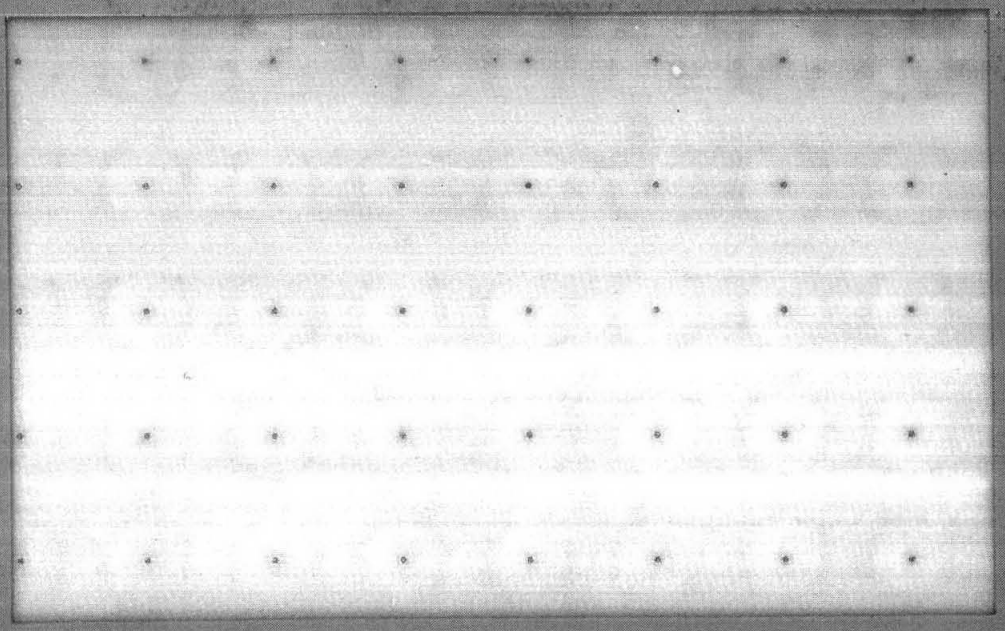

Water Resources

TECHNICAL SERVICES DIVISION

DEPARTMENT OF LAND & WATER CONSERVATION
TECHNICAL SERVICES DIVISION

SCONE FLOOD STUDY
VOLUME I - MAIN REPORT

November 1996

DESIGN HYDROLOGY UNIT

TS96.046

Hydrology Unit Calculation File Nos: 2102

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Auhor: Bruce Caldwell

Reviewed by: Richard Cooke and Ian Mark

Printed November 1996

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EXECUTIVE SUMMARY

This report presents the results of a detailed Flood Study for the Scone district. The study identifies the nature and extent of flooding along the three main waterways, Middle Brook, Kingdon Ponds and Parsons Gully, located west of the Scone town centre. It does not deal with flooding in minor tributary creeks such as Fig Tree Gully.

The quality of calibration data available as a result of recent floods (in particular February 1992) has enabled more reliable hydrologic and hydraulic modelling than for the previous most recent study conducted in 1986.

A computer based hydrological model of the catchment was developed. The model was calibrated to historic events, and design storms were applied to give estimates of the design flow hydrographs.

A computer based one dimensional model was developed for Middle Brook, Kingdon Ponds and Parsons Gully with hydrographs from the hydrologic model used as input. The hydraulic model was calibrated to reproduce recorded flood levels, and design hydrographs subsequently input to generate design flows and flood levels.

Estimates of design flows, flood levels and velocities for the 10yr, 20yr, 50yr, 100yr, 200yr Average Recurrence Intervals (ARIs) and Probable Maximum Flood were determined.

This **Report Volume I** is the Main Report, while **Report Volume II** presents the study drawings and includes the design flood contour drawings.

The hydraulic model developed as part of this study can be utilised to assess flood mitigation options as part of a floodplain management study.

FORWARD

The 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 a floodplain management system comprising four sequential stages:

1. Flood Study	-	Determines the nature and extent of the flood problem.
2. Floodplain Management Study	-	Evaluates management options for the floodplain in respect to 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, where viable, to protect existing development. Use of Local Environmental Plans to ensure that new development is compatible with flood hazard.

This Flood Study constitutes the first stage of the management process and has been prepared for Scone Council to define flood behaviour under current conditions.

The Floodplain Management Study forms the second stage of the process. It is to consider floodplain management options for the area taking into account both the problems of existing flood liable land and the impact of any future development planned for the area. The results of the Management Study, together with consideration of related social, ecological and economic issues, will enable Council to adopt a sound management plan for the floodplains of Middle Brook, Kingdon Ponds and Parsons Gully.

1. SUMMARY OF DATA

This chapter contains key information relevant to the Study. The information is presented as a check list and is intended for quick reference by persons unfamiliar with the study area.

1.1 Title

LOCALITY:	Scone.
TYPE OF STUDY:	Detailed.
DATE OF RELEASE:	1996.

1.2 Catchment

BASIN:	Hunter River
MAINSTREAM:	Kingdon Ponds.
CATCHMENT AREA:	358km^2.

1.3 Government

LOCAL GOVERNMENT AREA:	Scone.
STATE ELECTORATE:	Upper Hunter
FEDERAL ELECTORATE:	Hunter

1.4 Local Council

POSTAL ADDRESS:	Scone Shire Council
	PO Box 208
	SCONE NSW 2337.
TELEPHONE:	(065) 401100.

1.5 Data Base

TOPOGRAPHY:	Catchment data from CMA orthophoto maps and aerial photographs, and cross-section based on field survey by KF Murphy & Associates, Registered Surveyors (Scone) in 1995.
RAINFALL:	Three daily read gauges operated by the Bureau of Meteorology and one pluviometer operated by the Department of Land and Water Conservation.

STREAM FLOW:	One recording station located on Kingdon Ponds near Parkville (GS 210093).
FLOOD LEVELS:	January 1976 flood levels were obtained from "Scone Flood Study Report" Water Resources Commission NSW, September 1986. February 1992 flood levels were obtained from Scone Council.

1.6 Hydrology

FLOOD FLOWS:	Estimated using the computer based hydrologic modelling software RAFTS-XP, developed by WP Software.
CALIBRATION:	To the flood events of January 1976, March 1977 and February 1992.
BASIS OF DESIGN FLOWS:	Design rainfall information from Australian Rainfall and Runoff (1987).
DESIGN FLOWS:	As presented in **Table 5.2**.

1.7 Hydraulics

BASIS OF FLOOD LEVELS:	Estimated using the computer based one-dimensional unsteady flow hydraulic modelling software MIKE 11, developed by the Danish Hydraulic Institute.
CALIBRATION:	To the flood events of January 1976 and February 1992.
BASIS OF DESIGN LEVELS:	Design discharges produced by the calibrated hydrologic model.
DESIGN LEVELS:	As presented in **Tables MR10, MR20, MR50, MR100, MR200, MRPMF** and **Report Volume II, Figures FC1 to FC7** for the respective recurrence intervals.

2. INTRODUCTION

2.1 Flood Policy

The primary objective of the Flood Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers, and to reduce private and public losses resulting from flooding. The policy recognises the need to treat developed and undeveloped land differently and provides for all development and building proposals to be treated on their merits.

It reaffirms the basic responsibility for management of flood liable land rests with local government. In order to fulfil this responsibility, councils are encouraged to prepare and implement Floodplain Management Plans and incorporate these into Local Environment Plans. The role of the State Government is to provide financial, engineering and planning assistance. Technical advice on flooding is provided by the Department of Land and Water Conservation.

2.2 Flood Study Reports

Under the Policy, technical advice on flooding is to be provided in the form of Flood Study reports. These reports provide hydrologic and hydraulic input for Floodplain Management Plans. They also document the studies undertaken to assess the frequency and extent of inundation, and provide technical details on all other flooding aspects which must be considered when formulating a management plan.

It is intended that the Flood Study report provides all the relevant details in a comprehensive but succinct format. The body of the report describes the physical setting, the nature of flooding, the available information and procedures used to estimate the design discharges, velocities and flood levels. It provides the basis for locating areas of different flood hazard.

Prior to the formation of the DLWC, the Department of Water Resources (DWR) undertook two types of urban flood studies, namely detailed studies and reconnaissance studies.

Detailed studies involved detailed hydrologic and hydraulic investigations and extensive field surveys. Such studies were only undertaken for towns and areas where the severity of flooding warrants the considerable effort involved.

For smaller towns, or towns and areas with less significant flood problems, a reconnaissance flood study may have been undertaken. These studies documented the pattern of inundation for a large historical flood. In towns with minor flooding problems, the reconnaissance flood studies were adequate for the purpose of formulating a Floodplain Management Plan.

The 1986 Scone Flood Study was a "reconnaissance" study based on historical floods.

Formation of the DLWC saw it undertake the role of providing financial assistance for Councils to engage consultants for flood studies, and to provide technical support/advice to ensure that the studies are technically sound and comply with the Flood Policy.

This 1996 study is a detailed Flood Study for the Middle Brook, Kingdon Ponds and Parsons Gully waterways neighbouring Scone town. The study presents design flood levels, discharges and velocities for existing conditions only.

2.3 Designated Flood

An important change resulting from the 1984 policy is that the definition of flood liable land as that covered by a flood of an Average Recurrence Interval (ARI) of 100 years has been abandoned as a statewide standard. Instead the designated flood is to be determined by individual councils having regard to technical factors and local circumstances.

The flood standard, or "designated flood", is the size of the flood adopted as the basis for planning and controlling development on flood liable land. In selecting the designated flood, councils should take into consideration social, economic and ecological issues, as well as flooding considerations.

It may be some time before all the information necessary to select the appropriate designated flood is available. In the meantime councils will be required to make planning decisions and determinations on particular proposals on the basis of some interim designated flood. Scone Council has adopted the 1955 flood as its interim standard.

2.4 Terminology

In line with Australian Rainfall and Runoff (1987) (**Reference 1**), this report has adopted the following terminology:

- **Annual Exceedance Probability (AEP),** expressed either as a percentage or in the form 1 in Y, defines the magnitude of large flood events determined from annual series analyses. It is the probability of Exceedance of a given discharge within a one year period; and

- **Average Recurrence Interval (ARI),** expressed in years, defines the magnitude of flood or rainfall events based on partial series analysis. It is the average or expected value of the period between exceedances of a given flow or rainfall.

2.5 Reasons for Study

In 1986 the Water Resources Commission published a reconnaissance flood study for Middle Brook, Kingdon Ponds and Parsons Gully neighbouring Scone town, based on the 1955 flood. A recent major event in February 1992 was of similar magnitude to the 1955 flood.

In recognition of the flooding problem in the Scone area, and the need to plan for development and emergency procedures, flood information (including levels and velocities) for a range of flood magnitudes is required. Such information is not available in the 1986 study.

In December 1995 Scone Shire Council engaged DLWC (Technical Services Division) to undertake this study. The Study Brief is included in **Appendix B**.

The quality of calibration data available as a result of recent flooding has enabled the use of hydrologic and hydraulic modelling to estimate design flows, levels and velocities for the 10 year, 20 year, 50 year, 100 year and 200 year ARI events, and the Probable Maximum Flood (PMF).

2.6 Methods Adopted

A computer based hydrologic model of the catchment was constructed. The model was calibrated to historic events, and design storms were applied to generate estimates of the design flows. Hydrologic details are discussed in **Section 5**.

A computer based one-dimensional unsteady flow hydraulic model was constructed for Middle Brook, Kingdon Ponds and Parsons Gully. Using hydrographs from the hydrologic model as the input, the hydraulic model was calibrated to reproduce recorded flood levels. The hydrologic model design hydrographs were subsequently input to produce design flood levels. Hydraulic details are discussed in **Section 6**.

3. NATURE OF FLOODING

3.1 Physical Setting

The town of Scone is within the Study Area (see **Figure 3.1**) and lies in the upper Hunter Valley, 250km north-west of Sydney. The township is a rural centre with a population of approximately 4400. It serves important dairy and horse breeding industries and, increasingly, the coal and power generating industry. The town is the administrative centre for the Scone Shire Council.

The Study Area catchment is bounded by mountain ranges on three sides; to the east mountains including Gateleys Mountain, The Black Mountain and Scone Mountain, to the west the Brawboy Range, and to the north the Liverpool Range. The total catchment area at the downstream (southern) end of the Study Area is 358km^2.

Scone is located on the common flood plain of Kingdon Ponds, Middle Brook and Parsons Gully, which route to the west of Scone township in a north to south direction.

3.2 Flood Behaviour

Whilst the western portion of Scone can be flooded by any of the three streams (Kingdon Ponds, Middle Brook and Parsons Gully), in a major flood most flows come from the larger catchment of Kingdon Ponds. Limited protection against floods is provided by a natural levee bank along side Kingdon Ponds. However even in the 10 year ARI flood event considerable flows spill from Kingdon Ponds eastward into Parsons Gully.

Because the eastern side of the floodplain is generally lower than the western side, once the natural levee is overtopped excess flows enter Parsons Gully. As Parsons Gully carries surplus flows, changes in flood levels and velocities can be highly variable, particularly when surplus flows first enter the gully.

In major flood events flows inundate the western edge of Scone township, overtop Liverpool street and isolate the nearby settlement of Satur.

3.3 Flood History

Flood heights have been recorded in the Scone region since and including the major flood in February 1955. There is little information on the relative size of floods prior to this time. Recent floods causing inundation to the western areas of Scone include;

- 31 January to 1 February 1971.
- 22 to 24 January 1976.
- 2 to 6 March 1977.
- 8 to 10 February 1992.

Of these more recent floods, the February 1992 event has been the most significant but generally resulted in marginally less inundation than in February 1955.

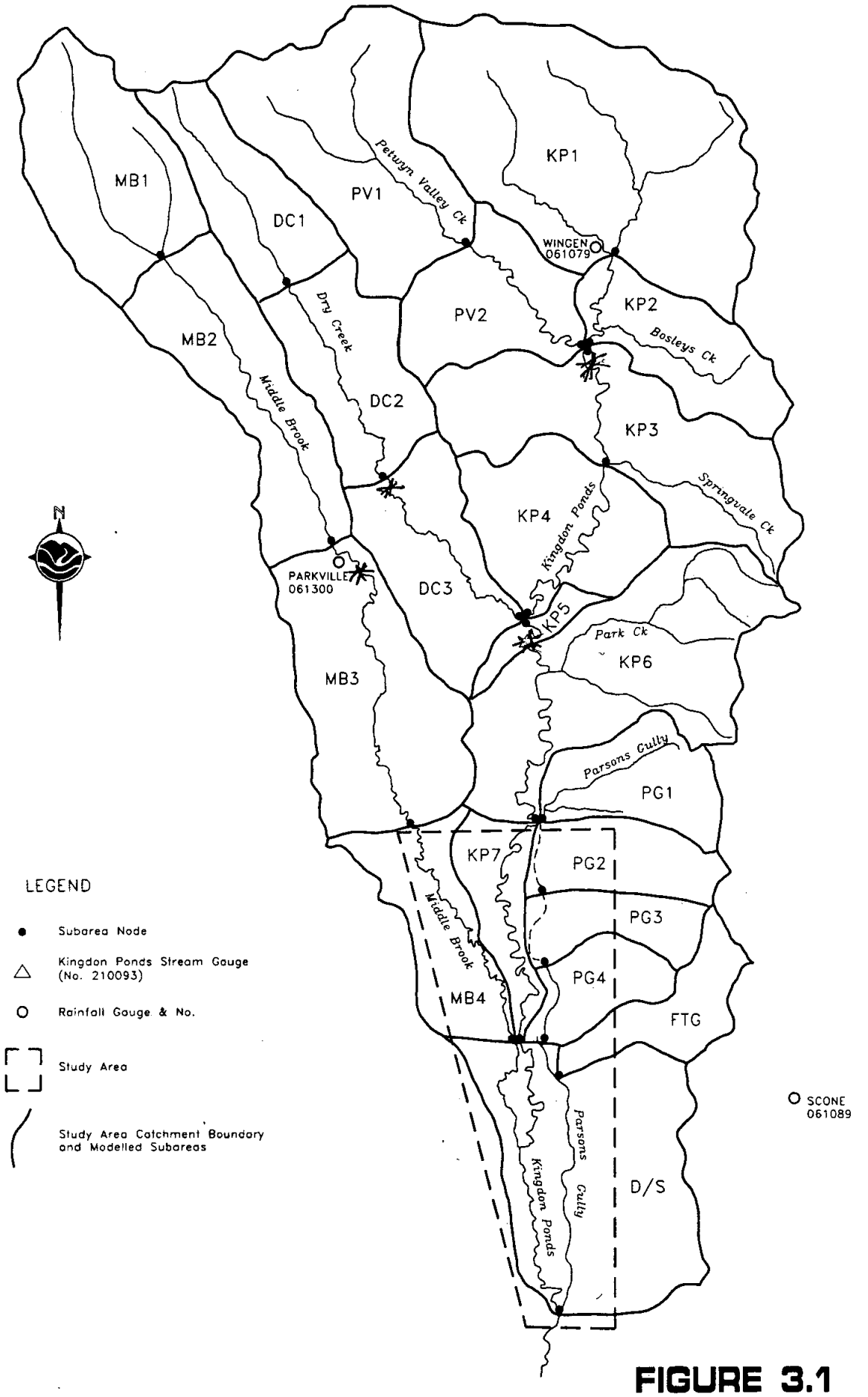


FIGURE 3.1

RAFTS-XP MODEL STRUCTURE

4. AVAILABLE DATA

4.1 Mapping and Aerial Photography

Maps and aerial photographs obtained for this study include;

Orthophoto Maps 1:100,000 (1984)

- Sheet No.9034 Murrurundi.
- Sheet No.9033 Muswellbrook.

