TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS

FOUR SOILS IN THE PANAMA CANAL ZONE

MISCELLANEOUS PAPER NO. 4-355

Report 1

September 1959

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
OFFICE OF THE DIRECTOR
VICKSBURG, MISSISSIPPI

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25 June 1959

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TO: Chief of Engineers (ENGNB)
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1. On 22 April we sent to you for comments and/or approval for publication a draft copy of a miscellaneous paper, "Moisture and Strength Predictions for Four Tropical-Climate Soils in the Panama Canal Zone," dated April 1959. In a telephone conversation on 24 June, Mr. Robert Jackson advised our Mr. A. A. Rula that this draft report was not in your office; therefore, we are inclosing another copy.

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/s/
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Acting Director

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DA, Office of the Chief of Engineers, Washington 25, D. C., 14 July 1959

TO: Director, USA Engineer Waterways Experiment Station, Vicksburg, Miss.

The inclosed paper is approved for publication and distribution as requested.

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ARMY-MRC VICKSBURG, MISS.

PREFACE

This study is part of a long-range investigation of means of forecasting the trafficability of soils and was conducted under Corps of Engineers Subproject 8-70-05-400, "Trafficability of Soils as Related to the Mobility of Military Vehicles." It was performed by personnel of the Army Mobility Research Center, Waterways Experiment Station, under the general supervision of Messrs. W. J. Turnbull, Chief, Soils Division, C. R. Foster, Assistant Chief, Soils Division, and S. J. Knight, Chief, Army Mobility Research Center. Messrs. A. A. Rula, Chief, and E. S. Rush, engineer, Trafficability Section, prepared this report. They were assisted in the analysis of the data by Mr. B. G. Stinson, mathematician, and Mrs. E. W. Balthis, engineering aide.

Acknowledgment is made to Mr. Stanley H. Robertson, Chief, Corps of Engineers Field Test Team (Tropic), Engineer Research and Development Laboratories, and to members of the Field Test Team for collecting the data for this report.

Directors of the Waterways Experiment Station during the conduct of this study and preparation of this report were Col. A. P. Rollins, Jr., CE, and Col. Edmund H. Lang, CE. Mr. J. B. Tiffany was Technical Director.

CONTENTS

SUMMARY

The study of soil trafficability prediction was extended to a humid tropical climate to determine whether the prediction system as developed for soils in temperate climates could also be successfully applied to soils in tropical climates. Four sites in the Panama Canal Zone were selected for study, and soil moisture and strength data were collected weekly from these sites for a period of eighteen months. The average prediction relations previously derived from data measured in a temperate climate (United States) and in a tropical climate (Puerto Rico) were then applied to the data collected in Panama. From a comparison of the predicted and measured soil-moisture values it is concluded that:

a. The average soil-moisture predictions developed from U. S. and Puerto Rico data can be used with some success on the soils of Panama or of regions having a similar climate.

b. The quality of moisture content-strength relations for tropical-climate soils is considerably lower than similar relations derived for temperate-climate soils.

A brief study of available data on the topography and soils of the Panama Canal Zone permits the following conclusions regarding the trafficability of the region:

a. The fine-grained upland soils of the Canal Zone usually retain high strength at high moisture contents. The lowland soils become wetter and strengths become critical from a trafficability standpoint.

b. Upland soils are generally trafficable during the wet season, but wheeled vehicles may fail to climb slopes because of slipperiness. The lowland soils are generally trafficable during the wet season only for low-ground-pressure tracked vehicles.

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS

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PART I: INTRODUCTION

1. The study reported herein is part of a program comprising the investigation of means of forecasting variations in the trafficability of soils caused by weather and climate. The trafficability of a given soil is affected primarily by its moisture content; therefore, if the moisture content of a soil can be predicted, an estimate of trafficability can be made from a predetermined relation between soil moisture and strength.

Purpose and Scope

2. As a result of a conference of consultants for the soil-moisture prediction study held at the Waterways Experiment Station in December 1954, it was decided that the study be extended to a humid tropical climate to determine whether the prediction system as developed for soils in temperate climates can be also applied to soils in tropical climates.

3. Arrangements were made with the Engineer Research and Development Laboratories, CE, for their Engineer Test Team (Tropic), located at Fort Clayton, Panama Canal Zone, to furnish the Waterways Experiment Station with soil moisture and strength data collected once a week for a period of 18 months at four sites in the Panama Canal Zone near Fort Clayton.

4. This report presents an application of average prediction relations derived from data measured in a temperate climate (United States) and in a tropical climate (Puerto Rico) to data collected in Panama during the period from 2 March 1955 through 31 August 1956 at the four test sites.

Previous Investigations

5. Previous investigations of meteorological effects on soil trafficability are reported in Technical Memorandum No. 3-331, Forecasting Trafficability of Soils, Reports 1 through 5.

6. Investigations of the trafficability of soils by physical

measurements include reports under the general series title, Trafficability of Soils, Technical Memorandum No. 3-240, with 14 supplements.

Definitions

Soil terms

7. Cone index. An index of the shearing resistance of soil to penetration by the cone penetrometer.

8. Remolding index. An expression of the ability of a soil to retain its original strength under the traffic of a vehicle. The special equipment and techniques for determination of remolding index are described under "Remolding test."

9. Rating cone index. The product of cone index and remolding index for the same soil layer.

10. Moisture content (weight basis). A ratio, expressed as a percentage, of the weight of water in the soil to the weight of the dry soil.

11. Moisture content (volume basis). A ratio, expressed as a percentage, of the volume of water to the volume of the dry soil. The expression used in this report is inches of water per six inches of soil depth. The equation used in computing these moisture contents is as follows:

$$\text{Moisture content in. of water per 6-in. soil depth} = \frac{\underset{\%\text{ by wt}}{\text{moisture content}} \times \underset{\text{lb/cu ft}}{\text{dry unit wt}} \times \text{6-in. depth}}{\text{unit wt of water, lb/cu ft} \times 100}$$

12. Field-maximum moisture content. The recurring maximum moisture content of a soil layer in its natural position.

13. Available storage. The difference between the field-maximum moisture content and moisture content at the time under consideration.

14. Density. The unit weight in pounds per cubic foot. Unless specifically stated otherwise, the density is the dry unit weight.

15. Plastic limit. The moisture content at which a thread of soil rolled to a diameter of 1/8 in. crumbles. It represents the moisture content at which a mixture of soil and water begins to take on plastic properties (i.e., undergoes appreciable deformation with little volume change).

16. Liquid limit. The moisture content at which soil, placed in a standard laboratory cup and grooved with a standard tool, will flow

together when jarred 25 times by letting the cup fall a prescribed distance. It represents the moisture content at which the characteristics of a mixture of soil and water change from plastic to liquid.

17. Plasticity index. The numerical difference between the liquid and plastic limits. The numerical value of the plasticity index is an indication of the plasticity or clayeyness of the soil. Highly plastic clays have high plasticity indexes; less plastic clays have lower plasticity indexes.

18. Prediction relations. Accretion and depletion relations and others needed for predicting soil moisture.

Instrument and equipment terms

19. Cone penetrometer. A field instrument consisting of a 30-deg cone with 1/2-sq-in. base area mounted on a shaft in such a way that it can be forced into the soil by hand. The force required to move the cone slowly through a plane of soil is indicated on a dial inside a proving ring mounted at the top of the shaft. This force is considered to be an index of the shearing resistance of soil and is called cone index.

20. Trafficability sampler. A piston-type soil sampler for securing soft soil samples. Spacer bars permit cutting of the sample to a constant volume such that the density of the soil in pounds per cubic foot may be obtained by multiplying the weight of sample in grams by 0.4.

21. Remolding test. The following equipment is used to conduct the remolding test: a cone penetrometer equipped with a 1/2-sq-in. base area cone, a trafficability sampler, a cylinder of the same diameter as the trafficability sampler cylinder mounted vertically on a base, and a 2-1/2-lb drop hammer which travels 12 in. on an 18-in. section of a cone penetrometer staff fitted with a circular foot. The remolding test is conducted in the following manner: a sample is taken with the trafficability sampler, loaded into the remolding cylinder, and pushed to the bottom with the drop hammer foot. Cone indexes are measured at the surface and at 1-in. intervals to a depth of 4 in. Next, 100 blows of the hammer are applied and cone indexes are remeasured in the remolded soil at the same depths. The quotient obtained when the sum of the five cone index readings made after remolding (a value of 300 is assigned to each depth not measured because of inability to penetrate firm samples) is divided by the sum of the five

readings made before remolding is termed remolding index.

Statistical terms*

22. Linear regression. A straight line through a series of data determined by the method of least squares. In the parlance of mathematical statistics, the descriptive term "regression" has largely replaced the word "function."

23. Correlation coefficient. A number varying from +1.0 to -1.0. The sign indicates whether the slope of the regression line is positive or negative, while the magnitude indicates the degree of association. Values between 0 and +1.0 indicate a direct relation between two variables; values between 0 and -1.0 indicate an inverse relation. The coefficient is 0 if no relation exists and ±1.0 if perfect correlation exists. The correlation coefficient is symbolized by the letter "r."

24. Standard error of estimate. A measure of the variation of observed values from computed values of a dependent variable. It yields an estimate of the range above and below the line of regression within which two-thirds of the points may be expected to fall, if the scatter is normal. In this report the standard error of estimate is symbolized by "Sy.x."

25. Statistical significance of the correlation coefficient. A correlation coefficient significant to the 1% level indicates that for the number of samples made, there are 99 chances out of 100 that the relation determined is the real relation between the two variables. For a correlation coefficient significant to the 5% level, the relation determined is the real relation in 95 chances out of 100.

* George W. Snedecor, Statistical Methods, 4th ed. (Ames, Iowa, Iowa State College Press, 1953).

PART II: TEST PROGRAM

Topography and Climate of Panama Canal Zone

26. The Panama Canal Zone is a strip of land approximately 10 miles wide, running northwest-southeast across the Republic of Panama from the Caribbean Sea to the Pacific Ocean. The terrain is generally rugged and hilly, especially along the continental divide where local relief may vary from 200 to 1000 ft within short distances. Most of the upland soils are fine-grained laterites or are lateritic in character. These soils exhibit claylike properties, are friable, highly permeable, and possess a high resistance to penetration. The fine-grained bottomland soils are somewhat more plastic than the upland soils, but sandy and silty soils are also encountered.

27. The climate of the Canal Zone is humid-tropical with fairly uniform, high ambient temperatures occurring the year around. The region has a relatively long rainy season, which usually occurs between the first of May and the first of the following February, and a short dry season usually lasting from the first of February until the end of April. The mean annual rainfall is about 70 in. on the Pacific side and about 130 in. on the Caribbean side.

Location and Description of Test Sites

28. The four test sites selected for this study were designated Las Cruces, Fort Kobbe, Fort Clayton, and Pedro Miguel. They are located in the southeast one-third of the Canal Zone at approximately latitude 9°N and longitude 79°35'W (see plate 1). Because of their low topographic positions and frequent high water table and surface flooding, the Las Cruces, Fort Kobbe, and Fort Clayton sites are considered to be poorly drained. The Pedro Miguel site is on top of a hill and is not subject to surface flooding or ground-water influence, so is considered a well-drained site.

29. Each test site was a 40- by 40-ft, level, undisturbed area supporting native vegetation of grasses or trees. During each visit to a test site, the necessary data were obtained at randomly selected points

within the test plot. Daily rainfall and other pertinent meteorological data were not measured at each site, but records were obtained from the nearest weather station which was the Air Weather Station at Albrook Air Force Base (see location in plate 1).

30. Grain-size curves and Atterberg limits of the soils in the 6- to 12-in. depths at the four test sites are shown in plate 2. The sites are described in the following paragraphs.

Las Cruces

31. This site is located 8 miles north-northwest of Fort Clayton, 50 yd west of Madden Road, and a few feet north of the Las Cruces tract in the Madden Forest Preserve. It is approximately 10 miles from the Albrook AFB weather station. Vegetation at the site is typical of the jungle on the Pacific side of the isthmus. The soil is a brown heavy clay containing some stones, with a shallow surface layer of organic material. According to a soils map prepared by Bennett,* the surface soil is classified as Arraijan clay with basalt as a parent material. Soil from the 6- to 12-in. depth is classified as MH according to the USCS (Unified Soil Classification System).

Fort Kobbe

32. This test site is located southwest of Panama City in the southwest corner of the Canal Zone about 0.5 mile north of the Pacific coast and 0.5 mile east of the boundary between the Canal Zone and the Republic of Panama. Albrook AFB weather station is approximately 6 miles from the test site. Vegetation consisted of a spotty growth of tall grasses. The soil is mapped by Bennett as San Jose phase of Arraijan clay. A geological map of the area identified the test site as muck. The soil is a black clay which appeared to be highly organic, and in the 6- to 12-in. depth classified as CH according to the USCS.

Fort Clayton

33. This test site is located on the north side of Fort Clayton on Curundu Military Reservation in a fairly broad area (which probably is a

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* H. H. Bennett, "Some comparisons of the properties of humid-tropical and humid-temperate American soils, with special reference to indicated relations between chemical composition and physical properties," Soil Science, vol XXI (1926).

stream terrace). The site is approximately 3 miles from the weather station. It was covered with tall grasses. The soil is clay, classified as Bluefields clay by Bennett, and as MH in the 6- to 12-in. depth according to the USCS. The area has been mapped in a heterogeneous geologic division consisting of tuffs, etc.

Pedro Miguel

34. This site is typical of the hill topography of the greater part of the Panama area. It is located 2 miles northwest of Fort Clayton on top of the first hill northwest of Pedro Miguel, and is 5 miles from the weather station. The soil is mapped as Arraijan clay (derived from basalt) by Bennett and the 6- to 12-in. depth was classified as an MH according to the USCS. This site is similar to the Las Cruces site except in soil texture, surface-drainage patterns, and grass growth which was not as dense at this site.

Soil Data Collected

35. The frequency, type, and number of samples obtained during each visit to a test site are described in the following paragraphs. A summary of the data collected is given in tables 1 and 2.

Physical properties

36. Soil data were collected weekly at all four sites from 2 March 1955 through 30 August 1956 except at Fort Kobbe where data collection was not begun until 10 March 1955. The following paragraphs describe the data collected.

37. Moisture content and density. When the soil was comparatively soft, the trafficability sampler was used to extract an undisturbed sample from the 0- to 6-in. depth and one from the 6- to 12-in. depth. Each sample provided both moisture-content and density data. When the soil was too firm for the proper employment of the trafficability sampler, a 2-in. auger was used to obtain disturbed samples from these two layers for moisture-content determination only.

38. Mechanical analysis and Atterberg limits. One set of samples was obtained at each site from the 6- to 12-in. depth and shipped to the Waterways Experiment Station's soils laboratory for mechanical analysis,

and Atterberg limits and specific gravity determinations. The mechanical analysis curves and Atterberg limits are shown in plate 2. Table 1 also shows Atterberg limits and percentages of sand and fines as well as specific gravities and average densities for the site.

Strength

39. Cone index. Three measurements of cone index were also made weekly at each site. They were taken at the surface and at 3-in. increments to a depth of 24 in., or to the depth where the soil was too firm to penetrate. The cone index values shown in plates and tables of this report are the average values of the three measurements.

40. Remolding index. Remolding tests were made on samples taken from the 6- to 12-in. depth, when possible. About 50 per cent of the time the soil was too hard and dry to permit sampling with the trafficability sampler.

41. Rating cone index. Rating cone index computations were made when remolding and cone index data were available for the 6- to 12-in. depth.

PART III: ANALYSIS OF DATA

42. In previous studies, methods of predicting soil moisture were derived using prediction relations peculiar to each site investigated. From these individual site prediction relations, average prediction relations were developed that can be applied to other sites. Reasonable soil-moisture predictions were obtained by using these average prediction relations and specific data on soil and site factors. The data collected for this study were first examined to determine if individual prediction relations could be derived, but the infrequency of data collection did not permit such derivations. Therefore, average prediction relations (for United States and Puerto Rico soils, respectively) were applied to the soils in this study as described in the following paragraphs. In addition, results of correlation of soil strength parameters and density with moisture content, and the general trafficability of the Panama Canal Zone are discussed.

Data Needed for Soil-Moisture Prediction

43. The prediction method and average prediction relations for United States soils used in this report are explained in detail in Waterways Experiment Station Technical Memorandum No. 3-331, Forecasting Trafficability of Soils, Report No. 5. The average prediction relations for Puerto Rico soils were taken from a report on derivation of prediction relations in Puerto Rico not yet published. The prediction relations include accretion and depletion relations. Accretion relations account for the soil wetting during periods of rain, and depletion relations account for soil drying during periods of no rain. Accretion relations are sufficiently similar for all soil textures (sandy, silty, and clayey soils) to permit the use of one average relation; however, depletion relations vary mainly according to soil texture. Soil factors pertinent to making the predictions discussed in this report include an identification of soil texture, and maximum and minimum moisture contents that occurred during the data-collection period which establish the limits of wetting and drying for a soil layer. The type of information necessary to make a soil-moisture prediction is listed on the following page, and the data used in making

soil-moisture predictions for the four test sites are discussed in the subsequent paragraphs.

a. Soil classification.

b. Moisture content in inches per 6-in. depth converted from moisture content in per cent.

c. Actual moisture contents, expressed in inches, of the 0- to 6-in. and 6- to 12-in. soil depths on the day the prediction starts.

d. The field-maximum and -minimum moisture contents for both soil depths.

e. The minimum-size storm that will cause accretion in the 0- to 12-in. depth.

f. The amount of rainfall for each storm that occurs during the period of prediction, in daily increments.

g. The amount of soil-moisture increase caused by rainfall (accretion).

h. The amount of soil-moisture loss between storms (depletion).

Data Used in This Study

Soil classification

44. According to the USCS, one site (Fort Kobbe) was classified as a CH soil and the other three as MH. Under the U. S. Department of Agriculture textural classification system, the Fort Clayton and Pedro Miguel soils classify as silty clay, Las Cruces as clay, and Fort Kobbe as clay loam.

Conversion of moisture content from per cent to inches per 6-in. depth

45. In the normal procedure for converting moisture content from per cent to inches per 6-in. depth in soil-moisture prediction studies, an average density obtained at several moisture contents representative of the natural range for the soil is used. However, since it appeared that density was significantly affected by moisture content at each of the four sites (see plates 10-12, inclusive), it was decided to test the prediction method by using both average density and the individual density (where available) obtained in each visit to a site in converting to inches of water. When density measurements were not made, a density value was

obtained by using the respective density-moisture content curve established for a given soil depth. It was found that the individual density values produced more reasonable-appearing values of moisture content in inches than did the average density values, and that better agreement was obtained between predicted values and measured values of moisture content as a consequence. The moisture contents given in the following paragraphs were determined from individual density measurements.

Actual moisture content for starting day

46. Starting dates and actual moisture contents on those dates at the four test sites were as follows:

Site	Starting Date	Actual Moisture Content, in./6 in. of Soil	
		0 to 6 in.	6 to 12 in.
Las Cruces	2 March 1955	2.78	2.82
Fort Kobbe	10 March 1955	1.17	1.47
Fort Clayton	2 March 1955	2.45	2.68
Pedro Miguel	2 March 1955	2.36	2.68

No other actual moisture-content values are used in the prediction process.

Field-maximum and -minimum moisture contents

47. Field maximum. The highest moisture contents that occurred during the wet period for a given soil depth at a given test site were considered in choosing field-maximum moisture content. The actual moisture content for each soil depth was plotted for the day on which it was measured and a visual average of the maximum values was made. In several instances, the measured moisture contents were in excess of the value computed to represent 100% saturation. Such data, although shown in table 2, were not plotted or used in the analysis. The field-maximum moisture content used for each depth at each site was as follows:

Site	Field-maximum Moisture Content, in./6 in. of Soil	
	0 to 6 in.	6 to 12 in.
Las Cruces	3.40	3.15
Fort Kobbe	2.95	2.60
Fort Clayton	3.70	3.30
Pedro Miguel	3.10	3.30

48. Field minimum. Field-minimum moisture contents were assigned to each soil depth by visually averaging the lowest moisture contents that occurred. The values assigned to each depth were:

Site	Field-Minimum Moisture Content, in./6 in. of Soil	
	0 to 6 in.	6 to 12 in.
Las Cruces	2.55	2.65
Fort Kobbe	1.00	1.20
Fort Clayton	1.80	2.10
Pedro Miguel	2.20	2.30

Minimum storm size

49. The minimum storm size for all four sites was 0.08 in. This value was selected by trial and error from an examination of rainfall and moisture data. It was considered that storms of 0.07 in. or less wetted only the plants and litter and little or no rain entered the soil. For prediction purposes, days with 0.07 in. or less are treated in the same manner as days without rain.

Rainfall by storms and dates

50. As stated previously, meteorological data were collected at only one weather station, Albrook AFB, which was as much as 10 miles away from one of the sites. Daily rainfall and other weather data for the entire prediction period are listed in table 4.

Accretion relations

51. Accretion relations apply to all soil textural classes (sand, silt, or clay). The average accretion relations for U. S. and Puerto Rico soils are shown in plate 3. Storm sizes are listed by accretion Classes I and II. Class I accretions relate rainfall to accretion, and Class II accretions relate available storage to accretion. Available storage is determined by subtracting the actual moisture content on the day before a storm from the field-maximum moisture content.

