LAKE NILLAHCOOTIE FLOOD STUDY

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Benalla Rural City

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EXECUTIVE SUMMARY

Lake Nillahcootie is a reservoir approximately 30km south of Benalla on the Broken River. It is used principally to provide water storage for irrigation and potentially provides some flood mitigation for Benalla. Goulburn-Murray Water have advised that there is no capability to manage or maximise this potential without affecting the primary role of the reservoir for water resource yield.

Historically, releases were made from Lake Nillahcootie for diversion to Lake Mokoan. Any airspace created would help absorb some of the floodwater that would otherwise pass downstream to Benalla.

This study seeks to quantify the level of flood mitigation benefit provided in Benalla by Lake Nillahcootie. Computer modelling was used to determine how rainfalls of different magnitude affect flood levels in Benalla and how different starting levels in the lake itself affect Benalla flood levels. The model was also run with Lake Nillahcootie completely removed to determine its impact at Benalla. Historic rainfall information and flow information from river gauges were used to calibrate the model.

The operating rules that were applied to transfer flows from Lake Nillahcootie to Lake Mokoan were analysed to determine their impact on the amount of airspace in Lake Nillahcootie.

This Executive Summary uses the common English term of 1 in 100 year, 1 in 50 year, etc. to describe the frequency of a flood. This is in preference to the more technically correct 1% “annual exceedance probability” (AEP), 2% AEP, etc. used elsewhere in the report.

Operation of Lake Nillahcootie and Lake Mokoan

Prior to 1992 operating rules were established that took into account Lake Nillahcootie target filling levels which varied from about 30% full in June to 75% full in November. If conditions were right and the volume in Lake Nillahcootie exceeded target levels, the water authority had the opportunity to transfer water to Lake Mokoan.

The target filling curves are only one consideration in transferring flows. Other constraints included the Lake Nillahcootie outlet structure capacity, downstream river channel limitations, the volume in Lake Mokoan, the ability to supply flows to Lake Mokoan from Holland Creek and the prevailing flows in the river from downstream tributaries.

Since 1992, Lake Nillahcootie has been operated to fill as early as possible during the winter/spring period. This change was introduced to manage the risk of Lake Mokoan being taken out of service due to a blue green algae outbreak. The current de-commissioning of Lake Mokoan will mean the present operating rules will remain.

Lake Nillahcootie now starts to fill up in May after the end of the irrigation season so that it is more likely to be full at the start of the next irrigation season.

The Effect of Lake Nillahcootie on Floods of Different Magnitudes

In order to understand how Lake Nillahcootie affects flood behaviour the computer model was run a number of times. The model was run for a variety of starting storage levels at the lake (empty, 25% full, 50% full, 75% full and 100% full) and for a range of design floods (1 in 10 year, 1 in 20 year, I in 50 year and 1 in 100 year events). The model was also run without the storage to see how the presence of Lake Nillahcootie influenced flood levels at Benalla.

The presence of Lake Nillahcootie reduces significantly the peak flow immediately downstream of Lake Nillahcootie, with these reductions becoming lesser at Benalla as it is further downstream. Flows from the remainder of the catchment downstream of Lake Nillahcootie were found to be a greater influence on the peak flow at Benalla. If Lake Nillahcootie happens to be less than 75% full prior to a flood event, flood levels at Benalla would be reduced by 0.07 m to 0.11 m for the range of flood events considered, compared to if the lake was at full capacity.

The results show that, without Lake Nillahcootie, flood levels in Benalla would be 0.23 m greater for a 1 in 100 year flood, compared to what happened in October 1993, when the reservoir was full. This shows the flood mitigation benefit that the storage has at Benalla for a major flood. For smaller floods the benefit is much less..

As a further check, the four largest historic floods since the construction of Lake Nillahcootie were computer modelled with Lake Nillahcootie at 0%, 25%, 50%, 75% and 100% full and also with no Lake Nillahcootie present. These historic floods were the May 1974 (1 in 14 year), September 1975 (1 in 7 year), July 1981 (1 in 10 year) and October 1993 (1 in 100 year) events.

The results showed that the peak flows at Benalla were significantly reduced because of the presence of Lake Nillahcootie. Furthermore there would have been some reduction in peak flows if the storage was less than 75% full at the start of the flood events. The results are consistent with those of the earlier analysis of the design floods.

In order to see the likliehood of Lake Nillahcootie being less than 75% full at the start of a flood event, a further analysis was undertaken. Historic records were analysed in detail for the May 1974, September 1975, July 1981 and October 1993 events.

The three earlier events applied to situations in which the operating rules allowed flow transfer from Lake Nillahcootie to Lake Mokoan when conditions were right. The October 1993 flood event occurred in a period in which there were no flow transfers to Lake Mokoan.

The analysis showed that, for three of these four events, Lake Nillahcootie was full and spilling before the flood events occurred. For the May 1974 event Lake Nillahcootie was 85% full prior to the flood. This occurred outside the period when flow transfers were most likely to take place (between June and November). The lowering of the Lake Nillahcootie storage levels observed in the months prior to the flood was likely to be due to irrigation demand rather than a transfer to Lake Mokoan.

Hence the situation would be the same regardless of which operating rules were applied.

In 1993, the operating policy was to maintain Lake Nillahcootie at or near 100% capacity over the winter/spring period. However, as this was the event that had the greatest affect on Benalla residents, a detailed analysis of the effect of the two operating rules was undertaken. The results confirmed that, irrespective of which operating rule was applied, Lake Nillahcootie would have filled in the months prior to the October 1993 flood. Had the pre-1992 operating rules applied there would have been no difference to the flooding at Benalla.

It is concluded that, Lake Nillahcootie can have an effect in reducing the impacts of flooding at Benalla. However the ability to draw down the reservoir before a flood is limited. Analysis of the four largest floods since the construction of the lake shows that application of either the pre or post 1992 operating rules would achieve the same result at Benalla.

The Influence of Lake Nillahcootie on the Timing of a Flood

To examine the effect of Lake Nillahcootie on the timing of peak flows reaching Benalla after the start of rainfall, the computer model was adapted. Rainfall upstream of Lake Nillahcootie was modelled for a 1 in 100 year event with no contributions from the other parts of the catchment. It was found that it took 42 hours after the commencement of the rainfall event for the flood peak to reach Benalla for a full storage, and longer if the storage was less than full.

In comparison, it only takes about 30 hours after commencement of rain for the flood peak to reach Benalla if all parts of the catchment are contributing. This means that the effect of the initial level in Nillahcootie is not a major factor in the peak flows at Benalla. Flows from the remainder of the catchment downstream of Lake Nillahcootie reach Benalla much sooner.

Peak flows from the Holland Creek and Broken River catchment downstream of Lake Nillahcootie reach Benalla at approximately the same time under design flood events. If more rain was to fall on the Holland Creek catchment during a storm event, the little difference that Lake Nillahcootie makes to the peak flow at Benalla would be further reduced.

Physical Impacts at Benalla

In order to better understand the physical impacts that available airspace at Lake Nillahcootie might have, further analysis was undertaken. Data from recent additional work for Benalla Rural City was used to assess the number of properties flooded.

The results indicate that the construction of Lake Nillahcootie has provided flood mitigation benefits to Benalla for the larger floods. Without the lake, flood levels at Benalla would rise by 0.23 m, flooding an additional 317 properties above their floor level in a 1 in 100 year event.

The results also show significant potential reductions in the number of properties flooded above floor level if the lake is at 75% capacity or less prior to a 1 in 100 or a 1 in 50 year flood. There is a reduction of 273 houses and 27 houses respectively. For lesser floods the impact is relatively small.

However there are severe physical and operational limitations in lowering Lake Nillahcootie ahead of a flood. Observation of the four largest historic flood events since the construction of Lake Nillahcootie reveals that only one event, the May 1974 flood, occurred when the lake was less than 100% full. For the other three events the reservoir was full.

Thus it is concluded that decommissioning Lake Mokoan will make no practical difference to flood levels at Benalla.

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1. INTRODUCTION

Cardno Lawson Treloar was engaged by the Rural City of Benalla to undertake flood modelling of the Broken River system to identify the impact of Lake Nillahcootie on flood levels at Benalla.

Lake Nillahcootie is a water storage approximately 30 kilometres south of Benalla. It is used to provide water storage for irrigation demands and potentially provides flood mitigation for Benalla through the interception of flows from the upper Broken River catchment. Historically, Lake Nillahcootie and Lake Mokoan have operated in tandem to provide irrigation water for the surrounding area. Lake Mokoan is in the process of being decommissioned and opportunities to transfer water from Lake Nillahcootie will be lost.

This study seeks to quantify the level of flood mitigation benefit provided for Benalla by Lake Nillahcootie, and in particular address the following questions:

- Has the past operation of Lake Nillahcootie been successful in reducing the frequency of flood impacts at Benalla, and what influence does Lake Nillahcootie pre and post 1992 “operating rules” have on flood flows?
- What are the changes in flood heights in Benalla and changes in the number of houses flooded, due to changes that have occurred since the construction of Lake Nillahcootie and the decommissioning of Lake Mokoan?
- What degree of influence does Lake Nillahcootie have in preventing convergence of peak flows from the two catchments to Benalla, namely Holland Creek and Broken River catchments?

2. CATCHMENT AND SYSTEM INFORMATION

Summary of Data Sources

The following data was acquired for use in the study:

- Contour and catchment information (Goulburn Broken Catchment Management Authority)
- Lake Nillahcootie Operational Parameters (Goulburn-Murray Water)
- Land cadastral Information (Goulburn Broken Catchment Management Authority)
- NASA Shuttle Radar Topography Mission elevation data (NASA)
- Pluviograph and rainfall data (Bureau of Meteorology)
- River flow and gauge data (www.vicwaterdata.net; Goulburn-Murray Water)
- Historical operational data for Lake Nillahcootie and Lake Mokoan (Goulburn-Murray Water)

2.1 Study Area

The study area encompasses the catchment of the Broken River upstream of Benalla, as shown in Figure 2.1, including the major tributaries of Holland Creek, Ryans Creek, Blind Creek and Moonee Creek. The total catchment area is approximately 1460 square kilometres at Benalla.

There have been significant rainfall events causing flooding at Benalla over the last 30 years. Of particular severity were the 1974, 1975, 1981 and 1993 flood events. The 1993 flood is considered to represent the 1% Annual Exceedance Probability flood event with a peak flow at Benalla of 1296 m^3/s (equivalent to 112,000 ML/d).

2.2 Operation of Lake Nillahcootie and Lake Mokoan

Lake Nillahcootie is used to store and provide water primarily for irrigation, domestic, stock and urban water supply purposes downstream of the dam. The storage is operated by Goulburn-Murray Water. The full storage capacity of the Lake is 40,400 megalitres (ML).

The Lake has operated under various storage targets since it was constructed in 1968 as shown in Table 2.1. The operating procedures for Lake Nillahcootie changed in 1992 due to outbreaks of bluegreen algae in Lake Mokoan.

In most years, the amount of water stored in the Lake has exceeded the 1983 target volume of 12,500 ML at the start of June. Current operating procedure (post 1992) is to have Lake Nillahcootie full when downstream irrigation demand emerges. A modest volume of airspace can be provided on the basis that inflows are sufficient to ensure the storage fills to capacity. This requires close monitoring of inflows and downstream demand requirements.

Table 2.1 – Lake Nillahcootie Storage Targets

Month Ending	1971 Targets	1983 Targets	Current Operating Regime (post 1992)
	(ML)	(ML)	(ML)
June	12,335	12,500	40,000
July	12,335	12,500	40,000
August	18,500	18,000	40,000
September	24,670	25,000	40,000
October		29,000	40,000
November		30,000 (75% full)	40,000

Water is diverted from the Broken River and Holland Creek to Lake Mokoan via a diversion channel from Broken Weir to Lake Mokoan via Holland Weir. The design capacity of this channel is 21 m^3/s (1800 ML/d) from the Broken Weir to Holland Weir and 28 m^3/s (2400 ML/d) from Holland Weir to Lake Mokoan. The full capacity of the diversion channel can often be provided by local inflows from Holland Creek and local drainage inflows, thereby restricting any transfer of water from the Broken River. The purpose of the diversion is to assist in the filling of Lake Mokoan which has a limited catchment area. Lake Mokoan was originally constructed with a capacity of 365,000 ML but this was reduced in 1992 to 255,000 ML due to outbreaks of blue-green algae. As a result of these outbreaks, the operating procedures for Lake Nillahcootie were changed in 1992. Lake Mokoan's purpose is to store and provide water for irrigation, domestic, stock and urban water supply.

There are also limits on the volume of water that can be transferred between Lake Nillahcootie to Lake Mokoan under controlled releases from the dam due to the capacity of the downstream channels. The design flow rate that could originally be diverted from Lake Nillahcootie was 14 m^3/s (1200 ML/d) however changes in channel morphology have limited this release. Flows in excess of 9 m^3/s (800 ML/d) have been found by experience to be the maximum controlled release from Lake Nillahcootie without causing localised downstream flooding problems.

It is important to note that Lake Nillahcootie may be at any storage level outside of the months specified in Table 2.1. High inflows, combined with circumstances in which diversions to Lake Mokoan aren't appropriate will lead to storage levels being kept above the storage targets. Conversely, low inflows during a drought may result in lake levels below the target.. In future, reliance on Nillahcootie as the only storage in the system is likely to result in the storage always being lower at the end of the irrigation season than it would have under similar inflow conditions to those experienced in the past.

2.3 Rainfall Information

Rainfall records were sourced from the Bureau of Meteorology for rain gauges in the vicinity of the study area. For the known storm events, rainfall data was obtained on an hourly timestep where available. A list of the rainfall data used is shown in Table 2.2, with locations of the rainfall gauges shown in Figure 2.2.

Table 2.2 – Rainfall Gauge Information

Site Name	Site Number	Duration		Data	
		Start Year	End Year	Daily	Hourly
STRATHBOGIE	82042	1902	Present	Yes	Yes
SPRING CREEK BASIN TWO	88153	1973	Present	Yes	Yes
DOOKIE AGRICULTURAL COLLEGE	81013	1879	Present	Yes	Yes
LIMA SOUTH (LAKE NILLAHCOOTIE)	82107	1968	Present	Yes	Yes
WHITFIELD	83031	1903	Present	Yes	Yes
LAKE WILLIAM HOVELL RESERVE	83074	1976	Present	Yes	Yes

2.4 Flow Information

Information on river flows was obtained from various sites in the study area. Of most importance for flood analysis is the instantaneous flow as this gives the best indication of flood peak. Records were obtained for the stations indicated in Table 2.3 and their locations are shown in Figure 2.3

Table 2.3 – River Flow Information

Station ID	Station Name	Instantaneous Flow Data	
		Start	End
404203	BrokenRiver @ Benalla	09 Feb 1978	18 May 2007
404206	Broken River @ Moorngag	14 Dec 1973	01 Jul 2007
404207	Holland Creek @ Kelfeera	01 Jan 1970	01 Jul 2007

3. HYDROLOGICAL MODELLING APPROACH

3.1 Introduction

The general approach to hydrologic modelling was that typical of similar catchment studies in rural regions of Victoria. Details of the approach and results are provided in the following sub-sections. In all instances the RORB hydrological model was used.

The RORB hydrological model (Laurenson and Mein, 1997) was used in this study. It is an event based model that calculates flood hydrographs from storm rainfall hyetographs and can be used for modelling natural, part urban and fully urban catchments. Simply speaking, RORB turns a rainfall into a flow and predicts the movement of that flow down a drainage system.

3.2 Catchment and Sub-catchment Definition

Catchment boundaries were based on the alignment of the ridges and valleys as defined by the contour information obtained from the GBCMA. The sub-catchment definition was guided by the critical locations for analysis including Lake Nillahcootie, the Broken River gauge at Moorngag, the Holland Creek gauge at Kelfeera and the township of Benalla. To ensure the robustness of the model, there are six subcatchments upstream of Lake Nillahcootie and all subcatchments are of a similar area. There are 33 subcatchments in total.

The subcatchment areas are shown in Table 3.1. All subcatchments were assumed to be rural in nature, with an effective fraction impervious of 0. The subcatchment layout is shown in Figure 3.1

Table 3.1 – Subcatchment Areas

Subcatchment ID	Area (square km)
A	49.09
B	56.85
C	58.69
D	46.71
E	42.79
F	45.08
G	89.3
H	30.17
I	44.23
J	38.51
K	51.34
L	18.41
M	53.38
N	54.93
O	45.37
P	39.94
Q	29.45
R	27.81
S	57.38
T	30.89
U	60.6
V	42.75
W	30.87
X	31.76
Y	43.37
Z	32.35
AA	50.13
AB	43.12
AC	42.8
AD	52.59
AE	42.73
AF	43.21
AG	31.92

3.3 Lake Nillahcootie Storage

Lake Nillahcootie has been defined in the hydrological model as a special storage. The lake can be defined by a stage-storage relationship; that is, at a specific elevation, Lake Nillahcootie can store a certain amount of water. The Full Supply Level (FSL) occurs at 264.5 m AHD. The stage-storage relationship has been obtained from Goulburn-Murray Water and is shown in Table 3.2 below.

Table 3.2 – Elevation Storage Table for Lake Nillahcootie

Elevation m AHD	Storage Volume ML
241	0
244	52
246	202
248	641
250	1540
252	3190
253	4350
254	5770
255	7430
256.3	10030
257	11629
258	14212
259	17140
260	20446
261	24113
262	28200
262.5	30416
263	32743
264	37736
264.5 (FSL)	40403
265	43190
266	49132
267	55539
268	62448
269	69862
270	77748

Water flowing from Lake Nillahcootie is controlled via two valves that operate on the main outlet pipe. The valves are 450 mm and 1350 mm in diameter and only a single valve can be operating at any one time. Advice from G-MW indicates that the flow valves are closed in a flood event.

Once the Full Supply Level (FSL) of 264.5 m AHD is reached in Lake Nillahcootie, a spillway begins to operate to protect the dam from overtopping. There is additional storage in the dam above the FSL and this storage serves to attenuate flood peaks, as flows are controlled by the spillway. The elevation-discharge relationship for Lake Nillahcootie under flood conditions is shown in Table 3.3.

Table 3.3 – Elevation-Discharge Table for Lake Nillahcootie

Stage (m AHD)	Discharge(m^3/s)	Comments
241	0	Bottom of Storage
248.35	0	Off-take Inlet Level
256.3	0	25% Capacity
260	0	50% Capacity
262.5	0	75% Capacity
264.5	0	100% Capacity, Full Supply Level, Weir Crest Level
265	44.6	
266	252.9	
267	564.6	
268	947.3	

3.4 RORB Model Development

A RORB model was created to investigate the Broken River catchment upstream of Benalla. The subcatchments described in Section 3.1 were used to develop an appropriate stream network that is based on the physical drainage properties of the catchment. Lake Nillahcootie was included as a special storage and the diversion channel to Lake Mokoan was also modelled. The RORB nodes and reaches can be seen in Figure 3.2.

3.4.1 Modelling of Lake Nillahcootie Storage

The elevation-storage and elevation-discharge tables for Lake Nillahcootie were used to define the storage parameters in the RORB models. Five models were created to represent the five starting conditions of the Lake, these being the 0%, 25%, 50%, 75%, and 100% full cases.

3.4.2 Modelling of Mokoan Diversion

The diversion of flows from the Broken River and Holland Creek is understood not to operate under severe flood conditions. As such, it has been excluded from the RORB model for the assessing the impact of Lake Nillahcootie on flood events. The diversion has been considered for the scenario analysis of the 1993 flood event (Section 6.2).

4. HYDROLOGICAL MODEL CALIBRATION

The hydrological model has been calibrated to known storm events for the purposes of determining appropriate model parameters. When calibrating hydrological models, a number of factors are important, including matching of peak flows, matching of runoff volume, timing of peak flows and the hydrograph shape. The October 1993 and July 1981 flood events were used for calibration of the RORB model, as recorded hydrographs at Benalla are available for these events.

4.1 Storm Rainfall

To allow for the spatial variability across the catchment, the hourly rainfall data from the Bureau of Meteorology was weighted based on the proximity to the gauge from the centroid of the subcatchment. The weight assigned to each rainfall station was based on a function using the inverse square of the distance to the catchment centroid, thereby ensuring that gauges closest to the catchment had the most effect on the assumed rainfall for the storm events. This is a standard practice for the estimation of known rainfall events and has been used previously in many studies and has been found to produce acceptable results.. The derivation of rainfall patterns on a subcatchment basis for observed storm events is the recommended approach in Australian Rainfall and Runoff 1998 (AR&R).

An hourly rainfall pluviograph was created for each subcatchment. The rainfall series used for the modelling of the 1981 and 1993 events can be found in Appendix A

A number of rainfall datasets were obtained from members of the public during the course of the study. These were usually hand recorded daily rainfall totals at private gauges throughout the catchment. Daily rainfall records are generally unsuitable for flood analysis and routing purposes as they lack the temporal definition required to accurately determine the rainfall intensity as the storm moved across the catchment. The obtained datasets were used to provide a check on the rainfall totals from the Bureau of Meteorology. It was found that the Bureau data and the recorded data in the catchment were consistent with regard to the timing and amount of rainfall.

4.2 Lake Nillahcootie Starting Level and Diversion to Mokoan

Information received from Goulburn-Murray Water indicates that Lake Nillahcootie was at full or near full capacity prior to both the July 1981 and October 1993 flood events. As such, we have assumed that the Lake is 100% full in the calibration events and the diversion to Lake Mokoan is not operating.

4.3 Model Calibration

The October 1993 flood event is considered to represent the 1% AEP event for Benalla. The RORB model was run for the 1993 event using the generated rainfall series and the model parameter, k_c, was adjusted to match the timing of the peak flow at Benalla. Initial and continuing losses were then adjusted to see if an appropriate fit to the generated hydrographs could be obtained. It was considered important to more closely match the peak flows at Benalla in preference to those at Moorngag and Kelfeera. Three interstation areas are included in the model at each gauging station. This allows the modification of loss parameters spatially across the catchment.

The RORB parameters found to achieve the best match after a number of trial and error simulations are shown in Table 4.1. The assumed loss parameters for each interstation area are shown in Table 4.2. The initial losses are high in order to remove the effect of rainfall earlier in the week of the storm event.

Table 4.1 – Calibrated RORB Model Parameters, 1993 Event

RORB Parameter	Value
k_c	50
m	0.8

Table 4.2 – Loss parameters, 1993 Storm Event

Loss parameters Interstation area above:	Initial Loss (mm)	Continuing loss (mm/h)
Broken River @ Moorngag	50	0.75
Holland Ck @ Kelfeera	42	0.48
Broken River @ Benalla Gauge	70	0.54

The results of the calibration for the three gauge locations are shown in Figures 4.1 - 4.3 and in Table 4.3

Table 4.3 – Calibration Results, 1993 Storm Event

Location	Parameter	Modelled Value	Recorded Value	Absolute Difference	Percentage Difference
Broken River @ Moorngag	Peak discharge,m³/s	444.3	443.7	0.5	0.1
	Time to peak, h	80	80	0	0
	Volume,m³	4.48E+07	3.91E+07	5.71E+06	14.6
Holland Ck @ Kelfeera	Peak discharge,m³/s	536	694.4	-158.5	-22.8
	Time to peak, h	79	76	3	3.9
	Volume,m³	4.69E+07	4.82E+07	-1.27E+06	-2.6
Broken River @ Benalla	Peak discharge,m³/s	1295	1295	0	0
	Time to peak, h	82	81	1	1.2
	Volume,m³	1.27E+08	1.21E+08	6.24E+06	5.2

For the 1993 storm event, the RORB parameters chosen match the peak flows at the Moorngag and Benalla gauges well, although the peak flow at the Kelfeera gauge is lower than recorded. This is likely due to the assumed rainfall distribution in the Holland Creek catchment, as the total runoff volume at each location is reproduced well. The peak flows, volumes and timings match well at Benalla and Moorngag providing an appropriate set of calibration parameters.

4.4 Model Validation

The calibration parameters found in Section 4.2 above were tested using the 1981 storm event to ensure that they were valid for other storm events. The assumed loss parameters for each interstation area are shown in Table 4.4.

Table 4.4 – Loss parameters, 1981 Storm Event

Loss parameters Interstation area above:	Initial Loss (mm)	Continuing loss (mm/h)
Broken River @ Moorngag	8	0.5
Holland Ck @ Kelfeera	20	1.3
Broken River @ Benalla Gauge	10	0.75

The results of the calibration are shown for the three gauge locations in Figures 4.4 - 4.6 and in Table 4.5

Table 4.5 – Validation Results, 1981 Storm Event

Location	Parameter	Modelled Value	Recorded Value	Absolute Difference	Percentage Difference
Broken River @ Moorngag	Peak discharge,m^3/s	214.7	277.4	-62.7	-22.6
	Time to peak, h	43	42	1	2.4
	Volume,m^3	5.18E+07	4.38E+07	8.08E+06	18.5
Holland Ck @ Kelfeera	Peak discharge,m^3/s	166.7	144.9	21.7	15
	Time to peak, h	37	43	-6	-14
	Volume,m^3	2.94E+07	3.73E+07-7	9.10E+05	-21.2
Broken River @ Benalla	Peak discharge,m^3/s	479.8	479.6	0.2	0
	Time to peak, h	44	50	-6	-12
	Volume,m^3	1.23E+08	1.24E+08	-6.20E+05	-0.5

The 1981 storm event has a triple peaked hydrograph which makes the spatial variation of rainfall important. The RORB parameters chosen as a result of the 1993 calibration match the peak flows value at Benalla and Kelfeera well, although the peak flow reaches these locations around six hours earlier than was recorded during the storm event. Total runoff volumes also match well at Benalla. It is likely that spatial variation across the catchment may not be as well represented in this event.

The 1981 flood event is equivalent to a 10% Annual Exceedance Probability event.

It is considered that the adopted RORB parameters for the 1993 storm event provide a reasonable match of key hydraulic conditions at Benalla for the 1981 storm event. As such, these values are suitable for the design hydrograph runs. The calibration achieves results comparable to those found in Benalla Floodplain Management Study. It is not possible to directly compare calibration parameters due to the use of the different XP-Rafts model in the Benalla Floodplain Management Plan.

5. RORB DESIGN RUNS

To examine the effectiveness of Lake Nillahcootie on flood attenuation at Benalla, the calibrated RORB model was run for a variety of starting storage levels. The RORB model used in the design case can be found in Appendix B.

5.1 Rainfall Variability

Large catchment areas will exhibit spatial and temporal variation in rainfall intensity. This has been accounted for in the model by using the same five rainfall zones as described in the Benalla Flood Study Report (Willing and Partners, 1995). Peak rainfall depths were estimated using the parameters described in Australian Rainfall and Runoff for each rainfall zone. The rainfall zones are shown in Figure 5.1. Areal reduction factors have been applied to each rainfall zone in accordance with the procedure described in Hydrological Recipes (Grayson, 1999) to determine the average rainfall depth for each storm duration and recurrence interval. The design rainfall depths for each zone are shown in Tables 5.1 - 5.4.

