

Dam Safety Emergency Plan for Clarrie Hall Dam

May 2022

Covering - Flooding, Earthquake, Other Emergency Situations

Version 8.3

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Revision List

- Proposals for amendment or addition to the Dam Safety Emergency Plan (DSEP) for Clarrie Hall Dam are to be forwarded to all names on the distribution list.
- Amendments circulated are to be entered and certified in the table below when the document has been amended.

AMENDMENT			ENTERED	
Item	Revision No:	Date	Entered By: (Print Name)	Date
Full document and Appendices following DWE request.	2	Sept 2009	Peter Haywood	7/9/09
Document with updated charts	3	Feb 2010	Peter Haywood	9/2/10
Removal of DWE	4	Mar2010	Peter Haywood	5/3/10
FINAL - New inundation maps, TSC template, updated contacts lists, removed Dept Commerce references and new SES Annex A inserted (Refer to Flow Chart Number 4).	5	Feb 2012	Peter Haywood	21/2/12
Amended after completion of Spillway Works, removal of reference to Dam Crest Flood, updated contact lists	6	Aug 2014	Rob Siebert	
Update and change of Third Party Consultant. New alert times and inflow/outflows	7	Aug 2017	Peter Haywood	2/8/17
Major Review – contacts updated, change of Third Party Consultant and contents restructured to align with new Dams Safety NSW guideline	8	Oct 2021	Mark Callander, Jazmine Cooke, Peter Haywood, Mitch Alward	26/10/21
Changes made to the flow chart references.	8.1	Nov 2021	Jazmine Cooke	10/11/21
Contacts updated, Table 8.1 updated, Operational Alarm Level Added, BOM website links added, Recommendations from external exercise held on 25/11/21 incorporated, Recommendations from internal exercise held on 10/11/21 incorporated.	8.2	Dec 2021	Mark Callander, Mitch Alward	7/12/21
Table 4.1 updated for highest observed level. Table 8.1 updated for DSEP activation	8.3	May 2022	Mark Callander	2/5/22

Drawings and text pages attached to this document should have the latest amendments marked on them.

TABLE OF CONTENTS

Revision List	i
Authorisation Signatories.....	1
Glossary of Terms	2
Abbreviations.....	5
1. Summary Information Sheet for Emergency Agencies.....	6
1.1 Background Information.....	6
1.2 Flooding Alert Levels.....	6
1.3 Notification Protocols.....	6
1.4 Consequence of Dam Failure.....	6
1.5 Flood Plan Name	6
2. Emergency Notification Flow Charts.....	7
Flow Chart Number 1 - DSEP for Flood Emergency	7
Flow Chart Number 2 - DSEP for Earthquakes.....	8
Flow Chart Number 3 - DSEP for other than Flood or Earthquakes	9
Flow Chart Number 4 – Emergency Service Notification	10
3. Notification and Responsibilities for Emergency Functions.....	15
3.1 Emergency Notifications and Responsibilities for Evaluation of Flooding ...	15
3.2 Emergency Notification and Responsibilities for Evaluation of Earthquakes	18
3.3 Emergency Notification and Responsibilities for Evaluation of Conditions other than Flooding or Earthquake	20
3.4 General Actions.....	23
4. Dam Failure Information	24
4.1 Description of Dam	24
4.2 Dambreak Study Summary.....	25
4.3 Downstream Study Area.....	27
4.4 Description of the Dambreak Model	27
4.5 Breach Parameters.....	28
4.6 Dambreak Flooding Conditions	28
4.7 Floodwave Arrival Time	28
5. Dam Monitoring Systems	30
6. Emergency Warning Systems	30
6.1 Potential Failure Indicators	31
7. Emergency Alerts and Notifications.....	31
7.1 Emergency Notification Flow Charts.....	31
7.2 Dams Safety NSW notification and involvement.....	32



7.3	Emergency Situations	32
7.3.1	Classification of Emergency Situations due to Flooding.....	32
7.3.2	Classification of Emergency Situations due to other than Flooding (Earthquake or Other Emergency).....	35
7.4	Access and Communication during Flooding	35
7.5	Actions to Lower the Reservoir or Limit Inflows or Outflows	35
7.5.1	Clarrie Hall Dam Emergency Lowering Constraints	35
8.	Emergency Exercises	36
8.1	Three yearly exercise.....	36
8.2	Five yearly practical exercise.....	36
8.3	Records.....	37
9.	Document Control	37
9.1	Review and Updating the emergency plan.....	37
9.1.1	Updating contact details.....	38
9.2	Emergency plan distribution	38
	References	39
	List of Relevant Drawings	40
	List of Maps	40
	List of Figures	40
	Appendix A	41
	Appendix B	54
	Appendix C	61
	Appendix D	66
	Appendix E	73
	Appendix F	75
	Appendix G	77



Authorisation Signatories

This document conforms to the Dams Safety Regulation 2019 requirements. It has been prepared in line with the Australian National Committee on Large Dams (ANCOLD) “Guidelines on Dam Safety Management, 2003” and the Dams Safety NSW guideline for Emergency Plans version 1.

The document covers preparedness in relation to the occurrence of an emergency condition at Clarrie Hall Dam and provides information necessary for emergency agencies to manage a downstream evacuation in the unlikely event of a potential dam failure.

The document identifies emergency conditions that may result in dam failure.

It describes procedures to be followed to investigate and provide warning of emergency conditions to appropriate emergency managers, so that they can implement preparedness and response measures for the protection of downstream persons and property.

The document also provides direction for operating staff in the situation of unsafe or emergency conditions where dam failure is unlikely, so that the dam can be returned to a safe condition with minimal delay.

The Dam Safety Emergency Plan is to be used to activate the Tweed Local Emergency Plan and associated Tweed Local Flood Plan. It is not intended as a replacement for the Tweed Local Emergency Plan. Instead it presents a plan of procedures to complement the needs of the Tweed Local Emergency Plan.

This document was originally produced by the NSW Department of Commerce, now Public Works Advisory specialising in dam engineering, and dam safety evaluation. The document has had several updates since by Tweed Shire Council.

It is proposed that the following stakeholders endorse the document (as indicated):

Approved

Brie Jowett

Manager Water and Wastewater – Operations, Tweed Shire Council

Date: _____



Glossary of Terms

Abutment	That part of the valley wall against which the dam is constructed.
ANCOLD	Australian National Committee on Large Dams.
Annual Exceedance Probability (AEP)	The probability of exceedance of a given magnitude event (e.g. earthquake or flood) within a period of one year.
Australian Height Datum (AHD)	A system of control points for height based on a network of levelling measurements which covered the whole of Australia and which was fitted to mean sea level as measured at tide gauges distributed around the Australian coast, over the period 1968-1970.
Average Recurrence Interval (ARI)	The average or expected value of the period between exceedances of a given magnitude event (e.g. earthquake or flood).
Catchment	The area drained by the streams or watercourses down to the point at which the dam is located.
Dam	Any man made barrier, temporary or permanent, including appurtenant works which does or could impound, divert or control water, other liquids, silts, debris or other liquid-borne material.
Dam Consultant	Consultant engaged by Tweed Shire Council to offer expertise in dam engineering and provides the capability and responsibility for the Dam Engineer role as well as conducting 3 rd party surveillance inspections.
Dam Crest	Frequently used to denote top of dam. However, the term Crest is usually applied to the level at which water may overflow the spillway section of the dam. The term “Top of Dam” is preferred to denote uppermost surface of the dam proper, excluding parapets, handrails, etc. – See Spillway Crest
Dam Crest Flood (DCF)	The flood event when routed through the reservoir results in a still water level which is the lowest point of the crest for an embankment dam and for a concrete dam – the uppermost level of the crest. For Clarrie Hall Dam this is the top of the wave wall.
Dam Owner	Any person, organisation or legal entity who owns a dam. Legal opinion indicates that the dam owner is that person, authority or legal entity that owns the land on which the dam structure is situated.
Dam Safety Emergency Plan (DSEP)	A continually updated document incorporating instructions and maps that, together with ongoing public education, outlines the actions to be taken by a dam owner to deal with the emergency situation or unusual occurrence at a given dam or reservoir.
Dams Safety NSW	Dams Safety NSW has been established under the Dams Safety Act 2015 to be an independent, transparent and effective regulator with responsibility for the safety of declared dams in the state. Created on November 1, 2019,

	<p>Dams Safety NSW makes decisions on how the Dams Safety Regulation 2019 and standards are administered.</p> <p>Dams Safety NSW replaces the Dams Safety Committee.</p>
Failure (Dam)	The uncontrolled release of the contents of a dam. The failure may consist of the collapse of the dam or some part of it, or excessive seepage or discharges in cases where hazardous substances are being stored.
Freeboard	The vertical distance between the surface of the stored water and the top of the dam. Examples of freeboards are the distances from the top of the dam to the normal full supply level (normal freeboard), and the design flood level (flood freeboard).
Full Supply Level (FSL)	The level of water surface when the reservoir is at maximum operating level, excluding periods of flood discharge.
Hazard	That which has the potential for creating adverse consequences such as loss of life, property and services damages and environmental effects (also see Risk).
Height of Dam	Normally this is the difference in level between the natural bed of the stream or watercourse at the downstream toe of the dam or, if it is not across a stream, channel or watercourse, between the lowest elevation of the outside limit of the dam, and the top of the dam. (See definition "Top of Dam".)
Imminent Failure Flood (IFF) (Superseded by Safety Check Flood)	The flood event which, when routed through the reservoir initially at FSL, with the existing spillway, just threatens failure of the dam.
Incremental Flood Hazard Category (IFHC)	Categories of potential incremental losses and effects as a consequence of dam failure due to inadequate spillway capacity (see DSC13 for details). Where IFF is greater than PMF, IFF is taken to be the PMF.
Maintenance	The routine work required to maintain existing works and systems (civil, hydraulic, mechanical and electrical) in a safe and functional condition.
Monitoring	The record and review of data from which can be deduced the performance and behavioural trends of a dam and appurtenant structures.
Operator	The person, organisation, or legal entity, which is responsible for the control, operation and maintenance of the dam and/or reservoir and the appurtenant works.
Outlet Works	The combination of intake structure, screens, conduits, tunnels and valves that permit water to be discharged under control from the reservoir.
Population at Risk (PAR)	All those persons who would be directly exposed to flood waters within the Dambreak affected zone if they took no action to evacuate.



	Note: The PAR may be much greater than the potential loss of life as PAR is determined by floodwater inundation area in the Dambreak affected zone. The floodwater maybe as little as 100mm deep. However loss of life would generally not be expected unless the floodwater is greater than about 300mm deep with a velocity of flow greater than about 1m/s.
Probable Maximum Flood (PMF)	The flood hydrograph resulting from PMP and, where applicable, snowmelt, coupled with the worst flood-producing catchment conditions that can be realistically expected in the prevailing meteorological conditions.
Probable Maximum Precipitation (PMP)	The theoretical greatest depth of precipitation for a given duration that is physically possible over a particular drainage basin.
Reservoir Capacity	The total or gross storage capacity of the reservoir up to FSL excluding flood surcharge.
Risk	A measure of the probability and severity of an adverse event as either the product of probability and consequences, or in a non-product form (See also Hazard).
Safety Check Flood	The “limit state” overall safety flood relating to potential extraordinary flood events in the safe limit of dam integrity (previously called Imminent Failure Flood).
Spillway	A weir, conduit, tunnel or other structure designed to permit discharges from the reservoir when water levels rise above the full supply level (FSL) and to convey flood-waters safely pass a dam.
Spillway Crest	The uppermost portion of the spillway overflow section.
State of Emergency	As defined by the State Emergency and Rescue Management Act, 1989 - Section 33 (1): If the Premier is satisfied that an emergency constitutes a significant and widespread danger to life or property in New South Wales, the Premier may, by order in writing, declare that a state of emergency exists in the whole, or in any specified part or parts, of New South Wales in relation to that emergency.
Tail water Level	The level of water in the discharge channel immediately downstream of the dam.
Top of Dam	The elevation of the uppermost surface of the dam proper, not taking into account any camber allowed for settlement, kerbs, parapets, guardrails or other structures that are not a part of the main water retaining structure. This elevation may be a roadway, walkway or the non-overflow section of the dam.



Abbreviations

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
DC	Department of Commerce
DEMC	District Emergency Management Controller, Tweed Police
DEOCON	District Emergency Operations Controller
DFL	Design Flood Level
DOI	Police – Duty Operations Inspector
DSEP	Dam Safety Emergency Plan
FSL	Full Supply Level
IFF	Imminent Failure Flood
LEMO	Local Emergency Management Officer, Tweed Shire Council
LEOCON	Local Emergency Operations Controller, Tweed Police
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PRM	Probabilistic Rational Method
REMO	Regional Emergency Management Officer
SCADA	Supervisory Control and Data Acquisition
SCF	Safety Check Flood
SES	State Emergency Service
TSC	Tweed Shire Council
UHF	Ultra high Frequency
VHF	Very high Frequency

1. Summary Information Sheet for Emergency Agencies

1.1 Background Information

- Dam Owner Tweed Shire Council, Civic and Cultural Centre
Tumbulgum Road, Murwillumbah NSW
- Dam Location Clarrie Hall Dam Rd, Off Main Road #142 (Kyogle Rd)
4 km south-west of Uki, NSW
- Material contained by Dam Untreated water
- Dam Data Dam Data is held by Tweed Shire Council
- Consequence Categories

Sunny day Dambreak Consequence Category is considered “**High A**”.

The Flood Consequence Category for the PMF with Dambreak case is categorised as “**High B**”

1.2 Flooding Alert Levels

Full Supply Level	61.5 m AHD
Operational Alarm ¹	62.5 m AHD
White Alert	64.5 m AHD
Amber Alert	67.5m AHD
Red Alert	69.0m AHD

Live reservoir level data <http://www.bom.gov.au/fwo/IDN60231/IDN60231.558028.tbl.shtml>

Live river heights Northern Rivers http://www.bom.gov.au/cgi-bin/wrap_fwo.pl?IDN60140.html

1.3 Notification Protocols

- As per **Section 3**

1.4 Consequence of Dam Failure

- As per **Table 4.3** in **Section 4.7**

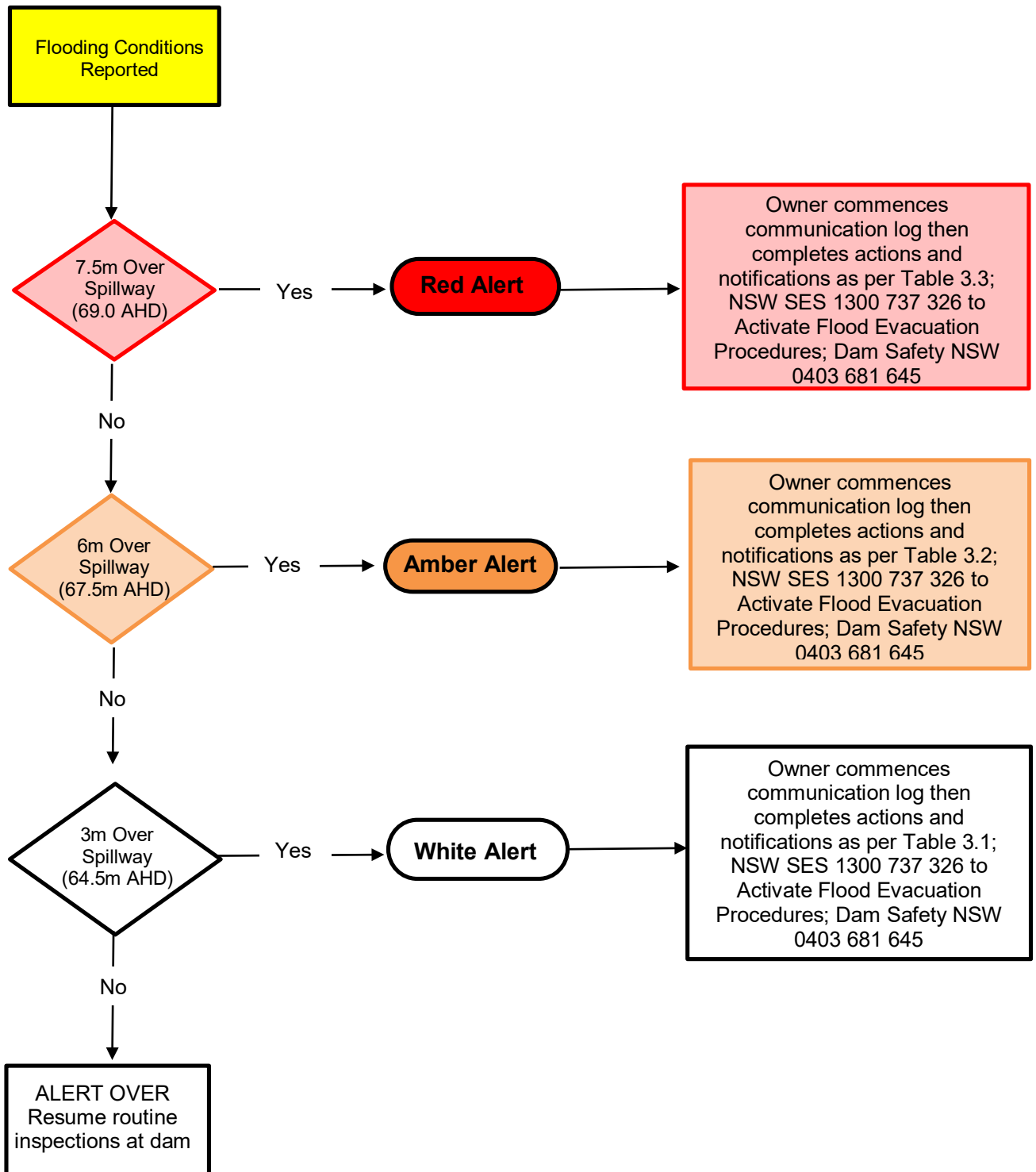
1.5 Flood Plan Name

- Tweed Shire Local Flood Plan

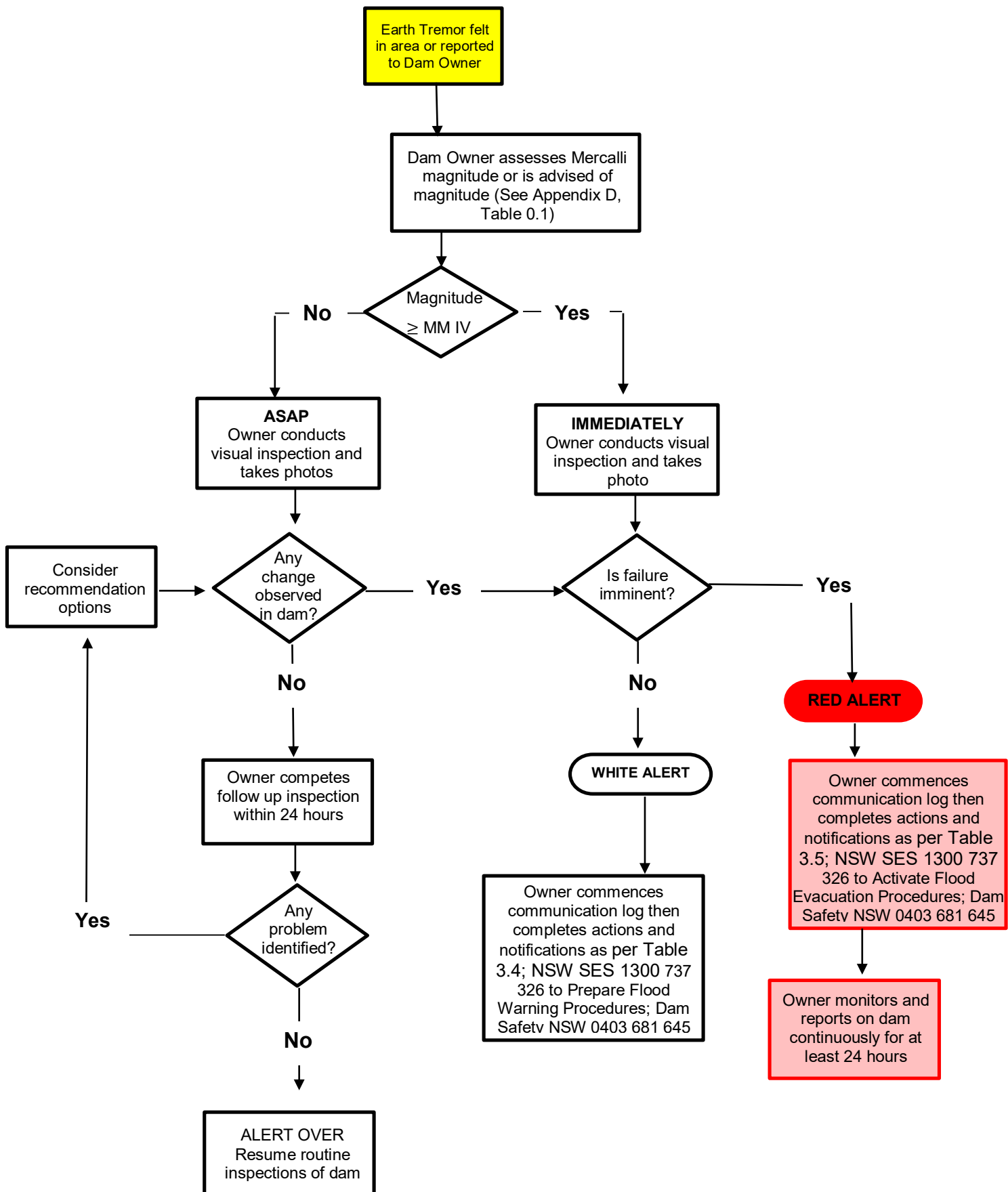
¹ Operational alarm level sent to on call operator to closely monitor rain forecasts and reservoir level and start to prepare plan if levels expected to rise. This is an internal alarm only and not part of the SES alert process.

