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Reports on Water Flow in the Susitna River for the Susitna Hydroelectric Project

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Stage Fluctuations Resulting from Discharge Variations Due to Load Changes

Studies are being undertaken to determine the discharge and stage variations at significant locations resulting from various constraints on maximum change in powerhouse discharge and maximum rate of change of discharge. The values to be considered include:



Maximum Rate of <u>Release Change</u>	Maximum Weekly <u>Release Variation</u>
cfs/hr	cfs (+)
500	1000
	2000
	3000
	5000
1000	1000
	2000
	3000
	5000
2000	1000
	2000
	3000
	5000

The analysis will involve a dynamic routing of weekly powerhouse releases between Watana and Gold Creek for spring, summer, fall and winter periods. Dynamic routing will not be considered under an ice cover. Instead, a survey is underway to determine winter operating policies at other northern hydroelectric projects and downstream effects.

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The purpose of the study is to provide information necessary to make a decision on allowable discharge variations from Watana operating alone or Devil Canyon when operating with Watana. Preliminary studies indicate that, for discharge fluctuations greater than shown in the table, downstream attenuation of the powerhouse release pattern is minimal. The difference between maximum and minimum discharges at a point near Sherman would be similar to the difference at the powerhouse. If this holds true for smaller release variations the stage fluctuations can be estimated on a worst case basis from steady state rating curves already developed.

Exhibits 1 through 4 may be used to determine the maximum weekly stage variation resulting from fluctuations in discharge about a given weekly average flow. These curves are based on steady state rating curves at the noted locations. Daily flow fluctuations resulting from changing powerhouse loads might not result in as large stage fluctuations since channel storage and friction would result in some attenuation. The maximum rate of stage fluctuation can also be estimated using these curves at a given weekly average flow using a given time rate of flow change.

For example, at RM 127.1 for a weekly average flow of 10,000 cfs the maximum weekly stage fluctuation for a 1000 \pm cfs or 10% \pm flow variation would be 0.44 ft (0.22 ft \pm). The corresponding fluctuation at RM 136.68 would be 0.6 feet (0.30 ft \pm).

Exhibits 1 through 4 have been drawn for locations near the upstream ends of Sloughs 8A, 9, 11 and 21. Examination of water surface profiles in the report "Susitna Hydroelectric Project - Middle and Lower River Water Surface Profiles and Discharge Rating Curves" (HE, 1984) indicates these are representative of the range in stage fluctuations in the Middle Reach of the Susitna River. The rating curve at the Slough 11 head appears to give near maximum stage fluctuations while those at Sloughs 8A and 21 give near minimum stage fluctuations.

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Exhibit 1

Cross Section at RM 127.1

Slough BA Head

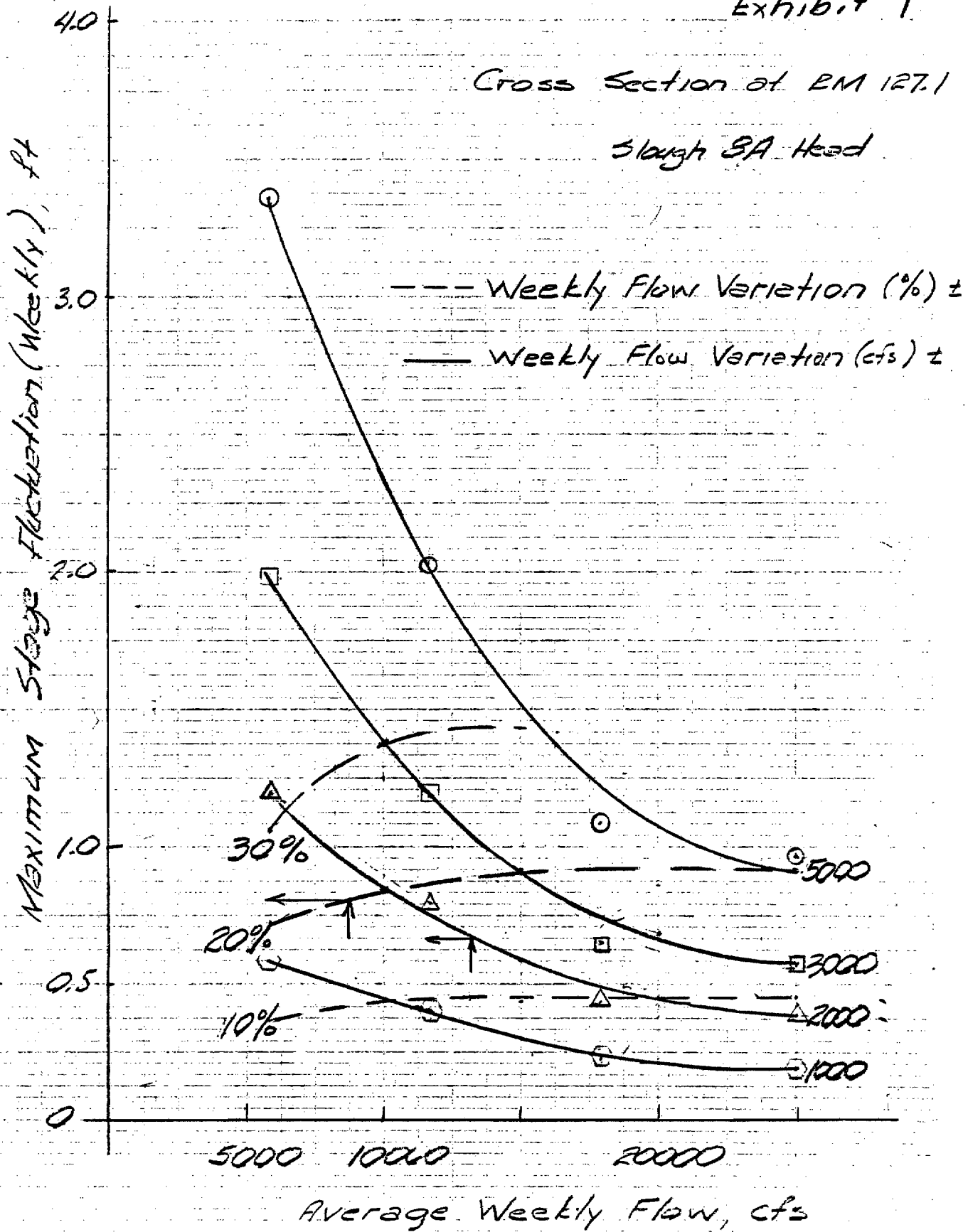
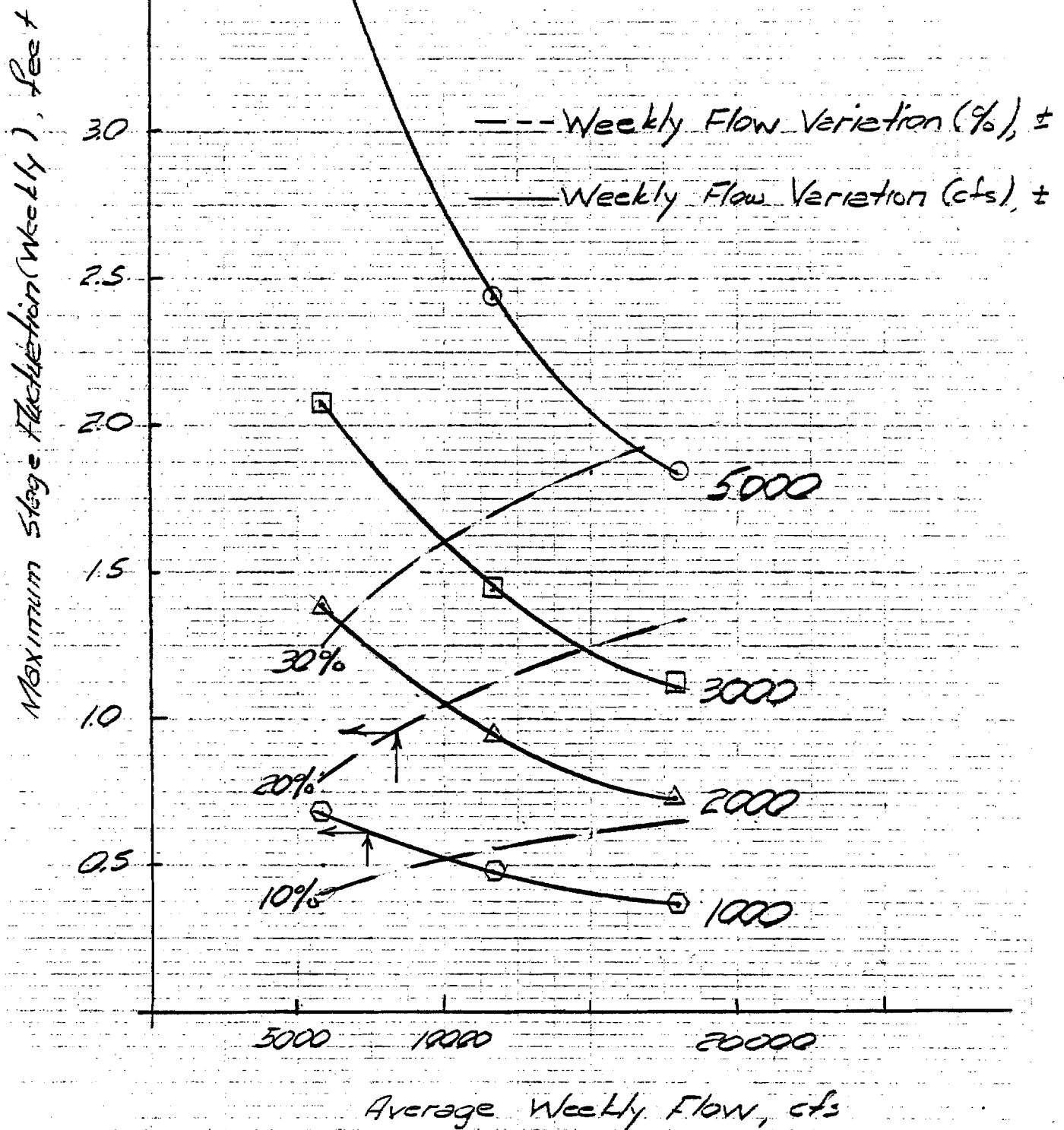


Exhibit 2

Cross Section at PM 129.3

SLOUGH 9 HEAD



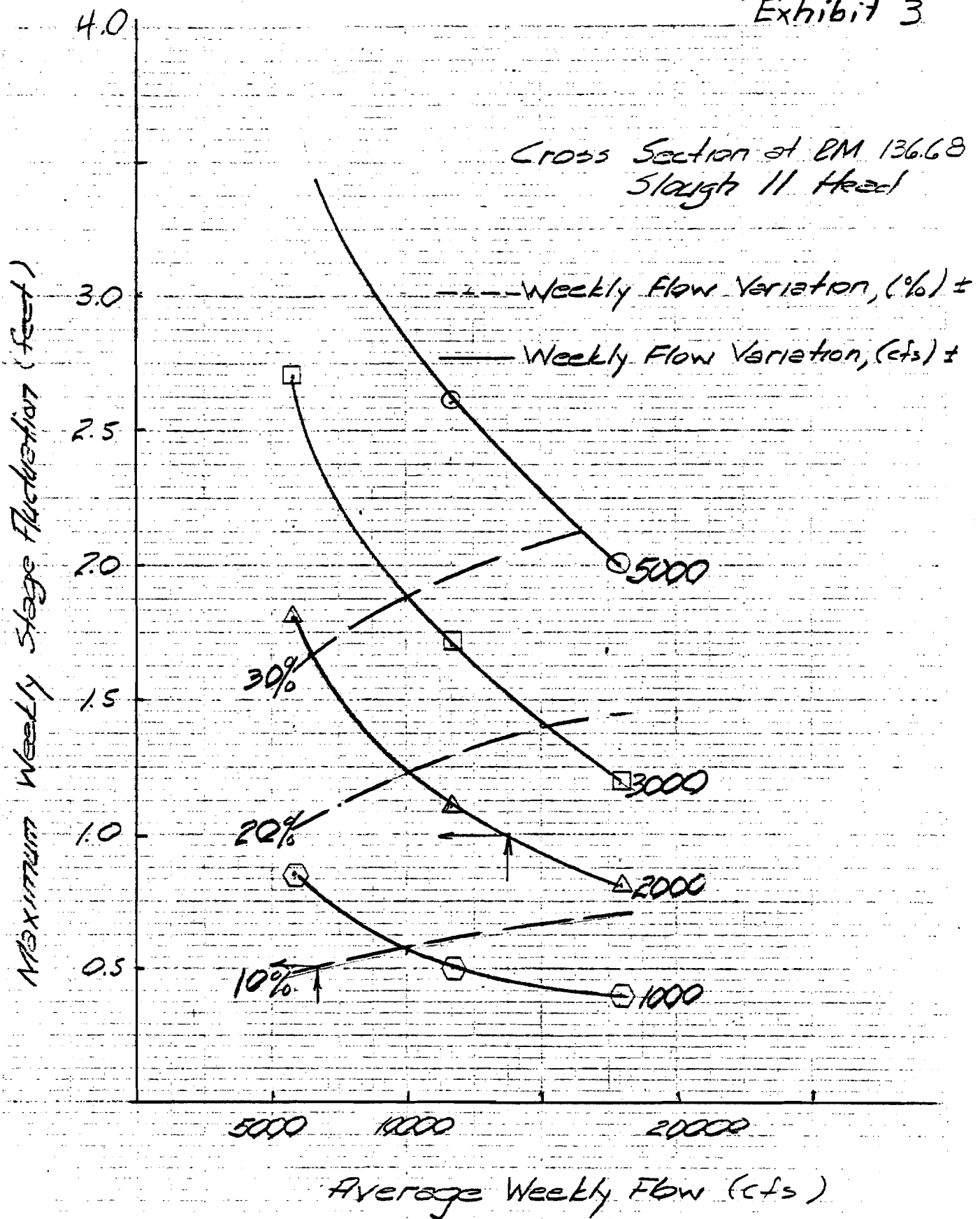
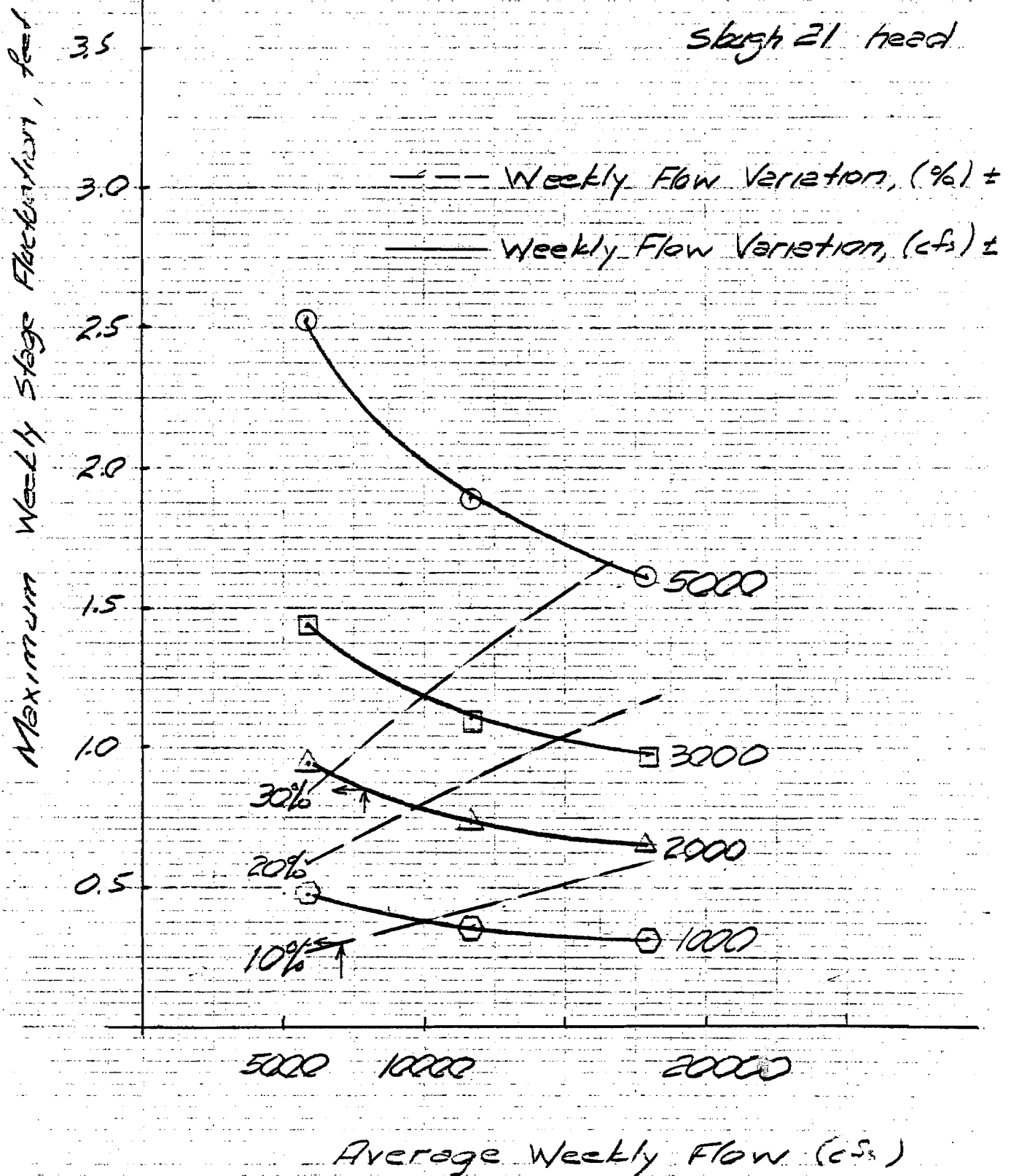


Exhibit 4

Cross Section at RM 142.2

Stage 21 head



HARZA-EBASCO SUSITNA JOINT VENTURE

WATANA FILLING WITH E-IV and E-VI

An analysis was made to determine the effects on filling of Watana Reservoir and Susitna River discharges at Gold Creek of the Case E-IV and E-VI Environmental Flow Constraints. The analysis was similar to that in the License Application (p E-2-79). Three year sequences of Susitna River flows representing high flow (10% exceedance) average flow (50% exceedance) and low flow (90% exceedance) were used. The Watana Dam was assumed to be constructed by the same schedule as in the License Application. The Case E-IV and E-VI flow constraints and reservoir rule curves used in the analysis are shown on Table 1. The results of the analysis are shown on the attached Exhibit.

