KOOTENAY LAKE POST CORRA LINN FLOW COMPUTATION

by

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December 4, 1979

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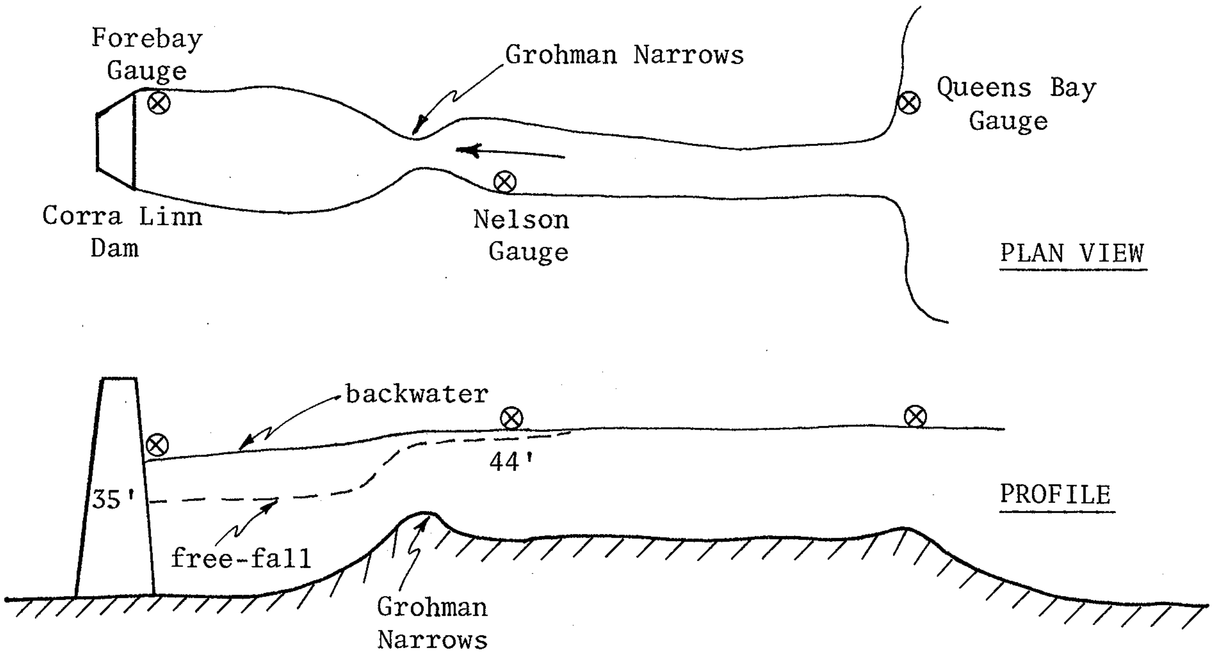
General Description

One of the major purposes of annual Columbia pre-project computations is to define the amount of peak flow reduction due to regulation by the Treaty projects. The Columbia SIMPAK Model described in the mannual entitled "Application of SIMPAK Program to the Columbia River Basin" (WP&M Library #524-7) produces pre-project flows under natural conditions, that is, without any flow regulation through the basin. However the Corra Linn Dam controlling Kootenay Lake was constructed in 1932 (with the Grohman Narrows excavated) before the Treaty projects and provides some flow regulations. Therefore it is necessary to route the pre-project flow through Kootenay Lake with regulation by Corra Linn Dam to determine what the peak stages at Kootenay Lake and at Trail would have been if only the Treaty projects were deleted. The differences between these values and the observed values represent the effect of the Treaty projects.

The regulation of Kootenay Lake isn't only dictated by the physical constraints of the Corra Linn Dam and Grohman Narrows, it is further complicated by the operation of the lake in accordance with IJC order of Approval (See Exhibit 1) which is administered by the Kootenay Lake Board of Control. Therefore the purpose of this write-up is to clarify the various lake outflow conditions due to physical restrictions and pre-specified regulation objectives.

Grohman Narrows

Grohman Narrows, immediately downstream of town of Nelson, serves as the bottleneck for Kootenay Lake outflow. The Narrows was first excavated around 1930 and prior to the construction of the Corra Linn Dam in order to increase the Kootenay Lake outflow capacity. Subsequently more excavation was done in 1939-40. However the excavations have not been able to relieve the bottleneck completely during flood season. Besides, the control of Corra Linn Forebay level can cause a variable backwater effect and thus reduce the lake outflow.



Pursuant to the IJC Order of Approval dated Nov. 11, 1938, the levels of Kootenay Lake are to be lowered during each flood season by definite minimum amounts below the levels that would have occurred had there been no modification of flow conditions by Corra Linn Dam or channel excavations at Grohman Narrows, i.e., under the outlet conditions of 1929, referred to as "original outlet" conditions. To comply with the IJC Order yet allow more efficient operation of the Corra Linn power plant, the forebay elevations are maintained at levels which provide discharge either under free-fall, representing the maximum outflow possible, or sufficient to meet the requirements for lake lowerings.

It should be noted that the storage in Corra Linn forebay is very small and can be drawn down to the desired level in a few hours. It is also noted that outlet capacity of Corra Linn Dam is large enough to pass maximum flow through the Grohman Narrows.

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Free-fall and Backwater Conditions

As described previously, Grohman Narrows acts as a section control at the outlet of Kootenay Lake. The difference between gauge heights at Nelson and forebay determine the head on this control. If the sluice gates at Corra Linn Dam are open sufficiently to eliminate backwater at the control, it is possible to establish a simple stage-discharge relation. This is called free-fall rating. The free-fall curve is a limiting curve which represents the maximum discharge possible at a given lake stage.

With fewer sluice gates open and backwater present on the control at Grohman the discharge varies with the fall in water surface between Nelson and Corra Linn as well as on the stage at Nelson. A rating under backwater conditions involving stage, fall and discharge can be represented by a multiple-correlation rating consisting of several relation curves.

The West Kootenay Power & Light Company has usually operated Corra Linn Dam so that the forebay would be at about 1735 feet during times of real flood threat in order to assure local residents that the maximum possible outflows from Kootenay Lake were being maintained. Since the completion of the Libby Dam upstream this flood threat has diminished significantly due to the regulation provided by the Libby storage. It should be noted that any lowering of the forebay elevation below that required for free-fall has no measureable effect in increasing the outflow from the lake.

For the Kootenay Lake pre-project post Corra Linn flow computation carried out by this office, the free-fall condition is adopted during flood season so as to be as close to actual operation as possible.

