

**U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT**

**PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD**

**SUBJECT: CHARACTERIZATION OF
METEOROLOGY**

PRESENTER: DR. ALAN FLINT

**PRESENTER'S TITLE
AND ORGANIZATION: HYDROLOGIST
U.S. GEOLOGICAL SURVEY
MERCURY, NEVADA**

**PRESENTER'S
TELEPHONE NUMBER: (702) 295-5805**

**REGISTRY HOTEL, DENVER, COLORADO
JUNE 25-27, 1991**

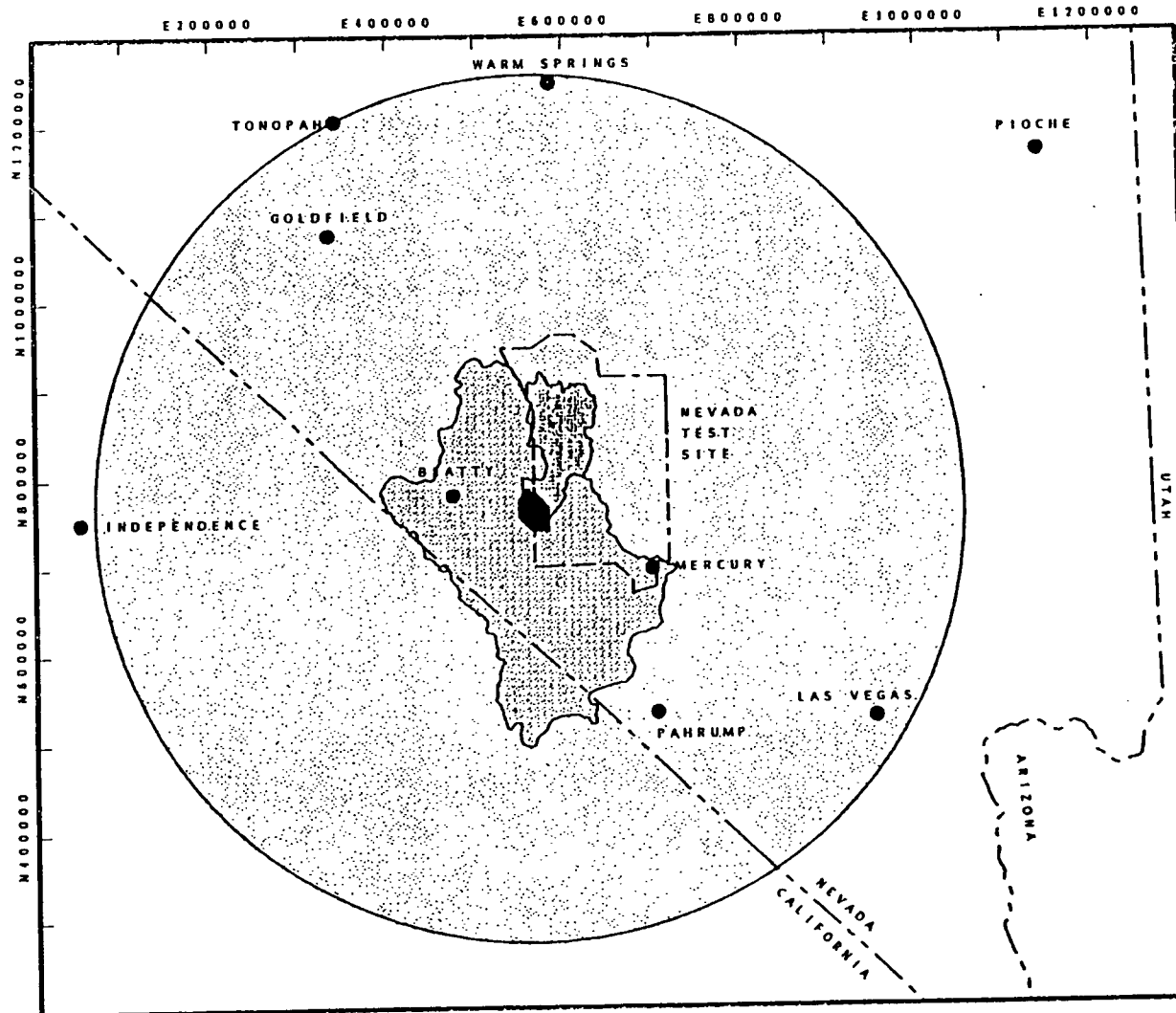
OBJECTIVE

- o TO CHARACTERIZE THE METEOROLOGICAL CONDITIONS SURROUNDING YUCCA MOUNTAIN WITH PARTICULAR EMPHASIS ON PRECIPITATION**





OUTLINE

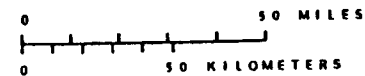
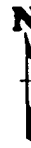
- **STUDY AREA**
- **CURRENT UNDERSTANDING**
- **DATA COLLECTION**
- **PAST/FUTURE CONDITIONS (SIMULATIONS)**

4 STUDY AREAS FOR REGIONAL METEOROLOGY



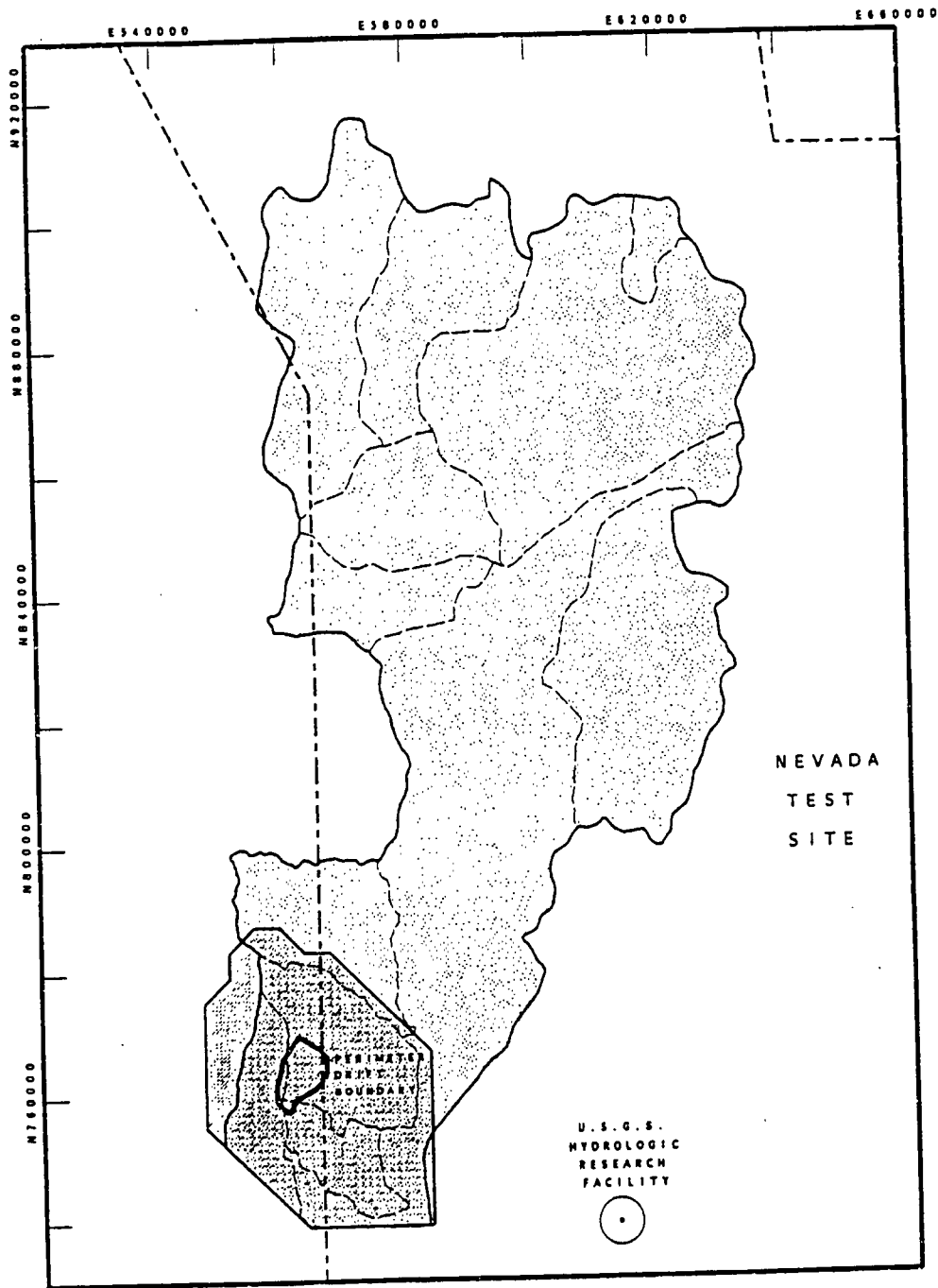
EXPLANATION

-  Study Area 1
-  Study Area 2, Fortymile Canyon Watershed
-  Study Area 3, Upper Amargosa River Watershed
-  Study Area 4, 150 km Radius



Nevada State Plane Coordinate
System, Central Zone

STUDY AREAS 1 AND 2



EXPLANATION

-  Study Area 1
-  Study Area 2, Fortymile Canyon Watershed



Nevada State Plane Coordinate
System, Central Zone

OUTLINE

- o **STUDY AREA**
- **CURRENT UNDERSTANDING**
- o **DATA COLLECTION**
- o **PAST/FUTURE CONDITIONS (SIMULATIONS)**





CURRENT UNDERSTANDING

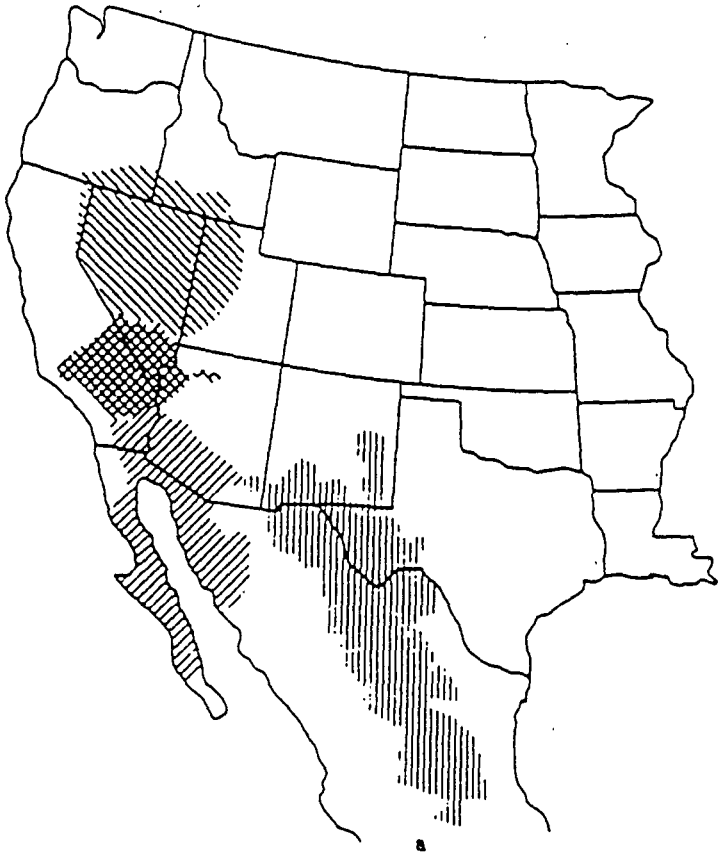
- o YUCCA MOUNTAIN IS IN THE NORTHERN MOJAVE**
 - TWO DISTINCT WEATHER PATTERNS (WINTER AND SUMMER)**
 - > 50% OF THE PRECIPITATION IS IN THE WINTER AS RAIN AND SNOW**
 - BIMODAL DISTRIBUTION EXISTS**











- o WINTER WEATHER DOMINATED BY 5 WEATHER TYPES (A-E)**
 - 3 TYPES BRING PRECIPITATION (1 IS INSIGNIFICANT)**
 - 2 TYPES BRING DRY CONDITIONS**

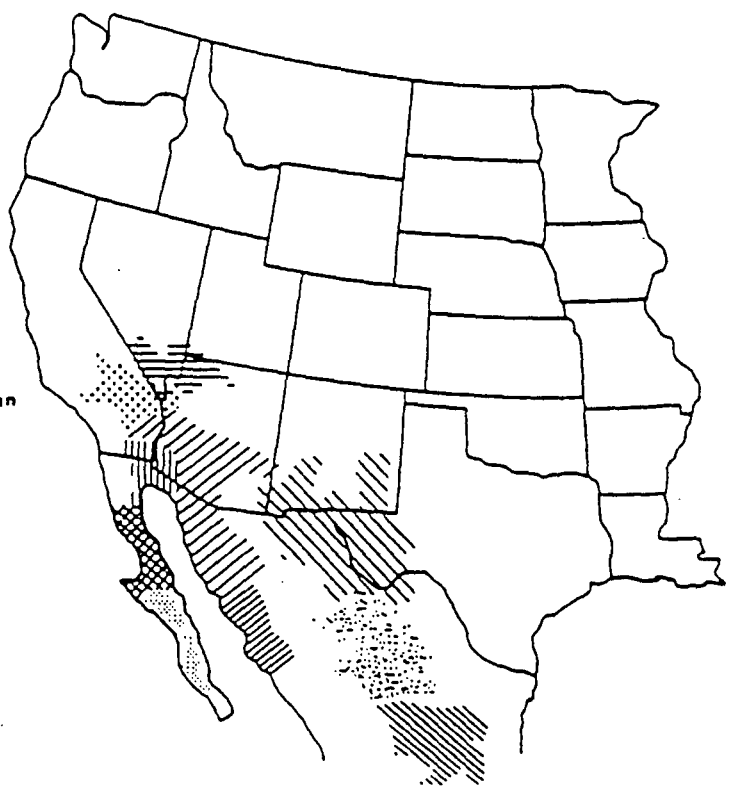
- o SUMMER WEATHER DOMINATED BY SOUTHWEST MONSOON**

NORTH AMERICAN DESERT BOUNDARIES AND HOT DESERT SUBDIVISIONS

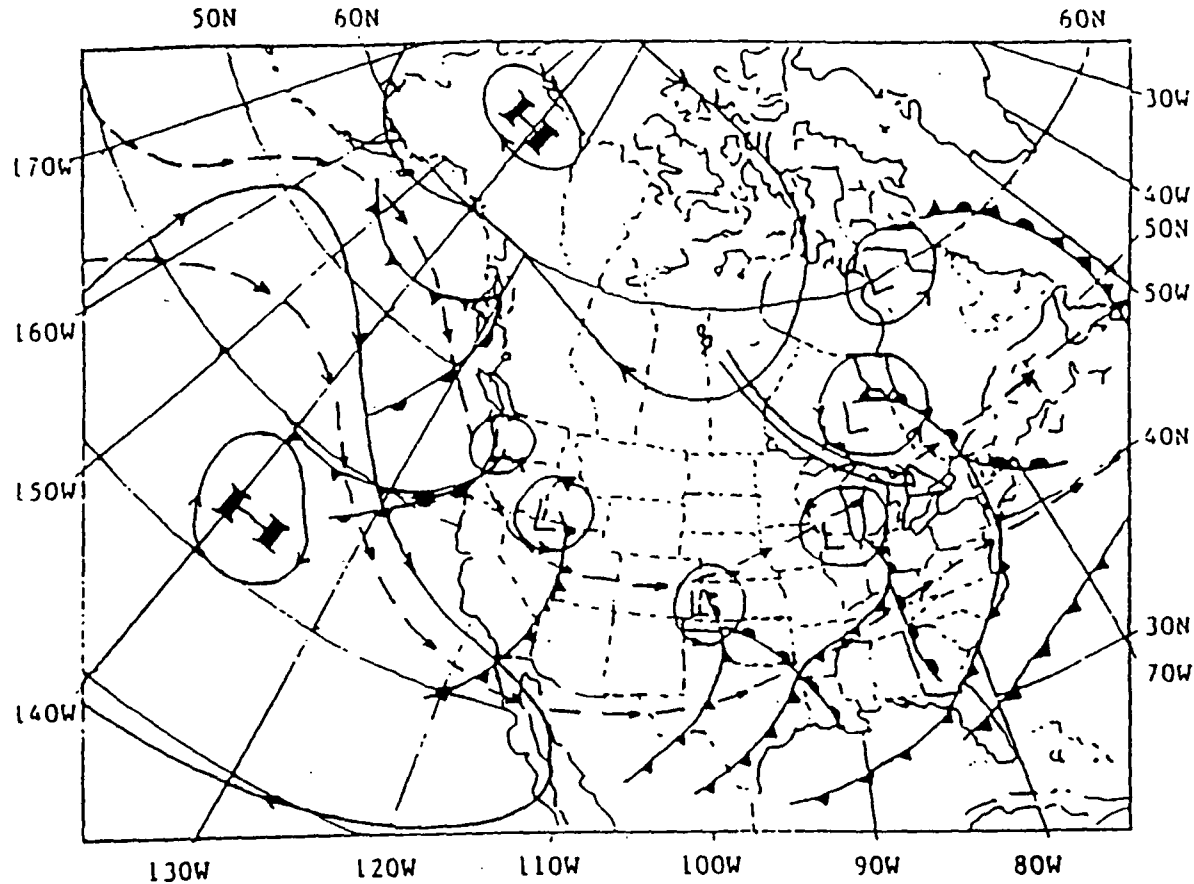
- Desert Boundaries**
-  Great Basin
 -  Mojave Desert
 -  Sonoran Desert
 -  Chihuahuan Desert



