FEDERAL PROVINCIAL FLOODPLAIN MAPPING AGREEMENT

PROVINCE OF BRITISH COLUMBIA
Ministry of Environment
Lands and Parks

Water Management Division
Floodplain Management Branch

A DESIGN BRIEF ON THE

Floodplain Mapping Study

SKEENA AND BULKLEY RIVERS

AT HAZELTON

An overview of the study undertaken to produce Floodplain Mapping for the Skeena and Bulkley Rivers at Hazelton

Village of Hazelton - Government St. - 1936 High Water

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Victoria, British Columbia
January, 1993
File: 400-0000H

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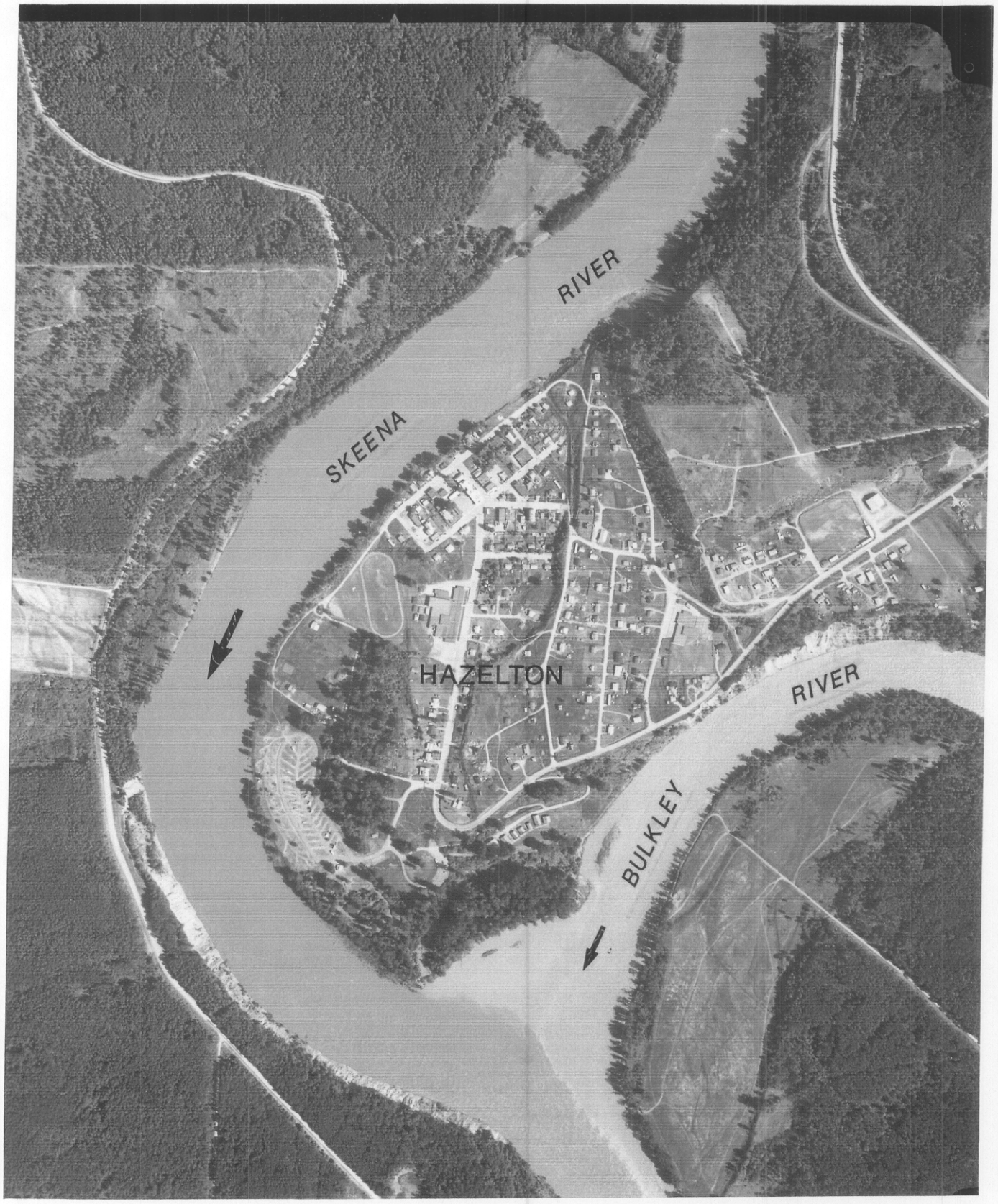

Province of British Columbia
Ministry of Environment, Lands and Parks
WATER MANAGEMENT DIVISION

TO ACCOMPANY A DESIGN BRIEF ON THE
FLOODPLAIN MAPPING STUDY
SKEENA AND BULKLEY RIVERS
AT HAZELTON
AIR PHOTO BCC 621 – 120

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DATE
JANUARY 1993

R.W. NICHOLS ENGINEER

FILE No 400-0000 DWG No .....

FLOODPLAIN MAPPING STUDY

SKEENA AND BULKLEY RIVERS AT HAZELTON

Preface

The purpose of this design brief is to present a description of the methodologies used and results of the study undertaken to delineate the floodplain of the Skeena and Bulkley Rivers at Hazelton, Drawing 91-1 sheet 1 (Appendix 4).

1. Background

The Village of Hazelton is situated at the confluence of the Skeena and Bulkley (originally known as Watsonquah) Rivers. Located at the end of the navigable waters of the Skeena, Hazelton served as a distribution point for the Omineca gold fields. In 1868 the settlement was officially established and its name derived from the abundance of hazel bushes growing in the area. Later, in 1881 a Hudson's Bay Co. trading post was established. (Appendix 1.1).

Since then, numerous flood events, both major and minor, have been recorded. These events are normally associated with Spring freshet flows, although occasional annual peaks have occurred in the fall. Water Survey of Canada flow records for the Skeena River at Glen Vowell (just upstream of the study area) have been maintained since 1960. The maximum recorded discharge occurred in 1972, although available data indicates that the highest flood level in the Village of Hazelton occurred in 1936.