2. Emergency Notification Flow Charts

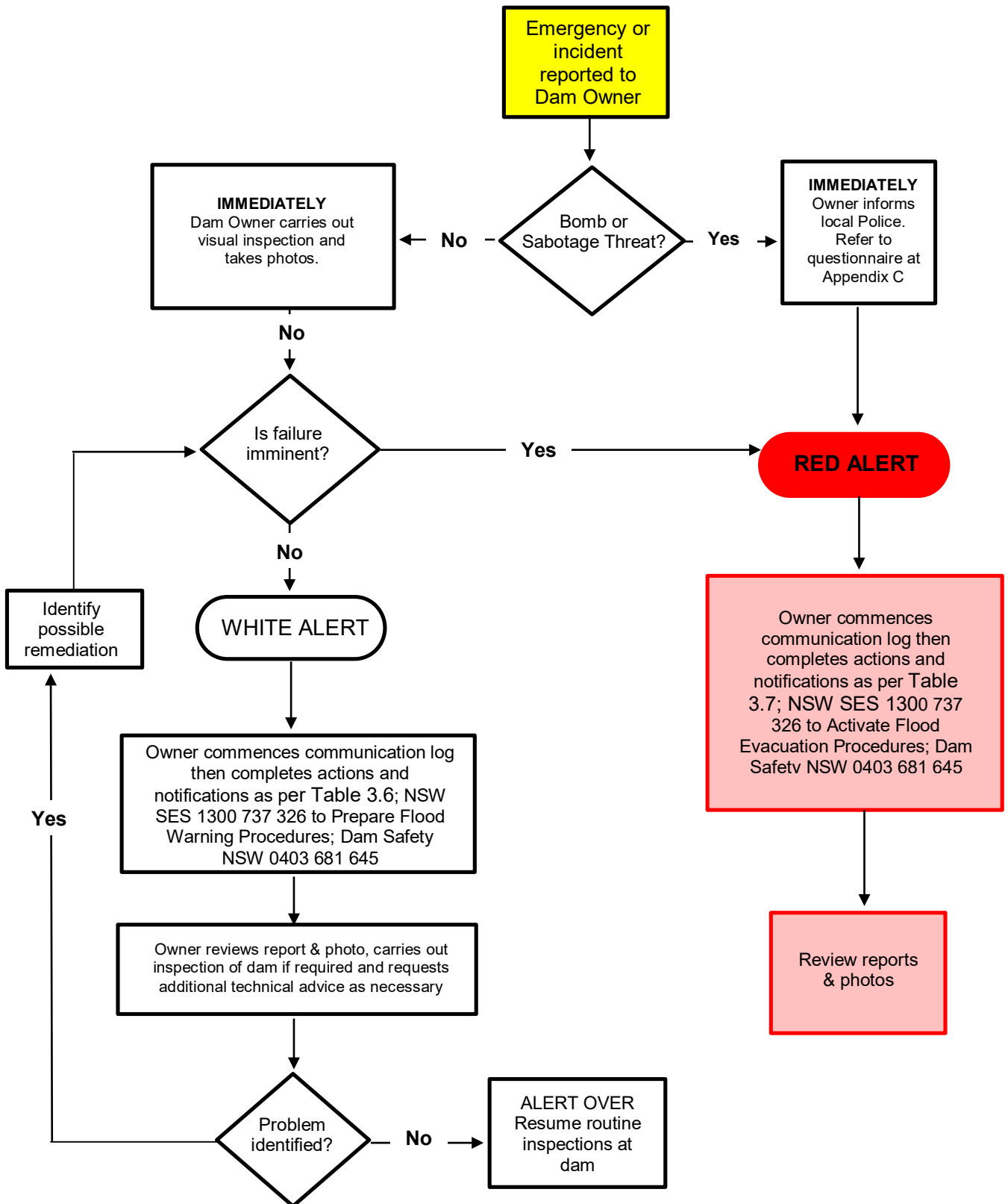
Flow Chart Number 1 - DSEP for Flood Emergency



Flow Chart Number 2 - DSEP for Earthquakes

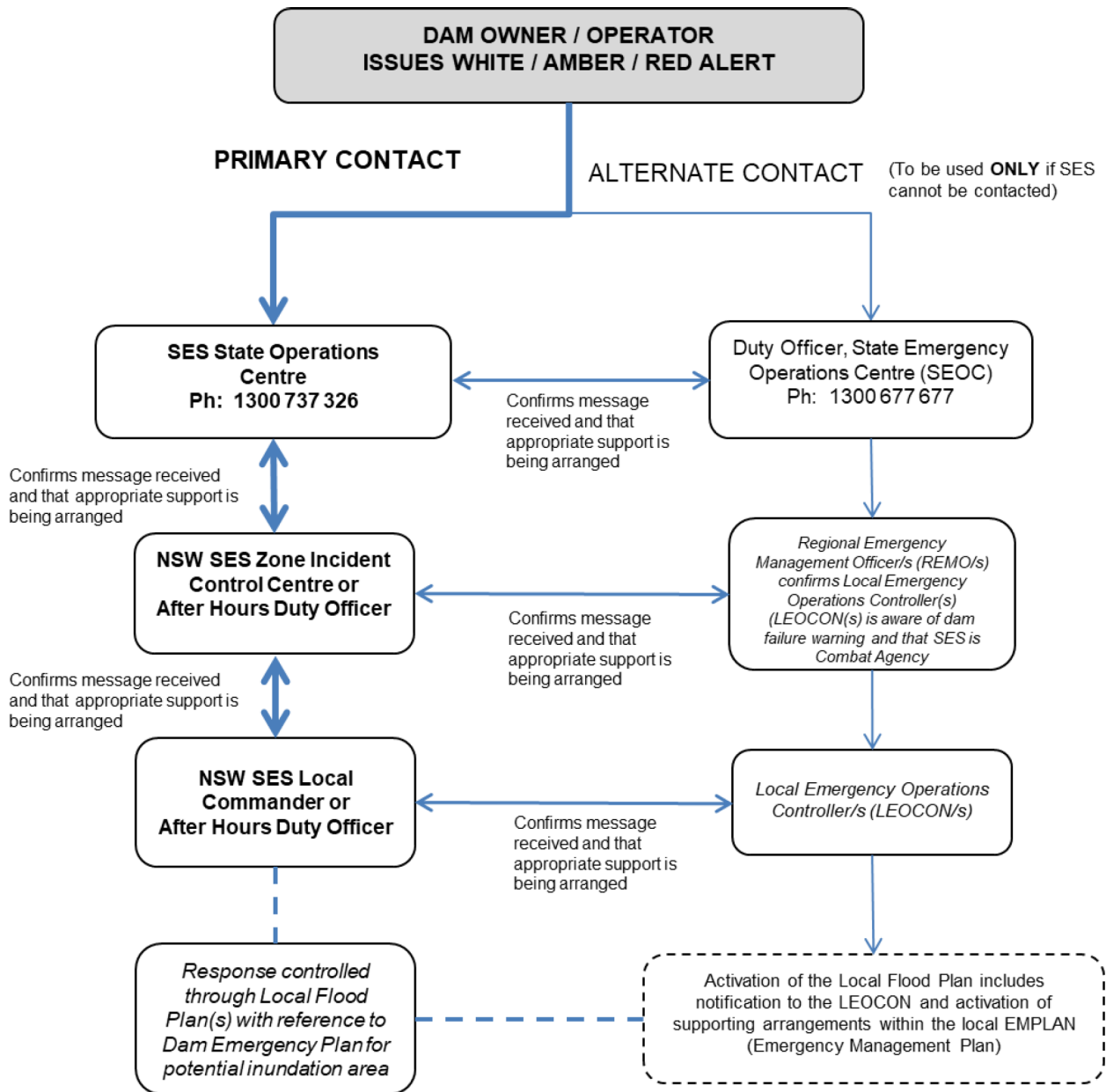


Flow Chart Number 3 - DSEP for other than Flood or Earthquakes



Flow Chart Number 4 – Emergency Service Notification

SES notification arrangements for potential or actual dam failure



Notes:

1. Dam owners should only contact the SEOC if the SES State Operations Centre (SOC) cannot be contacted.
2. The first priority for notification is to contact the NSW SES State Operations Centre. If unavailable, contact the SEOC. At each level, the contact agency should notify the alternate contact at the same level before making contact further down the line.
3. The triple zero (000) number for emergency services should not be used unless contact cannot be made with SES or the SEOC as it is likely the triple zero (000) operators will have difficulty dealing with the very unusual case of potential or actual dam failure.
4. Dam owners should send their draft Emergency Plan to the SES for review of the emergency management arrangements (see section 3.1 of Dams Safety NSW guideline for Emergency Plans).

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Organisation / Position in DSEP	Person Title	Business Address	Communications	After Hours
Tweed Shire Council				
Dams Manager	Brie Jowett Manager Water & Wastewater – Operations	PO Box 816 Murwillumbah NSW 2484	Ph: 02 6670 2192	M: 0434 730 383
Backup to Dams Manager	Anthony Burnham Manager Water & Wastewater – Business & Assets	PO Box 816 Murwillumbah NSW 2484	Ph: 02 6670 2411	M: 0427 239 396
Engineer/s	Peter Haywood Senior Engineer - Operations	PO Box 816 Murwillumbah NSW 2484	Ph: 02 6670 2748	M: 0427 286 435
	Mitch Alward A/Engineer - Treatment & Catchment	PO Box 816 Murwillumbah NSW 2484	Ph: 02 6670 2625	M: 0427 239 775
	Mark Callander Engineer - Asset Management, Planning, Assets & Development	PO Box 816 Murwillumbah NSW 2484	Ph: 02 6670 2454	
Dams Operator	Darren Lyndon Senior Operator	Water Treatment Plant, Durroon Ave, Bray Park NSW 2484	Ph: 02 6670 2181	M: 0418 645 608
LEMO	Doreen Harwood Emergency Management Officer	PO Box 816 Murwillumbah NSW 2484	Ph: 02 6670 2440	M: 0427 078 119
Dam Consultant (Hunter h2o)				
Dam Engineer	Daniel Daley	19 Spit Island Close, Steel River, Mayfield West NSW 2304	M: 0405 624 401 Ph: 02 4941 5000	M: 0405 624 401
Dam Engineer	Rhys Johns	19 Spit Island Close, Steel River, Mayfield West NSW 2304	M: 0422 578 027 Ph: 02 4941 5000	M: 0422 578 027
Principle Consulting Engineer	Jeffrey Gleeson	19 Spit Island Close, Steel River, Mayfield West NSW 2304	M: 0419 255 983 Ph: 02 4941 5000	M: 0419 255 983
Principle Civil Engineer	Alan Thornton	19 Spit Island Close, Steel River, Mayfield West NSW 2304	M: 0437 172 256 Ph: 02 4941 5000	M: 0437 172 256

Organisation / Position in DSEP	Person Title	Business Address	Communications	After Hours
Dams Safety NSW				
Regulator		4 Parramatta Square, 12 Darcy St, PARRAMATTA NSW 2150	M: 0403 681 645 General Inquiry Email: info@damsafety.nsw.gov.au Incident Notification Email: incident@damsafety.nsw.gov.au	M: 0403 681 645
Emergency Services				
SES State Headquarters		-	Ph: 1300 737 326 Alternate (SEOC) Ph: 1300 677 677	Ph: 1300 737 326 Alternate (SEOC) Ph: 1300 677 677
NSW SES State Operations Communications Centre		6-8 Regent St WOLLONGONG NSW 2500	Ph: 1300 737 326	Ph: 1300 737 326
NSW SES Richmond Tweed Region		7 Lancaster Drive GOONELLABAH NSW 2480	Ph: 02 6225 7700	Ph: 02 6225 7700
Regional Emergency Management Officer	Peter Mair REMO		Ph: 02 6626 0724	M: 0418 869 385
NSW Police	Duty Inspector	-	Ph: 02 9265 4407/8	Ph: 000 (all hours)
Tweed Police	Stewart Wilkinson LEOCON	NSW Police, Tweed Byron Local Area, Tweed Heads	Ph: 07 5536 0999	Ph: 07 5536 0999
NSW Ambulance		27 Queen Street, Murwillumbah	Ph: 131 233	
Fire Control Centre		Station Street, Mullumbimby	Ph: 02 6684 3662	
Tweed Fire Control Centre		Wardrop Valley Road Wardrop Valley 2484	Ph: 02 6672 7888	

Organisation / Position in DSEP	Person Title	Business Address	Communications	After Hours
Helicopter Service	Westpac Lifesaver Rescue Helicopter	60 Brunswick St Lismore NSW 2480 Gold Coast Helicopter Rescue Service, C/- John Flynn Hospital: Tweed Coast Air Sea Rescue 634 Coolong St, Point Danger	Ph: (02) 6627 4444 Ph : (07) 5598 0222 Ph : (07) 5536 9333	
Tweed Shire Council Drone Operator	Drone Operator	Tumbulgum Road, Murwillumbah 2484	Ph: (02) 6670 2568	
Local Radio Frequencies				
Radio 97 AM, Radio 104.1 FM and Radio 103.5 FM		8 Greenway Drive Tweed Heads South	Ph: 07 5524 4497	
Radio ZZZ FM		Bruxner Highway, Goonellabah	Ph: 02 6624 2433	
Radio ABC North Coast		61 High St Lismore	Ph: 02 6627 2011	
Local TV Channels				
NBN		Centenary Dr Goonellabah NSW 2480	Ph: 02 6625 2499	
Prime		60 / 207 Currumburra Road Ashmore QLD	Ph: 07 5556 8777	
Southern Cross		Ballina Road Goonellabah NSW 2480	Ph: 02 6627 1804	
Weather Information				
Bureau of Meteorology	Duty Meteorologists Public Weather	Level 16, 300 Elizabeth Street, Sydney	Ph: (02) 9296 1555	Ph: (03) 9669 4000 (Head Office)

3. Notification and Responsibilities for Emergency Functions

3.1 Emergency Notifications and Responsibilities for Evaluation of Flooding

Table 3.1 - White Alert Flooding

Dam Level / Over spillway		Emergency Condition	Organisation	Actions (in order)	DSEP Position	NOTES / COMMENTS			
64.5m AHD / 3.0m		White Alert	Tweed Shire Council	Form incident team and assign responsibilities Activate White Alert Advise SES SOCC / SEOC as per Flow Chart Number 4 – Emergency Service Notification Advise Dams Safety NSW Advise Dam Consultant Advise LEMO Consider resourcing and dam access availability if flood is worsening On reduction of level below White Alert, advise LEOCON, SES, Dams Safety NSW and Dam Consultant of cancellation of Alerts. Investigate weather forecasts relevant to the catchment. Monitor storage continuously for 24 hrs/day. Review surveillance data. Implement decision from incident team. Inform if weather data indicates the flood alert could escalate to Amber.	Dams Manager and their delegate/s	<ol style="list-style-type: none"> Record all events in a central communication log, spreadsheet on Teams, and send link to external parties. If that fails use Appendix F to record events Liaise with SES to consider appropriate warnings Water level must be monitored at agreed intervals, keeping the Dams Manager and the State Emergency Service continually advised. Other monitoring should include river levels and rainfall levels and best predictions. 			
				SES			Prepare flood warning procedures	Local Controller	Provide advice on downstream flooding conditions and other evacuations that may be in place
				Tweed Shire Council			Emergency Management in Tweed Shire Council local area	LEMO	<ol style="list-style-type: none"> Co-ordinate with SES as needed. Co-ordinate with Police, Fire Brigade, Ambulance if needed.

Refer to ATTACHMENT A for Emergency Communications Directory

Table 3.2 – Amber Alert Flooding

Dam Level / Height	Emergency Condition	Organisation	Actions (in order)	Position	NOTES / COMMENTS
67.5m AHD / 6.0m	Amber Alert	Tweed Shire Council	Convene incident team Activate Amber Alert, Consider actions listed in Section 3.4 Advise SES SOCC / SEOC as per Flow Chart Number 4 – Emergency Service Notification – Ensure SES are prepared to activate warning system. Advise Dams Safety NSW Advise Dam Consultant Advise LEMO Collect information and actions from each group and provide as input to incident team. Maintain contact and take advice from each of these groups as flooding progresses. On reduction of level below Amber Alert, advise LEOCON, SES, Dams Safety NSW of reduction to White. Investigate weather forecasts relevant to the catchment. Monitor storage continuously for 24 hrs/day. Continuously monitor available surveillance data & photos of flood emergency. Implement decision from incident team including reacting to all advice provided, remedial measures and additional monitoring. Provide assistance to SES if required. Inform the incident team if weather data indicates the flood alert could escalate to Red.	Dams Manager and their delegate/s	<ol style="list-style-type: none"> 1. Consider staff safety in continuing the monitoring of dam condition; collecting pertinent monitoring and surveillance data. 2. Record all events in a central communication log, spreadsheet on Teams, and send link to external parties. If that fails use Appendix F to record events 3. Advise SES to prepare to activate warning system 4. Water level must be monitored at agreed intervals, keeping the incident team continually advised. Other monitoring should include river levels and rainfall levels and best predictions.
		SES	Consider activation of flood warning system	Local Controller	If flooding is likely to escalate to Red Alert the warning system shall be activated for 'Amber Alert'
		Tweed Shire Council	Emergency Management in Tweed Shire Council local area	LEMO	<ol style="list-style-type: none"> 1. Co-ordinate with SES. 2. Co-ordinate with Police, Fire Brigade, Ambulance 3. Provide advice to incident team on downstream flooding conditions and other evacuations that may be in place.
		Dams Safety NSW	Receive notification	Duty Officer	
		Dam Consultant	Assist TSC and Dams Safety NSW in analysis of data and provide advice on structure safety	Dam Engineer	

Refer to ATTACHMENT A for Emergency Communications Directory.

Table 3.3 – Red Alert Flooding

Dam Level / Height	Emergency Condition	Organisation	Actions (in order)	Position	NOTES / COMMENTS
69.0m AHD / 7.5m	Red Alert	Tweed Shire Council	Convene incident team Activate Red alert Advise SES SOCC / SEOC as per Flow Chart Number 4 – Emergency Service Notification – Advise SES to activate warning system. Advise Dams Safety NSW Advise Dam Consultant Maintain contact with each of these groups with up-to-date information. On reduction of level below Red Alert, advise LEOCON, SES, Dams Safety NSW of reduction to Amber. Investigate weather forecasts relevant to the catchment. Monitor storage continuously 24 hrs/day. Ensure safety for all resources	Dams Manager and their delegate/s	1. Consider staff safety in continuing the monitoring of dam condition, collecting pertinent monitoring and surveillance data 2. Advise SES when to activate Auto mass dialling system for PAR. 3. Water level must be monitored at agreed intervals, keeping the Manager Operations and the State Emergency Service continually advised. Other monitoring should include river levels and rainfall levels and best predictions.
		SES	Activate flood evacuation system / procedures	Local Controller	
		Tweed Police	Emergency Management	LEOCON	
		Tweed Shire Council	Emergency Management in Tweed Shire local area – Activate Local Emergency Plan	LEMO	1. Co-ordinate with SES. 2. Co-ordinate with Police, Fire Brigade, Ambulance 3. Provide advice to incident team on downstream flooding conditions and other evacuations that may be in place.
		Dams Safety NSW	Receive notification	Duty Officer	
		Dam Consultant	Assist TSC and Dams Safety NSW in analysis of data and provide advice on structure safety	Dam Engineer	

Refer to ATTACHMENT A for Emergency Communications Directory.

3.2 Emergency Notification and Responsibilities for Evaluation of Earthquakes

Table 3.4 – White Alert Earthquakes

Magnitude Damage	Alert	Organisation	Actions	Position	NOTES / COMMENTS
<p>Assessed as < MM 4 (Refer <i>Mercalli Intensity Scale</i>)</p> <p>Damage may be visible but not serious enough to cause immediate failure of the dam, including:</p> <ul style="list-style-type: none"> - Increased Seepage - Increased Seepage turbidity - Wide and extensive cracks - Increase in Pore Pressure 	WHITE	Tweed Shire Council	<p>Form incident team and assign responsibilities</p> <p>Activate White Alert</p> <p>Consider actions listed in Section 3.4</p> <p>Conduct surveillance and review monitoring data & e-mail photos of any structural damage to Dams</p> <p>Safety NSW and Dam Consultant</p> <p>On reduction of level below White Alert, advise LEOCON, SES, Dams Safety NSW of cancellation of Alerts.</p> <p>Monitor condition of structure over 24 hours after the last 'after shock'</p> <p>Assist in surveillance inspection.</p>	Dams Manager and their delegate/s	<p>Record all events in a central communication log, spreadsheet on Teams, and send link to external parties . If that fails use Appendix F to record events</p> <p>Refer to Appendix D, Table 0.1 to assist with determination of severity of earthquake.</p> <p>Refer to Table 0.2 for post-earthquake response procedure.</p>
		Dam Consultant	<p>Review data and surveillance records to assist TSC and Dams Safety NSW in analysis of data and provide advice on structure safety</p>	Dam Engineer	

Refer to ATTACHMENT A for Emergency Communications Directory.

Table 3.5 – Red Alert Earthquakes

Magnitude Damage	Alert	Organisation	Actions	Position	NOTES / COMMENTS
<p>Assessed as ≥ MM 4 (Refer Mercalli Intensity Scale)</p> <p>Dam failure in progress or severe damage such as:</p> <ul style="list-style-type: none"> - Major change to any of the above conditions outlined for a Protection Alert - Seepage through cracks and joints - Seepage through abutments, downstream face, in galleries - Cracks in Concrete Structures with vertical displacement - Major Movement of Outlet Works Tunnel 	<p style="text-align: center; color: red; font-weight: bold;">RED</p>	Tweed Shire Council	<p>Form incident team and assign responsibilities</p> <p>Activate Red alert</p> <p>Consider actions listed in Section 3.4.</p> <p>Advise of damage assessment; SES SOCC / SEOC</p> <p>Dams Safety NSW</p> <p>Dam Consultant</p> <p>Maintain contact with each of these groups with up-to-date information.</p> <p>Advise SES and Dams Safety NSW of any change in alert status.</p> <p>Monitor structure 24 hrs / day.</p> <p>Complete regular surveillance & update monitoring data and photos of any structural damage.</p> <p>Implement actions from incident team decision.</p>	Dams Manager and their delegate/s	<p>Record all events in a central communication log, spreadsheet on Teams, and send link to external parties. If that fails use Appendix F to record events</p> <p>Refer to Appendix D, Table 0.1 to assist with determination of severity of earthquake.</p> <p>Refer to Table 0.2 for post-earthquake response procedure.</p> <p>Review safety of staff at or in vicinity of dam</p>
		SES	Activate flood evacuation system	Local Controller	
		Tweed Police	Emergency Management	LEOCON	
		Tweed Shire Council	Emergency Management in Tweed Shire Council local area – Activate Local Disaster Plan	LEMO	
		Dams Safety NSW	Receive notification	Duty Officer	
		Dam Consultant	Assist TSC and DSC in analysis of data and provide advice on structure safety	Dam Engineer	

3.3 Emergency Notification and Responsibilities for Evaluation of Conditions other than Flooding or Earthquake

Table 3.6 – White Alert Conditions other than Flooding or Earthquakes

Emergency Condition	Alert	Organisation	Actions	Position	NOTES / COMMENTS
<p>Visible damage but not enough to cause immediate failure of the dam, including:</p> <ul style="list-style-type: none"> - Increased Seepage - Increased Seepage turbidity - Wide and extensive cracks - Increase in Pore Pressure 	<p>WHITE</p>	<p>Tweed Shire Council</p>	<p>Form incident team and assign responsibilities Activate White Alert Consider actions listed in Section 3.4 Inform SES and Dams Safety NSW of assessment of the dam and advise any possible escalation in alert status On reduction of level below White Alert, advise LEOCON, SES, Dams Safety NSW of cancellation of Alert. Assess situation and monitor condition of structure.</p> <p>Collect and review surveillance & monitoring data & photos of any structural damage.</p> <p>Implement incident team decisions.</p>	<p>Dams Manager and their delegate/s</p>	<p>Record all events in a central communication log, spreadsheet on Teams, and send link to external parties. If that fails use Appendix F to record events. Immediate inspection of the dam must be made. Examples of White Alert:</p> <ul style="list-style-type: none"> • Increased volume or turbidity of seepage • Wetness in abutment or foundation adjacent to the toe • Outlet works pipeline or valve failure for example leakage from outlet pipes and valves, jamming of outlet valves, failure to seal etc. • Excessive concrete deterioration, for example pop outs, pitting, scaling, etc. • Surface defects such as honeycomb, stratification, uneven joints or surfaces. • Leakage from joints and cracks. • Blocked drains in spillway or dry tunnel. • Increased cracking; abrupt changes in direction or occurring over extensive areas. • Major electrical or mechanical equipment failure or damage. • Gradual increase in turbidity or volume of seepage flow (not related to rainfall or rise in storage level) • Appearances of new seepage flow not related to weather conditions. • Accident involving injury or death of any person.

