IRENE E. RYAN
RENEWED FOR 1972
209-E-1949
TERRITORY OF ALASKA
REGISTERED ENGINEER

FEASIBILITY STUDY

EYAK LAKE

WATER LEVEL STABILIZATION

CORDOVA, ALASKA

FOR

DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

DEPARTMENT OF PUBLIC WORKS
STATE OF ALASKA
PROJECT NO. FG-71-2

SEPTEMBER 25, 1970

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September 25, 1970

Mr. David L. Peterson
Deputy Commissioner
Department of Public Works
State of Alaska
Pouch Z,
Juneau, Alaska

Dear Mr. Peterson:

We have completed the preliminary investigation of the Eyak Lake Water Level Stabilization project and are submitting herein the final report on this phase of the study as outlined in your letter of July 27.

To summarize:

1. Eyak Lake level has dropped approximately six feet since the earthquake.

2. A rigid weir or rock dam across Eyak River could be constructed to raise the lake level, however, a study of the hydrology and the River itself shows that this type of structure will increase the present flood conditions.

3. During past floods, the water found its way out of the Lake by an old channel through Cordova. This has been further blocked since then by the highway fill. The culverts installed under the highway at this point do not look adequate to handle the excess, however a complete investigation of this channel was beyond the scope of the present work and budget.

MARYLAND
VIRGINIA
OKINAWA
THAILAND
VIETNAM
HONG KONG
INDONESIA
JAPAN
KOREA
LEBANON
LIBERIA
MALAYSIA
PHILIPPINES
TAIWAN

4. We suggest therefore the installation of the Fabridam Weir as the most practical and least expensive of the alternates. It will deflate during floods and permit the discharge of flood waters.

Very truly yours,

LYON ASSOCIATES, INC.

Irene E. Ryan

Irene Ryan, P. E.

EYAK LAKE WATER LEVEL STABILIZATION

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EYAK LAKE WATER LEVEL STABILIZATION

I. INTRODUCTION

A. Purpose and Scope.

The purpose and scope of this study is to determine the feasibility of raising Eyak Lake to its pre-earthquake MLW level and, if feasible, the location, type and estimated budget cost of the structure to accomplish this.

B. Pertinent Data.

1. Location of Weir — Approximately 150 feet downstream from the Eyak River Bridge.

2. Drainage Area (square miles)

Above Weir Site	40.5
Above Gauge Station on Power Creek	20.5
Between Weir Site and Gauge Station on Power Creek	20.0

3. Stream-flow (cubic feet per second)

Power Creek Gauge Station.

Maximum	5540 cfs (Sept. 28, 1949)
Minimum	13 cfs (April 29, 1950)

4. Probable Flood Flows for Eyak Lake (cfs)

Q (cfs)	Frequency (years)
11,800	20
14,000	50
16,000	100

5. Elevations, Feet (MLLW OCEAN 0.0 DATUM - POST-EARTHQUAKE)

Eyak Lake (Min.)	17.50 feet
Weir Crest	17.50 feet

6. Weir

Type	6.0 foot high Fabridam water gate
Construction Materials	Rubberized fabric tube, fixed in place on a concrete foundation, which is capable of being inflated and deflated.
Length	Two sections, each 92 feet long.

C. Investigations.

Listed below are the investigations that were made to develop this feasibility study. It should be noted that, due to the scope of the study and the time allocated to finish it, these investigations are of a preliminary nature. They were only developed to the point to ensure that the project is feasible, and the recommended structure can be constructed within the estimated budget cost.

1. Topographic and Hydrographic Survey of the area around Eyak River Bridge (Weir Site) and the invert and finish floor elevations of all structures affected by the raising of the lake level.

2. Hydrology of runoff and flood routing.

3. Geological and Subsurface Investigations of proposed weir site. The investigation was limited to a site visit and evaluation of existing data.

4. Real Estate and Relocation Studies.

5. Budget Cost Estimate.

II. SUMMARY AND CONCLUSIONS

A preliminary type survey has established the post-earthquake elevation of the MLW of Eyak Lake to be 17.70 feet above the MLLW ocean datum. This elevation is equivalent to the pre-earthquake MLW lake level of elevation 11.50 feet. Also, if the lake level raises above elevation 21.20 feet, some flood damage to the existing structures that surround the lake will occur.

Due to the flow characteristics of Eyak River, the maximum river flow, when the lake level is at elevation 21.20 feet and at low tide, is calculated to be only 5,100 cfs. This is less than the 20 year storm flood flow (11,800 cfs). This means that under the present conditions, floods will occur in the Eyak Lake area because Eyak River cannot handle the storm flows from the Eyak Lake drainage area. Thus, if any additional restrictions, such as a reinforced concrete weir, rock filled dam with a spillway or fish screens, are installed at the outlet to Eyak Lake, it would cause the water level in Eyak Lake to raise higher, during flood flow, than it does now. It can be seen that the above restrictions, if installed, would only increase the present flood damage potential.

One method to eliminate the present flood potential of Eyak Lake is to install a channel from the Lake through Cordova to the Gulf of Alaska. However, the solution to this problem is beyond the scope of work for this project.

The Fabridam is the recommended structure to raise the lake to a minimum level of 17.50 feet. The Fabridam is a rubberized fabric tube, fixed in place, which is capable of being automatically inflated and deflated. It will be pressurized with water in the summer, and air in the winter time. The Fabridam will remain fully inflated as long as the water level of the lake remains below 21.20 feet. When the water raises above this elevation, the Fabridam will automatically start to deflate. As the water level raises, the Fabridam will continue to deflate until it reaches its flat state. In the flat state, the river will essentially have its present flow characteristics. As the lake level subsides below elevation 21.20 feet, the Fabridam will automatically start to inflate.

The Fabridam will have two 6-feet high, 92-feet long sections. Between these two sections is a reinforced concrete weir, 15 feet wide. The concrete weir will be used by air boats to pass over the Fabridam. The crest elevation of the concrete weir and Fabridam is set at elevation 17.50 feet.

The Fabridam is located approximately 150 feet downstream from the Eyak River Bridge.

The estimated budget cost, excluding the engineering design fee, is $346,000.

