PROVINCE OF BRITISH COLUMBIA

MINISTRY OF ENVIRONMENT

WATER MANAGEMENT BRANCH

PEMBERTON VALLEY FLOOD PROTECTION

1985 STUDY

by

H.H. Nesbitt-Porter
Senior Hydraulic Engineer
Rivers Section
Planning and Resource Management Division

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SYNOPSIS

This study, which was authorized following the record October 1984 flooding, examines the various levels of flood protection for the predominantly rural Pemberton Valley.

Sub-area unit costs for the recommended flood protection proposals, excluding the airport area, range from $1355/ha to $4455/ha for 1:50 protection and from $1760/ha to $6030/ha for 1:200 year protection.

1:200 year flood protection for the Village of Pemberton and the surrounding urbanized region, where there are very considerable benefits to be derived from increased flood protection, is expected to cost $1.7 m.

The estimated overall cost for 1:50 year instantaneous flood protection works is $10 m and for 1:200 year protection is $13.7 m.

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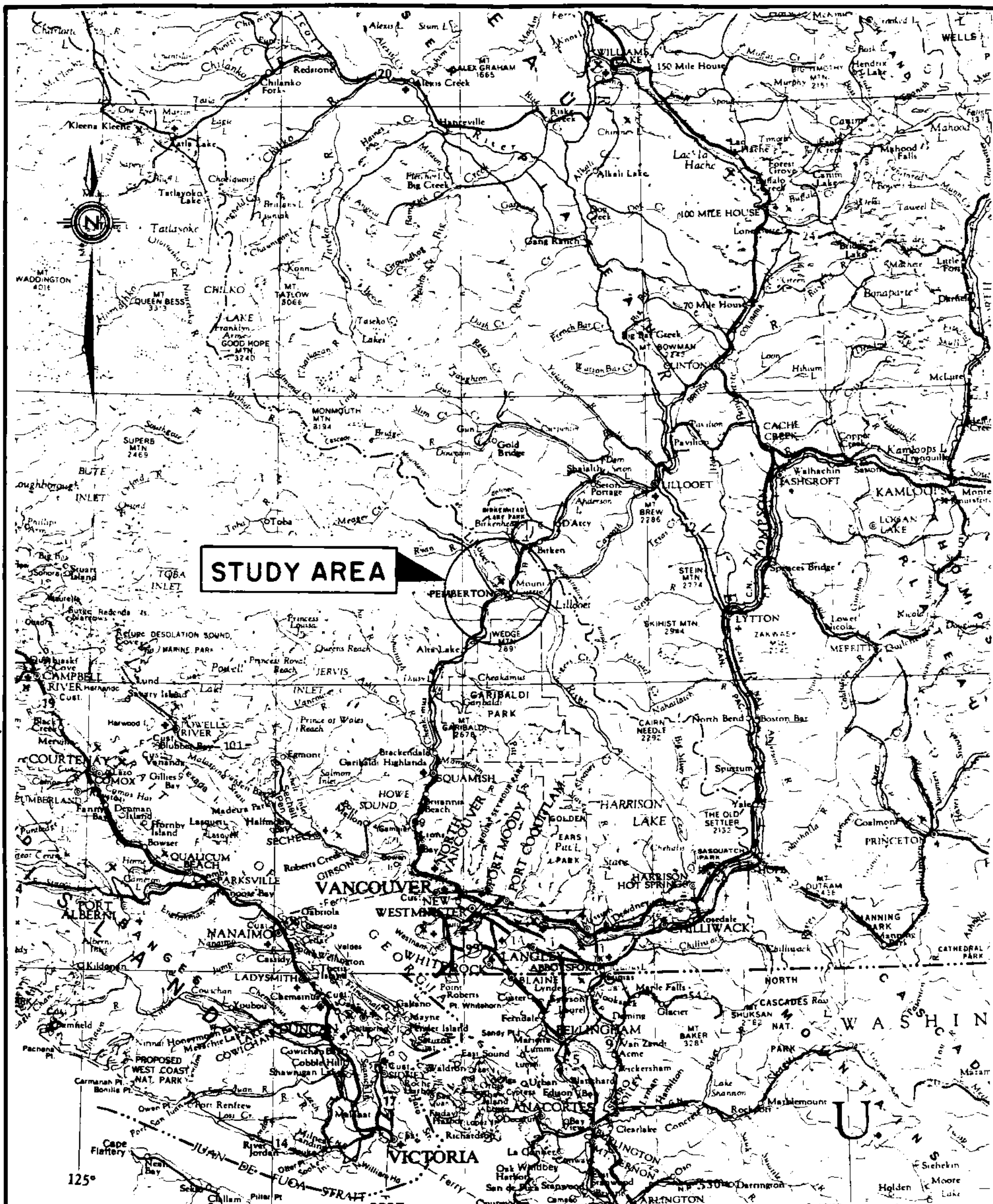

