TEXAS BOARD OF WATER ENGINEERS

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BULLETIN 6019

CONSUMPTIVE USE OF WATER BY MAJOR CROPS IN TEXAS

November 1960

Reprinted July 1962

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November 1960

Reprinted July 1962

First Printing, November 1960

Second Printing, September 1961

Third Printing, July 1962

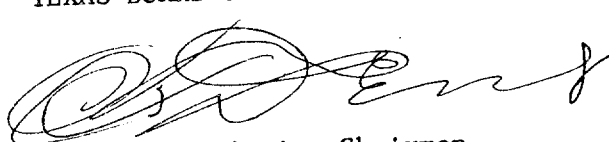
FOREWORD

Irrigation is practiced in different parts of Texas under various climatic conditions. In the far western portion of the State, irrigation supplies almost all of the water used by crops, while in the State's central region a significant part of crop water requirements is derived from rainfall. Rainfall on the eastern section of the State is sufficient for crop production most of the time, but crop yields are often assured through the use of "insurance" irrigation during infrequent critical dry periods of a few weeks duration.

This bulletin presents information on the water requirements of plants regardless of whether this water is supplied by precipitation directly, or by irrigation. The values given herein are not the amounts of water which are to be applied to the land, or pumped from a water supply source, to achieve agricultural production. Diversion amounts and field application volumes are dependent upon the soil characteristics, canal losses, deep percolation, and variations in times and amounts of rainfall. All these factors have to be considered in determining the amounts of water to be diverted from a supply for irrigation.

In order to determine the amount of irrigation water to be applied to the land, it is necessary to know the water requirements of plants. This bulletin presents the fundamental data of these water requirements of plants for use in water resources planning. Subsequent publications will describe studies of effective rainfall, irrigation efficiencies, and total diversion requirements.

TEXAS BOARD OF WATER ENGINEERS



O. F. Dent, Acting Chairman
November 23, 1960

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CONSUMPTIVE USE OF WATER BY MAJOR CROPS IN TEXAS

ABSTRACT

The study that resulted in the publication of this report was undertaken in order to obtain fundamental data of the average amounts of water used consumptively by agricultural crops, grown under favorable conditions including a full water supply, and thus to fulfill partly the need for information required for use in estimating the water requirements for irrigation.

The results published herein are estimates of average consumptive-use amounts for 12 major crops and crop groupings, and are tabulated by months for the respective length of growing season for each crop in each of 24 areas of major production in the State.

A method for estimating consumptive use of water by crops was developed by the Board of Water Engineers and used for the computation of the estimates tabulated. The TBWE (Texas Board of Water Engineers) Method is a procedure of relating experiment consumptive-use data to a composite relation of air temperature, dew point temperature, wind movement, and solar radiation, to obtain constant ratios or use coefficients for specific periods of time which vary with respect to length of periods and stage of development of vegetal growths.

The experiment data used were published consumptive-use amounts determined for crops grown in Texas, California, and Arizona. A composite relation of the aforementioned climatic data was used to compute average values for all areas of the state for the period 1946-55. These average values are called CLIMATIC-INDEX numbers. These numbers were used in conjunction with the use coefficients derived from the basic studies to compute estimates of monthly consumptive use by specific crops in each area of the State.

The estimated consumptive-use amounts for specific crops, as computed by this method, vary from place to place directly with the climatic-index number only.

These data provide a basis for estimating the monthly water requirements of plants on an average for production of agricultural crops in all areas of the State; and thus provide a basis for estimating amounts of water required from a source for irrigation when used with information describing amounts of rainfall effective in supplying the water requirements of crops, soil moisture available to crops, and losses involved with the distribution and application of water for crop use.

CONSUMPTIVE USE OF WATER BY MAJOR CROPS IN TEXAS

INTRODUCTION

The quantity of water required for the production of agricultural crops under irrigation must be known and inventoried in planning agricultural water-supply development.

This report presents estimates of average monthly depths of water used consumptively by major crops grown in Texas under conditions favorable to the production of agricultural crops, which includes a full water supply. Also included is a description of the TBWE (Texas Board of Water Engineers) method which has been developed for and used in the computation of these estimates of consumptive use. The values which are given for the water used consumptively by each crop are based on reliable data available at this time and are recommended for interim use until more extensive and precise data are obtained.

The estimates appearing in this report represent water requirements of plants only and not the gross amounts of water necessary for diversion from a surface or underground source to supply these plant requirements. Gross diversion requirements include consideration of many variable factors; such as canal losses, soil type, and method of water application, in addition to the water requirements of the plants. However, the water requirements of plants constitute the fundamental data used to develop estimates of quantities of water to be diverted for irrigation and are presented herein for this purpose.

ACKNOWLEDGEMENTS

All individuals and agencies, private and public, who have participated in the observation and collection of basic data related to the subject of this report are to be commended for their contributions. Particularly acknowledgement for assistance in the collection of basic data and in the interpretation of that data directly related to this report is given to:

The late Mr. Richard D. W. Blood, State Climatologist, U. S. Weather Bureau, Austin, Texas

Mr. Dean W. Bloodgood, Retired Irrigation Engineer, Board of Water Engineers, Austin, Texas and former Irrigation Engineer, U. S. Agricultural Research Service.

Dr. Morris E. Bloodworth, Professor of Soil Physics, Department of Agronomy, A. & M. College of Texas.

U. S. Study Commission-Texas, Irrigation Collaboration Group: Mr. Paul T. Gillett, Chairman; and members from the U. S. Bureau of Reclamation, the U. S. Soil Conservation Service, the State Soil Conservation Board, and the A. & M. College of Texas.

Mr. Tor J. Nordenson, Chief of Hydrologic Investigations Section, Hydrologic Services Division, U. S. Weather Bureau, Washington, D. C.

Mr. Robert V. Thurmond, Portland Cement Association, Austin, Texas. (Former Associate Planning Engineer, Texas Board of Water Engineers, and former Irrigation Engineer, Agricultural Extension Service, A. & M. College of Texas.)

PERSONNEL

Preliminary planning and inception of a report on consumptive use of water by, and irrigation requirements of, major crops grown under irrigation in Texas is credited to Robert V. Thurmond, working under the direction of McDonald D. Weinert, former Chief Engineer.

This report was prepared in Engineering Services, Board of Water Engineers, under the general supervision of John J. Vandertulip, Chief Engineer, and Seth D. Breeding, Chief Surface Water Engineer, by the Surface Water Division-Hydrologic Section for use by the Planning Division and is based on a method for consumptive-use determinations developed by Louis L. McDaniels, Acting Chief of the Hydrologic Section.

The Data Processing Division, directed by Ivan M. Stout, assisted Mr. McDaniels by performing extensive computations and preparing listings in tests of several accepted methods in preliminary studies prior to the development of the objective TBWE method for computing consumptive use of water by major crops grown under favorable conditions of available water.

DEFINITIONS

Terms used in this report to describe the method employed and to identify the relations and factors expressed are specifically defined, as follows:

CLIMATIC INDEX is a number expressing a composite relation of four climatic factors--air temperature, dew point temperature, wind movement, and solar radiation--as expressed by plate 2 in the USWB (U. S. Weather Bureau) Technical Paper 37 [1/] which in turn is based on Equation 14 in the USWB Research Paper 38 [2/].

[1/] Kohler, M. A., Nordenson, T. J., and Baker, D. R., 1959, Evaporation Maps for the United States: U. S. Weather Bureau Tech. Paper 37.

[2/] Kohler, M. A., Nordenson, T. J., and Fox, W. E., 1955, Evaporation from Pans and Lakes: U. S. Weather Bureau Research Paper 38.

Equation 14 was derived from evaporation research studies at Lake Hefner 3/ and at Lake Mead 4/.

CONSUMPTIVE USE is the depth of water, in inches, removed from a vegetated area by evaporation of moisture from soil surface, by evaporation of intercepted water from plant surfaces, by development of plant tissue, and by transpiration from vegetal growths. (Literature containing discussions of consumptive use of water by vegetation, evapotranspiration, and irrigation requirements of agricultural crops is quite voluminous. In lieu of many specific citations, a selected bibliography is presented at the end of this text.)

USE COEFFICIENT is a number expressing the ratio of a CONSUMPTIVE USE amount to a CLIMATIC INDEX.

The above terms are used in abbreviation, as follows: IC (CLIMATIC INDEX), UC (CONSUMPTIVE USE), AND KU (USE COEFFICIENT).

GENERAL DISCUSSION

Divisions of the State

The State was divided into eight areas (see figure 1, appendix A, page A-3) to form major land-resource divisions based on a complex characterized by similarities of vegetation, soil, climate, and water availability. These eight areas were further divided into 24 smaller areas (see figure 2, appendix A, page A-4) on a similar but more refined basis.

Crops and Crop Groupings

The following basic crops and crop groups are those for which consumptive-use amounts are presented:

Alfalfa
Corn
Cotton
Grains, Small
Orchards, Citrus
Orchards, Deciduous Fruit
Orchards, Pecan
Peanuts
Rice
Sorghum, Grain
Vegetables, Deep-Rooted
Vegetables, Shallow-Rooted

3/ U. S. Geological Survey, 1954, Water Loss Investigations: Vol. 1--Lake Hefner Studies: U. S. Geol. Survey Prof. Paper 269.

4/ U. S. Geological Survey, 1958, Water Loss Investigations: Lake Mead Studies: U. S. Geol. Survey Prof. Paper 298.

Included under deep-rooted vegetables, are the following:

Beans	Peas
Beets	Peppers
Cantaloupe	Pumpkin
Carrots	Squash
Chard	Sweet Potatoes
Cucumbers	Tomatoes
Eggplant	Turnips
Okra	Watermelons

Included under shallow-rooted vegetables, are the following:

Brussels Sprouts	Onions
Cabbage	Radishes
Cauliflower	Spinach
Celery	Sweet Corn
Lettuce	

Consumptive-use amounts for five of the major crops (alfalfa, corn, cotton, small grains, and grain sorghum) are shown for all areas of the state for purposes of comparison and reference. For other crops, these amounts are given for areas of major production only.

