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Unpublished Report

REPORT ON THE FLOOD OF NOVEMBER 1978 IN NORTHWEST BRITISH COLUMBIA

September 1979

Inland Waters Directorate
Pacific and Yukon Region
Vancouver, B.C.

19 September 1979

~~FINAL~~ REPORT ON THE FLOOD OF NOVEMBER 1978 IN NORTHWEST BRITISH COLUMBIA

LOCATION

The Terrace-Kitimat area in the Skeena and Kitimat River basins in the northwestern part of British Columbia was affected by floods in November 1978. Other major population centres involved were Prince Rupert, Lakelse, Smithers and Hatfield (see attached figure in Appendix I).

TIME

The peak flows occurred on 1 November 1978 and flows started to subside the next day. The duration of the flood was, thus, rather brief.

CAUSES

The flood was caused by prolonged rainstorm which began on 29 October 1978 and peaked on the night of 31 October-1 November. This multiday storm dumped about 200 mm of rain, with amounts of over 400 mm encountered west of Kitimat. The rain was accompanied by strong winds of 85-90 knots from the southwest. Damage was mostly caused by high wind and waves; washouts due to debris jams; flooding due to inadequate local drainage; and rock and mud slides. For details of meteorological conditions leading upto the storm, see Appendix II.

FREQUENCY AND MAGNITUDE

The return period for the multiday rainstorm was estimated to be in the 80 to 100 year range. The flood resulting from this storm was defined as a 30 year event for the over-all affected area, although there was considerable variation for different streams. As a flood event, therefore, the November 1978 flood was not extreme. What made it noteworthy was the amount of damage caused by the combined effect of wind, waves and water.

Except for flooding in subdivisions with inadequate local drainage, there was little noticeable inundation of the floodplain. For detailed hydrological analyses, see Appendix III.

ASSOCIATED ACTIVITIES

The flood was not forecast and no warning was given as the flood itself was not a particularly extreme event. Emergency measures, implemented by the Province, were aimed mainly at restoring the transportation and other public utilities such as communications, hydro and natural gas. There are no flood control structures to speak of on the affected streams. A few people, employees of the British Columbia Highways department, who were trapped because of slides and washouts, had to be rescued. For details refer to newspaper clippings in Appendix IV.

DAMAGES

Two persons, both employees of Canadian National Railways, lost their lives. Fortunately, no other fatalities were recorded.

Estimates of total damage caused by wind, waves, water and slides have increased from $2 million reported just after the storm to 50 million pronounced later by the British Columbia Highways Minister, Mr. Alex Fraser. An estimate in October 1979 by Emergency Measures Office places the damages around $7-8 million. However, this estimate does not include damages to railways, etc. It is anticipated that the details and official total of all of the damages will not be known for some time.

It should be noted that high flows and levels in rivers and lakes were responsible only for part of the damage caused. However, damage breakdown according to the cause of damage (flooding, wind, landslides, etc.) is not available at present. For details see Appendix V, to be included later when detailed information on damages becomes available.

FLOOD DAMAGE REDUCTION MEASURES IN EXISTENCE

No Flood Damage Reduction agreement has been signed with British Columbia. Flood damage reduction measures, such as forecasting and warning, flood-proofing, etc., are not known to exist in the affected area, except for some dyking in the vicinity of Kitimat.

PROPOSED FLOOD DAMAGE REDUCTION MEASURES

Negotiations for entering into a joint federal-provincial Flood Damage Reduction agreement with British Columbia are underway.

PAST FLOODS

A comparable flood occurred in 1974 in this area. The 1978 flows were generally higher, except for those in Hirsh Creek and Skeena River. The 1974 flood was not accompanied by severe wind and rainstorm and caused relatively minor damage.

FUTURE REPORTS

No future reports have been requested or planned at this time.

PREVIOUS REPORTS

These are included as Appendix ~~VI~~ IV.

APPENDICES

Appendix I: Map Showing Affected Area.

Appendix II: Meteorological Developments Contributing to the Terrace Area Flood of Early November 1978.

Appendix III: Terrace-Kitimat Flood Event of November 1978.

~~Appendix IV: Newspaper clippings.~~

~~Appendix V: Damages Caused by the Terrace-Kitimat Flood of November 1978.~~

Appendix ~~VI~~ *IV*: Previous Reports on Terrace-Kitimat Flood of November 1978.

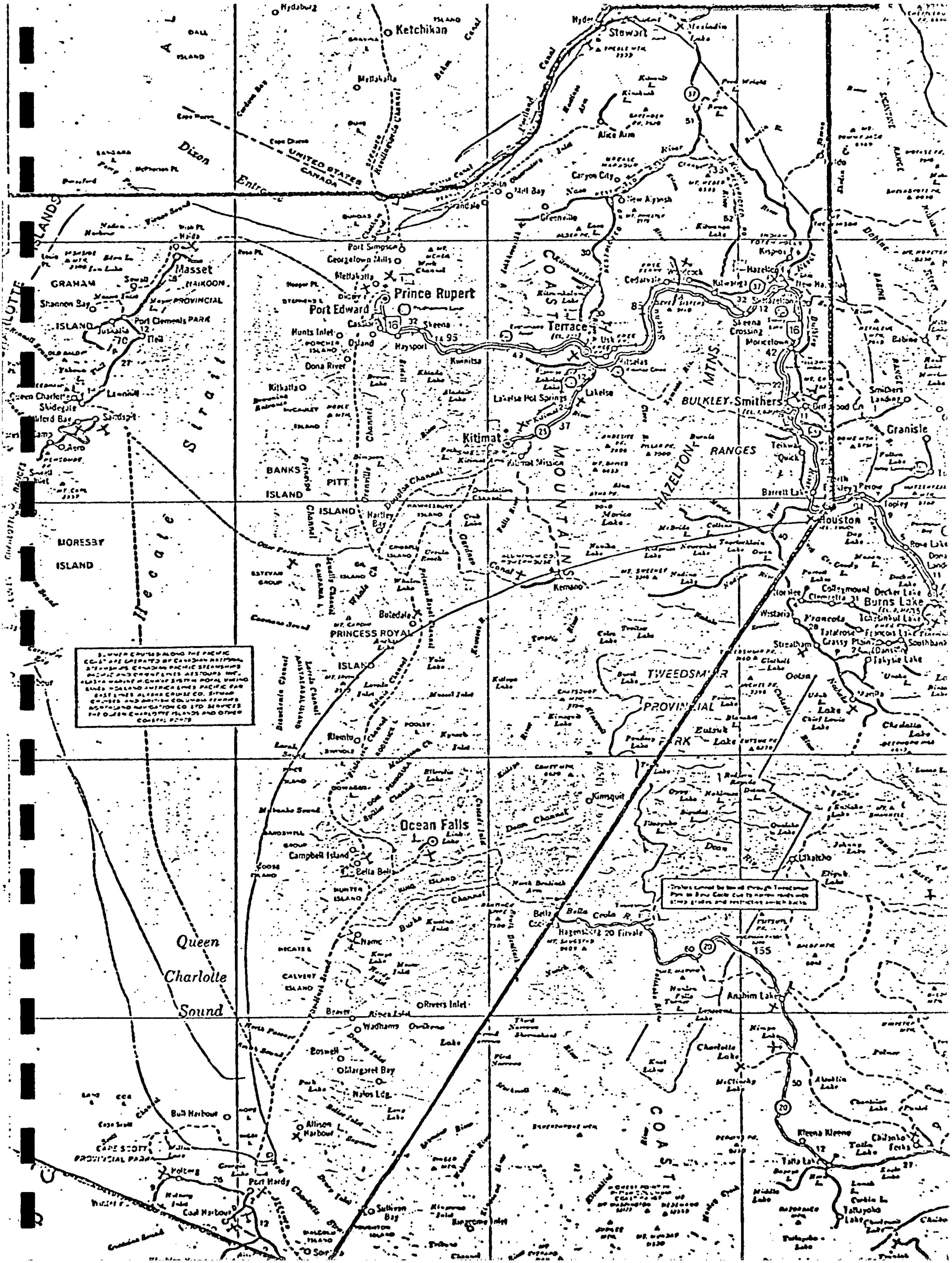
Note: ~~Appendices II to VI~~ *Newspaper clippings* are available at:

Water Planning and Management Branch
Inland Waters Directorate
Pacific and Yukon Region
Vancouver, B.C.

Telephone: 666-3356

APPENDIX I

MAP SHOWING AFFECTED AREA



Ketchikan
Stewart
Hyder
Alice Arm
Canyon City
New Aiyansh
Greenville
Port Simpson
Georgetown Mills
Prince Rupert
Port Edward
Masset
GRAHAM
Shannon Bay
ISLAND
Port Clements
Juskatla
Tlell
Queen Charlotte
Skidegate
Sandspit
Terrace
Usk
Kitselas
Lakelse Hot Springs
Lakelse
Kitimat
Kitimat Mission
Hunts Inlet
Oona River
Dona River
Kitkatla
Hartley Bay
Hazelton
Kispiox
South Hazelton
New Hazelton
Skeena Crossing
Moricetown
Smithers
BULKLEY
Telkwa
Quick
Barrett Lake
Houston
Topley
Granisle
Burns Lake
Decker Lake
Francois Lake
Southbank
Grassy Plains
Wistaria
Streatham
Ootsa
Lake
Kemano
TWEEDSMUIR
PROVINCIAL
PARK
Eutsuk
Lake
HAZELTON
MTNS
RANGES
MOUNTAINS
COAST
BANKS
ISLAND
PITT
ISLAND
MORESBY
ISLAND
PRINCESS ROYAL
ISLAND
Butedale
Ocean Falls
Kimsquit
Dean Channel
Campbell Island
Bella Bella
Namu
Bella Coola
Hagensborg
Firvale
Anahim Lake
Charlotte Lake
Rivers Inlet
Wadhams
Boswell
Margaret Bay
Nalos Ldg.
Allison Harbour
Bull Harbour
CAPE SCOTT
PROVINCIAL PARK
Holberg
Port Hardy
Coal Harbour
Sullivan Bay
Kleena Kleene
Tatla Lake
Chilanko Forks
Queen
Charlotte
Sound
Hecate
Strait
Dixon
UNITED STATES
CANADA
16
37
20
25

APPENDIX II

METEOROLOGICAL DEVELOPMENTS CONTRIBUTING TO THE TERRACE AREA FLOOD OF EARLY NOVEMBER 1978

Meteorological Developments Contributing to the Terrace Area Flood of Early November, 1978*

by

D. C. Schaefer, Scientific Services
Atmospheric Environment Service, Vancouver

Introduction

A multi-day rainfall event, heaviest on October 31 and November 1, 1978, resulted in serious flooding in the North Coast area surrounding Terrace, British Columbia. What follows is a description of the rainstorm including consideration of the antecedent conditions, the spatial pattern of precipitation revealed by data from climatological stations in the area and the temporal distribution obtained from recording raingauge records from Terrace Airport. Storm frequency estimates are given both for short durations (5 minutes to 24 hours) for Terrace Airport and for the multi-day storm for a number of stations in the area. Finally, a description of the synoptic features of the storm is provided.

Antecedent Conditions

A listing of the daily maximum and minimum temperatures and daily rainfall, snowfall and total precipitation for Terrace Airport for October and November, 1978, is presented in Table 1. For purposes of comparison the long-term averages for the site for October, which is normally the wettest month of the year, are as follows: mean daily maximum temperature 8.9°C, mean daily minimum temperature 3.7°C, mean rainfall 226.6 mm, mean snowfall 5.3 cm and mean total precipitation 231.9 mm (Canadian Normals, 1941-1970, Temperature and Precipitation, Atmospheric Environment Service, 1975). In this context it can be seen that temperatures were generally above normal during the first twenty days of October. Precipitation up to October 29, all in the form of rain, was just over 60 percent of the monthly normal.

During October, freezing levels on the North Coast indicated by atmospheric temperature profiles taken twice per day at the radiosonde station at Annette, Alaska, generally averaged about 1500 metres. Freezing levels reached 3000 metres on October 6 and close to that height on the fourteenth and the seventeenth. They fell below 1000 metres on the eleventh, the nineteenth and during the cool, dry period in the six days immediately preceding the flood producing rains that began at the end of the month.

By referring to freezing levels in conjunction with precipitation data, it can be seen that the most significant snowfall to be deposited on the mountains surrounding Terrace at elevations below 1000 metres would likely have fallen on October 19 although amounts were apparently not large. No snow fell at the elevation of Terrace during the month. These factors would tend to limit the contribution of snowmelt to the coming flood event.

*Prepared in March, 1979, as input to a report on the Terrace Area Flood by the Inland Waters Directorate of Environment Canada.