The computations indicate that with Case E-IV Environmental Flow Constraints the Watana Reservoir could be filled to its normal maximum water level (El. 2185) for wet and average sequences in a similar time frame to the filling using Case C. By August of the third summer of filling the reservoir would be full. In a dry sequence, using Case E-IV, the reservoir water level would only reach El. 2155 at the end of the third summer of filling. This is 10 feet below a dry sequence filling with Case C and represents about 350,000 ac-ft of water or about 200,000 gwh of electrical energy.

Case E-VI Filling Environmental Flow Constraints are keyed to reservoir water levels expected to be exceeded in all but the driest 10% of 3-year flow sequences during filling. Using these flow constraints, which are 1000 cfs less than for Case E-IV at all times during the summer, the final reservoir water level during the third summer of filling can be raised to El. 2175, an increase of 20 feet over Case E-IV or 10 feet over Case C. This results in a benefit of approximately 400,000 gwh of electrical energy over Case E-IV.

Susitna River discharges at Gold Creek are also shown on the attached Exhibit and Table 2. Reservoir filling would begin in the summer of 1991. The discharges shown for 1990 represent the natural conditions. During

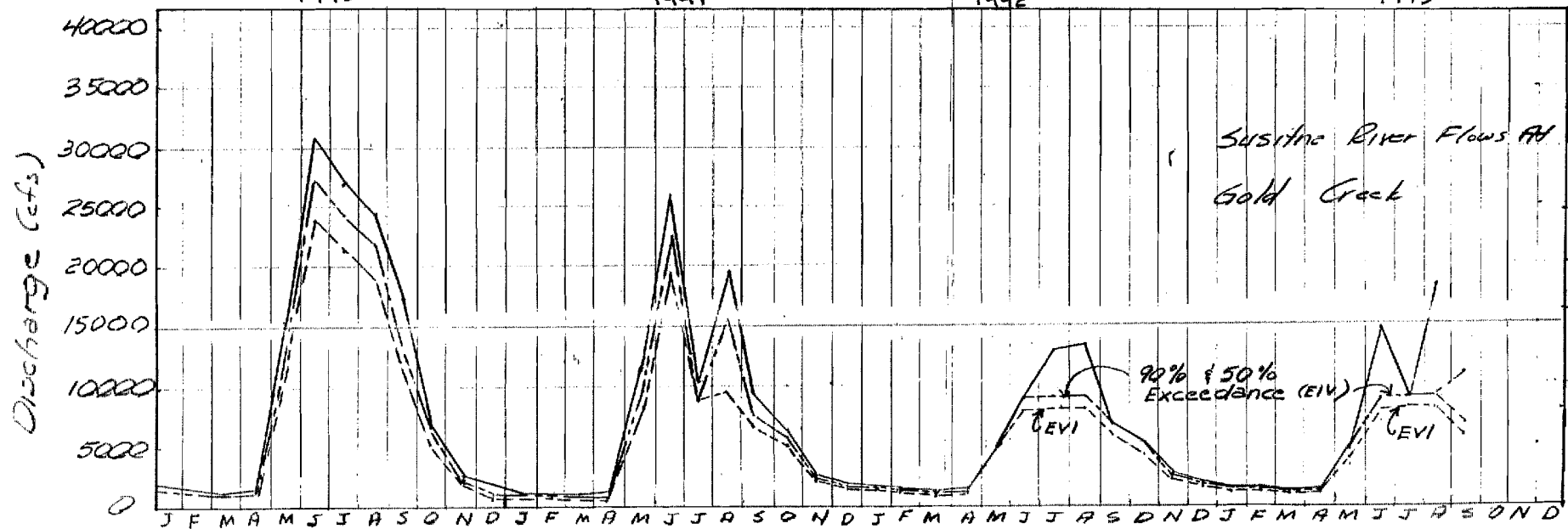
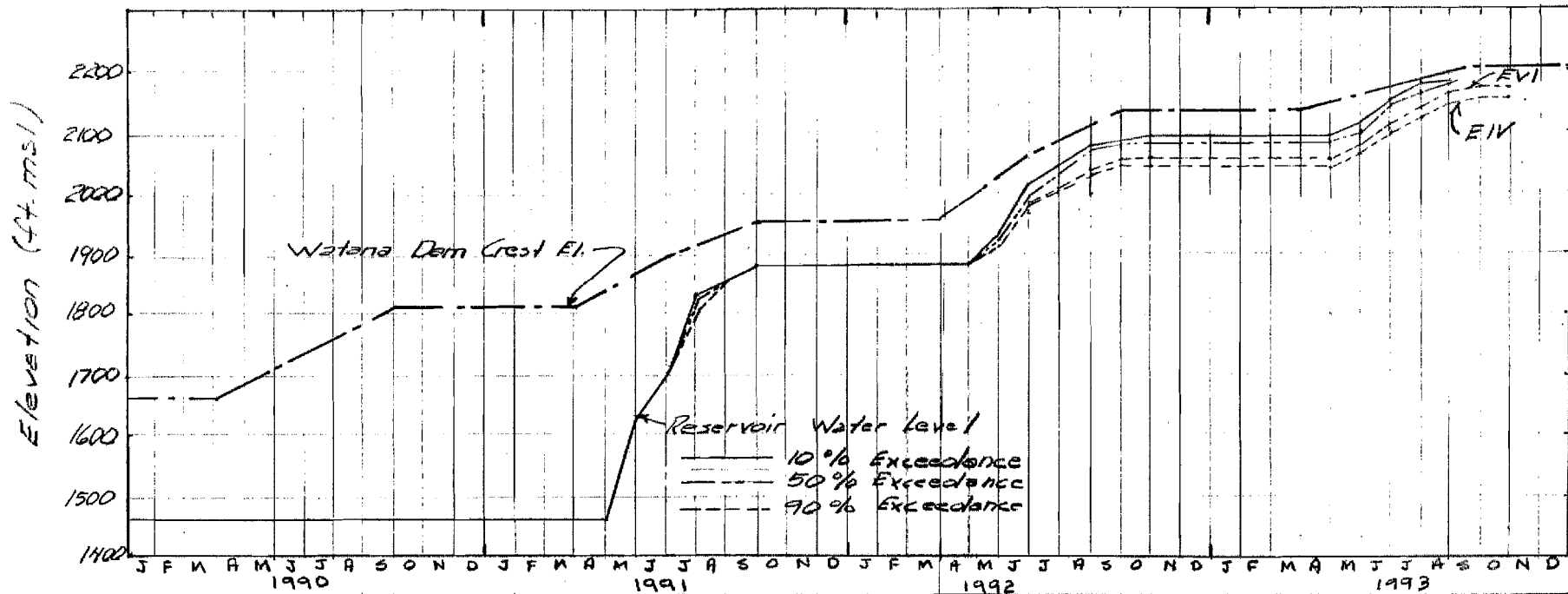
1991 discharges at Gold Creek would exceed the Case E-IV flows at almost all times since the flows during this period would be controlled by the height of Watana Dam in order to provide an adequate volume to store the 250 year flood. During the second summer of filling discharges during a wet sequence would also be controlled by the height of the dam and would exceed the Case E-IV constraints. During dry and average sequences the flows would be controlled by the Case E-IV or E-VI flow constraints. For a dry sequence the E-VI constraints would control flows at 1000 cfs less than the E-IV constraints beginning in June of the second summer of filling. During 1993 a wet sequence of inflows would result in filling of the reservoir in early August and Gold Creek flows would then be constrained by Case E-VI and power generation requirements. An average sequence of flows would fill the reservoir in September. Flows at Gold Creek for both average and dry sequences would be controlled by minimum flow requirements.

Table 1
Filling with E-VI Rule Curve

Water Week	Date	Watana Target Res. Elev.		Gold Creek Target Flow	
		Second Summer	Third Summer	If Target Met	If Target Not Met
1	Oct 1-7			6000	5000
2	Oct 8-14			6000	5000
3	Oct 15-21			5000	4000
4	Oct 22-28			4000	3000
5	Oct 29-Nov 4	2055 $\frac{1}{2}$ /		3000	2000
6	Nov 5			Natural	Natural
thru					
30	Apr 28			Natural	Natural
31	Apr 29-May 5			2000	2000
32	May 6-May 12			4000	3000
34	May 13-May 19			6000	5000
35	May 27-June 2	1908 $\frac{3}{4}$ /	2074 $\frac{3}{4}$ /	6000	5000
36	June 3-June 9			9000	8000
37	June 10-June 16			9000	8000
38	June 17-June 23			9000	8000
39	June 24-June 30	1965 $\frac{4}{5}$ /	2110 $\frac{4}{5}$ /	9000	8000
40	July 1-July 7			9000	8000
41	July 8-July 14			9000	8000
42	July 15-July 21			9000	8000
43	July 22-July 28			9000	8000
44	July 29-Aug 4	2006 $\frac{5}{6}$ /	2140 $\frac{5}{6}$ /	9000	8000
45	Aug 5-Aug 11			9000	8000
46	Aug 12-Aug 18			9000	8000
47	Aug 19-Aug 25			9000	8000
48	Aug 26-Sept 1	2037 $\frac{6}{7}$ /		9000	8000
49	Sept 2-Sept 8			8000	7000

Table 2
Susitna River Discharges (cfs)
Measured at Gold Creek
Watana Filling Cases

Year	Month	Wet Sequence	Avg. Sequence	Dry Sequence	
		10% Exceedance E-IV	50% Exceedance E-IV	90% Exceedance E-IV	E-VI
1991	April	1544	1371	1214	1214
	May	11414	9753	8231	8231
	June	25680	22220	19650	19050
	July	10312	9000	9000	9000
	August	19506	15016	9701	9701
1992	Sept	9446	7799	6800	6800
	Oct	6453	5732	5032	5032
	Nov	2879	2557	2263	2263
	Dec	2010	1785	1580	1580
	Jan	1640	1457	1290	1290
	Feb	1393	1238	1096	1096
	Mar	1258	1118	990	990
	Apr	1544	1371	1214	1214
	May	4903	4903	4903	4903
	June	8800	8800	8800	7800
	July	12800	9000	9000	8000
	Aug	13162	9000	9000	8000
	Sept	6800	6800	6800	5800
	Oct	5032	5032	5032	4032
	Nov	2879	2557	2263	2263
	Dec	2010	1785	1580	1580
	Jan	1640	1457	1290	1290
1993	Feb	1393	1238	1096	1096
	Mar	1258	1118	990	990
	Apr	1544	1371	1214	1214
	May	4903	4903	4903	3903
	June	14633	8800	8800	7800
	July	9000	9000	9000	8000
	Aug	17375	9000	9000	8000
	Sept		11099	6800	5800



WINTER STAGE FLUCTUATIONS

Fluctuating water levels during winter periods when an ice cover is forming, melting out or breaking up may tend to destabilize the ice cover. This could result in consolidation of the ice cover, thicker ice covers, higher water levels or ice jams. Permissible stage fluctuations (and corresponding flow fluctuations), with an ice cover on the river, to minimize these possibilities, depend on rate of flow change, amount of flow change, proximity of ice front to discharge point and strength of ice cover. The strength of the ice cover depends on air temperature and thickness of solid ice versus slush ice.

Tests done by Acres Consulting Services Limited on the Peace River indicate that a daily flow change of the order of $\pm 50\%$, near the end of winter, with the front already melting out, will result in consolidation of the front located about 100 miles downstream of the power plant, with subsequent rise of the ice cover about 1.5 ft a distance of 100 miles further downstream. The open-water surface fluctuation was about 3 ft near the powerplant, attenuating to about 2 ft. 60 miles downstream.

Based on the limited data we have, only a judgement is possible for the middle reach of the Susitna River. Effects of project flow changes on the Lower River ice cover will be minimal because of tributary flows and vast overbank relief areas. It seems reasonable that a flow change of the order of 10-20% over a 4 hour period should be no problem in mid-winter (February) in the Middle Reach. In January, when the front is advancing in the Middle Reach, flow changes should be minimized since the cover has no strength at this time. Similarly, in March and April when the cover is melting, flow changes should be minimized because the weakened cover can break, resulting in consolidation jams.

In summary, if freeboard is a problem anywhere on the Middle Reach, then flow fluctuations exceeding $\pm 10\%$ in a day should not be permitted in the

winter. A survey of experience in operating hydroelectric projects in cold regions is being made in order to better define the most acceptable manner of Susitna Project operation. Initial results of this study indicate that experience and tests during project operation are the normal manner of defining the allowable limits on discharge fluctuations in the winter.

LOW LEVEL OUTLET AT WATANA

Studies are being made to determine effects of drawing winter power flows from an intake located near El. 1800. This is approximately 200 feet below the bottom of the proposed multi-level intake. Use of this mid level intake in winter would allow water near 4°C to be discharged in many cases and would cause the ice cover to be as far downstream of the project as possible. Operation of the proposed multi-level intake in winter normally results in outflow temperatures between 2°C and 3°C depending on prevailing weather conditions. Removal of 4°C water in winter will reduce the total heat content of the reservoir. This could cause somewhat later warming of river temperatures in the spring and slightly reduced summer river temperatures than if winter outflow temperatures were near 2°C to 3°C. Ongoing studies will address both winter and summer impacts. Other considerations include possible reductions in water quality (deficient O₂ levels and increased turbidity) near El. 1800 as compared to the higher level intakes. Preliminary indications are that winter use of an intake at El. 1800 would move the ice front downstream to the vicinity of Slough 11 in the coldest winters for Watana operating alone.

Effect of Cone Valve Operation on River Temperatures

The Susitna Hydroelectric Project is being designed to provide a reliable source of electrical energy to the Railbelt Area of Alaska. This means that the project will be operated to provide a firm amount of electricity even in years when river flows, the source of electrical energy, are low. The greatest need for energy in the Railbelt Area occurs in winter while the greatest river flows are in summer. Therefore, in order to provide the reliable energy during the winter the project will be operated to fill the reservoirs by early October, even in dry years. The operating policy which is developed to meet this goal is conservative in that it ensures a firm amount of energy. It results in early filling of the reservoir in average and wet years. In these years water in excess of power requirements must be released from the reservoirs in July and August to prevent overtopping of the dams.