Depletion relations

52. In TM No. 3-331, Report No. 5, average depletion relations for U. S. soils are given for three seasons -- summer, transition, and winter -- and for three soil textural classes -- sand, silt, and clay. Since the Panama soils (MH) exhibited the plastic properties of clays when wet and the friable properties of silts when dry or moist, the depletion relations

for these soils were tested using both the clay and silt curves. It was found that better agreement between predicted and measured moisture contents was obtained when the curves for clay soils were used. In the first attempt at accounting for soil-moisture depletion, the summer curves were used but deviation of predicted from actual moisture content was nearly 0.50 in. low. This deviation indicated that a slower depletion rate was necessary. Therefore the transition depletion curves were used, and better agreement was obtained between actual and predicted moisture contents. The U. S. depletion curves used (transition season and clay soil) are shown in plate 4.

53. Data on the Puerto Rico soils were not sufficient to permit separating depletion rates on the basis of texture; however, a single curve appeared to express depletion for all seasons. An average depletion curve for the six MH soils investigated in Puerto Rico was determined and applied to the soils in Panama. The Puerto Rico depletion curves are also shown in plate 4.

54. In the application of average depletion curves to a specific soil depth, a correction factor must be used. This factor is based on a ratio of the water-holding capacity (field-maximum moisture content minus field-minimum moisture content) of the soil depth under consideration to that of the average depletion curve to be used. For example, the average depletion curve for the 0- to 6-in. depth shown for the U. S. in plate 4 has a range of 1.47 in., and the curve for the 0- to 6-in. depth at the Las Cruces test site has a water-holding capacity of 0.85 in. The ratio of 0.85/1.47 or 54 per cent of the average depletion rate is used as the correction factor to adjust the Las Cruces depletion rate for the 0- to 6-in. depth. The following table shows the correction factors for the Panama sites using the U. S. and Puerto Rico average depletion relations.

Site	U. S. Transition Period		Puerto Rico	
	0- to 6-in. Depth	6- to 12-in. Depth	0- to 6-in. Depth	6- to 12-in. Depth
Las Cruces	54	46	102	82
Fort Kobbe	129	129	235	231
Fort Clayton	129	111	229	197
Pedro Miguel	61	93	108	164

Other factors affecting
soil-moisture predictions

55. Moisture-content prediction for all four sites was carried on continuously. It started with the first-day actual moisture contents and continued for a period of 18 months. It was apparent from the field data that ground-water tables affected the actual moisture content at three of the sites during the period 1 January 1956 through 28 February 1956. The currently available prediction method does not take into account water table effects; therefore, the predicted moisture is probably in error throughout this period. Usually, a prediction is stopped at the beginning of a critical water table period and started again after the water table has receded to a depth at which it does not affect moisture content in the top 12 in. However, in this study two predictions were made: one was carried on through the critical water table period; in the other the water table period was omitted. Studies are under way to develop prediction relations for soil areas where moisture contents are affected by the water table.

56. Distance of the weather station from the test sites had some influence on the relation between rainfall and measured soil moisture; however, oddly enough, the site nearest the weather station gave the poorest comparison between predicted and actual results.

Accuracy of Prediction

57. Plots of actual and predicted moisture contents using average U. S. prediction relations and bar graphs of daily rainfall are shown in plates 5-8. Plots were not made on the basis of average Puerto Rico prediction relations.

58. The following tabulations list average deviations (regardless of sign) of predicted from actual moisture contents, using average prediction relations derived for both U. S. and Puerto Rico soils. The deviations shown in columns 2 and 3 represent the averages determined for the entire period of record, and columns 4 and 5 represent the averages by excluding the period in which three of the sites were influenced by high water tables.

Site	Average Deviations, in.			
	Entire Period		Excluding Water Table Period	
	0 to 6 in.	6 to 12 in.	0 to 6 in.	6 to 12 in.
Average U. S. Prediction Relations				
Las Cruces	0.20	0.13	0.16	0.13
Fort Kobbe	0.35	0.23	0.28	0.20
Fort Clayton	0.29	0.27	0.25	0.26
Pedro Miguel	0.17	0.18	----	----
Weighted Avg	0.25	0.20	0.21	0.19
Average Puerto Rico Prediction Relations				
Las Cruces	0.18	0.12	0.16	0.12
Fort Kobbe	0.34	0.27	0.28	0.21
Fort Clayton	0.31	0.31	0.27	0.26
Pedro Miguel	0.20	0.20	----	----
Weighted Avg	0.25	0.22	0.23	0.19

59. From this tabulation, it can be seen that the accuracy of prediction is practically the same whether average relations for the U. S. or Puerto Rico are used. The accuracy of both methods was increased by excluding the high water table period from the entire period of record. A comparison of U. S. and Puerto Rico accretion curves (plate 3) shows that accretion in Puerto Rico soils is generally greater than in U. S. soils. A comparison of corrected depletion curves indicated that depletion for a 10-day period is slower in Puerto Rico soils than in U. S. soils; however, beyond 10 days the Puerto Rico soils deplete somewhat faster. Apparently these differences compensate for each other. Corrected depletion curves for the Las Cruces test site using U. S. and Puerto Rico average depletion curves are shown in plate 9.

Soil Property-Moisture Content Relations

60. The usefulness of a soil trafficability prediction system depends upon the accuracy of the relations that can be developed between soil strength and the factors that influence soil strength. Soil moisture has been found to be the most influential of all the factors that affect soil strength; therefore, this analysis pertains primarily to strength-moisture

content relations. Other soil properties, such as density, Atterberg limits, and mechanical composition, were considered but no relations were apparent between these properties and soil strength. Density of the soils varied with moisture content. The results of the correlation studies are discussed in the following paragraphs.

Moisture content-density relations

61. Moisture content and density data for the 0- to 6-in. and 6- to 12-in. depths were plotted for each site. The individual plots and summary curves for each are shown in plates 10 and 11, respectively; and the summary curves are grouped in plate 12 for comparison. The individual plots show that the data are somewhat scattered, but the relation is reasonably well defined. The steepness of the curves indicates that density changes greatly with small moisture changes. The summary curves show that the relations are quite similar for all sites, and that the natural moisture content-density range is fairly similar for three of the sites.

Moisture content-strength relations

62. The measurements used to express soil strength are cone index, remolding index, and rating cone index. In this analysis, each of the soil strength measurements was plotted against moisture content, and where feasible, statistical procedures were used to define the best relations.

63. Moisture content versus cone index. Moisture content-cone index plots are shown in plate 13. Linear regression was used to express the relation between moisture content and cone index. Cone index values above 300 were excluded from the computations. The plots show that the data are fairly scattered. Most of the data collected during the dry period exceeded the capacity of the instrument (300). At Pedro Miguel, cone index remained high during both seasons. Correlation coefficients determined for these data plots are as follows:

Site	Correlation Coefficient (r)
Las Cruces	0.38*
Fort Kobbe	0.49*
Fort Clayton	0.39*
Pedro Miguel	0.37*

* Significant to 1% level.

These data are significant for the four sites, but the correlation coefficients show that agreement between moisture content and cone index is poor.

64. Because of the poor correlations obtained between moisture content and cone index, some of the individual site profiles were examined and the data used in one plot are given in table 3. Cone index was plotted with depth; and moisture-content measurements were plotted with the plotted points representing the center of the sample. Two cone index profiles were selected with moisture contents lower than the plastic limit and several profiles were selected with moisture contents falling within the plastic range. These plots are shown in plate 14. The open symbols and solid lines show the strength profiles and the dashed line and closed symbols show moisture-content profiles. The plastic range of the soil from the 6- to 12-in. depth is also shown in each plot.

65. An examination of plate 14 reveals that if the moisture content is less than the plastic limit, a cone index reading of 300 or greater is encountered at the 9-in. depth. Within the plastic range, cone indexes less than 300 are encountered but strength increases rapidly with depth, and cone index readings of 300 are encountered about 15 in. below the surface. It is also to be noted that at the 3- and 9-in. depths, where cone index and moisture content are plotted, several of the sites show a small change in cone index for a comparatively large range in moisture content. This small change suggests that the strength of these soils is not very sensitive to changes in moisture contents. Furthermore, there may not be an orderly decrease in strength with increase in moisture content.

66. Moisture content versus rating cone index. Moisture content-rating cone index plots are shown in plate 15. The relation obtained between moisture content and rating cone index is also poor. Plate 15 shows that at two of the sites (Fort Kobbe and Fort Clayton) rating cone indexes less than 70 were obtained, with the majority of the data for the Fort Kobbe site falling below this value. The Fort Kobbe site would present a trafficability problem for many military vehicles during the wet season. Statistical analysis of these data was attempted, but since the correlation coefficients (r) were not significant, lines of best visual fit were drawn through the data. Relations established for similar soils from other humid regions were used as a guide in placing these lines.

67. Moisture content versus remolding index. Plots of moisture content-remolding index are shown in plate 16. The data are widely scattered and do not show a definite relation. If the curves for cone index and rating cone index versus moisture content shown in plates 14 and 15, respectively, are accepted, and since rating cone index is the product of cone index and remolding index, a relation between moisture content and remolding index can be defined by dividing rating cone index by cone index values taken at the same moisture contents from the curves shown in plates 14 and 15. The curves shown in plate 16 were derived in this manner and it can be seen that the curves show some agreement with the measured data. These curves indicate that remolding index decreases with an increase in moisture content. For two of the curves (Fort Clayton and Pedro Miguel), remolding index tends to increase with an increase in moisture content above about 47 to 51 per cent.

68. An examination of the individual values for remolding index during the wet season indicates that the soil at all the sites except Fort Kobbe will retain from 50 to 100 per cent of its original strength under traffic; strength of the Fort Kobbe soil, however, may drop to as low as 30 per cent of its original value.

69. Summary. The discussions in the previous paragraphs show that poor correlations exist between moisture content and the strength parameters selected. In order to reduce the data to some usable form, average strength values are listed on the following page by site for the wet season (the entire year except the period from 15 February to 15 May). Several measurements that plotted as extreme outliers within a data plot were not considered in computing averages and ranges of values. The average values are arithmetic averages for each strength expression listed in table 2. Because of sampling difficulties encountered, remolding index and rating cone index averages are derived from less data than the cone index average. A conservative rating cone index value was also assigned to each site for estimating its trafficability during the wet season. This value was obtained by arranging all the data in descending order of rating cone index, dividing the data into equal quarters, and averaging the lowest quarter. These values are shown in the tabulation as average for "lowest quarter."

Site	Average Strength Measurements for Wet Season						
	Cone Index		Remolding Index		Rating Cone Index		
	Range	Avg	Range	Avg	Range	Avg	Lowest Quarter
Las Cruces	150-300+	212	0.56-1.07	0.80	95-219	156	110
Fort Kobbe	72-300+	138	0.28-1.13	0.53	27-259	71	43
Fort Clayton	92-300+	156	0.44-1.37	0.83	59-255	123	71
Pedro Miguel	207-300+	265	0.56-1.31	0.86	142-300+	214	153

70. A comparison of the average rating cone index given in this tabulation with wet season data for similar soil types in temperate climates as reported in TM 3-240, 11th Supplement, was made. This comparison revealed that Fort Kobbe (a CH soil) has an average wet season rating cone index 20 units lower, and the other three sites (all MH soils) have average rating cone index values somewhat higher than reported in the 11th Supplement for these soil types.

Trafficability of Panama Canal Zone Soils

71. From a reconnaissance made of the Fort Clayton area during the selection of the test sites, from the data collected at the four sites, and from a report of a terrain study made by C. R. McCullough* of the Fort Sherman area and vicinity, certain general comments can be made in regard to the trafficability of soils of the Panama Canal Zone.

Uplands

72. The upland soils are fine grained and exhibit claylike properties. Because of their high liquid limits and medium to low plasticity indexes, they are classified as MH soils according to the USCS. These soils are inorganic, but under forest cover the surface layer may contain some organic matter. The upland soils are firm and have a high penetration resistance even at high moisture contents. At high moisture contents they are somewhat sticky and slippery, and may cause wheeled vehicles without chains to become immobilized on slopes. The rating cone indexes computed for this study and by McCullough range for upland areas as follows: Pedro Miguel test site reported herein 142 to 300+, Fort Sherman uplands

* C. R. McCullough, Terrain Study of the Panama Canal Zone With Specific Reference to the Ft. Sherman Area and Vicinity (Raleigh, N. C., North Carolina State College of Agriculture and Engineering, July 1956).

126 to 300+, and Pina-Escobal highlands 95 to 193. These data reveal that the upland soils, in general, possess sufficient bearing capacity during the wet season for most military vehicles. During the dry season the soil strength is great enough to permit easy going to all off-road military vehicles.

Lowlands

73. In the lowlands the fine-grained soils tend to be more plastic but otherwise they are similar to the upland soils. Sandy and silty soils are also encountered in the lowlands. Clean sands with and without coral and shell are found along the beaches but are not considered in this analysis. Rating cone index data obtained from the various sources during the wet season indicate that these values are usually less than 100, with a low of 14 recorded for the Chagres-Mojinga-Gatun lowlands which lie along the Chagres River from its mouth to Gatun and extend between Fort Sherman uplands and the Mindi Hills to Limon Bay. In the swamp and savanna lowlands, rating cone indexes less than 40 are encountered; in pasturelands, this value approaches 100. In this study low rating cone indexes of 27 and 59 were reported at Fort Kobbe and Fort Clayton, respectively. In general, the rating cone index data reveal that the trafficability of soils in lowlands is poor during the wet season. During that season these areas would be passable only to low-ground-pressure tracked vehicles. In the dry season the soil tends to dry out, and except for the extremely low-lying portions, these areas become trafficable to most off-road military vehicles.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

74. On the basis of the analysis presented in this report, it is concluded that:

- *a*. The average soil-moisture predictions developed for U. S. and Puerto Rico soils can be used with some success on the soils of Panama. Soil-moisture depletion for Panama can be defined by one depletion curve for all seasons rather than the three curves (winter, summer, and transition periods) needed for definition of soil depletion in the U. S.
- *b*. There are indications that the quality of moisture content-strength relations for tropical-climate soils is considerably lower than similar relations derived for temperate-climate soils.
- *c*. The fine-grained soils found in the uplands of the Canal Zone usually retain high strength at high moisture contents; however, the more plastic lowland soils become wetter and reach strengths low enough to be critical from the soil trafficability standpoint.
- *d*. Upland soils are generally passable to most off-road military vehicles during the wet season, but wheeled vehicles without chains may fail on slopes because of slipperiness. The trafficability of lowland soils during the wet season is generally adequate only for low-ground-pressure tracked vehicles.

Recommendations

75. This study was designed as a pilot investigation wherein a minimum amount of data was collected to determine soil moisture-strength relations for a limited number of sites in one locality. It is recommended that additional detailed moisture content-strength studies of tropical-climate soils be conducted.

Table 1

Summary of Soils Data for Panama Canal Zone Test Sites

Location	Depth in.	USCS Symbol	Atterberg Limits LL	PL	PI	Gradation Sand >0.074 mm	Fines <0.074 mm	Avg* Dry Density lb/cu ft	Specific Gravity
Las	0-6	--	--	--	--	--	--	73.6	
Cruces	6-12	MH	73	42	31	16	84	84.7	2.83
Fort	0-6	--	--	--	--	--	--	88.2	
Kobbe	6-12	CH	54	22	32	34	66	100.6	2.86
Fort	0-6	--	--	--	--	--	--	66.1	
Clayton	6-12	MH	93	40	53	7	93	76.7	2.79
Pedro	0-6	--	--	--	--	--	--	74.8	
Miguel	6-12	MH	72	37	35	8	92	76.3	2.77

* Average density for period of record.

Table 2

Soil Moisture Content, Density, and Strength Data

Date	Dry Density lb/cu ft 0- to 6-in. Depth	Dry Density lb/cu ft 6- to 12-in. Depth	Moisture Content 0- to 6-in. Depth %	Moisture Content 0- to 6-in. Depth in.	Moisture Content 6- to 12-in. Depth %	Moisture Content 6- to 12-in. Depth in.	6- to 12-in. Depth Cone Index	6- to 12-in. Depth Remold. Index	6- to 12-in. Depth Rating Cone Index	Remarks
					Las Cruces, Panama					
1955										
3-2	87.2*	90.1*	33.2	2.78	32.5	2.82	300+			
3-10	----	89.9*	----	----	32.7	2.83	300+			Dry season 3/2/55 through 5/12/55
3-17	89.9*	92.8*	30.6	2.65	30.5	2.72	300+			
3-24	88.3*	91.0*	31.9	2.71	31.9	2.79	300+			
3-31	88.8*	94.9*	31.6	2.70	29.0	2.65	289			
4-7	92.4*	93.3*	28.3	2.52	30.2	2.71	300+			
4-14	91.4*	93.5*	29.2	2.57	30.0	2.70	300+			
4-21	91.8*	94.1*	28.8	2.54	29.7	2.69	300+			
4-28	91.6*	96.8*	29.0	2.55	27.6	2.57	300+			
5-5	91.8*	95.4*	28.9	2.55	28.7	2.63	267			
5-12			----	----	----	----	300+			
5-19	88.3*	91.6*	31.9	2.71	31.4	2.76	300+			
5-26	81.0*	70.9*	39.0	3.04	46.9	3.20	177			
6-2	75.1*	83.3*	44.4	3.21	37.6	3.01	211			
6-9	77.7	82.1*	44.2	3.30	38.4	3.03	245			
6-16	90.8	85.8	40.3**	----	45.0**	----	215			
6-23	81.3	100.3	54.1**	----	44.7**	----	238			
6-30	95.2	98.7	48.7**	----	40.8**	----	243			
7-7	93.4	114.1	48.7**	----	35.0**	----	254			
7-14	75.1*	83.3*	44.4	3.21	37.6	3.01	246			
7-21	68.2*	79.0*	50.9	3.34	40.8	3.10	240			
7-28	74.6	77.3	46.6	3.34	42.1	3.13	212			
8-4	76.4	82.7*	47.2	3.47	38.1	3.03	244			
8-18	74.6	76.8*	46.8	3.36	42.5	3.14	162			
8-25	75.4	87.8*	46.2	3.35	34.2	2.89	202			
9-1	75.3	80.7*	50.1**	----	39.6	3.07	192			
9-7	61.9*	76.2*	56.9	3.39	42.9	3.14	173			
9-15	79.3	77.0*	45.7**	----	42.3	3.13	195			
9-22	63.0*	70.6*	55.8	3.38	47.2	3.20	212			
9-29	66.3*	75.0*	52.7	3.36	43.8	3.16	213			
10-6	65.7*	76.9*	53.3	3.37	42.4	3.14	244			
10-13	62.1	73.5	58.1	3.47	45.8	3.24	168			
10-20	56.5*	78.2*	62.0	3.37	41.3	3.11	198			
10-27	52.8*	77.6*	64.7	3.28	41.8	3.12	190			
11-7	76.0*	73.9*	43.6	3.19	44.6	3.17	227			
11-10	65.2	65.6*	51.1	3.20	50.8	3.20	207			
11-17	66.3*	76.8*	52.7	3.36	42.5	3.14	97			
11-23	69.8	87.0	49.6	3.33	35.1	2.94	238	0.71	169	
12-1	74.7*	76.7*	44.9	3.23	42.6	3.14	208			
12-8	74.4	81.2*	48.7	3.48	39.2	3.06	238			
12-15	55.6*	64.2*	62.8	3.36	51.9	3.20	138			
12-21	65.3*	71.3*	53.7	3.37	46.6	3.19	179			
12-29	62.8*	77.6*	56.1	3.39	41.9	3.13	251			
1956										
1-5	59.0*	68.4*	59.7	3.39	48.8	3.21	150			
1-12	70.3*	80.1*	49.1	3.32	40.0	3.08	172			
1-18	69.1*	75.3*	50.1	3.33	43.6	3.16	300+			
1-26	64.6*	77.3*	54.3	3.37	42.1	3.13	241			
2-2	70.6	75.8	50.7	3.44	41.7	3.04	132			
2-9	65.6	79.6	47.2	2.98	39.6	3.03	230			
2-16	63.8	83.0	44.6	2.74	34.1	2.72	278			Dry season 2/16/56 through 5/10/.
2-23	78.8*	83.7*	41.0	3.11	37.3	3.00	300+			
3-1	60.6	81.2	39.9	2.32	28.0	2.21	300+			
3-7	86.8*	90.1*	33.6	2.80	32.5	2.82	300+			
3-15	86.1*	90.7*	34.1	2.82	32.1	2.80	300+			
3-22	77.6*	94.0*	42.2	3.15	29.7	2.68	300+			
3-29	85.6*	89.8*	34.7	2.86	32.7	2.82	300+			

(Continued)

* Density obtained from curves on plates 10 and 11 at the measured moisture content.
** Not used in analysis because per cent saturation exceeded theoretical maximum.