Following the 1972 event, the Regional District of Kitimat - Stikine prepared a report documenting the damages and problems incurred throughout the area for various flood events (Appendix 1.3). In this report, flood levels and areas of inundation in the Village of Hazelton for the 1936 and 1972 events and have been estimated by the Regional District Staff.

Rock groynes were constructed in the upstream reach of the Skeena during the 1960's by the Village to counter the erosion effects of freshet flows. Over the years the effects of high flows has taken its toll on these structures. Reconstruction of the groynes took place after the 1972 flood event and continual maintenance has been required since then. Additionally, "Gabion" mat type bank protection has been added (Appendix 1.2) to help alleviate this bank erosion problem.

Appendix 2 contains 6 photographs of the subject area including 2 historical photos of the 1936 flood. The photos including the cover photo, were obtained by staff of the Regional Office in Smithers on August 18, 1992, as indicated in Appendix 1.5.

2. Present Studies

The 1992 studies undertaken to delineate the floodplain of the Skeena and Bulkley Rivers at Hazelton are based on the following information:

- Survey data obtained by the Surveys Section, Water Management Division, Project 91 11 F004, in May 1991 (Appendix 1.4) and includes cross sectional data, longitudinal profiles and information regarding monitoring cross sections on the Skeena and Bulkley Rivers (Drawing No. 91-26, Sheet 1).

- Topographic base mapping of the study area was issued in May 1988, by the Mapping Section, Surveys and Resource Mapping Branch, Project 86-036 NAD27. The mapping uses air photography obtained in 1986 and is at a 1:5000 scale with one metre contour intervals.

3. Location

The Village of Hazelton is located in the Cassiar Land District of British Columbia at the confluence of the Skeena and Bulkley Rivers. The Skeena River originates in the Skeena Mountains and flows in a generally southerly direction to Hazelton, which is located about 280 km from the headwaters. From this point the Skeena swings westward another 220 km to the Pacific Ocean for a total distance of about 500 km. The Bulkley River originates in the Nechako Plateau and flows generally northwest 180 km to its juncture with the Skeena River.

Figure 1 is a location plan of the study area. Figure 2 is a key map showing the location of the floodplain mapping sheet for the study area at a 1:250,000 scale.

The drainage area of the Skeena River at Hazelton is 25,900 km2 and for the Bulkley River at Hazelton is 12,300 km2 giving a combined total of 38,200 km2 (Appendix 3).

4. Designated Flood

In accordance with the policy of the Ministry of Environment, Lands and Parks, the flood levels and floodplain limits shown on the floodplain mapping sheets are based on a designated (1:200 year frequency) flow plus an allowance for hydraulic and hydrologic uncertainties. At Gauge 08EB003 - Skeena River at Glen Vowell (no longer active) the estimated designated (daily) flow is 6432m^3/s. For Gauge 08EE001 - Bulkley River at Hazelton (no longer active) the estimated 1:200 year daily flow is 1654m^3/s. Section 5 provides a further discussion regarding estimated flows for the study area.

5. Flood Magnitudes

As stated in Appendix 3, the Skeena River is one of the major rivers of British Columbia's north coast. Its watershed is quite mountainous and drains the Coastal Mountains, the Skeena Mountains and a portion of the Nechako Plateau. The major portion of the annual runoff is the result of melting of the annual snowpack. The annual peak flows also show the impact of snowmelt with most of the annual peaks occurring in May or June. However, occasional winter storms producing heavy warm rain falling on a shallow snowpack do cause flooding problems but this is mostly confined to the tributaries near the mouth of the Skeena. On rare occasions these winter storms do cross the Coast Mountains and produce an annual peak in October or November on the upstream tributaries as well.

Gauge 08EF001 - Skeena River at Usk and Gauge 08EE004 - Bulkley River at Quick are the only gauges currently in operation and provide 57 and 61 years of daily flow data respectively. Gauge 08EB003 - Skeena River at Glen Vowell operating from 1961 to 1985 and Gauge 08EE001, Bulkley River near Hazelton, operating during the years from 1928 to 1932, and 1935 to 1941, inclusive, were also used in the studies. The Hydrology Section Report, Appendix 3, outlines the study undertaken to determine the peak flows at Hazelton.

Following is a summary of the estimated daily and instantaneous flows used in the study which is taken from Table 2 of Appendix 3.

Peak Daily and Instantaneous Discharge

			Bulkley R.	Skeena R.	Skeena R.
drainage area		km2	@ mouth 12,300	@ Glen Vowell 25,900	below Bulkley 38,200
200 year	daily	m3/s	1654	6432	7769
200 year	inst	m3/s	2018	6818	8002
20 year	daily	m3/s	1351	4892	5966
20 year	inst	m3/s	1648	5186	6145
June 1, 1936	daily	m3/s	1510	***	***
June 12, 1972	daily	m3/s	1493	5530	6946
June 12, 1972	inst	m3/s	***	5860	7293
May 10, 1991	daily	m3/s	668	1257	1832

6. Hydraulic Analyses

6.1 General

The information sources listed in Appendix 1 and 3 were utilized in the HEC-2 water surface profile computer program, version 6.4, developed by the Hydrologic Engineering Centre, U.S. Army Corps of Engineers in Davis, California. The flood profile studies assumed open channel flow conditions.

Flood profiles calculated for the Skeena and Bulkley Rivers in the study area are outlined as follows. A plot run of river cross sections was obtained. An assessment was made of the river channel survey data and cross section extensions which were obtained from the 1 metre contour topographic mapping. Output from the plot run was also used to review other data such as flow regime, loss coefficients, reach lengths, overbank information and relative Manning's "n" values.

6.2 Sensitivity studies

The total length of the Skeena River in the study area is 5.4 km. The average gradient of the flood profile in the study area is .12 percent. A total of 16 cross sections were used in this reach. The reach length of the Bulkley River is 2.3 km long. A total of 8 cross sections were used in this reach which has an average flood profile slope of .10 percent as shown in Figure 4. Water levels obtained from the May 10, 1991 survey were used to calibrate the model based on flow estimates listed in Section 5. Manning's "n" values for the channel varied from 0.027 in the lower reaches to 0.045 in the upper reaches (groyne area).