Table 5.1 – Rainfall Depths, 1% AEP Storm Event

Duration (hrs)	Total Rainfall (mm)				
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
9	92	96	94	118	105
12	99	104	103	132	117
18	104	109	112	141	125
24	118	124	129	165	145
30	129	136	145	185	163
36	138	146	157	203	176
48	152	162	178	232	200
72	169	181	207	274	234

Table 5.2 – Rainfall Depths, 2% AEP Storm Event

Duration (hrs)	Total Rainfall (mm)				
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
9	74	77	83	89	85
12	80	84	91	106	94
18	86	91	102	117	104
24	97	103	118	137	120
30	106	113	131	153	134
36	114	121	142	167	145
48	125	134	161	189	164
72	139	150	186	221	190

Table 5.3 – Rainfall Depths, 5% AEP Storm Event

Duration (hrs)	Total Rainfall (mm)				
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
9	57	60	70	78	66
12	62	65	76	94	74
18	70	74	89	110	86
24	79	84	102	128	98
30	86	92	114	143	109
36	92	99	123	155	118
48	101	109	139	176	132
72	112	123	160	205	152

Table 5.4 – Rainfall Depths, 10% AEP Storm Event

Duration (hrs)	Total Rainfall (mm)				
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
9	49	52	60	70	58
12	54	57	65	79	64
18	63	67	79	97	77
24	71	76	91	112	89
30	77	83	100	125	98
36	82	89	109	136	105
48	90	98	122	153	118
72	100	110	140	177	134

5.2 Storage Assumptions at Lake Nillahcootie

As discussed in Section 3.3 above, Lake Nillahcootie is defined as a special storage in the RORB model. For the each design storm event, five starting levels in the storage have been considered. The conditions assume the lake is at 0%, 25%, 50%, 75 or 100% of the capacity at full supply level at the start of the flood event. Outflows for each condition are as specified in Table 3.3 above.

5.3 Design Rainfall Events

The calibrated RORB model was used to generate design flood hydrographs. It should be noted that these are intended to provide a consistent comparison between storage levels for various flood events. The initial and continuing loss parameters were adjusted to ensure a maximum peak flow in the 1% AEP design event of approximately 1290 m^3/s, equivalent to the assumed 1% AEP flood at Benalla. The initial and continuing loss parameters are shown in Table 5.5. These design losses are based on the values defined in AR&R and are used to allow comparison between different design storm events as they provide a static set of initial catchment conditions. These parameters are not directly comparable to those calculated for known storm events.

Table 5.5 – Design Loss Parameters

Parameter	Initial Loss (mm)	Continuing Loss (mm/h)
Value	20	2.9

Design rainfall hydrographs were generated for the 1%, 2%, 5% and 10% AEP rainfalls for the 9, 12, 18, 36, 48 and 72 hour storms.

5.4 Results

Peak flows and hydrographs have been obtained for a number of locations along the Broken River, Holland Creek and other tributaries from the model for each design storm and Lake Nillahcootie initial condition. The peak flows for each modelled flood event are shown for each recording location in Tables 5.6 to 5.14. The maximum peak flow is highlighted. The 36 hour storm hydrographs for each starting condition and ARI are shown in Figures 5.2 to 5.10 as this is the critical storm duration at Benalla.

Table 5.6 – Lake Nillahcootie Inflow Peak Flows (m^3/s)

Storm Event	Storm Duration (hours)						
	9	12	18	24	36	48	72
1% AEP	850.5	853.2	480.8	535.0	591.1	645.8	418.3
2% AEP	850.5	853.2	480.8	535.0	591.1	645.8	418.3
5% AEP	850.5	853.2	480.8	535.0	591.1	645.8	418.3
10% AEP	850.5	853.2	480.8	535.0	591.1	645.8	418.3

Table 5.7 – Lake Nillahcootie Outflow Peak Flows (m^3/s)

		Storm Duration (hours)						
Storm Event	Nillahcootie % Full	9	12	18	24	36	48	72
1% AEP	100	286.8	337.0	293.8	343.0	426.4	435.0	303.1
	75	174.8	220.7	188.2	235.2	322.8	338.3	229.5
	50	0.0	76.7	60.7	112.8	189.8	205.2	178.3
	25	0.0	0.0	0.0	0.0	55.8	73.8	134.7
	0	0.0	0.0	0.0	0.0	0.0	0.0	32.4
2% AEP	100	193.4	223.8	210.0	237.4	300.8	303.5	209.4
	75	64.9	121.6	109.1	141.3	197.0	203.3	144.6
	50	0.0	0.0	0.0	25.2	72.2	80.3	107.9
	25	0.0	0.0	0.0	0.0	0.0	0.0	21.6
	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5% AEP	100	114.1	148.6	148.9	170.8	215.2	215.9	147.1
	75	0.0	32.7	43.0	69.5	116.9	119.7	98.5
	50	0.0	0.0	0.0	0.0	9.7	11.9	29.5
	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10% AEP	100	83.5	110.0	111.4	126.2	165.4	162.4	110.5
	75	0.0	0.0	16.9	28.4	62.8	61.3	59.1
	50	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.8 – Broken River @ Moorngag Peak Flows (m^3/s)

		Storm Duration (hours)						
Storm Event	Nillahcootie % Full	9	12	18	24	36	48	72
1% AEP	100	294.5	346.4	303.3	356.8	444.0	455.1	328.4
	75	196.1	222.6	190.1	238.8	328.6	346.3	249.1
	50	196.1	171.9	126.1	153.2	190.5	207.2	213.1
	25	196.1	171.9	126.1	153.2	164.9	162.1	141.8
	0	196.1	171.9	126.1	153.2	164.9	162.1	95.2
2% AEP	100	200.9	232.7	219.1	249.7	314.0	318.2	232.1
	75	161.7	141.9	109.3	142.8	201.4	208.5	178.4
	50	161.7	141.9	105.9	133.9	140.6	139.0	120.6
	25	161.7	141.9	105.9	133.9	140.6	139.0	79.8
	0	161.7	141.9	105.9	133.9	140.6	139.0	79.8
5% AEP	100	126.2	155.4	156.3	181.2	226.6	228.4	161.9
	75	123.9	111.3	88.7	117.5	121.4	121.5	121.0
	50	123.9	111.3	88.7	117.5	121.3	120.8	66.7
	25	123.9	111.3	88.7	117.5	121.3	120.8	66.7
	0	123.9	111.3	88.7	117.5	121.3	120.8	66.7
10% AEP	100	100.4	114.5	116.3	132.8	173.6	171.4	119.8
	75	98.9	86.0	70.0	94.5	97.6	97.6	67.4
	50	98.9	86.0	70.0	94.5	97.6	97.6	53.0
	25	98.9	86.0	70.0	94.5	97.6	97.6	53.0
	0	98.9	86.0	70.0	94.5	97.6	97.6	53.0

Table 5.9 – Moonee Creek @ Lima Inflow Peak Flows (m^3/s)

	Storm Duration (hours)						
Storm Event	9	12	18	24	36	48	72
1% AEP	230.9	223.0	172.8	181.1	216.3	220.9	131.9
2% AEP	185.5	183.7	145.7	156.7	185.0	189.3	110.7
5% AEP	132.7	142.5	121.2	133.5	158.9	164.7	93.2
10% AEP	103.1	108.5	95.2	103.9	127.4	133.0	74.2

Table 5.10 – Blind Creek Peak Flows (m^3/s)

	Storm Duration (hours)						
Storm Event	9	12	18	24	36	48	72
1% AEP	111.4	107.0	79.0	80.0	91.6	90.3	48.4
2% AEP	71.9	75.3	56.2	57.0	66.1	65.2	33.6
5% AEP	45.9	49.2	36.9	40.0	47.9	48.1	20.5
10% AEP	33.1	36.7	26.8	31.5	38.2	38.4	12.5

Table 5.11 – Broken River Only @ confluence with Holland Creek Peak Flows (m^3/s)

		Storm Duration (hours)						
Storm Event	Nillahcootie % Full	9	12	18	24	36	48	72
1% AEP	100	489.3	537.1	486.9	531.2	677.1	684.3	470.9
	75	459.6	498.9	448.3	476.4	606.1	589.1	389.7
	50	459.6	498.7	448.2	476.1	601.5	584.1	382.3
	25	459.6	498.7	448.2	476.1	601.4	584.1	382.4
	0	459.6	498.7	448.2	476.1	601.4	584.1	382.4
2% AEP	100	367.9	416.0	383.7	429.4	540.8	537.9	364.3
	75	346.2	388.8	353.6	388.3	486.9	468.3	299.9
	50	346.2	388.8	353.6	388.2	486.2	467.6	299.7
	25	346.2	388.8	353.6	388.2	486.2	467.6	299.7
	0	346.2	388.8	353.6	388.2	486.2	467.6	299.7
5% AEP	100	234.7	298.5	295.1	331.6	435.8	429.4	277.6
	75	222.6	280.2	273.7	303.0	391.7	376.7	232.6
	50	222.6	280.2	273.7	303.0	391.6	376.4	232.6
	25	222.6	280.2	273.7	303.0	391.6	376.4	232.6
	0	222.6	280.2	273.7	303.0	391.6	376.4	232.6
10% AEP	100	174.5	216.6	218.0	243.3	333.2	325.1	206.0
	75	166.1	204.2	203.4	224.6	302.7	293.6	174.3
	50	166.1	204.2	203.4	224.6	302.7	293.6	174.3
	25	166.1	204.2	203.4	224.6	302.7	293.6	174.3
	0	166.1	204.2	203.4	224.6	302.7	293.6	174.3

Table 5.12 – Holland Creek @ Kelfeera Inflow Peak Flows (m^3/s)

	Storm Duration (hours)						
Storm Event	9	12	18	24	36	48	72
1% AEP	484.3	538.0	453.0	491.2	609.9	597.3	373.1
2% AEP	297.4	358.4	313.4	344.0	425.3	404.6	250.0
5% AEP	190.9	250.2	238.6	266.0	349.1	333.5	210.3
10% AEP	140.0	178.9	175.7	206.0	272.0	261.1	153.6

Table 5.13 – Holland Creek Only @ confluence with Broken River Peak Flows (m^3/s)

	Storm Duration (hours)						
Storm Event	9	12	18	24	36	48	72
1% AEP	452.6	505.4	433.7	476.7	585.4	591.2	371.6
2% AEP	276.0	336.8	298.7	331.2	407.5	396.6	248.5
5% AEP	181.5	238.9	229.3	255.7	334.2	323.4	206.4
10% AEP	133.7	171.0	169.1	198.1	261.2	253.2	150.7

Table 5.14 – Broken River @ Benalla Gauge Peak Flows (m^3/s)

		Storm Duration (hours)						
Storm Event	Nillahcootie % Full	9	12	18	24	36	48	72
1% AEP	100	968.7	1071.7	946.8	1036.8	1298.1	1292.4	868.8
	75	946.6	1041.9	915.2	989.6	1232.6	1220.7	775.5
	50	946.6	1041.8	915.1	989.3	1228.0	1215.7	773.3
	25	946.6	1041.8	915.1	989.3	1228.0	1215.7	773.4
	0	946.6	1041.8	915.1	989.3	1228.0	1215.7	773.4
2% AEP	100	661.5	774.0	700.7	779.3	964.8	950.9	629.1
	75	643.3	750.6	671.9	742.7	921.4	888.9	558.6
	50	643.3	750.6	671.9	742.7	920.7	888.2	556.4
	25	643.3	750.6	671.9	742.7	920.7	888.2	556.4
	0	643.3	750.6	671.9	742.7	920.7	888.2	556.4
5% AEP	100	427.1	551.0	535.9	599.8	788.0	769.0	492.7
	75	416.1	533.7	513.2	568.7	740.3	716.3	443.5
	50	416.1	533.7	513.2	568.7	740.2	716.0	443.4
	25	416.1	533.7	513.2	568.7	740.2	716.0	443.4
	0	416.1	533.7	513.2	568.7	740.2	716.0	443.4
10% AEP	100	316.2	397.5	394.7	450.6	608.0	590.8	361.0
	75	308.2	385.4	379.5	431.7	577.6	559.3	329.3
	50	308.2	385.4	379.5	431.7	577.6	559.3	329.3
	25	308.2	385.4	379.5	431.7	577.6	559.3	329.3
	0	308.2	385.4	379.5	431.7	577.6	559.3	329.3

The peak flows have been converted to levels at the Benalla Gauge to give an indication of the impact of Lake Nillahcootie on flood levels at Benalla. The gauge level for each peak flow from Table 5.14 is shown in Table 5.15.

Table 5.15 – Peak Flow and Gauge Levels at Benalla

Storm Event	**10% AEP**		**5% AEP**		**2% AEP**		**1% AEP**	
Nillahcootie % FSL	**Peak Flow (m^3/s)**	**Gauge Level (m)**	**Peak Flow (m^3/s)**	**Gauge Level (m)**	**Peak Flow (m^3/s)**	**Gauge Level (m)**	**Peak Flow (m^3/s)**	**Gauge Level (m)**
100	608.0	4.27	788.0	4.68	964.8	4.99	1298.1	5.50
75	577.6	4.20	740.3	4.57	921.4	4.92	1232.6	5.41
50	577.6	4.20	740.2	4.57	920.7	4.92	1228.0	5.41
25	577.6	4.20	740.2	4.57	920.7	4.92	1228.0	5.41
0	577.6	4.20	740.2	4.57	920.7	4.92	1228.0	5.41

The results indicate that airspace in Lake Nillahcootie does have a small impact on peak flows at Benalla. If Lake Nillahcootie is less than 100% full at the start of the storm event, a reduction in the flood peak is observed at Benalla, until the starting level is below 75%, where it ceases to have a perceptible impact on the peak flows.

This result may appear counter-intuitive as no further differences are found when the initial volume in Lake Nillahcootie is less than 75%. The effect is due to the airspace provided when the lake is less than 75% full being sufficient to store and delay the any outflows such that the contribution to the nett flow is reduced at the time of the flood peak at Benalla. Effectively, this reduces the relative contribution of the Broken River to the peak flow at Benalla. The effect of the storage can be seen in 5.10 with the tails of the hydrographs after the peak being smaller as the starting storage decreases. This indicates a reduction in the total flow volume through Benalla.

Lake Nillahcootie does have a greater influence on flood levels in the Broken River immediately downstream of the storage, as can be seen in the hydrographs shown in Figures 5.3, 5.4 and 5.7. The results of the hydraulic modelling are generally comparable with those shown in the 1994 Benalla Floodplain Management Study.

Changes in the distribution of rainfall across the catchment would modify the results by varying the relative contribution of each catchment. In simple terms, if more rainfall fell on the Holland Creek catchment, the impact of Lake Nillahcootie would be reduced with respect to the peak flow experienced at Benalla. The hydrographs for both the Broken River and Holland Creek indicate that the peak flows from each catchment reach Benalla at approximately the same time under design storm conditions modelled above.

5.5 Timing of Peak Flows

To examine the effect that the timing of the flow from Lake Nillahcootie to Benalla has on the peak flow at Benalla, the model has been run with inflows from the 1% AEP 36 hour storm for subcatchments upstream of the lake only. All other inflows are set to zero. The impact of Lake Nillahcootie on catchment flows can then be determined independent of the remainder of the catchment. Table 5.16 indicates the time and magnitude of peak flows for inflow and outflow from Lake Nillahcootie and at Benalla for the 1% AEP 36 hour storm event.

Table 5.16 – Impact of Lake Nillahcootie (LN) on Hydrograph Peak, Inflow from Upstream Only

Initial LN % Full	Peak Flow (m^3/s)			Time to Peak (h)			Time to Peak @ Benalla (include d/s flow)
	LN Inflow	LN Outflow	Benalla	LN Inflow	LN Outflow	Benalla	
100	591.1	426.4	367.3	22	28	42	30
75	591.1	322.8	262.3	22	32	46	30
50	591.1	189.8	149.5	22	36	52	30
25	591.1	55.8	43.29	22	46	68	30
0	591.1	0	0	22	-	-	30

It can be seen from Table 5.16 that the peak flows from Lake Nillahcootie do not reach Benalla until at least 42 hours after the commencement of the rainfall event if the Lake is 100% full. The peak takes longer to reach Benalla if more airspace is available in Lake Nillahcootie and the overall peak is reduced. Analysis of the modelling undertaken in Section 5.4 indicates that the peak flow at Benalla occurs after 30 hours under any initial storage level in the Lake for the 1% AEP 36 hr storm event.

As such, the effect of the initial level in Nillahcootie is not a major factor in the peak flows at Benalla as flows from the remainder of the catchment downstream of Nillahcootie are a greater influence on the peak flow. This is especially noticeable in the 0% full case, where the contribution of flows from upstream of Lake Nillahcootie at Benalla is effectively zero, and the flood peak at Benalla is comprised of only catchment flows from downstream of the storage.

5.6 Removal of Lake Nillahcootie

In order to provide a means of placing the benefits of airspace at Lake Nillahcootie in context, it is worth examining the predicted flood flows at Benalla for a case prior to construction of the lake. Running the RORB model for the 1% AEP flood without the storage it was found that the critical storm duration was 48 hours and the peak 1% AEP flow was 1467 m^3/s. This is 12% higher than the 1% AEP flow for when the storage is 100% full (1298 m^3/s from Table 5.14). Without the storage the level would be 5.73 m at the

Benalla Gauge, an increase of 23 cm. This flood event would be larger than the current estimated 0.5% AEP event as reported in the Benalla Floodplain Management Study (Cardno Willing, 2002). In contrast, the Benalla Floodplain Management Study (SR&WSC, 1984) found that, without the effect of a full Lake Nillahcootie, flows at Benalla would increase by 7%. The difference is likely due to the higher estimate of the 1% AEP used in this study.

It is clear that Lake Nillahcootie, even when full, provides significant flood protection to Benalla when compared to conditions prior to its construction.

6. ROUTING OF KNOWN STORM RAINFALLS

To examine the impact of the pre 1992 and post 1992 operating conditions of Lake Nillahcootie (Section 2.1), an analysis has been undertaken using the 1974, 1975, 1981 and 1993 rainfall events. Analysis has been undertaken for two scenarios; a real world scenario examining if the proposed target levels could be met under the flow conditions at the time each known flood occurred and a theoretical scenario assuming a specific target level and initial condition in the Lake.

6.1 Analysis of "Real World" Conditions

To examine the effect of the operating regime of Lake Nillahcootie on the storage at the beginning of the flood event, the historical water levels prior to each flood event were examined. With the exception of the 1993 event, all events occurred when the level of Lake Nillahcootie was under operating conditions that aimed to keep the lake below the FSL.

The outflow from Lake Nillahcootie over this period was dependant on a number of factors, including the provision of water to Lake Mokoan from the Holland Creek catchment, the rate of release of water from Lake Nillahcootie, downstream tributary inflows and the level of Lake Mokoan. It can be inferred from the historical records that if Lake Nillahcootie was at a level greater than the specified target level, outflows from the lake would have been limited due to one of the aforementioned factors.

Figures 6.1 to 6.4 show the recorded volume of water in Lake Nillahcootie in the months before the known flood events of 1974, 1975, 1981 and 1993. Table 6.1 indicates the water level in Lake Nillahcootie immediately prior to the flood event.

Table 6.1 – Storage Level in Lake Nillahcootie Prior to Flood Event (Historical)

Flood Event	Date	Storage Volume (ML)	% Full Service Level	Applicable Minimum Operating Volume
1974	10-May-1974	34230	~ 85%	-
1975	12-Sep-1975	39790	~ 98%	26000
1981	17-Jul-1981	40540	~ 100%	12500
1993	01-Oct-1993	40630	~ 100%	28000

It can be seen from the table above that the minimum operating volumes of Lake Nillahcootie do not correspond with the recorded levels in the Lake due to the reasons outlined above. The period prior to each storm event is described below:

- 1974 Event – This event occurred outside the operating rule times of June to November (the storm occurred in mid-May). Drawdowns occurred prior to the flood event, likely from irrigation releases. There were significant inflows in the first week of May which raised the level of the lake to approximately 85% of FSL at the beginning of the storm event.
- 1975 Event - The flood event occurred in mid September, when the operating regime target was approximately 26000 ML. It can be seen from Figure 6.2 that the Lake met the operating targets in June and July and the levels steadily increased through August and early September, with the lake being effectively full at the beginning of the flood event. Again the catchment and operational conditions meant the lake exceeded the target levels during the year and the lake level prior to the storm event would have been no different under the post-1992 operating target.

- 1981 Event – The flood event occurred in mid-July when the operating regime target for the lake is 12335 ML. Figure 6.3 indicates that the operating target was met at the start of June, but the lake was full within six weeks as downstream transfer constraints limited the release of water from the Lake (as advised by G-MW). Any operating target would not have been effective under these conditions.
- 1993 Event – This was the largest flood recorded at Benalla with a flow of approximately 1294 m^3/s (112000 ML/d), occurring in early October. In 1993, the operating regime target was to maintain Lake Nillahcootie at or near FSL, due to issues at Lake Mokoan (including dam stability and blue-green algae). The excess inflows can be seen in Figure 6.4, where the Lake volume rises above the spillway level (40400 ML) a number of times during the months preceding the storm event.

6.2 Scenario Analysis - 1993 Flood Event

There has been a significant amount of debate regarding the operation of Lake Nillahcootie before the 1993 flood event. It has been argued that the change in operating conditions led to Lake Nillahcootie being full at the beginning of the flood event, which may have led to greater flooding in Benalla than if pre-1992 targets had been followed.

To examine the impact of the change in Lake Nillahcootie operating conditions for the period preceding the 1993 storm event is a complex task. Release of water from Lake Nillahcootie on any given day is governed by a number of factors, including:

- The level of Lake Mokoan
- Water level at Lake Nillahcootie
- Flows in Hollands Creek
- Flows in the Broken River
- The discharge capacity at Holland Weir

A spreadsheet model was developed to assess the change in flow regimes and the storage levels in both Lake Mokoan and Lake Nillahcootie. A storage balance approach was used to allow for local infows to Nillahcootie and Mokoan over the assessment period. The target supply level in Lake Mokoan has been set at 70% for the purposes of the evaluation. This is representative of the filling target that applied at the time. The decision tree for the release of water to Lake Mokoan from Lake Nillahcootie is shown below.

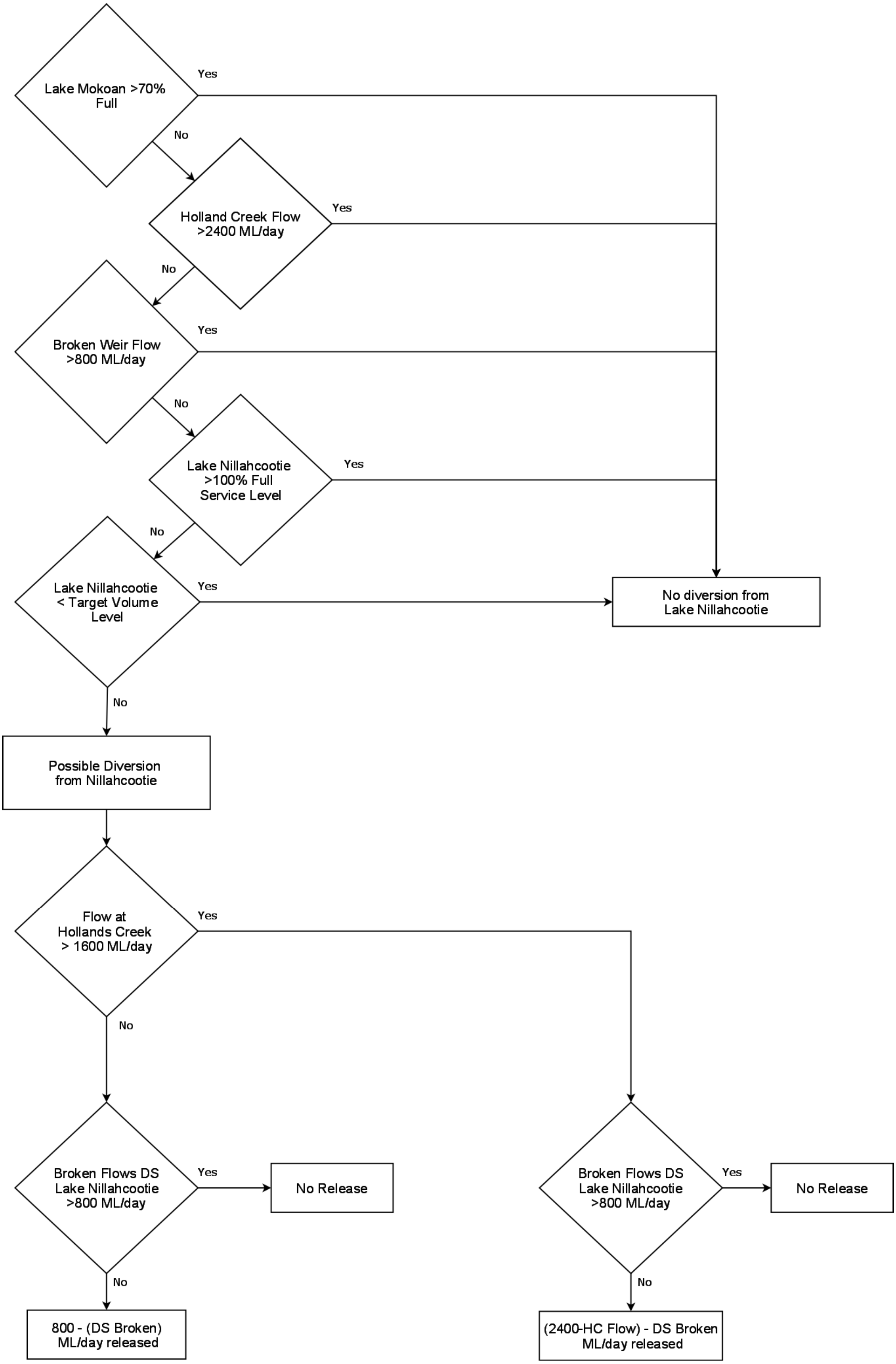
Lake Mokoan >70% Full
Yes
No
Holland Creek Flow >2400 ML/day
Yes
No
Broken Weir Flow >800 ML/day
Yes
No
Lake Nillahcootie >100% Full Service Level
Yes
No
Lake Nillahcootie < Target Volume Level
Yes
No diversion from Lake Nillahcootie
No
Possible Diversion from Nillahcootie
Flow at Hollands Creek > 1600 ML/day
Yes
No
Broken Flows DS Lake Nillahcootie >800 ML/day
Yes
No Release
No
800 - (DS Broken) ML/day released
Broken Flows DS Lake Nillahcootie >800 ML/day
Yes
No Release
No
(2400-HC Flow) - DS Broken ML/day released

Figure 6.5 shows the historical (post 1992 condition) and modelled (pre-1992 condition) storage volumes and the target supply level assumed for the period from May 1 to October 4 1993. It can be seen that the operation of Lake Nillahcootie in accordance with the pre-1992 operating conditions had no impact on the level of the storage at the start of the flood event. Rainfall in the months preceding the storm event is sufficient to fill the storage above the minimum target level. Figure 6.6 shows the recorded and modelled storage levels in Lake Mokoan.

6.3 Analysis of Known Flood Events

An alternate method of assessing the impact of the airspace in Lake Nillahcootie on flooding in Benalla is to consider the impact of the recorded flood events with varying initial water levels in the Lake at the beginning of the flood event.

Each of the known flood events described in section 6.1 was modelled with Lake Nillahcootie 0%, 25%, 50%, 75% and 100% full. Each storm was also assessed assuming Lake Nillahcootie was removed from the system, to allow the total flood protection benefits of the Lake to be considered.

Loss parameters were assumed to be as per Section 4 for the 1981 and 1993 events. As detailed hydrographs were not available for the 1974 and 1975 flood events, loss parameters have been chosen to achieve the peak flow rate measured at Benalla. For the 1974 flood event, Lake Nillahcootie was 85% full (section 6.1) and the peak flow at Benalla was 570 m^3/s. This equates to an initial loss of 20 mm and a continuing loss of 1.4 mm/h. For the 1975 flood event, Lake Nillahcootie was full at the beginning of the flood event and the peak flow at Benalla was 420 m^3/s. An initial loss of 20mm and a continuing loss of 2.75 mm/h were found to match the flow at Benalla.

