**In the matter of the *Commissions of Inquiry Act 1950***

***Commissions of Inquiry Order (No.1) 2011***

**Queensland Floods Commission of Inquiry**

**Second Witness Statement of Peter Baddiley**

I, Peter Baddiley, of Level 21, 69 Ann Street, Brisbane, in the State of Queensland, say as follows:

1. I am the Regional Hydrology Manager for Queensland in the Bureau of Meteorology (**the Bureau**). This is my second witness statement as my first witness statement was submitted to the Queensland Floods Commission of Inquiry (**the Commission**) on 5 April 2011.

2. This statement is provided in response to:

    a. matters which have been raised before the Commission which are relevant to the Bureau and require more detailed information and explanation from me in my capacity as Regional Hydrology Manager for Queensland in the Bureau;

    b. a request from the Commission dated 12 April 2011. Attached hereto and marked **"PB2-1"** is a copy of this request for information **(the 12 April Request)** regarding issues raised in submissions and statements received by the Commission relating to the Queensland regions of the Western Downs, Southern Darling Downs and Border districts;

    c. a request for information from the Commission dated 28 April 2011. Attached hereto and marked "**PB2-2**" is a copy of this request for information (**the 28 April Request**); and

    d. a request for information from Ipswich City Council dated 18 April 2011 (**the ICC request**) which was provided by the Commission to me on 29 April 2011. Attached hereto and marked **"PB2-3"** is a copy of this request for information.

3. Except where otherwise stated, I make this statement from my own knowledge and on information and belief after making enquiries within the Bureau.

Lodged on behalf of the Commonwealth of Australia

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**Correction to my first statement dated 5 April 2011**

4. In my first statement at paragraph number 18, in the first sentence I referred to the 'Ipswich City Council'. This was in error and I wish to correct that by deleting 'Ipswich City Council' and instead inserting the words 'Somerset Regional Council'. The first sentence of paragraph 18 should now read: 'In relation to communications with Seqwater other than the FOC, I was involved in a telephone conference on Monday 10 January from approximately 12:30pm to 1:20pm arranged by the SEQ Water Grid Manager which, as far as I am aware, involved the SEQ Water Grid Manager, Queensland Department of Premier and Cabinet, Seqwater, the Brisbane City Council, and the **Somerset Regional Council**.' (emphasis added)

**Report and background briefing previously provided by the Bureau to the Commission of Inquiry**

5. As advised in my first witness statement, I was involved in the preparation of a detailed report to the Commission titled 'Report to Queensland Floods Commission of Inquiry: provided in response to a request for information from the Queensland Floods Commission of Inquiry received by the Bureau of Meteorology on 4 March 2011' (**the Report**), which was prepared in response to an earlier request for information from the Commission received by the Bureau on 4 March 2011. A copy of the Report is attached as "JD-1" to Mr James Davidson's witness statement which was submitted to the Commission on 4 April 2011.

6. I also contributed to the 'Provision of Preliminary Meteorological and Hydrological Information: Background Briefing for the Queensland Floods Commission of Inquiry' (**the Background Briefing**) which was provided to the Commission on 17 March 2011. A copy of the Background Briefing is attached to my first witness statement and marked as "PB-2".

7. To avoid repetition, in responding to the issues outlined in paragraph 2 above, I will refer to relevant sections of the Background Briefing, Report, my first witness statement and the statement of Mr. James Davidson where it is appropriate.

**A. <u>Background information regarding the flood warning systems and services in Queensland</u>**

8. To address the issues identified in paragraph 2 above and to assist the Commission with its consideration of issues under its Terms of Reference, I provide further background information regarding the flood warning systems and services provided by the Bureau in Queensland. The following information should be considered in conjunction with the information already provided by the Bureau and its representatives to the Commission.

***Introduction***

9. The guidelines in 'Managing the Floodplain' (Manual 19, The Australian Emergency Manual Series published by Emergency Management Australia, Australian Government Attorney - General's Department ) annexed hereto and marked as **"PB2-4"**, identify flood emergency measures, such as flood warning, evacuation and recovery plans, as one of a group of management measures to address flood risk. These management measures include structural flood mitigation measures (e.g. dams, detention basins, levees, channel improvements, etc) and non-structural mitigation measures. The latter includes land use planning controls, development and building controls and flood emergency measures.

10. In Australia, and Queensland in particular, where the range of flood magnitude at any given location tends to be large, the risk of flooding can be reduced by the use of an appropriate mix of floodplain management measures (structural and non-structural), but it is rare th at the risk of flooding can be entirely removed. Thus, flood warning is generally required to assist in further reducing the risk to life (people and livestock) and property damage.

11. It is important for those agencies and communities involved in developing and contributing to the operation of flood warning systems to understand the flood risk at the location or area under consideration. An understanding of the flood risk, at least in terms of the nature of the hazard and its likely impact, if not its likeli hood, is especially important to those affected agencies, businesses and individuals who need to take appropriate action in the days and hours ahead of an impending flood.

***Flood likelihood***

12. Structural and non -structural flood management measures are general ly designed to a designated or selected flood standard which is less than the probable maximum flood magnitude at the location . For example, a flood standard for some more significant measures (such as a flood levee or for setting minimum habitable flood levels of a building) can be "the 1 in 100 year" flood or "Q100". It is instructive to examine the risk associated with using such a standard, because whilst it appears conservative or as having a low chance of occurring, from the perspect ives of at least designing and operating flood warning systems and community understanding of flood risk, the actual risk can be misunderstood if expressed in these terms.

13. Q100 is a flood magnitude that theoretically has a one percent chance of being equal led or exceeded in any given year for the location under consideration. It has an Annual Exceedance Probability (AEP) of 1% (or expressed as odds, "1 in 100"). In technical documentation and studies, AEP is the preferred terminology.

14. One hundred years is the average period (Average Recurrence Interval or ARI) between expected exceedances over a very long time period (say an expected occurrence of 10 times in 1000 years). It is important to note that an ARI of, say, 100 years does not necessarily mean that the event will only occur once every 100 years. In fact, for each and every year, there is a 1% chance (a 1 in 100 chance) that the Q100 flood will be equalled or exceeded (once or more than once). So, for example, floods of the magnitude of Q100 can occur in two successive years at the same location. Also, the estimation of the magnitude of a Q100 flood for a location may have considerable uncertainty because of the relatively short length of flood records.

15. For consideration of flood risk when evaluating t he need for a flood warning system or other flood mitigation measures, it is important to also consider the chance of occurrence over a longer period. For example, using statistical calculation, in a 50 year period there is approximately a 40% chance ("4 i n 10") of a "100 year" flood or greater at any location of interest. Thus, the chance of a developed area on a floodplain, even at the level of Q100, being flooded at least once in a period of decades is relatively high. Similarly, the chance of a Q100 levee being overtopped (and for which a flood warning system is required) at least once in the next several decades is relatively high – much higher than is generally understood by the expression of Q100 or "100 year" flood.

16. This statistical analysis can be further extended for flood warning and emergency response considerations to examine the risk of larger floods occurring. For example, the chance that the "1000 year" flood (Q1000) will occur in the next 10 years in any given location is approximate ly 1% ("1 in 100"). For the entire area of Queensland, the chance of flood events greater than the standard "Q100" occurring somewhere in Queensland in any given year is relatively high, particularly in wet periods.

17. These probability concepts similarly apply to rainfall probability (e.g. the "100 year" rainfall). A summary of rainfall statistics and ARI/AEP definitions is given at Appendix K of the Report. The Bureau also has a document available on its website titled 'Why do 100 year events happen so

often' (www.bom.gov.au/water/designRainfalls/rainfallEvents/why100years.shtml>) which explains why intense rainfall events seemingly occur more often than is typically expected.

