SUSITNA HYDROELECTRIC PROJECT

FLOOD FREQUENCY ANALYSES FOR NATURAL AND WITH-PROJECT CONDITIONS

Report By
Harza-Ebasco Susitna Joint Venture

Prepared for
Alaska Power Authority

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1.0 SUMMARY

Flood frequency analyses were made for the Susitna River at Gold Creek, Sunshine and Susitna Station for natural and with-project conditions. Flood frequency curves were derived for the natural conditions for annual, May-June and July-September periods using maximum historic floods in each period. Watana Reservoir inflow flood hydrographs for the 2-, 5-, 10-, 25- and 50-year recurrence intervals and for annual, May-June and July-September periods were derived by transposing the flood peaks and volumes of corresponding periods and recurrence intervals at Gold Creek. These hydrographs were routed through the reservoir using criteria discussed under Section 5.2.2 of this report to obtain with-project outflows from the Watana Reservoir. For the reservoir flood routings, starting reservoir elevations were derived from the "start of the week reservoir elevations" obtained from the weekly reservoir operations study for the period 1950 through 1983. They were assumed to be the median values during the June, May-June, and July-September periods, for annual, May-June and July-September floods, respectively. The median value for June was taken as the starting water surface elevation of annual floods because this is the month in which the annual flood is most likely to occur.

Median reservoir water surface elevations were computed based on the energy demands for the years 1996 and 2001 (Watana operation) and for the years 2002 and 2020 (Watana - Devil Canyon operation). Based on these elevations, Watana Reservoir outflows were determined for the selected recurrence intervals, for each flood series and for the energy demands of 1996, 2001, 2002, and 2020. Devil Canyon Reservoir operation studies indicated that the reservoir will remain at its normal maximum water surface elevation for essentially the entire flood season. Therefore, attenuation of flood peaks by the Devil Canyon Reservoir was assumed to be insignificant.

The Watana Reservoir outflows were combined with the flood flows of the corresponding recurrence interval from the intervening areas (between Watana Reservoir and the downstream location of interest) to determine with-project flood peaks at the downstream locations. The resulting flood peak frequency curves for

Gold Creek, Sunshine and Susitna Station for natural and with-project conditions (corresponding to different levels of energy demand) are shown on Exhibits 10, 12 and 14. Tables 2, 5 and 6 also show the flood peaks for the selected recurrence intervals.

The flood peak frequency data indicate a decrease in the difference between the floods peaks for natural and with-proejct conditions as the distance increases downstream from Gold Creek. This is because of the floods from the tributaries joining the Susitna River downstream from Gold Creek.

The with-project flood-frequency relationships presented in this study, are likely to change in the future if project operation criteria during floods are modified.

2.0 BACKGROUND

Acres American Incorporated (ACRES) developed with-project frequency curves at Gold Creek using the results of the weekly Watana/Devil Canyon reservoir operations based on the energy demands of 2002 and 2010 (ACRES, 1983).1/ The purpose of these curves and that for natural conditions was to demonstrate the decrease in the magnitude of floods because of the project operation. No frequency curves were developed for Sunshine and Susitna Station. Because the ACRES' with-project curve was based on results of operation studies using weekly mean flows, the flood peaks likely are underestimated thus, indicating a larger attenuation of flood by the reservoirs.

Since the ACRES' study, the reservoir operation criteria have been modified. The assessment of potential project impacts on the Lower Susitna River (between the confluence of the Susitna and Chulitna rivers) also has become necessary. Therefore, the flood frequency curves for Gold Creek were re-evaluated and similar curves for the Sunshine and Susitna Station (see Exhibit 1 for locations) were derived.

1/ Indicates reference at the end of the text.

3.0. SCOPE OF THE STUDY

The major work items of the present study include:

1. Generation of annual, May-June and July-September inflow flood hydrographs of various recurrence intervals for Watana Reservoir;

2. Routing of the above hydrographs through the reservoir using the most current reservoir operation criteria and starting reservoir elevations representative for 1996, 2001, 2002 and 2020 energy demands;

3. Estimation of the annual, May-June and July-September flood peaks from the interverning areas; and

4. Development of annual, May-June and July-September maximum flood peak frequency curves for Gold Creek, Sunshine and Susitna Station for natural and with-project conditions.

4.0 INFLOW FLOOD HYDROGRAPHS FOR WATANA

The annual, May-June and July-September flood peaks and 3-, 7- and 15-day flood volumes were estimated for the Watana damsite (with a drainage area of about 5,180 square miles) for the recurrence intervals of 2, 5, 10, 25 and 50 years (Table 1) using the procedures discussed in a previous Harza-Ebasco's report (H-E, January 1984). These data were used to develop the flood hydrographs shown on Exhibits 2 through 6 These hydrographs were shaped after the historic flood hydrographs recorded at Gold Creek which had flood peaks and volumes comparable to those shown on Table 1. The selected floods include those of June 1980, July 1981, August 1967, August 1971 and June 1964 which were used to shape the 2-, 5-, 10-, 25- and 50-year floods, respectively.

5.0 FLOOD FREQUENCY AT GOLD CREEK

5.1 NATURAL CONDITIONS

The flood peak frequency curve for Gold Creek (with a drainage area of about 6,160 square miles) are shown on Exhibit 7 for annual, May-June and July-September periods. The curves were developed using the procedures outlined by U.S. Water Resources Council (WRC) (WRC, 1981) and the annual, May-June and July-September maximum instantaneous discharges for the water years from 1949 through 1983. The plotting positions shown on the exhibit were computed using the Weibull's formula, P=M/(N+1), where P is the relative frequency, M is the rank of the flood event in order of magnitude with the events arranged in decending order and N is the number of years of record. The resulting flood peaks for selected recurrence intervals are given in Column 3 of Table 2.

5.2 WITH-PROJECT CONDITIONS

Floods at a location downstream from a major storage reservoir may be caused by a large regulated flood release from the reservoir combined with a relatively small contribution from the area intervening between the reservoir and the location of interest or by a smaller reservoir release combined with a high flood flow from the intervening area. However, as the distance between the reservoir and the downstream location increases, the flood from the intervening area becomes more dominant and the regulation effect of the reservoir becomes less important. For the purpose of this study, it was assumed that floods of the same recurrence interval would occur at the same time for the area above the dam and the intervening area downstream.

5.2.1 Floods from Intervening Area

The flood peak-frequency relationship for the area intervening between the Watana site and Gold Creek (about 980 square miles) were derived by transposing the flood- frequency relationship estimated for the area between Cantwell and

Gold Creek (about 2020 square miles). The relationships, shown on Exhibit 8, was developed by using the guidelines of WRC (WRC,1981) and the annual, May-June and July-September maximum daily intervening flows for the water years from 1961 through 1972 and the water years 1981 and 1982. The intervening flows were computed as differences between the observed flows at Cantwell and Gold Creek. No adjustment was made to the maximum daily intervening flows to obtain the instantaneous intervening flows. The maximum daily flows generally occurred on days other than those when the annual maximum instantaneous flood occurred at the two stations. For Gold Creek, the ratio between the annual maximum instantaneous flow and mean flow for the same day varies between 1.01 and 1.08. Thus, the ratios between the maximum instantaneous flow and the maximum daily flow for the three series are expected to be smaller. Furthermore, the assumption that floods of the same recurrence interval occur simulteanously in the intervening area and the area upstream from the dam is rather conservative and tends to yield a larger estimate of the combined flood. Therefore, it was decided not to adjust the maximum daily flows (for the intervening area) upward for the maximum instantaneous flows.

Since the 14 years of flood data are not sufficiently long to estimate floods of large recurrence intervals, the procedure recommended in United States Geological Survey Publication 78-129 (USGS 78-129) (Lamke, 1979) were used to develop another set of flood-frequency relationships. The procedure essentially involved the derivation of the relationship by using generalized regression equations. The resulting flood peaks for various recurrence intervals were then adjusted by using the ratio between the floods of 5-year recurrence interval taken from the curve based on observed data (Exhibit 8) and from the regression equation (Lambe, 1979).

The transposition of the resulting flood-frequency data for the area between Cantwell and Gold Creek to the area between the Watana dam site and Gold Creek was made by the following relationship:

$$Q = Q_g \frac{A}{A_g}^{n} \quad \ldots\ldots(1)$$

in which

Q = peak discharge from the area intervening between the Watana dam site and Gold Creek for a given recurrence interval, cfs;

Q_g = peak discharge from the area intervening between Cantwell and Gold Creek for the corresponding recurrence interval, cfs;

A = drainage area between Watana dam site and Gold Creek, square miles;

A_g = drainage area between Cantwell and Gold Creek, square miles; and

n = exponent.

A value of 0.5 was used for "n" as discussed in "Flood Frequency Analysis" by Harza-Ebasco (H-E, January 1984). Table 3 shows the resulting flood peak estimates for the selected recurrence intervals.

5.2.2 Watana Reservoir Releases

Flood Hydrographs shown on Exhibits 2 through 6 were routed through the Watana reservoir. An in-house reservoir routing program was used to determine the releases from the reseroir. The reserovir was operated using the folowing criteria:

A. Reservoir Level Constraints:

Active zone is between normal maximum level of 2185 ft and minimum level of 2065 ft. The environmental surcharge level is 2193 ft which allows 8 ft surcharge for flood regulation.

B. Cone Valve Release:

Assumed maximum cone valve capacity is 24,000 cfs. Releases from the cone valves are for satisfying the downstream flow requirement or for discharging flood flows as prescribed below:

1. When reservoir level is below 2185:

   The release is made to satisfying instream flow requirement at Gold Creek if the discharge through the turbines for system demand is insufficient to satisfy the requirement.

2. When reservoir level is at 2185:

   The reservior level is maintained at 2185 by releasing water from the turbines alone or the turbines and cone valves, depending upon inflow rates, system demand and instream flow requirements. The reservoir level will increase if the inflow is greater than the combined flow through the turbines and cone valves.

3. When reservoir level is higher than 2185:

   The discharge through the cone valves is assumed to be at the full capacity of 24,000 cfs. The reservoir level will continue to rise if the inflow is greater than the discharge capacity (of the turbines and cone valves) or will fall if the inflow is less than the capacity. If the reservoir level drops to and below 2185, follow steps 2 and 1 accordingly.

4. When reservoir level reaches 2193:

   The water level will be maintained at 2193 by setting inflow equal to outflow. The valve discharge will be kept at full capcity. The inflow in excess of the combined capacity of the cone valves and turbines will be passed through the spillway.

The reservoir volume-elevation curve used in the reservoir routing was that obtained from the ACRES's studies (ACRES, February 1983). The starting reservoir water surface elevations were derived from the "start of the week reservoir elevations" obtained through the weekly reservoir operation study for the period from 1950 through 1983 and were assumed to be the medium values during June, May-June and July-September periods, repectively, for the annual, May-June and July-September floods. The assumption that the annual flood is most likely to occur in the month of June is reasonable because about 60 percent of the maximum annual floods occurred in this month (Exhibit 9).

The median reservoiur water surface elevations (starting elevations) were computed for the Watana operation for 1996 and 2001 energy demands and for the Watana - Devil Canyon Operation for 2002 and 2020 energy demands. Based on the respective starting elevations, the maximum outflows from the Watana Reservoir that corresponded to the 2-, 5-, 10-, 25- and 50-year recurrence intervals and the 1996, 2001, 2002 and 2020 energy demands were determined through the reservoir routing as shown in Table 4. These flows are essentially constant for a number of days and hence were assumed to travel to Gold Creek and Sunshine and Susitna Station gages without attenuation.

The Watana Reservoir outflows (Table 4) indicate that the annual and seasonal 2-, 5-, 10-, 25- and 50-year floods occur in May and June would be controlled by the reservoir and the maximum outflow would not exceed the maximum discharge from the turbines, estimated to be about 7,000 cfs during the May-June periods. This conclusion remains the same for the energy demands of 1996, 2001, 2002 and 2020.

During the July-September period, the reservoir elevations at the beginning of the flood would generally be higher. Therefore, following the operation criteria prescribed earlier, the use of the cone valves would become necessary during the 50-year flood under the 1996 and 2001 energy demands and during the floods of all selected recurrence intervals under the 2002 energy demand. The more frequent use of the cone valves under 2002 energy demand is because Devil Canyon Reservoir becomes operational, and more water can be stored in Watana Reservoir while satisfying the system energy demand. At under 2020 energy demand, however, Watana Reservoir will have to be operated to meet the increased energy demand in 2020, and, thus, resulting in lower reservoir elevations. Under such conditions, the floods of all recurrence intervals shown in Table 4 would be controlled and the maximum outflow would be the same as the maximum turbine discharge, estimated to be about 7,400 cfs for the July-September period.

5.2.3 Floods at Gold Creek

The flood releases from Watana Reservoir for a given recurrence interval, were combined with the flood of corresponding recurrence interval from the area intervening between Watana and Gold Creek to determine with-project floods at Gold Creek. Results of the Devil Canyon Reservoir operation studies indicated that the reservoir water surface elevation will remain essentially at its normal maximum throughout the flood season. Therefore, attenuation of flood peaks by Devil Canyon Reservoir was assumed to insignificant. The resulting with-project floods are given in Columns 4 to 7 of Table 2. Exhibits 10 shows the frequency curves for natural and with-project conditions. The with-project frequency curves for July-September periods are not shown for the 1996 and 2001 energy demands because of discontinuation in the curves for recurrence intervals above 25-year. The discontinuation resulted because of the use of cone valves during the 50-year flood which resulted in a much higher outflow.

6.0 FLOOD FREQUENCY AT SUSITNA STATION

6.1 NATURAL CONDITION

The flood peak data at Susitna Station, with a drainage area of about 19,400 square miles, are available for the water years from 1975 through 1982. These data are too short to estimate flood peaks of large recurrence intervals. Therefore, the procedure recommended in USGS 78-129 (Lamke, 1979) was used to develop the flood frequency curve. The procedure has been discussed briefly under Subsection 5.2.1. Exhibit 11 shows the flood frequency curve for annual, May-June and July-September periods based on observed data. The plotting positions of the points shown on the curve, were computed using the Weibull's formula. The adjusted flood frequency curve is shown on Exhibit 12. The flood peaks of selected recurrence intervals are given in Column 3 of Table 5.

6.2 WITH-PROJECT CONDITIONS

The flood peaks for with-project conditions were obtained using the procedure adopted for Gold Creek. That is, the constant release from Watana for a given recurrence interval was added to the flood peak of the corresponding recurrence interval from the area (about 14,220 square miles) intervening between the Watana dam site and Susitna Station. The flood peak for the area between the Watana dam site and Susitna Station were derived by transposing the flood frequency relationship estimated for the area (about 13,240 square mile) between Gold Creek and Susitna Station. The relationship was estimated using flood frequency curves based on observed data (Exhibit 13) and the procedure recommended in USGS 78-129 (Lamke, 1979) because of the short length of record (for water years from 1975 through 1982). The transposition was made using Equation 1 given in Sub- section 5.2.1 with the values of flood peaks and drainage areas replaced by those between Watana and Susitna Station, and Gold Creek and Susitna Station.

The maximum daily intervening flows used in the frequency analysis were computed by the same method used for the area between Cantwell and Gold Creek. The resulting frequency curves shown on Exhibit 13, were derived using the guidelines of WRC (WRC, 1981).

The with-project flood frequency curve resulting from the analysis are shown on Exhibit 12. The flood peaks of selected recurrence intervals are given in Columns 4 to 7 of Table 5. The with-project frequency curves for July-September period are not shown for the 1996 and 2001 energy demands because of the same reasons given in sub-section 5.2.3.

7.0 FLOOD FREQUENCY AT SUNSHINE

7.1 NATURAL CONDITION

There are only about 3 years of flow record, for Sunshine, with a drainage area of about 11,100 square miles. These are not sufficient to derive a reliable flood frequency relationship. Therefore, the flood peak frequency relationship developed for Susitna Station for annual, May-June and July-September periods were transposed to this site by Equation 1 given in sub-section 5.2.1 using the appropriate values of flood peaks and drainage areas. A value of 0.5 was used for the exponent "n". The resulting curves for annual, May-June and July-September periods are shown on Exhibit 14. The flood peaks of selected recurrence intervals are given in Column 3 of Table 6.

7.2 WITH PROJECT CONDITIONS

The flood peaks for with-project conditions were estimated using the procedures adopted for Gold Creek and Susitna Station. The intervening area between the Watana dam site and Sunshine is about 5,920 square miles. The flood data for the intervening area were estimated by transposing the data for the area between Gold Creek and Susitna Station. The resulting curves for annual, May-June and July-September periods are shown on Exhibit 14, and the flood peaks of selected recurrence intervals are given in Columns 4 to 7 of Table 6. The curves for July-September period are not shown for the 1996 and 2001 energy demands because of the same reasons given in sub-section 5.2.3.

REFERENCES

Acres American Incorporated, February 1983: Before the Federal Energy Regulatory Commission, Application for License for Major Project, Susitna Hydroelectric Project, Volume 5A, Exhibit E, Chpater 2, prepared for Alaska Power Authority.

Harza-Ebasco Susitna Joint Venture, January 1984: Flood Frequency Analysis, Susitna Hydroelectric Project, Federal Energy Regulatory Commission Project No. 7114, Final Report, Document No. 474, prepared for Alaska Power Authority.

Lamke, R.D., Flood Characteristics of Alaskan Streams, 1979: U.S. Geological Survey, Water Resources Investigations 78-129, Anchorage, Alaska.

U.S. Water Resources Council, 1981: Guidelines for Determining Flood Frequency, Bulletin # 17B, Washington D.C.

Table 1

FLOOD FREQUENCY DATA AT WATANA[1/]
NATURAL CONDITIONS

	Recurrence Interval (Year)				
	2	5	10	25	50
Annual Series					
Flood Peak, cfs	43,500	57,400	67,000	79,800	89,500
Flood Volume, mean discharge, cfs					
3-day	36,028	47,062	54,485	64,027	71,251
7-day	32,297	41,182	46,910	54,015	59,233
15-day	28,529	35,004	39,049	43,950	47,478
May-June Period					
Flood Peak, cfs	39,000	51,500	60,800	73,800	84,400
Flood Volume, mean discharge, cfs					
3-day	32,188	42,242	49,592	59,732	67,900
7-day	29,114	37,701	43,813	52,043	58,553
15-day	26,036	32,968	37,432	42,969	47,034
July-September Period					
Flood Peak, cfs	34,200	45,700	54,500	67,200	77,800
Flood Volume, mean discharge, cfs					
3-day	28,013	36,783	43,547	53,233	61,341
7-day	25,766	32,521	37,379	43,970	49,210
15-day	23,840	28,728	31,795	35,530	38,227

1/ Source: Harza-Ebasco Susitna Joint Venture, Final Report January, 1984: Flood Frequncy Analysis, Susitna Hydroelectric Project No. 7114, Document No. 474, prepared for Alaska Power Authority.

Table 2

FLOOD PEAK FREQUENCY DATA AT GOLD CREEK
FOR NATURAL AND WITH-PROJECT CONDITIONS

Flood Period	Recurrence Interval (Year)	Natural[1/]	Flood Peaks (cfs) With-Project			
			1996	2001	2002	2020
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Annual	2	48,000	23,700	23,700	23,700	23,700
	5	63,300	31,400	31,400	31,400	31,400
	10	73,700	35,800	35,800	35,800	35,800
	25	87,300	39,700	39,700	39,700	39,700
	50	97,700	44,300	44,300	44,300	44,300
May-June	2	42,500	20,900	20,900	20,900	20,900
	5	56,200	27,900	27,900	27,900	27,900
	10	66,300	31,900	31,900	31,900	31,900
	25	80,500	35,000	35,000	35,000	35,000
	50	92,100	39,000	39,000	39,000	39,000
July-September	2	37,300	17,300	17,300	41,300	17,300
	5	49,800	22,900	22,900	46,900	22,900
	10	59,400	25,600	25,600	49,600	25,600
	25	73,200	28,100	28,100	52,100	28,100
	50	84,800	53,600	48,800	55,100	31,100

1/ Natural flood peaks from H-E report, January, 1984.