Rainfall Pattern

Daily precipitation totals for 39 stations in the study area for the period from October 29 to November 2, 1978, are listed in Table 2 along with the respective accumulated 5-day totals. It should be noted that values given are for the climatological day, which may differ from one station to the next. At first-order Atmospheric Environment Stations, such as Terrace Airport, the climatological day extends from 2200 PST (0600 GMT) on the previous day to 2200 PST on the date indicated. At nearby Terrace PCC the period runs from 1000 PST on the date indicated to 1000 PST on the following morning. At the majority of stations the climatological day extends from 0800 PST to 0800 PST on the following morning. The resulting tabulation may, therefore, indicate more or less precipitation on a given date depending on the timing of the event with respect to the climatological day of the station involved.

Although much of the rainfall was concentrated in a two to three day period, it was desirable to include lesser amounts which occurred at the beginning and end of the storm at some stations. Five-day precipitation totals as listed in Table 2 were transferred to an isohyetal map for the storm as presented in Figure 1. The 200-millimetre isohyet delineates an area in excess of 50,000 km^2 between Terrace and Prince Rupert and extending from the Alaska border southward to Ocean Falls. Amounts in excess of 400 mm are indicated in the mountainous region between Kitimat, Falls River and Hartley Bay. It should be noted that these isohyets are very much smoothed and are based upon data biased toward lower elevations. The configuration of the 300 and 400 mm isohyets reflects large blocks of higher elevation mountainous terrain but undoubtedly the true pattern is much more complex with considerably greater precipitation likely at some favoured sites.

The temporal distribution of the rainfall is well indicated by the continuous record from the tipping bucket raingauge at Terrace Airport. A mass-curve of accumulated precipitation based on those records is presented in Figure 2. Continuous rainfall began about 1630 PST on October 30. Greatest rates of accumulation for periods greater than one hour occurred during the first morning of the storm (i.e, between midnight and noon on October 31) although relatively heavy rain also fell at times during the morning and afternoon of November 1. A shower between 1800 and 1900 PST on November 1 marked the end of significant rainfall, although a few lighter showers occurred during the following night. Light precipitation fell during the period from November 2-4 with a further intensification on the fifth and sixth. During the period, however, it was the deluge of October 31 and November 1 that was responsible for the major flood in the area.

Storm Frequency Estimates

The return period, or inverse of the probability of occurrence, of a storm is a function of the duration of the event being considered. In any given case, return periods may be estimated for a number of durations for which a comparative data base is available for fitting to an appropriate statistical distribution. The duration of greatest interest will often depend on the time of concentration (related to area) of the watershed being considered. In typical urban drainage problems this may range from minutes to hours, whereas in large watersheds periods of several days may be more relevant.

In the present case, rainfall intensity-duration-frequency curves are available for Terrace Airport for durations from 5 minutes to 24 hours (Figure 7). In addition, tabulations of multi-day precipitation extremes for fixed periods from one to ten climatological days were made available by the Climatology Division, Resource Analysis Branch, B. C. Ministry of the Environment or, in the case of Terrace Airport, were previously available within the Atmospheric Environment Service. For any given duration data were fitted to the Gumbel extreme-value probability distribution in order to estimate the return periods of precipitation amounts observed during the storm.

Table 3 indicates the observed short-duration precipitation extremes for the climatological days of October 31 and November 1, 1978, at Terrace Airport as well as the equivalent intensities of rainfall. For durations of one hour or less peak intensities occurred during the shower which effectively ended the storm. The shower was unremarkable, with estimated return periods ranging from under 2 years to about 3 years for a duration of 1 hour. For durations from 2 hours to 24 hours peak intensities occurred on the morning of October 31 with estimated return periods increasing for longer durations to 35 years at 24 hours.

Analysis of multi-day precipitation statistics is somewhat less satisfactory than that for short-duration intensities since one must rely on fixed-period totals and these may vary, as previously mentioned, due to the timing of the event. Table 4 presents recorded extremes for periods from one to four days along with estimated return periods. Estimates labelled Terrace A (1) are based upon an analysis of 17 years of rainfall extremes carried out by the Atmospheric Environment Service. The remainder of the estimates are based on analyses of tabulations of multi-day precipitation extremes provided by the Resource Analysis Branch. Periods of record used ranged from 10 years at Smithers A to 46 years at Falls River. Twenty-three years of precipitation extremes were available for Terrace A (2). In most instances snowfall contributed little to extreme events, rendering similar curves for rainfall and total precipitation. However, extrapolation to longer return periods, based on the mean and standard deviation of the extremes, does involve a degree of uncertainty that varies from site to site.

As was seen in Figure 2, the fixed 1 and 2-day precipitation totals for Terrace Airport coincided exactly with the extremes for 24 and 48 hours observed during the storm. The one-day extreme of 114.8 mm established a new record for any month for Terrace Airport, although 116.6 mm had been observed in December, 1933 at Terrace. The two and three-day extremes in 1978 were greater than those of 1933 but, for the 4-day period, a greater amount (234.2 mm) was measured at Terrace in October, 1935.

Because of the coincidence of timing mentioned above, return-period estimates for one and two days for the rainfall at Terrace Airport were maximized. These ranged from 40 to 70 years for one day to 95 to 120 years for two days depending on the basis of computation. (The somewhat lower estimate for 24 hours given in Table 3 is based on floating time-base records from the tipping bucket gauge over a nine year period.) At Falls

River the greatest return period estimated was 85 years for the 3-day precipitation total; at Kitimat Townsite it was 65 years for the 3-day total. On the fringes of the storm, values at Prince Rupert A and Smithers A were all under 10 years and often less than 2 years. For the multi-day event one could then consider the storm to have had a return period in the range of 80 to 100 years in many of the areas most severely affected.

Synoptic Description

In previous sections the observed precipitation patterns and estimated storm frequencies were presented. In the following paragraphs the synoptic developments which led to these large rainfall accumulations are described.

On October 29 a ridge of high pressure lay across the North Coast both at the surface and aloft. A strong frontal zone oriented from the northeast to the southwest had entered the western Gulf of Alaska ahead of a deep low over western Alaska. An exceptionally wide and uniformly bright band of cloud along the front was evident on the satellite pictures of the day.

By the afternoon of October 30 the front lay from north of the Queen Charlotte Islands to the southwest. Aloft a strengthening, warming and moistening southwesterly flow at 50-kPa (about 5500 metres) paralleled the surface front. By the morning of October 31, with the rainstorm under way on the North Coast, a frontal wave moving from the southwest had reached the coast to the north of the Queen Charlotte Islands (Figure 3). Freezing levels had risen from under 1000 m to almost 2000 m at Annette, Alaska. Surface dewpoints in the warm sector had reached 10°C.

Following passage of the wave the front remained quasi-stationary in the area since it was aligned parallel to the now strong southwesterly upper flow. The 50-kPa chart for the afternoon of October 31 is presented in Figure 5. Southwest winds of 85 to 90 knots were indicated to be crossing the coast at the latitude of the Queen Charlotte Islands.

The nature of the airmass which was the source of the storm's heavy precipitation is revealed in Figure 6, which depicts the Port Hardy radiosonde ascent for the morning of November 1. The freezing level was near 3000 metres (70-kPa) and the airmass was close to saturation from the surface to 5000 metres with considerable moisture to higher levels. Above 80-kPa the wet-bulb potential temperature ranged from 14 to 16°C. In the active frontal zone it can be assumed that this airmass extended downward close to the surface since maximum temperatures on November 1 ranged from 12 to 14°C throughout much of the area.

Subsequent wave development on the front led to the formation of a deepening low pressure centre which was located just south of Ocean Station "Papa" on the evening of October 31. By the afternoon of November 1 the low had reached the Alaskan Panhandle and the cold front had impinged on the mainland coast (Figure 4). Persisting surface dewpoints in this final wave attained values of 12 to 13°C.

Moderate showers marked the passage of the cold front, following which the airmass cooled and dried out markedly. By the morning of November 2 the 50-kPa temperatures at Annette had dropped from peak values near -15°C to -35°C. The once saturated airmass had dried to a 50-kPa dewpoint temperature of -50°C; 90 knot winds at that level had decreased to only 35 knots. Freezing levels which had reached 3000 metres were now well below 1000 metres, resulting in the first low-elevation snowshowers of the year. Instability showers which occurred over several days following passage of the cold front gave way to renewed moderate frontal precipitation on November 5 and 6 but, compared to the deluge of October 31 and November 1, amounts were small and did little to increase the damage that had been done.

Summary

The rainstorm of late October - early November on the North Coast of British Columbia was characterized by a 200 mm isohyet delineating an area of over 50,000 km^2 with precipitation values to the west of Kitimat in excess of 400 mm. The return period of the multi-day storm was estimated to be in the 80 to 100 year range. Synoptically the storm was characterized by a frontal zone stretching from the north-east to the southwest parallel to a strong, warm, moist southwesterly flow of air aloft.

Table 1. Daily Precipitation and Temperature for Terrace Airport for October and November, 1978.

Oct.	Max.T (°C)	Min.T (°C)	Rain (mm)	Snow (cm)	Precip. (mm)	Nov.	Max.T (°C)	Min.T (°C)	Rain (mm)	Snow (cm)	Precip. (mm)
1	13.1	8.7	Tr		Tr	1	12.0	0.6	89.1		89.1
2	10.2	7.5	9.0		9.0	2	6.2	0.8	8.4	Tr	8.4
3	14.6	8.1	0.7		0.7	3	2.4	0.7	12.8	0.8	14.0
4	10.5	6.7	1.0		1.0	4	3.2	0.2	1.6	1.8	3.6
5	10.6	6.9	Tr		Tr	5	4.4	0.0	32.4	2.0	34.4
6	16.5	7.2				6	4.7	1.0	42.4		42.4
7	15.1	9.0	1.6		1.6	7	4.9	0.2	3.0		3.0
8	12.3	9.1	31.2		31.2	8	4.6	-0.9		1.0	0.8
9	11.6	4.3	13.8		13.8	9	1.8	-2.0		Tr	Tr
10	9.4	2.5	19.8		19.8	10	-1.7	-5.0			
11	9.7	4.3	4.9		4.9	11	-1.2	-4.0		4.0	3.8
12	7.5	4.5	10.8		10.8	12	-0.2	-3.3			
13	11.8	3.3	4.3		4.3	13	-1.0	-6.6			
14	13.9	8.7	Tr		Tr	14	0.7	-6.4	3.6	6.4	8.2
15	11.0	7.9				15	2.8	0.3	9.8		9.8
16	11.9	7.9	0.8		0.8	16	2.7	0.2	Tr	0.2	0.2
17	13.6	10.2	Tr		Tr	17	0.8	-9.4		Tr	Tr
18	13.6	11.6	1.6		1.6	18	-8.6	-13.0			
19	12.1	6.2	13.0		13.0	19	-7.8	-13.1			
20	9.8	3.8	Tr		Tr	20	-9.1	-13.5			
21	8.4	3.7	Tr		Tr	21	-6.6	-11.2			
22	6.7	4.2	19.6		19.6	22	-3.6	- 9.6		Tr	Tr
23	8.4	3.6	8.6		8.6	23	0.0	- 4.2	Tr	Tr	Tr
24	5.6	-0.1				24	4.1	- 0.3	0.4		0.4
25	6.5	2.6	0.2		0.2	25	4.5	1.2	1.2		1.2
26	8.8	2.0	Tr		Tr	26	3.7	1.3	Tr		Tr
27	5.9	-1.2				27	5.0	2.8	6.0		6.0
28	4.2	-2.2				28	5.0	1.5			
29	2.8	-2.9				29	1.9	- 0.5	Tr	8.8	7.0
30	9.3	2.5	8.8		8.8	30	2.2	- 0.3		0.8	0.6
31	8.0	1.0	114.8		114.8						

Table 2. Daily Precipitation (mm) for the Period October 29 to November 2, 1978, for Climatological Stations on the Northwest Coast of British Columbia.