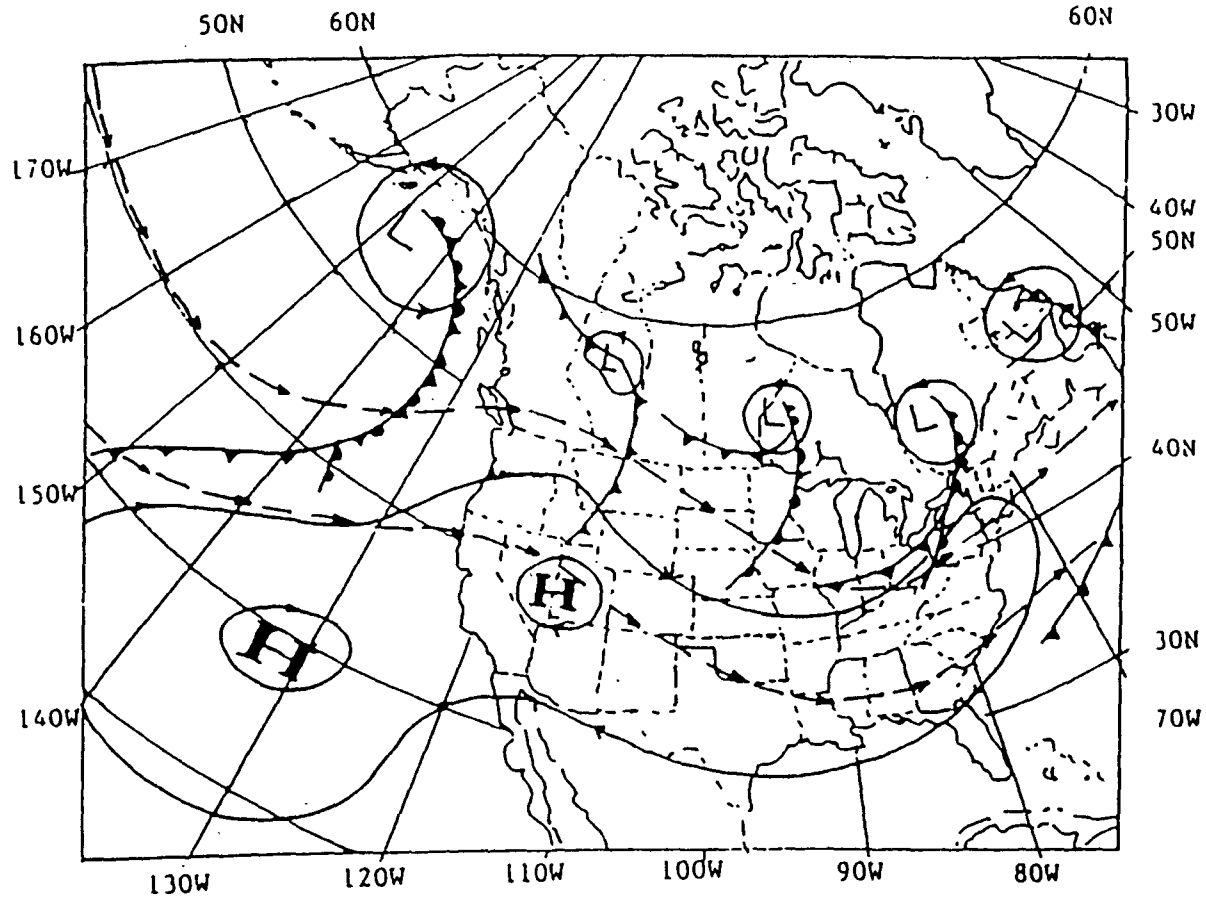
- Hot Desert Subdivisions**
-  Northern Mojave
 -  Southern Mojave
 -  Lower Colorado River Valley, Sonoran
 -  Arizona Upland, Sonoran
 -  Plains of Sonora, Sonoran
 -  Vizcaino, Sonoran
 -  Magdalena Plain, Sonoran
 -  Trans Pecos, Chihuahuan
 -  Mapimien, Chihuahuan
 -  Saladan, Chihuahuan



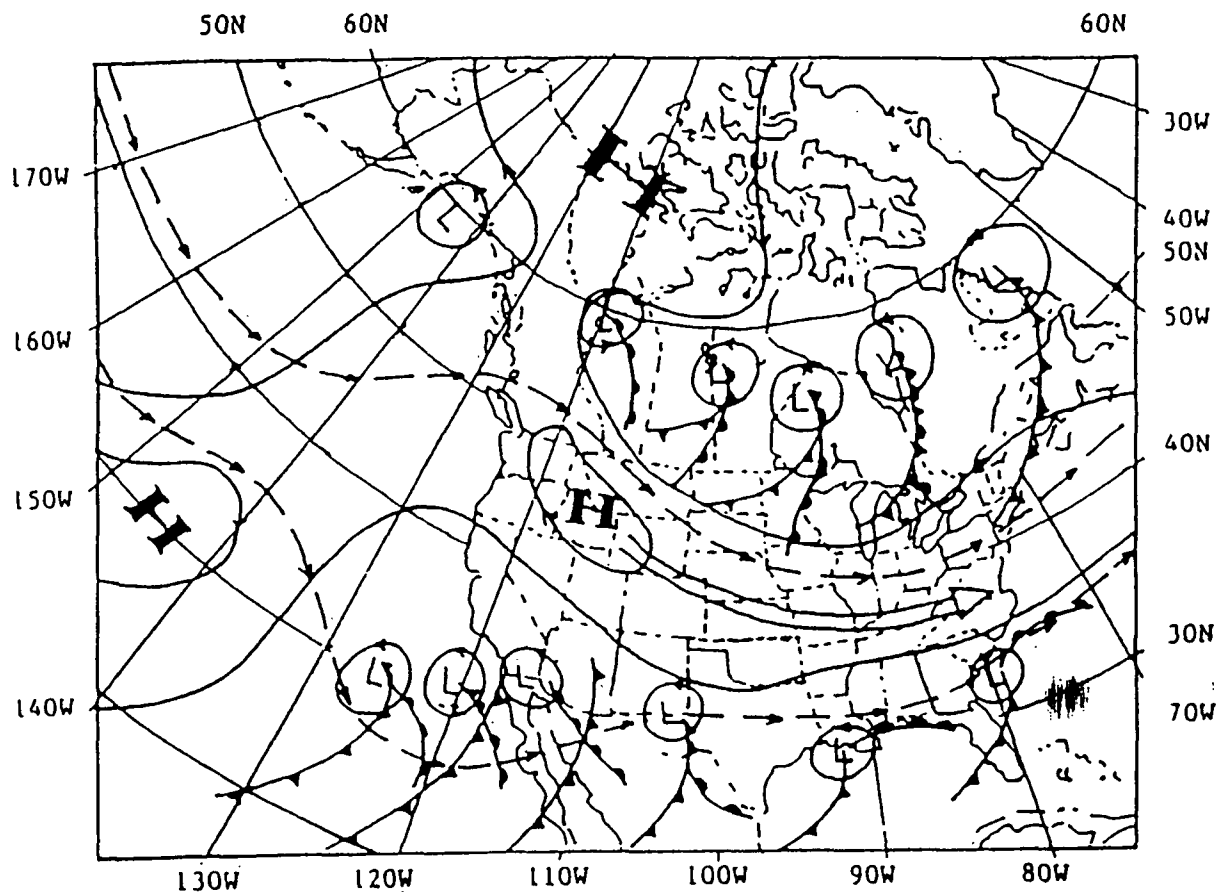
WINTER WEATHER TYPE A: PACIFIC HIGH PRESSURE IS FURTHER NW THAN NORMAL. STEERING WIND IS MAINTAINED NORTH OF SO. NEVADA. NO PRECIPITATION.



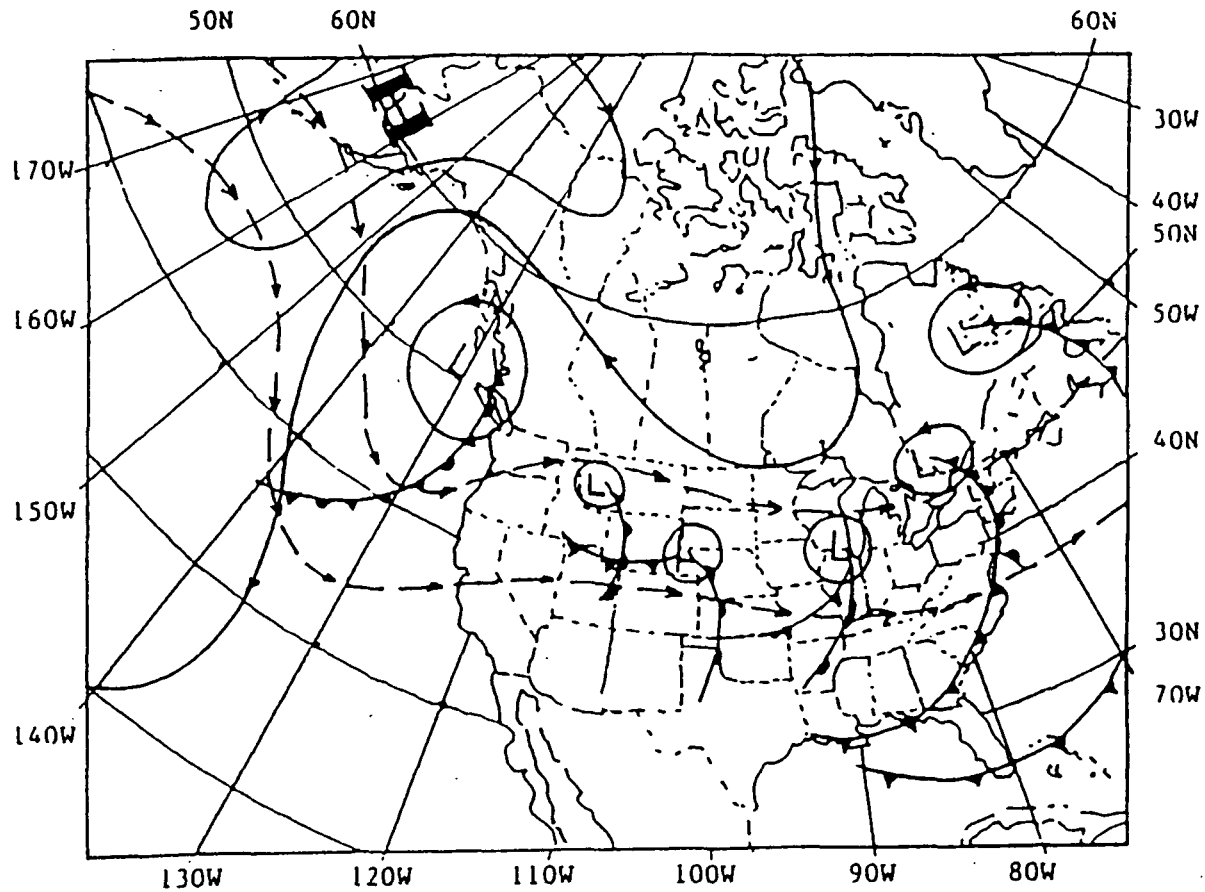
**WINTER WEATHER TYPE B: HIGH PRESSURE BELT DOMINATES
EASTERN PACIFIC AND SOUTHERN HALF OF THE U.S.
NO PRECIPITATION.**



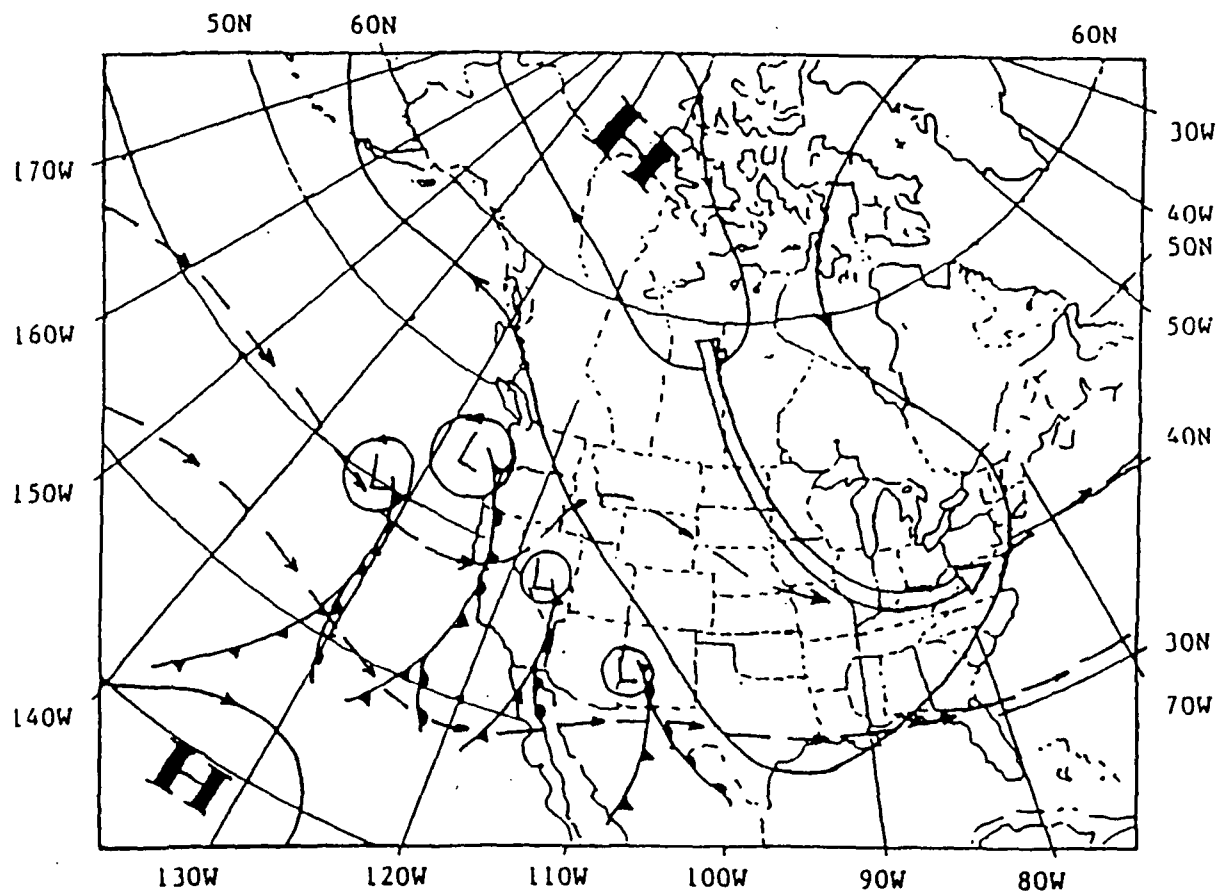
WINTER WEATHER TYPE C: HIGH PRESSURE BELT IS DISPLACED TO THE NORTH. STEERING WINDS BRING LOW PRESSURE CYCLONE CENTERS TO SO. NEVADA. HEAVIEST PRECIPITATION.



