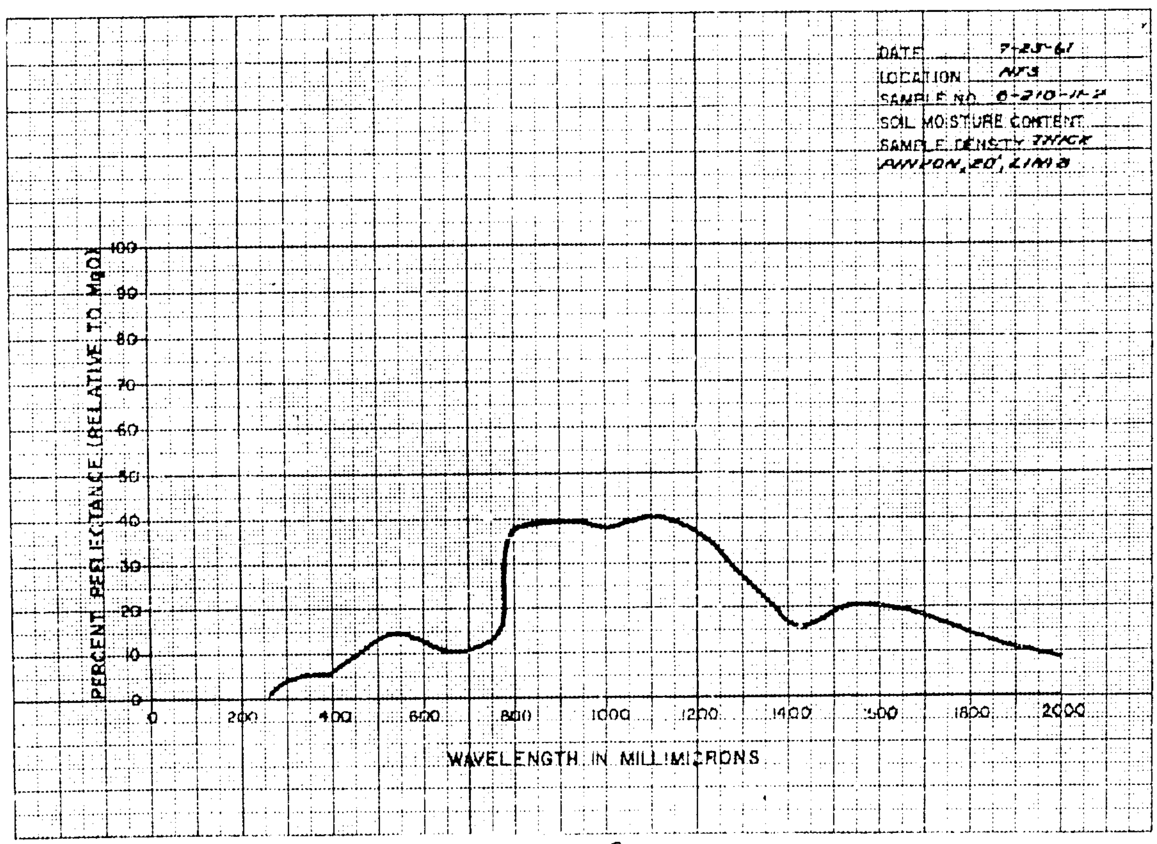

DATE 7-21-61
LOCATION NTS
SAMPLE NO. 9-260-111-6
SOIL MOISTURE CONTENT
SAMPLE DENSITY MED
PINYON, 4'
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

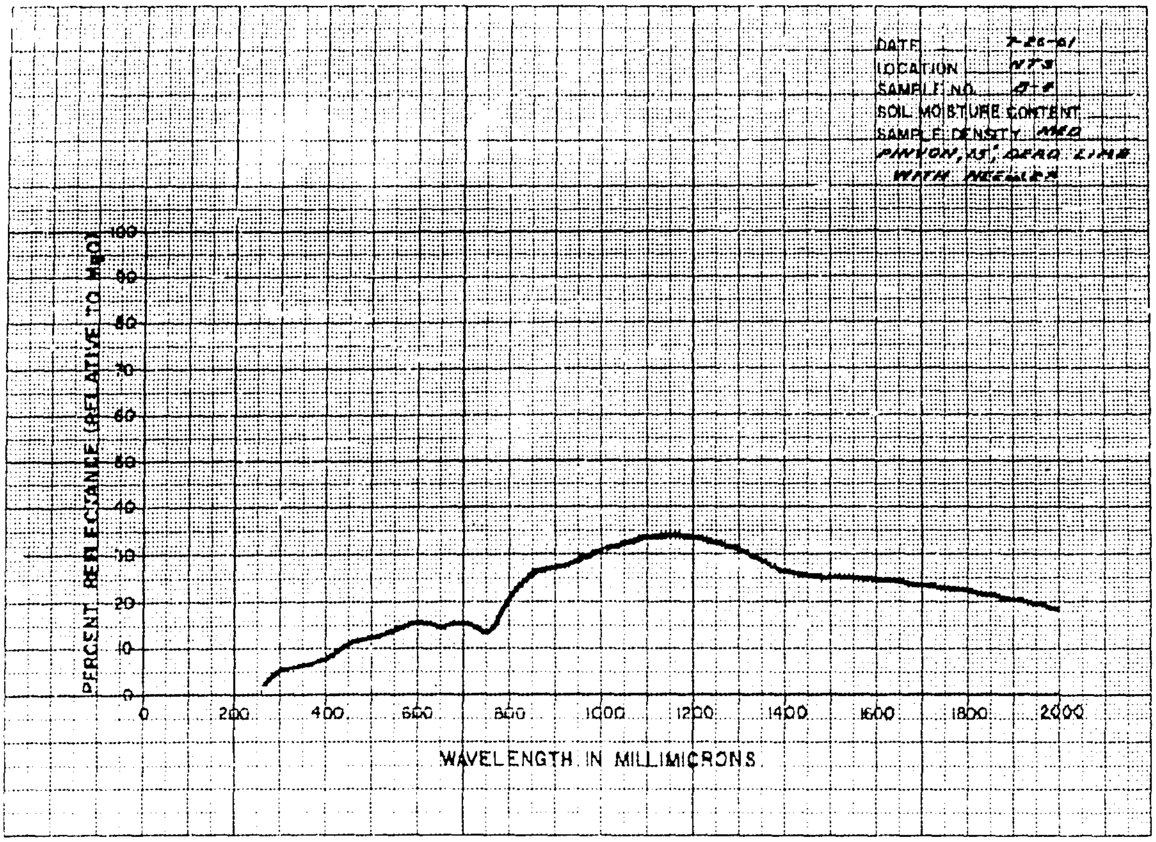

DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

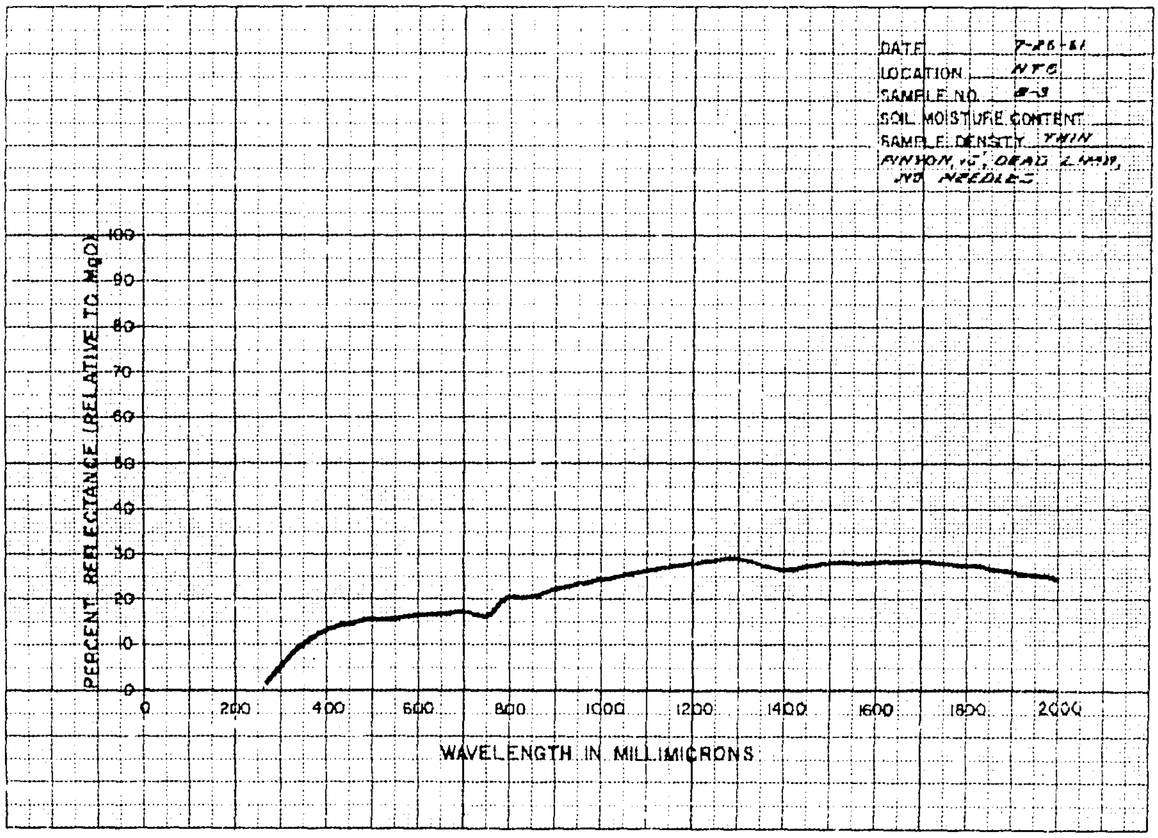

DATE
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY THICK
PINYON, 10', CUT BRANCH
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

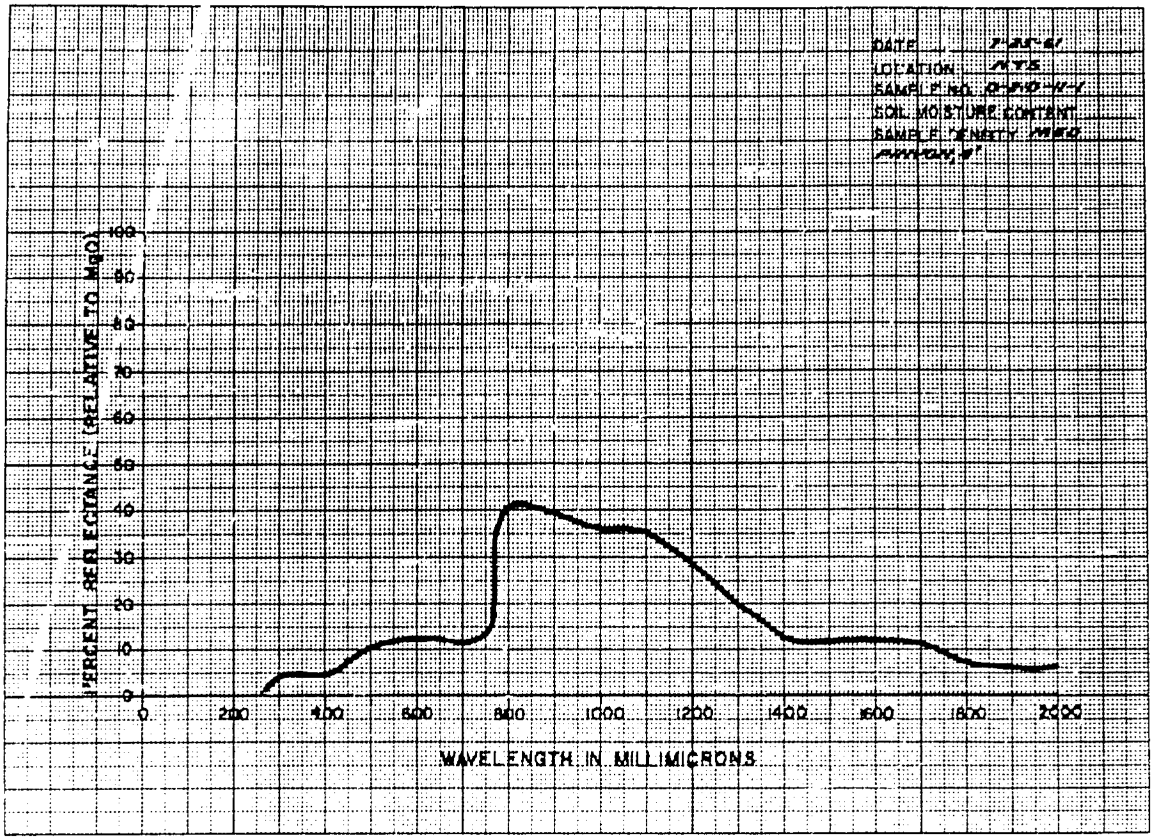

DATE
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY MED
PINYON, 12'
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

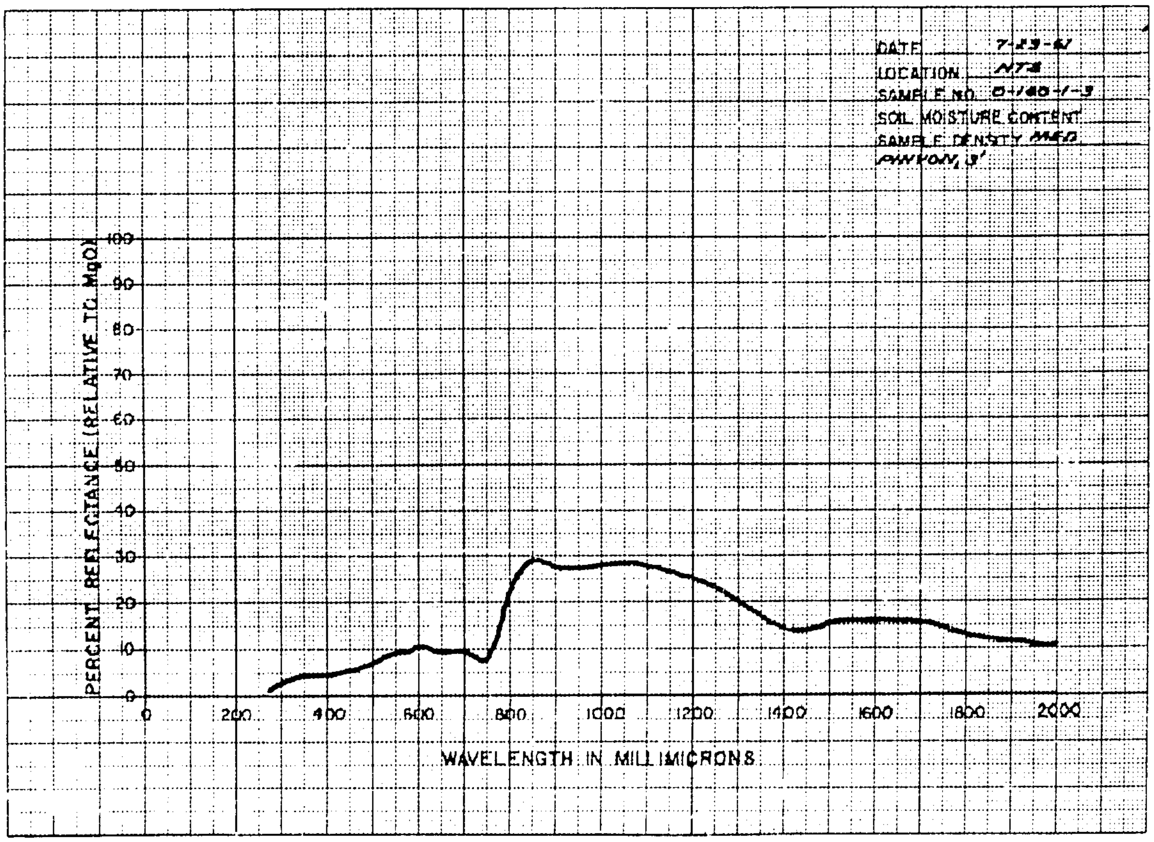

DATE 7-23-61
LOCATION N-10
SAMPLE NO. 0-140-1-2
SOIL MOISTURE CONTENT
SAMPLE DENSITY THIN
PINYON, 20', CUT LIMB
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

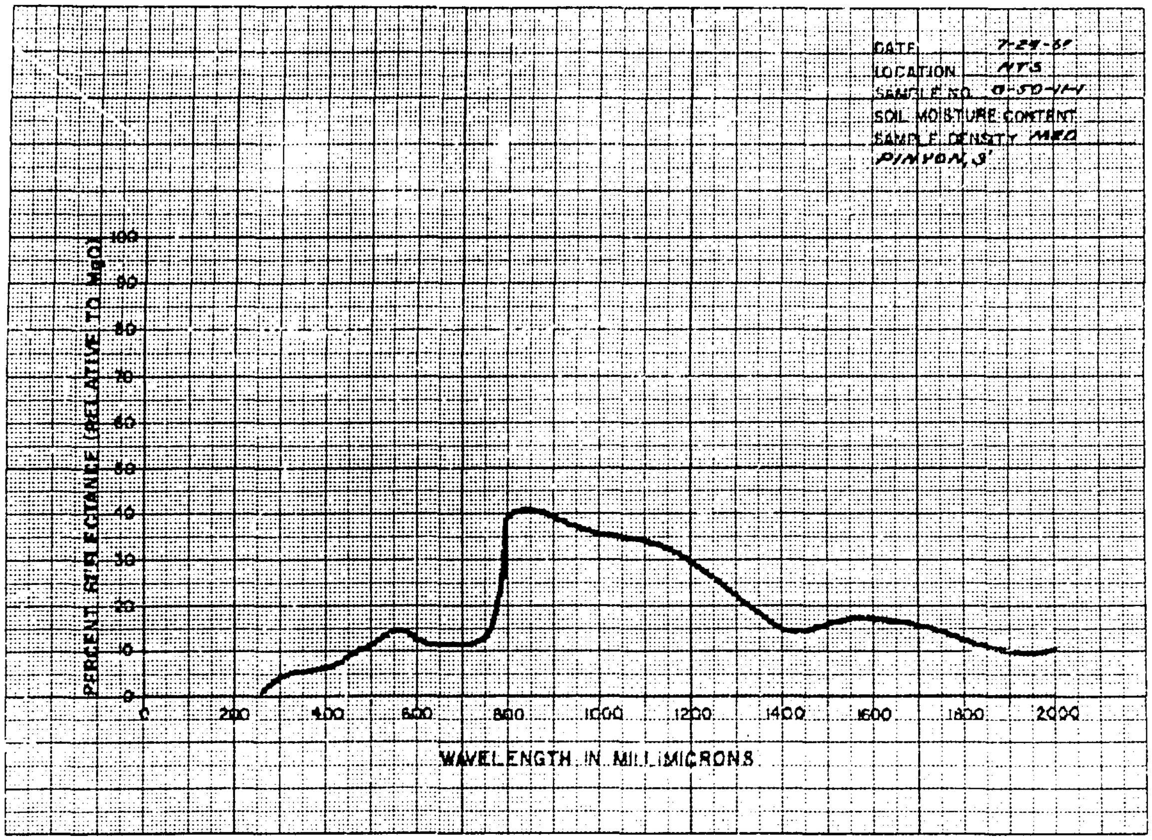

DATE 7-25-61
LOCATION N-3
SAMPLE NO. 0-210-11-2
SOIL MOISTURE CONTENT
SAMPLE DENSITY THICK
PINYON, 20', LIMB
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

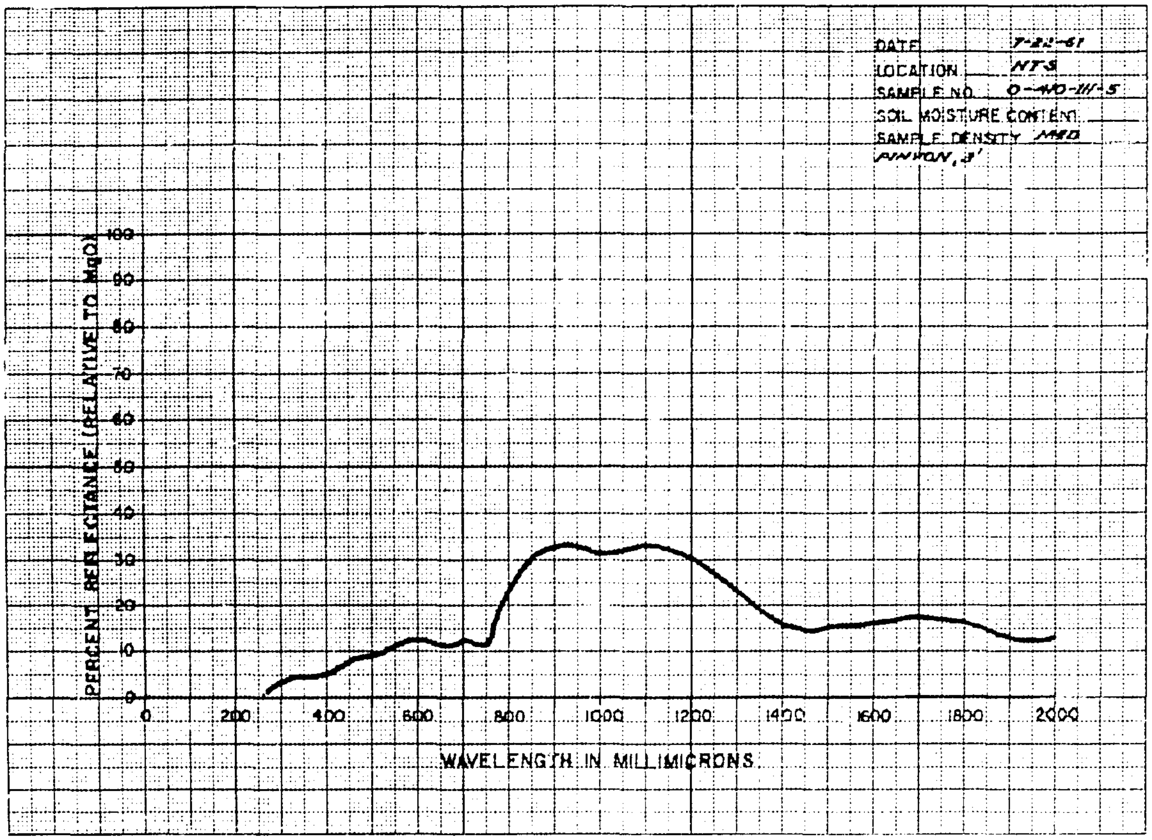

DATE 7-26-61
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY MED
PINYON, DEAD LIMB
WITH NEEDLES
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

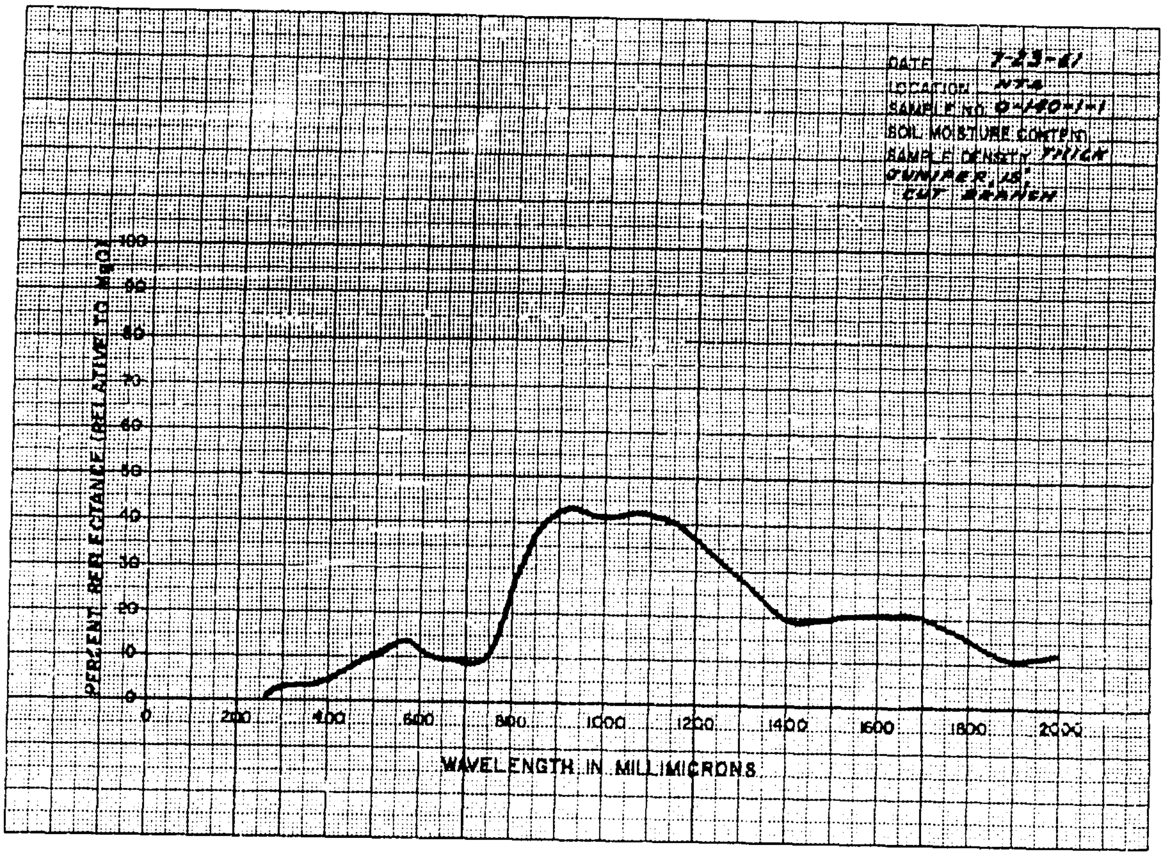

DATE 7-26-61
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY THIN
PINYON, DEAD LIMB,
NO NEEDLES
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