Method for Discharge Calculations

The methodology presented herewith for discharge calculation is applicable to both free-fall and backwater conditions. During 1969 a study of Multiple Correlation on Kootenay River at Grohman Narrows was carried out by this office. (Refer to CK1-H.W7) The correlation study was based on Queens Bay stages, Corra Linn stages and Grohman flow measurements. Using these data, the pertinent computations were performed to develop the following three curves:

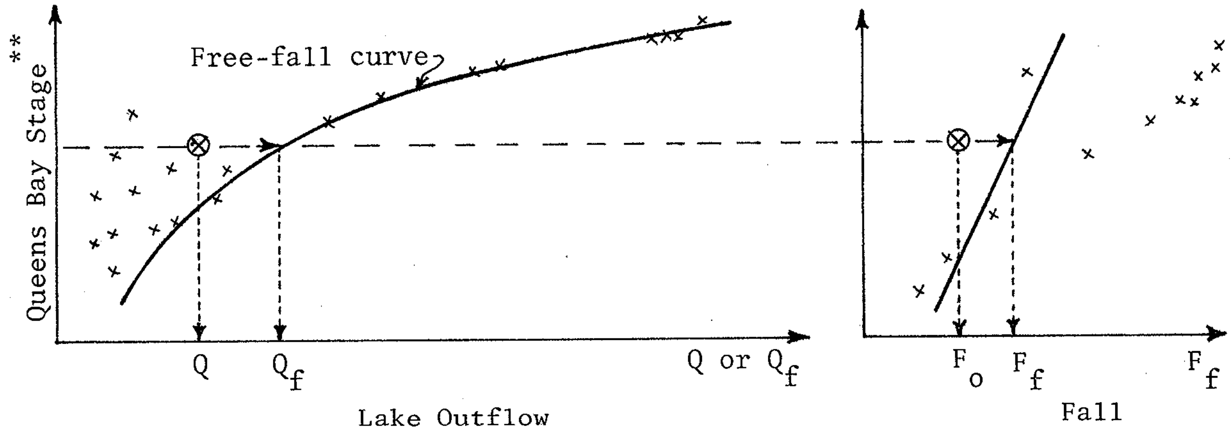
(1) Queens Bay stage vs. measured and adjusted discharge (Q_0, Q_f)

(2) Queens Bay stage vs. fall (F_f)

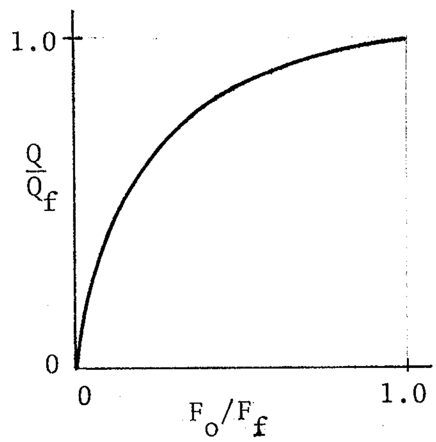
(3) Fall ratio vs. discharge ratio (J_f), i.e. $\frac{Q_o}{Q_f}$ vs. $\frac{F_o}{F_f}$

where F_0 is measured partial fall between Queens Bay and Corra Linn forebay.

The above three curves are illustrated as follows:



These relations are applicable only when the observed fall is greater than 0.4 ft. When the observed fall exceeds free-fall, the discharge ratio is 1.000.



** In a report entitled "Development of the Discharge Curve for Kootenay River at Grohman B.C., under Present Conditions" (WP&M Library #CK1-HF.2) by Waananen and Patterson, a similar type of study was conducted but with Nelson rather than Queens Bay gauge as base gauge.

To estimate Kootenay Lake outflow:

(i) For free-fall conditions: the free-fall curve or discharge table is used directly.

(ii) For backwater conditions:
- enter Nelson stage onto free-fall discharge curve to obtain Q_f
- enter Nelson stage onto stage-fall curve to obtain F_f
- with observed fall F_o known, the fall ratio F_o/F_f can be computed. This value is then entered onto the ratio curve to obtain discharge ratio Q/Q_f
- with Q_f and discharge ratio known, the lake outflow Q can be computed:

$$Q = Q_f \times \text{discharge ratio}$$

Columbia Pre-project Post Corra Linn Flow Computation

As described previously the Columbia SIMPAK Model produces pre-project flows under the natural condition. To take into consideration the effect of the construction of Corra Linn Dam and the associated excavation at Grohman Narrows, a computation procedure was set up to accept Kootenay Lake pre-project inflow as input and to compute Kootenay Lake routing under post Corra Linn conditions. The computation was done each year for the flood season starting on May 1.

During the flood season, Corra Linn Dam is operated in order to produce a free-fall, or maximum, discharge from the lake. An assumption is made for the computation that the initial outflow on May 1 is under free-fall condition. This may not be true for some years. However, after routing inflows through the lake for a few days the lake outflow and elevation will converge on the rising limb of free-fall hydrographs. May 1 beginning-of-day stage at Queens Bay is obtained from WSC record and used as input for this computation.

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Prior to 1976 the pre-project post Corra Linn flow computation was carried out manually by this office using WSC computation Form R-167 (see Exhibit 5). With beginning-of-day Queens Bay elevation (col. 3) known for May 1, the pre-project flows (col. 7) computed by the Columbia SIMPAK Model were routed through the lake by using trial and error procedures as follows:

(1) Assume a value for stage change during the day and compute mean stage for the day (col. 2)

(2) Compute equivalent storage change (col. 5) = stage change x (cfs/0.01')

(3) Assuming free-fall condition, enter mean stage to discharge table dated 16 April, 1969 to obtain lake discharge (col. 6)

(4) Calculate inflow by summing col. 5 and col. 6. If the computed inflow (figure in bracket) is within the allowable range of accuracy with pre-project flow, then the assumed value is correct and the computation is carried on to beginning-of-day stage for next day.

(5) If the computed inflow is not within the allowable range of accuracy with pre-project flow, then the assumed value has to be adjusted up or down accordingly and steps (1) to (4) should be repeated.

The manual routing by trial and error procedures described above is tedious and time-consuming work. Since the SIMPAK program can handle the lake routing more efficiently, a smaller model (see Exhibit 7) was set up in 1976 for Kootenay Lake pre-project post Corra Linn flow computation using the same May 1 initial condition described above.

The tables used in the pre-project flow computations, both pre and post Corra Linn, are given as follows:

(1) Kootenay Lake discharge table dated 1941 (see Exhibit 2).
This table is based on Queens Bay elevation and original outlet condition of the Grohman Narrows. The table is used by the Columbia SIMPAK Model for pre-project flow computation.

(2) Kootenay Lake free-fall discharge table dated 16 April, 1969 (see Exhibit 3).
This table is based on Queens Bay elevation and post Corra Linn condition (excavation at Grohman Narrows). The table is used only for free-fall conditions. This table is used by the smaller model for post Corra Linn flow computation.

(3) Kootenay Lake storage table dated March 24, 1969 (see Exhibit 4).
This table is based on Queens Bay elevation. The table is used in both computations noted in (1) and (2) above.

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WSC Kootenay Lake Storage Computation

The computation is done by WSC on Form R-167 Kootenay Lake Storage Computation, Sheet No. "A" (see Exhibit 6). We obtain the computation sheets from WSC every year in order to get May 1 beginning-of-day Queens Bay elevation for lake routing and to get the observed peak stage for comparison purposes.

