16

DEPARTMENT OF LANDS AND FORESTS

WATER RIGHTS BRANCH

GLOUETTE LAKE FLOODING

January 1961.

April 1961

T. M. Oxland,
Hydraulic Engineer.

VICTORIA, B. C.

May 9th, 1961

File No. 045208

Mr. A. F. Paget,
Comptroller of Water Rights,
Parliament Buildings,
Victoria

Dear Sir:

The enclosed report entitled "Alouette Lake Flooding January 1961" was prepared by Mr. T. H. Oxland, Hydraulic Engineer.

From the general information available it appears that the main (south) Alouette River in its lower stretches reached its peak about 7 PM on January 15, 1961.

The actual conditions upstream at the Alouette dam (reference plate VIII) show that the discharge occurring between 2 PM and 8 PM exceeded computed natural outflow conditions by between 500 and 1000 c.f.s. This amounts to between 4% and 8% of the outflow which is probably within the limits of the computing error. It would appear that allowing for a time lag in the 10 miles of intervening river that at least a portion of the upstream peak did coincide with maximum high water conditions to the south.

However, on a daily volume basis for January 15 this condition is reversed with the regulation discharge falling below the natural.

High tide itself does not appear to be too critical as it was reached about 3:30 PM and this would be well modified by 7 PM.

Rainfall figures as recorded at the Alouette dam for 24-hour periods between 8 AM and 8 AM show that the storm was practically over by the morning of January 15.

Jan. 9, 1961	1.32 inches	Jan. 14, 1961	3.06 inches
10, 1961	2.47 inches	15, 1961	1.36 inches
11, 1961	0.67 inches	16, 1961	0.21 inches
12, 1961	0.35 inches	17, 1961	0.05 inches
13, 1961	1.64 inches		

During the critical period some 1200 c.f.s. were diverted through the power tunnel to Stave Lake.

The company's operation therefore as a hydro power licensee was such that it was not possible while carrying the authorized storage to obtain reduced discharges over that which would have occurred under natural regulation for the period from 2 PM to 8 PM on January 15, 1961.

On the other hand with the power diversion to Stave Lake the volume discharge for the critical 24-hour period was reduced over natural conditions.

It is not possible to indicate the net effect of the above-mentioned two opposing factors on downstream flow other than to say that the peak discharge was probably increased by between 500 and 1000 c.f.s. while the maximum 24-hour volume flow was reduced by some 500 c.f.s. days.

Yours very truly,

T. A. J. Leach
Chief, Hydraulic Investigation Division

S Y N O P S I S

The average 2 hourly inflow for the 24-hour period ending at midnight January 15, 1961, on the Alouette River at Alouette dam amounting to 17135 cfs was the second highest ever recorded and has only been exceeded by the November 3, 1955 inflow of some 19335 cfs.

The maximum 24 hour period inflow occurred, however, between 1800 hours on January 14 to 15, 1961, when the average 2 hourly inflow amounted to 19527 cfs (Reference Table 5).

The maximum 24-hour discharge through the spillway and over the gates started one-half a day later when an average of 10,948 cfs were released between 0600 hrs on January 15 and 16, 1961 (Reference Plate VIII).

During these periods the maximum 2-hour inflow rate of 22,217 cfs (280 cfs per square mile of drainage area) occurred between 0200 hours and 0400 hours on January 15, 1961 while the maximum 2-hour outflow rate of 13505 cfs took place 12 hours later. Details of these conditions may be seen in the accompanying tables.

A comparison of the outflows which would have occurred under natural conditions without the existence of the dam indicate the following results:

1. The maximum 2 hour discharge over the dam was 13505 cfs which is some 1,105 cfs greater than the maximum 2-hour natural discharge of 12,400 cfs.

2. The maximum 24 hour discharge (0600 hours - January 15 to 16, 1961) based on the average of 12-2 hour measurements was 10,948 cfs some 452 cfs less than the daily discharge of 11,400 cfs computed under natural conditions.

3. The natural peak discharge would have occurred 2 hours after the peak over the dam.

4. The actual peak volume of discharge above 6000 cfs which started at 0400 hours on January 15, 1961, and dropped below this volume some 30 hours later amounted to 123,134 c.f.s. - 2 hours or 10,261 cfs-days. Under natural conditions a volume of 16,156 cfs-days above 6000 cfs would have occurred between 0 00 hr on January 15 to 0600 hrs on January 17.

5. The total volume passing over the spillway from January 14 to January 19, 1961, was 35,224 acre feet compared to a natural flood volume of 58,660 acre-feet for the same time.

Conclusions:

The presence of the dam reduces the flood volume and duration to a considerable extent and the only adverse effect is to sharpen the peak discharge over the spillway for a short period.

MAXIMUM 24 HR PERIOD DISCHARGE USED ON 2 MODEL

MEASUREMENTS OBSTRUCTED FROM TABLE VI

Date 1961	Time Hr.	Over Spillway cfs-2 hr	Over Gates cfs-2 hr	Total Spill cfs-2 hr	Inflow cfs - 2hr
Jan.15	0600				
		7475	320	7795	18,871
	0800				
		8950	477	9427	20,526
	1000				
		10250	625	10875	19,499
	1200				
		11200	740	11940	16,613
	1400				
		12000	835	12835	19,714
	1600				
Maximum 24 hr		12600	905	13505	17,397
	1800				
		12400	880	13280	10,206
	2000				
		11600	785	12385	9,312
	2200				
		10650	670	11320	5,472
Jan.16	2400				
		9700	560	10260	7,143
	0200				
		8900	475	9375	6,218
	0400				
		8000	375	8375	2,733
	0600				
		123,725	7647	131,372	
			24 hr. Aver.	10,948	

MAXIMUM 24 HR PERIOD INFLOW
BASED ON 2 HOURLY READINGS
ABSTRACT FROM TABLE VI

DATE	TIME HR	INFLOW CFS-2 HR	REMARKS
14 Jan.	1800		
		17927	
	2000		
		17644	
	2200		
		18330	
15 Jan.	2400		
		21814	
	0200		
		22217	Maximum Inflow
	0400		
		21077	
	0600		
		18871	
	0800		
		20526	
	1000		
		19499	
	1200		
		18813	
	1400		
		19714	
	1600		
		17897	Period of Maximum Spillway Discharge 13505 cfs
	1800		
	24 hr.Av.	19527	

DEPARTMENT OF LANDS AND FORESTS
BRITISH COLUMBIA
HONOURABLE R. G. WILLISTON, MINISTER
E. W. BASSETT, DEPUTY MINISTER OF LANDS G. S. ANDREWS, DIRECTOR OF SURVEYS AND MAPPING

6

FIRST EDITION — January 6th, 195

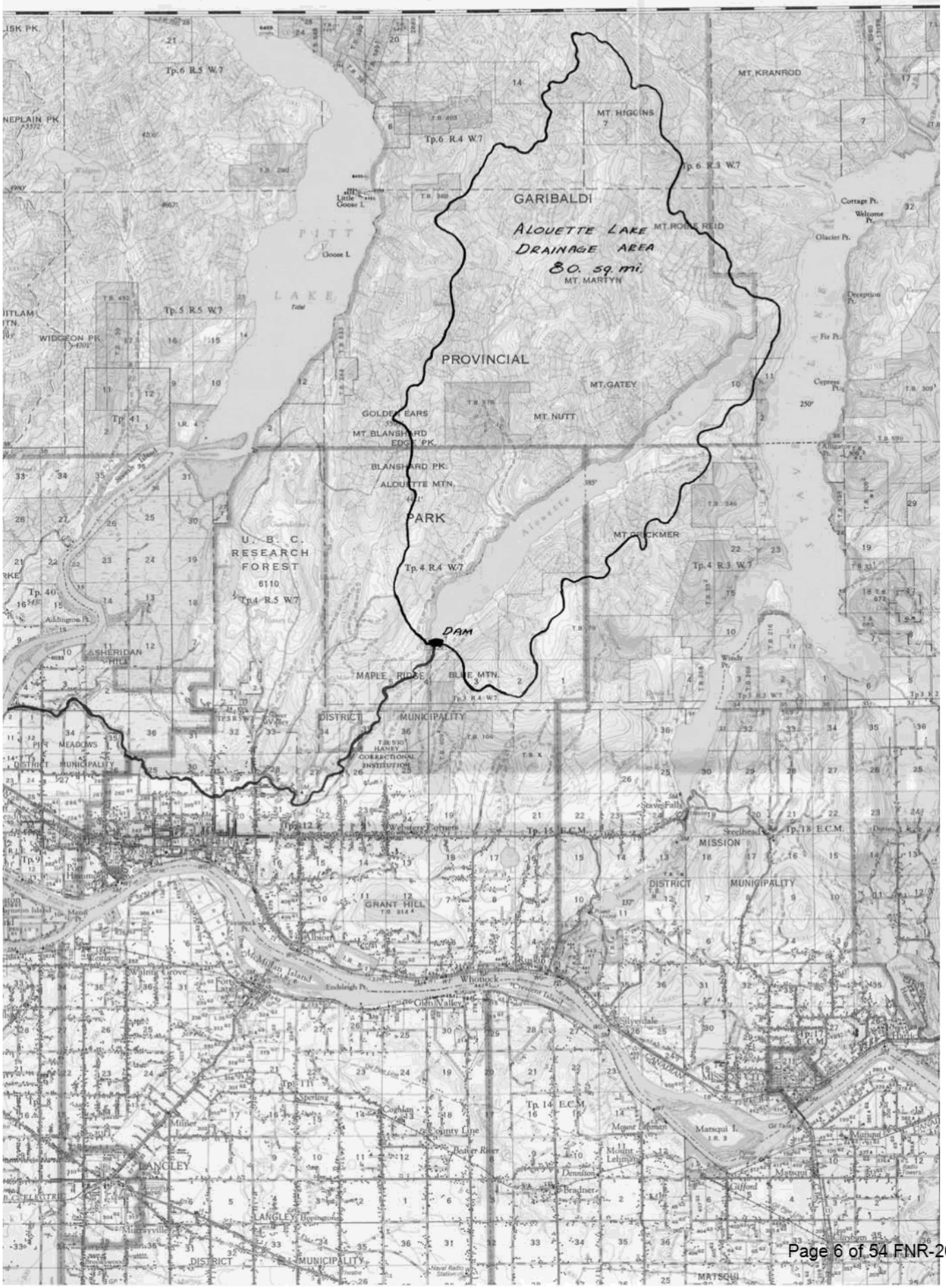


TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES (APPENDIX)

- - - -

ALOUETTE LAKE FLOODING

INTRODUCTION

Heavy rainfall occurring over the lower Fraser valley from the period December 1, 1960 to January 30, 1961, caused flooding on several of the tributaries flowing into the Fraser River from the north. This study deals with the investigation of the flow out of Alouette Lake watershed with particular reference to the high flow conditions between January 10, 1961 and January 17, 1961.

Hydrometric data are not available on any section of the river below the Alouette Dam hence results of this study refer only to flows at the damsite. No attempt is made to indicate the influence of these flows on the inhabited areas on the south Alouette River downstream of the dam.

Previous studies of high flows from this watershed have been carried out for the periods of February 1951, November 1955 and December 1957 to January 1958. These investigations reached the conclusion that flood flows from the Alouette Lake watershed have been reduced by operation of the Alouette Dam and that greater floods would have occurred naturally if the dam had not been there.

The report of February 1951 does emphasize, however, that in cases of continuous high flows the presence of the dam would be detrimental in increasing the outflow substantially over natural conditions.

HISTORICAL

Alouette Lake was originally comprised of two lakes, an Upper Lake and a Lower Lake. The lakes were joined by a channel, 25 ft. wide, 1000 ft. long, with bottom elevation approximately 437 Ruskin datum. These two lakes drained through the south end of the Lower Lake through a channel with bottom elevation approximately 430 Ruskin Datum.

Two schemes were proposed for the Alouette Lake development, the first in 1917 used datum base as mean sea level; the second in 1925 used the Ruskin Development datum.★

Since the operating level presently used at the Alouette dam is based on the Ruskin datum, all elevations in the following report are referred to it.

Drawings and plans referred to in the text are presently stored at the Alouette Damsite, no copies are available for attachment to this report.

For a description of the ultimate development of the Alouette Lake system the reader is referred to the report by Mr. T.A.J. Leach, January 1955 "Alouette Lake Storage Dam".

HYDROLOGY

Pertinent hydrologic information such as the natural stage/discharge and stage/area relationships are no longer available from the power company. Because of this two assumptions are necessary to formulate these basic relationships. They are:

1. The stage/discharge curve produced in 1923 refers to lake stage versus outflow from the natural lake with zero flow at Elevation 430 and;

★ Note: Ruskin Datum - 69.98 = Geodetic Datum. This is based on Geodetic Bench Mark 180J Quoted in Geodetic Survey of Canada Publication 24 (1951) at elevation 27.488.

2. the stage/area curve produced in the following text is accepted as the natural lake level/water surface area relationship existing prior to the construction of the dam in 1925.

Assumption 1.

The stage/discharge relationship, Plate IA and IB, submitted by the consulting engineer to the power company in December 1923, refers to lake stage versus discharge under natural conditions. Since construction plans indicate that the lower lake bottom at the gauge site was approximately elevation 430 (Ruskin datum) it has also been assumed that zero outflow from the lake occurs at stage elevation 430.

This first assumption is unavoidable since there is insufficient data available now to relate natural discharges to lake stage if the only stage discharge curve now available referred to a control section in the river.

Examination of old correspondence, photographs and construction plans indicate the following arguments in favour of this first assumption:

(a) Very little bed slope - if any at all - existed between the lower full width part of the lake and the gauge site. Under normal lake level conditions the surface of the water from the lake to the gauge was smooth and apparently still.

(b) The dry outlet channel shown on pictures taken during construction of the dam also indicates no elevated control existed between the lower part of the lake and the upstream toe of the dam. The diversion of the river during construction appears to have been affected by a 3 ft. diameter culvert which runs underneath the deepest part of the dam. The invert of the inlet structure upstream of the cofferdam is approximately 432.0 (Dwg. P 8826). It is possible this invert would be 1 or 2 higher than the natural channel bottom to allow for accumulation of debris in front of the intake.

(c) No evidence of a natural control having been removed during construction. This was not called for on any of the plans. Old photographs indicate that trees and brush grew down to the waters edge at the outlet of the lake. During low water in 1929 (?) the present dam operator recalls that the tops on small trees and brush appeared above low water outline the course of the original channel and that shallow water existed to more or less same depth from the 3 ft. diameter culvert inlet to the lake proper.

Assumption 2.

The stage capacity relationship for the present reservoir is tabulated on one of the construction drawings No. 5843 (see Plate II). The elevation for zero storage is shown at elevation 437 (Ruskin datum). This elevation cannot represent the level of zero natural storage in the light of arguments presented under the first assumption. From the information and drawings available the elevation 437 is the level of control of flow from Upper to Lower Lake under natural conditions and also approximates the minimum operating head on the intake for the tunnel to Stave Lake.

In order to produce a stage area curve for the combined upper and lower lakes it is necessary to combine the information given on Dwg. No. 15638 and Dwg. No.P18102. (Refer to Table I).

Drawing No. P18102 and No. 15638

From the capacity curve for Alouette Lake it is possible to show storage in acre-feet below 433.4, this being the limit of drawdown

from the lower lake through the trestle channel as shown on Dwg. No. W6841.

Upper Lake Area Only

TABLE I

Dwg.No.	Stage	Storage 10⁶ c.f.	Storage Increment	Storage Acre-Feet	Average Area	Estimated Area
216103	429	0				809
			2.0	4592	918	
	430	2				1013
			1.5	3444	1013	
	430.4	3.5				1017
15633	440.2					1092
Unknown	470.2					1182
15633	480.2					1216
Unknown	490.2					1250

The area of the Upper Lake is plotted on Plate III. From the same drawings it is possible to list the following areas for the Lower Lake.

Lower Lake Area Only

TABLE II

Stage	Area
440.2	2436
470.2	2729
480.2	2804
490.2	2896

These are also plotted on Plate III .

From drawing No.6843 the area of the combined lakes is given and plotted on Plate III.

Area of Upper & Lower Lakes

TABLE III

Stage	Area
437	3370
441	3485
450	3649
460	3808
470	3933
480	4045
482	4066

Although the areas shown on Dwg. No. 6843 do not exactly agree with the sum of the areas on Dwg. No. 15633 and 216103, they can be used together to estimate the areas of both lakes below 440. This has been done on Plate III and the area for natural conditions shown in purple.

On plan W6841 it is shown that when the Upper Lake is 440 the Lower Lake is 438.2 It has been assumed that the lakes reach the same level at 441. The area of the combined natural lake that will affect the natural storage capacity must be estimated below 441 by combining the individual lake areas for different lake levels. This combination is arbitrary and is shown on Plate III as a, b, c, and d.

A stage-capacity curve can now be drawn for the lakes under natural conditions:-

Stage/capacity under natural conditions prepared from following table:-

TABLE IV

Stage Feet	Area Acres	Average Area Acres	Capacity Acre-Feet
430	2660		0
		2805 x 2	
432	2950		5610
		3135 x 2	
434	3320		11980
		3345 x 2	
436	3370		18570
		3427 x 2	
438	3485		25424
		3492 x 2	
440	3500		32408
		3502 x 2	
442	3505		39412
		3587 x 2	
450	3670		68108
		3705 x 5	
455	3740		86633
		3775 x 5	
460	3810		105503
		3840 x 5	
465	3870		124708
		3900 x 5	
470	3930		144208
		3960 x 5	
475	3990		164003
		4015 x 5	
480	4040		184083
		4055 x 2	
482	4070		192193

FLOOD ROUTING PROCEDURE

Step I

All available hydrometric data covering December 1960 and January 1961 was requested and received from the [illegible] Electric Company. This included: -

(a) Daily to hourly reservoir levels.
(b) Rate water was diverted for power.
(c) Ratewater was diverted into Stave lake.
(d) Ratewater was spilled over spillway and gates.
(e) Record of gate operation.
(f) Rainfall records (daily).