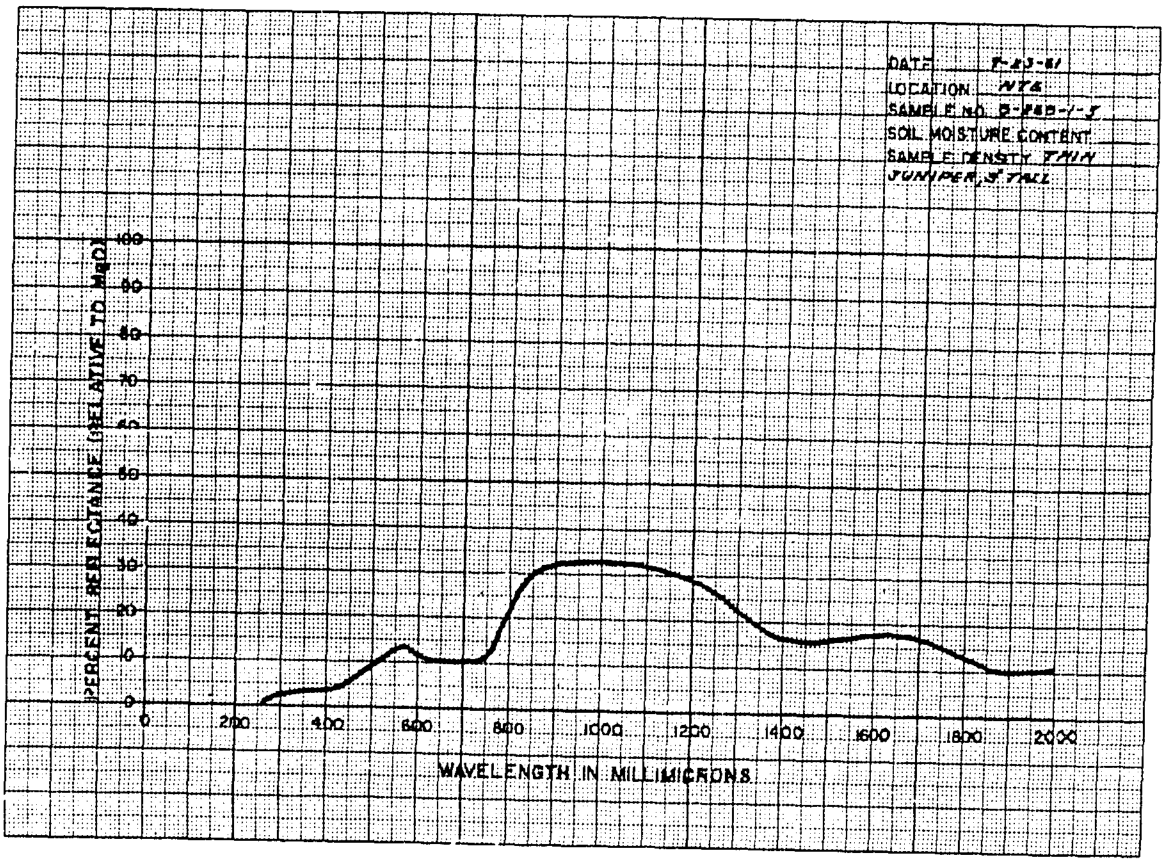

DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

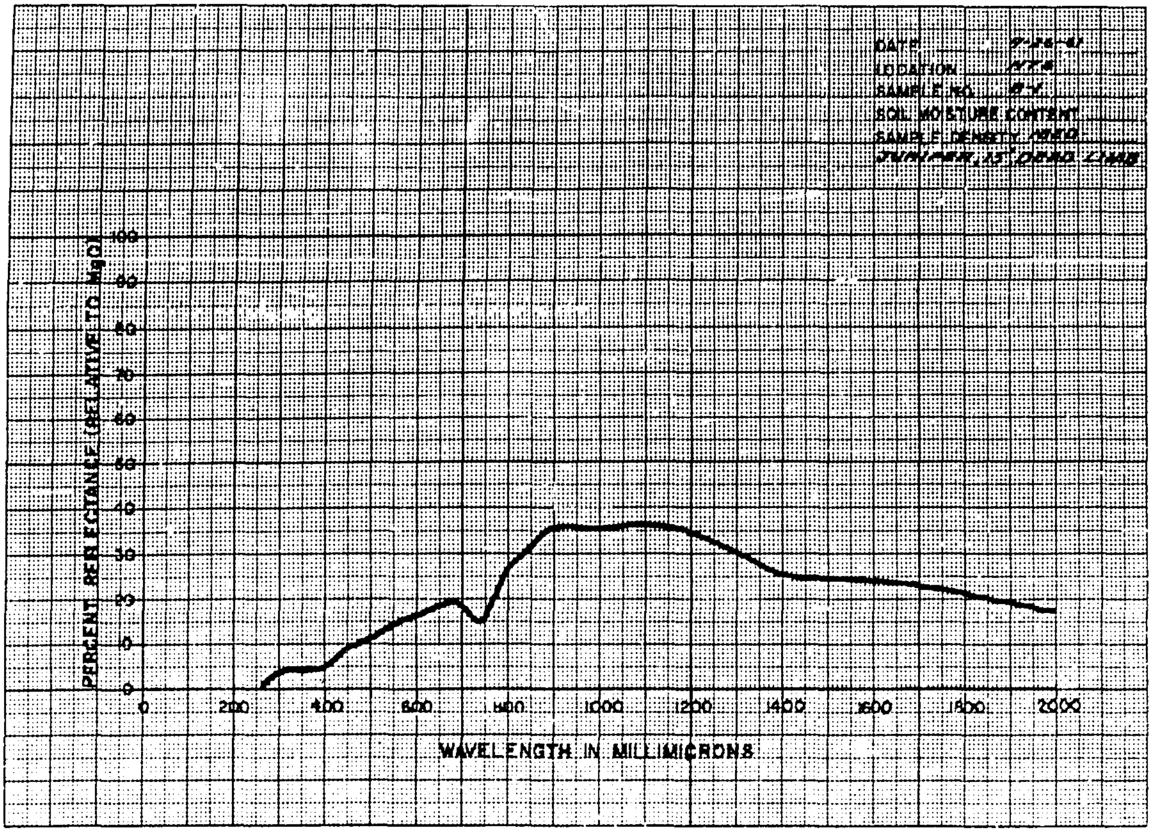

DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

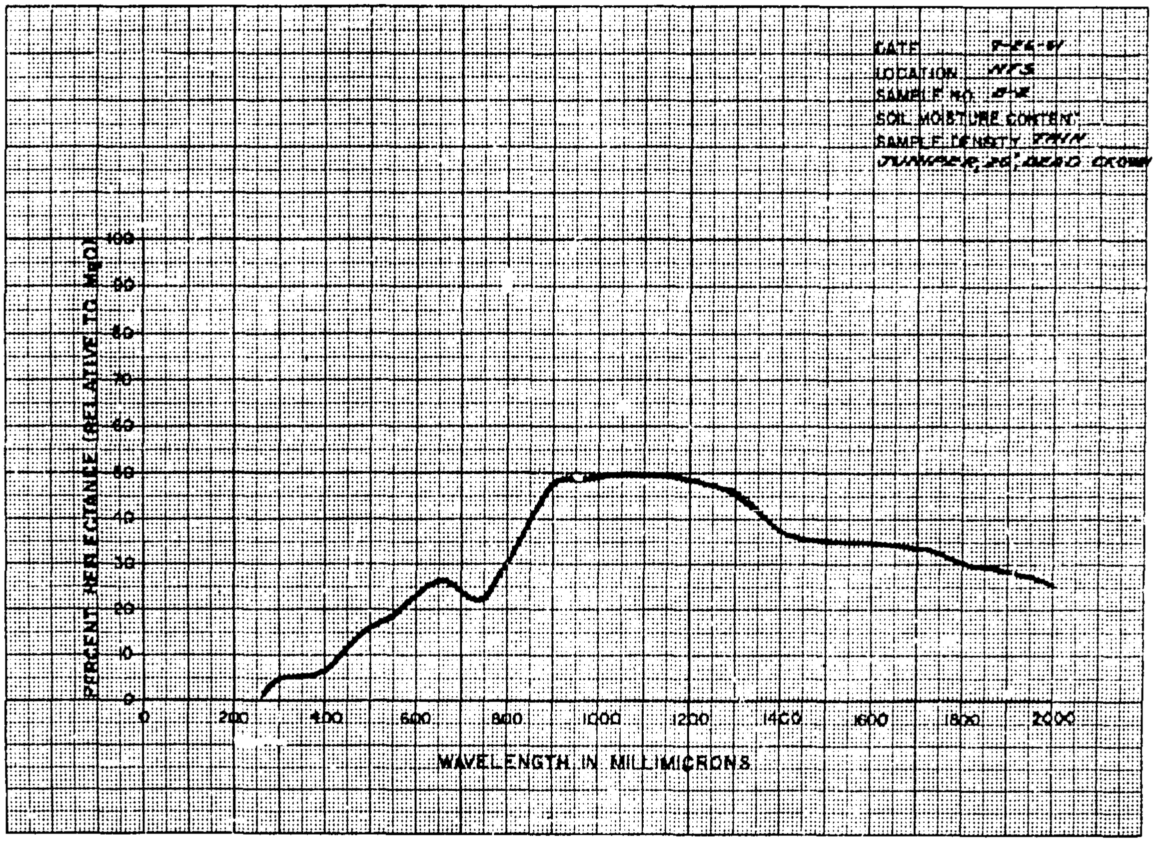

DATE 7-24-61
LOCATION NTS
SAMPLE NO. 0-50-I-1
SOIL MOISTURE CONTENT
SAMPLE DENSITY MED
PINYON, 3'
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

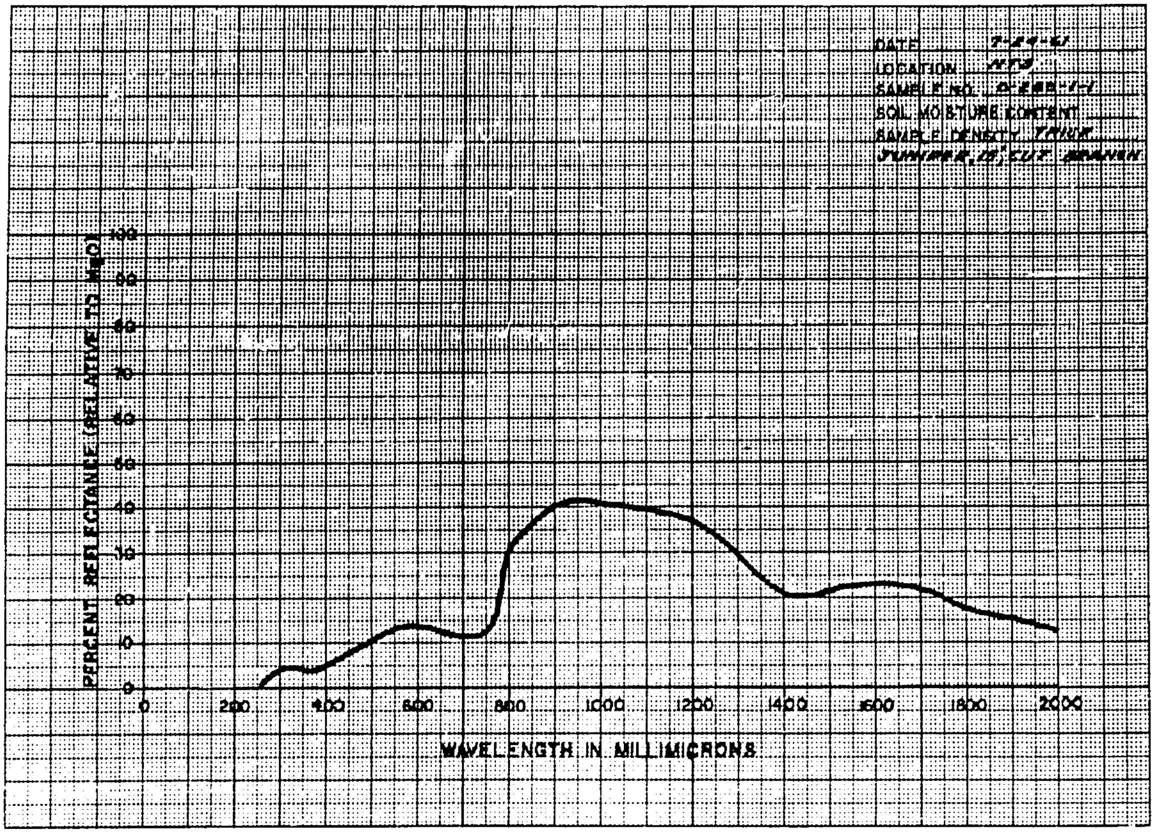

DATE 7-22-61
LOCATION NTS
SAMPLE NO. 0-40-III-5
SOIL MOISTURE CONTENT
SAMPLE DENSITY MED
PINYON, 3'
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS


DATE 7-23-61
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY THICK
JUNIPER, 15'
CUT BRANCH
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

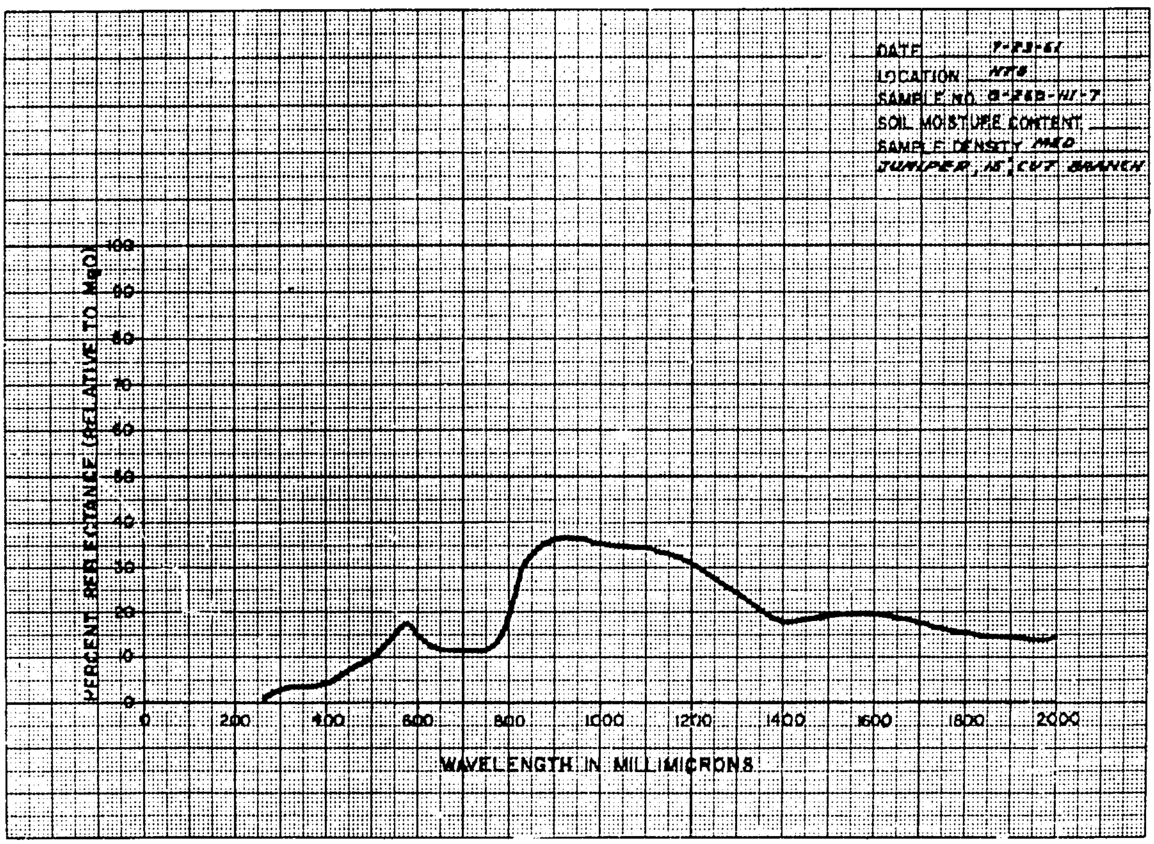

DATE 7-23-61
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY THIN
JUNIPER, 5' TALL
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS


DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

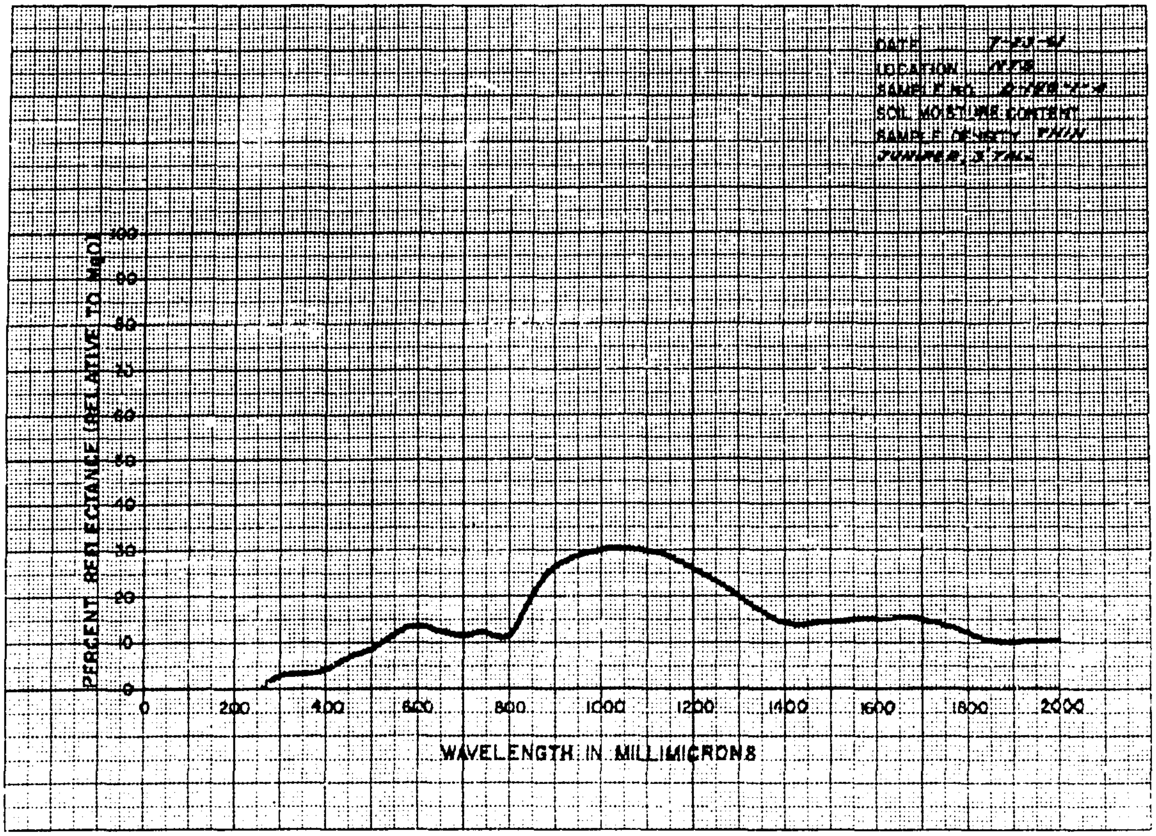

DATE
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY THIN
JUNIPER, 25', DEAD CROWN
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

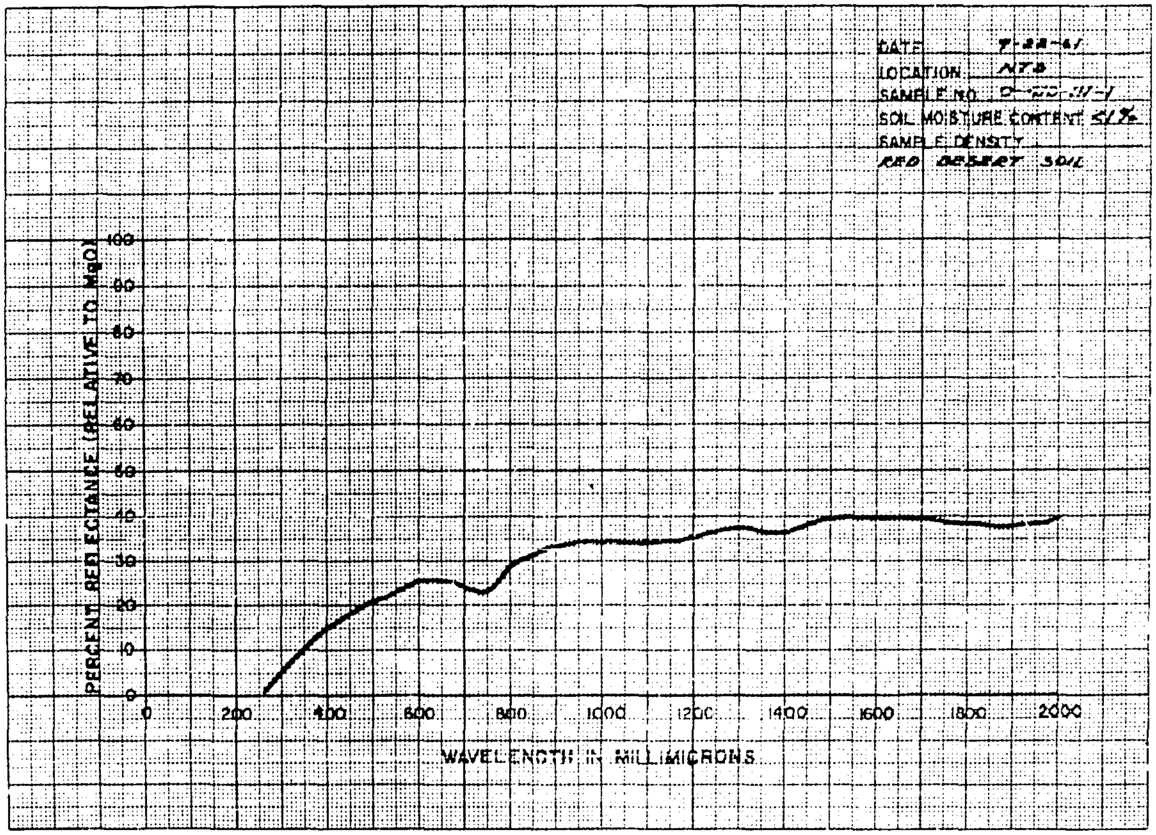


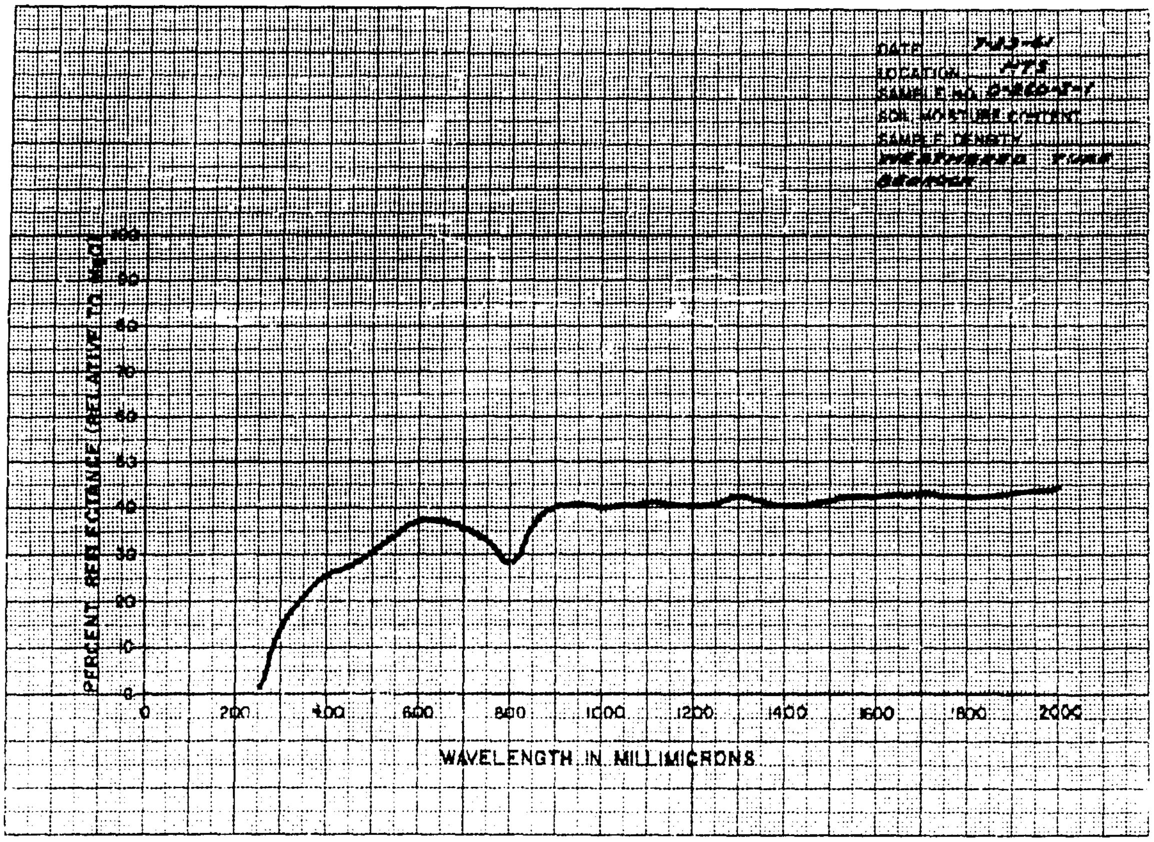
DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY THICK
JUNIPER, 15' CUT BRANCH
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS



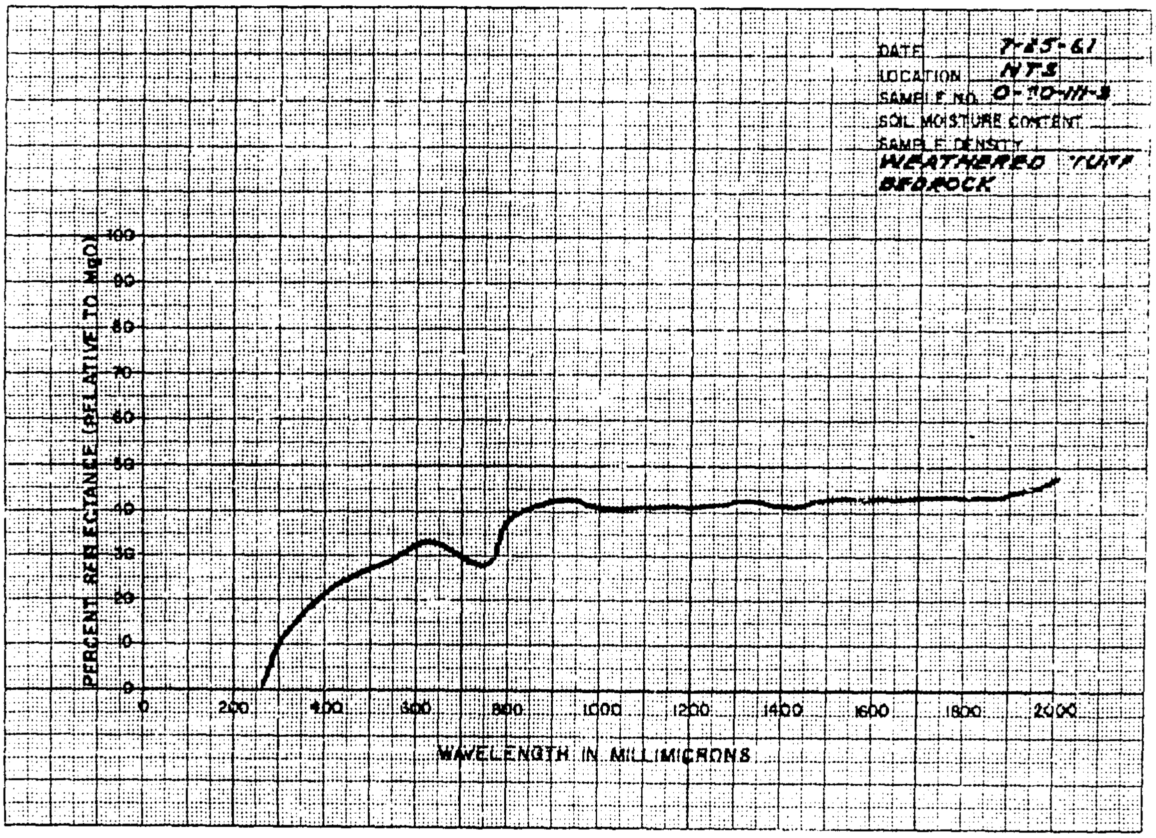
DATE
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY MED
JUNIPER, 15' CUT BRANCH
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS


DATE
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY THIN
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

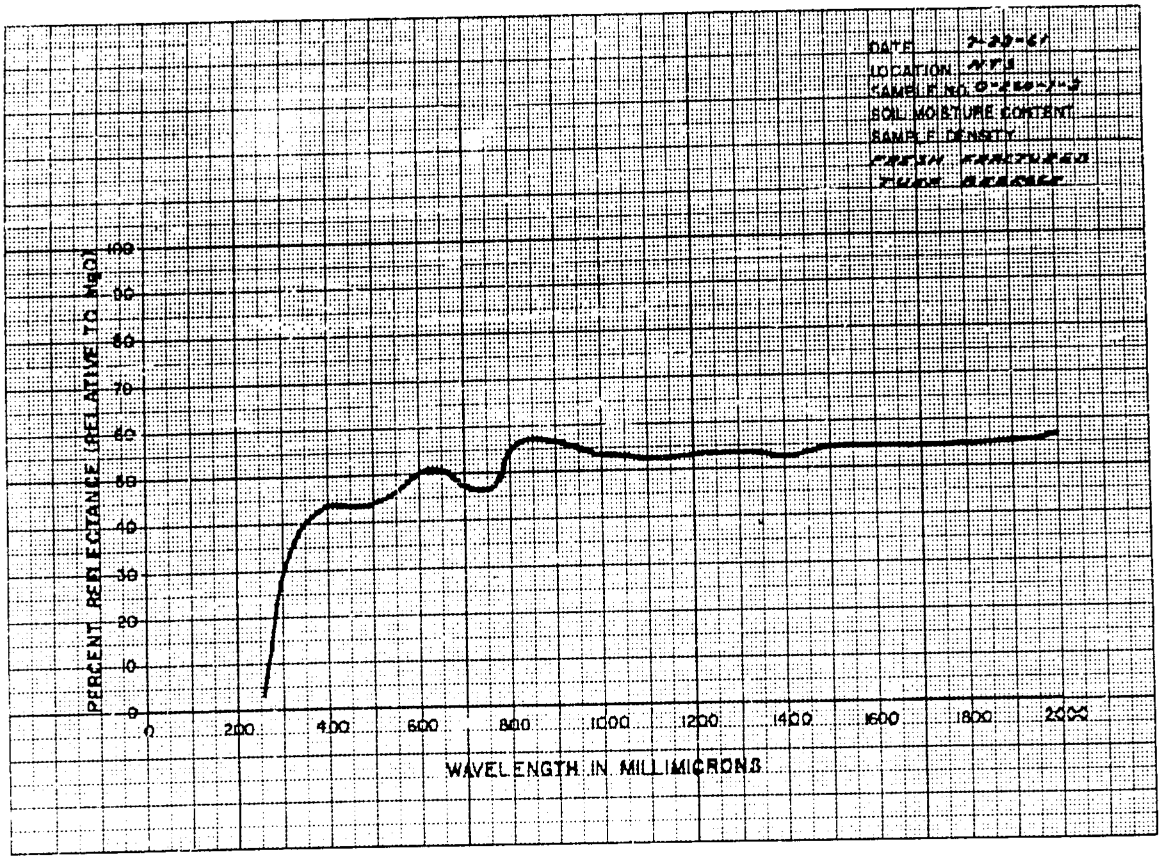

DATE
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT <1%
SAMPLE DENSITY
RED DESERT SOIL
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