Three of these crops were used as a basis for determining consumptive-use amounts for certain other crops. Consumptive use of water by perennial pasture was based on amounts shown for alfalfa; by leguminous fertilizers (used as soil conditioners) on amounts shown for small grains; and by silage sorghum and by forage sorghum on amounts shown for grain sorghum.

Crop Seasons

The variations in the climate and the habits and practices of farmers and agriculturists in Texas, from year to year and from area to area, necessitated the selection of uniform planting dates and length of growing season for crops in each area for use in this report. These selections, which use the first day or the sixteenth day of a month as starting dates for crops, were made on a practical basis from areal information to minimize the variations.

The average planting date in each of the 24 areas and the length of growing season for each crop in this report was based on field reports (except for shallow-rooted vegetables) from Agricultural Experiment Stations of the A. & M. College of Texas, and data revealing the physiology of plants which were collected and furnished by Dr. Morris E. Bloodworth. These dates and lengths of growing seasons are shown on figure 4 (appendix A, page A-6). For the shallow-rooted vegetable group, the one exception, one or more 3½-month growing seasons were indicated in the field reports. The lack of basic data on consumptive use, and the variations in planting dates and length of growing season for crops in this group were the reasons for the use of a 7-month season for shallow-rooted vegetables. This 7-month period generally spans the season characterized by staggered plantings and harvests of mixed combinations of vegetables in this group.

Methods of Estimating Consumptive Use

The need for knowledge of the consumptive use of water by major crops and native vegetation has been the incentive for extensive research and experiment. This need has been the stimulus for the development of methods for extrapolating the experiment data to other areas and different climatic regions. Recognizing that atmospheric phenomena, in addition to soil conditions, affected the growth of plants and their use of water, scientists have related research and experiment data to climatic data as a vehicle for use in estimating the consumptive use by crops in other areas. The sensitiveness and the objectiveness of these methods have been controlled by the type, the quantity, and the extent of the climatic data available. The number of atmospheric phenomena which comprise our climatic data recorded at meteorologic stations are few with respect to area of coverage and completeness of expression. The fewness of these data has been responsible generally for the development of methods which are adaptable to extensive areal usage, but which are lacking in sensitivity to changes in our geographic and climatic regions.

Several recognized methods for estimating consumptive use by agricultural crops and native vegetation have been used in the United States and in foreign countries. Some of the better-known methods are those discussed in "Methods of Computing Consumptive Use of Water" by Wayne D. Criddle, Paper 1507, IR-1, Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, January 1958, which include the following:

Lowry-Johnson Method
Thornthwaite Method
Blaney-Criddle Method
Hargreaves Method
Penman Method

The cited methods vary somewhat each from the other in the climatic data required and used to express relations in empirical or theoretical determinations of consumptive use during a part of, or throughout the life cycle of, specific vegetal growths at research and experiment sites.

Of these methods, the widely used Blaney-Criddle Method was seriously considered for use in estimating average-monthly consumptive-use amounts for the major crops grown in Texas under favorable conditions of available water. This method entails the use of: one variable which is mean air temperature, a constant for the site which is the percentage of daytime hours of a year at that latitude, and a use coefficient for each crop.

In the application of the Blaney-Criddle Method, the complexity of the use coefficient becomes apparent. This coefficient expresses an integration of the physiologic characteristics of a plant together with the effect of atmospheric phenomena other than (1) air temperature, and (2) the possible percentage of daytime hours of a year during each month. Heretofore, adjustment of this coefficient on the basis of relative humidity variations has been practiced in an effort to compensate for differences between geographic and climatic regions. Satisfactory results have been obtained in some areas by this procedure. The distribution of monthly and seasonal coefficients has been dependent on individual judgment.

Recognition of the subjectiveness of some of these methods previously adapted to widespread use reveals the acumen and adroitness of the cited authors and others whose work in this field is testimonial of their experience and judgment. However, the judgment procedures necessary to distribute the Blaney-Criddle use coefficients precluded the adoption of this method for use in estimating consumptive-use amounts for crops grown in Texas in this report, and provided the stimulus which led to the development of the method used.

TBWE METHOD

The TBWE Method developed for use in estimating consumptive-use amounts utilizes some of the basic research and experiment consumptive-use data presented by the cited authors. Similar data recently collected in Texas by the U. S. Agricultural Research Service and the Texas Agricultural Experiment Stations were used to develop constant-value USE COEFFICIENTS for a given crop.

The TBWE Method differs from other methods in the number of climatic variables utilized to express variations in consumptive-use amounts from place to place. Development of this method has been possible because of the availability of Equation 14, USWB Research Paper 38, and the related procedures presented in USWB Technical Paper 37, which provide the means of processing a greater and more varied amount of climatic data than heretofore practical.

The TBWE Method of estimating consumptive-use amounts for crops, is a procedure of relating a measured CONSUMPTIVE USE for a crop during a period of time, to a CLIMATIC INDEX at the site of measurement during the same period of time, to obtain a USE COEFFICIENT. This USE COEFFICIENT can then be applied to a CLIMATIC INDEX for the same length of time at any other site for which consumptive-use amounts are desired for that crop. This method and others are homogeneous in basic principles. However, this method employs constant USE COEFFICIENTS (KU) for specific crops in all geographic and climatic regions, and utilizes the variations in the composite relation of the four atmospheric phenomena to determine variations in consumptive-use (UC) amounts. Therefore, the amount of consumptive use estimated for a crop varies directly with the CLIMATIC INDEX (IC) only.

The only variation in a set of USE COEFFICIENTS for a crop is effected by the planting date and length of growing season; such as, the first of a month, the sixteenth of a month, or whatever date of a month is used. A set of USE COEFFICIENTS developed for a crop started on a specific planting date during any month and continuing throughout the length of the growing season for that crop from that date can be used without adjustment at sites other than the experiment site and beginning on the like planting date during any month. For example, USE COEFFICIENTS developed for cotton planted February 16 at Weslaco in Area 4A (see figure 4) can be used without change for cotton planted May 16 at Lubbock in Area 1B. The USE COEFFICIENTS developed were used in this manner for each specific crop in all areas having the same planting date of a month and the same length of growing season.

Procedure of Computation

The computation of USE COEFFICIENTS for each crop was accomplished in accordance with procedures described as follows:

A. Basic experiment data were related to CLIMATIC-INDEX numbers.

1. Measured CONSUMPTIVE-USE amounts were arranged by 15-day periods beginning with the planting date acknowledged in the experiment data used. These 15-day periods were arranged so that adjustments of the basic data could be made for use for crops started on the first or on the sixteenth day of a month.

2. CLIMATIC-INDEX numbers were computed for the same 15-day periods from climatic data for the experiment site or the nearest USWB first-order climatic station in accordance with the procedures described in the USWB Technical Paper 37. Paper 37 contains nomographs for the solution of Equation 14, USWB Research Paper 38. These numbers are called Evaporation from Lake Surfaces in the cited papers.

3. Each 15-day CONSUMPTIVE-USE amount was divided by the CLIMATIC INDEX for the corresponding 15-day period. The resulting ratios are 15-day USE COEFFICIENTS. (These 15-day ratios can be transferred to other sites and related to CLIMATIC-INDEX numbers for like periods to obtain estimates of CONSUMPTIVE USE by 15-day periods if desired.)

4. The 15-day amounts and numbers obtained in steps A1-3 were used to define growth-use curves which were plotted as histograms showing 15-day relations, and also plotted as mass curves showing total consumptive use for each crop during the period of experiment data available. These growth-use curves represent the consumptive use during various stages of vegetal growth.

B. The basic assumption of this method is that the growth of each crop and its corresponding water use is directly related to the four climatic factors described in the definition of CLIMATIC INDEX, and that this assumption is valid with the differing physiologic characteristics of various crops.

C. On the basis of the stated assumption under B, the growth-use curves described under A4 were used to adjust the experiment consumptive-use data to planting dates beginning on the first and sixteenth day of any month as desired.

1. CLIMATIC-INDEX numbers were computed for 15-day periods as needed for each experiment site in order to adjust experiment data for each crop to the selected planting dates used in the various areas.

2. The USE-COEFFICIENT numbers obtained by step A3 were used as constants for respective 15-day periods in sequence and were multiplied sequentially by the 15-day CLIMATIC-INDEX numbers obtained by step C1 to estimate CONSUMPTIVE-USE amounts at the experiment site as though a respective crop had been planted and grown at that site during the selected periods.

3. The CONSUMPTIVE-USE amounts and the CLIMATIC-INDEX numbers computed by steps C1 and C2 were combined into desired half-month and full-month arrangements to agree with the desired planting dates and the adopted length of growing season.

4. The half-month and full month values as combined in step C3 were then processed: UC/IC=KU--CONSUMPTIVE USE divided by CLIMATIC INDEX equals USE COEFFICIENT.

The KU numbers computed by the above-described procedure comprised sets of constant-value USE COEFFICIENTS which were employed in the computation of estimates of CONSUMPTIVE-USE amounts for respective crops in the areas of major production as desired.

BASIC DATA

Consumptive Use of Water by Crops

Amounts of water used consumptively by various crops, as determined at basic research and experiment sites, and presented in published and unpublished reports, were part of the basic data used to develop the relations and estimated consumptive-use amounts described and presented herein. These data were obtained at various sites in Arizona, California, and Texas. The sources of data for respective crops, are as follows:

Alfalfa consumptive-use amounts in San Fernando Valley, California, in 1940 5/

Corn based on consumptive-use amounts for grain sorghum at Bushland, Texas, 1956-58 5/,6/ and adjusted on the basis of growth-use relations for the two crops as indicated by figure 29 in Bulletin 937 7/

Cotton consumptive-use amounts at Weslaco, Texas, in 1958 8/

Small Grains consumptive use at Bushland, Texas, 1956-58 5/,6/

5/ Blaney, H. F., Haise, H. R., and Jensen, M. E., Monthly Consumptive Use by Irrigated Crops in Western United States: Supplement to U. S. Soil Conservation Service Tech. Paper 96.