Refer to ATTACHMENT A for Emergency Communications Directory.

Table 3.7 – Red Alert Conditions other than Flooding or Earthquakes

Magnitude Damage	Alert	Organisation	Actions	Position	NOTES / COMMENTS
Major visible damage to structure. Dam failure in progress or potential imminent dam failure likely.	RED	Tweed Shire Council	Form incident team and assign responsibilities Activate Red alert Consider actions listed in Section 3.4 Advise SES SOCC / SEOC Advise Dams Safety NSW Advise Dam Consultant Maintain contact with each of these groups with up-to-date information. Advise SES and Dams Safety NSW of any change in alert status. Assess situation and monitor condition of structure. Collect and review surveillance & monitoring data 24 hours a day. Take photos of any structural damage. Implement remedial measures and additional monitoring as deemed necessary.	Dams Manager and their delegate/s	Record all events in a central communication log, spreadsheet on Teams, and send link to external parties. If that fails use Appendix F to record events Immediate inspection of the dam must be made. Examples: <ul style="list-style-type: none"> • Significant displacement of dam, e.g. tilting, misalignment, differential movement. • Major change to any of the conditions of a Protection Alert. • Major new structural cracks or ones whose characteristics have changed dramatically • Any major, sudden, extensive concrete deterioration • Wide structural cracks with vertical displacement on the downstream face • Extensive water flow through cracks, which cannot be handled by the drainage system. • Significant new leakage on downstream face or in galleries. • Major changes in leakage/seepage pattern of flow. • Turbidity in seepage. Appendix C provides a questionnaire for threats to the dam
		SES	Activate flood evacuation system.	Local Controller	
		Tweed Police	Emergency Management	LEOCON	
		Tweed Shire Council	Emergency Management in Tweed Shire Council local area – Activate Local Disaster Plan	LEMO	
		Dams Safety NSW	Receive notification	Duty Officer	
		Dam Consultant	Assist TSC and Dams Safety NSW in analysis of data and provide advice on structure safety	Dam Engineer	

Refer to ATTACHMENT A for Emergency Communications Directory.

The general responsibilities of persons and organisations involved with this emergency management are detailed in **Table 3.8** below. Detailed responsibilities are included in **Table 3.1 to Table 3.7**

Table 3.8 – Responsibilities

Organisation	Responsible Position/(s)	General Responsibilities	Emergency Responsibilities
Tweed Shire Council	1. Dams Manager 2. Engineers 3. Dams Operator <i>This is a prioritise order (If 1. is not available 2 will carry out the role of 1)</i>	Dam management including: <ul style="list-style-type: none"> • O&M manual implementation and review; • Day to day operations • Routine inspections and collection of surveillance and monitoring data; • DSEP creation and review including consultation with relevant authorities • Nomination of consultant; Provide information to SES and Dam Safety NSW.	1. Identify unsafe conditions, due to floods, earthquakes or other. 2. Activate dam emergency <i>alerts</i> and advise in order of priority. 3. Liaise with SES, Consultant Dam Engineer and Dams Safety NSW during emergency. 4. Inspect and collect surveillance & monitoring data, including photos, under emergency conditions. 5. Request Consultant to inspect dam and provide technical advice if required. 6. React to the advice from the Consultant regarding temporary repairs to the dam and any additional monitoring requirements. 7. Provide assistance to local emergency response agencies (SES, etc.) if requested. Carry out temporary or permanent repairs recommended by the Consultant to return the dam and appurtenant works to a safe operational condition.
Dam Consultant	Dam Engineer	<ul style="list-style-type: none"> • Conduct Annual and Surveillance inspections on behalf of Tweed Shire Council. • Provide technical advice and recommendations, if requested Review and report on Council's documentation	<ul style="list-style-type: none"> • Provide technical advice and recommendations, if requested, during emergency situations. • Liaise with Dams Safety NSW and Tweed Shire Council.

State Emergency Services (SES)	State Emergency Operations Centre, Richmond Tweed Region Controller, Tweed Local Controller and Murwillumbah Unit Controller	Preparation of Local Flood Plans and coordination of evacuation.	<ul style="list-style-type: none"> Disseminate public alerts to region / local / unit controllers. Responding to indications of potential dam failure when Dam Failure Warning Systems are activated. Controlling warning, evacuation and flood response operations; and Carrying out flood tasks including those relating to evacuation, resupply, rescue, information provision and logistic support.
Tweed Shire Council	LEMO (Local Emergency Management Officer)	Emergency Management in Local Water Utility Area	Awareness of emergency alert level for dam. Provide flooding information to TSC Dam staff during emergencies.
Tweed Police	LEOCON (Police Sector Commander)	Preparation of disaster plans.	Preparation of disaster plans and support lead agency in emergency operations.
Dams Safety NSW		Regulation of dam safety in NSW	<ul style="list-style-type: none"> Inspect dam as required. Advise Dams Safety NSW Chairperson and Minister of alert escalations.

3.4 General Actions

In the event of a rapidly deteriorating structural deficiency which is likely to threaten the security of Clarrie Hall Dam (as per **Section 7.3** Emergency Situations), Clarrie Hall Dam Staff having reported a potential emergency situation, should do the following:

1. Ensure that a responsible person with portable communication, vehicle, sufficient rations and basic bedding is left in a safe position at the dam to monitor the emergency condition. See **Section 7.4** Communication Procedures, for details of communication procedures to be used during emergency conditions.
2. Obtain advice and determine the type of inspection areas to concentrate on, measurements to be taken, monitoring that is appropriate for the situation and the frequency of this monitoring.
3. Consider the need for a boat for inspections if safe to use (This may then require more than one staff member on-site).
4. Check communications to the site are working for both mobile phone coverage and instantaneous telemetry readings within the SCADA system.
5. Remove any public from within the compound and restrict access to the dam area. As a minimum the gate at the entrance road to Clarrie Hall Dam wall should be closed and locked. Office administrative staff and the Call Centre staff should be informed so information can be provided to the public through both the web and the Call Centre.

6. Liaise with emergency management authorities. See **Flow Chart Number 1 - DSEP for Flood Emergency**, **Flow Chart Number 2 - DSEP for Earthquakes**, **Flow Chart Number 3 - DSEP for other than Flood or Earthquakes**, **Flow Chart Number 4 – Emergency Service Notification** for appropriate actions, and **Table 3.8** for additional contact details.
7. If possible, document the emergency condition with photographs and/or a video camera.
8. For flooding events, monitor and record weather forecasts, stream flow information and rain gauge information.
9. Inform all involved personnel (see *Emergency Communication Directory* found at the front of this document) of any change in the emergency condition.

Do not take any unnecessary risks in undertaking the above actions.

4. Dam Failure Information

4.1 Description of Dam

Tweed Shire Council is the Local Water Utility responsible for the supply of water to commercial and domestic customers in Murwillumbah, Tweed Heads and the Kingscliff-Pottsville areas. Clarrie Hall Dam is located on Doon Doon Creek approximately 15km south-west of Murwillumbah and 650km north of Sydney. It was designed and constructed by the Public Works Department and was completed in 1983.

Clarrie Hall Dam consists of a 43m high concrete faced rock fill structure, a crest width of 6.4m, and a crest length of 175m. The dam has a storage capacity of 16,000ML and a catchment area of 60.2km². The upstream and downstream faces have a slope of 1V to 1.3H. A reinforced concrete, dog leg, ogee crest spillway, training walls, channel and flip bucket are located on the west end of the structure.

The intake tower consists of a 34m high, 4m outside diameter reinforced concrete tower of the wet well type situated on a tower base structure at the head of the outlet tunnel which is located under the right abutment.

The outlet works consists of two interconnected conduits that discharge into the downstream creek. The main conduit commences as a wet outlet tunnel at the base of the intake tower and converts at the tunnel plug into a 1200mm conduit within an accessible dry tunnel. A bypass outlet conduit commences at the base of the intake tower above the bulkhead gate and provides a second independent discharge to the creek. Each outlet conduit is fitted with independent guard and control valves to assist with the release of water into the creek.

Water is released down Doon Doon Creek to the Tweed River, which is subsequently harvested at the Bray Park Weir.

According to the Dambreak Study Clarrie Hall Dam has been categorised with a “High” hazard rating and a “High” incremental flood hazard. Details and features of the dam are listed below.

The dam spillway was upgraded in 2014 to allow it to pass the theoretical PMF without overtopping the parapet wall (dam crest).

Table 4.1 - Dam Data Clarrie Hall Dam

Storage Capacity at FSL	16,000ML	Type of Dam	Concrete face rock fill
Maximum Flood Level (PMF)	RL 70.4m AHD**	Catchment Area	60.2km ²
Spillway Crest Level	RL 61.5m AHD	Surface Area at FSL	2.2km ²
Full Supply Level (FSL)	RL 61.5m AHD	Type of Spillway	Dog leg Ogee & Chute
Embankment Crest Level	RL 67.5m AHD	Spillway Discharge Capacity (at zero freeboard)**	1355m ³ /s
Parapet Wave Wall Level	RL 70.4m AHD ²	Maximum spillway width	37.45m
Stream Bed Level	RL 28.0m AHD	Max Outlet Release Capacity at FSL	9.7m ³ /s
Height of Dam Wall	43m	PMF Inflow (36hr)	1,767m ³ /s ³
Crest Length	170m	PMF Outflow (36hr)	1,340m ³ /s ⁴
Crest Width	6.4m	PMF Inflow (6h)	2,973m ³ /s
Highest observed level	66.84m AHD on 28/2/22	PMF Outflow (6h)	1,248m ³ /s

Live reservoir level data <http://www.bom.gov.au/fwo/IDN60231/IDN60231.558028.tbl.shtml>

Live river heights Northern Rivers http://www.bom.gov.au/cgi-bin/wrap_fwo.pl?IDN60140.html

4.2 Dambreak Study Summary

The October 2006 Dambreak Study for Clarrie Hall Dam was prepared by the NSW Department of Commerce. The study details results of the dambreak study and the consequences of flooding from dam failure to determine the Consequence Category for Clarrie Hall Dam. The study was carried out in accordance with the NSW Dams Safety Committee requirements DSC13.

MIKE 11 was used to model the study area and carryout hydraulic simulations of the dambreak floods for the dam.

The following cases were considered in the study:

- a) Sunny day Dambreak
- b) Dam Crest Flood without Dambreak
- c) Dam Crest Flood with Dambreak

² Raised as part of the spillway work in 2014 from the original wave wall height of RL 68.5m AHD

³ From Alert Level Assessment and Hydrology for Clarrie Hall Dam DSEP Upgrade Date 14/5/14

⁴ From Clarrie Hall Dam Spillway Upgrade Design Report NSW PW DC 12044 June 2012

- d) Probable Maximum Flood without Dambreak
- e) Probable Maximum Flood with Dambreak

The Dambreak module simulated the dam failure according to a given set of failure parameters defining the breach development time, breach width, and the breach side slopes. The Sunny Day failure initiated at a given reservoir level without any inflow flood. The flood related dam failure was assumed to initiate as the water level reaches the predetermined flood level at the dam crest of the dams.

Inundation maps are based on the GIS information and have been produced from surveyed cross sections along the Doon Doon Creek and Tweed River.

The number of houses inundated by the various flood cases has been estimated from the flood inundation map prepared for the Dambreak Study. This information is summarised in **Table 4.2**.

Table 4.2 - Dambreak Study Key Findings

Dambreak Case	Dambreak Peak Discharge @ d/s of Dam (m ³ /s)	Inundated Houses	PAR	Incremental PAR
Sunny Day Dambreak	5,711	172	482	482
DCF Without Dambreak	776	401	1,122	-
DCF With Dambreak	11,036	478	1,338	216
PMF without Dambreak	1,542	476	1,332	-
PMF with Dambreak	15,571	508	1,422	90

NOTE: The water levels determined by the MIKE 11 (version 2000) model are expected to have an accuracy of about ± 0.5 m.

There are four bridges in the downstream study area, three bridges crossing the Tweed River and one crossing the Doon Doon Creek. The Sunny day Dambreak affects only the Byangum Bridge. The depth of flooding and the flood velocity are high, imposing danger to public. Both the PMF cases, with and without the Dambreak floods, result in flooding conditions at the bridges and impose danger to the public, as the flood depths and the associated flood velocity are high. For further details, refer to the October 2006 Dambreak Study.

The Sunny Day Dambreak Consequence Category is considered "High A". The Flood Consequence Category for the PMF with Dambreak case is categorised as "High B".

Inundation maps have been provided in **Appendix A**, for the areas between the dam and downstream to Byangum Bridge for the PMF with dambreak and Sunny Day dambreak events; produced as part of design work for the new spillway constructed in 2014.

Dambreak flood depths and velocities for locations including bridges are shown in tables in **Appendix A**.

4.3 Downstream Study Area

The study area covered a total of 35km along the Tweed River from Terragon in the upstream to Tumbulgum in the downstream. The model includes the 1.5km section of the Doon Doon Creek between the storage and the junction with Tweed River. The confluence of the Doon Doon Creek with the Tweed River is about 3.8km from the upstream boundary on the Tweed River. The narrow and rugged valley below the dam opens up after Byangum Bridge and the river flows through an extensive area of flat floodplain until it discharges into the ocean.

There are three bridges crossing the Tweed River; Byangum Bridge, Murwillumbah Bridge and Condong Bridge. A number of private access crossings / bridges exist. These are low level crossings with minimal public use. The population centres in the downstream area of the dam are Uki, Byangum, Murwillumbah and Tumbulgum. Apart from these population centres, there are also other residential dwellings scattered along the river.

4.4 Description of the Dambreak Model

Mike 11, Version 2005 program was used for the October 2005 Dambreak Study. It is an implicit finite difference model for computation of steady and unsteady flows in rivers. The program through the use of numerical methods, which adapt to the local flow conditions, can describe subcritical and supercritical flows.

MIKE 11 dambreak Module simulates the dambreak failure according to the given dam breach of failure parameters defining the breach development time, breach width and the side slopes. MIKE 11 Hydrodynamic Module routes the outflow dambreak flood wave through the downstream drainage system. This module calculates the flood velocities, flood discharges and corresponding flood levels at downstream cross-sections over the time simulation.

4.5 Breach Parameters

The Sunny Day failure at FSL 61.5mAHD would be from other causes apart from flood related failures. It was assumed that the DCF failure was initiated as soon as the storage water level reaches the maximum values of RL 68.5mAHD which is the RL at the top of the wave wall (at time study was completed). The PMF failure was initiated when the storage water level reaches RL 68.6mAHD considering the stability of the wave wall.

NOTE: Wave wall was raised in 2014 to 70.4mAHD in conjunction with a new spillway (entrance widened from 22m to 35m) to allow for the safe passing of a PMF event. CFD modelling determined the maximum design flood level to be 70.4mAHD. Elimination of the freeboard allowance from the design was justified based on the following:

- since the PMF estimate is based on conservative methodology (using a low k factor), it is considered that freeboard on top of the assessed design PMF level is “conservatism on conservatism”;
- Being a rockfill dam embankment, some short term overtopping can be tolerated since only minor damage and displacement of rocks is expected. Additionally, this would only occur in a PMF order of magnitude event which has an extremely low occurrence probability; and
- There are several dams where a zero freeboard allowance has been incorporated in the design under similar conditions.

4.6 Dambreak Flooding Conditions

The dambreak study estimated that 85 houses and only Byangum Bridge would be affected by the Sunny day Dambreak. The depth of flooding at the bridge and the flood velocity are high, imposing danger to the public.

The study also indicated that 365 and 410 houses would be affected by the DCF with and without Dambreak respectively, and 540 and 565 houses would be affected by the PMF with and without Dambreak respectively. The flooding condition at the bridges imposes danger to the public for both the DCF and PMF cases with and without Dambreak floods, as the flood depths and the associated flood velocity are high.

Refer to **Appendix A** : Map 1 to Map 5 for PMF Dambreak Flood Inundation maps and Map 6 to Map 10 for Sunnyday Dambreak Inundation maps; produced as part of design work for the new spillway constructed in 2014.

4.7 Floodwave Arrival Time

The floodwave travel time in the study is defined as the time taken by the dambreak flood wavefront to travel from the dam to a designated location. Floodwave travel times for the three dambreak cases are tabulated in **Table 4.3** below.

Table 4.3 – Travel Time of Flood Peak

Location	Chainage (km)	Sunny Day Dambreak (h:min)	DCF Dambreak (h:min)	PMF Dambreak (h:min)
Clarrie Hall Dam	0.00	0:00	0:00	0:00
Downstream of Dam	0.10	0:10	0:02	0:02
Junction with Upper Tweed River	1.60	0:20	0:08	0:11
Doon Doon Dip	1.93	0:26	0:08	0:11
Malabar	3.90	0:28	0:15	0:20
Uki	5.25	0:30	0:21	0:23
Trefern Stud	6.60	0:59	0:23	0:26
Glenrock	8.35	1:08	0:30	0:34
Upstream of Dum Dum	9.24	1:12	0:32	0:34
Upstream of Hattons Bluff	10.44	1:15	0:37	0:38
Upstream of Byangum Bridge	13.90	1:27	0:48	0:45
Tweed side	14.79	1:29	0:50	0:45
Upstream of Bray Park Weir	16.02	1:31	0:53	0:45
Trizah	17.24	1:35	1:02	1:03
Sunnymeadows Field	18.68	1:40	1:02	1:07
South Murwillumbah	20.51	1:45	1:03	1:07
Upstream of Murwillumbah Bridge	21.30	1:46	1:06	1:11
Downstream of Murwillumbah Bridge	21.66	1:48	1:08	1:13
South Murwillumbah Dip	22.35	1:49	1:12	1:15
Upstream of Condong Bridge	25.11	1:58	1:17	1:19
Bartlets	28.87	2:09	1:31	1:26
Camden Haven	30.36	2:14	1:38	1:34
Tumbulgum	31.54	2:15	-	-

The travel times estimated indicate that the DCF and PMF Dambreak floodwave travel times to downstream locations are faster than that of Sunny day Dambreak case. In consideration of the short floodwave travel time to the population centre coupled with high velocity and the depth of flooding, the dambreak flood impose danger to flood affected residences in the study area downstream of Clarrie Hall Dam.

5. Dam Monitoring Systems

The prime means of detecting the development of a potential emergency condition is through regular inspection of the dam by Tweed Shire Council Staff, and the regular inspection and monitoring activities of the consultant appointed by Council. Regular monitoring of the Dam for changes will allow remedial action to be enacted quickly and effectively if changes do occur. Clarrie Hall Dam is monitored by a network of instrumentation shown in **Table 5.1**.

Table 5.1 - Dam Instrumentation

Type of Instrumentation/Monitoring		Locations	Normal Monitoring Frequency
27	Surface settlement points	Upstream	Two yearly from 2014
11	Surface settlement points	Downstream	Two yearly from 2014
1	Seepage Weir	Toe of Dam	Manually, minimum 3 days per week unless flooded
2	Seepage Weirs. Tunnel	L&R drain in dry tunnel	continuously (telemetry)
1	Storage (ultrasonic)	At intake tower	continuously (telemetry)
1	Rainfall	At intake tower	Daily/continuously (telemetry)
2	Left and right spillway seepage		Manually, minimum 3 days per week when spillway is NOT active

Refer to the Standard Operating Procedure 'WWO Clarrie Hall Dam routine surveillance inspections' for the description of the frequency and nature of routine surveillance inspections performed by the Water and Wastewater Operations Unit.

If the changes discussed above are observed Tweed Shire Council, is to proceed as per **Flow Chart Number 1** - DSEP for Flood Emergency and **Flow Chart Number 4** – Emergency Service Notification as required by the relevant alert responses.

The observations that would be of serious concern when making dam or spillway inspections are listed in Section 3.3 (Conditions Other than Flooding or Earthquake) of this document. If any of the observations in these tables are evident then the relevant emergency alert is to be initiated by Tweed Shire Council.

6. Emergency Warning Systems

The Tweed Local Flood Plan, a sub plan of the DISPLAN contains the details of the public warning systems that will be utilised. It is the responsibility of SES to activate this system. Tweed Shire Council will consult with the different groups involved to establish and notify SES to initiate the warnings.

The first public warning would be likely to be sent out as the dam approaches Amber Alert and flooding is likely to continue.

6.1 Potential Failure Indicators

The two major possible causes of dam failure are:

- Failure due to extreme flood levels overtopping the dam; not theoretically possible since 2014 spillway upgrade and wave wall raising as this would entail a flood of greater magnitude than PMF;
- Failure due to a rapidly deteriorating structural deficiency such as may be induced by an extreme earthquake or internal erosion. (This is the so-called “Sunny Day” failure, i.e. not induced by an inflow flood).

Although the dam is currently in good condition, an unsafe or emergency condition could occur at any time due to extreme natural events. Failure from a cause not related to extreme natural events is always a possibility although the probability of occurrence is extremely low.

There are certain circumstances and behaviour traits for dams that may be indicative of the development of a potential emergency situation. In many cases important behaviour traits are evident in advance of a critical situation from the surveillance, monitoring and warning systems installed at the dam.

7. Emergency Alerts and Notifications

7.1 Emergency Notification Flow Charts

The notification flow charts (**Flow Chart Number 1** - DSEP for Flood Emergency, **Flow Chart Number 2** - DSEP for Earthquakes, **Flow Chart Number 3** - DSEP for other than Flood or Earthquakes **and Flow Chart Number 4** – Emergency Service Notification) are included at the beginning of this document to provide a quick reference. They summarise the persons to be notified, and the prioritised order of notifications in the event of an emergency situation. The flow charts set out the mandatory reporting that is required. Beyond these mandatory reporting's, those involved may make any contacts they judge to be appropriate within their normal authority.

- Emergency Evaluation Flooding, **Flow Chart Number 1** - DSEP for Flood Emergency
- Emergency Evaluation of Earthquake, **Flow Chart Number 2** - DSEP for Earthquakes
- Evaluation of Emergency other than Flooding or Earthquake, **Flow Chart Number 3** - DSEP for other than Flood or Earthquakes

Note that the notification **Flow Chart 4** has been adopted from the Dams Safety NSW guideline for Emergency Plans version 1. This flow chart provides details/protocols on notifying SES State Headquarters, SES Region(s), NSW Police and the NSW State Emergency Operations Centre (SEOC). Dam owners should make every attempt to call the SES.

The SES is the designated Combat Agency for floods in NSW and in all local government areas where a significant riverine or flash flood threat exist, the Service has produced flood plans which are sub-plans of their respective local disaster plans (DISPLAN). Potential dam failure can best be managed through the activation of the local flood plan/s. In some cases, where dams are particularly at risk of failure (deficient flood capacity or known structural problem), special additional planning may be incorporated into the local flood plan to account for potential dam failure.