With observed Queens Bay elevations and Corra Linn outflows recorded in cols. (2) and (6) respectively, the total inflows regulated by Duncan Dam and Libby Dam are computed and recorded in col. (7). The computation from col. (8) to (11) is used to obtain the lake stage under 1929 conditions (col. 9) and maximum allowable lake stage under IJC Order (col. 10). The details of the computation procedures are given in WP&M work data file under #CK1-A.W1. Columns (2), (9) and (10) can be expressed by the hydrographs (6), (4) and (5) described in the next chapter.

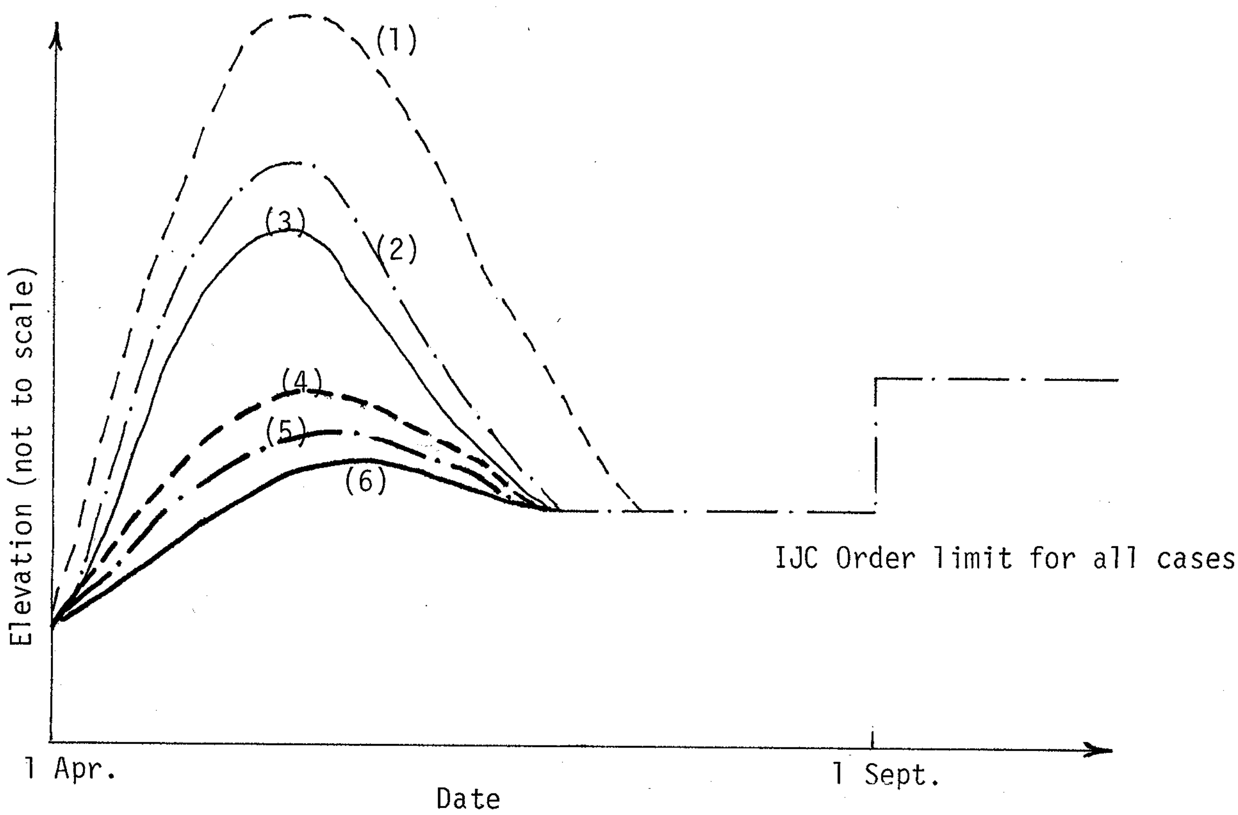
Comparison of Stages and Discharges Under Various Conditions

The 1979 peak stage and discharge for: (a) pre-project and original outlet condition; (b) pre-project but post Corra Linn under free-fall condition; (c) present condition with free-fall discharge; are given in the following table for comparison. It should be noted that all stages in the table are end-of-day stages at Queens Bay.

	(a) Pre-project Condition		(b) Post Corra Linn Condition		(c) Present Condition	
Day (June)	Stage (ft)	Discharge (cfs)	Stage (ft)	Discharge (cfs)	Stage (ft)	Discharge (cfs)
4	1752.16	65,690	1748.71	65,653	1743.42	35,000
5	52.48	67,329	49.05	67,344	43.57	35,600
6	52.77	69,336	49.35	69,439	43.65	36,000
7	→ 52.85	70,545	→ 49.43	70,711	43.57	35,100
8	52.74	70,460	49.32	70,602	43.42	34,900
9	52.54	69,436	49.10	69,501	43.28	34,800
10	52.36	68,192	48.92	68,182	43.20	34,700
11	52.18	67,025	48.73	66,976	43.17	28,900
12	52.21	66,518	48.76	66,462	43.40	23,200
13	52.28	66,851	48.84	66,809	43.59	23,300
14	52.25	66,988	48.80	66,954	43.67	23,400
15	52.10	66,408	48.65	66,363	43.68	23,300
16	51.87	65,199	48.41	65,115	43.69	22,800
17	51.58	63,559	48.11	63,394	43.66	23,100
18	51.35	61,941	47.88	61,707	43.69	23,700
19	51.20	60,768	47.73	60,517	43.78	23,300
20	51.05	59,853	47.58	59,606	43.80	23,500
21	50.92	58,995	47.45	58,752	→ 43.80	24,000
22	50.77	58,145	47.31	57,907	43.77	24,700
23	50.61	57,190	47.14	56,955	43.72	25,200
24	50.43	56,124	46.96	55,893	43.65	25,200
25	50.28	55,108	46.80	54,900	43.60	24,900

The various conditions are illustrated in the following diagram which shows the relative positions of the various hydrographs. The different hydrographs are:

