PARADISE DAM COMMISSION OF INQUIRY

Commissions of Inquiry Act 1950

STATEMENT OF RICHARD IAN HERWEYNEN

Name of witness:	**Richard Ian Herweynen**
Date of birth:	[redacted]
Current address	[redacted]
Occupation	**Civil Engineer (Principal Consultant)**
Contact details (phone/email):	[redacted]
Statement taken by:	**Shana Webster - Lawyer**

I, **Richard Ian Herweynen**, state as follows:

1 I am employed by Hydro-Electric Corporation trading as Hydro Tasmania (**Hydro Tasmania**) in the position of Principal Consultant, Civil Engineering in the business division which was known as Hydro Tasmania Consulting during the design construction period of the Burnett River Dam (**Paradise Dam**).

Qualifications and experience

2 **HYT.600.006.0001** is a copy of my curriculum vitae.

3 I hold the following qualifications:

(a) Bachelor of Engineering (Civil) (University of Tasmania, 1989);

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Corrs Chambers Westgarth
Level 42, 111 Eagle Street
Brisbane Qld 4000
Tel 07 3228 9377
Fax 07 3228 9444
Ref: MJK:9152525

(b) Graduate Diploma of Management (Technology Management) (Deakin University, 1998);

(c) Master of Geotechnical Engineering (University of New South Wales, 2014).

4 I commenced employment with Hydro Tasmania in January 1990 as a Graduate Engineer and have remained with Hydro Tasmania throughout my career. As a Graduate Engineer, I worked for two years in the Dams and Hydraulics department and one year in the Tunnels and Structures department.

5 In January 1993, I began working in the Hydrology department primarily on flood modelling, and was there for around 2 years.

6 In 1995, I returned to the Dams team, where I became a Senior Dams Engineer.

7 In January 1998, I became Team Leader of the Dams and Geotech team.

8 During my time with Hydro Tasmania I have been involved in a number of major projects, some of which are relevant to this project are:

(a) Samson Brook Pipehead Dam (in Western Australia) as Lead Dam Designer (2002 to early 2003);

(b) Paradise Dam as Lead Dam Designer (April 2003 to November 2006);

(c) Meander Dam (in Tasmania) as Project Director and Design Reviewer (July 2004 to December 2007);

(d) Logan River Early Works Alliance (in Queensland) as part of the Alliance Leadership Team (2007 to 2010);

(e) Wyaralong Dam (in Queensland) as Design Manager (January 2009 to July 2012);

(f) Independent advisor for Enlarged Cotter Dam Performance Audit undertaken for the ACT Audit Office (December 2014);

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(g) Murum Dam (in Malaysia) as Independent Dam Safety Engineer during the final years of construction, initial impoundment and first year of operation (2012 to 2015);

(h) Nagmati Dam (in Nepal) as Design Manager (2015 to 2017);

(i) Currently, Chair of Independent Review Panel for the Baleh Hydropower Project (in Malaysia) (from January 2019 to the present).

9 Samson Brook Pipehead Dam is a concrete gravity dam. Paradise Dam, Meander Dam and Wyaralong Dam are all roller compacted concrete (**RCC**) dams of about the same height. Murum Dam is an RCC dam of about 140 metres height.

10 I was part of the Australian National Committee on Large Dams (**ANCOLD**) working group that updated the concrete gravity dam guidelines titled "Guidelines on Design Criteria for Concrete Gravity Dams" (September 2013). I was also the Chairman of the International Commission on Large Dams (**ICOLD**) Technical Committee on Engineering Activities in the Planning Process for Water Resources Projects (from about 2009 until about 2018).

11 I am a member of the National Engineering Register (**NER**), and I am a Registered Professional Engineer of Queensland (**RPEQ**).

Commencement of Paradise Dam project

<u>ROI Stage</u>

12 On or about 20 January 2003, Burnett Water Pty Ltd (**Burnett Water**) issued a document titled "Burnett River Dam – Invitation to Submit a Registration of Interest" (**ROI Invitation**) (**HYT.006.004.2793**). I understood the purpose of this overall process was for Burnett Water to select partners with whom it would enter into an alliance for the design and construction of Paradise Dam. Burnett Water conducted this process in stages. The initial stage was the ROI Stage, which called for potential partners to respond with ROI submissions.

13 Hydro Tasmania came to be involved in the preparation of an ROI submission initially through I believe Mark Hamilton. At the time, Mark Hamilton was

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working for Walter Construction Group Limited (**Walter**). Mr Hamilton had approached Hydro Tasmania to join Walter on a bid for another project about one year earlier, but that bid did not go ahead. After Burnett Water issued the ROI for Paradise Dam, Mr Hamilton approached Hydro Tasmania to ascertain whether Hydro Tasmania would combine with Walter to prepare an ROI submission. My recollection is that after I and others at Hydro Tasmania considered the proposition, Hydro Tasmania advised Mr Hamilton that we did not think a consortium with just Hydro Tasmania and Walter alone would be a strong enough to win the bid, given the likely cost of the bidding process and slim chance of success and we decided not to bid. Mr Hamilton then approached Hydro Tasmania again proposing a consortium of Hydro Tasmania, Walter, Macmahon Contractors Pty Ltd (**Macmahon**) and SMEC Australia Pty Ltd (**SMEC**). In essence, Hydro Tasmania and SMEC would be responsible for design and Walter and Macmahon would be responsible for construction. Hydro Tasmania agreed to join the proposed consortium.

14 On or about 14 February 2003, we lodged our ROI submission with Burnett Water (**ROI Submission**). I was involved in the preparation of this document. My recollection is that the ROI Submission was not a detailed document and was predominantly focused on company profiles, financial position, basic systems, relevant experience and the senior people proposed to be involved in the project.

Stage 1

15 On or about 17 March 2003, Burnett Water issued a document titled "Burnett River Dam Stage 1 – Request for Proposals" (**Stage 1 RFP**) (**SWA.500.001.2366**). This next stage of the process for selecting the alliance partners was known as Stage 1. During Stage 1, those respondents who had been successful through the ROI Stage were invited to participate by visiting the site, attending interviews and preparing Stage 1 submissions (also called the "**Stage 1 proposal**"). My understanding is that there were three respondents who were invited to participate in Stage 1, one being our consortium. The other two respondents were a consortium led by Thiess and URS and a consortium led by Leightons (as it was then known).

16 Prior to the Stage 1 RFP being issued, a preliminary design for Paradise Dam had been prepared by SunWater on behalf of Burnett Water (**Preliminary Design**) (**DNR.003.7930, HYT.006.004.1338, HYT.006.004.0985, HYT.006.004.1233, HYT.006.004.0950, HYT.006.004.0913**). The Preliminary Design was provided to respondents as part of the Stage 1 RFP at Appendix F.

17 The Stage 1 proposal was required to set out a cost estimate for undertaking the project based on the Preliminary Design as well as discuss the Preliminary Design, possible innovations and key construction methodologies. Sunwater's Preliminary Design was based on the main spillway sections of the Dam being constructed of RCC, which was noted by Sunwater as being less costly and inherently as safe as conventionally placed concrete (see page 22, section 10.1).

18 On or about 11 April 2003, we lodged our Stage 1 proposal with Burnett Water (**Stage 1 Proposal**) (**HYT.510.004.0001**). I was one of the main people from Hydro Tasmania involved in the preparation of sections of this document.

19 Some of the key innovation features of the Stage 1 Proposal were to construct the entire Dam using RCC and to convert the right abutment into a secondary spillway, which would eliminate the need for a saddle dam (which was a separate additional structure included as part of the Preliminary Design).

<u>Stage 2</u>

20 The starting point for the Stage 2 design was the Preliminary Design prepared by SunWater, which had an RCC primary spillway, a 20m long apron in the primary spillway, and the apron level rose on the left side of the primary spillway.

