3. INSTRUMENTATION OF CATCHMENTS

The location of instruments to measure meteorological conditions and streamflow in the Experimental Area is shown in Figure 2.2. The equipment is discussed more fully in the following sections.

3.1 Meteorological Conditions

Details of the rain gauge network are given in Table 3.1. The Mort pluviometer and two 203mm rain gauges were commissioned at the Lower Meteorological Station in August 1963. A network of 203 mm rain gauges for the measurement of catchment rainfall, and a second Mort pluviometer, were then commissioned in 1966. This second pluviometer was installed at site 7. It is believed that this site was intended to act as an Upper Meteorological Station, but to date only rainfall recorders have been installed at this site. In 1976, Lambrecht pluviographs were installed at the Meteorological Station and at site 7. The Mort pluviometers have since been retained in operation as a reserve. Three additional 203mm rain gauges were installed in May 1978, and a further two in July 1981, to improve the measurement of catchment rainfall.

The 203mm rain gauges on the traverse of catchment 3 (site numbers 9-13) are mounted on top of masts (20-40m high) and are above canopy level. The exposure of the Reefton Meteorological Station is 2.5:1 relative to the canopy; the value for station 7 is 2:1. The other 203mm gauges in the network are near ground level in clearings with exposures of 1:1.

The Reefton Meteorological Station is situated in the general service area below and due west of catchment 3. The Station is at an elevation of 448m. The instrumentation at this Station is listed in Table 3.2.

All rain gauges are read weekly. The Mort pluviometer chart is changed weekly; the Lambrecht pluviograph chart is changed monthly. Hourly readings are then extracted manually from the more accurate chart. These readings are then adjusted so that the total volume for the week equals the value from the storage gauges. Daily rainfall figures are then stored on a HP 9845B computer.

Table 3.1 - Details of rain gauge network

Site No.	Station	Gauge Type	Gauge height above ground (m)	Start of record	Elevation(m)
1	Reefton Meteorological Station	Mort Lambrecht	1.3 1.2	7.8.63 25.8.76	448
2		B.G. B.G	0.10 0.18	28.8.63 28.8.63	
3		B.G.	0.23	25.5.78	640
4		B.G.	0.22	8.5.78	759
5		B.G.	0.22	19.12.66	628
6		B.G.	0.33	12.12.66	663

Site No.	Station	Gauge Type	Gauge height above ground (m)	Start of record	Elevation(m)
7		Mort Lambrecht B.G.	1.8 1.2 0.34	8.7.66 20.10.76 19.12.66	780
8		B.G.	0.27	15.5.78	686
9		B.G. Trough	22.1 0.1	10.10.66 30.10.67	609
10		B.G. Trough	40.3 0.1	10.10.66 30.10.67	589
11	Traverse	B.G. Trough	18.9 0.1	10.10.66 30.10.67	510
12		B.G. Trough	28.8 0.1	10.10.66 30.10.67	608
13		B.G. Trough	25.6 0.1	10.10.66 30.10.67	689
14	Dugout	B.G.	Not available	17.10.66 (ended 19.12.66)	830
31		B.G.	0.23	29.7.81	700
32		B.G.	0.26	15.7.81	692

B.G. - 203 mm diameter rain gauge

Table 3.2 - Meteorological instrumentation at Reefton Meteorological Station

Equipment	**Date of start**
Mort pluviometer	7.8.63
Lambrecht pluviograph	25.8.76
Australian sunken evaporation tank	28.8.63
Maximum thermometer (mercury in glass) Minimum thermometer (alcohol in glass) Wet/dry thermometer Lambrecht thermohygrograph	7.8.63
Munro Cup Counter Anemometer (removed 1981) Lambrecht wind speed/direction	18.4.66 13.1.77

3.2 Streamflow

The weirs for the six catchments are in three pairs (Figure 2.2). The design and construction of all the weirs are similar (Figure 3.1). The present weir plate configuration can be described as compound plate. The original plate configuration (Figure 3.2) was found to be inaccurate at low flows, and a 15cm high 90o V-notch was fitted to the first stage of the weir plates in mid-1967 (Figure 3.3).

Weir pond dimensions are 15.2 x 7.6 x 1.8m. The base of stage 1 is approximately 0.56 m above the weir floor. The weirs were constructed under contract. The weir pond is downstream of the cutoff wall. A stilling chamber is situated halfway along the weir wall. This is connected by a 5cm diameter pipe to a float chamber under the recorder housing. The recorder housing is discreetly positioned between the weirs. Leopold and Stevens Type 2A35 recorders, one for each pair of weirs, measure depth of water in the weir. Early in 1978, Leopold and Steven Type A71 recorders were installed over the stilling chambers in weirs 2-6. An A71 recorder was installed on weir 1 in March 1981.

The weirs are calibrated by establishing the relationship between depth of water in the weir pond and discharge over the weir plates. The Reef ton weirs have been calibrated using a combination of drum measurements in stage 1, a type-H flume in tandem with the weir for stages 1-3, and a theoretical relationship for all weir stages (Papworth 1979). The relations are shown in Figure 3.4. Weirs and recorders are checked at weekly intervals.

As noted earlier, each weir is fitted with two runoff recorders. Both recorders have been operating simultaneously to ensure a complete record. All charts are changed at six-monthly intervals. These charts are edited, and the record with less stoppages or irregularities is selected for tracing. The chart is processed on the MMBW digital trace analyser, which transforms chart heights into a series of water depths, and stores them on magnetic tape. This magnetic tape is read into the CSIRO CSIRONET system in Canberra. The data are corrected as necessary and analysed to produce dayflow figures.