Orthophoto Maps 1:25,000 (1982)

- Sheet No.9033-I-N Scone.
- Sheet No.9034-II-S Parkville.
- Sheet No.9034-II-N Murrurundi.
- Sheet No.9034-III-N Towarri.
- Sheet No.9034-III-S Kars Springs.

Orthophoto Maps 1:4,000 (1981)

- Scone U8247-2 and U8247-5.

Aerial Photographs 1:20,000 (27 November 1993)

4.2 Survey

Surveys obtained for this study include those by;

K F Murphy & Associates Registered Surveyors (engaged by Council in September 1995)

- 26 cross sections within the Study Area covering the three major waterways of Middle Brook, Kingdon Ponds and Parsons Gully, and their over bank floodplains.
- seven historic flood levels (February 1992) in Scone and to the immediate west.

Department of Land & Water Conservation (as part of Study)

- field assessment of catchment and waterway conditions.
- cross section at the Kingdon Pond gauging site near Parkville.
- twenty four historic flood levels (February 1992) within the Study Area.

4.3 Rainfall Data

4.3.1 Historic Rainfall Data

The five major rainfall events recorded within the Study Area (and related to recorded flooding see **Section 3.3**) occurred on the following dates;

- 16 to 17 February 1955.
- 31 January to 1 February 1971.
- 22 to 24 January 1976.
- 2 to 6 March 1977.
- 8 to 10 February 1992.

There is no pluviograph station located within the Study Area catchment. The nearest pluviograph station to the Study Area is located at the Scone Research Centre (station no. 061089), located approximately 5km east of Scone. The pluviograph data for the 1971, 1976, 1977 and 1992 events were obtained from the Bureau of Meteorology, and from the Scone Research Centre for the 1955 event.

Daily rainfall totals (i.e. 9am to 9pm) were acquired for Parkville (station no. 061300) for the 1976, 1977 and 1992 events, and for Wingen (station no. 06107) for all five events. Both these stations are located within the Study Area catchment.

Daily rainfall totals were also acquired for Aberdeen (station no. 061000) for all five events, Woodlands (station no. 061306) for the 1977 and 1992 events only, and Murrurundi (station no. 061051) for all five events. These stations are located adjacent to the Study Area.

4.3.2 Design Rainfall

Design rainfall data has been defined in accordance with Australian Rainfall and Runoff (ARR87) for the 10 year, 20 year, 50 year, 100 year and 200 year ARIs within the Study Area catchment.

Point location design rainfall intensities were calculated for Scone township (located at the southern end of the Study Area catchment) and Murrurundi (situated to the north of the Study Area catchment). ARR87 advises that a rainfall reduction factor of 5% may be appropriate when applying a point location rainfall to an area of the size of the Study Area catchment. However the design rainfall intensities for Murrurundi were typically 10% higher than for Scone. As such the design rainfall intensities for Scone were adopted over the Study Area catchment with no rainfall reduction factor.

Probable maximum precipitation (PMP) intensities and patterns were defined in accordance with Bureau of Meteorology, Bulletin 53 (**Reference 2**).

4.4 Stream Flow Recording

4.4.1 Stream Recorders

The Kingdon Ponds at Parkville gauging station (no. 210093) is the only stream flow recording station located within the Study Area.

Recorded stream levels available at this site include;

- information from a Bristol stream height recorder during 1972 to 1989. On the 20 May 1976 the gauging station was relocated 50m upstream from its initial location. On 5 January 1989 the gauge was removed,
- no information for the years of 1989, 1990 and 1991 is available,
- information from a continuous stream height (Mace) recorder which was installed at the site on 13 November 1991.

4.4.2 Rating Curve Definition

Stream recorders only record water level heights, therefore there is a need to establish a relationship of flow verses height.

At the Kingdon Ponds station site, stream flow gaugings have been conducted to determine a flow verses height relationship (i.e. a rating curve). However the maximum flow gauged was at a stream height of only 1.1m which represents low "within bank" flow. The 1992 recorded stream level reached 5.06m. This lack of high flow gaugings requires the rating curve to be extrapolated from recorded low flow levels (1.1m) up to flood levels . Uniform flow analysis was used to extend the rating curve.

Two "extended' rating curves were developed for use in this study;

- the first utilised the1986 survey information,and was adopted for the 1976 and 1977 flood events,
- and the other using 1996 survey, was adopted for the 1992 event.

An initial set of rating curves were developed (and reported in **Progress Report No. 2**), however during the hydraulic model calibration these rating curves were found to be a slight underestimate of flow at flood levels. These curves were amended and the adopted rating curves are presented in **Figure 4.1**.

Table 4.1 summarises available data and estimated annual peak flows for Kingdon Ponds at the Parkville gauge.

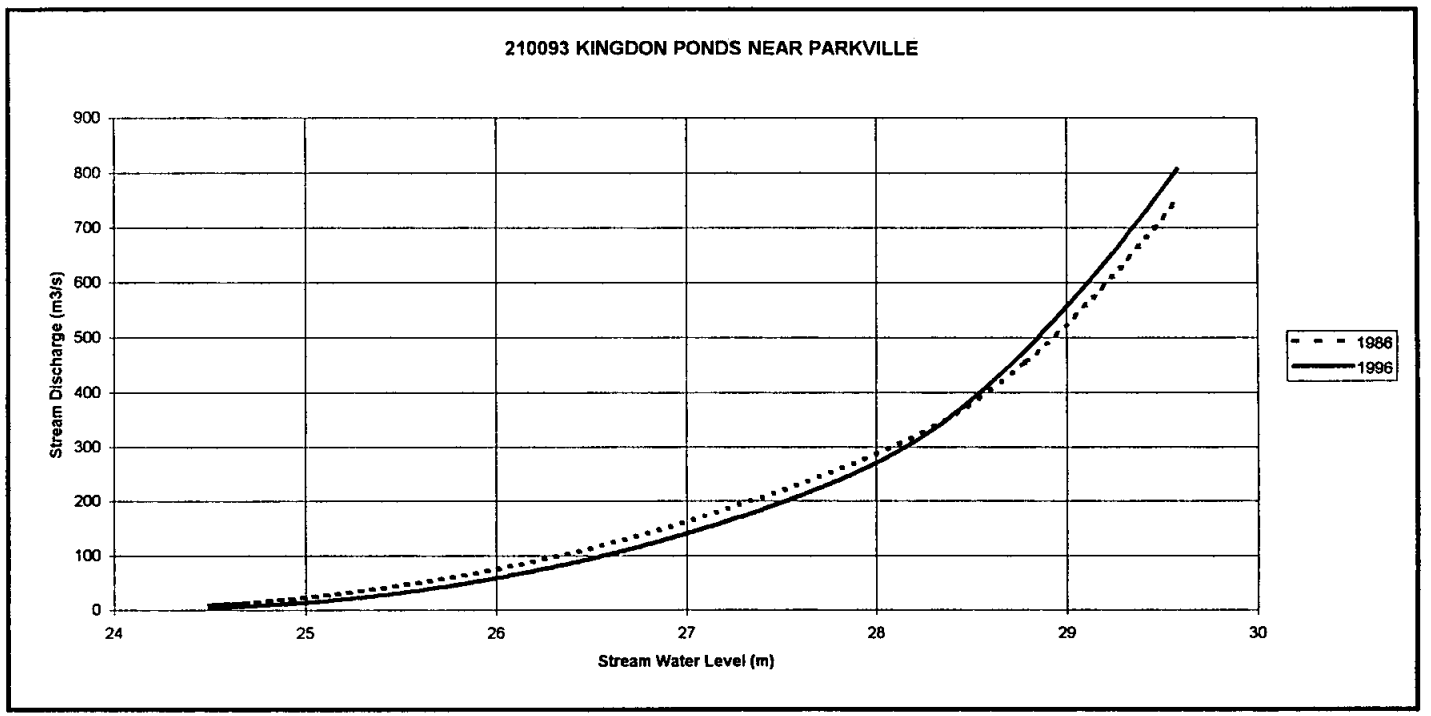
TABLE 4.1: KINGDON PONDS NEAR PARKVILLE
AVAILABLE DATA & ANNUAL PEAK FLOWS

YEAR	Q (m^3/s)
1971	n/a
1972	4
1973	9
1974	47
1975	9
1976	327*
1977	224*
1978	83
1979	16
1980	0
1981	10
1982	14
1983	6
1984	22
1985	6
1986	1
1987	3
1988	9
1989	n/a
1990	n/a
1991	n/a
1992	452 #
1993	18
1994	12

RANK	YEAR	Q (m^3/s)
1	1992	452 #
2	1976	327 *
3	1977	224*
4	1978	83
5	1974	47
6	1984	22
7	1993	18
8	1979	16
9	1982	14
10	1994	12
11	1981	10
12	1973	9
13	1975	9
14	1988	9
15	1983	6
16	1985	6
17	1972	4
18	1987	3
19	1986	1
20	1980	0
-	-	-
-	-	-
-	-	-
-	-	-

Notes:
1. Flows based on "hydsys" rating curve except as noted below:
   # indicates flows based on 1996 survey & rating curve.
   * indictes flows based on 1986 survey & rating curve.
2. n/a = not available.

FIGURE 4.1: KINGDON PONDS NEAR PARKVILLE RATING CURVES ADOPTED FOR SCONE FLOOD STUDY



Notes:
1. Stream water level based on gauge zero RL = 23.65m

4.5 Recorded Flood Levels

Adopted 1976 and 1992 recorded flood levels are presented in **Appendix A** and on **Report Volume II, Drawings MR1 to MR7** for the respective events.

Flood levels, depths, and location were reviewed to determine reliability and consistency. Some inconsistencies are evident in the 1976 and 1992 recorded flood levels (as seen in **Report Volume II, Drawings January 1976 and February 1992 MR3 and MR4)**, however all levels are included since their comparative reliability are unknown.

4.5.1 Urban Areas

Recorded flood levels available in the Scone town area generally indicate the following ranking (from highest to lowest) of flood levels; 16 February 1955, 1 February 1971, 9 February 1992 then 23 January 1976.

4.5.2 Rural Areas

A scatter of recorded flood levels were available in the neighbouring rural areas upstream and downstream of Scone for the 1955, 1971 and 1976 events.

For the 1992 event the only rural flood level available within the Study Area was located at Turnaville Road (pegged by Council and surveyed as part of this Study).

4.6 Previous Reports and Information

The following reports and information were collected and reviewed as part of this study.

Scone Shire Council

- "Proposed New Alignment and Associated Bridges at Parsons Gully, Kingdon Ponds and Middle Brook - Investigation and Conceptual Design" Webb, McKeown & Associates Pty Ltd, December 1986.
- "Liverpool Street reconstruction Plan & Longitudinal section Chainage 00-320" Sheet No.7 14/12/92.

Department of Land & Water Conservation

- "Scone Flood Study Report" Water Resources Commission of NSW, September 1986.
- Various correspondence and calculation files with respect to historic flows and flooding.

Sinclair Knight Consulting Engineers

- "Investigation of Flooding on Properties of Dr Pye and Mr Murray at Scone", December 1992.

5. HYDROLOGIC MODELLING

An hydrologic model of the Study Area catchment was developed, calibrated and used to produce design discharges as discussed in the following sections.

5.1 The Model

Hydrologic modelling was carried out using RAFTS-XP software (**Reference 3**). RAFTS-XP is a general runoff and stream flow routing program which generates flood hydrographs from rainfall and other channel inputs.

The main components of the catchment model are the sub-catchments and links.

To enable variability in rainfall and catchment characteristics to be modelled, the catchment area is divided into sub-catchments based on natural topographic and watershed boundaries. Division into sub-catchments also enables flow definition at stream confluences and other points of interest such as gauging stations. The sub-catchments are linked by a network of reaches representing the actual drainage network.

Rainfall inputs can be either historic events or design storms. Observed spatial and temporal variations in historic events can be catered for by entering different rainfall data for each sub-catchment, according to daily rainfall and pluviograph records.

Design storms are typically input as a dimensionless temporal pattern combined with average rainfall intensity for the particular duration storm.

The model subtracts losses from rainfall to produce rainfall excess which is routed through conceptual catchment storages to produce a surface runoff hydrograph.

Loss data for this study utilises an initial loss (simulating initial catchment wetting when no runoff is produced) and a subsequent continuing loss rate (to account for infiltration once the catchment is saturated).

Rainfall excess (i.e. total rainfall minus losses) appears as runoff for each subarea which is treated as a concentrated conceptual storage. The storage-discharge relationship used in RAFTS-XP is;

$$s = Bq^{n-1}$$

where s = storage

q = discharge (m^3/s)

B = storage delay time coefficient

n = storage non-linearity exponent.

5.2 Model Set-up

The Study Area catchment (as shown in **Figure 3.1**) has been represented by twenty two sub-catchments with division generally based on reflecting homogeneous sub-catchments.

5.3 Model Calibration

Calibration of the RAFTS-XP model was undertaken using the guidelines in ARR87. The aim of the calibration being to arrive at model parameters that reproduce, as best as practicable, the peak flow, time of peak and volume (hydrograph shape) of recorded floods. Once this has been achieved design floods can be modelled with greater confidence.

5.3.1 Approach

Calibration of the RAFTS-XP model utilised the three largest events for which recorded rainfall and flow data is available, i.e. the January 1976, March 1977 and February 1992 flood events.

The calibration location for the model was on Kingdon Ponds near Parkville (RAFTS-XP node KP5). This being the only location of stream flow recording within the Study Area catchment.

Rainfall temporal patterns for the three events have been based on the respective pluviograph recordings taken at the Scone Research Centre (station no. 061089, being the nearest continuous rainfall recording station to the Study Area).

Rainfall spatial distribution was established by factoring the temporal patterns in accordance with daily totals for the Scone (station no. 061089), Parkville (station no. 061300) and Wingen (station no. 061079).

Catchment losses have been based on;

- a single continuing loss of 2.5mm/h, as recommended by ARR87, and taking into account runoff volumes, and
- initial losses of 10mm to 80mm which account for apparent antecedent moisture conditions (noting daily rainfall prior to the initial hydrograph rise), and the initial recorded hydrograph shape.

5.3.2 Results

Calibration results are summarised in **Tables 5.1 and 5.1a**, and shown in **Figures 5.1, 5.2 and 5.3**.

Table 5.1 presents the "best fit" results for each of the 1976, 1977 and 1992 flood events, adopting catchment storage factors (Bxs) of 0.75, 0.55 and 0.75 respectively. **Table 5.1a** results are for a single catchment storage factor of Bx = 0.75.

Figure 5.1, **Figure 5.2** and **Figure 5.3** present the respective 1976, 1977 and 1992 recorded and modelled ("best fit") hydrographs.

It is noted that the 1992 event is the most reliable and applicable for calibration of major flood events on the catchment since;

- the 1976 and 1977 peak flows are actually estimated as shown in **Figures 5.1 and 5.2**, and
- the 1977 peak flow is considerably smaller than the 1976 and 1992 events.

With respect to the 1992 event the modelled "fit" is very close, particularly for the two (major) peaks and for the hydrograph volumes.

A closer total volumetric match could have been achieved by introducing a second "initial loss" following the initial small hydrograph peak, however this approach would not have further assisted calibration for the design storm events (and therefore was not pursued).

The variation in times to peak could have resulted from a different rainfall temporal pattern in the upper northern areas of the catchment compared to that of the adopted pattern.

5.4 Design Flows

5.4.1 Approach

Based on the calibration results, a storage factor of Bx = 0.75 was adopted for modelling the 10 year, 20 year, 50 year, 100 year, 200 year ARIs and the PMF design storm events.

Initial losses were defined in accordance with (**Reference 4**).

A continuing loss of 2.5mm/h was adopted for all events except the PMF event where 1.0mm/h was adopted, as recommended in ARR87.

A range of rainfall durations was assessed for each recurrence interval to determine the critical durations (i.e. the rainfall duration which resulted in the peak discharge for a given recurrence interval).