Province of British Columbia
Ministry of Environment
WATER MANAGEMENT BRANCH

TO ACCOMPANY REPORT ON
PEMBERTON VALLEY FLOOD PROTECTION
1985 STUDY
LOCATION PLAN

SCALE: 1:2 000 000	DATE	ENGINEER
MAP NO. 1J	JULY 1985	FILE No. P72-3 DWG No. 85-13-LOCATION PLAN

BCIL 7673-M.E.

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1.0 INTRODUCTION

Following the flooding of historic proportions which took place throughout the Pemberton (Lillooet River) Valley on October 8th and 9th, 1984, the area residents represented by the Squamish-Lillooet Regional District, the Village of Pemberton and the Pemberton Valley Dyking District requested this comprehensive study of flood alleviation measures.

Extensive reclamation[1] and erosion control work was undertaken throughout the valley by the Prairie Farm Rehabilitation Administration (P.F.R.A.) during the period from 1946 to 1953, followed by rehabilitation and further improvement work, mainly bank protection, carried out with A.R.D.S.A. funding over a five year period starting in 1979. The latter project included both extensive bank protection and limited dyking works on the Mt. Currie Indian Band lands. All of the Lillooet River Dyking Improvements were intended to protect to the 1:50 year instantaneous flood level although this was not defined precisely.

Coincident with the A.R.D.S.A. program was a series of flood events, starting with what was then a near record one on Dec. 26, 1980, followed by a higher one on Oct. 31, 1981, severe ice damage during January 1984 and culminating with the October 1984 flood. Federal-Provincial funding was provided through the Provincial Emergency Program to repair damages caused to the protective works by these events and to restore river channels blocked with gravel and debris. Most of the gravel removed under this program was utilized, in conjunction with the A.R.D.S.A. Program, to further improve the flood protection system, particularly in the Ryan River area.

The Pemberton Valley Dyking District is the local authority responsible for dyke construction and maintenance throughout most of the

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[1] Cut off channels shortened the channel length by 5.5 km (3.4 miles)

valley with the exception of the Indian Lands, which, although mostly within the Dyking District's boundaries, have not been subject to taxation. Responsibility for maintenance of the A.R.D.S.A. improvements on Indian Lands rests with the Federal Department of Indian and Northern Affairs.

Earlier reports pertaining to Pemberton Valley flooding include those prepared by Doughty-Davies[1], Wester[2] and Tempest[3], all of the Provincial Ministry of the Environment or its forerunners.

2.0 SCOPE OF REPORT

This report concerns protection for development within the Pemberton Valley extending from Lillooet Lake upstream past the Forest Service Bridge to and including Lot 813.

Embodied in the report are:

1. Water surface profiles for the updated, dyke confined 1:200 and 1:50 year instantaneous flood projections for all (6) significant watercourses within the study area.

2. Water surface profiles for the dyke confined (except in the case of Lillooet River), October 1984 flood, for the above watercourses.

3. Cost estimates, by areas, for dyking to protect against the 1:200 and 1:50 year floods; including appropriate alternatives.

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1 J.H. Doughty-Davies, Preliminary Report on Lillooet River Flood Control, B.C. Water Resources Service, Water Investigations Branch, (March 1972).

2 J. Wester, Preliminary Report on Pemberton Valley Dyking District Drainage Proposals, B.C. Water Resources Service, Water Investigations Branch, (Aug. 1967)

3 W. Tempest, Pemberton Valley Flood and Erosion Control, B.C. Ministry of Environment (Nov. 1977)

4. Examination of building elevation as an alternative to dyke construction.

5. Assessment of the potential flood relief achievable by the lowering of Lillooet Lake.

6. Consideration of the B.C. Railway embankment constriction.

7. Protection for the "McKenzie Cut" area.

8. Review of the options for drainage improvement in the Pemberton Village area.

9. Assessment of the extent and impact of timber harvesting in the area.

10. The relevance of seismic activity in relation to the October 1984 Meager Creek flood.

3. HYDROLOGY

3.1 October 1984 Storm

3.1.1 Observations

The Atmospheric Environmental Service[1], determined that heaviest precipitation from a broad frontal system which moved onto the B.C. Coast on October 7th, 1984, was concentrated in the Squamish area and in Central Vancouver Island.

