Chapter Eight

RIVER HYDROLOGY

Catchment Monitoring and Flood Frequency Analyses

Historical accounts of Hutt floods typically record events with a short duration at high stage, similar to a wave or "bore" moving quickly down the River. The 1955 flood as recorded in figures 14 and 15, p. 148 is a good example. (Photographs of residents trapped in the rapidly rising waters are contained on the front and rear covers of this report). Comparison of the hydrographs shows that in 1955, as today, the river channel from Maoribank to Hutt City (approximately 20 km) had little effect on the shape of the flood hydrograph and led to flood flow velocities averaging 10 km per hour.

This chapter contains brief reference to the engineering hydrology undertaken prior to 1990. Scheme Hydrology is reviewed in Scheme Review Volume 2 "Climatology and Hydrology".

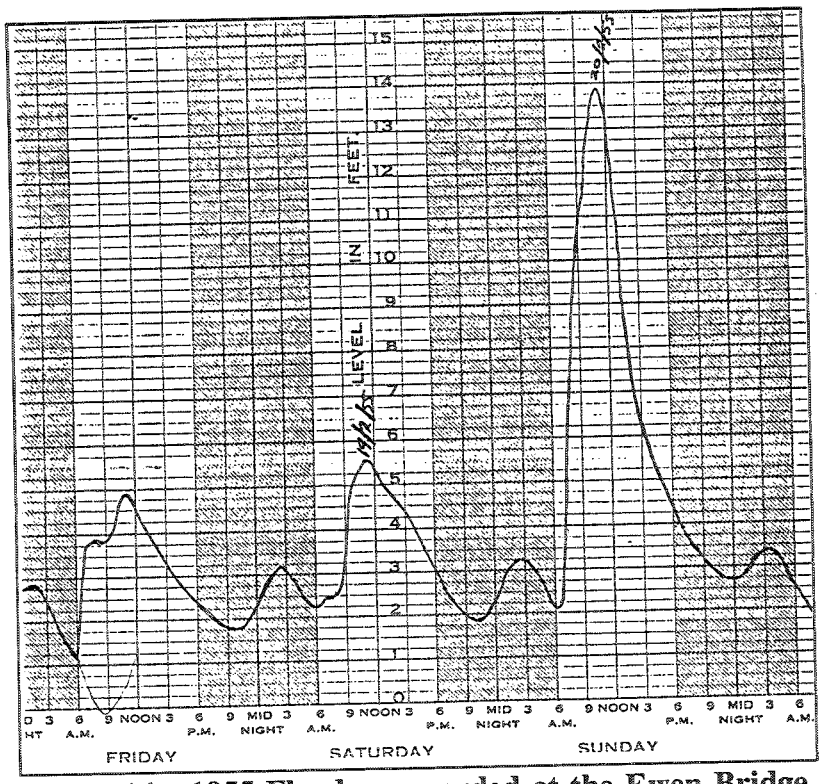

Figure 14: 1955 Flood as recorded at the Ewen Bridge, Hutt City.

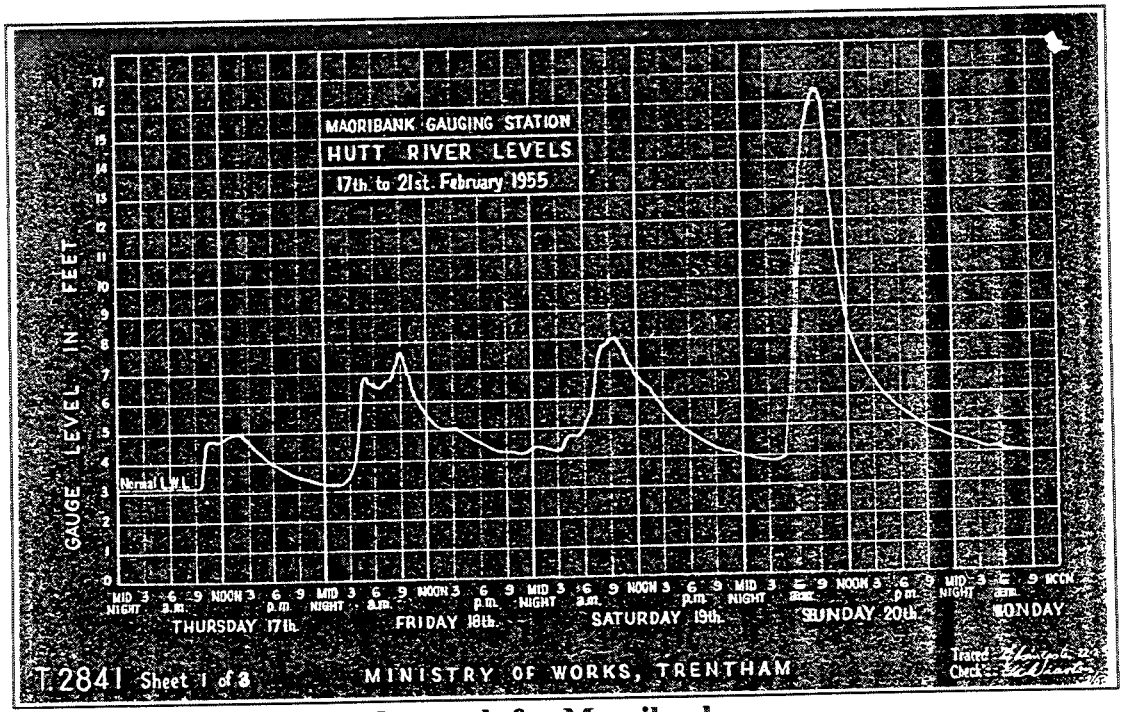

Figure 15: 1955 Flood hydrograph for Maoribank.

Floods and Monitoring Prior to 1940

Scientific monitoring of the Hutt River System commenced in 1941 with the establishment of the Ewen Bridge water level recorder at central Lower Hutt. Accounts of floods prior to 1930 are found scattered throughout the various archives. Table III, p. 150, is a compilation of these general observations, interpreted in terms of our current understanding of the historical river regimes and flood plain topography. (Taken from WRC HRFCS Report "Historical Flood Re-estimation by Channel Modelling", November 1989). Flood observations from 1924 are contained in Archive Table 18, p. 160.

Scientific Monitoring Post - 1940

From 1904 to 1941 the peak rise in flood level was recorded in terms of feet of rise at the Hutt Bridge. Readings were initially taken from the bridge itself but from 1928 were read from a staff gauge located "on the south end of the first pier from the east end of the new Hutt Bridge". Until 1941 floods were not formally recorded and there is no record of the Ewen Bridge recording station ever being rated either before or after the installation of the gauge. The data that has been recorded has been interpreted with reference to other flood observations, as for the pre 1930 data, to produce a synthetic partial series for 1840 to 1990 [refer Table IV, p. 151 and figure 16, p. 152]. The stage discharge relationships for several sections of the lower river and for Hutt Bridge, as generated from the historical backwater models, are included in figures 17 and 18, p. 153.

The Ewen Bridge Recorder was funded by the Soil Conservation and Rivers Control Council (SCRCC) as part of its 1940 nationwide campaign to develop an national hydrological archive. Although the recorder was retained until 1972, in 1951 the SCRCC encouraged its replacement with a new station at Maoribank. Reasons given for its replacement were the unreliability of the Ewen Bridge low flow data because of the tidal influence, and the need for an increased level of flood warning due to the "enormous" recent growth in the population of the Hutt. The historical ratings for the Ewen Bridge and Maoribank stations, effectively used for the design of all current scheme works, are included in figures 19 and 20, p. 154.

The Maoribank water level recording station proved difficult to maintain. The bed degraded, the intake pipes were subject to debris damage, and the cableway was apparently unsafe. Maoribank was in turn replaced as the principal recording and flood warning station by the Birchville Station in 1970. In addition to Birchville, two low flow stations were installed for the Underground Water Authority at Silverstream Bridge (1962-1980) and at Boulcott (1964 to present). In 1979 the Wellington Regional Water Board established an additional station at Taita Gorge to include a larger catchment area.

Table V summarises the past and present water level recorders and their periods of record. Scheme Review Volume 2, "Climatology and Hydrology", contains analysis of the station records and current rating information. It also contains description of the climate stations and consideration of the Hutt paleohydrology and historical climatology.

