BYRON SHIRE COUNCIL

BRUNSWICK RIVER

FLOOD STUDY

NOVEMBER, 1986

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WEBB, McKEOWN & ASSOCIATES PTY. LTD.
CONSULTING ENGINEERS

FOREWORD

The State Government's Flood Policy is directed at providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the policy the management of flood liable land remains the responsibility of local government. The State subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through the following four sequential stages:

1. Flood Study - determine the nature and extent of the flood problem.
2. Floodplain Management Study - evaluates management options for the floodplain in respect of both existing and proposed development.
3. Floodplain Management Plan - involves formal adoption by Council of a plan of management for the floodplain.
4. Implementation of the Plan - construction of flood mitigation works to protect existing development.
   - use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The Brunswick River Flood Study constitutes the first stage of the management process for the Brunswick River catchment and has been prepared for Byron Shire Council to define flood behaviour under current conditions.

BRUNSWICK RIVER
FLOOD STUDY

TABLE OF CONTENTS

LIST OF FIGURES

APPENDICES

1. SUMMARY AND CONCLUSIONS

This study was undertaken to determine flood behaviour in the Brunswick River and adjacent floodplain from the mouth at Brunswick Heads to a point approximately 3km upstream of Mullumbimby. Levels were also obtained in the main southern tributary, Simpsons Creek. The main northern tributary, Marshalls Creek, is the subject of a separate Flood Study.

Hydrological investigations associated with this study are presented in detail in the Hydrology Report (Reference 1).

A quasi-two-dimensional hydraulic computer model of the Brunswick River floodplain was set up and calibrated using data from a flood which occurred in March 1978. The calibration was then tested against data from a flood in February 1976 with satisfactory results.

Inflows to the model were obtained from the Hydrology Report and the downstream boundary conditions were established using ocean levels obtained from a PWD recorder on the Tweed River. Roughness coefficients within the model were adjusted so that heights produced by the model matched observed levels.

The calibration was then tested against data from a flood in February 1976 with satisfactory results.

The calibrated hydraulic model was used to establish behaviour for the 5%, 1% and extreme floods. Upstream inflows were obtained from Reference 1 and downstream tidal conditions were based on work reported in References 3 and 4. Early results indicated that the extreme flood would overflow the coastal sand dunes and adjustments were made to the calibrated model to allow for this.

Results for various actual and design floods are presented in Figures 6 to 10. The differences in height between the historical floods (both with a probability of occurrence slightly greater than 5%) and the 5% event were much greater in the lower reaches of the river than in the vicinity of Mullumbimby. This indicates that storm surge was not significant in either of the observed events.

2. INTRODUCTION

The Brunswick River has a catchment of 220 square kilometres, which rises from sea level at Brunswick Heads to a maximum elevation of 690m. The physical characteristics of the catchment vary from steep, heavily vegetated slopes to open grassed floodplain and flat swamp land behind the coastal dunes. There is no clear demarcation of the catchment boundary in the area of the coastal swamps.

The catchment is drained by four major streams: Marshalls Creek to the north; the Brunswick River and Mullumbimby Creek to the west; and Simpsons Creek to the south.

Most of the population of the valley is concentrated on the extensive floodplain in the lower reaches where the major towns of Mullumbimby and Brunswick Heads are situated. Much of Mullumbimby is flood prone while the future development of Brunswick Heads is severely restricted by the lack of flood-free land.

The general location of the catchment is shown on Figure 1 while Figure 2 shows the floodplain area in more detail.

The study of flood behaviour in the Brunswick River Valley has been carried out in order to assist Byron Shire Council in developing a floodplain management strategy for the valley.

The first stage of this project involved a study of the hydrology of the Brunswick Valley and estimation of flood flows for the 5%, 1% and extreme flood events. The results of this study were published in the Hydrology Report in July 1984 (Reference 1).

This report deals with the calibration and testing of the hydraulic model of the floodplain and assessment of flood behaviour in the valley. The model covers the Brunswick River from the ocean to 3km upstream of Mullumbimby and the main southern tributary, Simpsons Creek, to a point 4.5km from its junction with the Brunswick River. The northern tributary, Marshalls Creek, is the subject of a separate report (Reference 2).

3. APPROACH ADOPTED

The study area includes significant overbank flood storage areas and the hydraulic investigation required a model which would simulate the effects of the floodplain storage and accommodate flows both in the river and into and out of the storage basins. A further requirement was the ability to model unsteady flow conditions and to accomodate several inflows and varying ocean levels.

The model adopted was based on a quasi-two-dimensional computer programme developed by the University of Witwatersrand. This model simulates the study area as a series of interconnected cells and hence is known as the "Cell Model". Some details of the model are given in Appendix B and the cell layout adopted for this study is shown on Figure 3. The model was structured so that possible developments on the floodplain could be evaluated at a later stage without needing to substantially alter and recalibrate the model. A detailed discussion of the model is provided in Reference 5.

The Cell Model was calibrated against data from the flood of March 1978 and tested against the flood of February 1976. It was then used to derive heights throughout the study area for the 5%, 1% and extreme floods.

Input flow hydrographs were derived from Reference 1 and ocean tidal conditions for the design floods from References 3 and 4. The adopted tidal conditions are reproduced in Figure 5.

4. AVAILABLE DATA

4.1 Hydrologic Data

The available hydrologic data were detailed in the Hydrology Report (Reference 1), together with derived design floods from a mathematical runoff routing model which was calibrated against floods experienced in March 1974, February 1976 and March 1978.

In the 1974 and 1978 events the heaviest flood producing rainfalls occurred in the west of the catchment and led to high flows at Mullumbimby. These events were of similar magnitude at the Water Resources Commission gauging station at Durrumbul (upstream of Mullumbimby) and had a probability of occurrence slightly greater than 5%. In 1976 the highest rainfalls occurred to the south over the Simpsons Creek catchment.

Long term rainfall figures in the region were analysed to produce estimates of the 5% and 1% rainfalls and these were input to the calibrated runoff-routing model to produce the 5% and 1% flows. The rainfall for the extreme flood was estimated using a procedure recommended by the Bureau of Meteorology (Reference 6).

4.2 Flood Levels

The Public Works Department (PWD) had obtained a number of peak flood heights in Mullumbimby during previous investigations. These levels are presented on Figure 4.

As a result of extensive investigations by both Council and Consultants a number of levels elsewhere in the floodplain were obtained. Those relevant to model calibration are shown on Figure 2. All available flood level information is listed in Appendix A.

4.3 Survey Data

Hydrographic and topographic data for the river and floodplain were obtained from four sources:

(i) 1:4000 orthophotomaps produced by the Central Mapping Authority.
These cover most of the study area with the exception of a portion south-east of Mullumbimby. The maps have a contour interval of 2m but these contours are derived from photogrammetry and can be subject to considerable error.

(ii) A hydrographic survey taken by the Public Works Department (PWD) in 1983.
This survey included:

- a contour plan of the river bed from the entrance to the Pacific Highway bridge
- 50 cross-sections on the Brunswick River between the Highway bridge and a point upstream of Mullumbimby
- 27 cross-sections on Marshalls Creek
- 18 cross-sections on Simpsons Creek
- 6 cross-sections on Kings Creek.

(iii) A survey of the floodplain carried out by Council in 1983 specifically for this study.

(iv) An additional survey carried out by Council in 1984 which defined areas in and to the south of Mullumbimby in more detail.

Data from the two Council surveys are included in Appendix D.

All levels in this report are to Australian Height Datum (AHD). Other datums used in the area are:

MSD (m) = AHD (m) + 0.260m
BPD (m) = AHD (m) + 0.594m

where MSD = Mullumbimby Sewerage Datum
BPD = Brunswick Port Datum

4.4 Tidal Data

The PWD maintains a series of tide recorders along the New South Wales coast. A recorder was installed at Coffs Harbour in the 1950's and an instrument was installed on the Tweed River in 1977.

Ocean levels at the mouth of the Brunswick were assumed to be coincident with the levels at the closest available recorder. Thus tidal information for the 1976 flood was taken from the Coffs Harbour gauge and data for the 1978 event from the Tweed recorder.

The 5% and 1% design ocean levels adopted for this study were 2.3m AHD and 2.6m AHD respectively. These levels were based on data collected and analysed by the PWD and an investigation by Blain, Bremner and Williams (Reference 3). Design storm tides incorporating the above peak ocean levels are shown in Figure 5.

It should be noted that the levels shown on Figure 5 represent still water levels and do not take into account the effects of wave grouping or runup. As such they are appropriate for use as the downstream boundary condition for an investigation of river hydraulics but cannot be used for the consideration of back beach inundation.

5. CALIBRATION AND TESTING

5.1 Selection of Suitable Flood Events

The Hydrology Report identified three floods for which adequate rainfall and streamflow data were available to enable calibration and testing of the hydrologic model. These floods occurred in March 1974, February 1976 and March 1978.

A reasonable amount of flood level data were available for the March 1978 event. Most of the data were at Mullumbimby while minimal data were available elsewhere. As this was the best data set available, the 1978 flood was used to calibrate the Cell Model.

Two flood levels were available for the February 1976 flood. One of these was at Kings Creek, in the middle of the study area, and the other at Mullumbimby, at the upper end of the study area. Although limited, these data were useful for testing the calibrated model.

One observed flood level was available for the March 1974 event and that was at Brunswick Heads. Because this height was near the downstream end of the study area, it was of little value for calibration or testing of a model of the entire floodplain. Consequently this flood was not used in the testing procedure.

5.2 Calibration - March 1978

Inflow hydrographs for the March 1978 flood were obtained from the Hydrology Report and ocean levels from the Tweed River gauge. Given these inputs, the model was calibrated by adjusting the roughness coefficient (Manning's 'n') of cross-sections and weirs to obtain a close fit to the observed flood levels.

The results from the calibrated model are shown on Figures 6 and 7 together with the observed heights. The fit to observed levels was within the order of accuracy of the model throughout (see Appendix B).

The adopted values of 'n' are listed in Appendix B.

5.3 Test - February 1976

Flows and ocean hydrographs for the February 1976 flood were applied to the calibrated model. In this case the ocean levels were obtained from the Coffs Harbour gauge. Figure 6 shows the flood profile produced by the model and Figure 7 shows peak heights and the observed levels. The modelled and observed levels were within 0.03m at Mullumbimby while the modelled level was 0.17m lower than observed to the south of the town. These values were within the order of accuracy of the model and confirmed the calibration.

6. DESIGN FLOODS

Flooding in the Brunswick River is usually produced by either tropical cyclones or east coast lows. As these phenomena also produce storm tides, both flows and ocean levels were considered in deriving the design floods.

Data on the magnitude of design streamflows and design ocean levels were available from various sources as discussed in Sections 4.1 and 4.4.

Reference 4 suggests that the one meteorological event would produce rainfalls and ocean levels of approximately the same probability of occurrence. Thus, for example, 5% catchment flows and 5% ocean levels would occur in the same event to produce the 5% flood. The 5% and 1% events were modelled in this way, however, as no estimate of an extreme ocean level was available, the extreme flood was modelled as a combination of extreme flow and the 1% ocean level.

Reference 4 also suggests that, for a catchment like the Brunswick, maximum rainfall intensities would occur when a cyclone crossed the coast and peak surge tides would occur at the same time. The design flows and tides were therefore input to the Cell Model with this relative timing.

Due to the effects of storage and travel time within the catchment, the model indicated that the peak flow at the entrance occurred approximately four hours after the peak ocean level. The sensitivity of flood levels to the relative timing of peak flow and ocean level was analysed and the results are presented in Appendix C.