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[1] John Thomas, Pacific Region Technical Notes, 84-014, Canada, Atmospheric Environmental Service.

The extreme runoff experienced in both the Squamish and Pemberton areas was attributed to the duration and north-south orientation of the frontal system, rather than to its intensity which, as may be seen from the following rainfall analysis summary, Table 1, was not exceptionally great in the Pemberton Village area.

TABLE 1

PEMBERTON VILLAGE RAINFALL[1] ANALYSIS

Duration	Precipitation	Return Period
1-day	68.4 mm	5 years
3-day	119.8 mm	20 years

Flow information from nearby gauged watersheds confirms the severity of this storm. The Squamish River peak instantaneous flow exceeded the previous record by some 15 percent, while the Elaho R. had its second highest peak flow and the Cheakamus River gauge near Brackendale recorded its third highest peak flow. In the small, glacier fed watersheds, Bridge River below the Bridge Glacier experienced a peak flow in the order of 200 m^3/s, more than double the previous record flow (5 year period), Place Creek near Birken registered a peak flow 70 percent geater than the previous 16 year record, and at Sentinel Creek, above Garibaldi Lake, the gauging station which had been in place for 19 years was washed away!

Within the Lillooet River Basin the only active hydrometric station is #08MG005, on the Lillooet River near Pemberton, a station for which 64

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[1] B.C. Forest Service Precipitation Gauge, Pemberton Village

years of records dating back to 1914 are available. Unfortunately, during the 1984 flood, dyke overtopping and subsequent failure in the Miller Creek area caused a considerable flow, estimated[1] to have averaged 184 m^3/s, to bypass this gauging station. Thus, the only reasonably accurate October 1984 flow data for the watershed are estimates for one location, derived from observed river flows adjusted to reflect bypassing overbank flow. The resulting provisional[2] estimated flows at this station, together with the previous recorded maximums, are:

Instantaneous Peak Flow	1310 m^3/s	Previous Record 993 m^3/s	Dec. 1980
Daily Peak Flow	1110 m^3/s	Previous Record 900 m^3/s	Oct. 1940

3.1.2 Analysis

The estimated maximum instantaneous and maximum daily flows at the Lillooet River gauging station, together with data from analysis[3] of flow records from previous major floods which had occurred while hydrometric stations were also in operation on the Green and Soo Rivers and on Rutherford Creek, were used to derive the probable flows at other locations throughout the drainage basin - see Table 3. Computer modelling techniques were then employed to reconcile these derived flows with flood profiles plotted from observed highwater marks[4]; appropriate adjustments were made where necessary.

3.2 Seismic Activity

The possibility that seismic activity might have triggered the sudden Meager Creek flood surge, which caused extensive damage on Oct. 9th,

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1 R.W. Nichols, B.C. Ministry of Environment, Water Management Branch
2 Beyond the range of the rating curve
3 Appendix A
4 Reference Water Management Branch Drawings No. 85-13-1 to 5 incl. not included in general distribution copies of report.

may be discounted since it has been established that the only recent preceding earth tremor of any significance, measuring 3.0 on the Richter Scale, occurred on September 22nd, and was centred in the Homathco Snowfield some 120 km to the northwest. A tremor of this magnitude would not be expected to cause ground or ice movement, even at its epicenter.

Examination of the Meager Creek watershed during the snow-free season would be necessary to determine the extent to which factors other than precipitation may have contributed to local problems in that area. The findings of such an investigation would, however, be inconsequential insofar as the study area is concerned since the steep Meager watershed constitutes only 13.5% of the Lillooet River drainage basin, as measured above the Ryan River confluence, and any sudden flow surges resulting from the collapse of channel blockages would have dissipated before reaching the study area.

3.3 Effects of Timber Harvesting

An assessment of the extent of timber harvesting activity and its effect on peak flows was undertaken by the Surface Water Section[1]. A synopsis of this assessment, details of which are to be found in Appendix C, is as follows.

During the period since 1958, when logging in the Pemberton Valley was first recorded, the average cutting rate has been 262 hectares (ha) per annum, for a total cut of 6800 ha or 3.1 percent of the total watershed area - see Table 2; of this area approximately fifty percent has been replanted since 1965 - see Figure 2.

