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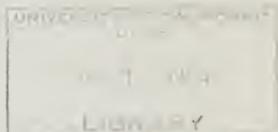


THE RESOURCES AGENCY OF CALIFORNIA
Department of Water Resources

BULLETIN No. 113

VEGETATIVE
WATER USE STUDIES
1954-1960

Interim Report



AUGUST 1963

HUGO FISHER

Administrator

The Resources Agency of California

EDMUND G. BROWN

Governor

State of California

WILLIAM E. WARNE

Director

Department of Water Resources

State of California
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ERRATA

Bulletin No. 113, "Vegetative Water Use Studies, 1954 - 1960"

Plate 1, Agroclimatic Stations No. 4, 57, 61, 75, 93, 101:

For "Inactive - 1960" read "Active - 1960"

Plate 2, For "Evapotransperometer" read "Evapotranspirometer"

Page 58, line 10, For "Figures E and F" read "Figures A and B"

Page 66, line 21, For "Figures A and B" read "Figures E and F"

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THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

1120 N. STREET, SACRAMENTO

June 20, 1963

Honorable Edmund G. Brown, Governor
and Members of the Legislature
of the State of California

Gentlemen:

I have the honor to transmit herewith Bulletin No. 113, "Interim Report on Vegetative Water Use Studies, 1954-1960," of the Department of Water Resources, dated May 1963. This report describes techniques and approaches which have evolved, and summarizes data on vegetative consumptive use or evapotranspiration. Interrelationships between these data are set forth, together with evapotranspiration values for some crops in Central and Northern California agricultural areas. This is a continuing study with many conclusions yet to be reached.

Data pertaining to evapotranspiration, irrigation requirements, and agricultural hydrology are basic to most water resource development studies. With the continued growth of the State, necessitating more complex and costly water development facilities, there is increasing need for more accurate water use data. Such data will enable developed surface and ground water resources to be used effectively, and will facilitate design and operation of land drainage systems.

The studies reported herein were initiated in 1954 as part of the Northeastern Counties Investigation. A continuing Vegetative Water Use Studies Program was established, and the studies were broadened, as a result of Senate Bill 434, 1959 Legislative Session. Specific authorization for these studies is set forth in Section 226(e) of the Water Code.

Sincerely yours,

William E. Warne
Director

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

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ACKNOWLEDGEMENT

The Department of Water Resources wishes to express appreciation to many organizations and individuals who have assisted the department in the Vegetative Water Use Program. Many private farm operators have provided use of their property and equipment, as well as time. The list is too numerous to completely enumerate; however, the Frick Farms at Arvin, Roland Hutchings at Pittville, and the U. S. Fish and Wildlife Service (formerly Dorris Ranch) at Alturas have been particularly helpful.

A very considerable amount of technical guidance has been given by the Irrigation Department of the University of California at Davis. The University Agricultural Extension has given assistance in the search for plot sites.

The assistance and collaboration provided by the U. S. Forest Service, the Agricultural Research Service and the Soil Conservation Service of the U. S. Department of Agriculture; the California Division of Forestry; and the Agricultural Commissioner's Office, to mention a few, are likewise gratefully acknowledged.

CHAPTER I. INTRODUCTION

This report presents data on vegetative consumptive use of water, or evapotranspiration, together with certain interrelationships with agricultural climatic factors influencing such use. The findings summarized cover the period 1954-1960, and represent a large quantity of individual measurements of evapotranspiration and related agricultural climatic data. The measurements of evapotranspiration represent scores of soil samples, neutron probe readings, and evapotranspirometer measurements of irrigated alfalfa, pasture, plums, cotton, and grass crops. Agricultural climatic or agroclimatic data are likewise summarized from a large number of measurements of evaporation from pans and atmometers. Certain other agroclimatic data, such as measurements of solar radiation and relative humidity, were collected at a few stations. These data have not been analyzed as yet, and will be reported in later publications.

Need for Vegetative Water Use Studies

Historically, irrigated agriculture has been the largest user of our developed water resources. This condition probably will continue indefinitely. The Department of Water Resources, hereinafter referred to as the department, and its predecessor agencies, have made many measurements of water deliveries for agricultural uses with regard to water right adjudication. However, for broad planning purposes the department has relied largely upon

empirical methods for estimating seasonal values of evapotranspiration or consumptive use for various crops. State Water Resources Board Bulletin No. 2, "Water Utilization and Requirements of California, 1955," has been the primary source for such estimates.

As more complex and costly water development facilities are contemplated, more accurate values for irrigation requirements and evapotranspiration will be needed. The location and sizing of reservoirs, distribution systems, and final disposal or drainage systems are dependent upon accurate estimates of at least monthly values of irrigation requirements and evapotranspiration for various kinds of vegetation. Accurate irrigation requirements and evapotranspiration values are also important in planning for the conjunctive operation of ground water reservoirs, the reclamation of salt-affected lands, and in the maintenance of a favorable salt balance within agricultural soils. Moreover, as water costs rise, more accurate knowledge of evapotranspiration rates will become of increasing importance in order to achieve greater efficiencies in irrigation practices.

Authorization

Estimates of evapotranspiration and irrigation requirements have long been a part of water development investigations, as conducted by the department and its predecessor agencies. The present program, designed to provide more accurate data on rates of evapotranspiration, was initiated in July 1954 and broadened in 1959, pursuant to Senate Bill 434, 1959 Legislative Session. Specific authorization for conducting these studies is set forth

in Section 226 (e) of the Water Code, which states that the department may "Conduct investigations of the rate of use of water for various purposes and considering various soil conditions."

Objective

The overall objective of the vegetative water use studies is to investigate and establish a means whereby the department can accurately determine long-term monthly and seasonal irrigation requirements and evapotranspiration for the principal crops grown within the various agricultural zones throughout California. To accomplish this broad objective, the vegetative water use studies are divided into three principal programs; namely, agroclimatic monitoring, evapotranspiration measurement and correlation, and irrigation requirement determination. The first two of these programs are designed to accomplish the following primary objectives: first, to collect agroclimatic data in major agricultural areas to provide a means of dividing the State into agroclimatic zones of potential water use, and for estimating evapotranspiration within those zones; and second, to test, on a statewide basis, certain procedures suggested by fundamental research by the University of California and other agencies, regarding correlation of evapotranspiration with various types of agroclimatic data. The objective of the third program is to correlate measured values of total applied water with evapotranspiration. These data will make possible the calculation of other pertinent water use information, such as irrigation efficiencies and drainage requirements. Very little has been accomplished on the third program to date.

Scope of Present Program and Report

To accomplish the foregoing objectives, it is necessary to measure evapotranspiration for various crops within the major agricultural zones of the State, and to measure various climatic, plant, and soil factors which influence evapotranspiration. To date, accurate measurements of evaporation have been made of only a few crops within certain of the major agricultural service areas of the State, because of financial and personnel limitations. Additional installations will be required to provide complete evaluation of all major agricultural zones and the principal crops grown within California.

In order to maximize the utility of the data provided by the relatively few evapotranspiration measurement stations, a correlative program has been carried on to relate evapotranspiration to evaporation indices. Theoretically, coefficients derived by comparing evapotranspiration to evaporation from pans or atmometers can be used to make reliable estimates of evapotranspiration within any agroclimatic zone where evaporation data are available. Basic research on such relationships is being conducted by the University of California as a part of the vegetative water use program.

The agroclimatic monitoring program, described fully in Chapter II, is designed to collect the basic agroclimatic data necessary to make reliable estimates of evapotranspiration within each agroclimatic zone. Chapter III discusses evapotranspiration measurements and the collection of data relative to plant conditions, soil moisture, and other factors which may affect evapotranspiration rates. The criteria, methods, and instrumentation

used in the measurements are described generally, and the data collected through 1960 are summarized. Since the initiation of this program in 1954, improvements and standardizations within the program have vastly improved the quality of the data collected, such that one hesitates to compare data collected in 1960 with earlier years of records. Consequently, judgment was exercised in summarizing certain of the earlier data.

In Chapter IV, measured evapotranspiration rates described in Chapter III are correlated with pan and atmometer evaporation data which were collected concurrently at the evapotranspiration plots. The pan and atmometer coefficients, so derived, are then applied to the agroclimatic data to estimate evapotranspiration for a few crops throughout much of the northern part of the State. While comparisons are made with the values published in Bulletin No. 2, it is not the intent of this report to imply a question as to the accuracy of previous values used by the department. Instead, this report is intended to indicate some of the problems involved in the collection and analysis of the data and, to the extent of the data collected, to show tentative values that may be used for the determination of water requirements for certain crops.

A great deal of the basic research fundamental to this study was conducted by the University of California at Davis, both prior to and since the initiation of this program. The continuing counsel and guidance provided by various members of the University of California have been of invaluable assistance in the development of these studies.



CHAPTER II. AGROCLIMATIC MONITORING PROGRAM

As stated in Chapter I, the objective of the agroclimatic monitoring program is to collect and analyze climatological data throughout the various agricultural water service areas within the State. The analyses of these data will accomplish two purposes. First, they will enable segregation and delineation of zones or areas with similar evaporation potentials. Secondly, these data will provide a basis for estimating evapotranspiration rates of various crops within those zones. This can be accomplished by utilizing coefficients which relate measured crop evapotranspiration (to be discussed in Chapter III) to agroclimatic data. The program of correlating measured evapotranspiration to various evaporative indices, such as evaporation pans and atmometers, is discussed in Chapter IV.

To date, agroclimatic stations have been established at typical locations within certain of the major inland agricultural areas in the central and northern portions of the State. The data collected and summarized in this report comprise weekly measurements of evaporation from U. S. Weather Bureau Standard Class A pans, and differences of evaporation between Livingston black and white atmometers. Measurement of solar radiation, air temperature, and humidity was made at a few locations. These data, however, are not included in this report, as research regarding their relationships to evapotranspiration and methods of analysis are still in the process of development.

As of 1960, the program included 52 stations, although a total of 112 stations have been operated for various periods of

time. Many of the original stations have been discontinued because of unfavorable site conditions or other causes. The location and status of each station are shown on Plate 1, entitled "General Locations of Agroclimatic Stations, 1954-60." A more detailed description of each of the agroclimatic stations is presented in Table A-1 of Appendix A.

Instrumentation at Agroclimatic Stations

Two types of equipment were utilized to measure evaporation potential; the Livingston spherical atmometer, and the U. S. Weather Bureau Standard Class A evaporation pan. U. S. Forest Service precipitation gages, approximately 8 inches in diameter and 10.5 inches in height, were installed at all agroclimatic stations at the same elevation above ground as prescribed for a standard U. S. Weather Bureau nonrecording rain gage. Following is a description of evaporation equipment in use and methods of installation.

Atmometers

A Livingston spherical atmometer is a specialized instrument used for measurement of evaporation. The atmometer is a hollow porous porcelain sphere 5 centimeters in diameter. In a typical assembly the sphere is mounted on a 1-gallon water supply bottle by means of a small-diameter glass tube. The sphere and connecting tube are filled with distilled water, with the lower end of the tube extending nearly to the bottom of the reservoir bottle. Thus, there is a continuous water system from the reservoir bottle to the outer surface of the porous sphere, where evaporation takes place.

Evaporation is determined by measuring the amount of water required to refill the reservoir bottle to a reference mark. A typical atmometer assembly is shown on Figure 1.

Atmometers are operated as pairs consisting of one white and one black sphere set 15 inches apart and 54 inches above ground surface. Prior to 1958, many installations had only a single pair of atmometers; however, since that time three or more pairs of atmometers have been installed at each of the stations included in the monitoring program.

Evaporation Pans

U. S. Weather Bureau Standard Class A evaporation pans were adopted in the agroclimatic program in 1957 and installed at certain of the stations. The pans were installed in accordance with the procedure prescribed in "Instructions for Climatological Observers," Circular B. Tenth Edition, Revised October 1955, U. S. Department of Commerce.

All stations included in the Agroclimatic Monitoring Program are periodically inspected to ascertain that equipment is correctly installed and properly exposed. Complete records for all stations are available in the files of the department. Typical agroclimatic station installations are shown in Figure 2.

Agroclimatic Data Analysis

Summaries of the agroclimatic data collected during the period from July 1954 through December 1960 are shown in Tables 1 and 2. Table 1 shows the means of monthly evaporation from standard

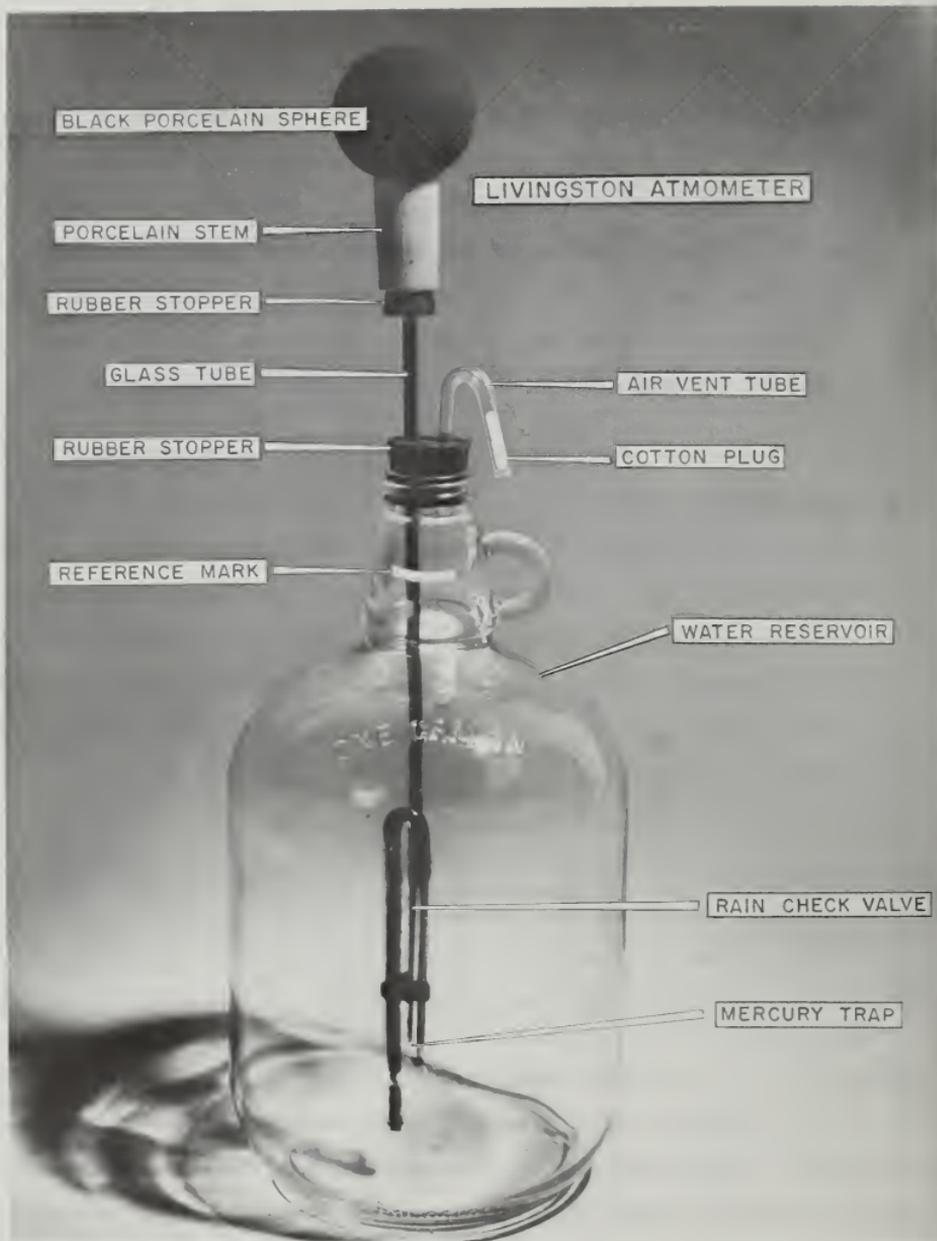


Figure 1, ATMOMETER ASSEMBLY



Station Located
in Irrigated Pasture
near Lodi

Station Located
in Dryland
Environment
near Redding



Station Located
in Non-irrigated
Alfalfa near
Adin, Modoc County

FIGURE 2. TYPICAL AGROCLIMATIC STATIONS

TABLE 1
 MEAN MONTHLY EVAPORATION FROM STANDARD
 U. S. WEATHER BUREAU EVAPORATION PANS
 (in inches)

Environment and area	: Number of : : Station : : Years : Record :	Years :	MONTHS												: May : Sept. : Total
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
<u>Pasture</u>															
Klamath-Trinity Mt. Valleys	2	1959-60					6.95	8.76	11.06	8.44	6.18				41.39
Sacramento River Basin Mountain Valleys	9	1957-60	-	1.48	3.25	5.10	6.16	7.69	8.96	8.78	6.16	3.86	1.66	0.66	37.75
Sacramento River Basin Foothills	7	1957-60	1.52	2.29	3.56	5.19	6.30	9.15	10.66	9.27	6.44	5.00	2.20	1.52	41.82
Sacramento River Basin Valley Floor	12	1958-60	1.65	2.49	4.04	5.48	7.26	10.28	10.73	9.18	6.87	5.34	2.58	1.74	44.32
San Joaquin River Basin Valley Floor	11	1959-60	1.67	2.18	4.19	6.08	8.84	10.60	10.55	9.08	6.75	5.14	1.92	1.30	45.83
Tulare Lake Basin Valley Floor	6	1958-60	1.79	2.18	4.15	5.76	8.77	9.74	9.36	8.11	6.00	4.24	1.98	1.16	41.98
Lassen-Alpine Mountain Valleys	6	1957-60	--	--	--	--	6.30	8.91	10.97	9.81	6.85	4.35	--	--	42.84
<u>Dryland</u>															
Sacramento River Basin Mountain Valleys	8	1958-60	--	1.20	2.99	5.98	5.95	10.02	12.03	11.06	7.41	4.60	2.09	--	46.47
Sacramento River Basin Foothills	7	1958-60	1.42	2.75	4.60	6.52	8.69	13.36	15.04	12.46	10.27	7.42	3.89	2.94	59.82
Sacramento River Basin Valley Floor	9	1958-60	1.26	2.48	4.88	6.52	8.95	13.25	14.03	11.87	9.45	7.24	3.19	1.90	57.55

TABLE 2
 MEAN MONTHLY EVAPORATION DIFFERENCE BETWEEN
 LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
 (in milliliters)

Environment and area	: Number : : of : : Stations : Record :	Years :	MONTHS												May Sept. Total
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
<u>Pasture</u>															
Sacramento River Basin Mountain Valleys	13	1955-60					463	550	600	545	417				2575
Sacramento River Basin Foothills	10	1958-60		292	453	494	572	619	562	466	375				2713
Sacramento River Basin Valley Floor	13	1958-60		324	424	491	568	614	549	443	366				2695
San Joaquin River Basin Valley Floor	11	1959-60		374	460	529	569	580	543	449	366				2670
Tulare Lake Basin Valley Floor	6	1958-60		440	520	572	580	551	444	373	231				2667
Lassen-Alpine Mountain Valleys	8	1955-60					460	545	572	550	454				2981
<u>Alfalfa</u>															
Klamath-Trinity Mountain Valleys	3	1955						550	598	539					
Sacramento River Basin Mountain Valleys	11	1955-59					486	537	566	568	444				2601
Sacramento River Basin Valley Floor	17	1955, 58-60		384	445	539	580	618	556	472	389				2765
San Joaquin River Basin Valley Floor	13	1958-60		284	470	548	571	582	548	454	379				2703
Tulare Lake Basin Valley Floor	9	1958-60		402	462	538	589	617	563	447	409				2754
<u>Dryland</u>															
Klamath-Trinity Mountain Valleys	15	1954-60					446	521	584	546	413				2510
Sacramento River Basin Mountain Valleys	26	1954-60					470	536	569	540	408	310			2523
Sacramento River Basin Foothills	4	1959-60		323	395	468	576	658	593	458	388				2753
Sacramento River Basin Valley Floor	17	1954-60		366	426	511	568	655	573	465	366				2792
Lassen-Alpine Mountain Valleys	7	1955-56 & 1958-59						520	582	535					
<u>Miscellaneous</u>															
Sacramento River Basin Valley Floor	9	1954-55, 57, & 60				403	511	581	628	567	442	351			2789

U. S. Weather Bureau pans. Table 2 indicates the mean monthly difference of evaporation between Livingston spherical black and white atmometers.

At the initiation of the program in 1954, little was known of the effects of the immediate ground cover environment on evaporation from atmometers and pans. Furthermore, little consideration had ever been given to the effects on evaporation rates of surrounding land areas or cleanliness of pans at stations having apparently similar immediate environmental conditions. In analyzing the data it became apparent that certain of these factors are extremely important.

In the initial tabulations of evaporation data, great differences were noted between adjacent stations having dissimilar environmental conditions. A tabulation on the basis of station environment shows this to be especially true for evaporation pans, as may be noted in Table 1. For example, Table 1 indicates that the May through September total of the mean monthly evaporation from pans located on dry-farmed rangelands was more than 25 percent greater than evaporation from pans situated on irrigated pasture. This difference became increasingly greater during the summer months. The higher and increasingly greater evaporation on dry-farmed rangelands resulted from the greater availability of energy in surrounding dryland areas, and the increase of advective heating that results as the drylands exhaust moisture carried over from wintertime precipitation during the summer.

An interesting fact determined from studies at the Bakersfield station was that cleanliness, or presence of algae growth, had little effect upon evaporation rates from evaporation pans. During an 18-month period starting in January 1959, three pans were maintained in the same environment and were treated in an identical manner, except that algae was permitted to grow in one pan while the other two were cleaned frequently. The difference of evaporation was small, with only 3 percent greater evaporation in the pan where algae was allowed to grow.

In an evaporation investigation carried on by A. A. Young in Southern California during the period from 1935 to 1939, inclusive, a study was conducted to determine the effect of pan color upon evaporation. He found differences varying from approximately 17 percent less to 7 percent more than from a standard U. S. Weather Bureau pan. It is of interest to note that evaporation from a dark green colored pan was 2.5 percent greater than that from the standard U. S. Weather Bureau pan. The presence and growth of algae appear to give similar results.

The difference in evaporation between black and white atmometers, as shown in Table 2, appears to be affected less by environmental conditions than are pans. This indicates a difference in response between pans and atmometers to various climatic conditions. This will be discussed further in Chapter IV.

Monthly evaporation data from pans and atmometers for each year and for each station are set forth in Tables A-2 and A-3, respectively, of Appendix A. The data are segregated by area and by environment.

The area designations set forth in this report are arbitrary and, in general, principally geographical subdivisions. When additional years of data become available, these area breakdowns must be reconsidered. Analysis of the records of individual stations to date indicates as much variability in evaporation between adjacent stations, within any one area, as between areas. This variability is shown in Tables 3 and 4, in which all of the stations located on irrigated pasture in 1959 and 1960 were arranged in order of decreasing evaporation rate by month. The same was done for the 1959 and 1960 dryland stations. On the basis of these data, it is concluded that no definite segregation of the stations into areas of uniform evaporation is possible.

A general pattern has been discerned with certain of the stations tending to be high and others low. There are indications that, for stations having similar environments immediately surrounding the site, adjacent dryland areas exert climatic influences and affect evaporation rates at the station site.

This factor is being given further consideration in relation to the agroclimatic stations currently in operation. Efforts are being made to standardize conditions where pan and atmometer data are collected. Insofar as possible, large, well-irrigated pastures providing nearly 100 percent ground cover are being selected as sites for agroclimatic stations. As data are obtained under similar environmental conditions, more conclusive comparisons may be made. It may be found that there are small differences in monthly evaporative rates between different agricultural areas of the State, and that the length of growing season is the most important factor affecting seasonal evapotranspiration in inland areas.

TABLE 3

MONTHLY EVAPORATION FROM STANDARD U. S. WEATHER BUREAU
EVAPORATION PANS IN ORDER OF DECREASING MAGNITUDE FOR IRRIGATED PASTURE AND DRYLAND STATIONS
(In inches)

Environment and year	January	February	March	April	May	June
Irrigated Pasture 1959	Red Bluff Cone Ranch	1.88	2.62	5.12	6.35	9.52
	Lincoln Vineyard	1.72	2.36	5.07	6.33	9.36
	Gold Hill Doty	1.49	2.18	4.49	6.23	9.16
	Penn Valley	1.36	2.14	4.49	6.03	9.05
	Fall River Mills 4NW	1.07	1.99	4.25	5.99	8.39
			1.96	4.19	5.97	8.21
			1.84	4.17	5.97	8.09
			1.83	3.86	5.87	7.26
			1.73	3.54	5.80	6.99
			1.59	3.39	5.63	6.93
					5.61	6.91
					5.54	6.11
					5.34	6.09
					5.25	6.02
						5.83
1960	Corning 3NE	2.28	2.88	4.61	6.40	9.59
	Lincoln Vineyard	1.99	2.76	4.34	6.17	9.15
	Arvin Frick	1.84	2.76	4.22	6.09	9.06
	Stockton 9S	1.83	2.72	4.14	6.05	9.02
	Gold Hill Doty	1.80	2.69	4.14	5.82	8.81
	Palemo 3SW	1.76	2.69	3.97	5.69	8.72
	El Solyo Ranch	1.67	2.49	3.80	5.66	8.56
	Kingsburg 5S #2	1.53	2.48	3.75	5.46	8.28
	Yuba City 9W	1.50	2.48	3.75	5.46	8.28
	Red Bluff Cone	1.43	2.32	3.68	5.35	8.06
	Thornton 2S	1.40	2.31	3.68	5.20	7.96
	Penn Valley	1.39	2.16	3.59	5.20	7.86
	Elk Grove 4NW	1.34	2.02	3.44	4.95	7.72
	Anderson 4E	0.91	1.70	3.22	4.68	7.60
			1.51	2.96	4.65	7.50
			1.40	2.85	4.53	7.46
			1.40	2.58	4.37	7.34
			1.08	2.58	4.02	7.26
					3.82	7.17
						7.94
					7.71	
					12.57	
					11.62	
					11.29	
					10.62	
					10.34	
					10.32	
					10.31	
					10.15	
					10.08	
					10.05	
					9.98	
					9.96	
					9.72	
					9.67	
					9.64	
					9.31	
					9.15	
					9.01	
					8.95	
					8.79	
					8.76	
					8.69	
					8.00	
					7.87	

TABLE 3 (continued)

MONTHLY EVAPORATION FROM STANDARD U. S. WEATHER BUREAU
EVAPORATION PANS IN ORDER OF DECREASING MAGNITUDE FOR IRRIGATED PASTURE AND DRYLAND STATIONS

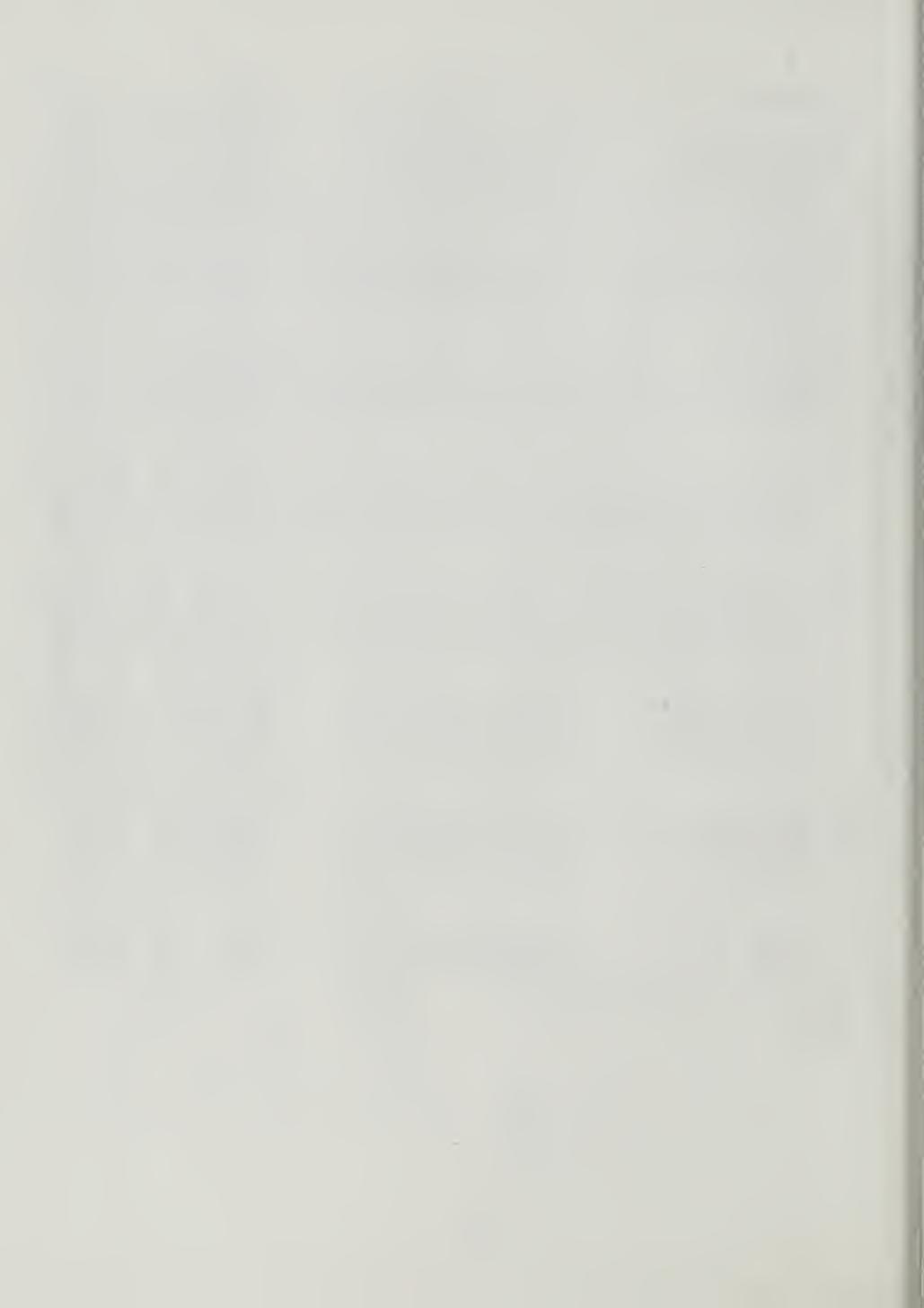
(in inches)

Environment and year	Months											
	July	August	September	October	November	December	January	February	March	April	May	June
Irrigated Pasture 1959	Merced SSE	13.08	Cedarville 2E	11.35	Fall River Mills	8.99	Lincoln Vineyard	6.06	Lincoln Vineyard	3.50	Lincoln Vineyard	2.41
	Montague 3NE	12.50	Merced SSE	10.63	4NW	Red Bluff Cone	5.98	Gold Hill Doty	Flat	Gold Hill Doty	Flat	Gold Hill Doty
	Standish 4NW	11.96	Fall River Mills	10.07	4NW	Merced SSE	8.32	Red Bluff Cone	5.54	Red Bluff Cone	3.35	Red Bluff Cone
	Lincoln Vineyard	11.80	Lincoln Vineyard	9.77	Merced SSE	7.98	Ranch	5.34	Ranch	3.34	Ranch	2.23
	Cedarville 2E	11.56	Standish 4NW	9.39	Cedarville 2E	7.31	Merced SSE	5.43	Anderson 4E	2.76	El Solyo Ranch	2.10
	Gold Hill Doty	11.32	Penn Valley	9.01	Lincoln Vineyard	6.74	Cedarville 2E	5.47	Merced SSE	2.68	Thornion 2S	1.94
	Red Bluff Cone	10.81	El Solyo Ranch	9.01	Anderson 4E	6.62	Lodi 35W	4.98	Cedarville 2E	2.58	Arvin Frick	1.69
	Penn Valley	10.79	Gold Hill Doty	8.91	Penn Valley	6.43	Stockton 9S	4.82	El Solyo Ranch	2.53	Penn Valley	1.60
	Stockton 9S	10.70	Red Bluff Cone	8.72	Stockton 9S	6.41	Anderson 4E	4.64	Stockton 9S	2.43	Anderson 4E	1.58
	El Solyo Ranch	10.66	Ranch	8.67	Gold Hill Doty	6.37	Penn Valley	4.61	Fall River Mills	2.40	Stockton 9S	1.55
	Lookout Hunt	10.07	Stockton 9S	8.65	Flat	6.37	Arvin Frick	4.49	4NW	2.33	Stockton 9S	1.58
	Arvin Frick	9.95	Arvin Frick	8.56	Montague 3NE	6.30	Kingburg 5S #2	4.31	Lodi 35W	2.10	Kingburg 5S #2	1.38
	Lodi 35W	9.84	Alturas-Dorris	8.22	Lookout Hunt	6.00	Lookout Hunt	4.10	Kingburg 5S #2	2.17	Kingburg 5S #2	1.38
	Alturas-Dorris	9.83	Alturas-Dorris	8.22	Kingburg 5S #2	5.93	4NW	4.09	Penn Valley	2.16	Penn Valley	1.93
	Anderson 4E	9.54	Lookout Hunt	8.05	Montague 3NE	6.00	Kingburg 5S #2	3.59	Alturas-Dorris	1.72	Alturas-Dorris	1.72
Kingburg 5S #2	9.26	Kingburg 5S #2	7.57	Kingburg 5S #2	5.74	Ranch	4.91	Ranch	1.72	Ranch	1.72	
Kingburg 5S #2	9.26	Kingburg 5S #2	7.57	Ranch	4.91	Ranch	4.91	Ranch	1.72	Ranch	1.72	
1960	Lincoln Vineyard	12.97	Lincoln Vineyard	12.16	Corning 3NE	9.02	Corning 3NE	7.55	Corning 3NE	3.90	Corning 3NE	1.93
	Corning 3NE	12.73	Merced SSE	11.41	Merced SSE	8.05	Newman 1SE	6.24	Lincoln Vineyard	2.66	Red Bluff Cone	1.81
	Merced SSE	12.12	Cedarville 2E	10.65	Cedarville 2E	7.76	Lincoln Vineyard	6.12	Yuba City 9W	2.45	Ranch	1.81
	Cedarville 2E	12.01	Standish 4NW	10.33	Standish 4NW	7.21	Ranch	5.70	Thornion 2S	2.39	Lincoln Vineyard	1.75
	Red Bluff Cone	11.37	Palemo 35A	9.49	Lincoln Vineyard	7.21	Stockton 9S	5.66	Stockton 9S	2.15	Yuba City 9W	1.59
	Ranch	11.37	Palermo 35A	9.43	Loma Rica	7.06	Stockton 9S	5.66	Stockton 9S	2.07	Palermo 35A	1.59
	Ranch	10.74	Palermo 35A	9.20	Red Bluff Cone	7.06	Yuba City 9W	5.66	Gold Hill Doty	2.07	Palermo 35A	1.59
	Gold Hill Doty	10.74	Lookout Hunt	9.15	Ranch	7.05	Palermo 35A	5.27	Flat	2.05	Anderson 4E	1.32
	Stockton 9S	10.42	Penn Valley	8.98	Gold Hill Doty	6.63	Gold Hill Doty	5.16	Red Bluff Cone	2.00	Loma Rica	1.17
	Glenburn DfR	10.40	Flat	8.91	Palemo 35W	6.63	Flat	5.16	Ranch	1.98	Penn Valley	1.12
	Palermo 35A	10.31	Standish 4NW	8.89	Newman 1SE	6.63	Merced SSE	4.95	Newman 1SE	1.98	Arvin Frick	1.09
	Standish 4NW	10.00	Stockton 9S	8.84	Berenda 2E	6.43	El Solyo Ranch	4.94	Penn Valley	1.97	Gold Hill Doty	1.08
	Penn Valley	9.78	Newman 1SE	8.77	El Solyo Ranch	6.43	Loma Rica	4.94	Arvin Frick	1.87	Flat	1.07
	Lookout Hunt	9.67	Anderson 4E	8.70	El Solyo Ranch	6.43	Cedarville 2E	4.82	Loma Rica	1.83	Stockton 9S	1.06
	Montague 3NE	9.62	Kingburg 5S #2	8.55	Kingburg 5S #2	6.20	Penn Valley	4.51	El Solyo Ranch	1.75	Merced SSE	0.96
Anderson 4E	9.58	Kingburg 5S #2	8.36	Stockton 9S	6.18	Berenda 2W	4.46	Elk Grove 4NW	1.75	Newman 1SE	0.95	
Thornion 2S	9.50	Red Bluff Cone	8.36	Anderson 4E	6.15	Elk Grove 4NW	4.39	Glenburn DfR	1.75	Thornion 2S	0.94	
Arvin Frick	9.39	Red Bluff Cone	8.36	Arvin Frick	6.13	Thornion 2S	4.38	Merced SSE	1.65	Cedarville 2E	0.86	
Kingburg 5S #2	9.37	Montague 3NE	8.33	Merced SSE	6.07	Kernan 2ESE	4.28	Anderson 4E	1.63	Kingburg 5S #2	0.86	
Elk Grove 4NW	9.25	Alturas-Dorris	8.31	Lookout Hunt	6.00	Arvin Frick	4.08	Kernan 2ESE	1.63	Kernan 2ESE	0.80	
Newman 1SE	9.25	Alturas-Dorris	8.31	Penn Valley	5.99	Glenburn DfR	3.97	Kingburg 5S #2	1.62	Elk Grove 4NW	0.79	
El Solyo Ranch	9.15	Yuba City 9W	8.03	Thornion 2S	5.99	Anderson 4E	3.91	Cedarville 2E	1.60	Ranch	0.74	
Yuba City 9W	8.84	Arvin Frick	8.03	Yuba City 9W	5.99	Anderson 4E	3.91	Berenda 2W	1.43	Lookout Hunt	0.74	
Thornion 2S	8.61	Thornion 2S	7.96	Alturas-Dorris	5.94	Alturas-Dorris	3.71	Alturas-Dorris	1.13	Alturas-Dorris	0.65	
Alturas-Dorris	8.61	Elk Grove 4NW	7.56	Ranch	5.86	Lookout Hunt	3.71	Ranch	1.13	Ranch	0.65	
Ranch	8.62	Kernan 2ESE	7.43	Glenburn DfR	5.86	Lookout Hunt	3.71	Lookout Hunt	0.82	Glenburn DfR	0.65	
Ranch	8.62	Kernan 2ESE	7.43	Elk Grove 4NW	5.86	Lookout Hunt	3.71	Lookout Hunt	0.82	Glenburn DfR	0.65	