Actions and responsibilities to be taken after notification are detailed in table as listed below for each Emergency Condition:

- Flooding: **Table 3.1, Table 3.2 and Table 3.3.**
- Earthquake: **Table 3.4 and Table 3.5.**
- Other than Flood or Earthquake: **Table 3.6 and Table 3.7.**

7.2 Dams Safety NSW notification and involvement

Clause 19 of the regulation requires that dam owners report incidents to Dams Safety NSW. Notification requirements are listed in the Emergency Flowcharts.

The contact details for emergency notification are listed on the Dams Safety NSW website and in the Emergency Communication Directory. Notification needs to be via telephone and in writing. The Website has an Incident Reporting Form that is required to be filled out

(<https://forms.office.com/Pages/ResponsePage.aspx?id=IYjvljkqHEe4mmewgz3Tuai dRb3KJfBJn9nm31ZQrEBUOE5WOTHrRQ1NWNTFQMFINNDVSM1VIVzILVi4u>).

If this form is unavailable at this link contact Dam Safety NSW. Additional information may need to be sent to incident@damsafety.nsw.gov.au

7.3 Emergency Situations

Emergency situations are categorised on the basis of severity, with each category having corresponding responses/alerts for the particular emergency condition (flooding, earthquake or other emergency). Examples of emergency situations are given to assist in categorising any emergency situation. The examples are not in any way intended to reflect upon the integrity of the structure, and potential emergency situations are not limited to the examples that are given.

7.3.1 Classification of Emergency Situations due to Flooding

Tweed Shire Council will keep the SES informed of the reservoir level and discharge through the spillway. The alerts levels for a flooding event will be sent to the SES as they occur.

The Alert Levels have been set as follows based on the 36hr PMF event:

- Red Alert was set 1.4m below the parapet wall at RL 69.0m. This level is estimated to represent a flood magnitude of approximately 1 in 100,000 AEP. Routing analyses indicates approximately 4 hours would be available to evacuate downstream residents before the flood peaks at RL 70.35m.
- Amber Alert set at the dam crest, RL 67.5m AHD. The level is estimated to represent a flood magnitude of approximately 1 in 10,000 AEP. Routing

analyses indicates approximately 4.5 hours would be available between the Amber and Red Alerts.

- White Alert set at RL 64.5m AHD. The level is estimated to represent a flood magnitude of approximately 1 in 100 AEP and approximately 3m above the FSL. Routing analyses indicates approximately 14 hours would be available between the White and Amber Alerts. The level also corresponds with the historic high of the reservoir of 64.53m AHD reached in 2017 which as per Dam Safety NSW’s guideline it is a requirement for White Alert status when reservoir exceeds the historic high.

The time modelled for the reservoir to reach the alert levels for a 36hr and 6hr PMF event are shown in Tables 3.1 and 3.2 respectively. These alert times were calculated by reservoir routing of the critical PMF inflow hydrograph using the height-storage of the main embankment dam, height-discharge of existing spillway data with the initial water level 100% full at the spillway (RL 61.5m AHD).

Table 7.1 - Estimated Timings of Alerts for 36hr PMF Event

Water Level	Height over Spillway	Alert	Time to reach alert H:M ⁵
61.5m AHD	0.00	Nil - Full Service Level	0:00
64.5 m AHD	3.0m	White Alert	8:30
67.5 m AHD	6.0m	Amber Alert	22:30
69.0 m AHD	7.5m	Red Alert	27:00
70.4 m AHD ⁶	8.9m	PMF/DCF (water level just threatens overtopping the top of the parapet wall)	31:00

Table 7.2 - Estimated Timings of Alerts for 6hr PMF Event

Water Level	Height over Spillway	Alert	Time to reach alert H:M ⁷
61.5m AHD	0.00	Nil - Full Service Level	
64.5 m AHD	3.0m	White Alert	1:30
67.5 m AHD	6.0m	Amber Alert	2:36
69.0 m AHD	7.5m	Red Alert	3:48
69.876 m AHD	8.376m	Maximum Flood Level for 6hr PMF Event	5:30

⁵ The times are from 0:00 hours and are not cumulative.

⁶ Study (Alert Level Assessment and Hydrology for Clarrie Hall Dam DSEP Upgrade NSW Public Works May 2014) determined that maximum flood level is 70.35mAHD however Design report from spillway upgrade has the PMF at 70.4mAHD

⁷ The times are from 0:00 hours and are not cumulative.

The inflow hydrograph results from an extreme rainfall event referred to as the Probable Maximum Precipitation (PMP). The PMP is the greatest depth of precipitation for a given duration that is considered physically possible over a particular drainage area.

Reservoir routing of the estimated PMF inflow hydrographs were undertaken using the height-storage of the dam and height-discharge of existing spillway data.

The PMF from the different deviation PMPs were tested to identify which gave the largest peak outflow which is of relevance to the safety of the dam and thus to examine the sensitivity of the outflows to model parameter values. Depending on the dam storage and spillway characteristics, the PMP that produces the largest PMF peak inflow may not be the same PMP that produces the largest peak outflow. The PMP that results in the largest peak outflow is regarded as the “critical” PMF.

The critical Inflow/ Outflow Hydrograph was determined to be for the 36 hour duration for the PMF. The critical storm results are tabulated below in **Table 7.3**. The inflow and outflow hydrographs for both the 6hr and 36hr PMF events are shown in **Figure 0.1** and **Figure 0.2**. The reservoir height versus time for both the 6hr and 36hr PMF events are shown in **Figure 0.3** and **Figure 0.4**.

Table 7.3 - Flood Routing Results

Storm Duration (hr)	PMF (Peak Inflow) m ³ /sec	PMF (Peak Outflow) m ³ /sec	Max Flood Level (mAHD)	Time to Peak (hrs:mins)
6	2,973	1,248	69.80	5:30
36	1,767	1,340	70.35	31:00

The ogee type crest spillway and chute, according to Clarrie Hall Dam Spillway Upgrade Design Report June 2012, has a design capacity of 1,355m³/s. The dam storage volume versus height relationship for Clarrie Hall Dam is shown at **Figure 0.6**. The dam has been designed to contain a PMF behind the parapet wall along the dam crest.

A rating curve for the spillway (up to the Dam Crest level) is shown at **Figure 0.5**.

The data was obtained from the following references:

- Clarrie Hall Dam Portfolio Risk Assessment, DLWC July 2002;
- Addendum to Probable Maximum Flood Study for Clarrie Hall Dam, Department of Commerce, DPWS98177 (addendum), July 2004;
- Clarrie Hall Dam Concurrent Flood Hydrology Study, Report number 06175, September 2006;
- Clarrie Hall Dam Dambreak Study, Report number DC06206, October 2006;
- Clarrie Hall Dam Spillway Upgrade, Report Number DC12044, June 2012; and

- Alert Level Assessment and Hydrology for Clarrie Hall Dam DSEP Upgrade, NSW Public Works, May 2014.

7.3.2 Classification of Emergency Situations due to other than Flooding (Earthquake or Other Emergency)

These events need evaluation. To complete an evaluation, examples are provided in Emergency Notifications **3.2 and 3.3**. The event shall be determined as either: White Alert or Red Alert.

Red Alert - Emergency Situation: Dam Safety Implications – Potential for Imminent Dam Failure.

White Alert - Emergency Situation: Potential Dam Safety Implications but Early Failure Unlikely – Situations Requiring Immediate Response/Possibly Major Unplanned Maintenance.

7.4 Access and Communication during Flooding

When flooding becomes too great and the access roads are flooded, access to the dam will be via helicopter service. Contact details for helicopter services are provided in the Emergency Communications Directory.

Severe flooding would also be likely to cause significant damage to roads, bridges, power lines and other infrastructure. If power supplies or communications have been interrupted, attempts should be made to repair these or make arrangements for temporary or backup systems, including portable generators, two-way radios, mobile telephones etc.

7.5 Actions to Lower the Reservoir or Limit Inflows or Outflows

Lowering the storage level is the single most useful preventative action. However, it is really only useful for Sunny Day failure modes, because flood inflows far exceed the release capacity.

It may be necessary during an emergency with the consent from the Manager Operations, to lower the Clarrie Hall Dam storage level to decrease seepage and/or loading on the structure to minimise the impact of any failure. This would only be an option when an emergency condition was identified in its early stages.

Operation of outlet works shall only be carried out in accordance with the Operations and Maintenance Plan by competent TSC staff.

Prior to and during emergency lowering of the storage level, the Manager Operations shall monitor information on storage levels, discharges and anticipated discharges.

7.5.1 Clarrie Hall Dam Emergency Lowering Constraints

The main issue that needs to be considered with regard to the lowering of the storage level is the maximum possible release constraints through the outlet works. The rate of release from the Dam is governed by the water level at the time of the proposed drawdown. However, as dewatering is generally only possible in a Sunny Day failure mode, it is assumed the storage in Clarrie Hall Dam is at Full Supply Level (FSL).

Table 7.4 below, indicates the number of days required to dewater Clarrie Hall Dam from the relevant level assuming no inflows into the storage. Note this could cause minor flooding downstream depending on downstream tributary inflows.

Table 7.4 – Emergency Dewatering

Storage Level (m AHD)	Available Volume (ML)	Storage Percentage Full (%)	Dewatering Time (with no Inflow) (Days)
61.5	16,000	100	20
60	13,300	83	17
55	7,100	44	9
50	3,850	24	5
45	2,100	13	3
40	550	3.5	1
35	150	1.5	0.5
34.85	0	0	0

The maximum discharge at FSL including flow through the outlet system is 9.72 m³/s (840ML/day).

8. Emergency Exercises

The regulation requires emergency exercises to be undertaken every three years (and a practical emergency exercise for high and extreme consequence dams every five years).

Good practice would also include an annual seminar, or ‘run-through’ of emergency procedures, with key onsite staff, to help familiarise them with emergency systems and procedures and measures for emergency preparedness. An annual seminar would also assist in identifying the equipment, resources and materials required to respond in an emergency.

8.1 Three yearly exercise

The requirement for the regulation’s three yearly exercise shall be coordinated by the Engineer Treatment & Catchment and scheduled to occur each year prior to the intermediate inspection. This shall be in the form of a classroom exercise where an actual physical response to the simulated emergency is not performed. The exercise shall involve staff who are involved in the operation of the dam and who would be involved in an emergency response. These exercises shall be discussions and theoretical run-throughs of emergency procedures, to help familiarise participants with emergency systems and procedures and measures for emergency preparedness. They shall also assist in identifying the equipment, resources and materials required to respond in an emergency.

8.2 Five yearly practical exercise

The requirement for the Regulation’s five yearly practical exercise shall be organised by the Engineer Treatment & Catchment and scheduled in conjunction with the dam’s five yearly comprehensive inspection. Creditable hypothetical scenarios shall be devised and simulated by an external facilitator/consultant. The participants shall include staff who are involved in the operation of the dam, the Dam Consultant (separate to the facilitator and with no prior knowledge of scenario) and the SES (as far as practicable). The simulated scenarios shall be in the form of a classroom

exercise and may or may not require an actual physical response to the simulated emergency. Participants shall verbally explain the coordination or execution of their emergency task/s in each event as the scenario is played out.

8.3 Records

Records shall be documented in an emergency exercise evaluation report which will include the exercise participants, scenario, exercise results and any required corrective actions to the DSEP. This report will be made available to all agencies involved in the exercise and saved in Council's ECM Document Management System.

DSEP exercise history is shown in **Table 8.1**.

Table 8.1 DSEP Exercise History

	Date of Exercise of DSEP	Exercise Control
1	25/1/2012	Activation of alert due to flooding
2	28/1/2013	Activation of alert due to flooding
3	30/3/2017	Activation of White Alert due to flooding event, Reservoir reached 64.53mAHD. SES notified as per White Alert procedure
4	10/11/2021	Internal exercise facilitated by Mitch Alward (Engineer, Treatment & Catchment) Covers 3 yearly Requirement
5	25/11/2021	External exercise facilitated by Hunterh2o. SES and DSNSW were contacted as part of the exercise and Dam Safety Engineers (Hunterh2o separate to facilitator) were actively involved. Covers 5 yearly Requirement
6	28/2/2022	Activation of White Alert due to flooding, Reservoir reached 66.84mAHD. Hunterh2o, SES & DSNSW notified as per White Alert procedure. Written incident report submitted to DSNSW on 2/3/2022.

9. Document Control

9.1 Review and Updating the emergency plan

The Clarrie Hall Dam DSEP manual is to be reviewed annually by Tweed Shire Council staff and updated at least once every 5 years.

The emergency plan shall also be updated (within 30 days) if the consequence category changes, if there has been a significant change to the number of persons at risk, or if emergency arrangements change.

The dam owner shall also update the emergency plan after an emergency exercise to incorporate any lesson learnt from the exercise.

9.1.1 Updating contact details

The emergency plan shall be reviewed yearly to ensure that changes to the contact details of a person responsible for exercising functions in the event of an emergency are updated as soon as practicable after the change

9.2 Emergency plan distribution

The emergency plan shall be provided to the following organisations:

- Dams Safety NSW;
- SES; and
- Dam Consultant.

The emergency plan will be provided in electronic form, for example in portable document format (PDF) as soon as reasonably practicable after the plan is prepared or updated.

Any flood extents generated in a dambreak study within the emergency plan should be provided in a format that can be used in a Geographic Information System.

The SES has established a flood data portal to store flood information, including declared dam emergency plans (<https://floodata.ses.nsw.gov.au/>). The portal provides a single location for important emergency information and includes security features to protect sensitive information. The SES should be contacted for information on how to submit the dam emergency plan to the SES for inclusion on the portal.

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Mike 11

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ACER Technical Memorandum No. 3 "Criteria and Guidelines for Evacuating Storage Reservoirs and Sizing Low-Level Outlet Works", 1982.

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Portfolio Risk Assessment for Clarrie Hall Dam, July 2002

Department of Commerce

Clarrie Hall Dam, Addendum to Probable Maximum Flood Study, Report No.: DPWS98177 (Addendum), July 2004.

NSW Public Works

Clarrie Hall Dam Spillway Upgrade Design Report, Report No DC12044, June 2012
Alert Level Assessment & Hydrology for Clarrie Hall Dam DSEP Upgrade. Date:
14/5/14

List of Relevant Drawings

AVAILABLE FROM COUNCIL

80067-001	Regional and Locality Plan
80067-003A	Clarrie Hall Dam – General Arrangement
80067-007	Clarrie Hall Dam - Outlet Works, Sequence of Development
80067-101A	Clarrie Hall Dam - Embankment General Arrangement
80067-102	Clarrie Hall Dam – Embankment Details
80067-201A	Clarrie Hall Dam - Spillway General Arrangement
80067-301	Clarrie Hall Dam - General Arrangement of Intake Tower
80067-131	Clarrie Hal Dam - Instrumentation Deformation Monitoring
80067-401B	Clarrie Hall Dam - Outlet Works General Arrangement

List of Maps

Map 1 – PMF Dambreak Flood Inundation Map 2014 (1 of 5).....	44
Map 2 – PMF Dambreak Flood Inundation Map 2014 (2 of 5).....	45
Map 3 – PMF Dambreak Flood Inundation Map 2014 (3 of 5).....	46
Map 4 – PMF Dambreak Flood Inundation Map 2014 (4 of 5).....	47
Map 5 – PMF Dambreak Flood Inundation Map 2014 (5 of 5).....	48
Map 6 - Sunnyday Dambreak Inundation Map 2014 (1 of 5).....	49
Map 7 - Sunnyday Dambreak Inundation Map 2014 (2 of 5).....	50
Map 8 - Sunnyday Dambreak Inundation Map 2014 (3 of 5).....	51
Map 9 - Sunnyday Dambreak Inundation Map 2014 (4 of 5).....	52
Map 10 - Sunnyday Dambreak Inundation Map 2014 (5 of 5).....	53

List of Figures

Figure 1, CHD PMF, 6 hour Inflow/ Outflow Hydrograph.....	55
Figure 2, CHD PMF, 36 hour Inflow/ Outflow Hydrograph.....	56
Figure 3, CHD PMF, 6 hour RL v Time.....	57
Figure 4, CHD PMF, 36 hour RL v Time.....	58
Figure 5, CHD Spillway Rating Curve.....	59
Figure 6, CHD Storage Capacity Curve.....	60



Appendix A

Dambreak Flood Conditions & Inundation Maps

Table 2 Clarrie Hall Dam Sunny Day Dambreak Results Summary

Distance DS of Dam (km)	Bed Level (m AHD)	Sunny Day Dambreak			Remarks
		WL	Flow	Velocity	
		(m AHD)	(m ³ /s)	(m/s)	
0 00	25 00	61 60	-	-	Clarrie Hall Dam
0 10	25.00	38 41	5711	10 2	d/s of Dam
1 60	17 20	30 72	5637	6 5	Junction with Upper Tweed River
1 93	16 30	30 21	5208	4 9	
3 90	14 00	24 85	4751	6 9	Malabar
5 25	9 30	20 84	4449	7 1	UKI
6 60	5 20	17 57	4315	6 3	Trefern Stud
8 35	3 40	14 23	4246	6 6	Glenrock
9 24	3 40	12 65	4217	6 4	u/s of Dum Dum
10 44	0 00	11 35	4119	4 7	
13 90	-3 30	8 41	3780	2 9	u/s of Byangum Bridge
14 79	-2 80	8 38	3600	2 4	Tweedside
16 02	-2 74	7 50	3028	4 9	u/s of Bray Park Weir
17 24	-3 04	6 39	2744	4 7	Tirzah
18 68	-2 17	6 19	2392	1 4	Sunnymeadows
20 51	-3 74	6 06	2063	1 7	Murwillumbah
21 30	-3 55	5 88	2000	2 4	u/s of Murwillumbah Bridge
21 66	-3 29	5 27	1958	5 7	
22 35	-3 64	5 15	1839	1 6	South Murwillumbah Dip
25 11	-4 93	3 94	1672	4 4	u/s of Condong Bridge
28 87	-5 29	2 46	1649	2 4	Bartlets Creek
30 36	-5 24	2 21	1652	1 5	Camden Haven
31 54	-7 29	1 83	1654	2 0	Tumbulgum

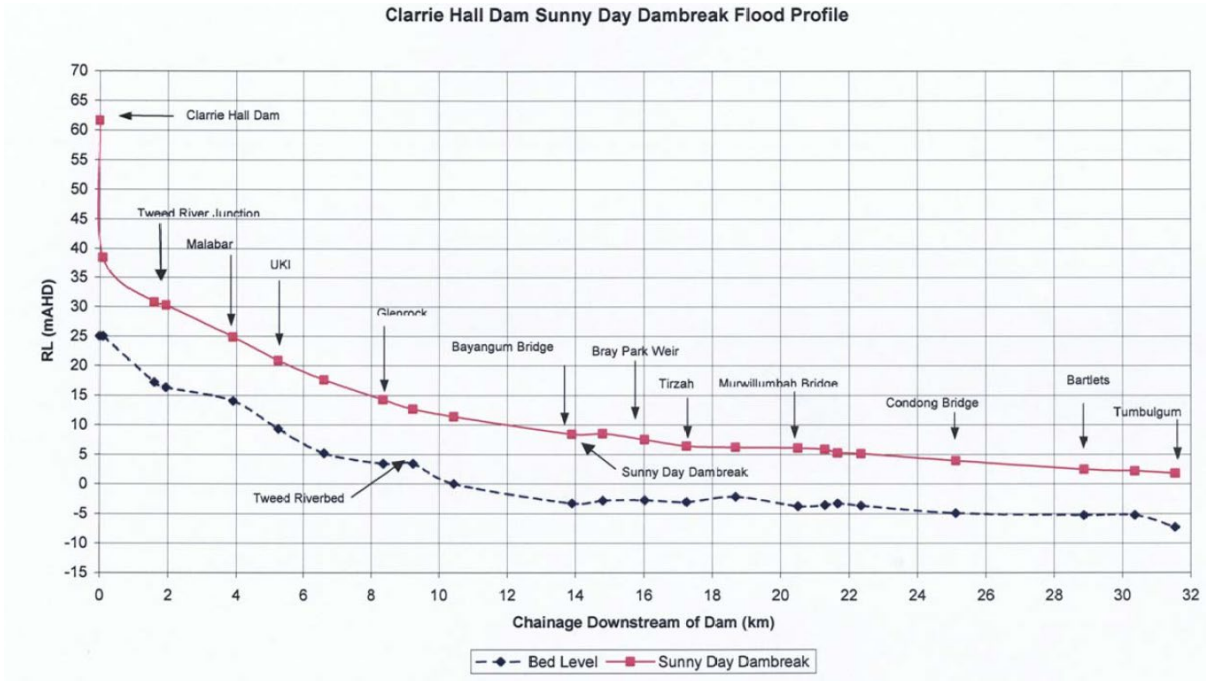


Table 4 Clarrie Hall Dam PMF Dambreak Results Summary

Distance DS of Dam (km)	Bed Level (m AHD)	PMF			PMF-DB			Incr. WL (m)	Remarks
		WL (m AHD)	Flow (m3/s)	Velocity (m/s)	WL (m AHD)	Flow (m3/s)	Velocity (m/s)		
0 00	25 00	70 08	-	-	70 08	-	-	-	Clarrie Hall Dam
0 10	25 00	33 51	1542	2 0	44 64	15571	14 3	11 1	d/s of Dam
1 60	17 20	32 08	1536	1 9	37 33	15394	4 8	5 2	Junction with Upper Tweed River
1 93	16 30	31 54	6581	4 4	36 41	17893	6 3	4 9	
3 90	14 00	27 28	6752	6 4	31 96	17350	6 4	4 7	Malabar
5 25	9 30	24 12	8213	8 1	28 38	17933	9 9	4 3	UKI
6 60	5 20	22 12	8643	6 1	27 25	17813	6 1	5 1	Trefern Stud
8 35	3 40	20 70	8720	7 1	22 86	17930	9 4	2 2	Glenrock
9 24	3 40	20 11	8713	5 4	22 79	17888	5 4	2 7	u/s of Dum Dum
10 44	0 00	19 89	8910	4 0	22 52	17920	4 1	2 6	
13 90	-3 30	19 59	15650	2 4	22 50	22609	2 4	2 9	u/s of Byangum Bridge
14 79	-2 80	19 51	15399	3 0	22 51	21280	3 0	3 0	Tweedside
16 02	-2 74	19 13	15462	6 8	22 22	20633	6 8	3 1	u/s of Bray Park Weir
17 24	-3 04	17 34	15603	6 9	18 51	20498	6 9	1 2	Tirzah
18 88	-2 17	17 16	15795	3 0	18 50	20362	3 5	1 3	Sunnymeadows
20 51	-3 74	16 99	16776	2 9	18 49	20631	3 1	1 5	Murwillumbah
21 30	-3 55	16 46	16722	4 0	17 88	20620	4 3	1 4	u/s of Murwillumbah Bridge
21 66	-3 29	14 17	16769	15 9	15 38	20617	17 5	1 2	
22 35	-3 64	13 11	16663	5 1	14 09	20621	5 9	1 0	South Murwillumbah Dip
25 11	-4 93	11 20	16587	6 4	12 45	20350	6 3	1 2	u/s of Condong Bridge
28 87	-5 29	8 19	16387	7 9	8 94	19675	8 2	0 8	Bartlets Creek
30 36	-5 24	6 50	16375	4 5	7 05	19647	4 9	0 6	Camden Haven
31 54	-7 29	2 97	16375	14 8	3 25	19640	16 4	0 3	Tumbulgum

