POWER AND WATER AUTHORITY

FLOODPLAIN MAPPING
FOR KATHERINE RURAL
(DOWNSTREAM) AREA

REPORT 3/1988

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ABSTRACT

This report describes studies undertaken to map areas of Katherine rural area, downstream of the township, which may be inundated as a result of the 1 in 100 year Annual Exceedence Probability (AEP) flood. A two-dimensional cell-type model, PL2DFLOW, originally developed by Snowy Mountains Engineering Corporation (SMEC) and modified in-house, was used to model flood levels. Using the 1 in 100 year AEP design flood, detailed maps showing the extent of flooding, flood level contours, and the floodway in the study area have been produced for floodplain management purposes.
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1. The terms "1 in 100 AEP flood" and "1% AEP flood" refer to floods with an Annual Exceedence Probability of 1%. That is, there is a 1% or 1 in 100 chance that such a flood will be equalled or exceeded in any year.

2. The Interim Floodplain Management Policy (Reference 5) gives the following definitions which have been adopted in this study.

Floodplain. This refers to all parts of a valley which are subject to flooding by the maximum probable flood. Such a flood can be calculated for a particular location having regard to the catchment characteristics and the most critical combination likely to occur in the region. The accuracy of such calculation depends largely on the amount and precision of data available, particularly the length of hydrologic and meteorologic data record.

Land Liable to Flooding. This is land that would be inundated as a result of a flood that is the greater of either the highest flood on record or that which has a statistical chance of one percent of occurring in any one year. (This land is of course, within a floodplain. The boundaries can be calculated from hydrologic, meteorologic and topographic data. Similar remarks on accuracy apply as for the floodplain definition).
The Floodway. This is a zone where unrestricted passage of comparatively frequent floods is provided by restricting its use to flood-tolerant applications such as parkland, nature reserves or recreational grounds. It includes the normal stream channels and other parts of the floodplain that are also covered by floods of the selected frequency. It will also include areas subject to particularly dangerous flood conditions such as high velocities and deep water.

Flood Fringe. This is land within land liable to flooding but outside the floodway, where certain development can be allowed provided appropriate measures, such as flood-proofing and flood warning are incorporated in the development.

3. Floodway in this study is defined as the area where the depth of flooding exceeds 2 metres, or the product of depth in metres and velocity in metres per second exceeds 1.0 for the 1 in 100 AEP flood.
1. INTRODUCTION

The Interim Floodplain Management Policy adopted by the Northern Territory Government in 1980, provides for the identification of land liable to flooding, and the control of development on such land.

In accordance with this policy, and at the direction of the Floodplain Management Committee, the Water Directorate of the Power And Water Authority has been carrying out a series of flood studies and the production of flood maps of flood prone areas.

This report describes one such investigation; to determine the extent and severity of flooding in a 21 kilometre reach downstream of Katherine township below the low level bridge crossing, and in the immediate surrounding area. The report and associated maps are designed to assist in the planning of appropriate development of the area, and to assist with counter disaster planning.

A mathematical model of the floodplain has been used to determine the depths and velocities of flooding in the area of interest. This information has then been mapped.
2. DESCRIPTION OF THE STUDY AREA

The catchment area of the Katherine River upstream of the study area is about 8,650 square kilometres (Figure 2(a)).

The study area is immediately downstream of the Old Highway crossing extending over a 21 km reach along the Katherine River (Figure 2(b)).

Undulating plains, savannah grasslands and woodlands are some of the physical features of the study area. The river channel is well confined and lined with thick vegetation.

Several small streams drain into the Katherine River in the study reach. Runoff contributions from these streams during major flooding is expected to be insignificant.

Land use in this area includes rural residential, pastoral activities and farming.
MODEL CELL CONFIGURATION

LEGEND

- MODEL CELL BOUNDARY AND NUMBER
- MAXIMUM FLOOD LEVEL INDICATORS
- CENTRELINE OF KATHERINE RIVER
- SOURCES OR SINKS

Fig. 2(b)
3. STUDY METHOD

The following methodology was used in this study:-

. Collection and interpretation of available flood and topographic data.

. Establishing the mathematical model to represent the topography and hydraulic behaviour of the study area. The cell type model PL2DFLOW (References 2, 3 and 4) was used for this study. A total of 74 cells were used to model the study area. (Figure 2(b)).

. Calibration of the model using 1967 recorded flood data. The outflow hydrograph from the Katherine township model (Reference 1) was used as the inflow hydrograph for this model.

. Estimation of the 1 in 100 (AEP) flood profiles using the PL2DFLOW model. In this case the 1957 flood data was used as the 1 in 100 (AEP) event (Section 7.1). Once again the modelled output results from the Katherine township model were used as the input data.

. Production of flood maps from the model results.