TABLE 3 (cont. in next)

MONTHLY EVAPORATION FROM STANDARD U. S. WEATHER BUREAU
EVAPORATION PANS IN ORDER OF DECREASING MAGNITUDE FOR IRRIGATED PASTURE AND DRYLAND STATIONS

Environment and year	January	February	March	April	May	June						
Dryland 1959	Bronx Valley 3ME 1.38	Croville Agric.	Bella Vista 4NE	5.99	Bella Vista 4NE	8.02	Newville	10.65	Fanuche Junction	16.15		
	Sacramento Refuge 1.35	Commission	Redding Stayer	5.60	Redding Stayer	7.94	Redding Stayer	10.18	Sacramento Refuge	14.25		
	Redding Stayer 1.24	Bronx Valley 3ME	Croville Agric.	5.60	Croville Agric.	7.72	Croville Agric.	9.87	Newville	13.99		
		Davis Creek 4WM	Commission	5.41	Sacramento Refuge	7.26	Commission	9.80	Redding Stayer	13.79		
		Davis Creek 4WM	Sacramento Refuge	4.83	Oroville Agric.	7.26	Commission	9.80	Oroville Agric.	13.41		
		Sacramento Refuge	Newville	4.84	Commission	7.48	Bella Vista 4NE	9.39	Commission	13.41		
		Adin Harper	Bronx Valley 3ME	4.54	Bronx Valley 3ME	6.96	Bronx Valley 3ME	8.99	Bella Vista 4NE	12.91		
		Big Sage Reser-	Davis Creek 4WM	3.46	Bronx Valley 3ME	6.29	Adin Harper	5.77	Bronx Valley 3ME	12.77		
		voir	Adin Harper	3.44	voir	6.24	Cedarville 2E	5.73	West Valley	10.22		
			Big Sage Reser-	2.62	Davis Creek 4WM	6.22	voir	5.69	Adin Harper	10.10		
			voir		West Valley	6.22	voir	5.69	Davis Creek 4WM	9.63		
					Reservoir	5.96	Reservoir	5.24	Big Sage Reser-	9.19		
									voir			
1960	Bronx Valley 3ME 1.47	Newville	Fanuche Junction	5.73	Bronx Valley 3ME	5.51	Sacramento Refuge	8.34	Fanuche Junction	16.15		
	Redding Stayer	2.67	Newville	4.29	Newville	5.50	Redding Stayer	8.16	Redding Stayer	14.93		
	Newville	1.42	Bronx Valley 3ME	4.28	Redding Stayer	5.46	Bronx Valley 3ME	7.82	Bella Vista 4NE	14.30		
	Sacramento Refuge	2.50	Redding Stayer	4.21	Bella Vista 4NE	5.30	Newville	7.62	Bella Vista 4NE	14.07		
	Big Sage Reser-	voir	Bronx Valley 3ME	3.67	Davis Creek 4WM	5.18	Bella Vista 4NE	7.37	Sacramento Refuge	12.69		
	voir	1.09	Sacramento Refuge	3.63	Sacramento Refuge	5.15	Eagle Lake Stone	7.26	Bronx Valley 3ME	12.11		
	Davis Creek 4WM	0.91	Davis Creek 4WM	2.46	Ranch		Ranch	7.26	Eagle Lake Stone	10.99		
	Adin Harper				Davis Creek 4WM	1.93	Davis Creek 4WM	1.93	Davis Creek 4WM	10.99		
	Dryland 1959	Bella Vista 4NE	16.64	Redding Stayer	12.94	Newville	10.73	Croville Agric.	Newville	5.46	Bella Vista 4NE	4.22
Redding Stayer		15.02	Bella Vista 4NE	12.50	Bella Vista 4NE	9.99	Commission	8.43	Bella Vista 4NE	5.27	Newville	3.23
Newville		15.16	Redding Stayer	12.42	Croville Agric.	9.94	Newville	8.03	Redding Stayer	4.51	Redding Stayer	2.56
Croville Agric.		14.72	Croville Agric.	12.32	Commission	9.84	Bella Vista 4NE	7.37	Sacramento Refuge	3.83	Bronx Valley 3ME	2.21
Commission			Bronx Valley	12.32	Commission	9.84	Bronx Valley 3ME	6.99	Bronx Valley 3ME	3.14	Sacramento Refuge	2.15
Bronx Valley		14.35	3ME	12.11	Bronx Valley	9.09	Redding Stayer	6.77	West Valley	3.00		
Sacramento			Davis Creek 4WM	11.91	Sacramento Refuge	8.74	Redding Stayer	6.77	West Valley	3.00		
Refuge		13.24	West Valley	11.48	West Valley	7.77	Reservoir	5.15	Davis Creek 4WM	2.54		
Big Sage Reser-		voir	Reservoir	11.48	West Valley	7.27	Davis Creek 4WM	4.87	Big Sage Reser-	1.92		
voir		12.54	Big Sage Reser-	10.70	Reservoir	7.27	Adin Harper	4.85	voir			
Adin Harper		12.40	voir	10.70	Davis Creek 4WM	7.10	Big Sage Reser-	3.44				
West Valley		12.30	Sacramento	10.29	Big Sage Reser-	6.68	voir					
Refuge		10.82	Refuge	10.25	voir							
Davis Creek 4WM	10.82	Adin Harper										
1960	Fanuche Junction	17.83	Fanuche Junction	16.60	Bella Vista 4NE	12.78	Fanuche Junction	8.41	Bella Vista 4NE	3.73	Bella Vista 4NE	3.92
	Bella Vista 4NE	15.96	Bella Vista 4NE	15.05	Redding Stayer	10.54	Bella Vista 4NE	8.24	Newville	2.97	Newville	1.89
	Redding Stayer	15.95	Redding Stayer	14.38	Newville	10.44	Newville	7.73	Fanuche Junction	2.50	Redding Stayer	1.46
	Newville	14.70	Eagle Lake Stone	13.00	Redding Stayer	7.26	Sacramento Refuge	6.48	Sacramento Refuge	2.59	Sacramento Refuge	1.44
	Bronx Valley	13.40	Bronx Valley	12.05	Sacramento Refuge	6.48	Sacramento Refuge	6.48	Redding Stayer	1.91	Fanuche Junction	1.35
	3ME	13.40	3ME	12.05	Davis Creek 4WM	4.55	Davis Creek 4WM	4.55	Davis Creek 4WM	1.06	Davis Creek 4WM	0.34
	Sacramento		Sacramento	11.76	Davis Creek 4WM	8.23						
	Refuge	12.03	Refuge	11.76								
	Davis Creek 4WM	12.10	Eagle Lake Stone	11.03								
	Eagle Lake Stone	11.03	Davis Creek 4WM	10.96								
	Davis Creek 4WM	10.96	Davis Creek 4WM	10.96								
	Ranch		Ranch									



CHAPTER III. EVAPOTRANSPIRATION MEASUREMENT

The objective of the evapotranspiration measurement and correlation program is to provide a more accurate basis for predicting evapotranspiration for the major crops in the various agricultural areas of the State. This is to be accomplished through measurements of evapotranspiration of various crops at several inland locations having different climatic conditions, and correlating with the evaporative demand, as measured by evaporation pans and atmometers. This chapter discusses the techniques and procedures utilized in the measurement of evapotranspiration, and changes that have occurred during the development of the study. In Chapter IV the correlation of the evapotranspiration with pan and atmometer evaporation data will be discussed and analyzed.

The principal evapotranspiration stations are located near Bakersfield in the southern San Joaquin Valley and near Alturas and Fall River Mills in mountain valleys of the Sacramento River Basin. Plate 2, entitled "General Location of Evapotranspiration Stations, 1955-1960," shows the location, type, and status of each station. More detailed information is given in Tables A-4 and A-5 of Appendix A. Measurements were made primarily on alfalfa and grass, which are grown universally throughout the State. As plant and soil moisture conditions affect evapotranspiration rates, evaluation of these factors is also an essential part of evapotranspiration measurement.

Measurement of Data Related to Evapotranspiration

Correlative pan and atmometer evaporation measurements were made at agroclimatic stations established near the evapotranspiration measuring stations. These stations are listed in Table A of Appendix A. Detailed information regarding the agroclimatic stations, and pan and atmometer data, are given in Tables A-1, A-2, and A-3 of that appendix.

At Arvin (in Kern County) the pan and atmometer data were initially collected at stations (Arvin Jewett #1 and #2) located in an irrigated alfalfa field near the evapotranspiration station, or soil moisture depletion plots. In June 1959, a new station (Arvin-Frick) was established in an irrigated grass environment. All of the soil moisture depletion plots were within 1 mile of this station.

Only atmometer data were collected at the Pittville AA plot site (in eastern Shasta County) during 1959. This agroclimatic station is identified as Pittville 1 S. Pan data were collected within an irrigated pasture site, designated as Fall River Mills 4 Nw, during 1959, and until June 1960, but due to unfavorable operational procedures at this site in 1959, the pan data were not used in this report.

In June 1960, an agroclimatic station was established at a location within an irrigated pasture 8 miles west of the Pittville AA plot. This station is identified as Glenburn DWR. Comparison of atmometer evaporation measurements at the Pittville 1 S and the Glenburn DWR stations showed that the difference in evaporation between the black and white atmometers is very close for these two locations.

At the Arvin and Glenburn sites, three sets of new atmometers were installed at the beginning of each season, and each month one pair was replaced with a new pair. At Arvin, three pans were operated, and the evaporation, which was nearly the same, was averaged.

Data on percent of ground cover were collected to determine effects of varying cover on evapotranspiration rates. The term "percent ground cover," as used in this report, refers to the percentage of ground surface covered by a canopy of living foliage as viewed looking downward from directly above the crop. During the first years, 1955-1957, few records were kept of percent ground cover. However, from 1958 through 1960 it was standard procedure to measure crop height, estimate percent ground cover, and record both.

When most of the moisture which plants can readily extract from within the root zone has been used, crop growth is slowed and evapotranspiration rates may also be correspondingly affected. To estimate available soil moisture at the test plots, samples were taken and laboratory measurements of the moisture content of the soil were made, utilizing the pressure plate membrane technique with pressures varying from 0.1 to 15 atmospheres. Tensiometers, instruments which can be used to measure availability of soil moisture for crop utilization, were installed at some plots. Calculations of available soil moisture in the root zone were based on the difference between moisture profiles determined from field measurements and moisture profiles representing the moisture level below which crops cannot readily extract moisture.

Criteria for Selection of Plots

In the selection of plots for the measurement of evapotranspiration, certain physical conditions are recognized as essential to collecting valid data. Experience over the years has emphasized the importance of certain necessary conditions. Unfortunately, the most ideal plot conditions are difficult to find, and considerable time and effort have been expended over the years selecting the most favorable sites. However, this is not to imply that evapotranspiration rates would necessarily be different under different conditions. The following criteria indicate the conditions under which good measurements of evapotranspiration representative of field conditions can be obtained. After good measurements have been obtained under these conditions, the studies should be broadened to include some of the adverse soil and other conditions which might affect evapotranspiration.

1. Measurement sites should be located 200 feet inside the edge of the irrigated field to avoid accentuated border effects.

2. Generally, the land should be of smooth topography.

3. Since the sites are located on private lands, it is necessary to have freedom of access and cooperation of the landowner or manager.

4. The soil should be deep, well drained, productive, and unaffected by salinity. The soil preferably should also be medium textured, as very fine or very coarse textures have unfavorable soil-moisture relationships. The soil profile should not be stratified to such an extent as to impede moisture flow or create sampling problems.

5. The irrigated field should be located in typical irrigated areas, not on the fringe of irrigated areas.

6. There should be an adequate supply of irrigation water. It is highly desirable that there be possibilities for controlling and measuring the amount of water applied to the test plot.

7. Except for measurements which are made by evapotranspirometers, no water table should exist within or near the root zone of the crop.

Evapotranspiration Measurement Techniques and Discussion of Development and Current Methods

The tools and techniques used in this study to measure evapotranspiration fall into two general categories. One is field plot sampling, and the other is evapotranspirometer measurements.

Field Plot Sampling - Gravimetric Method

Periodic measurement of soil moisture provides a means of determining total change of water content within a selected portion of the soil profile. Evapotranspiration may be determined from data on soil moisture change and precipitation. Soil moisture must be sampled or measured each time at or near the same location in each plot, with several locations being situated in each plot. Moreover, the moisture determinations must be made at least twice following wetting of the soil by any heavy irrigation or heavy precipitation. To obtain satisfactory results, it is necessary that sufficient time lapse be permitted following thorough wetting of the soil (usually several days) before making the first moisture

determination in a cycle of measurements. Otherwise, moisture moving out of the sampled profile would be incorrectly included as evapotranspiration in the soil moisture depletion measurement.

During the growing season, the general procedure was to sample approximately every seven days, except as modified by irrigation, harvest, or other cultural (farming) operations. During the nongrowing season, measurements were made less frequently because of the lower rates of water use.

At the initiation of the evapotranspiration measuring program in 1955, the gravimetric technique was accepted as the best method available, and was the first technique employed in the studies reported here. Moisture content of soil samples was determined by weight change resulting from moisture loss during oven drying. Soil samples were taken by means of a soil tube, in 1-foot increments of depth, from the soil surface to a depth of 7 or 9 feet. As the soil tube is difficult to handle at depth below 9 feet, sampling below that depth was attempted only in special cases where knowledge of the substratum conditions was desired.

The initial evapotranspiration measurements were made in the mountain valley areas in the northern and northeastern part of the State, and in the northern Sacramento Valley. The objective at that time was to determine the irrigation requirements of only those areas. Plots in the mountain valleys were located on typical irrigated parcels of land. The irrigated lands in this area exist as narrow and isolated "oases" separated by large areas of native vegetation.

From three to eight core holes were made per sampling. This number did not prove to be adequate because of inherent variability of the soils.

During analysis of data collected during the 1955 season, it was determined that observation holes should have been maintained at all plots to determine if water table conditions existed. Through observation holes on a few of the plots, and examination of soil samples taken from the lower profiles, it was found that water tables did exist on some plots where they were not expected. When a water table is present in or near the root zone, there is a probability that the crop will utilize some of this source of moisture. It is impossible to determine this amount.

The greatest problem, however, was that irrigation in some cases added too much water, and in other cases was too infrequent or too little. As previously mentioned, when too much water is applied, downward moisture movement continues for a considerable length of time. A series of field moisture measurements will include both moisture movement, or change, due to plant extraction and evaporation. If too little water is applied, the soil moisture may become critically short, and crop growth may be affected. If the soils become very dry, the evapotranspiration rate may also be affected.

For the next several seasons, work was concentrated on fewer plots, and more detailed observations were made of crop growth, presence of water tables, and other conditions. As the need for irrigation control became recognized as being critical

to obtain adequate evapotranspiration data from soil moisture depletion measurements, attempts to modify irrigation were initiated.

It was observed that weekly visits to plot sites adversely affected the crop cover and soil conditions by trampling the crop. To overcome these undesirable effects, a portable sampling platform was built in 1956 to sample one of the plots. This was the forerunner of platforms which were used later with neutron probes.

In 1957, the water use studies were expanded to other areas of the State. Alfalfa fields were sampled in Stanislaus and Kings Counties. These plots were abandoned because data obtained from them were not considered reliable for estimating evapotranspiration because of excessive moisture movement that resulted from overirrigation at the Stanislaus County plots and unfavorable soil conditions at the plots in Kings County.

In 1958, one man was stationed in Kern County following a reconnaissance for plot sites. Plots of alfalfa, grapes, and plums were sampled. Problems of two kinds were encountered. On plots receiving lesser quantities of irrigation, the crops extracted moisture from below the zone sampled, while on plots receiving very frequent irrigations, considerable moisture movement occurred between sampling.

No further gravimetric samples were taken following the adoption of neutron scattering equipment in the spring of 1959. While complete detailed records were kept and calculations made for each of the gravimetric sampling sites, the results of these measurements are not included in this report.

Field Plot Sampling - Neutron Scattering Technique

A recently developed method to obtain the soil moisture data, referred to as the neutron scattering technique, is based upon the principle that high energy or "fast" neutrons are moderated, or "slowed down," in soils almost exclusively by hydrogen atoms contained in soil moisture. The instrument consists of a source of "fast" neutrons, a detector tube which is sensitive only to "slow" neutrons, and a slow neutron counter. Both source and detector are combined in a cylindrical probe 1.5 inches in diameter by 14 inches long. The probe is lowered into the soil through a small-diameter, cased hole to the desired depth, suspended by its electrical cable. The cable is connected to the counting device which counts pulses produced by slow neutrons returning to the detector. Since the "fast" neutron output of the source is essentially constant, the count recorded in a fixed time period may be used with a suitable calibration to determine the moisture content in the soil surrounding the probe.

The neutron scattering technique has certain advantages over the gravimetric technique. In addition to the ease of making deeper measurements, the neutron measurements take less time, repeatedly represent approximately the same soil mass, and are generally more precise than gravimetric measurements. Measurement of the same soil mass is particularly important, since soil moisture distribution and extraction patterns appear to be nonuniform. It must be noted, however, that overirrigation and resulting moisture movement remain a problem with this method. Also, for greater

accuracy, measurements of the soil surface layer, to a depth of about 1 foot, require a different calibration than the measurements at greater depth below the soil surface. Determination of a suitable calibration is under study by the department and other agencies at this time. It is believed at the present that the error of measuring the losses of water from the soil surface is not large, considering the total water use from the entire profile, in the case of deeper rooted crops.

Inherent variabilities, such as found in physical measurements of any natural phenomenon, occur in soil moisture depletion measurements. Generally, although affecting any given measurement, such variations tend to be compensating and, over a period of time, such as a year, tend to cancel out.

Two neutron scattering devices were acquired in 1958, shortly after this equipment became commercially available. The neutron equipment was used for determination of soil moisture in all field plots since early spring of 1959. The same criteria used for selection of gravimetric sampling plots were followed in establishing the plots sampled with the neutron probe.

Effort was made to keep the crop in the plot area generally typical of the normal conditions of the entire field. Light weight, portable sampling platforms with working areas of 15 to 30 square feet were fabricated in 1959 to carry the neutron scattering equipment. These also served as portable working platforms. They have been particularly advantageous in facilitating the field work and in avoiding trampling and injury to the alfalfa and grass crops

and compaction of the soils. Three types of portable sampling platforms used at Fall River Mills and Bakersfield are shown in Figure 3.

To provide neutron probe access into the soil, thin-walled aluminum tubes 20 feet in length with removable 18-inch extensions at the top were permanently installed flush with the soil surface. Stoppers were placed in the tube at the surface and immediately below the extension to exclude foreign material from the tubes. In this way, the tubes did not extend above the ground to interfere with tillage and crop cultural operations. When tillage operations damaged the upper extensions, they were simply and easily replaced. The access tube design is shown in Figure 4.

Pittville Neutron Probe Moisture Depletion Measurements.

The Pittville site is located at an elevation of about 3,340 feet, in the northeastern intermountain region, at a latitude of 41 degrees. Selection of the neutron measurement site was preceded by four years of gravimetric sampling in the Fall River Valley and other mountain valleys in the northeastern area. The Pittville 1 S site was sampled using the gravimetric technique in 1956, 1957, and 1958. This prior experience indicated that the Pittville alfalfa field possessed the desirable combination of soil and irrigation conditions for a moisture depletion plot. Topographically, the site is gently sloping with small swales. There is a small ridge 600 feet north of the plot site, which is about 100 feet higher than the plot. The land at the plot site slopes 5 percent



Platform Developed
in Early Stage of
Program for Obtaining
Soil Cores

Small, Wheeled
Platform Used to
Measure Soil
Moisture Depletion
by the Neutron
Scattering Technique



Aluminum Platform
Used with the
Neutron Scattering
Equipment

FIGURE 3. PLATFORMS USED TO MINIMIZE CROP DAMAGE AND SOIL COMPACTION

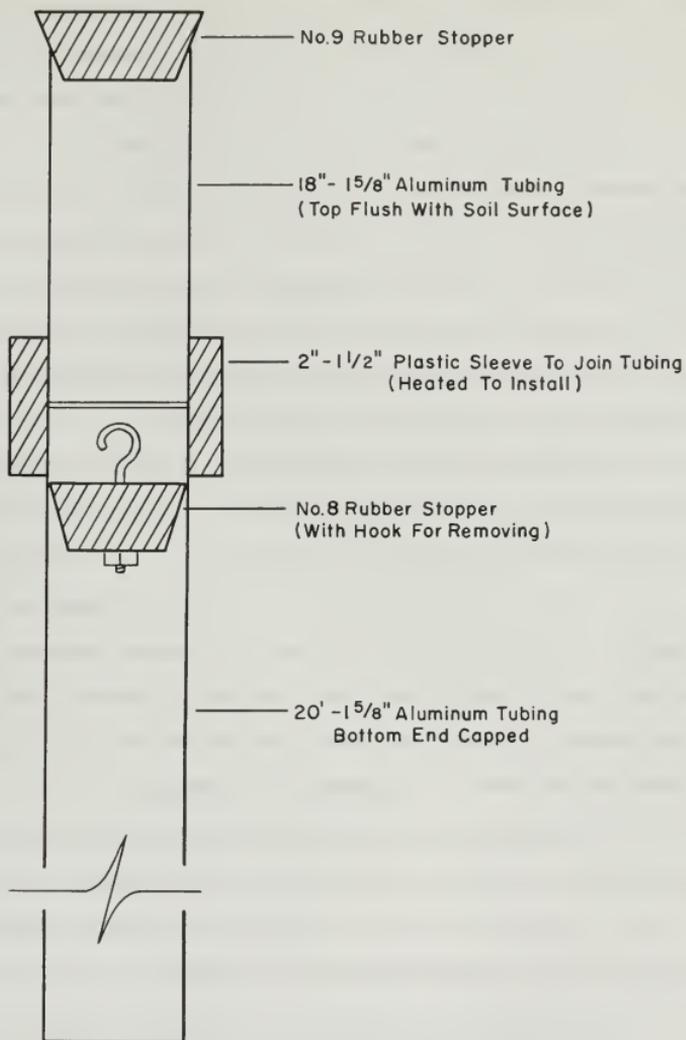


Figure 4, ACCESS TUBE DESIGN

to the south-southwest, and the 30 acres of alfalfa in the field are surrounded by small irrigated fields, dry-farmed grain, and native vegetation. Prevailing winds in the area are from the west

Initially, three rows of five access tubes were installed 75 feet apart, with the tubes spaced in the rows 15 feet apart. In September 1959, four more tubes were installed in one of the rows, and the other two rows abandoned, reducing the plot to nine tubes. This enabled the plot to be irrigated in two days, rather than the three to four days required for the sprinklers to pass over the original three rows of access tubes.

Irrigation water is applied by a portable sprinkler system, using full circle (360 degrees) rotating sprinklers. The sprinklers sometimes stuck in one position, and irrigation application, as a result, was not uniform enough to determine applied water from pumping records. This plot was subjected to somewhat deficit irrigation, which left a dry zone generally below a depth of 8 feet. For this reason, the soil moisture measurements can be used with confidence as estimate of evapotranspiration.

Neutron moisture depletion measurements were made during 1959 and 1960 at another alfalfa site 3 miles west of the Pittville plot. Due to apparent excessive moisture movement, however, the results of these measurements are not included in the report.

Arvin Neutron Probe Moisture Depletion Measurements.

These measurement sites are in the southern San Joaquin Valley, near the 35 degree latitude, located at an elevation of about 440 feet. The plot sites are on broad, smooth, recently formed fans

from the outwash of the Sierra Nevada Range at the southern end of the valley. The land slopes to the southwest at the plot area at about 30 feet per mile (0.6 percent).

Irrigation in the area is supplied from deep wells lifting water several hundred feet. All of the Arvin plots are located on Hesperia fine, sandy loam. This soil has no apparent clay or cemented layers. Moisture drainage is good. Noncontinuous silt layers and pockets of silt of varying thickness are found from 3 feet down to 22 feet below the surface. Plot sites were located where the least amount of silt layers are found. Surrounding the sampling areas were irrigated orchards, vineyards, alfalfa, cotton, and other crops. The irrigated area extends 20 miles to the north, 15 miles to the east, 40 miles to the south, and 60 miles to the west.

Four crops, cotton, alfalfa, plum orchard, and fescue grass, were sampled. All sites were irrigated by furrow or border methods. In order to obtain reasonably precise data, more than 20 sampling tubes were installed on the cotton and alfalfa. Six tubes each were installed on the plums and grass plots for exploratory purposes, the intent being to determine moisture extraction patterns.

The plum orchard is planted on a 24-foot square pattern. Water is applied to five or six straight furrows running in one direction. Results of the neutron probe measurements indicate that the extraction of moisture is greatest from the furrow area near the trees, intermediate from the middle furrows, and least from the soil in the tree rows. Extraction was noted to a depth of 16 feet. Depth of extraction probably depends largely on irrigation practices.

On the grass plot, the moisture was extracted primarily from the upper 2 or 3 feet. With such a large portion of the total water use from such shallow depths, the inherent uncertainty of surface neutron probe measurements assumes greater importance. It has been concluded that the neutron scattering technique is not well suited for measuring evapotranspiration of grasses due to their shallow moisture extraction patterns and frequent irrigations. Plans have been made to use evapotranspirometers on this crop.

On the alfalfa plot, ample tubes were sampled to obtain a good estimate of moisture depletion.

On the cotton plot, three sets of seven tubes each were placed at the upper, middle, and lower ends of the 440-foot furrow runs. The tubes were placed diagonally, crossing the rows, such that the tubes were located in the plant row, and in the furrow bottoms and furrow shoulders. The number of tubes was adequate to determine moisture change with good precision.

Cotton is not normally overirrigated, which is an advantage in soil moisture depletion studies, since soil moisture movement is not as much a problem in data interpretation as with most other crops. Portable water meters were used to measure the water applied to the cotton. These measurements confirmed the seasonal depletion record obtained from the neutron probe measurements.

Evapotranspirometer Measurements

Evapotranspirometers, sometimes referred to as lysimeters, are instruments designed for the measurement of evapotranspiration. They can be of various shapes, sizes, and designs. Essentially,

they are devices which enable the evaluation of the moisture regime of a confined soil mass, of known dimensions, in which a crop is grown. Moisture changes of the crop-soil system are determined by periodic or continuous weighing, or by volumetric determination of water displaced, added, and/or removed from the system.

When used for the determination of field evapotranspiration, it is particularly important that the tanks be installed in such a manner that their presence does not modify the environment of the measured crop. Although this technique appears to be an excellent method for precise measurement of crop water use, certain factors, such as the artificial restriction of crop rooting and possible modification of soil heat transfer, have yet to be completely evaluated. Research on these factors is presently being conducted by the University of California.

The use of evapotranspirometers in the field was not common in California at the initiation of this program, although tanks had been used in the 1920's and 1930's. Because soil moisture depletion studies are not adapted to crops frequently irrigated or having high water tables, small evapotranspirometers were installed to provide a reliable measure of evapotranspiration under those conditions.

Alturas-Dorris Ranch Evapotranspirometer Measurements. In 1956, two small evapotranspirometers were installed near Alturas to measure evapotranspiration from high water table pasture. The plot site was in an irrigated meadow pasture containing high moisture favoring grasses, legumes, and broad-leafed plants found in improved

irrigated pasture mixes and in native mountain meadows. The pasture was grazed nearly continuously by cattle, and was usually short but fully covered the ground. Typical percentages of green growing leaf surfaces were as follows: In April, 40 percent, increasing to 100 percent by the end of the month; May through September, 100 percent; October, 100 percent, decreasing to 50 percent by the end of the month. Cover of green foliage varies between zero and 40 percent during the winter, depending to a large extent upon the severity of the winter. In milder winters, some green live shoots survive, while in severe winters the foliage is completely inactive, and the green color is gone.

The evapotranspirometer site was enclosed by a barbed-wire fence forming a 25- by 75-foot rectangle. Inside the fenced area the grass was mowed several times during the season to maintain approximately a 5-inch height. Two cylindrical steel evapotranspirometers, 36 inches in diameter and 30 inches deep, were installed in the soil within a fenced area, one at each end. Also, inside the plot were a hygromograph and evaporation pan, atometers, phyheliometer, and a precipitation gage.

Water was supplied to the evapotranspirometers by means of a steady, small flow, at a rate calculated to exceed evapotranspiration. It took approximately one week to utilize the water from a cylindrical supply tank 5 feet deep and 18 inches in diameter. A discharge tube was attached to the evapotranspirometer 6 inches below the ground surface, and the excess water not consumed in the transpirometer spilled into a buried sump tank, where it was measured.

The numerous mechanical problems encountered during the first 2.5 years rendered the collected data of questionable validity.

Therefore, these data have not been used for this report. The data collected in 1959 and 1960 are considered representative of evapotranspiration from high water table meadow pasture, and are reported herein.

Coleville Evapotranspirometer Measurements. In 1957, data on high water table meadow pasture were collected from an evapotranspirometer tank near Coleville in the Lassen-Alpine area. The measurement site was located at the eastern edge of the State, at a latitude of about $38^{\circ} 30''$, at an elevation of 5,100 feet. The site was similar to the Alturas-Dorris Ranch site in vegetation and in irrigation methods. The field was subject to long irrigations by wild flooding. The water level at this site varied from 0-16 inches below the ground surface, and was usually about 8 inches below the ground surface. A cylindrical steel evapotranspirometer, 36 inches in diameter by 3 feet deep, was installed. Water was supplied to the evapotranspirometer from a supply tank floated on the water table surrounding the evapotranspirometer. With this system the water table inside the evapotranspirometer was kept at essentially the same level as that in the field. Moisture utilized by the plants was constantly replaced from the supply tank. The level of the supply tank was recorded on a Stevens water stage recorder. The field water table level was also measured on a separate recorder. By integration of the two charts, the rate of evapotranspiration was determined.

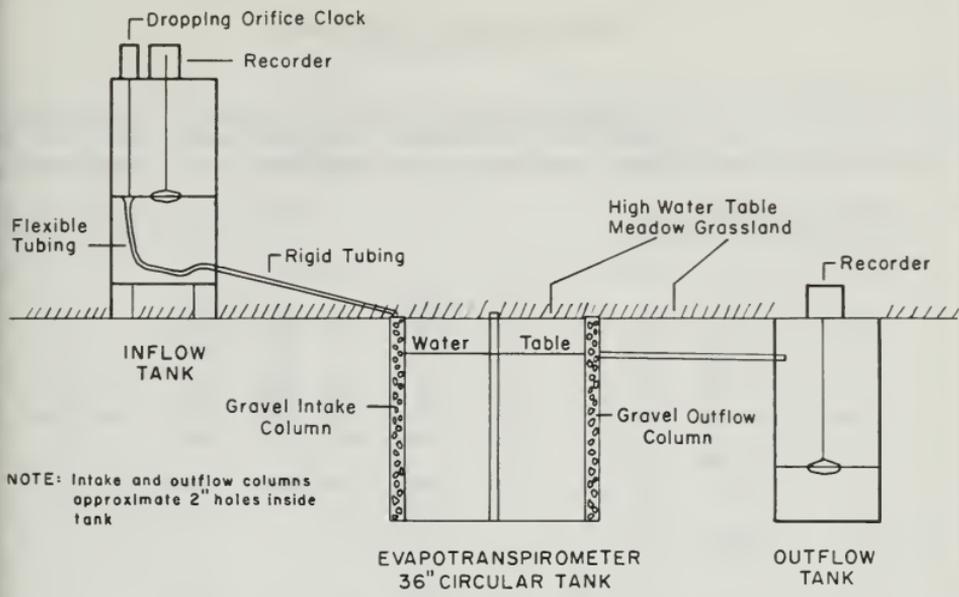
The topography in the area is smooth, with a 2 percent northerly slope. Data were collected at this site for one season in connection with an investigation of water use in watersheds in the eastern Sierra Nevada.

Figure 5 shows diagrammatically the functioning of the Alturas-Dorris Ranch and Coleville evapotranspirometers.

Davis Evapotranspirometer Measurements. In 1958, three small evapotranspirometers 2 feet in diameter were installed at Davis in cooperation with the Department of Irrigation of the University of California. The purpose was to determine how well these small tanks would compare with a large 20-foot diameter tank, which was installed by the university in 1958. Over a 10-month period, the mean evapotranspiration from the 2-foot evapotranspirometers differed less than 5 percent from the 20-foot evapotranspirometer. One reason for this favorable comparison is that both kinds of tanks were located in the same field environment having a continuous, uniform crop height and cover in and around the tanks. The data from the 2-foot evapotranspirometers are presented in this report.