***Flood risk in Queensland***

18. A study entitled 'Urban Flooding in Queensland– A Review', undertaken by Mr David Ingle Smith for the then Queensland Department of Natural Resources, was published in February 1998 (**the 1998 Study**) and is attached hereto and marked **"PB2-5"**. In relation to flood warning, the 1998 Study reported on approximately 100 localities in Queensland at risk from flooding. For these localities, estimates were provided of the number of buildings at risk from a 1% AEP flood (Q100); the existence of flood warnings systems (as at 1998) was detailed; and flood warning (lead) times were given. Some of the latter information was drawn from information sourced from the Bureau. The study commented that "*Analyses, provided by the Bureau of Meteorology, indicate that the warning times for flood forecasts for 100 flood prone urban locations (about 70% of the total) are less than 12 hours. Thus, the best possible preparedness and responses are necessary if the benefits of the forecasts are to be fully captured.".*

19. The Bureau has contributed to other specific publications on flood risk such as risk studies within the AGSO (Geosciences Australia) Cities Project. These include 'Community risk in Cairns: A multi-hazard risk assessment' (1999); 'Community risk in Mackay: A multi-hazard risk assessment' (2000) and 'Natural hazards & the risks they pose to south-east Queensland' (2001).

20. The assessment of flood risk to life and property for many locations needs to consider other characteristics in addition to area and depth of inundation, such as water velocities, natural and man-made levee overtopping, overland flow paths, "shrinking islands" (areas which become isolated by flood waters before being inundated as the flood increases) and flood impact on critical infrastructure. Although some of these behaviours are simply established or are learnt from experience, identification of these hazards mostly requires detailed hydraulic model studies of floodplains. Flood studies undertaken by Local Government, say for the purpose of land-use planning, should provide some of this additional information for the purposes of flood emergency management. However, additional specific studies undertaken by Local Government for flood emergency management planning are typically required to produce flood hazard maps and other detailed information for direct application during flood events. The Bureau provides, upon request, base data (e.g. past rainfall and water level data) and technical advice for some of

these flood studies. When flood studies are made available to the Bureau, the results are used to refine or adjust the Bureau's flood forecasting model.

***Flood warning***

21. In the context of management measures including flood warning, riverine floods are considered to be one of the most "manageable" natural disasters, in that they potentially have a useful level of predictability (of inundation area, depths and velocities on a floodplain) and intrinsic warning lead-time associated with the time for flooding to develop after rainfall and move downstream along watercourses. Furthermore, the impact and damage component of riverine flooding can be reduced or even avoided provided that appropriate action is taken by agencies and affected communities in the lead up to the expected or predicted flooding.

22. The manual titled "Flood Warning" (Manual 21, The Australian Emergency Manual Series published by Emergency Management Australia, Australian Government Attorney-General's Department) (**Manual 21**) annexed hereto and marked as **"PB2-6"**, describes the components of a "total flood warning system" (which is also commonly referred to as an "end-to-end" warning system). These components include: monitoring and prediction; interpretation; message construction; communication; protective behaviour; and review.

23. Table 1 on page 10 of Manual 21 provides a summary of current (as at 2009) organisational responsibilities for flood warning in Queensland as follows:

    a. Prediction: Bureau of Meteorology

    b. Interpretation: Department of Community Safety (DCS) and Local Government

    c. Dissemination: Bureau/DCS/Local Government

    d. Response: DCS/Queensland Police Service/Local Government

24. The Bureau recognises this allocation of responsibilities as striking a necessary and essential balance between the roles of the Bureau in flood warning with those of state and local government, especially in the critical areas of interpretation, dissemination and response. Especially for urban areas, state and local agencies play a crucial role in determining, for example, the floodplain areas which are likely to flood and which areas are to be evacuated, and promulgating this detailed information together with any specific actions that need to be taken

by the flood-affected community. The success of a flood warning service, and especially in the case of flash floods, in achieving the appropriate responses and actions to minimise loss of life and property damage depends on each of these elements bei ng present and working in a coordinated and effective manner. The Bureau works with other State and local government authorities across Australia in a similar manner.

***Catchment monitoring systems***

25. The Bureau's ability to provide flood warnings and predicti ons, and for local agencies and communities to monitor the status and progress of flooding is depend ent, to a large extent, on the existence of adequate catchment (rainfall and water level) monitoring. Catchment monitoring can range from very simple arran gements for the taking of rainfall and water level observations by individuals and communicating these to others (as has been the basis of flood warning in the past century) , to automated networks of rainfall and water level stations providing data through various telephone, radio and Internet communication channels.

26. The flood warning network (i.e. the network of rainfall and water level/river height stations) used for flood warning in Queensland is summarised at Section 1.2.4 of the Report (Paragraphs 38-43). Some matters relating to the duplication of equipment and the installation of new or upgraded flood warning systems are also addressed in my first statement at Paragraphs 26 to 30. A key feature of the flood warning network is the coo perative basis under which it is established and operated, as mentioned in Paragraph 42 of the Report.

27. Figure 1.2.4.1 of the Report (Paragraph 39) shows the sustained growth of the automated flood warning monitoring stations that has continued in Queensland since the late 1980s. The different types of monitoring systems used in flood warning are described in more detail in Paragraph 28 of this statement.

***Types of flood warning monitoring (rainfall and water level) systems***

28. There are four main types of rainfall and water level monitoring systems in use in flood warning in Queensland, briefly summarised as follows:

    a. ***Manual observations.*** Individuals (e.g. rural property landholders, town residents) and representatives of agencies (eg local government, Police) take readings of rainfall (from simple rain gauges) or water level from staff gauges (typically a set of one metre markers) which are provided to the Bureau's computer systems via the telephone (using

a purpose-built Bureau Remote Observer Terminal) or via the Internet. In the case of the latter, the rainfall or water level reading is lodged by using a Bureau website developed for this purpose.

b. ***Automatic telephone -based equipment*** . These are generically known as "telemeters" and comprise automatic rainfall and/or water level measurement equipment connected to a "data logger" which records the information and enables its communication to the Bureau and other agencies via one or more forms of telephone communication (landline, mobile and/or satellite). Typically, the information in the data logger at each telemeter station is downloaded at regular intervals (e.g. hourly or 3 hourly) to the Bureau computer system. This is known as "pull communication". The alternative is "push communication" whereby the field station initiates the reporting, typically using digital data transfer over Internet ("data over IP"). The latter is progressively becoming the standard as old equipment is replaced.

c. ***Flood ALERT systems.*** These comprise a network of automatic rainfall and/or water level monitoring stations (typically 5 to 50 stations, depending on catchment characteristics and flood risk) that effectively provide continuous reporting of changing conditions at each monitoring locati on throughout the area of concern (i.e. the area or catchment locally deemed to be at high risk of flooding orflash flooding). "ALERT" is an acronym for Automated Local Evaluation in Real Time. The data is reported via VHF radio communication (i.e. no reliance on telephone) to base station computers at the local agency (e.g. Local Government) and to the Bureau, and elsewhere as required.

***"Event-reporting in real -time":*** The reporting by ALERT systems is said to be "event -reporting in real -time" as reports are automatically triggered at the field station whenever an "event" occurs. In this context, an "event" is typically 1mm of rainfall occurring at a field station, or a rise or fall in water level of 5 centimetres. Different resolution events can be defined according to the requirement, for example, 0.2 millimetres of rainfall or 2 centimetres change in water level. The data is collected, analysed and displayed at the local base station computers by the Bureau's Enviromon software, which can also be used to send alarms to locally defined recipients (via email, SMS) for pre -defined threshold conditions (for example, exceeding a particular rainfall intensity or exceeding specified water levels at one or more field stations).

d. ***Other networks via FTP data transfers.*** Other agencies, for example DERM and SunWater, send updates of data from their networks of rainfall, water resource gauging and tide stations directly to the Bureau's computers using the "File Transfer Protocol" on Internet. The regularity of the data updates depends in turn on the updating that the owner-agency achieves from its particular monitoring station equipment which is predominantly telephone-based. Funding from the Australian Government's Modernisation and Extension of Hydrologic Monitoring Systems Program, administered by the Bureau, is being used to accelerate the modernisation of water resource gauging stations for the purposes of improved national water information. Further information on this program can be found at < http://www.bom.gov.au/water/regulations/fundingProgram/index.shtml>. Whilst this modernisation program does not provide funding specifically for flood warning purposes, the modernisation of water resources gauging stations and related data collection systems has provided, and will continue to do so, considerable supplementary benefits in making more timely data available for flood warning.

