QUEENSLAND FLOOD COMMISSION OF INQUIRY

WITNESS STATEMENT OF ROBERT ARNOLD AYRE

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I, **ROBERT ARNOLD AYRE**, of c/- SunWater Limited (**SunWater**), Level 10, 179 Turbot Street, Brisbane in the State of Queensland state as follows:

INTRODUCTION

My position at SunWater

1 I am the Headworks Design Manager employed by SunWater Limited (**SunWater**) in the Infrastructure Development Group.

2 I also have a further role at SunWater as a Senior Flood Operations Engineer. SunWater provides engineers and technical officers to assist Seqwater in operating the Flood Operations Centre during flood events. I was the Senior Flood Operations Engineer for Wivenhoe, Somerset and North Pine Dams during the January 2011 Flood Event.

3 The January 2011 Flood Event commenced on Thursday 6 January 2011 and finished on 19 January 2011.

Nature of this statement

4 This statement addresses my involvement in the January 2011 Flood Event in my capacity as the Senior Flood Operations Engineer for Wivenhoe, Somerset and North Pine Dams.

5 The opinions that are contained in this statement are my own. I do not provide this statement on behalf of Seqwater.

A preliminary statement

6 This statement has been provided without any knowledge of the contents of other evidence that will or may be adduced, or the submissions that have or will be made to the Commission of Inquiry. I will supplement this statement with addendum statements if it is necessary.

7 I will provide any further information or explanation required by the Commission of Inquiry.

8 A glossary of terms is contained on page 95 of this statement.

9 Documents referenced in this statement can be provided on request.

QUALIFICATIONS, EMPLOYMENT HISTORY AND EXPERIENCE

Qualifications & professional affiliations

10 I have obtained the following qualifications:

(a) Bachelor of Engineering (Civil) from the Queensland Institute of Technology – 1983; and

(b) Post-graduate Certificate in Hydrology from the University of New South Wales - 1986.

11 I have the following professional affiliations:

(a) Member of the Institution of Engineers, Australia;

(b) Chartered Professional Engineer;

(c) Registrant on the National Professional Engineers Register;

(d) Member of the Association of Professional Engineers, Scientists and Managers, Australia;

(e) Registered Professional Engineer with the Board of Professional Engineers Queensland; and

(f) Associate Member of the Australian Institute of Project Management.

Experience in water engineering

12 I have over 28 years experience in water engineering projects related to Queensland's surface water resources.

Areas of expertise

13 My areas of expertise include:

(a) Design flood hydrology;

(b) Dam safety and risk assessment;

(c) River hydraulic modelling;

(d) Water resource simulation;

(e) Drought management; and

(f) Environmental flow assessment.

14 In relation to dam safety and risk assessment, I have supervised the revision of design flood estimates for all of SunWater's dams and I have been involved in the assessment of downstream consequences as input into the Spillway Capacity Upgrade Program. This is a part of SunWater's overall Dam Safety Management Program and Dam Safety Upgrade Program.

15 My main area of technical interest includes flood estimation and hydraulic modelling of flood plain flows. I have developed expertise in the areas of flood forecasting and flood operation of dams with gated spillways.

16 In relation to hydrologic modelling, I have been involved in the following:

(a) Burrum River Flow Management Plan;

(b) South East Queensland Water Corporation Drought Management Strategy;

(c) Tweed Shire Council Drought Management Strategy;

(d) Brisbane River and Pine River Flood Studies;

(e) Comet River Dams – Design Flood Hydrology;

(f) Merrimac Drainage Study; and

(g) Callide Valley Conjunctive Use Study.

17 In relation to hydraulic modelling, I have been involved in the following:

(a) Connors River Dam Backwater Investigation;

(b) Nathan Dam Backwater Investigation;

(c) Nathan Dam Failure Impact Assessment;

(d) Rookwood Weir Backwater Investigation;

(e) Eden Bann Weir Raising Backwater Investigation;

(f) Lenthalls Dam – Dam Failure Analysis;

(g) Splityard Creek Dam – Dam Failure Analysis;

(h) Burnett River Dam Backwater Investigation;

(i) Coomera River Flood Study;

(j) Nogoa River Flood Plain Study;

(k) Nerang-Broadbeach Hydraulic Investigation;

(l) Townsville Port Access Road Investigation;

(m) Ingham Bypass Hydraulic Assessment;

(n) Nerang River Flood Plain Study;

(o) Babinda Bypass Hydraulic Assessment;

(p) Tully-Millstream Hydro-Electric Project;

(q) Bjelke-Petersen Dam – Dam Failure Analysis; and

(r) Dawson River Weirs Hydraulic Assessment.

18 The studies that I have been involved in have given me considerable experience in hydrologic modelling, which is necessary for the application of the Real Time Flood Model, which is used during flood events (as described in paragraph 159).

19 I am familiar with water resource planning and management, as well as dam safety and flood mitigation manual provisions of the *Water Supply (Safety and Reliability) Act 2008* (Qld).

20 I am experienced in hydrologic and hydraulic modelling systems ranging from databases, such as HYDSYS and TimeStudio, to runoff-routing models, such as RORB and URBS and water resource simulation models, such as WAM, WT16 and IQQM. I also have an intimate understanding of the RTFM System and the ALERT System.

21 I am very experienced in the use of one-dimensional and two-dimensional hydraulic models including RUBICON, MIKE-11 and FESWMS, a finite element depth averaged hydrodynamic model.

22 I pioneered the use of the US National Weather Service DAMBRK model in the Queensland Water Resource Commission for the conduct of dam failure analyses in the late 1980s.

23 Over the last 9 years, I have held roles as manager of water studies (a number of which are listed above), special projects and engineering design profit centres within the consultancy arm of SunWater. I have been responsible for the management of a range of project studies during that time.

24 From 1994 to 1996, I was the project leader for the hydrologic and hydraulic modelling team associated with a review of the design flood hydrology and conduct of a dam failure analysis of Somerset Dam, Wivenhoe Dam and North Pine Dam.

25 In this role, I was responsible for the revision of the design flood hydrology of each of the dams assessed using runoff-routing and flood frequency techniques.

26 In addition, dam failure analyses were undertaken using DAMBRK and RUBICON hydraulic models for input into Emergency Action Plans for the reservoirs.

Publications

27 I have had a number of publications published from 1987 to 2009. Relevant publications include:

(a) 'North Pine Dam Post-dam Flood Frequency Analysis.' 6th Queensland Hydrology Symposium, Institution of Engineers, Australia, February 1992;

(b) 'Areal Reduction factors for Large Catchments and Long Duration Storm Events.' 7th Queensland Hydrology Symposium, Institution of Engineers, Australia, February 1993 (co-authored with J L Ruffini);

(c) 'A Real Time Flood Operations Model for Somerset, Wivenhoe and North Pine Dams.' Fifth Hydraulics in Civil Engineering Conference, Institution of Engineers, Australia, February 1995 (co-authored with J L Ruffini, W Shallcross and B Alderton);

(d) 'Two-dimensional Hydraulic Modelling.' Australian Water and Wastewater Association, March 1998 (co-authored by M J Raymond);

(e) 'Flood Management Operations in Real Time.' Queensland Conference of the Institute of Public Waters Engineering Australia, October 2000;

(f) 'Meeting Referable Dam and Water Management Requirements of the Queensland Water Act – A '*How to*' Guide.' Australian National Committee of Large Dams Conference, October 2002 (co-authored by T L McGrath);

(g) 'Flood Management of Lake Burley Griffin.' 29th Hydrology and Water Resources Symposium, February 2005 (co-authored with W J Shallcross and S Sritharan);

(h) 'Revised Extreme Floods in Tropical Regions.' Australian National Committee of Large Dams Conference, November 2005 (co-authored by T L McGrath);

(i) 'Fairbairn Dam – Performance in Flood of Record.' Australian National Committee of Large Dams Conference, November 2008 (co-authored by T A Malone); and

(j) 'Ross River Dam Upgrade – Flood Commissioning Experience.' Australian National Committee of Large Dams Conference, November 2009 (co-authored by P R Richardson, S Gillespie and M Harvey).

Employment history

28 I joined the Queensland Water Resource Commission in 1983 as a graduate engineer and remained there until 1989.

29 From 1989 to 1990 I worked at Kinhill Cameron McNamara Pty Ltd in the water engineering section.

30 From 1990 to 1997 I was a senior engineer at the Department of Natural Resources in the Surface Water Assessment Group.

31 From 1997 to 2000 I returned to Kinhill Pty Ltd (as it was then called, it is now KBR Pty Ltd) as a senior engineer in the water engineering section. In that role I was involved in undertaking and supervising hydrologic and hydraulic investigations for a variety of clients and locations throughout Australia.

32 In June 2000, SunWater was awarded a contract for flood operations for Scrivener Dam and I was appointed the Senior Duty Flood Operations Engineer for the National Capital Authority.

33 From 2000 to 2002 I joined SunWater as a senior engineer in the capacity of a technical expert in hydrology and hydraulics. In this role I provided advice for the delivery of water resource projects and to manage the flood operations of dams.

34 My role in SunWater then changed to project manager of water studies in 2002 to 2004. In addition to my role as a technical expert in hydrology and hydraulics I was also responsible for the development and profitability of the Water Studies profit centre.

35 I was a Duty Flood Operations Engineer for Wivenhoe, Somerset and North Pine Dams from 1996 to 1997 and again from 2000 to 2002.

36 I have been the Senior Flood Operations Engineer for Wivenhoe, Somerset and North Pine Dams since 2002.

37 Since I have been the flood operations engineer for Wivenhoe, Somerset and North Pine Dams there have been the following flood events at the following Dams (I note the start dates for each flood event listed below is the date for when the first gate was operated at each Dam):

(a) 2000/2001 wet season:

(i) Wivenhoe Dam – 5 February 2001 to 10 February 2001;

(ii) Somerset Dam – 6 February 2001 to 10 February 2001; and

(iii) North Pine Dam – 6 February 2001 to 8 February 2001.

(b) 2008/2009 wet season:

(i) Somerset Dam – 14 April 2009 to 17 April 2009;

(ii) North Pine Dam – 19 May 2009 to 22 May 2009;

(iii) Somerset Dam – 19 May 2009 to 22 May 2009;

(iv) North Pine Dam – 4 June 2009 to 4 June 2009;

(v) Somerset Dam – 22 June 2009 to 8 July 2009; and

(vi) North Pine Dam – 22 June 2009 to 8 July 2009.

(c) 2009/2010 wet season:

(i) North Pine Dam – 16 February 2010 to 18 February 2010;

(ii) Somerset Dam – 24 February 2010 to 18 March 2010;

(iii) North Pine Dam – 26 February 2010 to 4 March 2010;

(iv) North Pine Dam – 4 March 2010 to 6 March 2010; and

(v) North Pine Dam – 10 March 2010 to 11 March 2010.

(d) 2010/2011 wet season:

(i) Somerset Dam – 9 October 2010 to 18 October 2010;

(ii) Wivenhoe Dam – 9 October 2010 to 18 October 2010;

(iii) North Pine Dam – 10 October 2010 to 14 October 2010;

(iv) North Pine Dam – 16 October 2010 to 16 October 2010;

(v) Somerset Dam – 2 December 2010 to 17 December 2010;

(vi) North Pine Dam – 4 December 2010 to 5 December 2010;

(vii) North Pine Dam – 6 December 2010 to 7 December 2010;

(viii) North Pine Dam – 9 December 2010 to 10 December 2010;

(ix) Wivenhoe Dam – 13 December 2010 to 16 December 2010;

(x) North Pine Dam – 14 December 2010 to 15 December 2010;

(xi) North Pine Dam – 16 December 2010 to 17 December 2010;

(xii) Wivenhoe Dam – 17 December 2010 to 24 December 2010;

(xiii) Somerset Dam – 18 December 2010 to 23 December 2010;

(xiv) North Pine Dam – 18 December 2010 to 19 December 2010;

(xv) North Pine Dam – 23 December 2010 to 24 December 2010;

(xvi) North Pine Dam – 25 December 2010 to 26 December 2010;

(xvii) Somerset Dam – 26 December 2010 to 31 December 2010;

(xviii) Wivenhoe Dam – 26 December 2010 to 2 January 2011;

(xix) North Pine Dam – 1 January 2011 to 2 January 2011;

(xx) North Pine Dam – 6 January 2011 to 14 January 2011;

(xxi) Wivenhoe Dam – 7 January 2011 to 19 January 2011;

(xxii) Somerset Dam – 8 January 2011 to 17 January 2011;

(xxiii) North Pine Dam – 18 January 2011 to 19 January 2011;

(xxiv) North Pine Dam – 20 January 2011 to 20 January 2011;

(xxv) North Pine Dam – 21 February 2011 to 22 February 2011; and

(xxvi) North Pine Dam – 4 March 2011 to 5 March 2011.

38 In November 2007, SunWater was awarded the contract for flood operations for Ross River Dam and I was appointed the Senior Duty Flood Operations Engineer for this contract.

CURRENT ROLES WITH SUNWATER

Headworks Design Manager

39 My current role with SunWater, which I commenced in July 2004, is as the Headworks Design Manager in the Infrastructure Development Business Unit.

40 In particular I am responsible for:

(a) Project management of projects controlled by the Headworks Design Group (**HDG**) ; and

(b) Business development and profitability of the HDG.

41 The HDG provides existing and potential water infrastructure owners with engineering and associated services including feasibility planning, design and project management for dams, weirs and fish ways.

Senior Flood Operations Engineer

42 In addition to my position as Headworks Design Manager, I am also the Senior Flood Operations Engineer for SunWater.

43 Although it is secondary to my Headworks Design Manager role, my role as Senior Flood Operations Engineer takes priority when there is a flood event.

44 In this role, I provide advice and conduct flood operations on behalf of SunWater for:

(a) Queensland Bulk Water Supply Authority, trading as Seqwater, flood operations management service – this includes Somerset, Wivenhoe and North Pine Dams;

(b) Ross River Dam flood operations – this dam is located in Townsville, North Queensland; and

(c) Scrivener Dam flood operations – this dam is located in the Australian Capital Territory.

45 In relation to the Seqwater flood management service, I am one of four engineers responsible for the direction of flood operations for Wivenhoe, Somerset and North Pine Dams and charged with ensuring that the Dams are operated in accordance with the flood operations manual requirements during flood events. My role as the Senior Flood Operations Engineer includes setting the strategy in accordance with the flood operations manuals during flood events. I deal with the strategies contained in the flood operation manuals in more detail later in this statement.

46 In my role as Senior Flood Operations Engineer, I am involved in the ongoing training of the flood response team members and supervision of the monitoring of the real time flood operations modelling system. This includes ensuring the performance of the system is to an appropriate standard.

47 I am also involved in the preparation and submission of routine reports and event reports to the regulator of dam safety within the Department of Environment and Resource Management (**DERM**).

48 From 1994 to 1996, I was also the project leader for the implementation and commissioning phase of the Brisbane River and Pine River Flood Study, which involved the finalisation of the development of a real time flood operations model for the dams owned and operated by Seqwater.

49 This role included responsibility for the supervision of the establishment of the flood control centre as it was named then, and now named 'Flood Operations Centre' (**FOC**), and the training of operators in the use of the system (as described below).

ABOUT SUNWATER AND SEQWATER

SunWater's history

50 SunWater was established as a statutory Government Owned Corporation on 1 October 2000.

51 On 1 July 2008, SunWater transitioned into a company Government Owned Corporation and became 'SunWater Limited'.

52 SunWater is a registered 'Large Service Provider for Water Supply and Sewerage Services' under the *Water Supply (Safety and Reliability Act) 2000* and is licensed to provide bulk, irrigation and retail water services as well as drainage and sewerage services.

53 SunWater is a bulk water infrastructure developer, owner and manager and specialises in:

(a) Design and design review services;

(b) Infrastructure development;

(c) Asset management, planning and review;

(d) Flood hydrology, hydraulics and flood management;

(e) Infrastructure operations and management;

(f) Customer water account management and billing; and

(g) Water management and policy strategy advice.

Seqwater

54 Seqwater is the trading name of the Queensland Bulk Water Supply Authority.

55 From 1990 to 1993, the Brisbane Area Water Board. In about 1993 or 1994, its name changed to the South East Queensland Water Board. In 2000 the South East Queensland Water Board's undertakings were transferred to the South East Queensland Water Corporation trading as SEQ Water. .

56 In 2007, the Queensland Bulk Water Supply Authority was established under section 6 of the *South East Queensland Water (Restructuring) Act 2007*. Prior to this date, a number of entities owned and operated bulk water supply infrastructure.

57 From 1 July 2008, the Queensland Bulk Water Supply Authority commenced trading as Seqwater and from this date took over ownership of bulk water supply infrastructure in South East Queensland, such as dams, weirs and aquifers including those which had been transferred to SunWater. Relevant staff were also transferred from SunWater from Seqwater as part of the aggregation of bulk supply infrastructure to Seqwater.

SunWater working with Seqwater

58 SunWater is a bulk water infrastructure developer, owner and manager. Prior to 2008, SunWater operated a number of dams for Seqwater under a facilities management agreement. Following a restructure of entities within the water industry under the *South East Queensland Water (Restructuring) Act 2007*, Seqwater acquired responsibility for the operation of a number of dams that had previously fallen under the facilities management agreement.

59 However, following that restructure, SunWater has provided and continues to provide flood operations services to Seqwater in respect of these dams under a Service Level Agreement in relation to the Wivenhoe, Somerset and North Pine Dams. Under this Agreement, SunWater provides the following services to Seqwater (in summary):

(a) SunWater has established and operates a FOC and back-up facility from which flood operations for those Dams is conducted by engineers from Seqwater, SunWater and DERM; and

(b) SunWater provides expert engineers and technical assistants for flood operations at those Dams; and

(c) SunWater engineers assist in the preparation of the flood report that is required by the flood operations manuals to be submitted by Seqwater to DERM for those Dams following a flood event.

60 In relation to (b) and (c) above, at present SunWater provides one expert engineer (me) and five technical assistants. The other three flood engineers and four technical assistants are employed by Seqwater and DERM.

61 The FOC from which flood events at Wivenhoe, Somerset and North Pine Dams are conducted is located in SunWater's premises on Turbot Street.

THE LEGISLATIVE FRAMEWORK GOVERNING WIVENHOE, SOMERSET AND NORTH PINE DAMS

62 The purpose of the *Water Supply (Safety and Reliability) Act 2008* is to provide for the safety and reliability of water supply (section 3(1)).

63 The purpose is achieved primarily by:

(a) Providing for:

(i) A regulatory framework for providing water and sewerage services in the State, including functions and powers of service providers;

(ii) A regulatory framework for providing recycled water and drinking water quality, primarily for protecting public health;

(iii) The regulation of referable dams;

(iv) Flood mitigation responsibilities; and

(b) Protecting the interests of customers of service providers.

64 Wivenhoe, Somerset and North Pine Dams are all referable dams within the meaning of section 341 of the *Water Supply (Safety and Reliability) Act 2008.*

65 Chapter 4, Division 5, Part 2 of the *Water Supply (Safety and Reliability) Act 2008* deals with the requirement for an owner of a dam nominated by regulation to prepare a 'flood mitigation manual' of operational procedures for flood mitigation for the dam.

66 Under section 370 of the *Water Supply (Safety and Reliability) Act 2008*, owners of dams prescribed by regulation under section 370 must prepare a flood mitigation manual for their dams for approval by the Chief Executive. The Chief Executive may approve the manual under section 371 of the *Water Supply (Safety and Reliability) Act 2008.*

67 The Explanatory Note to the *Water Supply (Safety and Reliability) Bill 2008* (at pages 122-123) states:

'A dam nominated in the regulation will be a dam which was constructed for the purpose of flood mitigation. A flood mitigation manual ensures that such dams make controlled releases of water for flood mitigation purposes in accordance with pre-

agreed conditions.'

68 No such regulation has yet been passed under the *Water Supply (Safety and Reliability) Act 2008*, however there are existing manuals approved under the now repealed provisions in the *Water Act 2000* (these provisions were essentially transferred to the *Water Supply (Safety and Reliability) Act 2008*). There are flood mitigation manuals for Wivenhoe, Somerset and North Pine Dams that were prepared and approved under the previous version of the *Water Act 2000*.

69 These manuals are taken to be manuals approved under section 371 by force of the transitional provisions set out in section 613 of the *Water Supply (Safety and Reliability) Act 2008*.

70 The current flood mitigation manuals for Wivenhoe, Somerset and North Pine Dams are:

(a) *Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam* (Revision 7: dated November 2009) (**the W&S Manual**)

(b) *Manual of Operational Procedures for Flood Mitigation at North Pine Dam* (Revision 5: dated August 2010) (**the NP Manual**)

71 In addition to the W&S and NP Manuals, the flood engineers operate under a Seqwater Flood Operations Procedures Manual (**the Procedures Manual**). The Procedures Manual is not a regulatory document. The Procedures Manual is a procedural document prepared to assist in flood management of the Dams. The procedures set out within the Procedures Manual are consistent with and supplement the requirements of the W&S and NP Manuals.

THE DAMS

Wivenhoe Dam

72 Wivenhoe Dam, on the Brisbane River, was built in 1984 and designed by the Queensland Water Resources Commission.

73 Wivenhoe Dam was built to supplement Brisbane's water supply and to provide flood mitigation for the Brisbane River. The Dam was fitted with radial gates, which increase the storage capacity and which are also used to release water at set times during flood events.

74 Wivenhoe Dam has a mass gravity concrete main spillway with a 2.1km long earth and rock fill embankment. There are also two earth and rock fill saddle dams located on the left bank looking downstream.

75 Wivenhoe Dam is a multi-functional dam, which is used for the storage and supply of water, for flood mitigation and also as the lower pumping pool for the hydro-electric generation scheme.

76 The policy behind the operation of Wivenhoe Dam involves the balancing of Wivenhoe Dam's functions, namely securing water supply and providing flood mitigation.

77 The catchment area of Wivenhoe Dam is approximately 7,000km^2. The surface area of Lake Wivenhoe is approximately 10,820ha.