TABLE III : HISTORICAL FLOODS 1840-1930
(Assigned flows are 1990 reassessments)

Date	Recorded Observations	Assigned Flow (cumecs)
1840	Overflows into the Alicetown area of .3 m leading to general flooding of low lying areas to approx 1 m deep.	1000
1842	General berm overflow into settlement.	800
1849	Heaviest flooding for many years. Sheep lost. Berm overflow.	1000
1852	General overflow. Recurrent event.	600
1855	600 mm higher than the 1849 event.	1500
1858	January flood. To bridge deck level. Flows of 1-1.2 m on high street leaving the road impassable.	2000
	September flood. Removed half of the third Hutt bridge.	1200
1868	Damaged the Hutt bridge.	1200
1871	Damaged the Hutt bridge.	1200
1878	Two floods. Both with widespread bermflow covering the "entire" valley. The second River Overflows through Boulcott operated.	1500
1880	Bankfull with overflows in the lower reaches.	800
1893	March flood. Flooding in central Petone to the top of boundary fences.	1500
	August flood. Flooding made use of the main road to Wellington difficult.	1700
1896	Serious flooding of Alicetown.	1350
1898	June flood. Water level .23 m below the deck of the Hutt Bridge. Alicetown flooded to 2.4-3.0 m. High Street flood to approx .9 m.	2000
	November flood. Water covering the "entire" valley but to a lesser depth than in June.	1500
1904	Flooding of lower berms.	400
1907	Flooding to the base of the embankments.	750
1909	High flood recorded.	750
1911	High flood.	750
1912	High flood.	750
1913	Levels .9 m below Melling suspension bridge.	1300
1915	Level 5.65 at Hutt bridge.	1350 (HRB 1287)
1921	Central channel full to embankments	750
1922	Rise at Hutt bridge 3.35 m..	1000
1924	600 mm below Hutt bridge deck.	1800
1926	Central channel bankfull.	400
1928	Berms covered.	700
1929	Berms covered.	700
1930	Rise at Hutt bridge 2.75 m.	800

TABLE IV : HUTT RIVER SYNTHETIC FLOOD SERIES 1840 TO 1990

Data for Floods up to 1972 has been obtained from observations at Lower Hutt, with the assigned discharge determined from synthetic ratings for the Hutt Bridge site, determined by modelling historical river conditions (refer HRFCSR Report "Historical Flood Re-estimation by Channel Modelling"). For the period 1840 to 1930 general observations have been used. From 1931 to 1941 observations in terms of the staff gauge on the Fifth Hutt Bridge have been used. From 1942 to 1972 automatic recording were taken at Ewen Bridge. It is probable that many of the lower order floods prior to 1930 have not been recorded.

For floods between 1972 and 1979 the flow has been calculated by a regression from the Birchville Flows (Hydrology Centre Rating 1989).

For floods from 1979 the flow is the Taita gorge recording.

date	flow	flow	flow	date	flow	flow	date	flow	flow	flow	flow	date	flow	flow	flow	flow
1840	1000			1880	900		1920					1960				
1841				1881			1921	750				1961	730			
1842	600			1882			1922	1000				1962	1280			
1843				1883			1923					1963				
1844				1884			1924					1964				
1845				1885			1925					1965	880	1300		
1846				1886			1926					1966	620	1180		
1847				1887			1927					1967	620	620		
1848				1885			1928	700				1968	730			
1849	1000			1889			1929	700				1969				
1850				1890			1930	800				1970				
1851				1891			1931	1400				1971	625	665	1050	
1852	600			1892			1932					1972	781			
1853				1893	1500	1700	1933					1973				
1854				1894			1934					1974				
1855	1500			1895			1935	630				1975				
1856				1896	1350		1936	910				1976	614	747		
1857				1897			1937	520				1977	792			
1858	2000	1200		1898	2000	1500	1938	865				1978				
1859				1899			1939	730	1600			1979	568	531	542	
1860				1900			1940	570				1980	1213	741	557	746
1861				1901			1941	570	770	680	740	1981	1298			
1862				1902			1942	825	720			1982	1302	813		
1863				1903			1943	570	625			1983	652	879	648	
1864				1904			1944	530				1984	1012			
1865				1905			1945	590	615			1985	748	790		
1866				1906			1946	590				1986	539			
1867	1200			1907	750		1947	775	850	970	700	1987				
1868				1908			1948	1200				1988	671	858		
1869				1909	750		1949	540				1989				
1870				1910			1950	580				1990	762			
1871	1200			1911	750		1951	530	520	790						
1872				1912	750		1952	535								
1873				1913	1300		1953	570								
1874				1914			1954	550								
1875				1915	1350		1955	535	640	930	1250					
1876				1916			1956	630	650	770						
1877				1917			1957									
1878	1500			1918			1958	520	520	730						
1879				1919			1959	540								

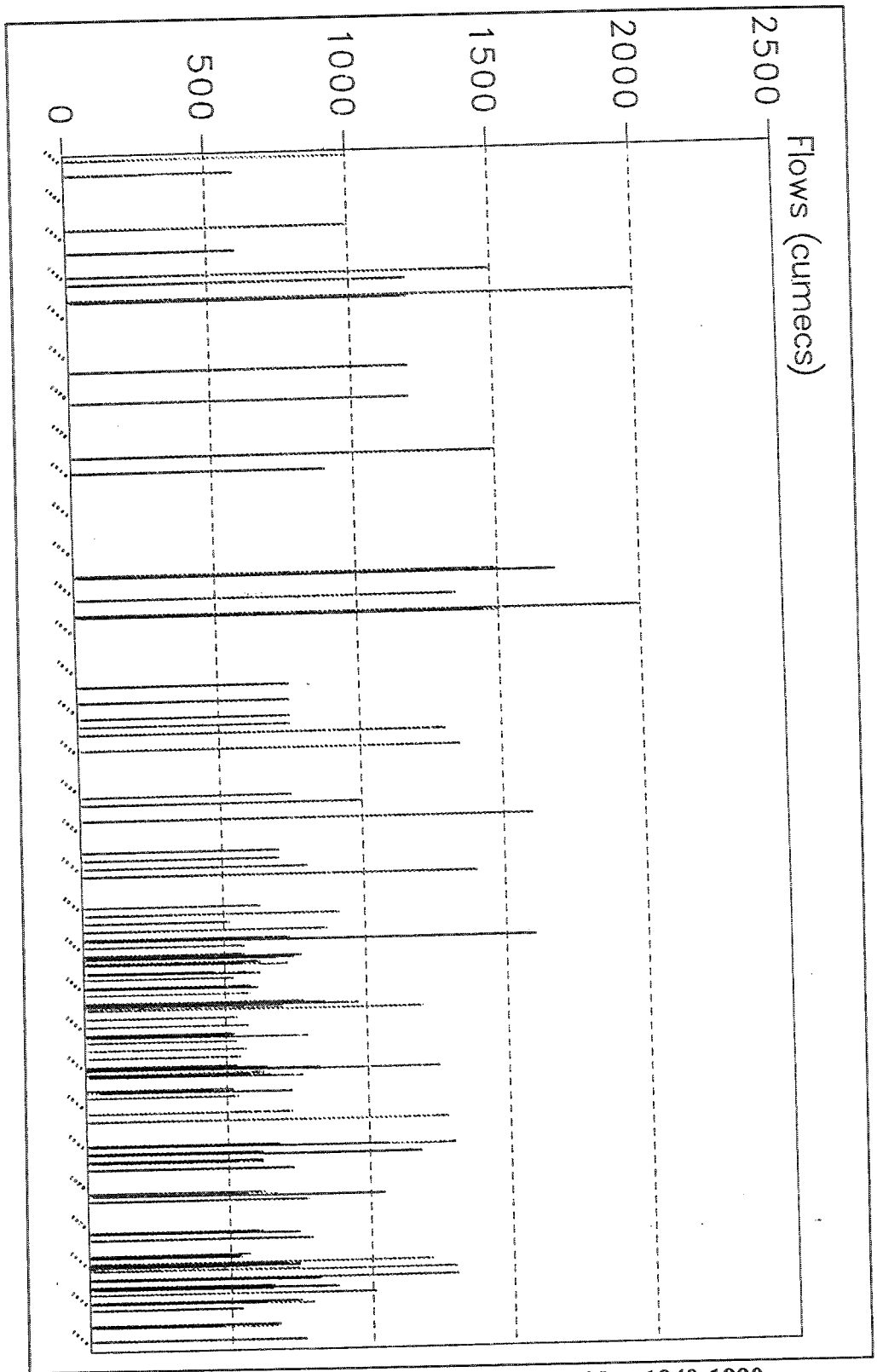

Figure 16: Synthetic Flood Series at Ewen Bridge 1840-1990.