29. The choice of which type of field monitoring equipment and systems to employ for flood warning in any particular catchment depends on a number of factors including the flood warning objective being sought; local agency involvement and capacity; the size of the catchment; rainfall-flood response times and available forecast lead times; the forecasting methods applicable (e.g. models and forecasts based on rainfall and/or flood routing from an upstream water level station); and reliability of communications and duplications required to achieve robustness of equipment and systems. The Bureau's view is that, whilst there is a place for a mix of manual and automatic observations to enhance system coverage and duplications, there are significant advantages in primarily utilising automated stations to achieve flood warning objectives. It is critical though that there is secure communications and a sustainable operation and maintenance capacity for the long-term operation of automated stations. There remains a role, however, for effective use by the Bureau of local information, including reports of rainfalls and river heights by volunteers, to support automatic monitoring stations.

***Summary of the cooperation between the Bureau, local governments and other water agencies in flood warning in Queensland***

30. The Bureau/state/local ownership of the rainfall and water level monitoring stations is summarised in the Report at Paragraph 42. The steady increase of numbers of automatic flood

warning stations over the past two decades is shown in the Report in Figure 1.2.4.1 at Paragraph 39.

31. As at 2011, approximately 28 local governments (based on post-amalgamation structures) are involved in the cooperative development of flood warning systems and monitoring networks, covering most of the more heavily populated parts of the state. Approximately 20 of these are involved in the operation of Flood ALERT systems and the remainder have been involved in establishing either manual river height stations or automatic telephone-based (telemeter) rainfall and/or water level stations.

32. In addition to local government activities with the Bureau, Seqwater and NQWater operate Flood ALERT systems associated with the operation of dams and storages in south east Queensland and for Ross River Dam (NQWater) near Townsville.

33. Including those systems installed by dam operators, the ALERT systems in Queensland comprise about 670 rainfall and/or river height stations, all of which have been installed since the late 1980s. Most of the ALERT systems are directed towards riverine or non-flash flood warning, but several systems have a component specifically for the purpose of flash flood monitoring and warning where local agencies have identified this as a major risk.

34. DERM and SunWater provide data from their respective water resource gauging station networks and dam monitoring networks freely to the Bureau for the purpose of flood warning. About 460 stations operated by DERM and about 75 SunWater stations are integrated into the flood warning system. Both agencies provide regular 'FTP data transfers' to the Bureau as described in Paragraph 28 of this Statement, as well as allowing the Bureau to make direct connection with gauging stations for downloading of data on demand (e.g. at 3 hourly intervals, or more frequently, during floods).

***Funding for flood warning monitoring stations (rainfall and water level)***

35. Since the mid 1990s, the funding of rainfall and water level monitoring stations specifically installed for flood information and warning purposes has largely been via a series of national programs including the Regional Flood Mitigation Program, the Natural Disaster Mitigation Program and currently the Natural Disaster Resilience Program (NDRP). In each of these funding programs, the essential principle is that the local agency (generally Local Government) determines a risk of flooding, applies for funding and if successful, receives Commonwealth and state funding support to establish a new or upgraded flood warning system which becomes an

asset owned and maintained by the funded local agency. Some local agencies have fully funded flood warning monitoring stations without seeking funding support.

36. The Bureau is not involved in the assessment process for NDRP applications, but will often provide information, by way of advice on the location of flood warning stations, technologies and costings, to agencies making application for flood warning systems.

37. The shared-funding and operation of flood warning monitoring and information systems realised through these funding programs is broadly consistent with the Commonwealth policy setting for flood warning established in 1987. In 1987, the Commonwealth developed an arrangement for sharing the responsibility for flood warning between the three levels of government, recognising that effective flood warning systems required coordinated involvement of all levels of government. This was consistent with the developing "total flood warning –response system" approach. This arrangement also specified that 'the Bureau of Meteorology would remain the lead agency'. These arrangements also provided some funding to the Bureau to ass ist the establishment of new and improved flood warning systems with state/local agencies according to the cost-sharing principles embodied in these new arrangements. Further details are provided at paragraph 38. Subsequently, Local Gove rnments in Queensland accessed the Regional Flood Mitigation Program (and successor programs) for funding.

38. In these arrangements, the cost -sharing principles for the development of non -flash flood systems prescribed that the Bureau share the costs of developing, maintaining and upgrading rainfall and river height networks with state/local government agencies. In general, the Bureau has responsibility for the rainfall networks and the state/local agencies have responsibility for the river height networks. Where flash -flood risk is ascertained by local agencies, the Bureau's role is to maintain a central source of advice and system know ledge and to provide assistance to state and local agencies.

***Specific arrangements for the State of Queensland***

39. In late 1987, the Bureau embarked on a program of meetings with States regarding the flood warning arrangements. In November 1987, the Bureau met with representatives of the then Premier's Department, Queensland Water Resources Commission, State Emergency Service and the Queensland Police Service.

40. Shortly after the meeting of November 1987, the Premier's Department agreed to the establishment of the Queensland Flood Warning Consultative Committee (FWCC) and

nominated the then State Emergency Service and Water Resources Commission as the state's representatives. The Local Government Association of Queensland (LGAQ) was also an inaugural member agency of the FWCC. The role of the FWCC was to facilitate cooperation among the partner agencies involved in flood warning and to assist the establishment of priorities for new and improved systems and services.

41. These interactions with State flood authorities and LGAQ regarding Bureau/state/local cooperation in flood warning continued into the 1990 s and 2000 s through the FWCC, and increasingly via direct communication between the Bureau and the current DERM, Emergency Management Queensland (EMQ) and specific local governments around the state. As described in my first witness statement at Paragraph 34, since 2007, the FWCC essentially acts as an advisory or liaison body to the Queensland Flood Consultative Committee (QFCC) which is chaired by EMQ. In practice, because of the commonality of membership between the two Committees and the overlapping interests, the FWCC effectively meets concurrently with the QFCC.

42. Where local agencies have been successful in gaining funding via the NDRP and previous funding programs, generally the Bureau has provided advice and assistance in the design and establishment of the flood warning monitoring stations or network. The type of flood monitoring stations includes manual stations and automatic telephone -based and Flood ALERT systems (described in Paragraph 28) depending on the situation. In most circumstances for ALERT -type systems, the Bureau has also provided and supported the Bureau software known as Enviromon (see Paragraph 28(c)). In recognition of its lea d agency role, the Bureau also assists the local agency to maintain automatic monitoring stations by local education and training and visits to monitoring stations in the company of the local agency or its contractor to ensure proper operation. Data from these monitoring stations is made freely available to the Bureau and is integrated into the Bureau's flood warning and information services, including at the Bureau's website for wide agency and public use.

43. As previously summarised in Paragraphs 30 to 34 of this Statement, the progress made in establishing flood monitoring systems in Queensland since the late 1980s has been very substantial. In 1986, the total number of stations (rainfall and river height) specifically for flood warning was 390 , of which only about 35 were automatic. In 2011, there are about 1,650 stations (not including a further 550 daily rainfall, synoptic and automatic weather stations) of which about 1,250 are automatic. However, while the Bureau is ready to provide general advice

on such arrangements for the establishment and operation of new systems and stations, the Bureau does not have the capacity to extend these arrangements to other catchments unless additional resources are provided through other State and Local Government funding arrangements (and as may be endorsed through the QFCC).

***Issues affecting flood warning and monitoring***

44. Whilst there has been significant growth in the development of flood warning monitoring systems in Queensland as summarised in Paragraphs 30 to 34 of this statement, there are many areas of Queensland for which there may exist a "basic" (incomplete and/or sparse) flood warning monitoring network, or no monitoring network at all. Some of these areas were affected by the past wet season flooding. Identification of the flood risk at any given location is of paramount importance in assessing the priorities for future investment in flood warning. As has been witnessed in the recent episodes of severe flooding, the experience of flooding and its unexpected impacts often occurs ahead of identification of the need for flood warning, and other flood risk management measures, through strategic flood risk management studies.

45. The best-practice principle of firstly "understanding the risk" to enable effective planning for floods, including the planning for flood emergency measures, is further explored in 'Flood Preparedness' (Manual 20 of the Australian Emergency Manual Series The Australian Emergency Manual Series published by Emergency Management Australia, Australian Government Attorney-General's Department) annexed hereto and marked as **"PB2-7"**.

46. The NDRP, similar to its predecessors, provides funding assistance for the establishment of flood warning systems (i.e. the cost of equipment and its installation), while funding for the ongoing operating and maintenance costs of these systems is largely the responsibility of the local agency. The sustainable maintenance of automated flood warning stations is a challenge for the smaller local agencies in particular due to resource constraints.

