7

January 2011 Flood Event

Report on the operation of Wivenhoe

QFCI

Date: 12/4/11

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Please note an unredacted copy of this document was tendered in public hearings of the Queensland Floods Commission of Inquiry. A redacted copy of the document is provided below.

January 2011
Flood Event

Report on the operation of North Pine Dam

11 March 2011

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EXECUTIVE SUMMARY

Background

North Pine Dam is located in the Pine Rivers Basin. The Dam supplies urban water (including drinking water) to South East Queensland and has no provision for flood mitigation.

January 2011 Flood Event

The January 2011 Flood Event impacted North Pine Dam between Thursday 6 January 2011 and Friday 14 January 2011. In the 31 days prior to Thursday 6 January 2011, above-average levels of rainfall were received in the Dam's catchment area, and flood water releases were made from the Dam on 25 days of this 31-day period. Rain continued to fall in the Dam catchments on the morning of Thursday 6 January 2011, which resulted in the mobilisation of Seqwater's Flood Operations Centre and signalled the beginning of the January 2011 Flood Event (Flood Operations were also occurring at Somerset and Wivenhoe Dams, however, these events are summarised in a separate report entitled ***January 2011 Flood Event Report on the operation of Somerset Dam and Wivenhoe Dam, 2 March 2011).*** This rainfall continued in the Dam's catchment area until Tuesday 11 January 2011 when unprecedented levels of rainfall resulted in the largest flood ever recorded in the Pine Rivers Basin.

During this time, and for a period following the peak of the flood, up to Friday 14 January 2011, North Pine Dam was operated in accordance with ***The Manual of Operational Procedures for Flood Mitigation at North Pine Dam (Revision 5)*** ("**the Manual**"). The Manual defines the strategies, objectives and procedures for operating the Dam during flood events. An understanding of the Manual is important when reading this Report.

To protect the structural safety of the Dam, the Manual dictates the strategy to be used to operate the Dam during flood events is to pass any flood water through the reservoir, ensuring peak outflow does not generally exceed peak inflow. This strategy was used during the January 2011 Flood Event. It should be noted, during the peak of the Event, flood flows contributing to flooding in the Pine Rivers, downstream of North Pine Dam, were generated from catchments not controlled by the Dam. This included flood flows from Lake Kurwongbah.

The January 2011 Flood Event impacting the Dam can be categorised as a rare event (Annual Exceedance Probability [AEP] of greater than 1 in 100) as defined by the Institution of Engineers Australia (Engineers Australia) national guidelines for the estimation of design flood characteristics ***Australian Rainfall and Runoff (Book 6)*** (AR&R).

Event management

Flood events that impact North Pine Dam are caused by rainfall events that vary in intensity, duration and distribution over a catchment area of 345km^2 above the Dam. During flood events, decisions regarding Dam releases are based on the rainfall occurring in the Dam's catchment area and the resulting inflow into the Dam.

Bureau of Meteorology (BoM) rainfall forecasts for the Dam's catchment area assist Seqwater in making operational decisions during flood events. These forecasts are derived using the best available meteorological practice, however, they are not sufficiently accurate to be used as the basis for making flood water releases from the Dam. Currently, a degree of uncertainty exists in all weather forecasts (particularly quantitative rainfall forecasts), and the longer the forecast lead times, the higher the degree of uncertainty in the forecast.

As significant inflows into the Dam can occur within two hours after heavy rainfall begins in the catchment area, the time available to prepare for large outflows can be limited. As the Pine Rivers Basin responds to rainfall within six hours, the BoM classifies flooding in the Pine River as 'flash flooding'. The BoM does not issue specific flood warnings for the Pine Rivers, however, the region is considered to be covered by generalised regional flood warnings and severe weather warnings.

The Manual

The Manual provides guidance for Dam Operators on the minimum level of flood water releases that must be made to ensure the safety of the Dam.

The Manual's primary objectives in order of importance are to:

- Ensure the structural safety of the Dam;
- Minimise disruption to the community in areas downstream of the Dam;
- Retain the storage at Full Supply Level (FSL) at the conclusion of the flood event;
- Minimise impacts to riparian flora and fauna during the Drain Down Phase of the flood event.

Seqwater ensures public safety remains a primary consideration when making flood water releases, while operating the Dam during flood events within these objectives. Prior to releases being made, every attempt is made to ensure authorities are provided with as much notice, to allow communities to prepare for any Dam outflows and to allow public roads to be closed prior to their inundation. The Manual allows releases from North Pine Dam to be timed to minimise disruptions to the local community caused by the inundation of Youngs Crossing on Youngs Crossing Road by outflows.

It is important to note, under the Manual's current operating rules, North Pine Dam is expected to fail during floods with an AEP larger than 1 in 100,000. This highlights the importance of maintaining the Dam's safety by ensuring floods impacting the Dam are passed through the reservoir.

Significance of the January 2011 Flood Event

AR&R categorises the January 2011 Flood Event as a rare event. Relevant statistics demonstrating this are:

- At individual rainfall stations within the North Pine Dam catchment, rainfall with an AEP of between 1 in 200 and 1 in 500 was recorded for durations between six hours and 12 hours. The rainfall recorded at the Mt Glorious rainfall station exceeded an AEP of 1 in 500 and was approaching an AEP of 1 in 1,000 for a duration of 12 hours. Rainfall recorded in the catchment area above North Pine Dam indicates the catchment average rainfall intensity for the 12-hour period to Tuesday 11 January 2011 at 15:00 had an AEP between 1 in 200 and 1 in 500.
- The volume of total inflow into North Pine Dam during the Event was 202,000ML or 94% of the total Dam storage volume. Of this total inflow volume, 102,000ML or almost half of the total Dam storage volume flowed into the Dam during the 14 hours to 22:00 on Tuesday 11 January 2011. This volume of inflow received in such a short time is unprecedented.
- The maximum inflow rate during the Event of 3,480m^3/s is more than double the largest previous flow rate into North Pine Dam ever recorded and the largest flow to have occurred in the North Pine River since records commenced in 1916.

North Pine operations during the January 2011 Flood Event

During the January 2011 Flood Event, operational decisions were made in accordance with the Manual. The available recorded data shows the January 2011 Flood Event was unprecedented in the history of North Pine Dam and is the largest flood in the recorded flood history of the region. The successful operation of the Dam during the Event protected the safety of the Dam and reduced flows downstream of the Dam. This is demonstrated below in Figure 2.1.2, where Dam outflow is generally less than inflow.

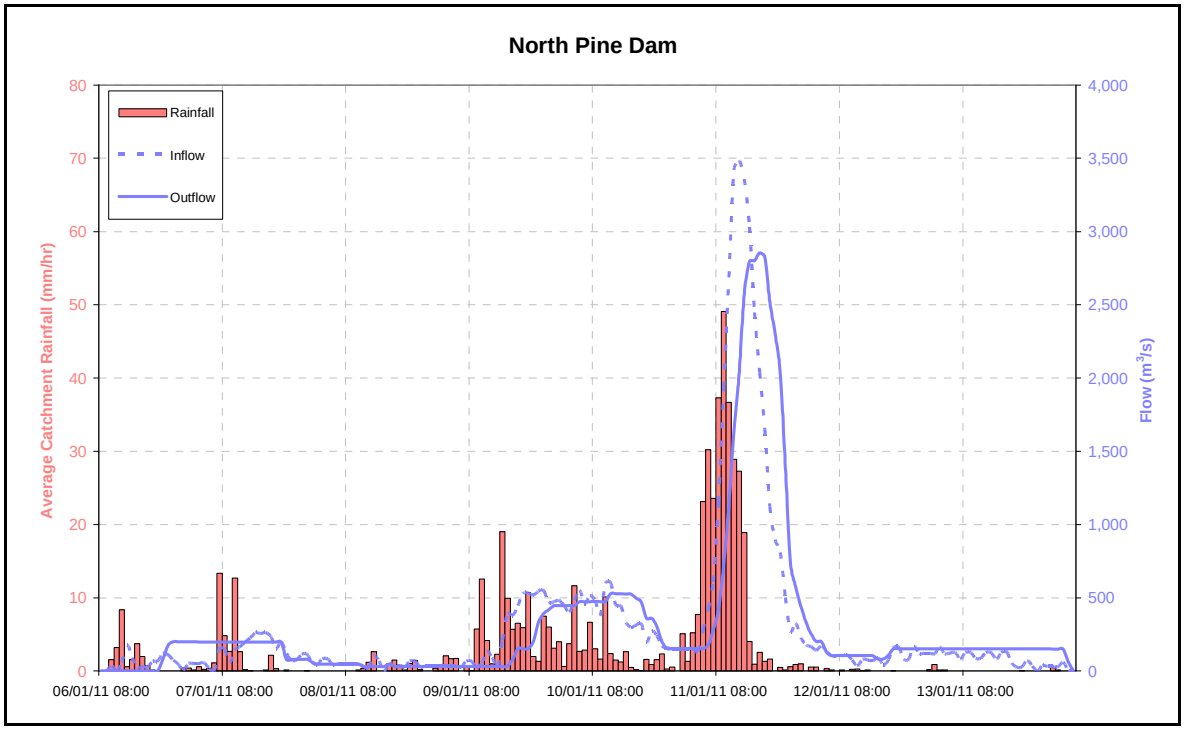

Figure 2.1.1 – North Pine Dam – January 2011 Flood Event – Dam inflow and outflow

Conclusions

The significant conclusions drawn from the information contained in this Report include:

- During the January 2011 Flood Event, North Pine Dam was operated in accordance with the Manual. The Dam was operated so the peak outflow from the Dam during the Event was only 82% of the peak inflow. This reduced flood flows downstream of the Dam. Further reductions in flood flows downstream of the Dam were not possible without risking the safety of the Dam.
- The data collection and flood modelling systems used to support decisions made during the Event performed well and assisted informed decision-making, in accordance with the Manual.
- During the Event, Seqwater provided information to the Moreton Bay Regional Council and other relevant agencies in relation to the flood releases being made from the Dam. Further discussions with the Moreton Bay Regional Council are needed to determine if the provision of information during flood events impacting on North Pine Dam can be improved.
- The January 2011 Flood Event was a rare flood event and the largest flood in the recorded flood history of the region. The safety of North Pine Dam was maintained at all times during the Event and the Dam did reduce downstream flood flows.
- The January 2011 Flood Event raised questions about the current understanding of design flood hydrology for North Pine Dam. Accordingly, a more detailed study is currently being conducted to properly assess the rarity of the Event. This study will have direct implications for the Acceptable Spillway Capacity of North Pine Dam. It is proceeding in accordance with the requirements of the Queensland Dam Safety Regulator.

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1 INTRODUCTION

1.1 Background

North Pine Dam was built to provide an urban water supply and has no provision for flood mitigation. Accordingly, the flood operation strategy is to pass any flood impacting the Dam through the reservoir, while ensuring peak outflow generally does not exceed peak inflow.

Given the Dam's size and its location within an urban area, it is imperative North Pine Dam is operated in accordance with clearly defined procedures during flood events to ensure the safety of the Dam. The current procedures are contained in ***The Manual of Operational Procedures for Flood Mitigation at North Pine Dam (Revision 5)*** ("**the Manual**"), which was gazetted in August 2010. The Manual is an approved flood mitigation manual under the ***Queensland Water Supply (Safety and Reliability) Act 2008***. An understanding of the Manual is important when reading this Report.

A flood event is defined as a situation where the Dam exceeds Full Supply Level (FSL) and flood water releases are made. In accordance with the Manual, the owner of North Pine Dam (currently Seqwater), must prepare a report after each flood event impacting the Dam. The report must contain details of the procedures used during the flood event, the reasons why procedures were used and other pertinent information.

North Pine Dam was impacted by 18 separate flood events between Sunday 10 October 2010 and Saturday 5 March 2011. Details of the timing of these flood events are contained in Table 1.1.1.

Flood event	Start	End
1	10/10/2010 06:30	14/10/2010 08:00
2	16/10/2010 06:00	16/10/2010 16:00
3	04/12/2010 19:05	05/12/2010 07:00
4	06/12/2010 12:35	07/12/2010 15:00
5	09/12/2010 19:10	10/12/2010 05:00
6	14/12/2010 19:20	15/12/2010 05:00
7	16/12/2010 19:40	17/12/2010 05:15
8	18/12/2010 19:10	19/12/2010 07:00
9	19/12/2010 21:10	21/12/2010 05:00
10	23/12/2010 19:20	24/12/2010 04:45
11	25/12/2010 19:15	26/12/2010 07:15
12	26/12/2010 20:00	29/12/2010 07:00
13	01/01/2011 19:30	02/01/2011 07:00
14	06/01/2011 19:00	14/01/2011 05:00
15	18/01/2011 21:15	19/01/2011 05:00
16	20/01/2011 00:40	20/01/2011 14:00
17	21/02/2011 21:00	22/02/2011 06:15
18	04/03/2011 19:00	05/03/2011 07:00

Table 1.1.1 – North Pine Dam – Timing of Flood Events, 10 October 2010 to 5 March 2011

This document reports on the operation of North Pine Dam during flood event 14, as defined in Table 1.1.1. Flood event 14 is by far the largest flood event ever to impact North Pine Dam. A Report covering flood events 1-13 and 15-18 in Table 1.1.1 will be available by 31 May 2011.

1.2 Meaning of terms

In this report, the following terms are defined as below:

"Act" means the Water Supply (Safety and Reliability) Act 2008;

"AEP" means Annual Exceedance Probability, the probability of a specified event being reached or exceeded in any one year. This may be expressed as a ratio (e.g. 1 in Y) or a percentage;

"Agency" includes a person, a local government and a department of state government within the meaning of the ***Acts Interpretation Act 1954***;

"AHD" means Australian Height Datum;

"ALERT" means Automated Local Evaluation in Real Time System, a system of monitoring and displaying rainfall and water level data. It is a combination of field stations, communication networks and data collection software;

"AMTD" means the Adopted Middle Thread Distance, which is the distance along the centre line of the mainstream from a junction, usually in kilometres;

"ANSI" means the American National Standards Institute;

"AR&R" means ***Australian Rainfall and Run-off (Book 6),*** The Institution of Engineers Australia (Engineers Australia) national guidelines for the estimation of design flood characteristics;

"BoM" means the Bureau of Meteorology;

"Chairperson" means the Chairperson of Seqwater;

"Chief Executive" means the Director-General of the Department of Environment and Resource Management or nominated delegate;

"Controlled Document" means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;

"Dam" means North Pine Dam;

"Dam Crest Flood" means the flood event which, when routed through the storage with the storage initially at Full Supply Level, results in the still water level in the storage reaching the lowest point in the dam embankment, excluding wind and wave effects;

"Dam Supervisor" means the senior on-site officer at North Pine Dam;

"DERM" means the Queensland Government department, the Department of Environment and Resource Management;

"Duty Flood Operations Engineer" means the Senior Flood Operations Engineer or Flood Operations Engineer rostered on duty to be in charge of Flood Operations at the Dams;

"EL" means elevation in metres Australian Height Datum;

"Enviromon" is the Bureau of Meteorology data collection software used to collect and display rainfall and water level data;

"ERRTS" means Event Reporting Radio Telemetry System;

"Flood Event" is a situation where the Duty Flood Operations Engineer expects the water level in the Dam to exceed the Full Supply Level;

"FLOOD-Col" is the data collection software used in the Flood Operations Centre to collect and display rainfall and water level data;

"FLOOD-Ops" is the modelling software used in the Flood Operations Centre to model the runoff from the catchments;

"Flood Operations Centre" means the office location used by Flood Operations Engineers during a flood event to manage the event;

"Flood Operations Engineer" means a person designated to direct flood operations at the Dams in accordance with Section 2.4 of the Manual;

"Flood Operations Engineers" means the collective group of persons who individually have designation as either a **Flood Operations Engineer** or a **Senior Flood Operations Engineer**;

"**Flood Operations Manager**" means the Senior Flood Operations Engineer or Flood Operations Engineer designated responsibility for the overall management of the Flood Operations Centre leading up to or during a Flood Event;

"**Flood Procedure Manual**" means the internal document that assigns responsibilities to Seqwater personnel for flood event preparation, mobilisation and operation, in relation to Seqwater's Dams;

"FSL" or "Full Supply Level" means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

"Gauge" when referred to in (m) means river level referenced to AHD or a local datum, and when referred to in (m^3/s) means flow rate in cubic metres per second;

"IFD" means Intensity Frequency Duration and refers to the statistical analysis of rainfall intensities;

"January 2011 Flood Event" means the Flood Event that impacted North Pine Dam between 6 January 2011 and 14 January 2011;

"**Manual**" or "**Manual of Operational Procedures for Flood Events at North Pine Dam**" means the current version (Revision 5) of the Manual;

"m^3/s" means a rate of water flow being one cubic metre of water per second or 1,000 litres of water per second;

"OOA" means 'out of action' in relation to the operation of a rainfall or river height gauge that provides catchment data;

"**QPF**" means Quantitative Precipitation Forecast provided by the Bureau of Meteorology and is an estimate of the predicted rainfall in millimetres, usually in the next 24 hours;

"RTFM" means Real Time Flood Model and is a combination of Flood-Col, Flood-Ops and other ancillary software;

"SD" means State Datum, which is a level height datum that is different from AHD;

"Senior Flood Operations Engineer" means a person designated in accordance with Section 2.3 of the Manual under whose general direction the procedures in the Manual must be carried out;

"Seqwater" means the Queensland Bulk Water Supply Authority, trading as Seqwater;

"Target Minimum Intervals" means the target minimum intervals for radial gates movements as described in the Manual.

"URBS" means Unified River Basin Simulator.

Note: Dam levels in this document represented as metres (m) are metres Australian Height Datum or (m AHD).

1.3 Flood operation objectives

The primary objectives of the procedures contained in the Manual, in order of importance are:

1. Ensure the structural safety of the Dam;
2. Minimise disruption to the community in areas downstream of the Dam;
3. Retain the storage at Full Supply Level (FSL) at the conclusion of the flood event;
4. Minimise impacts to riparian flora and fauna during the Drain Down Phase of the flood event.

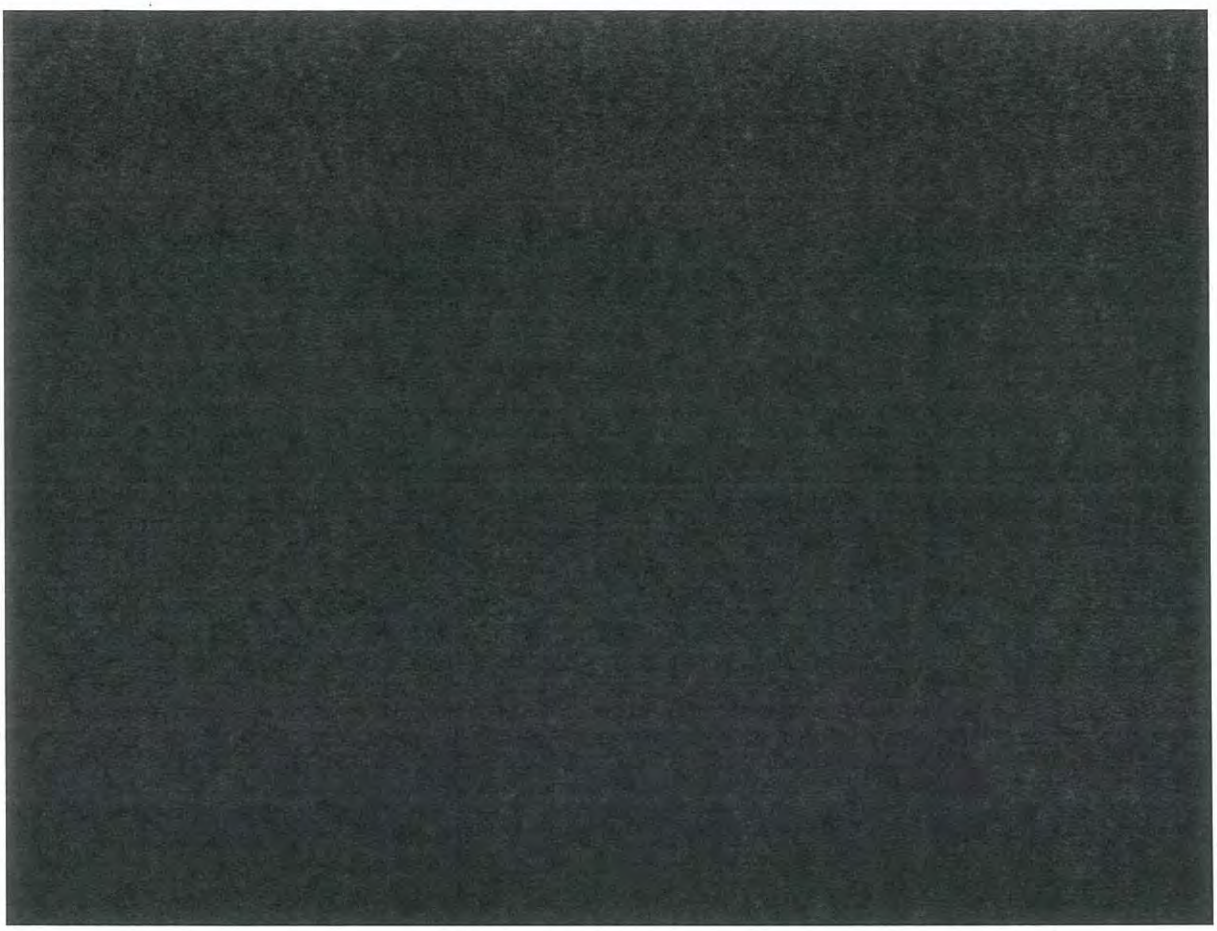
In meeting these objectives, the Dam must be operated to account for the potential impact of closely-spaced flood events. Accordingly, normal procedures require stored floodwaters to be emptied from the North Pine Dam as quickly as possible, while meeting all of the Manual's objectives.

1.4 North Pine Dam

North Pine Dam is an urban water supply dam with no significant flood storage compartment above FSL. The Manual refers to the Dam having a "flood storage compartment", however, the volume of this compartment effectively only provides a short time delay between FSL being reached and flood releases commencing. The flood storage compartment's volume (the volume of water between FSL and the radial gate opening trigger level) is 1,096ML, which represents only 0.5% of the full supply volume of the Dam and provides no practical flood mitigation benefits during flood events. In general terms, once the Dam is full, floods will pass through the reservoir with little mitigation other than the amount provided by the buffer effect of its storage volume.

During flood events, significant inflows into the Dam can occur within two hours of heavy rain commencing in the Dam catchment area. Accordingly, the Dam's response time during significant flood events is, in most cases, minimal. When the Dam is full, its FSL is 39.60m AHD. Radial gate operations to release flood water from the dam commence when the dam level reaches 39.65m AHD which is only 50mm above the FSL.

Radial gates are the primary infrastructure used to release water during significant flood events at North Pine Dam. Regulator valves may be used to control levels in small events but generally remain closed if radial gates are opened. The arrangement of the radial gates and regulator valves at North Pine Dam is shown in Figure 1.4.1.

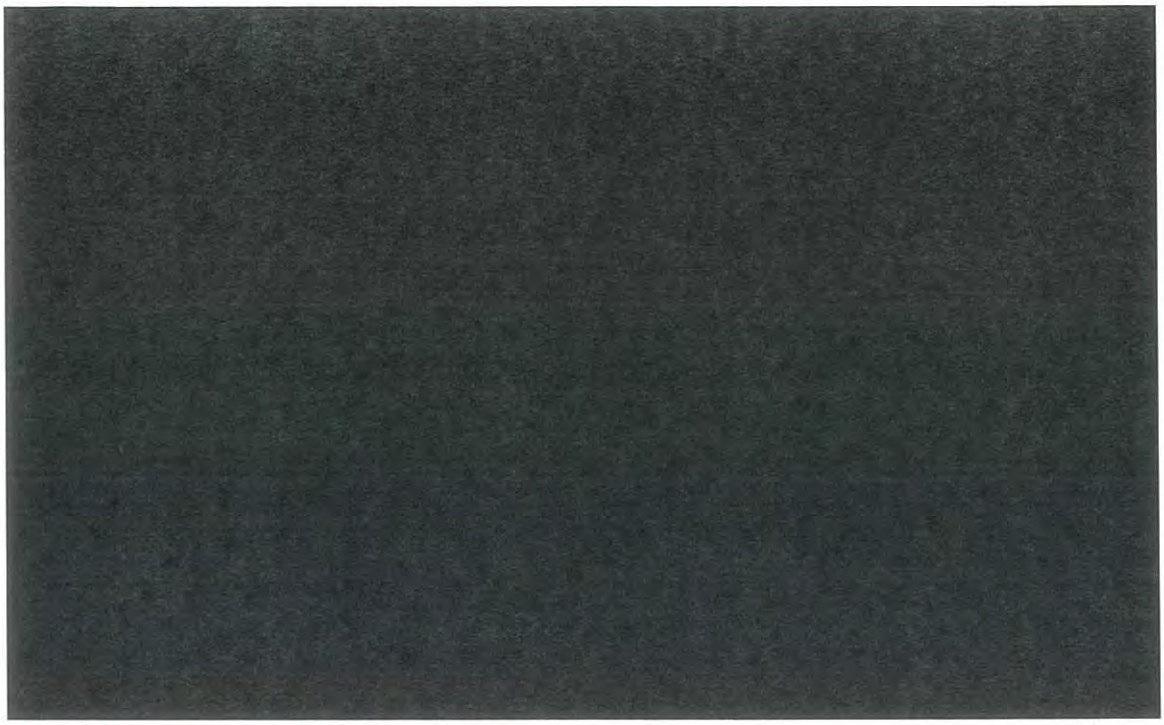


When a flood event is declared, the event's magnitude is assessed to include:

- A prediction of the maximum storage levels in the Dam;
- A prediction of the peak outflow rate from the Dam.

Prior to water being released from the radial gates, the Flood Operations Engineer must ensure the Grant Street causeway is closed to traffic and the Moreton Bay Regional Council has been advised of the potential impact of flood releases on Youngs Crossing. As Youngs Crossing has a very limited flow-carrying capacity (approximately $10m^3/s$), any release from North Pine Dam's radial gates will inundate the Crossing. Outflows from the uncontrolled Sideling Creek Dam (a separate catchment to North Pine Dam) can also impact Youngs Crossing. When operating North Pine Dam during very small events, consideration is given to limiting the combined outflows from both North Pine and Sideling Creek Dams to less than $10m^3/s$ as well as minimising the time Youngs Crossing is inundated.

In major flood events such as the January 2011 Flood Event, the northbound lane of Gympie Road known as AJ Wylie Bridge is also impacted when the flow in the North Pine River reaches $800m^3/s$. Figure 1.4.2 shows the location of crossings impacted by Dam releases.



1.5 January 2011 Flood Event

The January 2011 Flood Event is by far the biggest event to ever impact North Pine Dam in terms of both inflow volume and inflow rate. The Event commenced at 08:00 on Thursday 6 January 2011 and concluded at 05:00 on Friday 14 January 2011. Relevant statistics relating to the Event are contained in Table 1.5.1.

Dam inflow (ML)	Dam outflow (ML)	Peak inflow (m^3/s)	Peak outflow (m^3/s)	Peak level (m AHD)	Event peak (time)
202,000	206,000	3,480	2,850	41.11	14:00 on Tuesday 11 January 2011

Table 1.5.1 – January 2011 Flood Event statistics

The two main points to note from Table 1.5.1 are:

- The Dam was operated so the peak outflow from the Dam during the Event was only 82% of the peak inflow. This reduced flood flows downstream of the Dam. Further reductions in flood flows downstream of the Dam were not possible without risking the safety of the Dam;
- The peak water level of 41.11m reached during the Event was only 0.5m below the level of the radial gates' switch gear. If the switch gear is inundated, normal control of the radial gates is lost and the back-up system is initiated. For safety reasons, this situation is avoided if at all possible.

2 FLOOD EVENT SUMMARY

2.1 Summary of the January 2011 Flood Event

This summary must be read in conjunction with ***The Manual of Operational Procedures for Flood Mitigation at North Pine Dam (Revision 5)*** ("the Manual").

Table 2.1.2 (on the following page) summarises North Pine Dam's flood operations each day of the January 2011 Flood Event. All operations were undertaken in accordance with the Manual. The table shows flood operations were moderate and relatively routine until Tuesday 11 January 2001, when a twelve-hour burst of rainfall produced unprecedented inflows into the Dam. These inflows were more than double the peak inflow rate of the Dam's previous biggest flood.

The rainfall recorded in the North Pine Dam catchment area between Thursday 6 and Friday 14 January 2011 indicates the catchment average rainfall intensity for the 12-hour period to Tuesday 11 January 2011 at 15:00 had an Average Exceedance Probability (AEP) of between 1 in 200 and 1 in 500. Point rainfalls recorded in the catchment during this period had an AEP up to 1 in 1,000 for durations less than 12 hours. This rainfall burst is illustrated in Figure 2.1.1 below.

Preliminary post-event analysis shows the Flood Event impacting North Pine Dam on Tuesday 11 January 2011 had an AEP of approximately 1 in 200.

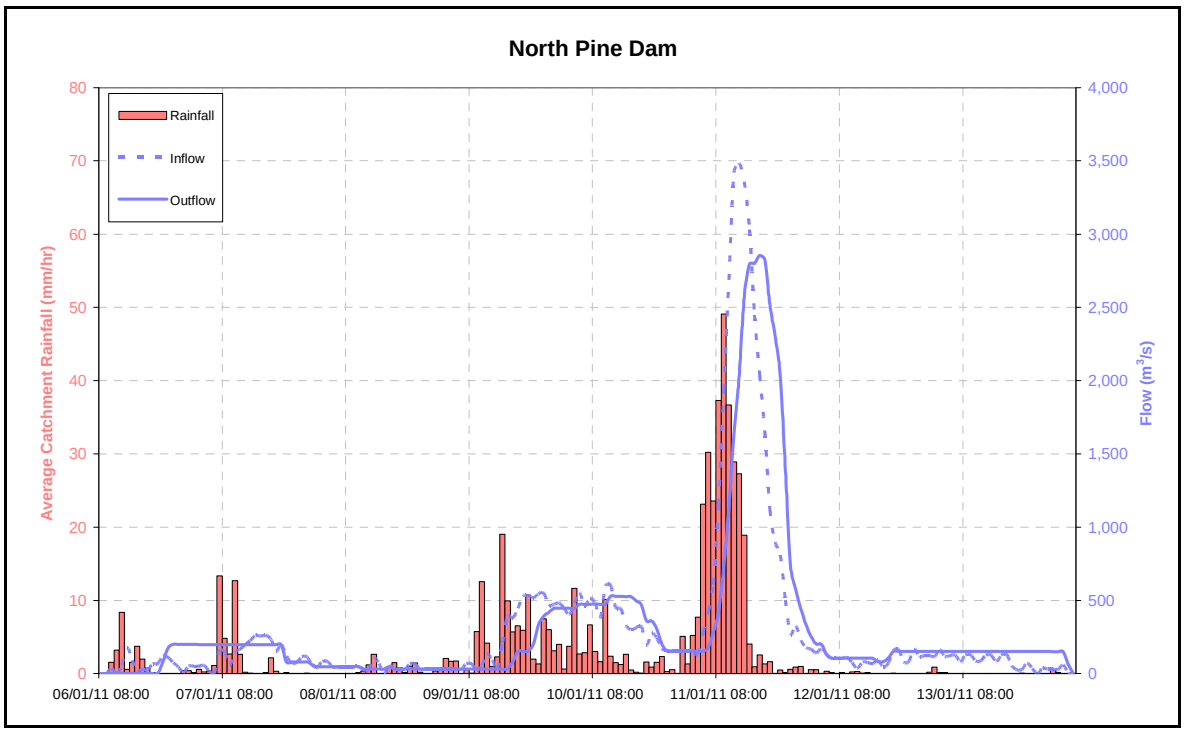


Figure 2.1.1 – North Pine Dam – January 2011 Flood Event – Dam inflow and outflow

2 FLOOD EVENT SUMMARY (continued)

Period ending	Average catchment rainfall at end of period	Inflow volume at end of period	Outflow volume at end of period	Peak inflow during period	Peak outflow during period	Inflow at end of period	Outflow at end of period	Dam level at end of period	Actions and strategies
	mm	ML	ML	m^3/s	m^3/s	m^3/s	m^3/s	m AHD	
00:00 07 Jan 2011 (16 hours)	22	3,350	3,100	178	200	7	199	39.64	• The Flood Operations Centre was mobilised at 08:00. The North Pine Dam lake level was well below the gate-opening trigger level, however, model results showed the rainfall recorded in the Dam catchment area would be sufficient to cause the lake level to exceed the gate trigger level later in the day. • At 12:00, it was agreed with the Moreton Bay Regional Council that radial gate releases would commence at 19:00. This would allow Youngs Crossing to remain open to traffic during the afternoon peak hour. • The Moreton Bay Regional Council closed Youngs Crossing at 19:00 and radial gate releases commenced at 19:15. The radial gate trigger level was exceeded by 60mm at this time, however, model results showed the Dam level would soon fall below the trigger level once gate operations commenced. The lake level did fall below the gate-opening trigger level just before midnight. • The discharge rate was selected to match the approximate peak inflow, with the aim being to allow Youngs Crossing to be reopened to traffic as soon as possible.
00:00 08 Jan 2011 (24 hours)	42	11,400	14,900	261	199	114	79	39.46	• Releases continued throughout the day at a rate that did not exceed peak inflow. As Dam inflows were expected to continue for some days, Dam outflow was matched to inflow and the Dam level was maintained just below the FSL. This occurred as there was an expectation FSL would be reached at the end of the Event due to the ongoing base flow following the completion of releases. • It was apparent Youngs Crossing would remain closed to traffic for some days. The Crossing was also being impacted by uncontrolled flood outflows from Lake Kurwongbah.

2 FLOOD EVENT SUMMARY (continued)

Period ending	Average catchment rainfall at end of period	Inflow volume at end of period	Outflow volume at end of period	Peak inflow during period	Peak outflow during period	Inflow at end of period	Outflow at end of period	Dam level at end of period	Actions and strategies
	mm	ML	ML	m^3/s	m^3/s	m^3/s	m^3/s	m AHD	
00:00 09 Jan 2011 (24 hours)	104	4,100	3,400	106	64	32	32	39.46	• Releases continued throughout the day at a rate that did not exceed peak inflow. As Dam inflows were expected to continue for some days, Dam outflow was matched to the inflow rate and the Dam level was maintained just below the FSL. This occurred as there was an expectation FSL would be reached at the end of the Event due to the ongoing base flow following the completion of releases. • Youngs Crossing remained closed to traffic.
00:00 10 Jan 2011 (24 hours)	111	20,500	10,100	550	450	472	446	39.49	• Steady rain commenced in the Dam's catchment area at 09:00 and continued throughout the day. As a result, an increase in Dam outflows commenced at 15:00 and continued until midnight. • Gates were operated in accordance with the radial gate settings tables in the Manual. • Youngs Crossing remained closed to traffic.
00:00 11 Jan 2011 (24 hours)	63	32,000	35,700	610	530	153	153	39.96	• Inflow into the Dam peaked at 11:00, and following this peak, Dam outflows were reduced to match inflow. • Gates were operated in accordance with the radial gate settings tables in the Manual. • Youngs Crossing remained closed to traffic.

Period ending	Average catchment rainfall at end of period	Inflow volume at end of period	Outflow volume at end of period	Peak inflow during period	Peak outflow during period	Inflow at end of period	Outflow at end of period	Dam level at end of period	Actions and strategies
	mm	ML	ML	m^3/s	m^3/s	m^3/s	m^3/s	m AHD	
00:00 12 Jan 2011 (24 hours)	308	112,500	111,600	3,489	2,850	227	443	39.80	• Heavy rain commenced in the Dam's catchment area at 05:00 and continued through to 13:00. As a result, a rapid increase in Dam inflows commenced at 07:00 and continued until 14:00. During this period, 85 gate opening operations were undertaken. Minimum openings were maintained and the gate opening interval was adjusted to ensure gate opening settings never fell significantly behind the minimum settings contained in the Manual. • The Moreton Bay Regional Council was contacted at 09:16, 09:17, 10:45, 11:19, 11:56, 11:57 and 11:59, and provided with an update on the developing situation using the agreed contact methods in the North Pine Dam Emergency Action Plan. Dam level peaked at 41.11m at 14:00. • Youngs Crossing remained closed to traffic.
00:00 13 Jan 2011 (24 hours)	3	9,520	12,200	180	330	122	152	39.86	• No significant rainfall occurred during the day and draining of the Dam continued through the day. • Youngs Crossing remained closed to traffic.
00:00 14 Jan 2011 (24 hours)	2	7,730	13,100	160	150	32	150	39.72	• No significant rainfall occurred during the day and draining of the Dam continued through the day. • Youngs Crossing remained closed to traffic.
05:00 14 Jan 2011 (5 hours)	1	440	1,850	60	150	0	0	39.40	• All radial gates were closed at 05:00 on Friday 14 January 2011 to allow Youngs Crossing to be re-opened to traffic in time for the morning peak hour. • The lake level at the final gate closure was 39.41m. FSL was expected to be reached in the days following the Event as a result of ongoing base flow into the Dam. • A fish recovery exercise commenced when the final gate was closed and Youngs Crossing was re-opened to traffic approximately two hours later.

Table 2.1.2 – North Pine Dam – January 2011 Flood Event daily summary

3 EVENT MOBILISATION AND STAFFING

3.1 Catchment conditions at Event commencement

In the 31 days prior to Thursday 6 January 2011, above-average levels of rainfall were received in the North Pine Dam catchment area, and flood water releases were made from the Dam on 25 days of this 31-day period. Less than four days before the January 2011 Flood Event commenced, flood water was being released from North Pine Dam.

Due to the rainfall received in the Dam catchments throughout December 2010, at the start of the January 2011 Flood Event, the catchment conditions were near saturation. However, the catchment was highly responsive, with the initial loss varying between 20mm and 25mm. Continuing loss rates were also unusually low. Because the degree of catchment saturation increased as the Event progressed, very high levels of run-off were generated throughout the Event.

3.2 Event mobilisation

No significant rainfall occurred in the 24 hours to 09:00 on Wednesday 5 January 2011, however, in the 24 hours to 08:00 on Thursday 6 January 2011, significant rain fell in the North Pine Dam catchment, with 30mm recorded at Mt Glorious. This rainfall was sufficient to trigger event mobilisation at 07:42 on Thursday 6 January 2011. The following actions were undertaken as soon as event mobilisation occurred:

- 24/7 staffing commenced at the Flood Operations Centre, with at least one Duty Flood Operations Engineer and at least one trained Flood Officer present (minimum two persons);
- 24/7 staffing commenced at North Pine Dam, with at least two trained Dam Operators present;
- Flood Operations Engineers were called back early from annual leave to assist with management of the Event.

Staffing at the Flood Operations Centre and the Dam continued on this basis until event de-mobilisation at 05:00 on Thursday 14 January 2011.

3.3 Qualifications of staff on duty

Flood Operations Engineers

The four Flood Operations Engineers approved by the Chief Executive to direct the operations of North Pine Dam during flood events are:

- Flood Operations Engineer 1;
- Flood Operations Engineer 2;
- Flood Operations Engineer 3;
- Flood Operations Engineer 4.

All Engineers had demonstrated to the Chief Executive they have:

1. Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and;
2. At least a total of five years' suitable experience, having demonstrated their expertise in at least two of the following areas:
    - Investigation, design or construction of major dams;
    - Operation and maintenance of major dams;
    - Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;
    - Applied hydrology with particular reference to flood forecasting and/or flood forecasting systems.

Flood Operations Engineers 1, 2 and 3 are three of the most experienced and expert Engineers in the industry, in relation to their knowledge of Pine Rivers flood hydrology. Flood Operations Engineer 4 is one of the most experienced Engineers in Queensland in relation to the operation and maintenance of gated dams.

The four current Flood Operations Engineers undertake flood operations duties as an addition to the full-time roles they fill within various State Government organisations. These flood operations duties include 24/7 on-call duties, 24/7 catchment monitoring during rainfall events, and undertaking 12-hour shifts during flood events. Flood Operations Engineers do not receive any additional payments or allowances to undertake flood operations duties. Duties also include requirements to work extended hours on Christmas Day, Boxing Day, New Years Day and other public holidays (as has occurred in recent months), and to return from annual leave if required for flood operation duties.

It should also be noted the Flood Operations Engineers managed flood operations activities at Somerset Dam and Wivenhoe Dam, in conjunction with the January 2011 Flood Event which impacted North Pine Dam.

Flood Officers

Nine Flood Officers, trained in Flood Operations Centre duties, assisted in the Flood Operations Centre during the Event.

1. Flood Officer 1;
2. Flood Officer 2;
3. Flood Officer 3;
4. Flood Officer 4;
5. Flood Officer 5;
6. Flood Officer 6;
7. Flood Officer 7;
8. Flood Officer 8;
9. Flood Officer 9.

Dam Operators

Seven Dam Operators, trained in Flood Operations Centre duties, operated North Pine Dam during the Event.

1. Dam Operator 14;
2. Dam Operator 15;
3. Dam Operator 16;
4. Dam Operator 17;
5. Dam Operator 18;
6. Dam Operator 19;
7. Dam Operator 20.

3.4 Flood Operations Centre staffing

Flood Operations Centre staffing details for the duration of the Event are recorded in Tables 3.4.1, 3.4.2 and 3.4.3 . Each table has been compiled in accordance with the Event Roster which was confirmed by the Flood Event Manager.

Seqwater has prepared a Flood Procedure Manual that assigns responsibilities to Seqwater personnel for flood event preparation, mobilisation and operation, in relation to Seqwater's Dams, including North Pine Dam. It is an internal document and was last revised and issued in January 2010.

Shift start time	Shift finish time	Flood Operations Engineers	Notes
Thu 06/01/2011 07:00	Thu 06/01/2011 19:00	Engineer 2	Standard shift handover occurred at the end of this shift in accordance with the Flood Procedure Manual.
Thu 06/01/2011 19:00	Fri 07/01/2011 07:00	Engineer 1	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Fri 07/01/2011 07:00	Fri 07/01/2011 19:00	Engineer 2	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Fri 07/01/2011 19:00	Sat 08/01/2011 07:00	Engineer 3	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Sat 08/01/2011 07:00	Sat 08/01/2011 19:00	Engineer 1	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Sat 08/01/2011 19:00	Sun 09/01/2011 07:00	Engineer 4	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Sun 09/01/2011 07:00	Sun 09/01/2011 19:00	Engineer 2	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Sun 09/01/2011 19:00	Mon 10/01/2011 07:00	Engineer 3 Engineer 1	Due to the developing rainfall scenario, Engineer 2 assisted until 22:00 on 9 January 2011 to provide an extended shift handover at the commencement of this shift. It was also decided at this time to have two Engineers on duty until the peak of the Event had passed. The handover at the end of this shift involved all four Flood Operations Engineers discussing strategy and the developing situation.
Mon 10/01/2011 07:00	Mon 10/01/2011 19:00	Engineer 2 Engineer 4	The handover at either end of this shift involved all four Flood Operations Engineers discussing strategy and the developing situation.
Mon 10/01/2011 19:00	Tue 11/01/2011 07:00	Engineer 3 Engineer 1	The handover at either end of this shift involved all four Flood Operations Engineers discussing strategy and the developing situation.
Tue 11/01/2011 07:00	Tue 11/01/2011 19:00	Engineer 2 Engineer 4	Engineer 1 and Engineer 3 assisted from 13:00 on 11 January 2011. The handover at either end of this shift involved all four Flood Operations Engineers discussing strategy and the developing situation.
Tue 11/01/2011 19:00	Wed 12/01/2011 07:00	Engineer 3 Engineer 1	Engineer 4 and Engineer 2 assisted until 23:00 on 11 January 2011. The handover at the end of this shift involved all four Flood Operations Engineers discussing strategy and the developing situation.

Shift start time	Shift finish time	Flood Operations Engineers	Notes
Wed 12/01/2011 07:00	Wed 12/01/2011 19:00	Engineer 2 Engineer 4	The handover at either end of this shift involved all four Flood Operations Engineers discussing strategy.
Wed 12/01/2011 19:00	Thu 13/01/2011 07:00	Engineer 3 Engineer 1	The handover at either end of this shift involved all four Flood Operations Engineers discussing strategy.
Thu 13/01/2011 07:00	Thu 13/01/2011 19:00	Engineer 2 Engineer 4	The handover at the commencement of this shift involved all four Flood Operations Engineers discussing strategy. A standard shift handover occurred at the end of this shift in accordance with the Flood Procedure Manual.
Thu 13/01/2011 19:00	Fri 14/01/2011 07:00	Engineer 1	Standard shift handovers occurred at the beginning of this shift in accordance with the Flood Procedure Manual.

Table 3.4.1 – Flood Operations Centre staffing – Flood Operations Engineers

Shift start times	Shift finish times	Flood Officers	Notes
Thu 06/01/2011 07:00	Thu 06/01/2011 19:00	Flood Officer 7	
Thu 06/01/2011 19:00	Fri 07/01/2011 07:00	Flood Officer 1	
Fri 07/01/2011 07:00	Fri 07/01/2011 19:00	Flood Officer 8	
Fri 07/01/2011 19:00	Sat 08/01/2011 07:00	Flood Officer 7	
Sat 08/01/2011 07:00	Sat 08/01/2011 19:00	Flood Officer 3	
Sat 08/01/2011 19:00	Sun 09/01/2011 07:00	Flood Officer 2	
Sun 09/01/2011 07:00	Sun 09/01/2011 19:00	Flood Officer 1	
Sun 09/01/2011 19:00	Mon 10/01/2011 07:00	Flood Officer 6	
Mon 10/01/2011 07:00	Mon 10/01/2011 19:00	Flood Officer 8	
Mon 10/01/2011 19:00	Tue 11/01/2011 07:00	Flood Officer 9	
Tue 11/01/2011 07:00	Tue 11/01/2011 19:00	Flood Officer 4 Flood Officer 2	Flood Officer 9 assisted as needed as he was living in the building during this period.
Tue 11/01/2011 19:00	Wed 12/01/2011 07:00	Flood Officer 3 Flood Officer 9	
Wed 12/01/2011 07:00	Wed 12/01/2011 19:00	Flood Officer 1 Flood Officer 2	Flood Officer 9 assisted as needed as he was living in the building during this period.
Wed 12/01/2011 19:00	Thu 13/01/2011 07:00	Flood Officer 7	
Thu 13/01/2011 07:00	Thu 13/01/2011 19:00	Flood Officer 9	
Thu 13/01/2011 19:00	Fri 14/01/2011 07:00	Flood Officer 4	

Table 3.4.2 – Flood Operations Centre staffing – Flood Officers

Shift start times	Shift finish times	Dam Operators
Thu 06/01/2011 07:00	Thu 06/01/2011 19:00	Dam Operator 14 Dam Operator 19
Thu 06/01/2011 19:00	Fri 07/01/2011 07:00	Dam Operator 15 Dam Operator 16
Fri 07/01/2011 07:00	Fri 07/01/2011 19:00	Dam Operator 17 Dam Operator 19
Fri 07/01/2011 19:00	Sat 08/01/2011 07:00	Dam Operator 16 Dam Operator 20
Sat 08/01/2011 07:00	Sat 08/01/2011 19:00	Dam Operator 18 Dam Operator 19
Sat 08/01/2011 19:00	Sun 09/01/2011 07:00	Dam Operator 16 Dam Operator 20
Sun 09/01/2011 07:00	Sun 09/01/2011 19:00	Dam Operator 18 Dam Operator 19
Sun 09/01/2011 19:00	Mon 10/01/2011 07:00	Dam Operator 16 Dam Operator 20
Mon 10/01/2011 07:00	Mon 10/01/2011 19:00	Dam Operator 18 Dam Operator 19
Mon 10/01/2011 19:00	Tue 11/01/2011 07:00	Dam Operator 16 Dam Operator 20
Tue 11/01/2011 07:00	Tue 11/01/2011 19:00	Dam Operator 18 Dam Operator 19
Tue 11/01/2011 19:00	Wed 12/01/2011 07:00	Dam Operator 16 Dam Operator 20
Wed 12/01/2011 07:00	Wed 12/01/2011 19:00	Dam Operator 18 Dam Operator 19
Wed 12/01/2011 19:00	Thu 13/01/2011 07:00	Dam Operator 16 Dam Operator 20
Thu 13/01/2011 07:00	Thu 13/01/2011 19:00	Dam Operator 18 Dam Operator 19
Thu 13/01/2011 19:00	Fri 14/01/2011 07:00	Dam Operator 16 Dam Operator 20

Table 3.4.3 – Flood Operations Centre staffing – North Pine Dam, Dam Operators

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4 FLOOD EVENT PROCEDURES

4.1 Introduction

Seqwater has prepared a Flood Procedure Manual that assigns responsibilities to Seqwater personnel for flood event preparation, mobilisation and operation, in relation to Seqwater's Dams, including North Pine Dam.