The discharge curve for the dam spillway and for overtopping of spillway gates are shown on Plate VA and VB.

The data collected was tabulated in two ways:-

1. On a daily basis - midnight to midnight each day and,
2. On a 2-hourly basis for the period Jan.14/61 to Jan.19/61.

The inflow was calaculated in both cases from the storage equation that:-

Inflow = Outflow + Power use + Diversion ± Change in Storage.

The stage-area curve for the reservoir used in the inflow calculations is shown on Plate II.

Step II

With calculated inflow, the natural stage-discharge curve, and the natural stage capacity curve it is now possible to develop routing curves so that the outflow under natural condition, prior to construction of the dam, can be computed. See Table V and VI.

The storage equation: $\bar{I} - \bar{O} = \Delta \frac{S}{t}$ where

$\bar{I}$ is average inflow over time t

$\bar{O}$ is average outflow over time t

ΔS is change in storage over time t is used in the form:

$$\frac{(I_1 + I_2)}{2} t - \frac{(O_1 + O_2)}{2} t = S_2 - S_1$$

or

$$I + \frac{(S_1 - O_1)}{t \quad 2} = \frac{(S_2 + O_2}{t \quad 2} \qquad 1.$$

Routing curves of $\frac{S}{t} + \frac{O}{2}$ are plotted against stage.

Two sets of curves are produced, one for flows calculated on a daily basis and one for 2-hr. flows.

Daily Flows:

TABLE VII

Lake Level	O-from Stage/Q Curve	$\frac{O}{2}$	S-from Stage/ capacity Curve	SY 1 5042 $= \frac{S}{t}$	$\frac{S}{t} + \frac{O}{2}$	$\frac{S}{t} - \frac{O}{2}$
	cfs-days	cfs-days	acre-ft.	cfs-days	cfs-days	cfs-days
430	0	0	0	0	0	0
431	100	50	2600	1412	1462	1362
432	300	150	5610	2829	2979	2679
433	650	325	8750	4412	4737	4087
434	1200	600	11880	5990	6590	5390
435	1950	975	15250	7689	8664	6714
436	2850	1425	18570	9363	10788	7938
437	3900	1950	22050	11118	13068	9168
438	5250	2625	25420	12817	15442	10192
439	6750	3375	28900	14571	17946	11196
440	8200	4100	32410	16341	20441	12241
441	9800	4900	35900	18101	23001	13201
442	11200	5600	39410	19870	25470	14270
443	12700	6350	43050	21709	28059	15359
444	14150	7075	46600	23496	30571	16421
445	15700	7850	50200	25311	33161	17461
446	17200	8600	53800	27126	35726	18526
447	18700	9350	57800	28941	38291	19591
448	20200	10100	60900	30706	40806	20606
449	21800	10900	64500	32521	43421	21621
450	23300	11650	68110	34341	45991	22691

Two Hour Flows:

TABLE VIII

Lake Level	O-from Stage/Q Curve cfs/2 hr	$\frac{O}{2}$ cfs/2 hr	S-from Stage/Cap. Curve acre-ft.	$\frac{2S}{t}$ = S cfs/2 hr	$\frac{S}{t} + \frac{O}{2}$ cfs/2 hr	$\frac{S}{t} - \frac{O}{2}$ cfs/2 hr
430	0	0	0	0	0	0
431	100	50	2860	16940	16990	16890
432	300	150	5610	33940	34090	33790
433	650	325	8750	52937	53262	52612
434	1200	600	11880	71874	72474	71274
435	1950	975	15250	92262	93237	91287
436	2850	1425	18570	112348	113773	110923
437	3900	1950	22050	133402	135352	131452
438	5250	2625	25920	153791	156416	151166
439	6750	3375	28900	174845	178220	171470
440	8200	4100	32410	196080	200180	191980
441	9800	4900	35900	217195	222095	212295
442	11200	5600	39410	238430	244030	232830
443	12700	6350	43050	260452	266802	254102
444	14150	7075	46600	281930	289005	274855
445	15700	7850	50200	303710	311560	295860
446	17200	8600	53800	325490	334090	316890
447	18700	9350	57400	347270	356620	337920
448	20200	10100	60900	368445	378545	358345
449	21800	10900	64500	390225	401125	379325
450	23300	11650	68110	412065	423715	400415

See Plate VI and VII (A to E) for plotted routing curves.

Step III

The outflow under natural conditions is now calculated using the routing curves developed. The results of the daily and 2-hourly routings are shown on Table X and XI. These results are also shown graphically on Plate VIII and IX.

RESULTS

The two-hour flow study

From the results of the routing of this flood the following conclusions can be made:

1. Considering the 2-hr. hydrograph the actual flood volume was less than the natural flood volume even after allowing for a natural base flow of 2000 cfs.

For the period of 20:00 hrs on January 14, 1961 to 8:00 hrs on January 19, 1961 the actual flood was 35224 acre feet as compared to a natural flood of 40797 acre feet. This is a decrease of 5573 acre feet or 13.7% of the flood volume that would have occurred had there been no dam.

If we compare the total volume passing out of the lake under both conditions we find the natural flood is 58,600 acre feet compared to 35,224 acre feet or some 66.5% greater than the actual volume.

Under this comparison the dam is most beneficial.

2. Again from the 2-hr. hydrograph the peak rate of flow for a 2-hr period for actual conditions is 13,505 cfs which exceed the similar peak flow under natural conditions of 12,600 cfs by some 1105 cfs or 8.9% of the natural rate.

This indicates that the artificial spillway is more efficient than the natural lake outlet and, as was pointed out in the report for February 1951, that under prolonged high water conditions the presence of the dam would increase the outflow substantially over that which would occur without the dam. The effect of the spillway for more prolonged floods would be to sharpen the peak flow of the river downstream rather than flatten it as would be expected when part of the flood is impounded. Unfortunately the capacity of the reservoir together with maintaining the reservoir levels for efficient operation of plant are not compatible with flood control requirements.

3. The duration of this flood is considerably reduced through the combination of availability of storage, efficient spillway and diversion of water to Stave Lake. The following table compares the length of flow for floods greater than 2000 cfs.

TABLE IX

Floods greater than cfs 2hr flow	Duration with Dam - hrs	Duration without Dam - hrs
2000	54	132
3000	46	90
4000	38	74
5000	34	66
6000	30	54
7000	26	46
8000	22	38
9000	20	30
10000	16	24
11000	12	16
12000	8	6
13000	4	0

From examination of results of the 2-hr period flow study the presence of the dam was beneficial in routing this particular flood through the system.

The daily flow study

The daily study gives somewhat different results than the two hour study. Here the dam reduces the flood by 32,500 acre feet or some 50.1 % of the natural flood (65500 acre-feet) that would have occurred. This is compared with the 33.5% reduction of the natural flood (53,400 acre-feet) calculated from the 2-hr study.

The results of the daily study should give preference to the results from the 2-hr study since using midnight to midnight levels for calculations of actual inflows does not include the effect of the peak of the flood. The peak occurred between 1600 and 1800 hours on January 15,1951.

Since floods on this particular watershed indicate short duration - high flow characteristics it is not recommended that any time period greater than 6 hours be used for a flood study.

February 2, 1961

Mr. T....J. Leach,
Chief,
Hydraulic Investigation Division,
Water Rights Branch,
Department of Lands and Forests,
Victoria, B.C.

Winter Flood Conditions
Your Files 0213069
0297956K

Dear Mr. Leach:

In response to your letter of January 25, 1961 and further to my acknowledgment of January 27, herewith please find data as follows:

...louette Dam, Precipitation, December 1960-January 1961
...louette Lake, Outflow in cfs., ditto (3 sheets)
Coquitlam Dam, Precipitation, ditto
Buntzen Dam, Precipitation, ditto
Coquitlam Lake, Outflow in cfs., ditto, (2 sheets)
Buntzen Lake, Outflow in cfs., ditto (2 sheets)
Coquitlam-Buntzen Tunnel, Operating Record, ditto (2 sheets)
Coquitlam-Buntzen Tunnel Gates, Rating Curve
Coquitlam Dam, Overflow Weir, Rating Curve
Coquitlam Dam, Undersluice Gates, Rating Curve
Buntzen Dam, Crest Gates, Rating Curve
Coquitlam Lake Storage Curve
Buntzen Lake, Storage Curve

The ...louette data is listed along similar lines to that supplied five years ago after the flood of November 1955. One new item is shown, the overpour above crest gates whose top in the closed position is at Elev. 484. We had overlooked this in the 1955-56 correspondence. ...s may be

COPY

seen, it adds appreciably to the down-river flow at the flood peak. We should revise upward the 1955 figures on Alouette spill, supplied with our letter of December 22, 1955 (your file No. 045208 #2) by addition of this overpour during the period when the crest gates were closed. This would change the total overpour for November 3, 1955 from 9,755 to 9,980 cusecs, and for November 5, 1955 from 9,903 to 10,740 cusecs.

The Coquitlam Lake data should be self-explanatory, with the possible exception of the Tunnel Operating Record. The tunnel has two gate settings in tandem at the intake, none at the outlet. The upstream control is a single ~~10~~-ft. sliding disc gate. About forty feet downstream is a pair of 5'-0" x 10'-0" roller gates, described as North and South gates. One gate at high lake level will almost but not quite keep the tunnel full.

9 ft. Fal.

Our Lake Buntzen generating units are only partially effective this winter. We had the misfortune to damage the shaft of the large machine at the rebuilt No. 1 Plant, and will not have the unit back in service until late spring. Fortunately we have been able to meet our winter peak loads without it, but it has hampered our ability to utilize the Coquitlam-Buntzen water. Following this unexpected outage we had to find staff for the older, manually-operated No. 2 Plant, building up from a one-shift five-day week to a two-shift seven-day week, which took a little time just ahead of the festive season. Since then, we have twice had coil trouble and shutdown of one or another of the old machines, one occurring on January 15th at the peak of the flood and the other a week later, with repair not yet completed at the month-end.

I hope the enclosed data will fill your present needs. The presentation is not too elegant, but we seem to be a bit short-staffed at the moment and I assume you would like to have a fairly prompt account. If you would like us to amplify or add to it in any way, please advise.

Yours truly,

F. A. Lazenby

F.A. Lazenby,
Assistant Chief Engineer (Executive)

Encls.

L/r

cc: Mr. Leach

Form 91915

BRITISH COLUMBIA ELECTRIC COMPANY LIMITED

COPY

February 10, 1961

Mr. T. ..J. Leach,
Chief,
Hydraulic Investigation Division,
Water Rights Branch,
Department of Lands and Forests
Victoria, B.C.

Winter Flood Conditions
Your Files 0213069
0297956K

Dear Mr. Leach:

In checking through the figures sent with our letter of February 2, we have made a couple of small corrections. These are embodied in the enclosed re-typed sheets as follows:

Coquitlam Lake, Outflow, December-January (2 sheets)
Buntzen Lake, Outflow, December-January (2 sheets)
Alouette Lake, Outflow, January only, 2 sheets

.. set of these is enclosed. Would you please substitute.

Yours truly,

F.... Lazenby,
Assistant Chief Engineer (Executive)

Encls.

L/r

cc: Mr. Leach

ALOUETTE PRECIPITATION

December 1960		January 1961	
1.	.16	1.	-
2.	.37	2.	-
3.	.02	3.	.53
4.	-	4.	2.01
5.	-	5.	.73
6.	-	6.	.05
7.	-	7.	.34
8.	-	8.	1.98
9.	-	9.	1.32
10.	.29	10.	2.47
11.	2.44	11.	.67
12.	.76	12.	.35
13.	1.22	13.	1.64
14.	-	14.	3.06
15.	-	15.	1.36
16.	.16	16.	.21
17.	.45	17.	.05
18.	1.51	18.	-
19.	.11	19.	-
20.	-	20.	-
21.	-	21.	-
22.	-	22.	-
23.	.32	23.	-
24.	.39	24.	-
25.	.01	25.	-
26.	-	26.	-
27.	-	27.	-
28.	-	28.	.18
29.	.13	29.	1.21
30.	.45	30.	.31
31.	.34		
December total	9.13	January 1-30 total	18.47

NOTES:- 1. Inches of rain at Alouette Dam.
2. 0.5 inches of snow fell on Dec. 30, and again Jan. 28. Both these amounts are included (at one-tenth) in the precipitation figures as listed above.

ALOUETTE LAKE: OUTFLOW IN C.F.S., DECEMBER 1960

		Hour	Lake Level	Diversion to Stave Lake: Turbine Draft	Diversion to Stave Lake: Adit Bypass	Diversion to Stave Lake: Total to Stave	Discharge Down Alouette River: Over Weir	Discharge Down Alouette River: Overtopped Gates	Discharge Down Alouette River: Total
					See Note				
Dec.	1	08:00	480.4	950		950			
1960	2		480.8	950		950			
	3		480.8	930		930			
	4		480.8	950		950			
	5		480.7	930		930			
	6		480.4	930		930			
	7		480.1	940		940			
	8		479.8	850	230*	1080			
	9		479.3	790	480	1270			
	10		478.8	790	480	1270			
	11		478.2	790	480	1270			
	12		478.9	790	480	1270			
	13		480.9	720	700*	1420			
	14		482.0	660	880	1540			
	15		481.7	650	880	1530			
	16		481.2	660	880	1540			
	17		480.5	660	870	1530	NIL	NIL	NIL
	18		479.9	660	870	1530			
	19		480.5	660	870	1530			
	20		480.4	670	870	1540			
	21		479.9	540	870	1410			
	22		479.4	670	860	1530			
	23		478.8	670	860	1530			
	24		478.1	670	850	1520			
	25		477.6	670	850	1520			
	26		477.0	660	840	1500			
	27		476.2	650	840	1490			
	28		475.5	710	670*	1380			
	29		474.9	770	470	1240			
	30		474.3	760	470	1230			
	31	08:00	473.8	760	460	1220			

* Average flow for 24 hour period

NOTE: -

Adit Gate Bypass to Stave Lake:

Dec. 1 to Dec. 7 closed.
Dec. 8 12:40 o'clock opened to 2'-0".
Dec. 13 10:50 o'clock opened to 4'-0".
Dec. 28 13:00 o'clock lowered to 2'-0".
Dec. 31 remained open 2'-0".

ALOUETTE LAKE: OUTFLOW IN C.F.S., JANUARY 1961

		Hour	Lake Level	Diversion to Stave Lake: Turbine Draft	Diversion to Stave Lake: Adit Bypass	Diversion to Stave Lake: Total to Stave	Discharge Down Alouette River: Over Weir	Discharge Down Alouette River: Overtopped Gates	Discharge Down Alouette River: Total
Jan.	1	08:00	473.2	750	460	1210	0	0	0
1961	2	08:00	472.6	750	460	1210	0	0	0
	3	08:00	472.0	760	460	1220	0	0	0
	4	08:00	471.5	730	450	1180	0	0	0
	5	08:00	471.6	760	450	1210	0	0	0
	6	08:00	471.8	760	450	1210	0	0	0
	7	08:00	471.4	750	450	1200	0	0	0
	8	08:00	471.1	750	450	1200	0	0	0
	9	08:00	471.8	750	450	1200	0	0	0
	10	08:00	473.1	790	460	1250	0	0	0
		16:00	474.5	790	460 to 0	1250 to 790	0	0	0
		20:00	475.7	790	0	790	0	0	0
	11	04:00	477.1	790	0	790	0	0	0
		08:00	477.4	790	0	790	0	0	0
		12:00	477.5	790	0 to 470	790 to 1260	0	0	0
		16:00	477.7	790	470	1260	0	0	0
	12	08:00	478.7	770	480	1250	0	0	0
	13	08:00	478.9	770	480	1250	0	0	0
	14	08:00	479.4	740	480	1220	0	0	0
		16:30	480.5	740	490	1230	0	0	0
		22:30	482.5	740	500	1240	460	0	460
	15	03:00	484.1	660	500	1160	3800	20	3820
		05:00	484.8	660	500	1160	6100	180	6280
		08:00	485.4	660	500	1160	8200	400	8600
		10:00	485.8	660	510	1170	9700	600	10300
		12:00	486.1	660	510 to 1240	1170 to 1900	10800	700	11500
		14:00	486.3	660	1240	1900	11600	790	12390
		16:00	486.5	660	1240	1900	12500	880	13380
		18:00	486.6	660	1250	1910	12900	930	13830
		20:00	486.4	660	1240	1900	12000	830	12830
		20:00	486.2	660	1240	1900	11200	740	11940
		24:00	485.9	660	1230	1890	10000	600	10600
	16	02:00	485.7	580	1230	1810	9300	520	9820
		04:00	485.5	580	1230	1810	8500	430	8930
		06:00	485.2	580	1220	1800	7400	320	7720
		08:00	485.0	580	1220	1800	6750	250	7000
		10:00	484.8	580	1220	1800	6000	190	6190
		12:00	484.6	580	1220	1800	5400	130	5530
	17	08:00	483.3	570	1210	1780	1850	0	1850
	18	08:00	482.5	410	1200	1610	460	0	460
	19	08:00	482.0	550	1200	1750	0	0	0
	20	08:00	481.3	570	1190	1760	0	0	0
	21	08:00	480.6	490	1180	1670	0	0	0
	22	08:00	479.9	580	1170	1750	0	0	0
	23	08:00	479.2	560	1170	1730	0	0	0
	24	08:00	478.4	590	1160	1750	0	0	0

/2

21

ALOUETTE LAKE: OUTFLOW IN C.F.S., JANUARY 1961 (CONTINUED)

	Hour	Lake Level	Diversion to Stave Lake: Turbine Draft	Diversion to Stave Lake: Adit Bypass	Diversion to Stave Lake: Total to Stave	Discharge Down Alouette River: Over Weir	Discharge Down Alouette River: Overtopped Gates	Discharge Down Alouette River: Total
Jan. 25	08:00	477.6	580	1150	1730	0	0	0
26	08:00	476.8	580	1140	1720	0	0	0
27	08:00	475.9		1140	1140	0	0	0

NOTE: - 1. Adit Gate Bypass to Stave Lake:

Jan. 1 remained open 2'-0".
Jan. 10 16:00 o'clock closed.
Jan. 11 12:00 o'clock opened to 2'-0".
Jan. 15 12:00 o'clock raised to 6'-0".
Jan. 31 remained open 6'-0".