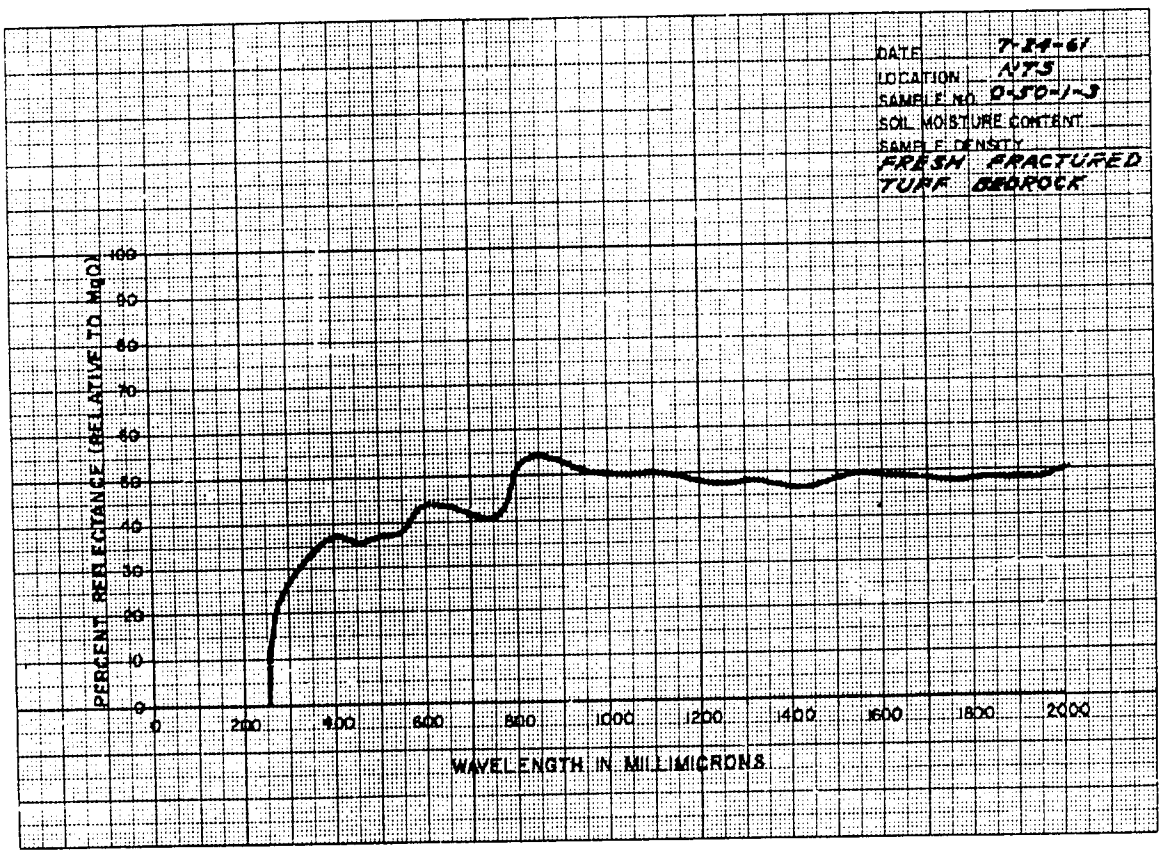


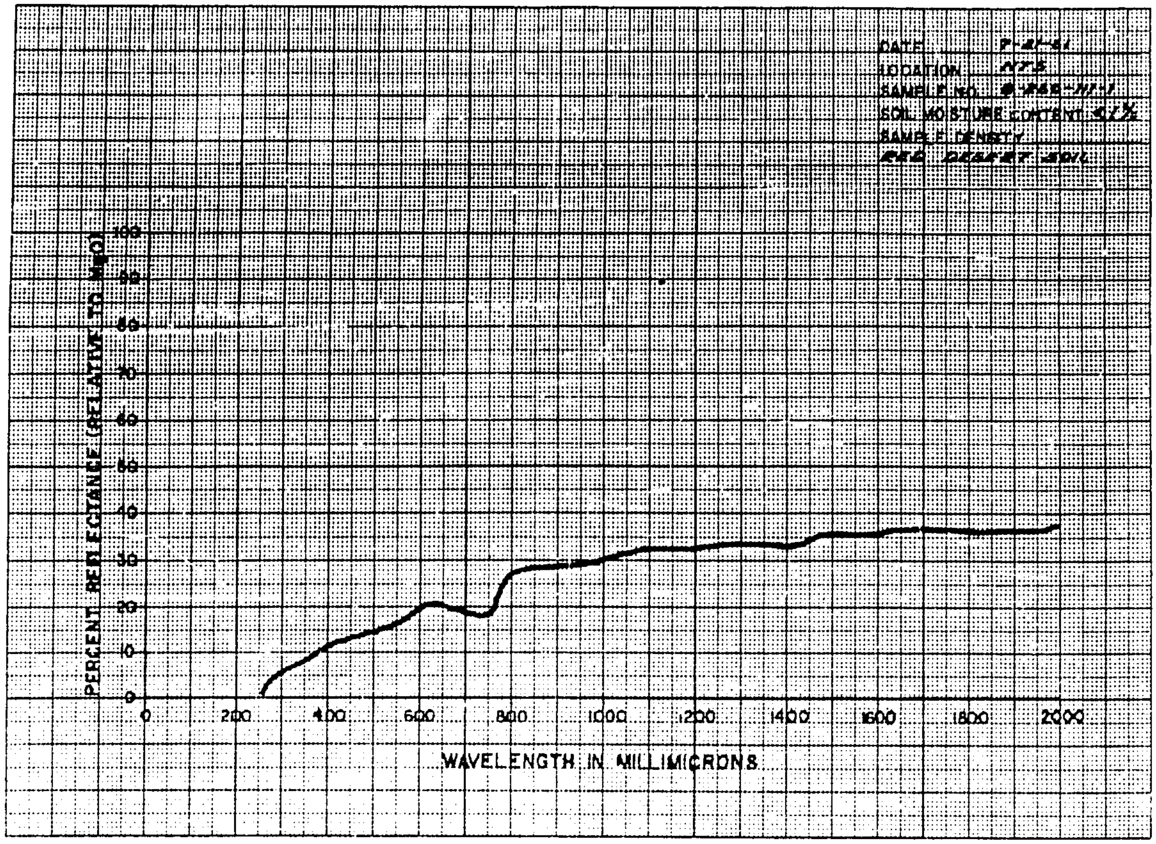
DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

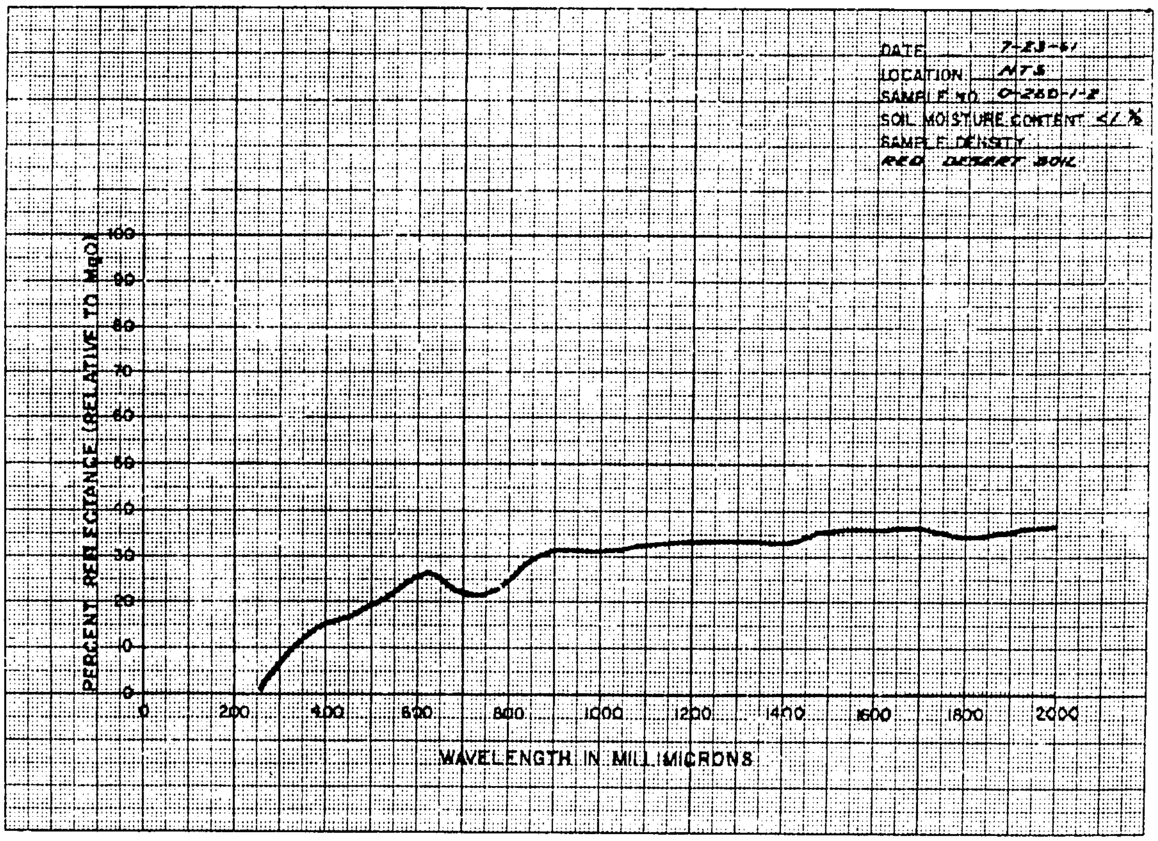


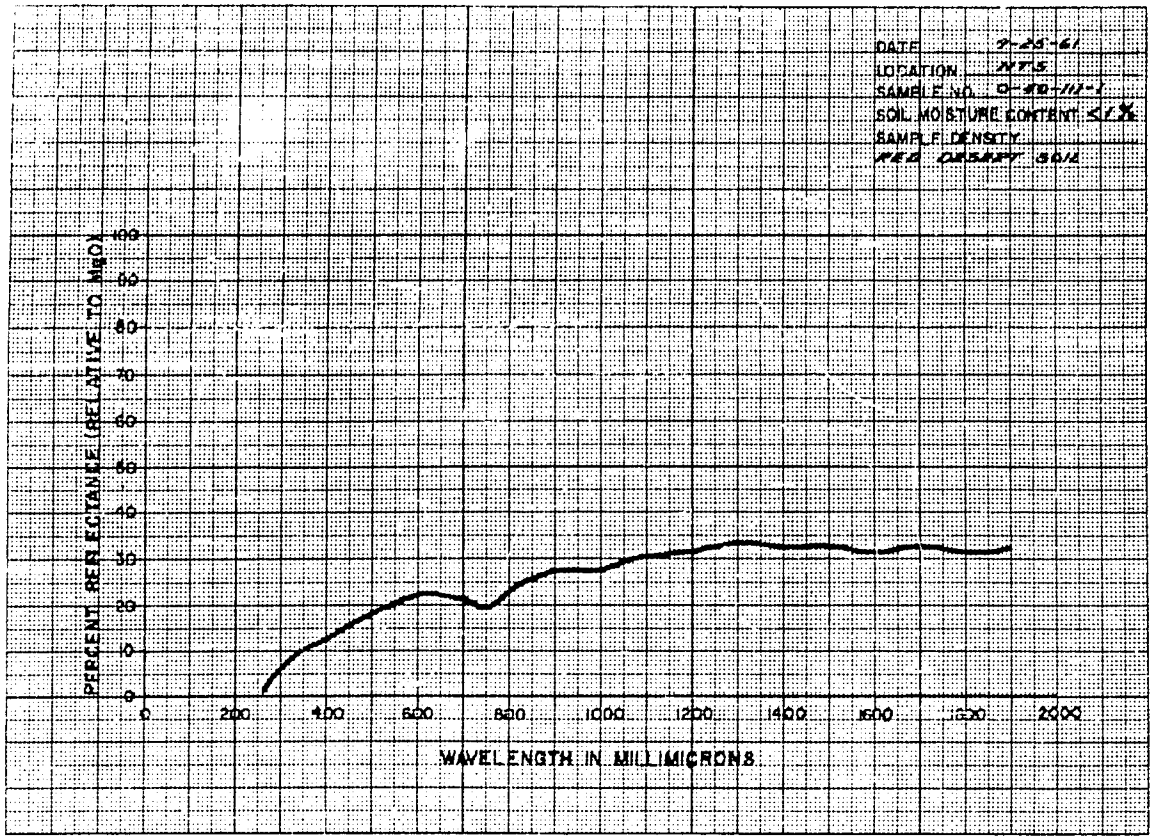
DATE 7-25-61
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
WEATHERED TUFF
BEDROCK
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

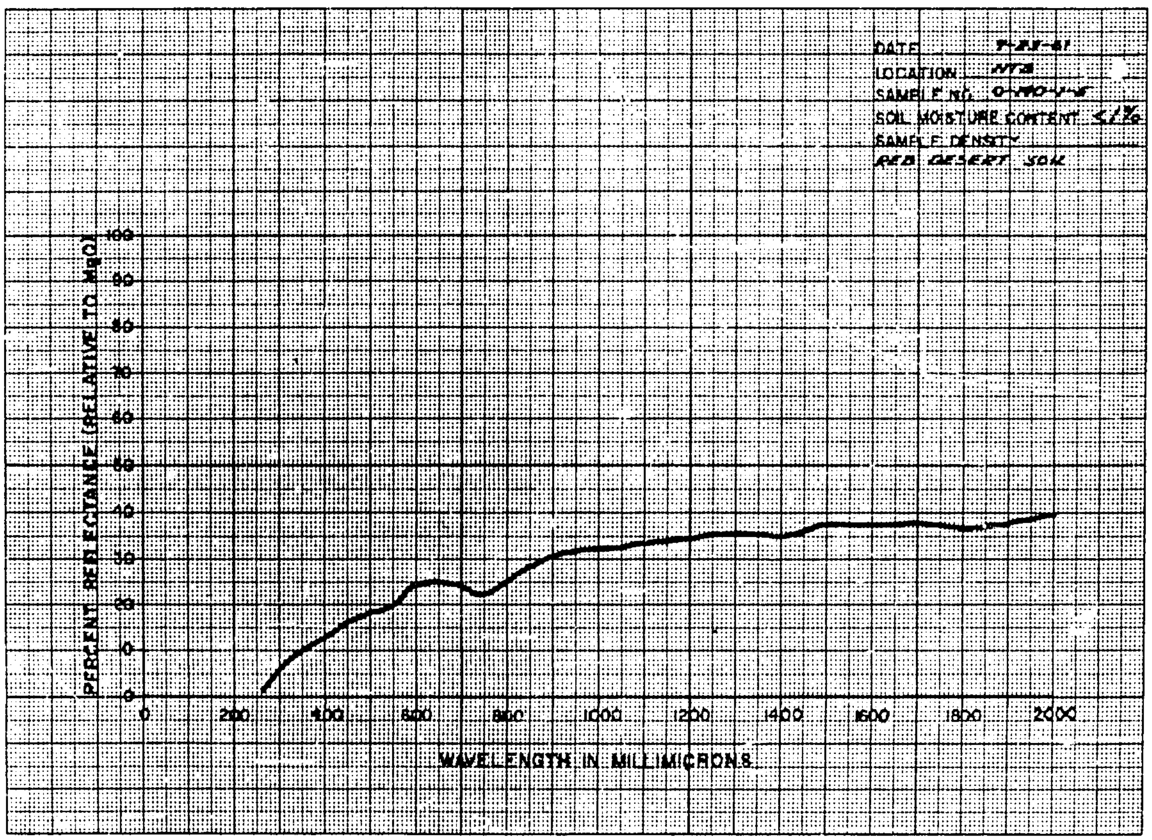

DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

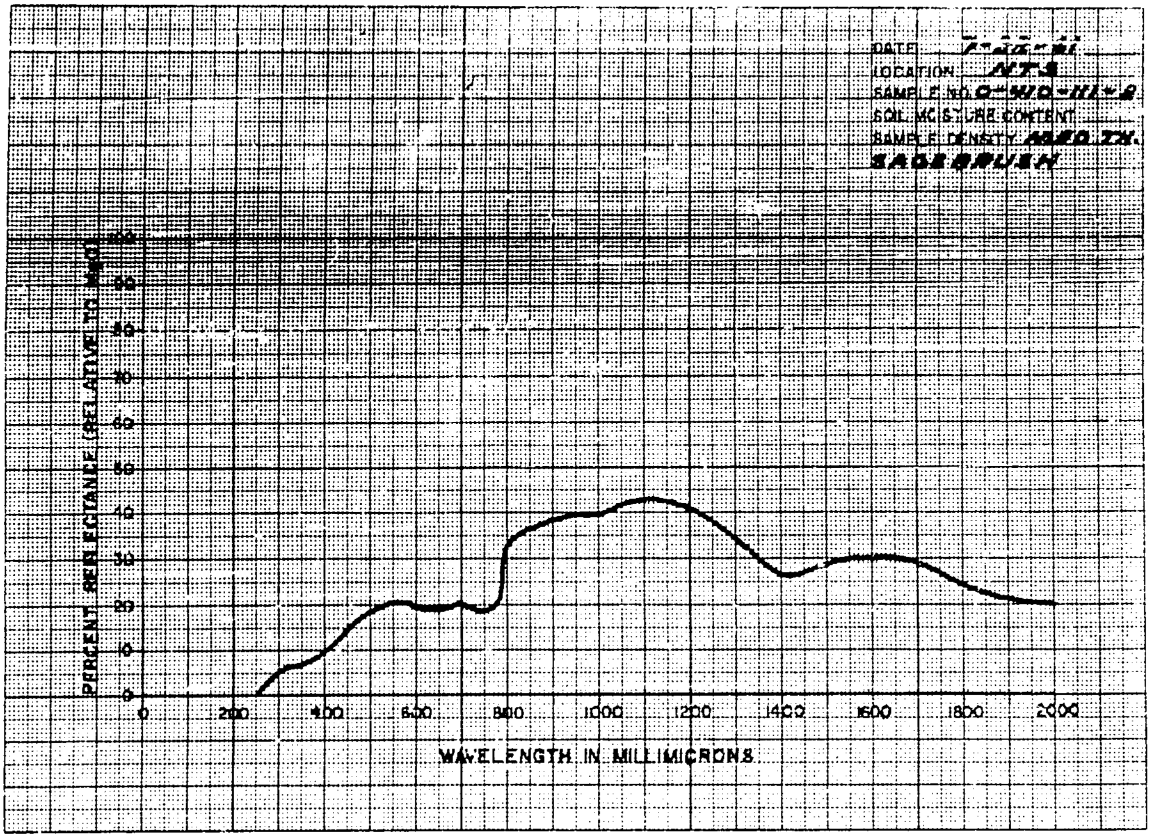

DATE 7-24-61
LOCATION NTS
SAMPLE NO. 0-50-1-3
SOIL MOISTURE CONTENT
SAMPLE DENSITY
FRESH FRACTURED
TUFF BEDROCK
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

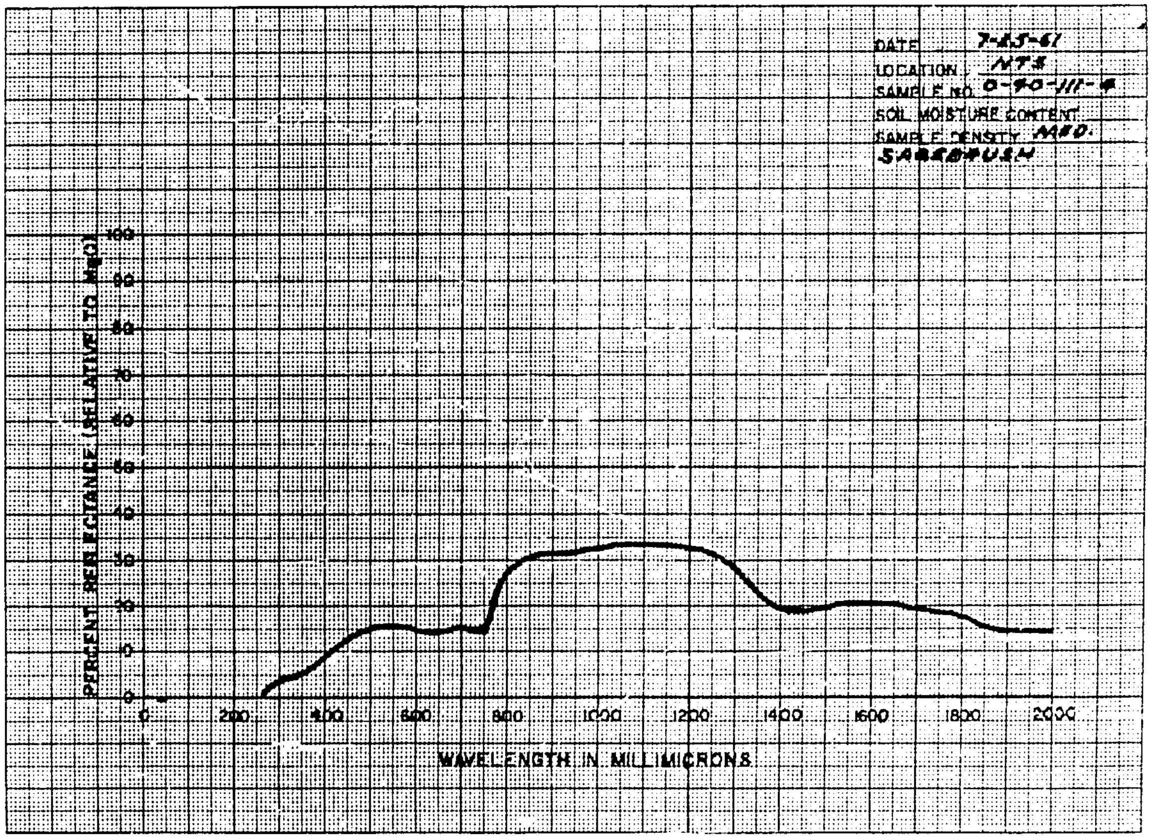

DATE
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT <1%
SAMPLE DENSITY
RED DESERT SOIL
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

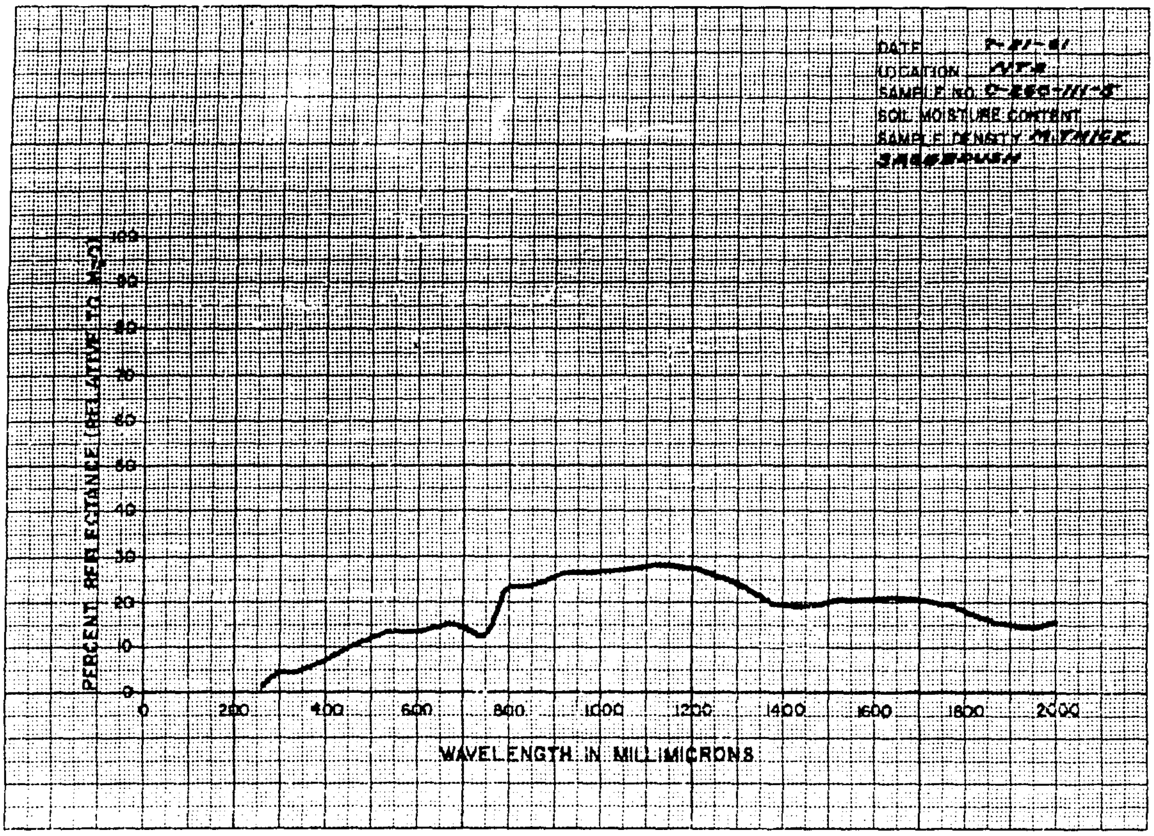

DATE 7-23-61
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT <1%
SAMPLE DENSITY
RED DESERT SOIL
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

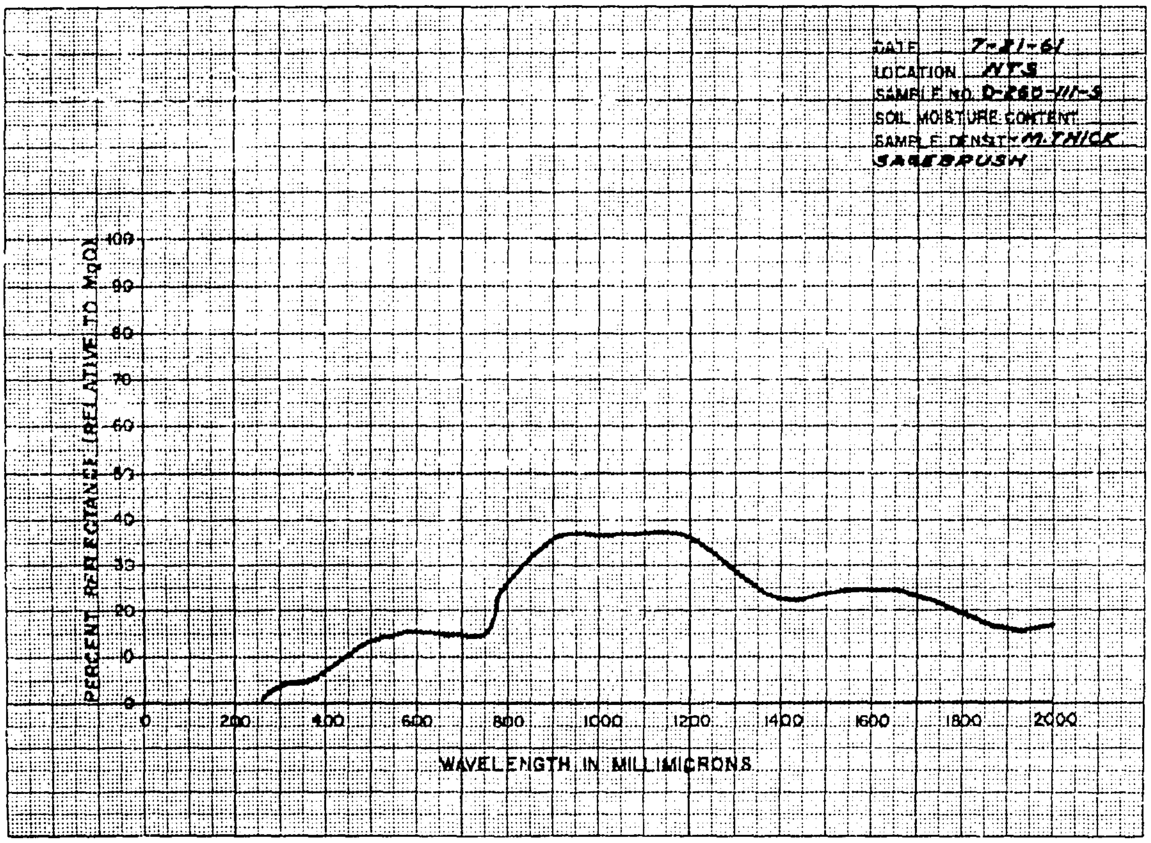

DATE 7-25-61
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT ≤1%
SAMPLE DENSITY
RED DESERT SOIL
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

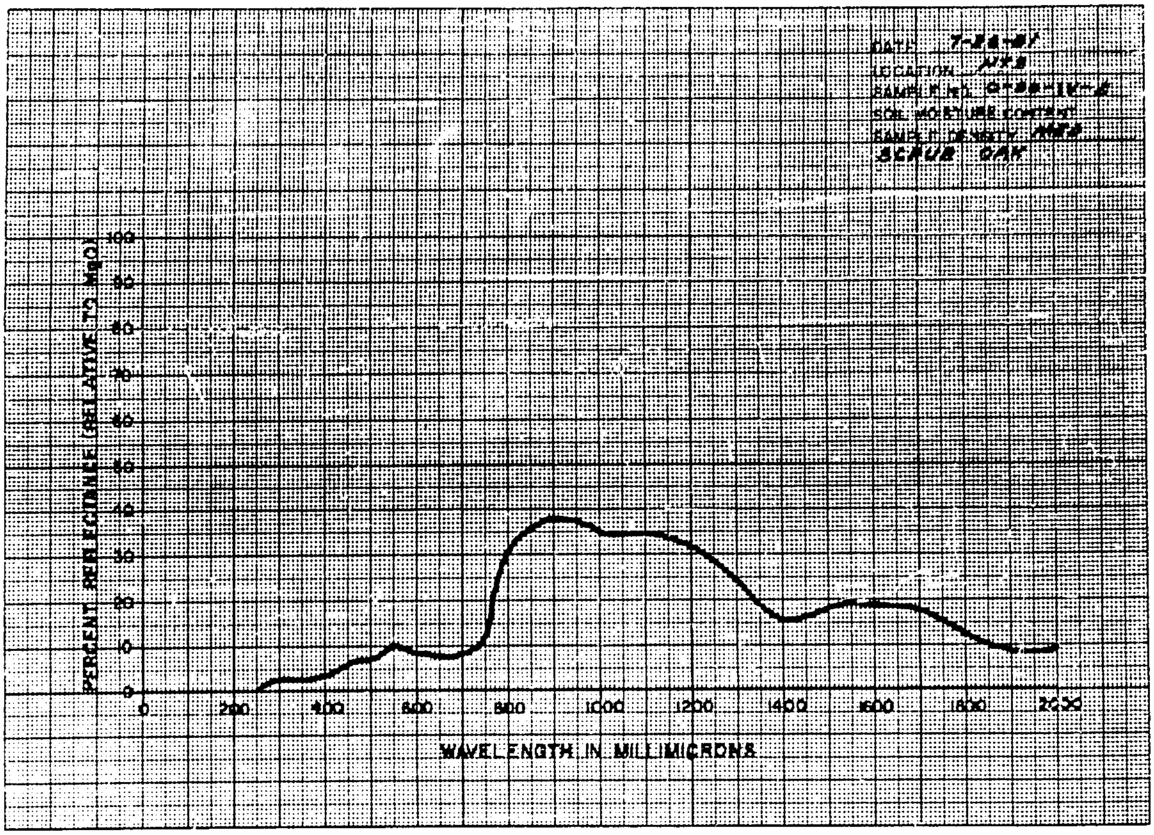

DATE 7-25-61
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT ≤1%
SAMPLE DENSITY
RED DESERT SOIL
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

