TELKWA WATERSHED

A Forest Hydrology Analysis

Prepared by:

Pierre G. Beaudry, R.P.F.
&
James W. Schwab, R.P.F.
Forest Sciences Section
B.C. Forest Service
Smithers, B.C.

For

Bulkley Forest District
B.C. Forest Service
October 1989

551.483/B371 1989

Telkwa Watershed: A Forest Hydrology Analysis

Beaudry, Pierre G. & others

TELKWA WATERSHED

EXECUTIVE SUMMARY

The Telkwa Town Council recently expressed concern over possible changes in water flows in the Telkwa River as a result of forest harvesting activities within the watershed. The Forest Service, Bulkey Forest District, requested us to assess the possible changes forest harvesting may have on the Telkwa River flow regime.

This study reviews physical watershed characteristics, historical stream flow, and climatic data relevant to the Telkwa watershed. A simple modelling exercise is done to show the possible worst case effects of various degrees of forest harvesting on the stream flow regime.

The more important features of the watershed and the forest harvesting plans relative to stream flow are:

1. The watershed is large, covering a land area of 1,200 km^2.

2. Nearly 50% of the watershed is above forest harvesting operability limits.

3. Large storms usually move into the watershed from the west over the Coast Range, arriving at the headwaters of the watershed first.

4. Typically, two peak flows occur annually. One in the spring caused by snowmelt and some rain and a second in the fall caused by high intensity rainfall.

5. Historical records show that the range of annual peak flows is large, varying from 100 m^3/sec (1977) to 430 m^3/sec (1978).

6. To facilitate analysis of the hydrological processes occuring throughout this large watershed, it was divided into 3 evenly sized sections; "upper", "middle" and "lower".

7. Greater than 50% of the peakflow volume is generated in the upper 1/3 of the watershed (the area of higher elevation and coastal influence). The two other sections generate 25 - 30% and 15 - 20% of annual peak flows for the middle and lower sections respectively.

8. The main spring peak flows are driven by high elevation snow melt which is not affected by clear-cutting.

9. In the lower elevations of the watershed, where commercial forest is present, the winter snowpack melts in April before the spring peakflows (June). Clear-cutting of these commercial forests would cause snowmelt and subsequent runoff to occur even earlier. Thus the earlier runoff would not contribute to the annual snowmelt peakflows.

10. Logging activities have been concentrated in the middle and lower sections of the watershed. Only 5% of th middle and 4.5% of the lower sections have been clear-cut over the past 20 years. Such rates of logging have no detectable effect on peakflows.

11. The five year dvelopment plan calls for an additional 2%, 2.3% and 1.1% of the lower, middle and upper sections to be clear-cut. This will bring the total 25 year harvest to 6.5%, 7.3% and 1.2% for the lower, middle and upper sections respectively. This could represent a theoretical increase of 2% in peak streamflow which could not be detectable even in watershed with sophisticated flow gauges.

The modelling exercise demonstrates that present logging plans should not significantly increase large snowmelt or rain generated peak flows. However, it is cautioned that on a smaller scale, within some of the smaller sub-basins, certain sites may be highly erodible, or have intrinsically higher fisheries or recreation values and site specific protection measures may be necessary.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

TELKWA WATERSHED REPORT

1.0 WATERSHED DESCRIPTION

1.1 Physical

1.1.1 Elevational Zone Boundaries and Areas:

The Telkwa watershed is located in the Bulkley Range of the Hazelton Mountains. Its headwaters are situated about halfway between Terrace and Telkwa. The main channel of the Telkwa River flows from west to east into the Bulkley River at the town of Telkwa (Figure 1).

The climatic regime over the watershed is variable. Weather usually moves in from the west over the Coast Range down the Telkwa watershed towards the Bulkley River. Annual precipitation regimes vary from 1500-2000 mm at the headwaters to 500 mm at its mouth, at the town of Telkwa. The distribution of land per elevation zone in the watershed is presented in Table 1.

Table 1: Telkwa Watershed: area per elevation band.

Elevation Band	Area (km^2)	percent of watershed
500 m	1.5	.1
500 - 750 m	115.0	9.7
750 - 1000 m	266.5	22.4
1000 - 1250 m	288.2	24.2
1250 - 1500 m	268.3	22.5
1500 +	251.5	21.1
Total	1,191	

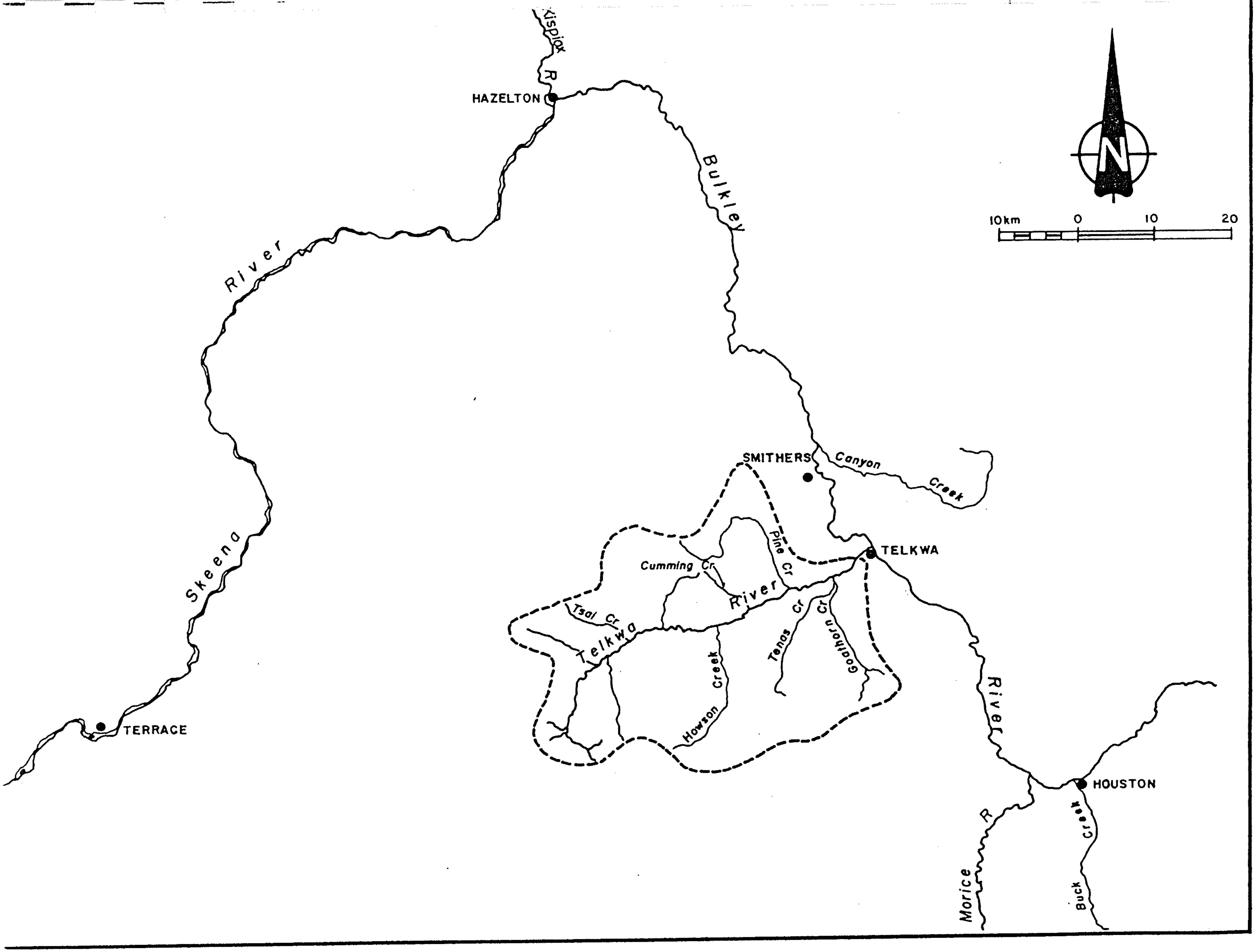

Figure 1: Location of Telkwa River watershed.

Nearly 50% of the watershed is above operable forest harvesting limits and almost one quarter of the watershed is classified as alpine and glacier. The breakdown of the watershed into finer units necessary for hydrologic analysis is presented in section 2.1.

1.1.2 Landforms and erosion

The landform and soils of the Telkwa River watershed are described by Runka (1974). In general, the landforms within the watershed are of glacial origin and in some instances, subsequently modified or buried by fluvial or colluvial action.

Natural erosion occurs throughout the watershed. Most natural sediment production comes from Pine creek, Cummings creek and a large section of eroding slumping bank on the main stem of the Telkwa (south side mid valley). The muddy colour of the Telkwa River during intense rainfall and high stream flows is a result of this natural erosion.

Potentially unstable terrain within the operable forest is generally associated with over steepened banks from active fluvial erosion along deeply incised and confined stream channels. Remnant kame terraces, which give the impression of collapsed benches at mid elevations along the main valley and within the sub-watersheds, are the most problematic landform (Roads tend to channelize surface water leading to deep gullying, for example, the Pine creek road).

1.2 Hydrology

1.2.1 Runoff Regime:

There are two Water Survey of Canada (W.S.C.) gauging stations located within the Telkwa River watershed. The station "Goathorn Creek near Telkwa" is located on Goathorn Creek above the confluence with Tenas Creek (Figure 1). This site has been in operation since 1960. The data from this site will serve to explain the hydrologic regime of the lower Telkwa basin. The second site "Telkwa River below Tsai Creek" is located on Telkwa River between the confluences of Sinclair and Winfield Creeks (Figure 1). This station began operation in 1975. The station has an upstream basin area of 368 km^2 which is 30% of the entire Telkwa watershed. Discharge measurements from this site will be used to describe the hydrology of the upper Telkwa basin. Discharges for the "Telkwa River at Mouth" were estimated by Miles (1983) on the basis of regional runoff correlations.

1.2.2 Annual Runnoff:

Average runoff values vary considerably within the Telkwa River drainage. The station at Tsai creek reports an annual runoff unit area value of 1228 mm, while the station at Goathorn Creek has a value of 430 mm. This difference reflects the higher annual precipitation that occurs in the western portion of the Telkwa watershed. Annual hydrographs for 3 stations are presented in Figure 2 (from Crows Nest Resources, 1983). The maximas, minimas and mean monthly discharges for the same hydrometric stations are presented in Figure 3.