6/ Jensen, M. E., and Sletten, W. H., 1959, Agricultural Reasearch Service Project Reports: ARS-SWC, Fort Collins, Colorado and Bushland, Texas.

7/ Bloodworth, M. E., 1959, Some Principles and Practices in the Irrigation of Texas Soils: Texas Agricultural Experiment Station Bull. 937, A. & M. College of Texas.

8/ Ross, P. E., and Boykin, J. W., Unpublished data for 1958 cotton crop at ARS-SWC station in Weslaco, Texas.

Citrus consumptive use is average of amounts for oranges and grapefruit in Salt River Valley, Arizona, 1931-54 9/ and the amounts for oranges in San Fernando Valley, California, in 1940 5/

Deciduous Fruit consumptive use in San Joaquin-Sacramento Delta, California, in 1928 9/

Pecans consumptive use based on amounts for walnuts in San Fernando Valley, California, in 1928 5/

Peanuts estimated average consumptive use in east Texas based on data in Bulletin 937 7/

Rice consumptive use and cultural flooding based on data from Rice-Pasture Experiment Station at Beaumont and Eagle Lake, Texas, in 1954

Grain sorghum consumptive use at Bushland, Texas, 1956-58 5/,6/

Deep-Rooted Vegetables consumptive use by tomatoes in Sacramento Valley, California, 1933-55 5/

Shallow-Rooted Vegetables consumptive use in San Joaquin Delta, California, in 1928 5/

The relations of the consumptive use of water by perennial pasture; by leguminous or other crops, used as fertilizers or soil conditioners; by silage sorghum and forage sorghum; to the consumptive use by the base crops described previously, were determined on the basis of sparse experiment data and recommendations by some of the agriculturists acknowledged.

The basic amounts of consumptive use at respective experiment sites by the above crops, as used to develop the USE COEFFICIENTS employed in the TBWE Method, are shown on table 1 (appendix B, page B-3). In some instances, the amounts shown as UC (CONSUMPTIVE USE) vary slightly from the amounts presented in the cited references. These variations result from the adjustment of the experiment data because of differences in planting dates.

5/ See footnote 5, page 10.

6/ See footnote 6, page 10.

7/ See footnote 7, page 10.

9/ Blaney, H. F., March 1959, Monthly Consumptive Use Requirements for Irrigated Crops: Am. Soc. Civil Engineers Proc. Paper 1963, Journal of the Irrigation and Drainage Division, Vol. 85, No. 1R-1, Part I.

Climatic Index

The basic value of the average annual CLIMATIC INDEX determined for each of the 24 areas of the state described under GENERAL DISCUSSION, Divisions of the State, is shown by the large numerals on figure 3 (appendix A, page A-5). These values were obtained by replotting the respective isograms shown on plate 2, USWB Technical Paper 37, onto a map of Texas showing the 24 areas, and then determining an average from these isograms in each area. The resulting chart shows the variation in the average-annual value of the CLIMATIC INDEX for the 10-year period 1946-55 across the State.

As mentioned before, the values shown on plate 2, USWB Technical Paper 37, and entitled: "AVERAGE ANNUAL LAKE EVAPORATION IN INCHES, PERIOD 1946-55", are called CLIMATIC-INDEX numbers in this report.

Monthly values of the CLIMATIC-INDEX numbers for each of the 24 areas were determined by multiplying the average annual CLIMATIC-INDEX number for an area by the monthly distribution coefficients for that area as shown in table 3 (appendix B, page B-7). These distribution coefficients were determined from values of the average monthly CLIMATIC-INDEX number computed for 31 USWB first-order climatic stations--20 in Texas and 11 in adjacent states. These first-order stations are listed in table 2 (appendix B, page B-6). The distribution coefficients are the ratios obtained by dividing the average monthly CLIMATIC-INDEX number by the average annual CLIMATIC-INDEX number. If expressed as a percentage, these coefficients represent the percentage of the annual CLIMATIC-INDEX number occurring each month of a year on an average. The distribution coefficients were assigned to each of the 24 areas on the basis of the definition afforded by the numbers computed for each first-order climatic station--using such numbers direct when applicable, and interpolating between such numbers for adjacent areas when applicable. The resulting CLIMATIC-INDEX numbers are shown in table 3.

Monthly values of the CLIMATIC-INDEX number were computed for each experiment site, for each year or each average of years, as needed for relating to CONSUMPTIVE-USE amounts for crops comprising the basic agricultural data used herein. These numbers are shown as IC for the respective sites and crops in table 1.

USE COEFFICIENTS

Constant-value USE COEFFICIENTS for each crop at each experiment site were computed from the basic data as previously described under TBWE METHOD, Procedure of Computation. For practical application of the method, the USE COEFFICIENTS for half-month periods were recomputed and related to one-half of a monthly CLIMATIC-INDEX number. This procedure allows the use of monthly values of the CLIMATIC-INDEX number divided by two when computing estimates of consumptive use by crops planted on the sixteenth of a month or harvested by the fifteenth of a month. The USE COEFFICIENTS for each crop and each starting date and length of growing season are shown as KU in table 1.

The consumptive-use amounts computed and shown for each crop are estimates of the average depth of water, in inches, required for the growth and full development of that crop under conditions favorable to the production of

agricultural crops having a full water supply in each of the areas for the periods indicated. These amounts are constituted as defined and do not include estimates of losses of water from distribution, leaching, seepage, and other causes not inherently a part of the experiment consumptive-use data described and used.

TABULATIONS OF DATA

A set of tables, numbers 1 to 4 (appendix B) and numbers 5 to 16 (appendix C), are used to present the relations described and the results obtained by the procedures set forth. These tables contain the basic experiment CONSUMPTIVE-USE data adjusted to planting dates used herein, the CLIMATIC-INDEX numbers for the experiment sites, the TBWE USE COEFFICIENTS evolved, the distribution coefficients used to convert average-annual climatic-index numbers to monthly numbers in the 24 areas covering Texas, the average-monthly and average-annual climatic-index numbers computed for each of the 24 areas, and monthly and seasonal consumptive-use amounts by areas for the crops included and listed under GENERAL DISCUSSION, Crops and Crop Groupings.

The 24 areas were listed on the tables in a sequence chosen to attain reasonably smooth transition between the extremes in the general geographic and climatic areas of the State.

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APPENDIX A

Descriptive Figures

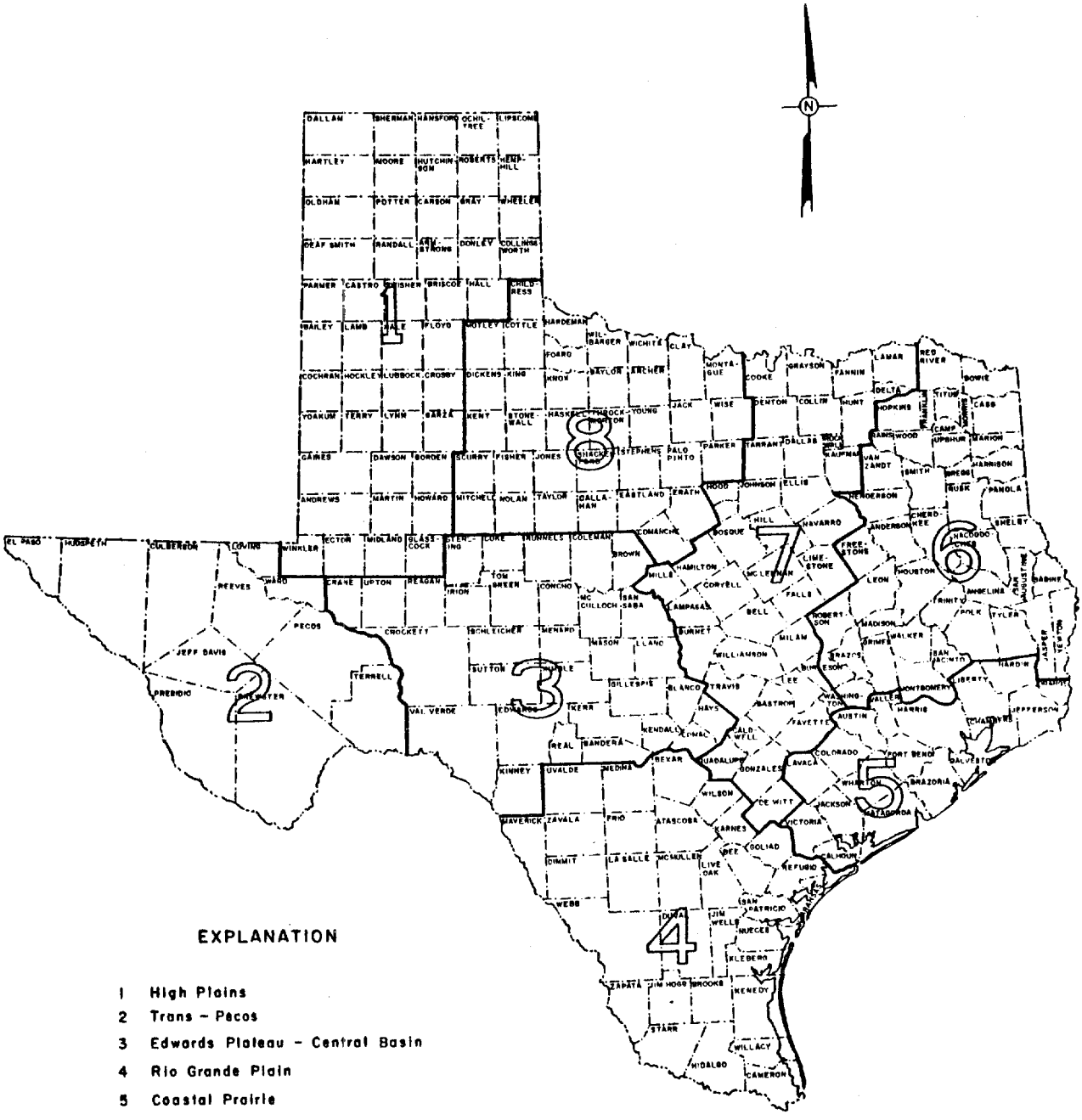


FIGURE 1. - Land resource divisions and irrigated areas.