5.4.2 Results

The 48 hour duration storms were found to generate the peak catchment flows through the Study Area for the 10 year and 20 year ARI events, with the 36 hour duration storms generating peak flows for the 50 year, 100 year and 200 year ARI events. The 4 hour duration storm generates peak flows for the PMF.

Design peak flows are presented in **Table 5.2**.The critical (i.e. highest) duration flows are highlighted in bold type.

5.4.3 Comparison of Design Flows

Flood frequency and probabilistic rational method analyses have been carried out.

These two methods produce peak flow estimates for specific recurrence intervals and so enable a comparison with estimates from the RAFTS-XP model.

The results, presented in **Table 5.3**, indicate that peak flows defined by RAFTS-XP modelling are of the same order of magnitude when compared to that defined by the other two methods.

The difference in flow values between the three methods is not unusual, and on the basis of available data and in accordance with the ARR87, the RAFTS-XP model results are considered most reliable for the assessed events.

FIGURE 5.1

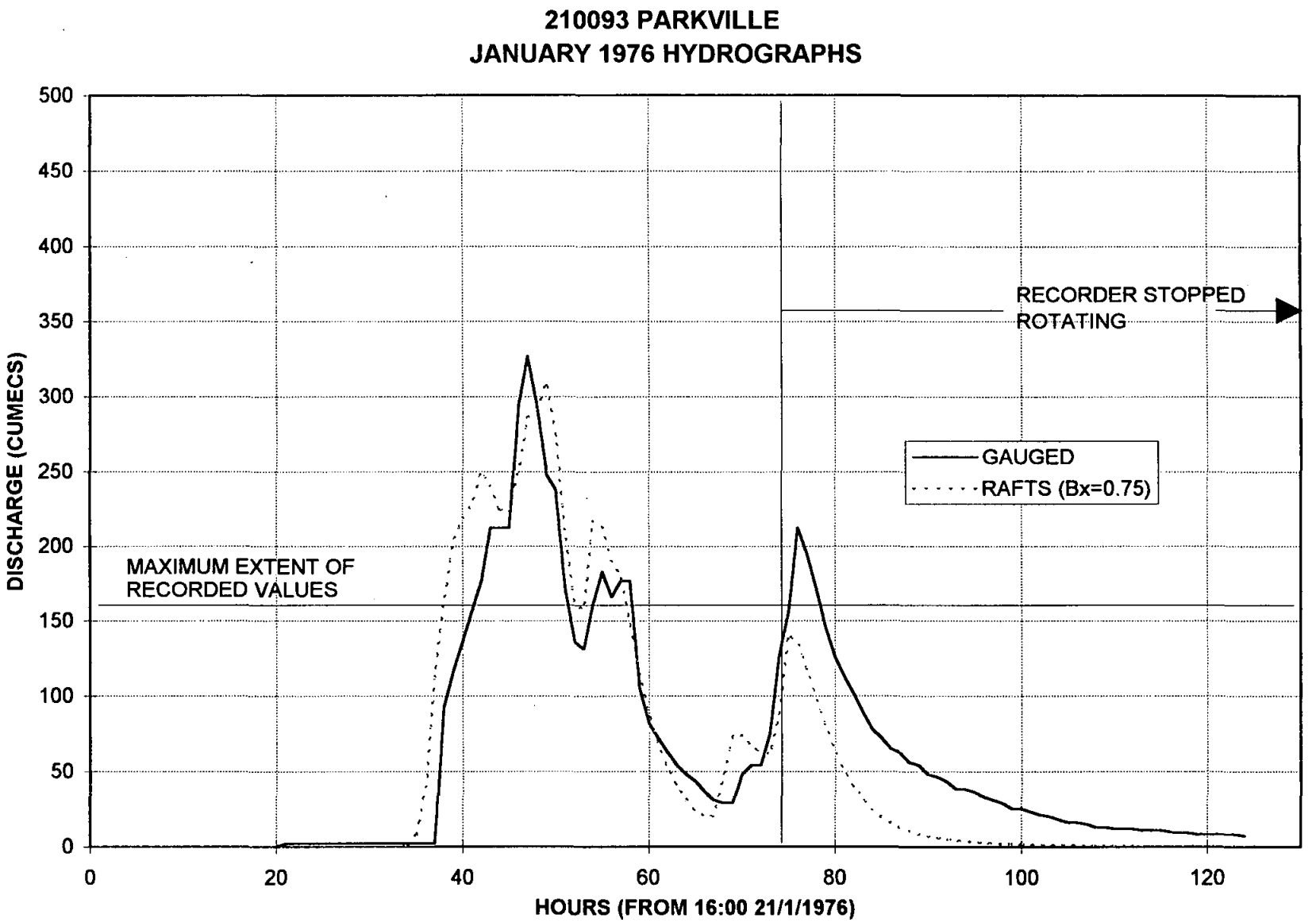


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FIGURE 5.2

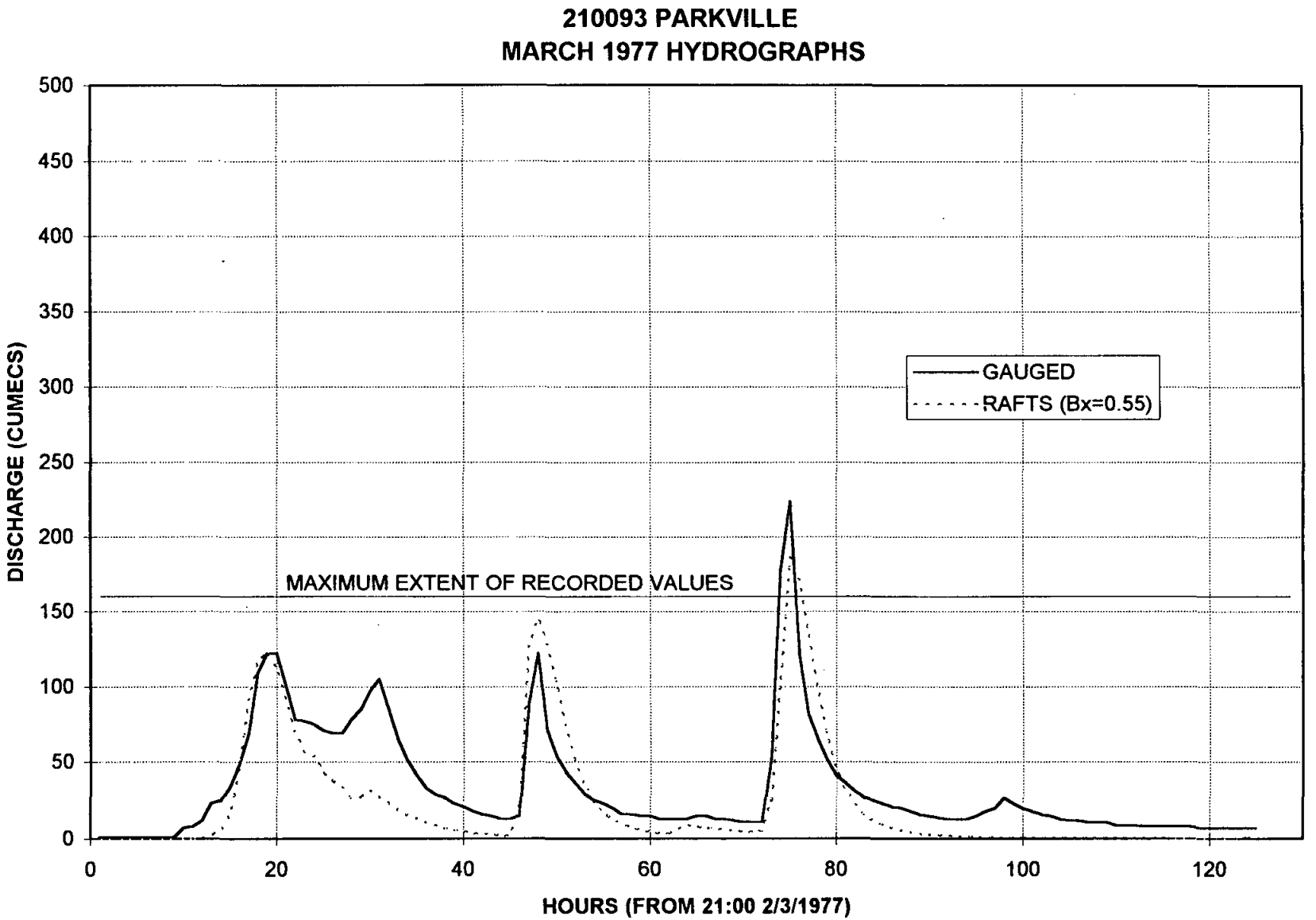

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FIGURE 5.3

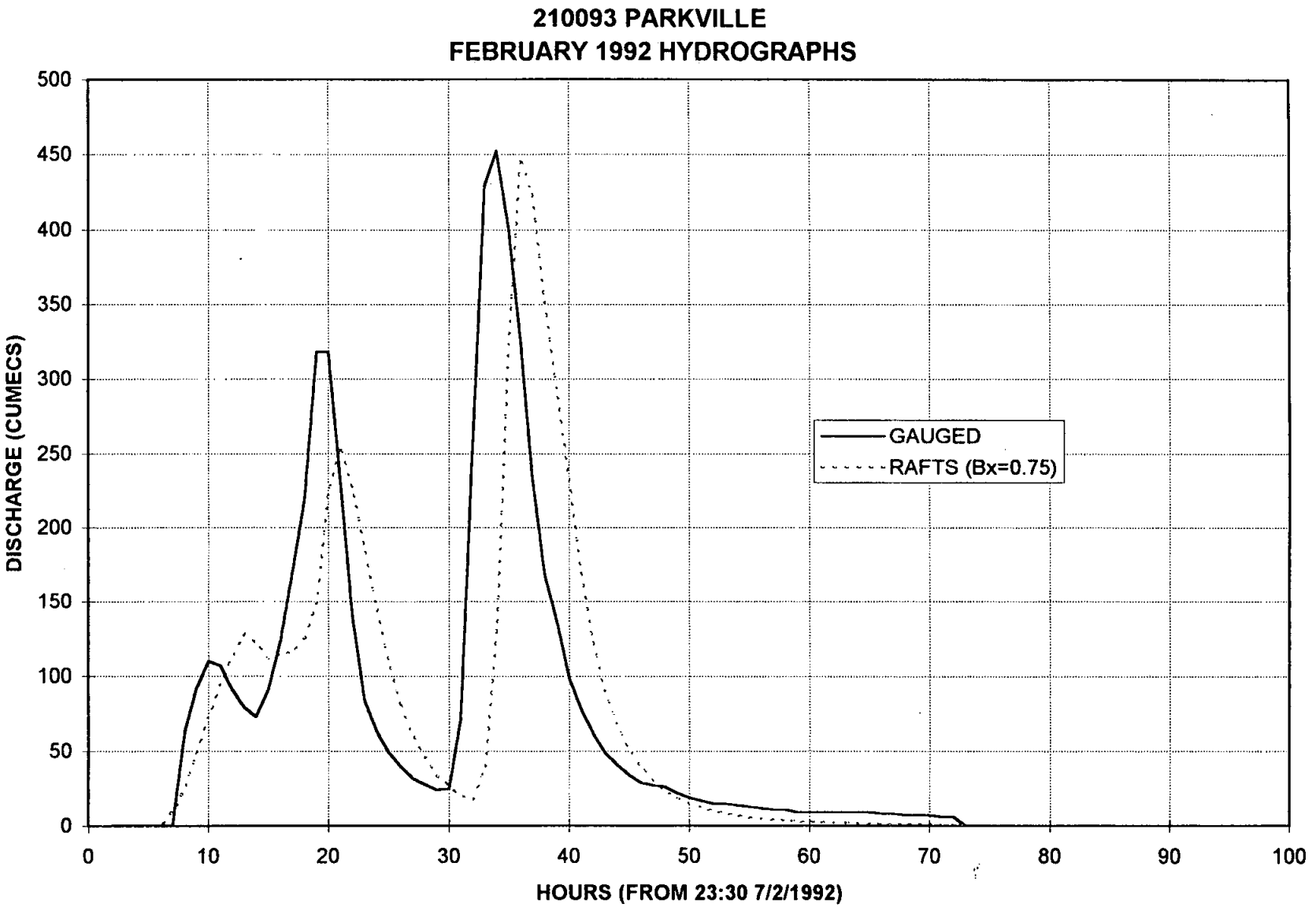

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TABLE 5.1: RAFTS CALIBRATION AT PARKVILLE GAUGING STATION (No.210093)

	Feb-92			Mar-77			Jan-76		
	GAUGE	MODEL (SCONE92f.XP) Bx=0.75 IL = 10/50mm*	DIFFERENCE (%)	GAUGE	MODEL (SCONE77f.XP) Bx=0.55 IL = 25mm	DIFFERENCE (%)	GAUGE	MODEL (SCONE76f.XP) Bx=0.75 IL = 80mm	DIFFERENCE (%)
Peak Flow (m^3/s)	452	450	-0.4	224	186	-17.0	327	310	-5.2
Volume ($m^3 \times 10^3$)	20679	20241	-2.1	14886	10557	-29.1	25617	23890	-6.7
Time to Peak (min)	2070	2190	5.8	4440	4440	0.0	2760	2880	4.3

Note: * indicates IL = 50mm for upper "Wingen" catchment areas.
CL = 2.5mm/h for all models

TABLE 5.1a: RAFTS CALIBRATION AT PARKVILLE GAUGING STATION (No.210093)

	Feb-92			Mar-77			Jan-76		
	GAUGE	MODEL (SCONE92f.XP) Bx=0.75 IL = 10/50mm*	DIFFERENCE (%)	GAUGE	MODEL (SCONE77f.XP) Bx=0.75 IL = 25mm	DIFFERENCE (%)	GAUGE	MODEL (SCONE76f.XP) Bx=0.75 IL = 80mm	DIFFERENCE (%)
Peak Flow (m^3/s)	452	450	-0.4	224	131	-41.5	327	310	-5.2
Volume ($m^3 \times 10^3$)	20679	20241	-2.1	14886	10554	-29.1	25617	23890	-6.7
Time to Peak (min)	2070	2190	5.8	4440	4470	0.7	2760	2880	4.3

Note: * indicates IL = 50mm for upper "Wingen" catchment areas.
CL = 2.5mm/h for all models

TABLE 5.2: RAFTS PEAK DESIGN FLOWS (m^3/s)
Bx=0.75, no rainfall reduction factor

LOCATION (RAFTS NODE)	10YR ARI IL=60mm (scone10.xp)							20YR ARI IL=55mm (scone20.xp)							50YR ARI IL=50mm (scone50.xp)						
	12hr	18hr	24hr	30hr	36hr	48hr	72hr	12hr	18hr	24hr	30hr	36hr	48hr	72hr	12hr	18hr	24hr	30hr	36hr	48hr	72hr
Kingdon Ponds Gauge (KP5)	92	104	124	251	231	**252**	115	213	232	220	376	374	**394**	155	397	376	346	495	514	**519**	243
U/S Study Boundary Middle Brook (MB3)	39	42	48	**98**	90	96	44	84	91	79	147	144	**149**	59	151	143	140	188	**193**	188	94
U/S Study Boundary Kingdon Ponds (KP6)	105	119	142	282	259	**284**	130	241	262	249	425	424	**449**	174	444	427	398	562	**587**	585	278
U/S Study Boundary Parsons Gully (PG1)	6	7	8	16	15	**16**	7	14	15	13	24	23	**25**	10	26	24	22	30	**32**	32	16
Liverpool Street * (COMBINED)	168	185	219	427	395	**427**	195	366	400	379	649	652	**659**	259	652	641	628	863	**902**	851	427
D/S Study Boundary * (D/S)	175	193	230	447	414	**448**	205	382	420	403	682	688	**694**	273	684	677	669	914	**958**	904	450

TABLE 5.2 cont..: RAFTS PEAK DESIGN FLOWS (m^3/s)
Bx=0.75, no rainfall reduction factor

LOCATION (RAFTS NODE)	100YR ARI IL=40mm (scone100.xp)							200YR ARI IL=30mm (scone200.xp)							PMF IL=0mm (sconepmf.xp)					
	12hr	18hr	24hr	30hr	36hr	48hr	72hr	12hr	18hr	24hr	30hr	36hr	48hr	72hr	1hr	2hr	3hr	4hr	5hr	6hr
Kingdon Ponds Gauge (KP5)	580	530	536	600	**643**	630	-	724	657	702	697	**756**	731	-	3370	5037	**5725**	5721	5401	5241
U/S Study Boundary Middle Brook (MB3)	212	195	208	223	**239**	224	-	258	248	266	258	**281**	260	-	862	1367	1583	**1680**	1606	1564
U/S Study Boundary Kingdon Ponds (KP6)	647	598	609	685	**732**	707	-	805	744	791	798	**863**	819	-	3693	5445	6258	**6318**	6120	5978
U/S Study Boundary Parsons Gully (PG1)	37	33	35	36	**39**	38	-	46	40	**46**	42	45	45	-	221	360	**374**	360	324	305
Liverpool Street * (COMBINED)	935	895	924	1049	**1132**	1040	-	1158	1147	1190	1219	**1336**	1212	-	4618	6863	8024	**8430**	8321	8250
D/S Study Boundary * (D/S)	985	951	981	1118	**1208**	1108	-	1230	1223	1266	1301	**1430**	1294	-	4622	6869	8039	**8451**	8357	8305

Note: Continuing Loss (CL) = 2.5mm/hr for all events except the PMF, PMF CL = 1.0mm/hr.
* indicates flows to be defined in hydraulic analysis

TABLE 5.3: COMPARISON OF PEAK DESIGN FLOWS AT KINGDON PONDS GAUGING STATION (NEAR PARKVILLE)

ARI (yr)	RURAL RATIONAL METHOD						FLOOD[1] FREQUENCY ANALYSIS	RAFTS-XP (KP5) Bx=0.75
	C_{10}	FFy	A (km^2)	Tc (hr)	I (mm/hr)	Q (m^3/s)	Q (m^3/s)	Q (m^3/s)
10	0.3	1.00	178	5.4	11.6	**172**	**180**	**252**
20	0.3	1.13	178	5.4	13.5	**226**	**327**	**394**
50	0.3	1.32	178	5.4	16.0	**313**	**595**	**519**
100	0.3	1.49	178	5.4	18.0	**397**	**866**	**643**

1992 $Q_{peak} \approx 452 m^3/s$

1955 Q_{peak} (DWR, 1986) ~ $500 m^3/s$

1. Annual Flood Frequency Analysis excluding annual maxima less than $18m^3/s$, probability of indifference is 1 in 6yr AEP.