III. LOCATION OF PROJECT AND TRIBUTARY AREA

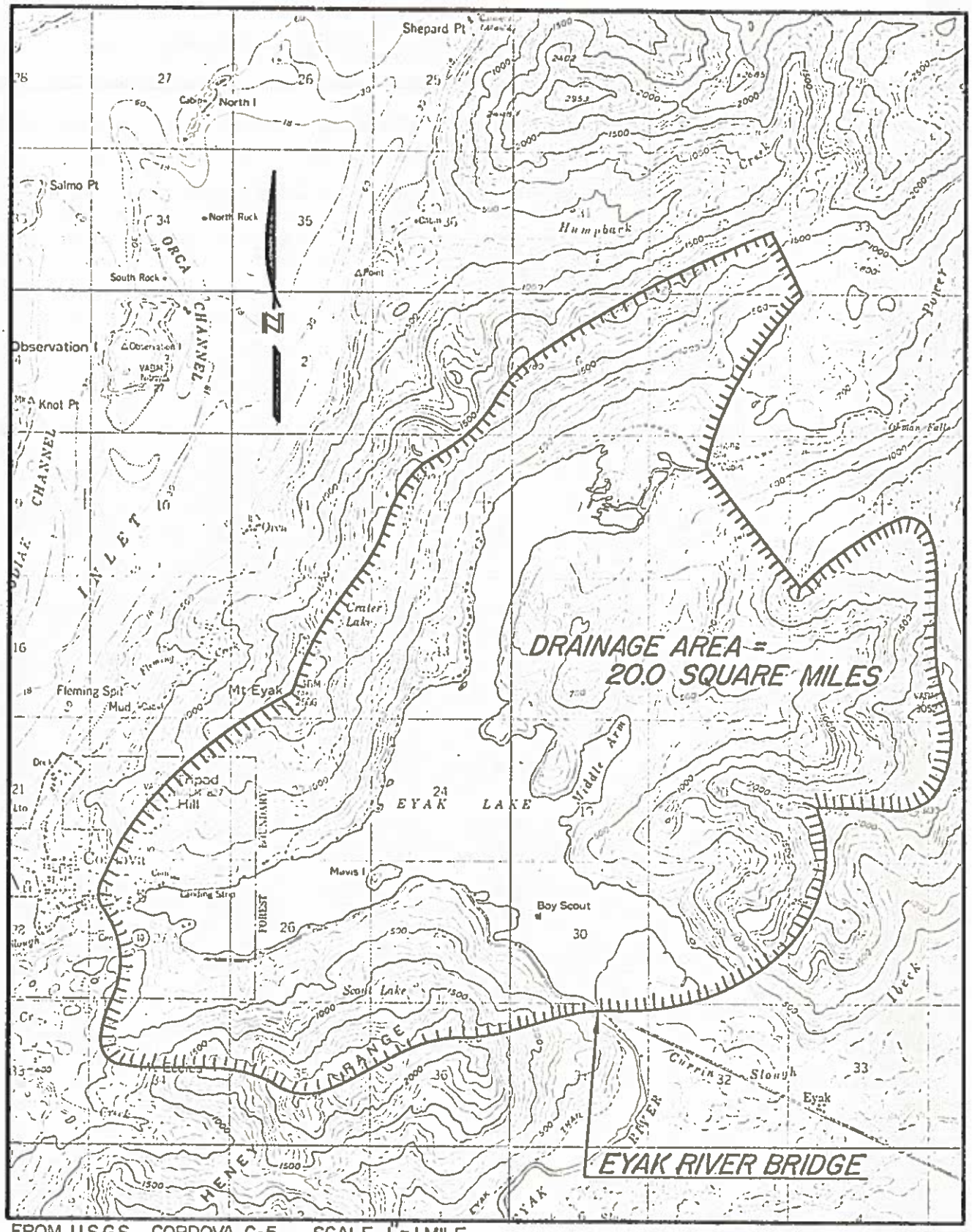
A. Location of Project.

The outlet for Eyak Lake is the Eyak River, which flows in a southwest direction and empties into the Gulf of Alaska at Boswell Bay. Eyak River Bridge, approximately 5½ miles east of Cordova, on the Copper River Highway, spans the Eyak River at the Lake outlet. The Fabridam Water Gate is located approximately 150 feet downstream from the Eyak River Bridge on Eyak River. The location of the Fabridam is shown on Plate I.

B. Tributary Area.

Eyak Lake receives its water source from two watersheds; the Power Creek Watershed above the gauging station and the watershed surrounding the lake. Both of these areas are mountainous, with maximum elevations of approximately 5,000 feet for the Power Creek area and 3,000 feet for the lake area. Glaciers cover approximately 25 percent of the Power Creek area. The total drainage area for Eyak Lake is 40.5 square

miles. The Power Creek contributes 20.5 square miles and the area around the lake 20.0 square miles. The drainage area surrounding Eyak Lake is shown on Plate II. The square mile drainage area for Power Creek was obtained from the data contained in the publication entitled "Water Resources Data for Alaska, Part 1. Surface Water Records" published by the United States Department of the Interior, Geological Survey.



FROM U.S.G.S., CORDOVA C-5, SCALE, 1" = 1 MILE

DRAINAGE AREA AROUND EYAK LAKE

PLATE II

IV. TOPOGRAPHIC AND HYDROGRAPHIC SURVEY

A. Vertical Control.

In order to raise Eyak Lake to its pre-earthquake level and determine the effect of the tide on the flow of Eyak River, it was necessary to establish the post-earthquake elevation of the bench mark on the southwest corner curb of the Eyak River Bridge. The pre-earthquake elevations for the mean low water and mean high water for Eyak Lake are tied into this bench mark.

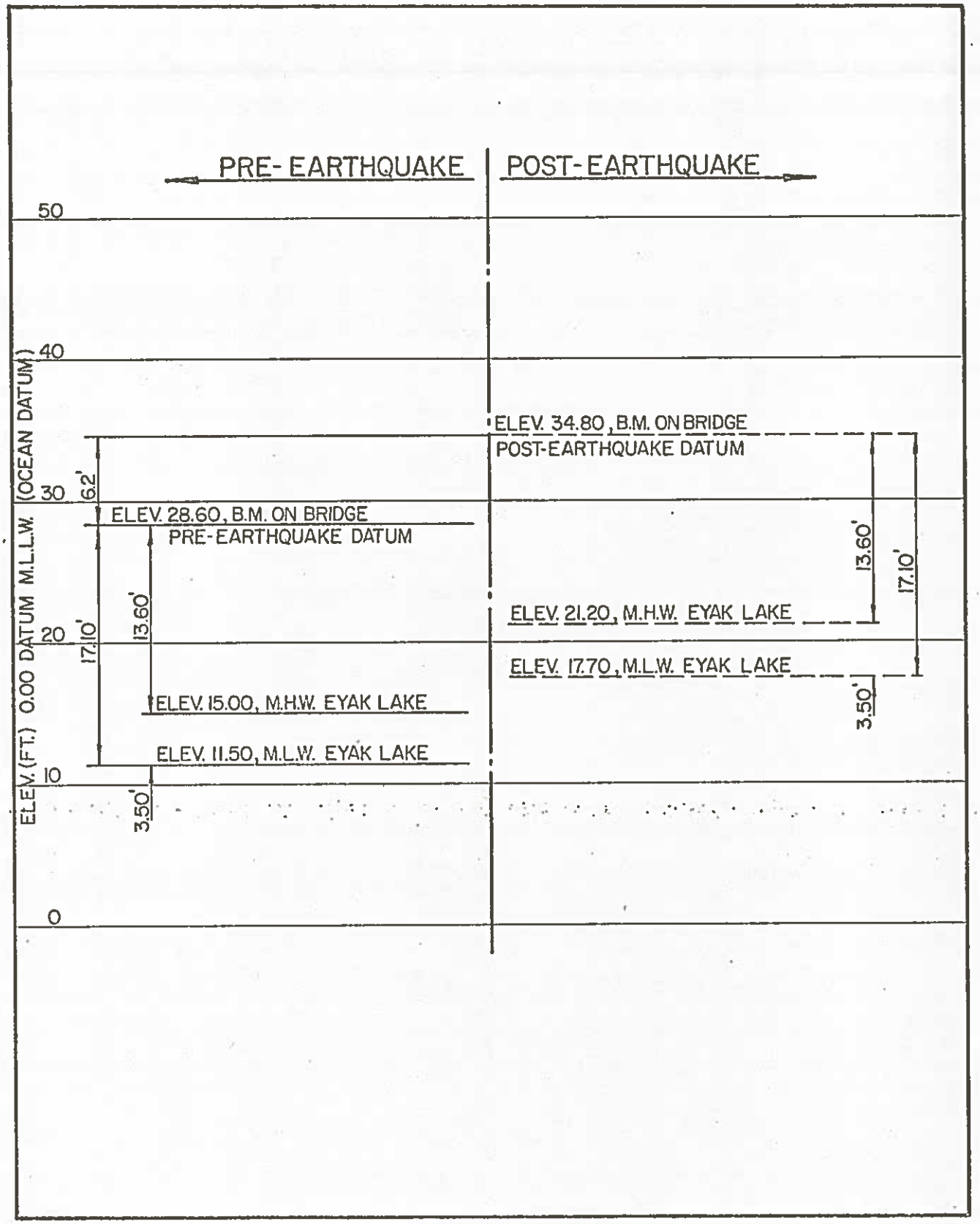
The as-built drawings for the Eyak Bridge show the Eyak Bridge bench mark elevation as 27.02 feet. However, the Alaska State Highway Department in Cordova stated the elevation for this bench mark was 28.60 feet. They also stated that it is the pre-earthquake elevation and was established by them by running looped levels from Bench Mark No. A71 (elevation 98.78' above mean lower low water) to the bench mark on Eyak Lake Bridge. Bench Mark No. A71 is located on the north side wall of the Cordova Post Office. It was set by the United States Coast and Geodetic Survey. The Coast and Geodetic Survey in Anchorage stated that the post-earthquake elevation for Bench Mark No. A71 is 111.40 feet above mean lower low water, which is 12.62 feet above the pre-earthquake

