

MAXIMUM POSSIBLE PRECIPITATION OVER THE TWEED RIVER VALLEY

by C. J. Wiesner

(Climatological Section, Weather Bureau, Sydney)

Introduction:

This report was compiled at the request of the Public Works Department of N.S.W. for application to flood mitigation works in the Tweed Valley. For design purposes, depths of the maximum possible precipitation for varying durations were required. Use was made of the methods the Hydrometeorological Branch of the U.S. Weather Bureau and the applications in Australia made by Walpole. Due to the absence of collated area depth data in Australia two storms were selected for study and the general maximum storm determined.

The Tweed River Valley:

The Tweed River catchment is 422 square miles in area and varies in height from sea level to above 3700 feet in the north-west and at Mt. Warning. It is bounded on the north by the Macpherson Range and, in the west, by extensions of the New England plateau (Tweed Range). This highland extends eastwards towards Doon Doon as a ridge and then, in less rugged country, in a north-easterly direction towards the sea coast near Cudgen. The basin is open to the sea in the east, and moist maritime air can penetrate into the valley without undergoing much lift, loss of moisture, or change of properties. (The 300 feet contour line encompasses portion of each of the arms of the river). However, in the upper tributaries, steeply rising ground would give rapid lift to an incident stream of air.

Maximum Possible Precipitation in the Valley:

Due to the comparatively small size of the catchment it is considered that, over short durations (12 hours or less), the greatest rainfall intensity would be derived from the thunderstorm model. (U.S. Weather Bureau 1947). Applying the principles in this publication and those in "Generalized Estimates of Maximum Possible Rainfall (Aust.)" (Walpole 1951a) depth duration values may be found. The maximum possible dew point which could occur in the valley is assumed to be 76 degrees, and no allowance is made for height as the valley opens to the sea and much of it is below 300 feet.

Depth Duration Values of Maximum Possible Rainfall over an Area of 422 miles in Tweed River Area and at Mean Sea Level:

Duration (mins)	60	180	360	720	1080	1440
(hrs)	1	3	6	12	18	24
Depth	4.9"	10.8"	14.2"	18.0"	20.5"	22.0"

For durations greater than 12 hours the general storm should be studied and adjustments made if a higher dew point could have occurred. To arrive at the general storm for the Tweed Valley, it would be desirable to examine all storms which have occurred in the meteorologically homogeneous zone of which the Tweed Valley is a part and, then, use the methods of the Hydrometeorological Branch of the U.S. Weather Bureau to transpose the storm to the Tweed catchment. However, due to the wide variations in topography along the coast and the marked effect that this has on the rainfall pattern and, also, as other information of interest can be derived, two storms were selected as being of significance in this study. These occurred within the catchment of the Tweed and resulted in the two worst floods on record and were experienced in February 1931 and in June 1945.

Of the two storms, the one in February 1931 gave a greater river height at Murwillumbah (20.59 ft.) but the second, in June 1945, (19.06 ft.) was reported, locally, as causing more damage.

The suggested reasons for this are:-

- (1) Greatest rain intensity in 1931 was on the last day of the three day storm and then rain eased but, in 1945 highest intensity was on the second day of the storm and was followed by further heavy rain on the next day. It is thought that the easing of rain in 1931, after the most intense rain, may have given time for the river to subside quickly, but in 1945, as the more intense period of rainfall of the storm was followed by further rain of comparable intensity, run off occurred into an already swollen river which consequently did not subside as rapidly. That is, the relation of rainfall intensity to run off was of more significance rather than amount of rain itself.
- (2) Evaporation is greater in February than June and consequently less water was lost from the catchment by this cause in June. Soil may have remained waterlogged longer.
- (3) Possibly there was a higher coefficient of run off in June 1945 than in February 1931. The rains prior to the 1945 flood were greater than those in 1931 and, taking in account the higher losses by evaporation in February than in June, it is likely that a higher coefficient of run off occurred in 1945.
- (4) Both floods were associated with high tides and heavy seas which prevented rapid "get away" of the water.

The Storm of February 1931

This originated as a tropical cyclone with the following history:-

1st Feb.	-	Between Willis Island and Cairns.	Central pressure	29.50
2nd Feb.	-	" " " Townsville	" "	29.20
3rd Feb.	-	Off Mackay	" "	29.30
4th Feb.	-	Off Rockhampton	" "	29.20
5th Feb.	-	Off Sandy Cape	" "	29.30
6th Feb.	-	Off Brisbane	" "	29.40
7th Feb.	-	Moved East	" "	29.50

For the period 1st to 7th February a very strong stream of moist air was in evidence on the East Coast and in particular in the Tweed River Valley. The heaviest rain occurred when the cyclone was moving south and the rain eased as it moved to the east. Mass rainfall curves for some of the main stations in the valley were constructed from details on original records as no pluviometer records were available.

They showed that, probably, the more intense rain commenced on the morning of the 3rd and continued until the 6th when it eased off in the afternoon. The period of more intense rain was about 90 hours with the most intense in the 24 hours ended 9 a.m. on the 6th.