The relationship between the Flood Procedure Manual and ***The Manual of Operational Procedures for Flood Mitigation at North Pine Dam*** (the Manual) is outlined in Figure 4.1.1.

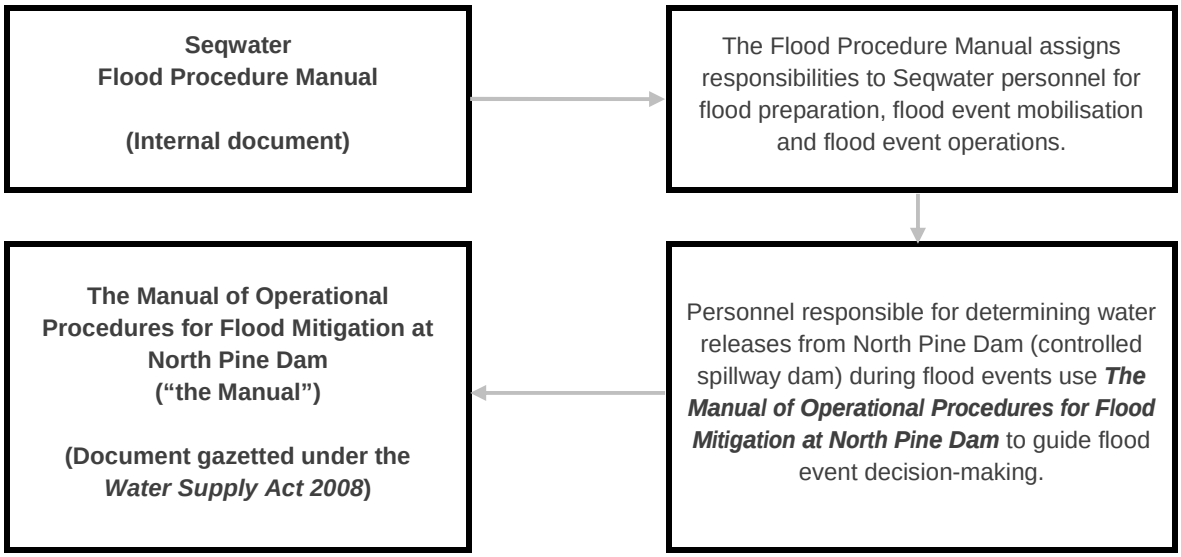

Figure 4.1.1 – Relationship between the Flood Procedure Manual and The Manual of Operational Procedures for Flood Mitigation at North Pine Dam

The Flood Procedure Manual is an internal document and is registered in Seqwater's internal document control system, ***Qpulse***. Controlled hardcopies are issued to the following personnel:

Agency	Responsible person	Location
Seqwater	Dam and Source Operations Manager	Margaret Street, Brisbane
Seqwater	Principal Hydrologist	Margaret Street, Brisbane
Seqwater	Senior Flood Operations Engineer	Flood Operations Centre, Brisbane
Seqwater	Principal Engineer Dam Safety	Karalee
Seqwater	Operations Coordinator, South	Karalee
Seqwater	Operations Coordinator, North	Landers Shute
Seqwater	Operations Coordinator, Central	Wivenhoe Dam
Seqwater	Storage Supervisor	Wivenhoe Dam
Seqwater	Storage Supervisor	Leslie Harrison Dam
Seqwater	Storage Supervisor	North Pine Dam
Seqwater	Storage Supervisor	Somerset Dam

Table 4.1.2 – Allocation of controlled hardcopies of the Seqwater Flood Procedure Manual

The issue date for the current Flood Procedure Manual is January 2010.

4.2 Flood Operations Centre preparedness

Prior to the January 2011 Flood Event, Flood Operations Engineer 2 was designated the Flood Operations Manager, in accordance with the requirements of the Seqwater Flood Procedure Manual. In conjunction with Flood Operations Engineer 1 (a Senior Flood Operations Engineer), Flood Operations Engineer 2 was responsible for the overall management of the Flood Operations Centre leading up to the Event and ensuring:

- A Flood Operations Engineer and three Flood Officers were on close call at all times, and ready to attend the Flood Operations Centre if called;
- Sufficient Flood Operations Engineers and Flood Officers were available to staff the Flood Operations Centre if a flood event was declared;
- Contact details for Flood Operations Engineers and Flood Officers were up-to-date;
- Current copies of the following documents were available in the Flood Operations Centre:
  - The Manual;
  - North Pine Dam – Emergency Action Plan.
- The following facilities were available in the Flood Operations Centre:
  - The data collection and modelling systems required to manage flood events at North Pine Dam;
  - Sufficient stationery and forms;
  - Landline telephone, mobile telephone, satellite telephone, Seqwater radio network, facsimile and email communication systems;
  - Power systems and back-up power systems required to ensure computer system reliability during the Flood Event.

As defined by the Seqwater Flood Procedure Manual, the role and responsibilities of the Flood Operations Manager are completely separate to the roles and responsibilities of Flood Operations Engineers. However, a single person can hold both roles at any point in time.

When one of the Flood Operations Engineers is on call, this person is referred to as the Duty Flood Operations Engineer. There is always a single designated Duty Flood Operations Engineer on call 24 hours a day, seven days a week.

When on call, the Duty Flood Operations Engineer (one of the four Flood Operations Engineers described in Section 3.3) ensured they:

- Were contactable at all times by telephone;
- Had constant access to facilities providing appropriate real-time monitoring of Dam and catchment conditions;
- Were able to travel to the Flood Operations Centre within two hours to direct the mobilisation and operation of the Flood Event, without compromising the safety of the Dam or the intent of the Manual;
- As incoming Duty Flood Operations Engineer, organised the handover from the current duty staff;
- As outgoing Duty Flood Operations Engineer, prepared a status summary sheet for North Pine Dam;
- Contacted the Flood Operations Manager if any issues arose with the potential to adversely impact the operations of the Flood Operations Centre.

When on call, the nine Flood Officers (described in Section 3.3) ensured they:

- Were contactable at all times by telephone;
- Reported to the Duty Flood Operations Engineer if at any time, while being on call, they became unfit for duty;
- Were able to travel to the Flood Operations Centre within two hours of being called;
- Attended the close call handover meetings organised by the Duty Flood Operations Engineers.

4.3 Flood Operations Centre mobilisation

The Seqwater Flood Procedure Manual requires the Duty Flood Operations Engineer to declare a flood event and mobilise the Flood Operations Centre if:

- The Duty Flood Operations Engineer considers it likely North Pine Dam's Full Supply Level (FSL) will be exceeded as a result of rainfall occurring in the Dam catchments, and;
- Flood releases are likely.

The Flood Operations Centre is mobilised as soon as a flood event is declared. Flood Operations Engineer 2 was the Duty Flood Operations Engineer who declared the January 2011 Flood Event by email at 07:42 on Thursday 6 January 2011.

When the Flood Operations Centre was mobilised, the Duty Flood Operations Engineer ensured the following actions were undertaken:

- Notified the Senior Flood Operations Engineers of the mobilisation;
- Commenced recording significant events in the Event Log;
- Contacted the required Flood Officers to commence duty at the Flood Operations Centre;
- Contacted the Seqwater Operations Coordinator responsible for North Pine Dam, and provided instructions to send Dam operations staff to the Dam. The Operations Coordinator was also advised of the expected duration of the Flood Event to allow time to organise suitable staffing arrangements for the duration of the Event;
- Established 09:00 on Sunday 2 January 2011 as the start time for the Event, for the purposes of modelling predictions;
- Established a suitable directory structure within the computer network to manage Flood Event data;
- Examined and edited all rainfall and stream flow data for the Event prior to use in the flood modelling systems;
- Derived inflow hydrographs for North Pine Dam across a variety of appropriate rainfall scenarios and examined these derived inflow hydrographs;
- Inputted the derived inflow hydrographs for North Pine Dam into the North Pine Dam operations spreadsheet and ran this program;
- Determined gate operation strategies for North Pine Dam based on the resulting data from the operations spreadsheet and in accordance with the requirements of the Manual;
- Advised Moreton Bay Regional Council of likely gate operation requirements to allow roads to be closed prior to inundation;
- Directed gate operations at the Dam as appropriate by instructing the Dam Supervisors by email and facsimile. Instructions were also given verbally by telephone prior to written instructions being released;
- Advised Seqwater's Dam and Source Operations Manager of gate operations by providing a copy of all Flood Operations Directives and regular updates, including advice of longer-term strategies to manage the Flood Event. This allowed Seqwater to provide appropriate flood event advice to the public and other stakeholders, including the Queensland Water Commission and the Water Grid Manager;
- Advised the Dam Safety Regulator of the likely gate operation requirements.

4.4 Flood Operations Centre operations

During the Flood Event, the four Flood Operations Engineers worked closely together to ensure the following took place, in accordance with the Flood Procedure Manual:

- Suitable staffing arrangements were in place for the Flood Operations Centre and the Dam for the duration of the Flood Event;
- Staff working in the Flood Operations Centre during the Event signed the Flood Event Shift Log at the start and end of a shift. However, because a number of staff lived in the building housing the Flood Operations Centre during the Event, some sign on and sign off details were not properly recorded. This has been recognised as an area for improvement for future flood events.

During the Flood Event, the Senior Flood Operations Engineer set the overall strategy for managing the Flood Event, in accordance with the Manual. The Duty Flood Operations Engineers directed the operations of the Flood Control Centre, in accordance with the overall strategy. In situations where two or more Flood Operations Engineers were on duty simultaneously, these duties were shared equally. The Duty Flood Operations Engineers ensured the following actions took place during the Event, in accordance with the Flood Procedure Manual:

- All significant events were recorded in the Event Log;
- Flood releases from the Dam were in accordance with the Manual, and the Real Time Flood Model (RTFM) was used to support the decision-making processes regarding the releases;
- Software issues impacting on the operation of the ALERT System were identified and resolved;
- All notifications specified in the Flood Manuals and Emergency Action Plans were recorded in the Event Log;
- Accurate plots of headwater levels were maintained for the Dam;
- Appropriate handovers took place at the end of each shift to ensure incoming Officers had the following information:
    - Reservoir storage elevations at the Dam;
    - Radial gate, sluice gate and regulator valve openings at the Dam;
    - Flood release procedures being applied and the reason for their selection;
    - Status of compliance with the Flood Manuals and Emergency Action Plans;
    - Status of the communication systems;
    - Status of the data gathering network;
    - Status of computer systems and Flood Modelling Systems;
    - Any areas of concern associated with the management of the Flood Event;
    - Areas in which discretion has been exercised, in accordance with the Manual.
- Flood Officers on duty in the Flood Operations Centre undertook all duties as directed by the Duty Flood Operations Engineer;
- The Moreton Bay Regional Council was contacted as appropriate to allow roads to be closed prior to inundation and for any necessary arrangements to be made to manage impacts to the community resulting from the Dam flood water releases. (The Manual allows for immediate releases to be initiated if the safety of the Dam is at risk. However, in accordance with Seqwater's public safety duty of care, when making Dam releases, every attempt is made to ensure impacted roads are closed prior to inundation, and appropriate arrangements are made within the impacted community, due to the risk to public safety.);
- Gate operations were directed at the Dam as appropriate, by instructing the Dam Supervisors about gate movements;
- Seqwater's Dam and Source Operations Manager was advised of all gate operations through the provision of a copy of all Flood Operations Directives and regular updates, including advice about longer-term strategies to manage the Flood Event. This allowed Seqwater to provide appropriate Flood Event advice to the public and other stakeholders, including the Queensland Water Commission and the Water Grid Manager;
- The Dam Safety Regulator was advised of the gate operation requirements.

As the Flood Event progressed, a number of situations arose with the potential to adversely impact on the Flood Operations Centre. All situations were managed by the Flood Operations Engineers as they arose and no issues adversely affecting the Flood Operations Centre were experienced during the Event. Details of these situations, how they were managed and the back-up facilities in place are as follows:

- The Flood Operations Engineers were aware of the potential for the Flood Operations Centre to lose both mains power and the communication link between the main (Turbot Street) and back-up (George Street) Flood Operations Centres due to the flooding impacting the Brisbane CBD. To resolve this issue communications were initiated with relevant agencies and personnel including ENERGEX and the building managers from both the Turbot Street and George Street locations. These communications advised of the critical role of the Flood Operations Centre in managing the Flood Event. As a result, mains power and telephone communication were maintained at the Flood Operations Centre throughout the Event, however, the back-up Centre did operate under stand-by power for the period the Brisbane CBD was impacted by flooding.
- Both the main and back-up Flood Operations Centres are connected to an uninterrupted power supply and emergency standby power facilities to ensure they can continue to operate even if mains power is lost.
- The RTFM worked well over the full duration of the Flood Event. One interesting situation that was noted was that minor file corruption errors appeared in the daily routine system checks associated with the back-up Linux PC (NAMAH), which houses a duplicate of the RTFM. These minor errors were attributed to a minor failure of the file mirroring process, which ensures back-up copies of the data in the main Flood Operations Centre PC (NOAH) are captured on the back-up PC (NAMAH). This problem was easily rectified by re-booting the back-up computer, however, the exact cause of this issue is still under investigation.
- It was noted, during the Flood Event, when ALERT data captured in the RTFM was compared against equivalent data captured in Enviromon, the RTFM appeared to have received less total data for some sensors. Although this has no impact on modelling results, this issue is being investigated further as the reason could relate to a number of factors, including data transmission, data reception and data filtering processes. The differences detected are of no significance, however, the reason for this anomaly should be fully understood.
- During the Event, the email server in the Flood Operations Centre exceeded its size limit. This caused a short and temporary pause in email communication to and from the Flood Operations Centre and required the file working space to be freed to allow email traffic to flow again. This issue arose due to a combination of the volume of email traffic during certain periods of the Event, and also the size of some of the emails being transmitted. A routine clearing of the email server's working area easily solved this problem, and actions have been taken to ensure this issue does not arise again during flood events.
- Due to flooding in the Brisbane CBD, which resulted in parts of the city being disconnected from mains power, Seqwater's corporate communications were also impacted. Seqwater's corporate computer systems were unavailable for a period towards the end of the Event, however, this had no impact at all on the functioning of the main or back-up Flood Operations Centres.

4.5 North Pine Dam preparedness

Prior to the Flood Event, the Seqwater Operations Coordinator responsible for North Pine Dam ensured the following actions took place, in accordance with the Flood Procedure Manual:

- At least two Dam Operators were on close call for North Pine Dam at all times;
- Sufficient Dam Operators were available to staff North Pine Dam should a major flood event be declared;
- Contact details for the Dam Operators were up-to-date;
- Current copies of the following documents were available at North Pine Dam:
    - The Manual;
    - Emergency Action Plan;
    - Standing Operating Procedures;
    - Operation and Maintenance Manual.

- The following facilities were available at North Pine Dam:
  - Sufficient stationery and forms;
  - Landline telephone, mobile telephone, satellite telephone, Seqwater radio network, facsimile and email communication systems;
  - Power systems and back-up power systems to ensure computer systems and communication systems were able to operate reliably during the Flood Event.
- All preventative maintenance work was undertaken at the Dam, in accordance with the Dam Operation and Maintenance Manuals;
- Flood release infrastructure and associated back-up systems at the Dam were kept operationally ready;
- While on close call, Dam Operators ensured:
  - They were contactable at all times by telephone;
  - In the event of being “unfit for duty”, they reported to the Duty Flood Operations Engineer currently on close call;
  - They were able to travel to the Dam they were assigned to within two hours of being called.

4.6 North Pine Dam mobilisation

Following notification the Flood Event had been declared, the Seqwater Operations Coordinator responsible for North Pine Dam ensured the following actions were completed, in accordance with the Flood Procedure Manual:

- The Principal Engineer of Dam Safety was notified of the mobilisation;
- Significant events were recorded in the Event Log;
- The Dam Operators on close call were contacted and directed to travel to the Dam. Two Dam Operators were directed to site and at least two Dam Operators remained on duty at all times during the Event;
- During each shift, a Dam Operator was nominated to be the Dam Supervisor for the purposes of managing the Flood Event.

When arriving at the Dam, the Dam Supervisor completed the following actions, in accordance with the Flood Procedure Manual:

- Checked communication existed with the Flood Operations Centre;
- Commenced recording significant events in the Event Log;
- Completed the Flood Readiness Checklist contained in the Flood Procedure Manual;
- Undertook flood operations as directed by the Flood Operations Centre.

4.7 North Pine Dam operations

As the Flood Event commenced, the Dam Supervisor at North Pine Dam ensured the following actions took place in accordance with the Flood Procedure Manual:

- All significant events were recorded in the Event Log;
- Flood releases were undertaken in accordance with directions provided by the Flood Operations Centre;
- All notifications required by the Manuals and Emergency Action Plans were made;
- Handovers at the end of each shift were conducted to ensure incoming Officers were aware of:
  - Reservoir storage elevations at the Dam;
  - Radial gate, sluice gate and regulator valve openings at the Dam;
  - Status of the communication systems;
  - Any areas of concern associated with the management of the Flood Event.

- The Duty Flood Operations Engineer was advised of any issues arising during the Event, with the potential to adversely impact flood operations.
- A new Dam Supervisor was appointed at the beginning of each shift.

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5 DATA COLLECTION SYSTEM PERFORMANCE

5.1 Background

A real-time flood monitoring and forecasting system has been established to monitor rainfall and water levels in the Pine Rivers Basin and to provide adequate, accurate and timely information for informed decision-making.

Field stations consisting of rainfall and water level gauges use the Event Reporting Radio Telemetry System (ERRTS) to communicate data to the Flood Operations Centre. More than one gauge may be located at an individual field station. Water level gauges are often located at the Department of Environment and Resource Management (DERM) gauging stations. DERM is responsible for maintaining the water level gauges and Seqwater for maintaining the ERRTS equipment.

Rainfall gauges consist of a standard tipping bucket. Water level gauges vary in type and model but include shaft encoders, wet pressure transducers and dry pressure transducers. At a rainfall gauge, an event is defined as the tip of the bucket. At a water level rainfall gauge, an event is defined as an incremental increase or decrease in water level.

When an event is triggered at a gauge, data is transmitted via VHF radio through a series of redundant radio repeaters to the Flood Operations Centre and other data collection centres including BoM and Moreton Bay Regional Council. Each signal has a unique identification number. When the signal arrives at the Flood Operations Centre base station, it is relayed to a computer hardware platform serial port via a decoder. It is then time stamped, read, decoded, accepted or rejected, filtered, validated and then stored in a gauge database in the Centre's FLOOD-Col and Enviromon databases. Redundant base stations at Mineral House and the Land Centre in Brisbane's CBD are synchronised with the Flood Operations Centre database.

The FLOOD-Col and Enviromon databases contain gauge details including:

- Gauge name;
- ALERT number;
- Type of gauge;
- Calibration information;
- Alarm thresholds;
- Rating curve information, if applicable.

Both FLOOD-Col and Enviromon allow filtered gauge data to be viewed in either a text or graphical format. Information that can be viewed or edited includes height, discharge, rainfall pluviographs, rainfall hyetographs, lake levels and Dam volumes, and applications are also available for viewing groups of gauges.

The combination of ERRTS field stations, rainfall gauges and water level gauges, radio network and data collection software is referred to as an ALERT system. ALERT, or Automated Local Evaluation in Real Time System, has become a standard for flood warning systems in Australia and the United States of America, and is widely used by the Bureau of Meteorology (BoM) and other flood warning agencies throughout the world.

FLOOD-Ops is the modelling software used to analyse and produce forecast runoff. It extracts data from the FLOOD-Col database, calculates areal rainfalls and generates hydrographs of runoff. Model parameters can be adjusted and forecast rainfall included as an option. Results can be displayed and imported into gate operation models. The ALERT system, FLOOD-Ops and ancillary software make up the Real Time Flood Model (RTFM).

5.2 Field station descriptions

Seqwater operates 10 rain gauges and seven water level gauge field stations within and around the Pine Rivers Basin which report to the Flood Operations Centre via the ALERT system.

Manual gauge board readings are taken at North Pine Dam and Sideling Creek Dam (Lake Kurwongbah) to confirm the ALERT data received from these sites. These manual observations, taken as frequently as hourly at North Pine Dam, provided the basis for gate operations.

In addition to the Seqwater-owned and operated network, the Flood Operations Centre also has access to Enviromon, which collects data from an additional 225 rain gauges and nearly 200 water level gauges throughout South East Queensland.

Locations of the Seqwater rainfall stations are shown in Figure 5.2.1, and the Seqwater water level network is shown in Figure 5.2.2.

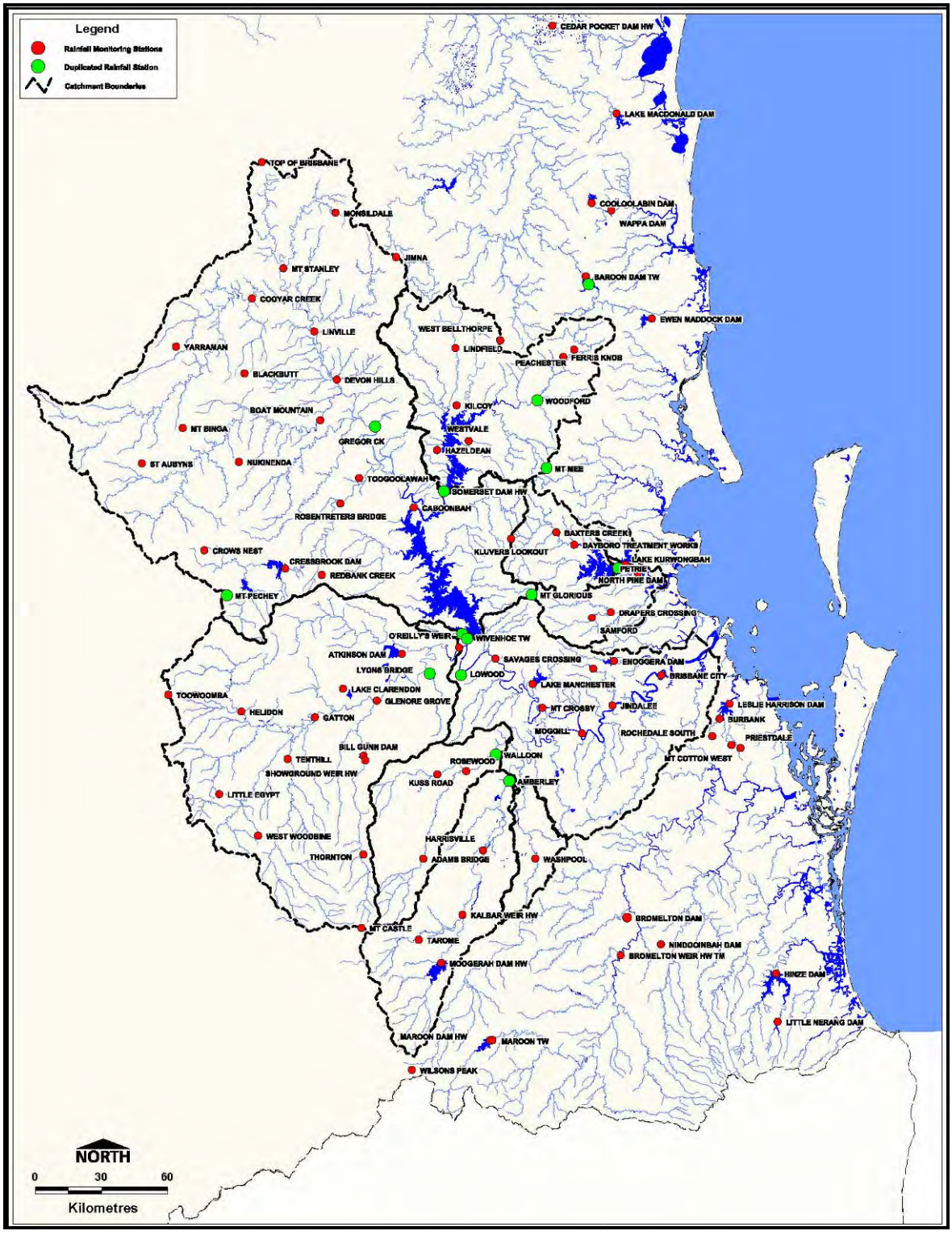

Figure 5.2.1 – Seqwater rainfall station network as at January 2011

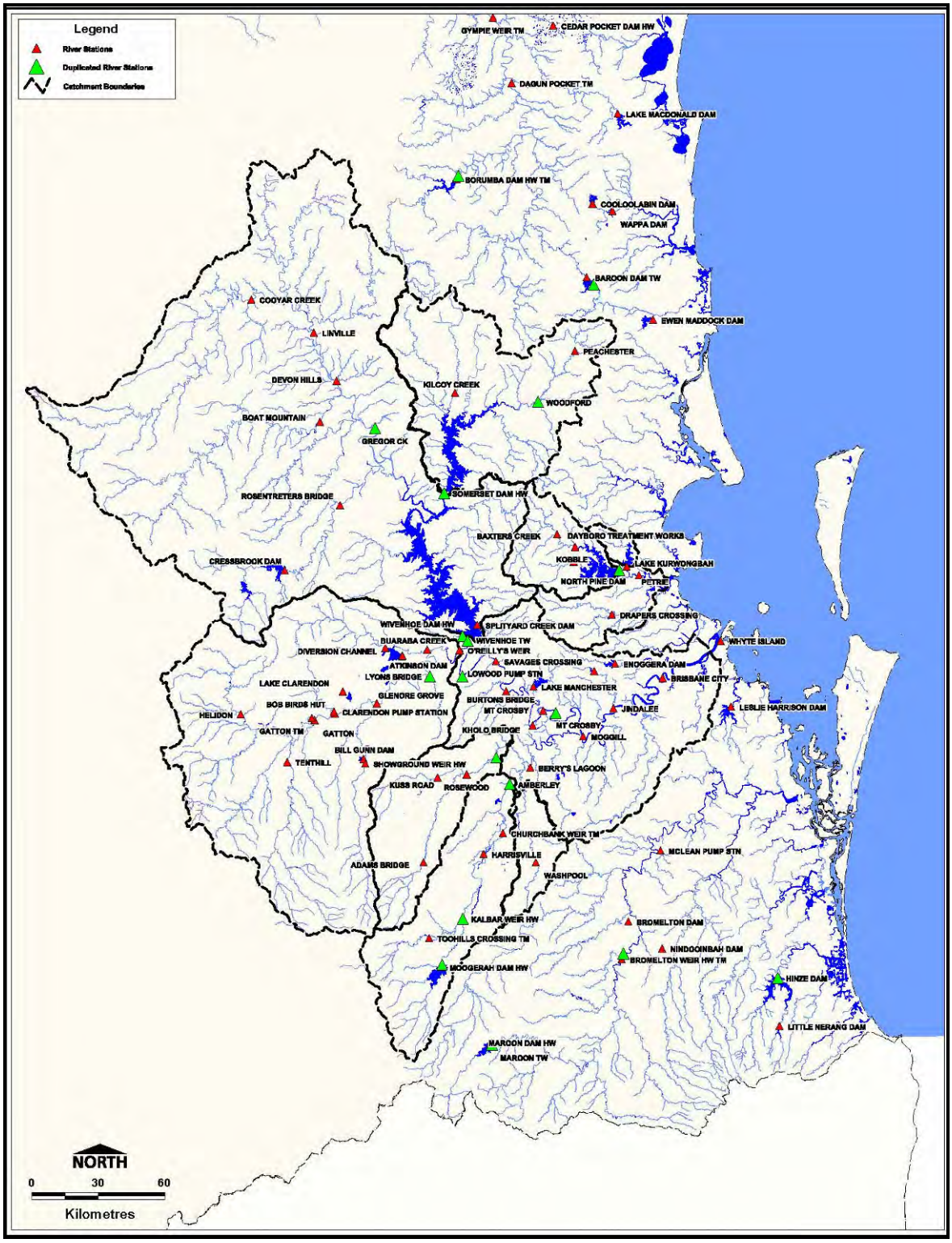

Figure 5.2.2 – Seqwater water level network as at January 2011

At all critical locations such as North Pine Dam, more than one gauge is located on an individual station site. This allows for the expected periodic non-operation of individual gauges that occurs due to the gauge (by necessity) being located in an exposed and harsh field environment. Accordingly, due to this in-built network redundancy, the presence of occasional non-operational gauges does not impact data quality.

At the commencement of the January 2011 Flood Event, 10 rain gauges (100% availability) and five out of seven river gauges (71% availability) were operational. The two water level gauges were marked 'Out of Action'. Details of these gauges are listed in Table 5.2.3.

River ID	Site	Status date 6 Jan 2011	Comment
6764	Petrie	Out of Action	This station is a long-term 'Out of Action' station that has been identified as redundant due to the availability of Council-owned stations nearby.
6762	North Pine Dam	Out of Action	Readings from this sensor were oscillating and did not match the gauge board observations. This did not impact operations due to the availability of manual readings. Manual readings are always used in preference to automatic gauge readings during flood events.

Table 5.2.3 – Water level gauges marked 'out of action'

For the duration of the Flood Event, approximately 132,000 individual observations (32,000 rainfall readings and 100,000 water level readings) were received in the Flood Operations Centre from the Seqwater ALERT network, including the stations in the Pine Rivers Basin. This provides an indication of the system load required to be managed during the Event.

5.3 Network maintenance

Seqwater's hydrographic unit is responsible for operating and maintaining the rainfall and water level network. This unit is assisted by RoadTek, the commercial construction arm of the Department of Transport and Main Roads.

Most rainfall stations are stand-alone instruments or are co-located with river level stations. Where possible, ALERT water level gauges take advantage of data provided by DERM-owned and maintained gauging stations to provide a robust source of reliable water level sensing.

5.4 Review of data collection system performance during the Event

The performance of the data collection system during the Event was satisfactory. No significant field failures or loss of data events occurred, and good quality data was provided to the Flood Operations Centre on a constant basis throughout the Event.

However, given such a major flood occurred, a routine review of system performance will be undertaken in conjunction with the BoM and the Moreton Bay Regional Council to determine if the system can be improved. At the time of writing, this process had not commenced, however, this work will proceed as soon as the appropriate personnel are available to undertake the review. Two factors that will be examined include:

- The expansion of the RTFM to include the Seqwater rainfall station at Dayboro WWTP;
- A revision of the rating at the Baxter's Creek water level station to account for the exceptionally high level reached by the gauge during the Event.

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6 EVENT DATA

6.1 Introduction

A real-time flood monitoring and forecasting system has been established to monitor rainfall and water levels in the Dam catchments and provide adequate, accurate and timely information for informed decision-making. This system is described in Section 5. A description of the operational rainfall and river height data collected during the Flood Event using this system, as well as a description of other supporting information used by the Flood Operations Centre to support decision-making during the Event, is included in this, Section 6.

> ***It should be noted, the data contained in this Section is operational data that was collected during the Event and upon which operational decisions were made. The data is considered accurate, however, only real-time validation of the data has been undertaken. More information may become available over time to add to the Event data presented in this Section.***

Within the operational system, the Pine Rivers Basin is divided into the four sub-catchments shown in Figure 6.1.1. The North Pine catchment represents the average catchment rainfall in the North Pine River to North Pine Dam. The Sideling Creek catchment shows the average catchment rainfall to Sideling Creek Dam. The South Pine catchment runs from the South Pine River to Cashs Crossing, and the Lower Pine represents the residual catchment area of the Pine Rivers Basin.

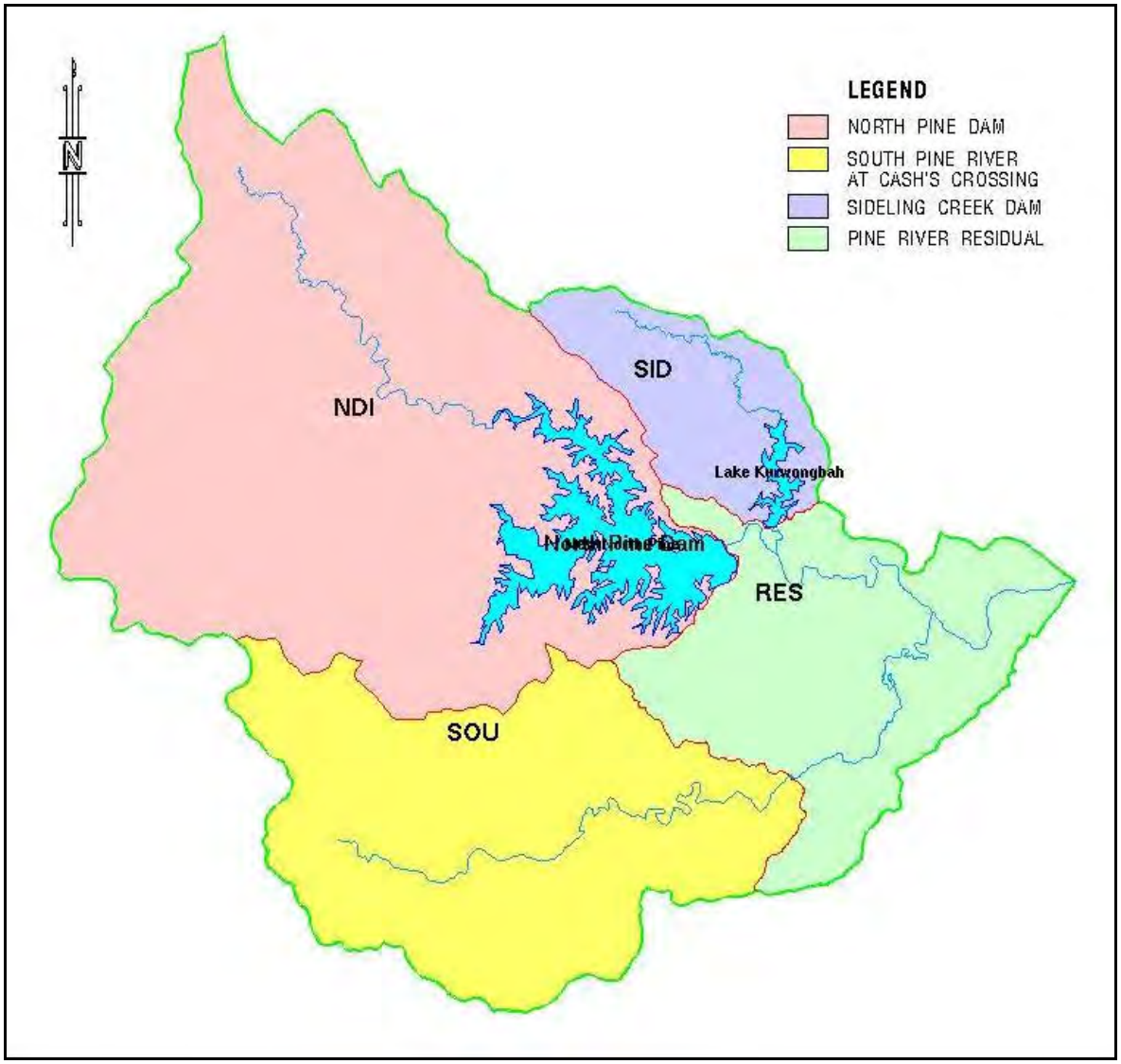

Figure 6.1.1 – Pine Rivers Basin region layout

6.2 Event rainfall totals

Table 6.2.1 shows the daily rainfall totals collected by the Flood Operations Centre (both FLOOD-Col and Enviromon) at selected rainfall stations (with ALERT numbers) during flood events at North Pine Dam.

Stations highlighted in **red** are configured in the flood models and are used to model flows.

24 hour period ending 09:00	Mt Mee	Kluvers Lookout	Mt Glorious	Dayboro WWTP	Baxters Creek	Mt Samson Road	North Pine Dam	Browns Creek	Lake Kurwongbah	Samford Village	Drapers Crossing	Petrie
	6690	6610	6680	1972	6711	1985	6759	1974	6766	1950	6769	6763
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
06/01/2011	10	5	30	14	4	20	5	2	6	16	3	6
07/01/2011	55	52	46	43	37	42	45	69	39	45	47	60
08/01/2011	48	24	17	29	24	24	5	14	7	6	9	5
09/01/2011	30	18	24	20	17	19	11	14	13	8	10	14
10/01/2011	221	124	204	150	127	146	83	132	79	153	124	121
11/01/2011	139	164	262	197	173	185	53	99	32	49	47	62
12/01/2011	179	192	229	228	194	149	68	102	57	103	86	55
13/01/2011	9	4	2	0	1	4	0	1	1	3	2	1
14/01/2011	4	1	0	1	1	1	1	1	0	0	0	2
15/01/2011	0	0	0	0	0	0	0	0	0	0	0	0

Table 6.2.1 – Daily rainfall totals by station for the period of North Pine Dam operations

Figures 6.2.2 to 6.2.9 illustrate the data contained in Table 6.2.1. Figures in **red** indicate possible errors in the data.

The 24-hour totals in Table 6.2.1 were created after the Event using the Event's full data record. The 24-hour totals shown on the map for each day may be slightly different as they represent the data as it was at that point in time. If a data signal was not received, the interpolations to 09:00 will vary from the complete data set.

Rainfall in the 24 hours to 09:00 on Thursday 6 January 2011

In the 24 hours to 09:00 on Thursday 6 January 2011, only light rainfall was recorded throughout the area, with totals ranging from 4mm to 30mm.

Figure 6.2.2 - Rainfall in the 24 hours to 09:00 on Thursday 6 January 2011

Rainfall in the 24 hours to 09:00 on Friday 7 January 2011

Compared to the previous period, rainfall intensified and was more widespread in the 24 hours to 09:00 on Friday 7 January 2011 with totals generally between 40mm to 60mm.

Figure 6.2.3 - Rainfall in the 24 hours to 09:00 on Friday 7 January 2011

Rainfall in the 24 hours to 09:00 on Saturday 8 January 2011

Rainfall totals in the 24 hours to 09:00 on Saturday 8 January 2011 were generally much lower than the previous 24 hours. Totals were below 25mm, however, there was an isolated high fall of 48mm at Mt Mee.

Figure 6.2.4 - Rainfall in the 24 hours to 09:00 on Saturday 8 January 2011

Rainfall in the 24 hours to 09:00 on Sunday 9 January 2011

Rainfall throughout the Pine Rivers Basin was widespread in the 24 hours to 09:00 on Sunday 9 January 2011, with totals between 10mm to 30mm.

Figure 6.2.5 - Rainfall in the 24 hours to 09:00 on Sunday 9 January 2011

Rainfall in the 24 hours to 09:00 on Monday 10 January 2011

The rainfall in the 24 hours to 09:00 on Monday 10 January 2011 was especially high along the western ridge of the Pine River catchment. Falls of 221mm and 204mm were recorded at Mt Mee in the north and Mt Glorious in the south. Elsewhere, widespread falls ranging from 83mm to 132mm were recorded.

Figure 6.2.6 - Rainfall in the 24 hours to 09:00 on Monday 10 January 2011

Rainfall in the 24 hours to 09:00 on Tuesday 11 January 2011

Heavy rain continued to be recorded throughout the Pine Rivers Basin in the 24 hours to 09:00 on Tuesday 11 January 2011, with the highest total of 262mm recorded at Mt Glorious. The highest rainfall appears to have been limited to the catchment area upstream of the reservoir area. In the lower reaches of the North Pine River, around the Dam itself, totals were limited to between 50mm and 70mm. One of the rainfall gauges located at the Dam wall malfunctioned during this period and is shown in **red**. This did not affect operational decision-making as manual rainfall readings were also available.

Figure 6.2.7 - Rainfall in the 24 hours to 09:00 on Tuesday 11 January 2011

Rainfall in the 24 hours to 09:00 on Wednesday 12 January 2011

Similar to the previous day, high rainfall continued in the upper reaches of the North Pine and South Pine Rivers, with falls exceeding 220mm in the 24 hours to 09:00 on Wednesday 12 January 2011.

The heaviest falls appear to have been limited to the area upstream of the Dam itself, with falls around the Dam being half the level of those recorded in the upper part of the catchment.

Figure 6.2.8 – Rainfall in the 24 hours to 09:00 on Wednesday 12 January 2011

Rainfall in the seven days to 09:00 on Wednesday 12 January 2011

Figure 6.2.9 illustrates the rainfall distribution during the seven-day period to 09:00 on Wednesday 12 January 2011.

The highest totals were recorded in the headwater ridges of the North Pine Dam catchment and along the D'Aguilar Range from Mt Mee to Mt Glorious. Elsewhere throughout the Pine Rivers Basin, rainfall totals – while still significant – were half the level of those recorded at elevated stations.

Figure 6.2.9 - Rainfall in the seven days to 09:00 on Wednesday 12 January 2011

6.3 Event rainfall temporal patterns

Temporal patterns are critical to the flood modelling process and the resulting inflow hydrographs. They define the distribution of the rainfall with time, and indicate the distinct periods of heavy rainfall that occurred throughout the Pine Rivers Basin. The following conclusions can be drawn by examining the hourly rainfall data in Table 6.3.1 showing data for selected stations (with ALERT numbers):

- The period of heaviest rainfall recorded in North Pine catchment commenced on the morning of Tuesday 11 January 2011 and continued into the afternoon (these values are bolded in the table);
- Hourly rainfall totals during the critical period of heavy rainfall, on the morning of Tuesday 11 January 2011, are highlighted in Table 6.3.1. The table shows heavy rainfall commenced at approximately 05:00 and continued until 14:00, with totals of nearly 400mm recorded.