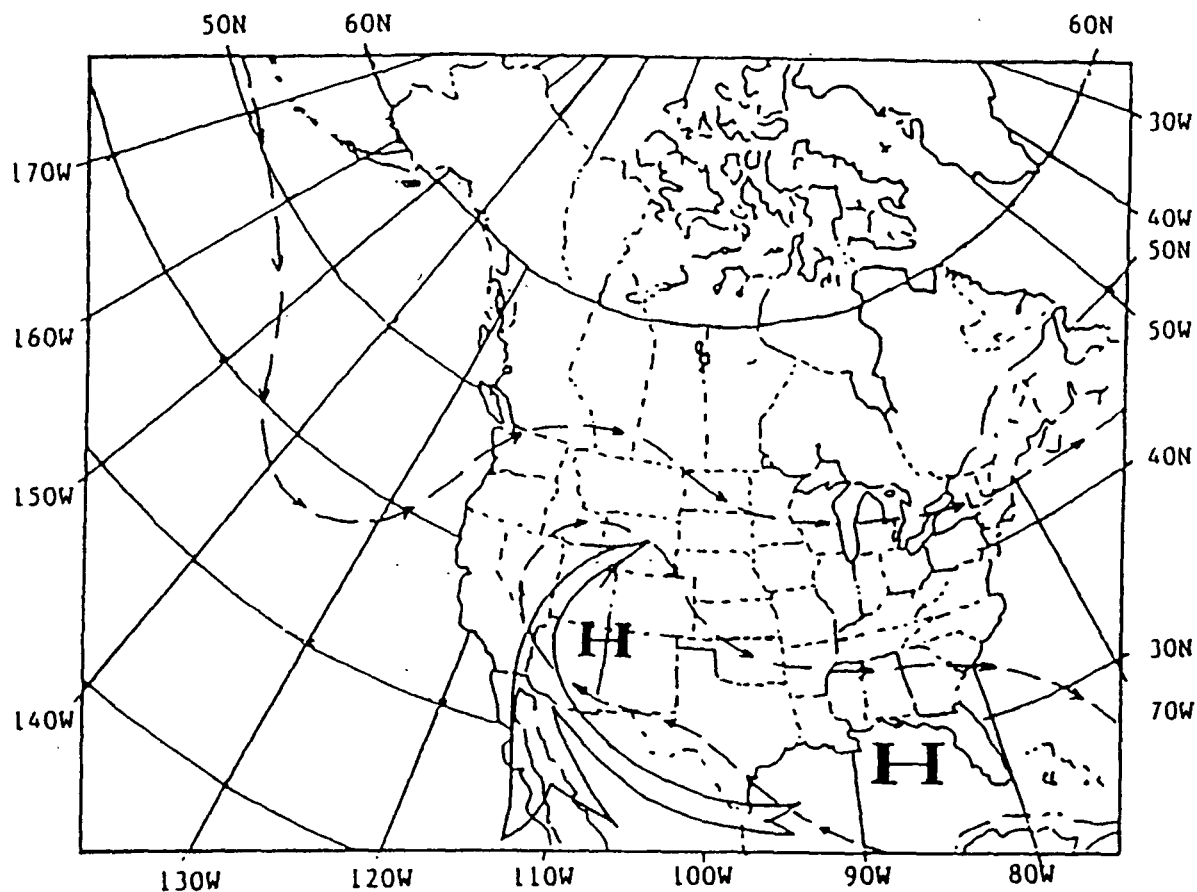
WINTER WEATHER TYPE D: SUBARCTIC HIGH PRESSURE MAINTAINS STEERING WINDS WAY NORTH OF SO. NEVADA. POLAR OUTBREAKS BRING COLD TEMPERATURES AND SNOW TO GREAT BASIN AND SO. NEVADA. INSIGNIFICANT PRECIPITATION.



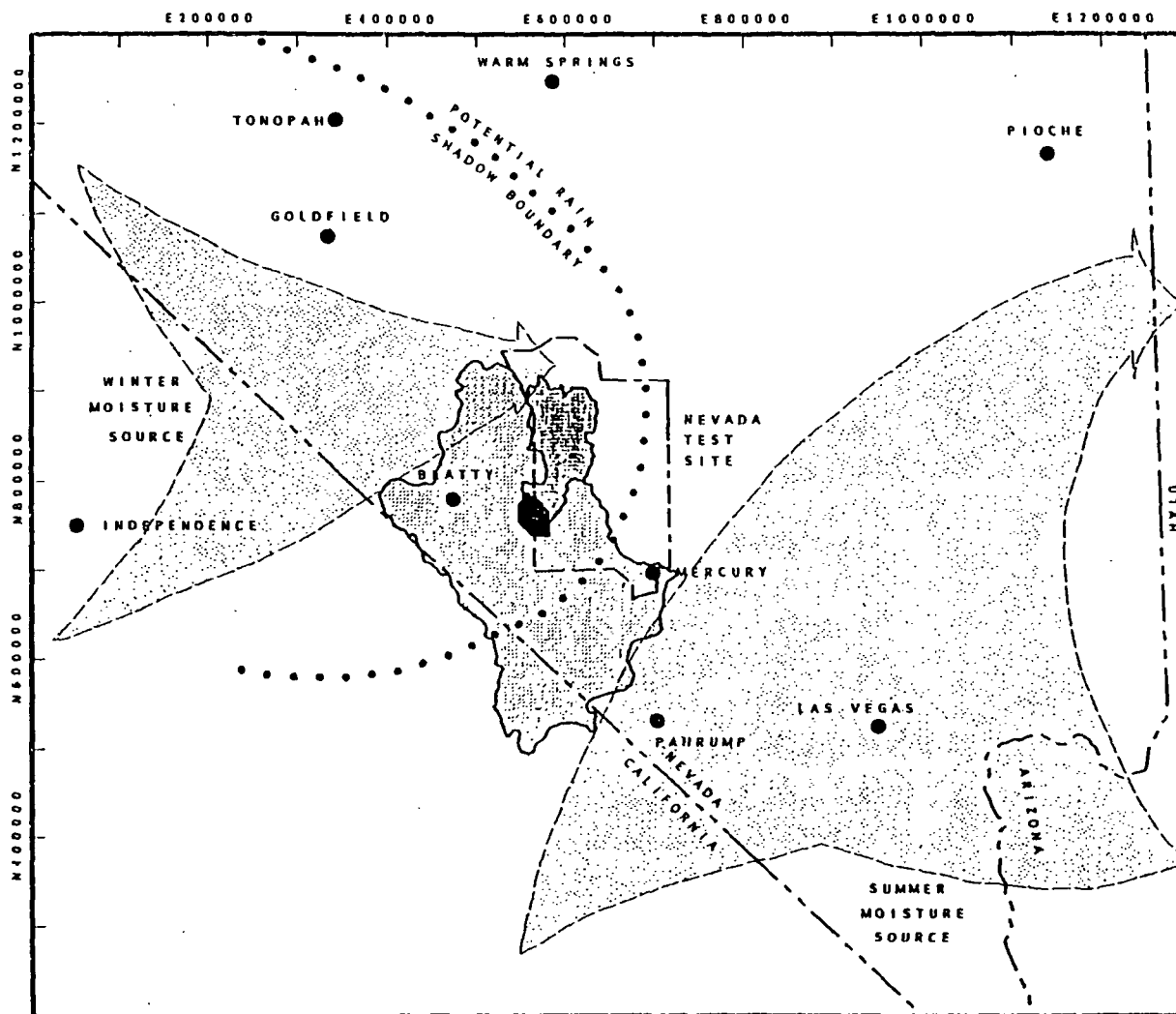
**WINTER WEATHER TYPE E: CONTINENTAL HIGH PRESSURE AND
PACIFIC HIGH PRESSURE BRACKET STEERING CURRENT.
MOISTURE AVAILABILITY AND RAIN SHADOW CONTROL
PRECIPITATION IN SO. NEVADA. SOME PRECIPITATION.**






SUMMER SOUTHWEST MONSOON: LOW LEVEL MOISTURE FROM THE GULF OF CALIF. AND UPPER LEVEL MOISTURE FROM THE GULF OF MEXICO MIX AND BRING HIGH INTENSITY, SHORT DURATION THUNDERSTORMS TO SO. NEVADA.

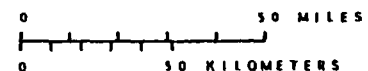
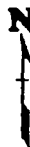


SUMMER AND WINTER MOISTURE SOURCES FOR SO. NEVADA



EXPLANATION

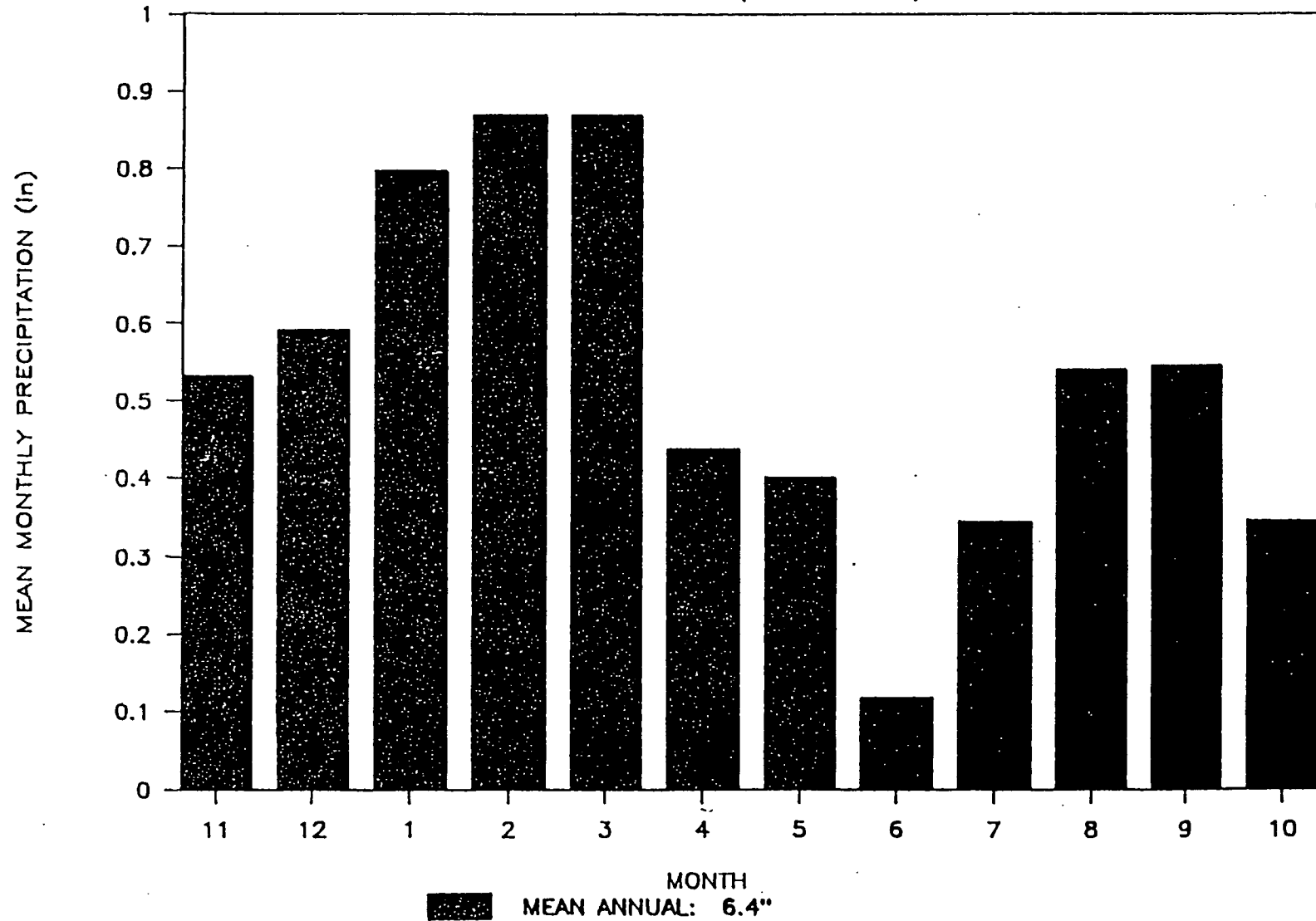
-  Study Area 1
-  Study Area 2, Fortymile Canyon Watershed
-  Study Area 3, Upper Amargosa River Watershed



Nevada State Plane Coordinate
System, Central Zone

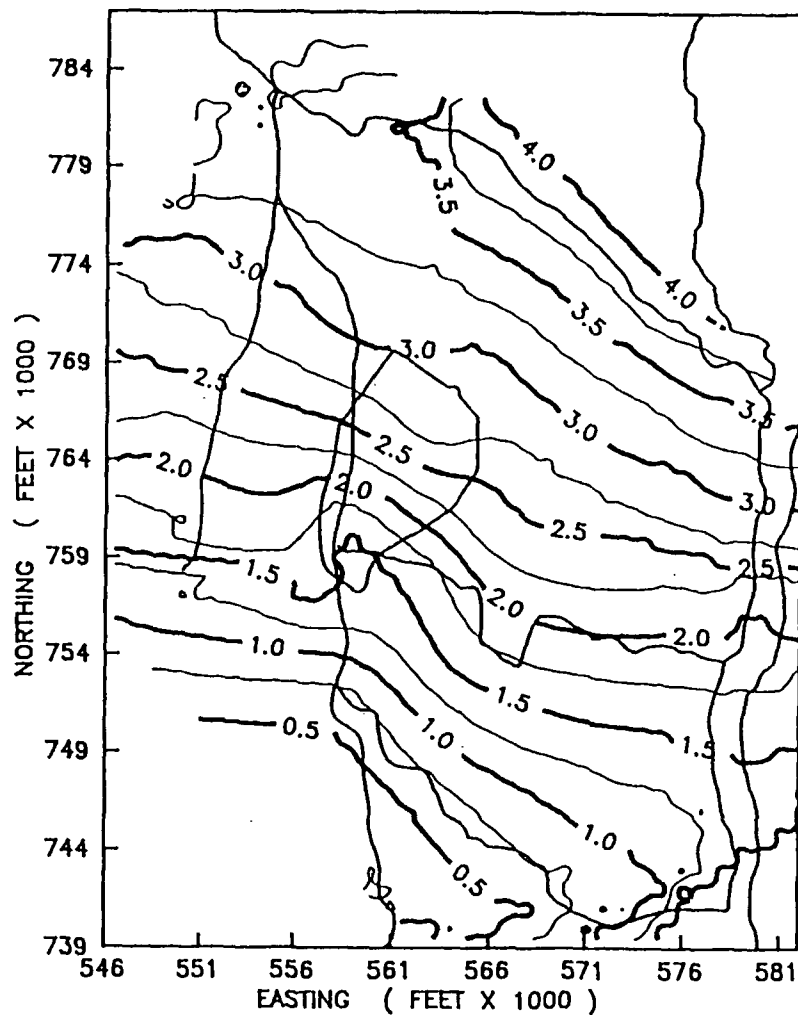
MEAN MONTHLY PRECIPITATION

AT BEATTY, NEVADA (1973 - 1989)