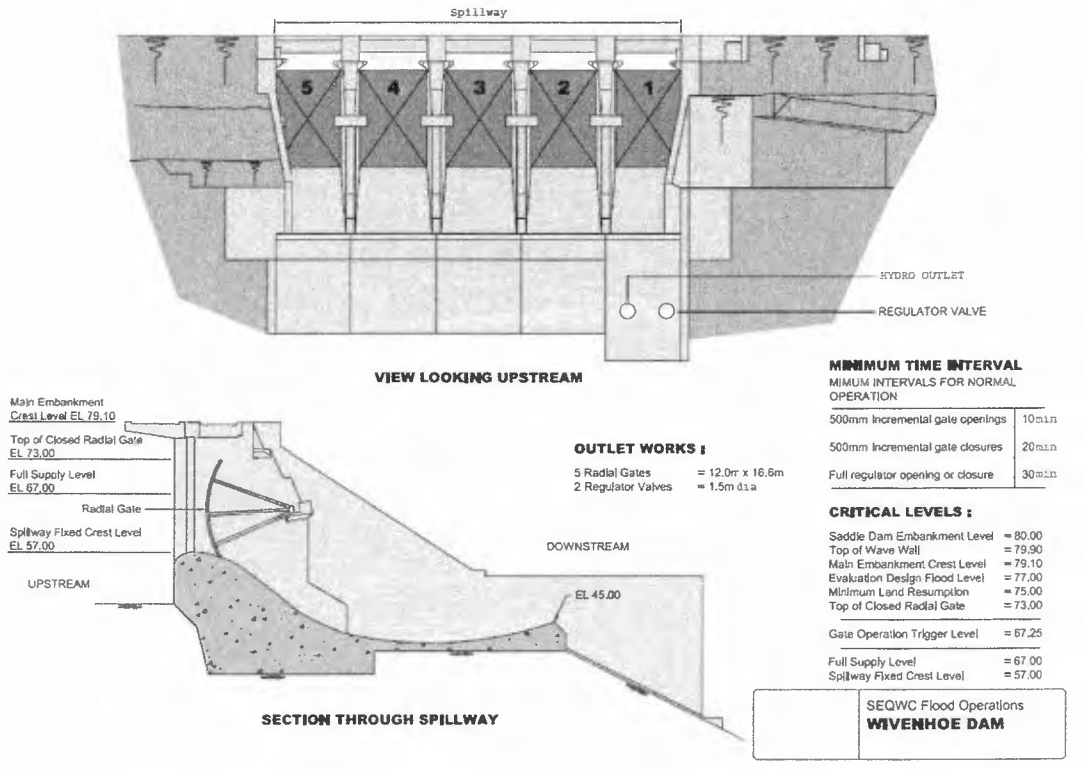
78 According to the W&S Manual, the spillway gates are not to be opened for flood control purposes prior to the reservoir level exceeding 67.25m Australian Height Datum (**AHD**).

79 The primary infrastructure used to release floodwaters during flood events at Wivenhoe Dam consists of radial gates and an auxiliary spillway. There are five radial gates located in the main spillway. The auxiliary spillway consists of a three bay fuse plug spillway at the right of the abutment.

80 The radial gates are numbered sequentially from 1 to 5 from left to right looking in the downstream direction (see Appendix H to the W&S Manual). The flip bucket in the main spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. This operates to dissipate the energy of the discharge through the flip bucket throwing the discharge clear of the concrete structures into a plunge pool where the energy is dissipated by turbulence.

81 Each radial gate consists of a cylindrical upstream skin-plate segment that is attached to the radial arms. The cylindrical axis is horizontal and each gate rotates about two spherical trunnion bearings that are on this axis. The position of the gate is controlled by hydraulically driven winches that are located on the piers beside the gates. Wire ropes are attached to the downstream face of the skin plate through a pulley system. When the hydraulic motors are not energised, the gates are held in position by spring loaded friction brakes on the winches.

82 The arrangement of the radial gates is shown in the following diagram:



83 In the event of an equipment malfunction, back-up means of operating the gates are in place. Normal gate operation is by means of two electrical hydraulic pumps supplied by external mains supply electrical power, with pump number 1 connected to gates 1 and 2 and the penstock gate, while pump number 2 is connected to gates 3, 4 and 5. In the event of an external electric power failure, a diesel electric generator is used to supply power. The generator supplies sufficient power to operate the gates normally. This generator was available during the January 2011 Flood Event in the event of loss of external mains electric power. In the event of one of the electric hydraulic pumps failing, connecting valves between the pumps can be switched so that both sets of hydraulic lines are connected to the operable pump, thus allowing operation of all five gates, one at a time. In the event that both electric hydraulic pumps fail, either the mobile or fixed emergency pump can be used to operate the gates one at a time.

84 The capacity of the urban supply compartment that relates to Wivenhoe Dam's full supply level (**FSL**) is 1,165,000ML. The reservoir volume above the FSL that is used as temporary flood storage is 1,420,000ML, totalling 2,585,000ML. In rough figures, the FSL is approximately 45% of the total storage and flood mitigation capacity.

Somerset Dam

85 Somerset Dam on Lake Somerset is located on the Stanley River near Kilcoy, and has a catchment area of 1,340km². The surface area of Lake Somerset is approximately 4,400ha.

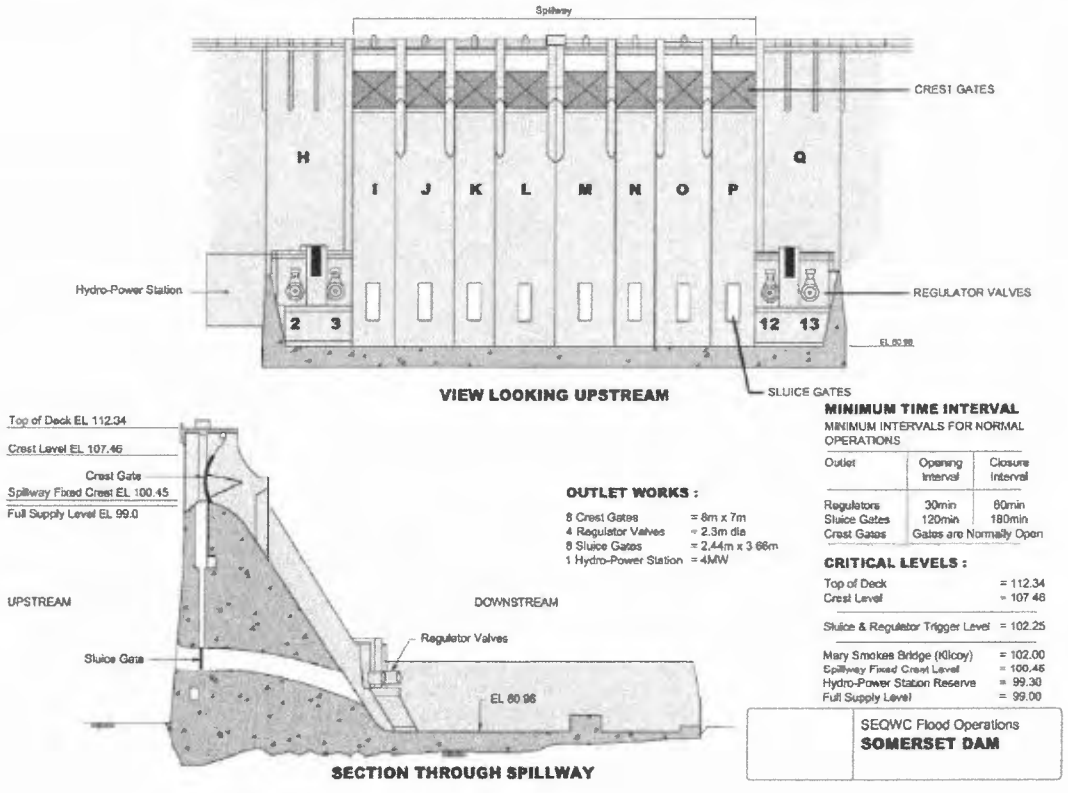
86 Somerset Dam was constructed by the Bureau of Industry Stanley River Works Board, with construction completed in 1953. Construction on Somerset Dam commenced in 1935, but was suspended due to the Second World War, before constructions resumed in 1948.

87 Somerset Dam releases into Wivenhoe Dam, which in turn releases into the Brisbane River.

88 The FSL of Somerset Dam is 99.0m AHD with a total current capacity of approximately 379,800ML. The Dam's flood mitigation capacity is 520,900ML above full capacity, totalling 900,700ML. The FSL represents approximately 42% of the total storage and flood mitigation capacity.

89 Radial crest gates, sluice gates and regulator valves are the primary infrastructure used to release water during flood events at Somerset Dam.

90 The following diagram displays the arrangement of the radial crest gates, sluice gates and regulator valves.



91 Somerset Dam is approximately 305m in length, and the maximum thickness at the base of the wall is approximately 41m. The Somerset Dam wall is a mass concrete gravity type, using a volume of 203,000m^3 of concrete, which resist the thrust of water by its weight alone. The top of the eight radial crest gates (8 x 7.97 x 7.01m) is 108m above sea level, 47m above the original stream bed and 53m above the base foundation of the wall.

92 In the event of a power supply failure at Somerset Dam, both a fixed and mobile diesel generator are available to operate the regulators, sluice gates and radial gates. The fixed generator can also power the crane. A mobile auxiliary generator is also available for the operation of the regulators and gates. If the spillway gate cannot be raised due to failure of the lifting machinery, the gantry crane may be attached to the gate to lift the gate manually.

Combined operation of Wivenhoe and Somerset Dams

93 Maximum overall flood mitigation is best achieved by operating Wivenhoe Dam in conjunction with Somerset Dam. To achieve this, a Wivenhoe / Somerset Operating Target Line is used to set a goal for balancing the flood storage in each Dam. The Operating Target Line seeks to achieve a relative equilibrium in dam levels between Wivenhoe and Somerset Dam to maximise the benefits of operating the Dams in conjunction with one another. I have provided further information in respect to the Operating Target Line from paragraph 282 of my statement below.

North Pine Dam

94 North Pine Dam on Lake Samsonvale is located on the North Pine River at Petrie. Construction of the Dam was completed in 1976. It has a catchment area of approximately 348km^2. The surface area of Lake Samsonvale is approximately 2,075ha.

95 North Pine Dam is a water supply dam with only a small flood storage compartment above FSL. It effectively has no significant provision for flood mitigation, and once the dam is full, floods will pass through the reservoir with little mitigation. The FSL is 39.6m AHD.

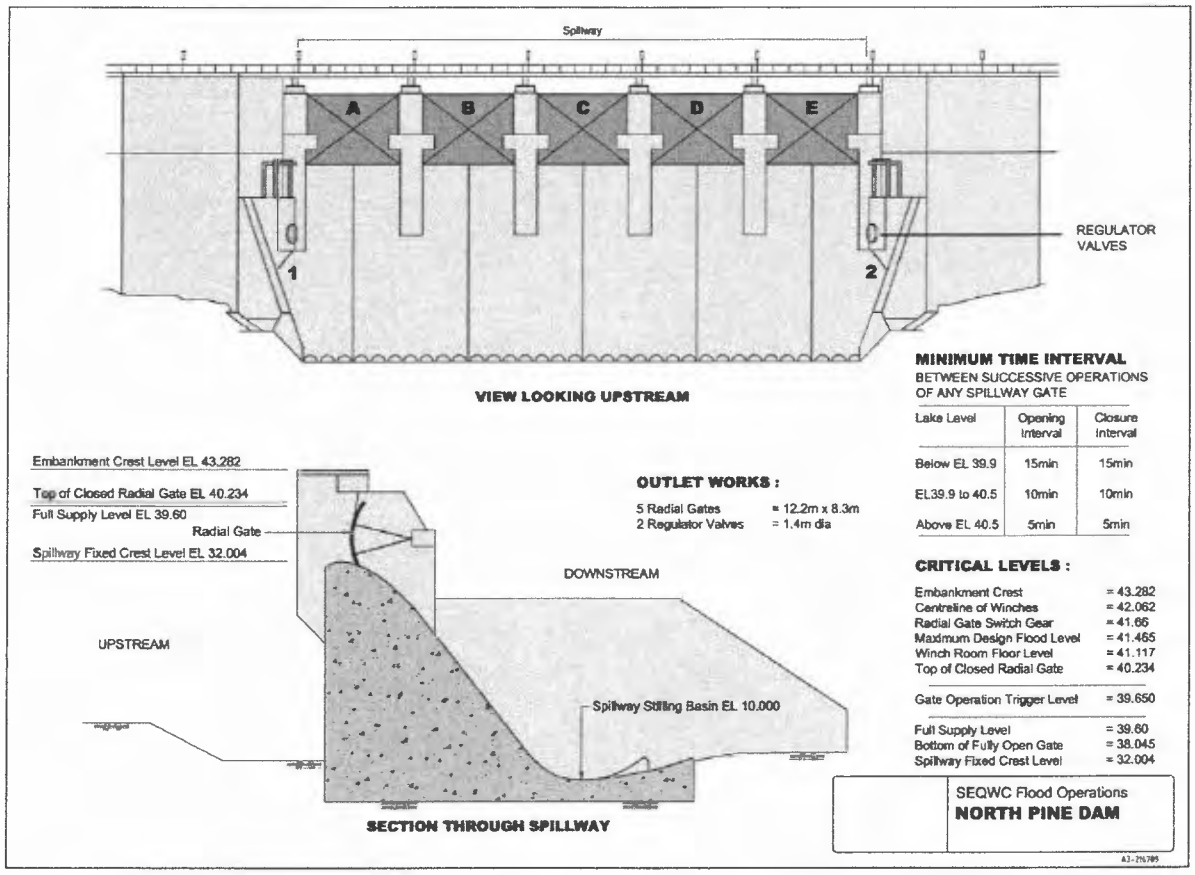
96 The NP Manual does refer to the Dam as having a "flood storage compartment", however, the volume of this compartment effectively only provides a short time delay between FSL being reached and flood releases commencing. The flood storage compartment's volume (the volume of water between FSL and the radial gate

opening trigger level) is 1,096ML, which represents only 0.5% of the full supply volume of the Dam.

97 The outlet system is a gated spillway located in a concrete gravity section with stilling basin and flanking retaining walls. North Pine Dam is a concrete gravity dam with earth fill embankments on abutments. The Dam wall is 580m long. There are also three earth fill saddle dams located on the right bank looking downstream.

98 Radial gates are the primary infrastructure used to release water during flood events at North Pine Dam. There are five radial gates. The spillway gates can be raised and lowered using electric motor driven winches that are normally powered from the mains electric supply. A standby diesel generator automatically cuts in to maintain electric supply in the event of a failure of the mains supply. There is also a mobile hydraulic unit, which can be used from the bridge deck of the Dam to operate individual gates as a further fall back option.

99 The following diagram demonstrates the arrangement of the five radial gates.



100 Gate operating sequences are conducted according to target minimum intervals. Section 8.6 of the NP Manual sets out the Target Minimum Intervals based upon lake levels. The gate opening sequence is different to that applied at Wivenhoe and

Somerset Dams. At North Pine Dam, the middle gate is opened first, followed by the two outside gates, followed by the two gates nearer the middle gate. A particular sequence is prescribed by the NP Manual, which is designed to minimise downstream erosion.

FUNCTIONS OF A DAM

101 Dams are typically designed to fulfil a particular purpose, or a combination of purposes, such as water supply, flood mitigation or hydro-electrical generation.

102 Wivenhoe and Somerset Dam are designed to fulfil a water supply and flood mitigation purpose. As previously explained, North Pine Dam is a water supply dam and does not provide any significant provision for flood mitigation.

103 If the purpose, or one of the purposes of the dam is water supply, that dam is designed and operated to store water in times of excess flow to capture that water to meet the needs of water users.

104 If one of the purposes of the dam is to mitigate floodwaters downstream, that dam can be used to reduce the impact of flooding downstream.

How the Dams attenuate or mitigate floods

105 The extent to which a dam impacts upon downstream floodwaters in a river system depends upon whether the dam has a flood mitigation capacity or not.

106 Dams with a flood mitigation capacity offer different benefits to dams that do not have a flood mitigation capacity, however, all dams attenuate a flood, whether they have a flood mitigation capacity or not.

Flood attenuation

107 Attenuation is the modifying effect a storage has on the shape of a flood wave or hydrograph (Water Resource Engineering, RK Linsley and JB Franzini, 3rd Ed 1984, p 60). A dam can attenuate floods in two ways. First, the peak of the discharge or the outflow from a dam will be less than the peak inflow. This mitigates a flood in two ways. The downstream flow rates do not achieve the same peak, and the downstream river heights will not be as high as they would otherwise have been. Secondly, the storage will delay the peak so that the peak outflow will occur some time after the peak inflow. This allows rainfall and runoff from rivers below a dam to

dissipate and expel before all of the inflow above the catchment is expelled from the dam. Similarly, this can reduce peak river heights and river flows.

Flood mitigation

108 Using a dam for flood mitigation is the process of reducing the impact of flooding downstream of the dam. Flood mitigation does not necessarily prevent downstream flooding. The larger an inflow event, the less capacity a dam has to mitigate the effects of flooding. A flood mitigation dam cannot completely prevent a flood where the total volume of water inflow during the flood event is greater than the Dam's flood storage capacity.

109 Further, the ratio of water supply to flood mitigation will limit the capacity of a dam to mitigate a flood. The higher the FSL relative to the flood storage capacity, the less capacity a dam has to mitigate the effects of flooding. The FSL for Wivenhoe Dam is 45% of the total flood storage capacity and for Somerset it is 42%. The flood storage compartment volume at North Pine Dam is only 0.5% of the FSL of the Dam.

110 Finally, a dam's capacity to mitigate closely occurring floods requires the return of the dam to FSL before the onset of a following flood event. If successive flood events occur before a dam can be returned to FSL, the dam will not be able to achieve its full potential in terms of flood mitigation.

Can Wivenhoe, Somerset and North Pine Dams mitigate floods?

111 Wivenhoe and Somerset Dam have the capacity to mitigate a range of floods. These dams can mitigate floods by controlling the outflow of floodwaters from the dams in accordance with predefined objectives.

112 North Pine Dam will offer an insubstantial flood mitigation benefit, but will offer a benefit in terms of flood attenuation by delaying the peak of the flood and reducing the peak outflow from what would otherwise have occurred and this would especially be the case if the level of the Dam was below FSL prior to the flood event occurring.

THE FLOOD OPERATIONS CENTRE

The FOC generally

113 The FOC for Wivenhoe, Somerset and North Pine Dams is the primary facility for collecting and analysing rainfall, river height and lake level data. The FOC is

currently located at SunWater's premises at 179 Turbot Street, Brisbane. The FOC is maintained in a fully operational state at all times and contains the following features:

(a) It is a locked, electronic protected room, but provides authorised personnel with access 24 hours a day, seven days a week.

(b) It contains all of the computer hardware and software required to gather data and forecast flood flows, with at least one layer of redundancy at all levels.

(c) It is connected to the building emergency power system and an un-interruptible power supply (UPS).

(d) It obtains rainfall and stream height data via direct feed radio base station facilities located within the building. Should these facilities fail, data can also be obtained using dedicated data lines connected to direct feed radio base station facilities at both Mineral House and at the Land Centre.

114 A back-up FOC facility is located at Mineral House and is operated by Seqwater. The back-up facility maintains similar operational characteristics.

115 During the January 2011 Flood Event the back-up FOC lost power, however, this did not impact upon the FOC, as the FOC remained fully functional during the event. Even if a loss of power had been experienced, the FOC is connected to the building's emergency standby generator, which starts when the mains power goes out.

116 All data review and analysis is undertaken from the FOC, and all operational decisions are made from the FOC. The FOC has a suite of computers and work stations that allow data to be received, analysed, reviewed and incorporated into models, which calculate predicted dam levels and runoff volumes. Various computers are dedicated to various tasks. A number of back-up computers are available to allow ancillary functions and tasks to be performed, such as internet and email access.

117 Communications from the FOC during a flood event are available through a landline telephone, a mobile telephone, a satellite telephone, the Seqwater radio network, facsimile and email.

Staffing of the FOC

118 There are four Flood Operations Engineers approved by the Chief Executive to direct the operations of Wivenhoe, Somerset and North Pine Dams during flood events. I

was the Senior Flood Operations Engineer during the January 2011 Flood Event for Wivenhoe, Somerset and North Pine Dams.

119 The FOC is not routinely staffed unless a flood event has been declared. A technical assistant will visit the FOC about once a day when there is no flood event to monitor the status of the Dams.

120 A 'flood event' is a situation where the Duty Flood Operations Engineer expects the water level at the dam to exceed the FSL.

121 Once a flood event occurs, or is expected to occur, the Duty Flood Operations Engineer on roster is required to declare a flood event, which results in the FOC being mobilised.

122 To maintain privacy of other individuals, I have referred to the three other Flood Operations Engineers as Engineer 2, Engineer 3 and Engineer 4.

123 In addition, there are nine technical assistants who work on a roster system in the FOC as Flood Officers. The technical assistants are allocated a specific part of the data collection network to review each week, such as rainfall or stream flow data.

124 The roles of the Senior Flood Operations Engineer and Flood Operations Engineers are defined in sections 2.3 and 2.4 of the W&S and NP Manuals. I will address these roles in more detail later in my statement.

125 When the FOC is mobilised, a Duty Flood Operations Engineer and two technical assistants operate the FOC. During the January 2011 Flood Event, the four Flood Operations Engineers each worked a shift on a rotational basis, with one engineer each working a 12 hour shift from 7am until 7pm. From 7pm on Sunday 9 January 2011, two engineers worked on each shift until the peak of the flood had passed and conditions had improved.

126 From Tuesday 11 January 2011 to Friday 14 January 2011, myself, Engineer 2 and Engineer 4 all stayed in the building because we could not get home during the flood event. Engineer 3 was able to get to and from home. The Duty Flood Operations Engineers who were not rostered to operate the FOC often went into the FOC to see if we could be of any assistance. However, the responsibility for flood operations always rested with the Duty Flood Operations Engineers on shift.

127 During the flood event, I slept in one of the meeting rooms outside of the FOC, and would return once I had rested and had something to eat even when I was not on shift.

128 Routinely, the four Duty Flood Operations Engineers work on a monthly roster, each doing one week on call at a time.

129 When a Duty Flood Operations Engineer is on call, he is required to stay within two hours of the FOC and needs to be contactable at all times. Each Duty Flood Operations Engineer has a separate mobile phone specifically used for the FOC.

130 Each Duty Flood Operations Engineer has remote Virtual Public Network (VPN) dial-in access to the FOC so that they are able to keep informed of the status of the dams and the strategies being implemented even when he is not rostered on.

131 When I am on call, I will generally be at my desk, where I can regularly check my emails. If I am aware that there is a lot of rainfall forecast during the night, I will check the levels and status of the dams throughout the night using remote access on blackberry or home computer. If the situation warrants, I would then attend the FOC to continue monitoring.

132 During the January 2011 Flood Event, a handover would occur at the end of each shift. This handover allowed oncoming flood engineers to be appraised of the current operational situation.