Table 6.2 shows the peak flow rates at Benalla for the known flood events, assuming various initial water levels in Lake Nillahcootie. The hydrographs for each event at Benalla are shown in Figures 6.7 to 6.11.

Table 6.2 - Peak Flow at Benalla for Known Flood Events

	Lake Nillahcootie Initial % Full					No Lake Nillahcootie
Flood Event	0% full	25% full	50% full	75% full	100% full	
1974	555.4	555.4	555.4	556.1	642.3	680.7
1975	357.9	357.9	357.9	358.1	423.5	441.0
1981	379.2	379.2	379.2	380.4	479.8	532.7
1993	1154.2	1154.2	1154.3	1164.7	1295.0	1447.6

It can be seen from table 6.2 above that peak flows at Benalla are significantly reduced due to the presence of Lake Nillahcootie. It can also be seen that would have been some reduction in peak flows at Benalla if the storage was less than 75% full at the start of the flood event, confirming the results of the design storm analysis. The analysis in sections 6.1 and 6.2 shows that the reduction in storage level to below 75% prior to the flood event was not possible under the ‘real world’ conditions.

It should be noted that rare flood events cannot be accurately predicted far in advance of their occurrence. It is extremely unlikely that enough warning time could be given to draw down Lake Nillahcootie to below the 75% full threshold prior to a significant flood event. The maximum safe outflow from Lake Nillahcootie is 800ML per day assuming no downstream constraints, indicating that it could take at least 12 days to draw the lake down from 100% to 75% of capacity.

The GBCMA have advised that the 1974 flood event is equivalent to a 1 in 14 year ARI event and the 1975 flood event is equivalent to a 1 in 7-year ARI flood event. These estimates are consistent with the flows shown in Table 5.14.

7. IMPACT ON PROPERTIES AT BENALLA

Recent work undertaken by Cardno Willing (2008) has linked the river gauge level at Benalla to each property for the purposes of determining the number of properties and the number of floors affected by flooding, in 0.25 m increments. This provides a basis for estimating flood impacts at Benalla.

The maximum gauge height considered was 5.62 m, representing a 0.5% AEP event. It is not possible to estimate of the number of properties flooded above this level.

Table 7.1 indicates the number of affected properties and floors under the 100% full initial level condition of Lake Nillahcootie and for the other initial level conditions (from Table 5.15 once the storage level had dropped below 75% full, further changes in levels were minimal). The impact of having no storage is also shown for the 1% AEP event.

The numbers given in Table 7.1 are based on interpolations from modelling outside the scope of this study and should be taken as an indication of flood impacts. Table 7.2 shows the differences between the 100% full number affected and 75% number affected for each ARI event

Table 7.1 – Number of Flood Affected Properties at Benalla

Storm Event	**No Lake Nillahcootie (1% AEP)***	**1% AEP**		**2% AEP**		**5% AEP**		**10% AEP**	
Initial LN % Full	n/a	100	<=75	100	<=75	100	<=75	100	<=75
Benalla Gauge Height	**5.73**	**5.50**	**5.41**	**4.99**	**4.92**	**4.68**	**4.57**	**4.27**	**4.20**
Number of Properties Flooded*	>2766**	2214	2160	1088	1064	909	724	667	666
Number of Floors Flooded*	>1340**	1023	750	170	143	84	75	69	68

* - some properties included in this table are flooded by local drainage elements
** does not include properties or floors that may be flooded when the gauge level exceeds 5.62 m

Table 7.2 – Impact of Lake Nillahcootie on Flooding in Benalla

	Difference from 100% Full Case			
Storm Event	**No Nillahcootie**		**<75% Full**	
	Properties	**Floors**	**Properties**	**Floors**
1% AEP	>552	>317	-54	-273
2% AEP	N/A		-24	-27
5% AEP			-185	-9
10% AEP			-1	-1

It is clear that Lake Nillahcootie, even when full, provides significant flood protection to Benalla when compared to conditions prior to its construction. It is also clear that if some airspace is available at Lake Nillahcootie, this can provide some additional flood mitigation benefits to Benalla, particularly for the 1% AEP event.

As indicated in section 6, there are practical difficulties in achieving a lowering of Lake Nillahcootie ahead of a flood. Observation of the four largest historic flood events in Section 6.1 reveals that only one event – the May 1974 flood – occurred when the lake was below the FSL, at 85% of capacity at the start of the event.

8. CONCLUSIONS

This study sought to answer three main questions with regard to the operation of Lake Nillahcootie and its impact on flooding at Benalla. The following conclusions can be drawn from the study:

- *Has the past operation of Lake Nillahcootie been successful in reducing the frequency of flood impacts at Benalla, and what influence does Lake Nillahcootie pre and post 1992 "operating rules" have on flood flows?*

    - The construction of Lake Nillahcootie has reduced the impact of flooding at Benalla. If the reservoir is full, flood flows are attenuated by 12% in a 1% AEP event, effectively reducing a 0.5% AEP flood to a 1% AEP flood. *(Section 5.6).*
    - The change in operating rules has had no impact on the flood magnitudes at Benalla for the known flood events. Therefore the frequency of flooding would not have changed as a result of the different operating rules. *(Sections 6.1 & 6.2)*
    - Lake Nillahcootie provides significant flood mitigation for areas immediately downstream of the Lake along the Broken River. These impacts are greatest when the level of Lake Nillahcootie is lowest at the start of the storm event. For the smaller floods the flood frequency will reduce downstream of the reservoir because of the greater potential for Lake Nillahcootie to absorb them without spilling. This is unlikely to affect the frequency of flooding at Benalla as the main contributors to the flood peak are Holland Creek and the tributaries downstream of Lake Nillahcootie. *(Sections 5.4 & 5.5)*
    - Lake Nillahcootie can reduce the magnitude of flood events if, when the flood occurs, the lake is less than 100% full. Analysis of the four largest floods since the construction of Lake Nillahcootie indicates that the operational targets of the lake are a relatively small component of the determination of the lake level at the beginning of the storm event. Storage levels at the lake are mainly governed by the local inflows in the weeks preceding the flood event, the limited flood warning time available to draw down the reservoir ahead of a flood, the limited capacity of the outlet structures at Nillahcootie and the limited capacity of the Broken River downstream of the lake to accept flow releases. *(Sections 6.2 & 6.3)*

- *What are the changes in flood heights in Benalla and changes in the number of houses flooded, due to changes that have occurred since the construction of Lake Nillahcootie and the decommissioning of Lake Mokoan?*

    - Lake Nillahcootie provides significant benefits to Benalla even when full. Without the lake, 1% AEP flood levels would increase by 0.23 m at Benalla, flooding at least an additional 317 properties above floor level. *(Sections 5.6 & 7)*
    - If Lake Nillahcootie is below the full supply level prior to the flood event, additional flood mitigation benefits are found at Benalla. For a 1% AEP flood there will be reductions in flood levels of around 0.09 m at Benalla if the reservoir is at 75% capacity or less, reducing the estimated number of floors flooded from 1023 to 750. Reductions of up to 0.11 m can occur for lesser events. *(Sections 5.4 & 7)*

- *What degree of influence does Lake Nillahcootie have in preventing convergence of peak flows from the two catchments to Benalla, namely Holland Creek and Broken River catchments?*

    - Lake Nillahcootie delays the peak flow from areas upstream of the lake reaching Benalla by about 12 hours if the lake is 100% full and longer if the lake is emptier. *(Section 5.5)*
    - The timing of peak flows is such that the major influence on flood levels at Benalla is the combination of flows from the Broken River downstream of Lake Nillahcootie and the Holland Creek catchment. Peak flows from the Holland Creek and Broken River catchment downstream of Lake Nillahcootie reach Benalla at approximately the same time under design flood events. *(Sections 5.4 & 5.5)*
    - Analysis of the design storm events indicates that no additional benefit on flood levels at Benalla is obtained when the level of Lake Nillahcootie at the start of the flood event is 75% full or less. *(Sections 5.4, 6.3 & 7)*

9. REFERENCES

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CARDNO WILLING (2002), *Benalla Floodplain Management Study,* Final Report

