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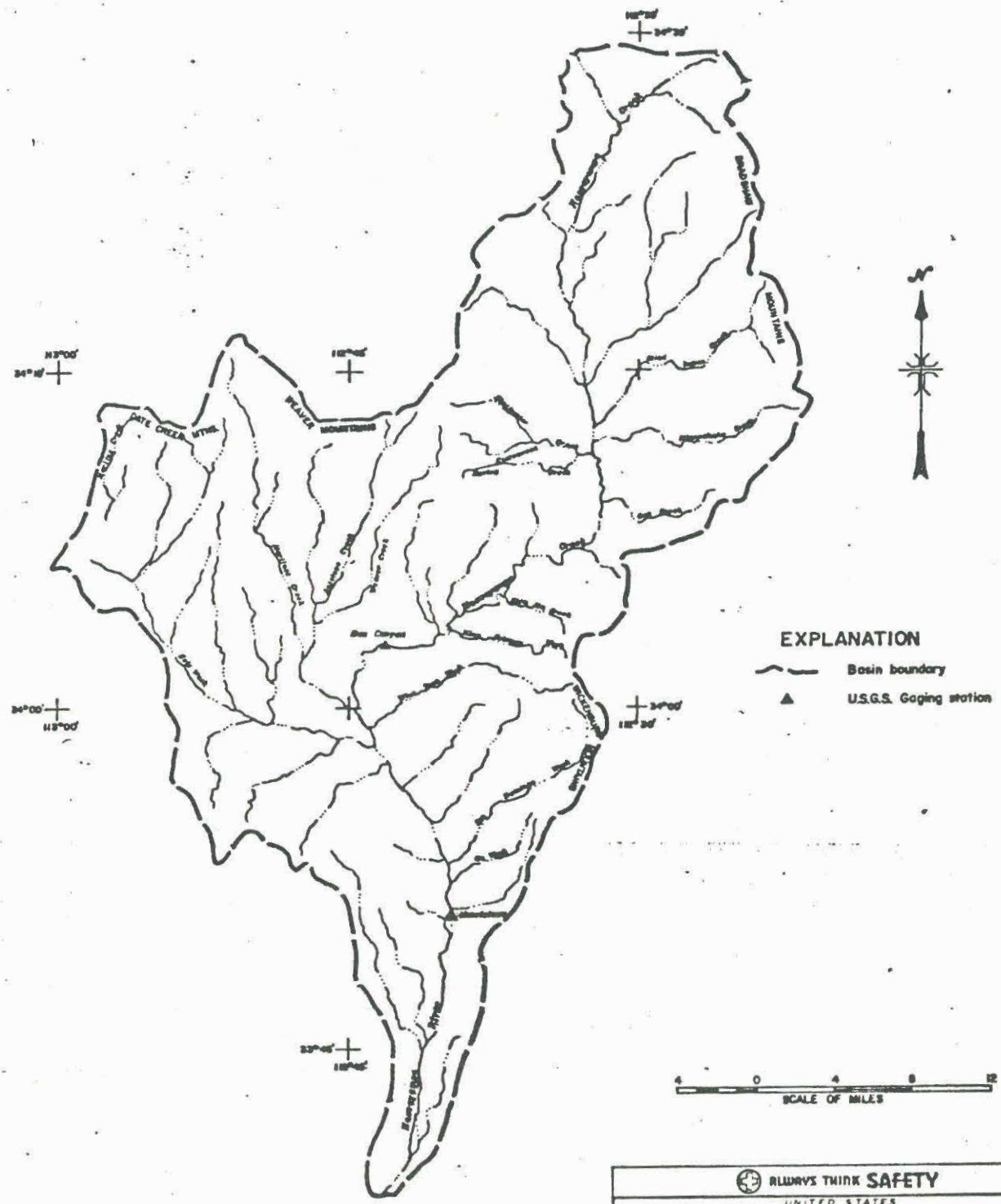
HASSAYAMPA RIVER SIPHON CROSSING

100-YEAR FLOOD STUDY

September 1976

Charlie A. Maish

06-0-00-1-09/76



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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT
GRANITE REEF DIVISION—ARIZONA

HASSAYAMPA RIVER SIPHON

BASIN MAP

DESIGNED ..... SUBMITTED .....
DRAWN JK ..... RECOMMENDED .....
CHECKED ..... APPROVED .....

PHOENIX, ARIZONA NOVEMBER 1, 1976 | 344-330-T-575

Hassayampa River

The proposed siphon crossing is located approximately 22 miles south of Wickenburg, Arizona. Previous studies on the siphon were made with the location approximately two miles upstream from present location.

The design 100-year flood for Hassayampa River Siphon has a peak discharge of 50,700 cubic feet per second.

Prior Study

A prior study prepared by the Phoenix Development Office in 1966, and approved by the Chief Engineer's Office, recommended a 100-year design value of 68,000 cubic feet per second be used in making scour estimates at the Hassayampa River siphon location. This study was for 852 square miles of drainage area and was based on 100-year-frequency rainfall and summation graph procedures, as derived by the Corps of Engineers for Streams in Arizona and southern California and presented in their report on flood control for Phoenix, Arizona and vicinity dated January 15, 1964.

Drainage Basin

Total drainage area above the proposed Hassayampa River Siphon crossing is about 880 square miles. The elongated basin is bounded to the east and north by the Bradshaw Mountains. The west boundary is determined by the Weaver and Date Creek mountain ranges, and by the drainage boundaries of Centennial and Jackrabbit Washes.