It is likely that the rain commenced on the coast and northern border but, for most of the period it was simultaneous over the catchment with intensities in proportion to the total falls for the 24 hours. It is considered that it would not take more than three or four hours for the rain to extend to all parts of the catchment.

Dew points and temperatures at Lismore for the period were examined and a graph drawn of dew point against time. The mean temperatures at Condong and Lismore agreed to within a degree so it was assumed that the Lismore dew points would also represent the air mass within the Tweed Valley.

The dew points associated with the air mass over varying periods of time were:-

24 hrs. 73 deg: 48 hrs. 71 degs: 72 hrs. 70 deg:

Prior to the intense rain the dew point was 73 degrees (maximum 73.6), and during the heavy rain, it varied from 66 degrees to 71 degrees.

Isohyet maps were drawn for varying periods (from one to five days) and the depths of rainfall which occurred in the catchment were determined and found to be as in the second column hereunder:-

Time (Hrs.)	Depth (Inches)	Adjusted Depth	(Inches at dew point of 76 degrees)
For 24	12.6	15.1	
48	19.9	23.9	
72	22.9	27.5	
96	24.3	29.0	
120	26.3	31.6	

The maximum dew points which could persist in Australia for a period of 24 hours have been determined by Walpole (1951a). No work has been published in Australia on the maximum dew points which could persist over periods other than 24 hours but, for the purpose of determining the maximum depths which might occur, it should be sufficient to accept the 24 hour figures and assume that the variation of dew point over longer periods is similar for both the individual storm and for the maximum values.

Accordingly, the maximum dew point which could occur over a period of 24 hours was at this time of year taken as 76 degrees (Walpole 1951a). Therefore, the above storm could be increased in the proportion of

$$\frac{\text{effective precipitable water at } 76^{\circ}}{\text{effective precipitable water at } 73^{\circ}} = \frac{1.8}{1.5} = \frac{120}{100}$$

The depths adjusted for maximum dew point are given above in Column 3.

The Storm of June 1945

This probably occurred as a wave on a meridional front which, on 7th June, was lying from Rockhampton to New Zealand. A strong south-west stream was in evidence along the east coast. On the 8th June, a trough formed south from Rockhampton and intensified on the 9th with signs of a low centre. On the 10th, this low developed with very strong east to south-east winds and moved southwards. At 0600 on 11th June there was cyclonic centre with pressure to 29.54 ins. east of Brisbane.

At 0900 on 11th June the cyclonic centre was in Tweed Valley. At 0300 on 12th June the cyclonic centre had moved to S.S.E. of Lismore. The cyclone then moved rapidly to the south-east with cessation of activity. The lowest pressure at Lismore was probably 29.53" on the 11th.

It appeared that this cyclone was located within the Tweed Valley as the heavier rainfall was not on the coast. By expressing the rainfall over 72 hours in this storm as a percentage of the average annual rainfall it was determined that more than 30% of the average annual was received near Condong,

Murwillumbah and Uki, The isopleths of percentage rainfall also showed the probable path of the cyclone (assuming this can be indicated by the precipitation pattern) was from Tomewyn to Condong to Uki and Whiam.

No pluviometer records were available so mass rainfall curves were constructed from the records of some of the stations within the valley. These showed that the rain started on the night of the 9th (about 9 p.m.) and continued until the morning of the 12th (before 9 a.m.). The more intense rain occurred over a period of 60 hours with the greatest intensity in the 24 hours ended 9 a.m. on the 11th. It is probable that the rainfall was simultaneous for most of the period over the whole catchment although it may have commenced an hour or so earlier in the north and also stopped correspondingly earlier here. The movement of the cyclone would confirm this.

The dew points and temperatures at Lismore were examined and a graph constructed giving the probable variation of dew point throughout the period. Mean temperatures at Condong and Lismore agreed to within one degree indicating that dew points at Lismore should represent the air mass in the storm.

