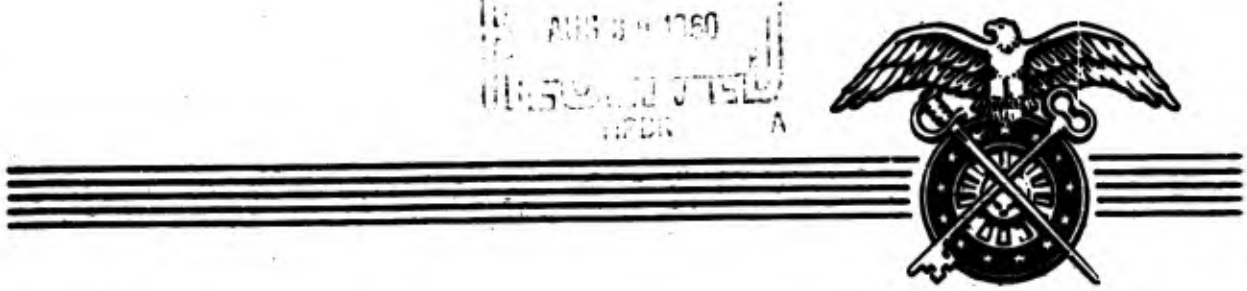
NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

HEADQUARTERS
QUARTERMASTER RESEARCH & ENGINEERING COMMAND
U S ARMY

TECHNICAL REPORT

EP-136

THE NIGHTTIME INFLUENCE OF IRRIGATION UPON DESERT HUMIDITIES



QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

JULY 1960

NATICK, MASSACHUSETTS

HEADQUARTERS
QUARTERMASTER RESEARCH & ENGINEERING COMMAND
U S ARMY

TECHNICAL REPORT

EP-136

THE NIGHTTIME INFLUENCE OF IRRIGATION UPON DESERT HUMIDITIES

QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

JULY 1960

NATICK, MASSACHUSETTS

HEADQUARTERS
QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
Quartermaster Research & Engineering Center
Natick, Massachusetts

ENVIRONMENTAL PROTECTION RESEARCH DIVISION

Technical Report
EP-136

THE NIGHTTIME INFLUENCE OF IRRIGATION UPON DESERT HUMIDITIES

Iven Bennett
Geographer
Environmental Analysis Branch

Ronald A. Nelson
1st Lt MSC
Regional Environments
Research Branch

Project Reference:
7-83-01-008

July 1960

FOREWORD

IT HAS LONG BEEN KNOWN THAT LARGE DESERT OASES PRODUCE PROFOUND CHANGES IN THE MOISTURE CONTENT OF NORMALLY DRY DESERT AIR, BUT FEW ATTEMPTS HAVE BEEN MADE TO MEASURE THE MAGNITUDE OF THESE CHANGES OR TO MEASURE THE EXTENT TO WHICH THEY ARE TRANSPORTED INTO THE DESERT BY HORIZONTAL MOVEMENT OF AIR. THIS REPORT, A STUDY OF NIGHTTIME CONDITIONS, FOLLOWS AN EARLIER DAYTIME STUDY IN ATTEMPTING TO PROVIDE INFORMATION ABOUT THESE PROBLEMS. THE YUMA OASIS OF SOUTHWESTERN ARIZONA WAS SELECTED FOR BOTH STUDIES BECAUSE IT IS REPRESENTATIVE OF OASES IN MANY PARTS OF THE WORLD, AND ITS SELECTION PERMITTED DETERMINATION OF THE EFFECT OF THE OASIS UPON HUMIDITY CONDITIONS AT YUMA TEST STATION.

AUSTIN HENSCHEL, PH.D.
CHIEF
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

APPROVED:

PHILIP J. RORK, LT COL, QMC
COMMANDING OFFICER
QM R AND E CENTER LABORATORIES

DALE H. SIELING, PH.D.
SCIENTIFIC DIRECTOR
QM RESEARCH & ENGINEERING COMMAND

CONTENTS

Abstract

Field observations were made in and around the Yuma oasis of southwestern Arizona during the summer of 1956 to examine the role of irrigated farmland in modifying the nighttime humidity of desert air. Synoptic measurements of temperature, humidity, and wind at standard height were taken in the desert and in various crops within the oasis.

A moderate increase was observed in moisture content of the air in the oasis compared with desert air. The magnitude of the increase was related to the general moisture level of the two prevailing summer air-masses; with dry Pacific air the increase amounted to 15° to 20° F in dewpoint, and with moist air from the Gulf of Mexico it was limited to 5° to 10° F. Similar but smaller differences were noted between moist and dry cropland within the oasis. Advection of moist air from the oasis into the desert could not be sharply delimited quantitatively, but within the first few hundred yards from the edge of the oasis, advection diminished rapidly and seemed barely evident at one mile. Nighttime evaporation and small daytime storage of heat in the oasis soil, contrasted with negligible nighttime evaporation and large heat storage in the soil of the desert, combined to produce minimum daily temperatures 5° to 15° F lower in the oasis than in the adjoining desert.

THE NIGHTTIME INFLUENCE OF IRRIGATION UPON DESERT HUMIDITIES

1. Introduction

In a previous study (9), the condition of localized areas of high humidity in desert regions, such as are found in oases or strips of river marsh, was investigated under daytime conditions. The present study complements this 1956 study by using the same moisture source, the irrigated farmland of the US Bureau of Reclamation's Yuma and Gila projects in southwestern Arizona, to analyze the nighttime influence of irrigation on the surrounding desert. As in the previous study, a particular concern is the effect on humidities at the US Army Yuma Test Station, an area in the desert northeast of the irrigated districts for research and testing under hot, dry conditions. The report is also concerned with the necessity of planning for high humidities within and near oases in desert military operations.

Following the practice of the daytime study, dewpoint temperature was selected for differentiation of areal variations in water content of the air. Dewpoint (the temperature to which a given mass of air must be cooled at constant pressure to become saturated) is suited for this purpose because of its conservative behavior with isobaric changes in temperature. That is, air temperature change per se will not affect the dewpoint of an airmass in any way. Alteration of air pressure produces changes in dewpoint, but the magnitude of normal diurnal and synoptic pressure variations is so small that the effect is negligible. Dry adiabatic changes also affect dewpoint (a drop of approximately 1F* degree in dewpoint occurs with every 1,000-foot increase in elevation); in the present study the greatest difference in elevation between observation sites is little more than 100 feet, so this too can be ignored. In practical application, the only way in which the dewpoint can be seriously altered in any given mass of air is by adding or subtracting water vapor from the air itself.

a. Results of Yuma daytime study

The Yuma daytime study indicates that evaporation and transpiration cause an average dewpoint increase of 6 to 8 F degrees at a height of 4 to 5 feet above ground surface within the irrigated area, but that the lateral extent of this effect is limited to 100 feet or less into the desert. This almost complete absence of advection of moisture from the irrigated farmland is attributed to strong convection from intense

*Throughout the present report, temperature and dewpoint will be presented in Fahrenheit.

SURFACE HEATING OF THE ARIZONA DESERT IN SUMMER, THE EFFECT OF THE CONVECTION BEING TO CARRY MOISTURE ALOFT BEFORE SURFACE WINDS CAN TRANSPORT IT HORIZONTALLY. CONSEQUENTLY, THE LOW HUMIDITY OF YUMA TEST STATION WAS NOT ALTERED DURING DAYTIME BY MOISTURE FROM THE OASIS. THE QUESTION OF WHETHER ADDITION OF WATER VAPOR TO AIR THROUGH VERTICAL MIXING ALTERS THE MACROCLIMATE OF THE SOUTHWESTERN SECTION OF ARIZONA WAS DECIDED IN THE NEGATIVE. TO QUOTE FROM THE EARLIER REPORT:

> "CONSIDERING, HOWEVER, THAT THE 100,000 ACRES OF IRRIGATION COMPRISE LESS THAN ONE PERCENT OF THE TOTAL ACREAGE OF SOUTHERN ARIZONA AND THAT ONLY A SMALL PROPORTION OF THE LAND IS UNDER IRRIGATION AT ANY GIVEN TIME, THE EFFECT ON THE TOTAL VOLUME OF AIR MUST BE VERY LOCAL INDEED, AND IS CONSIDERED AN INCONSEQUENTIAL FACTOR IN ALTERING THE AIRMASS CHARACTERISTICS FOR THE REGION."

B. STUDIES OF OTHER OASES

BEFORE THE DESCRIPTION AND ANALYSIS OF DATA FROM THE PRESENT STUDY IS PRESENTED, IT WOULD BE WORTHWHILE TO MENTION OTHER STUDIES WHICH HAVE DEALT WITH THE GENERAL PROBLEM OF THE EFFECT OF A LOCAL MOISTURE SOURCE ON DESERT HUMIDITIES.*

THORNTHWAITE (12) REPORTS ON THE RESULTS OF WORK IN THIS COUNTRY AND THE SOVIET UNION. CONDITIONS SURROUNDING LAKE MEAD (THE RESERVOIR CREATED BY HOOVER DAM ON THE COLORADO RIVER) AND THE SALTON SEA (CALIF.) WERE INVESTIGATED AND REVEALED SCARCELY ANY CHANGE IN THE CLIMATE OF THE ADJACENT DESERT, EVEN OF THAT IN THE IMMEDIATE VICINITY. FOR INSTANCE, 2,000 FEET INTO THE DESERT FROM THE SHORE OF THE SALTON SEA, THE MOISTURE CONTENT OF THE SURFACE AIR WAS RELATIVELY UNAFFECTED. SIMILAR RESULTS WERE OBTAINED IN AN INVESTIGATION OF CONDITIONS CREATED BY THE RESERVOIR OF THE RYBINSK DAM IN THE USSR.

LIAKHOV (8) STUDIED THE INFLUENCE OF THE VOLGA RIVER, NORTH OF ASTRAKHAN, ON THE MICROCLIMATE OF THE ADJOINING DESERT. MICROCLIMATIC STATIONS WERE SET UP ON THE BANKS OF THE VOLGA AND AT DISTANCES RANGING FROM 200 TO 5,000 METERS FROM THE WESTERN BANK TO DETERMINE THE DEGREE TO WHICH THE RIVER AMELIORATED A HOT, DESSICATING EAST WIND, LOCALLY CALLED A SUKHOVEI, COMMONLY EXPERIENCED IN THIS REGION IN SUMMER. MEASUREMENTS OF TEMPERATURE, HUMIDITY, AND WIND WERE MADE AT HEIGHTS OF 20 CM AND 2 M ABOVE THE GROUND. MODIFICATION OF THE HUMIDITY DURING DAYTIME (NIGHTTIME CONDITIONS WERE NOT GIVEN) APPARENTLY WAS LIMITED TO WITHIN 500 METERS OF THE RIVER. AT 2 METERS ABOVE THE GROUND, THE MEAN VAPOR PRESSURE

*SOME OF THE INFORMATION PRESENTED FROM THESE STUDIES REFERS TO DAYTIME CONDITIONS, BUT BECAUSE IT IS NEW INFORMATION, TRANSLATED INTO ENGLISH SINCE PUBLICATION OF THE DAYTIME STUDY, IT HAS BEEN INCLUDED.

AT 1300 WAS 11.9 MB ON THE WEST BANK OF THE RIVER, 11.0 MB AT A DISTANCE OF 500 METERS AND 11.1 MB AT 2,000 METERS. CONVERTING THESE TO DEWPOINT IN DEGREES FAHRENHEIT YIELDS VALUES OF 49.3°, 47.1° AND 47.3°, RESPECTIVELY.

IN A REPORT DESCRIBING OBSERVATIONS IN A PARTIALLY IRRIGATED GROUP OF FIELDS IN VORONEZH PROVINCE OF THE USSR, ARKHIPOVA AND GLEBOVA (2) GIVE DIFFERENCES BETWEEN IRRIGATED AND NONIRRIGATED FIELDS ON CLEAR DAYS. AIR HUMIDITY WAS HIGHER OVER IRRIGATED AREAS, BUT AT 20 CM ABOVE THE GROUND (THE ONLY HEIGHT FOR WHICH VALUES WERE GIVEN) THE DIFFERENCES WERE SLIGHT, AMOUNTING TO BUT 2 MB IN VAPOR PRESSURE. ASSUMING THAT DRY BULB TEMPERATURES WERE BETWEEN 80° AND 100°, AND RELATIVE HUMIDITY BETWEEN 20 AND 50 PERCENT, THIS WOULD MEAN A DEWPOINT VARIATION OF NO MORE THAN 3 DEGREES.

ALISSOW, DROSDOW, AND RUBINSTEIN (1) (IN A PROMINENT SOVIET TEXTBOOK ON CLIMATOLOGY) DISCUSS VARIOUS STUDIES IN THE USSR THAT HAVE DEALT WITH THE INFLUENCE OF IRRIGATION ON OASIS CLIMATE. THEY POINT OUT THAT THE OASES OF CENTRAL ASIA, IN ADDITION TO THE REGULAR PRECIPITATION OF THE GROWING SEASON, RECEIVE FROM IRRIGATION WATER THE EQUIVALENT OF 16 TO 20 INCHES OF RAIN, THUS PRODUCING AN OASIS CLIMATE MARKEDLY DIFFERENT FROM THAT OF THE SURROUNDING SEMIARID LANDS. THE RESULTING CLIMATIC DIFFERENCES ARE DEPENDENT UPON THE SIZE OF THE INDIVIDUAL OASIS AND THE INTENSITY OF IRRIGATION.

THE DATA IN TABLE I GIVE CONDITIONS ENCOUNTERED AT MIDDAY IN A SMALL IRRIGATED AREA DURING THE HEIGHT OF SUMMER. DEWPOINT AT THE 2-METER LEVEL IS NEARLY THE SAME OVER THE ALFALFA AND DRY FIELD, AND SHOWS ONLY AN 8-DEGREE INCREASE OVER THE RICE COMPARED TO THE DRY FIELD. THESE SMALL DIFFERENCES ARE EXPLAINED AS THE RESULT OF ADVECTION OF DRY AIR FROM THE SURROUNDING NON-IRRIGATED LANDS.

MONTHLY MEANS FOR THE LARGE AMI DARYA OASIS ARE GIVEN IN TABLE II. DIFFERENCES DURING DAYTIME ARE SMALL, EVEN AT THE HEIGHT OF IRRIGATION IN MIDSUMMER, PROBABLY DUE TO STRONG TURBULENT EXCHANGE. ASSUMING A DRY BULB OF 95°F AND A DEWPOINT IN THE 50'S, THE 8 PERCENT DIFFERENCE IN RELATIVE HUMIDITY FOR JULY WOULD MEAN A DEWPOINT DIFFERENCE OF SOME 8 DEGREES BETWEEN DESERT AND OASIS. AT NIGHT, WEAKENED TURBULENCE PERMITS GREATER BUILD-UP OF WATER VAPOR IN AIR NEAR THE GROUND AND RELATIVE HUMIDITY DIFFERENCES OF MORE THAN 20 PERCENT. WITH AN ASSUMED TEMPERATURE OF 70° AND DEWPOINT IN THE 50'S, THIS IS A DEWPOINT VARIATION OF 20 TO 25 DEGREES.

c. Location of the Yuma Oasis

THE YUMA RECLAMATION PROJECT IS AN AREA APPROXIMATELY 28 MILES LONG AND 11 MILES WIDE, THE LONG AXIS OF WHICH EXTENDS ALONG THE COLORADO RIVER NEAR LAGUNA DAM IN THE NORTHEAST TO THE MEXICAN BORDER IN THE

TABLE I

TEMPERATURE AND HUMIDITY IN A SMALL OASIS*
(1300, 17 JULY 1927)

	AIR TEMP. (°F)			REL. HUM. (%)		DEWPOINT (°F)**	
	HEIGHT IN METERS						
TYPE OF SURFACE	0.0	0.5	2.0	0	2	0	2
UNIRRIGATED	108.0	88.6	96.4	22	24	61	54
ALFALFA	91.0	93.9	94.8	78	26	83	55
RICE	87.8	90.5	94.6	56	34	70	62

*FROM ALISSOW, DROSDOW, AND RUBINSTEIN (1). THE EXACT LOCATION OF THE OASIS IS NOT GIVEN, ONLY THAT IT IS LOCATED IN CENTRAL ASIA.

** DEWPOINTS WERE NOT INCLUDED IN THE ORIGINAL TABLE. THEY HAVE BEEN CALCULATED ON THE BASIS OF THE KNOWN TEMPERATURES AND RELATIVE HUMIDITIES, ASSUMING AN AIR PRESSURE OF 30 INCHES.

TABLE II

RELATIVE HUMIDITY DIFFERENCE (IN PERCENT) BETWEEN A LARGE OASIS AND ADJACENT DESERT, AT 2 METERS ABOVE THE GROUND*

HOUR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
0700	11	4	7	16	22	23	21	19	10
1300	5	2	5	7	8	8	8	4	1
2100	3	3	7	16	21	23	13	16	1

*FROM ALISSOW, DROSDOW, AND RUBINSTEIN (1).

SOUTHWEST (FIG. 1). THE PROJECT LIES ALMOST ENTIRELY WITHIN ARIZONA BUT AT ITS UPPER END THE IRRIGATED LANDS ARE ALSO FOUND ON THE CALIFORNIA SIDE OF THE RIVER.

IN RECENT YEARS, PARTS OF THE GILA RIVER VALLEY, WHICH EXTENDS EAST-NORTHEAST FROM ITS JUNCTION WITH THE COLORADO NORTH OF YUMA, HAVE BEEN BROUGHT UNDER IRRIGATION. EXCEPT FOR 2 AREAS WHICH, FROM THE STANDPOINT OF GEOGRAPHICAL LOCATION, ARE ACTUALLY PART OF THE YUMA DISTRICT, THE GILA DISTRICT IS LOCATED FAR UP THE GILA VALLEY IN THE WELLTON-MOHAWK AREA AND OF DOUBTFUL CONSEQUENCE TO EITHER THE STUDY AREA OR YUMA TEST STATION. ALONG THE COLORADO, SOUTH OF THE MEXICAN BORDER, LIES ANOTHER IRRIGATION DEVELOPMENT, BUT THESE LANDS LIKEWISE ARE FAR FROM THE STUDY AREA AND YUMA TEST STATION.

AT THE TIME OF THE STUDY, IRRIGATION WAS PRACTICED ON APPROXIMATELY 100,000 ACRES WITHIN THE YUMA AREA, 70 TO 80 PERCENT OF WHICH WERE LOCATED ON THE LOW-LYING VALLEY LANDS ADJACENT TO THE COLORADO RIVER. THE REMAINDER WERE ON THE YUMA MESA (ACTUALLY A TERRACE OF THE COLORADO RIVER), AN AREA 75 TO 100 FEET HIGHER THAN THE VALLEY AND LYING SOUTH AND SOUTHEAST OF THE TOWN OF YUMA (FIG. 1). THE OASIS IS NOT A SOLID MOSAIC OF INTENSELY CULTIVATED AND IRRIGATED FIELDS. THERE ARE LARGE AREAS IN WHICH NO CROPS ARE GROWN AND WHICH HAVE NO IRRIGATION FACILITIES, AND IN CULTIVATED SECTIONS AT ANY GIVEN TIME MANY FIELDS ARE NOT IN CROPS AND NOT SUBJECT TO IRRIGATION. DURING THE PERIOD OF THE STUDY, MANY FIELDS FROM WHICH CANTALOUPE HAD BEEN RECENTLY HARVESTED LAY BARREN AND DRY.