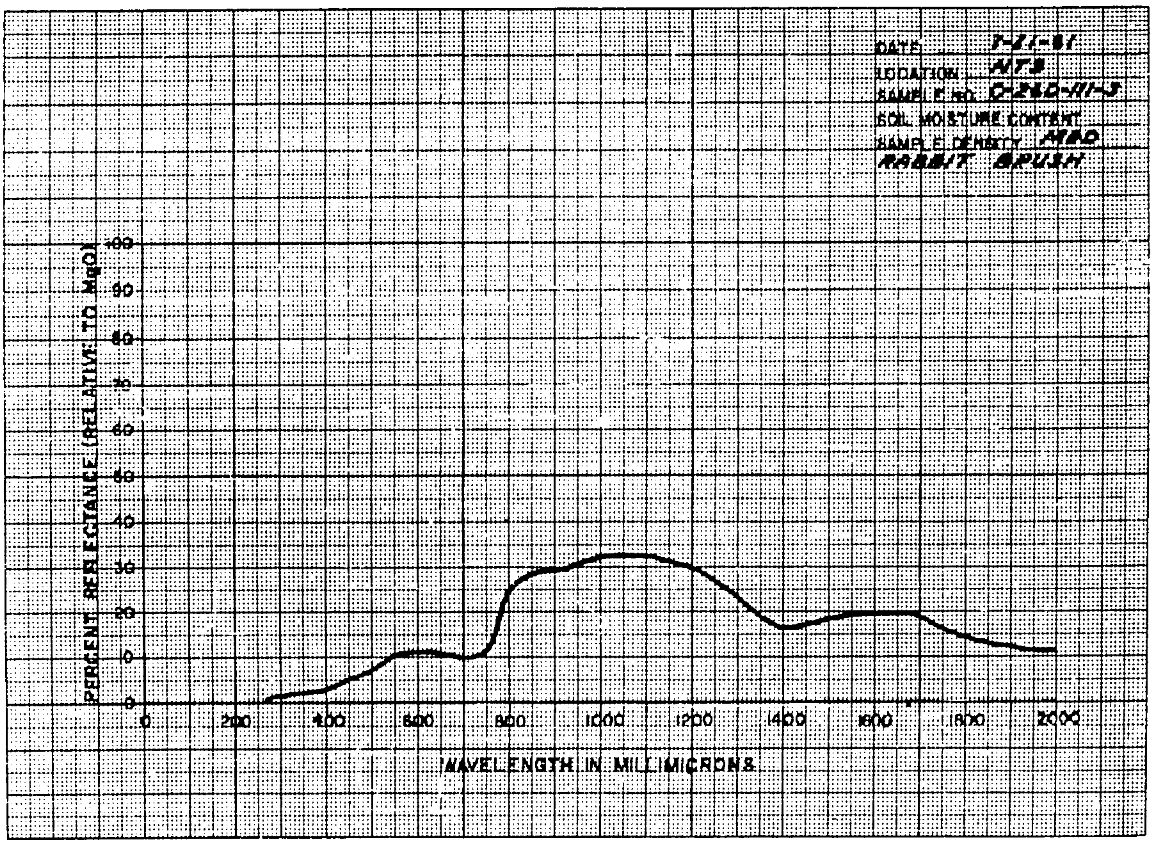

DATE
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
SAGEBRUSH
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

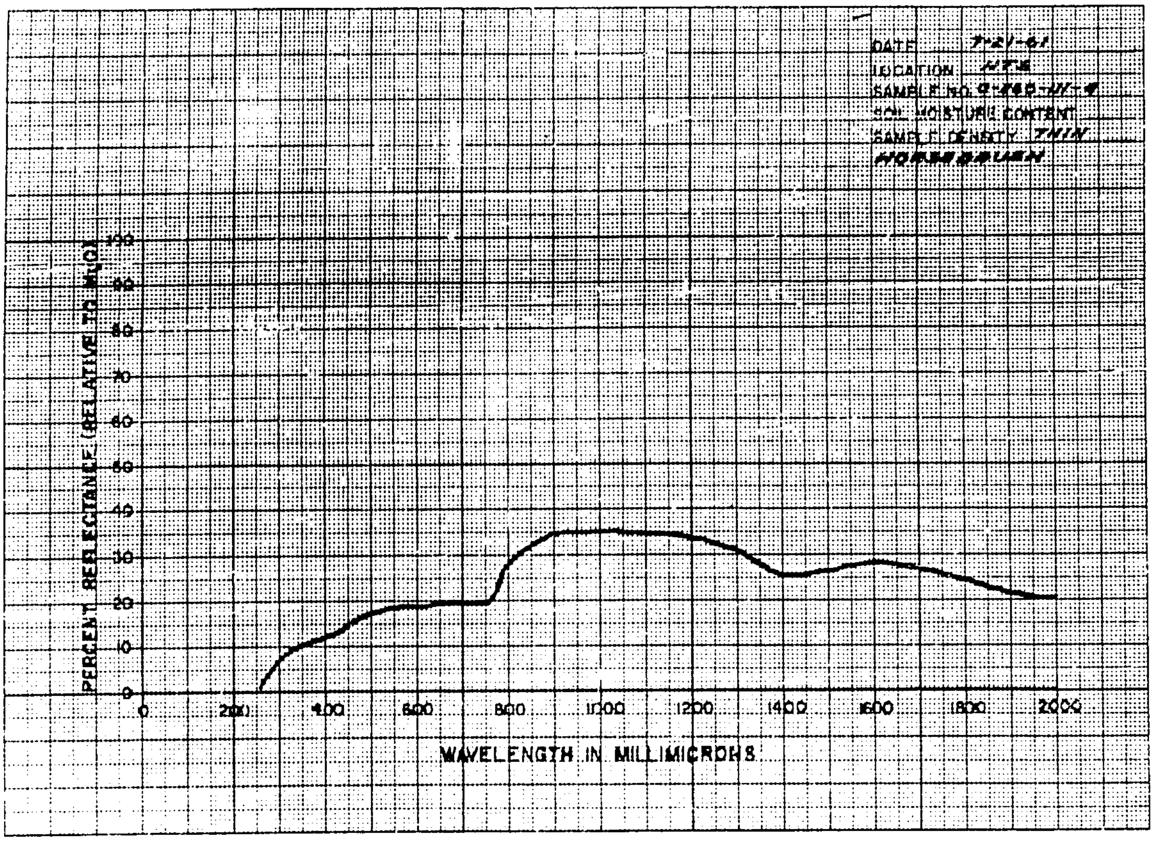

DATE
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY MED.
SAGEBRUSH
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

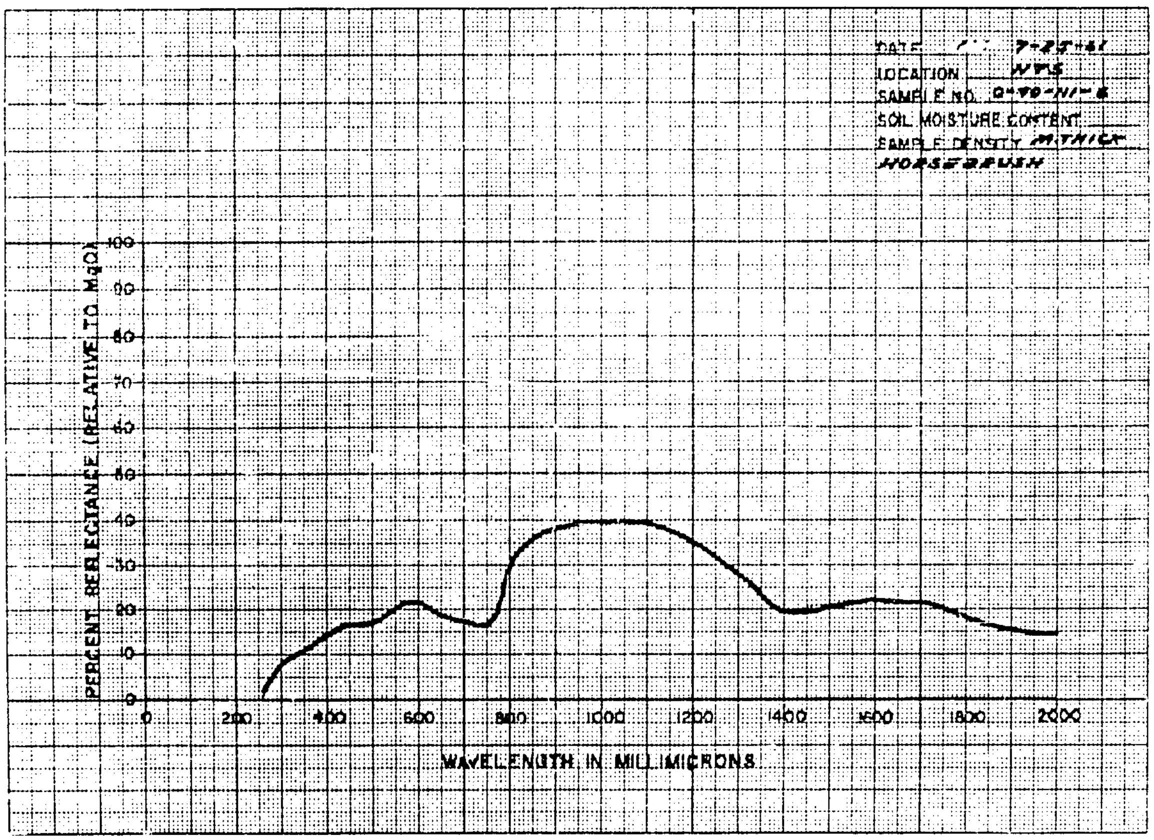

DATE 7-21-61
LOCATION NTS
SAMPLE NO. D-260-111-S
SOIL MOISTURE CONTENT
SAMPLE DENSITY M.THICK SAGEBRUSH
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

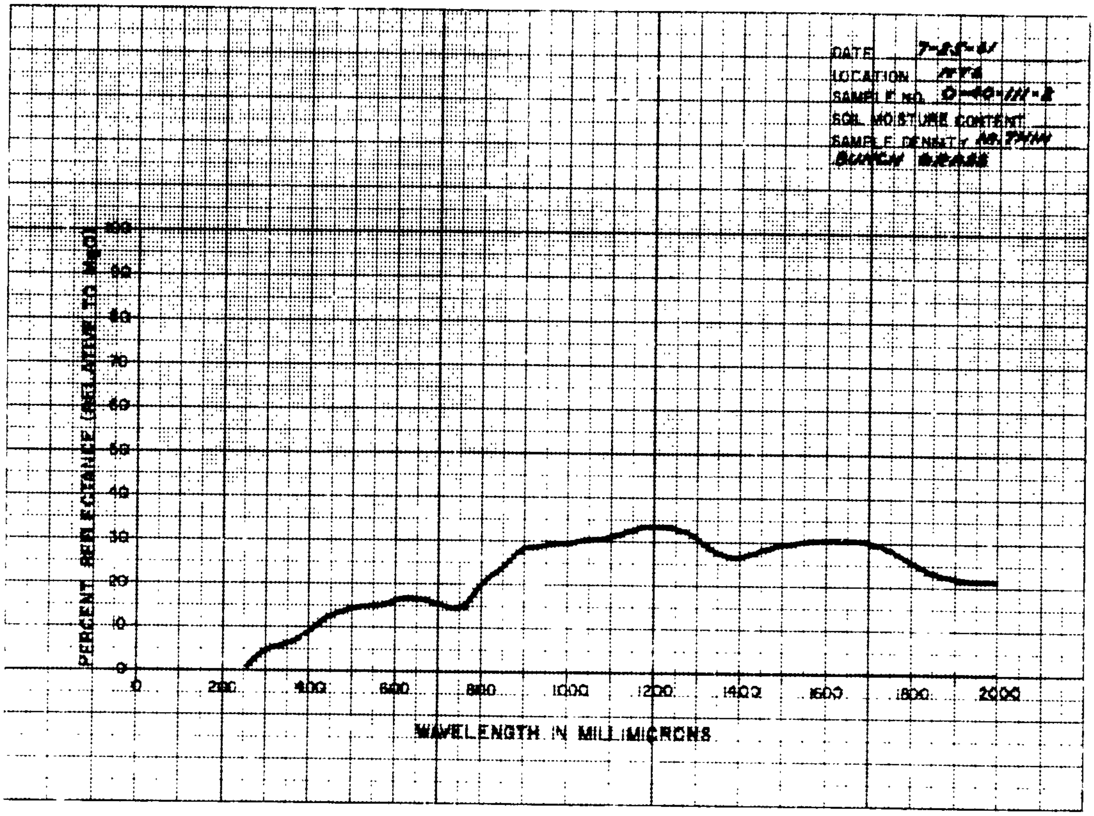

DATE 7-21-61
LOCATION NTS
SAMPLE NO. D-260-111-S
SOIL MOISTURE CONTENT
SAMPLE DENSITY M.THICK SAGEBRUSH
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

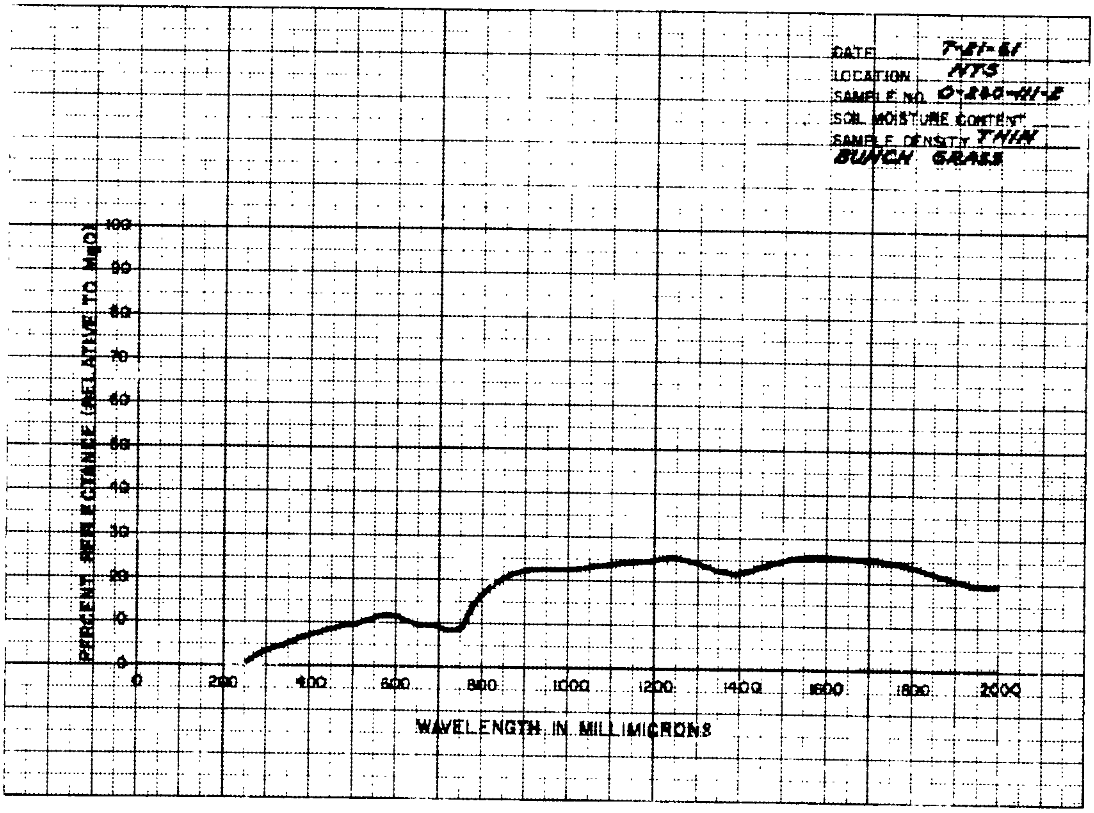

DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
SCRUB OAK
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

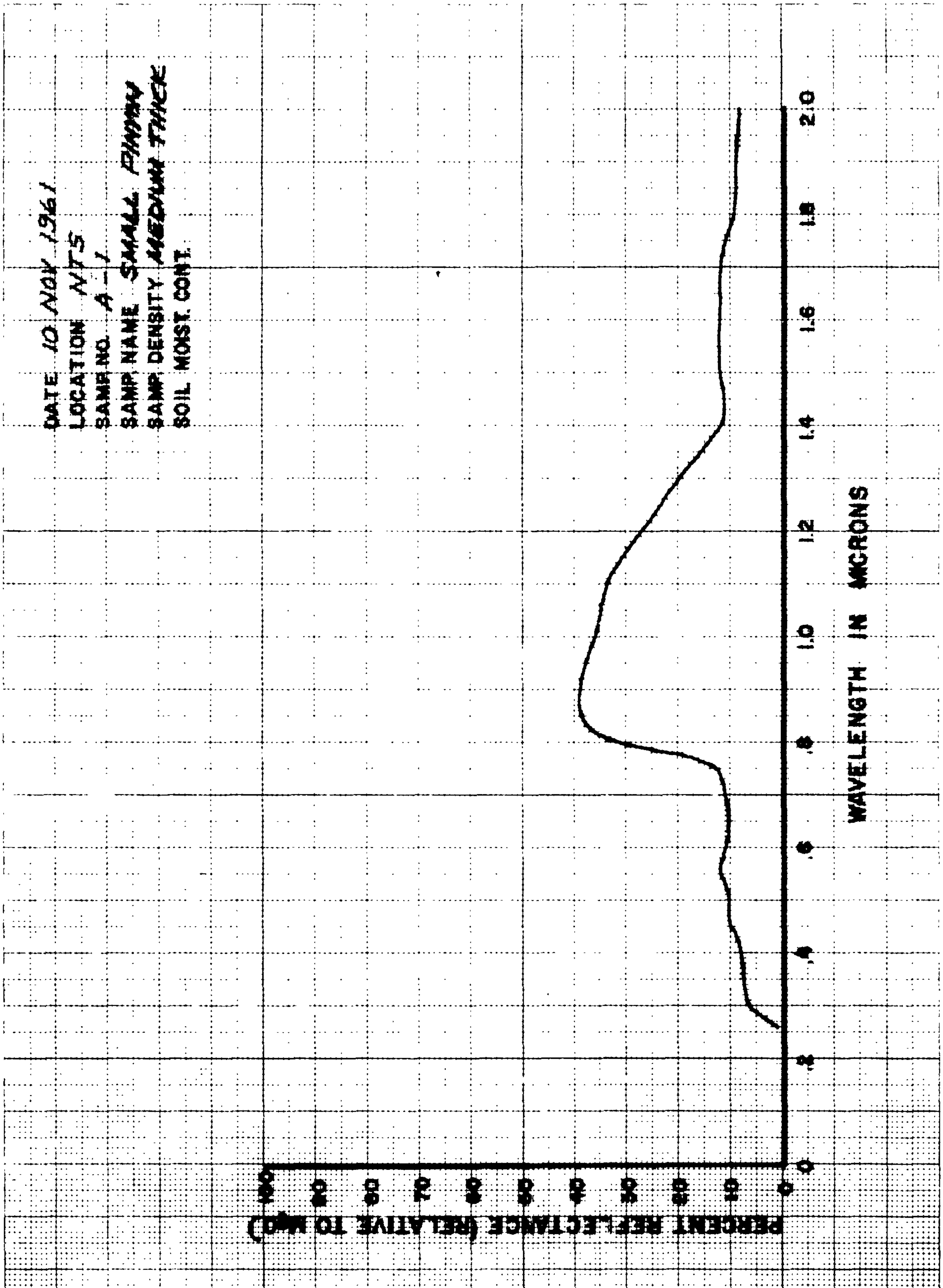

DATE 7-21-81
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
RABBIT BRUSH
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

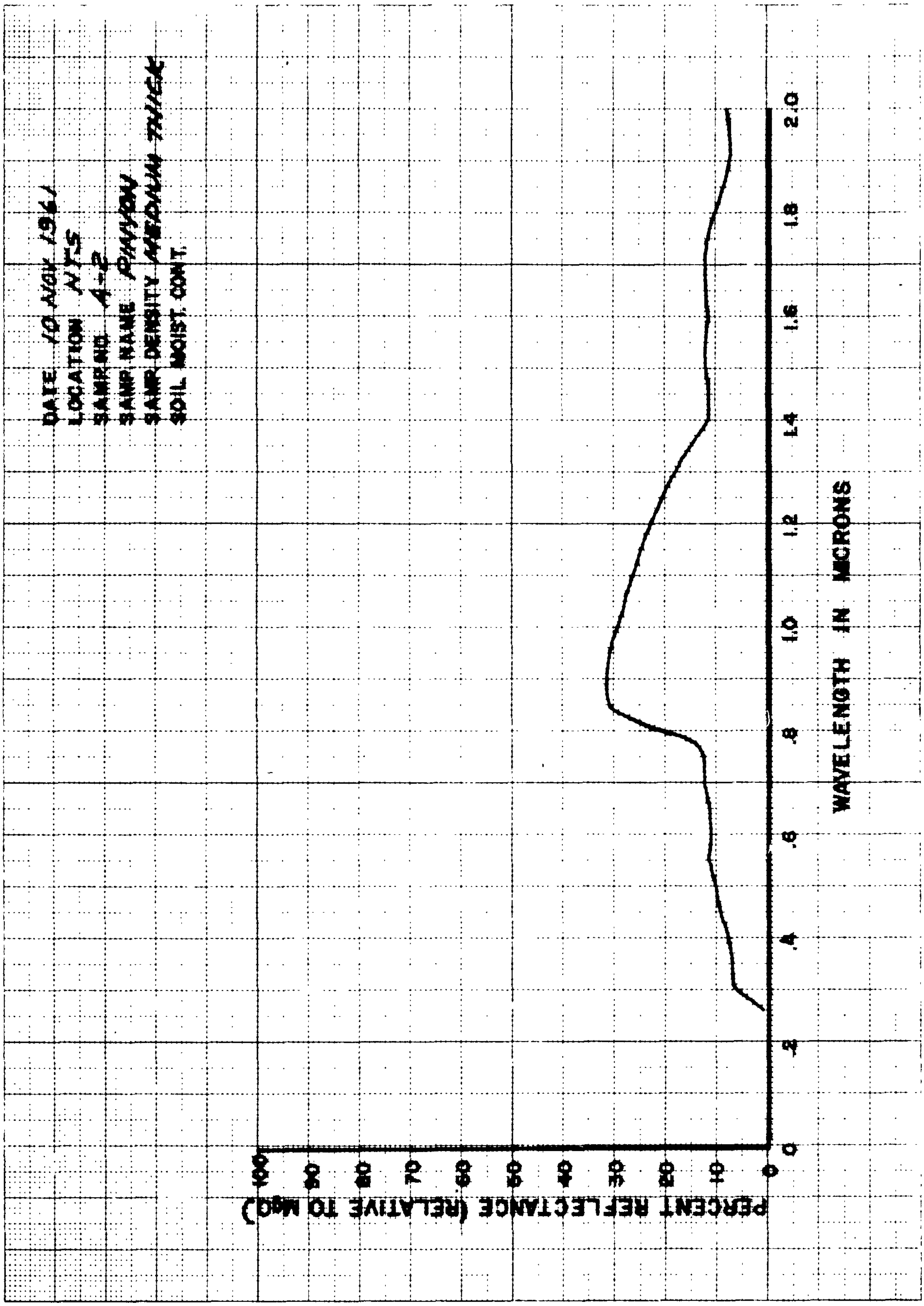

DATE 7-21-61
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY THIN
HORSEBRUSH
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

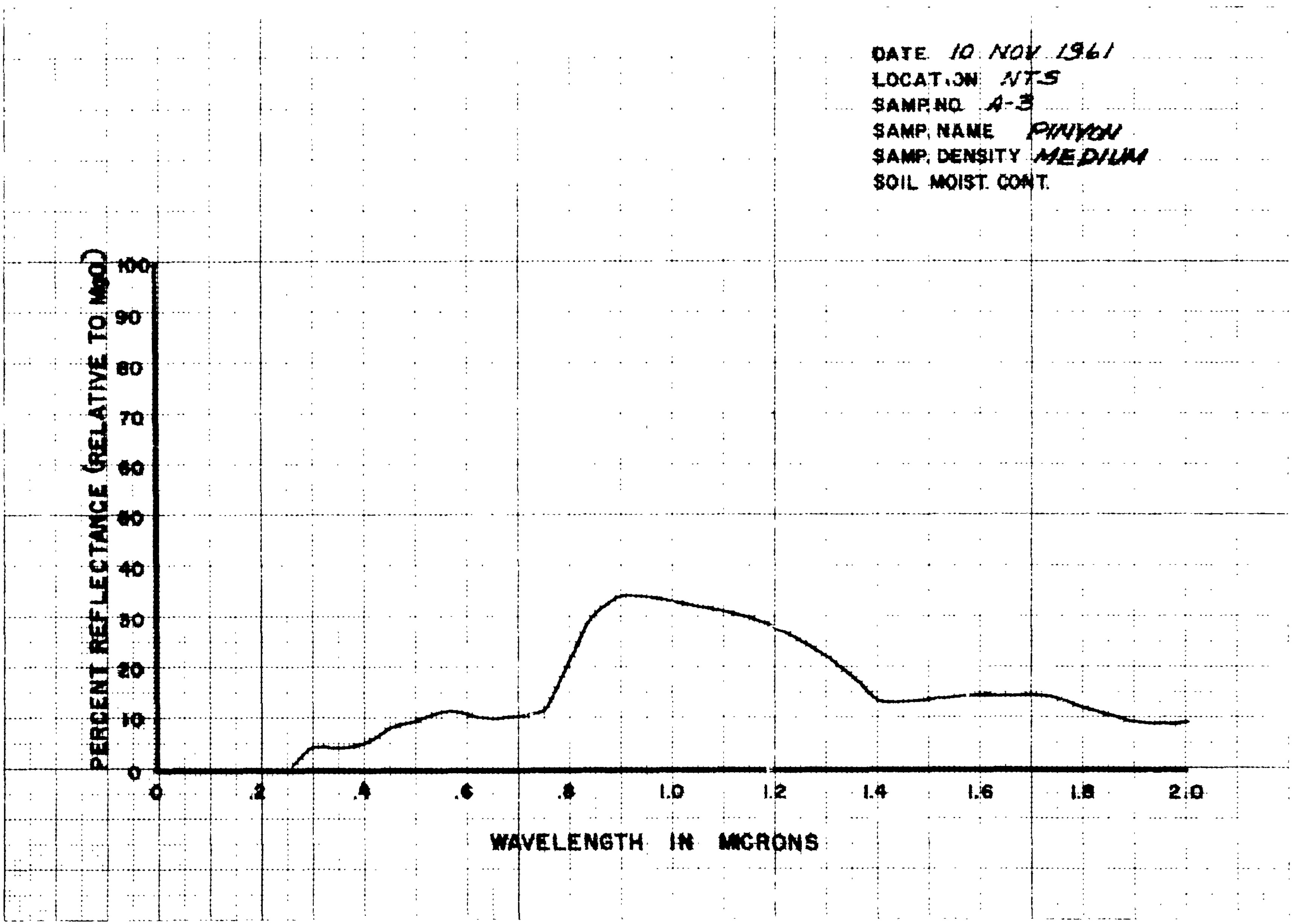

DATE 7-25-61
LOCATION NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY M. THICK
HORSEBRUSH
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS


DATE
LOCATION
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
BUNCH GRASS
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

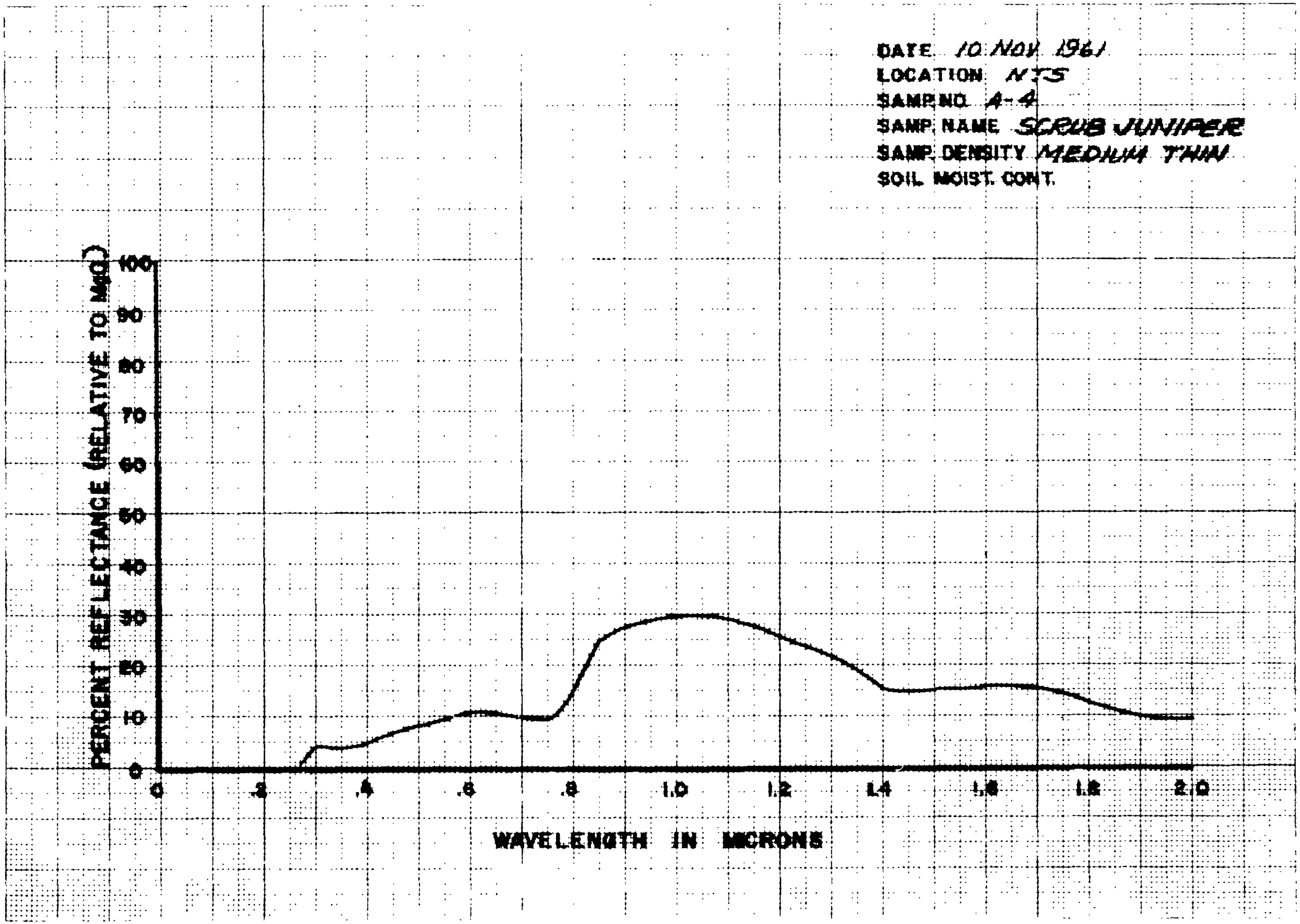

DATE
7-21-61
LOCATION
NTS
SAMPLE NO.
SOIL MOISTURE CONTENT
SAMPLE DENSITY
THIN
BUNCH GRASS
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
WAVELENGTH IN MILLIMICRONS

