POWER AND WATER AUTHORITY
WATER RESOURCES DIVISION

COOMALIE/LITCHFIELD
FLOODPLAIN MAPPING
BATCHelor/COOMALIE CREEK SECTION

REPORT 33/1994D

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DARWIN
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SYNOPSIS

This report describes the determination of the boundary of the land liable to flooding (on a 1:25,000 scale topographical map), on the Coomalie Creek floodplain lying within the administrative area of the Coomalie Community Government Council.

The 1 in 100 Annual Exceedence Probability (AEP) flood discharge of Coomalie Creek at the Stuart Highway Crossing G8170066 was determined by frequency analysis of annual flood maxima at G8170066. Frequency analysis was shown to produce a more accurate estimate of the 1 in 100 AEP flood discharge at G8170066 than a rainfall runoff model. The 1 in 100 AEP flood level at Coomalie Creek/Stuart Highway crossing was then determined from the extended rating curve.

The 1 in 100 AEP flood discharge of Coomalie Creek was also estimated at a surveyed river section 7 kilometres upstream of G8170066, using the RORB model with a regional value for the RORB parameter. The 1 in 100 AEP flood level at this section was then determined from Manning's formula.

The boundary of the land liable to flooding, east of Batchelor on the Coomalie Creek floodplain, and immediately downstream of the Coomalie Creek/Stuart Highway crossing was found by assuming an uniform flood slope. This slope was computed from the estimated 1 in 100 AEP flood levels at G8170066 and X.
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1. INTRODUCTION

1.1 General

The Floodplain Management Policy of the Northern Territory Government (Northern Territory Department of Lands 1981) provides for the identification and mapping of land liable to flooding (including coastal surge zones) and sets out guidelines and requirements to allow development to proceed on such land. In accordance with the policy and at the direction of the Northern Territory Floodplain Management Committee, the Power and Water Authority (PAWA) has been carrying out flood estimation and mapping of several towns and areas in the Northern Territory.

This report describes the analysis of the extent of flooding by a 1 in 100 Annual Exceedence Probability (AEP) flood and flood mapping of the area, east of Batchelor and west of the Stuart Highway, on the Coomalie Creek floodplain, proposed for rural residential development in the Darwin Regional Land Use Structure Plan 1990 (Northern Territory Department of Lands and Housing 1990). This area comes under the administrative control of the Coomalie Community Government Council (Figure 1.1).

1.2 Study Area

The study area (Figure 1.1) lies on the floodplain of Coomalie Creek, and is generally on the northern and southern sides of Batchelor Road, between Batchelor Town and the Stuart Highway, and immediately east of the Coomalie Creek/Stuart Highway crossing.

Land use in the study area consists of rural residential and pastoral activity.

The study area falls within the climate zone classified as 'Summer Rainfall - Tropical' (Bureau of Meteorology 1986). This zone is characterized by heavy periodic rains (heavier in coastal areas), generally hot and humid in coastal areas during the summer (November - March). The winter months (May - September) are generally rainless, mild to warm and dry. The months of April and October represent transition periods of change from one season to the other.

The rainfall is seasonal and 80 - 90 % of the annual rainfall occurs in the four months from December to March. Although a substantial portion of the rainfall is caused by thunderstorm activity, flood producing rainfalls mainly result from monsoonal depressions or cyclonic activity.
1.3 Purpose of Study

The purpose of this study is to define the land liable to flooding within the study area and, if possible, to produce flood maps showing the severity of flooding. This would greatly assist in the planning of drainage and flood corridors through the area east of Batchelor, zoned for rural/residential development, in the Darwin Regional Land Use Structure Plan 1990.

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1Land liable to flooding is defined as land that would be inundated as a result of a flood event that has a statistical chance of 1% of being equalled or exceeded during any one year. This flood event has been generally adopted for planning purposes.
2. BASIC DATA

2.1 Topographic Maps

The study area (Figure 1.1) is covered by 1:50,000 scale maps with 20 m contours, 1:250,000 scale maps with 20 m contours and 1:25,000 scale maps with 5 m contours.