Station Name	Precipitation Amounts by Climatological Day					Precipitation Total for the 5-Day Period
	Oct.29	Oct.30	Oct.31	Nov. 1	Nov. 2	
Aiyansh 2SE	1.4	56.2	45.0	76.2	5.4	184.2
Bella Coola	Tr	3.0	82.4	19.4	1.2	106.0
Bella Coola B.C. Hydro	0.0	10.0	66.1	38.0	5.5	119.6
Boat Bluff	7.2	75.4	160.0	95.8	15.4	353.8
Bonilla Island	Tr	9.2	15.8	7.4	1.6	34.0
Cedarville	0.0	24.6	81.3	41.8	1.4	149.1
Dryad Point	0.4	7.2	34.6	29.8	5.0	77.0
Ethelda Bay	0.9	23.6	82.1	66.1	0.6	173.3
Falls River	10.0	110.0	138.0	90.0	22.0	370.0
Hartley Bay	9.9	88.9	146.1	96.5	26.2	367.6
Hays Mountain (RAB)*	9.0	38.0	79.0	47.0	4.0	177.0
Hazelton Temlaham	0.0	10.2	42.9	22.0	2.0	77.1
Kemano	1.0	27.2	108.2	76.2	3.8	216.4
Kildala	6.4	59.4	122.4	48.3	5.6	242.1
Kispiox	0.0	3.0	32.6	31.6	2.0	69.2
Kitimat Townsite	9.0	63.9	130.0	64.0	8.0	274.9
Kitimat 2	23.3	90.2	179.4	99.8	14.3	407.0
Kitwanga	0.0	18.0	49.4	36.3	0.0	103.7
Kitwanga (RAB)	0.0	19.0	51.0	52.0	1.0	123.0
Maxam #1 (RAB)	0.0	1.0	11.0	3.0	0.0	15.0
McInnes Island	0.0	21.0	88.0	89.8	1.4	200.2
Murder Creek	0.0	15.2	0.0	30.4	1.0	46.6
Nora Lee North	0.0	0.4	17.6	3.2	0.0	21.2
Ocean Falls	0.0	4.6	40.1	105.4	51.3	201.4
Ootsa Lake Skinsh Spillway	0.0	0.0	0.0	0.0	0.0	0.0
Prince Rupert A	3.0	17.2	46.8	55.3	5.2	127.5
Prince Rupert Mont Circle	20.6	64.4	82.4	58.6	9.4	235.4
Prince Rupert R Park	16.2	48.3	64.6	52.6	10.0	191.7
Pr. Rupert Shawatlans	14.6	75.0	87.4	39.0	8.4	224.4
Quick	0.5	Tr	18.6	2.3	0.3	21.7
Rosswood	1.0	62.4	81.0	73.2	8.4	226.0
Salvas Camp**	8.0	63.5	E67.2	58.0	20.0	E216.7
Smithers A	0.0	Tr	30.0	34.6	0.8	65.4
Stewart A	1.0	49.2	52.2	68.6	31.9	202.9
Tahtsa Lake West	0.0	Tr	38.1	133.4	83.8	255.3
Terrace A	0.0	8.8	114.8	89.1	8.4	221.1
Terrace PCC	1.6	51.2	85.9	47.5	9.8	196.0
Triple Island	0.2	2.6	10.6	14.6	Tr	28.0
Wistaria	0.0	0.0	2.0	0.0	0.0	2.0

*Data for stations indicated by RAB abstracted from recording rain gauge charts provided by the Climatology Division, Resource Analysis Branch, B. C. Ministry of the Environment.

**Data for the period ending on the morning of November 1 estimated.

Table 3. Short-Duration Precipitation Extremes and Estimated Return Periods for Terrace Airport for the Storm of October 31 - November 1, 1978.

Duration	Amount (mm)	Intensity (mm/h)	Time of Occurrence	Return Period
5 minutes	2.3	27.6		Under 2 yrs.
10 minutes	3.5	21.0	Between	Under 2 yrs.
15 minutes	4.3	17.2	1800 and 1900 PST	Under 2 yrs.
30 minutes	6.5	13.0	on Nov. 1	Under 2 yrs.
60 minutes	11.2	11.2		3 yrs.
2 hours	17.0	8.5	0600-0800 PST-Oct.31	3 yrs.
6 hours	45.2	7.5	0300-0900 PST-Oct.31	20 yrs.
12 hours	73.4	6.1	0000-1200 PST-Oct.31	30 yrs.
24 hours	114.8	4.8	2200-2200 PST-Oct.31	35 yrs.

Table 4. Multi-Day Precipitation Extremes and Estimated Return Periods for Selected Stations for the Period October 29 to November 2, 1978.

Station	Precipitation Amounts (mm) and Return Periods (years)							
	1-Day		2-Day		3-Day		4-Day	
	Amt.	Ret.Prd.	Amt.	Ret.Prd.	Amt.	Ret.Prd.	Amt.	Ret.Pr
Terrace A (1)*	114.8	40	203.9	95	212.7	85	221.1	90
Terrace A (2)	114.8	70	203.9	120	212.7	75	221.1	70
Falls River	138.0	12	248.0	30	338.0	85	360.0	40
Kitimat Townsite	130.0	10	194.0	17	257.9	65	266.9	17
Prince Rupert A	55.3	<2	102.1	2	119.3	<2	124.5	<2
Smithers A	34.6	3	64.6	6	65.4	5	65.4	4

* See text regarding source of comparative data for return-period estimates.

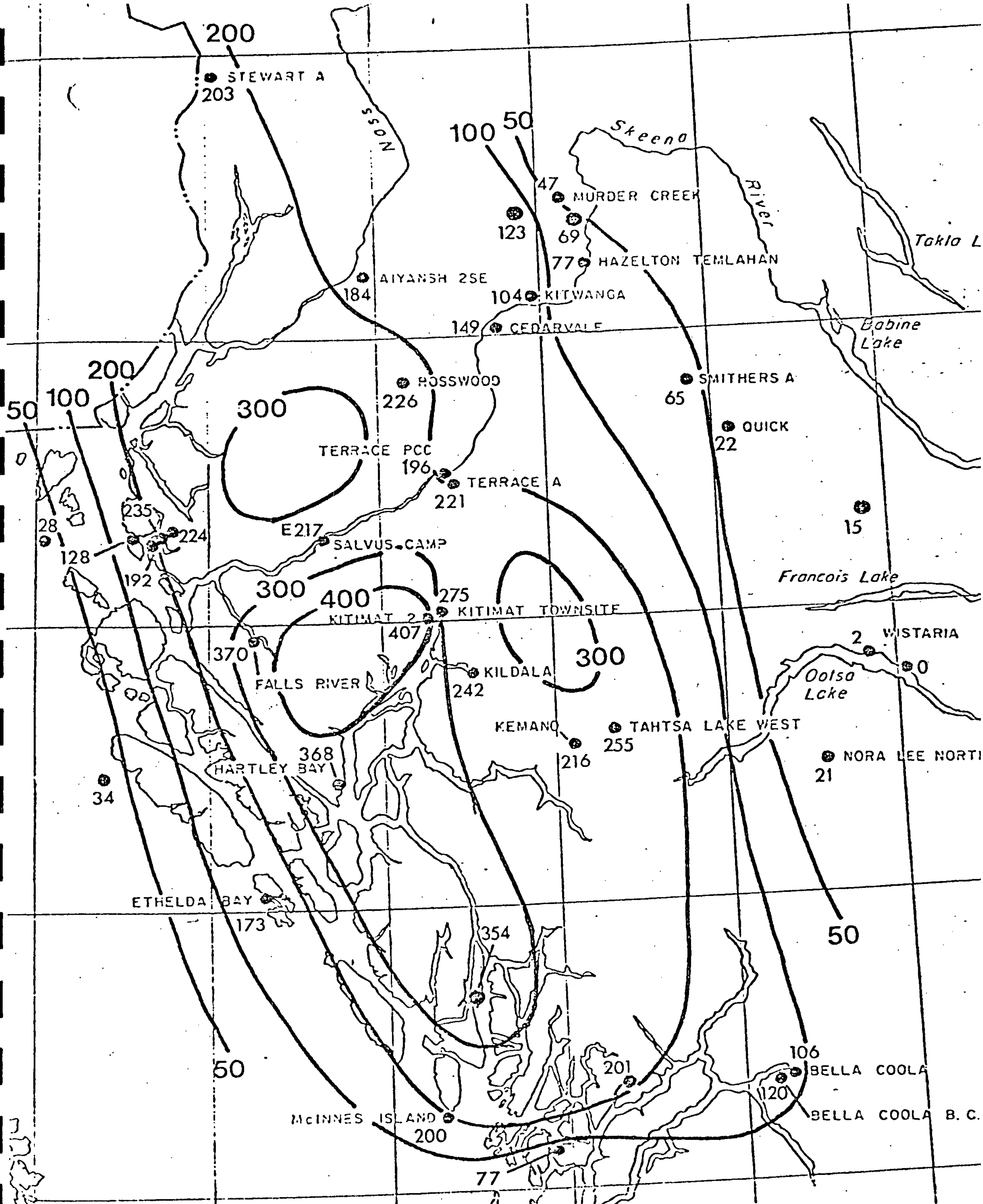


Figure 1. Isohyetal Map of Total Precipitation (mm) for the 5-Day Period from October 29 - November 2, 1978.

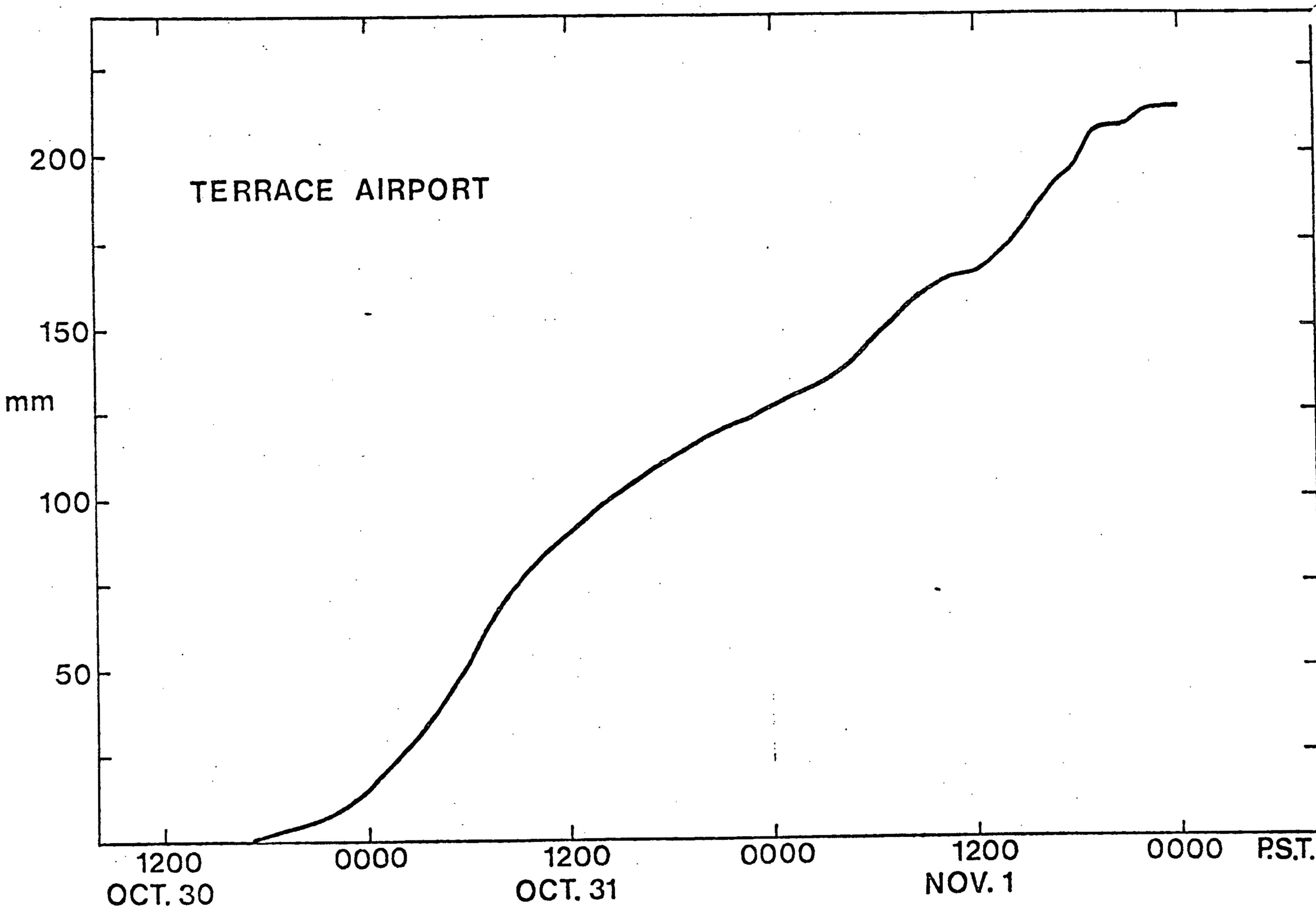


Figure 2. Mass-Curve of Accumulated Precipitation at Terrace Airport for the Rainstorm of October 31 - November 1, 1978.