133 The following table sets out the shift start times and finish times, the Duty Flood Operations Engineer on duty, and records the shift hand over occurrences:

Shift start time	**Shift finish time**	**Flood Operations Engineers**	**Notes**
Thu 06/01/2011 07:00	Thu 06/01/2011 19:00	Engineer 2	Standard shift handover occurred at the end of this shift in accordance with the Flood Procedure Manual.
Thu 06/01/2011 19:00	Fri 07/01/2011 07:00	Rob Ayre	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Fri 07/01/2011 07:00	Fri 07/01/2011 19:00	Engineer 2	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Fri 07/01/2011 19:00	Sat 08/01/2011 07:00	Engineer 3	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Sat 08/01/2011 07:00	Sat 08/01/2011 19:00	Rob Ayre	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.

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

Shift start time	Shift finish time	Flood Operations Engineers	Notes
		Rob Ayre	Operations Engineers discussing strategy.
Thu 13/01/2011 07:00	Thu 13/01/2011 19:00	Engineer 2 Engineer 4	The handover at the commencement of this shift involved all four Flood Operations Engineers discussing strategy. A standard shift handover occurred at the end of this shift in accordance with the Flood Procedure Manual.
Thu 13/01/2011 19:00	Fri 14/01/2011 07:00	Rob Ayre	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Fri 14/01/2011 07:00	Fri 14/01/2011 19:00	Engineer 2	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Fri 14/01/2011 19:00	Sat 15/01/2011 07:00	Engineer 4	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Sat 15/01/2011 07:00	Sat 15/01/2011 19:00	Engineer 2	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Sat 15/01/2011 19:00	Sun 16/01/2011 07:00	Engineer 3	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Sun 16/01/2011 07:00	Sun 16/01/2011 19:00	Rob Ayre	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Sun 16/01/2011 19:00	Mon 17/01/2011 07:00	Engineer 4	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Mon 17/01/2011 07:00	Mon 17/01/2011 19:00	Engineer 3	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Mon 17/01/2011 19:00	Tue 18/01/2011 07:00	Engineer 2	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Tue 18/01/2011 07:00	Tue 18/01/2011 19:00	Rob Ayre	Standard shift handovers occurred at either end of this shift in accordance with the Flood Procedure Manual.
Tue 18/01/2011 19:00	Wed 19/01/2011 07:00	Engineer 4	Standard shift handovers occurred at either end of this shift in accordance

Shift start time	Shift finish time	Flood Operations Engineers	Notes
			with the Flood Procedure Manual.
Wed 19/01/2011 07:00	Wed 19/01/2011 14:00	Engineer 2	Standard shift handovers occurred at the beginning of this shift in accordance with the Flood Procedure Manual.

134 From 6 January 2011 to 20 January 2011 an Event Log of the Flood Event was kept in accordance with the Procedures Manual. A copy of the Event Log is contained at Appendix M to the Wivenhoe and Somerset Dams Flood Report 2011 (submitted by Seqwater to DERM on 2 March 2011). Because simultaneous flood events occurred at Wivenhoe, Somerset and North Pine Dams, a combined Event Log was kept for all three Dams.

135 An Event Folder is created as soon as a flood event is declared. The Event Folder includes the Event Log, correspondence sent to and from the FOC, directives sent to the dam operators and situation reports sent out to relevant agencies. The Event Log is compiled by the technical assistant on shift. Information in the Event Log about telephone conversations is not a verbatim transcript of the conversation.

136 The Procedures Manual provides for an event sign in sheet to be kept and that each employee 'sign in' when commencing a shift and to 'sign out' when leaving a shift.

137 An event sign in sheet was kept in the FOC during the January 2011 Flood Event. However, during critical periods, I did not record every time I entered or exited the FOC. This was particularly the case during the period in which I was sleeping in the meeting room outside the FOC.

Staffing considerations during the January 2011 Flood Event

138 FOC staff were required to work extended hours over the December and January flood events, including public holidays.

139 During the January 2011 Flood Event, from Tuesday 11 January 2011 to Friday 14 January 2011 I stayed and slept at the FOC to avoid a situation where I was cut-off from attending my shifts in the FOC. Many other staff also stayed in at the FOC. We generally slept in meeting rooms. As the Senior Flood Operations Engineer, I

considered it vital that I be immediately available to staff in the FOC, even at times when I was not actually rostered on to work in the FOC.

140 One of the considerations in the Wivenhoe and Somerset Dams Flood Report 2011 is to consider arrangements for staff accommodation and communication during future flood events.

COMPLIANCE WITH PROCEDURAL REQUIREMENTS UNDER THE MANUALS

141 The W&S and NP Manuals set out a number of procedures that must be followed during a flood event.

142 I believe that the procedural requirements of the W&S and NP Manuals were complied with during the January 2011 Flood Event. I have summarised the key steps taken to comply with the W&S and NP Manuals below.

The FOC was prepared for the January 2011 Flood Event

143 The W&S and NP Manuals require that certain steps be taken before each wet season to prepare for possible flood events. The W&S and NP Manuals, at section 7.2, also require that a report be prepared and submitted to DERM, which confirms the state of preparedness of the operations personnel, the flood monitoring forecast systems and communication networks. I confirm that:

(a) A report entitled, 'A *Flood Operations Preparedness Report*' for Wivenhoe, Somerset and North Pine Dam was submitted by Seqwater in October 2010 in preparation for 2010/2011 wet season (**the Preparedness Report**);

(b) Sufficient numbers of suitably qualified personnel were available to operate the dams during the January 2011 Flood Event;

(c) Sufficient numbers of suitably qualified personnel were available to operate the FOC during the January 2011 Flood Event;

(d) A Duty Flood Operations Engineer was on call at all times;

(e) Contact details for Flood Operations Engineers and Flood Officers were kept up-to-date;

(f) A Senior Flood Operations Engineer was designated to be in charge of the flood operations during the January 2011 Flood Event. I fulfilled that role;

(g) Release of water at the dams during the January 2011 Flood Event was carried out under the direction of a Duty Flood Operations Engineer;

(h) The FOC had:

(i) Data collection and modelling systems available to manage flood events at Somerset and Wivenhoe Dams;

(ii) Sufficient stationery and forms;

(iii) Landline telephone, mobile telephone, satellite telephone, Seqwater radio network, facsimile and email communications systems; and

(iv) Power systems and back up power systems required to ensure computer system reliability during the January 2011 Flood Event.

144 All practical attempts were made to liaise with the Chief Executive's nominated delegate, the dam safety regulator from DERM. During the January 2011 Flood Event there was regular communication with the dam safety regulator.

145 Weather forecasts and catchment rainfall was constantly received and reviewed in the FOC.

146 The Preparedness Report assessed the following key areas:

(a) The adequacy of the communication and data gathering facilities;

(b) The reliability of the system over the previous period;

(c) The reliability of forecasting flood flows and heights;

(d) Training and state of preparedness of operations personnel; and

(e) The overall state of preparedness of the system.

Controlled versions of the W&S and NP Manuals

147 The W&S and NP Manuals are controlled documents, which means that they can only be amended by the document owner, Seqwater, and are amended in accordance with a set procedure involving consultation and rigorous review.

148 Only controlled manuals are permitted to be used in the direction of flood mitigation activities. Present in the FOC during the January 2011 Flood Event was the *Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam* (Revision 7 dated November 2009 Controlled Copy # 6) and the *Manual of Operational Procedures for Flood Mitigation at North Pine Dam* (Revision 5 dated August 2010 Controlled Copy # 5).

149 Seqwater is required to provide the agencies listed in Appendix A to the W&S and NP Manuals controlled copies of the W&S and NP Manuals. To the best of my knowledge Seqwater complied with this requirement.

Mobilisation of the FOC

150 The January 2011 Flood Event for North Pine Dam, Somerset Dam and Wivenhoe Dam was simultaneously declared at 7:42am on Thursday 6 January 2011 when there had been rainfall that had generated runoff (i.e. surface water that flowed from the catchment land area into the dam). The Dams were above FSL and the outlook was for further rainfall.

151 Once the FOC was mobilised, the Flood Event Manager, Engineer 2, ensured the Event Log was created.

152 During the January 2011 Flood Event, a handover occurred at the end of each shift. (see the table at paragraph 133).

153 The handover at the end of each shift ensured that all oncoming Duty Flood Operations Engineers had the following information available to them:

(a) Reservoir storage elevations at each Dam;

(b) Radial gate, sluice gate and regulator valve openings at each Dam;

(c) Flood release procedures being applied and the reason for their selection;

(d) Status of compliance with the Flood Manuals and Emergency Actions Plans;

(e) Status of the communications systems;

(f) Status of the data gathering network;

(g) Status of computer systems and flood monitoring systems; and

(h) Any areas of concern associated with the management of the flood event.

Reporting after a flood event

154 A report is required to be completed after each flood event. The Flood Reports in respect to the January 2011 Flood Event have been prepared and submitted to the Chief Executive of DERM. There is a joint Flood Report for Wivenhoe and Somerset Dam, submitted on 2 March 2011, and a separate Flood Report for North Pine Dam, submitted on 11 March 2011. I assisted in the preparation of both of the flood reports and I consider that the reports are an accurate record of the January 2011 Flood Event.

155 In my view, consideration ought to be given to extending the six week time frame within which this report must be prepared in the case of repeated flood events. Somerset Dam and Wivenhoe Dam have already been operated on five separate occasions during 2011, whilst North Pine Dam has operated on at least 18 separate occasions (so far) since October 2010, including the January 2011 Flood Event. FOC staff have been mobilised during these flood events, and it has been difficult to balance these operating requirements with the report compliance requirements. This is a particular concern in years with frequent or repetitive flood events, such as have occurred during the present wet season.

FLOOD MONITORING SYSTEMS

Flood Monitoring under the W&S and NP Manuals

156 The W&S and NP Manuals provide an overview of the flood monitoring to be undertaken during a flood event.

157 Specifically, the W&S and NP Manuals provide as follows (at section 5.1):

'*A real time flood monitoring and forecast system has been established in the dam catchments. This system employs radio telemetry to collect, transmit and receive rainfall and stream flow information. The system consists of more than 100 field stations that automatically record rainfall and/or river heights at selected locations in the dam catchments. Some of the field stations are owned by Seqwater with the remainder belonging to other agencies.*

The rainfall and river height data is transmitted to Seqwater's Flood Operations Centre in real time. Once received in the Flood Operations Centre, the data is processed using a Real Time Flood Model (RTFM) to estimate likely dam inflows and evaluate a range of possible inflow scenarios based on forecast and potential rainfall in the dam catchments. The RTFM is a suite of hydrologic and hydraulic computer programs that utilise the real time data to assist in the operation of the dams during flood events. Seqwater is responsible for providing and maintaining the RTFM and for ensuring that sufficient data is available to allow proper operation of the RTFM during a Flood Event.'

158 In respect to the quote above, in fact most of the field stations are owned by Seqwater with the remainder belonging to other agencies, such as the Bureau of Meteorology (**the BoM**), DERM and some of the local authorities.

159 The W&S and NP Manuals direct the Flood Operations Engineers to use the Real Time Flood Monitoring System (RTFM System) for flood monitoring and forecasting during flood events.

RTFM System

160 The current RTFM System was developed in 1994 as part of the Brisbane River and Pine River Flood Study (DNR, 1994) and consists of two integrated modules, namely FLOOD–Col and FLOOD-Ops (together known as the FLOOD system). FLOOD-Col is the data capture module, while FLOOD-Ops is the data analysis module of the RTFM. The FLOOD system is approved by DERM, the dam safety regulator.

161 I have a very good understanding of the FLOOD system, as I helped develop it.

162 Whilst the software still functions adequately overall from an operational perspective, replacement software (Deltares FEWS) is currently being developed because the FLOOD system is 15 years old and the software system needs to be upgraded in light of advances in computing and availability of off-the-shelf products, which provide greater support.

163 The rainfall and water level gauges in the catchments areas provide the primary source of the RTFM's raw data. This data is collected through field stations consisting of rainfall and water level gauges. These gauges use the Event Reporting Radio Telemetry System (ERRTS) to communicate data to the FOC (and the back-up FOC). Rainfall gauges consist of a standard tipping bucket, whereas water level gauges vary in type and model. At a rainfall gauge, an event is defined as the tip of the bucket, and at a water level gauge, an event is defined as an incremental increase or decrease in water level. When an event is triggered at a gauge, the ERRTS transmits data via VHF radio through a series of radio repeaters to the FOC (and other data collections agencies). Once the data arrives at the FOC base station, it is relayed to computers, where it is time stamped, read, decoded, accepted/rejected, filtered, validated and then stored in a gauge database in the FLOOD-Col database.

164 The combination of ERRTS field stations, rainfall and water level gauges, the radio network and data collection software is collectively referred to as an ALERT system (Automated Local Evaluation in Real Time System).

165 FLOOD-Ops is the modelling software used to analyse and produce forecast runoff. It works by extracting data from the FLOOD-Col database, from which it calculates

areal rainfalls and generates hydrographs of runoff. The parameters can be adjusted and forecast rainfall can be included as one of the options.

166 A secondary component of the RTFM software (WIVOPS), which assists in formulating the gate operations strategy at Wivenhoe Dam, is no longer applicable. This has occurred due to the recent changes to the W&S Manual and the inability to modify the program (WIVOPS) to account for these changes. This is due to a number of factors including the age of the program (over 15 years), the absence of detailed program documentation and the complexity of the inclusion into WIVOPS of W&S Manual changes in 2009 in respect to the Somerset Dam release strategies. As an interim measure, spreadsheets have been developed to provide the required functionality. These customised spreadsheets were used during the January 2011 Flood Event, and performed satisfactorily. Replacement software is currently being developed by Seqwater.

167 The current ALERT data collection network has now been operational since 1995.

168 The 2010 Preparedness Report confirmed that the overall performance of the system in 2009/2010 was satisfactory and that the following improvements had been made from 2008 by Seqwater:

(a) Seqwater employed a dedicated hydrographic team to enhance and maintain the data collection network;

(b) During 2008/2009, approximately 30 stations were upgraded with new generation ALERT (ERRTS) equipment. During 2009/2010, a further 55 sites were upgraded (meaning that nearly all of the ERRTS equipment in the ALERT network had been upgraded prior to the January 2011 Flood Event);

(c) Between 2008 and 2010, new rainfall stations were constructed and installed at Linfield, Westvale, Hazeldean, Monsildale, Mt Stanley, Mt Binga, Blackbutt and Redbank Creek;

(d) New rain / river heights gauging stations were constructed and installed at Atkinson Dam, Bill Gunn Dam, Lake Claredon Dam, Moogerah Dam, North Pine River at Dayboro WWTP; and

(e) New river heights gauging stations were installed at Kilcoy Creek downstream of Kilcoy Weir and at Kobble Creek at Mt Samson.

169 75 rain gauge and 71 river gauge field stations operate within and around the Brisbane River Basin. 129 of these operate under the ALERT system, and the remaining 17 operate as telephone telemeter gauging stations, but are not directly

available in the operational suite. Seqwater operates 10 rain gauges and seven water level gauge field stations within and around the Pine Rivers Basin.

170 Not all of the data that is transmitted is used because there is a possibility that some of the rainfall data may be incorrect if it is not validated. Validation of data is important, because there can be corrupt data that is sent to the system, which causes a spike in the data. A good indicator of corrupted data can be a significant and unexplained spike in the data. This would generally put the technical assistant on notice that that piece of data requires validation before being input into the models. One method to validate the data collected is to check the data against manual gauge board readings taken at North Pine, Somerset and Wivenhoe Dam to confirm the ALERT data received from these sites.

171 The technical assistants in the FOC will review the data being received to ensure that the data is not corrupted or erroneous. The technical assistants will either delete or edit any corrupted data prior to inputting the data into a model. Data can be corrupted in a number of ways, for instance, if two sensors transmit at the same time, which results in a clash of data or if a station ceases recording due to instrument failure.

172 All data, corrupt or not, is retained on the system.

Enviromon

173 The FOC also has access to a software data system developed by the BoM named 'Enviromon'. Enviromon collects data from an additional 225 rain gauges and nearly 200 water level gauges throughout South East Queensland. Enviromon is similar in nature to FLOOD-Col in that both systems allow you to store, view and edit real time flood warning data. Enviromon is a further way in which the FOC can assess the integrity of the data being received from ALERT stations.

174 The FLOOD-Col and Enviromon databases contain gauge details such as:

(a) The name of the gauge;

(b) ALERT number;

(c) Type of gauge;

(d) Calibration information;

(e) Alarm thresholds; and

(f) Rating curve information, if applicable.

Modelling

175 The RTFM System allows the Duty Flood Operations Engineers to run models to assist in understanding factors such as runoff, lake levels and river flows. Models are generally run every three to six hours during a flood event.

176 Various parameters can be input into the models, and they can be run by incorporating the BoM forecasts. The forecast that is generally used is the 24 hour forecast (the Quantitative Precipitation Forecast (**QPF**)), however, longer duration forecasts are also used to gain an understanding of how a flood event might progress. The FOC has access to a range of forecasting information provided by the BoM. The BoM provides the QPF at approximately 10am and 4pm each day.

177 Inputting data as it is received continually refines the models. The models that are available in the RTFM System are hydrologic models, which are calibrated on previous historical events.

178 The models also incorporate a conceptual runoff-routing model, which is the Australian Standard model in relation to runoff to assist in flood estimation. The amount of expected runoff into a dam is an important factor in monitoring a flood event.

179 The FOC uses gate operation spreadsheets in predicting dam levels (see paragraph 166). The runoff-routing model must account for a loss rate because not all of the rain that falls in a catchment area will ultimately make it into a dam. The loss rate accounts for an amount of runoff that would not make it into the dam because the rain is intercepted by vegetation or is soaked into soil. The loss rate in predicting runoff is impacted by the saturation levels in the catchment. The drier the catchment, the higher the loss rate and the lower the runoff levels. The converse is also true. The higher the saturation levels in the catchment, the more water will be received into the dam.

180 This 'loss' parameter is the most subjective aspect of the models, however, the runoff is constantly being refined during flood events by taking manual lake level observations, which is the most effective and reliable means of determining the accuracy of predicted runoff.

181 The current system (the RTFM System) for the Dams has been used successfully since 1999.

182 I believe that the data collection and modelling systems constitute a robust system and provide adequate results during flood events. The proposed FEWS system was

tested during the December 2010 Flood Events and January 2011 Flood Event but was not used as an operational platform.

The operation of the data collection system (ALERT) – Wivenhoe and Somerset Dams

183 At the commencement of the January 2011 Flood Event, four out of 75 rain gauges and six out of 71 river gauges were out of action in the Brisbane River Basin.

184 The rainfall gauges that were out of action in the Brisbane River Basin at the start of the January 2011 Flood Event are listed in the following table:

Rain ID	Site	Status date 6 Jan 2011	Comment
6517	Gregors Creek AL-B	Out of action	Redundant gauge. Another rainfall gauge is available at this site.
6526	Helidon AL	Out of action	Data from adjacent stations at Toowoomba and Gatton was used as a substitute for this data. However, data from this station was available for use through the BoM Enviromon system.
6736	Kuss Road AL	Out of action	This site is located in the Bremer River catchment and the data is of limited value in gate operations decision-making.
6744	Wilsons Peak AL	Out of action	Data from adjacent stations at Tarome and Kalbar was used as a substitute for this data.

185 The river gauges that were out of action at the start of the January 2011 Flood Event are listed in the following table:

River ID	Site	Status date 6 Jan 2011	Comment
6654	Amberley AL-B	Out of action	Redundant gauge. Another stream height gauge is available at this site. This station has been marked for relocation.
6524	Cressbrook Dam AL	Out of action	The downstream stream height gauge at Rosentretter provides more useful information than this site.
6518	Gregors Creek AL-B	Out of action	Redundant gauge. Another river height gauge is available at this site.
6650	Lowood AL-P	Out of action	Redundant gauge. Another river height gauge is available at this site.
6566	Tenthill AL	Out of action	The downstream stream height gauge at Gatton provides more useful information than this site.
6743	Walloon AL-B	Out of action	This is a redundant gauge. Another river height gauge is available at this site.

186 A number of the field stations were damaged during the January 2011 Flood Event. An additional four rain gauges and ten river gauges were damaged due to water inundation, debris, lightning strikes or loss of power. There were also a number of field stations that were completely destroyed during the event. The following rain gauges were marked damaged or destroyed during the January 2001 Flood Event:

Rain ID	Site	Status date 19 Jan 2011	Comment
6633	Lyons Bridge AL-P	Out of action from 15:00 on 11 Jan 2011	Although this data was marked out of action in the system, it was also available for use through the BoM Enviromon system.
6630	Lyons Bridge AL-B	Out of action from 09:00 on 11 Jan 2011	Although this data was marked out of action in the system, it was also available for use through the BoM Enviromon system.
6568	O'Reillys Weir AL	Out of action from 19:34 on 11 Jan 2011	This site was severely damaged by flood water at the time indicated. This was late in the Event and rainfall after this time was minimal.
6641	Wivenhoe Dam TW AL-B	Out of action from 22:30 on 11 Jan 2011	This site was severely damaged by flood water at the time indicated. This was late in the Event and rainfall after this time was minimal. Manual readings are also available at this site.

187 The river gauges that were marked damaged or destroyed during the January 2011 Flood Event are contained in the following table:

River ID	Site	Status date 19 Jan 2011	Comment
6756	Burtons Bridge	Out of action from 08:00 on 12 Jan 2011	The adjacent stream height gauges at Savages Crossing and Mt Crosby Weir provide more useful information than this site during high flows.
6527	Helidon	Out of action from 14:40 on 8 Jan 2011	The downstream stream height gauge at Glenore Grove was used as a substitute for this data.
6578	Gatton	Out of action from 17:31 on 10 Jan 2011	The downstream stream height gauge at Glenore Grove was used as a substitute for this data.
6757	Kholo Bridge	Out of action from 15:20 on 11 Jan 2011	The adjacent stream height gauges at Savages Crossing and Mt Crosby Weir provide more useful information than this site during high flows.
6737	Kuss Road	Out of action from 15:22 on 8 Jan 2011	This site is located in the Bremer River catchment and the data is of limited value in gate operations decision-making.
6647	Lowood AL-B	Out of action from 07:30 on 14 Jan 2011	The adjacent stream height gauge at Savages Crossing provides more useful information than this site during high flows.
6758	Mt Crosby AL-B	Out of action from 16:30 on 10 Jan 2011	This is a redundant gauge. Another river height gauge is available at this site.
6569	O'Reillys Weir	Out of action from 07:30 on 11 Jan 2011	This station is impacted by backwater from Wivenhoe Dam releases. This cannot be avoided. Data from adjacent stations at Lyons Bridge and Savages Crossing was used as a substitute for this data.
6637	Wivenhoe Dam HW AL-A	Out of action from 10:00 on 11 Jan 2011	This is a redundant gauge and manual readings are available at this site.
6638	Wivenhoe Dam HW AL-B	Out of action from 11:00 on 10 Jan 2011	This is a redundant gauge and manual readings are available at this site.