21 On or around 9 May 2003, Burnett Water issued a document titled "Burnett River Dam Stage 2 – Request for Proposal" (**Stage 2 RFP**) (**SWA.500.001.2068**). The document included a functional specification for the Dam facility. Following evaluation of the Stage 1 submissions, Burnett Water appointed two successful respondents to proceed to Stage 2 – they were our consortium and the consortium led by Thiess and URS. During Stage 2, a Burnett Water representative was placed in each of the consortiums and there was regular interaction with a wider group of representatives from Burnett Water, and their

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Technical Advisors, SunWater, as the consortiums prepared Stage 2 submissions (also called the "**Stage 2 proposal**").

22 The Stage 2 proposal was required to be a full tender design for the design and construction of the Dam, including consideration of the best technical solution and most favourable commercial terms with a target cost that would then form the basis for the risk / reward model in the eventual alliance agreement.

23 At this point there were a number of key decisions made by our consortium, including the decision to use lean RCC, to adopt an upstream membrane and to use reinforced RCC for the dam aprons. These key decisions were generally presented during these meeting and workshop interactions during the Stage 2 design to Burnett Water and their Technical Advisor, SunWater and in our final bid submission.

24 On or about 1 August 2003, our consortium, being Hydro Tasmania, Walter, Macmahon and SMEC, entered into the "Burnett River Dam Consortium Agreement" to formalise the consortium for the preparation and submission of the Stage 2 proposal and entry into the alliance (**2003 Consortium Agreement**) (**HYT.520.005.0001**). Wagners Quarries Pty Ltd (**Wagner**) was also a party to the Consortium Agreement, although not a consortium (or alliance) member.

25 On or about 1 August 2003, we lodged our Stage 2 proposal with Burnett Water (**Stage 2 Proposal**) (**DNR.007.0477**). This included an initial design report, construction method statements, and a draft versions of at least some of the specifications. There was considerable design effort undertaken during this Stage 2 design period, with a considerable team based in Brisbane. I was one of the main people from Hydro Tasmania involved in the preparation of this document.

The Alliance

26 Following evaluation of the Stage 2 submissions, Burnett Water announced that our consortium had been successful.

27 Accordingly, in about October 2003, Burnett Water, Hydro Tasmania, Walter, Macmahon and SMEC entered into the "Alliance Agreement – Burnett River Dam" (**2003 Alliance Agreement**) to formalise the alliance for the development

of the Paradise Dam (**Alliance**) (**ALL.144.002.0258**).

28 I understand that on or about 23 May 2005, the 2003 Consortium Agreement and 2003 Alliance Agreement were both replaced by a Consortium Agreement (**2005 Consortium Agreement**) (**HYT.522.002.0019**) and Alliance Agreement (**2005 Alliance Agreement**) (**ALL.144.002.0389)** without Walter as a party due to Walter going into voluntary administration.

29 My recollection is that following Walters' entry into insolvency Macmahon took over its role in the Alliance and all site construction works. To achieve this I recall Mark Hamilton was employed by Macmahon and that Macmahon employed all of Walter's site based staff. There was, as a result, little disruption to the Paradise Dam project that I could see due to Walter's insolvency because all relevant site construction staff were simply employed by Macmahon.

Governance and key personnel of the Alliance

30 Having won the bid and formed the Alliance to develop Paradise Dam, we moved into the detail design phase, which was sometimes referred to as Stage 3 (**Detail Design Phase**). The Detail Design Phase required the Alliance to complete the detailed design in order to progress to construction of the Dam.

31 A draft of the document titled "Burnett River Dam Alliance Design Management Plan" (**Design Management Plan**) (**HYT.514.006.0293**) was prepared I recall during the early part of Stage 2.

32 The Design Management Plan sets out the management system for the Detail Design Phase, including key personnel and roles, meetings, review and certification and approval procedures. Andreas Neumaier (who was the Design Manager, discussed below) prepared the Design Management Plan with input from other people including myself. I refer in particular to pages 12 to 15 (structure and key personnel), 16 to 17 (meetings) and 18 to 21 (review and approval procedures). As a general comment, the systems set out in this document were, in my experience, followed by the Alliance.

33 At the top of the Alliance was the Project Alliance Board (**PAB** or **Board**), which had ultimate governance of the project and consisted of a representative from each of the Alliance members. The level of governance, as I understood,

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commenced on and from Stage 2 – as this stage of the detailed design this project governance, as many key decisions were already made, or were going to be made, during this stage.

34 The Alliance had its own filing system and own server, and all members of the Alliance had a 'BDA' email address (@BDA.com.au). It is my understanding that all of these hard copy files and the full server of electronic and email records was handed over to Sunwater at the completion of the project. However, based on information I have seen in recent months, it appears that a significant amount of documentation has not been made available to the Alliance, including minutes of the Alliance Management Team meetings, minutes of Design Team meetings, records of the Alliance Coaching workshops, Burnett Dam Alliance emails, etc. I believe that it is critical to see all of these documents to properly understand key Alliance decisions.

35 Larry Polglase was the Hydro Tasmania representative on the PAB. I understood the PAB met monthly, but that special meetings were sometimes called. I was not involved with the PAB at all.

36 Below the Board was the Alliance Project Manager, which was Mark Hamilton (who was employed by Walter but, as discussed above, subsequently transferred to Macmahon following Walters' insolvency). The Alliance Project Manager managed the overall project (i.e.. both design and construction) and reported directly to the Board.

37 Below the Alliance Project Manager was the Design Manager and the Construction Manager, who were in charge of the two major aspects of the project, design and construction.

38 The Design Manager was Andreas Neumaier (who was from SMEC) and the Construction Manager was initially Steve Johnson, and later at some stage during construction, became Bruce Embery.

39 The Design Manager oversaw everything related to the design of the Paradise Dam (which involved multiple components), managed the interface between the various design components and approved matters concerning design during the Detail Design Phase. The Construction Manager performed a similar role, but in

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relation to construction.

40 Below the Design Manager were the leaders of the various design components and the Supervising Draftsman, who was from SMEC. I believe this was either Chris Higgins or Steve Wallace.

41 My role was Dam Design Leader, which was one of the design components referred to above, being the design of the Dam body (**Dam Design**). Other Design Leaders were Ron Wyburn, the Outlet Works design lead (who was contracted by SMEC), and Trevor Sullivan, the Infrastructure design lead (who was from SMEC). David Starr of Golder Associates (**Golder**) was the lead for geology and geotechnical on the project. We all reported to Andreas Neumaier in his role as Design Manager.

42 As Dam Design Leader, I was responsible for the design of elements such as the dam wall, spillway crest, non-overflow crest, and aprons. It is important to note that this does not mean that I prepared all the design myself. This involved a team of engineers. In developing and co-ordinating the dam design, I also relied on experts in their respective sub-disciplines of expertise, including geology, geotechnical, hydrology, and RCC mix design and associated properties.

43 The experts in these sub-disciplines of expertise that I relied on were:

(a) Mike Wallis: Mr Wallis was responsible for all of the physical and numerical hydraulic modelling and hydraulic design. Mr Wallis was from Hydro Tasmania and had about 30 years' experience as a hydraulics engineer at that time. He communicated with me in relation to his work associated with the Dam structure, and in particular the primary and secondary spillways, but he communicated with Ron Wyburn in relation to his hydraulic modelling work associated with the intake, outlet and fishway.

(b) David Starr: Mr Starr led the geological and geotechnical assessments and analysis undertaken for the project by Golder. Mr Starr had about 20 years' experience in geology, particularly in rock mechanics. We used Mr Starr's (Golder's) inputs for the Dam Design, but he did not report to me. He reported directly to Andreas Neumaier (Design Manager). Mike Marley and Brett Collins were also key personnel from Golder I recall who were involved in the project. Brett Collins was located full time in the Alliance office, to enable good interaction with all of the design team.