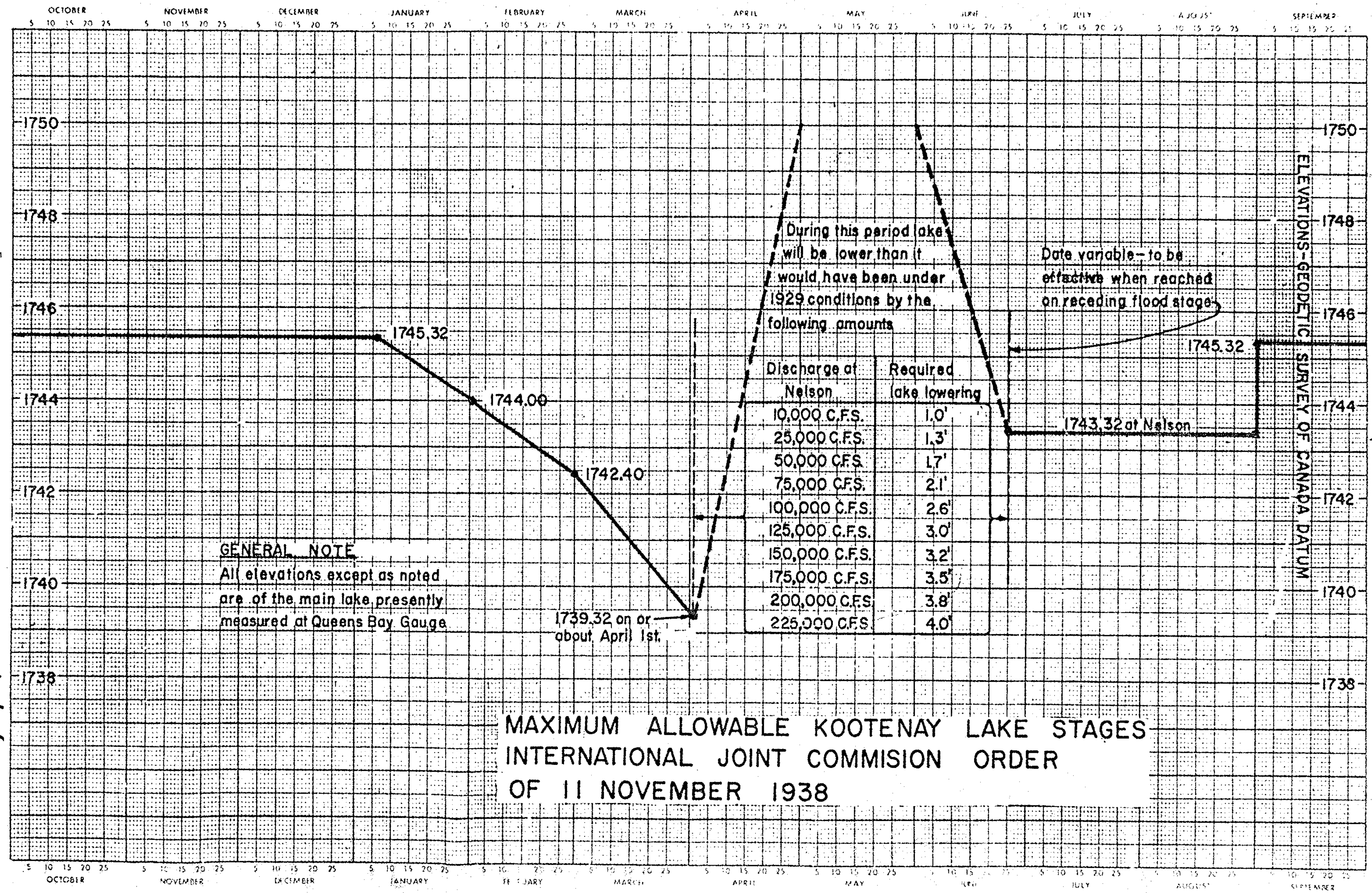
(1) Pre-Duncan, Pre-Libby and original outlet condition
(2) " " , post Corra Linn, IJC Order limits
(3) " " , " " " but operated under free-fall condition
(4) Post-Duncan, Post-Libby and original outlet condition
(5) " " , post Corra Linn, IJC Order limits
(6) " " , " " " but operated under free-fall condition



Note that (1) illustrates item (a) in the preceding table,
(3) " item (b) " " " " ,
(6) " item (c) " " " " .

Also note that observed hydrograph is somewhere between (5) and (6).

CK1-A.W1



Discharge at Nelson	Required lake lowering
10,000 C.F.S.	1.0'
25,000 C.F.S.	1.3'
50,000 C.F.S.	1.7'
75,000 C.F.S.	2.1'
100,000 C.F.S.	2.6'
125,000 C.F.S.	3.0'
150,000 C.F.S.	3.2'
175,000 C.F.S.	3.5'
200,000 C.F.S.	3.8'
225,000 C.F.S.	4.0'

Exhibit 1

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES WATER RESOURCES BRANCH

Stage-Discharge Table No. 6 for Kootenay River, Elevation at Queen's Bay, Flow at Corra Linn for conditions prior to 1930 (Virgin conditions) Station No.

Computed by T.M.P. Checked by T.M.P. Date 1941

G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs
.00			39.00	4900	180	41.00	9800	310	43.00	17100	410	45.00	26000	480
.10			.10	5080	190	.10	10110	320	.10	17510	420	.10	26480	480
.20			.20	5270	200	.20	10430	330	.20	17930	420	.20	26960	480
.30			.30	5470	200	.30	10760	330	.30	18350	420	.30	27440	490
.40			.40	5670	210	.40	11090	340	.40	18770	430	.40	27930	490
.50			.50	5880	210	.50	11430	340	.50	19200	430	.50	28420	490
.60			.60	6090	220	.60	11770	350	.60	19630	440	.60	28910	490
.70			.70	6310	220	.70	12120	350	.70	20070	440	.70	29400	500
.80			.80	6530	230	.80	12470	360	.80	20510	440	.80	29900	500
.90			.90	6760	240	.90	12830	370	.90	20950	450	.90	30400	500
38.00	3300	140	40.00	7000	250	42.00	13200	370	44.00	21400	450	46.00	30900	500
.10	3440	150	.10	7250	250	.10	13570	380	.10	21850	450	.10	31400	510
.20	3590	150	.20	7500	260	.20	13950	380	.20	22300	450	.20	31910	510
.30	3740	150	.30	7760	270	.30	14330	380	.30	22750	460	.30	32420	510
.40	3890	160	.40	8030	280	.40	14710	390	.40	23210	460	.40	32930	510
.50	4050	160	.50	8310	290	.50	15100	390	.50	23670	460	.50	33440	520
.60	4210	160	.60	8600	290	.60	15490	400	.60	24130	460	.60	33960	520
.70	4370	170	.70	8890	300	.70	15890	400	.70	24590	470	.70	34480	520
.80	4540	180	.80	9190	300	.80	16290	400	.80	25060	470	.80	35000	520
.90	4720	180	.90	9490	310	.90	16690	410	.90	25530	470	.90	35520	530

Remarks: Table copied from Table #6, Report 563 (WSC) 4/1941

To reduce above gauge heights to Geodetic Survey of Canada 1928 datum, add 1700 feet.

Period of Use:

Sheet 1 of 4

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Exhibit 2

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES WATER RESOURCES BRANCH

Stage-Discharge Table No. 6 for Kootenay River, Elevation at Queen's Bay Flow at Corra Linn for conditions prior to 1930 Station No. ....