188 During the January 2011 Flood Event around 132,000 individual data observations were transmitted from the field stations and received in the FOC.

The operation of the data collection system (ALERT) – North Pine Dam

189 At the commencement of the January 2011 Flood Event, all of the ten rain gauges were available in the Pine Rivers Basin, and four out of six river gauges were operational. The two river gauges that were out of action are listed in the following table:

River ID	Site	Status date 6 Jan 2011	Comment
6764	Petrie	Out of Action	This station is a long-term 'Out of Action' station that has been identified as redundant due to the availability of Council-owned stations nearby.
6762	North Pine Dam	Out of Action	Readings from this sensor were oscillating and did not match the gauge board observations.

River ID	Site	Status date 6 Jan 2011	Comment
			This did not impact operations due to the availability of manual readings. Manual readings are always used in preference to automatic gauge readings during flood events.

190 The ALERT gauge at Dayboro was damaged when the riverbank collapsed. The gauge had provided sufficiently accurate information until that time. The gauge is not included in the RTFM System and is therefore not used for any modelling.

191 The manual gauge boards at North Pine Dam were used in determining gate operations. One of the automatic gauges at North Pine Dam gave readings, which at times fluctuated during the event, and the other gave readings slightly lower that the manual gauge board reading, but was still within acceptable tolerances.

Overall performance of the data collection system (ALERT)

192 In my view, the data collection system worked well during the January 2011 Flood Event particularly given the magnitude of the event.

193 The January 2011 Flood Event was a significant test of the capability of the rainfall and stream height field stations used to collect data. These stations had not previously experienced a flood event of this size. I believe that the ALERT System operated satisfactorily and gathered reliable data for use in the models run in the FOC.

194 As previously noted, a number of the field stations were damaged during the flood event, and some were completely destroyed.

195 There is a gap in the rainfall gauging data for rain that fell directly on the Lakes. On Tuesday 11 January 2011, there was a period of intense rainfall on Wivenhoe Lake that resulted in a rapid rise in the lake level at Wivenhoe Dam, which was not captured in gauging data. This is because rainfall experienced during this time fell directly on or near Lake Wivenhoe where there are no catchment gauges. Subsequent calculations estimate that in the nine hours from 5am to 2pm on Tuesday 11 January 2011, approximately 610mm fell on Wivenhoe Lake. Despite that gap in the rainfall gauging systems, manual lake level readings were taken and, in accordance with the W&S Manual, those manual lake level readings were used to determine releases from Wivenhoe Dam.

196 Rainfall gauges can only capture rainfall that falls within the range of that particular gauge. During severe weather, such as occurred in the January 2011 Flood Event, intense rainfall was not always captured as it fell in areas where there were no rainfall field stations and, therefore, the rainfall in these areas could not be recorded by gauges. This impacts upon the ability of the FOC to respond to rainfall in a timely manner but the balancing consideration is the cost of installing and maintaining further gauges.

197 An expansion of the network of rainfall gauge field stations will potentially increase the reliability of the rainfall data collected, however, due to the size of the Brisbane Basin and the Pine River Basin catchment areas, practical difficulties exist in ensuring that all future rainfall events will be captured. Obviously, the greater the number of rainfall gauge field stations, the more reliable the data received. Any gap in the network brings with it the potential for rainfall data to be missed.

Overall performance of the RTFM System

198 The RTFM System provided sufficient information to support flood operations decision making during the January 2011 Flood Event. The system did not fail during the event, and there were no operational flaws or errors detected in the existing RTFM System that adversely impacted upon the decisions made during the January 2011 Flood Event. The results provided by the RTFM System correlated generally with the results provided by the back-up system, using the URBS models and also the model results provided by the BoM.

RAINFALL FORECASTING

199 Under the W&S and NP Manuals the strategies to determine the release of water from the Dams are determined by inflow and projected lake levels, however, rainfall forecasts are used in modelling to evaluate a range of possible inflow scenarios.

200 The FOC does not have the capacity to make its own forecasting of rainfall events. The FOC relied on a number of different tools provided by the BoM to inform decision-making throughout the January 2011 Flood Event.

201 There were significant differences between forecast rainfall and actual rainfall during the January 2011 Flood Event. This is consistent with observations made in previous heavy rain and flood events since 1996.

202 This is not to say that the BoM, or its staff, failed in the performance of their jobs in any manner, or that they lack any expertise. It is simply a function of the unpredictable nature of weather systems and the technology that is available to predict and quantify expected rainfall.

203 There is a degree of uncertainty associated with the reliability of rainfall forecasts. Generally speaking, the longer the forecast period, the higher the degree of uncertainty in the accuracy of the forecast. In assessing the strategies used during any flood event, rainfall forecasts provide an awareness of potential flood event conditions but the forecasts by themselves do not provide a sufficiently reliable basis upon which to make operational decisions on releasing floodwaters from the Dams during flood events.

204 During the January 2011 Flood Event, a number of different BoM supplied tools were used and examined to assess forecast rainfall:

(a) 24 Hour QPFs for the Dam catchments;

(b) the weather radar (available through the BoM website);

(c) SILO meteograms forecast rainfall (based on the BoM ACCESS Model);

(d) interactive weather and wave forecast rainfall maps (based on ACCESS Model);

(e) water and land forecast rainfall (based on an ensemble of several numerical weather predictions models); and

(f) severe weather warnings.

Performance of rain forecasting information

205 The QPFs are the most reliable of the forecasting tools available because they are a 24 hour short-term forecast, and thus are the primary source of forecast information used by the FOC. A comparison of the QPF catchment average rainfall forecasts against the catchment average actual rainfall received reveals significant variations.

206 In the Brisbane River catchment, that comparison reveals significant variations between forecast rainfall and actual rainfall received. The table set out below (which was created for the purposes of the Wivenhoe and Somerset Dams Flood Report 2011 after the event) shows the relevant comparisons for the Wivenhoe and Somerset Dams' catchments. The more significant underestimated forecasts are highlighted in red and the more significant overestimated forecasts are highlighted in blue:

Date / time of issue	Forecast for 24 hours to	24-hour Catchment average forecast rainfall (mm)	24-hour Catchment average actual rainfall (mm)
Mon 03/01/2011 11:36	Tue 04/01/2011 09:00	8	5
Mon 03/01/2011 16:00	Tue 04/01/2011 15:00	15	4
Tue 04/01/2011 11:30	Wed 05/01/2011 09:00	15	0
Tue 04/01/2011 16:00	Wed 05/01/2011 15:00	10	2
Wed 05/01/2011 10:03	Thu 06/01/2011 09:00	25	26
Wed 05/01/2011 16:00	Thu 06/01/2011 15:00	40	44
Thu 06/01/2011 10:21	Fri 07/01/2011 09:00	40	38
Thu 06/01/2011 16:00	Fri 07/01/2011 15:00	25	43
Fri 07/01/2011 10:03	Sat 08/01/2011 10:00	25	26
Fri 07/01/2011 16:04	Sat 08/01/2011 16:00	25	6
Sat 08/01/2011 10:03	Sun 09/01/2011 09:00	40	28
Sat 08/01/2011 16:00	Sun 09/01/2011 15:00	40	80
Sun 09/01/2011 10:03	Mon 10/01/2011 09:00	50	149
Sun 09/01/2011 16:00	Mon 10/01/2011 15:00	65	125
Mon 10/01/2011 10:03	Tue 11/01/2011 10:00	75	120
Mon 10/01/2011 16:00	Tue 11/01/2011 16:00	38	129
Tue 11/01/2011 10:13	Wed 12/01/2011 10:00	100	51
Tue 11/01/2011 16:13	Wed 12/01/2011 16:00	75	12
Wed 12/01/2011 10:03	Thu 13/01/2011 10:00	10	2
Wed 12/01/2011 16:00	Thu 13/01/2011 16:00	5	1
Thu 13/01/2011 14:25	Fri 14/01/2011 16:00	5	0
Thu 13/01/2011 16:00	Fri 14/01/2011 15:00	5	0
Fri 14/01/2011 10:03	Sat 15/01/2011 09:00	3	0
Fri 14/01/2011 16:00	Sat 15/01/2011 15:00	3	0

207 The ACCESS Model data provided by the BoM allowed three-day and five-day catchment average rainfall forecasts to be considered during the January 2011 Flood Event. The following table of the Wivenhoe and Somerset Dams Flood Report 2011 compares the catchment average forecast three and five day rainfall against the catchment average actual rainfall received. Again, significant variations between what was actually received and what was forecast were observed during the flood event.

Comparison of actual and forecast rainfall from the BoM ACCESS model								
Forecast date and time	Somerset Dam catchment average rainfall				Wivenhoe Dam catchment average rainfall (excluding Somerset Dam catchment)			
	3 Days from		5 Days from		3 Days from		5 Days from	
	Forecast rainfall (mm)	Actual rainfall (mm)	Forecast rainfall (mm)	Actual rainfall (mm)	Forecast rainfall (mm)	Actual rainfall (mm)	Forecast rainfall (mm)	Actual rainfall (mm)
06/01/2011 00:00	73	90	115	403	90	79	114	275
06/01/2011 12:00	85	150	133	515	51	87	78	335
07/01/2011 00:00	189	298	206	568	133	180	144	347
07/01/2011 12:00	123	321	137	536	79	183	89	322
08/01/2011 00:00	191	332	206	527	207	205	218	309
08/01/2011 12:00	165	447	169	527	136	284	139	309
09/01/2011 00:00	230	500	231	510	267	298	268	301
09/01/2011 12:00	140	441	141	446	170	271	171	273
10/01/2011 00:00	463	278	465	280	171	169	171	170
10/01/2011 12:00	59	218	60	219	389	140	390	141
11/01/2011 00:00	19	196	19	197	231	105	231	105

208 Similar fluctuations were seen at North Pine Dam in terms of forecast catchment average rainfall and average actual rainfall. Significant variations are observed between forecast and actual 24 hour catchment average rainfall. The following table demonstrates the variations in 24 hour forecast catchment average forecasts and received rain at North Pine Dam:

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

Date / time of issue	Forecast for 24 hours to	24 hour catchment average forecast rainfall (mm)	24 hour catchment average actual rainfall (mm)
10/01/201116:00	11/01/2011 16:00	80	307
11/01/201110:13	12/01/2011 10:00	113	127
11/01/201116:13	12/01/2011 16:00	63	11
12/01/201110:03	13/01/2011 10:00	125	43
12/01/201116:00	13/01/2011 16:00	90	47
13/01/201114:25	14/01/2011 16:00	5	26

209 The BoM forecasting tools were useful in providing awareness that possible heavy rainfall activity might occur, however, the forecast variations were significant when compared to rainfall received.

Comment on the viability of pre-release strategies

210 There is no strategy in the W&S Manual that allows the early release of water from the Dams before the Dam reaches the FSL. Whilst the NP Manual does address early release (at section 8.4), any departures from the flood operations strategies (and gate operations detailed in the tables at Appendix C to the NP Manual) are subject to the provisions of section 2.8 being satisfied (see paragraph 270).

211 The W&S Manual states at section 8.3 that '*The spillway gates are not to be opened for flood control purposes prior to the reservoir level exceeding EL 67.25*', which is 250mm above FSL. The NP Manual at section 8.3 states that *'Releases from the radial gates should not commence until the lake level exceeds FSL by 50 millimetres (39.65 m AHD).'*

212 By setting minimum levels before gate operations can commence, the W&S and NP Manuals reflect the fact that Wivenhoe, Somerset and North Pine Dams are the primary urban water supply for South East Queensland and that it is important that all opportunities to fill the Dams are taken. The W&S and NP Manuals state at section 3.5 that there should be no reason why the Dams should not be returned to FSL following a flood event.

213 The W&S and NP Manuals do not authorise the Senior Flood Operations Engineer to alter the setting of the FSL in the Dams. Thus, the strategies that are required to be implemented to achieve the stated objectives have been designed having regard to

the FSL that has been set for each dam. The flood mitigation capacity of the dams must operate within the context of the setting of the FSL for the Dams.

214 The degree of accuracy in forecasts varies with the catchment area being considered, however, for Wivenhoe, Somerset and North Pine Dams, the level of uncertainty in forecast predictions means that they are not relied upon for the purposes of making decisions about the release of water from Wivenhoe, Somerset and North Pine Dams prior to the onset of a flood event or the wet season.

215 I was aware of previous research specific to Wivenhoe, Somerset and North Pine Dams that supports that proposition. This research concluded that pre-release based upon forecasts was not a viable strategy in managing the dams.

216 For example, in 2001 I investigated the feasibility of making pre-releases from Wivenhoe, Somerset and North Pine Dams. That research culminated in a report prepared by me in September 2001 dealing with the feasibility of pre-releases from dams. The report was prepared for the South East Queensland Water Corporation (which was a predecessor of Seqwater). The report is entitled *'Feasibility of Making Pre-Releases from SEQWC Reservoirs'*.

217 The report concluded that the use of pre-releases from Wivenhoe, Somerset and North Pine Dams was hard to justify on the basis of the current level of rainfall forecast accuracy in those catchments.

218 The report notes that whilst the QPF provides awareness that flood activity is likely, the forecasts themselves do not provide a definitive basis on which to quantify likely rainfall amounts and hence should not be used as the basis to set release strategies. The report commented that experience from previous flood events suggested that operational strategies are best made on the basis of rainfall already on the ground, rather than rainfall yet to fall.

219 The report concluded that in frequently occurring floods (ie. flood events of an average recurrence interval of less than 1 in 10 years), pre-release would likely result in the needless inundation of low level crossings and a risk of a compromised water supply. Whilst the use of a pre-release strategy for the purpose of protecting the structural integrity of the dam is most suited to large or rare flood events (such as those in excess of the 1 in 10,000 year average occurrence as such events are most likely to threaten the safety of the dams), the report did not recommend the use of pre-releases because the effectiveness of the pre-release strategy is limited by the likelihood that there will not be sufficient lead time for a pre-release strategy to make any real impact on such an event and there is a consequential adverse impact on

water reliability because a large amount of water storage would have to be released to have any impact.

220 Further, the report noted that 24 hour QPF forecasts do not provide a definitive basis upon which to quantify likely runoff amounts and hence release strategies. In relation to the SILO meteogram long term forecast, the report concluded that this model does not produce results of sufficient accuracy to prepare operational strategies with any degree of certainty. However, the report noted that if the accuracy of medium term forecasting improves sufficiently, pre-releases might become viable.

Connell Wagner study

221 I am also aware of a Connell Wagner study that essentially concluded that pre-release based upon forecasting was not a viable option at this point in time. For the purpose of the report Connell Wagner reviewed the BoM meteorological forecasting capabilities. Connell Wagner concluded that the lack of accuracy in the technology available meant that forecasting should not be used as a strategy for pre-release from Wivenhoe Dam. I do not presently have access to that report, however, I am familiar with its contents.

COMMUNICATIONS

Communications during flood events under the W&S and NP Manuals

222 Section 6 of the W&S and NP Manuals deals with communications during a flood event.

223 The W&S and NP Manuals provide that the Senior Flood Operations Engineer and the Flood Operations Engineers must supply information to each of the named agencies during a flood event.

224 Those agencies named under the W&S Manual are:

(a) The BoM – which issues flood warnings for Brisbane River basin;

(b) DERM – which reviews flood operations and approves discretionary powers of the Senior Flood Operations Engineer;

(c) Somerset Regional Council (**SRC**) – which makes use of flood level information upstream of Somerset Dam and downstream of Wivenhoe Dam;

(d) Ipswich City Council (**ICC**) – which makes use of flood level information for Ipswich City area; and

(e) Brisbane City Council (**BCC**) – which makes use of flood level information for the Brisbane City area.

225 Those agencies named under the NP Manual are:

(a) the BoM – which issues flood warnings, although because the Pine Rivers basin is considered a flash flood area, the BoM will give flood warnings on a general basis but will not issue specific flood warnings;

(b) DERM – which reviews flood operations and approves discretionary powers of the Senior Flood Engineer;

(c) Moreton Bay Regional Council (**MBRC**) – which makes use of flood level information downstream of North Pine Dam; and

(d) BCC – which makes use of flood level information for Brisbane City area.

226 The W&S and NP Manuals provide (at section 6.2) that:

'*Agencies other than Seqwater have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public associated with Flood Events. Adequate and timely information is to be supplied to agencies responsible for the operation of facilities affected by flooding and for providing warnings and information to the public.*'

227 In order to comply with the requirements of the W&S and NP Manuals, the FOC sends out communications known as 'situation reports' to the agencies listed in the W&S and NP Manuals, as well as a number of other organisations, which may need information as to releases and projected releases from the Dams. The situation reports are sent at least twice per day, but during the January 2011 Flood Event they were sent more regularly in light of the changing circumstances during the event.

228 The situation reports contain information as to the recorded rainfall in the period since the last situation report, the current lake level and rate of release from each Dam, information as to the projected releases (based on available forecasts and inflow information) and a description about the impact of the releases.

229 In my view, it is important that the FOC continues to have a limited and focussed role in the provision of communications from the FOC to other agencies during a flood event in order to allow the FOC staff to focus their attention upon matters such as the rainfall and inflow data, lake levels, directives, status of the Dams and any other issue that may arise during a flood event. I would be concerned if the FOC's role in providing information were to be significantly expanded because it may adversely

impact upon the FOC's ability to conduct flood operations and upon the FOC's resourcing.

230 Also, for the first time, Seqwater provided further communications, known as 'technical situation reports' to the Water Grid Manager.

231 The technical situation reports are a feature of a draft communications protocol (**the Protocol**), which was developed following the October 2010 Flood Event at Wivenhoe and Somerset Dams. The Protocol was provided by DERM to Seqwater shortly before the December 2010 Flood Events.

232 The Protocol aims to ensure effective communication between local, State and Commonwealth agencies impacted by the release of floodwater from the Dams.

233 The process for the distribution of technical situation reports is that the situation reports are sent from the FOC to the dam operations manager at Seqwater. The dam operations manager then uses the situation report to prepare a technical situation report, which he sends through to the Water Grid Manager. The Water Grid Manager then sends the technical situation report on to other agencies, such as the Queensland Police Service, the Department of Community Safety and the Department of Premier and Cabinet.

Performance of communications during the January 2011 Flood Event

234 I believe that the Event Log can be improved by adopting a more structured format and consistency amongst the technical assistants in the type of information recorded and the language that they use. Entries were made into the Event Log by a number of individuals, so there is some inconsistency in the styles and type of information put into the Event Log by individual users. A more consistent approach to entries in the Event Log will assist the operations of the FOC, particularly in debriefing sessions.

235 During the January 2011 Flood Event, actual and projected dam outflow modelling was compared to the BoM flood modelling in discussions between FOC staff and the BoM staff. This process assisted in ensuring that the modelling was functioning satisfactorily.

236 Modelling of projected and actual releases from Wivenhoe Dam was also shared by the FOC with the BCC in accordance with the Protocol.

237 Regular informal discussions were held with the BoM regarding rainfall forecasts. This process could be improved by including formal processes and procedures in the

Protocol, which outlines the frequency and type of information obtained by the FOC from the BoM.

238 Situation reports and technical situation reports were provided to relevant agencies during the January 2011 Flood Event.

239 The January 2011 Flood Event was the first time in which the Protocol had operated. I believe that it would be appropriate to now review this document to assess its performance and identify areas in which the Protocol can be improved.

240 One issue that arose in discharging the obligation under the W&S and NP Manuals of providing information to named agencies was the difficulty in contacting some of those agencies during the critical periods in the flood events:

(a) The Flood Information Centre at BCC – unable to be contacted during certain periods;

(b) The Local Disaster Response Co-ordinator at SRC – unable to be contacted during periods of flooding but we were provided with an alternative email for the SRC emergency management plan contact;

(c) The call centre at MBRC – unable to be contacted during periods; and

(d) The flood warning centre at the BoM – lost telephones while power was out in Brisbane CBD.

241 Further, Seqwater's corporate office lost communications when the CBD was flooded and they provided alternate contact numbers.

242 The difficulty in contacting some of the named agencies did not impact significantly on the FOC operations, as the FOC was still able to provide information to those agencies.

REVIEW OF THE W&S AND NP MANUALS

243 The W&S and NP Manuals are reviewed a minimum of every five years.

244 The review generally takes into account the continued suitability of the communication network and the flood monitoring and forecasting system (including any upgrades or new systems that might be available), as well as the hydrological and hydraulic engineering assessments of the operational procedures.

245 An operational review is conducted of the W&S and NP Manuals after each significant flood event. This review requires a report to be submitted within six weeks

of any flood event that requires mobilisation of the FOC and must address the effectiveness of the operational procedures contained in the W&S and NP Manuals.

246 The last complete review of the W&S Manual took place in 2009 with the revised manual produced in November 2009.

247 The last complete review of the NP Manual took place in 2010 with the revised manual produced in August 2010.

248 I participated in those reviews. A technical review panel was formed, which included me and the other Duty Flood Operations Engineers, Seqwater and the dam safety regulator.

249 During the 2009 review, the panel discussed that the W&S Manual required updating in relation to the change in institutional arrangements of a number of the listed agencies, for example, the local councils had been restructured since the last review of the W&S Manual. The W&S Manual was also reviewed due to a change in legislation and also a change in hydrological assessments of the design floods for Somerset Dam.

250 The review also focussed on the rewording of some of the procedures and objectives in order to highlight what the W&S Manual was trying to achieve in regards to the changed hydrological assessments.

251 One difference in the 2009 version of the W&S Manual from the previous version is that there is an express requirement that impacts to riparian flora and fauna be minimised. This was inserted at section 3.6 in the 7th revision of the W&S Manual.

252 There was also the addition of reference in the W&S Manual to the maintenance of the dams at FSL at the end of the event in recognition of water security issues. This was inserted at section 3.5 in the 7th revision of the W&S Manual. The procedure of emptying the flood compartments of the dams over seven days after a flood event was, however, already a part of the W&S Manual.

253 The 2009 review changed the name 'procedures' to 'strategies' under section 8 of the W&S Manual. Under the 6th revision of the W&S Manual, the 'procedures' were implemented on actual lake levels, with the exception of Procedure 4 (which is the equivalent of strategy W4), which although normally triggered when the Dam level reached 74.0m AHD, the operating procedures within that procedure were dependant upon the predicted peak water level. The 7th revision now defines the procedures in terms of 'strategies', and includes a table of conditions applicable for those strategies.