(c) Dr Ernie Schrader and David Brett and Jack Linard:

In relation to RCC, the Alliance recognised early on that it required expert RCC advice and design input. Dr Schrader was a consulting engineer with over 30 years' experience with RCC having done many RCC dams around the world, including some of the first RCC dams ever built. He was recognised as a world leading RCC expert. Dr Schrader was introduced to us by Walter (my recollection is that an employee of Walters who was working on construction methodology and cost estimating had worked with him before on an RCC dam project in Australia).

Dr Schrader was initially retained by Walter during the tender phase and then was ultimately retained by Hydro Tasmania for Stage 2 onwards. He was the lead RCC expert who provided the main RCC design and specifications input into the project. He was responsible for the design of the RCC mix, supply of RCC materials properties for input into the dam design and preparation of RCC related construction specifications, including placement and quality control/management (a copy of his engagement can be found at **HYT.505.004.0147**).

Mr Brett was an Australian engineer and RCC consultant, who Hydro Tasmania had worked with before, he had more than 25 years' experience with dam design (including designing the Craigbourne Dam in Australia which was an RCC dam) and was recognised as someone with RCC expertise in Australia. He was retained from the outset by Hydro Tasmania and was engaged for the provision of advice and expert review of the RCC mix design and material properties and review of the RCC related construction specifications, including placement and quality control (each of which were initially prepared by Dr Schrader) (a copy of

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his engagement can be found at **HYT.510.003.0049**).

Jack Linard was a consultant retained by SMEC and had worked with them on previous projects internationally involving RCC, who also provided RCC advice primarily during the Stage 2 design phase, and possibly also during the earlier Stage 1.

44 I had a number of direct reports. The key direct report relevant to the matters I discuss in this witness statement was Tim Griggs. Mr Griggs was responsible for the dam structural stability analysis and design calculations and he reported to me. Mr Griggs was from Hydro Tasmania and had about 10 years' experience in dam stability analysis, dam design and dam safety reviews at the time of the Paradise Dam project.

45 My recollection is that I prepared work assignment documents for my direct reports, which indicated the tasks that they would be undertaking.

46 I was responsible for managing the interaction and input between the various sub-disciplines within Dam Design. During the Detail Design Phase, the Dam Design team was co-located in a project office set up in Walters' office in Brisbane, Queensland. We had regular design meetings which were generally chaired by Andreas Neumaier, and minutes of these meetings were prepared, highlighting key decisions and actions, and the person responsible for these.

47 For each element of the Dam Design (for example, the spilling basin, ogee crest, upstream face panels, downstream conventional concrete steps, etc.), there was a Design Plan prepared. The Design Plan stated the functional requirements to be met by the design, the key design inputs and the basis of design for that element (refer to **DNR.005.4145**). Each sub-discipline provided input into the development of this document. I would manage this process and if any changes were to be made to the document I would approve them.

48 The process for review of design work during the Detail Design Phase was that I reviewed all work under my area of responsibility as Dam Design Leader. For disciplines that were not in my area of core expertise, my review did not include verification of that work; I would require another person with expertise in that discipline to peer review it and verify the work. Andreas Neumaier (as Design

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Manager) would then review, and at times require certain matters to be addressed, and provide final approval of all design work before signing and issuing it for use by the Alliance.

49 Throughout the design process during Stage 2 design, Burnett Water had a technical expert named David Murray (who had been seconded from Sunwater) who regularly received and, if required, provided comments to the Alliance (this was made within the frameworks of this competitive process). Key decisions, such as the inclusion of the RCC secondary spillway on the right abutment, the installation of an upstream membrane, the removal of the gallery, and the use of RCC in the apron, were presented to Burnett Water, including their Technical Expert, Mr Murray, and other Technical Advisors from SunWater. When Burnett Water accepted our Stage 2 Design, we believed it was endorsed by Burnett Water, Mr Murray and the SunWater Technical Advisors. The Alliance, and in particular the Design Team, never received any report or documentation to the contrary.

50 I understood that if there was any aspect of the design work that Mr Murray considered needed peer review he could and would call on the relevant subject matter expertise within Sunwater to review it. In relation to RCC mix, that relevant Sunwater person was Daryl Brigden who I recall being involved at various stages during the Stage 2 Design, including the substantial mix design program that our team undertook during the Stage 2 period.

51 Document **HYT.510.003.0165** is a copy of an email which I sent to Maurice Rimes on 12 January 2004 regarding the potential formal engagement of Mr Brigden by the Alliance for advice on RCC. In fact, Mr Brigden was never engaged by Hydro Tasmania. He instead remained with Sunwater and I do not recall his involvement during the Stage 3 design and construction, but do recall him coming to site on a couple of occasions. I also cannot recall Mr Murray's role following the completion of Stage 2, but I do recall at least some interaction early in the Stage 3 design process, when the Thiess / URS submission was provided to us.

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52 Burnett Water did not engage an independent review panel as part of the Alliance structure. However independent expert (peer) reviewers did undertake reviews of elements of the design work to ensure that the overall design was acceptable and tested. This was undertaken in the final stages of the Detail Design Phase and the Detailed Design Report (**GHD.002.0001**) was provided to them as the basis for the design undertaken (this was prior to construction) and each independent interviewer was engaged directly by the Alliance, and provided the Alliance with a report. Some of the expert peer reviews included:

(a) Patrick MacGregor who reviewed the geology and geotechnical associated with the foundation;

(b) Mike Fitzpatrick who reviewed the dam;

(c) Eric Leisleighter who reviewed hydraulics associated with the intake / outlet works;

(d) Brian Shannon who reviewed the foundations;

(e) Jack Linard (who was involved in the early RCC design stages) who undertook a review of the overall design including foundation, dam and intake / outlet works); and

(f) John Mapson who reviewed the overall design from an owner/operational and quality perspective.

53 Each reviewer also produced a review report or reports of their findings (refer to the Final Design Report (**ALC.002.001.0950**) which lists the expert peer reviewers, and to Andreas Neumaier's memorandum dated 27 January 2004 titled "Result of Peer Review" (**DNR.010.0929**), Patrick MacGregor Peer Review (**DNR.010.0929** at **DNR.010.0945**), Mike Fitzpatrick Peer Review (**DNR.010.0929** at **DNR.010.0937**), Eric Lesleighter Peer Review (**DNR.010.0929** at **DNR.010.0952**), Jack Linard Peer Review (**DNR.010.0929** at **DNR.010.0958**); Brian Shannon Peer Review (**DNR.010.0918**); and John Mapson Review (**HYT.519.003.0008**). This was in the later stage of the Stage 3 detailed design process. A record of the recommendations of each reviewer and the actions taken in response was provided in the Final Design Report, as a

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record that these had been addressed by the design team.

54 Throughout Stage 2 and the Detail Design Phase, an additional level of design review and acceptance was in place which involved meetings with the dam regulator to present our design plans and key design decisions. One of the purposes of these meetings was to get an indication from the regulator regarding the regulator's acceptance of key decisions, and whether they had any fundamental concerns with our design. Some of these meetings were held at the regulator's office, and some were held at the Alliance office. Peter Allen was the regulator and David Ryan was from the regulator's office. They were who we most regularly dealt with from the regulator. If Mr Allen had a concern about anything it was minuted as an action and followed through as an action that the design team would undertake.

55 By way of example, I refer to the following documents which contains details of one such meeting with the regulator which occurred on 19 February 2004:

(a) **DNR.020.019.2606** (at **DNR.020.019.2606**) is a copy of a memorandum from me to the Alliance dated 16 February 2004 setting out a draft agenda for this meeting;

(b) **DNR.020.019.2606** (at **DNR.020.019.2609**) is a copy of a presentation which I was involved in giving to the regulator at this meeting;

(c) **DNR.020.019.2606** (at **DNR.020.019.2607**) is a copy of minutes from this meeting. I do not recall who prepared the minutes.