Evapotranspiration Data Summary

Summaries of evapotranspiration for measured and estimated periods are tabulated in Table 5, with corresponding measurements of pan and atmometer evaporation. Evapotranspiration for missing periods was usually estimated as the product of appropriate pan or atmometer coefficients, and pan or atmometer evaporation data collected during these periods, plus calculated increments for surface evaporation following irrigation. Monthly evapotranspiration totals have been computed and are also presented in Table 5. A detailed tabulation of evapotranspiration and related data are presented in Tables A-6 and A-7 of Appendix A, for the approximately weekly measurement schedule. Variability of soil moisture values



ALTURAS - DORRIS RANCH EVAPOTRANSPIROMETER

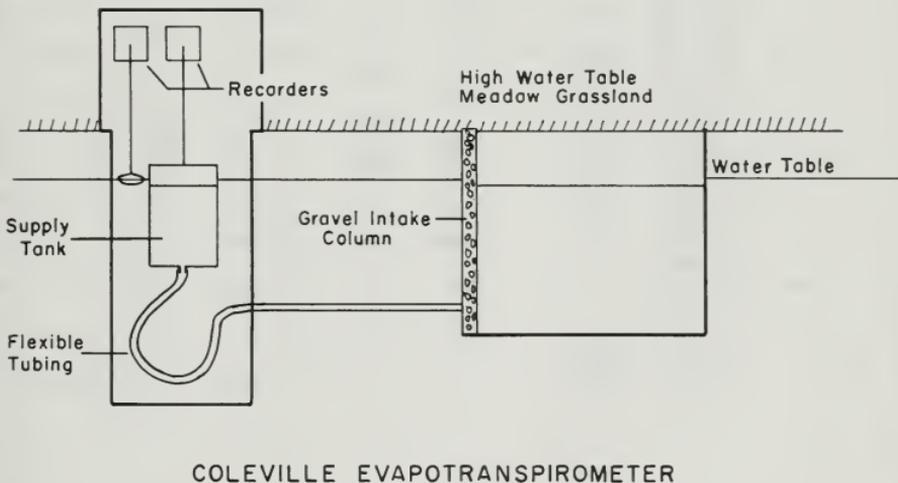


Figure 5, EVAPOTRANSPIROMETER DESIGN

TABLE 5

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA

Year	Month	Period	Evapotranspiration			Pan evaporation			Atmometer evaporation	
			Meas- ured	Esti- mated	Accum. :Monthly : totals : est.	Each : period	Accum. :Monthly : totals : est.	Each : period	Accum. :Monthly : totals : est.	
<u>Sacramento River Mountain Valleys</u>										
<u>Pasture - Alturas - Dorrie Ranch</u>										
1959	Apr.	4/7 - 4/30	4.03		4.03		4.35	4.35		
		3/31 - 4/30				5.15			5.54	
	May	4/30 - 5/31	5.99		10.02	5.99	6.09	10.44	6.09	
	June	5/31 - 6/30	8.95		18.97	8.95	7.94	18.38	7.94	
		6/2 - 6/30	(8.33)							510 510
	July	6/30 - 7/31	10.45		29.42	10.45	9.83	28.21	9.83	645 1,155
	Aug.	7/31 - 8/31	9.04		38.46	9.04	8.65	36.86	8.65	547 1,702
	Sept.	8/31 - 9/30	4.90		43.36	4.90	5.41	42.27	5.41	
		8/31 - 9/22	(3.78)							315 2,017
	Oct.	9/30-11/2	3.02		46.38	2.85	3.80	46.07	3.59	
TOTALS		4/7 -11/2	46.38				46.07			
		6/2 - 9/22	31.60							2,017
1960	Apr.	4/8 - 5/1	2.33		2.33	2.99	3.50	3.50	4.53	
	May	5/1 - 5/31	4.61		6.94	4.78	5.71	9.21	5.90	
	June	5/31 - 6/7		1.96	8.90		1.96			
		6/7 - 6/14	1.41		10.31		1.73	12.90		129 129
		6/14 - 6/21		1.96	12.27		1.96			116
		6/21 - 6/28	1.62		13.89		1.98	16.84		140 385
		5/31 - 6/30				6.56			8.00	
	July	6/28 - 8/1	10.33		24.22		9.45	26.29		608 993
		6/30 - 7/31				9.61			8.82	
	Aug.	8/1 - 8/31	8.99		33.21		8.02	34.31		480 1,473
		7/31 - 8/31				9.31			8.31	
	Sept.	8/31 - 9/30	6.01		39.22	6.01	5.91	40.22	5.91	421 1,894
	Oct.	9/30-10/31	3.56		42.78	3.56	3.81	44.03	3.81	
		9/30-10/3	(0.47)							43 1,934
	Nov.	10/31-11/21		0.71	43.49		0.76			
		11/21-12/1	0.17		43.66		0.38	45.17		
		10/31-11/30				0.51			0.76	
	Dec.	12/1 -12/31	0.75		44.41		0.62	45.79		
		11/30-12/31				0.78			0.65	
TOTALS		4/8 -12/31	39.78				41.11			
		6/7 -10/3	28.83							1,821

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

Year	Month	Period	Evapotranspiration				Pan evaporation		Atmometer evaporation		
			Meas- ured	Esti- mated	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.	Each period	Accum. totals
<u>Sacramento River Basin Valley Floor</u>											
<u>Pasture - Davis Campbell</u>											
1959	Jan.	12/31- 2/2	1.42		1.42		2.03	2.03			
		12/31- 1/31				1.15				1.65	
	Feb.	2/2 - 2/27	2.27		3.69		2.18	4.21			
		1/31- 2/28				2.56				2.65	
	Mar.	2/27- 4/1	4.45		8.14		6.57	10.78			
		2/28- 3/31				4.31				6.32	
	Apr.	4/1 - 4/16	2.51		10.65		4.26	15.04			
		4/16- 4/30		1.82	12.47		2.23	17.27			
		3/31- 4/30				4.45				7.55	
	May	4/30- 5/14	2.87		15.34		4.34	21.61			
		5/14- 5/21		1.56	16.90		2.56	24.17			
		5/21- 5/28	1.06		17.96		1.91	26.08			
		4/30- 5/31				6.05				9.75	
	June	5/28- 6/8		2.19	20.15		3.67	29.75			
		6/8 - 6/15	1.67		21.82		2.23	31.98			
		6/15- 6/30		4.08	25.90		5.72	37.70			
		5/31- 6/30				7.38				11.02	
	July	6/30- 7/29	8.11		34.01		10.74	48.44			
		6/30- 7/31				8.74				11.15	
	Aug.	7/29- 8/31	7.65		41.66		9.88	58.32			
		7/31- 8/31				7.02				9.13	
	Sept.	8/31- 9/3		0.76	42.42		0.59	58.91			
		9/3 -10/2	5.63		48.05		8.23	67.14			
		8/31- 9/30				5.97				8.14	
	Oct.	10/2 -11/2	4.26		52.31		6.66	73.80			
		9/30-10/31				4.56				7.11	
	Nov.	11/2 -12/5	2.12		54.43		4.19	77.99			
		10/31-11/30				1.92				3.53	
	Dec.	12/5 -12/31	0.88		55.31		1.68	79.67			
		11/30-12/31				(1.25)				2.65	
TOTALS		12/31/58-12/31/59	44.90				64.90				
1960	Jan.	12/31- 1/30	0.84		0.84		1.48	1.48			
		12/31- 1/31				0.88				1.63	
	Feb.	1/30- 2/26	1.53		2.37		2.88	4.36			
		1/31- 2/29				1.78				3.08	

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

Year	Month	Period	Evapotranspiration			Pan evaporation			Atmometer evaporat					
			Meas- ured	Esti- mated	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.	Each period	Accum. totals	Mon- thly est.		
1960	Mar.	2/26- 3/31	3.35		5.72		4.21	8.57						
		2/29- 3/31				3.06				3.86				
	Apr.	3/31- 4/29	4.85		10.57		5.65	14.22						
		4/18- 4/29	(1.73)								138	138		
		3/31- 4/30				5.27				6.11				
	May	4/29- 6/1	7.50		18.07		9.20	23.42						
		4/30- 5/31				7.10				8.74	570	708		
	June	6/1 - 7/1	5.87		23.94		12.02	35.44						
		5/31- 6/30				5.87			12.02		607	1,315		
	July	7/1 - 7/19	4.25		28.19		6.44	41.88			390	1,705		
TOTALS		12/31- 7/19	28.19				41.88							
		4/18- 7/19	19.35								1,705			

Lassen - Alpine Mountain ValleysPasture - Coleville - 2E

1957	May	5/27- 6/3	1.34		1.34		1.38	1.38						
	June	6/3 - 6/30	6.91		8.25		7.31	8.69						
		5/31- 6/30				7.53				7.95				
		6/10- 6/30	(5.23)								434	434		
	July	6/30- 8/1	9.12		17.37	9.12	9.33	18.02	9.33		601	1,035		60
	Aug.	8/1 - 8/31	7.76		25.13	7.76	9.09	27.11	9.09		583	1,618		58
	Sept.	8/31- 9/23	3.39		28.52		4.63	31.74			359	1,977		
TOTALS		5/27- 9/23	28.52				31.74							
		6/10- 9/23	25.50								1,977			

Sacramento River Basin Mountain ValleysAlfalfa - Fall River Mills - Plot AA

1959	Mar.	3/17- 4/8	1.92		1.92									
		3/17- 3/31				1.26								
	Apr.	4/8 - 4/23	3.86		5.78									
		4/23- 4/30		1.34	7.12									
		3/31- 4/30				5.86								
	May	4/30- 5/6	1.33		8.45									
		5/6 - 5/28	4.24		12.69									
		4/30- 5/31				6.76								
	June	5/28- 7/2	8.48		21.17						715	715		
		5/31- 6/30				6.88								
	July	7/2 - 7/6	1.27		22.44						86	801		60
		7/6 - 7/27	6.41		28.85						463	1,264		
		7/27- 7/31	0.95		29.80						70	1,334		
		6/30- 7/31				9.04								65

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

Year	Month	Period	Evapotranspiration			Pan evaporation		Atmometer evaporation						
			Meas- ured	Esti- mated	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.		
1959	Aug.	7/31- 8/3		0.86	30.66			59	1,393					
		8/3 - 8/14	1.81		32.47			232	1,625					
		8/14- 8/31		3.58	36.05			355	1,980					
			7/31- 8/31			6.25							646	
	Sept.	8/31- 9/3		0.92	36.97			65	2,045					
		9/3 - 9/15	3.49		40.46			207	2,252					
		9/15- 9/30		2.51	42.97			209	2,461					
		8/31- 9/30				6.92							481	
	TOTALS	3/17- 9/30	30.21											
		5/28- 9/30	20.19						1,617					

Sacramento River Basin Mountain ValleysAlfalfa - Fall River Mills - Plot AA

1960	Mar.	3/10- 4/19	3.71		3.71		5.91	5.91					
		3/10- 3/31				1.90			3.80				
	Apr.	4/19- 5/11	2.39		6.10		3.82	9.73					
		3/31- 4/30				2.83			4.65				
May		5/11- 5/19		2.37	8.47		2.25	11.98					
		5/19- 6/3	3.31		11.78		2.91	14.89					
		4/30- 5/31				6.42			6.67				
June		6/3 - 6/24	3.29		15.07		6.20	21.09					
		6/10- 6/24	(1.21)						275				
		6/24- 6/30		1.28	16.35		1.64	22.73		121	396		
		5/31- 6/30				5.57			8.69				588
July		6/30- 7/25	7.85		24.20		8.61	31.34		492	888		
		7/25- 8/1		0.92	25.12		2.09	33.43		114	1,002		
		6/30- 7/31				8.40			10.40				584
Aug.		8/1 - 8/5		1.06	26.18		1.33	34.76		80	1,082		
		8/5 - 8/26	6.30		32.48		6.41	41.17		375	1,457		
		8/26- 9/1		1.52	34.00		1.46	42.63		97	1,554		
		7/31- 8/31				8.88			9.20				550
Sept.		9/1 - 9/28	4.55		38.55		5.41	48.04		425	1,979		
		8/31- 9/30				5.10			5.85				452
Oct.		9/28-11/8	4.82		43.37		5.05	53.09					
		9/30-10/31				3.80			3.97				
TOTALS		3/10-11/8	36.22				44.32						
		6/10- 9/28	19.91							1,567			

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

Year	Month	Period	Evapotranspiration			Pan evaporation		Atmometer evaporation				
			Meas- ured	Esti- mated	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.
<u>Tulare Lake Basin Valley Floor</u>												
<u>Alfalfa - Arvin - Plot CC</u>												
1959	Mar.	3/13- 3/27	1.07		1.07		2.28	2.28		186	186	
		3/27- 4/3		1.06	2.13		1.35	3.63		106	292	
		- 3/31							4.53			
	Apr.	4/3 - 4/21	2.54		4.67		4.16	7.79		293	585	
		4/21- 4/28		1.16	5.83		1.77	9.56		100	685	
		3/31- 4/30				4.49			7.00			
	May	4/28- 5/14		2.34	8.17		3.82	13.38		244	929	
		5/14- 5/25	1.31		9.48		2.96	16.34		172	1,101	
		5/25- 6/1		1.34	10.82		2.58	18.92		123	1,224	
		4/30- 5/31				4.54			8.69			
	June	6/1 - 6/9	2.06		12.88		2.45	21.37		148	1,372	
		6/9 - 6/15		0.93	13.81		1.81	23.18		112	1,484	
		6/15- 6/22	1.00		14.81		2.13	25.31		142	1,626	
		6/22- 6/29		1.45	16.26		2.22			132	1,758	
		5/31- 6/30				5.80			9.06			
	July	6/29- 7/3	1.09		17.35		1.58	29.11		88	1,846	
		7/3 - 7/8		0.90	18.25		1.54	30.65		102	1,948	
		7/8 - 7/17	1.20		19.45		2.71	33.36		170	2,118	
		7/17- 7/22		1.10	20.55		1.37	34.73		84	2,202	
		7/22- 7/29	1.70		22.25		2.30	37.03		126	2,328	
		6/30- 7/31				6.34			9.95			
	Aug.	7/29- 8/8		2.38	24.63		2.83	39.86		168	2,496	
		8/8 - 8/13	0.39		25.02		1.67	41.53		102	2,598	
		8/13- 8/27		2.56	27.58		3.50	45.03		220	2,818	
		7/31- 8/31				6.07			8.67			
	Sept.	8/27- 9/15	3.86		31.44		3.96	48.99		312	3,130	
		9/15- 9/22		1.30	32.74		1.40	50.39		106	3,236	
		9/22-10/2	1.74		34.48		2.11	52.50		158	3,394	
		8/31- 9/30				5.27			5.93			
	Oct.	10/2 -10/9		0.90	35.38		1.04	53.54		96	3,490	
		10/9 -10/21	1.29		36.67		1.72	55.26		172	3,662	
		10/21-11/3		1.04	37.71		1.65	56.91		135	3,797	
		9/30-10/31				3.22			4.49			
	Nov.	11/3 - 12/2	2.52		40.23		2.49	59.40				
		10/31-11/30				2.76			2.69			
	Dec.	12/2 - 1/5	2.01		42.24		1.76	61.16				
		11/30-12/31				1.87			1.68			
TOTALS		3/13- 1/5	23.78				34.28					
		3/13-10/21	19.25							2,069		

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

Year	Month	Period	Evapotranspiration			Pan evaporation			Atmometer evaporation			
			Meas- ured	Esti- mated	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.
1960	May	5/12- 5/31	2.98		2.98		5.58	5.58		354	354	
	June	5/31- 6/24		6.69	9.67		8.24	13.82		541	895	
		6/24- 7/1	1.01		10.68		1.93	15.75		138	1,033	
		5/31- 6/30				7.67			9.98			670
	July	7/1 - 7/8		1.44	12.12		2.27	18.02		151	1,184	
		7/8 - 8/1	4.56		16.68		7.13	25.15		488	1,672	
		6/30- 7/31				6.00			9.39			639
	Aug.	8/1 - 8/10		1.36	18.04		2.53	27.68		180	1,852	
		8/10- 9/1	5.27		23.31		5.56	33.24		402	2,254	
		7/31- 8/31				6.63			8.09			582
	Sept.	9/1 - 9/16		1.67	24.98		3.19	36.43		251	2,505	
		9/16- 9/22	1.58		26.56		1.19	37.62		98	2,603	
		9/22- 9/29		0.72	27.28		1.44	39.06		108	2,711	
		8/31- 9/30				4.10			6.13			480
	Oct.	9/29-10/27	2.42		29.70		3.85	42.91		341	2,052	
		9/30-10/31				2.59			4.08			372
	Nov.	10/27-11/18	0.87		30.57		1.60	44.51		179	3,231	
TOTALS		5/12-11/18	18.69				26.84			2,000		

Tulare Lake Basin Valley Floor
Cotton - Arvin - Plot CD

1959	May	4/30- 5/8		0.13	0.13		1.68	1.68		117	117	
		5/8 - 5/21	0.32		0.45		3.88	5.56		217	334	
		5/21- 6/3		1.54	1.99		3.76	9.32		210	544	
		4/30- 5/31				1.58			8.69			498
	June	6/3 - 6/16	1.88		3.87		4.19	13.51		252	796	
		6/16- 6/23		2.51	6.38		2.16	15.67		153	949	
		6/23- 6/30	2.67		9.05		2.11	17.78		126	1,075	
		5/31- 6/30				7.47			9.06			571
	July	6/30- 7/7	2.41		11.46		2.43	20.21		138	1,213	
		7/7 - 7/15		2.79	14.25		2.56	22.77		159	1,372	
		7/15- 7/28	4.55		18.80		4.02	26.79		236	1,608	
		6/30- 7/31				10.67			9.95			582
	Aug.	7/28- 8/4	2.31		21.11		2.23	29.02		126	1,734	
		8/4 - 8/11		1.86	22.97		2.15	31.17		131	1,865	
		8/11- 8/18	1.38		24.35		1.91	33.08		125	1,990	
		8/18- 8/25		1.50	25.85		1.63	34.71		106	2,096	
		8/25- 9/2	2.22		28.07		2.23	36.94		146	2,242	
		7/31- 8/31				7.76			8.67			548
	Sept.	9/2 - 9/24	3.85		31.92		4.18	41.12		338	2,580	
		8/31- 9/30				5.10			5.93			473

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

Year	Month	Period	Evapotranspiration				Pan evaporation			Atmometer evaporation		
			Meas- ured	Esti- mated	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.
1959	Oct.	9/24-10/19	3.68		35.60		4.21	45.33		372	2,952	
		Defoliated										
		10/19-11/4	0.36		35.96		2.01	47.34		163	3,115	
		9/30-10/31				2.95			4.49			41
	Nov.	11/4 -12/17	0.33		36.29		3.21	50.55				
		10/31-11/30				0.19			2.69			
TOTALS		5/8 -12/17	25.96				36.61					
		5/8 -11/4	25.63							2,239		

Tulare Lake Basin Valley Floor
Cotton - Arvin - Plot CP

1960	Mar.	3/18- 3/23		0.50	0.50		0.85	0.85				
		Planted 4/6										
	Apr.	3/23- 5/6	1.46		1.96		8.40	9.25		634	634	
		3/31- 4/30				0.83			5.82			43
	May	5/6 - 6/9	0.37		2.33		10.39	19.64		666	1,300	
		4/30- 5/31				0.31			8.72			57
	June	6/9 - 6/15	0.84		3.17		2.03	21.67		131	1,431	
		6/15- 6/20		1.81	4.98		1.82	23.49		124	1,555	
		6/20- 6/30	2.41		7.39		3.20	26.69		226	1,781	
		5/31- 6/30				5.31			9.98			67
	July	6/30- 7/7	1.94		9.33		2.13	28.82		138	1,919	
		7/7 - 7/15		2.63	11.96		2.54	31.36		179	2,098	
		7/15- 7/28	4.15		16.11		3.59	34.95		249	2,347	
		6/30- 7/31				10.14			9.39			63
	Aug.	7/28- 8/9		4.25	20.36		3.44	38.39		234	2,581	
		8/9 - 8/19	3.28		23.64		2.62	41.01		198	2,779	
		8/19- 8/23		1.43	25.07		1.34	42.35		86	2,865	
		8/23- 8/31	1.29		26.36		1.71	44.06		127	2,992	
		7/31- 8/31				8.87			8.09			58
	Sept.	8/31- 9/21	4.35		30.71		4.61	48.67		346	3,338	
		8/31- 9/30				5.04			6.13			48
	Oct.	9/21-10/14	1.79		32.50		3.96	52.63		318	3,656	
		Defoliated -10/19										
		9/30-10/31				1.03			4.08			37
	Nov.	10/14-11/22	0.94		33.44		3.45	56.08		365	4,021	
		10/31-11/22				1.02			1.89			28
TOTALS		3/23-11/22	22.82				46.09			3,398		

obtained during any one period of depletion is expressed in Table A-6 under the heading "Twice the Standard Error."

The effects of percent ground cover and, possibly, of stage of crop maturity and available soil moisture, are illustrated in Plate 3, which compares accumulated evapotranspiration of different crops. These measurements were made in the Arvin area under similar climatic conditions and on the same soil series. Differences in percent ground cover and possibly crop maturity and available soil moisture cause differences in slopes of the curves shown in Plate 3. Defoliation caused the abrupt changes in evapotranspiration rates reflected in the curves on cotton and plums. Alfalfa remains green at this location throughout the year, and shows little seasonal slope changes. It is of interest to note the much higher July and August rates of evapotranspiration by cotton, as compared to alfalfa and plums in both 1959 and 1960. A complete explanation for this cannot be presented; however, certain of the factors affecting evapotranspiration are discussed in the following chapter.



CHAPTER IV. CORRELATION OF EVAPOTRANSPIRATION DATA WITH AGROCLIMATIC DATA

To attempt concurrently to measure evapotranspiration of the many species of irrigated crops presently grown in California is impractical because of financial and manpower requirements. Likewise impractical is the measurement of evapotranspiration of a single crop at more than a few locations.

The most promising approach at this time appears to be to determine the important and measurable parameters affecting evapotranspiration rates, and to correlate actual measurements of evapotranspiration with those parameters. Three important parameters which appear independently to affect evapotranspiration are climate, plant conditions, including physiological factors, and soil moisture availability. Differences in the physical and chemical properties of soils and soil fertility are not considered to directly affect evapotranspiration, even though they may have indirect effects.

This chapter discusses the relationship of each of those parameters of evapotranspiration, and summarizes the analysis of data collected through 1960. In this regard, basic research on factors affecting evapotranspiration is being conducted by the University of California, as an integral part of the Vegetative Water Use Program. The Agricultural Research Service is also conducting basic research in this field. The results of these research programs have affected, and shall continue to influence, the course of these studies.

Evapotranspiration and Climatic Data

Climate in the evapotranspiration process can be thought of as a combination of evaporative elements, such as air temperature, wind, dryness of the air, and solar radiation. Other factors of climate, such as length of daylight, may be indirectly related to evaporation.

The energy sources for the evapotranspiration processes are derived principally from direct solar radiation and advection or exchangeable heat from the air. The evaporative demand of the atmosphere is largely a function of those two elements. However, not all of the solar radiation that falls directly on the plant or ground surface is used in evapotranspiration. A portion is reflected back into the atmosphere, a portion is utilized in heating the air, a portion is absorbed in heating the soil, and the balance is utilized in evapotranspiration and plant growth. It is likewise probable that the energy available from advection is not all utilized, depending upon many factors, such as vapor pressure deficit and extent of wind movement. Under certain conditions, it has been demonstrated that advective cooling, as well as advective heating may occur.

As the moisture content of the air increases through evaporation and/or transpiration, the moisture gradient (vapor pressure gradient) between an air mass and an evaporating surface becomes less steep and retards further moisture transfer. Under field conditions, the air mass near the ground is far from stable. Air movements act to mix moisture-saturated air near the evaporating

surface with drier air from above. Wind speeds and surface roughness influence the relative turbulence of the air, moving the moisture away from the evaporating surface and bringing in drier air to further the evaporation process. Thus, it is apparent that the evaporative demand of the atmosphere is determined by the interaction of several climatic elements.

Progress is being made in determining the relationships between the aforementioned climatic factors to arrive at a quantitative approach to estimating evapotranspiration.

Evapotranspiration and Plant Conditions

The term "evapotranspiration" implies the sum of evaporation plus transpiration. In the case of plants that are actively growing and well supplied with moisture, transpiration is related and responsive to climatic conditions. Evaporation from soils, however, is related more closely to, and limited by, the moisture content of the exposed soil surface than to climatic conditions. In most irrigated areas in California, rain is sparse during the growing season and, except for areas of high water tables, soil surfaces soon dry through evaporation following irrigation. As a result, under California irrigation conditions, transpiration is usually the larger of the two components comprising evapotranspiration.

The primary plant parameter affecting evapotranspiration rate appears to be the percent of ground cover. This is an important consideration when determining evapotranspiration for annual field crops, such as sugar beets and cotton, and for other

crops having variable ground cover percentages, such as alfalfa, which is cut frequently.

Crops having rapid growth rates and vigor tend to provide greater ground cover more rapidly than a slow-growing crop, even of the same species. Thus, differences in growth rate may affect evapotranspiration rates through the direct mechanism of percent of ground cover, although other physiological factors, such as stage of maturity or growth, may also affect evapotranspiration.

Evapotranspiration and Soil Moisture

Research findings relative to the effect of variations of available soil moisture upon evapotranspiration and plant growth are varied.

The amount of soil moisture available above the permanent wilting point does not seem to affect the evapotranspiration rate of crops, according to many research reports. Other research has indicated that maximum growth rates are obtained only under conditions of high moisture availability, and that growth rates and yields are retarded as soil moisture availability decreases. These concepts differ from other research investigations which have indicated a close relationship between evapotranspiration and plant growth. These concepts are of particular importance in considering if evapotranspiration rates are affected by low soil moisture levels which appear to affect growth rates, such as occur when irrigation is deliberately withheld from grapes and cotton to change their fruiting characteristics.

Besides intentional withholding of irrigation, there are also occasions of drought due to insufficient irrigation water

supplies. Due to the foregoing reasons, crops are frequently subjected to drought for periods of time varying from a few hours up to several weeks.

Therefore, in the studies reported here, an evaluation was made of the effect of available moisture upon evapotranspiration.

Available moisture was determined for the principal root zone for each crop from selected neutron probe soil moisture data. In the case of the alfalfa, a perennial crop, a single zone from 0-12 feet was used for the entire study. For cotton, an annual crop, the zone was increased from the 0-1-foot depth to the 0-11-foot depth as the crop grew and the root system developed and expanded. The results of the evaluations are discussed further under the sections on crop coefficients.

Other Factors Affecting Evapotranspiration

Soil fertility and other physical factors of the soil, such as texture, structure, salinity, and even color, affect the growth rate of a crop. Soil properties, such as texture, structure, and salinity may also affect, to some degree, moisture movement and utilization. These factors have an undetermined, and probably much lesser, effect on evapotranspiration than drought, climate, and plant conditions.

Determination of Coefficients

Results of various research projects have indicated that the processes of evapotranspiration and evaporation are both responsive to the same factors. As will be discussed in ensuing

paragraphs, a definite relationship exists between evapotranspiration and rates of evaporation from pans or atmometers. This relationship is considered fundamental to estimating evapotranspiration for other crops and in other agricultural areas throughout the State.

The ratio of evapotranspiration (ET) to evaporation from an evaporation pan (Ep) is referred to as a "pan coefficient" (ET/Ep); in like manner, the ratio of evapotranspiration to net atmometer evaporation, or the difference of evaporation from a black and white Livingston Spherical Atmometer (Eb-w), is referred to as the "atmometer coefficient" (ET/eb-w).

Pan and/or atmometer coefficients for individual evapotranspiration measurement periods for the various plots sampled are shown in Appendix A in Tables A-6 and A-7. A casual examination of these individual periods reveals wide variations which would appear to discount the validity of such comparisons. However, a more detailed analysis of the data indicates that certain relationships do exist, and upon such relationships tentative values can be established. Certain variations of the pan and atmometer coefficients from time to time are caused by plants responding differently to evaporation influences than do pans and atmometers. Likewise, variations in the coefficients were due also to individual differences in the response of atmometers or pans to these climatic influences.

Analysis of data for each individual crop and the conclusions drawn therefrom are discussed in the following paragraphs

Grass and Pasture Coefficients

Pan and atmometer coefficients have been determined using data from grass and grass-pasture evapotranspirometer tanks located in the Sacramento River Basin mountain valleys, in the Lassen-Alpine mountain area, and in the Sacramento Valley floor (Alturas, Coleville, and Davis).

Graphs of coefficients and percent of ground cover for pasture and grass, plotted against time, are presented in Figures A through E of Plate 4, entitled "Variation of Pan and Atmometer Coefficients for Individual Periods of Measurements." Percent of ground cover is relatively constant for those crops, and wide variations of the coefficients occur less than with alfalfa and cotton. During the growing period, the grass was at nearly 100 percent ground cover in all of the evapotranspirometer tanks, as mowings did not clip the foliage short enough to cause large reductions in ground cover. While the ground was always sod-covered, the colder climate at the mountain sites caused dormancy to some degree during late fall, winter, and early spring. Approximate ground cover percentages indicated on Figures A, B, and E of Plate 4 are for the green and actively growing fraction of the foliage. At Davis, the climate is not cold enough to force the grass completely into winter dormancy. Occasionally at the Davis site, however, small areas of ground surface were exposed throughout the year, as indicated on Plate 4, Figures C and D.

High water table conditions, typical of the predominant irrigation practice in the mountain valleys, were maintained in the Alturas and Coleville tanks. There was, therefore, no

moisture shortage at these sites. The evapotranspirometer tanks and ryegrass field at Davis were frequently irrigated, and it is probable that soil moisture was not limiting there. Availability of soil moisture is assumed to have had little effect on evapotranspiration rates and coefficients at any of the three sites.

Seasonal accumulated evapotranspiration plotted against accumulated pan evaporation and, except for Davis, accumulated atmometer evaporation are shown on Plate 5, entitled "Comparison of Pan and Atmometer Coefficients for Cotton, Alfalfa, and Grass," Figures E and F. Each curve is for an individual year, and has separate zero lines for plotting evapotranspiration. Evaporation from pans or atmometers was plotted using the date of June 30 as the common point on all curves. Coefficients for the period of record for both years were consistently similar for Alturas for both pan and atmometer. The pan coefficient for the period of record at Davis was likewise similar.

Coefficients from three seasons of record in the mountain areas, combining Alturas and Coleville, are compared with coefficients from Davis in Table 6. Coefficients are shown for both the growing seasons assumed in Bulletin No. 2 and for the longer period for which data were obtained. The reason for the differences between the valley and mountain coefficients has not been ascertained.

Alfalfa Coefficients

Pan and atmometer coefficients have been determined from an alfalfa plot located near Pittville in the Sacramento River Basin mountain valleys, and from an alfalfa plot near Arvin in the Tulare Lake Basin Valley floor at the southern end of the Central Valley

PAN AND ATMOMETER COEFFICIENTS FOR PASTURE AND GRASS

Month	Pan Coefficients			Atmometer Coefficients			
	Sacramento River Basin Valley Floor (Davis Campbell 1959 & 1960)	Mountain Valleys ^{1/} (Alturas Dorris Ranch 1959 & 1960 Coleville 1957)	No. Days : of Record :	Sacramento River Basin Valley Floor (Davis Campbell 1959 & 1960)	Mountain Valleys ^{1/} (Alturas Dorris Ranch 1959 & 1960 Coleville 1957)	No. Days : of Record :	
January	63	0.64	--	--	--	--	
February	52	0.75	--	--	--	--	
March	67	0.72	--	--	--	--	
April	44	0.74	46	0.81	11	0.0125	
May	54	0.74	65	0.90	33	0.0132	
June	7	0.75	74	1.00	--	--	
July	47	0.72	96	1.04	47	0.0127	
August	33	0.77	92	1.00	29	0.0108	
September	29	0.68	83	0.90	31	0.0100	
October	31	0.64	64	0.87	10	0.0060	
November	33	0.51	10	0.45	--	--	
December	26	0.52	30	1.21	--	--	
Average Coefficient for Growing Season ^{2/}	245	0.72 ^{a/}	410	0.98 ^{b/}	151	0.0120 ^{c/}	325
Period of Record	486	0.71	560	0.96	161	0.0117	328

^{1/} Mountain Valleys = Sacramento River Basin Mountain Valleys and Lassen-Alpine Mountain Valleys.

^{2/} For growing season periods used in Bulletin No. 2.

^{a/} April-October

^{b/} May-September

* ET/Ep = Pan Coefficient, ET/Eb-w = Atmometer Coefficient

One of the most notable details of the alfalfa coefficients determined from both areas is the variation associated with percentage of ground cover. It is important to point out that the method of collecting data on percentage of ground cover was subjective, being based upon personal judgment, and that estimates by individual observers differ by perhaps 5 to 15 percent. There is, however, general agreement that following mowing the ground cover is usually reduced to 5 to 10 percent, and that ground cover usually approaches 100 percent cover prior to mowing. Although there are exceptions due to possible experimental error and other factors, the coefficients are smaller when the ground cover is low following mowing, and become larger as the ground cover increases. Plate 4, Figures F, G, H, and I, illustrate these relationships between coefficients and percent of ground cover, plotted against time.

A more direct comparison of pan and atmometer coefficients with percent of ground cover is shown in Plate 6, entitled "Relationship Between Pan and Atmometer Coefficients for Alfalfa and Ground Cover." Figure A shows atmometer coefficients, and Figure B shows pan coefficients. The data for both figures were the same utilized in Plate 4. As indicated in Plate 6, the Pittville coefficients appear to be higher than the Arvin coefficients. Two linear regression lines have been fitted to the data. However, it may be that additional data will indicate a somewhat curvilinear relation. It seems reasonable to assume that coefficients at 100 percent of ground cover would not be proportionally higher than coefficients at 80 percent of ground cover, which, for practical purposes, also provide nearly complete shade, except near noonday.

Since the soil at both plot sites was deep, and alfalfa is a perennial crop, moisture in the 0-12-foot zone was used to estimate available soil moisture.

The lowest moistures occurred at the Pittville plot, where on several occasions the available moisture was reduced to less than 2 inches in the 12 feet, or less than 0.2 inch of moisture per foot of soil, on the average. When this condition occurred, the upper portion of the profile was usually relatively drier than the deeper soil. On several of these occasions, crop growth at the Pittville plot was slow, and considerable flower blooms and dark blue-green leaf color associated with moisture deficiency appeared. As indicated on Figures F and G of Plate 4, low available soil moisture may account for some of the smaller coefficients noted prior to mowing. The Arvin plot, in contrast, was very well supplied with soil moisture. As shown on Figures H and I, the available moisture at Arvin ranged above 1 and up to 2 inches per foot during the measurement periods.

If evapotranspiration were reduced by low available soil moisture, the pan and atmometer coefficients would be smaller. This does not appear to be the case for the Pittville plot, although several of the coefficients just prior to mowing are smaller than would be expected, considering the percent of ground cover. Overall, the pan and atmometer coefficients of the Pittville data are as high, if not higher, than the Arvin coefficients, regardless of the lower soil moistures at Pittville.

Since coefficients from the Pittville and Arvin plots show monthly variations reflecting mowing schedules, farm practices,

and, perhaps, effects of plant growth environments, it is deemed best to compare seasonal rather than monthly coefficients.

Seasonal coefficients have been determined for periods when evapotranspiration measurements were made using data shown in Table 5, and are summarized here as follows:

Seasonal Alfalfa Coefficients Determined
From Measured Periods Only

	<u>Pan Coefficient</u>		<u>Atmometer Coefficient</u>	
	<u>1959</u>	<u>1960</u>	<u>1959</u>	<u>1960</u>
Pittville	nr	0.82	0.0125	0.0127
Arvin	0.69	0.70	0.0093	0.0093

In order to take into account the possibility that the sampling periods could be biased and not representative of ground cover conditions, and also to include estimated evaporation increments following irrigations, estimates of evapotranspiration were made for the irrigation periods. These estimates fill in the missing records. Seasonal coefficients determined from these data are summarized as follows:

Seasonal Alfalfa Coefficients,
Including Estimated Data

	<u>Pan Coefficient</u>		<u>Atmometer Coefficient</u>	
	<u>1959</u>	<u>1960</u>	<u>1959</u>	<u>1960</u>
Pittville	nr	0.82	0.0123	0.0125
Arvin	0.69	0.69	0.0099	0.0095

The close similarity between the coefficients determined from the measured periods as compared with the total seasonal period of record, including estimated periods, indicates that the

measured periods are not biased, and the seasonal coefficients appear to be reasonable. Curves of seasonal accumulated evapotranspiration versus evaporation are shown on Plate 5, Figures C and D. As noted previously, each curve on Plate 5 is plotted for an individual year, with separate zero lines for indication of evapotranspiration. Evaporation from pan and atmometers was plotted, using the date of June 30 as the common point on all curves.

The pan and atmometer coefficients derived after combining the two years of record at the Pittville AA plot are shown in Table 7, and are compared with coefficients derived in the same manner at the Arvin CC plot. For purposes of comparison, average coefficients were determined not only for the period of record, but also for the growing season, as shown in Bulletin No. 2.

By any method of determining seasonal coefficients, the Pittville pan coefficient is approximately 17 percent higher than the Arvin coefficient, and the Pittville atmometer coefficient is approximately 27 percent higher than the Arvin coefficient. Whether the difference is due primarily to basic climatic differences between the two areas, which affect different plant and evaporation response, or due to experimental error, is not known at this time.

Cotton Coefficients

Pan and atmometer coefficients for cotton for each period of measurement during 1959 and 1960 are shown in Figures J and K of Plate 4. Also shown are estimates of the percent of ground cover, available moisture, and other factors affecting plant growth and water use. There is a rather close agreement between the two years

TABLE 7
PAN AND ATMOMETER COEFFICIENTS FOR ALFALFA

Month	Pan Coefficients			Atmometer Coefficients			
	Tulare Lake Basin (Arvin (CC) 1959 & 1960)	Sacramento River Basin (Pittville (AA) 1960 only)	No. Days : of Record :	Tulare Lake Basin (Arvin (CC) 1959 & 1960)	Valley Floor (Pittville (AA) 1959 & 1960)	No. Days : of Record :	Sacramento River Basin (Pittville (AA) 1959 & 1960)
	ET/Ep*	ET/Ep	ET/Ep**	ET/Ep	ET/Ep**	ET/Ep-w	ET/Ep-w
January	--	--	--	--	--	--	--
February	--	--	--	--	--	--	--
March	18	0.53	21	18	0.0065	19	0.0108
April	30	0.64	30	30	0.0095	60	0.0104
May	51	0.52	31	51	0.0088	62	0.0110
June	60	0.71	30	60	0.0109	62	0.0127
July	62	0.64	31	62	0.0101	60	0.0129
August	62	0.76	31	62	0.0112	60	--
September	60	0.78	30	60	0.0098	60	--
October	62	0.88	31	62	0.0074	60	--
November	47	0.88	8	17	0.0046	--	--
December	31	1.11	--	--	--	--	--
Average Coefficient for Growing Season ^{1/}	295	0.68a/	153	387	0.0099a/	263	0.0121b/
Period of Record	483	0.69	243	422	0.0097	--	--

^{1/} For growing season periods used in Bulletin No. 2.

^{a/} April-October

^{b/} May-September

* ET/Ep = Pan Coefficient, ET/Ep-w = Atmometer Coefficient

in regard to the general pattern of plant growth and the relationships of the coefficient with the various factors affecting water use. The soil moisture observations are believed to be of reliable quality, particularly for the 1960 data, where a dry soil zone was maintained at depth below the root zone, assuring that no deep percolation of irrigation water occurred.