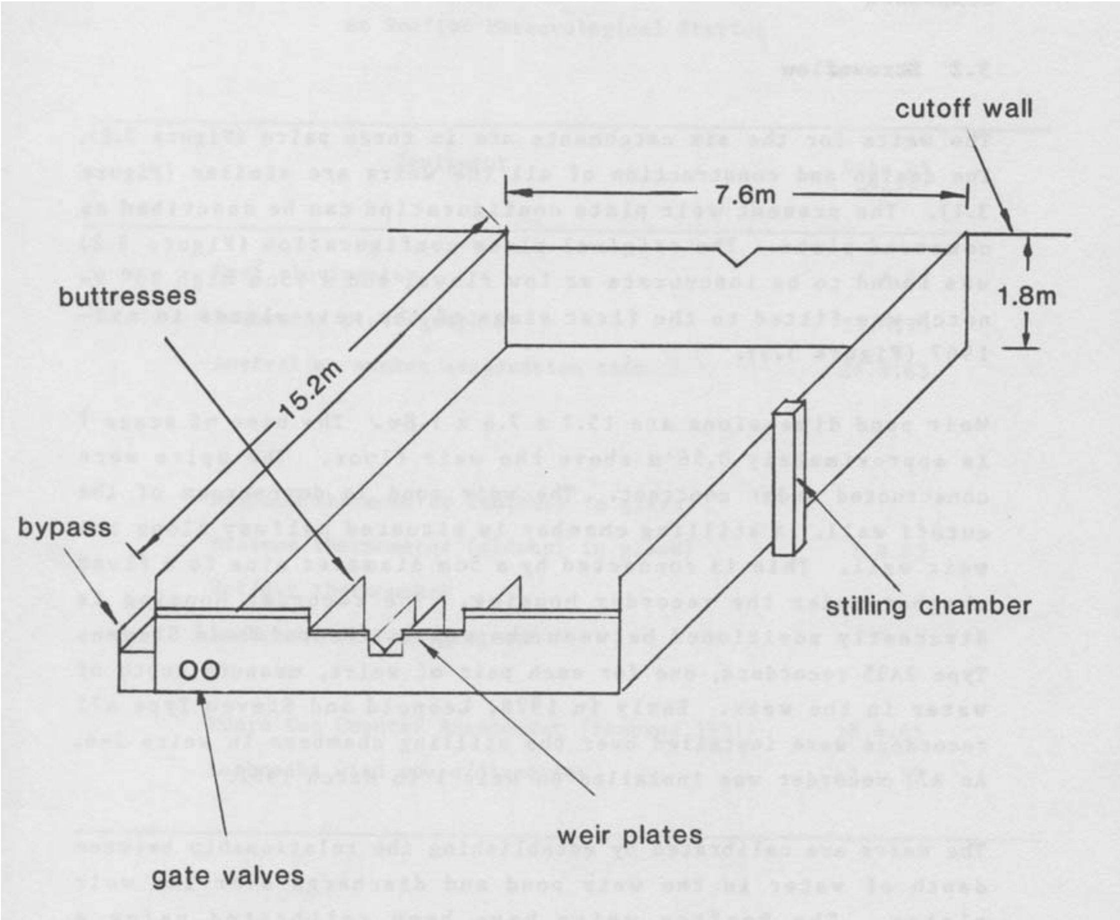

Figure 3.1 - Schematic diagram of a Reefton weir pond

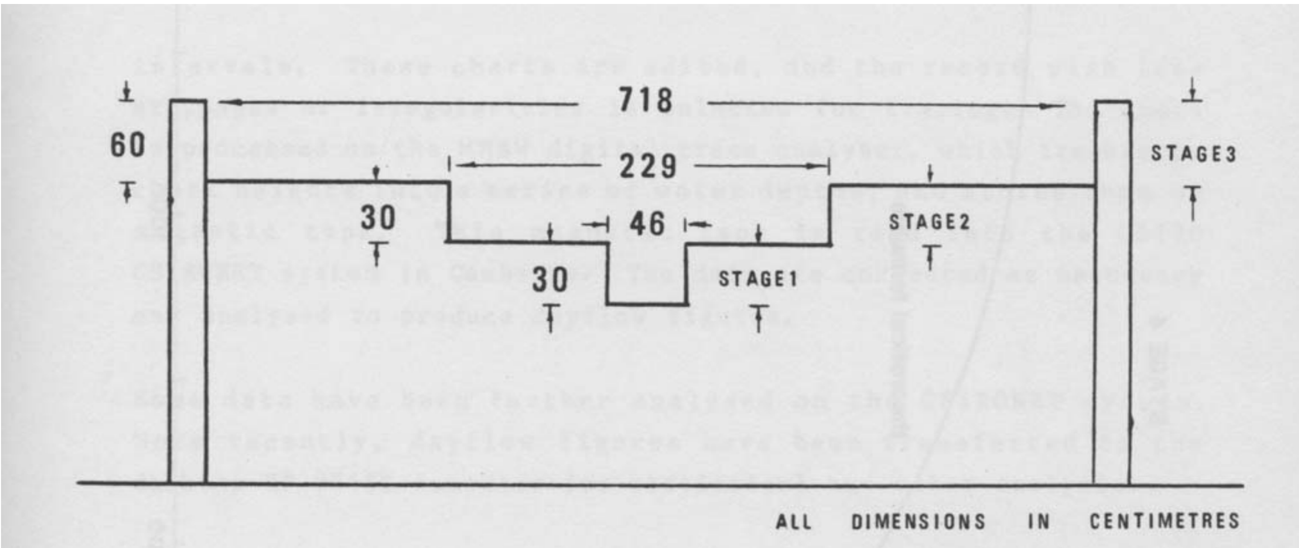

Figure 3.2 - original weir plate configuration

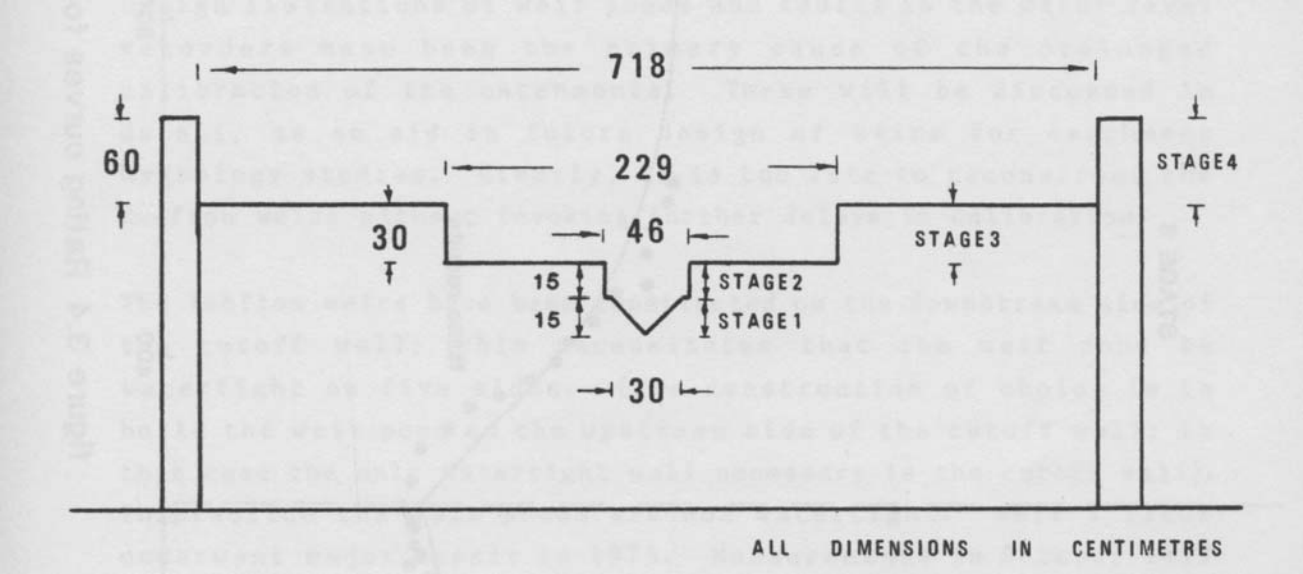

Figure 3.3 - Present weir plate configuration

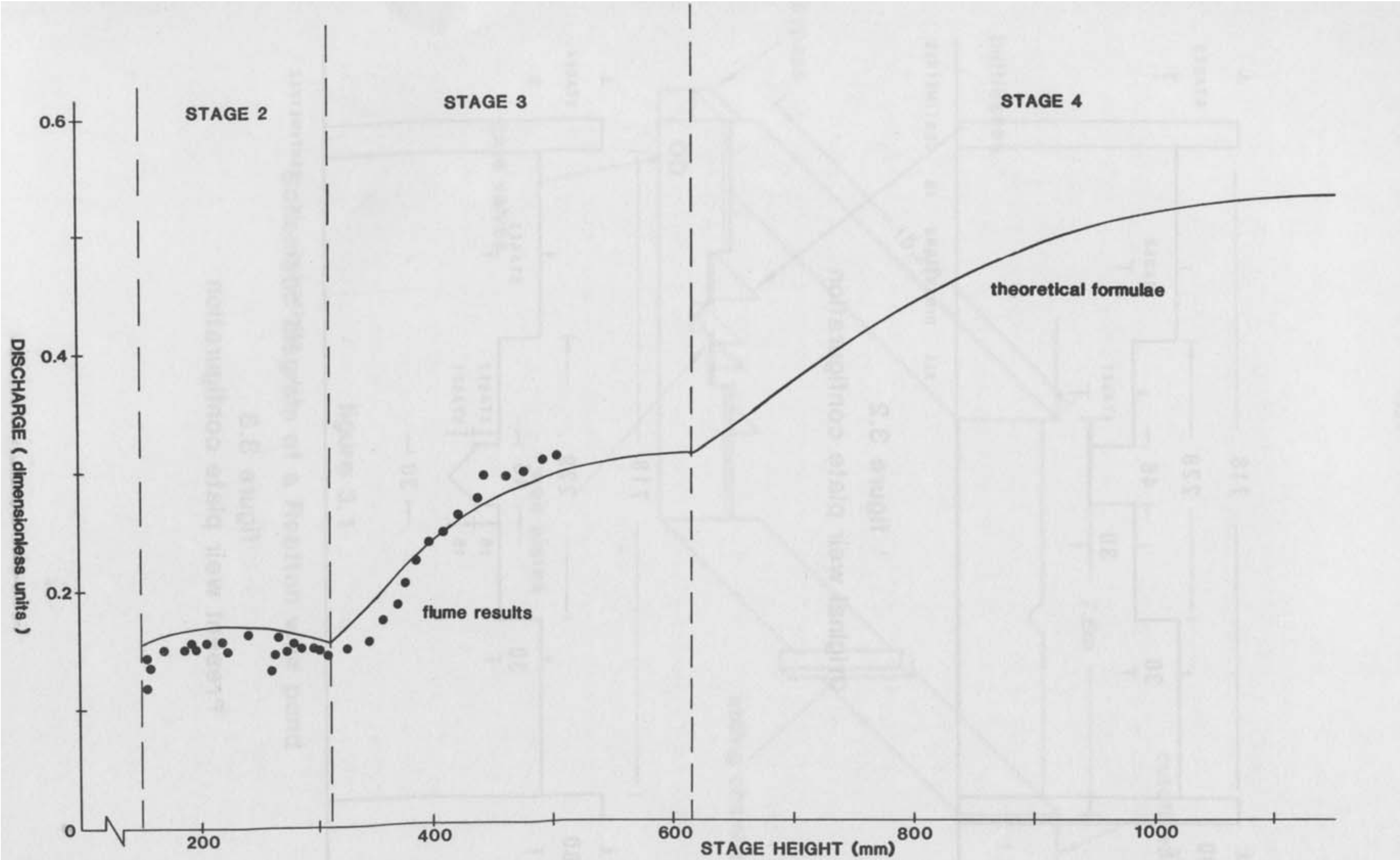

Figure 3.4 Rating curves for Reefton weirs

Some data have been further analysed on the CSIRONET system. More recently, dayflow figures have been transferred to the desktop HP 9845B computer for statistical and other analysis.

Missing data are estimated by comparison with adjacent weirs. If the fault is clock stoppage the maximum and minimum stage heights have been recorded on the chart; the shape of the hydrograph is determined by interpolation. All data are plotted on a logarithmic-linear scale to compress the runoff data and facilitate comparison. An example is shown in Figure 3.5.

Design limitations of weir ponds and faults in the water level recorders have been the primary cause of the prolonged calibration of the catchments. These will be discussed in detail, as an aid in future design of weirs for catchment hydrology studies. Clearly, it is too late to reconstruct the Reefton weirs without invoking further delays in calibration.

The Reefton weirs have been constructed on the downstream side of the cutoff wall; this necessitates that the weir pond be watertight on five sides. (The construction of choice is to build the weir pond on the upstream side of the cutoff wall; in this case the only watertight wall necessary is the cutoff wall). In practice the weir ponds are not watertight. Weir 1 floor underwent major repair in 1975. Measurements in October 1977 following cleaning of all weirs in January 1977 indicated that leakage for weirs 1 to 5 was less than 0.1 ls-1 (Papworth, unpublished data).