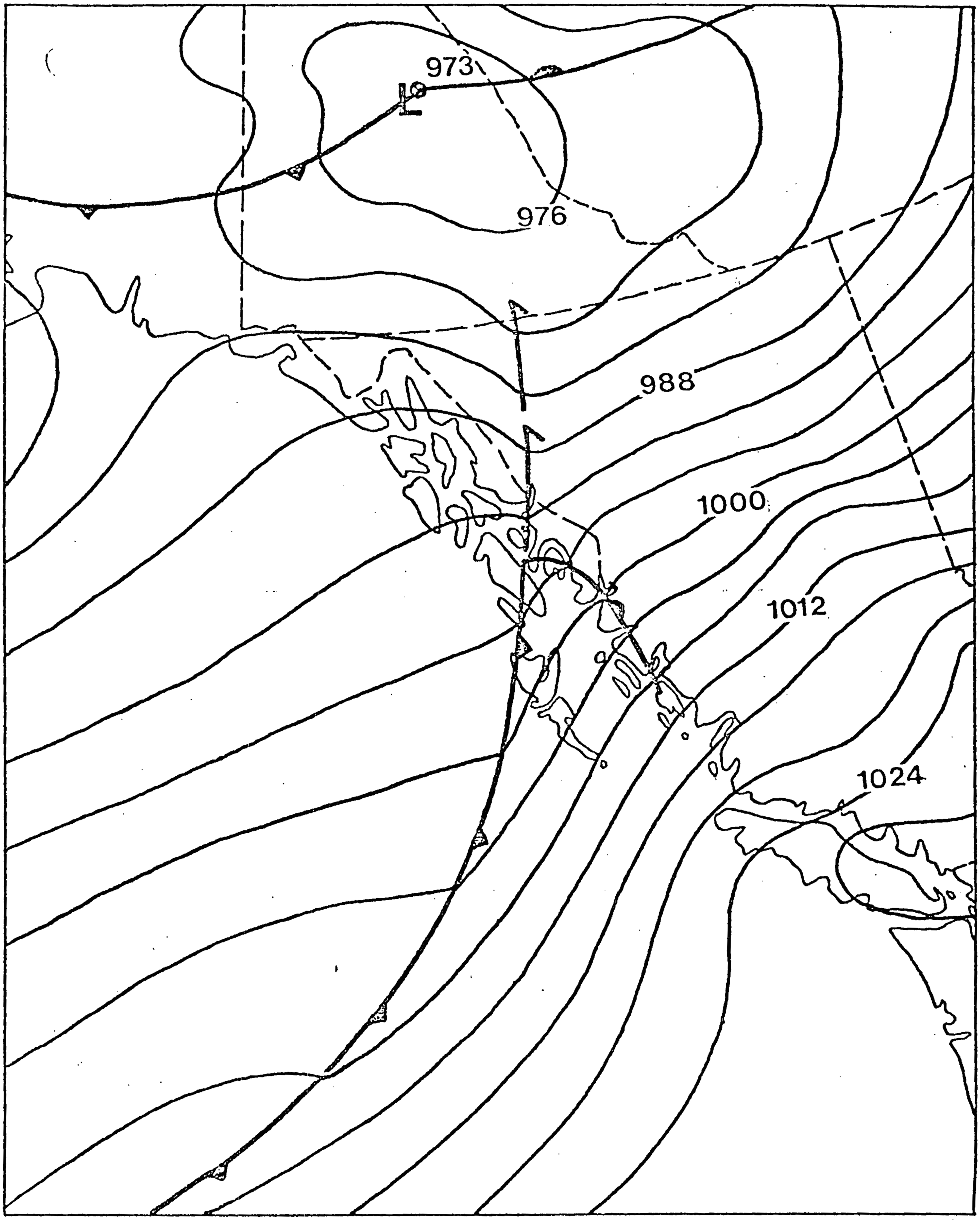


Figure 3. Surface Chart for 0400 P.S.T., October 31 (1200 G.M.T., October 31), 1978.

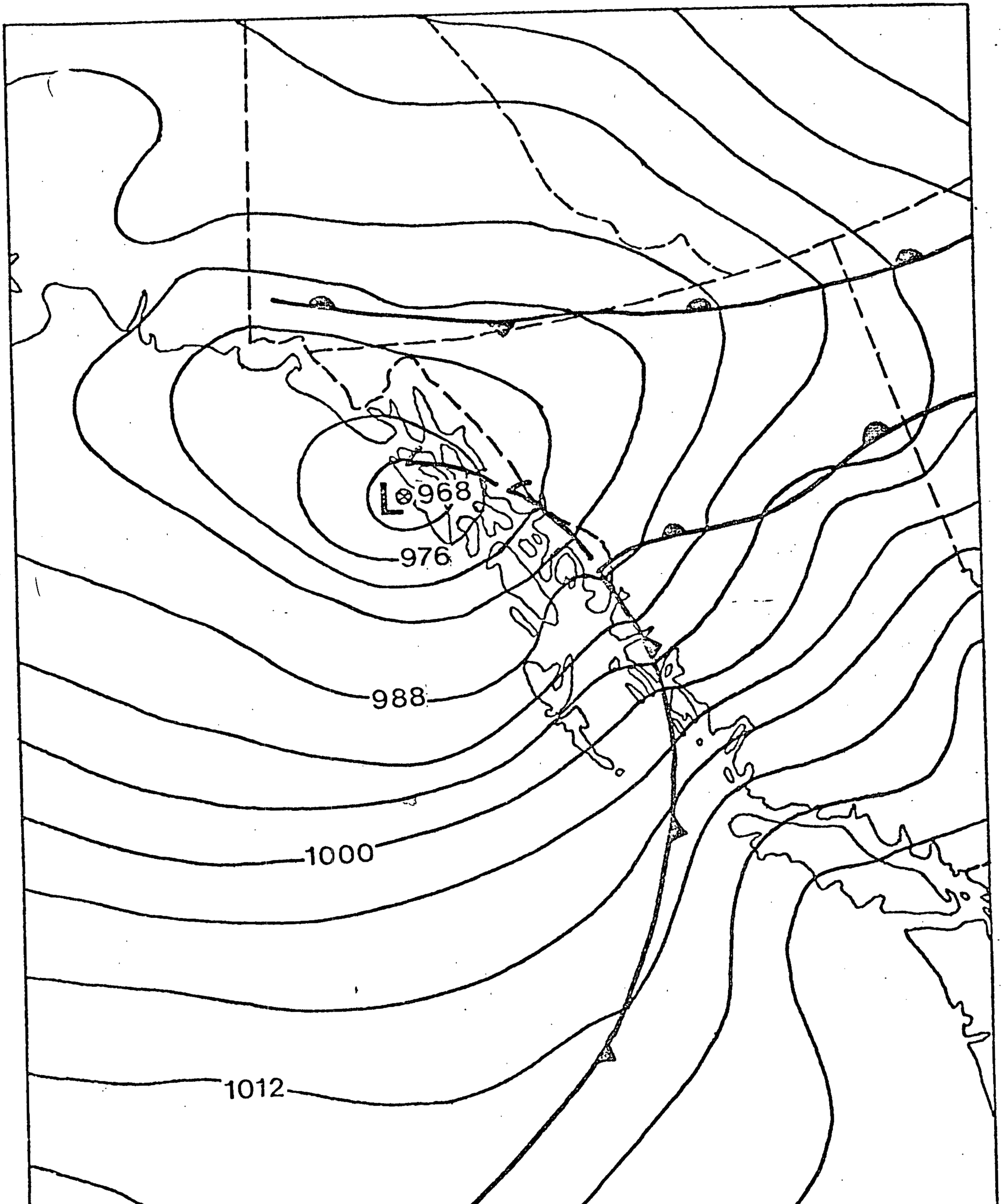


Figure 4. Surface Chart for 1600 P.S.T., November 1 (0000 G.M.T., November 2), 1978.

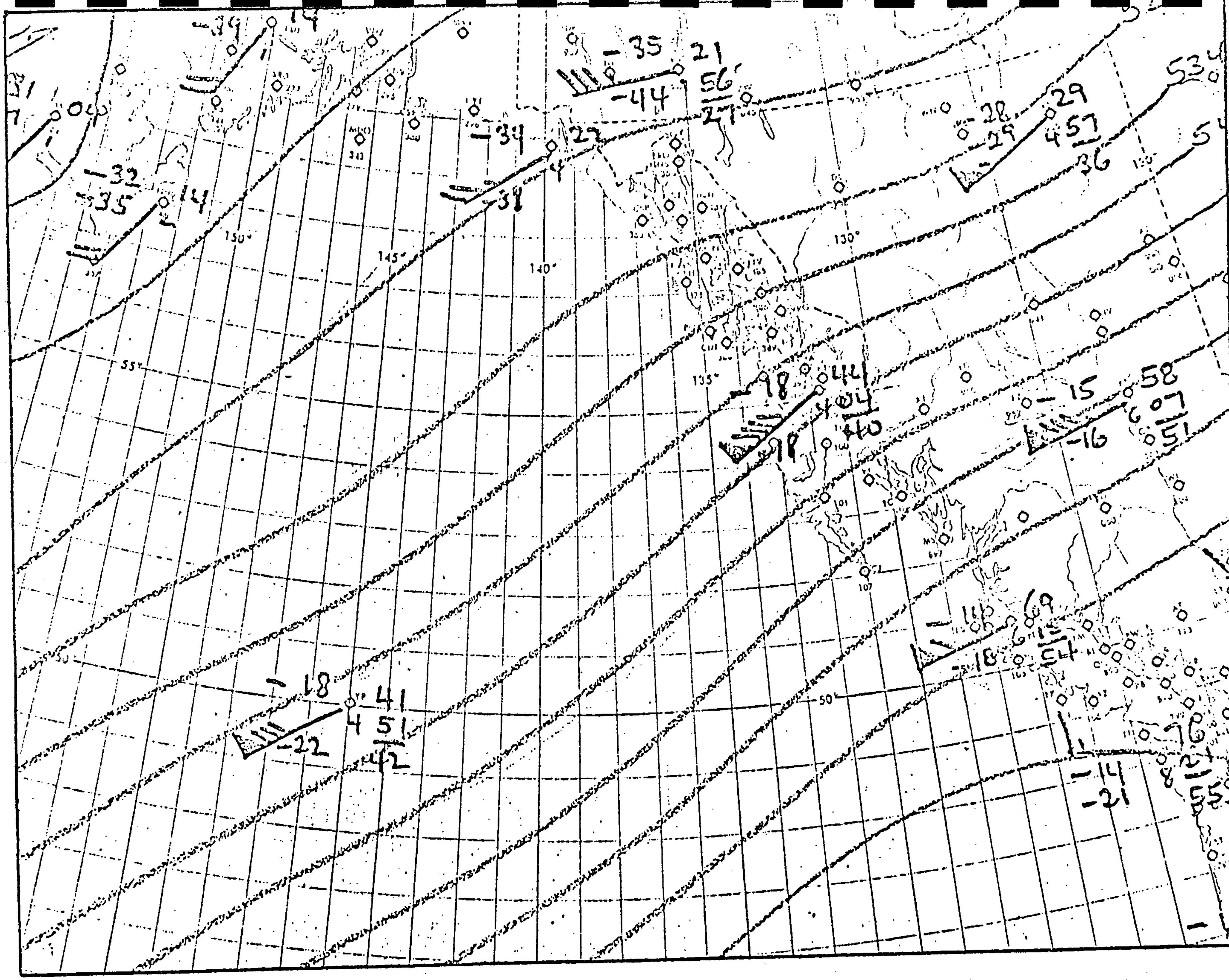


Figure 5. 50-kPa Chart for 1600 P.S.T., October 31 (0000 G.M.T., November 1), 1978.

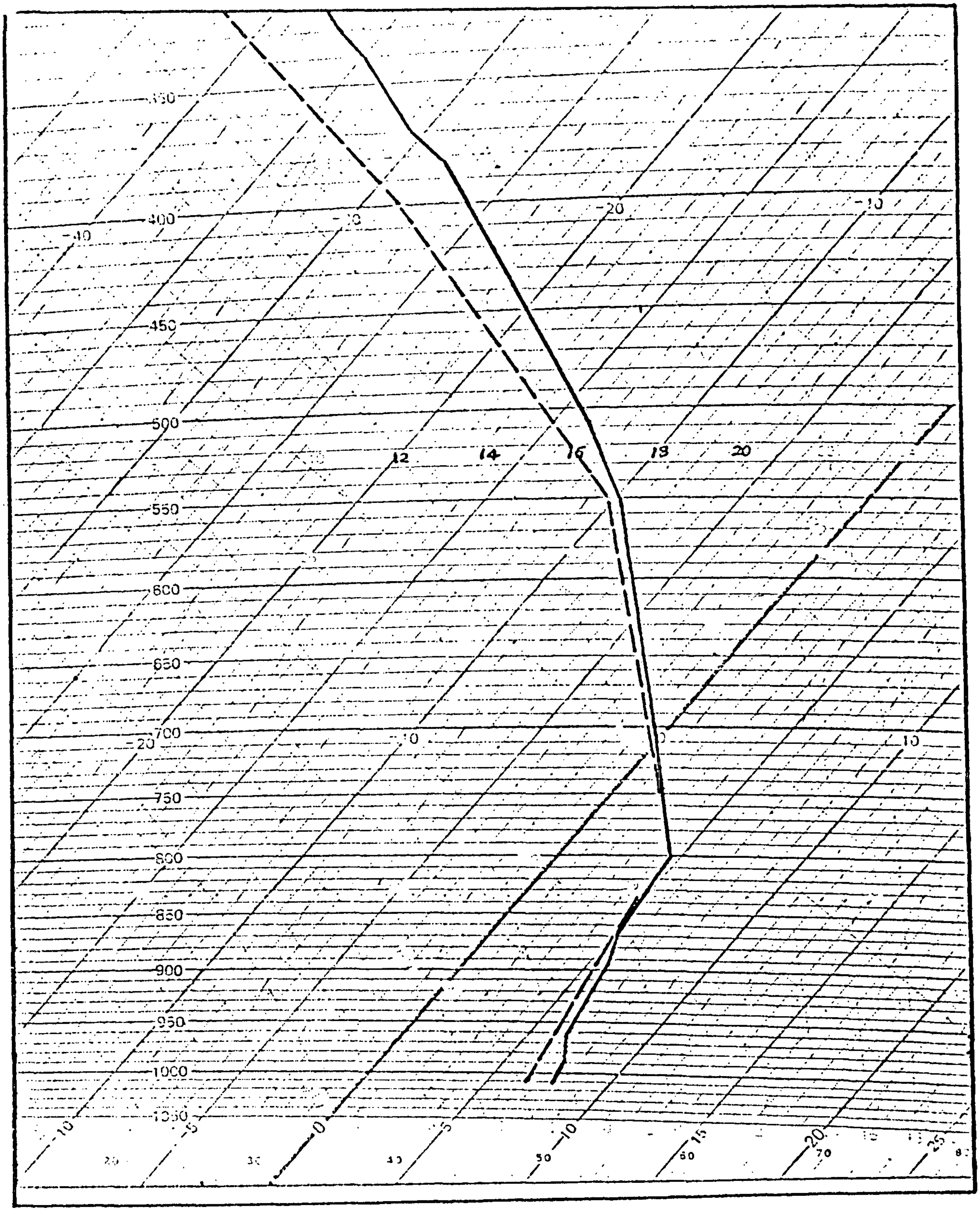


Figure 6. Port Hardy Radiosonde Observation for 0400 P.S.T. (1200 G.M.T.), November 1, 1978.