Table 2 (Continued)

Date	Dry Density lb/cu ft 0- to 6-in. Depth	Dry Density lb/cu ft 6- to 12-in. Depth	Moisture Content 0- to 6-in. Depth %	Moisture Content 0- to 6-in. Depth in.	Moisture Content 6- to 12-in. Depth %	Moisture Content 6- to 12-in. Depth in.	6- to 12-in. Depth Cone Index	6- to 12-in. Depth Remold. Index	6- to 12-in. Depth Rating Cone Index	Remarks
					Las Cruces, Panama (Continued)					
1956										
4-12	86.3*	90.5*	34.0	2.82	32.2	2.80	300+			
4-19	70.7	91.0*	34.3	2.33	31.9	2.79	292			
4-26	97.4*	89.6*	23.3	2.18	32.8	2.82	300+			
5-3	83.7*	89.8*	36.4	2.93	32.7	2.82	300+			
5-10	70.8	84.2	54.5**	----	36.6	2.96	152	1.06	161	
5-17	70.2	80.2	46.4	3.13	36.9	2.84	202	0.74	149	
5-24	72.2	76.6	50.2	3.49	42.8	3.15	212	0.69	146	
5-31	72.9	74.7	49.1	3.44	43.7	3.14	242	0.80	194	
6-7	74.1	86.2	41.5	2.96	33.1	2.74	178	0.71	126	
6-13	73.1	82.6	47.5	3.34	39.2	3.11	219	0.99	217	
6-21	70.4	87.8	48.0	3.25	34.7	2.93	158	0.77	122	
6-28	68.2	83.5	45.7	3.00	38.0	3.05	205	1.07	219	
7-5	70.3	83.3	51.3	3.47	39.6	3.17	142	0.68	97	
7-12	72.4	82.5	50.4	3.51	39.0	3.09	163	0.83	135	
7-19	76.2	83.1	39.1	2.86	39.9	3.19	181	0.89	161	
7-26	68.6	86.3	54.0	3.56	36.7	3.04	181	0.91	165	
8-2	63.4	78.7	56.2	3.43	42.9	3.25	169	0.56	95	
8-9	73.9	87.2	47.9	3.40	34.4	2.88	211	0.75	158	
8-16	74.2	83.4	44.0	3.14	35.7	2.86	185	0.81	150	Free water in sample holes
8-23	83.9	81.3	30.1	2.43	36.4	2.84	180	1.03	185	
8-30	72.9	87.0	42.1	2.95	33.2	2.78	183	0.86	157	
					Fort Kobbe, Panama					
1955										
3-10	116.8*	106.5*	10.4	1.17	14.4	1.47	300+	----	---	
3-17	118.2*	108.5*	9.4	1.07	12.4	1.29	300+	----	---	
3-24	117.2*	102.1*	10.2	1.15	18.6	1.83	300+	----	---	
3-31	116.1*	111.5*	12.0	1.34	9.7	1.04	300+	----	---	
4-7	120.1*	113.4*	8.0	0.92	7.8	0.85	300+	----	---	Dry season 3/2/55 through 5/12/55
4-14	121.0*	109.6*	7.9	0.92	11.4	1.20	300+	----	---	
4-21	100.6*	98.5*	22.6	2.19	22.0	2.08	300+	----	---	
4-28	123.3*	111.5*	5.7	0.68	9.7	1.04	300+	----	---	
5-5	95.0*	96.6*	27.5	2.51	23.8	2.21	246	----	---	
5-12	104.2*	94.4*	20.2	2.02	25.8	2.34	283	----	---	
5-19	111.9*	109.1*	14.2	1.53	11.9	1.25	300+	----	---	Surface water in test site
5-26	102.3*	96.2*	21.4	2.10	24.1	2.23	129	0.47	61	depressions
6-2	84.1	98.0	33.6	2.72	28.9	2.72	160	0.46	74	
6-9	82.9	96.4	34.9	2.78	27.8	2.58	125	0.62	78	Surface water in test site
6-16	83.4	98.0	34.9	2.80	28.0	2.64	106	0.34	36	depressions
6-23	87.4	98.2	33.0	2.76	26.9	2.54	135	0.47	63	
6-30	86.8	103.2	32.8	2.74	26.0*	----	157	0.39	61	
7-7	86.9	103.1	38.4**	----	27.2*	----	134	0.40	54	
7-14	91.0	96.3*	29.7	2.60	23.8	2.20	160	0.54	86	
7-21	90.6	93.3*	30.0	2.61	27.0	2.42	167	0.72	120	
7-28	81.8	99.8	37.9	2.98	28.5**	----	133	0.38	51	Surface water on test site
8-4	88.2	97.4	29.9	2.54	27.4	2.57	115	0.44	51	Surface water on test site
8-18	89.6	104.9	28.8	2.48	23.6	2.38	180	0.80	144	
8-25	99.3	92.8	24.4	2.33	27.7	2.47	121	0.67	81	Surface water on test site
9-1	87.8	108.5	33.0	2.78	22.4	2.34	153	0.78	119	
9-7	98.9	101.2	33.3**	----	26.9**	----	115	0.80	91	Surface water on test site
9-15	94.8	104.2	29.1	2.65	24.1	2.41	164	0.44	72	
9-22	86.3	103.1	33.2	2.75	23.6	2.34	126	0.42	53	Surface water on test site
9-29	86.3	103.3	33.9	2.81	24.3	2.41	107	0.45	48	
10-6	86.9	100.9	33.5	2.80	26.2	2.54	134	0.42	56	Surface water on test site
10-13	85.4	101.1	30.6	2.50	25.2	2.45	143	0.32	46	Surface water on test site
10-25	86.4	101.4	32.6	2.71	23.8	2.32	164	0.40	66	Surface water on test site
11-7	96.5	98.6	27.4	2.54	25.9	2.46	128	0.81	113	Surface water on test site
11-10	93.3	103.6	31.3	2.81	25.6**	----	82	0.33	27	Surface water on test site

(Continued)

* Density obtained from curves on plates 10 and 11 at the measured moisture content.
** Not used in analysis because per cent saturation exceeded theoretical maximum.

Table 2 (Continued)

Date	Dry Density lb/cu ft 0- to 6-in. Depth	Dry Density lb/cu ft 6- to 12-in. Depth	Moisture Content 0- to 6-in. Depth %	Moisture Content 0- to 6-in. Depth in.	Moisture Content 6- to 12-in. Depth %	Moisture Content 6- to 12-in. Depth in.	6- to 12-in. Depth Cone Index	6- to 12-in. Depth Remold. Index	6- to 12-in. Depth Rating Cone Index	Remarks
					Fort Kobbe, Panama (Continued)					
1955										
12-1	98.3	96.6	32.3**	----	28.8	2.68	97	0.81	79	Surface water on test site
12-15	96.1	106.7	29.7	2.74	25.5**	----	104	0.29	30	
12-21	90.3	115.8	32.2	2.79	27.6**	----	118	0.54	64	
12-29	86.8	98.1	34.7	2.90	27.6	2.60	110	0.65	72	
1956										
1-5	84.2	96.6	36.6	2.96	28.7	2.66	72	0.60	43	
1-12	90.8	113.4	31.4	2.74	24.0**	----	148	0.46	68	
1-18	85.7	104.8	36.5	3.01	25.3**	----	146	0.39	57	
1-26	88.2	98.4*	30.6	2.60	22.1	2.09	288	----	---	
2-2	89.0	98.8	32.9	2.82	26.6	2.53	82	0.55	45	Surface water in test site depressions
2-9	84.4	99.7	36.1	2.93	25.4	2.43	122	1.13	138	
2-16	82.2	96.6	34.4	2.72	24.9	2.31	229	1.13	259	Dry season 2/16/56 through 5/10/56
2-23	87.8	99.9*	26.3	2.22	20.6	1.98	300+	----	---	
3-1	112.1*	105.9*	14.0	1.51	15.0	1.53	300+	----	---	
3-7	112.3*	108.2*	13.9	1.50	12.7	1.32	300+	----	---	
3-15	122.8*	108.8*	6.0	0.71	12.1	1.26	300+	----	---	
3-22	116.2*	108.6*	11.7	1.31	12.4	1.29	300+	----	---	
3-29	90.4*	92.7*	30.1	2.62	27.5	2.45	300+	----	---	
4-12	114.4*	104.9*	12.3	1.35	15.9	1.60	300+	----	---	
4-19	90.2	99.2*	26.7	2.32	21.3	2.03	249	0.43	107	
4-26	115.7*	105.4*	11.3	1.26	15.4	1.56	300+	----	---	
5-3	104.1*	103.3*	20.0	2.00	17.5	1.74	300+	----	---	
5-10	105.7*	105.8*	18.9	1.92	15.1	1.54	300+	----	---	
5-17	83.4	100.8	30.9	2.48	23.1	2.24	232	0.52	121	
5-24	87.7	102.8	32.5	2.74	24.9	2.46	138	0.86	119	Surface water near test site
5-31	94.3	102.8	26.0	2.36	23.9	2.36	167	0.86	144	
6-7	90.6	104.4	29.6	2.58	22.7	2.28	125	0.52	65	Surface water on test site
6-13	85.9	98.6	34.5	2.85	26.0	2.46	144	0.41	59	Surface water near test site
6-21	91.4	97.0	28.9	2.54	24.2	2.26	120	0.49	59	
6-28	87.1	77.4*	34.1	2.86	28.2	2.10	115	0.49	56	Surface water near test site
7-5	84.6	94.9	36.8	2.99	27.8	2.54	149	0.45	67	Surface water near test site
7-12	83.3	92.5	36.7	2.94	30.1	2.68	126	0.56	71	Surface water near test site
7-19	96.4	104.4	28.9	2.68	24.8	2.49	129	0.52	67	Surface water near test site
7-26	82.2	94.1	38.7	3.06	28.4	2.57	144	0.38	55	
8-2	86.2	92.8	36.2	3.00	29.2	2.60	123	0.46	57	Surface water near test site
8-9	93.3	100.3	30.3	2.69	26.6	2.56	135	0.44	59	Surface water near test site
8-16	85.2	104.6	33.9	2.78	22.6	2.27	129	0.41	53	Surface water near test site
8-23	80.0	97.0	38.2	2.94	26.0	2.42	72	0.60	43	
8-30	78.7	95.3	40.8	3.09	28.4	2.60	127	0.32	41	
					Fort Clayton, Panama					
1955										
3-2	85.8*	94.0*	29.7	2.45	29.7	2.68	---	----	---	Dry season 3/21/55 through 5/12/55
3-10	85.0*	119.5*	30.5	2.49	9.1	1.04	300+	----	---	
3-17	97.0*	103.9*	15.2	1.42	21.6	2.16	300+	----	---	
3-24	95.6*	91.6*	16.8	1.54	31.5	2.77	300+	----	---	
3-31	91.2*	99.8*	22.6	1.98	24.9	2.39	300+	----	---	
4-7	92.4*	79.3*	21.1	1.87	41.3	3.15	300+	----	---	
4-14	94.0*	108.5*	18.9	1.71	17.9	1.87	300+	----	---	
4-21	90.4*	98.3*	23.6	2.05	26.1	2.47	300+	----	---	
4-28	84.6*	100.4*	31.0	2.52	24.4	2.36	300+	----	---	
5-5	89.8*	88.1*	24.4	2.11	34.4	2.91	300+	----	---	
5-12	83.9*	100.0*	31.9	2.57	24.8	2.38	300+	----	---	
5-19	90.6*	94.3*	23.3	2.03	29.4	2.66	300+	----	---	
5-26	81.5*	90.3*	35.1	2.75	32.6	2.83	300+	----	---	
6-2	81.9*	89.1*	32.1	2.53	33.5	2.87	300+	----	---	
6-9	76.0*	79.3*	42.2	3.08	41.5	3.16	125	----	---	Surface water in spots
6-16	61.3*	69.3*	61.0	3.60	49.7	3.31	96	0.64	61	
6-23	64.5	73.6*	60.8	3.77	46.1	3.26	119	----	---	
6-30	64.6	76.8*	56.6	3.52	43.5	3.21	101	----	---	

(Continued)

* Density obtained from curves on plates 10 and 11 at the measured moisture content.
** Not used in analysis because per cent saturation exceeded theoretical maximum.

Table 2 (Continued)

Date	Dry Density lb/cu ft 0- to 6-in. Depth	Dry Density lb/cu ft 6- to 12-in. Depth	Moisture Content 0- to 6-in. Depth %	Moisture Content 0- to 6-in. Depth in.	Moisture Content 6- to 12-in. Depth %	Moisture Content 6- to 12-in. Depth in.	6- to 12-in. Depth Cone Index	6- to 12-in. Depth Remold. Index	6- to 12-in. Depth Rating Cone Index	Remarks
Fort Clayton, Panama (Continued)										
1955										
7-7	63.5	59.9*	58.1	3.55	57.2	3.29	113	0.60	68	
7-14	63.6	86.0	55.7	3.41	39.0**	----	156	0.95	148	
7-21	58.3	70.8	67.0	3.76	48.3	3.29	106	0.72	76	
7-28	61.7	69.6*	59.4	3.52	49.4	3.31	141	1.35	190	Surface water near site
8-4	64.0	80.1	56.7	3.49	46.5**	----	141	1.08	152	Surface water near site
8-18	65.8	77.0	53.8	3.40	44.7	3.31	196	0.66	129	Surface water near site
8-25	69.0	82.4	51.8	3.44	46.4**	----	117	1.33	156	Surface water near site
9-1	60.8	75.4	60.0	3.51	46.3	3.36	108	0.81	87	Surface water near site
9-7	57.7	82.3	64.8	3.60	42.4**	----	121	0.56	68	Surface water near site
9-15	48.6	60.2	69.0**	3.22	47.3	2.74	133	0.81	108	Surface water near site
9-22	62.1	69.7	60.5	3.61	45.5	3.05	134	0.52	70	Surface water partly on site
9-29	54.1	68.6	69.0	3.59	49.8	3.28	112	0.98	110	
10-6	66.0	73.8	53.5	3.40	45.0	3.19	174	0.87	151	Surface water near site
10-13	58.3	72.2	61.4	3.44	46.2	3.21	142	0.58	82	Surface water near site
10-20	63.3	71.7	54.7	3.36	45.9	3.16	173	0.57	99	
10-27	64.3	71.8	58.0	3.58	50.3**	3.47	159	1.37	218	
11-7	65.7	77.6	56.3	3.56	46.4**	----	176	0.94	165	Surface water near site
11-10	63.2	75.2	60.5	3.68	44.4	3.21	136	0.96	131	Surface water near site
11-17	71.8	83.2	49.7	3.43	41.0**	----	159	0.94	145	Surface water near site
11-23	66.2	78.6	54.5	3.47	42.1	3.18	161	0.95	153	Surface water near site
12-1	66.9	70.0	58.0**	----	54.9**	----	134	0.44	59	Surface water near site
12-8	75.9	66.7	44.8	3.27	40.5**	----	100	0.63	63	Surface water near site
12-15	71.5	73.0	50.7	3.48	55.6**	----	118	0.85	100	Surface water on test site
12-21	63.4	77.5	58.7	3.58	46.2**	----	111	0.98	109	Surface water on test site
12-29	62.4	67.6	61.0	3.66	50.9	3.31	140	0.98	137	Surface water near test site
1956										
1-5	67.3	71.7	54.9	3.55	46.8	3.23	148	0.66	98	
1-12	59.6	78.5	63.1	3.62	46.6**	----	130	0.80	104	
1-18	65.6	74.6	54.0	3.41	45.1	3.24	186	----	---	
1-26	65.0	79.3	52.9	3.31	39.1	2.98	198	----	---	
2-2	68.4	79.7	51.8	3.41	41.4	3.17	92	0.92	88	Free water in sample holes
2-9	62.2	65.3	58.6	3.50	55.3	3.47	158	1.02	161	Surface water near test site
2-16	72.2	59.5	44.8	3.11	48.4**	2.77	246	0.98	241	Dry season 2/16/56 through 5/10/56
2-23	56.8	69.8	32.6	1.78	36.8	2.47	300+	----	---	
3-1	59.8	77.4	34.2	1.97	33.6	2.50	300+	----		
3-7	91.6*	104.0*	22.1	1.95	21.6	2.16	300+	----		
3-15	93.8*	105.4*	19.3	1.74	20.4	2.07	300+	----		
3-22	93.6*	95.6*	19.6	1.76	28.3	2.60	300+	----		
3-29	93.1*	105.1*	20.1	1.80	20.7	2.09	300+	----		
4-12	83.5*	81.4*	32.5	2.61	29.8	2.33	276	----		
4-19	62.8	91.5*	38.7	2.34	31.7	2.79	300+	----		
4-26	84.5*	93.3*	31.2	2.54	30.2	2.71	300+	----		
5-3	89.4*	104.0*	24.9	2.14	26.6**	----	300+	----		
5-10	82.4*	93.0*	33.8	2.68	30.4	2.72	300+	----		
5-17	66.8	68.6	45.0	2.89	30.2	1.99	242	----		
5-24	70.3	81.1	51.6	3.49	40.5	3.16	170	0.66	112	Surface water near test site
5-31	81.0	88.5*	41.6**	----	34.1	2.90	288	0.82	236	
6-7	94.9	86.7	26.1	2.38	20.5†	1.71	153	1.03†	158†	Surface water on test site
6-13	83.8	85.0	37.4	3.01	36.0	2.94	188	0.92	173	Surface water near test site
6-21	86.6	83.7	30.2	2.51	35.0	2.82	246	0.79	194	
6-28	74.9	88.4*	41.6	3.00	32.4†	2.75	300+	0.85†	255	
7-5	59.1	74.0	61.1	3.47	47.4	3.37	119	0.66	79	Surface water near test site
7-12	65.9	80.1	58.2	3.69	41.0	3.16	110	0.61	67	
7-19	63.0	75.5	59.1	3.58	45.0	3.27	117	0.76	89	
7-26	59.3	77.9	65.5	3.73	41.9	3.14	135	0.97	131	

(Continued)

* Density obtained from curves on plates 10 and 11 at the measured moisture content.
** Not used in analysis because per cent saturation exceeded theoretical maximum.
† Points not used in analysis.

Table 2 (Continued)

Date	Dry Density lb/cu ft 0- to 6-in. Depth	Dry Density lb/cu ft 6- to 12-in. Depth	Moisture Content 0- to 6-in. Depth %	Moisture Content 0- to 6-in. Depth in.	Moisture Content 6- to 12-in. Depth %	Moisture Content 6- to 12-in. Depth in.	6- to 12-in. Depth Cone Index	6- to 12-in. Depth Remold. Index	6- to 12-in. Depth Rating Cone Index	Remarks
					Fort Clayton, Panama (Continued)					
1956										
8-2	67.6	81.6	55.4	3.60	40.9	3.21	138	0.82	113	Surface water near test site
8-9	63.1	78.9	61.4	3.72	43.2	3.28	130	0.71	92	
8-16	64.5	81.1	49.8	3.09	35.9	2.80	111	0.81	90	Surface water near test site
8-23	71.6	84.8	40.7	2.80	31.9†	2.60	142	0.98	139†	
8-30	72.4	85.4	40.9	2.85	32.7†	2.68	113	1.08	122†	
					Pedro Miguel, Panama					
1955										
3-2	89.7*	88.2*	27.6	2.36	31.6	2.68	300+			Dry season 3/2/55 to 5/12/55
3-10	87.5*	85.5*	29.7	2.50	34.4	2.83	300+			
3-17	94.7*	91.0*	23.1	2.10	28.7	2.51	300+			
3-24	92.5*	89.9*	25.0	2.22	29.8	2.58	300+			
3-31	89.3*	87.3*	28.0	2.40	32.3	2.71	300+			
4-7	81.7*	86.3*	34.8	2.73	33.6	2.79	300+			
4-14	86.0*	86.4*	31.0	2.56	33.5	2.78	300+			
4-21	91.4*	90.3*	26.0	2.28	29.5	2.56	300+			
4-28	82.5*	82.9*	34.1	2.70	37.2	2.96	272			
5-5	82.7*	77.1*	33.9	2.70	38.8	2.88	286			
5-12	80.0*	82.6*	36.3	2.79	37.4	2.97	300+			
5-19	82.4*	81.5*	34.1	2.70	38.5	3.02	300+			
5-26	76.5*	74.8*	39.4	2.90	45.3	3.26	247			
6-2	66.4*	72.7*	47.5	3.03	47.5	3.32	207			
6-9	73.5*	70.9*	42.1	2.96	49.3	3.36	251			
6-16	67.8*	73.9*	47.2	3.08	46.3	3.29	258			
6-23	70.1*	73.3*	45.0	3.03	46.9	3.30	270			
6-30	80.3*	79.9*	36.0	3.78	40.1	3.08	266			
7-7	76.3*	72.3*	39.6	2.90	47.0	3.27	266			
7-14	84.2*	79.7*	32.6	2.64	40.3	3.09	280			
7-21	73.7*	75.1*	41.8	2.96	45.1	3.26	258			
7-28	72.5*	75.6*	43.0	3.00	44.7	3.25	272			
8-4	62.3*	77.7*	52.6**	3.15	42.4	3.17	280			
8-18	79.3*	82.5*	36.8	2.81	37.5	2.97	288			
8-25	80.9*	85.3*	35.4	2.75	34.7	2.85	280			
9-1	68.0*	74.5*	47.0	3.07	45.7	3.27	231			
9-7	71.2*	84.3*	44.2	3.03	35.6	2.89	256			
9-15	70.9*	70.3*	44.4	3.03	50.0	3.38	269			
9-22	73.3*	76.5*	42.3	2.86	43.7	3.21	276			
9-29	74.1*	80.1*	41.6	2.96	39.9	3.07	276			
10-6	76.8*	81.0*	39.2	2.89	39.0	3.04	300+			
10-13	80.3*	81.5*	36.0	2.78	38.6	3.02	279			
10-20	75.7*	78.7*	40.1	2.92	41.4	3.13	269			
10-27	77.5*	78.0*	38.6	2.86	42.2	3.16	284			
11-7	69.5*	73.8*	45.3	3.03	46.4**	3.29	267			
11-10	72.2	79.6	44.5	3.09	43.5**	----	242			
11-17	72.8*	78.5*	42.7	2.99	41.5	3.13	247			
11-23	67.9*	79.5*	47.1	3.08	40.5	3.10	259			
12-1	64.5*	78.0*	50.0	3.10	42.0	3.15	258			
12-8	60.1*	73.0*	54.0	3.12	47.3	3.32	256			
12-15	65.0*	72.0*	49.6	3.10	48.3	3.34	231			
12-21	78.8	96.3	36.6	2.77	40.1**	2.76	273			
12-29	81.4*	82.2*	35.0	2.74	37.7	2.98	300			
1956										
1-5	72.5*	78.8*	42.9	2.99	41.2	3.12	262			
1-12	85.4*	87.3*	31.5	2.59	32.4	2.72	300+			
1-18	83.8	89.9	33.4	2.69	29.8	2.58	300+			
1-26	81.0*	81.5*	35.4	2.76	36.5	2.86	300+			

(Continued)

* Density obtained from curves on plates 10 and 11 at the measured moisture content.
** Not used in analysis because per cent saturation exceeded theoretical maximum.
† Points not used in analysis.