BORDERING THE IRRIGATED LAND ON THE SOUTH, AND EXTENDING MANY MILES INTO MEXICO, IS THE GENTLY ROLLING SURFACE OF THE YUMA DESERT, AN AREA ALMOST TOTALLY DEVOID OF SOURCES OF MOISTURE. TO THE WEST AND NORTHWEST ARE LOW HILLS, BARREN OF VEGETATION AND SO HIGHLY DISSECTED THAT THEY APPROACH BADLAND TOPOGRAPHY IN ROUGHNESS. NUMEROUS STREAM CHANNELS OR WASHES, TOO DRY TO ACT AS MOISTURE SOURCES EXCEPT FOR THE RARE INTERVAL WHEN IN FLOOD, LEAD FROM THIS HILLY AREA TO THE LOWLANDS OF THE VALLEY. THEY SERVE AS POTENTIAL LINES OF DRAINAGE OF DRY AIR INTO THE VALLEY AT NIGHT. ON THE EAST AND NORTHEAST, THE IRRIGATED DISTRICT ABUTS ON THE CHOCOLATE, LAGUNA, AND GILA MOUNTAINS WITH SUMMIT ELEVATIONS OF 1,000 TO 1,500 FEET WHICH, WITH THE EXCEPTION OF THE NARROW BREAKS OF THE COLORADO AND GILA RIVERS, FORM A BARRIER BETWEEN THE MAIN PART OF THE IRRIGATED AREA AND THE YUMA TEST STATION. IN EFFECT, THE YUMA AREA IS AN "ISLAND OASIS" SURROUNDED BY LAND THAT HAS ALMOST NO EQUAL ON THE NORTH AMERICAN CONTINENT IN ITS ARIDITY.

D. EXPOSURE OF YUMA TEST STATION TO MOISTURE SOURCES

THE EXTREME SOUTHWESTERN CORNER OF THE TEST STATION IS LOCATED NO MORE THAN ONE MILE FROM IRRIGATED LAND, BUT IS IN THE RUGGED LAGUNA MOUNTAINS, HENCE IS LITTLE USED. OTHER MOISTURE SOURCES "THREATEN" THE

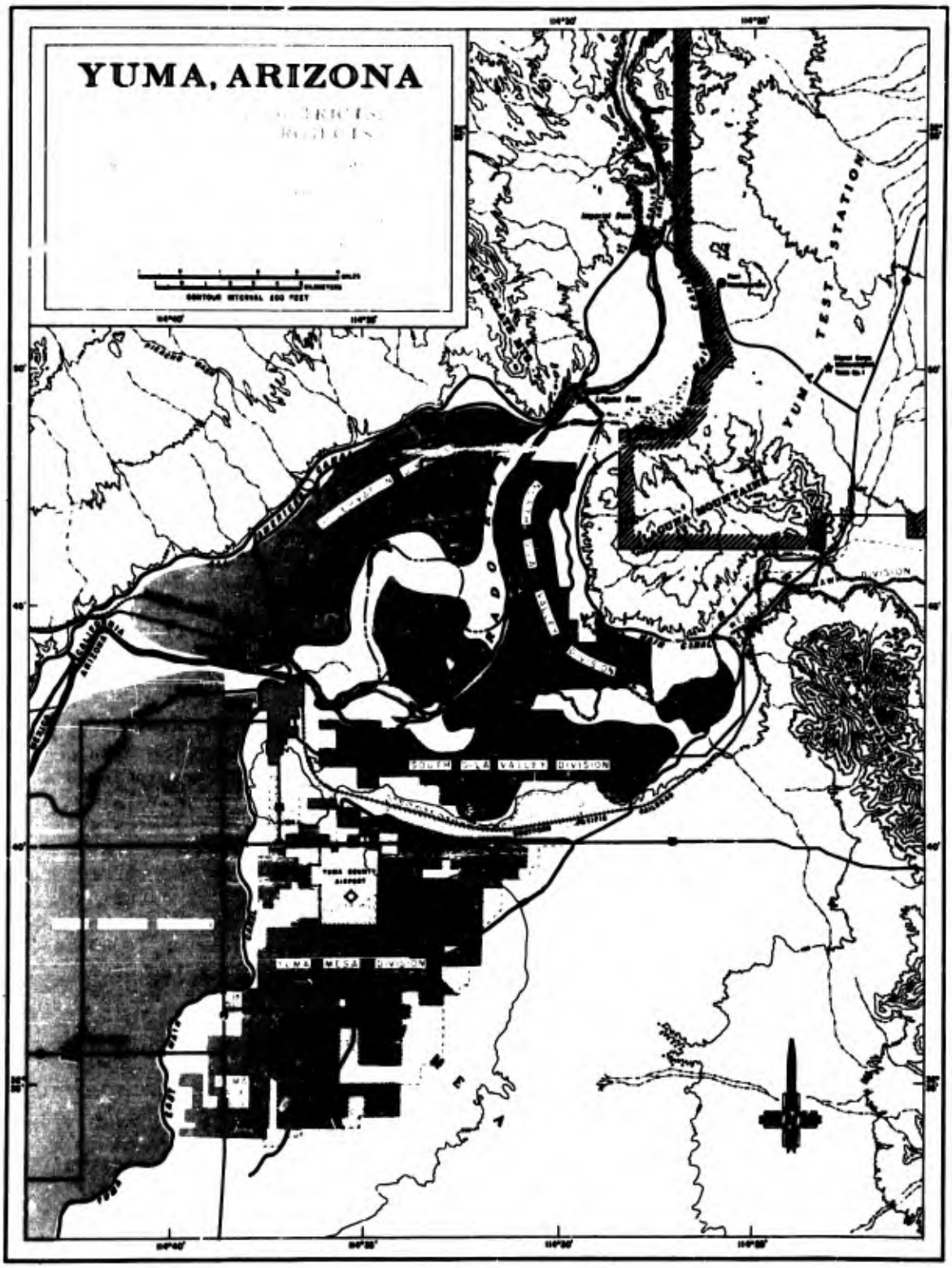


FIGURE 1. ONLY MINOR ADDITIONS WERE MADE TO THE IRRIGATED AREAS BETWEEN 1954, WHEN THE DAYTIME STUDY WAS MADE, TO 1956, THE YEAR IN WHICH THE PRESENT STUDY WAS CONDUCTED.

HOT-DRY ENVIRONMENT OF THE STATION. JUST SOUTH OF IMPERIAL DAM, FOR A DISTANCE OF SOME 5 MILES, THE MARSHY, SILT-FILLED ABANDONED RESERVOIR OF LAGUNA DAM ACTUALLY BORDERS ON THE TEST STATION, AND NORTHWARD FROM IMPERIAL DAM THE PRESENT RESERVOIR LIES NEARLY CONTIGUOUS TO THE WESTERN BOUNDARY OF THE STATION FOR MANY MILES.

E. CLIMATE OF YUMA AREA

YUMA IS SITUATED IN ONE OF THE HOTTEST AND DRIEST PARTS OF THE UNITED STATES.* MEAN ANNUAL RAINFALL, BASED ON NEARLY 80 YEARS OF RECORD, IS A MERE 3.4 INCHES.** AS IN MANY DESERT AREAS, THERE IS WIDE VARIATION FROM THE MEAN; AN ABSOLUTE MINIMUM OF 0.31 INCH WAS RECORDED IN 1953 AND AN ABSOLUTE MAXIMUM OF 11.4 INCHES IN 1905. CONSIDERING THE HIGH AVERAGE TEMPERATURE AND EVAPORATION, EVEN THE "WETTEST" YEARS ARE DECIDEDLY ARID. NO SEASON, OF COURSE, CAN BE DESCRIBED AS RAINY, ALTHOUGH IN MOST YEARS THERE IS DECIDED CONCENTRATION OF PRECIPITATION INTO TWO PERIODS. JULY TO OCTOBER RECEIVES 50 PERCENT OF THE MEAN ANNUAL TOTAL, PRIMARILY AS THUNDERSHOWERS, WHILE THE PERIOD DECEMBER TO MARCH RECEIVES 42 PERCENT, LARGELY AS LIGHT RAINS ASSOCIATED WITH MIGRATORY CYCLONIC STORMS. APRIL THROUGH JUNE IS DRIEST, AVERAGING ONLY 0.13 INCH, OR 4 PERCENT OF THE YEARLY TOTAL.

AS COULD BE EXPECTED, RELATIVE HUMIDITY IS COMPARATIVELY LOW, ALTHOUGH THE LEVEL IS RAISED DURING JULY, AUGUST, AND SEPTEMBER BY ADVECTION OF MARITIME TROPICAL AIR INTO THE REGION FROM THE GULF OF MEXICO (THE SO-CALLED ARIZONA SUMMER MONSOON***) AND POSSIBLY BY LOCAL ADVECTION OF MOIST AIR FROM THE GULF OF CALIFORNIA. MEAN RELATIVE HUMIDITIES FOR THESE 3 MONTHS AT THE YUMA COUNTY AIRPORT (US WEATHER BUREAU STATION) ARE 51, 56, AND 53 PERCENT RESPECTIVELY FOR 0530****, AND 23, 24, AND 18 PERCENT RESPECTIVELY FOR 1730.

DEWPOINT VARIES WIDELY DURING SUMMER. IN MAY AND JUNE, APPROXIMATELY 80 PERCENT OF ALL HOURLY VALUES ARE BETWEEN 30° AND 50°, BUT IN JULY AND AUGUST 80 PERCENT LIE BETWEEN 50° AND 75°, REVEALING THE PREDOMINANCE OF MORE HUMID AIR DURING THE LATTER PERIOD. DURING BOTH THE DRY AND HUMID PERIODS THERE IS A DIURNAL VARIATION OF 5 TO 10 DEGREES WITH THE MAXIMUM OCCURRING AROUND 0800 AND THE MINIMUM FROM 1500 TO 1700 (FIG. 2).

---

*FOR A MORE COMPLETE DISCUSSION OF THE CLIMATE OF YUMA SEE REFERENCE (5).

**DATA ON THE CLIMATE OF YUMA PRESENTED IN THIS DISCUSSION ARE FROM REFERENCE (13).

***SEE BRYSON AND LOWRY (3, 4).

****ALL TIMES SHOWN ARE MOUNTAIN STANDARD TIME.

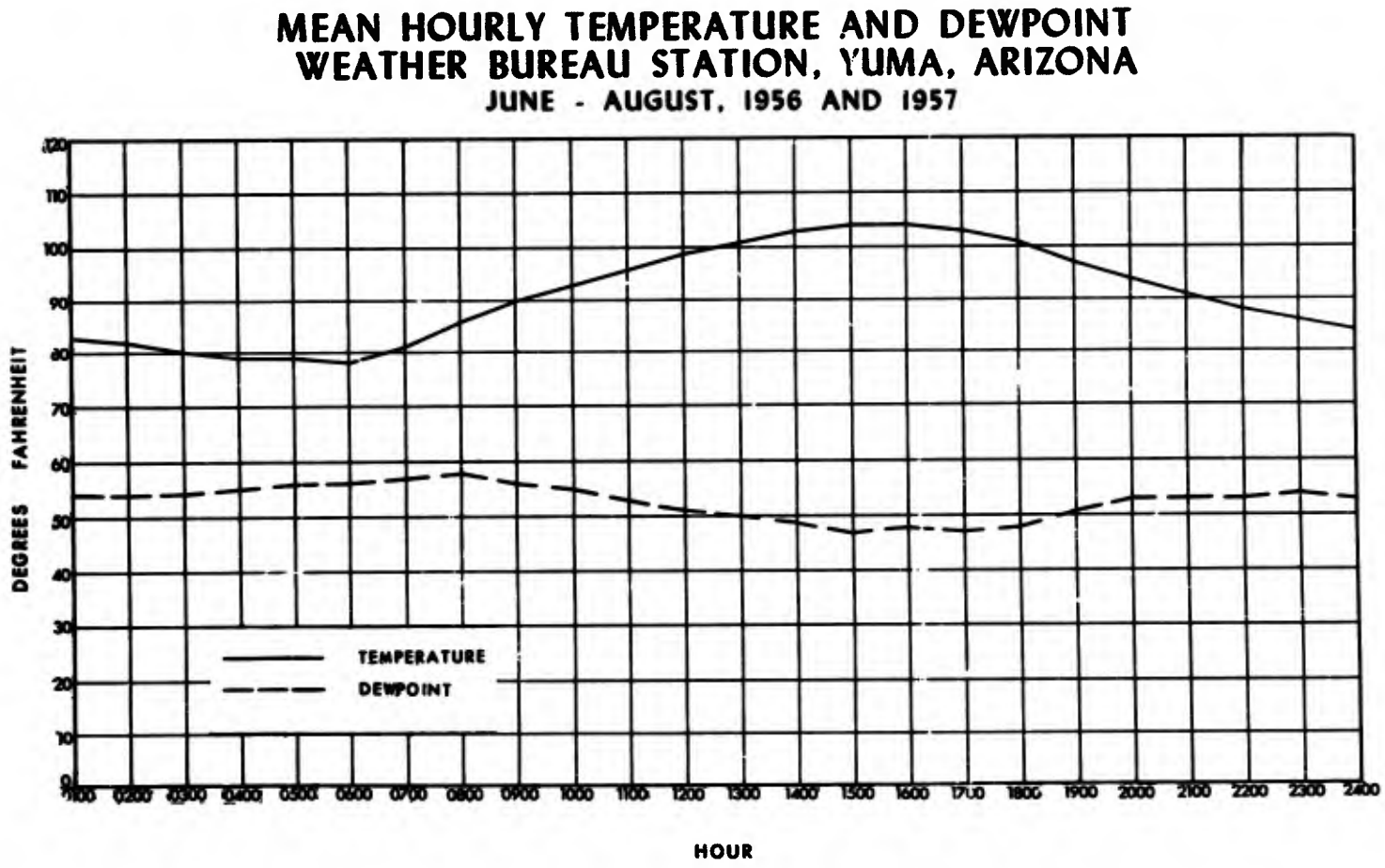


FIGURE 2. DIURNAL VARIATION OF TEMPERATURE AND DEWPOINT AT YUMA IN SUMMER. IN CONTRAST TO HUMID CLIMATES. DEWPOINTS ARE HIGHEST IN THE EARLY MORNING AND LOWEST IN THE AFTERNOON. NOTE THAT THE TEMPERATURE RANGE IS NOT LARGE (APPROXIMATELY 26 F DEGREES) CONSIDERING THE DESERT ENVIRONMENT.

THIS CONDITION, THE REVERSE OF THAT FOUND IN HUMID REGIONS, IS EXPLAINED IN SECTION 3A. THE DRY AND HUMID PERIODS ARE EACH MARKED BY INTERVALS OF A FEW DAYS DURING WHICH DEWPOINT DEPARTS MARKEDLY FROM THE GENERAL RUN OF VALUES. IN JULY AND AUGUST, FOR EXAMPLE, NIGHTTIME DEWPOINTS USUALLY AVERAGE BETWEEN 60° AND 75° BUT OCCASIONALLY DROP FOR A FEW NIGHTS TO THE 30'S AND 40'S OR EVEN LOWER.

IN TEMPERATURES, THE YUMA SUMMER CLIMATE IS LONG AND HOT. MAXIMUM DAILY TEMPERATURES COMMONLY REACH 100° FROM THE FIRST PART OF JUNE INTO JULY AND AUGUST. TEMPERATURES OF 115° ARE NOT UNCOMMON DURING THE HEIGHT OF THE HOT SEASON. NIGHTTIME TEMPERATURES LIKEWISE ARE HIGH, ESPECIALLY IN THE MORE HUMID WEATHER OF JULY AND AUGUST (FIG. 2). MEAN DAILY MINIMUM TEMPERATURES FOR JUNE, JULY, AND AUGUST ARE 72°, 77°, AND 74° RESPECTIVELY. TABLE III SUMMARIZES MIDNIGHT AND EARLY MORNING TEMPERATURE FOR JULY AND AUGUST.

TABLE III

MEAN AIR TEMPERATURE (°F), JULY AND AUGUST 1956 AND 1957, YUMA COUNTY AIRPORT

TIME	MEAN	ABSOLUTE MIN. FOR PERIOD	ABSOLUTE MAX. FOR PERIOD	% AT 90° OR HIGHER
2400	86	73	97	32
0400	82	68	92	5

IN MAY AND JUNE, AND OCCASIONALLY AFTERWARDS, NIGHTTIME TEMPERATURES FALL TO LOWER LEVELS THAN THOSE IN THE TABLE, DUE TO THE PRESENCE OF DRIER AIR AND THE CONSEQUENT GREATER EVAPORATION AND LOSS OF LONGWAVE RADIATION FROM THE EARTH'S SURFACE. AN EXAMPLE OCCURRED IN EARLY JULY 1956. AFTER SEVERAL DAYS WITH DAILY MINIMUM TEMPERATURES OF 83° TO 85°, THEY SUDDENLY FELL TO 67° TO 70° FOR 4 DAYS BEFORE RISING AGAIN TO THE 80'S. IN THIS SAME 4-DAY PERIOD, HUMIDITY DROPPED SHARPLY AS EVIDENCED BY DEWPOINTS OF 15° TO 30° INSTEAD OF 60° TO 70°.

SUMMER WINDS IN THE YUMA AREA ARE PREDOMINANTLY FROM THE SOUTH; APPROXIMATELY 60 PERCENT OF HOURLY WINDS FOR JUNE THROUGH AUGUST ARE FROM THE SOUTHEAST THROUGH SOUTHWEST. AT NIGHT (2400 TO 0600), THE WIND STILL BLOWS PREDOMINANTLY FROM THE SOUTH BUT TENDS TO BE A LITTLE MORE VARIABLE THAN IN THE DAYTIME (1200 TO 1800). MEAN WIND VELOCITIES AT NIGHT ARE ONLY SLIGHTLY LESS THAN DAYTIME VALUES, 8.1 MPH VS. 9.9, BUT THE PERCENTAGE OF CALMS AND VERY LIGHT WINDS IS CONSIDERABLY HIGHER AT NIGHT; CALM IS REPORTED 16 PERCENT OF THE TIME BETWEEN 2400 AND 0600 AND ONLY 2.5

PERCENT OF THE TIME BETWEEN 1200 AND 1800. OCCASIONALLY VERY STRONG WINDS OCCUR AT NIGHT, USUALLY ASSOCIATED WITH THUNDERSTORM ACTIVITY, AND CAUSE MUCH DUST AND FINE SAND TO BE PICKED UP AND CARRIED THROUGH THE AIR.

2. METHODS OF INVESTIGATION

TO DETERMINE HUMIDITY RELATIONSHIPS BETWEEN THE OASIS AND THE DESERT, AND BETWEEN DIFFERENT CROP AND CULTIVATION TYPES WITHIN THE OASIS, DATA WERE COLLECTED IN THE FIELD FROM 23 JUNE TO 12 JULY 1956. THIS TIME OF THE YEAR WAS SELECTED TO PERMIT SAMPLING DURING BOTH THE DRY AND HUMID PHASES OF THE SUMMER.

TWO METHODS OF COLLECTING DATA WERE EMPLOYED. FIVE METEOROLOGICAL SUBSTATIONS WERE SET UP ALONG A 20-MILE TRANSECT EXTENDING FROM THE DESERT SOUTH OF THE IRRIGATED AREA NORTHWARD ACROSS THE OASIS TO PICACHO WASH (FIG. 3).