Table 3

FLOOD PEAK FREQUENCY DATA
FOR INTERVENING AREAS

		Recurrence Interval, (Year) Flood Peaks, (cfs)				
		2	5	10	25	50
1. Between Cantwell and Gold Creek						
	Annual	24,000	35,000	41,300	46,900	53,600
	May-June	20,000	30,000	35,400	40,200	45,900
	July-September	14,200	22,200	26,200	29,700	34,000
2. Between Watana and Gold Creek						
	Annual	16,700	24,400	28,800	32,700	37,300
	May-June	13,900	20,900	24,700	28,000	32,000
	July-September	9,890	15,500	18,200	20,700	23,700
3. Between Gold Creek and Susitna Station						
	Annual	149,000	173,000	192,000	212,000	230,000
	May-June	115,000	131,000	146,400	161,000	174,000
	July-September	147,000	172,200	191,000	211,000	229,000
4. Between Watana and Sunshine						
	Annual	99,700	116,000	128,000	142,000	154,000
	May-June	76,900	87,600	97,700	108,000	116,000
	July-September	98,300	115,000	128,000	141,000	153,000
5. Between Watana and Susitna Station						
	Annual	154,000	180,000	199,000	220,000	239,000
	May-June	119,000	136,000	151,000	167,000	180,000
	July-September	152,000	178,000	198,000	219,000	237,000

Table 4

MAXIMUM OUTFLOWS AT WATANA RESERVOIR

Year	Flood Period	Starting Reser. El. (ft)	Recurrence Interval, (Year) 2	5	10	25	50
			Flood Peaks, (cfs)				
1996	Annual	2112.8	7,000	7,000	7,000	7,000	7,000
	May-June	2096.4	7,000	7,000	7,000	7,000	7,000
	July-September	2162.3	7,400	7,400	7,400	7,400	29,900
2001	Annual	2111.0	7,000	7,000	7,000	7,000	7,000
	May-June	2094.6	7,000	7,000	7,000	7,000	7,000
	July-September	2161.0	7,400	7,400	7,400	7,400	25,100
2002	Annual	2157.4	7,000	7,000	7,000	7,000	7,000
	May-June	2138.6	7,000	7,000	7,000	7,000	7,000
	July-September	2185.0	31,400	31,400	31,400	31,400	31,400
2020	Annual	2103.7	7,000	7,000	7,000	7,000	7,000
	May-June	2085.5	7,000	7,000	7,000	7,000	7,000
	July-September	2159.0	7,400	7,400	7,400	7,400	7,400

Table 5

FLOOD PEAK FREQUENCY DATA AT SUSITNA STATION
FOR NATURAL AND WITH-PROJECT CONDITIONS

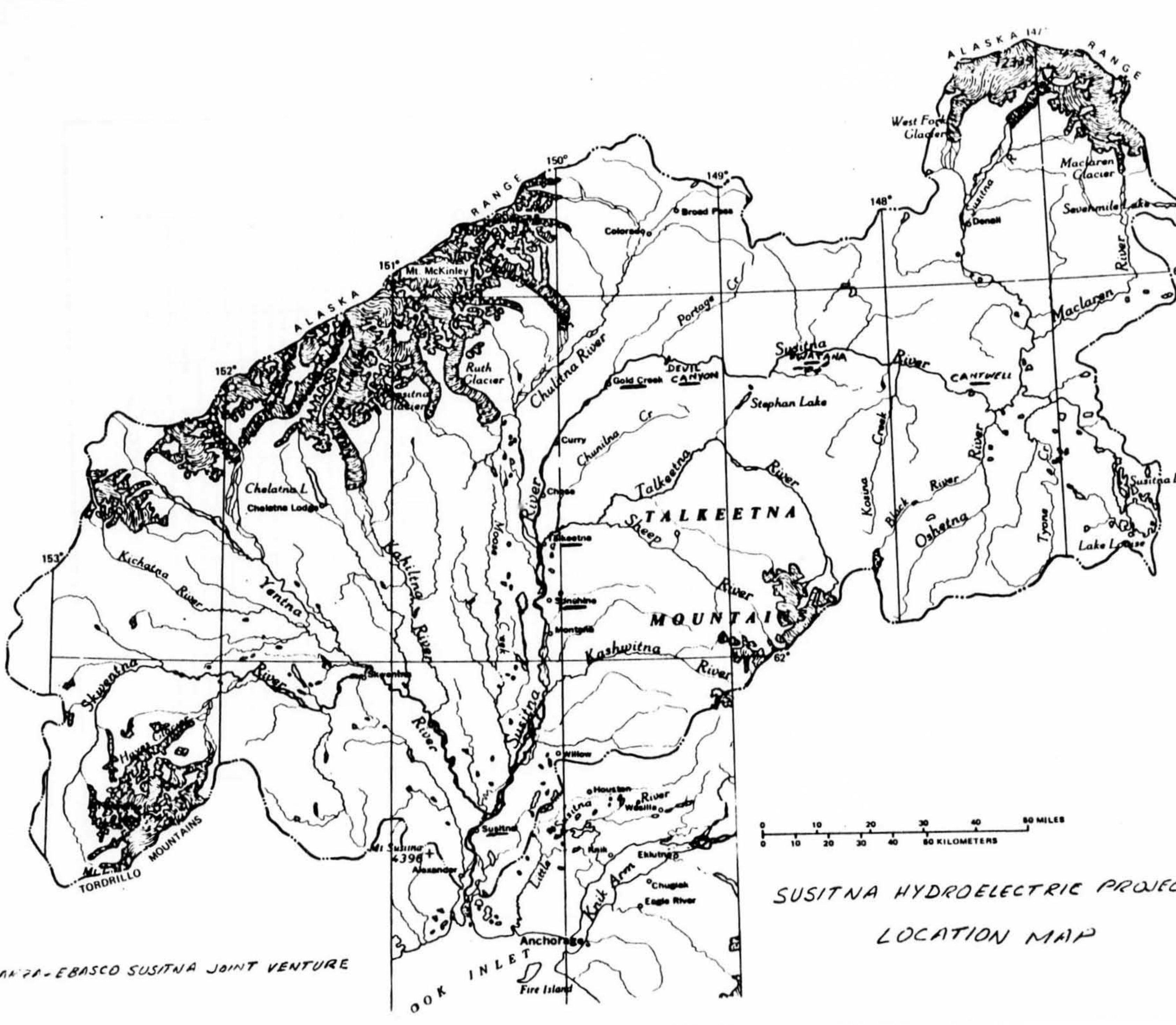
Flood Period	Recurrence Interval (Year)	Natural	Flood Peaks (cfs) With-Project 1996	2001	2002	2020
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Annual	2	189,000	161,000	161,000	161,000	161,000
	5	220,000	187,000	187,000	187,000	187,000
	10	242,000	206,000	206,000	206,000	206,000
	25	264,000	227,000	227,000	227,000	227,000
	50	283,000	246,000	246,000	246,000	246,000
May-June	2	156,000	126,000	126,000	126,000	126,000
	5	179,000	143,000	143,000	143,000	143,000
	10	197,000	158,000	158,000	158,000	158,000
	25	215,000	174,000	174,000	174,000	174,000
	50	230,000	187,000	187,000	187,000	187,000
July-	2	183,000	159,000	159,000	183,000	159,000
	5	216,000	185,000	185,000	209,000	185,000
	10	238,000	205,000	205,000	229,000	205,000
	25	259,000	226,000	226,000	250,000	226,000
	50	278,000	267,000	262,000	269,000	234,000

Table 6

FLOOD PEAK FREQUENCY DATA AT SUSHINE
FOR NATURAL AND WITH-PROJECT CONDITIONS

Flood Period	Recurrence Interval (Year)	Natural	Flood Peaks (cfs) With-Project 1996	2001	2002	2020
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Annual	2	143,000	107,000	107,000	107,000	107,000
	5	166,000	123,000	123,000	123,000	123,000
	10	183,000	135,000	135,000	135,000	135,000
	25	200,000	149,000	149,000	149,000	149,000
	50	214,000	161,000	161,000	161,000	161,000
May-June	2	118,000	83,900	83,900	83,900	83,900
	5	135,000	94,600	94,600	94,600	94,600
	10	149,000	105,000	105,000	105,000	105,000
	25	163,000	115,000	115,000	115,000	115,000
	50	174,000	123,000	123,000	123,000	123,000
July-September	2	138,000	106,000	106,000	130,000	106,000
	5	163,000	122,000	122,000	146,000	122,000
	10	180,000	135,000	135,000	159,000	135,000
	25	196,000	148,000	148,000	172,000	148,000
	50	210,000	183,000	178,000	185,000	160,000

EXHIBIT I



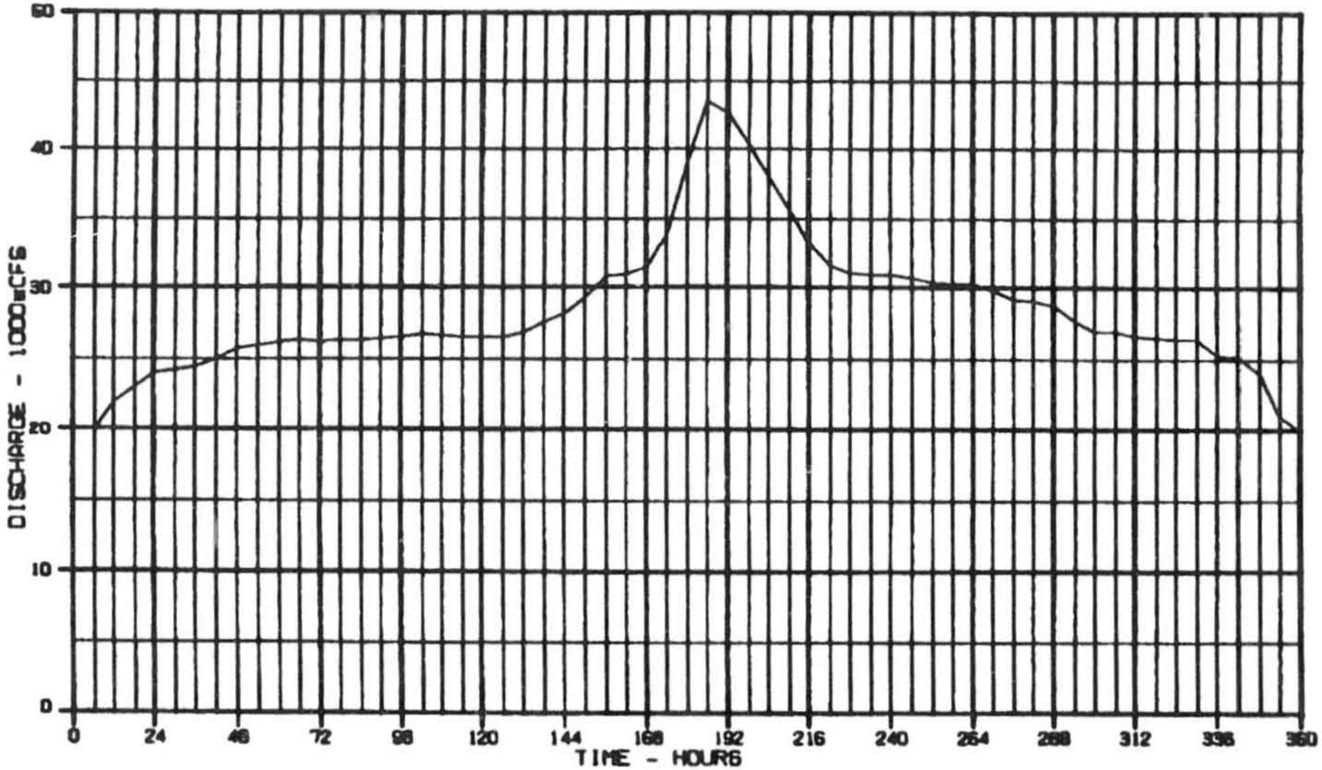
SUSITNA HYDROELECTRIC PROJECT

LOCATION MAP

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 2

SHEET 1 OF 3

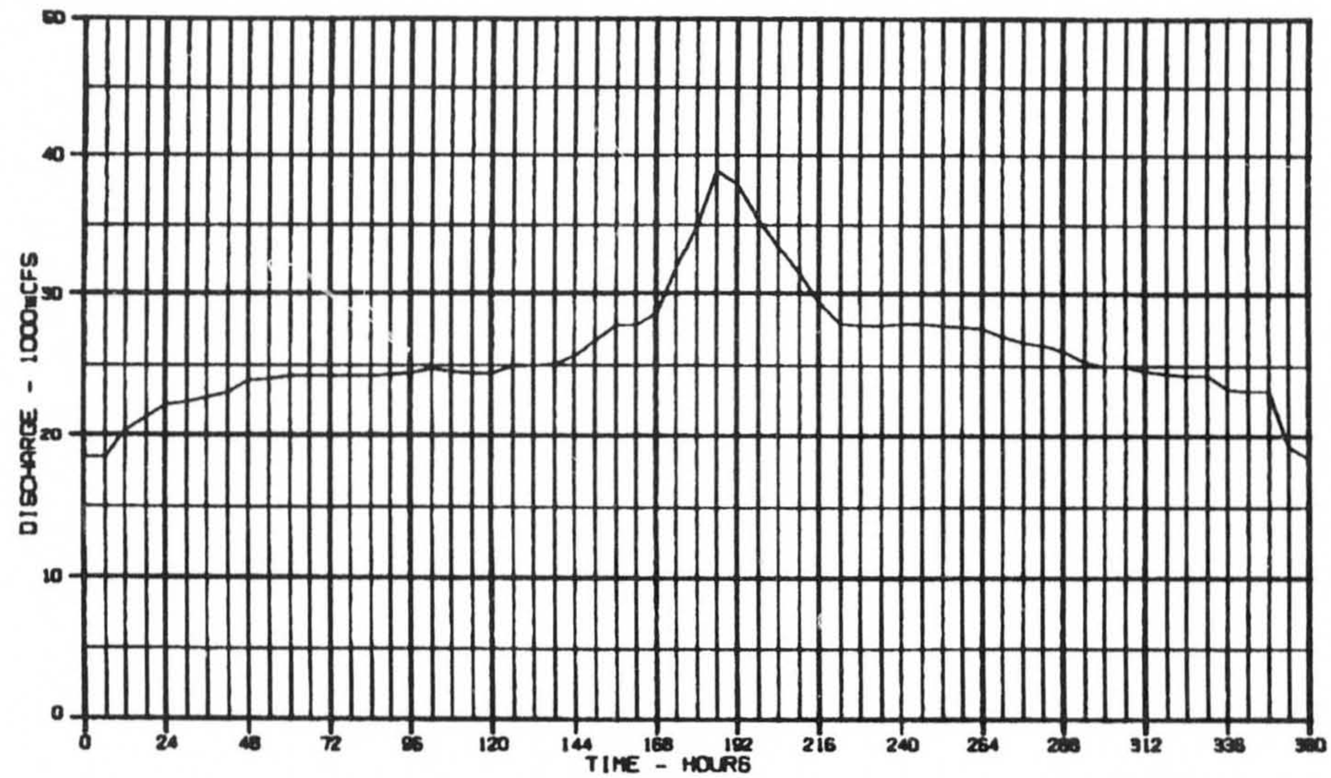


PEAK = 43500 CFS. 16-DAY VOLUME = 0.86*10**6 ACRE-FEET

ALASKA POWER AUTHORITY
SUSITNA PROJECT / HYDROLOGY
2-YEAR ANNUAL MAXIMUM FLOOD HYDROGRAPH AT WATANA
HARZA-EBASCO JOINT VENTURE
42-010-21

HARZA-EBASCO SUSITNA JOINT VENTURE

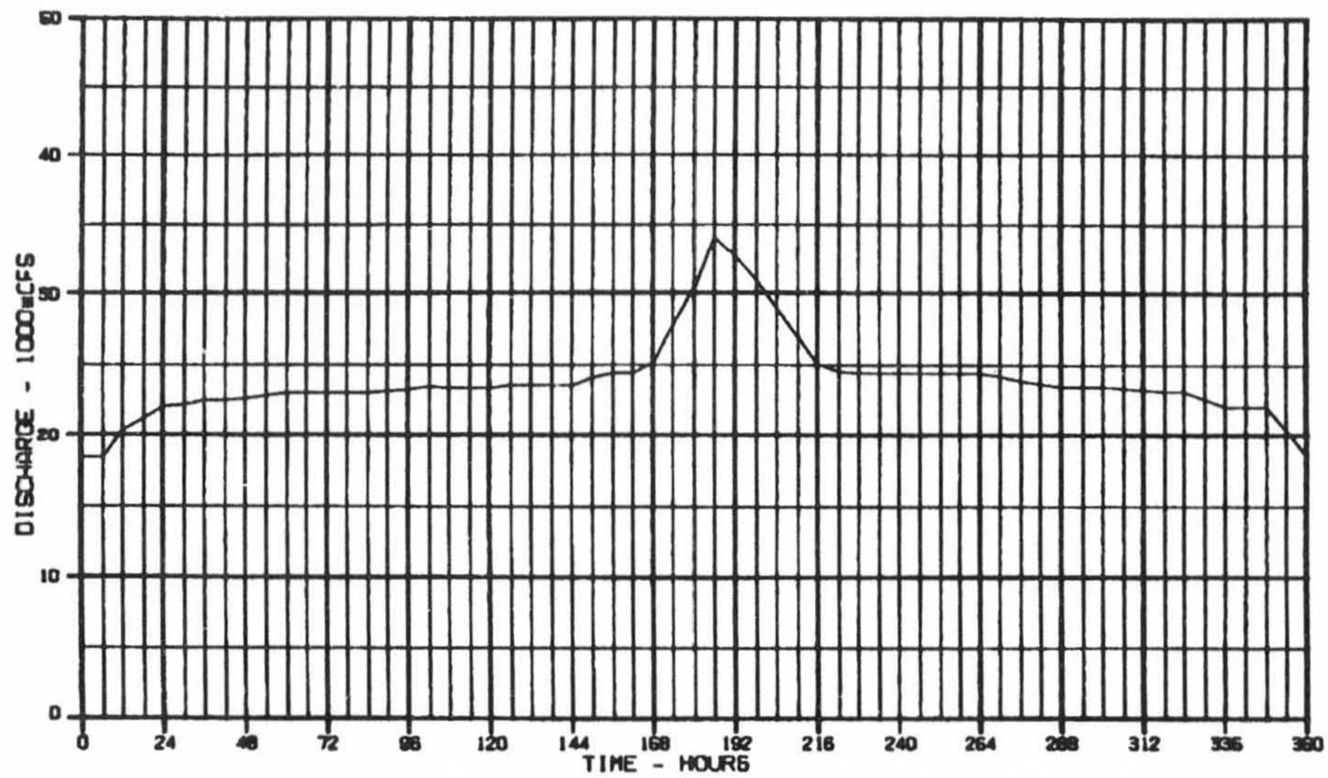
EXHIBIT 2
SHEET 2 OF 3



ALASKA POWER AUTHORITY	
SUSITNA PROJECT	HYDROLOGY
2-YEAR MAY-JUNE MAXIMUM FLOOD HYDROGRAPH AT WATANA	
HARZA-EBASCO JOINT VENTURE	
	42-010-21

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 2
SHEET 3 OF 3



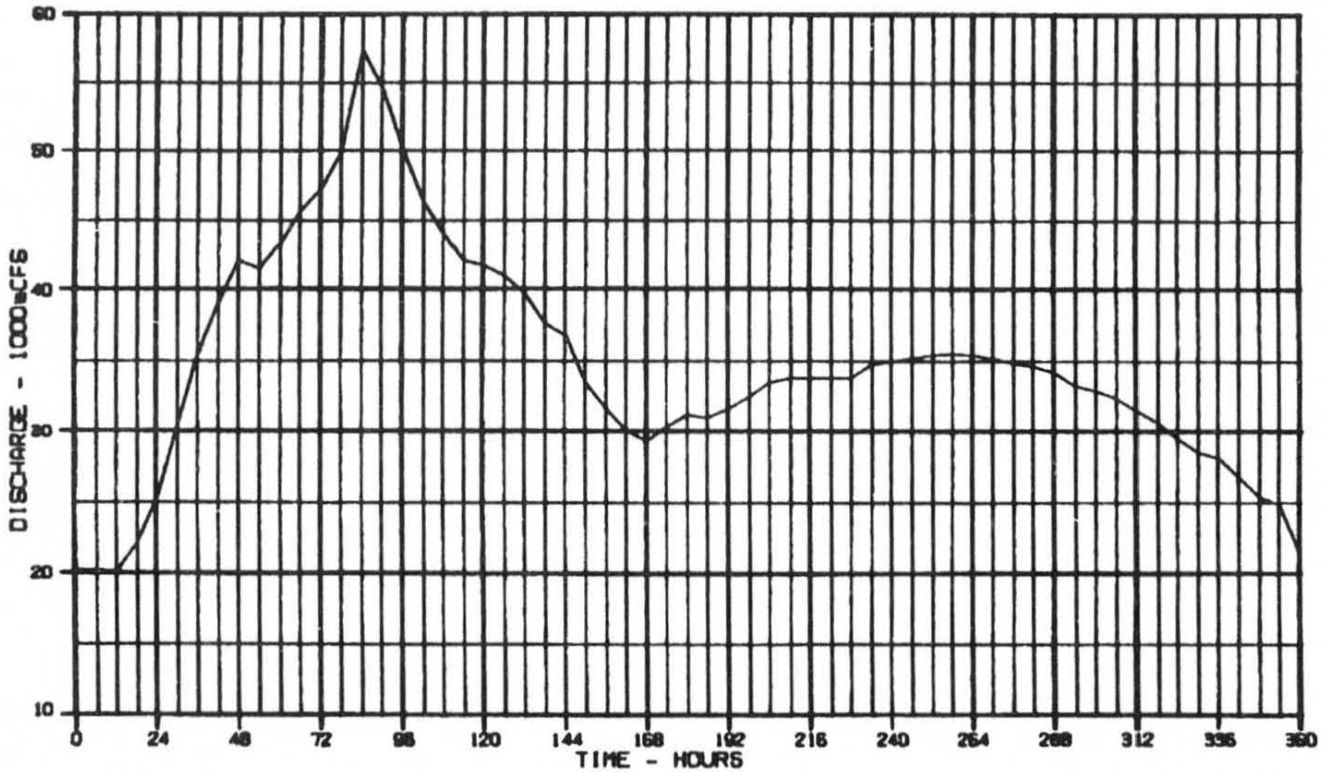
PEAK = 34200 CFS. 16-DAY VOLUME = 0.71*10**6 ACRE-FEET

ALASKA POWER AUTHORITY	
SUSITNA PROJECT	HYDROLOGY
2-YEAR JULY-SEPTEMBER MAXIMUM FLOOD HYDROGRAPH AT WATANA	
HARZA-EBASCO JOINT VENTURE	
42-010-21	