Hourly rainfall stations North Pine Dam

Hour ending	Mt Mee	Kluvers Lookout	Mt Glorious	Dayboro WWTP	Baxters Creek	Mt Samson Road	North Pine Dam	Browns Creek	Lake Kurwongbah	Samford Village	Drapers Crossing	Petrie
	6690	6610	6680	1972	6711	1985	6759	1974	6766	1950	6769	6763
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
05/01/2011 10:00	0	0	0	0	0	0	0	0	0	0	0	0
05/01/2011 11:00	0	0	0	0	0	0	0	0	0	0	0	0
05/01/2011 12:00	0	0	0	0	0	0	0	0	0	0	0	0
05/01/2011 13:00	0	0	0	0	0	0	0	0	0	0	0	0
05/01/2011 14:00	0	0	0	0	0	0	0	0	0	0	0	0
05/01/2011 15:00	0	0	0	0	0	0	0	0	0	0	0	0
05/01/2011 16:00	0	0	0	0	0	0	0	0	0	0	0	0
05/01/2011 17:00	0	0	0	0	0	0	0	0	0	0	0	0
05/01/2011 18:00	4	0	5	10	1	4	0	0	0	0	0	0
05/01/2011 19:00	0	0	1	1	0	9	0	0	0	7	1	0
05/01/2011 20:00	0	0	0	0	0	0	0	0	0	0	0	0
05/01/2011 21:00	1	1	7	0	0	3	0	0	0	0	0	0
05/01/2011 22:00	4	2	16	3	3	3	4	1	4	8	2	6
05/01/2011 23:00	1	1	0	0	0	1	0	1	0	1	0	0
06/01/2011 00:00	0	0	0	0	0	0	0	0	2	0	0	0
06/01/2011 01:00	0	0	0	0	0	0	0	0	0	0	0	0
06/01/2011 02:00	0	0	0	0	0	0	0	0	0	0	0	0
06/01/2011 03:00	0	0	0	0	0	0	0	0	0	0	0	0
06/01/2011 04:00	0	0	1	0	0	0	0	0	0	0	0	0
06/01/2011 05:00	0	1	0	0	0	0	0	0	0	0	0	0
06/01/2011 06:00	0	0	0	0	0	0	0	0	0	0	0	0
06/01/2011 07:00	0	0	0	0	0	0	1	0	0	0	0	0
06/01/2011 08:00	0	0	0	0	0	0	0	0	0	0	0	0

Hourly rainfall stations North Pine Dam

Hour ending	Mt Mee	Kluvers Lookout	Mt Glorious	Dayboro WWTP	Baxters Creek	Mt Samson Road	North Pine Dam	Browns Creek	Lake Kurwongbah	Samford Village	Drapers Crossing	Petrie
	6690	6610	6680	1972	6711	1985	6759	1974	6766	1950	6769	6763
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
06/01/2011 09:00	0	0	0	0	0	0	0	0	0	0	0	0
06/01/2011 10:00	0	0	0	0	0	0	0	0	0	0	0	0
06/01/2011 11:00	0	0	0	0	0	0	0	0	0	0	0	0
06/01/2011 12:00	0	7	0	0	0	0	0	0	0	0	11	0
06/01/2011 13:00	0	6	13	0	0	0	0	0	0	1	1	8
06/01/2011 14:00	16	12	6	8	6	9	10	28	7	16	7	12
06/01/2011 15:00	0	0	0	1	1	0	2	2	7	2	1	5
06/01/2011 16:00	1	2	1	2	2	1	1	1	0	0	0	0
06/01/2011 17:00	3	4	3	6	4	5	4	7	5	3	3	4
06/01/2011 18:00	1	0	2	3	2	5	4	7	4	4	4	4
06/01/2011 19:00	0	0	0	0	1	0	2	1	1	1	1	2
06/01/2011 20:00	0	0	0	0	0	0	1	1	2	0	0	1
06/01/2011 21:00	0	0	0	0	0	0	0	0	0	0	0	0
06/01/2011 22:00	0	0	0	0	0	0	0	0	0	0	0	0
06/01/2011 23:00	0	0	0	0	0	0	0	0	0	0	0	0
07/01/2011 00:00	0	0	0	0	0	0	0	0	0	0	0	0
07/01/2011 01:00	0	0	0	0	0	0	0	0	0	0	0	0
07/01/2011 02:00	1	1	1	0	0	0	0	0	0	0	1	0
07/01/2011 03:00	1	0	2	1	0	1	0	0	0	0	0	0
07/01/2011 04:00	0	0	1	0	0	0	0	0	0	0	0	0
07/01/2011 05:00	3	0	0	0	1	0	0	0	0	0	0	0
07/01/2011 06:00	4	0	0	0	0	0	0	0	0	0	0	0
07/01/2011 07:00	1	2	0	1	0	0	0	0	0	0	0	0
07/01/2011 08:00	12	0	0	0	1	0	0	10	1	0	0	0
07/01/2011 09:00	7	14	7	15	15	17	18	8	12	5	12	22
07/01/2011 10:00	4	4	10	6	4	4	2	4	0	13	6	2
07/01/2011 11:00	13	3	4	2	1	2	2	1	1	1	1	0
07/01/2011 12:00	28	14	2	23	19	13	2	12	3	3	4	3
07/01/2011 13:00	4	4	8	1	1	3	0	0	0	1	0	0
07/01/2011 14:00	1	1	0	0	0	0	0	0	0	0	0	1
07/01/2011 15:00	1	0	0	0	0	3	0	1	0	0	0	0
07/01/2011 16:00	0	0	0	0	0	0	0	0	0	0	0	0
07/01/2011 17:00	0	0	0	0	0	0	0	0	0	0	0	0

Hourly rainfall stations North Pine Dam

Hour ending	Mt Mee	Kluvers Lookout	Mt Glorious	Dayboro WWTP	Baxters Creek	Mt Samson Road	North Pine Dam	Browns Creek	Lake Kurwongbah	Samford Village	Drapers Crossing	Petrie
	6690	6610	6680	1972	6711	1985	6759	1974	6766	1950	6769	6763
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
07/01/2011 18:00	0	0	0	0	0	0	0	0	0	0	4	0
07/01/2011 19:00	1	1	2	3	3	3	2	0	2	0	1	1
07/01/2011 20:00	0	2	0	0	0	0	0	0	0	0	0	0
07/01/2011 21:00	0	0	0	0	0	0	0	0	0	0	0	0
07/01/2011 22:00	0	0	1	0	0	0	0	0	0	1	0	0
07/01/2011 23:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 00:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 01:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 02:00	1	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 03:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 04:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 05:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 06:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 07:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 08:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 09:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 10:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 11:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 12:00	0	0	1	0	0	0	0	0	0	0	0	0
08/01/2011 13:00	0	0	1	1	0	1	1	0	1	0	1	2
08/01/2011 14:00	0	1	1	1	2	1	0	0	1	0	0	1
08/01/2011 15:00	1	2	4	3	2	5	4	3	4	0	3	5
08/01/2011 16:00	0	0	0	0	0	0	0	0	0	0	0	0
08/01/2011 17:00	0	0	0	0	0	0	0	1	0	0	0	0
08/01/2011 18:00	1	1	1	0	1	1	1	0	0	0	0	0
08/01/2011 19:00	4	0	0	4	3	1	0	1	0	0	0	0
08/01/2011 20:00	1	1	1	1	1	0	0	0	0	0	0	0
08/01/2011 21:00	0	0	0	0	0	0	1	1	0	0	0	1
08/01/2011 22:00	1	0	3	1	1	3	0	0	0	2	1	0
08/01/2011 23:00	2	5	3	0	0	2	0	0	1	0	0	0
09/01/2011 00:00	1	1	0	0	0	0	0	1	0	0	0	0
09/01/2011 01:00	0	0	0	0	0	1	0	0	0	0	0	0
09/01/2011 02:00	0	0	0	0	0	0	0	0	0	0	0	0

Hourly rainfall stations North Pine Dam

Hour ending	Mt Mee	Kluvers Lookout	Mt Glorious	Dayboro WWTP	Baxters Creek	Mt Samson Road	North Pine Dam	Browns Creek	Lake Kurwongbah	Samford Village	Drapers Crossing	Petrie
	6690	6610	6680	1972	6711	1985	6759	1974	6766	1950	6769	6763
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
09/01/2011 03:00	0	1	1	0	0	0	0	0	0	0	1	0
09/01/2011 04:00	1	0	1	1	1	0	0	1	0	0	1	0
09/01/2011 05:00	3	1	1	3	3	2	2	2	4	0	0	4
09/01/2011 06:00	6	2	0	3	2	1	1	3	0	0	0	0
09/01/2011 07:00	7	1	4	1	1	0	0	0	0	2	1	0
09/01/2011 08:00	0	0	0	0	0	0	0	0	1	0	0	0
09/01/2011 09:00	0	1	1	0	0	0	1	0	0	4	2	0
09/01/2011 10:00	1	0	0	0	0	0	0	0	0	0	0	0
09/01/2011 11:00	18	7	5	6	6	3	0	5	1	9	4	1
09/01/2011 12:00	18	10	22	10	11	15	5	6	7	24	19	10
09/01/2011 13:00	6	7	5	7	4	2	1	7	0	0	0	1
09/01/2011 14:00	4	1	1	1	1	0	0	1	3	1	0	0
09/01/2011 15:00	13	2	2	2	2	0	0	4	0	1	0	0
09/01/2011 16:00	41	18	17	28	20	30	13	26	20	11	11	13
09/01/2011 17:00	10	11	25	6	5	15	6	2	6	14	8	5
09/01/2011 18:00	8	5	4	8	8	3	2	6	0	2	2	2
09/01/2011 19:00	20	6	8	6	6	6	2	5	0	3	4	4
09/01/2011 20:00	7	5	8	7	6	4	4	5	9	9	6	3
09/01/2011 21:00	7	9	30	5	6	7	3	4	6	25	19	8
09/01/2011 22:00	10	2	1	3	2	2	0	2	1	2	1	1
09/01/2011 23:00	1	1	3	1	1	0	1	1	1	0	0	0
10/01/2011 00:00	9	5	9	10	8	10	8	9	11	5	5	10
10/01/2011 01:00	10	4	9	7	6	6	3	6	4	3	3	3
10/01/2011 02:00	3	2	3	5	4	3	2	5	4	3	3	4
10/01/2011 03:00	2	2	4	5	6	4	2	3	3	2	2	3
10/01/2011 04:00	2	1	1	1	0	0	1	1	1	0	1	1
10/01/2011 05:00	6	3	3	5	4	4	4	5	0	2	3	4
10/01/2011 06:00	10	8	23	11	8	18	13	14	0	13	13	16
10/01/2011 07:00	3	4	5	3	2	2	1	2	2	3	1	2
10/01/2011 08:00	4	2	3	4	3	3	3	6	1	3	2	4
10/01/2011 09:00	6	6	9	5	5	7	7	4	0	16	16	26
10/01/2011 10:00	4	4	4	4	3	3	1	4	0	1	1	1
10/01/2011 11:00	0	1	1	1	1	1	5	0	0	3	4	24

Hourly rainfall stations North Pine Dam

Hour ending	Mt Mee	Kluvers Lookout	Mt Glorious	Dayboro WWTP	Baxters Creek	Mt Samson Road	North Pine Dam	Browns Creek	Lake Kurwongbah	Samford Village	Drapers Crossing	Petrie
	6690	6610	6680	1972	6711	1985	6759	1974	6766	1950	6769	6763
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
10/01/2011 12:00	8	7	20	4	2	18	25	3	0	13	13	8
10/01/2011 13:00	5	4	1	3	3	1	0	1	0	0	0	0
10/01/2011 14:00	2	3	3	2	1	0	0	0	0	0	0	0
10/01/2011 15:00	5	0	3	1	1	2	0	0	0	1	1	0
10/01/2011 16:00	1	4	3	2	3	3	1	3	1	1	0	1
10/01/2011 17:00	0	1	2	0	0	0	0	0	0	0	0	0
10/01/2011 18:00	0	0	1	0	0	2	0	0	0	2	1	0
10/01/2011 19:00	1	0	0	0	0	0	0	0	0	0	0	0
10/01/2011 20:00	1	2	3	1	1	4	2	0	1	0	0	0
10/01/2011 21:00	5	0	1	2	1	1	0	1	0	0	0	1
10/01/2011 22:00	3	2	3	2	1	2	0	1	1	3	3	3
10/01/2011 23:00	1	2	9	1	1	2	0	0	0	1	0	0
11/01/2011 00:00	2	0	1	1	0	0	0	0	0	1	0	0
11/01/2011 01:00	1	2	1	0	0	0	0	0	0	0	0	0
11/01/2011 02:00	0	0	0	0	0	0	0	0	0	0	0	0
11/01/2011 03:00	0	1	1	5	10	0	3	0	2	2	3	0
11/01/2011 04:00	4	2	3	0	0	2	1	1	0	3	2	4
11/01/2011 05:00	9	1	9	15	7	7	0	6	0	1	1	0
11/01/2011 06:00	14	12	14	14	6	11	0	15	0	1	1	1
11/01/2011 07:00	24	26	27	23	30	17	2	7	2	3	1	0
11/01/2011 08:00	29	46	28	26	37	26	3	13	6	8	9	8
11/01/2011 09:00	9	7	57	46	28	48	3	23	5	0	0	3
11/01/2011 10:00	15	40	**71**	48	39	38	9	24	12	6	8	9
11/01/2011 11:00	16	36	51	**82**	**70**	**51**	**22**	**46**	**24**	**24**	**25**	21
11/01/2011 12:00	24	**50**	50	43	43	17	2	4	0	21	9	3
11/01/2011 13:00	33	33	39	52	28	34	18	26	15	19	14	6
11/01/2011 14:00	**59**	33	28	26	26	27	14	14	19	16	17	12
11/01/2011 15:00	9	20	28	17	22	12	6	9	0	9	7	6
11/01/2011 16:00	5	7	5	2	3	3	2	1	0	4	5	2
11/01/2011 17:00	4	1	3	1	0	0	0	1	0	2	1	2
11/01/2011 18:00	13	6	4	0	0	0	1	0	0	0	0	0
11/01/2011 19:00	5	1	2	1	1	1	0	0	0	2	3	0
11/01/2011 20:00	1	3	3	1	1	2	1	1	0	1	0	2

Hourly rainfall stations North Pine Dam												
Hour ending	Mt Mee	Kluvers Lookout	Mt Glorious	Dayboro WWTP	Baxters Creek	Mt Samson Road	North Pine Dam	Browns Creek	Lake Kurwongbah	Samford Village	Drapers Crossing	Petrie
	6690	6610	6680	1972	6711	1985	6759	1974	6766	1950	6769	6763
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
11/01/2011 21:00	0	0	0	1	0	0	0	1	0	1	0	0
11/01/2011 22:00	0	1	2	0	0	0	0	0	0	0	0	0
11/01/2011 23:00	2	0	0	0	0	0	0	0	0	0	0	1
12/01/2011 00:00	2	0	2	1	0	0	1	0	0	2	0	0
12/01/2011 01:00	1	1	1	0	1	0	0	0	0	0	2	0
12/01/2011 02:00	3	0	4	0	0	1	0	0	1	1	3	0
12/01/2011 03:00	0	0	0	0	0	0	0	0	0	1	0	0
12/01/2011 04:00	1	1	1	1	0	0	1	0	0	0	0	0
12/01/2011 05:00	0	0	3	0	0	0	0	0	0	0	1	0
12/01/2011 06:00	0	0	0	0	0	0	0	0	0	0	0	0
12/01/2011 07:00	0	0	2	0	0	1	0	0	0	0	0	0
12/01/2011 08:00	0	0	1	0	0	0	0	0	0	0	0	0
12/01/2011 09:00	0	0	0	0	0	0	0	0	0	0	0	0

Table 6.3.1 – Hourly rainfall totals recorded seven days ending 09:00 on Wednesday 12 January 2011

Temporal patterns for selected stations in Table 6.3.1 are located in the sub-catchment of those shown in Figures 6.2.2 to 6.2.9. They are plotted in Figures 6.3.2 to 6.3.5 below, to demonstrate the difference between sub-catchment and station intensities and patterns.

For this Event, the Baxters Creek gauge, near the centre of the catchment, represents the temporal pattern of the rainfall on the North Pine Dam catchment. This is the same for the Samford Village gauge which represents the South Pine River catchment, the Browns Creek gauge for Sideling Creek catchment and the Petrie gauge for the Lower Pine catchment.

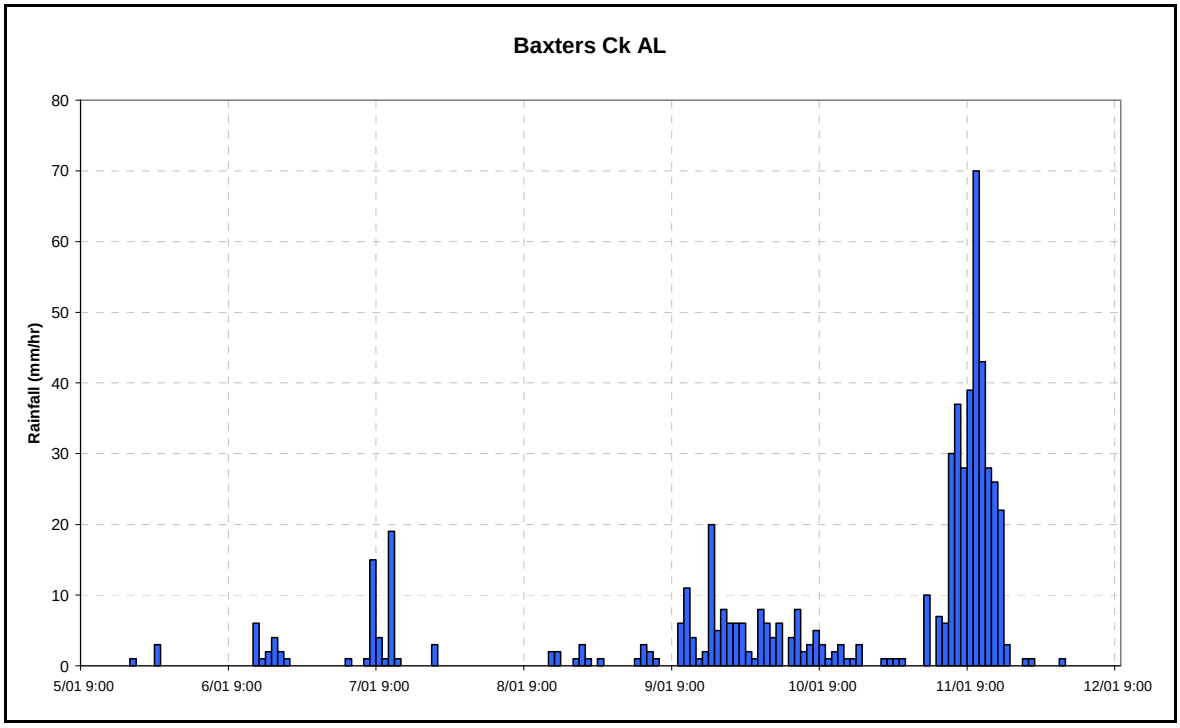

Figure 6.3.2 – Baxters Creek gauge, North Pine Dam catchment

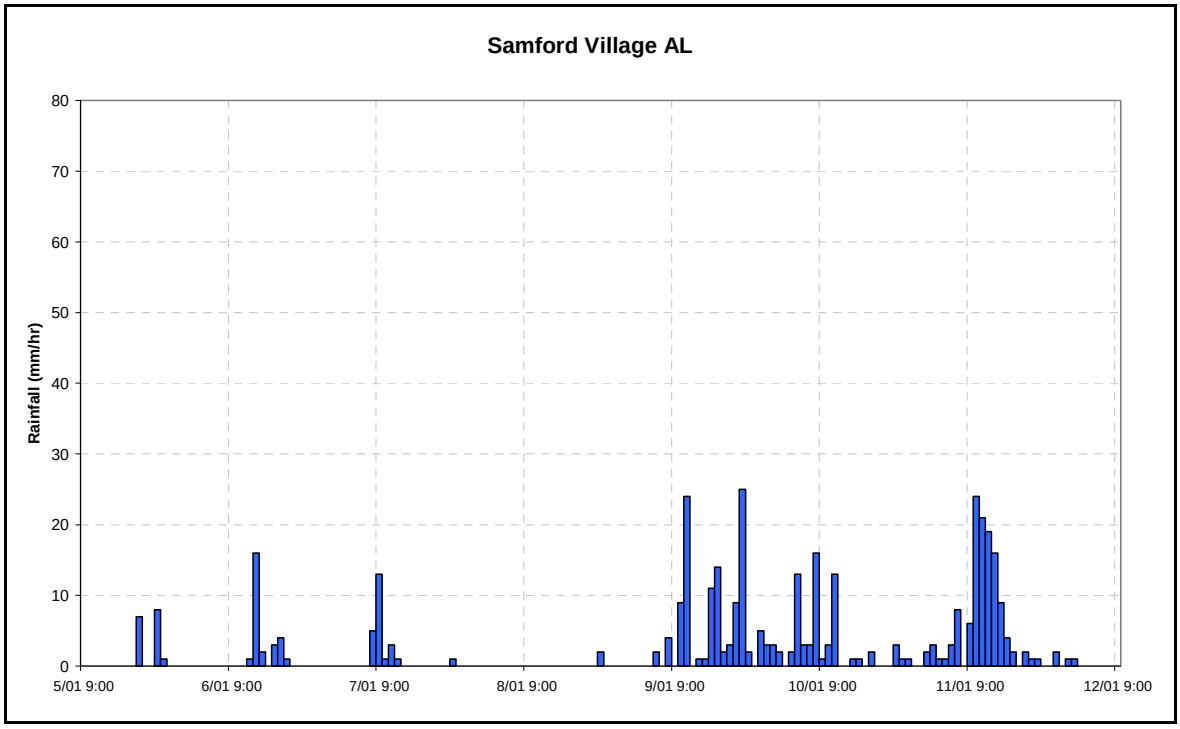

Figure 6.3.3 – Samford Village gauge, South Pine River catchment

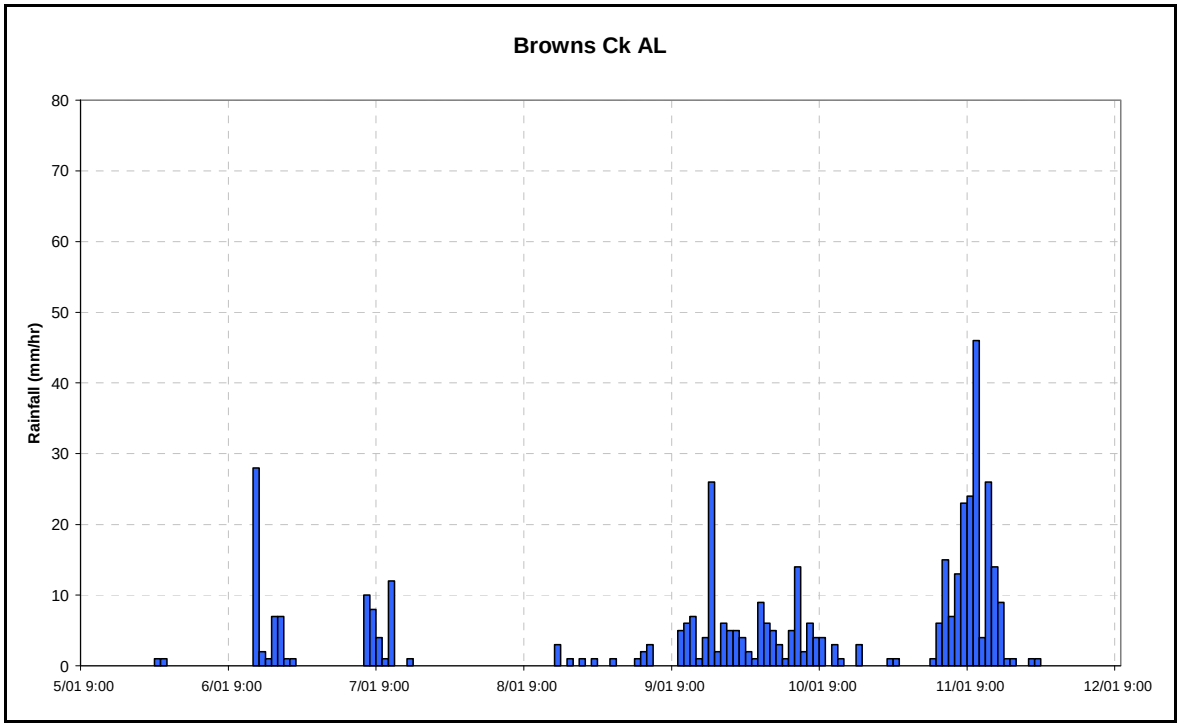

Figure 6.3.4 – Browns Creek gauge, Sideling Creek catchment

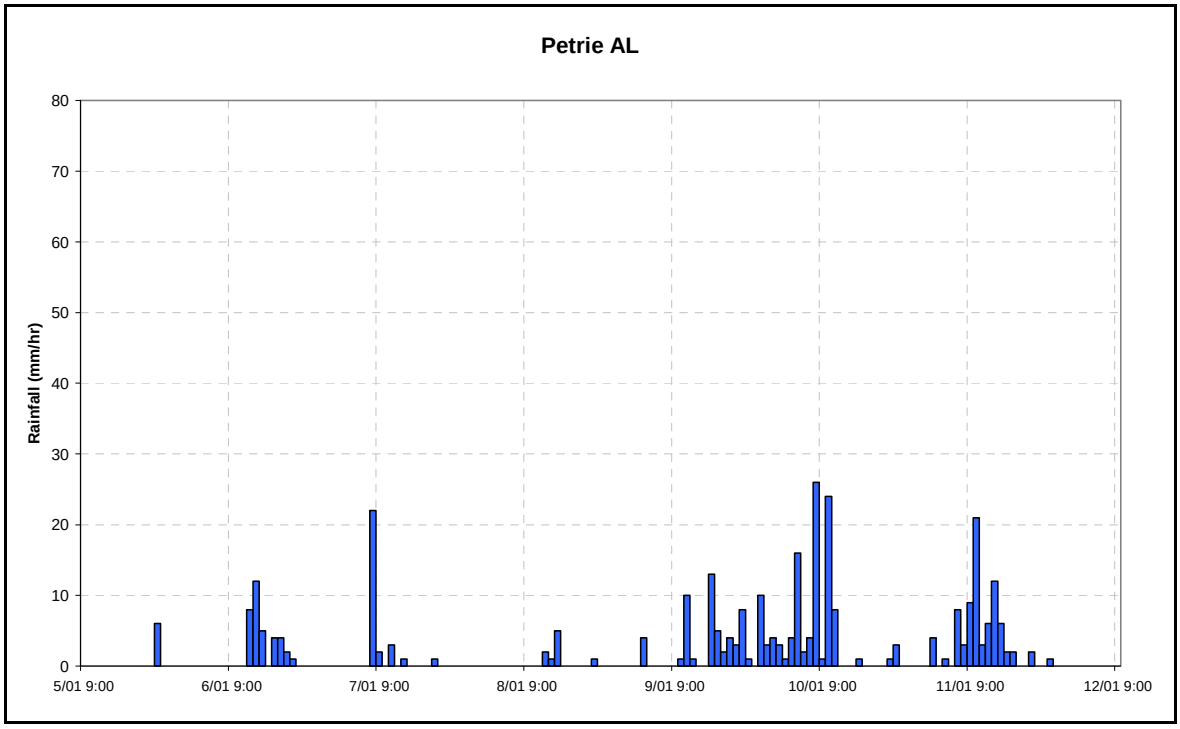

Figure 6.3.5 – Petrie gauge, Lower Pine catchment

6.4 Average catchment rainfalls

Over the seven-day period of the Event (Event 14) ending 09:00 on Wednesday 12 January 2011, the highest rainfall total recorded in any of the Seqwater-operated gauges was 814mm. This was recorded at the Mt Glorious gauge, just to the west of North Pine Dam.

The individual highest daily (24 hours to 09:00 on the date indicated) rainfall totals were:

- Mt Mee 222mm on Monday 10 January 2011;
- Mt Glorious 262mm on Tuesday 11 January 2011;
- Mt Glorious 229mm on Wednesday 12 January 2011.

The average rainfall for each sub-catchment in the Pine Rivers Basin is determined by applying a weighting to the rainfall depth at each available station within the sub-catchment.

Daily rainfall (mm)								
Period ending 09:00	North Pine (NDI)		Sideling Creek (SID)		South Pine (SOU)		Lower Pine (RES)	
	Period	Σ	Period	Σ	Period	Σ	Period	Σ
	mm	mm	mm	mm	mm	mm	mm	mm
06/01/2011	9	9	5	5	14	14	5	5
07/01/2011	43	52	40	46	41	56	50	55
08/01/2011	21	74	8	54	10	65	6	61
09/01/2011	18	91	12	66	16	81	11	72
10/01/2011	139	230	87	153	122	203	108	180
11/01/2011	161	391	54	207	109	312	52	232
12/01/2011	176	567	79	286	117	429	61	293
13/01/2011	2	569	1	287	2	431	1	294

Table 6.4.1 – Daily rainfall throughout the total Pine Rivers Basin

The following catchment average rainfall hyetographs (Figures 6.4.3 to 6.4.6) are based on the catchment average rainfall shown in Table 6.4.2, however, they do not necessarily reflect the localised high intensity rainfall recorded throughout the Basin at various times and locations.

Catchment rainfalls can include hourly intensities at individual stations which can be up to five times the catchment average.

Start of period	North Pine (NDI)	Sideling Creek (SID)	South Pine (SOU)	Lower Pine (RES)
05/01/2011 09:00				
05/01/2011 10:00	0.0	0.0	0.0	0.0
05/01/2011 11:00	0.0	0.0	0.0	0.0
05/01/2011 12:00	0.0	0.0	0.0	0.0
05/01/2011 13:00	0.0	0.0	0.0	0.0
05/01/2011 14:00	0.0	0.0	0.0	0.0
05/01/2011 15:00	0.0	0.0	0.0	0.0
05/01/2011 16:00	0.0	0.0	0.0	0.0

Start of period	North Pine (NDI)	Sideling Creek (SID)	South Pine (SOU)	Lower Pine (RES)
05/01/2011 17:00	1.5	0.0	1.7	0.0
05/01/2011 18:00	0.2	0.0	1.0	0.3
05/01/2011 19:00	0.0	0.0	0.0	0.0
05/01/2011 20:00	1.4	0.0	2.4	0.0
05/01/2011 21:00	5.2	2.4	6.8	4.3
05/01/2011 22:00	0.2	0.0	0.0	0.0
05/01/2011 23:00	0.0	1.2	0.0	0.1
06/01/2011 00:00	0.0	0.0	0.0	0.0
06/01/2011 01:00	0.0	0.0	0.0	0.0
06/01/2011 02:00	0.0	0.0	0.0	0.0
06/01/2011 03:00	0.2	0.0	0.3	0.0
06/01/2011 04:00	0.2	0.0	0.0	0.0
06/01/2011 05:00	0.0	0.0	0.0	0.0
06/01/2011 06:00	0.2	0.0	0.0	0.1
06/01/2011 07:00	0.0	0.0	0.0	0.0
06/01/2011 08:00	0.0	0.0	0.0	0.0
06/01/2011 09:00	0.0	0.0	0.0	0.0
06/01/2011 10:00	0.0	0.0	0.0	0.0
06/01/2011 11:00	1.6	0.0	7.3	2.8
06/01/2011 12:00	3.2	0.0	5.1	4.6
06/01/2011 13:00	8.4	4.3	6.7	9.7
06/01/2011 14:00	0.6	4.3	0.7	3.3
06/01/2011 15:00	1.5	0.0	0.3	0.1
06/01/2011 16:00	3.7	3.1	3.0	3.6
06/01/2011 17:00	2.0	2.4	3.3	3.8
06/01/2011 18:00	0.8	0.6	0.7	1.6
06/01/2011 19:00	0.2	1.2	0.0	0.7
06/01/2011 20:00	0.0	0.0	0.0	0.0
06/01/2011 21:00	0.0	0.0	0.0	0.0
06/01/2011 22:00	0.0	0.0	0.0	0.0
06/01/2011 23:00	0.0	0.0	0.0	0.0
07/01/2011 00:00	0.0	0.0	0.0	0.0
07/01/2011 01:00	0.4	0.0	1.0	0.3
07/01/2011 02:00	0.4	0.0	0.7	0.0
07/01/2011 03:00	0.2	0.0	0.3	0.0
07/01/2011 04:00	0.6	0.0	0.0	0.0
07/01/2011 05:00	0.2	0.0	0.0	0.0
07/01/2011 06:00	0.4	0.0	0.0	0.0
07/01/2011 07:00	1.1	0.6	0.0	0.0
07/01/2011 08:00	13.3	7.3	10.3	17.3
07/01/2011 09:00	4.8	0.0	7.4	2.8

6 EVENT DATA (continued)

Start of period	North Pine (NDI)	Sideling Creek (SID)	South Pine (SOU)	Lower Pine (RES)
07/01/2011 10:00	2.7	0.6	2.0	0.5
07/01/2011 11:00	12.7	1.8	3.3	3.0
07/01/2011 12:00	2.7	0.0	2.7	0.0
07/01/2011 13:00	0.2	0.0	0.0	0.5
07/01/2011 14:00	0.1	0.0	0.0	0.0
07/01/2011 15:00	0.0	0.0	0.0	0.0
07/01/2011 16:00	0.0	0.0	0.0	0.0
07/01/2011 17:00	0.2	0.0	2.6	1.0
07/01/2011 18:00	2.2	1.2	1.3	1.1
07/01/2011 19:00	0.3	0.0	0.0	0.0
07/01/2011 20:00	0.0	0.0	0.0	0.0
07/01/2011 21:00	0.2	0.0	0.3	0.0
07/01/2011 22:00	0.0	0.0	0.0	0.0
07/01/2011 23:00	0.0	0.0	0.0	0.0
08/01/2011 00:00	0.0	0.0	0.0	0.0
08/01/2011 01:00	0.1	0.0	0.0	0.0
08/01/2011 02:00	0.0	0.0	0.0	0.0
08/01/2011 03:00	0.0	0.0	0.0	0.0
08/01/2011 04:00	0.0	0.0	0.0	0.0
08/01/2011 05:00	0.0	0.0	0.0	0.0
08/01/2011 06:00	0.0	0.0	0.0	0.0
08/01/2011 07:00	0.0	0.0	0.0	0.0
08/01/2011 08:00	0.0	0.0	0.0	0.0
08/01/2011 09:00	0.0	0.0	0.0	0.0
08/01/2011 10:00	0.0	0.0	0.0	0.0
08/01/2011 11:00	0.2	0.0	0.3	0.0
08/01/2011 12:00	0.4	0.6	1.0	1.5
08/01/2011 13:00	1.2	0.6	0.3	0.6
08/01/2011 14:00	2.6	2.4	3.3	4.1
08/01/2011 15:00	0.0	0.0	0.0	0.0
08/01/2011 16:00	0.0	0.0	0.0	0.0
08/01/2011 17:00	1.0	0.0	0.3	0.1
08/01/2011 18:00	1.5	0.0	0.0	0.0
08/01/2011 19:00	0.8	0.0	0.3	0.0
08/01/2011 20:00	0.2	0.0	0.0	0.7
08/01/2011 21:00	1.0	0.0	1.7	0.3
08/01/2011 22:00	1.4	0.6	1.0	0.0
08/01/2011 23:00	0.2	0.0	0.0	0.0
09/01/2011 00:00	0.0	0.0	0.0	0.0
09/01/2011 01:00	0.0	0.0	0.0	0.0
09/01/2011 02:00	0.4	0.0	1.0	0.3

Start of period	North Pine (NDI)	Sideling Creek (SID)	South Pine (SOU)	Lower Pine (RES)
09/01/2011 03:00	0.7	0.0	1.0	0.3
09/01/2011 04:00	2.1	2.4	0.3	2.5
09/01/2011 05:00	1.7	0.0	0.0	0.1
09/01/2011 06:00	1.7	0.0	2.0	0.3
09/01/2011 07:00	0.0	0.6	0.0	0.0
09/01/2011 08:00	0.6	0.0	1.7	0.6
09/01/2011 09:00	0.1	0.0	0.0	0.0
09/01/2011 10:00	5.7	0.6	4.3	1.6
09/01/2011 11:00	12.6	4.3	20.0	11.0
09/01/2011 12:00	4.2	0.0	1.7	0.7
09/01/2011 13:00	1.0	1.8	0.3	0.1
09/01/2011 14:00	2.3	0.0	0.7	0.0
09/01/2011 15:00	19.0	12.2	13.0	12.0
09/01/2011 16:00	9.9	3.7	13.8	5.6
09/01/2011 17:00	5.7	0.0	2.7	1.8
09/01/2011 18:00	6.5	0.0	5.4	3.4
09/01/2011 19:00	5.9	5.5	6.7	3.9
09/01/2011 20:00	10.7	3.7	22.7	9.6
09/01/2011 21:00	2.0	0.6	1.0	0.8
09/01/2011 22:00	1.3	0.6	1.0	0.2
09/01/2011 23:00	7.5	6.7	6.4	7.9
10/01/2011 00:00	6.0	2.4	5.0	3.0
10/01/2011 01:00	3.1	2.4	3.0	3.3
10/01/2011 02:00	4.0	1.8	2.7	2.5
10/01/2011 03:00	0.6	0.6	1.0	0.9
10/01/2011 04:00	3.8	0.0	3.0	3.4
10/01/2011 05:00	11.6	0.0	16.4	13.3
10/01/2011 06:00	2.7	1.2	2.4	1.5
10/01/2011 07:00	2.9	0.6	2.3	3.0
10/01/2011 08:00	6.6	0.0	13.6	18.8
10/01/2011 09:00	3.0	0.0	2.0	0.9
10/01/2011 10:00	1.7	0.0	3.0	14.5
10/01/2011 11:00	10.1	0.0	15.4	10.3
10/01/2011 12:00	2.4	0.0	0.3	0.0
10/01/2011 13:00	1.5	0.0	1.0	0.0
10/01/2011 14:00	1.3	0.0	1.7	0.3
10/01/2011 15:00	2.6	0.6	1.0	0.7
10/01/2011 16:00	0.5	0.0	0.7	0.0
10/01/2011 17:00	0.2	0.0	1.0	0.3
10/01/2011 18:00	0.1	0.0	0.0	0.0
10/01/2011 19:00	1.6	0.6	1.0	0.3

Start of period	North Pine (NDI)	Sideling Creek (SID)	South Pine (SOU)	Lower Pine (RES)
10/01/2011 20:00	0.9	0.0	0.3	0.5
10/01/2011 21:00	1.6	0.6	3.0	2.4
10/01/2011 22:00	2.3	0.0	3.1	0.0
10/01/2011 23:00	0.3	0.0	0.3	0.0
11/01/2011 00:00	0.6	0.0	0.3	0.0
11/01/2011 01:00	0.0	0.0	0.0	0.0
11/01/2011 02:00	5.1	1.2	2.3	1.2
11/01/2011 03:00	1.3	0.0	2.3	2.8
11/01/2011 04:00	5.2	0.0	3.7	0.3
11/01/2011 05:00	7.7	0.0	5.4	0.8
11/01/2011 06:00	23.1	1.2	9.8	0.6
11/01/2011 07:00	30.2	3.7	15.5	7.1
11/01/2011 08:00	23.6	3.1	19.4	2.2
11/01/2011 09:00	37.3	7.3	29.4	8.2
11/01/2011 10:00	49.1	14.6	33.8	21.0
11/01/2011 11:00	36.7	0.0	22.9	4.1
11/01/2011 12:00	28.9	9.2	22.5	9.3
11/01/2011 13:00	27.3	11.6	20.7	13.0
11/01/2011 14:00	18.9	0.0	14.1	5.7
11/01/2011 15:00	4.0	0.0	5.0	2.6
11/01/2011 16:00	1.0	0.0	1.7	1.3
11/01/2011 17:00	2.6	0.0	1.4	0.1
11/01/2011 18:00	1.3	0.0	2.7	0.8
11/01/2011 19:00	1.6	0.0	1.0	1.2
11/01/2011 20:00	0.0	0.0	0.0	0.0
11/01/2011 21:00	0.5	0.0	0.7	0.0
11/01/2011 22:00	0.1	0.0	0.0	0.5
11/01/2011 23:00	0.6	0.0	0.7	0.1
12/01/2011 00:00	0.9	0.0	1.7	0.5
12/01/2011 01:00	1.0	0.6	3.3	0.8
12/01/2011 02:00	0.0	0.0	0.0	0.0
12/01/2011 03:00	0.5	0.0	0.3	0.1
12/01/2011 04:00	0.6	0.0	1.7	0.3
12/01/2011 05:00	0.0	0.0	0.0	0.0
12/01/2011 06:00	0.3	0.0	0.7	0.0
12/01/2011 07:00	0.2	0.0	0.3	0.0
12/01/2011 08:00	0.0	0.0	0.0	0.0
12/01/2011 09:00	0.1	0.0	0.0	0.0

Table 6.4.2 – Catchment average rainfall (mm) to 09:00 on Wednesday 12 January 2011

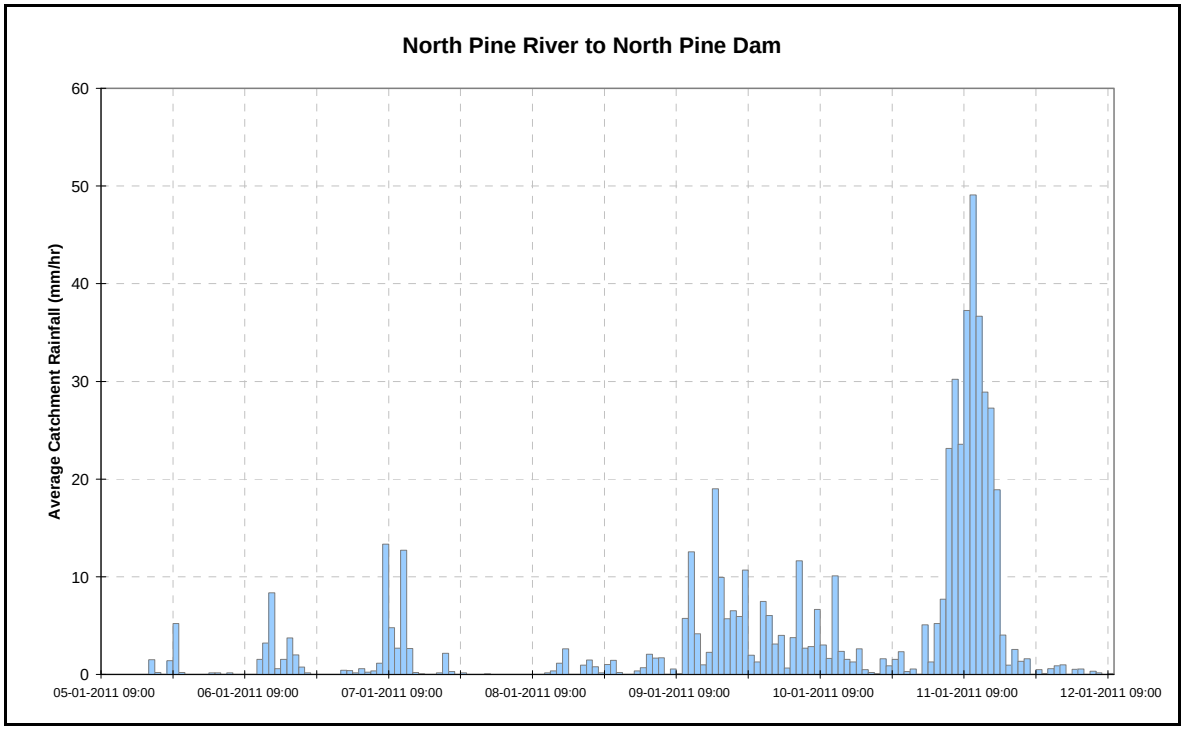

Figure 6.4.3 – North Pine River average hourly rainfalls

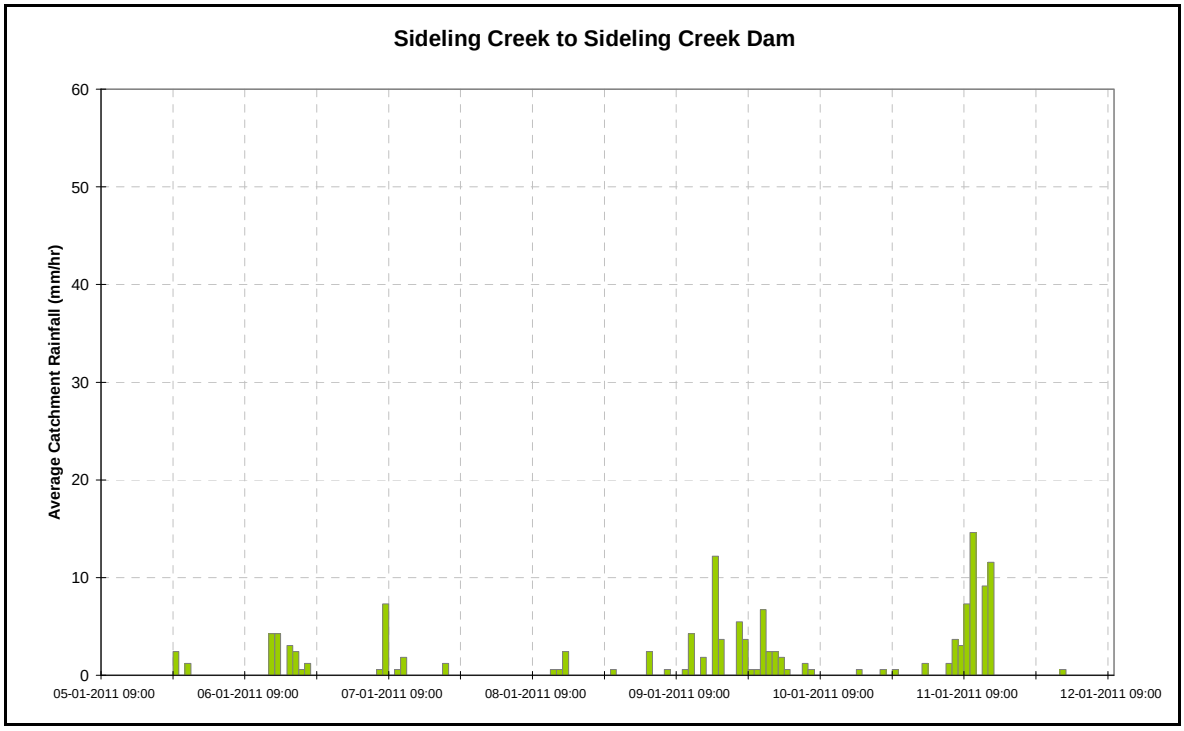

Figure 6.4.4 – Sideling Creek average hourly rainfalls

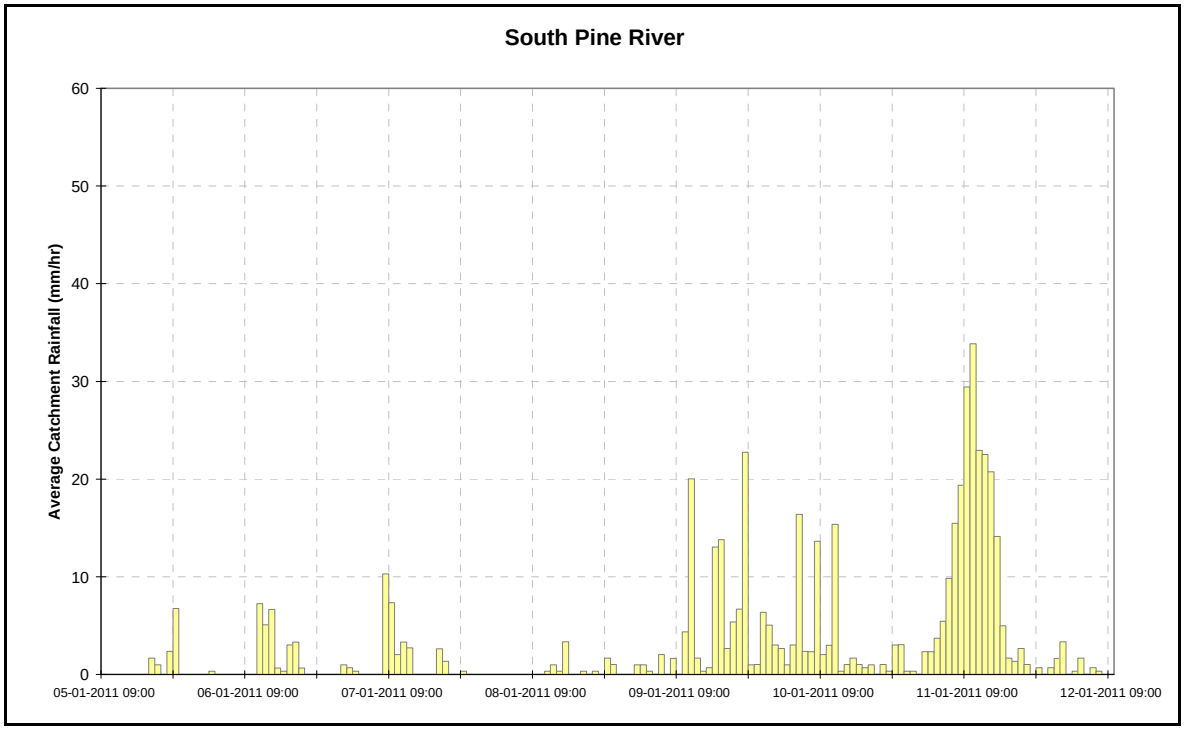

Figure 6.4.5 – South Pine River average hourly rainfalls

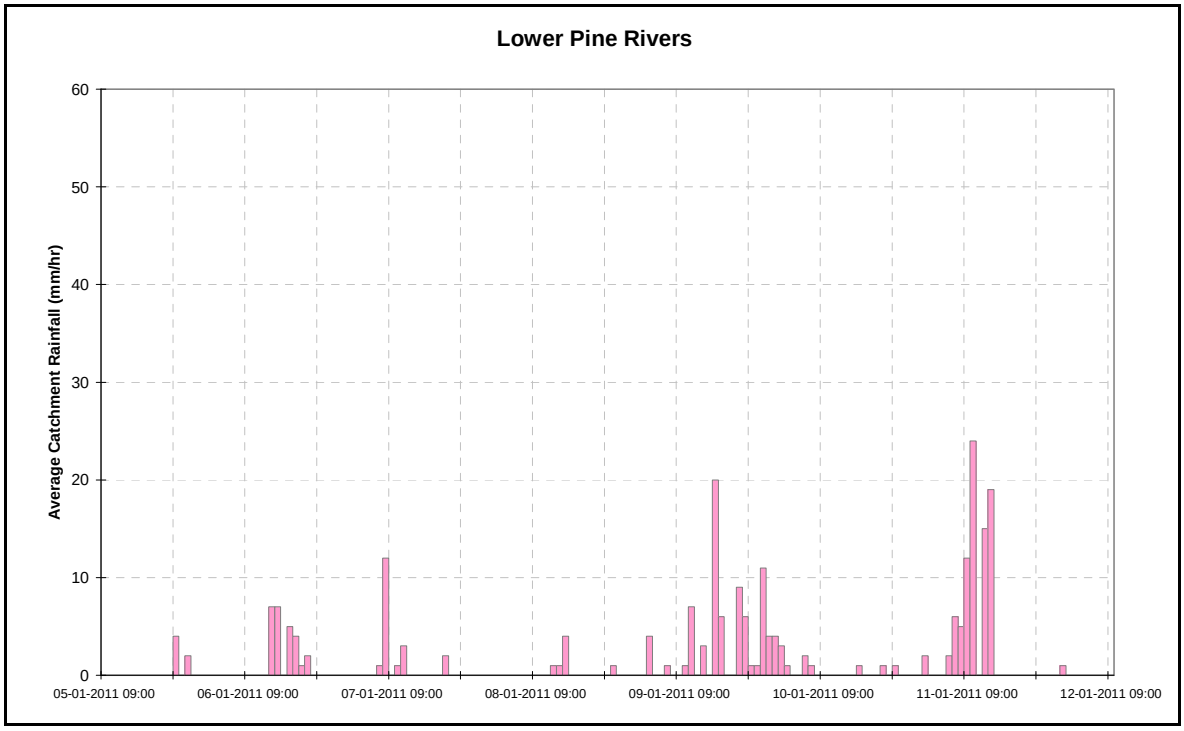

Figure 6.4.6 – Lower Pine average hourly rainfalls

The average catchment rainfall graphs clearly show a number of individual and linked rainfall bursts over the Event. The most intense burst occurred relatively late in the Event between 06:00 and 14:00 on Tuesday 11 January 2011, when average hourly rainfall levels were well in excess of 10mm per hour.