SUBSTATION 1 OF THIS TRANSECT, OR THE SOUTH YUMA DESERT STATION AS IT WILL BE REFERRED TO HENCEFORTH (SEE FIG. 4 FOR A PICTURE OF THE STATION), WAS ON A BROAD AND NEARLY LEVEL EXPANSE OF THE SAND AND GRAVEL SURFACE OF THE YUMA DESERT 1 1/2 MILES SOUTH OF THE SOUTHERN EDGE OF THE OASIS, THUS BEING EXPOSED PREDOMINANTLY TO WINDS FROM THE UNINTERRUPTED STRETCH OF DESERT TO THE SOUTH. IT IS CONSIDERED THE CONTROL STATION FOR DESERT CONDITIONS. SUBSTATION 2, OGRAM FARM (FIG. 5), WAS ON THE NORTHERN MARGIN OF A COTTONFIELD WELL WITHIN THE IRRIGATED AREA AND 11 MILES NORTH OF THE SOUTH YUMA DESERT STATION. SUBSTATION 3, EXPERIMENTAL FARM (FIG. 6), WAS 6 MILES DUE WEST OF OGRAM FARM IN A COTTONFIELD NEAR THE WESTERN LIMIT OF THE OASIS. SUBSTATION 4, PICACHO #2 (FIG. 7), WAS SOME 200 YARDS NORTH OF THE NORTHERN EDGE OF THE OASIS ON A FLAT SAND- AND BUSH-COVERED SURFACE.* SUBSTATION 5, PICACHO #1 (FIG. 8), WAS TWO-THIRDS OF A MILE FARTHER NORTH IN THE BED OF PICACHO WASH NEAR THE POINT WHERE THE WASH DEBOUCHES FROM THE HILLY AREA INTO THE VALLEY.

INSTRUMENTATION AT EACH STATION CONSISTED OF A HAIR HYGROTHERMOGRAPH AND A BECKMAN AND WHITLEY RECORDING ANEMOMETER. THE INSTRUMENTS WERE CHECKED EVERY SECOND OR THIRD DAY FOR CALIBRATION. DUE TO THE LOW RELIABILITY OF THE HAIR ELEMENT IN THE HYGROTHERMOGRAPH, THE HUMIDITY DATA FOR THIS TRANSECT MUST BE VIEWED WITH CAUTION.

DATA WERE ALSO COLLECTED THROUGH HAND OBSERVATIONS BY TEAMS OF 4 TO 6 MEN ALONG TRANSECTS LOCATED EITHER ENTIRELY WITHIN THE OASIS OR PARTLY IN THE OASIS AND PARTLY IN THE OPEN DESERT. THESE OBSERVATIONS WERE TAKEN BETWEEN 2400 AND 0600, THE TIME DURING WHICH NIGHTTIME CONDITIONS

*THIS STATION WAS FIRST LOCATED IN PICACHO WASH 2 1/2 MILES FROM THE MOUTH OF THE WASH, BUT ON 26 JUNE 1956 WAS MOVED TO THE SITE DESCRIBED ABOVE.

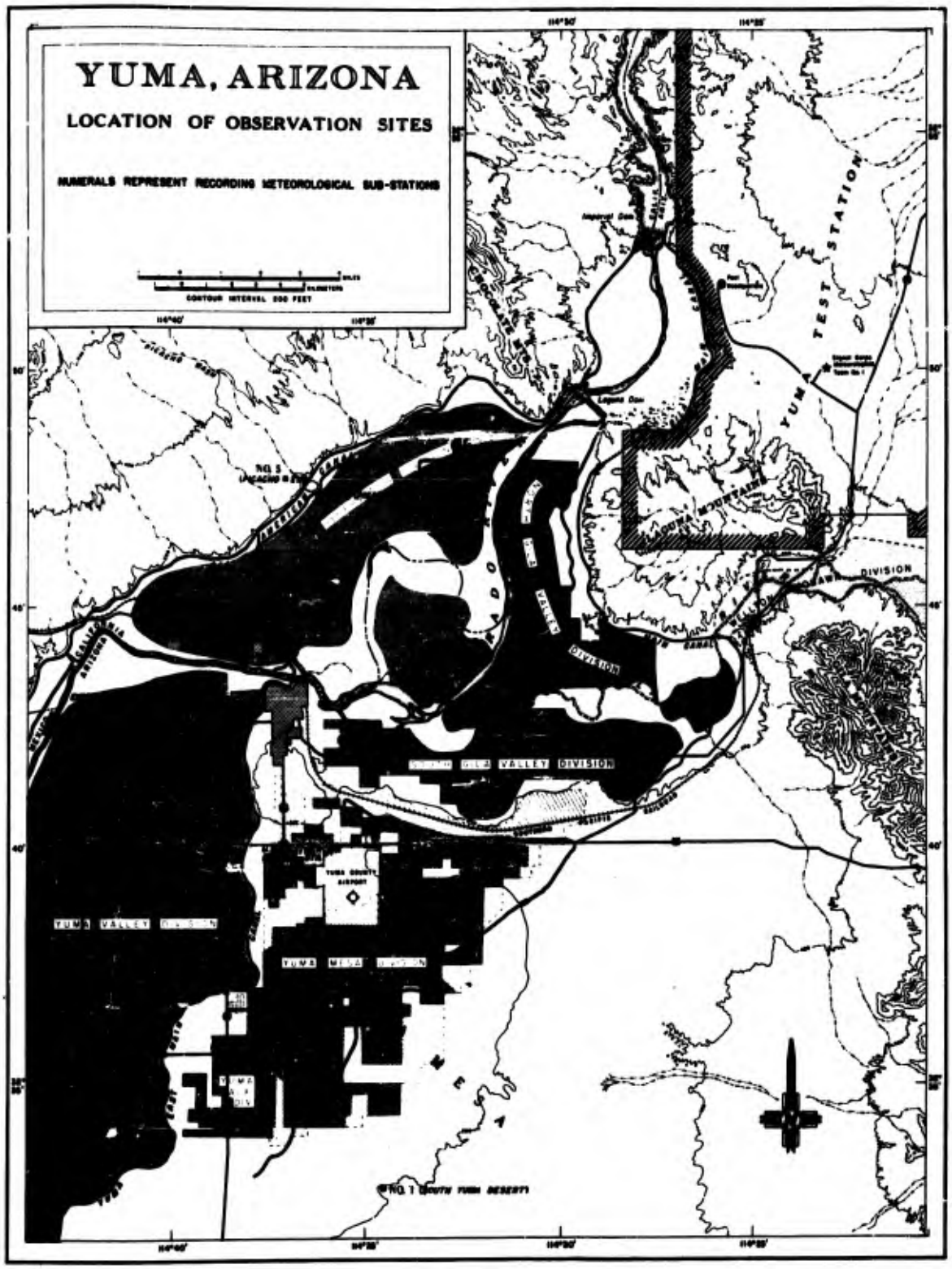


FIGURE 3. LOCATION OF SUBSTATIONS USED IN THE STUDY.

FIGURE 4. SUBSTATION 1 (SOUTH YUMA DESERT), LOOKING SOUTH OVER THE GENTLY UNDULATING SURFACE OF THE MESA.

FIGURE 5. SUBSTATION 2 (OGRAM FARM) LOCATED AT THE NORTHERN EDGE OF A COTTONFIELD ON THE COLORADO RIVER FLOODPLAIN. THE EDGE OF THE YUMA MESA IS IN THE DISTANCE.

FIGURE 6. SUBSTATION 3 (EXPERIMENTAL FARM) LOCATED IN A COTTONFIELD AT THE UNIVERSITY OF ARIZONA EXPERIMENTAL FARM NEAR THE WESTERN MARGIN OF THE YUMA OASIS.

FIGURE 7. SUBSTATION 4 (PICACHO #2) LOCATED AT THE NORTHERN EDGE OF THE OASIS. THE CROP IN THE BACKGROUND IS ALFALFA. THE VIEW IS SOUTH ACROSS THE LEVEL SURFACE OF THE VALLEY PORTION OF THE OASIS.

FIGURE 8. SUBSTATION 5 (PICACHO #1) LOCATED IN THE BED OF PICACHO WASH NEAR ITS MOUTH. THE VIEW IS UPSTREAM.

WERE MOST HIGHLY DEVELOPED. INSTRUMENTS WERE THE STANDARD SIGNAL CORPS SLING PSYCHROMETER (ML-34) AND THE ASSMANN ELECTRICALLY-VENTILATED PSYCHROMETER (AN/TMQ-6, XE-1). EXCEPT WHEN VERTICAL PROFILES WERE TAKEN, PSYCHROMETER READINGS WERE MADE 3 TO 4 FEET ABOVE THE GROUND. WIND WAS MEASURED AT THE SAME HEIGHT WITH A HAND ANEMOMETER (ML-433/PM). STATIONARY AND RUNNING TRANSECTS WERE USED. IN THE FORMER, EACH OBSERVER REMAINED AT ONE POINT DURING THE ENTIRE PERIOD OF OBSERVATIONS; IN THE LATTER, A TEAM MOVED EITHER ON FOOT OR BY VEHICLE ALONG A TRANSECT, STOPPING TO TAKE OBSERVATIONS AT REGULAR DISTANCES. VERTICAL DISTRIBUTION OF HUMIDITY IN VARIOUS CROP TYPES WAS OBSERVED AT 1-FOOT INTERVALS FROM THE SURFACE TO 15 FEET USING THE ASSMANN ELECTRIC PSYCHROMETER.

3. ANALYSIS OF DATA

A. INTRODUCTION

IT HAS BEEN POINTED OUT IN SECTION 1 THAT DEWPOINT IS HIGHLY CONSERVATIVE FOR ISOBARIC TEMPERATURE VARIATIONS. THAT IS TO SAY, GIVEN AN AREA OCCUPIED BY A HOMOGENEOUS AIRMASS EXPERIENCING NO ADVECTIVE EXCHANGES WITH OUTSIDE AIRMASSES, THERE SHOULD BE NO APPRECIABLE FLUCTUATION OF DEWPOINT AS A RESULT OF AREAL DIFFERENTIATION OF DIURNAL HEATING AND

COOLING. AT LEVELS SOME DISTANCE ABOVE THE GROUND THIS HOLDS REASONABLY TRUE, BUT NEAR THE SURFACE, TEMPERATURE CHANGES SET IN OPERATION OTHER PROCESSES THAT OFTEN BRING ABOUT THE ADDITION OR SUBTRACTION OF MOISTURE FROM THE AIR.

IN HUMID REGIONS, WHEN SOIL OR WATER IS HEATED BY SOLAR RADIATION, THE VAPOR PRESSURE GRADIENT FROM THE SURFACE UPWARD THROUGH THE AMBIENT AIR INCREASES WITH THE RESULT THAT EVAPORATION ACCELERATES, MOISTURE IS ADDED TO THE AIR, AND THE DEWPOINT RISES ALONG WITH AIR TEMPERATURE. CONVERSELY, AT NIGHT WHEN THE SURFACE COOLS, THE VAPOR PRESSURE GRADIENT DECREASES AND MAY REVERSE SO THAT DEW IS DEPOSITED; THE DEWPOINT IS THEN LOWERED. EQUALLY IMPORTANT TO THIS DIURNAL FLUCTUATION OF DEWPOINT IS TRANSPIRATION FROM PLANTS. FOR MOST PLANTS IN HUMID REGIONS, TRANSPIRATION IS AT A MAXIMUM DURING DAYLIGHT HOURS AND AT A MINIMUM AT NIGHT, THEREFORE IT ADDS TO THE PROCESS OF DAYTIME EVAPORATION. THE OPERATION OF THESE PROCESSES PRODUCES A DEWPOINT MAXIMUM DURING THE DAY AND A MINIMUM AT NIGHT, WITH A DIURNAL AMPLITUDE OF ABOUT ONE-FIFTH TO ONE-SIXTH THAT OF AIR TEMPERATURE.*

IN ARID REGIONS, THE SITUATION IS REVERSED DUE TO RELATIVELY SMALL EVAPORATION AND TRANSPIRATION FROM THE DRY GROUND AND INTENSE VERTICAL MIXING WITH DRIER AIR FROM ALOFT IN HEAVY DAYTIME CONVECTION. FIGURE 2 PRESENTS THE DAILY MARCH OF DEWPOINT FOR THE YUMA WEATHER BUREAU STATION DETERMINED FROM HOURLY OBSERVATIONS FOR JULY AND AUGUST 1956 AND JUNE THROUGH AUGUST 1957. THE PERIOD WITH LOWEST DEWPOINT, 1500 TO 1700, COINCIDES WITH THE TIME OF MAXIMUM TEMPERATURE AND GREATEST VERTICAL EDDY TRANSFER OF WATER VAPOR. MAXIMUM DEWPOINTS, INTERESTINGLY, DO NOT OCCUR AT THE TIME OF MINIMUM TEMPERATURE AND LEAST VERTICAL MIXING; INSTEAD, THEY USUALLY ARE ENCOUNTERED BETWEEN 0700 AND 0900, A TIME WHEN THE AIR IS STILL STABLE AND STRATIFIED FROM NIGHTTIME SURFACE COOLING BUT WHEN SURFACE HEATING FROM THE RISING SUN HAS PROCEEDED FAR ENOUGH TO ADD SOME MOISTURE TO THE LOWER LEVELS OF THE AIR. AS THE SUN CLIMBS HIGHER AND SURFACE HEATING INCREASES, CONVECTIVE ACTIVITY INTENSIFIES RAPIDLY AND ALTHOUGH EVAPORATION MAY INCREASE (TRANSPIRATION OF SOME DESERT PLANTS ACTUALLY DECREASES DURING THE HEAT OF THE DAY)**, THE RAPIDLY ACCELERATING STRENGTH OF VERTICAL MIXING BECOMES THE CONTROLLING PROCESS AND CAUSES A DECLINE OF DEWPOINT NEAR THE SURFACE OF THE GROUND.

*FOR A GENERAL DISCUSSION OF DIURNAL DEWPOINT REGIME SEE HAURWITZ AND AUSTIN (7), P. 89 AND 90.

**EVAPORATION FROM DRY DESERT SOIL MAY ALSO DECREASE DURING THE HEAT OF DAY. THE EXTREMELY HIGH VAPOR PRESSURE GRADIENTS ESTABLISHED BY EXCESSIVE HEATING OF SOIL SURFACES (UP TO 165° UNDER EXTREME CONDITIONS) CAUSE FASTER REMOVAL OF MOISTURE FROM THE IMMEDIATE SOIL SURFACE THAN CAN BE REPLACED FROM BELOW BY CAPILLARY ACTION. CONSEQUENTLY, THERE IS A DECLINE OF MOISTURE IN THE HOTTEST PART OF THE DAY.

In arid and semiarid regions where there are marked areal contrasts in surface moisture available for evaporation and transpiration, differences in dewpoint can develop to a high degree. Such a situation is provided by an oasis and the encompassing desert. Abundant moisture within the oasis contributes huge quantities of water vapor to the air immediately above the oasis during day and night, while the desert yields comparatively small amounts to its surface layer of air. The nighttime magnitude of the resulting differences between oasis and desert and the degree to which advection of water vapor occurs between the surface air of the two is discussed in the following pages.

B. Substation Data

In spite of limitations mentioned earlier, it is felt the substation hygrothermograph data can be used. This belief is supported by (1) close correspondence of dewpoint variation between substations based on psychrometer readings and data from the hygrothermograph traces, and (2) the high comparability of hygrothermograph data for the South Yuma Desert substation and Yuma Test Station psychrometer data, the last two areas dominated at night by dry winds from the desert.

Table IV presents mean temperatures, relative humidities, and dewpoints at 0230 and 0530 from 23 June to 12 July for the substations and for Yuma Weather Bureau and Yuma Test Station. Dewpoints of the South Yuma Desert substation (means of 45° and 50° for 0230 and 0530) averaged lower than those of any other station. Mean values for the two stations located within the irrigated district (Ogram Farm and Experimental Farm) were somewhat higher (59° and 65°, and 56° and 59°). For the 0530 observation, this indicates 70 percent and 38 percent more water vapor in the air at the oasis stations than at the South Yuma Desert site.* All stations show an increase in mean dewpoint from 0230 to 0530 (from 1 degree for Yuma Test Station to 6 degrees for Ogram Farm), thus conforming to the diurnal fluctuation of dewpoint shown by the curve in Figure 2.

Figure 9 gives the 0230 and 0530 dewpoints for all stations during the 20 days of the investigation. It is apparent from the day-to-day trend that the Yuma area experienced 4 intervals of alternating dominance by moist and dry airmasses, each of which controlled the weather of the area for 4 to 5 days. As pointed out earlier, this cyclic change between high and low airmass moisture content is typical of the transition from the extremely dry conditions of May and June to the more humid weather of July and August.

*The vapor pressure in air with a dewpoint of 50° is 12.3 mb. For 65° and 59° it is 21.0 mb and 17.0 mb respectively.

TABLE IV

MEAN TEMPERATURE, RELATIVE HUMIDITY, AND DEWPOINT
23 JUNE TO 12 JULY 1956

	TIME	MEAN VALUES T(°F)	R.H.(%)	D.P.(°F)
S. YUMA DESERT*	0230	81	32	45
	0530	76	43	50
OGRAM FARM*	0230	76	56	59
	0530	73	78	65
EXP. FARM*	0230	75	53	56
	0530	69	70	59
PICACHO #1*	0230	78	39	49
	0530	74	47	51
YUMA TEST STA.	0230	83	32	49
	0530	79	38	50
YUMA WEATHER BUREAU	0230	83	35	51
	0530	80	44	54

*CALCULATED ON BASIS OF TEMPERATURE AND RELATIVE HUMIDITY VALUES TAKEN FROM HYGROTHERMOGRAPH TRACE.

FROM THE BEGINNING OF THE PERIOD OF INVESTIGATION ON 23 JUNE THROUGH 26 JUNE, DRY CONDITIONS PREVAILED. DURING THESE 4 DAYS, DEWPOINTS RANGED FROM 41° TO 50° AT YUMA TEST STATION, PROBABLY THE STATION WITH THE MOST REPRESENTATIVE VALUES FOR THE AIRMASS BECAUSE OF THE RELIABILITY OF THE OBSERVATIONS AND THE ASSUMED LACK OF MODIFICATION BY ADDITION OF MOISTURE FROM LOCAL SOURCES. FROM 26 JUNE TO 30 JUNE, DEWPOINTS AT THE STATION VARIED BETWEEN A LOW OF 57° AND A HIGH OF 68°, INDICATING THE PRESENCE OF A MORE HUMID AIRMASS. ON 1 JULY, VALUES FELL SHARPLY AS AN EXTREMELY DRY AIRMASS MOVED INTO THE AREA. AT 0530 ON 5 JULY A LOW OF 24° WAS OBSERVED. BY 9 JULY, MOIST AIR WAS IN CONTROL AGAIN WITH VALUES AT THE TEST STATION MOSTLY BETWEEN 60° AND 68°, AND CONTINUED SO UNTIL THE END OF THE STUDY PERIOD. THESE ALTERNATING DRY AND HUMID SPELLS ARE SIGNIFICANT TO THIS INVESTIGATION, FOR IT WILL BE SEEN THAT THE GENERAL MOISTURE LEVEL IN THE AIRMASS DOMINATING THE YUMA AREA IS A FACTOR IN THE MAGNITUDE OF DIFFERENCE BETWEEN THE VARIOUS SITES.