elevation. Looped levels were run from B.M. No. A71 to the Copper River Highway at Station 40+00, which is just inside the city limits of Cordova. This elevation was found to be 45.38 feet. The pre-earthquake elevation for this same point was 39.45 feet, which is only 5.93 feet lower than the post-earthquake elevation. Levels were run from Station 40+00 to the B.M. on the Eyak River Bridge, and the elevation was found to be 34.80 feet above MLLW, which is 6.20 feet above the pre-earthquake elevation. Since this was only a preliminary survey, the level run between Station 40+00 and Eyak Bridge was not looped. However, shots were taken on the water surface of the lake along the level run, and the elevation of the lake was found to be the same at each shot. This indicates that the levels are of sufficient accuracy for a preliminary survey.

The relationship between the pre- and post-earthquake MHW and MLW elevations of Eyak Lake are shown on Plate III.

B. Weir Site

A preliminary topographic and hydrographic survey was made at the Weir Site. The results of this survey are shown on Plate I.



PRE- AND POST-EARTHQUAKE ELEVATIONS
FOR
EYAK LAKE

PLATE III

C. Survey Around Eyak Lane

In order to establish the level to which the lake could be raised without flood damage to existing structures adjacent to the lake, it was necessary to determine the post-earthquake controlling elevations for these structures; such as finish floors of buildings, inverts of culverts and outfall lines to septic tanks. These controlling elevations were obtained by the following method:

1. The elevation of the lake was established from the B.M. at Eyak Bridge. This was periodically checked throughout the survey.

2. Levels were run from the lake level to each elevation desired.

The results of this survey are shown on Plate IV.

V. PROJECT PLAN

A. General.

It is planned to raise the level of Eyak Lake to a minimum post-earthquake elevation of approximately 17.50 feet above MLLW (ocean datum) which is 0.2 feet below the equivalent pre-earthquake MLW elevation of Eyak Lake. To accomplish this, a submerged type weir will be installed across the outlet of Eyak Lake.

The weir must not only maintain the minimum lake level, but also limit a maximum lake level during flood flow. As seen on Plate IV, the majority of the invert elevations on outfall septic tanks lines are around 21.00 ft. However, the elevation of the float plane spit is 21.60 feet, which is lower than the runway for Cordova Aircraft Service (23.80 feet) or the lowest finish floor elevation (24.13 feet-Home of Mr. B. Cunningham). Therefore, if the maximum level of the lake could be limited to elevation 21.20 feet, which is equivalent to the pre-earthquake MHW level, little or no flood damage would occur.

The maximum flow in a river per unit of specific energy head is limited by the slope, shape and roughness (n) of the river. Using the maximum lake elevation (21.20 feet), which would cause little or no flood damage, and assuming no backwater effect from the tide (flow at low tide), the calculated maximum flow in Eyak River is 5,100 cfs (see Plate VI, page 29). This is less than the estimated storm flood flow (11,800 cfs) for a 20 year storm. This means that, under the present conditions, floods will occur in the Eyak Lake area. The flood which occurred in September, 1949 substantiates this fact. It can be seen from the above that any further restrictions installed at the outlet to Eyak Lake, such as a reinforced concrete weir, rock filled dam with a spillway or fish

screens, would only increase the present flood damage potential. Therefore, in order not to increase the present flooding conditions during flood flow, the structure used to control the level of the lake could not essentially alter the present flow characteristics of the outlet to the lake. A system of flood gates could be used. However, the cost to install and maintain them would be prohibitive. Thus, the Fabridam Water Gate, explained below, is the recommended structure to be installed on the Eyak Lake outlet to raise it to a minimum level of approximately 17.50 feet.

B. Weir.

1. Type

The Fabridam water gate is a rubberized fabric tube, fixed in place on a concrete foundation, which is capable of being inflated and deflated with water or air or a combination of both. Due to the below freezing temperatures in Cordova, the pressurizing system will be a combination of air and water; water in the summer time and air in the winter time.

The main feature of this type of water gate is its ability to change from its normal design height to a deflated and flat state. When the dam is in the flat state, the basic flow characteristic of the river is unchanged. Deflation and inflation

are done automatically.

As previously stated, when the lake level raises above elevation 21.20 feet, some flood damage will occur. Thus, when the lake level starts to raise above this level, the Fabridam will automatically start to deflate. This will allow more water to pass over the water gate. As flood flow increases, the Fabridam will continue to deflate until it reaches its flat state. When the quantity of flood flow decreases to the point that the lake level starts to go below elevation 21.20 feet, the water gate will automatically start to inflate. The Fabridam will always maintain its fully inflated state as long as the lake level is at or below elevation 21.20 feet.

Since the minimum flow into the lake is approximately 26 cfs, the crest elevation of the Fabridam will have to be 17.50 feet to maintain the minimum lake water level at elevation 17.50 feet.

The Fabridam consists of two 92 foot long sections, 6 feet high. In order to allow for the passage of Air Boats over the water gate, a 15-foot wide concrete weir, with a crest elevation of 17.50 feet, has been placed between the two sections of Fabridam.

2. Location.

The weir will be located, as shown on Plate I, approximately 150 feet downstream from the Eyak River Bridge. This is one of the narrowest portions of the river where the banks are of sufficient height to eliminate the need of building expensive dikes to prevent water flowing around the weir.

3. Construction Materials.

a. Fabridam

The Fabridam is constructed of high-strength nylon fabric coated with durable Neoprene synthetic rubber. The nylon is woven and laminated into plies in a manner similar to low pressure tubeless automobile tires, for tear and puncture resistance. The Neoprene synthetic rubber seals the fabric and provides a long-term weathering ability. It is little affected by sunlight, and temperature changes, and provides resistance to abrasion and erosion. The Fabridam has passed such heavy debris as a wrecked auto body, trees with roots, boulders and ice, without damage to the dam. Also, Neoprene is flame resistant and will not support combustion by itself.

If the Fabridam is punctured, temporary repairs can usually be made without deflation. To repair these punctures, plugs similar to those used in tire repairs are adequate. Screw type plugs or mechanical clamps may also be used. However, permanent repairs are made by applying reinforced patches.

The ultimate service life of the Fabridam is not yet known, because it has only been in use since 1957. These Fabridams which were originally installed are still in use. The ones which have been properly maintained show very little deterioration.

As with any product, serviceability is related to use and care. Thus, if the Fabridam and related equipment are properly maintained, the estimated service life would be 20 to 25 years.

The cross-sections of the Fabridam are shown on Plate I.

b. Foundation

The Fabridam will be secured to a reinforced concrete slab. Special clamp bars, on both the upstream and downstream edge of the dam, anchor the dam continuously across the slab. This forms a seal to prevent leakage of impounded water between the concrete and the dam.