CARDNO WILLING (2008), *Benalla Flood Mapping (Post Flood Management Works)*

FIGURES

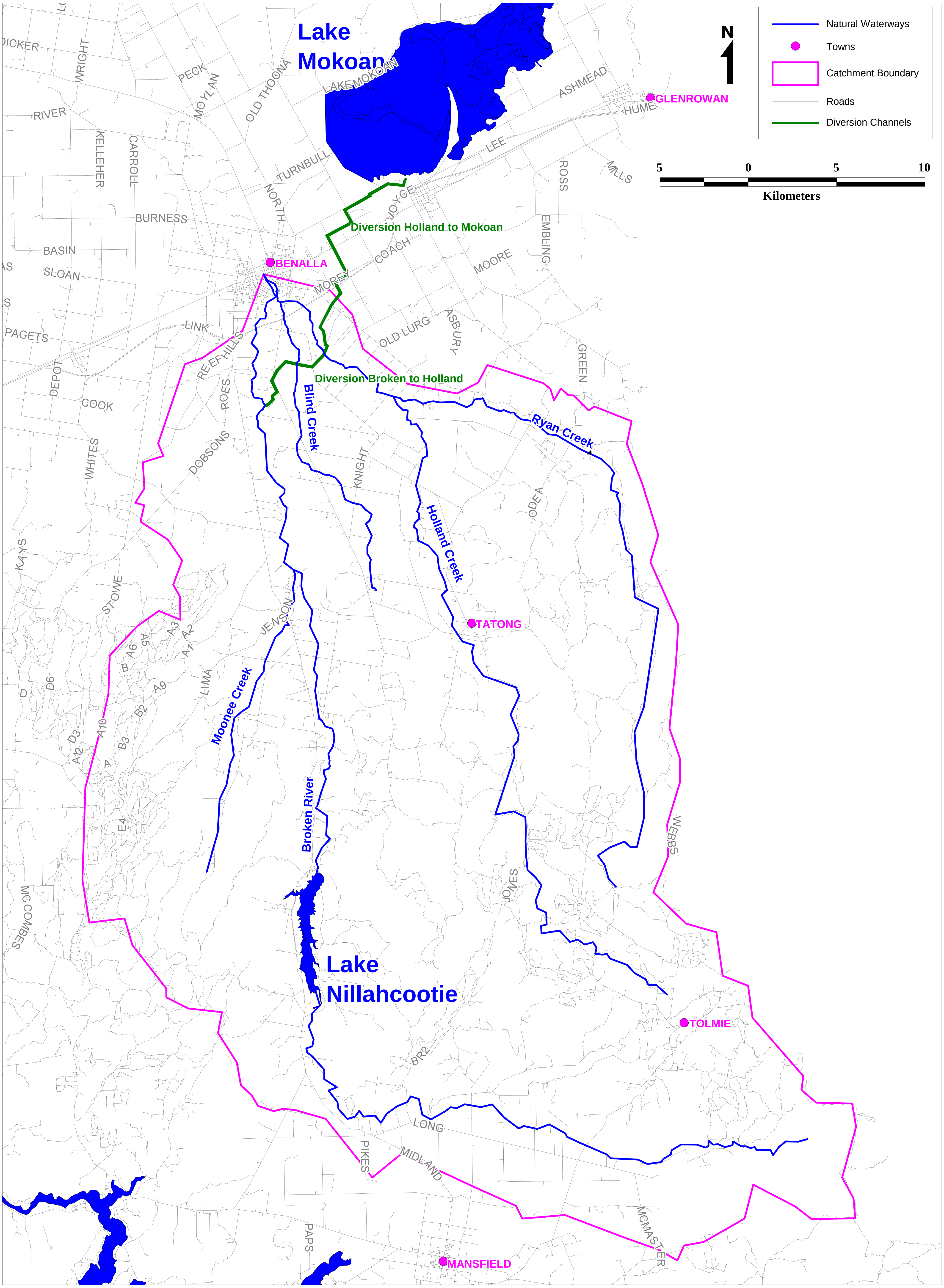

Figure 2.1 - Study Area

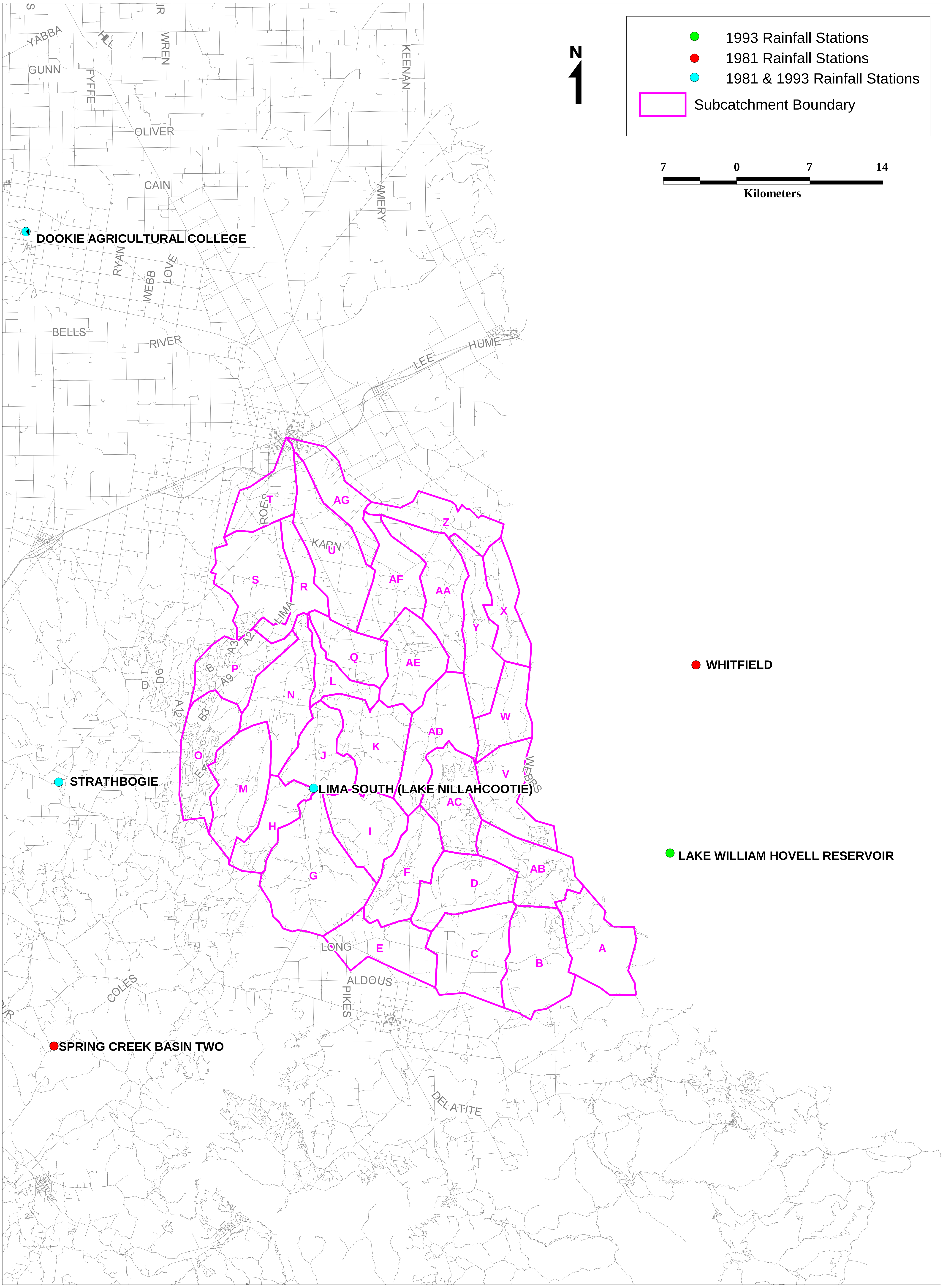

Figure 2.2 - Rainfall Station Locations

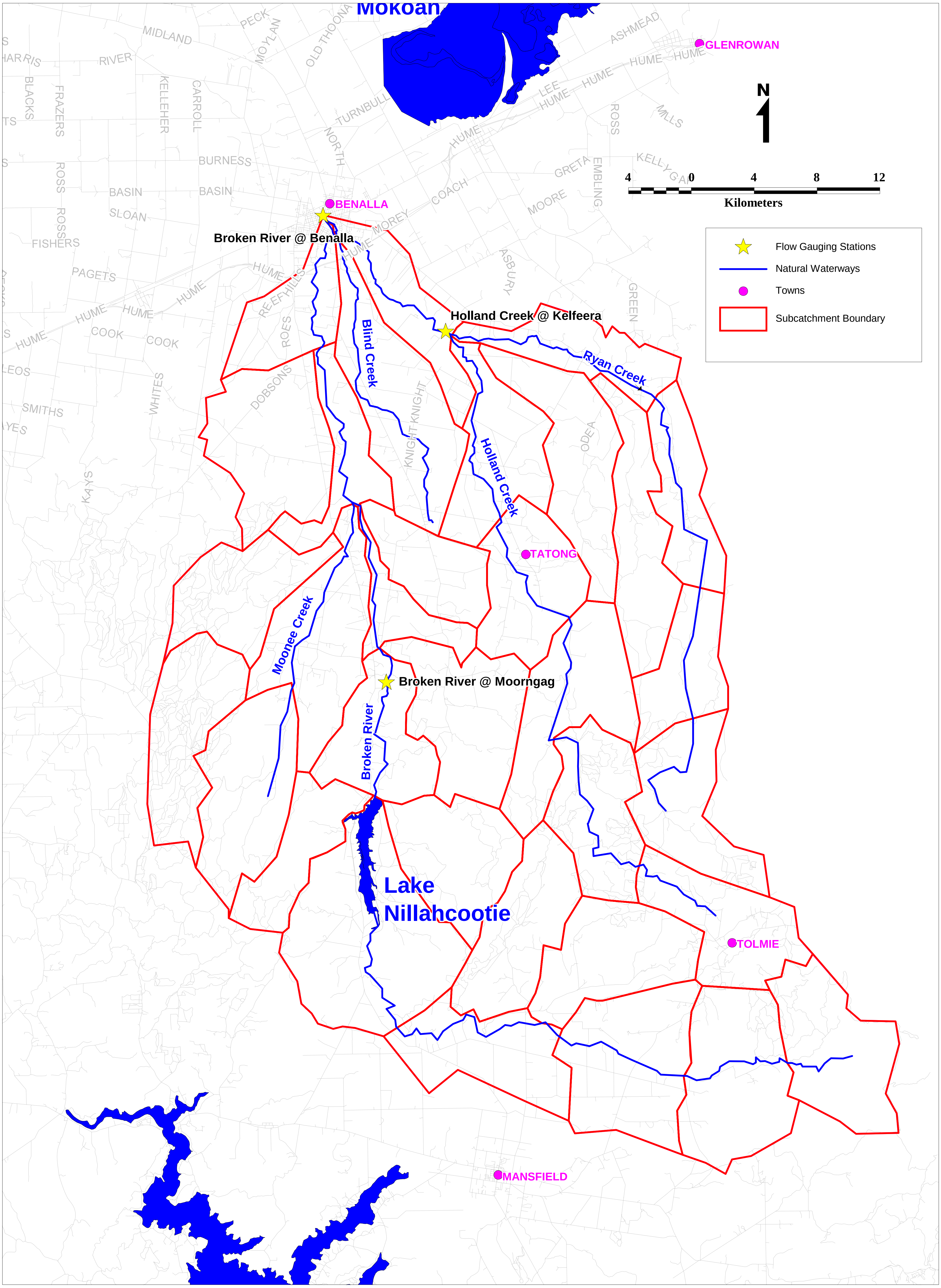

Figure 2.3 - Flow Gauging Stations

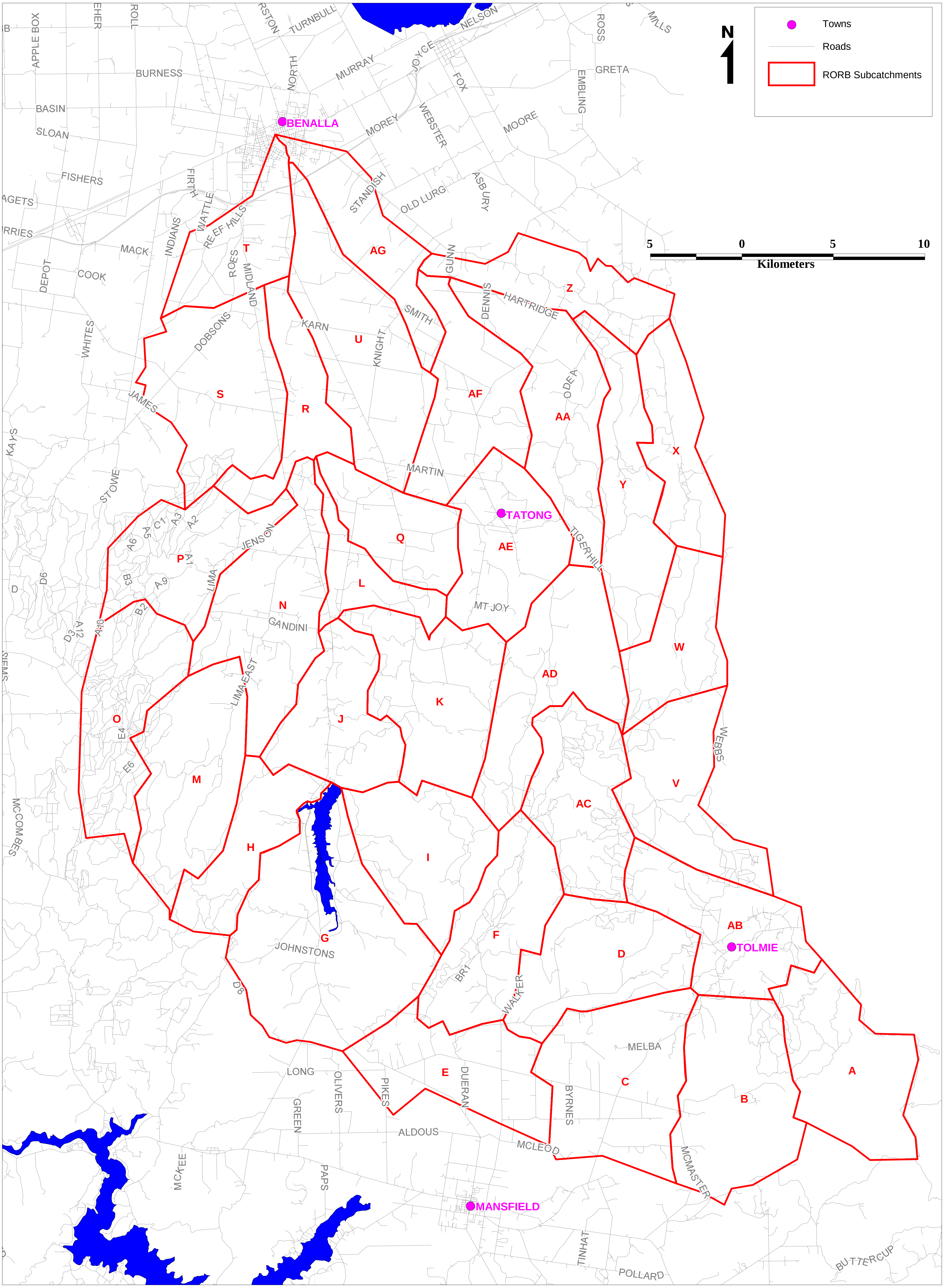

Figure 3.1 - RORB Subcatchments

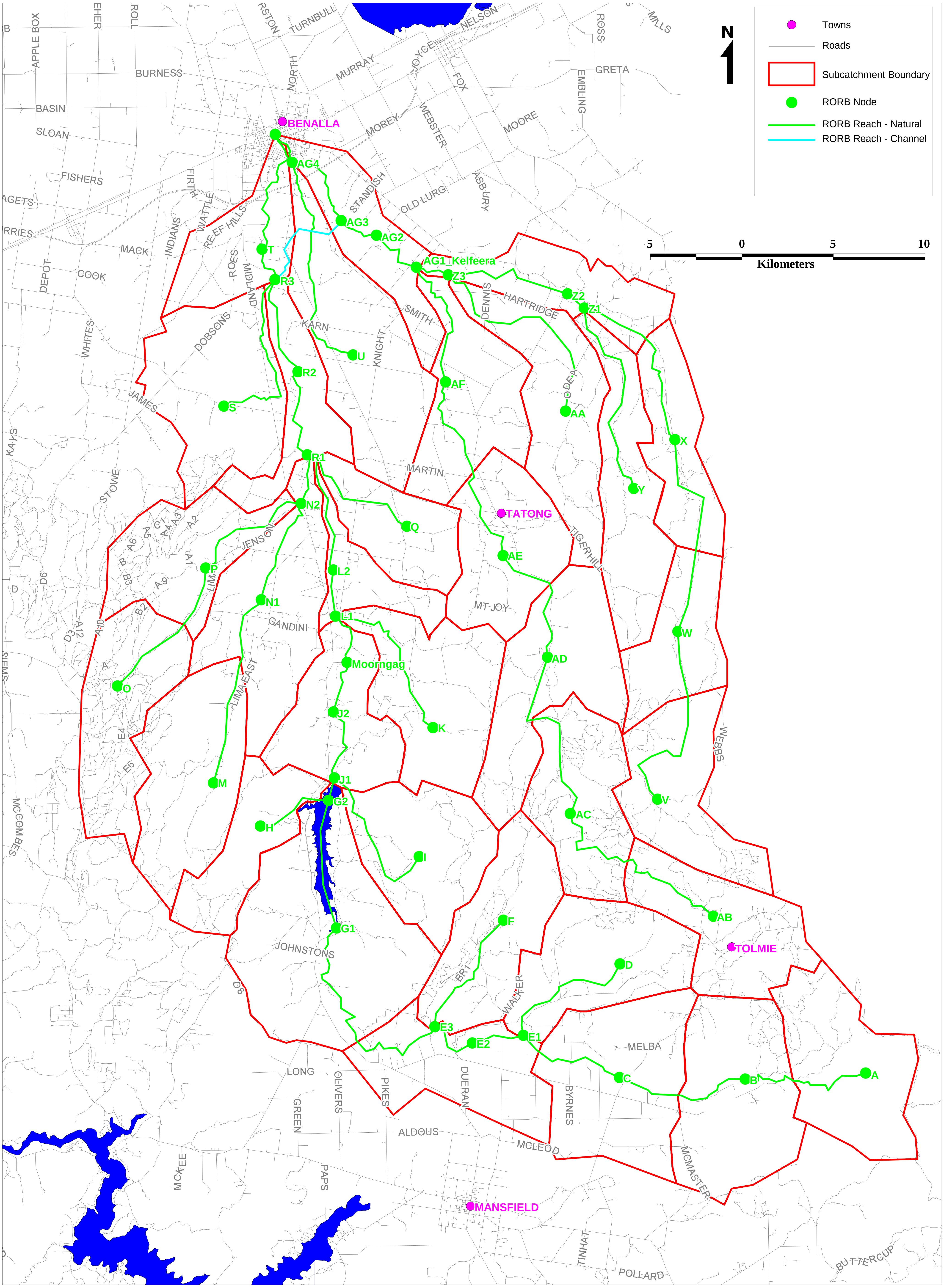

Figure 3.2 - RORB Layout

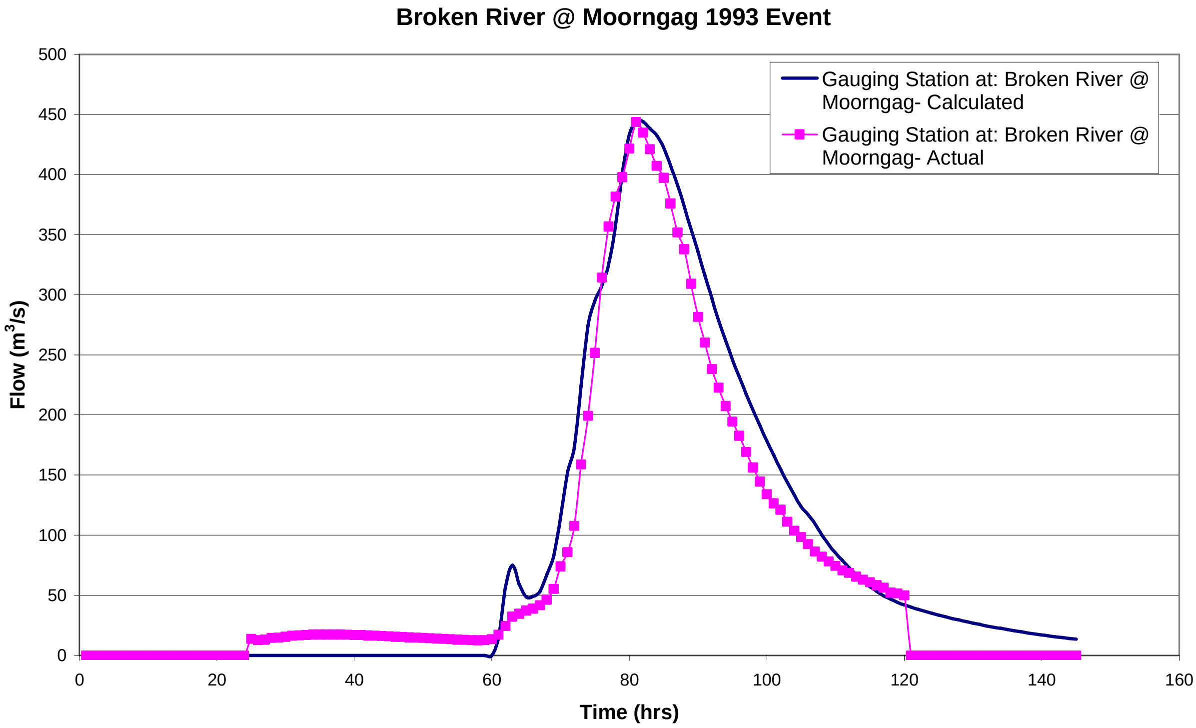

Figure 4.1 Calibration results, 1993 event at Broken River @ Moorngag

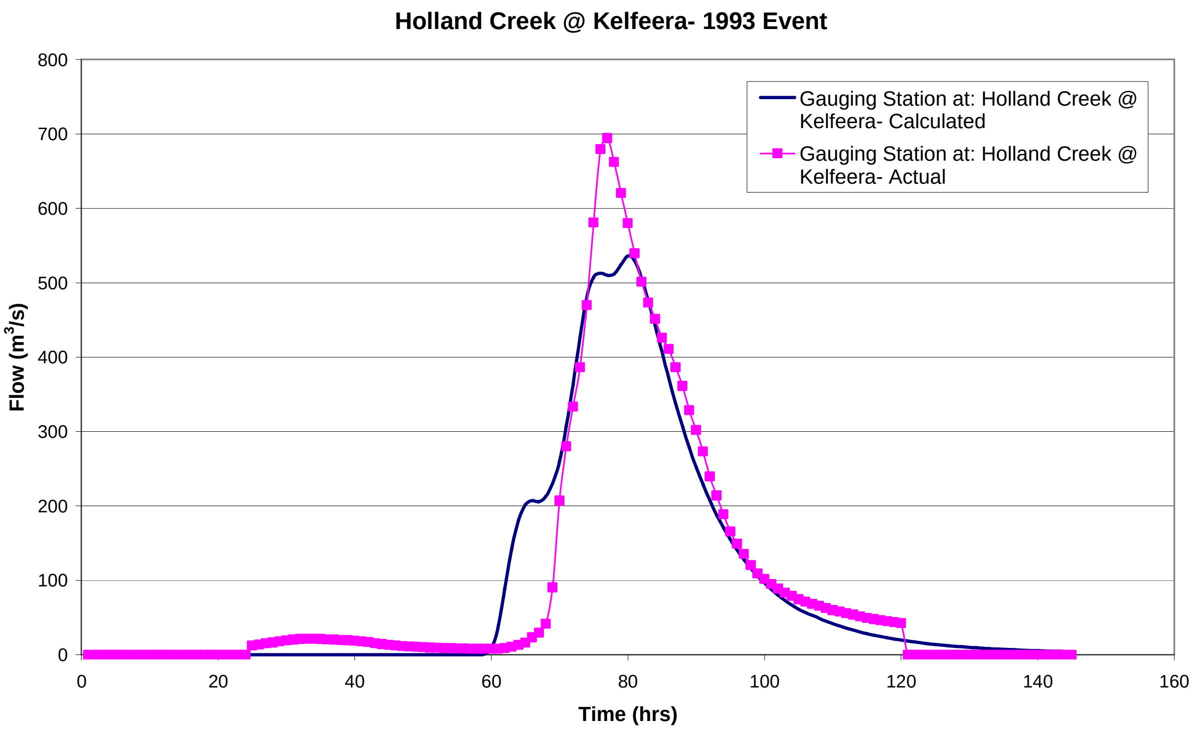

Figure 4.2 Calibration results, 1993 event at Holland Creek @ Kelfeera

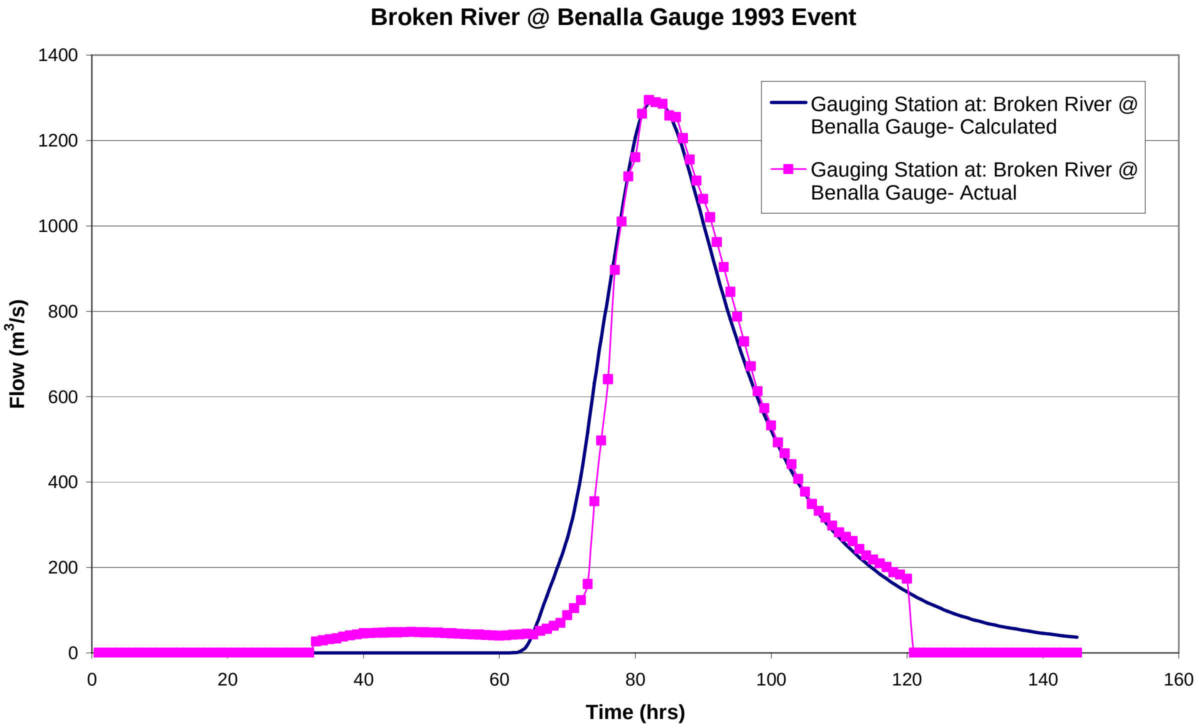

Figure 4.3 Calibration results, 1993 event at Broken River @ Benalla Gauge

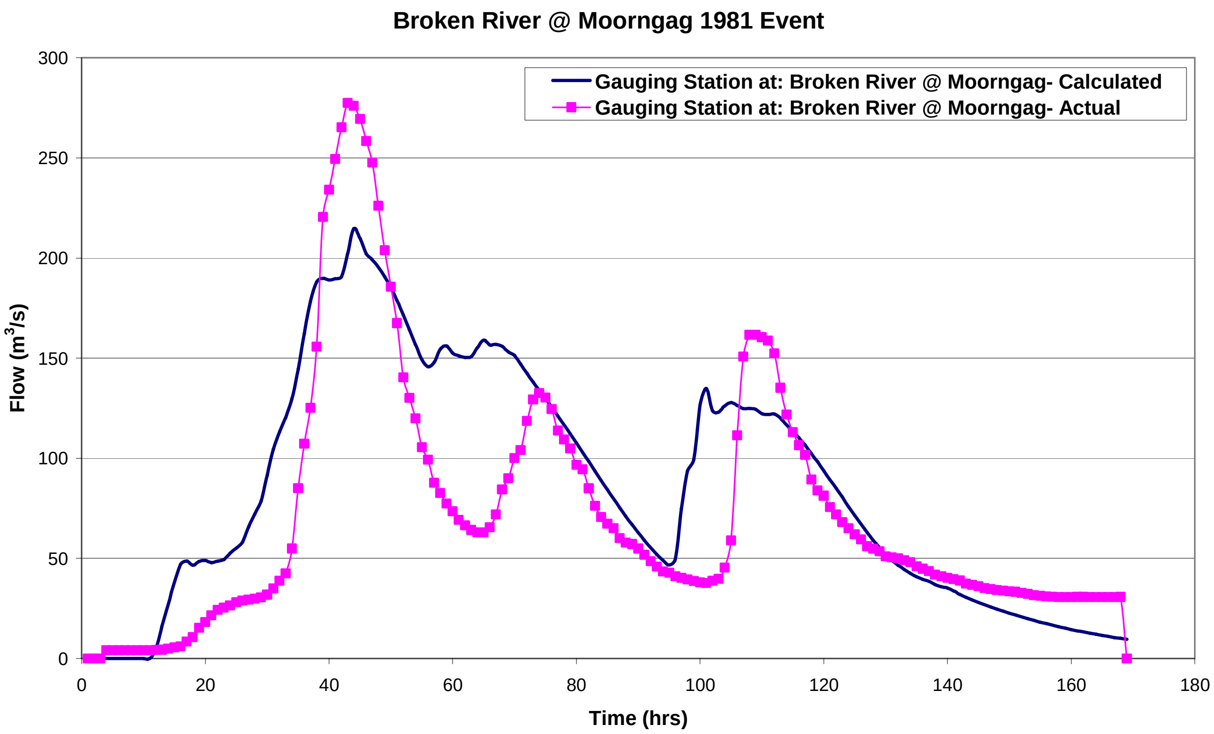

Figure 4.4 Calibration results, 1981 event at Broken River @ Moorngag

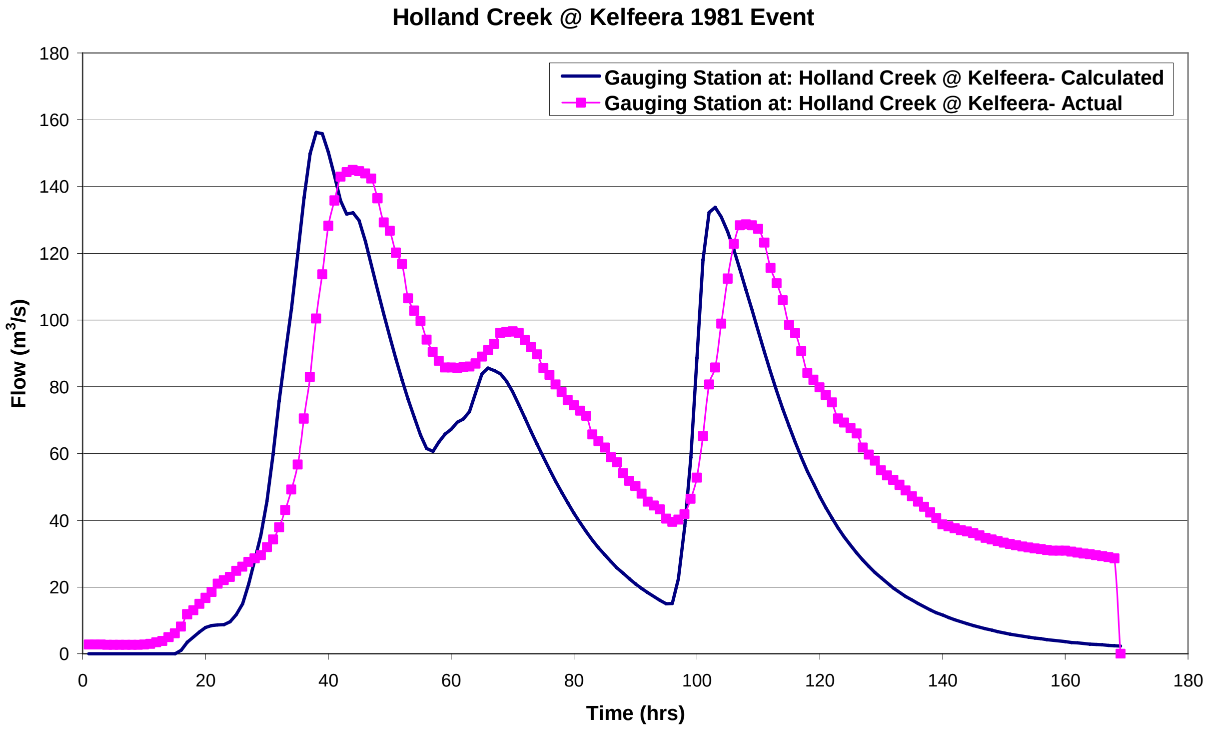

Figure 4.5 Calibration results, 1981 event at Holland Creek @ Kelfeera

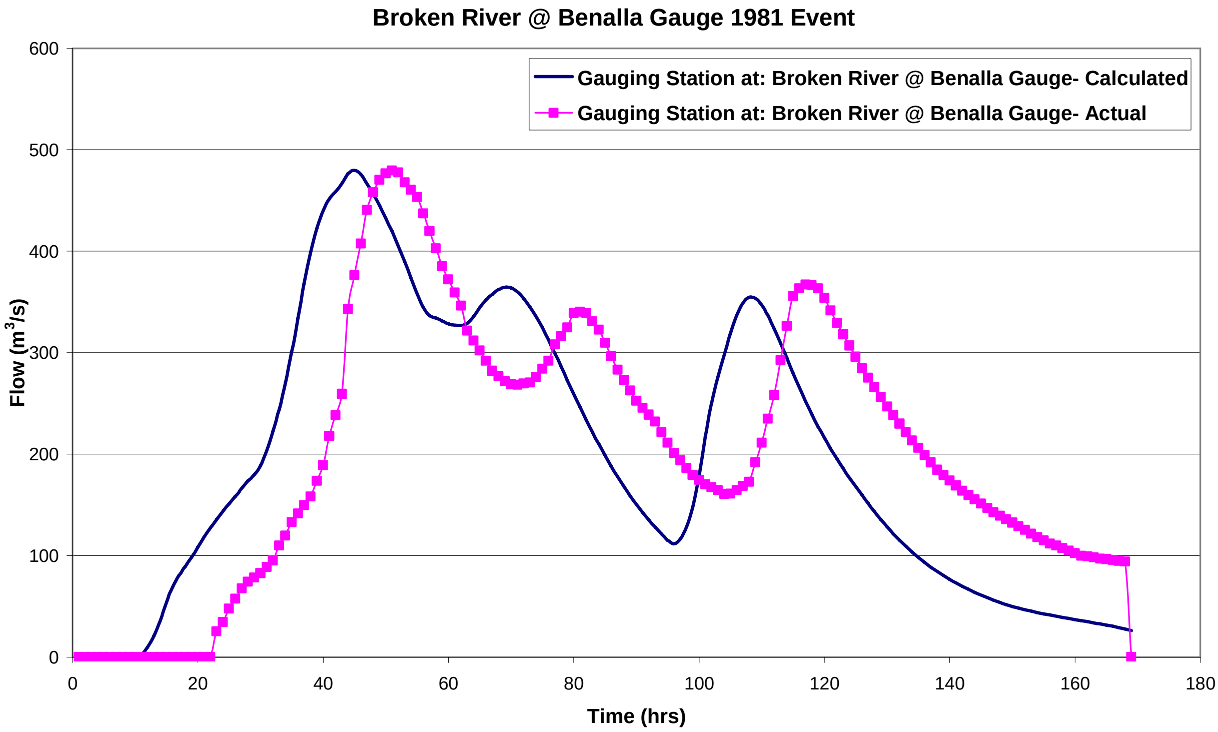

Figure 4.6 Calibration results, 1981 event at Broken River @ Benalla Gauge

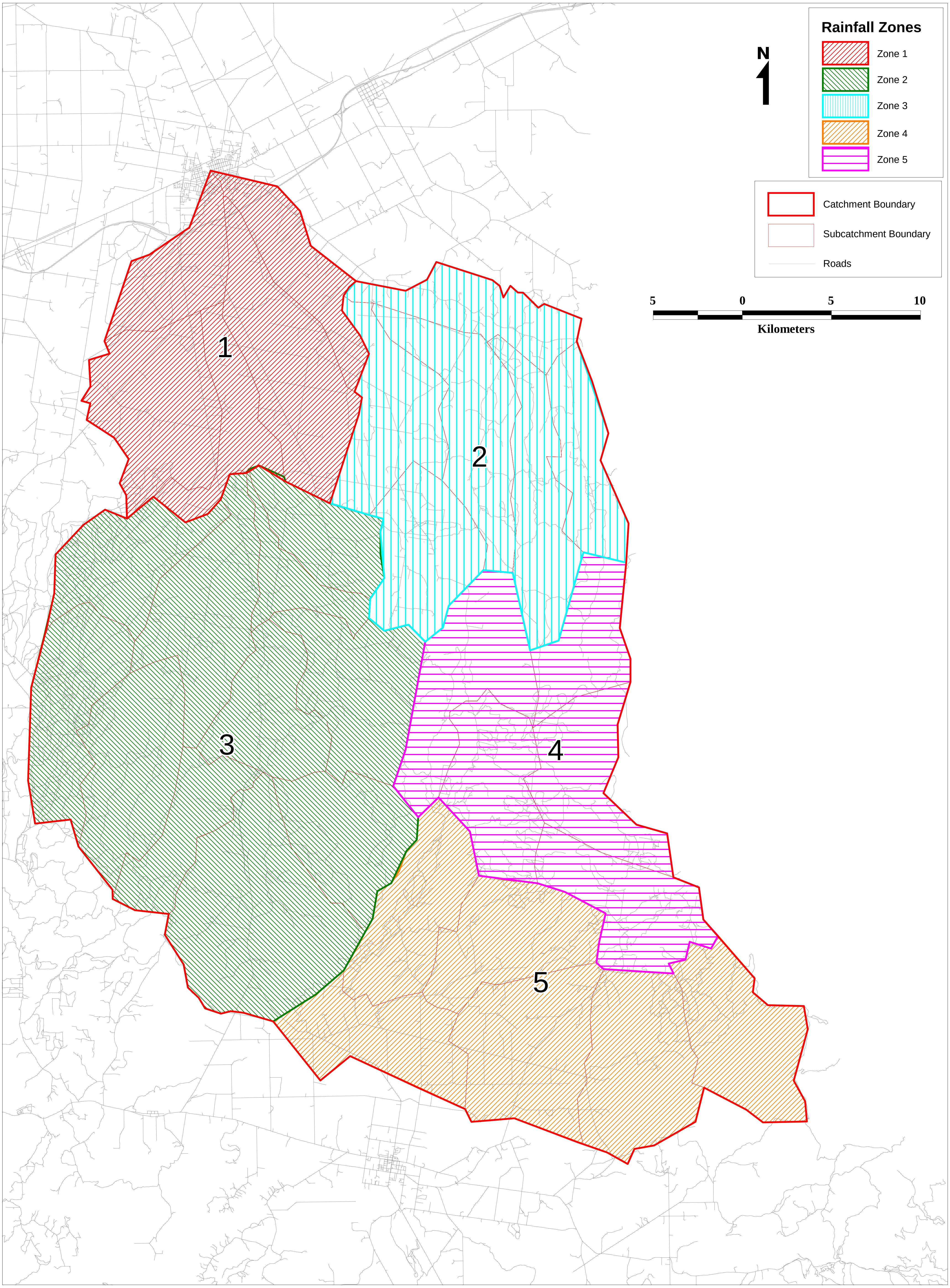

Figure 5.1 - RAINFALL ZONES

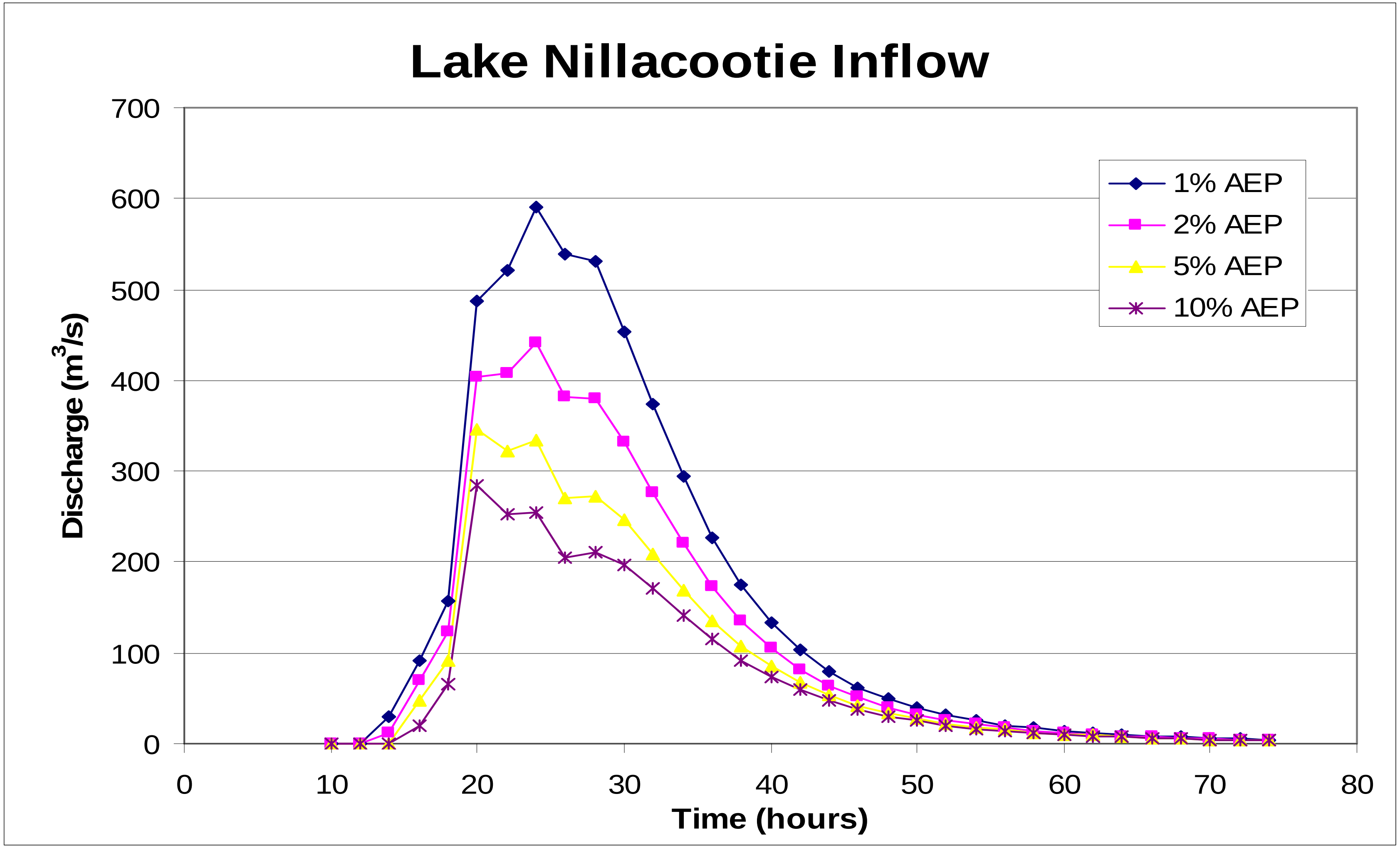

Figure 5.2 Hydrographs for Lake Nillahcootie Inflow for 100, 50, 20 and 10 Year Events.