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 3

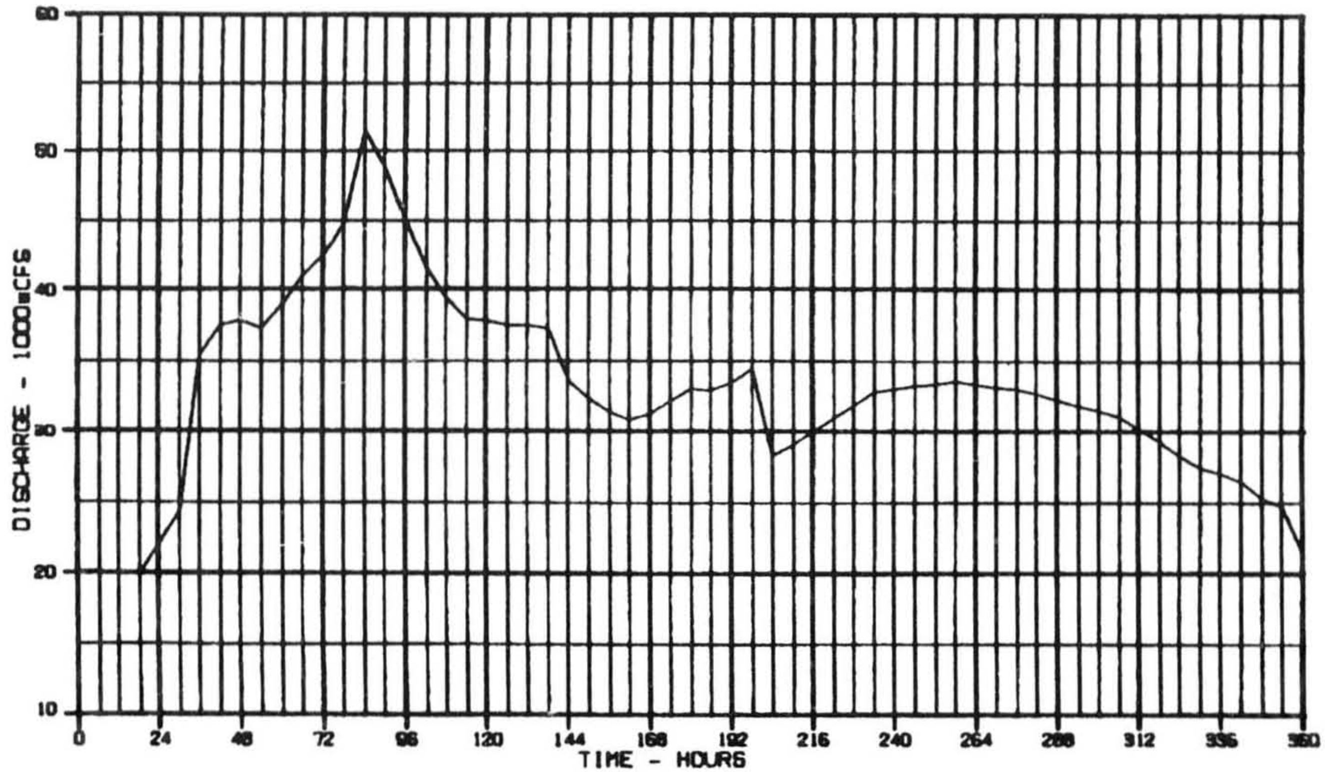
SHEET 1 OF 3



PEAK = 67400 CFS. 15-DAY VOLUME = 1.04*10**6 ACRE-FEET

ALASKA POWER AUTHORITY	
SUSITNA PROJECT	HYDROLOGY
5-YEAR ANNUAL MAXIMUM FLOOD HYDROGRAPH AT WATANA	
HARZA-EBASCO JOINT VENTURE	
	42-010-21

HARZA-EBASCO SUSITNA JOINT VENTURE



PEAK = 61600 CFS. 16-DAY VOLUME = 0.98*10**6 ACRE-FEET

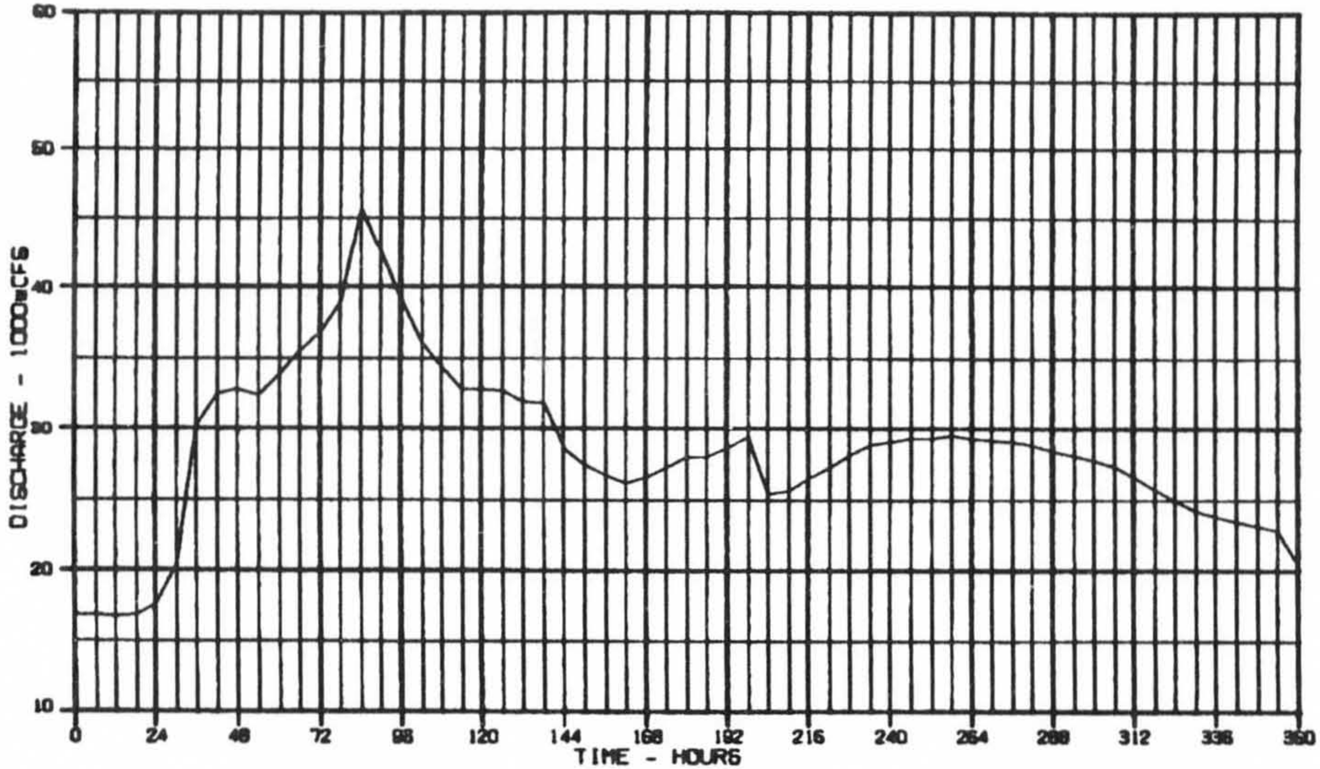
ALASKA POWER AUTHORITY	
SUSITNA PROJECT	HYDROLOGY
5-YEAR MAY-JUNE MAXIMUM FLOOD HYDROGRAPH AT WATANA	
HARZA-EBASCO JOINT VENTURE	
	42-010-21

EXHIBIT 3
SHEET 2 OF 3

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 3

SHEET 3 OF 3



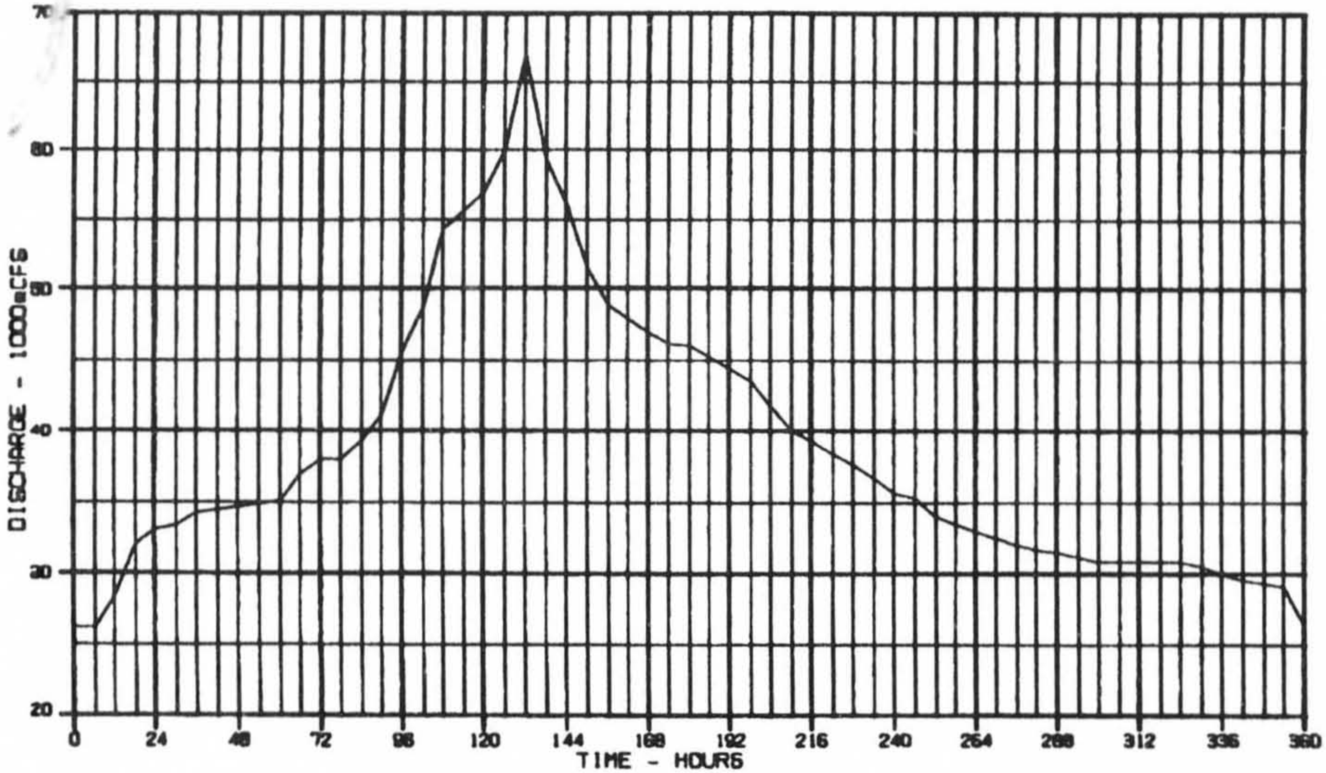
PEAK = 45700 CFS. 16-DAY VOLUME = 0.86*10**6 ACRE-FEET

ALASKA POWER AUTHORITY	
SUSITNA PROJECT	HYDROLOGY
5-YEAR JULY-SEPTEMBER MAXIMUM FLOOD HYDROGRAPH AT WATANA	
HARZA-EBASCO JOINT VENTURE	
	42-010-21

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 4

SHEET 1 OF 3



PEAK = 67000 CFS. 16-DAY VOLUME = 1.16*10**6 ACRE-FEET

ALASKA POWER AUTHORITY

10-YEAR ANNUAL MAXIMUM FLOOD HYDROGRAPH AT WATANA

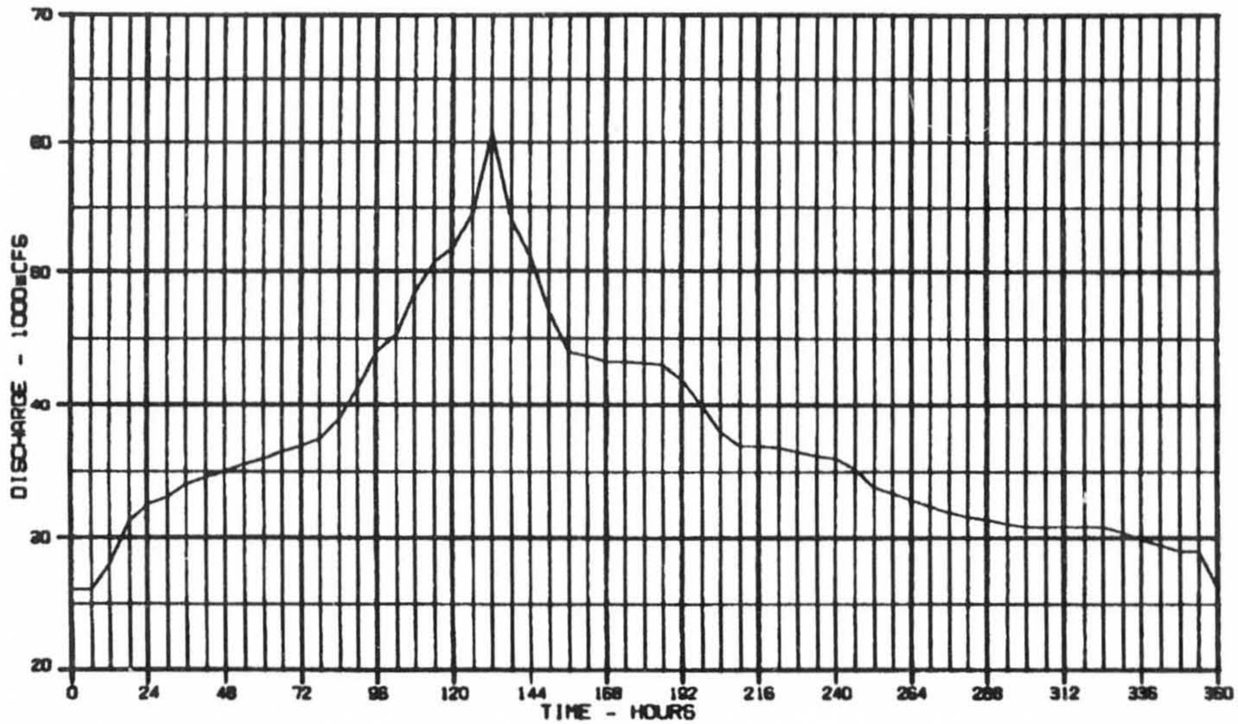
HARZA-EBASCO JOINT VENTURE

42-010-21

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 4

SHEET 2 OF 3

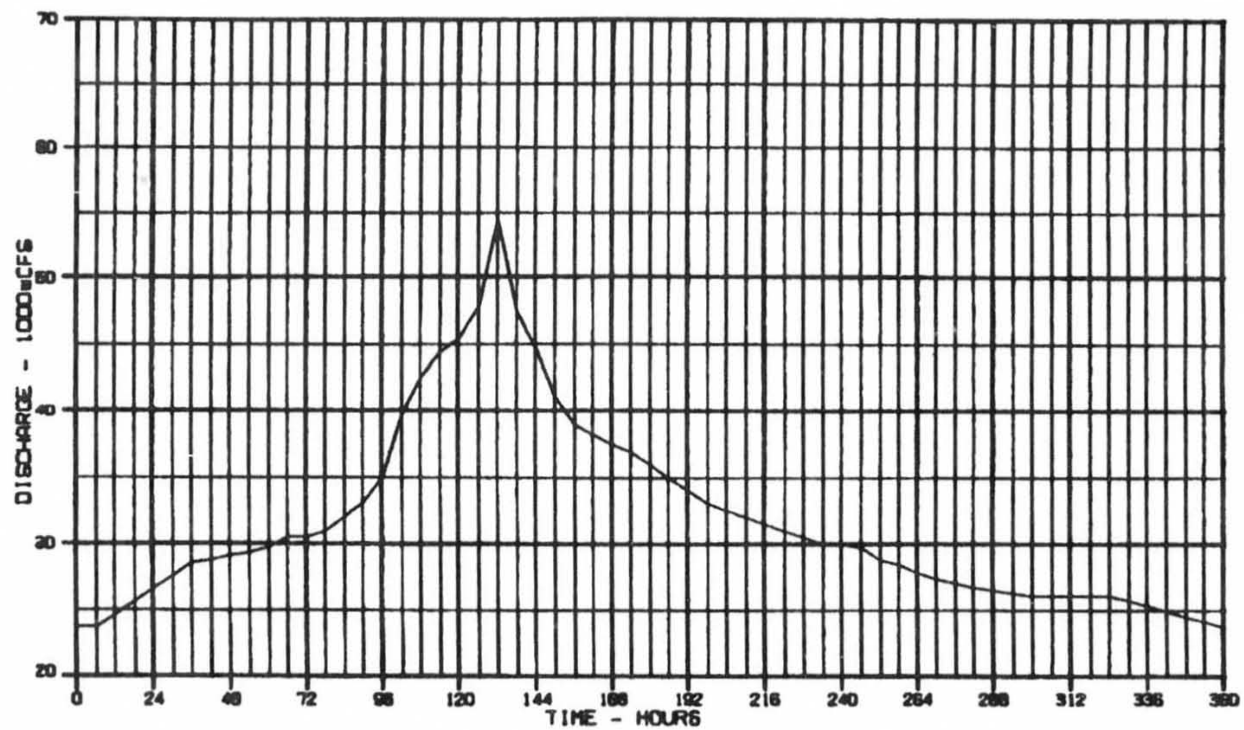


PEAK = 60800 CFS. 16-DAY VOLUME = 1.11=10==6 ACRE-FEET

ALASKA POWER AUTHORITY
SUSITNA PROJECT — HYDROLOGY
10-YEAR MAY-JUNE MAXIMUM FLOOD HYDROGRAPH AT WATANA
HARZA-EBASCO JOINT VENTURE
CHICAGO, ILLINOIS — 42-010-21

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT A
SHEET 3 OF 3



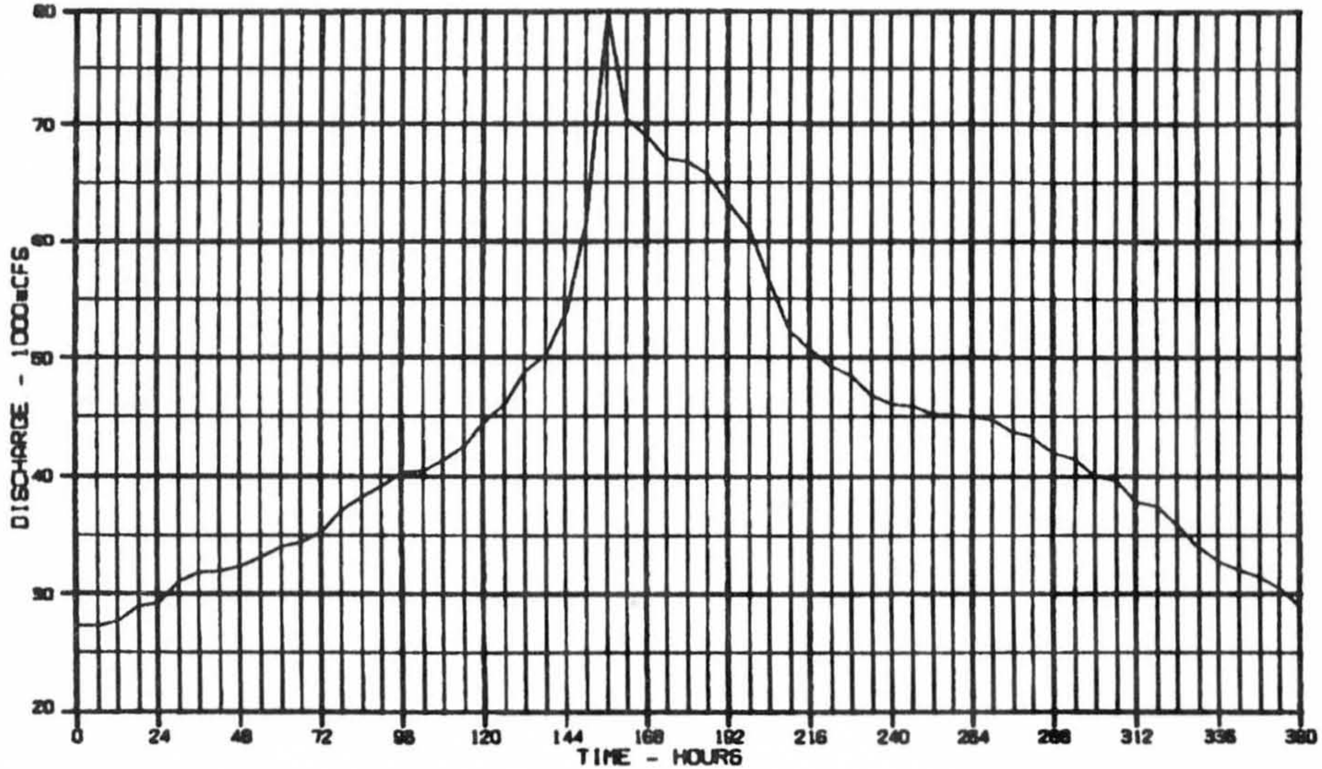
PEAK = 64600 CFS. 16-DAY VOLUME = 0.96*10**6 ACRE-FEET

ALASKA POWER AUTHORITY	
SUSITNA PROJECT	HYDROLOGY
10-YEAR JULY-SEPTEMBER MAXIMUM FLOOD HYDROGRAPH AT WATANA	
HARZA-EBASCO JOINT VENTURE	
	42-010-21