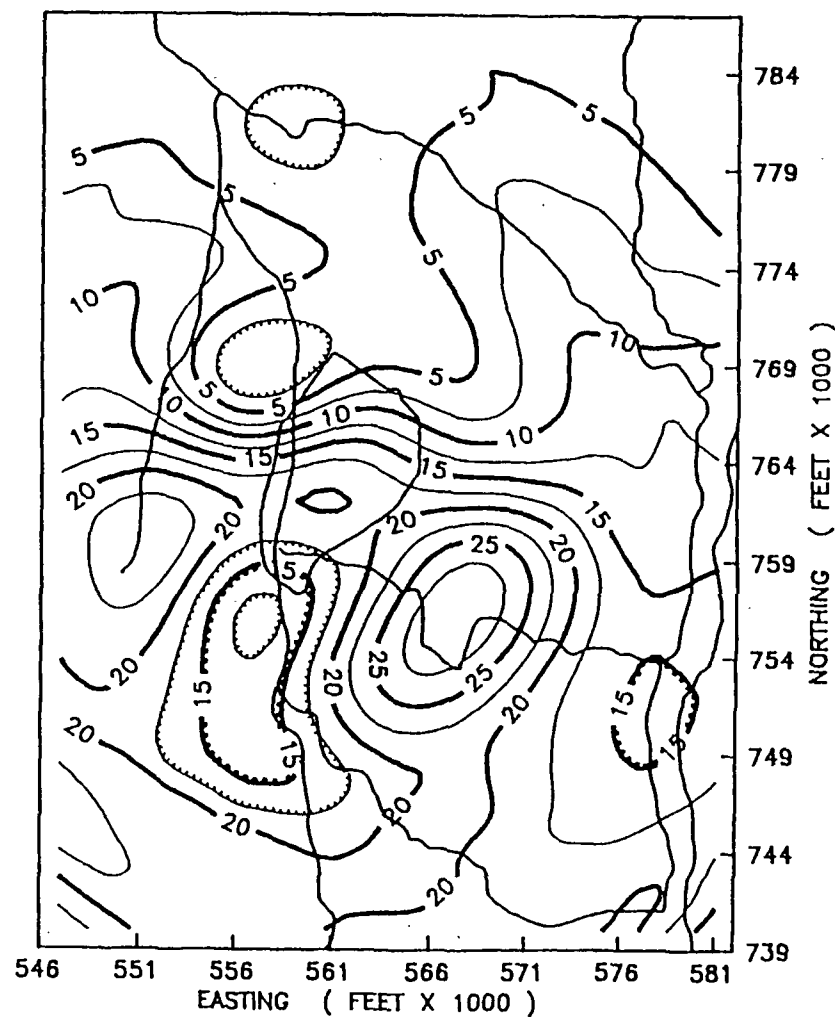


KRIGED PRECIPITATION ESTIMATES FOR STRATIFORM WINTER STORM AND SUMMER CONVECTIVE STORM CELLS

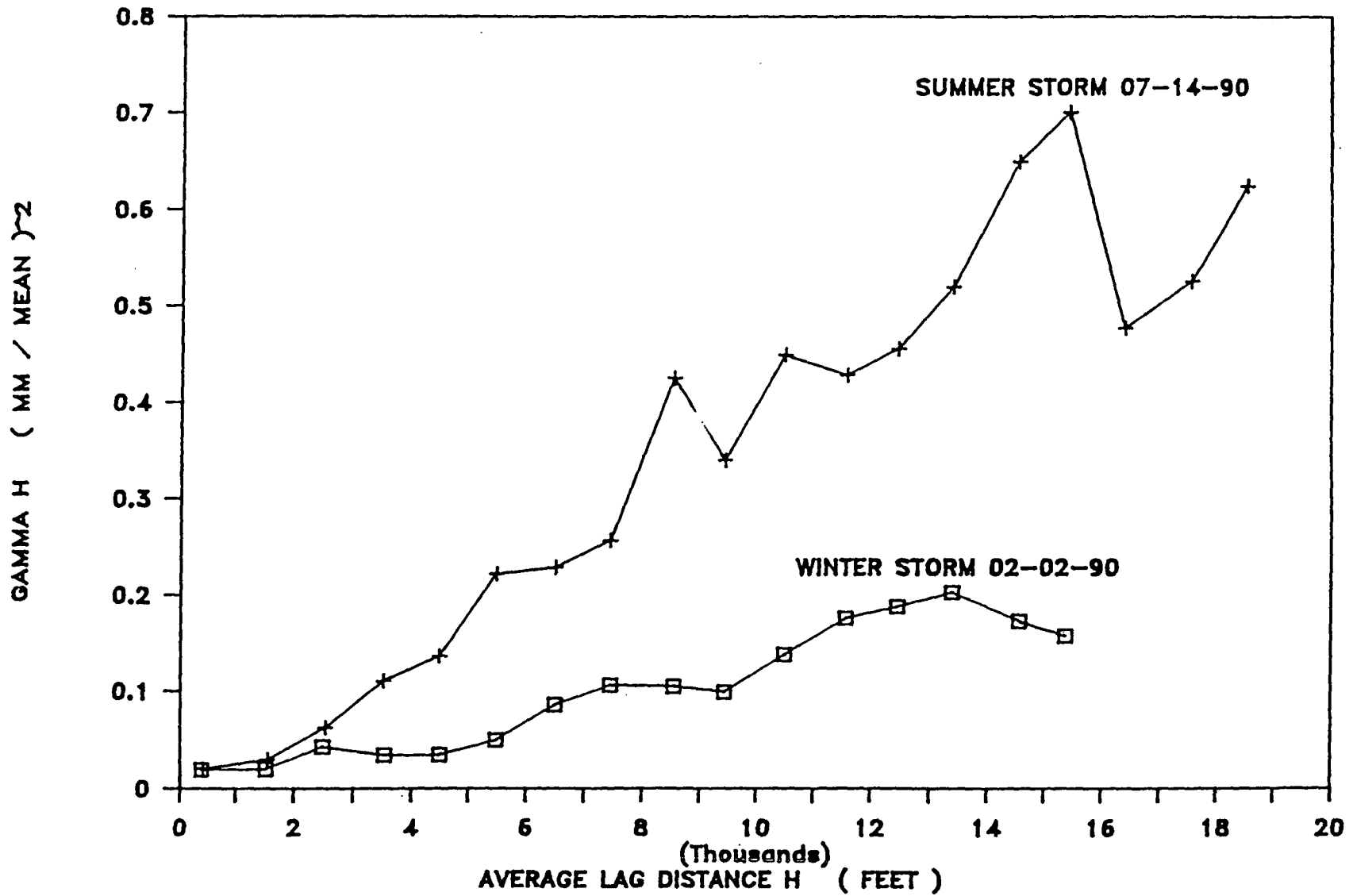
STORM 02-02-90 KRIGED PRECIP (MM)



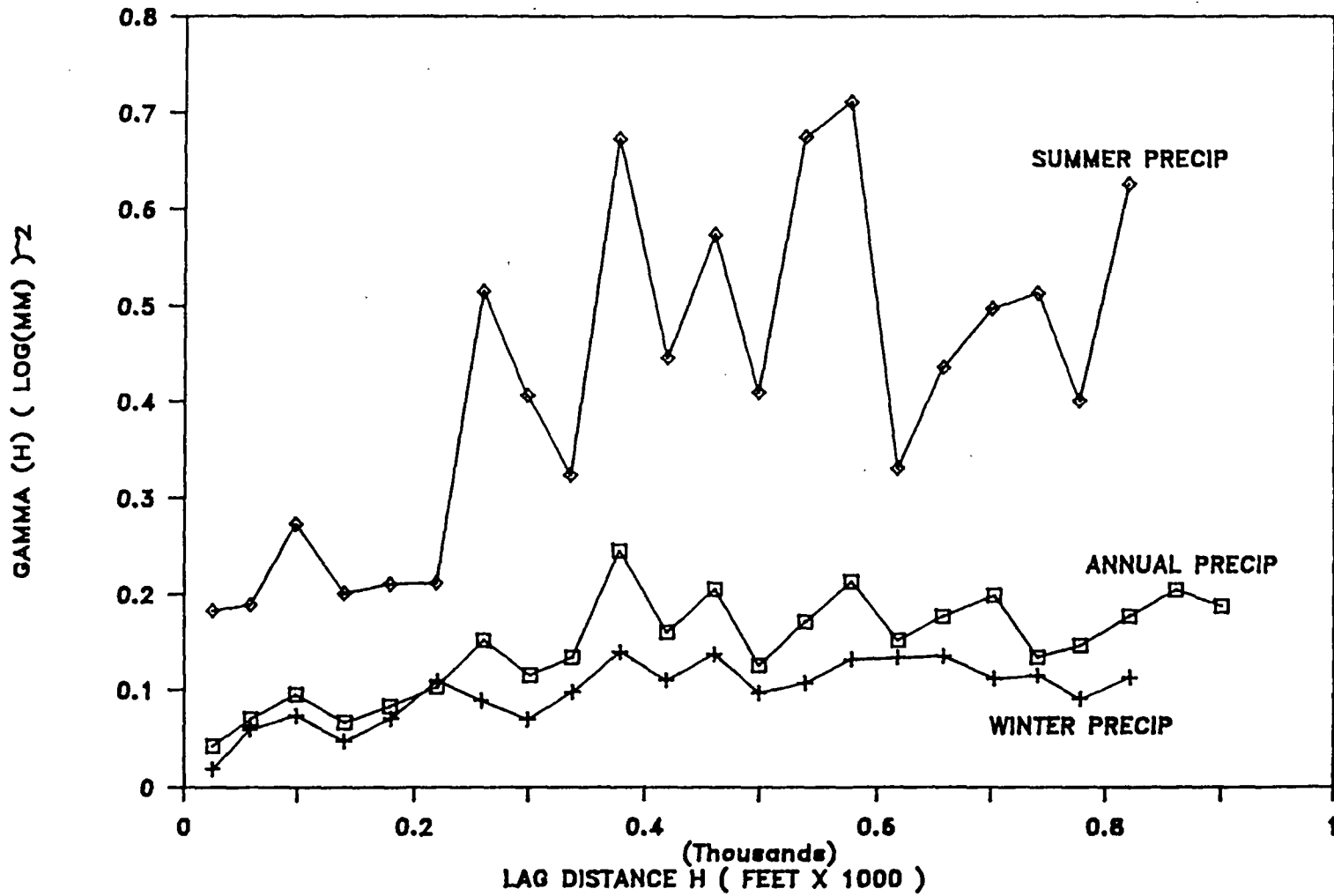
STORM 07-14-90 KRIGED PRECIP (MM)