Stage 3 Design/Detail Design Phase

56 Once the Alliance moved into what was known as Stage 3 Design (or the '**Detail Design Phase'**), we had to complete the detailed design in order to progress to construction.

57 Stability analysis was undertaken for the various loads, and for various levels within each of the section. These results were summarised in tabular form. I recall in the earlier stage of design that we also provided the 'Sliding Factor', which is the total horizontal force divided by the total vertical force, for these stability summaries. There was never any target criteria for the 'Sliding Factor',

the sliding stability criteria was always based on the 'Shear Friction Factor', which includes both friction and cohesion. However, the reciprocal of the 'Sliding Factor' would give you the factor of safety for a 45 degree friction angle and zero cohesion.

58 At the beginning of the Detail Design Phase, we were given by Burnett Water the Stage 2 proposal submitted by the unsuccessful Thiess / URS consortium. Part of the work we did in the Detail Design Phase included considering any points of difference between our design and the Thiess / URS design to see if there were any further optimisations or issues raised that we incorporated into our design process, with actions to address these. This submission had a number of similarities to our design, including an all RCC construction, the secondary spillway on the right abutment, a 20m long apron, and the apron rising on the left of the primary spillway **DNR.020.019.2555**.

59 One of the comparisons undertaken between the proposals was a comparison of material properties and sliding strengths. The memorandum **DNR.020.019.2555** identifies that we, at that stage, had identified a sliding factor of safety (for 45 degrees friction angle and no cohesion) of 1 for usual loads. While for the usual and extreme loads we required cohesion. It was concluded in this memorandum that our Stage 2 design criteria were still considered to be acceptable, which was based on a Shear Friction Factor, including both friction and cohesion.

60 The Detail Design Phase culminated in a report titled "Burnett River Dam Detail Design Report", which was completed in about July 2004 (**Detail Design Report**) (**GHD.002.0001**).

61 The Detail Design Report was made up of multiple sections with supporting volumes. It was prepared by a number of different authors, each authoring their particular section based on their field of expertise and area of responsibility during the design. This document provides a summary record of the design work that was undertaken. Relevantly:

(a) 'Section 5 – Dam' was prepared by the Dam Design team which I was the leader of, relying upon inputs as needed from subject matter experts in sub-disciplines such as geological, geotechnical, hydrology, hydraulics and RCC mix design and material properties. The dam design presented in section 5 depended upon these inputs. I reviewed and verified the contents of this section in its entirety, adopting these subject matter inputs.

(b) 'Section 6 – RCC Design' was prepared by Dr Ernie Schrader. I reviewed this section to ensure it was consistent with 'Section 5 – Dam' and that it reflected the knowledge that I had of the trial mix program and captured the key inputs provided by Dr Schrader during the design process. All of the RCC mix design development was also reviewed and contributed to by Mr David Brett. I did not personally have any expertise in RCC mix design, materials properties, placement methodology or RCC related specifications, and therefore relied upon Dr Schrader and Mr Brett for their expertise and advice in this regard.

62 The entirety of the Detail Resign Report, consisting of these various sections, was then read, commented on and approved by Andreas Neumaier.

63 The Detail Design Phase also involved the preparation of specific construction specifications, which formed multiple sections of a document collectively titled "Burnett River Dam Specification" (**Specification**). Relevantly, document **DNR.004.4559** (at **DNR.004.4584**) is a copy of 'Section 3 – Surface Excavation and Earthworks', and document **DNR.003.8385** (at **DNR.003.8440**) is a copy of 'Section 11 – RCC Dam Construction' of the Specification.

64 The Specification was prepared progressively throughout the Detailed Design Phase and was finalised in April 2004 (prior to the Detail Design Report) by numerous authors depending on the particular section and the subject matter expertise required to develop that section of the Specification.

65 I was involved in the preparation of multiple sections of the Specification. The entirety of the Specification document was then read, commented on and approved by Andreas Neumaier and reviewed and approved for construction by the Alliance Manager, Mr Mark Hamilton.

66 Document **DNR.010.0889** (at **DNR.010.0899**) is a copy of a table titled "Dam – Derivation of Principal Design Criteria". I was involved in preparing this document. It sets out the functional design requirements set by Burnett Water

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and what the Dam Design Team was doing to meet those requirements.

Dam foundation design in Stage 3

67 A key element of any dam design is its foundations. The foundation design of Paradise Dam was heavily informed by the geological and geotechnical work undertaken by Golder, including Golder's development of a geological model which included the identification of key geological defects e.g. bedding, joints, shear zones, and faults.

68 The development of the foundation design was an iterative process which involved the Dam Design Team and Golder working closely together. An example of this is the development of the dam foundation excavation levels. By the Detail Design Phase, Golder had already prepared an overall geological and geotechnical model based on investigations undertaken by Sunwater and its own additional investigations. Based on the preliminary stability analysis undertaken by the Dam Design Team, the required foundation engineering properties were communicated to Golder, including shear strength, bearing capacity, stiffness etc. Golder then undertook assessments for the various areas of the foundation, including in some cases additional in situ investigations, to determine the depth of foundation where these engineering properties could be achieved. Golder then communicated this back to the Dam Design Team and it formed the basis for the design excavation levels. Golder was required to confirm and sign off on the final adopted foundation levels based on these known engineering properties. If the foundation did not meet these requirements, then excavation would continue until Golder was satisfied. Final sign off was by both Golder (for the geotechnical properties), and the Dam Design Engineer (from a stability point of view).

69 Another example of where the Dam Design Team and Golder worked closely together on the dam design is the process for the retention and stability of the basalt pimple. Again, based on Sunwater's investigations and additional investigations undertaken by Golder, a detailed three dimensional model was developed by Golder of the basalt region. Using this model the design and construction team developed an alignment of the diversion channel to target the area where the alluvial material that was sandwiched between the basalt and the

Goodnight beds was extensive. The Golder model indicated that the alluvial material pinched out under the remaining basalt pimple. However, it was recognised by the Dam Design Team that the stability of the basalt pimple would depend on the presence or not of this alluvial material. As a result, Golders undertook extensive investigations of this contact region and undertook a stability assessment of this basalt pimple. This was presented and reviewed by the Dam Design Team and stability checks were undertaken to confirm these results. Golders also supervised the treatment of the interface between the basalt and the Goodnight beds with extensive grouting and water pressure testing. This is all well documented in an ITP from that time (**DNR.010.2038**).

70 Golder's work investigating the geological conditions of the site and Golder's interpretation of the geological model and geotechnical parameters available or discovered about the geology at the site culminated in its report titled "Geotechnical Design Report – Burnett River Dam, Queensland" dated June 2004 (**Geotechnical Design Report**) (refer to document **GHD.002.0001 at GHD.002.0687** – Appendix C). This document is referenced at various sections of the Detail Design Report, including Section 2 (Geology and Geotechnical Design) and Section 5.6 for the foundation design.

71 Foundation depths in the Detailed Design were dependent on the strength, stiffness and shear strength required by the dam section at various locations (captured as various chainage points in the specification). For example, the requirements of the primary spillway foundations were different from the upper secondary spillway on the right abutment, predominately due to the fact the height of the dam was different in those two locations.

72 In the development of the shear strength parameters for the foundation, strength parameters were considered by Golder for three potential modes of failure: (1) sliding at the interface between the RCC bedding mix and rock surface, (2) failure within the rock mass, and (3) failure through a continuous discontinuity or a small number of discontinuities beneath the foundation level. This was discussed in a memorandum from David Starr to Andreas Neumaier (the Design Manager) (copying me) dated 5 December 2003 (**DNR.005.3464** at **DNR.005.3632-3642**).