The upper third of the basin consists of mountains with heavy forest cover and contributes most of the runoff. Alluvial hills make up the central third and the southern third is typical desert terrain. Little streamflow occurs except during and immediately following rains.

The Hassayampa River heads in the Bradshaw Mountains at an elevation of about 7600 feet and ranges down to about 1380 feet at the siphon location. The mean slope of the river channel is 53.5 feet per mile. The centroid of the drainage area is about 42 stream miles above the siphon crossing.

Past Floods

No records exist for floods at the proposed siphon crossing, but streamflow records collected by the U.S. Geological Survey at two sites above and one site below the siphon do give an indication of the magnitude of past floods.

In the prior study prepared by the Phoenix Development Office in 1966, a study was also made for the 100-year frequency discharge at the Hassayampa River Siphon Crossing. A Hazen frequency was determined at the Box Canyon gaging station, with 20 years of record. A peak discharge of 40,980 cubic feet per second was obtained, results are included on plate 1. Since the gage measured about one-half the drainage area, a mean peak discharge which was selected from a mean peak discharge vs. drainage

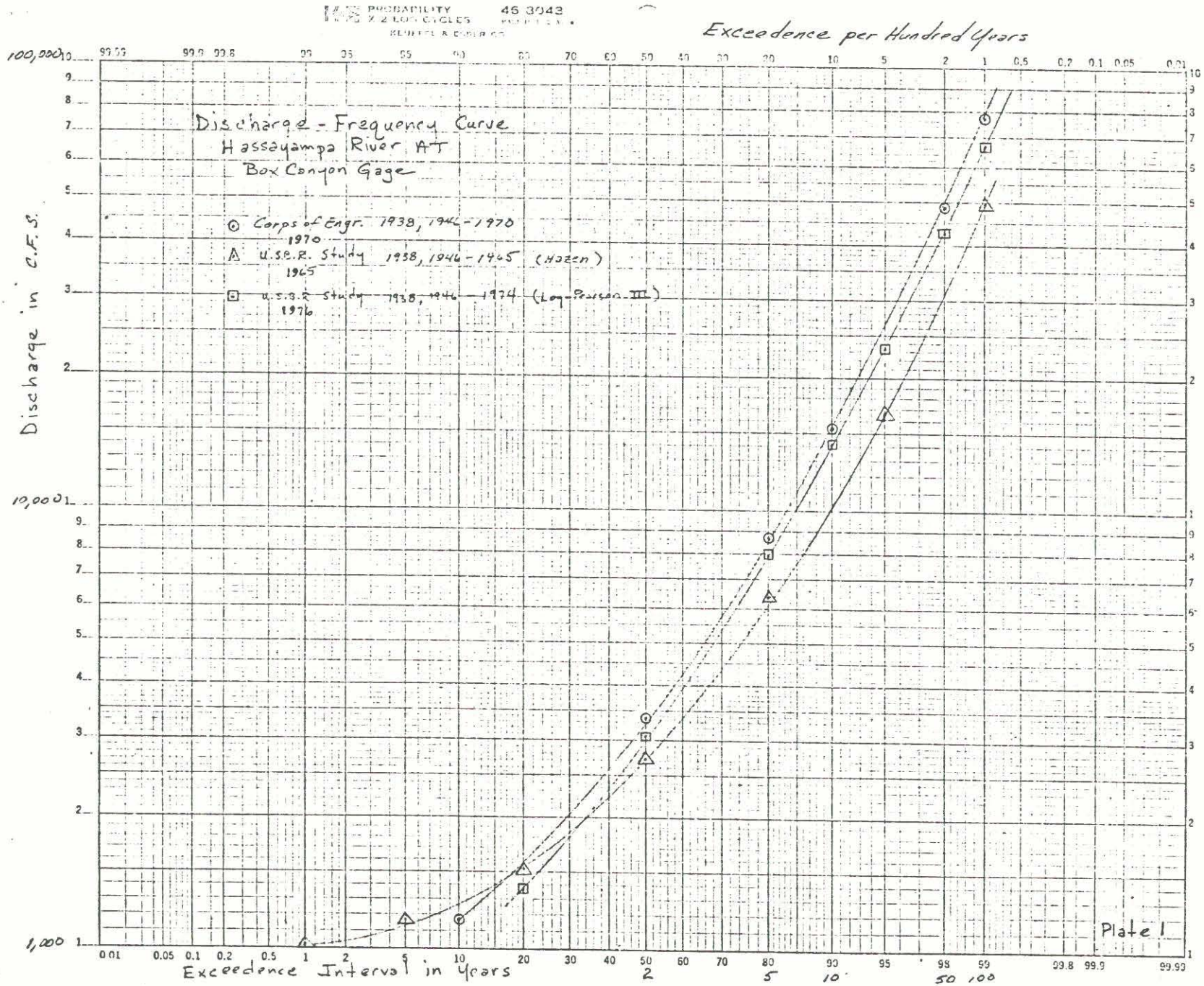
area curve derived for streams of this type and frequency distribution characteristics of the Box Canyon gage were applied to the Hassayampa River siphon crossing. In doing so, the discharge flow at the siphon crossing was increased to 55,440 cubic feet per second. However, indications from the downstream gage show that the large intervening drainage area, where runoff is mostly from desert areas and miles of sandy channel between locations prohibited the direct transfer of discharges from the Box Canyon gage to the siphon crossing. Conversely, many of the peaks to be expected at the siphon crossing can originate below the Box Canyon gaging station.