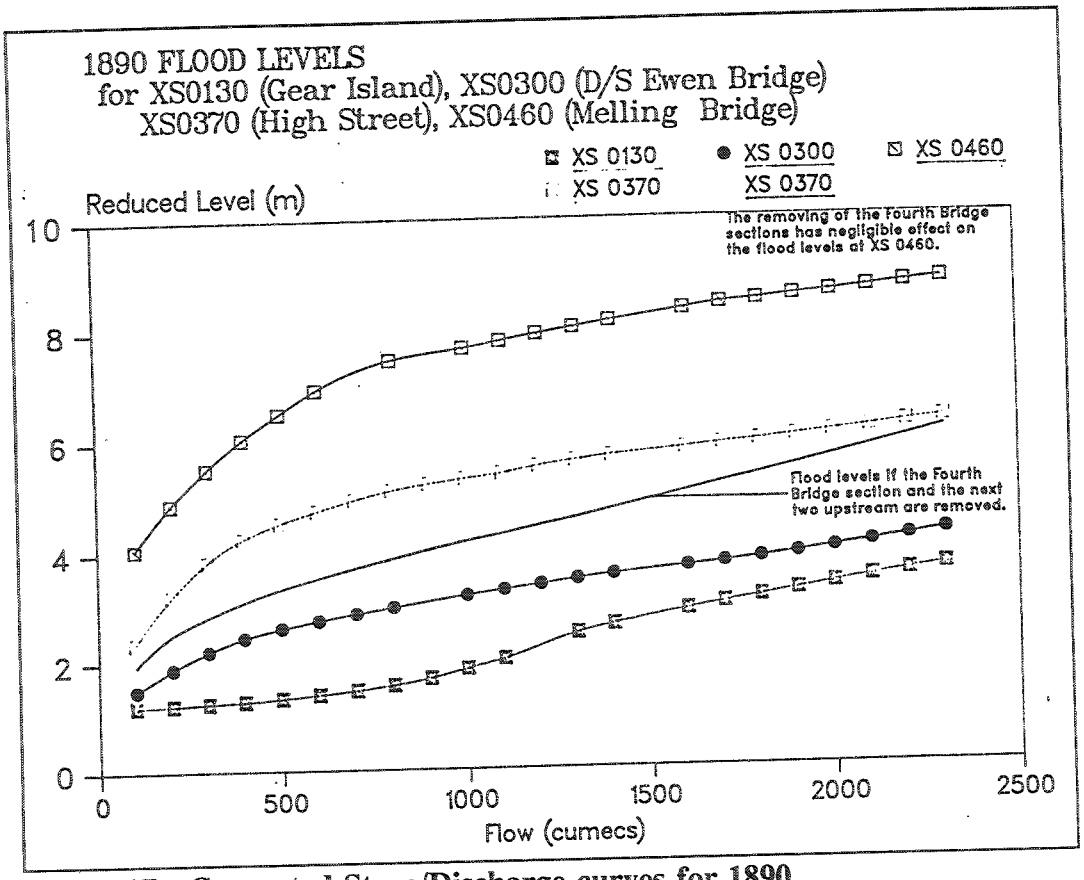

Figure 17: Computed Stage/Discharge curves for 1890

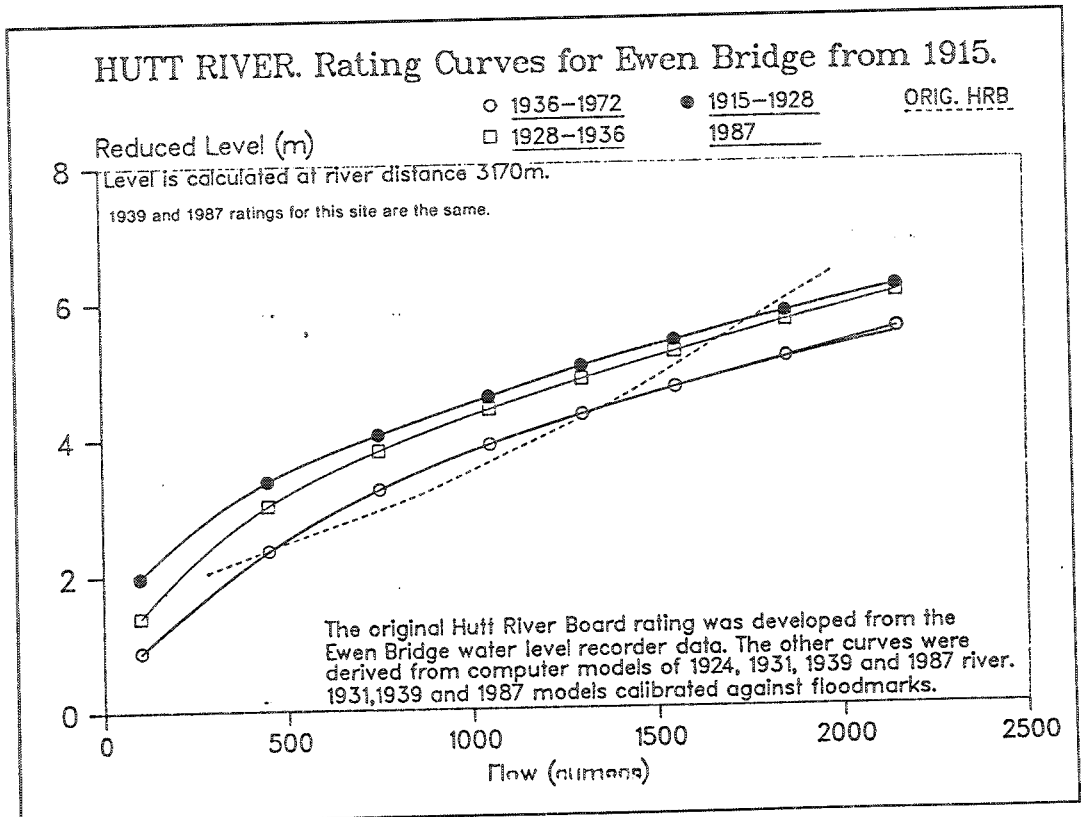

Figure 18: Computed Rating Curves for Ewen Bridge.

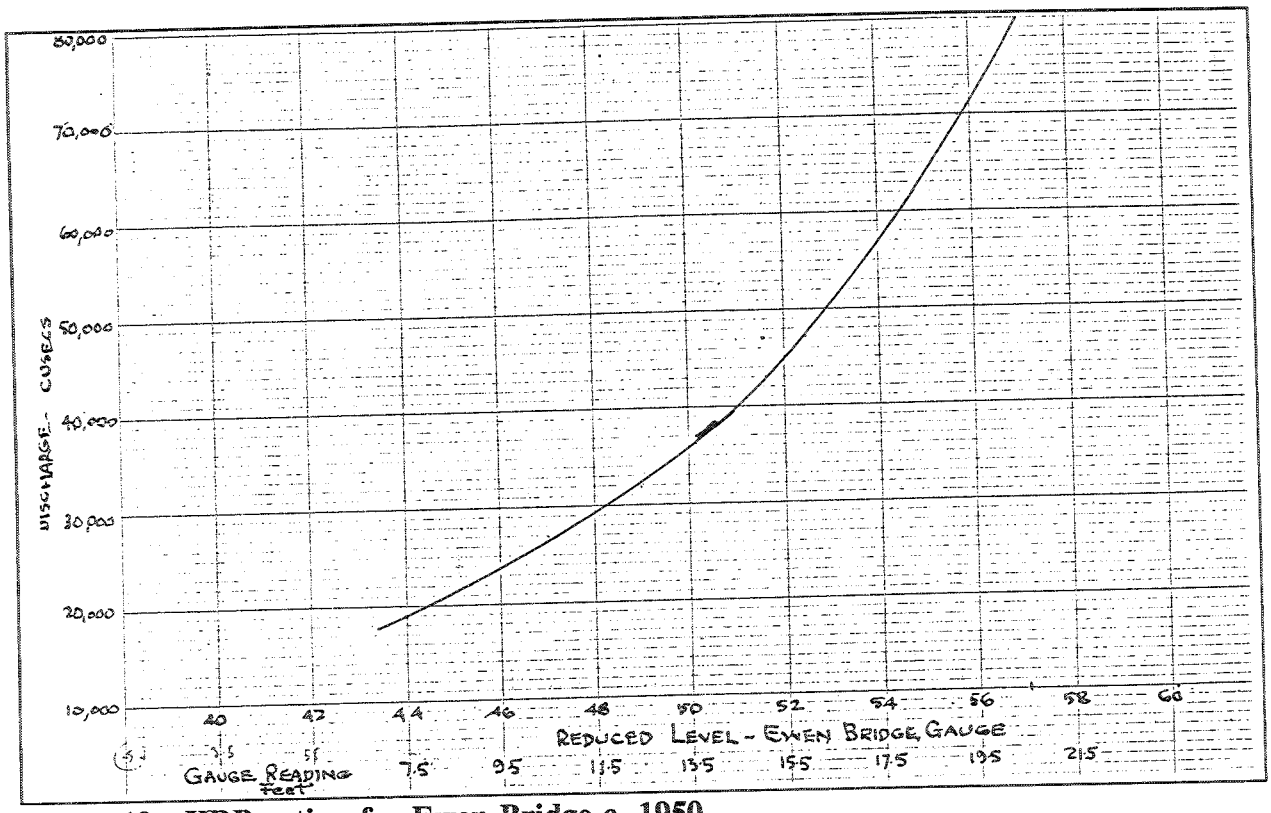

Figure 19: HRB rating for Ewen Bridge c. 1950.