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73 The development of the foundation design involved a process where the Dam Design Team communicated the required foundation strength parameters, and Golder communicated back their predicted foundation shear strengths for the proposed excavation depths, which involved different levels of weathering. This process is reflected in the Geotechnical Design Report at Section 3 'Foundation Requirements (from Designers)', and Section 4 'Foundation Material Properties' developed by Golder.

74 To ensure we arrived at a foundation that had the necessary engineering properties, a detailed foundation excavation, clean-off, mapping and approval process was developed by Golder and the Alliance Design Team. This is presented in the Specification (refer to **DNR.004.4559** (at **DNR.004.4584**).

75 This process was independently reviewed by Sunwater's Brian Shannon (**DNR.010.0918**) and accepted.

76 The dam foundation excavation work removed all of the basalt material (including any paleo gravels) from under the foundation of the dam, excavating this material down to the Goodnight beds. The only area of the basalt that was left in place was referred to as the "pimple" and extensive investigations were undertaken to demonstrate that there were no paleo gravels (ie. alluvial material) under the pimple (the initial geological investigation which was presented in a 3D geological model by Golder indicated that the paleo gravels pinched out as they got closer to the river channel). This was reported in the Golder's Geotechnical Design Report (**GHD.002.0001** at **GHD.002.0687** - Appendix C), the corresponding 3-dimensional geological model, and additional investigations undertaken on-site on the interface between the basalt and the Goodnight bed material at the "pimple".

77 The foundation design, including keeping the basalt "pimple" in the dam foundation, was reviewed by Patrick McGregor as an independent reviewer. His comments were incorporated into the final design as indicated in the Alliance's Final Design Report.

78 Grouting of the interface between the basalt "pimple" and the Goodnight beds was also undertaken as part of construction. The full summary in relation to this investigation and grouting of the "pimple" is given in the Design Inspection and

Test Plan for the Basalt "Pimple" prepared by Golder dated August 2005 (**DNR.003.8676**)

79 I do not personally recall Golder identifying the fault zone described in the TRP Report No. 2 (**IGE.051.0001**) on the downstream side of the left-hand side of the primary spillway at the time of Detailed Design. I have reviewed the Preliminary Geotechnical Investigations (**HYT.006.004.0950**), Golder's Geotechnical Design Report (**GHD.002.0001** at **GHD.002.0687** - Appendix C) and the URS Dam Design Report (**DNR.007.1087**) and none of these reports mentioned these faults. I reviewed the independent review by Patrick MacGregor and note that it states: "*Although the valley orientation appears to be controlled by geological structure, no evidence of major faulting in the valley floor has been located*".

80 I am aware that during the foundation excavation process Tim Griggs identified an area that he was concerned about on the far left of the primary spillway which was visibly different (refer to email correspondence with David Starr of Golder, **DNR.013.7263** at **DNR.013.7320**). Treatment of this was determined with guidance from Golder and undertaken as described in the Final Design Report (**ALC.002.001.0950**, at Sections 2.2.1 (**ALC.002.001.0957**) & 2.4.1 (**ALC.002.001.0960**)). Golder gave no indication that any of these features combined to provide a mechanism of concern for either dam stability or erosion downstream of the apron.

81 Based on my observations and knowledge, the excavation for, and construction of, the foundations was undertaken in accordance with the Detail Design and Specification.

82 As an added level of foundations quality review on-site, Brian Shannon was brought in for the Construction Phase to review the foundation level, preparation and sign-off process prior to RCC placement. As part of this review, he undertook a site inspection of the foundations and made some recommendations which were incorporated into the final process (refer to **HYT.519.003.0021**).

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83 This final process was followed, including hold points and sign-off by both Golder representatives on site and Tim Griggs, who was the full time design presence on site at the time. This included geological mapping of the entire foundation excavation prior to RCC placement, and localised treatment of any defects and reshaping of the excavated surface to avoid stress concentrations, under Golder's guidance.

84 Bedding mix was also applied to the entire foundation surface prior to the placement of the first RCC layer, to ensure a good bond between the foundation rock and the RCC.

Erosion protection

85 Design decisions relating to the dissipater apron and erosion protection were reliant upon key inputs and assessments from both the hydraulic lead, Mr Mike Wallis, and the geotechnical engineers, Golder.

86 Mr Wallis was responsible for all of the hydraulic modelling and hydraulic analysis associated with the spillway and dissipater aprons. Information associated with depths, velocities, and pressures from this modelling, and assessments were communicated to the Dam Design Team and to other design leads.

87 Golder was responsible for developing the geological and geotechnical model for the dam foundation, including the downstream zone. Their work included identification of key defects within the foundation rock (e.g. bedding, faults, joints) based on both investigation work, mapping of exposures and ongoing mapping of the dam foundation excavation footprint. Using this geological data, Golder undertook erosion assessments of the various foundation regions downstream of the dam using the Annandale Method. This work was communicated to the Dam Design Team who modified design details based on recommendations by Golder.

88 Section 8 of Golder's Geotechnical Design Report highlights the design features developed between Golder and the Dam Design Team to ensure the progression of any erosion did not undermine the toe of dam.

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Downstream of the primary spillway

89 For the primary spillway, Golder noted that it is founded in slightly weathered to fresh Goodnight beds and that these materials, although relatively closely jointed, are generally of high strength and erosion resistant) (refer to **GHD.002.0001** at **GHD.002.0687** - Appendix C). At no time during either the design or construction period did any Golder representative inform me, or to my knowledge any member of the Design Team, that there was any combination of defects that could lead to an unfavourable erosion or stability mechanism in this area.

90 The Preliminary Design of the dam by SunWater specified a width of the primary spillway apron of 20m, and this was based on typical hydraulic calculations and design charts based on precedent, as is revealed in Sunwater's Preliminary Design Report.

91 As I understand it, one input into the hydraulic design of any energy dissipater apron is the expected tailwater levels.

92 A tailwater rating was provided in Sunwater's Preliminary Design Report to the Alliance design team. As part of our review of the unsuccessful URS team's design it was noted that the URS had adopted a higher tailwater rating curve in its design than the tailwater rating curve supplied by Sunwater. The Alliance design team undertook a review of the Sunwater tailwater rating curve based on the available river gauging data for the area and river channel hydraulic modelling using available survey data to seek to verify it. This check indicated a very similar rating curve to the Sunwater rating curve. This is documented in section 4 of the Design Report (**GHD.002.0001 at GHD.002.0055**).

93 I recall that SunWater commenced the construction of the 3-dimensional physical hydraulic model in their Rocklea laboratory during Stage 2 (the competitive phase, when there were only 2 teams remaining).

94 The topography of the river channel, which was a major part of the model construction, could be constructed independent of any one design which permitted this model construction to commence before the project was awarded to a bidder. The decision to build the 3-dimensional model to a 1:100 scale was

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made by Sunwater.

95 The Alliance Design Team undertook physical hydraulic modelling of both the spillway and the outlet works.

96 Michael Wallis, the Hydraulic Lead from the Alliance supervised the hydraulic model study which was undertaken at the Sunwater laboratory at Rocklea.

97 Two physical models were constructed by SunWater associated with the spillway dissipater apron. One was a 1 to 100 scale three-dimensional model and the other a 1 to 75 scale two-dimensional model.

98 Based on this modelling work, I recall that that Mr Wallis concluded that the 20m apron width proposed in SunWater's preliminary design was satisfactory from a hydraulic performance perspective. This length of apron, along with a 1m end wall, was demonstrated by the hydraulic modelling to contain the hydraulic jump within the apron area, for all modelled flood events. The hydraulic Model Study Report for Dam, Outlet Works and Fishway, authored by Mr Wallis, is documented at Appendix D of the Detail Design Report (**GHD.002.0001** at **GHD.002.0553**).