Sensitivity to discharge (Q) studies were made using estimated flows for the Q20 daily and instantaneous, Q200 daily and instantaneous and the Q200 instantaneous multiplied by a factor of 1.1. From these runs it was determined that the daily level + 0.6m dominates over the instantaneous level + 0.3m. The levels produced by the daily criteria, including the 0.6m allowance for uncertainties, generally yields a value equal to the levels produced by the 1:200 year instantaneous flow when multiplied by a factor of 1.1. Additional runs were made using the Q200 daily flows factored by 0.9, 1.0, 1.1 and 1.2. These runs indicate a general water level increase of about 0.4m for each 10% increase in "Q".

Sensitivity studies were also undertaken to determine the effect of increased Manning's "n" values on flood levels.

6.2 Sensitivity studies cont.

A comparative run using the Q200 daily flow and factored "n" values of 0.7, 0.85, 1.0 and 1.15 resulted in an average rise in levels of about 0.5m for each incremental increase in "n" value.

From these studies it was determined that the floodplain isrelatively sensitive to both "Q" and "n" changes as a result of the "U" shaped configuration of the valley in this area (see Figure 5). It was therefore decided to adopt a conservative approach and use the calibration "n" values multiplied by a factor of 1.15 combined with the "Q200" daily criteria to determine the flood levels.

At the request of Mr. Reid White, P.Eng., of the Smithers Regional Water Management Branch Office, a number of river cross sections surveyed in 1979 in the study area were re-surveyed in 1992. Figure 5 indicates data from sections 5 and 11 on the Skeena River for 1979 and 1991. This data is typical of the information obtained at 9 other sections in the area and available in the survey package (Appendix 1.4). The calculated flood levels are indicated on these sections. There appears to be no significant degradation/aggradation trend effecting flood levels.

Figure 3 and 4 are profiles showing the thalweg, surveyed water level, high water marks for the various flood events and flood level determined in the study for the Skeena and Bulkley Rivers respectively .

7. Floodplain Mapping

7.1 General

The designated flood levels determined in the study were used to delineate the floodplain limits onto the existing 1 metre contour mapping of the study area. The studies were based on the information noted in Section 2.

The floodplain mapping of the Skeena and Bulkley Rivers, Drawing 91-1 Sheet 1 (Appendix 4) was produced and provides the following information:
- the location of river cross sections
- the designated floodplain limits
- the flood levels determined in the study
- the location of survey monuments established in May 1991.

8. Conclusions

1. This design brief presents an overview of the studies undertaken to produce the floodplain mapping sheets of the Skeena and Bulkley Rivers at Hazelton.

2. The floodplain in the study area is relatively sensitive to changes in "Q" and "n" values due to the valleys "U" shaped configuration.

3. The limit of inundation during the 1936 flood event (Appendix 1.2) in the Village of Hazelton is equivalent to the designated floodplain limits shown on Drawing 91-1 Sheet 1.

9. Recommendations

1. It is recommended that the floodplain delineated on Drawing 91-1, Sheet 1, be designated under the terms of the Federal Provincial Floodplain Mapping Agreement.

2. The Drawing may be used for administrative purposes related to the preparation of hazard map schedules for official plans; floodproofing requirements in zoning and building bylaws; the designation of floodplains in floodplain management plans; and the identification of floodable land by Subdivision Approving Officers.

3. Flood level data from significant events such as occurred in 1972 and 1936 should be obtained in the Village area to provide future additional hydraulic model confirmation data.

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Flood Hazard Identification Section

RWN/sc

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TO ACCOMPANY A DESIGN BRIEF ON THE
FLOODPLAIN MAPPING STUDY
SKEENA AND BULKLEY RIVERS AT HAZELTON
STUDY AREA LOCATION

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DATE
JANUARY 1993

R.W. NICHOLS ENGINEER

FILE No. 400-0000 DWG No. FIGURE 1

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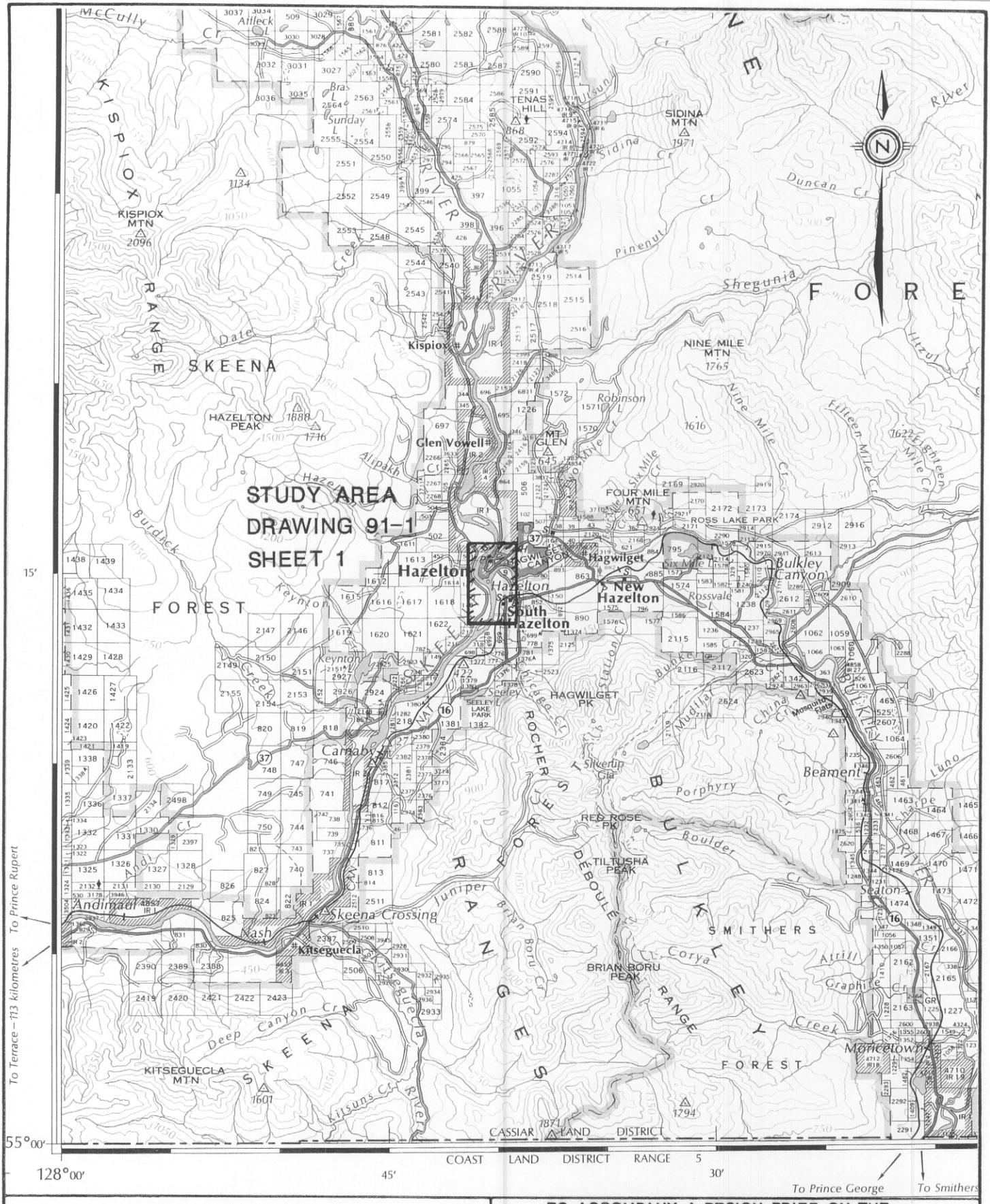