Extreme flood flows were approximately double the 1% flows and flood behaviour was very difficult to maltohM Hsa Aabb Zrlab _as first run with the same layout as used for the 5% and 1% floods with all the flow passing through the river mouth. This gave peak flood levels in the lower reaches of Marshalls and Simpsons Creeks which were significantly above the level of the sand dunes separating the creeks from the ocean. Clearly this was not a realistic result as flood waters would flow across the dunes.

In order to approximate the actual situation more closely, the following assumptions were made:

- Marshalls Creek would break out to the ocean approximately 1km from its confluence with the Brunswick and virtually no flow would enter the modelled area.

- the sand dunes to the east of Marshalls Creek in the modelled area would be overtopped and scour to about 1.0m AHD. This would provide an alternate outlet for main river flow.

- Simpsons Creek would overflow the dunes at various points outside the modelled area. For this reason, the flow into the model was adopted as half that calculated by the hydrologic model.

- there would be no overflow of the dunes east of Simpsons Creek in the modelled area because these are above flood level and well vegetated to resist scour.

- flow would occur over parts of the Highway not previously flooded and hence some would bypass the restrictions in the main river in the vicinity of the marina.

The amendments made to the model to reflect these conditions are discussed in Appendix B.

The possibility of other floods overtopping the sand dunes was also considered. The heights produced for the 1% flood indicated that this event would be very near to overtopping the dunes but would probably not cause major breakouts. Thus the modelling of the 1% flood using the original model layout was considered realistic.

7. RESULTS

The longitudinal peak height profiles of both the historical and design floods are shown on Figure 6. Maps showing design flood level contours and average velocities are included as Figures 8 to 10. The area between Mullumbimby and Brunswick Heads is characterised by a flat flood gradient and for this reach flood levels may be obtained directly from Figure 6. Upstream of Mullumbimby the contours shown on Figures 8 to 10 should be utilised. The velocities shown on these Figures are peak average values taken at right angles to the cell boundaries of the model. Localised velocities could be considerably higher than the average figure due to the effects of local obstructions to flow which were not considered in the model.

With regard to the historical floods, the model reflected the different mechanisms involved in the 1976 and 1978 floods (Section 4.1). The 1978 event was higher in the vicinity of Mullumbimby while the 1976 flood was higher in the lower reaches. The 5% flood was considerably higher than either in the lower reaches, largely because of the effect of ocean conditions. The available records indicate that ocean levels were close to normal in both years with a peak level of 0.5m AHD in 1976 and 0.4m AHD in 1978. The peak ocean level in the 5% flood is predicted to be 2.3m AHD.

The influence of the restricted ocean entrance is also evident. The relatively flat slope of the 5% and 1% floods between CS21 and CS7 indicates that the narrow channel at the entrance controls levels to a large degree in this area. The effect was not evident in the historical floods, partly because the flows were lower and partly because flows on the rising limb of the hydrograph were not held back by high ocean levels.

The results for the extreme flood using the modified model (see Section 6) are indicated on Figure 6. The extreme flood was up to 1.4m higher than the 1% event around the Kings Creek junction in the middle reaches of the floodplain. The difference in levels decreased to approximately 0.8m at Mullumbimby. This was because the town itself became a major flow path in the extreme event.

8. ACKNOWLEDGEMENTS

The report was compiled by engineering consultants Webb, McKeown & Associates Pty Ltd. Conduct of the study was overseen and supervised by the River and Ports Branch of the Public Works Department.

During the course of the study co-operation was received from landowners and householders in the Brunswick River catchment and from Byron Shire Council and the Byron Flood Committee. Their assistance is gratefully acknowledged.

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The Estimation of Probable Maximum Precipitation in Australia - Past and Current Practice, AWRC Conference
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FIGURES