6. HYDRAULIC MODELLING

6.1 The Model

The hydraulic flow modelling for this study was carried out using the MIKE 11 software package (**Reference 5**). It is a one-dimensional model for rivers and floodplains using the full Saint Venant Equations of momentum and continuity for unsteady flow.

The model allows flow to occur in one-dimensional flow paths which can be linked in a network to represent two-dimensional flow behaviour. By this method it is possible to model different flow paths, allowing the combining of overbank flows with adjacent waterways.

The model was developed for those sections of Middlebrook, Kingdon Ponds and Parsons Gully that lie within the Study Area. The model estimates design flood levels, flows and velocities.

6.2 Model Set-up

The model incorporates twenty six survey sections to represent the three main waterways, Middle Brook, Kingdon Ponds and Parsons Gully together with their adjacent floodplains. In the model the dx-max was set greater than the maximum survey section spacing so there would be no interpolation of section data.

Formulating the model involved defining the waterway characteristics, the model boundary conditions and initial water levels.

At each survey section the model allows for overbank spill from one waterway to the other with the overall model structure outlined in **Figure 6.1**.

6.2.1 Boundary Conditions

Inflow hydrographs previously calculated by the RAFTS-XP hydrological model were used as the upstream boundary condition.

For the downstream boundary a rating curve was calculated for the cross section using uniform flow analysis. The downstream boundary was located far enough downstream so that the rating curve does not affect flood levels towards the town.

6.2.2 Waterway Characteristics

Surveyed cross-sections were used to describe the channels and associated floodplains. The cross-sections extended some six kilometres upstream from Liverpool Street and a similar distance downstream of Liverpool Street. Most of the cross-sections include more than one channel.

The high ground immediately east of Middle Brook and Kingdon Ponds (most often the top of the eastern banks) served a boundary for the flow paths. **Report Volume II Waterway Sections** shows all the adopted boundaries for each flow path.

Chainages have been adopted assuming direct flow paths (i.e. simulating overbank flow).

Cross-sections in adjacent channels were linked to allow flow distribution to occur. This overbank flow was modelled as a broad waterway (with narrow conceptual slots to avoid model instabilities). The invert was taken as the high point between the two channels. Overbank depressions were assumed to have active flow.

Bridges and culverts were modelled as broad-crested weirs with waterway openings defined using the culvert option in MIKE 11. The Parsons Gully culvert at Liverpool Street was modelled with two sets of culverts to represent different culvert dimensions (see **Figure 6.1**).

Resistance to flow is a function of surface roughness in the channel and floodplain, and is affected by vegetation, development etc. Roughness coefficients were represented by Manning's "n" values.

Based on field observation and recommended text book values (**Reference 6**) a global Manning's "n" = 0.06 was adopted, and roughnesses for specific locations as summarised in **Table 6.1**.

TABLE 6.1: MIKE 11 MODEL ROUGHNESS COEFFICIENTS

Mike 11 Node	Location	Roughness
WMB3 0.00 - 0.02	Middle Brook, road "weir" overflow at Liverpool St	0.03
WKP6 6.00 - 6.02	Kingdon Ponds, road "weir" overflow at Liverpool St	0.03
WKP6A 0.00 - 0.02	Kingdon Ponds, road "weir" overflow at Turanville Rd	0.03
WPG1 6.00 - 6.02	Parsons Gully, road "weir" overflow at Liverpool St	0.02
PG1 6.01/PG1C 0.01	Parsons Gully culvert at Liverpool Street	0.015
KP6 6.01	Kingdon Ponds bridge waterway at Liverpool Street	0.03
KP6 12.16	Kingdon Ponds bridge waterway at Turanville Road	0.03
MB3 4.03	Middle Brook bridge waterway at Liverpool Street.	0.03

6.2.3 Initial Water Levels

Initial water levels and discharges needed to be set for each cross-section in the model. Top of bank levels and estimated 2 year ARI flows were adopted to create a "hot start" file which was subsequently used for initial model conditions.

6.2.4 Model Stability

A 0.2 minute timestep was adopted for model stability over the full range of assessed flood events. Time steps of longer duration resulted in some model instability at bridge and culvert waterway sections.

The instabilities may be satisfactorily overcome for running time steps up to 1 minute (without impacting model output) by modelling the Liverpool Street Parsons Gully culvert as a single set of equal sized culverts (rather than the presently modelled two sets of varying sized culverts), and adopting DELTA = 1.0 (rather than the adopted default value of 0.5).

6.3 Model Calibration

6.3.1 Approach

Calibration of the MIKE 11 model utilised the two largest events for which recorded rainfall, flow data and flood levels are available, i.e. the January 1976 and February 1992 flood events.

The 1992 flood being the larger and more recent flood event was considered the more reliable and applicable for calibration. However, apart from a single flood level on Kingdon Ponds at Turanville Road, recorded flood levels are available only for the urban area (i.e. between survey section 8 in the south to survey section 13 in the north, as shown in **Report Volume II, Drawings February 1992 MR3 and MR4**).

For the 1976 event a broader scatter of recorded flood levels was available over the Study Area (between survey section 4 in the south to survey section 16 in the north, shown in **Report Volume II, Drawings January 1976 MR2 to MR5**) but no information was available to cover the northern and southern limits.

To represent the floodplain as it existed in 1976 and in 1992 the following adjustments to the present day information were made in the respective MIKE 11 models;

- for the 1992 model, the Parsons Gully Liverpool Street culvert and road alignment were amended,
- for the 1976 model, the Parsons Gully Liverpool Street road alignment was further amended and the new race course was excluded. (No adjustments were necessary to represent the "pre-current" sewerage works treatment plant since 1976 flood water levels were not impacted by the development of this site.)

Model inflows were those generated from the RAFTS-XP hydrological modelling.

The downstream boundary condition was defined by a rating curve developed from uniform flow analysis.

Successive runs of the MIKE 11 model were made using various combinations of upstream boundary inflows (due to the lack of high gaugings as discussed in Section 4.4.2), downstream boundary rating curves and floodplain roughness until observed flood levels were "best" matched.

6.3.2 Results

Generated peak water levels, peak flows, peak average velocities and where applicable, cross flows between waterways are presented in **Tables MR76 and MR92.**

The tabulated flood levels and flows are also presented in plan in **Report Volume II.** The **Mike 11 Key Plan** shows that for each event seven plans are used to present the results (**Drawings January 1976 MR1 to MR7 and February 1992 MR1 to MR7**).

The results indicate the following:

Urban Area

The urban area flood levels predicted by the model are shown in **Report Volume II, Drawings January 1976 MR4 and MR5 and February 1992 MR4 and MR5.** Surveyed recorded flood levels are also shown on these plans.

Comparison of modelled and recorded flood levels shows general agreement to within 0.1m to 0.2m for most sections, however;

- modelled levels are approximately 0.5m above recorded levels at survey section 13 in Parsons Gully for the 1976 event. This discrepancy between levels could result from limited survey details available to determine modelled flow distribution on the floodplain (see discussion in following Northern Rural areas). It is also noteworthy that the 1976 modelled levels for survey sections at both upstream and downstream in Parsons Gully are consistent with nearby recorded levels.

- a difference of 0.4m below recorded levels in Parsons Gully at survey section 8. This discrepancy between modelled and recorded levels appears to result from limited survey detail downstream of survey section 8.

  Survey section 8 shows that Parsons Gully flows are essentially conveyed through a uniform "V" section over Kingdon Street (ignoring the low flow culvert) with a peak average velocity of 2.0m/s for both events. The next survey section 7 (located 500m downstream with an invert drop of over 3m) indicates that Parsons Gully flows are through the broad cross section of the sports ground with a peak average velocity between 0.4 to 0.5m/s.

  Significant survey information between sections 7 and 8 would be necessary to enable accurate modelling of what is expected to be a complex split/spill of flows from Kingdon Street overland into the sports ground.

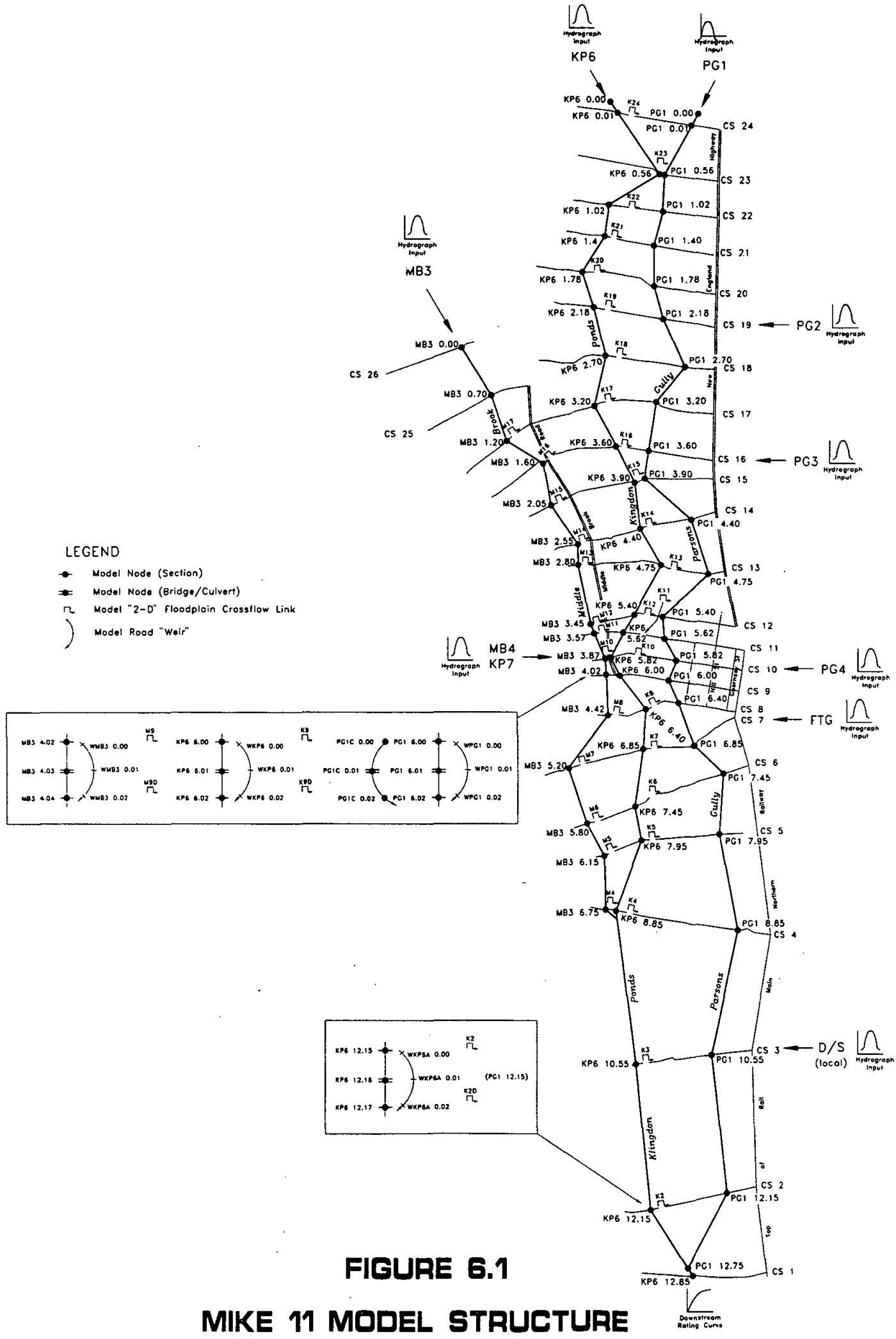


FIGURE 6.1

MIKE 11 MODEL STRUCTURE

- overall there is better agreement for the larger (1992) event then for the smaller (1976) event. This better agreement is achieved because at higher flows the limited survey information available on the breakout of flows across the floodplain becomes less critical.

Northern Rural Areas

In the northern rural areas modelled flood levels generally appear to be a reasonable representation of the 1976 recorded flood levels. However in Parsons Gully the 1976 modelled levels are up to 0.8m above the nearby recorded levels at survey section 15.

This large discrepancy between modelled and recorded levels appears to result from inaccurately modelled flow distribution on the floodplain. In particular, with survey sections approximately 500m apart in this location, the radical meanders in Kingdon Ponds are not represented in detail. More overbank flows may route to the higher western floodplain in this region rather than to the east into Parsons Gully, although this has not been confirmed by the existing survey.

Should more overbank flows route to the west, the apparent discrepancy in flood levels for the relatively small 1976 event would be expected to be less in the larger design events when overbank flows are significantly greater. This is because the western overbank capacity remains limited and Parsons Gully flood levels are particularly sensitive to initial flows into the Gully, but quite insensitive to high flows (being a broad floodplain area).

Southern Rural Areas

In the southern rural areas modelled flood levels generally appear to have a reasonable match to the 1976 recorded flood levels. However in Parsons Gully the 1976 modelled level is approximately 1.0m below a single recorded level near survey section 5.

It is noted that this single recorded flood level is described as being "at ground level at a wooden gate". This ground level is not consistent with the nearby survey section 5 spot levels, appearing to be over 1 metre above that expected from interpolation. It is also noted that the 1976 modelled flood levels for Parsons Gully upstream and downstream of survey section 5 appear to be consistent with nearby recorded flood levels (although only based on extrapolation). It is possible that the recorded level may be inaccurate.

However it is also possible with the combination of widely spaced survey sections (up to 1000m apart) and a relatively steep waterway gradient (the invert falls 5.4m from survey section 6 to survey section 4) that local floodplain variations may not be fully represented.

6.3.3 Sensitivity Analysis

Poor flood level reproduction from the initial hydraulic modelling led to a review of flows originally derived by the hydrologic model (and reported in **Progress Report No.2**). The flows were amended by adjusting the Kingdon Ponds rating curve at Parkville see **Section 4.4.2**).

The rating curve adjustment meant catchment flows were increased for the respective gauging station stage levels. For the 1992 events this meant that the modelled peak flow at the gauging station was increased from 379m^3/s to 450m^3/s. The increased flows resulted in a general increase of urban area flood levels of 0.1m (for the 1992 event).

Waterway roughness sensitivity was tested by increasing the adopted waterway and floodplain roughness of n = 0.06, to n = 0.07 for the 1992 event. An increase in flood levels of the order of 0.1m resulted.

Downstream boundary sensitivity was tested by increasing the uniform flow slope from s = 0.0015 to s = 0.0025, resulting in lower downstream boundary flood levels. In the 100 year ARI design event the downstream boundary flood level was reduced from 181.4mAHD to 181.1mAHD. The impact on flood levels extended for a distance of approximately 1.0km upstream. At survey section 2 (located 0.7km upstream from the downstream model boundary) the 100 year ARI design event flood level was reduced by 0.1m.

6.3.4 Discussion of Calibration and Sensitivity Testing

The sensitivity analysis indicates that for major events flood levels on the floodplain are;

- not very sensitive to the roughness variations within the expected range of catchment conditions,
- not significantly affected by changes in the downstream boundary rating curve (within the expected range of parameters).