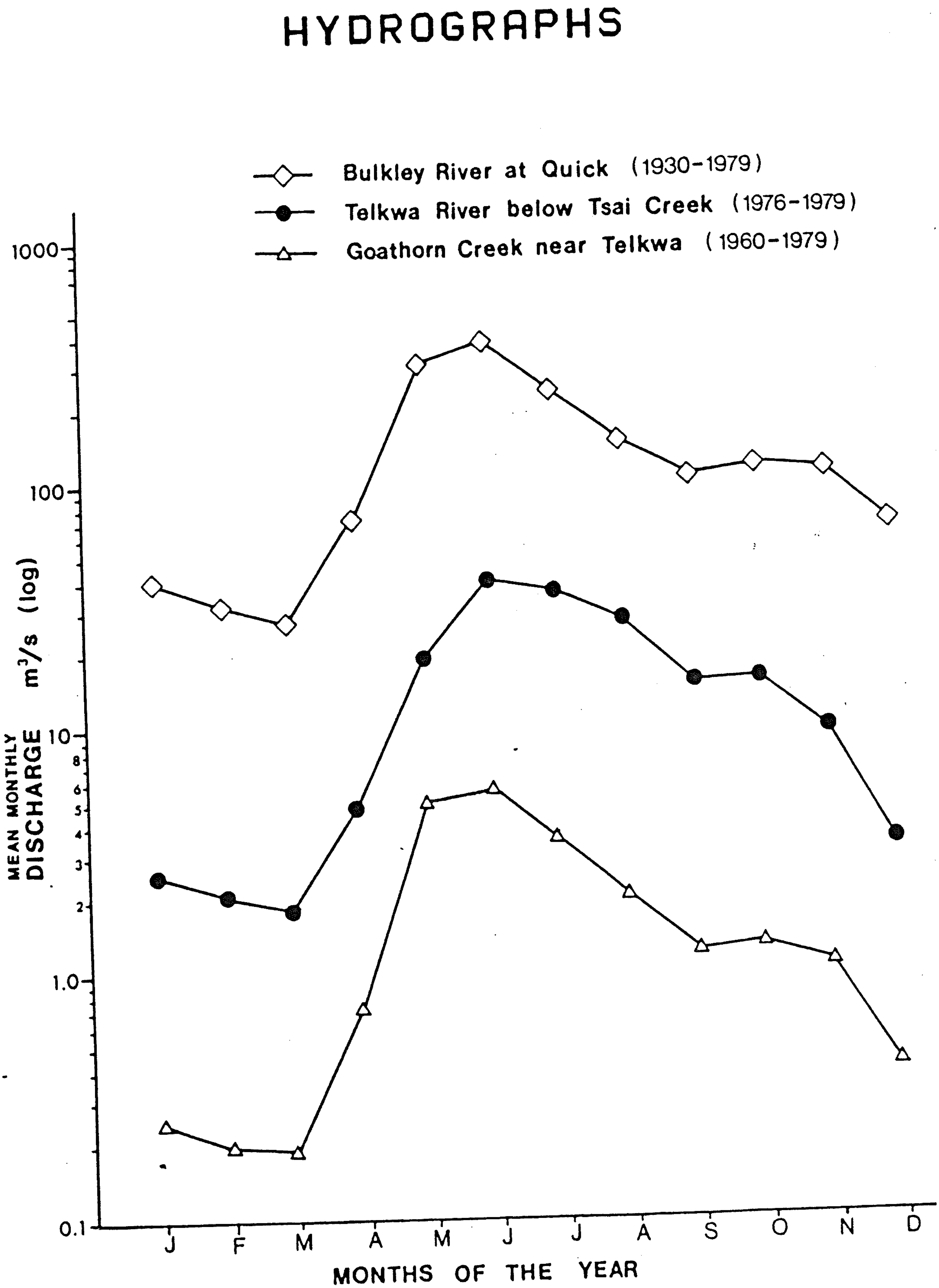

Figure 2: Hydrographs (Source: Crows Nests Resources, 1983).

1.2.3 Seasonal Distribution of Runoff:

For Goathorn Creek, the mean monthy discharge typically reaches a peak in May or June (Figure 3C). However, the data from the Telkwa River station indicate that mean monthly flows in the upper Telkwa drainage generally reach a maximum in June or July (Figure 3A). The higher elevations and extensive areas with snow and ice cover in the upper Telkwa basin cause this late spring maximum runoff.

After snowmelt, flows gradually decrease until August or September. There is usually a slight increase in monthly flows during October and November because of fall rains, followed by a continued decrease until March (Figures 3A, 3B and 3C).

For both the Goathorn and Telkwa watersheds the annual maximum daily discharge occurs as a result of either spring snowmelt or fall rainstorms. For both watersheds the largest peak of the year generally occurs in the spring, however, annual peaks can occur in the fall. Table 2 presents how often annual peaks have occured in the spring or the fall for the period of measurement for both waterhseds.

Table 2: Temporal distribution of peak flows for Telkwa and Goathorn watersheds.

Telkwa (1976 - 1987)		Goathorn (1961 -1987)	
Spring Peaks	Fall Peaks	Spring Peaks	Fall Peaks
10	3	22	4

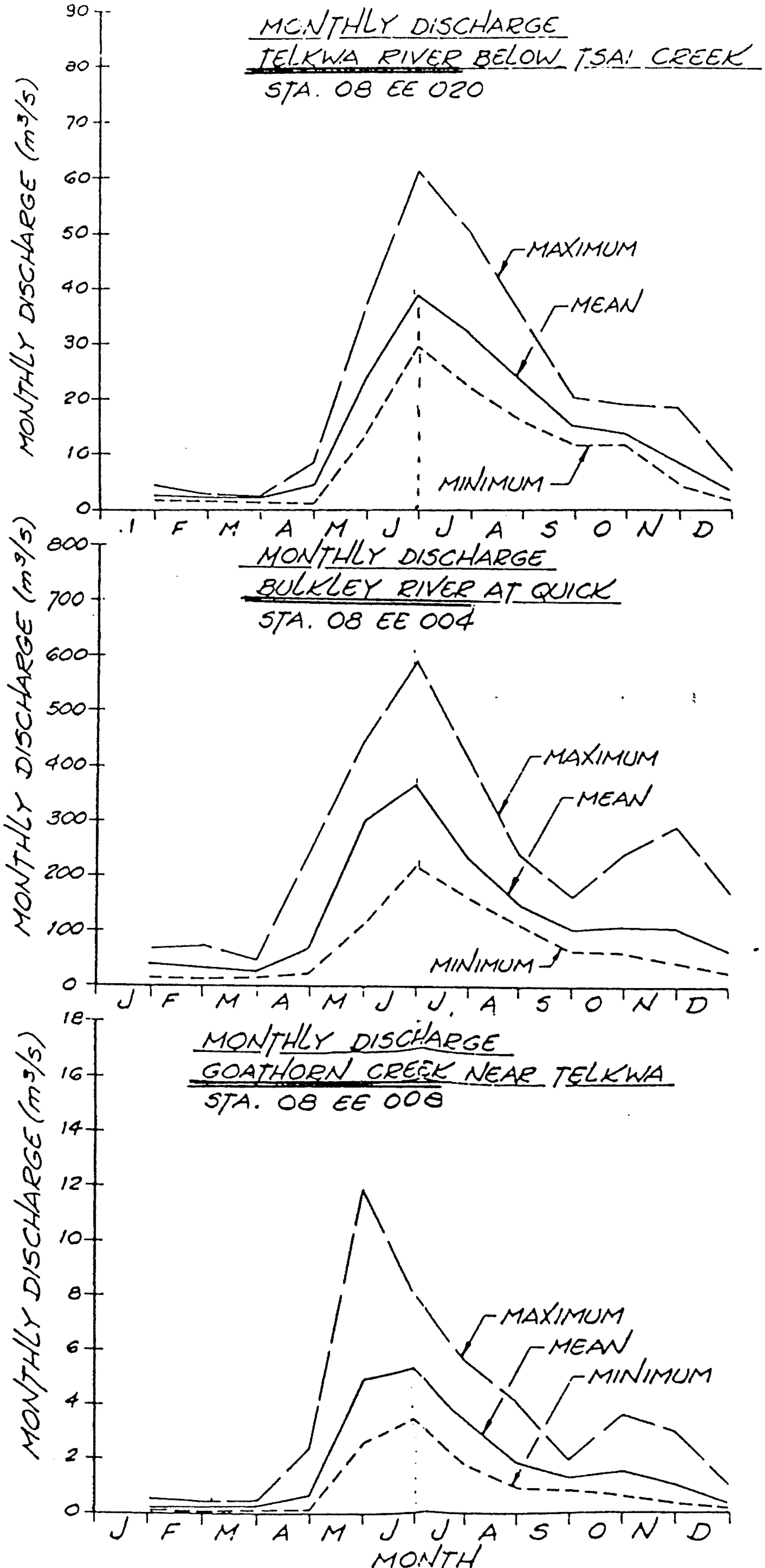

Figure 3. Monthly discharges - Telkwa, Bulkley & Goathorn
(Source: Crows Nest Resources, 1983)

At Goathorn Creek the three largest peaks recorded have all been spring peaks. For the Telkwa River the largest recorded peak was a fall event with the second and third largest peaks being spring events.

1.2.4 Variations in Runoff Within the Telkwa Watershed

The relationship between discharge per unit area and basin size has been applied to estimate discharges for ungauged sites (Miles, 1983). Using these relationships, annual high flows were calcuated for the Telkwa River at the mouth and the Telkwa River below Cumming Creek (Table 3). It is important to note that the statistical analysis (Miles, 1983) indicates that the confidence limits about the calculated discharge can be quite large. This problem originates from the lack of available data.

Because variations in annual runoff between different geographical areas in the Telkwa watershed are high, we decided to divide the watershed into three sections (Figure 4). This allows for a better understanding of the potential impacts that may occur to streamflows as a result of forest harvesting activities. The divisions are:

Section 1: (Lower) The drainage area below Cumming Creek which includes Pine Goathorn and Tenas creeks.

Section 2: (Middle) The drainage area between section 1 and 3 which includes Howson, Winfield, Jonas, Cummings and a few unnamed sub-watersheds.

Section 3: (Upper) The drainage area above the stream gauge at Sinclair Creek.