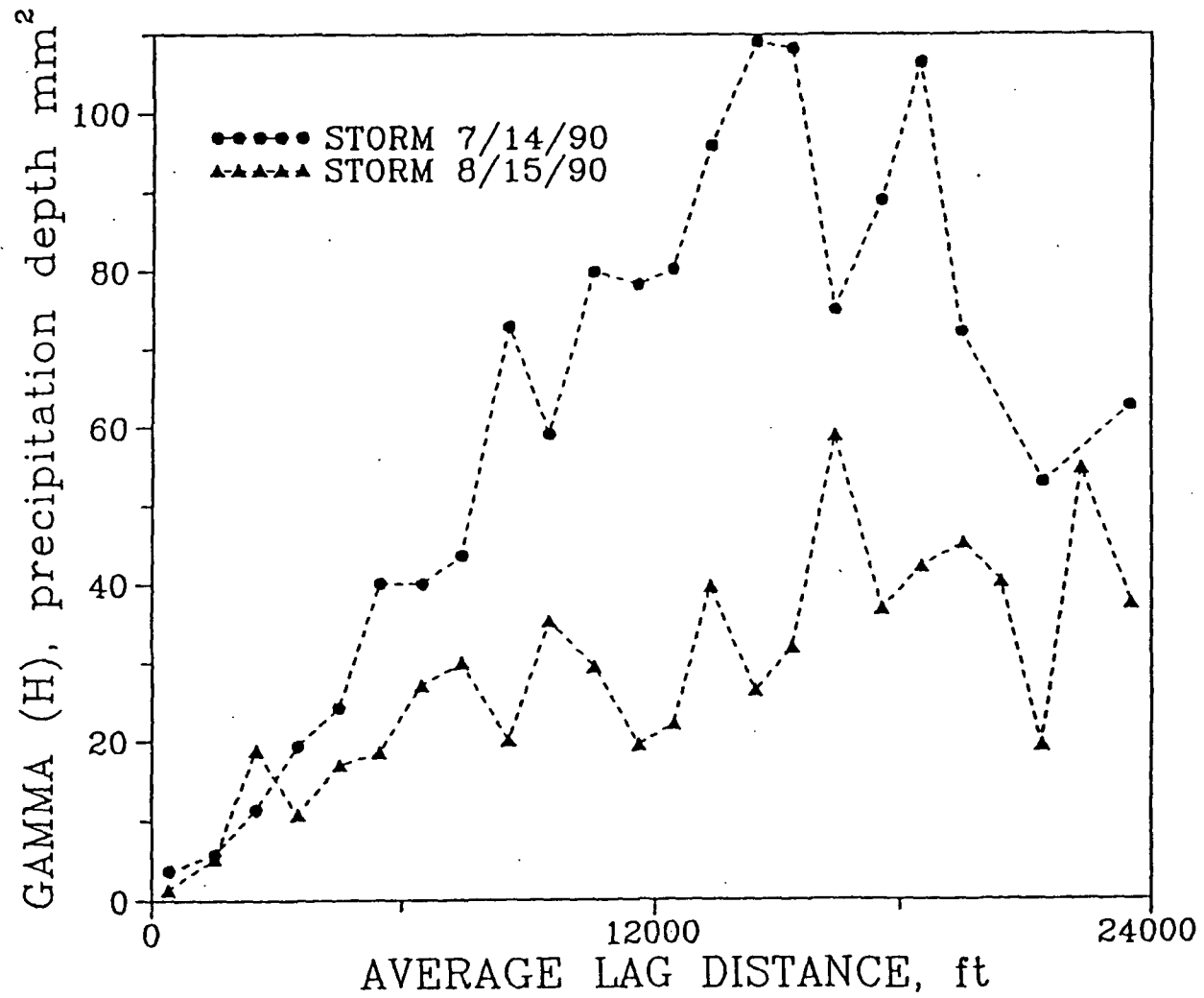
STORM PRECIP STANDARDIZED VARIOGRAMS



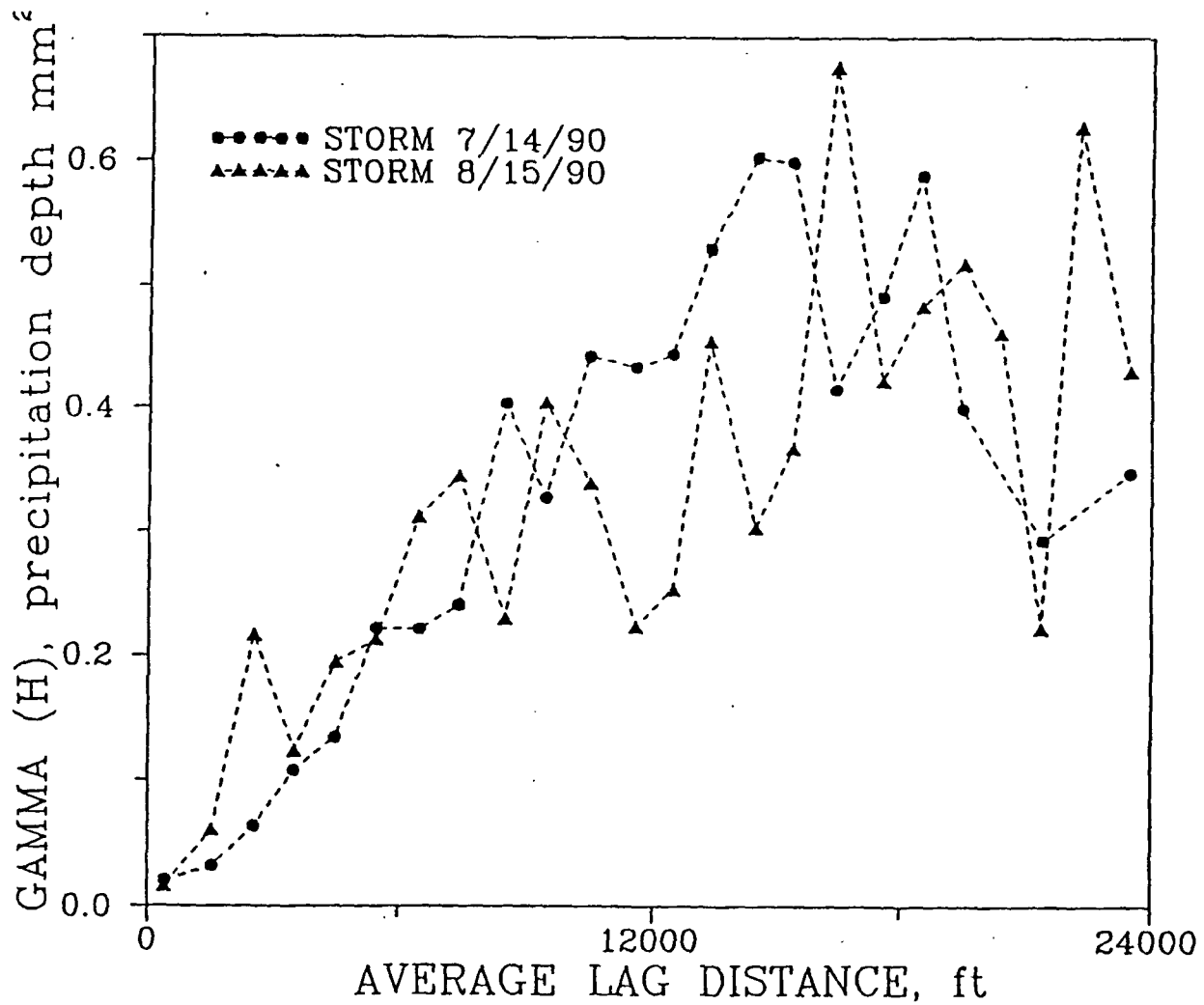
1988 LOG(PRECIP) SAMPLE VARIOGRAMS



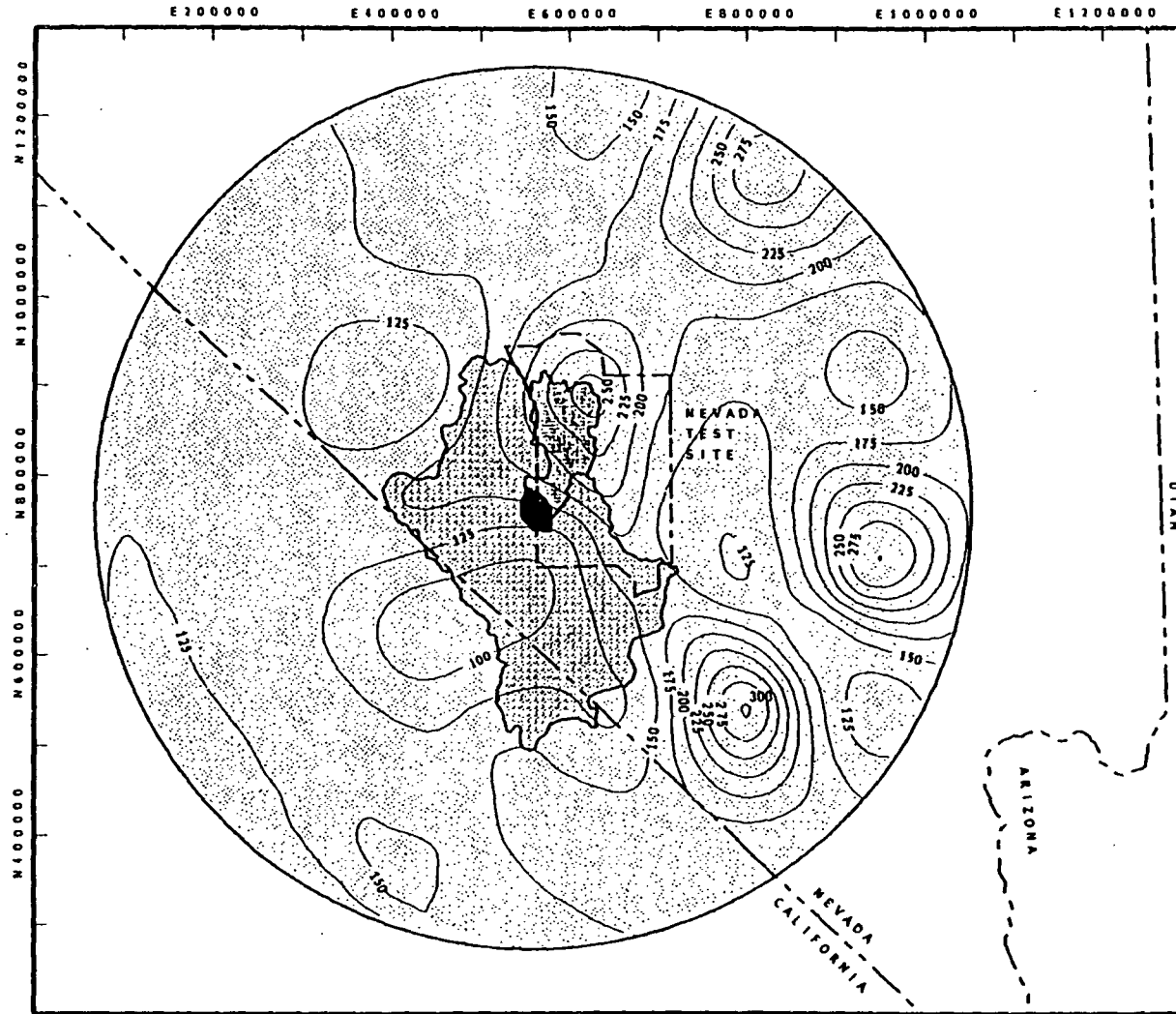
1990 SUMMER STORM VARIOGRAMS







STANDARDIZED SUMMER STORM VARIOGRAMS



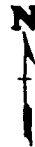
KRIGED PRECIPITATION ESTIMATE FOR SOUTHERN NEVADA



EXPLANATION

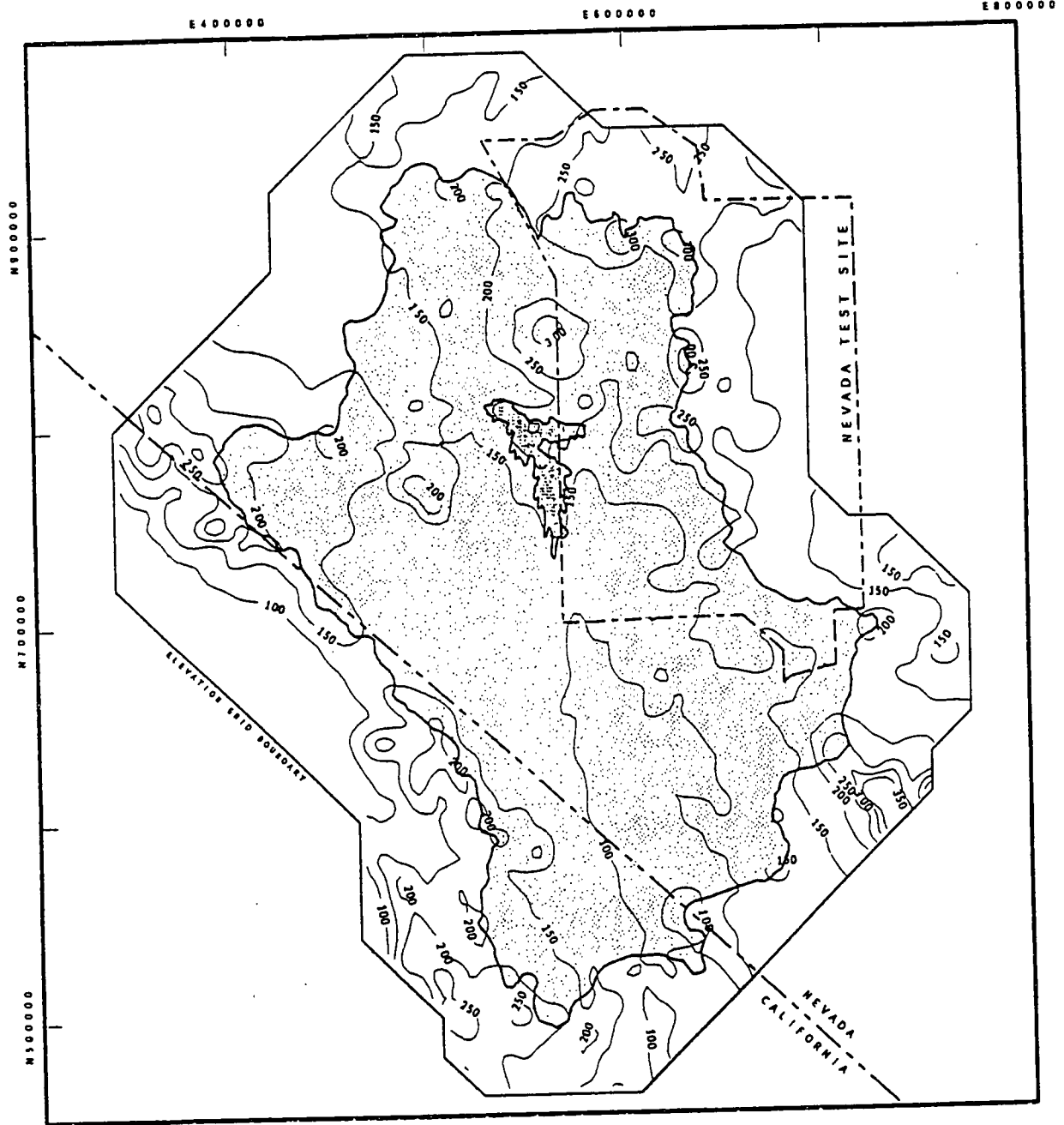
-  Study Area 1
-  Study Area 2, Fortymile Canyon Watershed
-  Study Area 3, Upper Amargosa River Watershed
-  Study Area 4, 150 km Radius

ISOHYETS ARE IN MILLIMETERS



Nevada State Plane Coordinate
System, Central Zone

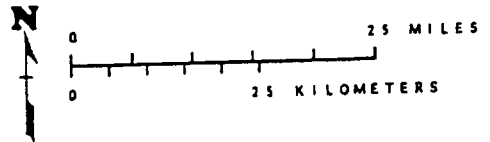
COKRIGED PRECIPITATION ESTIMATE FOR THE UPPER AMARGOSA RIVER WATERSHED



EXPLANATION

-  Yucca Mountain Upland Area
-  Upper Amargosa River Watershed

ISOHYETS ARE IN MILLIMETERS



Nevada State Plane Coordinate System, Central Zone

OUTLINE

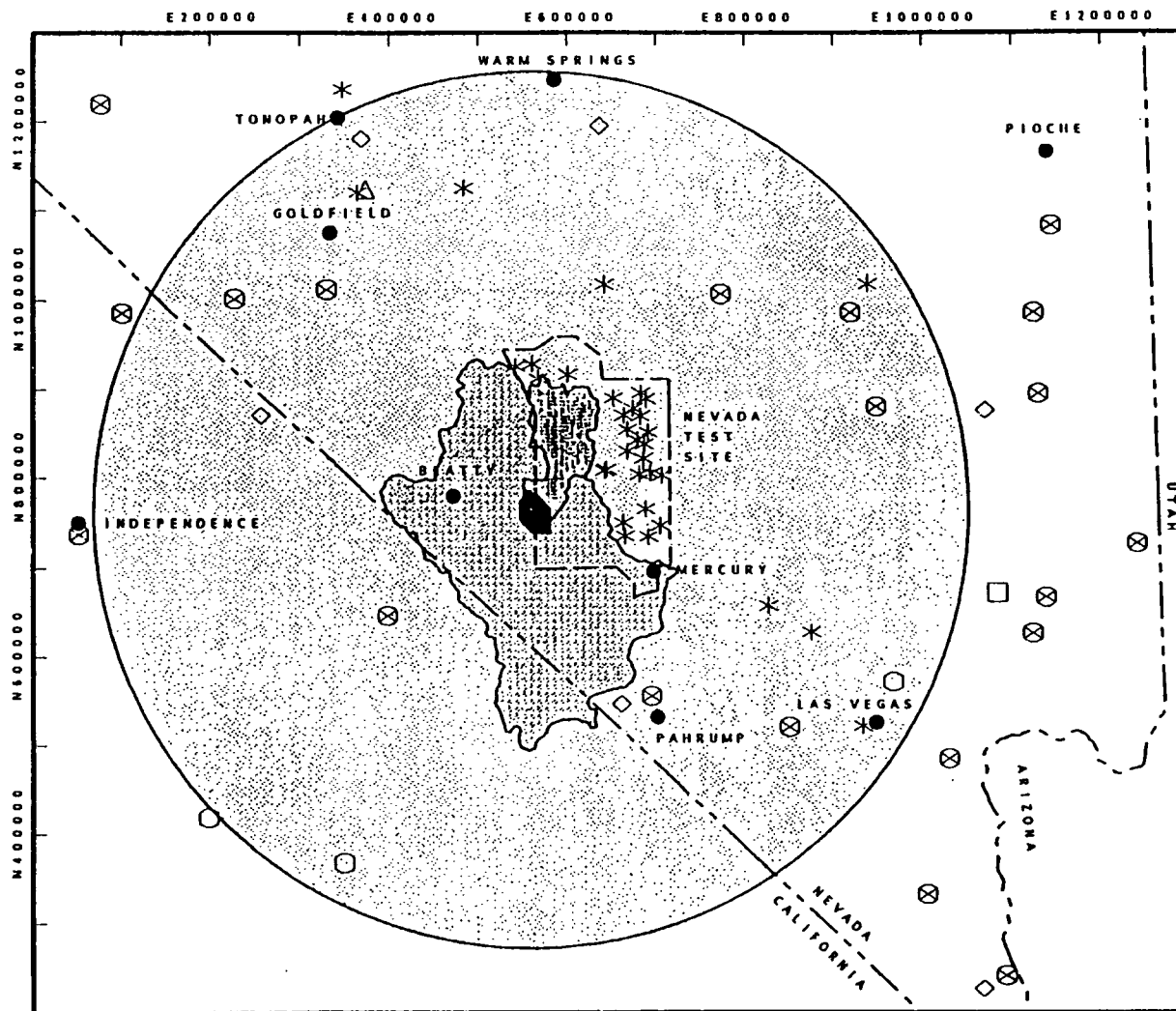
- o **STUDY AREA**
- o **CURRENT UNDERSTANDING**
- **DATA COLLECTION**
- o **PAST/FUTURE CONDITIONS (SIMULATIONS)**

DATA COLLECTION




- o MEASUREMENT PARAMETERS OF INTEREST**
 - PRECIPITATION**
 - AIR TEMPERATURE**
 - RELATIVE HUMIDITY**
 - BAROMETRIC PRESSURE**
 - SHORT WAVE RADIATION**
 - WIND SPEED AND DIRECTION**

- o ADDITIONAL INFORMATION**
 - LIGHTNING (GROUND TO CLOUD)**
 - LIGHTNING (CLOUD TO CLOUD)**
 - CLOUD TOP TEMPERATURES**
 - VIDEO TAPE OF METEOROLOGICAL EVENTS**
 - SATELLITE IMAGES OF GLOBAL AND SYNOPTIC EVENTS**







ACTIVE PRECIPITATION STATIONS IN STUDY AREA 4



EXPLANATION

-  Study Area 1
-  Study Area 2, Fortymile Canyon Watershed
-  Study Area 3, Upper Amargosa River Watershed
-  Study Area 4, 150 km Radius

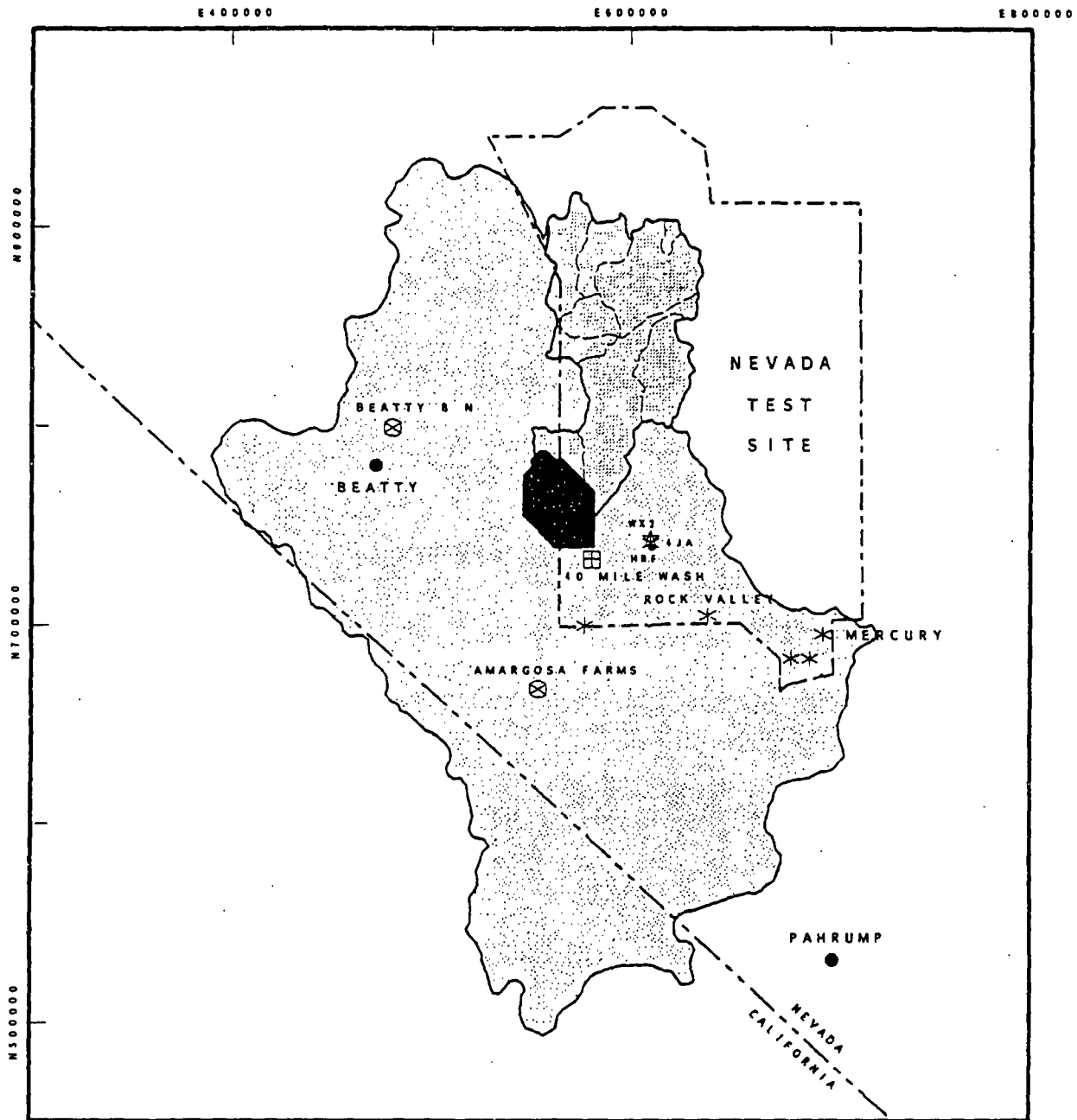
PRECIPITATION STATIONS

- | | |
|--|---|
|  DOD |  BLM |
|  CO-OP |  EGAMI |
|  NWS (MEDA) |  FAA |



Nevada State Plane Coordinate
System, Central Zone

UPPER AMARGOSA RIVER WATERSHED

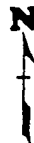


EXPLANATION

-  Study Area 1
-  Study Area 2, Fortymile Canyon Watershed
-  Study area 3, Upper Amargosa River Watershed