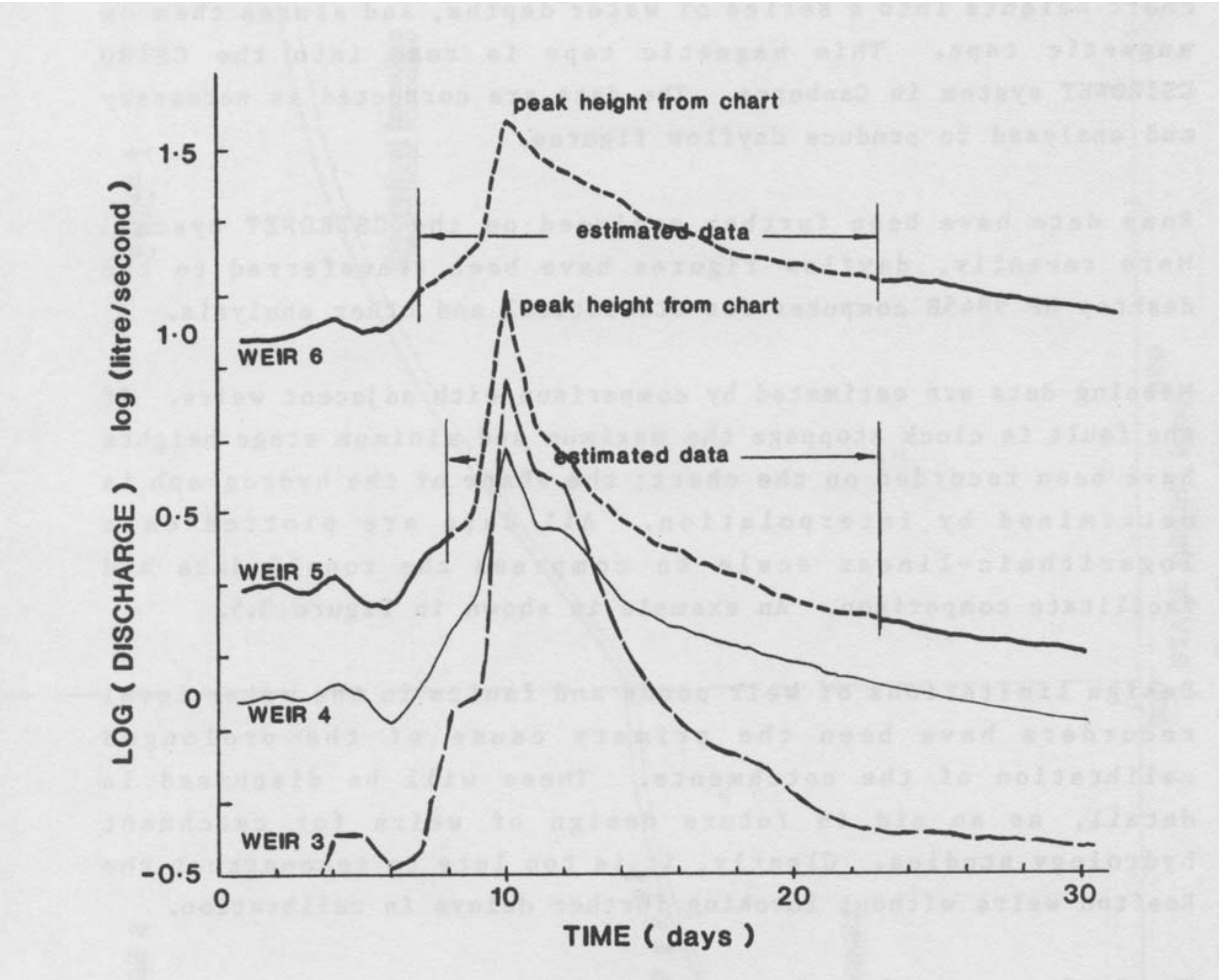

Figure 3.5 - Repair of no streamflow record by logarithmic plot

Catchment hydrology studies require all flows to be measured with maximum accuracy and with high sensitivity. Thus, 90° V-plates (or similar) are desirable for maximum sensitivity to low flows. If a change in shape of weir plates is necessary for higher flows, then a gradual transition is advised.

The compound weir plates at Reefton do not meet the above criteria. Although flows up to the top of stage 1 (Figure 3.3) are measured with good accuracy, there is a sudden drop in sensitivity for stage 2 flows and higher. In addition, the sharp discontinuities in width between stages introduce uncertainties into the weir rating tables.

For these reasons, the recommended weir plate configuration for catchments similar to Reefton are 90° V-plates or similar, of size suited to the flows involved.

Faults in the water level recorders were also experienced in the early years of the study. As noted earlier, the weir ponds are grouped in pairs. Consequently, the stilling wells and the recorder housing were set up to record water levels from two adjacent weirs on the single chart of a 2A35 recorder. There have been long periods of clock stoppage and/or chart overrunning with loss of data from two weirs. Additional faults have been blockage of the pipes from the stilling well to the recorder housing, and jamming of the two recorder pens against each other where the two traces should have crossed.

These problems have been alleviated to some extent by:

(i) running the 2A35 recorders at a slower speed (change to 12.2 cm day-1 was made in 1968);
(ii) a more rigorous checking and maintenance program;
(iii) installation of Leopold and Stevens A71 recorders in 1978.

Figure 3.6 shows the total number of days of no streamflow record for all weirs. Missing data from January 1971 onwards have been estimated as described earlier. Despite the long periods of missing records, repair of some data in the period 1963 to 1970 is possible to complete months. This will be undertaken at a later date. Operation of the 2A35 recorders is shown in greater detail in Figure 3.7 for the period 1963 to 1970, and in Figure 3.8 for 1971 to 1980 inclusive.

3.3 Water Quality and Bedload

As noted earlier, one of the objectives of the study in the Reefton Experimental Area is to examine the effects of various forest activities on water quality. To this end, grab samples have been collected at weekly intervals between 1964 and 1975. Sampling points are located a short distance above each weir. Streamwater samples have been transported at ambient temperature to the FCV laboratory and stored, also at ambient temperature, for varying periods prior to analysis. Analyses have been generally completed within one month of sample collection. Samples have been analysed for the physical parameters, turbidity, colour, electrical conductivity, suspended soils and pH using standard methods (APHA 1976). From 1976 to December, 1980, sampling has been undertaken monthly with determinations of suspended solids and colour being replaced by analyses for individual cations (sodium, potassium, calcium and magnesium) and anions (chloride, sulphate, bicarbonate). Weekly sampling recommenced in November 1981; samples are analysed for the five physical parameters noted above. Geary (1982) has undertaken a detailed examination of the water quality data; his results are presented in Section 4.3.