254 One of the differences in the strategies is the reference to the 'predicted' Wivenhoe storage level in the conditions table at the start of each strategy. This change in wording was incorporated to make clear that runoff from rainfall that had already occurred in the catchment area should be taken into account in determining the implementation of strategies. This is because the models that are run in the FOC can determine the projected runoff and loss rates from rainfall that had already occurred in the catchment area (but had not yet resulted in rises in the lake level) with satisfactory accuracy as rainfall in the catchment is recorded in the various gauges across the ALERT system. By inserting the reference to 'predicted' Wivenhoe Dam storage levels, it was not intended that 'predicted' storage levels be determined by models run solely on a 'with forecast rainfall' basis. This would be an inappropriate manner of operating the Dams for the reasons explained in paragraph 305 of my statement.

255 A discussion relating to forecasts was lead by the BoM.

256 The outcome of that discussion was that the BoM would continue to provide the same types of forecasts at the same frequency that they had previously provided. There was some discussion lead by the BoM in regards to radar based technology in rainfall measurement (that is, using radar for real time rainfall assessments rather than rain gauges); however, the BoM advised that the research had not matured sufficiently to contemplate using this technology in operations.

257 The panel also discussed a study commissioned by the BCC in 2007 in respect to the threshold of damage for urban areas below Moggill. No change was made to the reference to 4,000m^3/s, in strategy W3, as the *'upper limit of non-damaging floods downstream'* (page 28 of the W&S Manual).

OBJECTIVES CONTAINED WITHIN THE W&S AND NP MANUALS

Purpose and objectives of the W&S Manual

258 The purpose of the W&S Manual (section 1.3) is:

'...to define procedures for the operation of Wivenhoe Dam and Somerset Dam to reduce, as far as practicable, the effects of flooding associated with the dams.'

259 The W&S Manual makes it clear that this purpose is achieved by (section 1.3):

'...the proper control and regulation in time of the flood release infrastructure at the dams, with due regard to the safety of the dam structures.'

260 That purpose is important because (section 1.1):

'Given their potential significant impact on downstream populations, it is imperative that Wivenhoe and Somerset Dams be operated during flood events in accordance with clearly defined procedures to minimise the impacts to life and property.'

261 The primary objectives of the procedures contained in the W&S Manual, which are set out on page 1, in order of importance are:

- *'Ensure the structural safety of the dams;*
- *Provide optimum protection of urbanised areas from inundation;*
- *Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers;*
- *Retain the storage at Full Supply Level at the conclusion of the Flood Event.*
- *Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.'*

262 Section 1.3 of the W&S Manual relevantly provides:

'The procedures in this Manual have been developed on the basis that the community is to be protected to the maximum extent practical against flood hazards recognising the limitations on being able to:

- *Obtain accurate forecasts of rainfall during flood events;*
- *Accurately estimate flood run-off within the dam catchments;*
- *Identify all potential flood hazards and their likelihood;*
- *Remove or reduce community vulnerability to flood hazards;*
- *Effectively respond to flooding;*
- *Provide resources in a cost effective manner.'*

Purpose and objectives of the NP Manual

263 The purpose of the NP Manual (section 1.3) is:

'...to define procedures for the operation of North Pine Dam during flood events.'

264 The NP Manual makes it clear that the procedures have been developed (section 1.3):

'...on the basis that the structural safety of the dam is paramount within the scope of minimising the downstream impacts associated with releasing flood water from the dam.'

265 That purpose is important because (section 1.1):

'Given its size and location, it is imperative that North Pine Dam be operated during flood events in accordance with clearly defined procedures to minimise hazard to life and property.'

266 The primary objectives of the procedures contained in the NP Manual, which are set out on page 1, in order of importance are:

- *'Ensure the structural safety of the dam;*
- *Minimise disruption to the community in areas downstream of the dam;*
- *Retain the storage at Full Supply Level at the conclusion of the Flood Event.*
- *Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.'*

<u>*Defined terms*</u>

267 The following relevant terms are defined in the W&S and NP Manuals (on pages 1 and 2):

(a) AEP – '*annual exceedance probability, the probability of a specified event being exceeded in any year*';

(b) AHD – '*Australian Height Datum*';

(c) Chairperson – '*the Chairperson of Seqwater*';

(d) Chief Executive – '*the Director General of the Department of Environment and Resource Management or nominated delegate*';

(e) Dams – '*dams to which this Manual applies, that is Wivenhoe Dam and Somerset Dam'* (or in relation to the NP Manual *"dam to which this manual applies, that is North Pine Dam'*);

(f) Duty Flood Operations Engineer – '*the Senior Flood Operations Engineer or Flood Operations Engineer rostered on duty to be in charge of Flood Operations at the dams"* (or the '*dam'* in the case of the NP Manual);

(g) EL – '*elevation in metres Australian Height Datum*';

(h) Flood Event – '*a situation where the Duty Flood Operations Engineer expects the water level in either of the Dams to exceed the Fully Supply Level*' (or '*the dam*' under the NP Manual);

(i) Flood Operations Centre – '*the Centre used during by Flood Operations Engineers to manage Flood Events*';

(j) Flood Operations Engineer – '*a person designated to direct flood operations at the dams in accordance with section 2.4 of this Manual*' (of '*the dam*' under the NP Manual);

(k) FSL or Full Supply Level – '*the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge*';

(l) Senior Flood Operations Engineer – '*a person designated in accordance with Section 2.3 of this Manual under whose general direction the procedures in this Manual must be carried out.*'

Mandatory compliance with the operational procedures

268 Clause 1.7 of the W&S and NP Manuals state that operational procedures for the Dams must be used for the operation of the Dams during flood events.

269 The W&S and NP Manuals do allow for departure from the procedures set out in the W&S and NP Manuals if the Senior Flood Operations Engineer is of the opinion that it is necessary to depart from the procedures set out in the W&S and NP Manuals to meet the flood mitigation objectives set out in section 3 of the W&S and NP Manuals.

270 The Senior Flood Operations Engineer's ability to apply 'reasonable discretion' when managing a flood event is governed by section 2.8 of the W&S and NP Manuals, which provides:

'*If in the opinion of the Senior Flood Operations Engineer, it is necessary to depart from the procedures set out in this Manual to meet the flood mitigation objectives set out in Section 3, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary subject to the following:*

- *Before exercising discretion under this Section of the Manual with respect to flood mitigation operations, the Senior Flood Operations Engineer must make a reasonable attempt to consult with both the Chairperson and Chief Executive.*

- *The Chief Executive would normally authorise any departures from the Manual. However if the Chief Executive cannot be contacted within a reasonable time, departures from the Manual can be authorised by the Chairperson.*
- *If both the Chairperson and the Chief Executive cannot be contacted within a reasonable time, the Senior Flood Operations Engineer may proceed with the procedures considered necessary and report such action at the earliest opportunity to the Chairperson and Chief Executive.'*

271 During the January 2011 Flood Event, the only occasion on which I considered exercising my discretion under section 2.8 (at approximately 9pm on Monday 10 January 2011) was in proposing not to invoke strategy W4 at a time when Wivenhoe Dam was approaching the 74.0m AHD level but to keep the release rates below a level of 4,000m^3/s in order to allow the peak flow to pass from the Lockyer Creek and Bremer River into the Brisbane River so as not to exceed the damaging flood level at Moggill. The effect of keeping the release rates below a level of 4,000m^3/s would be that the lake level would rise and in my view this would not be in keeping with strategy W4. I consulted with the dam safety regulator to seek his views on a possible departure from strategy W4. The dam safety regulator indicated that he would support that proposal if our modelling showed that 74.0m AHD would only be exceeded by a relatively small amount (100-200mm) and for a relatively short time (no more than 12 hours). Following that conversation I conducted modelling, which showed that the dam safety regulator's requirements could not be met and, therefore, I determined that I would not exercise my discretion to depart from strategy W4. As further significant rainfall was received into the Dam later on Tuesday 11 January 2011, it became obvious that strategy W4 had to be implemented.

Responsibility for implementation of the strategies and objectives

Obligations of the Senior Flood Operations Engineer under the W&S and NP Manuals

272 The Senior Flood Operations Engineer has a number of obligations under the W&S and NP Manuals.

273 When rostered on duty during a flood event, the responsibilities of the Senior Flood Operations Engineer (as set out in section 2.3 of the W&S and NP Manuals), are:

- *'Set the overall strategy for management of the Flood Event in accordance with the objectives of this Manual.*
- *Provide instructions to site staff to make releases of water from the Dams during Flood Events that are in accordance with this Manual.*
- *Apply reasonable direction in managing a Flood Event as described in Section 2.8.'*

Obligations of the Flood Operations Engineers

274 During the January 2011 Flood Event, I was assisted by a number of Flood Operations Engineers. The responsibilities of the Flood Operations Engineers are set out in 2.4 of the W&S and NP Manuals:

- *'Direct the operation of the dams during a flood event in accordance with the general strategy determined by the Senior Flood Operations Engineer.*
- *Follow any direction from the Senior Flood Operations Engineer in relation to applying reasonable discretion in managing a Flood Event as described in Section 2.8. Unless otherwise directed, a Flood Operations Engineer is to follow this Manual in managing Flood Events and is not to apply reasonable discretion unless directed by the Senior Flood Operations Engineer or the Chief Executive.*
- *Provide instructions to site staff to make releases of water from the Dams during Flood Events that are in accordance with this Manual.'*

275 According to the W&S and NP Manuals, the structural safety of the Dams is of 'paramount importance' or the 'first consideration' in the operation of the Dams (refer to page 9 of the W&S and NP Manuals). The W&S Manual recognises that structural failure of Wivenhoe Dam would have catastrophic consequences, and structural failure of Somerset Dam could have catastrophic consequences. Whilst Wivenhoe Dam has the capacity to mitigate the effects of a failure at Somerset Dam in the absence of any other flooding, if Somerset Dam failed during major flooding, Wivenhoe Dam might also be overtopped and destroyed. Similarly, the NP Manual recognises that failure of North Pine Dam could have catastrophic consequences due to the magnitude of flood damage that would be caused downstream, and also due to the loss of a water supply source.

276 In meeting the flood mitigation objectives, the Dams must be operated to account for the potential effects of closely spaced flood events. Normal procedures require

stored floodwaters to be emptied from Wivenhoe and Somerset Dams within seven days of the flood event peak passing through the Dams and as quickly as possible from North Pine Dam (section 3.1 of the W&S Manual and section 3.3 of the NP Manual). This is known as the 'drain down period'. This requirement serves to ensure that the flood mitigation capacities of the Dams are restored as quickly as possible in the event of successive flood events. This requirement takes account of the significant possibility of two or more flood producing storms occurring in the Brisbane River system within a short period of each other. This seven day drain down period takes into account historical weather records from the Brisbane area. Indeed, the January 2011 Flood Event is an example of such an event. The capacity of the Dams to mitigate floods is compromised if a second flood event occurs before the Dams have been returned to FSL. Further, the risk of overtopping is greatly enhanced if successive flood events occur before the flood compartment of the Dams has been restored.

277 One final consideration in operating the Dams is that the Dams constitute the primary urban water supply for South East Queensland. In operating the Dams during a flood event, the goal is to retain the storage at FSL at the conclusion of the flood event. The W&S and NP Manuals expressly require this (section 1.1 of the W&S and NP Manuals).

278 The initial flood control action required to be undertaken under the W&S Manual once a flood event is declared, is to assess the magnitude of the flood event including (section 8.3):

- *'A prediction of the maximum storage levels in Wivenhoe and Somerset Dams.*
- *A prediction of the peak flow rate at the Lowood Gauge excluding Wivenhoe Dam releases.*
- *A prediction of the peak flow rate at the Moggill Gauge excluding Wivenhoe Dam releases.'*

279 The initial flood control action required to be undertaken under the NP Manual once a Flood Event is declared, is to assess the magnitude of the flood event, including (section 8.3):

- *'A prediction of the maximum storage levels in the dam.*
- *A prediction of the peak outflow rate from the dam.'*

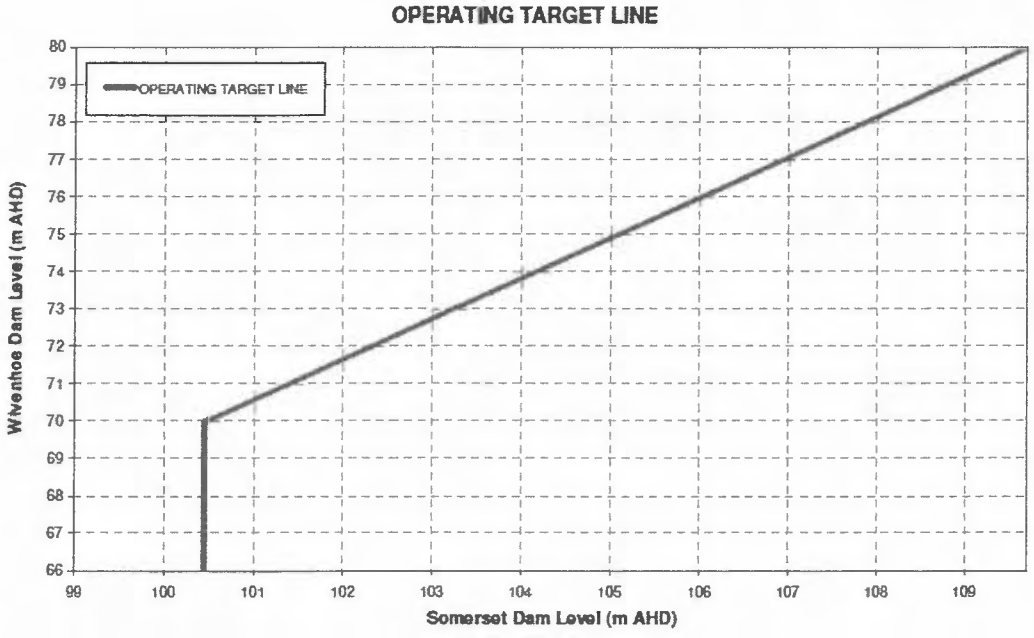
280 These requirements were fulfilled at the start of the January 2011 Flood Event.

Considerations in the operation of Wivenhoe and Somerset Dams

281 Different strategies are to be applied at Wivenhoe and Somerset Dams during a flood event. Although each dam has separate strategies, the maximum flood mitigation effect will be achieved by operating Wivenhoe Dam in conjunction with Somerset Dam.

282 To achieve this, a Wivenhoe / Somerset Operating Target Line (also known as the 'Interaction Line') is used to set a goal for balancing the flood storage in each dam. The Operating Target Line seeks to achieve relative equilibrium in dam levels between Wivenhoe and Somerset Dam to maximise the benefits of operating the dams in conjunction with one another.

283 The diagram below shows the Operating Target Line:



284 The Operating Target Line was selected following an optimisation study by Seqwater in about 2009. The Operating Target Line was selected based on the following factors:

(a) Equal minimisation of flood level peaks in both dams in relation to their associated dam failure levels;

(b) Minimisation of flows in the Brisbane River downstream of Wivenhoe Dam; and

(c) Consideration of the time needed at the onset of a Flood Event to properly assess the magnitude of the event and the likely impacts, so that the likely

optimal strategy to maximise the Flood Mitigation benefits of the storages can be selected.

285 The level of 109.7m AHD is selected as the end point for Somerset Dam and 80.0m AHD is chosen as the end point for Wivenhoe Dam on the Operating Target Line. These levels represent the imminent failure for the Dams. The level of 80.0m AHD also represents the top of the Wivenhoe Dam Wave Wall.

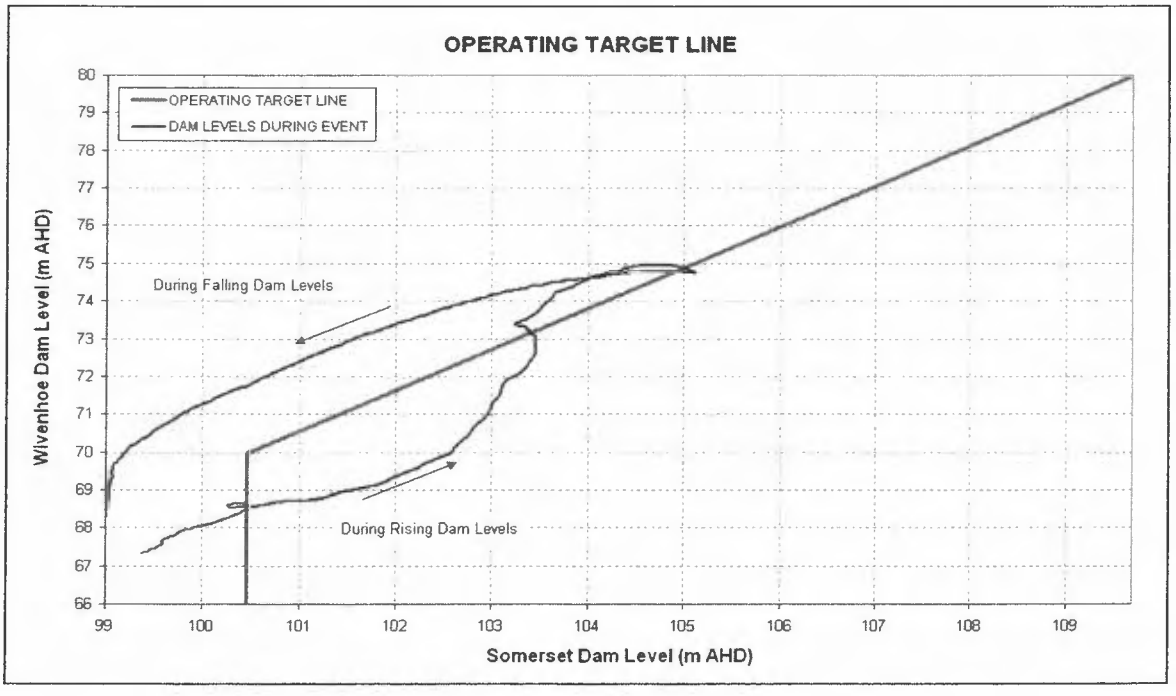
286 Gate movements allow the movement of the duty point towards the target line in a progressive manner. The aim, in operating the Dams in conjunction, is to track along the target line as closely as possible by adjusting releases from the dams in an effort to move the duty point as close to the target line as possible.

287 It is not necessarily possible to adjust the duty point directly towards the target line in a single gate operation. Several gate operations might be required to achieve this.

288 Simply put, if there is too much water in Somerset Dam, the duty point will be below the Operating Target Line, and if there is too much water in Wivenhoe Dam, the duty point will be above the Operating Target Line.

289 The aim of the Operating Target Line is to ensure the mitigation effect of both Dams is maximised during the period of time before failure of one or both of the Dams. This may require increasing or reducing flows from the Dams to achieve an equilibrium in the Operating Target Line.

290 The following graph demonstrates how the Operating Target Line behaved during the January 2011 Flood Event:



291 The auxiliary spillway constructed at Wivenhoe Dam in 2005 is also required to be taken into account in operating Wivenhoe and Somerset Dams during flood events. The auxiliary spillway at Wivenhoe Dam incorporates fuse plugs that trigger as a safety mechanism designed to ensure the structural safety of the dam and prevent overtopping. The auxiliary spillway consists of a concrete ogee spillway crest with an erodible embankment constructed on top. The embankments have a pilot channel, which when the level of the lake gets above the channel invert, will erode the embankment thereby creating an uncontrolled release of further water. The first central bay releases approximately 1,600m^3/s (75.7 m AHD), the second right side bay releases approximately 4,000m^3/s (76.2m AHD) and the third left side bay releases approximately 5,000m^3/s upon initiation (76.7m AHD). It should be noted, however, that the auxiliary spillway is not designed to prevent overtopping in events with a greater than 1 in 100,000 Annual Exceedance Probability (**AEP**). A further auxiliary spillway to be placed on the saddle dam on the left bank of Wivenhoe Dam is planned to be built in 2035 to provide further protection.

292 Wivenhoe Dam is predominantly a central core rock fill dam, and it is susceptible to breaching should overtopping occur. Overtopping is a major threat to the security of Wivenhoe Dam. The W&S Manual requires that where possible, gate operations at Wivenhoe and Somerset Dams should be formulated to prevent operation of the fuse plugs, as the triggering of a fuse plug will increase flood levels down stream (section 3.1 of the W&S Manual).

293 Somerset Dam is a mass concrete dam, and can withstand limited overtopping without damage. However, failure of Somerset Dam would create very severe and destructive flood impacts downstream and would have a dramatic impact on flows into Wivenhoe Dam (which in turn could compromise the structural integrity of Wivenhoe Dam).

Wivenhoe Dam strategies

294 There are four strategies provided in the W&S Manual for operating Wivenhoe Dam during a flood event.

295 The four magnitudes of flooding are classified as follows (section 4 of the W&S Manual):

(a) Minor Flooding – '*Causes inconvenience. Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged.*'

(b) Moderate Flooding – '*In addition to the impacts experienced during Minor Flooding, the evacuation of some houses may be required. Main traffic routes may be impacted. The area of inundation is substantial in rural areas requiring the removal of stock.*'

(c) Major Flooding – *'In addition to the impacts experienced during Moderate Flooding, extensive rural areas and/or urban areas are inundated. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuations of people from flood affected areas may be required. The 1974 flood that impacted on the Ipswich and Brisbane areas is classified as a major flood.*'

(d) Extreme Flooding – '*This causes flooding impacts equal to or in excess of levels previously experienced. In addition to the impacts experienced during Major Floods, the general evacuation of people from significant populated areas is likely to be required.*'

296 These categories are based on the BoM Standards Flood Classifications for Australia.

297 The current classifications for key reference gauges in the Brisbane River are given in Appendix B to the W&S Manual.

298 The January 2011 Flood Event was a Major Flooding event. Had Somerset and Wivenhoe Dams not been available to mitigate the effects of the flood, it is likely that the event would have been in the extreme category (in excess of the 1893 recorded levels).

299 The W&S Manual allows for a degree of flexibility when implementing strategies (see page 22):

'*The strategy chosen at any point in time will depend on the actual levels in the dams and the following predictions, which are to be made using the best forecast rainfall and stream flow information available at the time:*

- *Maximum storage levels in Wivenhoe and Somerset Dams.*
- *Peak flow rate at the Lowood Gauge (excluding Wivenhoe Dam releases).*
- *Peak flow rate at the Moggill Gauge (excluding Wivenhoe Dam releases).*

Strategies are likely to change during a flood event as forecasts change and rain is received in the catchments. It is not possible to predict the range of strategies that will be used during the course of a flood event at the commencement of the event.

Strategies are changed in response to changing rainfall forecasts and stream flow conditions to maximise flood mitigation benefits of the dams.'