Coefficients for individual period of measurements show a pattern of progressive increase from the low early season value to a peak in July, and then a progressive decrease to the year's end. The differences in coefficients during the early season emphasized the direct relationship between the evapotranspiration and percent of ground cover. The decreasing pattern of coefficients after July reflects the integrated effect of decreasing ground cover, physiological aging of the plants, and availability of soil moisture.

It is of interest that, although ground cover on these plots reached 80 and 95 percent, the maximum coefficients were reached at a ground cover of about 60 percent. This corresponds in time to the boll setting. It is believed that physiological factors may have had an influence on the transpiration rate at this stage of plant development. Physiological factors are believed to have caused similar effects in other crops. With small grains, for example, peak water use rates are reported to occur at the heading stage.

Late-season use of water by cotton is dependent to some extent upon the amount of moisture available prior to natural or

induced defoliation. The plants will generally use all available moisture within the root zone. The amount of use is a function of the amount of moisture available. This is to say that the availability of soil moisture is often the limiting factor in the late-season evapotranspiration. This also may account, in part, for the August-September coefficients being lower than the July coefficient.

Early- or late-season precipitation, although a part of evapotranspiration and reflected in the pan and atmometer coefficients, is, quite often, not a beneficial source of moisture to the plants. Early-season precipitation is evaporated from the soil surface with little gainful effect upon plant growth. Late-season precipitation is either evaporated from the soil or vegetative surface, and/or transpired by the plant without contributing substantially to the plant cultural requirements. Thus, pan and atmometer coefficients for early and late season must be applied with caution and only after a thorough evaluation of rainfall amount, frequency and pattern, as well as knowledge of the late-season availability of soil moisture.

Based on the information summarized in Table 5, monthly pan and atmometer coefficients for the two years of record have been determined, and are shown on Figures A and B on Plate 5. There is, in general, rather close agreement between the monthly pan or atmometer coefficients for both 1959 and 1960. There are also several indications that evapotranspiration for cotton sometimes exceeds evaporation from pans. The July pan coefficients for 1959 and 1960 were respectively 1.07 and 1.08, which indicates that evapotranspiration exceeds evaporation from the free-water

surface. It is believed that the crop surface roughness may, through greater air mixing, be one of the influencing factors.

Average monthly pan and atmometer coefficients for cotton for the two years of record are presented in Table 8. For purposes of comparing with Bulletin 2 estimates, an average coefficient for the Tulare Lake Basin Valley Floor Hydrographic Units was determined for the growing season used in Bulletin 2. For the period from May through October, the active growing season, the average pan coefficient is 0.68, and the atmometer coefficient is 0.0098. The monthly coefficients for the period from June through September are considered to be primarily the effect of climatic evaporative demand and crop conditions, and are not subject to the influence of early-or late-season nonbeneficial uses.

Application of Coefficients and Evaporation Data to Estimation of Evapotranspiration

Using the average pan or atmometer evaporation observed in each area, as shown in Tables 2 and 3 in Chapter II, and applying the appropriate pan or atmometer coefficients as described in Tables 6, 7, and 8, estimates of monthly consumptive use values were made for several crops. These monthly estimates are summarized in Table 9, and are compared with values utilized in Bulletin 2, "Water Utilization and Requirements in California," published by the department in 1955. To make the comparison with Bulletin 2 values valid, the growing seasons used in Bulletin 2 were used in all calculations for Tables 6 through 9. In general, the estimates based upon the pan and atmometer coefficients are approximately equal to or greater than the Bulletin 2 values. This is also true where measured values of consumptive use are available. This, in

TABLE 8

PAN AND ATMOMETER COEFFICIENTS FOR COTTON

Month	Pan Coefficients		Atmometer Coefficients	
	Tulare Lake Basin Valley Floor		Tulare Lake Basin Valley Floor	
	(Arvin (CD) 1959)		(Arvin (CD) 1959)	
	Arvin (CF) 1960		Arvin (CF) 1960	
	No. Days		No. Days	
	of Record	ET/Ep*	of Record	ET/Eb-w*
January	--	--	--	--
February	--	--	--	--
March	8	0.75	--	--
April	30	0.14	30	0.0019
May	62	0.11	62	0.0018
June	60	0.67	60	0.0103
July	62	1.08	62	0.0170
August	62	0.99	62	0.0147
September	60	0.84	60	0.0106
October	62	0.46	62	0.0051
November	60	0.26	60	0.0023
December	62	0.15	--	--
Average Coefficient for Growing Season ^{1/}	398	0.68 ^{a/}	398	0.0098 ^{a/}
Period of Record	--	--	--	--

^{1/} For growing season periods used in Bulletin No. 2, Tulare Lake Basin Valley Floor hydrographic units.

^{a/} April-October

* ET/Ep = Pan Coefficient, ET/Eb-w = Atmometer Coefficient

COMPARISON OF SEASONAL CONSUMPTIVE USE
OF ALFALFA, PASTURE, AND COTTON
BASED ON BULLETIN NO. 2 GROWING SEASON

(in inches)

Area	Alfalfa		Pasture-Grass		Cotton						
	Based on : Pan Data: #2 :Data										
Klamath-Trinity Mountain Valleys	34.77	32.66	27.41	--	40.56	38.98	27.41	--	--	--	--
Sacramento River Basin Mountain Valleys	31.71	31.93	25.15	35.11	37.00	38.11	25.15	37.79	--	--	--
Sacramento River Basin Foothills	28.44*	27.94	29.65	--	29.69*	30.66*	29.65	--	--	--	--
	35.13**	33.64	29.65	--	40.98**	40.15**	29.65	--	--	--	--
Sacramento River Basin Valley Floor	37.50	34.40	36.48	--	39.70	39.96	36.48	45.11	--	--	--
San Joaquin River Basin Valley Floor	38.79	34.61	35.84	--	41.08	40.19	35.84	--	36.49	31.28	23.43
Tulare Lake Basin Valley Floor	35.35	34.45	37.14	35.87	37.42	40.03	37.14	--	33.43	32.24	28.78
Lassen-Alpine Mountain Valleys	35.98	32.00	27.24	--	41.98	38.20	27.24	--	--	--	--

* Calculated using valley coefficient.

** Calculated using mountain coefficient.

itself, does not prove that the estimates based upon pan and atmometer coefficients are more accurate. Additional supporting data shall be required to confirm this possibility.

Examination of the data in Table 9 indicates that estimates of consumptive use can be made with equal confidence, on the basis of either pan or atmometer data. It should be emphasized also that the consumptive use values must be determined for the actual period of active plant growth. The actual growing season for most crops in the various areas of the State still remains to be determined. Furthermore, a careful analysis of precipitation pattern, frequency, and amounts must be made for both growing and nongrowing seasons, to determine the effectiveness of this moisture source toward meeting the water demand of the various crops.

CHAPTER V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents a concise summary of the vegetative water use studies, the conclusions drawn therefrom, and recommendations with regard to the future lines of study.

Summary

Precise knowledge of the total seasonal as well as the distribution pattern of water use throughout the year is basic to the planning, design, and operation of comprehensive water development projects. In developing this essential knowledge, the department has been engaged in studies directed toward determination of evapotranspiration. During the period from 1954 to 1960, these studies were limited to certain geographic regions of northern and central California.

Accurate measurement of evapotranspiration is so complex and costly that practical considerations limit collection of these data to relatively few locations. Recent research work by various groups throughout the world has pointed out certain fundamental relationships between the evapotranspiration process and climatic factors. Transpiring crops respond to the same energy sources as evaporation devices. The response of crops, however, is modified by physical and physiological characteristics. Under any given climatic condition, factors such as availability of soil moisture, percent of vegetative ground cover, and physiological development control the rate of evapotranspiration.

The approach taken in these studies has been to study at a few locations the relationship between measured evapotranspiration, under specified crop conditions, and certain climatic indices. Concurrently with the measurement and correlation of evapotranspiration and climatic factors, a network of agroclimatic stations was established and observed throughout the several major inland agricultural areas in northern and central California. Having determined evaporation at these stations, estimates of evapotranspiration can be extrapolated into these areas by using the relationship between evapotranspiration and evaporation data measured at the key evapotranspiration stations.

In the early years of these studies, available knowledge on climatic station environmental requirements was very meager. However, as data were collected and analyzed, the importance of certain environmental effects became apparent. Stations were relocated to sites where they were surrounded by an extensive area of vigorous, low-growing vegetation at full ground cover. Large, well-managed pastures best meet these requirements. At such sites, the confounding effects of micro-environment differences are minimized.

The techniques used for the determination of evapotranspiration were the best available methods for the task, at the time they were employed. However, as the study progressed, techniques were modified to take advantage of new and better tools as they became available. The initial soil moisture measurements to determine evapotranspiration were made by the

gravimetric technique. The development and refinement of the neutron scattering technique offered promise of a far superior method of making soil moisture determinations. For this reason, this new equipment was adopted shortly after it became commercially available.

Small evapotranspirometer tanks of various designs were installed and used where high-water table conditions prohibited the use of soil moisture depletion techniques, and were later installed on sites where no high water tables existed. The success of these devices has encouraged the extension of this method to other close growing crops.

Estimates of evapotranspiration were made for all areas studied, using pan and atmometer coefficients and evaporation data collected as part of the agroclimatic program. These estimates were compared to Bulletin 2 consumptive use values, using the Bulletin 2 growing seasons. In many cases, the estimates obtained by using the evaporation correlation technique were higher than were the Bulletin 2 values.

Data collected at the evapotranspiration field plots indicate that the actual periods of active growth are considerably longer than those assumed in the determination of Bulletin 2 values. On a yearly basis, the estimates shown in this report may show even a greater variance with Bulletin 2 values.

As the estimated values presented in this report are based upon only two years of record, they should be used with considerable caution. However, the evaporation correlation

technique appears to promise a reasonable means of estimating, with precision heretofore unknown, evapotranspiration rates for crops in the various geographic areas of California.

Conclusions

1. Correlation of evaporation with evapotranspiration appears to promise a reasonable means of estimating evapotranspiration within the various agricultural area of the State.

2. Reasonable estimates may be obtained by using either pan, or atmometer coefficients.

3. Pan and atmometer coefficients are strongly influenced by percent of ground cover, particularly for ground cover percentage less than (60%) sixty percent.

4. Estimated values presented in this report are based upon only two years of record, and so should be used with considerable judgment.

5. On the basis of the agroclimatic data collected, no definite segregation of the State into areas of uniform evaporation is possible at present. Inland areas appear to have more uniform evaporation rates than expected, although effects of microenvironment cause large differences of evaporation between individual measurement sites.

6. It may be found that the length of growing season is the most important factor affecting seasonal evapotranspiration in inland areas.

Recommendations

On the basis of the collection and analysis of the data on vegetative water use, as presented in this report, and on the conclusions drawn therefrom, it is recommended that:

1. The evapotranspiration studies at the present sites be continued until sufficient data can be collected to provide reasonable estimates of evapotranspiration under the range of climatic conditions which can occur at these locations.

2. Additional sites for evapotranspiration measurements be established in locations having different climatic conditions than those now being measured to determine variability of evapotranspiration coefficients (i.e., Delta area, coastal areas, and desert areas).

3. The scope of the present program be expanded to include measurements of applied water under different irrigation practices and lengths of growing seasons for major crops within the various agricultural zones of the State. This would provide the basic information needed to determine irrigation efficiencies, drainage requirements, and, with the unit evapotranspiration values, to determine total irrigation water requirements.



APPENDIX A

Supplemental Agroclimatic and Evapotranspiration Data

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TABLE A-1

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	MDB&M	County	Location	Description	Elevation, in feet	Observer	Evaporation equipment	Irriga- tion method
<u>NORTH COASTAL</u>								
<u>KLAMATH, TRINITY MOUNTAIN VALLEYS</u>								
<u>Pasture</u>								
Montague 3NE	T45N R6W	Siskiyou	3 mi. NE of Montague		2600	DWR	x	Surface
<u>Alfalfa</u>								
Callahan Towne Ranch	T41N R9W	Siskiyou	5 mi. N of Callahan		2891	DWR	-	Surface
Gazelle 3NW	T43N R6W	Siskiyou	3 mi. NNW of Gazelle		2720	DWR	x	Sprinkler
Grenada 6E	T44N R5W	Siskiyou	6 mi. E of Grenada		2640	DWR	-	Surface
<u>Dryland</u>								
Fort Jones R. S.	T43N R9W	Siskiyou	Town of Fort Jones		2720	USFS	x	--
Gazelle 1NE	T43N R6W	Siskiyou	1 mi. NNE of Gazelle		2720	DWR	x	--
Hayfork R. S.	T31N R12W	Trinity	1 mi. E of Hayfork		2346	USFS	-	--
Macedoel F. S.	T46N RLW	Siskiyou	Town of Macedoel		2718	CDF	x	--
Yreka 1NE	T45N R7W	Siskiyou	1 mi. NE of Yreka		2625	DWR	x	--
<u>CENTRAL VALLEY</u>								
<u>SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS</u>								
<u>Pasture</u>								
Alturas Dorris Ranch	T42N RL3E	Modoc	2 mi. SE of Alturas		4450	DWR	x	Surface
Fall River Mills 4NW	T37N R1E	Shasta	4 mi. NW of Fall River Mills		3500	DWR	x	Sprinkler
Glenburn DWR	T37N R4E	Shasta	1/2 mi. SSE of Glenburn		3500	DWR	x	Surface
Hat Creek 3N	T34N R4E	Shasta	3 mi. N of Hat Creek		3350	DWR	-	Surface
Likely Williams Ranch	T40N, RL3E	Modoc	3 mi. N of Likely		4400	DWR	-	Surface
Lookout Hunt	T39N R7E	Lassen	3 mi. S of Lookout		4200	DWR	x	Surface

TABLE A-1 (continued)

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	MISAM	County	Location	Description	Eleva- tion, in feet	Ob- serva- tion	Evapora- tion, equipment	Irriga- tion method
<u>SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)</u>								
<u>Alfalfa</u>								
Bieber 4E	T38W R9E	Lesser	4 mi. E of Bieber		4200	DMR	-	Sprinkler
Canby 11SW	T43W R8E	Modoc	11 mi. SW of Canby		4500	DMR	-	Surface
Hat Creek 3SE	T33W R4E	Shasta	3 mi. SE of Hat Creek		3660	DMR	-	Surface
Lookout 1S	T39W R7E	Lesser	1 mi. S of Lookout		4200	DMR	-	Surface
McArthur 2E	T37W R5E	Shasta	2 mi. E of McArthur		3325	DMR	-	Surface
Pittville 1S	T37W R5E	Shasta	1 mi. S of Pittville		3300	DMR	-	Sprinkler
<u>Dryland</u>								
Adin Harper	T39W R9E	Modoc	2 mi. NE of Adin		4200	DMR	-	-
Alturas Park Avenue	T42W R13E	Modoc	Town of Alturas		4440	DMR	-	-
Bieber S.C.S.	T38W R7E	Lesser	Town of Bieber		4169	USDA	-	-
Big Sage Reservoir	T43W R11E	Modoc	South side of reservoir		4400	DMR	-	-
Canby 01W	T42W R9E	Modoc	1 mi. W of Canby		4310	DMR	-	-
Canby R. S.	T42W R10E	Modoc	Town of Canby		4310	USFS	-	-
Davis Creek 4NW	T45W R13E	Modoc	4 mi. NW of Davis Creek		5000	DMR	-	-
Fall River Mills Intake	T37W R6E	Shasta	1 mi. W of Fall River Mills		3325	FOAE	-	-
Fall River Mills R.S.	T37W R5E	Shasta	Town of Fall River Mills		3325	USFS	-	-
Lisely 4W	T40W R13E	Modoc	4 mi. W of Likely		4400	DMR	-	-
Loyalton 5W	T22W R15E	Sierra	5 mi. W of Loyalton		4680	DMR	-	-
Loyalton 7W	T22W R15E	Sierra	7 mi. W of Loyalton		4680	DMR	-	-
Mt. Shasta City W.B.	T32W R4W	Plumas	Town of Mt. Shasta		3554	USFS	-	-
Quincy R.S.	T24W R9E	Plumas	Town of Quincy		3442	USFS	-	-
West Valley Reservoir	T39W R16E	Modoc	7 mi. E of Likely		5500	DMR	-	-
<u>Miscellaneous</u>								
Adin R.S.	T39W R9E	Modoc	Town of Adin		4200	USFS	-	-

TABLE A-1 (continued)

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	NDBM	Location		Eleva- tion in feet	Ob- serv- ers	Pan:Atometers	Evapora- tion equipment	Irriga- tion method
		County	Description					
<u>CENTRAL VALLEY (continued)</u>								
<u>SACRAMENTO RIVER BASIN FOOTHILLS</u>								
<u>Pasture</u>								
Auburn Mt. Vernon	TL3N R7E 25E1	Placer	7 mi. NW of Auburn	1085	DWR	-	x	Sprinkler
Gold Hill Doty Flat	TL2N R7E 12D1	Placer	2 mi. NW of Newcastle	730	DWR	x	x	Surface
Loma Rica	TL7N R5E 34J1	Yuba	3½ mi. NE of Browns Valley	439	DWR	x	x	Surface
Penn Valley	TL6N R7E 28H1	Nevada	6 mi. E of Smartville	1388	DWR	x	x	Surface
<u>Dryland</u>								
Bella Vista 4NE	T33N R3W 27E1	Shasta	4 mi. NE of Bella Vista	960	CPF	x	x	Surface
Browns Valley 3NE	TL6N R5E 12H1	Yuba	3 mi. NE of Browns Valley	388	DWR	x	-	--
Newville	T22N R6W 2E1	Glenn	1 mi. E of Newville	650	DWR	x	x	--
<u>SACRAMENTO RIVER BASIN VALLEY FLOOR</u>								
<u>SACRAMENTO RIVER BASIN VALLEY FLOOR</u>								
<u>Pasture</u>								
Anderson 4E	T30N R3W 17F1	Shasta	4 mi. E of Anderson	390	DWR	x	x	Surface
Corning 3NE	T24N R3W 12E1	Tehama	3 mi. NE of Corning	240	DWR	x	x	Surface
Davis Campbell #1	T3N R2E 17K1	Yolo	Univ. of Calif. farm	50	DWR	-	x	Surface
Elk Grove 4NW	T7N R5E 28E1	Sacramento	4 mi. NW of Elk Grove	23	DWR	x	x	Surface
Lincoln Vineyard	TL3N R6E 26G1	Placer	5 mi. N of Lincoln	270	DWR	x	x	Surface
Palermo 3SW	TL8N R4E 19D1	Butte	3 mi. SW of Palermo	169	DWR	x	x	Surface
Red Bluff Cone Ranch	T27N R2W 30D1	Tehama	5 mi. E of Red Bluff	275	DWR	x	x	Surface
Yuba City 9W	TL5N R2E 21R1	Sutter	9 mi. W of Yuba City	42	DWR	x	x	Surface
<u>Alfalfa</u>								
Anderson 2E	T30N R3W 18G1	Shasta	2 mi. E of Anderson	390	DWR	-	x	Surface
Anderson 3E	T30N R3W 17M1	Shasta	3½ mi. E of Anderson	390	DWR	-	x	Surface
Arbuckle 1S	TL3N R2W 11E1	Colusa	1 mi. S of Arbuckle	191	DWR	-	x	Sprinkler
Corning Jobe	T24N R3W 20D1	Tehama	2 mi. W of Corning	307	DWR	-	x	Surface

TABLE A-1 (continued)

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	MOB&M	County	Location	Description	Elevation, in feet	Ob- server ^a	Evapora- tion	Equip- ment	Irriga- tion
<u>CENTRAL VALLEY (continued)</u>									
<u>SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)</u>									
<u>Alfalfa (continued)</u>									
Hamilton City	T22N R1E 20W1	Glenn	1 mi. N of Hamilton City		150	DMR	-	x	Surface
Red Bluff 3E	T27N R3W 23J1	Tehama	3 mi. E of Red Bluff		270	DMR	-	x	Surface
Rocklin Igarashi	T11N R7E 29C1	Placer	1 mi. SE of Rocklin		310	DMR	-	x	Sprinkler
Vina Beck	T24N R2W 23Q1	Tehama	2 mi. S of Vina		188	DMR	-	x	Surface
Yuba City	T15N R2E 22D1	Sutter	9 mi. W of Yuba City		46	DMR	-	x	Surface
<u>Dryland</u>									
Davis Campbell #2	T6N R2E 17K1	Yolo	Univ. of Calif. farm		50	DMR	-	x	--
Mills Orchard	T22N R3W 26F1	Glenn	2 mi. W of Hamilton City		175	DMR	-	x	--
Oroville Agric. Com.	T19N R4E 6M1	Butte	1 mi. NW of Oroville		270	DMR	x	x	--
Redding 6SE	T31N R4W 15Q1	Shasta	6 mi. SE of Redding		515	DMR	-	x	--
Redding Stayer	T31N R4W 15K1	Shasta	6 mi. SE of Redding		510	DMR	-	x	--
Sacramento Refuge	T18N R3W 10F1	Glenn	6 mi. S of Willows		96	DMR	-	x	--
<u>Miscellaneous</u>									
Corning 3NW	T24N R3W 8K1	Tehama	3 mi. NW of Corning		307	DMR	-	x	--
Live Oak 3SE	T16N R3E 10R1	Yuba	3 mi. SE of Live Oak		70	DMR	-	x	Surface
Pennington 3NW	T17N R1E 15K1	Butte	3 mi. NW of Pennington		60	DMR	x	x	Marsh
Redding A.P.	T31N R4W 27K1	Shasta	7 mi. SE of Redding		500	DMR	-	x	Sprinkler
Redding R.S.	T31N R5W 10D1	Shasta	Town of Redding		500	CAP	-	x	Sprinkler
Richvale 1E	T19N R2E 23D1	Butte	1 mi. E of Richvale		105	DMR	-	x	--
<u>SAN JOAQUIN RIVER BASIN VALLEY FLOOR</u>									
<u>Pasture</u>									
Berenda 2W	T10S R17E 8P1	Madera	2 mi. N of Berenda		270	DMR	-	x	Surface
El Solyo Ranch	T4S R7E 5J1	Stanislaus	4 mi. SE of Vernalis		35	DMR	-	x	Surface

TABLE A-1 (continued)

AGROCLIMATIC STATIONS.
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	MDBM	County	Location	Description	Eleva- tion, in feet	Ob- serve ^s	Evapora- tion equipment	Irriga- tion method
<u>CENTRAL VALLEY (continued)</u>								
<u>SAN JOAQUIN RIVER BASIN VALLEY FLOOR (continued)</u>								
<u>Pasture (continued)</u>								
Lodi 35W	T3N R6E 2791	San Joaquin	3 mi. SW of Lodi		29	DWR	x	Surface
Merced 5SE	T6S R15E 6E1	Merced	5 mi. SE of Merced		198	DWR	x	Surface
Newman 1SE	T7S R9E 29E1	Merced	1 mi. SE of Newman		87	DWR	x	Surface
Stockton 9S	T1S R7E 19H1	San Joaquin	9 mi. S of Stockton		27	DWR	x	Surface
Thornion 2S	T4N R5E 15H1	San Joaquin	2 mi. S of Thornion		7	DWR	x	Surface
<u>Alfalfa</u>								
Atwater 1N	T7S R12E 35P1	Merced	1 mi. N of Atwater		150	DWR	-	Sprinkler
Ceres 3E	T4S R10E 7J1	Stanislaus	3 mi. E of Ceres		104	DWR	x	Surface
Lodi 3S	T3N R7E 30K1	San Joaquin	3 mi. S of Lodi		41	DWR	x	Surface
Los Banos 3S	T10S R10E 33P1	Merced	3 mi. S of Los Banos		161	USDA	-	Surface
Los Banos 8SE	T11S R11E 19K1	Merced	8 mi. SE of Los Banos		140	USDA	-	Surface
Stockton 8S	T1S R7E 39E1	San Joaquin	8 mi. S of Stockton		25	DWR	-	Surface
Vernalis 3SE	T4S R7E 5J1	Stanislaus	3 mi. SE of Vernalis		69	DWR	x	Surface
<u>Miscellaneous</u>								
Los Banos Equipment Yard	T10S R10E 32K1	Merced	6 mi. S of Los Banos		160	USBR	x	--
Twitchell Island	T3N R3E 16K1	Sacramento	6 mi. SE of RIO Vista		10	DWR	x	--
<u>TULARE LAKE BASIN VALLEY FLOOR</u>								
<u>Pasture</u>								
Arvin Frick	T1S R29E 16F1	Kern	4 mi. NW of Arvin		437	DWR	x	Surface
Kerman 2ESE	T14S R18E 17H1	Fresno	2 mi. ESE of Kerman		225	DWR	x	Surface
Kingsburg 5S #2	T17S R22E 16H1	Kings	5 mi. SW of Kingsburg		277	DWR	x	Surface
<u>Alfalfa</u>								
Arvin Jewett #1	T31S R29E 16H1	Kern	2 1/2 mi. NW of Arvin		448	DWR	x	Surface
Arvin Jewett #2	T31S R29E 16G1	Kern	2 1/2 mi. NW of Arvin		440	DWR	x	Surface
Fresno Kearney Park	T14S R19E 19K1	Fresno	2 mi. SW of Kearney Park		238	DWR	-	Surface
Kingsburg 5S #1	T17S R22# 15H1	Kings	5 mi. SW of Kingsburg		276	DWR	-	Surface
Mendota Murietta Ranch	R15S R14E 4N1	Fresno	6 mi. SW of Mendota		253	MFC	-	Surface
Shafter 2NW	T27S R25E 32J1	Kern	2 mi. NW of Shafter		353	DWR	x	Surface

TABLE A-1 (continued)

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	MDERM	County	Location	Description	Eleva- tion, in feet	Ob- server ^a	Evaporation equipment	Irriga- tion method
<u>CENTRAL VALLEY (continued)</u>								
<u>TULARE LAKE BASIN VALLEY FLOOR (continued)</u>								
<u>Dryland</u>								
Panoche Junction	T16S R14E 16P1	Fresno	15 mi. SSW of Mendota		500	DWR	x	--
<u>LASSEN-ALPINE MOUNTAIN VALLEYS</u>								
<u>Pasture</u>								
Cedarville 2E	T42N R16E 10E1	Modoc	2 mi. E of Cedarville		4670	DWR	x	Subsurface
Coleville 2W	T8N R22E 3K1	Mono	2 mi. N of Coleville		5120	DWR	x	Subsurface
Standish 4NW	T29N R13E 1LW1	Lassen	4 mi. NW of Standish		4100	DWR	x	Subsurface
<u>Alfalfa</u>								
Cedarville 1E	T42N R16E 4P1	Modoc	1 mi. E of Cedarville		4670	DWR	-	Sprinkler
Standish 1NW	T29N R14E 18R1	Lassen	1 mi. NW of Standish		4060	DWR	-	Surface
<u>Dryland</u>								
Bridgeport DWR	T5N R25E 33D1	Mono	Town of Bridgeport		6465	DWR	-	--
Eagle Lake Stone Ranch	T32N R12E 5N1	Shasta	22 mi. NW of Susanville		5120	DWR	x	--
Cedarville Chevron	T42N R16E 5Q1	Modoc	Town of Cedarville		4670	DWR	-	--
Leavitt Lake	T29N R13E 16W1	Lassen	10 mi. SE of Susanville		4112	PC	-	--
Madeline 3W	T37N R13E 19Q1	Lassen	3 mi. SW of Madeline		5400	DFG	-	--
Termo	T35N R13E 25W1	Lassen	Town of Termo		5290	DWR	-	--
Woodfords	T11W R20E 35D1	Alpine	Town of Woodfords		5526	DWR	-	--
<u>Miscellaneous</u>								
Taboe	T15N R17E 7R1	Placer	1 mi. S of Truckee Dam		5818	DWR	-	--

^a/ CAA - Civil Aeronautics Administration
 CDF - California Division of Forestry
 CSR - City of Santa Rosa
 DFG - California Department of Fish and Game
 DWR - California Department of Water Resources
 MFC - Murietta Farms Company
 PC - Private Cooperator
 P&E - Pacific Gas and Electric Company
 UC - University of California
 USBR - United States Bureau of Reclamation
 USDA - United States Department of Agriculture
 USFS - United States Forestry Service

TABLE A-2

MONTHLY EVAPORATION FROM STANDARD
U. S. WEATHER BUREAU EVAPORATION PANS
(in inches)

Area, environment, and station name	Year of: record	Months												: May-Sept. : total			
		: Jan.	: Feb.	: Mar.	: Apr.	: May	: June	: July	: Aug.	: Sept.	: Oct.	: Nov.	: Dec.				
<u>NORTH COASTAL</u>																	
KLAUWATH, TRINITY MOUNTAIN VALLEYS																	
Pasture																	
Montague 3NE	1959			5.34	8.09	8.74	12.50	8.56	6.30								44.19
Montague 3NE	1960			3.82	5.81	8.79	9.62	8.33	6.07								38.62
Dryland																	
Fort Jones R. S.	1955			5.46	10.10	10.89	10.38	3.79									40.62
Yreka 1NE	1955			4.71	11.13	11.23	12.36	6.18	2.35								45.61
<u>CENTRAL VALLEY</u>																	
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS																	
Pasture																	
Alturas Dorris Ranch	1957					7.16	6.72	7.69	5.73								
Alturas Dorris Ranch	1958					5.56	7.23	8.39	5.26								
Alturas Dorris Ranch	1959		1.83	3.39	5.54	6.09	9.83	8.65	5.51					3.39	1.72		38.02
Alturas Dorris Ranch	1960		1.40	2.58	4.53	5.90	8.82	8.31	5.86					4.01	1.13	0.5	36.89
Fall River Mills 4NW	1959		1.07	1.59	5.87	6.99	10.07	8.99									
Fall River Mills 4NW	1960			1.51	3.80	4.65	6.67	8.69	10.40	9.20	5.35			3.97	1.74	0.58	
Glenburn DWR	1960					7.71	10.07	6.11	6.11	4.10	2.17						
Lookout Hunt	1959		1.08	3.22	4.37	5.32	8.76	9.67	9.15	6.00	3.71	0.82	0.74				38.90
Lookout Hunt	1960		1.48	3.25	5.10	6.16	7.69	8.96	8.78	6.16	3.86	1.66	0.66				
Mean																	
Alfalfa																	
Canty 11SW	1958							7.03	5.58								
Canty 11SW	1959					5.15	7.54	11.39	9.38	7.32	4.13	1.31					41.29
Lookout 1S	1959		1.46	1.89	3.78												
McArthur 2E	1956							9.53	7.75	6.07							
Pittville 1S	1956							9.55	7.80	1.24							
Pittville 1S	1957				4.82	8.51	6.89	8.19	6.04								34.75
Pittville 1S	1958					6.05	7.79	8.49	3.33								
Mean						7.37	9.03	8.16	5.56								

TABLE A-2 (continued)

MONTHLY EVAPORATION FROM STANDARD
U. S. WEATHER BUREAU EVAPORATION PANS

(in inches)

Area, environment, and station name	:Year of: :record : Jan. : Feb. : Mar. : Apr. : May : June : July : Aug. : Sept. : Oct. : Nov. : Dec. : total													
CENTRAL VALLEY (continued)														
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)														
<u>Dryland</u>														
Adin Harper	1959	1.25	3.44	6.22	5.77	10.10	12.40	10.25	7.77	4.85	2.54			46.29
Adin Harper	1960	0.91												44.80
Big Sage Reservoir	1959	1.06	2.62	6.29	5.69	9.19	12.54	10.70	6.68	3.44	1.92			
Big Sage Reservoir	1960	1.09												
Davis Creek 4, NW	1959	1.83	3.46	6.24		9.63	10.32	11.21	7.10	4.37	1.93			
Davis Creek 4, NW	1960	1.02	2.46	5.13	7.12	10.95	12.10	10.93	8.23	4.55	1.06	0.34		49.38
West Valley Reservoir	1953													
West Valley Reservoir	1959	1.20	2.99	5.98	5.24	10.22	12.30	11.43	7.27	3.15	3.00			46.51
Mean					5.95	10.02	12.03	11.06	7.41	4.60	2.09			
SACRAMENTO RIVER BASIN FOOTHILLS														
<u>Pasture</u>														
Gold Hill Doty Flat	1958													
Gold Hill Doty Flat	1959	1.49	2.36	4.25	5.80	6.93	9.8	11.32	8.91	5.98	2.52			43.21
Gold Hill Doty Flat	1960	1.33	2.72	3.59	5.59	6.10	9.9	10.70	8.91	5.63	2.05			42.84
Loma Rica	1960													
Loma Rica	1961													
Penn Valley	1953													
Penn Valley	1959	1.36	3.34	5.25	5.33	9.08	10.79	9.36	5.43	4.1	1.93			41.51
Penn Valley	1960	1.39	1.70	2.52	4.02	5.95	7.97	9.73	3.98	4.51	1.97			38.48
Penn Valley	Mean	1.52	2.29	3.56	5.19	6.30	9.15	10.66	9.27	5.00	2.20			
<u>Dryland</u>														
Lella Vista 4NE	1959													
Lella Vista 4NE	1960													
Lella Vista 4NE	1961													
Lronvs Valley 3NE	1959	1.38	2.32	4.54	6.96	8.99	12.77	14.35	12.11	9.09	3.14			57.31
Lronvs Valley 3NE	1960	1.47	2.53	3.77	5.61	7.94	12.11	13.40	12.05					
Lronvs Valley 3NE	1961													
Newville	1959	1.42	2.89	4.29	5.50	7.82	14.34	14.70	13.00	10.44	7.73			62.95
Newville	1960	1.42	2.75	6.52	8.69	13.36	15.04	12.46	10.27	7.42	3.89			60.30
Newville	Mean													

TABLE A-2 (continued)

MONTHLY EVAPORATION FROM STANDARD
U. S. WEATHER BUREAU EVAPORATION PANS
(in inches)

Area, environment, and station name	Year of: record	Months												: May-Sept. : total			
		: Jan.	: Feb.	: Mar.	: Apr.	: May	: June	: July	: Aug.	: Sept.	: Oct.	: Nov.	: Dec.				
CENTRAL VALLEY (continued)																	
SAN JOAQUIN RIVER BASIN VALLEY FLOOR																	
Pasture																	
Hierenda 2N	1960				9.06	10.31	10.74	9.49	6.43	4.46	1.43	0.74	46.03				
El Solyo Ranch	1959		1.73	3.86	5.97	9.32	11.12	10.66	9.01	7.17	2.53	2.10	47.48				
El Solyo Ranch	1960	1.67	2.76	4.14	6.17	9.02	10.34	9.15	8.55	6.43	4.94	1.79	43.49				
Lodi 35W	1959		1.84	4.50	5.99	8.21	10.10	9.84	8.22	6.41	4.98	2.33	42.78				
Merced 5SE	1959		1.96	4.49	6.03	9.36	12.03	13.08	10.63	7.98	5.53	2.68	53.08				
Merced 5SE	1960	1.76	2.02	4.22	6.10	9.59	11.29	12.12	10.65	8.05	4.95	1.69	51.70				
Newman 1SE	1960				6.33	9.16	11.05	9.25	8.77	6.60	6.24	1.98	0.95				
Stockton 9S	1959	1.84	2.48	4.34	6.40	8.56	10.32	10.42	8.84	6.37	4.82	2.43	45.98				
Stockton 9S	1960	1.40	2.49	3.75	5.66	7.12	9.34	9.50	7.96	5.99	4.38	2.15	39.91				
Thornton 2S	1960	1.67	2.18	4.19	6.08	8.84	10.60	10.55	9.08	6.76	5.14	1.92	44.32				
Thornton 2S	Mean												1.69				
Alfalfa																	
Ceres 33	1957				6.83	6.22	8.57	8.60	6.50	5.89	1.77	3.14	37.19				
Ceres 3E	1958				6.85	8.51	9.61	10.00	8.05	6.71	2.35	3.79	42.22				
Ceres 3E	1959	1.55	4.35	6.85	8.51	9.61	10.00	8.05	6.05	5.73	2.52	1.82	37.30				
Ceres 3E	1960	1.78	2.35	3.64	6.52	8.38	8.77	8.93	6.30	4.92	4.03	1.37	37.30				
Lodi 3S	1958				7.48	7.44	9.94	5.94	6.46	3.97	2.45	1.59	37.26				
Vernalis 3SE	1958				6.73	7.65	8.60	9.37	6.78	6.01	4.55	2.76	37.26				
Mean													1.43				
Miscellaneous																	
Los Banos Equipment Yard	1959	1.16	2.16	4.78	9.00	12.27	15.11	15.61	12.59	9.79	6.68	3.08	66.37				
Los Banos Equipment Yard	1960				7.96	11.99	16.47	16.29	14.04	9.75	6.22	1.90	68.54				
Twitchell Island	1959				6.19	8.36	12.38	11.57	8.17	6.03	2.95	2.04					
Twitchell Island	1960	1.59	3.08	4.24	6.19	8.36	12.38	11.57	11.16	8.17	7.70	1.96	51.64				