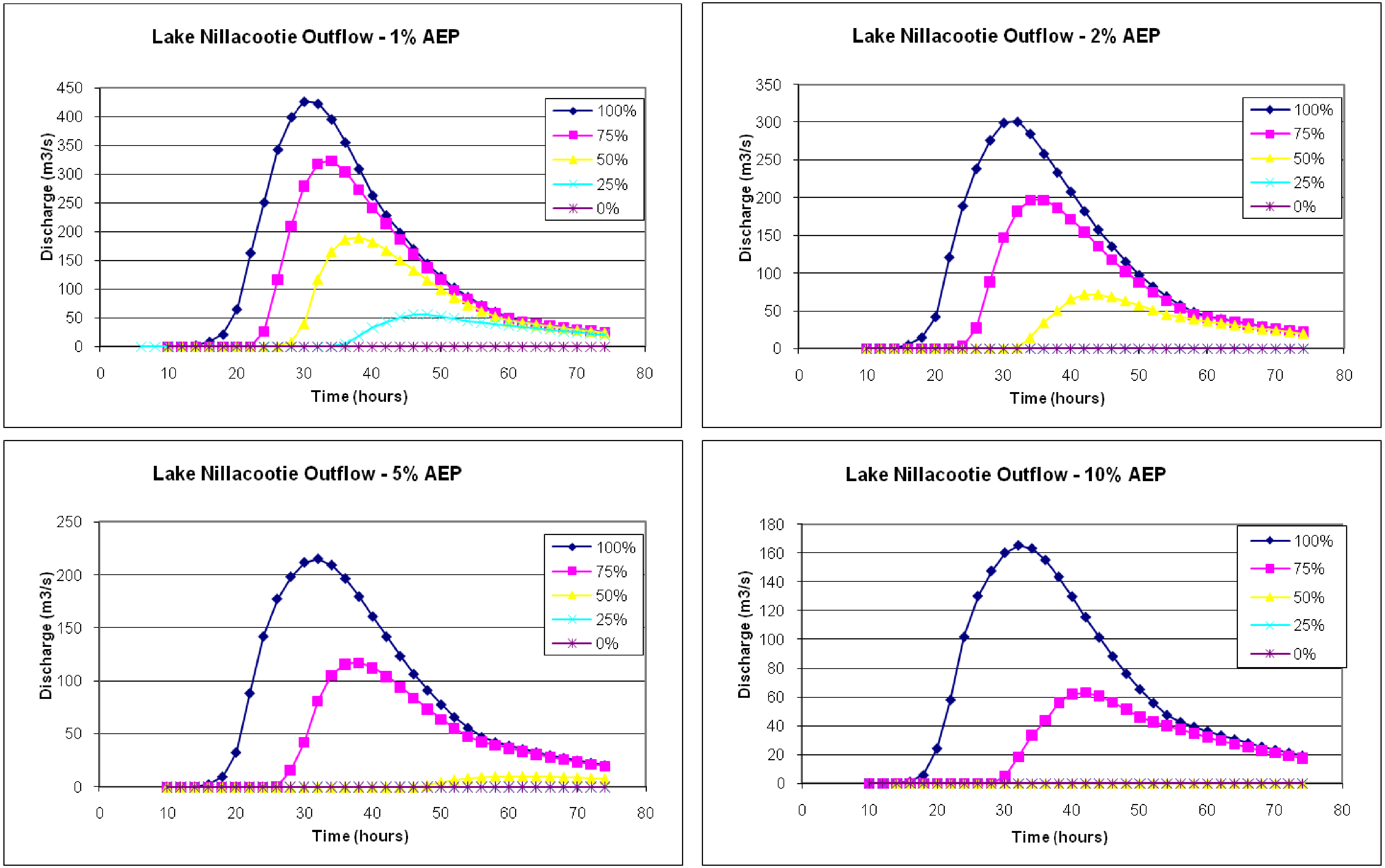

Figure 5.3 - Hydrographs for Lake Nillahcootie Outflow for 100, 50, 20 and 10 Year Events

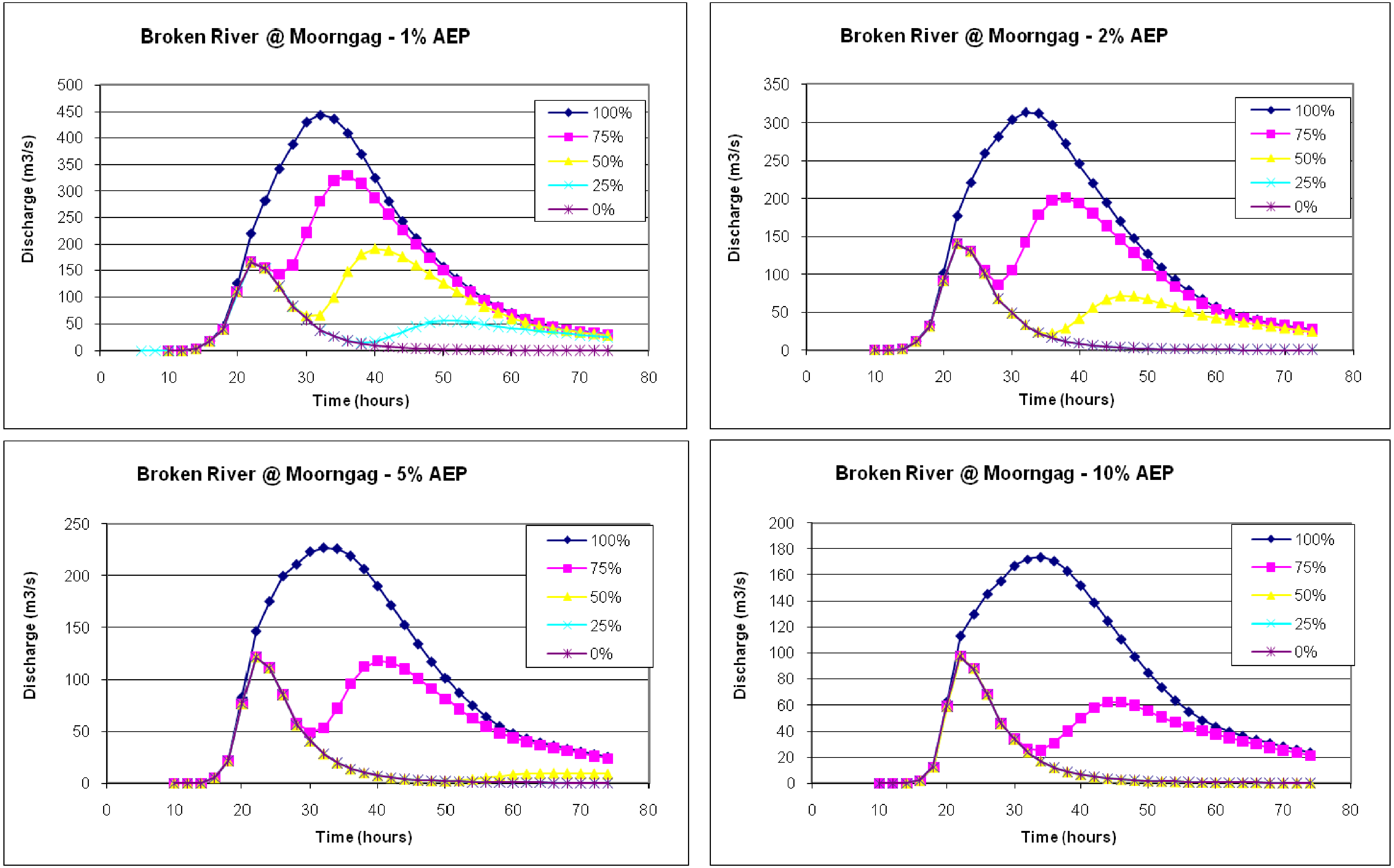

Figure 5.4 - Hydrographs for Broken River @ Moorngag for 100, 50, 20 and 10 Year Events

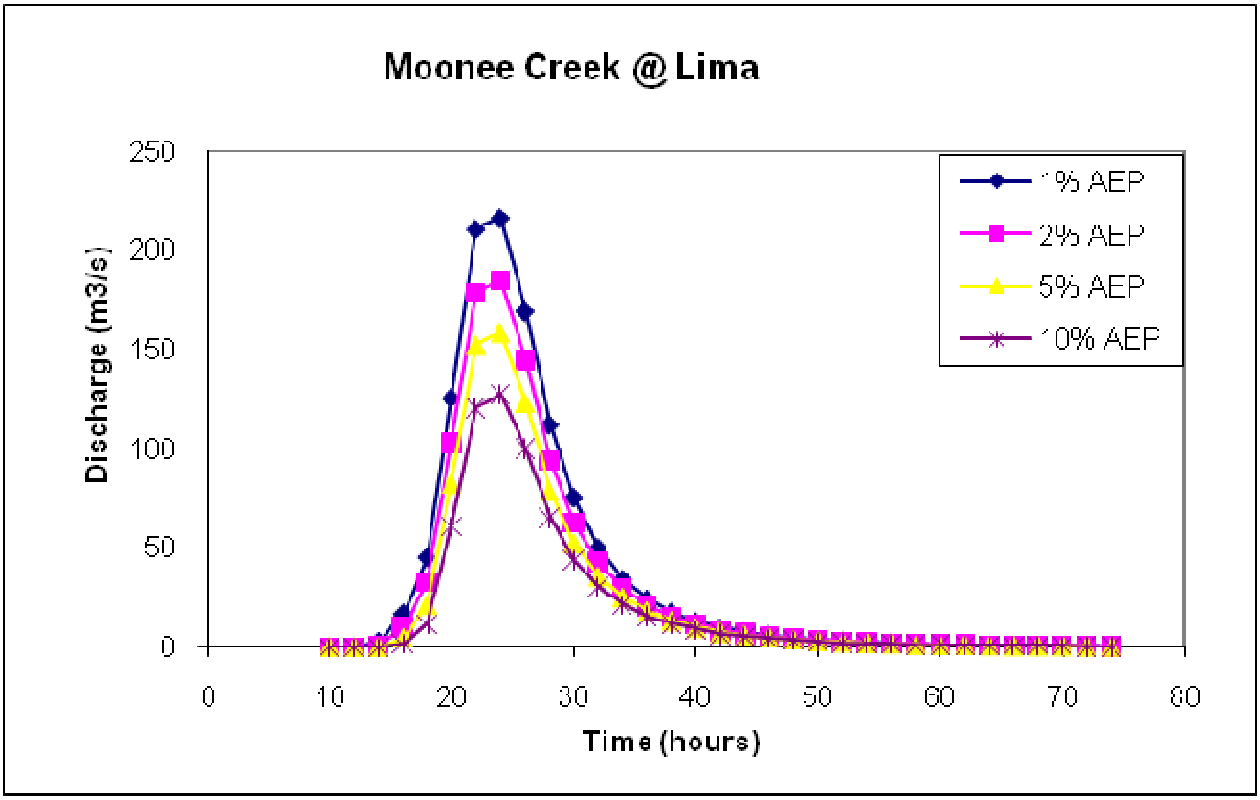

Figure 5.5 - Hydrographs for Moonee Creek @ Lima for 100, 50, 20 and 10 Year Events

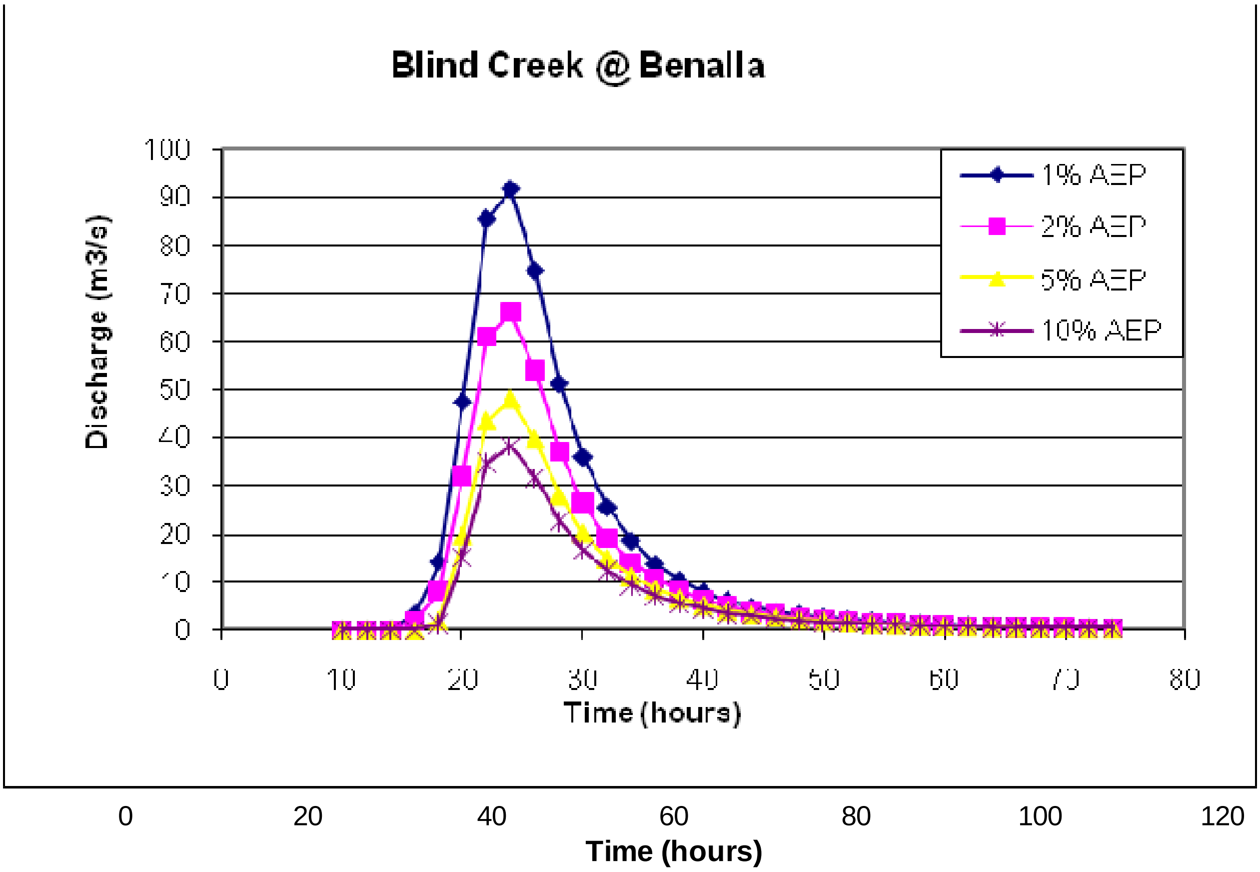

Figure 5.6 Hydrographs for Blind Creek @ Benalla for 100, 50, 20 and 10 Year Events.

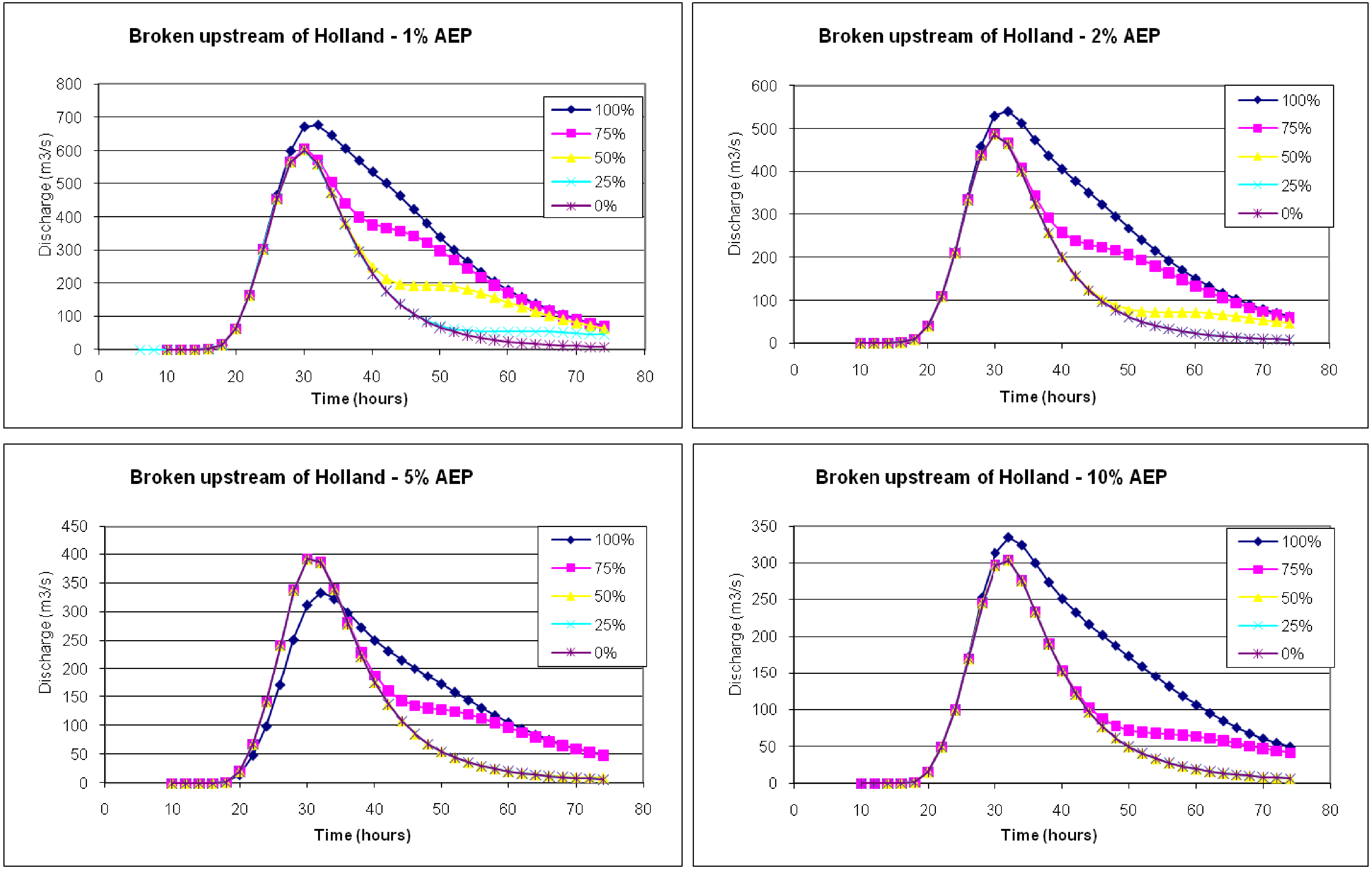

Figure 5.7 Hydrographs for Broken River Upstream of Holland Creek for 100, 50, 20 and 10 Year Events.

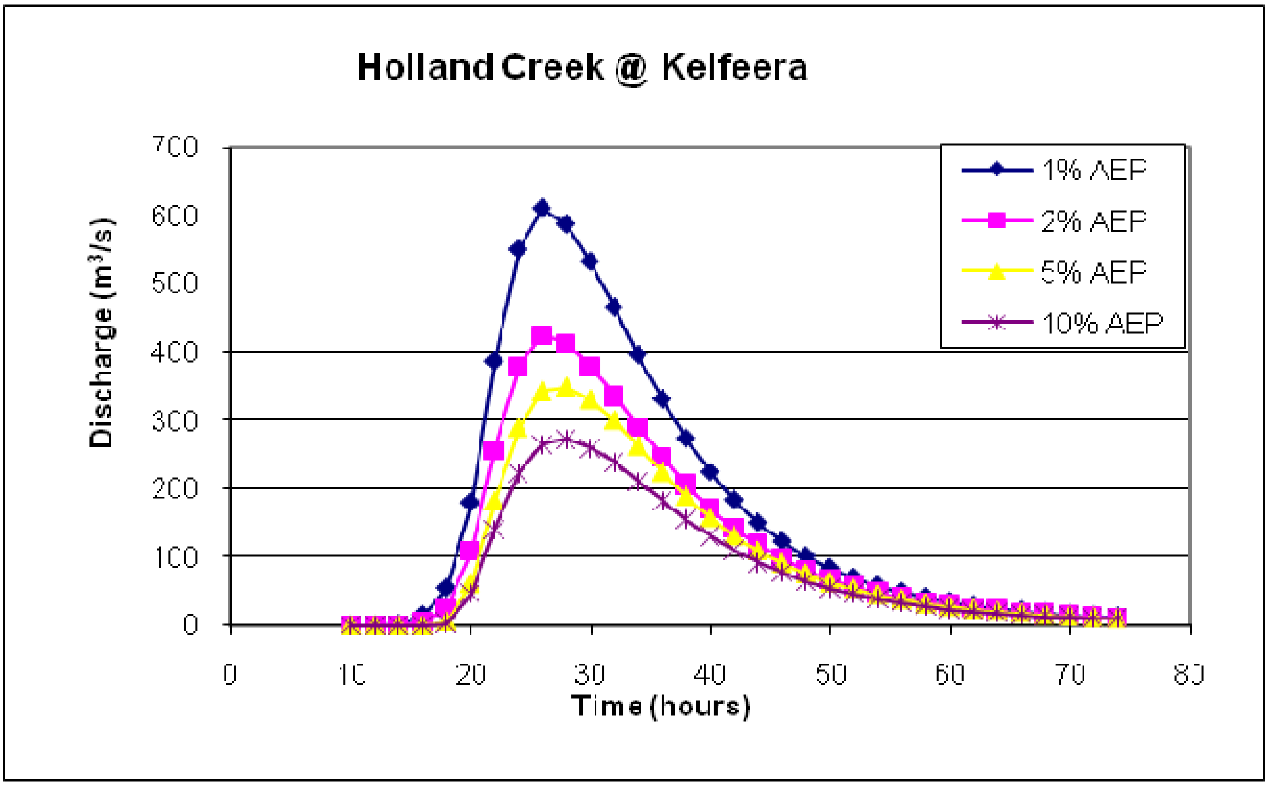

Figure 5.8 Hydrographs for Holland Creek @ Kelfeera for 100, 50, 20 and 10 Year Events.

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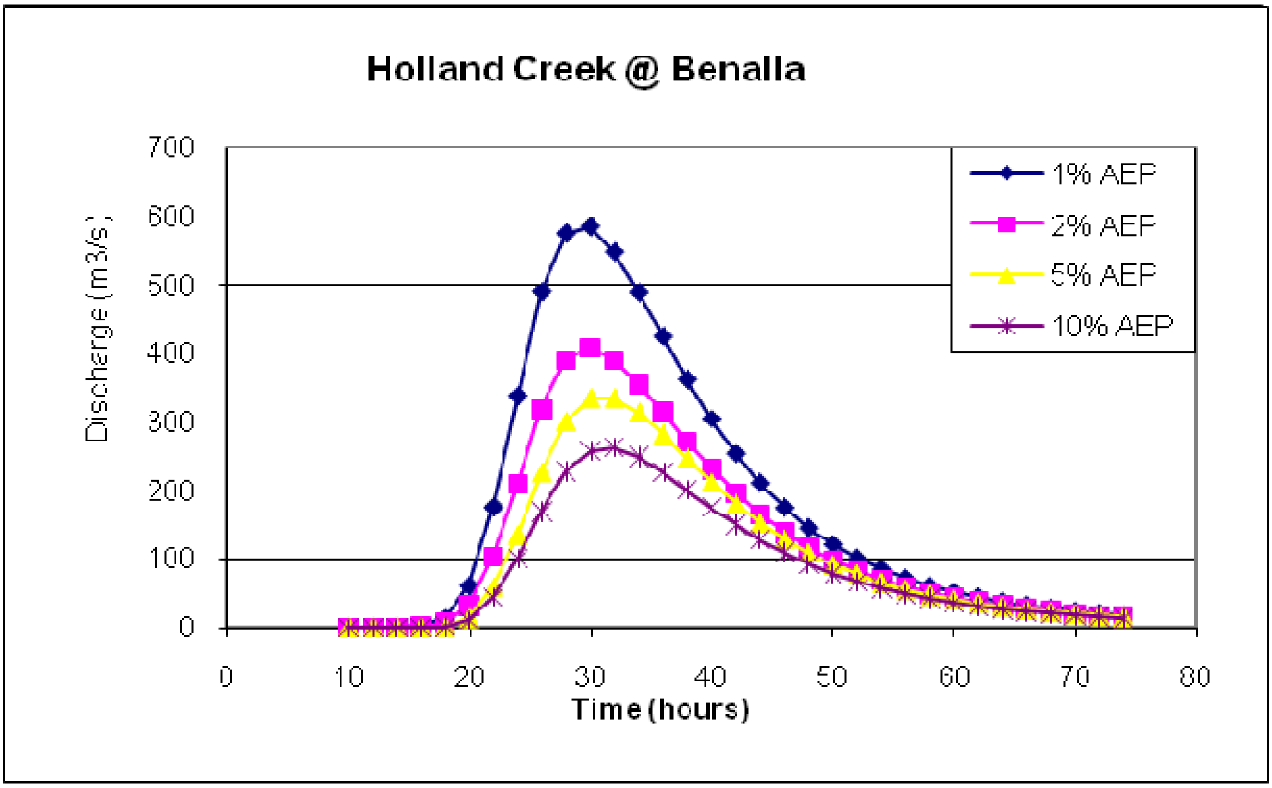

Figure 5.9 Hydrographs for Holland Creek @ Benalla for 100, 50, 20 and 10 Year Events.

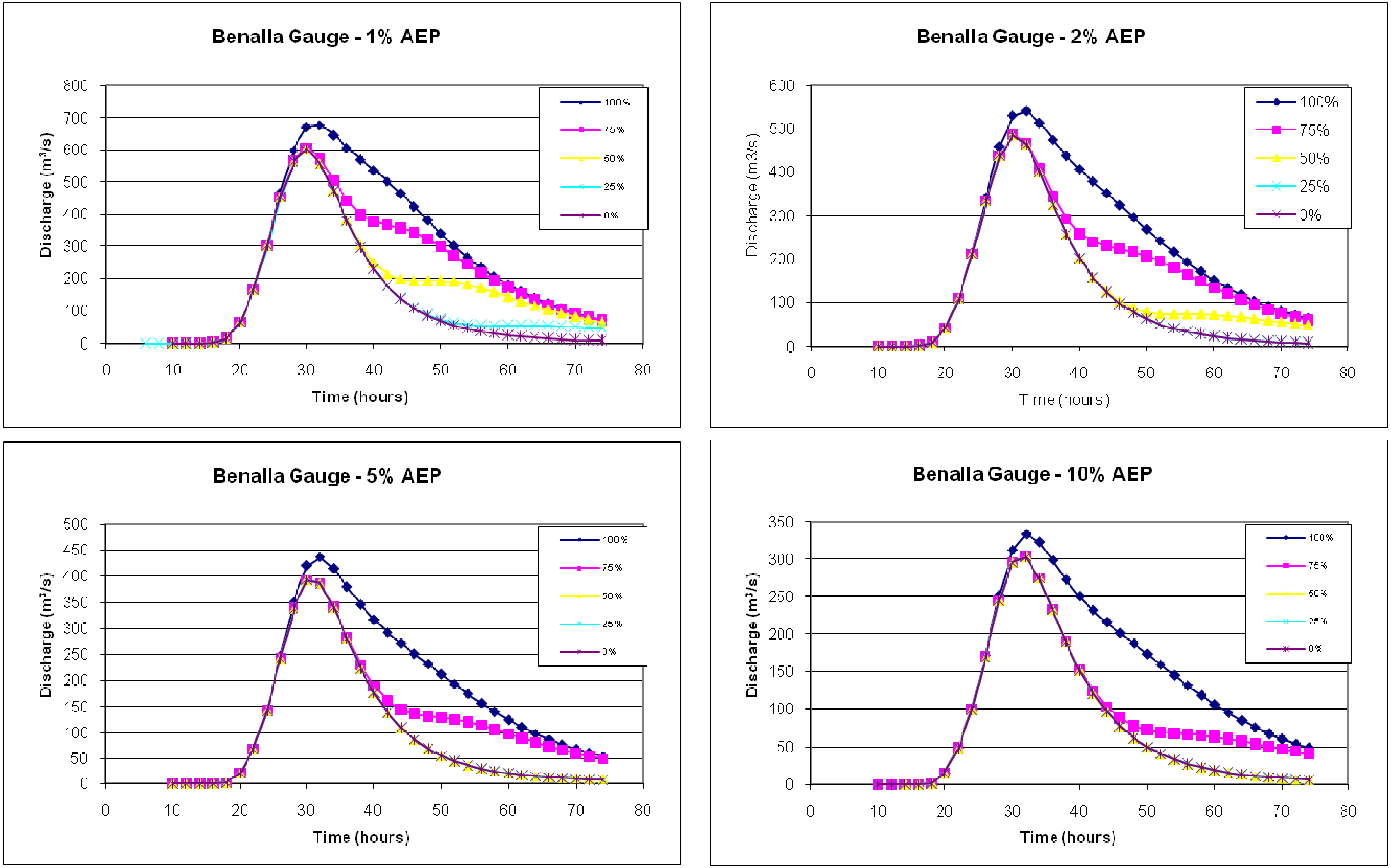

Figure 5.10 Hydrographs for Benalla Gauge for 100, 50, 20 and 10 Year Events.