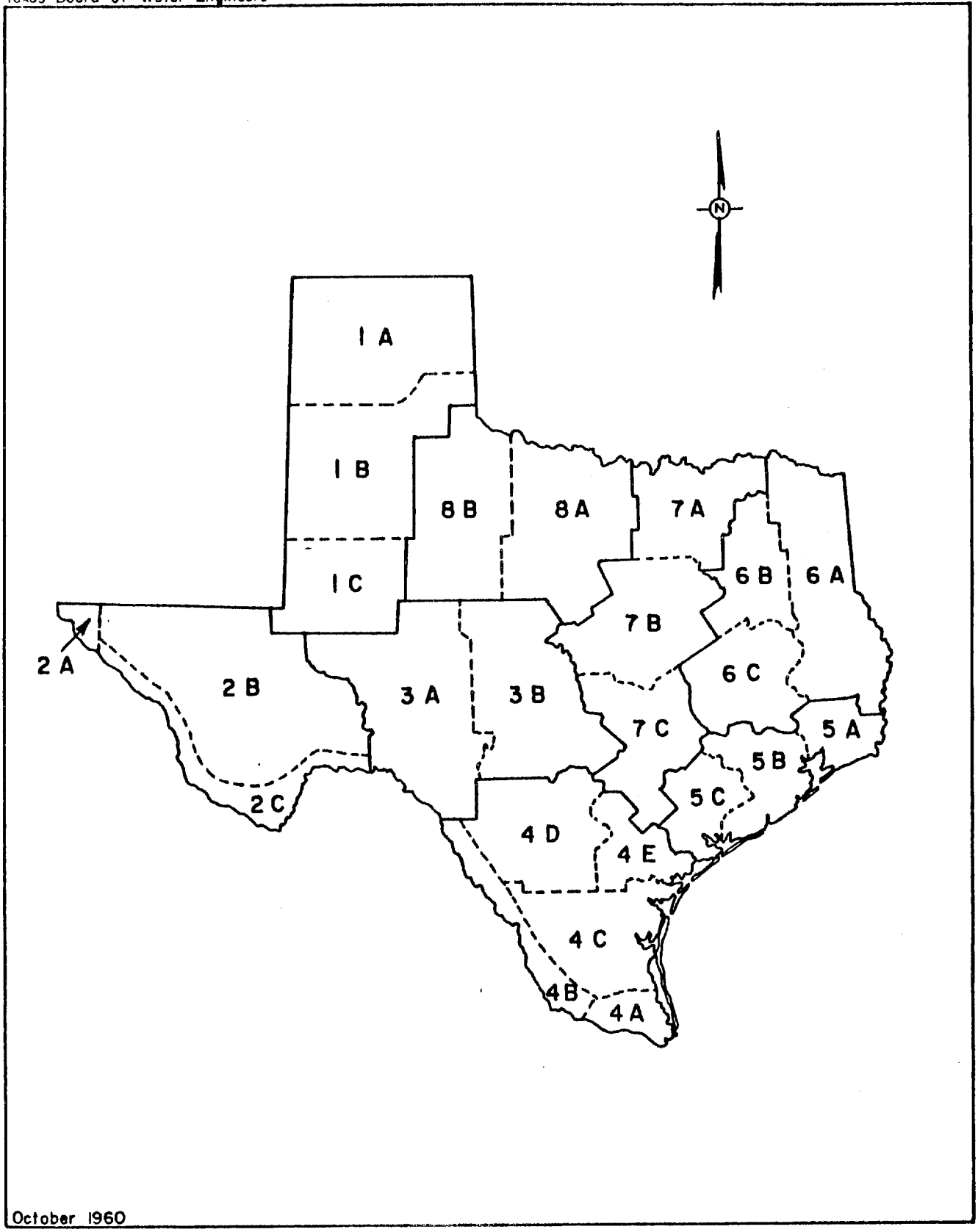
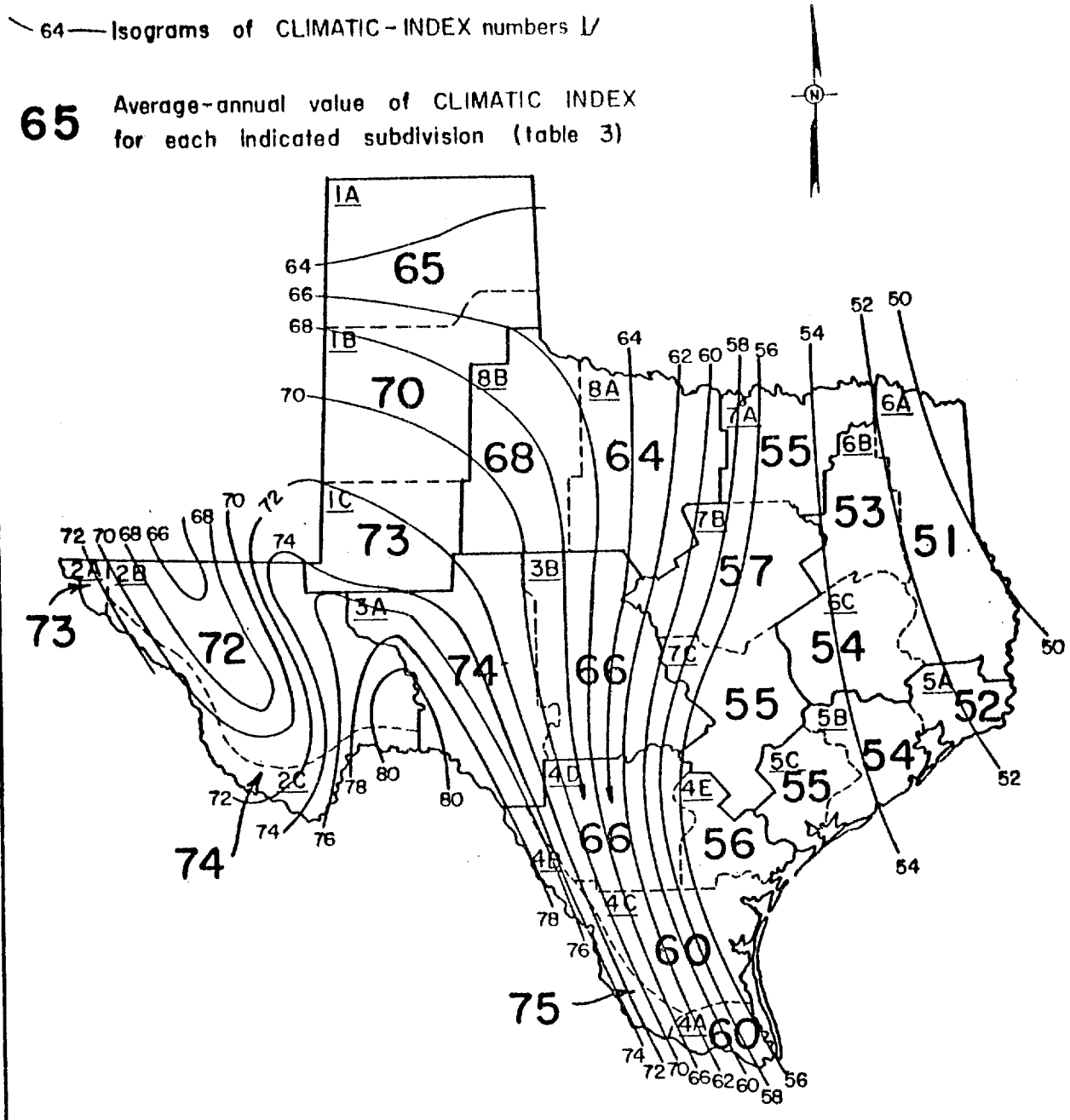


FIGURE 2.— Subdivisions of irrigated areas



1/ Average-annual numbers, for the period 1946-55, as expressed on plate 2 of the U. S. Weather Bureau Technical Paper No. 37, Evaporation Maps for the United States.