The ends of the dam will be secured to the vertical headwalls of the concrete weir and sloping headwalls on the banks of the river. The concrete slab will be 10.0 feet wide, which is wide enough to accommodate the dam in its deflated condition. The slab is secured to a row of sheet pile, driven down to the rock line, on the upstream face of the slab. All mud and fine silt will be excavated from underneath the slab area, backfilled with granular material and levelled off. The top elevation of the concrete slab will be set at elevation 11.50 feet.

The scope of work for this project did not include any drilling for subsurface exploration. However, a review of the pile driving reports on the Eyak River Bridge, which is approximately 150 feet upstream from the weir site, indicates that the rock line is from approximately 12.0' to 38.0' below the river bottom. Rock outcropping and rock cuts on the bridge approach also indicate that the rock line is not too far below the surface of the river bottom.

4. Construction Sequence.

To facilitate the construction of the Fabridam, it should be installed under dry conditions. Therefore,

the weir will be installed in two stages. One section, including the concrete weir, will be diked-off, de-watered and installed. After this section is completed, the temporary dike will be removed and placed around the remaining section to be constructed. Thus, by constructing the weir in this manner, a portion of the river will always be left open for flow, eliminating the need for a diversion channel, and the weir will be installed under dry conditions.

VI. HYDROLOGY AND HYDRAULIC ANALYSIS

A. Hydrology.

1. General

As previously stated, Eyak River, the outlet to Eyak Lake, is not capable of handling the present flood flows from Eyak Lake. The flood which occurred in September, 1949 and the hydraulic analysis (see paragraph VI B 1.) for Eyak River substantiates this fact. Therefore, since the recommended structure to raise the level of Eyak Lake will not appreciably alter the present flow characteristics of Eyak River, a detailed analysis of the hydrology of the area is not warranted at this time. However, the analysis presented below is of sufficient accuracy to obtain the order of magnitude of flood flows from Eyak Lake.

2. Reference Reports.

The following reference reports were used in deter-

mining the flood flow for Eyak Lake:

a. Power Creek Project No. 2656 by Cordova Public Utilities

b. Water Resource Data for Alaska, Part 1. Surface Water Records, published by United States Dept. of the Interior, Geological Survey.

c. Climatological Data published by U. S. Department of Commerce, Weather Bureau.

3. Flood Flow

Eyak Lake obtains its water source from two watershed areas; the Power Creek area and the area surrounding Eyak Lake. The drainage area of Power Creek is 20.5 square miles, and the area around Eyak Lake is 20.0 square miles. Thus, making a total drainage area of 40.5 square miles. Since the total drainage area is small and both areas have approximately the same topographic features, it is reasonable to assume that they have the same run-off characteristics. However, to determine if the run-off for both areas can be added together to obtain the peak flow for the total area, the time of concentration and duration of the storm must be analyzed.

Using figure 13, page 47, of Design of Small Dams, the average elevation of headwater of 3,000 feet and a distance of 80,000 feet from the headwater to Eyak Lake, the approximate time of

concentration for this portion of Power Creek is 2½ hours. The inlet water into Eyak Lake from Power Creek moves through the lake to its outlet largely by a process of translation with a velocity equal to $\sqrt{gd}$. Assuming the average depth of the lake of 20 feet and the distance from Power Creek inlet to the lake outlet as 4 miles, the time of concentration for this portion is 0.3 hrs. Thus, the total time of concentration from the headwater of Power Creek to Eyak Lake outlet is 2.8 hours; say 3.0 hours.

The time of concentration for the area around Eyak Lake is 1.0 hours.

Climatological data received from the Weather Bureau indicates that large storms last longer than the time of concentration (3.0 hours) of Power Creek.

Based upon the above, the peak flood flows from each drainage area can be added together to obtain the peak flood flows for the entire drainage area for Eyak Lake.

The maximum 24 hour peak yearly flow (Q cfs) from 1947 to 1968 for Power Creek are shown in Column 2 on Table 1, page 25. These values were obtained from Water Resources Data for Alaska, Part 1.,

Surface Water Records.

The maximum 24 hour peak yearly flow for Eyak Lake is shown in Column 4 of Table I, page 25. The values were obtained by multiplying the ratio of the drainage areas (20.0/20.5) times the flood flow for Power Creek, and adding this result to the same flood flow.

During the site visit to Eyak Lake, the velocity of flow was roughly determined by floats at Eyak Bridge. From this velocity and the cross-section of flow, the quantity of flow was computed. This flow varied from 900 to 1400 cfs. The flood flow for Power Creek, during this same period, varied from 366 to 590 cfs, which would be 730 to 1170 cfs for Eyak Lake. Keeping in mind the rough method of determining the velocity at Eyak Bridge, these values compare quite favorably. Thus, the method for determining the flood flows for Eyak Lake as shown on Plate V, page 24, is within reason.

4. Probable Flood Flows for Eyak Lake

The probable frequency of a flood of a given magnitude may be determined on a mathematical basis by the laws of probability, provided that the records of river discharge upon which the study is based

are truly representative of average conditions. As stated above (paragraph VI A), the flood flows for Power Creek represent sufficiently, for this report, the average conditions for the Eyak Lake drainage area.

The flood probability curves for Power Creek and Eyak Lake are shown on Plate V, page 24. The probability curves are based upon the Yearly Flood method.

An estimate of the probable frequency of 24 hour flood peaks is described below, and the calculations are shown in Table I, page 25.

Col. 1 shows the year of the flood and Col. 2 shows the maximum 24 hour peak flow, Q, for Power Creek for that year. The order of magnitude of Q for Power Creek is shown in Col. 3. Col. 4 gives the 24 hour peak flows, in order of magnitude, for Eyak Lake. Col. 6 shows "P", the probable percentage of future years in which a flood equal or greater than a discharge "Q" will occur. "P" is obtained from the following equation: $P = \frac{100n}{y}$.