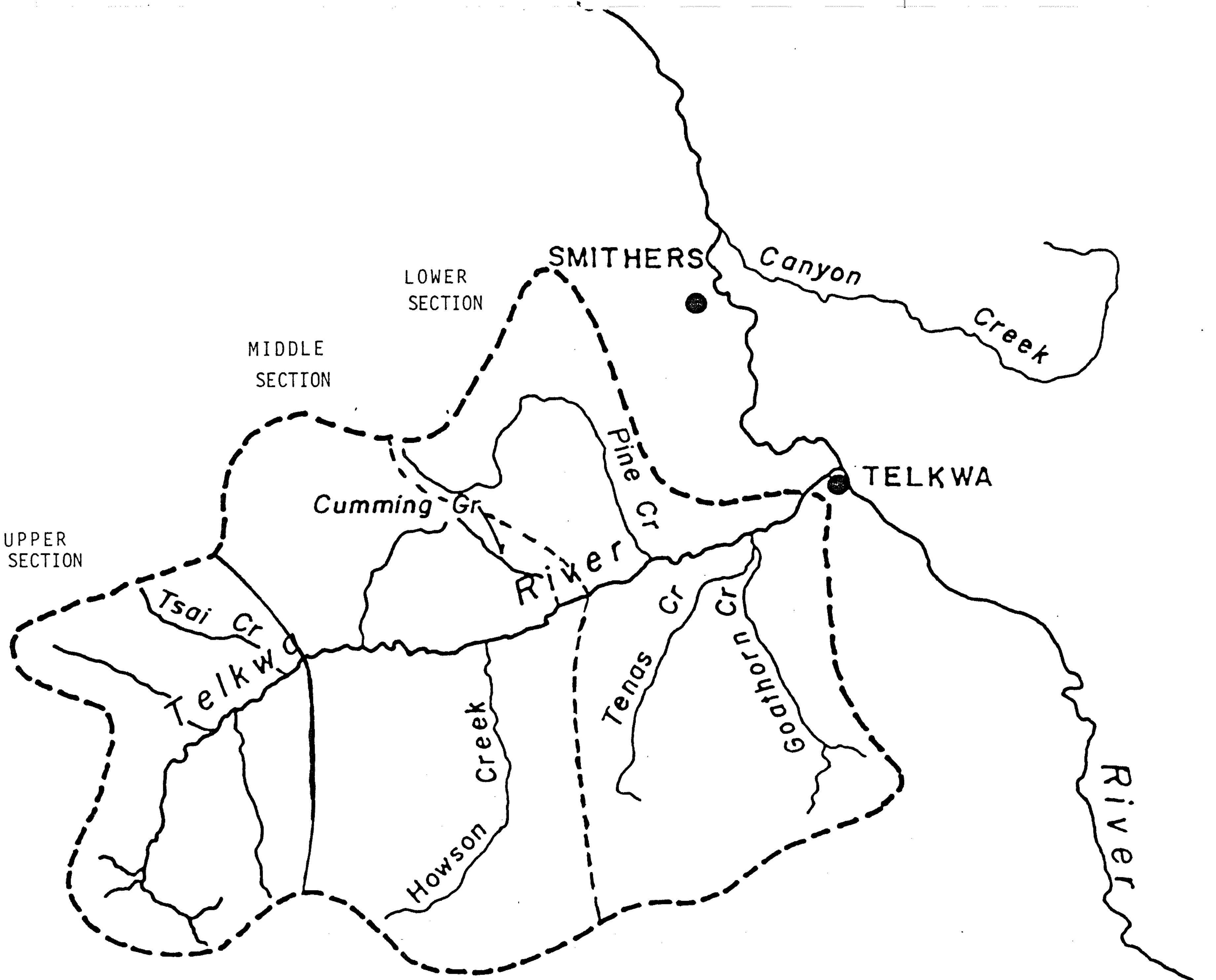

Figure 4: Three sections of the Telkwa Watershed

Important hydrolgical characteristics of these sections are presented in the following table.

Table 3: Characteristics of the three sections of the Telkwa River

Section	Area (ha)	Annual runoff (mm)	Estimated prec.(mm)	Average Annual high-flow	% of Total Telkwa flow
Upper	37,032 ha	1200 (obtained from Weir)	1500	77 m^3/sec	59
Middle	43,500	500-700 (estimated)	800-1000	32 m^3/sec	25
Lower	46,467	400 (extrapo-lated from Goathorn)	500-650	21 m^3/sec	16
Telkwa townsite		150	500	----	----

The hydrologic response of each of these sections are quite different from one another because of their different geographic locations and precipitation regimes. Although the upper section represents less than one third of the total area, it generates more than 50% of the peak flow volume. This distribution of flows is caused by the greater precipitation that occurs in the upper section (coastal influence) and the presence of more high elevation snow and ice relative to the middle and lower sections. We estimated that the midddle section generates about 25-30% of the peak flows, while the lower section only generates about 15-20%.

1.3 Climate Regime and Snow Patterns

1.3.1 Climate

Atmospheric Environment Services (AES) climatological stations exist at Quick, Telkwa and Smithers and data from a temporary station that was established at the coal mine site in the lower Telkwa watershed. Unfortunately, no data are available that will suitably describe the climatic regime of the mid and upper sections of the Telkwa watershed. Thus, for these sections, we made estimates. Long term average temperatures and precipitation regimes are presented in Tables 4, 5 and Figure 5 (from Crows Nest Resources, 1983).

1.3.2 Snow

Only five active snow courses exist in the general vicinity of the Telkwa Watershed. These are:

McKendrick Creek,	Elevation:	1050 m
Mount Cronin,	Elevation:	1480 m
Hudson Bay Mountain,	Elevation:	1480 m
Chapman Lake	Elevation:	1460 m
Kidprice Lake	Elevation:	1370 m

Hudson Bay Mountain is the only snow course located within the Telkwa Watershed. Because snow accumulation and melt vary considerably with elevation and location, one must be careful in extrapolating these data. Mean monthly water equivalencies for these snow courses, for the periods of record are presented in Table 6.

TABLE 4 LONG TERM AVERAGE TEMPERATURES - SMITHERS AIRPORT AND TELKWA RIVER

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
AILY MAXIMUM													
Smithers Airport	-6.8	-0.4	3.9	9.9	15.4	18.9	21.3	20.6	15.7	9.0	0.8	-3.9	8.7
Telkwa River	-9.5	-3.1	0.7	8.1	13.8	17.5	20.1	19.3	14.2	6.9	-1.7	-6.8	6.7
AILY MINIMUM													
Smithers Airport	-15.1	-10.1	-6.4	-1.7	2.5	6.0	8.1	7.6	4.0	0.5	-5.5	-11.2	-1.8
Telkwa River	-16.7	-11.7	-8.2	-3.6	0.4	3.8	5.8	5.3	1.8	-1.6	-7.4	-12.9	-3.8
AILY MEAN													
Smithers Airport	-10.9	-5.3	-1.3	4.2	9.0	12.5	14.7	14.1	9.8	4.7	-2.3	-7.6	3.5
Telkwa River	-13.2	-7.4	-3.3	2.2	7.1	10.7	13.0	12.3	8.0	2.7	-4.6	-9.9	1.5
XTREMES OF RECORD T SMITHERS AIRPORT													
Maximum	15.6	11.7	15.6	24.3	31.3	33.9	34.4	33.9	30.6	22.2	15.6	11.5	34.4
Minimum	-43.9	-35.6	-33.3	-18.3	-2.2	-1.1	-2.2	-6.7	-15.6	-31.7	-36.7	-36.7	-43.9

SOURCE: Atmospheric Environment Service
Air Studies Branch

Smithers Airport 1942-1980
Telkwa River 1967-1977, normalized to Smithers Airport

TABLE 5 AVERAGE PRECIPITATION AT SMITHERS AIRPORT, TELKWA MACLURE LAKE AND TELKWA RIVER

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	May -Oct.	Yea
NFALL (mm)														
Smithers Airport	8.4	5.5	6.0	11.4	28.8	40.0	45.9	43.7	50.1	56.0	23.7	11.7		331.
NFALL (cm														
Smithers Airport	57.1	30.7	22.3	7.0	1.2	0.0	0.0	0.0	0.2	8.3	38.5	56.3		221
AL PRECIPITATION (mm)														
Smithers Airport	55.6	31.6	25.6	17.6	30.0	40.0	45.9	43.7	50.3	63.8	58.3	59.8	274	522
Telkwa MacLure Lake	49.8	27.2	21.8	11.6	28.4	38.5	38.1	46.7	38.8	44.5	47.2	59.6	198	452
Telkwa River					26	35	39	38	43	60			240	

SOURCE: Atmospheric Environment Service

Air Studies Branch

Smithers Airport	1942 - 1980
Telkwa MacLure Lake	1970 - 1980
Telkwa River	1967 - 1977, normalized to Smithers Airport.

PRECIPITATION - SMITHERS AIRPORT

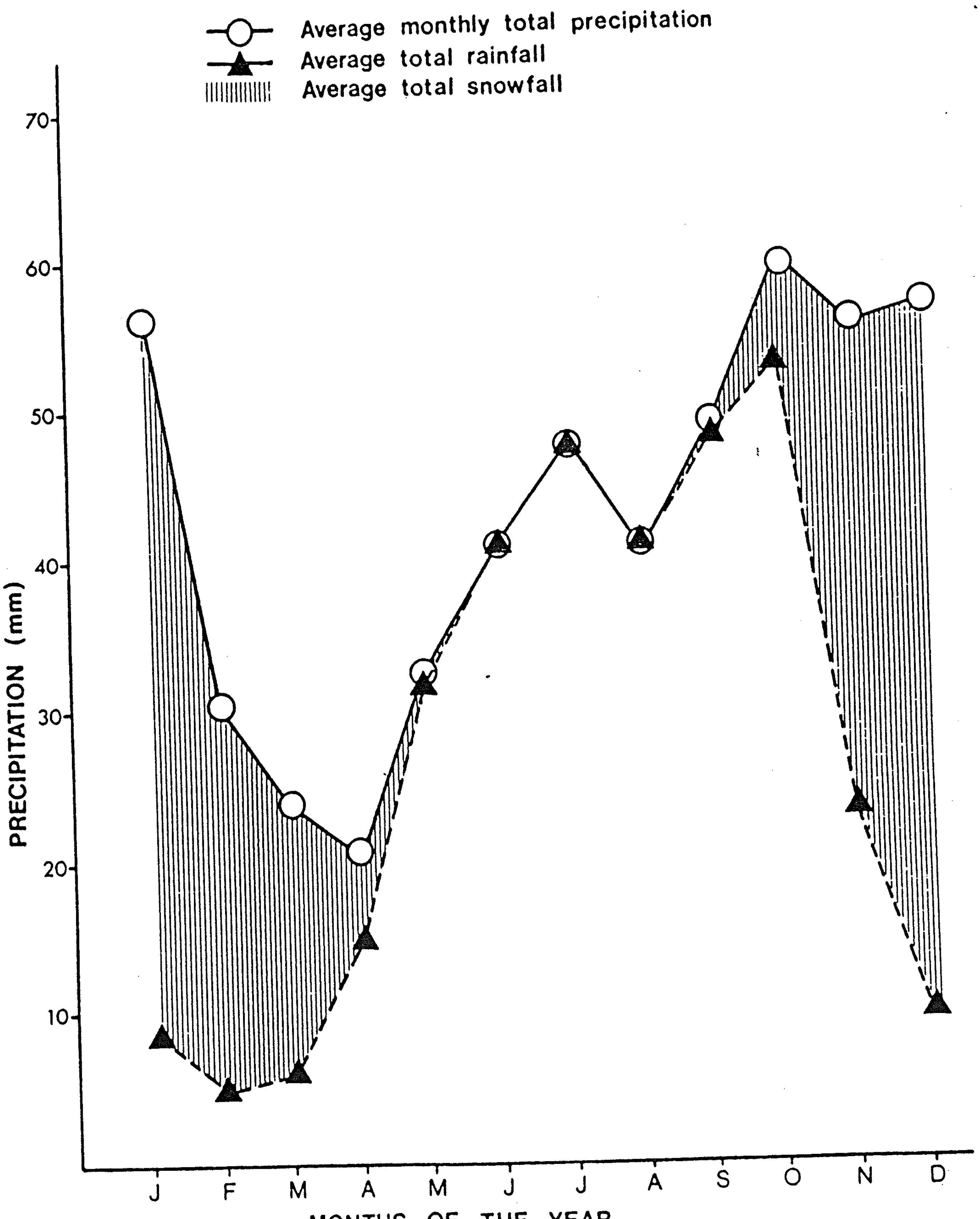

Figure 5: Precipitation - Smithers Airport (Source: Crows Nest Resources, 1983

SNOW COURSE DATA (REGULAR MEASUREMENTS)