Computed by T.M.P. Checked by T.M.P. Date 1941

G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs
47.00	36050	530	49.00	47100	580	51.00	59000	620	53.00	71700	660	55.00	85150	690
.10	36580	530	.10	47680	580	.10	59620	620	.10	72360	660	.10	85840	690
.20	37110	530	.20	48260	580	.20	60240	620	.20	73020	660	.20	86530	690
.30	37640	540	.30	48840	580	.30	60860	620	.30	73680	660	.30	87220	690
.40	38180	540	.40	49420	580	.40	61480	620	.40	74340	660	.40	87910	690
.50	38720	540	.50	50000	590	.50	62100	630	.50	75000	670	.50	88600	700
.60	39260	540	.60	50590	590	.60	62730	630	.60	75670	670	.60	89300	700
.70	39800	550	.70	51180	590	.70	63360	630	.70	76340	670	.70	90000	700
.80	40350	550	.80	51770	590	.80	63990	630	.80	77010	670	.80	90700	700
.90	40900	550	.90	52360	590	.90	64620	630	.90	77680	670	.90	91400	700
48.00	41450	550	50.00	52950	600	52.00	65250	640	54.00	78350	670	56.00	92100	700
.10	42000	560	.10	53550	600	.10	65890	640	.10	79020	670	.10	92800	700
.20	42560	560	.20	54150	600	.20	66530	640	.20	79690	680	.20	93500	710
.30	43120	560	.30	54750	600	.30	67170	640	.30	80370	680	.30	94210	710
.40	43680	560	.40	55350	600	.40	67810	640	.40	81050	680	.40	94920	710
.50	44240	570	.50	55950	610	.50	68450	650	.50	81730	680	.50	95630	710
.60	44810	570	.60	56560	610	.60	69100	650	.60	82410	680	.60	96340	710
.70	45380	570	.70	57170	610	.70	69750	650	.70	83090	680	.70	97050	710
.80	45950	570	.80	57780	610	.80	70400	650	.80	83770	690	.80	97760	720
.90	46520	580	.90	58390	610	.90	71050	650	.90	84460	690	.90	98480	720

Remarks: To reduce above gauge heights to Geodetic Survey of Canada, 1928 datum, add 1700 feet.

Table copied from Table #6, WSC Report 563 d/1941.

Period of Use: ....

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DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES WATER RESOURCES BRANCH

Stage-Discharge Table No. 6 for Kootenay River - Elevation at Queen's Bay Flow at Corra Linn for conditions prior To 1930 Station No.

Computed by T.M.P. Checked by T.M.P. Date 1941

G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs
57.00	99200	720	59.00	113850	750	61.00	129100	780	63.00	144950	810	65.00	161400	840
.10	99920	720	.10	114600	750	.10	129880	780	.10	145760	810	.10	162240	840
.20	100640	720	.20	115350	750	.20	130660	780	.20	146570	810	.20	163080	840
.30	101360	720	.30	116100	750	.30	131440	780	.30	147380	810	.30	163920	840
.40	102080	720	.40	116850	750	.40	132220	780	.40	148190	810	.40	164760	840
.50	102800	730	.50	117600	760	.50	133000	790	.50	149000	820	.50	165600	840
.60	103530	730	.60	118360	760	.60	133790	790	.60	149820	820	.60	166440	840
.70	104260	730	.70	119120	760	.70	134580	790	.70	150640	820	.70	167280	840
.80	104990	730	.80	119880	760	.80	135370	790	.80	151460	820	.80	168120	840
.90	105720	730	.90	120640	760	.90	136160	790	.90	152280	820	.90	168960	840
58.00	106450	730	60.00	121400	760	62.00	136950	790	64.00	153100	820	66.00	169800	850
.10	107180	730	.10	122160	760	.10	137740	790	.10	153920	820	.10	170650	850
.20	107910	740	.20	122920	770	.20	138530	800	.20	154740	830	.20	171500	850
.30	108650	740	.30	123690	770	.30	139330	800	.30	155570	830	.30	172350	850
.40	109390	740	.40	124460	770	.40	140130	800	.40	156400	830	.40	173200	850
.50	110130	740	.50	125230	770	.50	140930	800	.50	157230	830	.50	174050	850
.60	110870	740	.60	126000	770	.60	141730	800	.60	158060	830	.60	174900	850
.70	111610	740	.70	126770	770	.70	142530	800	.70	158890	830	.70	175750	850
.80	112350	750	.80	127540	780	.80	143330	810	.80	159720	840	.80	176600	850
.90	113100	750	.90	128320	780	.90	144140	810	.90	160560	840	.90	177450	850

Remarks:

To reduce above gauge heights To Geodetic Survey of Canada 1928 datum add 1700 feet.

Table copied from Table #6, WSC Report 563 d/1941

Period of Use:

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DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES WATER RESOURCES BRANCH

Stage-Discharge Table No. 6 for Kootenay River - Elevation at Queen's Bay Flow at Corra Linn for conditions prior To 1930 Station No.

Computed by T.M.P. Checked by T.M.P. Date 1941

G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs
67.00	178300	850	69.00	195600	880	71.00	213300		.00			.00		
.10	179150	860	.10	196480	880	.10			.10			.10		
.20	180010	860	.20	197360	880	.20			.20			.20		
.30	180870	860	.30	198240	880	.30			.30			.30		
.40	181730	860	.40	199120	880	.40			.40			.40		
.50	182590	860	.50	200000	880	.50			.50			.50		
.60	183450	860	.60	200880	880	.60			.60			.60		
.70	184310	860	.70	201760	880	.70			.70			.70		
.80	185170	860	.80	202640	880	.80			.80			.80		
.90	186030	870	.90	203520	880	.90			.90			.90		
68.00	186900	870	70.00	204400	890	.00			.00			.00		
.10	187770	870	.10	205290	690	.10			.10			.10		
.20	188640	870	.20	206180	890	.20			.20			.20		
.30	189510	870	.30	207070	890	.30			.30			.30		
.40	190380	870	.40	207960	890	.40			.40			.40		
.50	191250	870	.50	208850	890	.50			.50			.50		
.60	192120	870	.60	209740	890	.60			.60			.60		
.70	192990	870	.70	210630	890	.70			.70			.70		
.80	193860	870	.80	211520	890	.80			.80			.80		
.90	194730	870	.90	212410	890	.90			.90			.90		

Remarks:

To reduce above gauge heights To Geodetic Survey of Canada 1928 datum, add 1700 feet.

Table copied from Table #6. W.S.C. Report 563 d/1941.

Period of Use:

Sheet 4 of 4

CK-H.W7 R42 (1-62)

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES WATER RESOURCES BRANCH

Free Fall Stage-Discharge Table No. .... for ....

Kootenay R. at Corra Linn for Queens Bay Stage ...... Station No. ....