99 The URS design also adopted this 20m wide apron, although they also indicated that they would need to check this through a physical hydraulic model. The URS design also had the apron level rising on the left side of the primary spillway.

100 Golder considered erosion downstream of the apron but did not believe further protection was necessary beyond the 20m apron as is highlighted in section 8.3 of the Golder's Geotechnical Design Report (**GHD.002.0001** at **GHD.002.0761**).

101 Finally, in the Peer Review of Foundation Adequacy by Brian Shannon from SunWater (**DNR.010.0918**), Mr Shannon concluded at Section 6 that: "*No doubt some erosion of the rock downstream of the dissipator apron will occur initially with little consequence*".

102 Based on the above, I had no cause to consider any further need for additional erosion protection downstream of the primary spillway.

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Downstream of the secondary spillway

103 There was no secondary spillway in SunWater's Preliminary Design. However, this was proposed both by the Alliance, and by the unsuccessful URS bid, as an improvement to Sunwater's Preliminary Design.

104 The Alliance proposed to protect the toe of the secondary spillway with a concrete apron, while our review of the URS design after we were awarded the project identified that URS had proposed to protect the downstream toe of the secondary apron with riprap (large rock boulders), rather than the use of any dissipator apron.

105 The Alliance conducted an analysis of URS' proposed riprap protection method and concluded that it was insufficient and believed that a more positive form of protection in the form of an apron was a better alternative (refer to **DNR.020.019.2555**).

106 Document **DNR.020.019.2052** is a copy of an email from Mr Wallis to me attaching a memorandum dated 10 December 2003 containing his assessment of the dissipator apron width for the secondary spillway.

107 The width of the secondary spillway apron was then considered in the physical hydraulic model study. Widths from 10m to 20m were considered in that physical model. However, it was concluded from that study by Mr Wallis that there was no hydraulic benefit in using an apron any wider than 10m for that part of the spillway.

108 Golder assessed that there would be some erosion downstream of the secondary spillway should it ever operate (refer Section 8.2 Golders Geotechnical Design Report (**DNR.006.3286**)). However, Golder concluded that the secondary spillway would not operate until a relatively large flood. Therefore some erosion was considered tolerable as long as the apron was not undermined.

109 In addition to this, Brian Shannon from SunWater stated in Section 6 of his report titled 'Peer Review of Foundation Adequacy' (**DNR.010.0918**) that: "*While significant erosion, in moderately weathered rock downstream, could be*

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tolerated for such rare events, some defence under the sill (grout anchors) could be justified in order to protect the dam toe".

110 On 19 February 2004, Mr Brett Collins of Golder issued a memorandum to Andreas Neumeier and myself regarding his assessment of erosion potential downstream of the apron and spillways (**DNR.020.019.316**). In that document he noted the risk of erosion existed immediately downstream of the secondary spillway under certain flow conditions and concluded that: "*A possible solution includes construction of a cut-off wall down to medium strength rock (using cobble/boulder size rock fragments wrapped in geotextile)*".

111 Following receipt of Mr Collins' memorandum, Andreas Neumeier discussed this with me, and we agreed that, to avoid undermining of the apron beneath the secondary spillway, the apron end wall would be excavated down to act as a concrete cut-off, as an improvement on the solution proposed by Mr Brett Collins of Golder (refer to **DNR.020.019.3164**). In addition to this, anchors were to be installed in the apron. These changes are reflected in the final design drawings.

112 Document **DNR.004.7778** (at **DNR.004.7943**) is a copy of a memorandum from myself to Tim Griggs dated 3 July 2004 titled "Secondary Spillway Apron between Ch 635 – 680" which shows modifications I suggested to the design detail of the secondary spillway apron to match the topography and construction conditions. This was incorporated into the design drawings by the Design Team.

113 In his report titled 'Peer Review of Foundation Adequacy' Brian Shannon from Sunwater (**DNR.010.0918**) stated "*I witnessed the provision of the cut-off wall beneath the sill terminating the apron. In addition, anchor bars into the rock were being provided. Both measures are a welcome provision.*"

114 Based on the above I had no cause to consider any further need for additional erosion protection downstream of the secondary spillway.

<u>Further decisions in relation to the spillway aprons</u>

115 The primary and secondary spillway aprons were initially designed by the Dam Design Team to be constructed from reinforced conventional concrete. As discussed above, the key decision to use reinforced RCC was made in Stage 2.

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116 Throughout the tender phase and detailed design phases of the project value engineering workshops called 'breakthrough workshops' were routinely held. These workshops were facilitated by, I believe, SRD or Evans and Peck who were engaged by the Project Alliance Board as Alliance Coaches. During these workshops the objective was to find both cost and schedule savings for the project without compromising the functional requirements for the dam through a brainstorming process involving Burnett Water, the contractor and the designer. A record of these meetings was always prepared by the Alliance Coaches and this was distributed to the team.

117 One of these workshops was one held on 29 and 30 October 2003 at which there were at least two declarations (or sometimes referred to as stretch targets) made. One of the declarations made was to seek to reduce the use of conventional concrete across the project by 30% in an attempt to reduce cost or improve construction as the project was generally geared up for RCC, with an initial list of possible target areas identified. The other was to reduce the minimum thickness of the RCC dissipator aprons from 900mm to 600mm.

118 Following this breakthrough workshop, the Design Manager allocated the identified areas to individual work teams. The design work team considered a number of these items including crest concrete, face concrete and dissipator slab concrete with a view to determining whether a reduction of conventional concrete in those areas was possible (refer **DNR.020.019.2656**). The same process was used for the proposed reduction in minimum thickness of the RCC dissipator aprons (refer **DNR.020.019.1888**).

119 At some time prior to this breakthrough workshop, on a date I cannot now recall, I believe another breakthrough workshop was held and the declaration from that workshop was to investigate the possibility of changing the materials used for the dissipator aprons beneath the primary and secondary spillways from reinforced conventional concrete to reinforced RCC with a higher cement content than the rest of the lean RCC mix used at the dam.

120 I recall Dr Schrader was either present at this particular breakthrough meeting or was consulted by me shortly afterwards to determine whether the dissipator aprons could in fact in his expert opinion be constructed from reinforced RCC,

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and whether he was aware of any precedent for doing so. Dr Schrader advised me that it could be done. I asked Dr Schrader to provide justification for this conclusion and some examples of where this had been used elsewhere.

121 In response to my request for justification and past precedent, Dr Schrader provided me with a paper titled 'Roller Compacted Concrete – Cavitation and Erosion Resistance' which provided examples and discussed several designs which relied on the demonstrated resistance of RCC to erosion. The key conclusion of this paper was *"laboratory studies, full scale tests and field experience have all shown that, even at relatively low strength and cementitious contents, RCC has exceptional resistance to cavitation, erosion and abrasion damage to high and low velocity water flows. This applies to both rough and smoothed surfaces."* (refer **GHD.002.0001** at **GHD.002.0186** – Section 5.7.6).

122 In addition to this paper, Dr Schrader provided me with a photograph of one of these past precedent examples where a high flow and major debris had passed over the reinforced RCC in use at that project and was shown to have sustained this with minimal evidence of damage to the surface (even with this extensive debris).

123 American Society for Testing and Material (ASTM) also had developed procedures for evaluating the resistance of concrete to wear and abrasion by debris and water over concrete surfaces, namely test method C1138. Dr Schrader provided me with results of tests using this method comparing the erosion resistance of cement stabilised sand, RCC and conventional concrete. A summary of these results can be seen at Figure 5.29 of Section 5 of the Design Report (**GHD 002.0001** at **GHD.002.0187**). These results indicated that RCC provided the best performance for erosion resistance compared to conventional concrete.

124 Based on the above, I was satisfied that the change could be implemented, and I had no reason to doubt the accuracy of Dr Schrader's expert input in this regard.