Additionally, in the early years of project operation, summer electrical energy requirements may not be large enough to require powerhouse releases equal to the minimum environmental flow requirements. In this period powerhouse flows will be augmented by the additional release required to meet the environmental flow requirements.

In both of these cases, reservoir releases will be made through the cone valves. These valves are expected to minimize the possibility that nitrogen saturation in excess of that allowed by state regulation or detrimental levels will occur. The intakes to these cone valves are located approximately 180 feet below the water surface at Watana and 450 feet below the water surface at Devil Canyon. The intakes are located at these levels:

1. To provide a means for evacuating the Watana Reservoir to El. 2065 if maintenance on a submerged structure is required, and

?

2. To provide for diversion of Susitna River flows during construction of Devil Canyon Dam, and to provide for evacuation of Devil Canyon reservoir in the case that maintenance on a submerged structure is required.

During the periods when these cone valves will operate, the water temperature at the level of the cone valve intakes will be lower than the temperature of the water being released through the powerhouse. This is because the operating powerhouse intakes will be in the warm epilimnion water while the cone valve intakes will be in the thermocline (Watana) or the hypolimnion (Devil Canyon).

It is anticipated that the cone valves would be opened gradually in accordance with the need to pass flood flows or to augment power flows. This would minimize any sudden temperature drops resulting from cone valve operation. However, there would still be a reduction in outflow temperatures which could be as high as 5°C. This temperature reduction will be greatest in the early years of Devil Canyon operation for two reasons:

1. The Devil Canyon cone valve intakes are located in the hypolimnion,
2. During the early years of Devil Canyon operation the energy demand on the project will be less than the project can supply requiring larger releases through the cone valves.

The attached Exhibits 1 and 2 show the simulated outflow temperatures from:

1. Watana operating alone in a wet year with 1996 energy demands.
2. Devil Canyon with both Devil Canyon and Watana operating for a wet year with 2002 energy demands.

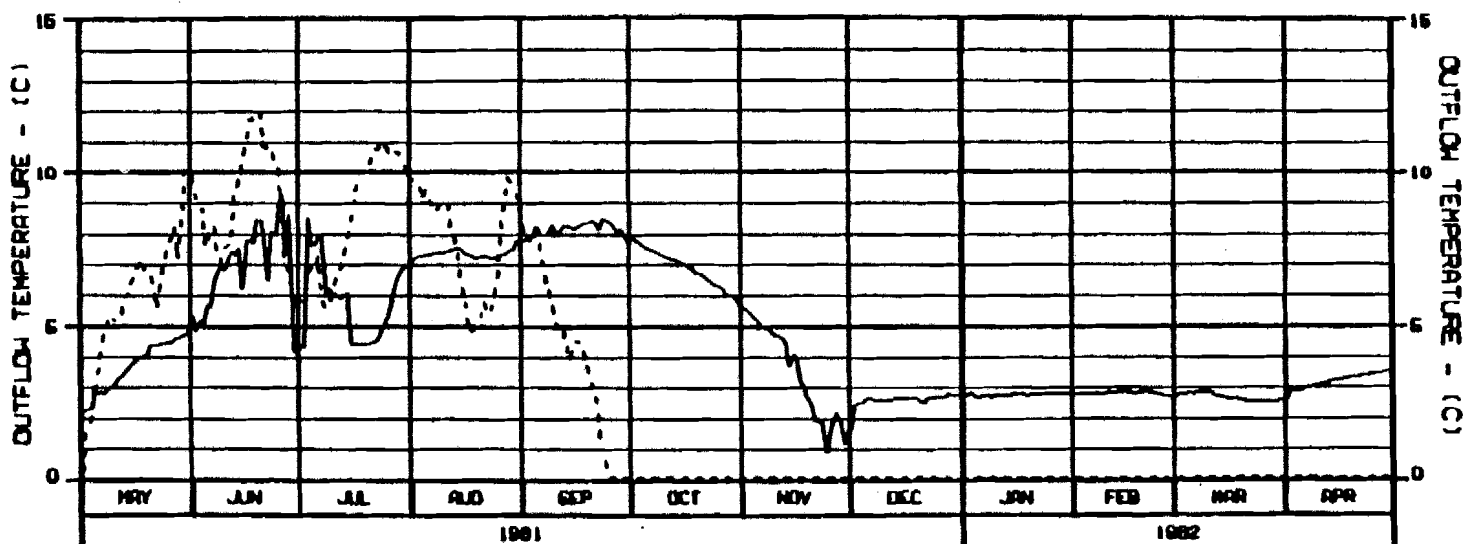
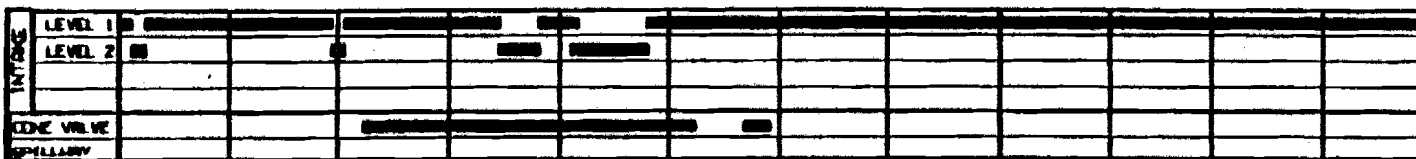
The simulations were prepared for Case C environmental flow constraints. Case E-VI constraints are not expected to result in a significant change in cone valve flows during wet years. The temperature effects of cone valve operation will be similar.

Exhibits 3 and 4 show simulated weekly average temperatures at RM 130 corresponding to the reservoir temperature simulations in Exhibits 1 and 2 respectively. Note the effect of cone valve operation on temperature, especially in 2002 with Devil Canyon and Watana operating. Exhibits 5 and 6 show simulated weekly average temperatures at Sunshine, downstream of the Susitna-Chulitna-Talkeetna confluence. Note the reduction in temperature drop at this location. Exhibits 7 and 8 compare simulated river temperatures at RM 130 with fish temperature tolerance levels for the periods simulated.

Further studies of river and reservoir temperatures are being undertaken:

1. To verify that Case E-VI temperatures are not significantly different than Case C.
2. To determine the feasibility and impacts of having a high intake to the Devil Canyon cone valves.

These studies will be reported when available.



LEGEND: CASE: DC81182102D - DEVIL CANYON OPERATION WITH MATANA IN 2002
 - MATANA WEATHER STATION DATA
 ——— PREDICTED OUTFLOW TEMPERATURE FROM DEVIL CANYON RESERVOIR
 - - - - - INFLOW TEMPERATURE TO MATANA RESERVOIR

- NOTES: 1. INTAKE PORT LEVEL 1 AT ELEVATION 1425 FT (434.34 M)
 2. INTAKE PORT LEVEL 2 AT ELEVATION 1375 FT (419.10 M)
 3. CONE VALVE AT ELEVATION 980 FT (299.76 M)
 4. SPILLWAY CREST AT ELEVATION 1404 FT (427.94 M)