2.2 Streamflow Data

Within the study area, Coomalie Creek is gauged at the Coomalie Creek/Stuart Highway Crossing G8170066 (catchment area 73.3 km²). G8170066 was opened in July 1958 and continuous stage recording commenced in November 1963. Current meter measurements are also carried out at this station, and since 1958, 287 discharge measurements have been made. The discharge measurements are sufficient to derive a stage discharge relationship up to a discharge of 58.26 m³/s (highest discharge measurement) at the gauge height of 2.91 m. The gauge height of the highest stage recorded, to date, is 3.75 m (in March 1977). As, the cross section (Figure 2.1) had no marked discontinuities, between gauge heights 2.91 m and 4.70 m, the rating curve was extended logarithmically (up to 4.70 m gauge height). The digitized stage records (1963 - 1993) were processed using the extended rating curve (Figure 2.2) and the discharges (1963 - 1993) obtained.

The annual peak discharges at G8170066 are shown in Table 2.1.

2.3 Pluviometer Records

During the period of the gauge record, pluviometers have been operated for different periods within and near the catchment at G8170066, as follows (Figure 2.3).

<table>
<thead>
<tr>
<th>STATION NO</th>
<th>STATION NAME</th>
<th>LAT</th>
<th>LONG</th>
<th>PERIOD RECORD</th>
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<tr>
<td>R8150332</td>
<td>DRD West Track</td>
<td>1258</td>
<td>13105</td>
<td>01.1963 - 05.1977</td>
</tr>
<tr>
<td>R8150202</td>
<td>Tailings Creek</td>
<td>1259</td>
<td>13100</td>
<td>01.1982 - 07.1988</td>
</tr>
<tr>
<td>R8150205</td>
<td>East Finnis</td>
<td>1259</td>
<td>13100</td>
<td>08 1984 - present</td>
</tr>
<tr>
<td>R8170013</td>
<td>Woodcutters Mine</td>
<td>1255</td>
<td>13108</td>
<td>01 1963 - 06 1977*</td>
</tr>
<tr>
<td>R8170303</td>
<td>Stapleton Creek</td>
<td>1307</td>
<td>13105</td>
<td>08 1973 - 06 1981</td>
</tr>
</tbody>
</table>

* There were no pluviometer records for the periods, 0400 hours / 03.12.1964 - 1500 hours / 04.12.1964 and 0730 hours / 06.03.1977 - 1045 hours / 25.03.1977
Fig. 2.1
NT Water Resources

GB170066 Coomalie Creek At Stuart Highway

Gaugings from 28/05/1958 to 14/03/1994

Rating Table 2.01

17/07/1973 to Present

Fig. 2

140 - Stream Discharge in Cubic Metres/Second
Table 2.1

Annual Peak Discharges
At
Coomalie Creek/Stuart Highway Crossing
G8170066

<table>
<thead>
<tr>
<th>Water Year</th>
<th>Discharge (m$^3$/s)</th>
<th>Flood Level m GD</th>
<th>Water Year</th>
<th>Discharge (m$^3$/s)</th>
<th>Flood Level m GD</th>
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<tbody>
<tr>
<td>1963/64</td>
<td>22</td>
<td>2.30</td>
<td>1978/79</td>
<td>13</td>
<td>1.84</td>
</tr>
<tr>
<td>1964/65</td>
<td>66</td>
<td>3.29</td>
<td>1979/80</td>
<td>66</td>
<td>3.01</td>
</tr>
<tr>
<td>1965/66</td>
<td>31</td>
<td>2.57</td>
<td>1980/81</td>
<td>134</td>
<td>3.74</td>
</tr>
<tr>
<td>1967/68</td>
<td>nr</td>
<td>nr</td>
<td>1982/83</td>
<td>11</td>
<td>1.74</td>
</tr>
<tr>
<td>1968/69</td>
<td>76</td>
<td>3.44</td>
<td>1983/84</td>
<td>54</td>
<td>2.84</td>
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<tr>
<td>1969/70</td>
<td>36</td>
<td>2.72</td>
<td>1984/85</td>
<td>35</td>
<td>2.18</td>
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<tr>
<td>1970/71</td>
<td>44</td>
<td>2.89</td>
<td>1985/86</td>
<td>16</td>
<td>1.95</td>
</tr>
<tr>
<td>1971/72</td>
<td>26</td>
<td>2.45</td>
<td>1986/87</td>
<td>11</td>
<td>1.75</td>
</tr>
<tr>
<td>1972/73</td>
<td>45</td>
<td>2.91</td>
<td>1987/88</td>
<td>8</td>
<td>1.60</td>
</tr>
<tr>
<td>1974/75</td>
<td>55</td>
<td>2.85</td>
<td>1989/90</td>
<td>5</td>
<td>1.41</td>
</tr>
<tr>
<td>1975/76</td>
<td>95</td>
<td>3.33</td>
<td>1990/91</td>
<td>70</td>
<td>3.05</td>
</tr>
<tr>
<td>1976/77</td>
<td>135</td>
<td>3.75</td>
<td>1991/92</td>
<td>16</td>
<td>1.96</td>
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<tr>
<td>1977/78</td>
<td>31</td>
<td>2.41</td>
<td>1992/93</td>
<td>42</td>
<td>2.62</td>
</tr>
</tbody>
</table>