Overall the calibration process indicates geographically that modelled flood levels for the urban area floodplain downstream of survey section 13 and upstream of survey section 8 (presented results on 1:5000 scale plans) are expected to be more reliable than those areas further north and south.

Model reliability in terms of flood magnitude is difficult to quantify. On the basis of limited "local" floodplain detail the model would not be expected to be reliable for events smaller than the 10 year ARI design flood. Also with February 1992 being the largest calibration event (with flows approximating the 20 year ARI event) as floods increase in magnitude greater than the 20 year ARI event, the model can be expected to have decreasing reliability.

More reliable modelled flood levels would require considerably more rainfall and stream gauging data, extensive field survey and a more extensive spread of recorded flood levels for significant and gauged flood events.

Recorded flood levels over the full extent of the floodplain during significant events is particularly useful flood data that Council and those within the catchment can collect.

TABLE MR76: MIKE 11 RESULTS (SCONE76X.RRF & SCONE76X.VRF) - JANUARY 1976 FLOOD EVENT

SURVEY SECTION	WATERWAY												"CROSS FLOW"	
	Middle Brook (MB3)				Kingdon Ponds (KP6)				Parsons Gully (PG1)				Middle Brook to Kingdon Ponds	Kingdon Ponds to Parsons Gully
	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	(m^3/s)	(m^3/s)
26	0.00	223.8	101	1.5	-	-	-	-	-	-	-	-	-	-
25	0.70	219.2	101	2.3	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	0.10	228.6	297	1.8	0.10	225.9	45	2.8	-	37
23	-	-	-	-	0.56	225.0	212	1.6	0.56	224.7	128	0.8	-	84
22	-	-	-	-	1.02	223.1	212	1.2	1.02	222.5	128	0.8	-	0
21	-	-	-	-	1.40	221.7	212	2.3	1.40	220.3	128	0.5	-	0
20	-	-	-	-	1.78	219.8	212	1.1	1.78	219.4	127	0.4	-	0
19	-	-	-	-	2.18	218.8	212	1.6	2.18	217.6	130	0.7	-	0
18	-	-	-	-	2.70	216.2	107	1.8	2.70	215.4	234	1.3	-	106
17	1.20	215.6	101	0.9	3.20	213.7	107	1.5	3.20	213.2	234	1.3	0	0
16	1.60	214.7	71	2.4	3.60	212.1	86	0.9	3.60	210.6	281	0.8	29	49
15	2.05	210.3	71	1.7	3.90	210.5	88	2.1	3.90	209.6	281	0.7	0	0
14	2.55	208.4	71	1.1	4.40	208.0	88	1.2	4.40	208.1	281	1.1	0	0
13	2.80	207.8	68	1.1	4.75	206.5	90	1.2	4.75	206.0	281	1.0	3	0
12	3.45	205.5	52	1.3	5.40	204.6	105	1.0	5.40	203.2	281	0.7	16	0
11	3.57	205.0	45	1.1	5.62	204.1	113	1.1	5.62	202.5	281	0.9	9	0
10	3.87	204.1	55	1.6	5.82	203.7	116	0.9	5.82	201.9	283	0.6	0	0
9	4.02 [A]	203.4	55	1.4	6.00 [B]	203.1	116	1.8	6.00 [C]	201.4	283	0.7	0	0
8	4.42	201.0	55	2.2	6.40	201.1	116	1.2	6.40	199.8	283	2.0	0	0
7	5.20	198.5	110	1.0	6.85	198.7	56	1.8	6.85	197.5	285	0.4	-60	0
6	5.80	196.4	84	1.6	7.45	195.8	81	1.1	7.45	197.0	285	1.4	26	0
5	6.15	194.8	61	1.1	7.95	194.8	103	1.3	7.95	194.1	286	0.9	23	0
4	6.75	193.7	53	1.3	8.85	193.6	108	0.8	8.85	191.4	294	1.0	14	10
3	-	-	-	-	10.55	188.8	66	1.7	10.55	187.2	397	0.7	-	89
2	-	-	-	-	12.15 [D]	181.8	71	2.0	12.15	182.4	396	0.7	-	0
1	-	-	-	-	12.85 [#]	180.6	462	1.0	#	#	#	#	-	-

Notes:

1. Mike 11 run 15/5/96, delta = 0.5, timestep = 0.2 minute.
2. Mike 11 files: scone76x.rdf, scone76f.nrf,scone76.bsf, sconeh.ssf (hot.rrf hot start @ 6.00hrs).
3. Velocity is average over full waterway width.
4. A. includes road "weir" overflow = 0 m^3/s
   B. includes road "weir" overflow = 0 m^3/s
   C. includes road "weir" overflow = 201 m^3/s
   D. includes road "weir" overflow = 0 m^3/s
5. # indicates that Kingdon Ponds and Parsons Gully is treated as a combined system.

TABLE MR92: MIKE 11 RESULTS (SCONE92X.RRF & SCONE92X.VRF) - FEBRUARY 1992 FLOOD EVENT

SURVEY SECTION	WATERWAY												"CROSS FLOW"	
	Middle Brook (MB3)				Kingdon Ponds (KP6)				Parsons Gully (PG1)				Middle Brook to Kingdon Ponds	Kingdon Ponds to Parsons Gully
	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	(m^3/s)	(m^3/s)
26	0.00	223.9	174	1.1	-	-	-	-	-	-	-	-	-	-
25	0.70	220.2	174	2.4	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	0.10	228.8	388	1.8	0.10	226.4	133	1.0	-	114
23	-	-	-	-	0.56	225.3	277	1.6	0.56	225.0	243	1.0	-	110
22	-	-	-	-	1.02	223.2	277	1.1	1.02	222.7	243	0.9	-	0
21	-	-	-	-	1.40	221.8	277	2.3	1.40	220.5	243	0.6	-	0
20	-	-	-	-	1.78	220.0	274	1.0	1.78	219.5	245	0.5	-	3
19	-	-	-	-	2.18	218.9	266	1.6	2.18	217.8	260	0.8	-	8
18	-	-	-	-	2.70	216.3	148	1.9	2.70	215.6	376	1.3	-	117
17	1.20	216.9	106	1.1	3.20	214.0	204	1.4	3.20	213.4	376	1.5	68	0
16	1.60	214.8	72	2.4	3.60	212.2	135	1.1	3.60	210.9	471	1.0	34	97
15	2.05	210.3	72	1.7	3.90	210.6	132	2.2	3.90	209.9	472	0.9	0	2
14	2.55	208.4	72	1.0	4.40	208.2	133	1.2	4.40	208.3	472	1.1	0	0
13	2.80	207.9	68	1.0	4.75	206.7	136	1.1	4.75	206.3	472	1.2	3	0
12	3.45	205.6	53	1.3	5.40	204.7	137	1.0	5.40	203.5	484	0.8	16	13
11	3.57	205.0	47	1.1	5.62	204.3	143	1.1	5.62	202.8	484	1.0	9	0
10	3.87	204.1	57	1.6	5.82	204.0	148	1.1	5.82	202.1	486	0.8	0	0
9	4.02 [A]	203.5	57	1.4	6.00 [B]	203.4	139	1.8	6.00 [C]	201.6	485	0.8	0	0
8	4.42	201.1	57	2.3	6.40	201.1	148	1.2	6.40	200.3	485	2.0	0	0
7	5.20	198.6	129	1.0	6.85	198.7	75	1.8	6.85	197.9	485	0.5	-74	0
6	5.80	196.5	91	1.6	7.45	196.2	112	1.2	7.45	197.2	481	1.4	38	0
5	6.15	194.9	66	1.1	7.95	194.9	134	1.3	7.95	194.5	493	1.1	25	0
4	6.75	193.7	52	1.3	8.85	193.7	116	0.8	8.85	191.6	530	0.9	17	35
3	-	-	-	-	10.55	188.8	68	1.6	10.55	187.4	645	0.8	-	99
2	-	-	-	-	12.15 [D]	181.8	72	2.1	12.15	182.7	630	0.8	-	0
1	-	-	-	-	12.85 [#]	180.9	696	1.0	#	#	#	#	-	-

Notes:

1. Mike 11 run 14/5/96, delta = 0.5, timestep = 0.2 minute.
2. Mike 11 files: scone92x.rdf, scone92f.nrf,scone92.bsf, sconeh.ssf (hot.rrf hot start @ 6.00hrs).
3. Velocity is average over full waterway width.
4. A. includes road "weir" overflow = 0 m^3/s
   B. includes road "weir" overflow = 9 m^3/s
   C. includes road "weir" overflow = 456 m^3/s
   D. includes road "weir" overflow = 0 m^3/s
5. # indicates that Kingdon Ponds and Parsons Gully is treated as a combined system.

6.4 Design Assessment

Estimated design flood levels, flows and indicative velocities for the 10 year, 20 year, 50 year, 100 year, 200 year ARIs and the PMF have been generated for Middle Brook, Kingdon Ponds and Parsons Gully and their floodplains using the calibrated MIKE 11 model.

Design inflows were defined by the RAFTS-XP hydrological modelling.

Based on the calibration results a waterway and floodplain roughness of n = 0.06 was adopted for modelling the critical duration design flow events.

6.4.1 Model Results

The MIKE 11 design results are presented in **Tables MR10, MR20, MR50, MR100, MR200 and MRPMF,** and **Report Volume II, Drawings MR1 to MR7** for the respective recurrence intervals.

The presented flows at model sections along Middle Brook, Kingdon Ponds and Parsons Gully represent the section inflows less any adjacent "cross flow".

Some implications of modelling this complex "two dimensional" flood plain (which has significant overbank flows) with only limited overbank break out and water run definition are;

- overbank flows and velocities are only indicative. Detailed flood plain survey is necessary to determine overbank break out locations and water runs.
- the tabulated peak average velocities are across the total modelled sections and do not represent peak velocities in waterways and overbank water runs.
- that there are significant water surface profile gradients "along stream", and "off stream" between the waterways of Middle Brook, Kingdon Ponds and Parsons Gully. Therefore one dimensional flood profiles are not considered adequate for flood level definition. To limit the danger of information misuse only 100 year ARI MIKE 11 profiles are included in **Appendix C**. Flood level definition should be based on the interpolated design flood contours.

6.4.2 Interpolated Design Flood Contours

Based on **Drawings MR1 to MR7,** flood level interpolation has been conducted to produce flood contour mapping for Middle Brook, Kingdon Ponds and Parsons Gully. The design recurrence interval flood contours are presented in **Report Volume II, Drawings FC1 to FC7** for the respective recurrence interval flood levels.

The interpolation procedure has involved the following;

- drawing a straight line between MIKE 11 defined flood levels along each of the three waterways (Middle Brook, Kingdon Ponds and Parsons Gully) and interpolating flood levels along the drawn line,
- projecting the interpolated flood levels (parallel to adjacent survey sections) onto the within bank waterway,
- joining matching flood level contours for each of the three waterways.

The underlying assumption for joining matching contours is that overbank breakout flows are possible, although not necessarily defined in the MIKE 11 model due to limited survey.

Flood level contours are presented as a broken line where the uncertainty of overbank breakout flow is present.

The flood level contours do **not** define the extent of flood liable land. The extent of flood liable land can only be estimated by comparing the estimated flood levels with surveyed ground levels.

TABLE MR10: MIKE 11 RESULTS (SCONE10.RRF & SCONE10.VRF) - 10 YEAR ARI DESIGN FLOOD EVENT

SURVEY SECTION	WATERWAY												"CROSS FLOW"	
	Middle Brook (MB3)				Kingdon Ponds (KP6)				Parsons Gully (PG1)				Middle Brook to Kingdon Ponds	Kingdon Ponds to Parsons Gully
	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	(m^3/s)	(m^3/s)
26	0.00	223.8	96	1.1	-	-	-	-	-	-	-	-	-	-
25	0.70	219.9	96	1.5	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	0.10	228.6	270	1.8	0.10	225.7	25	0.9	-	14
23	-	-	-	-	0.56	224.9	207	1.6	0.56	224.4	87	0.7	-	63
22	-	-	-	-	1.02	223.1	207	1.1	1.02	222.4	87	0.7	-	0
21	-	-	-	-	1.40	221.7	207	2.3	1.40	220.2	87	0.4	-	0
20	-	-	-	-	1.78	219.8	207	1.0	1.78	219.3	87	0.4	-	0
19	-	-	-	-	2.18	218.8	206	1.6	2.18	217.6	93	0.6	-	0
18	-	-	-	-	2.70	216.2	105	1.8	2.70	215.3	194	1.3	-	101
17	1.20	216.8	70	1.1	3.20	213.8	126	1.4	3.20	213.1	194	1.3	26	0
16	1.60	214.6	68	2.3	3.60	212.1	80	0.9	3.60	210.6	242	0.8	3	49
15	2.05	210.2	68	1.7	3.90	210.4	79	2.2	3.90	209.5	242	0.7	0	0
14	2.55	208.4	68	1.0	4.40	208.0	76	1.2	4.40	208.0	242	1.2	0	0
13	2.80	207.8	66	1.0	4.75	206.5	76	1.1	4.75	206.0	242	1.0	2	0
12	3.45	205.5	51	1.3	5.40	204.5	89	0.9	5.40	203.1	242	0.6	15	0
11	3.57	205.0	47	1.1	5.62	204.0	93	1.1	5.62	202.5	242	0.8	7	0
10	3.87	204.3	62	1.5	5.82	203.5	99	0.9	5.82	201.7	244	0.8	2	0
9	4.02 [A]	203.9	62	1.4	6.00 [B]	202.9	99	1.7	6.00 [C]	201.1	244	0.9	0	0
8	4.42	201.3	63	2.2	6.40	201.0	99	1.2	6.40	199.7	244	2.0	0	0
7	5.20	198.5	108	1.0	6.85	198.6	49	1.8	6.85	197.4	246	0.4	-50	0
6	5.80	196.4	83	1.6	7.45	195.7	74	1.2	7.45	196.9	244	1.1	25	0
5	6.15	194.8	60	1.1	7.95	194.7	96	1.3	7.95	194.1	251	0.8	23	0
4	6.75	193.6	53	1.4	8.85	193.6	105	0.6	8.85	191.3	252	0.9	13	4
3	-	-	-	-	10.55	188.7	66	1.6	10.55	187.2	357	0.6	-	86
2	-	-	-	-	12.15 [D]	181.8	70	2.0	12.15	182.3	351	0.7	-	0
1	-	-	-	-	12.85 [#]	180.5	416	1.0	#	#	#	#	-	-

Notes:

1. Mike 11 run 14/5/96, dx-max > maximum section spacing, delta = 0.5, timestep = 0.2 minute.
2. Mike 11 files: scone96x.rdf, scone10.nrf,scone96.bsf, sconeh.ssf (hot.nrf hot start @ 6.00hrs).
3. Velocity is average over full waterway width.
4. A. peak road "weir" overflow = 8 m^3/s
   B. peak road "weir" overflow = 0 m^3/s
   C. peak road "weir" overflow = 32 m^3/s
   D. peak road "weir" overflow = 0 m^3/s
5. # indicates that Kingdon Ponds and Parsons Gully is treated as a combined system.