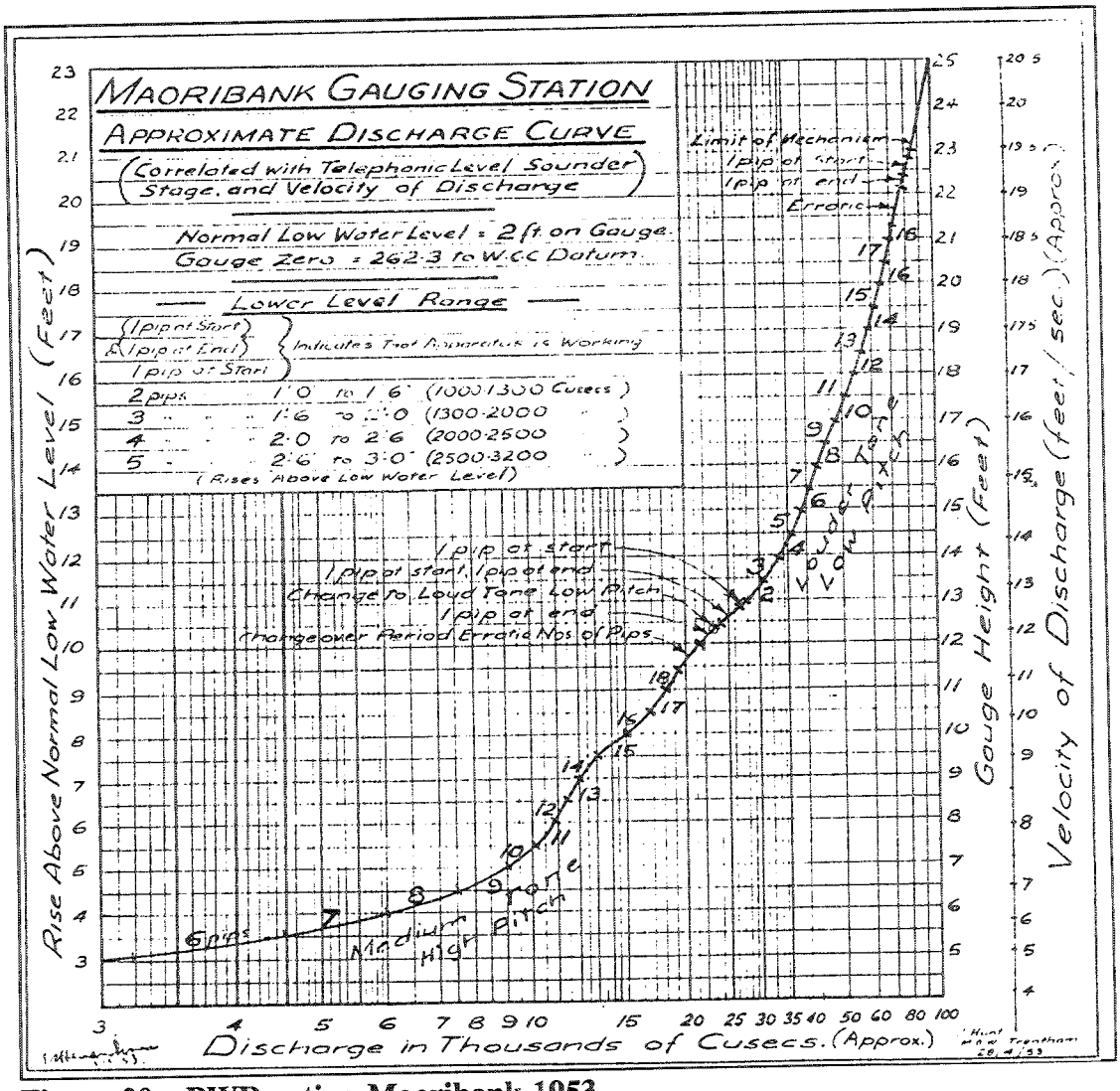

Figure 20: PWD rating Maoribank 1953.

TABLE V : HUTT CATCHMENT MONITORING STATIONS

Number	Name	General Description				Period	
NW&SCA 1987	River,Location	Map Ref yard grid metric grid	Purpose: refer key	Area sqkm	Type: refer key	Begin	End

Key to Abbreviations FC Flood Control invest; FW Flood Warning; WR Water Resources; Ug Underground Water; TR Tidal recording; WS Water Suppiy Invest; RS Research Area; Rg Regional Catchment; MR Major River; Eric Ericson; Kent Kent; F&P Fischer & Porter; L&S Leupold & Stevens digital; Fox Foxboro; FRev Fischer & Porter Event Raingauge; PSION datalogger; (T) Telemetered.

WRC Water Level Recording Stations						
29801	Hutt, Maoribank	N161:628439 R27:860090	FC,FW	427	Eric Kent	52 79
29803	Hutt, Silverstream Replaced by 29809	N160:538392 R27:776050	WR,Ug,FW	547	F&P	62 79
29809	Hutt, Taita Gorge Replaces 29803	N160:525375 R27:764035	WR,Ug,FC,FW	555	L&S(T) Fo	79
29811	Hutt, Boulcott	N160:470327 R27:708992	WR,Ug	604	L&S	64
28816	Hutt, Taita Rock	N160:508365 R27:764034	WR,FC,Ug	557	F&P	74 79
29830	Mangaroa, Te Marua	N161:658453 R26:888103	WR,FW	102	L&S(T)	69
29837	Hutt, Ewen Bridge	N160:448309 R27:692976	FC	610	Kent	41 75
29838	Hutt, Estuary Bridge	N164:450284 R27:693954	FC,TR,Ug,Ws	623	F&P(T)	76
29840	Hutt, Sewer Crossing	N160:535388 R27:773046	Ug,WR	547	F&P	78 79
29841	Whakatiki, Dude Ranch	N161:568469 R26:806119	WR,WS,FW	46	L&S	76
29842	Mangaroa, Black Swamp	N161:618403 R27:849058	RS	11	Fox	77 78
29843	Pakuratahi, Truss Bridge	N161:713418 R27:938069	WR,FW	37	L&S	78
29844	Akatarawa, Cemetery	N161:631463 R26:863112	WR,FW	113	L&S(T)	79
29845	Waiwhetu, Whites Line East	N164:468295 R27:710962	FC	12	Fox PSION	69
29846	Waiwhetu, Bell Rd Bridge	N164:465290 R27:707958	FC	14	Fox	78 80
29847	Hutt, County Lane	N160:540393 R27:778050	WR,FC	547	Fox	64 65
29853	Hutt, Te Marua	N161:673474 S26:902121	Ws	191	Fox PSION	84
DSIR Water level Recorder Sites						
29808	Hutt, Kaitoke	N161:716507	Rg,WR,WS,FW	89	L&S(T)	55
29818	Hutt, Birchville	N161:624448	FW,FC,MR	427	L&S(T)	70
WRC Raingauge Sites						
59007	Akatarawa, Warwicks altitude 345 m	N157:610620 R26:853252	WR,FW	-	Frev (T)	80
150002	Whakatiki, Putaputaweta altitude 240 m	N160:544554 R26:786198	FW,WR,WS	-	FRev	86
150010	Whakatiki, Blue Gum Spur altitude 335 m	N161:558509	FW,WR,WS	-	FRev (T)	81 86 89
150108	Akatarawa, Cemetery altitude 100 m	N161:631463 R26:863112	WR,WS,FW	-	Aquitel (T)	89
150111	Hutt, Twin Lakes altitude 92 m	N161:669466 R26:899114	WR,WS	-	FRev	84
151202	Pakuratahi, Centre Ridge altitude 440 m	N161:724408 S27:948062	WR,FW	-	FRev (T)	84
152004	Mangaroa, Tasman Vaccine altitude 229 m	N161:555334 R27:790996	WR,FW	-	FRev (T)	80
DSIR Raingauge Sites						
150210	Hutt, Phillips altitude 300 m	N161:743516 S26:967158	-	-	FRev (T)	72

Flood Frequency Analyses

Hutt River Board Frequency Analysis Prior to 1951

On the basis of the Ewen Bridge records for the 10 year period from 1941-1951 Sladden produced a flood frequency relationship, reproduced as figure 21. This document is the first frequency relationship referred to in the engineering archives and was probably developed as a result of Soil Conservation and Rivers Control Council prompting. The Hutt River Board had previously designed for the "maximum" event, probably estimated by reference to previous Hutt floods, and by the application of a "Probable Maximum Flood" catchment area relationship.