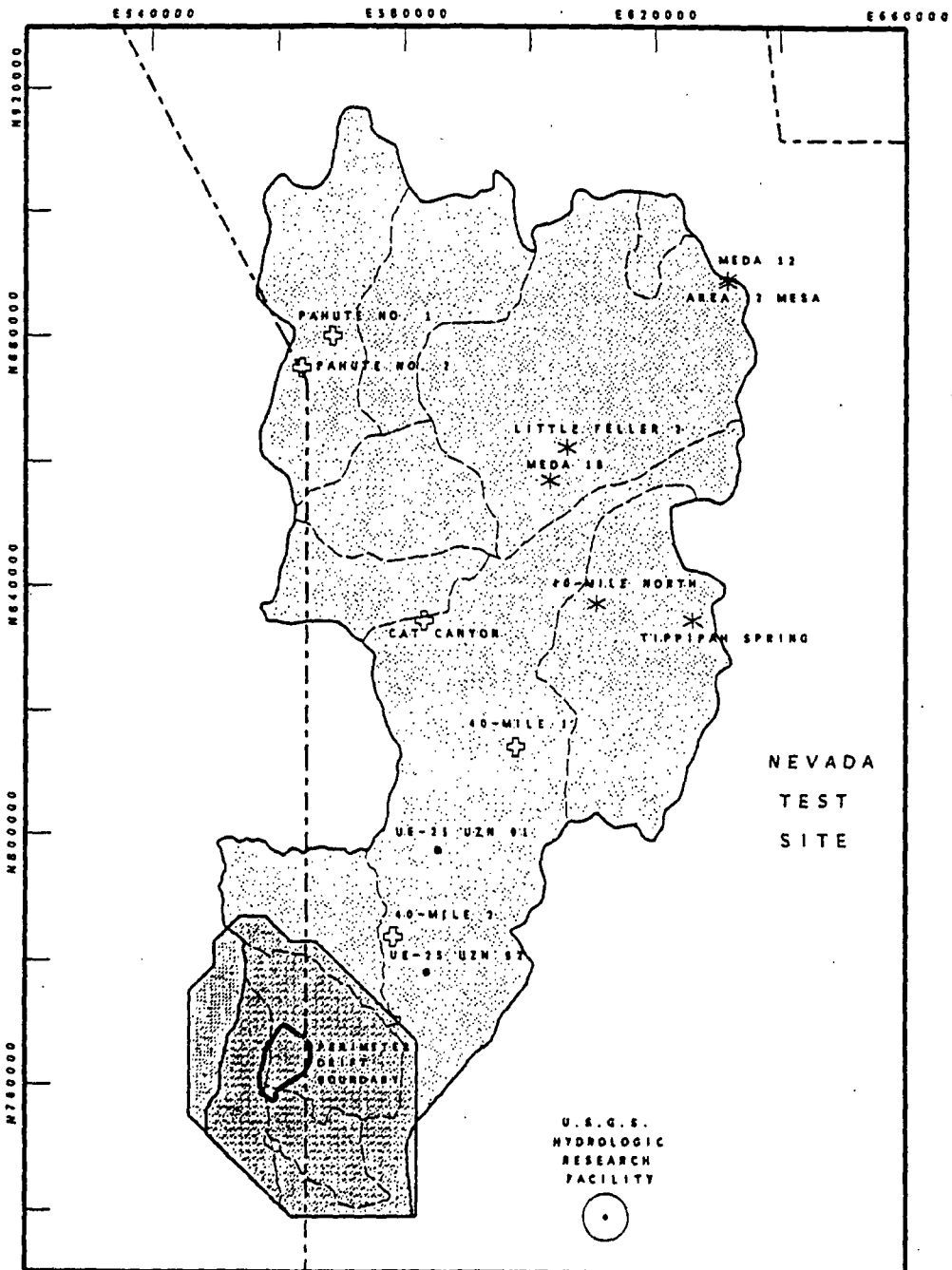
PRECIPITATION STATIONS

- * N.W.S. (meda) ☆ U.S.G.S. (auto.)
- ⊗ CO-OP • U.S.G.S. (storage)
- ⊞ S.A.I.C.



Nevada State Plane Coordinate System, Central Zone




ACTIVE PRECIPITATION STATIONS IN STUDY AREA 2



EXPLANATION

-  Study Area 1
-  Study Area 2, Fortymile Canyon Watershed

PRECIPITATION STATIONS

-  D.R.I.
-  N.W.S.
-  U.S.G.S. (storage)



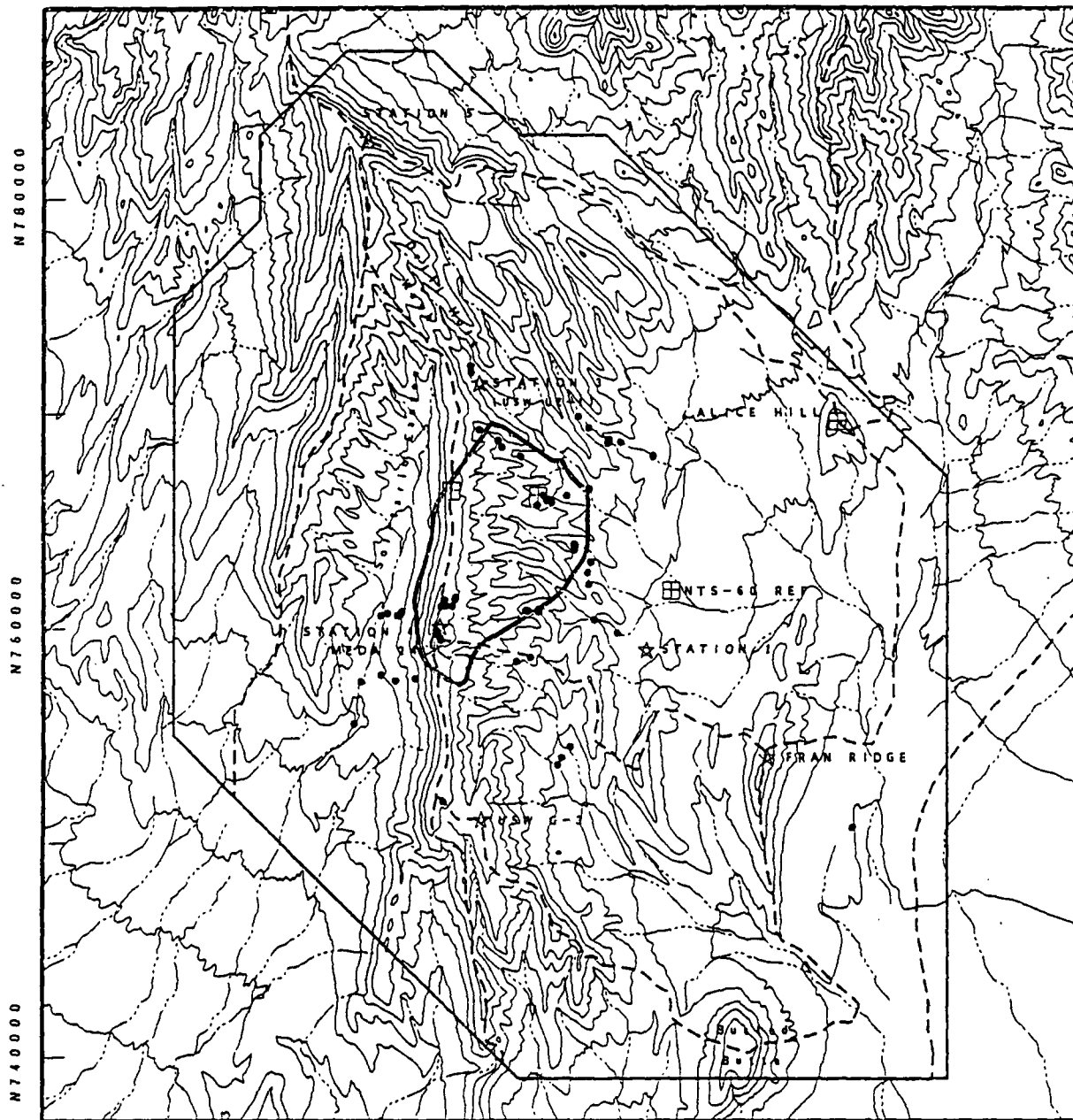
Nevada State Plane Coordinate System, Central Zone

PRECIPITATION STATIONS IN STUDY AREA 1

E 540000

E 560000

E 580000



EXPLANATION

- Perimeter Drift Boundary
- - - Sub-basin Watershed Boundary
- Study Area 1

PRECIPITATION STATIONS

- | | | | |
|---|---------------|---|----------------------|
| ⊠ | S.A.I.C. | ☆ | U.S.G.S. (Automated) |
| * | N.W.S. (Meda) | • | U.S.G.S. (storage) |



Nevada State Plane Coordinate
System, Central Zone

DATA COLLECTION PLATFORMS

- o STANDARD PENMAN WEATHERSTATION**
- o RAINGAGE/SNOWGAGE (AUTOMATED AND STORAGE)**
- o LIGHTNING DETECTION NETWORK**
- o GOES/POLAR SATELLITE**
- o TIME LAPSE PHOTOGRAPHY**
- o SUPPORTING DATA FROM OTHER ACTIVITIES**
 - MICROMETEOROLOGY**
 - STREAM GAGING STATIONS**
 - ENVIRONMENTAL COMPLIANCE METEOROLOGICAL STATIONS**
- o COMBINED INTO STATISTICAL AND DETERMINISTIC ANALYSES**
 - PRECIPITATION**
 - OTHER METEOROLOGICAL PARAMETERS**

PHOTO OF WEATHERSTATION

SUMMARY OF DATA FROM WEATHERSTATION NEAR THE CREST OF YUCCA MOUNTAIN, 1988

1988 DATA									
Month	Extreme Max	Mean Max	Mean Monthly	Mean Min	Extreme Min	Mean Direction	Mean Speed	Extreme Speed	Precipitation
	(_____ °C _____)				(Degrees)		(M/S)		(mm)
Jan	14.4	11.0	3.7	-4.5	-8.1	76	3.3	14.7	8.0
Feb	19.0	14.1	8.8	1.1	-2.8	38	3.3	13.2	17.0
Mar	24.5	19.1	9.8	0.7	-3.9	82	3.9	14.7	0.0
Apr	25.5	20.2	12.7	4.5	2.0	132	3.7	13.1	47.0
May	30.5	25.0	17.6	4.8	-1.6	127	4.0	12.9	8.0
Jun	35.8	30.1	23.9	11.9	5.3	135	4.4	12.9	0.0
Jul	39.8	34.0	28.8	24.4	17.8	125	3.6	11.5	3.0
Aug	35.9	30.1	26.0	23.3	17.4	132	3.4	11.8	16.0
Sep	35.1	30.1	22.2	10.1	7.1	107	3.3	10.3	8.0
Oct	30.0	25.2	21.1	16.4	12.7	125	3.3	8.3	0.0
Nov	24.9	19.5	9.1	-0.1	-2.2	107	3.5	11.5	0.0
Dec	19.0	14.4	4.6	-6.4	-10.1	80	3.4	12.3	2.0

PHOTOS OF SNOW GAGES AND RAIN WEDGES

STATISTICAL ANALYSES OF THREE STORM EVENTS

Variable	***** Total Precipitation, mm *****		
	Storm 1/14/90	Storm 1/17/90	Storm 2/02/90
Sample size	46	50	74
Mean	1.94	7.31	2.35
Median	1.90	7.31	2.54
Mode	2.03	7.62	2.79
Variance	0.359	5.76	0.808
Coefficient of variation	0.305	0.325	0.379
Standard deviation	0.599	2.40	0.899
Standard error	0.088	0.339	0.104
Minimum	0.508	2.00	0.254
Maximum	3.56	13.00	5.84
Skewness	0.531	-0.250	0.704
Standardized skewness	1.47	-0.710	2.47
Kurtosis	0.688	0.510	2.88
Standardized kurtosis	0.953	0.740	5.06
Correlation coefficients			
Precip-Elevation	-0.268	-0.440	-0.490
Precip-Easting			0.669
Precip-Northing			0.853

PHOTOS OF LIGHTNING DETECTION NETWORK
- LIGHTNING STRIKE INFORMATION
- GRIDDED DATA AT 100 SQ. KM AREAS

**PHOTOS OF SATELLITE IMAGES AND CLOUD TOP
TEMPERATURES**

OUTLINE

- o STUDY AREA**
- o CURRENT UNDERSTANDING**
- o DATA COLLECTION**
- PAST/FUTURE CONDITIONS (SIMULATIONS)**

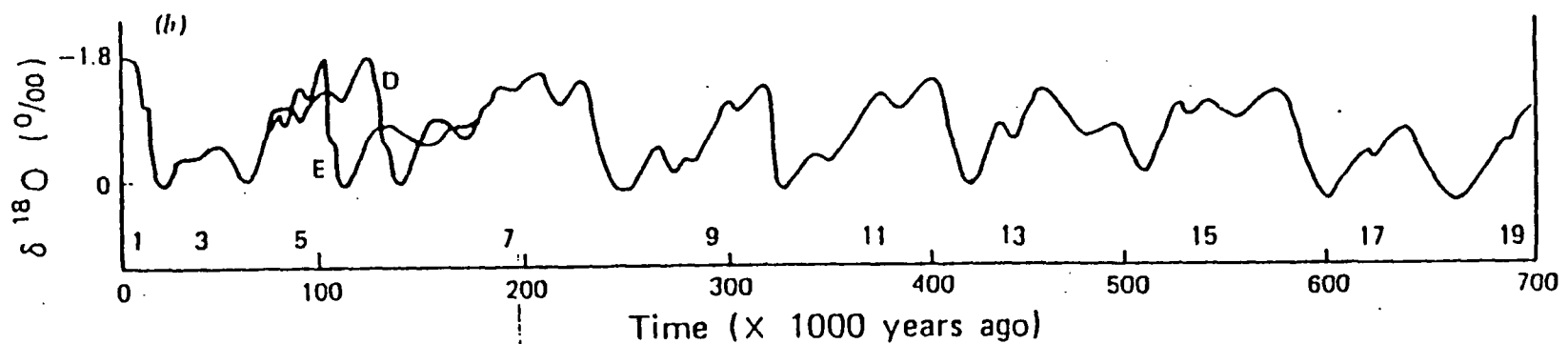
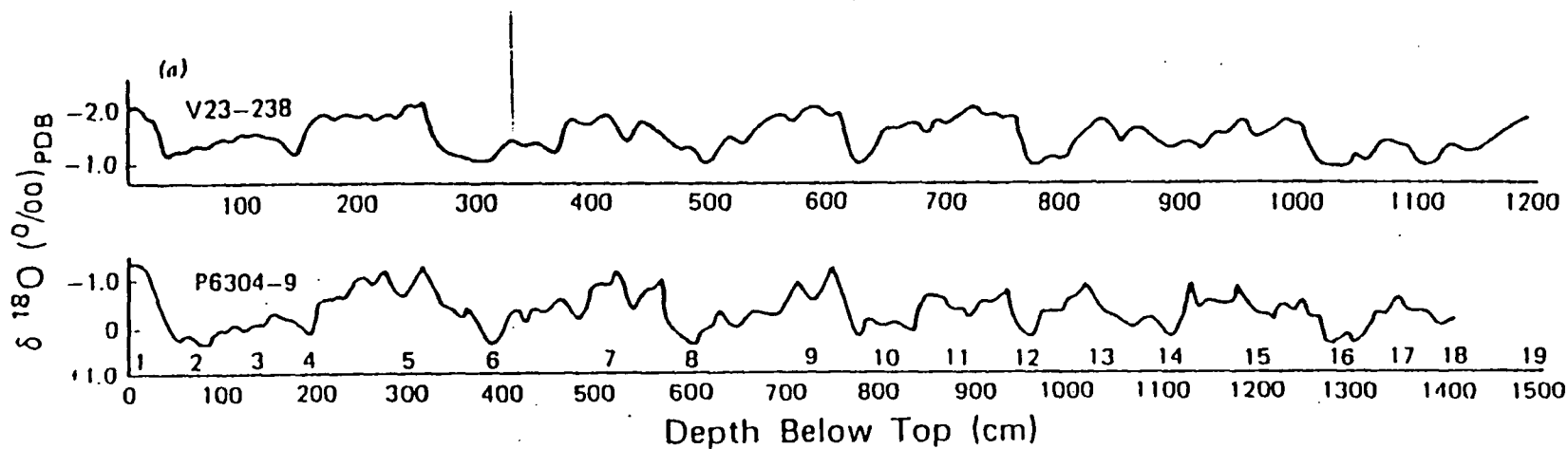
CONSTRUCTION OF A NUMERICAL RAINFALL SIMULATOR