* nr denotes missing records, m GD denotes meters gauge datum
COOMALIE CREEK CATCHMENT AT STUART HIGHWAY CROSSING G8170066

Fig. 2.3
3. COMPUTATION OF DESIGN FLOODS

3.1 General

Design Floods can be derived from flood frequency analysis of discharge records or from a rainfall runoff model. Where flood frequency analysis is used, the required peak flow is found from a frequency distribution\(^1\) of recorded annual flood maxima. Rainfall runoff based methods, usually, use either a runoff routing model or a unit hydrograph and give a complete hydrograph of the design flood.

The extent to which a flood frequency analysis can be extrapolated before an alternative rainfall based method becomes preferable depends on the accuracy of the latter method and the characteristics of the design rainfall data (IE Aust. 1987). In addition, it depends on the length of the flood record \( (N) \) in years, the standard deviation \((S)\) and coefficient of skew \((g)\) of the logarithms of the flood values (IE Aust. 1987).

Based on the above considerations, Australian Rainfall and Runoff (ARR) (IE Aust. 1987) has set out three empirical equations for finding \( Y \) (for a flood of AEP of 1 in \( Y \)), one for catchments greater than 150 km\(^2\) where Meteorological Bureau design rainfalls (in ARR) are based on daily data, and the other two for catchments smaller than 100 km\(^2\) where the design rainfalls were based on pluviometer records.

The annual exceedence probability (AEP) at which the rainfall based method becomes more accurate than flood frequency analysis (for a catchment area less than 100 km\(^2\)), is denoted by \( 1 \) in \( Y \) \(^2\) for a rainfall - runoff method calibrated "on site" (and \( 1 \) in \( 3Y \) for a rainfall - runoff method using regional parameters).

Applying the above empirical equation to the flood record at G8170066, it was derived that frequency analysis would produce a more accurate estimate of the flood than a calibrated rainfall - runoff model, for annual exceedence probabilities greater than 1 in 293. The LP111 frequency distribution of the annual flood maxima at G8170066, for the period 1963/64 - 1992/93 is shown in Figure 3.1. The mean, standard deviation and coefficient of skew of the logarithms of the annual flow maxima are 1.546, 0.367 and -0.439 respectively. The 1 in 100 AEP flood was 191 m\(^3\)/s, and after adjustment for small sample bias, was 218 m\(^3\)/s.

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1 The Log Pearson Type 111 (LP111) distribution is used as a standard in Australia and lends itself well to flood data which tend to have a lower limit but no upper limit.

2 \( Y = 1.5FN^0.75\exp(0.06N) \) where \( F \) depends on the values of \( S \) and \( g \) and is taken from Table 12.2 in ARR.
Flood frequency analysis g8170066
LOG PEARSON TYPE III DISTRIBUTION

Fig. 3.1
3.2 Runoff Routing Model

For comparison with the flood estimate obtained by frequency analysis, the 1 in 100 AEP flood was also computed using a calibrated rainfall runoff model.

The rainfall - runoff model used was the RORB runoff routing model version 4 developed by Laurenson and Mein (1988). The model computes the flood hydrograph from rainfall and other channel inputs by subtracting the losses from rainfall and routing the rainfall excess through each subcatchment storage. The model is non linear and accounts for temporal and areal variation of rainfall and losses. The key parameters in the model are the dimensionless exponent $m$, a measure of the nonlinearity of the catchment (usually, $0.6 \leq m \leq 1.0$), and the empirical coefficient $K_c$, a dimensionless measure of the storage delay time of the whole catchment.