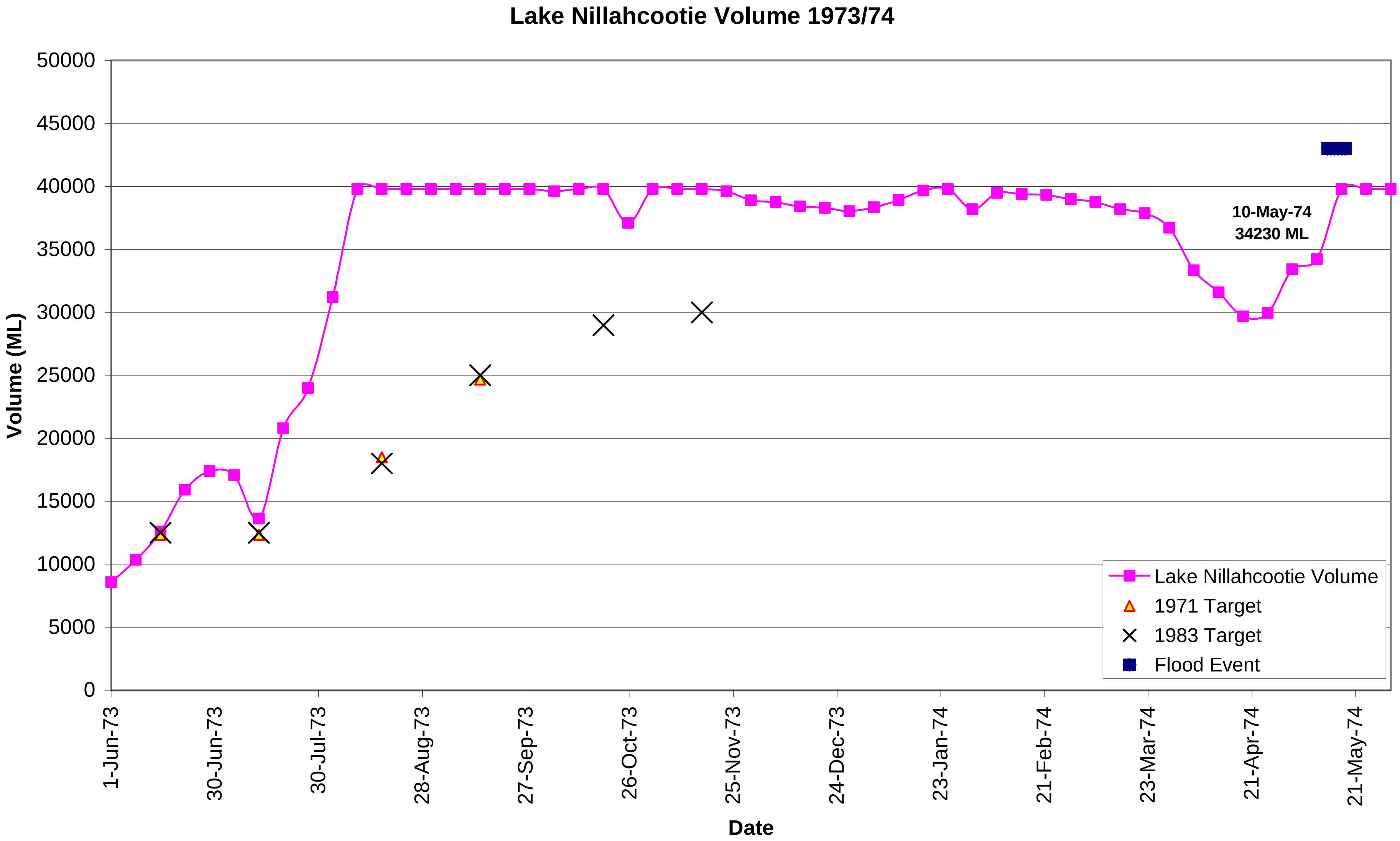

Figure 6.1 - Lake Nillahcootie Recorded volume 1973-1974

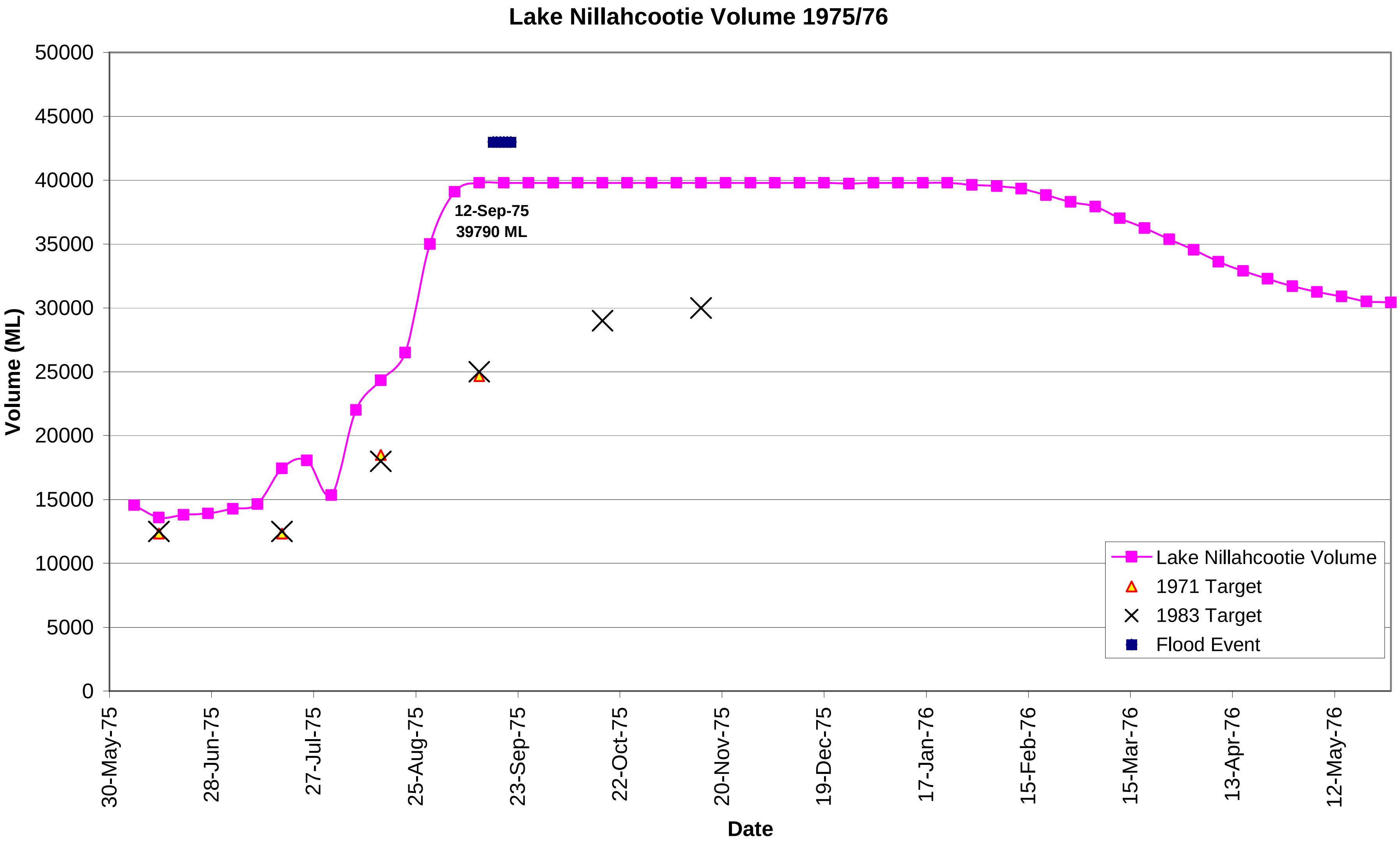

Figure 6.2 - Lake Nillahcootie Recorded volume 1975-1976

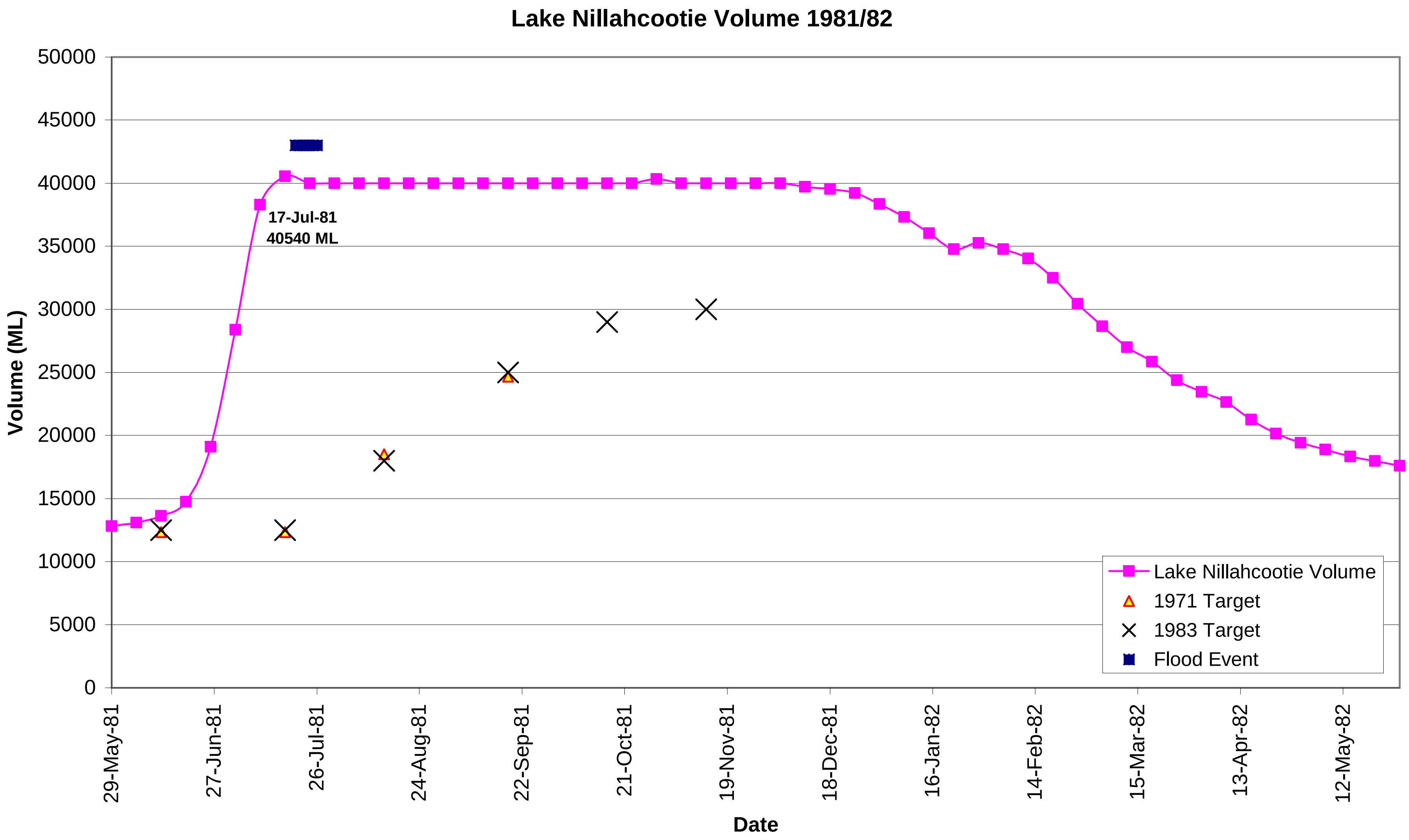

Figure 6.3 - Lake Nillahcootie Recorded volume 1981-1982

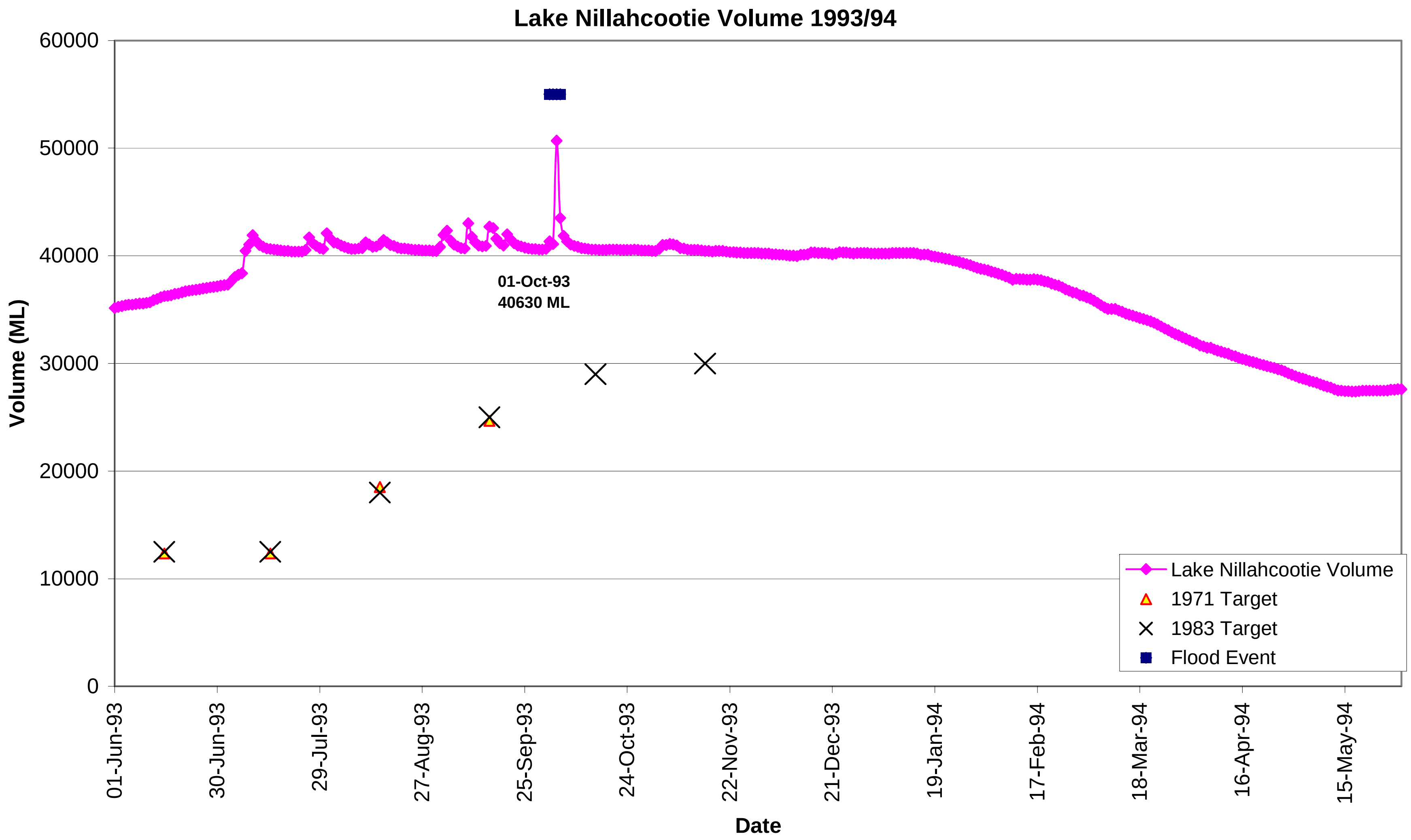

Figure 6.4 - Lake Nillahcootie Recorded volume 1993-1994

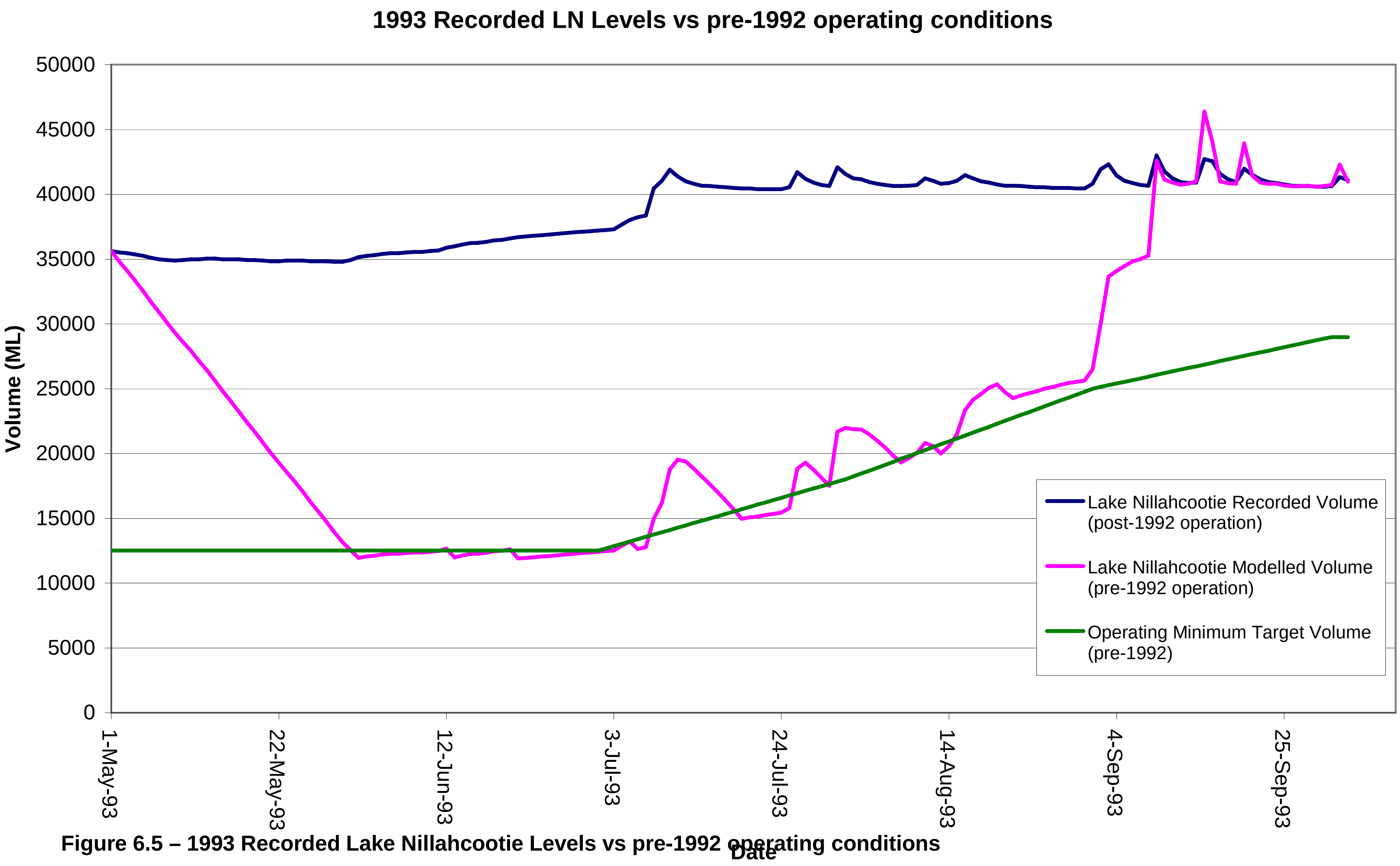

Figure 6.5 – 1993 Recorded Lake Nillahcootie Levels vs pre-1992 operating conditions

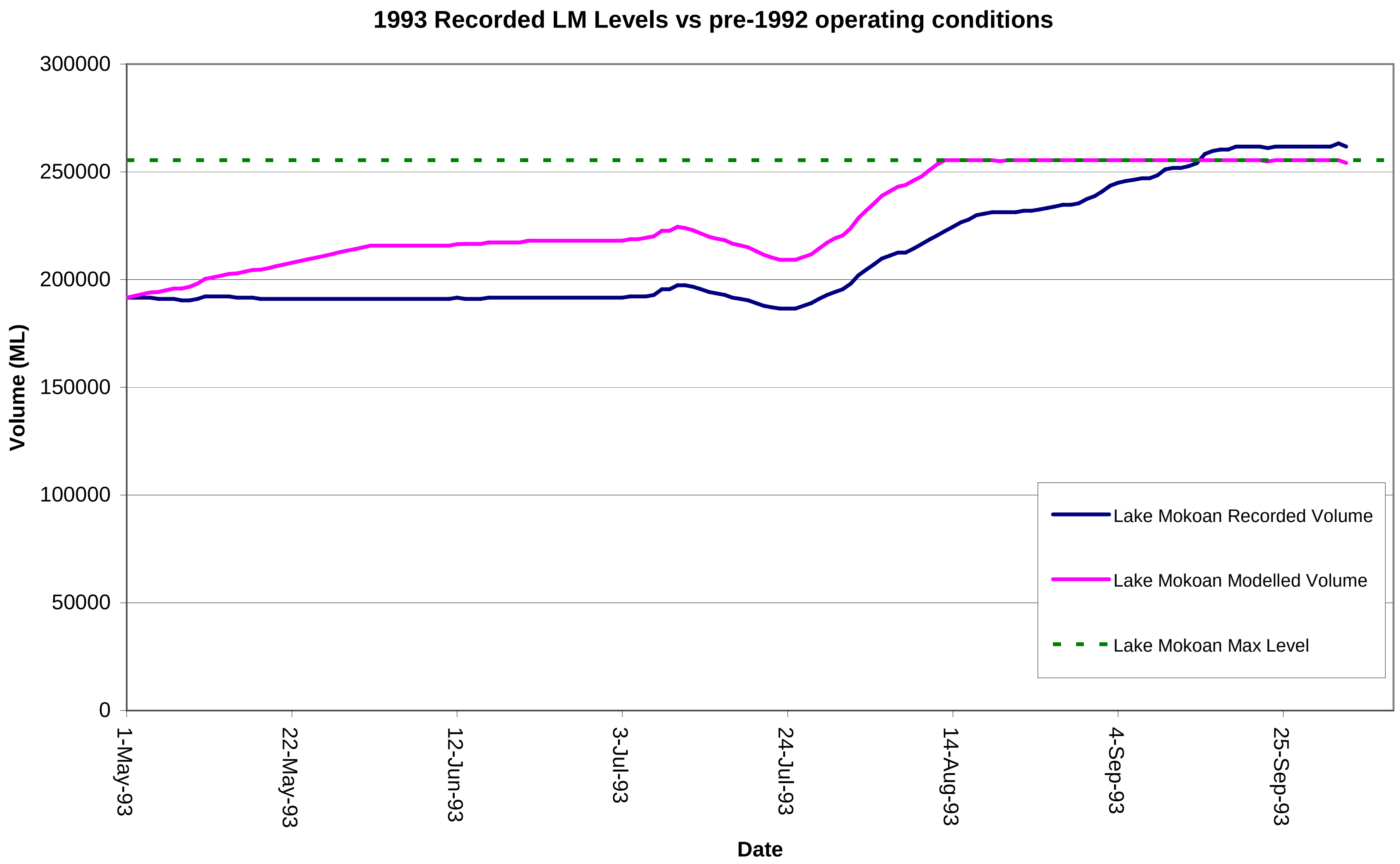

Figure 6.6 – 1993 Recorded Lake Mokoan Levels vs pre-1992 operating conditions

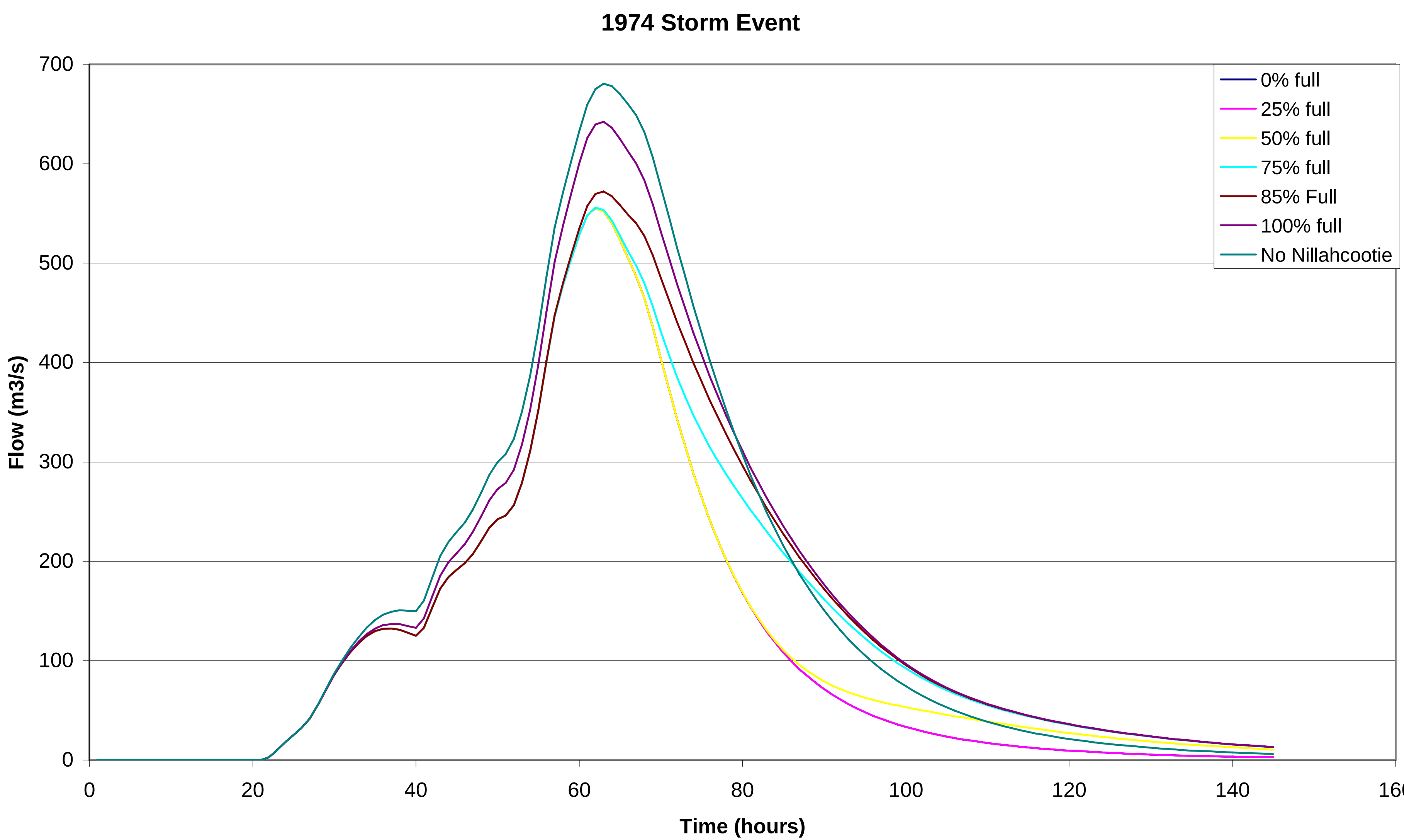

Figure 6.7 – Hydrographs at Benalla for the 1974 storm event with differing starting levels