No. 4B03A (Active) **HUDSON BAY MTN.** Basin: NORTHERN B.C.

Elev. 1480 metres Lat. 54°46′ Long. 127°16′ Drainage: SKEENA/NASS

JANUARY 1			FEBRUARY 1			MARCH 1			APRIL 1			YEAR	MAY 1			MAY 15			JUNE 1			JUNE 15		
DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm		DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm
			01-30	135	404	02-27	180	544	03-26	188	663	1972	05-01	190	737	05-15	147	620	05-31	89	437	06-15	0	0
			01-31	190	605	02-27	201	701	03-29	201	780	1973	04-26	180	787	05-15	137	645	05-31	117	533			
			02-03	163	427	02-27	163	493	03-31	163	554	1974	04-30	137	538	05-14	140	528	05-29	122	531	06-16	74	345
			02-03	122	317	02-26	150	391	03-31	140	457	1975	04-29	132	523	05-15	107	455	05-29	84	358	06-16	0	0
01-02	168	470	02-02	193	665	03-01	188	719	04-01	218	846	1976	05-03	173	785	05-14	160	752	05-31	147	729	06-09	127	673
01-02	84	226	01-28	109	317	02-28	130	411	03-28	160	500	1977	05-02	109	457				06-01	56	244			
01-05	97	269	01-26	109	307	02-27	127	378	04-03	137	442	1978	04-27	127	447	05-12	109	404	05-31	74	282			
12-28	120	315	01-29	140	388	02-26	166	499	03-26	150	547	1979	04-27	147	555	05-14	136	558	05-29	108	478			
12-27	58	135	01-29	84	221	02-28	117	287	03-31	124	356	1980	05-01	100	363	05-13	64	246	05-29	23	91			
12-24	97	204B	01-30	106	313	02-27	139	385	03-31	135	438	1981	04-30	165	595	05-15	131	511	05-29	78	336			
12-29	90	215	01-29	153	377	02-25	166	475	03-29	170	531	1982	04-29	161	563	05-14	140	545	05-28	115	493	06-14	32	142
12-30	76	176	01-28	120	299	02-28	122	370	03-30	118	396	1983	04-28	94	378	05-11	82	343	05-30	11	49			
01-04	99	234	01-30	111	294	02-29	129	375	04-02	126	422	1984	04-27	125	454	05-15	122	453	05-31	90	388	06-18	28	111
12-31	102	280	01-31	99	309	02-26	155	454	03-29	164	536	1985	04-29	178	649	05-15	163	649	05-31	82	363	06-14	46	210
	106	268		130	369		152	457		157	522	NORMAL		146	552		126	502		87	374			
	99	258		131	375		152	463		157	533	MEAN		144	559		126	516		85	379		44	212

No. 4B04 (Active) **CHAPMAN LAKE** Basin: NORTHERN B.C.

Elev. 1460 metres Lat. 54°53′ Long. 126°44′ Drainage: SKEENA/NASS

JANUARY 1			FEBRUARY 1			MARCH 1			APRIL 1			YEAR	MAY 1			MAY 15			JUNE 1			JUNE 15		
DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm		DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm
						02-27	147	424	03-27	127	409	1965	04-24	165	488									
						02-25	142	424	03-26	163	495	1966	04-30	150	523									
						02-25	183	549	03-29	196	676	1967	04-29	183	742	05-13	157	683	05-28	124	594	06-16	0	0
						02-23	132	368	03-23	140	442B	1968	04-27	147	490									
						03-01	112	307	03-29	117	351	1969	04-26	117	384									
						02-22	107	325	03-27	122	381	1970	04-25	117	404									
						02-27	124	340	03-28	157	455	1971	04-28	122	432									
						02-27	137	411	03-30	183	645	1972	05-02	183	706									
						03-01	201	691	04-01	203	762	1973	04-27	188	749									
						03-01	165	465	04-01	168	554	1974	05-01	145	538									
						02-27	119	310	03-30	132	391	1975	05-01	122	432									
						03-03	178	630	03-30	198	711	1976	04-29	170	739									
						02-27	109	300	03-27	132	386	1977												
						02-28	109	305	03-31	124	351	1978	04-28	104	340									
						02-27	132	350	03-28	117	377	1979	04-27	117	410									
						03-04	107	268	03-31	112	315	1980	05-01	88	308									
						03-03	108	303	04-01	118	327	1981	04-30	137	439									
						03-02	174	480	03-30	160	504	1982	04-29	142	507									
						02-28	123	368	03-30	115	383	1983	04-28	93	344									
						02-29	131	363	03-30	125	398	1984	04-27	125	444									
						02-26	144	416	03-29	153	466	1985	04-29	155	540									
							137	400		145	462	NORMAL		139	491									
							137	400		146	467	MEAN		139	498		157	683		124	594		0	0

No. 4B07 (Active) **MCKENDRICK CREEK** Basin: NORTHERN B.C.

Elev. 1050 metres Lat. 54°50′ Long. 126°46′ Drainage: SKEENA/NASS

JANUARY 1			FEBRUARY 1			MARCH 1			APRIL 1			YEAR	MAY 1			MAY 15			JUNE 1			JUNE 15		
DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm		DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm
						02-24	119	325	03-23	114	356B	1968	04-29	109	376	05-11	76	277						
						03-02	86	208	03-28	79	224	1969	04-26	56	203	05-16	0	0						
						02-22	66	190	03-27	79	224	1970	04-25	61	203	05-16	0	0						
						02-26	107	302	03-30	119	361	1971	04-30	86	290	05-16	41	142						
						02-28	137	391	03-30	119	427	1972	05-02	114	422	05-18	61	259	06-02	0	0			
						02-28	132	378	04-01	119	417	1973	04-27	97	335	05-16	0	0	05-30	0	0			
			02-02	117	264	02-28	127	333	04-01	117	371	1974	05-01	86	310	05-15	71	239	05-29	0	0			
						02-27	97	249	03-30	97	267	1975	05-05	66	254									
						03-03	124	376	03-30	135	427	1976	04-29	89	363	05-14	48	201	05-30	0	0			
						02-27	89	239	03-27	112	310	1977	05-02	48	173									
						03-01	84	224	03-31	89	244	1978	05-01	56	170									
						02-27	110	277	03-26	89	288	1979	04-27	80	253									
						03-04	79	196	03-31	92	247	1980	05-01	42	145									
						03-03	84	204	04-01	74	183	1981	04-30	75	241									
						03-02	136	329	03-30	117	356	1982	04-29	96	341									
						02-28	74	200	03-30	71	205	1983	04-29	22	80									
						02-29	76	192	03-30	70	216	1984	04-27	49	172									
						02-26	102	261	03-29	112	310	1985	04-29	91	302	05-15	68	252	05-31	0	0			
							102	272		101	299	NORMAL		74	257		27	101						
				117	264		102	271		99	299	MEAN		74	257		41	152		0	0			

Table 6: Snow course data (Source: B.C. Ministry of Environment; 1985)

No. 4B08 (Active) **MOUNT CRONIN** Basin: NORTHERN B.C.

Elev. 1480 metres Lat. 54°56′ Long. 126°48′ Drainage: SKEENA/NASS

JANUARY 1			FEBRUARY 1			MARCH 1			APRIL 1			YEAR	MAY 1			MAY 15			JUNE 1			JUNE 15		
DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm		DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm
						03-01	163	495	03-29	157	541	1969	04-26	175	597	05-16	150	589						
						02-22	137	447	03-27	163	556	1970	04-24	160	584	05-16	170	622						
						02-26	163	505	03-30	198	650	1971	04-30	173	686	05-16	137	615						
						02-28	216	691	03-30	208	813	1972	05-02	224	919	05-18	185	808	06-02	124	610	06-15	76	376
						02-28	246	869	04-01	249	1054	1973	04-27	239	1046	05-16	185	919	05-30	163	823	06-15	130	681
						02-28	213	589	04-01	198	693	1974	05-01	178	732	05-15	190	747	05-29	160	704	06-16	112	574
						02-27	152	429	03-30	163	5[illegible]	1975	05-01	155	579									
						03-03	231	719	03-30	254	1037	1976	04-29	224	1125	05-14	193	927	05-30	196	927	06-16	142	742
						02-27	127	348	03-27	160	455	1977	05-02	104	422									
						02-23	147	429	03-30	170	531	1978	04-27	152	551									
						02-27	158	458	03-26	142	501	1979	04-27	152	547									
						03-04	136	370	03-31	144	433	1980	05-01	128	468									
						03-03	142	430	04-01	158	456	1981	04-30	190	642									
						03-02	214	639	03-30	197	689	1982	04-29	187	705									
						02-28	164	514	03-30	155	552	1983	04-28	132	522									
						02-29	159	467	03-30	164	557	1984	04-27	170	629									
						02-26	159	456	03-29	178	562	1985	04-29	187	654									
							174	526		183	623	NORMAL		176	666		157	652						
							172	521		180	627	MEAN		172	671		173	747		161	766		115	593

No. 4B01 (Active) **KIDPRICE LAKE** Basin: NORTHERN B.C.