300 The reservoir volume above FSL of 67.0m AHD is available as temporary flood storage. The spillway gates are not to be opened for flood control purposes prior to the reservoir level exceeding 67.25m AHD (section 8.3 of the W&S Manual). How much of the flood storage compartment is used, will depend primarily on the magnitude of the flood being regulated but also on the initial reservoir level below FSL and the strategies adopted. The ability of Wivenhoe Dam to mitigate the effects of flooding is constrained by the setting of the FSL at 67.0m AHD as well as the magnitude of the flood. The higher the FSL, the less effective Wivenhoe Dam will be in mitigating floods. However, the lower the FSL, the less effective Wivenhoe Dam will be in securing urban water supply. Strategy W4 is invoked once Wivenhoe Dam storage level is predicted to exceed 74.0m AHD. Accordingly, there is 7.0m between FSL and 74.0m AHD. The auxiliary fuse plugs will commence triggering from 75.5m AHD. In the January 2011 Flood Event, Wivenhoe Dam reached 74.97m AHD.

301 The W&S Manual includes a flowchart of when each strategy is invoked. A copy of this flowchart is on page 23 of the W&S Manual. I believe that there is an error in this flowchart in the centre box. The questions in the centre box, which ask the reader to determine whether to use strategy W2 or strategy W3 should be separated by the word 'or' rather than 'and' plus the centre box should refer to the need of the Duty Flood Operations Engineer to consider the natural occurring peak at Lowood and whether strategy W2 can in fact be implemented. In my experience, the Duty Flood Operations Engineers do not rely on the flowchart for direction as to the operation of Wivenhoe Dam, but they refer to the description of strategy W2 found on page 27 of the W&S Manual. Page 27 of the W&S Manual does refer to the consideration of the natural peak flow at Lowood excluding Wivenhoe Dam releases. Therefore, the error in the flowchart did not have an impact on the decision making process during the January 2011 Flood Event. I will seek to have this flowchart amended at the next review of the W&S Manual.

302 In summary, the four strategies contained in the W&S Manual, provide as follows:

(a) Strategy W1 (Wivenhoe Dam storage level predicted to be less than 68.50m AHD and the maximum release is predicted to be less than 1,900 m^3/s):

(i) The primary consideration is minimising disruption to downstream rural life;

(ii) The intent of this strategy is to not submerge the bridges downstream of the Dam prematurely;

(iii) The limiting condition for this strategy is the submergence of Mt Crosby Weir Bridge that occurs at approximately 1,900m³/s; and

(iv) Strategy W1 is broken up into five sub-strategies W1A–W1E, which each provide for a certain lake level and a maximum release.

(refer to pages 24 to 26 of the W&S Manual).

(b) Strategy W2 (Wivenhoe Dam storage level is predicted to be between 68.5m AHD and 74.0m AHD and the maximum release is predicted to be less than 3,500m³/s):

(i) This is a transition strategy where the primary consideration changes from minimising impact to downstream rural life to protecting urban areas from inundation;

(ii) Lower level objectives are still considered when making decisions on water releases. Objectives are always considered in order of importance;

(iii) The intent of this strategy is to limit the flow in the Brisbane River to less than the naturally occurring peaks at Lowood and Moggill, while remaining within the upper limit of non-damaging floods at Lowood (3,500m³/s);

(iv) The target maximum flow in the Brisbane River at Lowood is the lesser of:

(A) the natural peak flow at Lowood excluding Wivenhoe Dam releases; and

(B) 3,500m³/s;

(v) The target maximum flow in the Brisbane River at Moggill is the lesser of:

(A) the natural peak flow at Moggill excluding Wivenhoe Dam releases; and

(B) 4,000m³/s.

(refer to page 27 of the W&S Manual)

(c) Strategy W3 (Wivenhoe storage level is predicted to be between 68.50m and 74.00m AHD and the maximum release should not exceed 4,000 m^3/s):

(i) The primary consideration is protecting urban areas from inundation;

(ii) Lower level objectives are still considered when making decisions on water releases. Objectives are always considered in order of importance;

(iii) The intent of this strategy is to limit the flow of the Brisbane River at Moggill to less than 4,000 m^3/s, noting that 4,000 m^3/s is the upper limit of non-damaging floods downstream;

(iv) The combined peak river flow targets for this strategy are:

(A) prior to the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases), the flow at Moggill is to be minimised; and

(B) after the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases), the flow at Moggill is to be lowered to 4,000 m^3/s as soon as possible;

(v) It is noted that depending on the natural flows from the Lockyer and the Bremer catchments, it may not be possible to limit the flow at Moggill to below 4,000 m^3/s, in which case the flow is to be kept as low as possible

(refer to page 28 of the W&S Manual).

(d) Strategy W4 (Wivenhoe storage level is predicted to exceed 74.00m AHD. There is no limit on the maximum release rate):

(i) The primary consideration is protecting the structural safety of the dam;

(ii) The intent of this strategy is to ensure the safety of the dam while limiting downstream impacts as much as possible;

(iii) Lower level objectives are still considered when making decisions on water releases. Objectives are always considered in order of importance; and

(iv) Strategy W4 is broken up into to sub-strategies, W4A and W4B, which are to be implemented depending on whether a fuse plug initiation is expected.

(refer to pages 29 and 30 of the W&S Manual)

303 The strategies in the W&S Manual refer to 'predicted' storage levels, whereas the strategies also use the words 'lake level greater than' or 'if the level reaches', or 'the water level reaches', which may be seen to refer to actual lake levels, rather than predicted lake levels. In my view, the W&S Manual allows the Duty Flood Operations Engineers to use actual lake levels when operating within strategy W1 to determine the appropriate release levels (for example, strategies W1A to W1E where bridge levels must be considered), whereas movements to higher levels (for example, from W1 to W2 or W3) would normally occur based upon the predicted lake level as determined by a 'no further rainfall' model, which takes into account the projected catchment runoff from rain already captured in the ALERT system that has not yet resulted in rises in the lake level. I also believe that it is the most practical and appropriate way in which to operate the Dams because it affords the appropriate latitude in implementing the transition between strategies and accounts for lead time for directions to be given to dam operators and then implemented by the operators.

304 The W&S Manual does not define the phrase 'predicted' Wivenhoe storage level, and does not dictate the manner in which the 'predicted' lake level is to be determined. However, as previously explained, the word 'predicted' was inserted following the 2009 review of the W&S Manual to make clear that rainfall data that had been collected through the ALERT system in the catchment area and projected runoff that had not yet resulted in lake level rises should be taken into account (see also paragraph 254). Predicted lake levels are best calculated on the basis of models that are run on a 'no further rainfall' as it allows rainfall runoff and loss rates to be incorporated into the model to determine the 'predicted' lake level.

305 Whilst models on a 'with forecast rainfall' are regularly run to provide awareness on how a flood event might progress, (and are particularly useful in preparing the situation reports provided to the relevant agencies that include details of possible bridge closures, river flows and releases rates), they are not the best basis upon which to assess 'predicted' lake levels. It would be inappropriate to base 'predicted' lake levels on models that are run solely on a 'with forecast rainfall' basis for a number of reasons, including the uncertainty in forecasts, the need to protect the urban water supply and ensure that all opportunities to fill the Dams are taken, the requirements and considerations in the particular strategy being used at the time, the downstream conditions relevant to that particular strategy, actual lake levels and catchment conditions, and the consideration of lower level objectives as expressly required by the W&S Manual. For instance, implementing strategies based upon

predicted lake levels determined by models run on a 'with forecast rainfall' might result in the needless inundation of bridges, needless impacts on riparian flora and fauna, the needless inundation of rural communities, the needless inundation of urban areas and the needless compromise of the urban water supply. Further, a range of various forecasts are available at any one time, and any predicted lake level based on forecasts would vary (often significantly) depending upon which forecasting tool was used.

306 The W&S Manual also provides strategies to apply when the level in Wivenhoe Dam begins to fall. These are known as the Gate Closing Strategies under section 8.5 of the W&S Manual. Generally, gate closing will occur in the reverse order to the opening, with the final gate closure occurring when the lake level has returned to FSL. When determining gate closure sequences, the W&S Manual dictates that the following requirements be considered:

- *'Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the event.*
- *The maximum discharge from the dam during closure should generally be less than the peak inflow into Wivenhoe Dam experienced during the event. The discharge from Wivenhoe Dam includes discharge from triggered fuse plugs, gates, regulator cone dispersion valve and hydro release.*
- *If, at the time the lake level in Wivenhoe Dam begins to fall, the combined flows at Lowood is in excess of 3,500m^3/s then the combined flow at Lowood is to be reduced to 3,500m^3/s as quickly as practicable.*
- *The aim should always be to empty stored floodwaters stored above EL 67.0m within seven days after the flood peak has passed through the dams. However, provided a favourable weather outlook is available, this requirement can be relaxed for the volume between EL 67.0m and EL 67.5m, to obtain positive environmental outcomes.*
- *If the flood storage compartment of Wivenhoe Dam and Somerset Dam can be emptied within seven days, the maximum flow in the Brisbane River at Lowood should not exceed 3,500m^3/s.*
- *To minimise the stranding of fish downstream of the dam, final closure sequences should consider Seqwater policies relating to fish protection at the dam.'*

307 Section 8.6 of the W&S Manual outlines the target minimum interval for radial gate opening and gate closure and the normal gate operation sequences. Generally speaking, gate operations start with the middle gate number 3 and progress outwards so as to ensure that the spillway flows do not impinge on the sidewalls of the spillway cutting, hence limiting the risk of erosion.

Somerset Dam strategies

308 There are three strategies provided in the W&S Manual for operating Somerset Dam during a flood event.

309 As stated above, Somerset Dam and Wivenhoe Dam are to be operated in conjunction to optimise the flood mitigation benefits downstream of Wivenhoe Dam.

310 When a flood event is first declared, the initial flood control action to be taken at Somerset Dam is to fully open all radial crest gates and to generally fully close regulator valves and sluice gates.

311 The W&S Manual provides (at page 37) that:

'*The strategy chosen at any point in time will depend on predictions of the maximum storage levels at Wivenhoe and Somerset Dams which are to be made using the best forecast rainfall and stream flow information available at the time.*

Strategies are likely to change during a flood event as forecasts change and rain is received in the catchments.'

312 A flowchart for when each strategy is to be invoked is provided in the W&S Manual at page 38. The order for opening the sluices under each strategy is from the middle sluice first to the outer sluices last and sluices are to be closed in reverse order of opening.

313 In summary, the strategies for Somerset Dam provide as follows:

(a) Strategy S1 (Somerset Dam Level is expected to exceed 99.0m AHD and Wivenhoe Dam is not expected to reach 67.0m AHD (FSL) during the course of a flood event):

(i) The intent of this strategy is to return the dam to full supply level while minimising the impact on rural life upstream of the dam; and

(ii) Consideration is also given to minimising the downstream environmental impacts from the releases.

(refer to page 39 of the W&S Manual)

(b) Strategy S2 (Somerset Dam level is expected to exceed 99.0m AHD and Wivenhoe Dam level is expected to exceed 67.0m AHD (FSL) but not exceed 75.5m AHD (fuse plug initiation) during the course of a flood event):

(i) The aim for this strategy is to minimise the impacts below Wivenhoe Dam;

(ii) The intent of this strategy is to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dams; and

(iii) The W&S Manual provides guidance on the operating conditions and actions for strategy S2 by reference to the Wivenhoe Dam Operating Target Line.

(refer to pages 39 & 40 of the W&S Manual)

(c) Strategy S3 (Somerset Dam level is expected to exceed 99.0m AHD and Wivenhoe Dam level is expected to exceed 75.5m AHD (fuse plug initiation) during the course of a flood event):

(i) The aim for this strategy is to protect the structural safety of the dam;

(ii) The intent of this strategy is to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dams;

(iii) In addition to the operating protocols used in strategy S2, to prevent fuse plug initiation, consideration can be given to temporary departure from the operating protocols contained in this strategy under the following conditions:

(A) The safety of Somerset Dam is the primary consideration and cannot be compromised; and

(B) The peak level in Somerset Dam cannot exceed 109.7m AHD.

(refer to page 41 of the W&S Manual)

314 Gate closing strategies for Somerset Dam are also provided for in the W&S Manual. In general, gate closing commences when the level in Somerset Dam begins to fall and is generally to occur in the reverse order to opening. The final gate closure should occur when the lake level has returned to FSL. The following requirements are required to be considered:

(a) Unless determined otherwise by the Senior Flood Operations Engineer in accordance with section 2.8 of the W&S Manual, the aim should be to empty stored floodwaters within seven days after the flood peak has passed through the dams; and

(b) To minimise the stranding of fish downstream of the Dam, final closure sequences should consider Seqwater policies relating to fish protection at the dam.

315 The W&S Manual provides guidance on the gate operations sequences and intervals for normal operations.

How are operational strategies implemented for Wivenhoe and Somerset Dams?

316 When determining the appropriate strategy to invoke for Wivenhoe and Somerset Dams a number of factors must be considered and balanced. The combined operation of Wivenhoe and Somerset Dams must be taken into account, rainfall, loss rates and runoff must be calculated, dam levels must be monitored and river flow rates downstream of the Dams need to be considered (including flows from Lockyer Creek and Bremer River into the Brisbane River).

Considerations in the operations of North Pine Dam

317 One important consideration in operating North Pine Dam is the positioning of the winch motors. The electric winch motors used to control the radial gates are vulnerable to inundation at 41.66m AHD. The winch motors are located on platforms beneath the bridge deck forming the dam crest. If these motors became submerged, the electric winch motors would not operate and the winches would not be accessible to enable operation using the compressed air system. An auxiliary gate operating system (a trailer mounted motor with petrol driven generator) was installed in 1997/1998 that allows the winches to be operated from the crest of the dam in the event of failure of both the mains electric supply and the standby diesel generator, or in the event of failure or submergence of the electric winch motors.

318 Overtopping of the Dam is an important consideration in operating North Pine Dam. Overtopping of the Dam is likely to result in a dam failure. Every endeavour must be made to prevent overtopping of North Pine Dam by the progressive opening of operative spillway gates (section 9.2 of the NP Manual).

319 North Pine Dam effectively has no significant provision for flood mitigation and once the dam is full, ensuring the structural safety of the dam is paramount. Accordingly,

the flood operation strategy is to pass any significant flood through the reservoir, while ensuring that peak outflows generally do not exceed peak inflow while aiming to empty stored floodwaters as quickly as possible.

320 Some of the critical levels that must be kept in mind in operating North Pine Dam are:

Critical Point	m AHD
Embankment Crest	43.282
Centreline of Winches	42.062
Radial Gate Switch Gear	41.66
Maximum Design Flood Level	41.465
Winch Room Floor Level	41.117
Top of Closed Radial Gate	40.234
Gate Operation Trigger Level	39.650
Full Supply Level	39.60
Bottom of Fully Open Gate	38.045
Spillway Fixed Crest Level	32.004

321 The embankment crest is 43.28m AHD. Overtopping of the dam crest may result in a breach of the embankment by erosion. While concrete sections can withstand limited overtopping without damage, embankment sections on the other hand will washout rapidly if overtopped and cause failure of the dam, resulting in severe flooding downstream.

322 Very little flood mitigation capacity is available above the FSL before operations at the dam are endangered.

323 Runoff into North Pine Dam may occur very quickly. Significant inflow may occur in the catchment approximately two to four hours after the commencement of heavy rainfall. Once significant rainfall is received in the catchment area, it does not take long for the dam levels to start rising. This short response period also reduces the loss that might occur in larger catchment areas. Once rainfall is received, the time available to prepare for large outflows is limited.

North Pine Dam strategies

324 North Pine Dam is operated on a very different basis to Wivenhoe and Somerset Dams. As North Pine Dam effectively has no significant provision for flood mitigation, the flood operation strategy is to pass any significant flood through the reservoir,

while ensuring peak outflow generally does not exceed peak inflow (section 8.4 of the NP Manual).

325 To achieve this strategy, the NP Manual provides a detailed list of minimum gate opening settings that are used to determine flood releases. These gate opening settings are set out in the table provided at Appendix C to the NP Manual. As the dam level rises and AHD trigger points are reached, gate operations occur in accordance with those trigger points. Target minimum gate movement intervals are provided in the NP Manual. If the Dam level is below 39.9m AHD, the target minimum gate opening and closing interval is 15 minutes. Between 39.9m AHD and 40.5m AHD 10 minutes is the target minimum interval and 5 minutes for levels above 40.5m AHD.

326 Gate closing should generally commence when the level in North Pine Dam begins to fall and the closing sequence is generally to occur in the reverse order to opening.

How are operational strategies implemented for North Pine Dam?

327 Operational strategies for North Pine Dam are implemented by following the gate opening sequences as trigger levels in the dam are reached. The gate sequences should generally occur in accordance with the target minimum operating intervals.

2010/2011 FLOOD EVENTS

October 2010 Flood Event

328 The FOC was operated for nine days from 9 October 2010 to 18 October 2010 with North Pine, Somerset and Wivenhoe Dams all becoming operational.

329 Wivenhoe Dam filled in excess of FSL and releases were made under the W&S Manual accordingly.

330 All bridges up to Mt Crosby Weir Bridge were closed and releases peaked at approximately 1,600m^3/s.

331 North Pine Dam was operated on two occasions in October 2010.

332 During the October 2010 Flood Event the FOC issued communications to the agencies listed in the W&S Manual. The communications during that event were called 'flood advice' but contained similar information to the situation reports, which were issued in the January 2011 Flood Event.

333 Following the peak of the October 2010 Flood Event, the drain down was initiated in accordance with the W&S Manual and Wivenhoe Dam returned to FSL within seven days.

334 As set out earlier in this statement (from paragraph 231), following the October 2010 Flood Event the Protocol was prepared, which led to the implementation of technical situation reports from Seqwater to the various agencies referred to.

December 2010 Flood Events

335 December saw three separate flood events at Wivenhoe and Somerset Dams which required gate operations in accordance with the release strategies under the W&S Manual:

(a) 70,000ML was released between 13 December 2010 and 16 December 2010;

(b) 150,000ML was released between 17 December 2010 and 24 December 2010; and

(c) 470,000ML was released between 26 December 2010 and 2 January 2011.

336 Following those flood events there were seven day drain down periods and the lake level returned to FSL.

337 North Pine Dam was operated on 11 occasions in December 2010.

338 I was on annual leave from 10 December 2010 to 17 December 2010, however, I came back one day early on 16 December 2010 due to the December 2010 Flood Events.

339 Less than four days separated the flood event that commenced on 26 December 2010 (and concluded on 2 January 2011) and the commencement of the January 2011 Flood Event.

340 On 2 January 2011, at about 8am, the gates at Wivenhoe Dam were closed and the FOC was demobilised in order to allow fish recovery teams to undertake fish recovery on the weekend of 2 January 2011.

341 Following completion of fish recovery, operational releases were commenced again through to 5 January 2011 and Wivenhoe Dam reached a lake level of approximately 67.08m AHD.

342 On 5 January 2011, about 25 to 40mm fell across the catchment. I spoke with Engineer 2 in the evening of 5 January 2011, as he was the Duty Flood Operations Engineer at that time. During the phone conversation Engineer 2 said that he would

monitor the situation overnight and mobilise the FOC on Thursday morning if necessary.

343 On the evening of 5 January 2011, I also kept on eye on the developing situation from home.

344 At 7:42am on 6 January 2011, the FOC was mobilised for the commencement of the January 2011 Flood Event.

Overview and significance of the January 2011 Flood Event at Wivenhoe and Somerset Dam

345 December 2010 had been significant in terms of rainfall recorded in South East Queensland. In some areas, rainfall exceeded the December average by as much as 400mm.

346 Leading up to the January 2011 Flood Event, Wivenhoe Dam and Somerset Dam had operated in October and December 2010, with large releases from Somerset and Wivenhoe Dam. The Brisbane River Basin catchment's antecedent wetness levels were elevated, which led to elevated runoff into the Dams and contributed to the rising dam levels during the event.

347 When compared with historical events, the flood volumes indicated that the volume of the January 2011 Flood Event was almost double that of the January 1974 flood and rivals the February 1893 flood.

348 Overall, the January 2011 Flood Event falls within the category of a large to rare event as defined by the Institution of Engineers Australia (Engineers Australia) national guidelines for design flood estimation, *Australian Rainfall and Runoff* (Book VI) (AR&R), in terms of rainfall, flood peaks, inflow volume and peak heights. The flood level classifications adopted by the BoM also define the January 2011 Flood Event as a major flood.

349 Rainfall totals beyond the credible limit of extrapolation (AEP of 1 in 2000) were recorded for durations of between 6 hours and 48 hours at various locations within the catchments of the Dams (refer to the table below).

January 2011 Flood Event – Highest rainfall intensities					
Duration	ALERT ID	Station	Recorded intensity mm/hr	End time	AEP 1 in Y
3 H	6559	Savages Crossing	70.5	11/01/2011 09:34	500 - 1000
6 H	6559	Savages Crossing	47.8	11/01/2011 12:49	> 2000
	6649	Lowood	40.0	11/01/2011 14:04	
12 H	6559	Savages Crossing	30.7	11/01/2011 14:34	> 2000
	6643	Wivenhoe Dam	29.4	11/01/2011 16:29	
	6649	Lowood	29.0	11/01/2011 14:49	
18 H	6649	Lowood	19.6	11/01/2011 19:34	> 2000
24 H	6649	Lowood	14.8	11/01/2011 19:19	> 2000
48 H	6649	Lowood	9.0	11/01/2011 14:49	> 2000
72 H	6649	Lowood	6.4	12/01/2011 01:19	1000 - 2000
96 H	6649	Lowood	4.9	12/01/2011 01:19	500 - 1000
120 H	6649	Lowood	4.0	12/01/2011 01:04	500 - 1000

350 The volume of total inflow into Wivenhoe Dam during the event was almost double (190%) the comparable volume of inflow from the January 1974 flood event, and comparable to the flood of 1893. The January 2011 inflow was characterised by two separate flood peaks about 30 hours apart. The maximum flow rate at the first peak is estimated to be around 200% of the comparable flow rate calculated from the January 1974 event, while the maximum flow rate at the second peak is estimated to have been approximately 230% of the comparable flow rate from the January 1974 event.

351 The January 2011 Flood Event was the largest flood event recorded at Wivenhoe and Somerset Dams since the Dams were built.