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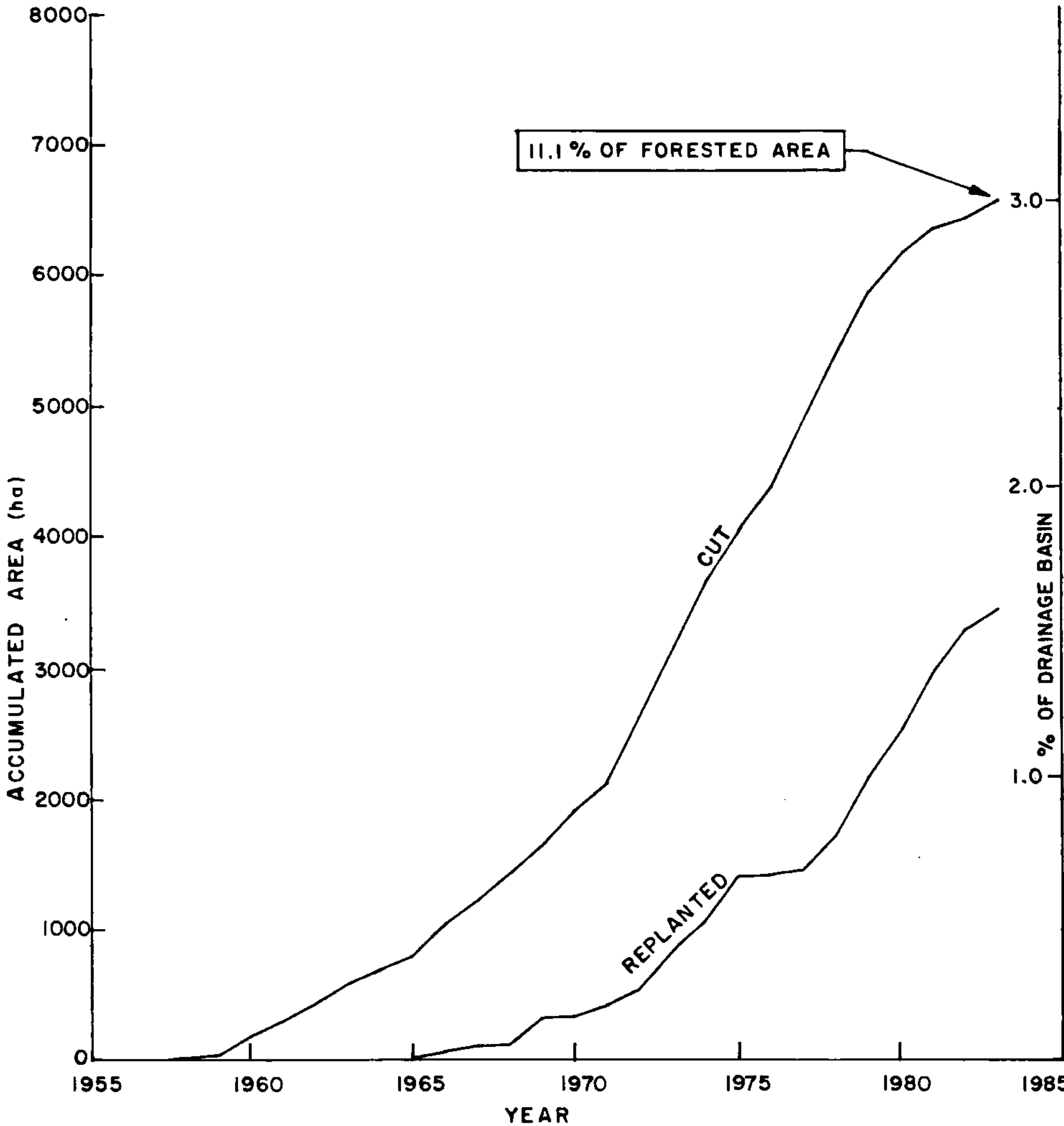
[1] D.E. Reksten, Technical Memorandum, Ministry of Environment, Planning and Resource Management Division, Water Management Branch, (Jan. 1985)



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TO ACCOMPANY REPORT ON
PEMBERTON VALLEY FLOOD PROTECTION
1985 STUDY
LILLOOET RIVER BASIN
LOGGING HISTORY 1938-83

SCALE: AS SHOWN
DATE JUNE 1985
D. E. REKSTEN / H.H.N - PORTER ENGINEER
FILE No. P 72-3 DWG No. 85-13-18

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FIGURE 2

In this watershed economically merchantable timber stands generally do not extend above the 1200 m elevation, consequently, to provide a more representative assessment of the stage to which harvesting has progressed the Timber Harvesting Summary provided in Table 2 includes "cut areas" as percentages of the "forested" watershed areas below the 1200 m elevation, for both the whole basin and for selected sub-basins.