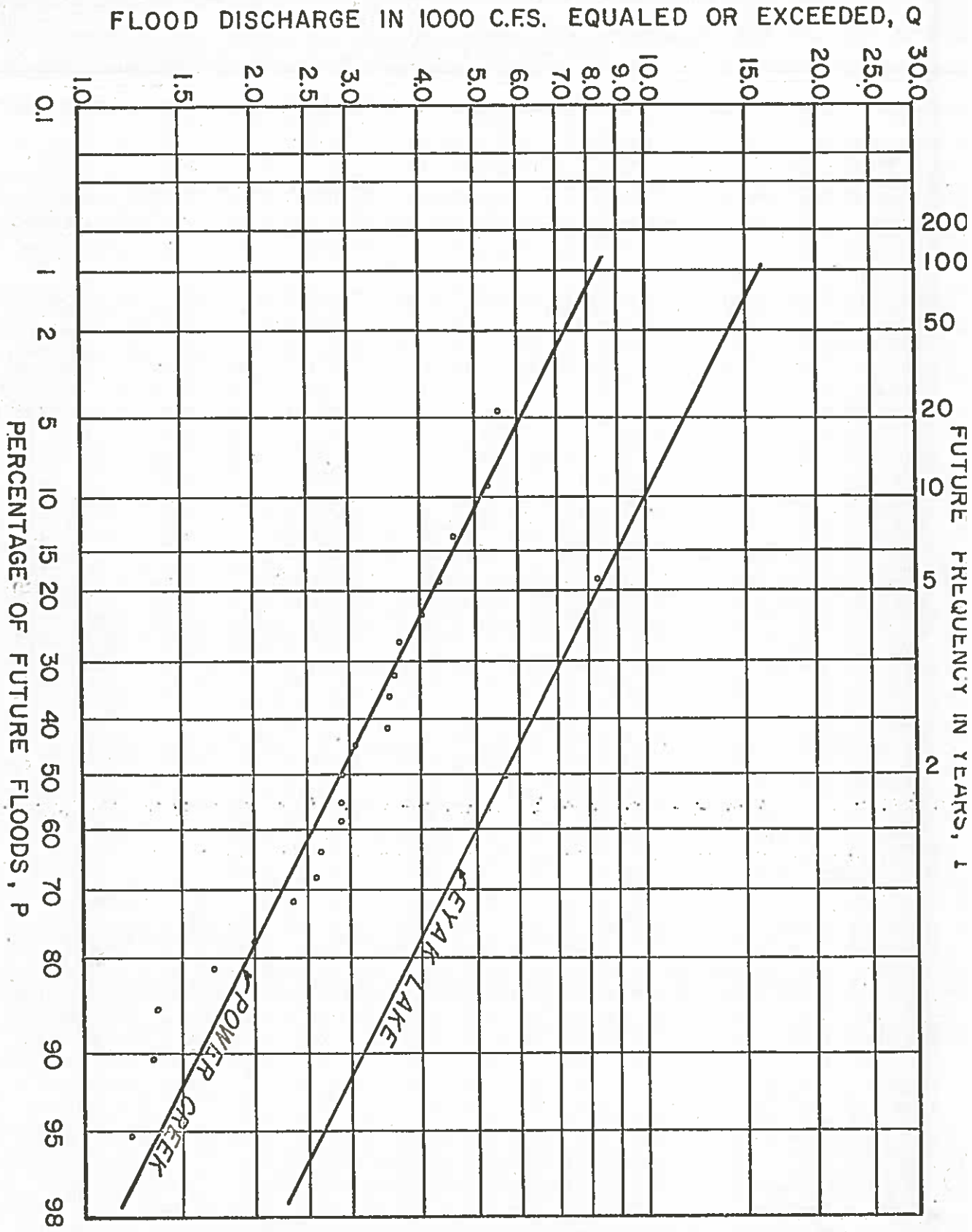
n = the number of years during the period of record that a flood, Q, was equalled or exceeded. This value is shown in Col. 5.

y = the total number of years on record (in this case 22 years).

The interval in years between floods equalling or exceeding a given flood, Q, is shown in Col. 7 (I), and is equal to $\frac{100}{P}$.

The estimated probable flood flows for Eyak Lake, taken from Plate V, are as follows:

Q (cfs)	Frequency (years)
11,800	20
14,000	50
16,000	100



FLOOD PROBABILITY CURVES
FOR
POWER CREEK AND EYAK LAKE

(29)

PLATE V

TABLE I

CALCULATIONS FOR PROBABILITY PLOTTING OF FLOOD DISCHARGES OF EYAK LAKE

1	2	3	4	5	6	7
YEAR	POWER CREEK MAX. 24 HR. YEARLY PEAK Q C.F.S.	ARRANGED IN ORDER OF MAGNITUDE	EYAK LAKE MAX. 24 HR. YEARLY PEAK Q C.F.S.	NUMBER OF TIMES "n" PEAK WAS EQUALED OR EXCEEDED	PERCENTAGE OF YEARS P	FUTURE FLOOD FREQUENCY I-YEARS
1947	2,850	1,090	2,160	22	100.0	1.00
1948	2,630	1,220	2,420	21	95.3	1.05
1949	5,540	1,330	2,630	20	90.8	1.10
1950	2,600	1,340	2,670	19	86.3	1.16
1951	3,650	1,760	3,480	18	81.7	1.22
1952	3,490	2,000	3,960	17	77.2	1.29
1953	2,400	2,400	4,750	16	72.7	1.37
1954	3,090	2,600	5,150	15	68.1	1.47
1955	3,470	2,630	5,250	14	63.6	1.57
1956	2,860	2,850	5,650	13	59.0	1.69
1957	4,270	2,860	5,670	12	54.5	1.83
1958	5,250	2,880	5,700	11	50.0	2.0
1959	4,590	3,090	6,120	10	45.4	2.2
1960	2,880	3,470	6,870	9	40.9	2.44
1961	1,330	3,490	6,900	8	36.3	2.75
1962	1,090	3,650	7,230	7	31.8	3.14
1963	1,340	3,680	7,280	6	27.3	3.67
1964	1,220	4,020	7,950	5	22.7	4.40
1965	3,680	4,270	8,450	4	18.2	5.50
1966	4,020	4,590	9,100	3	13.6	7.33
1967	2,000	5,250	10,500	2	9.1	11.00
1968	1,760	5,540	11,000	1	4.5	22.00

B. Hydraulic Analysis.

1. Eyak River

During flood flow, the elevation to which the lake level will raise is related to the quantity of flow of the outlet. Therefore, to determine if flood damage will occur in the Eyak Lake area during flood flow, it is necessary to compute the maximum quantity of flow in Eyak River at different lake levels.

As previously stated, little or no flood damage will occur if the lake level does not raise above elevation 21.20 feet. Thus, if the quantity of flow through Eyak River is greater than or equal to the estimated 100 year storm flow (16,000 cfs) while the lake level is at or below 21.20 feet, no flood damage will occur for this storm flow.

The maximum flow in a river per unit of specific energy head is limited by the slope, shape and roughness (n) of the river.

In order to obtain the flow in Eyak River for different water elevations of Eyak Lake, it is necessary to compute back-water curves for different quantities of flow in Eyak River. These back-water curves start from a point of control and proceed

upstream or downstream depending on the type of flow. For subcritical flow, the curve proceeds upstream from the point of control. Since the slope of Eyak River is mild, and the normal depth of flow is above the critical depth, the flow condition is subcritical. Therefore, the back-water curves will start from a point downstream from the lake outlet and proceed upstream.

The results of the back-water curves calculations are shown on Plate VI, page 29, and the calculations are shown on pages 30 through 35 .