47. The Bureau makes available a large amount of detailed rainfall, river height and flood information on its website. The website contains maps of catchments and rivers showing the monitoring locations for which detailed information is available. This information is both static (e.g. levels of minor, moderate and major flooding; past flood information; heights of road crossings, etc) and changing information (e.g. the latest available rainfall or river height readings). The flood warnings cannot contain all of the available information for all locations. Only some of the more significant information can be included in river height bulletins and flood

warnings. The Bureau's flood warning website for Queensland at http://www.bom.gov.au/qld/flood/ makes all of this additional flood-related data accessible via maps and links. In addition, representatives of local governments often telephone the Bureau's hydrologists during floods for more detailed information regarding predictions for locations included in flood warnings and for more information for locations that are not included in flood warnings. These telephone discussions may also involve the provision of scenarios, for example, of potential flood heights based on forecast rainfall, and consideration of possible higher levels being reached where predictions are uncertain.

**B. <u>Flood warning service during the December 2010 – January 2011 period</u>**

48. An overview of the flooding during the December 2010 – January 2011 period is given in the Report at Paragraphs 82-98. The flood warning service provided during that period is briefly described in the Report at Paragraphs 32-37. The Flood Warning Centre (FWC) of the Bureau participated in numerous disaster management and media briefings, an overview of which is provided in the Report at Paragraphs 99-118 and at Appendix J of the Report.

49. Paragraph 37 of the Report refers to about 800 Flood Warnings (later determined to be almost 890) having been prepared and issued by the FWC of the Bureau for the two month period of December 2010 and January 2011, a significant increase on previous similar periods. A full copy of the Flood Warnings (which also contain the river height predictions) issued by the Bureau are attached hereto and marked as **"PB2-8".** More "metric" information regarding other services and numbers of products supplied by the FWC during the December 2010 and January 2011 period, including river height predictions, is attached hereto and marked as **"PB2-9".**

50. During February and March 2011, another 400 Flood Warnings, containing about 220 predictions for about 40 locations, were issued for the flooding which was continuing to occur in Queensland.

51. Bureau River Height Bulletins for all river stations in Queensland are issued 3 hourly during the period of a flood event. Flood Warnings are generally issued 6 hourly during flood events, although at times more frequently for smaller river systems where the situation can change rapidly. In some locations this may be insufficient and more frequent updates may be needed. The Flood Warning Centre (FWC) updates modelling and predictions more frequently depending on the situation and the rainfall and water level data that is available, and has more information than can be presented in the public Warnings and website. Local council engineers are

encouraged to contact the FWC hydrologists on a regular basis during floods for updates as required.

**C. River height predictions during the December 2010 – January 2011 period**

52. A description of the flood modelling undertaken by the Bureau is described in the Report at Paragraphs 46 -53. The flood modelling assists the preparation of Flood Warnings and river height predictions at specific locations. As shown in PB2 -9, almost 1200 quantitative river height predictions (i.e. a specific river height in metres, as distinct to a qualitative prediction in terms of the broad descriptors of minor, moderate and major flooding) for over 100 locations in Queensland were provided in the Flood Warnings issued during the December 2010 – January 2011 period. This figure only includes those predictions published within the Flood Warnings and does not include additional predictions for addit ional locations provided during briefings and upon request.

53. Appendix I of the Report (pages 629 to 770) contains location specific flood summaries for 24 locations. In addition to providing some information describing the flood at each locatio n, these summaries provide key information regarding the Flood Warnings issued and the river height predictions issued for each of the 24 locations.

**D. Factors to consider in interpreting flood warnings and river height predictions**

54. For the interpretation of expected floods, it is important to understand that quantitative river height predictions given within Flood Warnings and in briefings are generally of two types:

    *a.* **Rising flood height prediction** , e.g. *"reach 7 metres at 6pm with further rises".* These predictions (also known technically as "rising limb predictions") are given when it is not possible to predict a peak flood level because the flood situation is continuing to develop (e.g. rainfall is continuing in the catchment) or it is too far ahead in time to make a reasonable prediction of the peak height to be reached at a downstream location. The key message is that the river height is predicted to be reached at or by the nominated time, and then exceeded; and

    *b.* **Peak flood height prediction** , e.g. *"peak at about 7 metres at 6pm".* A peak flood height prediction indicates a likely maximum flood level to occur and its estimated time. It is important to understand from a flood management and response perspective that the flood may have reached near to its peak he ight well before it actually achieves the peak

flood level. This depends on the shape of the hydrograph (how the river height or flow varies with time) – some are very "broad" whereas others are described as "narrow" or "peaky".

55. Where a flood warning monitoring and prediction system exists, typical forecast "lead" times (i.e. the amount of advance warning time for a river height prediction) for a particular location are broadly determined and constrained by either the duration of the rain-to-flood delay (catchment response time), dam release strategies by the dam operators or the flood travel time available from an upstream location, or a combination of all three.

56. For a given location, longer forecast lead times of a river height are generally less certain (or potentially less accurate) and forecast rainfall may be critical depending on the particular circumstances. Longer lead-time predictions (i.e. looking further ahead than that given publicly in the Flood Warning) are often given by the Bureau in the various emergency management briefings and can be scenario based (e.g. scenarios of longer-range projections of upstream flood peaks occurring, or based on a range of forecast rainfall amounts).

57. Large floods, such as occurred in many locations during December 2010 and January 2011, often have much less time for warning, prediction and response because of high rainfalls over the upstream catchments, including those in an immediate upstream area. High local inflows can be generated which can significantly reduce time to flooding, and hence significantly reduce the time available for an appropriate response to be taken by agencies and those affected on the floodplain. In addition, some local area catchments may not be well monitored, or may have no rainfall or water level monitoring stations.

58. The issue of large floods with a potentially shorter time available for forecasting and response, has implications for flood forecasters and disaster managers, and needs to be taken into account as far as possible in the design of monitoring, forecasting and warning systems and in the planning for an operational response to large floods.

**E. <u>Information associated with flood warnings and predictions</u>**

59. In Paragraph 23 of this statement, I referred to Table 1 on page 10 of Manual 21 as it sets out the organisational responsibilities in Queensland for components of the total flood warning-response system. The task of interpreting flood predictions (i.e. information on the expected effect of flooding for a predicted flood height) is the responsibility of DCS and Local Government under this arrangement.

60. The flood warnings and information on the Bureau's website, provides assistance to agencies to enable high-level interpretation of expected flooding and the potential impact on floodplain communities and infrastructure. The information which is directly provided or can be obtained from flood warnings and the Bureau's website includes:

    a. actual and predicted river heights;

    b. descriptions of flooding in terms of minor, moderate and major flooding (as described in further detail in Paragraph 89 of the Report);

    c. depths above/below key road crossings, bridges etc in River Height Bulletins, and at times in Flood Warnings for significant road crossings (e.g. highway, or key bridge in a remote area);

    d. comparisons of actual and predicted river heights with recent or historically significant past floods in Flood Warnings, and in supporting information on the Bureau's website for each river basin (see Paragraph 35 of the Report);

    e. information linking river heights and the likely impact, as described at Paragraph 91 of the Report, and which is provided (with appropriate disclaimer as necessary) in disaster management briefings at times;

    f. the level of the "gauge zero" in Australian Height Datum (AHD) for most river height stations which enables actual and predicted river height readings to be converted to a value in AHD. These are available on the Bureau website via the index at: http://www.bom.gov.au/hydro/flood/qld/networks/index.shtml, using the link "Survey Details for River Height Stations".

61. The latter technical information regarding river height gauge levels in AHD is publicly available, but it is primarily intended for agencies to use in converting actual and predicted river heights to AHD which allows a direct comparison with flood maps (if available and utilised for response activities) for that location and the levels of critical infrastructure (e.g. the height of transport or communications infrastructure, or the height of a levee). The actual or predicted river height referenced to AHD can also be used by property owners on the floodplain to assess the impact on their property and what action to take, if there is access to flood maps keyed to river height gauges, either in paper form or electronically (e.g. as described in Manual 21, Chapter 4, pages

33-34). The use of flood maps, preferably referenced to heights at flood warning gauges, also assists in the important aspect of taking into account flood "slope". Flood levels are higher upstream of the location for which predicted heights are given, and conv ersely lower, in areas downstream.