<u>RCC mix design</u>

125 The use of RCC was always contemplated for Paradise Dam – both in the Preliminary Design Stage (by Sunwater), and through Stages 1 and 2 (by all

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bidders) and in our successful bid.

126 The RCC Design was developed over a period of about a year, following rigorous testing, analysis and discussions.

127 Our consortium had strong concrete gravity dam experience. However, as discussed above, we recognised from the outset that our consortium had not designed a concrete gravity dam using RCC as the primary construction material before. At that time, there had in fact only been a handful of RCC dams constructed in Australia, most of which had been constructed considerably earlier than Paradise Dam.

128 We therefore sought and engaged RCC expert consultants from the beginning, who were relied upon to develop the design and provide all RCC inputs into the dam design and construction. As Dam Design Lead, I relied on the expertise of these specialist RCC experts. As discussed above, those experts were primarily, Dr Ernie Schrader (who was recognised as a world-leading RCC expert) and David Brett (who had local Australian RCC experience), both of whom were involved through the Detail Design Phase and completed various reports and analyses of various aspects of RCC. This included the trial mix design through laboratory testing, decisions around the development of RCC mix design, preparation of the RCC specifications, and the requirements of the trial embankment process.

129 The dominant RCC related design inputs ultimately came from Dr Schrader who wrote the two RCC sections of the Specification (being Section 11 and Section 12, discussed further below) and the RCC section of the Detail Design Report (being Section 6, discussed above).

130 The core features and decisions relating to the design that was associated with the RCC was decided upon with in consultation with and agreement of David Brett. Jack Linard was also involved in the early part of the design process and was then used as a peer reviewer for the overall design of the dam.

131 I recall that the RCC mix design when developed was presented to Sunwater's technical expert, Mr David Murry, and Sunwater's RCC mix design expert Mr Daryl Brigden, during the Stage 2 design process. The dam regulator was also

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presented with all key decisions in relation to the RCC mix and I do not recall any objections being raised about any aspect of the RCC mix or design during the Stage 2 phase.

132 The RCC mix design decided upon was what is described as a low cement (or lean) mix.

133 From the outset of their involvement in the project, I believe the direction of the RCC mix proposed by Dr Schrader and Mr Brett was a lean RCC mix.

134 The remaining issues to be decided were the need or otherwise of impermeable lift joints, which was really a question of whether an upstream membrane was to be adopted or not, and therefore how lean the mix could be.

135 The option of adopting a Carpi membrane on the upstream face to achieve permeability was a suggestion made by Dr Schrader based on his experience on previous case studies, which were presented to us. This same presentation also highlighted things like the advantages of using conveyers over trucks for the placement of RCC.

136 The decision on whether to use an upstream membrane was seen to be a key decision for the Alliance in Stage 2 and had fundamental implications on the direction of the design (e.g., mix design properties, uplift pressures within the lift joint, the placement of pre-cast concrete panels on the upstream face). All of these key decisions were made together as an Alliance, including design, construction and Burnett Water, including their technical advisors from Sunwater.

137 Given the importance of this decision for the design, construction methodology, and final bid price, it was decided in Stage 2 to test the acceptance of the upstream membrane. I recall this being a presentation to Sunwater's technical expert, Mr David Murray, and I recall that a number of Sunwater experts that Mr Murray would often use were present at this meeting, as was often the case in Stage 2 (refer to **HYT.502.006.0003**). I recall that this was also presented to the regulator (which is confirmed in the Detail Design Report, at section 5.3.2), along with other key decisions such as the elimination of the drainage gallery.

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138 The option of using a membrane and whether it should be external or internal was explored. I do not recall any objections by any Sunwater expert to the upstream membrane per se – but there was a preference by Sunwater experts and Mr Murray for an internal membrane, due to the potential risk of vandalism and associated maintenance issues with an exposed external membrane.

139 Following the feedback received, the Alliance made a decision to proceed with the option of an upstream membrane behind precast concrete panels (this was referred to as the 'Winchester Method', a method that had been used in previous projects). This decision eliminated the need to seek to achieve a higher paste mix which would provide low permeability RCC lift joints. This allowed the RCC mix design to focus on the achievement of the necessary strength requirements without simultaneously trying to achieve low permeability lift joints.

140 The design also incorporated a drainage system immediately behind the membrane (consisting of geofabric, horizontal strip drains, and vertical collector drains) to deal with any risk of seepage through any part of the membrane.

141 We also included against the upstream face of each lift joint a design requirement for a minimum of 600mm of bedding mix as an added layer of seepage protection.

142 Dr Schrader and Mr Brett undertook testing in Brisbane of the RCC mix options with a range of cement content, moisture content, varying levels of fly ash and impact of the goodnight bed material within the aggregate. This process commenced early in the Stage 2 design phase through until the later stage of detailed design phase (Stage 3), where actual on-site crushed aggregate was used in the testing to gauge how the site based materials would perform.

143 The mix design testing undertaken by Dr Schrader and Mr Brett was used to make a number of important decisions in relation to the RCC mix. This included the cement content, whether or not to include fly ash in our mix, and the identity of the cement supplier to be used by the Alliance.

144 Cements from various suppliers were tested, including blended cements. A decision was made by the Alliance not to use a blended cement following recommendations by Dr Schrader (refer to **DNR.020.019.1037**

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(at **DNR.020.019.1043**), which is a copy of a memorandum from David Brett to me dated 28 January 2004 providing review and comment on Dr Schrader's memorandum dated 21 January 2004 regarding RCC mixes referred to above). Mr Brett provided some analysis but ultimately concluded that 'good RCC meeting the design requirements' could be produced with the RCC mix proposed by Dr Schrader.

145 The testing also showed that the necessary compressive strengths, based on the stresses assessed by the Design Team within the Dam section, could be achieved with cement contents in the range of 60-65kg/m^3 These results were presented in progress reports which were often authored by David Brett and reviewed by Dr Schrader, and I was provided copies of these as the work progressed.

146 These reports/documents included the following:

(a) **DNR.010.0323**, which is a copy of a report titled "Progress Report on RCC Testing" dated 14 October 2003 prepared by David Brett, which he provided to me. This is an example of a series of reports prepared in relation to RCC.

(b) **DNR.010.0367**, which is a copy of a report titled "Report on Selection of Cementitious Material for RCC Testing" dated 4 November 2003 prepared by David Brett, which he provided to me. This is another example of a series of reports prepared in relation to RCC.

(c) **DNR.010.0317,** which is a copy of an email from David Brett to me (copying others) dated 12 November 2003 attaching a report titled "2nd Report on Selection of Cementitious Material for RCC" dated 12 November 2003 prepared by David Brett.

147 This testing also showed that adding fly ash to the mix provided no strength benefit. Dr Schrader and Mr Brett concluded that this was due to pozzolanic material in the basalt crusher dust. A comparison to the strength performance of our RCC mix with that of the unsuccessful URS bid test data also reinforced the conclusion that the inclusion of fly ash added no strength benefit. As a result, the Alliance made a decision not to use fly ash in the mix (refer to

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HYT.509.004.0105 which is a copy of a memorandum from Dr Schrader to Steve Johnson and me dated 25 January 2004 regarding analysis of the Thiess / URS RCC mixes).

148 In early 2004, Dr Schrader assumed primary responsibility for RCC within the project as the lead RCC consultant and Mr Brett took a secondary role. Notwithstanding this, I continued to consult Mr Brett on RCC issues and decisions to give myself further comfort about our RCC mix design and add a further layer of review. This continued until the commencement of RCC placement on site.

149 The final RCC mix adopted by the Alliance used standard cement (that is, cement that was not blended), had at least 60kg/ m^3 of cement (the final amount adopted at the mixer on site was 63 kg/m^3, to provide some tolerance) and had no fly ash. Based on both the RCC strength and shear strength parameters provided to the Design Team by Dr Schrader for this final mix **SUN.010.002.0356**, the Design Team was satisfied that this mix would meet the design requirements in relation to dam stability **ALC.002.001.0950**.