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 5

SHEET 1 OF 3

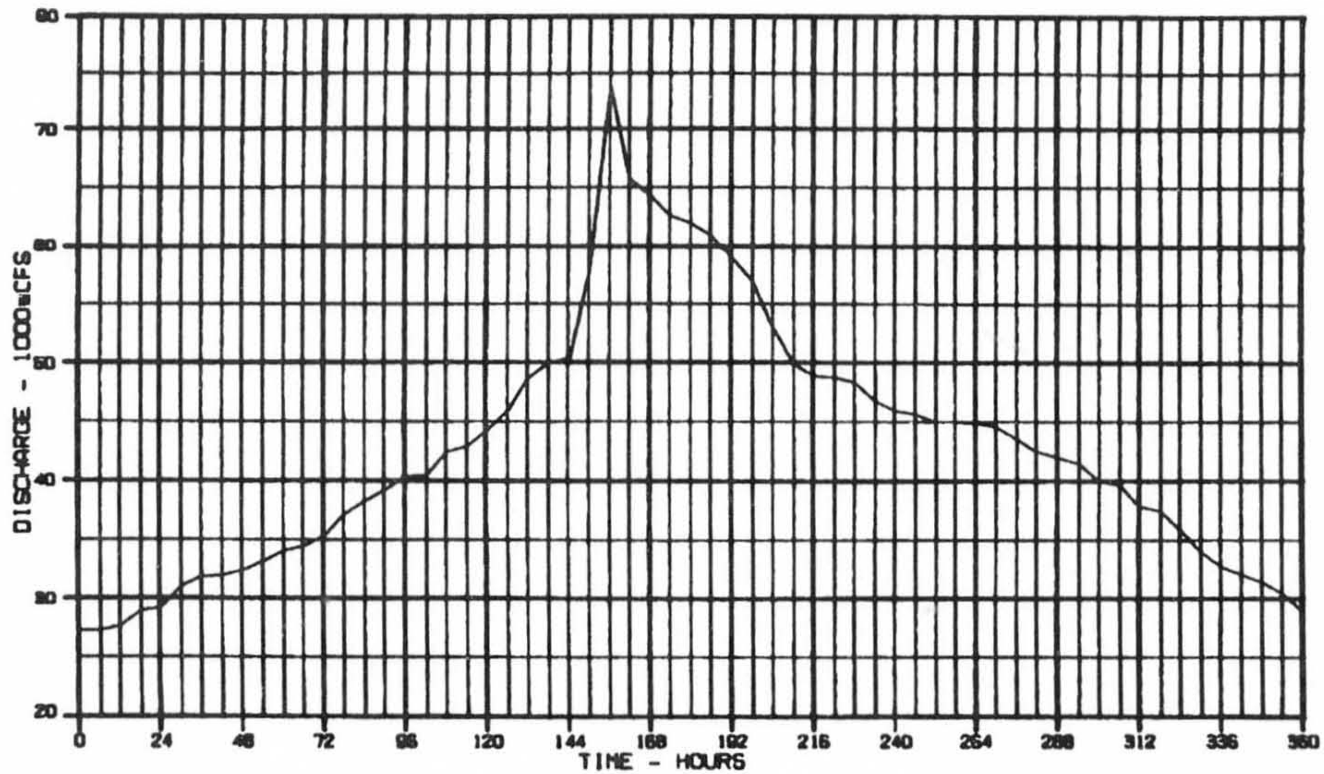


PEAK = 79800 CFS. 16-DAY VOLUME = 1.31*10**6 ACRE-FEET

ALASKA POWER AUTHORITY	
SUSITNA PROJECT	HYDROLOGY
25-YEAR ANNUAL MAXIMUM FLOOD HYDROGRAPH AT WATANA	
HARZA-EBASCO JOINT VENTURE	
42-010-21	

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 5
SHEET 2 OF 3



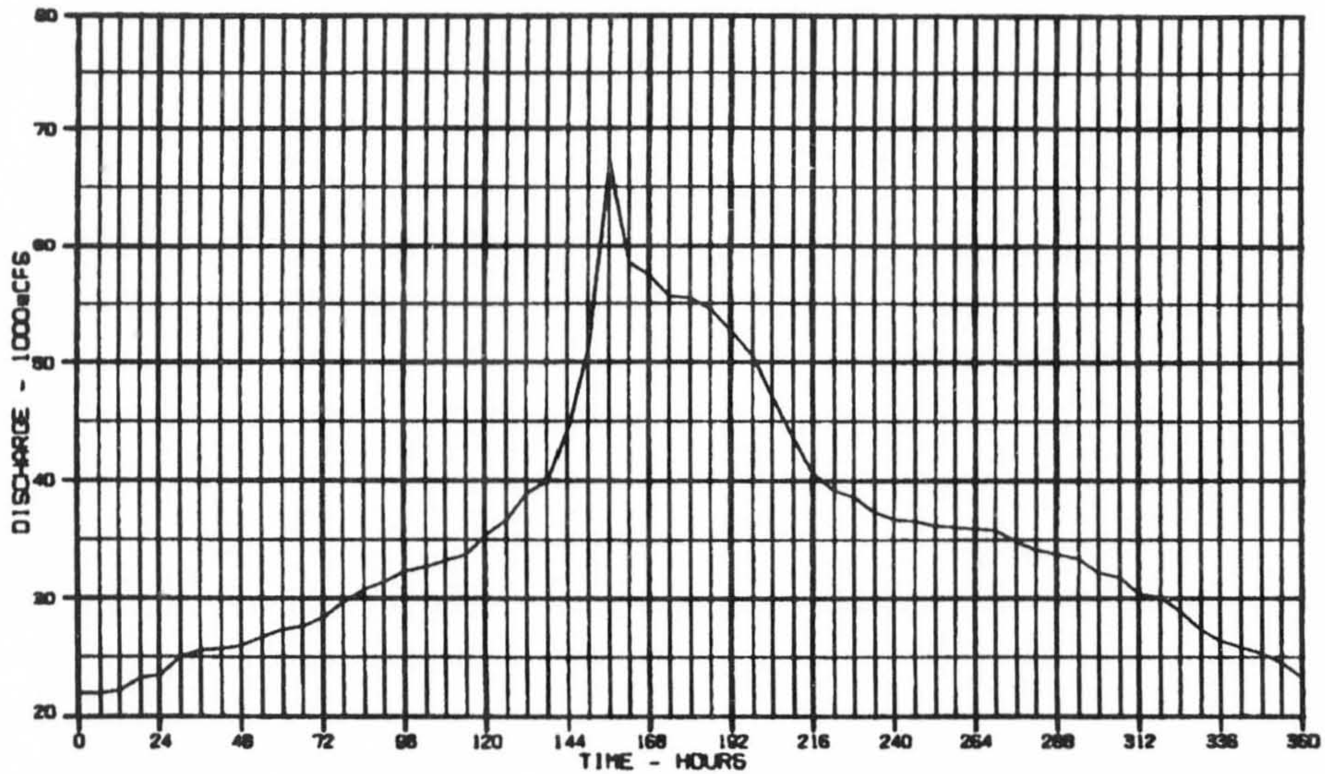
PEAK = 73800 CFS. 16-DAY VOLUME = 1.28*10**6 ACRE-FEET

ALASKA POWER AUTHORITY	
SUSITNA PROJECT	HYDROLOGY
25-YEAR MAY-JUNE MAXIMUM FLOOD HYDROGRAPH AT WATANA	
HARZA-EBASCO JOINT VENTURE	
[illegible]	42-010-21

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 5

SHEET 3 OF 3

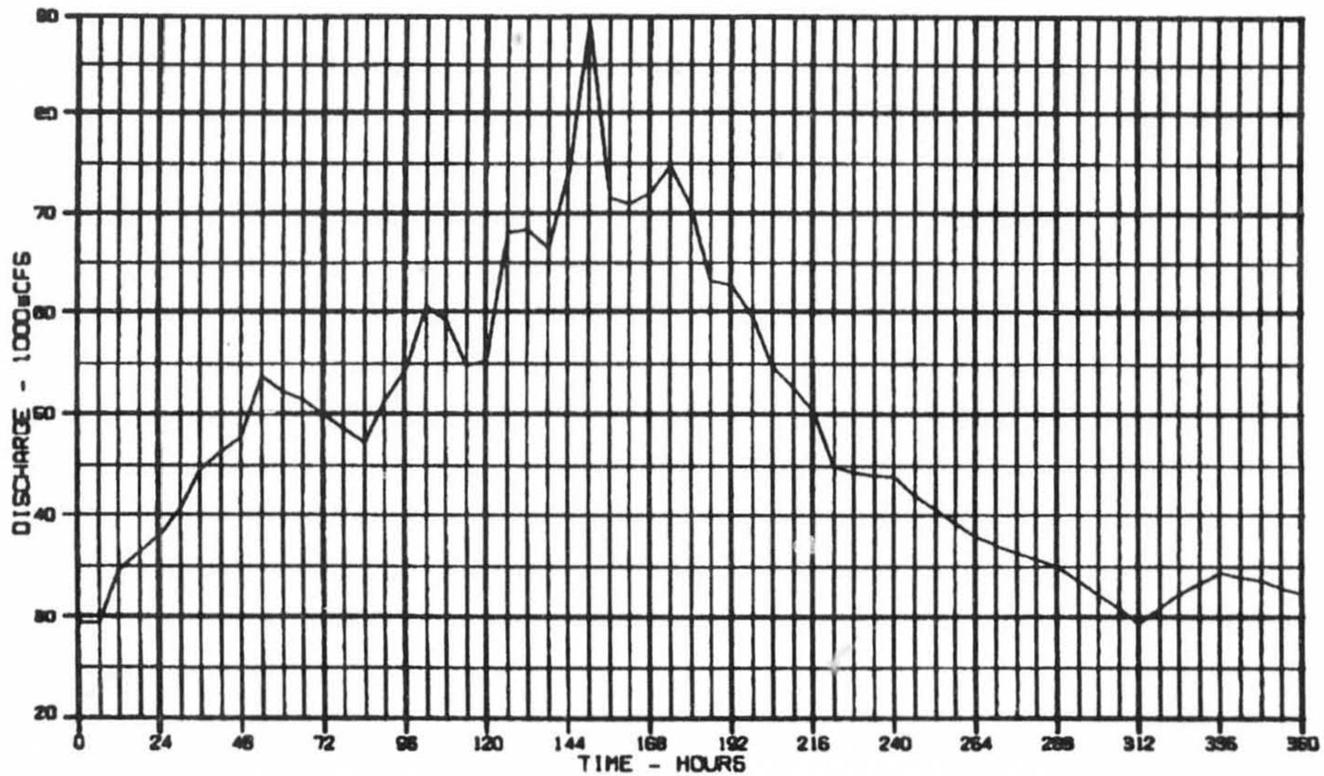


PEAK = 67200 CFS. 16-DAY VOLUME = 1.06*10**6 ACRE-FEET

ALASKA POWER AUTHORITY
SUSITNA PROJECT / HYDROLOGY
25-YEAR JULY-SEPTEMBER MAXIMUM FLOOD HYDROGRAPH AT WATANA
HARZA-EBASCO JOINT VENTURE
42-010-21

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 6
SHEET 1 OF 3



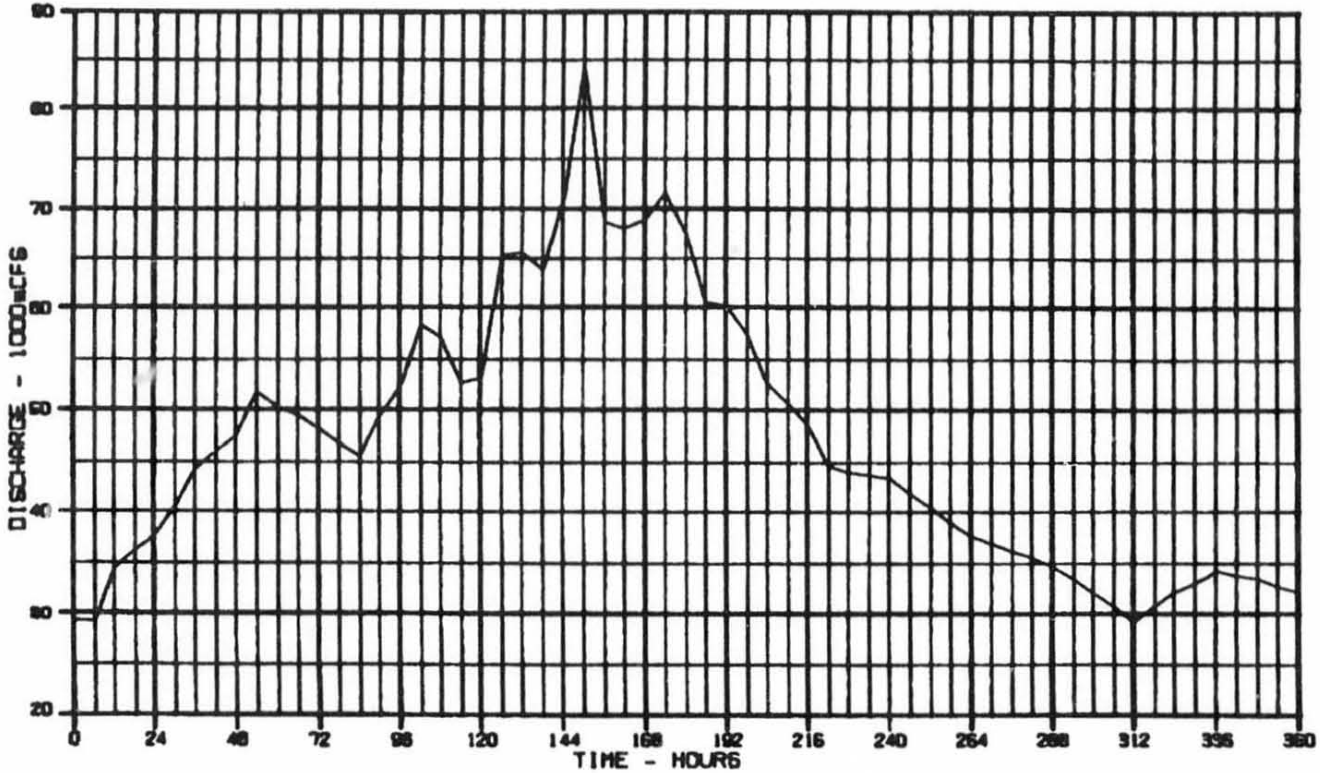
PEAK = 89600 CFS. 16-DAY VOLUME = 1.43x10**6 ACRE-FEET

ALASKA POWER AUTHORITY	
SUSITNA PROJECT	HYDROLOGY
50-YEAR ANNUAL MAXIMUM FLOOD HYDROGRAPH AT WATANA	
HARZA-EBASCO JOINT VENTURE	

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 6

SHEET 2 OF 3

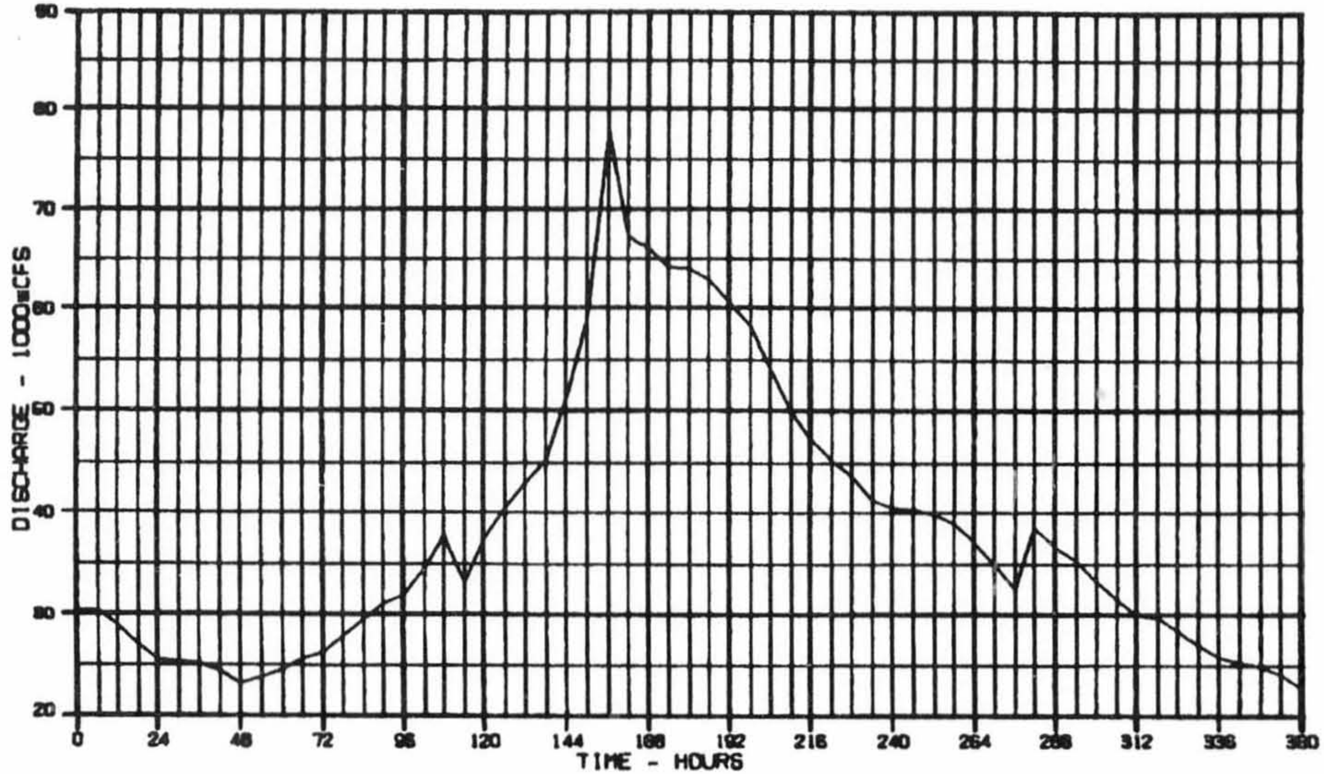


PEAK = 84400 CFS. 16-DAY VOLUME = 1.40*10**6 ACRE-FEET

ALASKA POWER AUTHORITY	
SUSITNA PROJECT	HYDROLOGY
50-YEAR MAY-JUNE MAXIMUM FLOOD HYDROGRAPH AT WATANA	
HARZA-EBASCO JOINT VENTURE	