Bedload data for the Reefton catchments have been studied to establish a baseline before treatments are imposed. Accumulated sediment in each weir pond (bedload) has been measured annually for several years. Measurements are made in January (defined as end of sediment year) when there is generally no flow through weir ponds 1 and 3 and a minimal flow through weir pond 2.

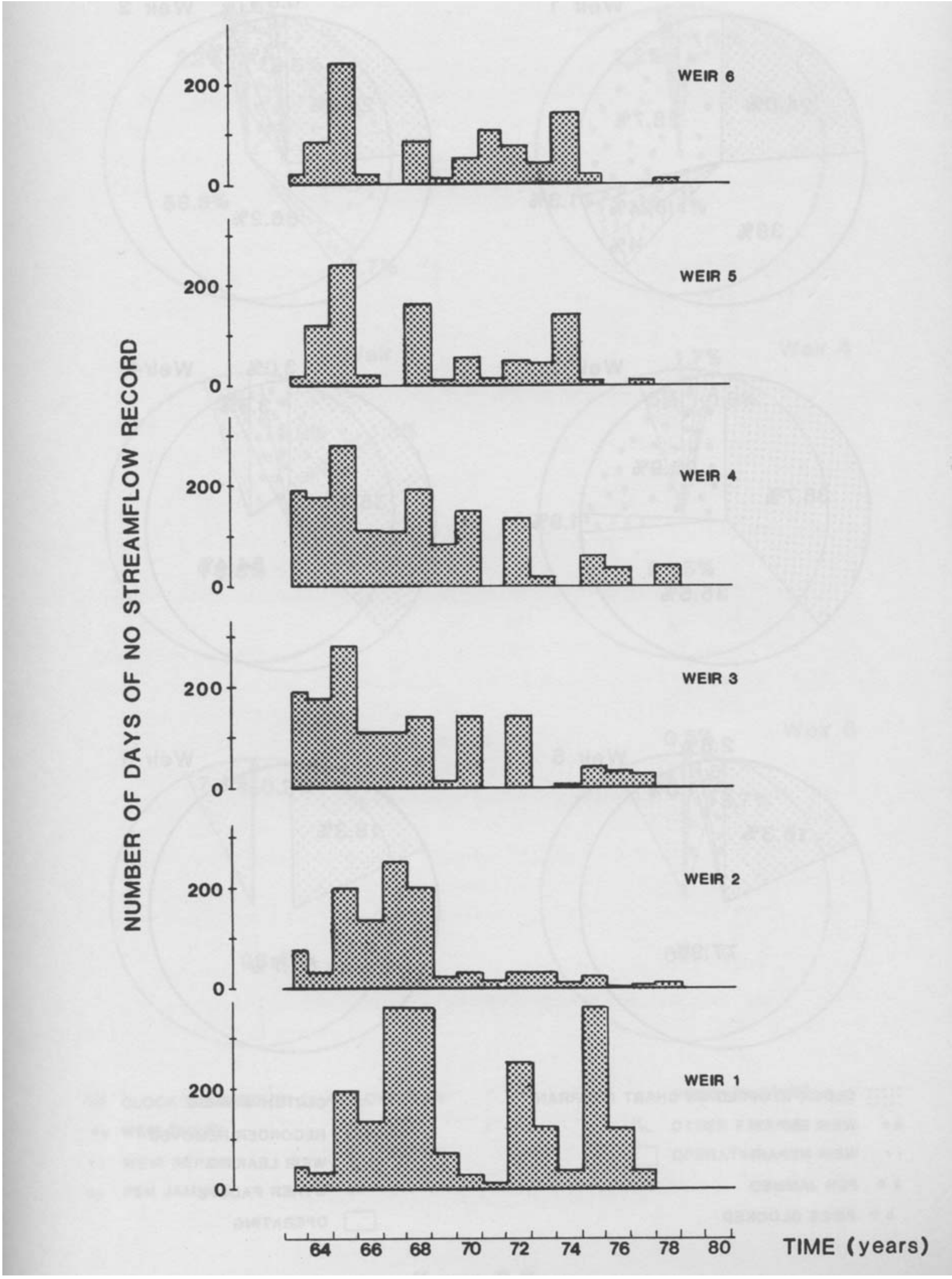

Figure 3.6 - Number of days of no streamflow record