ALASKA POWER AUTHORITY

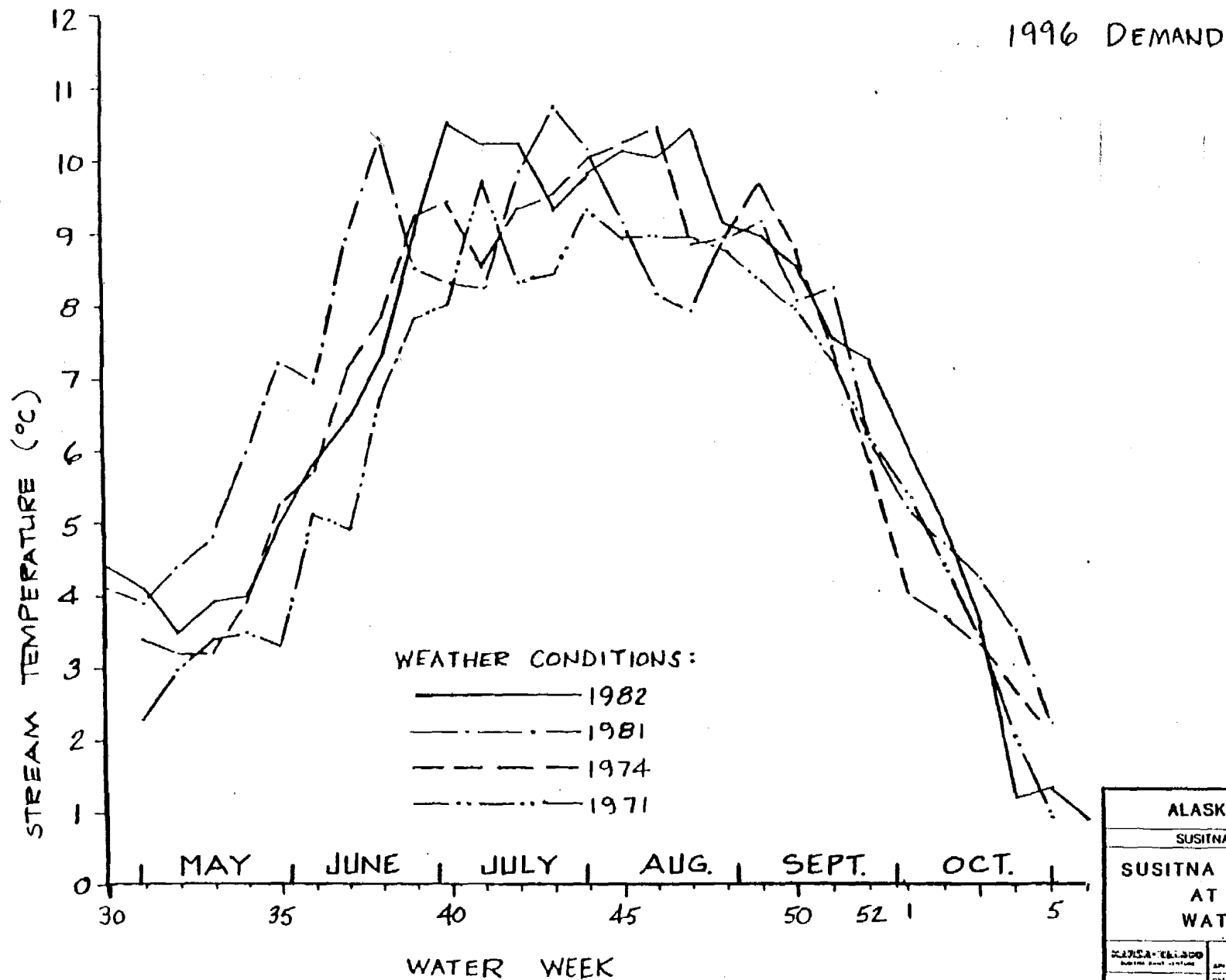
DEVELOPMENT PROJECT OPERATIONAL MODEL

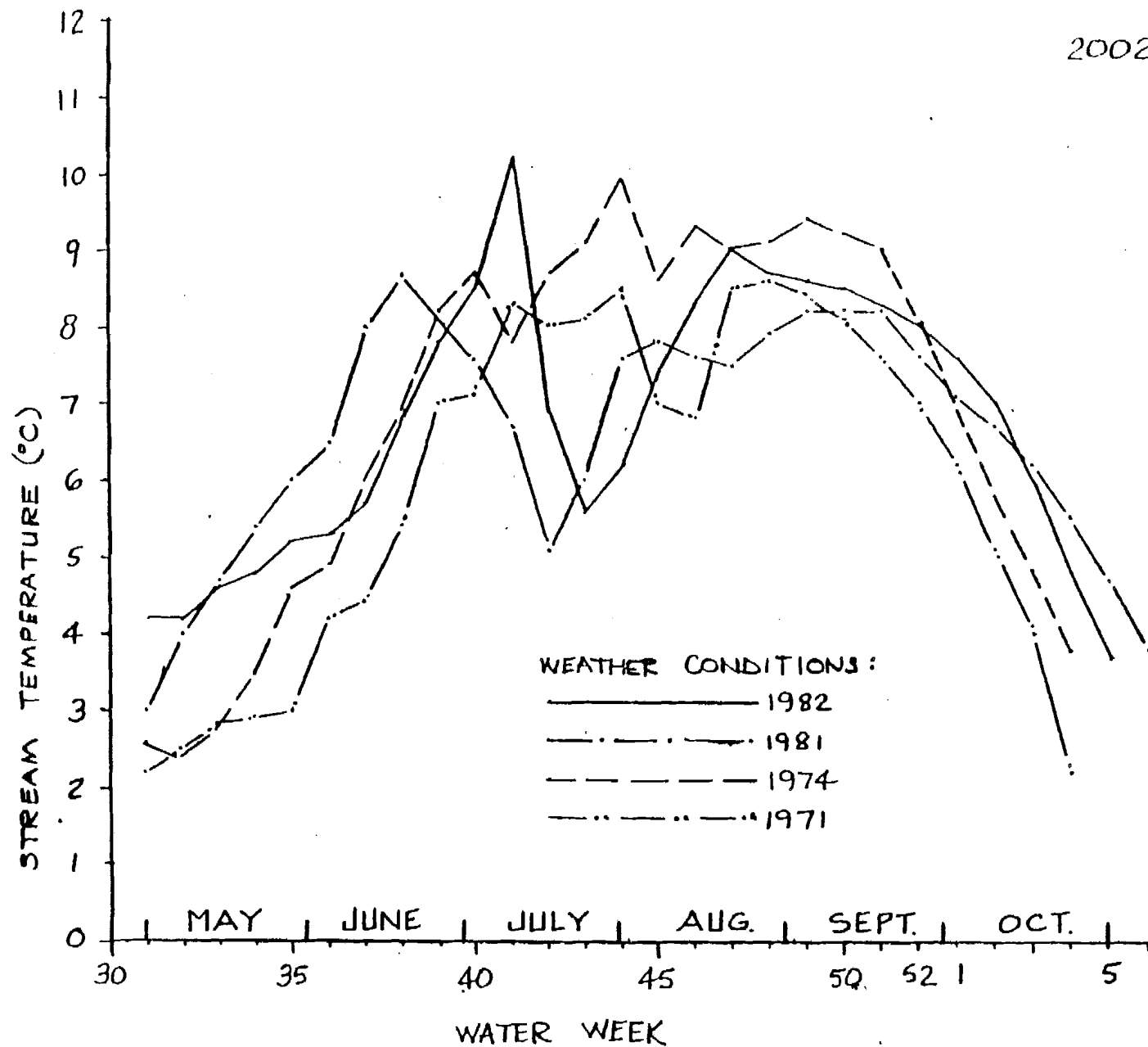
DEVIL CANYON RESERVOIR
 OUTFLOW TEMPERATURE
 AND ICE GROWTH

HARZA-EDBECO JOINT VENTURE

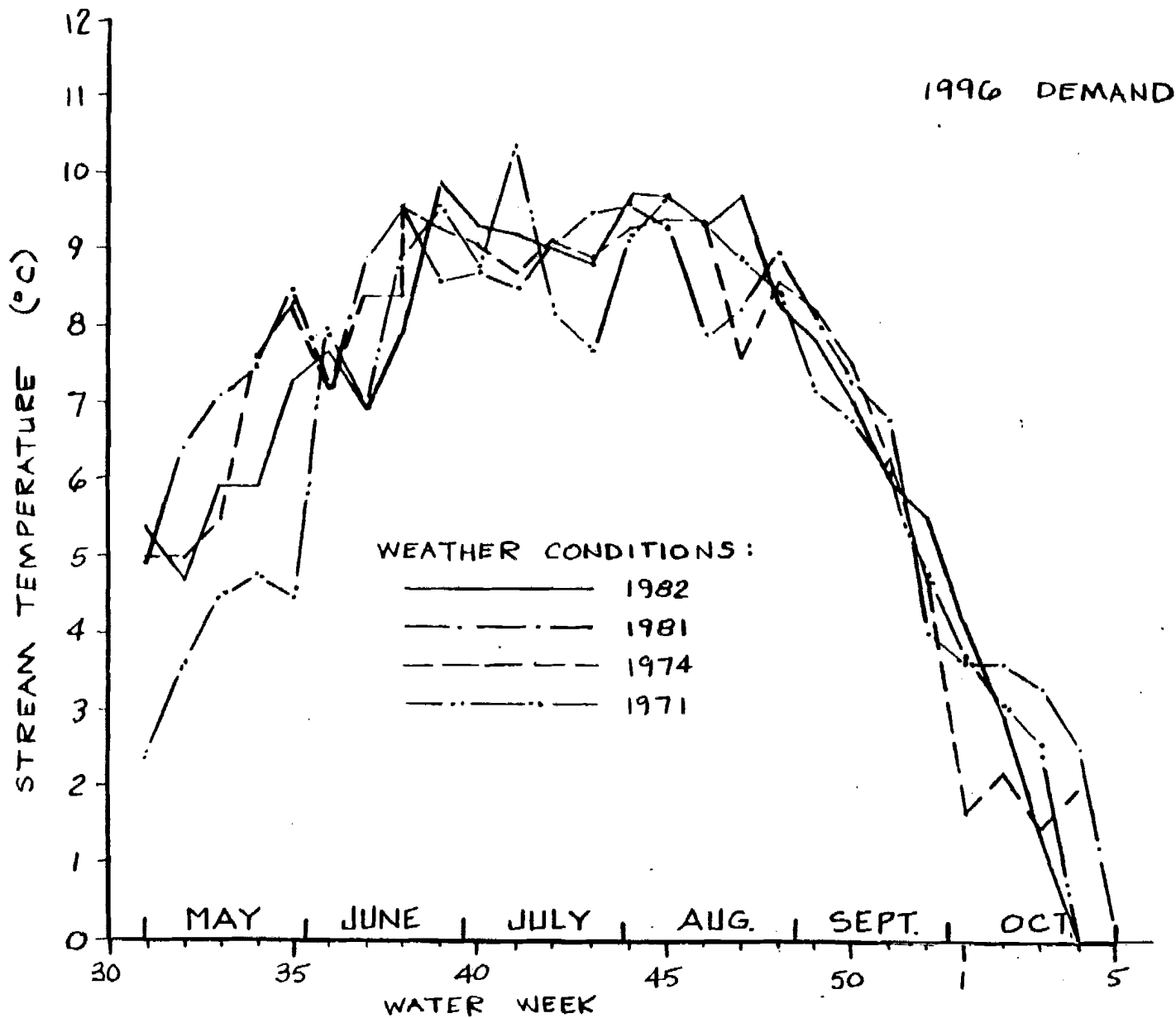
DESIGNED: J. L. DODD 7 JAN 82 MOD. 1.0 25-000-04

Exhibit 2

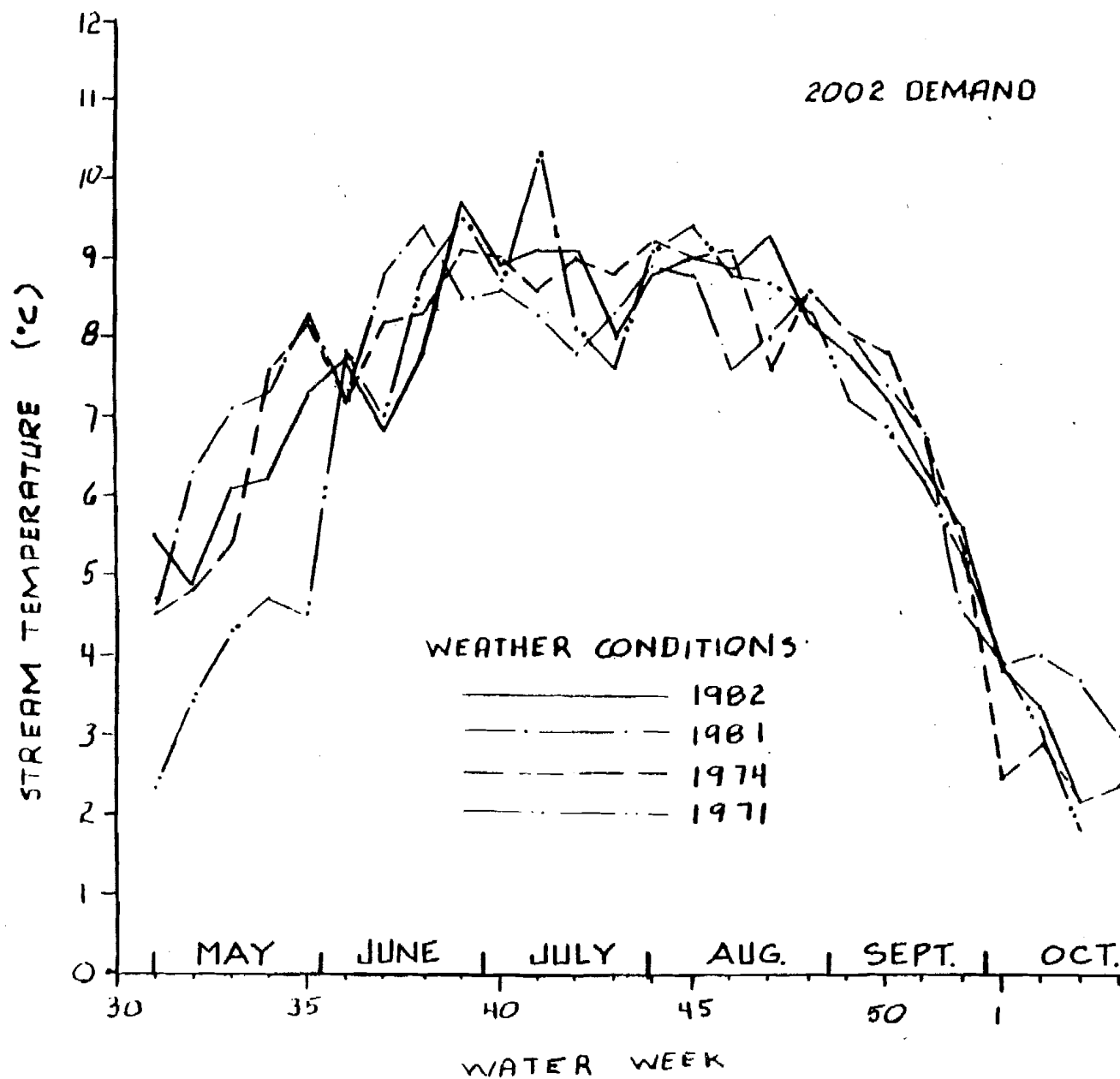




ALASKA POWER AUTHORITY		
SUSITNA HYDROELECTRIC PROJECT		
SUSITNA RIVER TEMPERATURES AT RIVER MILE 130 WATANA AND DEVIL CANYON OPERATING		
ALASKA-18-03-00 WATANA AND DEVIL CANYON	APPROVED	
WENHOVAGE, ALASKA	DATE	SHOWN, NO

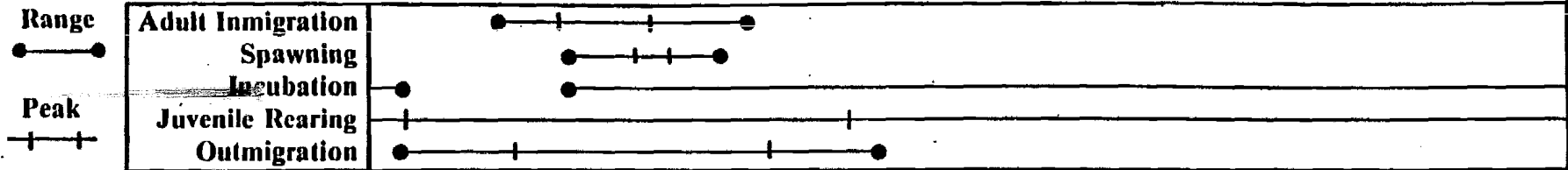


ALASKA POWER AUTHORITY		
SUSITNA HYDROELECTRIC PROJECT		
SUSITNA RIVER TEMPERATURES AT RIVER MILE 84 WATANA OPERATING		
WATANA-88-000 SUSITNA RIVER TEMPERATURE	APPROVED	DATE
ANCHORAGE, ALASKA		ISSUED NO.



ALASKA POWER AUTHORITY	
SUSITNA HYDROELECTRIC PROJECT	
SUSITNA RIVER TEMPERATURES	
AT RIVER MILE 84	
WATANA AND DEVIL CANYON	
OPERATING	
SUSITNA RIVER WATER AND WEATHER ANCHORAGE, ALASKA	DATED DATE (SHEET NO.)

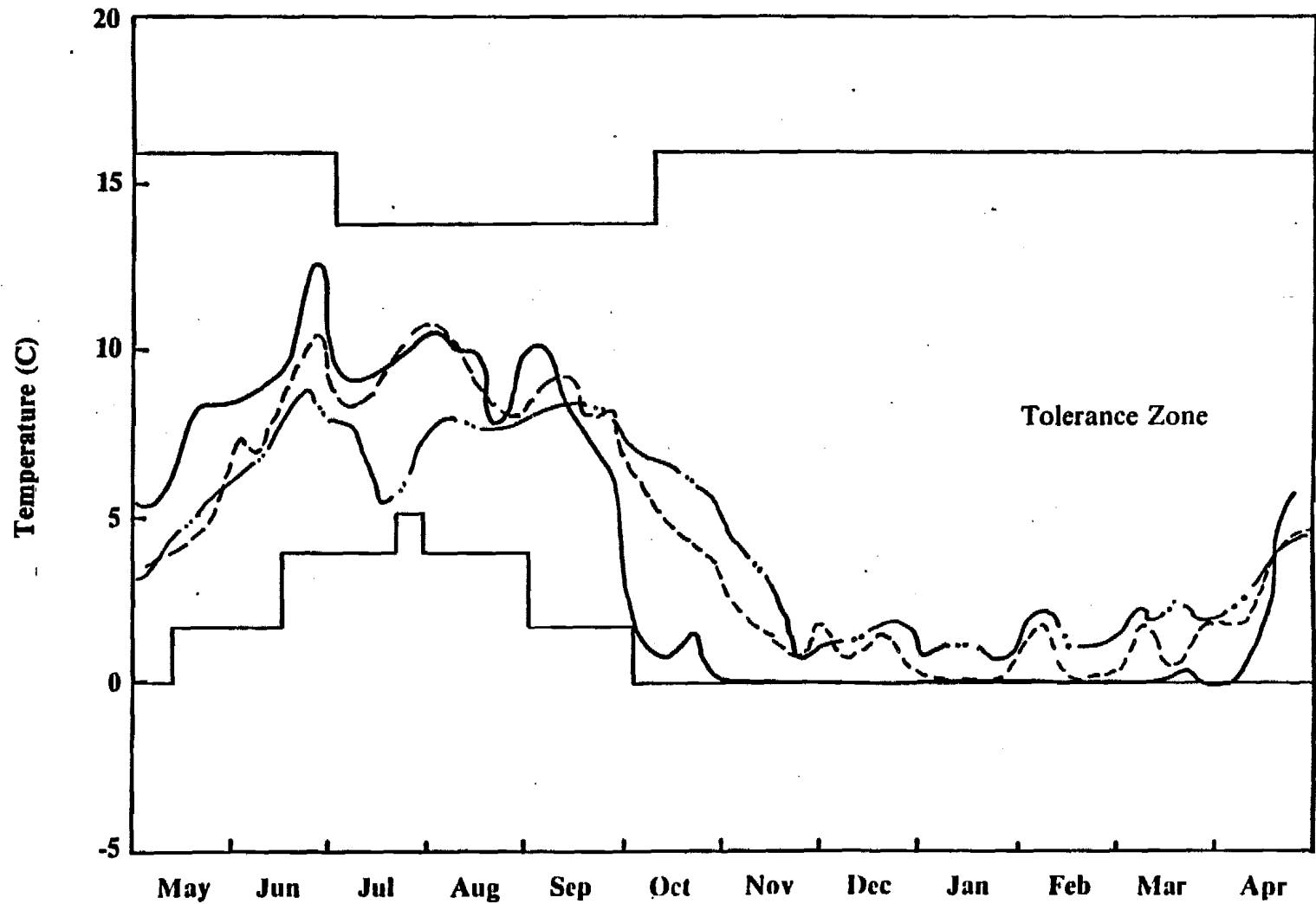
CHINOOK SALMON



Devil Canyon
2002
H92

Watana
1996

Natural



1981-1982
River Mile 130

CHUM SALMON

Range



Peak



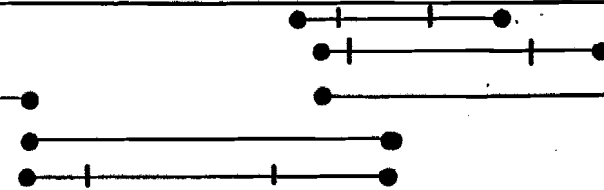
Adult Immigration

Spawning

Incubation

Juvenile Rearing

Outmigration



H71 Devil Canyon
2002

Watana
1996

Natural

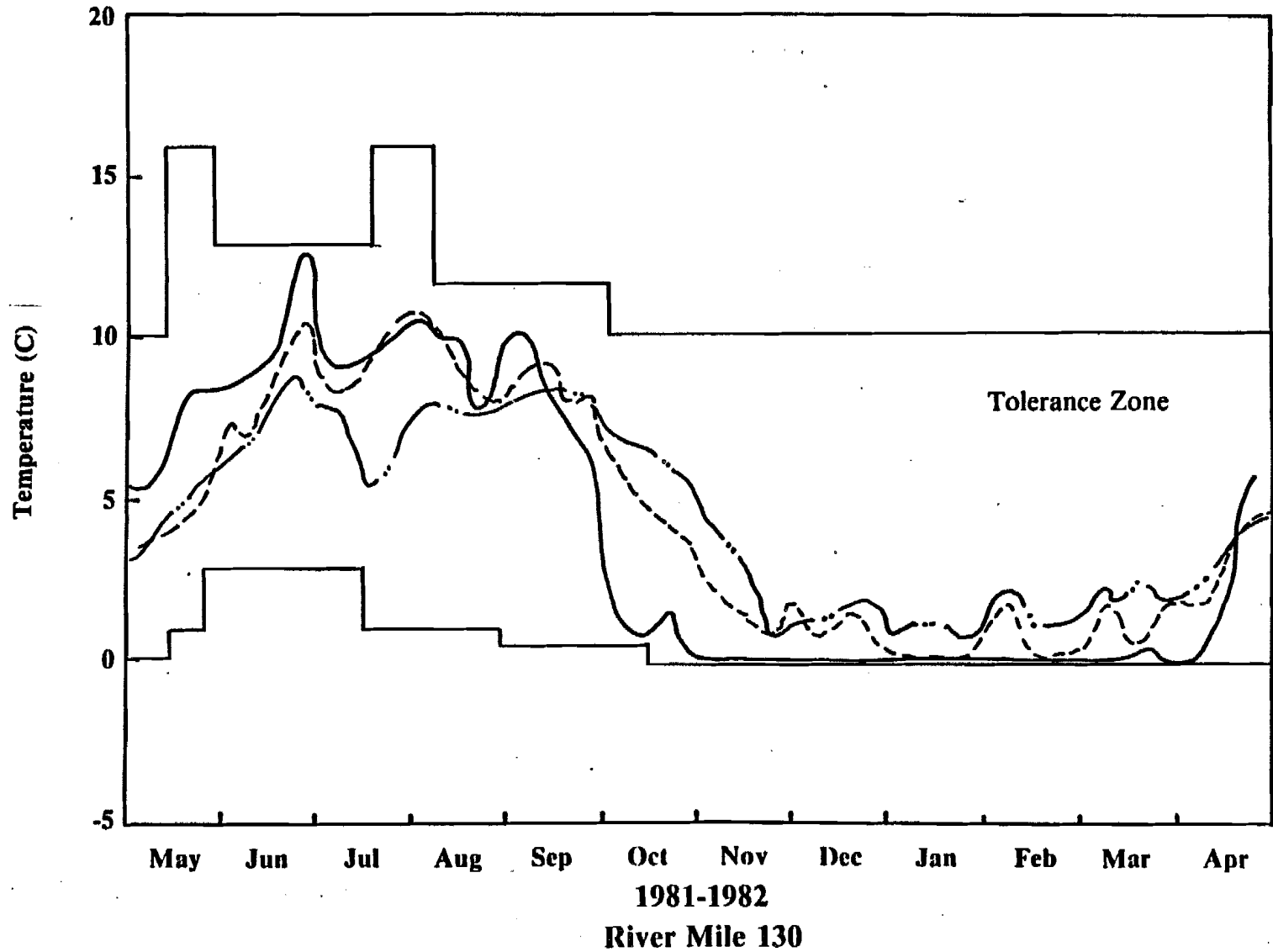


Exhibit 8

HABITAT SUBSTRATE STABILITY

SUMMARY

Under natural conditions the bed material size distribution in the Susitna River depends upon the magnitudes and durations of high flows occurring during a flood season. These flows tend to sort out the bed material and shape the channel configuration. Bed material samples taken during 1983 at five main channel study sites in the Middle Reach of the Susitna River are well graded having a maximum size (D_{90} - the equivalent diameter that 90% of the material, by weight, is finer than) of approximately 3 inches, an average size (D_{50}) of 1 inch and a minimum size (D_{10}) of about 0.05 inch. The streambed at these sites appears to be in a stable regime over a long period. Material of less than approximately 3 inches is constantly being removed from the areas and replaced with similar size material from the bed load sediment transported by the river.