FIGURE 1

LOCALITY PLAN

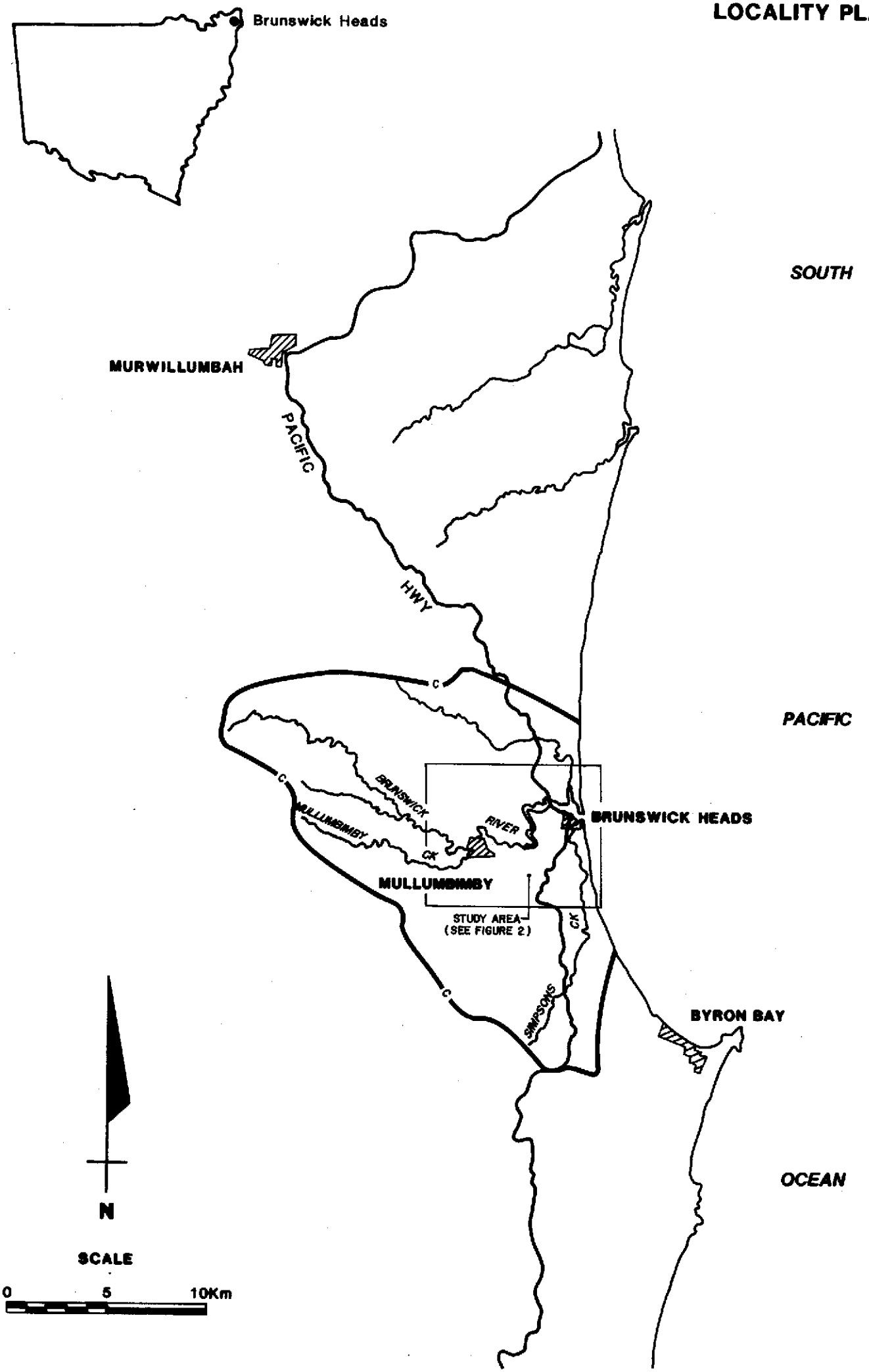


FIGURE 2

STUDY AREA

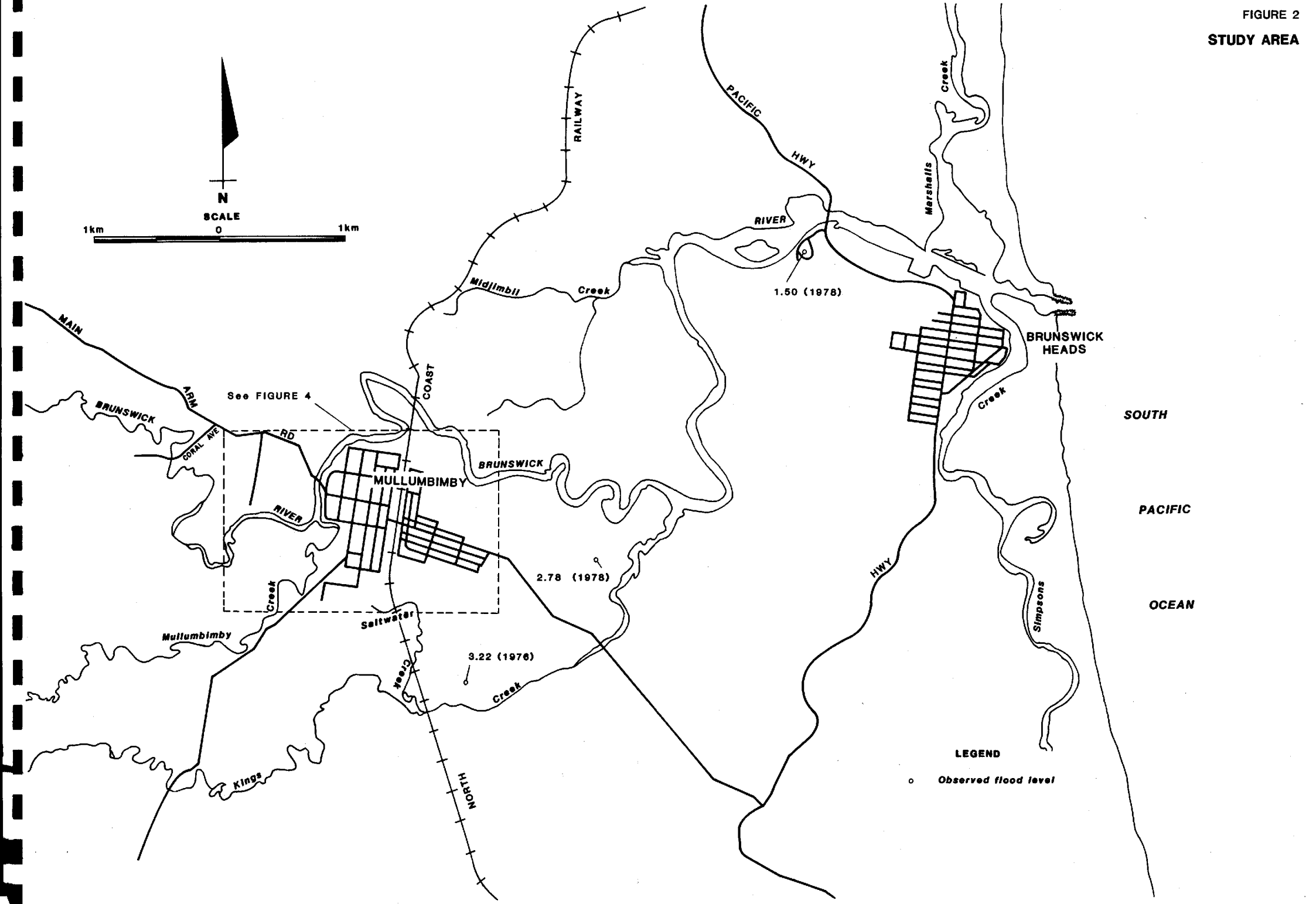


FIGURE 3

CELL LAYOUT

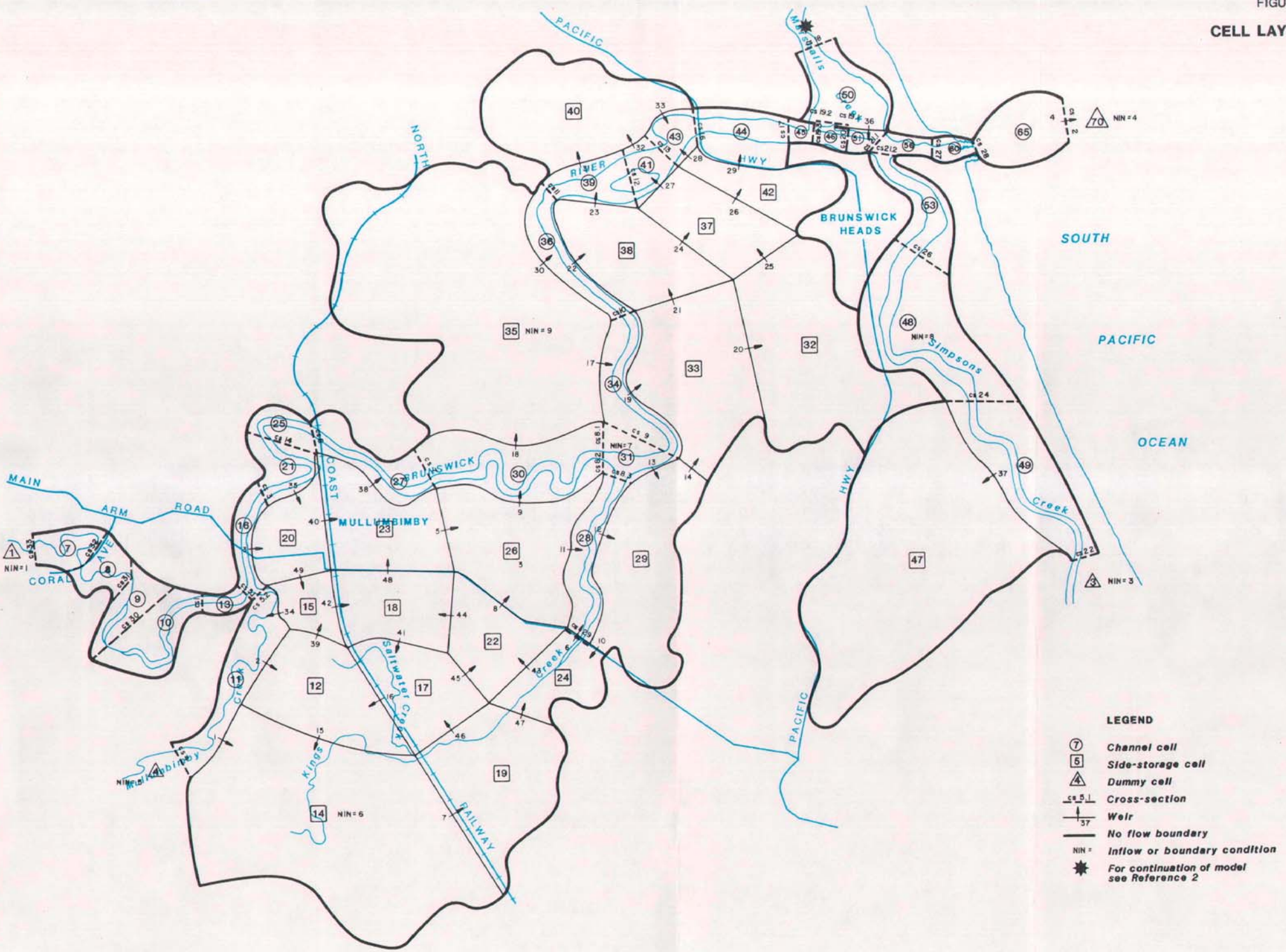


FIGURE 4

MULLUMBIMBY
HISTORICAL FLOOD LEVELS

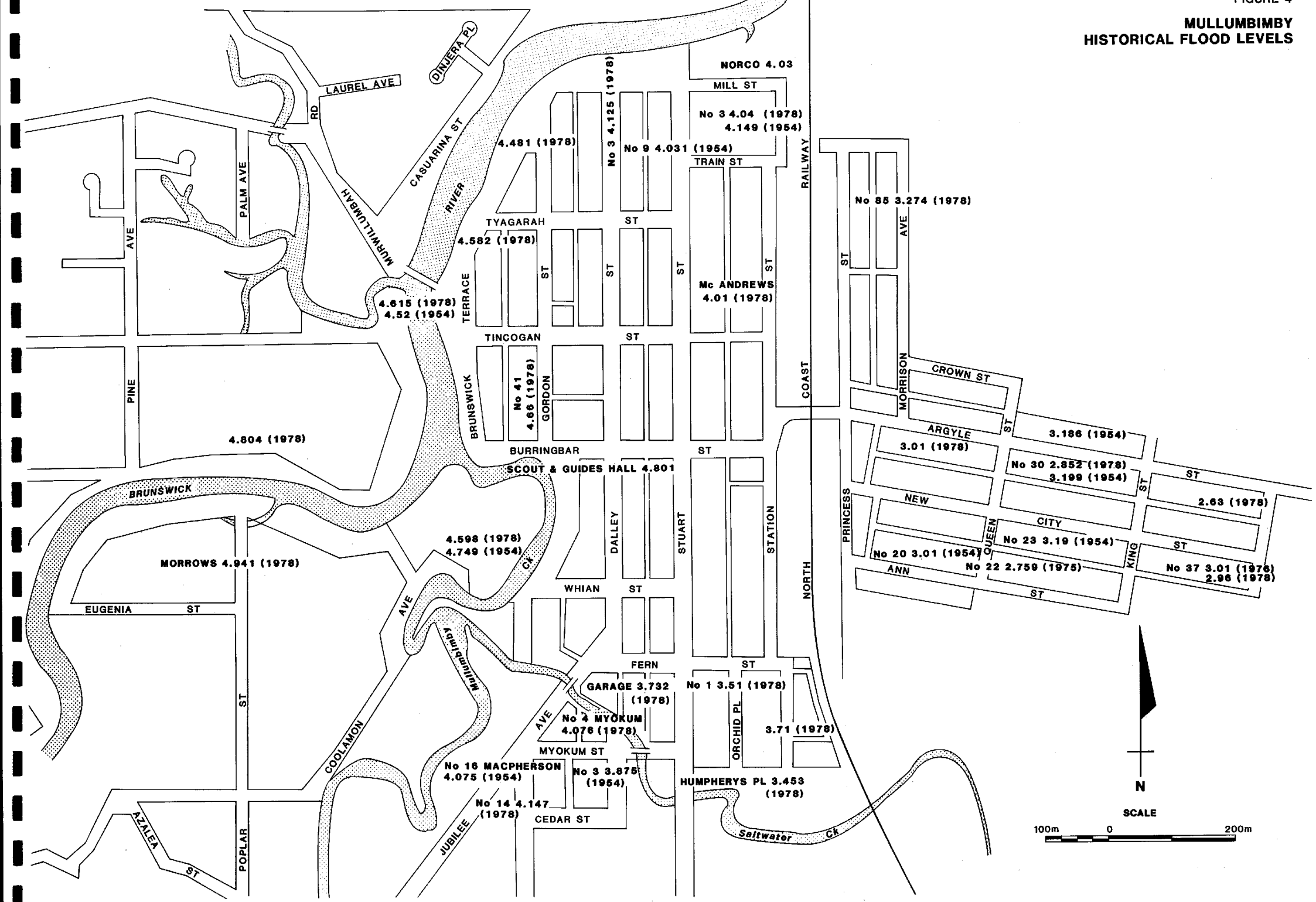
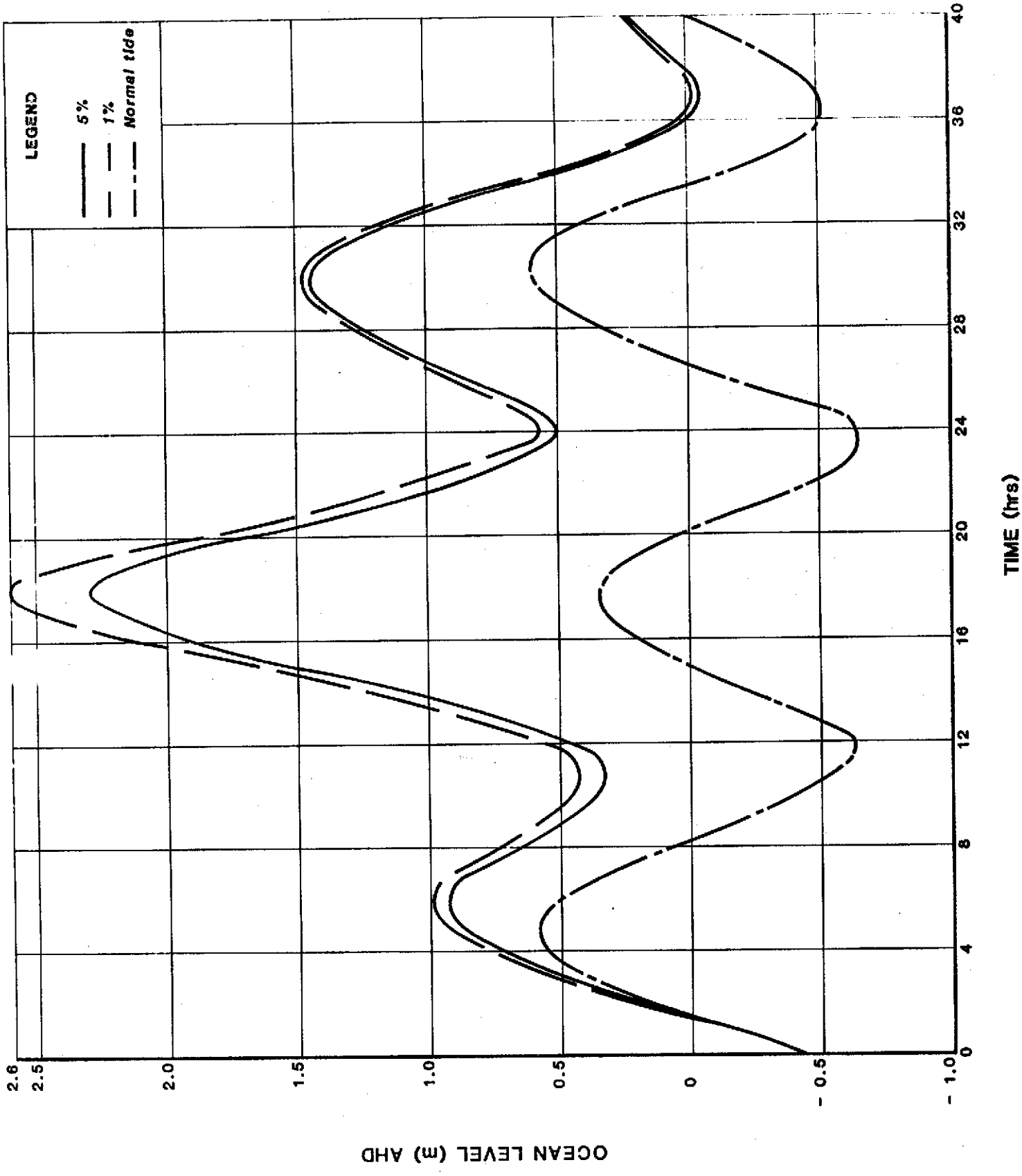