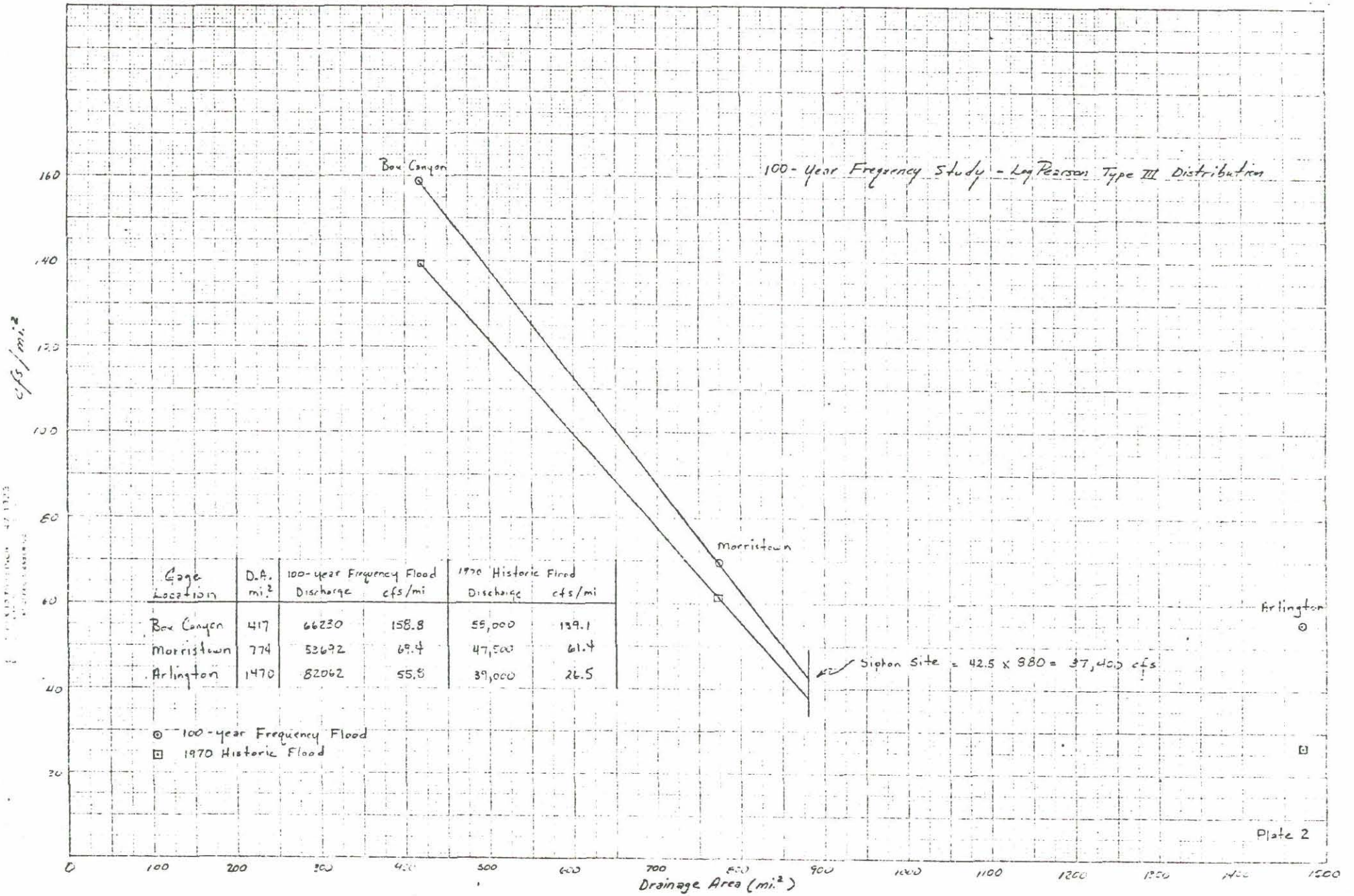
The present study applies a Log-Pearson frequency with 30 years of record at the Box Canyon gage station. Results of this area are shown on plate 1. The additional years increased the magnitude of the 100-year frequency at this location. This was due mainly from a major storm which occurred in 1970 with a peak discharge more than double the previous peak. A plot of values determined by the Corps of Engineers for Floodplain - Information in the Wickenburg area for years ending with the large flood indicated even a higher peak value. This is due to the absence of low peak values which have occurred since then. Hundred-year frequencies were also determined at the Morristown gage with 17 years of record (plate 3) and also at the Arlington gage with 11 years of record.

A plot of discharge, in cubic feet per second per square miles vs. discharge area (plate 2), resulted in a peak flow at the siphon crossing of 37,400 cubic feet per second. The relationship occurring between Morristown and Arlington gaging stations was omitted since flows at the Arlington location are influenced by the large intervening area, especially discharges by Jackrabbit Wash.

A least square fit for flood events occurring on the same date was applied at Box Canyon and Morristown gages to compute discharges for missing years at the Morristown gage. The frequency curve shown on plate 3 was obtained at the Morristown gage with 37 years of record. The peak discharge was less than obtained with actual gage readings and was therefore omitted. The 100-year discharge of 54,000 cubic feet per second was used as an estimate of flow at the Morristown gage.