October 1960

FIGURE 3.- Average-annual CLIMATIC-INDEX numbers for subdivisions of irrigated areas

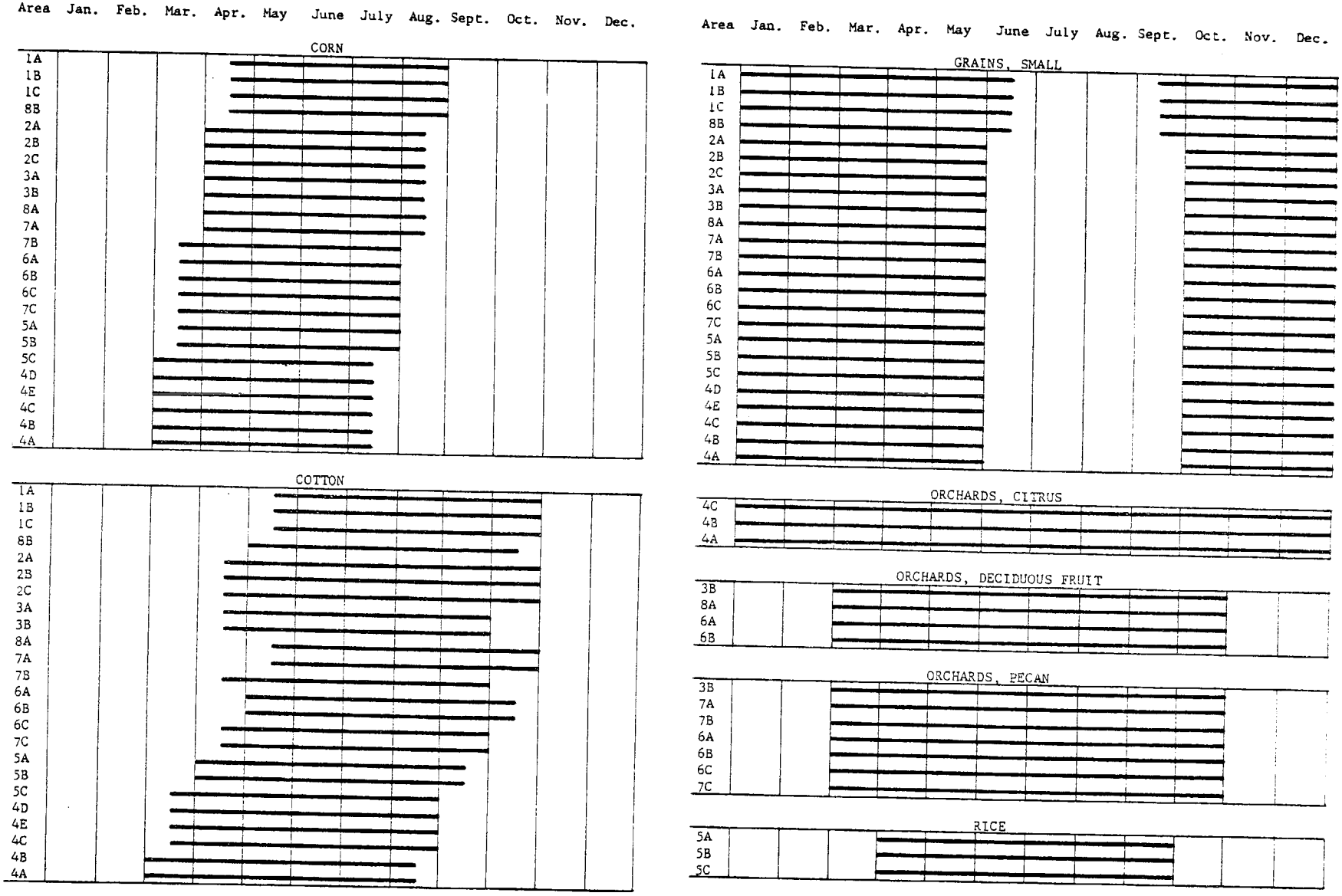
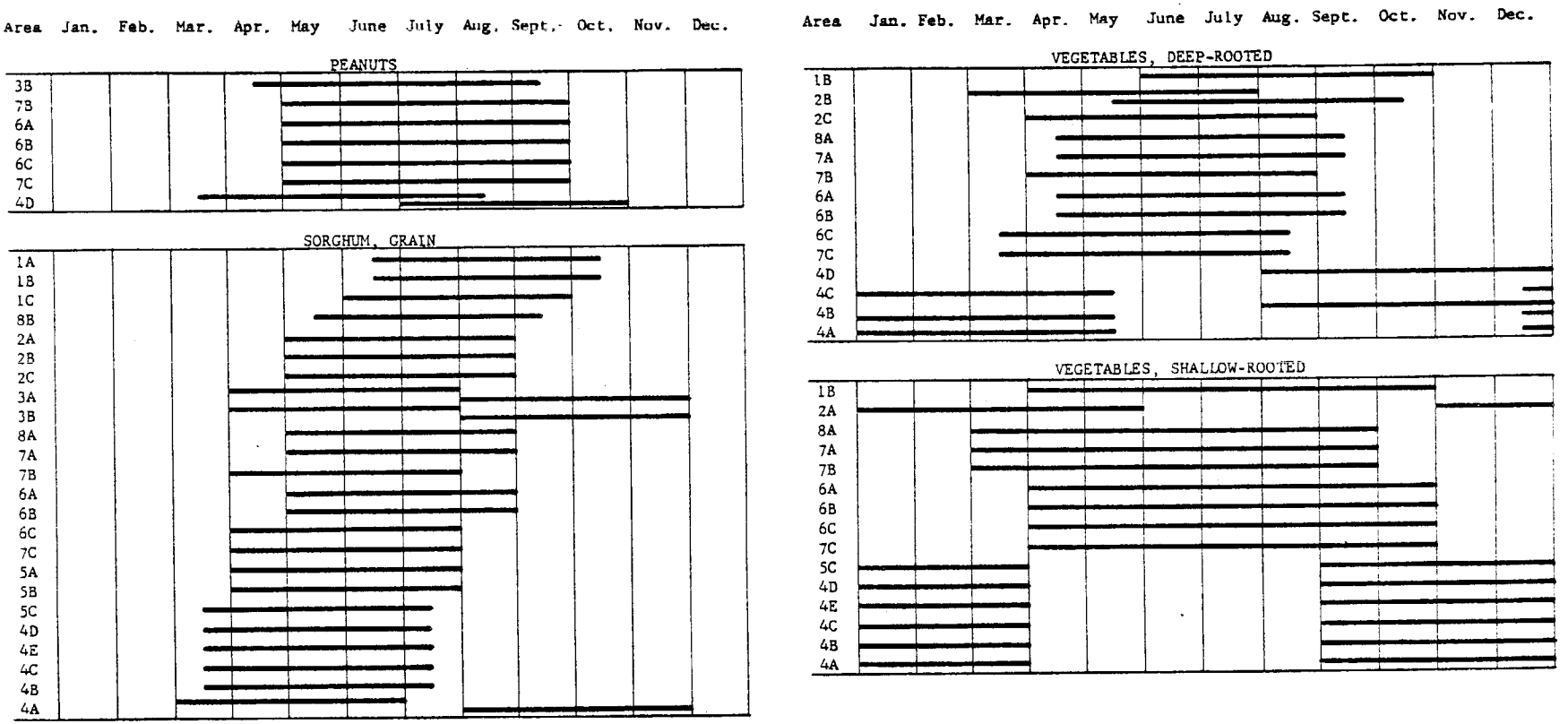


FIGURE 4.-Average planting date and length of growing season of crops, by areas, in Texas



Note.--Alfalfa, a perennial usually planted in September, is omitted from the above chart. The average planting date used for each crop is the first or middle of a month as indicated. In some areas for some crops, two bars indicate two crops yearly.

FIGURE 4. --Continued

APPENDIX B

Tables of Experiment Data and Basic Relations

Table 1

BASIC DATA

UC--CONSUMPTIVE USE; IC--CLIMATIC INDEX; KU--USE COEFFICIENT; values at experiment sites and times

Data	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
ALFALFA: San Fernando Valley, California, 1940													
UC	1.3	1.6	3.1	3.3	6.7	5.4	7.8	4.2	5.6	4.4	3.1	1.3	47.8
IC	2.2	2.7	3.8	4.3	5.9	5.4	7.6	5.9	5.4	4.3	3.8	2.7	54.0
KU	0.59	0.59	0.82	0.77	1.14	1.00	1.03	0.71	1.04	1.02	0.82	0.48	0.89
CORN: Based on grain sorghum at Bushland, Texas, 1956-58, planted on 1st day of a month													
UC						1.3	4.0	6.5	8.4	*2.9			23.1
IC						8.4	8.8	8.0	6.2	5.7÷2			34.2
KU						0.15	0.45	0.81	1.35	1.00			0.68
CORN: Based on grain sorghum at Bushland, Texas, 1956-58, planted on 16th day of month													
UC						*0.4	2.8	4.6	7.3	6.7			21.6
IC						8.4÷2	8.8	8.0	6.2	5.7			32.9
KU						0.09	0.32	0.58	1.18	1.18			0.66
COTTON: Weslaco, Texas, 1958, planted on 1st day of a month, 5½-month season													
UC			0.7	1.2	6.1	5.5	4.5	*.04					18.4
IC			3.1	5.1	5.9	6.6	7.4	7.8÷2					32.0
KU			0.23	0.24	1.03	0.83	0.61	0.10					0.58
COTTON: Weslaco, Texas, 1958, planted on 16th day of a month, 5½-month season													
UC			*0.3	1.3	4.0	7.2	5.1	1.7					19.6
IC			3.1÷2	5.1	5.9	6.6	7.4	7.8					34.3
KU			0.18	0.25	0.68	1.09	0.69	0.22					0.57
COTTON: Weslaco, Texas, 1958, planted on 16th day of a month, 6½-month season													
UC			*0.3	1.3	3.6	6.0	6.4	5.5	3.5				26.6
IC			3.1÷2	5.1	5.9	6.6	7.4	7.8	4.5				38.3
KU			0.18	0.25	0.61	0.91	0.86	0.71	0.77				[illegible]

* One-half month.