One of the requirements in any hydrologic/hydraulic modelling process is to test the accuracy of the calibrated model against other recorded flood events not used in the calibration process. No detailed flood records were available, however model behaviour could be compared with observed flood behaviour (Section 5.2).
4. DATA REQUIREMENTS AND AVAILABILITY

4.1 Topographic Information

Photogrammetric contour maps at a scale of 1:5 000 and 1 metre contour intervals covering the study area were available. Topographic information needed to establish the mathematical model were:

- depth - area relationship at cell connections
- minimum elevation at each cell connection
- depth - volume relationship of each cell
- minimum elevation of each cell

4.2 Hydrological Information

There is no gauge station located in the study area.

Outflow hydrographs from the Katherine township model served as input hydrographs to this downstream model.

4.3 Peak Stage Records

Peak stage indicators were established in October 1986 in the locations shown in Fig 2(b). Peak levels recorded by these indicators were used to calibrate the model. Recorded peak levels are shown in Table 5.
5. MODEL ESTABLISHMENT, CALIBRATION, AND VERIFICATION

5.1 Model Establishment

The PL2DFLOW model is operated by considering the area to be studied as a number of cells as shown in Figure 2(b). The topography of the floodplain and of the river channel are represented by a fourth order depth-volume polynomial relationship above a specified minimum elevation for each cell and a fourth-order depth-area polynomial relationship and a minimum elevation for each cell connection. Computer programs (Reference 2) were used to fit these polynomial relationships to data obtained from contour maps.

Flow between cells is controlled by frictional effects calculated using Manning's formula. To allow for variations in roughness with depth, the following equations relating Manning's 'n' with depth were used.

For the main river channel:

\[
\text{'n'} = N + a \text{DEPTH} + b(\text{DEPTH})^2
\]

5.1.1

For the floodplain:

\[
\begin{align*}
\text{'n'} &= N + k \text{DEPTH} \quad (\text{DEPTH} \leq 0.15 \text{m}) \\
\text{'n'} &= C/\text{DEPTH} + k \quad (\text{DEPTH} > 0.15 \text{m})
\end{align*}
\]

5.1.2

5.1.3

The depth/roughness relationship previously developed for the Katherine town model was adopted for floodplain connections (Figure 5.1). Katherine town model relationship was used initially for river channel connections but varied as required during calibration of the model to obtain a good fit between modelled and observed floods.
FIG. 5.1

MODEL ROUGHNESS RELATIONSHIPS
Inflow (source) is defined by one or more hydrographs entering nominated cells. Outflow (sink) is controlled by rating curves (height/flow relationships) at all cell boundaries where outflow could occur. In this instance, sink rating curves had to be derived using Manning's formula as no actual rating curves were available for the sink cells.

Three sources of inflow at cells 2, 4 and 7 were used in the model with three sinks at cells 70, 71 and 72.

5.2 Model Calibration

The model was calibrated by inputing a known flood hydrograph and then adjusting the model parameters (cell boundary roughnesses and sink outflow ratings) until the model reproduced the known flood behaviour elsewhere on the floodplain. The only data available for calibration were the recorded 1987 peak water levels as shown in Table 5.

The following procedure was used in the calibration phase:-

- the outflow hydrographs from the upstream Katherine township model were used as inflow hydrographs at Cells 2, 4 and 7.

- the model was run a number of times with adjustments being made to cell configurations, boundary roughness and sink ratings until reasonable agreement between recorded and modelled flood levels was attained. Table 5 shows available recorded levels and corresponding modelled levels.
TABLE 5
Recorded and Modelled Peak Flood Levels

<table>
<thead>
<tr>
<th>Cell Number</th>
<th>Flood Peak Levels (AHD)</th>
<th>Recorded</th>
<th>Modelled</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>100.20</td>
<td>99.97*</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>100.19</td>
<td>100.20</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>100.41</td>
<td>99.98*</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>98.40</td>
<td>98.26</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>97.39</td>
<td>97.24</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>91.65</td>
<td>91.55**</td>
<td></td>
</tr>
</tbody>
</table>

* Recorded levels at these two points may have been affected by local runoff.

** Indicator is located at down stream end of Cell 71. Modelled level is estimated from level at cell centre and gradient between Cells 67 and 71.

Fig 5.2 shows the modelled peak water surface profile along the river, together with recorded levels.
Fig. 5.2

PEAK WATER SURFACE PROFILES
ALONG RIVER CELLS
5.3 Model Verification

As mentioned in Chapter 3, there were no recorded data available for model verification. The only historic information available on the 1957 flood in the study area was the description given by Mr Wal Christie, a resident in the area who observed the flood. Modelled flood levels in the vicinity of Mr Christie's property located on the south-east corner of NT Portion 2911 (at the river end of Cossack road) conform to his description. That portion of land remained dry. This may be regarded as a partial verification and hence can be said that predicted flood levels for the 1 in 100 year flood are reasonable.
6. DESIGN FLOODS

A design flood is a statistical estimate based on probability analysis of recorded rainfall or flood data.

Flood frequency analysis of annual peak flows at gauge station GS8140001 (Katherine Railway Bridge) showed that the 1 in 100 year (AEP) flood could be represented by the 1957 flood event (Reference 1). This was confirmed by results obtained from running of the Katherine township model.