TABLE A-2 (continued)

MONTHLY EVAPORATION FROM STANDARD
U. S. WEATHER BUREAU EVAPORATION PANS
(in inches)

Area, environment, and station name	:Year of: :Record	Months												: May-Sept. : total
		: Jan.	: Feb.	: Mar.	: Apr.	: May	: June	: July	: Aug.	: Sept.	: Oct.	: Nov.	: Dec.	
<u>CENTRAL VALLEY (continued)</u>														
<u>TULARE LAKE BASIN VALLEY FLOOR</u>														
Pasture	1959	1.96	2.24	4.30	5.82	8.72	9.06	9.95	8.67	5.93	4.49	2.69	1.68	
Arvin Frick	1960					8.72	9.93	9.39	8.09	6.13	4.08	1.89	1.08	42.31
Kerman DESE	1960					9.15	10.05	8.81	7.43	6.02	4.28	1.63	0.80	41.46
Kingsburg 5S No. 2	1958								8.56		4.25	1.88		
Kingsburg 5S No. 2	1959		2.14	4.17	5.37	8.39	9.93	9.26	7.57	5.74	4.31	2.16	1.38	40.89
Kingsburg 5S No. 2	1960	1.63	2.15	3.97	6.09	8.81	9.67	9.37	8.36	6.20	4.04	1.62	0.86	42.41
Mean		1.79	2.18	4.15	5.76	8.77	9.74	9.36	8.11	6.00	4.24	1.98	1.16	
Alfalfa	1958					6.44	8.59	9.45	9.83	4.24	5.10	2.31	1.68	38.55
Arvin Jewett No. 1	1958													
Arvin Jewett No. 2	1959	1.84	2.51	4.53	7.00	8.69			5.06	4.60	2.48	1.21	0.78	
Kingsburg 5S No. 1	1957								8.88	5.94	4.25	2.25		
Shafter 2NW	1958								7.92	4.93	3.94	1.92		
Mean														
Dryland	1960			5.73			16.15	17.83	16.60		8.41	2.90	1.35	
Panoche Junction														
<u>LAHONTAN</u>														
<u>LASSER, ALPINE MOUNTAIN VALLEYS</u>														
Pasture	1958					5.73				5.93	4.14			
Cedarville 2E	1959					6.57		11.56	11.35	7.31	5.00	2.58		
Cedarville 2E	1960						9.01	12.01	10.33	7.76	4.82	1.60	0.86	45.68
Coleville 2W	1957	2.16	3.17	5.46			8.38	9.33	9.09	6.45	3.44			
Standish 4NW	1959					6.11	9.31	11.96	9.39	5.91				42.68
Standish 4NW	1960				5.38	6.81	8.95	10.00	8.89	7.75				42.40
Mean						6.30	8.91	10.97	9.81	6.85	4.35			
Dryland	1960					7.26	10.99	10.40	11.03	8.66				48.34
Eagle Lake Stone Ranch														

TABLE A-3

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ANEMOMETERS
(in milliliters)

Area, environment, and station name	: Year :	Months												: May- September : total			
		:record:	Jan. :	Feb. :	Mar. :	Apr. :	May :	June :	July :	Aug. :	Sept. :	Oct. :	Nov. :		Dec. :		
<u>NORTH COASTAL</u>																	
<u>KLAMATH, TRINITY MOUNTAIN VALLEYS</u>																	
<u>Pasture</u>																	
Montague 3NE	1959					454	575	624	531	368							2,552
Montague 3NE	1960					450	621	634	559	452							2,716
<u>Alfalfa</u>																	
Calahan Towne Ranch	1955						590	582	560								
Gazelle 3NNW	1955						528	507	510								
Grenada 6E	1955					392	533	584	547								
Mean							550	558	539								
<u>Dryland</u>																	
Fort Jones R. S.	1954																
Fort Jones R. S.	1955					320	525	566	427	371							
Gazalle 1NNE	1958					530	486	569	507	438							2,530
Gazalle 1NNE	1959				388	444	556	599	541	370							2,510
Gazalle 1NNE	1960					489	661	758	682	534							3,124
Hayfork R. S.	1954																
Hayfork R. S.	1955				226	462	486	493	473	350							
Hayfork R. S.	1956						513	630	611	416							2,613
Hayfork R. S.	1957					432	566	582	567	466							2,138
Hayfork R. S.	1958					464	369	416	519	421							2,483
Hayfork R. S.	1959					428	537	607	513	398							
Hayfork R. S.	1960						598	589	612	683							
Macdoel F. S.	1955						398	560	491								
Yreka 1NE	1954						556	579	576	363							
Yreka 1NE	1955					446	521	584	546	413							
Mean																	
<u>CENTRAL VALLEY</u>																	
<u>SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS</u>																	
<u>Pasture</u>																	
Alturas Dorris Ranch	1956																
Alturas Dorris Ranch	1957					380	544	607	599	387							2,456
Alturas Dorris Ranch	1958					476	471	535	501								
Alturas Dorris Ranch	1959						547	643	551	422							
Alturas Dorris Ranch	1960						562	560	501								

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS

(in milliliters)

Area, environment, and station name	Year : of record	Months												
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	May - September total
<u>SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)</u>														
<u>Pasture (continued)</u>														
Fall River Mills 44W	1958					577	596	503	384					386
Fall River Mills 44W	1959					588	584	550	374					374
Glenburn DWR	1960					488	623	589	452					451
Itacreek 3N	1955				510	505	556	535						
Likely Williams Ranch	1958					584	663	545	401					
Likely Williams Ranch	1959					586	650	567	424					
Lookout Hunt	1959					584	561	458	424					
Lookout Hunt	1960				463	550	600	545	417					
Mean														2,689
<u>Alfalfa</u>														
Bieber 4E	1956					576	666	586	385					
Canby 11SW	1958					523	410	477	387					
Canby 11SW	1959					547	520	535						
Hat Creek 3SE	1958				547	520	460	590						
Lookout 1S	1958					547	520	590						
McArthur 2E	1955					428	563	591	519					448
McArthur 2E	1956					428	563	591	519					448
Pittville 1S	1956					484	626	634	535					428
Pittville 1S	1957					484	626	634	535					428
Pittville 1S	1957					474	579	602	450					457
Pittville 1S	1958					606	659	646	481					481
Pittville 1S	1959				486	537	566	568	444					444
Mean														2,570
<u>Dryland</u>														
Adin Harper	1958							536	402					
Adin Harper	1959							536	364					
Alturas Park Avenue	1955				423	474	571	538	380					288
Bieber S.C.S.	1955					598	633	633						
Big Sage Reservoir	1958					464	573	458	366					
Big Sage Reservoir	1959					499	571	546	360					
Canby Ohm	1958					514	530	463	357					
Canby Ohm	1959					546	575	569						
Canby R. S.	1955				432	546	575	569						
Davis Creek 44NW	1958													411

TABLE A-3 (continued)

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

Area, environment, and station name	Year of record	Months												
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	May - September
<u>CENTRAL VALLEY (continued)</u>														
<u>SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)</u>														
<u>Dryland (continued)</u>														
Davis Creek 44NW	1958 7					584	595	573	379					
Fall River Mills Intake	1956					512	575	497	512					
Fall River Mills Intake	1957			408		581								
Fall River Mills R. S.	1955					534	594	628	479	342				
Fall River Mills R. S.	1956					536	612	578	464					
Fall River Mills R. S.	1957			493		554	508	513	418					
Likely 4N	1954					601	601	543	461					
Loyalton 5W	1954					616	616	519						
Loyalton 7N	1958			484		497	555	543						
Loyalton 7N	1959			578		612	479							
Loyalton 7N	1960					580	536							
Mt. Shasta City W.B.	1955					547	535	580	387	301				
Quincy R. S.	1954					560	560	507	469					
Quincy R. S.	1955					528	528	502	370					
West Valley Reservoir	1958					474	575	527	328					
West Valley Reservoir	1959			470		536	569	540	408	310				
Mean														2,486
<u>Miscellaneous Lands</u>														
Adin R. S.	1955			425		554	640	589	478	300				2,686
<u>SACRAMENTO RIVER BASIN FOOTHILLS</u>														
<u>Pasture</u>														
Auburn Mt. Vernon	1958					503	623	554	463	397				
Auburn Mt. Vernon	1959			485		562	589	532	457	402				2,625
Auburn Mt. Vernon	1960			432		602	614	532	454	350				2,694
Gold Hill Doty Flat	1958		302	433		544	642	575	466	391				
Gold Hill Doty Flat	1959			471		575	625	556	441	390				2,688
Gold Hill Doty Flat	1960		292	450		628	645	611	515	381				2,915
Loma Rica	1960					547	634	562	466	360				
Penn Valley	1958					610	626	552	448	387				2,745
Penn Valley	1959		281	391		574	567	586	484	375				2,681
Penn Valley	1960		292	453		572	619	562	466	375				
Mean														

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

Area, environment, and station name	: Year : : of : : record:	Months												
		: Jan. :	: Feb. :	: Mar. :	: Apr. :	: May :	: June :	: July :	: Aug. :	: Sept. :	: Oct. :	: Nov. :	: Dec. :	: May - : September : total
<u>CENTRAL VALLEY (continued)</u>														
<u>SACRAMENTO RIVER BASIN FOOTHILLS (continued)</u>														
<u>Dryland</u>														
Bella Vista 4NE	1959			404	437	494	674	493	393	343				2,491
Bella Vista 4NE	1960			330	436	535			353	350				2,769
Newville	1959	272		383	437	499	632	573	470	409				3,176
Newville	1960	314		410	501	681	667	713	614	451				
Mean		323		395	468	576	658	593	458	388				
<u>SACRAMENTO RIVER BASIN VALLEY FLOOR</u>														
<u>Pasture</u>														
Anderson 4E	1958			433	466	548	602	563	483	385				2,558
Anderson 4E	1959	377		433	466	548	592	540	412	356				2,548
Anderson 4E	1960	284		357	442	572	598	515	421	308				2,701
Corning 3NE	1960	326		417	476	568	633	562	462	385				2,904
Davis Campbell #1	1960				532	608	653	597	514	398				
Elk Grove 4NW	1960	331		448	530	594	587	550	391	358				2,652
Lincoln Vineyard	1958			469	516	589	662	579	493	425				2,683
Lincoln Vineyard	1959			407	454	554	555	512	440	349				2,515
Lincoln Vineyard	1960	283		426	499	594	635	602	474	378				2,604
Palermo 3SW	1959	310		460	481	641	680	544	444	376				2,790
Red Bluff Cone Ranch	1960	301		393	487	600	606	499	412	323				2,604
Red Bluff Cone Ranch	1960	339		429	519	601	591	530	427	337				2,668
Yuba City 9W	1960	324		424	491	588	614	549	443	366				
Mean														
<u>Alfalfa</u>														
Anderson 3E	1955			406	584	513	623	572	504	352				2,796
Anderson 2E	1958			522	542	602	602	563	483	385				2,742
Arbuckle 1S	1958			489	561	552	601	557	483	452				2,754
Arbuckle 1S	1959	404		450	497	589	609	508	416	357				2,619
Arbuckle 1S	1960	330		392	504	555	559	516	430	334				2,564
Arbuckle 1S	1960			430	561	572	644	611	481	454				2,869
Corning Jobe	1958			463	524	604	660	573	456	381				2,817
Corning Jobe	1959			609	609	649	680	618	531	423				3,087
Hamilton City	1955													
Red Bluff 3E	1958			445	532	567	578	526	521	342				2,724
Rocklin Igarashi	1958					558	612	552	487	417				

TABLE A-3 (continued)

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

Area, environment, and station name	: Year : : of : : record:	Months												
		: Jan. :	: Feb. :	: Mar. :	: Apr. :	: May :	: June :	: July :	: Aug. :	: Sept. :	: Oct. :	: Nov. :	: Dec. :	: May - September total
<u>CENTRAL VALLEY (continued)</u>														
<u>SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)</u>														
<u>Alfalfa (continued)</u>														
Rocklin Igarashi	1959			472	531	563	628	565	442	369				2,729
Rocklin Igarashi	1960	327		436	504	606	584	529	448	346				2,671
Vina Beck	1958			449	546	615	644	581	445	419				2,831
Vina Beck	1959	440		446	507	579	612	582	457	379				2,707
Vina Beck	1960			448	530	615	592	498						
Yuba City	1958			416	535	559	648	576	521	426				2,839
Yuba City	1959	417		488	545	619	634	551	451	390				2,800
Mean		384		445	539	580	618	556	472	389				
<u>Dryland</u>														
Davis Campbell #2	1960							537	435	351				
Mills Orchard	1954								459	373				
Mills Orchard	1955								469	362				
Oroville Agri. Comm.	1959	386		327	555	547	601	570	469	425				2,740
Redding GSE	1955			471	516	574	607	580	485	425				2,808
Redding GSE	1956			572	607	685	647	685	492	395				3,001
Redding GSE	1957			452	559	611	516	412						2,550
Redding GSE	1957			461	625	595	595	485	379	252				
Redding GSE	1958			500	506	506	590	590	500	397				
Redding Stayer	1958			449	491	633	739	602	456	396				2,921
Redding Stayer	1959	389		373	470	632	677	567	463	316				2,809
Redding Stayer	1960	281				448	641	614	529	421				
Sacramento Refuge	1955			407	503	613	690	609	481	336				2,896
Sacramento Refuge	1956					638	681	618	486	330				2,956
Sacramento Refuge	1957					589	659	573	457	357				2,816
Sacramento Refuge	1958	419		489	538	637	662	559	481	405				2,878
Sacramento Refuge	1959	353		434	518	623	623	570	464	371				2,798
Sacramento Refuge	1960	366		426	511	588	655	573	465	366				
Mean														
<u>Miscellaneous Lands</u>														
Corning 3NW	1954							546	525	414				
Live Oak 3SE	1954						540	478	421	338				162
Pennington 3NW	1960							526	435	325				
Redding A. P.	1957			427	474			524	324	275				

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS

(in milliliters)

Area, environment, and station name	: Year :	Months												: May- : September : total
		: of :	: Jan. :	: Feb. :	: Mar. :	: Apr. :	: May :	: June :	: July :	: Aug. :	: Sept. :	: Oct. :	: Nov. :	

CENTRAL VALLEY (continued)

SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)

Miscellaneous Lands (continued)													
Richvale 1E	1957								668	428	314		
Richvale 1E	1958				603	655	579	441	441	441	349		2,827
Richvale 1E	1959	355	446	549	603	613	703	573	573	451	390		2,873
Richvale 1E	1960	309	425	516	639	636	612	474	612	474	370	179	2,877
Mean			403	511	581	628	567	442			351		

SAN JOAQUIN RIVER BASIN VALLEY FLOOR

Pasture													
Berenda 2N	1959			528	598	620	571	471	413				2,788
Berenda 2N	1960			538	558	511	495	436	347				2,538
El Solyo Ranch	1959	353	441	531	590	610	515	419	366				2,665
El Solyo Ranch	1960	362	438	528	583	591	547	452	390				2,701
Lodi 3SW	1959	402	454	479	486	535	515	448	390				2,463
Merced 5SE	1959	415	475	515	588	576	536	427	388				2,642
Merced 5SE	1960	371	457	526	578	567	541	442	359				2,654
Newman 1SE	1960			543	542	533	426	321					
Stockton 9S	1959		481	484	523	587	535	444	378				2,573
Stockton 9S	1960	310	442	612	588	612	618	484	354				2,914
Thornton 2S	1960	356	480	546	625	631	564	495	363				2,861
Mean		374	460	529	569	580	543	449	366				

Alfalfa

Atwater 1N	1958			584	598	608	566	475	359				2,831
Atwater 1N	1959	372	471	541	591	606	557	452	395				2,747
Atwater 1N	1960	345	412	541	573	479	519	435	354				2,527
Ceres 3E	1958			529	559	542	592	583	414				2,710
Ceres 3E	1959	400	460	520	573	549	513	379	335				2,534
Ceres 3E	1960	373	445	569	600	577	554	501	402				2,801
Lodi 3S	1958					564	573	459	388				
Lodi 3S	1959	417	472	503	478	572	522	467	419				2,542
Los Banos 3S	1958			539	631								
Los Banos 8SE	1958					638	552	449	412				
Stockton 8S	1958					614	578	482	356				

TABLE A-3 (continued)

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

Area, environment, and station name	Year of record	Months												
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	May - September total
<u>CENTRAL VALLEY (continued)</u>														
<u>SAN JOAQUIN RIVER BASIN VALLEY FLOOR (continued)</u>														
<u>Alfalfa (continued)</u>														
Stockton 8S	1959	400	435	514	577	606	524	435	362					2,656
Vernalis 3SE	1958			581	567	576	532	476	359					2,732
Mean		284	470	548	571	582	548	454	379					
<u>Miscellaneous Lands</u>														
Los Banos Equip. Yard	1959		455	468	533	561	421	394	283					2,377
Los Banos Equip. Yard	1960	289	388	496	460	447	476	432	356					2,311
<u>TULARE LAKE BASIN VALLEY FLOOR</u>														
<u>Pasture</u>														
Arvin Frick	1959				571	582	548	473	413	293				
Arvin Frick	1960		438	570	670	639	582	480	372	223				2,941
Kerman 2ESE	1960			490	536	540	516	415	343	176				2,497
Kingsburg 5S #2	1958				599	611	638	469	407					2,625
Kingsburg 5S #2	1959	421	455	517	544	604	529	431	371					2,409
Kingsburg 5S #2	1960		427	502	511	507	494	395	330					
Mean			440	520	572	580	551	444	313	231				
<u>Alfalfa</u>														
Arvin Jewett #1	1958			555	571	610	551	460	378					2,747
Arvin Jewett #2	1959	390	473	498	586	664	540	400	408					2,778
Fresno Kearney Park	1958			588	664	664	540	400	408					2,671
Fresno Kearney Park	1959		432	494	605	600	551	421	365					
Fresno Kearney Park	1960	406	424											
Mendota Murietta Ranch	1958		516	534	587	643	541	434	511					2,739
Mendota Murietta Ranch	1959		410	561	595	590	561	456	420					2,763
Mendota Murietta Ranch	1960		452				593	502	371					
Shafter 2NW	1958	402	462	538	589	617	596	456	407					
Mean							617	447	409					

Dryland

TABLE A-3 (continued)

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

Area, environment, and station name	Year : of : record	Months												May - September total
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
<u>LAHONTAN</u>														
<u>LASSEN, ALPINE MOUNTAIN VALLEYS</u>														
<u>Pasture</u>														
Cedarville 2E	1958						570	472						472
Cedarville 2E	1959					539		572						584
Coleville 2W	1955							584						407
Coleville 2W	1956						653	654						539
Coleville 2W	1957						609	588						467
Coleville 2W	1958					540	590	572						446
Standish 4NW	1959						456	418						412
Standish 4NW	1960						552	537						
Mean							460	454						2,302
							460	550						454
<u>Alfalfa</u>														
Cedarville 1E	1958						467	475						378
Standish 1NW	1958						550	527						412
<u>Dryland</u>														
Bridgeport DWR	1956							569						565
Cedarville Chevron	1955						496	626						591
Leavitt Lake	1955						507	590						590
Madeline 3SW	1955						502	535						372
Madeline 3SW	1958							474						
Termo	1959						521	548						467
Woodfords	1956						574	584						523
Mean							520	582						535
<u>Miscellaneous Lands</u>														
Tahoe	1956						538	495						449
														320

TABLE A-4

LOCATION OF EVAPOTRANSPIRATION
MEASURING STATIONS

Area and station name	Crop	MD&M	County	Location	Description
KLAMATH-TRINITY MOUNTAIN VALLEYS					
Gezelle Dougherty #1	Alfalfa	T43N R6W 22W1	Siskiyou	C. C. Dougherty Ranch, 3-1/2 mi. NW of Gazelle	
Gezelle Dougherty #2	Alfalfa	T43N R6W 22W2	Siskiyou	C. C. Dougherty Ranch, 3-1/2 mi. NW of Gazelle	
Gezelle Dougherty #3	Alfalfa	T43N R6W 21J1	Siskiyou	C. C. Dougherty Ranch, 3-1/2 mi. NW of Gazelle	
CENTRAL VALLEY					
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS					
Alturas Dorris Ranch	Pasture	T42N R13E 19L1	Modoc	Dorris Ranch, 2 mi. SE of Alturas	
Bieber 3E	Alfalfa	T38N R8E 18D1	Lassen	Earl Leonard Ranch, 3 mi. E of Bieber	
Bieber Leonard	Alfalfa	T38N R8E 17R1	Lassen	Francis Leonard, 4 mi. E of Bieber	
Canby Bushey	Alfalfa	T42N R9E 8R1	Modoc	R. Bushey Ranch, 5 mi. SW of Canby	
Hat Creek Kern	Alfalfa	T34N R4E 15E1	Shasta	B. S. Kern Ranch, 4 mi. N of Hat Creek	
Hat Creek Opdyke	Alfalfa	T34N R4E 15E1	Shasta	P. Opdyke Ranch, 2 mi. NW of Hat Creek	
McArthur Albaugh #1	Alfalfa	T37N R5E 11Q1	Shasta	C. A. Albaugh Ranch, 1 mi. W of Pittville	
McArthur Albaugh #2	Alfalfa	T37N R5E 11Q2	Shasta	C. A. Albaugh Ranch, 1 mi. W of Pittville	
McArthur 1 NE	Alfalfa	T37N R5E 9R1	Shasta	J. McArthur Ranch, 1/2 mi. NE of McArthur	
Pittville 1S	Alfalfa	T37N R5E 13A1	Shasta	L. Owens Ranch, 1 mi. S of Pittville	
Pittville (AA)	Alfalfa	T37N R5E 13R2	Shasta	L. Owens Ranch, 1 mi. S of Pittville	
McArthur (AB)	Alfalfa	T37N R5E 16R1	Shasta	J. McArthur Ranch, 1 mi. SE of McArthur	
SACRAMENTO RIVER BASIN VALLEY FLOOR					
Davis Campbell	Ryegrass	T8N R2E 17L1	Yolo	Campbell Tract, Univ. of Calif. at Davis	
Anderson 2N	Alfalfa	T30N R4W 10A1	Shasta	Floyd Leonard Ranch, 2 mi. N of Anderson	
Anderson 3E	Alfalfa	T30N R3W 8G1	Shasta	R. Haller Ranch, 3 mi. E of Anderson	
Anderson Trisdale	Alfalfa	T30N R3W 8B1	Shasta	J. H. Trisdale Ranch, 4 mi. E of Anderson	
Mills Orchard	Alfalfa	T22N R2W 30K1	Glenn	Mills Orchard Co., 2 mi. W of Hamilton C.	
Redding 6SE	Alfalfa	T31N R4W 15O1	Shasta	L. A. Stayer Ranch, 6 mi. SE of Redding	

TABLE A-4 (Continuing)
 LOCATION OF EVAPOTRANSPIRATION
 MEASURING STATIONS

Area and station name	Crop	MDB&M	County	Location	Description
<u>CENTRAL VALLEY (continued)</u>					
<u>TULARE LAKE BASIN VALLEY FLOOR</u>					
Arvin (CE)	Grass	T31S R29E 16F1	Kern	Howard Frick Ranch, 2-1/2 mi. NW of Arvin	
Arvin Jewett	Alfalfa	T31S R29E 16E1	Kern	H. S. Jewett Ranch, 4 mi. NW of Arvin	
Arvin Jewett #2	Alfalfa	T31S R29E 16E2	Kern	H. S. Jewett Ranch, 4 mi. NW of Arvin	
Arvin Jewett #3	Alfalfa	T31S R29E 16E3	Kern	H. S. Jewett Ranch, 4 mi. NW of Arvin	
Arvin (CC)	Alfalfa	T31S R29E 16F2	Kern	Howard Frick Ranch, 2-3/4 mi. NW of Arvin	
Arvin (CB)	Plums	T31S R29E 10N1	Kern	DiGiorgio Farms, 4 mi. NW of Arvin	
Arvin (CD)	Cotton	T31S R29E 9N1	Kern	Howard Frick Ranch, 3 mi. NW of Arvin	
Arvin (CF)	Cotton	T31S R29E 16D1	Kern	Howard Frick Ranch, 3 mi. NW of Arvin	
<u>LASSEN-ALPINE MOUNTAIN VALLEYS</u>					
Coleville 2W	Pasture	T8N R22E 3K1	Mono	F. Spring Ranch, 2 mi. W of Coleville	
Leavitt Lake	Alfalfa	T29N R13E 16W1	Lassen	P. Milton Ranch, 10 mi. SE of Susanville	

TABLE A-5

GENERAL INFORMATION RELATIVE TO EVAPORANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Dates of cutting or irrigation	Dates of harvesting	Approximate: growing season	Elevation: station	Correlative: station
<u>NORTH COASTAL</u>									
KAPPAHI-TRINITY MOUNTAIN VALLEYS									
<u>ALFALFA</u>									
Gaselle Dougherty #1	1955	Sandy loam 0-7 feet.	Three gravimetric sampling stations. Total sampling depth, 7 feet.	Sprinkler	Apr. 6 May 19 July 31 Sept. 26	June 12 July 30 Sept. 26	May 1 - Sept. 20	2,720	Gaselle 3NW
Gaselle Dougherty #2	1955	Sandy loam 0-7 feet.	Three gravimetric sampling stations. Total sampling depth, 7 feet.	Sprinkler	Apr. 6 May 17 June 27 Aug. 14, 29	June 12 July 30 Sept. 26	May 1 - Sept. 20	2,720	Gaselle 3NW
Gaselle Dougherty #3	1955	Sandy loam 0-7 feet.	Three gravimetric sampling stations. Total sampling depth, 7 feet.	Sprinkler	Apr. 6 May 18 June 27 July 6 Aug. 14, 28	June 12 July 31 Sept. 26	May 1 - Sept. 20	2,720	Gaselle 3NW
<u>CENTRAL VALLEY</u>									
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS									
<u>PASTURE</u>									
Alturas Dorris Ranch	1959 1960	Undisturbed clay loam throughout.	Inflow-outflow evapotranspirometer.	Continuous surface application high water table level maintained.	Continuous		May 15 - Sept. 15	4,050	Alturas Dorris Ranch
<u>ALFALFA</u>									
Bieber 3E	1955	Fine sandy loam overlying relatively impervious consolidated material at $\frac{3}{4}$ feet.	Four gravimetric sampling stations. Total sampling depth, $3\frac{1}{2}$ feet.	Sprinkler	July 1 Aug. 29	July 8 Aug. 17	May 15 - Sept. 15	4,200	Bieber S.C.S.

TABLE A-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Date of irrigation	Date of cutting or harvesting	Approximate growing season	Relative Evapotranspiration	Correlative station
<u>CENTRAL VALLEY (continued)</u>									
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)									
<u>ALPALZA (continued)</u>									
Bieber Leonard	1956	Sandy loam 0-18", Partially cemented sandy loam 18-36" Loamy sand 36-68". Distomaceous earth below 68".	Sixteen gravimetric sampling stations. Total sampling depth, 7 feet.	Sprinkler	July 3, 19 Aug. 27	July 1 Aug. 18	May 15 - Sept. 15	4,200	Bieber LE
Canby Bushy	1955	Clay loam 0-8 feet.	Three gravimetric sampling stations. Total sampling depth, 8 feet.	Wild flooding	July 15 Aug. 21 Sept. 26	July 8 Sept. 2	May 15 - Sept. 15	4,300 (est.)	Canby R.S.
Hat Creek Kern	1955	Sandy loam underlain by coarse sand at four feet.	One gravimetric sampling station. Total sampling depth, 6 feet.	Border irri- gation. Length of run, 1,000 feet.	May 18 June 9, 28 July 18 Aug. 6, 21 Aug. 29 Sept. 18	July 5 Sept. 1	May 1 - Sept. 30	3,350 (est.)	Hat Creek 3H
Hat Creek Opdyke	1955	Fine sandy loam underlain by sand and gravel at 4 feet. Water table at 6 feet.	One gravimetric sampling station. Total sampling depth, 4 feet.	Border irri- gation. Length of run, 500 feet.	May 24 June 8 July 5, 24 Aug. 34 Sept. 6	July 6 Aug. 29	May 1 - Sept. 30	3,350 (est.)	Hat Creek 3H
McArthur Albaugh #1	1955	Sandy loam 0-13' underlain by coarse sand.	Two gravimetric sampling stations. Total sampling depth, 7 feet.	Wild flooding.	May 11 June 2, 28 July 17 Aug. 19 Oct. 2	June 16 Aug. 6 Sept. 13	April 15 - Oct. 15	3,325	McArthur 2E
McArthur Albaugh #1	1956	Sandy loam 0-13 feet underlain by coarse sand.	Sixteen gravimetric sampling stations. Total sampling depth, 9 feet.	Wild flooding.	April 27 June 21 July 17 Aug. 13 Sept. 13	June 7 July 23 Sept. 4	April 1 - Sept. 30	3,325	McArthur 2E
McArthur Albaugh #2	1956	Sandy loam 0-9' underlain by clay.	Twelve gravimetric sampling stations. Total sampling depth, 9 feet.	Wild flooding.	April 27 June 21 July 17 Aug. 13 Sept. 13	Oct. 3	April 1 - Sept. 30	3,325	McArthur 2E

TABLE 4-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Date of irrigation	Date of cutting or harvesting	Approximate amount of water used per season	Correlative meteorological station
CENTRAL VALLEY (continued)								
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)								
ALFAFA (continued)								
McArthur 1ME	1955	Sandy loam 0-3' underlain by sand.	One gravimetric sampling station. Total sampling depth, 4 feet.	Border irrigation. Length of run, 1,200 feet.	May 21 June 15 July 19 Aug. 2, 11, 24	June 7 July 25 Sept. 5	April 1 - 3,350 Sept. 30	McArthur 2E
Pittville 1S	1956	Sandy loam underlain by coarse sand at 18'. Water table at 19'.	Eight gravimetric sampling stations. Total sampling depth, 9 feet.	Sprinkler	May 16 June 29 July 20 Aug. 14 Sept. 5	June 16 July 27 Sept. 12	April 1 - 3,300 Sept. 30	McArthur 2E
Pittville 1S	1957	Sandy loam underlain by coarse sand at 18'. Water table at 19'.	Eight gravimetric sampling stations. Total sampling depth, 9 feet.	Sprinkler	May 14 June 25 Aug. 16, 27 Sept. 5	June 7 Aug. 5 Sept. 17	April 15 - 3,300 Oct. 15	Pittville 1S
Pittville 1S	1958	Sandy loam underlain by coarse sand at 18'. Water table at 19'.	Five gravimetric sampling stations. Total sampling depth, 9 feet.	Sprinkler	May 23 July 9 Aug. 29	June 19 Aug. 4 Sept. 25	April 15 - 3,300 Oct. 15	Pittville 1S
Pittville (AA)	1959	Sandy loam underlain by coarse sand at 18'. Dense clay at 20'.	Neutron scattering.	Sprinkler	Shown in Table 8	June 15 Aug. 1 Sept. 23	April 15 - 3,300 Oct. 15	Pittville 1S
Pittville (AA)	1960	Sandy loam underlain by coarse sand at 18'. Dense clay at 20'.	Neutron scattering.	Sprinkler	Shown in Table 8	June 10 July 18 Sept. 15	April 15 - 3,300 Oct. 15	Olenburn DWR
McArthur (AB)	1959	Stratified loam and clay loam 0-20 feet.	Neutron scattering.	Sprinkler	Shown in Table 8	May 25 July 10 Aug. 13 Sept. 25	April 15 - 3,350 Oct. 15	Pittville 1S
McArthur (AB)	1960	Stratified loam and clay loam 0-20 feet.	Neutron scattering.	Sprinkler	Shown in Table 8	June 1 July 5 Aug. 17 Sept. 30	April 15 - 3,350 Oct. 15	Olenburn DWR

TABLE A-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPORIMETER MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Dates of cutting or irrigation	Date of harvesting	Approximate growing season	Correlative elevation: station
CENTRAL VALLEY (continued)								
SACRAMENTO RIVER BASIN VALLEY FLOOR								
RYEGRASS								
Davis Campbell	1958	Disturbed Yolo loam. Uniform throughout.	Weighing type evapotranspirometers.	Sprinkler	Sept. 12, 27 Oct. 30	Sept. 16 Oct. 29 Dec. 2	Mar. 1 - Oct. 31	50 Davis-Campbell, ft.
Davis Campbell	1959	Disturbed Yolo loam. Uniform throughout.	Weighing type evapotranspirometers.	Sprinkler	Apr. 27-29 May 19-22 June 5-7 19-20, 28-29 July 6, 16, 27 21-23 July 31-Aug. 1 26, 31 Aug. 11-12, 21-22 Sept. 1-2, 13-14 Oct. 4-5, 31-Nov. 1 Nov. 6-7	Mar. 17 Apr. 20 May 6, 15 June 5, 16, 24 July 6, 16, 27 Aug. 10, 17, 21 Sept. 11, 23 Oct. 14 Nov. 6 Dec. 1	Mar. 1 - Oct. 31	50 Davis-Campbell, ft.
Davis Campbell	1960	Disturbed Yolo loam. Uniform throughout.	Weighing type evapotranspirometers.	Sprinkler	April 12, 16, 29 May 9 June 3, 12, 18, 20, 28, 29, 30 July 11, 17	Mar. 31 Apr. 8, 15 May 4, 16, 31 June 10, 17, 27 July 6, 13	Mar. 1 - Oct. 31	50 Davis-Campbell, ft.
ALPALPA								
Anderson 2B	1955	Sandy loam underlain by loamy sand at 5'. Sand and cobble at 8-10 feet.	One gravimetric sampling station. Total sampling depth, 7 feet.	Sprinkler	May 25 June 4, 14 July 12 Aug. 9, 20 Aug. 28	May 19 July 31 Sept. 8 Oct. 21	April 1 - Nov. 1 (est.)	390 Anderson 3E
Anderson 3E	1955	Sandy loam 0-5 feet.	One gravimetric sampling station. Total sampling depth, 7 feet.	Border irrigation, length of run, 100 feet.	May 27 July 5 Sept. 22	May 17 June 20 Aug. 3 Sept. 6	March 15 - Nov. 1 (est.)	390 Anderson 3F

TABLE A-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Dates of irrigation	Dates of cutting or harvesting	Approximate growing season	Correlative Evapotranspiration station
CENTRAL VALLEY (continued)								
SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)								
ALFALFA (continued)								
Anderson Trisdale	1955	Sandy clay loam 0-10 feet.	One gravimetric sampling station. Total sampling depth, 7 feet.	Border irrigation, run, 600 feet.	May 31 July 10 Aug. 4 Oct. 9	May 16 June 20 July 28 Sept. 25	April 1 - Nov. 1	390 Anderson 3E (est.)
Mills Orchard	1955	Silty clay loam underlain by fine sandy loam at 5½ feet.	One gravimetric sampling station. Total sampling depth, 7 feet.	Border irrigation, run, 1,200 feet.	Apr. 9 May 15 June 11, 19 July 10, 21 Aug. 16 Sept. 20	Apr. 15 June 4 Aug. 3 Sept. 9 Oct. 12	March 15 - Nov. 1	175 Mills Orchard
Redding GSE	1955	Reddish clay loam interspersed with cobble.	One gravimetric sampling station. Total sampling depth, 4 feet.	Sprinkler	Apr. 5 Apr. 17, 30 June 18 Aug. 5 July 2, 11, 28 Aug. 13, 23 Sept. 3, 27	Apr. 18 June 26 Aug. 5 Sept. 19	April 1 - Nov. 1	515 Redding GSE
TULARE LAKE BASIN VALLEY FLOOR								
GROSS								
Arvin (GE)	1959	Hesperia fine sandy loam, fairly uniform.	Neutron scattering	Border irrigation, run, 440 feet.	Shown in Table 8	Moved every two weeks.	Jan. 1 - Dec. 31	437 Arvin-Frick
	1960	0-12 feet overlying stratified layers varying in texture from sand to clay loam.						
ALFALFA								
Arvin Jewett	1957-58	Hesperia fine sandy loam, fairly uniform throughout 0-9 feet.	Ten gravimetric sampling stations. Total sampling depth, 9 feet.	Border irrigation, run, 1,300 feet.	Feb. 7 May 20, 30	Mar. 28 May 25	Feb. 1 - Nov. 30	440 Arvin Jewett #1
Arvin Jewett #2	1957-58	Hesperia fine sandy loam, fairly uniform throughout 0-9 feet.	Ten gravimetric sampling stations. Total sampling depth, 9 feet.	Border irrigation, run, 1,300 feet.	Feb. 7 May 20, 30	Mar. 28 May 25	Feb. 1 - Nov. 30	448 Arvin Jewett #1
Arvin Jewett #3	1958	Hesperia fine sandy loam, fairly uniform throughout 0-9 feet.	Ten gravimetric sampling stations. Total sampling depth, 9 feet.	Border irrigation, run, 1,300 feet.	Feb. 7 May 20, 30	Mar. 28 May 25	Feb. 1 - Nov. 30	448 Arvin Jewett #1