Elev. 1370 metres Lat. 53°51′ Long. 127°26′ Drainage: SKEENA/NASS

JANUARY 1			FEBRUARY 1			MARCH 1			APRIL 1			YEAR	MAY 1			MAY 15			JUNE 1			JUNE 15		
DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm		DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm	DATE	SNOW DEPTH cm	WATER EQUIVALENT mm
						02-27	173	450	04-08	246	790B	1952	05-06	216	780A									
			02-10	234	648B	02-24	218	744A	04-01	257	993	1953	04-29	234	914				05-26	132	610			
			02-04	188	668	03-01	244	823	03-30	218	892	1954	04-29	201	825									
						02-25	140	429	04-11	183	650B	1955	04-28	155	635									
			01-31	152	452	03-05	173	574	04-10	183	635B	1956	05-02	147	551									
			01-31	180	549	02-28	196	597	03-26	224	678	1957	05-01	203	798									
			02-04	183	521	02-27	211	696	03-27	213	813	1958	04-25	211	884									
			01-29	173	528	03-05	201	668	03-29	211	780	1959	04-27	147	607									
			01-28	173	544	02-26	198	691	03-31	231	785	1960	04-27	218	932									
			02-03	165	493	03-02	246	772	03-29	229	851	1961	04-27	201	894									
			01-28	236	780	02-26	216	780	03-29	231	851	1962	04-28	226	828									
			01-30	137	465	02-24	190	632	03-30	216	716	1963	04-27	201	782									
			01-30	234	688	02-26	226	841	02-29	248	955	1964	04-30	259	1029									
			02-01	175	523	03-03	218	724	03-30	201	698	1965	04-27	173	681									
						02-28	224	691	04-02	249	853	1966	04-27	208	876									
						03-02	274	919	03-28	272	1031	1967	04-29	257	1026									
			01-29	208	648	02-27	226	775	03-30	262	935	1968	04-30	259	1031									
			01-29	193	632	02-24	246	851	03-27	246	978	1969	04-29	251	1001									
						02-26	147	500	03-30	180	622	1970	04-27	188	770									
			02-02	249	612	02-24	224	744	03-26	259	899	1971	04-29	213	884									
			01-27	170	574	02-28	264	861	03-27	267	1079	1972	04-28	267	1090									
			01-29	262	790	03-02	248	917	03-26	249	978	1973	05-02	213	955									
			01-29	234	663	02-25	259	831	03-29	257	993	1974	05-08	218	1052B									
			01-28	190	579	02-25	221	706	03-27	218	800	1975	04-28	183	798									
			01-29	262	866	02-26	284	1067	03-30	330	1247	1976	04-29	290	1367	05-14	249	1278	05-31	229	1209			
			01-29	163	526	02-24	185	617	03-28	246	823	1977	04-29	175	800				06-05	86	472			
			01-27	152	531	02-27	175	602	03-28	211	721	1978	04-26	198	808				05-31	114	559			
			01-26	175	471	02-26	208	679	04-02	186	747	1979	04-30	164	790				05-28	108	575			
			01-28	150	462	03-02	184	599	03-26	185	675	1980	04-28	156	554				05-29	62	298			
			01-28	150	440	02-25	210	689	04-01	205	768	1981	04-29	228	936				05-25	139	780			
			01-26	231	702	02-23	258	865	03-26	250	1002	1982	04-26	233	1058				05-26	180	929			
			01-26	186	609	02-24	199	718	03-28	189	763	1983	04-25	157	739				05-26	57	307			
			01-30	189	604	02-29	229	793	03-26	224	882	1984	04-25	209	915				05-30	154	758			
			01-28	140	492	02-25	250	857	03-26	254	973	1985	04-29	275	1135				05-28	165	925			
				192	592		224	761		234	874	NORMAL		216	912					131	681			
				189	586		217	727		233	864	MEAN		210	869		249	1278		130	675			

Table 6. continued

2.0 FOREST MANAGEMENT REGIMES AND POTENTIAL IMPACTS

2.1 Introduction

To evaluate the effects of forest management activities on the river hydrograph it is necessary to know the physical make-up of the watershed. This would include knowledge of the extent and location of such items as alpine areas, glaciers, lakes and swamps, sensitive and non-sensitive forest sites and of course past logging activities and future logging plans. In total, twelve individual land types were identified, and their areas calculated and mapped using the Ministry of Forests geographical information system (GEOMAP). The Land types are: 1) streams and lakes, 2)swamps, 3) alpine and glacier, 4) non-forest/alienated, 5) sub-alpine forests (non-sensitive), 6) forested - special constraints - harvesting, 7) productive forests - mature, 8) productive forests - immature, 9) disturbance 1983-1988, 10) disturbance 1978-1983, 11) disturbance 1968-1977, 12) disturbance Pre.-1968.

The areal extent of each land type was calculated for each of the three sections of the watersheds. These data are presented in table 7. Also, a coloured map of the watershed was produced to show the extent and location of each of the 12 land types. The data were then used to chararterize each section of the watershed and to evaluate the effects of historical and future land use on the streamflow regime.

Table 7: Areal Extent of land types by watershed section

Land Type	% of total area for each section		
	Lower section 1	Middle section 2	Upper section 3
Alpine & glaciers	13	24.4	52.4
Streams and lakes	.7	.7	.5
Swamps	.9	1.7	2.2
Non-forest - private Land	5.3	0.6	0.6
Sub-alpine forest	4.2	3.4	5.5
Forested - special constraints	18.6	32.2	17.8
Productive forests - mature	34.8	24.9	18.8
Productive forests - immature	13.0	5.9	2.0
Forest harvesting post 1968	4.5	5.0	0.1
Forest harvesting pre 1968	3.0	1.4	0.0
Planned forest harvest 88-90	2.0	2.3	1.1

Unfortunately the state-of-the-art in hydrology does not allow the presentation of a regionalized, detailed, process oriented methodology for evaluating the impact, if any, of site disturbance on individual storm hydrographs. This evaluation must be done by extrapolating published results from experimental watersheds to the watershed in question (i.e. Telkwa) and using local data and knowledge. Based on technical knowledge of how certain processes operate within the watershed, and the comparisons between watersheds, we conceptualize what may be the effects of certain land use practices on the streamflow regimes.

In this report we will present the important hydrologic characteristics for each of the 3 sections of the watershed and then discuss how the proposed harvesting plans may affect streamflows.

2.2 Description of the hydrologic characteristics of the 3 Sections of the Telkwa River

2.2.1 Lower Section

The analysis of this section takes into account only the portion of the watershed that drains into the section of the Telkwa River below Cumming Creek. The analysis isolates this section, treating it as an independant watershed of 46,467 ha, removing the influences and streamflow contributions of the upper 2 sections. The hydrometric data from Goathorn Creek provide a model to predict the behavior of the lower Telkwa River. Some of the distinguishing hydrologic features of the lower section are:

1. The small percentage of the total area classified as alpine and glacier (13%, Table 7).

2. lower annual precipitation and consequently lower runoff (Table 3).
3. earlier spring peaks (Figure 3).
4. a greater chance of the annual peak being a spring peak (Table 2).
5. a greater portion of private lands (Table 7).

2.2.2 Middle Section

This section of the watershed covers the area drained between Cumming and Winfield Creeks. Within this section there are no hydrometric or climate stations. The values obtained for streamflow and precipitation are interpolations between the data available for the upper section and those available for the lower section.

Distinguishing hydrologic features of the middle section are:

1. the numerous small sub-basins and the one large sub-basin (Howson).
2. one quarter of the area classified as alpine and glacier.
3. the relatively large percentage of the area that is potentially harvestable.

2.2.3 Upper Section

This section has the best hydrometric data available of the three sections. A Water Survey of Canada gauging station records data specifically for this section. Snow survey information can be compared to Kidprice Lake, which is in a similar geographical situation. However, climate and precipitation information is lacking and must be extrapolated from stations located relatively long distances away.

The annual precipitation (1500 mm) was estimated by adding a value of evapotranspiration to the measured runoff value of 1200 mm, and comparisons with precipitation records of similar sites elsewhere.

The salient hydrologic features of this section are:

1. the large percentage of area classified as alpine and glacier.
2. the higher mean elevation.
3. the higher annual precipitation.
4. the lower percent in harvestable timber.

2.3 Peak flow generating mechanisms and how they are affected by clear-cutting

2.3.1 General

Streamflow peaks can occur in the spring, associated with rain and snowmelt or in the fall as a result of relatively long duration rainfall. Routing of rain water to the stream is an extremely variable and complex process. Depending on numerous variables such as basin size, antecedant moisture conditions, vegetation type and density, soils, topography, geology and man induced soil disturbances, rain or melt water may be routed quckly or slowly to the stream. A watershed with a short time of concentration (the amount of time needed for the water to be routed to the stream) is often termed as being "flashy". Because of the generally steep topography, the underlying geology, and short distances from ridges to valley bottoms, the Telkwa watershed has a short time of concentration. The dominant ground water flow process is probably lateral movement at shallow depths because of the presence of a restrictive layer relatively close to the surface.

Inherently water is routed quickly from the headwaters of each sub-basin to the main stream channel, where because of slope, the streamflow travels rapidly down the streambed. The effects of clearcutting on streamflow generation are dependant mostly on the following factors.

1. size of individual blocks.
2. distribution of blocks within the watershed.
3. total areal extent of clearcuts that are younger than 20 years.
4. amount of land disturbed by roads, landings and skid trails.

Different processes of energy exchange and water movement are associated with snowmelt as compared to rainfall. Thus, removal of the trees have different effects on peak flows depending on whether it is a rainfall or snowmelt generated peak.

2.3.1.1 Snowmelt peaks

Spring peak flows are generated by rapid melting of the winter snowpack as a result of warm and/or sunny weather (radiation and convective melt). If the period of warm, sunny weather is followed immediately by long duration and/or high intensity rainfalls, extreme peaks can occur (e.g. June 15, 1986).

It has frequently been demonstrated, both on the Coast and in the Interior, that clearcuts (either agriculture or forestry) will accumulate more snow than the surrounding forest. Two processes are responsible for this: 1) redistribution of snow by wind, from surrounding canopies into the clearcut, 2) absence of interception loss that occurs in the forest canopy.

In addition to accumulating more snow, forest removal will cause the snow to melt earlier in the season and over a shorter period of time.

Thus, extensive clearcut harvesting in the lower elevations of the watershed, over a relatively short period would generate more streamflow sooner than is presently the case.

2.3.1.2 Rainfall peaks

The magnitude of rainfall peaks is substantially influenced by the antecedant moisture conditions of the soils in the watershed. Forest hydrology research has frequently demonstrated that the removal of the forest canopy will:

1. reduce interception loss and consequently make more water available for streamflow (note: as the size of a rainfall event increases the % of the rainfall lost to interception and evaporation decreases).
2. reduce summer evapotranspiration which reduces on-site soil water depletion. This results in wetter soils which may be able to respond to precipitation inputs at a faster rate.
3. change drainage patterns and accelerate surface runoff (roads, landings, skid trails) thus reducing the time of concentration.
4. extends the duration of groundwater flow; beginning earlier in the spring and extending later into the summer and fall.