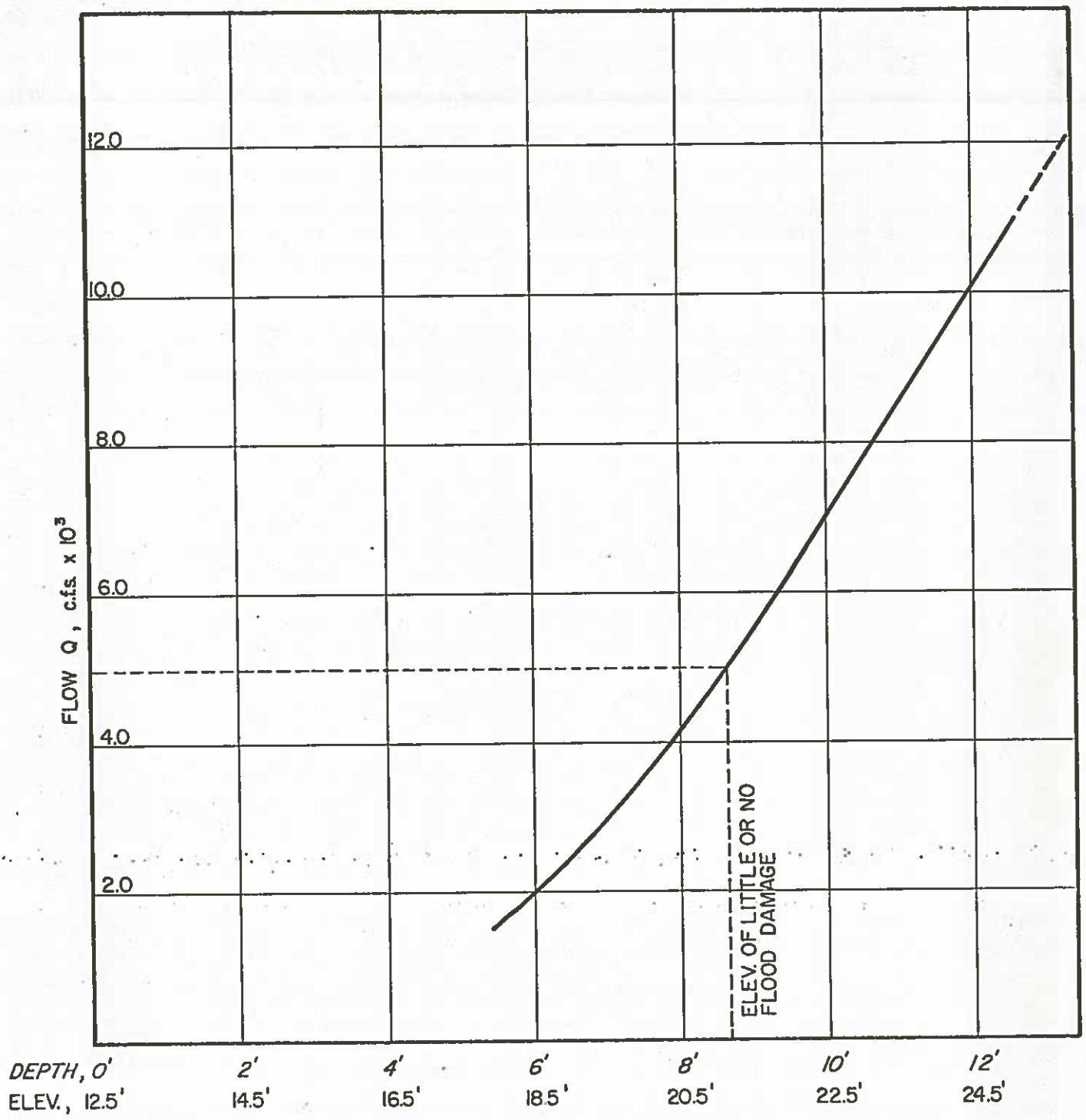
Plate VI shows that the quantity of flow in Eyak River, when the lake water level elevation is at 21.20 feet, is 5100 cfs. This flow is less than the estimated 20 year storm flow of 11,800 cfs. This means that under the present flow conditions of Eyak River, floods will occur in the Eyak Lake area during storm flood flow. The flood which occurred in September, 1949 substantiates this fact.

The lake water level for the 1949 flood, as per discussions with local residents, was two feet above the Cordova Aircraft Service runway. This is equivalent to the post-earthquake elevation of 25.80 feet. The storm that caused this flood was

a 22 year storm with an estimated flood flow of 12,200 cfs. The calculated Eyak River flow for the lake at this elevation is approximately 12,000 cfs. This indicates that the methods and assumptions used in the flow calculations for Eyak River per Eyak Lake Water Surface Elevation are within reason.

The mean higher high water level is 12.40 feet above mean lower low water (0.00 datum). The elevation of section 1 (see Plate I) is approximately 12.00 feet. Therefore, the flow in Eyak River will be less, due to the back-water effect, during high tide than at low tide.

The calculated flows for Eyak River were based upon the assumption that flow occurred at low tide. This assumption gives the maximum quantity of flow. Thus, since Eyak River cannot handle the flood flow during ideal conditions, it would only be academic, and serve no purpose for this report, to calculate the flow at different tide stages.



DEPTH OF WATER AT ENTRANCE OF OUTLET AND WATER SURFACE ELEVATION OF EYAK RIVER.

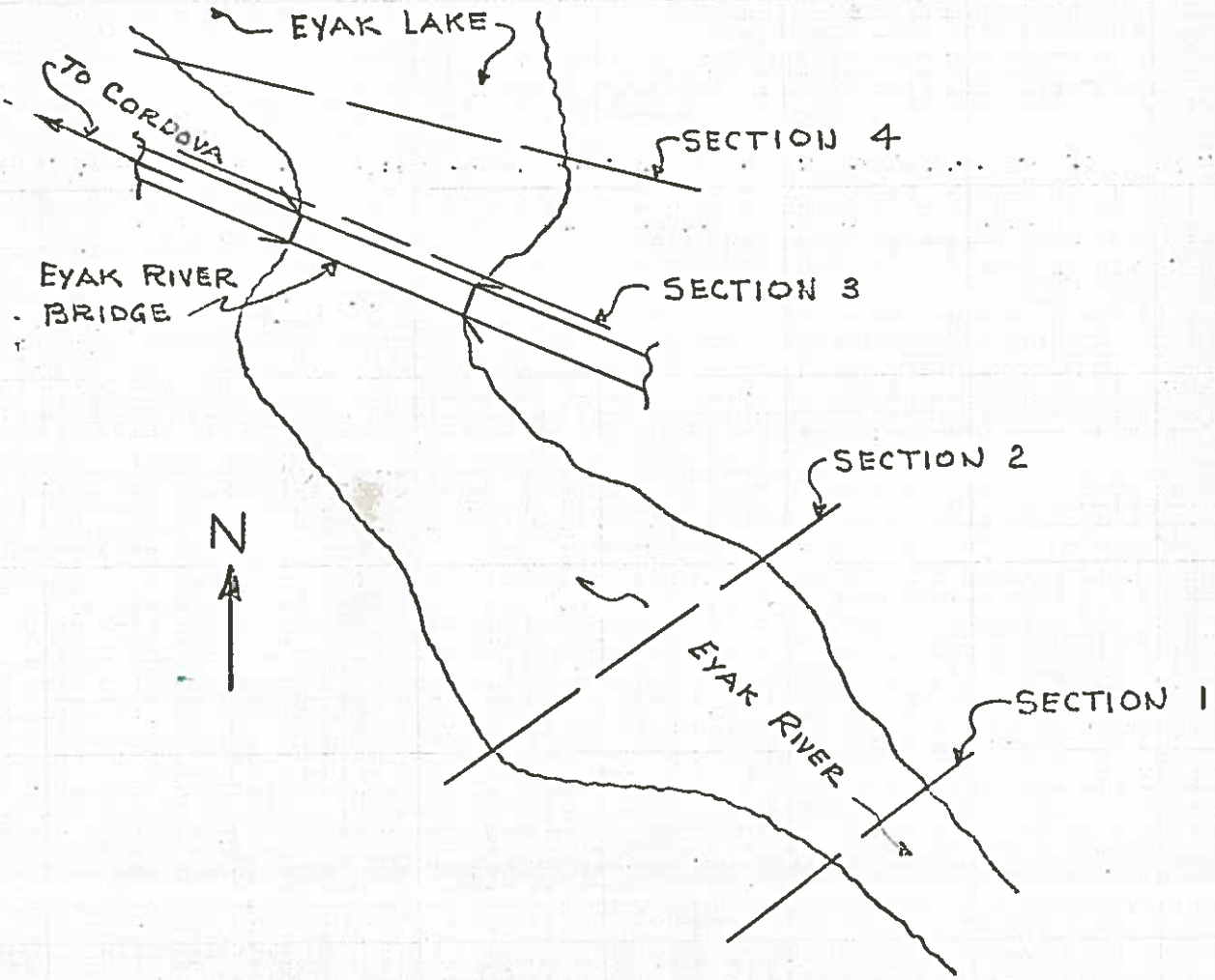
QUANTITY OF FLOW (c.f.s.) IN EYAK RIVER PER EYAK LAKE WATER SURFACE ELEVATION

PLATE VI

CALCULATIONS FOR THE QUANTITY OF FLOW (Q) IN EYAK RIVER PER EYAK LAKE WATER SURFACE ELEVATION

NOTE: THE FOLLOWING CALCULATIONS ARE BASED UPON THE ASSUMPTION THAT THE FLOW IS AT LOW TIDE

BELOW ARE THE CONTROL SECTIONS FOR COMPUTING THE FLOW. SEE PLATE 1 FOR LOCATION AND EXISTING GROUND ELEVATION FOR EACH SECTION



NORMAL DEPTH OF FLOW OF EYAK RIVER.