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TO ACCOMPANY A DESIGN BRIEF ON THE
FLOODPLAIN MAPPING STUDY
SKEENA AND BULKLEY RIVERS AT HAZELTON
KEY MAP

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DATE
JANUARY 1993

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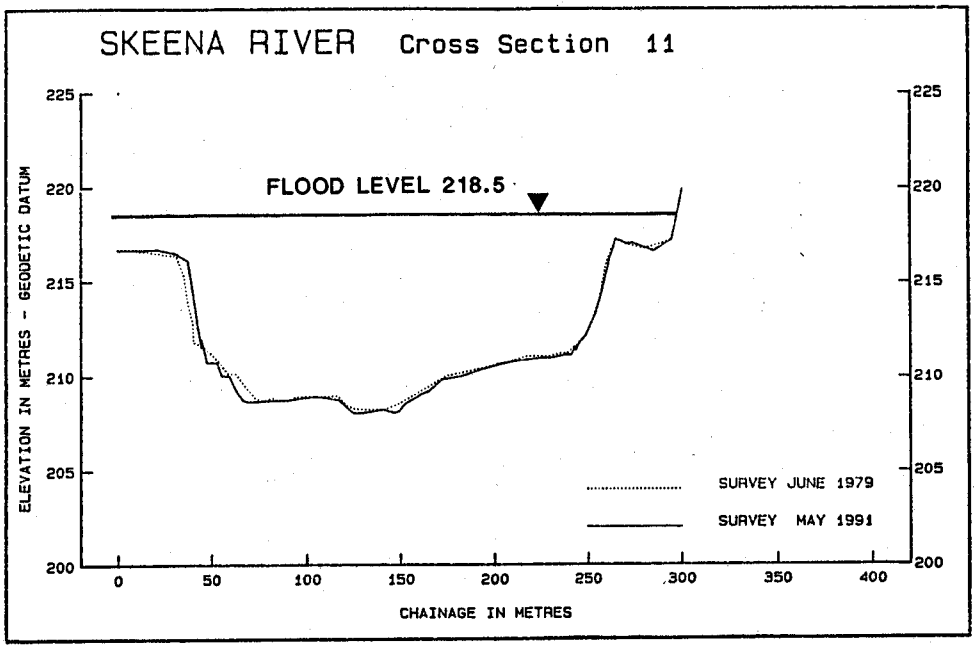
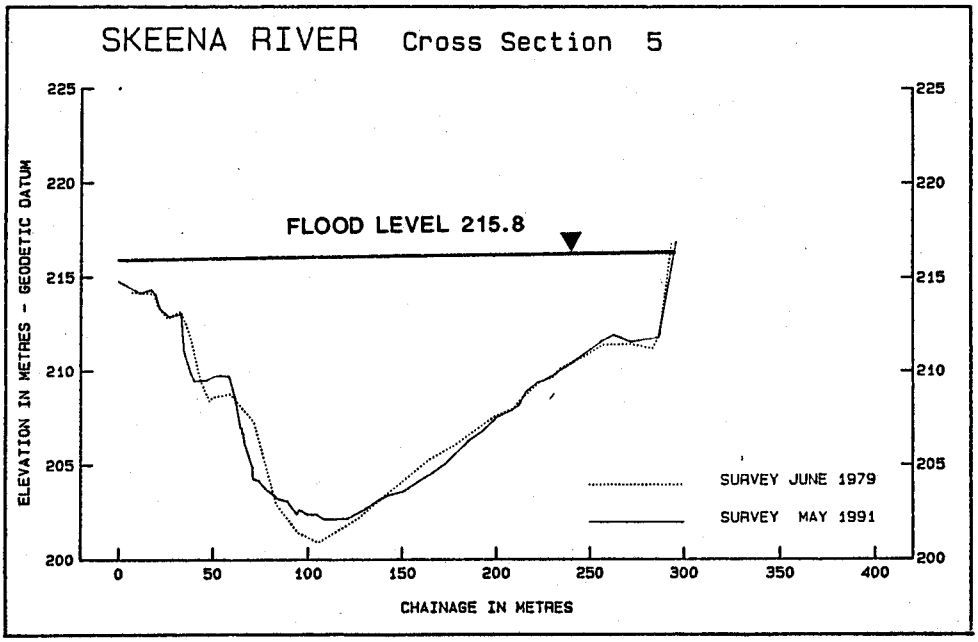
FILE No. 400-0000 DWG No. FIGURE 2

VAN CAL 15712





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TO ACCOMPANY A DESIGN BRIEF ON THE
FLOODPLAIN MAPPING STUDY
SKEENA AND BULKLEY RIVERS