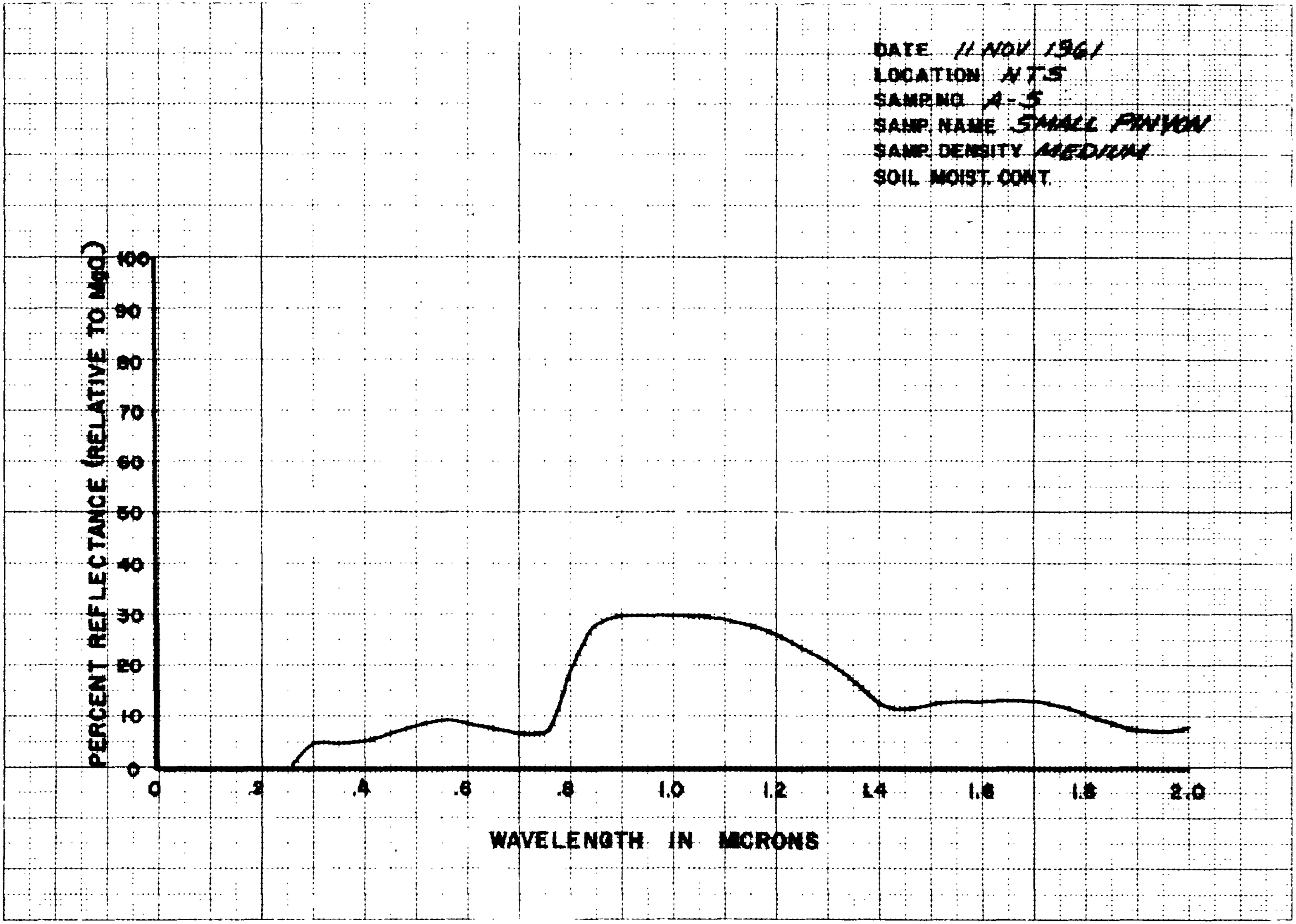

DATE 10 NOV 1961
LOCATION NTS
SAMP. NO. A-1
SAMP. NAME SMALL
SAMP. DENSITY MEDIUM THICK
SOIL MOIST. CONT.
WAVELENGTH IN MICRONS
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100

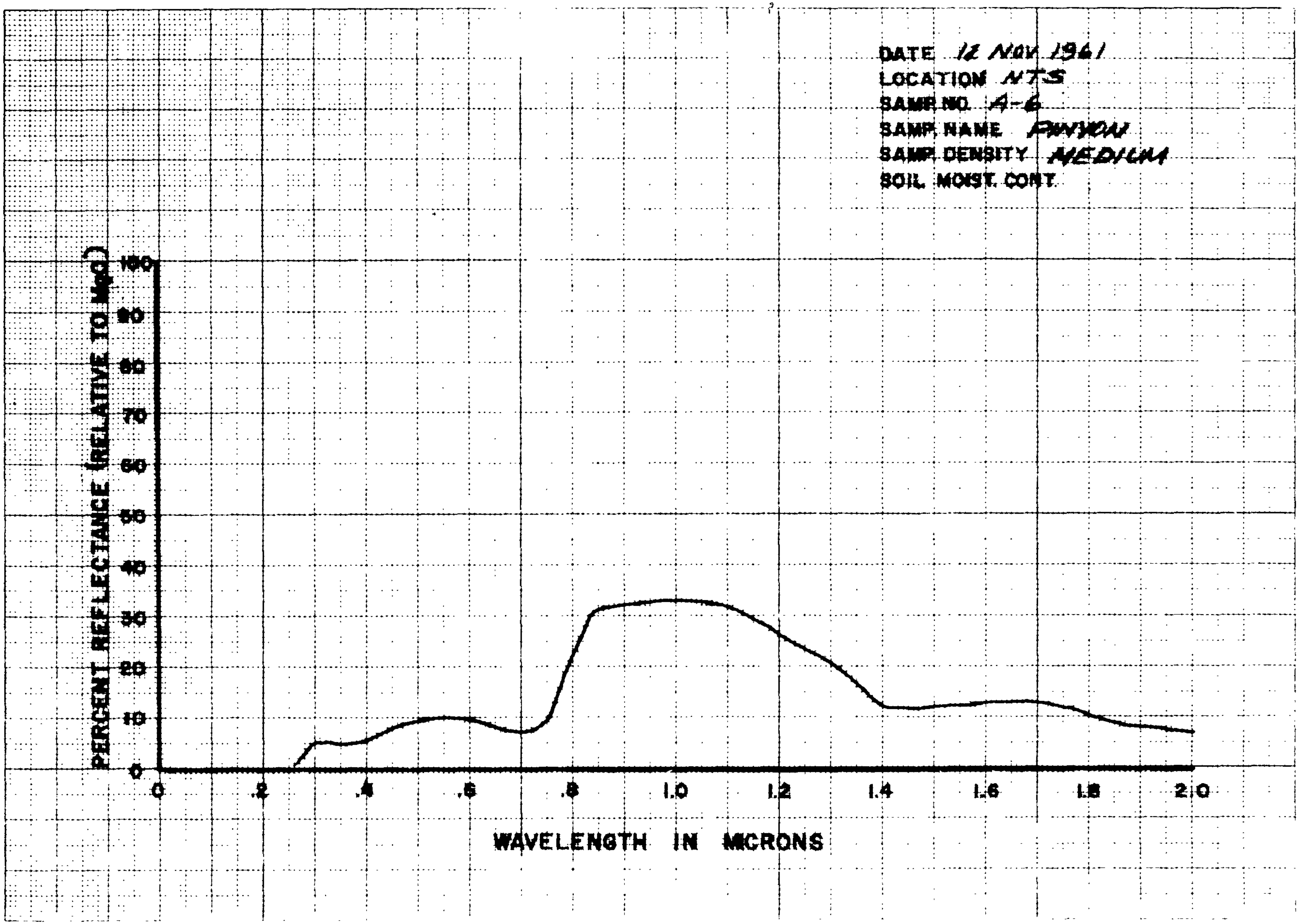

DATE 10 NOV 1961
LOCATION NTS
SAMP. NO. A-2
SAMP. NAME PINYON
SAMP. DENSITY MEDIUM THICK
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
WAVELENGTH IN MICRONS
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0

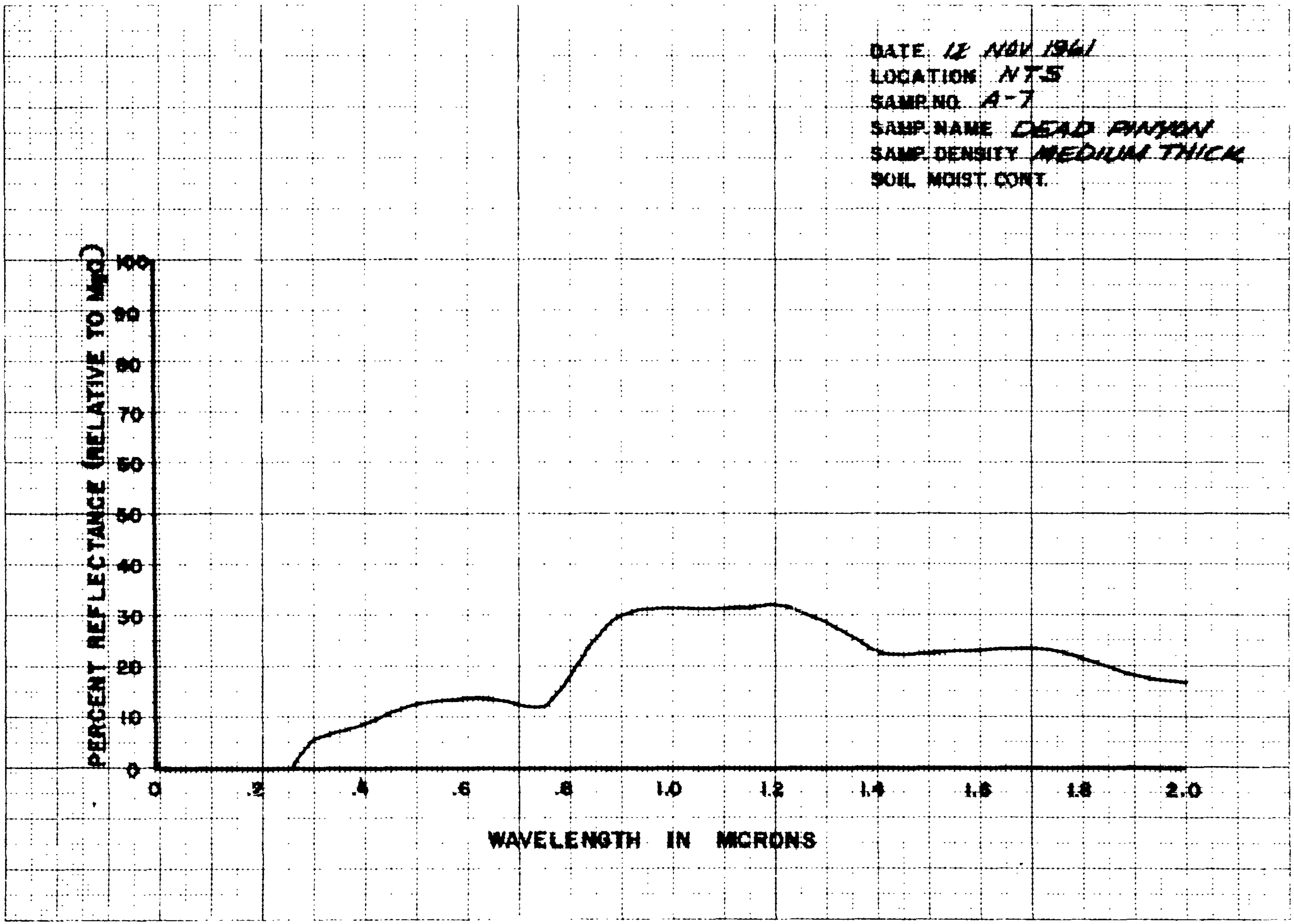


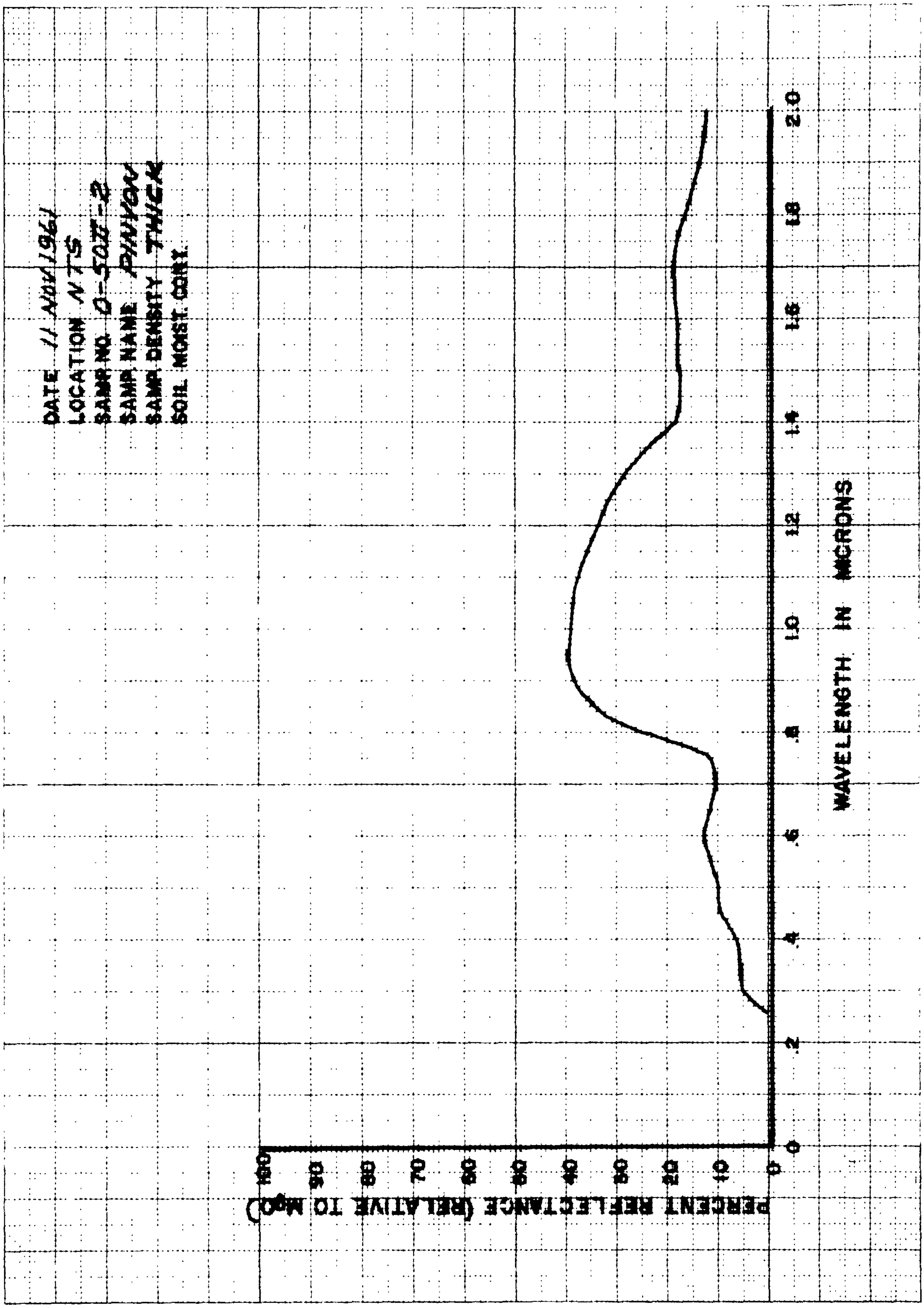
DATE 10 NOV 1961
LOCATION NTS
SAMP. NO. A-3
SAMP. NAME PINYON
SAMP. DENSITY MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

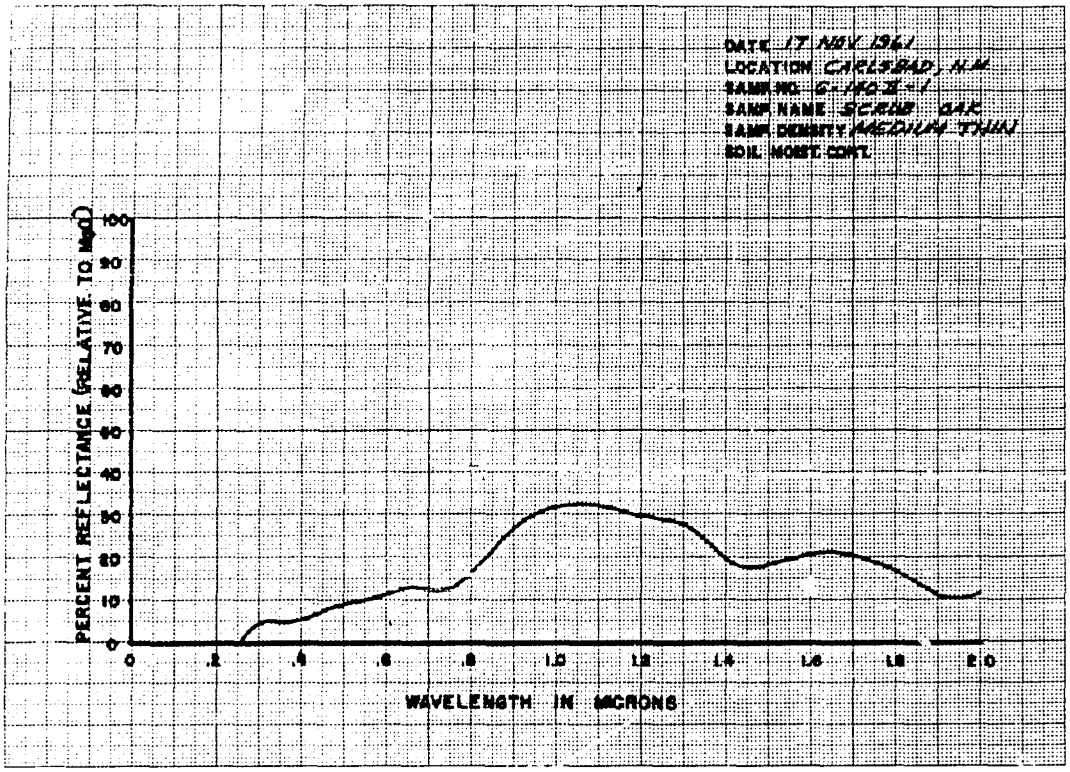

DATE 10 NOV 1961
LOCATION NTS
SAMP. NO. 4-4
SAMP. NAME SCRUB JUNIPER
SAMP. DENSITY MEDIUM THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

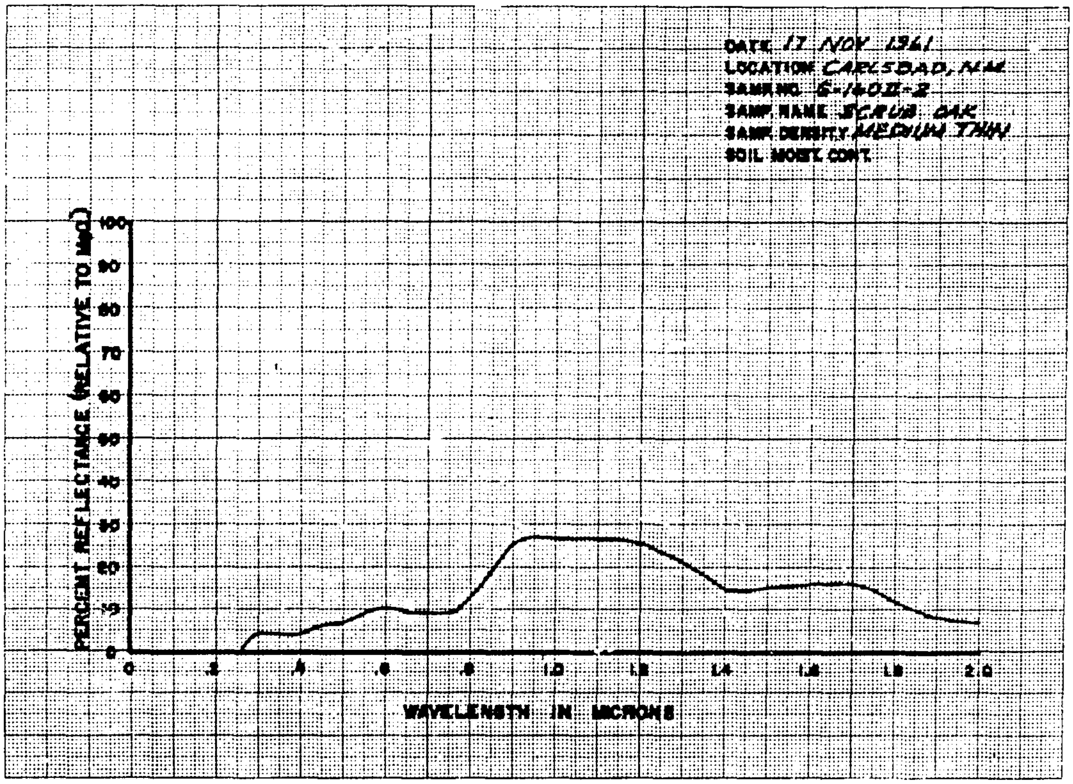

DATE 11 NOV 1961
LOCATION NTS
SAMP. NO. A-5
SAMP. NAME SMALL PINYON
SAMP. DENSITY MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

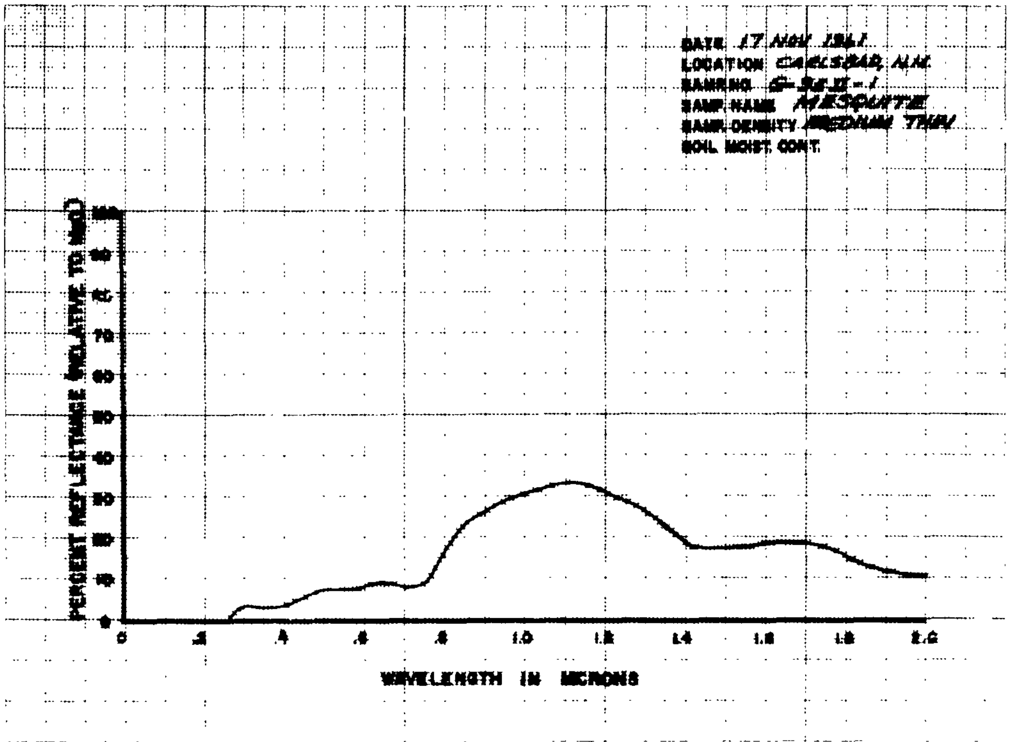

DATE 12 NOV 1961
LOCATION NTS
SAMP. NO. A-6
SAMP. NAME PINYON
SAMP. DENSITY MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

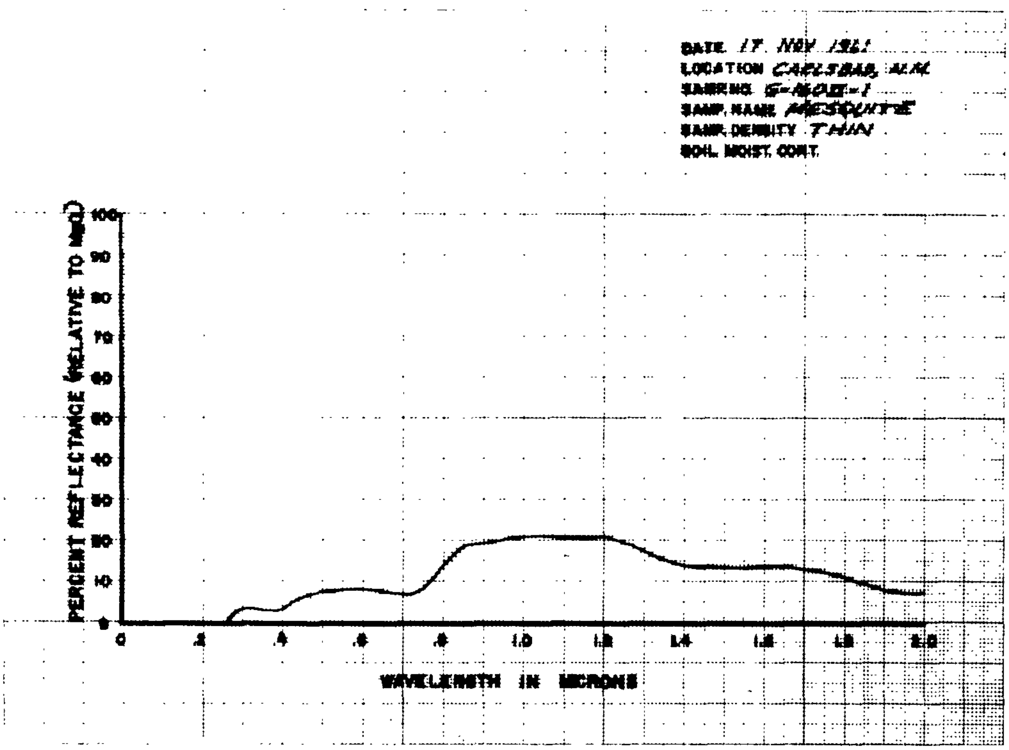

DATE 12 NOV 1961
LOCATION NTS
SAMP. NO. A-7
SAMP. NAME DEAD PINYON
SAMP. DENSITY MEDIUM THICK
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

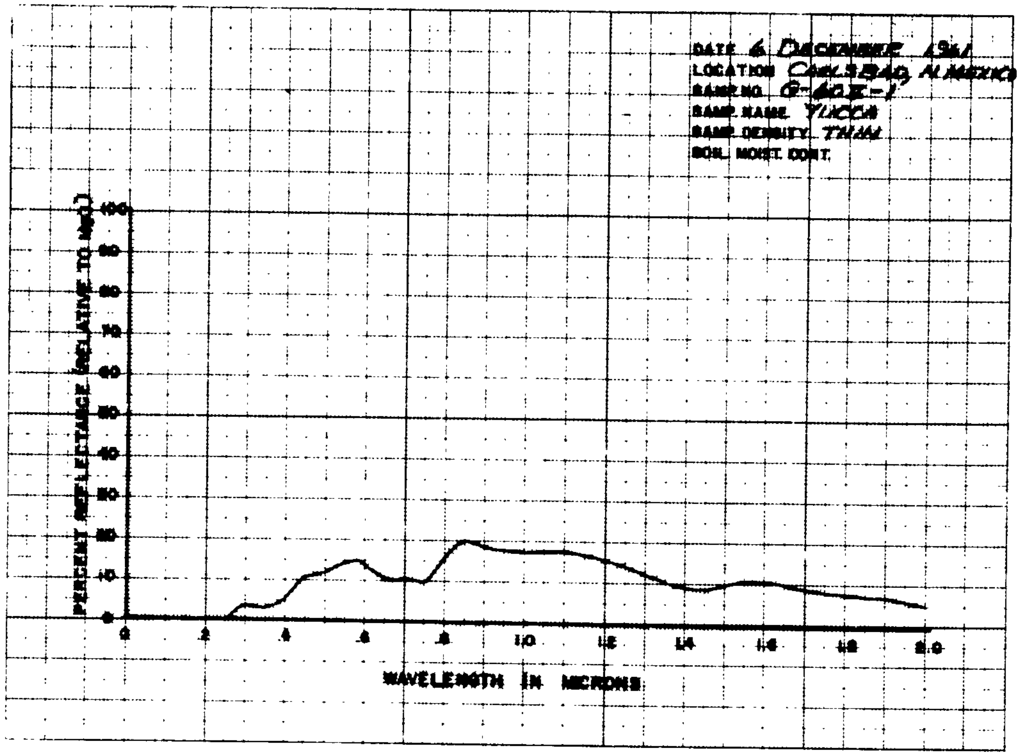

DATE 11 Nov 1961
LOCATION NTS
SAMP. NO. 0-50II-2
SAMP. NAME PINYON
SAMP. DENSITY THICK
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

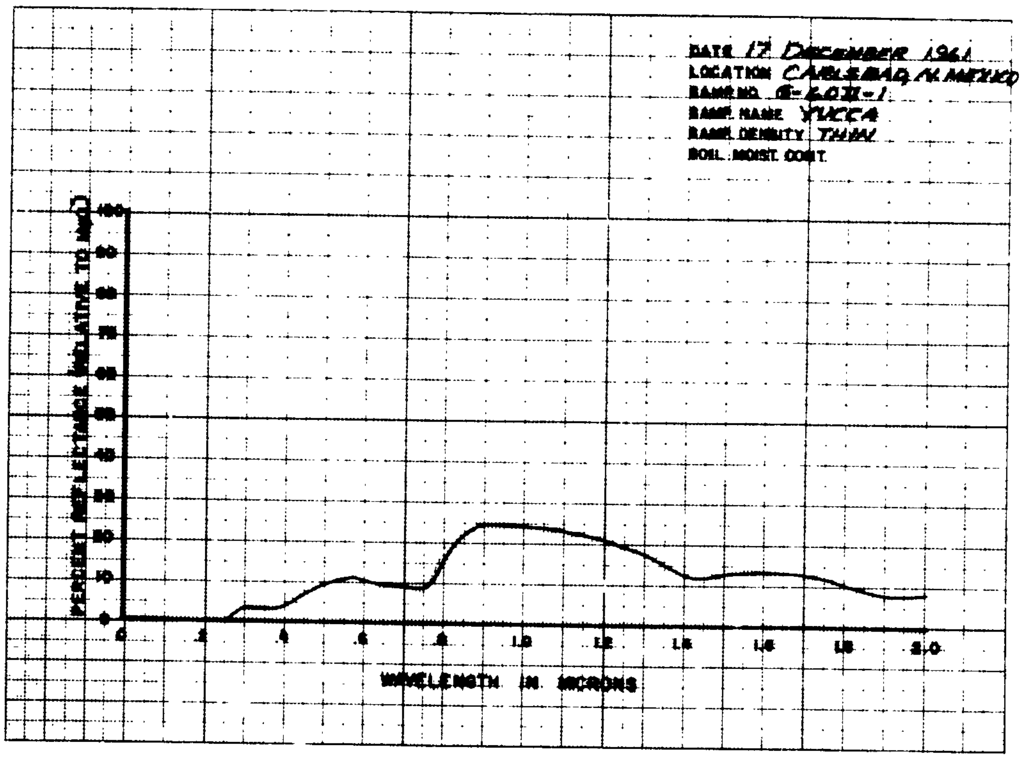

DATE 17 NOV 1961
LOCATION CARLSBAD, N.M.
SAMP. NO. S-140 II-1
SAMP. NAME SCRUB OAK
SAMP. DENSITY MEDIUM THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