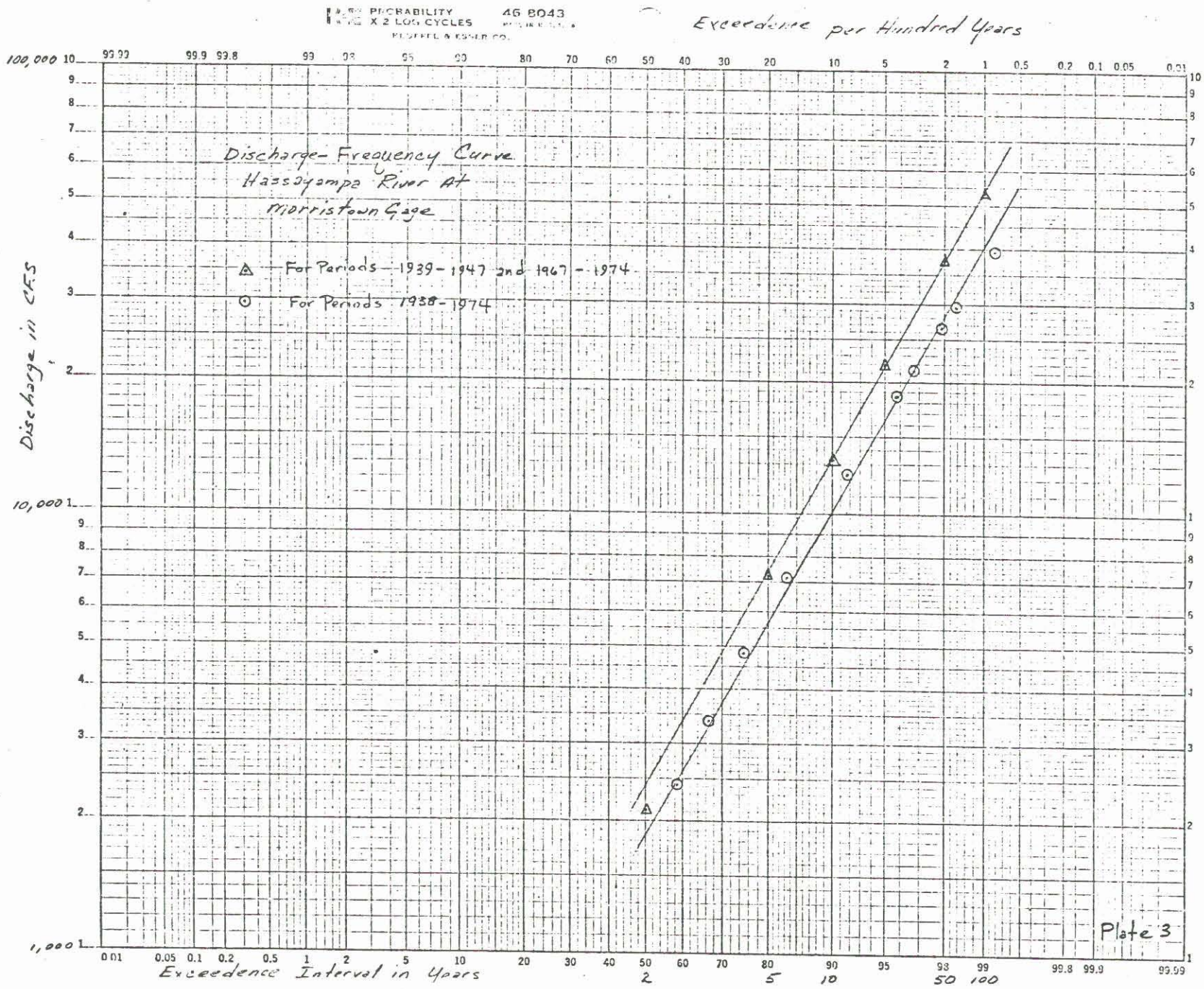
Since the siphon crossing is in close proximity to the Morristown gage, the relationship that the flow at the siphon crossing is approximately equal to $\sqrt{\text{D.A. at the Morristown gage/D.A. at the siphon crossing}}$ X discharge at the Morristown gage, yielded a peak discharge of 50,643 cubic feet per second.


PROBABILITY 46 3043
X 2 LOG CYCLES
KEUFFEL & ESSER CO.
Exceedence per Hundred Years
Discharge - Frequency Curve
Hassayampa River AT
Box Canyon Gage
Corps of Engr. 1938, 1946-1970
U.S.B.R. Study 1938, 1946-1965 (Hazen)
U.S.G.S. Study 1938, 1946-1974 (Log-Pearson III)
Discharge in C.F.S.
100,000
10,000
1,000
Exceedence Interval in Years
Plate 1



Gage Location	D.A. mi.²	100-year Frequency Flood Discharge	cfs/mi	1970 Historic Flood Discharge	cfs/mi
Box Canyon	417	66230	158.8	58,000	139.1
Morristown	774	53692	69.4	47,500	61.4
Arlington	1470	82062	55.8	39,000	26.5

Plate 2


PROBABILITY
X 2 LOG CYCLES
46 8043
KEUFFEL & ESSER CO.
Exceedence per Hundred Years
Discharge-Frequency Curve
Hassayampa River At
Morristown Gage
For Periods 1939-1947 and 1967-1974
For Periods 1938-1974
Discharge in CFS
100,000
10,000
1,000
Exceedence Interval in Years
Plate 3