Table 1--Continued

BASIC DATA

Data	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
GRAINS, SMALL: Bushland, Texas, 1956-58, planted on 1st day of a month, 8-month season													
UC	1.6	2.4	5.4	7.5	6.4					1.6	1.6	1.5	28.0
IC	2.0	2.3	3.6	5.1	6.9					5.7	2.8	2.5	30.9
KU	0.80	1.04	1.50	1.47	0.93					0.28	0.57	0.60	0.91
GRAINS, SMALL: Bushland, Texas, 1956-58, planted on 16th day of a month, 9-month season													
UC	1.0	1.8	3.9	6.5	7.0	*3.1			*0.7	1.6	1.4	1.1	28.1
IC	2.0	2.3	3.6	5.1	6.9	8.4÷2			6.2÷2	5.7	2.8	2.5	38.2
KU	0.50	0.78	1.08	1.27	1.01	0.74			0.23	0.28	0.50	0.44	0.74
ORCHARDS, CITRUS: Average for oranges and grapefruit, Salt River Valley, Arizona, 1931-54													
UC	1.6	1.7	2.5	3.2	4.2	4.9	5.6	5.6	4.8	3.5	2.4	1.7	41.7
IC	2.3	3.3	5.0	7.1	8.9	9.9	9.2	8.1	5.2	5.0	3.0	2.2	69.2
KU	0.69	0.52	0.50	0.45	0.47	0.49	0.61	0.69	0.92	0.70	0.80	0.77	0.60
Oranges, San Fernando Valley, California, 1940													
UC	1.1	2.2	2.3	4.0	4.4	4.6	4.0	3.4	2.8	2.6	2.0	1.6	35.0
IC	2.2	2.7	3.8	4.3	5.9	5.4	7.6	5.9	5.4	4.3	3.8	2.7	54.0
KU	0.50	0.81	0.61	0.93	0.75	0.85	0.53	0.58	0.52	0.60	0.53	0.59	0.65
ORCHARDS, CITRUS: Average values													
KU	0.60	0.66	0.56	0.69	0.61	0.67	0.57	0.64	0.72	0.65	0.66	0.68	0.62
ORCHARDS, DECIDUOUS FRUIT: San Joaquin-Sacramento Delta, California, 1928													
UC			1.0	2.2	3.8	6.0	6.8	4.8	2.8	0.8			28.2
IC			2.4	4.8	4.3	5.8	7.2	6.7	6.2	3.4			40.8
KU			0.42	0.46	0.88	1.03	0.92	0.72	0.45	0.24			0.69
ORCHARDS, PECAN: San Fernando Valley, California, 1928													
UC			1.5	3.8	5.0	5.9	6.1	5.0	2.8	2.0			32.6
IC			2.6	5.1	4.6	6.1	7.6	7.1	6.6	3.6			43.3
KU			0.58	0.75	1.09	0.97	0.80	0.70	0.42	0.56			0.75

* One-half month.

Table 1--Continued

BASIC DATA

Data	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
PEANUTS: Estimated UC, East Texas, planted on 1st day of a month, 4-month season													
UC					2.1	5.1	6.4	4.3					17.9
IC					5.6	6.6	7.1	6.6					25.9
KU					0.38	0.77	0.90	0.65					0.69
PEANUTS: Estimated UC, East Texas, planted on 1st day of a month, 5-month season													
UC					1.1	2.9	4.3	6.3	3.5				18.1
IC					5.6	6.6	7.1	6.6	5.1				31.0
KU					0.20	0.44	0.61	0.95	0.69				0.58
PEANUTS: Estimated UC, East Texas, planted on 16th day of a month, 5-month season													
UC				*0.4	2.0	3.4	5.5	5.3	*1.3				17.9
IC				4.6÷2	5.6	6.6	7.1	6.6	5.1÷2				30.8
KU				0.15	0.33	0.49	0.80	0.90	0.54				0.58
RICE: Based on data from Rice-Pasture Experiment Stations, Beaumont and Eagle Lake, Texas, 1954													
UC				7.6	6.8	15.0	10.2	6.8	9.6				56.0
IC				4.2	6.8	7.5	6.8	6.8	6.0				38.1
KU				1.80	1.00	2.00	1.50	1.00	1.60				1.47
SORGHUM, GRAIN: Bushland, Texas, 1956-58, planted on 1st day of a month													
UC						3.6	7.4	8.1	3.7				22.8
IC						8.4	8.8	8.0	6.2				31.4
KU						0.43	0.84	1.01	0.60				0.73
SORGHUM, GRAIN: Bushland, Texas, 1956-58, planted on 16th day of a month													
UC						*0.9	5.8	8.6	5.0	*1.1			21.5
IC						8.4÷2	8.8	8.0	6.2	5.7÷2			30.0
KU						0.21	0.66	1.08	0.81	0.38			0.72
VEGETABLES, DEEP-ROOTED: Tomatoes, Sacramento Valley, California, 1933-55, planted on 1st day of a month													
UC						3.0	4.2	7.0	5.1	2.1			21.4
IC						7.8	8.7	7.5	6.5	3.7			34.2
KU						0.38	0.48	0.93	0.78	0.57			0.63

* One-half month.

Table 1--Continued

BASIC DATA

Data	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
VEGETABLES, DEEP-ROOTED: Tomatoes, Sacramento Valley, California, 1933-55, planted on 16th day of a month													
UC					*1.2	3.3	5.7	7.3	4.5	*0.8			22.8
IC					6.1÷2	7.8	8.7	7.5	6.5	3.7÷2			35.4
KU					0.38	0.42	0.66	0.97	0.69	0.43			0.66
VEGETABLES, SHALLOW-ROOTED: San Joaquin Delta, California, 1928, planted on 1st day of a month													
UC				1.2	3.0	6.0	5.4	5.4	3.6	1.8			26.4
IC				4.8	4.3	5.8	7.2	6.7	6.2	3.4			38.4
KU				0.25	0.70	1.03	0.75	0.81	0.58	0.53			0.69

*One-half month.

Table 2

U. S. WEATHER BUREAU First-Order Stations

Texas

Abilene	Dallas	Houston	San Angelo
Amarillo	Del Rio	Laredo	San Antonio
Austin	El Paso	Lubbock	Victoria
Brownsville	Fort Worth	Palestine	Waco
Corpus Christi	Galveston	Port Arthur	Wichita Falls

Arkansas	Louisiana	New Mexico	Oklahoma
Fort Smith	Baton Rouge	Albuquerque	Oklahoma City
Little Rock	Lake Charles	Clayton	Tulsa
Texarkana	Shreveport	Roswell	

Table 3

CLIMATIC-INDEX COEFFICIENTS

Coefficients for monthly distribution of average-annual climatic-index numbers, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1A	0.03	0.04	0.07	0.10	0.11	0.14	0.13	0.12	0.10	0.07	0.05	0.04	1.00
1B	.03	.05	.08	.10	.11	.14	.13	.13	.09	.07	.04	.03	1.00
1C	.03	.04	.07	.10	.12	.13	.14	.12	.10	.07	.05	.03	1.00
8B	.03	.04	.07	.09	.11	.14	.14	.13	.10	.07	.05	.03	1.00
2A	.03	.04	.07	.10	.13	.14	.13	.11	.10	.07	.05	.03	1.00
2B	.03	.04	.07	.10	.12	.13	.14	.12	.10	.07	.05	.03	1.00
2C	.03	.04	.07	.10	.12	.13	.14	.12	.10	.07	.05	.03	1.00
3A	.03	.04	.07	.09	.12	.13	.14	.12	.10	.08	.05	.03	1.00
3B	.04	.04	.07	.09	.11	.13	.13	.12	.10	.08	.05	.04	1.00
8A	.03	.04	.07	.09	.11	.14	.14	.13	.10	.08	.04	.03	1.00
7A	.03	.04	.07	.09	.11	.14	.14	.14	.10	.07	.04	.03	1.00
7B	.03	.04	.07	.09	.11	.13	.14	.14	.10	.08	.04	.03	1.00
6A	.03	.04	.07	.09	.11	.13	.14	.13	.10	.08	.04	.04	1.00
6B	.03	.04	.07	.09	.11	.13	.14	.14	.10	.07	.04	.04	1.00
6C	.03	.04	.07	.09	.11	.13	.14	.13	.10	.08	.04	.04	1.00
7C	.03	.04	.07	.09	.11	.13	.13	.13	.10	.08	.05	.04	1.00
5A	.03	.05	.07	.09	.12	.13	.12	.12	.10	.08	.05	.04	1.00
5B	.03	.04	.06	.09	.11	.14	.13	.13	.10	.08	.05	.04	1.00
5C	.03	.04	.07	.09	.11	.13	.13	.13	.10	.08	.05	.04	1.00
4D	.04	.05	.07	.08	.11	.12	.14	.13	.09	.08	.05	.04	1.00
4E	.04	.05	.07	.09	.11	.12	.13	.13	.09	.08	.05	.04	1.00
4C	.04	.05	.07	.09	.10	.12	.14	.13	.09	.08	.05	.04	1.00
4B	.04	.05	.06	.09	.11	.12	.14	.13	.09	.08	.05	.04	1.00
4A	.04	.05	.07	.09	.11	.12	.14	.12	.09	.08	.05	.04	1.00