2. Crest Gates were closed throughout. This column lists estimated flow over top of gates when water level is above elevation 484.

INFLOW = POWER + OUTFLOW ± STORAGE DAILY BASIS

DATE DEC 1960	LAKE LEVEL 0:00 HRS	CHANGE IN LEVEL	AVERAGE AREA OF LAKE	VOLUME AC-FT.	VOLUME CFS-DAYS	VOL POWER USE	VOL TO STORE LAKE	VOL OVER SPILLWAY	VOL OVER GATES	INFLOW
1	480.4	0	4050	0	0	950				950
2	480.4	+0.3	4052	+1216	+613	950				1563
3	480.7	+0.1	4054	+405	+204	930				1134
4	480.8	-0.05	4055	-203	-102	950				845
5	480.75	-0.25	4052	-1013	-511	930				419
6	480.5	-0.3	4046	-1214	-612	930				318
7	480.2	-0.3	4040	-1214	-612	940	0			328
8	479.9	-0.4	4044	-1616	-816	850	220			265
9	479.5	-0.5	4036	-2018	-1017	790	480			252
10	479.0	-0.6	4032	-2419	-1220	790	480			50
11	478.4	+0.3	4028	+1208	+609	790	480			1679
12	478.7	+1.55	4025	+6259	+3156	790	480			4426
13	480.25	+1.40	4056	+5676	+2863	720	700			4263
14	481.65	+0.15	4069	+611	+307	660	880			1847
15	471.8	-0.4	4062	-1625	-819	650	880			711
16	481.4	-0.65	4056	-2636	-1329	660	880			211
17	480.75	-0.65	4050	-2633	-1321	660	870			208
18	480.1	+0.2	4048	+810	+405	660	870			1938
19	480.3	+0.15	4050	+607	+306	660	870			1836
20	480.45	-0.4	4046	-1619	-816	670	870			724
21	480.05	-0.65	4044	-2629	-1325	540	870			85
22	479.4	-0.4	4036	-1614	-814	670	860			716
23	479.0	-0.55	4032	-2218	-1118	670	860			412
24	478.45	-0.65	4029	-2610	-1319	670	850			201
25	477.8	-0.6	4016	-2410	-1215	670	850			505
26	477.2	-0.7	4010	-2807	-1415	660	840			86
27	476.5	-0.75	4002	-3003	-1513	650	840			0
28	475.75	-0.65	3995	-2597	-1309	710	670			71
29	475.1	-0.6	3986	-2392	-1206	770	470			34
30	474.5	-0.5	3982	-1991	-1004	760	470			226
31	474.0	-0.6	3975	-2385	-1202	760	460			17
1961 1	473.4	-0.6	3968	-2381	-1240	750	460			10
2	472.8	-0.6	3962	-2377	-1199	750	460			11
3	472.2	-0.55	3956	-2176	-1097	760	460			125
4	471.65	-0.1	3952	-395	-199	730	450			981
5	471.55	+0.2	3954	+791	+399	760	450			1609
6	471.75	-0.2	3952	-790	-398	760	450			811
7	471.55	-0.35	3948	-1382	-697	750	450			503
8	471.2	+0.4	3948	+1579	+796	750	450			1996
9	471.6	+1.1	3958	+4354	+2195	770	460			3425
10	472.7	+3.65	3984	+14542	+7332	790	240			8362
11	476.35	+1.80	4020	+7236	+3646	790	240			4678
12	478.15	+0.7	4029	+2820	+1422	770	480			2672
13	478.85	+0.4	4035	+1614	+814	750	480			2044
14	479.25	+3.85	4057	+15619	+7875	740	540	700		9615
15	483.1	+2.80	4092	+11456	+5777	620	675	5700	315	13287
16	485.9	-2.05	4086	-8397	-4234	580	1220	6550	315	4431
17	483.85	-1.1	4060	-4495	-2263	540	1200	2000		1477
18	482.75	-0.6	4072	-2443	-1232	480	1200	525		973
19	482.15	-0.6	4065	-2439	-1230	560	1200	75		605
20	481.55	-0.7	4056	-2841	-1432	570	1190			328
21	480.85	-0.7	4052	-2836	-1430	420	1180			240
22	480.15	-0.7	4044	-2831	-1427	580	1170			323
23	479.45	-0.75	4035	-3026	-1526	560	1170			204
24	478.7	-0.8	4026	-3221	-1624	590	1160			126
25	477.9	-0.85	4018	-3415	-1722	580	1150			8
26	477.05	-0.9	4008	-3607	-1819	580	1140			0
27	476.15									

AVERAGE DAILY VOLUMES OF 1½ CFS

TAPE X

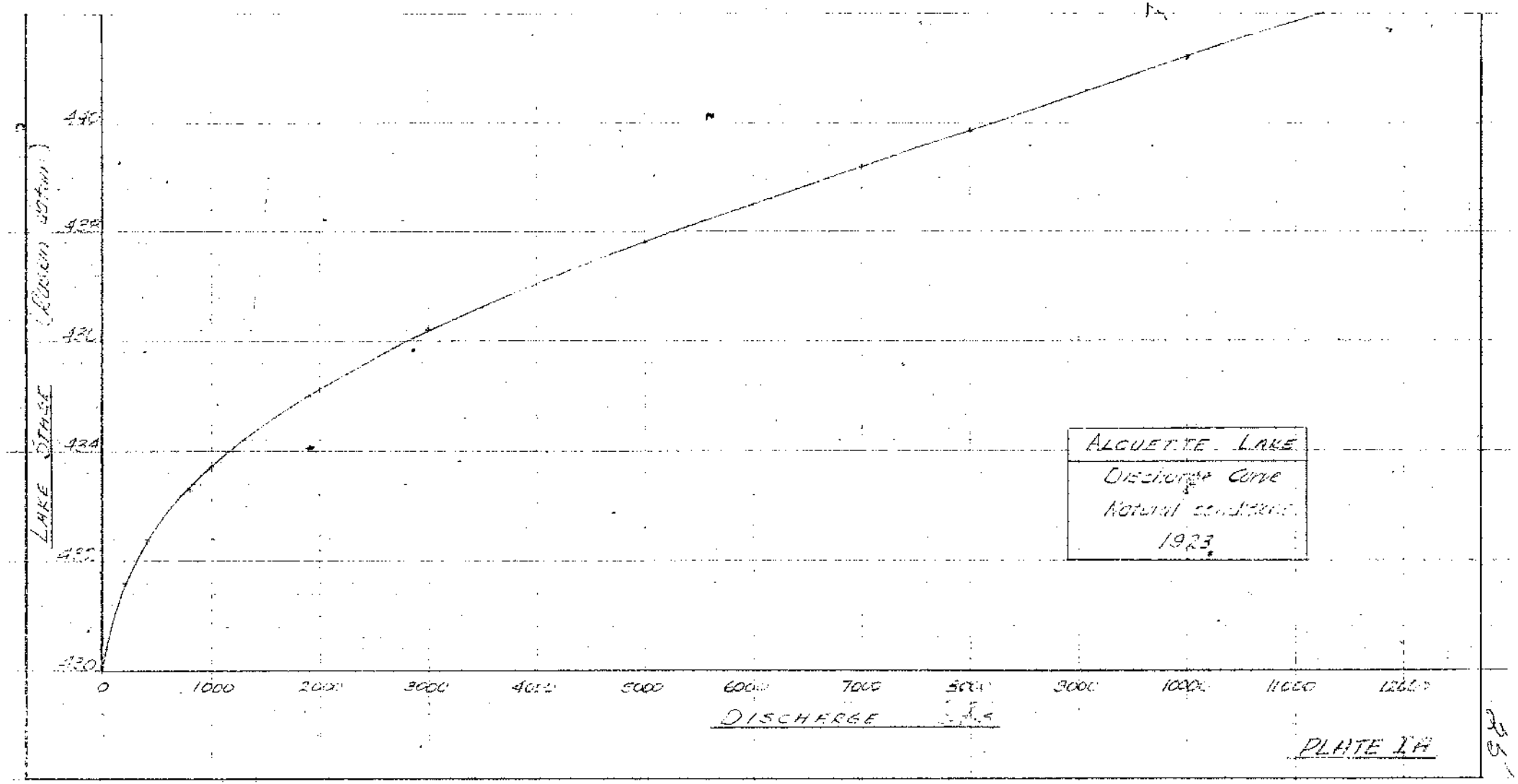
2 HOURLY BASIS

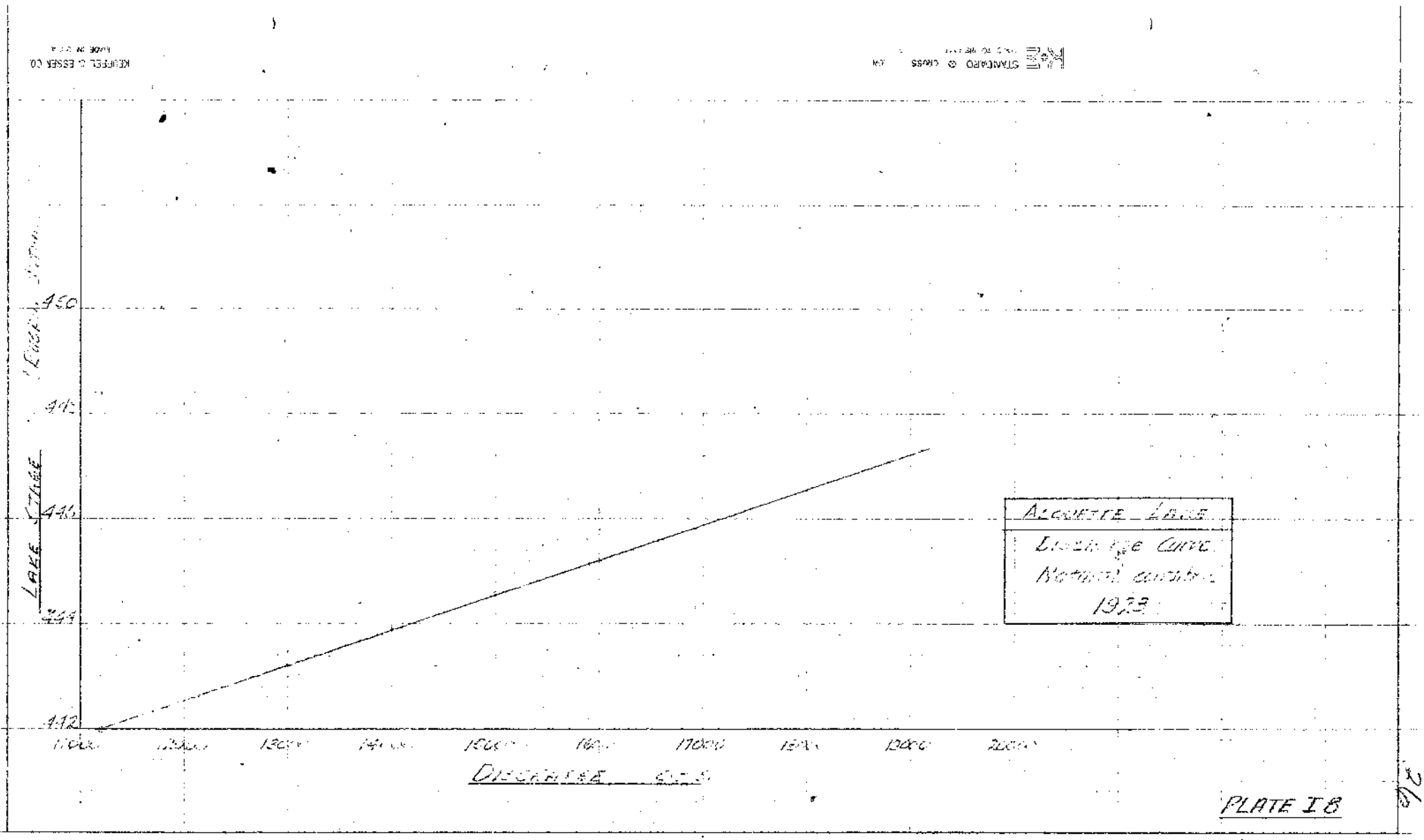
DATE JAN 1964	HOUR	LAKE LEVEL	CHANGE IN LEVEL ft	AVERAGE AREA OF LAKE ac.	VOL. CHGE. ac ft	RATE OF VOL CHGE 2 HRS cfs	RATE POWER USE 2 HR cfs	RATE TO STRUCT. 2 HR cfs	RATE OVER CIRCUIT 2 HR cfs	RATE ... GATES 2 HR cfs	INFLOW RATE 2 HR cfs
14	0:00	479.25	+ 0.03	4040	+ 121	+ 732	748	480			1960
	2:00	479.28	+ 0.04	4040	+ 161	+ 980	745	480			2205
	4:00	479.32	+ 0.04	4040	+ 161	+ 980	742	480			2202
	6:00	479.36	+ 0.04	4040	+ 162	+ 980	740	480			2200
	8:00	479.40	+ 0.26	4042	+ 1051	+ 6359	740	482			7581
	10:00	479.66	+ 0.26	4042	+ 1051	+ 6359	740	485			7584
	12:00	479.92	+ 0.26	4045	+ 1051	+ 6365	740	487			7592
	14:00	480.18	+ 0.24	4045	+ 971	+ 5875	740	490			7105
	16:00	480.42	+ 0.58	4052	+ 2350	+ 14218	740	492			15450
	18:00	481.00	+ 0.68	4058	+ 2759	+ 16692	740	495	0		17927
	20:00	481.68	+ 0.66	4065	+ 2683	+ 16232	740	497	175		17644
	22:00	482.34	+ 0.66	4075	+ 2690	+ 16275	730	500	825		18330
15	24:00	483.00	+ 0.75	4082	+ 3061	+ 18519	695	500	2100	0	21814
	2:00	483.75	+ 0.69	4087	+ 2820	+ 17061	660	500	3900	96	22217
	4:00	484.44	+ 0.56	4095	+ 2293	+ 13873	660	500	5825	219	21077
	6:00	485.00	+ 0.40	4096	+ 1638	+ 9910	660	510	7475	320	18871
	8:00	485.40	+ 0.40	4104	+ 1642	+ 9934	660	505	8050	477	19526
	10:00	485.80	+ 0.30	4108	+ 1232	+ 7454	660	510	10250	625	19499
	12:00	486.10	+ 0.20	4112	+ 822	+ 4973	660	1240	11200	740	18813
	14:00	486.30	+ 0.20	4114	+ 823	+ 4979	660	1240	12000	835	19714
	16:00	486.50	+ 0.10	4112	+ 411	+ 2487	660	1245	12600	905	17607
	18:00	486.60	- 0.20	4114	- 823	- 4979	660	1245	12400	880	10206
	20:00	486.40	- 0.20	4112	- 822	- 4973	660	1240	11600	785	9212
	22:00	486.20	- 0.30	4106	- 1232	- 7453	660	1235	10650	670	5672
16	24:00	485.90	- 0.20	4106	- 821	- 4967	620	1230	9700	560	7143
	2:00	485.70	- 0.20	4104	- 821	- 4967	590	1230	8900	475	6218
	4:00	485.50	- 0.30	4102	- 1231	- 7447	580	1225	8000	375	2733
	6:00	485.20	- 0.20	4098	- 820	- 4961	580	1220	7125	285	4249
	8:00	485.00	- 0.20	4096	- 819	- 4955	580	1220	6425	215	3465
	10:00	484.80	- 0.20	4094	- 819	- 4955	580	1220	5750	155	2750
	12:00	484.60	- 0.14	4092	- 573	- 3467	580	1220	5175	110	3618
	14:00	484.46	- 0.12	4090	- 491	- 2970	580	1220	4275	80	3665
	16:00	484.34	- 0.14	4088	- 572	- 3461	575	1220	4400	55	2780
	18:00	484.20	- 0.12	4088	- 490	- 2965	575	1215	4000	27	2853
	20:00	484.08	- 0.13	4086	- 531	- 3212	575	1215	3650	7	2235
	22:00	483.95	- 0.15	4082	- 612	- 3703	572	1215	3250	0	1334
17	24:00	483.80	- 0.12	4080	- 490	- 2964	572	1215	2810		1633
	2:00	483.68	- 0.12	4080	- 490	- 2964	572	1215	2465		1308
	4:00	483.56	- 0.14	4078	- 571	- 3454	570	1210	2225		551
	6:00	483.42	- 0.12	4078	- 489	- 2958	570	1210	1950		772
	8:00	483.30	- 0.08	4078	- 326	- 1972	565	1210	1750		1553
	10:00	483.22	- 0.06	4078	- 245	- 1482	550	1210	1600		1878
	12:00	483.16	- 0.08	4078	- 326	- 1972	535	1210	1420		1193
	14:00	483.08	- 0.06	4078	- 245	- 1482	525	1205	1325		1573
	16:00	483.02	- 0.07	4078	- 285	- 1724	510	1200	1242		1228
	18:00	482.95	- 0.05	4078	- 204	- 1234	495	1200	1142		1603
	20:00	482.90	- 0.08	4078	- 326	- 1972	485	1200	1050		763
	22:00	482.82	- 0.07	4078	- 285	- 1724	470	1200	920		866
18	24:00	482.75	- 0.05	4078	- 204	- 1234	455	1200	830		1251
	2:00	482.70	- 0.06	4078	- 245	- 1482	445	1200	775		938
	4:00	482.64	- 0.09	4076	- 367	- 2220	430	1200	630		40
	6:00	482.55	- 0.05	4076	- 204	- 1234	415	1200	495		876
	8:00	482.50	- 0.05	4076	- 204	- 1234	415	1200	425		806
	10:00	482.45	- 0.05	4076	- 204	- 1234	425	1200	360		751
	12:00	482.40	- 0.04	4076	- 163	- 986	440	1200	305		959
	14:00	482.36	- 0.02	4074	- 81	- 490	450	1200	270		1430
	16:00	482.34	- 0.06	4074	- 244	- 1476	460	1200	230		414
	18:00	482.28	- 0.03	4074	- 122	- 738	475	1200	180		1117
	20:00	482.25	- 0.05	4074	- 204	- 1234	485	1200	145		596
	22:00	482.20	- 0.04	4074	- 162	- 980	495	1200	110		825
19	24:00	482.16	- 0.04	4072	- 163	- 986	510	1200	75		799
	2:00	482.12	- 0.04	4072	- 163	- 986	520	1200	50		784
	4:00	482.08	- 0.04	4072	- 163	- 986	530	1200	30		774
	6:00	482.04	- 0.04	4072	- 163	- 986	545	1200	10		769
	8:00	482.00	- 0.05	4072	- 204	- 1234	550	1200	0		516
	10:00	481.96	- 0.05	4072	- 204	- 1234	550	1200	0		521