FIGURE 5

DESIGN TIDES



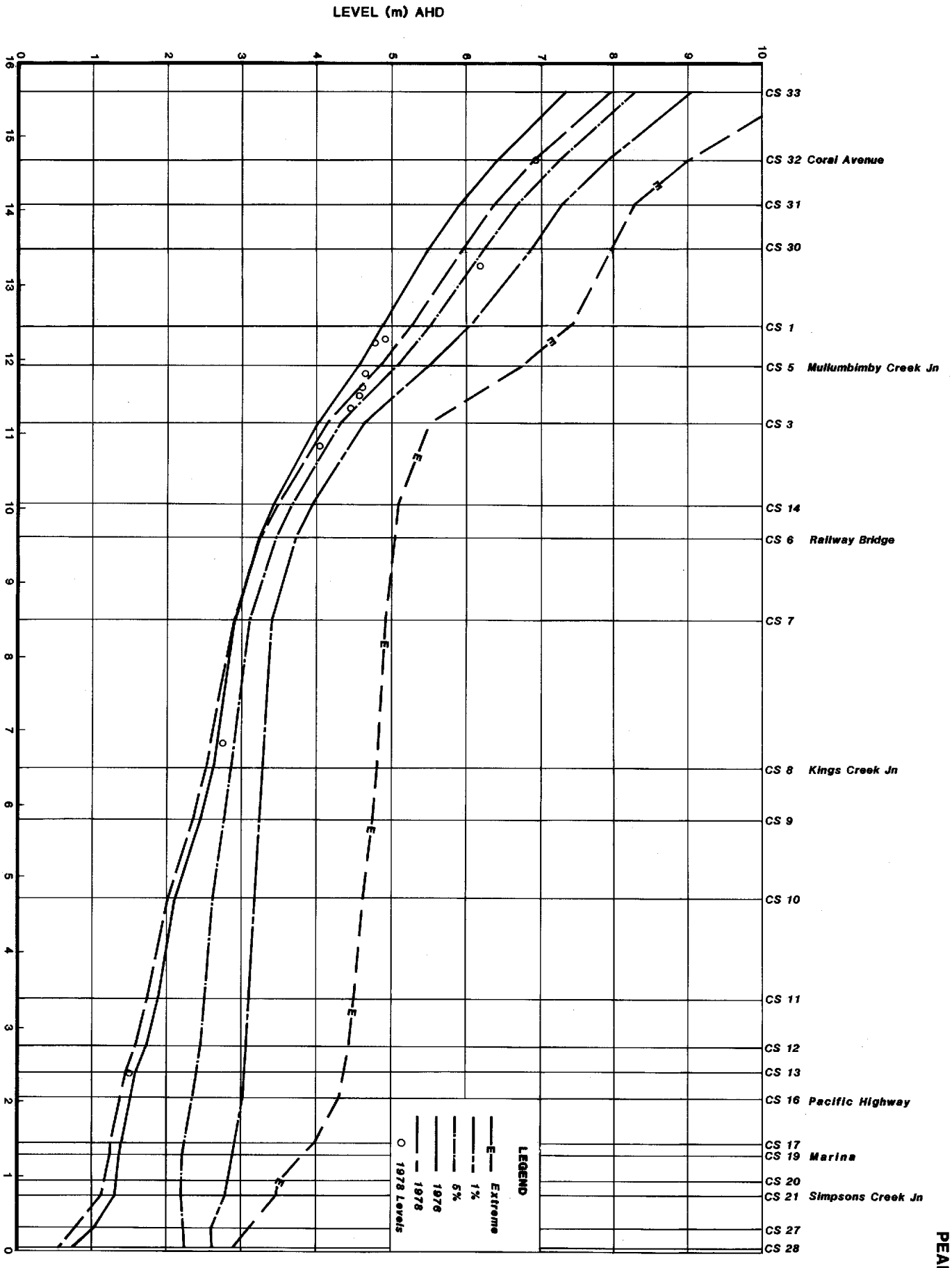
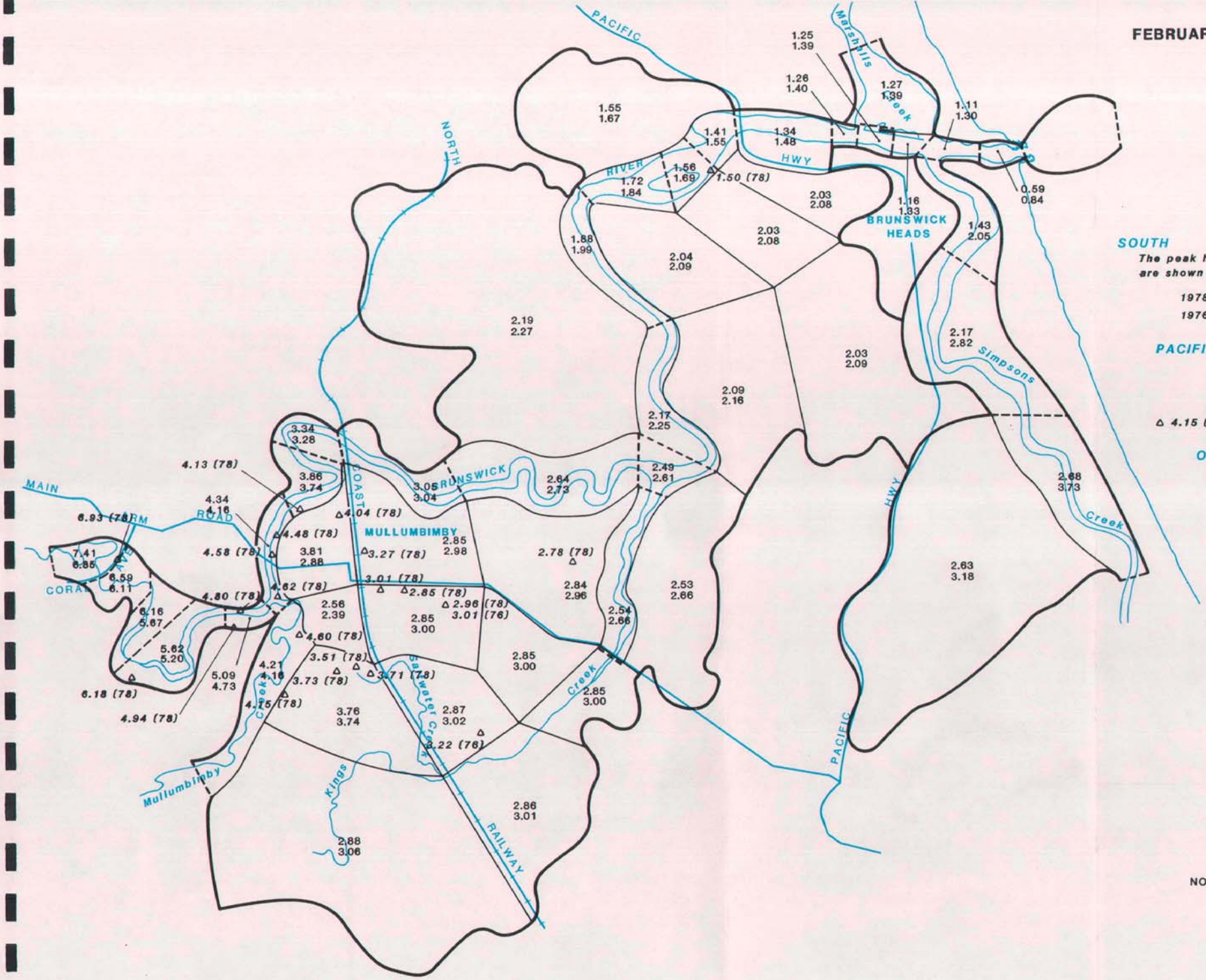


FIGURE 6

PEAK HEIGHT PROFILES

FIGURE 7

FEBRUARY 1976 AND MARCH 1978 PEAK HEIGHTS



NOTE: Heights are in m AHD

FIGURE 8

1% FLOOD CONTOURS AND VELOCITIES

LEGEND

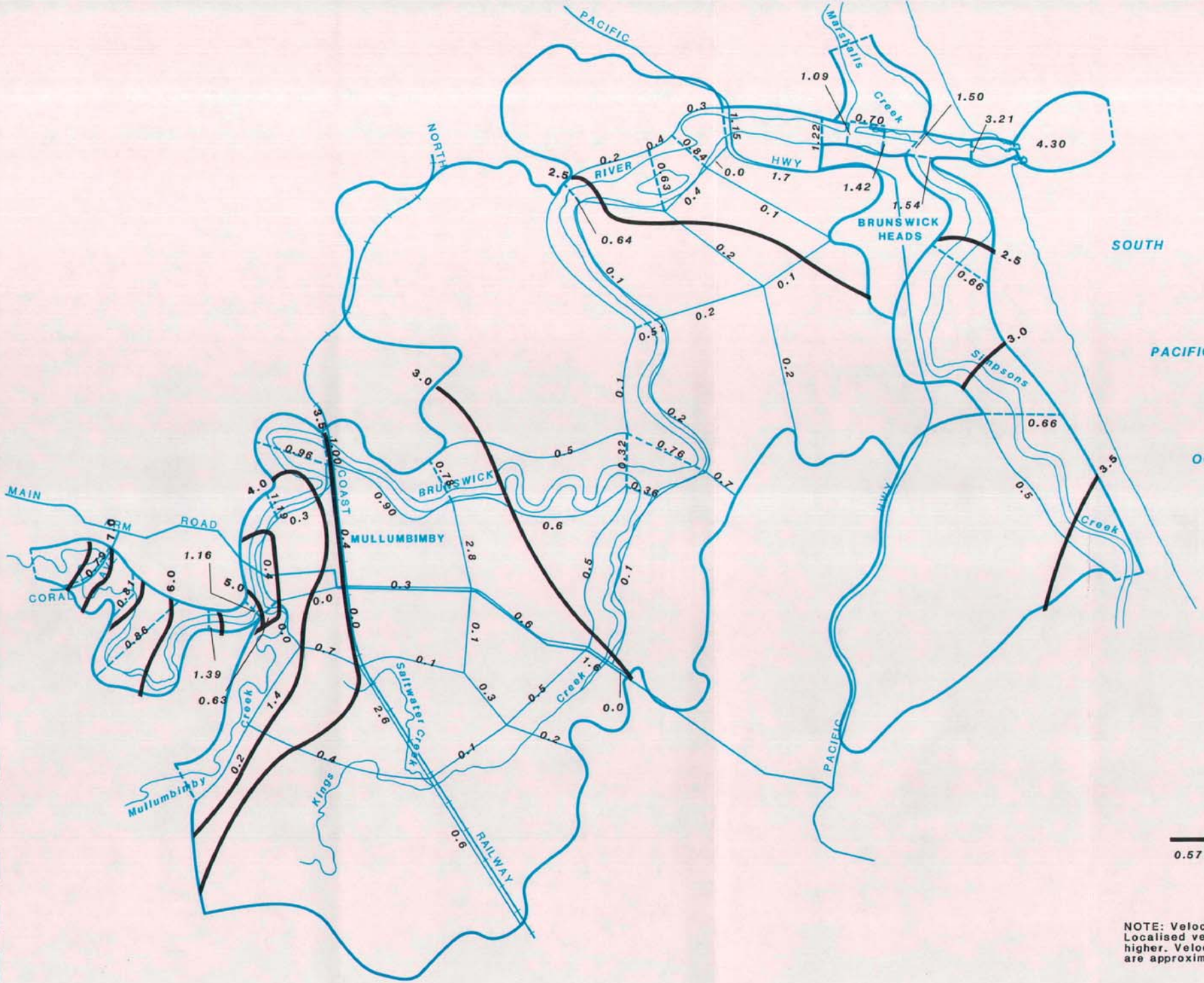
— *Peak height contour (mAHD)*

0.81 *Peak average velocity (m/s)*

NOTE: Velocities shown are average values. Localised velocities could be considerably higher. Velocities in overbank areas are approximate only.