Table 2 (Concluded)

Date	Dry Density lb/cu ft 0- to 6-in. Depth	Dry Density lb/cu ft 6- to 12-in. Depth	Moisture Content 0- to 6-in. Depth %	Moisture Content 0- to 6-in. Depth in.	Moisture Content 6- to 12-in. Depth %	Moisture Content 6- to 12-in. Depth in.	6- to 12-in. Depth Cone Index	6- to 12-in. Depth Remold. Index	6- to 12-in. Depth Rating Cone Index	Remarks
					Pedro Miguel, Panama (Continued)					
1956										
2-2	70.5	66.5	38.6	2.62	38.5	2.46	153			
2-9	65.1	66.7	32.8	2.05	34.3	2.20	276			
2-16	63.1	91.5*	30.6	1.86	27.9	2.45	300+			Dry season 2/16/56 through 5/10/56
2-23	87.6*	91.5*	29.5	2.48	29.6	2.56	300+			
3-1	84.0*	92.0*	32.8	2.65	27.0	2.39	300+			
3-7	90.0*	90.6*	27.3	2.36	29.2	2.54	300+			
3-15	96.0*	94.2*	21.8	2.01	25.4	2.30	300+			
3-22	91.8*	90.0*	25.6	2.26	29.8	2.58	300+			
3-29	90.0*	93.1*	27.3	2.36	26.6	2.38	300+			
4-12	92.8*	95.8*	24.9	2.22	23.9	2.20	300+			
4-19	90.4*	84.4*	26.9	2.34	35.4	2.87	300+			
4-26	93.2*	91.2*	24.4	2.19	28.5	2.50	300+			
5-3	91.5*	92.8*	25.8	2.27	26.9	2.40	300+			
5-10	76.9*	78.4*	39.1	2.89	41.7	3.14	227			
5-17	76.7*	80.1*	39.3	2.90	39.9	3.07	276			
5-24	73.0	73.2	44.2	3.10	48.4**	3.41	217	1.18	256	
5-31	73.6	66.8	36.3	2.57	53.0**	3.40	240	1.14	274	
6-7	80.0	69.9	25.7	1.98	35.1	2.36	281	1.00	281	
6-13	74.2	73.7	46.3	3.30	47.3†	3.35	283	1.31	300+	
6-21	76.6	75.2	29.9	2.20	40.4	2.92	277	0.71	197	
6-28	72.8	67.6	40.9	2.86	34.1	2.22	300	----	---	
7-5	77.8	76.4	39.6	2.96	45.4	3.34	239	0.69	165	
7-12	63.8	80.4	51.1	3.13	41.2	3.18	239	0.62	148	
7-19	71.9	76.4	46.9	3.24	45.0**	3.30	276	0.82	226	
7-26	80.3	75.8	38.3	2.96	43.3	3.16	214	0.86	184	
8-2	76.8	69.1	42.6	3.14	49.5	3.29	251	0.65	163	
8-9	73.7	70.8	40.5	2.89	48.5	3.30	229	0.85	195	
8-16	80.9	80.6	35.2	2.74	37.3	2.89	254	0.56	142	
8-23	83.2	87.1	35.5	2.84	31.2	2.61	290	0.67	194	
8-30	77.8	84.8	34.2	2.56	32.8	2.67	262	1.05	275	

* Density obtained from curves on plates 10 and 11 at the measured moisture content.
** Not used in analysis because per cent saturation exceeded theoretical maximum.
† Points not used in analysis.

Table 3

Typical Site Cone Index-Moisture Content Profiles

Site	Date	Moisture Content, % 0- to 6-in. Depth	Moisture Content, % 6- to 12-in. Depth	Average Cone Index at Depths of 0 in.	3 in.	6 in.	9 in.	12 in.	15 in.	18 in.
Las Cruces	5/3/56	36.4	32.7	73	247	300				
	3/17/55	30.6	30.5	78	173	300				
	1/12/56	49.1	40.0	37	73	85	130	300		
	1/5/56	59.7	48.8	35	73	123	140	187	240	
	12/15/55	62.8	51.9	35	83	100	130	183	230	
Fort Kobbe	8/9/56	30.0	26.6	48	58	102	125	177	223	260
	7/26/56	37.5	28.4	38	80	97	135	200	300	
	3/31/55	12.0	9.7	137	300					
	5/26/55	21.4	24.1	43	70	130	117	140	246	300
Fort Clayton	9/29/55	69.0	49.8	20	53	113	107	117	133	161
	3/31/55	22.6	24.9	83	300					
	5/12/55	31.9	24.8	90	280	300				
	6/30/55	56.6	43.5	33	50	73	113	117	120	125
	12/15/55	57.7	55.6	23	48	88	118	148	195	211
Pedro Miguel	3/24/55	25.0	29.8	77	273	300				
	4/7/55	34.8	33.6	137	267	300				
	11/10/55	44.5	43.5	57	120	180	247	300		
	12/1/55	50.0	42.0	42	140	207	267	300		
	2/2/56	38.6	38.5	35	103	113	130	217		

Table 4

Meteorological Data for Panama Canal Zone Area*

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				February 1955					
7	90	75	82.5	92	52	72.0	9	C	0.09
8	87	75	81.0	95	63	79.0	12	C	1.41
9	88	74	81.0	95	59	77.0	13	C	0.05
10	89	73	81.0	94	56	75.0	11	C	T
11	89	73	81.0	94	59	76.5	10	C	0
12	88	76	82.0	86	59	67.5	9	3	T
13	86	76	81.0	78	54	66.0	15	C	T
14	86	75	80.5	82	49	65.5	14	C	T
15	87	73	80.0	88	54	71.0	14	3	0
16	90	74	82.0	88	54	71.0	11	3	0
17	91	75	83.0	89	50	69.5	12	3	0
18	89	74	81.5	93	55	73.0	14	C	0
19	88	74	81.0	94	61	77.5	12	C	0
20	91	74	82.5	92	53	72.5	10	C	T
21	91	74	82.5	90	51	70.5	14	C	0
22	90	74	82.0	86	43	64.5	13	3	0
23	91	73	82.0	91	46	68.5	14	C	0
24	91	73	82.0	88	43	65.5	14	3	0
25	90	74	82.0	84	37	60.5	13	4	0
26	90	73	81.5	84	51	67.5	14	3	0
27	91	72	81.5	93	44	68.5	13	C	0
28	91	75	83.0	83	43	63.0	13	C	0
				March 1955					
1	90	72	81.0	92	41	66.5	17	3	0
2	91	72	81.5	88	44	66.0	15	3	0
3	92	72	82.0	88	35	61.5	14	3	0
4	92	71	81.5	92	43	67.5	12	C	0
5	91	73	82.0	89	52	70.5	15	C	0
6	89	73	81.0	86	52	69.5	10	C	0
7	89	73	81.0	86	45	65.5	16	C	0
8	90	71	80.5	88	43	65.5	16	C	0
9	90	75	81.5	80	38	59.0	18	C	0
10	90	74	82.0	81	37	59.0	16	C	0
11	92	74	83.0	85	42	63.5	14	3	0
12	92	73	82.5	87	47	67.0	17	C	0
13	92	72	82.0	86	46	66.0	15	C	0
14	91	73	82.0	86	42	64.0	17	3	0
15	90	73	81.5	87	43	65.0	16	C	0
16	90	72	81.0	91	49	70.0	13	C	0

(Continued)

* From daily weather charts, Albrook Air Force Base area, Canal Zone.

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				March 1955 (Continued)					
17	91	75	83.0	86	49	67.5	15	3	0
18	90	75	82.5	87	57	72.0	15	3	0
19	93	76	84.5	87	52	69.5	14	C	0
20	90	75	82.5	87	48	67.5	12	C	0
21	88	73	80.5	91	54	72.5	17	C	0
22	92	75	83.5	89	50	69.5	10	3	T
23	90	73	81.5	94	55	74.5	11	C	T
24	91	74	82.5	91	53	72.0	13	C	0
25	92	79	85.5	83	51	67.0	11	C	0
26	92	74	83.0	90	52	71.0	12	C	0
27	89	76	82.5	90	61	75.5	19	4	T
28	89	76	82.5	88	55	71.5	21	3	0
29	88	75	81.0	87	55	71.0	17	C	T
30	86	75	80.0	87	59	73.0	12	C	0
31	82	75	78.0	95	73	84.0	10	C	0.51
				April 1955					
1	86	70	78.0	91	55	73.0	12	C	0
2	89	71	80.0	92	52	72.0	10	C	T
3	86	71	78.5	93	56	74.5	14	C	T
4	89	72	80.5	91	50	70.5	10	C	0
5	88	74	81.0	90	57	74.0	12	C	T
6	92	73	82.5	88	48	68.5	15	C	0
7	92	74	83.0	86	52	69.5	17	C	0
8	90	75	82.5	84	46	65.5	20	C	0
9	90	74	82.0	85	50	67.5	17	3	0
10	89	76	82.5	84	56	70.0	17	C	0
11	90	77	83.5	85	55	71.0	15	3	0
12	90	77	83.5	84	52	69.0	14	C	0
13	93	76	84.5	83	39	61.0	15	3	0
14	93	74	83.5	85	45	65.0	15	C	0
15	94	74	84.0	91	40	65.5	18	3	0
16	93	74	83.5	87	40	63.5	16	3	0
17	93	75	84.0	76	47	61.5	17	C	0
18	92	74	83.0	89	47	68.0	20	C	0
19	92	75	83.5	88	50	69.0	14	C	0.03
20	91	74	82.5	92	51	71.5	16	C	0
21	92	77	84.5	82	46	64.0	16	C	T
22	92	76	84.0	86	47	66.5	14	3	0
23	92	77	84.5	81	44	62.5	15	C	0
24	93	74	83.5	93	50	71.5	14	C	T
25	88	74	81.0	94	56	75.0	10	C	0
26	87	75	81.0	96	64	80.0	12	C	0
27	89	76	82.5	93	63	78.0	17	C	0

(Continued)

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				April 1955 (Continued)					
28	86	75	80.5	91	62	76.5	16	C	0.02
29	90	73	81.5	94	59	76.5	15	C	0.01
30	93	75	84.0	90	45	67.5	17	C	0
				May 1955					
1	94	76	85.0	92	40	65.0	17	C	0.01
2	90	74	82.0	91	54	72.5	11	C	T
3	89	74	81.5	88	56	72.0	13	3	0
4	88	75	81.5	94	59	76.5	10	3	0.08
5	85	73	79.0	94	64	79.0	15	3	0.02
6	86	74	80.0	92	61	76.5	15	3	0
7	89	74	81.5	95	58	76.5	10	3	0.03
8	90	76	83.0	94	58	76.0	10	C	0.61
9	90	77	82.5	92	61	76.5	11	C	0.17
10	90	76	82.0	96	54	74.0	12	C	0.01
11	91	76	82.5	94	59	75.5	10	C	0
12	94	77	84.5	90	45	67.5	15	C	0.02
13	92	77	83.5	86	52	69.0	17	C	0.02
14	91	75	82.0	89	54	71.5	10	C	0
15	91	75	82.0	91	56	73.5	13	4	0
16	92	77	83.5	91	51	71.0	13	C	T
17	91	77	83.0	89	60	75.0	9	C	0
18	89	75	81.0	96	58	77.5	9	C	0
19	91	76	82.5	94	57	75.5	8	C	0
20	90	76	82.0	93	58	75.5	15	C	0.03
21	90	75	81.5	95	62	78.5	14	C	0.29
22	91	76	82.5	98	60	79.0	19	C	1.57
23	90	76	82.0	97	61	79.0	10	C	T
24	82	74	78.0	96	82	89.0	10	C	1.77
25	86	73	79.5	97	62	79.5	11	C	0.14
26	84	73	80.5	97	71	84.0	13	C	0.02
27	87	75	83.0	95	67	86.0	9	C	T
28	89	75	84.0	94	59	76.5	11	C	T
29	87	76	83.5	96	65	80.5	7	C	0.58
30	88	76	84.0	96	67	81.5	8	C	0.13
31	87	74	82.5	89	67	83.0	14	C	0.91
				June 1955					
1	87	73	82.0	98	70	84.0	12	C	0.44
2	87	72	81.5	96	67	81.5	9	C	0.02
3	87	74	82.5	98	65	81.5	13	C	0.24
4	85	74	81.5	98	67	82.5	13	C	0.57
5	86	74	82.0	96	64	80.0	14	C	1.78

(Continued)

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				June 1955 (Continued)					
6	88	75	83.5	97	68	82.5	8	C	0.31
7	89	73	83.0	98	66	82.0	10	C	T
8	86	77	81.5	95	71	83.0	9	3	T
9	88	76	82.0	97	63	80.0	12	C	0.33
10	89	75	82.0	96	70	83.0	12	C	0.67
11	85	74	79.5	97	76	86.5	12	C	T
12	87	74	80.5	95	76	85.5	13	C	T
13	87	73	80.0	98	73	85.5	12	C	1.05
14	85	75	80.0	95	71	83.0	11	C	T
15	85	75	80.0	97	82	89.5	9	C	1.07
16	81	74	77.5	97	80	88.5	7	C	0.46
17	87	75	81.0	95	74	84.5	13	C	T
18	90	75	82.5	95	62	78.5	7	C	0.41
19	90	76	83.0	96	62	79.0	8	C	0.05
20	90	77	83.5	97	68	82.5	7	C	T
21	85	74	79.5	97	76	86.5	26	C	0.18
22	90	73	81.5	97	59	78.0	11	C	0
23	89	76	82.5	96	75	85.5	14	C	0.07
24	84	76	80.5	96	78	87.5	13	C	T
25	88	71	79.5	98	73	85.5	10	C	T
26	88	75	81.5	95	66	80.5	8	C	T
27	88	75	81.5	95	69	82.0	22	C	0.67
28	90	76	83.0	96	66	81.0	7	C	0.03
29	87	76	81.5	96	70	83.0	12	C	0.04
30	85	76	80.5	97	71	84.0	10	C	0.02
				July 1955					
1	84	75	79.5	96	74	85.0	7	C	T
2	88	74	81.0	97	67	82.0	10	C	0.10
3	83	75	80.0	97	75	86.0	14	C	0.69
4	86	74	81.0	97	69	83.0	8	C	0.79
5	86	73	80.5	97	74	85.5	12	C	0.12
6	87	74	81.5	96	71	83.5	8	C	0.54
7	88	75	82.5	97	68	82.5	9	C	0.14
8	82	76	85.0	98	80	89.0	10	C	0.46
9	84	73	84.5	99	76	87.5	15	C	2.11
10	84	73	84.5	99	73	85.0	13	C	0.29
11	86	74	86.0	98	71	83.5	11	C	0.34
12	88	73	86.5	98	70	83.0	10	C	0
13	86	75	86.5	98	71	83.5	7	C	T
14	87	77	88.0	96	73	83.5	8	C	T
15	90	74	88.0	96	70	82.0	8	C	0.04
16	85	74	85.5	97	74	84.5	8	C	1.78
17	83	73	84.0	96	74	84.0	9	C	0.30

(Continued)

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				July 1955 (Continued)					
18	86	75	86.5	93	73	82.0	11	C	T
19	91	73	88.0	96	65	80.5	9	C	0.02
20	89	76	88.5	97	71	84.0	13	C	T
21	81	73	83.0	97	85	91.5	9	C	0.18
22	89	72	86.5	97	64	80.5	9	C	0
23	88	75	87.5	95	73	84.0	7	C	T
24	86	76	87.0	95	74	84.5	9	C	0.80
25	84	75	85.5	98	78	88.0	9	C	0.38
26	81	73	83.0	98	77	87.5	10	C	0.51
27	85	73	85.0	97	72	84.5	9	C	0.59
28	88	72	86.0	97	65	81.5	6	C	0.01
29	88	73	86.5	96	67	82.0	10	C	T
30	90	75	88.5	96	67	82.0	13	C	T
31	89	75	88.0	96	65	81.0	9	C	T
				August 1955					
1	81	75	78.0	97	82	89.5	7	C	0.26
2	84	72	78.0	97	75	86.0	13	C	0.88
3	85	70	77.5	98	66	82.0	10	C	0
4	90	73	81.5	96	60	78.0	10	3	0.42
5	89	74	75.0	98	65	81.5	18	C	1.63
6	87	63	80.0	98	64	81.0	10	C	0.04
7	86	74	77.5	97	70	83.5	13	C	0.35
8	83	72	77.5	96	70	83.0	12	C	T
9	83	73	78.0	98	70	84.0	12	C	0.36
10	88	74	81.0	95	66	80.5	10	C	0
11	82	74	78.0	97	76	86.5	7	C	T
12	86	75	80.5	95	68	81.5	6	C	0.15
13	90	75	82.5	95	62	78.5	9	C	0.13
14	89	75	82.0	97	65	81.0	8	C	T
15	87	75	81.0	97	70	83.5	9	C	T
16	85	75	80.0	94	69	81.5	7	C	T
17	88	76	82.0	95	67	81.0	7	C	0.05
18	86	75	80.5	99	67	83.0	10	C	1.00
19	83	73	78.0	96	73	79.5	6	C	0.45
20	90	73	81.5	98	56	77.0	15	C	0.82
21	91	74	82.5	98	65	86.5	12	C	1.13
22	89	75	82.0	97	61	84.0	17	C	0.12
23	85	75	80.0	97	74	90.5	7	C	0.10
24	86	74	80.0	96	66	81.0	9	C	T
25	85	75	80.0	96	71	83.5	11	C	0.04
26	87	75	81.0	97	63	80.0	8	C	T
27	89	73	81.0	98	62	80.0	8	C	0
28	88	73	80.5	95	62	78.5	11	C	0

(Continued)

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				August 1955 (Continued)					
29	88	70	79.0	97	69	83.0	16	C	2.94
30	86	72	79.0	97	65	81.0	10	C	0.26
31	87	75	81.0	96	64	80.0	11	C	0.11
				September 1955					
1	87	75	81.0	95	62	78.5	9	C	0
2	87	73	80.0	97	63	80.0	13	C	0.01
3	86	73	79.5	95	64	79.5	10	3	T
4	83	72	77.5	98	74	86.0	13	C	0.30
5	82	73	77.5	96	77	86.5	8	C	0.26
6	85	75	80.0	96	70	83.0	13	C	0.36
7	85	75	80.0	98	71	84.0	8	C	0.41
8	84	72	78.0	97	68	82.0	9	C	T
9	90	74	82.0	96	59	77.0	7	C	0
10	88	74	81.0	96	64	79.5	8	C	0.19
11	85	74	79.5	97	72	84.0	10	C	0.06
12	86	73	79.5	96	63	79.0	15	C	0.88
13	86	74	80.0	97	66	81.0	14	C	0.03
14	87	72	79.5	98	62	82.5	9	C	1.83
15	86	73	79.5	97	68	85.0	15	C	0.09
16	85	74	79.5	97	70	86.0	12	C	0
17	88	77	82.5	94	57	75.5	10	C	0
18	85	75	80.0	94	69	84.0	8	C	0.02
19	84	74	79.0	96	70	85.5	9	C	T
20	91	74	82.5	98	57	77.5	8	C	0
21	90	73	81.5	97	65	86.5	12	C	0.87
22	88	74	81.0	98	66	87.5	11	C	1.73
23	85	73	79.0	95	66	86.0	10	C	T
24	86	75	80.5	95	70	88.0	9	C	0
25	88	75	81.5	96	67	87.0	10	C	0
26	89	74	81.5	98	64	81.0	13	C	0.04
27	88	79	83.5	93	65	79.0	10	3	T
28	89	71	80.0	99	62	80.5	37	C	1.53
29	86	71	78.5	95	67	81.0	13	C	0.17
30	85	73	79.5	96	72	84.0	10	C	0
				October 1955					
1	84	74	79.5	95	73	84.0	10	C	0.06
2	84	75	80.0	97	72	84.5	14	C	0.27
3	88	75	82.0	95	62	78.5	11	C	T
4	85	76	81.0	93	70	81.5	9	C	T
5	85	76	81.0	96	73	84.5	11	C	0.24
6	88	75	82.0	98	69	83.5	9	C	0

(Continued)