Max 8981 cfs during
average Max 17135 cfs
Average Discharge 10,948 cfs
Max 3591 cfs
average 2 hr

NATURAL OUTFLOW — 2 HR. PERIOD (24)

DATE JAN 1961	HOUR	I CFS-2Hr.	$\frac{S_1}{t} - \frac{O_1}{2}$	$\frac{S_2}{t} - \frac{O_2}{2}$	$\frac{S_2}{t} + \frac{O_2}{2}$	O_1	STAGE	O_2 CFS-2Hr.	STAGE
14	0 - 2	1960	92250	92220	94210	1960 Estimate	435.05	1960	435.04
	2 - 4	2205	92220	92400	94425			2025	435.06
	4 - 6	2202	92400	92600	94602			2002	435.07
	6 - 8	2200	92600	92800	94800			2000	435.08
	8 - 10	7581	92800	98100	100381			2281	435.35
	10 - 12	7584	98100	103200	105684			2484	435.60
	12 - 14	7592	103200	108200	110792			2592	435.85
	14 - 16	7105	108200	112400	115305			2905	436.10
	16 - 18	15450	112400	124300	127850			3550	436.65
	18 - 20	17927	124300	137800	142227			4427	437.30
	20 - 22	17644	137800	150200	155444			5244	437.95
15	22 - 24	18330	150200	162300	168530			6230	438.55
	0 - 2	21814	162300	177000	184114			7114	439.25
	2 - 4	22217	177000	191100	199217			8117	439.95
	4 - 6	21077	191100	203200	212177			8977	440.55
	6 - 8	18871	203200	212300	222071			9771	441.20
	8 - 10	20526	212300	222300	232826			10526	441.50
	10 - 12	19499	222300	230700	241799			11099	441.90
	12 - 14	18813	230700	237900	249513			11613	442.25
	14 - 16	19714	237900	245500	257614			12114	442.60
	16 - 18	17897	245500	251000	263397			12397	442.85
→	18 - 20	10200	251000	248800	261200		→	(12400)	442.75
	20 - 22	9312	248800	246000	258112			12112	442.60
16	22 - 24	5672	246000	239900	251672			11772	442.35
	0 - 2	7143	239900	235600	247043			11443	442.15
	2 - 4	6216	235600	230700	241816			11116	441.90
	4 - 6	2733	230700	223000	233433			10433	441.50
	6 - 8	4249	223000	217200	227249			10049	441.20
	8 - 10	3485	217200	211200	220685			9485	440.95
	10 - 12	2750	211200	204900	213950			9050	440.60
	12 - 14	3616	204900	199700	208516			8816	440.40
	14 - 16	3685	199700	195000	203385			8385	440.15
	16 - 18	2789	195000	189700	197789			8089	439.90
	18 - 20	2852	189700	184900	192552			7652	439.65
	20 - 22	2235	184900	179700	187135			7435	439.40
17	22 - 24	1334	179700	174200	181034			6834	439.15
	0 - 2	1633	174200	169300	175833			6533	438.90
	2 - 4	1308	169300	164400	170608			6208	438.65
	4 - 6	537	164400	159100	164937			5837	438.40
	6 - 8	772	159100	154300	159872			5572	438.15
	8 - 10	1553	154300	150600	155853			5253	437.95
	10 - 12	1878	150600	147400	152478			5078	437.80
	12 - 14	1198	147400	143800	148598			4798	437.60
	14 - 16	1573	143800	140800	145373			4573	437.45
	16 - 18	1228	140800	137700	142028			4328	437.30
	18 - 20	1603	137700	135100	139303			4203	437.20
	20 - 22	763	135100	132000	135863			3863	437.05
18	22 - 24	866	132000	129000	132866			3866	436.90
	0 - 2	1251	129000	126500	130251			3751	436.75
	2 - 4	938	126500	124000	127438			3438	436.65
	4 - 6	40	124000	120700	124040			3340	436.50
	6 - 8	876	120700	118400	121576			3176	436.35
	8 - 10	806	118400	116200	119206			3006	436.25
	10 - 12	757	116200	114000	116957			2957	436.15
	12 - 14	959	114000	112100	114959			2859	436.05
	14 - 16	1430	112100	110700	113530			2830	436.00
	16 - 18	414	110700	108700	111114			2414	435.85
	18 - 20	1117	108700	107100	109817			2717	435.80
	20 - 22	596	107100	105100	107696			2596	435.70
19	22 - 24	825	105100	103400	105925			2525	435.60
	0 - 2	799	103400	101800	104199			2399	435.50
	2 - 4	784	101800	100200	102584			2384	435.45
	4 - 6	774	100200	98700	100974			2274	435.35
	6 - 8	763	98700	97300	99463			2163	435.30
	8 - 10	516	97300	95700	97816	TABLE XI		2116	435.20
	10 - 12	521	95700	94200	96221			2021	435.15


LAKE LEVEL (ABOVE SEA LEVEL)
440
430
420
410
400
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
DISCHARGE
ALOUETTE LAKE
Discharge Curve
Natural Conditions
1923.
PLATE IA


KEUFFEL & ESSER CO
STANDARD
LAKE LEVEL
950
949
948
947
946
ALGONQUIN LAKE
Discharge curve
Natural conditions
1923
DISCHARGE
PLATE I 8

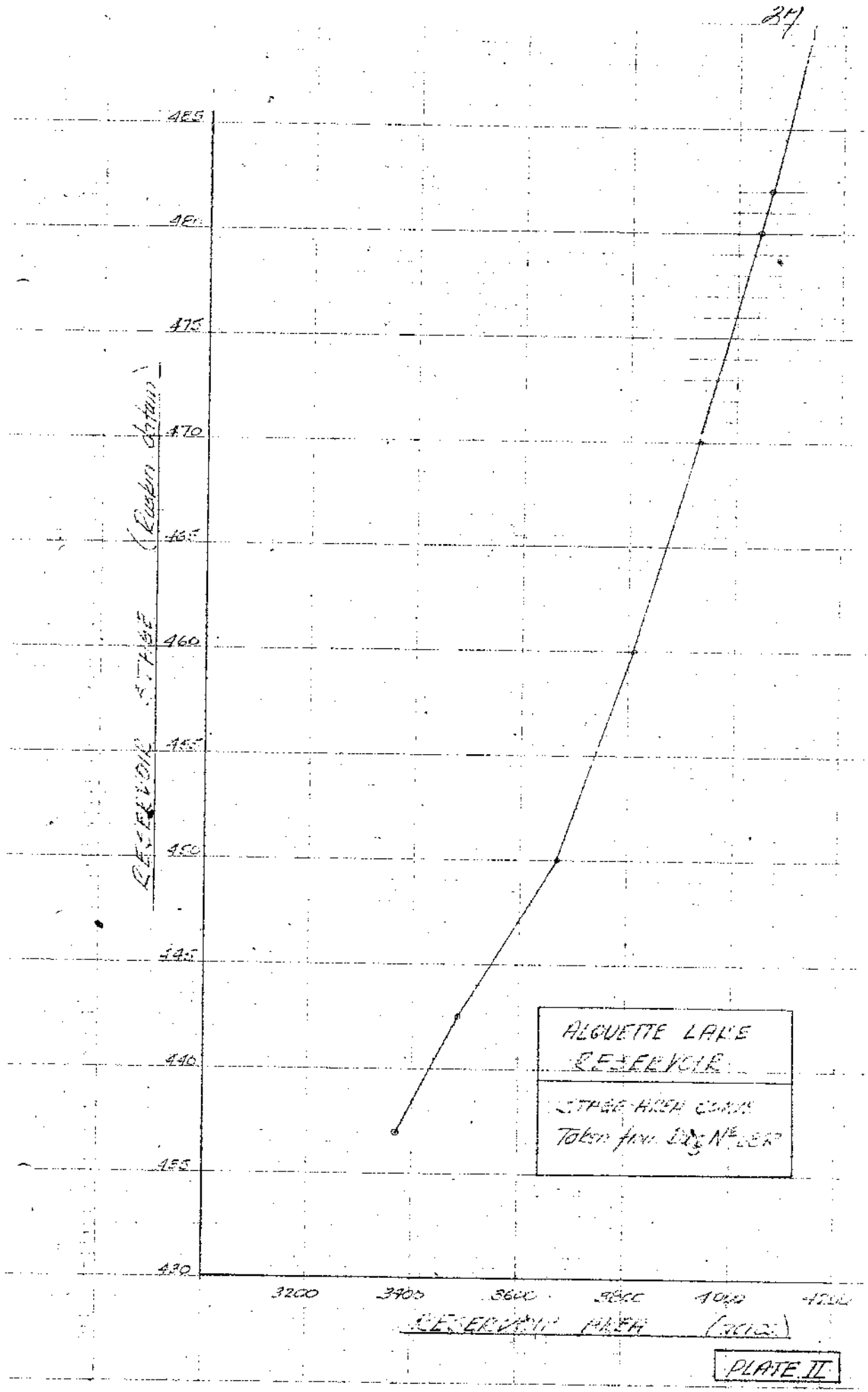
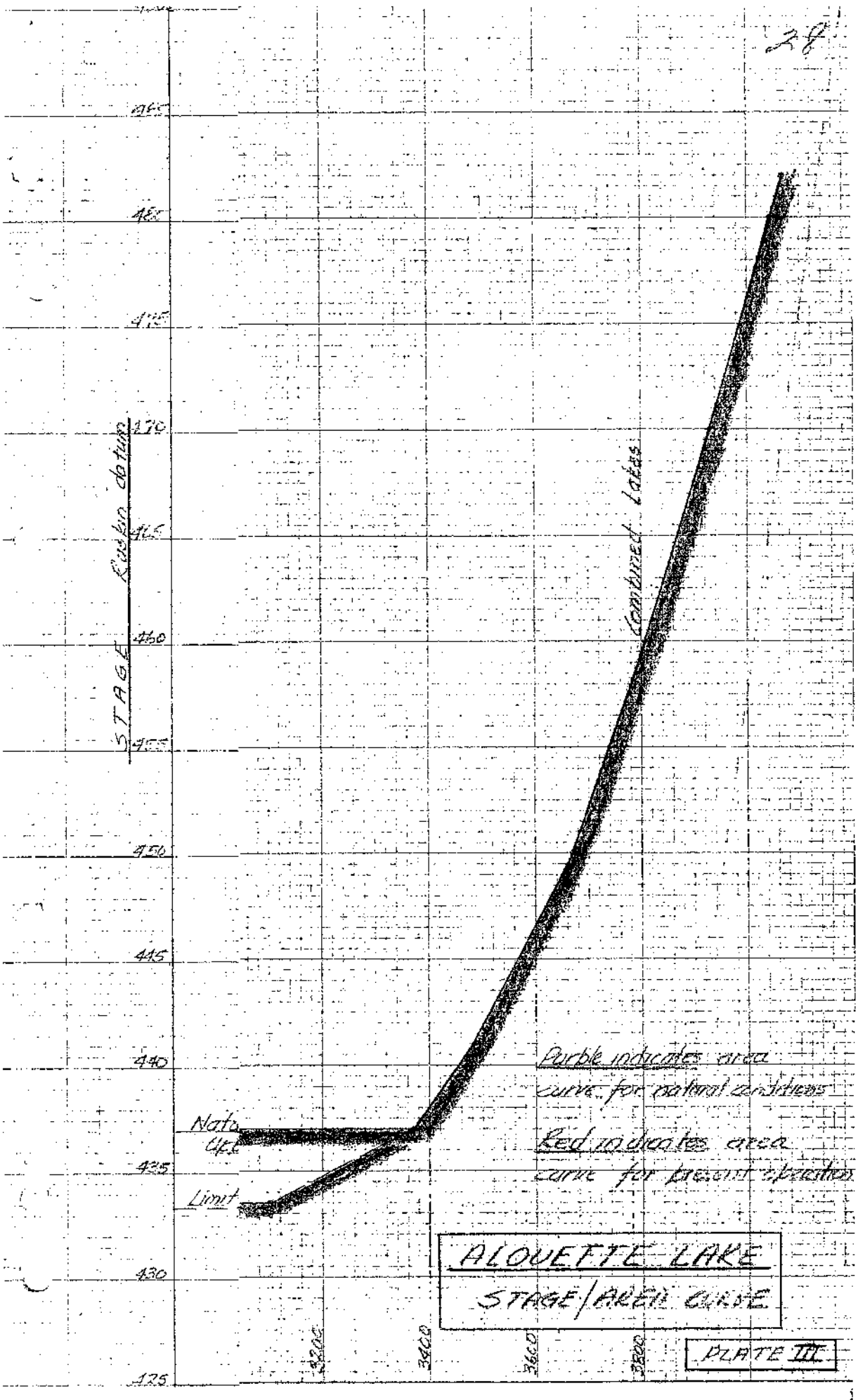
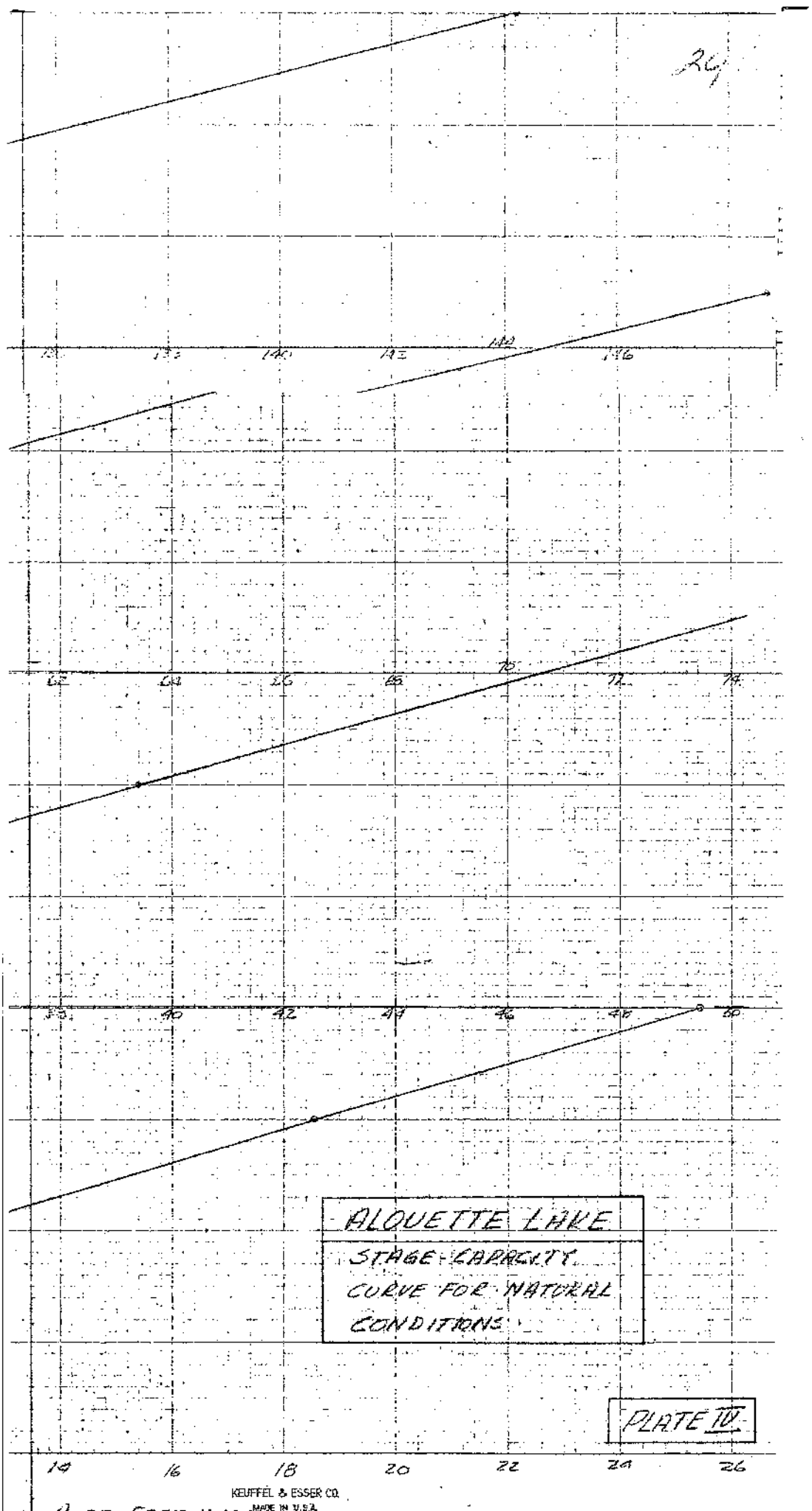
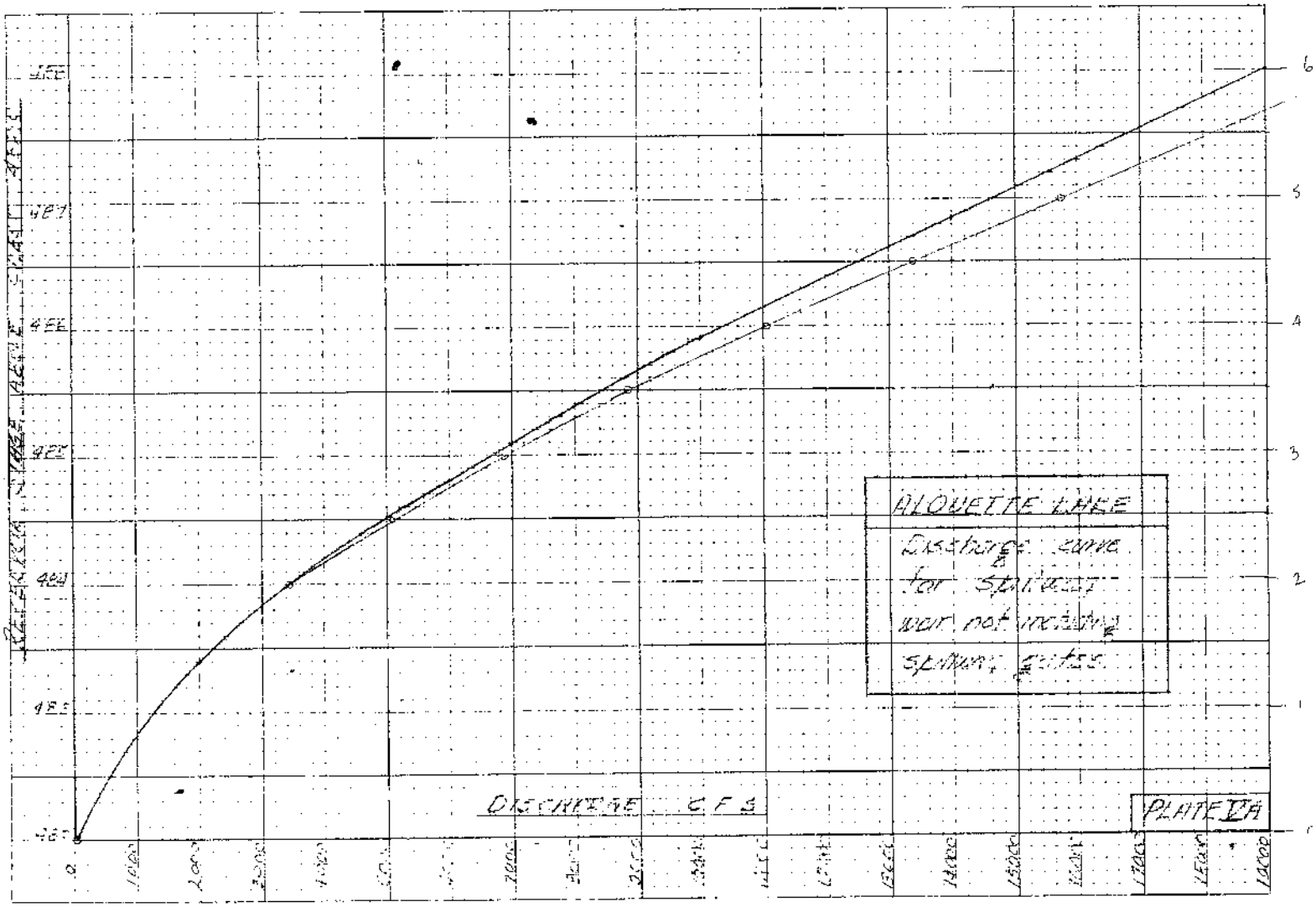
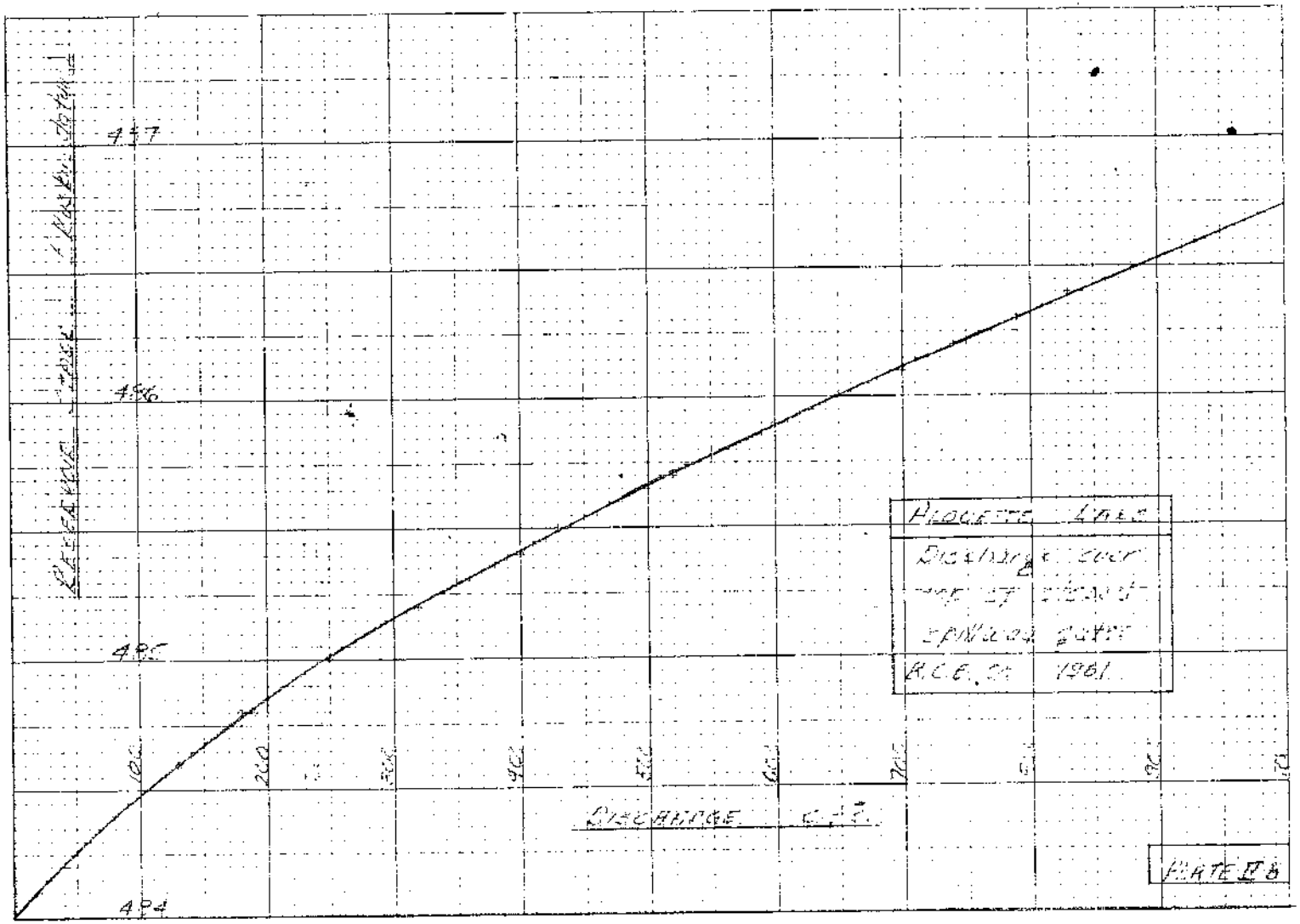