The mean annual or dominant discharge is generally considered as a measure of the ability of a stream to shape the channel configuration. This discharge, if allowed to flow continuously, would have the same overall channel shaping effect as the naturally fluctuating discharges would. With project, the dominant discharge in the river will be reduced, and bed load sediment transport movement will depend on the magnitude and duration of the spiking flows which may be implemented. Bed load sediment from upstream of the project will be trapped in the reservoirs. Material finer than transportable sizes for the project flows will not be replaced once removed from the bed. Therefore, the streambed at these study sites will degrade. It is estimated that the degradation will be between one ft. and three ft. depending on the magnitude and length of the spiking flows. As the spiking flow increases toward 50,000 cfs, the material will become less well graded and will approach a uniform size of 3 inches. If spiking flows are not implemented the bed material at these sites will be more well graded.

The studies presented herein are preliminary and pertain only to Middle River mainstem study sites. Additional studies of substrate stability in sloughs are being made. No generalization can be made from the studies herein to the sloughs because of the different nature of the hydraulics and sediment transport characteristics.

DISCUSSION

Studies are being made to determine the stability of habitat substrate material under project conditions, including potential spiking flows. These studies should be completed in the near future and a report will be issued. Mainstem and side slough habitat areas are being considered.

Preliminary analyses have been completed for the following areas:

1. Main channel near cross section 4, RM 99.0 to 100.0 (Exhibit 1).
2. Main channel between cross sections 12 and 13, RM 108.5 -110.0 (Exhibit 2).
3. Main channel upstream from Lane Creek, RM 113.6 - 114.2 (Exhibit 3).
4. Main channel upstream from 4th of July Creek, RM 131.2 - 132.2 (Exhibit 4).
5. Main channel between cross sections 46 and 48, RM 136.9 - 137.3 (Exhibit 5).

These areas are considered typical of Middle River main channel spawning areas because of the well graded substrate material.

Exhibits 6 through 10 show the measured bed material size distributions at the respective study sites. Exhibits 11 through 15 show the transportable

bed material sizes (armoring sizes) at the study sites for various flows. The theory of dominant discharge explained in the U.S. Bureau of Reclamation publication "Design of Small Dams" was used to determine stable material sizes at the given study sites.

The dominant discharge under natural conditions is the mean annual flood of approximately 50,000 cfs. With project the dominant discharge has been estimated to be approximately 15,000 cfs due to regulation of flood events by the reservoir. Spiking flows were not considered in this determination. The following table shows the armoring size at natural and with project dominant discharges at the study sites.

Existing Substrate Material and Natural and With Project Armoring Sizes
at Five Main Channel Study Sites

Main Channel Near	Existing Subs rate Materials ^{1/}			Armoring Size ^{2/}				
				Natural Conditions	With Project			
	<u>D₁₀</u> in	<u>D₅₀</u> in	<u>D₉₀</u> in	<u>(50000 cfs)^{3/}</u> in	<u>(15000 cfs)^{3/}</u> in	<u>(25000 cfs)^{3/}</u> in	<u>(35000 cfs)^{3/}</u> in	<u>(45000 cfs)^{3/}</u> in
Cross Section 4	0.02	0.8	2.6	1.8	1.1	1.4	1.6	1.7
Cross Sections 12 and 13	0.03	1.3	3.0	2.8	1.5	1.9	2.2	2.5
Upstream from Lane Creek	0.06	1.3	3.0	2.7	1.5	1.9	2.2	2.5
Upstream from 4th of July Creek	0.03	1.1	3.2	2.7	1.6	2.0	2.2	2.5
Cross Sections 46 and 48	0.04	0.8	3.0	3.5	1.9	2.4	2.9	3.3

^{1/} From Exhibits 6 to 10

^{2/} From Exhibits 11 to 15

^{3/} Corresponding discharge from which armoring size is estimated.

Under natural conditions the armor layer is in a state of dynamic equilibrium (stable regime over a long period), that is, material in the armor layer may be displaced by some flows and replaced by bed load sediment moving downstream. Large flood events tend to disturb the equilibrium and tend to degrade or aggrade the stream channel at various locations. Bed load sediment transported from upstream as a result of the flood or following the flood could deposit in areas degraded by the flood. This counteracts degradation and depending on downstream hydraulic and sediment processes may increase bed elevations. In this case the armoring process will be renewed and the river bed will reach equilibrium at a new elevation when the armoring process has been completed.

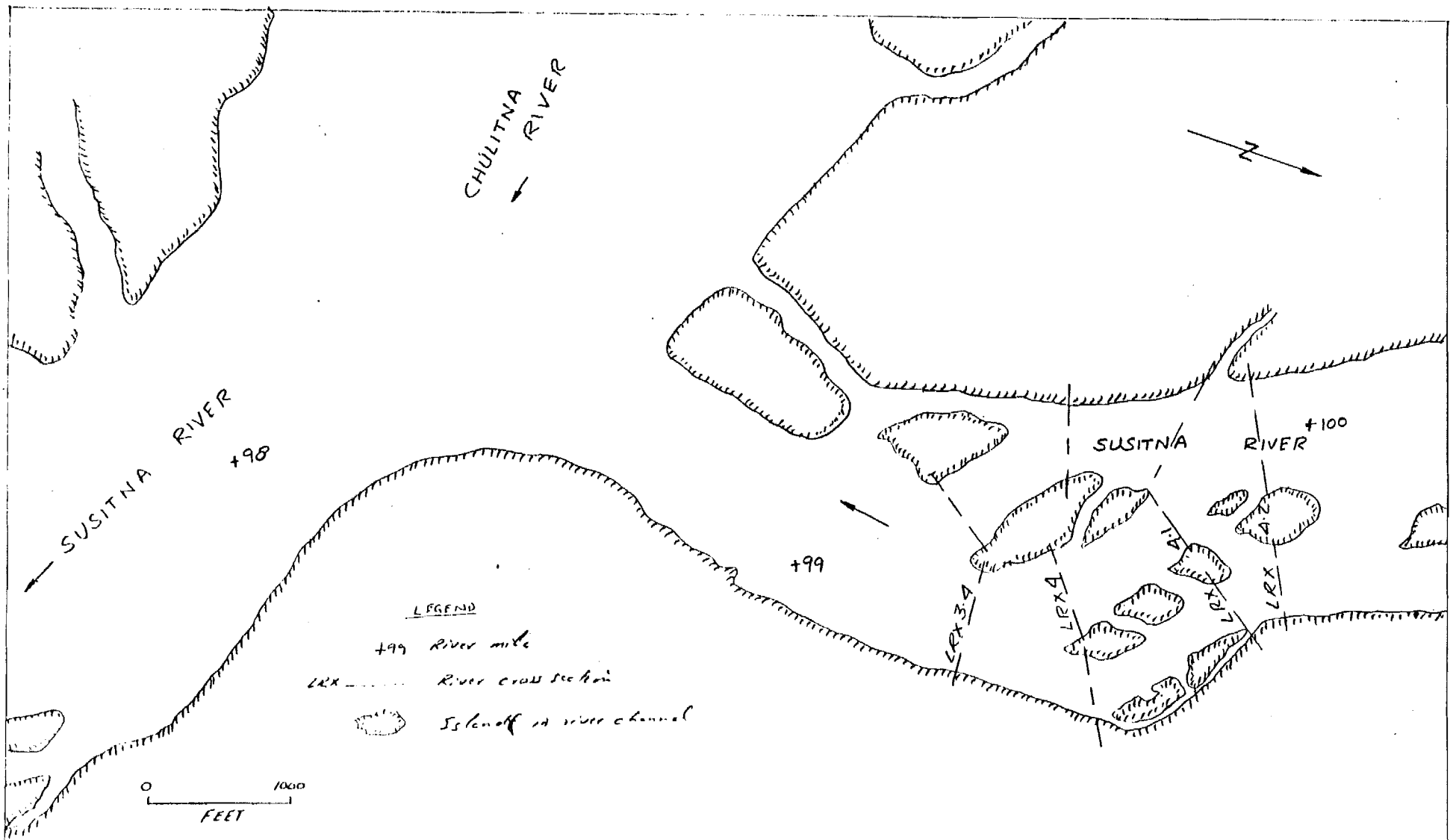
There is some evidence from an examination of photographs of the Susitna River between 1949 and the present that some areas of the Middle Reach of the river are currently in a state of long term degradation. (Draft report by AEIDC, "Geomorphic Change in the Devil Canyon to Talkeetna Reach of the Susitna River Since 1949").

The construction and operation of the Susitna Hydroelectric Project will substantially reduce the transport of bed load in the Middle Reach of the Susitna River. Most bed load sediment will be trapped in the reservoirs and will be eliminated as a replacement for fine material removed from the bed downstream of the dams. In time, the minimum size of material at these study sites will increase toward the armoring size. Additionally, the streambed will degrade until it is armored. The Harza-Ebasco Report "Reservoir and River Sedimentation" indicates that long-term average bed degradation in the Middle Reach, with project, will not exceed 0.3 feet and will average 0.1 to 0.2 feet. Localized degradation may be higher or lower depending on bed material composition as indicated in the preliminary results contained herein.

The following table shows the expected armoring sizes and amounts of degradation at the study sites for various discharges. If spiking flows of these magnitudes are implemented, the expected degradations will approach the values given in the table. These are conservative values because they are based on given discharges assuming currently available bed material size distribution. Spiking flows may change from year to year or may not be used annually. Higher spiking flows may only be used occasionally. Under such conditions, the magnitude of degradation for higher flows is likely to be less than shown in the table because lower spiking flows will make the bed material coarser than assumed.

Estimated Armoring Sizes and Degradation
For Various Dominant Discharges

Main Channel Near	15,000 cfs		25,000 cfs		35,000 cfs		45,000 cfs	
	Armoring		Armoring		Armoring		Armoring	
	Size in	Degradation in	Size in	Degradation in	Size in	Degradation in	Size in	Degradation in
Cross Section 4	1.1	12	1.4	18	1.6	23	1.7	28
Cross Sections 12 and 13	1.5	7	1.9	11	2.3	16	2.6	26
Upstream from Lane Creek	1.5	7	1.9	11	2.2	17	2.5	26
Upstream of 4th of July Creek	1.6	10	2.0	13	2.2	19	2.5	29
Cross Sections 46 to 48	1.9	12	2.4	20	2.9	30	3.3	43

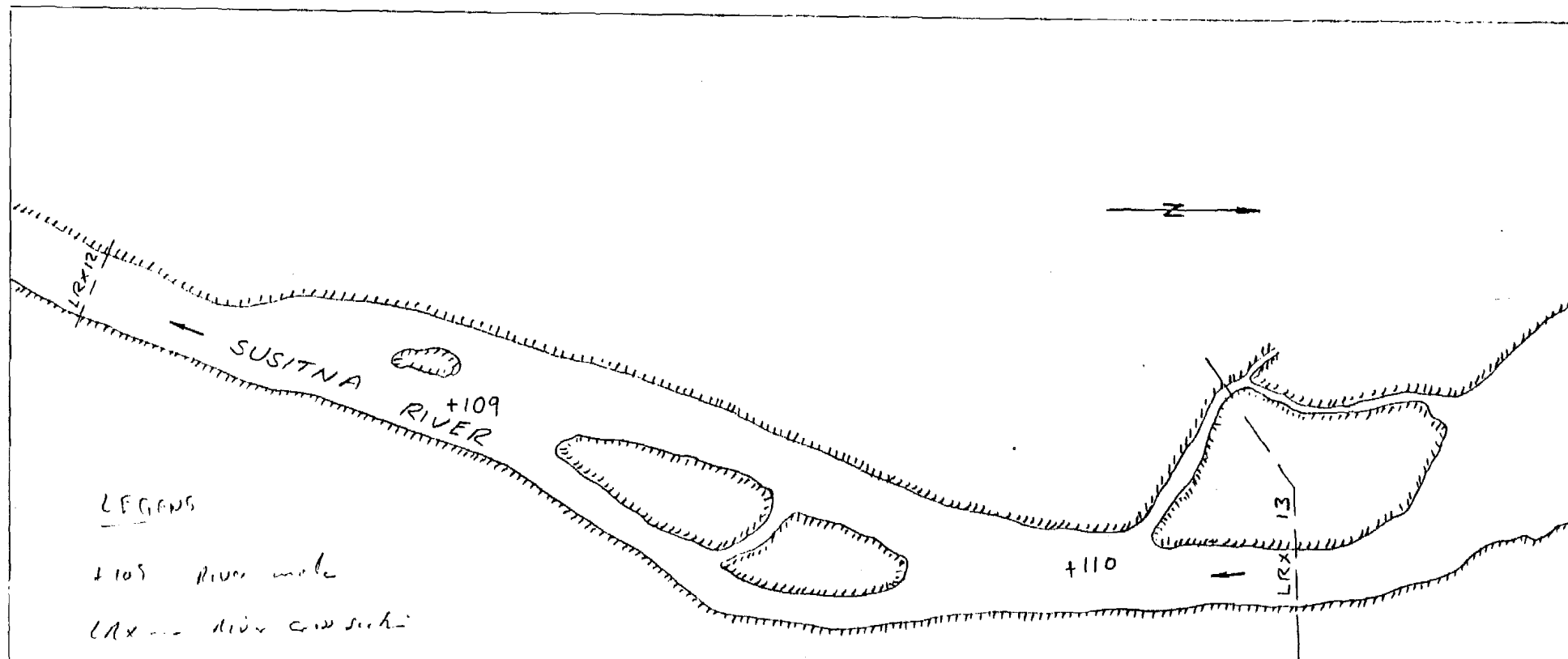


SUSITNA HYDROELECTRIC PROJECT
MAIN RIVER CHANNEL NEAR
RIVER CROSS SECTION LIX 4

Scale 1/4" = 1 mile

1/4" = 1 mile SUSITNA RIVER PROJECT

EXHIBIT 1

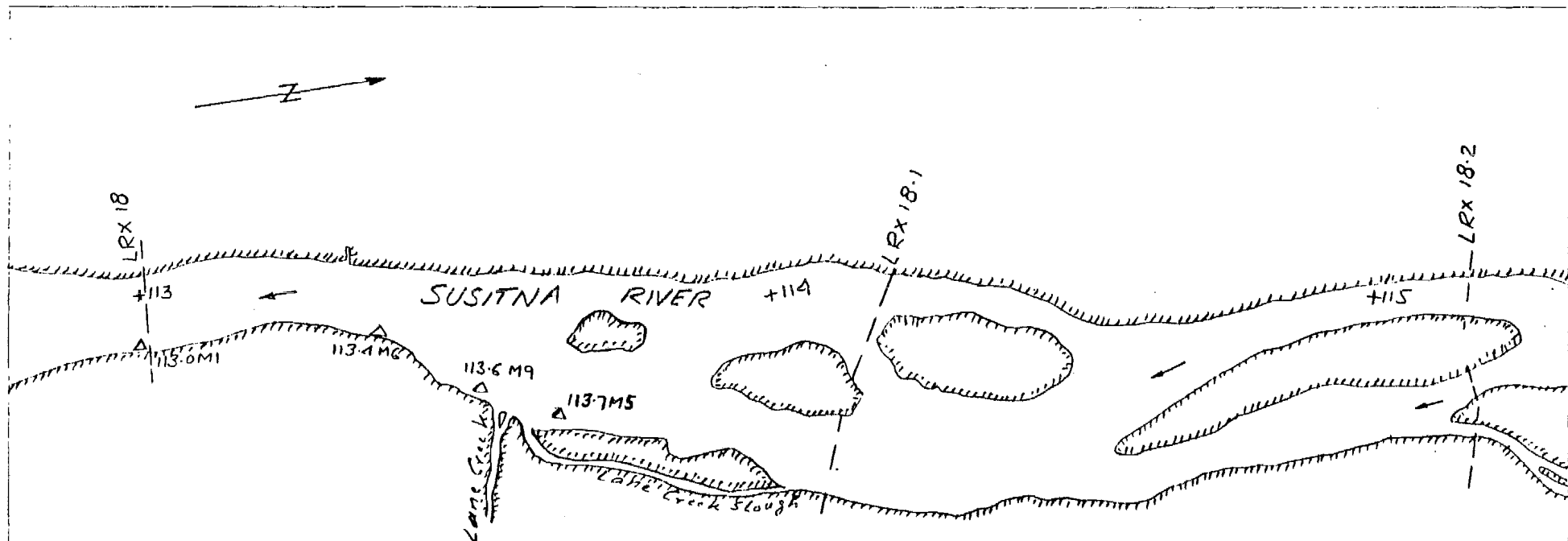


SUSITNA HYDROELECTRIC PROJECT
 MAIN CHANNEL BETWEEN
 RIVER CROSS SECTIONS LRX 12 AND 13

SOURCE: R. M. Smith.