SKEENA RIVER CROSS SECTIONS 5 AND 11

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JANUARY 1993

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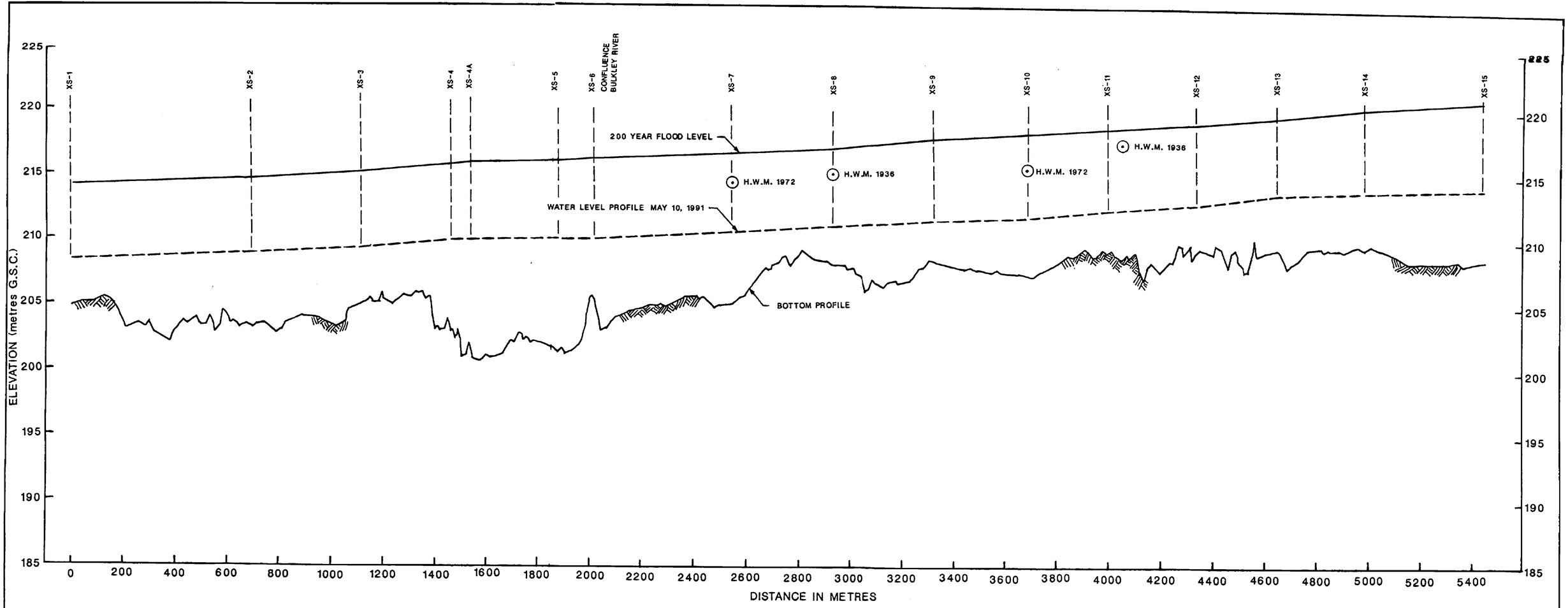
FILE No. 400-0000 DWG No. FIGURE 5

VAN CAL 15712



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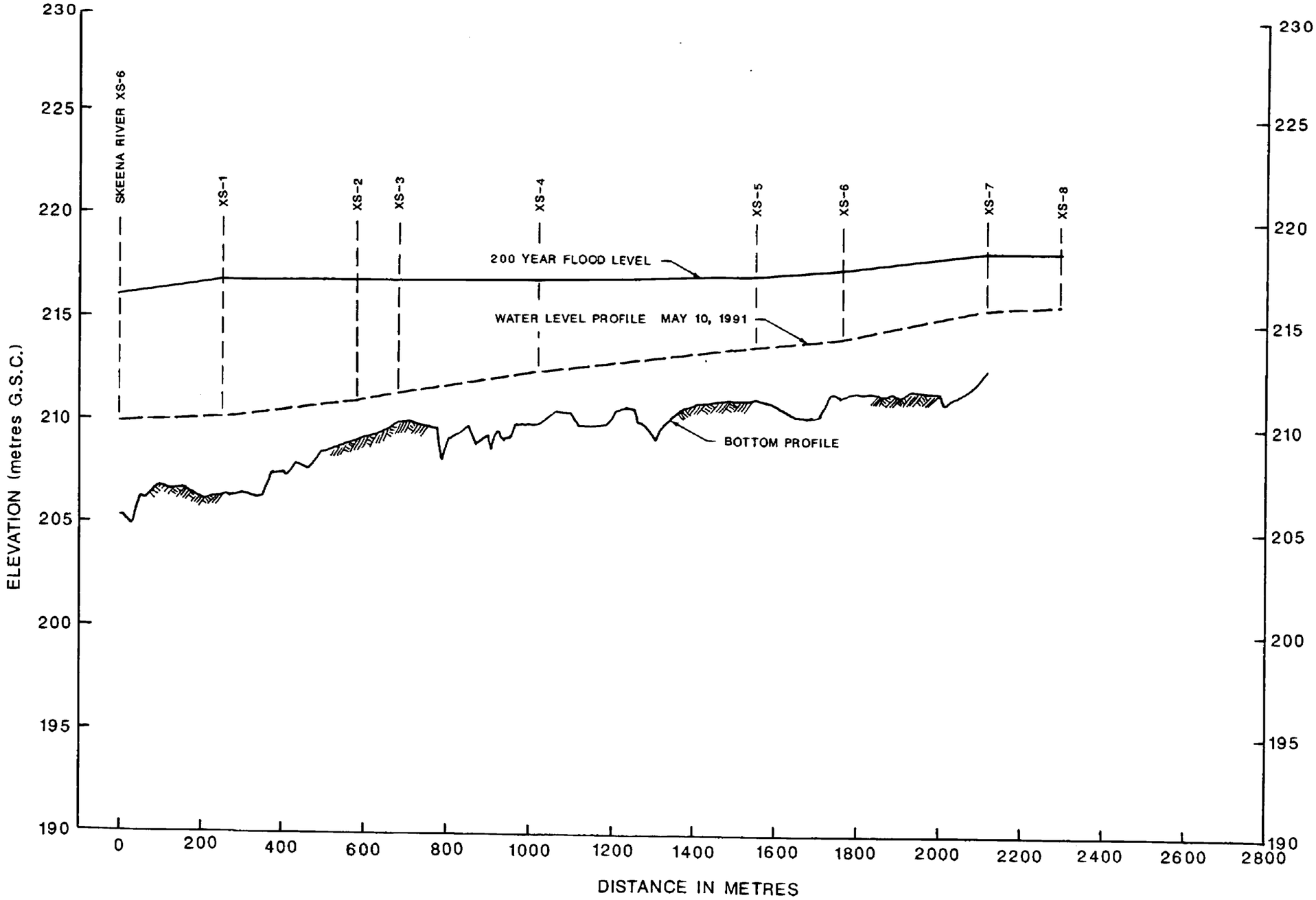
FLOODPLAIN MAPPING STUDY
SKEENA AND BULKLEY RIVERS
AT HAZELTON
SKEENA RIVER AT HAZELTON PROFILE