FIGURE 9

5% FLOOD CONTOURS AND VELOCITIES



LEGEND

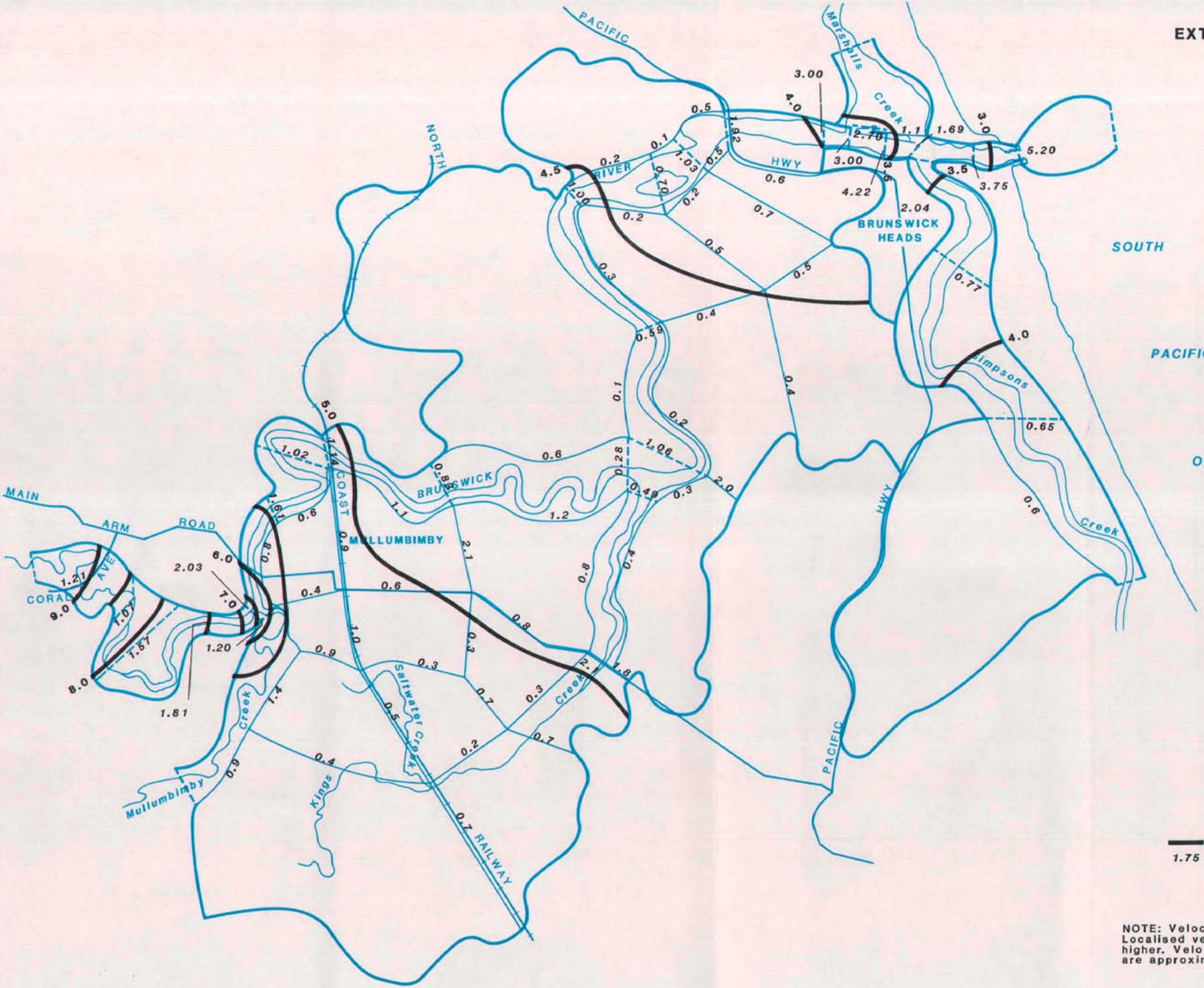
— *Peak height contour (mAHD)*

0.57 *Peak average velocity (m/s)*

NOTE: Velocities shown are average values. Localised velocities could be considerably higher. Velocities in overbank areas are approximate only.

FIGURE 10

EXTREME FLOOD CONTOURS AND VELOCITIES



LEGEND

— *Peak height contour (mAHD)*

1.75 *Peak average velocity (m/s)*

NOTE: Velocities shown are average values. Localised velocities could be considerably higher. Velocities in overbank areas are approximate only.

APPENDICES

March 1978

Mullumbimby	2.63	Argyle Street area	PWD
	2.85	30 Argyle Street	PWD
	2.96	37 New City Street	PWD
	3.01	Argyle Street	PWD
	3.14	Cnr Poinciana & Morrison Sts	PWD
	3.27	85 Prince Street	PWD
	3.45	Humphery's Place	PWD
	3.51	1 Orchid Place	PWD
	3.71	Station Street	PWD
	3.73	Garage on Fern Street	PWD
	4.01	31 Station Street	PWD
	4.03	Mill Street	PWD
	4.04	3 Station Street	PWD
	4.08	4 Myocum Street	PWD
	4.13	3 Dalley Street	PWD
	4.15	14 Jubilee Avenue	PWD
	4.48	Brunswick Terrace	PWD
	4.58	Brunswick Terrace	PWD
	4.60	Coolamon Avenue	PWD
	4.62	Federal bridge	PWD
	4.66	41 Burringbar Street	PWD
	4.80	Burringbar Street Scout Hall	PWD
	4.94	Poplar Street	PWD
	5.24	Chinbible Avenue	PWD
	6.18	Lot 12 Azalea Street	PWD
	6.93	Coral Avenue	PWD
Kings Creek	2.78	Homestead	WMA
Brunswick Heads	1.50	Mr Frith's House Riverside Crescent	WMA

APPENDIX B
THE CELL MODEL

B1 General

The Cell Model represents a river channel system and adjoining floodplain as a series of "cells" which are interconnected either by channel cross-sections or weirs as appropriate.

Input data are:

- A description of the cell network and connecting cross-sections and weirs.
- The topography and roughness of each cross-section. This is processed by a separate programme which calculates the hydraulic parameters of each section at given height increments and outputs the results to a file which then forms part of the input for the main programme.
- A height-discharge relationship for each weir.
- An elevation-surface area relationship for each storage.
- The initial water level in the centre of each cell.
- Boundary conditions, which consist of either a stage hydrograph or a discharge hydrograph.

At pre-determined time increments the programme outputs:

- The height at the centre of each cell.
- The flow across each weir.
- The flow, average velocity and height at each cross-section.

A detailed description on the programme can be found in Reference B1. This Appendix gives some details of the approach adopted in setting up and calibrating the Cell Model for simulation of the Brunswick Valley. Further details are given in the Computer Manual (Reference B2).

B2 BRUNSWICK MODEL

B2.1 Cell Layout

The cell layout adopted for this study is presented on Figure 3. The layout was designed to give as accurate a representation as possible of flow paths within the limitations of the scale of the area to be modelled.

Major obstructions that were modelled included: the highway (Weir 29) and highway bridge (CS 16); the railway (Weirs 7, 16, 40, 42) and railway bridge (CS 6); the Mullumbimby-Brunswick Heads road (Weirs 8, 10, 48); and the retaining walls near the entrance (CS 19.3, 20, 21.1, 27, 28). Natural features such as the island upstream of the highway were included (CS 12) and most of the weirs follow natural ridges.

B2.2 Cross-sections

Topographic data and river chainages were obtained primarily from the PWD survey. For each cross-section, a series of points defined by level and distance was input to the programme XSECT (Reference B2), which produced a table of various hydraulic values at selected height increments. This table formed one of the inputs to the Cell Model.

The distance between cross-sections is calculated by the Cell Model from the respective river chainages but this can be overridden from the cell layout input file. In the Brunswick model the calculated chainage was used throughout, except for Cell 65 where the chainage was adjusted to place the centre of the cell at the river bar.

Manning's 'n' values were initially estimated from site inspections and the orthophotomaps and subsequently modified during calibration.

B2.3 Weirs

The lengths and crest levels of the weirs were obtained principally from the two Council Surveys and the PWD survey, interpreted where necessary by reference to orthophotomaps. Aerial photographs and field visits also provided information.

A table of height versus flow was required for each weir. To obtain these relationships each weir was idealised as a series of horizontal crests the height and length of which were estimated from the survey data. The flows were then calculated using a procedure based on that given in Reference B3. Manning's 'n' values were estimated by comparison with the values obtained for cross-sections.

B2.4 Storage Areas

Storage capacities for channel cells are calculated by the Cell Model using cross-section data. The information for each side storage cell was entered as an elevation versus surface area table.

Data were obtained principally from the orthophotomaps in conjunction with the Council surveys. Aerial photograph stereo pairs at 1:16 000 (November 1980) and information gathered from several site visits were also used. The boundaries of the storage basins at various levels were traced and the areas enclosed derived by planimetering.

B2.5 Boundary Hydrographs

Boundary inflow hydrographs were derived from the Boyd Model analysis carried out in the Hydrology Report. Other inflows were input directly into cells within the model to represent rainfall on these areas and those nearby. The inflows were calculated from the isohyetal maps in the Hydrology Report.

The downstream ocean level hydrograph was derived from historical data for the calibration floods and the curves presented in Figure 4 for the design conditions.

B3 CALIBRATION

The model was calibrated against the March 1978 flood by adjusting Manning's 'n' values for both cross-sections and weirs. Initially cross-section values were adjusted to obtain a reasonably close fit to the observed data. Flows through the weirs were then adjusted so that their 'n' values bore a realistic relation to the values for the cross-sections. Finally the model was fine tuned with small adjustments where necessary. Calibration was achieved with physically realistic values of Manning's 'n' in all cases.

The values adopted for the various cross-sections are listed in Table B1.

B4 MODIFICATIONS FOR THE EXTREME FLOOD

Section 7 lists the assumptions made regarding flow patterns in the extreme flood. These were reflected in the model by the following adjustments:

- Input hydrograph 2 reduced to a maximum of 150m^3/s.
- Input hydrograph 3 reduced to half the values calculated by the hydrologic model.
- Weir 50 added linking Cell 50 and Cell 65. This weir was originally set above 4m AHD and made to breach to 1.0m AHD at t = 6 hours. This meant that the weir excluded backflow from the peak ocean level and gave a reasonable simulation of the dunes breaching.
- Weir 51 was added linking Cell 42 and Cell 46 to represent additional flow over the Highway.

TABLE B1

Adopted Manning's 'n' Coefficients

Cross-section	Manning's 'n'	Cross-section	Manning's 'n'
1.1	.030	17	.030
1.2	.030	18.1	.130
1.3	.030	18.2	.035
2	.030	18.3	.130
3.1	.060	19.1	.035
3.2	.060	19.2	.035
4	.060	19.3	.030
5.1	.060	20	.030
5.2	.060	21.1	.025
6	.050	21.2	.030
7.1	.070	22.1	.110
7.2	.060	22.2	.060
7.3	.110	22.3	.090
8.1	.090	24.1	.110
8.2	.060	24.2	.060
8.3	.060	24.3	.130
9.1	.130	26.1	.110
9.2	.060	26.2	.060
10.1	.110	26.3	.130
10.2	.060	27	.035
10.3	.090	28	.025
11.1	.110	29	.020
11.2	.060	30.1	.045
11.3	.090	30.2	.050
12.1	.040	30.3	.080
12.2	.130	31.1	.065
12.3	.040	31.2	.085
13.1	.130	31.3	.045
13.2	.040	32.1	.065
13.3	.110	32.2	.095
14.1	.060	32.3	.065
14.2	.040	33.1	.090
16	.030	33.2	.055

B5 ACCURACY AND LIMITATIONS

The model was calibrated and tested against the floods of March 1978 and February 1976 with good agreement. However, there were shortcomings with the data as follows:

- the floods available for calibration (Section 4.1) were of similar magnitude with a probability of occurrence of approximately 5%. Therefore it was not possible to test the model over a range of larger flows.