THE RELATIONSHIP BETWEEN THE NORMAL DEPTH OF FLOW AND THE AMOUNT OF DISCHARGE (C.F.S.) IS GIVEN BY THE FOLLOWING EQUATION:

$$AR^{2/3} = \frac{Qn}{1.486\ S^{1/2}} \quad \text{OR} \quad Q = \frac{AR^{2/3} \times 1.486 \times S^{1/2}}{n}$$

A = AREA OF FLOW, (SQ. FT.)
R = HYDRAULIC RADIUS (ft.)
Q = AMOUNT OF DISCHARGE (cfs.)
n = MANNING'S ROUGHNESS COEFFICIENT
S = SLOPE OF ENERGY GRADE LINE - IN THIS CASE, ONLY, IS EQUAL TO THE RIVER BOTTOM SLOPE

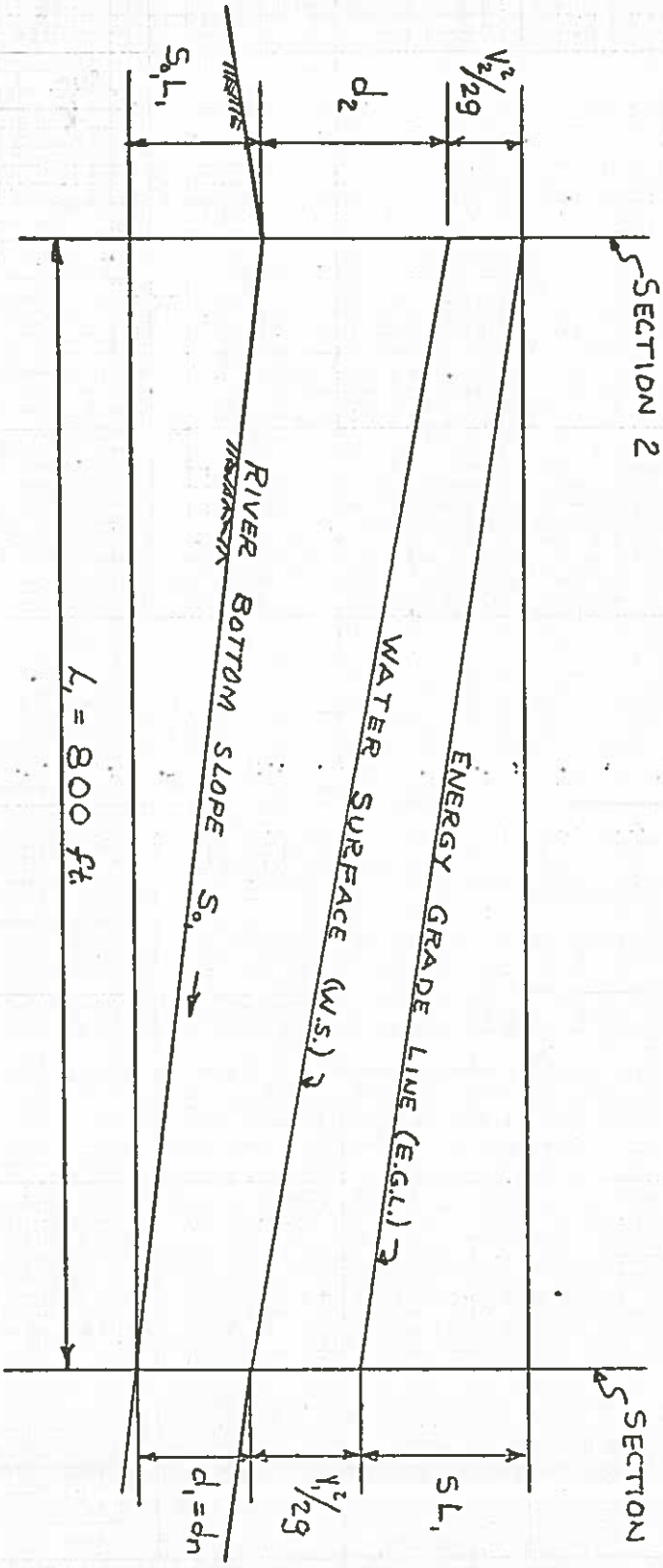
ASSUME:

$n = 0.035$ $\quad S_o = S = 0.0013$ $\quad S^{1/2} = 0.036$

FLOW AT LOW TIDE

d_1	A_1	R_1	$R_1^{2/3}$	$AR^{2/3}$	$\frac{1.486 \times S^{1/2}}{n}$	Q (cfs)	$V_1 = \frac{Q}{A}$
3	490	2.76	1.97	965	1.53	1,480	3.0
4	680	3.68	2.37	1610		2,460	3.6
5	870	4.50	2.74	2380		3,640	4.2
6	1050	5.25	3.02	3180		4,870	4.7
7	1250	6.02	3.31	4140		6,340	5.1
8	1440	6.67	3.54	5100		7,800	5.4
9	1630	7.28	3.74	6100		9,350	5.7
10	1820	7.83	3.94	7170	1.53	11,000	6.0