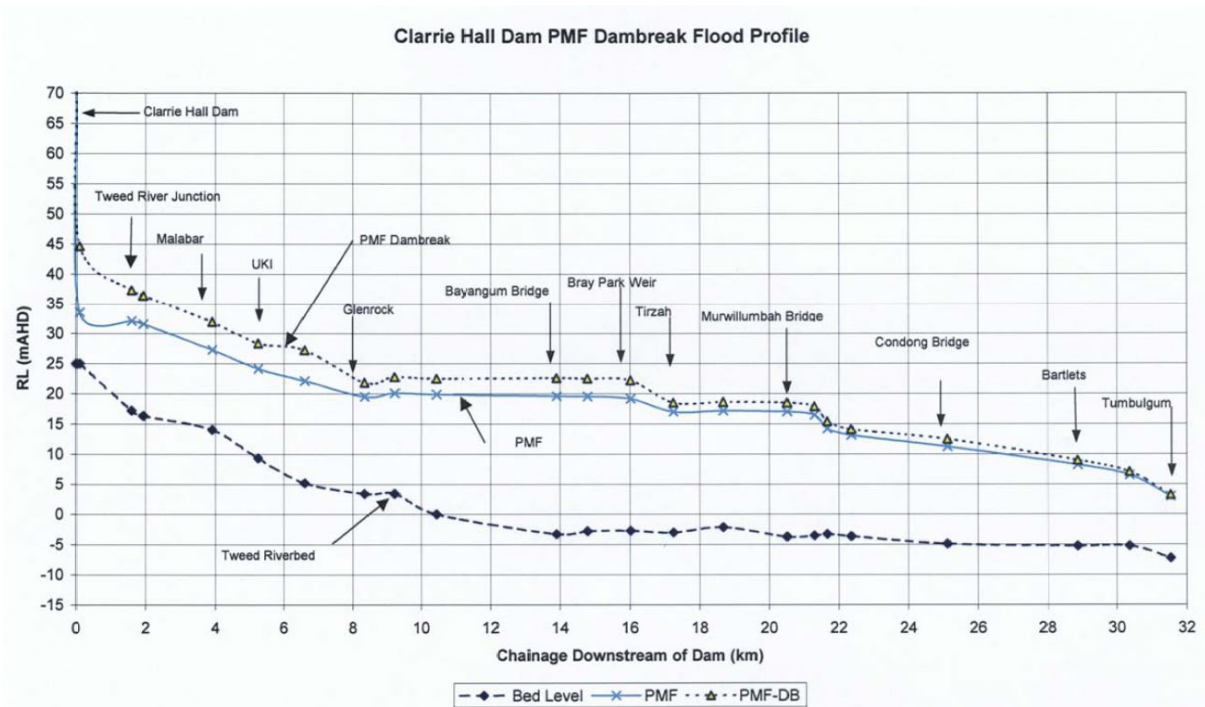
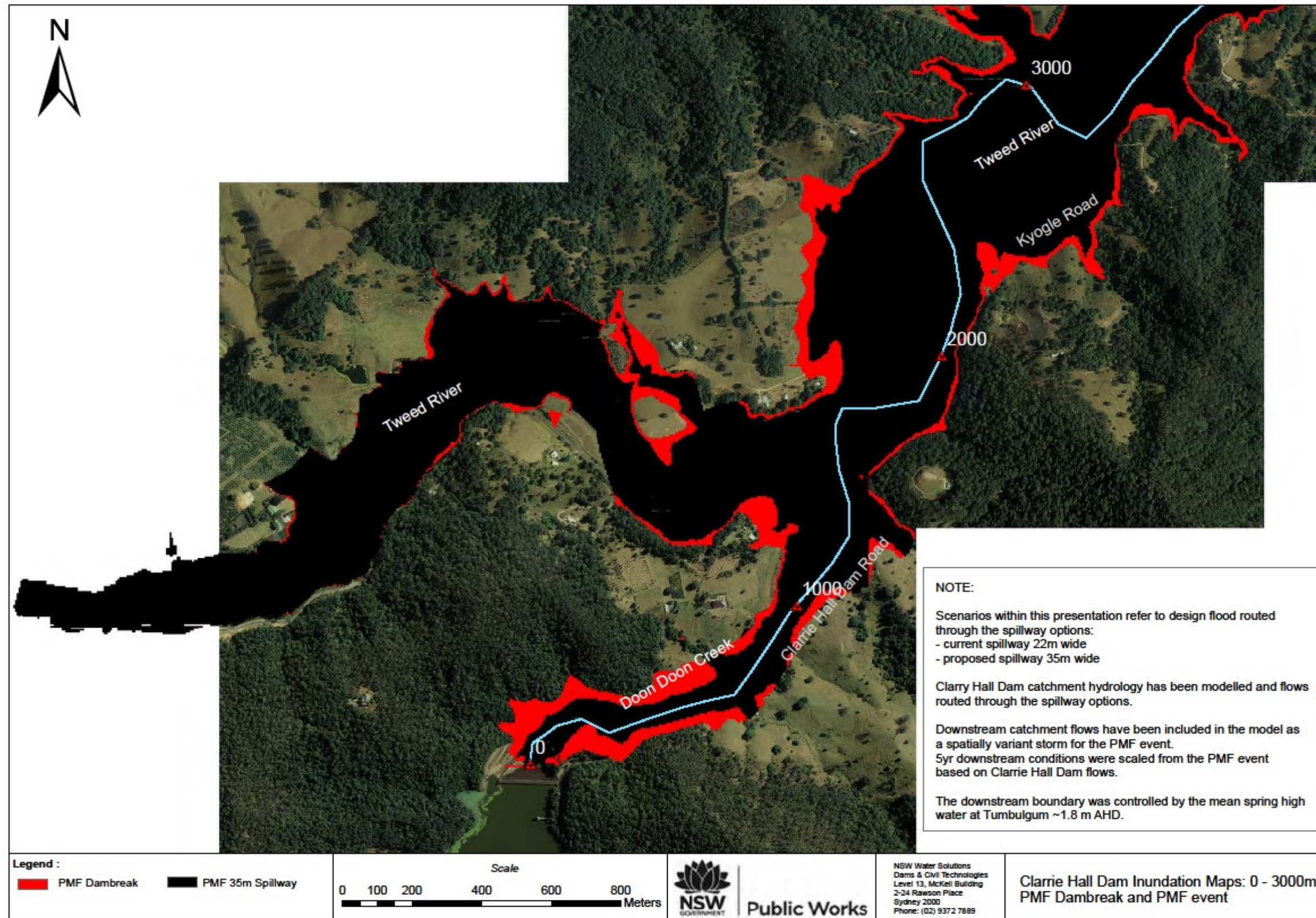


Table 7 Flooding Conditions of Bridges

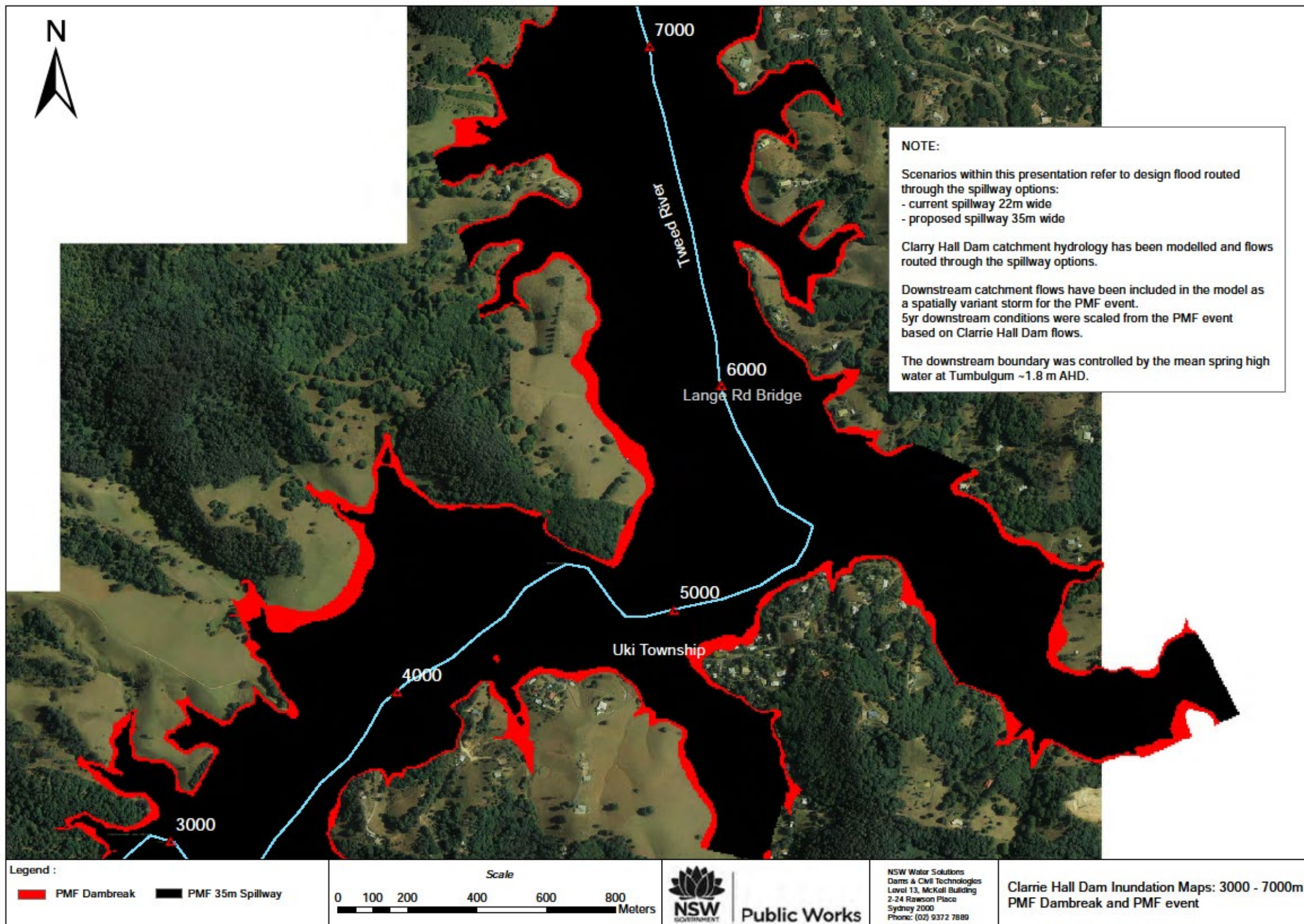
Bridges	DS of Dam (km)	Deck Level (m AHD)	Flood Level (m AHD)	Fld-Depth (m)	Vel (m2)	Fld-Depth*Vel (m2/s)	Flood Level (m AHD)	Fld-Depth (m)	Vel (m2)	Fld-Depth*Vel (m2/s)
Sunny Day Dambreak										
Doon Doon Creek Bridge	1.48	31.50	30.84		5.87					
Byangum Bridge	13.84	6.00	8.41	2.41	2.82	6.8				
Murwillumbah Bridge	21.24	7.33	5.88		2.44					
Condong Bridge	25.11	5.65	3.95		4.07					
DCF										
Doon Doon Creek Bridge	1.48	31.50	28.90		4.18		34.52	3.02	5.40	16.3
Byangum Bridge	13.84	6.00	14.86	8.86	1.72	15.2	16.40	10.40	2.37	24.7
Murwillumbah Bridge	21.24	7.33	13.21	5.88	3.00	17.6	14.01	6.68	4.34	29.0
Condong Bridge	25.11	5.65	8.98	3.33	6.87	22.9	9.25	3.60	7.18	25.9
PMF										
Doon Doon Creek Bridge	1.48	31.50	32.07	0.57	3.99	2.3	37.20	5.70	5.40	30.8
Byangum Bridge	13.84	6.00	19.59	13.59	2.37	32.2	22.60	16.60	2.37	39.4
Murwillumbah Bridge	21.24	7.33	16.46	9.13	4.03	36.8	17.88	10.55	4.34	45.8
Condong Bridge	25.11	5.65	11.25	5.60	7.18	40.2	12.60	6.95	7.18	49.9

Note Flood Depths are not shown for conditions not affected by floods

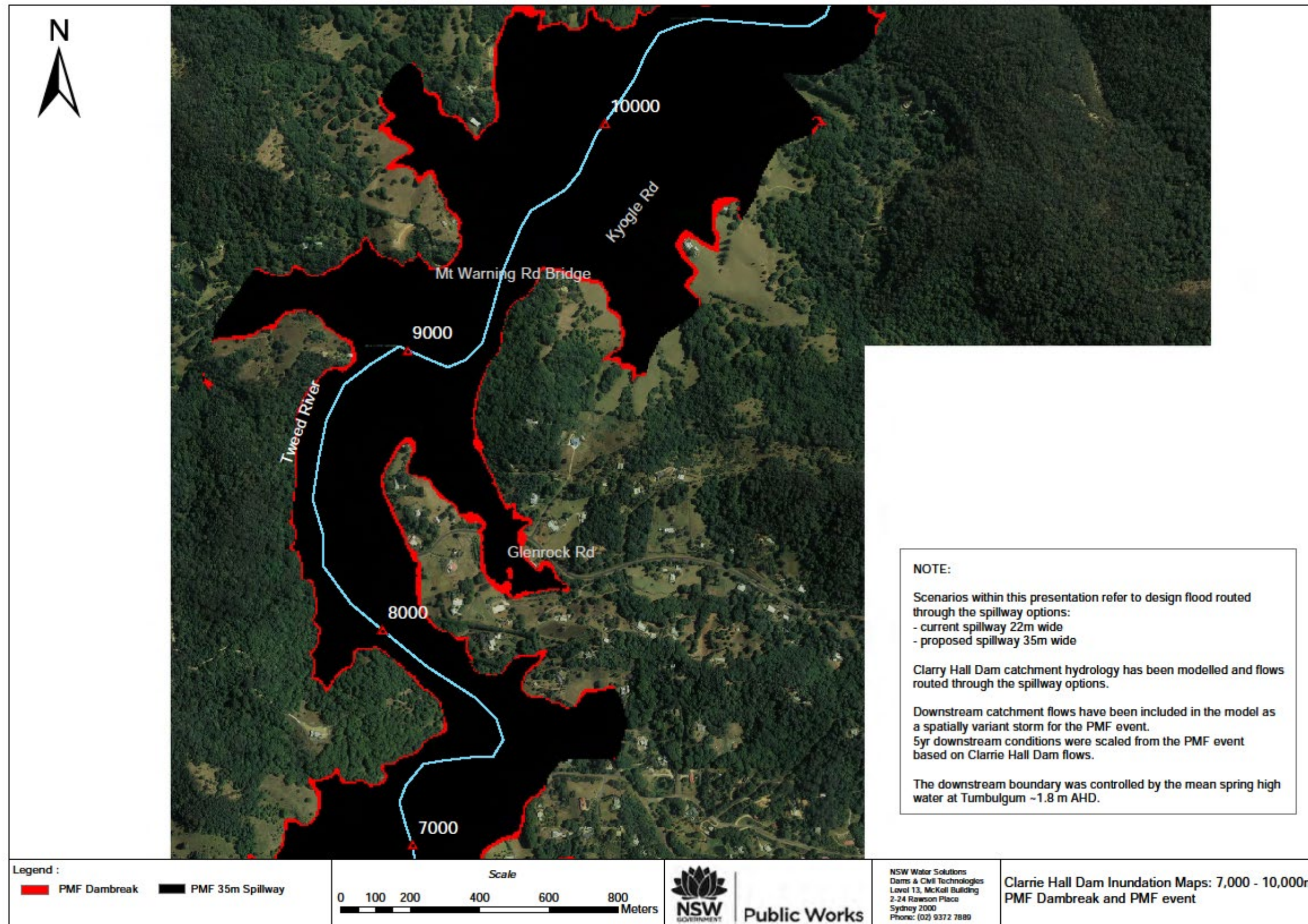
Map 1 – PMF Dambreak Flood Inundation Map 2014 (1 of 5)



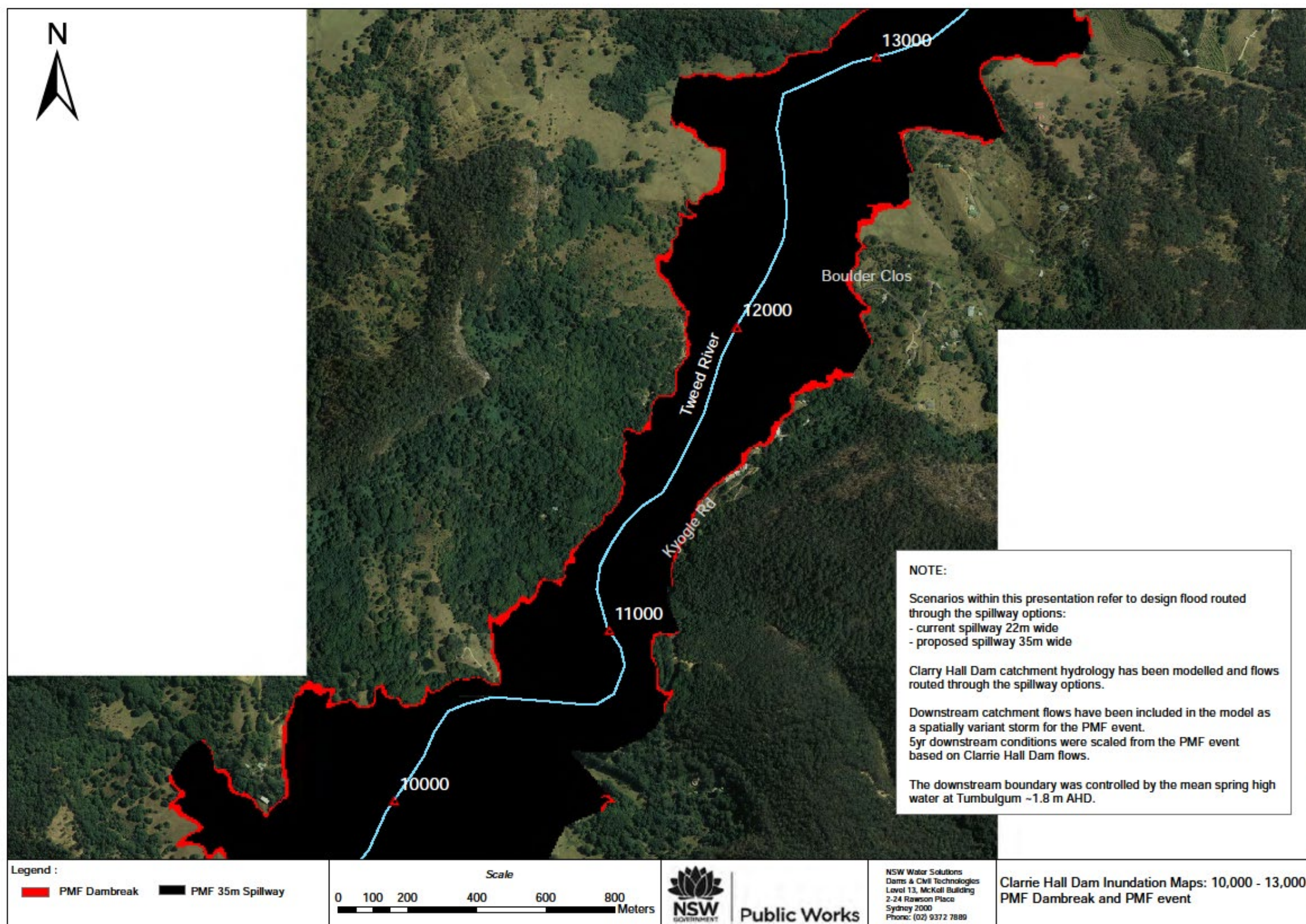
Map 2 – PMF Dambreak Flood Inundation Map 2014 (2 of 5)



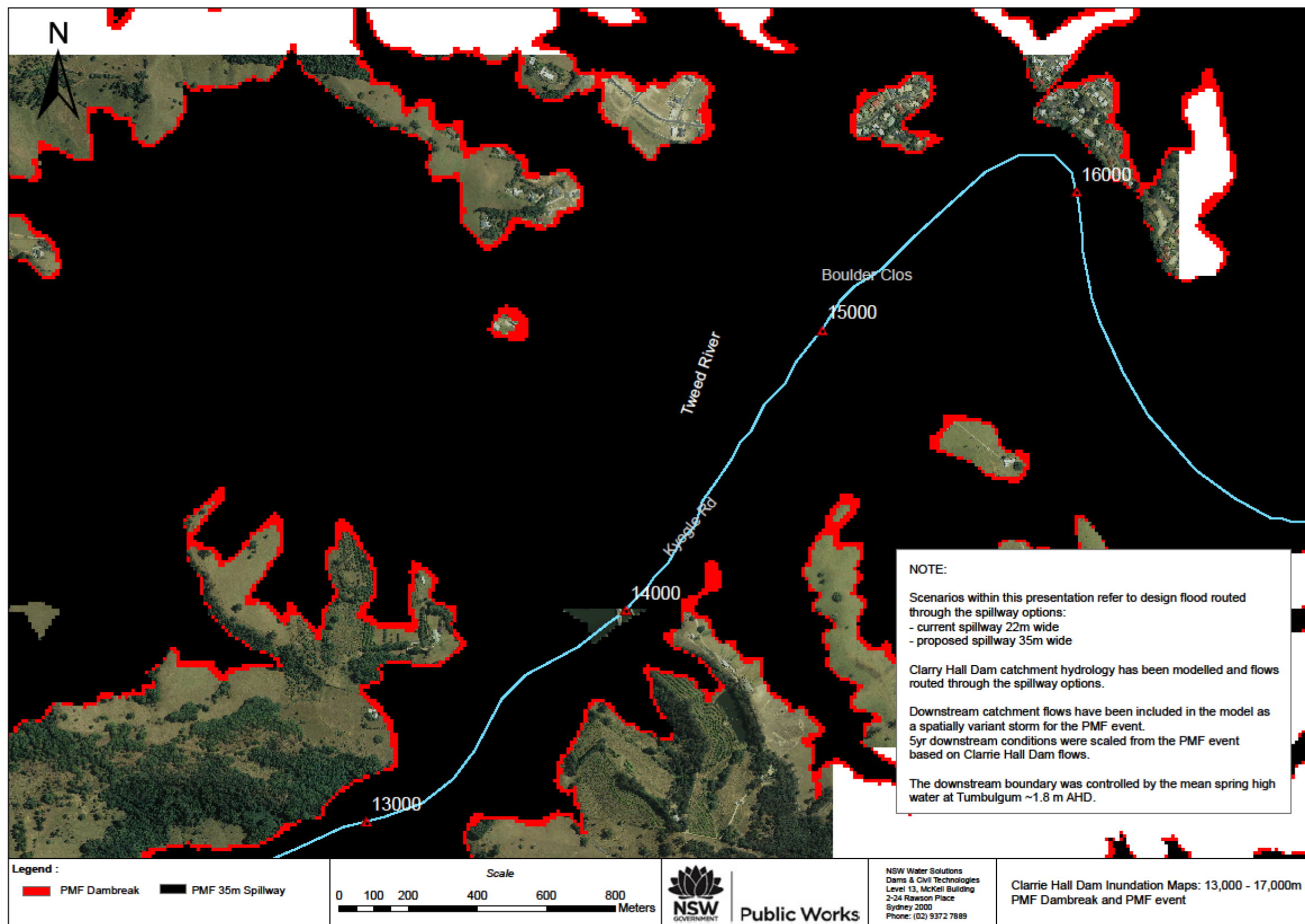
Map 3 – PMF Dambreak Flood Inundation Map 2014 (3 of 5)