6.5 Spatial extent of critical rainfall

Seqwater commenced developing a new flood modelling system, FEWS, in March 2010. A prototype was delivered in early November 2010, at which time rainfall from Enviromon was imported into the system. The following maps have been generated using FEWS.

The figures below show the spatial extent of the rainfall during critical periods in the North Pine Dam catchment; in the six hours to 12:00 on Wednesday 11 January 2011 and in the 12 hours to 15:00 on Wednesday 11 January 2011. It is clear the areas of heaviest rainfall occur in the upper reaches of the North Pine River around Dayboro and in the headwater area of the South Pine River.

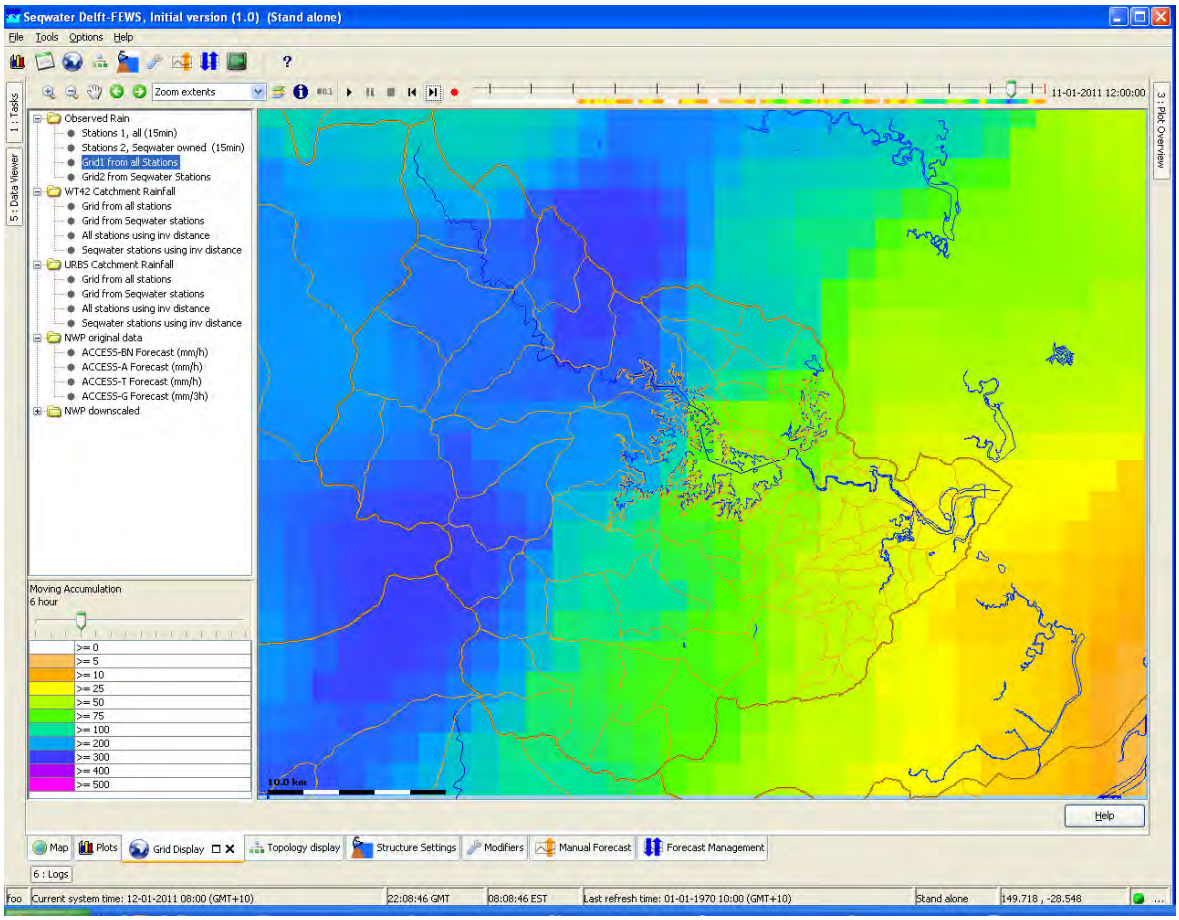

Figure 6.5.1 – Rainfall in the six hours to 15:00 on Wednesday 11 January 2011

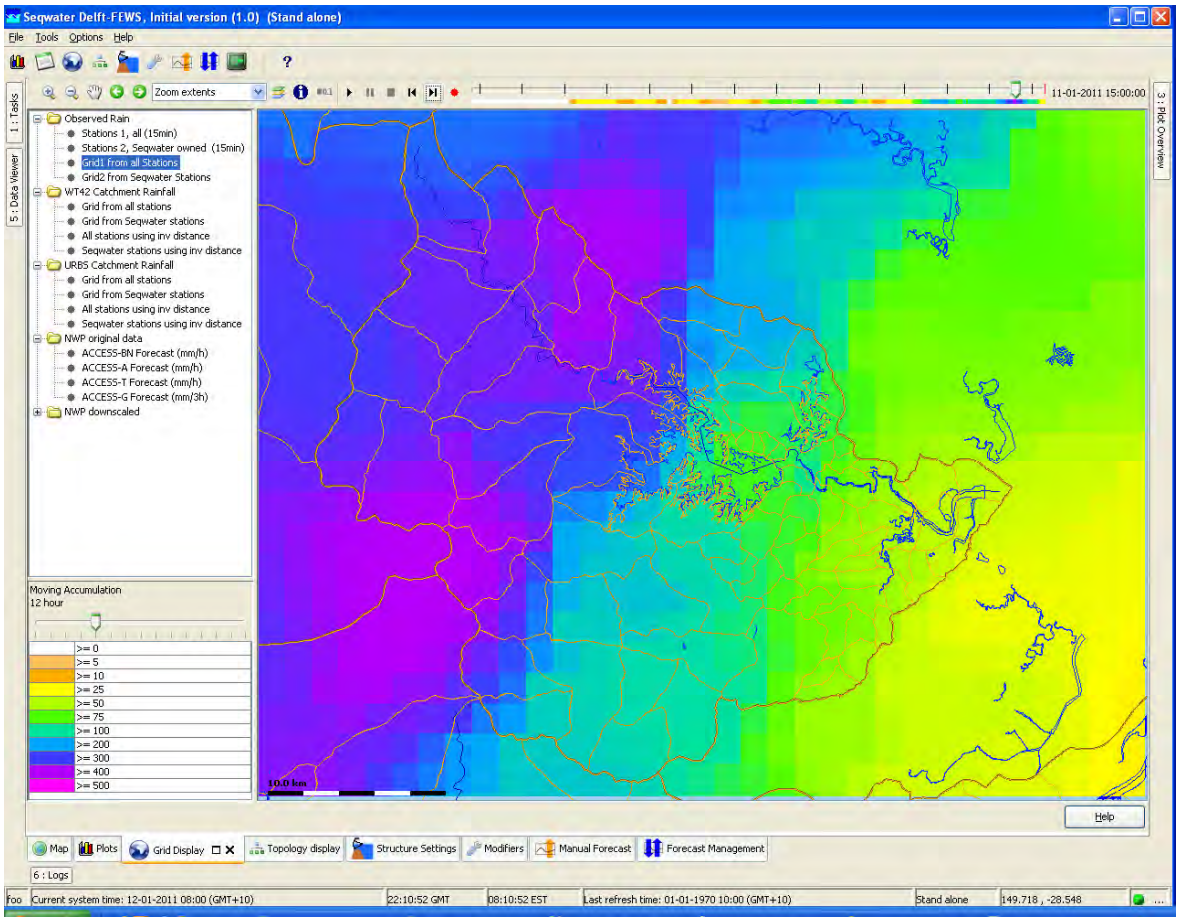

Figure 6.5.2 – Rainfall in the 12 hours to 15:00 on Wednesday 11 January 2011

6.6 Forecast rainfall

As North Pine Dam does not have a flood mitigation role, the Dam's operation is generally based on recorded rainfall and water level. However, the Flood Operations Centre is provided with twice daily Quantitative Precipitation Forecasts (QPF) issued by the BoM for the North Pine Dam catchment. These forecasts can be used in Model runs to assist in managing flood events and providing extended projections.

While rainfall forecasts create an awareness of potential flood event conditions, as shown below and in previous flood event reports, the forecasts themselves do not provide a definitive basis on which to make operational decisions on releasing flood water from the Dam. Generally, the longer the forecast lead times, the higher the degree of uncertainty in the forecast.

The BoM forecast tools examined during the event were:

- 24-hour QPFs for the Dam catchment;
- The weather radar (available through www.bom.gov.au);
- SILO meteograms forecast rainfall (based on BoM ACCESS Model);
- Interactive weather and wave forecast rainfall maps (based on ACCESS Model);
- Water and land forecast rainfall (based on an ensemble of several numerical weather prediction models);
- Severe weather warnings.

Table 6.6.1 compares the forecast and recorded catchment average rainfall for the period of the Event. Initially, in the first few days of the event, the QPF provided a reasonable estimate of the rainfall, however, rainfall was generally overestimated until Monday 9 January 2011. After that time, the forecast for the days of heavy rainfall between Monday 10 January 2011 and Tuesday 11 January 2011 significantly underestimated the recorded rainfall.

Date / time of issue	Forecast for 24 hours to	24-hour catchment average forecast rainfall (mm)	24-hour catchment average actual rainfall (mm)
06/01/201110:21	07/01/2011 09:00	25	43
06/01/201116:00	07/01/2011 15:00	40	47
07/01/201110:03	08/01/2011 10:00	40	26
07/01/201116:04	08/01/2011 16:00	25	7
08/01/201110:03	09/01/2011 09:00	45	18
08/01/201116:00	09/01/2011 15:00	45	58
09/01/201110:03	10/01/2011 09:00	50	139
09/01/201116:00	10/01/2011 15:00	50	113
10/01/201110:03	11/01/2011 10:00	50	209
10/01/201116:00	11/01/2011 16:00	80	307
11/01/201110:13	12/01/2011 10:00	113	127
11/01/201116:13	12/01/2011 16:00	63	11
12/01/201110:03	13/01/2011 10:00	125	43
12/01/201116:00	13/01/2011 16:00	90	47
13/01/201114:25	14/01/2011 16:00	5	26

Table 6.6.1 – Comparison of actual and forecast rainfall

6.7 Event water levels

Seqwater uses a network of six automated stream height stations within the Pine Rivers Basin to gather Dam level and stream height data during flood events. Data from this network is automatically collected in real-time using a radio telemetry collection system and every recorded change in water level at each station is sent directly to the Flood Operations Centre as it is recorded.

Data sent to the Flood Operations Centre in this way is operational data and is not validated. Both manual and automatic data checking is undertaken in the Flood Operations Centre at regular and routine intervals over the course of the Event.

While the vast majority of the water level data contained in this Report was collected automatically via the Seqwater ALERT network, manual observations of gauge boards at North Pine Dam were also collected via email and phone during the events. These gauge board observations are more reliable than the automatically provided readings and, therefore, provided the basis for gate operations at the Dam during this Event.

Table 6.7.1 includes details of the peak heights recorded by the gauging stations used during the Event. It also shows the data received in the Flood Operations Centre which has not been verified by field survey.

Primary ALERT ID	Watercourse	Station	Date and time	Gauge height (m)
6712	North Pine River	Baxters Creek	11/01/2011 10:51	9.20
1988	North Pine River	Dayboro WWTP	11/01/2011 11:46	8.26
1991	Kobble Ck	Mt Samson Rd	11/01/2011 10:35	5.77
Gauge Board	North Pine River	North Pine Dam	11/01/2011 14:00	41.11
6767	Sideling Creek	Sideling Creek Dam	11/01/2011 13:01	20.75
1954	North Pine River	Youngs Crossing	11/01/2011 17:21	13.42
6770	South Pine River	Drapers Crossing	11/01/2011 14:07	7.68
1960	South Pine River	Cashs Crossing	11/01/2011 15:13	5.60
1977	North Pine River	Lawton	11/01/2011 16:57	5.92

Table 6.7.1 – Peak heights recorded at automatic gauging stations during the January 2011 Flood Event

Height hydrographs (Figures 6.7.2 to 6.7.10) for selected key stations within the Pine Rivers Basin during Event 14 are plotted below. Flood Officers were responsible for basic data checking.

North Pine River at Baxters Creek

The North Pine River at Baxters Creek is a key gauging station upstream of North Pine Dam and is included in the RTFM, however, it only represents around 40% of the catchment to the Dam and is poorly rated. This gauge operated reliably and provided sufficiently accurate operational data for modelling purposes.

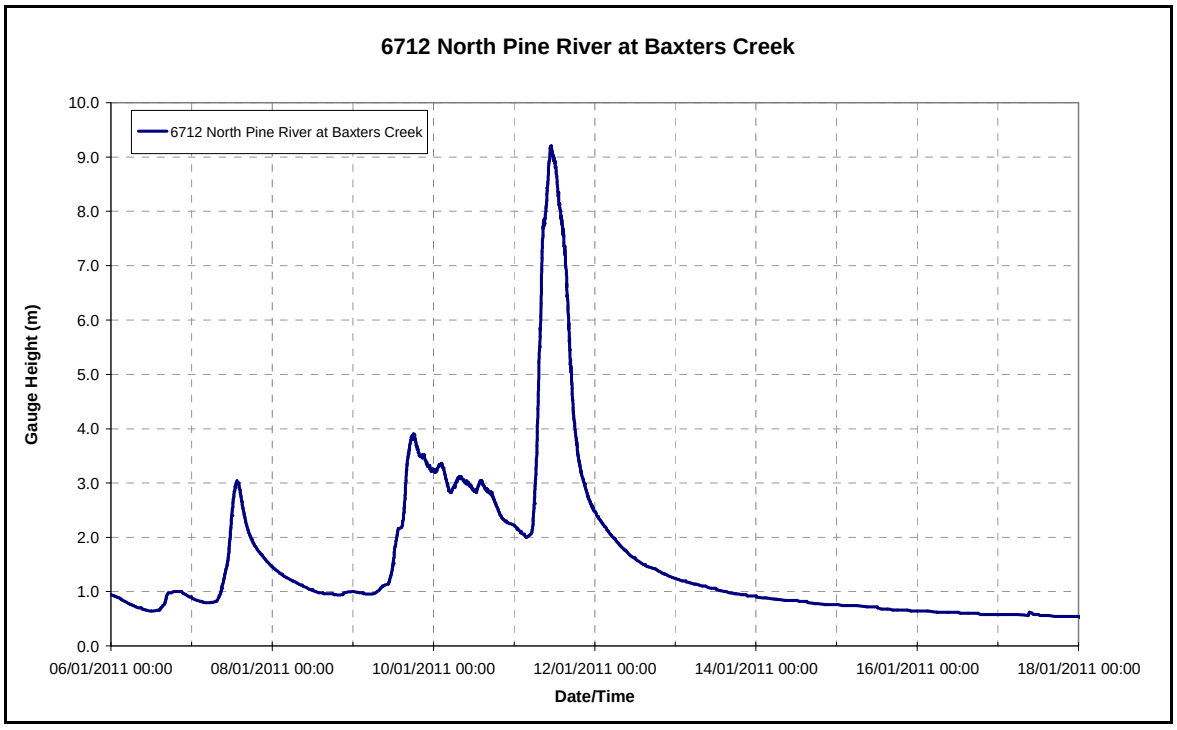

Figure 6.7.2 – Gauge height, North Pine River at Baxters Creek

Dayboro WWTP

The ALERT gauge at Dayboro WWTP is a relatively new Seqwater gauge downstream from the Baxters Creek gauge. It is not included in the RTFM. This gauge operated reliably up to the point where the river bank collapsed and provided sufficiently accurate operational data.

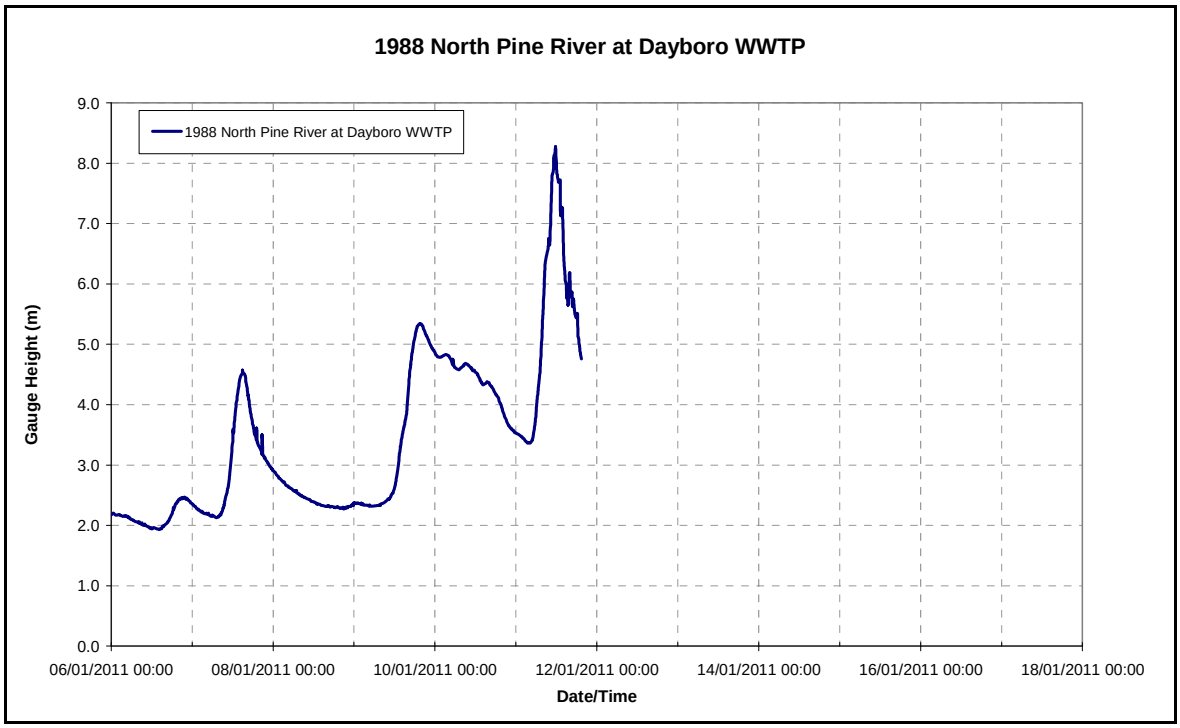

Figure 6.7.3 – Gauge height, North Pine River at Dayboro WTTP

Kobble Creek at Mt Samson Road

The ALERT gauge at Mt Samson Road is a relatively new Seqwater gauge downstream from the Baxters Creek gauge and is not included in the RTFM. This gauge operated reliably and provided sufficiently accurate operational data.

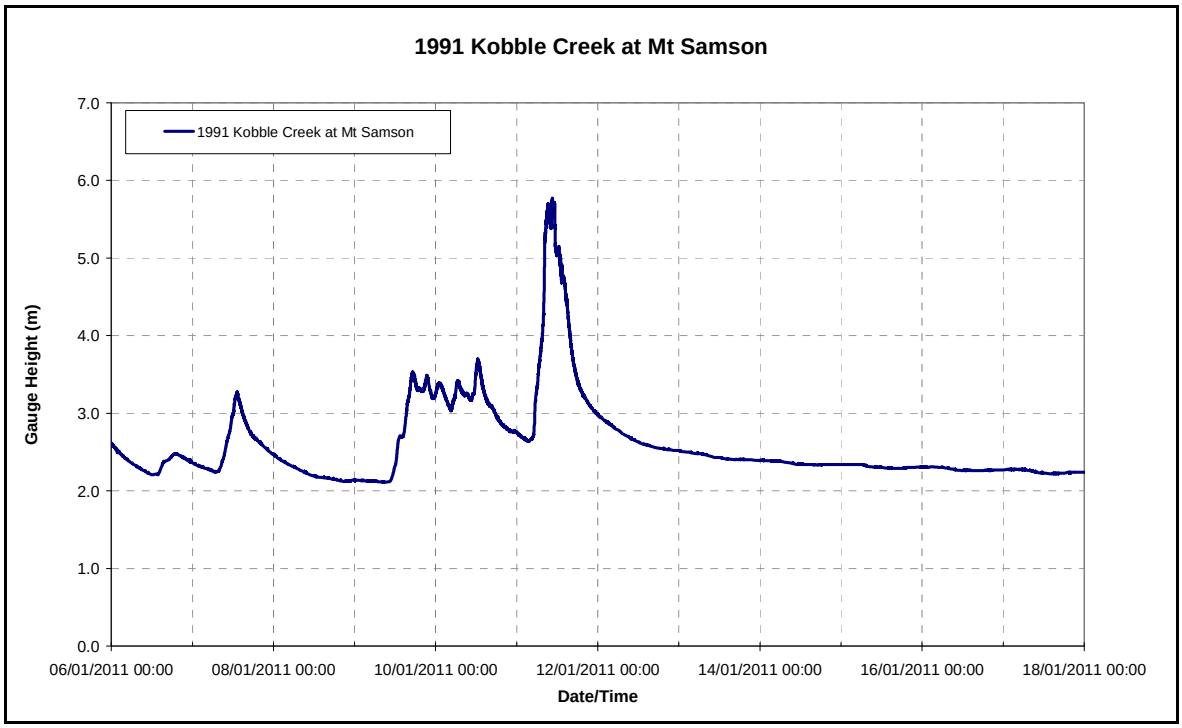

Figure 6.7.4 – Gauge height, Kobble Creek at Mt Samson Road

North Pine Dam

The manually read gauge board used during this Event is located near the edge of the right Dam embankment. There are two automatic gauges at North Pine Dam. Sensor 6637 provided a reading which fluctuated during the Event and was not used. The other sensor, Sensor 6761, provided a reading slightly lower than the manual gauge board readings, however, within acceptable tolerances. Gate openings were made on the basis of gauge board readings.

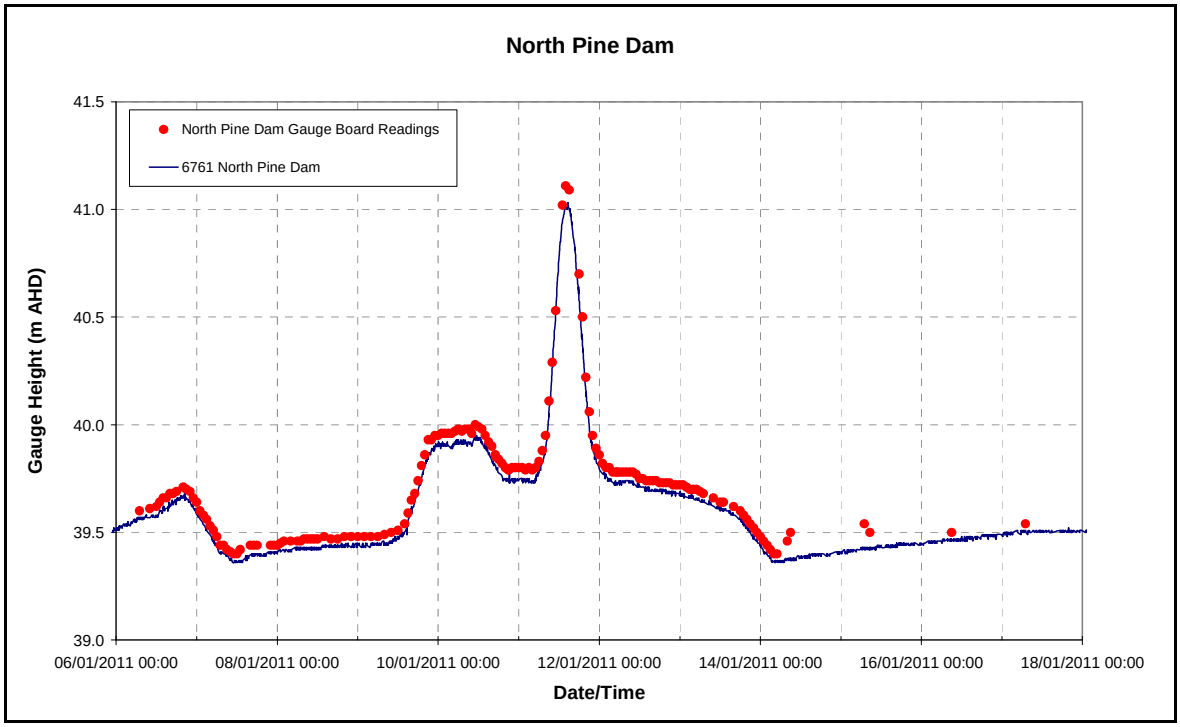

Figure 6.7.5 – Gauge height, North Pine Dam

Sideling Creek at Sideling Creek Dam

The ALERT gauge at Sideling Creek monitors the headwater level of Lake Kurwongbah. It is included in the RTFM and operated reliably during the Event. Data from this gauge is only considered during small events which may adversely impact traffic access across Youngs Crossing. This gauge operated reliably and provided sufficiently accurate operational data, however, the calibration of the gauge in Flood-Col was incorrect.

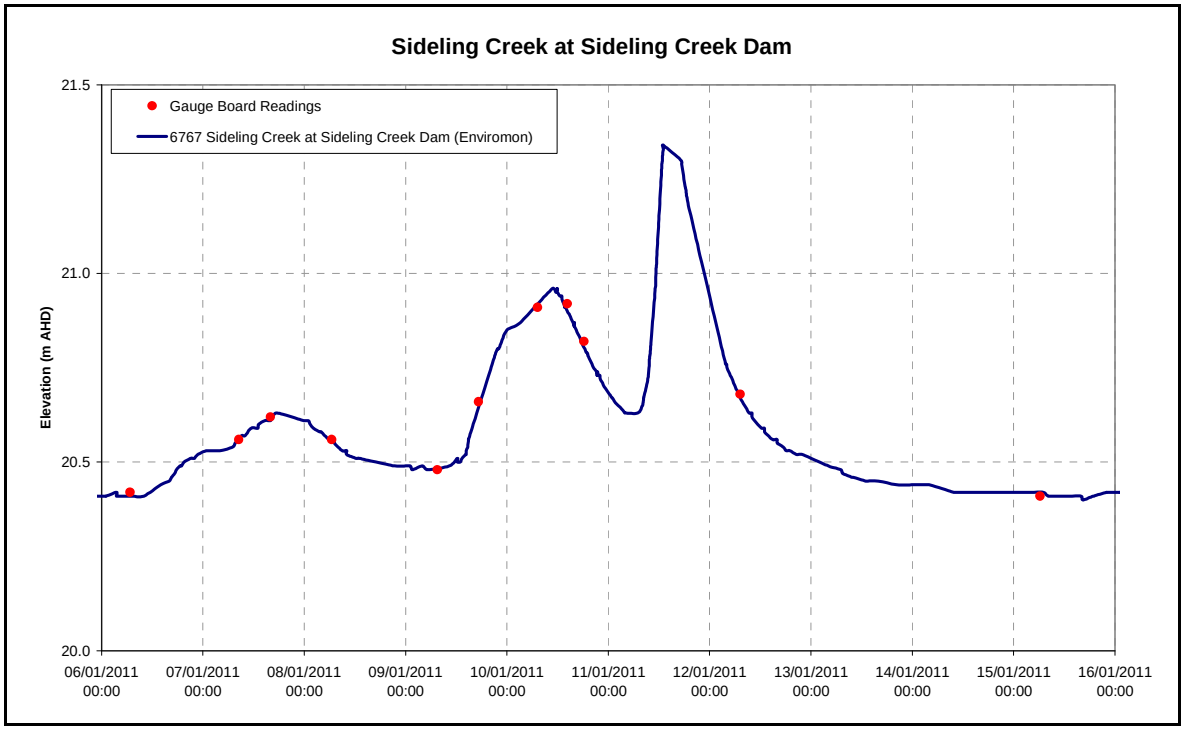

Figure 6.7.6 – Gauge height, Sideling Creek Dam

North Pine River at Youngs Crossing

The ALERT gauge at Youngs Crossing, immediately upstream of the road crossing, is operated by Moreton Bay Regional Council. It is not included in the RTFM. This gauge operated reliably and is only included in this report for completeness.

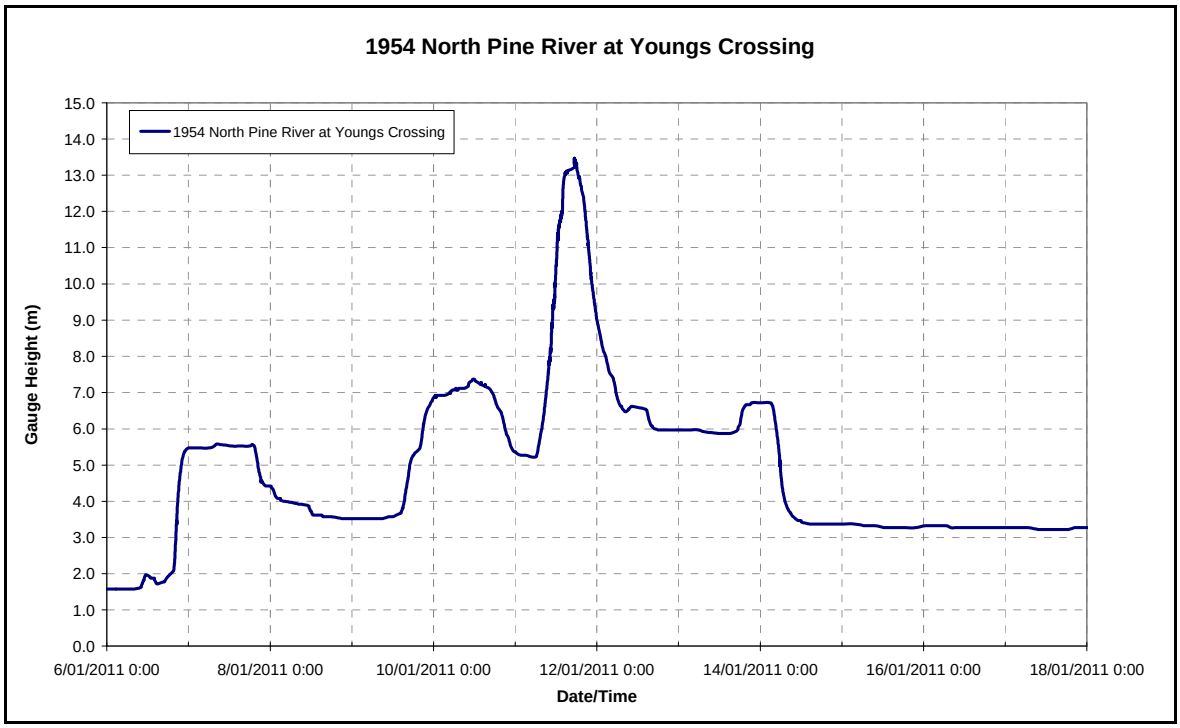

Figure 6.7.7 – Gauge height, North Pine River at Youngs Crossing

North Pine River at Lawton

As the Seqwater gauge at Petrie was 'Out of Action', the Moreton Bay Regional Council gauge at Lawton was used. This gauge provided sufficiently accurate operational data during the Event.

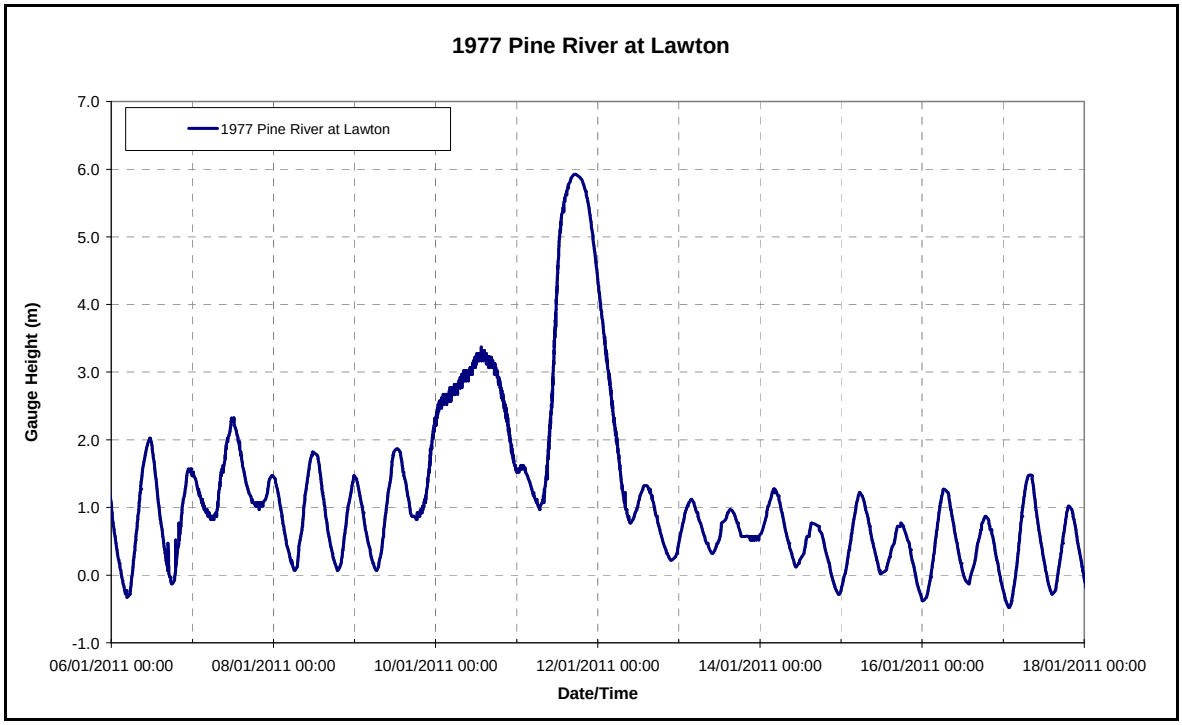

Figure 6.7.8 – Gauge height, North Pine River at Lawton

South Pine River at Drapers Crossing

Drapers Crossing is a key gauging station on the South Pine River and is included in the RTFM. This gauge operated reliably and provided sufficiently accurate operational data for modelling purposes.

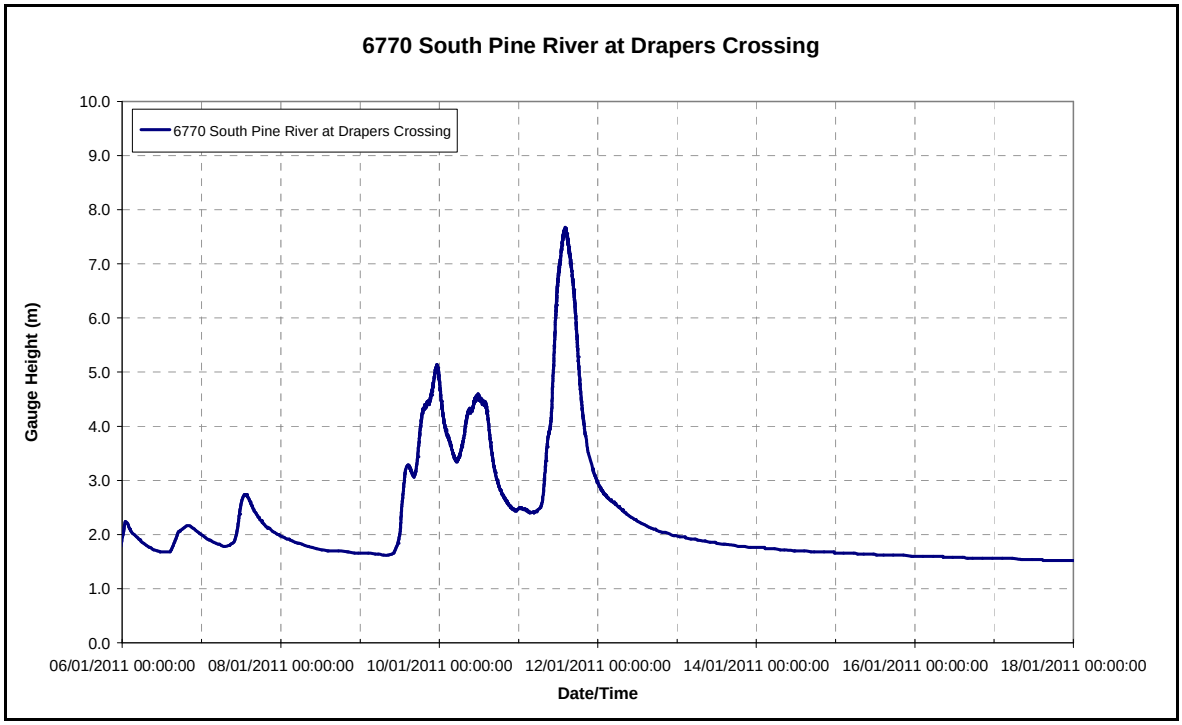

Figure 6.7.9 – Gauge height, South Pine River at Drapers Crossing

South Pine River at Cashs Crossing

The ALERT gauge at Cashs Crossing is operated by Moreton Bay Regional Council but is not included in the RTFM. This gauge operated reliably and is only included in this report for completeness.

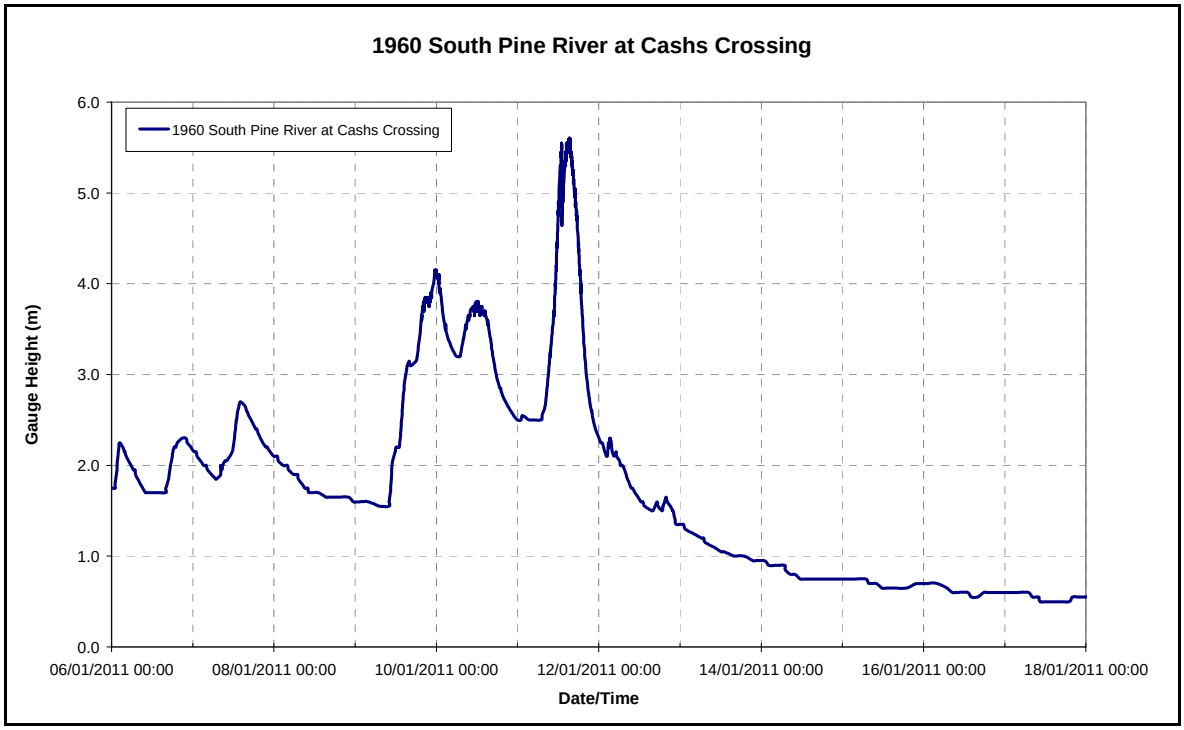

Figure 6.7.10 – Gauge height, South Pine River at Cashs Crossing

6.8 Dam inflows and outflows

A summary of the inflows and outflows from North Pine Dam during all flood events appear in Table 6.8.1. Detailed information is contained in Section 8. Dam inflow is estimated by reverse routing. Reverse routing is estimated by calculating the rate of change of the Dam storage and adding the outflow.

Dam inflow (ML)	Dam outflow (ML)	Peak inflow (m^3/s)	Peak outflow (m^3/s)	Peak level (m AHD)	Event peak (time)
202,000	206,000	3,480	2,850	41.11	14:00 on Tuesday 11 January 2011

Table 6.8.1 – Summary inflows and outflows for North Pine Dam

The inflow into North Pine Dam during Event 14 is characterised by dual peaks. This inflow is illustrated by the blue dotted line on Figure 6.8.2. The first peak on the morning of Monday 10 January 2011 is the broad, flat peak of approximately 500m^3/s, the second, on the afternoon of Tuesday 11 January 2011, is the sharp crested peak of nearly 3,480m^3/s. The peak water level and corresponding peak outflow occurred on the afternoon of Tuesday 11 January 2011 at 14:00 when four gates were opened by 19 increments and one by 20 increments. This information is summarised in Table 6.8.1 and Figure 6.8.2.

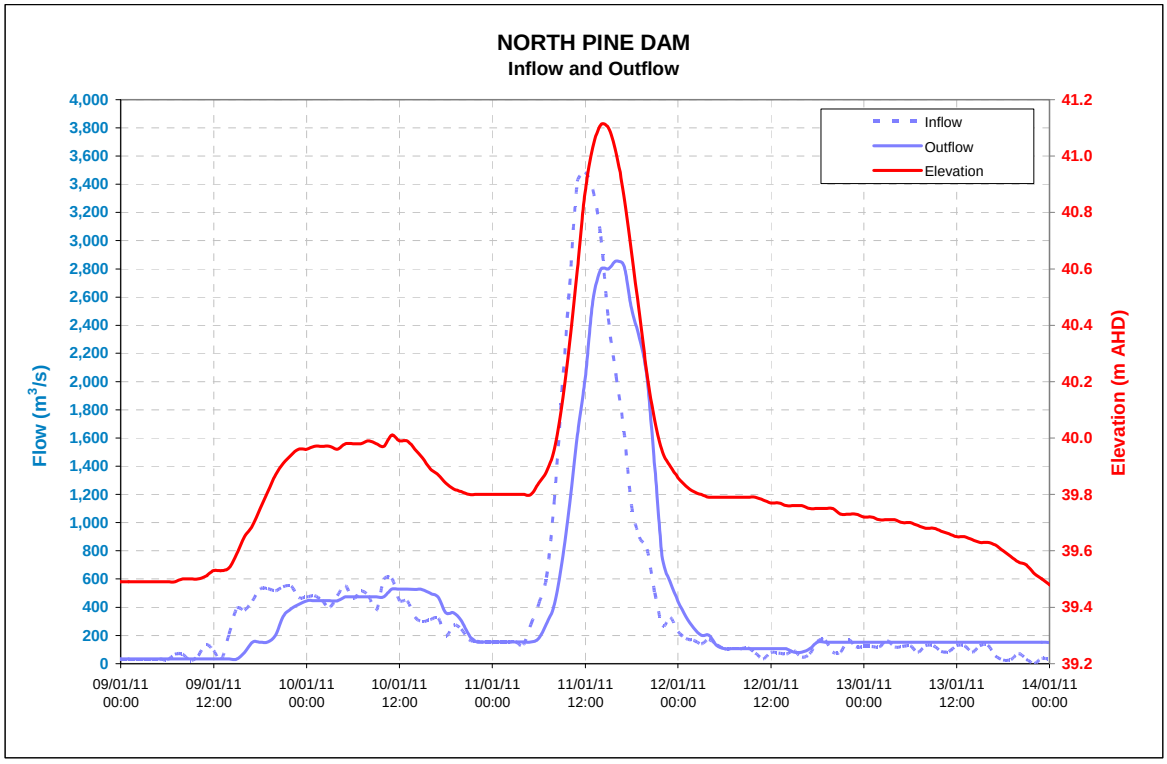

Figure 6.8.2 – North Pine Dam inflow and outflow

6.9 Other data sources

Enviromon, the BoM replacement software for FLOOD-Col, (including all available ALERT stations in South East Queensland and a large number of non-Seqwater stations) is a support tool that was also examined and considered in conjunction with the modelling results.

During the Event, discussions were also held with the BoM to discuss rainfall forecast information in the region.

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7 FLOOD MODEL VALIDITY AND PERFORMANCE

7.1 Background

A real-time flood monitoring and forecasting system is used to monitor rainfall and water levels in the North Pine Dam catchment and to provide adequate, accurate and timely information to inform decision-making. This system is described in detail in Section 5.

As the real-time rainfall and river height data is received in the Flood Operations Centre, a Real Time Flood Model (RTFM) is used to estimate likely inflows and to evaluate a range of possible inflow scenarios based on recorded and forecast rainfall in the Dam catchment. It comprises a suite of hydrologic computer programs that process real-time data. This data is used by Flood Operations Engineers to operate the Dams during flood events, in accordance with the Manual. The Manual's objectives and procedures ensure Dam releases are optimised in order to minimise the impact of flooding.

Seqwater is responsible for providing and maintaining the RTFM, and ensuring sufficient data is available for the model to operate effectively during a flood event.

Seqwater is continually improving the operation of the RTFM by:

- Implementing improvements based on flood event audits and reviews;
- Improving RTFM calibration as further data becomes available;
- Updating software in line with modern day standards;
- Improving the coverage and reliability of the data collection network to optimise data availability during flood events.

This Section describes the RTFM in detail and assesses its performance during the January 2011 Flood Event.

7.2 Model description

The current RTFM was developed in 1994 as part of the ***Brisbane River and Pine River Flood Study, (DNR, 1994***) and consists of two integrated modules:

- FLOOD-Col;
- FLOOD-Ops.

FLOOD-Col is the data capture module, while FLOOD-Ops is the data analysis module of the RTFM. The System is accessed through a flexible Graphical User Interface (GUI), which was developed under a UNIX operating environment using OSF/Motif GFUI under the XWindows system. In 2008, the system was ported to a LINUX operating environment and is currently running on a DELL PowerEdge 1800 Server.

The RTFM:

- Automatically and continuously collects, filters and stores rainfall and water level data in real-time;
- Assigns temporal and spatial distributions of actual and forecast rainfall for extension into the future;
- Evaluates the spatial and temporal distribution of antecedent catchment soil moisture conditions on a daily basis;
- Performs hydrologic routing of stream flows in an integrated environment;
- Provides estimates of storage performance and resulting downstream releases;
- Prepares summary output in textual and graphical format for storage operation and resulting downstream flood levels and flows.

As described in Section 5, the rainfall and water level gauges located within and around the Pine Rivers catchments provide the primary sources of the RTFM's raw data.

