THE DETERMINATION OF STORM AVERAGE LOSS RATES FOR RODING RIVER REGIONAL CATCHMENT, NELSON.

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INTRODUCTION

The Nelson Catchment District, comprising some 2,800 square miles, is situated at the north western corner of the South Island. The area has been divided into six main hydrological regions. The aims and bases of this are to be found in Hydrology Annual No.7 (Soil Cons. & R.C.C., 1959) which also contains details of the Roding Catchment. The Catchment lies in the region to the east of Waimea Plain.

This paper outlines an investigation of storm rainfall and runoff in the Roding River Catchment for the purpose of arriving at the average loss rate, or PHi index (ϕ), for each storm. The results are plotted against excess rainfall duration in an endeavour to show a relationship between these factors when using antecedent conditions as a parameter.

RODING CATCHMENT

The Roding Regional Catchment (Fig.1) comprises an area of 15.1 sq.miles of steep country ranging in elevation from 600 to 3,646ft. The area comprises approximately 45% native forest (chiefly beech), the remainder being in low scrub and reverted pasture.

River heights are continuously recorded at the Nelson City Council weir. A daily Dines automatic raingauge is located downstream of the weir and a 95-day Casella automatic raingauge is installed on Dun Mountain at 3,500ft. In addition, storage raingauges are located at various elevations throughout the catchment. These are read monthly and a provisional correlation has been made after one year's recordings for the purpose of calculating catchment monthly mean rainfalls (Grant, 1961).

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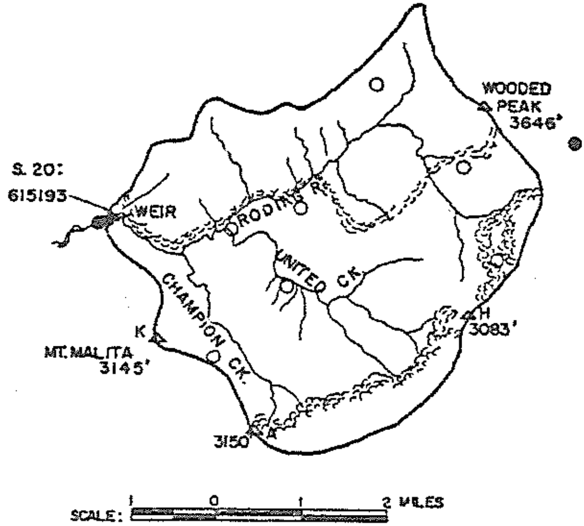

Fig.1 - Roding catchment; storage raingauges are denoted by open circles, automatic raingauges by solid circles.

ANALYTICAL CONSIDERATIONS

The calculated catchment monthly mean rainfall correlates reasonably well with Dun and Roding automatic records. The relationship is:

$$\text{Catchment mean rainfall} = 1.1 \times \frac{\text{Dun and Roding}}{2}$$

This relationship has been assumed to apply to the 23 independent storms which have been analysed.

The calculation of the Ø index is mainly for use in unitgraph studies and therefore to keep the time base length relatively short, a recession curve of base flow plus interflow was subtracted from each total runoff hydrograph to obtain a hydrograph of surface flow.

Multi-peaked hydrographs were separated using average recession curves of total runoff.

The hydrograph was studied in conjunction with hourly precipitation rates to obtain the Ø index (Toebes,1961). Other factors which have been taken out for each storm are:

(a) The duration of excess precipitation (Te),
(b) The average precipitation intensity during the time Te. This is equal to $\frac{Qs+Ø}{Te}$ inches per hour, where Qs is the depth of surface runoff in inches.
(c) Base flow at the start of each rise.

Date	Average Loss rate, Ø (in./hr)	Total Precip. (ins)	Surface runoff, Qs (ins)	Duration of excess Precip., Te. (hr)	$\frac{Qs}{Te} + Ø$ (in./hr)	Base flow at start of rise (c.f.s.)	Remarks
5. 3.61	0.19	3.34	1.43	6	0.43	10	Very dry antecedent
24. 3.61	0.18	2.35	0.99	6	0.35	6	" "
1. 6.62	0.04	7.08	6.06	21	0.34	40	Wet
29. 3.62	0.08	2.73	1.41	10	0.22	13	No rain for fortnight
30. 4.62	0.065	6.27	4.51	22	0.27	40	2nd rise
1. 5.62	0.12	1.20	0.79	3	0.38	200	3rd rise
4. 5.62	0.13	2.41	1.31	6	0.35	110	4th rise
4. 3.62	0.16	2.93	1.55	7	0.38	22	2nd rise
19. 5.62	0.08	1.84	1.17	6	0.28	70	double peak, wet
17. 7.62	0.04	1.13	0.88	10	0.13	13	very light rain