TABLE MR20: MIKE 11 RESULTS (SCONE20.RRF & SCONE20.VRF) - 20 YEAR ARI DESIGN FLOOD EVENT

SURVEY SECTION	WATERWAY												"CROSS FLOW"	
	Middle Brook (MB3)				Kingdon Ponds (KP6)				Parsons Gully (PG1)				Middle Brook to Kingdon Ponds	Kingdon Ponds to Parsons Gully
	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	(m^3/s)	(m^3/s)
26	0.00	223.9	149	1.1	-	-	-	-	-	-	-	-	-	-
25	0.70	220.1	148	1.9	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	0.10	228.8	360	1.8	0.10	226.3	107	1.4	-	88
23	-	-	-	-	0.56	225.2	256	1.6	0.56	224.9	208	1.0	-	104
22	-	-	-	-	1.02	223.2	256	1.1	1.02	222.6	208	0.9	-	0
21	-	-	-	-	1.40	221.8	256	2.3	1.40	220.5	208	0.6	-	0
20	-	-	-	-	1.78	219.9	255	1.1	1.78	219.5	207	0.6	-	0
19	-	-	-	-	2.18	218.9	250	1.6	2.18	217.8	223	0.8	-	4
18	-	-	-	-	2.70	216.2	137	1.8	2.70	215.5	335	1.1	-	113
17	1.20	216.9	94	1.1	3.20	213.9	184	1.4	3.20	213.3	334	1.4	54	0
16	1.60	214.7	71	2.4	3.60	212.2	120	1.0	3.60	210.8	421	0.9	23	83
15	2.05	210.3	71	1.7	3.90	210.6	119	2.2	3.90	209.8	421	0.8	0	0
14	2.55	208.4	71	1.0	4.40	208.1	119	1.2	4.40	208.3	420	1.2	0	0
13	2.80	207.8	68	1.4	4.75	206.6	121	1.1	4.75	206.2	421	1.2	3	0
12	3.45	205.6	52	1.3	5.40	204.7	129	0.9	5.40	203.4	428	0.7	16	8
11	3.57	205.0	49	1.1	5.62	204.3	133	1.1	5.62	202.7	427	1.0	4	0
10	3.87	204.4	65	1.5	5.82	204.0	147	0.9	5.82	202.1	432	0.8	11	0
9	4.02 [A]	204.1	65	1.4	6.00 [B]	203.4	147	1.8	6.00 [C]	201.7	432	1.0	0	0
8	4.42	201.6	60	1.9	6.40	201.2	150	1.3	6.40	200.2	431	2.0	11	0
7	5.20	198.6	133	1.0	6.85	198.7	77	1.8	6.85	197.8	433	0.5	-74	0
6	5.80	196.5	92	1.6	7.45	196.2	116	1.3	7.45	197.1	432	1.1	41	0
5	6.15	194.9	67	1.1	7.95	194.9	139	1.4	7.95	194.3	434	1.0	25	0
4	6.75	193.7	53	1.5	8.85	193.7	117	0.6	8.85	191.6	471	0.9	17	39
3	-	-	-	-	10.55	188.8	68	1.7	10.55	187.4	606	0.7	-	100
2	-	-	-	-	12.15 [D]	181.8	71	2.1	12.15	182.7	600	0.8	-	0
1	-	-	-	-	12.85 [#]	180.8	668	1.0	#	#	#	#	-	-

Notes:

1. Mike 11 run 15/5/96, dx-max > maximum section spacing, delta = 0.5, timestep = 0.2 minute.
2. Mike 11 files: scone96x.rdf, scone20.nrf,scone96.bsf, sconeh.ssf (hot.nrf hot start @ 6.00hrs).
3. Velocity is average over full waterway width.
4. A. peak road "weir" overflow = 12 m^3/s
   B. peak road "weir" overflow = 9 m^3/s
   C. peak road "weir" overflow = 201 m^3/s
   D. peak road "weir" overflow = 0 m^3/s
5. # indicates that Kingdon Ponds and Parsons Gully is treated as a combined system.

TABLE MR50: MIKE 11 RESULTS (SCONE50.RRF & SCONE50.VRF) - 50 YEAR ARI DESIGN FLOOD EVENT

SURVEY SECTION	WATERWAY												"CROSS FLOW"	
	Middle Brook (MB3)				Kingdon Ponds (KP6)				Parsons Gully (PG1)				Middle Brook to Kingdon Ponds	Kingdon Ponds to Parsons Gully
	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	(m^3/s)	(m^3/s)
26	0.00	224.0	193	1.1	-	-	-	-	-	-	-	-	-	-
25	0.70	220.2	193	1.5	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	0.10	228.9	431	1.8	0.10	226.5	182	1.0	-	155
23	-	-	-	-	0.56	225.3	310	1.6	0.56	225.1	302	1.1	-	121
22	-	-	-	-	1.02	223.3	310	1.1	1.02	222.7	302	1.0	-	0
21	-	-	-	-	1.40	221.9	310	2.3	1.40	220.6	302	0.6	-	0
20	-	-	-	-	1.78	220.0	301	1.0	1.78	219.6	310	0.6	-	9
19	-	-	-	-	2.18	218.9	286	1.6	2.18	217.9	343	0.9	-	14
18	-	-	-	-	2.70	216.3	165	1.9	2.70	215.7	464	1.1	-	121
17	1.20	216.9	117	1.1	3.20	214.0	234	1.4	3.20	213.5	463	1.5	76	0
16	1.60	214.8	73	2.4	3.60	212.3	163	1.1	3.60	211.0	583	1.0	44	112
15	2.05	210.3	73	1.7	3.90	210.7	156	2.2	3.90	210.1	590	1.0	0	7
14	2.55	208.4	73	1.0	4.40	208.2	156	1.1	4.40	208.5	590	1.2	0	0
13	2.80	207.9	69	1.1	4.75	206.7	160	1.1	4.75	206.4	590	1.3	4	0
12	3.45	205.6	53	1.3	5.40	204.8	151	0.9	5.40	203.7	613	0.8	16	25
11	3.57	205.0	49	1.1	5.62	204.5	155	1.1	5.62	203.0	613	1.1	4	0
10	3.87	204.4	71	1.5	5.82	204.2	169	1.0	5.82	202.4	633	0.8	16	12
9	4.02 [A]	204.2	71	1.3	6.00 [B]	203.6	169	1.8	6.00 [C]	202.0	633	1.0	1	0
8	4.42	201.6	64	1.9	6.40	201.2	175	1.3	6.40	200.6	633	2.0	12	0
7	5.20	198.7	145	1.0	6.85	198.8	93	1.8	6.85	198.1	643	0.6	-81	0
6	5.80	196.6	96	1.6	7.45	196.3	143	1.3	7.45	197.3	643	1.1	49	0
5	6.15	195.0	73	1.1	7.95	195.0	164	1.4	7.95	194.6	643	1.2	26	0
4	6.75	193.7	54	1.5	8.85	193.7	124	0.6	8.85	191.8	701	1.0	20	61
3	-	-	-	-	10.55	188.8	70	1.7	10.55	187.5	864	0.8	-	108
2	-	-	-	-	12.15 [D]	182.0	71	2.1	12.15	183.0	860	0.9	-	0
1	-	-	-	-	12.85 [#]	181.2	929	1.0	#	#	#	#	-	-

Notes:

1. Mike 11 run 15/5/96, dx-max > maximum section spacing, delta = 0.5, timestep = 0.2 minute.
2. Mike 11 files: scone96x.rdf, scone50.nrf,scone96.bsf, sconeh.ssf (hot.rrf hot start @ 6.00hrs).
3. Velocity is average over full waterway width.
4. A. peak road "weir" overflow = 16 m^3/s
   B. peak road "weir" overflow = 17 m^3/s
   C. peak road "weir" overflow = 473 m^3/s
   D. peak road "weir" overflow = 0 m^3/s
5. # indicates that Kingdon Ponds and Parsons Gully is treated as a combined system.

TABLE MR100: MIKE 11 RESULTS (SCONE100.RRF & SCONE100.VRF) - 100 YEAR ARI DESIGN FLOOD EVENT

SURVEY SECTION	WATERWAY												"CROSS FLOW"	
	Middle Brook (MB3)				Kingdon Ponds (KP6)				Parsons Gully (PG1)				Middle Brook to Kingdon Ponds	Kingdon Ponds to Parsons Gully
	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	(m^3/s)	(m^3/s)
26	0.00	224.0	239	1.0	-	-	-	-	-	-	-	-	-	-
25	0.70	220.3	239	1.5	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	0.10	228.9	504	1.8	0.10	226.7	261	0.9	-	228
23	-	-	-	-	0.56	225.4	368	1.6	0.56	225.3	397	1.2	-	136
22	-	-	-	-	1.02	223.4	367	1.1	1.02	222.8	397	1.1	-	0
21	-	-	-	-	1.40	222.1	367	2.1	1.40	220.7	397	0.7	-	0
20	-	-	-	-	1.78	220.1	346	1.0	1.78	219.7	419	0.7	-	22
19	-	-	-	-	2.18	219.0	320	1.6	2.18	218.0	469	0.9	-	26
18	-	-	-	-	2.70	216.3	192	1.8	2.70	215.8	596	1.2	-	128
17	1.20	217.0	141	1.1	3.20	214.1	281	1.4	3.20	213.6	595	1.5	98	0
16	1.60	214.8	74	2.3	3.60	212.3	209	0.9	3.60	211.2	745	1.1	67	137
15	2.05	210.3	74	1.7	3.90	210.8	192	2.2	3.90	210.3	760	1.1	0	16
14	2.55	208.4	74	1.0	4.40	208.3	192	1.1	4.40	208.6	760	1.2	0	0
13	2.80	207.9	70	1.0	4.75	206.8	196	1.1	4.75	206.6	760	1.4	4	0
12	3.45	205.6	54	1.3	5.40	204.8	170	0.9	5.40	203.9	801	0.9	16	42
11	3.57	205.0	50	1.1	5.62	204.6	175	1.1	5.62	203.2	801	1.1	4	0
10	3.87	204.5	77	1.5	5.82	204.3	183	1.0	5.82	202.6	840	0.9	19	25
9	4.02 [A]	204.2	75	1.4	6.00 [B]	203.7	183	1.8	6.00 [C]	202.2	840	1.1	3	0
8	4.42	201.6	67	1.9	6.40	201.2	191	1.2	6.40	200.8	839	2.0	11	0
7	5.20	198.7	154	1.0	6.85	198.8	104	1.8	6.85	198.4	856	0.7	-87	0
6	5.80	196.6	98	1.7	7.45	196.3	159	1.3	7.45	197.5	856	1.2	56	0
5	6.15	195.1	77	1.1	7.95	195.1	180	1.4	7.95	194.8	857	1.4	26	0
4	6.75	193.8	54	1.3	8.85	193.7	129	0.6	8.85	191.9	928	0.9	22	74
3	-	-	-	-	10.55	188.8	72	1.6	10.55	187.7	1113	0.9	-	112
2	-	-	-	-	12.15 [D]	182.1	72	2.1	12.15	183.2	1109	1.0	-	0
1	-	-	-	-	12.85 [#]	181.4	1181	1.0	#	#	#	#	-	-

Notes:

1. Mike 11 run 15/5/96, dx-max > maximum section spacing, delta = 0.5, timestep = 0.2 minute.
2. Mike 11 files: scone96x.rdf, scone100.nrf,scone96.bsf, sconeh.ssf (hot.nrf hot start @ 6.00hrs).
3. Velocity is average over full waterway width.
4. A. peak road "weir" overflow = 21 m^3/s
   B. peak road "weir" overflow = 22 m^3/s
   C. peak road "weir" overflow = 707 m^3/s
   D. peak road "weir" overflow = 0 m^3/s
5. # indicates that Kingdon Ponds and Parsons Gully is treated as a combined system.

TABLE MR200: MIKE 11 RESULTS (SCONE200.RRF & SCONE200.VRF) - 200 YEAR ARI DESIGN FLOOD EVENT

SURVEY SECTION	WATERWAY												"CROSS FLOW"	
	Middle Brook (MB3)				Kingdon Ponds (KP6)				Parsons Gully (PG1)				Middle Brook to Kingdon Ponds	Kingdon Ponds to Parsons Gully
	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	(m^3/s)	(m^3/s)
26	0.00	224.1	279	1.0	-	-	-	-	-	-	-	-	-	-
25	0.70	220.4	279	1.5	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	0.10	229.0	569	1.8	0.10	226.8	326	1.0	-	288
23	-	-	-	-	0.56	225.5	430	1.2	0.56	225.4	465	1.2	-	140
22	-	-	-	-	1.02	223.5	421	1.1	1.02	222.9	474	1.1	-	9
21	-	-	-	-	1.40	222.2	421	2.1	1.40	220.8	474	0.8	-	0
20	-	-	-	-	1.78	220.2	384	1.0	1.78	219.8	510	0.7	-	36
19	-	-	-	-	2.18	219.0	348	1.6	2.18	218.1	575	1.0	-	36
18	-	-	-	-	2.70	216.3	215	1.8	2.70	215.9	708	1.3	-	133
17	1.20	217.0	159	1.1	3.20	214.2	323	1.4	3.20	213.7	710	1.4	119	3
16	1.60	214.9	75	2.3	3.60	212.4	248	0.9	3.60	211.4	883	1.1	84	157
15	2.05	210.3	75	1.8	3.90	210.8	223	2.2	3.90	210.4	907	1.1	0	25
14	2.55	208.4	75	1.0	4.40	208.3	223	1.1	4.40	208.8	907	1.2	0	0
13	2.80	207.9	71	1.0	4.75	206.9	227	1.1	4.75	206.8	907	1.5	5	0
12	3.45	205.6	54	1.3	5.40	204.9	187	0.9	5.40	204.0	962	0.9	16	56
11	3.57	205.0	50	1.1	5.62	204.6	192	1.0	5.62	203.4	962	1.1	7	0
10	3.87	204.5	83	1.4	5.82	204.3	192	1.0	5.82	202.8	1016	0.9	20	36
9	4.02 [A]	204.2	81	1.3	6.00 [B]	203.8	192	1.8	6.00 [C]	202.3	1016	1.2	2	0
8	4.42	201.2	81	2.5	6.40	201.3	194	1.2	6.40	201.0	1015	2.0	0	0
7	5.20	198.8	163	1.0	6.85	198.8	111	1.8	6.85	198.6	1037	0.7	-83	0
6	5.80	196.6	101	1.7	7.45	196.3	174	1.2	7.45	197.6	1036	1.2	63	0
5	6.15	195.2	80	1.1	7.95	195.2	194	1.3	7.95	195.0	1037	1.4	26	0
4	6.75	193.8	56	1.3	8.85	193.8	133	0.7	8.85	192.1	1120	0.9	24	85
3	-	-	-	-	10.55	188.8	74	1.6	10.55	187.8	1327	1.0	-	115
2	-	-	-	-	12.15 [D]	182.2	74	2.1	12.15	183.4	1323	1.0	-	0
1	-	-	-	-	12.85 #	181.6	1396	1.0	#	#	#	#	-	-

Notes:

1. Mike 11 run 15/5/96, dx-max > maximum section spacing, delta = 0.5, timestep = 0.2 minute.
2. Mike 11 files: scone96x.rdf, scone200.nrf,scone96.bsf, sconeh.ssf (hot.rrf hot start @ 6.00hrs).
3. Velocity is average over full waterway width.
4. A. peak road "weir" overflow = 21 m^3/s
   B. peak road "weir" overflow = 25 m^3/s
   C. peak road "weir" overflow = 898 m^3/s
   D. peak road "weir" overflow = 0 m^3/s
5. # indicates that Kingdon Ponds and Parsons Gully is treated as a combined system.

TABLE MRPMF: MIKE 11 RESULTS (SCONPMP4.RRF & SCONPMP4.VRF) - PMF DESIGN FLOOD EVENT

SURVEY SECTION	WATERWAY												"CROSS FLOW"	
	Middle Brook (MB3)				Kingdon Ponds (KP6)				Parsons Gully (PG1)				Middle Brook to Kingdon Ponds	Kingdon Ponds to Parsons Gully
	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	Model Node	Peak Water Level (mAHD)	Peak Flow (m3/s)	Peak Average Velocity (m/s)	(m3/s)	(m3/s)
26	0.00	225.2	1680	1.5	-	-	-	-	-	-	-	-	-	-
25	0.70	221.6	1676	1.7	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	0.10	230.7	3485	3.1	0.10	229.1	3012	1.6	-	2834
23	-	-	-	-	0.56	227.4	3359	1.7	0.56	227.4	3134	2.6	-	187
22	-	-	-	-	1.02	225.4	2357	1.7	1.02	224.8	4135	2.3	-	1001
21	-	-	-	-	1.40	223.8	1781	2.4	1.40	223.0	4709	1.9	-	575
20	-	-	-	-	1.78	221.6	1516	1.6	1.78	221.6	4972	1.7	-	265
19	-	-	-	-	2.18	220.0	1543	1.9	2.18	220.0	5034	1.9	-	115
18	-	-	-	-	2.70	217.7	1830	2.4	2.70	217.7	4743	1.8	-	-291
17	1.20	217.9	752	1.5	3.20	215.7	2275	2.0	3.20	215.6	5060	2.2	923	368
16	1.60	215.6	200	2.5	3.60	213.8	2671	1.9	3.60	213.8	5182	2.0	570	371
15	2.05	211.5	312	2.1	3.90	212.5	3064	2.5	3.90	212.7	4667	2.2	-120	-515
14	2.55	209.9	646	1.1	4.40	210.2	3233	2.3	4.40	210.5	4160	2.1	-336	-506
13	2.80	209.1	295	1.4	4.75	208.9	2976	1.4	4.75	208.7	4763	2.8	350	605
12	3.45	207.1	264	2.7	5.40	207.1	1661	1.1	5.40	206.7	6105	1.6	31	1346
11	3.57	206.8	377	1.9	5.62	206.8	1188	1.1	5.62	206.2	6469	1.9	-113	365
10	3.87	206.2	515	1.5	5.82	206.2	857	2.3	5.82	205.8	6930	1.7	131	435
9	4.02 [A]	205.8	453	1.4	6.00 [B]	205.7	805	1.9	6.00 [C]	205.4	7046	2.1	64	116
8	4.42	202.8	404	2.0	6.40	202.8	1778	1.8	6.40	203.4	6115	3.0	-68	-822
7	5.20	200.6	799	1.4	6.85	200.6	1675	1.7	6.85	201.1	5848	1.7	-411	-299
6	5.80	198.9	358	2.0	7.45	198.9	2531	1.7	7.45	199.5	5421	1.9	442	-430
5	6.15	197.4	329	1.6	7.95	197.4	2195	1.6	7.95	197.0	5777	2.3	33	362
4	6.75	195.1	145	1.7	8.85	195.0	442	1.2	8.85	194.3	7708	1.7	184	1936
3	-	-	-	-	10.55	190.2	347	3.2	10.55	190.2	7932	1.9	-	234
2	-	-	-	-	12.15 [D]	186.3	1309	3.0	12.15	186.4	6970	1.5	-	-962
1	-	-	-	-	12.85 #	185.1	8244	1.8	#	#	#	#	-	-

Notes:

1. Mike 11 run 15/7/96, dx-max > maximum section spacing, delta = 0.5, timestep = 0.2 minute.
2. Mike 11 files: scone96x.rdf, sconpmp4.nrf,scone96.bsf, sconeh.ssf (hot.rrf hot start @ 6.00hrs).
3. Velocity is average over full waterway width.
4. A. peak road "weir" overflow = 338 m^3/s
   B. peak road "weir" overflow = 554 m^3/s
   C. peak road "weir" overflow = 6747 m^3/s
   D. peak road "weir" overflow = 1257 m^3/s
5. # indicates that Kingdon Ponds and Parsons Gully is treated as a combined system.
6. Cross flows; M9D = 116 m^3/s, K9D = -104 m^3/s and K2D = -938 m^3/s, are not itemised in table.