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				October 1955 (Continued)					
7	88	73	81.0	96	67	81.5	7	C	0
8	82	73	78.0	97	83	90.0	17	C	1.29
9	83	73	78.5	96	74	85.0	12	C	0.01
10	85	76	81.0	90	71	80.5	13	C	0.03
11	89	73	81.5	97	68	82.5	11	C	0.02
12	87	74	81.0	98	65	81.5	10	C	T
13	86	76	81.5	96	68	82.0	14	C	0
14	84	75	80.5	96	71	83.5	10	C	0.66
15	82	75	79.5	98	78	88.0	6	C	0.09
16	86	73	80.5	98	65	81.5	13	C	0.50
17	84	73	79.5	98	72	85.0	16	C	0.53
18	85	75	81.0	96	65	80.5	12	5	0.07
19	86	75	81.5	98	65	81.5	11	C	0.03
20	86	74	81.0	99	65	82.0	10	C	0.37
21	87	73	81.0	98	62	80.0	13	C	0.33
22	87	72	80.5	97	63	80.0	11	C	0
23	87	74	81.5	95	64	79.5	16	C	0.14
24	83	75	80.0	87	70	78.5	19	7	T
25	85	76	81.5	85	64	74.5	10	3	T
26	85	72	79.5	91	60	75.5	14	C	0
27	89	72	81.5	94	66	80.0	9	C	0
28	86	75	81.5	95	65	80.0	10	C	0.02
29	86	74	81.0	98	67	82.5	12	C	0
30	86	73	80.0	98	65	81.5	11	C	0.17
31	85	73	79.5	99	72	85.5	7	C	2.13
				November 1955					
1	80	74	77.5	98	88	92.0	10	C	0.52
2	86	73	80.0	98	63	80.5	10	C	2.86
3	85	73	79.5	98	68	83.0	9	C	0.15
4	86	73	80.0	96	71	83.5	10	C	0.15
5	86	75	81.0	96	66	81.0	7	C	0
6	87	74	81.0	96	63	79.5	10	C	T
7	89	74	81.5	97	65	81.0	8	C	T
8	89	76	82.5	95	65	80.0	8	C	0.70
9	84	76	80.0	95	79	87.0	8	C	T
10	87	75	81.0	95	64	79.5	10	C	T
11	87	75	81.0	99	72	85.5	13	C	1.20
12	88	74	81.0	97	70	83.5	13	C	0.34
13	86	76	81.0	96	73	84.5	5	C	0.01
14	85	72	78.5	99	71	85.0	6	C	0.33
15	83	72	77.5	98	72	85.0	10	C	T
16	83	74	78.5	98	71	84.5	9	C	T
17	85	72	78.5	98	76	87.0	6	C	0.80

(Continued)

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				November 1955 (Continued)					
18	86	74	80.0	99	72	85.5	7	C	2.68
19	83	74	78.5	97	72	84.5	10	C	0.19
20	87	73	80.0	96	69	82.5	6	C	0.04
21	85	73	79.0	97	68	82.5	7	3	T
22	88	74	81.0	95	62	78.5	8	C	0.18
23	88	74	81.0	98	67	82.5	7	C	0.61
24	85	74	79.5	99	73	86.0	31	C	0.35
25	85	73	79.0	98	74	86.0	9	C	0.11
26	83	73	78.0	96	77	86.5	9	C	T
27	88	73	80.5	97	65	81.0	7	3	0.36
28	88	74	81.0	98	65	81.5	8	C	0.27
29	84	74	79.0	100	75	87.5	7	C	1.32
30	81	74	77.5	98	85	91.5	8	C	1.35
				December 1955					
1	84	73	78.5	98	73	86.5	5	C	T
2	86	72	79.0	98	67	82.5	8	C	0.08
3	86	73	79.5	98	67	82.5	6	C	0
4	86	74	80.0	98	70	84.0	8	C	1.65
5	86	74	80.0	96	70	83.0	10	C	1.11
6	86	74	80.0	98	62	80.0	10	C	0
7	86	74	80.0	97	68	82.5	8	C	T
8	87	72	79.5	98	64	81.5	5	C	0.51
9	87	73	80.0	95	62	79.5	12	C	0.23
10	85	74	79.5	96	73	85.5	7	3	0.12
11	88	75	81.5	96	66	82.0	30	3	0.44
12	88	75	81.5	95	69	83.0	8	C	0.75
13	89	73	81.0	98	65	82.5	15	C	0.57
14	86	73	79.5	99	69	84.5	14	C	0.30
15	86	72	79.0	98	63	81.0	6	C	0
16	90	73	81.5	98	58	78.5	13	C	T
17	86	72	80.0	96	69	82.5	10	C	0.40
18	88	74	82.0	98	67	82.5	5	C	T
19	90	75	83.5	98	67	82.5	5	C	T
20	87	75	82.0	96	60	77.0	7	C	0.05
21	87	74	81.5	97	64	79.5	8	C	1.61
22	85	73	80.0	95	64	78.5	8	C	T
23	88	73	81.5	97	61	78.0	8	C	1.70
24	88	73	81.5	97	60	77.5	11	3	0
25	91	73	83.0	95	55	75.0	8	C	T
26	89	72	81.5	95	54	74.5	9	C	0.19
27	86	73	80.5	96	64	80.0	16	C	1.42
28	88	72	81.0	97	63	80.0	12	C	0.37
29	87	73	81.0	93	65	79.0	13	C	0.14
30	90	72	82.0	93	53	73.0	14	C	0
31	87	72	80.5	95	61	78.0	12	3	T

(Continued)

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				January 1956					
1	85	74	80.5	91	63	77.0	14	3	0.03
2	88	74	82.0	96	58	77.0	10	2	0.02
3	85	74	80.5	95	68	81.5	19	3	0.36
4	85	73	80.0	97	62	79.5	15	C	0.05
5	85	72	79.5	92	59	75.5	15	C	T
6	78	71	75.5	93	71	82.0	12	3	0.01
7	86	71	74.5	91	59	75.0	15	C	T
8	85	67	72.0	89	52	70.5	11	C	0
9	85	69	73.0	89	49	69.0	10	3	0
10	85	69	73.0	94	50	72.0	15	C	0
11	85	65	71.0	92	63	77.5	15	4	T
12	85	69	73.0	92	59	75.5	13	3	0
13	84	70	73.0	92	56	73.0	12	3	T
14	83	80	81.5	89	65	77.0	9	3	T
15	86	69	77.5	91	56	73.5	10	C	0
16	84	67	75.5	96	56	75.5	7	C	0
17	88	67	77.5	96	50	72.5	10	C	0
18	89	75	82.0	93	60	76.5	10	3	0.05
19	91	73	82.0	95	73	84.0	11	C	0
20	90	73	81.5	92	55	73.5	12	C	0
21	90	73	81.5	92	53	72.5	12	3	0
22	89	73	81.0	90	55	72.5	13	3	0
23	90	73	81.5	91	53	72.0	12	3	0.10
24	89	73	81.0	95	53	74.0	12	C	0.02
25	87	73	80.0	95	60	77.5	13	C	T
26	88	73	80.5	97	61	79.0	15	C	0.60
27	82	73	77.5	97	83	90.0	8	C	0.04
28	85	73	79.0	97	62	79.5	13	C	T
29	88	72	80.0	97	60	78.5	10	C	0.10
30	86	73	79.5	94	54	74.0	11	C	0.02
31	84	72	78.0	100	65	82.5	12	C	0.81
				February 1956					
1	85	72	78.5	96	63	80.0	7	C	0
2	89	71	80.0	96	59	78.0	9	C	0.55
3	89	73	81.0	97	58	78.0	10	C	T
4	90	74	82.0	97	60	79.0	11	C	T
5	88	74	81.0	96	63	80.0	13	C	0.24
6	88	75	81.5	94	60	77.5	12	C	0.28
7	92	75	83.5	93	54	74.0	12	C	T
8	89	74	81.5	92	60	76.5	13	C	0
9	91	75	83.0	90	54	72.5	12	C	T
10	90	73	81.5	95	55	75.5	14	C	0
11	90	72	81.0	96	52	74.5	11	C	0

(Continued)

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				February 1956 (Continued)					
12	90	73	81.5	96	61	79.0	13	C	0
13	90	73	81.5	92	51	71.5	10	3	0
14	90	72	81.0	92	51	71.5	11	C	T
15	91	74	82.5	93	52	72.5	11	C	0
16	89	75	82.0	87	55	71.0	13	C	0
17	89	74	81.5	90	57	73.5	12	2	0
18	92	75	83.5	89	52	70.5	10	4	0
19	91	75	83.0	91	53	72.0	11	C	0
20	91	75	83.0	88	47	67.5	15	C	0
21	91	73	82.0	91	48	69.5	14	C	0
22	87	74	80.5	90	58	74.0	11	2	T
23	91	72	81.5	90	41	65.5	13	2	0
24	91	72	81.5	90	52	71.0	15	3	0
25	88	75	81.5	91	58	74.5	12	2	0.10
26	90	73	81.5	93	55	74.0	13	C	0
27	88	75	81.5	91	60	75.5	11	C	0.08
28	92	76	84.0	92	49	65.5	10	C	0
29	89	74	81.5	88	50	69.0	14	4	T
				March 1956					
1	87	74	80.5	93	53	73.0	20	2	T
2	89	73	81.0	89	48	68.5	18	2	0
3	89	74	81.5	92	61	76.5	13	C	0
4	88	77	82.5	88	60	74.0	15	3	0
5	92	75	83.5	90	50	70.0	14	C	0
6	91	75	83.0	90	56	73.0	11	C	0
7	91	75	83.0	89	49	69.0	13	C	0
8	90	74	82.0	93	62	77.5	12	C	T
9	93	74	83.5	89	52	70.5	12	C	0
10	91	74	82.5	90	53	71.5	13	C	0
11	92	74	83.0	88	44	66.0	15	3	0
12	92	72	82.0	90	46	68.0	14	3	0
13	90	71	80.5	91	48	69.5	8	C	0
14	91	70	80.5	95	54	74.5	9	C	T
15	90	71	80.5	91	52	71.5	11	C	T
16	91	71	81.0	92	56	74.0	15	C	0
17	93	72	82.5	93	50	71.5	14	C	0
18	93	72	82.5	93	50	71.5	9	C	0
19	91	74	82.5	94	56	75.0	13	3	0
20	90	75	82.5	90	56	73.0	15	C	T
21	92	73	82.5	92	50	71.0	13	C	0
22	90	75	82.5	89	55	72.0	13	4	T
23	87	73	80.0	94	62	78.0	10	3	0.02
24	88	73	80.5	92	60	76.0	10	C	0

(Continued)

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				March 1956 (Continued)					
25	92	74	83.0	88	53	70.5	14	C	0
26	86	74	80.0	89	65	77.0	14	3	T
27	95	75	85.0	93	49	71.0	13	2	0
28	91	76	83.5	92	56	74.0	13	C	0
29	93	74	83.5	91	51	71.0	12	C	0
30	93	75	84.0	88	51	69.5	12	C	0
31	90	76	83.0	87	52	69.5	14	4	T
				April 1956					
1	91	77	84.0	87	58	72.5	14	4	T
2	93	76	84.5	88	50	69.0	14	C	T
3	95	76	85.5	88	50	69.0	15	3	0
4	95	76	85.5	92	48	70.0	10	3	0
5	93	77	85.0	88	46	67.0	13	5	0
6	93	75	84.0	91	47	69.0	15	C	0
7	94	76	85.0	86	48	67.0	15	3	0
8	96	74	85.0	91	46	68.5	13	C	0
9	95	75	85.0	90	47	68.5	14	3	0
10	95	76	85.5	93	51	72.0	10	C	0
11	87	75	81.0	93	59	76.0	10	C	0
12	87	76	81.5	95	69	82.0	6	C	T
13	88	76	82.0	94	63	78.5	15	C	0.08
14	82	74	78.0	95	73	84.0	10	C	0.11
15	86	74	80.0	93	63	78.0	10	C	0
16	91	73	82.0	94	56	75.0	12	C	0.07
17	90	74	82.0	98	59	78.5	10	C	0
18	88	75	81.5	97	71	84.0	10	C	0.24
19	94	76	85.0	92	47	69.5	12	3	0
20	94	75	84.5	89	53	71.0	14	C	0
21	92	76	84.0	88	51	69.5	16	2	T
22	93	77	85.0	86	53	69.5	14	2	T
23	94	77	85.5	89	56	72.5	12	C	0
24	93	78	85.5	89	51	70.0	13	C	0
25	95	77	86.0	89	46	67.5	12	3	0
26	94	74	84.0	92	51	71.5	16	3	0
27	87	75	81.0	96	71	83.5	10	C	0.60
28	91	75	83.0	92	48	70.0	11	C	0.10
29	90	73	81.5	92	54	73.0	8	C	T
30	90	75	82.5	92	59	75.5	8	C	T
				May 1956					
1	91	76	83.5	92	56	74.0	14	C	T
2	92	77	84.5	91	58	74.5	10	2	0

(Continued)

Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				May 1956 (Continued)					
3	93	77	85.0	99	55	77.0	14	C	0.43
4	88	77	82.5	96	67	81.5	12	C	0.08
5	89	77	83.0	95	66	80.5	18	C	0.60
6	85	77	81.0	95	72	83.5	7	C	0.07
7	86	77	81.5	91	71	81.0	8	C	0
8	78	73	75.5	99	86	92.5	8	C	0.78
9	89	74	81.5	93	62	77.5	7	C	T
10	86	74	80.0	96	68	82.0	10	C	0.90
11	89	75	82.0	95	67	81.0	10	C	0.33
12	89	76	82.5	97	64	80.5	8	C	0
13	88	74	81.0	95	67	81.0	8	C	0.23
14	84	73	78.5	97	69	83.0	10	C	1.18
15	90	72	81.0	98	55	76.5	10	C	0
16	88	73	80.5	95	64	79.5	8	C	0
17	91	74	82.5	94	58	76.0	12	C	0.02
18	90	74	82.0	95	63	79.0	8	C	0
19	90	75	82.5	98	62	80.0	12	C	1.93
20	87	74	80.5	96	70	83.0	7	C	0.10
21	83	74	78.5	96	76	86.0	6	C	0.05
22	87	76	81.5	97	70	83.5	6	C	T
23	85	73	79.0	99	73	86.0	9	C	3.24
24	83	74	78.5	96	76	86.0	6	C	T
25	85	76	80.5	95	69	82.0	6	C	0.05
26	86	73	79.5	97	69	83.0	10	C	T
27	89	75	82.0	96	66	81.0	13	C	0.13
28	85	75	80.0	94	70	82.0	8	C	T
29	87	74	80.5	97	63	80.0	8	C	T
30	89	75	82.0	94	64	79.0	12	C	0.42
31	84	76	80.0	92	70	81.0	8	C	T
				June 1956					
1	88	75	81.5	93	66	79.5	10	2	T
2	89	77	83.0	94	66	80.0	8	2	0
3	81	76	73.5	95	74	79.5	7	C	0.11
4	86	76	76.0	96	72	84.0	6	C	0.43
5	81	75	73.0	99	82	90.5	8	C	0.65
6	85	74	74.5	95	69	82.0	11	C	0.08
7	82	76	74.0	99	82	95.0	10	C	2.03
8	88	74	81.0	96	68	82.0	7	C	0.13
9	87	75	81.0	97	67	82.0	14	C	0.49
10	85	74	79.5	97	73	85.0	12	C	0.19
11	85	75	80.0	96	73	84.5	8	C	1.27
12	89	74	81.5	97	66	81.5	8	C	0.89
13	81	75	78	97	82	89.5	8	C	0.04

(Continued)

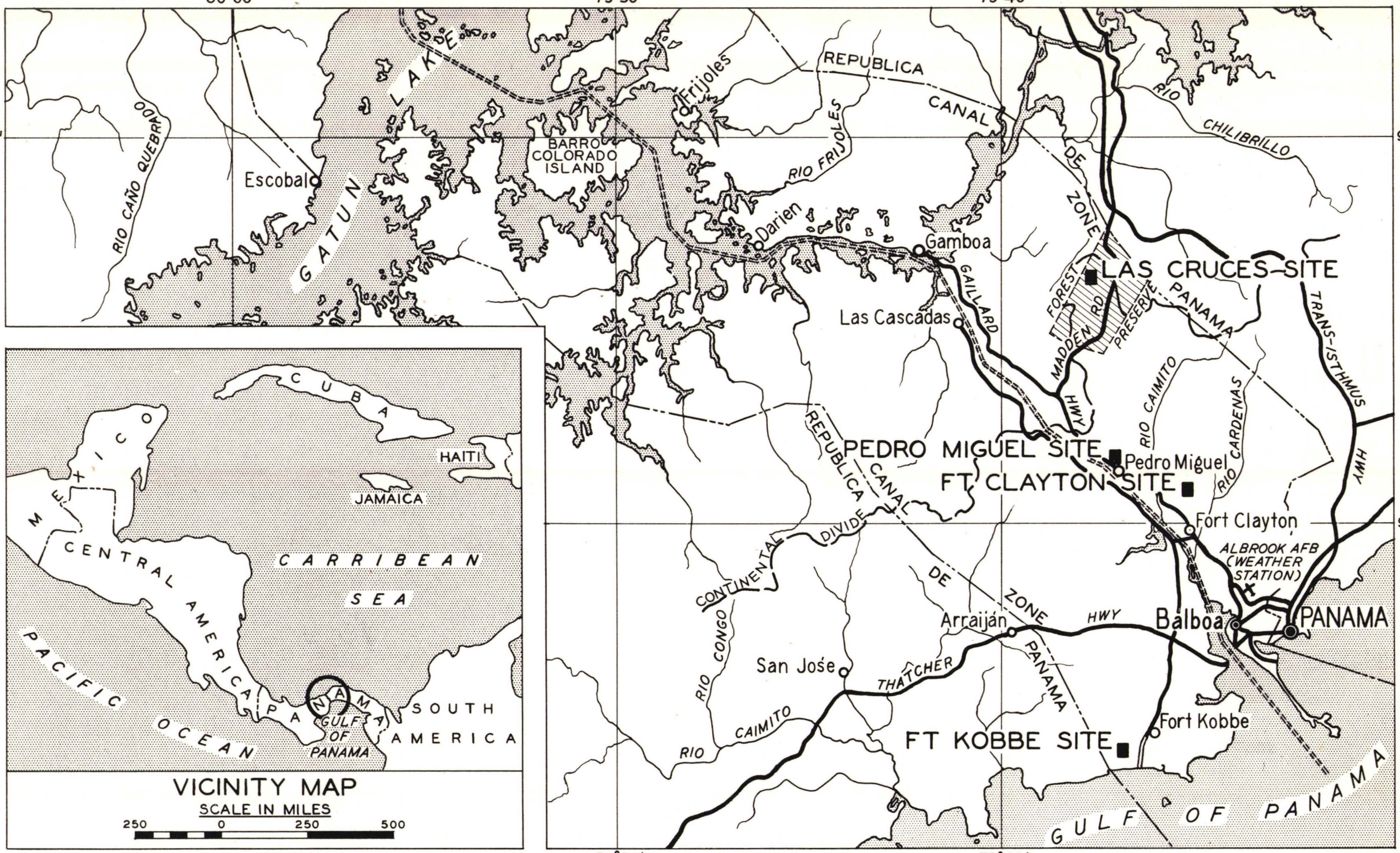
Table 4 (Continued)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				June 1956 (Continued)					
14	89	74	81.5	97	67	82.0	9	C	0.30
15	88	73	80.5	97	68	82.5	13	C	1.72
16	85	72	78.5	98	72	85.0	6	C	T
17	82	72	77.0	97	81	89.0	6	C	0.77
18	87	73	80.0	97	62	79.0	8	C	T
19	84	74	78.0	97	71	84.0	7	C	0.13
20	89	74	80.5	99	59	79.0	10	C	T
21	88	74	80.0	95	70	82.5	10	C	0.16
22	86	75	79.5	98	72	85.0	10	C	0.16
23	85	75	79.0	94	72	83.0	7	3	T
24	85	75	79.0	95	71	83.0	8	C	T
25	85	74	78.5	96	75	85.5	6	C	T
26	88	73	79.5	97	71	84.0	8	C	0.18
27	92	75	83.5	95	63	79.0	9	C	T
28	89	74	81.5	95	65	80.0	8	C	T
29	88	75	81.5	97	63	80.0	8	C	0
30	87	75	81.0	98	73	85.5	7	C	0.10
				July 1956					
1	90	76	83.0	97	68	82.5	8	C	0.01
2	85	73	79.0	97	72	84.5	6	C	4.06
3	85	74	79.5	97	74	85.5	10	C	3.71
4	86	73	79.5	98	65	81.5	7	C	0.74
5	82	73	77.5	98	74	86.0	10	C	0.18
6	89	72	80.5	96	60	78.0	10	C	0.04
7	90	73	81.5	95	65	80.0	10	C	0.05
8	90	73	81.5	94	68	81.0	15	C	T
9	88	73	80.5	95	70	82.5	6	C	0
10	84	75	79.5	95	73	84.0	12	C	T
11	88	75	81.5	95	70	82.5	12	2	T
12	87	74	80.5	97	70	83.5	15	C	0.88
13	82	74	78.0	97	80	88.5	9	C	T
14	89	75	82.0	96	70	83.0	8	C	0.16
15	89	75	82.0	95	68	81.5	10	C	0.24
16	89	75	82.0	95	67	81.0	12	C	T
17	89	75	82.0	97	69	83.0	8	2	0.05
18	90	75	82.5	96	67	81.5	8	2	0.37
19	87	75	81.0	96	69	82.5	12	C	0.35
20	88	75	81.5	96	53	74.5	23	3	1.36
21	89	75	82.0	95	66	80.5	18	C	0.55
22	87	74	81.0	94	70	82.0	9	C	0.28
23	87	74	81.0	97	68	82.5	18	C	0.92
24	84	73	79.0	94	72	83.0	10	C	0.02
25	87	71	79.5	96	65	81.5	11	C	0.09