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 6
SHEET 3 OF 3



PEAK = 77800 CFS. 16-DAY VOLUME = 1.14*10**6 ACRE-FEET

ALASKA POWER AUTHORITY

SUSITNA PROJECT | HYDROLOGY

50-YEAR JULY-SEPTEMBER MAXIMUM FLOOD HYDROGRAPH AT WATANA

HARZA-EBASCO JOINT VENTURE

42-010-21

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 7
SHEET 1 OF 3

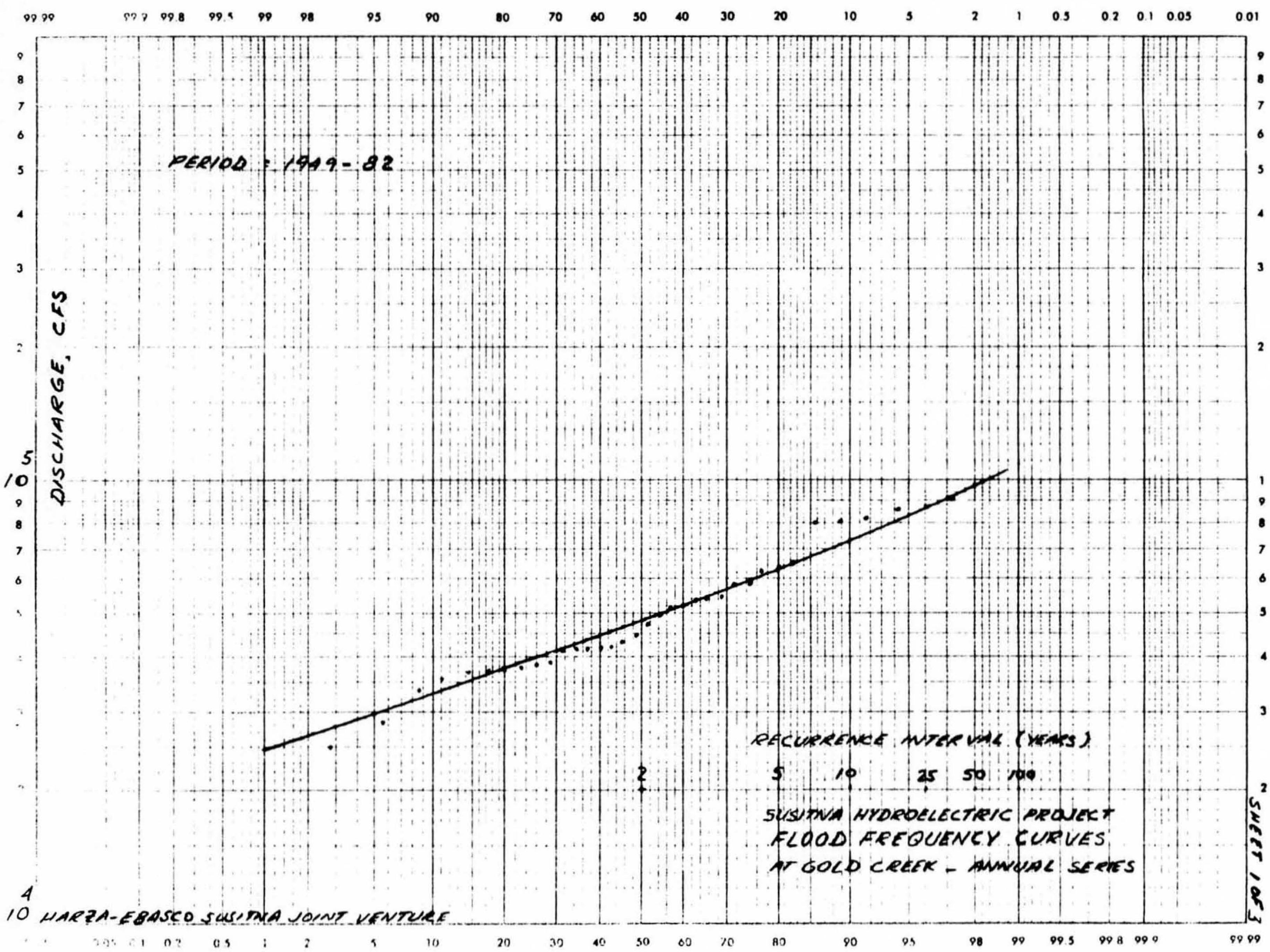
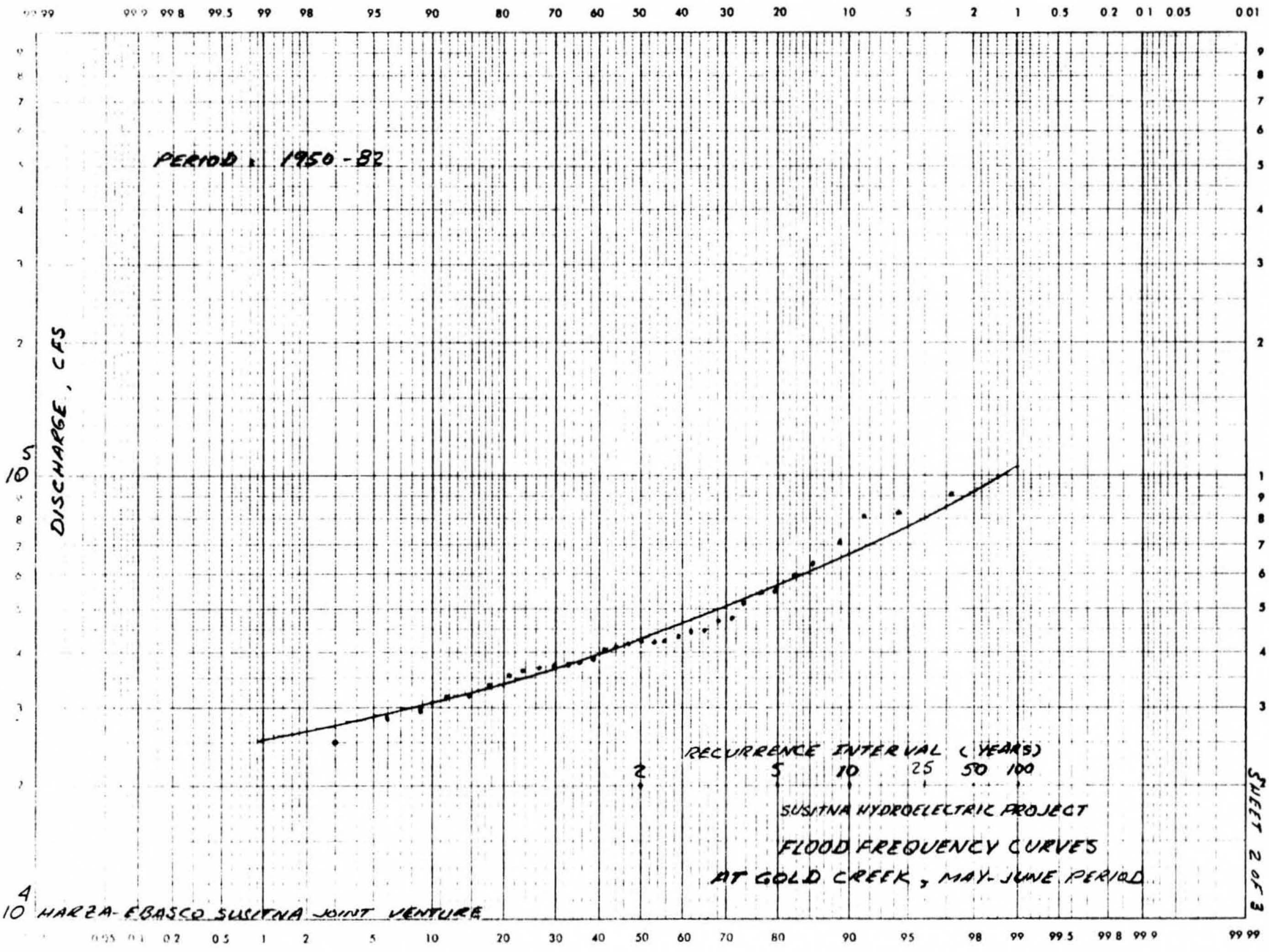


EXHIBIT 7
SHEET 2 OF 3



SUSITNA HYDROELECTRIC PROJECT

FLOOD FREQUENCY CURVES AT GOLD CREEK, MAY-JUNE PERIOD

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 7
SHEET 3 OF 3

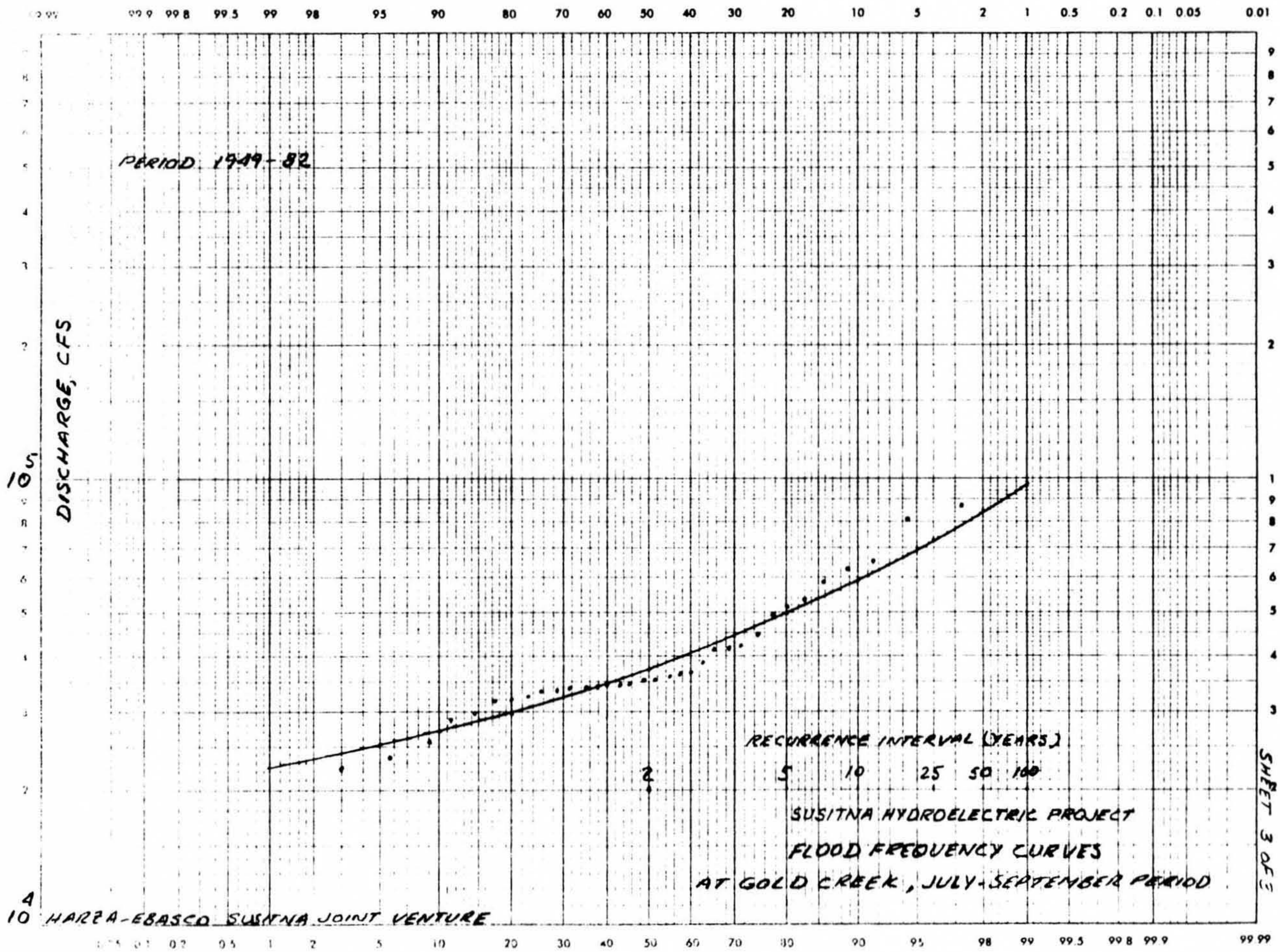


EXHIBIT 8
SHEET 1 OF 3

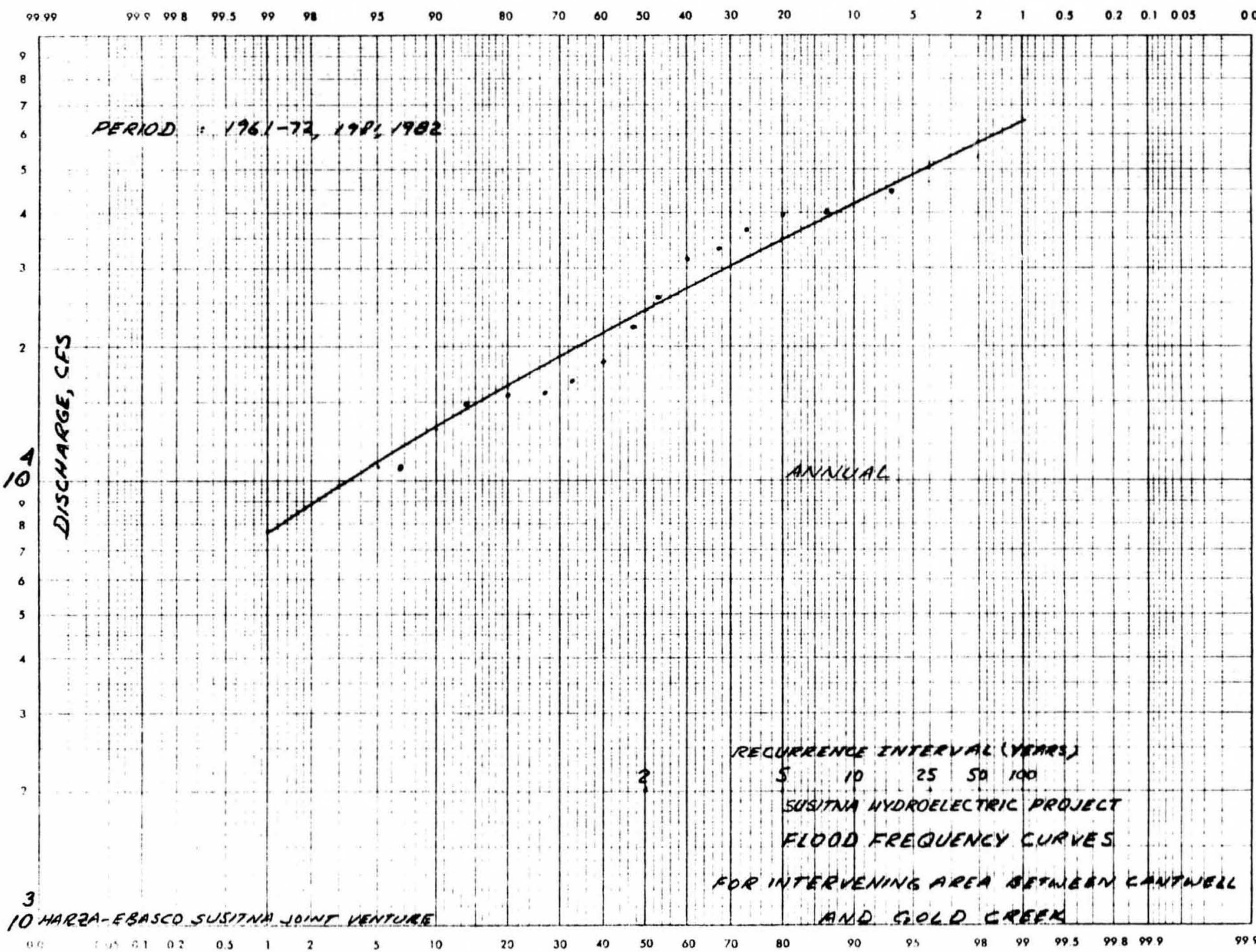


EXHIBIT 8
SHEET 2 OF 3

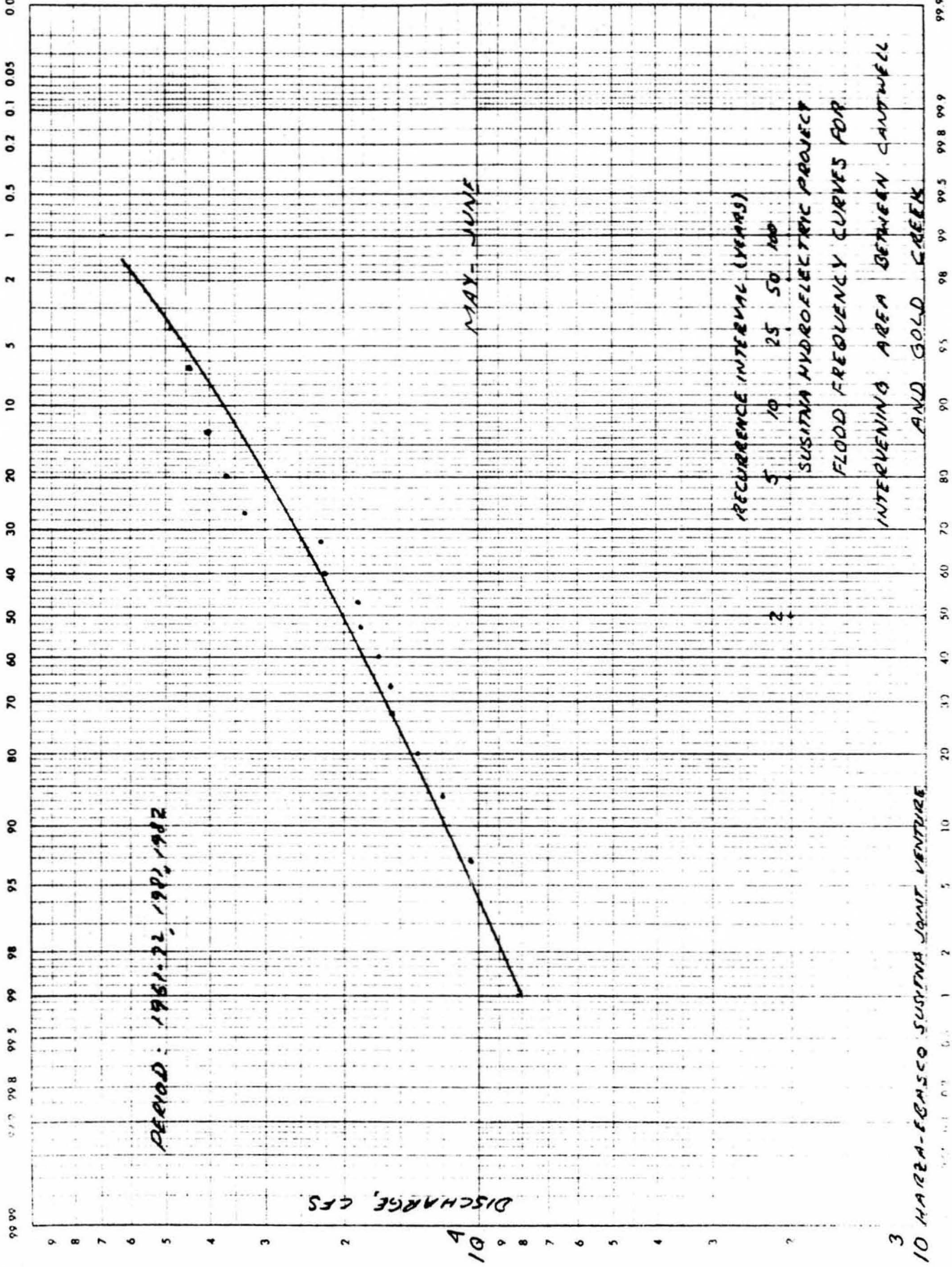


EXHIBIT 8
SHEET 3 OF 3

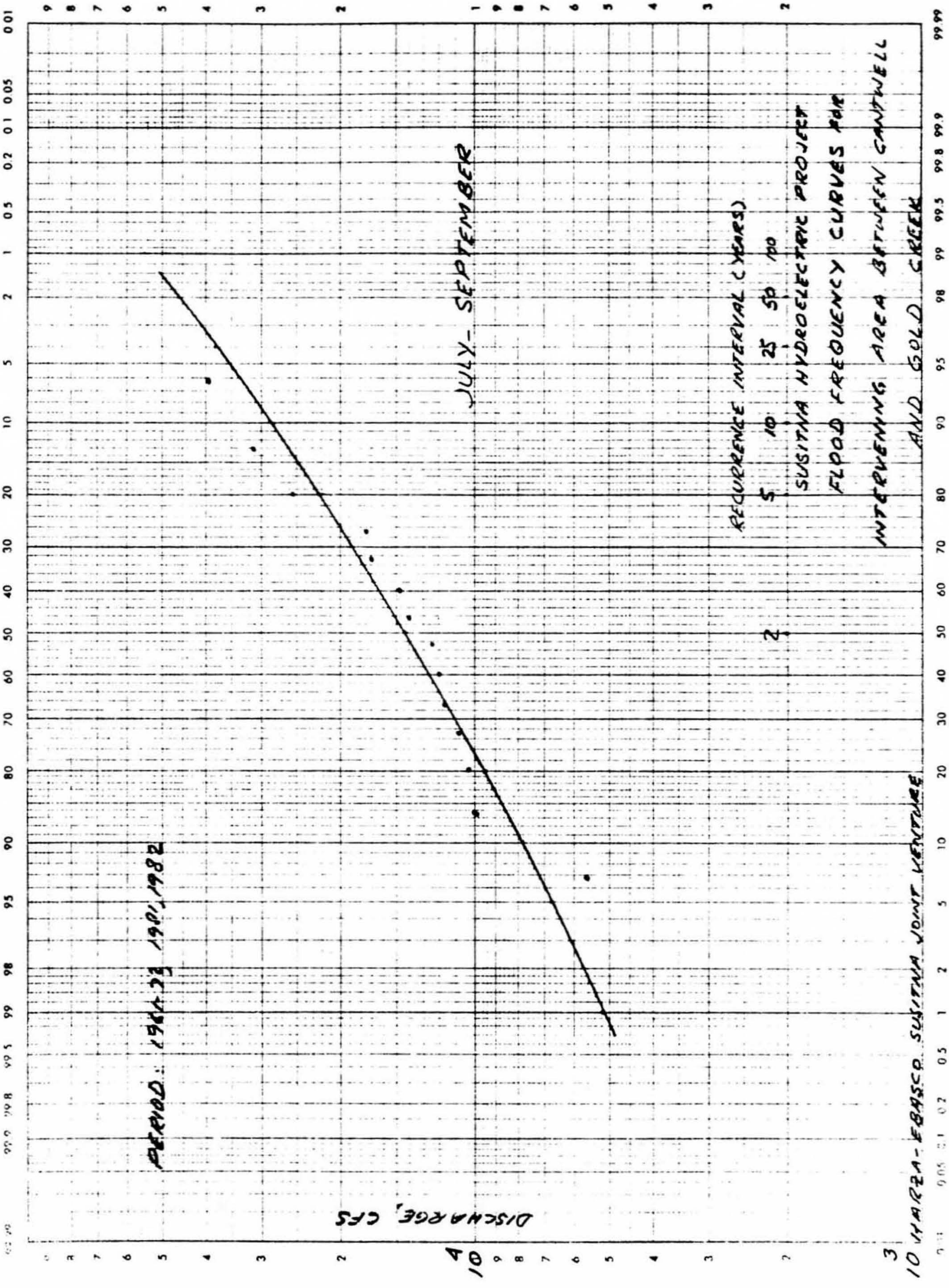
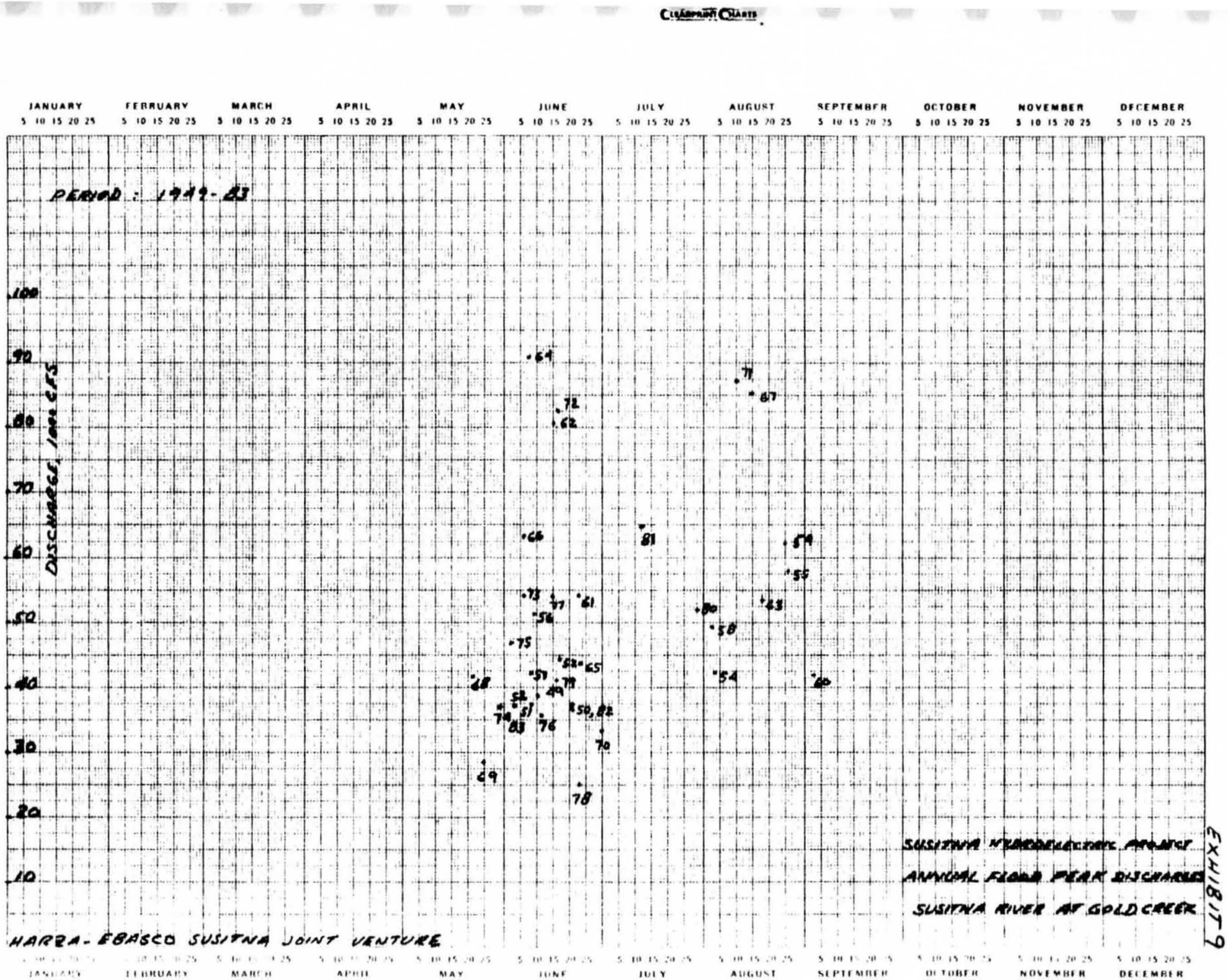