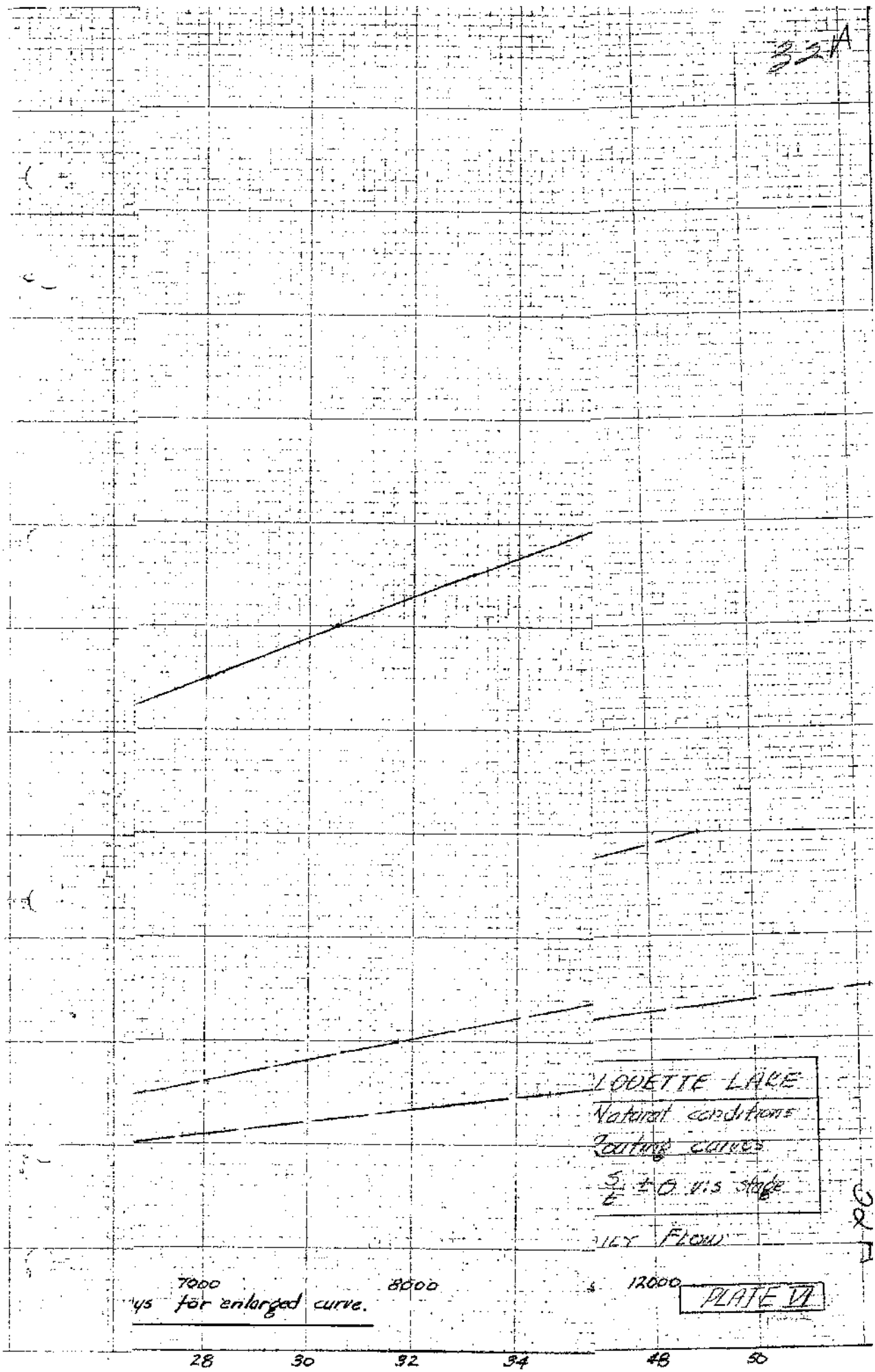
PLATE II

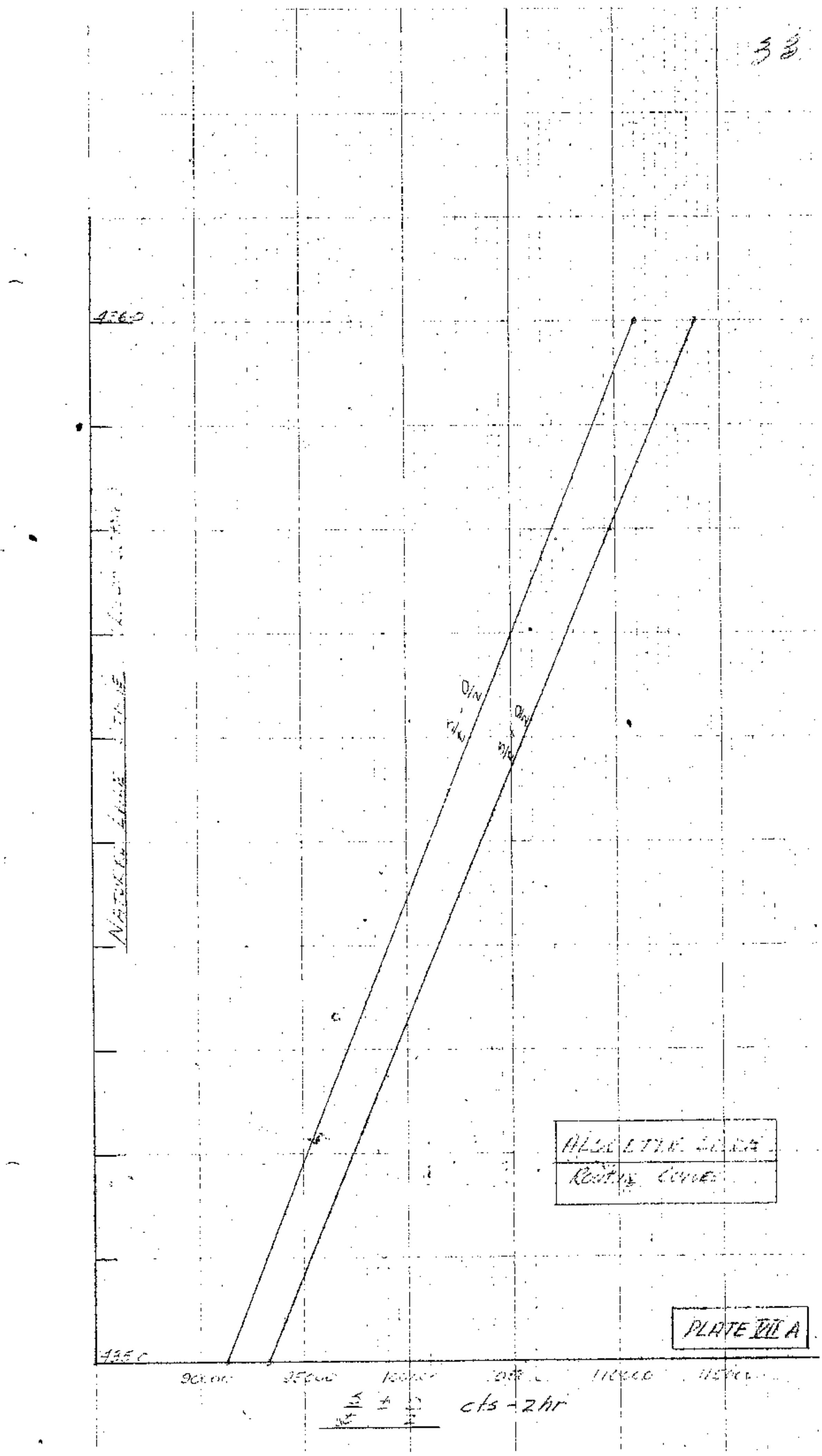

28
STAGE Existing datum
470
465
460
455
450
445
440
435
430
425
Combined Lakes
Purple indicates area curve for natural conditions
Red indicates area curve for present operation
Natural Limit
ALOUETTE LAKE
STAGE/AREA CURVE
PLATE III
3200
3400
3600
3800

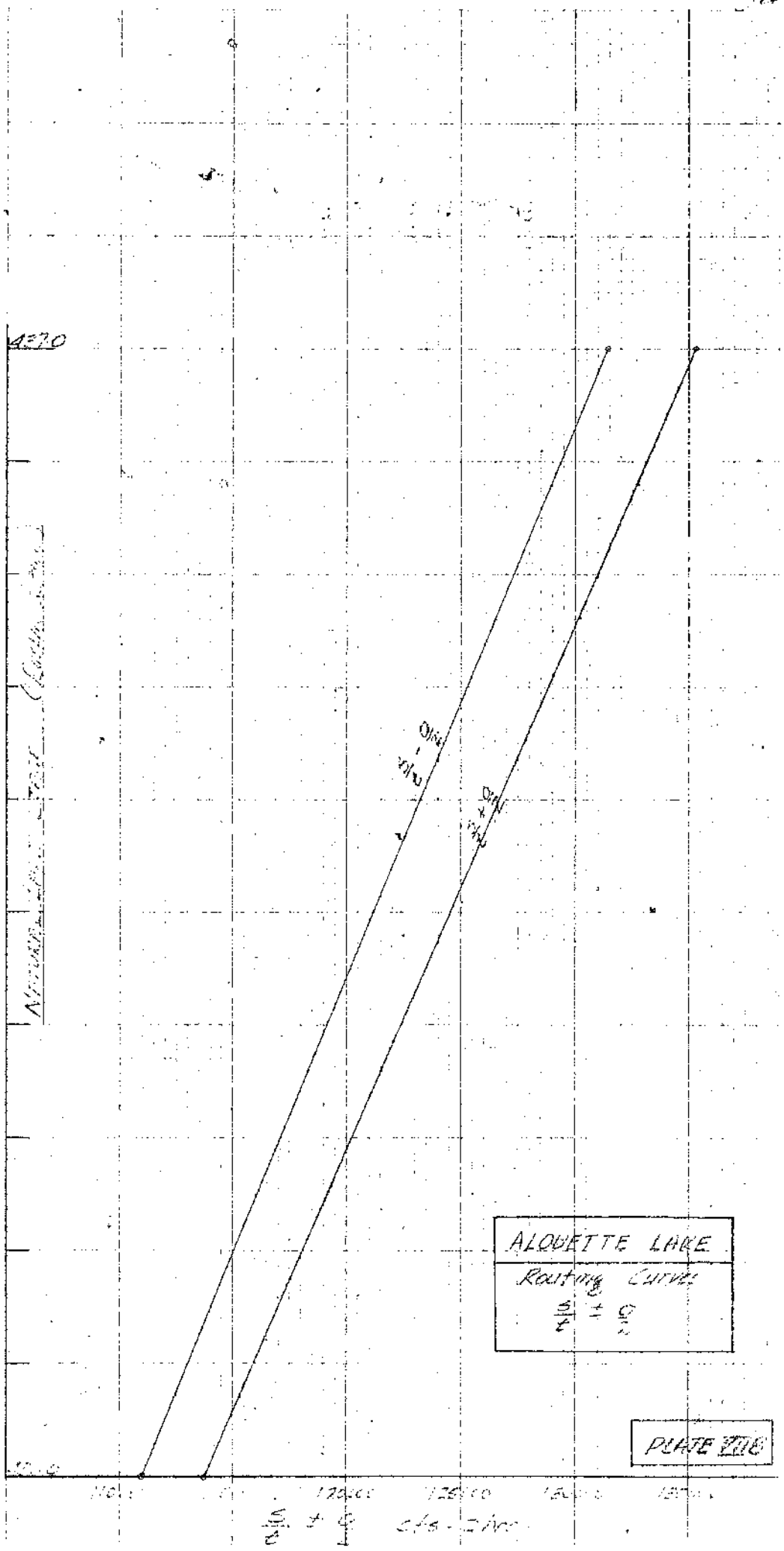

24
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
ALOUETTE LAKE
STAGE-CAPACITY
CURVE FOR NATURAL
CONDITIONS
PLATE IV
KEUFFEL & ESSER CO.
MADE IN U.S.A.
N ACRE-FEET X 1000