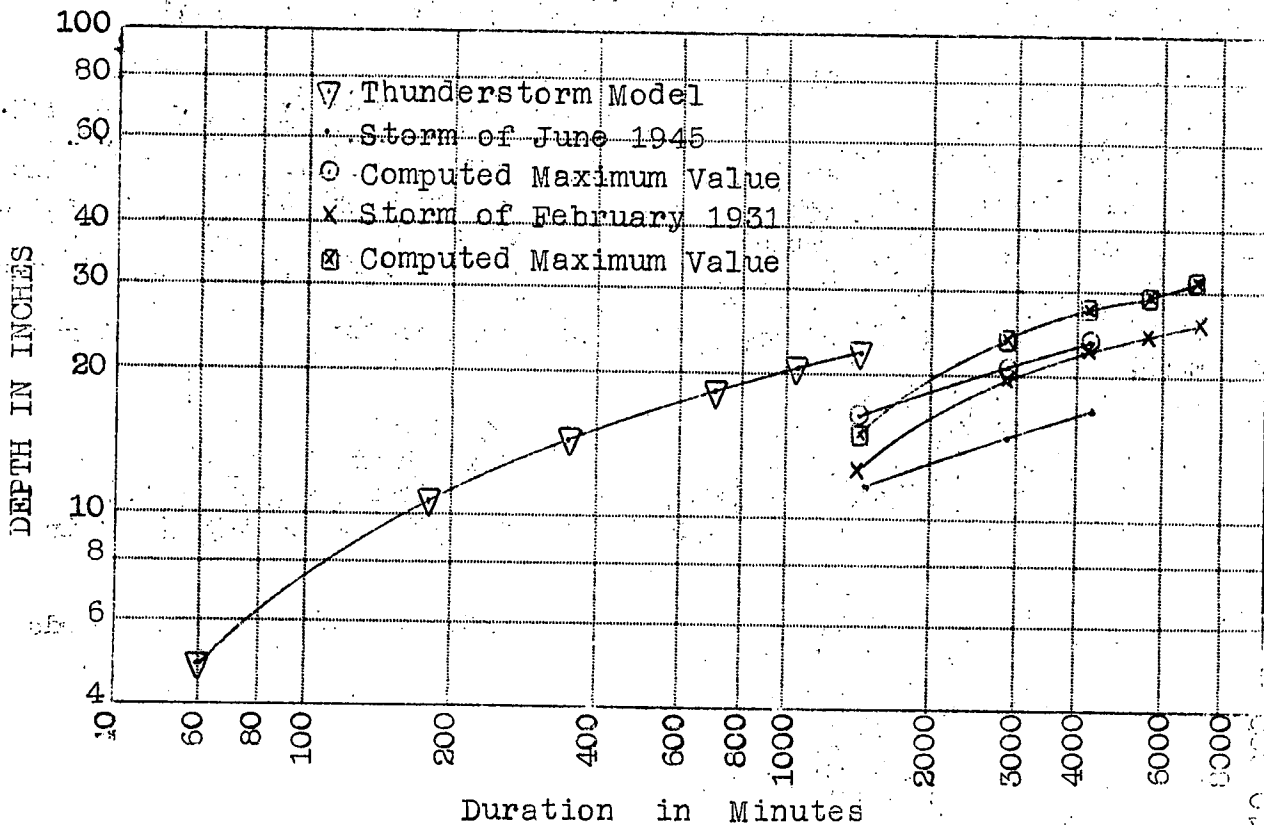
The dew points associated with the air mass over varying periods of time were as follows:-

24 hours	62 degrees
36 "	61 "
48 "	60 "
60 "	59 "
72 "	59 "

Dew points were highest (to 62.5) during the period of the storm and were lower (58 degrees prior to the start of the more intense rain and in the passage of the storm to the east.

Isohyet maps were drawn for periods of 24 hours, 48 hours, 72 hours and the depths of rainfall corresponding to these periods determined as in the second column below:-

Time (Hrs)	Depth (inches)	Adjusted Depth	(Inches at dew point of 68 degrees)
24	11.8	16.5	
48	14.9	20.6	
72	17.0	23.5	



DEPTH DURATION VALUES --- TWEED VALLEY N.S.W.

At this time of year, June, the maximum dew point which could occur over a period of 24 hours is 68 degrees (Walpole 1951a). Therefore the above storm could be increased in the proportion of:-

$$\frac{\text{Equivalent precipitable water at 68 degrees}}{\text{Equivalent precipitable water at 62 degrees}} = \frac{1.1}{.8} = \frac{138}{100}$$

or 38% greater.

Both of the above storms were accompanied by gale force winds which varied between the east and south-east. An examination of the valley indicated that the most important and significant wind direction would be from the south-east as the inflow width would be at a maximum for this direction. No data has yet been extracted in Australia on the maximum values which winds from varying direction can attain. Nor have figures been derived on the duration in time

and run of wind from the various direction. However, the storms in question are considered to have approached the maximum values of the winds and so no adjustment is proposed for this factor.

Duration-depth curves were plotted for the thunderstorm model and for both storms, and are shown in the graph opposite. Allowing for the higher dew points which might occur, curves of maximum depths are obtained for the two storms and are shown on the same figure. The storms considered were the worst which had been known in the region, and the envelope encompassing them and the curve for the thunderstorm model for durations of 12 hours and less should indicate the maximum depths for varying durations which would occur in the valley.

References :-

- | | | |
|------------------------------------|-------|---|
| BERNARD, M.M. | 1943 | The Primary Role of Meteorology
in Flood Flow Forecasting
(Trans. A.S.C.E., Jan. 1943) |
| SHOWALTER, A.K.
and SOLOT, S.B. | 1942 | Trans. Amer. Geophysical Union. |
| U.S. WEATHER BUREAU | 1947 | Hydrometeorological Report No. 5. |
| WALPOLE, J. | 1951a | Generalised Estimate of Maximum
Possible Rainfall (Australia)
(C.W.B. roneoed paper, Melbourne) |
| | 1951b | Rainfall Intensities over Upper
Yarra Catchment Area (Victoria)
(C.W.B. unpublished paper, Melb.) |

.

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..