Computed by [illegible] ...... Checked by [illegible] ...... Date 16 April, 1969

see page 3 for 1738'–1739'

G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs
1739.00	17400	400	1741.00	25900	450	1743.00	34900	470	1745.00	44600	520	1747.00	55600	600
.10	17800	400	.10	26350	450	.10	35370	470	.10	45120	520	.10	56200	600
.20	18200	400	.20	26800	450	.20	35840	470	.20	45640	520	.20	56800	600
.30	18600	400	.30	27250	450	.30	36310	470	.30	46160	520	.30	57400	600
.40	19000	400	.40	27700	450	.40	36780	470	.40	46680	520	.40	58000	600
.50	19400	400	.50	28150	450	.50	37250	470	.50	47200	520	.50	58600	620
.60	19800	420	.60	28600	450	.60	37720	470	.60	47720	520	.60	59220	620
.70	20220	420	.70	29050	450	.70	38190	470	.70	48240	520	.70	59840	620
.80	20640	430	.80	29500	450	.80	38660	470	.80	48760	520	.80	60460	620
.90	21070	430	.90	29950	450	.90	39130	470	.90	49280	520	.90	61080	620
1740.00	21500	430	1742.00	30400	450	1744.00	39600	500	1746.00	49800	580	1748.00	61700	640
.10	21930	430	.10	30850	450	.10	40100	500	.10	50380	580	.10	62340	640
.20	22360	430	.20	31300	450	.20	40600	500	.20	50960	580	.20	62980	640
.30	22790	430	.30	31750	450	.30	41100	500	.30	51540	580	.30	63620	640
.40	23220	430	.40	32200	450	.40	41600	500	.40	52120	580	.40	64260	640
.50	23650	450	.50	32650	450	.50	42100	500	.50	52700	580	.50	64900	640
.60	24100	450	.60	33100	450	.60	42600	500	.60	53280	580	.60	65540	640
.70	24550	450	.70	33550	450	.70	43100	500	.70	53860	580	.70	66180	640
.80	25000	450	.80	34000	450	.80	43600	500	.80	54440	580	.80	66820	640
.90	25450	450	.90	34450	450	.90	44100	500	.90	55020	580	.90	67460	640

Remarks: Table is for free-fall conditions. NOT backwater conditions.

Period of Use:

Exhibit 3

Sheet 1 of 3

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES WATER RESOURCES BRANCH

Stage-Discharge Table No. .... for ....

Kootenay R. at Corra Linn for Queen's Bay Stage .... Station No. ....

Computed by ...[illegible]... Checked by ...[illegible]... Date 16 April 1969

G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs
1749.00	68100	670	1751.00	81800	720	1753.00	96300	770	1755.00	112000	840	1757.00	129000	920
.10	68770	670	.10	82520	720	.10	97070	770	.10	112840	840	.10	129920	920
.20	69440	670	.20	83240	720	.20	97840	770	.20	113680	840	.20	130840	920
.30	70110	670	.30	83960	720	.30	98610	770	.30	114520	840	.30	131760	920
.40	70780	670	.40	84680	720	.40	99380	770	.40	115360	840	.40	132680	920
.50	71450	670	.50	85400	720	.50	100150	770	.50	116200	840	.50	133600	920
.60	72120	670	.60	86120	720	.60	100920	770	.60	117040	840	.60	134520	920
.70	72790	670	.70	86840	720	.70	101690	770	.70	117880	840	.70	135440	920
.80	73460	670	.80	87560	720	.80	102460	770	.80	118720	840	.80	136360	920
.90	74130	670	.90	88280	720	.90	103230	770	.90	119560	840	.90	137280	920
1750.00	74800	700	1752.00	89000	730	1754.00	104000	800	1756.00	120400	860	1758.00	138200	930
.10	75500	700	.10	89730	730	.10	104800	800	.10	121260	860	.10	139130	930
.20	76200	700	.20	90460	730	.20	105600	800	.20	122120	860	.20	140060	930
.30	76900	700	.30	91190	730	.30	106400	800	.30	122980	860	.30	140990	930
.40	77600	700	.40	91920	730	.40	107200	800	.40	123840	860	.40	141920	930
.50	78300	700	.50	92650	730	.50	108000	800	.50	124700	860	.50	142850	930
.60	79000	700	.60	93380	730	.60	108800	800	.60	125560	860	.60	143780	930
.70	79700	700	.70	94110	730	.70	109600	800	.70	126420	860	.70	144710	930
.80	80400	700	.80	94840	730	.80	110400	800	.80	127280	860	.80	145640	930
.90	81100	700	.90	95570	730	.90	111200	800	.90	128140	860	.90	146570	930

Remarks: ....

Period of Use: ....

CK-H.107 R42 (1-62)

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES WATER RESOURCES BRANCH

Stage-Discharge Table No. .... for .... Koot. R. at Corra Linn for Queens Bay Stage Station No. ....

Computed by ..... MNP/GB ..... Checked by ..... MGW ..... Date ..... 16 April 1969

G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs	G.H. feet	Discharge cfs	Diff. cfs
1759 .00	147500	1000	1761 .00	167500	1000	1763 .00			.00			1738 .00	13500	300
.10	148500	1000	.10	168500	1000	.10			.10			.10	13800	400
.20	149500	1000	.20	169500	1000	.20			.20			.20	14200	400
.30	150500	1000	.30	170500	1000	.30			.30			.30	14600	400
.40	151500	1000	.40	171500	1000	.40			.40			.40	15000	400
.50	152500	1000	.50	172500	1000	.50			.50			.50	15400	400
.60	153500	1000	.60	173500	1000	.60			.60			.60	15800	400
.70	154500	1000	.70	174500	1000	.70			.70			.70	16200	400
.80	155500	1000	.80	175500	1000	.80			.80			.80	16600	400
.90	156500	1000	.90	176500	1000	.90			.90			.90	17000	400
1760 .00	157500	1000	1762 .00	177500	1000	.00			.00			1739 .00	17400	
.10	158500	1000	.10	178500		.10			.10			.10		
.20	159500	1000	.20			.20			.20			.20		
.30	160500	1000	.30			.30			.30			.30		
.40	161500	1000	.40			.40			.40			.40		
.50	162500	1000	.50			.50			.50			.50		
.60	163500	1000	.60			.60			.60			.60		
.70	164500	1000	.70			.70			.70			.70		
.80	165500	1000	.80			.80			.80			.80		
.90	166500	1000	.90			.90			.90			.90		

Remarks: ....

Period of Use: ....

Sheet ... 3 ... of 3

March 24, 1969.

WATER SURVEY OF CANADA

KOOTENAY LAKE STORAGE CONVERSION TABLE

Queen's Bay stage (elevation) and corresponding storage change for each 0.01 foot change in stage converted to cubic feet per second per day