Hassayampa River

Year	Box Canyon D.A.= 417 mi.^{2}	Morristown D.A.= 774 mi.^{2}	Arlington D.A.= 1470 mi.^{2}
1974	5560	650	
1973	2600	2000	12300
1972	800	700	225
1971	556	2000	1230
1970	58000	47500	39000
1969	4630	650	
1968	11200	4800	4000
1967	1740	1150	5270
1966	5560		1600
1965	9060		3000
1964	1230		6500
1963	2150		1930
1962	1510		470
1961	1150		
1960	3210		
1959	5110		
1958	10600		
1957	1980		
1956	1210		
19 -	8840		
1954	3090		

1953	865			
1952	1590			
1951	27000			
1950	5500			
1949	2910			
1948	5600			
1947	2300	6000		
1946	1710	2310		
1945		2200		
1944		3520		
1943		7700		
1942		100		
1941		6100		
1940		160		
1939		6200		
1938	10000			

FLOOD FREQUENCY STUDY-PEARSON TYPE 3 DISTRIBUTION (LOGARITHMS)

HASSAYAMPA RIVER NEAR BOX DAM SITE - ANNUAL PEAKS

DA = 417 SQ MI PERIOD 1938 AND 1946-1974

YEAR	DISCHARGE (CFS)	DISCHARGE (LOG 10)	PLOTTING POSITION
1970	58000	4.7634280	1.667
1951	27000	4.4313638	5.000
1968	11200	4.0492180	8.333
1958	10600	4.0253059	11.667
1938	10000	4.0000000	15.000
1965	9060	3.9571282	18.333
1955	8840	3.9464523	21.667
1948	5600	3.7481880	25.000
1966	5560	3.7450748	28.333
1974	5560	3.7450748	31.667
1950	5500	3.7403627	35.000
1959	5110	3.7084209	38.333
1969	4630	3.6655810	41.667
1960	3210	3.5065050	45.000
1954	3090	3.4899585	48.333
1949	2910	3.4638930	51.667
1973	2600	3.4149733	55.000
1947	2300	3.3617278	58.333
1963	2150	3.3324385	61.667
1957	1980	3.2966652	65.000
1967	1740	3.2405492	68.333
1946	1710	3.2329961	71.667
1952	1590	3.2013971	75.000
1962	1510	3.1789769	78.333
1964	1230	3.0899051	81.667
1956	1210	3.0827854	85.000
1961	1150	3.0606978	88.333
1953	865	2.9370161	91.667
1972	800	2.9030900	95.000
1971	556	2.7450748	98.333

FLOOD FREQUENCY STUDY-PEARSON TYPE 3 DISTRIBUTION (LOGARITHMS)

HASSAYAMPA RIVER NEAR BOX DAM SITE - ANNUAL PEAKS
DA = 417 SQ MI PERIOD 1938 AND 1946-1974

NUMBER OF FLOOD PEAKS(OBSERVATIONS) = 30

ARITHMETIC MEAN = 6575.367

NUMBER OF OBSERVATIONS EQUAL TO ZERO = 0

NUMBER OF OBSERVATIONS USED (STATISTICS) = 30

MEAN OF LOGARITHMS = 3.5354749

GEOMETRIC MEAN = 3431.428

STANDARD DEVIATION OF LOGARITHMS = .4615789

COEFFICIENT OF SKEWNESS(LOG10) = .6378

SKEW FACTORS	SELECTED RECURRENCE INTERVAL (PERCENT)	COMPUTED DISCHARGES (LOG 10)	(CFS)
-1.858	99.00	2.6779544	476
-1.445	95.00	2.8683097	738
-1.193	90.00	2.9847337	965
-.856	80.00	3.1405425	1382
-.105	50.00	3.4869600	3068
.794	20.00	3.9021032	7981
1.328	10.00	4.1485384	14077
1.804	5.00	4.3681164	23340
1.949	4.00	4.4348985	27220
2.378	2.00	4.6333070	42984
2.765	1.00	4.8210594	66230
3.175	.50	5.0007820	100180
4.031	.10	5.3958729	248812
5.178	.01	5.9254241	842217

FLOOD FREQUENCY STUDY-PEARSON TYPE 3 DISTRIBUTION (LOGARITHMS)

HASSAYAMPA RIVER NEAR MORRISTOWN - ANNUAL PEAKS PAGE 1
DA = 774 SQ MI PERIOD 1939-1947 AND 1967-1974

YEAR	DISCHARGE (CFS)	DISCHARGE (LOG 10)	PLOTTING POSITION
1970	47500	4.6766936	2.941
1943	7700	3.8864907	8.824
1939	6200	3.7923917	14.706
1941	6100	3.7853298	20.588
1947	6000	3.7781513	26.471
1968	4800	3.6812412	32.353
1944	3520	3.5465427	38.235
1946	2310	3.3636120	44.118
1945	2200	3.3424227	50.000
1971	2000	3.3010300	55.882
1973	2000	3.3010300	61.765
1967	1150	3.0606978	67.647
1972	700	2.8450980	73.529
1969	650	2.8129134	79.412
1974	650	2.8129134	85.294
1940	160	2.2041200	91.176
1942	100	2.0000000	97.059

FLOOD FREQUENCY STUDY-PEARSON TYPE 3 DISTRIBUTION (LOGARITHMS)