Sladden used a slope-area method for the estimation of flood discharges. Until about the time of the installation of the automatic recorder at Ewen Bridge, the estimations were based on an average gradient between levels at the Hutt Bridge and Rail Bridge and on the cross sectional area at the Hutt Bridge. A roughness coefficient of n = 0.03 to 0.035 was used in the velocity determination, giving velocities of the order of 10 ft per second.

For some years after 1941 the gradient was measured between the gauging station and a level at Dudley Street 28.2 chains upstream and was presumably the basis for the "rating" of the Ewen Bridge site.. Later still, the flood discharges were calculated assuming an average velocity of 10 ft/sec at the Hutt Bridge section. There is no recorded attempt to verify these estimations by gauging or other means.

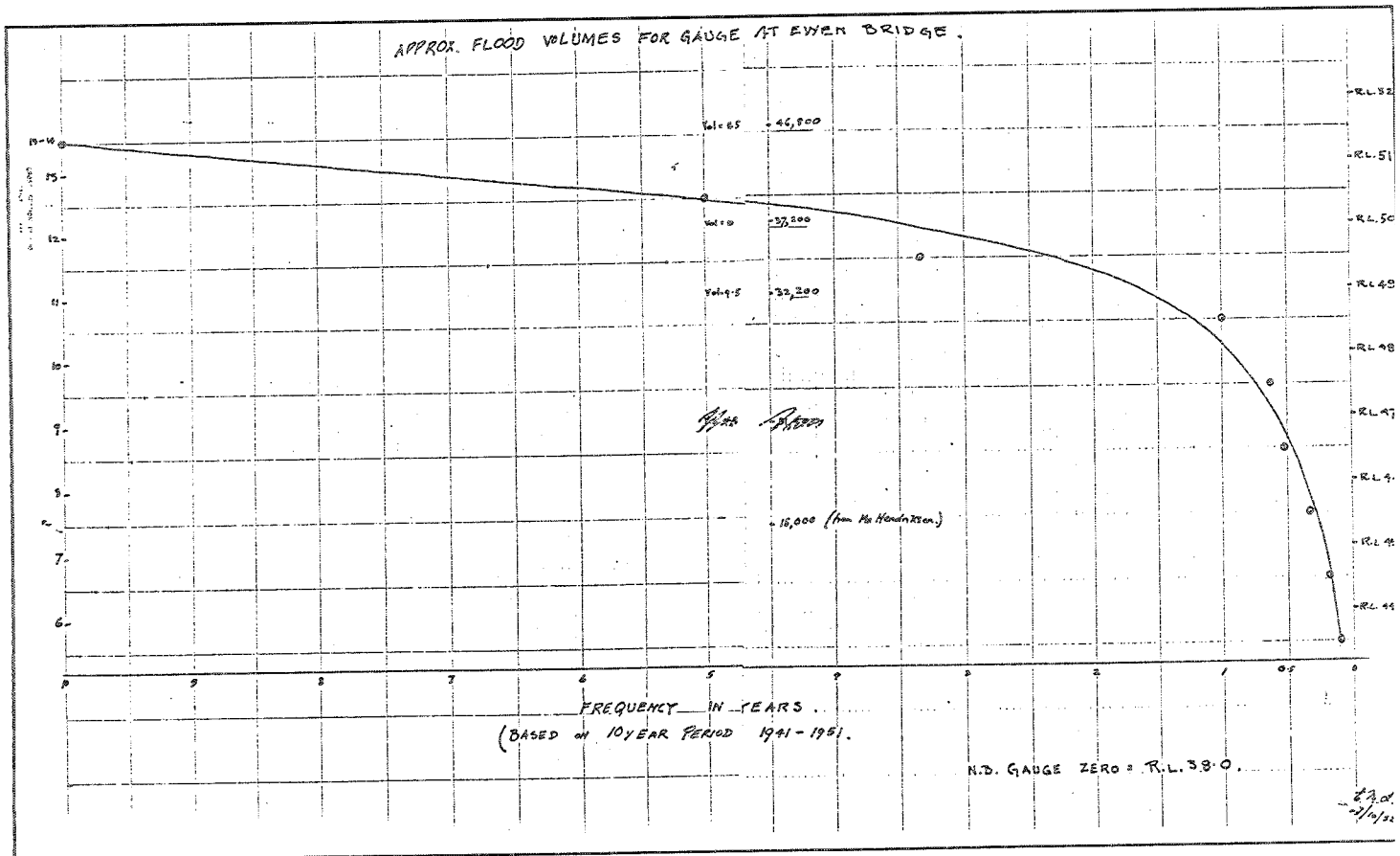

Figure 21: HRB 1951 Flood Frequency Relationship.

It would appear that Sladden used the surveyed flood gradients directly in his calculations and did not compensate for the irregularities in these reaches (although he may have intuitively compensated in the choice of the roughness parameter, selection of flood mark, etc.). At both the Hutt and Ava Bridges heading is required to overcome pier losses. The section at Dudley Street has been variously upstream and downstream of a central channel meander pattern, and the cross sectional areas at the Hutt Bridge, Dudley Street, and Ava Bridge are significantly different.

Sladden's "computed" discharges (copied into this report) should be regarded as approximate only. Preference has been given to the "nett rise" figure quoted in the archives, as it is likely that this figure is correct.

Computational methods based on historical survey and using the "nett rise" have been used to develop the partial series for the period 1840 to 1990.

Hutt River Board/Public Works Department Frequency Analysis 1951-1976

Up until the time of the major scheme extension and upgrade (1945-1975) there had been no call to develop a flood frequency relationship, although evidence given in support of the petition to include Petone into the Hutt District (1948) states that a 100,000 cusec flood was likely to occur at least once in every 200 years. Scheme works were generally designed to pass the greatest known (usually the last) flood plus a substantial freeboard, so that a much larger flood could be contained. There appears to have been no pressure to limit the works to a specific design standard. On the contrary there was the intention to provide for the maximum flood. During the design for the upgraded scheme a suitable design standard was considered and agreed to by Hutt River Board and Public Works Department engineers to be 100,000 cusecs plus a 2 ft freeboard. The hydrological basis for this figure is not known. [Refer Archive Table 17, p. 116.] Although the Public Works Department archives refer to various design floods of various frequencies, there does not appear to have been a formal flood frequency relationship developed until 1976.

Wellington Regional Water Board/Ministry of Works and Development Flood Frequency Relationship 1976-1990

Throughout the remaining period of the scheme reconstruction (1948-1972) the 100,000 discharge continued to be regarded as a highly improbable event and it was considered that the redesigned scheme would be able to pass the maximum flood within the freeboard allowance.

Scheme risk analysis seems to have been introduced sometime in the 1965-1975 period. By 1973 the records of the Wellington Regional Water Board (successor to the Hutt River 1972) assign a 100 year frequency of exceedence to the 100,000 cusec flood. There is no analysis on record to support this concept. The most likely explanation is that, in the absence of detailed engineering records, it was assumed that the Government subsidised works had been built to Government agency standards: in 1975 urban areas were to be protected from the 100 year flood (and, incidentally, were to show an internal rate of return of 8 percent or more - a concept that was not considered in the 1950s during the scheme redesign).

It is not clear why at this time there was a need to relate discharge to frequency of exceedence but it may have been to satisfy the conditions of Treasury/Soilcon for the continued Government support of the Scheme maintenance.