ADAPTED FROM SUSITNA JOINT VENTURE,

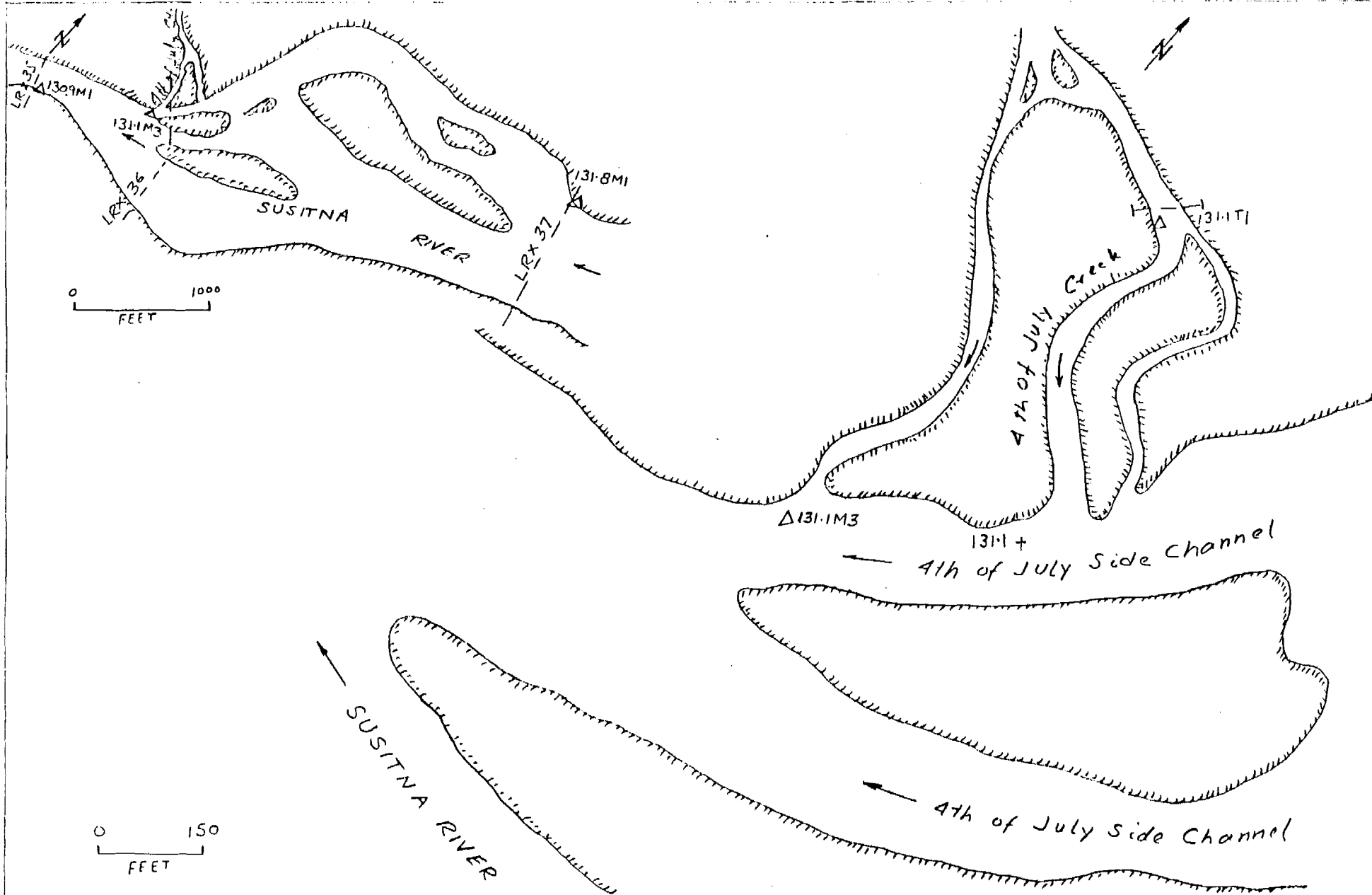
EXHIBIT 2



SUSITNA HYDRO ELECTRIC PROJECT
 MAIN CHANNEL UPSTREAM
 FROM LANE CREEK

SOURCE: RESNAIS Incorporated.

HMP 7A - EBASCO SUSITNA JOINT VENTURE

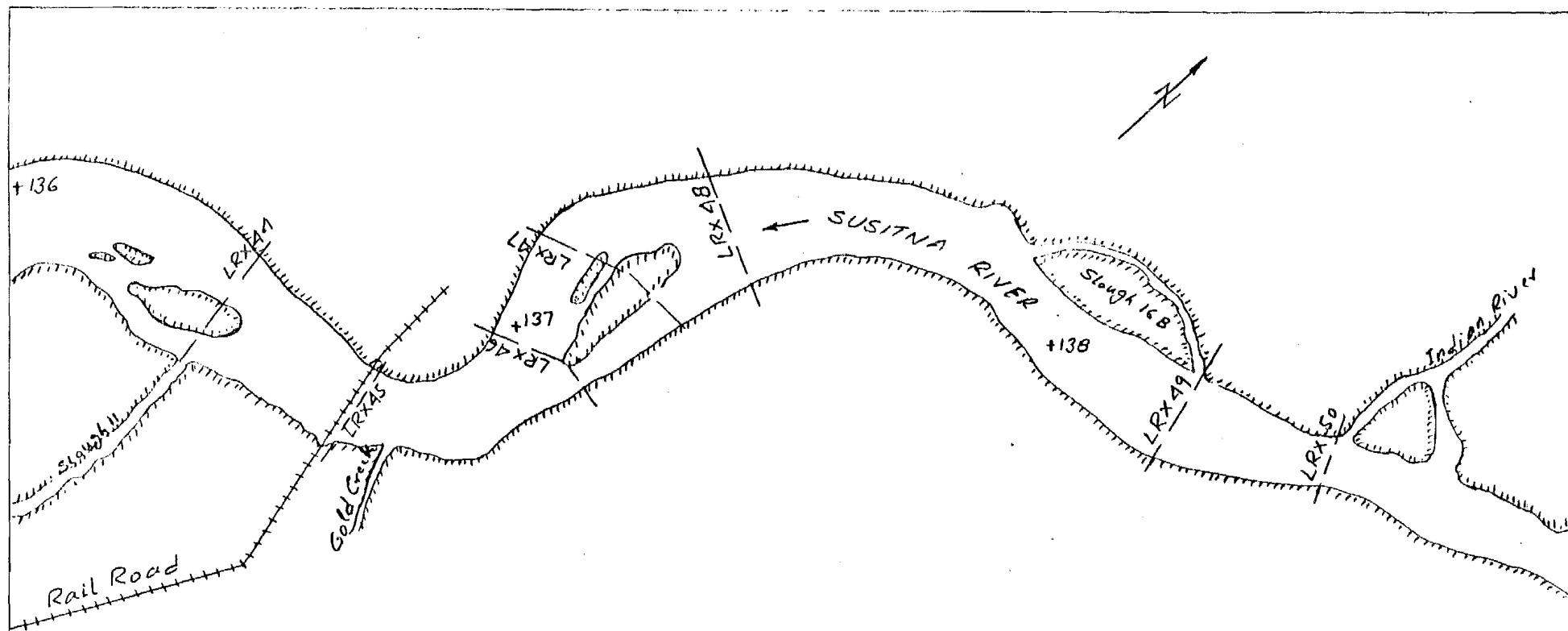


SOURCE: (S) Field notes.