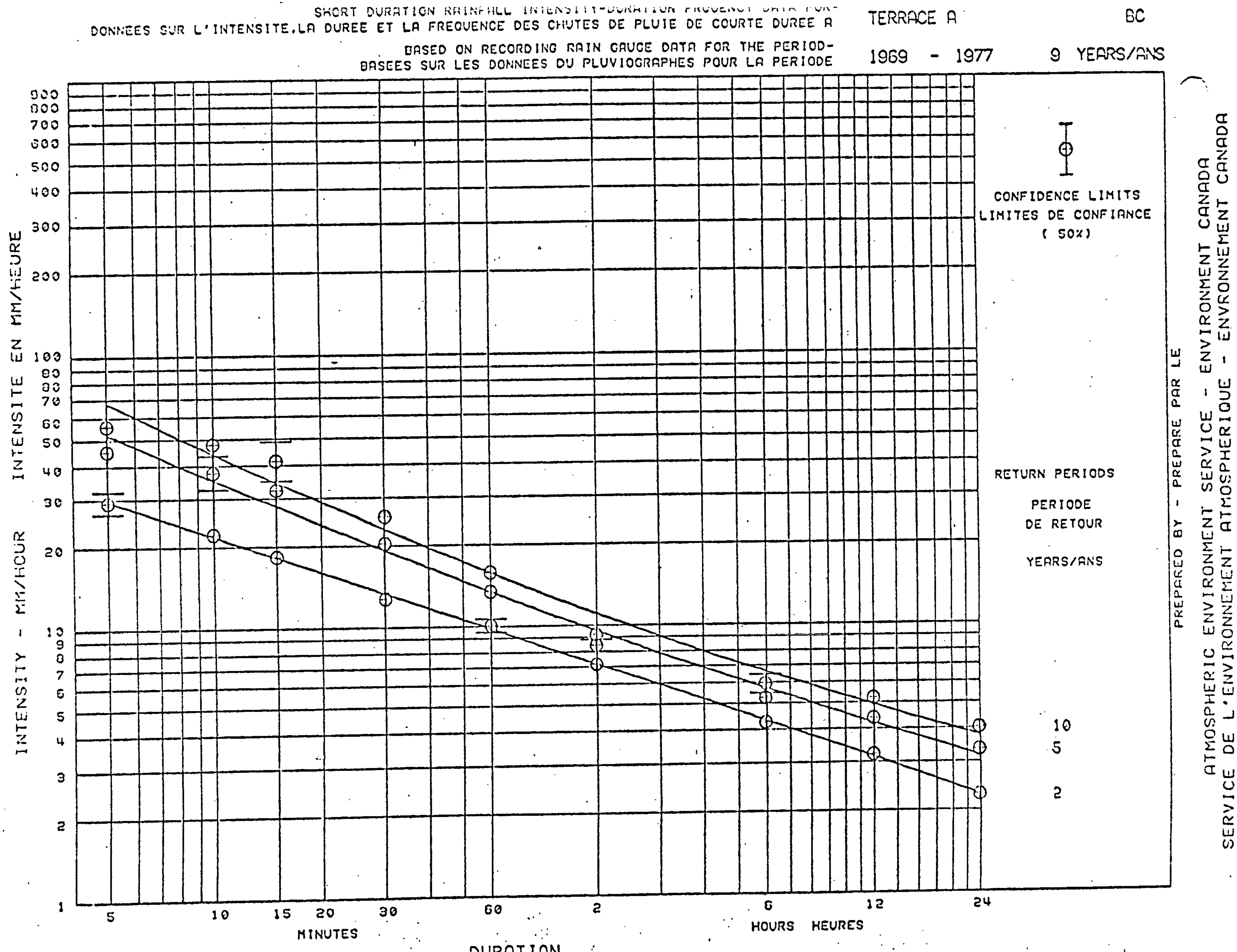


Figure 7. Rainfall Intensity-Duration-Frequency Curves for Terrace Airport

APPENDIX III

TERRACE-KITIMAT FLOOD EVENT OF NOVEMBER 1978

Government of Canada / Gouvernement du Canada

MEMORANDUM / NOTE DE SERVICE

10 May 1979

SECURITY CLASSIFICATION - DE SÉCURITÉ	
OUR FILE - N/RÉFÉRENCE	505-2
YOUR FILE - V/RÉFÉRENCE	
DATE	10 May 1979

TO / A: ~~Mr. M.M. Wiggins, Chief,~~
Water Planning & Management Branch,
Vancouver, B-C.

FROM / DE: Mr. R.J. White, Head,
Systems & Regulation Division,
Water Planning & Management Branch

SUBJECT / OBJET: Comments on Terrace-Kitimat Flood of November 1978:
Water Survey of Canada ~~memorandum~~ report
dated 5 February 1979. preliminary

Mr. Kreuder's report presents the hydrologic data for this flood event in an acceptable manner. Periods of record are far too short (12 to 19 years) to determine flood magnitudes in terms of recurrence intervals with any high degree of confidence. The best that can be done is to obtain rather rough estimates of recurrence values.

In November 1978 historical extreme discharges were recorded in five streams tributary to the Skeena River below Usk. The Skeena River at Usk was high for October but well below flood levels. Fall rains ordinarily cause the highest discharges of tributary streams in this area.

Of the five streams, recorded data for annual maximum discharges of the Zymoetz and the Zymagotitz Rivers include both fall rain and snowmelt floods. For the Zymagotitz only two out of 19 appear plainly snowmelt and two snowmelt augmented by concurrent precipitation. No attempt to separate these records into separate series is justified because the effect on resulting recurrence intervals for fall floods would be negligible.

In the record for the Zymoetz River, seven of sixteen annual maxima appear to be mainly snowmelt. Separation into two series would reduce the estimated recurrence interval for the 1978 event from about 30 years to about 17 years in terms of rainfall events (method of maximum likelihood fitting applied to Log Pearson III distribution). Such separation is not clearly valid and therefore is not recommended.

For the sake of consistency it is suggested that curves fitted (where possible) by the method of maximum likelihood assuming Log Pearson III distribution be adopted. It should be emphasized that recurrence intervals can only be accepted as approximations. This then defines the November 1978 flood as an event that can be expected to occur, on the average, about once in thirty years for the Zymoetz, Kitimat, Exchamsiks and Little Wedeene Rivers. On the Zymagotitz River the recurrence interval was computed on the same basis as about ten years, although it was the largest in nineteen years of record.

It seems realistic to describe the flood as a thirty year event generally in that coastal area.

R.J. White, Head,
Systems & Regulation Division

White/aa

Water Survey of Canada
Vancouver, B.C.

Preliminary Report
February 5, 1979

Terrace - Kitimat Flood of November 1978

The Skeena River Basin

The Skeena River basin has an area of about 20,000 square miles with main channels of approximately 320 miles length from its sources on the slopes of the Skeena Mountains in the north and Babine Lake in the east to its mouth in Chatham Sound near Prince Rupert. Proceeding downstream, the Skeena River receives several major tributaries as well as many minor ones; the largest are the Babine, Bulkley and Zymoetz Rivers.

The furthest downstream streamflow gauge is located at Usk (85 miles from the mouth) where the contributing drainage area is estimated at 16,300 square miles. Considerable runoff volumes are contributed to the Skeena River below Usk by the precipitation generated in the Coast Mountain range. This contribution can be estimated from flow measured at hydrometric stations on the Zymoetz River, Zymagotitz River and the Exchamsiks River.

The Kitimat River Basin

The Kitimat River is a coastal stream which originates near Atna Peak and flows some 50 miles to its mouth into Douglas Channel. The largest contributors are the Wedeene River and Hirsch Creek. The Kitimat River basin has an area of approximately 780 square miles. Flows are measured at hydrometric stations on the Little Wedeene River, Hirsch Creek and the Kitimat River below Hirsch Creek.

October 1974 Flood

Excessive runoff occurred during the first two weeks in October and was caused by heavy rainfall and high freezing levels that prevailed. Fifteen inches of rain fell at Prince Rupert between the 1st and the 10th of the month with nearly five inches occurring during one 24-hour period. On the Skeena River at Usk new maximum monthly and daily discharges for October were recorded.

On the coastal streams below Usk and in the Kitimat basin new maximum annual discharges were reported. The instantaneous peak flow values are shown below:

Instantaneous Peak Flows October 1974

08EF005	Zymoetz R. above O.K. Cr.	104,000 cfs	Oct. 15
08EG011	Zymagotitz R. near Terrace	19,400 cfs	Oct. 15
08EG012	Exchamsiks R. near Terrace	25,800 cfs	Oct. 15
08FF001	Kitimat R. below Hirsch Cr.	71,400 cfs	Oct. 15
08FF002	Hirsch Cr. near the Mouth	28,500 cfs	Oct. 15
08FF003	Little Wedeene R. bel. Bowbyes Cr.	7,550 cfs	Oct. 15
08EF001	Skeena R. at Usk	209,000 cfs	Oct. 10
08FE003	Kemano R. above Tailrace	31,400 cfs	Oct. 15

November 1978 Flood

A stalled weather system lying over the northern mainland over the end of October caused heavy precipitation, especially on the 31st of October and November 1st. Severe flooding occurred at Terrace where the two-day total precipitation was in excess of 200 mm. The total of 114.8 mm on the 31st was the heaviest 24-hour total recorded at Terrace at any time of the year. Land slides occurred, highway bridges and sections of roads were washed out. Flows on the coastal streams peaked on November 1st. Previous historical extremes were approached or exceeded on most of the coastal streams where streamflow records have been kept prior to the 1974 flood event. Skeena River at Usk peaked at about 150,000 cfs which is less than the average of the annual extreme flows recorded since 1953 at that site. Preliminary estimates of the peaks are shown below; these estimates are derived from an interpretation of the stage discharge relationship at the high water levels recorded during the flood event, and are subject to confirmation or revision.

Instantaneous Peak Flows November 1978

08EF005	Zymoetz R. above O.K. Cr.	111,000 cfs	Nov. 1
08EG011	Zymagotitz R. near Terrace	18,700 cfs	Nov. 1
08EG012	Exchamsiks R. near Terrace	30,500 cfs	Nov. 1

Instantaneous Peak Flows November 1978 (continued)

08FF001	Kitimat River below Hirsch Cr.	99,900 cfs	Nov. 1
08FF002	Hirsch Cr. near the Mouth	23,500 cfs	Nov. 1
08FF003	Little Wedeene bel. Bowbyes Cr.	13,500 cfs	Nov. 1
08EF001	Skeena R. at Usk	150,000 cfs	Nov. 2
08FE003	Kemano R. above Tailrace	35,000 cfs	Nov. 1

The storm appears to have centred around the Kitimat-Terrace area, since flows recorded at stations east of this area on the Morice and Nanika Rivers were not near their historical extremes.

Frequency Analysis

The November 1978 peak flows represent the highest flows on record with the exception of Hirsch Creek and Skeena River at Usk. The length of record of instantaneous peak flows ranges from 7 years on the Kemano River to 19 years on the Zymagotitz River. The relatively short record of flow at a site may contain large sampling errors because of chance variations in rainfall during the period of record, therefore a short record may be a poor indicator of the basic long-time distribution of floods at the site. Nevertheless, for the purpose of this study four different distributions were used to fit the data at all stations except the Kemano River where only seven years are available. The types of distributions that were used are: Gumbel 1, Log Normal, 3 Parameter Log Normal, Log Pearson III by the method of moments and the method of maximum likelihood. In addition a power transformation for normalizing skewed distributions of the peak flows at each station was used to estimate the flood peaks at the various recurrence intervals. As an alternative estimation procedure a bi-modal normal distribution was estimated for the peak flows; a simulation was run to establish a range for the 100-year event. The results of these estimating procedures (distribution fitting and simulation) are shown in Figures 1 to 7.