Table 4

CLIMATIC-INDEX NUMBERS

Average monthly and annual climatic-index numbers, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1A	2.0	2.6	4.6	6.5	7.2	9.1	8.4	7.8	6.5	4.6	3.2	2.6	65
1B	2.1	3.5	5.6	7.0	7.7	9.8	9.1	9.1	6.3	4.9	2.8	2.1	70
1C	2.2	2.9	5.1	7.3	8.8	9.5	10.2	8.8	7.3	5.1	3.6	2.2	73
8B	2.0	2.7	4.8	6.1	7.5	9.5	9.5	8.8	6.8	4.8	3.4	2.0	68
2A	2.2	2.9	5.1	7.3	9.5	10.2	9.5	8.0	7.3	5.1	3.6	2.2	73
2B	2.2	2.9	5.0	7.2	8.6	9.4	10.1	8.6	7.2	5.0	3.6	2.2	72
2C	2.2	3.0	5.2	7.4	8.9	9.6	10.4	8.9	7.4	5.2	3.7	2.2	74
3A	2.2	3.0	5.2	6.7	8.9	9.6	10.4	8.9	7.4	5.9	3.7	2.2	74
3B	2.6	2.6	4.6	5.9	7.3	8.6	8.6	7.9	6.6	5.3	3.3	2.6	66
8A	1.9	2.6	4.5	5.8	7.0	9.0	9.0	8.3	6.4	5.1	2.6	1.9	64
7A	1.6	2.2	3.8	5.0	6.0	7.7	7.7	7.7	5.5	3.8	2.2	1.6	55
7B	1.7	2.3	4.0	5.1	6.3	7.4	8.0	8.0	5.7	4.6	2.3	1.7	57
6A	1.5	2.0	3.6	4.6	5.6	6.6	7.1	6.6	5.1	4.1	2.0	2.0	51
6B	1.6	2.1	3.7	4.8	5.8	6.9	7.4	7.4	5.3	3.7	2.1	2.1	53
6C	1.6	2.2	3.8	4.9	5.9	7.0	7.6	7.0	5.4	4.3	2.2	2.2	54
7C	1.6	2.2	3.8	5.0	6.0	7.2	7.2	7.2	5.5	4.4	2.8	2.2	55
5A	1.6	2.6	3.6	4.7	6.2	6.8	6.2	6.2	5.2	4.2	2.6	2.1	52
5B	1.6	2.2	3.2	4.9	5.9	7.6	7.0	7.0	5.4	4.3	2.7	2.2	54
5C	1.6	2.2	3.8	5.0	6.0	7.2	7.2	7.2	5.5	4.4	2.8	2.2	55
4D	2.6	3.3	4.6	5.3	7.3	7.9	9.2	8.6	5.9	5.3	3.3	2.6	66
4E	2.2	2.8	3.9	5.0	6.2	6.7	7.3	7.3	5.0	4.5	2.8	2.2	56
4C	2.4	3.0	4.2	5.4	6.0	7.2	8.4	7.8	5.4	4.8	3.0	2.4	60
4B	3.0	3.8	4.5	6.8	8.2	9.0	10.5	9.8	6.8	6.0	3.8	3.0	75
4A	2.4	3.0	4.2	5.4	6.6	7.2	8.4	7.2	5.4	4.8	3.0	2.4	60

APPENDIX C

Tables of Crop Consumptive Use

Average monthly and annual consumptive use,
depth in inches, by areas, 1946-55

Table 5

ALFALFA

Average monthly and annual consumptive use, depth in inches, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1A	1.2	1.5	3.8	5.0	8.2	9.1	8.7	5.5	6.8	4.7	2.6	1.2	58.3
1B	1.2	2.1	4.6	5.4	8.8	9.8	9.4	6.5	6.6	5.0	2.3	1.0	62.7
1C	1.3	1.7	4.2	5.6	10.0	9.5	10.5	6.2	7.6	5.2	3.0	1.1	65.9
8B	1.2	1.6	3.9	4.7	8.6	9.5	9.8	6.2	7.1	4.9	2.8	1.0	61.3
2A	1.3	1.7	4.2	5.6	10.8	10.2	9.8	5.7	7.6	5.2	3.0	1.1	66.2
2B	1.3	1.7	4.1	5.5	9.8	9.4	10.4	6.1	7.5	5.1	3.0	1.1	65.0
2C	1.3	1.8	4.3	5.7	10.1	9.6	10.7	6.3	7.7	5.3	3.0	1.1	66.9
3A	1.3	1.8	4.3	5.2	10.1	9.6	10.7	6.3	7.7	6.0	3.0	1.1	67.1
3B	1.5	1.5	3.8	4.5	8.3	8.6	8.9	5.6	6.9	5.4	2.7	1.2	58.9
8A	1.1	1.5	3.7	4.5	8.0	9.0	9.3	5.9	6.7	5.2	2.1	.9	57.9
7A	.9	1.3	3.1	3.8	6.8	7.7	7.9	5.5	5.7	3.9	1.8	.8	49.2
7B	1.0	1.4	3.3	3.9	7.2	7.4	8.2	5.7	5.9	4.7	1.9	.8	51.4
6A	.9	1.2	3.0	3.5	6.4	6.6	7.3	4.7	5.3	4.2	1.6	1.0	45.7
6B	.9	1.2	3.0	3.7	6.6	6.9	7.6	5.3	5.5	3.8	1.7	1.0	47.2
6C	.9	1.3	3.1	3.8	6.7	7.0	7.8	5.0	5.6	4.4	1.8	1.1	48.5
7C	.9	1.3	3.1	3.8	6.8	7.2	7.4	5.1	5.7	4.5	2.3	1.1	49.2
5A	.9	1.5	3.0	3.6	7.1	6.8	6.4	4.4	5.4	4.3	2.1	1.0	46.5
5B	.9	1.3	2.6	3.8	6.7	7.6	7.2	5.0	5.6	4.4	2.2	1.1	48.4
5C	.9	1.3	3.1	3.8	6.8	7.2	7.4	5.1	5.7	4.5	2.3	1.1	49.2
4D	1.5	1.9	3.8	4.1	8.3	7.9	9.5	6.1	6.1	5.4	2.7	1.2	58.5
4E	1.3	1.7	3.2	3.8	7.1	6.7	7.5	5.2	5.2	4.6	2.3	1.1	49.7
4C	1.4	1.8	3.4	4.2	6.8	7.2	8.7	5.5	5.6	4.9	2.5	1.2	53.2
4B	1.8	2.2	3.7	5.2	9.3	9.0	10.8	7.0	7.1	6.1	3.1	1.4	66.7
4A	1.4	1.8	3.4	4.2	7.5	7.2	8.7	5.1	5.6	4.9	2.5	1.2	53.5

Note.--PERENNIAL PASTURE: Use 90 percent of monthly amount shown for ALFALFA as estimate of consumptive use.

Table 6

CORN

Average monthly and annual consumptive use, depth in inches, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1A				*0.3	2.3	5.3	9.9	9.2					27.0
1B				*.3	2.5	5.7	10.7	10.7					29.9
1C				*.3	2.8	5.5	12.0	10.4					31.0
8B				*.3	2.4	5.5	11.2	10.4					29.8
2A				1.1	4.3	8.3	12.8	*4.0					30.5
2B				1.1	3.9	7.6	13.6	*4.3					30.5
2C				1.1	4.0	7.8	14.0	*4.4					31.3
3A				1.0	4.0	7.8	14.0	*4.4					31.2
3B				.9	3.3	7.0	11.6	*4.0					26.8
8A				.9	3.2	7.3	12.2	*4.2					27.8
7A				.8	2.7	6.2	10.4	*3.8					23.9
7B			*0.2	1.6	3.7	8.7	9.4						23.6
6A			*.2	1.5	3.2	7.8	8.4						21.1
6B			*.2	1.5	3.4	8.1	8.7						21.9
6C			*.2	1.6	3.4	8.3	9.0						22.5
7C			*.2	1.6	3.5	8.5	8.5						22.3
5A			*.2	1.5	3.6	8.0	7.3						20.6
5B			*.1	1.6	3.4	9.0	8.3						22.4
5C			.6	2.2	4.9	9.7	*3.6						21.0
4D			.7	2.4	5.9	10.7	*4.6						24.3
4E			.6	2.2	5.0	9.0	*3.6						20.4
4C			.6	2.4	4.9	9.7	*4.2						21.8
4B			.7	3.1	6.6	12.2	*5.2						27.8
4A			.6	2.4	5.3	9.7	*4.2						22.2

* One-half month.

Table 7

COTTON

Average monthly and annual consumptive use, depth in inches, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
1A					*0.6	2.3	5.7	8.5	4.5	1.0			22.8
1B					*.7	2.4	6.2	9.9	4.3	1.1			24.6
1C					*.8	2.4	6.9	9.6	5.0	1.1			25.8
8B					1.7	2.3	9.8	7.3	4.1	*.2			25.4
2A				*0.7	2.4	6.2	8.6	6.9	5.2	3.9			33.9
2B				*.6	2.2	5.7	9.2	7.4	5.1	3.8			34.0
2C				*.7	2.2	5.9	9.5	7.7	5.3	4.0			35.3
3A				*.6	2.2	6.5	11.3	6.1	1.6				28.3
3B				*.5	1.8	5.8	9.4	5.5	1.5				24.5
8A					*.6	2.2	6.1	9.0	4.4	1.1			23.4
7A					*.5	1.9	5.2	8.4	3.8	.8			20.6
7B				*.5	1.6	5.0	8.7	5.5	1.3				22.6
6A					1.3	1.6	7.3	5.5	3.1	*.2			19.0
6B					1.3	1.7	7.6	6.1	3.2	*.2			20.1
6C				*.4	1.5	4.8	8.3	4.8	1.2				21.0
7C				*.4	1.5	4.9	7.8	5.0	1.2				20.8
5A				1.1	1.5	7.0	5.1	3.8	*.3				18.8
5B				1.1	1.4	7.8	5.8	4.3	*.3				20.7
5C			*0.3	1.2	4.1	7.8	5.0	1.6					20.0
4D			*.4	1.3	5.0	8.6	6.3	1.9					23.5
4E			*.4	1.2	4.2	7.3	5.0	1.6					19.7
4C			*.4	1.4	4.1	7.8	5.8	1.7					21.2
4B			1.0	1.6	8.4	7.5	6.4	*.5					25.4
4A			1.0	1.3	6.8	6.0	5.1	*.4					20.6