TABLE A-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of : measure- ment	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Length of irrigation	Dates of cutting or harvesting	Approximate : growing : season	Correlative : Eleva- : tion
<u>CENTRAL VALLEY (continued)</u>								
<u>TULARE LAKE BASIN VALLEY FLOOR (continued)</u>								
<u>ALFALFA (continued)</u>								
Arvin (CC)	1959	Hesperia fine sandy loam 0-12 feet overlying stratified layers varying in texture from sand to clay loam.	Neutron scattering.	Border irrigation, 440 feet.	Shown in Table 8	Mar. 12 Apr. 10 May 16 June 15 July 11 Aug. 8 Sept. 5 Oct. 17	Feb. 15 - Dec. 15	437 Arvin Jewett #2 and Arvin Frick
Arvin (CC)	1960	Hesperia fine sandy loam 0-12 feet overlying stratified layers varying in texture from sand to clay loam.	Neutron scattering.	Border irrigation, 440 feet.	Shown in Table 8	Mar. 21 Apr. 20 May 23 July 24 Aug. 25 Sept. 26	Feb. 15 - Dec. 15	437 Arvin Frick
<u>PLUMS</u>								
Arvin (CB)	1959	Hesperia fine sandy loam 0-18 feet overlying sand.	Neutron scattering.	Burrow irrigation, 325 feet.	Shown in Table 8	June 8	Mar. 1 - Nov. 30	470 Arvin Jewett #2 and Arvin Frick
Arvin (CB)	1960	Hesperia fine sandy loam 0-18 feet overlying sand.	Neutron scattering.	Burrow irrigation, 325 feet.	Shown in Table 8	June 14	Mar. 1 - Nov. 30	470 Arvin Frick
<u>COTTON</u>								
Arvin (CB)	1959	Hesperia fine sandy loam, fairly uniform 0-10 feet overlying sandy loam stratified with sand and clay layers.	Neutron scattering.	Burrow irrigation, 440 feet.	Shown in Table 8	Nov. 5 Dec. 12	Apr. 1 - Oct. 31	440 Arvin Jewett #2 and Arvin Frick
Arvin (CB)	1960	Hesperia fine sandy loam, fairly uniform 0-10 feet overlying sandy loam stratified with sand and clay layers.	Neutron scattering.	Burrow irrigation, 440 feet.	Shown in Table 8	Nov. 30, 1960 Jan. 12, 1961	Apr. 1 - Oct. 31	435 Arvin Frick

TABLE A-5 (continued)
GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Dates of irrigation	Dates of cutting or harvesting	Approximate growing season	Elevation	Correlative station
<u>LARDINGTON</u>									
<u>LASSEN-ALPINE MOUNTAIN VALLEYS</u>									
<u>PASTURE</u>									
Coleville 24	1957	Peat 0-1½ feet, underlain by sandy loam.	Evapotranspirometer	Continuous sub-irrigation with variable high water table levels.	Continuous		April 15 - Sept. 15	5,100	Coleville 24
<u>ALFALFA</u>									
Leavitt Lake	1955	Loam 0-9', silty clay loam 9-13', Compact silt 13-16', Sand 16-18', Water table 11-16'.	Four gravimetric sampling stations. Total sampling depth, 6-8 feet.	Border irrigation. Length of run, 1,200 feet.	May 1 July 26 Aug. 15, 27	Aug. 1 Sept. 27	May 15 - Sept. 15	4,112	Leavitt Lake

NEWTOWN PROBE MEASUREMENTS OF EVAPORANSPIRATION
AND RELATED DATA, 1959 AND 1960

Area	Station	Depth of water applied	Soil moisture in inches	Evaporation (E _T) in inches	Black minus white stemmometer	Black minus white stemmometer	Plant material	Crop
name	number	inches	change	inches	in inches	in millimeters	name	symbol
date	of	of	of	of	of	of	of	of
ending	beginning	depth	depth	depth	depth	depth	of	of
days	days	in	in	in	in	in	height	height
		feet	feet	feet	feet	feet	inches	inches
		Mean	Mean	Mean	Mean	Mean	cover	cover
		error	error	error	error	error	inches	inches
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS								
CENTRAL VALLEY								
Alcalá								
Pittville (AA), 1959								
1/7	12	1.92	0.44	1.92	0.09	5/13/59	20	3
1/8	12	3.60	0.26	3.85	0.26		75	18
4/23	15	4/25-29	NR	1.20	0.98		75	18
5/6	12	0.00	0.00	1.47	0.45		95	28
5/12	11	0.79	0.24	0.83	0.14		95	28
5/28	12	1.00	0.37	1.26	0.21	288	100	30
6/10	12	4.03	0.42	4.03	0.33	349	237	12
6/21	12	0.53	0.00	0.53	0.13	126	89	5
6/24	7	1.65	0.48	1.65	0.24	157	86	7
7/2	12	1.26	0.35	1.61	0.20	157	100	3
7/6	12	0.55	0.00	0.55	0.17	177	103	40
7/6	12	0.55	0.00	0.55	0.17	177	103	40
7/15	9	2.77	0.54	2.77	0.31	22	1,059	50
7/27	12	3.64	0.90	3.64	0.30	195	1,084	100
7/31	12	0.00	0.00	0.95	0.29	268	1,552	100
8/3	3	0.00	0.00	0.86	0.66	50	1,681	30
8/4	12	1.81	0.34	1.81	0.16	79	1,681	10
8/27	11	0.00	0.00	32.47	0.16	232	1,913	30
9/3	7	0.00	0.00	2.10	0.36	232	2,184	8
9/10	8	1.64	0.46	1.64	0.23	149	2,333	14
9/14	8	0.00	0.00	38.61	0.23	132	2,465	100
9/30	15	0.00	0.00	2.51	0.37	209	2,769	100
TOTALS	197	29.19	1.02	30.21	12.76	42.97	2,461	30
Pittville (AA), 1960								
3/10	8	3.03	0.48	3.03	0.10	1/25/60	20	5
4/29	9	1.31	0.36	1.72	0.13	8.68	80	10
5/11	13	0.00	0.00	6.30	0.13	8.29	80	10
5/16	9	2.55	0.60	2.55	0.63	1.44	95	34
6/10	9	1.98	0.32	1.98	0.22	2.91	100	27
6/24	14	1.21	0.30	1.21	0.09	2.08	100	30
6/26	2	0.00	0.00	15.07	0.09	4.12	325	10
6/26	4	0.00	0.00	0.55	0.24	2.77	20	5
6/30	8	3.45	0.48	3.45	0.36	1.09	0.0044	20
7/9	8	0.00	0.00	2.80	0.21	121	446	40
7/25	8	0.93	0.38	0.93	0.18	195	641	100
8/1	7	0.00	0.00	24.23	0.18	139	1,322	90
8/12	13	1.54	0.44	1.54	0.22	2.33	1,322	90
8/12	13	2.65	0.50	2.65	0.41	2.10	1,322	90
8/26	9	1.91	0.46	1.91	0.27	20.3	43.85	NR
8/28	2	0.00	0.00	0.18	0.22	0.17	44.02	NR
9/1	15	3.12	0.22	3.12	0.40	1.39	4.47	24
9/26	15	2.37	0.34	2.37	0.26	2.62	1,831	10
10/11	13	1.69	0.36	1.69	0.20	2.03	2,009	30
11/8	9	0.00	0.00	43.37	0.08	3.04	0.77	10
TOTALS	243	33.55	2.67	36.22	7.15	43.37	3,009	20

NEUTRON PROBE MEASUREMENTS OF EVAPORANSPIRATION
AND RELATED DATA FOR SEVERAL IRRIGATED CROPS,
1959 and 1960

Area, station, name, number, period, of ending days	Depth of water applied	Soil moisture determination				Evapotranspiration (E _T), Pan evaporation (E _p),				Black minus white				Crop development
		Moisture in inches	deple- tion in inches	change, in inches	Soil moisture in inches	Mean in inches	Meas- ured in inches	Mean in inches	Evap- orated in inches	Pan in inches	Black minus white in inches	Plant height, inches	Plant height, inches	
CENTRAL VALLEY (continued)														
TULARE LAKE BASIN (continued)														
Alfalfa (continued)														
Arvin (6), 1959 (Continued)					3/13/59				12/31/58					3/1/59
4/3	6	1.81	0.00	0.96	2.13	1.48	1.99	0.51	1.48	1.99	0.51	1.48	1.99	0.51
4/21	6	0.73	0.20	0.53	0.15	1.68	1.65	0.43	1.68	1.65	0.43	1.68	1.65	0.43
4/24	NR	---	0.00	0.73	4.67	0.12	---	---	0.71	14.36	0.71	14.36	0.71	
4/28	NR	---	0.42	0.86	5.83	1.06	15.42	---	1.06	15.42	---	1.06	15.42	---
5/7	NR	---	0.00	1.13	6.95	1.88	17.30	---	1.88	17.30	---	1.88	17.30	---
5/14	NR	---	0.00	1.21	8.17	1.94	19.24	---	1.94	19.24	---	1.94	19.24	---
5/19	5	0.77	0.12	0.65	8.94	0.15	20.52	0.60	74	1.16	0.0104	10	3	0-12
5/25	6	0.54	0.08	0.46	9.40	0.09	1.88	0.32	98	1.28	0.0055	50	9	0-12
5/29	NR	---	0.00	0.58	10.68	1.88	22.00	---	68	1.34	---	---	---	---
6/1	3	2.06	0.42	1.64	10.82	0.26	24.78	0.19	57	1.37	0.0139	95	23	0-12
6/9	NR	---	0.00	0.78	12.88	0.26	27.83	0.94	148	1.59	---	---	---	---
6/10	6/10	---	0.00	0.72	13.81	0.27	29.64	---	97	1.63	---	5	3	0-12
6/22	7	1.00	1.00	2.13	14.81	0.14	31.17	0.47	142	1.73	0.0070	40	8	0-12
6/25	3	---	0.00	0.49	15.29	---	32.20	---	65	1.83	---	---	---	---
6/29	4	---	0.00	0.87	16.23	---	32.20	---	65	1.83	---	---	---	---
7/3	1	1.09	0.16	0.93	17.35	0.27	34.97	0.69	86	1.93	0.0124	85	19	0-12
7/4	1	---	0.00	0.04	17.39	---	35.03	---	9	2.02	---	85	19	0-12
7/8	4	---	0.00	0.86	18.25	---	36.51	---	93	2.095	---	95	24	0-12
7/13	5	0.81	0.06	0.75	19.05	0.16	37.97	0.55	90	2.185	0.0090	10	4	0-12
7/17	2	0.59	0.08	0.51	19.45	0.10	39.22	0.51	80	2.265	0.0049	20	5	0-12
7/19	2	---	0.00	0.16	19.61	---	39.75	---	34	2.299	---	---	---	---
7/22	3	---	0.00	0.94	20.55	---	40.89	---	150	2.359	0.0134	40	8	0-12
7/29	13	1.70	0.16	1.54	22.25	0.24	42.69	0.74	126	2.475	---	---	---	---
7/30	3	---	0.00	0.19	22.44	---	43.15	---	17	2.492	---	---	---	---
8/8	9	---	0.00	2.19	24.63	---	45.98	---	168	2.620	---	---	---	---
8/13	6	0.39	0.00	0.39	25.22	0.08	46.19	0.23	156	2.618	0.0039	---	---	---
8/17	NR	---	0.00	0.69	25.90	---	49.37	---	54	2.672	---	---	---	---
8/20	3	---	0.00	0.69	25.90	---	49.37	---	54	2.672	---	---	---	---
8/24	NR	---	0.00	0.56	26.46	---	50.17	---	56	2.688	---	---	---	---
8/29	4	---	0.00	1.16	29.82	---	53.11	---	142	3.024	---	---	---	---
9/4	11	2.24	0.22	2.02	29.82	0.18	53.11	1.14	170	3.294	0.0158	80	17	0-12
9/15	8	1.28	0.34	0.94	31.44	0.15	55.63	0.81	170	3.294	0.0095	10	4	0-12
9/17	NR	---	0.00	0.82	31.86	---	55.63	---	32	3.386	---	---	---	---
9/22	5	---	0.06	0.88	32.74	---	56.51	---	74	3.400	---	---	---	---
10/2	10	1.74	0.22	1.52	34.43	0.17	58.62	0.82	158	3.558	0.0110	75	15	0-12
10/3	NR	---	0.00	1.12	34.60	---	58.76	---	14	3.572	---	---	---	---
10/9	12	---	0.00	0.78	37.35	---	61.98	---	172	3.684	---	---	---	---
10/21	12	1.29	0.12	1.17	37.35	0.11	61.98	0.75	172	3.684	0.0075	10	3	0-12
10/29	8	---	0.00	0.40	37.07	---	62.39	---	90	3.916	---	---	---	---
11/3	5	---	0.00	0.64	37.71	---	63.03	---	45	3.961	---	---	---	---
1/5/60	34	1.62	0.30	1.32	42.23	0.08	67.28	1.14	---	---	---	---	---	---
TOTALS 298	---	23.10	23.78	18.46	42.24	61.42	3.814	3.814	3/	3/29/60	---	---	---	---
Arvin (cc), 1960					5/12/60				1/1/60					
4/11	31	---	---	---	---	---	---	---	17.30	---	---	10	15	0-12
5/12	31	---	0.55	---	0.00	---	---	---	759	---	---	10	15	0-12
5/24	12	2.71	0.24	2.47	0.23	3.54	20.64	0.76	206	905	0.0132	15	4	0-12
5/31	7	0.27	---	---	2.93	0.04	22.68	0.13	1,113	---	0.0018	50	5	0-12

NEUTRON PHOSOR MEASUREMENTS OF SEPARATIONSTATION
AND RELATED DATA FOR SEVERAL IRRIGATED CROPS,
1959 AND 1960

Area, station, period, of ending days	Date	Depth of water	Soil moisture change, in inches	Precip- itation, in inches	Mean inches	Standard error	Mean error	Evapotranspiration (E _T), inches	Span evaporation (E _{Sp}), inches	Black minus white atomometer evaporation, in milliliters	Crop development	Soil moisture in milliliters	Soil moisture in inches	Soil moisture in feet

CENTRAL VALLEY (continued)

TULARE LAKE BASIN (continued)														
Area, station, period, of ending days	Date	Depth of water	Soil moisture change, in inches	Precip- itation, in inches	Mean inches	Standard error	Mean error	Evapotranspiration (E _T), inches	Span evaporation (E _{Sp}), inches	Black minus white atomometer evaporation, in milliliters	Crop development	Soil moisture in milliliters	Soil moisture in inches	Soil moisture in feet
TOTALS 285 30.7 25.06 10.36 36.32 51.23 3.115														
Cotton (continued)														
Arvin (CP), 1960														
3/23	ε	3.18												
Planted	44													
5/6														
5/26	20													
6/26	14													
6/9														
6/15	6	6/15												
6/20	5													
6/30	4													
7/7	7	1/ε												
7/15	7													
7/22	7													
7/28	6													
7/29	1	1/29												
8/9	11													
8/20	11	8/20												
8/23	3													
8/31	8													
9/8	8													
9/21	13													
10/14	23													
10/28	23													
11/22	39													
1/16/61	55													
3/10/61	53													
TOTALS 357		25.34												

22	12	3.65	0.26	0.00	3.68	---	3.60	0.11	4.21	61.22	0.88	372	3,815	0.0099	75	NR	0-12	3.44	
21	12	0.36	0.12	0.00	0.36	---	35.96	0.02	2.01	63.23	0.18	163	3,978	0.0022	NR	NR	0-12	3.09	
21	12	0.33	0.16	T	0.33	---	36.29	0.01	3.21	66.44	0.10	---	---	---	NR	NR	---	---	
---	---	---	---	---	0.33	---	0.03	36.32	---	67.12	---	---	---	---	---	NR	NR	---	---
---	---	---	---	---	0.36	---	25.06	10.36	36.32	51.23	---	---	---	---	---	---	---	---	---
---	---	---	---	---	---	---	3/18/60	---	2/	1/2/60	---	3/	3/23/60	---	---	---	---	---	---
---	---	---	---	---	0.50	---	0.50	---	0.85	7.04	---	---	---	---	---	---	---	---	---
10	2	-0.05/ε		1.52	1.16	---	1.96	0.03	0.40	13.44	0.17	634	534	0.0023	1	---	0-1	1.53	
23	10	10		---	0.20	---	2.16	0.01	5.86	21.30	0.03	369	1,003	0.0005	2	4	0-1	1.39	
23	10	10		---	0.17	---	2.33	0.01	4.53	25.83	0.04	297	1,300	0.0006	2	8	0-2	2.61	
7	7	1/ε		---	0.04	---	3.17	0.14	2.03	27.86	0.41	131	1,431	0.0064	4	10	0-3	2.40	
22	4			---	2.41	---	1.81	4.98	---	29.68	---	124	1,555	---	10	12	0-4	5.72	
22	5			---	6.30	---	7.39	0.24	1.82	35.88	0.75	286	1,781	0.0107	30	16	0-5	4.81	
22	5			---	1.94	---	9.33	0.28	2.13	35.01	0.91	138	1,919	0.0140	40	24	0-5	2.93	
7	7			---	0.25	---	9.58	0.31	35.32	---	---	28	1,943	---	---	---	---	---	
7	7			---	2.38	---	11.96	---	2.23	37.55	---	155	2,098	---	60	28	0-7	5.09	
7	7			---	2.26	---	14.22	0.32	2.12	39.67	1.07	148	2,246	0.0153	55	32	0-7	2.83	
7	7			---	1.89	---	16.13	0.22	1.47	41.44	1.28	101	2,347	0.0187	---	36	0-9	4.06	
7	7			---	0.29	---	16.40	---	0.27	41.41	---	19	2,365	---	---	36	0-9	2.17	
8	9			---	3.96	---	20.36	---	3.17	44.83	---	215	2,581	---	80	40	0-9	4.69	
8	9			---	3.28	---	21.13	0.33	4.79	47.89	1.25	290	2,603	0.0166	60	48	0-9	1.41	
8	9			---	0.58	---	25.07	---	0.95	48.54	---	57	2,865	---	75	44	0-9	8.27	
8	9			---	1.29	---	26.37	0.16	1.71	50.25	0.75	187	2,992	0.0102	---	44	0-9	6.98	
8	9			---	1.60	---	27.94	0.20	1.79	52.04	0.89	141	3,133	0.0113	60	40	0-9	5.36	
8	9			---	2.7	---	30.71	0.21	2.62	54.66	1.05	205	3,138	0.0134	---	40	0-9	2.63	
8	9			---	1.7	---	32.50	0.08	3.96	58.62	0.45	318	3,656	0.0056	60	40	0-9	0.84	
8	9			---	0.94	---	33.44	0.02	3.45	62.07	0.27	367	4,021	0.0026	---	40	0-9	1.94	
8	9			---	0.57	---	34.01	0.01	2.06	64.13	0.28	NR	---	---	---	---	---	---	
8	9			---	2.7	---	39.27	0.01	4.80	68.33	0.54	NR	---	---	---	---	---	---	
8	9			---	1.1	---	10.62	36.27	62.14	---	---	---	---	---	---	---	---	---	
8	9			---	---	---	3/31/59	---	2/	12/31/59	---	3/	3/1/59	---	---	---	---	---	---
8	9			---	0.00	---	0.00	---	---	8.48	---	---	390	---	NR	NR	---	---	
8	9			---	0.19	---	0.19	0.15	0.25	9.23	---	---	280	---	NR	NR	---	---	
8	9			---	2.1	---	4.2	0.12	1.39	17.06	0.50	---	940	---	NR	NR	---	---	
8	9			---	0.13	---	4.30	---	0.26	18.30	---	---	962	---	NR	NR	---	---	
8	9			---	2.42	---	4.17	---	4.2	20.70	---	---	280	---	NR	NR	---	---	
8	9			---	1.8	---	4.12	---	1.69	24.74	---	---	119	---	NR	NR	---	---	
8	9			---	1.1	---	11.17	0.11	2.81	28.73	0.26	---	1,495	0.0107	---	---	---	---	

TABLE A-7

 EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
 FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches			Atmometer evaporation, in milliliters		ET / /Eb-v : :in inches :	Pan evapora- :tion Ep, : :in inches :
			Tank 1	Tank 2	Tank 3	Mean	Black		
<u>CENTRAL VALLEY</u>									
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS									
Pasture	1959								
Alturas-Dorris Ranch	Apr. 7	-	---	---	---	---	---	---	---
	Apr. 14	7	1.21	1.27	1.24	0.18	---	---	1.34
	Apr. 21	7	1.49	1.26	1.39	0.20	---	---	1.34
	Apr. 30	9	1.32	1.49	1.40	0.16	---	---	1.67
	May 5	5	0.66	0.89	0.77	0.15	---	---	1.29
	May 12	7	1.49	1.30	1.39	0.20	---	---	1.34
	May 19	7	1.37	1.46	1.42	0.20	---	---	1.27
	May 26	7	1.81	1.49	1.65	0.24	---	---	1.36
	May 31	5	0.68	0.83	0.76	0.15	---	---	0.83
	June 2	2	0.58	0.67	0.62	0.31	---	---	0.48
	June 9	7	2.18	2.20	2.19	0.31	425	311	1.74
	June 16	7	2.23	2.04	2.14	0.31	524	383	2.01
	June 23	7	2.51	2.26	2.38	0.34	516	363	2.12
	June 30	7	1.54	1.70	1.62	0.23	350	248	1.59
	July 7	7	2.48	2.39	2.44	0.35	552	401	2.57
	July 14	7	2.41	2.40	2.41	0.34	556	383	2.00
	July 21	7	2.64	2.80	2.72	0.39	536	394	1.99
	July 28	7	2.05	2.06	2.06	0.29	c/	c/	2.36
	July 31	3	0.79	0.85	0.82	0.27	876	677	0.89
	Aug. 4	4	1.30	1.39	1.34	0.34	460	346	1.46
	Aug. 11	7	2.21	1.98	2.10	0.30	428	336	1.97
	Aug. 18	7	1.99	2.48	2.24	0.32	548	413	1.99
	Aug. 25	7	1.49	1.58	1.54	0.22	372	265	1.47
	Aug. 31	6	1.84	1.31	1.57	0.26	423	324	1.76

TABLE A-7 (continued)

 EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
 FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches			Atmosphere evaporation, in milliliters		Pan evaporation, in inches	
			Tank 1	Tank 2	Tank 3	Mean daily	Black		White
<u>CENTRAL VALLEY (continued)</u>									
<u>SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)</u>									
<u>Pasture (continued)</u>									
<u>Alturas Dairy Ranch 5/9</u>									
(continued)									
	Sept. 1	1	0.23	0.24	0.23	0.23	57	18	0.0130
	Sept. 8	7	1.43	1.37	1.40	0.20	446	319	0.0110
	Sept. 15	7	1.42	1.34	1.38	0.20	497	401	0.0144
	Sept. 22	7	0.85	0.68	0.77	0.11	231	157	0.0104
	Sept. 30	8	1.33	0.91	1.12	0.14	---	---	---
	Oct. 6	6	0.85	0.77	0.81	0.14	---	---	0.07
	Oct. 13	7	0.25	0.29	0.27	0.04	---	---	1.70
	Oct. 20	7	0.66	0.50	0.58	0.08	---	---	1.74
	Oct. 27	7	0.41	0.59	0.50	0.07	---	---	0.84
	Oct. 31	4	0.94	0.04	0.49	0.12	---	---	0.92
	Nov. 2	2	0.70	0.04	0.37	0.18	---	---	1.06
									0.85
									0.40
									0.62
									0.61
									0.82
									0.62
									1.39
<u>1960</u>									
	Apr. 8	3	0.46	---	---	0.15	---	---	---
	Apr. 11	7	0.61	0.79	0.70	0.10	---	---	0.59
	Apr. 18	7	0.61	0.79	0.70	0.10	---	---	0.74
	Apr. 25	7	0.47	0.60	0.54	0.08	---	---	0.89
	May 1	6	0.61	0.65	0.63	0.10	---	---	1.07
	May 9	8	0.62	---	---	0.08	---	---	1.20
	May 16	7	1.53	---	---	0.22	---	---	0.81
	May 23	7	---	1.14	---	0.16	---	---	1.21
	May 25	2	0.32	0.30	0.31	0.16	---	---	0.94
	May 31	6	1.01	---	---	0.17	---	---	1.24
									1.17
									0.86

TABLE A-7 (continued)

 EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
 FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period : ending :	Number : of days :	Evapotranspiration (ET) for period of measurement, in inches			Atmosphere		Pan : evapora- : tion Ep, : /Sp				
			Tank 1 :	Tank 2 :	Tank 3 :	Mean :	daily :		Black :	White :	Eb-v :	Eb-v :
CENTRAL VALLEY (continued)												
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)												
Pasture (continued)	1960											
Alturas Dorris	June 7	7	1.96 ^d /	0.28	500 ^f /	360 ^f /	140 ^f /	1.96	---	---	---	---
Ranch 5/b/	June 14	7	---	0.20	437	308	129	1.73	0.0109	---	---	---
(continued)	June 21	7	1.96 ^d /	0.28	459	343	116	1.96	---	---	---	---
	June 22	1	0.26 ^e /	---	---	---	---	---	---	---	---	---
	June 28	6	---	0.23	459	319	140	1.98	0.0116 ^g /	---	---	0.82 ^h /
	July 5	7	1.94	1.93	466	331	135	1.82	0.0143	0.0143	1.06	1.06
	July 12	7	2.21	2.30	536	410	126	2.11	0.0183	0.0183	1.09	1.09
	July 19	7	2.42	2.37	524	385	139	1.95	0.0170	0.0170	1.21	1.21
	July 26	7	---	---	592	469	123	2.18	0.0182	0.0182	1.03	1.03
	Aug. 1	6	---	---	347	262	85	1.39	0.0175	0.0175	1.07	1.07
	Aug. 3	2	0.62	0.31	---	---	---	0.55	---	---	1.13	1.13
	Aug. 8	5	---	0.29	495	370	125	1.32	0.0118	0.0118	1.11	1.11
	Aug. 16	6	2.46	---	540	430	110	2.27	0.0224	0.0224	1.08	1.08
	Aug. 22	6	---	0.33	546	433	113	1.82	0.0174	0.0174	1.08	1.08
	Aug. 29	7	1.88	0.27	387	282	105	1.55	0.0179	0.0179	1.21	1.21
	Aug. 31	2	---	0.30	133	106	27	0.51	0.0218	0.0218	1.16	1.16
	Sept. 5	5	---	---	358	285	73	1.31	0.0171	0.0171	0.95	0.95
	Sept. 12	7	1.44	0.25	371	272	99	1.32	0.0145	0.0145	1.09	1.09
	Sept. 19	7	1.37	0.20	406	300	106	1.44	0.0129	0.0129	0.95	0.95
	Sept. 26	7	1.37	1.29	371	272	99	1.24	0.0130	0.0130	1.04	1.04
	Sept. 30	4	0.63	0.66	188	144	44	0.60	0.0150	0.0150	1.10	1.10
	Oct. 3	3	0.49	0.47	159	116	43	0.50	0.0109	0.0109	0.94	0.94
	Oct. 10	7	0.86	0.90	---	---	---	0.94	---	---	0.96	0.96
	Oct. 16	6	0.64	0.11	---	---	---	0.61	---	---	1.05	1.05

TABLE A-7 (continued)

EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches			Mean daily	Atmosphere		ET / Eb-v	Pan evaporation, in inches
			Tank 1	Tank 2	Tank 3		White	Black		
<u>CENTRAL VALLEY (continued)</u>										
<u>SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)</u>										
Pasture (continued)	1960									
Alturas Dorris Ranch 5/b/ (continued)	Oct. 22	6	0.64	0.66	0.65	0.11	---	---	---	0.86
	Oct. 28	6	0.60	0.72	0.66	0.11	---	---	---	0.89
	Oct. 31	3	0.21	0.26	0.24	0.08	---	---	---	0.92
	Nov. 7	7	---	---	0.55 ^d	0.08	---	---	---	0.59
	Nov. 14	7	---	---	0.13 ^d	0.02	---	---	---	0.14
	Nov. 21	7	---	---	0.03 ^d	0.00	---	---	---	0.03
	Dec. 1	10	0.23	0.11	0.17	0.02	---	---	---	0.38
	Dec. 9	8	0.12	0.46	0.29	0.04	---	---	---	0.16
	Dec. 14	5	0.02	0.18	0.10	0.02	---	---	---	0.09
	Dec. 20	6	0.13	0.21	0.17	0.03	---	---	---	0.12
	Dec. 28	8	0.11	0.19	0.15	0.02	---	---	---	0.23
	Dec. 31	3	0.07	0.01	0.04	0.01	---	---	---	0.02
<u>SACRAMENTO RIVER BASIN VALLEY FLOOR</u>										
Ryegrass Davis Campbell b/i/	1958									
	Sept. 6	4	---	---	---	---	---	---	---	---
	Sept. 10	3	1.22	0.80	1.02	0.26	344	270	74 ^b / 0.0174	1.28
	Sept. 13	3	---	---	---	---	189	133	56 ^b / 0.0171	0.75
	Sept. 18	5	1.10	0.98	1.02	0.20	469	369	100 ^b / 0.0102	1.62
	Sept. 25	7	1.70	1.03	1.25	0.18	673	539	134 ^b / 0.0093	2.22
	Sept. 29	4	---	---	---	---	298	222	76 ^b / 0.0174	0.89
	Oct. 6	7	1.96	1.53	1.65	0.24	565	470	95 ^b / 0.0171	1.81
	Oct. 15	9	2.02	1.96	1.86	0.21	681	572	104 ^b / 0.0171	2.10
	Oct. 22	7	1.13	1.13	1.15	0.16	486	421	65 ^b / 0.0177	1.43
	Oct. 29	7	0.80	0.86	0.88	0.13	297	246	51 ^b / 0.0172	0.92

TABLE A-7 (continued)

 EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
 FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches			Mean daily	Atmometer, in milliliters			ET/Eb-w	Pan evaporation, in inches	ET/evaporation, in inches
			Tank 1	Tank 2	Tank 3		Black	White	Eb-w			
SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)												
Ryegrass (continued) 1958												
Davis Campbell												
b/l/ (continued)												
Nov. 4	6	0.99	0.93	1.12	1.01	231	189	424/	0.64	0.80	0.80	0.80
Nov. 13	9	0.48	0.60	0.48	0.52	377	316	614/	1.26	1.04	1.04	1.04
Nov. 18	5	0.43	0.31	0.37	0.37	---	---	---	0.50	0.80	0.80	0.80
Nov. 26	8	0.55	0.49	0.31	0.45	---	---	---	---	---	---	---
Dec. 2	6	0.06	0.37	0.18	0.20	---	---	---	---	---	---	---
Dec. 15	13	0.60	0.53	0.60	0.58	---	---	---	---	---	---	---
Dec. 31	16											
1959												
Dec. 31												
Feb. 2	33	1.22	1.40	1.65	1.42	---	---	---	2.03	0.70	0.70	0.70
Feb. 19	17	1.53	2.08	1.71	1.77	---	---	---	1.46	1.21	1.21	1.21
Feb. 27	8	0.42	0.60	0.48	0.50	---	---	---	0.72	0.69	0.69	0.69
Mar. 17	18	2.20	2.45	3.43	2.69	---	---	---	4.31	0.62	0.62	0.62
Apr. 1	15	1.47	1.84	1.96	1.76	---	---	---	2.26	0.78	0.78	0.78
Apr. 16	15	2.69	3.24	1.59	2.51	---	---	---	4.26	0.59	0.59	0.59
Apr. 20	4	---	---	---	0.54/	---	---	---	0.93	---	---	---
Apr. 23	3	---	---	---	0.35/	---	---	---	0.61	---	---	---
Apr. 30	7	---	---	---	0.93/	---	---	---	1.59	---	---	---
May 7	7	1.41	1.10	0.92	1.14	---	---	---	1.99	0.57	0.57	0.57
May 14	7	1.84	1.65	1.71	1.73	---	---	---	2.35	0.74	0.74	0.74
May 21	7	---	---	---	1.56/	---	---	---	2.56	---	---	---
May 28	7	0.98	1.10	1.10	1.06	---	---	---	1.91	0.56	0.56	0.56

TABLE A-7 (continued)

EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches			Atmometer evaporation, in milliliters			ET/ET/ : Pan : : evapora- : : tion Sp, : : /bp	
			Tank 1	Tank 2	Tank 3	Mean	Black	White		ET/ : : /Eb-v : : in inches :
CENTRAL VALLEY (continued)										
SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)										
Ryegrass (continued)	1959									
Davis Campbell	June 4	7	---	---	1.34 ^{1/2}	0.19	---	---	---	2.23
b/i/ (continued)	June 8	4	---	---	0.85 ^{1/2}	0.21	---	---	---	1.44
	June 15	7	1.35	2.14	1.67	0.24	---	---	---	2.23
	June 22	7	---	---	1.86 ^{1/2}	0.26	---	---	---	2.63
	June 30	8	---	---	2.22 ^{1/2}	0.28	787	584	---	3.09
	July 7	7	2.09	2.15	2.02	0.30	654	490	0.0127	2.69
	July 13	6	1.71	1.64	1.38	0.26	580	464	0.0136	2.10
	July 23	10	2.57	2.69	2.94	0.27	879	685	0.0140	3.46
	July 29	6	1.90	1.87	1.35	0.28	537	416	0.0141	2.49
	Aug. 3	5	1.67	1.51	1.16	0.29	427	337	0.0161	1.73
	Aug. 10	7	1.71	1.77	1.74	0.25	---	---	---	1.89
	Aug. 12	2	0.43	0.44	0.58	0.24	---	---	---	0.63
	Aug. 18	6	1.44	1.28	1.41	0.23	---	---	---	1.93
	Aug. 22	4	0.74	0.66	0.41	0.15	---	---	---	1.10
	Aug. 28	6	1.13	1.35	1.28	0.21	---	---	---	1.61
	Aug. 31	3	0.83	0.67	0.76	0.25	201	139	0.0121	0.99
	Sept. 3	3	---	---	0.76 ^{1/2}	0.25	225	165	---	0.59
	Sept. 11	8	1.71	1.84	1.80	0.22	586	423	0.0110	2.45
	Sept. 14	3	---	0.46	0.49	0.16	229	172	0.0084	0.84
	Sept. 21	7	1.12	0.87	0.96	0.14	249	164	0.0115	1.07
	Sept. 23	2	0.28	0.21	0.43	0.16	146	108	0.0082	0.50
	Oct. 2	9	2.63 ^{1/2}	2.08	2.02	0.23	963	803	0.0129	3.37
	Oct. 7	5	0.57 ^{1/2}	0.60	0.53	0.11	261	192	0.0081	0.87
	Oct. 16	9	1.94 ^{1/2}	1.61	1.46	0.17	634	496	0.0112	2.00
	Oct. 24	8	1.16 ^{1/2}	0.73	0.80	0.10	416	310	0.0072	1.12

TABLE A-7 (continued)

 EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
 FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches			Mean daily	Atomometer evaporation, in milliliters		ET/ET/Ep	Pan evaporation Ep, in inches			
			Tank 1	Tank 2	Tank 3		Black	White					
CENTRAL VALLEY (continued)													
SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)													
Ryegrass (continued) 1959													
Davis Campbell	Nov. 12	9	1.38 $\frac{1}{2}$	1.43	1.37	1.40	0.16	752	634	113 $\frac{1}{2}$	0.0143	2.67	0.52
b/l/ (continued)	Nov. 20	10	0.84 $\frac{1}{2}$	0.67	---	0.67	0.07	472	360	112 $\frac{1}{2}$	0.0060	1.23	0.54
	Nov. 20	8	0.49	0.55	---	0.52	0.06	---	---	---	---	0.58	0.90
	Dec. 5	15	0.83	0.92	1.04	0.93	0.06	---	---	---	---	2.38	0.41
	Dec. 15	10	0.28	0.31	0.34	0.31	0.31	---	---	---	---	1.04	0.30
	Dec. 22	7	0.24	0.12	0.21	0.19	0.03	---	---	---	---	0.31	0.61
	Dec. 31	9	0.48	0.39	0.27	0.38	0.04	---	---	---	---	0.33	1.15
1960													
	Dec. 31	-	---	---	---	---	---	---	---	---	---	---	---
	Jan. 12	12	0.22	0.34	0.34	0.30	0.02	---	---	---	---	0.73	0.41
	Jan. 19	7	0.21	0.28	0.09	0.19	0.03	---	---	---	---	0.37	0.51
	Jan. 26	7	0.57	0.11	0.24	0.31	0.04	---	---	---	---	0.28	1.11
	Jan. 30	4	0.03	0.00	0.09	0.04	0.01	---	---	---	---	0.10	0.40
	Feb. 8	9	---	---	m/	0.16 $\frac{1}{2}$	0.02	---	---	---	---	0.60	0.27
	Feb. 15	7	---	---	m/	0.53 $\frac{1}{2}$	0.08	---	---	---	---	0.68	0.78
	Feb. 26	11	0.80	0.86	0.86	0.84	0.08	---	---	---	---	1.60	0.52
	Mar. 8	11	0.54	0.79	0.54	0.62	0.06	---	---	---	---	0.75	0.83
	Mar. 18	10	0.94	1.18	1.47	1.20	0.12	---	---	---	---	1.65	0.73
	Mar. 31	13	1.81	1.32	1.45	1.53	0.12	---	---	---	---	1.81	0.85
	Apr. 12	12	1.92	2.04	1.98	1.98	0.16	---	---	---	---	2.43	0.81
	Apr. 18	6	1.04	1.22	1.16	1.14	0.19	---	---	---	---	1.62	0.70
	Apr. 29	11	1.68	1.72	1.76	1.73	0.16	446	308	138	0.0125	1.60	1.08