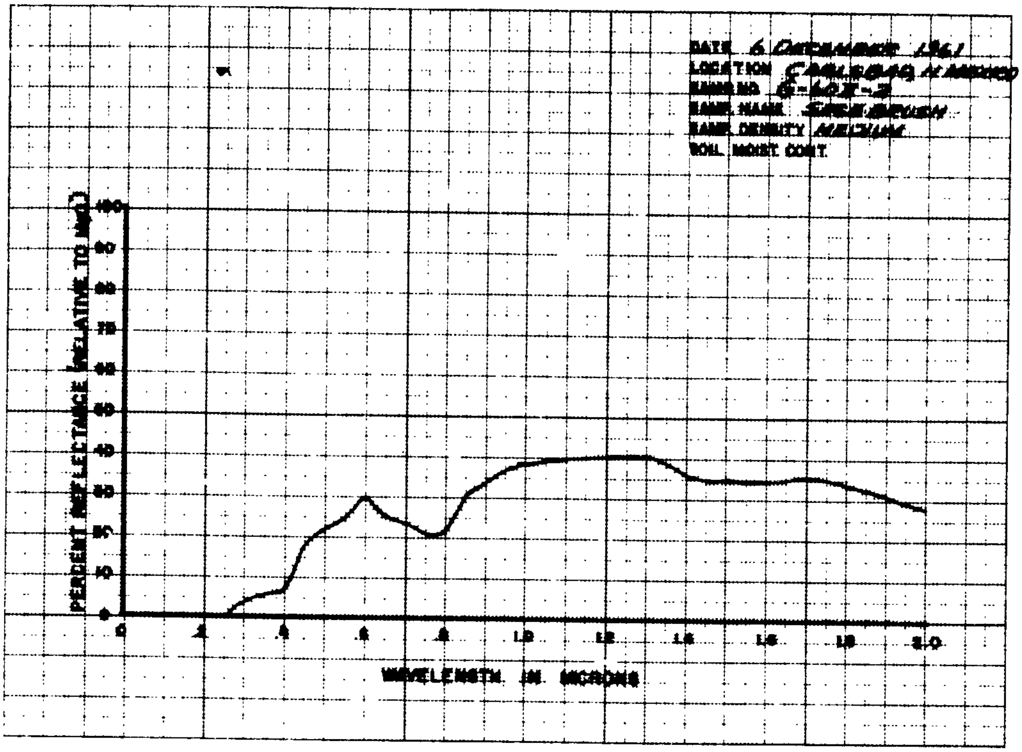

DATE 17 NOV 1961
LOCATION CARLSBAD, N.M.
SAMP. NO. S-140 II-2
SAMP. NAME SCRUB OAK
SAMP. DENSITY MEDIUM THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS


DATE 17 NOV
LOCATION CARLSBAD, N.M.
SAMP. NAME MESQUITE
SAMP. DENSITY MEDIUM THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

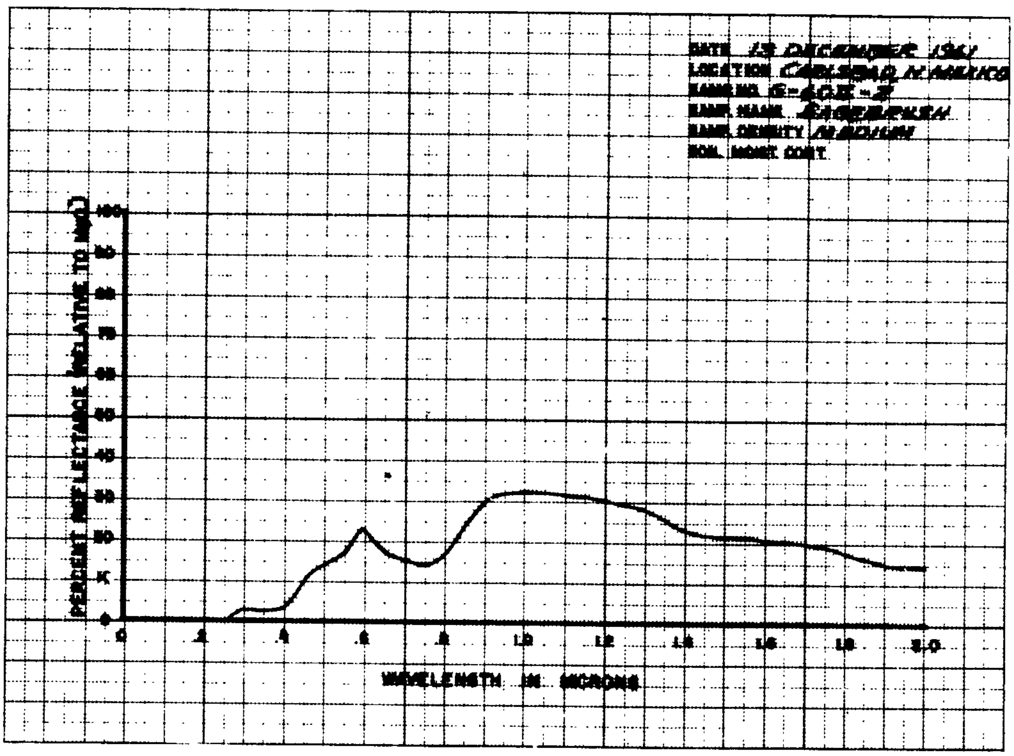

DATE 17 NOV
LOCATION CARLSBAD, N.M.
SAMP. NAME MESQUITE
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS


DATE 6 DECEMBER 1961
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-60 II-1
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

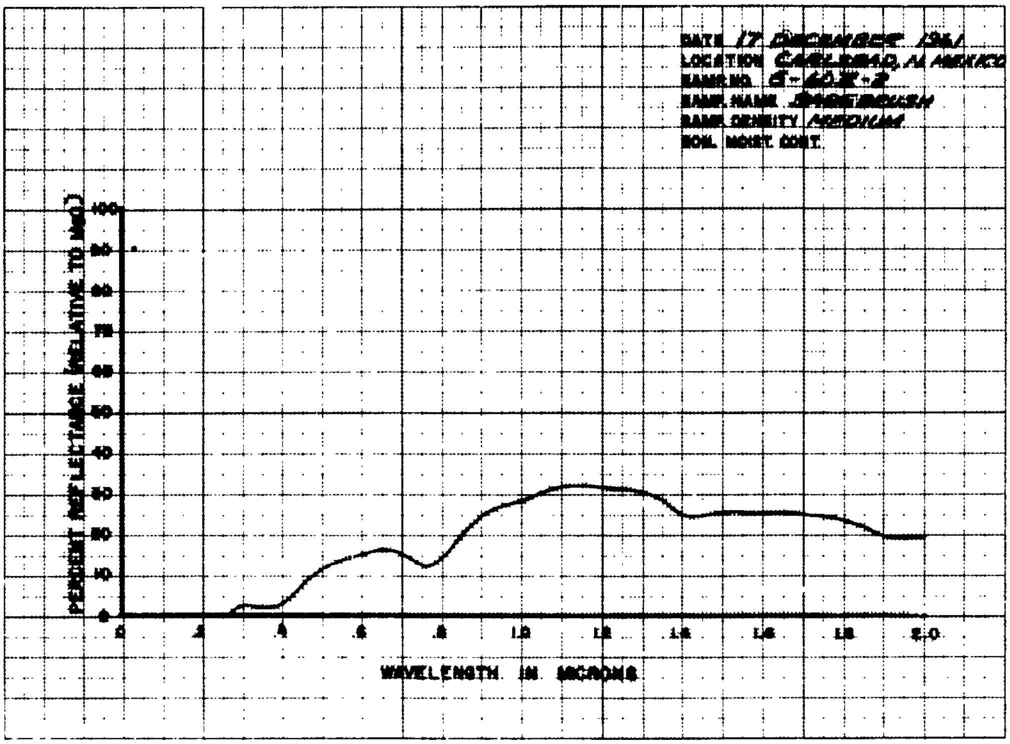

DATE 17 DECEMBER 1961
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-60 II-1
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

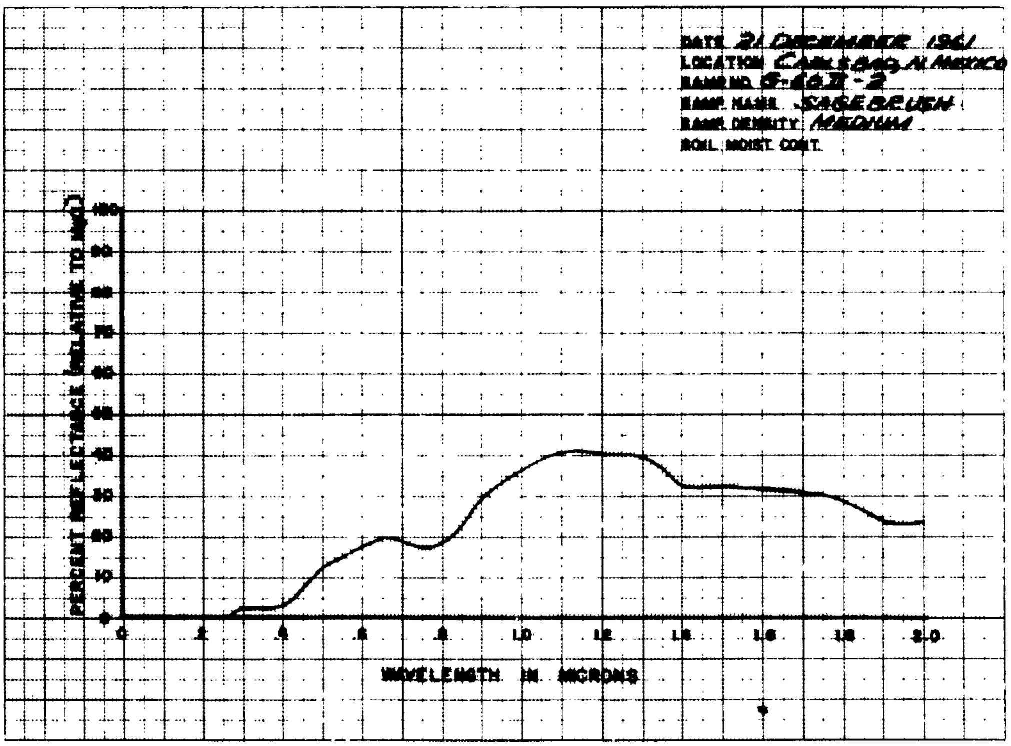


LOCATION
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

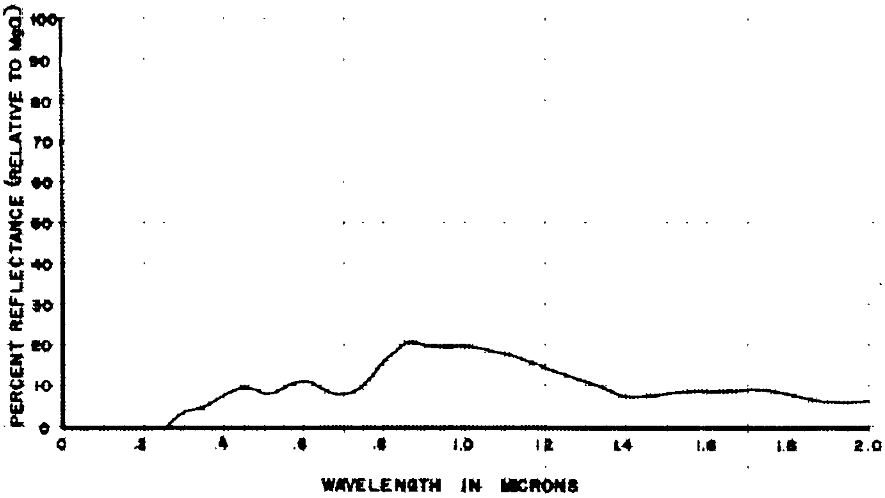


LOCATION
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

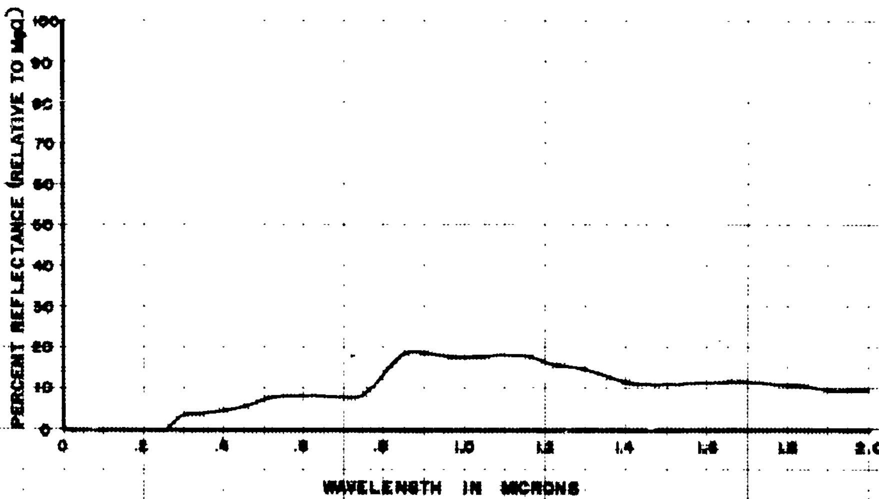

DATE
LOCATION
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

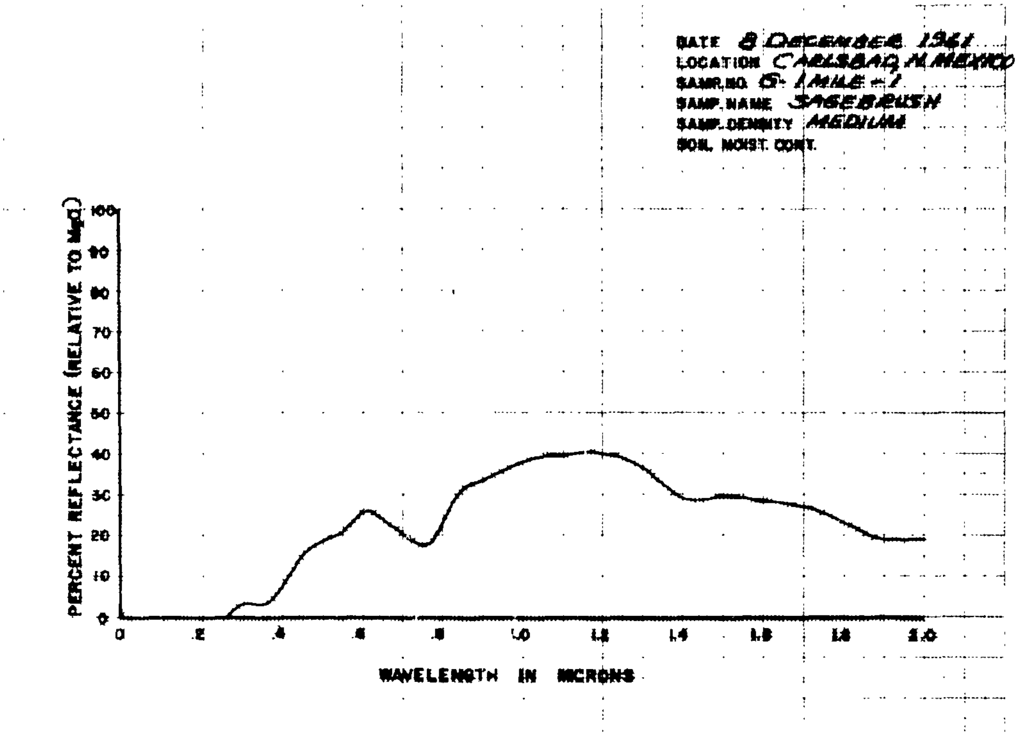

DATE 21 DECEMBER 1961
LOCATION CARLSBAD, N MEXICO
SAGEBRUSH
MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

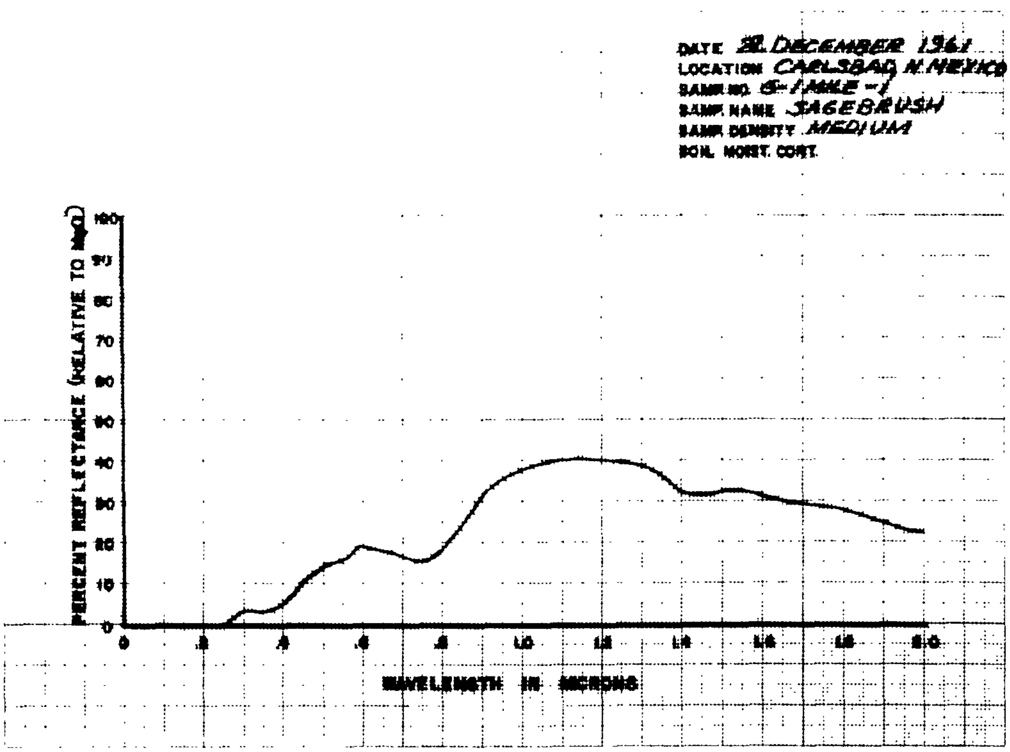
DATE 8 DECEMBER 1961
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-1 MILE-2
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.

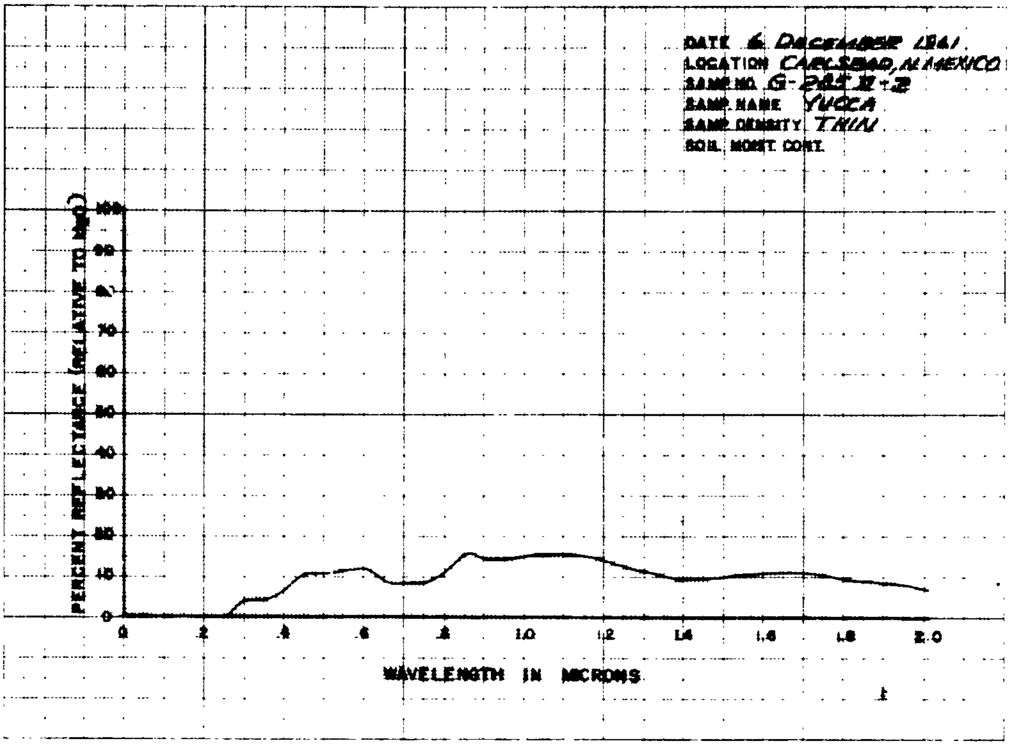


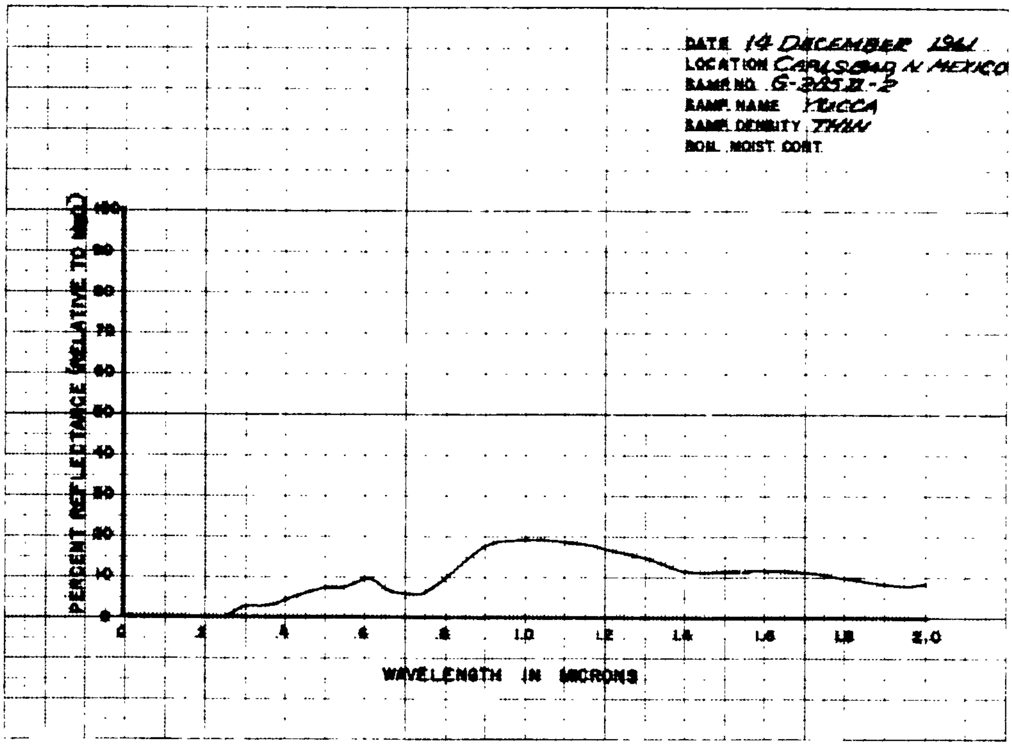
DATE 28 DECEMBER 1961
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-1 MILE-2
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.

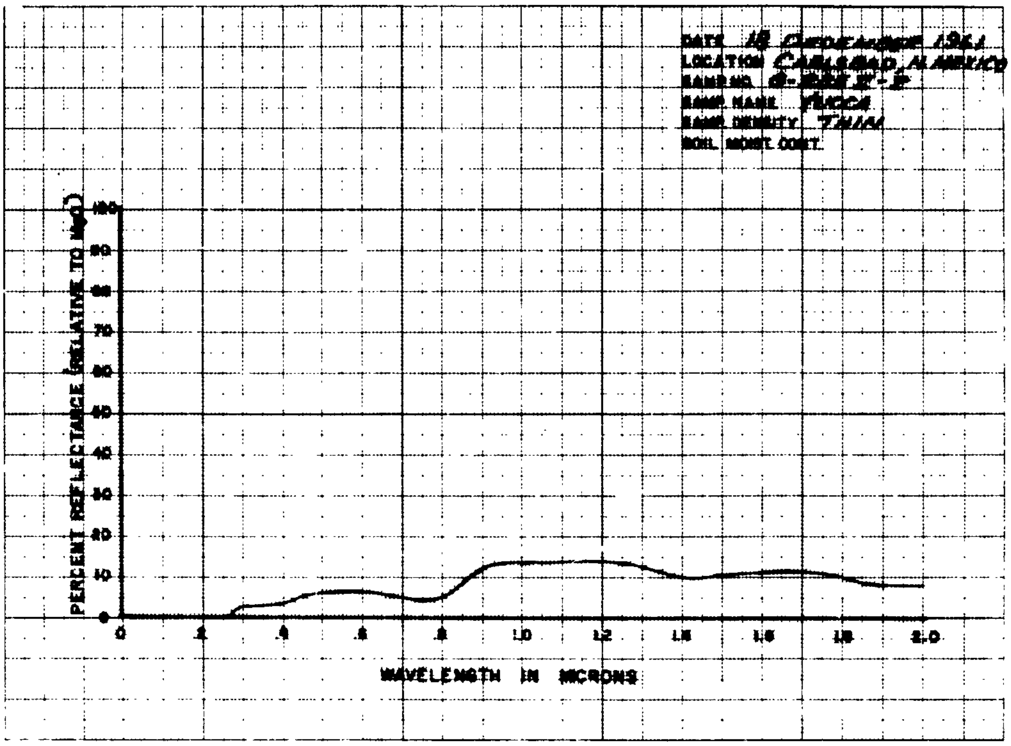


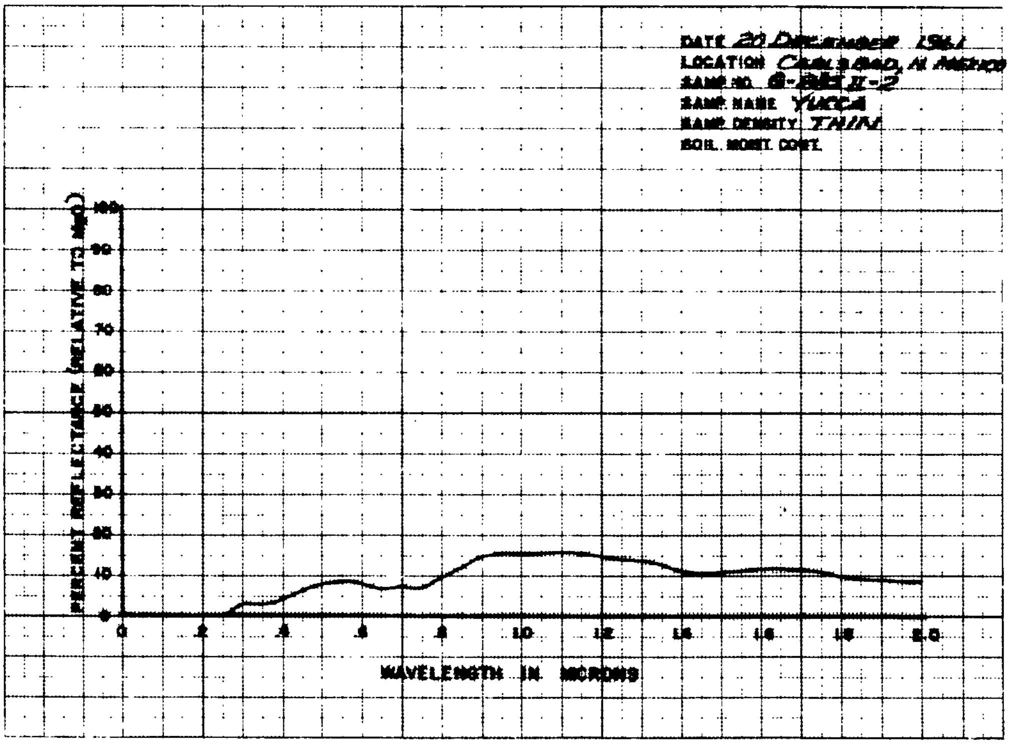

DATE 8 DECEMBER 1961
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. S-1 MILE-1
SAMP. NAME SAGEBRUSH
SAMP. DENSITY MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
2.0
WAVELENGTH IN MICRONS