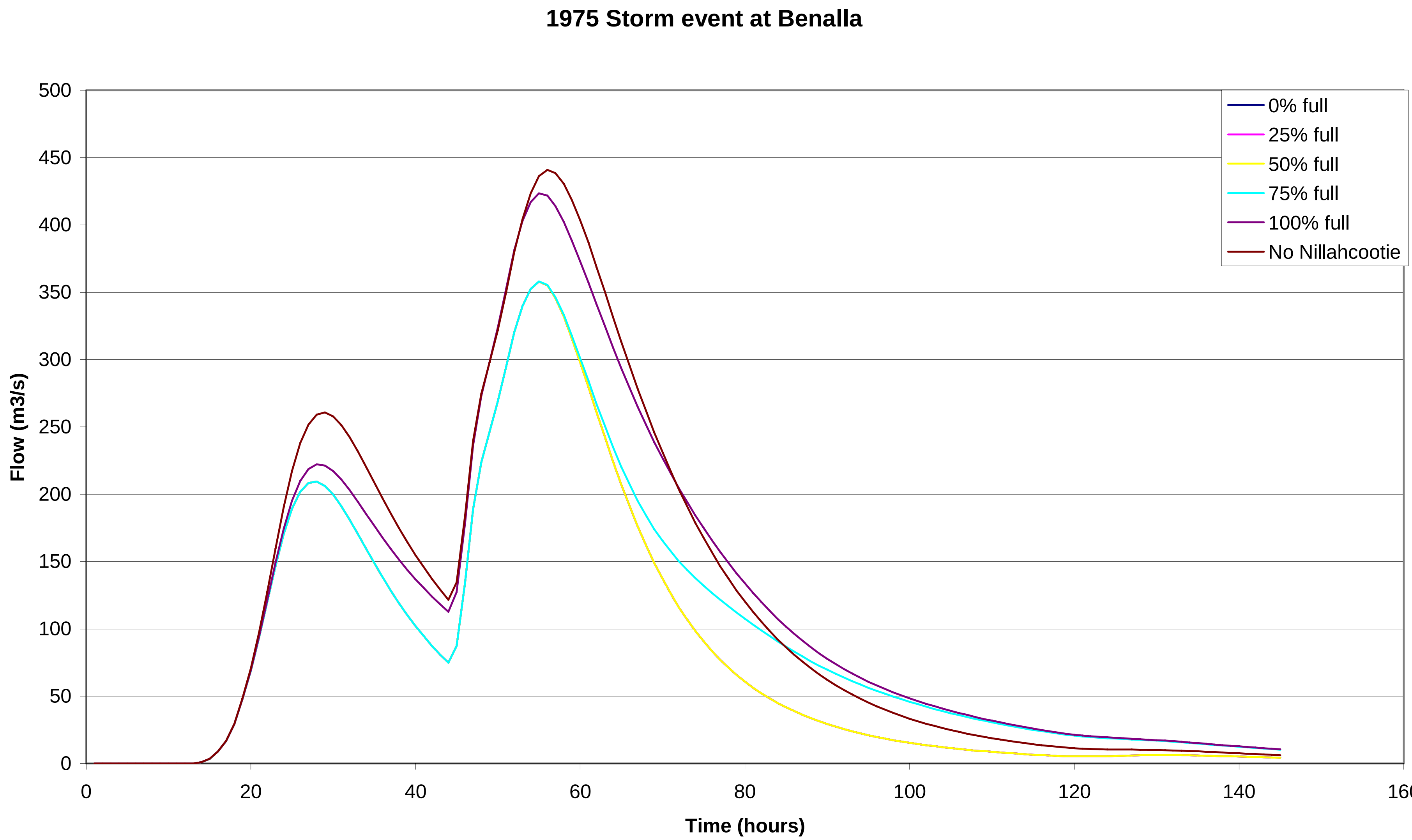

Figure 6.8 – Hydrographs at Benalla for the 1975 storm event with differing starting levels

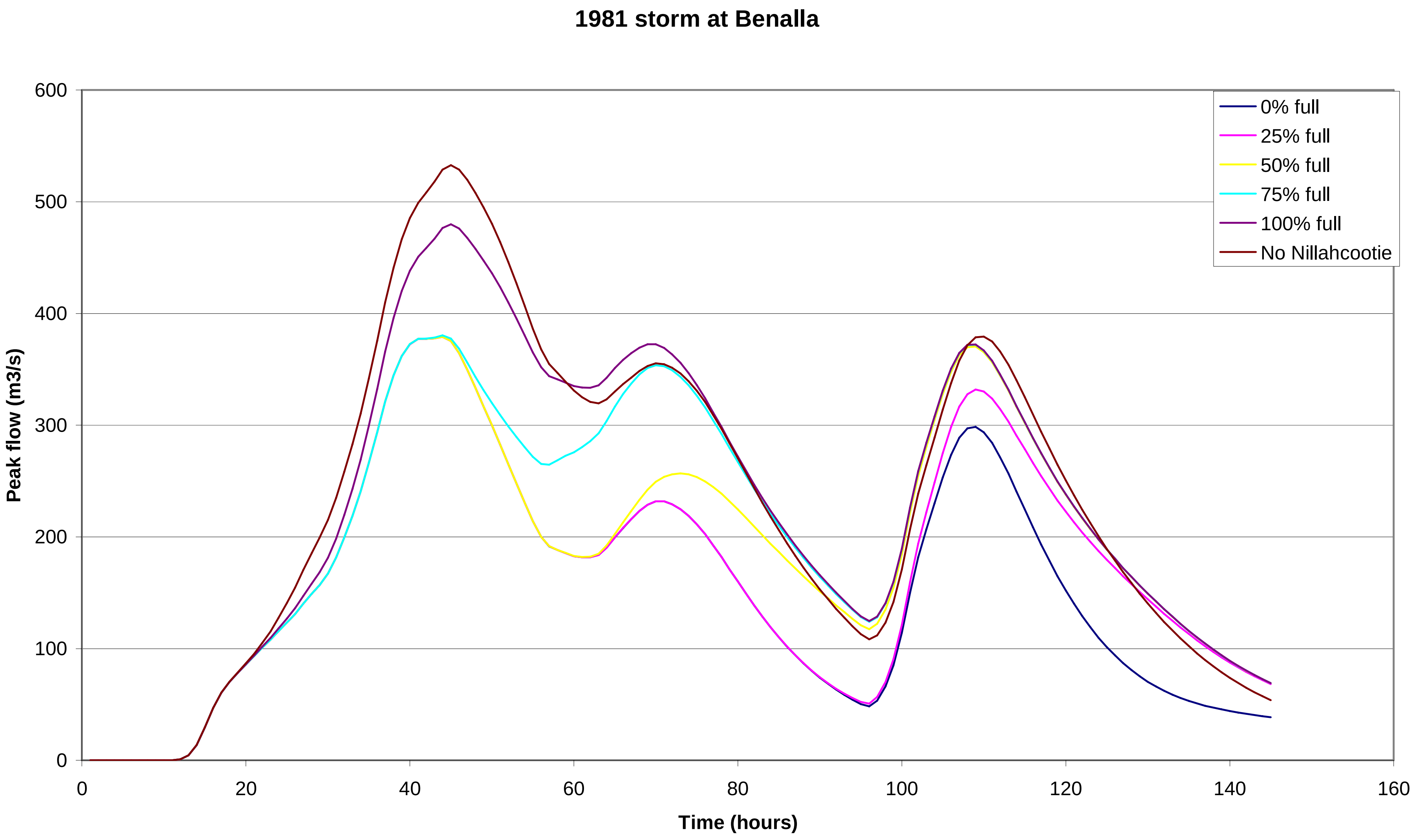

Figure 6.9 – Hydrographs at Benalla for the 1981 storm event with differing starting levels

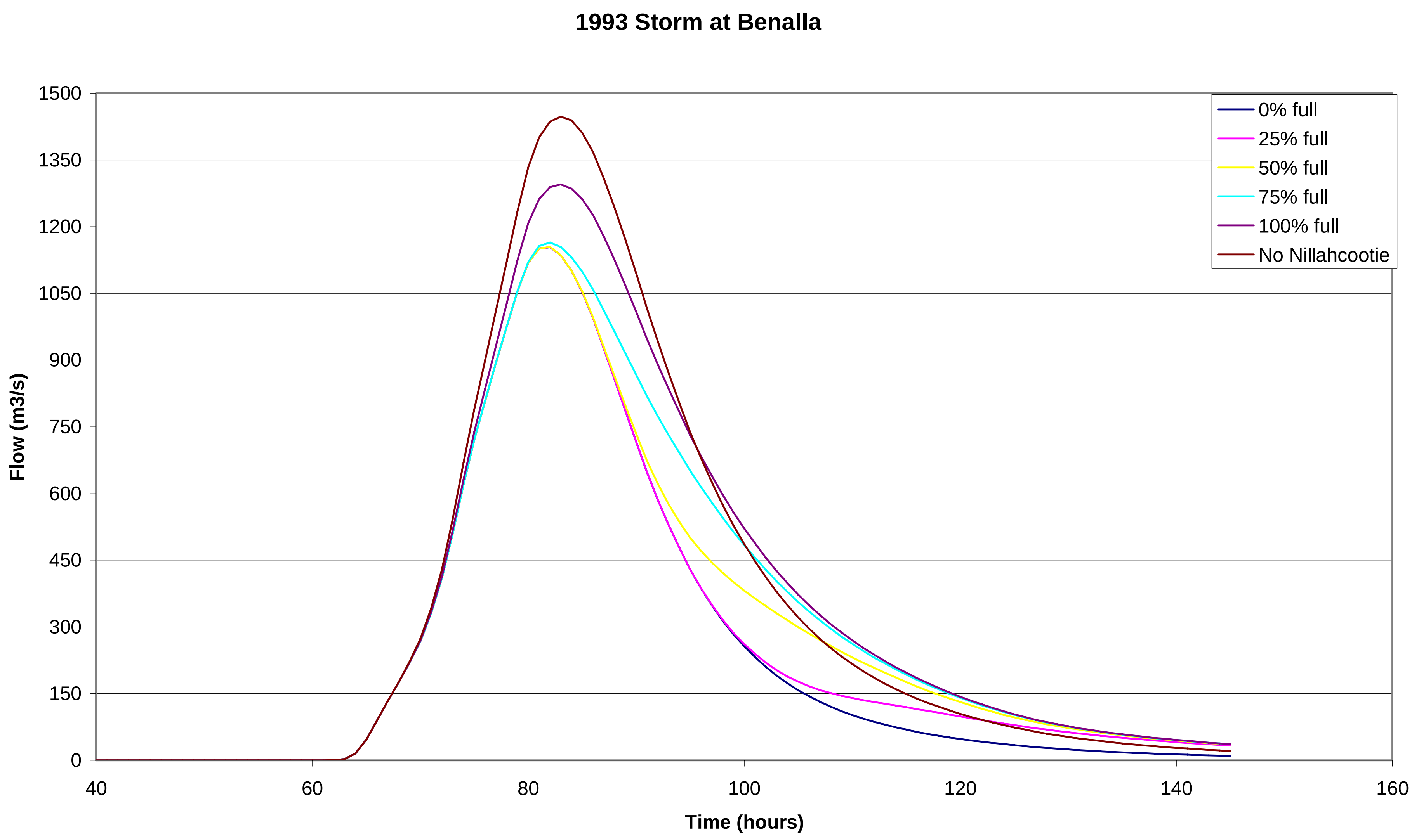

Figure 6.10 – Hydrographs at Benalla for the 1993 storm event with differing starting levels

APPENDIX A

Estimated Rainfall Series for Known Storm Events

1981 Storm Event

	Subcatchment																																
Time	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
20-Jul 00:00	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
20-Jul 01:00	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
20-Jul 02:00	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
20-Jul 03:00	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
20-Jul 04:00	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
20-Jul 05:00	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
20-Jul 06:00	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.6	0.5	0.3	0.4	0.5	0.4	0.4	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.4
20-Jul 07:00	0.9	0.8	0.7	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.4	0.5	0.5	0.5	1.0	0.9	0.6	0.9	1.0	1.1	0.9	0.8	0.8	1.0	0.9	1.0	0.9	0.8	0.6	0.6	0.7	0.9	1.0
20-Jul 08:00	1.6	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.5	1.6	1.8	1.8	1.8	2.6	2.3	1.8	2.2	2.4	2.5	2.2	1.6	1.6	1.6	1.7	1.9	1.8	1.6	1.6	1.7	1.8	2.0	2.2
20-Jul 09:00	2.9	3.3	3.6	3.8	4.0	4.3	4.6	4.8	4.7	4.8	4.6	4.5	4.8	4.6	4.9	4.7	4.3	4.2	4.3	4.0	4.0	3.4	3.1	2.8	3.2	3.3	3.4	3.2	4.0	4.1	4.0	3.8	3.8
20-Jul 10:00	3.8	3.7	3.6	3.6	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.5	3.4	3.4	3.5	3.5	3.5	3.6	3.6	3.6	3.6	3.8	3.9	4.0	3.9	3.8	3.8	3.8	3.6	3.6	3.6	3.7	3.7
20-Jul 11:00	3.9	3.7	3.5	3.6	3.2	3.4	3.3	3.3	3.3	3.3	3.3	3.4	3.3	3.4	3.5	3.4	3.5	3.5	3.5	3.5	3.6	3.9	4.1	4.3	4.0	3.9	3.9	3.9	3.5	3.6	3.6	3.7	3.6
20-Jul 12:00	4.4	4.2	4.0	4.2	3.9	4.2	4.1	4.2	4.3	4.3	4.3	4.2	4.1	4.2	3.8	4.0	4.2	4.1	4.1	4.2	4.2	4.5	4.6	4.7	4.6	4.5	4.5	4.4	4.3	4.3	4.3	4.3	4.3
20-Jul 13:00	3.5	3.5	3.5	3.7	3.6	3.8	3.8	4.0	4.0	4.1	4.0	3.9	3.9	3.9	3.5	3.7	3.8	3.8	3.8	4.1	3.9	3.7	3.7	3.6	3.7	3.8	3.7	3.6	3.8	3.8	3.8	3.8	4.0
20-Jul 14:00	2.3	2.4	2.7	2.9	2.9	3.3	3.6	3.8	3.8	4.0	3.8	3.4	3.6	3.5	2.6	2.8	3.2	2.7	2.6	2.4	2.6	2.7	2.5	2.3	2.5	2.4	2.6	2.5	3.2	3.2	3.0	2.7	2.5
20-Jul 15:00	2.1	1.9	1.8	1.8	1.6	1.7	1.6	1.6	1.6	1.6	1.7	1.7	1.6	1.6	1.4	1.5	1.7	1.6	1.6	1.6	1.7	2.1	2.2	2.3	2.2	2.0	2.0	2.1	1.8	1.8	1.8	1.9	1.7
20-Jul 16:00	1.8	1.7	1.5	1.6	1.4	1.5	1.4	1.4	1.4	1.4	1.4	1.5	1.4	1.5	1.6	1.5	1.5	1.6	1.5	1.5	1.6	1.8	1.9	2.0	1.9	1.8	1.8	1.8	1.6	1.6	1.6	1.7	1.6
20-Jul 17:00	2.2	1.9	1.6	1.7	1.4	1.5	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.2	1.3	1.5	1.5	1.4	1.4	1.6	2.1	2.3	2.5	2.2	2.1	2.0	2.1	1.7	1.7	1.7	1.8	1.6
20-Jul 18:00	1.8	1.4	1.1	1.1	0.7	0.6	0.4	0.3	0.4	0.3	0.4	0.6	0.4	0.5	0.7	0.7	0.8	0.9	0.9	1.1	1.1	1.5	1.9	2.2	1.8	1.7	1.6	1.6	0.9	0.9	1.0	1.3	1.2
20-Jul 19:00	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.9	0.7	0.6	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6
20-Jul 20:00	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.8	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7
20-Jul 21:00	1.5	1.2	0.9	1.0	0.7	0.7	0.5	0.5	0.6	0.5	0.6	0.6	0.5	0.6	0.5	0.6	0.7	0.8	0.7	0.8	0.9	1.3	1.6	1.7	1.5	1.4	1.3	1.3	0.9	0.9	0.9	1.1	1.0
20-Jul 22:00	2.2	1.9	1.6	1.7	1.4	1.5	1.4	1.4	1.5	1.5	1.5	1.5	1.4	1.4	1.2	1.3	1.5	1.4	1.3	1.2	1.5	2.1	2.4	2.5	2.2	2.0	2.0	2.1	1.7	1.7	1.7	1.7	1.5
20-Jul 23:00	2.1	1.7	1.4	1.4	1.0	1.0	0.8	0.8	0.8	0.7	0.9	1.0	0.8	0.9	0.9	0.9	1.1	1.2	1.1	1.2	1.3	1.9	2.2	2.5	2.1	2.0	1.9	2.0	1.3	1.3	1.4	1.6	1.4
21-Jul 00:00	2.6	2.2	2.0	2.0	1.7	1.7	1.6	1.6	1.6	1.6	1.7	1.7	1.6	1.7	1.8	1.8	1.8	1.9	1.8	1.8	2.0	2.4	2.7	2.9	2.6	2.5	2.4	2.5	2.0	2.0	2.0	2.2	2.0
21-Jul 01:00	3.1	2.7	2.4	2.5	2.1	2.2	2.0	2.0	2.1	2.0	2.1	2.2	2.0	2.1	2.0	2.1	2.3	2.4	2.3	2.5	2.5	3.0	3.3	3.6	3.2	3.1	3.0	3.0	2.5	2.5	2.6	2.7	2.7
21-Jul 02:00	2.8	2.3	2.0	2.1	1.6	1.7	1.6	1.6	1.6	1.6	1.7	1.7	1.5	1.6	1.3	1.5	1.8	1.8	1.6	1.7	1.9	2.6	3.0	3.3	2.9	2.6	2.6	2.7	2.1	2.1	2.1	2.2	2.0
21-Jul 03:00	2.8	2.5	2.3	2.4	2.1	2.2	2.0	2.0	2.1	2.0	2.1	2.2	2.1	2.1	2.2	2.2	2.2	2.3	2.2	2.2	2.3	2.8	3.0	3.2	2.9	2.8	2.7	2.8	2.4	2.4	2.4	2.5	2.3
21-Jul 04:00	3.7	3.4	3.3	3.4	3.1	3.3	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.4	3.3	3.3	3.3	3.2	3.1	3.3	3.7	3.8	3.9	3.8	3.6	3.6	3.6	3.4	3.4	3.4	3.4	3.2
21-Jul 05:00	4.2	3.8	3.4	3.5	3.1	3.1	2.8	2.8	2.9	2.8	2.9	3.0	2.8	2.9	2.9	3.0	3.1	3.2	3.1	3.3	3.4	4.0	4.4	4.6	4.2	4.1	4.0	4.1	3.4	3.4	3.5	3.6	3.5
21-Jul 06:00	4.1	3.8	3.5	3.4	3.2	3.0	2.8	2.7	2.7	2.5	2.7	3.0	2.9	2.9	3.6	3.4	3.1	3.4	3.4	3.3	3.4	3.8	4.1	4.3	4.0	3.9	3.8	3.9	3.2	3.2	3.4	3.6	3.5

Time	Subcatchment																																
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
21-Jul 07:00	3.4	3.1	2.8	2.8	2.5	2.3	2.1	2.0	2.1	1.9	2.1	2.3	2.1	2.2	2.3	2.4	2.4	2.6	2.6	2.7	2.7	3.1	3.4	3.7	3.4	3.3	3.2	3.2	2.6	2.6	2.7	2.9	2.8
21-Jul 08:00	3.6	3.4	3.2	3.2	3.0	2.9	2.7	2.6	2.6	2.5	2.7	2.9	2.8	2.9	3.5	3.3	3.1	3.4	3.6	3.8	3.6	3.4	3.6	3.8	3.6	3.8	3.6	3.5	3.1	3.1	3.2	3.5	3.7
21-Jul 09:00	4.7	4.2	3.9	4.0	3.6	3.6	3.4	3.4	3.5	3.4	3.5	3.5	3.4	3.5	3.4	3.4	3.7	3.6	3.4	3.3	3.6	4.5	4.8	5.1	4.7	4.4	4.4	4.5	3.9	3.9	3.9	4.0	3.6
21-Jul 10:00	4.1	3.9	3.7	3.9	3.6	3.8	3.8	3.9	3.9	4.0	3.9	3.8	3.8	3.8	3.5	3.6	3.8	3.5	3.4	3.1	3.5	4.2	4.4	4.4	4.2	3.9	4.0	4.1	4.0	4.0	3.9	3.8	3.4
21-Jul 11:00	2.5	2.6	2.8	3.0	3.0	3.3	3.5	3.7	3.6	3.8	3.6	3.4	3.6	3.5	3.5	3.3	3.3	3.0	2.9	2.4	2.7	2.8	2.7	2.4	2.6	2.5	2.7	2.7	3.2	3.2	3.1	2.8	2.5
21-Jul 12:00	2.5	2.3	2.2	2.3	2.1	2.3	2.3	2.5	2.5	2.6	2.5	2.3	2.3	2.3	1.7	1.9	2.3	2.0	1.8	1.6	2.0	2.6	2.7	2.8	2.6	2.3	2.4	2.5	2.5	2.5	2.4	2.2	1.9
21-Jul 13:00	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.1	1.1	1.1	1.1	1.0	1.1	1.2	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.1
21-Jul 14:00	0.7	0.6	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.2	0.3	0.2	0.2	0.4	0.4	0.3	0.4	0.5	0.5	0.5	0.6	0.7	0.8	0.7	0.7	0.6	0.6	0.4	0.4	0.4	0.5	0.5
21-Jul 15:00	0.6	0.4	0.3	0.3	0.2	0.2	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.5	0.6	0.7	0.6	0.5	0.5	0.5	0.3	0.3	0.3	0.4	0.3
21-Jul 16:00	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.5	0.3	0.3	0.3	0.4	0.4
21-Jul 17:00	2.1	2.4	2.6	2.8	2.9	3.2	3.4	3.6	3.5	3.6	3.5	3.3	3.6	3.4	3.6	3.4	3.2	3.0	3.0	2.6	2.7	2.5	2.2	1.9	2.2	2.2	2.4	2.3	3.0	3.0	2.9	2.6	2.5
21-Jul 18:00	2.8	2.5	2.3	2.5	2.1	2.4	2.3	2.5	2.5	2.6	2.5	2.3	2.3	2.3	1.6	1.8	2.3	2.0	1.7	1.6	2.0	2.9	3.1	3.2	2.9	2.6	2.6	2.8	2.6	2.6	2.5	2.4	1.9
21-Jul 19:00	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
21-Jul 20:00	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1
21-Jul 21:00	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.2
21-Jul 22:00	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0
21-Jul 23:00	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0
22-Jul 00:00	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.3	0.3	0.4	0.3	0.3	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.3	0.2
22-Jul 01:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1
22-Jul 02:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-Jul 03:00	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1
22-Jul 04:00	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-Jul 05:00	0.1	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.4	0.3	0.2	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2
22-Jul 06:00	1.3	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.6	1.6	1.6	1.7	1.8	1.8	2.3	2.1	1.7	1.8	1.9	1.6	1.6	1.4	1.3	1.2	1.3	1.4	1.4	1.4	1.5	1.5	1.6	1.5	1.5
22-Jul 07:00	2.2	2.5	2.7	2.6	2.9	2.7	2.8	2.7	2.7	2.6	2.7	2.7	2.9	2.8	3.5	3.1	2.7	2.8	3.0	2.7	2.7	2.2	2.0	1.8	2.1	2.2	2.3	2.2	2.5	2.5	2.5	2.5	2.5
22-Jul 08:00	2.5	2.7	2.9	3.0	3.1	3.4	3.6	3.8	3.8	3.9	3.7	3.5	3.7	3.6	3.2	3.2	3.3	2.9	2.8	2.3	2.7	2.8	2.6	2.4	2.6	2.4	2.6	2.7	3.3	3.3	3.1	2.7	2.4
22-Jul 09:00	1.8	1.8	1.8	2.0	1.8	2.1	2.2	2.3	2.3	2.4	2.3	2.1	2.1	2.1	1.6	1.7	2.0	1.7	1.5	1.3	1.6	2.0	2.0	2.0	1.9	1.7	1.9	1.9	2.1	2.1	2.0	1.8	1.5
22-Jul 10:00	2.4	2.2	2.1	2.2	2.0	2.2	2.2	2.2	2.2	2.3	2.2	2.2	2.2	2.2	2.1	2.1	2.2	2.0	1.9	1.8	2.0	2.4	2.5	2.6	2.4	2.2	2.3	2.4	2.3	2.3	2.3	2.2	1.9
22-Jul 11:00	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.5	2.3	2.1	2.1	2.1	1.9	2.0	2.0	2.0	2.0	2.0	1.9	2.0	2.0	2.0	2.0	2.0	2.0	1.9
22-Jul 12:00	1.7	1.7	1.7	1.8	1.7	1.8	1.9	1.9	1.9	2.0	1.9	1.8	1.9	1.8	1.7	1.7	1.8	1.6	1.5	1.4	1.6	1.8	1.9	1.8	1.8	1.7	1.7	1.8	1.8	1.9	1.8	1.7	1.5
22-Jul 13:00	2.9	2.6	2.4	2.4	2.1	2.2	2.1	2.1	2.1	2.1	2.2	2.2	2.1	2.1	2.1	2.1	2.3	2.2	2.1	2.0	2.2	2.8	3.1	3.3	3.0	2.7	2.7	2.9	2.4	2.4	2.5	2.5	2.2
22-Jul 14:00	2.9	2.8	2.7	2.9	2.7	2.9	3.0	3.1	3.1	3.2	3.1	3.0	3.0	3.0	2.9	2.8	2.9	2.7	2.6	2.3	2.6	3.0	3.1	3.0	3.0	2.8	2.9	2.9	3.0	3.0	2.9	2.8	2.5
22-Jul 15:00	2.4	2.3	2.2	2.3	2.1	2.3	2.3	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.2	2.2	2.3	2.1	2.0	1.8	2.1	2.5	2.5	2.6	2.5	2.3	2.3	2.4	2.4	2.4	2.3	2.2	2.0

	Subcatchment																																
Time	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
22-Jul 16:00	1.0	1.1	1.3	1.3	1.4	1.5	1.6	1.7	1.6	1.7	1.6	1.6	1.7	1.6	1.7	1.6	1.5	1.4	1.4	1.2	1.3	1.2	1.1	0.9	1.1	1.0	1.1	1.1	1.4	1.4	1.4	1.2	1.1
22-Jul 17:00	1.6	1.7	1.8	1.9	1.9	2.1	2.2	2.3	2.3	2.3	2.2	2.2	2.3	2.2	2.3	2.1	2.1	1.9	1.9	1.6	1.8	1.8	1.7	1.6	1.7	1.6	1.7	1.7	2.0	2.0	2.0	1.8	1.6
22-Jul 18:00	1.7	1.5	1.4	1.4	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.4	1.3	1.3	1.3	1.3	1.2	1.3	1.6	1.8	1.9	1.7	1.6	1.6	1.6	1.3	1.3	1.4	1.4	1.3
22-Jul 19:00	1.5	1.4	1.3	1.4	1.2	1.4	1.3	1.4	1.4	1.5	1.4	1.3	1.3	1.3	1.0	1.1	1.3	1.1	1.0	1.0	1.2	1.6	1.7	1.7	1.6	1.4	1.4	1.5	1.4	1.4	1.4	1.3	1.1
22-Jul 20:00	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.6	0.6	0.7	0.6	0.5	0.4	0.5	0.6	0.6	0.5	0.6	0.5	0.6	0.6	0.7	0.7	0.7	0.6	0.5
22-Jul 21:00	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.6	0.5	0.6	0.5	0.4	0.4	0.5	0.4	0.3	0.3	0.3	0.4	0.3	0.2	0.3	0.3	0.3	0.3	0.5	0.5	0.4	0.3	0.3
22-Jul 22:00	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1
22-Jul 23:00	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.1
23-Jul 00:00	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
23-Jul 01:00	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
23-Jul 02:00	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
23-Jul 03:00	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 04:00	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
23-Jul 05:00	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 06:00	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 07:00	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 08:00	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 09:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 10:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 11:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 12:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 13:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 14:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 15:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 16:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 17:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 18:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 19:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-Jul 20:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
23-Jul 21:00	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.3	0.2	0.2	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2
23-Jul 22:00	1.4	1.7	1.9	1.9	2.1	2.1	2.3	2.3	2.2	2.2	2.2	2.2	2.4	2.3	2.9	2.6	2.1	2.2	2.3	1.9	2.0	1.6	1.4	1.2	1.5	1.5	1.6	1.5	2.0	2.0	1.9	1.8	1.8
23-Jul 23:00	4.6	4.9	5.4	5.8	5.9	6.7	7.2	7.7	7.7	8.2	7.6	6.8	7.1	6.9	5.0	5.4	6.3	5.2	4.8	4.3	4.9	5.5	5.0	4.5	4.9	4.5	5.0	5.1	6.4	6.4	6.0	5.1	4.5
24-Jul 00:00	4.9	4.4	4.0	4.2	3.7	3.9	3.7	3.8	3.8	3.8	3.9	3.8	3.7	3.8	3.5	3.6	3.9	3.7	3.5	3.3	3.8	4.8	5.1	5.4	5.0	4.5	4.6	4.8	4.2	4.2	4.2	4.2	3.7