(Continued)

Table 4 (Concluded)

Day	Temperature, F Max	Min	Mean	Relative Humidity % Max	Min	Mean	Wind Speed (knots) Max	Min	Precipitation in.
				July 1956 (Continued)					
26	91	74	82.5	94	62	79.0	12	C	T
27	85	74	79.5	96	74	86.0	6	C	0.30
28	83	74	78.5	98	74	87.0	8	C	0.22
29	90	74	82.0	95	68	81.5	12	C	0
30	90	76	83.0	94	67	80.5	10	C	0.46
31	88	75	81.5	96	74	80.0	10	C	0.07
				August 1956					
1	91	74	82.5	97	60	78.5	8	C	0.42
2	89	74	81.5	95	65	80.0	10	C	0.48
3	83	75	79.0	95	83	89.0	9	C	0.52
4	90	73	81.5	93	64	78.5	11	C	0
5	92	76	84.0	93	65	79.0	10	C	T
6	94	75	84.5	95	64	79.5	9	C	0.01
7	94	74	84.0	96	54	75.0	11	C	0
8	91	76	83.5	90	61	75.5	10	2	0.03
9	91	77	84.0	94	64	79.0	8	C	0.27
10	87	76	81.5	95	63	79.0	14	C	0.04
11	85	72	78.5	95	76	80.5	16	C	1.22
12	89	73	81.0	97	61	79.0	12	C	0
13	88	75	81.5	96	67	81.5	13	C	1.27
14	89	75	82.0	97	65	81.0	13	C	0.80
15	82	75	78.5	96	77	86.5	11	C	0.37
16	87	74	80.5	97	70	83.5	11	C	0
17	88	75	81.5	96	65	80.5	11	C	0
18	92	75	83.5	95	63	79.0	14	C	0.15
19	90	77	83.5	96	64	80.0	14	C	0.34
20	90	76	88.0	93	66	79.5	15	C	0
21	82	74	78.0	96	72	84.0	9	C	0.21
22	85	74	78.5	96	71	83.5	11	C	0.04
23	86	74	79.0	96	64	80.0	8	C	0.03
24	86	74	79.0	95	74	84.5	12	C	0.05
25	90	72	81.0	96	61	78.5	12	C	0
26	89	74	81.5	95	62	78.5	13	C	0.51
27	89	74	81.5	95	66	80.5	16	2	0.05
28	89	73	81.0	97	62	79.5	12	C	2.84
29	86	75	80.5	96	70	83.0	11	C	T
30	85	72	78.5	97	69	83.0	13	C	T
31	91	73	82.0	97	54	75.5	15	C	T

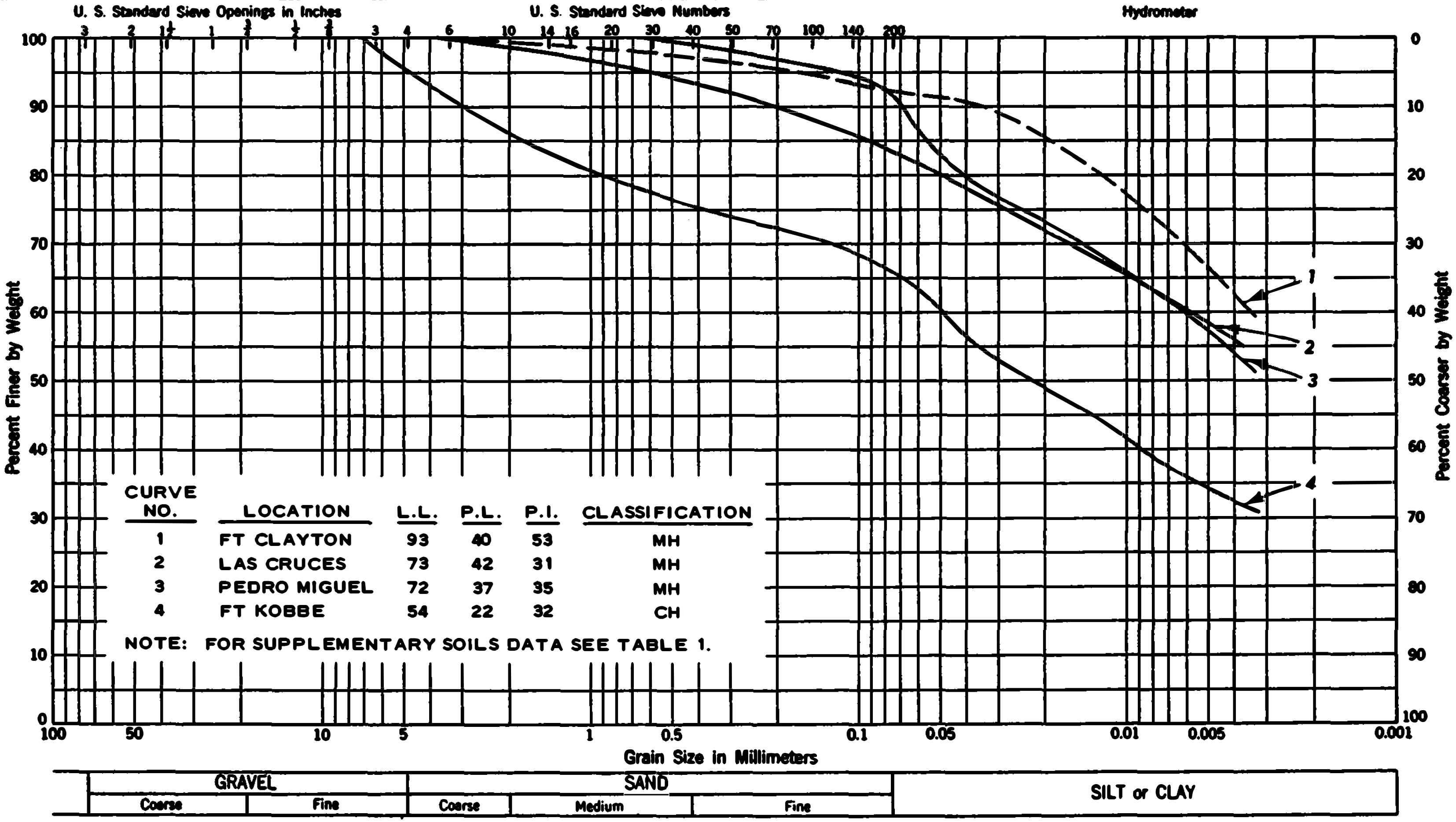


LOCATIONS OF SITES
PANAMA CANAL ZONE

SCALE IN MILES
3 0 3 6

PLATE 1

PLATE 2



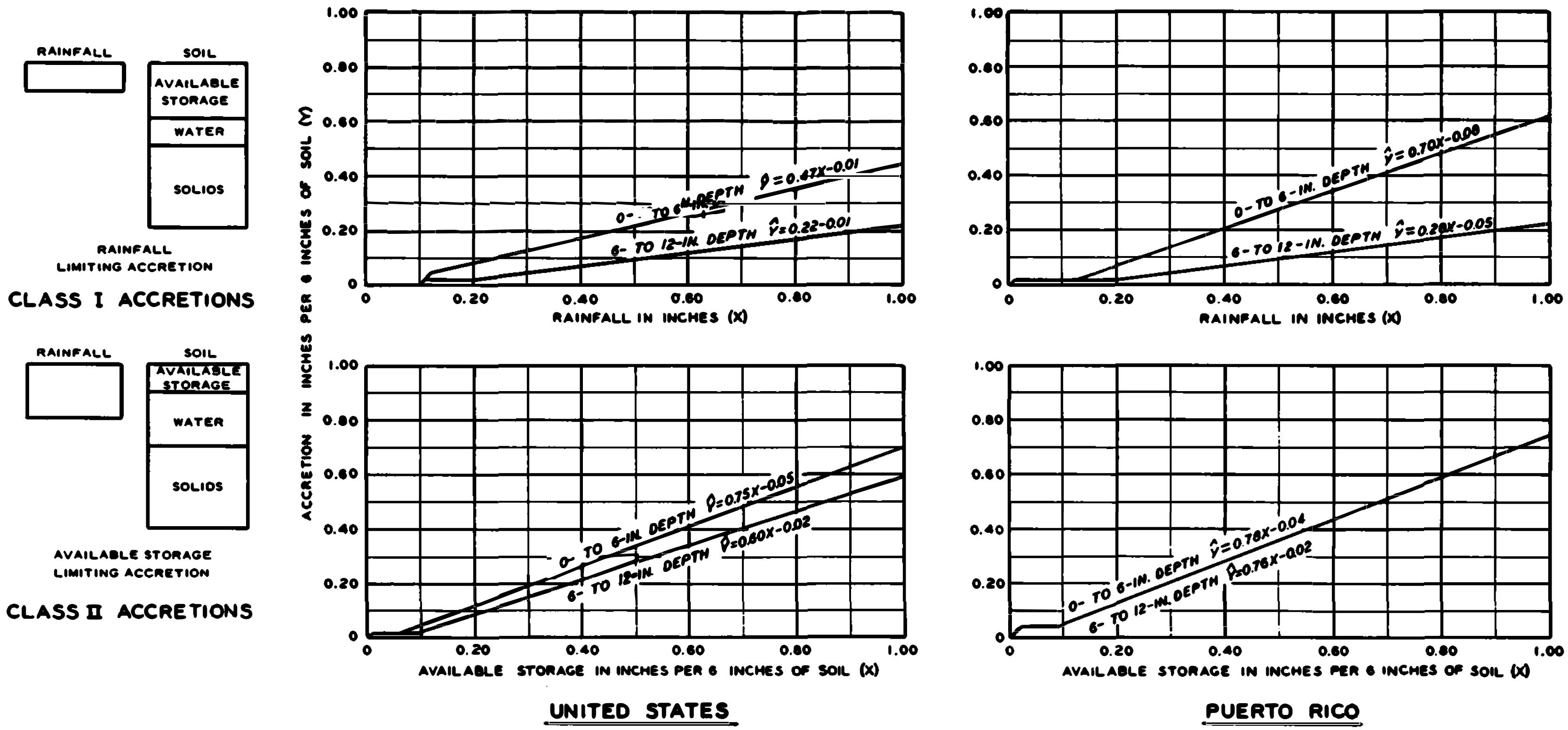
CURVE NO.	LOCATION	L.L.	P.L.	P.I.	CLASSIFICATION
1	FT CLAYTON	93	40	53	MH
2	LAS CRUCES	73	42	31	MH
3	PEDRO MIGUEL	72	37	35	MH
4	FT KOBBE	54	22	32	CH

NOTE: FOR SUPPLEMENTARY SOILS DATA SEE TABLE 1.