Subcatchment storages are assumed to be governed by a storage - discharge equation of the form

$$S = 3600 K_c K_r Q^m$$

where,

- $S$ = storage (m$^3$)
- $Q$ = outflow discharge (m$^3$/s)
- $m$ = dimensionless exponent
- $K_c$ = empirical coefficient applicable to the whole catchment and stream network
- $K_r$ = dimensionless ratio called the relative delay time applicable to individual reach storages

3.3 Calibration of the RORB Model

The RORB model was calibrated for the February 1973, March 1974, March 1984 and February 1993 flood events. Week's procedure (Weeks 1980) was used to obtain an optimum combination of $m$ and $K_c$. For each of the flood events, a range of $m$ values was used. For each $m$ value, $K_c$ was varied until the best fit with that $m$ value was obtained. Graphs of $K_c$ versus $m$ for the flood events were then plotted (Figure 3.2). The graph indicated an optimal combination of $m$ and $K_c$ to be 1.0 and 6.8 (average), respectively.
The results of the calibrations were as follows.

### RORB MODEL CALIBRATION

**AT COOMALIE CREEK/STUART HIGHWAY CROSSING
G8170066**

<table>
<thead>
<tr>
<th>Flood Event</th>
<th>Peak (m^3/s)</th>
<th>Initial Loss (mm)</th>
<th>Continuing Loss (mm/hr)</th>
<th>Kc</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972/73</td>
<td>45</td>
<td>0.0</td>
<td>21.3</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15.3</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11.7</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8.6</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.3</td>
<td>1.0</td>
</tr>
<tr>
<td>1973/74</td>
<td>108</td>
<td>28.0</td>
<td>33.0</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.69</td>
<td>22.6</td>
<td>15.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15.4</td>
<td>10.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7.0</td>
<td>1.0</td>
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<tr>
<td>1983/84</td>
<td>54</td>
<td>20.0</td>
<td>26.0</td>
<td>2.2</td>
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<td></td>
<td></td>
<td>2.21</td>
<td>18.5</td>
<td>13.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9.5</td>
<td>6.8</td>
</tr>
<tr>
<td>1992/93</td>
<td>42</td>
<td>0.0</td>
<td>30.2</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.71</td>
<td>20.8</td>
<td>14.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10.1</td>
<td>7.0</td>
</tr>
</tbody>
</table>

The RORB model parameter Kc (for m = 0.8) was also obtained from the regional relationship\(^1\) for the humid region of the Northern Territory (IE Aust. 1987). Kc (for m = 0.8) was computed to be 13.5 at G8170066.

To obtain the 1 in 100 AEP flood at G8170066, the 100 year ARI design rainfall from ARR (IE Aust. 1987) together with the 100 year ARI rainfall temporal patterns (IE Aust. 1987) were applied to the RORB model. The rainfall hyetograph for input to the model was derived by first applying an areal reduction factor (IE Aust. 1987) to the 1 in 100 year AEP point rainfall. Storm durations of 2, 3, 6 and 12 hours were used.

The results of the modelling of the 1 in 100 AEP floods for Coomalie Creek at G8170066 are shown in Table 3.1.

\(^1\) For the humid region of the Northern Territory Kc = 1.8(A/S^{0.5})^{0.55} where, A is the catchment area in km\(^2\) and S is the equal area slope of the catchment in m/km.

13
Table 3.1
RORB MODELLING OF 1 IN 100 AEP COOMALIE CREEK PEAK FLOW AT COOMALIE CREEK/STUART HIGHWAY CROSSING

<table>
<thead>
<tr>
<th>Storm Duration (Hours)</th>
<th>Areal Reduction Factor</th>
<th>Total Rainfall (mm)</th>
<th>Peak Flow Kc</th>
<th>m = 0.8</th>
<th>m = 1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11 = 0 mm</td>
<td>11 = 0 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>c1 = 1.4 mm/hr</td>
<td>c1 = 1.80 mm/hr **</td>
</tr>
<tr>
<td>2</td>
<td>0.96</td>
<td>137</td>
<td>129</td>
<td>354</td>
<td>295</td>
</tr>
<tr>
<td>3</td>
<td>0.97</td>
<td>151</td>
<td>145</td>
<td>440</td>
<td>342</td>
</tr>
<tr>
<td>6</td>
<td>0.98</td>
<td>170</td>
<td>175</td>
<td>462</td>
<td>332</td>
</tr>
<tr>
<td>12</td>
<td>0.98</td>
<td>211</td>
<td>207</td>
<td>430</td>
<td>307</td>
</tr>
</tbody>
</table>

Note: Kc, m, n - RORB parameters, 11 - initial loss, c1 - continuing loss
* The regional value of the RORB parameter Kc is 13.5
** The mean of the continuing losses from calibration is 1.8 mm/hr


3.4 The 1 in 100 AEP flood estimate

The 1 in 100 AEP flood peak estimates obtained by frequency analysis and RORB runoff routing are as follows.