Time	Subcatchment																																
Time	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
24-Jul 01:00	5.5	5.4	5.4	5.5	5.4	5.5	5.6	5.7	5.7	5.8	5.7	5.5	5.6	5.5	5.2	5.1	5.4	5.0	4.8	4.3	4.9	5.6	5.7	5.6	5.5	5.1	5.4	5.6	5.6	5.6	5.5	5.2	4.6
24-Jul 02:00	6.5	6.5	6.7	7.0	6.8	7.4	7.6	8.0	8.0	8.3	7.9	7.4	7.6	7.4	6.2	6.5	7.2	6.3	6.0	5.5	6.1	7.0	7.0	6.7	6.8	6.3	6.6	6.8	7.4	7.4	7.1	6.5	5.8
24-Jul 03:00	4.1	3.5	2.9	2.9	2.2	2.2	1.9	1.7	1.9	1.7	2.0	2.2	1.7	2.0	1.6	2.0	2.5	2.9	2.8	3.7	3.3	3.7	4.3	4.9	4.3	4.4	3.9	3.8	2.7	2.8	3.0	3.5	3.8
24-Jul 04:00	1.5	1.2	1.0	1.0	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.5	0.6	0.8	0.8	0.7	0.8	0.9	1.4	1.6	1.8	1.5	1.4	1.3	1.4	1.0	1.0	1.0	1.1	1.0
24-Jul 05:00	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2
24-Jul 06:00	0.4	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.8	0.8	0.9	0.8	0.9	0.8	0.7	0.7	0.7	0.6	0.6	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.6	0.6
24-Jul 07:00	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
24-Jul 08:00	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.2	0.3	0.3	0.3	0.6	0.5	0.3	0.4	0.5	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.4
24-Jul 09:00	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.6	0.5	0.3	0.4	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4
24-Jul 10:00	0.5	0.5	0.6	0.6	0.6	0.7	0.8	0.8	0.8	0.9	0.8	0.7	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.5	0.5	0.6	0.5	0.4	0.5	0.5	0.5	0.5	0.7	0.7	0.6	0.5	0.5
24-Jul 11:00	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2
24-Jul 12:00	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
24-Jul 13:00	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.7	0.6	0.7	0.6	0.5	0.5	0.6	0.5	0.4	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.6	0.5	0.4	0.4
24-Jul 14:00	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.8	0.9	0.8	0.7	0.8	0.8	0.6	0.6	0.7	0.6	0.5	0.4	0.5	0.6	0.5	0.4	0.5	0.4	0.5	0.5	0.7	0.7	0.6	0.5	0.5
24-Jul 15:00	0.3	0.3	0.3	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2
24-Jul 16:00	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1
24-Jul 17:00	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1
24-Jul 18:00	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1
24-Jul 19:00	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
24-Jul 20:00	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
24-Jul 21:00	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
24-Jul 22:00	0.2	0.2	0.2	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2
24-Jul 23:00	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
25-Jul 00:00	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.3
25-Jul 01:00	0.2	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
25-Jul 02:00	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1
25-Jul 03:00	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.2
25-Jul 04:00	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
25-Jul 05:00	0.2	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
25-Jul 06:00	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
25-Jul 07:00	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
25-Jul 08:00	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
25-Jul 09:00	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0

	Subcatchment																																
Time	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
25-Jul 10:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-Jul 11:00	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-Jul 12:00	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
25-Jul 13:00	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.4	0.3	0.1	0.2	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2
25-Jul 14:00	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.7	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
25-Jul 15:00	0.4	0.5	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.9	0.8	0.6	0.7	0.7	0.6	0.6	0.5	0.4	0.3	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6
25-Jul 16:00	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
25-Jul 17:00	0.2	0.3	0.4	0.4	0.4	0.5	0.6	0.6	0.6	0.7	0.6	0.5	0.6	0.5	0.4	0.4	0.5	0.4	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.2	0.3	0.3	0.5	0.5	0.4	0.3	0.3
25-Jul 18:00	0.2	0.3	0.4	0.4	0.4	0.5	0.6	0.6	0.6	0.7	0.6	0.5	0.6	0.6	0.4	0.4	0.5	0.4	0.3	0.2	0.3	0.4	0.3	0.2	0.3	0.2	0.3	0.3	0.5	0.5	0.4	0.3	0.3
25-Jul 19:00	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
25-Jul 20:00	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
25-Jul 21:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-Jul 22:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-Jul 23:00	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total Rainfall	159	152	148	152	143	149	148	151	151	152	152	150	150	150	148	147	150	146	143	137	145	161	166	169	163	156	158	160	154	155	154	152	143

1993 Storm Event

	Subcatchment																																
Time	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1-Oct 00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-Oct 01:00	0.5	0.4	0.3	0.3	0.2	0.2	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.3	0.2	0.1	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.4	0.2	0.2	0.2	0.2	0.3
1-Oct 02:00	1.7	1.5	1.3	1.2	1.0	1.0	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.9	1.3	1.2	1.1	1.1	1.0	1.0	1.5	1.1	1.0	1.0	0.9	0.9
1-Oct 03:00	1.2	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	1.0	1.0	0.9	0.9	0.9	0.9	1.1	0.9	0.9	0.9	0.9	0.8
1-Oct 04:00	0.6	0.7	0.8	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	1.2	1.1	0.9	1.0	1.1	1.1	1.0	0.7	0.8	0.8	0.9	0.9	0.9	0.6	0.8	0.8	0.9	0.9	1.0
1-Oct 05:00	0.6	0.8	1.0	1.0	1.2	1.3	1.4	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.0	1.0	1.1	1.1	1.1	1.2	0.8	1.2	1.2	1.2	1.2	1.2
1-Oct 06:00	1.6	1.6	1.6	1.5	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.4	1.5	1.5	1.9	1.7	1.5	1.6	1.7	1.6	1.6	1.5	1.5	1.6	1.5	1.6	1.6	1.6	1.5	1.5	1.5	1.6	1.6
1-Oct 07:00	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.0	1.0	1.1	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.2	1.1	1.0	0.9
1-Oct 08:00	1.1	0.9	0.7	0.6	0.4	0.3	0.1	0.1	0.1	0.0	0.1	0.2	0.1	0.2	0.3	0.3	0.3	0.4	0.4	0.6	0.5	0.7	0.6	0.6	0.5	0.6	0.5	0.9	0.4	0.3	0.3	0.5	0.5
1-Oct 09:00	2.3	2.6	2.9	2.7	3.1	2.7	2.6	2.4	2.3	2.1	2.3	2.9	2.9	3.0	5.0	4.3	3.0	3.9	4.3	4.2	3.8	2.6	2.7	3.1	3.1	3.5	3.3	2.4	2.6	2.7	3.0	3.4	3.9
1-Oct 10:00	4.3	4.8	5.5	5.7	6.4	6.6	7.0	7.2	7.1	7.3	7.0	6.9	7.1	6.9	6.8	6.7	6.6	6.3	6.2	5.6	6.0	5.5	5.6	5.6	5.9	5.7	5.9	4.7	6.2	6.5	6.4	6.1	5.7
1-Oct 11:00	5.4	4.8	4.2	4.2	3.5	3.5	3.2	3.2	3.3	3.2	3.3	3.2	3.1	3.2	2.9	3.0	3.2	3.0	2.8	2.6	3.0	4.3	4.1	3.8	3.7	3.3	3.4	5.0	3.8	3.5	3.4	3.2	2.8
1-Oct 12:00	3.9	3.4	3.0	2.9	2.4	2.5	2.3	2.3	2.4	2.4	2.4	2.2	2.2	2.2	1.6	1.8	2.2	1.9	1.7	1.5	1.9	3.1	2.9	2.6	2.5	2.2	2.3	3.6	2.7	2.5	2.3	2.1	1.8

	Subcatchment																																
Time	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1-Oct 13:00	1.5	1.5	1.4	1.5	1.4	1.5	1.6	1.6	1.6	1.7	1.6	1.5	1.5	1.5	1.1	1.2	1.4	1.2	1.1	1.0	1.2	1.5	1.5	1.4	1.4	1.2	1.3	1.5	1.5	1.5	1.4	1.3	1.1
1-Oct 14:00	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.1	1.1	0.8	0.8	1.0	0.8	0.7	0.6	0.8	1.1	1.0	1.0	1.0	0.8	0.9	1.1	1.1	1.1	1.0	0.9	0.7
1-Oct 15:00	1.2	1.1	1.0	1.0	0.9	0.9	0.9	0.9	1.0	1.0	1.0	0.9	0.9	0.9	0.6	0.7	0.9	0.7	0.7	0.6	0.7	1.1	1.0	0.9	0.9	0.8	0.9	1.1	1.0	0.9	0.9	0.8	0.7
1-Oct 16:00	0.5	0.8	1.1	1.2	1.5	1.6	1.8	1.8	1.8	1.8	1.7	1.7	1.8	1.7	1.8	1.7	1.6	1.5	1.5	1.3	1.4	1.1	1.1	1.2	1.3	1.3	1.3	0.7	1.4	1.5	1.5	1.4	1.3
1-Oct 17:00	1.2	1.9	2.6	2.7	3.5	3.5	3.8	3.8	3.7	3.8	3.7	3.8	4.0	3.9	4.6	4.2	3.7	3.8	4.0	3.7	3.7	2.4	2.7	2.9	3.1	3.3	3.3	1.7	3.1	3.4	3.5	3.5	3.6
1-Oct 18:00	3.8	3.7	3.5	3.4	3.3	3.0	2.8	2.7	2.6	2.5	2.7	3.0	3.0	3.0	4.2	3.7	3.1	3.5	3.8	3.6	3.5	3.4	3.4	3.5	3.4	3.5	3.4	3.6	3.1	3.0	3.2	3.4	3.5
1-Oct 19:00	1.4	2.0	2.8	3.0	3.7	4.1	4.7	4.9	4.8	5.2	4.8	4.4	4.7	4.5	3.5	3.7	4.1	3.4	3.1	2.6	3.1	2.8	2.9	2.9	3.1	2.8	3.2	1.9	3.7	4.0	3.8	3.3	2.7
1-Oct 20:00	2.8	2.4	1.9	1.9	1.4	1.3	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1	1.0	1.0	1.1	1.1	1.0	0.9	1.1	2.0	1.8	1.6	1.5	1.3	1.4	2.5	1.5	1.4	1.3	1.3	1.1
1-Oct 21:00	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.5	0.3	0.3	0.3	0.3	0.3
1-Oct 22:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-Oct 23:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 01:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 02:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 03:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 04:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 05:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 06:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 07:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 08:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 09:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 10:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 11:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 12:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 13:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 14:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 15:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 16:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 17:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 18:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 19:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 20:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 21:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	Subcatchment																																
Time	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
2-Oct 22:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-Oct 23:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-Oct 00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-Oct 01:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-Oct 02:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-Oct 03:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-Oct 04:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-Oct 05:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-Oct 06:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-Oct 07:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.2
3-Oct 08:00	0.1	0.3	0.4	0.4	0.5	0.3	0.3	0.2	0.2	0.1	0.2	0.4	0.4	0.5	1.3	1.1	0.6	1.0	1.3	1.5	1.1	0.3	0.4	0.6	0.6	1.0	0.8	0.2	0.3	0.4	0.5	0.9	1.3
3-Oct 09:00	1.7	2.1	2.6	2.7	3.1	3.2	3.5	3.5	3.5	3.6	3.5	3.4	3.5	3.4	3.1	3.3	3.3	3.3	3.3	3.5	3.3	2.5	2.7	2.8	2.9	3.1	3.1	2.0	3.0	3.2	3.2	3.2	3.4
3-Oct 10:00	4.6	4.8	4.8	4.7	4.8	4.5	4.4	4.2	4.2	4.0	4.2	4.6	4.5	4.6	5.6	5.5	4.9	5.7	6.1	7.0	6.0	4.7	4.8	5.3	5.2	5.9	5.4	4.7	4.6	4.6	4.9	5.5	6.5
3-Oct 11:00	5.8	6.7	7.9	8.3	9.4	9.9	10.7	11.0	10.9	11.3	10.8	10.4	10.7	10.5	9.4	9.5	10.0	9.2	9.0	8.5	8.9	7.9	8.2	8.3	8.6	8.5	8.8	6.6	9.3	9.7	9.6	9.0	8.6
3-Oct 12:00	9.1	9.1	9.3	9.5	9.5	10.2	10.5	10.9	10.9	11.3	10.8	10.1	10.2	10.1	7.8	8.4	9.7	8.5	7.8	7.3	8.3	9.5	9.4	9.0	9.1	8.4	8.9	9.3	10.0	10.1	9.7	8.8	7.9
3-Oct 13:00	9.5	8.3	6.9	6.8	5.3	5.3	4.7	4.6	4.8	4.7	4.8	4.6	4.4	4.5	3.6	3.9	4.7	4.2	3.8	3.6	4.2	7.2	6.7	6.0	5.7	5.0	5.2	8.6	5.9	5.4	5.1	4.8	4.1
3-Oct 14:00	9.5	7.7	5.5	5.0	2.8	2.3	1.1	0.7	1.0	0.6	1.1	1.4	0.8	1.1	1.0	1.5	1.9	2.5	2.5	3.7	3.1	5.7	5.2	4.8	4.1	4.2	3.7	8.0	3.4	2.6	2.6	3.2	3.8
3-Oct 15:00	2.4	2.0	1.5	1.4	0.9	0.7	0.3	0.2	0.3	0.2	0.4	0.5	0.3	0.4	0.4	0.7	0.7	1.2	1.4	2.3	1.6	1.6	1.5	1.6	1.4	1.9	1.4	2.1	1.0	0.8	0.9	1.4	2.1
3-Oct 16:00	2.3	1.8	1.3	1.2	0.7	0.6	0.3	0.2	0.3	0.2	0.3	0.3	0.2	0.3	0.3	0.4	0.5	0.6	0.6	0.8	0.7	1.4	1.2	1.1	1.0	1.0	0.9	1.9	0.8	0.6	0.6	0.8	0.9
3-Oct 17:00	1.5	1.4	1.3	1.3	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.0	1.0	1.2	1.1	1.0	0.9	1.1	1.4	1.3	1.2	1.2	1.1	1.2	1.4	1.3	1.3	1.2	1.1	1.0
3-Oct 18:00	3.5	3.7	3.9	3.9	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.3	4.4	4.3	3.8	3.9	4.0	4.1	4.2	4.1	3.6	4.0	4.1	4.1	4.2	4.3
3-Oct 19:00	3.4	3.6	3.8	3.7	4.0	3.8	3.8	3.7	3.6	3.5	3.6	3.9	4.0	4.0	5.2	4.7	3.9	4.2	4.4	3.9	4.0	3.6	3.7	3.7	3.8	3.8	3.8	3.5	3.7	3.7	3.8	3.9	3.8
3-Oct 20:00	4.6	5.3	6.3	6.7	7.6	8.2	9.0	9.4	9.3	9.7	9.2	8.6	8.9	8.6	7.1	7.4	8.1	6.8	6.4	5.4	6.4	6.4	6.5	6.3	6.7	6.0	6.7	5.3	7.7	8.0	7.7	6.8	5.8
3-Oct 21:00	12.2	11.3	10.2	9.9	9.0	8.3	7.7	7.3	7.3	6.9	7.4	7.8	7.8	7.9	9.9	9.1	8.1	8.6	8.8	7.9	8.4	10.1	9.8	9.4	9.2	8.7	8.9	11.4	8.8	8.4	8.4	8.6	8.1
3-Oct 22:00	11.1	10.0	8.6	8.4	6.9	6.8	6.0	5.9	6.1	5.9	6.1	6.1	5.8	6.0	5.3	5.7	6.4	6.4	6.2	6.8	6.7	8.8	8.4	8.0	7.7	7.5	7.3	10.2	7.4	6.9	6.8	7.0	7.0
3-Oct 23:00	5.7	6.9	8.3	8.7	10.1	10.6	11.5	11.8	11.7	12.1	11.6	11.2	11.5	11.3	10.2	10.5	10.9	10.3	10.2	10.1	10.2	8.3	8.7	9.0	9.4	9.6	9.7	6.7	9.9	10.5	10.4	10.0	10.0
4-Oct 00:00	3.3	4.0	4.8	5.1	5.9	6.3	6.9	7.2	7.1	7.4	7.1	6.7	7.0	6.8	6.0	6.0	6.3	5.6	5.3	4.6	5.2	4.8	5.0	4.9	5.2	4.9	5.3	3.9	5.9	6.2	6.0	5.4	4.8
4-Oct 01:00	4.5	4.5	4.5	4.6	4.5	4.7	4.8	5.0	5.0	5.1	5.0	4.7	4.8	4.7	3.9	4.0	4.5	3.9	3.6	3.1	3.7	4.5	4.5	4.2	4.3	3.8	4.1	4.5	4.7	4.7	4.5	4.0	3.4
4-Oct 02:00	2.9	2.8	2.7	2.6	2.5	2.3	2.2	2.1	2.1	2.1	2.2	2.3	2.2	2.3	2.6	2.6	2.4	2.8	2.9	3.2	2.9	2.6	2.6	2.8	2.7	2.9	2.7	2.8	2.4	2.4	2.5	2.7	3.1
4-Oct 03:00	1.6	2.1	2.6	2.7	3.3	3.2	3.4	3.3	3.2	3.2	3.3	3.5	3.5	3.5	4.2	4.0	3.5	4.0	4.2	4.5	4.0	2.5	2.7	3.1	3.2	3.7	3.4	1.9	3.0	3.2	3.3	3.6	4.2
4-Oct 04:00	2.5	3.1	3.9	4.0	4.7	4.7	5.1	5.1	5.0	5.1	5.0	5.1	5.2	5.2	5.5	5.3	5.0	5.2	5.3	5.4	5.1	3.7	4.0	4.3	4.4	4.8	4.7	3.0	4.4	4.7	4.8	4.9	5.2
4-Oct 05:00	4.6	5.2	6.0	6.1	6.9	7.1	7.6	7.8	7.7	7.9	7.6	7.4	7.7	7.5	7.2	7.2	7.2	6.8	6.7	6.2	6.5	5.9	6.1	6.1	6.4	6.2	6.5	5.1	6.7	7.0	6.9	6.6	6.2
4-Oct 06:00	3.4	3.6	4.0	4.1	4.4	4.6	4.9	5.1	5.0	5.2	5.0	4.7	4.8	4.8	4.0	4.2	4.6	4.2	4.0	3.8	4.1	4.0	4.1	4.0	4.1	4.0	4.1	3.6	4.4	4.6	4.5	4.2	3.9

Time	Subcatchment																																
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
4-Oct 07:00	2.6	2.6	2.7	2.8	2.8	3.0	3.1	3.3	3.3	3.4	3.2	3.0	3.0	3.0	2.2	2.4	2.9	2.4	2.2	2.0	2.4	2.8	2.7	2.6	2.7	2.4	2.6	2.7	2.9	3.0	2.8	2.5	2.2
4-Oct 08:00	2.3	2.0	1.5	1.4	1.0	0.9	0.6	0.5	0.6	0.5	0.6	0.7	0.6	0.6	0.7	0.7	0.8	1.0	1.0	1.2	1.1	1.6	1.5	1.4	1.3	1.3	1.2	2.0	1.1	0.9	0.9	1.1	1.2
4-Oct 09:00	5.6	4.4	3.0	2.8	1.4	1.1	0.3	0.1	0.3	0.1	0.4	0.5	0.2	0.3	0.3	0.4	0.7	0.9	0.8	1.1	1.1	3.2	2.8	2.4	2.0	1.8	1.7	4.6	1.7	1.2	1.2	1.3	1.3
4-Oct 10:00	1.6	1.2	0.9	0.8	0.4	0.3	0.1	0.0	0.1	0.0	0.1	0.2	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.5	0.4	0.9	0.8	0.7	0.6	0.6	0.5	1.3	0.5	0.4	0.4	0.4	0.5
4-Oct 11:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 12:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 13:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 14:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 15:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 16:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 17:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 18:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 19:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 20:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 21:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 22:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-Oct 23:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 01:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 02:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 03:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 04:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 05:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 06:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 07:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 08:00	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.4	1.3	1.5	1.3	1.2	1.3	1.2	0.8	0.9	1.1	0.8	0.7	0.6	0.7	0.6	0.7	0.7	0.8	0.7	0.8	0.3	1.0	1.0	1.0	0.8	0.6
5-Oct 09:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 10:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 11:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 12:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 13:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 14:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 15:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	Subcatchment																																
Time	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
5-Oct 16:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 17:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 18:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 19:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 20:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 21:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 22:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-Oct 23:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rainfall Total	160	159	159	159	158	159	160	160	160	161	160	159	159	159	155	155	158	154	153	150	153	159	159	157	157	154	156	160	159	159	158	155	152

APPENDIX B

RORB Model

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Nillahcootie 100% Full
C Created July 2008,PRG, Cardno Lawson Treloar, Melbourne
C Calibration for 1993 Run, no diversion to Mokoan
C Reach Type Flag,Varies
0
C The Control Vector
1,1,7.69,-99      Gen H'graph from Sub-area A and route to B
2,1,7.28,-99      Gen & add H'graph from Sub-area B and route to C
2,1,5.96,-99      Gen & add H'graph from Sub-area C and route to E1
3                 Store H'graph at E1
1,1,7.51,-99      Gen H'graph from Sub-area D and route to E1
4                 Add stored H'graph
5,1,2.83,-99      Route from E1-E2
2,1,2.88,-99      Gen & add H'graph from Sub-area E and route to E3
3                 Store H'graph at E3
1,1,7.11,-99      Gen H'graph from Sub-area F and route to E3
4                 Add stored H'graph
5,1,13.25,-99     Route from E3-G1
2,4,6.81,-99      Gen & add H'graph from Sub-area G and route to G2 - Drowned reach
3                 Store H'graph at G2
1,1,4.2,-99       Gen H'graph from Sub-area H and route to G2
4                 Add stored H'graph at G2
16
Lake Nillahcootie
C Storage-Discharge r'ship,zero drawdown, 5 pairs
1,0,5
0,0,2786997,44.6,8728915,252.9,15135656,564.6,22045411,947.3,-99
C H-S r'ship flag
1,5               H-S table with 5 pairs of values
264.5,0,265,2786997,266,8728915,267,15135656,268,22045411,-99
5,1,1.21,-99      Route from G2-J1
3                 Store H'graph at J1
1,1,8.49,-99      Gen H'graph from Sub-area I and route to J1
4                 Add stored H'graph
5,1,4.06,-99      Route from J1-J2
2,1,2.91,-99      Gen & add H'graph from Sub-area J and route to Moorngag
7.1               Broken River @ Moorngag
5,1,2.92,-99      Route from Moorngag-L1
3                 Store H'graph at L1
1,1,9.15,-99      Gen H'graph from Sub-area K and route to L1
4                 Add stored H'graph
5,1,2.43,-99      Route from L1-L2
2,1,6.67,-99      Gen & add H'graph from Sub-area L and route to R1
3                 Store H'graph at R1
1,1,10.01,-99     Gen H'graph from Sub-area M and route to N1
2,1,6.05,-99      Gen & add H'graph from Sub-area N and route to N2
7
Moonee Creek NEAR Lima
3                 Store H'graph at N2
1,1,8,-99         Gen H'graph from Sub-area O and route to P
2,1,6.88,-99      Gen & add H'graph from Sub-area P and route to N2
4                 Add stored H'graph at N2
5,1,2.69,-99      Route from N2-R1
4                 Add stored H'graph at R1
3                 Store H'graph at R1
1,1,7.12,-99      Gen H'graph from Sub-area Q and route to R1
4                 Add stored H'graph
5,1,5.14,-99      Route from R1-R2
```

2,1,5.46,-99	Gen & add H'graph from Sub-area R and route to R3
3	Store H'graph at R3
1,1,10.03,-99	Gen H'graph from Sub-area S and route to R3
4	Add stored H'graph at R3

C Diversion from
C 19,3,0,0,100
C Broken-Mokoan Diversion
C C Diversion, with I/O table, concentrated outflow, main stream to be modelled next, 100 identifier

C 3,	3 pairs of values

C 11,0,50,21,1000,21,-99 Up to Q=11m3/s, no diversion, At Q=50m3/s, max div 21m3/s

5,1,1.91,-99	Route from R3-T
2,1,7.35,-99	Gen & add H'graph from Sub-area T and route to BENALLA
7	

Broken River @ Benalla

3	Store H'graph at BENALLA
1,1,12.01,-99	Gen H'graph from Sub-area U and route to AG4
7	

Blind Creek @ Benalla

3	Store H'graph at AG4
1,1,11.21,-99	Gen H'graph from Sub-area V and route to W
2,1,11.02,-99	Gen & add H'graph from Sub-area W and route to X
2,1,9.66,-99	Gen & add H'graph from Sub-area X and route to Z1
3	Store H'graph at Z1
1,1,11.1,-99	Gen H'graph from Sub-area Y and route to Z1
4	Add stored H'graph at Z1
5,1,1.14,-99	Route from Z1-Z2
2,1,6.88,-99	Gen & add H'graph from Sub-area Z and route to Z3
3	Store H'graph at Z3
1,1,11.9,-99	Gen H'graph from Sub-area AA and route to Z3
4	Add stored H'graph at Z3
5,1,1.83,-99	Route from Z3-AG1
3	Store H'graph at AG1
1,1,11.51,-99	Gen H'graph from Sub-area AB and route to AC
2,1,10.32,-99	Gen & add H'graph from Sub-area AC and route to AD
2,1,7.11,-99	Gen & add H'graph from Sub-area AD and route to AE
2,1,10.93,-99	Gen & add H'graph from Sub-area AE and route to AF
2,1,7.31,-99	Gen & add H'graph from Sub-area AF and route to AG1
4	Add stored H'graph at AG1
7.1	Holland Ck @ Kelfeera
5,1,3.2,-99	Route from AG1-AG2
2,1,2.17,-99	Gen & add H'graph from Sub-area AG and route to AG3
C 3	Store H'graph at AG3
C 9,2,0,1, 100,-99	Inflow from Broken_MokoanInletChannel
C 5,3,5.8,0.1,-99	MokoanInletChannel - Broken to Holland - Route R3 to AG3
C 4	Add stored H'graph at AG3

C 19,3,0,0,0,-99
C Holland-Mokoan Diversion
C C Diversion, with I/O table, concentrated outflow, main stream to be modelled next, 0 identifier

C 3,	3 pairs of values

C 11,0,50,28,1000,28,-99 Up to Q=11m3/s, no diversion, At Q=50m3/s, max div 28m3/s

5,1,4.62,-99	Route from AG3-AG4
7	

Holland Ck @ Benalla

4	Add stored H'graph at AG4
5,1,1.99,-99	Route from AG4-BENALLA
4	Add stored H'graph at BENALLA

7.1 Benalla Gauge
0
C Sub Area Data
C Areas, km^2, of subareas A,B,
49.09,56.85,58.69,46.71,42.79,45.08,89.3,30.17,
44.23,38.51,51.34,18.41,53.38,54.93,45.37,39.94,
29.45,27.81,57.38,30.89,60.6,42.75,30.87,31.76,
43.37,32.35,50.13,43.12,42.8,52.59,42.73,43.21,
31.92,-99
C Impervious Area Flag
0, -99 All rural