TABLE 2

TIMBER HARVESTING SUMMARY

Basin	Basin Area (km^2)	Area Cut 1958-1983 (km^2)	Cut Area as % of Basin	Forested Area (km^2)	Cut Area as % of Forested Area
Lillooet River incl. tribs.	2160	68	3.1	610	11.1
<u>Sub-basins</u>					
Ryan River	419	17	4.1	82	20.8
Meager Creek	225	6	2.1	77	7.7
Pebble Creek	132	0.5	0.4	11	4.3
North Creek	82	2	2.4	14	14.0

From this tabulation, it is apparent that the extent of logging along the major watercourses has been comparatively small, ranging from 0.4 to 4.1 percent of watershed areas, and, consequently, will have had very little effect on the magnitudes of the recent flood events.

3.4 Flood Frequency - Discharge Estimates

3.4.1 Peak Daily Flows

An analysis of the records from the seven hydrometric stations which have operated whithin the Lillooet River drainage basin was carried out by the Modelling Section[1]. In cases where the period of record was short, the resulting frequency estimates were adjusted to correspond with those for the longer etablished Lillooet River Station 08MG005.

For other Lillooet River locations and for the smaller ungauged watersheds the return period estimates were derived, by the Surface Water Section[2], from those for appropriate gauged locations using the 'regional envelope curve' published by the Water Suvery of Canada[3].

For the larger Ryan River watershed, the return period flows were determined from a plot of the return period estimates derived for the Green and Soo Rivers and for Rutherford Creek.

3.4.2 Instantaneous Peak Flows

Return period estimates for instantaneous peaks for the Lillooet and Green River hydrometric stations (near Pemberton), and for the Lillooet Lake (stage) were determined, as for the daily peak flows,

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1 R. Wyman, Technical Memorandum, Ministry of Environment, Modelling Section, Feb. 22, 1985. - See Appendix B

2 D.E. Reksten, Technical Memorandum, Ministry of Environment, Surface Water Section, June 26, 1985. - See Appendix A.

3 Canada, Inland Waters Directorate - Pacific and Yukon Region, Magnitude of Floods - British Columbia - Yukon Territory, (Vancouver:1982), Vol. 3

from analysis of records for these stations. Elsewhere along the Lillooet River the return period instantaneous flows were calculated from the return period daily flows, using modifications of the ratio of instantaneous to daily peak flows (I/D) as determined for the Lillooet River gauging station (08MG005).

For the other watersheds appropriate I/D factors[1] were used to obtain the return period instantaneous peak flows, the confidence limits for which are considerably wider than for the mainstem Lillooet River locations.

Figures 3 to 8 show the flood frequency-discharge relationships which were developed for representative locations in each watershed. Figure 9 shows the stage-frequency curves for Lillooet Lake.