EXHIBIT 9



CLEARPRINT CHARTS
JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
5 10 15 20 25
PERIOD : 1949-83
DISCHARGE, 1000 CFS
100
90
80
70
60
50
40
30
20
10
64
72
62
71
87
66
81
54
55
73
77
61
56
80
58
63
75
52
65
57
79
54
60
68
52
49
51
50, 82
74
83
76
70
69
78
SUSITNA HYDROELECTRIC PROJECT
ANNUAL FLOOD PEAK DISCHARGES
SUSITNA RIVER AT GOLD CREEK
HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 10
SHEET 1 OF 3

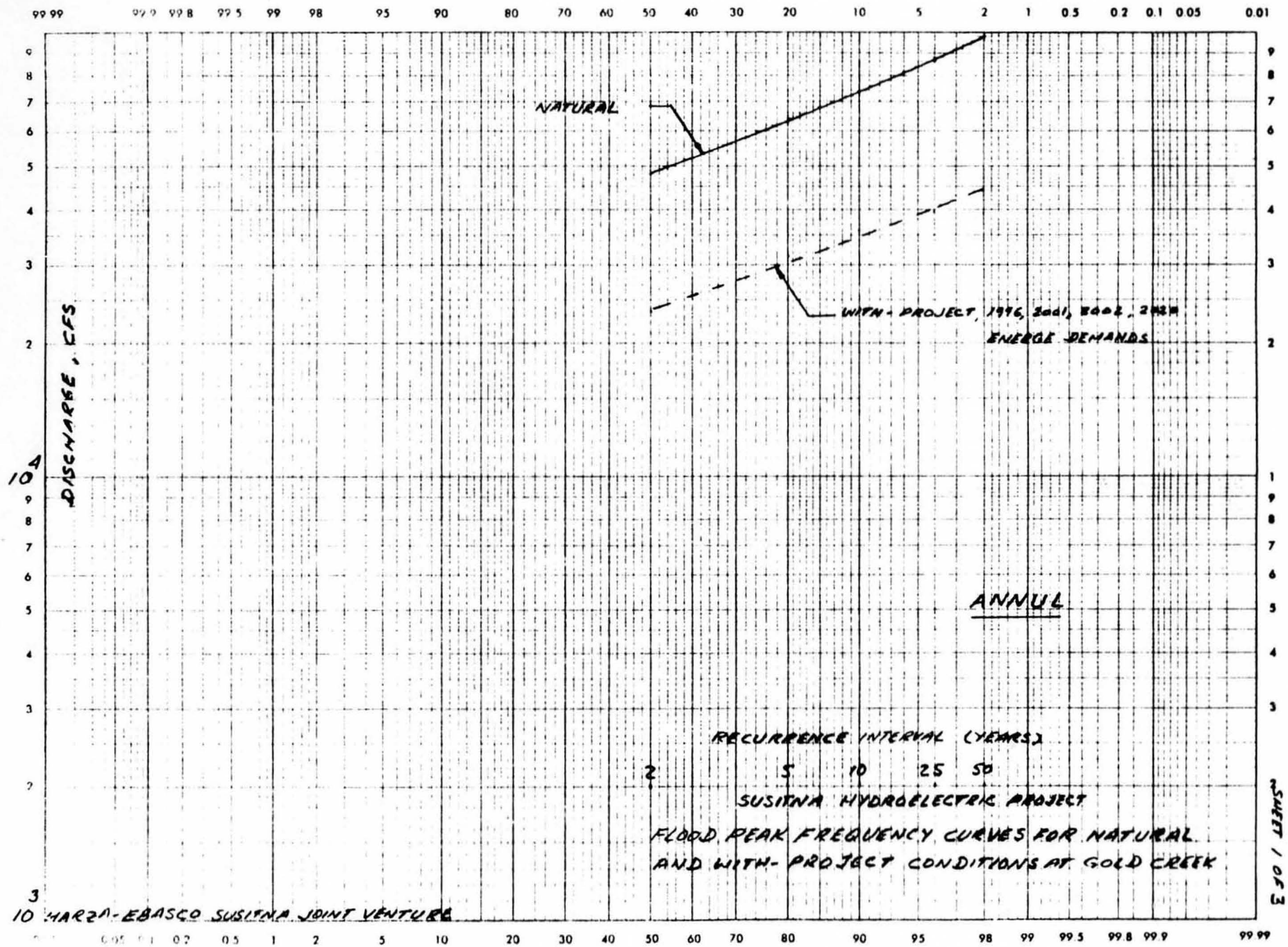
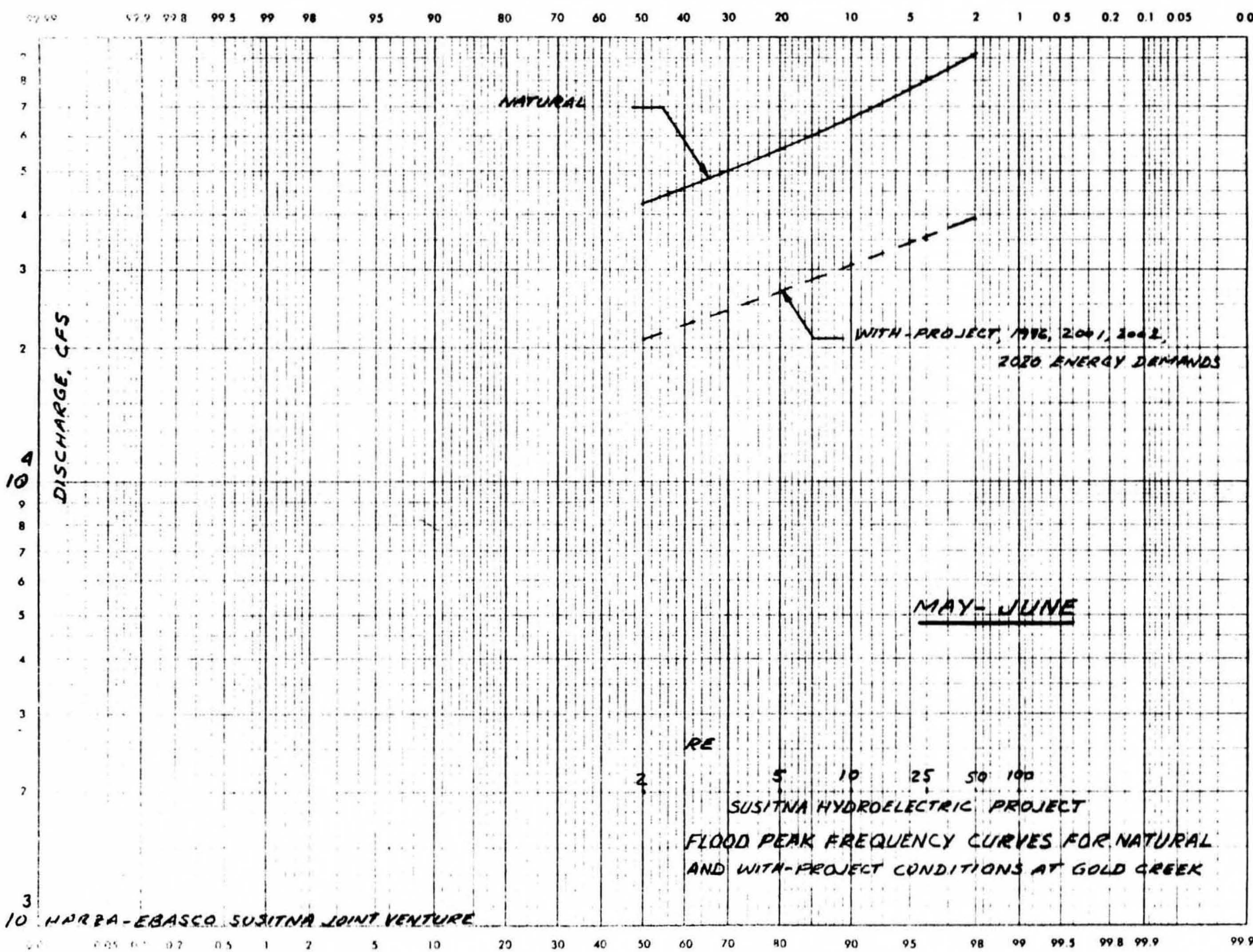
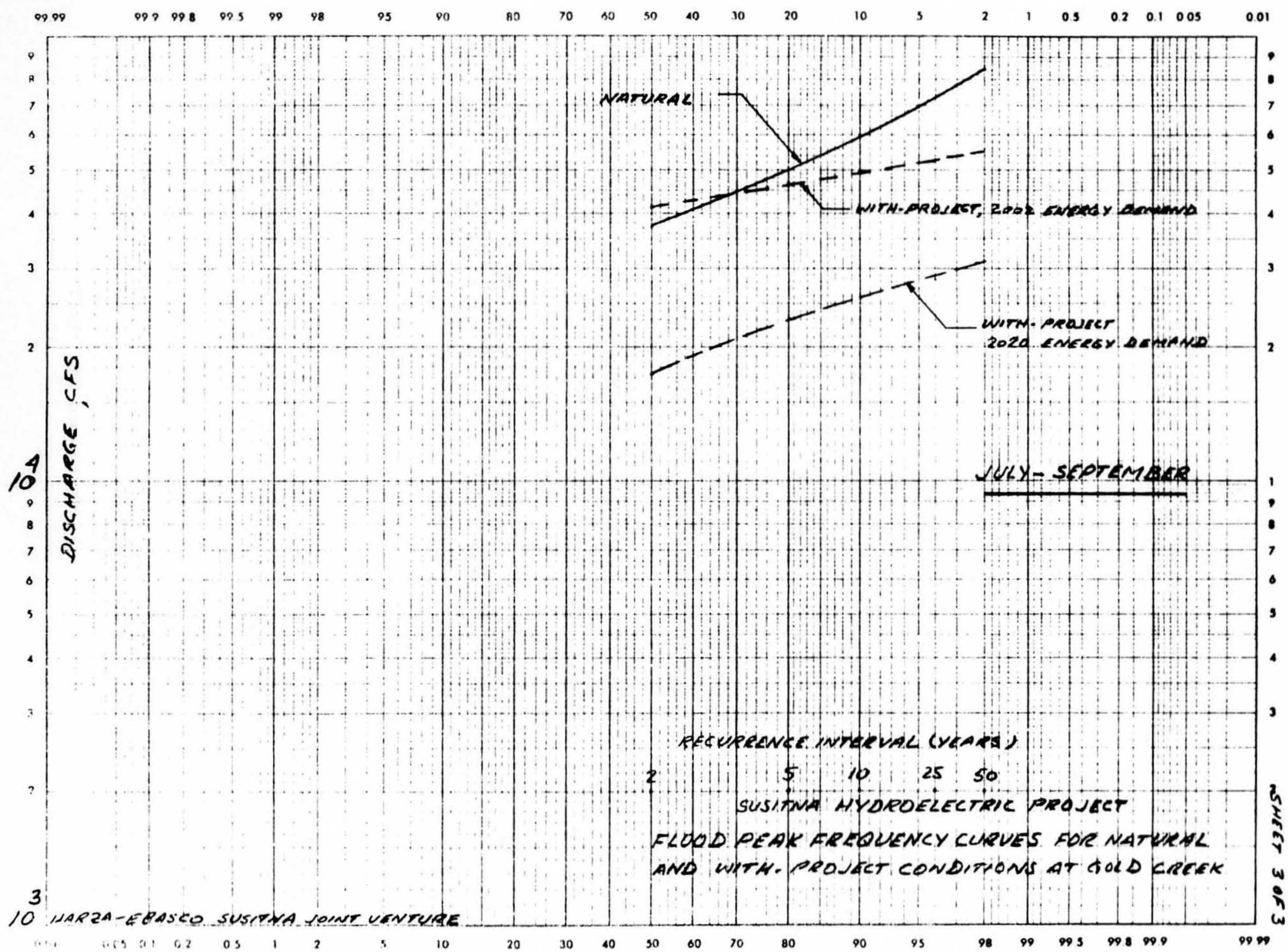


EXHIBIT 10
SHEET 2 OF 3




NATURAL
WITH-PROJECT, 2002 ENERGY DEMAND
WITH-PROJECT
2020 ENERGY DEMAND
JULY - SEPTEMBER
DISCHARGE, CFS
RECURRENCE INTERVAL (YEARS)
2
5
10
25
50
SUSITNA HYDROELECTRIC PROJECT
FLOOD PEAK FREQUENCY CURVES FOR NATURAL AND WITH-PROJECT CONDITIONS AT GOLD CREEK
HARZA-EBASCO SUSITNA JOINT VENTURE

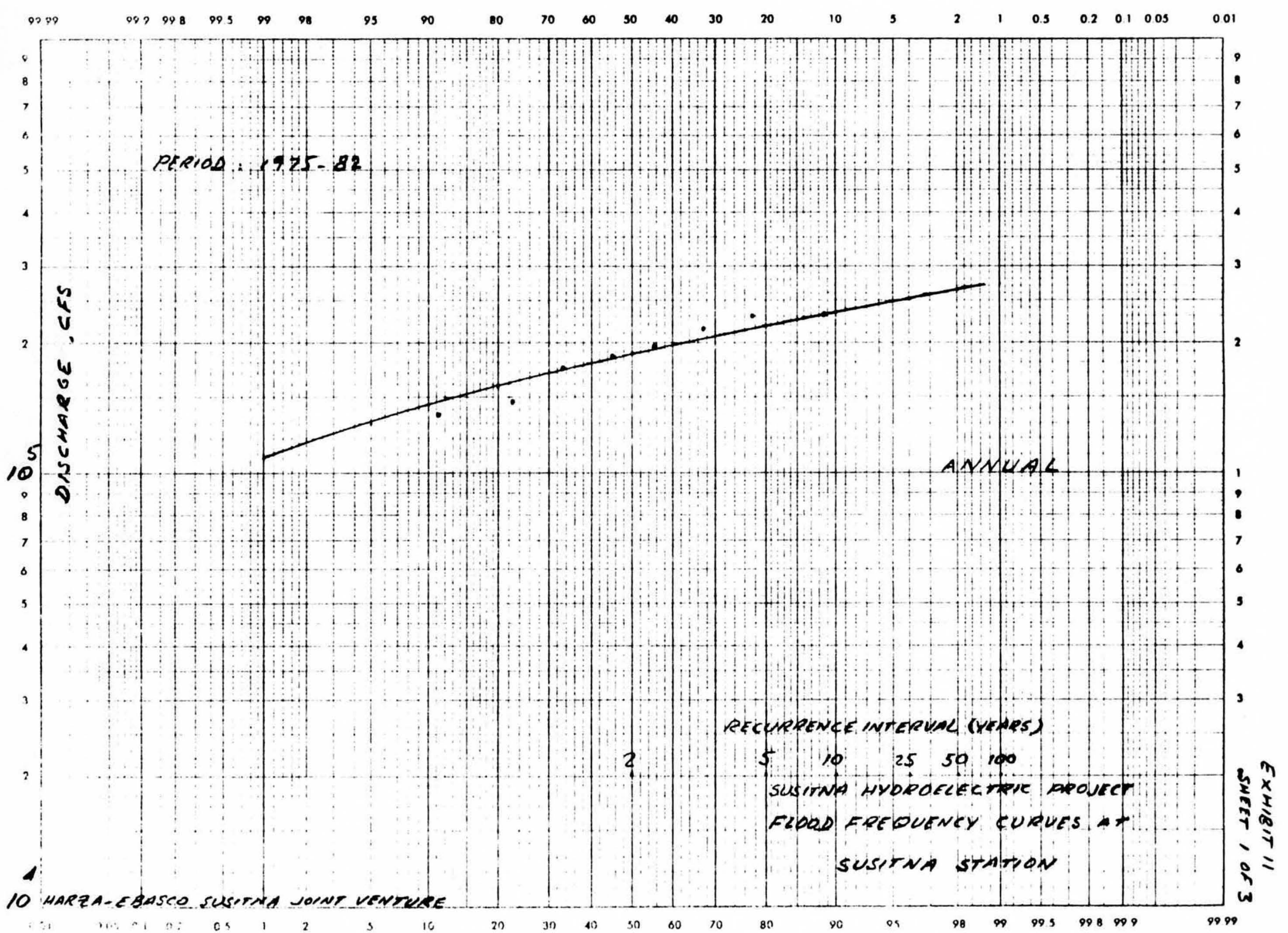


EXHIBIT 11
SHEET 1 OF 3
PERIOD: 1975-82
DISCHARGE, CFS
10^5
10^4
ANNUAL
RECURRENCE INTERVAL (YEARS)
2 5 10 25 50 100
SUSITNA HYDROELECTRIC PROJECT
FLOOD FREQUENCY CURVES AT
SUSITNA STATION
HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 11
SHEET 2 of 3