62. The information (described in Paragraph 60) provided by the Bureau may be of particular value to landholders and residents in rural areas as they may only require actual and predicted river heights at an upstream lo cation to have a good understanding, based on their previous flood experience, of what impacts are expected downstream, and critically, what action needs to be taken to minimise the flood impact. This is in contrast to an urbanised community that generally requires more detailed information to know what actions to take, especially where floods are infrequent.

63. In the special case of flash flooding, people need to know specifically what actions to take (e.g move quickly to higher ground where possible), and s pecifically what actions not to take in the limited time available to respond. This information needs to be determined by those persons who have local knowledge and be provided in a timely manner by local agencies. The Bureau provides general area "heavy r ainfall conducive to flash flooding advice" in its severe weather warnings to advise local communities and agencies that they may be affected , especially where there is local knowledge of flash flooding.

**F. <u>Flood modelling</u>**

64. The Report at Paragraphs 46 -54 provides further comments regarding the Bureau's flood modelling capacity and the limitations of modelling. Large and record floods, as occurred in many areas in Queensland during December 2010 – January 2011, are inherently harder to predict accurately because of greater uncertainty in the ratings (the relationships between flow and river height for each location) and paucity of large flood travel time information. By definition, record floods are beyond the bounds of data us ed in the model calibration. Flood design studies conducted by local authorities assist in ascertaining the upper bound of possible flood levels, particularly when floods are likely to exceed historical levels. These studies may require regular updating to take account of changes on the floodplain including land use, features and infrastructure.

65. As discussed in the Report at Paragraph 49, flood forecasting models provide guidance only to hydrologists. Hydrologists need to exercise consider able judgement, based on professional

understanding of flood behaviour and experience, in making river height predictions for most locations. This situation is even more pronounced when providing longer -range scenarios to assist disaster management planning.

**G. Three monthly seasonal rainfall outlooks**

66. The issue of three monthly seasonal rainfall outlooks and how they are determined was mentioned in earlier hearings of the Commission. The Bureau's Seasonal Climate Outlook (SCO) statistical model is based upon the relationship between Australian rainfall from all years during the period 1950 -1999 and four variables (sea surface temperatures in the Indian Ocean and in Pacific Oceans at one and three months lag). Every month the National Climate Centre holds an internal videoconference among climate specialists from the Bureau offices in States and Territories to discuss the current climate prognosis for the months ahead. During this discussion, they consider a wide range of information including outputs from several models and multi - model ensembles. This information adds context to the seasonal climate forecast.

**H. Particular matters relating to flood warnings and predictions for the Cities of Ipswich and Brisbane**

67. A summary of the flood event and the warnings and predictions provided for Ipswich and Brisbane is provided in the Report at Appendix I. A full copy of all Flood Warnings for the Bremer River and the included river hight predictions for Ipswich and the Brisbane River at Moggill, Jindalee and Brisbane City is provided as an annexure to this Statement at **PB2-8.**

68. Actual and predicted heights at both Ipswich and Moggill assist in determining the flood impact at Ipswich City. Flood classifications are described in the Report at Paragraphs 88-90.

69. The flood classification for the Bremer River at Ipswich gauge is Minor 7 metres, Moderate 9 metres and Major 11.7 metres. Thus, the threshold or lower level of major flooding is 11.7 metres, but there is a significant range of flood heigh ts possible at Ipswich, up to at least 24.5 metres which was recorded in 1893.

70. The flood classification for the Brisbane River at Moggill gauge is Minor 10 metres, Moderate 13 metres, Major 15.5 metres.

71. Flooding at Ipswich can result from local rainfall an d flash floods in metropolitan creek systems, Bremer River flooding (from the 1,850 square kilometre catchment above Ipswich) and backwater flooding from the Brisbane River. In most previous floods, it was a combination of all

three, as was the case in the January 1974 flood. The January 2011 flood resulted primarily from a combination of Bremer River flooding and backwater flooding from the Brisbane River.

72. In the flood warnings issued on Monday 10 January and Tuesday 11 January 2011, the predicted heights for Ipswich were not given as predictions of the peak flood height at Ipswich as the flood was continuing to develop with continuing rainfall, and further rainfall was forecast. For example, the Flood Warning issued at 4:16pm on Monday 10 Januarysaid the following:

    a. *"The Bremer River at Ipswich is expected to reach about 12.7 metres on Tuesday afternoon. Higher levels are possible."*

    b. *"Ipswich: Reach about 12.7 metres (major) during Tuesday afternoon. Quicker rises and higher levels are possible depending on further rainfall tonight."*

    c. Following the predicted heights given in the Warning for the four locations of Ipswich, Moggill, Jindalee and Brisbane: *"Further rises are possible at all four locations depending on further rain."*

73. The Flood Warning issued at 9:28am on Tuesday 11 January said that:

    a. *"The Bremer River at Ipswich is expected to reach about 16 metres during Wednesday. Higher levels are expected."*

    b. *"Ipswich: Reach at least 16 metres (major) during Wednesday; further rises."*

    c. *"Further rises are expected at all four locations with continued rainfall."*

74. Very heavy rainfall re-commenced in the catchments of Wivenhoe Dam, Lockyer Creek, Bremer River and the middle reaches of the Brisbane River below Wivenhoe Dam on Tuesday 11 January.

75. During the 11am briefing on 11 January 2011 of the State Disaster Coordination Centre (SDCC), I provided an updated predicted height for Ipswich of "18 metres plus" for overnight that night (i.e. Tuesday night). This was not a prediction of the peak height at Ipswich. The flood situation for Ipswich was continuing to worsen, primarily because of the continuing heavy rain and runoff in the Bremer River catchments above Ipswich and middle Brisbane River catchments above Moggill. At this time (11am Tuesday, 11 January), the Wivenhoe Dam release strategy was indicating a peak discharge of 3,737 cumecs, as shown in the Report at Paragraph 242, Figure 7.1. At 11:38am, the FWC received an updated release strategy to a peak of 4,062 cumecs which

represented a marginal increase and did not require a further change to the river height predictions for Ipswich and elsewhere.

76. Following the SDCC briefing, at 11:45am, Mr Stuart and I spoke with Ipswich City Council (ICC) regarding the updated prediction for Ipswich of "18 metres plus" tonight (i.e. Tuesday night) with further rises on Wednesday. During that conversation, ICC advised that their response plans at that time used the Bureau predicted height plus an extra one metre. I also asked what messages we should provide in respect of the Ipswich flood situation, as we were constantly on radio broadcasts covering the Ipswich area. The advice from ICC was to direct ICC residents to the ICC website and advise that "if you live close to a stream, you need to self-evacuate", or words to that effect.

77. At 1:28pm, the FOC sent an email relaying a request from Mr Borrows of Seqwater for the Bureau to consider the effect on river heights at Brisbane City for a scenario of releases of 9,000 cumecs from Wivenhoe Dam. The FWC did not undertake the request at that time because a new release strategy was received at 1:31pm for which detailed modelling was immediately commenced. Before this scenario of 9,000 cumecs could be considered, a new request from the SEQ Water Grid Manager for a scenario of 10,000 cumecs was requested at 3:30pm as detailed in Paragraph 82.

78. At 1:31pm on 11 January, the Bureau's FWC received from the FOC a revised strategy for releases from Wivenhoe Dam which advised of a significant increase in projected releases to 6,675 cumecs, from earlier expectations of about 4,000 cumecs. Copies of emails from FOC to the Bureau advising actual and projected releases are contained in Annexure PB-5 of my first Statement. This was a significant change in release volumes which prompted the FWC to immediately commence new modelling.

79. Between 1:31pm and about 3:00pm on 11 January, the FWC updated the Brisbane, Lockyer and Bremer River flood forecast model to take account of the new release strategy and latest rainfall which was continuing.