Elev.	CFS Days	Elev.	CFS Days	Elev.	CFS Days
1738.0	527	1744.0	557	1750.0	588
.1		.1	558	.1	589
.2	527	.2	558	.2	589
.3	528	.3	559	.3	590
.4		.4	560	.4	591
.5		.5	560	.5	591
.6	528	.6	561	.6	592
.7	529	.7	562	.7	593
.8		.8	562	.8	593
.9	529	.9	563	.9	594
39.0	530	45.0	564	51.0	595
.1		.1	564	.1	595
.2	530	.2	565	.2	596
.3	531	.3	565	.3	596
.4		.4	566	.4	597
.5		.5	566	.5	597
.6	531	.6	567	.6	598
.7	532	.7	567	.7	598
.8		.8	568	.8	599
.9	532	.9	568	.9	599
40.0	533	46.0	569	52.0	600
.1		.1	570	.1	601
.2	533	.2		.2	602
.3	534	.3	570	.3	603
.4		.4	571	.4	604
.5		.5	571	.5	606
.6	534	.6	572	.6	607
.7	535	.7		.7	608
.8		.8	572	.8	609
.9	535	.9	573	.9	610
41.0	536	47.0		53.0	610
.1	536	.1	573	.1	611
.2	537	.2	574	.2	612
.3	537	.3	574	.3	612
.4	538	.4	575	.4	613
.5	538	.5	575	.5	613
.6	539	.6	576	.6	614
.7	539	.7	576	.7	614
.8	540	.8	577	.8	615
.9	540	.9	577	.9	616
42.0	541	48.0	578	54.0	617
.1	542	.1	578	.1	617
.2	542	.2	579	.2	618
.3	543	.3	579	.3	619
.4	544	.4	580	.4	620
.5	544	.5	580	.5	620
.6	545	.6	581	.6	621
.7	546	.7	581	.7	622
.8	546	.8	582	.8	623
.9	547	.9	582	.9	
43.0	548	49.0	583	55.0	
.1	549	.1	583	.1	623
.2	550	.2	584	.2	624
.3	551	.3	584	.3	624
.4	553	.4	585	.4	625
.5	554	.5	585	.5	625
.6	555	.6	586	.6	626
.7	556	.7	586	.7	626
.8	557	.8	587	.8	627
.9		.9	587	.9	627

Exhibit 4

Elev.	CFS Days	Elev.	CFS Days	Elev.	CFS Days
1756.0	627	1761.0	653	1766.0	670
.1	628	.1		.1	670
.2	628	.2	653	.2	671
.3	629	.3	654	.3	671
.4	630	.4		.4	672
.5	630	.5		.5	672
.6	631	.6	654	.6	673
.7	632	.7	655	.7	673
.8	632	.8		.8	674
.9	633	.9	655	.9	674
57.0	634	62.0	656	67.0	675
.1	635	.1		.1	
.2	635	.2	656	.2	675
.3	636	.3	657	.3	676
.4		.4		.4	
.5		.5		.5	
.6	636	.6	657	.6	676
.7	637	.7	658	.7	677
.8	637	.8		.8	
.9	638	.9	658	.9	677
58.0	639	63.0	659	68.0	678
.1	639	.1	659	.1	
.2	640	.2	660	.2	678
.3	640	.3	660	.3	679
.4	641	.4	661	.4	
.5	641	.5	661	.5	
.6	642	.6	662	.6	679
.7	642	.7	662	.7	680
.8	643	.8	663	.8	
.9	643	.9	663	.9	680
59.0	644	64.0	664	69.0	681
.1	644	.1		.1	681
.2	645	.2	664	.2	682
.3	645	.3	665	.3	682
.4	646	.4		.4	683
.5	646	.5		.5	683
.6	647	.6	665	.6	684
.7	647	.7	666	.7	684
.8	648	.8		.8	685
.9		.9	666	.9	685
60.0		65.0	667	70.0	
.1	648	.1			
.2	649	.2	667		
.3	649	.3	668		
.4	650	.4			
.5	650	.5			
.6	651	.6	668		
.7	651	.7	669		
.8	652	.8			
.9	652	.9	669		

Revised using Elev. 39.54 on May 1st

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES—WATER RESOURCES BRANCH

SHEET NO.________

R-167

KOOTENAY LAKE STORAGE COMPUTATIONS

(SHOWING TOTAL SUPPLY TO THE LAKE AND THE NET EFFECT OF THE OPERATIONS OF THE WEST KOOTENAY POWER AND LIGHT COMPANY, LTD., ON THE LEVELS OF THE LAKE AT QUEEN'S BAY)

Hand Routing Koot. L. Inflows (Pre Duncan, Pre Libby) thru Koot. L

YEAR 1975

MONTH May

NOTE: ADD 1700.00 TO REDUCE ELEVATIONS TO MEAN SEA LEVEL DATUM (G.S. OF CANADA)

DAY	ACTUAL CONDITIONS: ELEV. AT QUEEN'S BAY: MEAN FOR DAY	ACTUAL CONDITIONS: ELEV. AT QUEEN'S BAY: MIDNIGHT & CHANGE DURING THE DAY	ACTUAL CONDITIONS: EQUIV. CHANGE: CFS / 0.01'	ACTUAL CONDITIONS: EQUIV. CHANGE: CFS	ACTUAL CONDITIONS: DISCHARGE AT CORRA LINN IN CFS	Pre-project Inflow TOTAL SUPPLY IN CFS	ELEV. AT QUEEN'S BAY 1929 OUTLET CONDITIONS: MIDNIGHT & CHANGE DURING THE DAY	ELEV. AT QUEEN'S BAY 1929 OUTLET CONDITIONS: MEAN FOR DAY	QUEEN'S BAY MEAN DAILY STAGE: MAXIMUM ALLOWABLE	QUEEN'S BAY MEAN DAILY STAGE: DIFFERENCE (MAX. ALLOWABLE MINUS ACTUAL)	DAY
1	2	3	4	5	6	7	8	9	10	11	12
		39.54				(22870)	[illegible]				
1	39.57	+0.06	531	3190	19680	22600					1
		39.60				(24750)					
2	39.64	+0.09	531	4780	19970	24,700					2
		39.69				(27390)					
3	39.76	+0.13	532	6920	20470	27,700					3
		39.82				(30690)					
4	39.91	+0.18	532	9580	21110	30900					4
		40.00				(28690)					
5	40.06	+0.13	533	6930	21760	28500					5
		40.13				(30360)					
6	40.20	+0.15	533	8000	22360	30100					6
		40.28				(32700)					
7	40.37	+0.18	534	9610	23090	32700					7
		40.46				(33490)					
8	40.55	+0.18	534	9610	23880	33300					8
		40.64				(41010)					
9	40.79	+0.30	535	16050	24960	41200					9
		40.94				(47434)					
10	41.14	+0.39	536	20904	26530	47500					10
		41.33				(54920)					
11	41.58	+0.49	539	26410	28510	55100					11
		41.82				(64000)					
12	42.12	+0.61	542	33060	30940	64200					12
		42.43				(71580)					
13	42.78	+0.69	546	37670	33910	71700					13
		43.12				(74180)					
14	43.46	+0.67	554	37120	37060	74300					14
		43.79				(89250)					
15	44.22	+0.87	558	48550	40700	89500					15
		44.66				(99470)					
16	45.14	+0.96	564	54140	45330	99300					16
		45.62				(102130)					
17	46.08	+0.91	570	51870	50260	102000					17
		46.53				(99260)					
18	46.92	+0.77	573	44120	55140	99100					18
		47.30				(91930)					
19	47.58	+0.57	576	32830	59100	91700					19
		47.87				(82,828)					
20	48.05	+0.36	578	20808	62020	82900					20
		48.23				(69280)					
21	48.28	+0.10	579	5790	63490	69100					21
		48.33				(66260)					
22	48.35	+0.04	579	2320	63940	66000					22
		48.37				(65290)					
23	48.38	+0.02	580	1160	64130	65500					23
		48.39				(63550)					
24	48.38	-0.01	580	-580	64130	63300					24
		48.38				(61100)					
25	48.36	-0.05	580	-2900	64000	61100					25
		48.33				(54610)					
26	48.25	-0.15	579	-8690	63300	54600					26
		48.18				(52510)					
27	48.10	-0.17	578	-9830	62340	52700					27
		48.01				(52670)					
28	47.94	-0.15	577	-8660	61330	52500					28
		47.86				(57190)					
29	47.83	-0.06	577	-3460	60650	57000					29
		47.80				(68920)					
30	47.87	+0.14	577	+8080	60690	68900					30
		47.94				(84490)					
31	48.13	+0.38	578	+21960	62530	84400					31
		48.32									