TABLE A-7 (continued)
 EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
 FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches			Mean		Atmometer evaporation, in milliliters		ET/Eb-v	Pan evaporation, in inches
			Tank 1	Tank 2	Tank 3	daily	Black	White	Eb-v		
CENTRAL VALLEY (continued)											
SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)											
Ryegrass (continued)	1960										
Davis Campbell	May 10	11	2.35	2.19	2.23	2.26	0.21	604	183	0.0123	2.50
h/1/ (continued)	May 26	16	3.69	3.71	3.62	3.67	0.23	1169	270	0.0136	4.95
	June 1	6	1.65	1.47	1.59	1.57	0.26	509	117	0.0135	1.75
	June 9	8	1.42	1.29	1.30	1.34	0.17	788	154	0.0087	3.60
	June 13	4	0.95	0.89	1.29	1.04	0.26	335	85	0.0122	1.34
	June 22	9	1.50	1.29	1.12	1.30	0.14	1047	183	0.0071	3.95
	July 1	9	2.05	2.40	2.11	2.19	0.24	717	185	0.0117	3.13
	July 6	5	1.29	1.22	1.35	1.29	0.26	423	105	0.0123	1.78
	July 8	2	0.61	0.55	0.61	0.59	0.30	163	123	0.0148	0.72
	July 12	4	0.74	0.80	0.61	0.72	0.18	338	88	0.0082	1.46
	July 19	7	1.64	1.64	1.67	1.65	0.24	633	157	0.0105	2.48
LASSEN-ALPINE MOUNTAIN VALLEYS											
LAHONTAN											
Pasture	1957										
Coleville 2W 2/h/	May 27	-	-----	-----	-----	-----	-----	-----	---	-----	-----
	June 3	7	1.34	-----	-----	-----	0.19	-----	---	-----	1.38
	June 6	3	0.73	-----	-----	-----	0.24	-----	---	-----	0.79
	June 10	4	0.95	-----	-----	-----	0.24	-----	---	-----	0.75
	June 17	7	1.34	-----	-----	-----	0.19	502	137	0.0098	1.63
	June 24	7	1.93	-----	-----	-----	0.28	569	154	0.0125	2.29
	June 30	6	1.96	-----	-----	-----	0.33	542	399	0.0137	1.85
	July 8	8	2.27	-----	-----	-----	0.28	639	491	0.0153	2.22
	July 16	8	2.50	-----	-----	-----	0.31	693	527	0.0151	2.46
	July 29	13	3.58	-----	-----	-----	0.28	995	760	0.0152	3.70
	Aug. 1	3	0.77	-----	-----	-----	0.26	277	225	0.0148	0.95

EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches			Atmometer evaporation, in milliliters			ET / Evaporation	Pan evaporation	ET / Evaporation	
			Tank 1	Tank 2	Tank 3	Mean	Black	White				Black
LASSEN-ALPINE MOUNTAIN VALLEYS												
LAHONTAN												
Pasture (continued)	1957											
Coleville 2 ^W 0714	Aug. 5	4	1.25	---	---	0.31	437	346	91	0.0136	1.51	0.83
(continued)	Aug. 12	7	1.88	---	---	0.27	532	392	140	0.0134	1.94	0.97
	Aug. 19	7	1.78	---	---	0.25	587	453	134	0.0133	2.11	0.84
	Aug. 26	7	1.75	---	---	0.25	635	499	136	0.0129	2.22	0.79
	Aug. 31	5	1.10	---	---	0.22	388	306	82	0.0134	1.31	0.84
	Sept. 2	2	0.21	---	---	0.10	118	86	32	0.0066	0.41	0.51
	Sept. 9	7	1.09	---	---	0.16	512	386	126	0.0086	1.72	0.63
	Sept. 13	4	0.71	---	---	0.18	202	152	50	0.0142	0.70	1.01
	Sept. 16	3	0.50	---	---	0.17	187	140	47	0.0106	0.64	0.78
	Sept. 23	7	0.88	---	---	0.13	345	241	104	0.0085	1.16	0.76

a - Ground cover 100 percent May through September, 40 - 100 percent during April, and 0 - 40 percent November and December.

b - High water table evapotranspirometer with water stage recorders on supply and outflow tanks. Elevation of water table in tanks 6 - 8 inches below ground surface.

c - Included in following measurement.

d - Estimated value. Estimate based on U. S. Weather Bureau pan evaporation.

e - Interpolated value from mean daily rate.

f - Atmometer values accumulated from May 23.

g - Coefficients derived from a measured period plus a short period of estimated evapotranspiration.

h - Ground cover 100 percent for all periods of measurement.

i - Weighing tanks.

j - Atmometer values obtained from U. C. Campbell Tract Climatic Station.

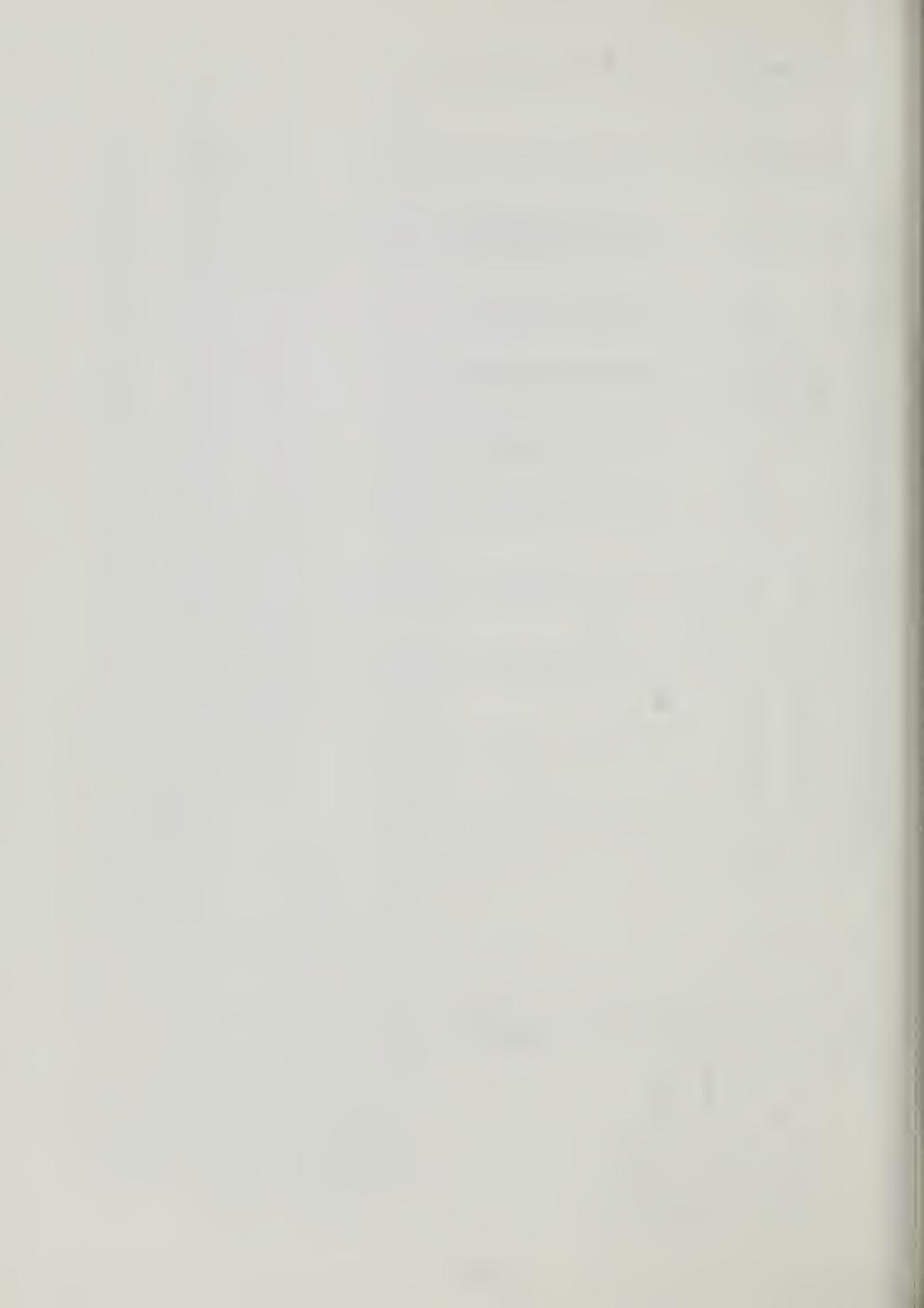
k - Estimated value based on U. S. Weather Bureau pan evaporation. Evapotranspiration for these periods were estimated because reliable measurements were not available on the amount of water that entered each evapotranspirometer from sprinkler irrigations.

l - Tank 1 values were not used in calculating the mean. The grass in this evapotranspirometer was allowed to grow to a considerable height to determine effect thereof on evapotranspiration rate.

m - Heavy rainfall caused overflow of tanks.

n - Evapotranspiration values of the 20-foot Davis evapotranspirometer was used because heavy rainfall during this period overflowed from the evapotranspirometers and the amount of rainfall that remained in the evapotranspirometers could not be determined.

o - ET measured as water supply to one evapotranspirometer tank. Water level in tank automatically adjusted to reflect a one- to three-foot variable water table elevation of surrounding area.



AGROCLIMATIC STATIONS

†

● ACTIVE-1960

○ ACTIVE-PRE 1960

- | | | |
|-----------------------------|----------------------------|-------------------------------|
| 1. Macdoel F. S. | 39. Bella Vista 4NE | 76. Arbuckle 1S |
| 2. Montague 3NE | 40. Eagle Lake Stone Ranch | 77. Lincoln Vineyard |
| 3. Yreka 1NE | 41. Hayfork R. S. | 78. Auburn Mt. Vernon |
| 4. Davis Creek 4WNW | 42. Redding R. S. | 79. Gold Hill Doty Flat |
| 5. Grenada 6E | 43. Redding Stayer | 80. Rocklin Igarashi |
| 6. Fort Jones R. S. | 44. Redding 6SE | 81. Woodfoords |
| 7. Gazelle 1NNE | 45. Redding A. P. | 82. Davis Campbell #1 |
| 8. Gazelle 3NNW | 46. Anderson 2E | 83. Davis Campbell #2 |
| 9. Big Sage Reservoir | 47. Anderson 3E | 84. Coleville 2W |
| 10. Cedarville Chevron | 48. Anderson 4E | 85. Elk Grove 4NW |
| 11. Cedarville 2E | 49. Leavitt Lake | 86. Bridgeport DWR |
| 12. Cedarville 1E | 50. Standish 4NW | 87. Thornton 2S |
| 13. Alturas Park Avenue | 51. Standish 1NW | 88. Twitchell Island |
| 14. Alturas Dorris Ranch | 52. Red Bluff 3E | 89. Lodi 3SW |
| 15. Canby Ohm | 53. Red Bluff Cone Ranch | 90. Lodi 3S |
| 16. Canby R. S. | 54. Corning 3NW | 91. Stockton 8S |
| 17. Canby 11SW | 55. Corning 3NE | 92. Stockton 9S |
| 18. Callahan Towne Ranch | 56. Corning Jobe | 93. El Solyo Ranch |
| 19. Mt. Shasta City W. B. | 57. Vina Beck | 94. Vernalis 3SE |
| 20. Likely Williams Ranch | 58. Quincy R. S. | 95. Ceres 3E |
| 21. Likely 4N | 59. Newville | 96. Atwater 1N |
| 22. Adin Harper | 60. Loyalton 5W | 97. Newman 1SE |
| 23. Adin R. S. | 61. Loyalton 7N | 98. Merced 5SE |
| 24. West Valley Reservoir | 62. Hamilton City | 99. Berenda 2N |
| 25. Lookout 1S | 63. Mills Orchard | 100. Los Banos 3S |
| 26. Lookout Hunt | 64. Oroville Agric. Comm. | 101. Los Banos Equipment Yard |
| 27. Bieber 4E | 65. Richvale 1E | 102. Los Banos 8SE |
| 28. Bieber S. C. S. | 66. Sacramento Refuge | 103. Kerman 2ESE |
| 29. McArthur 2E | 67. Palermo 3SW | 104. Fresno Kearney Pa. k |
| 30. Pittville 1S | 68. Pennington 3NW | 105. Mendota Murietta Ranch |
| 31. Glenburn DWR | 69. Live Oak 3SE | 106. Panoche Junction |
| 32. Fall River Mills 4NW | 70. Loma Rica | 107. Kingsburg 5S #1 |
| 33. Fall River Mills R. S. | 71. Browns Valley 3NE | 108. Kingsburg 5S #2 |
| 34. Fall River Mills Intake | 72. Penn Valley | 109. Shafter 2NW |
| 35. Madeline 3SW | 73. Tahoe | 110. Arvin Frick |
| 36. Termo | 74. Yuba City | 111. Arvin Jewett #1 |
| 37. Hat Creek 3N | 75. Yuba City 9W | 112. Arvin Jewett #2 |



STATE OF CALIFORNIA
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VEGETATIVE WATER USE STUDIES
INTERIM REPORT

GENERAL LOCATION
OF
AGROCLIMATIC STATIONS
1954-1960

SCALE OF MILES

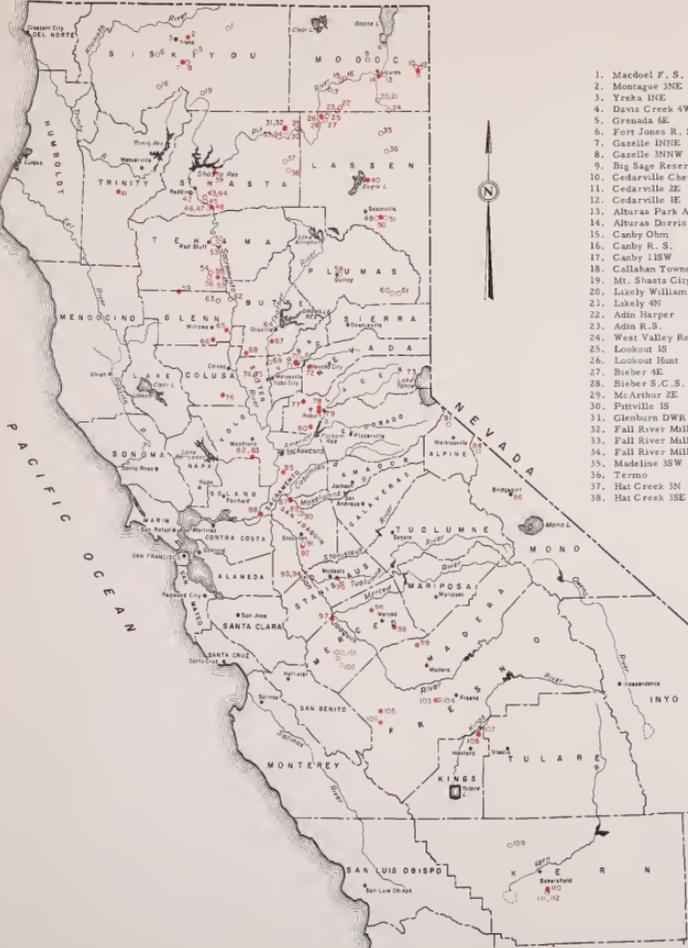
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OREGON

AGROCLIMATIC STATIONS

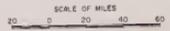
- ACTIVE-1960
- ACTIVE-PRE 1960

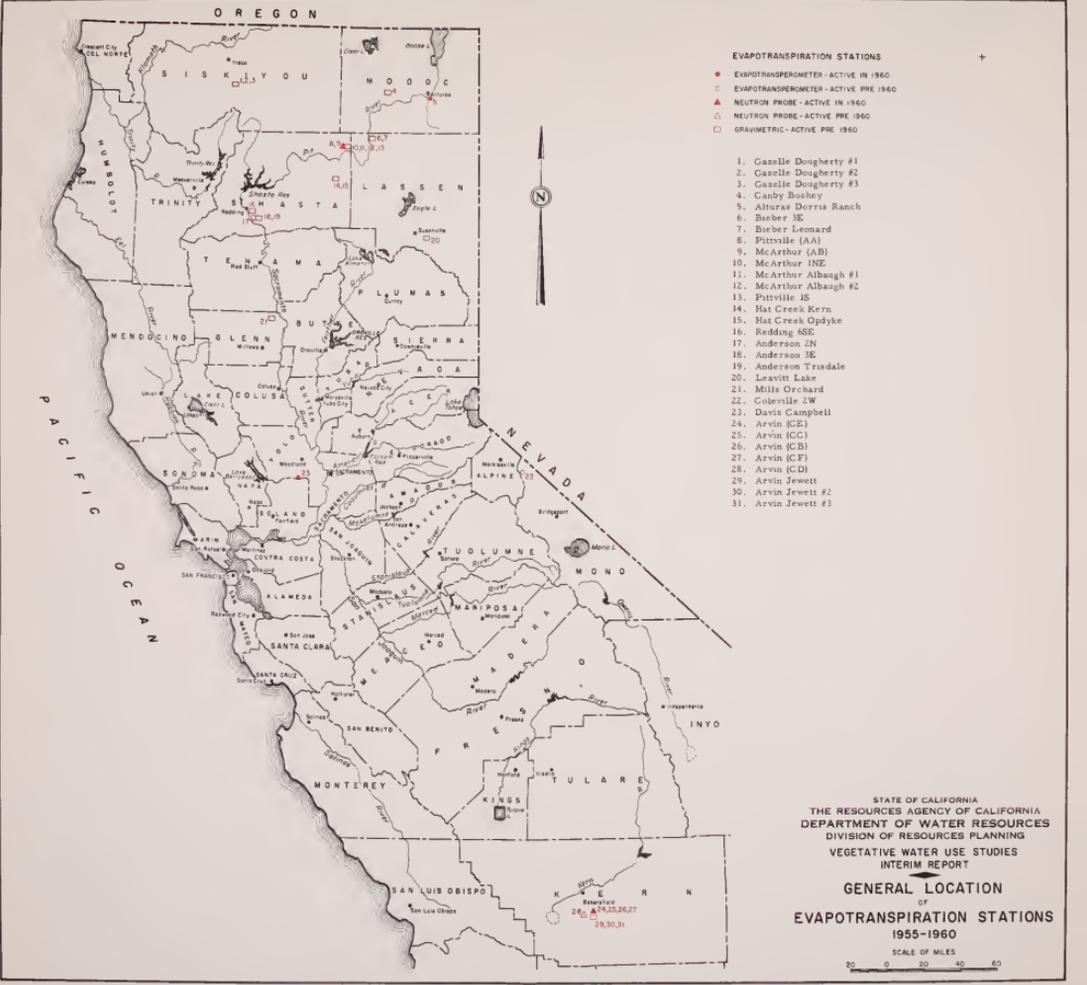
1. Macdoel F. S.
2. Montague JNE
3. Vreke INE
4. Davis Creek 4WNW
5. Grenada EE
6. Fort Jones R. S.
7. Gaselle INNE
8. Gaselle 3NNW
9. Big Sage Reservoir
10. Cedarville Chevron
11. Cedarville 2E
12. Cedarville 4E
13. Alturas Park Avenue
14. Alturas Dorris Ranch
15. Canby Ohm
16. Canby R. S.
17. Canby 11SW
18. Callahan Towne Ranch
19. Mt. Shasta City W.B.
20. Lively Williams Ranch
21. Lkeley 4N
22. Adin Harper
23. Adin R.S.
24. West Valley Reservoir
25. Lookout IS
26. Lookout Hunt
27. Butler 4E
28. Bieber S.C.S.
29. McArthur 2E
30. Putville IS
31. Glenburn DWR
32. Fall River Mills 4NW
33. Fall River Mills R.S.
34. Fall River Mills Intake
35. Madeline 3SW
36. Termo
37. Hat Creek 3N
38. Hat Creek 3SE
39. Bella Vista 4NE
40. Eagle Lake Stone Ranch
41. Hayfork R. S.
42. Redding R. S.
43. Redding Stayer
44. Redding SSE
45. Redding A. P.
46. Anderson SE
47. Anderson 3E
48. Anderson 4E
49. Leavitt Lake
50. Standush 4NW
51. Standush 3NW
52. Red Bluff 3E
53. Red Bluff Cone Ranch
54. Corning 3NW
55. Corning 3NE
56. Corning Jobe
57. Vina Beck
58. Quincy R. S.
59. Neville
60. Loyaltion 5W
61. Loyaltion 7N
62. Hamilton City
63. Mills Orchard
64. Oroville Agric. Comm.
65. Richvale IE
66. Sacramento Refuge
67. Palermo 3W
68. Pennington 3W
69. Live Oak 3SE
70. Loma Rica
71. Browns Valley 3NE
72. Penn Valley
73. Tahoe
74. Yuba City
75. Yuba City 9W
76. Arbuckle IS
77. Lincoln Vineyard
78. Auburn Mr. Vernon
79. Gold Hill Duty Flat
80. Rocklin Igarashi
81. Woodford
82. Davis Campbell #1
83. Davis Campbell #2
84. Colville 2W
85. Elk Grove 4SW
86. Bridgeport DWR
87. Thornton 2S
88. Testicelli Island
89. Lodi 3SW
90. Lodi 3S
91. Stockton 8S
92. Stockton 9S
93. El Solvo Ranch
94. Vernalis 3SE
95. Ceres 3E
96. Atwater IN
97. Newman 3SE
98. Merced SSE
99. Berenda 2N
100. Los Banos 3S
101. Los Banos Equipment Yard
102. Los Banos SSE
103. Kernan 2ESE
104. Fresno Kearney Pa. k
105. Mendota Murietta Ranch
106. Panocbe Junction
107. Kingsburg 3S #1
108. Kingsburg 3S #2
109. Shafter 2SW
110. Arvin Frick
111. Arvin Jewett #1
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GENERAL LOCATION
 OF
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 1954-1960





- EVAPOTRANSPIRATION STATIONS**
- EVAPOTRANSPIROMETER - ACTIVE IN 1960
 - EVAPOTRANSPIROMETER - ACTIVE PRE 1960
 - ▲ NEUTRON PROBE - ACTIVE IN 1960
 - △ NEUTRON PROBE - ACTIVE PRE 1960
 - GRAVIMETRIC - ACTIVE PRE 1960

1. Gazelle Dougherty #1
2. Gazelle Dougherty #2
3. Gazelle Dougherty #3
4. Canby Bushey
5. Alturas Dorris Ranch
6. Bamber 3E
7. Bamber Leonard
8. Pittville (AA)
9. McArthur (AB)
10. McArthur 1NE
11. McArthur Albaugh #1
12. McArthur Albaugh #2
13. Pittville IS
14. Hat Creek Kern
15. Hat Creek Opdyke
16. Redding 6SE
17. Anderson 2N
18. Anderson 3E
19. Anderson Trisdale
20. Leavitt Lake
21. Mills Orchard
22. Coleville 2W
23. Davis Campbell
24. Arvin (CE)
25. Arvin (CG)
26. Arvin (CB)
27. Arvin (CF)
28. Arvin (CD)
29. Arvin Jewett
30. Arvin Jewett #2
31. Arvin Jewett #3

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**GENERAL LOCATION
 OF
 EVAPOTRANSPIRATION STATIONS
 1955-1960**

SCALE OF MILES
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PACIFIC OCEAN

OREGON

NEVADA

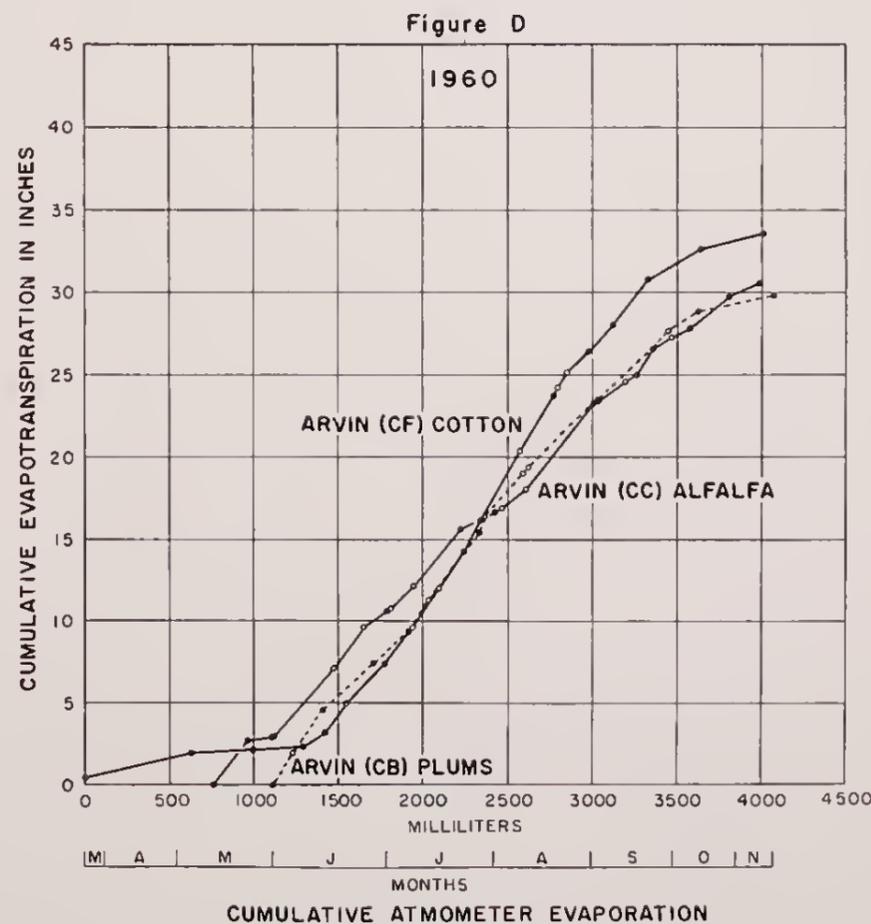
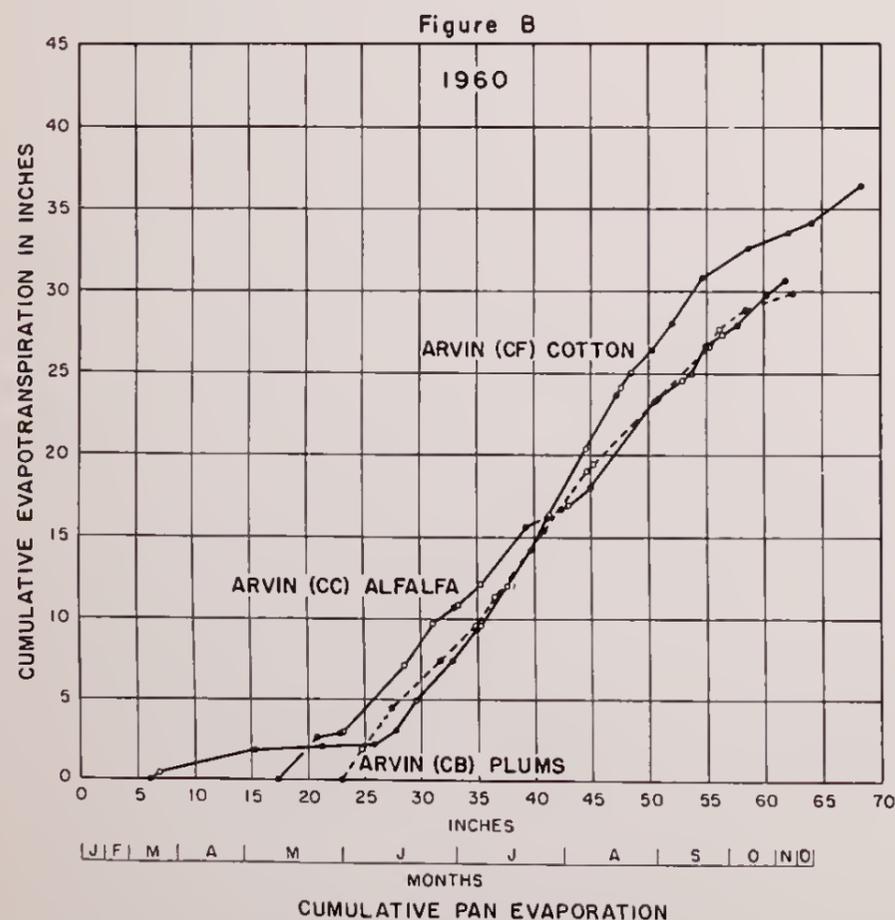
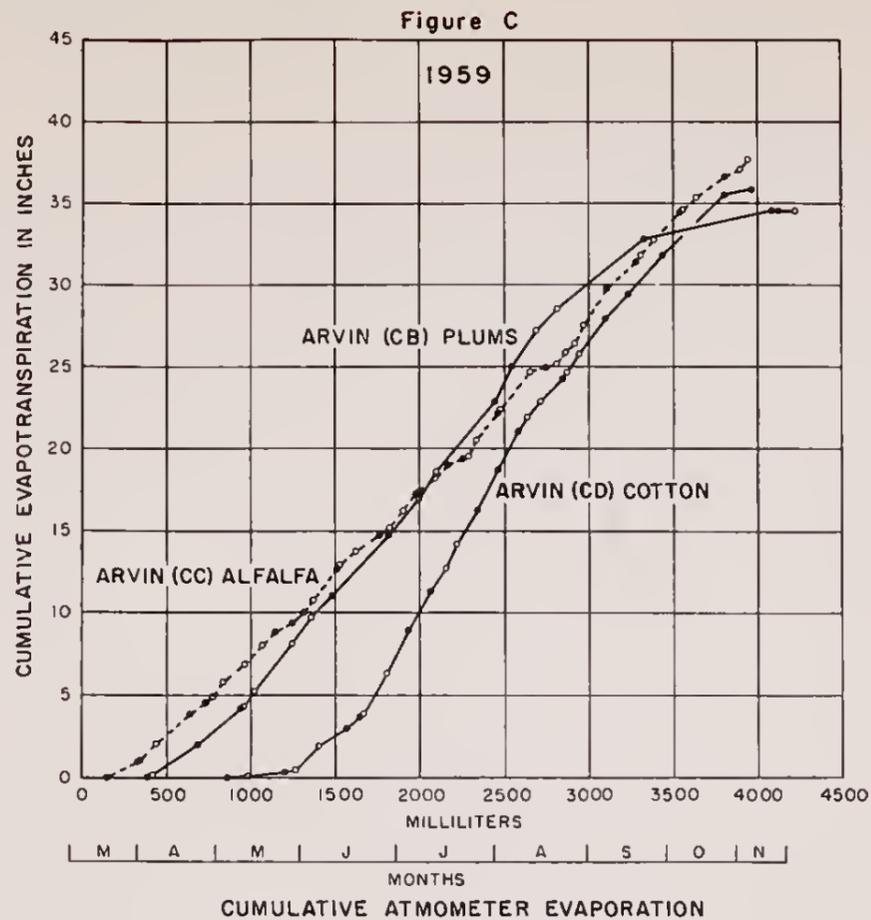
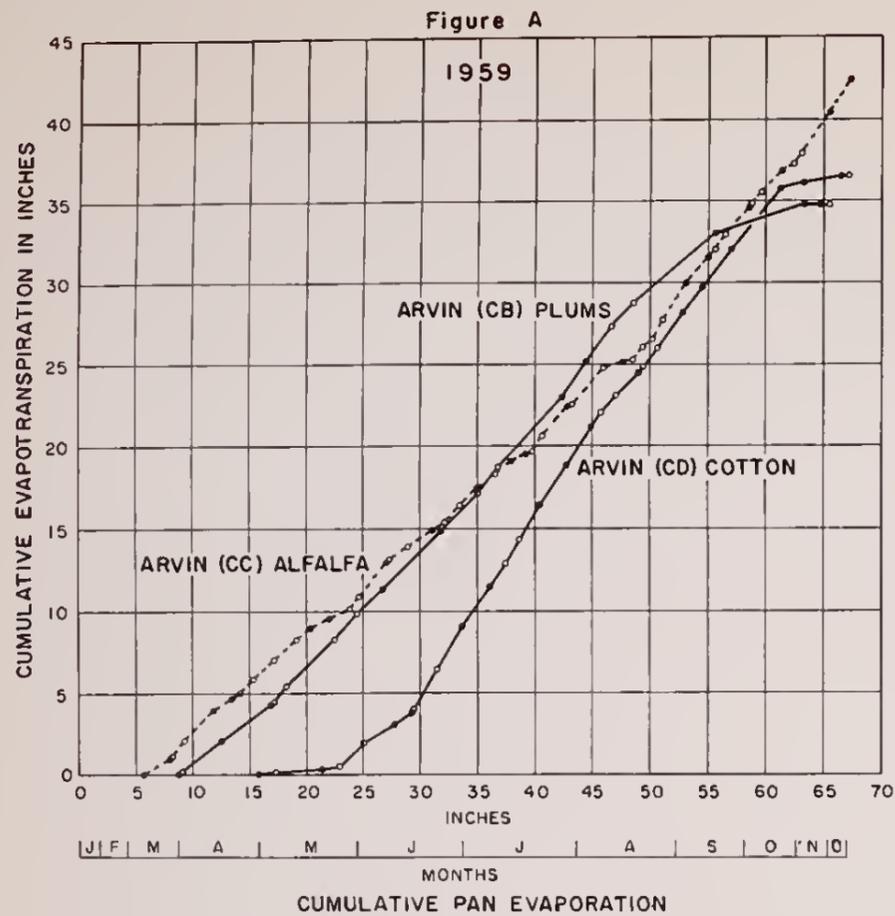
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IDAHO

ARIZONA

SAN LUIS OBISPO

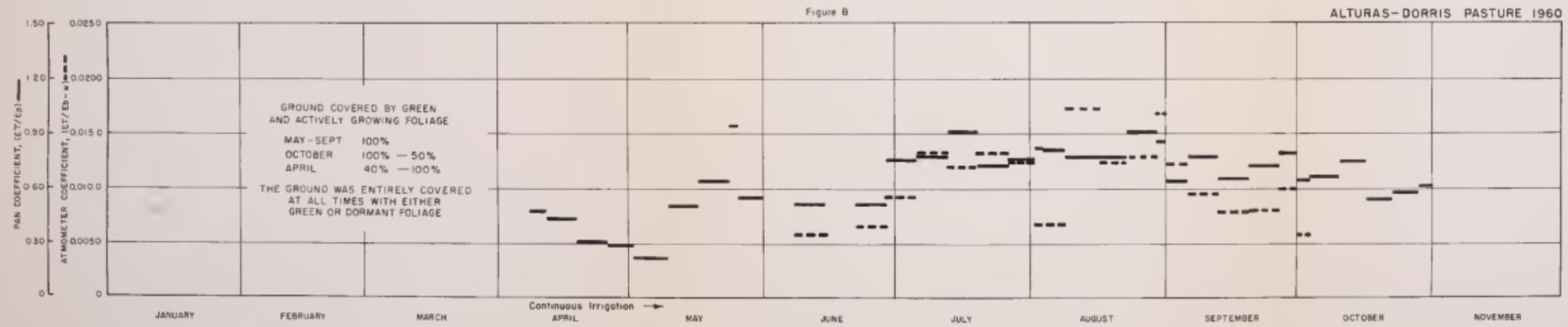
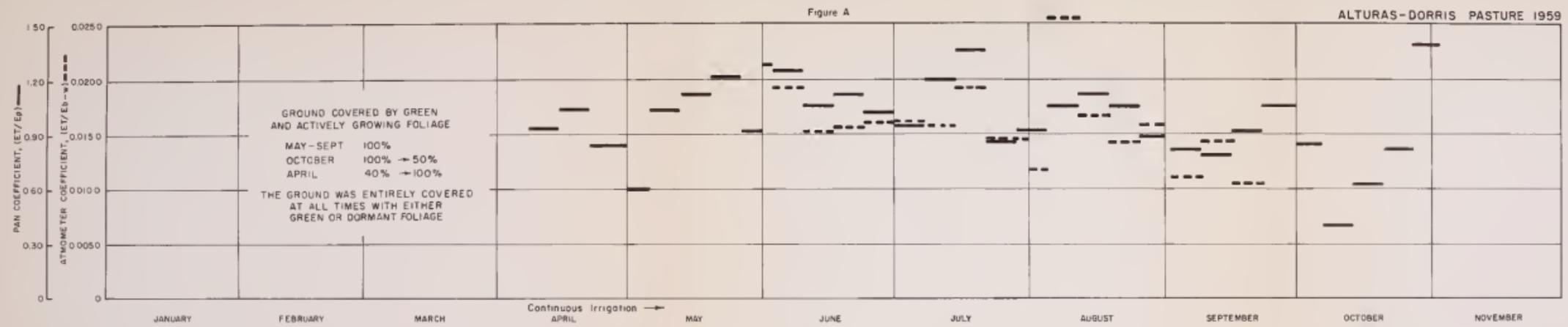
RESERVED
 25, 26, 27, 28, 29, 30, 31