Consequently, if a larger portion (greater than 30%) of a small watershed is clearcut over a short period of time (less than 5 years):

-total flows will increase.

-both spring and summer peak flows will increase (% increase will depend on % of area cut).

-time of concentration will decrease.

However, on a large watershed streamflow is generated at different times from different parts of the watershed. If the peak streamflow generation processes, from each section of the watershed, are slightly desynchronized in relation to each other, the resulting main channel peak will be less than if all sections produce their peaks at the same time (i.e. synchronization).

The questions that need exploring in this particular study are:

1. Does the present and future harvesting operations favour synchronization or desynchronization, thus resulting in larger or smaller rain induced streamflow peaks? 2. Will the change due to the past and proposed harvest be large enough to have any consequence? 3. How much forest removal is necessary before significant effects occur?

2.3.2 Telkwa Watershed - General

An analysis of these streamflow generating mechanisms and their timing is reviewed individually for each of the three sections of the watershed. Because of the dissimilarity of the hydrology of each section, it is important to understand the mechanisms that generate runoff so that the effects of land use, on synchronization and desynchronization of peak flows within each section, can be evaluated.

Presently, spring peak flows in the Telkwa River are mostly generated from the high elevation snow and ice melt which occurs from mid May to early July in the back end of the watershed. The middle and lower sections of the watershed generate spring peak flows earlier because of their lower elevations and the lesser extent of alpine and glacier covered areas.

Thus, in many cases the spring peak flows generated from streams in different sections of the watershed are naturally desynchronized with each other. In this section we investigate how forest harvesting related activities in each of the three sections can affect the timing and magnitude of peak flows, and how these activities might affect the streamflow regime.

Although all three sections will be reviewed, the focus of the discussion and the bulk of the analysis will be on the middle section. This is the section where forest harvesting activities can have the greatest effects on streamflow regime.

2.3.3 Lower Section

2.3.3.1 Snowmelt Peaks

The streams of the lower section of the Telkwa watershed (e.g. Goathorn, Tenas) peak earlier than the main Telkwa River. The creation of clear-cuts and other similar openings in the watershed will cause more snow to accumulate on the ground and earlier snowmelt. This will in turn cause earlier peak flows in those lower section streams. Thus, theoretically, the spring peak flows of the lower section streams could be increased, but the change in timing would be such that it would not contribute to the main peaks of the Telkwa River.

To affect the streamflow regime of a watershed, a certain proportion of that watershed must be disturbed.

Presently only 4.5% of the lower area has been disturbed since 1968 (Table 7). Numerous studies (Bosch and Hewlett, 1982) have shown that measurable changes in the streamflow regimes do not occur until 15 to 20% of the watershed has been clearcut (both interior and coastal watersheds).

The five year logging plan only calls for an additional 2.0% of the lower section of the watershed to be logged. Since the lower part of the watershed only supplies 15 to 20% of total peak flow, the total 6.5% disturbance over 25 years in this lower section will not have a significant effect on changing the flow regime of the Telkwa River at its mouth.

2.3.3.2 Fall Peaks

The effects of clear-cutting in the lower section on the fall peak flows of the Telkwa River will not be significant because:

1. The lower section does not generally experience large fall rain storms which cause annual streamflow peaks.
2. The lower section provides a relatively small contribution (15-20%) to the total peak flows of the Telkwa River.

2.3.4 Middle Section

It is within this section of the watershed that forestry related activities can have the greatest influence on the streamflow regime. As mentioned above, the lower section only generates about 15-20% of the runoff, while the upper section is so dominated by alpine and glacier that forest harvesting activities would have very little effect.

Charactertics of forest harvesting activities that may influence streamflow are as follows:

-size, elevation and aspect of each clearcut.

-total area clearcut within a basin or sub-basin of interest.

-stage of hydrologic recovery of planted or natural vegetation on clearcut areas.

-areal extent and network of roads and landings.

2.3.4.1 Snowmelt Peaks

In this middle section only 5.0% of the area has been harvested since 1968. It is assumed that the area that was harvested prior to 1968 (1.4%) has had sufficient time to recover hydrologically (vegetation regrown and evapotranspiration is estimated to have recovered to close to pre-harvest levels). Most of the clearcutting in this section of the watershed has occurred at low elevations on south facing aspects. In a few of the smaller sub-basins up to 25% of the sub-basin has been logged (i.e. Cummings and Jonas). If these sub-basins are clearcut to a much greater extent, significant increases in spring peak flows can be expected for those particular streams. However, because these are low elevation sub-basins the snowmelt and resulting generated streamflows would occur much earlier than the main peak of the Telkwa River, as explained for the lower section. Thus, these south facing, low elevation clearcuts may have a beneficial effect on the main snowmelt streamflow regime through increased desynchronization of flows between the sub-basin and main river.

The five year cutting plan, for the mid-section concentrates on the lower elevation southern slopes (700 to 1100 m). Although there are only a few snow courses in the Smithers - Telkwa vicinity, the snow courses "Hudson Bay Mtn." and "McKendrick Creek" may give us some information as to when snowmelt occurs in the elevation band 750 to 1110 m. At McKendrick Creek (elevation 1050 m) snow is often gone by May 15 and always gone by June 1(Table 6). At Hudson Bay Mtn. (elevation 1480 m), which is much higher in elevation than the logging activity, a substantial snowpack is present on June 1 and (374 mm we.) often gone by June 15 (peak snowpack is reached around May 1, Table 6).

These data suggest that the Telkwa River spring peak flows (which usually occur early to mid-June) are generated by snowmelt occurring above 1300 m. These data also suggest that snowmelt in the logging blocks (elevations lower than 1000 m) occur mid-April to early May. Thus, although peak snowmelt runoff from the logged block would be higher than if no logging had occurred, it will not contribute to the Telkwa River main peak flows. Since no substantial logging is planned at the higher elevations (ESSF), the higher elevation snowmelt that drives the spring peaks will not be accelerated by forest clearcutting.

2.3.4.2 Rainfall generated peaks

Large rainfall events generally move from west to east over the Coast Range, arriving at the upper section of the watershed first. Because of the very shallow soils in this section and the large percentage of the watershed in alpine and glacier, the time to peak is short. As the storm moves away from the Coast Range towards the Bulkley Valley, rainfall intensities usually decrease, and consequently so does the amount of stormflow generated. Although the flood wave is already about 60% of its total size by the time it reaches the middle section it builds as it travels through the middle and lower sections.

Without some kind of model it is difficult to conceptualize how the peak flow may build as it moves down the watershed and how it can be affected by clear-cutting. To assist in visualizing what may happen to rainfall generated peak flows, as clear-cutting increases in the watershed, we have developed a conceptual model using the June 15, 1986 "Fathers Day" storm (Figure 6). We look at several scenarios of different intensity of logging and how it should theoretically affect peak flows.