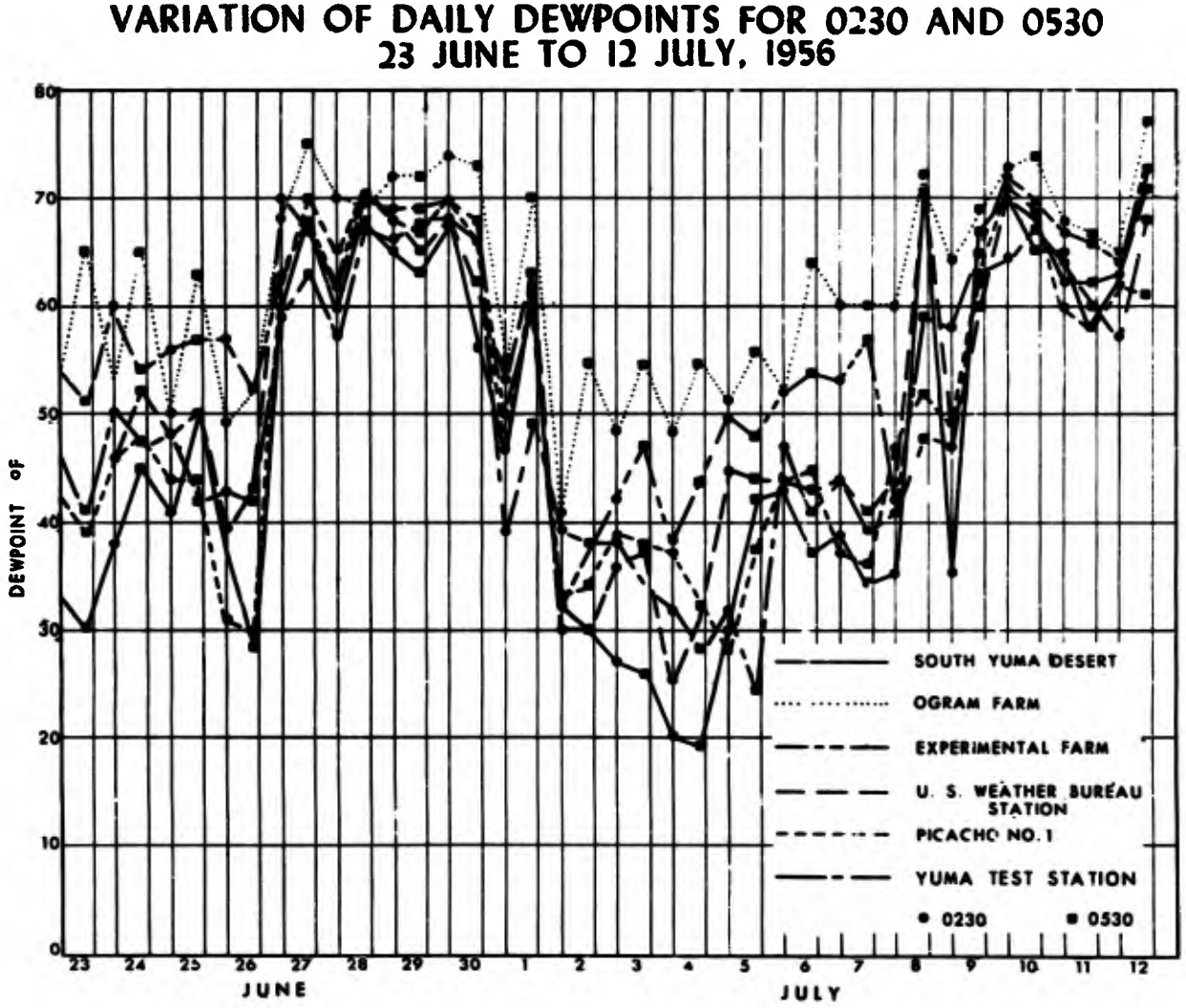


FIGURE 9. THE DAILY MARCH OF DEWPOINT DURING THE STUDY PERIOD. NOTE THE TWO SPELLS OF DRY AIRMASS CONTROL AND THE TWO WHEN MOIST AIR PREVAILED. A GREATER DISPARITY OF DEWPOINTS EXISTED BETWEEN DESERT AND OASIS DURING THE FORMER THAN THE LATTER.

THROUGHOUT THE INVESTIGATION, THE 0230 AND 0530 VALUES FOR THE OASIS SUBSTATIONS, OGRAM FARM AND EXPERIMENTAL FARM, WERE CONSISTENTLY HIGHER THAN THOSE FOR OTHER SITES. IN CONTRAST, VALUES AT THE SOUTH YUMA DESERT SITE WERE CONSISTENTLY LOW; IT WAS THE LOWEST OF ALL STATIONS FOR HALF THE 40 OBSERVATIONS IN FIGURE 9 AND NEAR THE LOWEST FOR THE REMAINDER. ON ONLY 3 OCCASIONS WAS THE DEWPOINT HIGHER AT THE DESERT LOCATION THAN AT EITHER OASIS LOCATION, AND ON ONLY 3 OCCASIONS WAS IT EQUAL TO THE LESSER OASIS VALUE; WITH BUT ONE EXCEPTION, THESE WERE AT TIMES WHEN HUMID AIR CONTROLLED THE WEATHER. THE YUMA WEATHER BUREAU, YUMA TEST STATION, AND PICACHO WASH #1 CURVES GENERALLY CORRESPOND TO THAT OF THE SOUTH YUMA DESERT STATION, BUT USUALLY WITH SLIGHTLY HIGHER DEWPOINTS.

FIGURE 9 REVEALS A GREATER DISPARITY IN DEWPOINTS BETWEEN DESERT AND OASIS WITH DRY THAN WITH HUMID AIRMASSES. IN THE DRY PERIODS, MEAN DEWPOINTS OF THE MOST HUMID SITE (OGRAM FARM) AVERAGED 55° COMPARED WITH 34° FOR THE DRIEST SITE (SOUTH YUMA DESERT), A DIFFERENCE OF 21 DEGREES, WHEREAS DURING HUMID AIRMASS CONTROL OGRAM FARM AVERAGED 71° AND SOUTH YUMA DESERT 63° FOR A DIFFERENCE OF ONLY 8 DEGREES.* DEWPOINTS WITHIN THE OASIS REMAINED AT FAIRLY HIGH LEVELS AT ALL TIMES DUE TO CONSTANT AVAILABILITY OF MOISTURE FOR EVAPORATION AND TRANSPIRATION, WHILE IN THE DESERT WHEN DRY AIR MOVED INTO THE AREA NOTHING PREVENTED DEWPOINTS FROM CHANGING TO THE LOW LEVEL OF THE AIRMASS.

TABLE V

MEAN DEWPOINT AND VAPOR PRESSURE WITH DRY AND HUMID AIRMASSES

	OGRAM FARM		SOUTH YUMA DESERT	
	MEAN DEWPOINT (°)	VAPOR PRESSURE (MB)	MEAN DEWPOINT (°)	VAPOR PRESSURE (MB)
DRY PERIODS (23-26 JUNE, 2-7 JULY)	55	14.7	34	6.6
HUMID PERIODS (27 JUNE-1 JULY, 8-12 JULY)	71	26.0	63	19.6

*ACTUAL DIFFERENCE IN MOISTURE CONTENT OF THE AIR AS INDICATED BY THE VAPOR PRESSURE (TABLE V), IS NOT AS GREAT AS THE 21-DEGREE AND 8-DEGREE TEMPERATURE DIFFERENCES SEEM TO INDICATE, BEING 8.1 MB HIGHER IN THE OASIS FOR THE DRY PERIOD AND 6.4 MB HIGHER FOR THE HUMID PERIOD.

One might ask why oasis dewpoints did not increase as sharply with the change from dry to humid air as did dewpoints in the desert. In other words, why the dewpoint at Ogram Farm did not increase 29 degrees to 84° to keep pace with the rise from 34 degrees to 63° at the desert site. The answer seems to be that oasis nighttime ground surface and ambient air temperatures were not high enough to permit the addition of much water vapor to the large amounts already present in the humid airmass. In the Ogram Farm data, it is seen that during humid periods air temperature was usually no higher than 80°, consequently dewpoints could not rise above that figure.

That the mean dewpoint did not reach even 80° arises from the fact that evaporation from a surface, in the absence of wind and ignoring the slight variations in air pressure, is dependent upon the difference between the saturation vapor pressure (or temperature) of the evaporating surface and the actual vapor pressure (or dewpoint) of the air. When evaporation from the surface raises the dewpoint of the air to the level of the temperature of the surface, a state of equilibrium results and unless conditions change no further moisture can be added to the air. That is to say, the dewpoint cannot be raised above the temperature of the evaporating surface, which in this case was unknown, but since conditions of radiative and evaporative cooling existed, would have been less than 80°. In summary, dewpoints of 70° to 75° were near the maximum that could exist at night in the oasis under the existing conditions of air and surface temperature.

There was no apparent relationship between variations in wind direction and dewpoints at the substations. Advection of moisture for any considerable distance away from the irrigated areas should have produced higher dewpoints at the South Yuma Desert location with north and west winds than with south or east winds. Unfortunately, data for the substations are not numerous enough to permit thorough analysis of this problem. Hourly wind data indicate that during nighttime (2400 to 0600), air movement at the South Yuma Desert site was almost always from the desert and seldom from the oasis. On the few occasions when there was a shift of wind from off the desert to off the oasis, or vice versa, no consistent pattern of dewpoint change was apparent. From 0600 to 0700 on 6 July, for example, the wind changed from NW 4 mph to SE 7 mph or directly from the irrigated area to directly from the desert, yet the dewpoint rose from 37° to 40°.

Table VI shows the relationship between wind and dewpoint at the South Yuma Desert station for 0100 to 0800 on 7 July and indicates that changing wind direction had little effect on dewpoints at the desert site. This conclusion seems particularly valid when the 38° to 44° dewpoint range of the table is compared with values of 55° to 60° recorded

TABLE VI

WIND AND DEWPOINT AT S. YUMA DESERT SUBSTATION
(1 JULY 1956)

TIME	WIND (DIR.)	WIND (MPH)	DEWPOINT* (°)
0100	N	5	39
0200	SW	4	41
0300	SW	4	43
0400	SE	4	42
0500	SW	3	41
0600	NW	5	38
0700	W	4	40
0800	S	5	44

*CALCULATED FROM TEMPERATURE AND RELATIVE HUMIDITY VALUES TAKEN FROM HYGROTHERMOGRAPH. THESE VALUES COMPARED CLOSELY WITH THOSE TAKEN AT THE SAME TIME BY MEANS OF SLING PSYCHROMETER AT YUMA TEST STATION.

AT THE SAME TIME IN THE OASIS (OGRAM FARM AND EXPERIMENTAL FARM). WITH SUCH LARGE DIFFERENCES BETWEEN OASIS AND DESERT, ANY APPRECIABLE HORIZONTAL TRANSPORT OF MOISTURE WOULD HAVE PRODUCED GREATER FLUCTUATIONS OF DEWPOINT. A PUZZLING CIRCUMSTANCE AT THE DESERT SITE WAS THE LARGE INCREASE OR DECREASE IN DEWPOINT WITHIN AN HOUR OR SO, OFTEN AS LARGE AS 15 DEGREES OR MORE, WITH NO APPRECIABLE CHANGE IN WIND DIRECTION OR VELOCITY.

c. HIGHWAY 95 TRANSECTS

TO EXAMINE MORE CLOSELY SURFACE HUMIDITY FLUX BETWEEN DESERT AND OASIS AND WITHIN THE OASIS ITSELF, THREE TRANSECTS WERE RUN FROM THE DESERT NORTHWARD INTO THE IRRIGATED AREAS ALONG HIGHWAY 95 AND AVENUE B (SEE FIG. 1). THESE TRANSECTS PERMITTED THE USE OF MORE RELIABLE INSTRUMENTATION THAN THAT USED IN THE SUBSTATIONS.

(1) MESA SYNOPTIC TRANSECT

ON 26 JUNE, ALONG A 1.6 MILE TRANSECT ON A FLAT PORTION OF THE MESA, OBSERVERS TOOK TEMPERATURES AND DEWPOINT READINGS EVERY HALF HOUR FROM 0300 TO 0500 AT TWO POINTS IN AN IRRIGATED ORANGE GROVE AND THREE POINTS IN THE DESERT. TEMPERATURES RANGED BETWEEN 64° AND 76° ALONG THE TRANSECT AND WERE HIGHEST AT THE DESERT END (A IN FIG. 10), WHERE THE MEAN FOR THE PERIOD WAS 76°, AND LOWEST AT THE ORANGE GROVE END (POINT E), WHERE

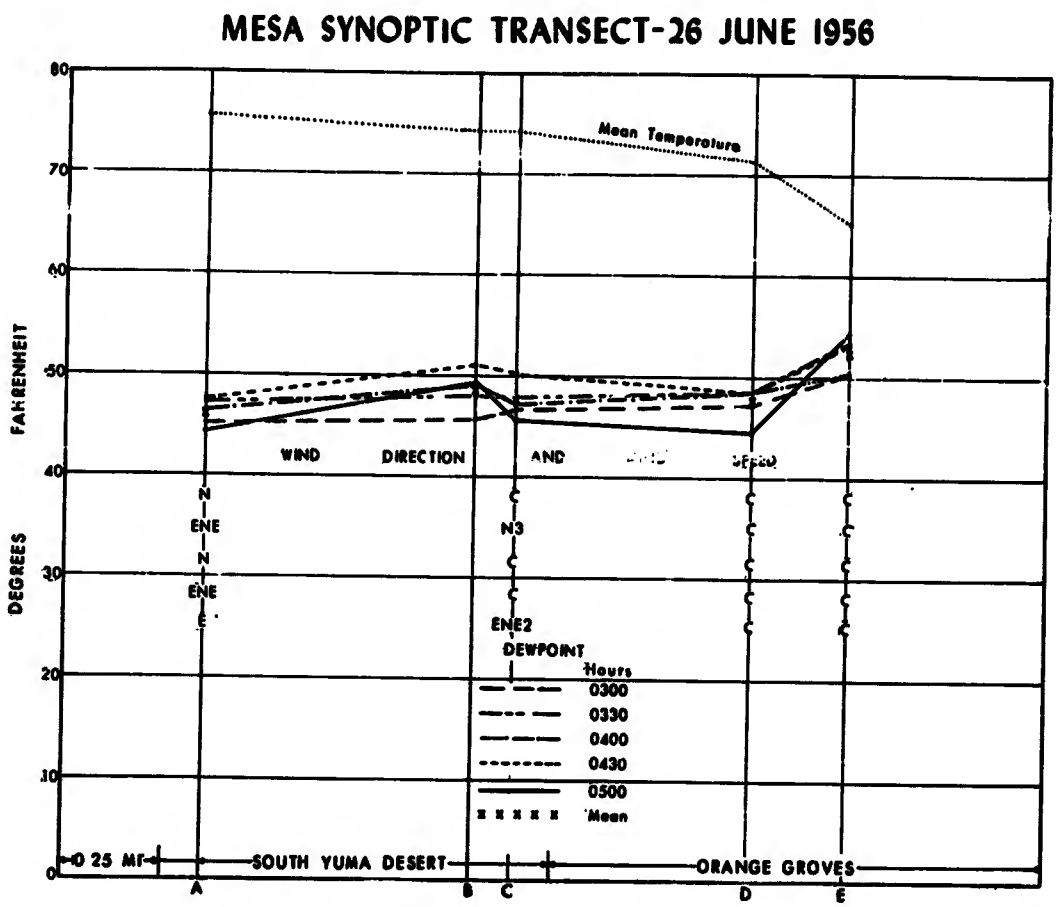


FIGURE 10. SIMULTANEOUS OBSERVATIONS OF TEMPERATURE, DEWPOINT, AND WIND ARE SHOWN FOR A DESERT — OASIS TRANSECT. TEMPERATURE AVERAGED 10 DEGREES HIGHER AND DEWPOINT 6.5 DEGREES LOWER AT THE DESERT THAN AT THE OASIS END.

THE MEAN WAS 65°. WIND WAS CALM WITHIN THE ORCHARD AND CALM OR BLOWING GENTLY FROM THE EAST OR NORTH IN THE DESERT. MEAN DEWPOINT FOR THE PERIOD OF OBSERVATION WAS 6.5 DEGREES HIGHER AT THE OASIS END OF THE TRANSECT THAN AT THE DESERT END. IT SEEMS CLEAR THAT, IN CONTRAST WITH THE DESERT, THERE WAS DEFINITE MOISTURE ENRICHMENT OF THE AIR WITHIN THE ORCHARDS.*

*THE 50- TO 55°-RANGE OF DEWPOINTS AT E IS CLOSE TO THE 49° TO 57° RANGE RECORDED DURING THE SAME PERIOD AT THE OGRAN FARM AND EXPERIMENTAL FARM STATIONS.

THE LOW VALUES AT D IN THE ORCHARD ONLY ONE-QUARTER MILE FROM E (ALSO IN THE ORCHARD) AND ONE-HALF MILE FROM THE SOUTHERN EDGE OF THE OASIS, INDICATE THAT ENRICHMENT DID NOT OCCUR TO THE SAME DEGREE EVERYWHERE WITHIN THE OASIS. THESE LOWER VALUES AT D MIGHT HAVE BEEN THE PRODUCT OF THE TRANSPORT OF DRY AIR FROM THE DESERT INTO THE OUTER MARGIN OF THE ORCHARD AREA, BUT THE LIGHT NORTH WINDS AT THE EDGE OF THE OASIS ARGUE AGAINST THIS EXPLANATION. SUBSIDENCE OF DRIER AIR FROM ALOFT COULD BE A FACTOR. FINALLY, THE DROP OF APPROXIMATELY 1.5 AND 2.7 DEGREES IN MEAN DEWPOINT FROM LOCATIONS B AND C, 0.1 AND 0.2 MILE SOUTH OF THE OASIS BORDER, TO LOCATION A, 0.9 MILE FROM THE BORDER, THOUGH SMALL, IS EVIDENCE OF SOME SURFACE ADVECTION OF MOISTURE INTO THE DESERT.*

(2) MESA-VALLEY SYNOPTIC TRANSECT

FROM 0330 TO 0500 ON 2 JULY, OBSERVATIONS WERE MADE AT HALF-HOUR INTERVALS AT 6 POINTS ALONG A 14-MILE SECTION OF THE HIGHWAY 95 — AVENUE A ROUTE FROM THE SOUTH YUMA DESERT THROUGH A CROSS SECTION OF CROP TYPES IN THE OASIS TO THE IRRIGATED LANDS NEAR THE NORTHWEST BORDER OF THE OASIS.

AT THE TIME, THE YUMA AREA WAS UNDER THE CONTROL OF A DRY, COOL AIRMASS WITH TEMPERATURES 8 TO 10 DEGREES LOWER AND DEWPOINTS 20 DEGREES LOWER THAN NORMAL FOR THAT TIME OF THE YEAR. A STRONG GROUND-TO-AIR VAPOR PRESSURE GRADIENT EXISTED. WITH THE MOISTURE LEVEL AT SUCH A LOW POINT, CONDITIONS WERE IDEAL FOR HEAVY ENRICHMENT IN THE OASIS COMPARED WITH THE DESERT. IN ADDITION, STRONGER THAN USUAL RADIATIONAL COOLING (DUE TO DRYNESS OF THE AIRMASS) AND NEARLY CALM WIND CONDITIONS (CALM OR FROM N OR E 1 TO 2 MPH) PRODUCED GREATER STAGNATION OF SURFACE AIR, HENCE THE OPPORTUNITY FOR GREATER ENRICHMENT OF AIR AT ANY PARTICULAR LOCATION. THESE SAME CONDITIONS SHOULD HAVE PRODUCED LARGE DIFFERENCES IN DEWPOINT WITHIN THE IRRIGATED AREA FROM VARIATION IN MOISTURE AVAILABLE AT THE SURFACE FOR EVAPORATION AND TRANSPIRATION.