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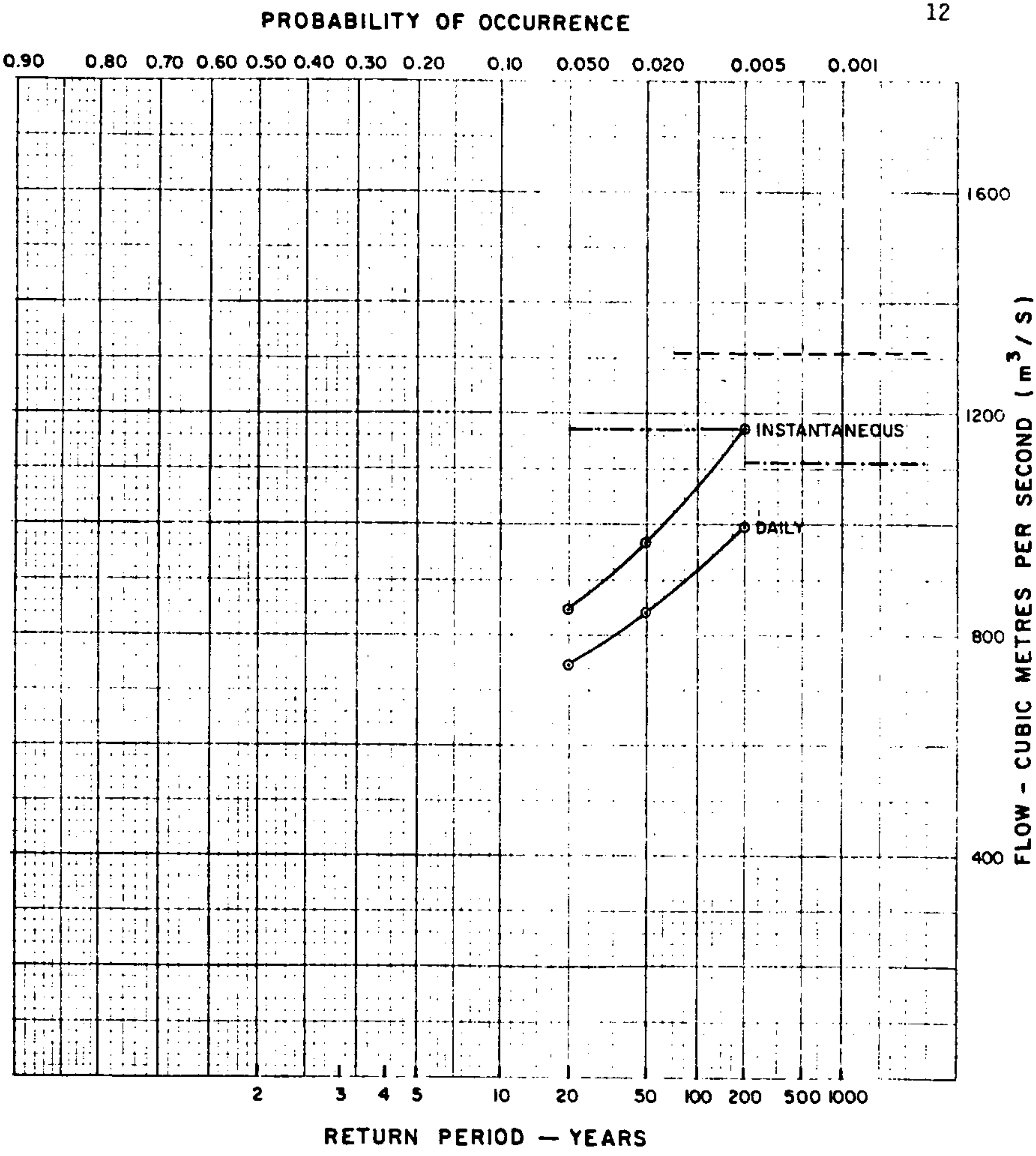
1 See Appendix A, Table 2

TABLE 3

FLOOD MAGNITUDE AND RETURN PERIOD PREDICTION DATA

	LILLOOET RIVER					RYAN R.	MILLER CR.	PEMBERTON CR.	GREEN R.	BIRKENHEAD R.	
	Above Wolverine Creek	Above Ryan River	Nr. Pemberton Gauge #8MG005	Above Green River	Lillooet L. #8MG020	At Mouth	At Mouth	At Mouth	At Mouth	At Gauge # 8MG008	At Mouth
DRAINAGE AREA (km^2)	1560	1660	2160	2218	3200	419	78	51	868	597	638
EVENT											
October 1984 Flood											
- Daily flow	835	863	1110[1]	1139	1513	330[2]	124	25	350	149	160
- Instantaneous flow	1002	1049	1310[1]	1344	1755	430[2]	174	(37)	(392)	(194)	(208)
20 Year Return Period											
- Daily flow	593	622	746	765	990	256	100	46	382	267	278
- Instantaneous flow	670	703	843	864	1130	333	140	69	416	347	361
50 Year Return Period											
- Daily flow	655	690	840	860	1107	323	124	56	478	338	354
- Instantaneous flow	753	792	966	990	1290	420	174	84	525	439	460
200 year Return Period											
- Daily flow	796	830	992	1020	1312	432	170	79	660	536	565
- Instantaneous flow	939	979	1170	1200	1570	562	240	118	740	697	734

Footnotes:
1 Measured channel flow corrected for overbank loss
2 Derived from flood profile analysis
( ) May be grossly in error due to lack of data



—··—·· PRELIMINARY OCT. 1984 INSTANTANEOUS PEAK FLOW AS RECORDED AT GAUGE

— — — — PROBABLE OCT. 1984 INSTANTANEOUS PEAK FLOW

—·—·— PROBABLE OCT. 1984 DAILY PEAK FLOW

HYDROMETRIC STATION No. 08MG005

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PEMBERTON VALLEY FLOOD PROTECTION
1985 STUDY
FREQUENCY - DISCHARGE CURVES
LILLOOET RIVER NR. PEMBERTON