- with the exception of Mullumbimby for the 1978 flood, observed data consisted of single, isolated points. Experience has shown that such marks, even when observed by careful and reliable people, can vary from the true flood level by 0.2m or more. The scatter of levels in Mullumbimby in 1978 is a good example of this problem.

These considerations lead to the following comments on model accuracy:

- the absolute accuracy of flood levels reproduced by the model is of the order of $\pm$ 0.2m.

- since the model has not been tested for flows with a probability of occurrence less than approximately 5% there is no observational confirmation of flow patterns predicted for the 1% and extreme floods. This is particularly relevant in the vicinity of the Pacific Highway where flows over the road in the historic floods were minimal, while in the 1% event the flow became highly significant, being of the same order of magnitude as the flow in the river. While this appears a reasonable result it cannot be tested quantitatively until a larger flood occurs. Further comments on the extreme flood are included in Section 6.

B6 REFERENCES

B1 Public Works Department of NSW
CSA Time-Sharing Terminal Users' Manual for Programme SAMOD,1981.

B2 Byron Shire Council
Brunswick Valley Cell Model Manual
Webb, McKeown & Associates Pty Ltd, 1986.

B3 Richmond River County Council,
Tuckurimba Levee Effect on Flood Levels
July 1980.

APPENDIX C
SENSITIVITY TO RELATIVE TIMING OF FLOW AND OCEAN CONDITIONS

Section 6 discusses the relative timing of streamflow and ocean levels. To check the sensitivity of flood levels to the stated assumptions, four runs of the 1% flood were made with relative timing varied as follows:

Run A - peak rainfall coincided with peak tide (the assumption adopted in Section 6). The lag time of the catchment meant that the peak flow occurred approximately 4 hours after the peak ocean level.

Run B - peak flow coincident with peak ocean level

Run C - peak flow coincident with neap ocean level after peak (i.e. approximately 6 hours after the peak ocean level)

Run D - peak flow coincident with second high ocean level (i.e. approximately 12 hours after the peak ocean level).

The results of these four runs are shown in Figure C1.

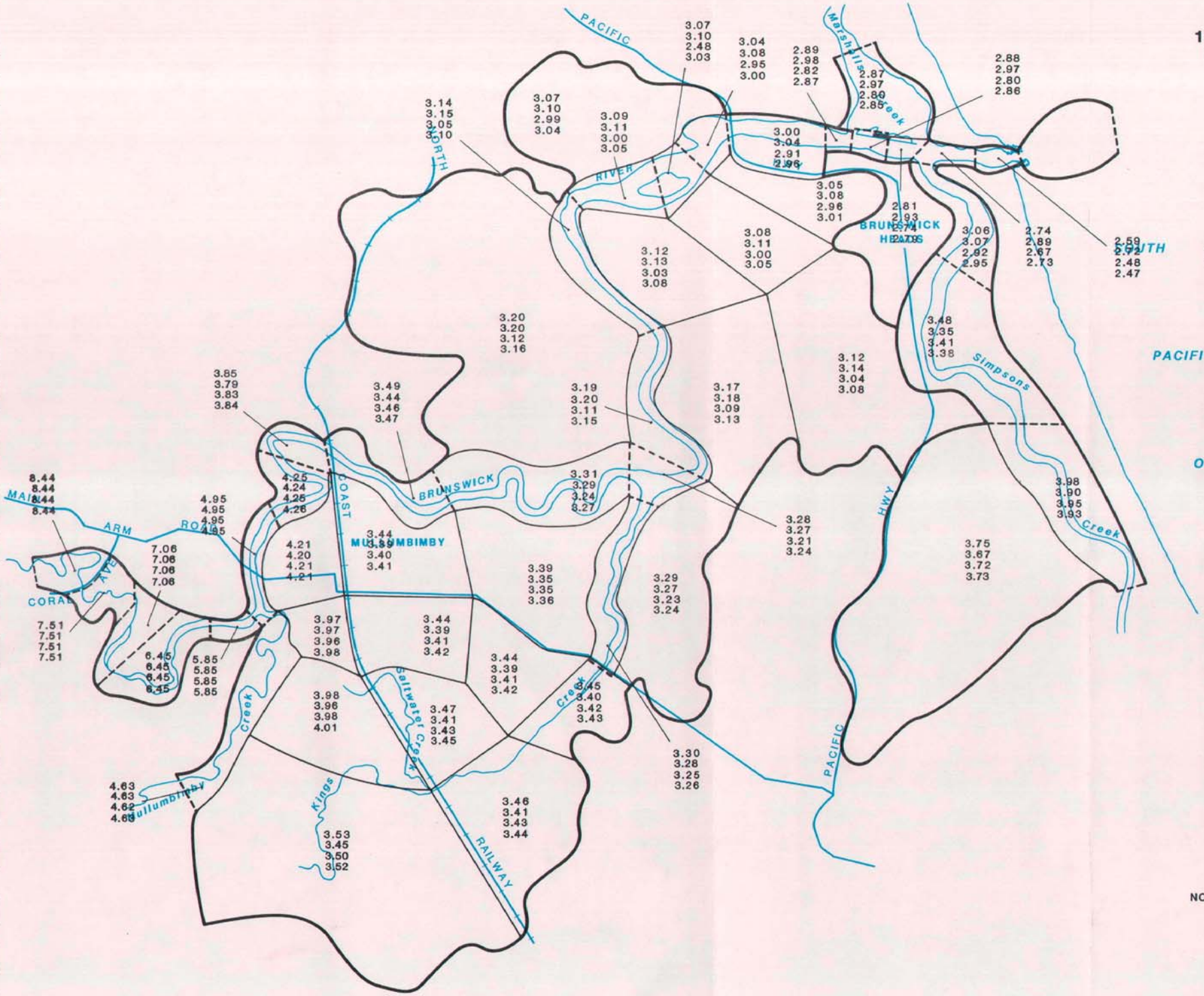
Run B produced the greatest levels in the downstream reaches being 0.15m higher than Run A just inside the entrance and 0.05m higher near the Pacific Highway bridge. Upstream of the Highway the maximum difference was 0.04m and this quickly decreased. At the Kings Creek junction, Run A was higher by 0.01m, while at the Mullumbimby railway bridge it was higher by 0.05m. Throughout most of this reach, Runs C and D were lower than either Run A or B, however, at the railway both Runs C and D were up to 0.05m above Run B and within 0.02m of Run A. Above the railway bridge the effect of ocean conditions was negligible.

Run A was higher in the middle reaches because the high ocean level, occurring four hours before the peak flow, restricted outflow from the river leading to an increase in storage in overbank areas. The effect of the increased storage, coupled with a still abnormally high ocean level, was greater than the effect of the higher ocean level alone as simulated in Run B.

Overall, this analysis indicated that, away from the immediate vicinity of the entrance, flood levels were not significantly affected by the assumption on relative timing.

FIGURE C1

1% FLOOD - SENSITIVITY TO RELATIVE TIMING OF FLOW AND OCEAN CONDITIONS



The peak heights in each cell are shown in the following order

Run A
Run B
Run C
Run D

NOTE: Heights are in m AHD

APPENDIX D
SURVEY DATA

As listed in Section 4.3 a considerable amount of survey data was already available for this study including a hydrographic survey conducted by the PWD in 1983. There was a need to extend these data, especially in overbank areas to provide the information required for the Cell Model. The additional survey was supplied by Byron Shire Council and is detailed below. Figure D1 shows the location of the various survey lines.

DATUM: 100m below AHD
Chainages in metres

LINE A

Under transmission line crossing Synotts Lane.

Chainage	Surface Level	Details
00	106.65	All of section passes through well
100	103.49	grazed paddock with very few trees.
200	102.72	Paddocks are criss-crossed with
300	102.83	many shallow drainage ditches. Between
400	102.53	Ch 700 & Ch 1080 ground appears
500	102.46	permanently water soaked.
600	102.25	
700	101.96	
800	101.45	
900	101.18	
990	101.11	
1080	101.67	
1190	103.21	
1225	105.02	

LINE B

Under transmission line north of Ocean Shores Sewerage Treatment Works.

Chainage	Surface Level	Details
00	107.56	Cleared paddock not grazed some
40	105.60	weed to 1.5m high
110	102.25	
180	101.37	
290	102.03	Bolt in centre of road
375	101.10	
390	101.13	From Ch 375 to Ch 770 cleared of
470	101.19	timber, however grass up to 2.1m
570	101.02	high over permanently wet ground.
680	100.98	
770	101.20	
820	101.83	Swamp ends
825	103.14	
875	105.00	
910	106.49	
940	104.41	Small gully
965	106.85	
1040	118.95	

LINE C

From north bank of main arm opposite Kings Creek junction runs north west and thence north east to junction of Midjimbil Creek and Main Arm of river.

Chainage	Surface Level	Details
00	101.78	From Ch 00 to Ch 430 light timber
50	101.66	and grass to 1.2m high
100	101.63	
195	101.59	
280	101.79	
375	101.94	
430	102.26	From Ch 430 to Ch 845 dense timber
475	101.94	and thick undergrowth.
590	101.90	
705	101.71	
845	101.66	From Ch 845 to Ch 1075 along
965	102.48	cleared track, light timber.
1075	102.39	From Ch 1075 to Ch 1525 cleared, well
1125	102.41	grazed paddock.
1225	102.28	
1325	102.49	
1425	102.03	
1525	101.51	Ch 1525 to Ch 2215 some timber and
1625	101.73	grass generally up to .9m high.
1665	101.62	
1715	101.63	
1765	101.79	
1815	105.33	
1865	110.98	
1915	107.90	
1965	107.06	
2015	104.61	
2075	101.35	
2115	101.43	
2155	101.32	
2165	101.32	
2215	101.23	
2280	101.34	Midjimbil Creek IL approx 99.2
2330	101.59	Approx 30m water way.
2390	101.63	Ch 2330 to Ch 2697 cleared paddock
2490	101.77	well grazed.
2590	101.61	
2697	101.52	
2795	101.33	Ch 2795 to Ch 2881 dense oak forest
2831	101.39	with clear floor.
2881	101.40	
2917	100.65	On mangrove flat
2965	101.33	On spit between mangroves
3015	100.37	On mangrove flat
3065	100.55	On mangrove flat
3100	100.24	On mangrove flat

LINE D

From Ch 2831 of Line "C" north east onto ridge.

Chainage	Surface Level	Details
93	101.19	
154	103.01	Between Ch 93 & Ch 154 drain with IL
178	105.50	approx 99.60.
203	108.94	

LINE E

Extension of Cross-section CS 25 (PWD) south east to ridge.

Chainage	Surface Level	Details
00	102.55	Ch 00 to Ch 150 cleared paddock.
40	102.54	Ch 150 to Ch 390 generally well
150	101.96	grazed with light timber.
190	101.38	
240	101.11	At Ch 240 drain runs 90^{0} to section
250	101.26	line IL 100.73.
290	101.73	
315	102.48	
340	104.33	
360	107.00	
390	111.60	

LINE F

Extension of Cross-section CS 301 (PWD) south east to ridge.