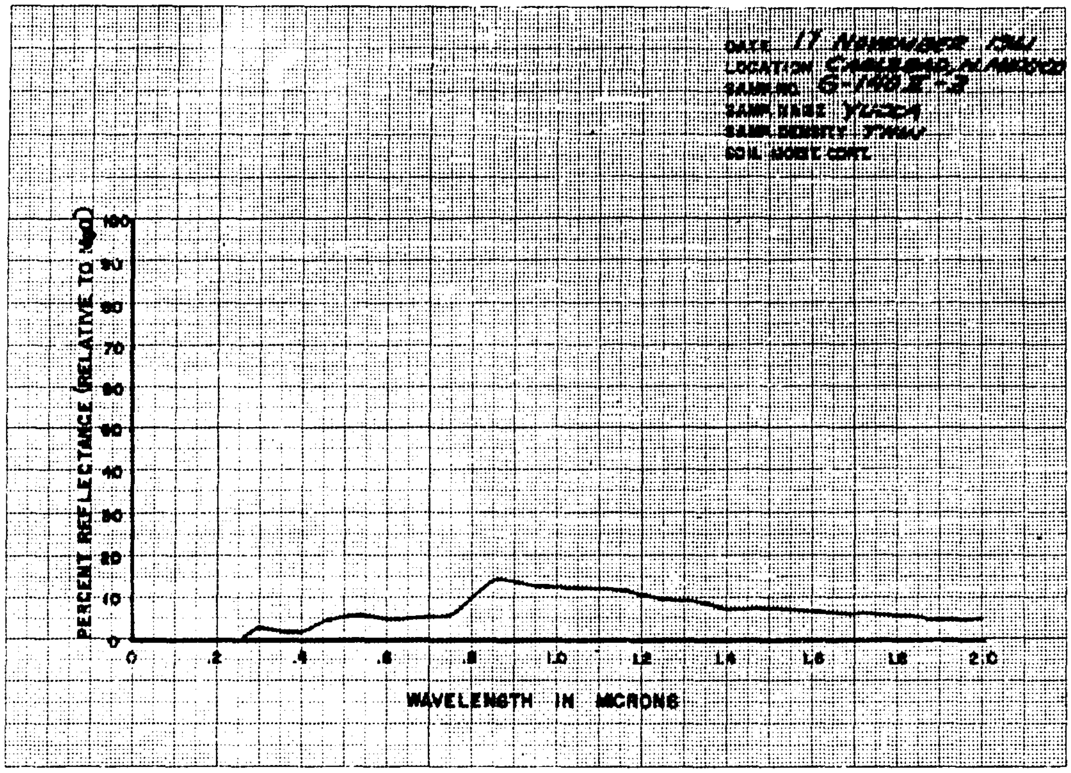

DATE DECEMBER 1961
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. S-1 MILE-1
SAMP. NAME SAGEBRUSH
SAMP. DENSITY MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
70
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

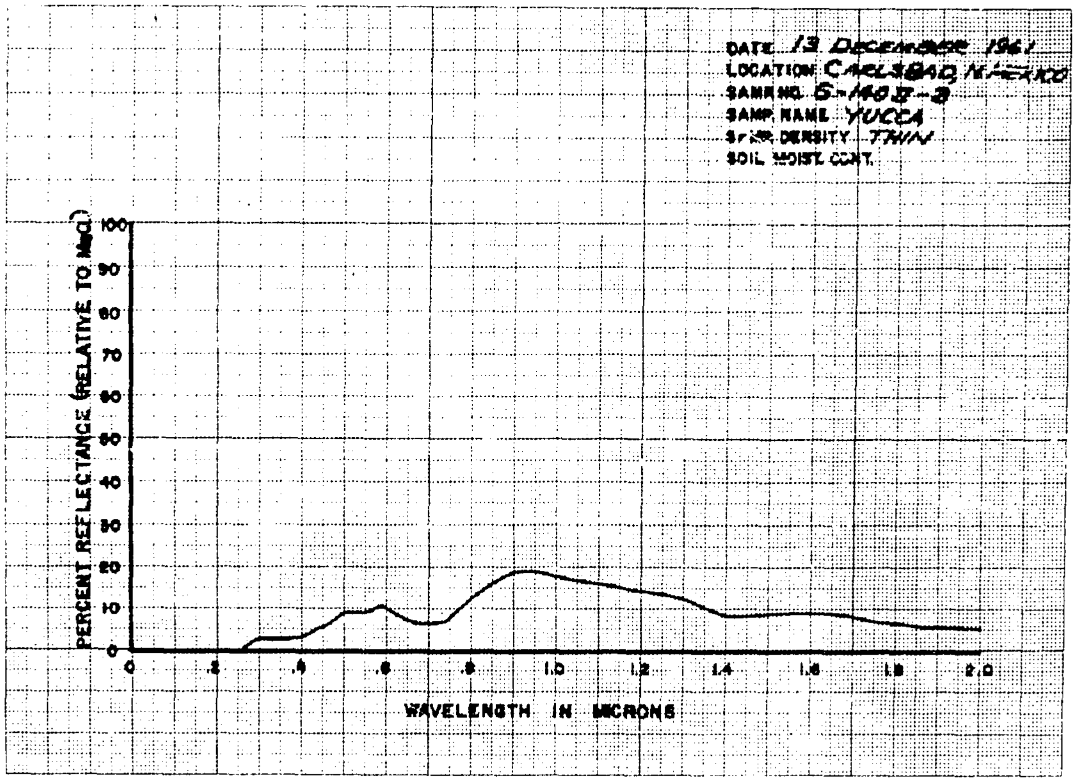

DATE 6 DECEMBER 1961
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-285 II-2
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

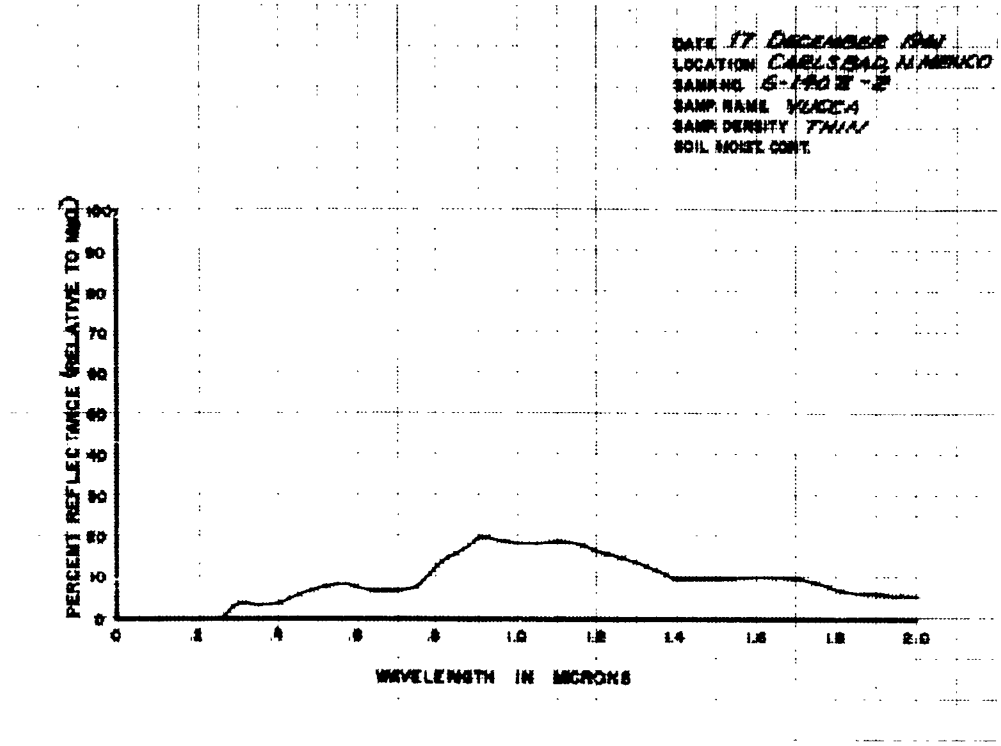

DATE 14 DECEMBER 1961
LOCATION CARLSBAD N. MEXICO
SAMP. NO. G-285 II-2
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

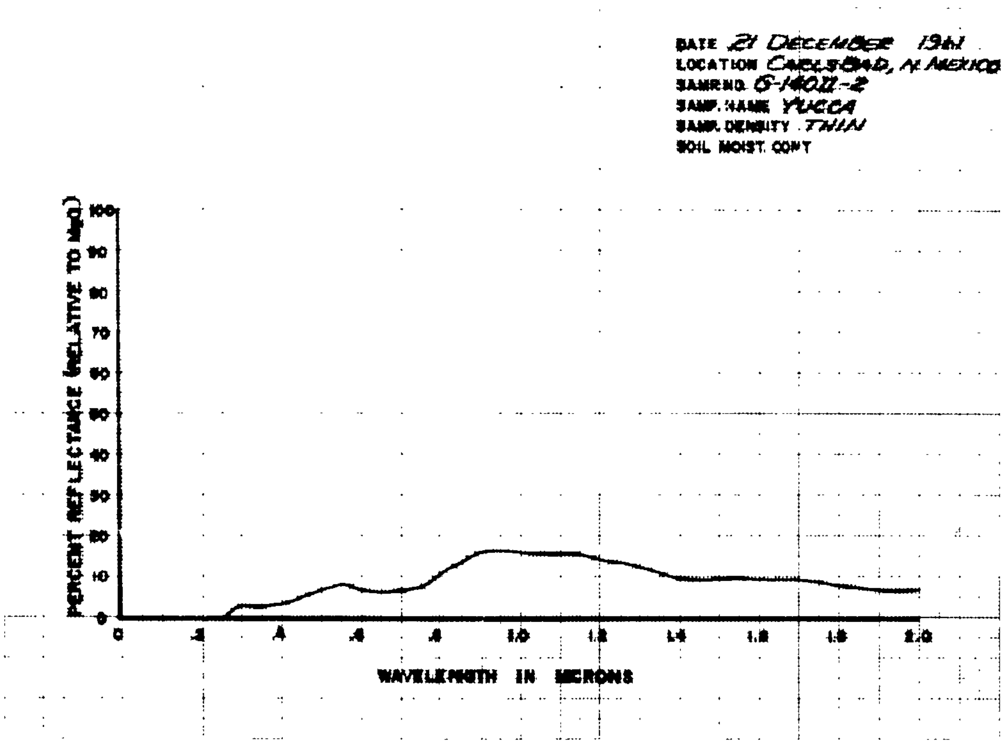

DATE 18 1961
LOCATION
SAMP. NO.
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

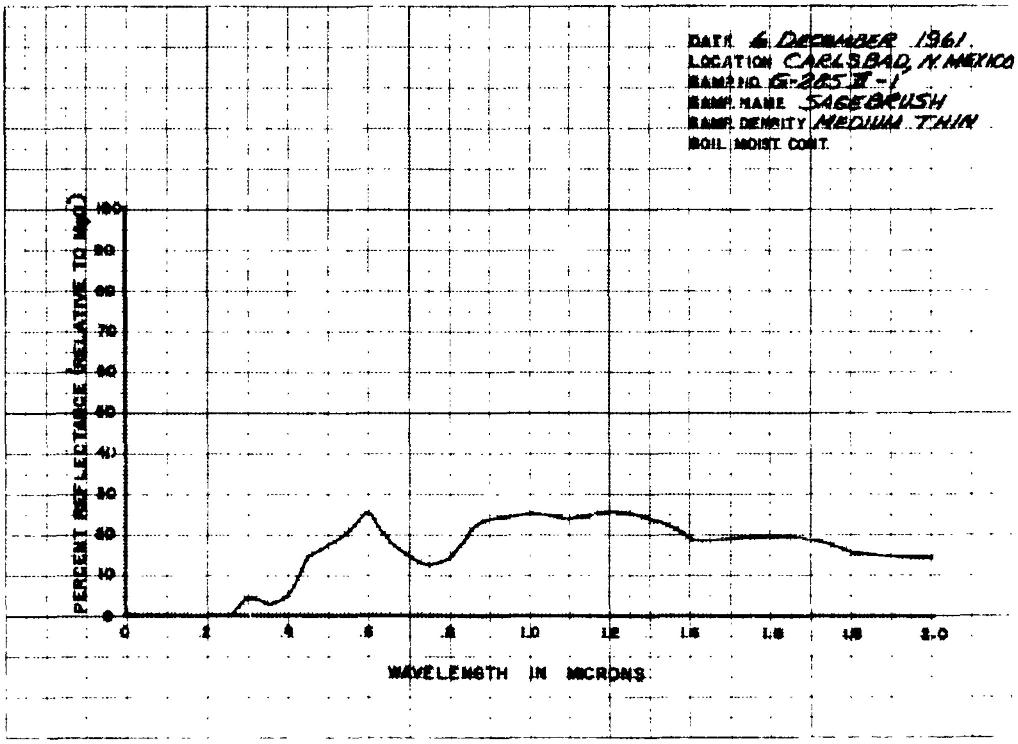

DATE 20 DECEMBER 1961
LOCATION
SAMP. NO.
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

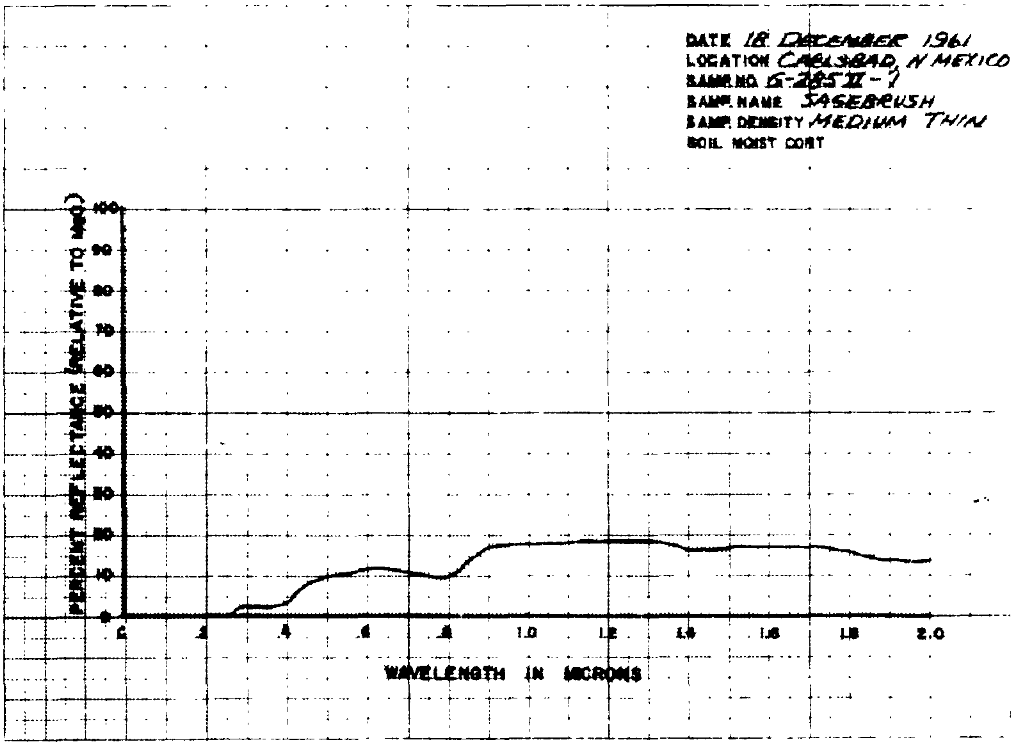

SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0 .2 .4 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0
WAVELENGTH IN MICRONS

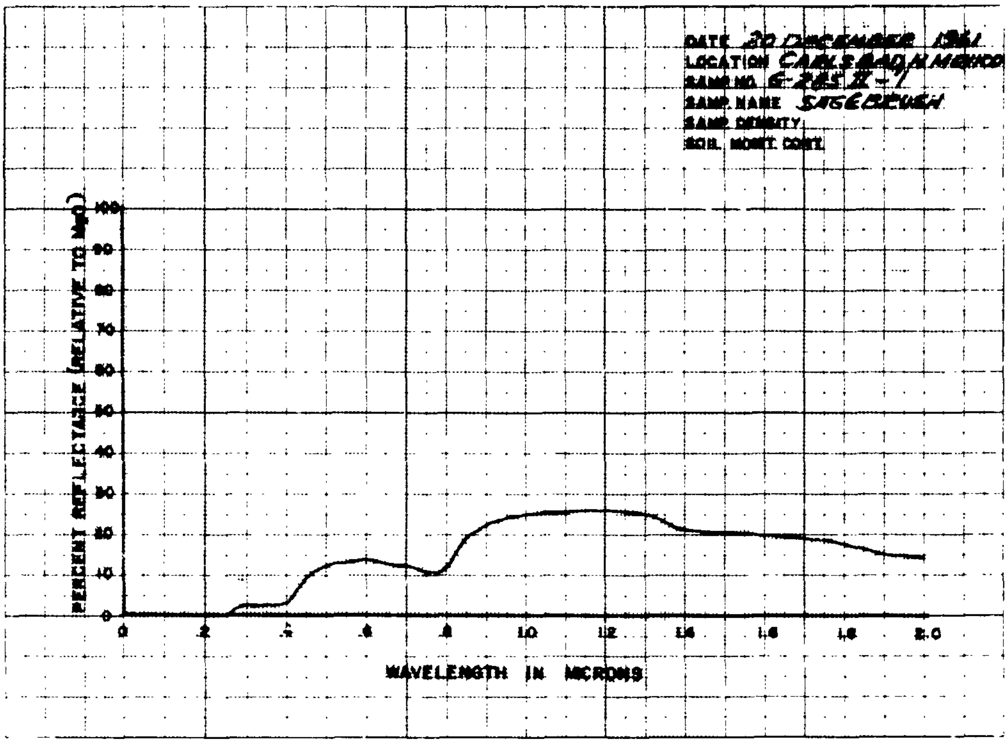

DATE 13 DECEMBER 1961
LOCATION CARLSBAD, N. MEXICO
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0 .2 .4 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0
WAVELENGTH IN MICRONS

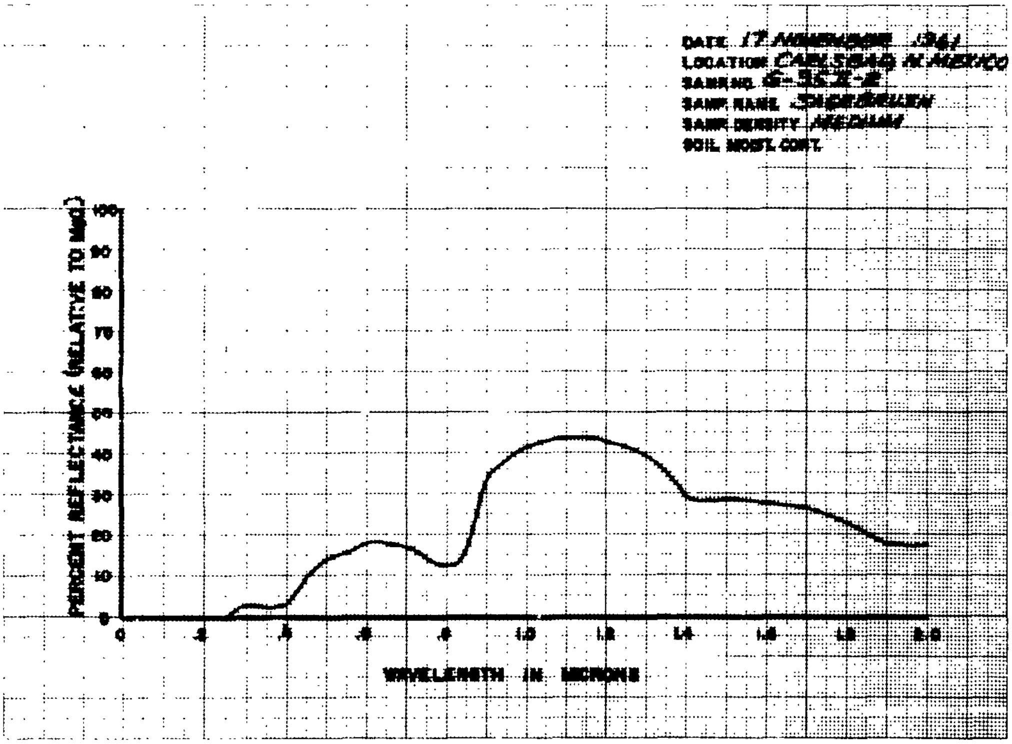

DATE 17 DECEMBER
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. 6-140 II-2
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

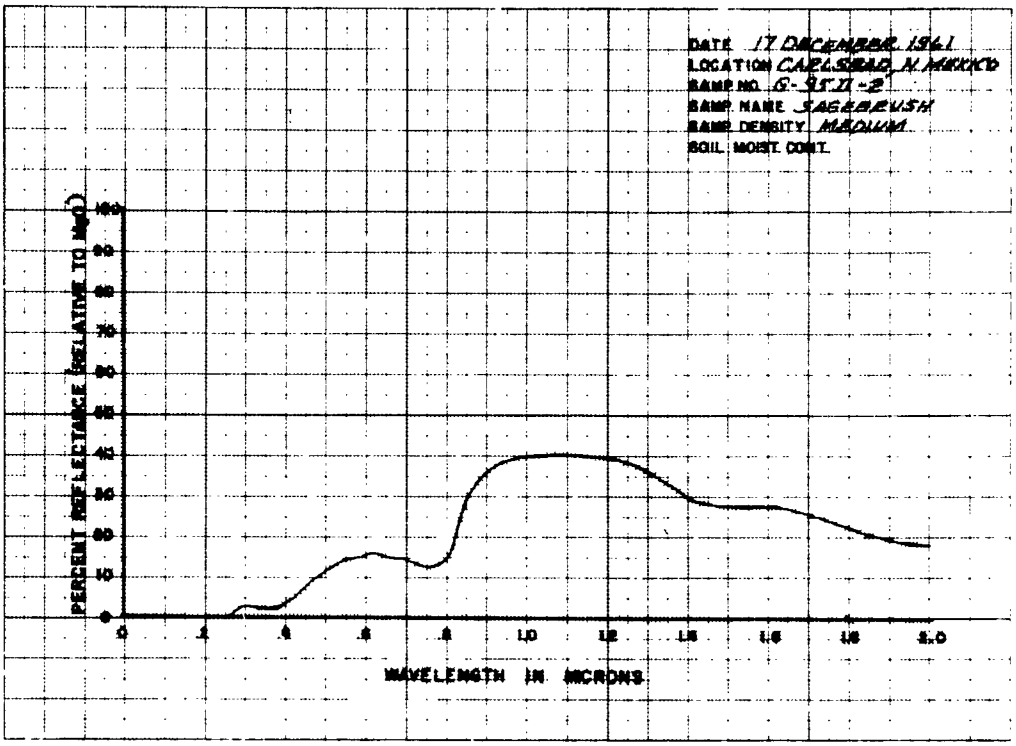

DATE 21 DECEMBER
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. 6-140 II-2
SAMP. NAME YUCCA
SAMP. DENSITY THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

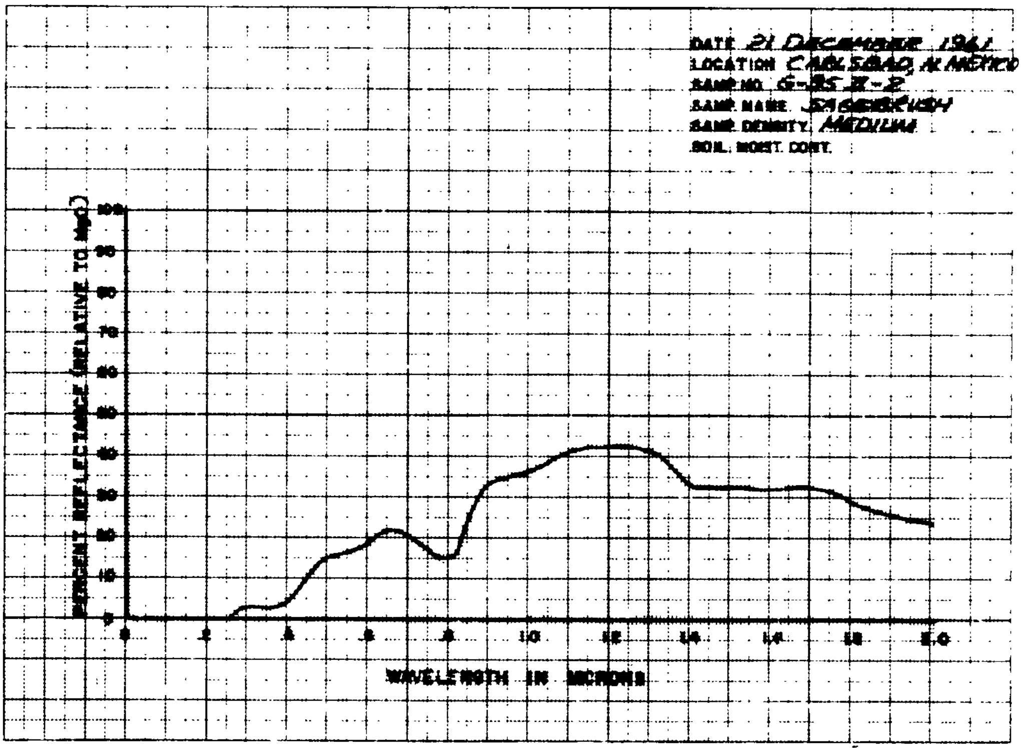

DATE 6 DECEMBER 1961.
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-285 II-1
SAMP. NAME SAGEBRUSH
SAMP. DENSITY MEDIUM THIN
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

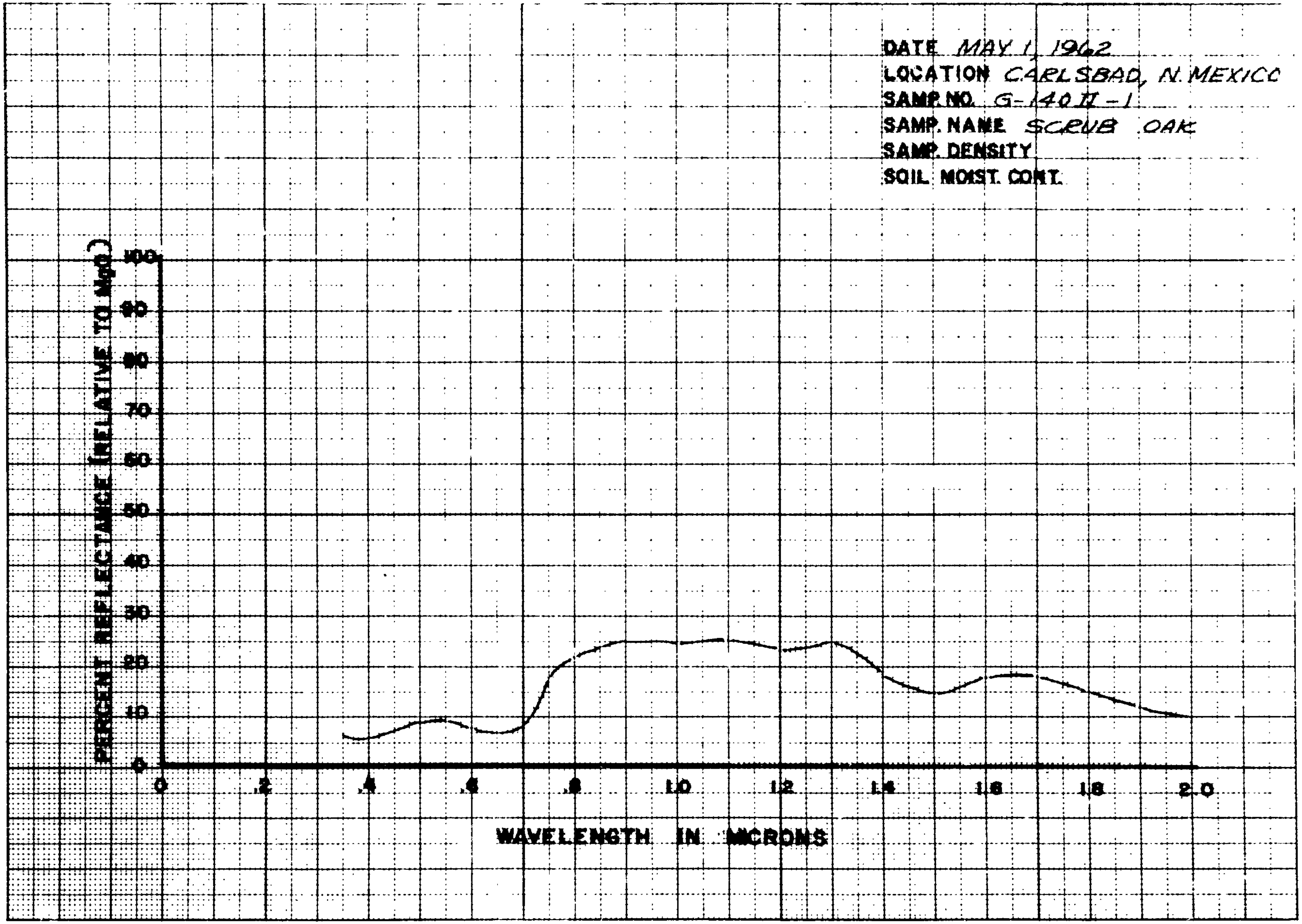

DATE 18 DECEMBER 1961
LOCATION CARLSBAD, N MEXICO
SAMP. NO. G-285 II-1
SAMP. NAME SAGEBRUSH
SAMP. DENSITY MEDIUM THIN
SOIL MOIST CONT
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

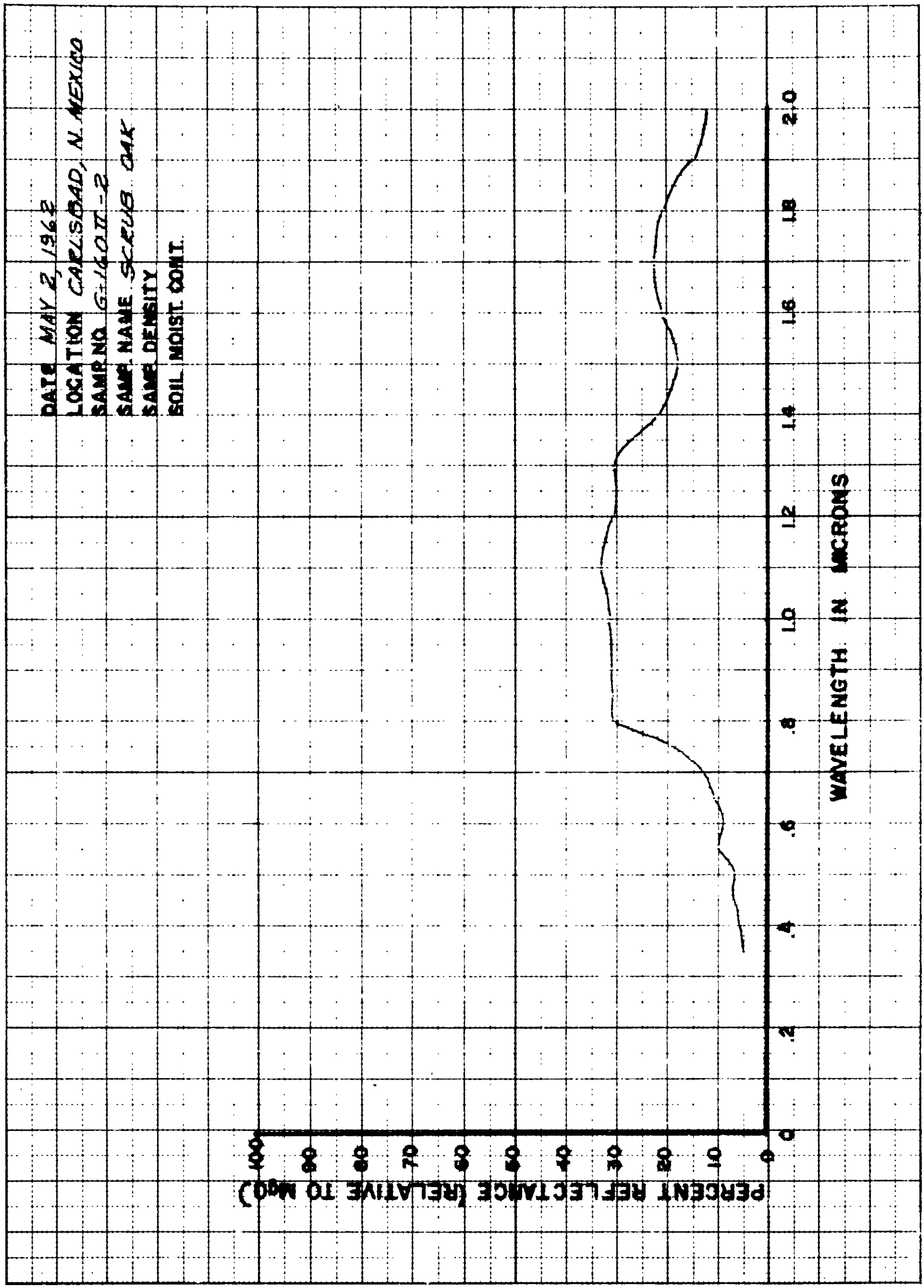

DATE
LOCATION CARLSBAD N MEXICO
SAMP. NO.
SAMP. NAME SAGEBRUSH
SAMP. DENSITY
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