BACKWATER PROFILE BETWEEN SECTIONS 1 & 2



$$S_0L + d_2 + V_2^2/2g = d_1 + V_1^2/2g + SL_1$$

$$S = \frac{n^2 \times V_1^2}{2.21 \times R^{4/3}}$$

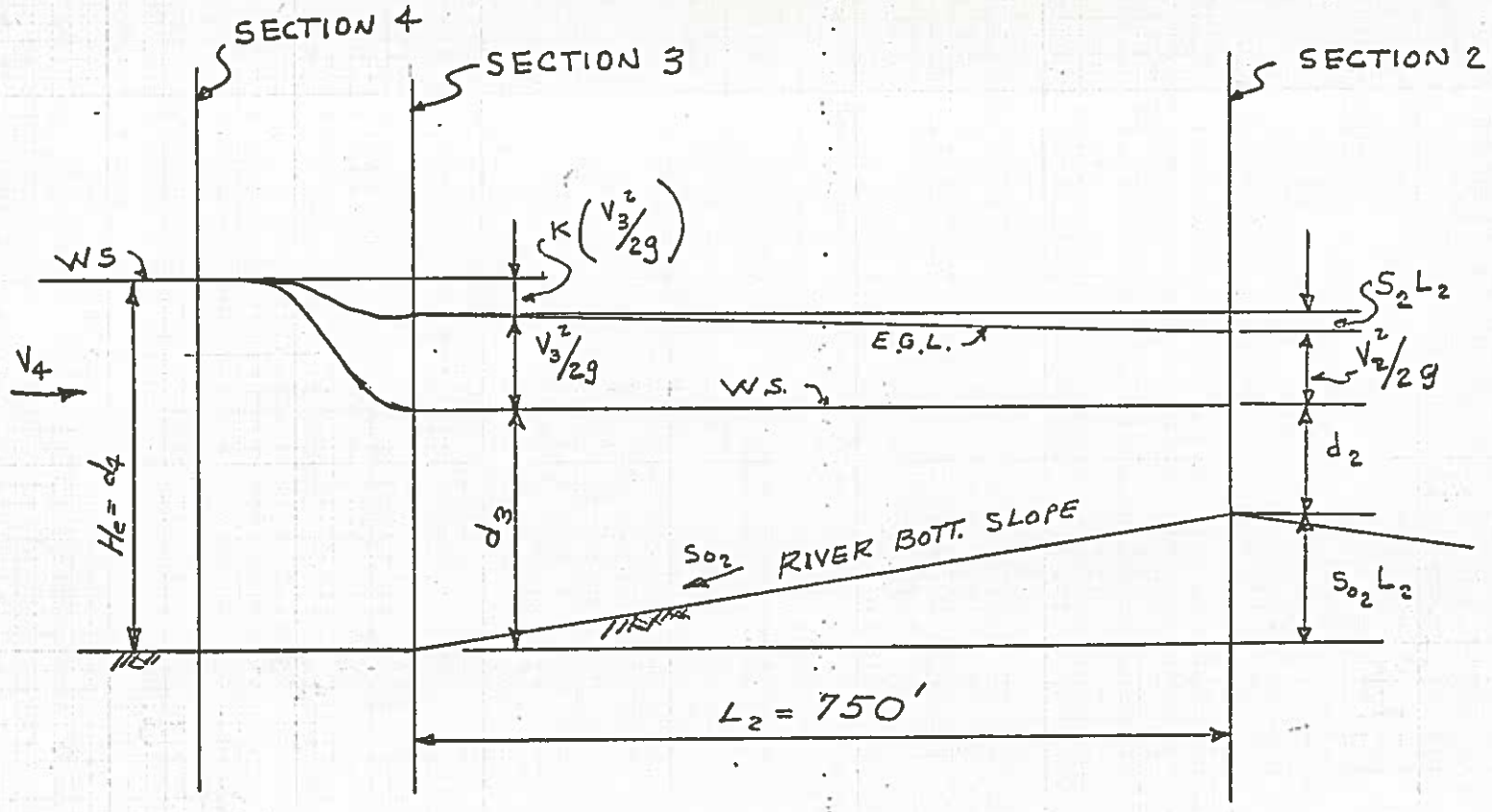
d_n = NORMAL DEPTH OF FLOW

$n = 0.035$ $\quad S_0 = 0.0013$

BACKWATE PROFILE BETWEEN SECTIONS 1 & 2 (CON'T.)

Q	d_1	V_1^2	$V_1^2/2g$	$R_1^{4/3}$	$\frac{n^2}{2.21}$	S	S_1L_1	$S_{o_1}L_1$	$d_1 + V_1^2/2g + S_1L_1 - S_{o_1}L_1$	d_2	A_2	$V_2 = \frac{Q}{A_2}$	$V_2^2/2g$	$d_2 + V_2^2/2g$
1,480	3.0	9.0	0.1	3.9	5.5×10^{-4}	0.0013	1.0	1.0	3.1	3.0	780	1.9	0.1	3.1
2,460	4.0	13.0	0.2	5.7		.0013	1.0		4.2	4.1	1220	2.0	0.1	4.2
3,640	5.0	17.6	0.3	7.5		.0013	1.0		5.3	5.2	1640	2.2	0.1	5.3
4,870	6.0	22.0	0.4	9.2		.0013	1.0		6.4	6.3	2080	2.3	0.1	6.4
6,340	7.0	26.0	0.4	11.0		.0013	1.0		7.4	7.3	2490	2.5	0.1	7.4
7,800	8.0	29.0	0.5	12.6		.0013	1.0		8.5	8.4	3020	2.6	0.1	8.5
9,350	9.0	32.5	0.5	14.2		.0013	1.0		9.5	9.4	3490	2.7	0.1	9.5
11,000	10.0	36.0	0.6	15.6	5.5×10^{-4}	.0013	1.0	1.0	10.6	10.5	4000	2.8	0.1	10.6

BACKWATER PROFILE BETWEEN SECTIONS 2, 3 & 4



$$d_3 + V_3^2/2g = d_2 + V_2^2/2g + S_{o_2} L_2 + S_2 L_2$$

$$d_4 = d_3 + V_3^2/2g + K\left(V_3^2/2g\right)$$ ASSUMING VELOCITY OF APPROACH $(V_4) = 0.0$

$K = 0.1$

$n = 0.035$ $\quad S_{o_2} = 0.0024$ $\quad S_2 = \dfrac{n^2 V_2^2}{2.21\, R_2^{4/3}}$

BACKWATER PROFILE BETWEEN SECTIONS 2, 3 & 4 (CON'T.)

Q	d_2	V_2^2	$V_2^2/2g$	R_2	$R_2^{4/3}$	S_2	S_2L_2	$S_{o_2}L_2$	$d_2+V_2^2/2g+S_2L_2+S_{o_2}L_2$	d_3	A_3	$V_3=Q/A_3$	$V_3^2/2g$	$d_3+V_3^2/2g$	$K(V_3^2/2g)$	$d_3+V_3^2/2g+K(V_3^2/2g)$	EL OF W.S.
1,480	3.6	3.6	0.1	2.1	2.7	.00073	0.5	1.8	5.4	5.4	1050	1.4	—	5.4	—	5.4	17.9
2,460	4.1	4.0	0.1	3.1	4.5	.0005	0.4		6.4	6.3	1240	2.0	0.1	6.4	—	6.4	18.9
3,640	5.2	4.9	0.1	3.8	5.9	.0005	0.4		7.5	7.4	1450	2.4	0.1	7.5	—	7.5	20.0
4,870	6.3	5.3	0.1	4.6	7.7	.0004	0.3		8.5	8.4	1650	3.0	0.1	8.5	—	8.5	21.0
6,340	7.3	6.3	0.1	5.3	9.3	.0004	0.3		9.5	9.4	1850	3.5	0.1	9.5	—	9.5	22.0
7,800	8.4	6.8	0.1	6.3	11.6	.0003	0.2		10.5	10.3	2030	3.8	0.2	10.5	—	10.5	23.0
9,350	9.4	7.3	0.1	7.0	13.4	.0003	0.2		11.5	11.2	2210	4.2	0.3	11.5	—	11.5	24.0
11,000	10.5	8.1	0.1	7.8	15.4	.0003	0.2	1.8	12.6	12.3	2430	4.5	0.3	12.6	—	12.6	25.1

2. Weir

Since the minimum flow into Eyak Lake is approximately 26 cfs, it can be seen that the water head to produce this flow over the Fabridam and concrete weir is negligible. Therefore, the crest elevation for both the Fabridam and concrete weir were set at elevation 17.50 feet.

The Fabridam will start to deflate when the water head above the dam is 3.70 feet. Also, the dam will have little effect on the quantity of flow in the river in its flat state. Therefore, it is not necessary to compute the quantity of flow over the dam for different heads.

The location of the Fabridam does not have an adverse effect on the velocity through the Eyak Bridge opening for the following reasons:

a. When the Fabridam is in the inflated state, the velocity through the Bridge opening will be the same as the present velocity for a given quantity of flow.

b. Since the Fabridam deflates gradually as the water head over the dam increases, the velocity through the Bridge opening will not be greater than the present velocity for the same quantity of flow.

c. When the Fabridam is in the deflated state, the flow characteristics of the Eyak River are essentially the same as the present flow conditions.

VII. BUDGET COST ESTIMATE

Below is the estimated budget cost, excluding the engineering design cost, for the Fabridam Water Gate.

Item of Work	Estimated Cost
Earthwork	$ 5,000
Concrete Work	40,000
Sheet Pile	28,000
Erosion Control	15,000
Fabridam (excluding Fdn.)	125,000
Diversion (Dike & Dewatering)	17,000
TOTAL DIRECT COST:	$ 230,000
Contractor's Profit & Overhead - 27%	63,000
Estimated Construction Cost	$ 293,000
Contingency - 10%	30,000
	$ 323,000
Supervision, Inspection & Overhead-7%	23,000
* TOTAL ESTIMATED BUDGET COST:	$ 346,000

* NOTE: The total estimated budget cost does not include the engineering design cost.