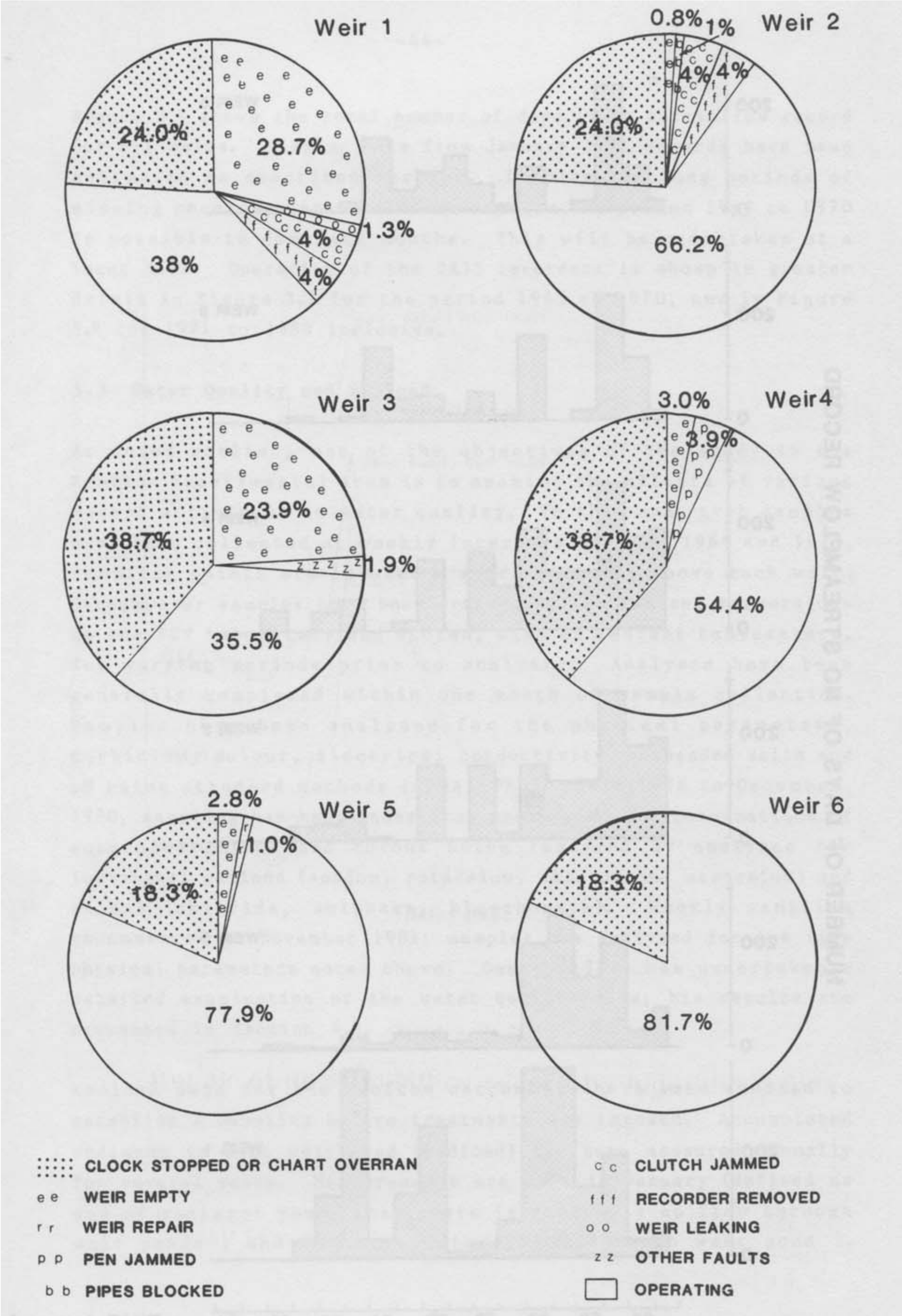

Figure 3.7 - 2A35 recorder operation 1963-1970

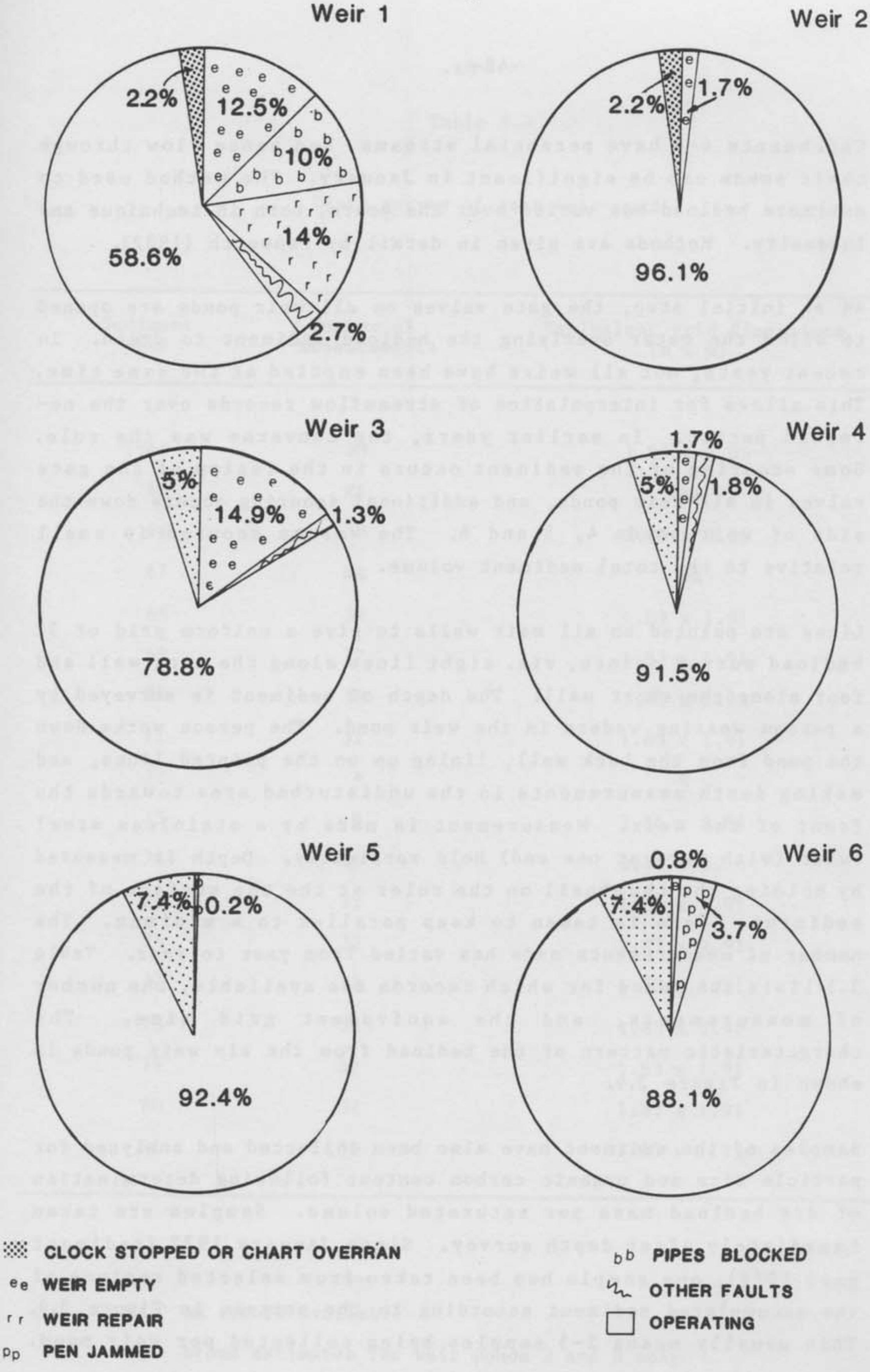

Figure 3.8 - 2A35 recorder operation 1971-1980

Catchments 4-6 have perennial streams, and hence flow through their ponds can be significant in January. The method used to estimate bedload has varied over the years, both in technique and intensity. Methods are given in detail by Papworth (1982).