WATERA, FRANCISCO SUSITNA JOINT VENTURE

SUSITNA HYDROELECTRIC PROJECT
MAIN CHANNEL NEAR M111
UPSTREAM FROM 4TH OF JULY CREEK

EXHIBIT 11

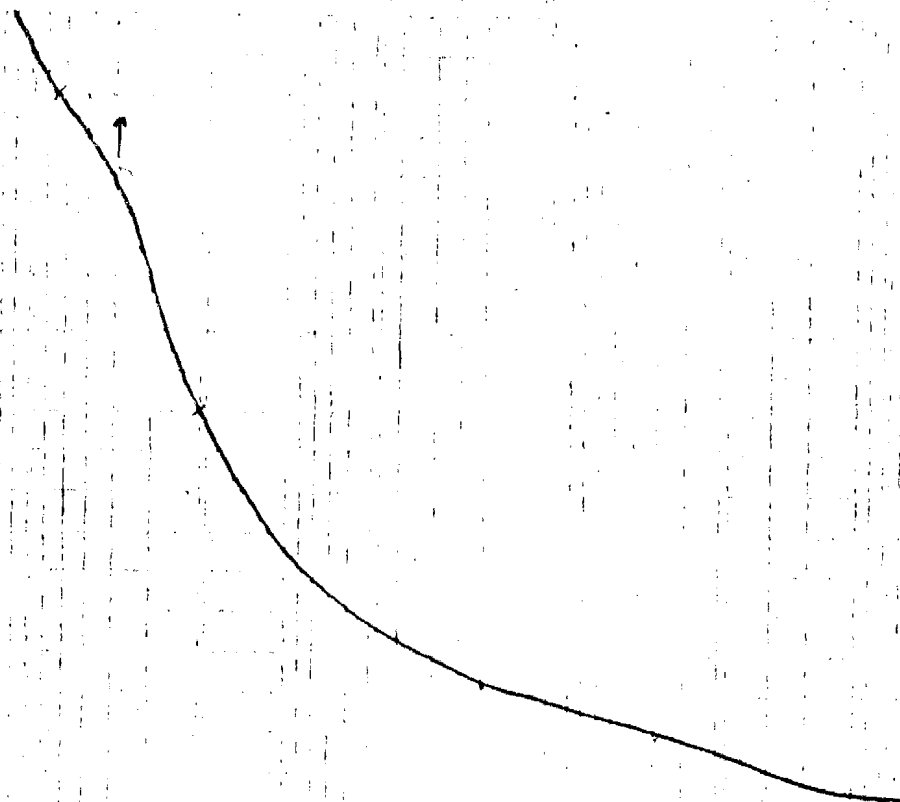


SUSITNA HYDROELECTRIC PROJECT
MAIN CHANNEL BETWEEN RIVER
CROSS SECTIONS 46 AND 48

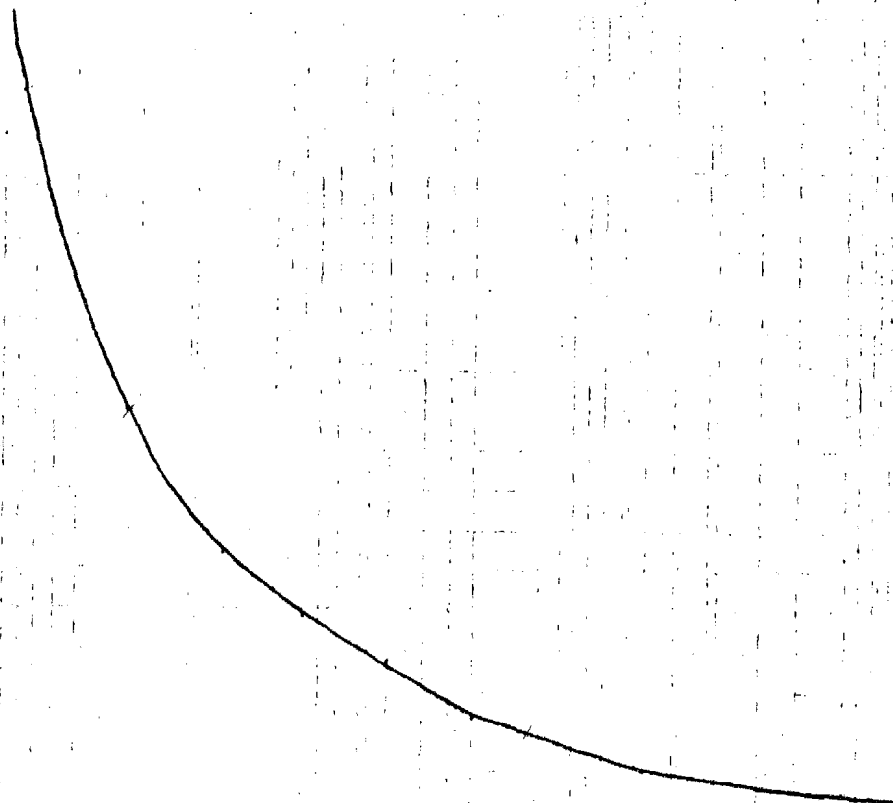
SOURCE: R&A Incorporated

HARRY A. FRASCO SUSITNA JOINT VENTURE

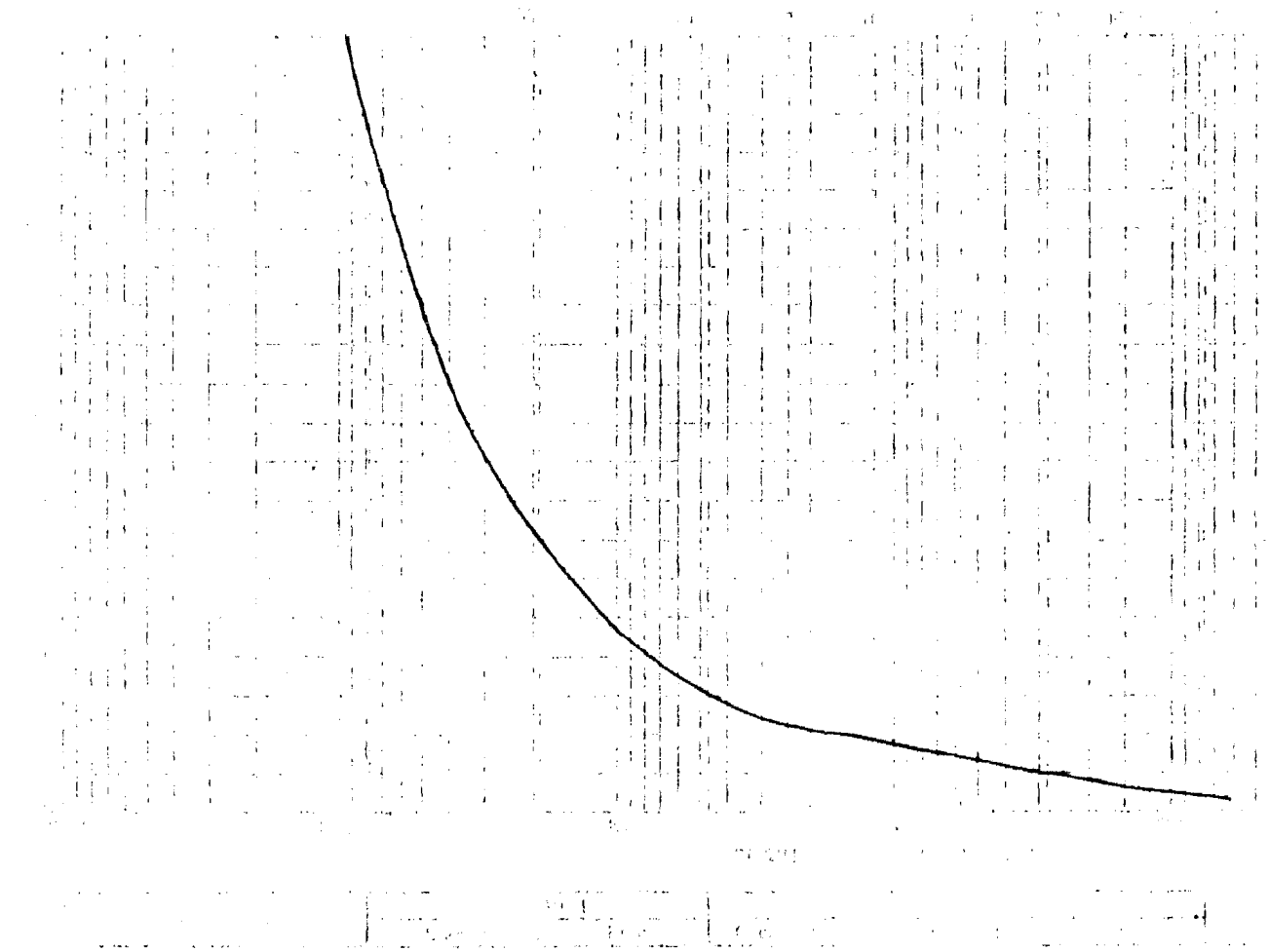
EXHIBIT 1



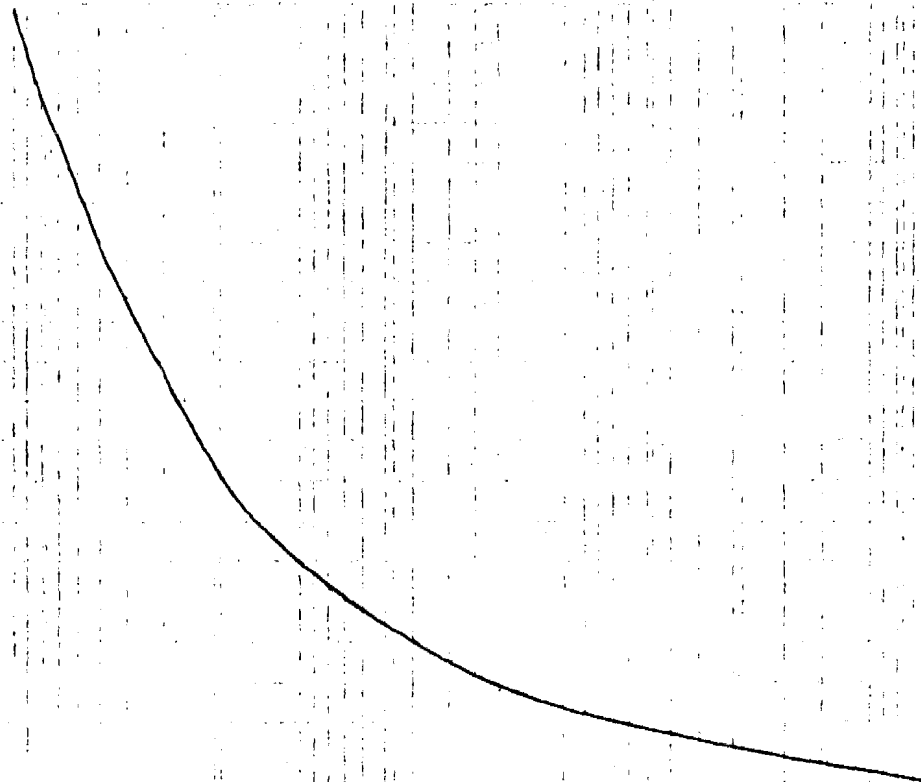
SUSITNA HYDROELECTRIC PROJECT
SIZE DISTRIBUTION OF BED
MATERIAL IN MAIN CHANNEL
NR. CROSS SECTION 4.0



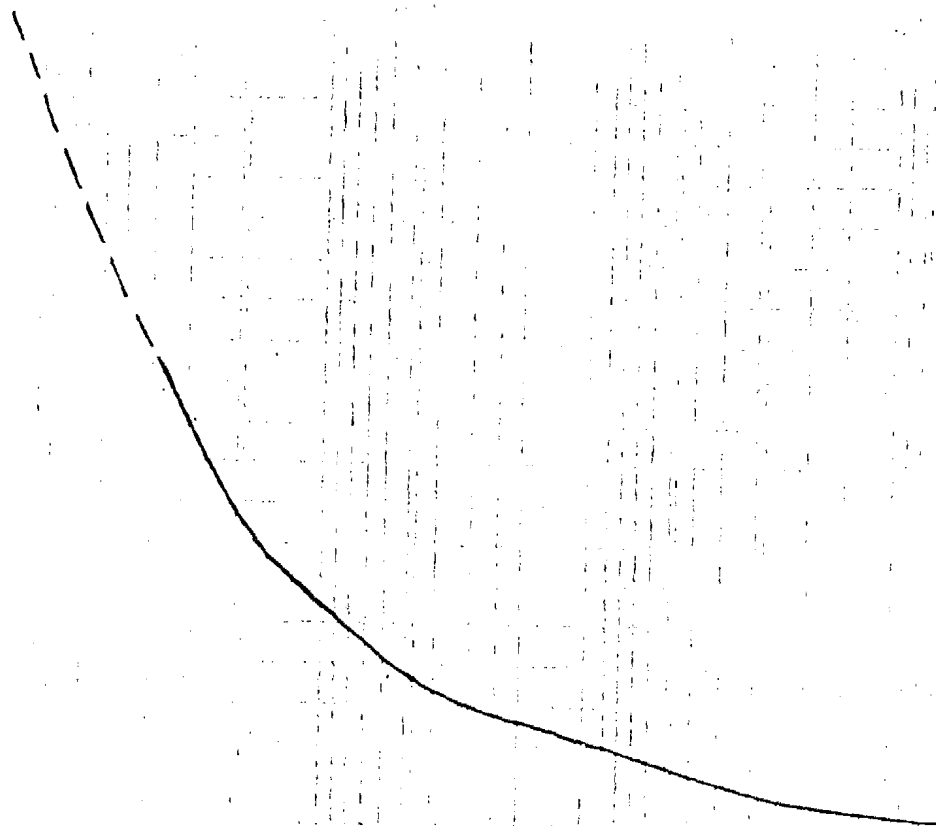
SUSITNA HYDROELECTRIC PROJECT
SIZE DISTRIBUTION OF BED
MATERIAL IN MAIN CHANNEL
NR. CROSS SECTIONS 12 AND 13



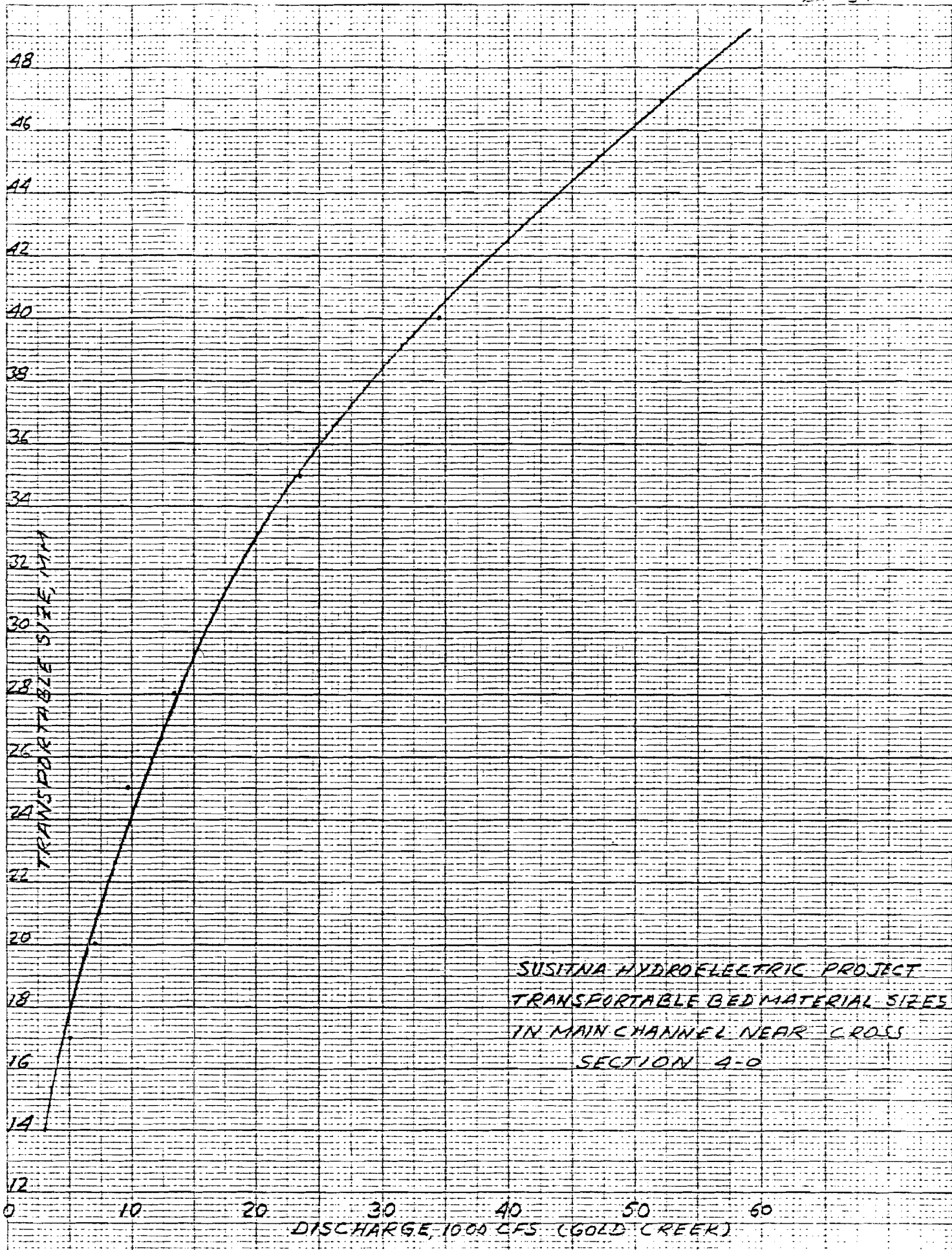
SUSITNA HYDROELECTRIC PROJECT
 SIZE DISTRIBUTION OF BED
 MATERIAL IN MAIN CHANNEL
 NR. LANE CREEK (UPSTREAM)