SCALE: VERT. 1:200
HOR. 1:10,000

DATE
JANUARY 1993

R.W. NICHOLS ENGINEER

FILE No. 400-0000 DWG No. FIGURE 3



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AT HAZELTON
BULKLEY RIVER AT HAZELTON PROFILE

SCALE: VERT. 1:200
HOR. 1:10,000

DATE
JANUARY 1993

R.W. NICHOLS ENGINEER

FILE No. 400-0000 DWG No. FIGURE 4

APPENDIX 1
Detailed Information Sources
Skeena and Bulkley Rivers
Floodplain Mapping Study

No.	Source	Contents
1	"The Skeena - river of destiny" R.G. Large, 1957	History of the Skeena Valley
2.	"Village of Hazelton - Skeena River Erosion Protection" Northwest Hydraulic Consultants Ltd.	Report on the history of erosion problems at Hazelton and remedial works.
3.	"Floodplain Study" Regional District of Kitimat-Stikine, 1974	Documentation of flood data of the Skeena watershed
4.	"Project No. 91 11 F004", May 1991, Surveys Section, Water Management Division, Ministry of Environment, Lands and Parks	1 Volume containing channel cross sections, high water elevations, thalweg and water level profiles and videotape of the cross sections.
5.	Booklet of Photos (19 pages) provided by Mr. Reid White, R.P. Bio, P.Eng, Smithers Regional Office, File 35100-01/Hazelton	Series of photos of Skeena and Bulkley Rivers at Hazelton obtained on August18, 1992.

APPENDIX 2
Skeena River at Hazelton
Floodplain Mapping Study
Photos of Study Area

SKEENA RIVER LOOKING DOWNSTREAM - GOVERNMENT STREET ON LEFT

SKEENA RIVER LOOKING UPSTREAM FROM XS 12

(All photos provided by Mr. Reid White, Smithers Regional Office)

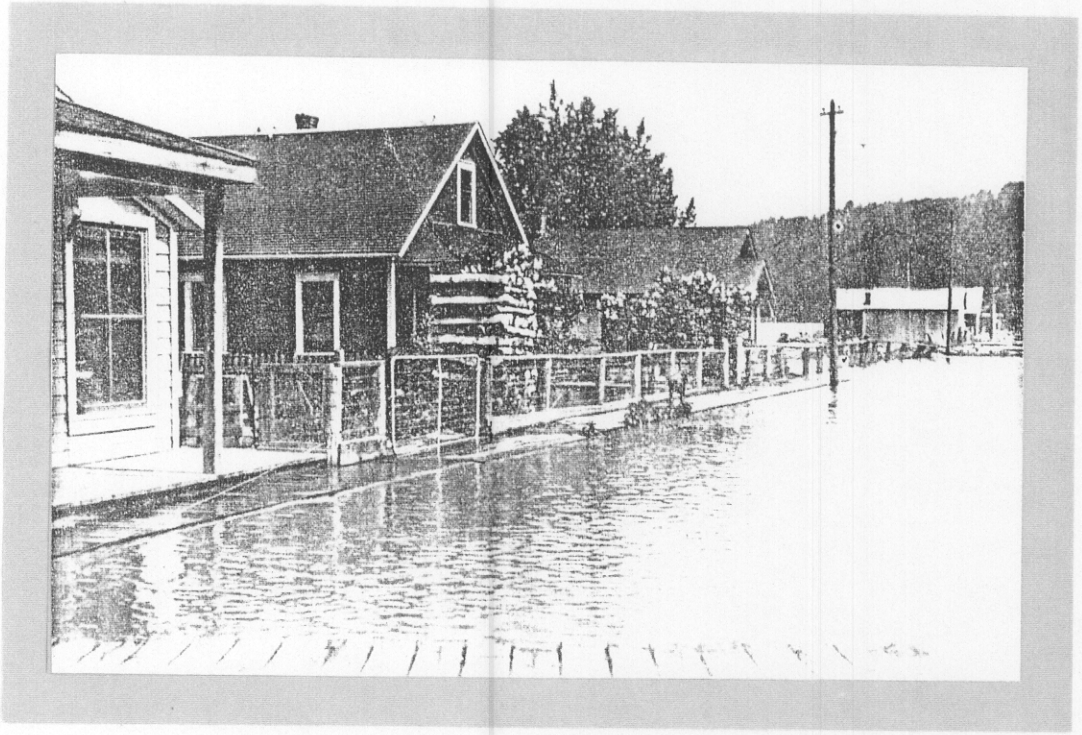
APPENDIX 2
Skeena River at Hazelton
Floodplain Mapping Study
Photos of Study Area