- o PAST CLIMATIC CONDITIONS**
 - CURRENTLY INTERGLACIAL/INTERPLUVIAL**
 - NO DRIFT BUT HIGH VARIATION**

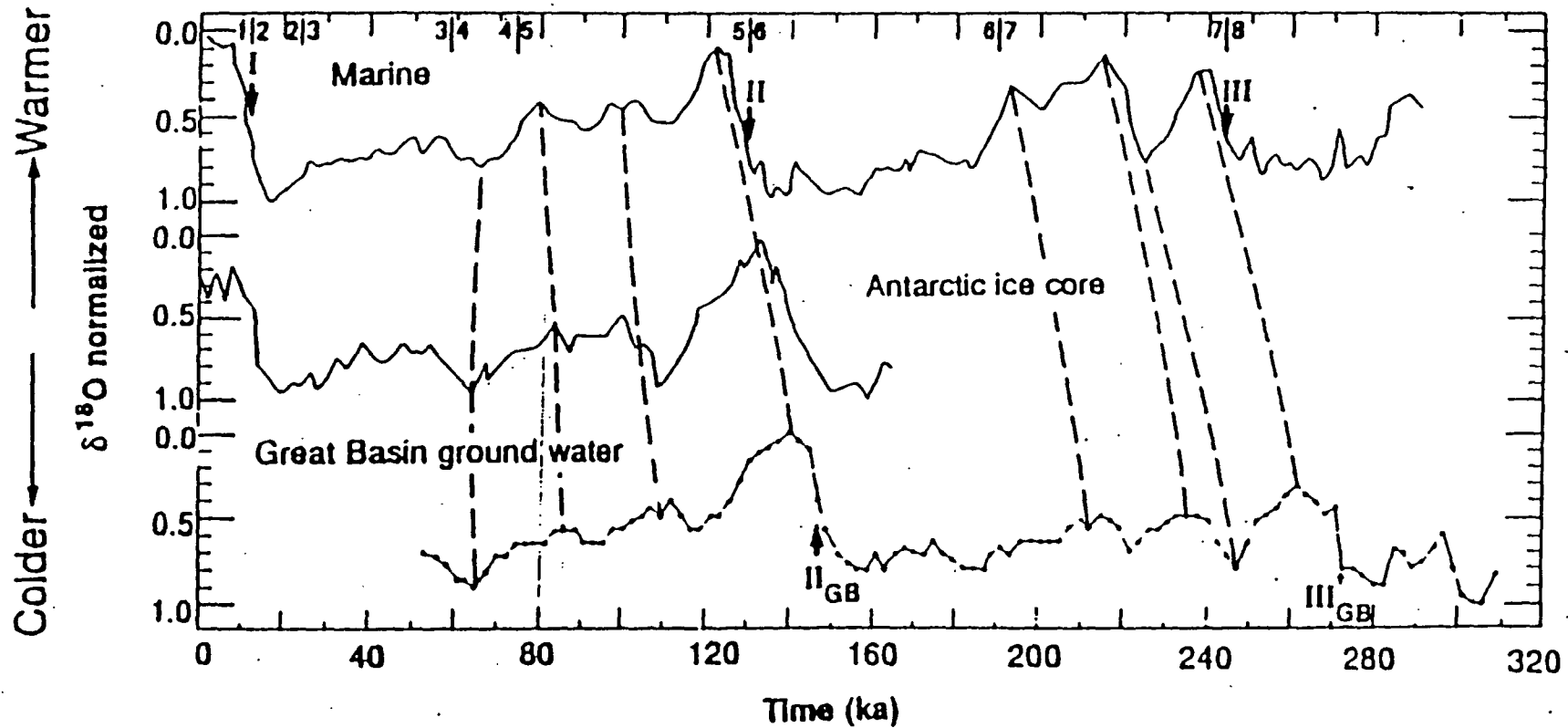
- o FUTURE CONDITIONS**
 - COLDER AND WETTER (BASED ON MILANKOVITCH CYCLES)**
 - WARMER AND DRIER (BASED ON GREENHOUSE GASES)**
 - YUCCA MOUNTAIN?**

- o RAINFALL SIMULATION**
 - PROBABILITY BASED**
 - TEMPORALLY AND SPATIALLY VARIABLE**

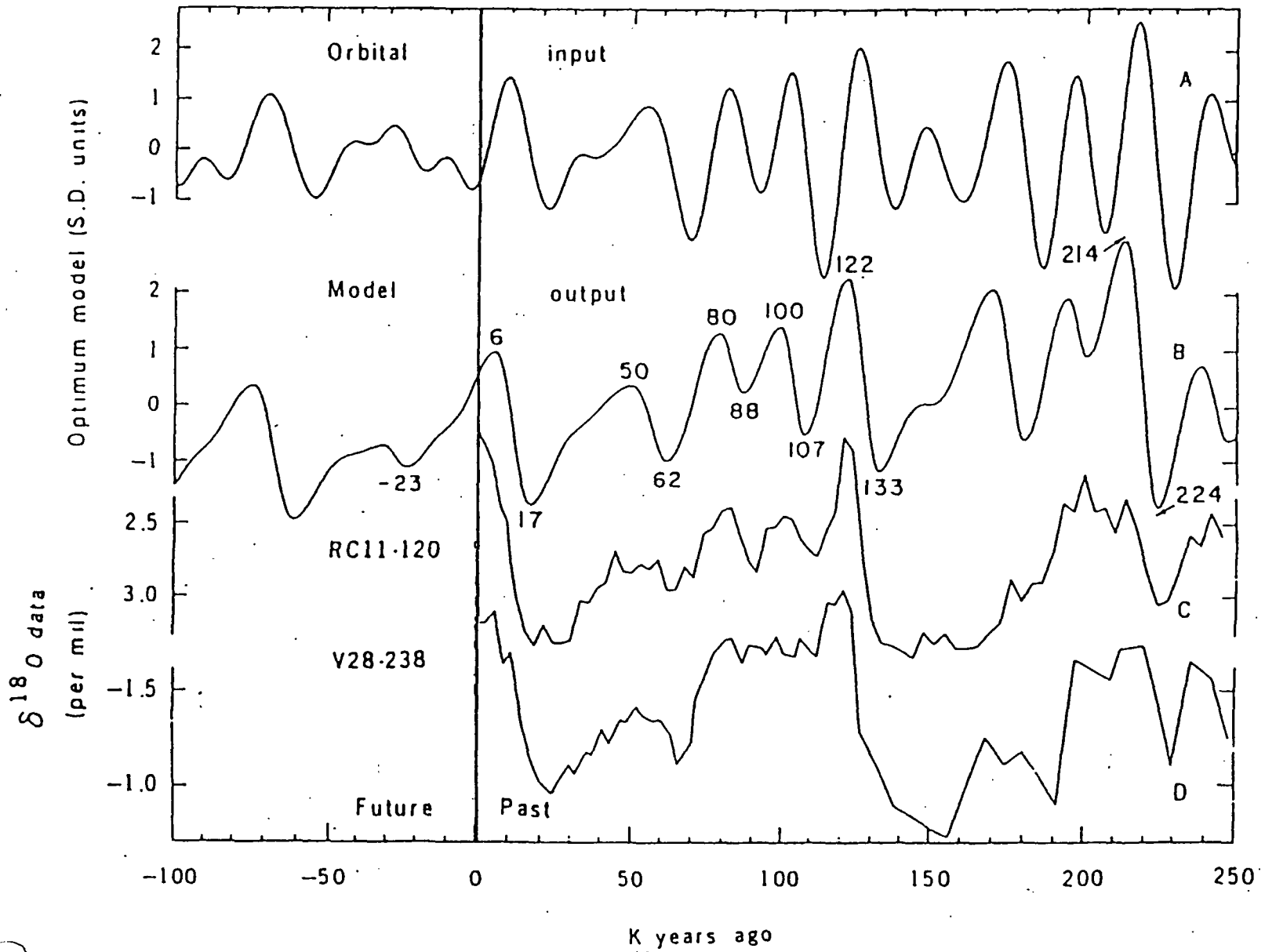
STABLE OXYGEN ISOTOPE RATIO VARIATIONS IN MICROFAUNA IN OCEAN CORES ILLUSTRATING REGULAR PATTERNS



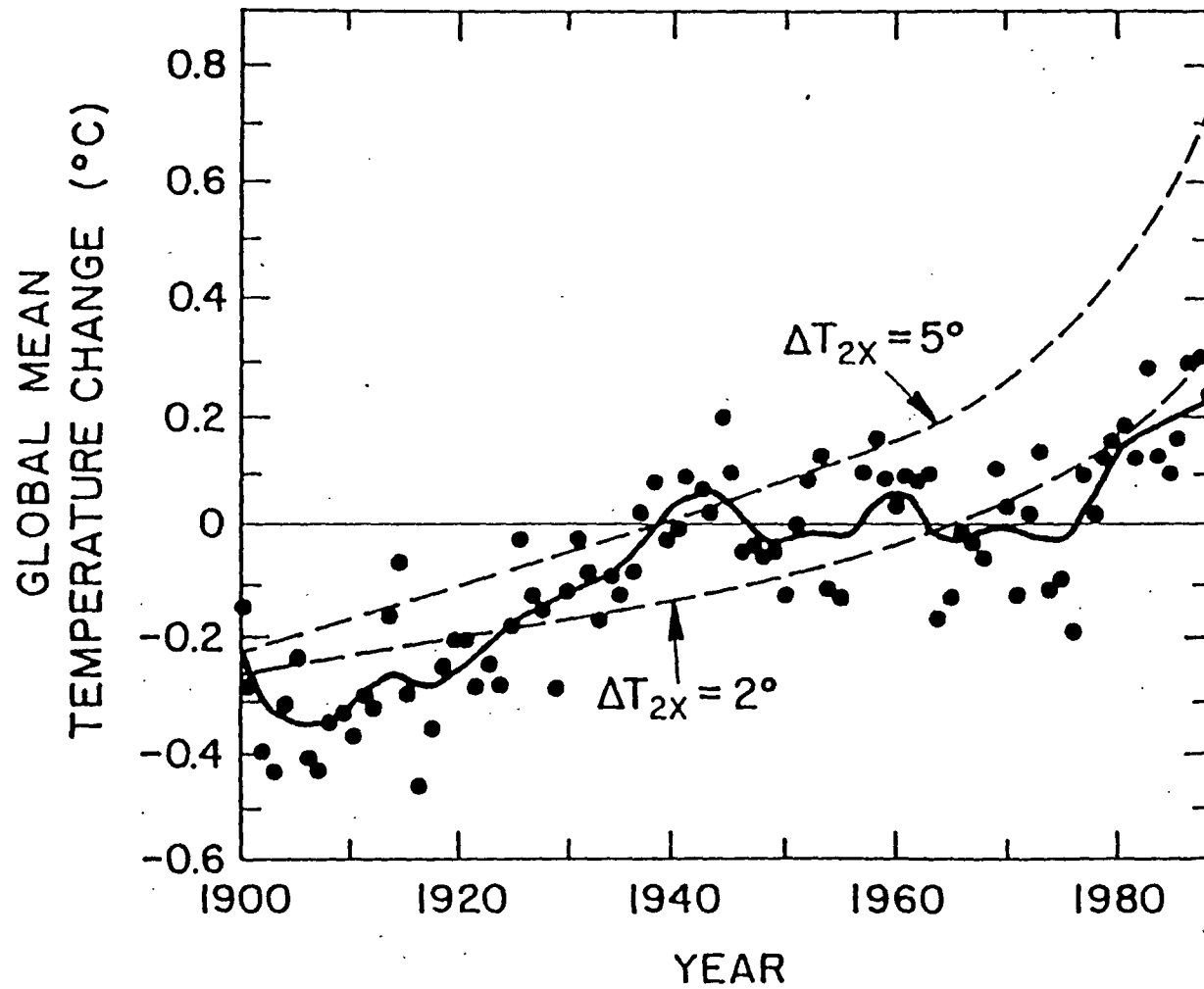
STABLE OXYGEN ISOTOPE RATIO VARIATIONS IN VEIN-FILLING CALCITE AT DEVIL'S HOLE, COMPARED WITH OCEAN CORE RECORD