As an initial step, the gate valves on all weir ponds are opened to allow the water overlying the bedload sediment to drain. In recent years, not all weirs have been emptied at the same time. This allows for interpolation of streamflow records over the no-record period. In earlier years, the converse was the rule. Some scouring of the sediment occurs in the region of the gate valves in all weir ponds, and additional scouring occurs down the side of weir ponds 4, 5 and 6. The volume scoured is small relative to the total sediment volume.

Lines are painted on all weir walls to give a uniform grid of 32 bedload survey points, viz. eight lines along the long wall and four along the short wall. The depth of sediment is surveyed by a person wearing waders in the weir pond. The person works down the pond from the back wall, lining up on the painted lines, and making depth measurements in the undisturbed area towards the front of the weir. Measurement is made by a stainless steel ruler (with zero at one end) held vertically. Depth is measured by holding the thumbnail on the ruler at the top surface of the sediment. Care is taken to keep parallax to a minimum. The number of measurements made has varied from year to year. Table 3.3 lists the years for which records are available, the number of measurements, and the equivalent grid size. The characteristic pattern of the bedload from the six weir ponds is shown in Figure 3.9.

Samples of the sediment have also been collected and analysed for particle size and organic carbon content following determination of dry bedload mass per saturated volume. Samples are taken immediately after depth survey. Since January 1977 (sediment year 1976), one sample has been taken from selected regions of the accumulated sediment according to the pattern in Figure 3.9. This usually means 2-3 samples being collected per weir pond.

Table 3.3 - Depth survey of each weir pond

Sediment year	Number of measurements	Equivalent grid dimensions (m x m)
1964	20	1.83 x 3.05
65	NA	NA
66	30	1.83 x 3.05
67	NA	NA
68	32	1.83 x 1.91
69	32	1.83 x 1.91
70	32	1.83 x 1.91
71	32	1.83 x 1.91
72	*	*
73	8	3.66 x 3.81
74	21	2.44 x 2.18
75	32	1.83 x 1.91
76	32	1.83 x 1.91
77	32	1.83 x 1.91
78	32	1.83 x 1.91
79	32	1.83 x 1.91
80	32	1.83 x 1.91
81	32	1.83 x 1.91

NA no record available
* broad estimates for weir ponds 2 and 3 only

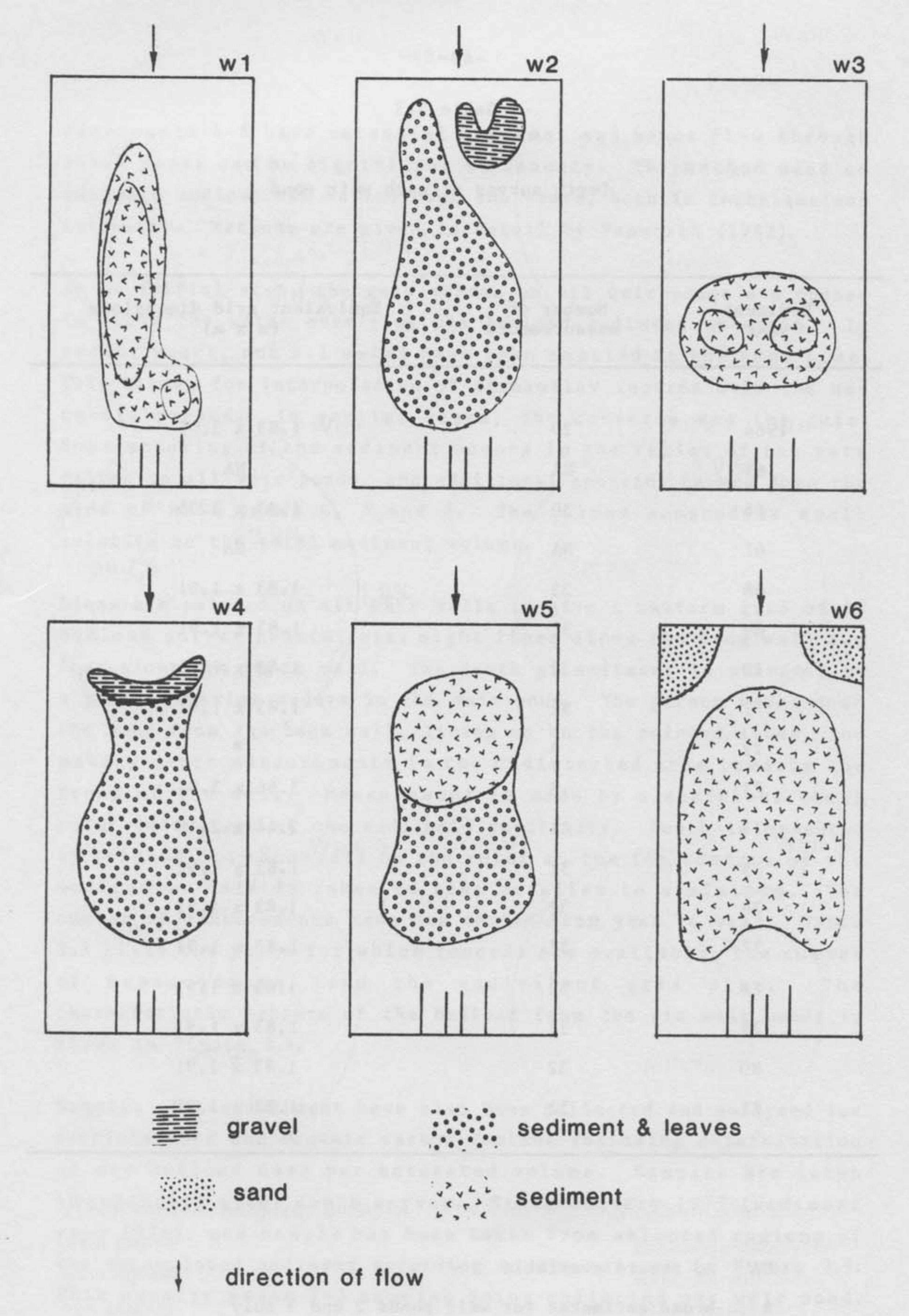

Figure 3.9 - General pattern of bedload in weir pond

However, the number of samples taken has varied markedly from year to year (Table 3.4). A sample of sediment is obtained by taking a scoop with a rectangular plastic container (dimensions 180 x 65 cm). Care is taken to ensure that the container scrapes the bottom of the weir pond.