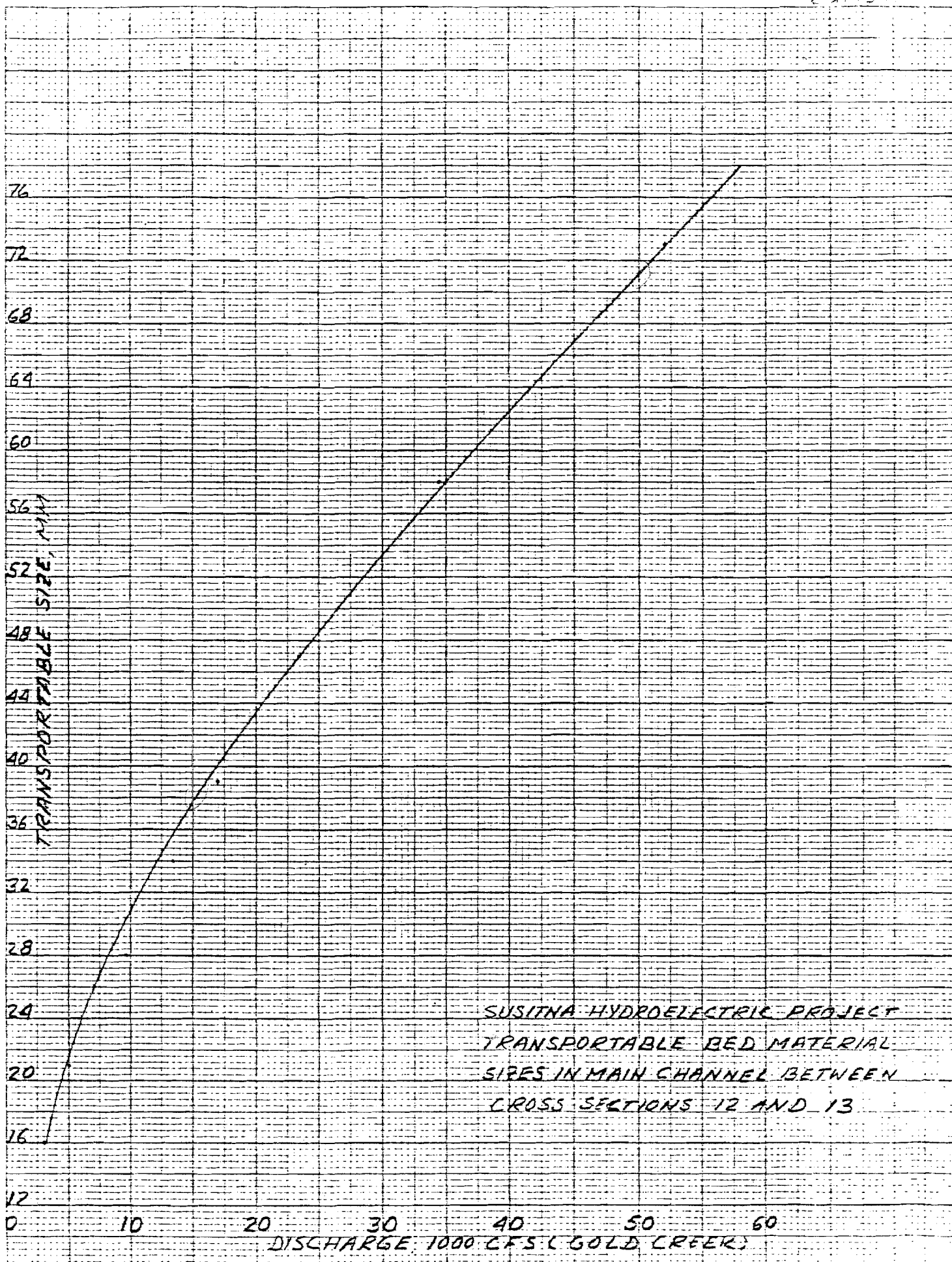


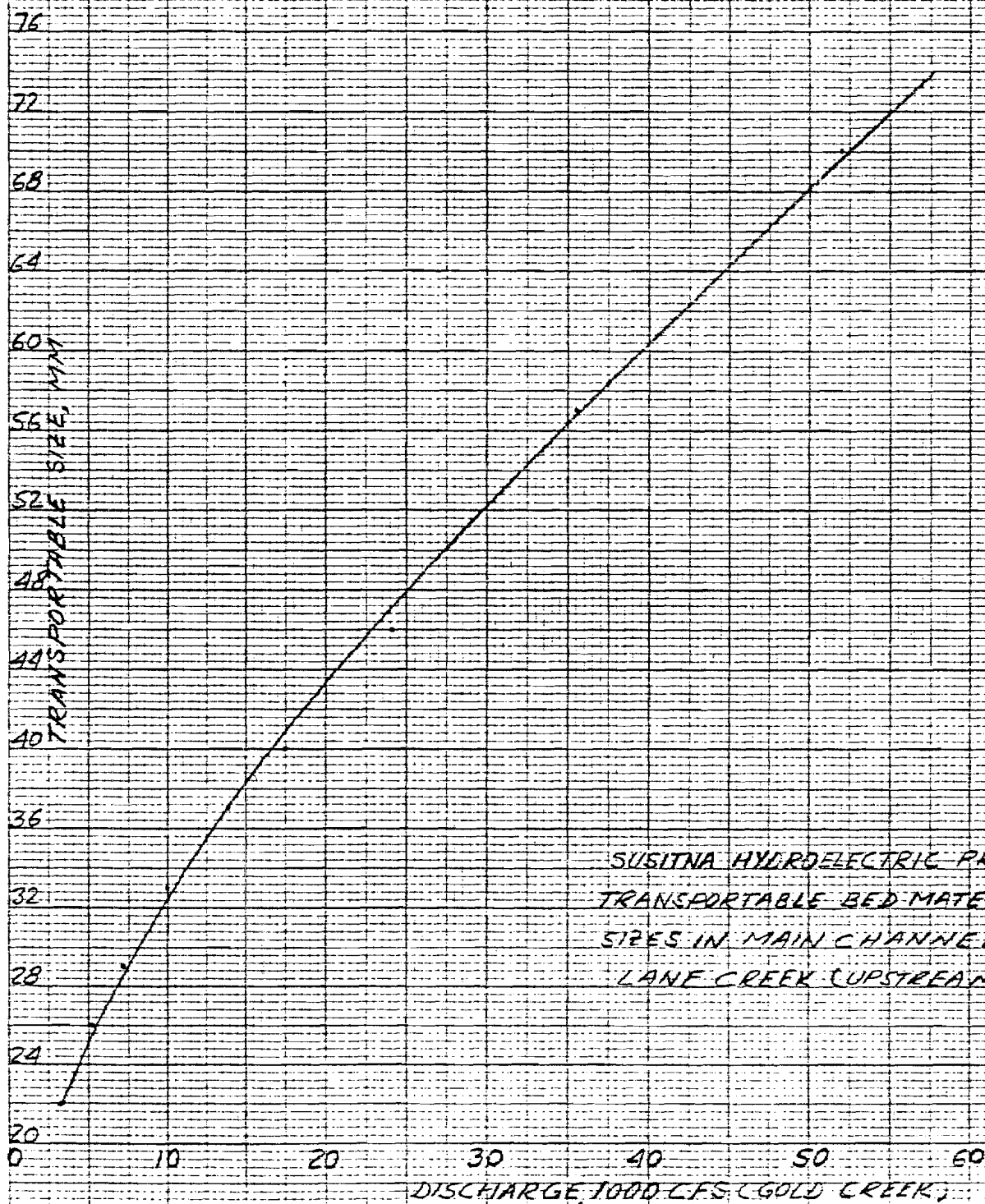
SUSITNA HYDROELECTRIC PROJECT
SIZE DISTRIBUTION OF BED
MATERIAL IN MAIN CHANNEL
UPSTREAM FROM MOUTH OF JULY CREEK

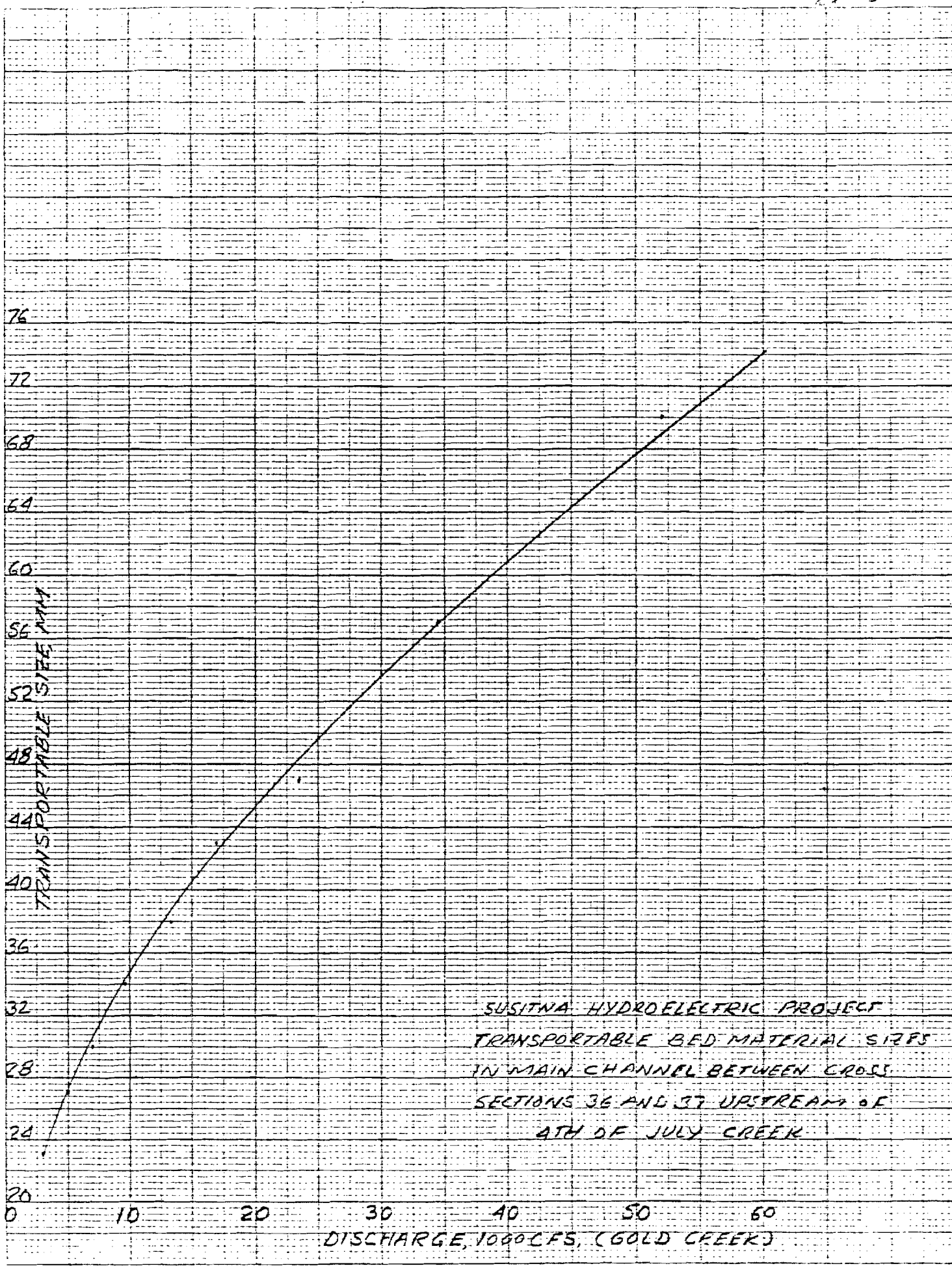


SUSITNA HYDROELECTRIC PROJECT
SIZE DISTRIBUTION OF BED
MATERIAL IN MAIN CHANNEL
BETWEEN CROSS SECTIONS 46 AND 48

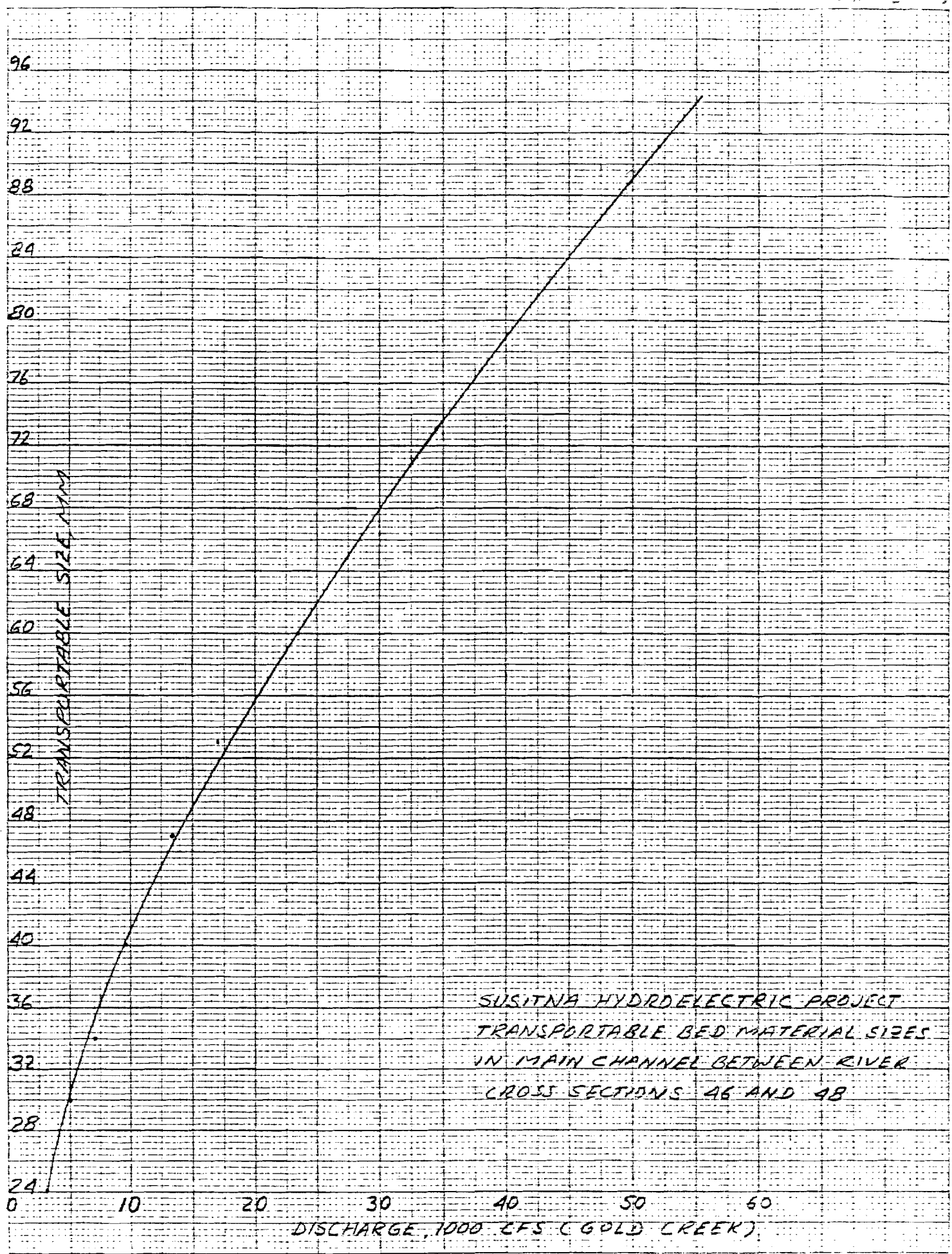








SUSITNA HYDROELECTRIC PROJECT
TRANSPORTABLE BED MATERIAL SIZES
IN MAIN CHANNEL BETWEEN CROSS
SECTIONS 36 AND 37 UPSTREAM OF
MOUTH OF JULY CREEK



INTRA-OFFICE MEMORANDUM

LOCATION Anchorage DATE December 12, 1984
TO File NUMBER 4.3.41
FROM W. M. Dyok
SUBJECT Susitna Hydroelectric Project
Cost to Provide Spiking Flows to Flush Sloughs

Detailed costs of spiking flows will be obtained by use of a combination of the weekly reservoir operations computer program, the hourly operations computer program and the Multi-Area Production Simulation computer program. Since this information is not expected to be available for several months, the cost of the spiking flows for the period when Watana operates alone (1996-2002) was estimated for the Case EI June spike by the following procedure.

- (1) From 1983 historical hourly load data, the average daily minimum summer demand was determined (200 MW) along with the average daily maximum summer demand (340 MW).
- (2) These summer demands were factored up to 1996 and 2002 by multiplying by the ratio of the annual peaks to the 1983 annual peak demand (1.64 and 1.84 respectively). Since the resulting average maximum and minimum daily demands were reasonably similar for 1996 and 2002, (minimum 328 and 368 MW respectively), the averaged values for 1996 and 2002 were assumed to apply to all years between 1996 and 2002.
- (3) A conversion factor of 2000 cfs per 100 MW of power at Watana was developed to relate flow to power production (this factor assumes an average reservoir level of 2140 feet). In early June the reservoir would be lower than this resulting in approximately 5 percent greater flow per 100 MW (i.e., 2100 cfs per 100 MW) whereas in late summer these would be about 5 percent less flow per 100 MW (i.e., 1900 cfs per MW).

It was assumed that energy which could have been stored in summer would be generated at a uniform rate throughout. (This would yield an average flow of 2000 cfs per 100 MW during winter.)

- (4) Intervening flows between Watana and Gold Creek during the June spike were determined to be 2000 cfs, 5000 cfs and 9000 cfs for dry, average, and wet hydrological conditions.
- (5) The intervening flows were subtracted from the Case EI flow requirements at Gold Creek to yield flow requirements at Watana.

INTRA-OFFICE MEMORANDUM

LOCATION Anchorage DATE December 12, 1984
TO File NUMBER 4.3.41
FROM W. M. Dyok Page 2
SUBJECT Susitna Hydroelectric Project
Cost to Provide Spiking Flows to Flush Sloughs

- (6) The volume of flow to be discharged at Watana during the spiking period was calculated (135,000 cfs days).
- (7) The flow volume which would be used to generate usable energy was calculated for each day of the spike, summed and subtracted from the total volume contained in the spike.
- (8) The resultant flow volume release was assumed available for winter generation. (This implies the Watana reservoir would not be filled to elevation 2105 feet by the end of summer, thereby allowing storage of the volume released.) The equivalent energy contained in the spike was determined.
- (9) Assuming a value of 6 cents/kWh (1982 dollars), the cost of each spike was calculated. This was determined to be \$6,900,000, \$5,700,000, and \$4,500,000 for high, average, and low intervening flows respectively, during the time of the spike.
- (10) The present worth of the annual spikes in 1982 for the period 1996 to 2002 was calculated. This was determined to be \$21,500,000 for average intervening flow conditions.

In this analysis, no account was taken of the potential benefit of fuel savings by generating part of the usable energy in the June spike at another time of the year when less efficient generation units would be operating.

A similar analysis could be undertaken for the period that both Watana and Devil Canyon are operating. The spiking flow volume would be expected to come from Devil Canyon during Watana/Devil Canyon operation. During Watana/ Devil Canyon operation, the probability of flow releases is high in the early years of operation because of the energy production capability of the project relative to the railbelt load. Because of this high probability, the cost of spiking in the early years of Watana would be reduced and would need to be considered in the cost analysis. As the railbelt load increases, the probability of filling the Watana and Devil Canyon reservoirs and then having to release water decreases, resulting in higher costs to provide the spiking flows.

INTRA-OFFICE MEMORANDUM

LOCATION Anchorage DATE December 12, 1984
TO File NUMBER 42.2.1
FROM W.M. Dyok
SUBJECT Susitna Hydroelectric Project
Maximum Hourly Flow Variation and
Minimum Flow Requirements

In a September 4, 1984 memorandum from W.M. Dyok to W.E. Larson, it was proposed that during the period when Watana is operating alone, discharge variations of plus or minus 10 percent of the mean weekly discharge as measured at Gold Creek would be allowed. In varying the discharge between the allowable maximum and minimum flows for a given week, it was also proposed that the maximum hourly rate of change of discharge would be 10 percent of the weekly average discharge when discharge is being increased and 500 cfs per hour when discharge is being reduced. (The more stringent requirement during flow reductions minimizes the possibility of stranding fish).

If the weekly average discharge is changed at the beginning of the week, the above rates of change of discharge would govern. Therefore, in changing flow from one week to the next, flow could be increased from 10 percent less than the past weekly average to 10 percent greater than the present weekly average at a maximum rate of 10 percent per hour of the weekly average flow. Conversely, the flow could be decreased from 10 percent greater than the past weekly average to 10 percent less than the present weekly average at a maximum rate of 500 cfs per hour.

It is anticipated that future studies will refine the allowable hourly flow variations on both a seasonal and daily basis. The change in wetted channel geometry with changing discharge may also lead to a series of allowable hourly flow changes for given discharge ranges. However, until such studies are completed, the above maximum hourly flow variations will be assumed in reservoir and energy studies.

In reservoir operation studies, it has been assumed that the minimum flow requirements relate to the mean weekly flow. Therefore, if the mean weekly flow is equal to or slightly greater than the minimum flow requirement for a given week, it is possible to have flows up to 10 percent less than the minimum flow requirement for a part of the week. If further studies indicate that the minimum requirements should not be violated at any time during the week, reservoir operation will be modified to ensure that the weekly minimum flow requirements are not violated.

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