FIGURE 11 CONFIRMS MOST OF THE IDEAS PRESENTED ABOVE. ASSUMING THAT THE MEAN DEWPOINT OF 36° FOR THE 4 OBSERVATIONS AT THE SOUTH YUMA DESERT SITE WAS CLOSE TO THE GENERAL AIRMASS VALUE, AN INCREASE TO 56° AT THE ORANGE GROVE SITE REPRESENTED MORE THAN A TWOFOLD INCREASE IN ACTUAL WATER-VAPOR CONTENT OF THE AIR (7.2 MB TO 15.3 MB). EVEN AIR AT THE OASIS SITE WITH THE LOWEST MEAN DEWPOINTS (C, WITH 45°) CONTAINED 40 PERCENT MORE WATER VAPOR THAN AIR OVER THE DESERT.

* IN VIEW OF THE SMALL NUMBER OF OBSERVATIONS AND THE SLIGHT DIFFERENCES IN DEWPOINT, SUCH CONCLUSIONS MUST NECESSARILY BE VIEWED WITH CAUTION. FURTHER, IN ORDER TO DETERMINE WHETHER LOCATION A WAS AFFECTED, IT WOULD HAVE BEEN NECESSARY TO HAVE OBTAINED DATA FOR GREATER DISTANCE FROM THE OASIS.

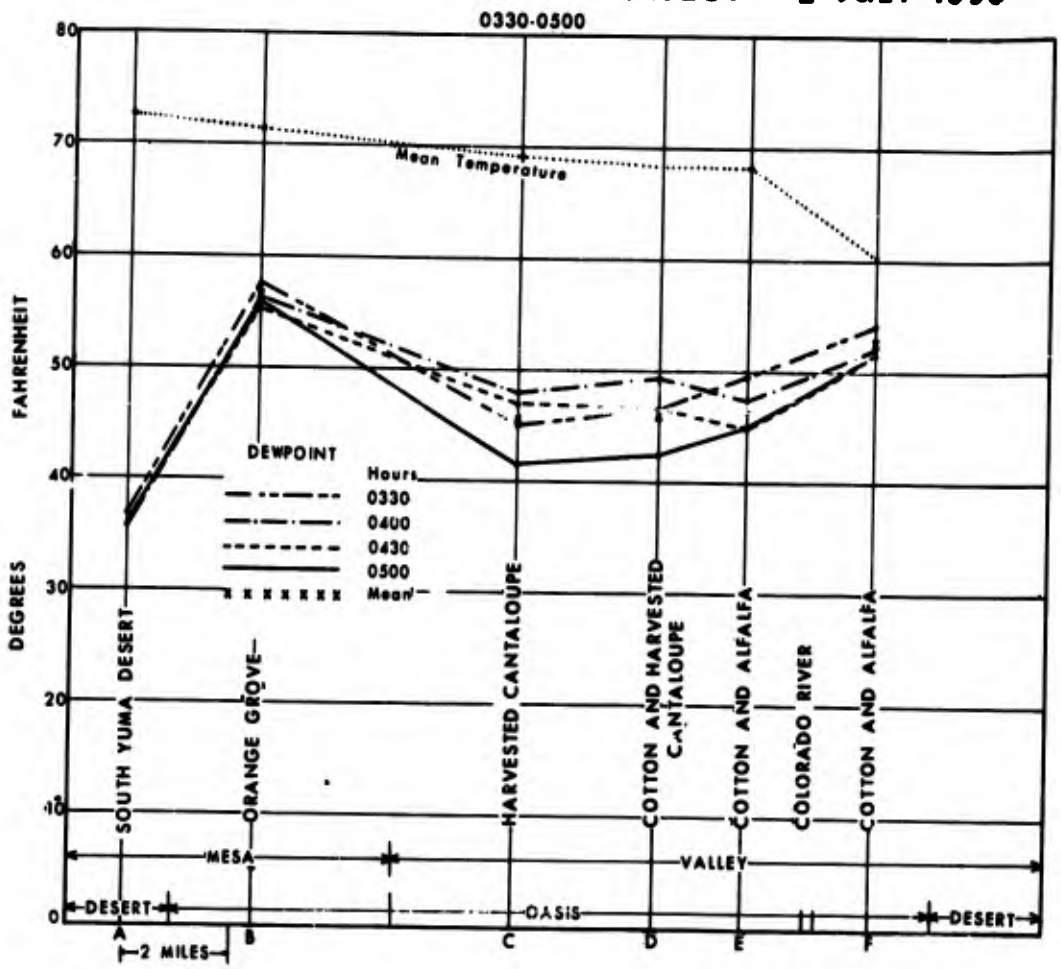


FIGURE 11. SIMULTANEOUS OBSERVATIONS OF TEMPERATURE AND DEWPOINT ARE SHOWN FOR 6 POINTS ALONG A 14-MILE DESERT — OASIS TRANSECT. NOTE THE 20-DEGREE DIFFERENCE IN DEWPOINTS FROM THE DESERT TO THE ORANGE GROVES WITHIN A DISTANCE OF SLIGHTLY MORE THAN 2 MILES.

ANOTHER INTERESTING CONDITION IS THAT THE MAXIMUM RANGE IN DEWPOINTS, 10 DEGREES, AMONG STATIONS WITHIN THE OASIS, WAS AS GREAT AS THE DIFFERENCE BETWEEN 3 OF THE OASIS STATIONS AND THE DESERT SITE. IT IS NOT KNOWN WHETHER THIS WAS DUE TO DIFFERENCES IN AVAILABLE SURFACE MOISTURE OR SOME OTHER FACTOR. THE EXPLANATION MIGHT BE RELATED TO THE FACT THAT AT THE 3 OASIS SITES (C, D, AND E) WITH LOWEST MEAN DEWPOINTS, THE DEWPOINT FLUCTUATED MORE DURING THE OBSERVATION PERIOD (6.7-, 7.0-, AND

3.7-DEGREE RANGES) THAN AT THE TWO SITES (E AND F) WITH HIGHER MEAN DEWPOINTS (1.7- AND 3.1-DEGREE RANGES RESPECTIVELY). ASSUMING SLIGHTLY GREATER MOVEMENT OF AIR AT C, D, AND E, THERE WOULD HAVE BEEN GREATER DISPERSAL OF MOISTURE BOTH VERTICALLY AND HORIZONTALLY AND THUS LESS OPPORTUNITY FOR HIGH DEWPOINTS TO FORM. THE RELATIVE INSENSITIVITY OF THE WIND EQUIPMENT MAKES IT DIFFICULT TO ASCERTAIN WHETHER DIFFERENCES IN AIRFLOW DID EXIST BETWEEN THE STATIONS. THE SAME CONDITION COULD EXPLAIN THE FLUCTUATION OF DEWPOINTS WITH TIME SINCE WITH STRONG RADIATIONAL COOLING AND NEARLY CALM WINDS, AIR DRAINAGE OCCURS IN SURGES RATHER THAN AS SMOOTH, STEADY FLOW, THUS PERMITTING THE MODERATE ENRICHMENT OF A MASS OF AIR AND ITS REPLACEMENT BY DRIER AIR WHICH IS ENRICHED IN TURN. ON THE OTHER HAND, HIGH DEGREE OF STAGNATION OF SURFACE AIR, SUCH AS MIGHT OCCUR IN THE ORANGE GROVES, WOULD PRODUCE MAXIMUM DEWPOINTS AND VERY SLIGHT VARIATION IN DEWPOINT WITH TIME.

(3) MESA-VALLEY RUNNING TRAVERSE

ON 3 JULY, A RUNNING SOUTH-TO-NORTH TRAVERSE WAS MADE ALONG THE ROUTE JUST DESCRIBED, BETWEEN 0315 AND 0450. A 1/4-TON TRUCK WAS USED FOR TRANSPORTATION. FROM POINT A IN THE SOUTH YUMA DESERT, OBSERVATIONS WERE TAKEN EACH TENTH OF A MILE FOR THE FIRST MILE (UNTIL THE IRRIGATION AREA WAS REACHED) AND EVERY HALF MILE THEREAFTER. USE OF THE ELECTRICALLY-VENTILATED PSYCHROMETER PERMITTED RAPID OBSERVATIONS, THEREBY REDUCING TIME AS A FACTOR IN DIFFERENCES ALONG THE ROUTE.* DURING THE 95 MINUTES REQUIRED TO COMPLETE THE RUN, THE DEWPOINT ROSE APPROXIMATELY 1 DEGREE AT THE YUMA WEATHER BUREAU STATION AND NO MORE THAN 1 TO 2 DEGREES AT THE OGRAM FARM AND EXPERIMENTAL FARM SUBSTATIONS; THEREFORE, IT IS BELIEVED THAT CHANGES DURING THE 95 MINUTES DUE TO THE NORMAL SWING OF THE DIURNAL CURVE OF DEWPOINT CAN BE IGNORED. AS IN THE NON-RUNNING TRANSECT JUST DESCRIBED, YUMA WAS DOMINATED BY A COOL AND EXTREMELY DRY AIRMASS, WIND WAS CALM TO 1 TO 2 MPH, AND CONDITIONS WERE IDEAL FOR DEVELOPMENT OF MAXIMUM AREAL DIFFERENCES IN MOISTURE CONTENT OF THE AIR.

DEWPOINT AND TEMPERATURE DATA FOR THIS TRAVERSE, SHOWN GRAPHICALLY IN FIGURE 12, PRESENT ESSENTIALLY THE SAME PICTURE AS FIGURE 11: A DEWPOINT MINIMUM OF 33° AT THE DESERT END OF THE ROUTE, A RAPID INCREASE TO 55° IN THE ORANGE GROVES NEAR THE SOUTHERN EDGE OF THE OASIS, THEN NORTHWARD ACROSS THE REMAINDER OF THE OASIS A FLUCTUATION BETWEEN APPROXIMATELY

*SAPOZHNIKOVA (11) REPORTS THAT FOR MICROCLIMATIC STUDIES BY QUICK, NON-SYNOPTIC SURVEYS, SUCH AS IS DESCRIBED HERE, OBSERVATIONS TAKEN 1 TO 2 HOURS BEFORE SUNRISE ARE REPRESENTATIVE. THIS IS A TIME WHEN LOCAL CHANGES ARE SLOW, SO THAT SEVERAL MILES CAN BE TRAVERSED WITHOUT APPRECIABLE LOSS OF COMPARABILITY.

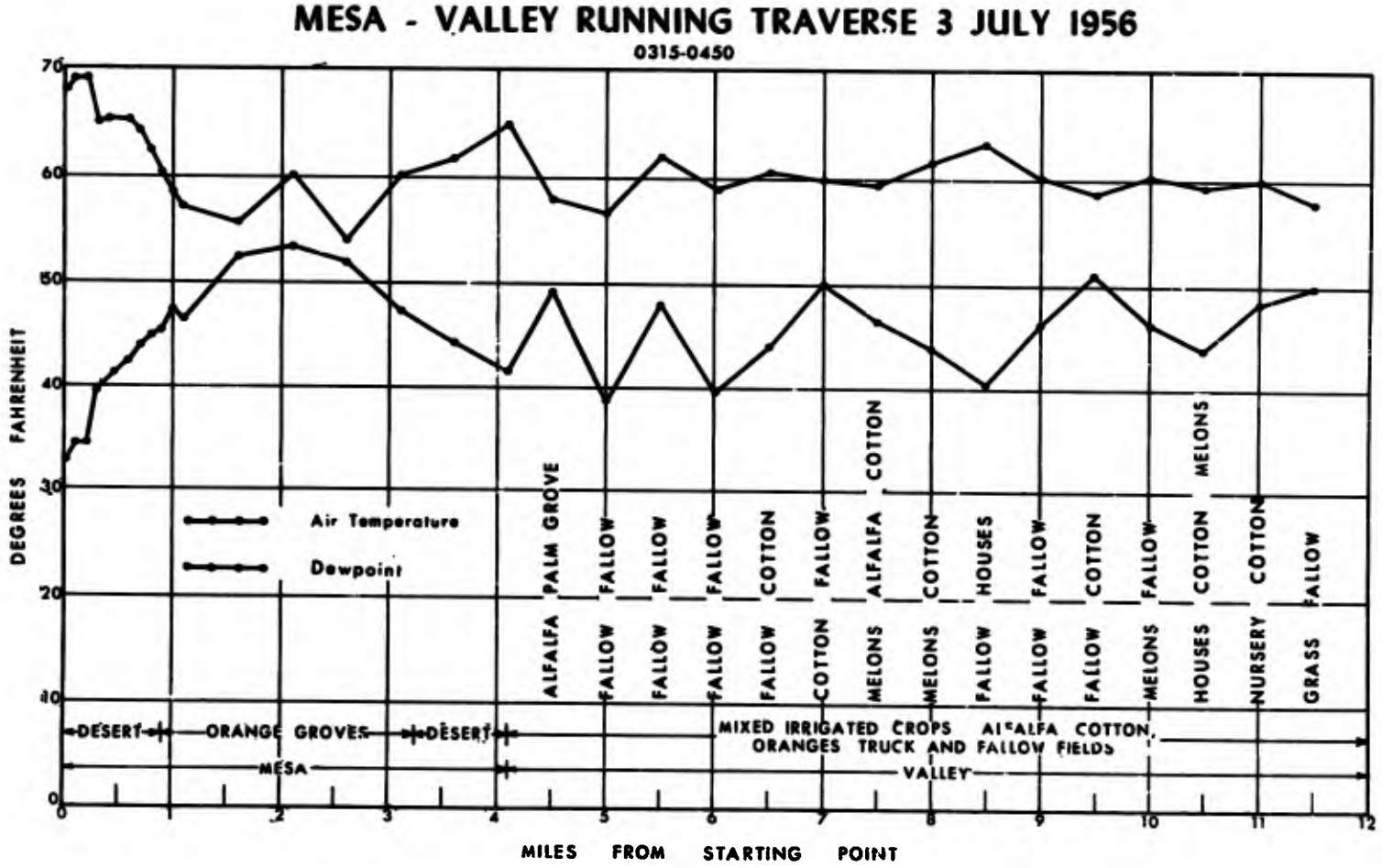


FIGURE 12. OBSERVATIONS OF TEMPERATURE AND DEWPOINT ARE SHOWN FOR AN 11.5-MILE DESERT — OASIS TRAVERSE. TEMPERATURE DECREASES AND DEWPOINT INCREASES FROM THE DESERT INTO THE OASIS, THEN BOTH FLUCTUATE WIDELY WITHIN THE OASIS.

40° AND 50°.* NORTH WINDS 1 TO 2 MPH IN THE DESERT CREATED IDEAL CONDITIONS FOR ADVECTION OF MOISTURE FROM THE OASIS TO THE DESERT. THAT ADVECTION OCCURRED TO SOME DEGREE FOR A FEW TENTHS OF A MILE IS INDICATED BY THE ASYMPTOTIC SHAPE OF THE DEWPOINT CURVE BETWEEN POINTS 0.5 AND 2.0. SINCE THE TREND OF THE CURVE IS SHARPLY UPWARD (AN INCREASE OF 1.6 DEGREES) FROM THE FIRST TO THE SECOND POINT OF THE TRAVERSE, IT IS POSSIBLE HORIZONTAL TRANSPORT OCCURRED EVEN FARTHER THAN THE 0.9 MILE FROM THE EDGE OF THE OASIS TO THE START OF THE TRAVERSE.

WITHIN THE OASIS IT IS DIFFICULT TO ESTABLISH A CLEAR RELATIONSHIP BETWEEN CROP TYPE OR SURFACE CONDITION AND DEWPOINT. HIGHEST VALUES OCCURRED IN THE ORANGE GROVES, AS ON THE TRANSECT OF THE PRECEDING NIGHT, BUT OTHERWISE THERE WAS NO REAL EVIDENCE OF CONTROL OF DEWPOINT BY GROUND CONDITION DESPITE DEWPOINT VARIATIONS OF OVER 11 DEGREES WITHIN A HALF MILE. IN PARTICULAR, THE SERRATE CURVE FROM 4 MILES NORTHWARD HAS NO CLEAR DEPENDENCE ON GROUND COVER.

IT IS BELIEVED, NEVERTHELESS, THAT THE BASIC CAUSE FOR VARIATION IN DEWPOINT FROM PLACE TO PLACE WITHIN THE OASIS IS RELATED TO THE NATURE OF THE GROUND SURFACE. AIR ABOVE HEAVY CROPS, ESPECIALLY THOSE RECENTLY IRRIGATED, DEFINITELY RECEIVES LARGER QUANTITIES OF WATER VAPOR FROM THE UNDERLYING SURFACE THAN FALLOW AREAS WITH MEAGER OR NO PLANT COVER (SEE SECTION 3E). WITH CALM OR NEARLY CALM WINDS AND A STABLE AIRMASS TO DAMPEN VERTICAL TRANSPORT, THE AIR WITHIN AND JUST ABOVE CERTAIN CROPS COULD BE ENRICHED TO A HIGH DEGREE.

HOWEVER, AIR SELDOM STAGNATES COMPLETELY EVEN UNDER STRONG NOCTURNAL COOLING, PARTICULARLY IF THERE EXISTS A SLOPE IN TERRAIN, HOWEVER SLIGHT, AND WEAK HORIZONTAL CURRENTS WILL REMOVE AIR BEFORE ITS MOISTURE SUPPLY CAN BE RAISED TO A HIGH LEVEL. MOTION OF THIS TYPE IS IRREGULAR, THUS PRODUCING MINOR MASSES OF AIR WITH CONTRAST IN WATER-VAPOR CONTENT WHICH MOVE SLOWLY OVER THE SURFACE. POOLING OF AIR IN AREAS OF CONCAVE TERRAIN ALSO WILL PRODUCE UNEQUAL DEWPOINTS WITHOUT REGARD TO AVAILABLE SURFACE MOISTURE. LAND SURFACE WHICH APPEARS FLAT TO THE EYE OFTEN HAS SLIGHT DEPRESSIONS WHICH WILL RECEIVE CONCENTRATIONS OF COOLER AND DENSER AIR WHICH, SINCE IT FLOWS OVER THE GROUND IN THE LOWEST LEVELS, WILL ALSO HAVE A HIGH MOISTURE CONTENT. SUBSIDENCE OF DRIER AIR FROM ALOFT COULD BE ANOTHER CONTRIBUTING FACTOR.**

*THE VARIATIONS IN TEMPERATURE AND DEWPOINT ALONG THE TRAVERSE WERE GROSS ENOUGH TO BE FELT BY THE OBSERVERS RIDING IN THE TRUCK. IT IS A COMMON EXPERIENCE WHEN RIDING ACROSS SUCH AN AREA ON CALM CLEAR NIGHTS TO NOTICE ABRUPT CONTRASTS IN TEMPERATURE AND HUMIDITY OF THE AIR. OF COURSE, IT IS A CHANGE IN RELATIVE HUMIDITY THAT IS SENSED; AN INCREASED FEELING OF DAMPNESS IN THE AIR DOES NOT NECESSARILY REPRESENT AN INCREASE IN ACTUAL WATER-VAPOR CONTENT.