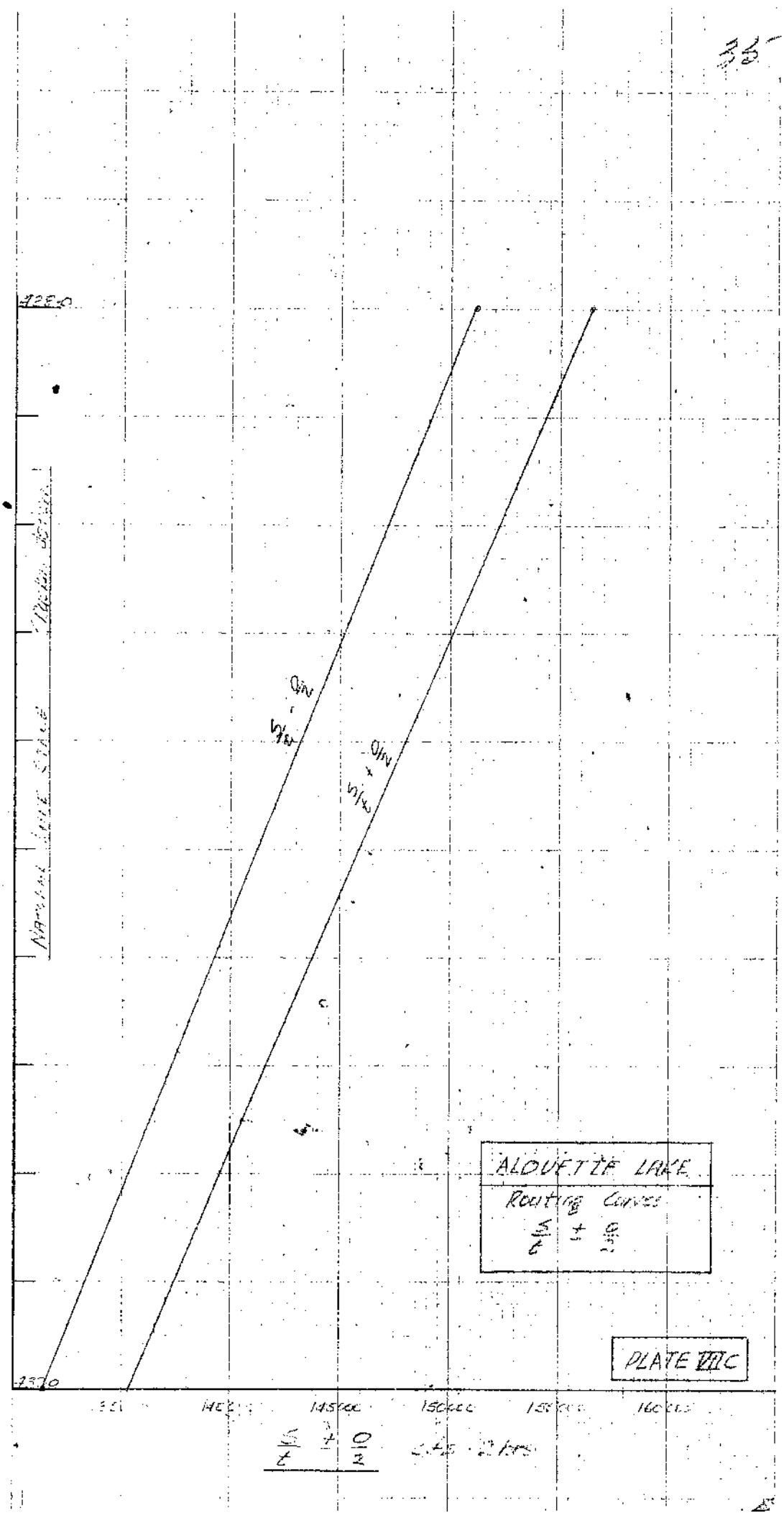

ALOUETTE LAKE
Discharge curve for Spillway weir not including Spillway gates
DISCHARGE C F S
PLATE IA

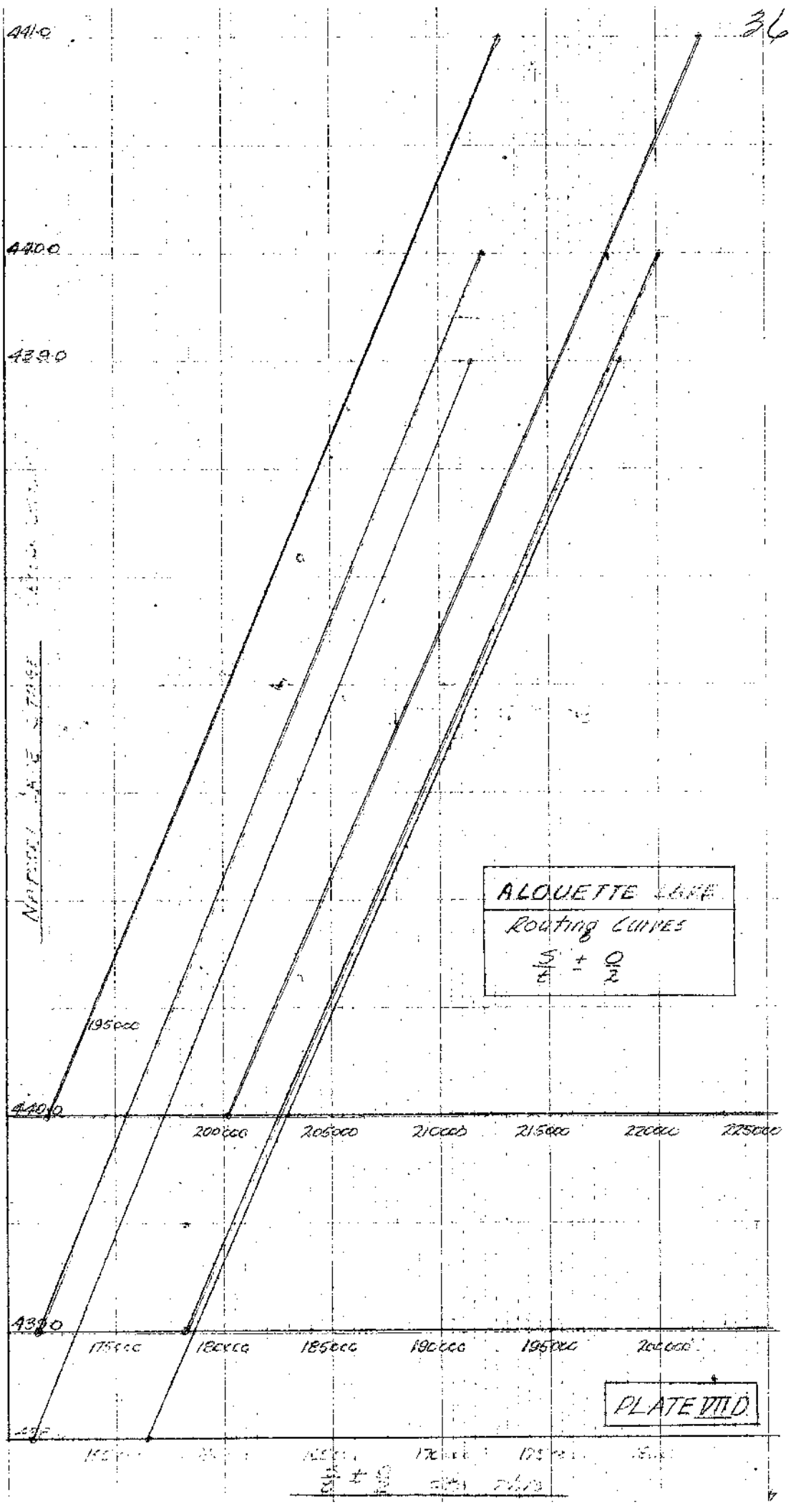

4.47
4.46
4.45
4.44
PLATE B

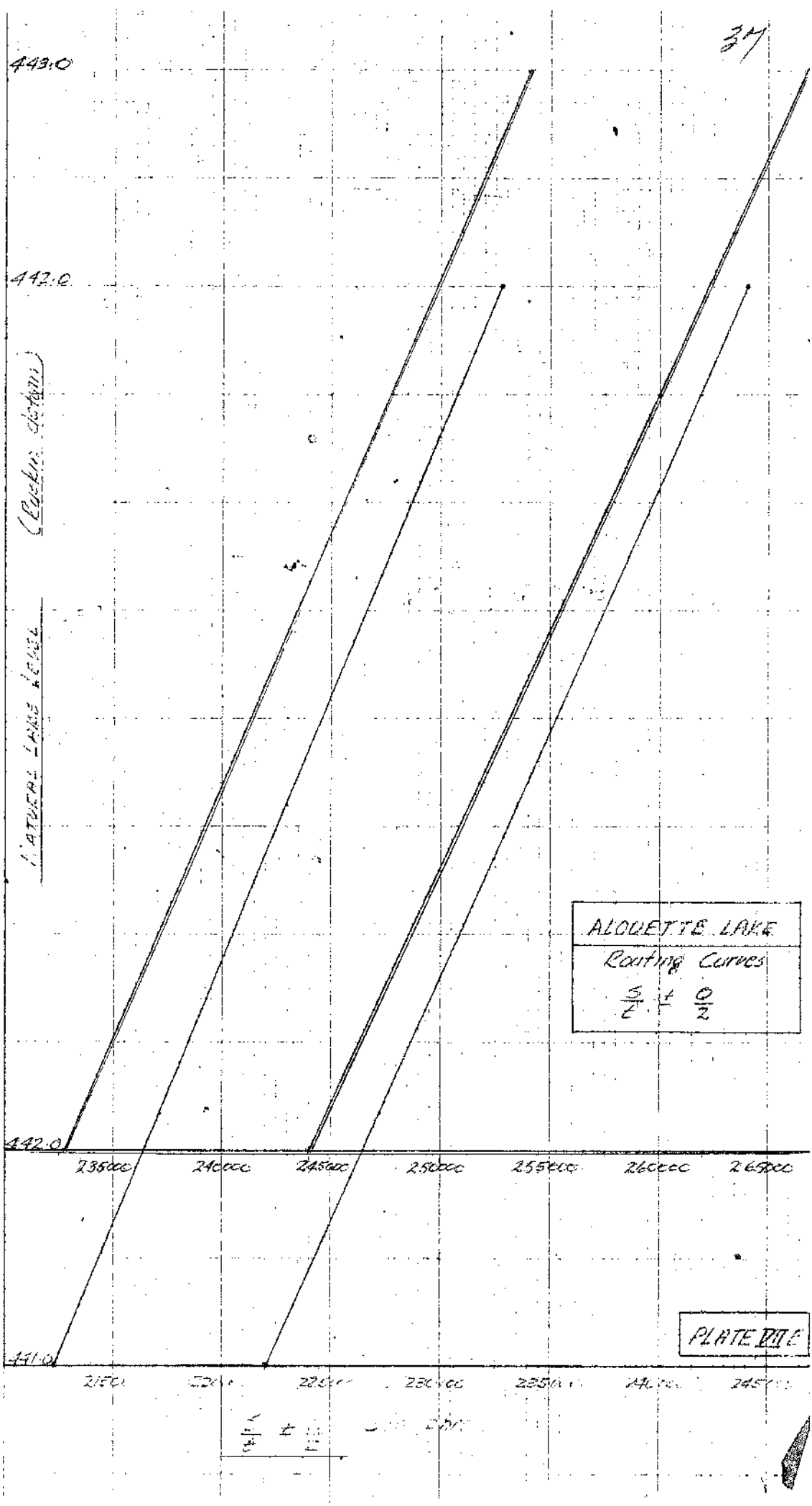

32A
LOVETTE LAKE
Natural conditions
Routing curves
S/E = 0 v.s Stage
Flow
7000
8000
12000
PLATE VI
for enlarged curve.
28
30
32
34
48
50
KEUFFEL & ESSER CO.
1000