TIME SERIES ANALYSIS OF OXYGEN ISOTOPE VARIATIONS IN OCEAN CORES



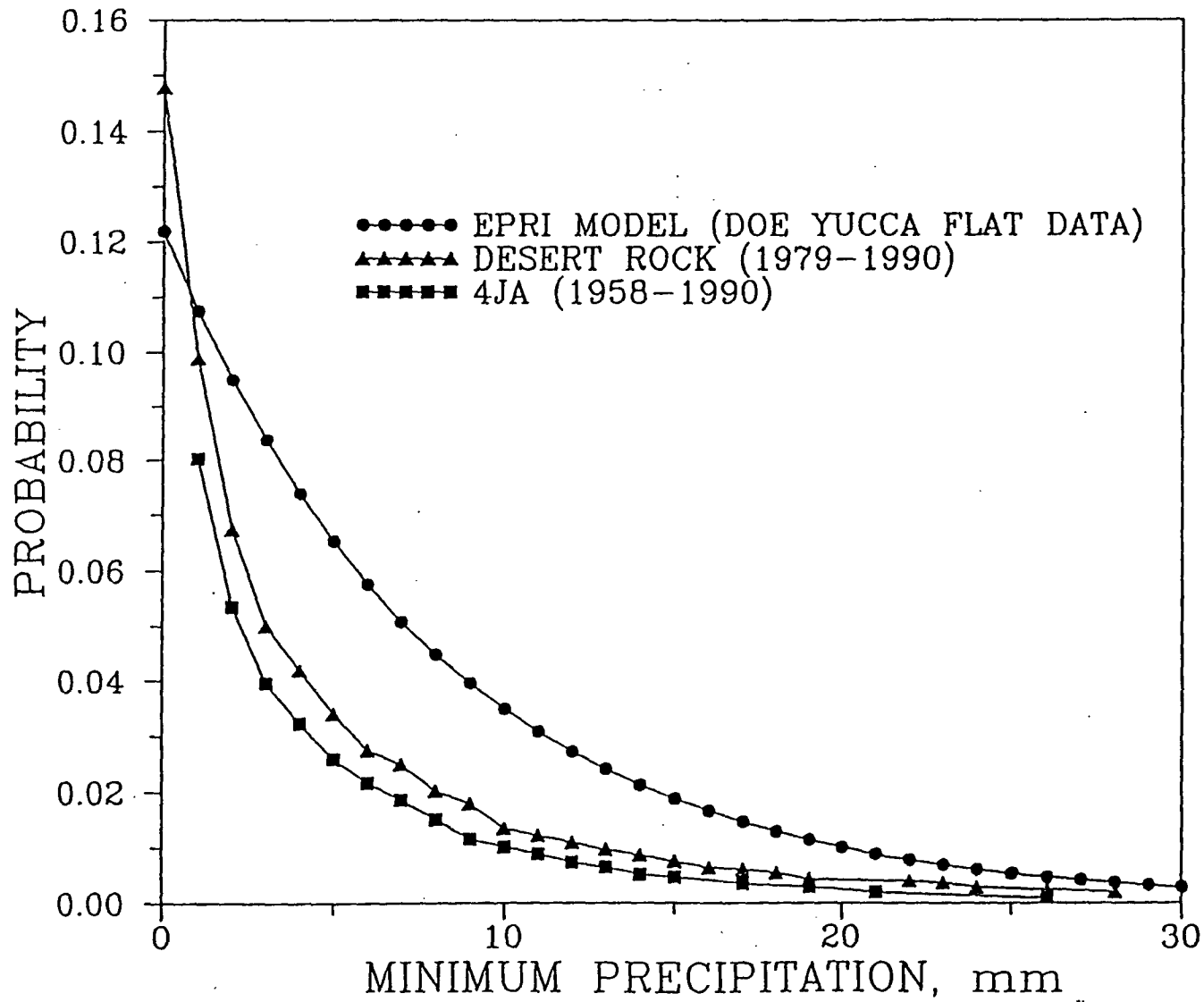
COMBINED LAND-AIR AND SEA SURFACE TEMPERATURES
FROM 1900, RELATIVE TO 1951-1980



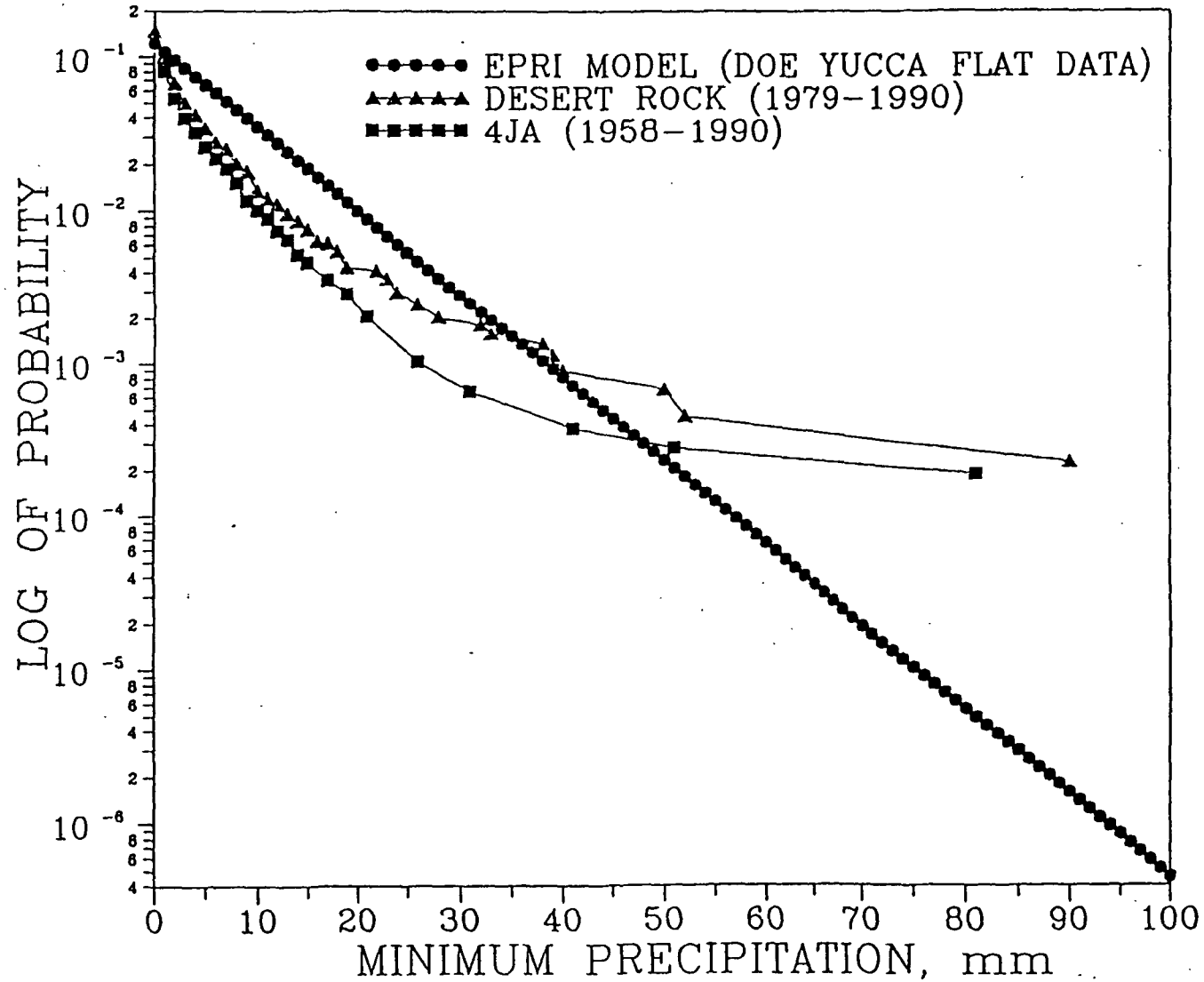
PRECIPITATION UNDER FUTURE CONDITIONS

<u>TEMPERATURE</u>	SAME	DRIER	WETTER
SAME	WINTER > 50% SUMMER < 50% NATURAL INFIL.	WINTER ↓ SUMMER ↓↓	WINTER ↑ SUMMER ↑ ARTIFICIAL INFIL.
COLDER	WINTER ↑ SUMMER ↓	WINTER ? SUMMER ↓	WINTER ↑ SUMMER ?
WARMER	WINTER ↓ SUMMER ↑	WINTER ↓ SUMMER ?	WINTER ? SUMMER ↑

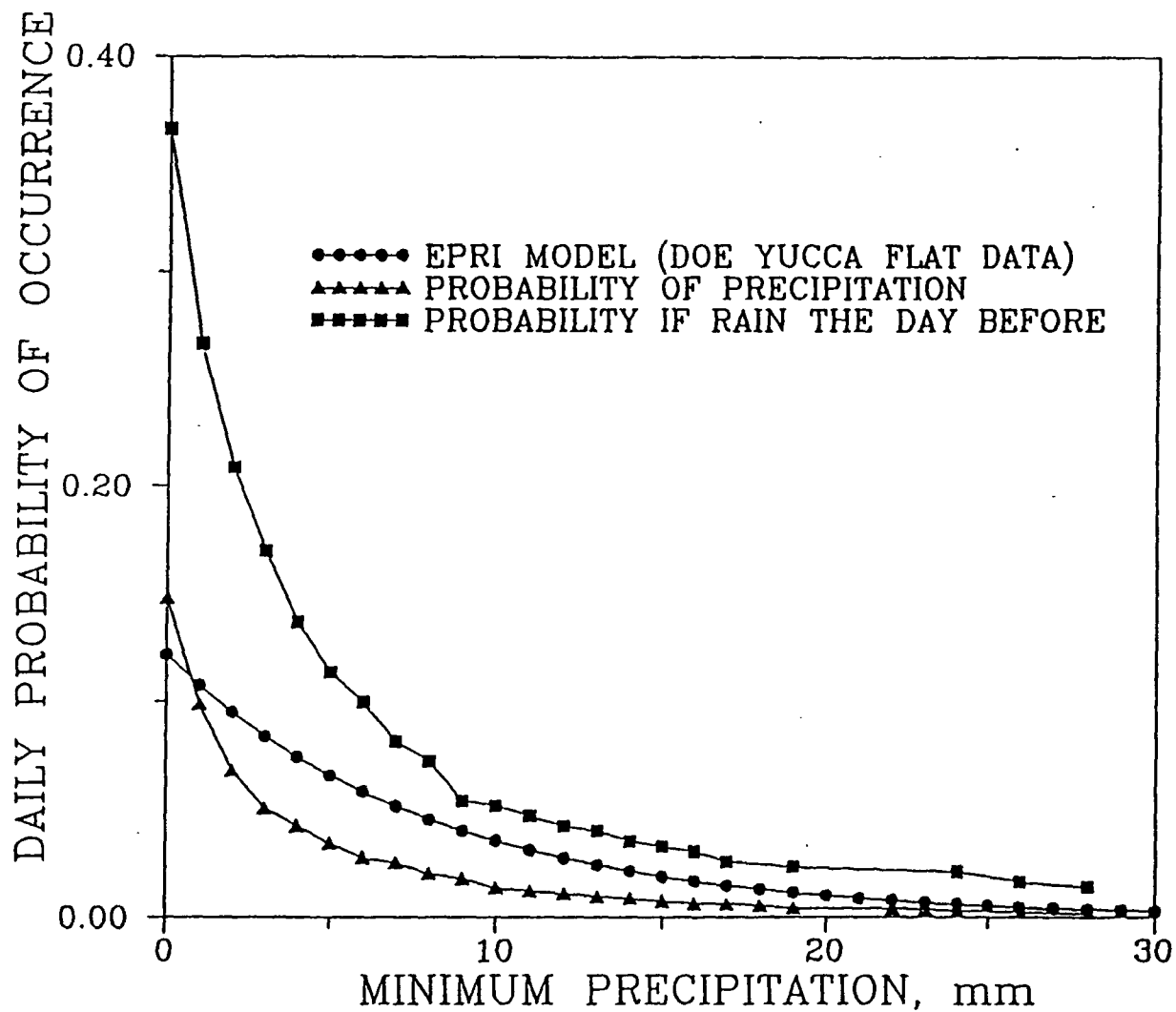
PROBABILITY OF PRECIPITATION



PROBABILITY OF PRECIPITATION



PROBABILITY OF PRECIPITATION AT DESERT ROCK



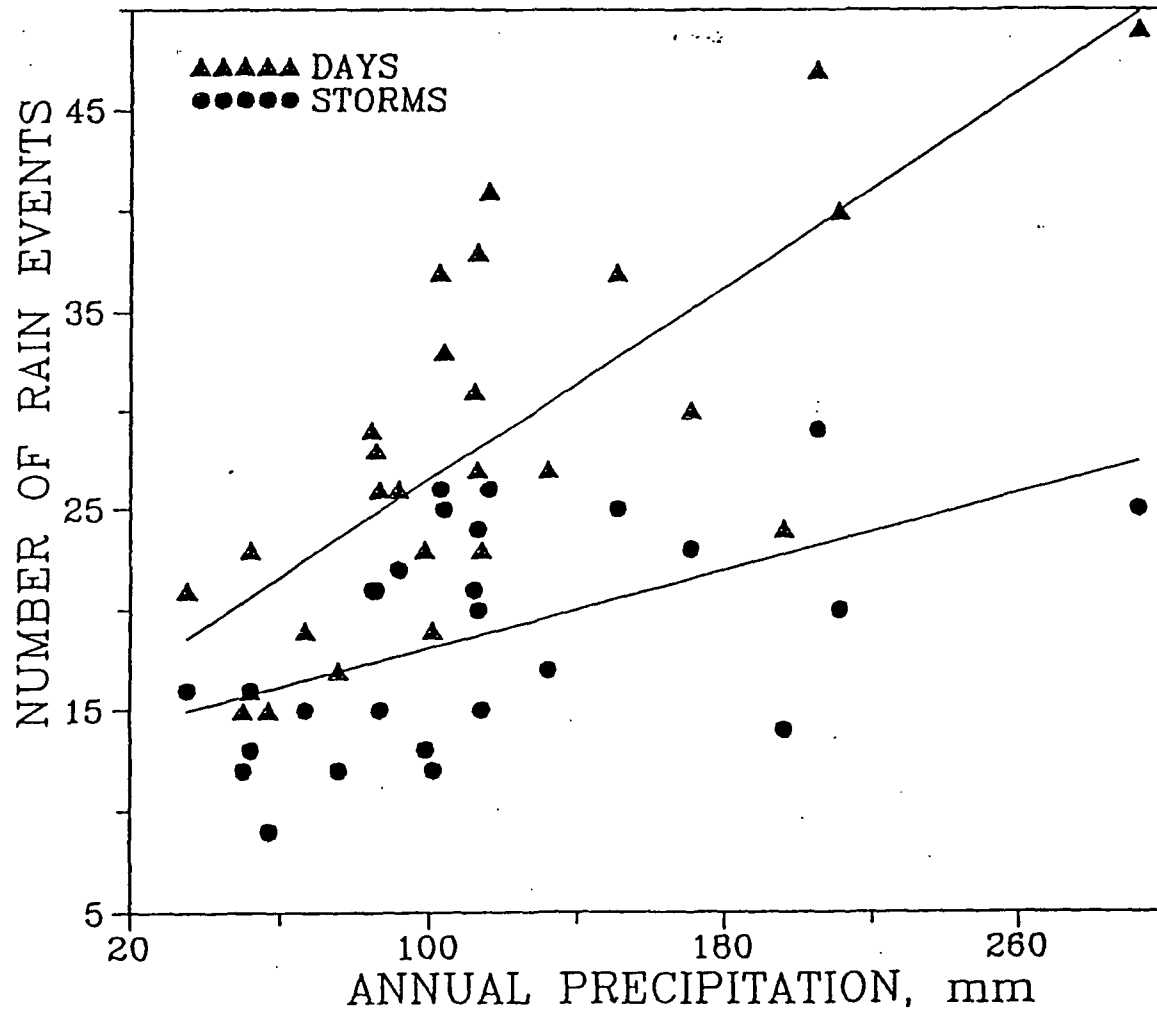
**NUMBER OF EVENTS IN WHICH A STORM ($\geq 0.5''$)
IS FOLLOWED BY ANOTHER STORM ($\geq 0.5''$)**

	1949-1972 Las Vegas	1948-1972 Beatty	1957-1985 4JA	1948-1972 Caliente
7 days	2 (11.5)*	2 (12.0)	6 (4.7)	4 (6.0)
14 days	6 (3.8)	3 (8.0)	8 (3.5)	6 (4.0)
21 days	8 (2.9)	3 (8.0)	11 (2.5)	8 (3.0)

* (Years/Events)

STORM DISTRIBUTION FOR 4JA (1958-1990)

DATASET INCLUDES YEARS WITH <10 PERCENT MISSING DAYS



RAINFALL SIMULATION

- o STOCHASTIC MODEL VARIABLE SPATIALLY AND TEMPORALLY**
- o CONSISTENT WITH CURRENT MECHANISMS AND DISTRIBUTIONS OF PRECIPITATION (GEOSTATISTICS-INDICATOR KRIGING, TIME SERIES)**
- o COUPLED WITH INFILTRATION SIMULATION AND ASSOCIATED MECHANISMS**
- o NCAR GLOBAL AND MESOSCALE CLIMATE MODEL**

SUMMARY

- o STUDY AREA IS 70,000 SQ. KILOMETERS CENTERED ON YUCCA MTN**
 - DETAIL INCREASES CLOSER TO YUCCA MOUNTAIN**
 - MANY SUPPORTING AGENCIES**

- o STRONG WINTER AND SUMMER REGIMES**
 - STRATIFORM PRECIPITATION (WINTER)**
 - CONVECTIVE CELLS (SUMMER)**

- o DATA COLLECTION IS ONGOING ACTIVITY**
 - WEATHER STATIONS**
 - PRECIPITATION STATIONS (AUTOMATED AND STORAGE)**
 - LIGHTNING DETECTION**
 - SATELLITE IMAGERY**
 - VIDEO TAPE OF STORM DEVELOPMENT**

- o DATA ANALYSIS**
 - STATISTICAL**
 - DETERMINISTIC**

- o USE EXISTING INFORMATION TO BUILD A NUMERICAL RAINFALL SIMULATOR**
 - CONSISTENT WITH KNOWN CONDITIONS, BUT VARIABLE FOR FUTURE CLIMATIC CHANGES**
 - USED AS INPUT TO INFILTRATION PROGRAM**
 - USED AS INPUT TO REGIONAL SATURATED ZONE PROGRAM**
 - USED AS INPUT TO FLOODING/RUNOFF ANALYSIS**