Data collection is completely independent to data analysis within the RTFM system. Filtered gauge data from individual or groups of gauges can be viewed in either a textual or graphical format. The types of information that can be viewed or edited include height, discharge, rainfall pluviographs, rainfall hyetographs, lake levels and Dam volumes.

Regions, Processes and Cases

The data analysis system and modelling within the RTFM have been developed with reference to the concepts of Regions, Processes and Cases. A Region is an area of land above a stream gauge station. A Process is a computer-generated model of a physical hydrologic mechanism, such as soil moisture accounting, runoff-routing, reservoir-routing and base flow. A Case is an event-based sequence of processes applied to Regions.

Regions

Regions – land above gauging stations – can be assigned Processes depending on the nature of the Region. For example, a sub-catchment Region is assigned a soil moisture accounting Process and a runoff-routing Process, whereas a reservoir Region is only assigned a reservoir-routing Process. Regions' relationships with neighbouring Regions are defined for each Process associated with the Region. Generally, outflow from one Region is inflow into its adjoining downstream Region.

The Region database contains the following information:

- Extent and location of sub-areas within Regions and Regions within catchments;
- Connectivity of sub-areas within Regions and Regions with catchments;
- The list of Processes associated with each Region;
- Process module input definitions.

Figure 7.2.1 shows the Region layout adopted in the RTFM system.

7 FLOOD MODEL VALIDITY AND PERFORMANCE (continued)

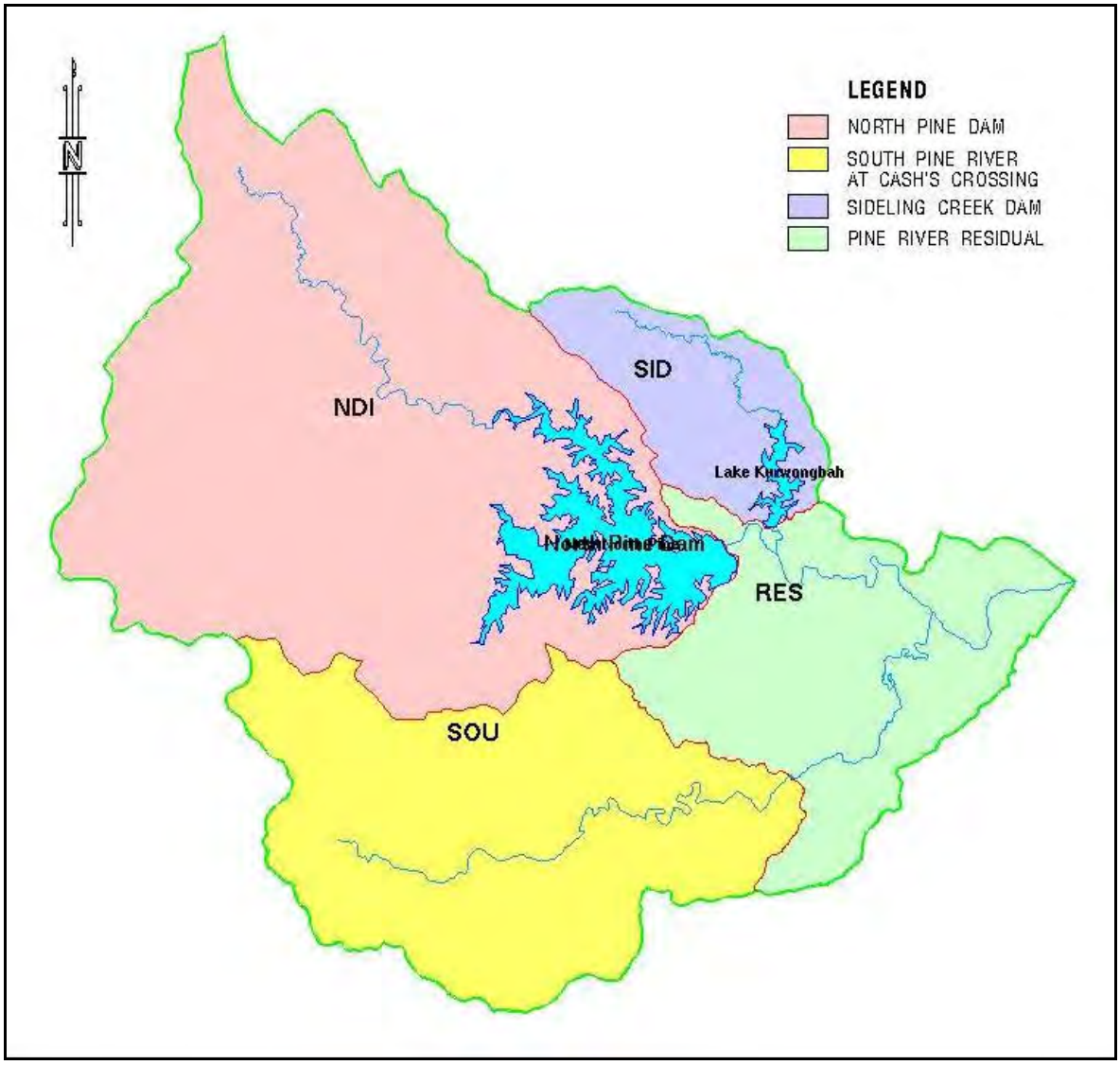

Figure 7.2.1 – RTFM Regions

Relevant statistics relating to each Region, as defined in the RTFM, are shown in Table 7.2.2.

Region Code	Stream gauge	AMTD (km)	Area (km^2)	Distance to outlet (km)
Pine Rivers Basin				
NDI	North Pine River at North Pine Dam	20.3	345	20.4
SOU	South Pine River at Cashs Crossing	14.0	179	17.7
SID	Sideling Creek at Lake Kurwongbah	1.3	53	7.7
RES	Pine River at Bramble Bay	0.0	127	22.2

Table 7.2.2 – RTFM Region statistics

Processes

A Process is a computer-generated model of a physical hydrologic mechanism. The Processes contained in the RTFM are soil moisture accounting, runoff-routing, reservoir-routing and base flow. These are explained in detail below:

- **Soil moisture accounting**

  Soil moisture accounting is used to indicate catchment saturation at the commencement of a flood event. Relationships have been derived that relate conceptual soil moisture storage volumes to rainfall losses. The RTFM contains a number of different Process models that perform similar functions. For example, the soil moisture accounting module consists of several different types of models, including:

  - Antecedent Precipitation Index (API);
  - Residual Baseflow Index;
  - SACRAMENTO Model.

  These models are described in detail in the ***Brisbane River and Pine River Flood Study Report Series, (DNR, 1994), Report on Regional Loss Model Relationships, June 1994.***

  During the January 2011 Flood Event, the API model was used to derive initial estimates of rainfall losses during the early period of the Event. These initial estimates were updated as initial stream rises were detected. This allowed the Event loss rates to be closely estimated by matching model results with the actual data received from the water level gauges in the Dam catchments. Relationships were derived by the Bureau of Meteorology (BoM) linking API and initial loss, using the following equations:

  Initial Loss (summer period)

  - IL = 62.5 - 0.4386*API

  Where:

  - IL = Initial Loss (mm);
  - API = Antecedent Precipitation Index based upon 30 day rainfalls (mm);
  - Minimum API = 5mm;
  - Maximum API = 150mm.

- **Runoff-routing**

  Runoff-routing is used to estimate the surface runoff from rainfall within a Region. This Process uses concentrated storages distributed over a Region, which have a non-linear storage-discharge relationship. This Process originated as model WT42 but was rewritten in ANSI C to be included in the RTFM. This allowed the system to use improved structures to access data more efficiently, in real time. The Process was also modified to operate in a manner that allowed separate Regions to be run as a series of linked cascading models, allowing for the more effective use of spatially varying data.

  The runoff-routing Process was calibrated using ten historical flood events (up to 1994) and was used to successfully simulate operational floods in February 1999, March 1999, February 2001, February 2010, March 2010 and October 2010. The calibration of these models are described in detail in the ***Brisbane River and Pine River Flood Study Report Series, (DNR, 1994), Pine River Hydrology Report Volume I Report on Runoff Routing Model Calibration, August 1991***

Table 7.2.3 below shows the Region runoff-routing parameters the RTFM uses.

Region code	Kc	m
Pine Rivers Basin		
NDI	46.1	0.8
SOU	19.3	0.8
SID	8.3	0.8
RES	11.3	0.8

Table 7.2.3 – Region runoff-routing parameters

- **Reservoir-routing**

Reservoir-routing is used to estimate the outflow from a reservoir within a Region. The RTFM incorporates this Process based on level pool routing algorithms. Standard gate operations are incorporated into the reservoir-routing model.

The current reservoir-routing operational Process in the RTFM uses Dam inflow estimates and catchment stream flow extracted from the FLOOD-Ops. This data is imported into customised gate operation spreadsheets to determine appropriate gate operation strategies, in accordance with the Manual. This system has been proven to work very effectively.

- **Base flow**

Base flow is used to estimate residual stream flow, additional to surface runoff. FLOOD-Ops only estimates surface runoff, which is generally the major component of the total runoff. Accurate assessment of the total runoff is required to accurately model rises in Dam storage levels.

The base flow component was introduced to more accurately determine the total inflow volumes into the Dams.

The base flow model (after Boughton) has the form:

- $\text{Base Flow}_t = ((\text{Base Flow}_{t-1} \times BR) + (BC \times Q_t)^{\wedge}BM))$

Where:

- Base Flow_t = Baseflow at time t (m^3/s);
- BR = Base Flow Recession Constant (~0.975 or less than unity);
- Q_t = Modelled Surface Runoff at time t (m^3/s);
- BC = Surface Runoff Factor (~0.002);
- BM = Exponent (~1.0).

As stated above, FLOOD-Ops only estimates surface runoff and does not calculate base flow, as this is added in the gate operations spreadsheets. This should be noted when comparing output data from FLOOD-Ops to the final estimated Dam inflow volumes. Base flow coefficients can be adjusted during flood events to allow matching of model results with actual data.

At the start of the January 2011 Flood Event, there was a residual base flow into North Pine Dam, resulting from the post-Christmas flood. As a result, the starting base flow used in the RTFM was relatively high and was adjusted to match the water level rises in the Dams in the absence of surface runoff. As surface runoff increased during the Event, the base flow component of the total runoff hydrograph decreased, and by the end of the Event, was around 8% of the total inflow volume into the Dam. Final Event estimates of

base flow, in terms of volume for North Pine Dam, were 17,000ML out of a total event inflow volume of approximately 200,000ML. Figure 7.2.4 shows the estimated base flow component in comparison to the total surface runoff into North Pine Dam from the North Pine River.

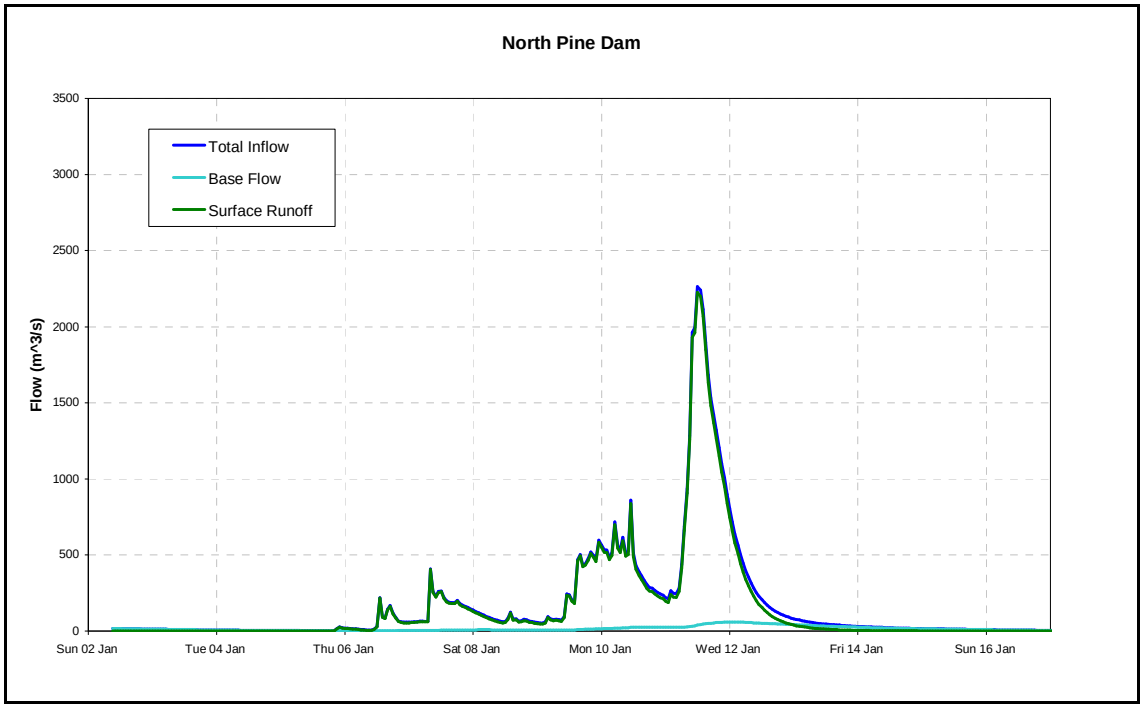

Figure 7.2.4 – Modelled inflow into North Pine Dam

Cases

A Case is an event-based sequence of processes applied to a number of Regions. Generally, all Regions are included in a Case, which is identified by a unique Case name. The following items are required to define a Case:

- Name and description of Case;
- Simulation start time, current time, simulation finish time and computational time step;
- Rainfall from simulation start time to the current time;
- Rainfall loss model type, required rainfall loss rates and spatial distribution;
- Forecast rainfall duration, depth, spatial and temporal distribution;
- Regions included in Case;
- Hydrologic model routing parameters;
- Reservoir start volume and operating procedure.

The output from a Case provides model results that are used in flood event decision-making.

7.3 Model performance during the Event

Data

As discussed in Section 5 and Section 6, there were no issues of concern observed that significantly impacted on the operation of the RTFM data collection system during the January 2011 Flood Event.

Ratings

A Rating is a unique relationship between height and flow at a water level recording station and is used to convert the recorded water level to an estimated flow rate.

Ratings are generally derived from field measurements of flow, and extrapolated by a variety of techniques for flows that are beyond the range of available field measurements. This allows for coverage of a full range of potential gauge heights. Therefore, there can be considerable uncertainty in the estimation of high flows from recorded water level data, especially at heights such as those experienced during the January 2011 Flood Event.

It should be noted that the rating for the only station upstream of North Pine Dam, Baxters Creek, has been derived and contains of uncertainty.

Actual water levels exceeded the range of available field measurements at a number of gauges during the January 2011 Flood Event. This factor caused additional uncertainty to be associated with the RTFM results, but did not have a significant impact on Flood Event decision-making.

Soil moisture accounting model

The spring and early summer rainfall totals were above average for all Regions. Flood-producing rainfall was recorded in October 2010 and again throughout late November 2010 and December 2010. A number of separate flood events, listed in Table 1.1.1, were experienced during this period with a flood event finishing on Sunday 2 January 2011. As a consequence of these flood events, the catchments were close to saturation at the commencement of the January 2011 Flood Event, as evidenced by the estimates of initial loss shown in the table below.

The values shown in Table 7.3.1 were used as a starting point for the calibration of the runoff-routing Process.

Loss rate estimates of regions – Wednesday 5 January 2011

Region code	API Initial loss (mm)	SACREMENTO Initial loss (mm)	SACREMENTO Continuing loss (mm/hr)
Pine River			
NDI	25.2	20.9	1.2
SOU	20.2	11.7	0.5
SID	26.6	23.4	1.2
RES	25.3	20.5	1.2

Table 7.3.1 – Region loss rate estimates at Wednesday 5 January 2011

During the Event, continuing loss rates were changed to ensure the overall shape and volume of the Flood Event was being matched to an acceptable level. Given the multi-peaked nature of the hydrographs and the prolonged duration of the Event, the continuing loss rates tended to reduce as the Event progressed. Table 7.3.2 shows the final Event values used in the RTFM.

To continue producing accurate modelling outputs, the final continuing loss rates adopted were substantially lower than the initial values. This clearly indicates the increasing impact of catchment saturation over the duration of the Flood Event.

Adopted loss rate estimates of regions – January 2001 (final)		
Region code	**Initial loss (mm)**	**Continuing loss (mm/hr)**
Pine River		
NDI	10	0.3
SOU	10	0.3
SID	10	0.3
RES	10	0.3

Table 7.3.2 – Region loss rates (final) January 2011

The continuing loss rates in Table 7.3.2 are well within the range of those used to model historic flood events, including the January 1974 event, and are certainly within the calibration range of the RTFM. However, while the continuing loss rate has some physical basis, the continuing loss rate is also an indicator of the quality of the recorded data. The consistency of continuing loss rate estimates between events positively indicate the rainfall network provides adequate coverage and that stream gauge ratings are relatively reliable.

Cases

Two basic Case scenarios were examined during the event:

- No Forecast Rainfall – accounted for rainfall on the ground to the time of the simulation run;
- Forecast Rainfall – included an extension of rainfall based on the BoM forecasts (either QPF or SILO).

As is standard practice, a number of simulations were conducted during the initial phases of the Event to develop an understanding of the Event. During this period, between rainfall commencing and runoff being recorded at water level gauges, the modelling focused on matching the rising limb of the hydrographs. Once the start of the rise of the hydrograph was matched sufficiently, modelling focused on estimating the peak flow and the volume of the flood, especially for stations located above the Dams. Normally, peak flow rates and flood volumes are matched to at least within 20% of recorded values.

The No Forecast Rain and Forecast Rain scenarios were examined to establish possible operational requirements within lower and upper bound model estimates. Attempts were made to match flows at all available gauging stations, with emphasis placed on stations located upstream of the Dam. These key locations for each catchment (with associated ALERT sensor identification numbers) were:

- **North Pine River**
  North Pine River at Baxters Creek (6712)
  North Pine River at North Pine Dam headwater A (6761), B (6768) and C (6762);
- **South Pine River**
  South River at Drapers Crossing (6770);
- **Sideling Creek**
  Sideling Creek at Lake Kurwongbah (6767).

There are not any suitable stream gauge locations in the residual catchment area and, as a result, no calibration is considered in this region.

7 FLOOD MODEL VALIDITY AND PERFORMANCE (continued)

The recorded headwater levels and gate settings at the Dam were also used to ensure the modelled inflows were appropriate, before using projected inflows to determine future gate operations. Manually-read gauge board readings obtained from the storage operators were used to validate the automatic gauge information at the Dams and were used in preference to automatic gauge information for operational decision-making.

During this Event, some Cases were over-written. This occurred because Cases are generally created by using the most recent Case as a base. If the Case being used as a base is not explicitly saved, it will be lost. This does not present a problem from an operational sense as historical Cases quickly become "out of date" as further rain falls in the Dam catchments. "Out of date" Cases have little bearing on current time operational decision-making as they do not consider all of the rain that has fallen since the commencement of the flood event to the current time. Cases can also easily be re-created at any time during or after the flood event as all Case data is archived. Table 7.3.3 provides a list of preserved Cases developed during the Flood Event.

Run number	Run date and time	Case name	Case description
A	16:00 6/01/2011	201101061600	No Forecast Rain
B	21:00 6/01/2011	201101062100	No Forecast Rain
C	18:00 7/01/2011	201101071800	No Forecast Rain
D	10:00 8/01/2011	201101081000	No Forecast Rain
Dfs	10:00 8/01/2011	201101081000-72h	SILO – Forecast Rain
E	15:00 8/01/2011	201101081500	No Forecast Rain
F	15:00 9/01/2011	201101091500	No Forecast Rain
G	18:00 9/01/2011	201101091800	No Forecast Rain
H	22:00 9/01/2011	201101092200	No Forecast Rain
I	03:00 10/01/2011	201101100300	No Forecast Rain
J	05:00 10/01/2011	201101100500	No Forecast Rain
K	00:00 11/01/2011	201101110000	No Forecast Rain
L	10:00 11/01/2011	201101111000	No Forecast Rain
M	15:00 11/01/2011	201101111500	No Forecast Rain
N	00:00 12/01/2011	201101120000	No Forecast Rain
O	14:00 14/01/2011	201101141400	No Forecast Rain

Table 7.3.3 – Preserved model runs, January 2011 Flood Event

Table 7.3.4 presents a summary of Cases associated with the Event. A post-event naming convention was developed to facilitate presentation of these model runs. The mapping of this convention to preserve event model runs is summarised in Table 7.3.4.

Post-event run number	Date and time of run	Corresponding or previous event run number
1	16:00 on 06/01/2011	A
2	21:00 on 06/01/2011	B
3	18:00 on 07/01/2011	C
4	10:00 on 08/01/2011	D
5	15:00 on 08/01/2011	E
6	15:00 on 09/01/2011	F
7	18:00 on 09/01/2011	G
8	22:00 on 09/01/2011	H
9	03:00 on 10/01/2011	I
10	05:00 on 10/01/2011	J
11	00:00 on 11/01/2011	K
12	10:00 on 11/01/2011	L
13	15:00 on 11/01/2011	M
14	00:00 on 12/01/2011	N
15	14:00 on 14/01/2011	O

Table 7.3.4 – Model run naming convention

RTFM results

Overall, the RTFM provided sufficient information to support flood operations decision-making. Water level estimates did not require significant scaling to match recorded lake levels.

The results provided by the RTFM correlated with the results provided by the back-up RTFM system, using the URBS models.

The model performance also reflects the robustness of the original model calibrations, which were biased towards the larger historical flood events, such as January 1974. The January 2011 Flood Event has a magnitude that requires extrapolation of the model parameters beyond previous benchmarks. The availability of numerous rainfall stations in the catchment significantly and positively contributed to the overall model performance.

With respect to the application of the runoff-routing models in a forecasting model, it should be noted the projected flows are not updated using the recorded flows to the time of the simulation, but rather, the projected flows are derived from recorded rainfalls with or without a forecast rainfall extension.

Summaries of the results across the three key catchments are contained below.

- **North Pine River Catchment Model**
  The North Pine River Catchment Model generally performed well. The total modelled peak discharge and volume into the Dam generally provided good results but was underestimated in some instances despite relatively small loss rates being applied. This may indicate that the available rainfall gauges did not adequately capture the highest intensity rainfall that was experienced during the event. The underestimation was accounted for by adjusting estimated inflows to match the rates of rise and fall in the lake level in the gate operations spreadsheet.

- **South Pine River Catchment Model**
  The South Pine River Catchment Model performed well, especially in the high flow range. There appears to be some discrepancy with the low flow ratings and these will be investigated post-event.
- **Sideling Creek River Catchment Model**
  The Sideling Creek Catchment Model performed well, and allowed inflows into Lake Kurwongbah to be assessed. The adopted model parameters were derived by proportioning calibrated model parameters from the North Pine River Catchment Model. The appropriateness of these parameters needs to be assessed by comparing actual lake levels with the modeled estimates. The headwater sensor calibration parameters in the RTFM appear to be invalid during the January 2011 Flood Event, as there was a discrepancy between the manually observed values and the automatic gauge values.

The results in Table 7.3.5 are surface runoff results only and contain no base flow. Therefore, the values shown in this table will be lower than those shown in the gate operations spreadsheets and the final modelling results. The results shown in Table 7.3.5 are based on unverified stream height data and associated Ratings. Although the values shown in the Tables are presented to the nearest m^3/s or ML, the level of precision should not be inferred from this level of reporting.

Run 1 – 16:00 on Thursday 6 January 2011

This run was completed on the day of mobilisation of the Flood Operations Centre. Rainfall commenced the previous day, with the largest falls occurring in the North Pine River catchment.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	28	3,128	43	1,088	15	-2,040
Cashs Crossing	1	3	75	3,448	74	3,445

Run 3 – 18:00 on Friday 7 January 2011

This run was completed 35 hours after mobilisation of the Flood Operations Centre. Flows in the North Pine and South Pine Rivers had just peaked for a second time.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	91	6,425	126	7,219	35	795
Cashs Crossing	18	241	88	9,206	70	8,966

Run 5 – 15:00 on Saturday 8 January 2011

This run was completed 56 hours after mobilisation of the Flood Operations Centre. Both the North Pine and South Pine Rivers continued to recede.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	91	8,866	126	10,358	35	1,492
Cashs Crossing	18	242	88	11,271	70	11,029

Run 6 – 15:00 on Sunday 9 January 2011

This run was completed 80 hours after mobilisation of the Flood Operations Centre. Runoff was increasing in the South Pine River catchment as a consequence of developing heavy rainfall.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	91	11,373	126	12,907	35	1,533
Cashs Crossing	57	696	123	13,800	66	13,105

Run 8 – 22:00 on Sunday 9 January 2011

This run was completed 87 hours after mobilisation of the Flood Operations Centre. The North Pine River had just peaked for a third time and the South Pine River was still rising rapidly.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	117	14,054	250	18,317	133	4,263
Cashs Crossing	316	5,012	320	19,804	4	14,792

Run 10 – 05:00 on Monday 10 January 2011

This run was completed 94 hours after mobilisation of the Flood Operations Centre. All streams appeared to be receding, although heavy rain falling on all catchments suggested another rise was likely to occur.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	117	16,439	224	19,768	107	3,329
Cashs Crossing	384	10,279	292	22,752	-91	12,473

Run 11 – 00:00 on Tuesday 11 January 2011

This run was completed 113 hours after mobilisation of the Flood Operations Centre. A secondary peak occurred in the South Pine River, and the North Pine River continued to recede slowly.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	117	21,861	224	28,220	107	6,358
Cashs Crossing	384	17,322	292	32,559	-91	15,237

Run 12 – 10:00 on Tuesday 11 January 2011

This run was completed 123 hours after mobilisation of the Flood Operations Centre. Rapid rises occurred in the North Pine River, with associated increased runoff volumes into North Pine Dam.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	623	28,811	551	34,754	-72	5,943
Cashs Crossing	384	18,827	292	35,603	-91	16,776

Run 13 – 15:00 on Tuesday 11 January 2011

This run was completed 128 hours after mobilisation of the Flood Operations Centre. Heavy rainfall in the upper reaches of both the North Pine and South Pine Rivers suggested peak flow rates higher than the October 2010 flood event.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	749	39,776	1,048	60,899	299	21,123
Cashs Crossing	920	32,364	1,020	60,846	100	28,481

Run 14 – 00:00 on Wednesday 12 January 2011

This run was completed 137 hours after mobilisation of the Flood Operations Centre. All streams had peaked and had now receded.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	749	43,983	1,051	81,206	302	37,223
Cashs Crossing	920	40,906	1,025	77,921	105	37,015

Run 15 – 14:00 on Friday 14 January 2011

This run was completed 199 hours after mobilisation of the Flood Operations Centre. All catchments had peaked or had started to recede.

Stream gauge	Estimated		Modelled		Difference	
	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)	Peak flow (m^3/s)	Flood volume (ML)
Baxters Creek	749	43,983	1,051	88,229	302	44,246
Cashs Crossing	920	41,315	1,025	81,753	105	40,438

Table 7.3.5 – Model run peak flow and flood volume values

7 FLOOD MODEL VALIDITY AND PERFORMANCE (continued)

7.4 Review of system performance during the Event

The RTFM and associated systems performed well during the Event as described in detail earlier in this Section. No system failures occurred during the Event and, generally, the systems modelled actual stream flow to within acceptable tolerances, although the inflow into North Pine Dam was underestimated in some model runs. Additionally, there were no operational flaws or errors detected in the RTFM system during the Event that adversely impacted operational decision-making in any way.

8 DAM INFLOW AND FLOOD RELEASE DETAILS

8.1 Introduction

North Pine Dam has no provision for flood mitigation. To protect the structural safety of the Dam, the strategy used when operating the Dam during flood events is to pass any flood impacting the Dam through the reservoir, while ensuring peak outflow generally does not exceed peak inflow.

It is important to note, under the Manual's current operating rules, North Pine Dam is expected to fail during floods with an AEP larger than 1 in 100,000. This highlights the importance of maintaining the safety of the Dam by ensuring that the flood impacting the Dam is passed through the reservoir.

Section 8 provides details of the inflows to North Pine Dam and the flood releases made from the Dam during the January 2011 Flood Event.

8.2 Inflow and release details

Table 8.2.1 provides full details of inflows into and releases from North Pine Dam for the duration of the January 2011 Flood Event. Table 8.2.1 also shows the gate operation sequence was in accordance with the Manual over the duration of the Event.

Some points to note in relation to Table 8.2.1 are:

- Inflow and flood release calculations are based on the manual gauge board readings in the table that provide the lake level. During the Event, these manual gauge board readings were provided to the Flood Operations Centre on an hourly basis by the Dam Operators. Any missed readings have been interpolated from the closest available actual readings.
- Release calculations are based on the discharge rating tables contained in the Manual.
- Inflow calculations are derived using a reverse routing technique assuming level pool. For each time step, inflow is based on the rate of change of the storage calculated from the manual gauge board readings and the Dam storage curve plus the releases. The method tends to underestimate the rising limb and overestimate the falling limb of the inflow. The erratic shape of the inflow is due to small level differences resulting in large inflow volumes.
- Table 8.2.1 shows inflow rates and releases on the hour through the event. In some instances, gate operations may have occurred between hours or at less than one-hourly intervals. In these instances, the table shows the actual gate openings as they were at the time indicated.
- Although the values shown in Table 8.2.1 are presented to the nearest m^3/s or ML, precision should not be inferred from this level of reporting.

8 DAM INFLOW AND FLOOD RELEASE DETAILS (continued)

Date	Elevation	Volume	Incremental flow		Gate openings					Increments	Gate discharge					Total gate discharge	River release	Outflow	Inflow	Average catchment rainfall
					A	B	C	D	E		A	B	C	D	E					
	m AHD	ML	ML	m^3/s	3	5	1	4	2		m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	mm
06/01/2011 08:00	39.61	214,521	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	0	0.0
06/01/2011 09:00	39.61	214,521	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	0	0.0
06/01/2011 10:00	39.62	214,740	128	36	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	36	1.6
06/01/2011 11:00	39.62	214,740	-55	-15	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	0	3.2
06/01/2011 12:00	39.62	214,740	201	56	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	56	8.4
06/01/2011 13:00	39.64	215,179	639	178	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	178	0.6
06/01/2011 14:00	39.67	215,836	329	91	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	92	1.5
06/01/2011 15:00	39.67	215,836	73	20	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	21	3.7
06/01/2011 16:00	39.68	216,055	110	30	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	31	2.0
06/01/2011 17:00	39.68	216,055	91	25	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	26	0.8
06/01/2011 18:00	39.69	216,274	237	66	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	66	0.2
06/01/2011 19:00	39.70	216,494	237	66	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	66	0.0
06/01/2011 20:00	39.71	216,713	146	41	1	1	1	1	1	5	16	16	16	16	16	80	0.30	81	121	0.0
06/01/2011 21:00	39.71	216,713	-237	-66	2	1	2	2	2	9	40	16	40	40	40	176	0.30	176	110	0.0
06/01/2011 22:00	39.69	216,274	-457	-127	2	2	2	2	2	10	40	40	40	40	40	200	0.30	200	73	0.0
06/01/2011 23:00	39.67	215,836	-548	-152	2	2	2	2	2	10	40	40	40	40	40	200	0.30	200	48	0.0
07/01/2011 00:00	39.64	215,179	-694	-193	2	2	2	2	2	10	40	40	40	40	40	199	0.30	199	7	0.4
07/01/2011 01:00	39.61	214,521	-528	-147	2	2	2	2	2	10	40	40	40	40	40	199	0.30	199	53	0.4
07/01/2011 02:00	39.59	214,089	-535	-149	2	2	2	2	2	10	40	40	40	40	40	199	0.30	199	50	0.2
07/01/2011 03:00	39.56	213,450	-532	-148	2	2	2	2	2	10	40	40	40	40	40	198	0.30	198	51	0.6
07/01/2011 04:00	39.54	213,024	-515	-143	2	2	2	2	2	10	40	40	40	40	40	198	0.30	198	55	0.2
07/01/2011 05:00	39.51	212,384	-657	-183	2	2	2	2	2	10	40	40	40	40	40	198	0.30	198	15	0.4
07/01/2011 06:00	39.48	211,745	-710	-197	2	2	2	2	2	10	39	39	39	39	39	197	0.30	197	0	1.1
07/01/2011 07:00	39.45	211,106	-142	-39	2	2	2	2	2	10	39	39	39	39	39	197	0.30	197	158	13.3

8 DAM INFLOW AND FLOOD RELEASE DETAILS (continued)

Date	Elevation	Volume	Incremental flow		Gate openings					Increments	Gate discharge					Total gate discharge	River release	Outflow	Inflow	Average catchment rainfall
					A	B	C	D	E		A	B	C	D	E					
	m AHD	ML	ML	m^3/s	3	5	1	4	2		m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	mm
07/01/2011 08:00	39.46	211,319	-178	-49	2	2	2	2	2	10	39	39	39	39	39	197	0.30	197	148	4.8
07/01/2011 09:00	39.43	210,680	-497	-138	2	2	2	2	2	10	39	39	39	39	39	197	0.30	197	59	2.7
07/01/2011 10:00	39.42	210,467	-195	-54	2	2	2	2	2	10	39	39	39	39	39	196	0.30	197	142	12.7
07/01/2011 11:00	39.41	210,253	-107	-30	2	2	2	2	2	10	39	39	39	39	39	196	0.30	197	167	2.7
07/01/2011 12:00	39.41	210,253	0	0	2	2	2	2	2	10	39	39	39	39	39	196	0.30	197	197	0.2
07/01/2011 13:00	39.41	210,253	107	30	2	2	2	2	2	10	39	39	39	39	39	196	0.30	197	226	0.1
07/01/2011 14:00	39.42	210,467	231	64	2	2	2	2	2	10	39	39	39	39	39	196	0.30	197	261	0.0
07/01/2011 15:00	39.43	210,680	213	59	2	2	2	2	2	10	39	39	39	39	39	197	0.30	197	256	0.0
07/01/2011 16:00	39.44	210,893	231	64	2	2	2	2	2	10	39	39	39	39	39	197	0.30	197	261	0.2
07/01/2011 17:00	39.45	211,106	124	35	2	2	2	2	2	10	39	39	39	39	39	197	0.30	197	232	2.2
07/01/2011 18:00	39.45	211,106	-160	-44	2	2	2	2	2	10	39	39	39	39	39	197	0.30	197	153	0.3
07/01/2011 19:00	39.44	210,893	0	0	2	2	2	2	2	10	39	39	39	39	39	197	0.30	197	197	0.0
07/01/2011 20:00	39.45	211,106	142	39	1	1	1	1	1	5	16	16	16	16	16	79	0.30	79	119	0.2
07/01/2011 21:00	39.45	211,106	-18	-5	1	1	1	1	1	5	16	16	16	16	16	79	0.30	79	74	0.0
07/01/2011 22:00	39.45	211,106	-18	-5	1	1	1	1	1	5	16	16	16	16	16	79	0.30	79	74	0.0
07/01/2011 23:00	39.45	211,106	124	35	1	1	1	1	1	5	16	16	16	16	16	79	0.30	79	114	0.0
08/01/2011 00:00	39.46	211,319	124	35	1	1	1	1	1	5	16	16	16	16	16	79	0.30	79	114	0.1
08/01/2011 01:00	39.46	211,319	-18	-5	1	0	1	1	1	4	16	0	16	16	16	63	0.30	64	59	0.0
08/01/2011 02:00	39.46	211,319	-18	-5	1	0	1	0	1	3	16	0	16	0	16	47	0.30	48	43	0.0
08/01/2011 03:00	39.46	211,319	124	35	1	0	1	0	1	3	16	0	16	0	16	47	0.30	48	82	0.0
08/01/2011 04:00	39.47	211,532	124	35	1	0	1	0	1	3	16	0	16	0	16	47	0.30	48	82	0.0
08/01/2011 05:00	39.47	211,532	-18	-5	1	0	1	0	1	3	16	0	16	0	16	47	0.30	48	43	0.0
08/01/2011 06:00	39.47	211,532	0	0	1	0	1	0	1	3	16	0	16	0	16	47	0.30	48	48	0.0
08/01/2011 07:00	39.47	211,532	0	0	1	0	1	0	1	3	16	0	16	0	16	47	0.30	48	48	0.0

8 DAM INFLOW AND FLOOD RELEASE DETAILS (continued)

Date	Elevation	Volume	Incremental flow		Gate openings					Increments	Gate discharge					Total gate discharge	River release	Outflow	Inflow	Average catchment rainfall
					A	B	C	D	E		A	B	C	D	E					
	m AHD	ML	ML	m^3/s	3	5	1	4	2		m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	mm
08/01/2011 08:00	39.47	211,532	0	0	1	0	1	0	1	3	16	0	16	0	16	47	0.30	48	48	0.0
08/01/2011 09:00	39.47	211,532	0	0	1	0	1	0	1	3	16	0	16	0	16	47	0.30	48	48	0.0
08/01/2011 10:00	39.47	211,532	0	0	1	0	1	0	1	3	16	0	16	0	16	47	0.30	48	48	0.2
08/01/2011 11:00	39.47	211,532	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	0.4
08/01/2011 12:00	39.47	211,532	-36	-10	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	22	1.2
08/01/2011 13:00	39.47	211,532	266	74	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	106	2.6
08/01/2011 14:00	39.49	211,958	124	35	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	67	0.0
08/01/2011 15:00	39.48	211,745	-160	-44	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	0	0.0
08/01/2011 16:00	39.48	211,745	18	5	1	0	1	0	1	3	16	0	16	0	16	48	0.30	48	53	1.0
08/01/2011 17:00	39.48	211,745	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	1.5
08/01/2011 18:00	39.48	211,745	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	0.8
08/01/2011 19:00	39.48	211,745	-18	-5	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	27	0.2
08/01/2011 20:00	39.48	211,745	124	35	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	66	1.0
08/01/2011 21:00	39.49	211,958	124	35	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	67	1.4
08/01/2011 22:00	39.49	211,958	-18	-5	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	27	0.2
08/01/2011 23:00	39.49	211,958	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	0.0
09/01/2011 00:00	39.49	211,958	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	0.0
09/01/2011 01:00	39.49	211,958	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	0.4
09/01/2011 02:00	39.49	211,958	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	0.7
09/01/2011 03:00	39.49	211,958	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	2.1
09/01/2011 04:00	39.49	211,958	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	1.7
09/01/2011 05:00	39.49	211,958	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	1.7
09/01/2011 06:00	39.49	211,958	-18	-5	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	27	0.0
09/01/2011 07:00	39.49	211,958	124	35	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	67	0.6

8 DAM INFLOW AND FLOOD RELEASE DETAILS (continued)

Date	Elevation	Volume	Incremental flow		Gate openings					Increments	Gate discharge					Total gate discharge	River release	Outflow	Inflow	Average catchment rainfall
					A	B	C	D	E		A	B	C	D	E					
	m AHD	ML	ML	m^3/s	3	5	1	4	2		m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	mm
09/01/2011 08:00	39.50	212,171	124	35	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	67	0.1
09/01/2011 09:00	39.50	212,171	-36	-10	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	22	5.7
09/01/2011 10:00	39.50	212,171	89	25	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	57	12.6
09/01/2011 11:00	39.51	212,384	373	104	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	136	4.2
09/01/2011 12:00	39.53	212,810	213	59	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	91	1.0
09/01/2011 13:00	39.53	212,810	0	0	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	32	2.3
09/01/2011 14:00	39.54	213,024	637	177	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	209	19.0
09/01/2011 15:00	39.59	214,089	1294	359	0	0	1	0	1	2	0	0	16	0	16	32	0.30	32	392	9.9
09/01/2011 16:00	39.65	215,398	1076	299	1	1	1	1	1	5	16	16	16	16	16	80	0.30	80	379	5.7
09/01/2011 17:00	39.69	216,274	1059	294	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	447	6.5
09/01/2011 18:00	39.75	217,589	1352	375	2	1	2	1	2	8	40	16	40	16	40	152	0.30	153	528	5.9
09/01/2011 19:00	39.81	218,907	1363	379	2	1	2	1	2	8	40	16	40	16	40	153	0.30	153	532	10.7
09/01/2011 20:00	39.87	220,240	1131	314	2	2	2	2	2	10	40	40	40	40	40	202	0.30	202	516	2.0
09/01/2011 21:00	39.91	221,129	759	211	3	3	3	3	3	15	67	67	67	67	67	334	0.30	335	545	1.3
09/01/2011 22:00	39.94	221,796	574	159	3	3	4	3	4	17	67	67	94	67	94	390	0.30	390	550	7.5
09/01/2011 23:00	39.96	222,240	185	51	4	3	4	3	4	18	95	67	95	67	95	418	0.30	418	470	6.0
10/01/2011 00:00	39.96	222,240	93	26	4	3	4	4	4	19	95	67	95	95	95	446	0.30	446	472	3.1
10/01/2011 01:00	39.97	222,462	130	36	4	3	4	4	4	19	95	67	95	95	95	446	0.30	446	482	4.0
10/01/2011 02:00	39.97	222,462	0	0	4	3	4	4	4	19	95	67	95	95	95	446	0.30	446	446	0.6
10/01/2011 03:00	39.97	222,462	-167	-46	4	3	4	4	4	19	95	67	95	95	95	446	0.30	446	400	3.8
10/01/2011 04:00	39.96	222,240	130	36	4	3	4	4	4	19	95	67	95	95	95	446	0.30	446	482	11.6
10/01/2011 05:00	39.98	222,685	278	77	4	4	4	4	4	20	95	95	95	95	95	474	0.30	474	551	2.7
10/01/2011 06:00	39.98	222,685	-56	-15	4	4	4	4	4	20	95	95	95	95	95	474	0.30	474	459	2.9
10/01/2011 07:00	39.98	222,685	148	41	4	4	4	4	4	20	95	95	95	95	95	474	0.30	474	515	6.6

8 DAM INFLOW AND FLOOD RELEASE DETAILS (continued)

Date	Elevation	Volume	Incremental flow		Gate openings					Increments	Gate discharge					Total gate discharge	River release	Outflow	Inflow	Average catchment rainfall
					A	B	C	D	E		A	B	C	D	E					
	m AHD	ML	ML	m^3/s	3	5	1	4	2		m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	mm
10/01/2011 08:00	39.99	222,907	19	5	4	4	4	4	4	20	95	95	95	95	95	474	0.30	474	479	3.0
10/01/2011 09:00	39.98	222,685	-352	-98	4	4	4	4	4	20	95	95	95	95	95	474	0.30	474	376	1.7
10/01/2011 10:00	39.97	222,462	446	124	4	4	4	4	4	20	95	95	95	95	95	473	0.30	474	598	10.1
10/01/2011 11:00	40.01	223,354	278	77	4	4	5	4	5	22	95	95	121	95	121	527	0.30	528	605	2.4
10/01/2011 12:00	39.99	222,907	-280	-78	4	4	5	4	5	22	95	95	121	95	121	527	0.30	527	449	1.5
10/01/2011 13:00	39.99	222,907	-296	-82	4	4	5	4	5	22	95	95	121	95	121	527	0.30	527	445	1.3
10/01/2011 14:00	39.96	222,240	-704	-195	4	4	5	4	5	22	95	95	121	95	121	526	0.30	526	331	2.6
10/01/2011 15:00	39.93	221,574	-815	-226	4	4	5	4	5	22	94	94	121	94	121	525	0.30	525	299	0.5
10/01/2011 16:00	39.89	220,685	-667	-185	4	4	5	4	4	21	94	94	120	94	94	497	0.30	497	312	0.2
10/01/2011 17:00	39.87	220,240	-537	-149	4	4	4	4	4	20	94	94	94	94	94	470	0.30	471	321	0.1
10/01/2011 18:00	39.84	219,574	-593	-165	3	3	4	3	3	16	67	67	94	67	67	360	0.30	360	196	1.6
10/01/2011 19:00	39.82	219,129	-315	-87	3	3	4	3	3	16	66	66	94	66	66	360	0.30	360	272	0.9
10/01/2011 20:00	39.81	218,907	-222	-62	3	2	3	3	3	14	66	40	66	66	66	306	0.30	306	245	1.6
10/01/2011 21:00	39.80	218,685	-111	-31	2	2	2	2	2	10	40	40	40	40	40	201	0.30	201	171	2.3
10/01/2011 22:00	39.80	218,685	19	5	2	1	2	1	2	8	40	16	40	16	40	153	0.30	153	158	0.3
10/01/2011 23:00	39.80	218,685	0	0	2	1	2	1	2	8	40	16	40	16	40	153	0.30	153	153	0.6
11/01/2011 00:00	39.80	218,685	0	0	2	1	2	1	2	8	40	16	40	16	40	153	0.30	153	153	0.0
11/01/2011 01:00	39.80	218,685	0	0	2	1	2	1	2	8	40	16	40	16	40	153	0.30	153	153	5.1
11/01/2011 02:00	39.80	218,685	0	0	2	1	2	1	2	8	40	16	40	16	40	153	0.30	153	153	1.3
11/01/2011 03:00	39.80	218,685	0	0	2	1	2	1	2	8	40	16	40	16	40	153	0.30	153	153	5.2
11/01/2011 04:00	39.80	218,685	-74	-21	2	1	2	1	2	8	40	16	40	16	40	153	0.30	153	133	7.7
11/01/2011 05:00	39.80	218,685	444	123	2	1	2	1	2	8	40	16	40	16	40	153	0.30	153	277	23.1
11/01/2011 06:00	39.84	219,574	889	247	2	1	2	2	2	9	40	16	40	40	40	177	0.30	178	425	30.2
11/01/2011 07:00	39.88	220,463	1182	328	3	2	3	2	3	13	67	40	67	40	67	281	0.30	281	610	23.6