Number	Depth	Natural Moisture	L. L.	P. L.	P. I.	Classification

GRADATION CURVES
PANAMA CANAL ZONE

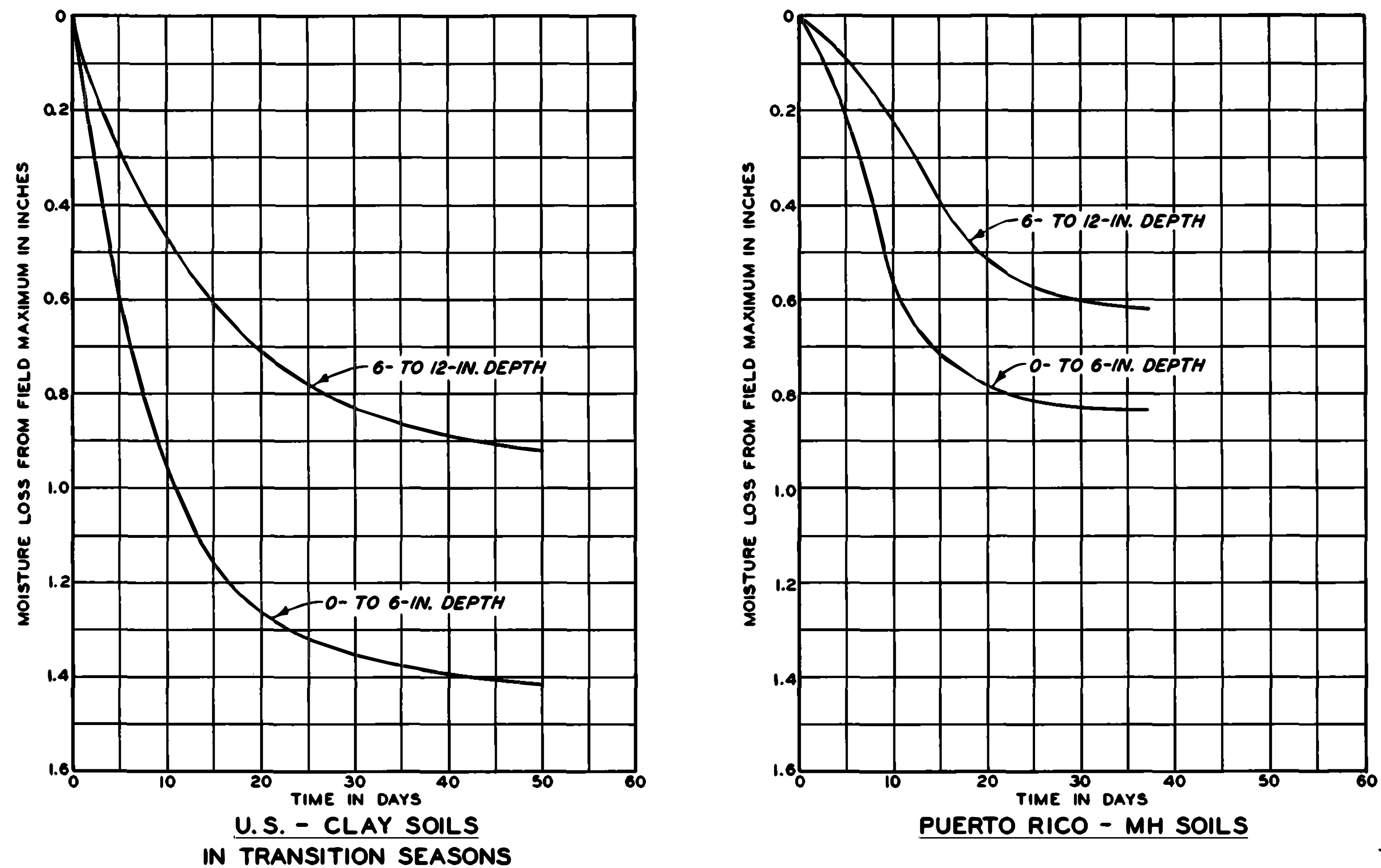
6- TO 12-IN. DEPTH



AVERAGE ACCRETION RELATIONS FOR UNITED STATES AND PUERTO RICO

PLATE 3

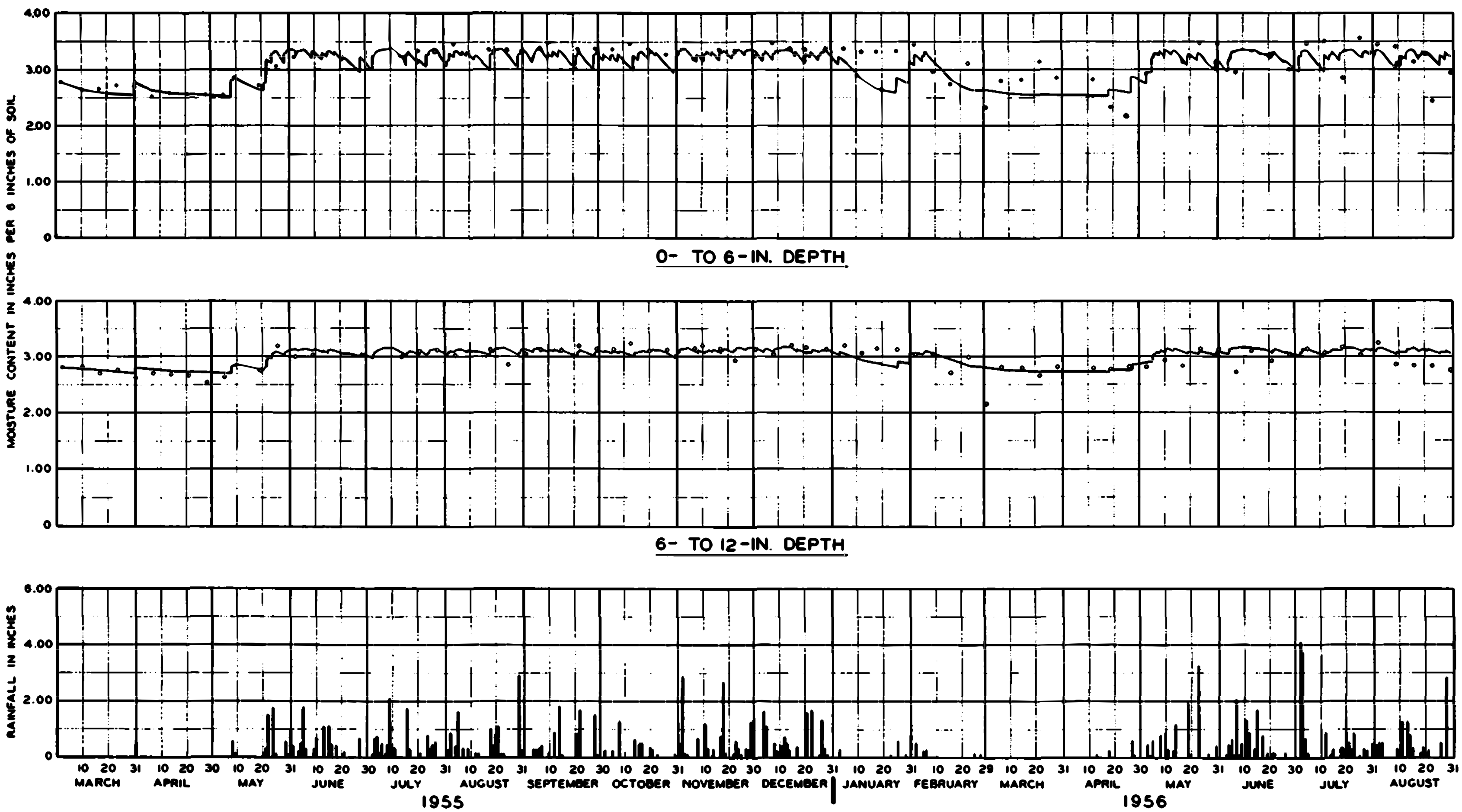
PLATE 4



AVERAGE DEPLETION CURVES

MOISTURE LOSS FROM FIELD MAXIMUM VS TIME

PLATE 5

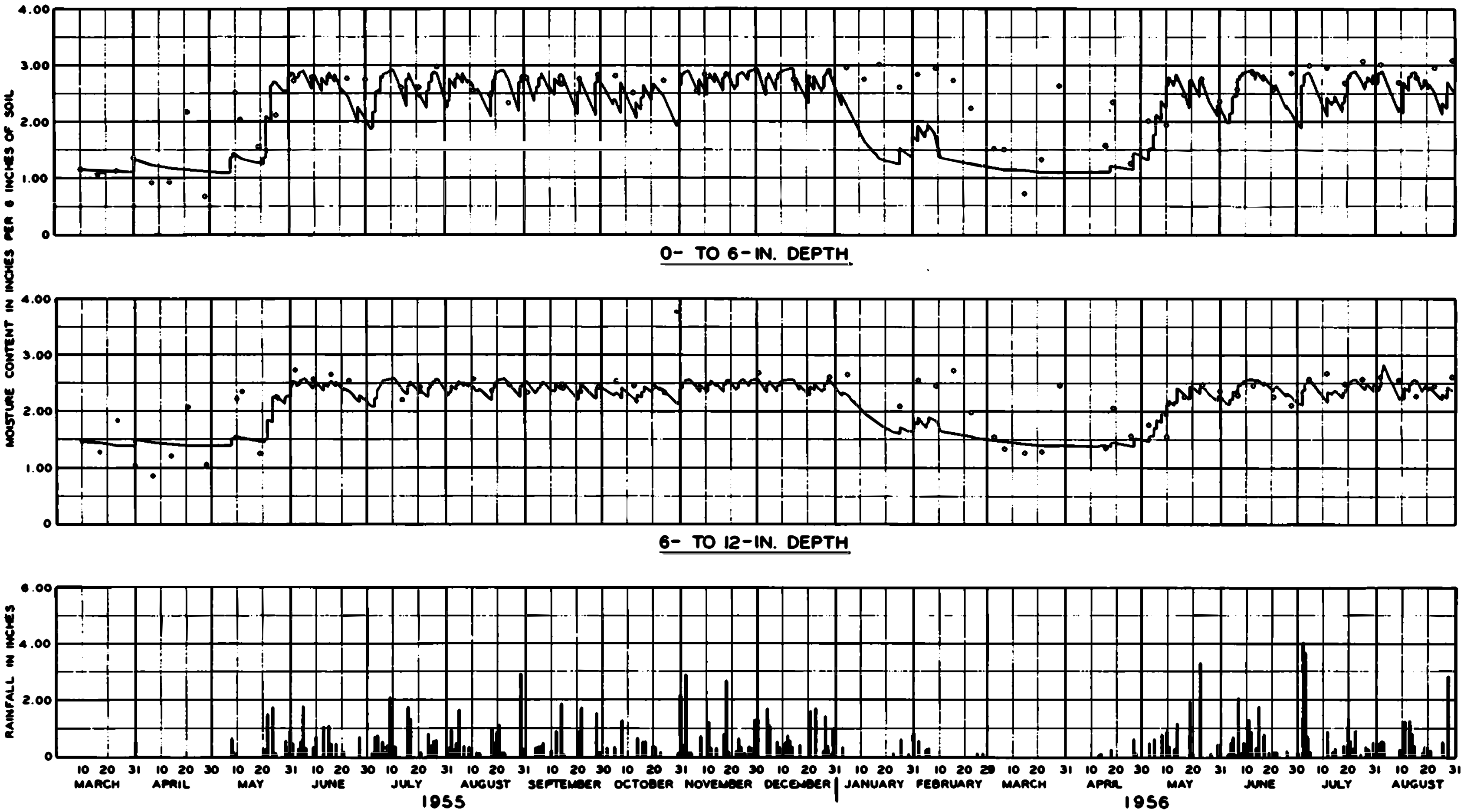


LEGEND

- ACTUAL MOISTURE CONTENT
- PREDICTED MOISTURE CONTENT

COMPARISON OF PREDICTED AND ACTUAL MOISTURE CONTENT

LAS CRUCES TEST SITE

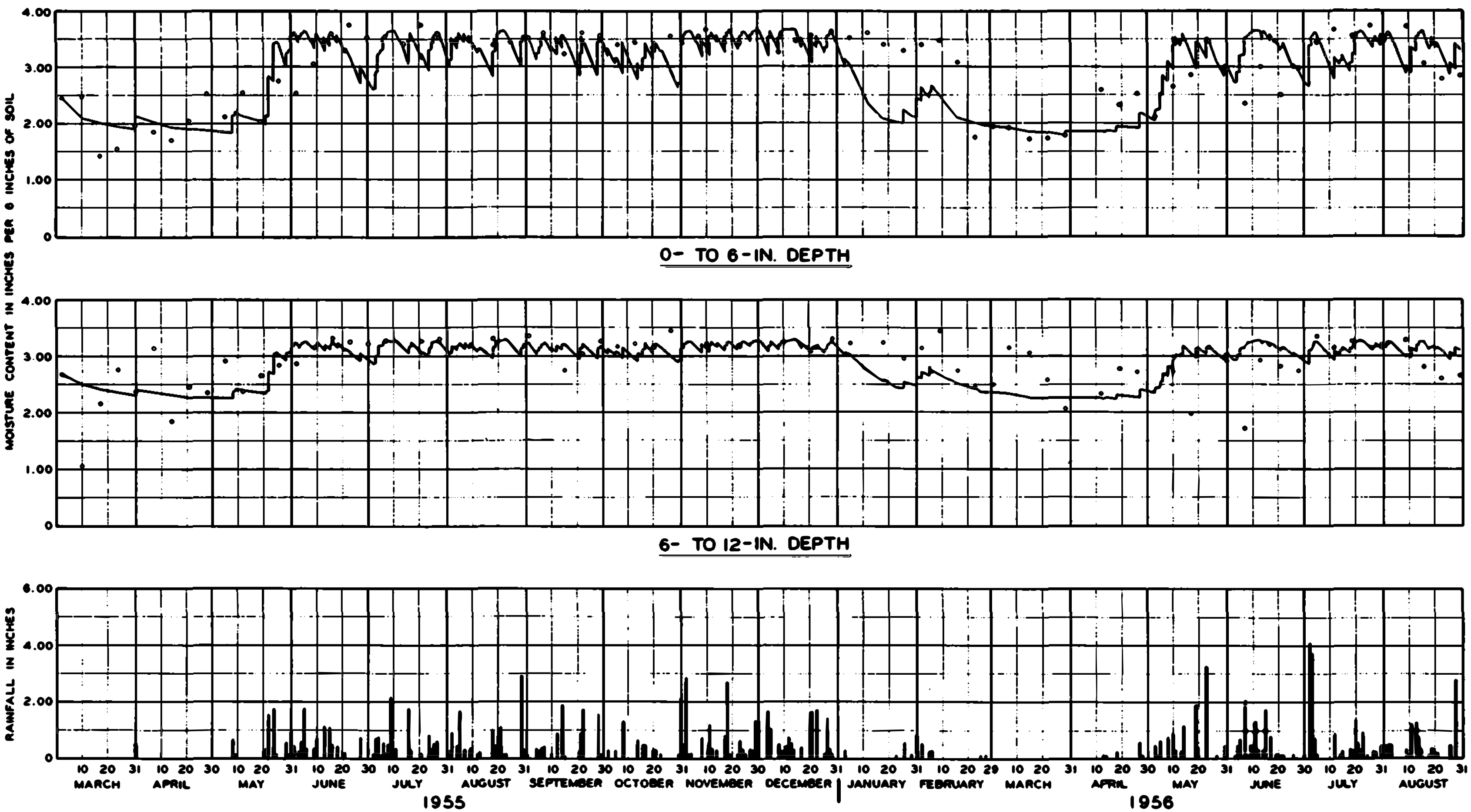


LEGEND

- • ACTUAL MOISTURE CONTENT
- PREDICTED MOISTURE CONTENT

COMPARISON OF PREDICTED AND ACTUAL MOISTURE CONTENT

FORT KOBBE TEST SITE



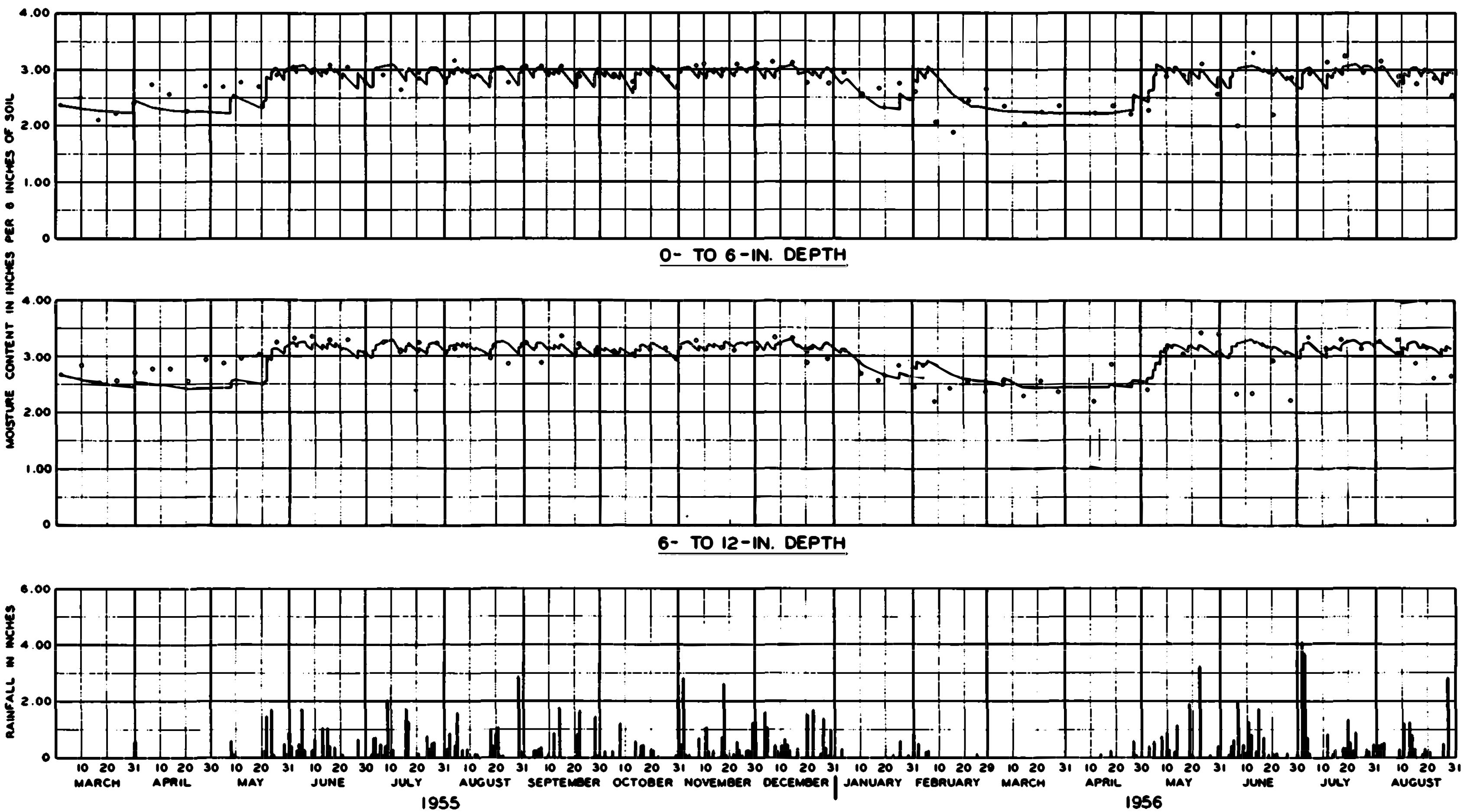
LEGEND

- • ACTUAL MOISTURE CONTENT
- PREDICTED MOISTURE CONTENT

COMPARISON OF PREDICTED AND ACTUAL MOISTURE CONTENT

FORT CLAYTON TEST SITE

PLATE 7

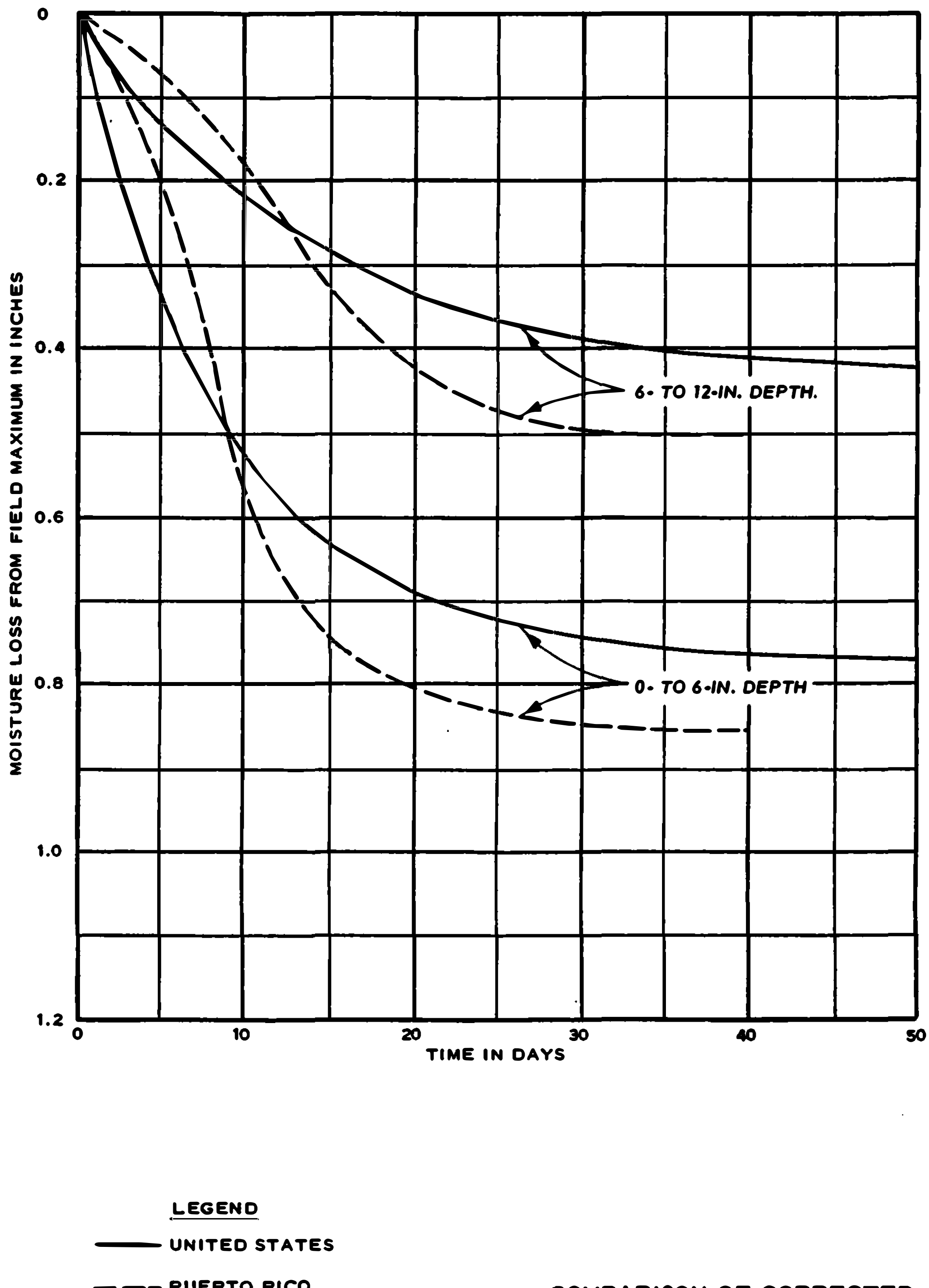


LEGEND

- ACTUAL MOISTURE CONTENT
- PREDICTED MOISTURE CONTENT

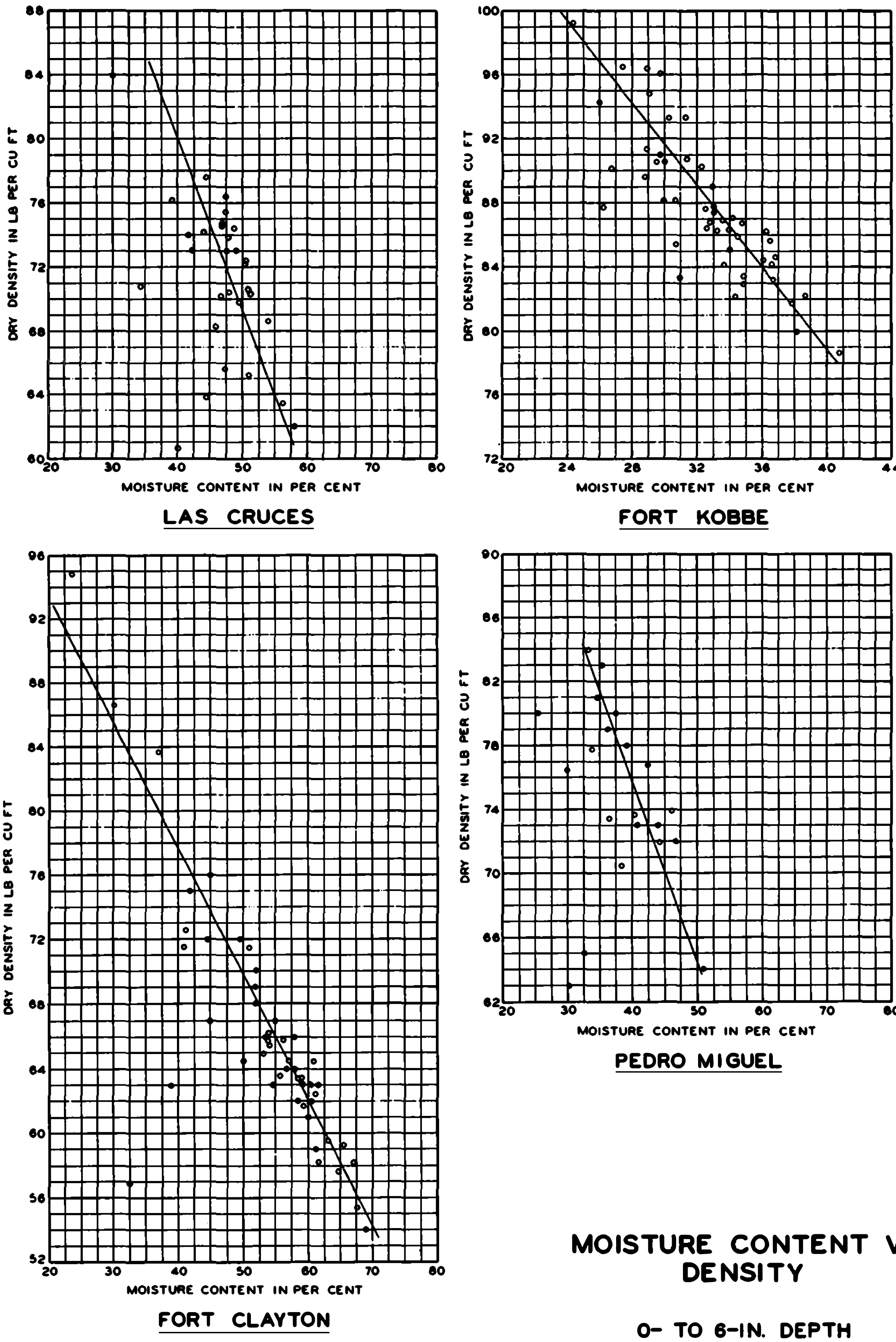
COMPARISON OF PREDICTED AND ACTUAL MOISTURE CONTENT