SKEENA RIVER LOOKING UPSTREAM FROM XS 11

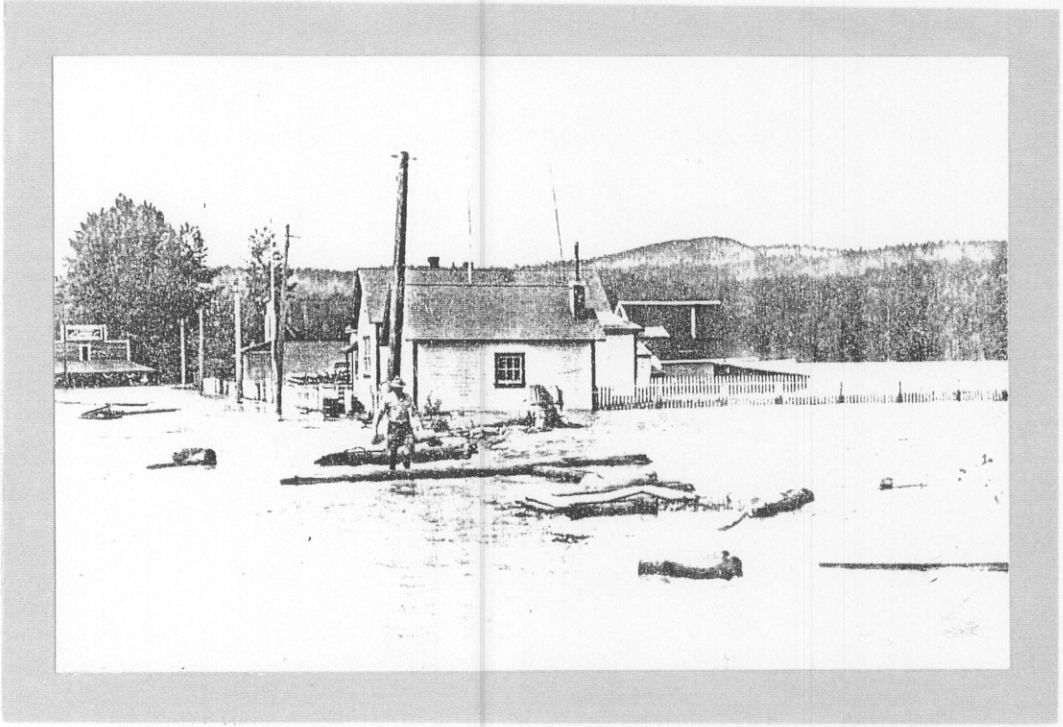
SKEENA RIVER LOOKING DOWNSTREAM TO XS 10

(All photos provided by Mr. Reid White, Smithers Regional Office)

APPENDIX 2
Skeena River at Hazelton
Floodplain Mapping Study
Photos of Study Area



GOVERNMENT STREET - HAZELTON 1936



GOVERNMENT STREET - HAZELTON 1936

(All photos provided by Mr. Reid White, Smithers Regional Office)

APPENDIX 3

Study No. 382
October 1992

HYDROLOGY SECTION REPORT

SKEENA AND BULKLEY RIVERS AT HAZELTON

DETERMINATION OF 20 AND 200 YEAR PEAK FLOWS

At the request of the Flood Hazard Identification Section, a hydrology study was carried out to determine the 20-year and 200-year peak flows on the Skeena River below and above the mouth of the Bulkley River and on the Bulkley River at the mouth.

The Skeena River is one of the major rivers of British Columbia's north coast. Its watershed is quite mountainous and drains the Coastal Mountains, the Skeena Mountains and a portion of the Nechako Plateau. The major portion of the annual runoff is the result of melting of the annual snowpack. The annual peak flows also show the impact of snowmelt with most of the annual peaks occurring in May or June. However, occasional winter storms producing heavy warm rain falling on a shallow snowpack do cause flooding problems but this is mostly confined to the tributaries near the mouth of the Skeena. On rare occasions these winter storms do cross the Coast Mountains and produce an annual peak in October or November on the upstream tributaries as well.

Hydrometric data are available from four gauges in the vicinity of the study area. These gauges with their period of record of annual peak flows is shown below.

Skeena River at Usk	8EF001	1928 to 1931 and 1937 to 1992
Skeena River at Glen Vowell	8EB003	1961 to 1985
Bulkley River near Hazelton	8EE001	1928 to 1941
Bulkley River at Quick	8EE004	1931 to 1992

The Skeena River gauge at Usk is located well downstream of the mouth of the Bulkley River and as such the flows at this gauge cannot be used directly to indicate the flows of the Skeena River just below the Bulkley River. The discontinued gauge at Glen Vowell was located a short distance upstream of the Bulkley River and can be used without adjustment. On the Bulkley River, the gauge at Quick with its long continuous record is located well upstream of the mouth. The discontinued gauge near Hazelton was located near enough to the mouth to indicate flows at this point.

1. Data Analysis

In order to make maximum use of all the available data, it was decided to extend the available record at Glen Vowell and Hazelton and to use this extended data to estimate the peak flow below the confluence. This should give a more consistent data set for frequency analysis and produce more dependable results. Table 1 lists the annual peak daily flow data and estimates for the four gauge locations and for the location below the mouth of the Bulkley River. A code letter is shown against each flow value to indicate the source; these codes are defined as follows:

A Peak flow for the Bulkley at Hazelton estimated by correlation of peak flows with the Bulkley at Quick

r = 0.809 b = 152
a = 1.402 n = 11

where "r" is the correlation coeficient, "a" is the linear slope, "b"is the intercept and "n" is the number of years of overlapping record.

B Peak flow for the Bulkley at Quick estimated by correlation of peak flows with Bulkley near Hazelton.

r = 0.809 b = 134
a = 0.466 n = 11

C Peak flow on the Skeena River below the Bulkley determined from the observed peak flow at Glen Vowell plus the estimated flow of the Bulkley River at the mouth for the same day as the peak at Glen Vowell. The estimate of the daily flow at the mouth of the Bulkley was based in daily flow correlations and watershed area.

D Peak flow for 1972 for the gauge at Glen Vowell revised, based on an observed but unpublished peak instantaneous flow of 5860 m^3/s. The daily peak flow was determined using an Inst./daily ratio of 1.06.

E Estimate of the peak flow for the Skeena below the Bulkley based on correlation with the peak flows at Usk.

r = 0.965 b = -27
a = 0.830 n = 25

F Estimate for the peak flow for the Skeena at Glen Vowell based on correlation with the peak flow for the Skeena below the Bulkley less the peak flow of the Bulkley at the mouth.

r = 0.991 b = 96
a = 0.998 n = 25

M Measured and published peak flow.

m Value missing, could not be estimated reliably.