* One-half month

Table 8

GRAINS, SMALL

Average monthly and annual consumptive use, depth in inches, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
1A	1.0	2.0	5.0	8.3	7.3	*3.4			*0.7	1.3	1.6	1.1	31.7
1B	1.0	2.7	6.0	8.9	7.8	*3.6			*.7	1.4	1.4	.9	34.4
1C	1.1	2.3	5.5	9.3	8.9	*3.5			*.8	1.4	1.8	1.0	35.6
8B	1.0	2.1	5.2	7.7	7.6	*3.5			*.8	1.3	1.7	.9	31.8
2A	1.8	3.0	7.6	10.7	8.8					1.4	2.1	1.3	36.7
2B	1.8	3.0	7.5	10.6	8.0					1.4	2.1	1.3	35.7
2C	1.8	3.1	7.8	10.9	8.3					1.5	2.1	1.3	36.8
3A	1.8	3.1	7.8	9.8	8.3					1.7	2.1	1.3	35.9
3B	2.1	2.7	6.9	8.7	6.8					1.5	1.9	1.6	32.2
8A	1.5	2.7	6.8	8.5	6.5					1.4	1.5	1.1	30.0
7A	1.3	2.3	5.7	7.4	5.6					1.1	1.3	1.0	25.7
7B	1.4	2.4	6.0	7.5	5.9					1.3	1.3	1.0	26.8
6A	1.2	2.1	5.4	6.8	5.2					1.1	1.1	1.2	24.1
6B	1.3	2.2	5.6	7.1	5.4					1.0	1.2	1.3	25.1
6C	1.3	2.3	5.7	7.2	5.5					1.2	1.3	1.3	25.8
7C	1.3	2.3	5.7	7.4	5.6					1.2	1.6	1.3	26.4
5A	1.3	2.7	5.4	6.9	5.8					1.2	1.5	1.3	26.1
5B	1.3	2.3	4.8	7.2	5.5					1.2	1.5	1.3	25.1
5C	1.3	2.3	5.7	7.4	5.6					1.2	1.6	1.3	26.4
4D	2.1	3.4	6.9	7.8	6.8					1.5	1.9	1.6	32.0
4E	1.8	2.9	5.8	7.4	5.8					1.3	1.6	1.3	27.9
4C	1.9	3.1	6.3	7.9	5.6					1.3	1.7	1.4	29.2
4B	2.4	4.0	6.8	10.0	7.6					1.7	2.2	1.8	36.5
4A	1.9	3.1	6.3	7.9	6.1					1.3	1.7	1.4	29.7

* One-half month

Note.--LEGUMINOUS FERTILIZERS: Use monthly amount shown for SMALL GRAINS for respective periods of growth.

Table 9

ORCHARDS, CITRUS

Average monthly and annual consumptive use, depth in inches, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
4C	1.4	2.0	2.4	3.7	3.7	4.8	4.8	5.0	3.9	3.1	2.0	1.6	38.4
4B	1.8	2.5	2.5	4.7	5.0	6.0	6.0	6.3	4.9	3.9	2.5	2.0	48.1
4A	1.4	2.0	2.4	3.7	4.0	4.8	4.8	4.6	3.9	3.1	2.0	1.6	38.3

Table 10

ORCHARDS, DECIDUOUS FRUIT

3B	1.9	2.7	6.4	8.9	7.9	5.7	3.0	1.3	37.8
8A	1.9	2.7	6.2	9.3	8.3	6.0	2.9	1.2	38.5
6A	1.5	2.1	4.9	6.8	6.5	4.8	2.3	1.0	29.9
6B	1.6	2.2	5.1	7.1	6.8	5.3	2.4	0.9	31.4

Table 11

ORCHARDS, PECAN

3B	2.7	4.4	8.0	8.3	6.9	5.5	2.8	3.0	41.6
7A	2.2	3.8	6.5	7.5	6.2	5.4	2.3	2.1	36.0
7B	2.3	3.8	6.9	7.2	6.4	5.6	2.4	2.6	37.2
6A	2.1	3.4	6.1	6.4	5.7	4.6	2.1	2.3	32.7
6B	2.1	3.6	6.3	6.7	5.9	5.2	2.2	2.1	34.1
6C	2.2	3.7	6.4	6.8	6.1	4.9	2.3	2.4	34.8
7C	2.2	3.8	6.5	7.0	5.8	5.0	2.3	2.5	35.1

Table 12

PEANUTS

Average monthly and annual consumptive use, depth in inches, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
3B				*0.4	2.4	4.2	6.9	7.1	*1.8				
7B					1.3	3.3	4.9	7.6	3.9				22.8
6A					1.1	2.9	4.3	6.3	3.5				21.0
6B					1.2	3.0	4.5	7.0	3.7				18.1
6C													19.4
7C					1.2	3.1	4.6	6.6	3.7				
≠4D					1.2	3.2	4.4	6.8	3.8				19.2
≠4D			*0.3	1.7	3.6	6.3	8.3	*2.3					19.4
							3.5	6.6	5.3	3.4			22.5
													18.8

Table 13

RICE

5A				8.5	6.2	13.6	9.3	6.2	8.3				52.1
5B				8.8	5.9	15.2	10.5	7.0	8.6				56.0
5C				9.0	6.0	14.4	10.8	7.2	8.8				56.2

* One-half month.
≠ Two crops yearly.

Table 14

SORGHUM, GRAIN

Average monthly and annual consumptive use, depth in inches, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
1A						*1.0	5.5	8.4	5.3	*0.9			21.1
1B						*1.0	6.0	9.8	5.1	*.9			22.8
1C						4.1	8.6	8.9	4.4				26.0
8B					*0.8	6.3	10.3	7.1	*1.3				25.8
2A					4.1	8.6	9.6	4.8					27.1
2B					3.7	7.9	10.2	5.2					27.0
2C					3.8	8.1	10.5	5.3					27.7
≠3A				2.9	7.5	9.7	6.2						26.3
≠3B				2.5	6.1	8.7	5.2						22.5
8A					3.0	7.6	9.1	5.0					24.7
7A					2.6	6.5	7.8	4.6					21.5
7B				2.2	5.3	7.5	4.8						19.8
6A					2.4	5.5	7.2	4.0					19.1
6B					2.5	5.8	7.5	4.4					20.2
6C				2.1	5.0	7.1	4.6						18.8
7C				2.2	5.0	7.3	4.3						18.8
5A				2.0	5.2	6.9	3.7						17.8
5B				2.1	5.0	7.7	4.2						19.0
5C			*0.4	3.3	6.5	5.8	*1.4						17.4
4D			*.5	3.5	7.9	6.4	*1.7						20.0
4E			*.4	3.3	6.7	5.4	*1.4						17.2
4C			*.4	3.6	6.5	5.8	*1.6						17.9
4B			*.5	4.5	8.9	7.3	*2.0						23.2
≠4A			1.8	4.5	6.7	4.3							17.3

* One-half month.
≠ Two crops yearly.

Table 14--Continued

SORGHUM, GRAIN

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
≠4A								3.1	4.5	4.8	1.8		14.2
≠3A								3.8	6.2	6.0	2.2		18.2
≠3B								3.4	5.5	5.4	2.0		16.3

≠ Two crops yearly.
Note.--SORGHUM, SILAGE AND FORAGE: Use monthly amount shown for GRAIN SORGHUM for respective periods of growth.

Table 15

VEGETABLES, DEEP-ROOTED

Average monthly and annual consumptive use, depth in inches, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
1B						3.7	4.4	8.5	4.9	2.8			24.3
≠2B			1.9	3.5	8.0	7.3	5.8						26.5
≠2B					*1.6	3.9	6.7	8.3	5.0	*1.1			26.6
2C				2.8	4.3	8.9	8.1	5.1					29.2
8A				*1.1	2.9	5.9	8.7	5.7	*1.4				25.7
7A				*1.0	2.5	5.1	7.5	5.3	*1.2				22.6
7B				1.9	3.0	6.9	6.2	4.6					22.6
6A				*.9	2.4	4.4	6.9	4.6	*1.1				20.3
6B				*.9	2.4	4.6	7.2	5.1	*1.1				21.3
6C			*.7	2.1	3.9	6.8	5.2	*1.5					20.2
7C			*.7	2.1	4.0	7.0	5.0	*1.5					20.3
4D								3.3	2.8	4.9	2.6	1.5	15.1

* One-half month.
≠ Two crops yearly.

Table 15--Continued

VEGETABLES, DEEP-ROOTED

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
4C	1.0	2.0	4.1	3.7	*1.3							*0.5	12.6
≠4B								3.7	3.3	5.6	3.0	1.7	17.3
≠4B	1.3	2.5	4.4	4.7	*1.8							*.6	15.3
4A	1.0	2.0	4.1	3.7	*1.4							*.5	12.7

Crops Included

Beans	Chard	Okra	Pumpkin	Tomatoes
Beets	Cucumbers	Peas	Squash	Turnips
Cantaloupe	Eggplant	Peppers	Sweet potatoes	Watermelons
Carrots				

* One-half month.
≠ Two crops yearly.

Table 16

VEGETABLES, SHALLOW-ROOTED

Average monthly and annual consumptive use, depth in inches, by areas, 1946-55

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Season
1B				1.8	5.4	10.1	6.8	7.4	3.7	2.6			37.8
2A	2.3	2.2	4.1	4.2	5.0						0.9	1.5	20.2
8A			1.1	4.1	7.2	6.8	7.3	4.8	3.4				34.7
7A			1.0	3.5	6.2	5.8	6.2	4.5	2.9				30.1
7B			1.0	3.6	6.5	5.6	6.5	4.6	3.0				30.8
6A				1.2	3.9	6.8	5.3	5.3	3.0	2.2			27.7
6B				1.2	4.1	7.1	5.6	6.0	3.1	2.0			29.1
6C				1.2	4.1	7.2	5.7	5.7	3.1	2.3			29.3
7C				1.2	4.2	7.4	5.4	5.8	3.2	2.3			29.5
5C	1.3	1.3	2.0						1.4	3.1	2.9	1.6	13.6
4D	2.1	1.9	2.4						1.5	3.7	3.4	2.0	17.0
4E	1.8	1.6	2.1						1.2	3.2	2.9	1.6	14.4
4C	1.9	1.7	2.2						1.4	3.4	3.1	1.8	15.5
4B	2.4	2.2	2.4						1.7	4.2	3.9	2.2	19.0
4A	1.9	1.7	2.2						1.4	3.4	3.1	1.8	15.5

Crops Included

Brussels sprouts
Cabbage
Cauliflower
Celery
Lettuce
Onions
Radishes
Spinach
Sweet Corn