PEDRO MIGUEL TEST SITE



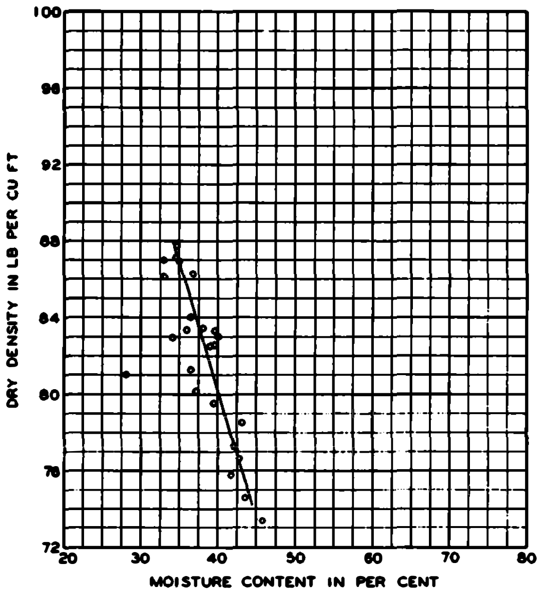
COMPARISON OF CORRECTED
U. S. AND PUERTO RICO
DEPLETION CURVES

LAS CRUCES TEST SITE

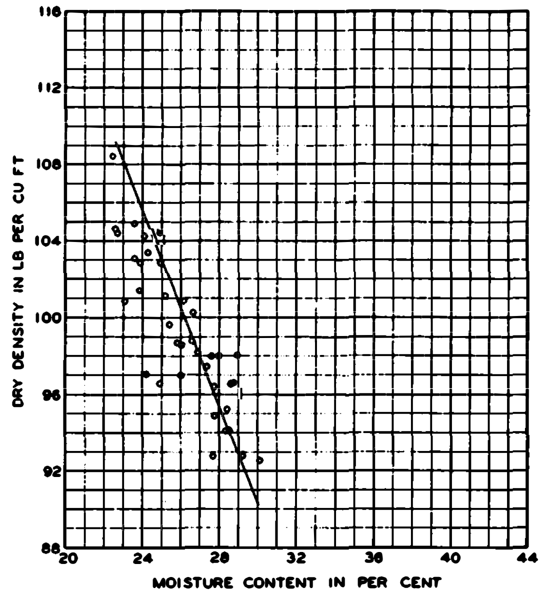


MOISTURE CONTENT VS DENSITY

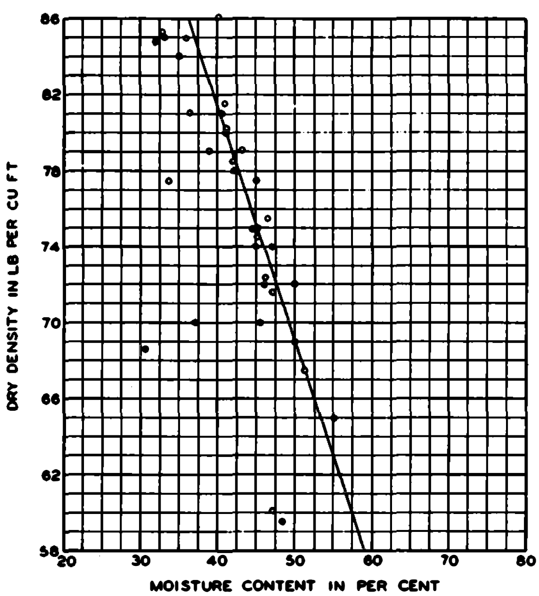
0- TO 6-IN. DEPTH



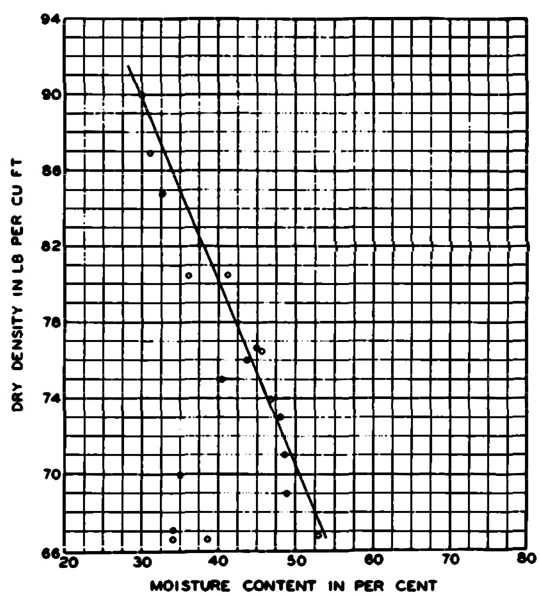
LAS CRUCES



FORT KOBBE



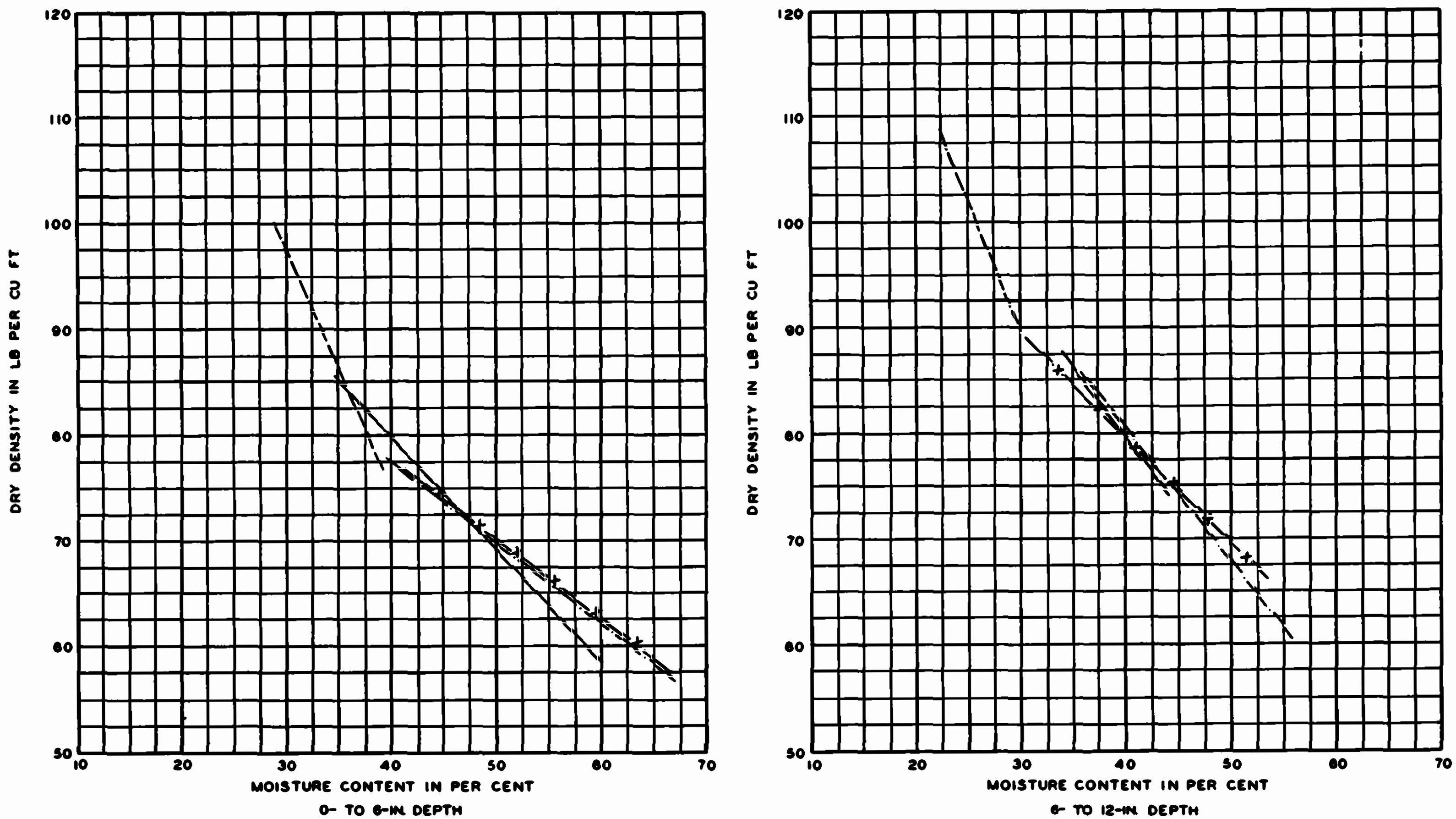
FORT CLAYTON



PEDRO MIGUEL

MOISTURE CONTENT VS DENSITY

6- TO 12-IN. DEPTH

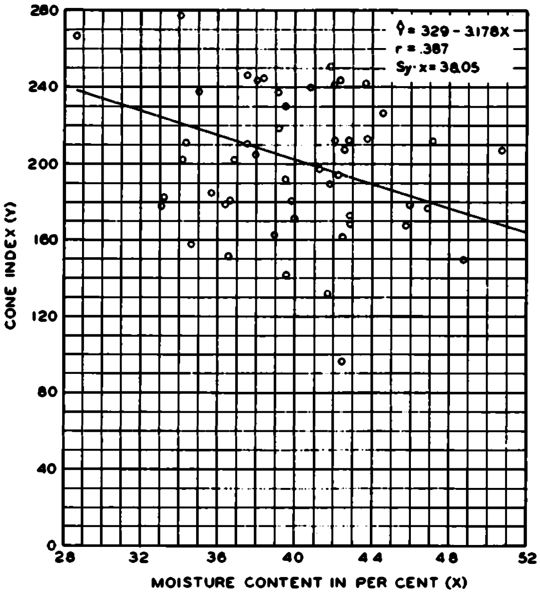


LEGEND

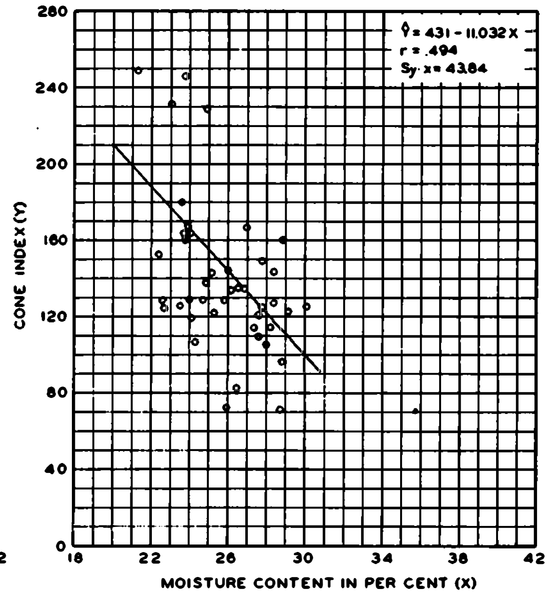
- ——— LAS CRUCES
- – – – – FORT KOBBE
- —·— FORT CLAYTON
- —x— PEDRO MIGUEL

SUMMARY CURVES

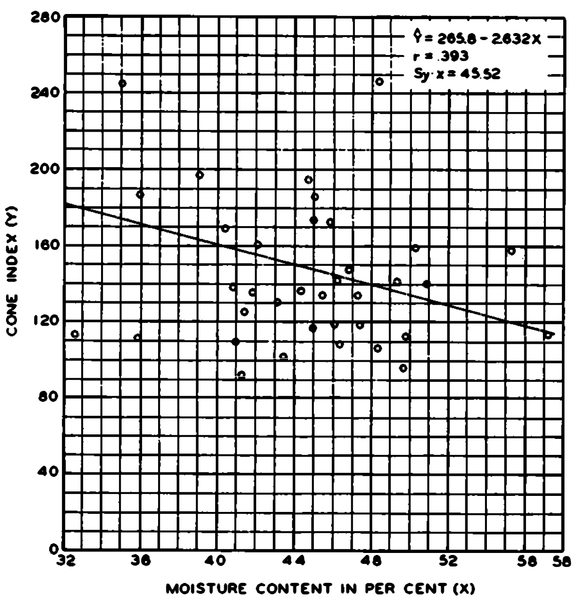
MOISTURE CONTENT VS DENSITY



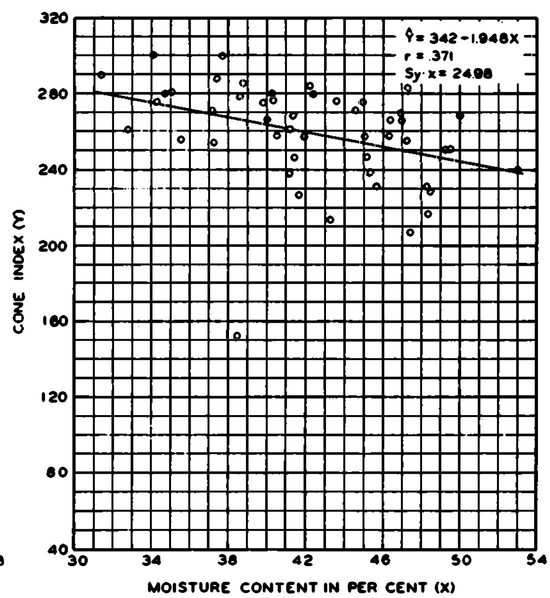
LAS CRUCES



FORT KOBBE



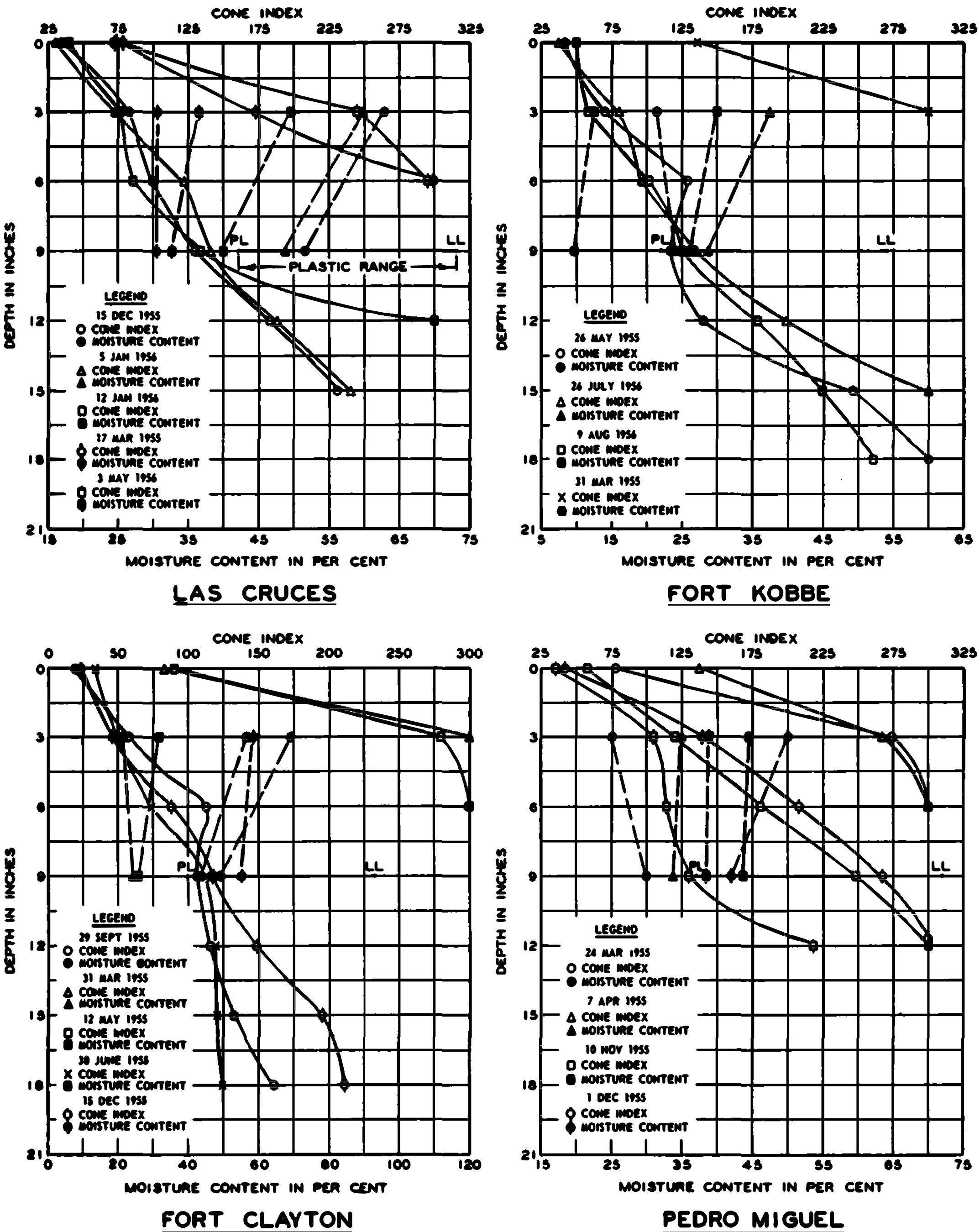
FORT CLAYTON



PEDRO MIGUEL

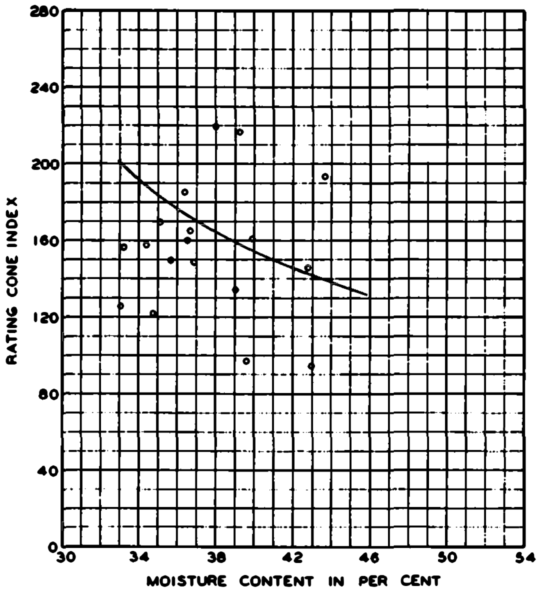
MOISTURE CONTENT VS CONE INDEX

6- TO 12-IN. DEPTH

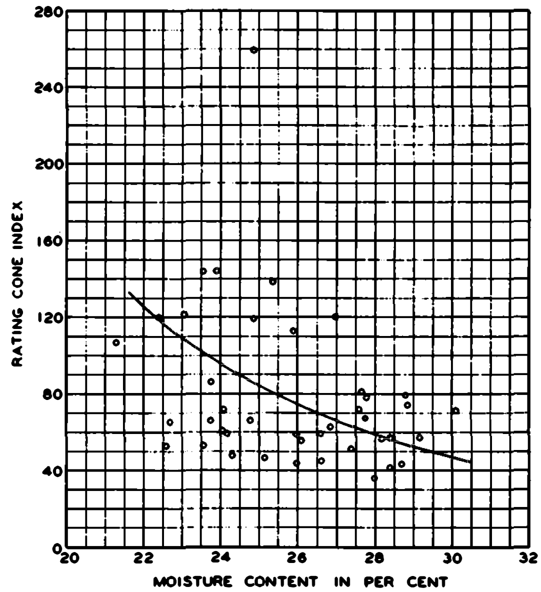


NOTE: FOR SUPPLEMENTARY DATA REFER TO TABLE 4 AND PARAGRAPH 63 IN TEXT.

CONE INDEX AND MOISTURE CONTENT PROFILES



LAS CRUCES



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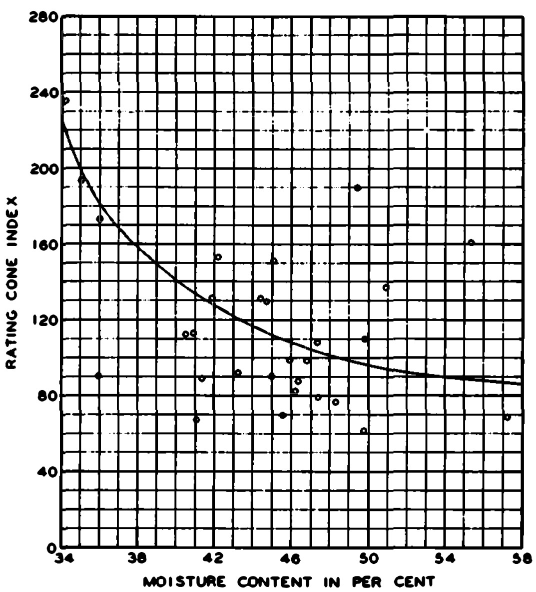
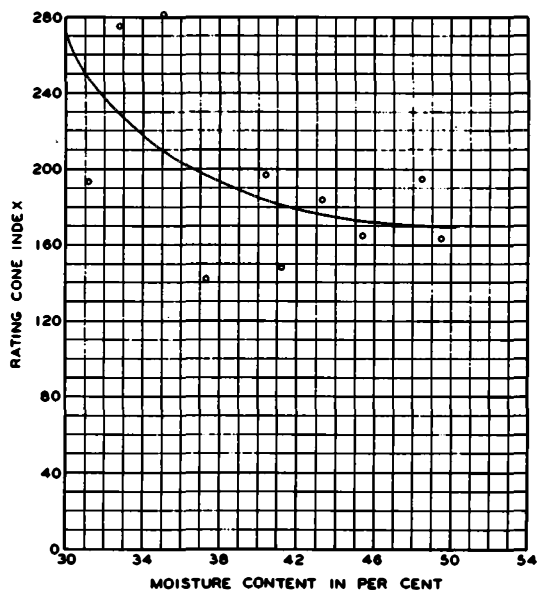


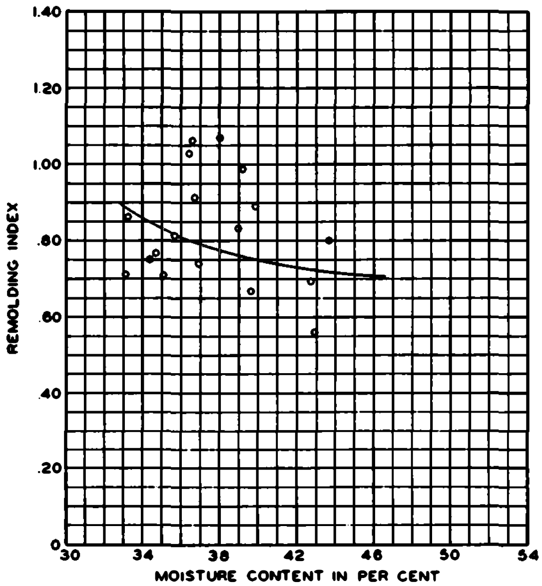
FORT CLAYTON



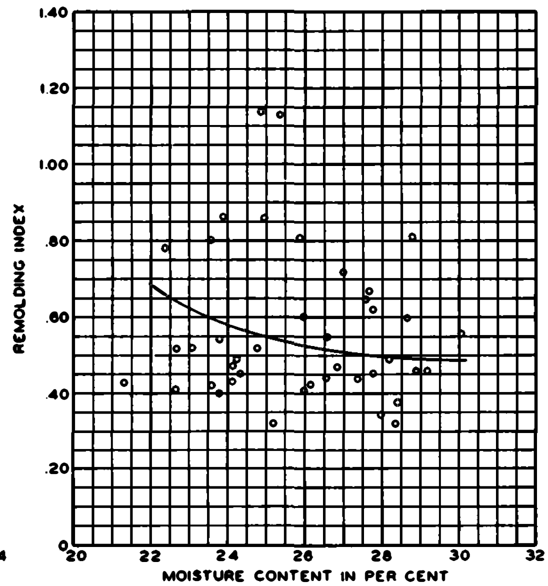
PEDRO MIGUEL

MOISTURE CONTENT VS RATING CONE INDEX

6- TO 12-IN. DEPTH



LAS CRUCES



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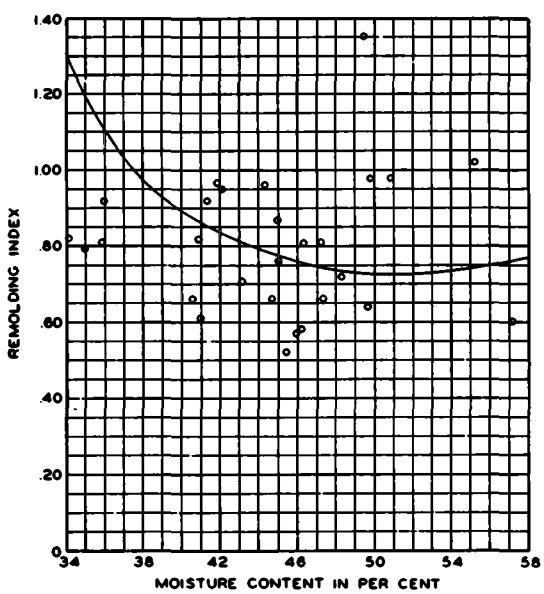
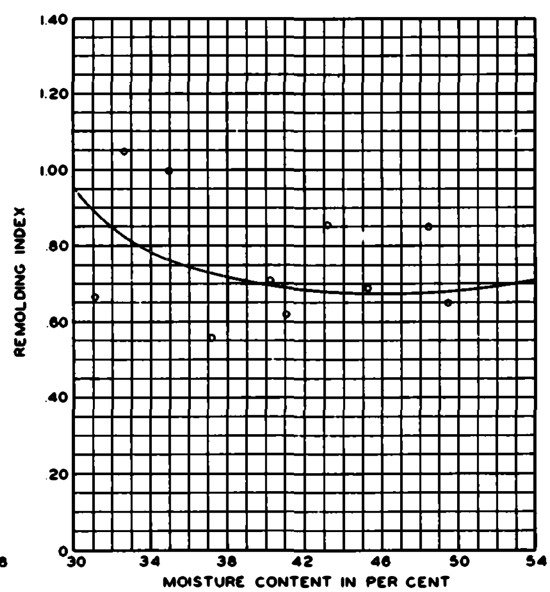


FORT CLAYTON



PEDRO MIGUEL

MOISTURE CONTENT VS REMOLDING INDEX

6- TO 12-IN. DEPTH