Table 1.

Skeena and Bulkley Rivers Observed and Estimated Peak Daily Discharge m 3/s

Year	Skeena River						Bulkley River			
	at Usk		below Bulkley R		at Glen Vowell		at Quick		at mouth	
1928	3910	M	3218	E	2451	F	534	B	858	M
1929	3620	M	2978	E	2538	F	381	B	530	M
1930	5010	M	4131	E	3407	F	513	B	813	M
1931	4730	M	3899	E	3201	F	405	M	787	M
1932	m		m		m		368	M	634	M
1933	m		m		m		575	M	787	M
1934	m		m		m		852	M	1520	M
1935	m		m		m		838	M	926	M
1936	m		m		m		807	M	1510	M
1937	4330	M	3567	E	2577	F	572	M	1080	M
1938	3450	M	2836	E	1985	F	589	M	943	M
1939	3340	M	2745	E	1757	F	572	M	1080	M
1940	3540	M	2911	E	2167	F	510	M	835	M
1941	3030	M	2488	E	1906	F	408	M	674	M
1942	3910	M	3218	E	2189	F	691	M	1120	A
1943	2920	M	2397	E	1856	F	343	M	633	A
1944	2890	M	2372	E	1902	F	292	M	561	A
1945	4960	M	4090	E	3241	F	561	M	938	A
1946	5240	M	4322	E	3489	F	549	M	921	A
1947	6000	M	4953	E	4134	F	538	M	906	A
1948	9340	M	7725	E	6401	F	895	M	1407	A
1949	3790	M	3119	E	2343	F	510	M	867	A
1950	6540	M	5401	E	4545	F	564	M	942	A
1951	4360	M	3592	E	2641	F	634	M	1041	A
1952	4190	M	3451	E	2531	F	612	M	1010	A
1953	5010	M	4131	E	3128	F	671	M	1092	A
1954	5920	M	4887	E	3925	F	640	M	1049	A
1955	5100	M	4206	E	3618	F	374	M	676	A
1956	3480	M	2861	E	2150	F	464	M	802	A
1957	6650	M	5493	E	4439	F	705	M	1140	A
1958	5660	M	4671	E	3710	F	640	M	1049	A
1959	4280	M	3525	E	2523	F	671	M	1092	A
1960	4560	M	3758	E	3065	F	450	M	783	A
1961	5970	M	5038	C	4160	M	569	M	949	A
1962	4670	M	3843	C	2710	M	748	M	1200	A
1963	4190	M	3437	C	2520	M	541	M	910	A
1964	7480	M	6043	C	4790	M	847	M	1339	A
1965	4760	M	3717	C	2860	M	498	M	850	A
1966	4760	M	4021	C	3260	M	532	M	898	A
1967	5580	M	4352	C	3280	M	651	M	1064	A
1968	5520	M	4068	C	2700	M	861	M	1359	A
1969	4500	M	3603	C	2630	M	609	M	1006	A
1970	5130	M	4112	C	3310	M	459	M	795	A
1971	4900	M	3487	C	2430	M	640	M	1049	A
1972	7790	M	6946	C	5530	D	957	M	1493	A
1973	4640	M	3959	C	2970	M	592	M	982	A
1974	5640	M	4427	C	4050	M	479	M	823	A
1975	3540	M	3103	C	2390	M	413	M	731	A
1976	6230	M	5261	C	4280	M	682	M	1108	A
1977	3090	M	2821	C	2240	M	566	M	945	A
1978	3940	M	3044	C	2310	M	547	M	919	A
1979	3980	M	3302	C	2510	M	532	M	898	A
1980	3260	M	2779	C	2110	M	408	M	724	A
1981	5600	M	4949	C	3940	M	677	M	1101	A
1982	4880	M	3971	C	3170	M	658	M	1074	A
1983	4930	M	4593	C	3890	M	406	M	721	A
1984	3510	M	2994	C	2380	M	354	M	648	A
1985	5310	M	4208	C	3250	M	642	M	1052	A
1986	5190	M	4281	E	3207	F	721	M	1163	A
1987	4090	M	3368	E	2692	F	438	M	766	A
1988	5230	M	4314	E	3517	F	523	M	885	A
1989	3640	M	2994	E	2192	F	529	M	893	A
1990	5840	M	4820	E	4013	F	530	M	895	A
1991	5310	M	4380	E	3721	F	425	M	748	A
1992	5960	M	4920	E	4126	F	520	M	881	A

2. Frequency Analysis of Daily Peak Flows

Standard frequency analysis was carried out for all the peak daily flow values listed in table 1. (An analysis was also carried out on the observed values for comparison.) A review of all results indicated that the Pearson Type III distribution produced the best overall fit; this distribution was selected for use for all analysis results. Table 2 lists the frequency analysis results for peak daily flows (20-year and 200-year return periods) for the three locations: Skeena above and below the Bulkley and Bulkley at the mouth.

Table 2.

Peak Daily and Instantenous Discharge

			Bulkley R	Skeena River	
			at mouth	Glen Vowell	bl Bulkley
drainage area		km2	12,300	25,900	38,200
200-year	daily	m3/s	1,654	6,432	7,769
200-year	inst	m3/s	2,018	6,818	8,002
20-year	daily	m3/s	1,351	4,892	5,966
20-year	inst	m3/s	1,648	5,186	6,145
1936 June 01	daily	m3/s	1,510	m	m
1972 June 12	daily	m3/s	1,493	5,530	6,946
1972 June 12	inst	m3/s	m	5,860	7,293
1991 May 10	daily	m3/s	668	1,257	1,832

3. Instantaneous Peak Flows

In order to determine instantaneous peak flows at the three required locations, a regional analysis of the ratios of instantaneous peak flow to daily peak flow as published was completed. This analysis gave inst./daily ratios as follows:

Skeena below Bulkley	1.03
Skeena at Glen Vowell	1.06
Bulkley at the mouth	1.22

Table 2 lists the instantaneous peak flows for the 20-year and 200-year return periods for the three locations these estimates use the above ratios.

Also shown in table 2 are observed or estimated flow values for three specific dates as requested; "m" indicates that a dependable estimate could not be made.

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