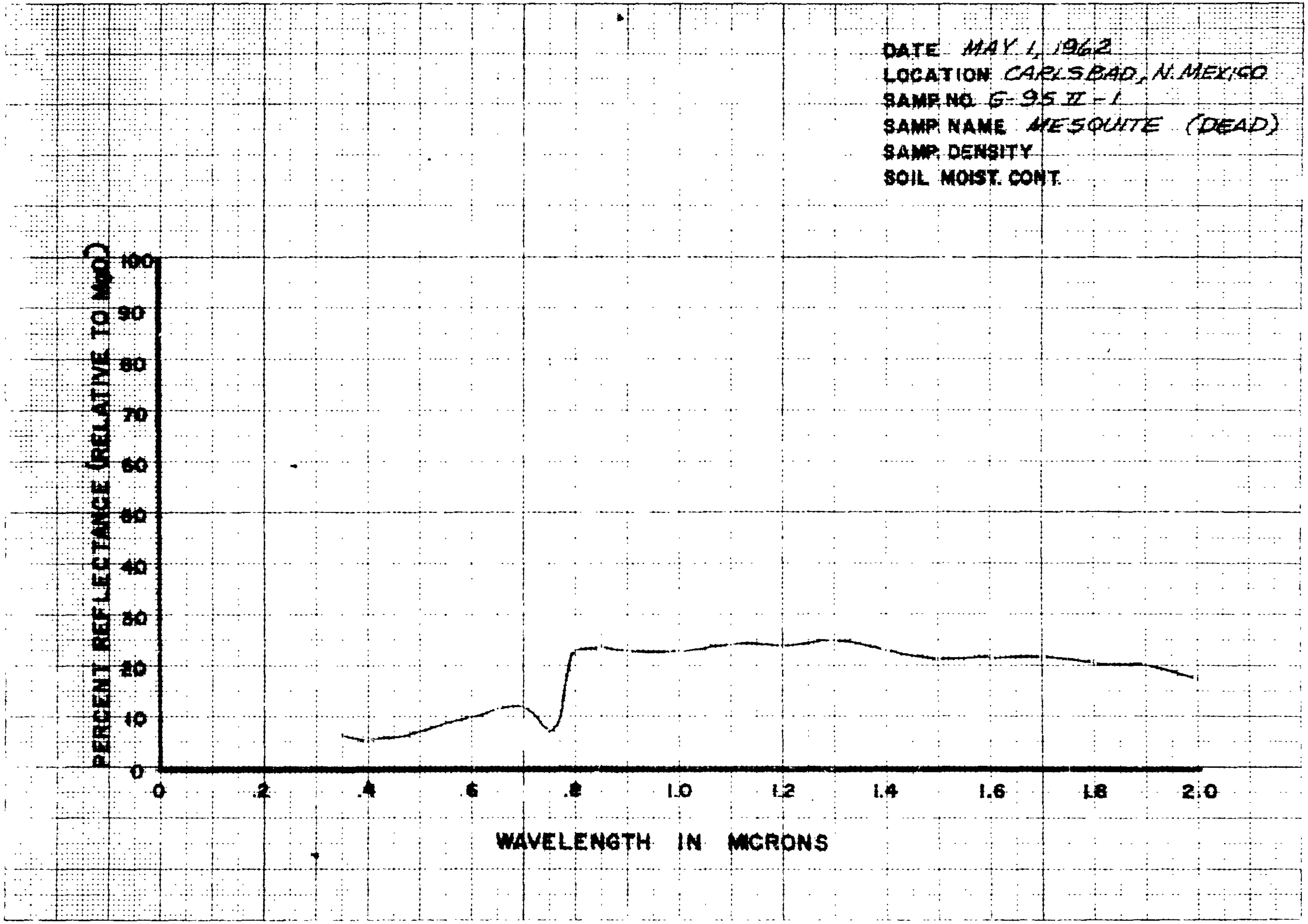

DATE
LOCATION CARLSBAD N MEXICO
SAMP. NO.
SAMP. NAME
SAMP. DENSITY MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

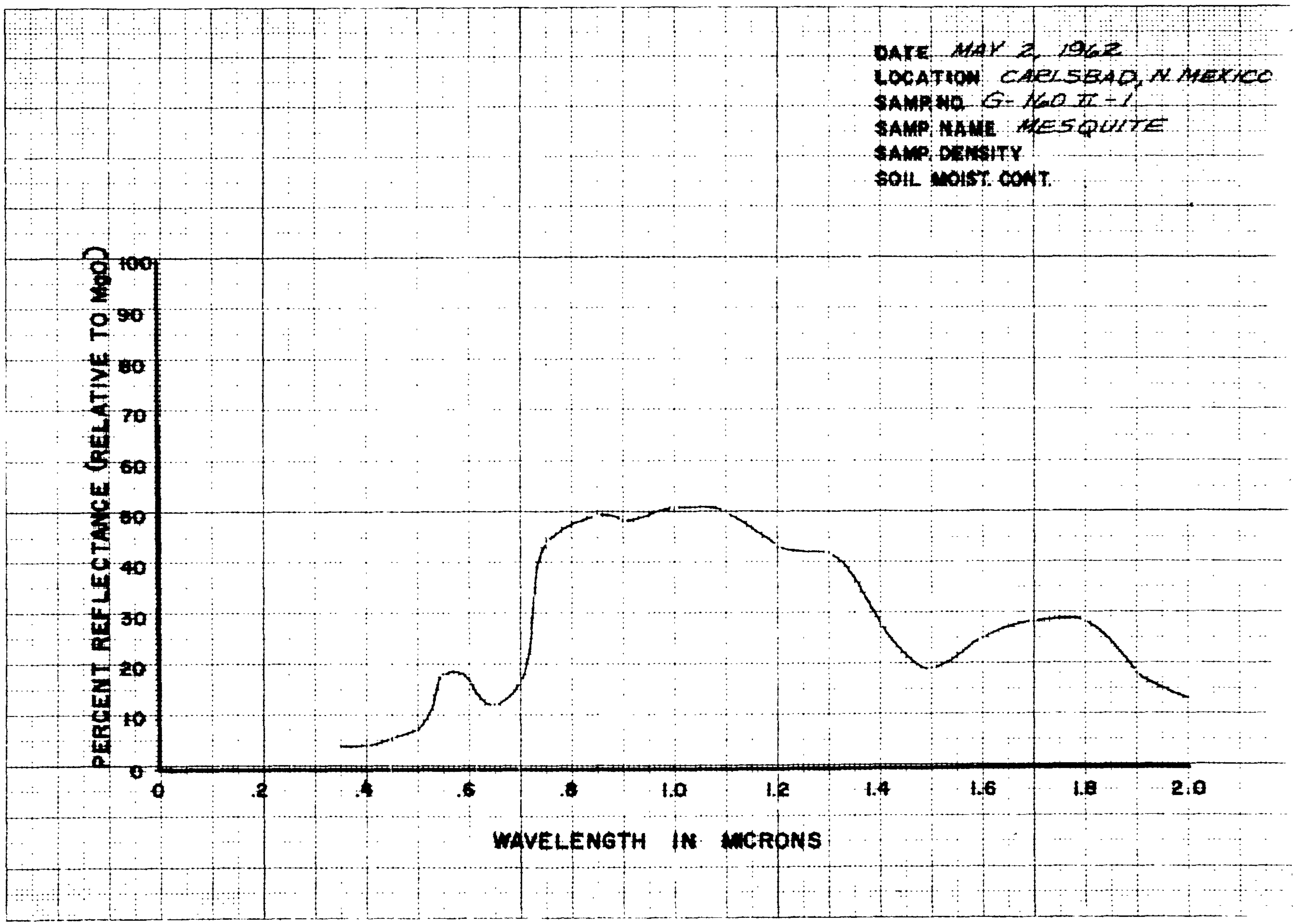

DATE 17 DECEMBER 1961
LOCATION CARLSBAD, N. MEXICO
SAMP. NAME SAGEBRUSH
SAMP. DENSITY MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

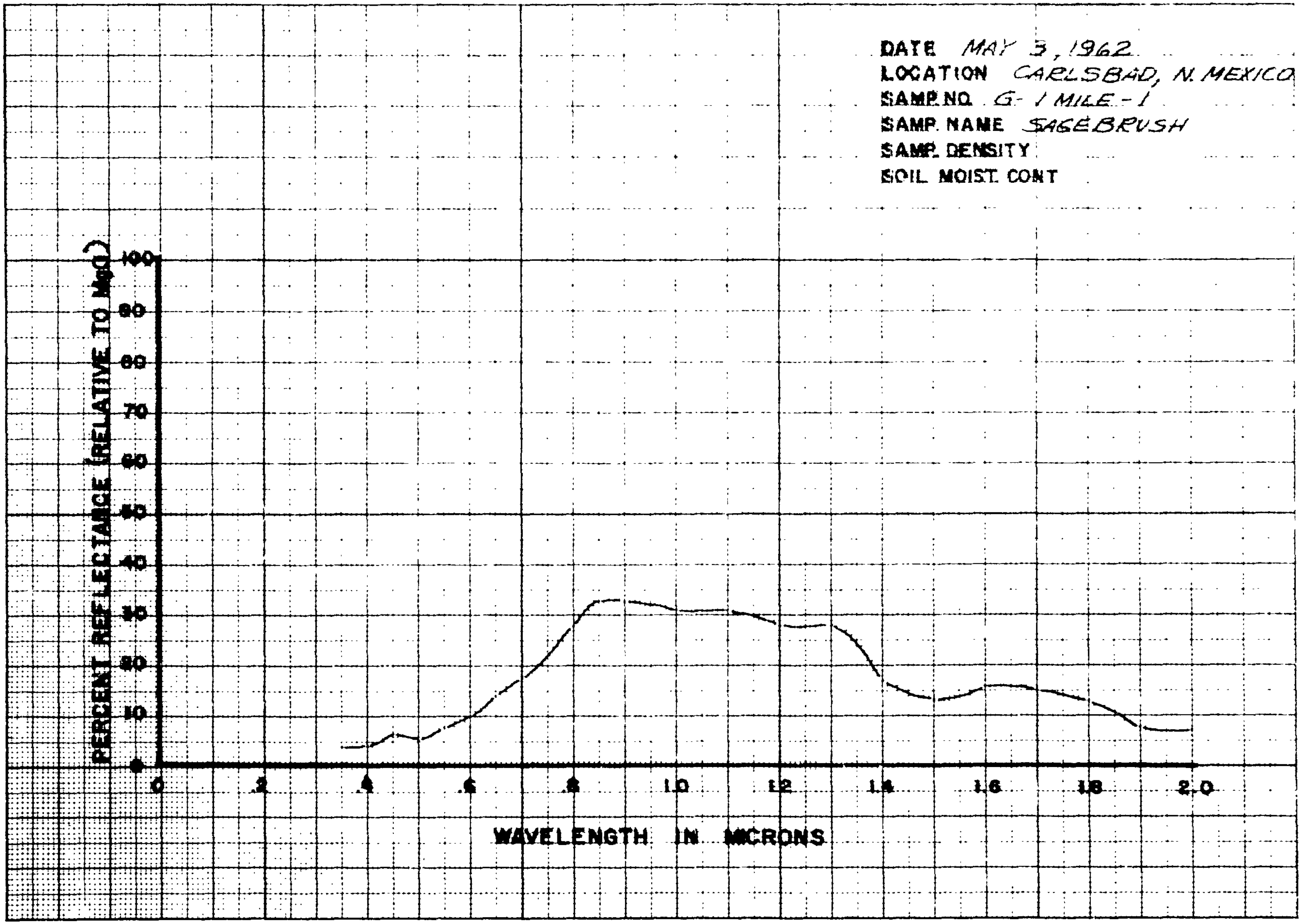

DATE 21 DECEMBER 1961
LOCATION CARLSBAD, N. MEXICO
SAMP. NAME SAGEBRUSH
SAMP. DENSITY MEDIUM
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
WAVELENGTH IN MICRONS

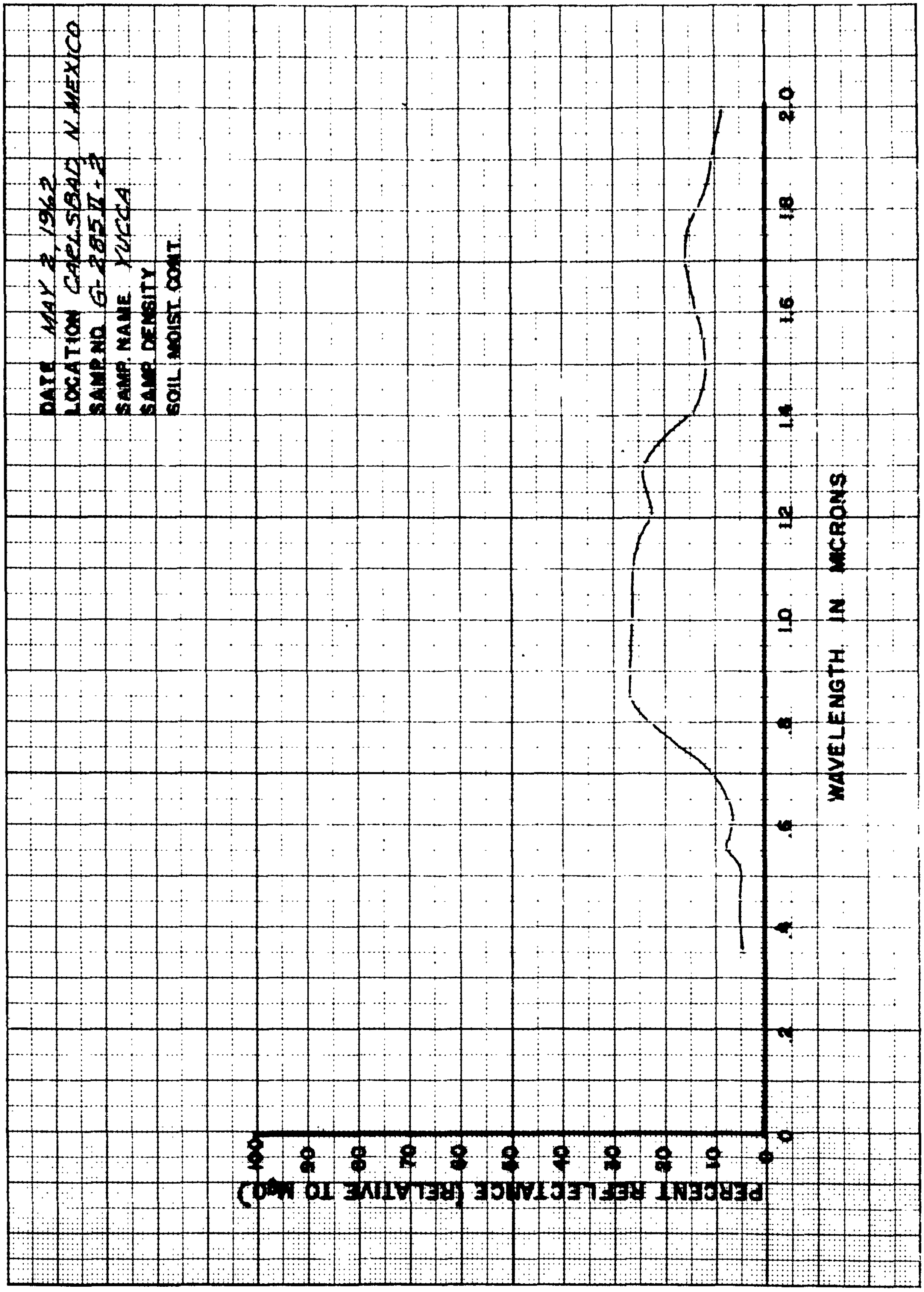

DATE MAY 1, 1962
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-140 II -1
SAMP. NAME SCRUB OAK
SAMP. DENSITY
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS


DATE MAY 2, 1962
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-160 II-2
SAMP. NAME SCRUB OAK
SAMP. DENSITY
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

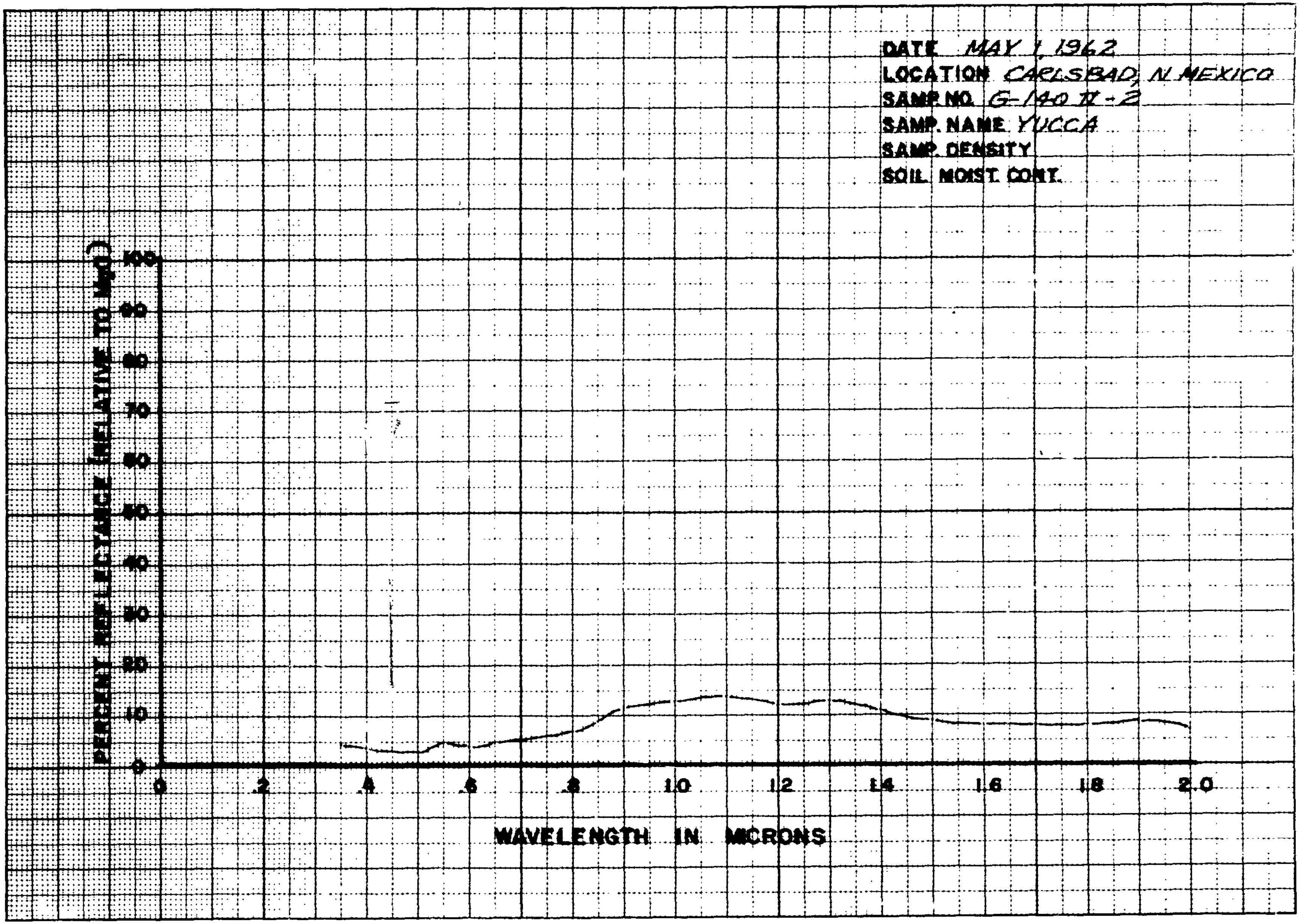

DATE MAY 1, 1962
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-95 II-1
SAMP. NAME MESQUITE (DEAD)
SAMP. DENSITY
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

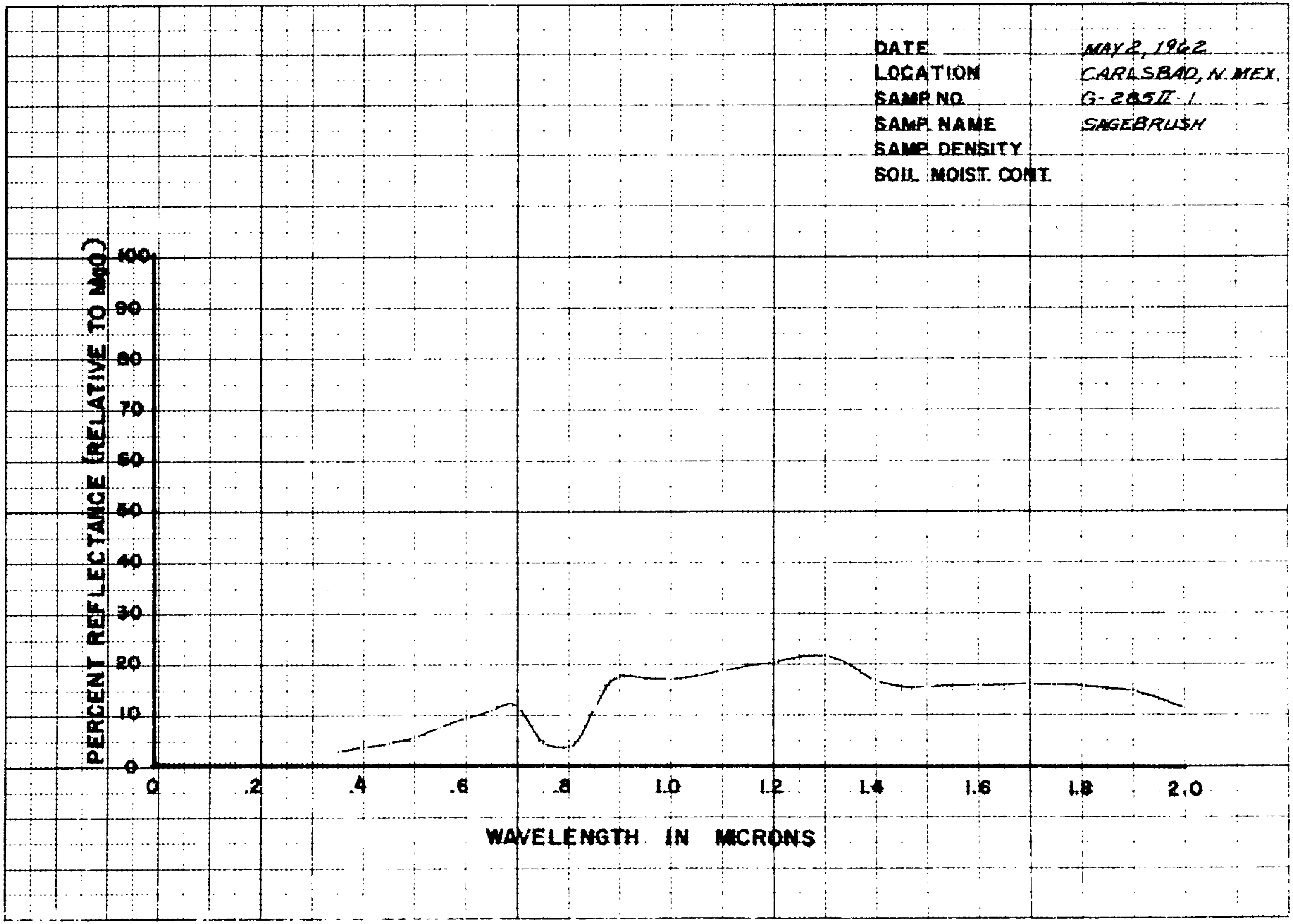

DATE MAY 2, 1962
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-N6D II-1
SAMP. NAME MESQUITE
SAMP. DENSITY
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS

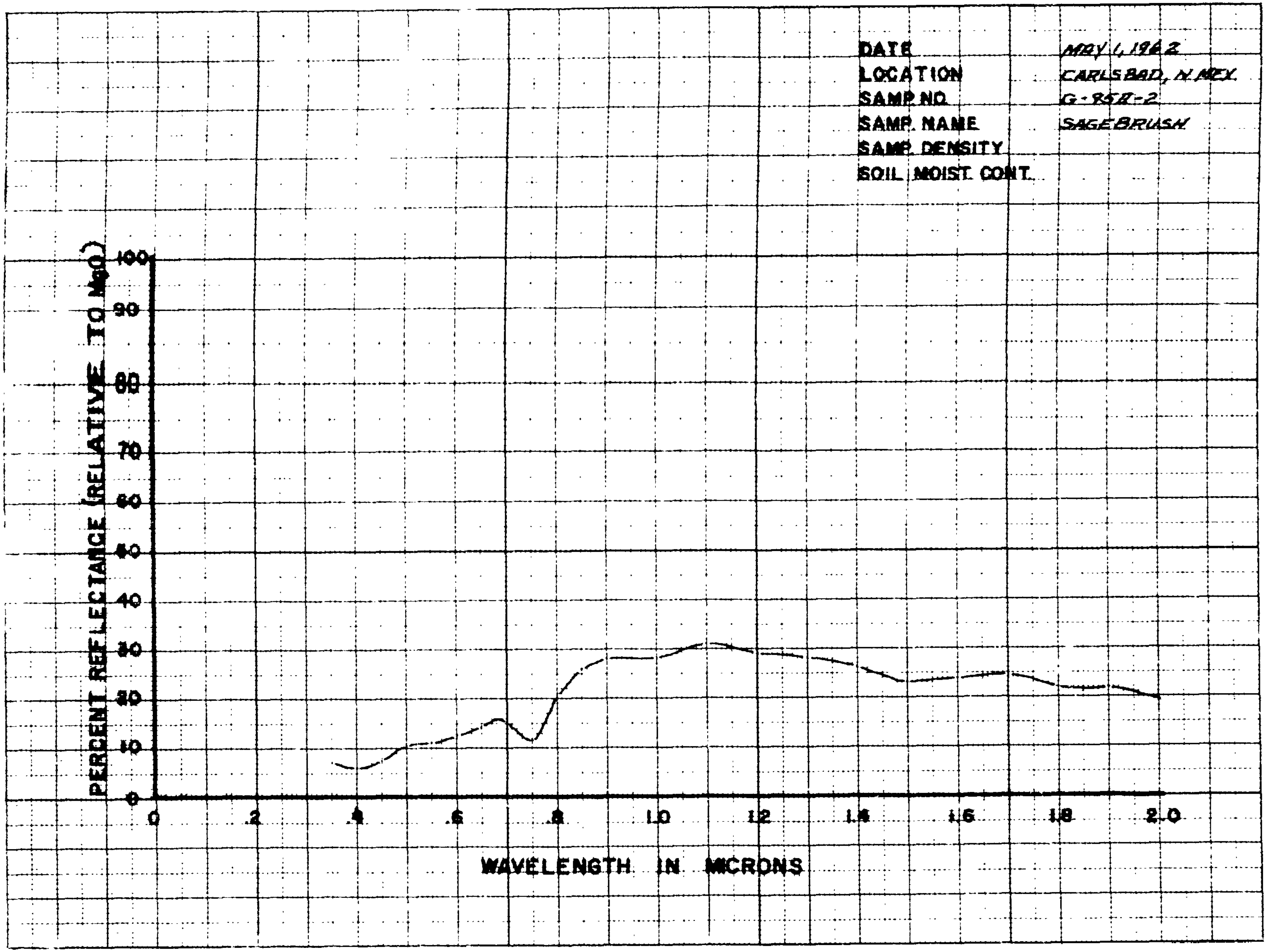

DATE MAY 3, 1962
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G - 1 MILE - 1
SAMP. NAME SAGEBRUSH
SAMP. DENSITY
SOIL MOIST. CONT
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS



DATE MAY 2 1962
LOCATION CARLSBAD, N.MEXICO
SAMP. NO. G-285II+3
SAMP. NAME YUCCA
SAMP. DENSITY
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS


DATE MAY 1, 1962
LOCATION CARLSBAD, N. MEXICO
SAMP. NO. G-140 II-2
SAMP. NAME YUCCA
SAMP. DENSITY
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS


DATE MAY 2, 1962
LOCATION CARLSBAD, N. MEX.
SAMP. NO. G-285II-1
SAMP. NAME SAGEBRUSH
SAMP. DENSITY
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
100
90
80
70
60
50
40
30
20
10
0
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS


DATE MAY 1, 1962
LOCATION CARLSBAD, N MEX
SAMP NO. G-952-2
SAMP. NAME SAGEBRUSH
SAMP. DENSITY
SOIL MOIST. CONT.
PERCENT REFLECTANCE (RELATIVE TO MgO)
0
10
20
30
40
50
60
70
80
90
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
WAVELENGTH IN MICRONS