HASSAYAMPA RIVER NEAR MORRISTOWN - ANNUAL PEAKS
DA = 774 SQ MI PERIOD 1939-1947 AND 1967-1974

NUMBER OF FLOOD PEAKS(OBSERVATIONS) = 17

ARITHMETIC MEAN = 5514.118

NUMBER OF OBSERVATIONS EQUAL TO ZERO = 0

NUMBER OF OBSERVATIONS USED (STATISTICS) = 17

MEAN OF LOGARITHMS = 3.3053340

GEOMETRIC MEAN = 2019.919

STANDARD DEVIATION OF LOGARITHMS = .6512984

COEFFICIENT OF SKEWNESS(LOG10) = -.1887

SKEW FACTORS	SELECTED RECURRENCE INTERVAL (PERCENT)	COMPUTED DISCHARGES (LOG 10)	(CFS)
-2.465	99.00	1.7002008	50
-1.697	95.00	2.2003093	158
-1.300	90.00	2.4587165	287
-.831	80.00	2.7641123	580
.031	50.00	3.3257963	2117
.849	20.00	3.8584924	7219
1.260	10.00	4.1256629	13355
1.589	5.00	4.3405607	21905
1.684	4.00	4.4022006	25246
1.951	2.00	4.5763083	37697
2.187	1.00	4.7299123	53692
2.399	.50	4.8680180	73793
2.825	.10	5.1454106	139768
3.326	.01	5.4712282	295956

FLOOD FREQUENCY STUDY-PEARSON TYPE 3 DISTRIBUTION (LOGARITHMS)

HASSAYAMPA RIVER NEAR MORRISTOWN - ANNUAL PEAKS
DA = 774 SQ MI PERIOD 1939-1947 AND 1967-1974

NUMBER OF FLOOD PEAKS(OBSERVATIONS) = 17

ARITHMETIC MEAN = 5514.118

NUMBER OF OBSERVATIONS EQUAL TO ZERO = 0

NUMBER OF OBSERVATIONS USED (STATISTICS) = 17

MEAN OF LOGARITHMS = 3.3053340

GEOMETRIC MEAN = 2019.919

STANDARD DEVIATION OF LOGARITHMS = .6512984

COEFFICIENT OF SKEWNESS(LOG10) = -.1887

SKEW FACTORS	SELECTED RECURRENCE INTERVAL (PERCENT)	COMPUTED DISCHARGES (LOG 10)	(CFS)
-2.465	99.00	1.7002008	50
-1.697	95.00	2.2003093	158
-1.300	90.00	2.4587165	287
-.831	80.00	2.7641123	580
.031	50.00	3.3257963	2117
.849	20.00	3.8584924	7219
1.260	10.00	4.1256629	13355
1.589	5.00	4.3405607	21905
1.684	4.00	4.4022006	25246
1.951	2.00	4.5763083	37697
2.187	1.00	4.7299123	53692
2.399	.50	4.8680180	73793
2.825	.10	5.1454106	139768
3.326	.01	5.4712282	295956

FLOOD FREQUENCY STUDY-PEARSON TYPE 3 DISTRIBUTION (LOGARITHMS)

HASSAYAMPA RIVER NEAR ARLINGTON - ANNUAL PEAKS PAGE 1
DA = 1470 SQ MI PERIOD 1962-1968 AND 1970-1973

YEAR	DISCHARGE (CFS)	DISCHARGE (LOG 10)	PLOTTING POSITION
1970	39000	4.5910646	4.545
1973	12300	4.0899051	13.636
1964	6500	3.8129134	22.727
1967	5270	3.7218106	31.818
1968	4000	3.6020600	40.909
1965	3000	3.4771213	50.000
1963	1930	3.2855573	59.091
1966	1600	3.2041200	68.182
1971	1230	3.0899051	77.273
1962	470	2.6720979	86.364
1972	225	2.3521825	95.455

FLOOD FREQUENCY STUDY-PEARSON TYPE 3 DISTRIBUTION (LOGARITHMS)

HASSAYAMPA RIVER NEAR ARLINGTON - ANNUAL PEAKS
DA = 1470 SQ MI PERIOD 1962-1968 AND 1970-1973

NUMBER OF FLOOD PEAKS(OBSERVATIONS) = 11

ARITHMETIC MEAN = 6865.909

NUMBER OF OBSERVATIONS EQUAL TO ZERO = 0

NUMBER OF OBSERVATIONS USED (STATISTICS) = 11

MEAN OF LOGARITHMS = 3.4453398

GEOMETRIC MEAN = 2788.302

STANDARD DEVIATION OF LOGARITHMS = .6299377

COEFFICIENT OF SKEWNESS(LOG10) = .0072

SKEW FACTORS	SELECTED RECURRENCE INTERVAL (PERCENT)	COMPUTED DISCHARGES (LOG 10)	(CFS)
-2.321	99.00	1.9832342	96
-1.643	95.00	2.4104833	257
-1.281	90.00	2.6385326	435
-.842	80.00	2.9149516	822
-.001	50.00	3.4445806	2783
.841	20.00	3.9752851	9446
1.282	10.00	4.2531224	17911
1.647	5.00	4.4827859	30393
1.753	4.00	4.5497315	35459
2.058	2.00	4.7415162	55146
2.332	1.00	4.9141444	82062
2.583	.50	5.0722306	118094
3.101	.10	5.3984862	250314
3.734	.01	5.7978408	627828

Common Flood Occurrences

Date	Box Canyon	Morristown
July 20 1974	5560	650
Oct 7 1973	2600	2000
Aug 27 1972	800	700
Sept 5 1970	58000	47500
Sept 13 1969	4630	650
Dec 19 1968	11200	4800
Dec 10 1966	5560	1600
Aug 8 1947	2300	6000