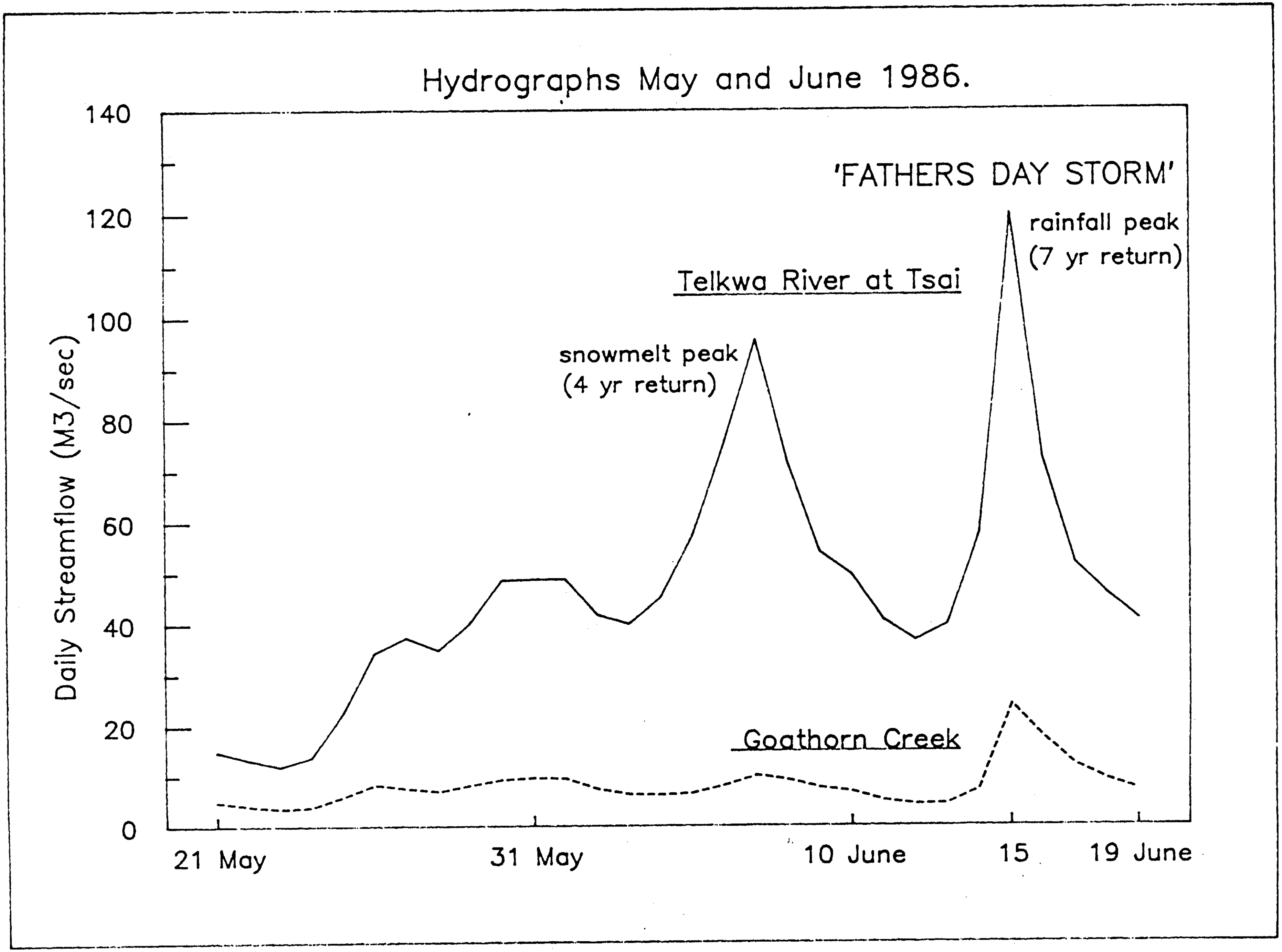

Figure 6: Hydrometric conditions leading up to the Fathers Day storm - June 1986

The unlogged model

Figure 7 presents hourly rainfall values for Terrace and Quick and hydrographs for "Telkwa River at Tsai Creek" and "Goathorn Creek" during the "Fathers Day" storm. At both climate stations (Terrace and Quick) the storm occured in two waves, each wave being clearly identifiable on Figure 7. Both rainfall peaks at Quick occured about 4 hours later than the corresponding peaks in Terrace. This suggests that rainfall began in the upper section several hours before it began in the lower section (as the storm moved from west to east). The streamflow peaks for each section reflect this delay in rainfall. The Telkwa River at Tsai peaked at 4:45 A.M. on June 15, about 5 hours after the larger peak rainfalls in Terrace. The peak on Goathorn Creek occurred at 9:15 A.M., also about 4 hours after the larger peak rainfalls, registered at Quick. Thus, as the flood wave moved down the Telkwa River, starting at the upper section, it seems that it would have been well timed to natually coincide with the maximum amounts of water generated from each of the two other sections. This is a good example of synchronization, i.e. peaks from the sub-basins synchronized in timing with the main channel peak. This synchronized type of building of the flood wave is the worst type of scenario, and any land management activities that would help to substantially desynchronize the peaks would be helpful. However, clear-cutting does not usually affect the timing of rain-generated peak flows, only the magnitude.

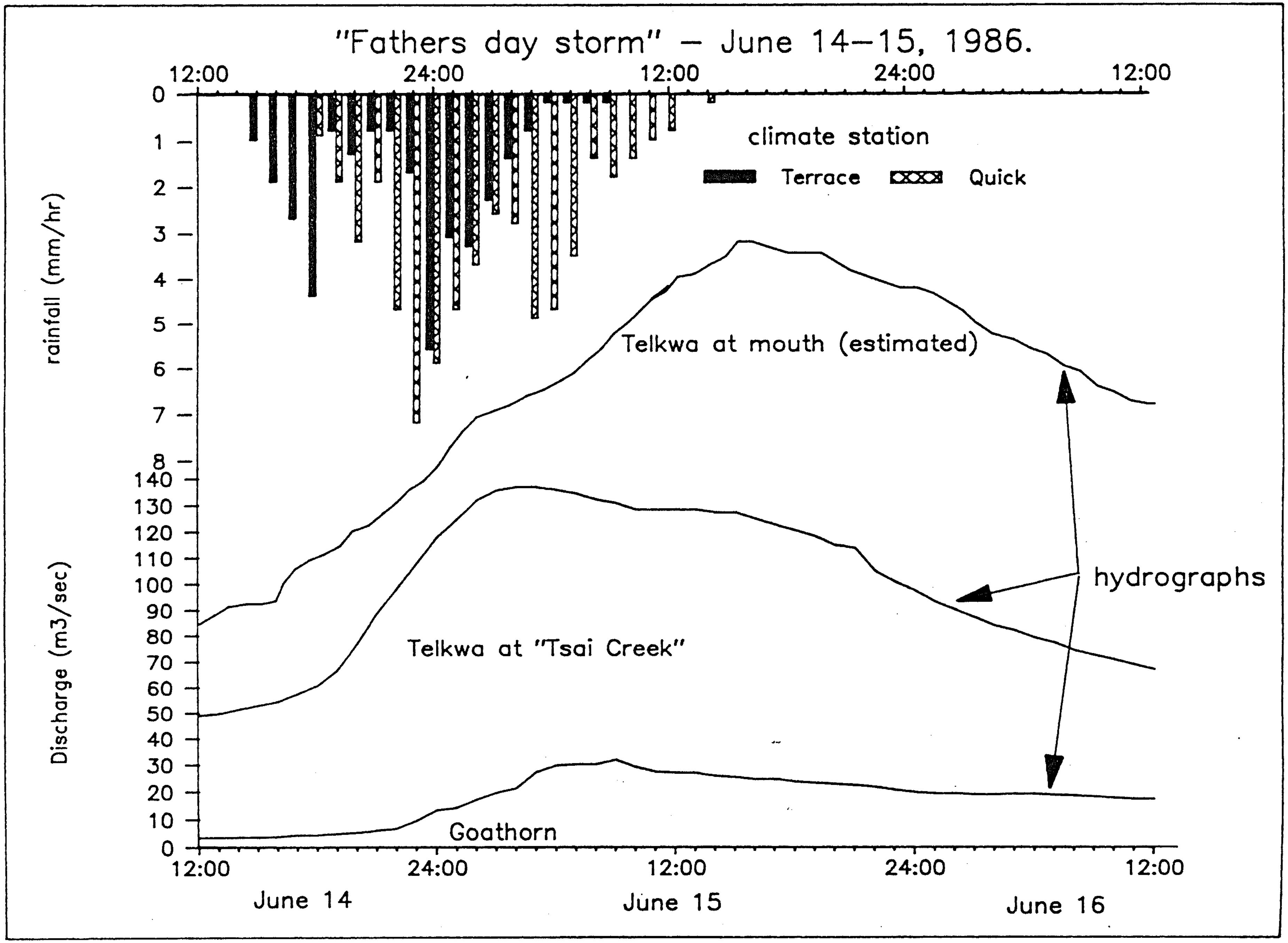

Figure 7: Fathers Day storm

The peak measured on the Telkwa at Tsai Creek was 132 m^3/sec. (W.S.C. 1986). Based on the information in Table 3 the peak flows generated independently from each of the two other sections were estimated at 60 m^3/sec. and 40 m^3/sec. for the middle and lower sections respectively.

The Logged Models

Forest hydrology research has frequently demonstrated that at least 15-20% of a watershed must be logged (and non-revegetated) before a detectable increase in rain generated peak flows occur. At that level rainfall generated peak flows on logged watersheds will be larger than in the unlogged state, but the timing is generally not substantially affected. Presently less than 7% of the middle section and less than 5% of the lower section have been logged in the last 20 years. Impacts from this level of logging on peak flows cannot possibly be detected. However, let us explore how greater levels of harvesting may affect peak flows.

Results from experimental watersheds on the impact of different levels of harvesting on changes in peak flows have been variable. Increases in rain generated peak flows due to clear-cutting, have varied from 0% to over 100%. Generally, the increase in peak flow is somewhat linearly dependant on the level of logging above a certain threshold (Figure 8A). Also, the larger the rainfall event the smaller is the % increase in flows, as the effects of reduced evapotranspiration, interception and infiltration become overwhelmed by the total amount of rainfall (Figure 8B). Thus, the total percentage of the watershed logged and the size of the storm have related effects on the increase in peakflows.

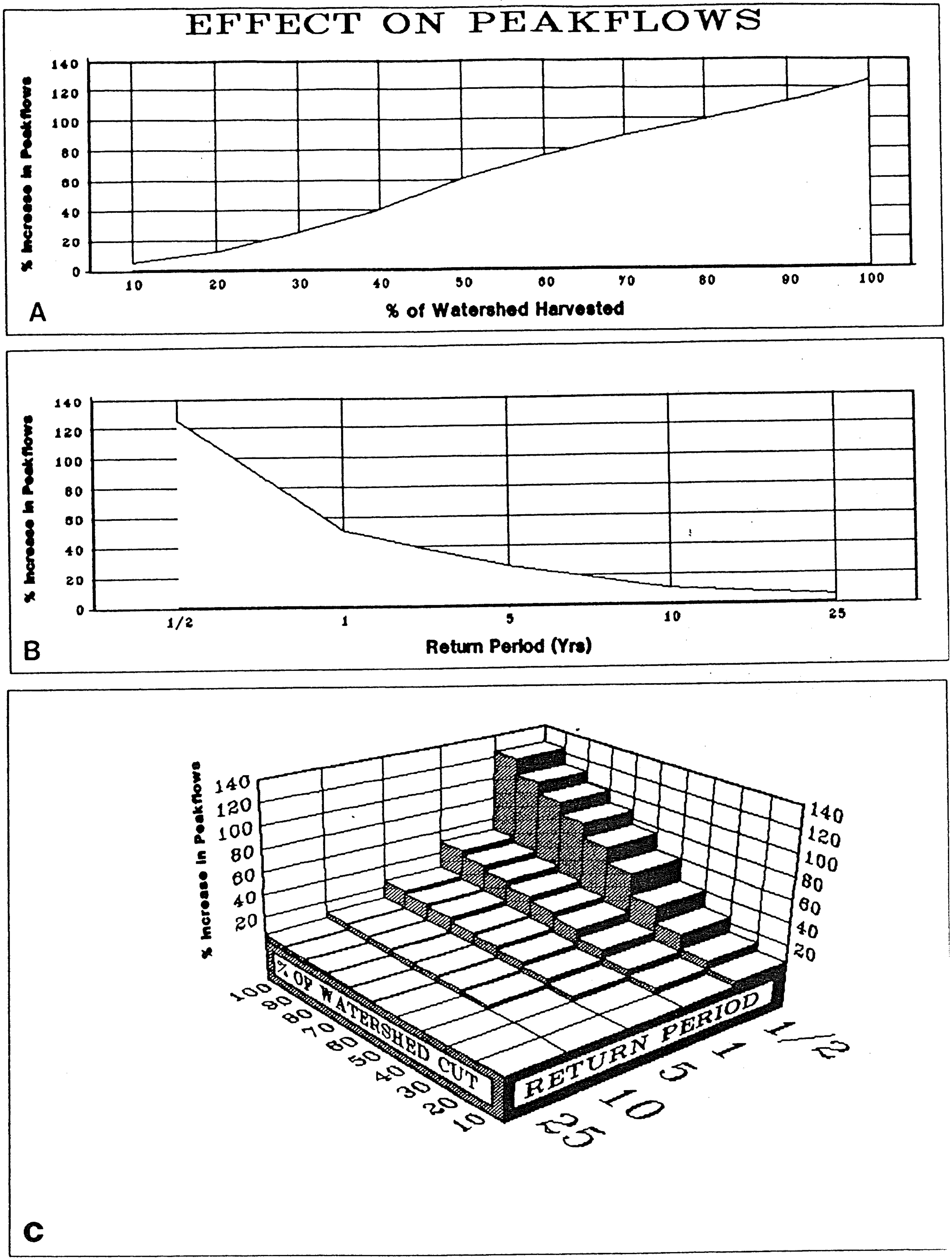

Figure 8: Effects of forest harvesting on peakflows

This relationship is graphically presented in figure 8C. In summary it means that a high percentage of clearcut harvesting can significantly affect frequent events of perhaps less than 1 year return periods[1] (i.e., small runoff events). It has minor, if any, effect on the annual event and has an almost insignificant effect on the 5 to 10 year event (USDA, 1980). Once the antecedant conditions for pre and post harvesting activities are equal, then the potential for a significant response due to the activity is eliminated. Also it must be realized that the impacts of well planned harvesting activities on a particular event are really minimal in light of the variability between individual events. Most events that are large enough to cause significant destruction will be unaffected or at last insignificantly so by the harvesting activity (literature on this topic is available in the Forest Sciences Section, Smithers).