Chainage	Surface Level	Details
00	101.43	Ch 00 to Ch 50 thin oak forest
27	101.29	
50	100.62	Ch 50 mangrove swamp
100	100.92	
150	101.21	Ch 150 to Ch 300 clear, well grazed
200	101.17	paddock
250	101.04	
300	101.19	Base of earth mound.
325	105.61	Outcrop from ridge.
350	101.21	Base of mound.
400	101.39	Ch 400 to Ch 450 dense timber cover
415	102.43	
450	106.84	Ch 450 to Ch 475 clear grass onto ridge
475	111.38	

LINE G

Additional section requested during field inspection

Chainage	Surface Level	Details
00	101.73	Ch 00 to Ch 760 generally uncleared
90	101.58	paddock with heavy timber, some dense
180	101.30	undergrowth, well grazed.
270	101.33	
315	101.17	Bank of mangrove
317	100.66	Sand flat
332	99.90	IL of water
350	100.72	Sand flat
352	101.18	Bank of creek
450	101.14	
540	101.56	
630	101.34	
720	101.23	
760	101.38	Ch 760 to Ch 1700 along cleared fence
845	101.29	however paddock both sides very heavy
860	101.36	timber and dense undergrowth exceeds
960	101.62	1.8m high. Ch 845, 450mm dia culvert
1060	101.88	IL 100.59.
1160	102.56	
1260	101.60	
1300	101.75	Ch 1300 1200mm dia culvert IL 110.40
1335	101.65	
1360	101.89	
1460	102.80	
1560	102.47	
1660	102.68	
1700	103.27	Ch 1700 to Ch 1890 cleared paddock
1800	103.19	well grazed with light timber
1825	103.37	
1855	105.60	Following track up the ridge.
1890	109.65	

LINE H

Along Rous County watermain from Bashforth's access track north to Riverside Crescent.

Chainage	Surface Level	Details
00	102.19	CL of Bashforth's Road
100	101.78	
200	102.43	Drain @ Ch 120 IL 101.28
300	102.85	
400	102.24	
500	101.59	Drain @ Ch 490 IL 100.83
600	102.62	Drain @ Ch 555 IL 101.57
700	102.21	
800	102.63	
900	102.71	
1000	102.55	
1100	102.16	Drain @ Ch 1130 IL 101.70
1200	102.34	
1300	102.60	
1354	101.47	Base of drop off from ridge
1400	101.16	
1500	101.36	Section from Ch 00 to Ch 1400 along
1600	101.25	cleared track through generally dense
1695	101.46	heath scrub approx 1.8m and higher.
1800	101.40	Ch 1400 to Ch 1800 across cleared
1900	101.23	paddock well grazed. Ch 1800 to
1965	101.23	Ch 1965 through oak trees with clear floor.

LINE I

From Cudgen Street north west to Riverside Crescent.

Chainage	Surface Level	Details
00	101.68	Top of kerb Cudgen Street
40	101.30	Ch 00 to Ch 240 along cleared track
140	101.37	through tall timber and thick
240	101.42	undergrowth.
360	101.23	Ch 240 to Ch 870 across cleared
480	101.02	paddock, well grazed, criss-crossed
580	100.95	with many shallow drains. Ch 870
680	100.81	to Ch 1040 through oak trees and clear
780	101.02	floor.
870	100.98	
970	101.04	
1040	101.24	

LINE J

Under transmission wires from Bashforth's Road north east to Teven Street.

Chainage	Surface Level	Details
00	102.80	CL Bashforth's Road
100	102.50	
200	101.87	Swamp
300	102.48	
400	102.71	Swamp
500	102.67	
600	102.77	Section from Ch 00 to Ch 800 along
700	102.36	cleared track through dense heath
800	102.25	1.5m and higher
920	104.63	CL Teven Street

LINE K

From Brunswick River Highway Bridge south along Highway to 50m south of Minyon Street.

Chainage	Location	Level	Details
00	East toe	101.25	At southern bridge abutment
	Centre line	102.72	
	West toe	101.41	
100	East toe	101.91	
	Centre line	102.54	
	West toe	101.94	
200	East toe	101.22	
	Centre line	102.35	
	West toe	101.24	
300	East toe	102.15	
	Centre line	102.44	
	West toe	102.58	
400	East toe	101.16	
	Centre line	102.37	
	West toe	100.83	
500	East toe	100.73	
	Centre line	102.35	
	West toe	100.71	
600	East toe	101.21	
	Centre line	102.37	
	West toe	100.99	
700	East toe	101.17	
	Centre line	102.58	
	West toe	101.22	
800	East toe	102.10	
	Centre line	102.54	
	West toe	101.35	
900	East toe	101.94	
	Centre line	102.22	
	West toe	101.43	

Notes

Toe - TOE OF EMBANKMENT
EOF - EDGE OF FORMATION

LINE K CONT'D

Chainage	Location	Level	Details
1000	East toe	102.06	
	Centre line	102.19	
	West toe	101.19	
1100	East EOF	102.57	
	Centre line	102.26	
	West EOF	101.87	
1200	East EOF	102.11	
	Centre line	102.28	
	West EOF	101.62	
1300	East EOF	102.02	
	Centre line	102.20	
	West EOF	101.92	
1400	East EOF	102.27	
	Centre line	102.31	
	West EOF	101.60	
1500	East EOF	103.72	
	Centre line	104.04	
	West EOF	103.66	
1600	East EOF	105.06	
	Centre line	105.20	
	West EOF	104.91	
1700	East EOF	105.02	
	Centre line	105.24	
	West EOF	105.05	
1800	East EOF	104.88	
	Centre line	105.13	
	West EOF	104.91	
1900	East EOF	104.50	
	Centre line	104.95	
	West EOF	104.47	
2000	East EOF	104.30	
	Centre line	104.87	
	West EOF	104.37	
2100	East EOF	104.64	
	Centre line	104.99	
	West EOF	104.76	
2200	East EOF	104.44	
	Centre line	105.22	
	West EOF	105.13	
2300	East EOF	104.70	
	Centre line	105.32	
	West EOF	104.90	
2400	East EOF	104.80	
	Centre line	105.29	
	West EOF	105.16	

LINE L

From MR 524 at entrance to football club access track north to nursery at end of Vallances Road.

Chainage	Surface Level	Details
00	102.12	Generally across well grazed cleared
100	102.02	paddock, few trees.
200	102.27	
300	102.01	
400	102.25	
500	102.29	
600	102.70	
687	102.72	Top of embankment
691	101.34	Base of embankment-river flat
700	100.75	On river bank
790	102.39	Top of northern river bank
890	102.49	Top of bank of lagoon
960	102.71	Top of bank of lagoon
1037	102.16	Top of bank of lagoon
1090	108.72	
1115	116.47	

LINE M

Along MR 524 south east towards Kings Bridge.

Chainage	Surface Level	Details
00	102.43	All levels are centre line of bitumen
100	102.60	seal.
200	102.76	See below for details of Kings
300	102.92	Bridge section.
400	102.97	
500	102.94	
600	103.09	
700	102.84	
800	103.04	
900	103.41	
1000	103.54	
1100	103.61	
1200	103.52	
1270	104.83	

KINGS CREEK BRIDGE ON MR 524 (CONSTRUCTED 1966)

1) Details of old road approaches :-

North abutment	102.22	(Approx. Ch 1048 on Line "M")
Ch 100 north of abutment	102.01	(Approx. Ch 948 on Line "M")
Ch 180 north of abutment	102.69	(Approx. Ch 868 on Line "M")
South abutment	102.37	(Approx. Ch 1072 on Line "M")
Ch 50 south of abutment	103.50	(Approx. Ch 1122 on Line "M")

2) Detail of creek section under bridge :-

North abutment road CL	Ch 1048	103.74
River bank	1051	101.24
	1053.6	99.98
	1056.2	99.27
	1058.8	98.29
	1061.4	97.10
	1064.0	99.04
	1066.6	100.43
	1069.2	102.10
	1072.4	102.77
South abutment road CL	1073	103.74

3) Culverts under road abutments :-

At Ch 870 on Line "M" triple 600 dia RCP culvert.

IL West side of new road	100.87	
IL East side of new road	100.68	
IL West side of old road	100.89	NOTE: Old road centre line approx 13m east of new road centre line
IL East side of old road	101.15	

LINE N

From MR 524 south towards McAuleys Lane Bridge over railway line.

Chainage	Surface Level	Details
00	102.43	Centre line of road
100	101.76	
200	101.45	Ch 100 to Ch 700 across well grazed
300	101.45	clear paddocks, some timber around
400	101.60	Ch 400 to Ch 450
500	101.37	
600	101.38	
700	101.96	
760	104.11	Top of earth bank approx 50m wide.
785	101.56	Base of bank and edge of drain.
810	101.56	Edge of drain IL approx 100.36
830	103.03	On earth bank approx 50m wide
850	102.90	
910	101.73	Edge of drain on bank
915	101.29	In drain
1020	100.99	In drain
1040	101.74	Edge of drain on bank
* 1976 Flood level on post in paddock		103.22
1100	101.38	Ch 1100 onwards across cleared, well
1200	101.16	grazed paddocks with many drains.
1300	101.15	See section Line "P" for IL's
1400	101.15	of these drains under railway line.
1500	101.23	
1600	101.10	
1650	101.27	Bank of Kings Creek. HWM approx 100.50
1700	101.05	
1800	101.19	
1900	101.42	
2000	101.94	
2100	102.24	

LINE O

From Argyle Street level crossing along railway line north to bridge over Main Arm.

Chainage	Top of Ballast	East Toe	West Toe	Details
00	104.10			At crossing
100	104.04	103.67	103.78	
200	103.97	103.54	103.51	
300	104.08	103.30	103.37	
400	103.98	102.94	103.03	
500	103.89	102.87	103.12	
600	103.93	103.21	103.33	
700	104.21	103.36	103.71	
800	104.74	103.23	(See Section CS 43)	
900	105.13			At bridge abutment

LINE P

From Argyle Street level crossing along railway line south to McAuleys Lane road bridge.

Chainage	Top of Ballast	East Toe	West Toe	Details
00	104.10			At crossing
90	103.75			
180	103.96			
270	103.84			
360	103.88	103.29	103.66	
450	103.87	103.39	103.72	
540	104.00	103.68	103.86	
630	103.98	103.70	103.79	
690	Culvert 23m wide IL 101.23			
720	103.94	102.98	102.91	
820	103.92	102.15	102.42	
920	103.95	103.00	102.54	
1020	103.96	102.76	102.74	
1120	104.03	103.15	102.79	
1200	Culvert 15m wide IL 101.18			
1240	104.04	102.79	103.05	
1340	103.83	102.38	102.38	
1440	103.42	101.69	101.90	
1540	103.14	101.03	101.06	
1580	Culvert 24m wide IL 99.76 creek width 3m level on banks 100.98 (Kings Creek).			
1640	103.08	101.19	101.13	
1740	103.05	101.23	101.08	
1840	102.99	101.46	101.04	
1940	103.04	101.12	100.97	
2040	103.07	101.12	101.13	
2080	Culvert 44m wide IL 99.78 creek width 3m level on banks 100.85 (Pipeclay Creek).			
2140	103.04	101.75	101.41	
2240	102.97	101.71	101.51	
2340	103.01	101.55	101.47	
2440	103.40	101.47	101.91	
2525	Culvert 14m wide IL 102.17			
2540	104.04	102.57	102.56	
2640	105.28	102.96	102.90	
2740	106.65	103.46	103.25	
2840	108.03			In cutting

LINE Q

From Coolamon Avenue generally north to Federation Bridge.