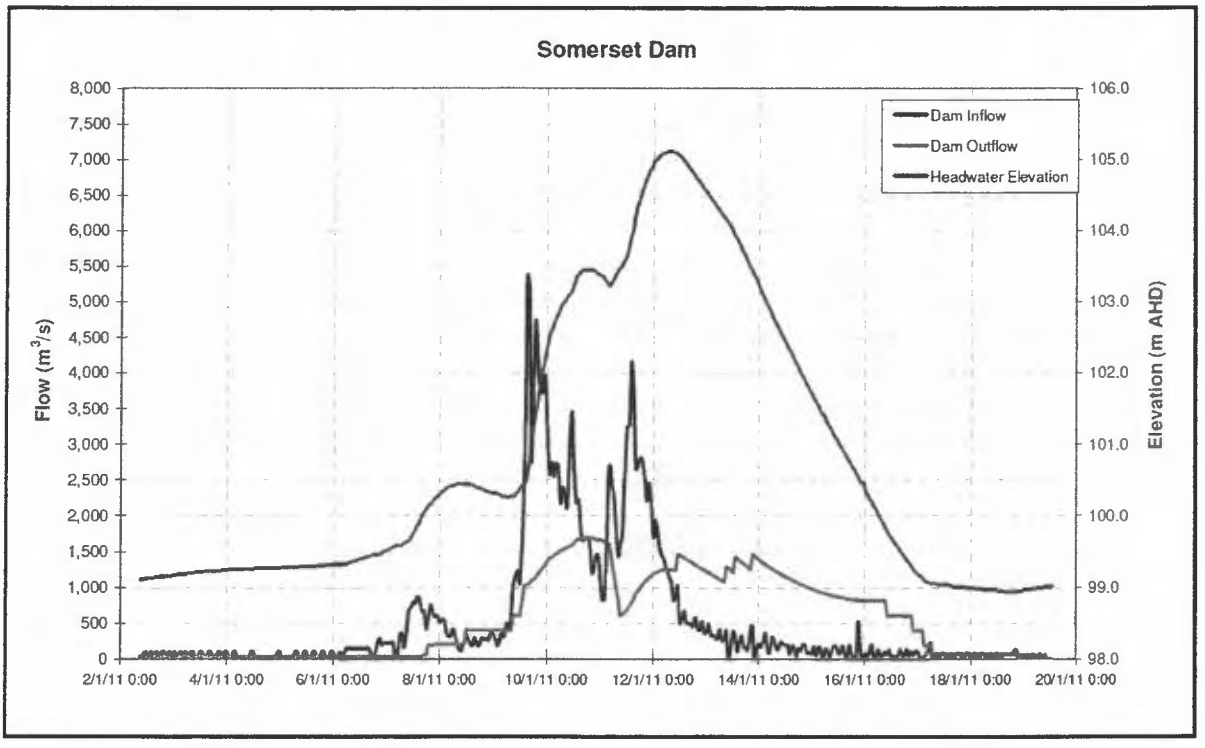
352 The findings of the subsequent modelling for the Wivenhoe and Somerset Dams Flood Report 2011 were that the peak flood height measured at the Port Office gauge near the Brisbane CBD would have been approximately 2.0m higher than was experienced had Wivenhoe and Somerset Dam not been available.

Somerset Dam

353 The inflow of waters into Somerset Dam involved dual peaks arriving at the Dam approximately 48 hours apart. The first peak on the afternoon of Sunday 9 January 2011 was higher than the peak that occurred on the afternoon of Tuesday 11 January. The peak of the outflow occurred late on Monday 10 January 2011, and was quickly arrested when Wivenhoe Dam levels began rising quickly. Somerset

Dam's maximum water level of 105.11m AHD was achieved on the morning of Wednesday 12 January 2011.

354 The following graph demonstrates the significant flood mitigation benefit provided by Somerset Dam during the January 2011 Flood Event:



355 Key points to note are that:

(a) The attenuation of the downstream flood was significant in that the peak of the outflow from the Dam was approximately 66% lower than the peak of the inflow. The peak outflow rate was 1,690m^3/s compared with a peak inflow of 5,350m^3/s;

(b) The volume of the flood storage was drained within seven days of the peak; and

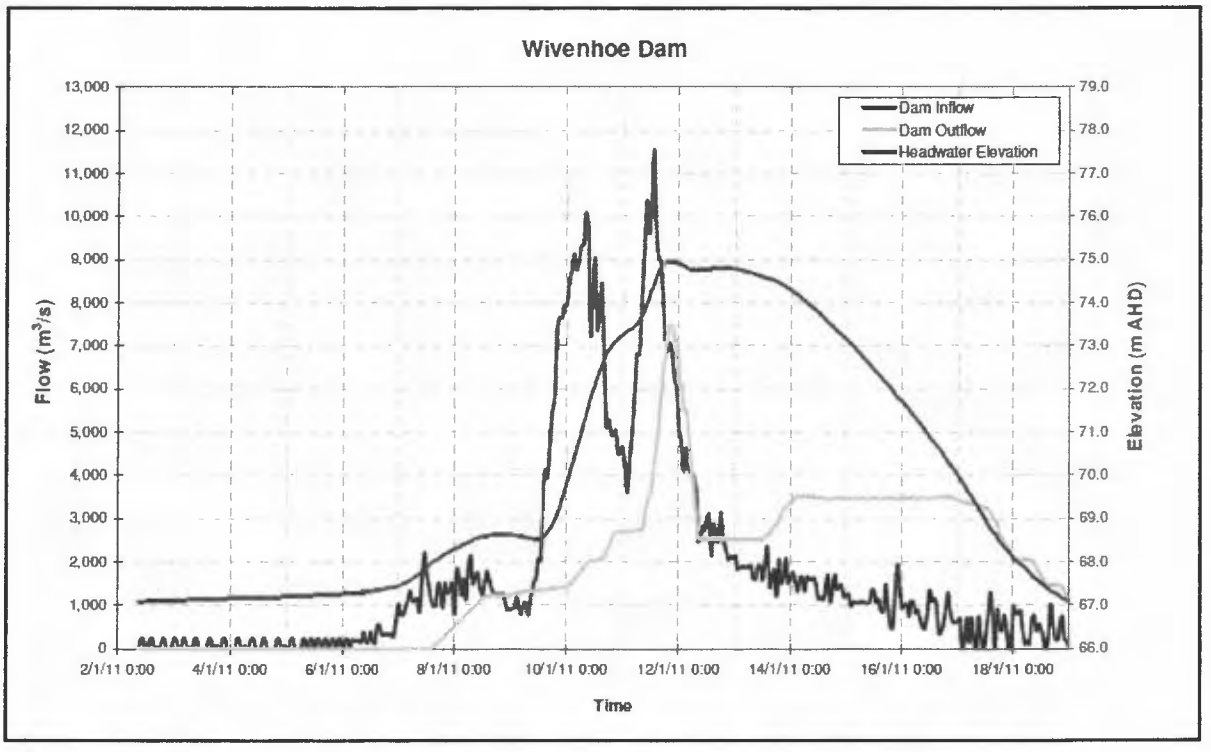
(c) The return of the lake level to FSL at the conclusion of the event.

Wivenhoe Dam

356 Similar to Somerset Dam, the January 2011 Flood Event actually consisted of two separate flood peaks arriving at the dam within close proximity of one another. The second peak, which arrived on the afternoon of Tuesday 11 January 2011, was higher than the first peak, which had arrived about 30 hours earlier on the morning of Monday 10 January 2011. The peak of the outflow occurred at 7pm on Tuesday 11

January 2011. Wivenhoe's peak water level of 74.97m AHD was reached at 7pm on Tuesday 11 January 2011.

357 The following graph demonstrates the significant flood mitigation benefit provided by Wivenhoe Dam during the January 2011 Flood Event:



358 Key points to note are that:

(a) The attenuation of the downstream flood was significant in that the peak of the outflow from the Dam was approximately 40% lower than the peak of the inflow. The peak outflow rate was 7,460m^3/s compared with a peak inflow of 11,600m^3/s;

(b) The Dam was able to absorb the first peak on Monday 10 January 2011 (so the peak outflow was able to be kept below 4,000m^3/s); however, the Dam was not able to absorb the second, higher, peak on Tuesday 11 January 2011 and so, with the lake levels rising above 74.0m AHD strategy W4 had to be triggered and release rates increased above 4,000m^3/s;

(c) The volume of the flood storage was drained within seven days of the peak; and

(d) The lake level returned to FSL at the conclusion of the event.

Overview and significance of the event at North Pine Dam

359 The January 2011 Flood Event impacted North Pine Dam between Thursday 6 January 2011 and Friday 14 January. In the 31 days prior to Thursday 6 January 2011, above average levels of rainfall were received in the Dam's catchment area, and flood water releases were made from the Dam on 25 days of this 31 day period. Rain continued to fall in the Dam catchments on the morning of Thursday 6 January 2011, which resulted in the mobilisation of the FOC. The rainfall continued in the Dam's catchment area until Tuesday 11 January 2011 when unprecedented levels of rainfall resulted in the largest flood in the Pine Rivers Basin ever recorded.

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

361 The January 2011 Flood Event at North Pine Dam was a major flood under the BoM classification.

362 At individual rainfall stations within the North Pine catchment, rainfall with an AEP of between 1 in 200 and 1 in 500 was recorded for durations of between 6 and 12 hours. The rainfall recorded in the Mt Glorious station exceeded an AEP of 1 in 500 and was approaching an AEP of 1 in 1000 for a duration of 12 hours.

363 The following table summarises the catchment average rainfalls in the Pine Rivers Basin. Catchment average rainfall intensities tend to be lower than point intensities due to the spatial variation of rainfall through the catchment, with some areas recording higher rainfall than others. This is particularly true for catchments such as the North Pine catchment, where there is significant spatial variation in the storm rainfall. However, the AEP for the North Pine Dam catchment was between the 1 in 100 and 1 in 500 range for rainfall durations between six hours to 72 hours. This was a significant rainfall event:

Duration	Recorded intensity	Event and Time	AEP
hrs	mm/hr		1 in Y
1	49.1	11/01/2011 10:00	< 5
3	41.0	11/01/2011 11:00	20-50
6	34.3	11/01/2011 12:00	100-200
12	24.3	11/01/2011 15:00	200-500
18	16.9	11/01/2011 19:00	100-200

Duration	Recorded intensity	Event and Time	AEP
hrs	mm/hr		1 in Y
24	12.9	11/01/2011 18:00	50-100
48	9.1	11/01/2011 14:00	50-100
72	6.7	11/01/2011 19:00	50-100
96	5.1	12/01/2011 09:00	20-50
120	4.4	12/01/2011 01:00	20-50

364 The volume of total inflow into North Pine Dam during the Event was 202,000ML or 94% of the total Dam storage volume (with the Dam starting at close to FSL prior to the commencement of the event). Of this total inflow volume, 102,000ML or almost half of the total Dam storage volume flowed into the Dam during the 14 hours to 22 hours on Tuesday 11 January 2011. Such a high volume of inflow is unprecedented in North Pine Dam's recorded history.

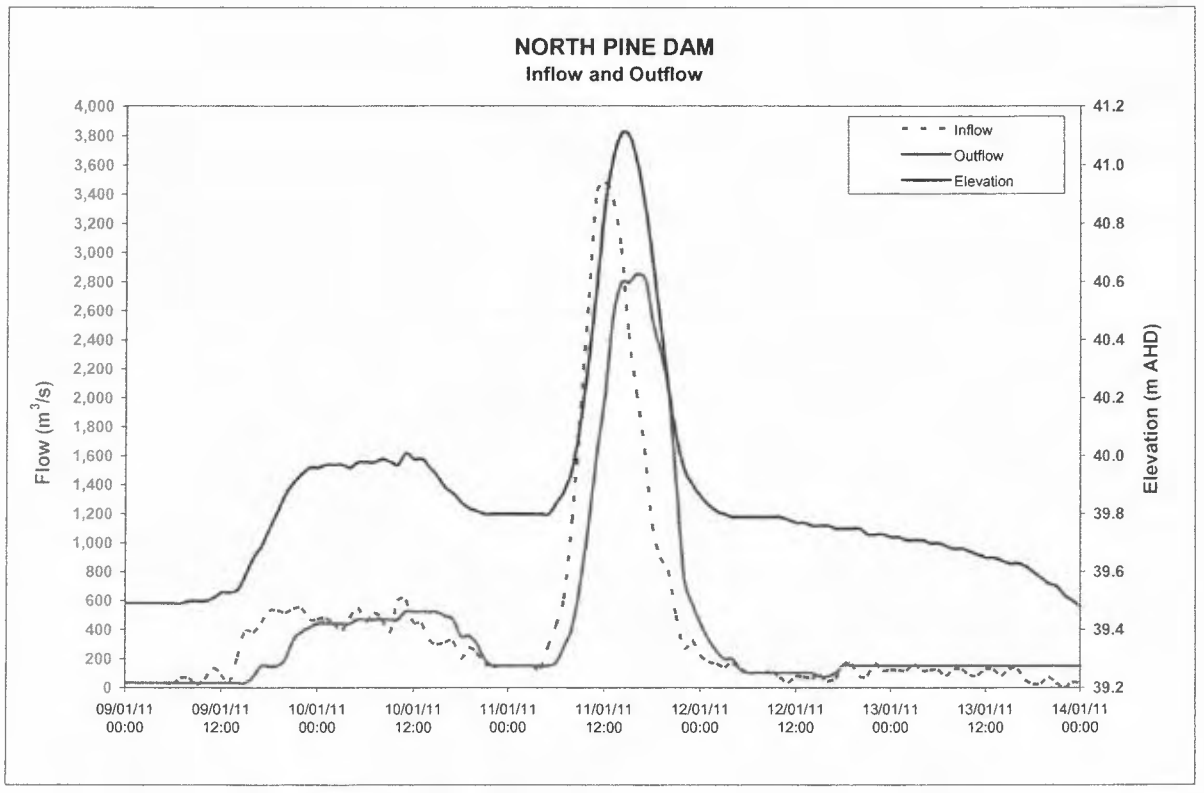
365 The maximum flow rate of 3,480m^3/s is approximately 235% of the largest previous flow rate into North Pine Dam ever recorded (in March 1989) and the largest flow to have occurred in the Pine River since records commenced in 1916.

366 Despite those rainfall and inflow amounts, the peak outflow from North Pine Dam during the January 2011 Flood Event was only 82% of the peak inflow. This reduced flood flows downstream of the Dam. Further reductions in flood flows downstream of the Dam were not possible without risking the safety of the Dam. Another way of putting this is that the peak inflow was approximately 22% greater than peak outflow. This is a significant flood attenuation benefit, notwithstanding that the Dam is not designed as a flood mitigation structure.

367 The total dam inflow during the event was 202,000ML, with an outflow of 206,000ML. The Dam level peaked at 41.11m AHD at 2pm on Tuesday 11 January 2011. The peak inflow was 3,480m^3/s and the peak outflow was 2,850m^3/s.

368 The level reached was only 0.5m below the level of the radial gates' switch gear. If that switch gear had been inundated, the normal control of the radial gates would have been lost and the back up system would need to have been used.

369 The significant flood mitigation benefit provided by North Pine Dam is demonstrated by the following table:



370 Key points to note include:

(a) The attenuation of the flood peaks with the peak outflow being 82% of the peak inflow;

(b) There was a delay of the flood peaks;

(c) The lake level was only 2.0m below the Dam crest level and 0.5m below the winch gear controls; and

(d) The lake level was returned to FSL at the conclusion of the event.

The combined mitigation effect of the Dams

Wivenhoe and Somerset Dams

371 For the purpose of the Wivenhoe and Somerset Dams Flood Report 2011, preliminary modelling was undertaken to show what the January 2011 Flood Event was likely to have looked like in downstream Brisbane on the following five different case scenarios:

(a) Case 1 (dark blue)– the actual downstream estimated flow during the January 2011 Flood Event;

(b) Case 2 (purple)– if (theoretically) Wivenhoe Dam could have retained all of the water, which flowed into the Wivenhoe Lake, bearing in mind that

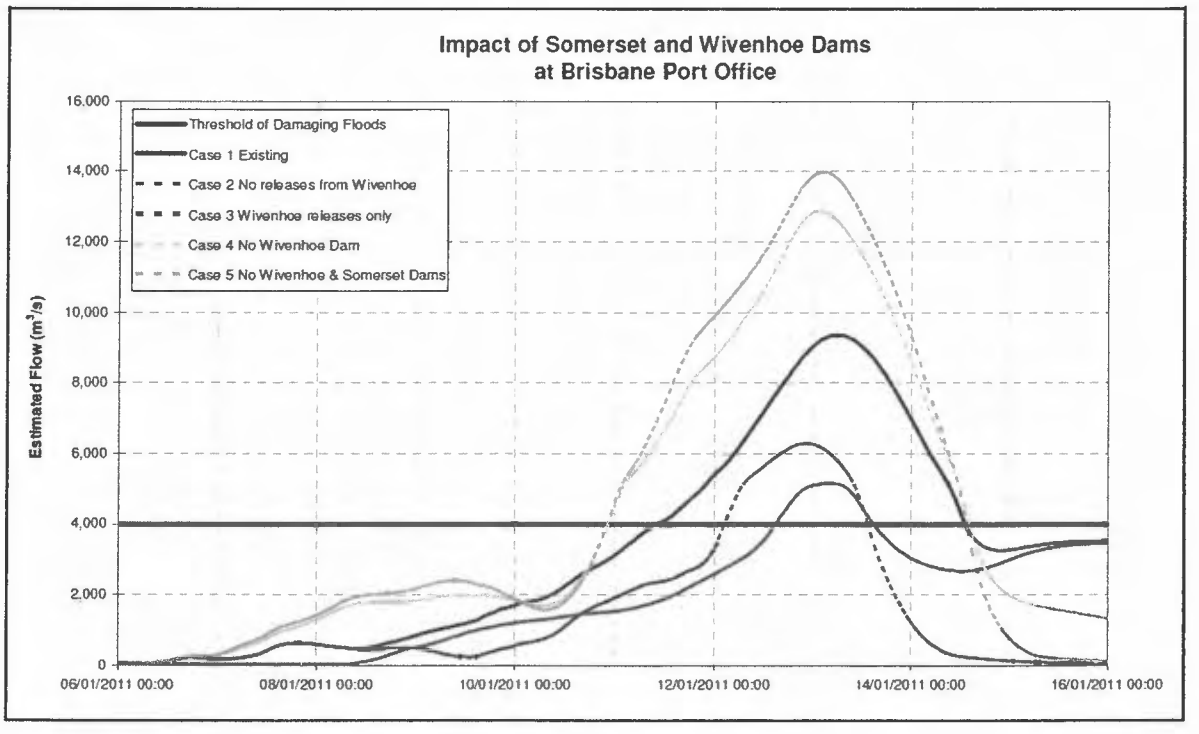
Brisbane would still be affected by flooding from Lockyer Creek, Bremer River and rainfall in the Brisbane catchment;

(c) Case 3 (red)– releases from Wivenhoe Dam only, excluding flows from Lockyer Creek, Bremer River and rainfall in the Brisbane catchment;

(d) Case 4 (light blue)- the downstream flooding had Wivenhoe Dam not existed; and

(e) Case 5 (yellow) – the downstream flooding had Wivenhoe and Somerset Dams not existed.

372 The results of the models are represented on the following graph:



373 The key points to note about this modelling are as follows:

(a) Had Wivenhoe and Somerset Dams, or just Wivenhoe Dam not existed (cases 5 and 4), the estimated flow at Brisbane would have been approximately 13,000m^3/s and 14,000m^3/s respectively, compared with the actual downstream flow (case 1) of approximately 9,500m^3/s (a reduction of approximately 40%). Further, the period of time above the damaging level of 4,000m^3/s, had there been no Wivenhoe and Somerset Dams, would have been approximately 12 hours longer; and

(b) Had there been no releases from Wivenhoe Dam at all (case 2), then the Brisbane River would still have flooded with the peak flow rates of about

6,200m^3/s for a period of approximately 35 hours. This flooding would have occurred from flows from the Lockyer Creek, Bremer River and rainfalls in the Brisbane catchment below Wivenhoe Dam. On the BoM flood scale this would still have been a moderate flood.

374 I am aware that there has been some media reports and public speculation that releases from Wivenhoe Dam were the cause of flooding in Brisbane. Those reports speculate that, had Wivenhoe Dam been operated in a different manner, there would have been no flooding in Brisbane. This modelling demonstrates that, even without the Wivenhoe Dam releases being taken into account, Brisbane would still have flooded as a result of flows from Lockyer Creek, Bremer River and rainfall in the Brisbane catchment below Wivenhoe Dam.

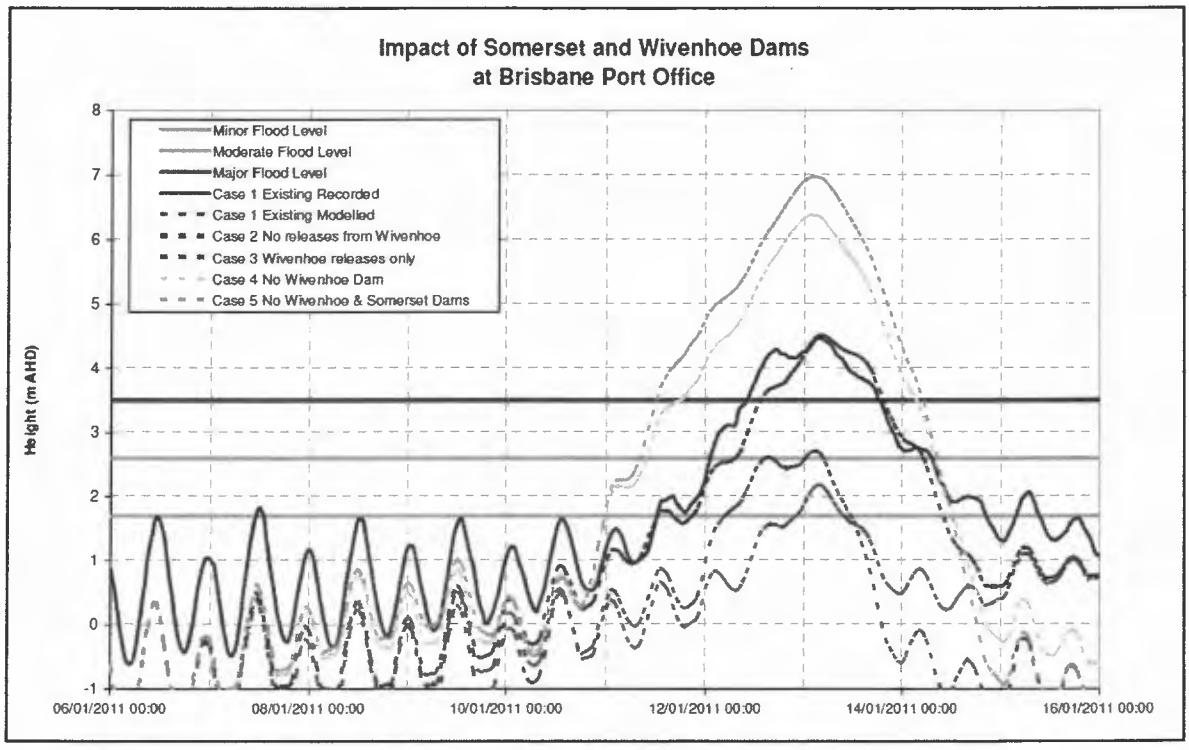
375 It is important to note, however, that these are approximate numbers because the figures are based on hydrologic models, which do not fully account for hydraulic factors, such as, the effect of tides in the Brisbane estuary.