80. At 3:24pm on 11 January, the Bureau issued a PRIORITY Flood Warning for the Lockyer, Bremer, Warrill and Brisbane River below Wivenhoe including Brisbane City, which included predicted heights for Moggill and Ipswich (both of which are important for Ipswich flooding). A copy of this warning is in Annexure PB2-8 of this Statement. Specific information was provided for the major

flooding in the Bremer River and Warrill Creek upstream of Ipswich. For Ipswich, the Warning said:

a. *"The Bremer River at Ipswich is expected to reach about 22 metres during Wednesday. Higher levels are possible as rainfall continues."*

b. *"Reach at least 22 metres (major) during Wednesday; further rises."*

81. The modelling of the Brisbane River and its tributaries, taking account of Wivenhoe Dam releases, especially when it is continuing to rain heavily in the catchment, is a complex task and ultimately requires significant hydrologist judgement in determining the river height predictions to be provided to agencies and the public. It requires modelling, discussion with the FOC and Flood Information Centre (FIC) of the Brisbane City Council, and consideration and the production of the wording and content of the warning itself. On the afternoon of 11 January, the production of the 3.24pm Priority Warning for the Brisbane River by hydrologists at the Bureau was efficient and timely. The warning effectively provided 24 hours notice for Ipswich of at least the 22m flood height prediction and 36 hours notice for Brisbane of exceeding the 1974 flood peak.

***Scenario of Wivenhoe Dam release of 10,000 cumecs***

82. At about 3:30pm on 11 January, I was contacted by Mr Barry Dennien of the SEQ Water Grid Manager for advice on a scenario of a Wivenhoe Dam release of 10,000 cumecs. Whilst on the telephone I calculated an estimated total flow in the lower Brisbane River for this scenario and advised estimated flood heights of:

a. Mt Crosby: 30 to 32 metres AHD

b. Moggill: 25 metres AHD

c. Jindalee: 18 metres AHD

d. Brisbane City Gauge: 7.5 metres AHD

83. I further advised Mr Dennien that, if it was to occur, the peak releases would take approximately 24 to 30 hours to reach the Brisbane area and for Brisbane City, it compared to the river heights of 8 metres and 8.35 metres reached in 1893. I did not estimate a particular height for Ipswich as this would be similar to the Moggill flood level for this type of flood, perhaps only slightly higher depending on the timing and amount of rain received in the catchments above Ipswich.

***Updating flood warnings with lower river height predictions***

84. After the heavy rainfall had ceased abruptly by Tuesday evening, and with updated release strategies, subsequent Flood Warnings provided during Tuesday night and Wednesday pr ovided slightly lower (than previously given) estimates of the predicted river height at Ipswich, Moggill, Jindalee and Brisbane. For Ipswich, the Flood Warning issued at 7:33am on Wednesday 12 January said:

    a. *"The Bremer River at Ipswich is expected to peak about 20.5 metres during Wednesday afternoon with major flooding. This is similar to the 1974 flood level."*

## I. Flooding in the Fernvale area

85. The hydrologic flood forecast modelling undertaken by the Bureau does include predictions for river height stations at Lowood and Savages Crossing, however these predictions are not included in the Flood Warnings. If predicted heights are required for the Fernvale area, then the Bureau would need to further consider that requirement together with Seqwater FOC given the proximity of the area to Wivenhoe Dam. The Bureau would need to coordinate with the provision of flood information from Seqwater as they have a role in supplying some information for areas below the dam when releases are being made.

86. The Bureau is not aware of the specific characteristics of the lower Fernvale flooding that occurred on Tuesday 11 January 2011 , and in particular , whether the flooding was primarily caused by the Brisbane River or the intense ra infall and local runoff which occurred in the area, or a combination of both. Predictions for Lowood and Savages Crossing, if they could be sufficiently timely and accurate, may not give a good indication of the Fernvale flooding if the flooding was partly caused by the intense rainfall and high runoff in local smaller streams flowing through the area to the Brisbane River. This would need to be further investigated by the Bureau with the local agency.

## J. Request for information from the Queensland Floods Commission of Inquiry dated 12 April 2011

87. The following is provided in response to a request for information from the Commission dated 12 April 2011 regarding specific issues raised in certain submissions and statements.

***Meandarra***

88. During the 2010 -11 floods, the Bureau was unable to assist with providing advice regarding flooding at Meandarra, as was advised in emails between the Bureau and Inspector Kajewski. This is because there is no rainfall or water level monitoring network in the Brigalow Creek catchment above Meandarra or within the township itself. As mentioned at Paragraph44 above, there are many such catchments and locations in Queensland that do not have flood monitoring and warning systems. The only information the Bureau receives from the Bri galow Creek catchment is a volunteer report of daily rainfall totals from Meandarra which is used along with other daily rainfall stations in the general area (at Glenmorgan and Hannaford) to very approximately model the flows from Undulla Creek into the m ain Condamine River. The location of these stations is shown in the flood warning network map on the Bureau's website <http://www.bom.gov.au/hydro/flood/qld/brochures/condamine_cotswold/map.pdf >.

89. As noted in the 12 April Request, Western Downs Regional Council working with the Bureau operates an ALERT flood warning system in Myall Creek to the township of Dalby. Whether a similar system is required elsewhere, fo r example at Meandarra, would be a matter for the relevant Council. The Bureau would, in the usual way, be available to provide advice on whether this was an appropriate system for an area under consideration, or whether other alternatives (e.g. telephone based stations) would meet the objectives being sought.

90. I now provide some information in response to the broad questions concerning Southern Darling Downs and Border districts raised in the 12 April Request.

***Structural integrity and placement of Bureau gauges along the Condamine/Balonne river system***

91. Information regarding the location of the river height stations along the Condamine/Balonne River system is given at the Bureau's Flood Warning Centre website at http://www.bom.gov.au/qld/flood/ (in partic ular, brochures are available via the index at <http://www.bom.gov.au/hydro/flood/qld/brochures/index.shtml> and additional specific information is indexed at< http://www.bom.gov.au/hydro/flood/qld/networks/index.shtml>.

92. The manual river height stations along the Condamine/Balonne river system are owned by the Bureau. As described in Paragraph 28 above, these water level stations have a series of staff gauges ("one metre markers") installed on the river bank or on bridges, crossing or roadways. Some of these may have sustained damage during the floods. As per standard practice, the Bureau will contact the "river readers" to assess any damage sustained at these river height stations and arrange for repairs.

93. During large floods, reporting of river height observations from manual stations is typically done up to 5 times per day, generally between 6am and 9pm. It does however rely on the volunteer efforts of a property owner or agency at each location. At times, these reports may be interrupted either by loss of communications (telephone or Internet) or by flooding at the location preventing observations being taken. For example, a volunteer river reader may need to evacuate during large floods. The Bureau does however take care in siting the manual river height stations and staff gauges such that , as far as possible, they are accessible and available during floods.

94. The automatic river height stations in the Condamine/Balonne River system are mostly telephone-based gauging stations owned and operated by DERM, and a few at or near storages are owned by SunWater (e.g. Chinchilla Weir, Beardmore Dam, Jack Taylor Weir). The structural integrity of the stations not owned by the Bureau would need to be discussed with their respective owner agency.

95. During floods, data from automatic telephone -based stations is typically updated 3 hourly, unless the station fails to report either because it is damaged by the floods, equipment fails or telephone communications fail. At critical times, the Bureau may invoke more regular updating (e.g. hourly) for short periods or update information on demand. There h ave been requests for more frequent updating on a continuous basis (e.g. every hour of every day). This would need to be done with caution during floods as it incurs a higher energy drain which may cause the solar - recharged batteries to be flattened render ing the station useless thereafter. New equipment should provide more frequent data reporting via "event reporting and push communications" as described in Paragraph 28 above.

***Moonie and Dumaresq river catchments***

96. The flood warning systems for these catchments are described in brochures available via the index on the Bureau's website at: <http://www.bom.gov.au/hydro/flood/qld/brochures/index.shtml>

97. The flood warnings and river h eight predictions provided for these areas are contained in Annexure PB2-8 of this Statement.

98. If the Commission has any further questions in relation to the Moonie and Dumaresq river catchments, the Bureau will assist by providing any other relevant information it possesses.

***Effect of levee banks and ring tanks on flood modelling during the January flood event***

99. The Bureau does not specifically model the effects of levee banks and ring tanks in its flood modelling, apart from implicitly taking account of major river levee banks (e.g. at Goondiwindi). Whilst levee banks and ring tanks may produce effects on the height and movement of water on the floodplains in their local vicinity, the Bureau does not usually need to take these into account when flood modelling and forecasting because they generally have a negligible effect at a river basin scale.