Conclusions

It is evident from the above procedures that the November 1978 flood was an extreme event at five of the sites: Zymoetz, Kitimat Exchamsiks, Zymagotitz, and Little Wedeene Rivers. If one makes the assumption that this flood event has not been exceeded in a historical period longer than the existing periods of record (12-19 years), one can usually express the flood probabilities as recurrence interval T greater than the finite sample represented by the short sampling period.

For example, the peak flows on Hirsch Creek (n = 13) when fitted to the Gumbel 1 distribution produced an estimate of the October 1974 flood of T = 60 years, while the 3-Parameter Log Normal distribution yields an estimate of T = 20 years. The table below lists the range of T for the five sites for the November 1978 event.

Zymoetz River	25 years to 100+ years
Kitimat River	20 years to 40 years
Exchamsiks River	25 years to 40 years
Little Wedeene River	25 years to 100 years
Zymagotitz River	about 20 years

The highest estimates of T are from the Gumbel 1 distribution while the lowest are from the 3-Parameter Log Normal distribution. The range of values of the 100-year flood estimated from the bi-modal simulation of the event is listed below for each station and shown on Figures 1 to 7.

Zymoetz River	117,000 - 167,000 cfs
Kitimat River	94,800 - 121,000 cfs
Exchamsiks River	26,600 - 33,800 cfs
Little Wedeene River	13,500 - 18,700 cfs
Hirsch Creek	18,900 - 43,200 cfs
Zymagotitz River	19,100 - 22,700 cfs
Skeena River at Usk	261,000 - 348,000 cfs

OBSERVED INSTANTANEOUS MAXIMUM FLOWS

08EF005 Zymoetz River		08EG011 Zymagotitz River		08FF003 Exchamsiks River	
Date	Flow in cfs	Date	Flow in cfs	Date	Flow in cfs
		15 Oct 1960	5560		
		31 Oct 1961	17500		
		17 Oct 1962	16000	17 Oct 1962	23100
2 Oct 1963	11500	2 Oct 1963	5130	2 Oct 1963	12900
11 Jun 1964	27400	12 Oct 1964	9090	19 Oct 1964	15300
22 Oct 1965	30000	22 Oct 1965	8120	22 Oct 1965	16200
24 Oct 1966	68500	24 Oct 1966	14900	24 Oct 1966	17900
7 Jun 1967	21900	23 Sep 1967	17100	23 Sep 1967	22200
21 May 1968	23900	20 May 1968	4570	24 Sep 1968	9390
4 Jun 1969	23000	12 Jun 1969	4800	30 Nov 1969	13500
4 Jun 1970	22200	3 Jul 1970	5560	26 Sep 1970	10000
19 Nov 1971	23000	19 Nov 1971	11500	19 Nov 1971	15600
24 Oct 1972	30200	24 Oct 1972	14200	24 Oct 1972	18800
15 May 1973	17300	6 Sep 1973	4040	6 Sep 1973	10800
15 Oct 1974	104000	15 Oct 1974	19400	15 Oct 1974	25800
2 Jun 1975	16400	26 Jul 1975	4600	26 Jul 1975	9740
27 Oct 1976	28200	27 Oct 1976	10600	27 Oct 1976	17200
22 Oct 1977	20400	12 Oct 1977	7650	12 Oct 1977	16100
2 Nov 1978	111000	1 Nov 1978	18700	1 Nov 1978	30500

OBSERVED INSTANTANEOUS MAXIMUM FLOWS

08FF001	Kitimat River	08FF002	Hirsch Creek	08FF003	Little Wedeene
Date	Flow in cfs	Date	Flow in cfs	Date	Flow in cfs
12 Oct 1964	40100				
22 Oct 1965	59400				
24 Oct 1966	59500	24 Oct 1966	13500	24 Oct 1966	6120
10 Oct 1967	33800	8 Oct 1967	4800	10 Oct 1967	6090
23 Jan 1968	38200	17 Oct 1968	5480	24 Sep 1968	4990
30 Nov 1969	54300	30 Nov 1969	14200	30 Nov 1969	5360
3 Jun 1970	22900	2 Jun 1970	4340	3 Jul 1970	4010
19 Nov 1971	35700	19 Nov 1971	8880	6 Oct 1971	4440
24 Oct 1972	35900	8 Oct 1972	12200	24 Oct 1972	4140
8 Sep 1973	23800	8 Sep 1973	9240	27 Oct 1973	2920
15 Oct 1974	71400	15 Oct 1974	28500	15 Oct 1974	7550
27 Jul 1975	25500	3 Nov 1975	7770	25 Jul 1975	4040
27 Oct 1976	66100	27 Oct 1976	12600	3 Nov 1976	10600
22 Oct 1977	62400	22 Oct 1977	13700		
1 Nov 1978	99900	1 Nov 1978	23500	1 Nov 1978	13500

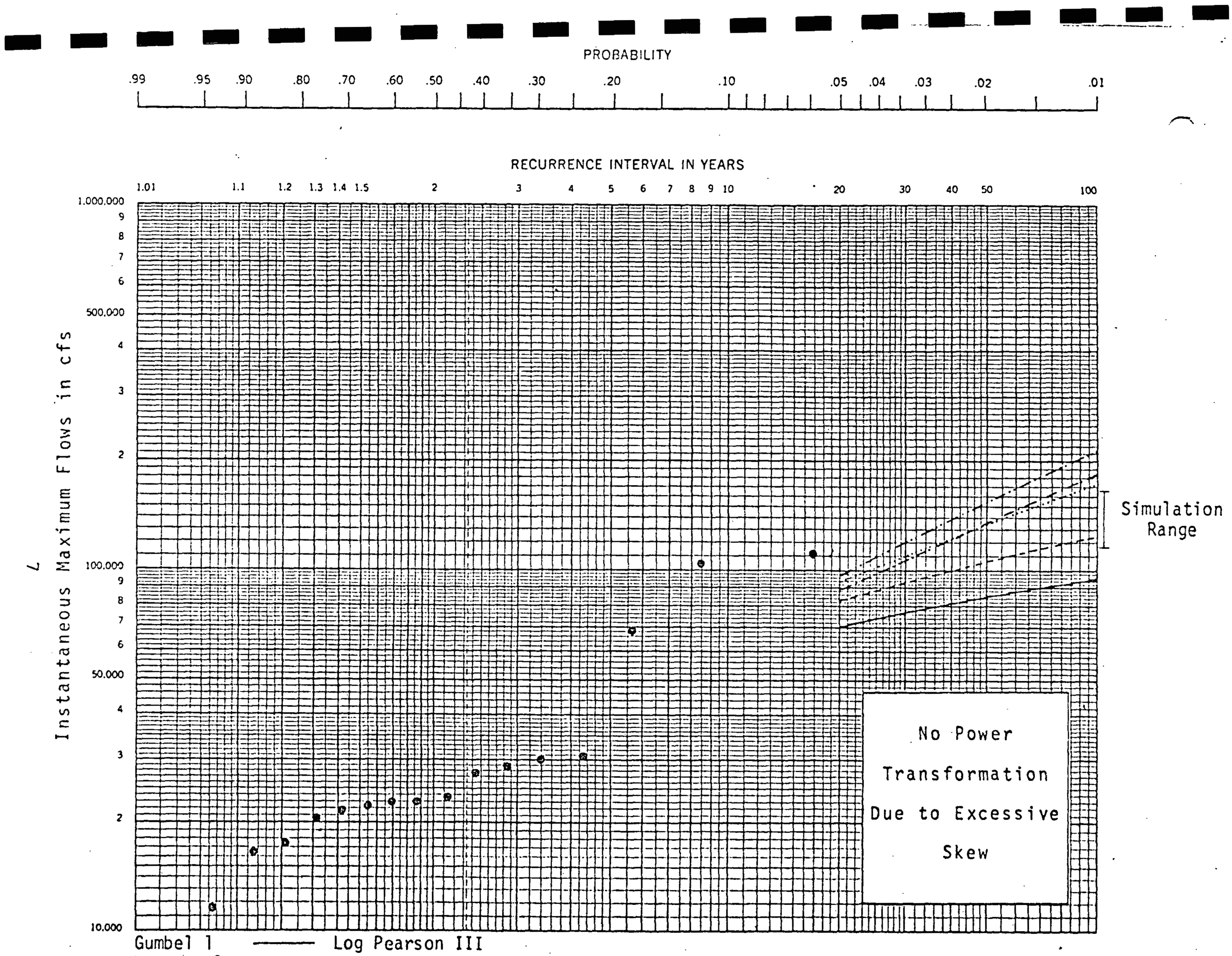
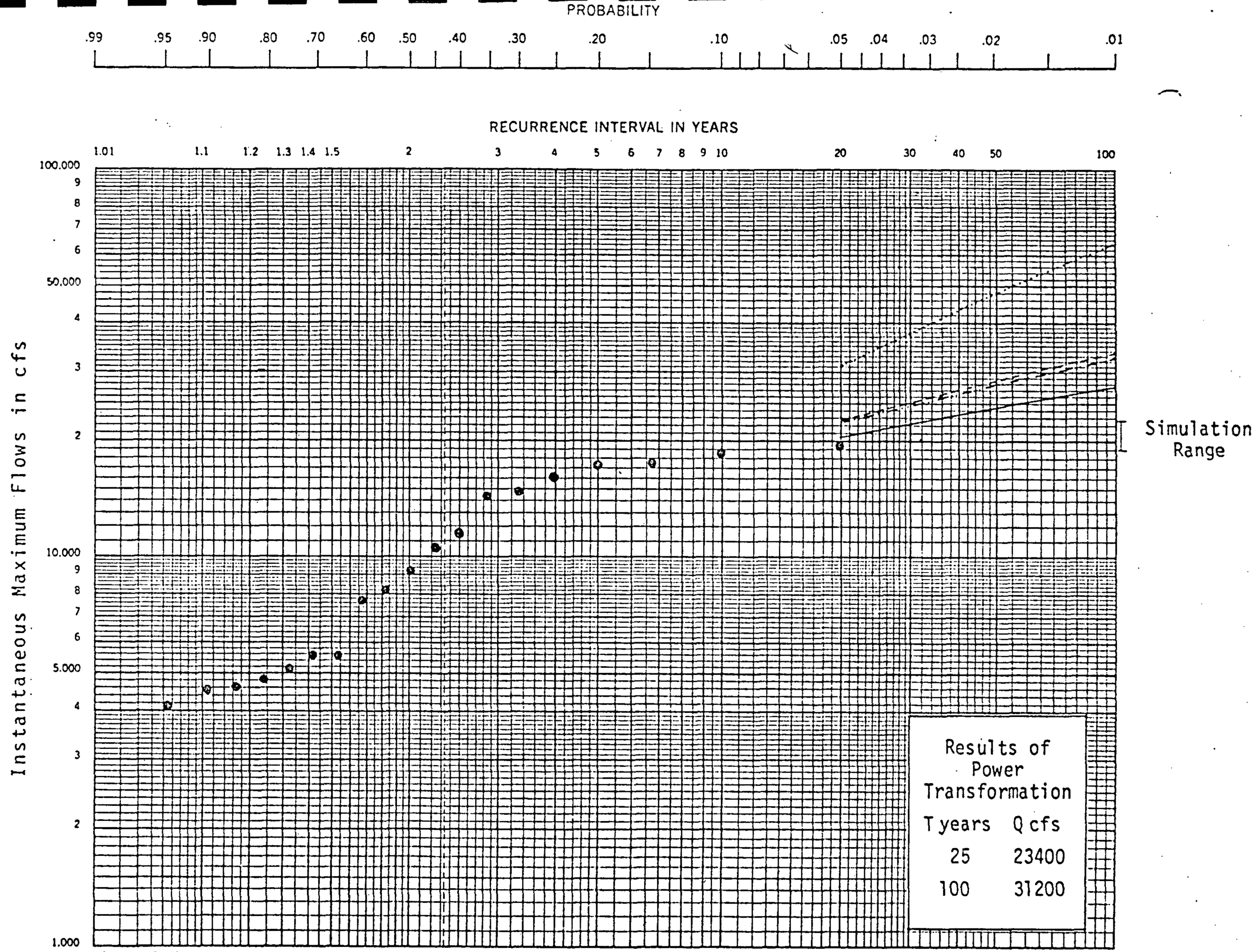


Figure 1. 08EF005 Zymoetz River above O.K. Creek



Gumbel 1 ——— Log Pearson III
Lognormal ------ Max.Likelihood
3-Parameter ...... Moments -·-·-·-