Thus the March 1957 flood data was used as the 1 in 100 year (AEP) design flood. Peak inflows were as shown in Table 6.

<table>
<thead>
<tr>
<th>Cell Number</th>
<th>Source Flow (m²/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3710</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>1239</td>
</tr>
</tbody>
</table>

Total Inflow 5049
7. MODELLING DESIGN FLOODS

7.1 Modelling

The output hydrographs for the Katherine township using the PL2DFLOW model for the 1957 flood event served as input hydrographs to the downstream model.

Figure 7.1 shows the inflow and modelled outflow hydrographs.

7.2 Mapping

Flood inundation maps of the 1 in 100 (AEP) flood have been produced at a scale of 1:5 000 covering the modelled area. These maps show the extent of flooding in a 1 in 100 AEP event and the level of floodwaters to Australian Height Datum. The above information is also shown on a reduced scale of 1:20 000 map for easy reference (Figure 7.2). Depths of flooding may be read from the 1:5 000 maps by deducting the ground level contour from the water surface contour.

Hazardous floodway areas are also shown on the maps. These are defined as areas where depths of flooding are greater than 2 m or where the product of depth in metres and velocity in metres per second, exceeds one.

7.3 Accuracy of Mapping

The accuracy of the flood maps is a function of both the accuracy of modelling and of the base maps. There were insufficient flood level data for detailed model calibrations and verifications in the study reach. The
modelled levels would be subject to some error but are the best available estimate of the 1 in 100 AEP flood levels. These are the levels shown by water level contours on the floodplain maps. Flooded areas as shown on the maps are also dependent on the accuracy of base map contours and would be less accurate where the ground is generally flat. Where accurate analysis of flooding of an existing or proposed development is required, actual ground or floor levels should be obtained by survey to compare with mapped flood levels.
8. EFFECT OF FLOODING ON EXISTING DEVELOPMENT

Flood damage to existing development depends on the location and extent of different land-use areas liable to flooding.

Existing land-uses in the study area include farming, pastoral and residential (rural). However, Katherine's sewerage treatment plant and explosives magazine area are also located within the area.

Results obtained from modelling the 1 in 100 year AEP flood through the study area show that:

- Existing dwellings are situated outside the floodway (as defined). Those dwellings located within the flood fringe may be subject to minor flooding if floor levels are below predicted flood levels.

- Evaporation ponds of the Katherine sewerage treatment plant are likely to be inundated.

- It is possible for water to enter the explosives magazine area through gaps in the embankment. The top of the embankment is however above predicted flood levels.

- Areas of farm land under crop would be affected by major flooding. The extent of damage would depend on the type and stage of development of the crop and the depth and duration of flooding. Grain sorghum, sesame, mungbeans and forage crops which are grown on the Katherine floodplains cannot withstand prolonged inundation.
Major stock losses would not be expected as the rise of flood waters would be slow enough to allow stock to be moved to high ground.

Florina Road, the Victoria Highway and a number of minor access roads would be inundated at the 1 in 100 flood level. Florina Road would be flooded at four locations, approximately 5.7 km, 6.6 km, 10.2 km and 20.3 km from its junction with Zimin Drive. The Victoria Highway would be flooded for over a length of about 500 m, immediately south of the township, about 4.5 km from the Victoria Highway/Stuart Highway junction.

Table 8 shows the depth and duration of flooding at these locations.

<table>
<thead>
<tr>
<th>Location</th>
<th>Maximum Depth Over Road (m)</th>
<th>*Duration of Flooding (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Florina Road 5.7 km</td>
<td>3.40</td>
<td>90</td>
</tr>
<tr>
<td>Florina Road 6.6 km</td>
<td>2.03</td>
<td>61</td>
</tr>
<tr>
<td>Florina Road 10.2 km</td>
<td>1.13</td>
<td>55</td>
</tr>
<tr>
<td>Florina Road 20.25 km</td>
<td>3.07</td>
<td>92</td>
</tr>
<tr>
<td>Victoria Highway</td>
<td>1.4</td>
<td>42</td>
</tr>
</tbody>
</table>

* For water depth greater than 0.3 m above existing road level.
9. CONSTRAINTS TO DEVELOPMENT

Rural residential dwellings should wherever possible be sited in flood-free locations. Where this is not practicable, floor levels should be at least 350 mm above the 1 in 100 flood level. This is in accordance with current policies.

If urban and/or industrial development should extend into this area in the future, it should be located above the 1 in 100 flood level.

Agricultural development of flood prone areas should be determined on economic grounds. Generally, flooding would be infrequent, and any flood losses incurred would be outweighed by the advantages of cropping fertile floodplain areas.
10. CONCLUSIONS

A two-dimensional cells model (PL2DFLOW) has been successfully used to investigate the extent of flooding and to predict maximum flood depths and velocities due to the 1 in 100 year AEP flood in the Katherine rural area.

Information obtained from the model has been mapped on 1:5000 photogrammetric contour maps. This report and associated maps are intended to assist in the planning of appropriate development of the area and assist with counter disaster planning.
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