In 1976 the first hydrologically based analysis was completed with the production of the "Hutt River Flood Frequency Report", undertaken by the Wellington Regional Water Board and approved by the Ministry of Works in 1977. The results reduced the "100 year" flood from 100,000 cusecs to 75,000 cusecs. The results of the analysis, which have been used for the approval and design of all works on or associated with the Hutt River from 1976 to the present, are reproduced in figure 23, p. 159.

The derived 100 year floods for Maoribank, using the Jenkinson and Gumbel analyses, were 58,484 cusecs (1,656 cumecs) and 59,486 cusecs (1,684 cumecs) respectively. The reason for increasing Q100 to 65,000 cusecs (1,840 cumecs) is not clear but probably reflects the assessment of error in the analysis. This analysis assigns the 100,000 cusec flood a return period of 600 years.

The frequency analysis was based on an annual series derived from water level data recorded at the Ewen Bridge and Maoribank stations and was compared with data obtained from the new Birchville station. The results of the WRWB analysis were compared to the derived discharges and to the historical floods of 1939, 1931 and 1915 and were considered reasonable.

The 1976 Frequency analysis has now been replaced by the 1990 Scheme Review analysis reproduced from Review Volume 2 as figure 22 below.

Hutt River Network Node	A (km^2)	Q_2	Q_5	Q_{10}	Q_{20}	Q_{50}	Q_{100}	Q_{200}
Hutt at Mouth	639	760	1070	1270	1460	1710	1900	2090
Hutt at Boulcott	608	760	1070	1270	1460	1710	1900	2090
Hutt at Taita Gorge	561	760	1070	1270	1460	1710	1900	2090
Hutt at Silverstream	543	760	1070	1270	1460	1710	1900	2090
Hutt at Birchville	428	670	960	1160	1340	1580	1760	1940
Hutt at Mangaroa	302	450	660	790	920	1090	1220	1350
Hutt at Pakuratahi	170	380	520	620	710	830	920	1010
Akatarawa at Cemetery	115	270	350	410	460	530	580	630
Mangaroa at Te Marua	104	120	180	210	250	300	330	360
Whakatiki at Hutt	93.1	140	185	220	240	280	310	340
Hutt at Kaitoke	87.2	260	340	390	440	510	560	610
Pakuratahi at Hutt	81.4	160	220	260	300	340	380	420
Whakatiki at Dude Ranch	44.4	64	92	110	130	150	170	190
Pakuratahi at Truss Br	38.1	82	100	120	130	150	160	170
Waiwhetu at Hutt	17.9	18	27	32	38	45	50	55
Waiwhetu at White Lines E	11.6	12	15	17	19	22	24	26
Stokes Valley at Hutt	11.3	16	23	27	32	38	42	46

Figure 22: 1990 HRFCS Flood Frequency Relationship. Recommended flood estimates of return periods 2, 5, 10, 20, 50, 100, and 200 years (in cumecs); Hydrology Centre, DSIR.

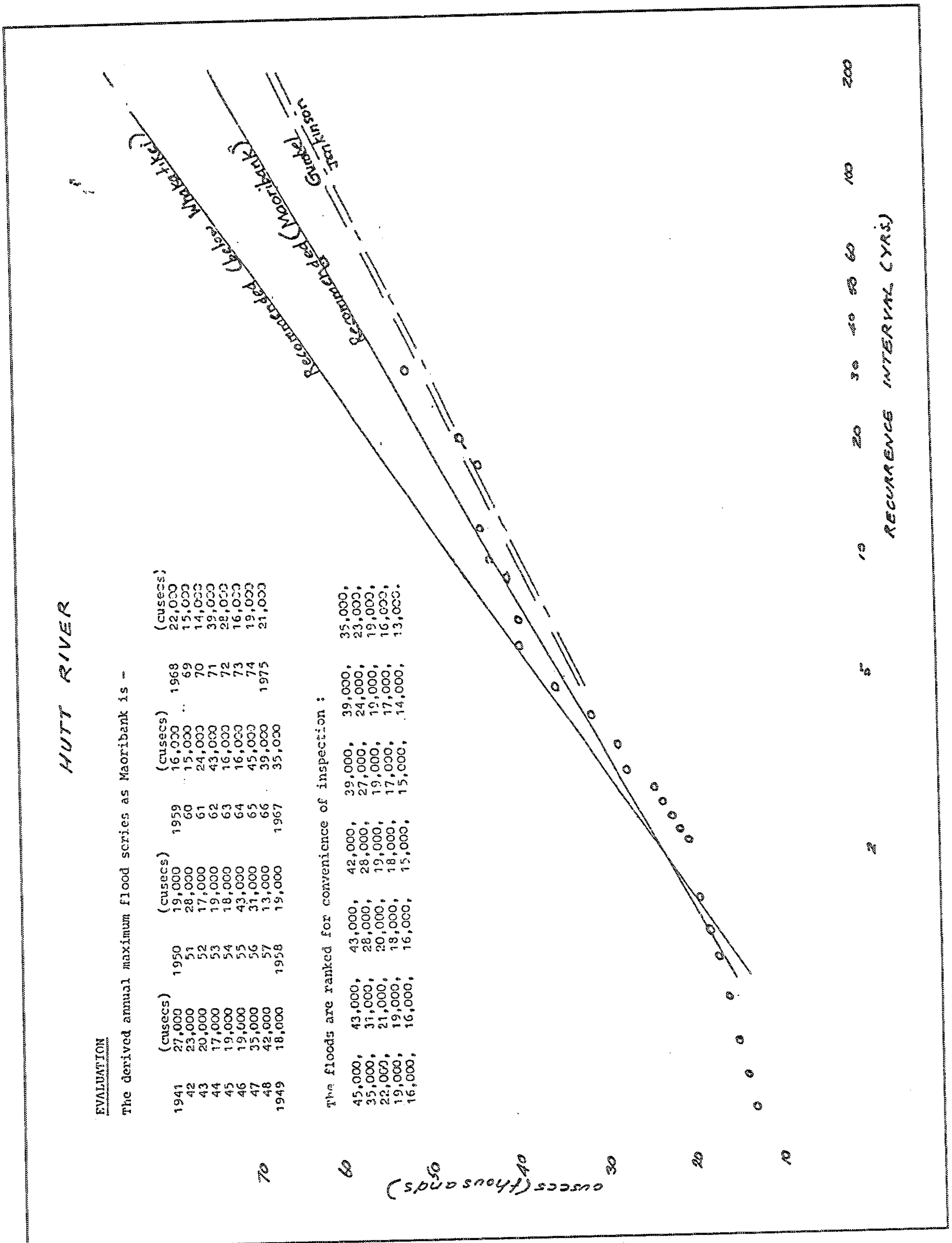

Figure 23:1976 WRWB Flood Frequency Relationship.

Flood Observations from 1924

(Abbreviations refer Archive Table 2, p. 7)

A36: 4 Aug 1926: SSPHRB6
Described as "high flood" by engineer, but "little damage".

A37: 11 Dec 1926: SSPHRB6
Flood; beam level of Mr George's suspension bridge (1180). Flooded main road and surrounding land at Silverstream Railway Bridge (1400-1600). Repair works included new boom groynes (29 piles, 67 booms), replacement of willow work, stone weirs.

A38: Jan 1928: SSPHRB6: 320
Flood levels: LHCC plan of Flood Gauge on new Hutt Bridge, to LHCC datum, recorded. Location of 3 others recorded.

A39: 3,6 May 1928: SSPHRB6
Fairly high floods of short duration. Flood of 3rd May highest for 12 months.

A40: 23 Aug 1928: SSPHRB6
5' rise Thursday and Friday previous. At Stellins (690) and Dickies (880) the position of the river to the west now established.

A41: 1-10 Nov 1928: SSPHRB6
"Big floods" - damage at Routleys (280), Burkes, Huses (1080), Giesens (840) with large volumes of shingle moved. Repairs required - 50 hardwood piles, 150 birch booms.

A42: 25 Aug 1929: SSPHRB6
"High flood" occurring during the previous week. Little damage.

A43: 7 or 8 Sep 1929: SSPHRB6
"Considerable flood",little damage.

A44: 27 Nov 1930: SSPHRB6
High flood of short duration. 9 feet at Ford Road bridge (Stokes Valley) (1180). Deck of Ford Road Bridge submerged. HRB pile driving punt broke free and badly damaged being set up on a groyne. The engine was lost (later found and reconditioned and installed on another second hand barge.) Highest flood since 1913.

A45: Feb 1931: SSPHRB6
A series of small floods that have risen and fallen quickly since the high flood of Nov. No significant damage.