Figure 2. 08EG011 Zymagotitz River near Terrace

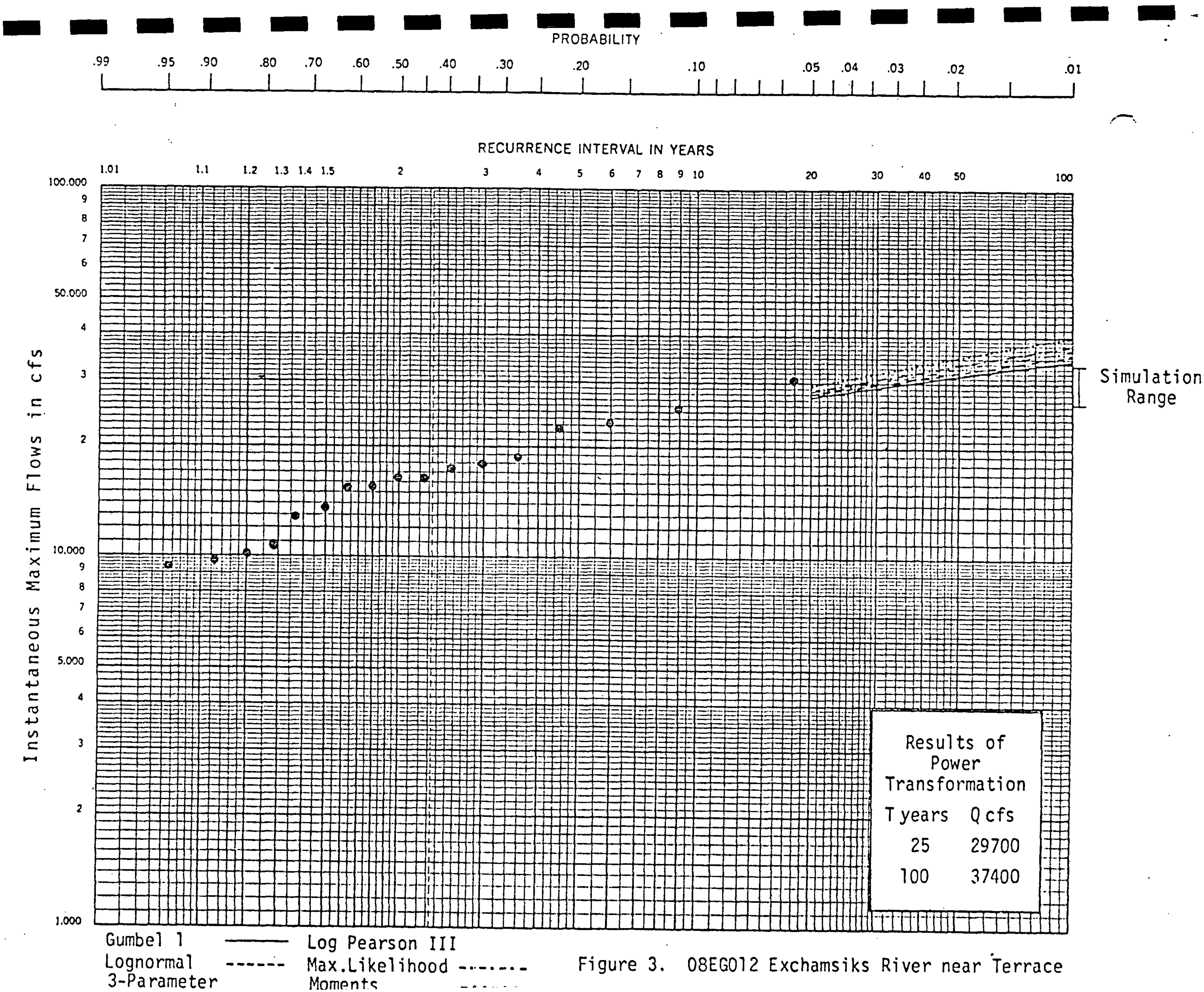


Figure 3. 08EG012 Exchamsiks River near Terrace

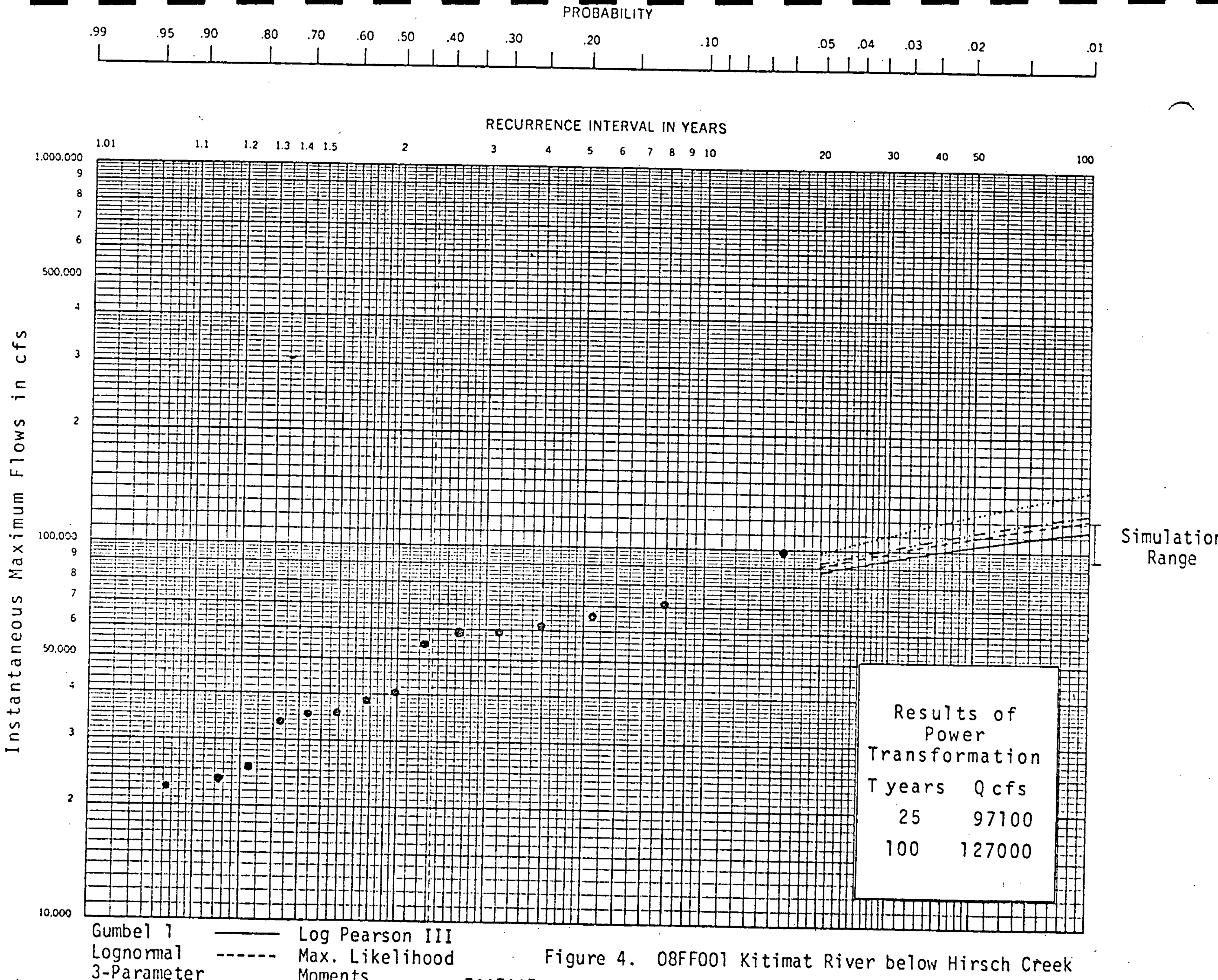


Figure 4. 08FF001 Kitimat River below Hirsch Creek

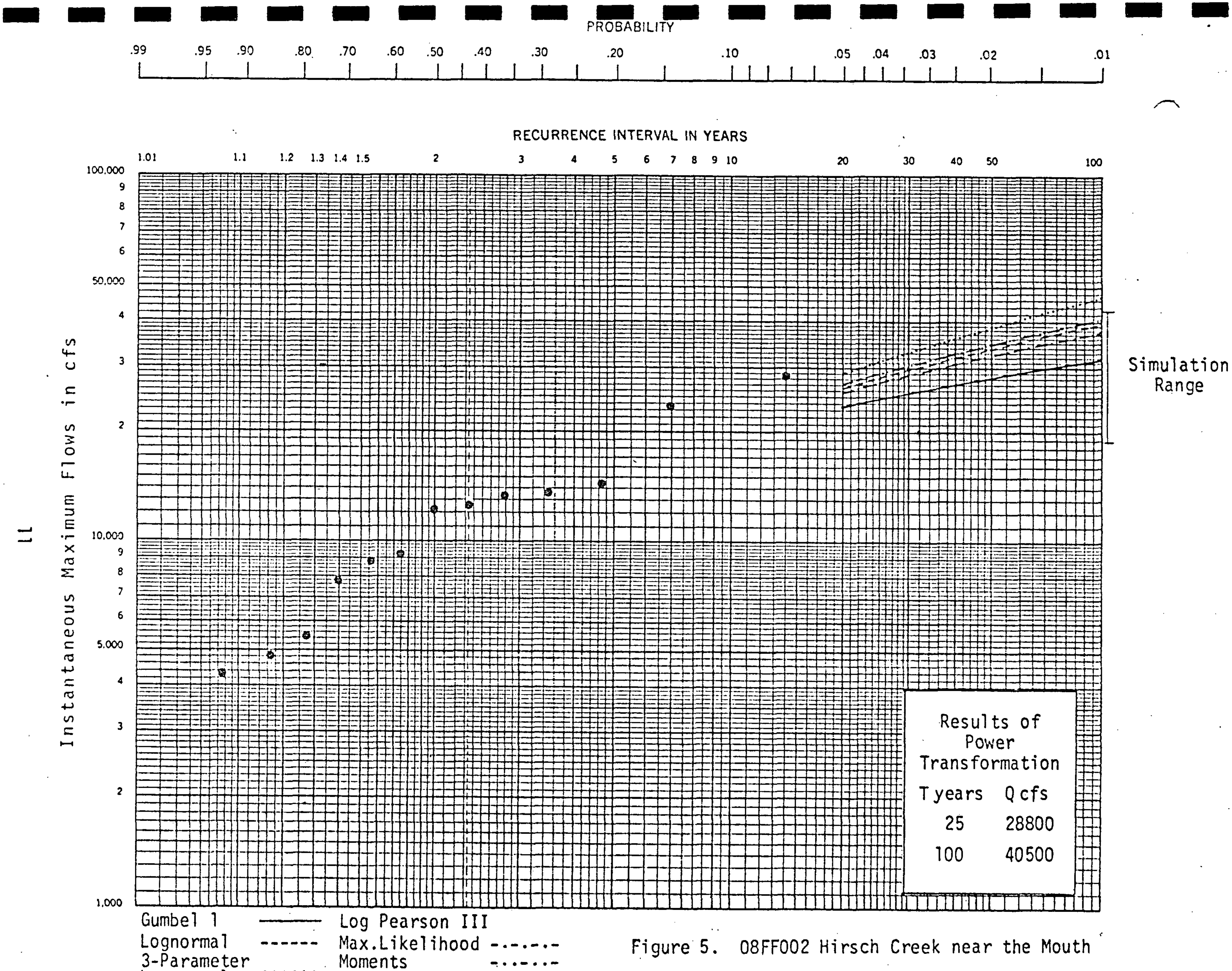
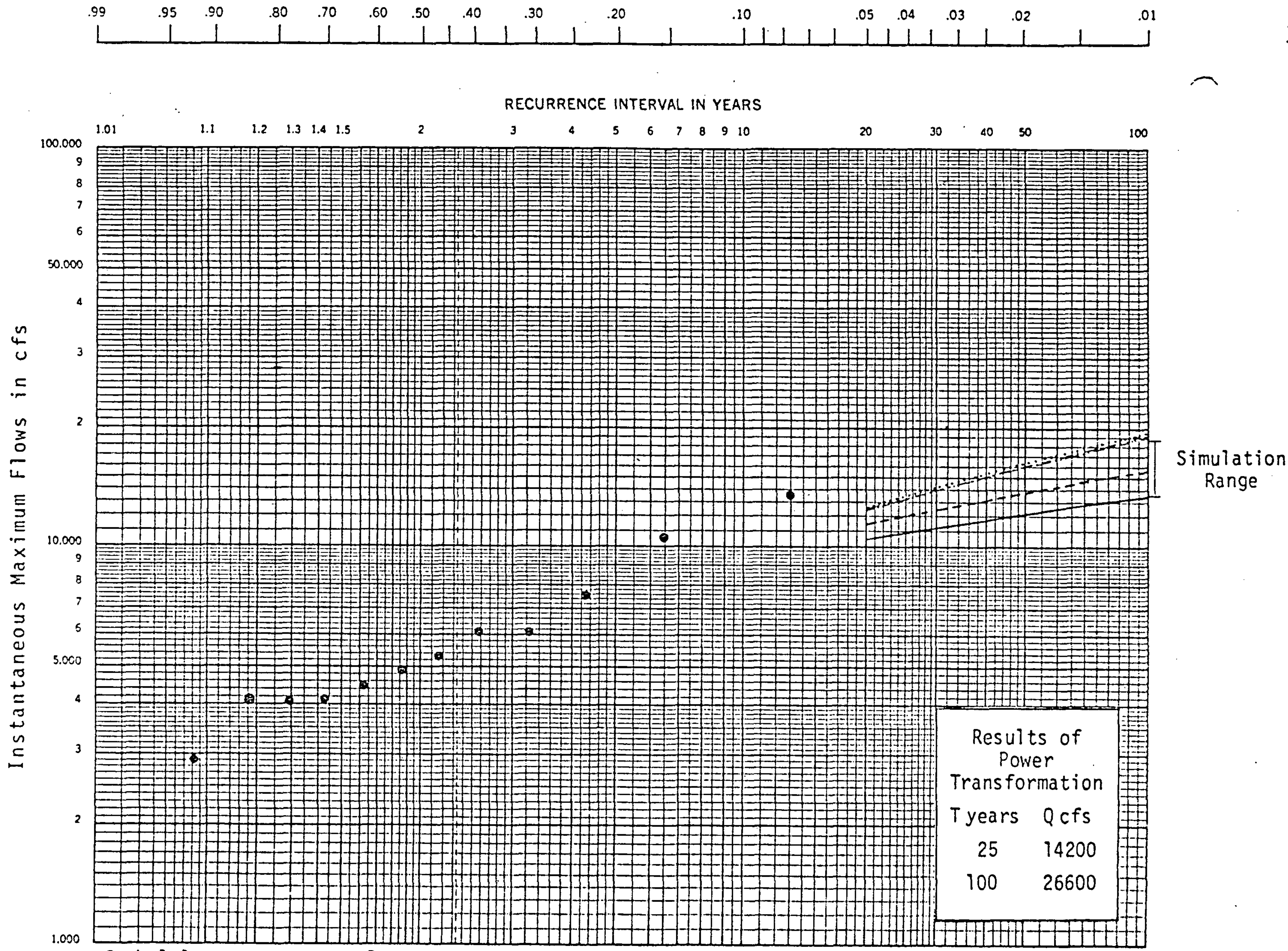