- Frequency Analysis: 218 m³/s
- Calibrated RORB model: 342 m³/s
- Regional RORB model: 462 m³/s

The 1 in 100 AEP flood estimate obtained by frequency analysis was used as the design flood estimate for flood mapping (in section 3.1, frequency analysis was shown to produce a more accurate estimate of the 1 in 100 AEP flood at G8170066, than a rainfall-runoff method).
4. FLOODPLAIN MAPPING

4.1 General

The scale of the topographical maps available for the study area was 1 : 25,000 with 5 m
contours. The accuracy of the topographical maps\(^1\) did not permit the use of either a 1 - D
or 2 - D gradually varied flow finite difference model, for simulating the flood flow.

With the available information it was not possible to determine flood contours, severities of
flooding etc. Only the approximate boundary of the area liable to flooding was determined.

4.2 Flood Mapping

The 1 in 100 AEP flood level of Coomalie Creek at G8170066 was estimated to be 49.85 m
AHD (gauge height 4.41 m).

To determine the extent of inundation of Coomalie Creek by a 1 in 100 AEP flood, it is
required to estimate the 1 in 100 AEP flood slope.

There was no gauging station or river gaugings available upstream of G8170066. A well
defined river section, was, however, found on Coomalie Creek, 7.0 kilometres upstream of
G8170066 (X in Figure 1.1). The 1 in 100 AEP flood discharge at this section (catchment
area 31.0 km\(^2\)) was obtained by RORB modelling, with the RORB parameter obtained from
the regional relationship for \(K_c\) (\(K_c\) was computed to be 8.4). The 1 in 100 AEP flood
discharge at X was estimated to be 197 m\(^3\)/s. The river section was surveyed for its cross
section and the 1 in 100 AEP flood height was estimated, using Manning's formula. A value
of 0.05 for Manning's "n" was used and was considered reasonable for the terrain. The 1 in
100 AEP flood level at X was estimated to be 67.00 m AHD.

The boundary of the land liable to flooding east of Batchelor on the Coomalie Creek
floodplain, and immediately downstream of the Coomalie Creek/Stuart Highway crossing was
found by assuming an uniform flood slope. This slope was computed from the estimated 1 in
100 AEP flood levels at G8170066 and X, and was found to be 0.0025. The average bed
slope of Coomalie Creek between G8170066 and X was 0.0033.

\(^1\) The error in interpolating levels from 5 m contours is about ±1.5 m.
4.3 Flood Map

The flood inundation map of the study area for a 1 in 100 AEP flood event is shown on the 1:25,000 scale topographical maps (with 5 m contours) (Figure 4.1).

Only the extent of flooding in a 1 in 100 AEP flood event has been shown. Due to the error (± 1.5 m) in interpolating levels from 5 m contour maps it was not possible to show, either, the flood contours or the hazardous floodway\(^1\) areas on the topographical maps.

\(^1\) Hazardous floodway is defined as an area where the depth of flooding is greater than 2 m, or where the product of depth in metres and velocity in m/s exceeds one.
5. REFERENCES

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title and Details</th>
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<td>Bureau of Meteorology (1986)</td>
<td>District Rainfall Deciles - Australia</td>
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<td>IE Aust. (1987)</td>
<td>Australian Rainfall and Runoff</td>
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<tr>
<td>Northern Territory Department of Lands (1981)</td>
<td>Land Use in Floodplains</td>
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<td>Northern Territory Department of Lands and Housing (1990)</td>
<td>Darwin Regional Land Use Structure Plan 1990</td>
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</table>
Figure 4.1

COOMALIE / LITCHFIELD FLOOD MAP
Batchelor/Coomalie Creek Section

Scale 1 : 25,000