A46: 3 Apr 1931: SSPHRB6&10
The peak occurred at 10pm Good Friday, 17 ft. at Lower Hutt, being 2 ft. higher than the 1915 flood. The river remained high for the following week and a moderate flood occurred on Saturday 11th.

The flood volume "considerably exceeded" the high flood of 1915, previously the highest flood since the inception of the HRB works. "The maximum flood is much in excess of that estimated when the protective works were designed some 30 years ago".

The flood severely taxed the control works which came close to failure in the Convent reach, left bank at the north end of Daly Street (400). The narrow berm was eroded through to the stopbank foundation and complete failure was apparently averted by the efforts of the entire HRB staff and others who worked through the night constructing a protective willow and wire mattress approx 5 ch. (100m) long. The concern was such that preparations were put in hand to ring the town bell and so order an evacuation of the town.

(To the compiler's knowledge the stopbanks have been under direct attack at only two other locations.

1. On the left bank south of Barbers Grove (140) (previously woollen scours and tannery) the stopbank foundation was severely scoured. This led to protective works and the closing off of Jorgenson's (130-160) and Chapman's (170-210) bends - the straightening of the river between the rail and Estuary bridges. The flood damage is undated but probably occurred during the 1913 or 1915 flood.
2. On the left bank south of Maoribank (2230-2260) in 1981. Other areas of severe lateral erosion occurred near MacLeod Street (1960-1970) and Ebdentown Road (2080-2120) prior to the construction of the Upper Hutt stopbanks, and between Taita and Boulcott (620-880), again prior to the construction of the stopbanks.

The damage from the 1931 flood is recorded:

1. Washout of the road at Taita Gorge (1130-1160).
2. Destruction of George's suspension bridge (Ford Road between Manor Park and Stokes Valley) (1180).
3. Washout behind Convent, Lower Hutt City (400).
4. Extensive shingle deposits and berm erosion at Manor Park Golf Course (1130-1290) and on Barnes farm (1030-1080) - now the Taita housing area.
5. Erosion of Kingdon's beach (380-410) railway siding - right bank present Melling Bridge area.
6. Destruction of a large number of boom groynes and willow and cable protection works but "less than expected"
7. In the upper reaches (of then HRB district - Silverstream to Avalon) "great quantities of shingle have been brought down". In the area north of the district - Upper Hutt Borough and Hutt County - there was "considerable damage by erosion and destruction of fences".

The Engineer reported:

1. Necessary to increase the height of the stopbanks from the Hutt Bridge to the estuary.
2. That the maximum flood volume had much increased as a result of forest denudation in the upper reaches.
3. The problem of bed aggrading as a result of moving shingle must be given careful consideration.
4. The dredging by shingle companies in the lower reaches had been of tremendous value. (different plants received damage of varying degree but some were able to go back into operation without much delay.)

The flood level at the northern end of the eastern stopbank (560) was 3 ft 2 in below the top of the stopbank. Residences on the flats near Haywards railway station were inundated. The terraces had never been flooded before and were considered above (maximum) flood level. On Manor Park Golf Course (1130-1290) approx. 18,000 c yds shingle were deposited.

There was a general call for the extension of the scheme to Maoribank.

There followed an engineering report for the raising of the stopbanks. Engineer's reports on SSPHRB10 include schedule of flood damages, Engineer's calculations for the flood discharge, x-sections at Hutt Bridge showing 1915 & 1931 flood levels. In summary;

Max volume approx 59,000 cusecs. Flood volume much above what the works were designed for. Considered highly probable that the max. discharge had "much increased" over the past 30 years. Margin from Hutt Bridge to Pipe Bridge not greater than 2'8" and in some places 18". Engineer also considered it might be necessary to raise small areas upstream of the Hutt Bridge.

Approx 20,000 cu. yds of material required to raise the stopbanks at cost of £3000. Sundry repair works £19O4, including £7OO behind Convent (400), £8OO for extra materials, remainder for wages, plant, etc.

A47: June 1931: SSPHRB6
"during the month there have been a series of floods - some of them high"

A48: Aug 1931: SSPHRB6
Series of floods. 6 feet rises on 12th and 18th. General satisfaction with the line of the channel - "closer to the ultimate alignment than it has ever been".

A49: 2 Oct 1931: SSPHRB6
Largest of a series of small floods in October.

Flood Observations from 1924

(Abbreviations, refer Archive Table 2, p. 7)

A50: 28,29 Aug 1932: SSPHRB6
Largest since Easter 1931.

A51: 21 Sep 1933: SSPHRB6
7 feet rise. Gradient steadily improving.

A52: 10 Jun 1935: SSPHRB6
11 feet rise at Taita Gorge and Hutt Bridge.

A53: 29 Oct 1935: SSPHRB6
Biggest for several years. Flooding across main highway at Silverstream (560-650), flooding of flats in upper reaches and beneficial silt deposits on Manor Park.

A54: 1936-1939: SSPHRB6
Floods recorded 1936-1939
2 Feb 36 13 feet rise
9 Feb 36 8 feet rise
3 Mar 36 10' rise
17 Jun 36 Described as fresh. Flooded Hutt golf links.
11 Aug 36 7' rise at Hutt golf links (560-650).
30 Aug 36 9' rise, short duration, flooded highway at Silverstream.
22 Dec 36 9' rises of short duration.
28 Dec 36
10 Jan 37
28 Jun 37 8'rise.
9 Sep 38 Highest since Dec/Jan 37
18 Sep 38
23 Jun 39 7.5' rise.
18 Aug 39 9' rise.

A55: 11 Dec 1939:
Generally regarded as the greatest flood on record.

> "River rising all day from morning and it increased rapidly from 5pm till 6.30pm bringing down much debris. From 6.30 pm till 4am on 12th Dec it fell about 1 foot and then fell fairly rapidly. High tide was about 5pm on 11th."

The flood was 1"9" higher at Mabey Road (740) and 3' higher at Hutt Bridge than the 1931 flood (59000 cusecs). 13" lower than 1915 flood (45550 cusecs).

Flood volume computed at 70000 cusecs (1980 cumecs).

Stopbank proved adequate although between the Hutt Bridge and Ava railway bridge the margin did not exceed 2' in places.

'Gradient' from the Railway Bridge to the estuary was considerably steeper in Dec 1939 than in 1931 even although 1931 at low tide and 1939 at high tide. This was put down to a substantial increase in the capacity of the channel. [Compilers Note: It may be that the heading required to drive the flood flows through the railway bridge constriction has been included in these calculations. The difference in gradient may have been due to choking of the bridge waterway.]

Engineer's report.
Calculation of flood volume based on measured gradient of 0.0017 between the Hutt Bridge and Railway Bridge. (Measured 5.82 ft. over 53 chains.) Taken n = 0.03, v = 13.33 ft/sec, Q = 70,209 cusecs

A56: 1940-1941: SSPHRB10
Recorded flood observations.
19 Apr 40 small fresh
27 Apr 40 medium fresh
23 May 40 4' rise
24 May 40 4' 6" rise
18 Oct 40 9' rise at Hutt Bridge - quick rise, short duration
25 Oct 40 7'6""
29 Oct 40 4""
21 Jan 41 9'rise
21 Aug 41 4'6" rise
7 Sep 41 5'6" rise

A57: 26 Sept 1941: SSPHRB6
Rapid rise from 12pm to 3pm, to peak at 10' 9" at 6pm and back to normal by 3am on 27th.

A58: 2 Oct 1941: SSPHRB6
Rise over 4am to 10pm to 10' above normal. Fell until 12pm on 4th to 2' above normal.

A59: 9 Oct 1941: SSPHRB6
Short duration rise began 3pm, to peak at 8.30 pm at 10' 6" above normal. Fell to 4' by 3am on the 10th. Rose to 6' 6" at 11am and fell to normal at 6am on the 11th.

Damage: a lot of planting done earlier in the season buried or destroyed. A large volume of timber washed down from the upper reaches. An area on the left bank around the Mabey Road/Taita (750-830) area eroded. Proposed stopbank position revised to prevent overflow.