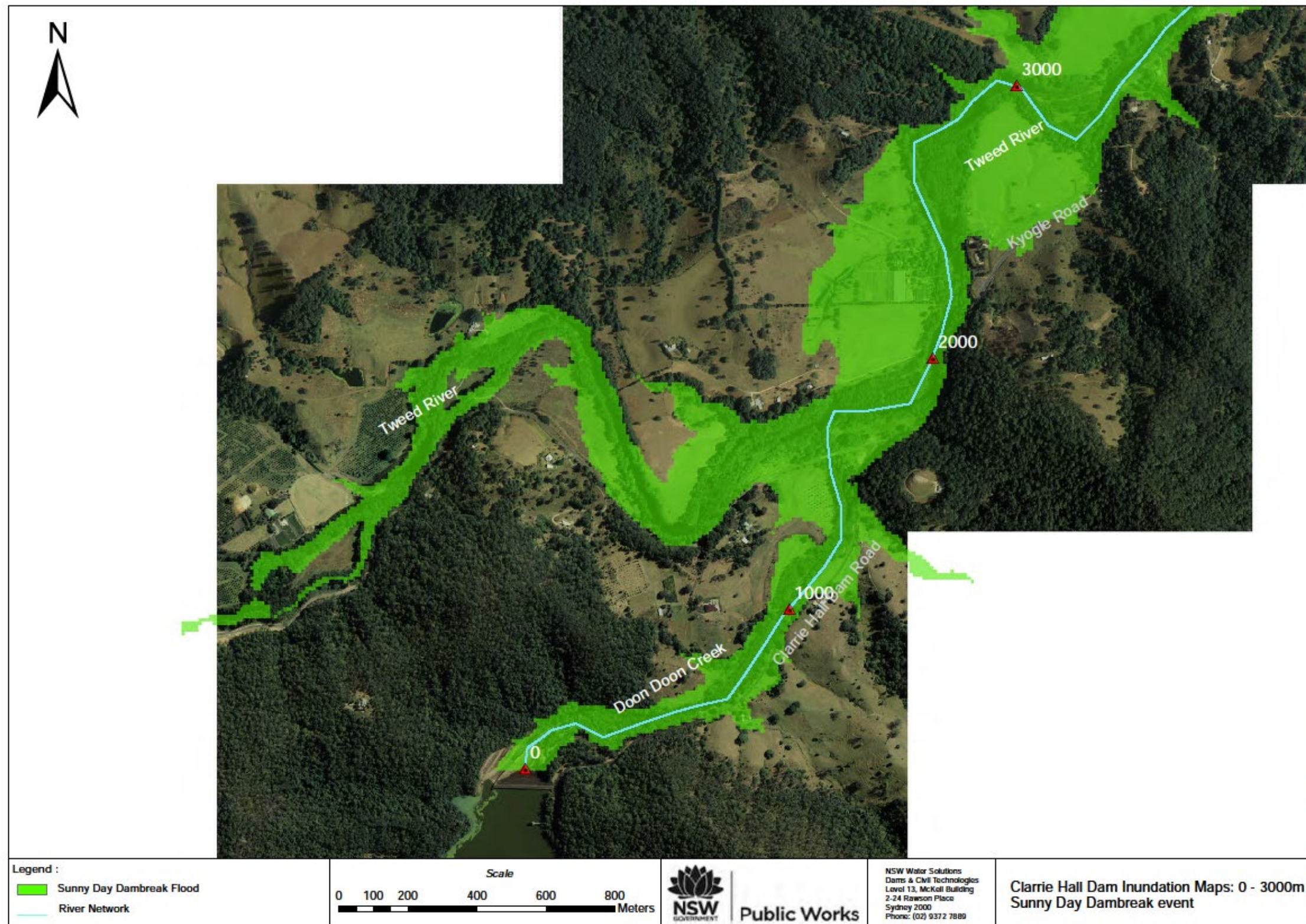
Map 4 – PMF Dambreak Flood Inundation Map 2014 (4 of 5)



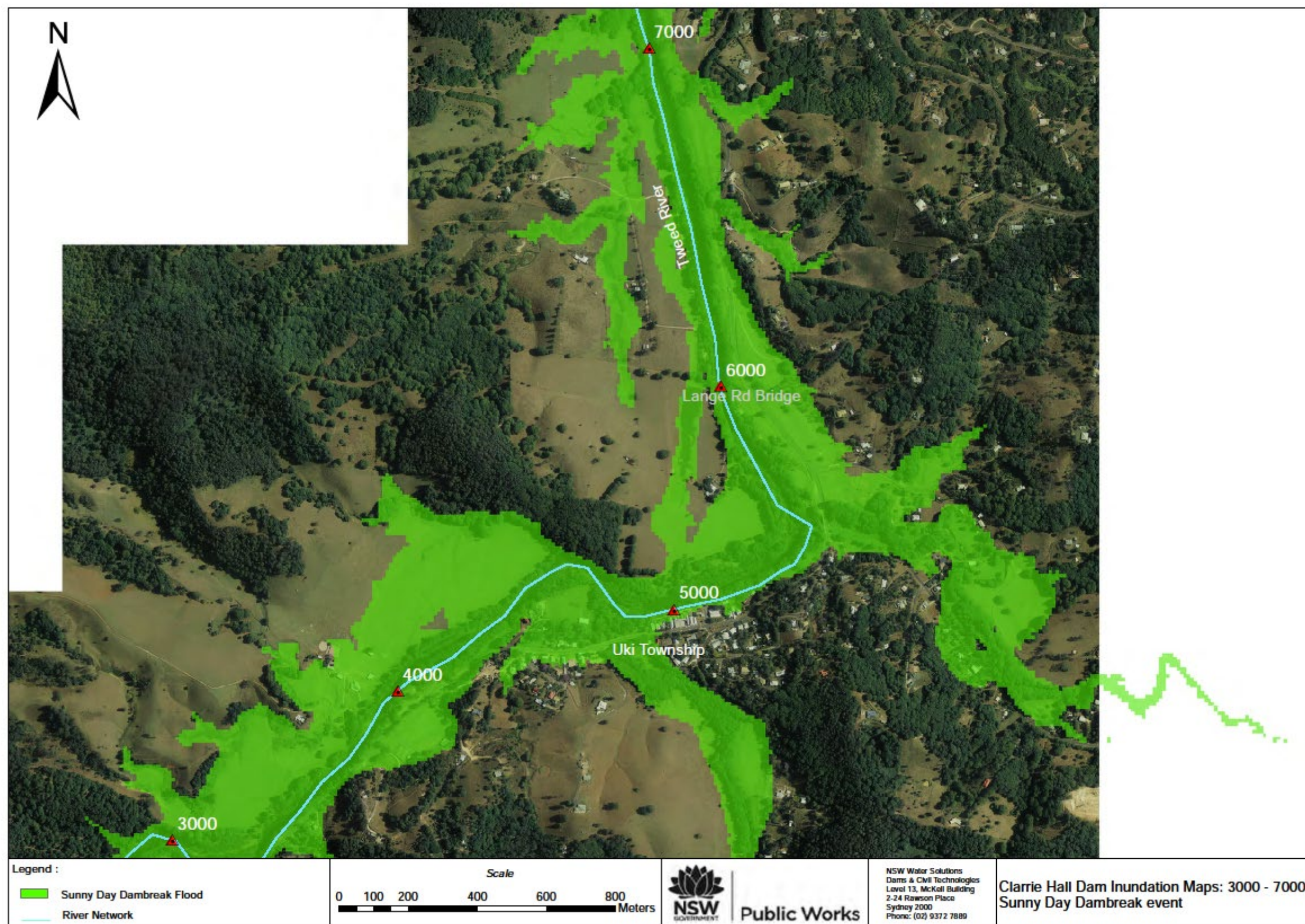
Map 5 – PMF Dambreak Flood Inundation Map 2014 (5 of 5)



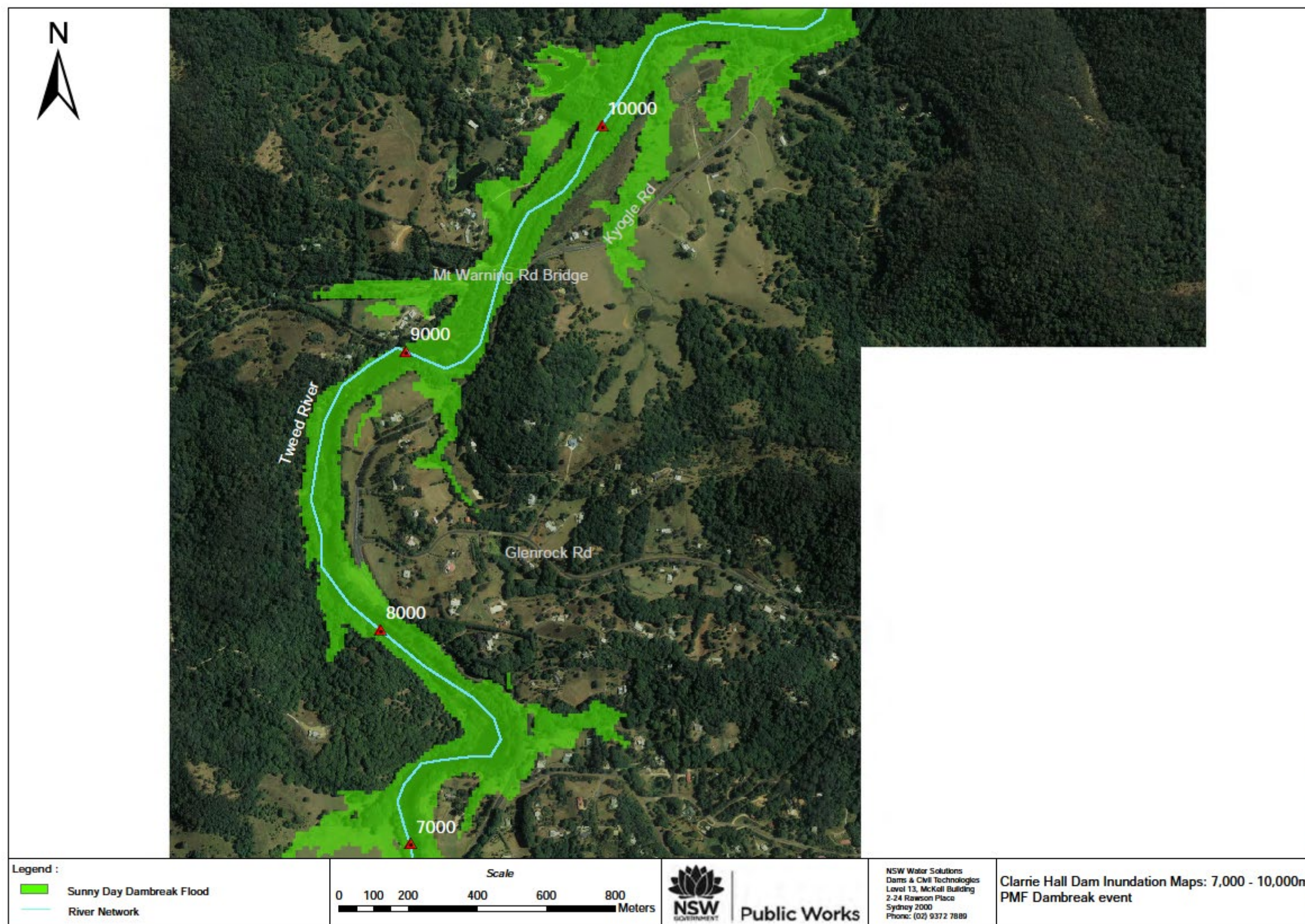
Map 6 - Sunnyday Dambreak Inundation Map 2014 (1 of 5)



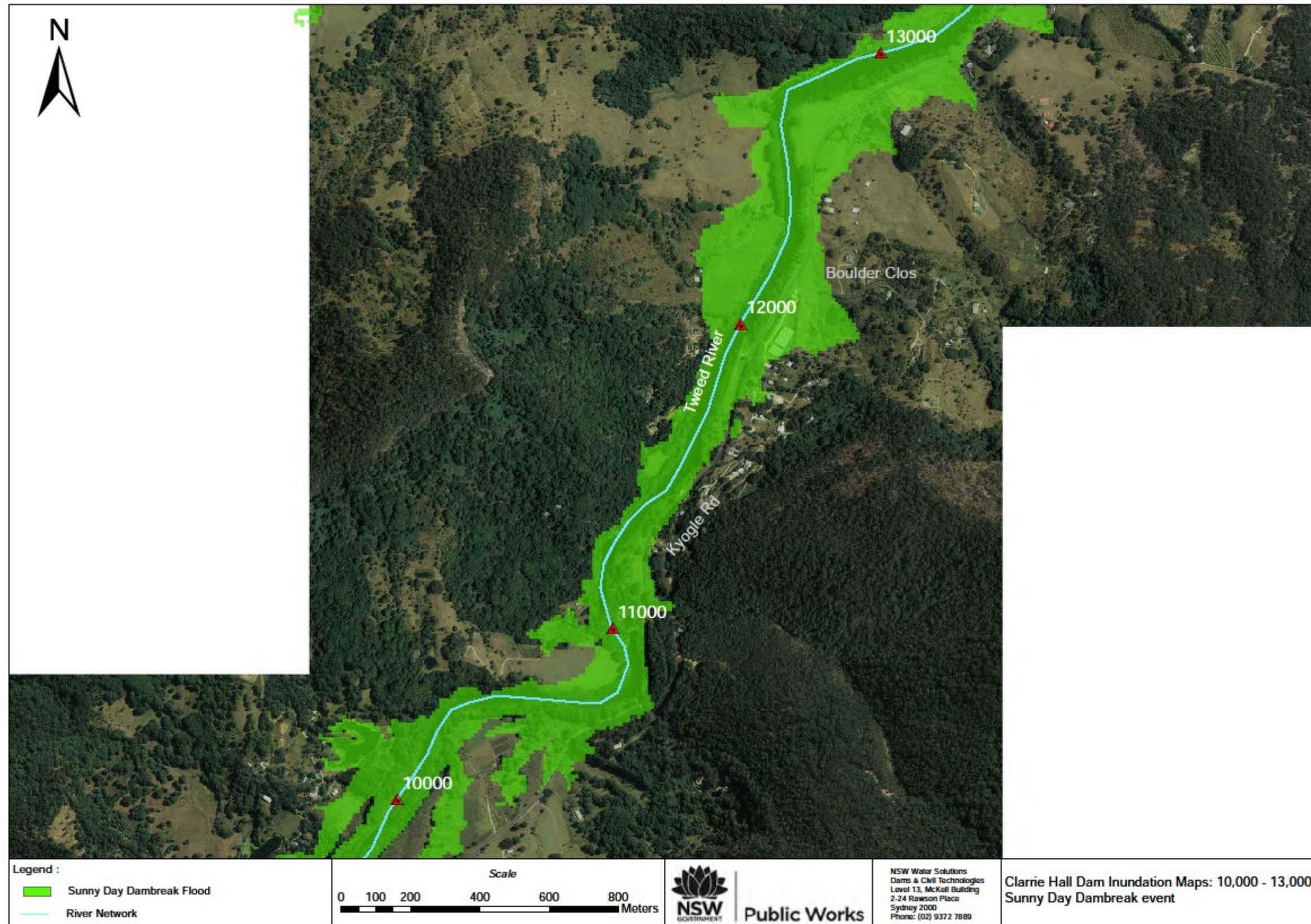
Map 7 - Sunnyday Dambreak Inundation Map 2014 (2 of 5)



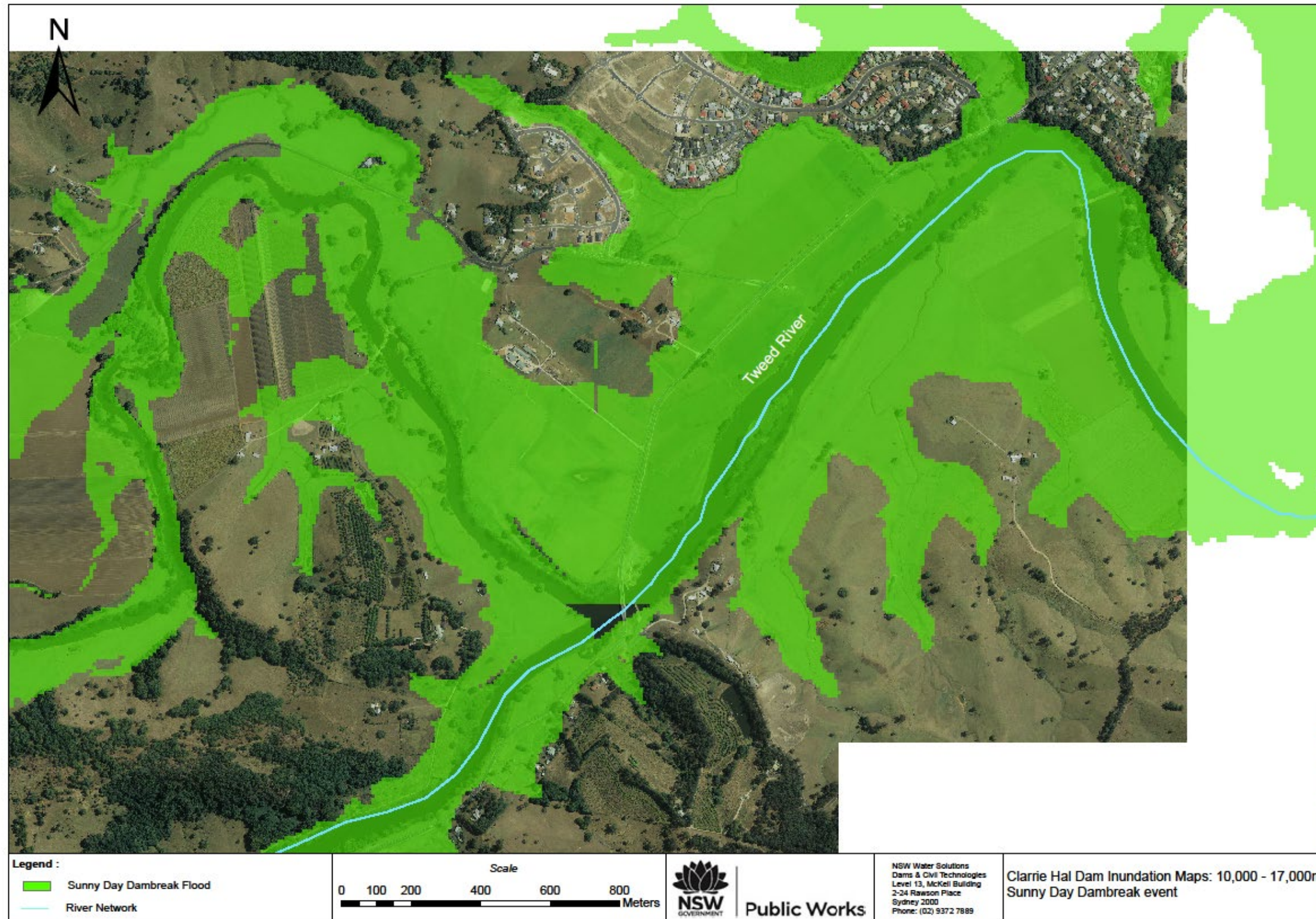
Map 8 - Sunnyday Dambreak Inundation Map 2014 (3 of 5)



Map 9 - Sunnyday Dambreak Inundation Map 2014 (4 of 5)



Map 10 - Sunnyday Dambreak Inundation Map 2014 (5 of 5)