Exhibit 5

DEPARTMENT OF THE ENVIRONMENT

WATER RESOURCES BRANCH – WATER SURVEY OF CANADA

SHEET NO. "A"

R-167

KOOTENAY LAKE STORAGE COMPUTATIONS

(SHOWING TOTAL SUPPLY TO THE LAKE AND THE NET EFFECT OF THE OPERATIONS OF THE WEST KOOTENAY POWER AND LIGHT COMPANY, LTD., ON THE LEVELS OF THE LAKE AT QUEEN'S BAY)

YEAR 1979

MONTH MAY

NOTE: ADD 1700.00 TO REDUCE ELEVATIONS TO MEAN SEA LEVEL DATUM (G.S. OF CANADA)

DAY	ACTUAL CONDITIONS					TOTAL SUPPLY IN CFS (Inflows)	ELEV. AT QUEEN'S BAY 1929 OUTLET CONDITIONS		QUEEN'S BAY MEAN DAILY STAGE		DAY
	ELEV. AT QUEEN'S BAY		EQUIV. CHANGE		DISCHARGE AT CORRA LINN IN CFS						
	MEAN FOR DAY	MIDNIGHT & CHANGE DURING THE DAY	CFS / 0.01'	CFS			MIDNIGHT & CHANGE DURING THE DAY	MEAN FOR DAY	MAXIMUM ALLOW-ABLE	DIFFER-ENCE (MAX. AL-LOWABLE MINUS ACTUAL)	
1	2	3	4	5	6	7	8	9	10	11	12
		38.95					42.12				
1	39.10	+0.29	530	+15,400	15,900	31,300	+0.32	42.28	41.20	+2.10	1
		39.24					42.44				
2	39.36	+0.25	531	+13,300	21,000	34,300	+0.35	42.62	41.52	+2.16	2
		39.49					42.79				
3	39.59	+0.20	531	+10,600	18,900	29,500	+0.23	42.90	41.78	+2.18	3
		39.69					43.02				
4	39.84	+0.29	532	+15,400	21,900	37,300	+0.35	43.20	42.05	+2.21	4
		39.98					43.38				
5	40.17	+0.38	533	+20,300	21,900	42,200	+0.41	43.58	42.40	+2.23	5
		40.36					43.79				
6	40.54	+0.37	534	+19,800	23,900	43,700	+0.41	44.00	42.79	+2.25	6
		40.73					44.20				
7	40.92	+0.38	535	+20,300	24,100	44,400	+0.38	44.39	43.15	+2.24	7
		41.11					44.58				
8	41.16	+0.09	537	+4,800	26,200	31,000	+0.12	44.64	43.39	+2.23	8
		41.20					44.70				
9	41.24	+0.09	537	+4,800	26,300	31,100	+0.11	44.76	43.49	+2.25	9
		41.29					44.81				
10	41.30	+0.01	537	+ 500	26,500	27,000	+0.03	44.82	43.55	+2.25	10
		41.30					44.84				
11	41.30	0	537	0	24,700	24,700	-0.01	44.84	43.57	+2.27	11
		41.30					44.83				
12	41.30	-0.01	537	- 500	27,100	26,600	+0.02	44.84	43.57	+2.27	12
		41.29					44.85				
13	41.29	0	537	0	26,600	26,600	+0.02	44.86	43.58	+2.29	13
		41.29					44.87				
14	41.31	+0.03	537	+1,600	26,500	28,100	+0.05	44.90	43.62	+2.31	14
		41.32					44.92				
15	41.36	+0.07	538	+3,800	27,100	30,900	+0.09	44.96	43.68	+2.32	15
		41.39					45.01				
16	41.49	+0.20	538	+10,800	27,100	37,900	+0.20	45.11	43.81	+2.32	16
		41.59					45.21				
17	41.66	+0.15	539	+8,100	28,000	36,100	+0.16	45.29	43.99	+2.33	17
		41.74					45.37				
18	41.80	+0.13	540	+7,000	28,300	35,300	+0.13	45.44	44.12	+2.32	18
		41.87					45.50				
19	41.91	+0.08	540	+4,300	28,400	32,700	+0.07	45.54	44.21	+2.30	19
		41.95					45.57				
20	41.97	+0.04	541	+2,200	30,000	32,200	+0.06	45.60	44.27	+2.30	20
		41.99					45.63				
21	42.02	+0.07	541	+3,800	30,000	33,800	+0.08	45.67	44.33	+2.31	21
		42.06					45.71				
22	42.10	+0.09	542	+4,900	30,700	35,600	+0.10	45.76	44.42	+2.32	22
		42.15					45.81				
23	42.24	+0.19	542	+10,300	30,500	40,800	+0.19	45.90	44.55	+2.31	23
		42.34					46.00				
24	42.50	+0.32	544	+17,400	31,500	48,900	+0.30	46.15	44.78	+2.28	24
		42.66					46.30				
25	42.80	+0.29	546	+15,800	33,400	49,200	+0.28	46.44	45.03	+2.23	25
		42.95					46.58				
26	43.12	+0.35	549	+19,200	34,400	53,600	+0.33	46.74	45.30	+2.18	26
		43.30					46.91				
27	43.46	+0.32	554	+17,700	34,800	52,500	+0.29	47.06	45.59	+2.13	27
		43.62					47.20				
28	43.66	+0.07	556	+3,900	36,800	40,700	+0.06	47.23	45.75	+2.09	28
		43.69					47.26				
29	43.66	-0.06	556	-3,400	36,400	33,000	-0.07	47.22	45.74	+2.08	29
		43.63					47.19				
30	43.56	-0.13	555	-7,200	36,100	28,900	-0.13	47.12	45.65	+2.09	30
		43.50					47.06				
31	43.42	-0.17	553	-9,400	35,400	26,000	-0.17	46.98	45.52	+2.10	31
		43.33					46.89				
				TOTAL:	870,400	1,105,900					
				MEAN:	28,100	35,700					

COMPUTED BY:

CHECKED BY: [illegible]

APPROVED BY: [illegible]

JUNE 1, 1979

Exhibit 6

~~FIGURE 2~~

Exhibit 7

THE SIMPAK MODEL FOR KOOTENAY LAKE POST CORRA LINN COMPUTATION