A60: 1942-1947: SSPHRB6&10
Recorded flood observations.
20 Mar 42 5'above low tide
8 May 42 7'6"rise
25 May 42 6'rise
5 Jul 42 4'9"rise
13 Jul 42 8'3"rise
18 Jul 42 3'10"rise
22 Jul 42 3'9"rise
6 Feb 43 3'2"rise
7 Feb 43 2'rise
11 Feb 43 3'3"rise
16 Feb 43 7'6"rise
19 Jun 43 4'6"rise
5 Sep 43 7'rise
8 Sep 43 3'rise
19 Sep 43 3'6"rise
20 Sep 43 3'3"rise
25 Sep 43 3'9"rise
7 Apr 44 4'rise
5 Aug 45 4'6'rise
4 Feb 46 7'3"rise
9 May 46 5'9"rise
13 Aug 46 7'3'rise
15 Feb 47 8'9"rise

A61: 24&28 June 1947: SSPHRB10
24 Jun 4710'3"rise
28 Jun 478'2"rise
From Engineer's monthly report;
Began to rise 5am on 24th June, to peak at 2pm. Dropped to 2' at 3am on Wed 25th and remained about 2'-4' up until 5pm on 27th.
Began to rise 12.30am on 28th, by 8am 6' above normal for 12 hours.
Damage: severe erosion in places including slumping of berm below stopbank behind Convent (400).

From Engineer's flood report;
Discharge of 37,200 cusecs based on the level at the recorder house and the gradient to Daly Street, 28.2 chains upstream. Gauge at 51.62 ft.

Repair Work Required: a very large volume of shingle moved by bulldozer in the reach from the Native Land (850) to Mabey Road (740). Substantial willow, cable and gabion work required from Bognuda's (250) to the Belmont Extension (810).

A62: 17 Oct 1947: SSPHRB32&10
9'6" rise.
New right channel in the Belmont reach proved effective and silt deposits built up to the height of the new weir. (Compiler's note: weir probably across the old channel along the eastern bank).

Archive Table 18: Flood Observations from 1924

Flood Observations from 1924

(Abbreviations, refer Archive Table 2, p. 7)

A63: 23 May 1948: SSPHRB10
Only two floods of greater volume have occurred in the last 48 years. Discharge of 46,800 cusecs estimated as for June 1947 flood.

> "reached peak at 8 am on Monday 23rd May 11' 6" above normal. Dropped 6' by 8pm on the same day. Volume estimated at 46,800 cusecs.....Volume about 10,000 cusecs greater than flood of June '47.....At the lowest point on the provisional stopbank at the Taita Housing Block (850) the freeboard was 3'6".....The diversion cut (500-540) opposite Certified (Concrete Ltd) upstream of Melling Bridge developed well .... Somewhat greater volume than the flood of 1915, which reached the greatest height of any flood in the last 48 years. However the 23 May 1948 flood was five feet lower than the 1915 flood."

Immediate repairs; block groynes at Mabey Road (760-800) - built of concrete-and-brick blocks used for war-time protection of petrol tanks.[Note: flood of 37,000 cusecs in June 1947 caused large expenditure. Flood of June 1948 did not require similar expenditure.]

A64: 26 Oct 1951: SSPHRB32&10
Flood: 9' rise, volume 32,200 cusecs, based on area at gauge house and velocity of 9.5 ft/sec. No change in channel conditions.

A65: 1952-1953: SSPHRB 32
Undated rating curve for Ewen Bridge - date and derivation unknown. A record of floods in the period 4/7/41 to 7/10/52 and for the period 7/10/52 to 17/5/72 filed. Flood Frequency and Rating Curves recorded for Ewen Bridge (330), based on 10 year period 1941-51. Hydrograph from Maoribank Recorder (2270) for flood of 7-10 Nov 1952. Rating Curve for Maoribank Gauging Station filed.

Flood gradient of 0.0017 from Ava Railway Bridge, obtained from earlier floods, brought up in discussions on improvements to Black Creek (200-210) outlet.

A66: 21 Jul 1954: SSPHRB32
Flood discharge calculation of 27,200 cusecs, based on n = 0.03, v = 8.5 ft/sec, area at gauge 3200 sq. ft.

A67: 17-21 Feb 1955: SSPHP'332
Hydrograph record from Maoribank Gauging Station (2270). Peak discharge of approx. 45,000 cusecs on 20/2/55. Also recorded is a hydrograph for "weir" (probably Kaitoke).

A68: 1955-1958: SSPHRB32
Recorded flood observations.

6 May 55 a rise of 4' in one hour.
19 July 56 9' to 10' rise. Discharge estimated 26,000 cusecs.
26-27 Nov 1957 7'6" rise. Estimated discharge 14,000 cusecs
14 Mar 58 9'3" rise at Maoribank (2270). Estimated discharge 19,000 cusecs.
12 May 58 9'11" rise at Maoribank. Estimated discharge 18,500 cusecs.

A69: 28 May 1958: SSPHRB32
1931 and subsequent flood levels at the Melling Substation (520) recorded. 1931 flood - 104.75 ft. 1939 flood - 103.37 ft. (ground level 101.0 ft.)

A70: 13 Jan 1962: SSPHRB32
Flood: 14' rise at Ewen Bridge.
Approximately the same discharge as occurred on the 23rd May 1948 and 20th February 1955, 47,000 cusecs.

Damage: From the Taita Housing Estate (900) to Melling (450), large volumes of shingle moved; many chains of protective willow and cable bank protection destroyed. McLeod Street Area (1960) - severe attack downstream of protective works constructed in 1955. Hudson Avenue Area (2070) - severe attack downstream of protective works constructed in 1955. Maoribank (2270) to Clouston Park (2170) - severe attack on right bank caused loss of 1/2 chain of bank over several chains. On the opposite bank downstream of Clouston Park Road 7 chains of bank subjected to attack (2130-2160).

Properties Flooded.

Upper Hutt: 2 houses in Clouston Park Road (2180), 1 house in Willow Grove (2040), a butchers shop in McLeod Street (1960). Also recorded that in the 1955 flood approximately 17 houses in the vicinity of Longfellow, Tennyson and Cottle Streets (1760-1840) were flooded above floor level. Since 1955 there had been some channel widening at the bottle neck above the Moonshine Bridge and behind Newton Street (now Poet's Park 1780-1840).

Haywards Settlement (1160): At least one house flooded.

Lower Hutt: One house flooded at Whites Line (220) due to banking up of water from the Okoutu Stream.

Rough estimate of the total cost of damage £14,000.

A72: 7 Nov 1965: SSPHRB32
Largest since December 1939. Duration about the same as in 1939. River 13 ft. or more above normal for 10 hours.

Engineer's Report and Description of Damage:

> "Discharge 50,000 cusecs... Many chains of willow bank protection destroyed... Erosion at the left bank, Upper Hutt, where a deep channel developed... This channel filled by machines and the right bank beach lowered...Weir built on left bank at Maoribank...Erosion to north abutment of bridge repaired with netted crates...Erosion in old channel near access to Mr Price's property...Further erosion could have undermined the stopbank - has since been backfilled... "Concrete block protection" of the new Western Hutt Road stood up well, although on a 3:1 batter....Flood debris was cleared from the Silverstream, Pomare, Melling and Ewen Bridges...Opposite the Car Park (Lower Hutt) a length of willow protection was destroyed and 10-15 ft. of berm eroded. 21 concrete blocks of 5 ton each subsequently placed...At Strand Park, sand up to 12" deep deposited...At Sladden Park, sand up to 2'6" deep deposited.

In Upper Hutt 5 houses flooded at the corner of Shakespeare Ave and Moonshine Road. The kindergarten in Thackeray St (1780) flooded.

In Lower Hutt several houses flooded due to ponding in the Okoutu Stream during floodgate closure.

A71: 26 Apr 1966: SSPHRB32
Flood: levels at Upper Hutt Borough

3.50 a.m. 12'4"
4.30 a.m. 13'2"
5.40 a.m. 14'0"
6.10 a.m. 14'1"
6.30 a.m. 13'6"

Pakuratahi running higher than in 1962.

A73: 17 Aug 1971: HRB GENERAL
Kaitoke rainfall138.3mm in 24 hrs to 8am
Wainui rainfall220.4mm on 16/8/71
73.5mm on 17/8/71 (total 220mm)

A74: 5 Oct 1971: SSPHRB32
Record of flood Hydrograph.

A75: 14 May 1972:
Record of flood Hydrograph.

A76: 16 June 1975: WRWB 8/7
Photographs on file showing flooding at Silverstream and Maoribank.

A77: Nov 1975: WRWB 8/7
Flood photographs filed at this date showing parts of the Hutt River in the Feb. 1955 flood of 47,000 cusecs.

A78: 26 Aug 1976: WRWB 8/7
Flood Frequency Report revising 100 year return period flood, C S Hovey, Design Engineer. Reported to and accepted by MWD.