For this modeling exercise I will assume reasonable worse case conditions. As a base assumption, we will assume that there will be a 50% increase in large rain generated peak flows (7 year return) if a watershed is a 100% clear-cut. We will compare 4 scenarios. Figure 9 and Table 8 compare the results of this modelling exercise, both in a graphical and tabular format.

---

1 the "return period" is a statistical descriptor of the size of a streamflow event. Thus a streamflow of " 1 year return period" should, on the average, only happen once a year, similarily a "10 year return period" should only happen once every 10 years (the bigger the return period, the bigger the flow).

Scenario 1: Log all merchanable timber in all 3 sections over a period of 30 years.

-for "section 1" this represents 35% of the area, thus a possible increase in peak flow of 35% x 50% = 17.5%.

-for "section 2" this represents 25% of the area, possible increase in peak flow of 25% x 50% = 13%.

-for "section 3" this represents 18% of the area, possible increase in peak flow of 18% x .50% = 9%

Using the data from the Fathers Day storm, the peak flow from section 1 would become:

$40\ m^3/sec. \times 1.175 = 47\ m^3/sec.$

from section 2:

$60\ m^3/sec. \times 1.130 = 68\ m^3/sec.$

from section 3:

$132\ m^3/sec. \times 1.09 = 144\ m^3/sec.$

Since the peaks would be synchronized, they are directly additive, for a total peak of 259 m^3/sec.

Scenario 2: (a more reasonable situation): Log 50% of merchanable timber in all three sections.

The calculations would be similar to above:

"Section 1": $[1 + (.5 \times .35 \times .50)] \times 40\ m^3/sec. = 44\ m^3/sec.$

"Section 2": $[1 + (.5 \times .25 \times .50)] \times 60\ m^3/sec. = 64\ m^3/sec.$

"Section 3": $[1 + (.5 \times .09 \times .50)] \times 132\ m^3/sec. = 135\ m^3/sec.$

total $= 243\ m^3/sec.$

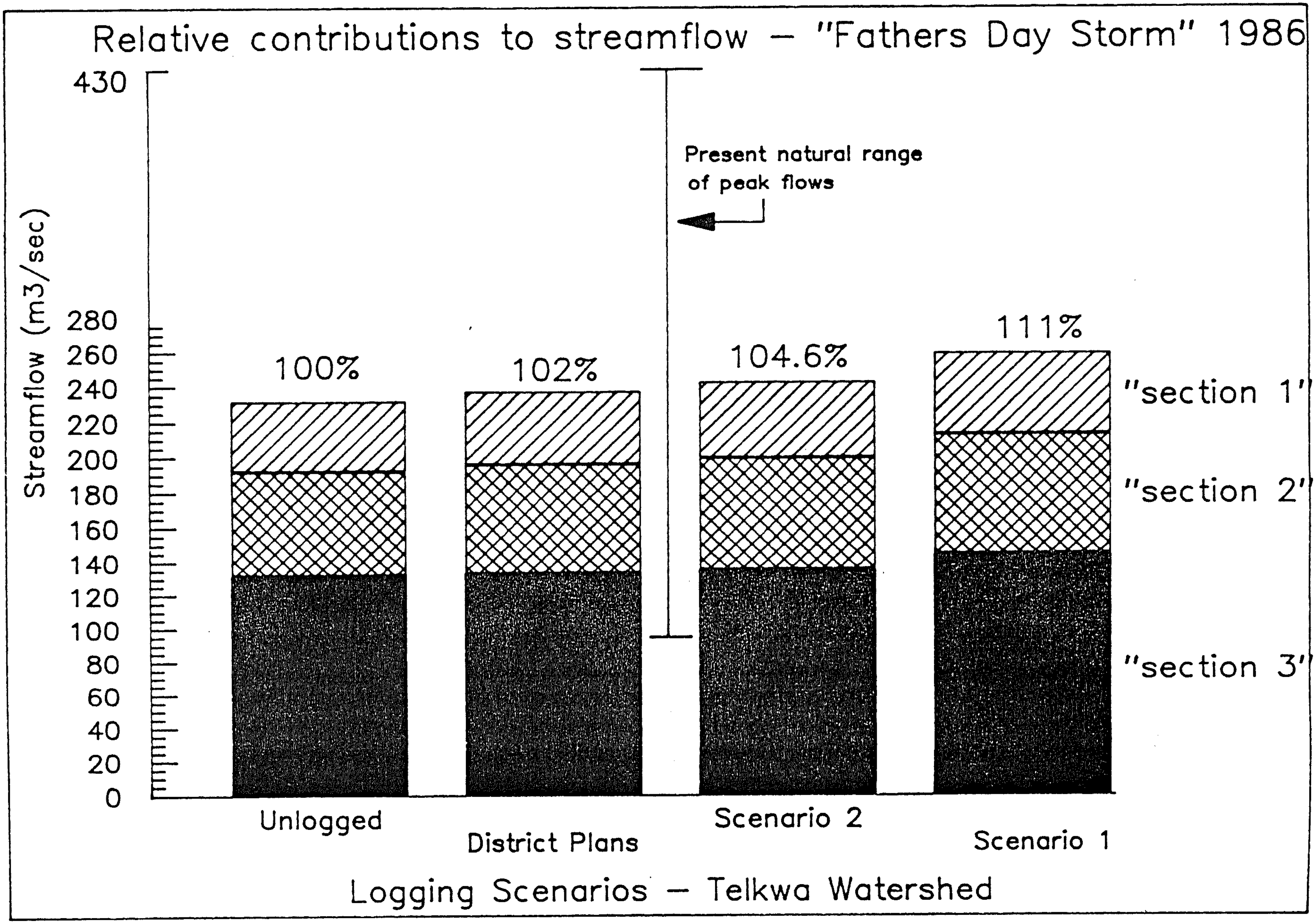

Figure 9: Relative contributions to peakflows of various logging scenarios

<u>Scenario 3</u>: (as planned by the District)

Section 1: 8% will be harvested in a period of 25 years. (1968-93)

Section 2: 9% will be harvested in a period of 25 years.

Section 3: 1.5% will be harvested in a period of 25 years.

Calculations are as follows:

Section 1: [1 + (.08 x .50)] x 40 m^3/sec. = 42 m^3/sec.

Section 2: [1 + (.09 x .50)] x 60 m^3/sec. = 63 m^3/sec.

Section 3: [1 + (.015 x .50)] x 132 m^3/sec. = 133 m^3/sec.

total = 238 m^3/sec.

This scenario represents only a 2% increase which would not be detectable even in an experimental watershed equipped with sophisticated flow gauges.

Table 8: Modeled increases in rain peak flows (m^3/sec) resulting from 3 logging scenarios.

Peak flows from 4 Scenarios				
SECTION	Unlogged (m^3/sec)	Scenario 1 (m^3/sec)	Scenario 2 (m^3/sec)	Scenario 3 (m^3/sec)
Lower Section	40	47	44	42
Middle Section	60	68	64	63
Upper Section	132	144	135	133
Total	232 (100%)	259 (111%)	243 (105%)	238 (102%)

2.3.5 Upper section

Less than 20% of the upper basin is merchanable timber and over 50% is alpine and glacier (Table 7). For this reason even the worst case scenario (i.e. removing all the merchanable timber over a period less than 20 years) would have very little effect on peak flows. Six harvesting blocks have been proposed for the next 5 years, but they only total about 400 ha, which is 1.1% of the total area of the upper basin.

3.0 SUMMARY & CONCLUSIONS

The past and proposed rate of harvest in the Telkwa watershed should not cause a detectable increase in snow or rain generated peak flows at the village of telkwa because of:

1. The small percentage of the watershed that has been and will be clearcut harvested.
2. The relatively large size of the watershed.
3. The large proportion of watershed that is alpine or glacier.
4. The fact that 60% of annual peak flows is generated by 1/3 of the watershed (the upper basin). The upper basin is dominated by glaciers and alpine, with less than 20% in merchanable timber. This offers little opportunity for harvesting activities to affect peak flows.
5. Most of the harvesting has occured and will occur below elevations of 1100 m. The snow at that elevation has melted several weeks before the spring peak flow of the Telkwa River.

A note of caution:

The present harvesting plan should not affect peak flows at the mouth of the Telkwa River. However, site specific problems may be encountered if large percentages of small sub-basins are logged too fast. This could be the case for watersheds such as Cummings and Jones creek. Although changes in their peakflow regimes would not significantly affect the peakflow of the Telkwa watershed, increased forest harvesting in these sub-basins could increase peak flows which would aggravate already unstable condition and increase sediment transport to the Telkwa River.

4.0 LITERATURE CITED

Bosch, J.M. and Hewlett, J.D., 1982. A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotraspiration J. Hydrol, 55: 3-23.

B.C. Ministry of Environment, 1985. Summary of snow survery measurements in British Columbia, 1935-1985. Inventory and Engineering Branch, Victoria, B.C.

Bustard D. and Associates, 1985. Aquatic resource assessment of the Telkwa coal project 1984 studies for Crows Nest Resources Limited February, 1985.

Crows Nest Resources Ltd. 1983. Telkwa coal project, stage I application. Submitted to Energy, Mines and Petroleum Resources, Government of British Columbia, Victoria. December, 1983.

Miles, M.J. 1983. Hydrology Component: Stage I studies, Crows Nest Resources Limited, Telkwa coal project prepared for Read Environmental & Planning Associates Ltd.

Runka, G.G., 1972. Soils Resources of the Smithers - Hazelton Area. Soil Survey Division, B.C. Department of Agriculture, Report Number 21 Kelowna, B.C. 234 pp.

Water Survey of Canada, 1986. Surface Water Data, British Columbia, 1986. Inland Waters/Lands Directorate, Water Resource Branch, Environment Canada, Ottawa.

USDA Forest Service, 1980. Approach to water resources evaluation of non-point silvicultural sources (WRENSS). A procedural handbook. Environmental Research Laboratory Office of Research and Development, U.S. Environmental Protection Agency. Athens, Georgia 30605.