376 A further graph was prepared for the purpose of the Wivenhoe and Somerset Dams Flood Report 2011, which shows the height of the Brisbane River at the CBD (Port Office) on those five case scenarios. I also note that this graph sets out (see case 1, 'existing recorded' in dark blue) the actual recorded heights during the January 2011 Flood Event as compared to the hydrologic modelling (see case 1, 'existing modelled' in broken dark blue) it shows that the hydrologic model is comparable to the actual recorded levels.

377 This graph again demonstrates:

(a) The likely height of the River at Brisbane had there been no Wivenhoe Dam and no Somerset Dam would have been approximately 7.0m; and

(b) The height of the River on a 'no release from Wivenhoe basis' (see case 2 'no releases from Wivenhoe') would still have been recorded as a moderate flood:



North Pine Dam

378 No similar models were prepared for North Pine Dam due to the fact that North Pine Dam is not designed for flood mitigation purposes.

COMPLIANCE WITH THE STRATEGIES DICTATED BY THE W&S AND NP MANUALS DURING THE JANUARY 2011 FLOOD EVENT

379 In my view, Wivenhoe, Somerset and North Pine Dams were operated in accordance with the relevant manuals. The strategies, procedures and gate operations adopted during the January 2011 Flood Event were in compliance with the requirements dictated by the manuals.

Compliance with W&S Manual strategies

380 I note that the Wivenhoe and Somerset Dams Flood Report 2011 contains at Appendix M, the Event Log that was kept during the January 2011 Flood Event.

381 The Event Log sets out the communications sent and received to and from the FOC during the January 2011 Flood Event. The Event Log is compiled by the technical assistant on shift.

382 However, in order to assist the Commission of Inquiry, I have prepared a detailed schedule, which sets out, on a day-by-day and hour-by-hour basis, statistics for each Dam, including the dam levels, inflow and release rates, as well as the strategy employed throughout the January 2011 Flood Event. This schedule is attached and marked as **Schedule 1** to this statement. Schedule 1 contains:

(a) Schedule 1A – Wivenhoe Dam;

(b) Schedule 1B – Somerset Dam;

(c) Schedule 1C – Brisbane River downstream impacts; and

(d) Schedule 1D – North Pine Dam.

383 In my view, the schedule demonstrates Wivenhoe, Somerset and North Pine Dams were all operated in accordance with the strategies dictated by the W&S and NP Manuals throughout the January 2011 Flood Event.

384 In order to further assist the Commission of Inquiry, I have set out in the table below a summary of the strategies implemented during the January 2011 Flood Event and how the requirements of those strategies were complied with:

Strategy Implemented	Time of Transition	Strategy Requirements	Compliance
W1A	6 January 2011 7:42am	Lake level greater than 67.25m AHD	The lake level had exceeded 67.25m AHD. The lake level was at 67.32m AHD at 9am
		Lake level predicted to be less than 68.5m AHD (note that lake level predictions referred to in this table are on a 'no forecast rainfall' model basis)	The lake level was predicted to peak below 68.50m AHD
		Maximum release of 110m^3/s	Gate releases had not commenced
		Maximum release predicted to be less than 1,900m^3/s	Maximum release was predicted to be less than 1,900m^3/s
S2		Somerset Dam level expected to exceed 99.00m AHD	Somerset Dam was predicted to exceed 99.00m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43). Somerset Dam was expected to exceed 99.00m AHD at all times up to and including the peak of Wivenhoe Dam at 7.00pm on 11 January 2011 (Wivenhoe Dam peaked at 74.97m AHD)
		Wivenhoe Dam level expected to exceed 67.0m AHD but not	Wivenhoe Dam level expected to exceed 67.0m AHD but not

Strategy Implemented	Time of Transition	Strategy Requirements	Compliance
		expected to exceed 75.5m AHD	expected to exceed 75.5m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43)
W1B	7 January 2011 2am	Lake level greater than 67.5m AHD	The lake level had exceeded 67.50m. The lake level had exceeded 67.5m AHD at 2am by reaching 67.52m AHD
		Lake level predicted to be less than 68.50m AHD	The lake level was predicted to peak at 68.20m AHD (model run 5)
		Maximum releases of 380m^3/s	Gate releases had not commenced
		Maximum release predicted to be less than 1,900m^3/s	Maximum release was predicted to be less than 1,900m^3/s
S2		Somerset Dam level expected to exceed 99.00m AHD	Somerset Dam was predicted to exceed 99.00m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43). Somerset Dam was expected to exceed 99.00m AHD at all times up to and including the peak of Wivenhoe Dam at 7pm on 11 January 2011 (Wivenhoe Dam peaked at 74.97m AHD)
		Wivenhoe Dam level expected to exceed 67.0m AHD but not expected to exceed 75.5m AHD.	Wivenhoe Dam level expected to exceed 67.0m AHD but not expected to exceed 75.5m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43)
W1C	7 January 2011 9am	Lake level greater than 67.75m AHD	The lake level had reached 67.75m at 9am
		Lake level predicted to be less than 68.50m AHD	The lake level was predicted to peak at 68.20m AHD (model run 7)
		Maximum Release 500m^3/s	Gate releases had not commenced
		Maximum release predicted to be less than 1,900m^3/s	Maximum release was predicted to be less than 1,900m^3/s
S2		Somerset Dam level expected to exceed 99.00m AHD	Somerset Dam was predicted to exceed 99.00m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43). Somerset Dam was expected to exceed 99.00m AHD at all times up to and including the peak of Wivenhoe

Strategy Implemented	Time of Transition	Strategy Requirements	Compliance
			Dam at 7pm on 11 January 2011 (Wivenhoe Dam peaked at 74.97m AHD)
		Wivenhoe Dam level expected to exceed 67.00m AHD but not expected to exceed 75.5m AHD	Wivenhoe Dam level expected to exceed 67.0m AHD but not expected to exceed 75.5m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43)
W1D	7 January 2011 3pm	Lake level greater than 67.75 m AHD	The lake level had exceeded 67.75m AHD by 3pm the lake had reached 68.03m AHD
		Lake level predicted to be less than 68.50m AHD	The lake level was predicted to peak at 68.40m AHD (model run 8) at 3pm
		Maximum release 500m^3/s	The release had not exceeded the specified amount. The peak outflow under this strategy was achieved at 9pm, releasing 403m^3/s
		Maximum release predicted to be less than 1,900m^3/s	Maximum release was predicted to be less than 1,900m^3/s
S2		Somerset Dam level expected to exceed 99.00m AHD	Somerset Dam was predicted to exceed 99.00m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43). Somerset Dam was expected to exceed 99.00m AHD at all times up to and including the peak of Wivenhoe Dam at 7pm on 11 January 2011 (Wivenhoe Dam peaked at 74.97m AHD)
		Wivenhoe Dam level expected to exceed 67.00m AHD but not expected to exceed 75.5m AHD	Wivenhoe Dam level expected to exceed 67.00m AHD but not expected to exceed 75.5m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43)
W1E	7 January 2011 10pm	Lake level greater than 68.25m AHD	The lake level had exceeded the 68.25m AHD level, reaching 68.26m AHD at 10pm
		Lake level predicted to be less than 68.50m AHD	Strategy W3 was implemented once it became apparent that Wivenhoe Dam would exceed 68.50m AHD at 8am on 8 January 2011 (model run 10)
		Maximum release 1,900m^3/s	The release had not exceeded the specified amount. The peak release flow under this

Strategy Implemented	Time of Transition	Strategy Requirements	Compliance
			strategy was 879m^3/s at 7am on 8 January 2011
S2		Somerset Dam level expected to exceed 99.00m AHD	Somerset Dam was predicted to exceed 99.00m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43). Somerset Dam was expected to exceed 99.00m AHD at all times up to and including the peak of Wivenhoe Dam at 7pm on 11 January 2011 (Wivenhoe Dam peaked at 74.97m AHD)
		Wivenhoe Dam level expected to exceed 67.0m AHD but not expected to exceed 75.5m AHD.	Wivenhoe Dam level expected to exceed 67.0m AHD but not expected to exceed 75.5m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43)
W2	8 January 2011 8am	This strategy was by-passed as it was not possible to achieve this strategy by limiting the flow in the Brisbane River to less than the naturally occurring peaks at Lowood and Moggill	A transition from strategy W1E directly to strategy W3 is expressly referred to on page 26 of the W&S Manual
W3	8 January 2011 8am	Wivenhoe Dam predicted water level above 68.5m AHD	The lake level had exceeded the 68.5m AHD level at 8am having reached 68.52m AHD
		Wivenhoe Dam predicted water level below 74.00m AHD	The lake level was not predicted to exceed 74.00m AHD (model runs 8, 10, 12, 14, 17, 21, 23, 26, 28, 31)
		Maximum release should not exceed 4,000m^3/s	The maximum release did not exceed the specified amount. The peak release flow under this strategy was. 2724m3/s at 3am on 11 January 2011
S2		Somerset Dam level expected to exceed 99.00m AHD	Somerset Dam was predicted to exceed 99.00m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43). Somerset Dam was expected to exceed 99.00m AHD at all times up to and including the peak of Wivenhoe Dam at 7pm on 11 January 2011 (Wivenhoe Dam peaked at 74.97m AHD)
		Wivenhoe Dam level expected to exceed 67.00m AHD but not expected to exceed 75.5m AHD.	Wivenhoe Dam level expected to exceed 67.00m AHD but not expected to exceed 75.5m AHD (model runs 5, 7, 8, 10, 12, 14,

Strategy Implemented	Time of Transition	Strategy Requirements	Compliance
			17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43)
W4A	11 January 2011 8am	Wivenhoe Dam predicted water level above 74.0m AHD	The lake level was predicted to exceed 74.0m AHD (model runs 35 and 37)
		There is no limit on the maximum release rate	The peak release rate reached was 7,464m^3/s at 7pm on 11 January 2011
		No expected fuse plug initiation (at 75.5m AHD)	Fuse plug initiation was not expected (highest predicted level was 75.0m AHD, model runs 39 and 41), therefore, strategy W4B not invoked
S2		Somerset Dam level expected to exceed 99.0m AHD	Somerset Dam was predicted to exceed 99.0m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43). Somerset Dam was expected to exceed 99.00m AHD at all times up to and including the peak of Wivenhoe Dam at 7pm on 11 January 2011 (Wivenhoe Dam peaked at 74.97m AHD)
		Wivenhoe Dam level expected to exceed 67.0m AHD but not expected to exceed 75.5m AHD	Wivenhoe Dam level expected to exceed 67.0m AHD but not expected to exceed 75.5m AHD (model runs 5, 7, 8, 10, 12, 14, 17, 21, 23, 26, 28, 31, 35, 37, 39, 41, 43)
Drain Down	12 January 2011	Return the Dam to FSL within 7 days	Wivenhoe Dam was returned to FSL on 19 January 2011
			Somerset Dam was returned to FSL on 17 January 2011

385 I further note that the Wivenhoe and Somerset Dams Flood Report 2011 provides information to show that the W&S and NP Manuals were complied with during the January 2011 Flood Event. In particular:

(a) The Wivenhoe and Somerset Dams Flood Report 2011 contains a 'Flood Event Summary' at section 2. This Flood Event Summary breaks the January 2011 Flood Event into 20 periods and explains the strategy that was applied during those periods. The 20 periods were chosen because at least one of the following occurred:

(i) There was a transition or change to the flood operation strategy used, as defined by the W&S Manual;

(ii) There was a period of stability during which no gate operations from either Somerset Dam or Wivenhoe Dam were directed; or

(iii) There was a period of sustained gate operations (either opening or closing) at either Somerset Dam or Wivenhoe Dam.

(b) Section 10 of the Wivenhoe and Somerset Dams Flood Report 2011 also includes an explanation of the Flood Management Strategies and Manual Compliance used during the January 2011 Flood Event and adopts the same time periods;

(c) The Wivenhoe and Somerset Dams Flood Report 2011 also contains a summary of the operational runs performed at Appendix A, with the models that were run without forecast rainfall contained at page 2 of Appendix A. As previously explained, operational strategies are primarily implemented on the basis of actual rainfall (which includes predicted runoff). I make reference to these model runs in the table at paragraph 384; and

(d) section 9 of the Wivenhoe and Somerset Dams Flood Report 2011 contains a table setting out hourly statistics for Wivenhoe Dam.

Compliance with NP Manual strategies

386 In my view, North Pine Dam was operated in accordance with the NP Manual.

387 North Pine Dam effectively has no significant provision for flood mitigation and once the Dam is full, ensuring the structural safety of the dam is paramount. Accordingly, the flood operation strategy is to pass any significant flood through the reservoir, while ensuring that peak outflow generally does not exceed peak inflow and while aiming to empty stored floodwaters as quickly as possible.

388 The flood operation strategy used during the January 2011 Flood Event involved passing the flood through the reservoir, while ensuring peak outflow generally did not exceed peak inflow. The peak outflow from the Dam was achieved at 4pm on 11 January 2011 releasing 2,854m^3/s. The peak inflow was recorded at 12pm earlier that day was 3,484m^3/s.

389 The aim was also to empty stored floodwaters as quickly as possible. To achieve this strategy, the radial gate opening settings contained in Appendix C of the NP Manual

were used to determine flood releases. The Dam had been returned to FSL by the end of the January 2011 Flood Event.

390 The NP Manual's target minimum intervals for radial gate openings were followed at all times, except during the rapid water level rises that occurred during Tuesday 11 January 2011. During these periods of rapid water level rises, water levels rose too quickly to allow minimum intervals to be observed. The gate opening interval was adjusted to ensure gate opening settings never fell more than three openings behind the minimum settings contained in the NP Manual. This adjustment of radial gate opening interval is in accordance with section 8.6 of the NP Manual. The target minimum intervals can be reduced if the gates are at risk of being overtopped or the safety of the Dam is at risk.

391 The NP Manual's target minimum intervals for radial gate closings were followed at all times, except directly following the flood peak that occurred during Tuesday 11 January 2011. During this period, the minimum settings contained in the NP Manual were reduced to preserve storage and reduce downstream flooding. This adjustment of the radial gate-closing interval is in accordance with section 8.6 of the NP Manual. Rapid closure of radial gates is permissible when there is a requirement to reduce downstream flooding.

392 During the January 2011 Flood Event, every attempt was made to minimise disruption to the community in areas downstream of the Dam, particularly by minimising the period during which Youngs Crossing was inundated and closed to traffic. However, uncontrolled flood outflows from Lake Kurwongbah over the period of the January 2011 Flood Event meant that even if no releases were made from North Pine Dam, Youngs Crossing would still have been inundated. The outflow required to close Youngs Crossing to traffic is only $10m^3/s$.

CONSIDERATIONS FOR THE INQUIRY

ALERT System – data collection

393 The Commission of Inquiry may wish to consider whether the network of rainfall and river gauges should be expanded. However, whilst an expansion of the data collection network by installing additional gauges is likely to increase the accuracy and reliability of rainfall data collected, it may not be possible to guarantee that all instances of heavy of rainfall are captured and the cost of installing and maintaining

the extra gauges would need to be considered. The Brisbane River Basin and the Pine Rivers Basin cover very large catchment areas.

RTFM System – data modelling

394 I am aware that a new data modelling system, Deltares FEWS, is currently being developed (see paragraph 162).

The FOC

395 During the January 2011 Flood Event, a number of FOC staff members slept in meeting rooms so that they could remain close to the FOC if required, and to avoid possible isolation from the FOC. This raised two difficulties:

(a) The accommodation arrangements were not ideal, but were adequate considering the circumstances. I slept in a meeting room on temporary bedding. Consideration of how accommodation arrangements during a large flood event could be improved might be useful; and

(b) Some of the FOC staff's family members were concerned for the safety of the FOC staff who were in the CBD. Whilst we were all safe, it is important that FOC family members be kept informed that the staff are safe. It is also important that these family members be able to contact staff in the event of an emergency at home.

396 Flood Operations Engineers worked long hours during the January 2011 Flood Event. Shifts were 12 hours long. A decision was made part way during the event that 2 Flood Operations Engineers would be on shift in the FOC at any point in time. This meant that the turn around time between shifts was shorter. An increased number of Flood Operations Engineers could assist in managing fatigue during long duration flood events, however, it is important that any additional flood operations engineers have suitable qualifications, knowledge and experience, as well as the approval of the Chief Executive in accordance with the W&S and NP Manuals.

397 I believe that consideration ought to be given to staffing the FOC during a flood event with three positions:

(a) A Duty Flood Operations Engineer (who has the responsibilities listed under the W&S and NP Manuals);

(b) A trainee Duty Flood Operations Engineer (whose primary responsibility would be to conduct modelling); and

(c) Technical assistants (who are responsible for reviewing and monitoring data).

398 This would allow the experienced Duty Flood Operations Engineer to focus his or her attention upon the strategies required to be used during the flood event under the W&S and NP Manuals and communication of those strategies and relevant information to relevant agencies.

399 The back-up FOC at Mineral House lost its supply of mains electrical power during the event, although standby generators were activated so there was no loss of power to the back-up FOC. I believe that an alternative back-up FOC site is being investigated.

Communications

400 As the January 2011 Flood Event was the first flood event operated under the Protocol, I believe this document should be reviewed to assess any possible areas for improvements.

401 The Event Log was a useful tool for oncoming staff to review at shift handover. I believe this document can be improved for future flood events by a more consistent approach to how information is recorded.

402 Similarly, the situation reports and the technical situation reports could be improved by a more structured and consistent approach to the information contained in those reports. I understand that this is being reviewed at present.

403 I believe that the directives given to the dam operators at Wivenhoe and Somerset Dams could be improved by the addition of further information, so that the operators have a better understanding of the context of the directives that they are receiving and the strategies being used.

404 There might be an opportunity to improve the communications between the FOC and the BoM during a flood event. It would be helpful during a flood event if there was more regular or more formalised communication between the Duty Flood Operations Engineers at the FOC and meteorological forecasters at the BoM in order to provide the Duty Flood Operations Engineers of a better understanding of the weather systems impacting the flood event.

W&S and NP Manual strategies and objectives

405 The W&S and NP Manuals are required to be reviewed after each significant flood event.

406 The flowchart on page 23 of the W&S Manual requires amendment as I have described earlier in my statement (see paragraph 301).

407 There is some inconsistent use of words in the W&S Manual. At times, the W&S Manual uses different words and phrases to explain the same strategy or concept. For instance, the W&S Manual refers to 'predicted' storage levels (for instance, see the conditions section for each Wivenhoe and Somerset strategy), whilst the flowcharts for Wivenhoe and Somerset Dams refer to 'likely' lake levels, and some of the Somerset Dam conditions refer to 'expected' lake levels. I believe that these inconsistencies should be reviewed and amended during the next review of the W&S and NP Manuals.

408 Further, the W&S Manual does not expressly state that predicted lake levels should be determined on a 'no further rainfall' basis. During previous flood events and during the January 2011 Flood Event, predicted lake levels were determined by reference to models based on 'no further rainfall'. I believe that the W&S Manual should expressly state that lake level predictions are ordinarily determined by a 'no further rainfall' model.

409 Strategy W3 of the W&S Manual notes that 4,000m^3/s at Moggill is the upper limit of non-damaging floods downstream. During the January 2011 Flood Event, information was received from the BCC that the BCC's flood damage study in 2007 indicated that the damage threshold was 3,500m^3/s. Whilst the requirements of the W&S Manual were complied with during the January 2011 Flood Event and the upper limit of non-damaging flows at Moggill of 4,000m^3/s as specified in the W&S Manual was applied as the upper limit of combined flows at Moggill under strategy W3, I believe this issue should be reconsidered at the next review of the W&S Manual.

410 Under strategy W3 of the W&S Manual, there is a tension between limiting the releases from Wivenhoe Dam to below the naturally occurring peak at Moggill and the requirement to drain the dam within seven days. For example, the naturally occurring peak at Moggill may be low and hence the release rate from Wivenhoe Dam would have to be limited so as not to exceed the low level at Moggill and this may prevent a drain down to FSL within the seven day period. The W&S Manual ought to clarify whether the seven day drain down period or maintaining the low level at Moggill takes precedence in the drain down phase.

411 There is a similar tension in strategies W3 and W4 between the requirement to consider lower level objectives, for example, inundation of lower level bridges, and the requirement to drain down within seven days. Again the W&S Manual ought to

clarify whether the seven day drain down period or consideration of lower level objectives takes precedence.

North Pine Dam operation

412 Consideration should be given to relocating the primary controls for the radial gates at North Pine Dam to ensure dam operator safety during large flood events. This is because during the January 2011 Flood Event when the lake level was in excess of approximately 40.0m AHD, the dam operators had to wade through the water to access and operate the radial gates.

413 Further, in light of the operational problems the dam operators had with the radial gates (refer to in paragraph 412 above), consideration should be given to the revision of the NP Manual 'Radial Gate Settings' table at Appendix C to the NP Manual to try and ensure the operational problems will not occur again. For example, the opening of the gates at lower lake levels or larger gate opening increments may alleviate the operational problems because it may ensure that by the time the lake level reaches approximately 40.0m AHD the radial gates will already be opened to the correct increment and the dam operators will not need to walk through water. An interim solution may need to be considered prior to a permanent solution being available.

Signed..[redacted].

Robert Arnold Ayre

Dated.....23/3/2011.....

GLOSSARY OF TERMS

TERM	DEFINITION
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
BCC	Brisbane City Council
BoM	Bureau of Meteorology
DERM	Department of Environment and Resource Management
FOC	Flood Operations Centre
FSL	Full Supply Level
ICC	Ipswich City Council
January 2011 Flood Event	The flood event that commenced on 6 January 2011 and finished on 19 January 2011
MBRC	Moreton Bay Regional Council
NP Manual	Manual of Operational Procedures for Flood Mitigation at North Pine Dam (Revision 5: dated August 2010)
Preparedness Report	A Flood Operations Preparedness Report for Wivenhoe, Somerset and North Pine Dams – submitted by Seqwater in October 2010
Procedures Manual	Seqwater Flood Operations Procedures Manual
Protocol	Draft communications protocol provided by DERM to Seqwater
QPF	Quantitative Precipitation Forecast
SRC	Somerset Regional Council
W&S Manual	Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam (Revision 7: dated November 2009)

SCHEDULE 1