Figure 5. 08FF002 Hirsch Creek near the Mouth



Gumbel 1 ———— Log Pearson III
Lognormal ------ Max.Likelihood -.-.-.-
3-Parameter Lognormal ...... Moments -.-.-.-

Figure 6. 08FF003 Little Wedeene River below Bowbyes Creek

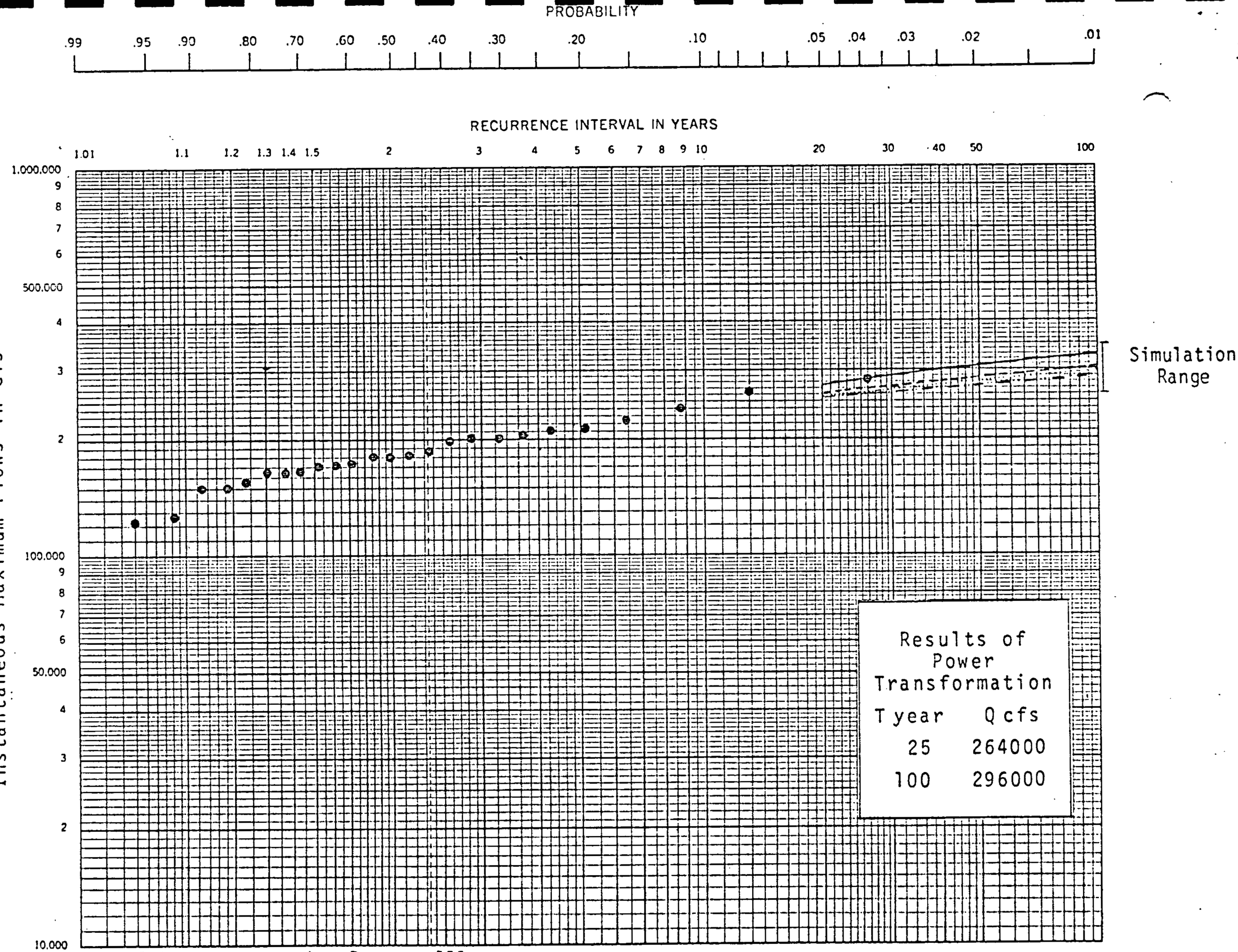


Figure 7. 08EF001 Skeena River at Usk

References

Chander, S., S.K. Spolia, and A. Kumar, Flood frequency analysis by power transformation, Journal of the Hydraulics Division, A.S.C.E., November 1978.

Singh, K.P., and C.G. Lonnquist, Two-Distribution method for modelling and sequential generation of monthly streamflows, Water Resources Research, A.G.U., August 1974.

Water Survey of Canada, Historical streamflow summary British Columbia to 1976, Water Survey of Canada, Ottawa, 1978.

APPENDIX IV

NEWSPAPER CLIPPINGS

NOT INCLUDED

APPENDIX V

DAMAGES CAUSED BY THE TERRACE-KITIMAT
FLOOD OF NOVEMBER 1978

NOT YET AVAILABLE

Out

APPENDIX ~~VI~~ IV

PREVIOUS REPORTS ON TERRACE-KITIMAT FLOOD OF NOVEMBER 1978

Environment Canada Environnement Canada

MEMORANDUM NOTE DE SERVICE

DATE 2 November 1978

Water Planning and M B
Vancouver, B.C.

FROM/DE: K.K. Sharma

Our file / Notre référence 5630-5054-1

Your file / Votre référence

TO/A: J.R. Oakey, Head,
Projects Division

SUBJECT/SUJET: Interim
Report No. 1 ~~2 November 1978~~
Recent Flooding in Northwest B.C.

CAUTION - This report is based on off-the-cuff information obtained from various sources. Most of the information has not been verified; in fact it would take several days before any verification is forthcoming.

Rainfall - Runoff Conditions

Prince Rupert - Terrace - Kitimat - Smithers area of Norwest B.C. was hit by a prolonged heavy rainstorm which peaked on the evening of 1 November 1978. This area was covered by recent snow which melted and added to the intensity and volume of runoff.

The rain ≈ 1:25 year event.
The runoff would be of even higher return period.

The effect of this 200 mm of rain was:

1. a rapid increase in the water levels of lakes and rivers in the area.
2. a number of land and mud slides.
3. extensive flooding, disruption of traffic, etc. due to 1. and 2.

Damage in the Affected Area

Damage to date includes the following.

1. Flooding in the city of Terrace itself is not serious.
2. Highways leading from Terrace to Kitimat, Prince Rupert, Smithers are badly damaged.
3. A number of highway bridges have been washed out.
4. Terrace to Smithers is the worst hit with damages estimated at $5 million.
5. Mud slides and 2 bridge failures have occurred on the CPR.

6. Extensive damage has occurred to homes in Remo and around Lake Ellse. People are being evacuated.
7. Extensive damage has occurred in Kitimat.

These damages will increase as reports come in.

Present Conditions

1. The weather system is moving out of the affected area.
2. Streams have started to subside.
3. Necessary supplies are being brought in by rescue workers.

K.K. Sharma

Sharma:cmd

K.K. Sharma

→ MNW

Government of Canada / Gouvernement du Canada

MEMORANDUM **NOTE DE SERVICE**

TO / A: J.R. Oakey, Head, Projects Division

→ RJW RHW
Copy to E.M.C.

SECURITY-CLASSIFICATION - DE SÉCURITÉ:

OUR FILE - N/RÉFÉRENCE: ~~539~~ 505-1

YOUR FILE - V/RÉFÉRENCE:

FROM / DE: K.K. Sharma

DATE: 3 November 1978

SUBJECT / OBJET: Interim Report No. 2 ~~Update of~~ Recent Flooding in Northwest B.C.

Top of page while for 2 Nov.

CAUTION - This update is based on off-the-cuff information obtained from various sources. Most of the information has not been verified; in fact it would take several days before any verification is forthcoming.

Present Situation

Flood waters in the affected streams are subsiding. Damage to public utilities such as roads, railways, gas lines, etc., is worse than first thought. Most of the people evacuated from their homes are still staying at alternative accommodations. Emergency repairs of highways and bridges are underway.

Damage Estimates

Damage to public and private property is estimated between $10 - $15 million. Since this damage is in excess of $1.00 per capita population, the province is entitled to federal financial assistance.

Developments Expected

The Province of B.C. (the Premier) is expected to contact Canada (the PM) for financial assistance. This request would likely be made this weekend.

Next report, if needed, will be made on Monday, 6 November 1978.

K. K. Sharma

K.K. Sharma

Sharma:gmd

~~File 505-2~~

set up as
for 2 Nov

8 December 1978

~~MEMORANDUM TO FILE~~

~~Subject:~~ Interim Report No. 3 - Inspection of Terrace Area

This report describes the observations made during an inspection (November 27-December 1) of the northwestern part of the Province (see attached map) where a severe and prolonged rainstorm occurred on or about 1 November 1978. The rain was also accompanied by high winds. The purpose of this field inspection was to observe the after effects of the storm on a firsthand basis.

The locations visited are situated in the vicinity of Terrace and were confined to those easily accessible. Areas north of Terrace towards Stewart and other off-the-road locations were not visited. Also the effect of the storm on railroads, power and gas lines, etc. was not observed.

The most severe damage was noticeable on the Terrace-Smithers highway (No.16) up to about 50 miles east of Terrace. The damage was caused by debris and high flows in the streams tributary to Skeena River. There was one culvert and three main bridge failures on this stretch of the highway. The fast flowing water washed out the fill behind and below bridge abutments. These abutments, which were not on piles but on footings, were then carried downstream causing the end spans to collapse. The middle span supported by piers on piles remained intact. The abutments are now being founded on piles.

A number of minor washouts were also noticed along this route. There were also a few mud and rock slides blocking the highway. These were being cleared.

South of Terrace on the Terrace-Kitimat highway (No. 25) the Kitimat River washed out a long stretch of embankment. Structures such as bridges etc. seemed to have handled the runoff without noticeable problems. A few minor washouts were also seen.

West of Terrace and in the town of Terrace itself, damage to highways and highway structures appeared to be minimal.

(North of Terrace area was not inspected due to accessibility problems).

Concerning private property, the houses and cottages along the shore of Lakelse Lake were the worst affected. There was considerable damage done to streets in this lakeside subdivision and many trees were uprooted. The major causes here were the wind and waves which hit these dwellings.

Copper River Estates, a subdivision east of Terrace, and Remo were also reported to have suffered property damage. However, at the time of field inspection, the extent of such damage was difficult to ascertain.

This report is the third one in a series of brief interim reports. A final and detailed report, following the outline recommended for reports to be forwarded to the United Nations, will be prepared when all of the rainfall, hydrological and damage cost information becomes available.

K.K. Sharma

/aa