SCALE: VERT. ....
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DATE
JUNE 1985

W. H. Nesbitt-Porter ENGINEER

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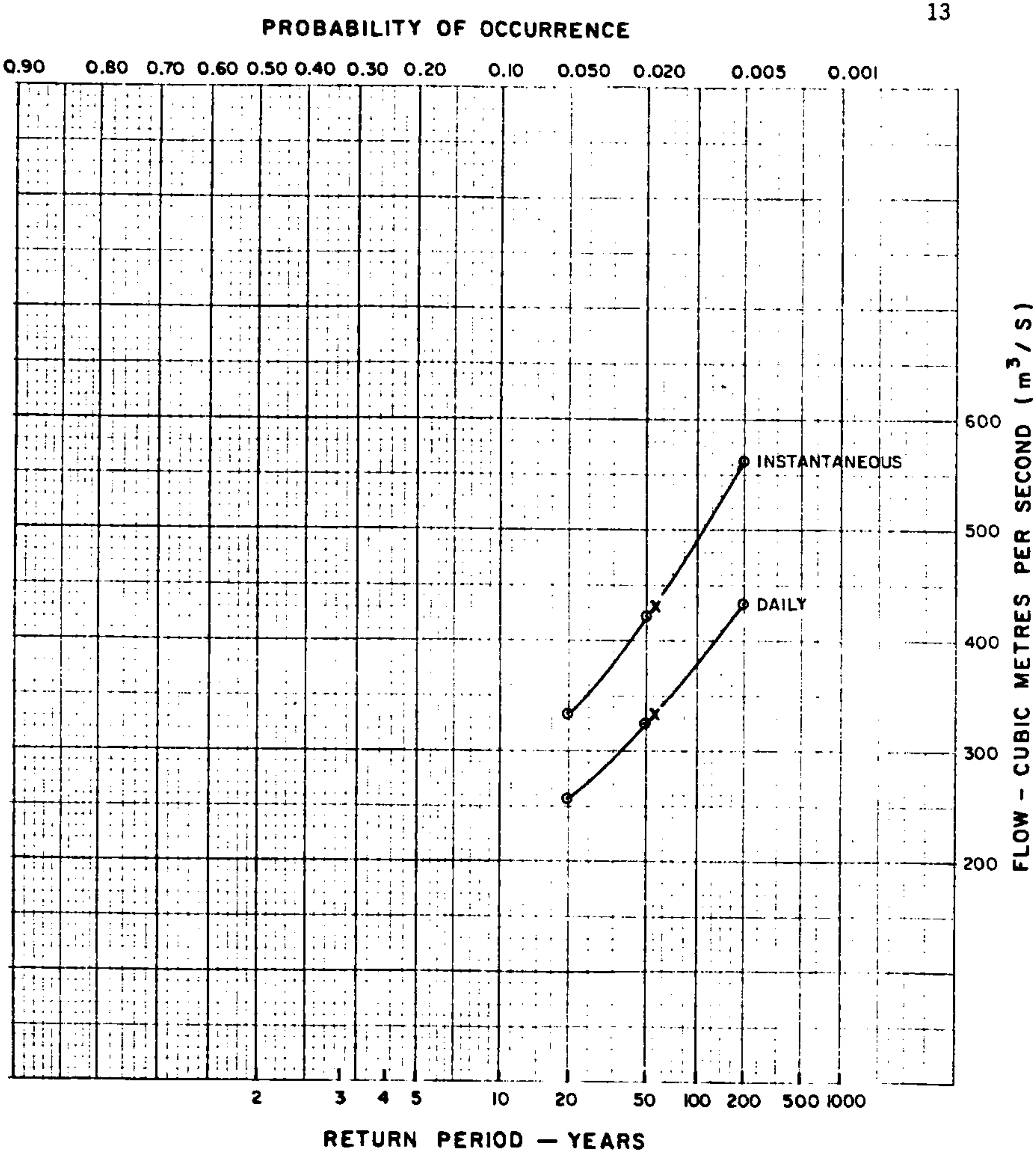
FIGURE 3



X PROBABLE OCT. 1984 FLOW

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PEMBERTON VALLEY FLOOD PROTECTION
1985 STUDY
FREQUENCY - DISCHARGE CURVES
RYAN RIVER AT MOUTH