***Bureau arrangements during the January flood event***

100. As described in the Report at Paragraphs 140 -142, the Bureau's provision of weather and flood forecast and warning services involves a roster of operational staff around the clock, covering the whole or parts of Queensland according to the specific functions and the individual forecasting and warning requirements at the time. Due to the strong La Nina and record sea surface temperatures in late 2010 in the eastern Pacific Ocean, it was clear that extreme weather and flooding was probable for Queensland. Accordingly, prior to the wet season commencing, the Bureau put in place special business continuity arrangements for the additional support to Queensland.

101. During busy situations in the Flood Warning Centre (FWC), the shift manager (i.e. the Duty FWC Engineer/Hydrologist) generally allocates specific warnings/river basins to hydrologists according to the workload and the priority/severity of the flood in particular catchments.

102. The 2010 -11 flood season, particularly in December -January, was an exceptionally busy period for the FWC and the Regional Forecast Centre (RFC), placing unusual demands on Bureau staff. Additional local staff were inducted into the FWC and RFC at various times. The Bureau brought additional experienced hydrologists from Adelaide and Melbourne to work in the FWC in Brisbane and additional experienced meteorologists for the RFC. Various other Bureau staff were inducted to provide extra support in the management of media information, telephone calls and briefings, and two members of the Bureau Executive attended Brisbane to provide additional coordination and support.

103. Despite the severity of events, the Bureau was able to maintain quality flood warning services, and weather services, across all areas of Queensland. This is shown by the high number of Flood Warnings and river height predictions issued (see PB2 -8 and PB2 -9) and the frequency

of participation of Bureau hydrologists and meteorologists in numerous briefings for disaster management agencies, the media, and other groups including councils and dam owners

104. The Bureau provided direct telephone access to meteorologists and hydrologists through a series of different numbers for emergency management and local government agencies, the media and the general public. Calls and briefing requests were managed accor ding to the information involved and their importance in relation to the weather and flood situation at the time. However, some requests for information could not be responded to , at least not immediately, due to the very high number of calls and requests for information which were received by the Bureau during the busiest periods. Due to the prolonged and widespread nature of these events, the Bureau was operating at a critical level even with contingency arrangements in place.

**K. <u>Request for information from the Ipswich City Council dated 18 April 2011</u>**

105. I refer to the queries outlined in Clayton's Utz's letter of 18 April 2011 on behalf of the Ipswich City Council provided under cover of a request from the Commission dated 29 April 2011 (annexed hereto as PB2-3). I will respond to these queries in the order in which they appear.

106. **Item 1:** The Bureau did not receive the 9 directives referred to in Clayton Utz's letter . The Bureau does not normally receive the directives for gate settings as w e do not use this information. It is not required to update warnings and river height predictions with each change of gate setting because the gates are progressively changed according to the release strategy which is included in the Bureau modelling. The Bureau receives the latest Wivenhoe Dam release strategy (i.e. in the form of a tabulation of actual and projected releases against time) via email in a pre-determined format from the FOC. The strategy is included in the flood forecasting model for the whole of the Brisbane River basin. The modelling is integrated such that the effect of Wivenhoe Dam releases; Lockyer Creek flows; local inflows from rainfall occurring in the catchment including over the middle Brisban e River catchments below the dam; and the Bremer River flows from the catchments above Ipswich, are all taken into account in predicting river heights at Ipswich.

107. **Item 2:** As described in the paragraph above, the Bureau uses the Wivenhoe Dam release strategies in the flood forecast model and does not use the release directives. The directives are consistent with the current release strategy and the strategies are included in the modelling by the Bureau.

108. **Item 3:** The request to consider a scenario of a 9,000 cumecs release is discussed at Paragraph 77 of this Statement. The request for modelling based on a scenario of a 10,000 cumecs release was made by Mr Dennien of the SEQ Water Grid Manager in a direct telephone call at about 3:30pm. I provided the advice immediately during the telephone conversation. After I provided the advice to Mr Dennien, I received an email at 3:42pm from the FOC to provide the same advice for a scenario of 10,000 cumecs. I did not reply to the email as I provided the information at the FWC-FOC technical discussion which commenced at about 3:45pm.

109. **Item 4:** The request from Mr Dennien did not require me to undertake "modelling" as such, but I instead made calculations and estimates using my experience and knowledge. I calculated an approximate total discharge and used the discharge-height relationships embedded in the Bureau flood forecasting model. I made notes as I did this and gave the results to Mr Dennien while he was on the telephone. These estimates are approximate for the scenario, but give a reasonable estimate of heights for the specified scenario.

110. **Item 5:** The result of my estimations is detailed in this Statement at Paragraphs 82 and 83.

111. **Item 6:** I participated in a teleconference with the FIC at about 3:45pm,which is a part of our standard procedures to discuss modelling results and occurs several times during the day and night. The scenario of 10,000 cumecs was briefly discussed, but this was not the primary purpose of that teleconference.

112. **Item 7:** I made comparisons with the heights of the 1893 flood as summarised at Paragraphs 82 and 83, but I do not believe there was any in-depth discussion as this was dealing with a scenario only. We had more detailed discussions on what was actually occurring and being modelled.

113. **Item 8:** Predictions contained in the Flood Warning issued at 9:28am on Tuesday 11 would have been based on a flood forecasting model run just after the Wivenhoe Dam release strategy was received at 8:10am. As it was continuing to rain heavily across parts of the catchments, this Warning could not, and did not, provide a prediction for the peak at Ipswich. The Warning stated that:

a. *"The Bremer River at Ipswich is expected to reach about 16 metres during Wednesday. Higher levels are expected."*

*b. "Ipswich: Reach at least 16 metres (major) during Wednesday; further rises."*

c. *"Further rises are expected at all four locations with continued rainfall."*

114. **Item 9:** The modelling mentioned above would have taken into account the 8:10am Wivenhoe Dam release strategy (with projected peak of 3737 cumecs).

115. **Item 10:** The Bureau's flood forecast model takes account of the actual and forecast river height in the Brisbane River at Moggill to calculate the expected height at Ipswich. It does this by using a tailwater dependent rating (i.e. it takes account of actual and predicted heights in the Brisbane River at Moggill) that has been developed and refined in the Bureau model calibration process. It yields satisfactory estimates of Ipswich river heights under the full range of combinations of concurrent Bremer River flow and Brisbane River flow.

116. **Item 11:** The term "during Wednesday" is intended to be any time on Wednesday, which includes any time after midnight Tuesday. It is an expression that indicates an inability to be more precise, especially when heavy rain is continuing. If heavy rainfall is received during the forecast period in the Bremer catchments above Ipswich or in the middle Brisbane River catchments above Moggill, then the river will rise much quicker at Ipswich than if it did not receive the rainfall in these particular areas in that particular period. For this case of local rainfall, our warning procedures indicate that we should typically provide shorter-term predictions 6-12 hours ahead. Because this was a combination flood involving both the Bremer River and backwater flooding from Brisbane River, we were giving longer (12-24 hours), but less certain, predictions for Ipswich to give the response agencies and the community more time for action. The matter of catchment response and flood warning lead times in large floods is discussed in this Statement at Paragraphs 57 and 58.

117. **Item 12:** As the rain and flood situation unfolded on 11 January, the quicker rises to 16 metres at Ipswich were caused by the heavy rain in these areas. In the daylight hours on 11 January, the heaviest rain occurred in both these areas, with 12 hour (6am to 6pm) rainfalls of 150 to over 300 millimetres in, for example, the Rosewood area upstream of Ipswich. For this case, our warning procedures indicate that we would typically give Ipswich predictions 6 to 12 hours ahead, but if we had done this, it is my view that the predictions, whilst being more accurate, would not have been as useful to the disaster response agencies. At this stage (9pm Tuesday 11 January), the quicker rising Ipswich flood level was not significantly affected by the sharp increase in releases at Wivenhoe Dam. These accelerated releases commenced at about

9am Tuesday and did not affect the Moggill and Ipswich area until around 3am to 9am Wednesday 12 January because of the time that it takes floodwaters to move from Wivenhoe Dam to Moggill.

118. These quicker rises at Ipswich were foreshadowed by me at the SDCC briefing at 11am Tuesday during which I announced an updated predicted height for Ipswich of "18 metres plus" for overnight tonight (i.e. Tuesday night). This was based on the latest modelling just before and during the SDCC briefing, and our 'hydrologist' judgement. The river height at Ipswich reached 18 metres at about 2:30am Wednesday.