8 DAM INFLOW AND FLOOD RELEASE DETAILS (continued)

Date	Elevation	Volume	Incremental flow		Gate openings					Increments	Gate discharge					Total gate discharge	River release	Outflow	Inflow	Average catchment rainfall
					A	B	C	D	E		A	B	C	D	E					
	m AHD	ML	ML	m^3/s	3	5	1	4	2		m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	mm
11/01/2011 08:00	39.96	222,240	2642	734	4	3	4	3	4	18	95	67	95	67	95	418	0.30	418	1,152	37.3
11/01/2011 09:00	40.12	225,833	4363	1212	6	5	6	6	6	29	150	122	150	150	150	721	0.30	721	1,933	49.1
11/01/2011 10:00	40.34	230,831	5586	1552	9	8	9	9	9	44	232	206	232	232	232	1134	0.30	1,134	2,686	36.7
11/01/2011 11:00	40.60	236,831	6475	1799	12	12	13	12	13	62	313	313	340	313	340	1621	0.30	1,621	3,420	28.9
11/01/2011 12:00	40.87	243,191	5276	1466	15	15	15	15	15	75	404	404	404	404	404	2018	0.30	2,019	3,484	27.3
11/01/2011 13:00	41.03	247,009	2843	790	18	18	18	18	18	90	514	514	514	514	514	2569	0.30	2,570	3,359	18.9
11/01/2011 14:00	41.11	248,938	848	235	19	19	20	19	19	96	547	547	606	547	547	2794	0.30	2,795	3,030	4.0
11/01/2011 15:00	41.10	248,697	-1270	-353	19	19	20	19	19	96	547	547	611	547	547	2799	0.30	2,800	2,447	1.0
11/01/2011 16:00	41.01	246,526	-2938	-816	19	19	20	19	19	96	545	545	674	545	545	2854	0.30	2,854	2,038	2.6
11/01/2011 17:00	40.86	242,953	-4227	-1174	19	19	20	19	19	96	541	541	657	541	541	2823	0.30	2,823	1,649	1.3
11/01/2011 18:00	40.66	238,239	-5033	-1398	18	18	18	18	18	90	504	504	504	504	504	2521	0.30	2,521	1,123	1.6
11/01/2011 19:00	40.44	233,127	-5074	-1409	18	16	17	17	17	85	498	425	461	461	461	2307	0.30	2,307	898	0.0
11/01/2011 20:00	40.23	228,320	-4412	-1226	16	15	16	15	16	78	420	388	420	388	420	2034	0.30	2,035	809	0.5
11/01/2011 21:00	40.06	224,481	-3183	-884	11	11	11	11	11	55	277	277	277	277	277	1386	0.30	1,386	502	0.1
11/01/2011 22:00	39.95	222,018	-1691	-470	6	6	6	6	6	30	148	148	148	148	148	740	0.30	740	270	0.6
11/01/2011 23:00	39.90	220,907	-906	-252	4	4	6	4	6	24	94	94	147	94	147	578	0.30	578	326	0.9
12/01/2011 00:00	39.86	220,018	-778	-216	4	3	4	4	4	19	94	67	94	94	94	443	0.30	443	227	1.0
12/01/2011 01:00	39.83	219,352	-555	-154	3	3	3	3	3	15	67	67	67	67	67	333	0.30	333	179	0.0
12/01/2011 02:00	39.81	218,907	-315	-88	3	2	2	2	3	12	66	40	40	40	66	254	0.30	254	166	0.5
12/01/2011 03:00	39.80	218,685	-220	-61	2	2	2	2	2	10	40	40	40	40	40	201	0.30	201	140	0.6
12/01/2011 04:00	39.79	218,466	-109	-30	2	2	2	2	2	10	40	40	40	40	40	201	0.30	201	171	0.0
12/01/2011 05:00	39.79	218,466	18	5	1	1	2	1	2	7	16	16	40	16	40	129	0.30	129	134	0.3
12/01/2011 06:00	39.79	218,466	0	0	1	1	2	1	1	6	16	16	40	16	16	105	0.30	105	105	0.2
12/01/2011 07:00	39.79	218,466	0	0	1	1	2	1	1	6	16	16	40	16	16	105	0.30	105	105	0.0

8 DAM INFLOW AND FLOOD RELEASE DETAILS (continued)

Date	Elevation	Volume	Incremental flow		Gate openings					Increments	Gate discharge					Total gate discharge	River release	Outflow	Inflow	Average catchment rainfall
					A	B	C	D	E		A	B	C	D	E					
	m AHD	ML	ML	m^3/s	3	5	1	4	2		m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	mm
12/01/2011 08:00	39.79	218,466	0	0	1	1	2	1	1	6	16	16	40	16	16	105	0.30	105	105	0.1
12/01/2011 09:00	39.79	218,466	18	5	1	1	2	1	1	6	16	16	40	16	16	105	0.30	105	110	0.0
12/01/2011 10:00	39.79	218,466	-110	-30	1	1	2	1	1	6	16	16	40	16	16	105	0.30	105	75	0.2
12/01/2011 11:00	39.78	218,247	-256	-71	1	1	2	1	1	6	16	16	40	16	16	105	0.30	105	34	0.3
12/01/2011 12:00	39.77	218,028	-91	-25	1	1	2	1	1	6	16	16	40	16	16	105	0.30	105	79	0.1
12/01/2011 13:00	39.77	218,028	-110	-30	1	1	2	1	1	6	16	16	40	16	16	105	0.30	105	74	0.1
12/01/2011 14:00	39.76	217,808	-128	-36	1	1	2	1	1	6	16	16	40	16	16	104	0.30	105	69	0.0
12/01/2011 15:00	39.76	217,808	37	10	1	1	1	1	1	5	16	16	16	16	16	80	0.30	81	91	0.0
12/01/2011 16:00	39.76	217,808	-128	-36	1	1	1	1	1	5	16	16	16	16	16	80	0.30	81	45	0.0
12/01/2011 17:00	39.75	217,589	-128	-36	1	1	2	1	1	6	16	16	40	16	16	104	0.30	105	69	0.0
12/01/2011 18:00	39.75	217,589	18	5	2	1	2	1	2	8	40	16	40	16	40	152	0.30	153	158	0.0
12/01/2011 19:00	39.75	217,589	37	10	2	1	2	1	2	8	40	16	40	16	40	152	0.30	153	163	0.0
12/01/2011 20:00	39.75	217,589	-256	-71	2	1	2	1	2	8	40	16	40	16	40	152	0.30	153	82	0.0
12/01/2011 21:00	39.73	217,151	-256	-71	2	1	2	1	2	8	40	16	40	16	40	152	0.30	153	82	0.0
12/01/2011 22:00	39.73	217,151	55	15	2	1	2	1	2	8	40	16	40	16	40	152	0.30	153	168	0.0
12/01/2011 23:00	39.73	217,151	-128	-36	2	1	2	1	2	8	40	16	40	16	40	152	0.30	153	117	0.0
13/01/2011 00:00	39.72	216,932	-110	-30	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	122	0.0
13/01/2011 01:00	39.72	216,932	-110	-30	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	122	0.2
13/01/2011 02:00	39.71	216,713	-128	-36	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	117	0.9
13/01/2011 03:00	39.71	216,713	37	10	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	163	0.2
13/01/2011 04:00	39.71	216,713	-128	-36	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	117	0.2
13/01/2011 05:00	39.70	216,494	-110	-30	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	122	0.0
13/01/2011 06:00	39.70	216,494	-91	-25	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	127	0.0
13/01/2011 07:00	39.69	216,274	-256	-71	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	81	0.0

8 DAM INFLOW AND FLOOD RELEASE DETAILS (continued)

Date	Elevation	Volume	Incremental flow		Gate openings					Increments	Gate discharge					Total gate discharge	River release	Outflow	Inflow	Average catchment rainfall
					A	B	C	D	E		A	B	C	D	E					
	m AHD	ML	ML	m^3/s	3	5	1	4	2		m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	mm
13/01/2011 08:00	39.68	216,055	-91	-25	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	127	0.0
13/01/2011 09:00	39.68	216,055	-91	-25	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	127	0.0
13/01/2011 10:00	39.67	215,836	-237	-66	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	86	0.0
13/01/2011 11:00	39.66	215,617	-237	-66	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	86	0.0
13/01/2011 12:00	39.65	215,398	-91	-25	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	126	0.0
13/01/2011 13:00	39.65	215,398	-91	-25	2	1	2	1	2	8	40	16	40	16	40	152	0.30	152	126	0.0
13/01/2011 14:00	39.64	215,179	-256	-71	2	1	2	1	2	8	40	16	40	16	40	151	0.30	152	81	0.0
13/01/2011 15:00	39.63	214,959	-91	-25	2	1	2	1	2	8	40	16	40	16	40	151	0.30	152	126	0.0
13/01/2011 16:00	39.63	214,959	-73	-20	2	1	2	1	2	8	40	16	40	16	40	151	0.30	152	131	0.0
13/01/2011 17:00	39.62	214,740	-348	-97	2	1	2	1	2	8	40	16	40	16	40	151	0.30	152	55	0.0
13/01/2011 18:00	39.60	214,302	-450	-125	2	1	2	1	2	8	40	16	40	16	40	151	0.30	151	26	0.0
13/01/2011 19:00	39.58	213,876	-443	-123	2	1	2	1	2	8	40	16	40	16	40	151	0.30	151	28	0.1
13/01/2011 20:00	39.56	213,450	-284	-79	2	1	2	1	2	8	40	16	40	16	40	151	0.30	151	72	0.0
13/01/2011 21:00	39.55	213,237	-426	-118	2	1	2	1	2	8	40	16	40	16	40	151	0.30	151	33	0.0
13/01/2011 22:00	39.52	212,597	-568	-158	2	1	2	1	2	8	40	16	40	16	40	150	0.30	151	0	0.1
13/01/2011 23:00	39.50	212,171	-408	-113	2	1	2	1	2	8	39	16	39	16	39	150	0.30	150	37	0.0
14/01/2011 00:00	39.48	211,745	-426	-118	2	1	2	1	2	8	39	16	39	16	39	150	0.30	150	32	0.0
14/01/2011 01:00	39.46	211,319	-426	-118	2	1	2	1	2	8	39	16	39	16	39	150	0.30	150	32	0.5
14/01/2011 02:00	39.44	210,893	-444	-123	2	1	2	1	2	8	39	16	39	16	39	150	0.30	150	27	0.2
14/01/2011 03:00	39.42	210,467	-320	-89	2	1	2	1	2	8	39	16	39	16	39	149	0.30	150	61	0.0
14/01/2011 04:00	39.41	210,253	-213	-59	1	0	1	1	1	4	16	0	16	16	16	63	0.30	63	4	0.0
14/01/2011 05:00	39.40	210,040	-124	-34	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0	0	0.0

Table 8.2.1 – North Pine Dam inflow and release data for the January 2011 Flood Event

A summary of the data in Table 8.2.1 is illustrated in Figure 8.2.2 which illustrates the flood mitigation benefits provided by North Pine Dam over the duration of the Event. The differences between Dam inflow and outflow are clear.

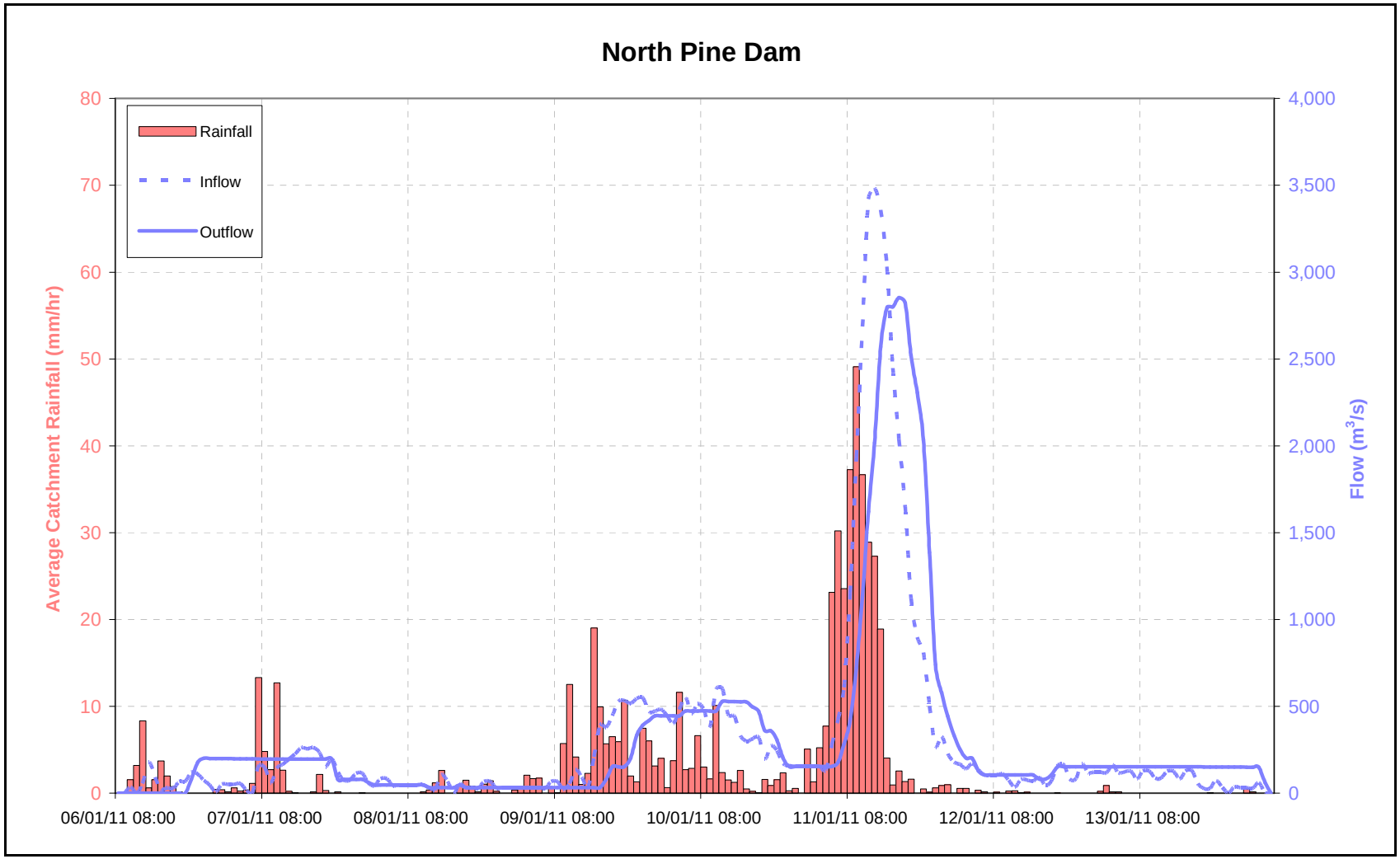

Figure 8.2.2 – North Pine Dam inflow and release summary for the January 2011 Flood Event

9 PRELIMINARY ASSESSMENT OF EVENT MAGNITUDE

9.1 Introduction

The significance of this Event can be determined by comparing rainfall, water levels and flood volumes measured during the period with historical records, and then undertaking a statistical analysis of this information. Australian Rainfall and Runoff (AR&R) categorises events according to their Annual Exceedance Probability (AEP), as illustrated in Figure 9.1.1. The Bureau of Meteorology (BoM) adopts a flood classification system based on minor, moderate and major flood levels which are defined by the BoM in conjunction with local Councils.

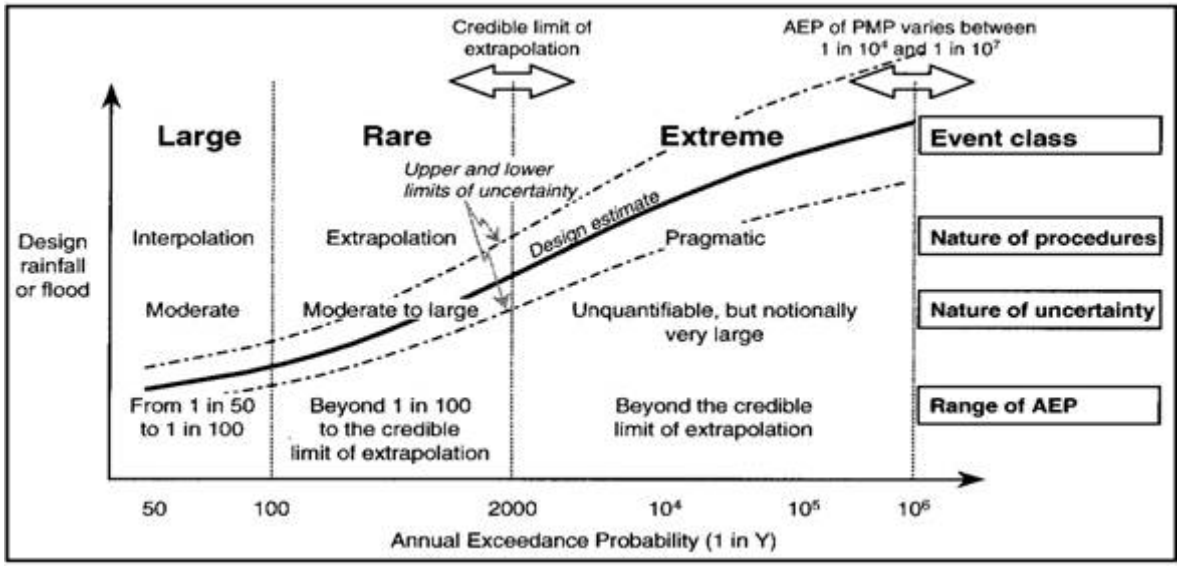

Figure 9.1.1 – Annual Exceedance Probability (AEP)

It should be noted the assessments carried out in this Section of the Report are preliminary only and are based upon operational data collected during the Event. More information may become available over time on which to base a more rigorous assessment of the Event magnitude.

Rainfall stations in the North Pine catchment have good record lengths that, in some cases, are greater than 100 years and, therefore, provide an effective basis for analysis. The analysis of rainfall intensity rather than depth provides a good indicator of the magnitude of floods in terms of peak flows and volumes.

Water level stations generally have shorter record lengths than rainfall stations, leading to a greater level of uncertainty when comparing recorded and historic water level data to determine event significance. Automatic stations have only been in widespread use since the 1960s, so continuous water level records are generally only available for maximum periods of approximately 50 years.

A preliminary flood frequency analysis was undertaken using available records, and this information is included in this Report.

9.2 Antecedent conditions

In the four weeks prior to Thursday 6 January 2011, rainfall levels in South East Queensland were well above the December average. In some areas, rainfall exceeded the December average by as much as 400mm. These results can be seen in Figure 9.2.1 provided by the BoM:

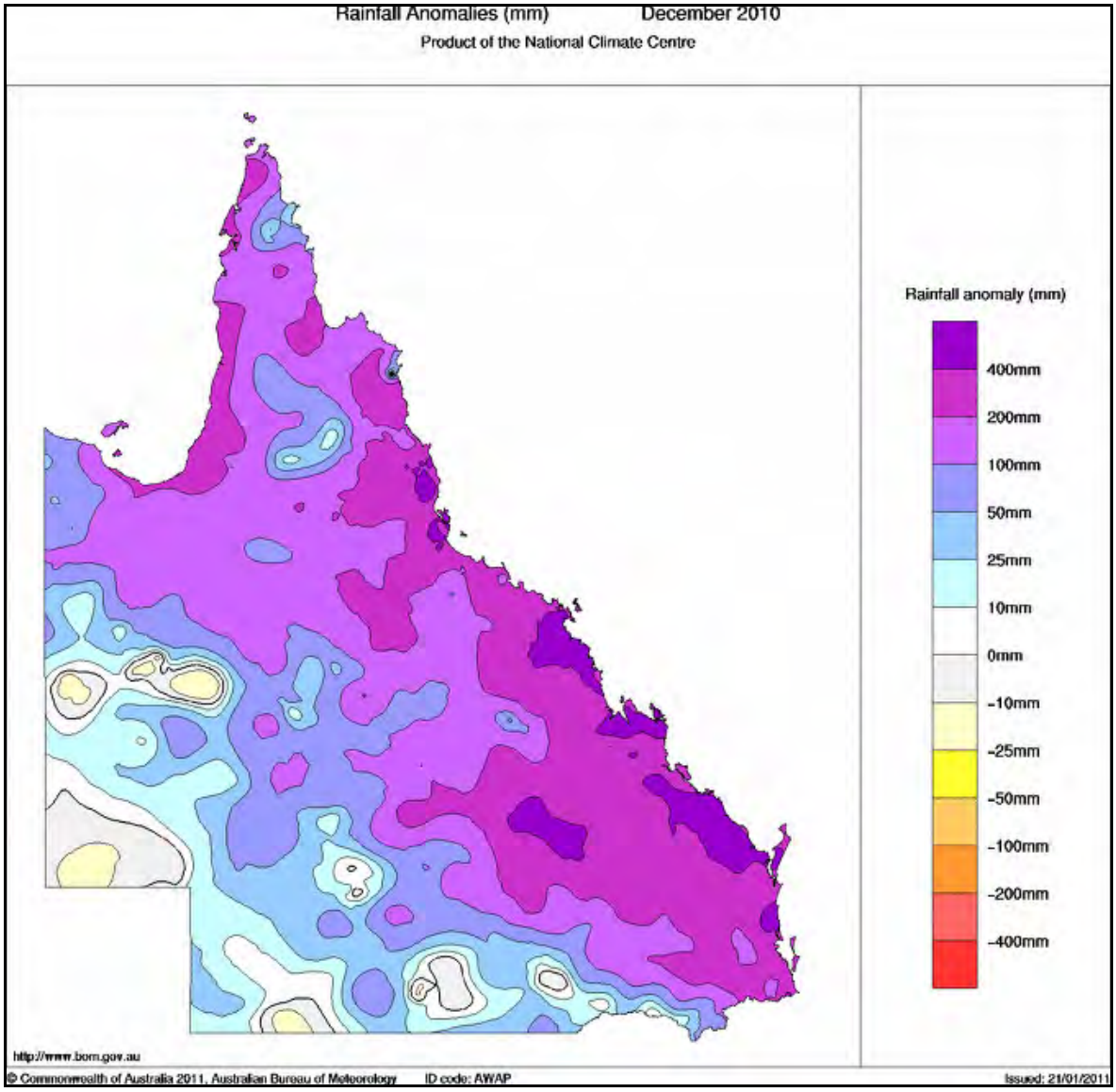

Figure 9.2.1 – Queensland rainfall (mm), December 2010

Several rainfall events in mid and late December 2010 lead to releases being required from North Pine Dam. As a result of these events, and the above average rainfall that had been experienced, the North Pine catchment was near saturation and primed to generate runoff from relatively low rainfall events.

9.3 Rainfall Intensity Frequency Duration analysis

Intensity Frequency Duration (IFD) analysis refers to the statistical analysis of rainfall intensities. Rainfall is typically described as depth in millimetres (mm) falling over a specified duration or period in hours. The rainfall rate or intensity is usually defined as the depth of rainfall per hour.

To determine the severity of a particular rainfall event, the intensity over particular periods of interest is compared with historical records to determine its frequency of occurrence. The Annual Exceedance Probability (AEP) is used to define this frequency of occurrence and is defined by the BoM as "***the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.***"

Depth and intensity may be used in IFD analysis, however, the BoM prefers to simply use rainfall intensity (mm/h). There are two generally accepted methods for IFD analysis:

- Australian Rainfall and Runoff (IEAust 1987);
- CRC-FORGE (Hargraves, 2004 & 2005).

The following section contains the analysis for both of these methodologies for a range of rainfall gauges in the Dam catchments for the January 2011 Flood Event. The AR&R (IEAust 1987) results are also available in real-time within the Real Time Flood Model (RTFM) and are used to assess the progression of flood events.

In the North Pine River catchment, the CRC-FORGE method and AR&R produce similar estimates for 1% AEP for durations from 24 hours to 72 hours. The CRC-FORGE method is the only IFD method used in relation to dams that provides design rainfall estimates for durations up to 120 hours.

The CRC-FORGE method is based on a regional rainfall frequency analysis that derives rainfall depth estimates of large to rare flood events, and uses the concept of an expanding region focused at the site of interest. When using CRC-FORGE, design rainfall estimates for frequent events (1 in 50 and 1 in 100 AEP) are based on pooled data from a few stations around the focal point, while design rainfall estimates at the AEP limit of extrapolation (1 in 2,000) are based on pooled rainfall data from up to several hundred stations. Before data from different sites can be pooled, maximum annual rainfalls from each site are standardised by dividing by an index variable. The index variable may be the mean annual maximum for the site, or rainfall of any specified AEP that is reasonable and accurately determined from a short record. An Areal Reduction Factor (ARF) is also used to correct the variation of rainfall intensity over a large catchment area and to convert point rainfall estimates to areal estimates.

The CRC-FORGE method was developed using daily rainfall totals. It should be noted there is some uncertainty in the AEP estimates of the recorded rainfall produced by the CRC-FORGE method for durations less than 24 hours. The shorter durations are extrapolated using ratios calculated from Australian Rainfall and Runoff. There are experimental techniques available for investigating the AEP for the shorter duration rainfalls, but time constraints associated with the preparation of this Report have not allowed this to be included in the analysis.

It should be noted, the intensity rainfall duration assessments at the point locations are correct, however, they may not be representative of the most intense rainfall experienced in the Dam catchment during the event.

Point IFD Analysis using AR&R (IEAust 1987)

For the January 2011 Flood Event, the AR&R (IEAust 1987) method was used to derive rainfall estimates for frequent to rare flood events, for storm durations from 15 minutes to 72 hours for point estimates. There is some uncertainty associated with the design rainfall estimates below, for AEPs less than 1 in 100. Their curves are shown dotted in the plots in Figures 9.3.3 to 9.3.11 below. Point IFD analysis, using the AR&R (IEAust 1987) method up to 1 in 100 AEP and extrapolated to 1 in 2000 using CRC-FORGE method growth curves, was carried out for each gauge in the rainfall network listed in Table 9.3.1.

ALERT ID	Station	Location	
		Latitude	Longitude
6610	Kluvers Lookout	-27.2070	152.7030
6680	Mt Glorious	-27.3220	152.7470
6690	Mt Mee	-27.0700	152.7800
6711	North Pine River at Baxters Creek	-27.1958	152.8000
6760	North Pine Dam	-27.2650	152.9300
6763	North Pine River at Petrie	-27.2700	152.9750
6766	Lake Kurwongbah	-27.2500	152.9500
6769	South Pine River at Drapers Crossing	-27.3500	152.9167
6778	South Pine River at Samford	-27.3610	152.8790

Table 9.3.1 –Pine Rivers Basin Rainfall Stations

Significant stations in each catchment were selected for inclusion in this section of the Report.

Table 9.3.2 summarises the highest AEPs at particular stations, estimated from an IFD analysis of the list of stations in the table. Table 9.3.2 shows that for durations of more than three hours, the highest AEPs of the recorded rainfall upstream of North Pine Dam were 1 in 100 or greater.

ALERT ID	Station	Annual Exceedance Probability (1 in Y)							
		1H	3H	6H	12H	18H	24H	48H	72H
6610	Kluvers Lookout	<5	<5	<5	20-50	200-500	200-500	100-200	50-100
6680	Mt Glorious	5-10	10-20	20-50	100-200	200-500	200-500	100-200	50-100
6690	Mt Mee	<5	<5	5-10	20-50	20-50	20-50	20-50	20-50
6711	Baxters Creek	<5	<5	10-20	100-200	200-500	200-500	100-200	50-100
6760	North Pine Dam	<5	<5	<5	<5	<5	<5	<5	<5
6763	Petrie	<5	<5	<5	<5	<5	<5	<5	<5
6766	Lake Kurwongbah	<5	<5	<5	<5	<5	<5	<5	<5
6769	Drapers Crossing	<5	<5	<5	<5	<5	<5	<5	<5
6778	Samford	<5	<5	<5	<5	<5	<5	<5	<5

Table 9.3.2 – Highest AEP rainfall intensities (AR&R), January 2011 Flood Event

IFD results for significant individual stations are defined further in this Section. Discussions on temporal patterns are also contained in Section 6. Overall, there was significant spatial variation in the rainfall intensities. Intensities were generally very high in the western part of the North Pine Dam catchment, however, they were not statistically significant at stations below the Dam.

6610 – Kluvers Lookout

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	82	07:46 11/01/2011	<5
30 M	66	07:31 11/01/2011	<5
1 H	51.3	07:01 11/01/2011	<5
3 H	43.9	11:46 11/01/2011	20-50
6 H	36.5	12:01 11/01/2011	200 - 500
12 H	26.0	15:01 11/01/2011	200 - 500
18 H	18.0	20:31 11/01/2011	100 - 200
24 H	13.8	19:16 11/01/2011	50 - 100
48 H	9.0	14:31 11/01/2011	100 - 200
72 H	6.8	020:31 11/01/2011	50 - 100

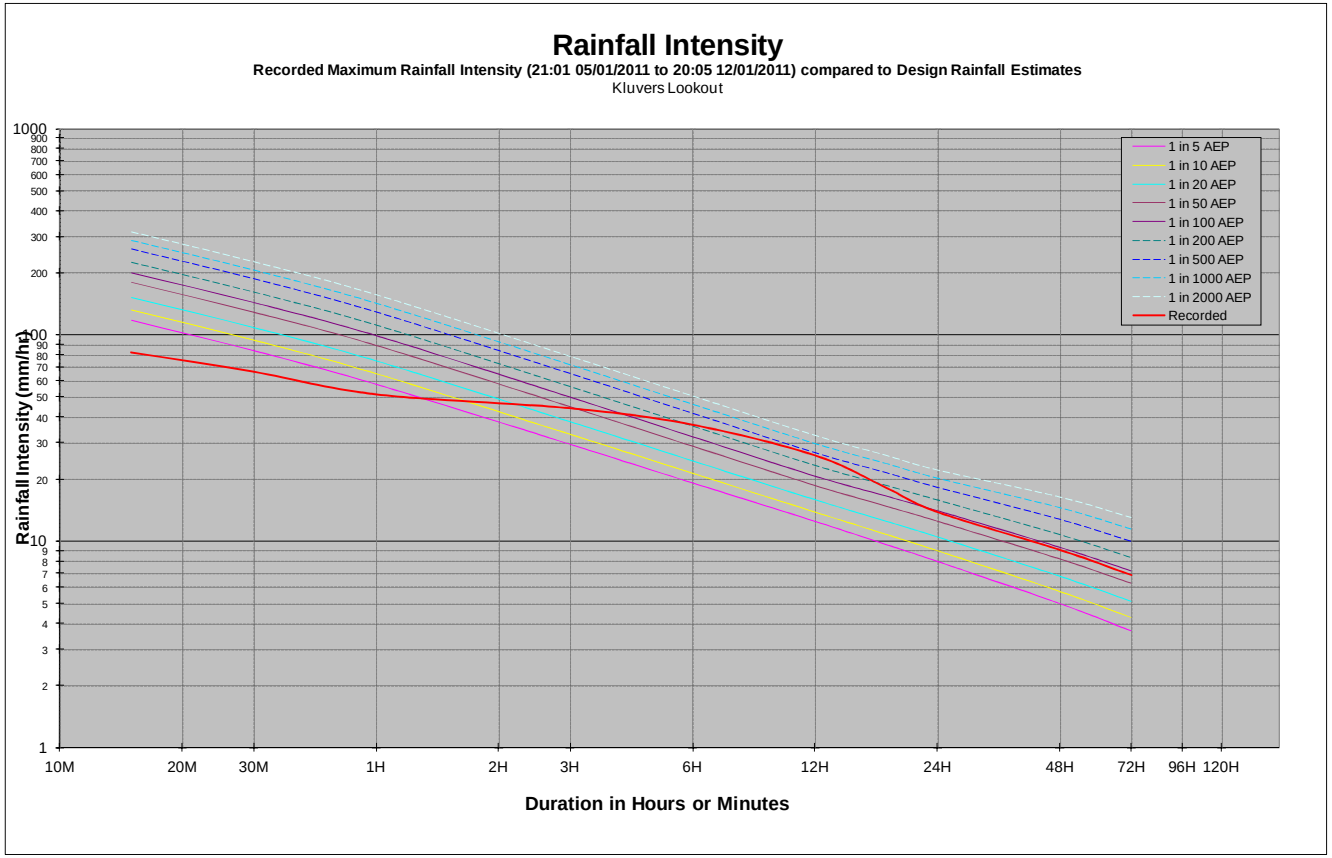

Figure 9.3.3 – Recorded rainfall intensity (AR&R), Kluvers Lookout

6680 – Mt Glorious

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	125.6	08:52 11/01/2011	5 - 10
30 M	101.6	08:52 11/01/2011	10 - 20
1 H	82.9	08:52 11/01/2011	20 - 50
3 H	62.5	10:37 11/01/2011	100 - 200
6 H	49.7	12:52 11/01/2011	200 - 500
12 H	33.9	15:37 11/01/2011	200 - 500
18 H	23.5	19:22 11/01/2011	100 - 200
24 H	18.3	19:07 11/01/2011	50 - 100
48 H	13.1	14:37 11/01/2011	100 - 200
72 H	9.7	05:22 12/01/2011	50 - 100

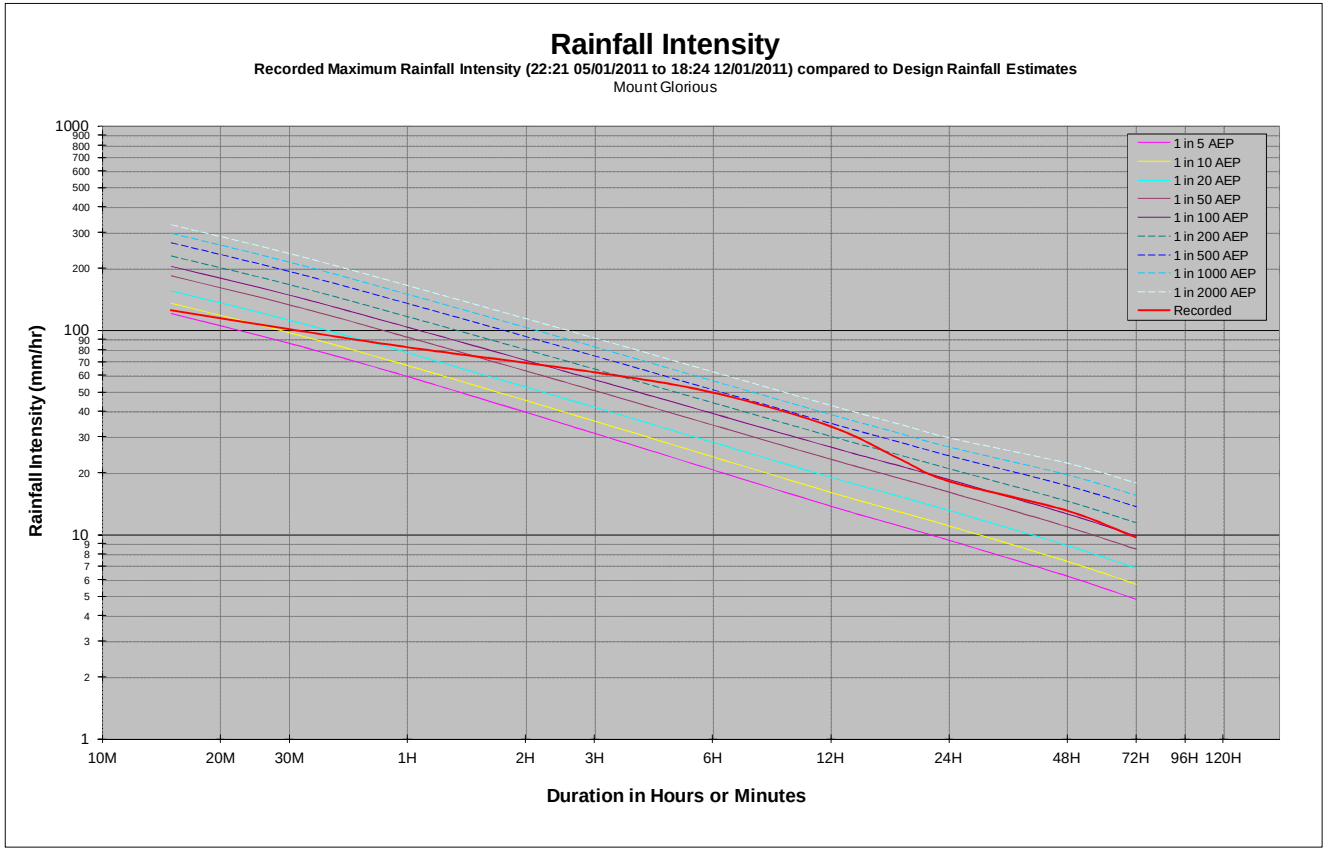

Figure 9.3.4 – Recorded rainfall intensity (AR&R), Mt Glorious

6690 – Mt Mee

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	79.2	12:44 11/01/2011	< 5
30 M	76.0	12:44 11/01/2011	< 5
1 H	58.6	13:14 11/01/2011	5 - 10
3 H	39.3	13:29 11/01/2011	20 - 50
6 H	27.0	13:44 11/01/2011	20 - 50
12 H	20.7	14:59 11/01/2011	20 - 50
18 H	15.2	18:59 11/01/2011	20 - 50
24 H	11.8	18:59 11/01/2011	20 - 50
48 H	9.4	13:44 11/01/2011	50 - 100
72 H	7.7	01:29 12/01/2011	100 - 200

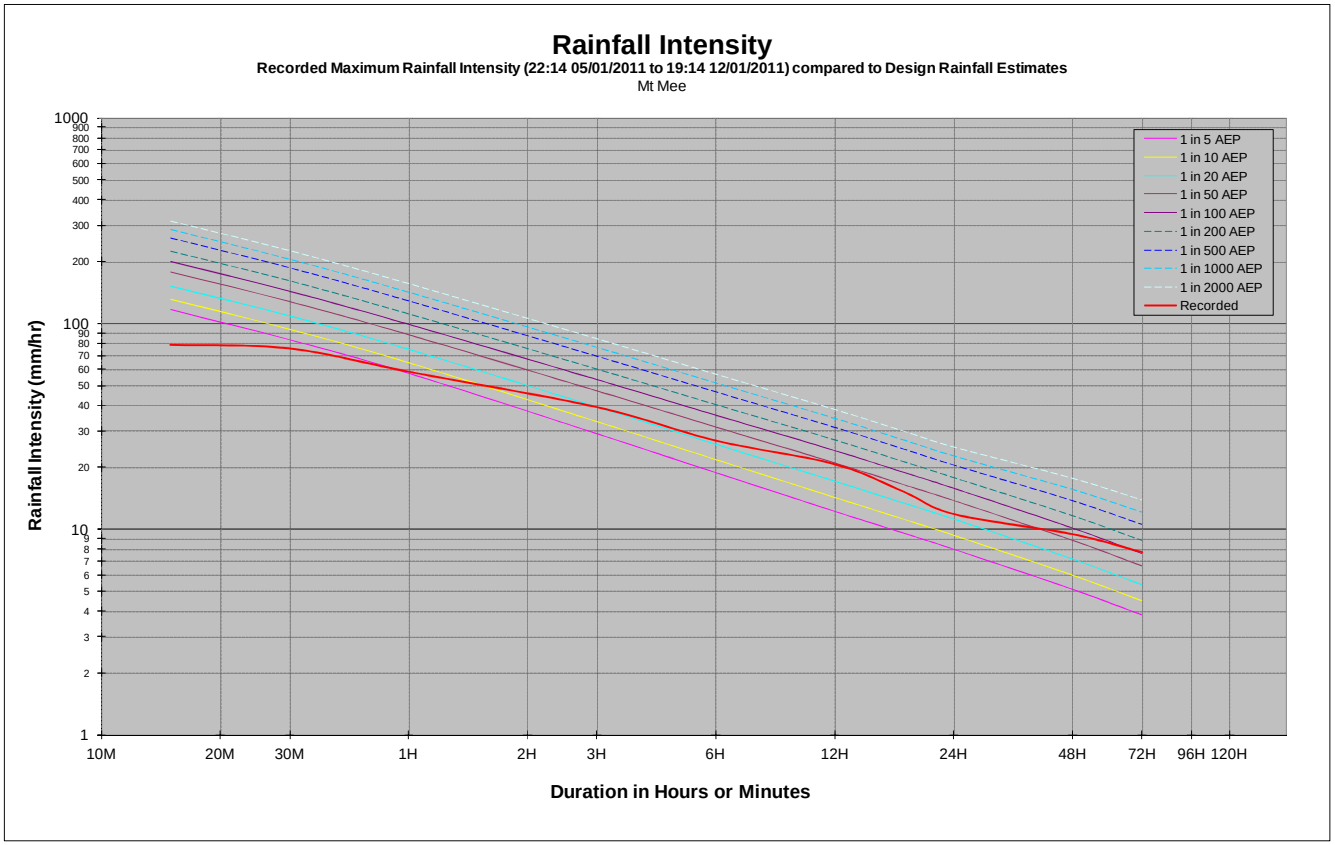

Figure 9.3.5 – Recorded rainfall intensity (AR&R), Mt Mee

6711 – North Pine River at Baxters Creek

Duration	Recorded Intensity	End Time	AEP
	mm/hr		1 in Y
15 M	96.8	09:48 11/01/2011	< 5
30 M	85.4	09:48 11/01/2011	< 5
1 H	76.5	10:03 11/01/2011	10 - 20
3 H	53.2	11:48 11/01/2011	100 - 200
6 H	41.2	11:18 11/01/2011	200 - 500
12 H	28.3	15:03 11/01/2011	200 - 500
18 H	19.5	18:48 11/01/2011	100 - 200
24 H	14.8	17:48 11/01/2011	50 - 100
48 H	9.7	14:18 11/01/2011	50 - 100
72 H	7.0	15:03 11/01/2011	20 - 50

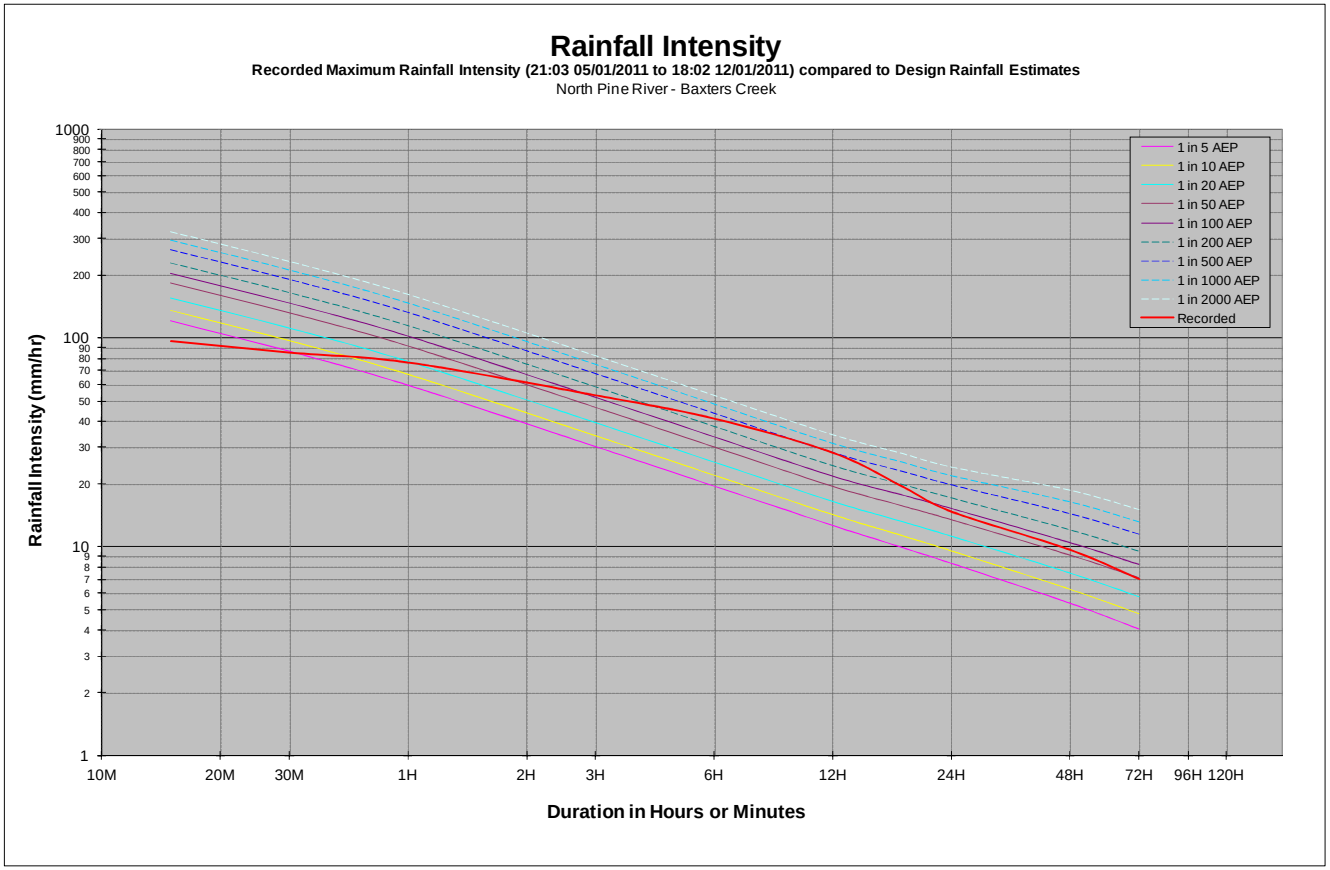

Figure 9.3.6 – Recorded rainfall intensity (AR&R), North Pine River at Baxters Creek

6760 – North Pine Dam

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	54.8	10:28 10/01/2011	< 5
30 M	48.2	10:43 10/01/2011	< 5
1 H	27.6	10:43 10/01/2011	< 5
3 H	14.5	12:43 11/01/2011	< 5
6 H	11.7	14:13 11/01/2011	< 5
12 H	6.7	16:13 11/01/2011	< 5
18 H	4.8	18:43 11/01/2011	< 5
24 H	4.5	10:43 10/01/2011	< 5
48 H	4.0	14:13 11/01/2011	< 5
72 H	2.9	02:43 12/01/2011	< 5

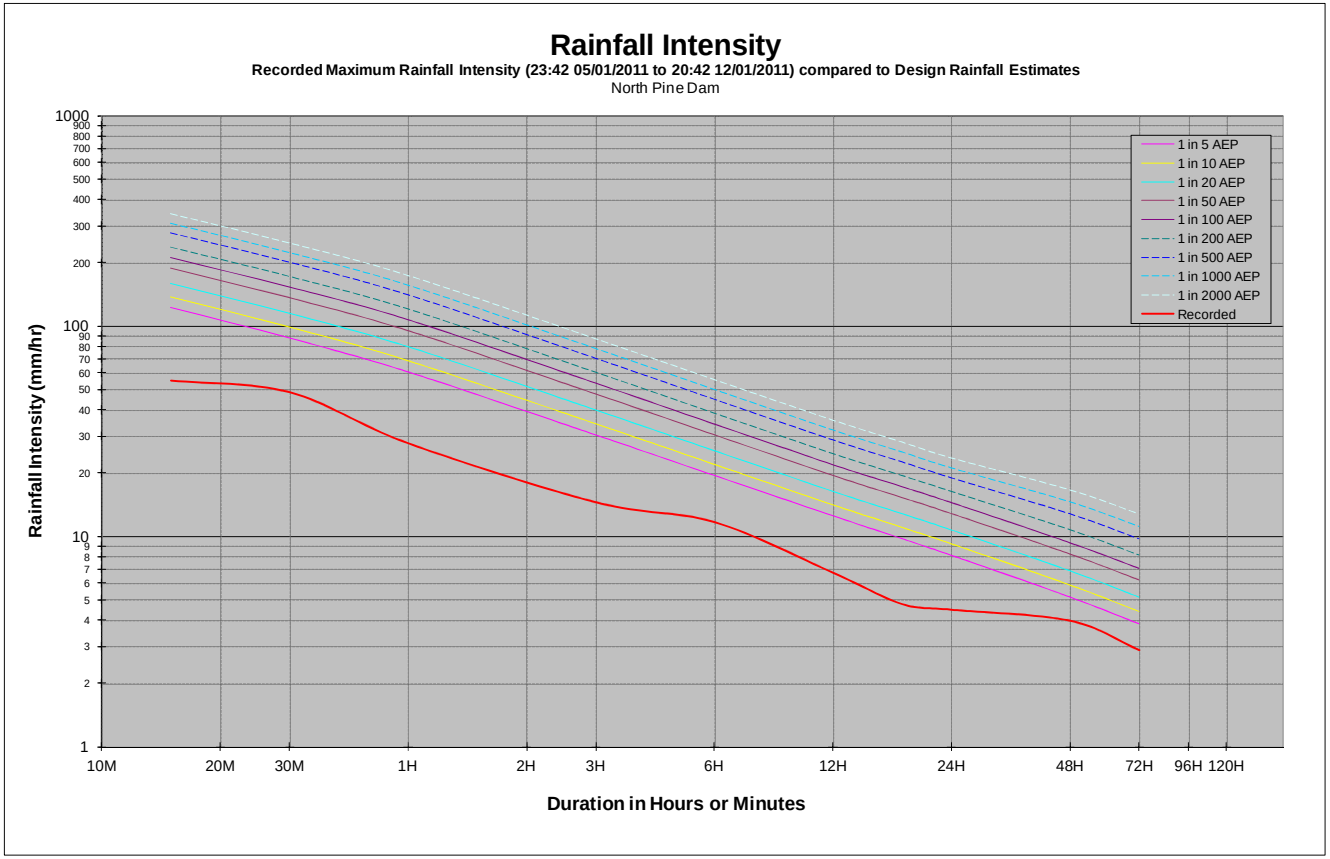

Figure 9.3.7 – Recorded rainfall intensity (AR&R), North Pine Dam

6763 – North Pine River at Petrie

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	82.8	10:16 10/01/2011	< 5
30 M	52.0	10:31 10/01/2011	< 5
1 H	30.3	10:31 10/01/2011	< 5
3 H	17.5	10:16 10/01/2011	< 5
6 H	12.5	10:31 10/01/2011	< 5
12 H	8.5	10:31 10/01/2011	< 5
18 H	6.7	10:31 10/01/2011	< 5
24 H	6.2	10:31 10/01/2011	< 5
48 H	4.6	14:16 11/01/2011	< 5
72 H	3.4	21:46 11/01/2011	< 5