7. REFERENCES

1. Institute of Engineers Australia, (1987). *"Australian Rainfall and Runoff - A Guide to Flood Estimation, Volumes 1 & 2"*, The Institute of Engineers Australia.

2. Bureau of Meteorology (1994). *"The Estimation of Probable Maximum Precipitation: Generalised Short Duration-Method"*, Bureau of Meteorology, Bulletin 53.

3. WP Software (1994). *"RAFTS-XP - Version 5 Runoff Analysis & Flow Training Simulation with XP Graphical Interface"*.

4. International Hydrology and Water Resources Symposium, Perth 2-4th October 1991, Walsh M.A., Pilgrim D.H. & Cordery I., (1991). *"Initial Losses for Design Flood Estimation in New South Wales"*.

5. Danish Hydraulic Institute (1986). *"MIKE11 User's Guide and Scientific Documentation"*, Danish Hydraulic Institute.

6. Chow V.T. (1959). *"Open Channel Hydraulics"*, McGraw-Hill, Sydney.

APPENDIX A - RECORDED FLOOD LEVELS

TABLE A92U: URBAN HISTORIC FLOOD LEVELS - FEBRUARY 1992

Dwg No. (1992)	Street No.	Street / Location	Observed Level (mAHD)	Comment
MR4	20	Liverpool	201.93	Above floor level
MR3	9	St Aubins	201.98	Above floor level
MR3	10	St Aubins	201.41	Above floor level
MR4	55	Wingen	200.94	Above floor level
MR4	59	Wingen	200.92	Above floor level
MR4	21	Kingdon	200.81	Above floor level
MR4	-	Old Court Theatre	200.61	Above floor level
MR4	95	Aberdeen	201.07	Above floor level
MR4	88	Aberdeen	200.92	Above floor level
MR4	-	Scone General Store	201.56	Above floor level
MR4	64	Liverpool	201.53	Above floor level
MR4	62	Liverpool	201.53	Above floor level
MR4	63	Liverpool	201.44	Above floor level
MR3	39	Aberdeen	203.17	Above floor level
MR3	58	Susan	203.02	Above floor level
MR3	5	Parker	203.34	0.45m above GL at front door
MR3	7	Parker	203.53	Above floor level
MR3	11	Parker	203.47	Above floor level
MR3	10	Parker	203.44	0.75m above GL at front door
MR3	16	Parker	203.49	Above floor level
MR3	13	Mount	203.74	Above floor level
MR3	-	Access to Milton Farm	206.07	0.34m above dumpy. Fence LHS going west , peg at GL around cnr on h'way side of creek
MR4	-	Halliday's house	203.54	Mark on gate post at horse paddock
MR6	-	Turanville Road	181.9	Peg highway side south fence
MR4	-	Liverpool	203.7	TOK nth side 2nd house from roundabout
MR4	-	Liverpool	201.5	TOK nth side in front of no.66
MR4	-	Kingdon	200.8	TOK nth side in front of grammar school
MR3	-	Susan	203.1	TOK sth side east of Aberdeen St
MR3	-	Parker	203.5	TOK sth side
MR3	-	Mount	203.7	TOK sth side in front of vacant block
MR3	-	Forbes	204.1	Peg on fenceline, nth side in Hill St reserve

TABLE A76U: URBAN HISTORIC FLOOD LEVELS - JANUARY 1976

Dwg No. (1976)	Street No.	Street	Observed Level (mAHD)	Comment
MR3	-	Aberdeen	203.99	Shed Nth Scone
MR3	53	Aberdeen	201.94	FM on shed wall
MR4	79	Aberdeen	201.54	Front fence
MR4	79	Aberdeen	201.41	Fence
MR4	94	Aberdeen	200.74	FL on garage door
MR4	-	Aberdeen	200.23	Old Court House garage door
MR4	25	Kingdon	200.47	Fence
MR4	44	Kingdon	200.63	FM front of house
MR4	10	Liverpool	203.43	Below previous floor level
MR4	12	Liverpool	201.63	Back verandah
MR4	-	Liverpool	203.34	FM on park fence
MR4	22	Liverpool	201.68	FM on house
MR3	-	Orthes	201.31	0.15m above GL at well, 100m NE of 12 Aubins St
MR3	16	Parker	203.4	Fence
MR3	11	Parker	203.25	Fence
MR3	7	Parker	203.28	Front porch
MR3	6	St Aubins	201.39	FM on gate
MR3	12	St Aubins	201.33	Fence
MR4	-	Wingen	201.21	Centre line Liverpool St, 20m south of intersection
MR4	53	Wingen	201.08	Fence

TABLE A76R: RURAL HISTORIC FLOOD LEVELS - JANUARY 1976

Dwg No. (1976)	Location	Observed Level (mAHD)	Comment
MR2	"Waawaarawa" Dr pye	210.69	Centreline depression +0.65m
MR2	"	210.74	Near RB Kingdon Ponds GL at power pole - feed trough
MR2	"	210.52	GL 10m east of cnr fence post
MR2	"	210.40	GL 7m east of pump shed
MR2	"	209.64	GL at half dead gum
MR2	"	210.06	GL at large gum
MR2	"	210.51	GL +0.15m LB Middlebrook 7m south fence
MR2	Middlebrook Road	209.28	GL +0.3m
MR3	Middlebrook Road	207.15	GL +0.15m
MR3	"	205.41	Old house
MR3	Middlebrook Road	204.01	Road fence line west side
MR3	"Middlebrook Farm", Mrs Kater	204.40	Fence line
MR4	Western end of Liverpool St	203.43	Near house
MR4	"	202.25	Bottom of gate
MR4	"	199.84	GL NW cnr of shed
MR5	"	196.88	Top well +0.03m
MR5	"Invermien", Chapman	194.89	Top well +0.03m
MR5	"	194.35	GL NW cnr of hayshed
MR5	"	193.00	GL fence line 60m east fence
MR5	"	193.25	GL inundation line
MR2	"Merry Glen"	208.71	Iron on bank of Parsons Gully GL RB
MR2	"	208.80	GL strainer post
MR2	"Jeanclair"	208.49	GL +0.3m
MR2	"	208.17	GL 10m west old irrigation pipes
MR2	"Milton Farm", W.Bishop	206.40	GL 6m east of well
MR3	"	206.20	GL +0.3m at laneway
MR3	"	205.13	GL +0.3m
MR3	Midway Aberdeen St & Kingdon Ponds	203.90	GL at fence line
MR4	"White Park"	201.65	Kingdon Ponds
MR4	"	199.02	GL + 0.31m at tree
MR4	"	198.46	Top of well
MR4	"Old Sewerage Works"	197.50	Information from Council Worker
MR5	"St Aubins (McMullin)	196.18	GL +0.3m at well
MR5	"	195.45	GL at wooden gate
MR5	"St Aubins (Smith)	192.97	Fence line 3rd barb from GL
MR5	"	192.93	Fence line 2nd wire from GL

APPENDIX B - STUDY BRIEF

SCONE FLOOD STUDY

TECHNICAL BRIEF

1. Introduction

The town of Scone lies in the upper Hunter Valley, 250km north-west of Sydney. The township is a rural centre with a population of approximately 4400. It serves important dairy and horse breeding industries and, increasingly, the coal and power generating industry. The town is the administrative centre for Scone Shire Council.

Scone is located on the common flood plain of Kingdon Ponds, Middle Brook and Parsons Gully. The total catchment area of the three streams at Scone is approximately 331km^2. Parsons Gully can be considered to be basically an anabranch of Kingdon Ponds. The western side of the town is moderately affected by major floods. During the record flood of February, 1955 the area to the west of Aberdeen Street was inundated. The most recent flood occurred in February, 1992.

Scone Shire Council proposes to prepare a comprehensive floodplain management plan (FMP) for Scone, as part of a Government program to mitigate against major flood impacts and hazards on the floodplain.

An important part of the process of preparing the FMP is the undertaking of a flood study. The flood study assists in determining the nature and extent of flooding through the estimation design flows, flood levels and velocities. The flood study should also provide information necessary for the preparation and implementation of a flood emergency plan for the study area.

2. Objectives

The aim of this study is to define flood behaviour along Kingdon Ponds, Middle Brook and Parsons Gully for the area shown on Figure 1. It will be necessary to undertake this through analyses using hydrologic and hydraulic mathematical models. The models are to be suitable for use, at a later date, for the evaluation of floodplain management options (including structural and broad development options) and options to improve emergency management procedures. With regard to the latter the consultant is required to liaise with State Emergency Services to ensure that it's requirements can be met.

Specifically the study will:

- review all hydrologic information available from previous studies and data from Scone Shire Council, the Bureau of Meteorology and data already held by this Department,
- provide estimates of the flood hydrographs of the 10%, 5%, 2%, 1% 0.5% and PMF design events,
- produce a computer based, fully dynamic network hydraulic model (eg MIKE-11)of the study area shown on Figure 1,
- calibrate and validate the hydraulic model using historic flood data and any other data that may be available or obtainable,
- define the behaviour of the 10%, 5%, 2%, 1%, 0.5% and PMF design flood events by presenting flood level contours at 0.2m intervals, flood profiles along each of the major flow paths, flood velocities and flow distributions.

3. Study Area

The whole of the catchment upstream of, and including the area shown on Figure 1, is to be included for the hydrologic analysis.

The study area for the hydraulic component of the study is shown on Figure 1. Flood behaviour shall be defined for the whole of the study area with emphasis on the built up areas of Scone and the residential area of Satur, on the right bank of Middle Brook.

4. Available Information

Including but not limited to:

From DLWC

- "Scone Flood Study Report" WRC, September,1986
- "Hunter Valley Flood Plain Atlas" WRC
- "Hunter Valley Flood Plain Management Study", SKP,1981
- "Hunter Valley Regional Flood Estimation", Lees, Sobinoff and Gardiner, 1981 - Hydrology Section Report, 81/33
- Streamflow/Stage records and Stage/Discharge relationships for various gauging stations
- Various calculation folders

From Scone Shire Council

- Report "Proposed New Alignment and Associated Bridges at Parsons Gully, Kingdon Ponds and Middle Brook - Investigation and Conceptual Design" Webb, McKeown & Associates Pty. Ltd., 1986
- Survey of floodplains at Scone by K.F.Murphy & Associates,1995. Included with this survey are some observed flood levels for the February,1992 flood.

NOTE: All data should be checked to confirm it's accuracy and suitability for it's intended use.

5. Additional Data Requirements

The consultant is to review all the available data and make an assessment of any additional data that may be required to complete the study. The consultant shall be responsible for all activities involved in obtaining this additional data.

6. Flood Study Methodology

If sufficient data can be obtained, the consultant is to select at least three flood events for calibration and validation of the model to be used in the study. If the data is not sufficient the consultant shall notify Scone Shire Council, through it's Floodplain Management Committee (FMC), and advise the number of flood events that can be used for calibration and validation. On completion of the calibration and validation process, the consultant shall discuss the results with the FMC and obtain it's concurrence before proceeding with the modelling of the design floods.

Hydrologic Model

The consultant is to set up, calibrate and validate an appropriate computer based hydrologic model(s) for the study area referred to in Section 3 of this brief. Results from the selected model(s) used are to be presented in the report and discussed in detail. Comparisons shall be made with historical data, where possible. The report is to include an assessment of the sensitivity of:

- Flood flows to variations in model parameters.
- rainfall distribution on flood flows.

If the use of hydrologic model(s) is not feasible, the consultant shall notify the FMC and advise it of the procedure(s) to be adopted to estimate peak discharges and/or flood hydrographs.

Hydraulic Model

The consultant is to set up, calibrate and validate an appropriate computer based, fully dynamic network hydraulic model(s) for the study area shown on Figure 1. Results from the selected model(s) used are to be presented in the report and discussed in detail. Comparisons shall be made with historical data, where possible. The report is to include an assessment of the sensitivity of the model results to:

- variations in model parameters.
- variations in flood flows.
- variations in boundary conditions

An objective of this study is to produce an hydraulic model(s) that can determine flood behaviour and be suitable for use in a future Floodplain Management Study. Although the Floodplain Management Study does not form part of this brief, the hydraulic model(s) produced should be sufficiently detailed to permit the assessment of the impact of future proposals, evaluate floodplain management options and options to improve emergency management procedures for the study area.

7. Reporting

The consultant is to provide progress reports to the FMC at the completion of the following stages:

- Assessment of all available data
- hydrology
- hydraulics
- draft report
- final report

The consultant shall attend meetings of the FMC to present these progress reports. These stages of the study will also form the basis for progress payments.

8. Draft Final and Final Reports

On completion of the study, the consultant shall prepare a final report. The format of the report is not rigid but should generally incorporate the following sections along with others that may become apparent during the course of the study:

Forward - Explaining the function of a flood study as part of the series of activities associated with the implementation of the Government's Flood Prone Land Policy

Summary -. Outlining the objectives, methodology and findings of the study.

Introduction - Setting the scene for the reader regarding the nature of the study, the need for it and the elements comprising the study.

Background - Detailing the parties involved, previous studies and data base.

Hydrology - Should include a review of available techniques and justification for the adoption of the selected methodology. If a hydrologic model was used, the results of the calibration/validation process, including the sensitivity of the results to changes in model parameters and rainfall distributions, and the modelling procedure should be discussed in detail. All relevant information and data bases used or generated should be summarised or referenced in this section and detailed in an appendix or compendium of data as appropriate.

Hydraulics - To include discussion of available techniques and justification for the adoption of the selected methodology, shortcomings, expected order of accuracy and assumptions necessarily associated with selected modelling procedures. The results of the calibration/validation process, including the sensitivity analyses, and the modelling procedure should be discussed in detail. All relevant information and data bases used or generated should be summarised or referenced in this section and detailed in an appendix or compendium of data as appropriate.

Findings - This section shall present the following information, for the whole of the study area, for the 10%, 5%, 2%, 1%, 0.5% AEP flood events:

- All flood profiles
- Flood level contour plans
- Plans showing nodal points at model cross sections and the percentage of flow and indicative velocities between these nodal points.

The flood level and flood velocity information shall also be presented in tabular form. Additionally, this section shall include flood profiles and indicative velocities for the PMF.

References - As appropriate.

Appendices - All historical rainfall and flood height data should be presented as appendices to the report or in a compendium of data as appropriate.

Five (5) copies of a draft final report shall be submitted to the FMC for review.

Twenty(20) copies of the final report will be required. Printing of the final report shall not proceed without written direction from the FMC.

9. Administration of the Study

9.1 Council's Authorised Representative

The study will be administered by Scone Shire Council through it's Floodplain Management Committee (FMC). Personnel authorised to issue instructions in regard to this study are:

Mr D. Casson - Manager, Land Use Planning.

9.2 Consultant's Project Manager

The consultant shall nominate a Project Manager who will represent the consultant at all meetings and discussions

10. Information to be Submitted with Proposal

The following information is to be submitted in a brief and concise form to assist in the evaluation of the proposal:

- An outline of the general approach to the study including a program and timetable for completion.
- Details of the consultant's study team including qualifications and relevant experience of each team member. Key personnel are to be identified. The tasks to be performed by each team member are to be nominated and variations will not be permitted without the approval of the FMC.
- Details of any sub-consultants to be used.
- The project fee - LUMP SUM
- Breakdown of the project fee to represent the following work packages:
    - Data assessment
    - Hydrology
    - Hydraulics
    - Draft report
    - Final report

  The breakdown, which will be used as the basis for the making of progress payment, is to show personnel, hours, charge-out rates, disbursements, printing and computing charges.