SCALE: VERT.
HOR

DATE
JUNE 1985

H. H. Nesbitt - Porter ENGINEER

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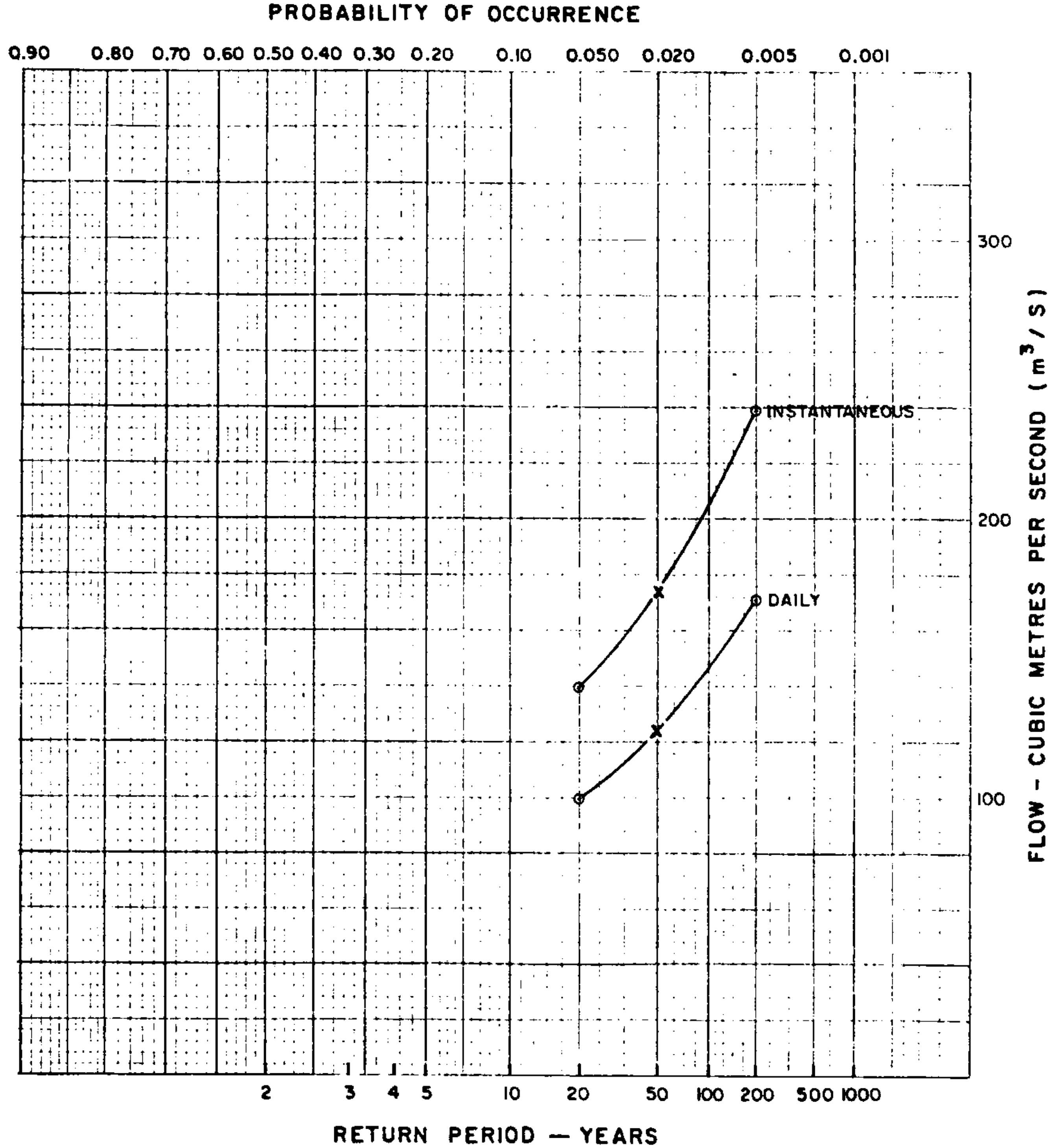
FIGURE 4



X PROBABLE OCT. 1984 FLOW

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PEMBERTON VALLEY FLOOD PROTECTION
1985 STUDY
FREQUENCY - DISCHARGE CURVES
MILLER CREEK AT MOUTH

SCALE: VERT.
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DATE JUNE 1985
ENGINEER
FILE No P 72 - 3 DWG No 85-13-30

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FIGURE 5