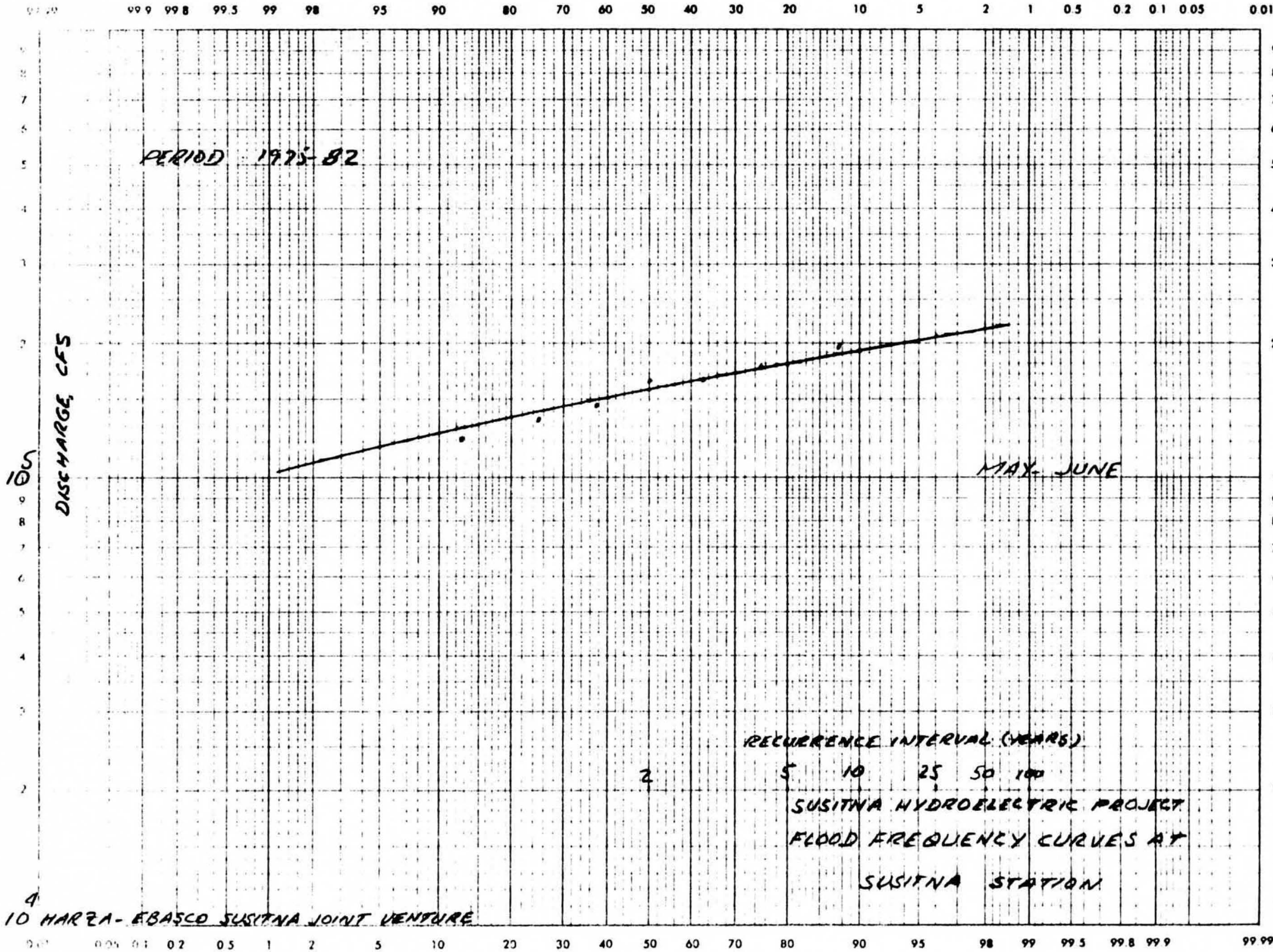
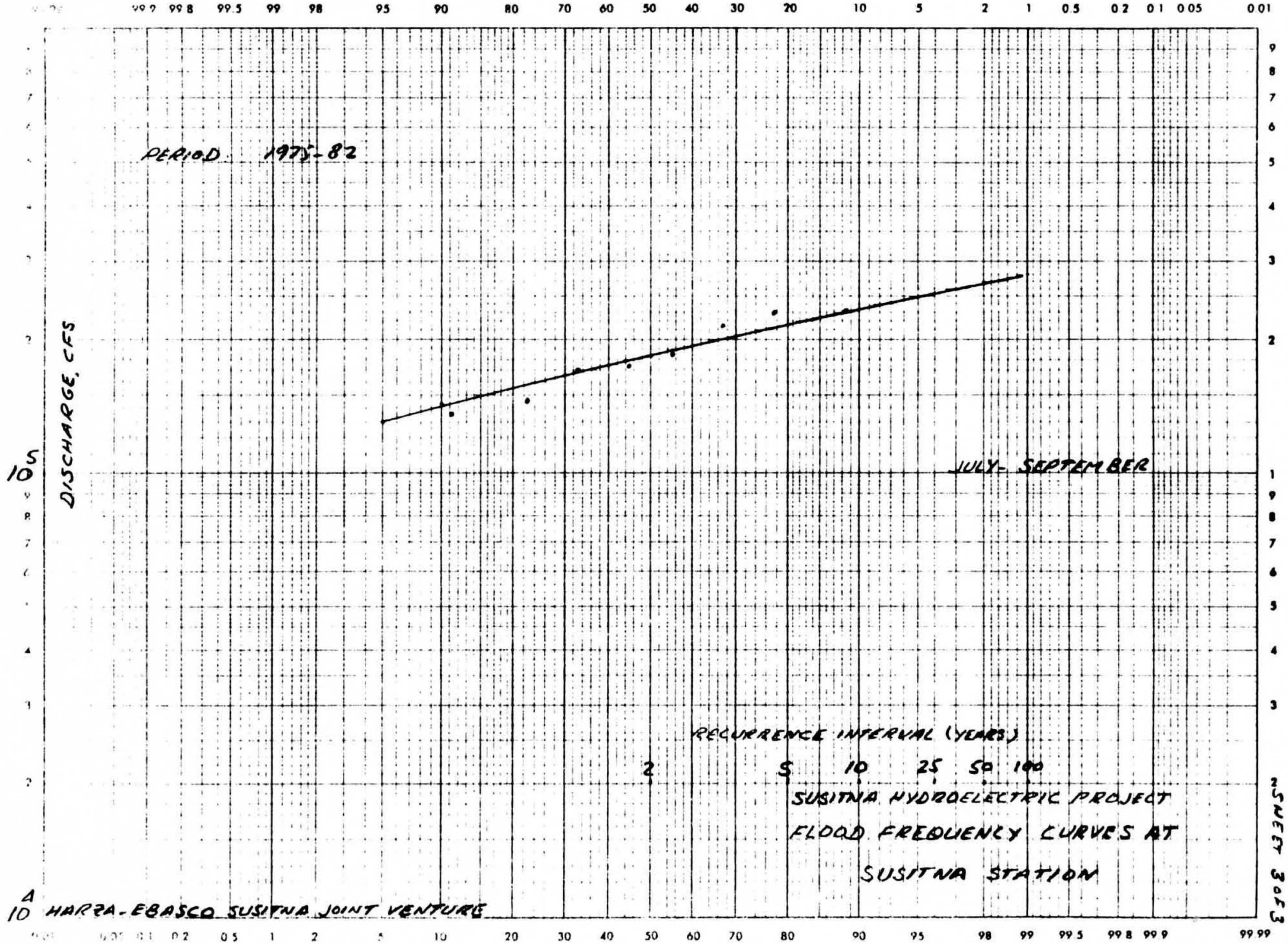


EXHIBIT 11
SHEET 3 OF 3



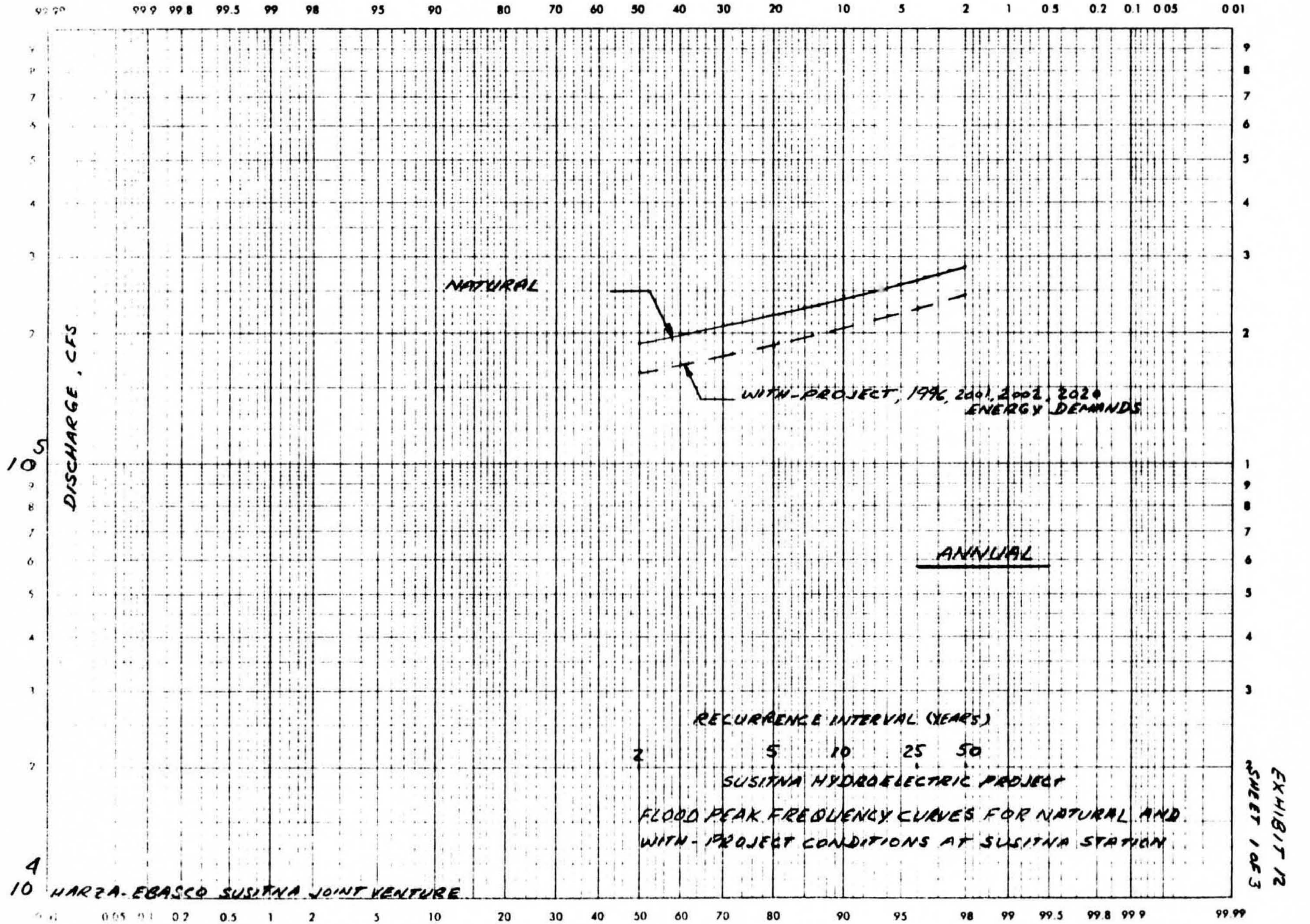
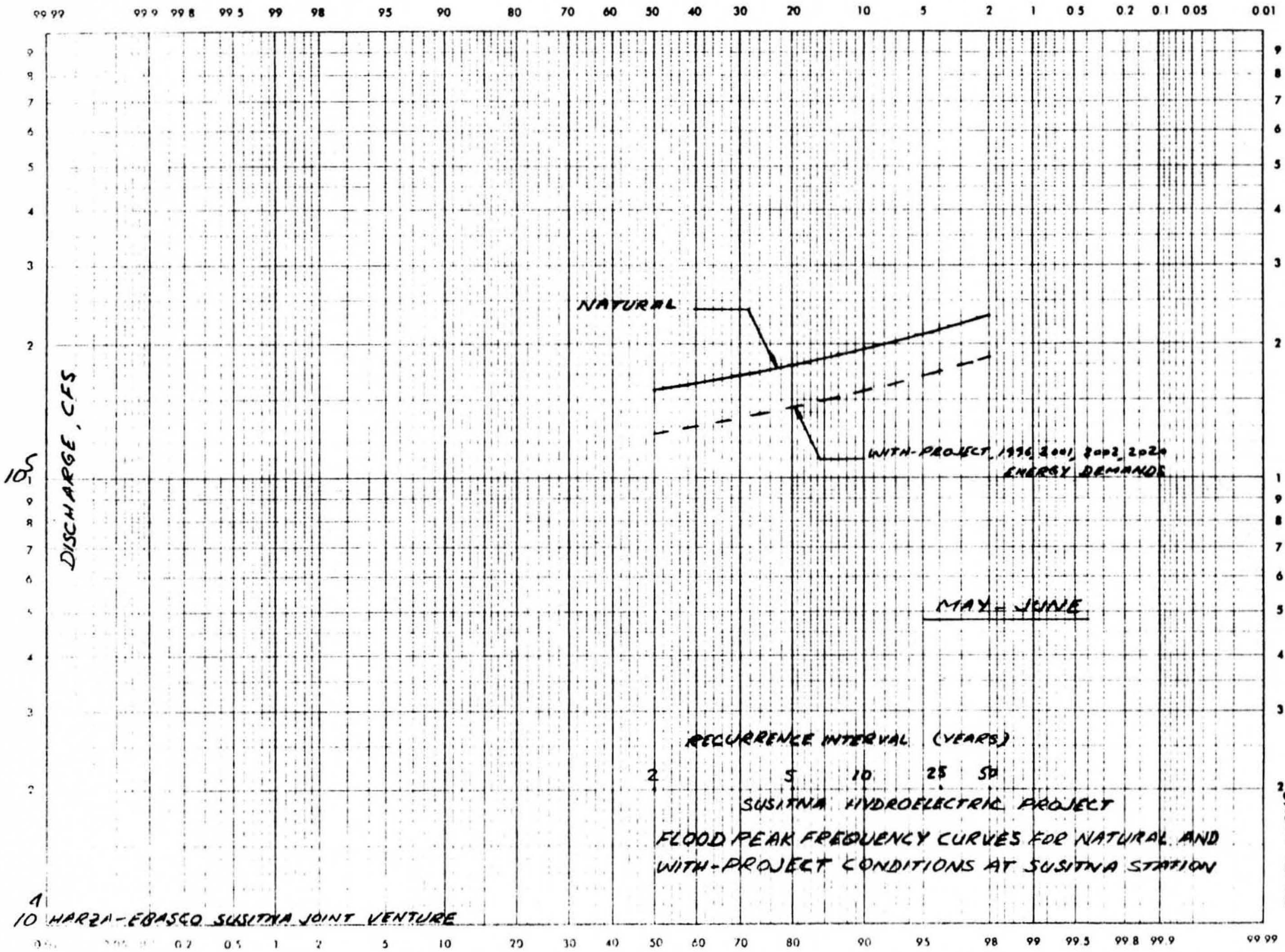


EXHIBIT 12
SHEET 1 OF 3
NATURAL
WITH-PROJECT, 1996, 2001, 2002, 2020 ENERGY DEMANDS
DISCHARGE, CFS
ANNUAL
RECURRENCE INTERVAL (YEARS)
2 5 10 25 50
SUSITNA HYDROELECTRIC PROJECT
FLOOD PEAK FREQUENCY CURVES FOR NATURAL AND WITH-PROJECT CONDITIONS AT SUSITNA STATION
HARZA-EBASCO SUSITNA JOINT VENTURE