**IF THE OBSERVATIONS ALONG THIS TRAVERSE HAD BEEN MADE IN THE CENTER OF THE FIELDS INSTEAD OF IN THE ROAD, POSSIBLY GREATER CORRELATIONS WOULD HAVE BEEN FOUND BETWEEN SURFACE TYPE AND DEWPOINT. THE ROAD IS BOUND TO HAVE BEEN A ZONE OF MIXING BECAUSE OF ITS BOUNDARY LOCATION AND THE CONVECTIVE ACTIVITY PRODUCED BY THE HEAT REMAINING IN THE PAVEMENT.

D. Picacho Wash Transects

Two transects were made in the Picacho Wash area. Picacho Wash is a dry channel, with a flat bed .1 to .25 mile wide, that, along with other channels, provides drainage for the hill land northwest of the oasis. It has a gradient of about 25 feet to the mile, consequently providing a favorable avenue for air drainage at night from the hills into the valley lands of the Colorado River.

(1) Synoptic transect of 25 June

On 25 June, during a period of low general humidity in the Yuma area, four men made psychrometric observations at intervals along a southeast-northwest line from 1 mile inside the northerwestern edge of the irrigated lands to .25 mile up the channel of the wash. The results are presented in Table VII.

TABLE VII

Picacho Wash Synoptic Transect
(25 June 1956)

	1 Alfalfa Field			2 Edge Irrig. Area			3 Mouth of Wash			4 1/4 Mi. up Wash		
Time	Tem.	Dewpt.	Wind	Tem.	Dewpt.	Wind	Tem.	Dewpt.	Wind	Tem.	Dewpt.	Wind
0330	66.8	55.7	NE 1	69.8	52.4	C	77.4	46.5	NW 4	77.4	42.9	WNW 2
0400	65.8	55.6	SSW 2	66.9	56.4	C	77.2	47.3	NW 4	75.7	41.8	W 2

Wind movement at the two wash stations was down the wash 2 to 4 mph. Thus air at Station 4, .25 mile up the wash, was in all likelihood representative of air flowing off the hills to the northwest. The dewpoints at this site were 42° and 43° in contrast to values of nearly 56° for the alfalfa field. With wind blowing down the wash into the valley, it might be supposed that dewpoints within the valley near the mouth of the wash would be lowered by the admixture of dry air, but it seems that any such influence was weak and not widespread. The observations at the edge of the irrigated area were closer to alfalfa field values than to those in the wash and in one case slightly higher than the alfalfa field value.

The calm at the edge of the irrigated area is also evidence of non-advection of drier air to this distance (.5 mile) from the mouth of the wash. Air temperatures at the wash sites were 8 to 10 degrees higher

THAN AT THE OTHER TWO SITES, HENCE THE COOL VALLEY AIR WAS PROBABLY OVERRIDEN BY WARMER AND LIGHTER AIR* MOVING DOWN THE WASH, THEREFORE ELIMINATING ANY CHANCE OF MIXING AT THE SURFACE. GRAVITY WINDS** ARE NOTED FOR THEIR RAPID LOSS OF ENERGY UPON MEETING AN OBJECT, WHETHER OROGRAPHIC OR AERODYNAMIC, AND THE AIR COMING DOWN THE WASH, ESPECIALLY SINCE THE FLOW WAS WEAK, WOULD NOT HAVE HAD THE ABILITY TO PUSH FAR AGAINST THE DEAD WEIGHT OF THE COOLER AND SLIGHTLY DENSER MASS OF AIR. DEWPOINTS AT THE MOUTH OF THE WASH WERE 3 TO 5 DEGREES HIGHER THAN .25 MILE UP THE WASH. THE AIR IN THE VALLEY, BEING DENSER THAN AIR IN THE WASH, FORCED ITS WAY A SHORT DISTANCE INTO THE WASH.

(2) Synoptic transect of 29 June

DURING THIS TRANSECT, THE YUMA AREA WAS OCCUPIED BY A HUMID AIRMASS. DEWPOINTS WERE NEAR THE HIGHEST REACHED DURING THE STUDY PERIOD, THUS MINIMUM DIFFERENCES BETWEEN THE DESERT AND OASIS WERE EXPECTED. VALUES WERE GENERALLY HIGHER IN THE OASIS THAN IN THE DESERT BUT THE DIFFERENCES WERE SLIGHT (3.9 DEGREES MAXIMUM), AS INDICATED IN FIGURE 13. IN THE EARLY OBSERVATIONS, TRANSPORT OF MOISTURE FROM THE OASIS BY THE SOUTHERLY WIND BLOWING AT THAT TIME COULD HAVE CAUSED THIS SMALL DIFFERENCE BUT NOT IN THE LATER OBSERVATIONS BECAUSE THE WIND HAD SHIFTED TO WEST AND WEST-NORTHWEST FROM OUT OF THE HILLS.

E. Humidity distribution in individual crop types

OBSERVATIONS IN SELECTED CROP TYPES WERE TAKEN IN AN ATTEMPT TO CLARIFY HUMIDITY DISTRIBUTION WITHIN THE OASIS. FIELDS OF MATURE CROPS IRRIGATED PERIODICALLY AND SURROUNDED BY BARE OR FALLOW FIELDS WERE DESIRED. THE FIELDS USED BY THE DAYTIME STUDY WERE STILL SUITABLE, AND TO FACILITATE COMPARISONS BETWEEN THE TWO STUDIES THEY WERE USED.

(1) Alfalfa field

MEASUREMENTS WERE MADE ON 30 JUNE AND 3 JULY IN AND AROUND AN ALFALFA FIELD, 0.6 MILE IN LENGTH FROM NORTH TO SOUTH AND 0.25 MILE WIDE, LOCATED IN THE VALLEY NEAR THE NORTHWESTERN BOUNDARY OF THE OASIS.

---

*DENSITY OF THE AIR AT 0400 WAS 1.17 KG/M3 AT THE WASH END OF THE TRANSECT AND 1.19 KG/M3 AT THE OASIS END.

**IT IS BELIEVED THAT THE WIND MOVING DOWN THE WASH WAS A GRAVITY WIND EVEN THOUGH IT WAS WARMER THAN AIR IN THE VALLEY. THE IMPORTANT FACTOR IN ITS MOVEMENT DOWNHILL WOULD HAVE BEEN ITS TEMPERATURE RELATIVE TO AIR AT HIGHER LEVELS IN THE HILLS, NOT AIR IN THE VALLEY. A GENERAL WIND DIRECTION OF SOUTHEAST, OR DIRECTLY OPPOSITE TO THIS FLOW, IN THE YUMA AREA AT THIS TIME TENDS TO CONFIRM THIS CONCLUSION.

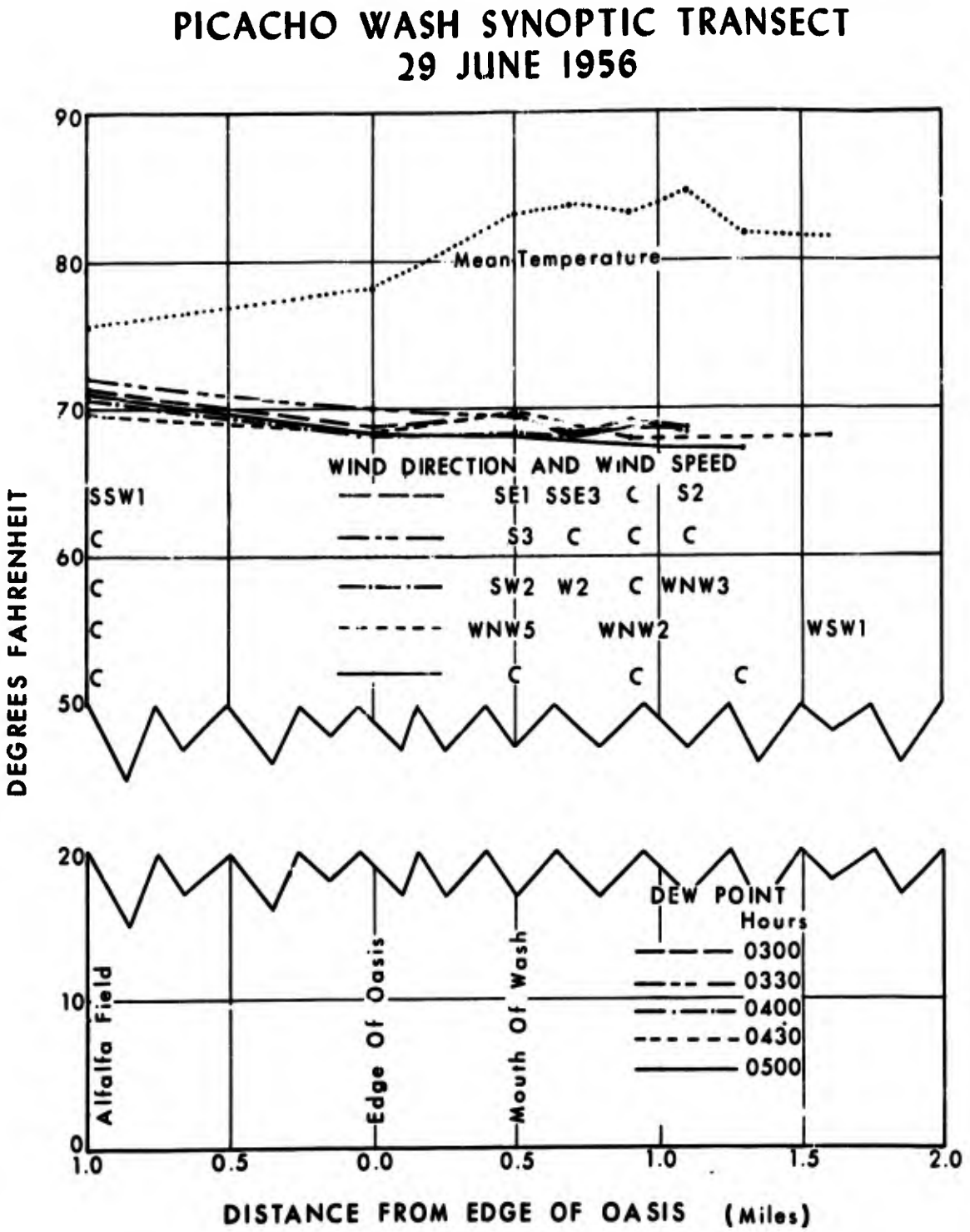


FIGURE 13. SIMULTANEOUS OBSERVATIONS OF TEMPERATURE, DEWPOINT, AND WIND FOR 8 POINTS ALONG A TRANSECT AT THE NORTHERN EDGE OF THE OASIS.

THE ALFALFA AVERAGED 12 TO 18 INCHES IN HEIGHT. TO NORTH AND SOUTH WERE CLEAN-CULTIVATED FIELDS COMPLETELY DEVOID OF VEGETATION; TO THE WEST WAS A LARGE DRY FIELD CONTAINING WITHERED CANTALOUPE PLANTS, REMAINS OF A CROP HARVESTED A WEEK OR TWO PREVIOUSLY; ON THE EAST WERE A SERIES OF SMALL FIELDS MOSTLY WITH DRY SURFACES CONTAINING ALFALFA, CANTALOUPE, FLAX, AND COTTON, AND AN AREA IN WHICH FARM BUILDINGS WERE LOCATED (SEE FIG. 14). ON BOTH NIGHTS A TRAVERSE BISECTING THE ALFALFA WAS MADE FROM THE DRY FIELD IN THE SOUTH TO THE DRY FIELD IN THE NORTH.

THE OBSERVATIONS OF 30 JUNE (TABLE VIII) WERE TAKEN DURING A PERIOD OF HIGH HUMIDITY WHICH WAS REFLECTED IN AN EXTREMELY SMALL DEWPOINT DIFFERENTIAL BETWEEN AIR OVER THE ALFALFA AND THE DRY FIELDS, EVEN THOUGH THE FORMER STILL CONTAINED AREAS OF STANDING WATER FROM IRRIGATION. THE GREATEST SPREAD IN DEWPOINT BETWEEN THE CONTRASTING AREAS WAS 2.8 DEGREES (BETWEEN A POINT IN THE DRY FIELD 240 FEET FROM THE SOUTHERN EDGE OF THE ALFALFA AND A POINT WELL WITHIN THE ALFALFA). IN THE NORTHERN DRY FIELD 200 FEET FROM THE EDGE OF THE ALFALFA THE GREATEST DISPARITY WAS 1.3 DEGREES, WHICH OCCURRED WITH A SOUTHEAST WIND OF 2 MPH. VIRTUALLY THE SAME DIFFERENCE (1.2 DEGREES) WAS OBSERVED BETWEEN THIS NORTHERN FIELD AND THE ALFALFA WHEN THE WIND WAS NORTH-NORTHWEST 2 MPH, BUT THERE WERE CULTIVATED FIELDS NORTH OF THIS DRY FIELD AND TRANSPORT FROM THESE UNDOUBTEDLY OCCURRED WITH A NORTH WIND.

A RUNNING TRAVERSE ON FOOT WITH OBSERVATIONS EVERY 75 FEET WAS MADE FROM SOUTH TO NORTH ON 3 JULY (FIG. 14). APPROXIMATELY ONE HOUR WAS REQUIRED TO COMPLETE THE RUN. IN CONTRAST TO THE PRECEDING TRAVERSE, LOW GENERAL HUMIDITY PREVAILED AT YUMA, CONSEQUENTLY THERE WAS GREATER CONTRAST BETWEEN IRRIGATED AND UNIRRIGATED FIELDS. DEWPOINTS INCREASED FROM 41° TO 42° IN THE BARE SOUTHERN FIELD TO 50° TO 51° IN THE CENTER OF THE ALFALFA AND DECREASED AGAIN TO THE NORTH, A RANGE VERY CLOSE TO THAT OF THE VALLEY PORTION OF THE HIGHWAY 95-AVENUE B RUNNING TRAVERSE AT THE SAME TIME ON THE SAME NIGHT. THE SAME WAS TRUE OF THE TEMPERATURE RANGE. THESE RESULTS INDICATE THAT DIFFERENCES IN THE NATURE OF THE SURFACE COVER ARE A MAJOR CAUSE OF HORIZONTAL VARIATION OF DEWPOINT WITHIN THE IRRIGATED DISTRICT.

THE GENERAL CONFIGURATION OF THE TEMPERATURE AND DEWPOINT CURVES FOR THIS TRAVERSE ARE SIMILAR TO THOSE OF THE DAYTIME STUDY FOR THE SAME FIELD. HOWEVER, THERE IS CONSIDERABLY LESS FLUCTUATION OF BOTH TEMPERATURE AND DEWPOINT ALONG THE NIGHT TRAVERSE, A CONSEQUENCE NO DOUBT OF MORE STABLE NIGHTTIME AIR, AND THE AMPLITUDE OF THE INCREASE FROM BARE FIELD TO IRRIGATED ALFALFA IS LESS THAN THAT FOR THE DAYTIME CURVE.

(2) ORANGE GROVE

ON 5 JULY, TWO TRAVERSES, ONE EAST-WEST AND ONE NORTH-SOUTH, WERE RUN SIMULTANEOUSLY BETWEEN 0340 AND 0420 THROUGH AN ORANGE GROVE ON

TABLE VIII

ALFALFA FIELD SYNOPTIC TRANSECT

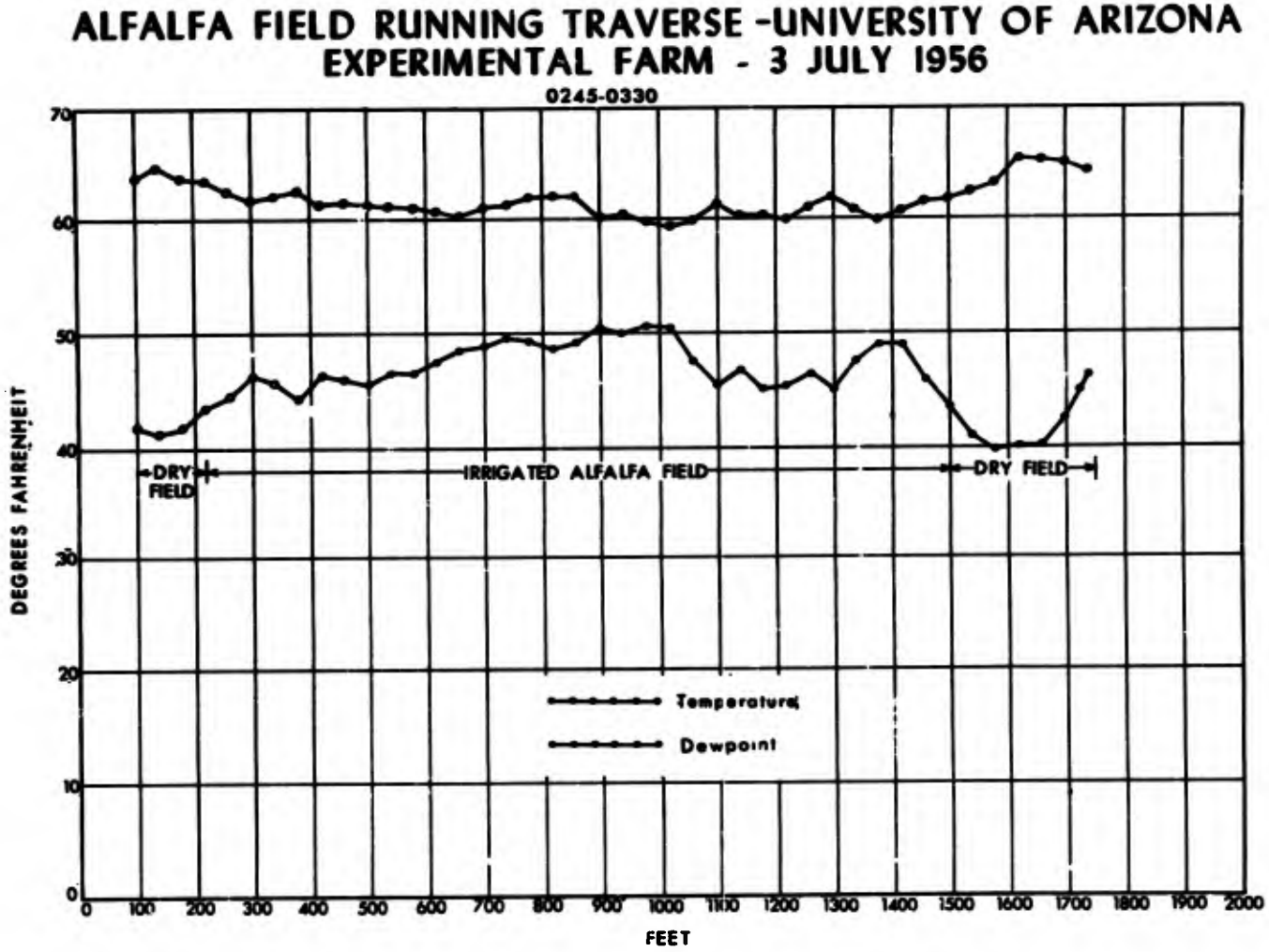
UNIVERSITY OF ARIZONA EXPERIMENTAL FARM
30 JUNE 1956

	South Dry Field														Alfalfa Field				North Dry Field	
	Distance From S. Edge of Alfalfa Field																		200' N. of N. Edge of Alfalfa Field	
Time	240'		180'		120'		90'		60'		30'		15'		Center		N. Edge			
	T.	D.P.	T.	D.P.	T.	D.P.	T.	D.P.	T.	D.P.	T.	D.P.	T.	D.P.	T.	D.P.	T.	D.P.	T.	D.P.
0340											76.1	69.7	76.7	69.8	76.0	69.6	76.5	69.4	76.9	68.4
0350									76.8	69.1	76.9	69.1			77.0	69.8	76.1	68.9	76.5	68.7
0400					77.8	66.8			78.0	68.0					76.8	68.5	77.8	67.2	75.6	68.4
0410			77.6	66.4			77.2	67.7							76.3	68.5	77.5	66.8	73.8	69.3
0420	78.9	65.8			77.9	66.2									76.8	68.6	77.8	66.4	77.6	67.3

THE MESA (FIG. 15). THE GROVE, WHICH MEASURED APPROXIMATELY 1200 FEET ON A SIDE, WAS BOUNDED ON THE SOUTH, WEST, AND NORTH BY LARGE DRY FIELDS NOT UNDER CULTIVATION, AND ON THE EAST BY A DATE GROVE AND ANOTHER GROVE OF ORANGES. THE GROUND IN THE GROVE WAS DAMP IN SPOTS FROM BEING IRRIGATED 2 DAYS PRIOR TO THE OBSERVATIONS. WIND WAS CALM THROUGHOUT THE PERIOD.