Appendix B
Inflow Flood Frequency Curve and Spillway Rating Curve

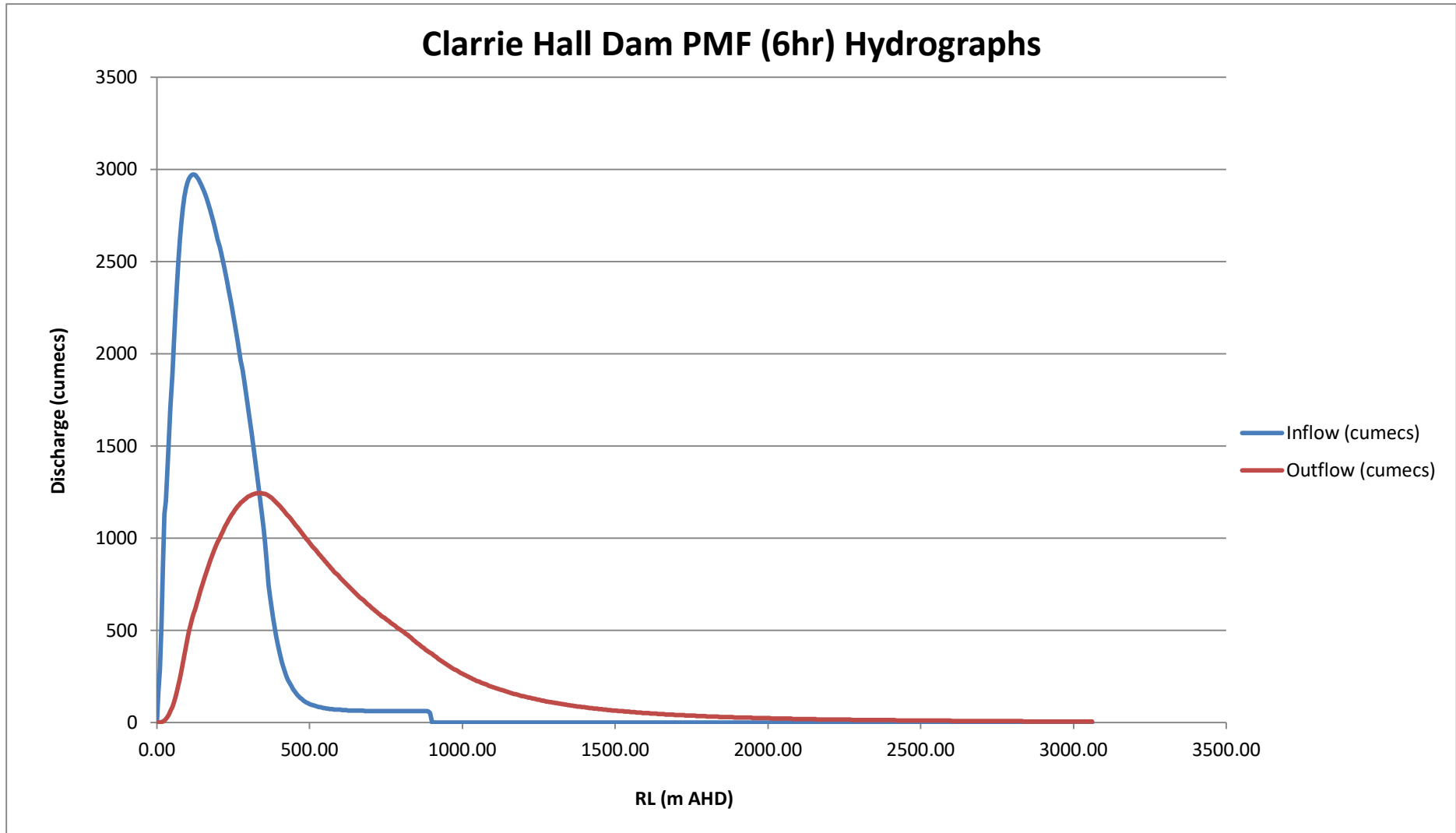


Figure 0.1, CHD PMF, 6 hour Inflow/ Outflow Hydrograph



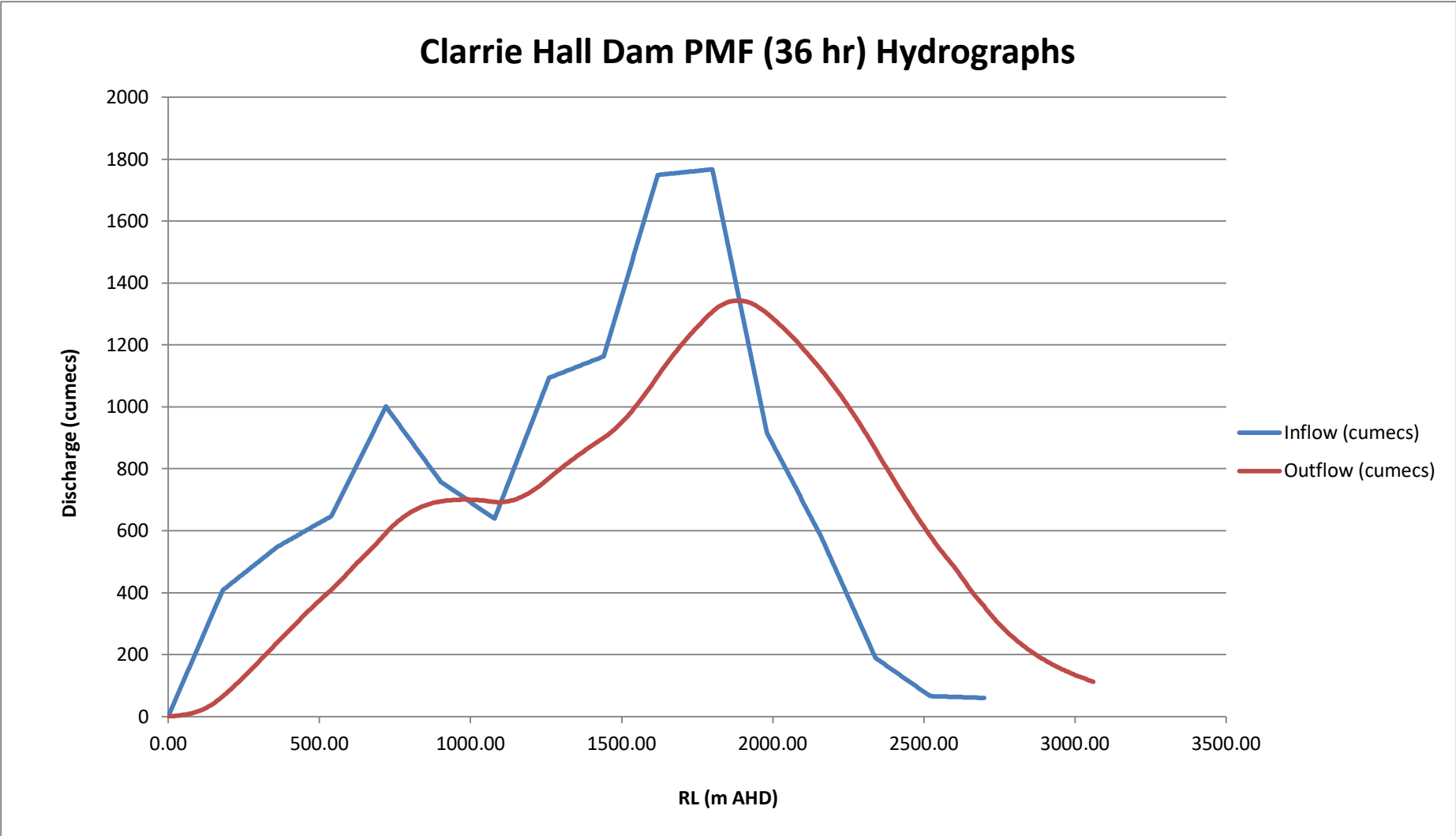


Figure 0.2, CHD PMF, 36 hour Inflow/ Outflow Hydrograph



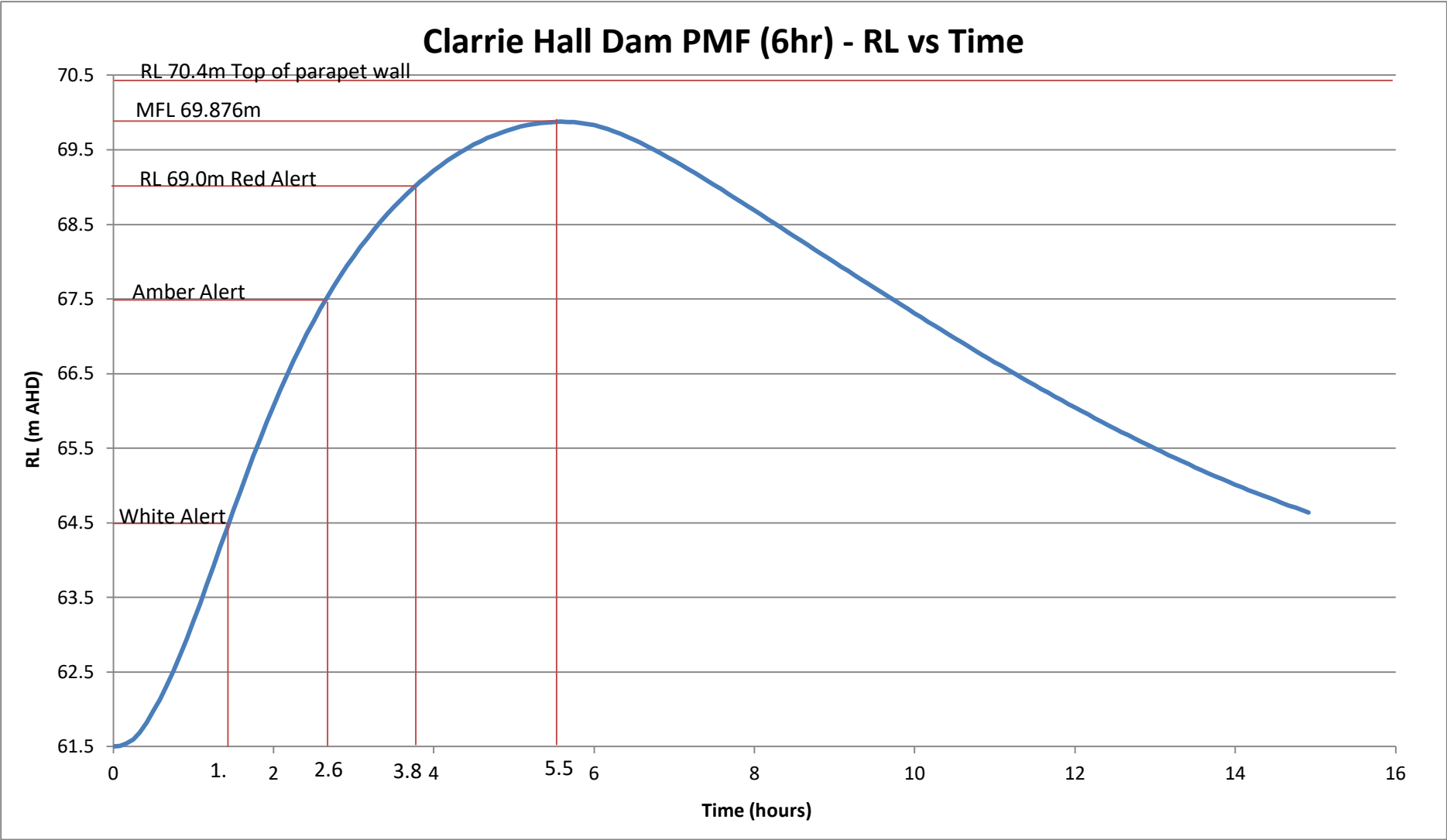


Figure 0.3, CHD PMF, 6 hour RL v Time



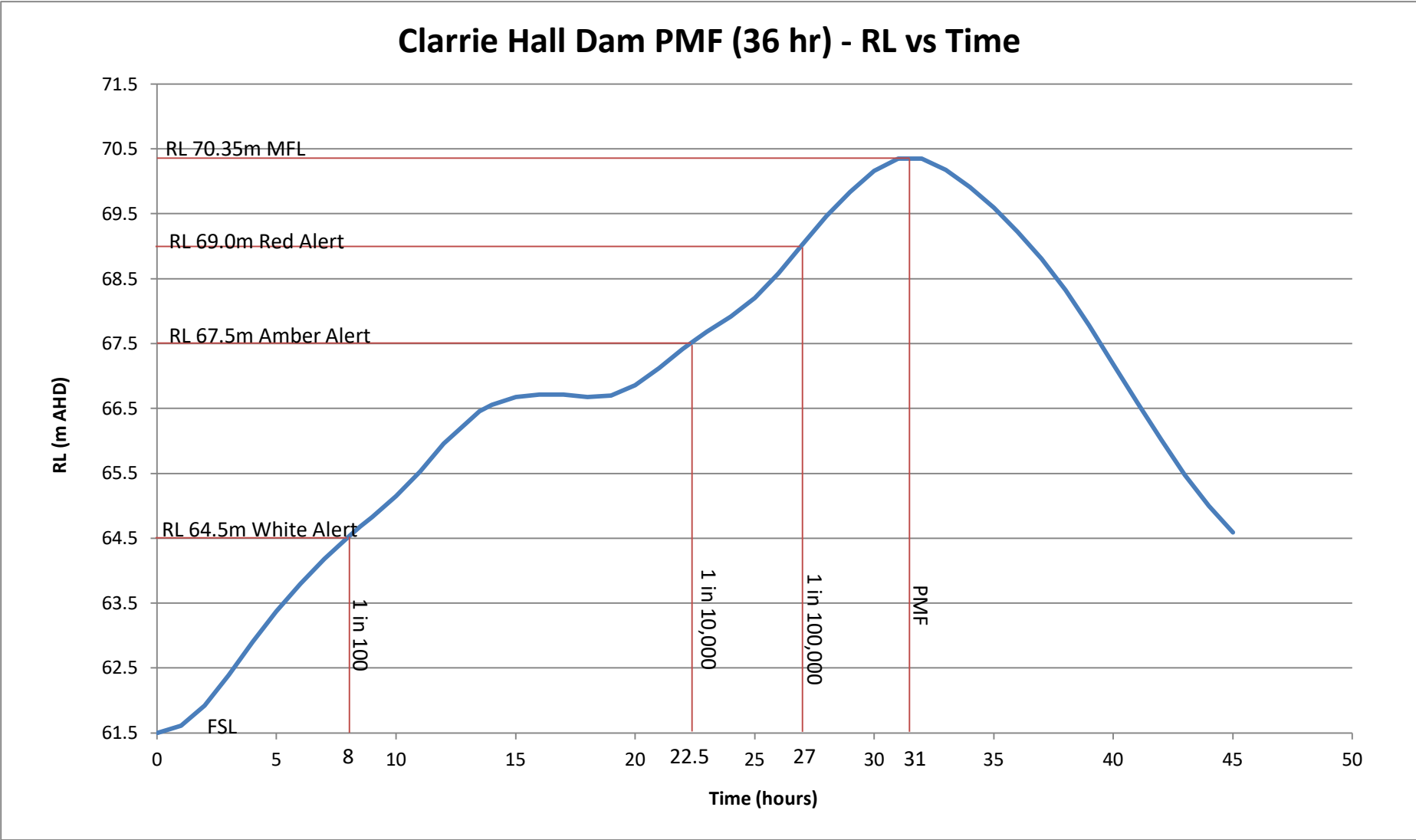


Figure 0.4, CHD PMF, 36 hour RL v Time

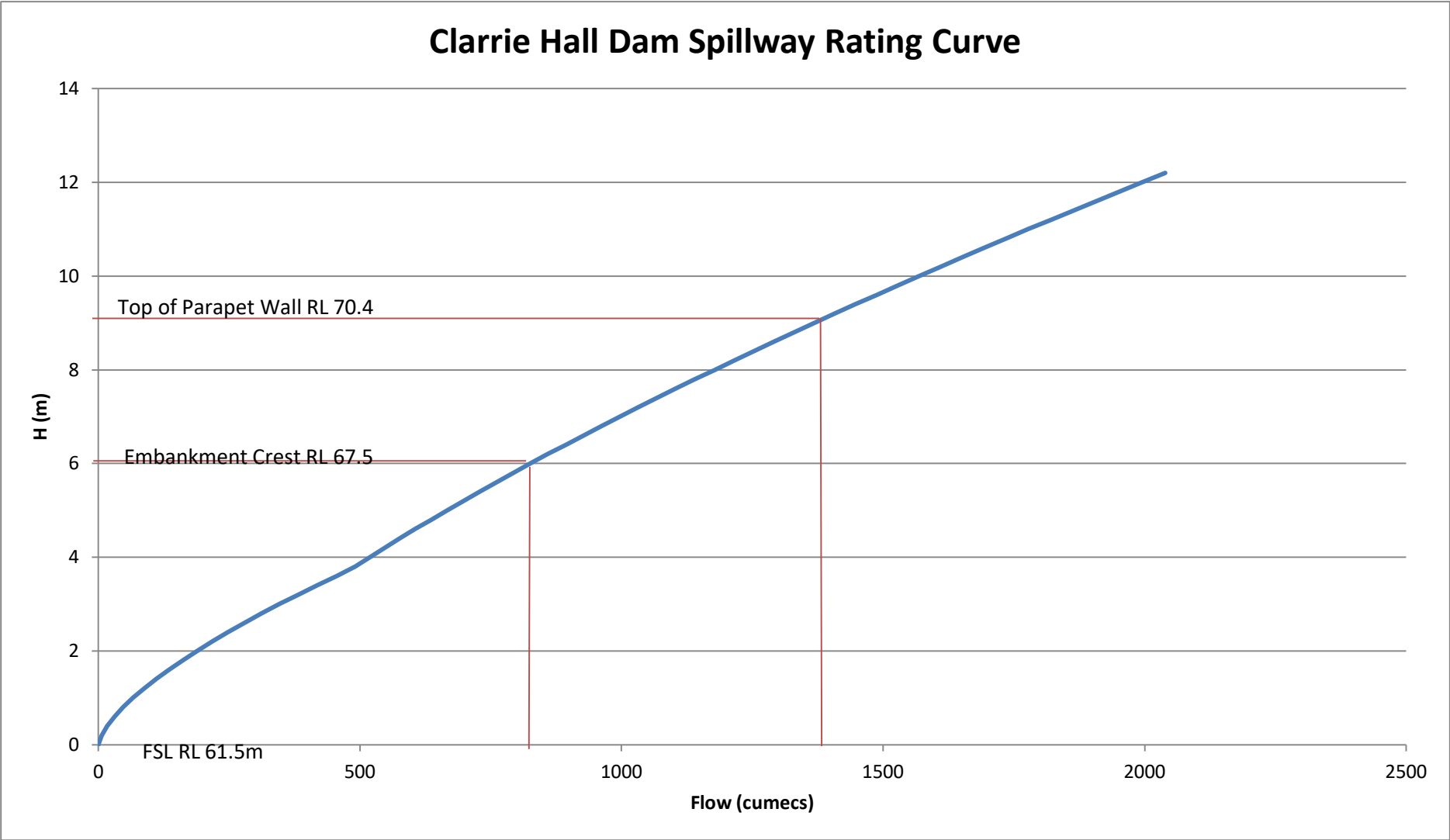


Figure 0.5, CHD Spillway Rating Curve



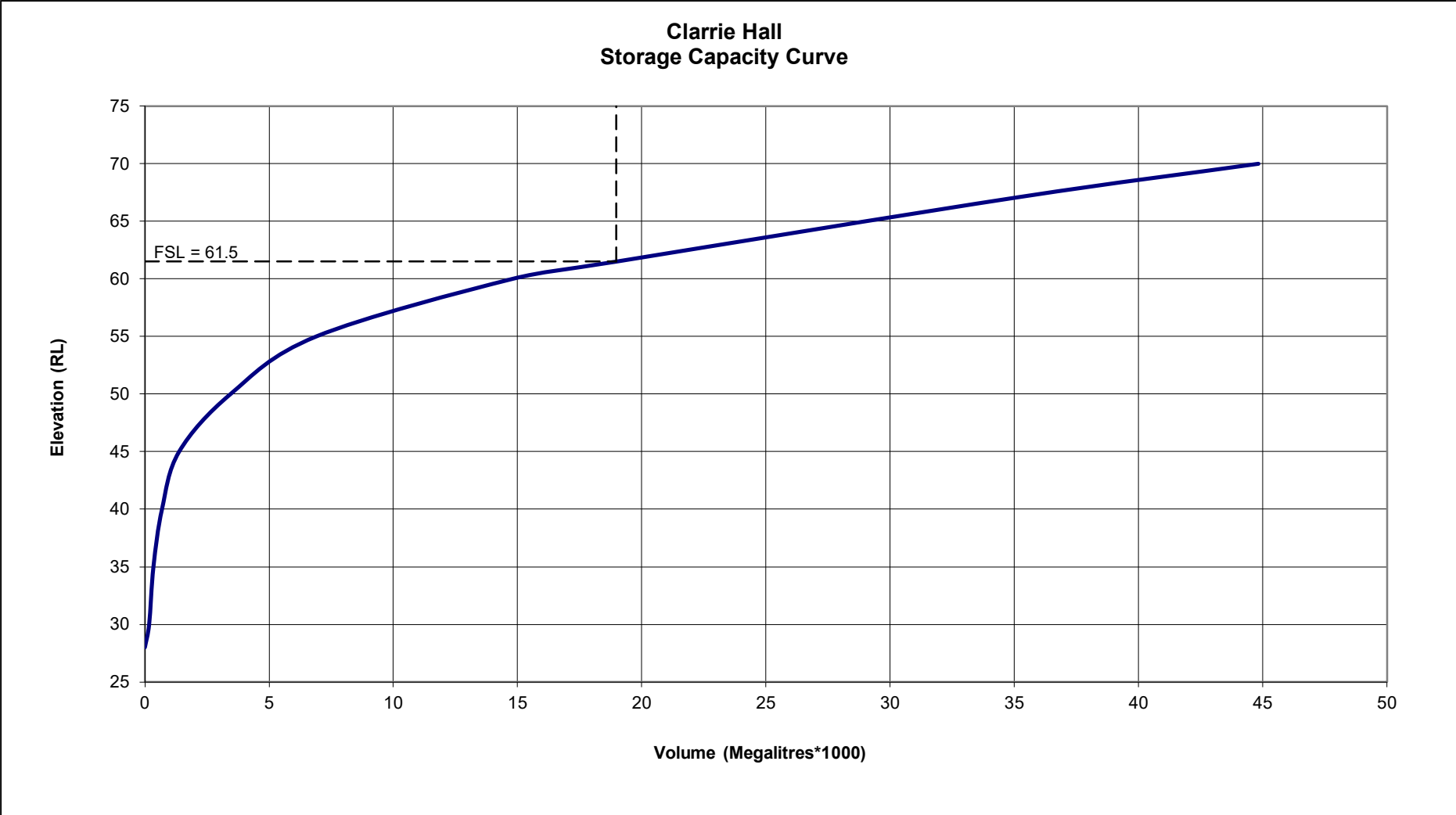


Figure 0.6, CHD Storage Capacity Curve



Appendix C

Terrorism and/or Sabotage Threats to the Dam Questionnaires

Questionnaires

The following provides a procedure for handling potential threats to the dam. This appendix has been divided up into 3 different types of threats that each has a relevant questionnaire that should be followed by a generic checklist during an emergency. These are:

- | | |
|--------------------|------------------------|
| QUESTIONNAIRE C-1: | Bomb Threat |
| QUESTIONNAIRE C-2: | Armed Threat |
| QUESTIONNAIRE C-3: | Threat to Water Supply |
| QUESTIONNAIRE C-4: | Checklist |



BOMB THREAT QUESTIONNAIRE C-1

If you receive a telephoned bomb threat, follow the instructions below:

- Signal to a colleague and if possible, have someone else listen to the line to help you remember important facts later.
- Ask someone else to call Police on another line so that an attempt can be made to trace the call.
- Try to keep the caller on the phone until Police arrive on site.

Ask the caller these questions:

1. When is the bomb set to go off?

2. Where is the bomb?.....

3 What kind of bomb is it?

4. What does it look like?

5. What will make it explode?

6. Why are you doing this?

7. How did you place it?

8. Who are you?
Name.....

Address

Date: Time: How long did the call last?

- Inform Dams Manager.

Complete details on QUESTIONNAIRE C-4.



**ARMED THREAT
QUESTIONNAIRE C-2**

If you receive an armed threat, follow the instructions below:

- **ENSURE YOUR OWN AND OTHER PEOPLE’S PERSONAL SAFETY AS A MATTER OF PRIORITY.**
- Disengage from any dangerous situation or threatening conversation as quickly as possible and withdraw from the scene.
- Call the Police and give details of the threat.
- Report the incident to the Dams Manager as appropriate.
- Advise Duty Officer and all other staff on site (on and off duty).

Record the following details:

- Was the threat made by an individual or more than one person?
.....
- What was the weapon used?
- Describe the person/people:
Articulate/Incoherent.....Male/Female.....Possible Age?
Accent?
- Emotion? (angry/calm/other)
- Description? (height/build/weight/hair colour/clothing/beard/glasses)
.....
- Did you recognise the person/people? (who?)
- Where was the threat made?
.....
- Where did the person go?
.....
- Was there a vehicle?
.....
- Who or what was the target of the threat? Be as exact as possible.
.....
.....

Date: Time: How long did the call last?

- Inform Dams Manager

Complete details on QUESTIONNAIRE C-4.



THREAT TO WATER SUPPLY QUESTIONNAIRE C-3

If you receive a telephoned threat to the water supply, eg. by poisoning, follow the instructions below:

- Signal to a colleague and if possible, have someone else listen to the line to help you remember important facts later.
- Ask someone else to call Police on another line so that an attempt can be made to trace the call.
- Try to keep the caller on the phone until Police arrive on site.