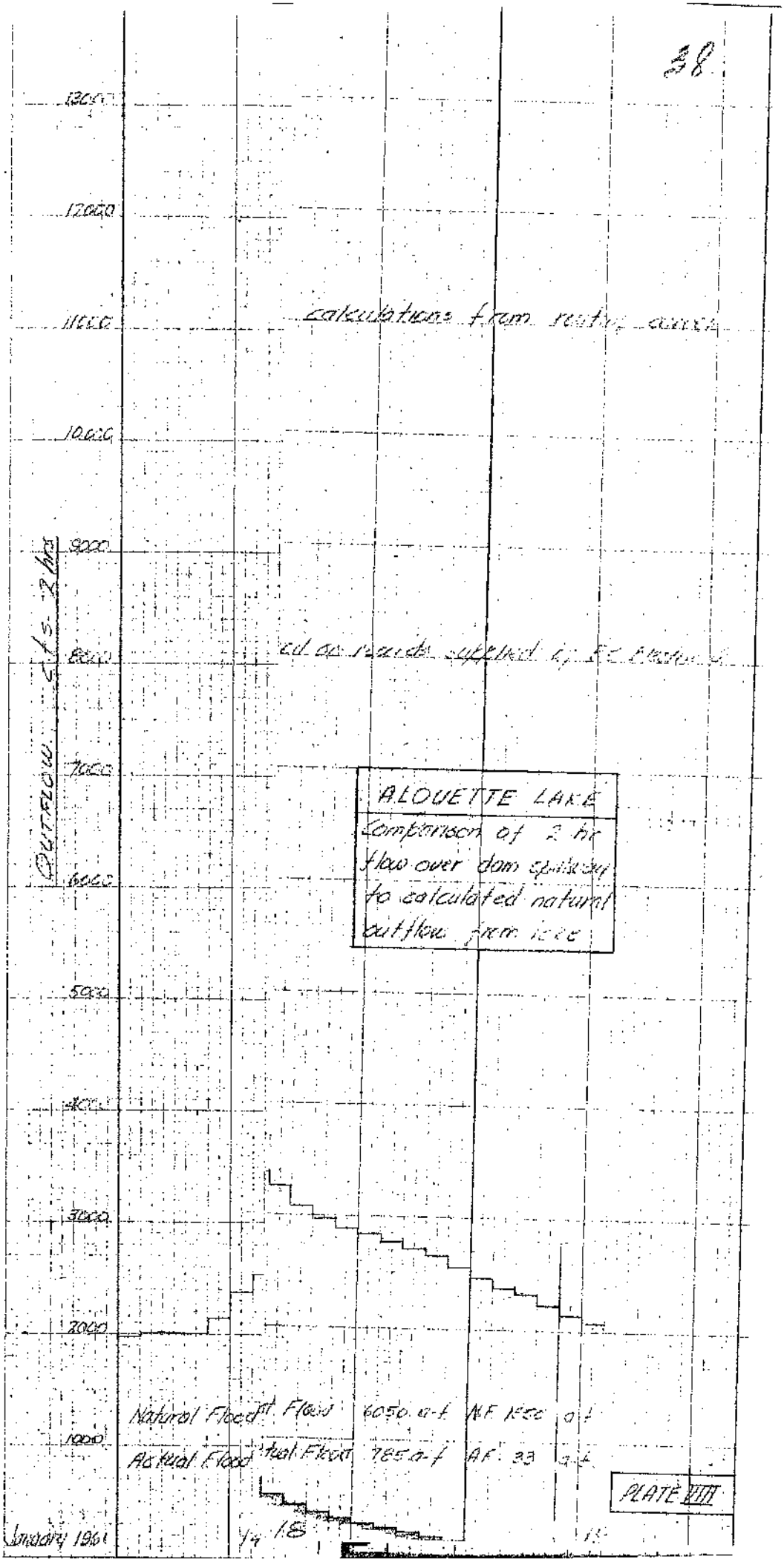

cts - 2hr

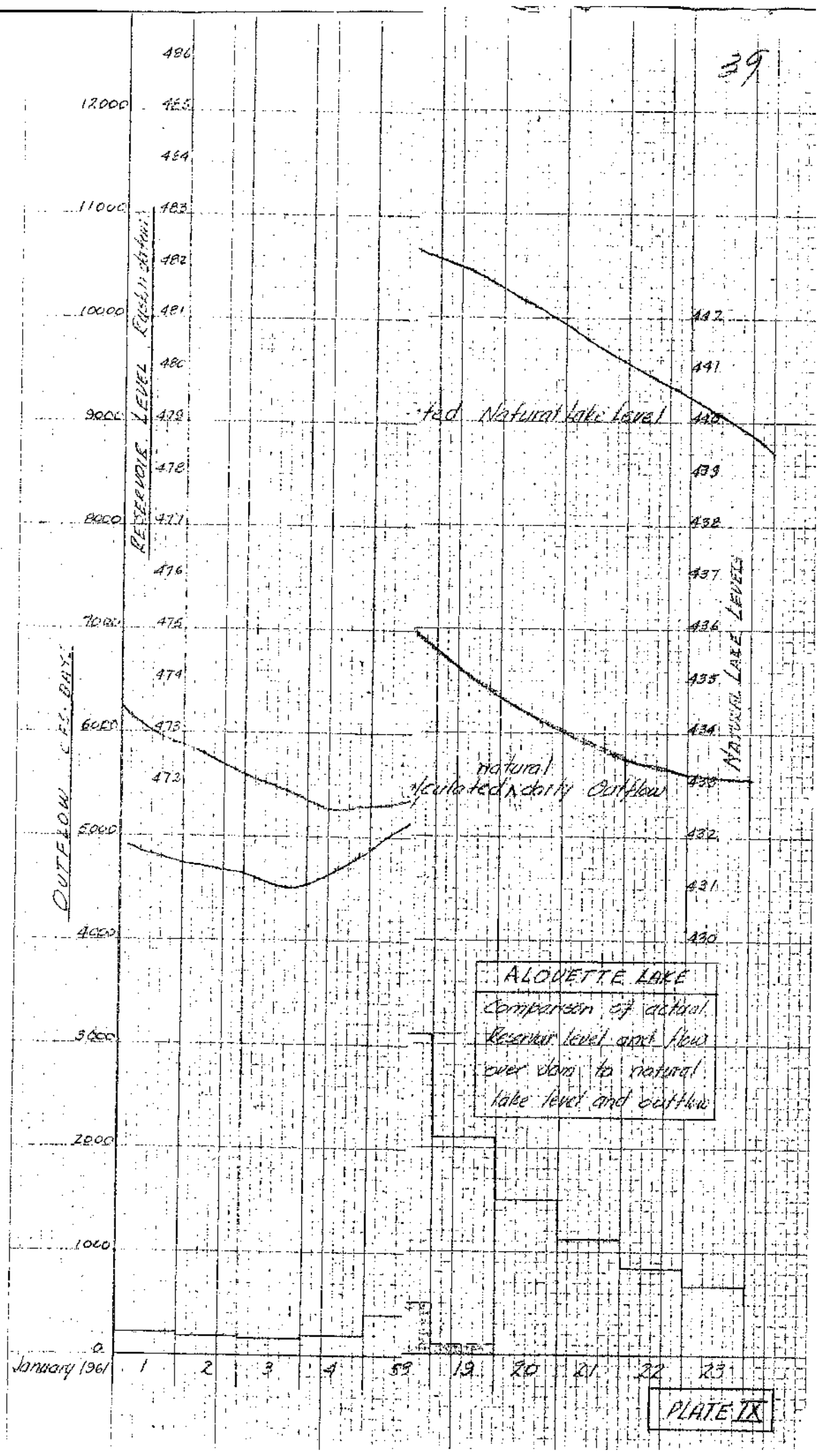

ZERO
ALOUETTE LAKE
Routing Curves
PLATE


ALOUETTE LAKE
Routing Curves
PLATE VIIIC




37
443.0
442.0
NATURAL LAKE LEVEL (Geodetic datum)
442.0
235000
240000
245000
250000
255000
260000
265000
ALOUETTE LAKE
Routing Curves
S/2 + O/2
PLATE VII.E





ALOUETTE RIVER FLOODPLAIN

Grubb & Lasaro Co.
Gold River.

W

T.W. Ewell
PO 1090
Nancy.

GOVERNMENT OF BRITISH COLUMBIA

MEMORANDUM

TO Mr. T. A. J. Leach, Chief,
Hydraulic Investigation Division,
Water Rights Branch,
Victoria, B. C.

FROM Mr. T. H. Oxland,
Hydraulic Engineer,
3rd February, 1961

SUBJECT Lower Fraser Valley Flooding,
January 14 to January 19, 1961.

OUR FILE 0213069

YOUR FILE

The following reports are submitted in connection with flooding in the Lower Fraser Valley during January 14, 1961 to January 19, 1961:-

1. Flooding on North and South Alouette Rivers
2. Flooding on Essondale Colony Farm
3. Tabulation of rainfall data from January 9, 1961 to January 17, 1961, from several "6 hour record" Meteorological Stations in the Lower Fraser Valley.

In regard to item 3, I visited Mr. Williams of the Meteorological Branch in Vancouver on January 19, 1961 and we decided on the following course to complete our 6 hour rainfall record coverage in the Lower Valley.

(a) Mr. Williams to act within the next month on

(i) Establishing a rain gauge at Harrison Lake

(ii) Finalize negotiations with Westcoast Transmission Co. to establish the automatic gauge at their pumping station in Huntington by middle of February, 1961.

(b) T. H. Oxland to contact those concerned in appropriate Provincial Government Departments to establish rain gauges at Cultus Lake Fish Hatchery and Prison Camps on the Vedder River and Alouette Lake.

(c) Collection of 6 hour rainfall data from the Automatic gauge at Agassiz and the gauge at Abbotsford be postponed until Mr. Bruce, of the Meteorological Branch in Toronto, can advise the Water Rights Branch of the necessity of this information.

(d) Some attempt should be made, possibly when gauges in (a) and (b) are established, to place a gauge in the Deroche area. The gauge reader approached last September (1960) is no longer interested in reading a gauge.

T. H. Oxland,
Hydraulic Engineer.

THO/ah

REPORT ON FLOODING ON THE ALOUETTE RIVER

January 14 to 16, 1961

Between January 15, 1961 and January 18, 1961 field party of T. H. Oxland and J. Zalanfy inspected the flooded areas of the North and South Alouette River.

The following report outlines the findings of this party starting at the Alouette Lake dam and proceeding downstream.

1. Alouette Lake Dam

Dam visited by T. H. Oxland on Janjary 18, 1961, 11:00 a.m. to 1:00 p.m. The access road to the dam via the south-east bank from 21st Avenue, Haney, was washed out approximately 1 mile downstream of the damsite. This washout was caused by a small sidehill creek overtopping a road culvert.

At the dam Mr. Dickenson, the operator, offered the following precipitation records. The daily record represents precipitation from 8:00 a.m. one day to 8:00 a.m. the following day.

Date	24-hr.rainfall,ins.	Lake level above dam	Spill level
Jan. 9	1.32	(8:00 a.m.) 471.8	482.0
10	2.47		
11	0.67		
12	0.35		
13	1.64		
14	3.06		
15	1.36	(8:00 a.m.) 485.4	
		(18:00) 486.6(max.)	
16	0.21		
17	0.05		

During this period the diversion tunnel into Stave Lake was in operation and all of the Diversion Dam gates were closed. The lake level reached the spillway level in late p.m. on Januty 14, 1961. The only minor damage left by this high water was the deposition of logging debris on the beaches of the public park opposite the dam.

2. North and South Alouette River and 14th Avenue

Site visited by T. H. Oxland on January 18, 1961.

The south Alouette here broke over the right bank, flooded Maple Ridge Park Picnic site, cut over the northern bridge approach on 14th Ave. then split into two streams, one stream flowing into the North Alouette River and one returning to the South Alouette.

Damage to property in this vicinity was centered on the Maple Ridge Park site. See photographs in Appendix . The private house and barn, although at one time partially surrounded by water, was not damaged.

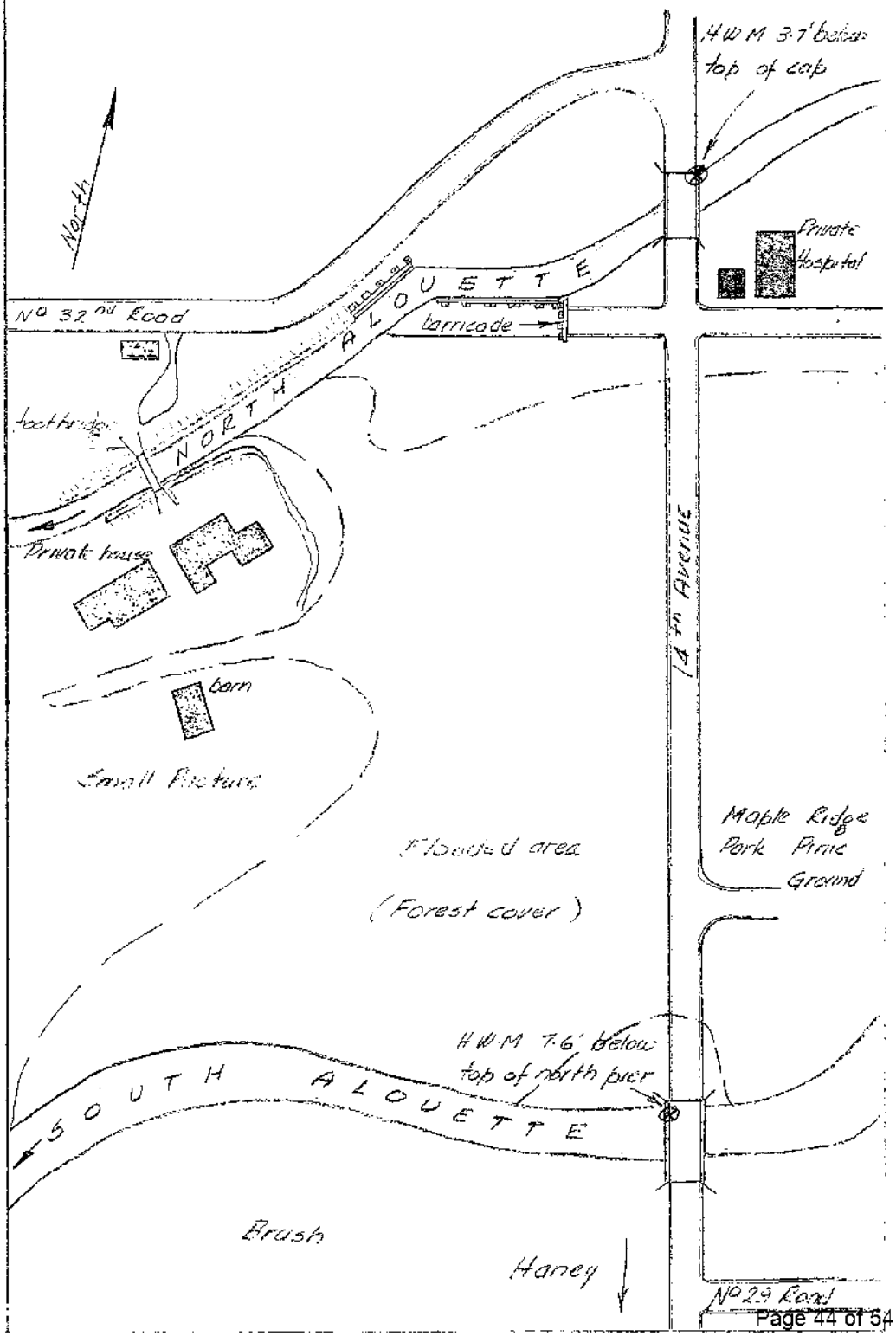
The North Alouette River above the bridge on 14th Ave. showed no signs of a damaging flood. The high water mark recorded was 3.7' below top of cap on upstream side of north bent marked X on sketch.

The South Alouette River high water mark was recorded as 7.6' below downstream top of the first concrete pier from the north approach marked X on sketch.

3. North and South Alouette River and 8th Avenue

Site visited by J. Zalanfy January 17, 1961.

Sketch showing bridges crossing the North & South Alouette Rivers on 14th Avenue Haney B.C.



The North Alouette River under the bridge showed no evidence of abnormal flooding. The only comment made by the inspector was that the water passage under the bridge was half blocked by debris. At the time of inspection January 17, 1961 no one had attempted to clear away this debris.

The South Alouette River acted in somewhat similar manner here as on 14th Avenue. In this case, however, there was no break through to the North Alouette, all flood waters joining the original river channel downstream of the bridge.

The private house shown in the sketch was unoccupied at the time of inspection however there was no visible flood damage.

North along 8th Avenue to the Schiller Dyking District: Here the area inside the Schiller dykes was still under some 3 feet of water. The reason for this flooding was not known however, it would be possible for water to come from the undyked section of the North Alouette on the South of this property, cross 8th Avenue and spill into the inside of Schillers dykes. There was no report or evidence of broken river dykes in this area.

4. South Alouette River and 5th Avenue

Site visited by J. Zalanfy on January 17, 1961.

The South Alouette remained within its banks at this point. The High Water Mark recorded was 3.6' below the deck surface of the north-east corner of the bridge. There is no crossing of the North Alouette at this point.

5. North and South Alouette River and Neaves Road

Site visited by T. H. Oxland and J. Zalanfy on January 16, 1961.

The South Alouette remained within its banks at this crossing. The High Water Mark was recorded at 13:08' G.S.C. The water level at 15:30 on January 16, 1961 was 9.91' G.S.C.

The low pasture land between the North and South Alouette along Neaves Road was flooded to a minor extent. The water level in the field at 15:45 on January 16, 1961 was determined to be 5:30' G.S.C.

The North Alouette at this point was also confined within its banks. The H.W.M. was 10.61' G.S.C. The water level at 15:50 on January 16, 1961 was 9.21' G.S.C.

Generally in the area north of the North Alouette River local flooding in fields was evident. This was, no doubt, due to the high stage in the Fraser River, and consequently the Pitt River, thereby eliminating gravity drainage and allowing the runoff to approach the capacity of the pumps.

6. Alouette River and Harris Road

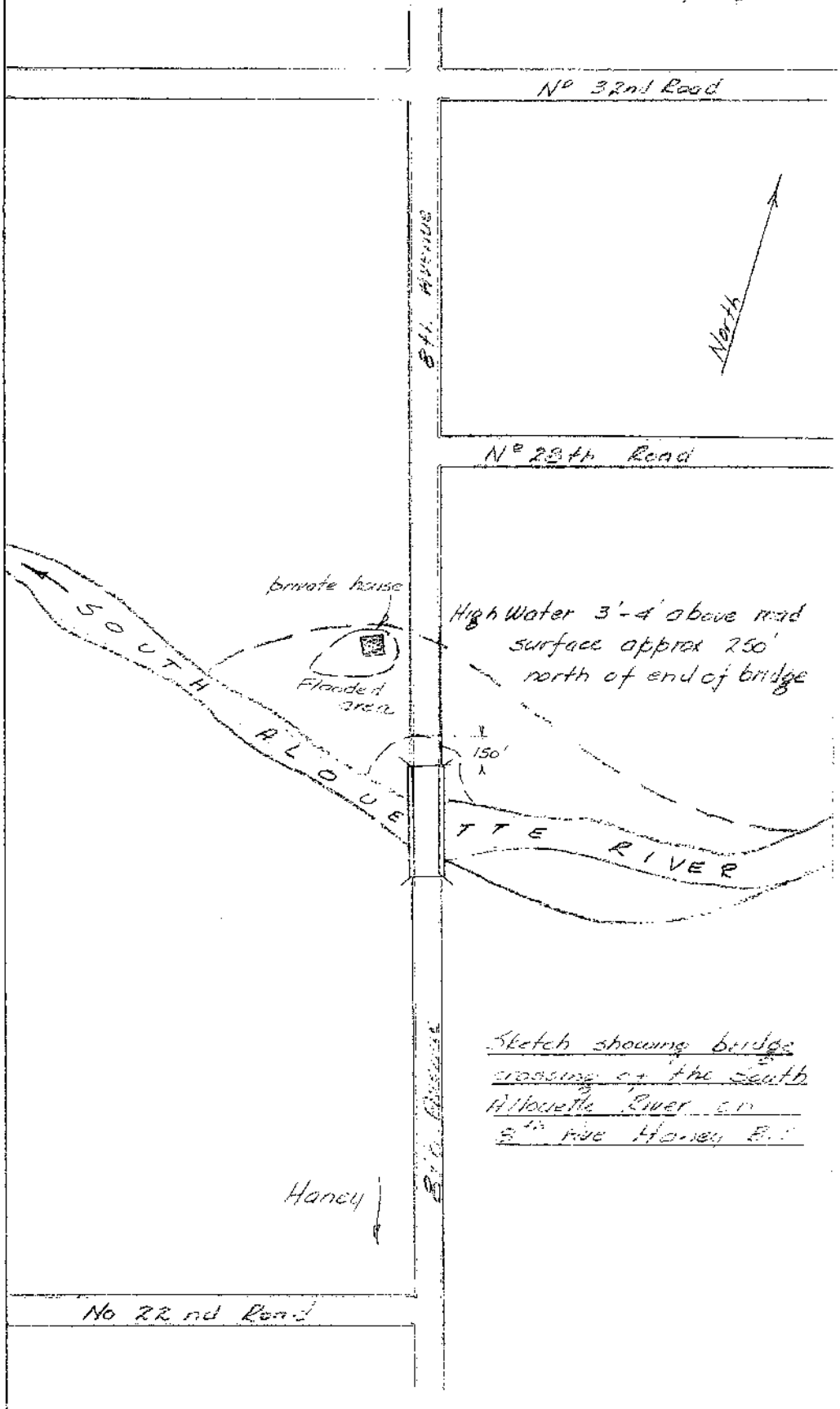
Site visited on January 16, 1961.

No evidence of over-bank flooding here. The High Water Level was 9.65' G.S.C. The water level at 16:30 on January 16, 1961 was 8.05' G.S.C.

7. Dewdney Trunk Road in Maple Ridge District

Site visited on January 16, 1961.