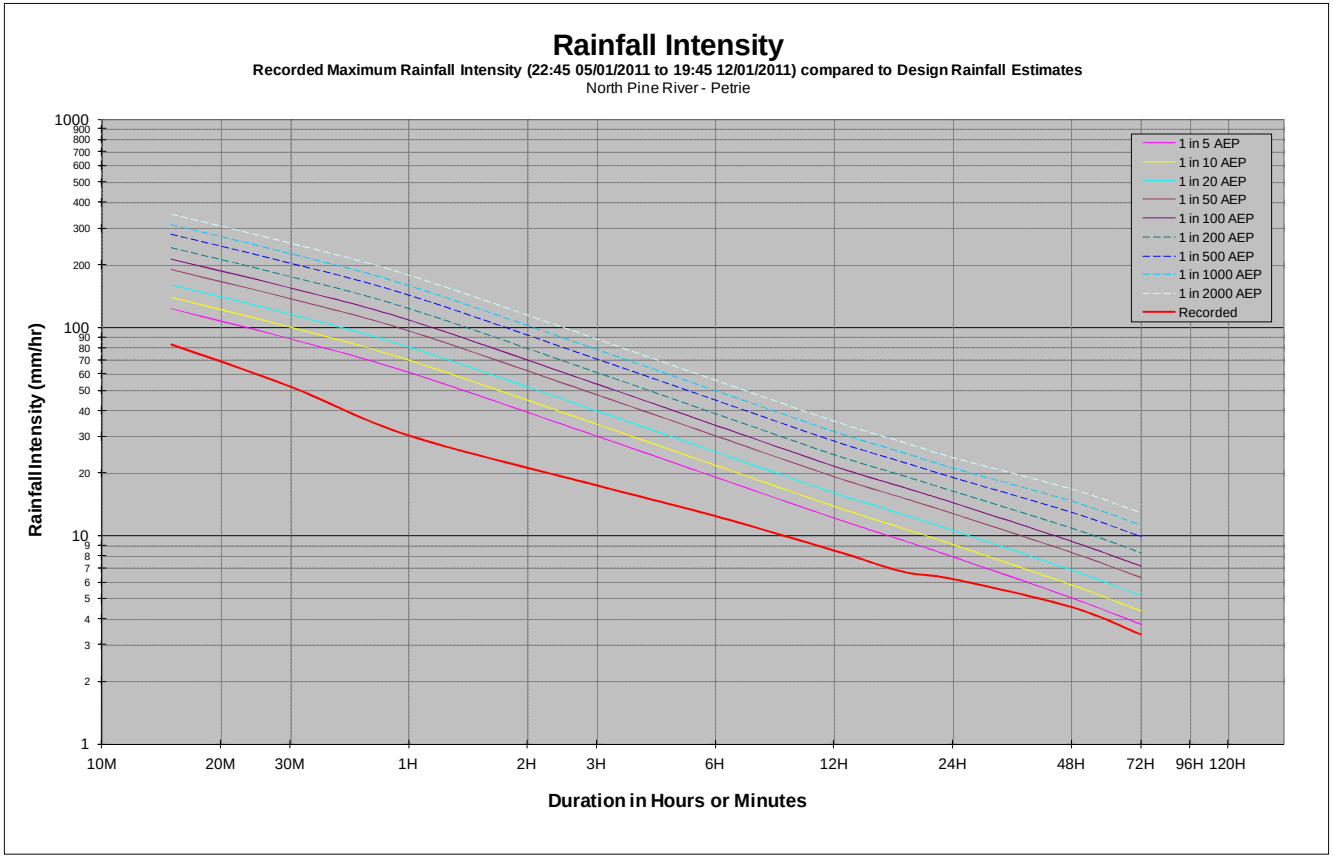

Figure 9.3.8 – Recorded rainfall intensity (AR&R), North Pine River at Petrie

6766 – Lake Kurwongbah

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	50.4	10:00 11/01/2011	< 5
30 M	35.2	10:15 11/01/2011	< 5
1 H	22.8	10:30 11/01/2011	< 5
3 H	15.4	12:30 11/01/2011	< 5
6 H	12.5	14:00 11/01/2011	< 5
12 H	7.9	18:15 11/01/2011	< 5
18 H	6.0	12:30 10/01/2011	< 5
24 H	6.0	12:45 10/01/2011	< 5
48 H	4.9	14:15 11/01/2011	< 5
72 H	3.7	01:15 12/01/2011	< 5

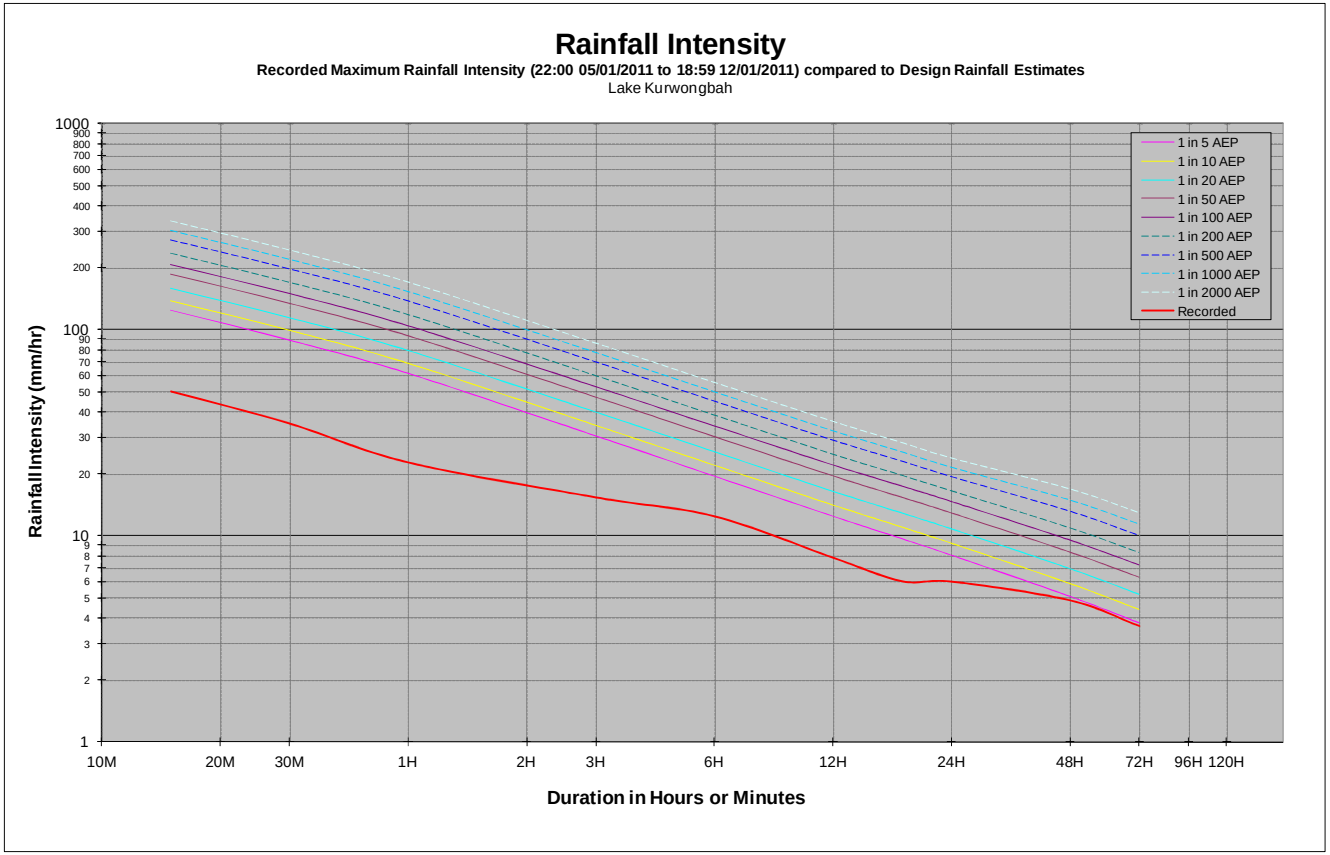

Figure 9.3.9 – Recorded rainfall intensity (AR&R), Lake Kurwongbah

6769 – South Pine River at Drapers Crossing

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	84.4	10:15 11/01/2011	< 5
30 M	53.0	10:30 11/01/2011	< 5
1 H	29.9	10:30 11/01/2011	< 5
3 H	18.5	12:45 11/01/2011	< 5
6 H	13.3	14:15 11/01/2011	< 5
12 H	8.1	15:45 11/01/2011	< 5
18 H	5.9	18:15 11/01/2011	< 5
24 H	5.2	10:15 10/01/2011	< 5
48 H	4.6	14:45 11/01/2011	< 5
72 H	3.6	01:00 12/01/2011	< 5

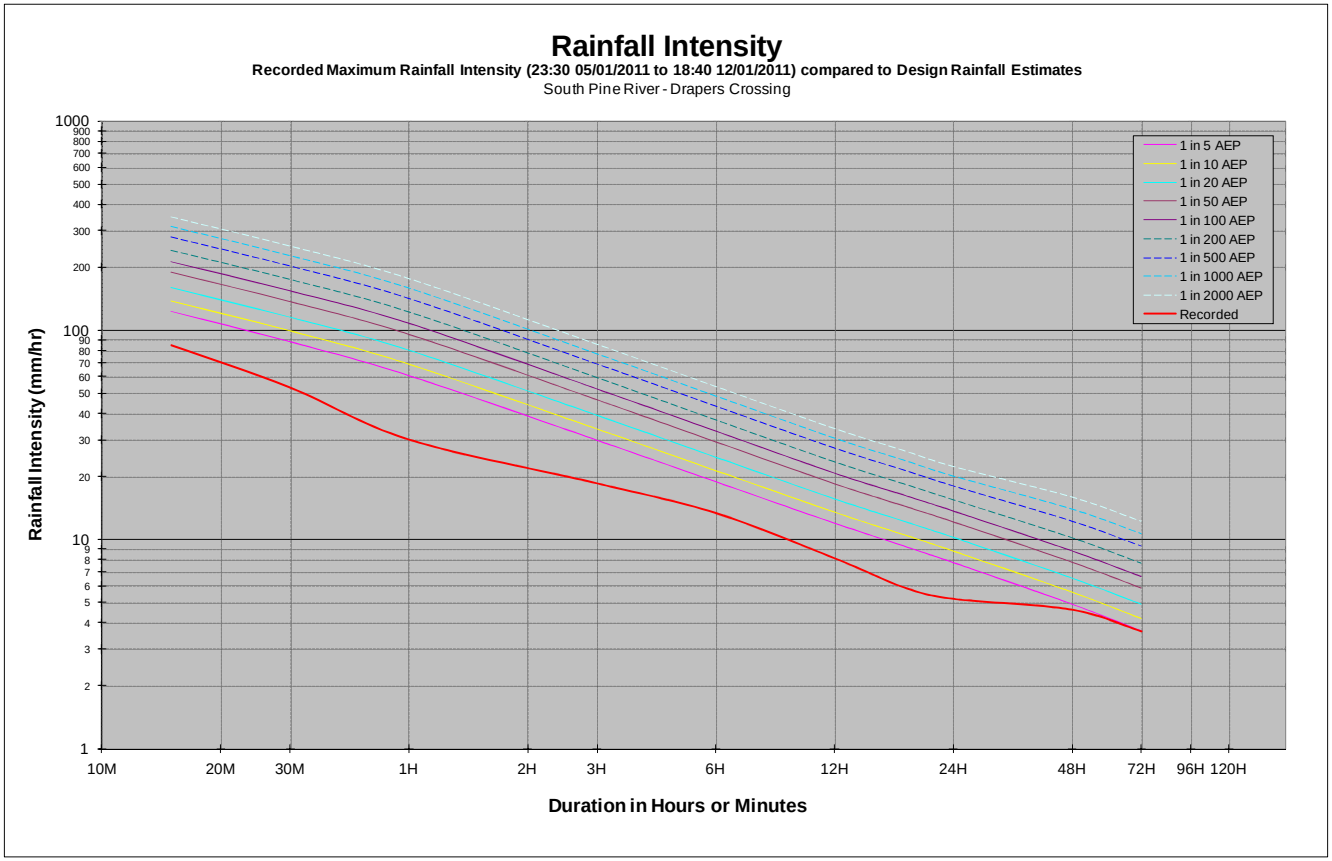

Figure 9.3.10 – Recorded rainfall intensity (AR&R), South Pine River at Drapers Crossing

6778 – South Pine River at Samford

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	89.6	10:20 11/01/2011	< 5
30 M	53.4	10:20 11/01/2011	< 5
1 H	31.8	10:50 11/01/2011	< 5
3 H	22.7	12:50 11/01/2011	< 5
6 H	15.4	14:20 11/01/2011	< 5
12 H	9.6	14:35 11/01/2011	< 5
18 H	6.8	18:05 11/01/2011	< 5
24 H	5.5	09:50 10/01/2011	< 5
48 H	5.2	14:35 11/01/2011	5 - 10
72 H	4.0	02:05 12/01/2011	5 - 10

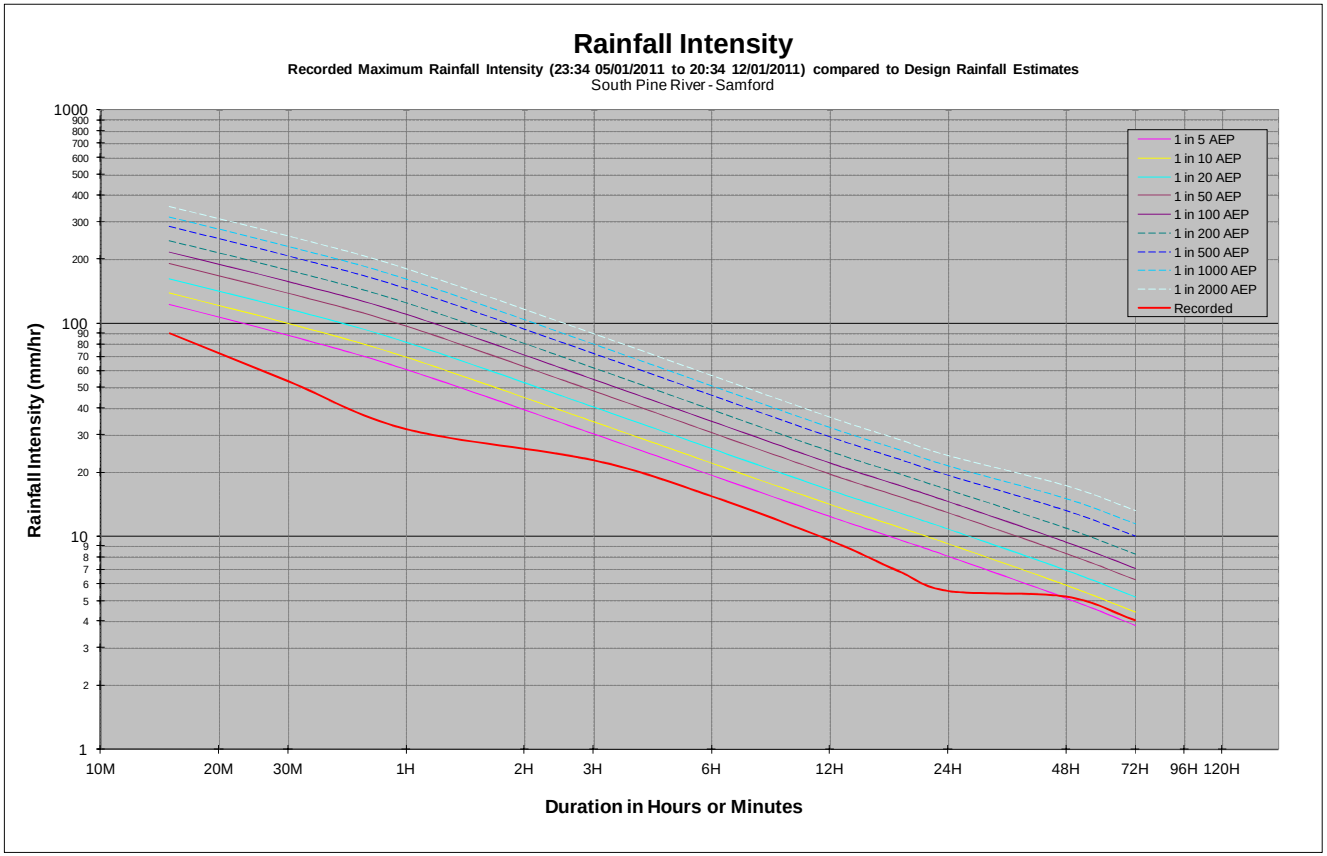

Figure 9.3.11 – Recorded rainfall intensity (AR&R), South Pine River at Samford

Point IFD Analysis using CRC-FORGE

For the January 2011 Flood Event, the CRC-FORGE method was used to derive rainfall estimates for frequent to rare flood events for storm durations from 15 minutes to 120 hours, for both point and areal estimates. There is some uncertainty associated with design rainfall estimates below 24-hour duration, so the curves are shown dotted in the plots below. Point IFD analysis using the CRC-FORGE method was carried out for each gauge in the rainfall network listed in Table 9.3.12.

ALERT ID	Station	Location	
		Latitude	Longitude
6610	Kluvers Lookout	-27.2070	152.7030
6680	Mt Glorious	-27.3220	152.7470
6690	Mt Mee	-27.0700	152.7800
6711	North Pine River at Baxters Creek	-27.1958	152.8000
6760	North Pine Dam	-27.2650	152.9300
6763	North Pine River at Petrie	-27.2700	152.9750
6766	Lake Kurwongbah	-27.2500	152.9500
6769	South Pine River at Drapers Crossing	-27.3500	152.9167
6778	South Pine River at Samford	-27.3610	152.8790

Table 9.3.12 – Rainfall stations IFD analysis

Significant stations in each catchment were selected for inclusion in this section of the Report.

Table 9.3.13 summarises the highest AEPs at particular stations, estimated from an IFD analysis of the list of stations in the table. Table 9.3.13 shows that for durations of more than three hours, the highest AEPs of the recorded rainfall upstream of North Pine Dam were 1 in 100 or greater. The blue highlighted numbers indicate values that have been interpolated and, as such, are less reliable.

ALERT ID	Station	Annual Exceedance Probability (1 in Y)									
		1H	3H	6H	12H	18H	24H	48H	72H	96H	120H
6610	Kluvers Lookout	< 5	50-100	200-500	200-500	100-200	50-100	50-100	50-100	50-100	50-100
6680	Mt Glorious	20-50	100-200	200-500	500-1000	100-200	100-200	100-200	50-100	50-100	50-100
6711	Baxters Creek	10-20	50-100	200-500	200-500	100-200	50-100	50-100	50-100	20-50	20-50
6690	Mt Mee	<5	<5	<5	10-20	10-20	20-50	20-50	10-20	20-50	20-50
6760	North Pine Dam	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
6763	Petrie	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
6766	Lake Kurwongbah	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
6769	Drapers Crossing	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
6778	Samford	<5	<5	<5	<5	<5	<5	5-10	5-10	<5	5-10

Table 9.3.13 – Highest AEP rainfall intensities (CRC-FORGE), January 2011 Flood Event

IFD results for significant individual stations are defined further in this Section. Discussions on temporal patterns are also contained in Section 6. Overall, there was significant spatial variation in the rainfall intensities. Intensities were generally very high in the western part of the North Pine Dam catchment; however, they were not statistically significant at stations below the Dam.

6610 – Kluvers Lookout

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	82.0	07:01 11/01/2011	< 5
30 M	66.0	07:01 11/01/2011	< 5
1 H	51.3	07:01 11/01/2011	< 5
3 H	43.9	11:46 11/01/2011	50 - 100
6 H	36.5	12:01 11/01/2011	200 - 500
12 H	26.0	15:01 11/01/2011	200 - 500
18 H	18.0	20:31 11/01/2011	100 - 200
24 H	13.8	19:16 11/01/2011	50 - 100
48 H	9.0	14:31 11/01/2011	50 - 100
72 H	6.8	20:31 11/01/2011	50 - 100
96 H	5.2	02:46 12/01/2011	50 - 100
120 H	4.5	02:46 12/01/2011	50 - 100

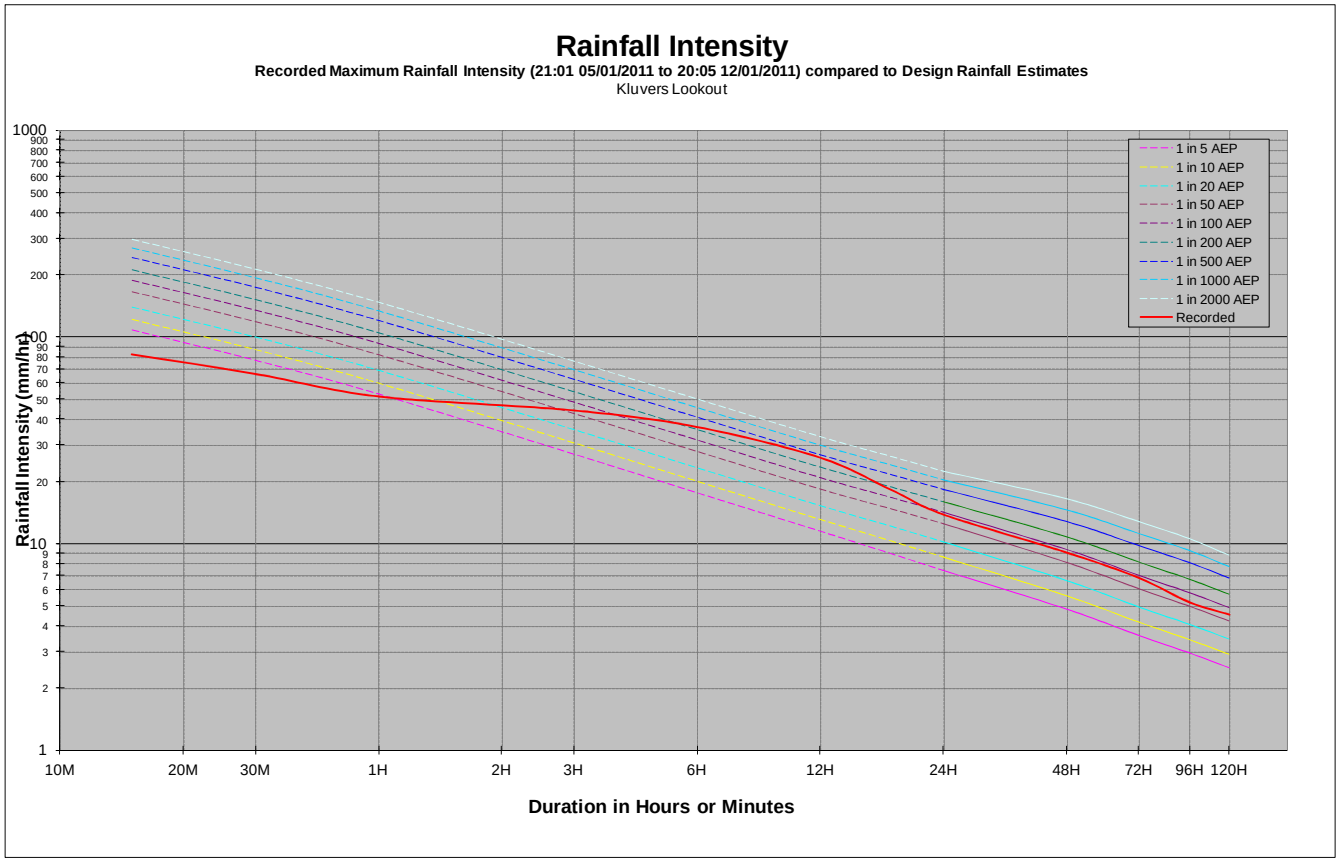

Figure 9.3.14 – Recorded rainfall intensity (CRC-FORGE), Kluvers Lookout

6680 – Mt Glorious

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	125.6	08:52 11/01/2011	< 5
30 M	101.6	08:52 11/01/2011	5 - 10
1 H	82.9	08:52 11/01/2011	20 - 50
3 H	62.5	10:37 11/01/2011	100 - 200
6 H	49.7	12:52 11/01/2011	200 - 500
12 H	33.9	15:37 11/01/2011	500 - 1000
18 H	23.5	19:22 11/01/2011	100 - 200
24 H	18.3	19:07 11/01/2011	100 - 200
48 H	13.1	14:37 11/01/2011	100 - 200
72 H	9.7	05:22 12/01/2011	50 - 100
96 H	7.5	09:07 12/01/2011	50 - 100
120 H	6.3	06:52 12/01/2011	50 - 100

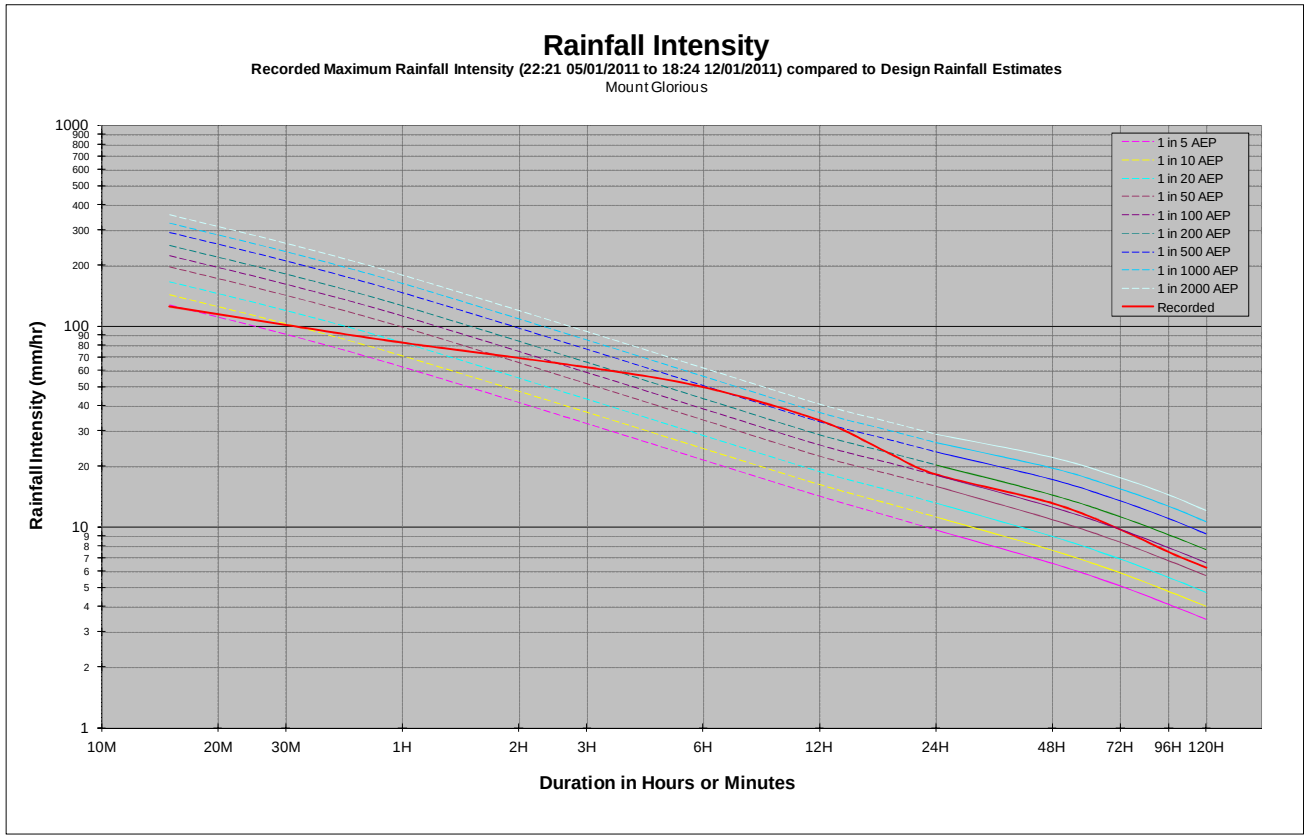

Figure 9.3.15 – Recorded rainfall intensity (CRC-FORGE), Mt Glorious

6711 – North Pine River at Baxters Creek

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	96.8	09:48 11/01/2011	< 5
30 M	85.4	09:48 11/01/2011	< 5
1 H	76.5	10:03 11/01/2011	10 - 20
3 H	53.2	11:48 11/01/2011	50 - 100
6 H	41.2	11:18 11/01/2011	200 - 500
12 H	28.3	15:03 11/01/2011	200 - 500
18 H	19.5	18:48 11/01/2011	100 - 200
24 H	14.8	17:48 11/01/2011	50 - 100
48 H	9.7	14:18 11/01/2011	50 - 100
72 H	7.0	15:03 11/01/2011	50 - 100
96 H	5.3	15:18 11/01/2011	20 - 50
120 H	4.7	15:03 11/01/2011	20 - 50

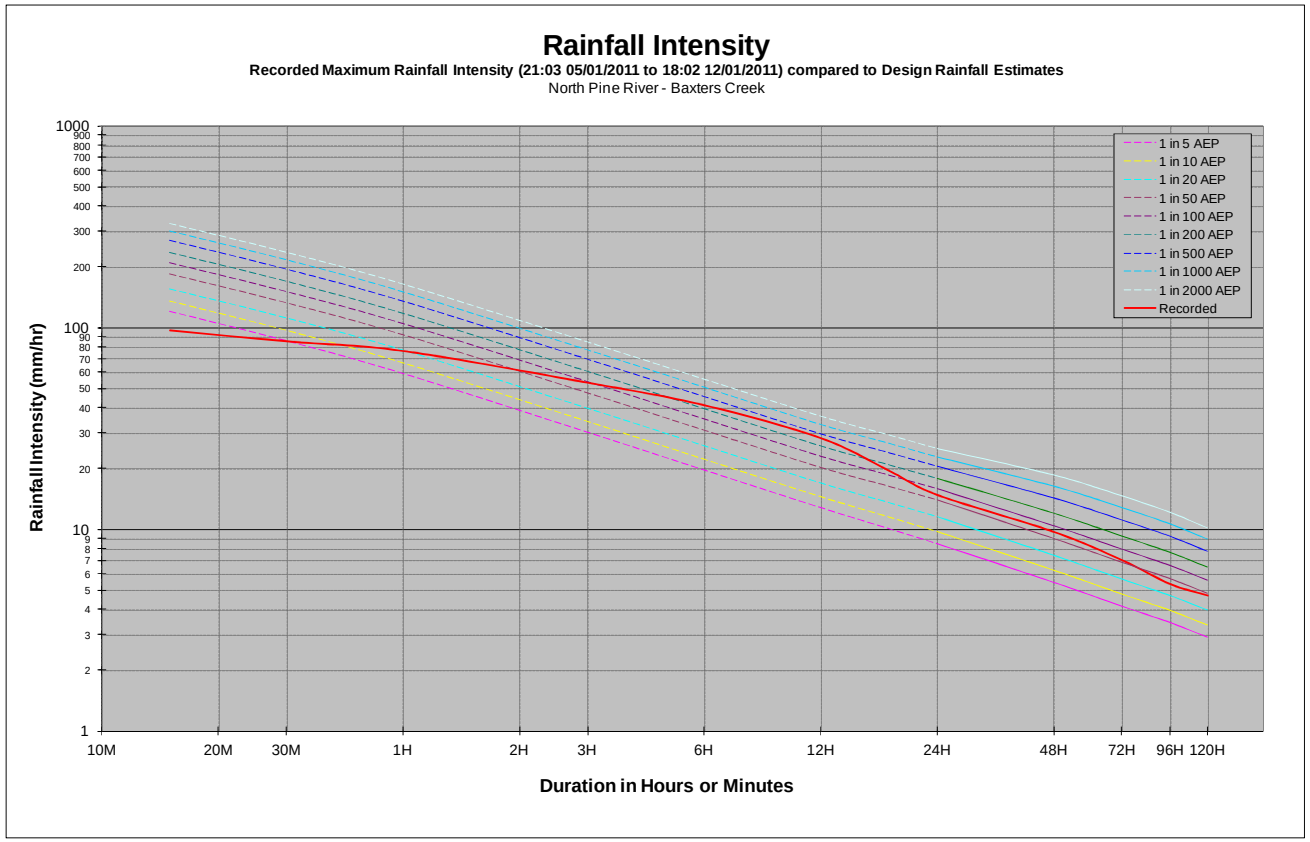

Figure 9.3.16 – Recorded rainfall intensity (CRC-FORGE), North Pine River at Baxters Creek

6690 – Mt Mee

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	79.2	12:44 11/01/2011	< 5
30 M	76.0	12:44 11/01/2011	< 5
1 H	58.6	13:14 11/01/2011	< 5
3 H	39.3	13:29 11/01/2011	10 - 20
6 H	27.0	13:44 11/01/2011	10 - 20
12 H	20.7	14:59 11/01/2011	20 - 50
18 H	15.2	18:59 11/01/2011	20 - 50
24 H	11.8	18:59 11/01/2011	10 - 20
48 H	9.4	13:44 11/01/2011	20 - 50
72 H	7.7	01:29 12/01/2011	20 - 50
96 H	6.0	13:29 12/01/2011	20 - 50
120 H	5.4	02:44 12/01/2011	20 - 50

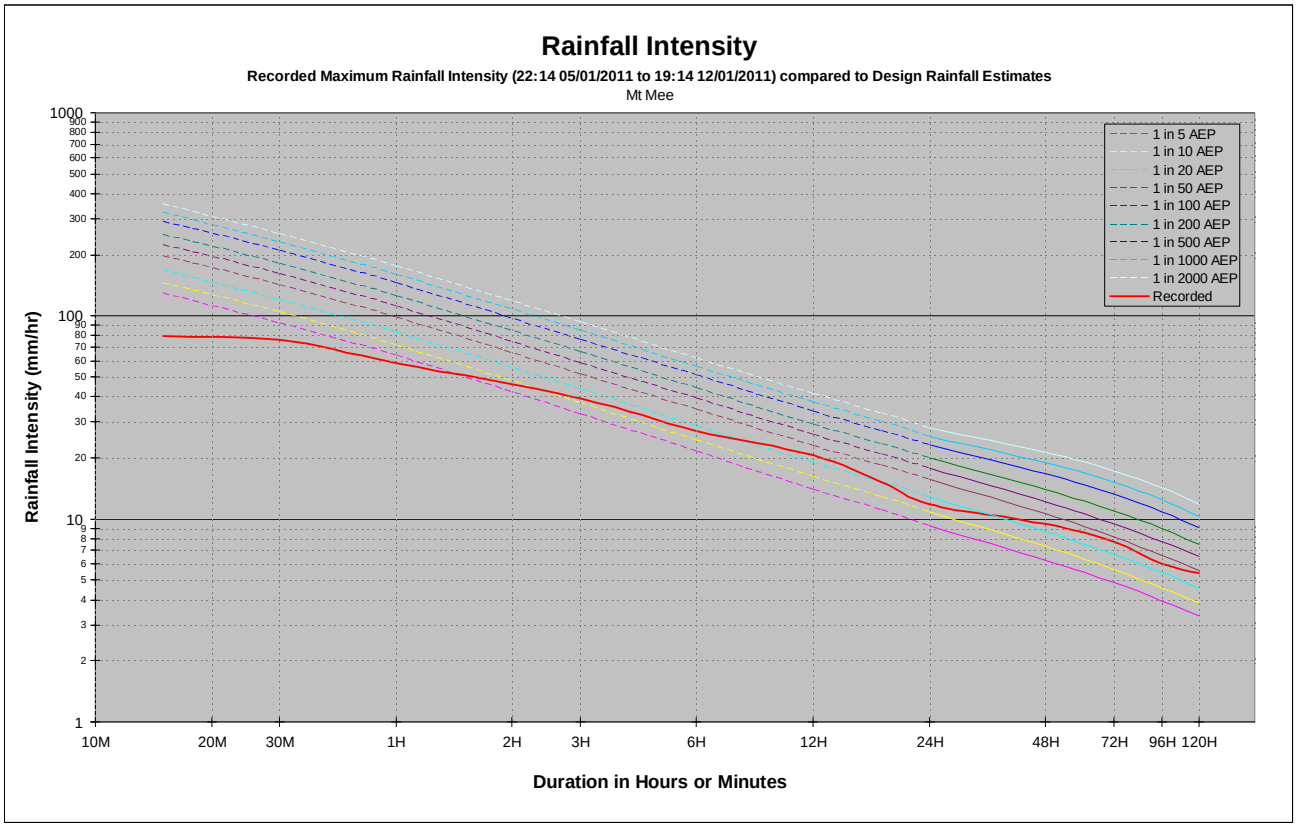

Figure 9.3.17 – Recorded rainfall intensity (CRC-FORGE), Mt Mee

6760 – North Pine Dam

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	54.8	10:28 10/01/2011	< 5
30 M	48.2	10:43 10/01/2011	< 5
1 H	27.6	10:43 10/01/2011	< 5
3 H	14.5	12:43 11/01/2011	< 5
6 H	11.7	14:13 11/01/2011	< 5
12 H	6.7	16:13 11/01/2011	< 5
18 H	4.8	18:43 11/01/2011	< 5
24 H	4.5	10:43 10/01/2011	< 5
48 H	4.0	14:13 11/01/2011	< 5
72 H	2.9	02:43 12/01/2011	< 5
96 H	2.2	02:43 12/01/2011	< 5
120 H	2.1	14:58 11/01/2011	< 5

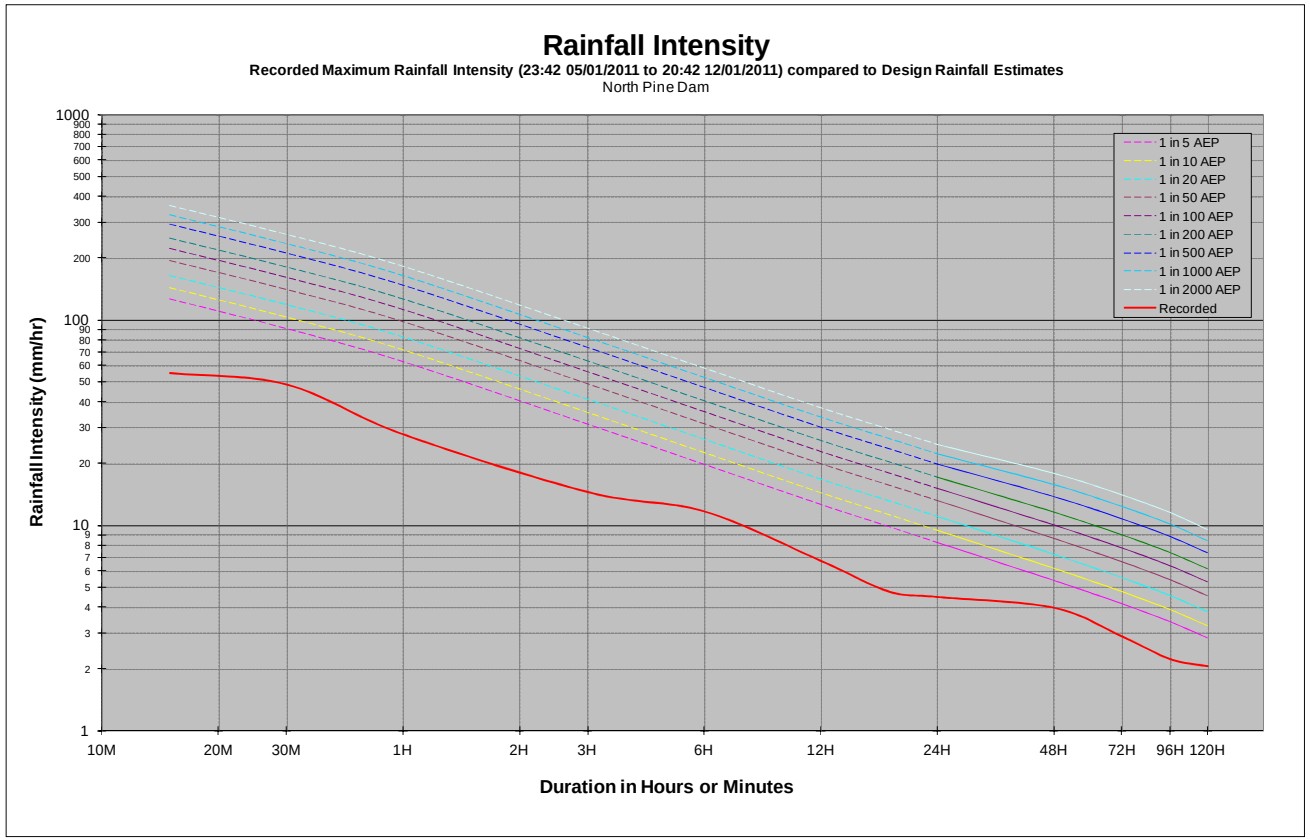

Figure 9.3.18 – Recorded rainfall intensity (CRC-FORGE), North Pine Dam

6763 – North Pine River at Petrie

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	82.8	10:16 10/01/2011	< 5
30 M	52.0	10:31 10/01/2011	< 5
1 H	30.3	10:31 10/01/2011	< 5
3 H	17.5	10:16 10/01/2011	< 5
6 H	12.5	10:31 10/01/2011	< 5
12 H	8.5	10:31 10/01/2011	< 5
18 H	6.7	10:31 10/01/2011	< 5
24 H	6.2	10:31 10/01/2011	< 5
48 H	4.6	14:16 11/01/2011	< 5
72 H	3.4	21:46 11/01/2011	< 5
96 H	2.6	21:46 11/01/2011	< 5
120 H	2.4	12:01 11/01/2011	< 5

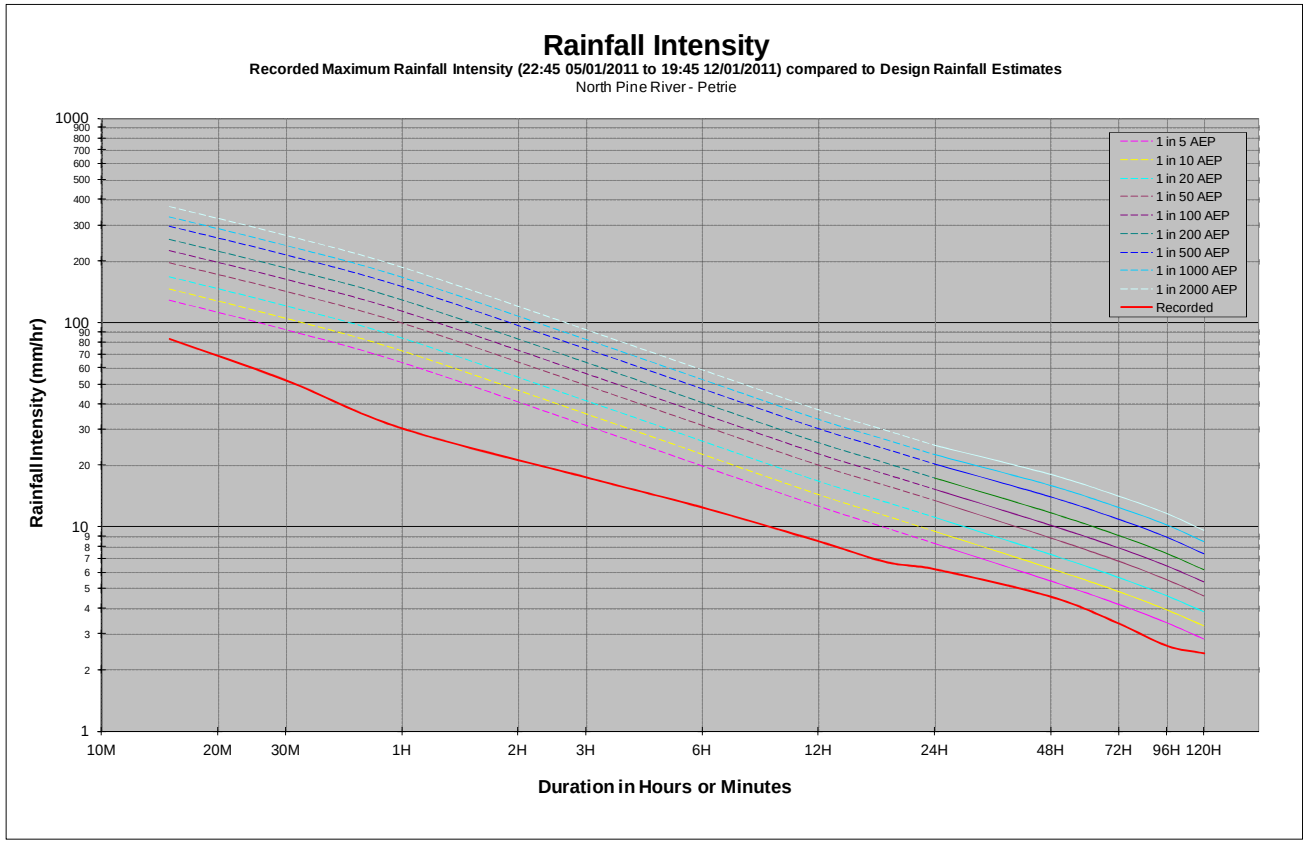

Figure 9.3.19 – Recorded rainfall intensity (CRC-FORGE), North Pine River at Petrie

6766 – Lake Kurwongbah

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	50.4	10:00 11/01/2011	< 5
30 M	35.2	10:15 11/01/2011	< 5
1 H	22.8	10:30 11/01/2011	< 5
3 H	15.4	12:30 11/01/2011	< 5
6 H	12.5	14:00 11/01/2011	< 5
12 H	7.9	18:15 11/01/2011	< 5
18 H	6.0	12:30 10/01/2011	< 5
24 H	6.0	12:45 10/01/2011	< 5
48 H	4.9	14:15 11/01/2011	< 5
72 H	3.7	01:15 12/01/2011	< 5
96 H	2.8	01:15 12/01/2011	< 5
120 H	2.6	12:45 11/01/2011	< 5