1.	18. 7.62	0.04	2.79	2.01	18	0.15	30	very light, 2nd rise
2.	19. 7.62	0.04	0.70	0.31	8	0.08	80	very light, 3rd rise
3.	9. 9.62	0.16	1.27	0.46	3	0.31	30	
4.	14. 9.62	0.12	1.67	0.75	6	0.24	30	
5.	30. 9.62	0.05	1.11	0.63	9	0.12	45	
6.	2.10.62	0.035	2.54	1.93	16	0.16	100	Multi-peaked
7.	4.10.62	0.07	1.06	0.43	7	0.13	200	
8.	4.10.62	0.11	2.46	1.59	6	0.37	200	2nd rise
9.	6.10.62	0.16	1.20	0.52	3	0.33	175	
0.	23.10.62	0.20	1.05	0.23	2	0.32	35	1st rise
1.	24.10.62	0.05	3.27	2.76	11	0.30	45	2nd rise
2.	25.10.62	0.13	1.08	0.48	3	0.29	90	3rd rise
3.	4. 3.62	0.36	1.64	0.24	1½	0.78	4	very dry

TABLE 1 - Analysis of 23 storms

Linsley, Kohler and Paulhus (1949:427) emphasise that the Ø index includes so many factors that it cannot be used for design purposes, except for determining the worst condition by selecting the lowest values.

The main factors affecting the Ø index are:

(a) Antecedent moisture conditions
(b) Duration of precipitation
(c) Temporal and areal pattern of precipitation
(d) Seasonal catchment changes.

In catchments where orographic effects tend to produce similar areal patterns for major storms, this factor can be neglected. Seasonal changes have relatively minor effects except in extreme cases where larger areas are under cultivation or subject to drastic changes in cover. If only storms of reasonably constant intensity are used then we can neglect the temporal pattern effect, and assume uniform intensity i.e. $\frac{Qs}{Te} + Ø$

We are then left with three variables:

(a) Duration of excess precipitation (Te)
(b) Antecedent moisture condition which can be defined approximately by base flow discharge immediately prior to the commencement of rise.
(c) Average intensity of precipitation during time Te.

Figure 2 shows the plot of values of Ø against Te with antecedent moisture condition as a parameter.

Antecedent moisture conditions have been classed as follows:

$<$ 25 c.f.s. - dry
25 - 70 c.f.s. - moist to wet
$>$ 70 c.f.s. - saturated

With the exception of No.10, the curve representing dry antecedent condition is a relatively good fit. Storm No.10 can be disregarded as it was of relatively low intensity. Some overlap occurs between moist to wet and saturated conditions. It is considered that this is due largely to errors in estimating the base flow discharge. Most overlap occurs with the results from later rises of multi-peaked hydrographs.

REMARKS

It is considered that the results are sufficiently encouraging to warrant further investigation on other regional catchments.

The results may well prove useful for application in other catchments within the Region where it may be necessary to obtain design storm excess precipitation for application to synthetic unitgraphs. The application of the Ø index to a storm will of course give an over estimation of excess precipitation at the start of the

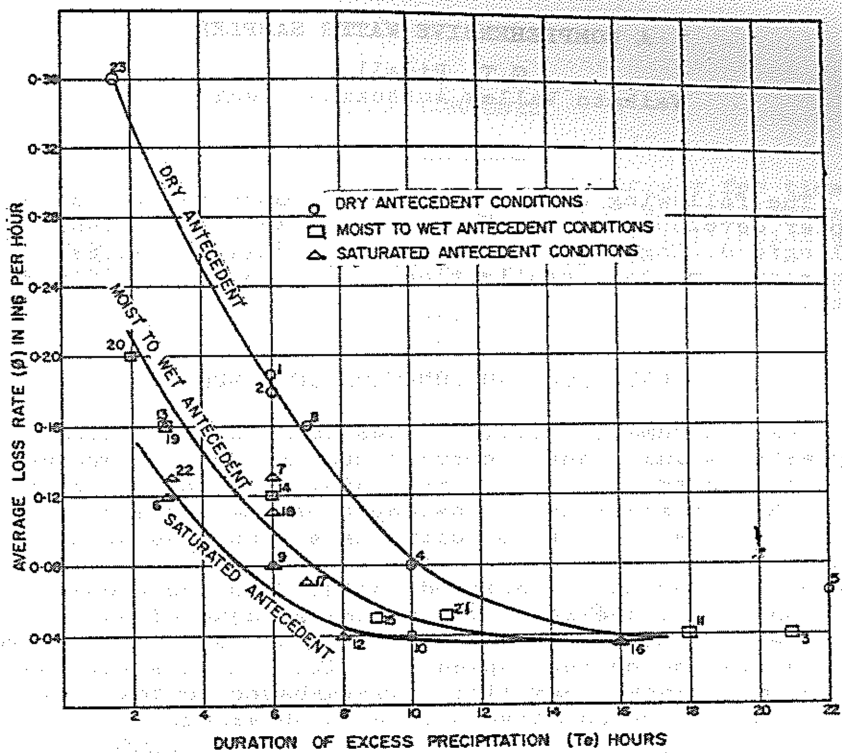

Fig.2 - Average loss rates in relation to excess precipitation.

As it is not practicable to derive infiltration curves for larger (> 10sq.mls) catchments, one refinement for them would be to subtract from total precipitation at the start of the storm an amount equal to initial losses and then apply a loss rate to the remainder. However, more investigation of initial losses are required before this method could be used with any greater accuracy than the simple Ø index subtraction.

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