ALTHOUGH YUMA WAS STILL UNDER THE DRY SPELL OF 2 TO 6 JULY, DEWPOINT DIFFERENCES BETWEEN GROVE AND ADJOINING DRY FIELDS WERE NOT GREAT. A MINIMUM DEWPOINT OF 51.5° WAS RECORDED IN THE DRY FIELD AT A POINT 140 FEET FROM THE SOUTH EDGE OF THE GROVE COMPARED TO A MAXIMUM OF 60° WITHIN THE GROVE, BUT MOST MEASUREMENTS WITHIN THE TWO CONTRASTING AREAS WERE MUCH CLOSER. IN FACT, WITH THE EXCEPTION OF THE DRY FIELD TO THE SOUTH, IT IS NOT POSSIBLE BY INSPECTION OF THE DEWPOINT CURVES ALONE TO LOCATE THE EDGES OF THE GROVE. INTO THE NORTHERN DRY FIELD, DEWPOINT REMAINED VIRTUALLY UNCHANGED FROM THE RELATIVELY HIGH LEVELS OF THE GROVE; TO THE WEST, AFTER DROPPING 3 TO 4 DEGREES INITIALLY, DEWPOINT WAS NEARLY EQUAL TO VALUES IN THE GROVE.

COMPARISON OF TEMPERATURE AND DEWPOINT CURVES REVEALS THAT, THOUGH THERE WAS A SLIGHT DIFFERENCE IN DEWPOINT INSIDE AND OUTSIDE THE GROVE, RELATIVE HUMIDITY DIFFERED CONSIDERABLY. THIS WAS PARTICULARLY TRUE BETWEEN THE ORCHARD AND THE WESTERN DRY FIELD, WHERE DESPITE UNIFORMITY OF DEWPOINTS, INCREASED TEMPERATURE IN THE DRY FIELD PRODUCED RELATIVE HUMIDITIES OF 60 TO 65 PERCENT IN CONTRAST TO ALMOST 90 PERCENT IN THE GROVE ALONG BOTH TRAVERSES. AN INTERESTING CONDITION WAS THE UNUSUALLY UNIFORM TEMPERATURES AND DEWPOINTS WITHIN THE GROVE, PROBABLY THE RESULT OF SLOW EDDY DIFFUSION OF A SUFFICIENT ORDER TO PERMIT THOROUGH MIXING, WHILE THE HEAVY FOLIAGE PREVENTED INVASION OF THE GROVE BY AIR FROM THE OUTSIDE.



F 2URE 14. TEMPERATURE AND DEWPOINT IN AN IRRIGATED ALFALFA FIELD AND ADJOINING DRY FIELDS.

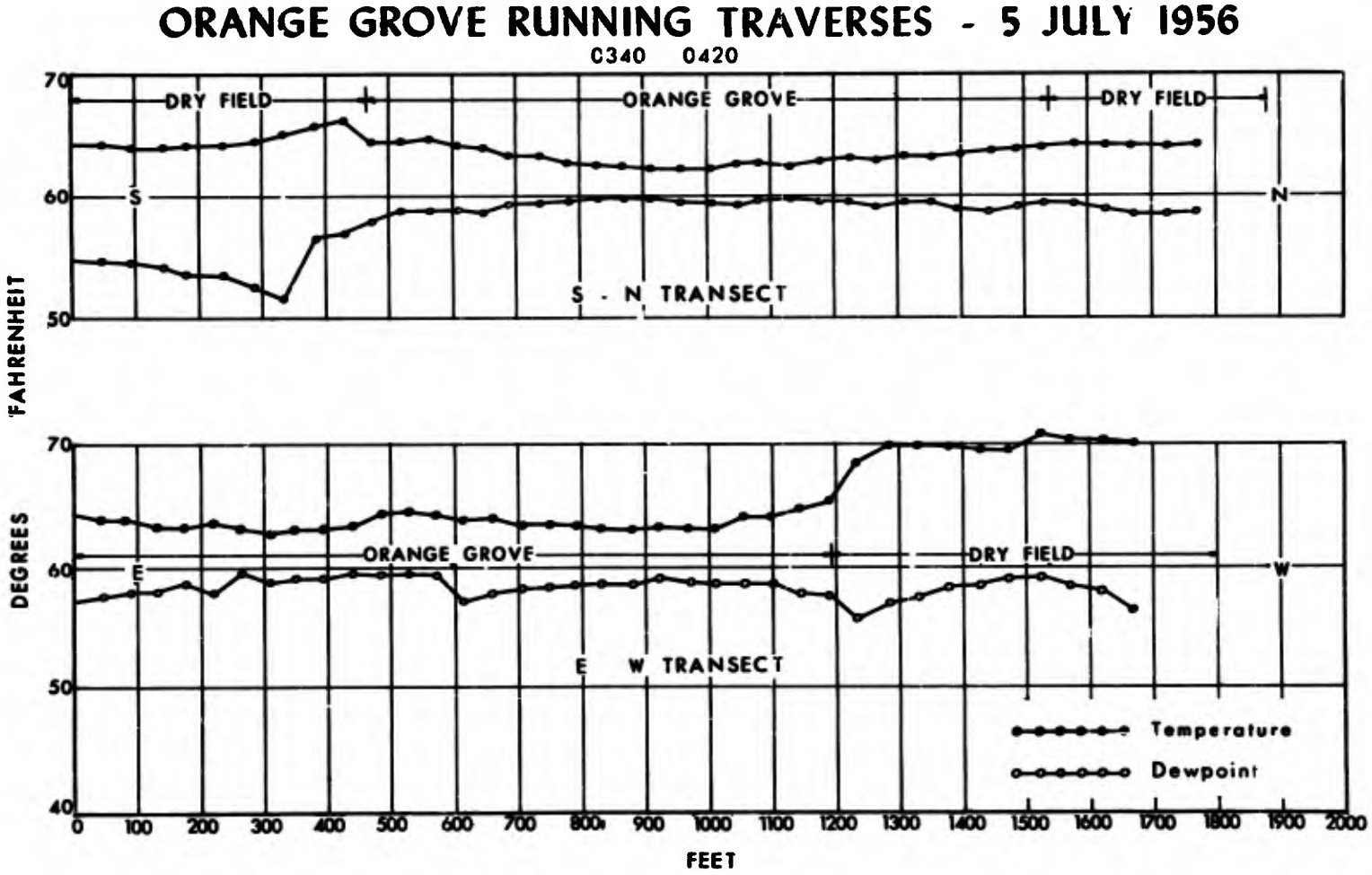


FIGURE 15. THE OBSERVATIONS OF TEMPERATURE AND DEWPOINT SHOWN HERE WERE MADE IN THE UNIVERSITY OF ARIZONA CITRUS FARM (SEE FIG. 3) LOCATED ON THE MESA.

F. Vertical Distribution of Humidity and Temperature

Vertical distribution of temperature and humidity was sampled in various crop types and in a bare field. Instrumentation to permit simultaneous readings at all levels was not available. Consequently a method of vertical traverses was employed. Using a stepladder, readings were taken at 1-foot intervals from the ground to 15 feet with the electric psychrometer which facilitated rapid sampling of the air at the desired level. Three runs were made in each field, with no more than 20 to 30 minutes elapsing before the beginning of the first and the completion of the last. The data are presented graphically in Figures 16 to 19.

Between the surface and 15 feet, dewpoints decreased 5 to 10 degrees and air temperatures increased 2 to 5 degrees. The latter is a smaller inversion of temperature than was expected and for practical purposes constitutes isothermal conditions. Surprisingly, the mean dewpoint lapse rate, 9.3 degrees, over the dry field was as large or larger than the lapse rate over the irrigated fields; only the alfalfa field lapse rates of 8 July were greater, having a mean value of 11.1 degrees and an extreme of 16.7 degrees for the 0310 observation.

Rates of change of temperature and dewpoint were usually fairly uniform, with no pronounced inversion or very steep lapses to indicate unusual concentration of cold or damp air at any particular level. The temperature curves almost without exception showed a regular increase of temperature from the surface to the 15-foot level. More refined instrumentation, such as the simultaneous use of thermocouples, might have shown more variation in the slope of the temperature curve, particularly in the lowest 6 feet. Dewpoint varied more than temperature from level to level but, with the exception of 2 or 3 of the curves, showed no sudden changes of large magnitude as is indicated by the mean values of lapse rate for successive 3-foot-thick layers over the various fields, presented in Table IX.

The steeper lapse rate below 9 feet and nearly isothermal conditions above this level for the cottonfield near Winterhaven, compared with isothermal conditions throughout the whole 15 feet in the Experimental Farm cottonfield, would seem to be the result of the wetter surface of the Winterhaven field. However, existence of a similar difference between the two runs in the Experimental Farm alfalfa field, where surface moisture was approximately the same on both occasions, indicates the difference was possibly a matter of normal variance within a statistical population.

Fluctuation with time of dewpoint and temperature at any one height varied considerably. Temperature seldom fluctuated more than 2 or 3 degrees at any one level from one observation to another and sometimes remained virtually constant. On the other hand, temperatures at the 5-foot level

ALFALFA FIELD - UNIVERSITY OF ARIZONA EXPERIMENTAL FARM 7 - 8 JULY 1956

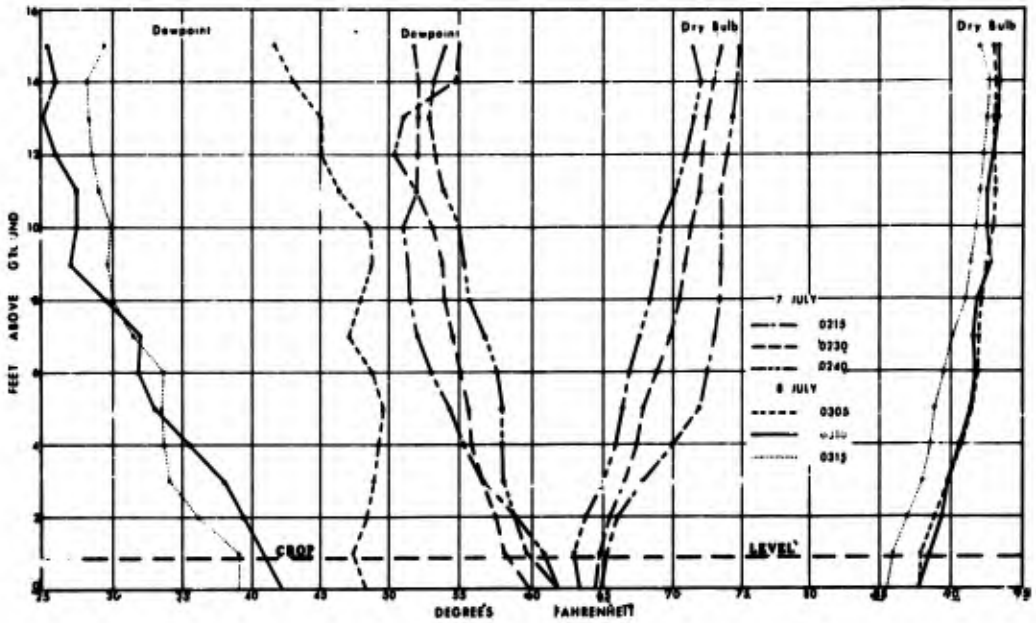


FIGURE 16. MEASUREMENTS OF TEMPERATURE AND DEWPOINT FROM THE SURFACE OF THE GROUND TO 15 FEET ABOVE THE GROUND IN AN IRRIGATED ALFALFA FIELD. NOTE THE EXTREMELY WARM, DRY AIR PRESENT OVER THE FIELD ON 8 JULY.

DRY FIELD - UNIVERSITY OF ARIZONA EXPERIMENTAL FARM 8 JULY 1956

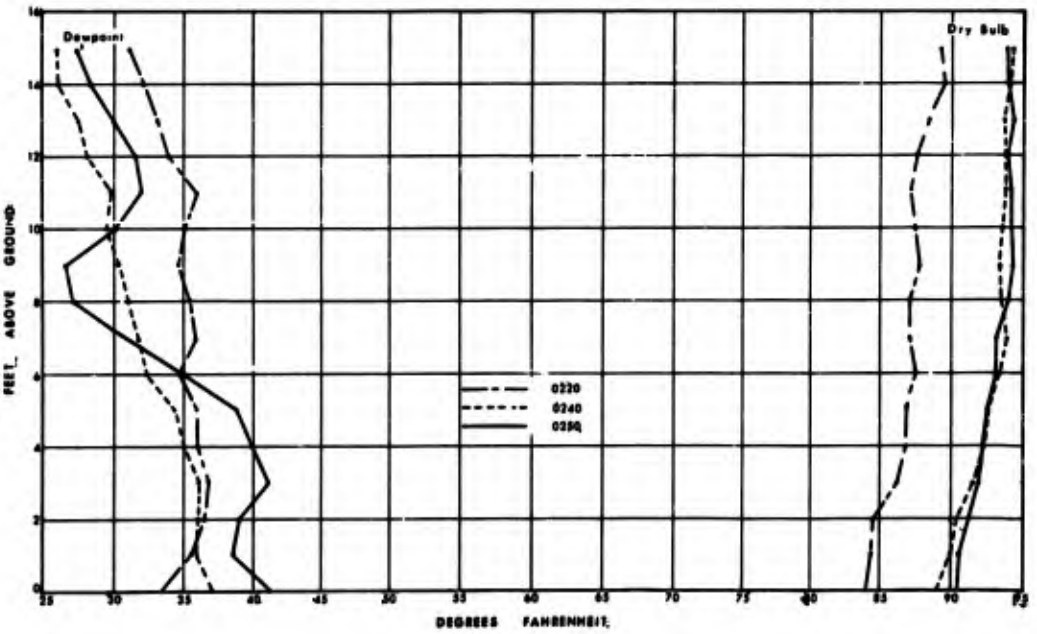


FIGURE 17. TEMPERATURE AND DEWPOINT OVER A DRY FIELD JUST NORTH OF THE ALFALFA OF FIGURE 16. THE CURVES FOR THE DRY FIELD ARE NEARLY IDENTICAL TO THOSE OVER THE ALFALFA FIELD ON THE NIGHT OF 8 JULY DESPITE THE GREAT CONTRAST IN MOISTURE CONTENT OF THE TWO FIELDS.

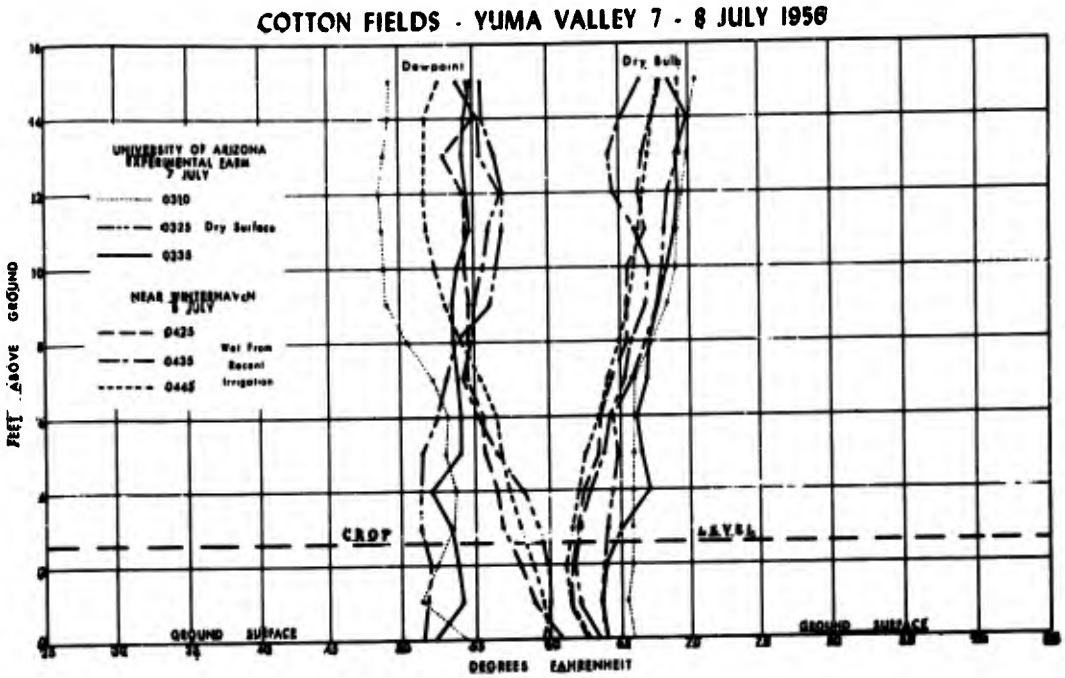


FIGURE 18. VERTICAL DISTRIBUTION OF TEMPERATURE AND DEWPOINT OVER IRRIGATED COTTON FIELDS IN THE VALLEY PORTION OF THE OASIS. HIGHER DEWPOINTS BELOW 6 FEET IN THE WINTERHAVEN FIELD SHOW THE INFLUENCE OF RECENT IRRIGATION.

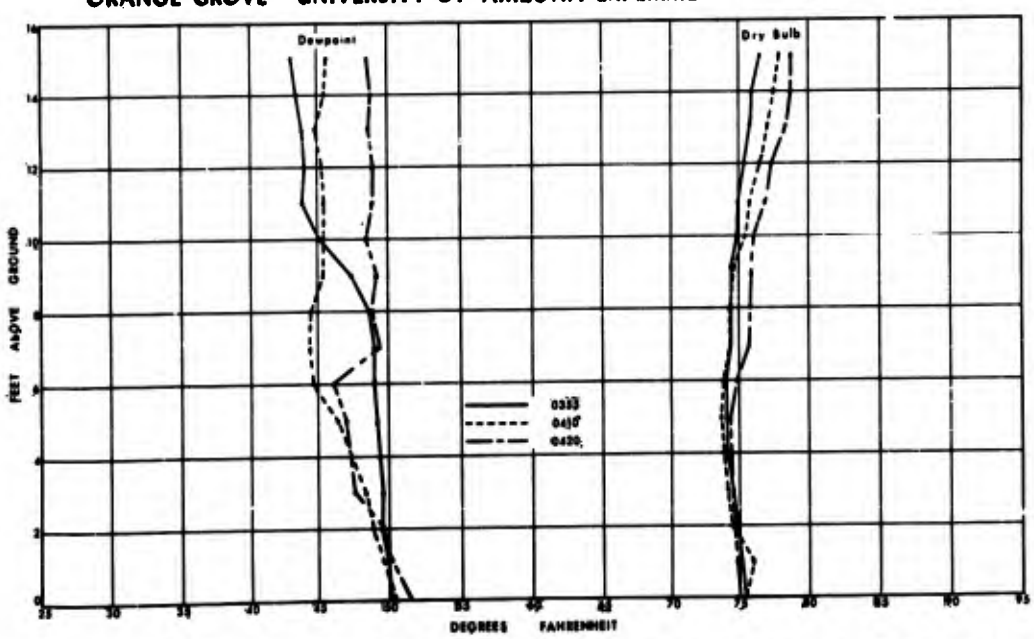


FIGURE 19. VERTICAL TEMPERATURE AND DEWPOINT DISTRIBUTION WITHIN AN ORANGE GROVE LOCATED ON THE MESA. ALL OBSERVATIONS ARE BELOW THE TOPS OF THE TREES WHICH ARE APPROXIMATELY 20 FEET ABOVE THE GROUND.