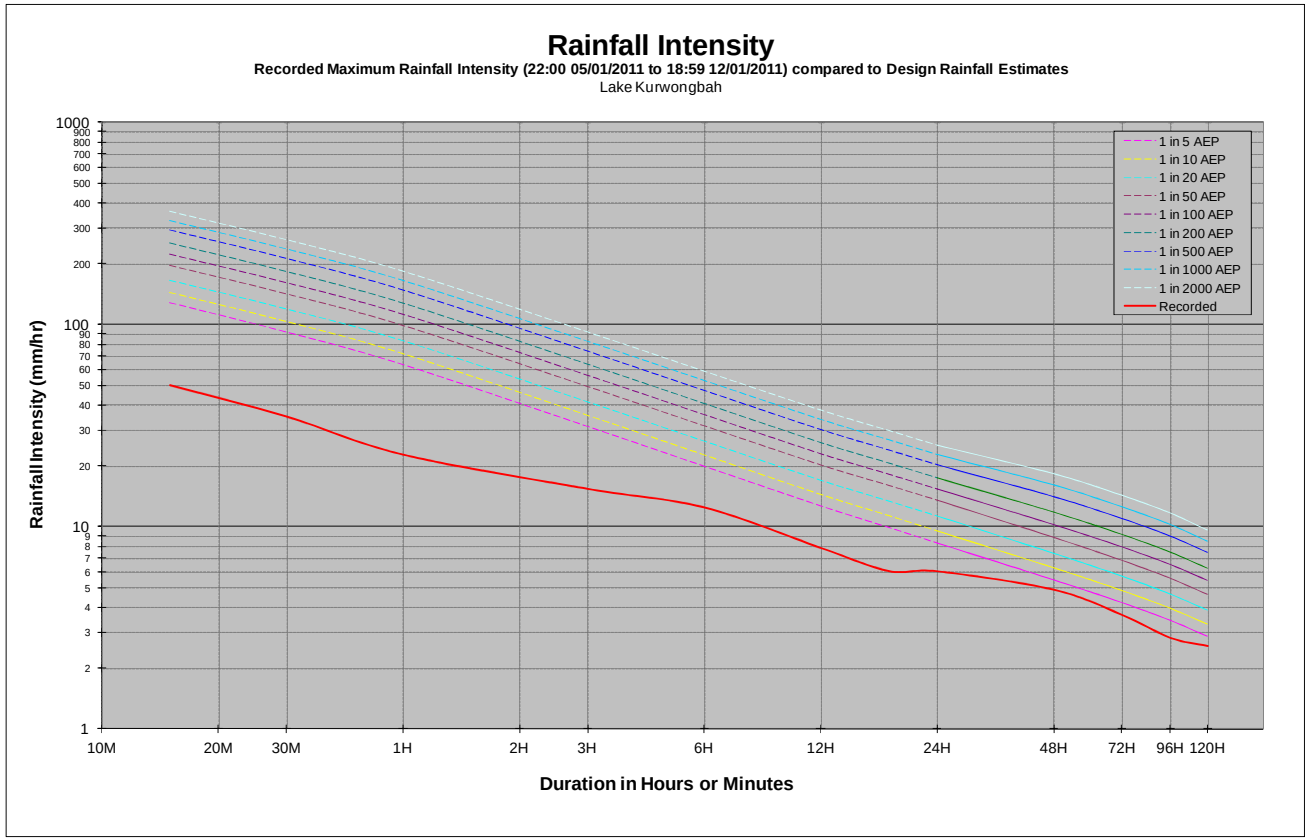

Figure 9.3.20 – Recorded rainfall intensity (CRC-FORGE), Lake Kurwongbah

6769 – South Pine River at Drapers Crossing

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	84.4	10:15 11/01/2011	< 5
30 M	53.0	10:30 11/01/2011	< 5
1 H	29.9	10:30 11/01/2011	< 5
3 H	18.5	12:45 11/01/2011	< 5
6 H	13.3	14:15 11/01/2011	< 5
12 H	8.1	15:45 11/01/2011	< 5
18 H	5.9	18:15 11/01/2011	< 5
24 H	5.2	10:15 10/01/2011	< 5
48 H	4.6	14:45 11/01/2011	< 5
72 H	3.6	01:00 12/01/2011	< 5
96 H	2.8	03:45 12/01/2011	< 5
120 H	2.5	03:45 12/01/2011	< 5

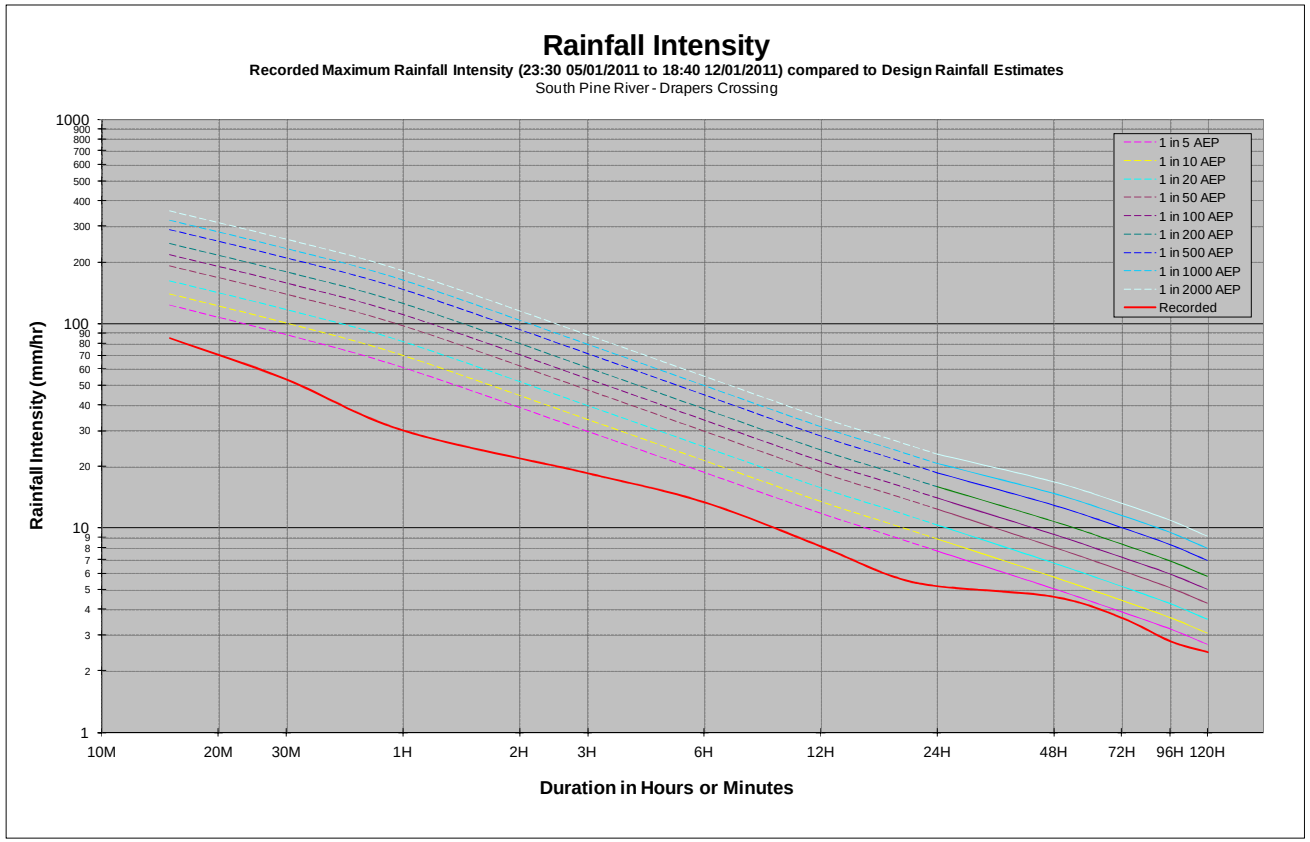

Figure 9.3.21 – Recorded rainfall intensity (CRC-FORGE), South Pine River at Drapers Crossing

6778 – South Pine River at Samford

Duration	Recorded intensity	End time	AEP
	mm/hr		1 in Y
15 M	89.6	10:20 11/01/2011	< 5
30 M	53.4	10:20 11/01/2011	< 5
1 H	31.8	10:50 11/01/2011	< 5
3 H	22.7	12:50 11/01/2011	< 5
6 H	15.4	14:20 11/01/2011	< 5
12 H	9.6	14:35 11/01/2011	< 5
18 H	6.8	18:05 11/01/2011	< 5
24 H	5.5	09:50 10/01/2011	< 5
48 H	5.2	14:35 11/01/2011	5 - 10
72 H	4.0	02:05 12/01/2011	5 - 10
96 H	3.1	02:20 12/01/2011	< 5
120 H	2.7	02:20 12/01/2011	5 - 10

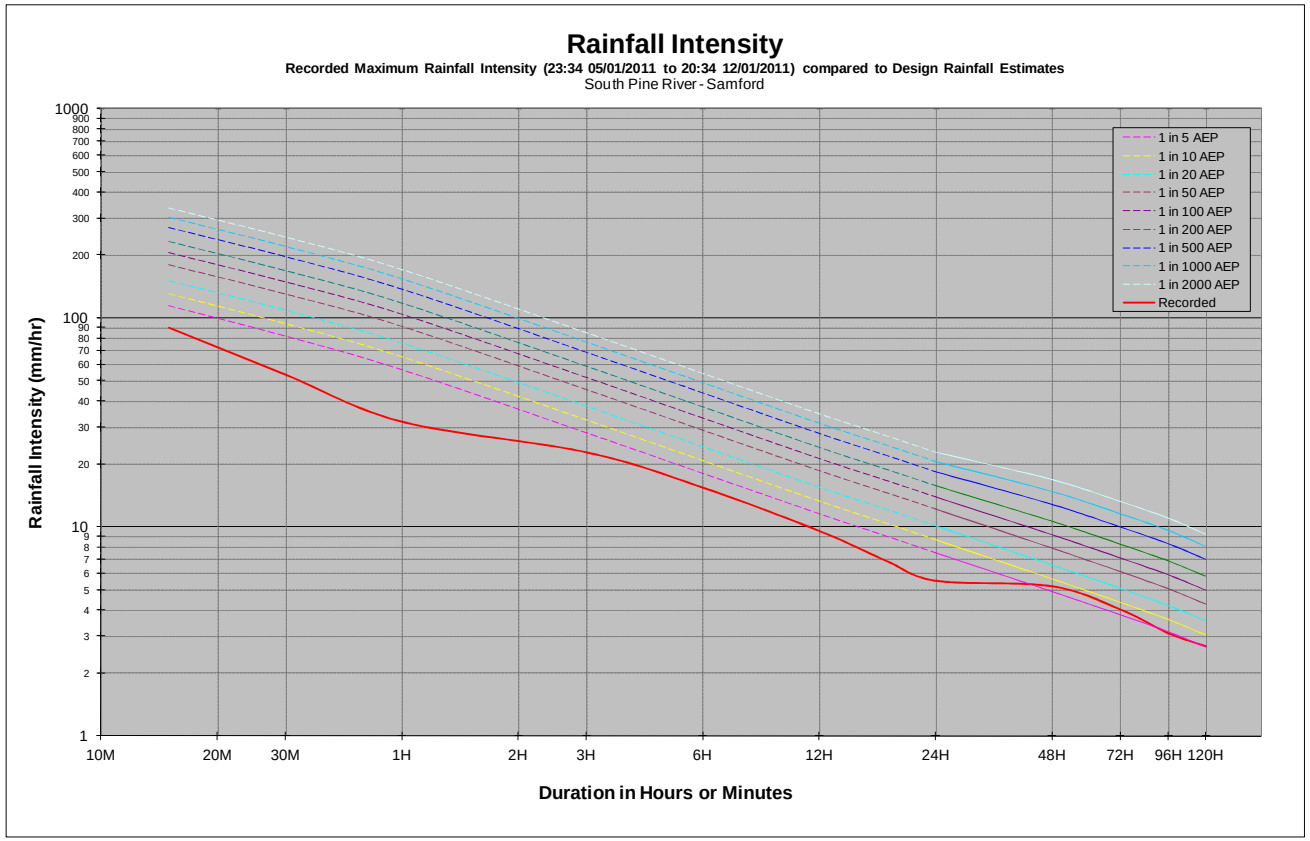

Figure 9.3.22 - Recorded rainfall intensity (CRC-FORGE), South Pine River at Samford

9.4 Catchment rainfall IFD analysis

While Point IFD analysis demonstrates the rainfall intensity in the immediate vicinity of the station, it does not indicate the significance of the rainfall over the entire catchment. The catchment average rainfall is determined by applying a weighting to each station in the network, then adding up the weighted station rainfall for each period of the analysis. Catchment IFD analysis derived using CRC-FORGE is based on assumed idealised spatial and temporal patterns, which can be quite different to the actual Event rainfall distributions.

By their nature, catchment average rainfall intensities tend to be lower than point intensities due to the spatial variation of rainfall through the catchment, with some areas recording higher rainfall than others. This is particularly true for catchments such as the North Pine catchment, where there is significant spatial variation in the storm rainfall. However, the AEPs for the North Pine Dam catchment were between the 1 in 100 and 1 in 500 range for rainfall durations between six hours to 72 hours. The conclusion that can be drawn from this is that this was a significant rainfall event.

Duration	Recorded intensity	Event and Time	AEP
hrs	mm/hr		1 in Y
1	49.1	11/01/2011 10:00	< 5
3	41.0	11/01/2011 11:00	20-50
6	34.3	11/01/2011 12:00	100-200
12	24.3	11/01/2011 15:00	200-500
18	16.9	11/01/2011 19:00	100-200
24	12.9	11/01/2011 18:00	50-100
48	9.1	11/01/2011 14:00	50-100
72	6.7	11/01/2011 19:00	50-100
96	5.1	12/01/2011 09:00	20-50
120	4.4	12/01/2011 01:00	20-50

Table 9.4.1 – North Pine Dam catchment AEPs

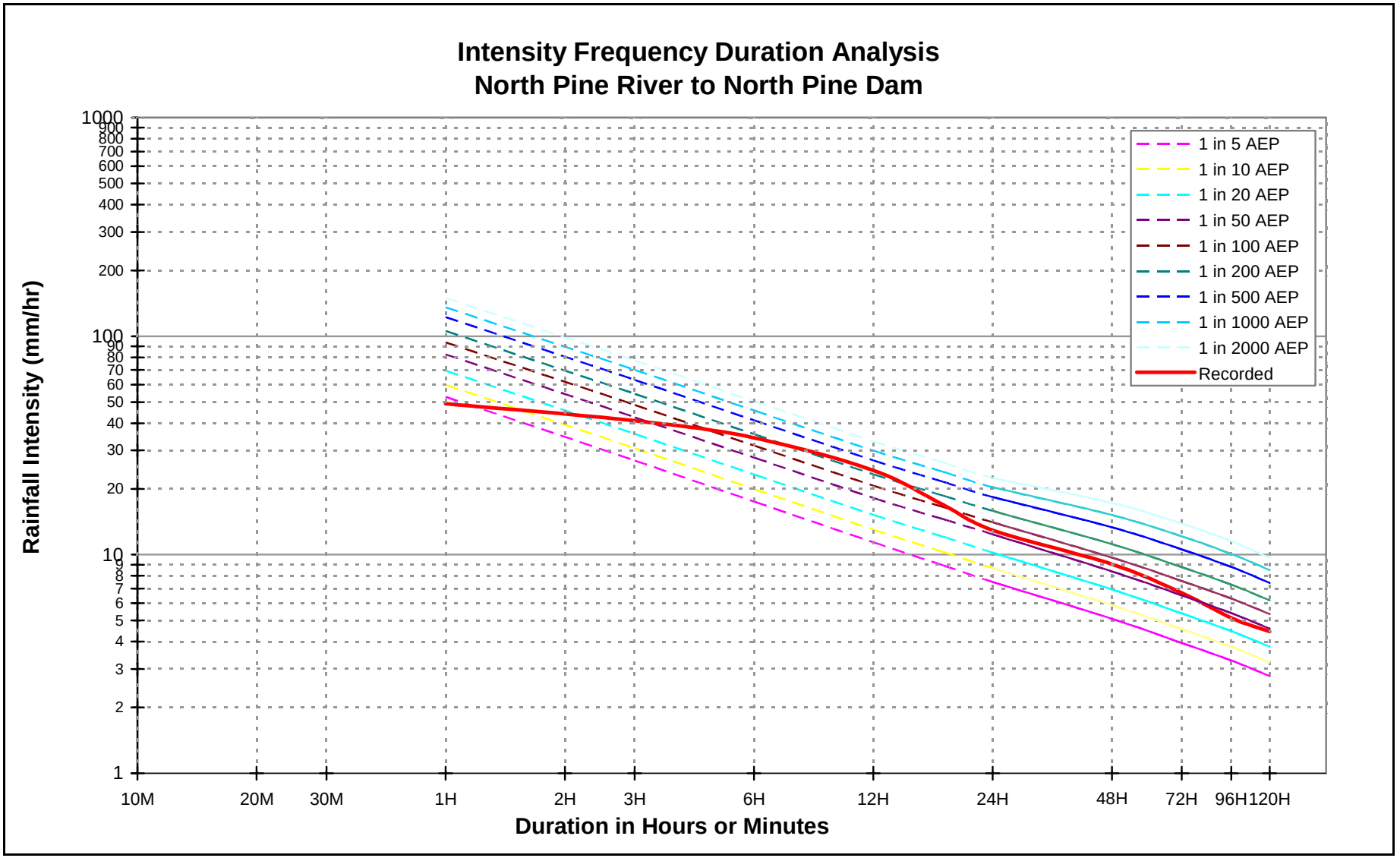

Figure 9.4.2 – Rainfall intensity, North Pine Dam

9 PRELIMINARY ASSESSMENT OF EVENT MAGNITUDE (continued)

9.5 Comparison of flood peaks

Comparison of flood peaks is critical in the assessment of flood magnitude at North Pine Dam. Starting level is also important; if the Dam is low at the start of the event, some of the flood water will be retained for urban water supply. However, if the Dam is full at the start of the event, the flood peak passes through the Dam with less attenuation.

During the design flood study (***North Pine Dam Design Flood Hydrology, Report, SunWater, October 2007***), several events were modelled to calibrate the flood model. These included several of the events listed in Table 9.5.1 below. The numbers in ***blue italics*** are estimated.

Table 9.5.1 shows that the peak inflow and outflow of the January 2011 Flood Event was more than double the peak of the previously highest flood in early March 1989.

Post-2007 flood data is from the Seqwater flood archive.

Event	Starting level		Peak flows	
			Inflow	Outflow
	m AHD	%	m^3/s	m^3/s
Pre-Dam period				
Dec-1970	n/a		270	
Feb-1972	n/a		***960***	
Jul-1973	n/a		430	
Jan-1974	n/a		***950***	
Post-Dam period				
Jun-1983	n/a		***760***	
Apr-1988	32.62	45.1	790	630
Mar-1989	39.61	100.1	1,430	1,430
Apr-1989	n/a		1,150	980
Dec-1991	n/a		***1,740***	
May-1996	35.23	62.1		0
Feb-1999	34.75	58.7	1,180	0
Feb-2001	37.57	80.8	420	0
Mar-2004	33.69	51.6	***460***	0
Nov-2008	31.01	36.4	***220***	0
Apr-2009	33.66	51.4	790	0
May-2009	36.61	72.7	910	330
Feb-2010	39.60	100.0	380	360
Oct-2010	39.26	96.6	1,000	910
Jan-2011	39.61	100.1	3,480	2,850

Table 9.5.1 – Recent and historical event flood volumes in the North Pine River at North Pine Dam

9.6 Flood frequency analysis

The annual flood series showing the largest flood in a water year (in South East Queensland, 1 October to 30 September) was extracted from the Department of Environment and Resource Management (DERM) website for the stations listed in Table 9.6.1.

Station number	Station name	Catchment area	Commenced	Ceased
		km^2		
142101A	North Pine River at Youngs Crossing	403	01/07/1915	16/11/1978
142102A	North Pine River at Dam Site	346	01/10/1954	20/10/1969
142102B	North Pine River at the Y.M.C.A Camp	350	01/10/1969	29/02/1972

Table 9.6.1 – Largest flood in a water year, South East Queensland

While the stations are not in exactly the same location as North Pine Dam, the records up to the time of construction of North Pine Dam are indicative of the inflows to the Dam, and have been treated as a continuous annual series of the flow for the purpose of this analysis.

Post the construction of North Pine Dam, the peak inflows from Table 9.6.1 have been added to the series to approximate an annual series of inflows starting in 1916 to the current year. No adjustment has been made to the post-Dam inflows to correct for the impacts of the Dam. It should be noted this is an incomplete non-homogeneous data set. The results derived from this analysis should be treated with caution. A Generalised Extreme Value (GEV) flood frequency analysis of these flows was undertaken, with the results shown below. While this analysis is preliminary and limited, it does indicate the inflow to North Pine Dam during the January 2011 Flood Event is rarer than 1 in 200.

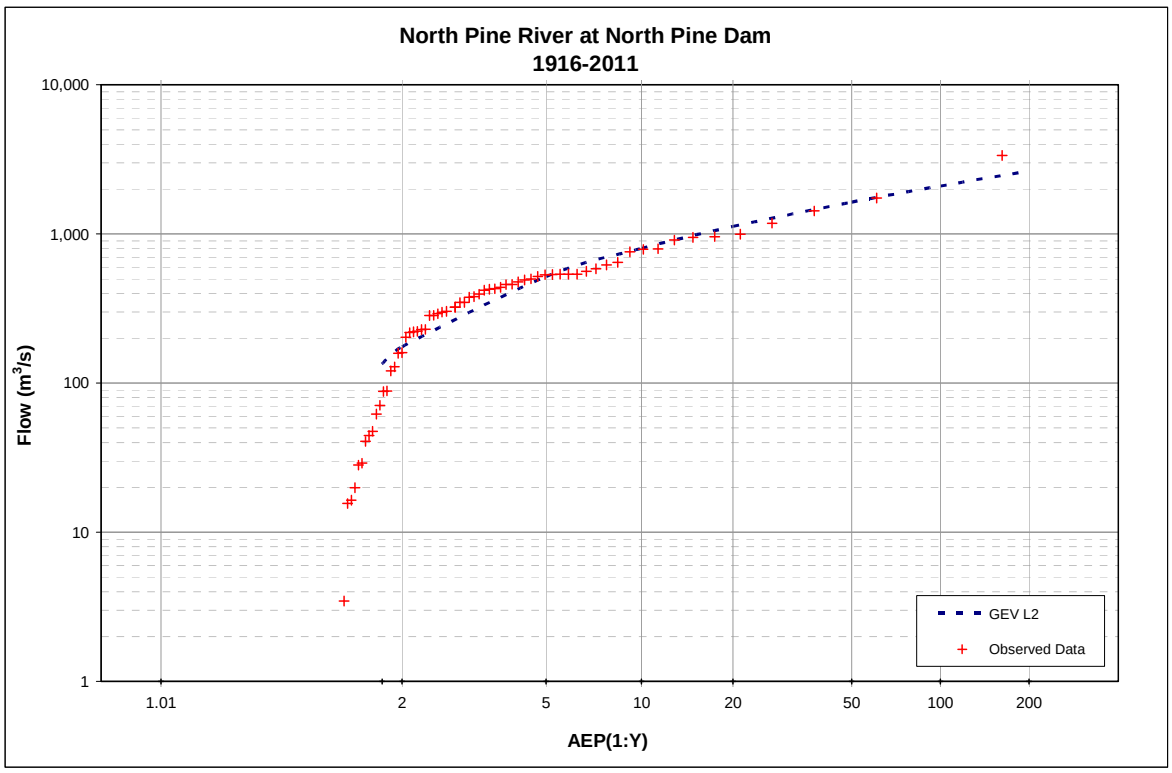

Figure 9.6.2 – Flood frequency, North Pine Dam

9 PRELIMINARY ASSESSMENT OF EVENT MAGNITUDE (continued)

9.7 Design flood comparisons

Some care should be exercised when comparing actual flows and levels with design flows and levels. Design flows and levels are based on idealised design storms distributed in time and space combined with average catchment conditions. These circumstances are not necessarily directly comparable with actual events such as the January 2011 Flood Event. However, these design cases do provide an indicative comparison.

Seqwater undertook a review of the design flood hydrology for North Pine Dam in October 2007 (***North Pine Dam Design Flood Hydrology, Report, SunWater, October 2007***).

This study found a 12-hour design storm generated a peak outflow of 2,900m^3/s for an event with an AEP of 1 in 10,000. This compares with the January 2011 Flood Event that produced a similar peak outflow of approximately 2,850m^3/s for a similar duration storm. It should be noted, the wet catchment conditions in the January 2011 Flood Event resulted in a lower loss rates than adopted in the design study.

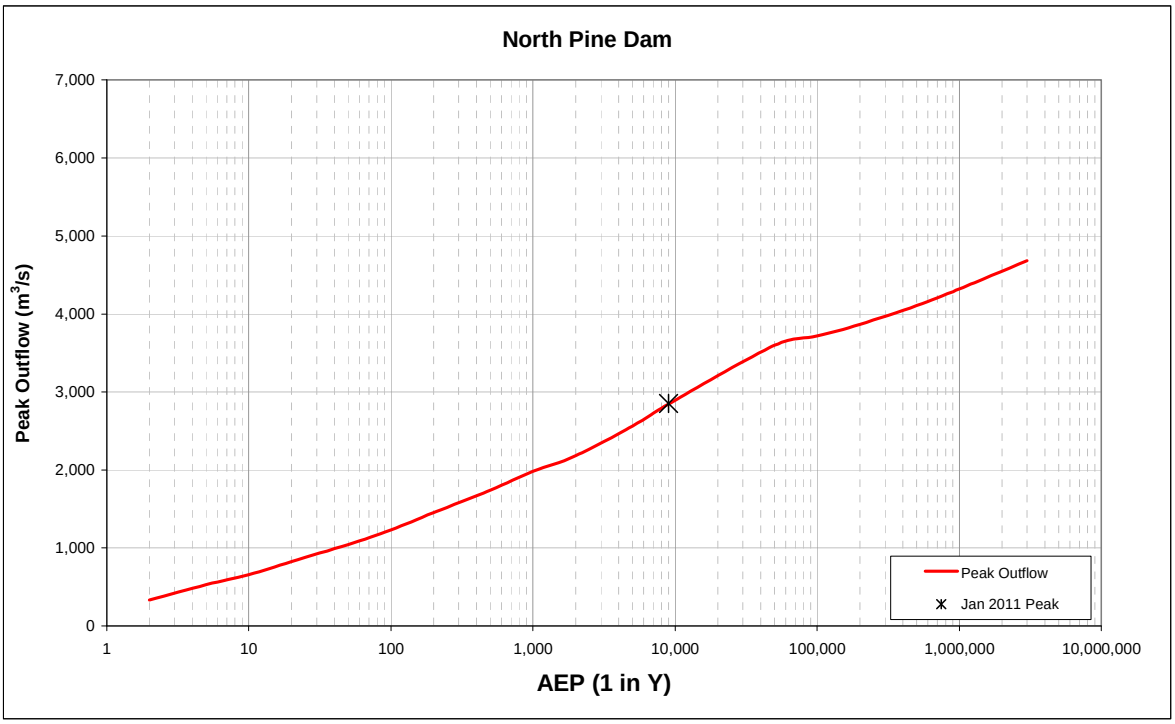

Figure 9.7.1 – Outflow flood frequency, North Pine Dam

During the January 2011 Flood Event, a peak water level of 41.11m was reached. According to the design study, this should occur during an event approaching an AEP of 1 in 10,000. The AEP of the event rainfall does not support a flood of this rarity. A more detailed study is currently being conducted to properly assess rarity of the Event and combination of catchment conditions, rainfall temporal and spatial conditions that produced this flood. This study will have direct implications for the Acceptable Spillway Capacity of North Pine Dam and the work is proceeding in accordance with the requirements of the Queensland Dam Safety Regulator.

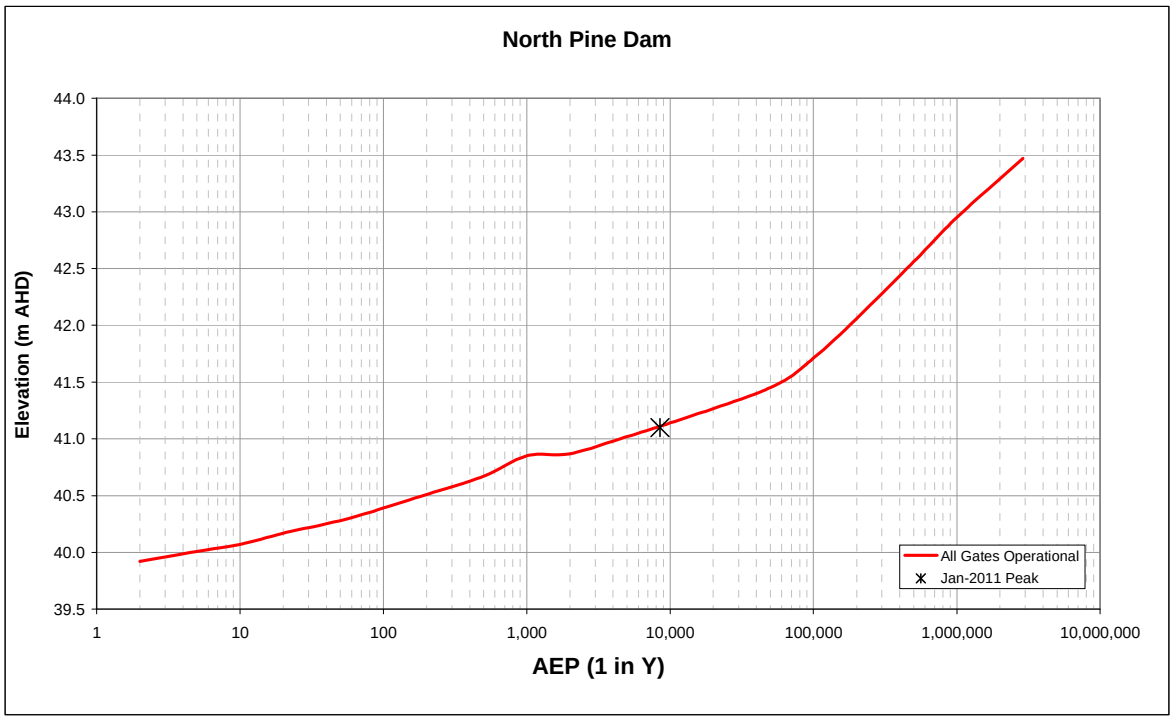

Figure 9.7.2 – Flood frequency of peak water level, North Pine Dam

9.8 Comparison with other catchments

The International Association for Hydro-Environment Engineering and Research (IAHR Publication 143) publishes a list of maximum recorded flows for Australian and international catchments. This data is plotted in Figure 9.8.1 below. The North Pine inflow peak is also plotted on this graph and it shows the peak inflow during the January 2011 Flood Event is comparable with maximum recorded flows for national and international catchments of similar area.

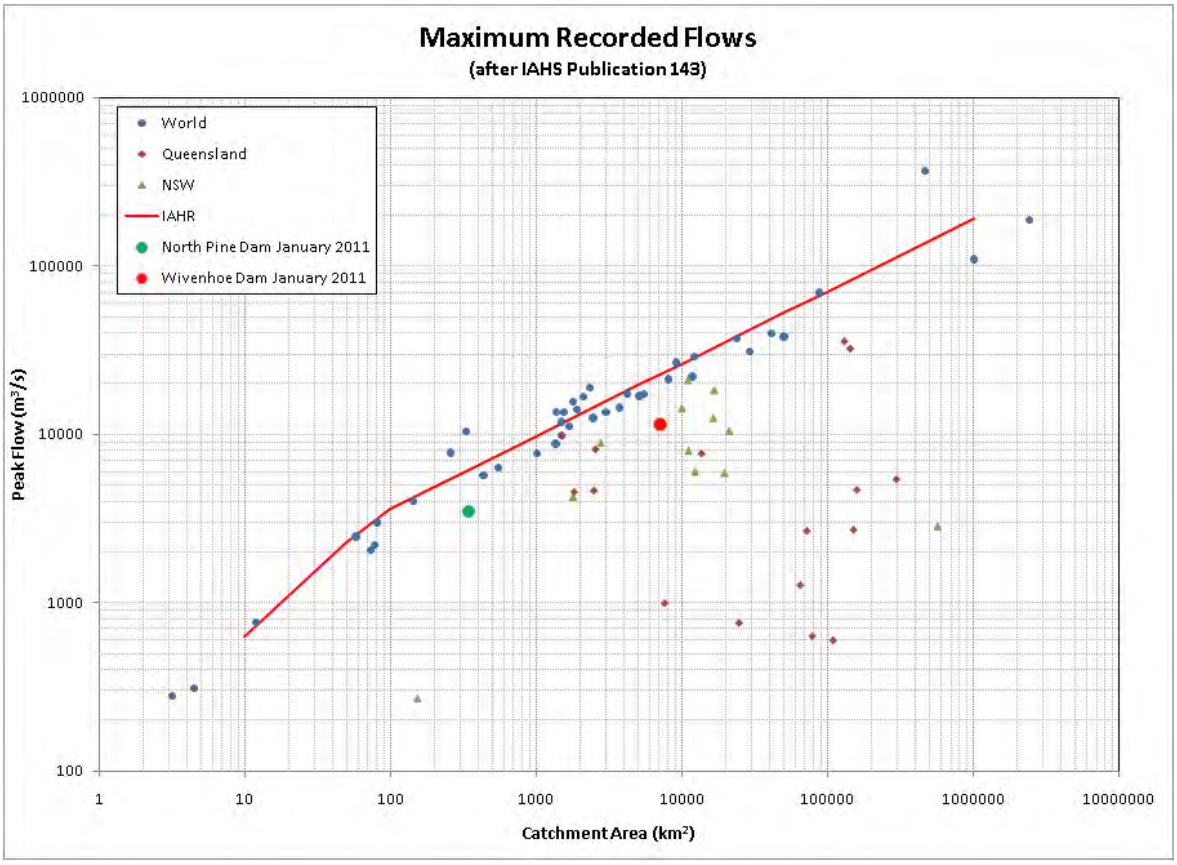

Figure 9.8.1 – Maximum recorded flows for Australian and international catchments

9.9 Conclusions

Based on the information in Section 9, the following conclusions can be made in relation to the significance of the January 2011 Flood Event at North Pine Dam:

- The rainfall intensities varied significantly in the catchment areas above the Dam, especially in the area around Baxters Creek where the AEP of the short duration rainfalls was between 1 in 200 to 1 in 500, and may be classified as rare.
- The AEP for the North Pine Dam average catchment rainfall was between the 1 in 200 and the 1 in 500 range for a duration of 12 hours, clearly highlighting the significance of the Event.
- When compared with historical events, flood peak flow indicates the peak of the January 2011 Flood Event was more than double any flood in North Pine Dam following its construction.
- Preliminary flood frequency analysis of available records indicates the Event peak was easily the largest peak flow on record (after records commenced in 1916). Preliminary flood frequency analysis of a composite flood series indicates the peak inflows are rarer than an AEP of 1 in 200.
- A comparison of the recorded peak outflows and peak levels at North Pine Dam with design estimates confirm the January 2011 Flood Event also exceeds 1 in 200 AEP and may be significantly rarer.
- Overall, the January 2011 Flood Event is considered to represent a rare event as defined by AR&R in terms of rainfall, flood peaks and peak water level.
- The January 2011 Flood Event has put into question the current understanding of design flood hydrology for North Pine Dam. Accordingly a more detailed study is currently being conducted to properly assess the rarity of the Event. This study will have direct implications for the Acceptable Spillway Capacity of North Pine Dam and the work is proceeding in accordance with the requirements of the Queensland Dam Safety Regulator.

10 FLOOD MANAGEMENT STRATEGIES AND MANUAL COMPLIANCE

10.1 Manual objectives

Flood events that impact North Pine Dam are caused by rainfall events that vary in intensity, duration and distribution over a catchment area of 345km^2 above the Dam. When making decisions about releasing water from the Dams during flood events, consideration is only given to rain falling in this catchment area and the resulting inflow into the Dam. Accordingly, the Manual provides guidance on the minimum level of flood releases that must be provided to ensure the safety of the Dam. Within this requirement for dam safety, some allowances can be made to minimise disruption to the community by minimising the inundation time of Youngs Crossing on Youngs Crossing Road.

The primary objectives of the Manual, in order of importance, are:

- Ensure the structural safety of the Dams;
- Minimise disruption to the community in areas downstream of the Dam;
- Retain the storage at Full Supply Level (FSL) at the conclusion of the flood event;
- Minimise impacts to riparian flora and fauna during the Drain Down Phase of the flood event.

While ensuring the Dam is operated during flood events within these objectives, Seqwater is aware that the safety of the public is a primary consideration when making flood releases from the Dam. Every attempt is made to ensure public roads are closed prior to inundation by Dam outflows and that authorities are provided with as much time as possible to prepare the community for large Dam outflows. However, as significant inflows into the Dam can occur within two hours after heavy rainfall begins in the catchment area, the time available to prepare for large dam outflows can be limited. As the Pine Rivers Basin responds to rainfall within six hours, the BoM classifies flooding in the Pine River as 'flash flooding'. The BoM does not issue specific flood warnings for the Pine Rivers but the region is considered to be covered by generalised regional flood and severe weather warnings.

10.2 North Pine Dam – Manual compliance

During the January 2011 Flood Event, operational decisions were made in accordance with the Manual. The available recorded data shows the January 2011 Flood Event was unprecedented in the history of North Pine Dam and rivals the largest floods in the recorded flood history of the region. The successful operation of the Dam during the Flood Event protected the safety of the Dam and reduced flood levels downstream. Procedures contained in the Manual relevant to these operations are as follows:

- The flood operation strategy used during this Event involved passing the flood through the reservoir, while ensuring peak outflow generally did not exceed peak inflow. The aim was also to empty stored floodwaters as quickly as possible. To achieve this strategy, the radial gate opening settings contained in Appendix C of the Manual were used to determine flood releases.
- The Manual's target minimum intervals for radial gate opening were followed at all times, except during the rapid water level rises that occurred during Tuesday 11 January 2011. During these periods of rapid water level rises, water levels rose too quickly to allow minimum intervals to be observed. The gate opening interval was adjusted to ensure gate opening settings never fell more than three openings behind the minimum settings contained in the Manual. This adjustment of radial gate opening interval is in accordance with Section 8.6 of the Manual.
- The Manual's target minimum intervals for radial gate closings were followed at all times, except directly following the flood peak that occurred during Tuesday 11 January 2011. During this period, the minimum settings contained in the Manual were reduced to preserve storage and reduce downstream flooding. This adjustment of the radial gate closing interval is in accordance with Section 8.6 of the Manual.

- During the Event, every attempt was made to minimise disruption to the community in areas downstream of the Dam, particularly by minimising the period during which Youngs Crossing was inundated and closed to traffic. However, uncontrolled flood outflows from Lake Kurwongbah over the period of the Event meant that even if no releases were made from North Pine Dam, Youngs Crossing would still have been inundated. The derived outflow hydrograph for Lake Kurwongbah during the period of the Event is shown in Figure 10.2.1. The outflow required to close Youngs Crossing to traffic is $10m^3/s$.

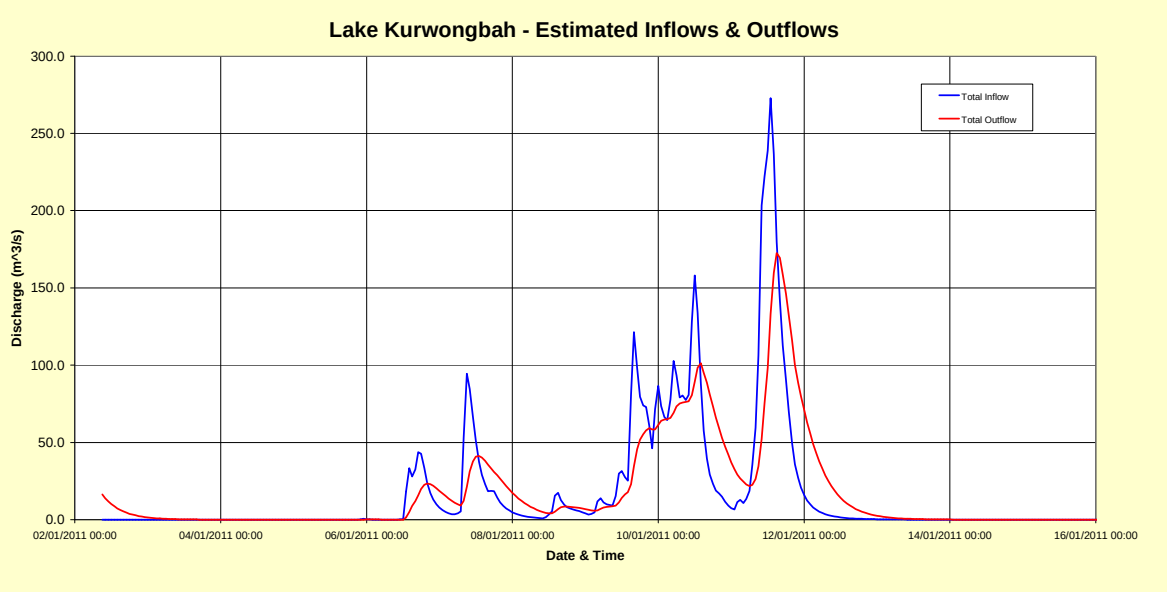

Figure 10.2.1 – Lake Kurwongbah – Derived Inflows and Outflows during the January 2011 Flood Event

10.3 North Pine Dam – Manual review

As a very large and rare flood event occurred, it is recommended a formal review of ***The Manual of Operational Procedures for Flood Mitigation at North Pine Dam (Revision 5)*** (the Manual) be undertaken in conjunction with the Department of Environment and Resource Management (DERM) and other relevant stakeholders. This is a requirement of the Manual when an event of this nature is experienced.

11 EVENT COMMUNICATION

The following table shows the agencies and personnel who have responsibilities during flood events impacting North Pine Dam. The table is based on a similar table in the North Pine Dam Emergency Action Plan ("the Plan"). Controlled copies of the Plan have been provided to:

- The Department of Environment and Resource Management (DERM);
- Department of Community Safety;
- Moreton Bay Regional Council;
- Brisbane City Council;
- Seqwater.

The Plan is owned and maintained by Seqwater. Flood Inundation Maps are contained in Appendix C of the Plan.

Agencies	Responsibilities during flood events
Seqwater	• Undertake emergency response at the Dam. • Determine the area of potential impact from the Flood Event. • Provide timely notification of impending and actual emergencies, including details of the emergency and estimates of potential impacts downstream of the Dam, to relevant disaster response agencies.
Seqwater Flood Operations Centre	• Direct flood operation actions at North Pine Dam during a flood event.
Director Dam Safety (DERM)	• Provide regulatory input during the flood event.
Regional or City Council	• Exercise primary responsibility for disaster response and management within its boundaries, in accordance with the ***Queensland Disaster Management Act 2003.*** • Deploy all appropriate resources to contribute to response and recovery during a dam safety emergency, until the Council's resources are fully committed. • Mobilise disaster response assistance from other relevant disaster response agencies, as appropriate during the emergency.

Table 11.1.1 – Agency Responsibilities

Under the requirements of the Manual, Seqwater is responsible for issuing information to the public and media regarding storage conditions and Dam releases. However, in relation to the entire Water Grid, the Water Grid Manager is the State's designated lead communication agency on floodwater releases. During the January 2011 Flood Event, Seqwater provided relevant and timely information to the Water Grid Manager, who then communicated this information to the public and media.

Seqwater understands the following agencies were responsible for communicating specific information during the Event:

- **Local governments / Local Disaster Management Groups –** Communicated the effects of weather-related events and the potential safety impacts for local communities, residents, and Council-owned assets. Local governments were primarily responsible for communicating with their community.
- **Water Grid Manager –** Publicly communicated aspects of floodwater release timing and the expected duration of the impacts. Seqwater operational staff ensured supporting technical information was provided to the Water Grid Manager, and the Water Grid Manager took responsibility for liaising with local governments and coordinating any public communication in relation to the flood releases.

During the January 2011 Flood Event, the intense rainfall and associated rapid inflow into the Dam on Tuesday 11 January 2011 provided limited opportunities to issue public flood warnings. The Bureau of Meteorology (BoM) classifies situations such as these as 'flash flood' events and does not provide specific public flood warnings in these instances. Accordingly, Seqwater is responsible for notifying the Moreton Bay

Regional Council when such rapid inflows into North Pine Dam occur. This provides the Council with as much warning as possible in the very limited time available, when flash flooding of this nature occurs.

On Tuesday 11 January 2011, heavy rain first commenced in the North Pine Dam catchment area at approximately 05:00. As a result, Dam outflows increased at approximately 07:00, however, it was not until 09:00 that it became apparent a major event was commencing. At this time, outflow was still approximately 420m^3/s, however, dam inflow had almost doubled in the hour since 08:00, to 1,150m^3/s.

The Moreton Bay Regional Council was contacted at 09:16, 09:17, 10:45, 11:19, 11:56, 11:57 and 11:59, and provided with an update on the developing situation using the agreed contact methods in the North Pine Dam Emergency Action Plan. The Dam level peaked at 41.11m at 14:00.

Seqwater believes communication during the January 2011 Flood Event impacting North Pine Dam was adequate. However, to properly assess communication, detailed feedback on the effectiveness of Seqwater communications during the Event must be obtained from the following agencies:

- Moreton Bay Regional Council;
- Brisbane City Council;
- Water Grid Manager;
- Queensland Police Service;
- Department of Community Safety;
- Department of Environment and Resource Management;
- Department of Premier and Cabinet;
- Bureau of Meteorology.

To date, this process has not commenced, however, this work will proceed as soon as appropriate personnel are available to undertake the necessary review.

12 REPORT CONCLUSIONS AND RECOMMENDATIONS

The significant conclusions drawn from this Report are:

- During the January 2011 Flood Event, North Pine Dam was operated in accordance with the Manual. The Dam was operated so that the peak outflow from the Dam during the Event was only 82% of the peak inflow. This reduced flood flows downstream of the Dam. Further reductions in flood flows downstream of the Dam were not possible without risking the safety of the Dam.
- The data collection and flood modelling systems used to support decisions made during the Event performed well and assisted informed decision-making, in accordance with the Manual.
- During the Event, Seqwater provided information to the Moreton Bay Regional Council and other relevant agencies in relation to the flood releases being made from the Dam. Further discussions with the Moreton Bay Regional Council are needed to determine if the provision of information during flood events impacting on North Pine Dam can be improved.
- The January 2011 Flood Event was a rare flood event and the largest flood in the recorded flood history of the region. The safety of North Pine Dam was maintained at all times during the Event and the Dam did reduce downstream flood flows.
- The January 2011 Flood Event raised questions about the current understanding of design flood hydrology for North Pine Dam. Accordingly, a more detailed study is currently being conducted to properly assess the rarity of the Event. This study will have direct implications for the Acceptable Spillway Capacity of North Pine Dam. It is proceeding in accordance with the requirements of the Queensland Dam Safety Regulator.

Following is a summary of the key recommendations contained in this Report:

- Given that a rare and very large flood event occurred, it is recommended a formal review of the Manual be undertaken. This is a requirement of the Manual when an event of this nature is experienced;
- In conjunction with the Moreton Bay Regional Council, the Bureau of Meteorology and other relevant agencies, it is recommended Seqwater participate in a review of the agency communication that occurred during the Flood Event to determine if opportunities exist to improve current processes.

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