Fields on both sides of the Dewdney Trunk Road between Harris Road and Neaves Road were covered with standing water. At the intersection of



Sketch showing bridge crossing of the South Alouette River on 8th Ave Honey B.C.

Hale Road and D.T. Rd. this level was determined to be 4.29' G.S.C. Generally in this area drainage ditches were brink full. Note photographs.

The party also visited the following dyking districts in this area:-

1. Upper Coquitlam Dyking District
2. Middle Coquitlam Dyking District
3. Maple Ridge North of the C.P.R.
4. Pitt Meadows No.2 Dyking District.

Apart from flooding in fields and full drainage ditches there was no evidence of serious flood damage.

T. H. Oxland
Hydraulic Engineer.

THO/pd
Enc.

The following table lists rainfall at various Meteorological Stations situated in the Lower Fraser Valley visited during the trip

Month	Essondale		24 hr total	Pitt Polder		24 hr total	Haney		24 hr total	Hatzic		24 hr total	Sumas		24 hr total	Langley		24 hr total	Chilliwack East of Vedder		24 hr total	Seymour Falls	Alouette Lake Dam
January																						2.30	1.32
9/61	8.00	0.88					8.00	1.11		7.30	1.00		8.00	0.58		7.00	0.56		6.00	0.37			
	20.00	0.15)	2.93				18.00	0.12)	1.69	17.00	0.08)	0.98	20.00	0.02)	0.83	19.00	0.03)	1.00	18.00	Tr)	0.56	2.85	2.47
10/61	8.00	1.78)					8.00	1.57)		7.30	0.90)		8.00	0.81)		7.00	0.97)		6.00	0.56)			
	20.00	2.92)	2.92				18.00	2.85)	3.06	17.00	1.62)	1.91	20.00	1.63)	1.66	19.00	1.90)	1.90	18.00	1.28)	1.37	3.09	0.67
11/61	8.00	Tr)					8.00	0.21)		7.30	0.29)		8.00	0.03)		7.00	Nil)		6.00	0.09)			
	20.00	0.41)	0.41				18.00	0.36)	0.36	17.00	0.37)	0.39	20.00	0.19)	0.19	19.00	0.31)	0.31	18.00	0.55)	0.57	1.51	0.35
12/61	8.00	.Tr)		nil			8.00	Tr)		7.30	0.02)		8.00	Tr)		7.00	Nil)		5.00	0.02)			
	20.00	Tr)	0.07	nil)	0.23		18.00	Nil)	0.04	17.00	Nil)	0.14	20.00	Tr)	0.06	19.00	Nil)	Nil	18.00	Nil)	0.07	0.82	1.64
13/61	8.00	0.07)		0.23)			8.00	0.04)		7.30	0.14)		8.00	0.06)		7.00	Nil)		6.00	0.07)			
	20.00	0.86)	1.55	0.86)	1.65		18.00	0.50)	1.20	17.00	0.40)	0.85	20.00	0.35)	0.74	19.00	0.28)	0.63	18.00	0.24)	0.34	2.74	3.06
14/61	8.00	0.69)		0.79)			8.00	0.70)		7.30	0.45)		8.00	0.39)		7.00	0.35)		6.00	0.10)			
	20.00	0.49)	2.07	1.06)	2.72		18.00	0.43)	1.92	17.00	0.41)	1.45	20.00	0.29)	0.92	19.00	0.61)	1.99	18.00	0.32)	1.65	2.35	1.36
15/61	8.00	1.58)		1.66)			8.00	1.49)		7.30	1.04)		8.00	0.63)		7.00	1.38)		6.00	1.33)			
	20.00	0.48)	0.48	0.69)	0.80		18.00	0.62)	0.70	17.00	0.90)	0.90	20.00	0.70)	0.74	19.00	0.62)	0.62	18.00	1.33)	1.33	4.08	0.21
16/61	8.00	Nil)		0.11)			8.00	0.08)		7.30	Tr)		8.00	0.04)		7.00	Nil)		6.00	Nil)			
	20.00	Nil)	0.51				18.00	Nil)		17.00	Nil)		20.00	Nil)	Nil	19.00	Nil)	0.20					0.05
17/61	8.00	0.51)											8.00	Nil		7.00	0.20						

Three proposed sites for Meteorological Stations were visited at Deroche, Harrison, and Cultus Lake. Since no direct action was taken by Met. Branch following a visit to Deroche and Harrison Lake in September 1960 the gauge readers interviewed at that time are no longer available as readers. The station at Cultus Lake is still inactive pending arrangements with the Provincial Parks Department.

FLOODING ON ESSONDALE COLONY FARM

January 14-19, 1961

The following is a report of the findings of the field party of T. H. Oxland and J. Zalanfy of the flooding of the Coquitlam River below the Lougheed Highway into the Essondale Colony Farm.

Arrived at the farm at 10:30 a.m., January 16, 1961. The Coquitlam River had breached the east dyke in four places on January 15, 1961 (see attached photo), flooded the fields over to Mary Hill and returned to the river through a cut in the east dyke just downstream of the wooden bridge. The east pump was completely flooded out.

Recorded H.W.M. of flooded field area at intersection of Barn access road and east dyke was 11.51' G.S.C. The present W.L.(10:30 a.m.) was 10.41' G.S.C. The recorded H.W.M. is assumed to be incorrect here and a more positive level was recorded downstream.

The H.W.M. in Coquitlam River was recorded with a galvanized nail driven into the north side of the second power pole, downstream of the intersection of the Barn access road and east dyke. This pole is the only one in the vicinity fixed with a guy-wire.

The H.W.M. on the east pump house, which was flooded out, was 12.45' on pumphouse gauge, the present water level is 8.70'. In G.S.C. datum H.W.M. is 13.55 and present level is 9.80 (10.45 a.m.).

Some 200' downstream of the east pumphouse the flood water had come on top of the dyke, however, since the top sloped to the east no complete overtopping occurred.

Some 200' downstream of the wooden bridge the dyke had been breached intentionally by the Essondale work crews on Sunday, January 15, 1961 to allow flood water back into the river. This was done not only to prevent flooding of the land between the south end of the field and the Fraser but also to prevent overtopping of dyke between pumphouse and bridge. The high water was within 1' of the floor of the new barn just prior to cutting.the dyke.

On the bridge upstream of the cut in the dyke the H.W.M. in the river was 1.65' below top of cap on first bent from west end of bridge. The water level at 11:00 a.m. was 4.25' below top of same cap.

The west dyke appeared in good order with both pumps operating. Some small patches of water were noted in the fields behind the west dyke but it was assumed that this would be normal at this time of the year.

The breaks in the dyke were then examined. The west 1000' of dyke that runs east over to Mary Hill appears to be the low section in the east dyke system and it was this section that failed during the flood. Examination of the well compacted material in the dyke would indicate that overtopping occurred first over a 1000' section then the water cut back through the dyke to form 4 separate channels each approximately 75' wide. This was later confirmed by a member of the Essondale Public Works staff.

The damage then in this part of the lower Coquitlam River consisted of losing a few hundred feet of dyke and drowning out the east pump and pumphouse. There was no evidence of flooded homes or barns requiring evacuation as flood waters were successfully contained in the large field between the east dyke and Mary Hill.

THO/pd
February 2, 1961.

T.H. Oxland,
Hydraulic Engineer.

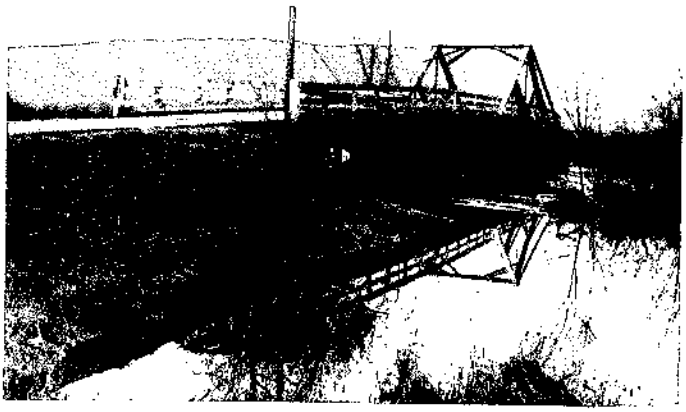
MAPLE RIDGE PARK PICNIC SITE. IN THE RIGHT BACKGROUND THE BRIDGE ON 14th AVE. OVER THE SOUTH ALOUETTE RIVER. PICTURE TAKEN FACING SOUTH.

MAPLE RIDGE PARK. THE BRIDGE OVER THE SOUTH ALOUETTE RIVER. PICTURE TAKEN FROM THE UPSTREAM SIDE OF THE NORTHERN APPROACH.

Approx. Hwy

MAPLE RIDGE PARK ENTRANCE FROM 14th AVE. PICTURE TAKEN FROM 14th AVE. FACING U. STREAM, (EAST).

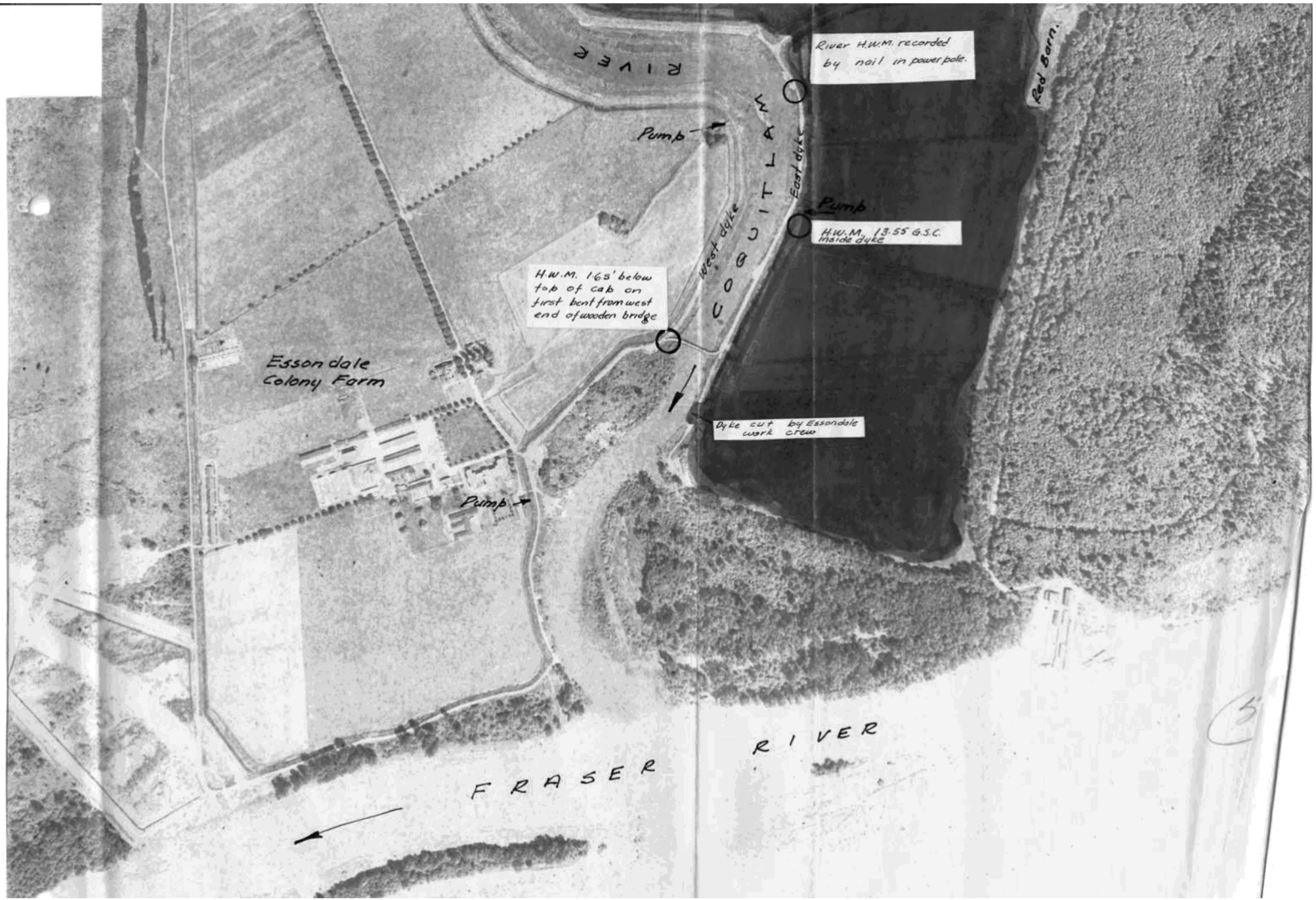
MAPLE RIDGE PARK. VIEW FACING NORTH ALONG 14th AVE TOWARDS THE BRIDGE OVER THE NORTH ALOUETTE RIVER. NOTE THE WINDROW OF SAND ON EITHER SIDE OF THE ROADWAY OPPOSITE THE VEHICLES.

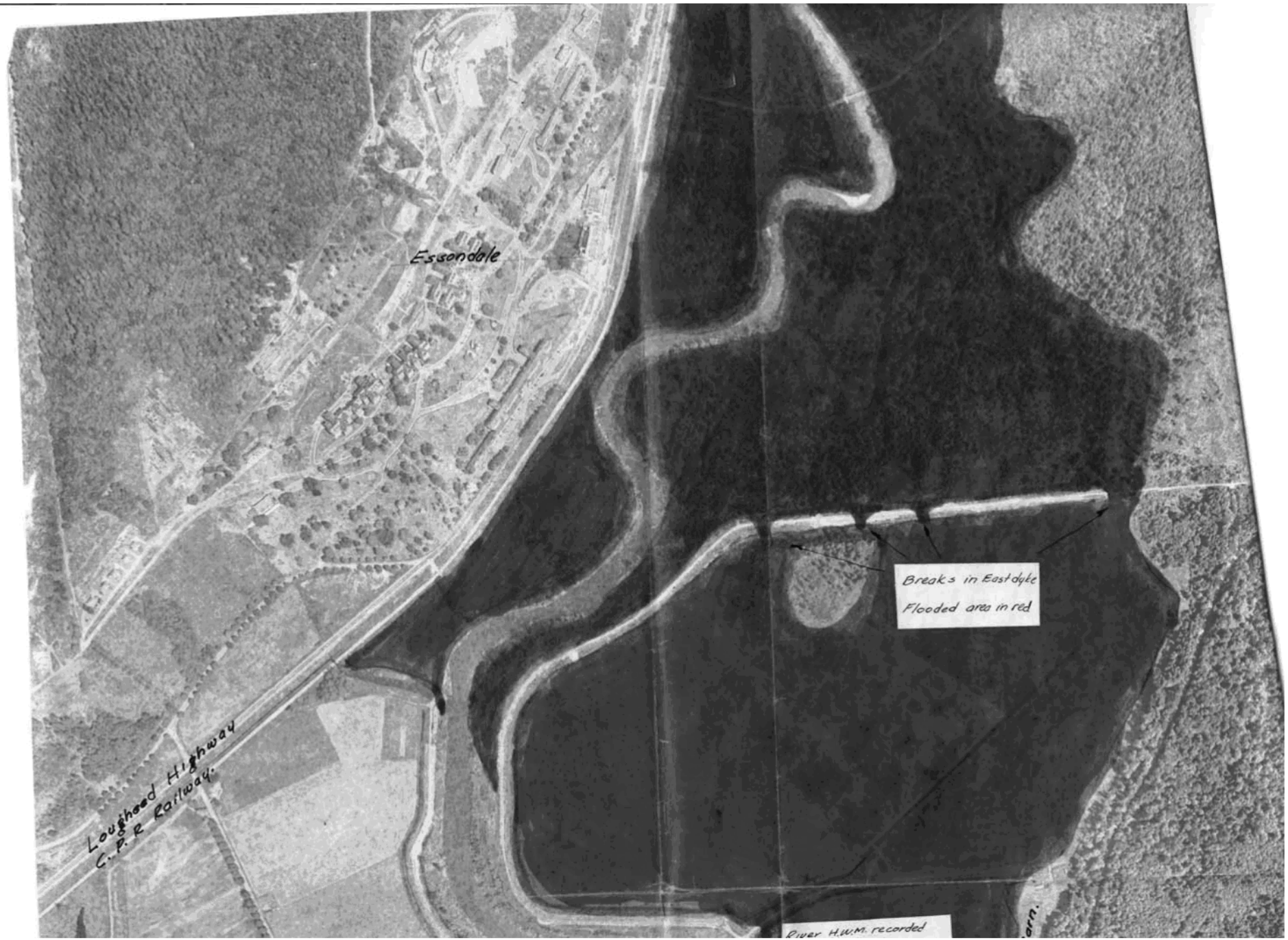


BRIDGE OVER THE SOUTH ALOUETTE RIVER ON MEADOWS ROAD. PICTURE TAKEN FROM THE SOUTH UPSTREAM BANK. H.W.M. 13.06 G.S.C.

...LE RIDGE DISTRICT. VIEW LOOKING SOUTH FROM THE DEWDNEY TRUNK ROAD JUST EAST OF THE INTERSECTION OF THE DEWDNEY TRUNK ROAD AND McKENCHNIE ROAD. WATER LEVEL IN FIELD IN FOREGROUND 4.29 G.S.C.

MAPLE RIDGE DISTRICT. VIEW LOOKING NORTH FROM DEWDNEY TRUNK ROAD FROM SAME POSITION AS IN PICTURE ABOVE. PITT POLDER IN THE BACKGROUND.


RIVER
COQUITLAM
Pump
East dyke
Pump
West dyke
River H.W.M. recorded by nail in power pole.
Red Barn.
H.W.M. 13.55 G.S.C. inside dyke
H.W.M. 1.65' below top of cap on first bent from west end of wooden bridge
Essondale Colony Farm
Dyke cut by Essondale work crew
Pump
FRASER
RIVER


Essondale
Breaks in East dyke
Flooded area in red
Loughheed Highway
C.P.R. Railway
River H.W.M. recorded