11. Special Requirement

At the completion of the Study (and in addition to the Reports referred to in Section 8 of this brief) the consultant shall provide Scone Shire Council with copies of the computer data files (and accompanying specifications), calculations, plans and other material generated during the study. Furthermore the consultant shall maintain the working computer models used in the study for a period of at least five (5) years from the date of completion of the study.

The consultant will **not** be required to provide Scone Shire Council with copies of the computer **programs** used in the study.

12. Conditions of Engagement

The conditions of engagement shall be the 'Standard Conditions of Engagement" shown at "Annexure A".

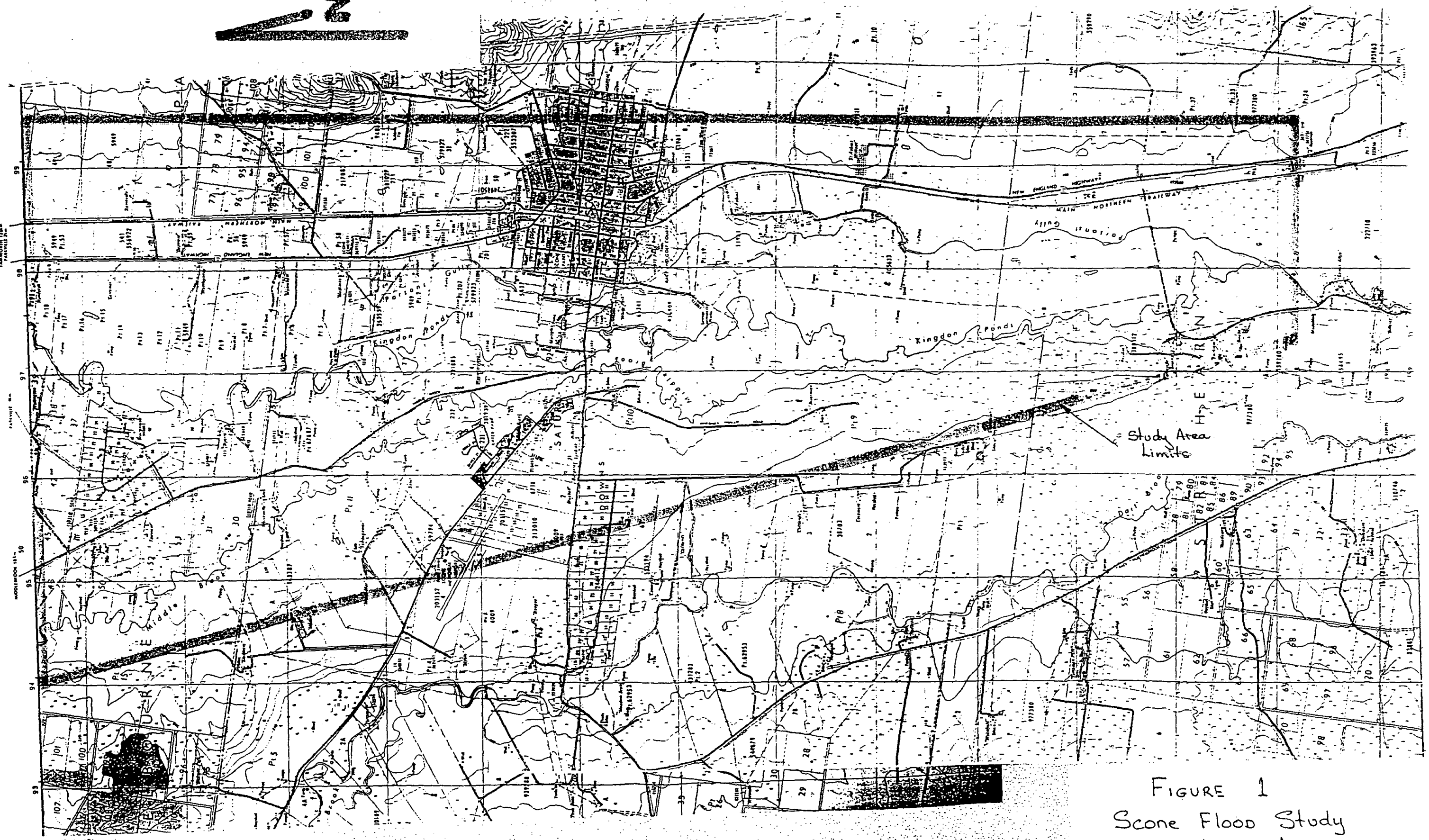
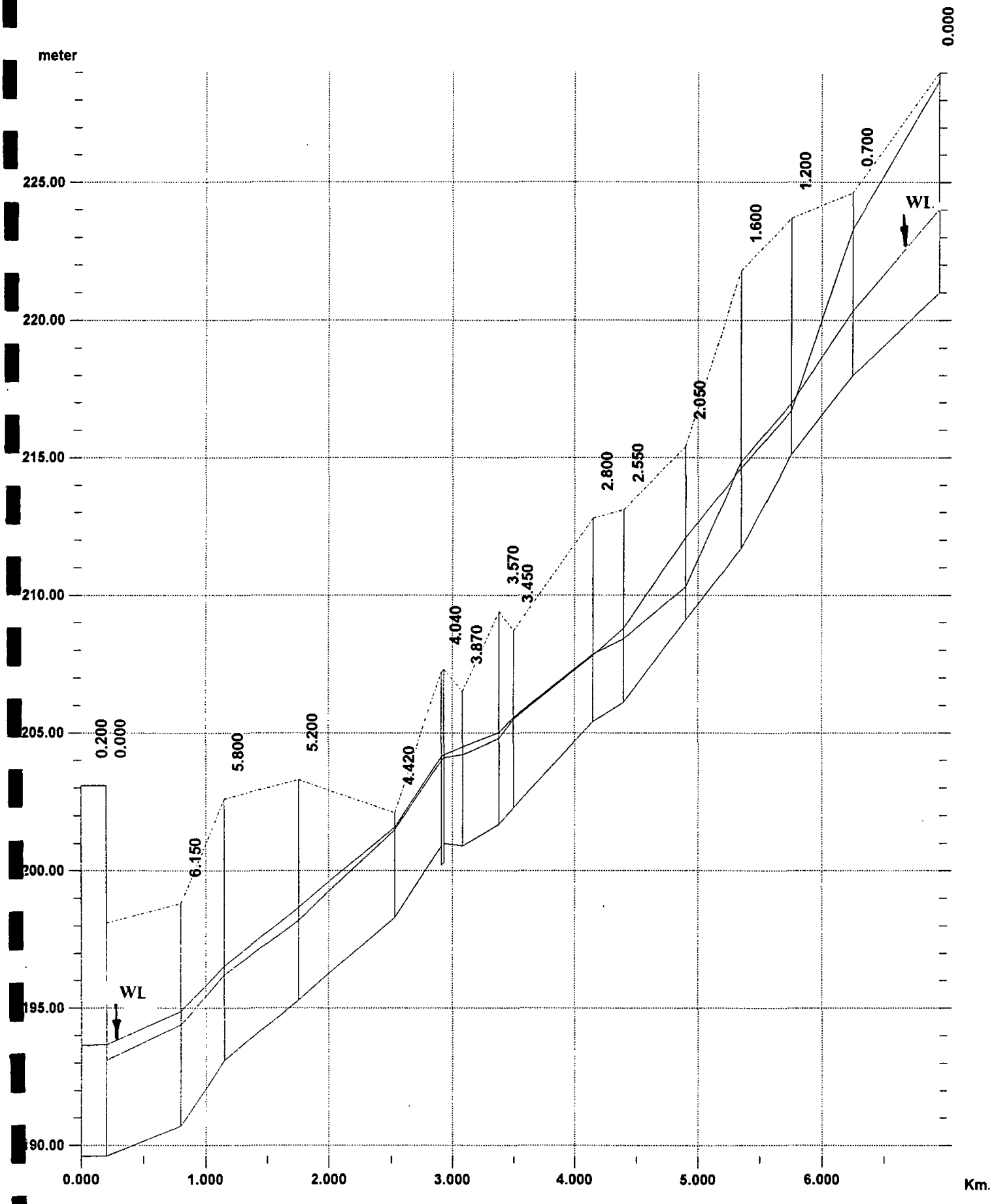


FIGURE 1
Scone Flood Study
Study Area

APPENDIX C - MIKE 11 WATER LEVEL PROFILES

100 yr ARI FLOOD EVENT



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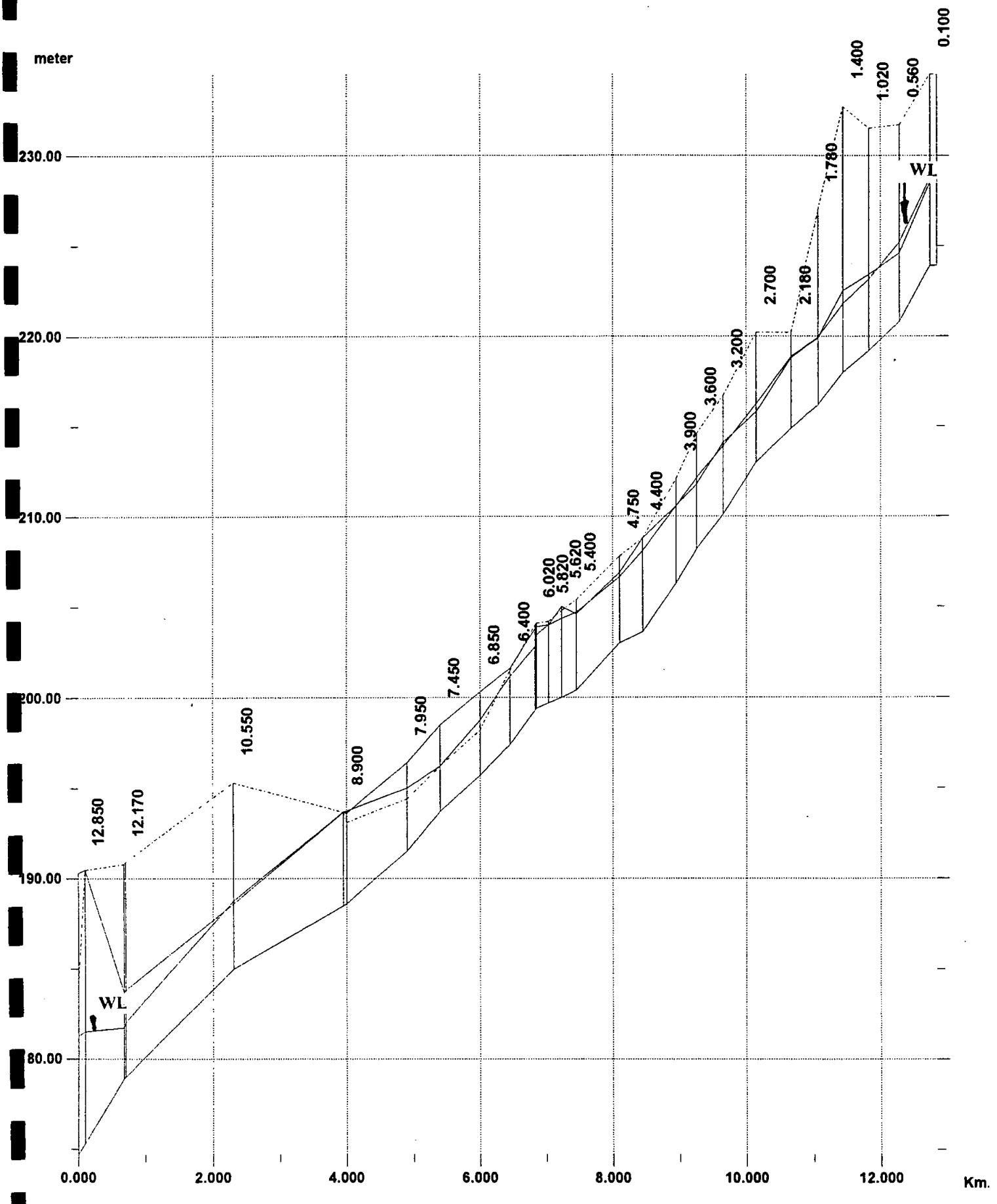
RESULT FILE : SCONE100.RRF

21-MAR-1996, 20:00
BOUNDARY FILE : SCONE96.BSF
CALCULATED : 15-MAJ-1996, 14:15

MIKE 11

Dwg no.:
MIDDLE BROOK

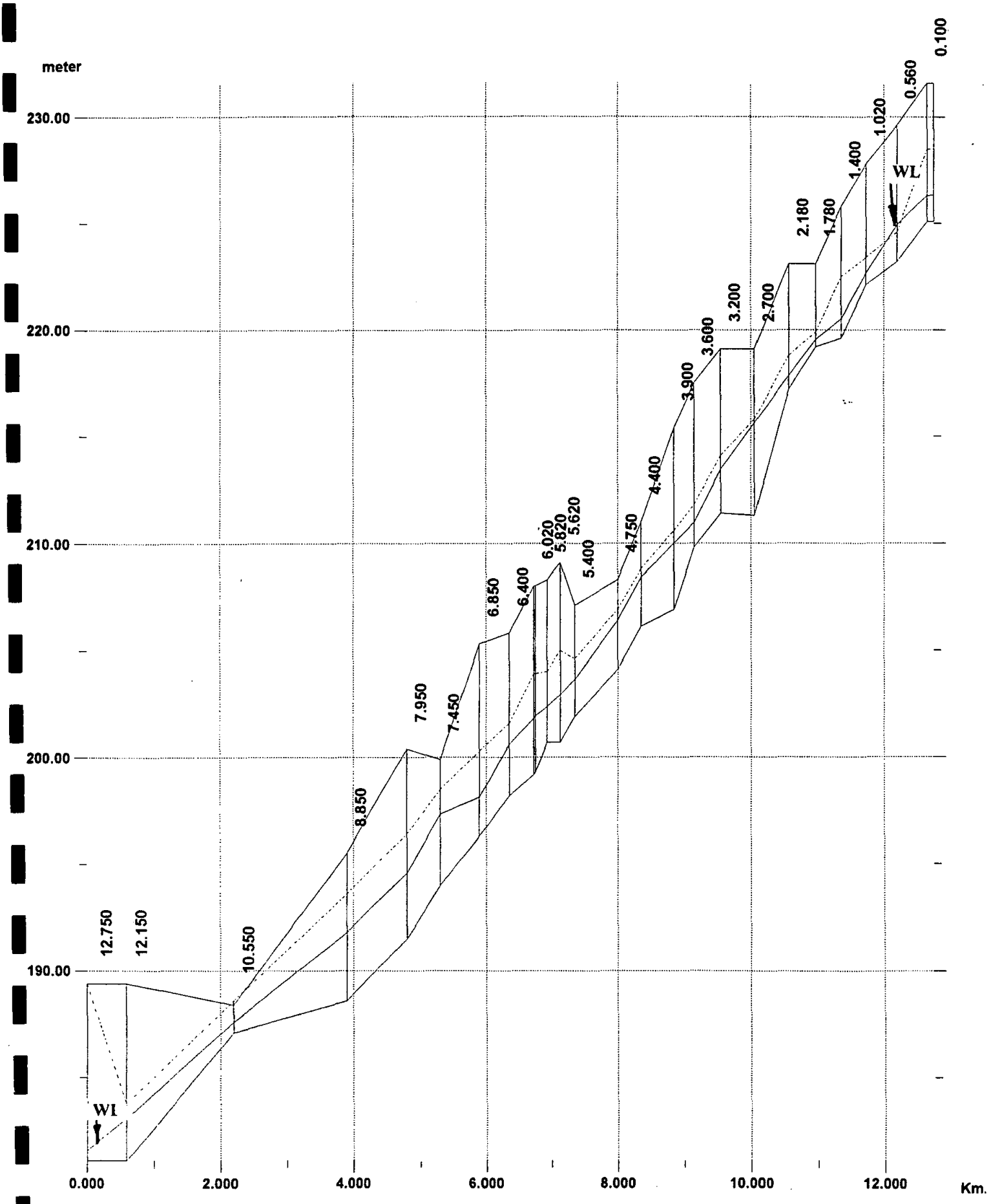


PARAMETER : WATER LEVEL
DATA FILE : SCONE96X.RDF
RESULT FILE : SCONE100.RRF

22-MAR-1996, 01:30
BOUNDARY FILE : SCONE96.BSF
CALCULATED : 15-MAJ-1996, 14:15

MIKE 11

Dwg no.:
KINGDON PONDS



PARAMETER : WATER LEVEL
DATA FILE : SCONE96X.RDF
RESULT FILE : SCONE100.RRF

22-MAR-1996, 01:00
BOUNDARY FILE : SCONE96.BSF
CALCULATED : 15-MAJ-1996, 14:15

MIKE 11

Dwg no.:

PARSONS GULLY