TABLE IX

DEWPOINT TEMPERATURE LAPSE RATE PER 3-FOOT INTERVAL

FEET	DRY FIELD	ALFALFA 7 JULY	ALFALFA 8 JULY	COTTON EXP. STA.	COTTON WINTER'N	GRAPE-FRUIT
12-15	-2.7	+1.7	-1.0	-0.1	-0.6	-0.3
9-12	+0.6	-1.6	-2.0	+0.4	-0.1	-1.3
6-9	-3.4	-1.8	-2.9	-0.3	-1.4	-0.8
3-6	-4.1	-1.8	-2.3	+0.5	-2.4	-2.0
0-3	-0.9	-4.4	-2.9	0.0	-2.0	-2.2

OVER THE ALFALFA FIELD ON 7 JULY DROPPED FROM 72.5° TO 66.5° IN 25 MINUTES. OVER THE DRY FIELD, TEMPERATURE INCREASED 5 TO 7 DEGREES AT ALL LEVELS BETWEEN 0220 AND 0240.* DEWPOINT FLUCTUATED MORE THAN TEMPERATURE OVER MOST FIELDS AND IN ONE OR TWO CASES SHOWED A TENDENCY TOWARD EXTREME VARIATION, AS OVER THE ALFALFA FIELD ON 8 JULY WHERE VALUES ALONG THE 0305 CURVE WERE 11 TO 20 DEGREES HIGHER THAN AT THE SAME LEVELS ON THE 0310 OR 0315 CURVES.

IN THE ALFALFA AND COTTON FIELDS, IT WAS NOT POSSIBLE TO DETECT ANY STRONG INFLUENCE BY THE CROP COVER ITSELF ON EITHER THE TEMPERATURE OR DEWPOINT CURVES. IN THE WINTERHAVEN COTTONFIELD, THERE WAS A SUGGESTION OF INCREASE IN BOTH DEWPOINT AND TEMPERATURE BENEATH THE TOPS OF THE PLANTS, AS OFTEN IS ENCOUNTERED IN SUCH SITUATIONS (6), BUT NO SUCH EVIDENCE WAS DETECTED IN THE ALFALFA FIELD NOR IN THE EXPERIMENTAL FARM COTTON FIELD.

G. MODIFICATION OF TEMPERATURE IN THE OASIS

NIGHTTIME TEMPERATURES WERE INVARIABLY LOWER IN THE OASIS THAN IN THE DESERT. MEAN DAILY MINIMUM TEMPERATURES FOR THE PERIOD OF THE STUDY WERE 70° AND 68° RESPECTIVELY AT THE OGRAM FARM AND EXPERIMENTAL FARM SUBSTATIONS AND 75° AND 79° AT SOUTH YUMA DESERT SUBSTATION AND YUMA TEST STATION. ON ONLY ONE OCCASION WAS A HIGHER MINIMUM TEMPERATURE OBSERVED IN THE OASIS THAN IN THE DESERT (70° AT THE EXPERIMENTAL FARM VS. 68° AT THE SOUTH YUMA DESERT ON 2 JULY). THESE DIFFERENCES ARE SIGNIFICANT BUT

*AN ERROR OF 5 DEGREES IN READING THE DRY BULB COULD EXPLAIN THESE DIFFERENCES.

COULD BE EXPLAINED BY TOPOGRAPHICAL INFLUENCES RATHER THAN DESERT VS. OASIS LOCATION WERE IT NOT THAT DATA FROM ALL TRANSECTS RUN FROM THE DESERT INTO THE OASIS REVEALED THE SAME RELATIONSHIP. IT IS CONCLUDED, THEREFORE, THAT DURING MAXIMUM NOCTURNAL COOLING THE OASIS BECOMES A COOL AIR SINK RELATIVE TO THE DESERT.

IN SEARCHING FOR AN EXPLANATION FOR THE LOWER OASIS TEMPERATURES, IT WAS THOUGHT THAT HIGH DAYTIME EVAPOTRANSPIRATION WITHIN THE OASIS WOULD PLAY A ROLE THROUGH RETARDATION OF MAXIMUM TEMPERATURES COMPARED TO THOSE IN THE DESERT, THEREBY GIVING THE OASIS A HEAD START IN NOCTURNAL COOLING. HOWEVER, MEAN DAILY MAXIMUM TEMPERATURES FOR THE STUDY PERIOD OF 103° AND 104° AT OGRAM FARM AND THE EXPERIMENTAL FARM AND 105° AT YUMA TEST STATION AND THE SOUTH YUMA DESERT ELIMINATE THIS AS A SIGNIFICANT FACTOR.

THOROUGH INVESTIGATION OF THIS PROBLEM WAS BEYOND THE SCOPE AND FACILITIES OF THE PRESENT STUDY; NEVERTHELESS, A TENTATIVE EXPLANATION IS OFFERED. DESERT AND OASIS RECEIVE APPROXIMATELY THE SAME AMOUNTS OF INCOMING SOLAR RADIATION (700 TO 850 GM CAL/CM^2/DAY FOR JUNE AND JULY ACCORDING TO OBSERVATIONS AT YUMA TEST STATION). ALBEDOS IN THE DESERT APPARENTLY AVERAGE HIGHER THAN IN THE OASIS* BUT SINCE THE DIFFERENCE IS NOT GREAT, BOTH AREAS RECEIVE AT THE SURFACE NEARLY THE SAME QUANTITY OF ENERGY. IN THE OASIS, A SIZEABLE PART OF THE RADIATION IS TRANSFORMED INTO LATENT ENERGY BY EVAPOTRANSPIRATION AND CARRIED ALOFT BY STRONG CONVECTIVE CURRENTS, AND THE HEAVY PLANT COVER SHADES THE GROUND AND PREVENTS ABSORPTION OF LARGE AMOUNTS OF HEAT IN THE SOIL (EXTREMELY SMALL AMOUNTS ARE ABSORBED BY THE PLANTS THEMSELVES). IN THE DESERT, LITTLE OF THE INCOMING ENERGY IS USED IN EVAPOTRANSPIRATION BUT LARGE QUANTITIES ARE ABSORBED INTO THE UNSHADED SOIL.** AT NIGHT THE RADIATION BALANCE IS REVERSED AND LOSS OF ENERGY TO SPACE OCCURS FROM THE GROUND AND AIR LAYERS NEAR THE GROUND, BUT THE RESERVOIR OF HEAT WITHIN THE DESERT SOIL RETARDS SOMEWHAT THE FALL OF TEMPERATURE IN AIR NEXT TO THE SURFACE. IN THE OASIS, THERE IS NO SUCH RESERVE SUPPLY OF HEAT, AND THE TEMPERATURE DROPS LARGELY UNIMPEDED.

WHATEVER THE PROCESS RESPONSIBLE FOR LOWER TEMPERATURES WITHIN THE OASIS, IT OPERATES STRONGLY ENOUGH TO OVERCOME ANOTHER CONDITION WHICH

---

*ALBEDO MEASUREMENTS TAKEN FROM A HELICOPTER IN THE SUMMER OF 1954 PRODUCED VALUES OF 15 TO 36 PERCENT FOR DESERT TERRAIN AND 16 TO 27 PERCENT FOR IRRIGATED CROPLAND.

**SOIL GRADIENT MEASUREMENTS AT THE YUMA TEST STATION AT 0200, 8 JULY 1956 SHOW A SURFACE TEMPERATURE OF 82° AND A TEMPERATURE AT 25 CM DEPTH OF 101°, THUS TESTIFYING TO THE LARGE QUANTITY OF HEAT ABSORBED INTO THE SOIL.

WOULD TEND TO PRODUCE THE OPPOSITE TEMPERATURE RELATIONSHIP. OTHER THINGS BEING EQUAL, DRY AIR PERMITS EXCESSIVE LOSS OF LONG-WAVE RADIATION AT NIGHT AND CONSEQUENTLY A LARGE DROP IN TEMPERATURE, WHEREAS HUMID AIR HAS A BLANKETING EFFECT AND INHIBITS RADIATION LOSS AND TEMPERATURE DROP. IF THIS WERE A MAJOR FACTOR IN THE YUMA AREA, ONE WOULD EXPECT A SMALLER DIFFERENCE IN MEAN MINIMUM TEMPERATURES BETWEEN DESERT AND OASIS IN DRY PERIODS THAN IN MOIST PERIODS. MOIST AIR IS PRESENT OVER THE OASIS AT ALL TIMES TO ACT AS A BLANKET, WHILE DURING DRY PERIODS, AIR IN THE DESERT IS VERY DRY COMPARED TO AIR IN THE OASIS, AND SINCE THE MINIMUM TEMPERATURE IN THE DESERT IS HIGHER IN ALL PERIODS IT SHOULD DROP CLOSER TO OASIS LEVELS DURING DRY WEATHER. HOWEVER, THE REVERSE HAPPENS. MEAN MINIMUM TEMPERATURES DURING THE DRY PERIODS OF 23 TO 26 JUNE AND 2 TO 7 JULY WERE 9.7 DEGREES HIGHER AT THE SOUTH YUMA DESERT AND YUMA TEST STATION SITES THAN AT OGRAM FARM AND THE EXPERIMENTAL FARM, AND ONLY 6.3 DEGREES HIGHER IN THE MOIST PERIODS OF 27 JUNE TO 1 JULY AND 8 TO 12 JULY. THE BLANKETING EFFECT APPARENTLY IS OVERCOME BY ENHANCED EVAPORATION IN THE OASIS IN DRY PERIODS.

FINALLY, BECAUSE OF THE LARGE TEMPERATURE AND HUMIDITY DIFFERENCES BETWEEN DESERT AND OASIS ENCOUNTERED IN THIS WORK AND IN THE EARLIER STUDY (9) OF DAYTIME CONDITIONS, DATA FROM DESERT WEATHER STATIONS, MANY OF WHICH ARE LOCATED IN THE MIDST OF OASES, SHOULD BE SUSPECTED OF BIAS TOWARD HUMID CONDITIONS. INDISCRIMINATE USE OF SUCH DATA TO PRESENT A PICTURE OF THE CLIMATE OF THE SURROUNDING DESERT IS APT TO LEAD TO ERRONEOUS CONCLUSIONS. AS HAS BEEN POINTED OUT BY ROSENAN (10), "...UNDER ARID CONDITIONS, REPRESENTATIVENESS OF A STATION FOR ITS SURROUNDINGS IS RATHER THE EXCEPTION THAN THE RULE."

4. SUMMARY

CONCLUSIONS DRAWN FROM THIS STUDY PERTAIN ONLY TO NIGHTTIME CONDITIONS AND PARTICULARLY TO THAT PORTION OF THE NIGHT BETWEEN 2400 AND 0600. IN ADDITION, OBSERVATIONS WERE CONDUCTED DURING A BRIEF PERIOD OF THE YEAR WHEN MAXIMUM DIFFERENCES BETWEEN OASIS AND DESERT COULD BE EXPECTED.

VIRTUALLY ALL EVIDENCE INDICATES THAT EVAPORATION AND POSSIBLY SOME TRANSPIRATION PRODUCED A SIGNIFICANT INCREASE IN THE MOISTURE CONTENT OF AIR AT STANDARD LEVELS WITHIN THE YUMA OASIS COMPARED WITH AIR AT THE SAME HEIGHT OVER THE OPEN DESERT. THIS INCREASE WAS LARGER DURING PERIODS OF DRY AIRMASS THAN DURING HUMID AIRMASS CONTROL. AN AVERAGE DEWPOINT DIFFERENCE OF 15 TO 25 DEGREES EXISTED DURING THE FORMER, AND 5 TO 10 DEGREES IN THE LATTER PERIOD. DUE TO THE EVER-PRESENT SOURCE OF MOISTURE, DEWPOINTS IN THE OASIS REMAINED MODERATELY HIGH AT ALL TIMES; IN THE DESERT THEY FLUCTUATED WITH CHANGING AIRMASSES.

AREAL VARIATIONS IN MOISTURE CONTENT OF THE AIR ALSO WERE FOUND WITHIN THE OASIS. OBSERVATIONS IN AND AROUND AN IRRIGATED ALFALFA FIELD SURROUNDED BY BARE, UNIRRIGATED FIELDS, SUGGEST THAT THESE VARIATIONS WERE

RELATED TO LAND USE. HOWEVER, TRAVERSES OF LARGE SECTIONS OF THE OASIS FAILED TO REVEAL SYSTEMATIC CONNECTION BETWEEN DEWPOINT AND THE NATURE OF THE LAND SURFACE OR CROP COVER (WITH THE EXCEPTION OF AN AREA OF ORANGE GROVES IN WHICH DEWPOINTS PERSISTENTLY RANGED HIGHER THAN ELSEWHERE). FAILURE TO FIND SUCH A RELATIONSHIP THROUGHOUT THE OASIS WAS LIKELY PARTLY DUE TO THE OBSERVATIONAL TECHNIQUE AND THE LIMITED NUMBER OF TRAVERSES. WITHIN THE OASIS, IT ALSO MAY HAVE BEEN RELATED TO SLOW HORIZONTAL MOVEMENT OF AIR WHICH TRANSPORTS BODIES OF MOIST AIR AND DRY AIR AWAY FROM FIELDS OVER WHICH THEY FORM. "POOLING" OF COOL, MOIST AIR IN LOW AREAS, AND SUBSIDENCE OF DRY AIR FROM ALOFT ALSO MAY HAVE BEEN FACTORS.

IT IS NOT POSSIBLE TO STATE THE DISTANCE OF ADVECTION OF MOISTURE FROM THE OASIS INTO THE DESERT. HOWEVER, RAPID DECREASE OF DEWPOINT WITHIN LITTLE MORE THAN A MILE FROM THE OASIS EDGE TO WHAT APPEAR TO HAVE BEEN REGIONAL AIRMASS LEVELS SIGNIFIES ADVECTION WAS MINOR. THE FACT THAT OVER A SHORT TIMESPAN, DEWPOINT VARIED LESS AT LOCATIONS OUTSIDE THE OASIS THAN AT GIVEN LOCATIONS WITHIN, IS EVIDENCE OF LACK OF ADVECTION INTO THE DESERT. DEWPOINTS AT YUMA TEST STATION COMPARED CLOSELY TO THOSE AT DESERT SITES; CONSEQUENTLY, THE CLIMATE OF THE STATION IS NOT BELIEVED TO BE SIGNIFICANTLY INFLUENCED BY MOISTURE FROM THE OASIS. THE POSSIBILITY OF OCCASIONAL ADVECTION OF HUMID AIR INTO THE TEST STATION AREA FROM WET LAND IN THE SILT-FILLED LAGUNA DAM RESERVOIR AND THE PRESENT RESERVOIR OF IMPERIAL DAM CANNOT BE COMPLETELY ELIMINATED.

5. ACKNOWLEDGEMENTS

THE AUTHORS ARE GRATEFUL TO A NUMBER OF INDIVIDUALS WHO HELPED WITH THE PREPARATION OF THE REPORT. FIRST LT. JAMES GANT, COMMANDING OFFICER, SIGNAL CORPS METEOROLOGICAL TEAM, YUMA TEST STATION, AND SEVERAL OF HIS MEN ASSISTED WITH THE FIELD OBSERVATIONS. MR. GEORGE OGRAM PERMITTED THE USE OF HIS FARMLAND, AND MR. FRANK PRITCHARD, MANAGER OF THE UNIVERSITY OF ARIZONA EXPERIMENTAL FARM, ALLOWED FREE ACCESS TO UNIVERSITY FARMLAND. DR. DAVID H. MILLER, DR. WALTER F. WOOD, AND MR. HOWARD L. OHMAN REVIEWED THE MANUSCRIPT AND HAD MANY HELPFUL SUGGESTIONS. DRAFTING OF THE MAPS AND CHARTS WAS DONE BY MR. AUBREY GREENWALD AND MR. ROLAND FRODIGH.

6. REFERENCES

1. ALISSOW, B. P., O. A. DROSDOW AND E. S. RUBINSTEIN. LEHRBUCH DER KLIMATOLOGIE (HANDBOOK OF CLIMATOLOGY). VEB DEUTSCHER VERLAG DER WISSENSCHAFTEN, BERLIN. (GERMAN TRANSLATION OF A BOOK ORIGINALLY PUBLISHED IN THE SOVIET UNION.) 1956.

2. ARKHIPOVA, E. P. AND M. [illegible]A. GLEBOVA. NEKOTORYE DANNYE O KLIMATE OROSHAEMOGO POLIA (SOME DATA ON THE CLIMATE OF AN IRRIGATED FIELD). METEOROLOGIIA I GIDROLOGIIA, MOSCOW 6:8-11, 1952.

3. Bryson, Reid A. and William P. Lowry. Synoptic Climatology of the Arizona Summer Monsoon, Scientific Report No. 1, Dept. of Meteorology, Univ. of Wisconsin, Madison, 1955.

4. -----. Synoptic climatology of the Arizona Summer precipitation singularity. Bul. Am. Meteorological Soc., 36(7):329-339 (Sep. 1955).

5. Env. Prot. Br., Res. & Dev. Div., Office of The Quartermaster General, Report 200, Handbook of Yuma Environment. Washington, D. C., Feb. 1953.

6. Geiger, Rudolf. The Climate Near the Ground. Harvard Univ. Press, Cambridge, Mass., 1950.

7. Haurwitz, Bernhard and James M. Austin. Climatology. McGraw-Hill, New York, 1944.

8. Liakhov, M. E. Mikroklimaticheskie nabliudeniia v raione Chernoso ĭara Astrakhanskoĭ Oblasti (Microclimatic observations in the District of Chernyi ĭar, Astrakhan Region). Akademiia Nauk SSSR, Institut Geografii (and) Institut Lesa, p. 86-93, Moscow, 1953.

9. Ohman, Howard L. and Richard L. Pratt. The Daytime Influence of Irrigation Upon Desert Humidities, Tech. Report EP-35, Env. Prot. Res. Div., QM R&E Center, Natick, Mass., May 1956.

10. Rosenan, N. Special problems in arid zone climatology. Paper presented at Second Session of the Commission for Climatology, World Meteorological Organization, Washington, D. C., 14-17 Jan. 1957.

11. Sapozhnikova, S. A. Mikroklimat i Mestnyiy Klimat (Microclimate and Local Climate). Gidromet. Izdat., Leningrad, 1950.

12. Thornthwaite, C. W. Introduction to arid zone climatology. Paper presented before the Australia — UNESCO Symposium on Arid Zone Climatology, Canberra, Australia, Oct. 1956.

13. U. S. Weather Bureau. Local Climatological Data, Yuma, Arizona, 1956, 1957.

UNCLASSIFIED