76/09/24. 16.53.55.
PROGRAM — CMHASS

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2600.000000	2000.000000
800.000000	700.000000
58000.000000	47500.000000
4630.000000	650.000000
11200.000000	4800.000000
5560.000000	1600.000000
2300.000000	6000.000000

0WEIGHT FACTOR = 1

0 NO. OF PARAMETERS = 2 NO. OF DATA POINTS = 8

Y OBS	Y CALC	RESIDUAL	RELATIVE ERROR
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2000.000000	752.669355	1247.330645	.623665
700.000000	-738.835845	1438.835845	2.055480
47500.000000	46657.884955	842.115045	.017729
650.000000	2434.755775	-1784.755775	-2.745778
4800.000000	7878.749755	-3078.749755	-.641406
1600.000000	3205.366795	-1605.366795	-1.003354
6000.000000	504.085155	5495.914845	.915986

EXPONENT OF X	PARAMETERS	VARIANCES	STD. ERRORS
0	-1401.727045	1644202.514143	1282.264604
1	.828614	.003669	.060570

COVARIANCES
-41.570593

$y = .828614\ x - 1401.727045$

VARIANCE AND STD. ERROR OF Y(I) SUM R SQ.
9385245.882184 3063.534867 56311475.293105

1 LEAST SQUARES, CONTINUED

0WEIGHT FACTOR = 1

0 NO. OF PARAMETERS = 3 NO. OF DATA POINTS = 8

Y OBS	Y CALC	RESIDUAL	RELATIVE ERROR
650.000000	2372.114618	-1722.114618	-2.649407
2000.000000	2016.115418	-16.115418	-.008058
700.000000	1928.149418	-1228.149418	-1.754499
47500.000000	52256.713418	-4756.713418	-.100141
650.000000	2231.945018	-1581.945018	-2.433762
4800.000000	3777.997418	1022.002582	.212917
1600.000000	2372.114618	-772.114618	-.482572
6000.000000	1994.704418	4005.295582	.667549

EXPONENT OF X	PARAMETERS	VARIANCES	STD. ERRORS
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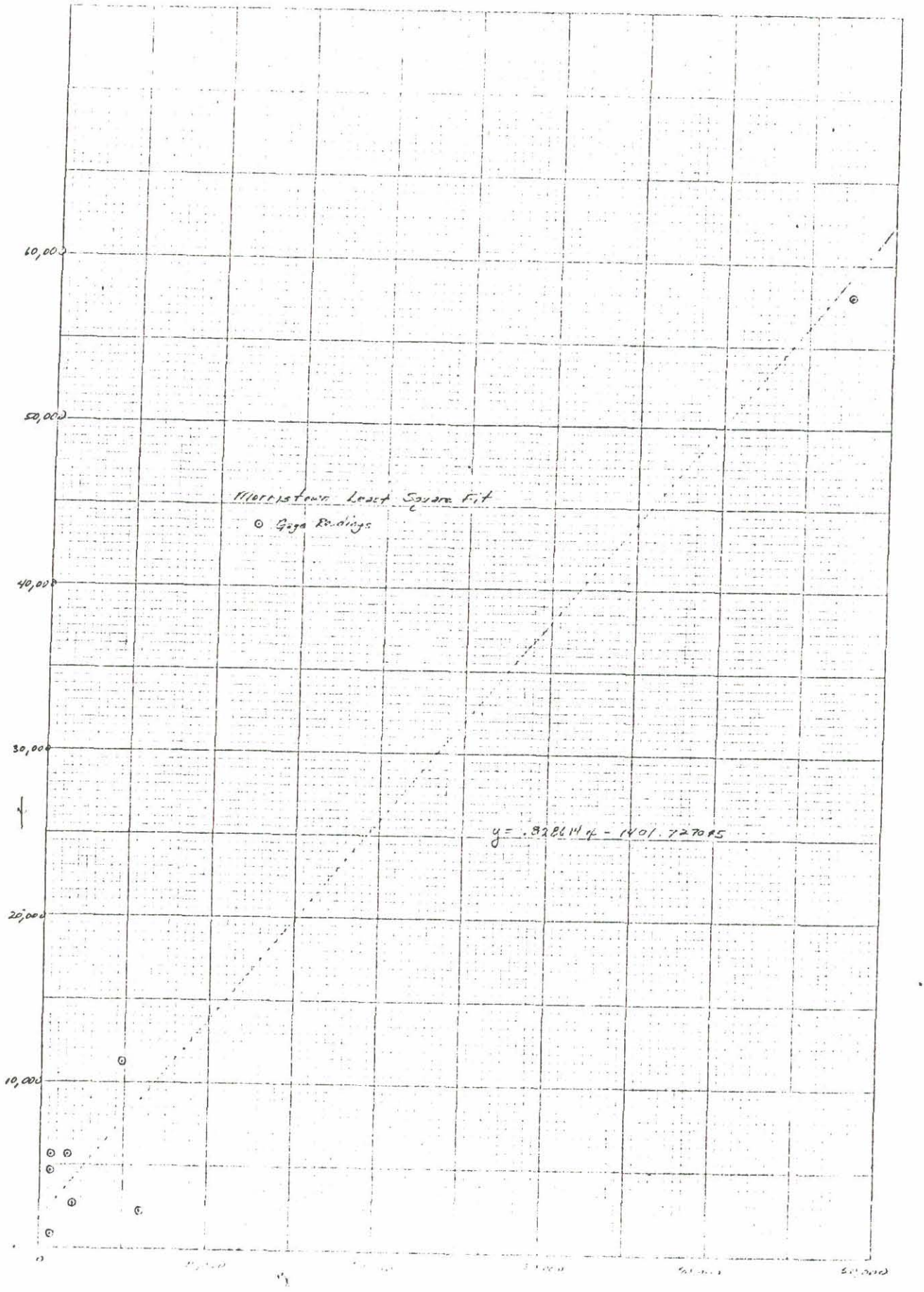
2	.000015	.000000	.000007