The analytical method in current use enables quantity of material exported from the catchments to be calculated. The method used is outlined in the flow chart in Figure 3.10. In the early years of the study, laboratory analyses have been made of percentage of coarse (> 2mm) and fine (< 2mm) fractions, and of loss on ignition to determine organic carbon content. The determination of 'density', i.e. dry mass per saturated volume, is necessary to give the mass of dry material. Measurement of loss on ignition gives the percentage of inorganic material in the bedload. Particle size analysis gives percentages of clay, silt, fine sand and coarse sand in the bedload.

In some weir ponds, gravel is a significant component of the bedload (usually weir 2 and sometimes weir 4). Each gravel sample is separated into a coarse (> 2 mm) and a fine (< 2mm) fraction by hand sieve. The fine fraction is analysed according to the flow chart, but without any grinding. The mass of the coarse fraction is determined gravimetrically, and its volume by displacement of water in a graduated cylinder. The results of these fractions are recorded separately.

Ignition of the bedload sample removes the water of crystallization attached to some clay particles. Therefore the results presented in Section 4.4 are underestimates. However, the use of a muffle furnace is a simple technique and gives reproducible results if used throughout a series of measurements. Five years of bedload samples have been studied using the current analytical method.

Table 3.4 - Number of bedload samples collected for analysis

Sediment year	**Weir pond**					
	1	**2**	**3**	**4**	**5**	**6**
1964*	3	3	NA	3	3	3
65	3	3	3	3	3	3
66	3	3	3	3	3	3
67	NA	NA	NA	NA	NA	NA
68	NA	NA	NA	NA	NA	NA
69	NA	32	32	32	32	32
70	32	32	32	32	31	31
71	10	NA	27	32	32	26
72	NA	NA	NA	NA	NA	NA
73	NA	NA	NA	NA	NA	NA
74	NA	NA	NA	NA	NA	NA
75	WR	NA	NA	NA	NA	NA
76	0	4	4	4	4	4

Sediment year	**Weir pond**					
	1	**2**	**3**	**4**	**5**	**6**
77	5	6	6	8	5	4
78	2	5	4	5	6	5
79	2	3	2	3	2	3
80	2	3	2	2	2	3
81	2	4	2	2	2	5

* composite samples taken across weir WR weir pond under repair
NA no record available

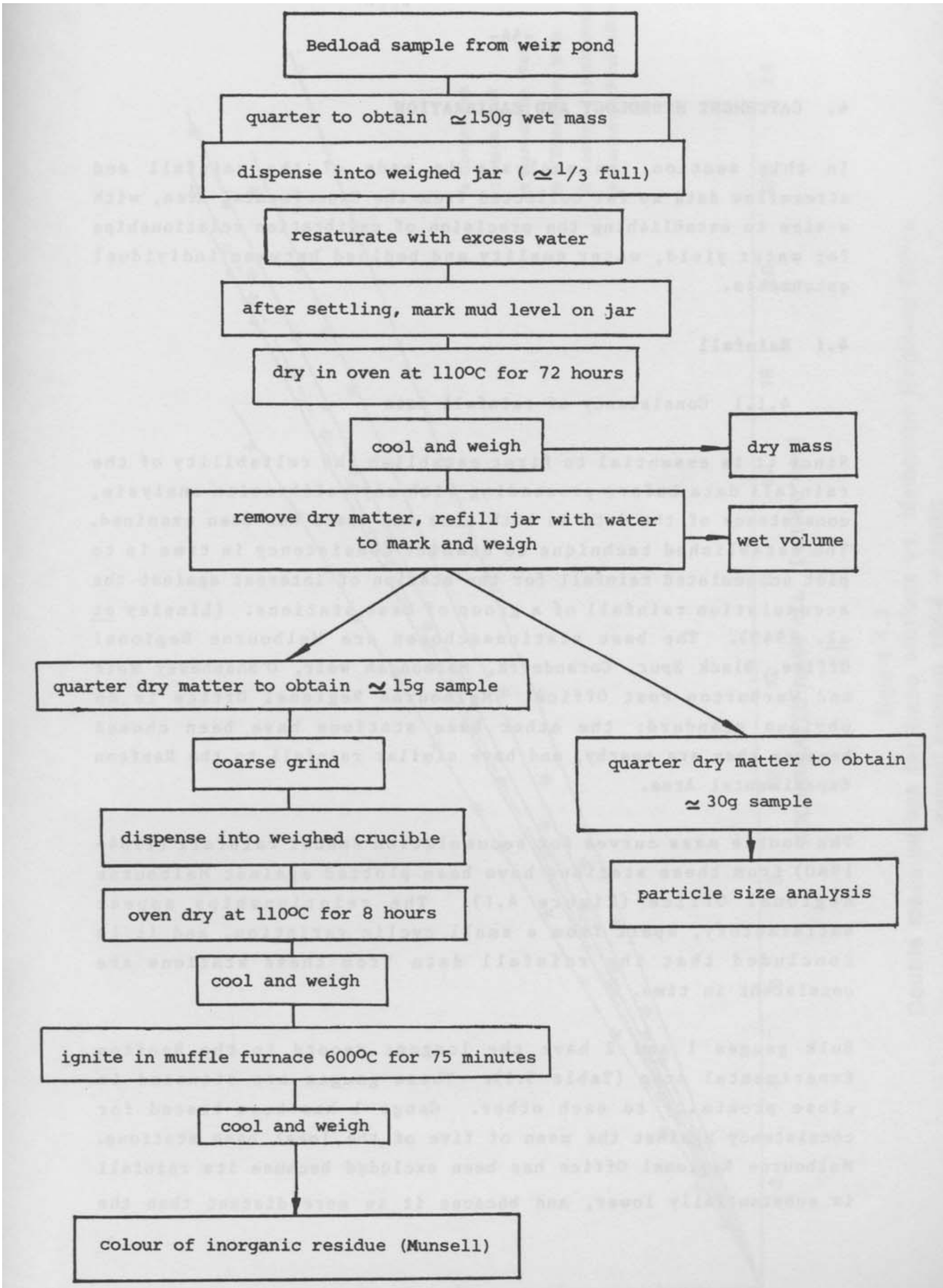

Figure 3.10 - Flow chart of laboratory analysis of bedload