NOTE: SLOPE DIFFERENCES ARE DUE TO PLANT CONDITIONS, SOIL MOISTURE AVAILABILITY, AND OTHER FACTORS
CODE: ● EVAPOTRANSPIRATION MEASURED
○ EVAPOTRANSPIRATION ESTIMATED

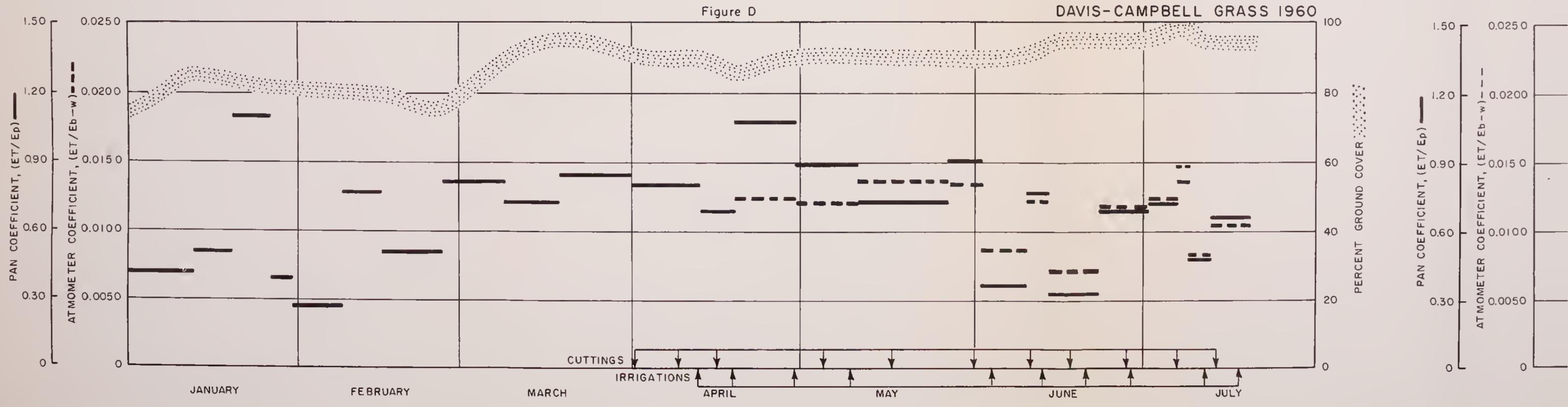
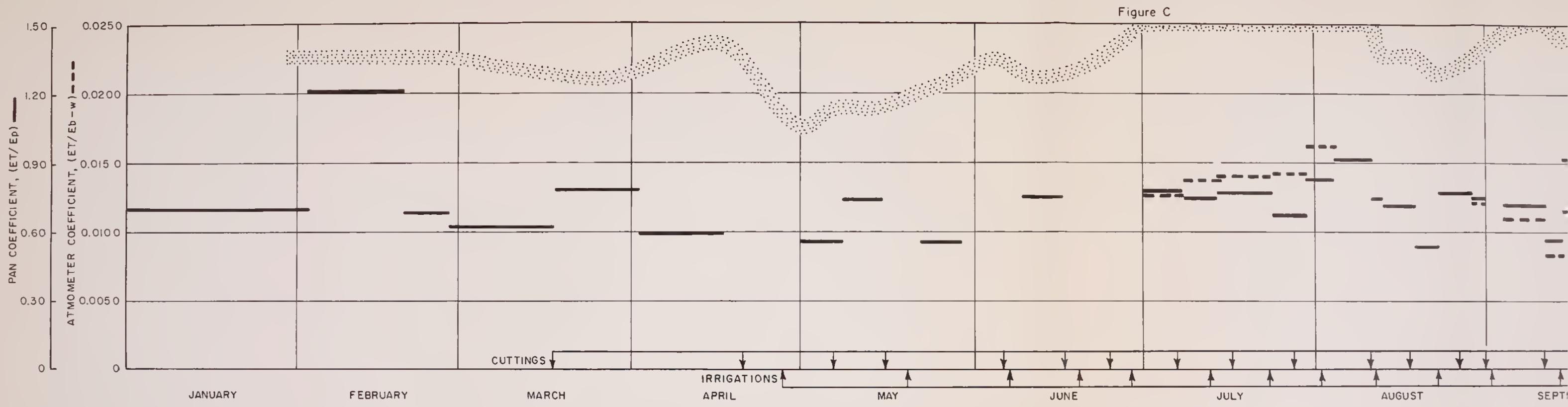
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COMPARISON OF EVAPOTRANSPIRATION CURVES
OF
DIFFERENT CROPS GROWN
AT THE
SAME LOCATION ON THE SAME SOIL SERIES
OCTOBER 1962



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**VARIATION OF PAN AND ATMOMETER COEFFICIENTS
 FOR
 INDIVIDUAL PERIODS OF MEASUREMENTS
 WITH RESPECT TO
 CROP GROUND COVER, AVAILABLE SOIL MOISTURE
 AND OTHER PLANT CONDITIONS
 OCTOBER 1962**



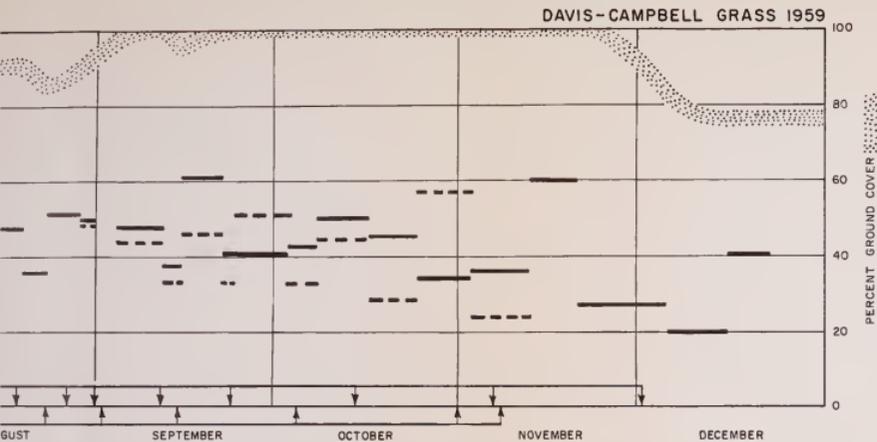
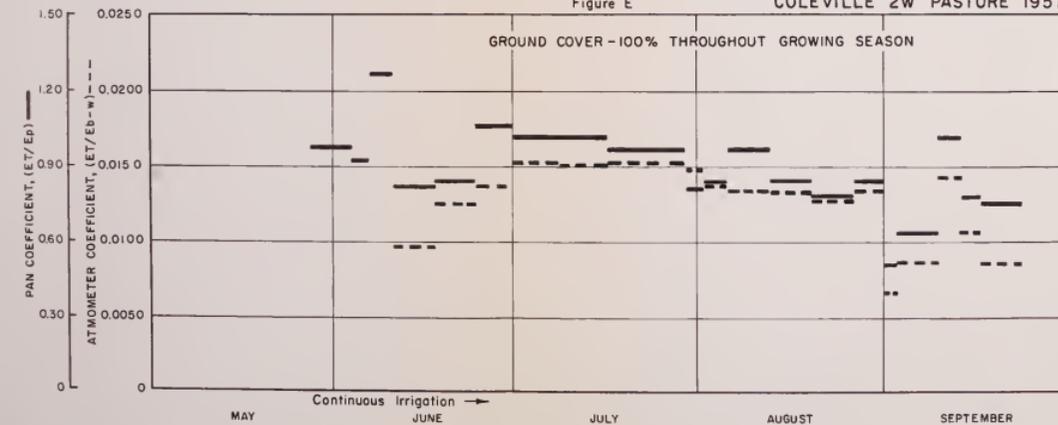
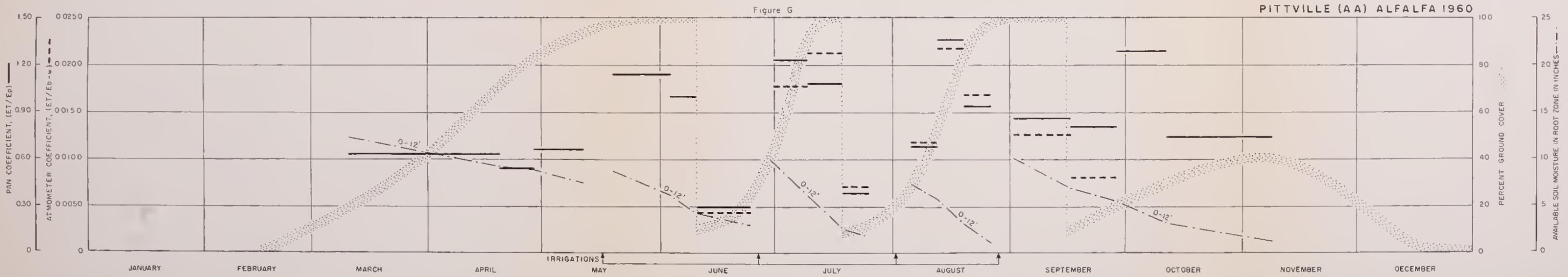
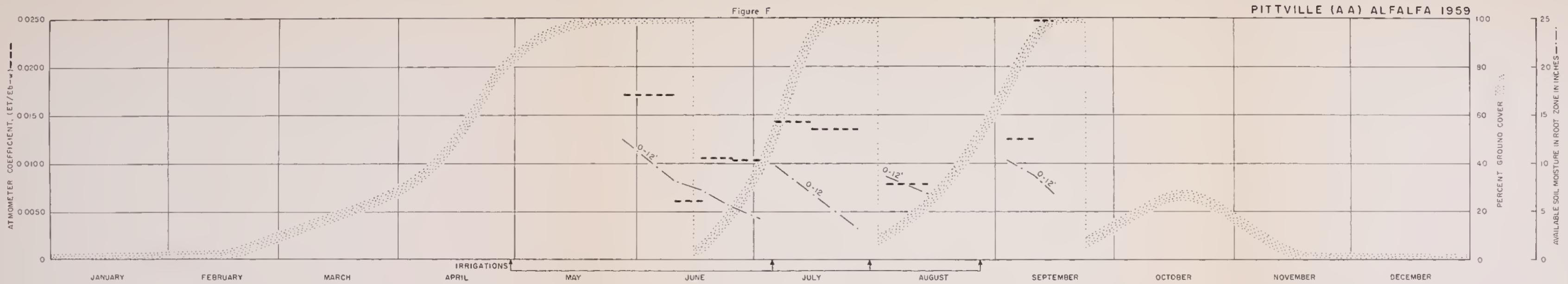


Figure E COLEVILLE 2W PASTURE 1957



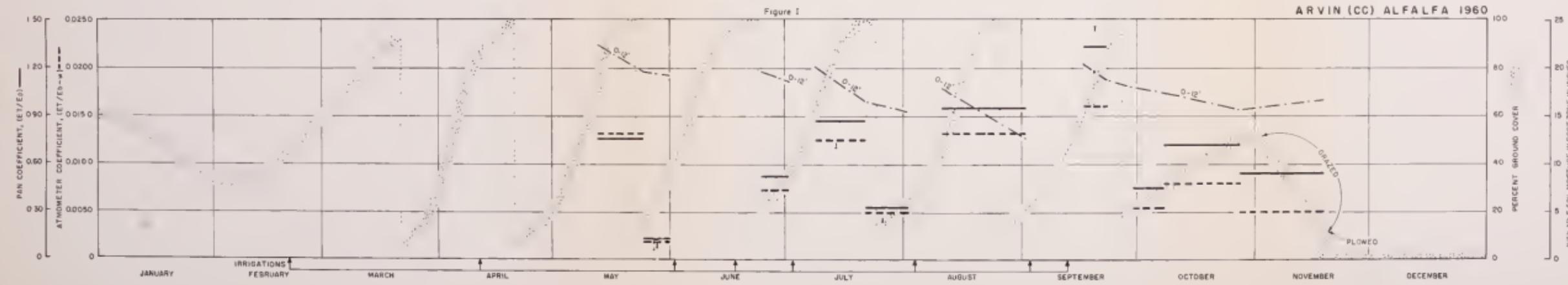
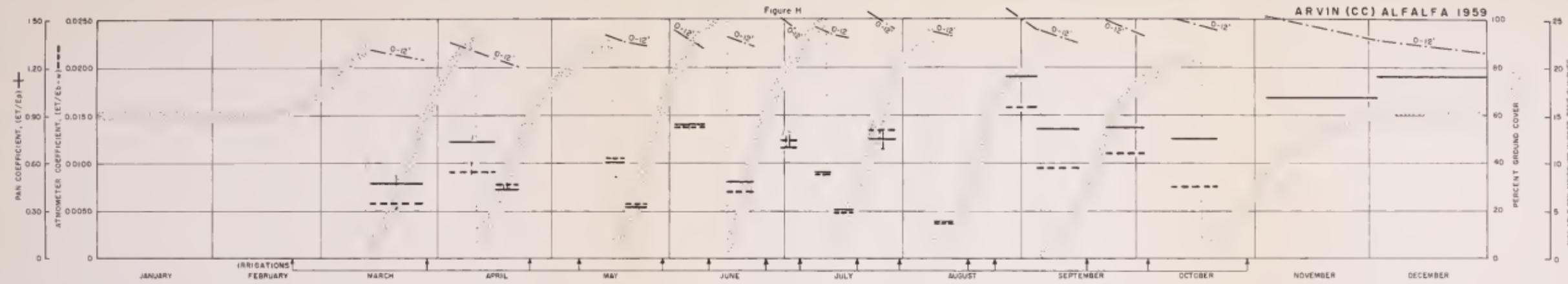
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 CROP GROUND COVER, AVAILABLE SOIL MOISTURE
 AND OTHER PLANT CONDITIONS
 OCTOBER 1962



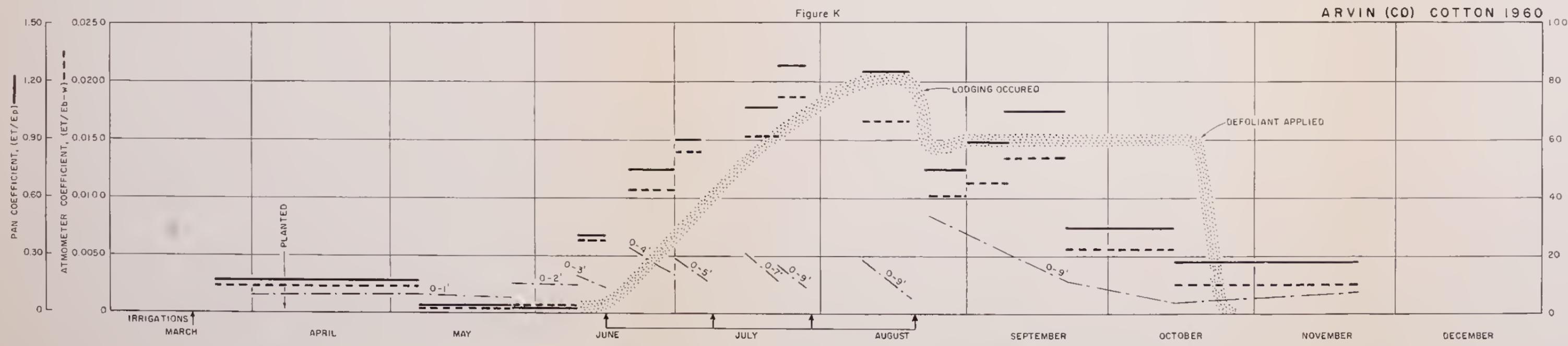
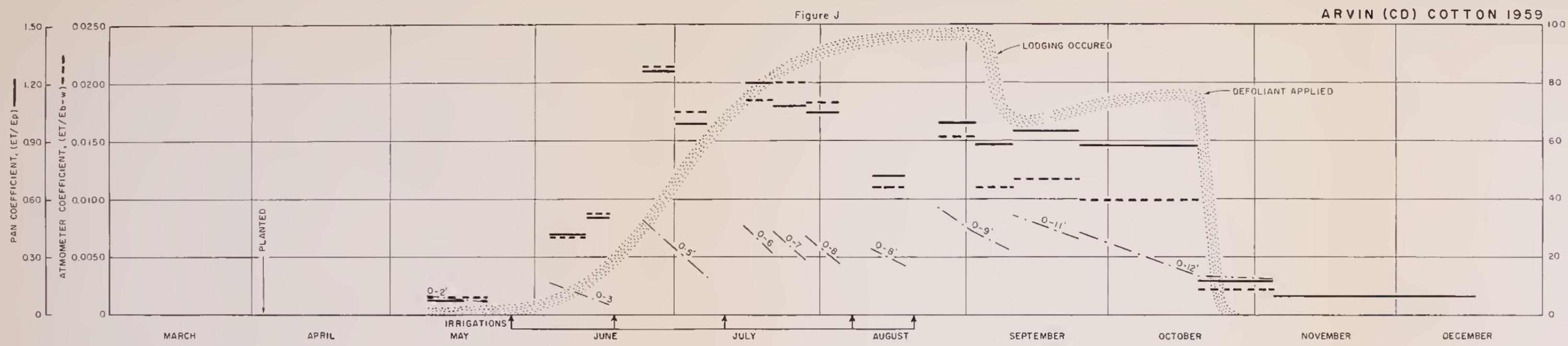
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 OCTOBER 1962



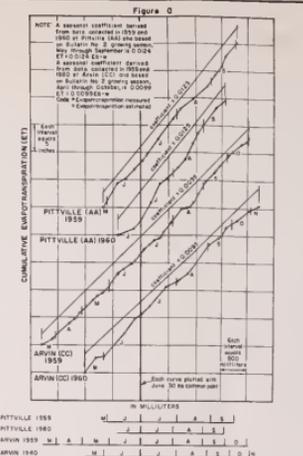
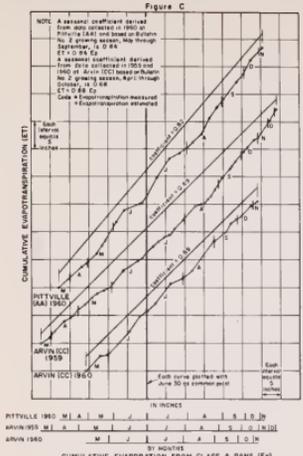
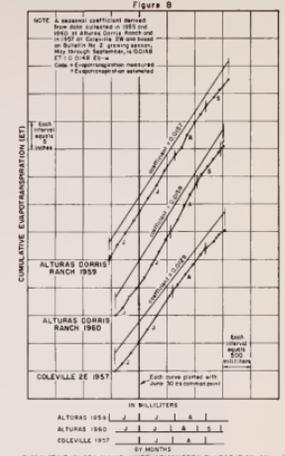
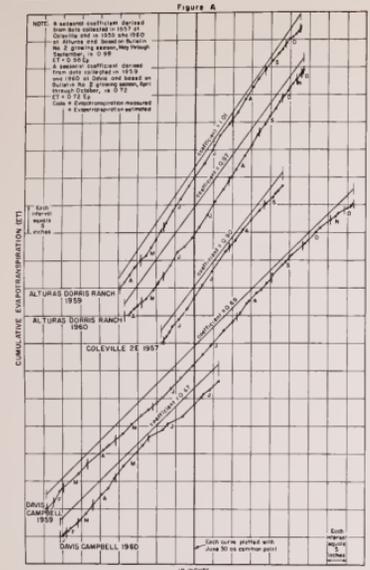
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 VEGETATIVE WATER USE STUDIES
 INTERIM REPORT

VARIATION OF PAN AND ATOMETER COEFFICIENTS
 FOR
 INDIVIDUAL PERIODS OF MEASUREMENTS
 WITH RESPECT TO
 CROP GROUND COVER, AVAILABLE SOIL MOISTURE
 AND OTHER PLANT CONDITIONS
 OCTOBER 1962



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 OCTOBER 1962



CUMULATIVE EVAPOTRANSPIRATION (ET) IN MILLIMETERS

ALTURAS 1959
ALTURAS 1959
COLEVILLE 1957

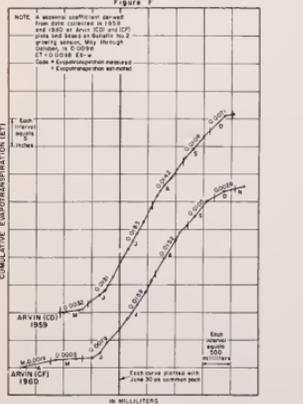
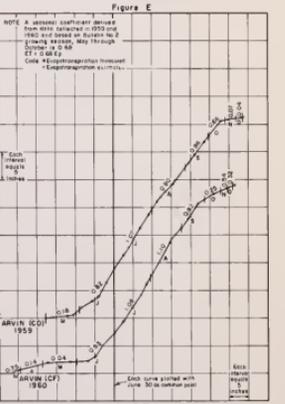
BY MONTHS

CUMULATIVE PERIOD OF RECORD ATMOMETER EVAPORATION (E_W) DETERMINED FROM CUMULATIVE EVAPOTRANSPIRATION AND EVAPORATION DATA

CUMULATIVE EVAPORATION FROM CLASS A PANS (E_P)

COMPARISON OF PERIOD OF RECORD PAN COEFFICIENTS FOR ALFALFA DETERMINED FROM CUMULATIVE EVAPOTRANSPIRATION AND EVAPORATION DATA

CUMULATIVE PERIOD OF RECORD ATMOMETER EVAPORATION (E_W) DETERMINED FROM CUMULATIVE EVAPOTRANSPIRATION AND EVAPORATION DATA



CUMULATIVE EVAPORATION FROM CLASS A PANS (E_P)

ALTURAS 1959
ALTURAS 1959
COLEVILLE 1957
DAVIS 1959
DAVIS 1960

BY MONTHS

CUMULATIVE EVAPORATION FROM CLASS A PANS (E_P)

COMPARISON OF MONTHLY PAN COEFFICIENTS FOR COTTON DETERMINED FROM CUMULATIVE EVAPOTRANSPIRATION AND EVAPORATION DATA

CUMULATIVE EVAPORATION FROM CLASS A PANS (E_P)

ARVIN 1959
ARVIN 1960

BY MONTHS

CUMULATIVE EVAPORATION FROM CLASS A PANS (E_P)

COMPARISON OF MONTHLY ATMOMETER COEFFICIENTS FOR COTTON DETERMINED FROM CUMULATIVE EVAPOTRANSPIRATION AND EVAPORATION DATA

NOTE: SLOPE DIFFERENCES ARE DUE TO PLANT CONDITION, SOIL MOISTURE AVAILABLE, AND OTHER FACTORS

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COMPARISON OF PAN AND ATMOMETER COEFFICIENTS FOR COTTON, ALFALFA AND GRASS
OCTOBER 1962

Figure A

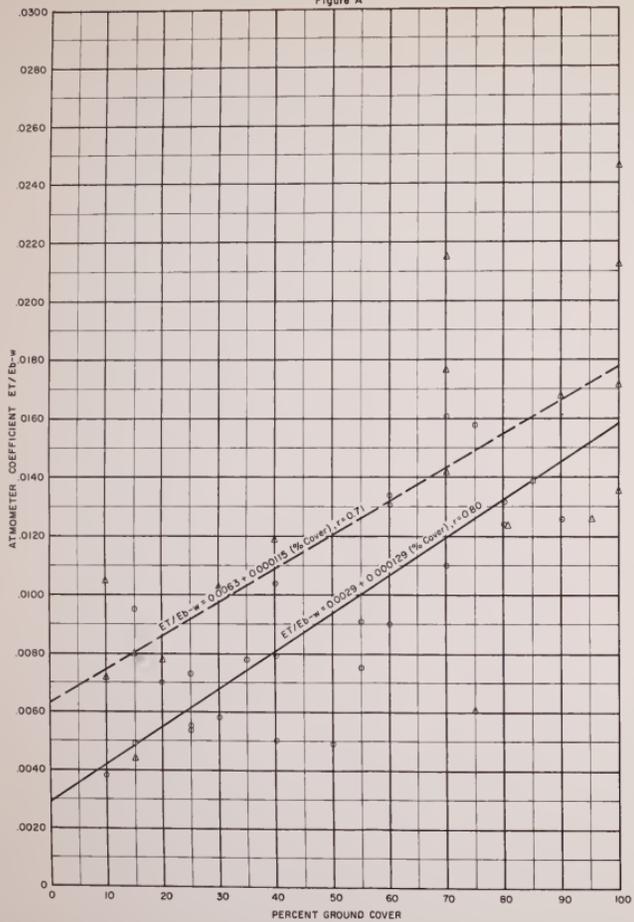
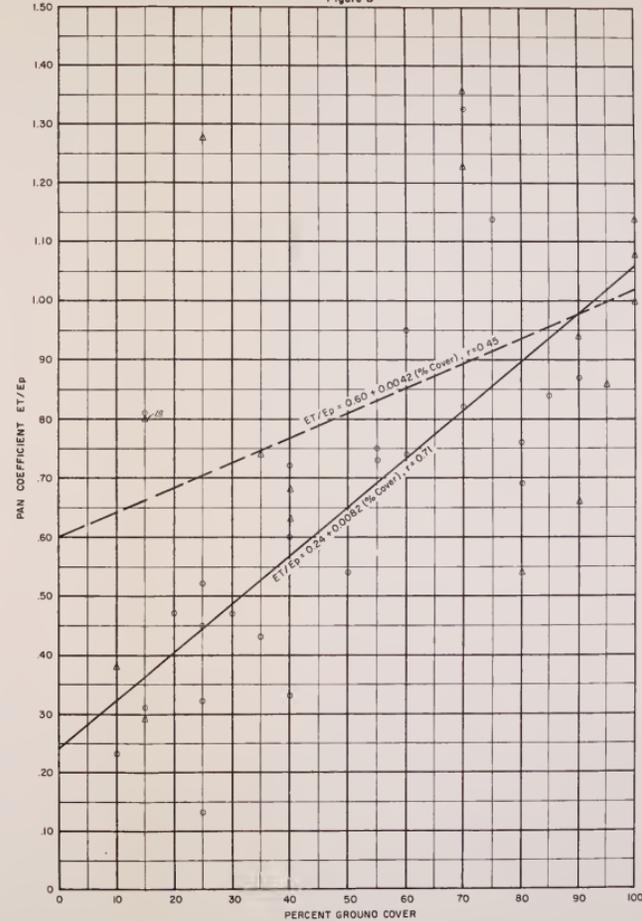


Figure B



LEGEND
 ○ ARVIN (CC) ALFALFA
 △ PITTVILLE (AK) ALFALFA

NOTE:
 △: SOMEWHAT HIGHER THAN WOULD BE EXPECTED DUE TO EVAPORATION OF PAN
 PERCENT GROUND COVER DATA TAKEN FROM TABULATION BASED ON CURVES DRAWN USING DATA IN APPENDIX TABLE OF NEUTRON DATA

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RELATIONSHIP BETWEEN
 PAN AND ATMOMETER COEFFICIENTS
 FOR ALFALFA AND GROUND COVER
 DATA ARE FOR 1959 AND 1960

EVAPOTRANSPIRATION STATIONS

+

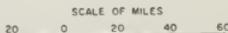
- EVAPOTRANSPIROMETER - ACTIVE IN 1960
- EVAPOTRANSPIROMETER - ACTIVE PRE 1960
- ▲ NEUTRON PROBE - ACTIVE IN 1960
- △ NEUTRON PROBE - ACTIVE PRE 1960
- GRAVIMETRIC - ACTIVE PRE 1960

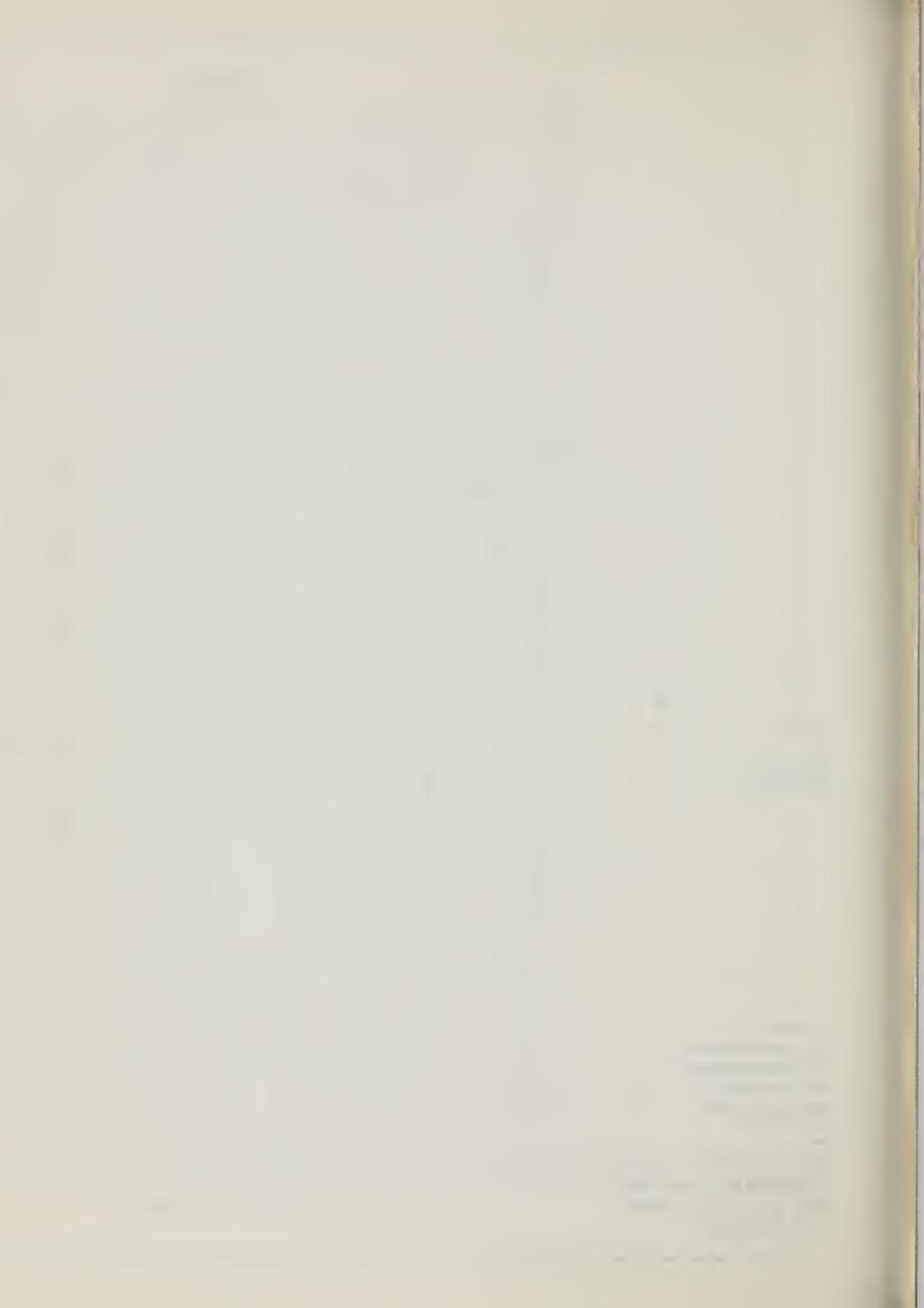
1. Gazelle Dougherty #1
2. Gazelle Dougherty #2
3. Gazelle Dougherty #3
4. Canby Bushey
5. Alturas Dorris Ranch
6. Bieber 3E
7. Bieber Leonard
8. Pittville (AA)
9. McArthur (AB)
10. McArthur 1NE
11. McArthur Albaugh #1
12. McArthur Albaugh #2
13. Pittville 1S
14. Hat Creek Kern
15. Hat Creek Opdyke
16. Redding 6SE
17. Anderson 2N
18. Anderson 3E
19. Anderson Trisdale
20. Leavitt Lake
21. Mills Orchard
22. Coleville 2W
23. Davis Campbell
24. Arvin (CE)
25. Arvin (CC)
26. Arvin (CB)
27. Arvin (CF)
28. Arvin (CD)
29. Arvin Jewett
30. Arvin Jewett #2
31. Arvin Jewett #3

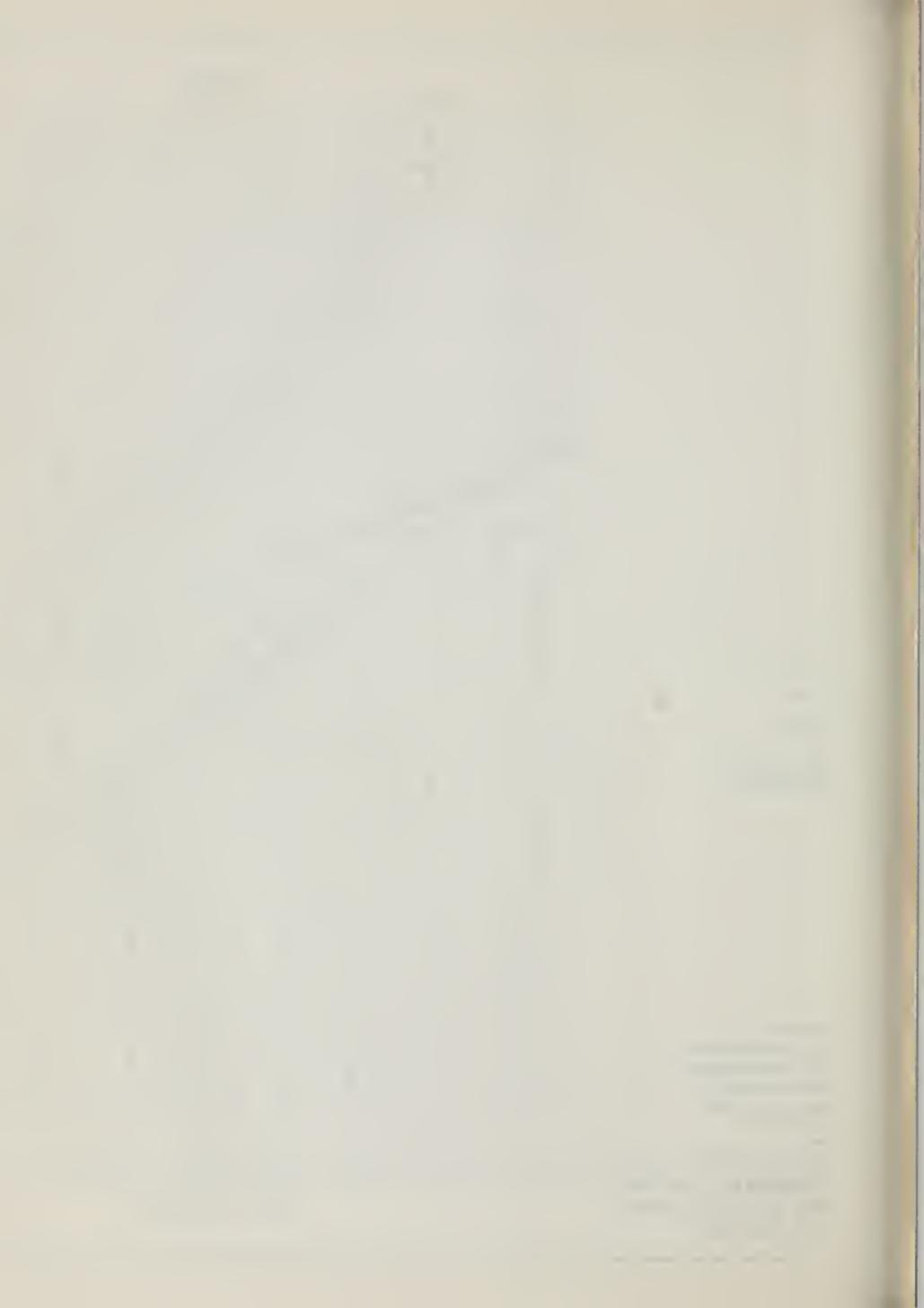


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GENERAL LOCATION
 OF
 EVAPOTRANSPIRATION STATIONS
 1955-1960







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