COVARIANCES


60,000
50,000
40,000
30,000
20,000
10,000
Morristown Least Square Fit
Gage Readings
y = .82814 x - 1401.72705

		y= .828614 X - 1401.72045
Year	Box Canyon	Morristown
1974	5560	650 *
1973	2600	2000 *
1972	800	700 *
1971	556	2000 *
1970	58000	47500 *
1969	4630	650 *
1968	11200	4800 *
1967	1740	1150 *
1966	5560	3205
1965	9060	6106
1964	1230	0
1963	2150	380
1962	1510	0
1961	1150	0
1960	3210	1258
1959	5110	2832
1958	10600	7382
1957	1980	239
1956	1210	0
1955	8840	5923
1954	3090	1159
1953	865	0
19[illegible]	1590	0
1951	27000	20971

cont. on next page

1950	5500	3156
1949	2910	1010
1948	5600	3239
1947	2300	6000 *
1946	1710	2310 *
1945		2200 *
1944		3520 *
1943		7700 *
1942		100 *
1941		6100 *
1940		160 *
1939		6200 *
1938	10000	6884

* Gage Readings

FLOOD FREQUENCY STUDY-PEARSON TYPE 3 DISTRIBUTION (LOGARITHMS)

HASSAYAMPA RIVER NEAR MORRISTOWN - DA = 774 SQ MI PAGE 1
FREQUENCY PERIOD 1938-1974

YEAR	DISCHARGE (CFS)	DISCHARGE (LOG 10)	PLOTTING POSITION
1970	47500	4.6766936	1.351
1951	20971	4.3216191	4.054
1943	7700	3.8864907	6.757
1958	7382	3.8681740	9.459
1938	6884	3.8378409	12.162
1939	6200	3.7923917	14.865
1965	6106	3.7857568	17.568
1941	6100	3.7853298	20.270
1947	6000	3.7781513	22.973
1955	5923	3.7725417	25.676
1968	4800	3.6812412	28.378
1944	3520	3.5465427	31.081
1948	3239	3.5104109	33.784
1966	3205	3.5058280	36.486
1950	3156	3.4991370	39.189
1959	2832	3.4520932	41.892
1946	2310	3.3636120	44.595
1945	2200	3.3424227	47.297
1971	2000	3.3010300	50.000
1973	2000	3.3010300	52.703
1960	1258	3.0996806	55.405
1954	1159	3.0640834	58.108
1967	1150	3.0606978	60.811
1949	1010	3.0043214	63.514
1972	700	2.8450980	66.216
1974	650	2.8129134	68.919
1969	650	2.8129134	71.622
1963	380	2.5797836	74.324
1957	239	2.3783979	77.027
1940	160	2.2041200	79.730
1942	100	2.0000000	82.432
1956	0.	INFINITY	85.135
1961	0.	INFINITY	87.838
1953	0.	INFINITY	90.541
1952	0.	INFINITY	93.243
1962	0.	INFINITY	95.946
1964	0.	INFINITY	98.649

FLOOD FREQUENCY STUDY-PEARSON TYPE 3 DISTRIBUTION (LOGARITHMS)

HASSAYAMPA RIVER NEAR MORRISTOWN - DA = 774 SQ MI
FREQUENCY PERIOD 1938-1974

NUMBER OF FLOOD PEAKS(OBSERVATIONS) = 37

ARITHMETIC MEAN = 4256.324

NUMBER OF OBSERVATIONS EQUAL TO ZERO = 6

NUMBER OF OBSERVATIONS USED (STATISTICS) = 31

MEAN OF LOGARITHMS = 3.3506564

GEOMETRIC MEAN = 2242.107

STANDARD DEVIATION OF LOGARITHMS = .5922759

COEFFICIENT OF SKEWNESS(LOG10) = -.3051

SKEW FACTORS	SELECTED RECURRENCE INTERVAL (PERCENT)	COMPUTED DISCHARGES (LOG-10)	(CFS)	ADJUSTED RECURRENCE INTERVAL (PERCENT)
-2.549	99.00	1.8409598	69	82.946
-1.727	95.00	2.3279732	212	79.595
-1.309	90.00	2.5751731	375	75.405
-.823	80.00	2.8632185	729	67.027
.051	50.00	3.3506990	2402	41.892
.300	40.00	3.5280627	3373	33.514
.559	30.00	3.6814961	4802	25.135
.853	20.00	3.8556197	7171	16.757
1.244	10.00	4.0875428	12233	8.378
1.554	5.00	4.2708626	18657	4.189
1.642	4.00	4.3228959	21032	3.351
1.812	2.50	4.4239769	26544	2.095
1.887	2.00	4.4685089	29410	1.676
2.101	1.00	4.5952633	39378	.838
2.291	.50	4.7078170	51028	.419
2.666	.10	4.9296887	85052	.084
2.806	.05	5.0124363	102904	.042
3.093	.01	5.1827485	152317	.008