119. As previously described in Paragraph 76 of this Statement , I also gave this updated prediction to Ipswich City Council at 11:45am by telephone, just following the SDCC briefing.This was an exceptionally busy period with rapid development of a serious flood.

120. **Item 13:** All factors were included in the modelling as previously described, including the updated Wivenhoe Dam release strategy (with predicted peak discharge of 6,675 cumecs) received at 1:31pm Tuesday. Again, the river level of 22 metres at Ipswich was not predicted as a peak. At that stage of the flood, it was possible, even likely, that Ipswich could have reached a higher level as the heavy rainfall was continuing. The modelling at that time, using the actual and projected releases and the rain that had been recorded was suggesting a possib le height of at least 22.5 metres at Ipswich on Wednesday.

121. **Item 14:** As described in this Statement at Paragraphs 75 and 76 , updated predictions for Ipswich were given, at the 11am SDCC briefing and to Ipswich City Council, during the period between the Flood Warnings issued at 9:29am and 3:24pm. This prediction extended the predicted height for Ipswich as far ahead as possible, while the situation was rapidly changing and an updated release strategy was being developed.

122. **Item 15:** The single major factor that led to the significant increase in the predicted flood heights for Ipswich, and for Moggill, Jindalee and Brisbane City, during the daylight hours of Tuesday 11 January was the intense rainfall producing high runoff which persisted for about 12 hours (approximately 5am to 5pm) over the Wivenhoe Dam and its immed iate catchment areas (resulting in the strategies of higher releases from Wivenhoe Dam), the lower Lockyer Creek, the middle reaches of the Brisbane River below Wivenhoe Dam and the Bremer River catchments immediately upstream of Ipswich.

123. **Item 16:** The inc reases in the actual and projected releases from Wivenhoe Dam, which were necessitated by the intense rain and runoff on 11 January, were a factor, but not the only factor, in the updated higher flood height predictions for Ipswich. The magnitude of the developing floods was also increasing in the lower Lockyer Creek, the middle reaches of the Brisbane River below Wivenhoe Dam and the Bremer River and Warrill Creek systems immediately upstream of Ipswich.

## L. Request for information from the Queensland Floods Commission of Inquiry dated 28 April 2011

124. I refer to the queries outlined in the Commission's letter of 28 April 2011 (annexed hereto as PB2-2). I will respond to these queries in the order in which they appear.

***Predicted river height peaks on 11 January 2011***

125. The significant increase in the predicted flood heigh ts for Ipswich, and for Moggill, Jindalee and Brisbane City, during the daylight hours of 11 January resulted from the intense rainfall producing high runoff which persisted for about 12 hours (approximately 5am to 5pm) over the Wivenhoe Dam and its immediate catchment areas (resulting in the strategies of higher releases from Wivenhoe Dam), the lower Lockyer Creek, the middle reaches of the Brisbane River below Wivenhoe Dam and the Bremer River catchments immediately upstream of Ipswich.

***Communications with the Brisbane City Council Flood Information Centre (FIC)***

126. On the 11 January 2011 , I participated in conversations with the Brisbane City Council FIC at 6:10am; about 8am; 9:10am; 1:40pm/2:15pm; 2:55pm and approximately 8pm. Additional conversations could have taken place between the FWC and the FIC on the 11 January. The only conversation that I am aware of which involved Mr Morris on the 11 January was at 2:55pm which I detail below, although he could have been involved as a "listener" in others.

127. The conversations between the FWC and FIC were via telephone and usually involved more than one person at each end, but not always. During 11 January, Mr James Stuart, senior hydrologist in the FWC, was also generally involved in the conv ersation with me as the phone was usually on "speaker setting" close to where the Brisbane River modelling was being undertaken. Mr Stuart and I, together or alone , may have had additional technical discussions with the FIC.

128. From a FWC perspective, the purpose of the conversations was to provide the Brisbane City Council FIC with updates on the predictions for the lower Brisbane River and to discuss these along with the flood forecast modelling results which were being regularly updat ed on the Bureau's registered user website.

129. I did not write detailed notes of each conversation. However, from my recollections and my brief annotations recorded along with some calculations and predi ctions, I can provi de the following information:

a. **FIC 6:10am.** I spoke with Mr James Charalambous. I gave an update on the situation based on my earlier conversation (at about 5am) with the Seqwater FOC, the current release strategy and our most recent modelling. I advised tha t we were waiting for the "new" release strategy (email containing actual and projected releases) from the FOC that was expected soon.

b. **FIC about 8am**: Between 7am and 8am, the FWC worked on an update of Brisbane River modelling and held discussions on the results with the Seqwater FOC. Just before 8am , there was contact with the FIC when the latest river height predictions for the lower Brisbane River were provided . These predictions were then provided in the 8am teleconference of the State Disaster Management Group.

c. **FIC at 9:10am:** Between 8am and 9am, the FWC again worked on an update of Brisbane River modelling to take account of the next release strategy (which was received at 8:10am) and the recent heavy rainfall that was continuing. I phoned the FIC at 9 :10am. I provided the latest Brisbane River predictions and made a brief annotation "agreed on predictions". As BCC were not doing the flood modelling, this refers to an agreem ent with the predictions which were to be included in the next flood warning that we were preparing at that time. The flood warning was then issued at 9:28am.

d. **FIC at 1:40pm/2:15pm**: I had some discussions with FIC ( although I have no recollection with whom) at 1:40 and wrote the annotation "discussion of wording/predictions". I then have a further annotation "Agreed with the above predictions with FIC @ 2:15pm". At this stage, the wording that was intended to be used in the next Flood War ning was "as high as January 1974 (5.45 metres) on Thursday" or words to that effect. It may or may not have been a continuous conversation between 1:40pm and 2:15pm as we were intensively re -modelling the releases scenario received by the FWC at 1:31pm. T his

release strategy indicated an increased release to a peak of 6,675 cumecs. Prior to that, we had just completed the modelling based on a release scenario of 4,062 cumecs.

e. **FIC at 2:55pm:** The flood situation continued to change rapidly with the very int ense rainfall continuing in the lower reaches of Lockyer Creek, middle reaches of the Brisbane River (Lowood area) and in the Bremer River above Ipswich. Between midday and 3pm on 11 January, the highest three hourly rainfall totals exceeded 100 millimetr es in these areas. We were preparing to re-issue the flood warning and predictions for Ipswich and the lower Brisbane River. These latest and continuing rainfalls needed to be taken into account with further modelling and analysis by Mr Stuart and me. Mr S tuart and I developed the Ipswich and lower Brisbane River predicted heights and timing. This required quite a deal of judgement, including with respect to the warning strategy (i.e. extending the forecast lead time to 36 hours for Brisbane City and the sp ecific wording to be used in the flood warning). Before 2:55pm, I rang Brisbane City Council and spoke personally with Mr Don Carroll and Mr Morris. I briefed them on our latest flood modelling results and hydrologist analysis. I had noted down the words "River rises will continue into Thursday with levels higher than 1974 expected" which were intended to be used in the warning. I wrote an annotation "14:55 agreement Don/Ken".

f. I then had a brief discussion with Mr Stuart to finalise predictions and wordings for the Flood Warning that was subsequently issued at 3:24pm. I had a pre -arranged teleconference with Mr Smith (Chair of the State Disaster Management Group) and the Premier due to commence at 3pm. As we had finalised the predictions and the wording of the Flood Warning, I was in a po sition to give the latest Ipswich and Brisbane River predictions.

g. Between 3pm and 8pm, the modelling and hydrologist analysis continued with two further Wivenhoe Dam release strategies received at 4:51pm and 6:06pm . I re-checked all my calculations especially with respect to the timing of various predicted heights and including other scenarios of higher floods while the intense rain continued. Many agency and media briefings were undertaken, including at the State Disaster Management Group meeting at 5pm.

h. **FIC at 8pm:** The intense rain eased unexpectedly at about 5pm to 6pm 11 January. We updated the Brisbane River basin flood modelling again in preparation for a Flood Warning that was subsequently issued at 8:05pm. The predicted river heights for Moggill

and Ipswich could be revised to slightly lower levels of 21.5 metres and 21 metres respectively since the heavy rain had eased in the Bremer catchment. I telephoned the FIC at approximately 8pm to advise of the slight change for Moggill, but that the predictions for Jindalee and Brisbane would remain as they had been in the 3:24pm warning.

Date: 11 May 2011

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Peter Baddiley