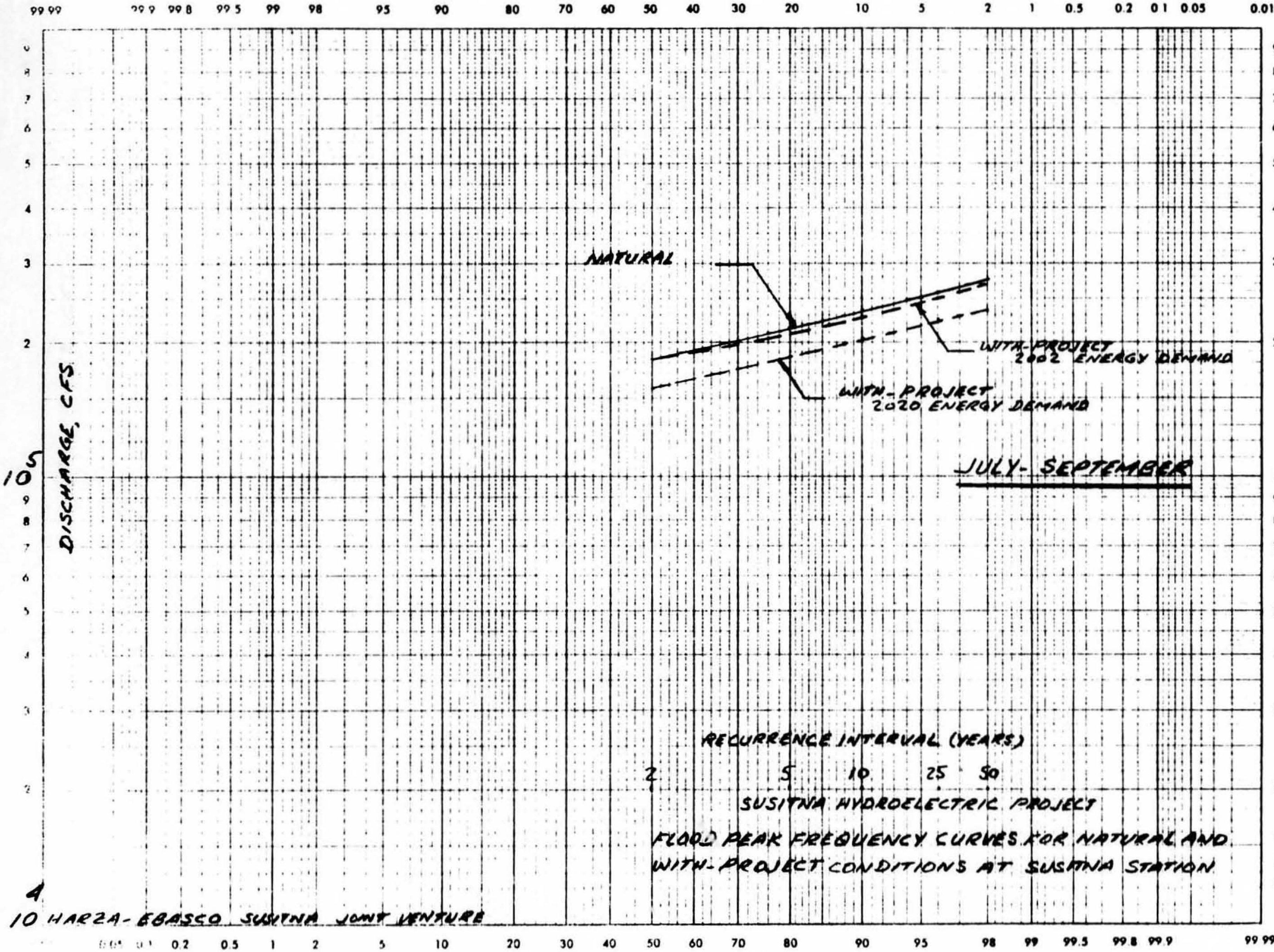


SUSITNA HYDROELECTRIC PROJECT

FLOOD PEAK FREQUENCY CURVES FOR NATURAL AND WITH-PROJECT CONDITIONS AT SUSITNA STATION

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 12
SHEET 2 OF 3



SUSITNA HYDROELECTRIC PROJECT

FLOOD PEAK FREQUENCY CURVES FOR NATURAL AND WITH-PROJECT CONDITIONS AT SUSITNA STATION

HARZA-EBASCO SUSITNA JOINT VENTURE

EXHIBIT 13
SHEET 1 OF 3

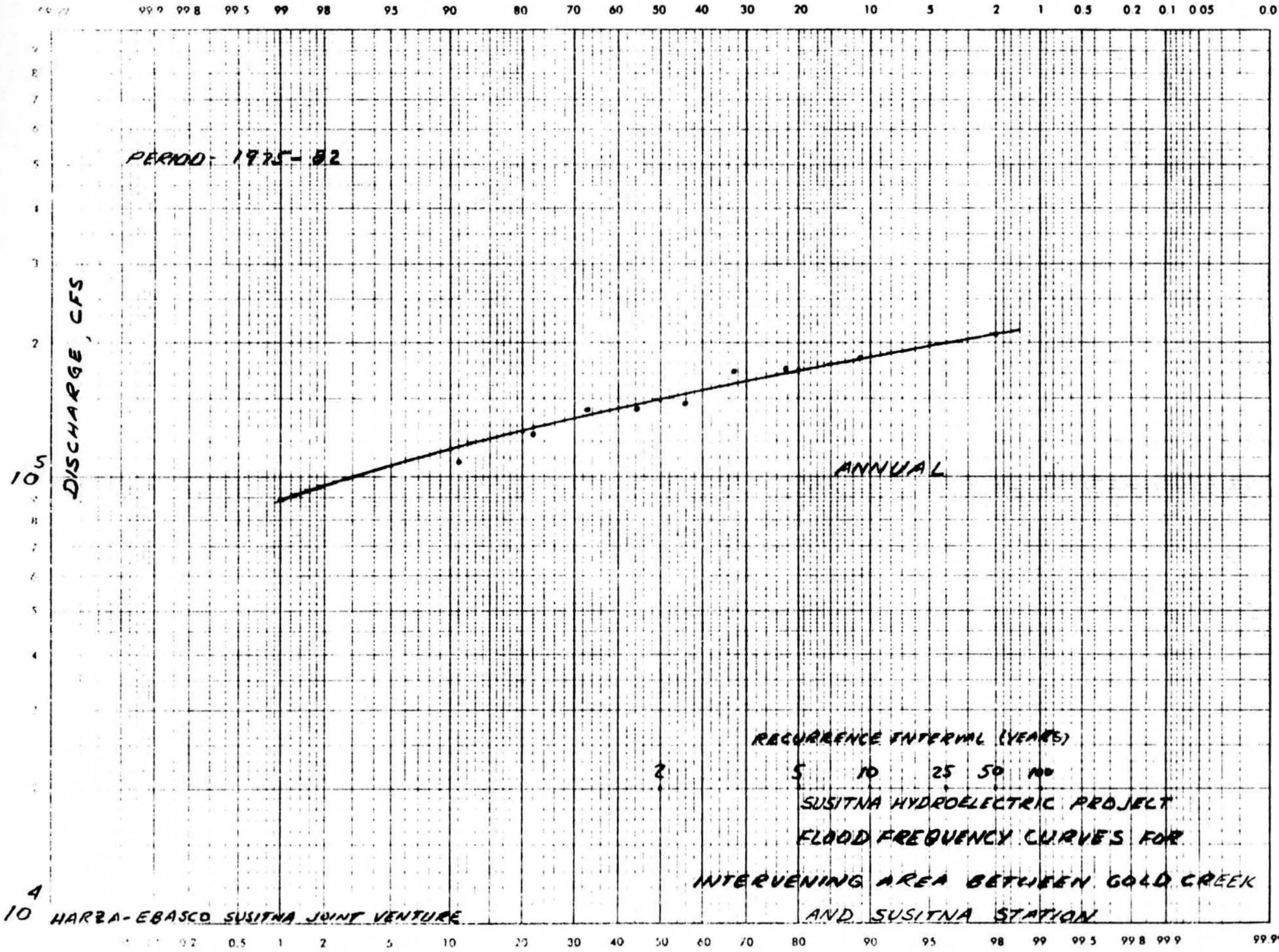


EXHIBIT 13
SHEET 2 OF 3

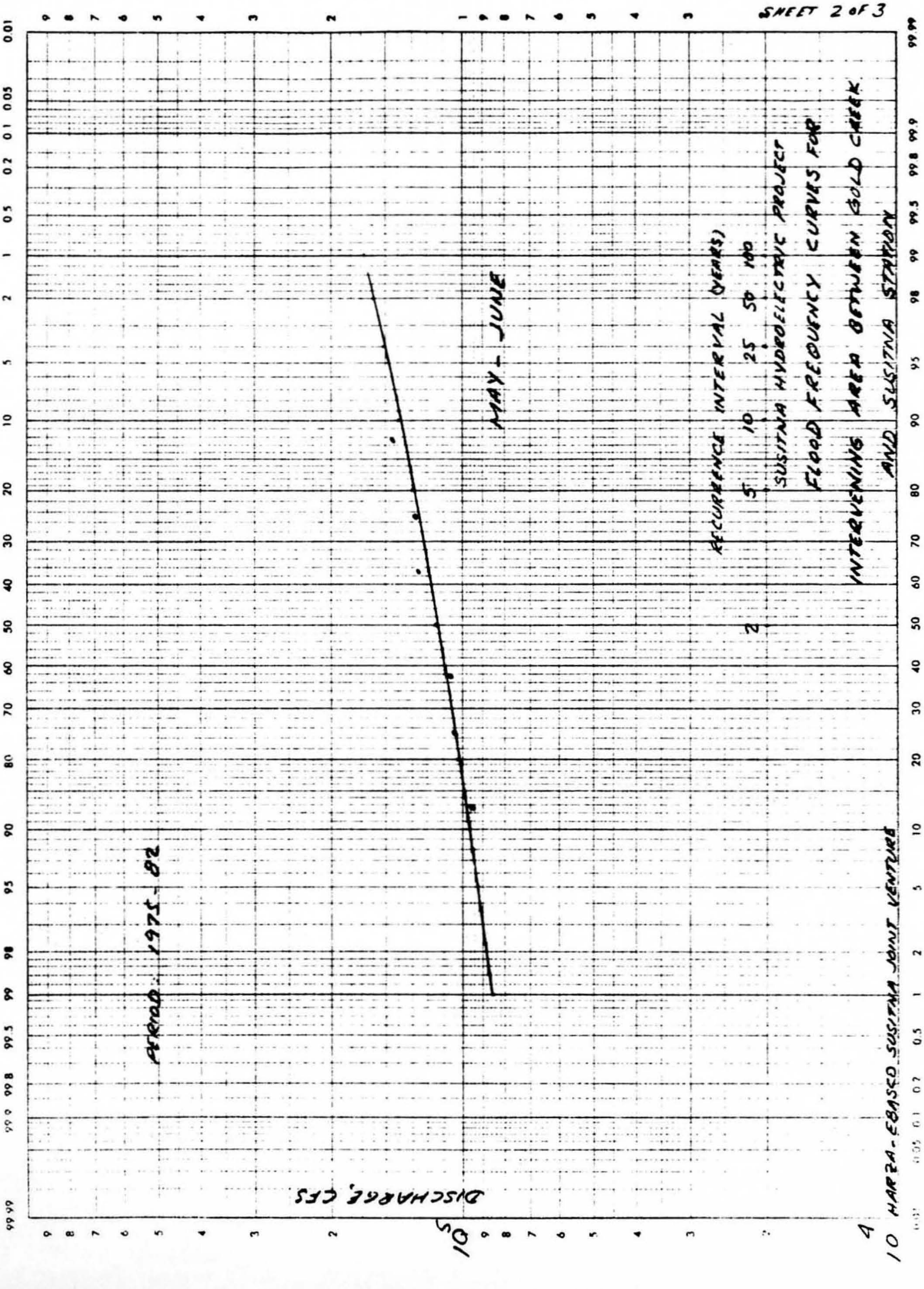
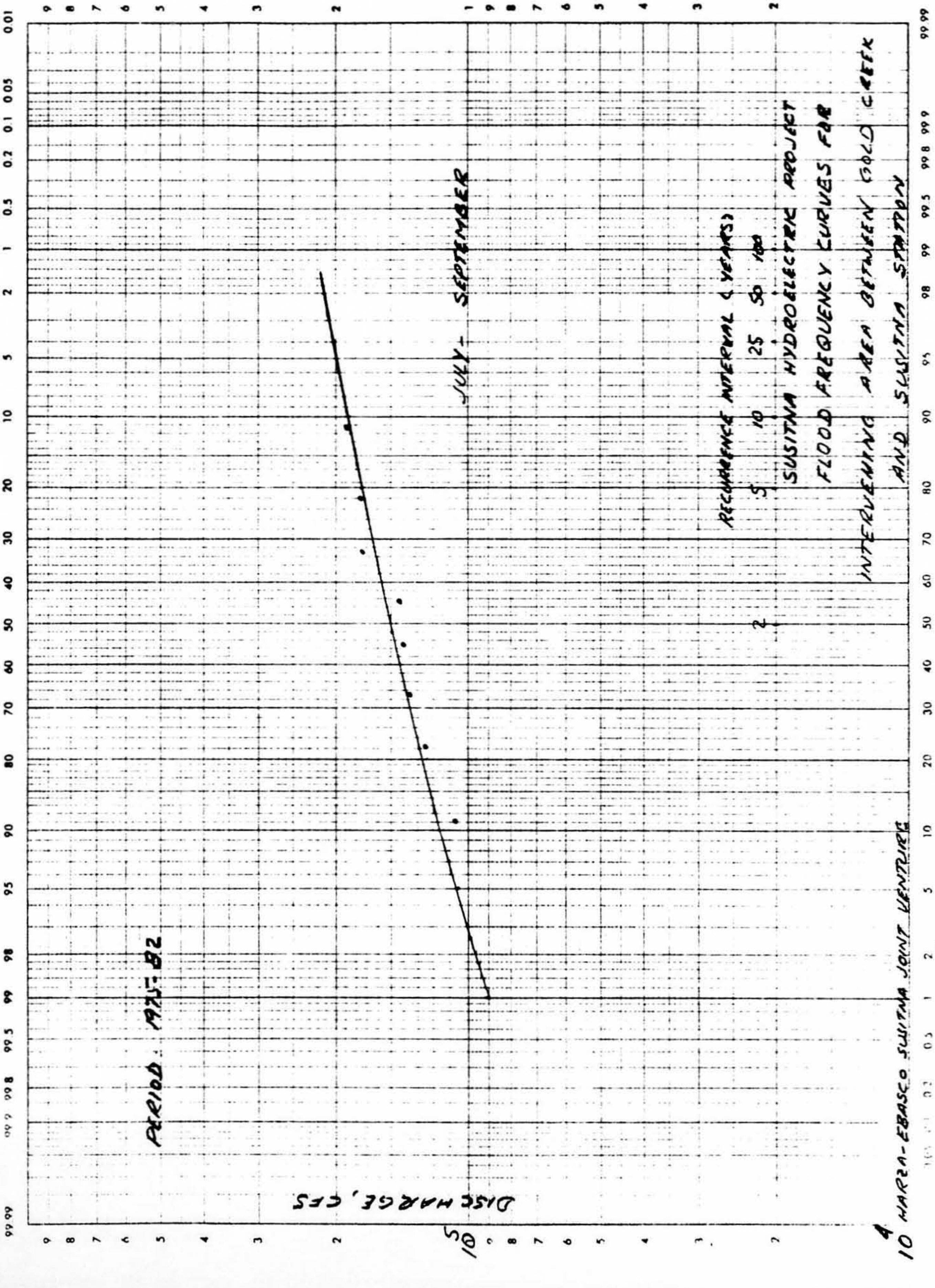
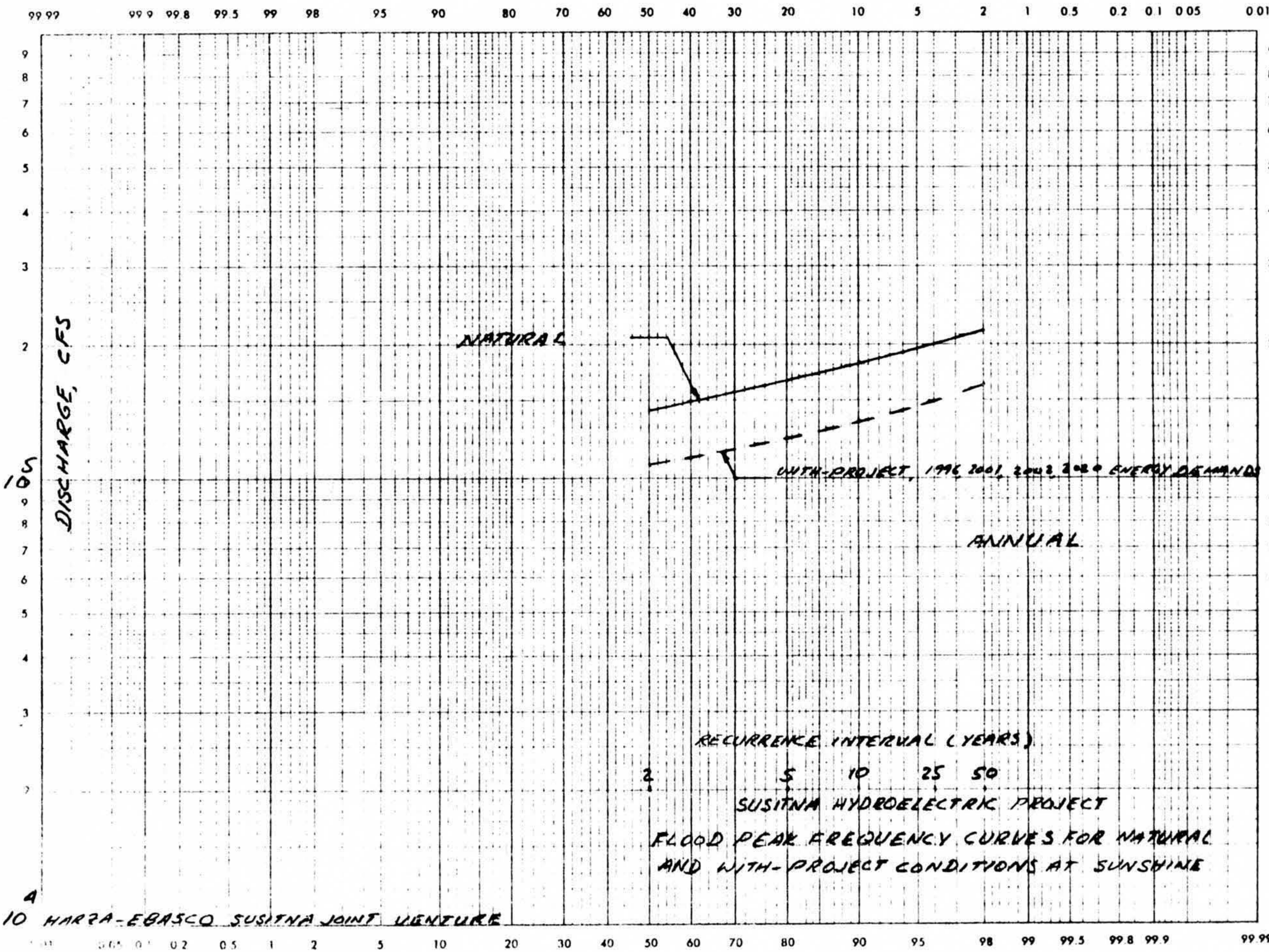
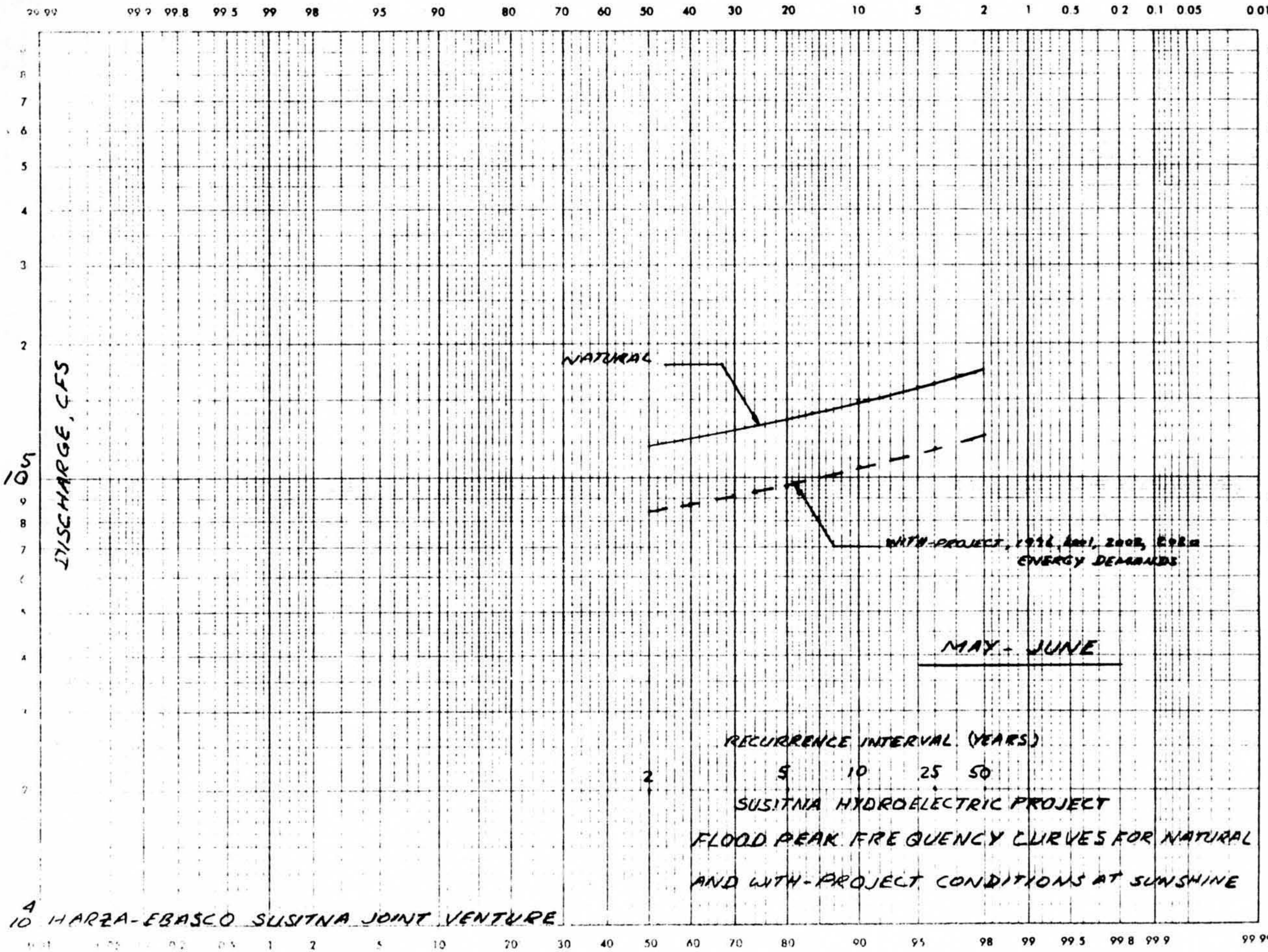
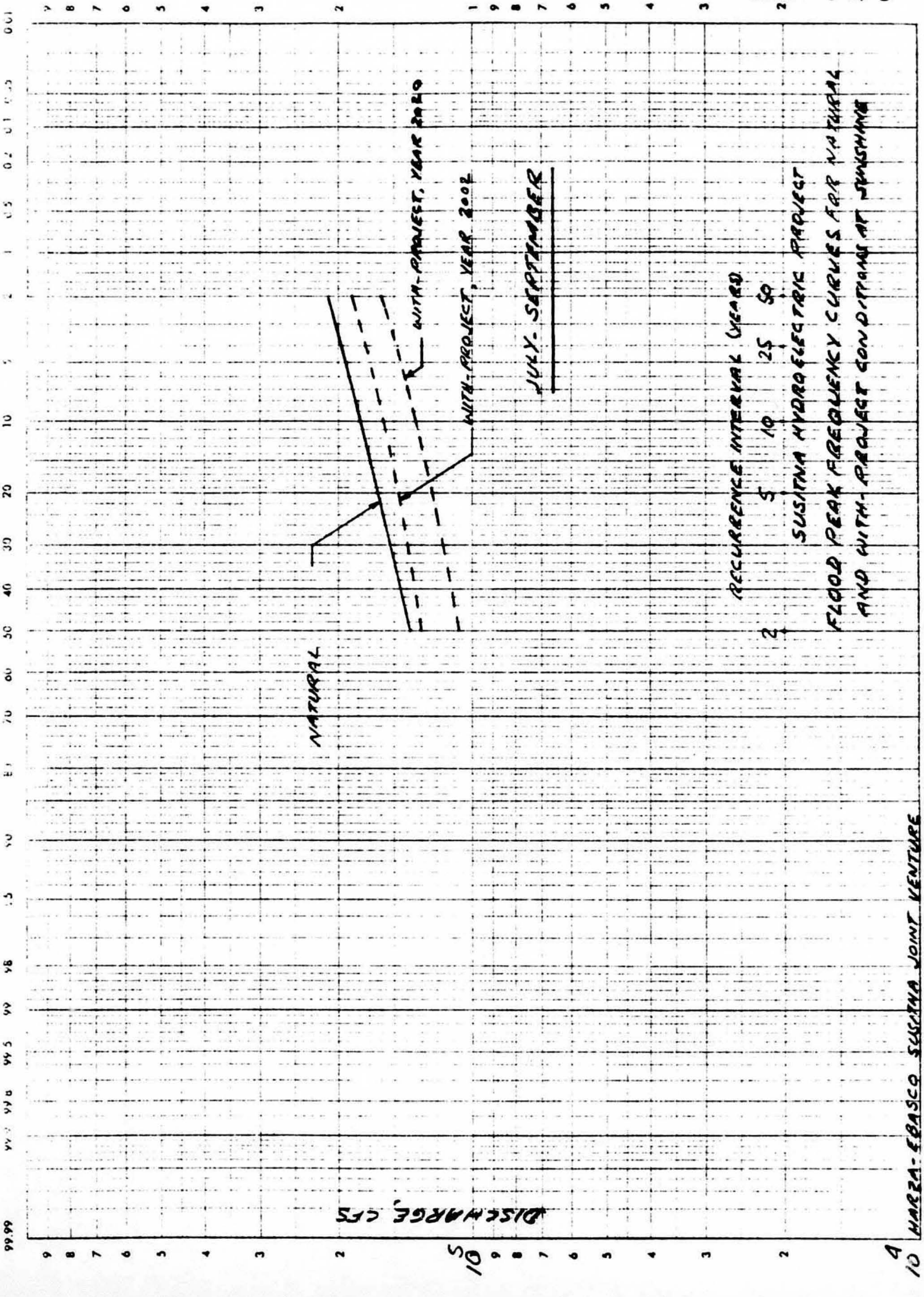


EXHIBIT 13
SHEET 3 OF 3




DISCHARGE, CFS
NATURAL
WITH-PROJECT, 1996, 2001, 2002, 2020 ENERGY DEMANDS
ANNUAL
RECURRENCE INTERVAL (YEARS)
2 5 10 25 50
SUSITNA HYDROELECTRIC PROJECT
FLOOD PEAK FREQUENCY CURVES FOR NATURAL AND WITH-PROJECT CONDITIONS AT SUNSHINE
HARZA-EBASCO SUSITNA JOINT VENTURE


DISCHARGE, CFS
NATURAL
WITH-PROJECT,
ENERGY DEMANDS
MAY - JUNE
RECURRENCE INTERVAL (YEARS)
2 5 10 25 50
SUSITNA HYDROELECTRIC PROJECT
FLOOD PEAK FREQUENCY CURVES FOR NATURAL
AND WITH-PROJECT CONDITIONS AT SUNSHINE
HARZA-EBASCO SUSITNA JOINT VENTURE


SUSITNA HYDROELECTRIC PROJECT
FLOOD PEAK FREQUENCY CURVES FOR NATURAL
AND WITH-PROJECT CONDITIONS AT SUNSHINE
JULY-SEPTEMBER
RECURRENCE INTERVAL (YEARS)
2
5
10
25
50
NATURAL
WITH-PROJECT, YEAR 2002
WITH-PROJECT, YEAR 2020
DISCHARGE, CFS
HARZA-EBASCO SUSITNA JOINT VENTURE