Try to ask the caller these questions:

1. What was added to the water?
.....
 2. How much (i.e., what volume of chemical, number of bacteria, etc.)?
.....
 3. What strength (eg. of chemical)?
.....
 4. When was it put into the water (dam, reservoir)?
.....
 5. Where was it put into the water?
.....
 6. How did you put it into the water?
.....
 7. Why have you done this?
.....
 8. Who are you? Name?
Address?
- Date: Time: How long did the call last?

- Inform Dams Manager.

Complete details on QUESTIONNAIRE C-4.



Appendix D

Earth Tremor Emergency Procedures

Earth Tremor Emergency Procedures

1. Assess the Severity of the Tremor

The following procedures shall be initiated if a tremor is felt, or if the Seismology Research Centre notifies you that a tremor has been detected in the area. Refer to the description of the Modified Mercalli Scale in **Table 0.1** to estimate its rating on this scale, based on the felt affects at the dam. Then follow the procedures below depending whether the assessment is less than MM4 or greater then MM4 (if instruments have detected the tremor, they will give a Magnitude in Richter Scale units, which are different from the Mercalli Scale).



Table 0.1

Modified Mercalli Intensity Scale		
Earthquake Intensity (MM)	Description of Earthquake	Richter Equivalent
I	People do not feel any earth movement	0 - 4.3
II	A few people might notice movement if they are at rest and/or on the upper floors of tall buildings.	
III	Many people indoors feel movement. Hanging objects swing back and forth. People outdoors might not realise that an earthquake is occurring.	
IV	Most people indoors feel movement. Hanging objects swing. Dishes, windows and doors rattle. The earthquake feels like a heavy truck hitting the wall. A few people outdoors may feel movement. Parked cars rock.	4.3 - 4.8
V	Almost everyone feels movement. Sleeping people are wakened. Doors swing open or close. Dishes are broken. Pictures on the wall move. Small objects move or are turned over. Trees might shake. Liquids might spill out of open containers.	
VI	Everyone feels movement. People have trouble walking. Objects fall from shelves, pictures fall off walls furniture moves. Plaster in walls might crack. Trees and bushes shake. Some slight damage in poorly built buildings however there is no structural damage.	4.8 – 6.2
VII	People have difficulty standing. Drivers feel their cars shaking. Some furniture breaks loose. Loose bricks fall off buildings. Damage is slight to moderate in well-built buildings and considerable in poorly built buildings	
VIII	Drivers have trouble steering. Houses that are not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Well-built structures suffer slight damage. Poorly built structures suffer severe damage. Tree branches break. Hillsides might crack if the ground is wet. Water levels in wells might change.	6.2 – 7.3
IX	Well-built buildings suffer considerable damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks and reservoirs suffer serious damage.	
X	Most buildings and their foundations are destroyed. Some bigger bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers and lakes. The ground cracks in large areas and rail lines are bent slightly.	
XI	Most buildings collapse. Some bridges are destroyed. Large cracks appear in the ground. Underground pipe lines are destroyed and rail lines are badly bent.	>7.3
XII	Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.	



If the earthquake falls into one of the following magnitude/distance categories, then the procedures for tremors greater than MM4 should be followed. Tremors greater than MM4 include but are not limited to:

Richter Magnitude > 4.0 within 25km radius

Richter Magnitude > 5.0 within 50km radius

Richter Magnitude > 6.0 within 80km radius

Richter Magnitude > 7.0 within 125km radius

Richter Magnitude > 8.0 within 200km radius

(NOTE: Magnitude indicated refers to the Richter Scale)

2. If the Tremor is LESS than MM4

Carry out a full inspection in accordance with the Standard Operating procedure 'WWO Clarrie Hall Dam routine surveillance inspections', if the tremor occurs in daytime, or at first light following a night-time tremor.

During a visual inspection read all seepage points, note any pronounced changes in the rate of flow and colour of seepage water - either increases or decreases from the normally recorded values.

If the inspection finds some changes due to the tremor, notify the Dams Manager immediately. If there is no effect from the tremor, notify them of its occurrence at the next convenient opportunity.

3. If the Tremor is EQUAL TO or GREATER than MM4

The Post-Earthquake Response Procedures, as outlined in **Table 0.2** should be implemented in the event of a seismic tremor equal to or greater than MM4.



Table 0.2

Earthquake Response Procedures		
Step No. (personnel)	Description	Action
1 (operator*)	General overall dam inspection	<ol style="list-style-type: none"> 1. The Operator or other staff member present at the dam shall immediately call on other staff members on duty. 2. One extra staff member contacted will notify the SES Operations Centre, Wollongong, of a felt earthquake of greater than MM4 and that the dam is to be inspected. Refer to Flow Charts 2 & 4 and the Emergency Communications Directory for contacts. 3. If tremor occurs in day time, immediately carry out a full inspection of the wall, pipes, valves and spillway in accordance with the Standard Operating Procedure 'WVO Clarrie Hall Dam routine surveillance inspections'. Inspect abutment for slips, cracks and/or change in seepage. Use all available officers who are familiar with the dam to carry out the inspection, to be able to detect and changes as soon as possible. 4. If a tremor occurs at night, use spotlights to inspect the crest, spillway and abutments. Also inspect from the toe for seepage and inspect all seepage measuring points. At first light, carry out a full inspection in accordance with the Routine Inspection Sheet. Read all seepage points. 5. Note any distinct change in the rate of flow and colour of seepage water – either increases or decreases from the normally recorded values. 6. If any change is found, immediately commence notifications as per Flow Chart 2. If no changes are found commence notifications at the conclusion of inspection. 7. Notify the SES Operations Centre, Wollongong, of inspection results <p>Note: If dam failure is considered imminent, proceed to Step 2, otherwise proceed to Step 3.</p>
2 (operator*)	Dam failure in progress or severe damage such as: <ol style="list-style-type: none"> 1. Major change to: <ul style="list-style-type: none"> - Seepage - Seepage turbidity - Sudden, extensive cracks 2. Seepage through joints and cracks 3. Seepage through abutment 4. Major cracks in concrete structures 5. Major movement of outlet works tunnel(s) 	Activate Emergency Response <i>Red Alert</i> Procedure.



Step No. (personnel)	Description	Action
3 (operator*)	Visible damage has occurred but is not serious enough to cause immediate failure of the dam.	<ol style="list-style-type: none"> 1. Activate White Alert; 2. Quickly observe nature, location and extent of damage - document and photographs relevant items such as seeps, depth and openness of cracks, reservoir level, mechanical function, etc; 3. Report all information to the relevant personnel as defined in Table 3.4. When reporting, state coherently all necessary information, especially the extent of damage; 4. Reinspect the site and maintain communications logs; 5. Be prepared to make additional inspections at any time because of possible aftershocks.
4 (team**)	Thorough post-earthquake inspection by experienced Inspector(s) to be carried out after Step 1 and Step 2.	<p>Thoroughly inspect dam embankment, abutments and appurtenant works. Include all items normally examined in routine inspections. In particular check for:</p> <ol style="list-style-type: none"> 1. Transverse cracks through the embankment, especially near the abutments; 2. Longitudinal cracks in the embankment near the crest especially at the maximum section; 3. Obvious settlement or misalignment of the dam crest - determine location; 4. Changed or new seepage - determine location, rate, turbidity; 5. Differential movement at all concrete/embankment interfaces - determine extent and degree of opening; 6. Damage to concrete structures, eg spillway, outlet tower, tunnels, etc; 7. Damage to mechanical and electrical plant, especially equipment used for drawing down the reservoir; 8. Mark all cracks and protect them from rainfall and erosion; ensure that a marking material, such as dye or paint, is introduced into open cracks, so that crack depths can be determined later. <p>Report all findings to the Dams Safety NSW, Dams Consultant and the Dams Manager.</p>
5 (operator* and/or team**)	Instrument monitoring.	<p>Monitor all dam instrumentation, including survey points, seepage points etc. This should be carried out as soon as possible after the event by trained personnel, and the monitoring of selected instruments should be repeated at frequent intervals if the dam has been damaged, or if there are anomalous instrument readings. If condition deteriorates so that dam failure becomes a possibility, activate a Red Alert.</p> <p>If damage is not visible and if instrument readings are normal, continue to visually inspect the facilities and monitor seepage and water levels once a day for at least two days, since damage effects may be delayed.</p>
6 (operator*)	There is no evidence of damage to the dam or appurtenant structures.	Submit a "No Damage" report. Proceed to Step 9.



Step No. (personnel)	Description	Action
7 (operator* and team**)	Primary actions (damaged dam).	<p>In the event of damage to the dam the following actions should be carried out if possible prior to the follow-up inspection and/or the implementation of any remedial works:</p> <ol style="list-style-type: none"> 1. Mark all cracks and protect them from rainfall and erosion; ensure that a marking material, such as a dye or paint, is introduced into open cracks, so that crack depths can be determined later. The cracks should be mapped for future reference in assessing damage to the dam and for planning repairs. If required, construct a barrier around the crack(s) in order to comply with OH&S requirements; 2. Ensure that power supplies and communications are operational. If not, repair them or make arrangements for temporary or backup systems including portable generators, two-way radios, mobiles, telephones, etc.; 3. Monitor any turbid seepage closely and in accordance with Chart 3 and Chart 4 until the causes are determined or the cloudiness stops. It may be that the spillway “plumbing” has been shaken and sediment in drains has loosened and is washing out, or it could be that piping and internal erosion failure has initiated; 4. Monitor any other unusual conditions. Any visual deformations are justification for a survey of measurement points, but survey should generally be initiated after strong earthquake shaking to obtain records; 5. Be prepared to draw down the reservoir if instructed by the investigation team – check all gates, valves, etc. are operational and no damage to the outlet conduits or tunnel is observed. Lowering the reservoir should NOT be carried out until these checks are made and the investigation team has determined that the draw down is necessary; 6. Carry out any other instructions issued by the investigation team.
8 (operator* & team**)	Seismic aftershocks.	Be prepared to restart the Procedures if any aftershocks meet the initiating criteria.



Step No. (personnel)	Description	Action
9 (operator* and team**)	Subsequent inspection.	Since some damage to structures may not be readily apparent during the post-earthquake inspection or conditions may deteriorate, over time. Carry out a subsequent inspection two to four weeks after the initial inspection if the earthquake accelerations have been recorded and are 0.05g or greater at the site, or if earthquake shaking has been felt within several kilometres of the dam.

* Operating/maintenance person or personnel

** Experienced inspector or engineer or team of experienced personnel with specialties pertinent to the dam structures.



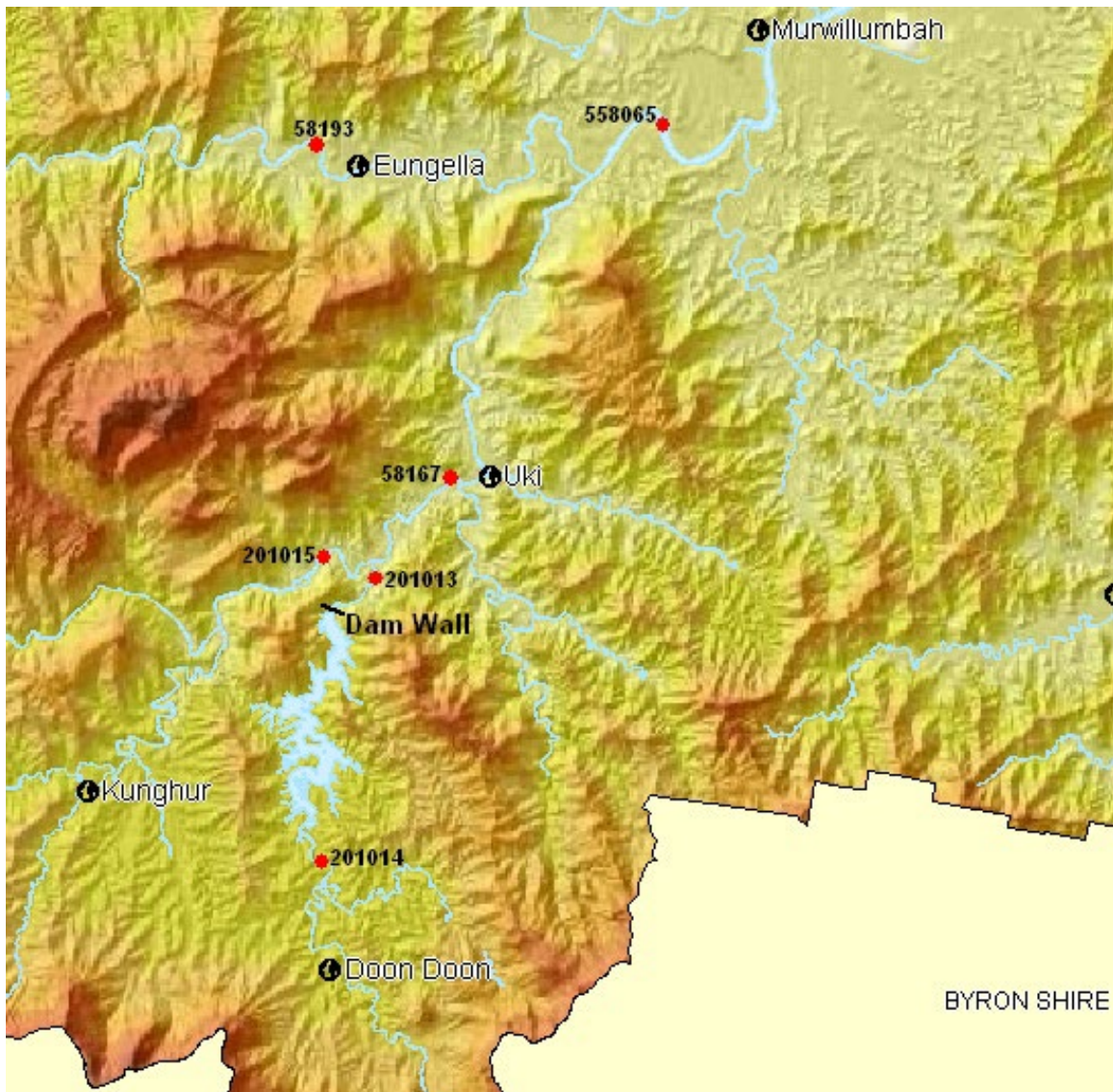
Appendix E
Stream Gauges Relevant to the Clarrie Hall Dam Area



Stream Gauges Relevant to the Clarrie Hall Dam Area

Table 0.1 – Relevant Stream Gauges

Station No	Location	Type (A or M)	Owner	Gauge Zero
201013	Doon Doon Creek. D/S CHD	Automatic (2009)	TSC	20.33m AHD
201015	Tweed River D/S Palmers Rd Crossing	Automatic (2009)	TSC	29.18m AHD
201014	Doon Doon Creek at Fogarty's Dip (Not operational)	Manual	TSC	
558065	Bray Park Weir	Automatic	TSC	1.00m AHD
58167	Uki D/S of WTP intake	Automatic	TSC	
58193	Eungella (Oxley River)	Automatic	TSC	



Geographical positions of stream gauges



Appendix F
Communications Log

COMMUNICATIONS LOG – CLARRIE HALL DAM DSEP

DATE	TIME	FROM	TO	Water Level	DISCUSSION	ACTION

Name: _____

Position: _____

Sheet ___ of ___

Signed: _____

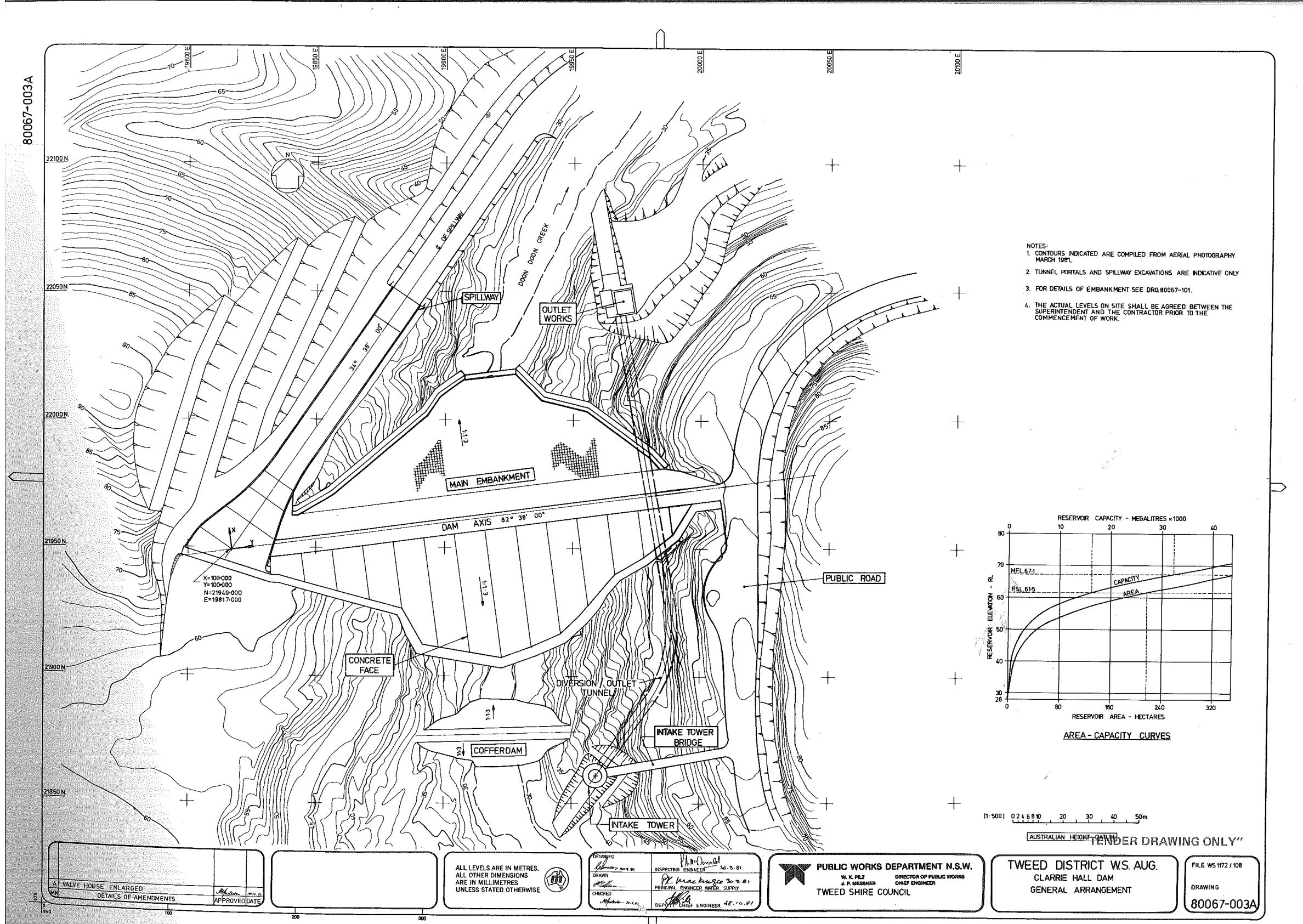
Date: _____ (Note – Rule a line before the start of each new record)



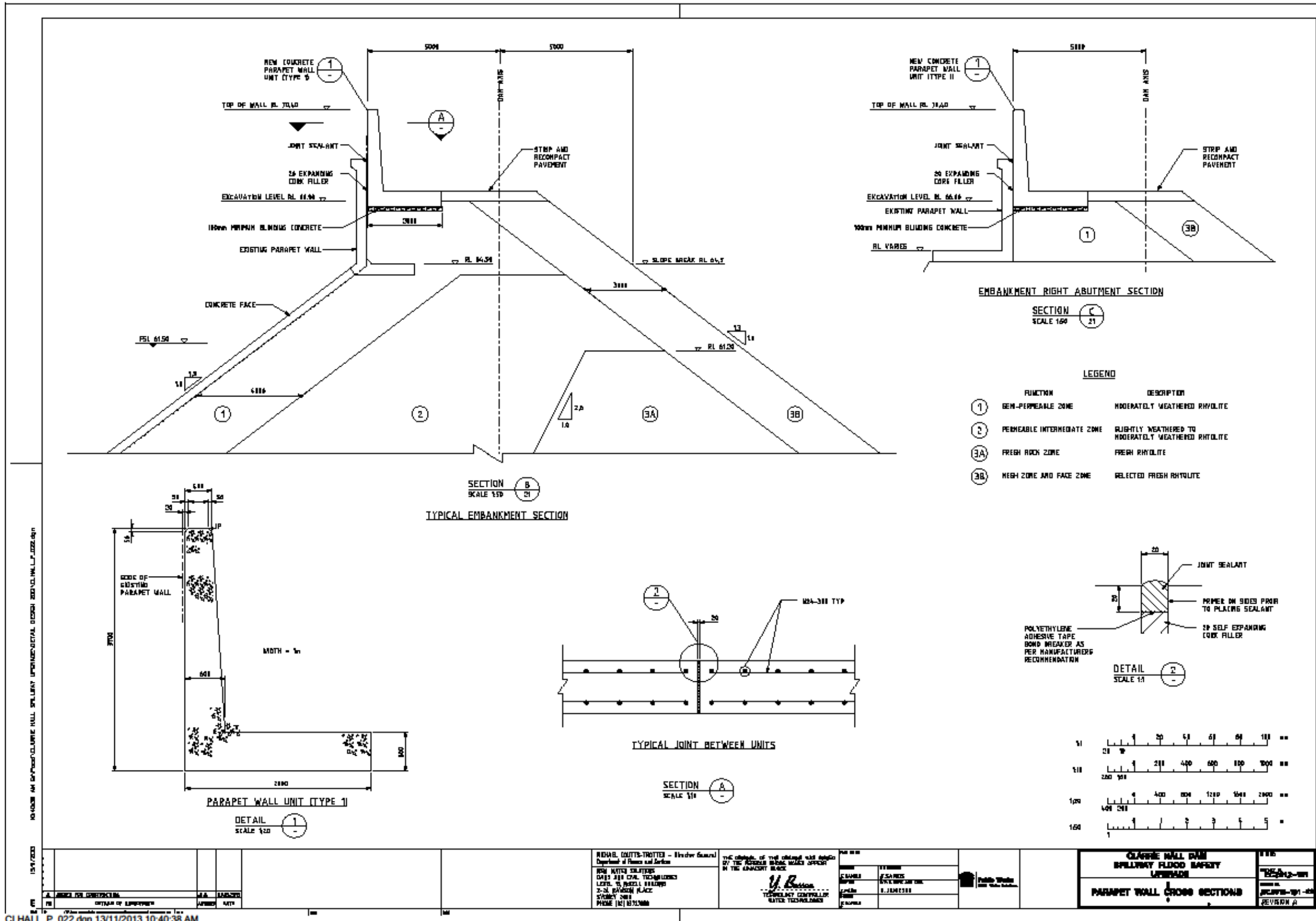
Appendix G

General Arrangement of Clarrie Hall Dam

Drawing 1 - 80067-003A



Drawing 3 - Clarrie Hall Dam Spillway Flood Safety Upgrade 022.dgn



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