Chainage	Surface Level	Details
00	105.13	Top of the bank Saltwater Creek
29	104.94	
87	105.43	
111	105.58	Top of bank Main Arm
158	102.58	Bank of northern side
208	104.25	
258	104.23	
308	103.37	
344	103.62	Edge of gully
354	102.09	IL of gully
370	103.29	Top of embankment
380	101.22	Toe of embankment - Gully
404	101.09	Toe of embankment - Gully
408	102.27	Top of embankment
422	102.47	Top of embankment
435	101.22	Toe of embankment - Gully
441	101.21	Toe of embankment - Gully
447	103.59	Top of embankment
458	103.69	Ch 158 to Ch 545 generally over clear
479	103.40	paddock, well grazed, many ditches and
485	102.73	drains.
508	103.19	
519	102.29	
526	101.14	
545	101.39	On the southern river bank

LINE R

From Azalea Street - Jubilee Avenue intersection north east along Jubilee Avenue to Dalley Street.

Chainage	Surface Level	Details
00	104.84	Levels are centre line of bitumen
100	104.48	formation.
200	104.39	
300	104.40	
400	104.20	
500	104.03	
600	104.65	
700	104.94	

LINE S

From Ch 00 above south west to Golf Club and thence to Coolamon Scenic Drive.

Chainage	Surface Level	Details
00	104.84	Levels are centre line of bitumen
100	105.43	formation.
200	104.63	
300	104.39	
400	104.58	
500	104.52	
600	104.38	
700	104.26	
800	104.05	
900	104.00	
1000	103.98	
1100	103.98	
1200	104.04	
1300	104.33	
1400	104.80	
1450	106.68	
1500	105.92	
1550	104.87	
1600	105.00	
1650	104.75	
1700	104.09	
1760	105.39	
1840	109.72	
1900	110.62	

Drainage structures under Coolamon Scenic Drive at :-

1) Ch 1700 Line S twin 900mm dia RCP. Flows west to east.
   IL West side 102.12
   IL East side 102.07
   Culvert is overgrown with reeds almost totally blocked.

2) Ch 1712 Line S single 900mm dia RCP. Flows west to east.
   IL West side 102.22
   IL East side 102.19
   This culvert is also overgrown.

LINE T

From Coolamon Scenic Drive outside Golf Club due north to bank of Mullumbimby Creek.

Chainage	Surface Level	Details
00	103.93	
50	104.22	Section over grazed paddock.
100	104.34	Clear to tree line on creek bank.
150	104.11	
250	104.57	
296	104.63	Drain 2m wide at Ch 120 IL 103.45
300	103.61	Over the edge of creek bank.

LINE U

From Ch 1400 Line S along Myocum Road eastward.

Chainage	Surface Level	Details
00	104.80	
100	104.28	Section along centre line of bitumen
200	103.85	road.
300	103.66	
400	103.61	
500	103.53	
600	103.29	Culvert at Ch 600, no details.
700	103.32	
800	103.10	
900	103.40	
965	104.45	
1000	105.23	
1100	106.06	

LINE V

From Pacific Highway (approx 1.2km north of intersection with MR 524) south-east towards Tandy's Lane.

Chainage	Surface Level	Details
00	105.97	Edge of bitumen highway
20	103.66	Base of embankment
70	102.40	
120	102.29	
170	102.29	
210	102.28	
230	102.38	
260	102.32	
305	102.58	
360	102.81	
405	102.82	
456	102.84	

LINE V CONT'D

Chainage	Surface Level	Details
506	103.05	
555	103.32	
604	106.39	
650	113.32	
750	127.77	

LINE W

From Pacific Highway (at old quarry approx 1.6km north of Ch 00 Line "V") thence towards Tandy's Lane.

Chainage	Surface Level	Details
00	105.09	Edge of highway bitumen
100	103.11	Ch 100 to Ch 300 old pasture with grass
200	102.70	to 1.8m high.
300	102.78	
400	102.90	Ch 300 to Ch 980 grazed heathland mostly
490	102.84	clear of timber. Many small drainage
580	102.89	ditches.
680	103.02	
780	102.95	
880	103.10	
980	103.20	Ch 980 to Ch 1045 dense paperbark trees
1045	103.78	with permanent swamp.
1080	105.28	
1130	109.96	
1180	116.30	
1230	121.09	

LINE X

From the Old Brunswick Road (350m east from the highway) south along the sand track and up to Tandy's Lane.

Chainage	Surface Level	Details
00	104.61	From Ch 00 to Ch 895 cleared sandy heath
100	104.47	with very low scrub not exceeding
200	104.32	0.6m high.
300	104.48	
400	104.31	
500	104.07	
600	104.38	
700	104.72	
800	104.42	
895	104.10	At bank of canal. See below for section
930	104.10	through canal.
1000	103.64	
1080	104.70	Ch 930 to Ch 1360 sandy heath with some
1200	104.53	timber. Dense ground cover to 1m high.
1300	103.91	Section due east of line between
1360	103.22	Ch 1000 and Ch 1360 shows very dense
1485	103.69	heath and tea tree scrub to 3m high.
1490	105.98	Ch 1360 to Ch 1680 cleared, well grazed
1600	115.84	paddock.
1680	129.83	

SECTION THROUGH CANAL BETWEEN CH 895 AND CH 930 LINE X

Chainage	Surface Level	Details
895	104.10	
898	103.43	
901	103.07	
904	102.37	
907	101.97	Ch 907 to Ch 912 actual water course.
909	101.88	Slope of banks of canal varies from
911	101.62	this section to much steeper, say
913	101.35	steeper than 1:1.
915	101.15	
917	101.53	
919	101.98	
922	102.42	
925	103.10	
928	103.84	
931	104.23	

LINE Q2

Parallel to Jubilee Avenue 120 m west of centre line

Chainage	Level	
00	103.26	
30	102.87	
60	102.50	
85	102.57	Top of bank
91	100.88	Base of bank
94	100.90	Edge of creek
95	99.61	Ch 94 to Ch 108-Mullumbimby Creek
98	99.53	
100	99.56	
102	99.49	
104	99.34	
106	99.28	
108	100.96	Edge of creek
109	102.86	Top of bank
140	102.82	
163	102.33	Top of bank
170	100.30	Edge of creek
171	99.96	In creek - Saltwater Creek
173	100.49	Edge of creek
178	100.68	Toe of bank
182	102.56	Top of bank
212	102.89	
237	102.34	
242	101.29	Floodway
253	101.87	
260	103.80	
281	103.94	Footway River Terrace

LINE 1

Kings Creek Bridge to Mullumbimby Rural Co-op. Starts at MR 524 at Kings Creek Bridge.

Chainage	Level	Details
00	103.242	Shoulder of Road
5	101.411	Base of Embankment
100	101.113	
170	99.771	IL Drain
200	100.989	
230	100.490	IL Drain
300	100.723	
335	100.843	IL Drain
400	101.565	Flood Level in Paddock 102.21
500	101.361	
600	102.095	
700	101.575	
800	101.298	
900	101.305	
1000	101.426	
1080	100.823	IL Drain
1100	100.719	
1120	99.860	
1160	101.493	
1200	101.448	
1300	101.337	
1400	101.182	
1475	101.149	Base of Railway Embankment
1490	103.000	
1497	101.162	
1517	100.426	
1547	100.569	
1590	101.385	
1680	101.716	
1780	101.707	
1840	100.600	IL Drain
1880	102.001	
1980	101.922	
2080	101.880	
2180	102.218	
2240	101.149	IL Drain
2280	101.451	
2340	101.113	IL Drain
2380	101.986	
2500	102.273	
2580	102.589	
2680	102.968	
2730	102.002	IL Drain
2780	103.085	
2880	103.089	
2980	103.475	
3100	104.383	

LINE 2

Jubilee Avenue opposite High School through recreation ground to railway.

Chainage	Level	Details
00	104.314	Footpath Jubilee Avenue
100	104.083	
200	104.106	
300	103.912	
400	103.576	
500	103.084	
560	102.749	IL Drain
600	103.464	
700	102.970	
735	102.444	IL Drain
780	102.213	IL Drain
800	102.769	
890	101.872	IL Drain
893	102.274	Base of Railway Embankment

LINE 3

From railway line approximately 600 m south of Argyle Street level crossing east and south east to Kings Creek.

Chainage	Level	Details
00	104.053	Ballast at Railway
100	104.884	
166	104.718	
200	104.690	
300	104.055	
400	103.140	
455	103.071	
500	102.815	
507	102.518	IL Drain
600	102.841	
700	104.718	
800	105.227	
900	104.664	
990	102.925	Bank of Drain
995	102.129	IL Drain
1000	104.749	Top of Embankment
1100	102.879	
1200	102.396	
1300	102.065	

LINE 4

This line was shifted slightly east of requested survey line due to restriction of access and vision along requested line. Starts at MR 524 at intersection of future football ground road and thence south west to intersect Line 3.

Chainage	Level	Details
00	102.743	Centre Line of MR 524
05	101.606	Table Drain of Road
08	101.791	In Paddock
46	101.866	IL Drain
52	102.344	Road Embankment
57	101.851	IL Drain
100	101.995	
200	101.427	
262	100.799	IL Drain
300	101.058	
400	101.936	
500	101.114	
590	101.250	
670	102.187	Base of Ridge

LINE 5

Corner Prince and Ann Streets along Ann Street east to intersect Line 4.

Chainage	Level	Details
00	103.779	Intersection Centre Line Prince and Ann Streets
100	103.466	Centre Line of Bitumen
200	103.089	Centre Line of Bitumen
300	102.610	Centre Line of Bitumen
400	102.197	Centre Line of Bitumen
500	101.652	In Paddock
600	101.870	
700	101.638	
800	101.215	

LINE 6

Intersection Jubilee Avenue and Fern Street along Fern Street east to Station Street.

Chainage	Level	Details
00	104.790	Intersection Centre Line of Jubilee Avenue and Fern Street
50	104.930	
100	105.052	
150	104.279	
200	103.566	
250	103.549	
305	104.369	Centre Line of Station Street

LINE 7

Intersection Mill and Dalley Streets south along Dalley Street to Fern Street.

Chainage	Level	Details
00	103.396	Intersection Mill and Dalley Streets
100	104.231	
200	104.416	
300	104.443	
400	104.862	
500	105.041	
600	104.963	
700	104.982	
800	105.334	
900	104.957	
960	104.927	Centre Line of Fern Street

LINE 8

Along Argyle Street starting approximately 130 m east of James Street to the Federation Bridge.

Chainage	Level	Details
00	102.362	
100	102.560	
200	102.627	
300	102.623	
400	102.807	
500	102.978	
600	103.198	
700	103.450	
800	103.731	
900	104.141	
1000	104.292	
1030	104.425	Intersection Burringbar and Station Streets
1130	104.664	
1230	105.030	
1330	104.787	
1430	104.381	
1515	104.026	Cnr Burringbar Street and Brunswick Terrace
1615	104.738	
1715	105.321	
1745	105.430	Centre Line of Approach to Bridge

LINE 9

From Intersection Queen and Argyle Streets north along Queen Street.

Chainage	Level	Details
00	103.218	
100	103.084	
200	103.069	
300	103.049	
400	102.314	
460	101.358	IL Drain
490	101.798	IL Drain
500	102.113	

SPECIFIC FLOOD LEVELS

1)	Riverside Crescent	101.63		1974
2)	Homestead Kings Creek	102.78		1978
3)	Homestead Wilsons Creek Road	106.20		1976
4)	Wrecking yard	104.36	(Includes 1m above floor)	1976
5)	Simpson house Tyagarah	104.51	(Includes 0.3m above floor)	1976

FIGURE D1

SURVEY LINES