<u>Dam stability analysis</u>

150 The stability analysis of the various monolith blocks forming the dam structure is important for the design of any concrete gravity dam. It involves assessing the stability of the dam design under various different load conditions to theoretically verify that the dam will safely withstand those load conditions.

151 The design criteria adopted for Paradise Dam is documented in the Detail Design Report.

152 The stability analysis for Paradise Dam was undertaken by Tim Griggs and reviewed by me (refer to **DNR.020.015.1040** for a copy of the stability analysis results).

153 The applicable ANCOLD guideline at the time of the design of Paradise Dam was the 1991 Guideline. This ANCOLD guideline, and other international guidelines including USBR (1977) and US Army Corp of Engineers (1995) were used in carrying out the stability analysis as indicated in the Detail Design

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Report.

154 An important input into Mr Griggs' stability analysis was the probable RCC shear strength values of friction angle (or tan ϕ) and cohesion for each lift joint. Dr Schrader provided these inputs to me and Mr Griggs. He indicated his best estimate of the shear strengths and the percentage reductions to apply to these shear strengths for various ages and quality of lift joints.

155 I understood from Dr Schrader that he had developed a large database of shear strength parameters over the course of his more than 30 years' experience with RCC in previous projects internationally, including the shear strength testing of RCC.

156 I recall that Dr Schrader used a large spreadsheet which correlated previous data, large scale test data, against comparable RCC mix parameters. It was my understanding that he used this spreadsheet to define expected shear strength values for our particular mix design from correlations with previous project test data using comparable mix designs, and then applied a reduction factor to arrive at his recommended probable shear strength assumptions for friction and cohesion to be used in our design and sensitivity analysis.

157 I did not know of (and do not now know of) any authoritative material that I could have consulted at the time to independently arrive at or verify these inputs.

158 It was also not practically possible to verify the inputs from physical in-situ shear strength testing because to do so would involve waiting about one year for the RCC to reach maximum shear strength. The project would have largely been constructed by then.

159 Accordingly, I considered it reasonable, necessary and appropriate to rely upon Dr Shrader's expertise and the shear strength design inputs he specified for the RCC mix design in different lift joint quality conditions.

160 The following document show the exchange of information between myself and Dr Schrader around the design of the RCC mix and shear strength parameter inputs into the design of the dam. This was an iterative process as the mix design was finalised, and therefore there was a number of versions leading to

the final one:

(a) **DNR.020.019.2507,** which is copy of an email from me to Dr Schrader (copying others) dated 12 November 2003 attaching a memorandum summarising the design parameters depending on the quality of RCC lift joints (based on information Mr Schrader had given us) and seeking Mr Schrader's input.

(b) **DNR.020.019.2507** (at **DNR.020.019.2509**), which is a copy of an email from Dr Schrader to me (copying Steve Johnson) dated 13 November 2003, which was in response to my email about the design parameters for RCC lift joints referred to above. In that email I note that Mr Schrader states "cohesion is not even needed for much of our dam, or we only need a little". To be clear, I did not understand Mr Schrader's comment to mean that this Dam did not require cohesion at all, but rather that given the stability analysis that had been undertaken (including sensitivity to different lift joint quality), cohesion did not seem to be as important to this particular dam as some other dams with which Mr Schrader had been involved.

(c) **DNR.011.1361**, which is a copy of a memorandum from Dr Schrader to Steve Johnson and me dated 18 January 2004 regarding analysis of material properties for various RCC mixes and thermal stresses.

161 Following receipt of Dr Schrader's email of 13 November 2003, I received from Dr Schrader a number of further iterations of the shear strength parameters culminating in the parameters which were included as table 6.3 of the Detailed Design Report **GHD.002.0001** (at **GHD.002.0229** to **GHD.002.0231**).

162 The final properties provided by Dr Ernie Schrader and the stability results summary that Tim Griggs provided Dr Ernie Schrader is captured in an email from Tim Griggs that was copied to me dated the 7 June 2004 (insert document number).

Final RCC mix verification

163 In about May 2004, after having undertaken trial mix testing throughout Stage 2

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and the Detail Design Phase for the RCC mix design, the Alliance undertook a verification mix program on-site to confirm the adopted RCC mix was acceptable using the actual RCC aggregate crushed on site from rock obtained from the excavation of the diversion channel, which was located in the basalt. It was necessary to do this before any placement of RCC could commence.

164 This verification trial mix program was held off until Jose Lopez, the RCC Quality Engineer, arrived. This decision is documented in the following documents:

(a) **DNR.011.1436** which is a copy of a memorandum from Dr Schrader to Steve Johnson, Jose Lopez and me dated 30 March 2004 regarding the handling of RCC aggregate and mix verification tests on-site to confirm the adopted mix. It refers to waiting for Mr Lopez as the RCC engineer to arrive on-site before conducting these RCC tests under his supervision.

(b) **DNR.020.019.1005** (at **DNR.020.019.1017**) which is a copy of an email chain between Dr Schrader and I (copying others) dated between 1 and 6 April 2004 regarding the RCC verification tests and waiting for Jose Lopez to be on-site.

(c) **DNR.007.2295** (at **DNR.007.2360**) which is a copy of an email from me to Mike Marley (Golder) (copying others) dated 6 April 2004 attaching a memorandum from Dr Schrader to Steve Johnson and I dated 10 March 2004 regarding the RCC mix verification.

165 These final RCC mix verification tests were supervised by Mr Lopez and my recollection is that no further changes were required to the RCC mix design as a result of using the on-site RCC aggregate from the actual stockpile.

RCC trial embankment

166 In order to test our placement methods and equipment prior to commencing full Construction, the Alliance undertook a trial embankment (also referred to as the 'test section') in about June 2004. The trial embankment was at the extreme end of the right abutment in order to be located in an area away from key flow areas and not substantially important to stability. This was to allow testing of different conditions, placement and treatment methods to show that the lift joints were adequate with a range of variables and to refine the process before

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commencing on the main primary spillway. It also tested the full construction methodology, including all of the elements required for the placement of RCC, preparation of lift joints, and installation of precast panels – as well as a practice, training, and orientation area for the construction personnel in the placement methods that would be used on the project.

167 A trial embankment is a necessary step for any RCC dam. The content and requirements of the trial were specified by the RCC experts, David Brett and Dr Schrader.

168 Section 11.19.1 of the Specification describes the intent of this trial section (refer **DNR.020.016.5720** which is a copy of a report titled "Proposal for RCC Trial Embankment" dated 25 November 2003 prepared by David Brett, which he provided to me).

169 The trial embankment works were closely supervised by the RCC quality engineers, Jose Lopez and Roberto Montalvo. Lessons were learnt from the trial embankment and these are documented in memorandums prepared by the RCC quality engineers in order to challenge, coach, continuously improve and upskill the workforce on the nuances and the exacting standards that Jose Lopez and Roberto Montalvo expected for the quality placement of RCC mix on the project (refer **SUN.009.002.0147**).

170 My recollection is that there was a workshop following the trial embankment which was specifically designed to capture the lessons learnt. I believe that the outcome of this workshop were documented in workshop minutes (which was typical practice for such processes within the Alliance). These minutes have not been able to be located. However, the following documents records the outcome of this workshop:

(a) **SUN.009.002.0147** (at **SUN.009.002.0147**); and

(b) **SUN.009.002.0147** (at **SUN.009.002.0155**).

These memorandums (any other memorandums associated with the trial embankment which highlight quality issues such as localised areas of segregation, poor compaction, inadequate clean-up or curing), need to be read

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in the context of the purpose of the trial embankment which was to improve construction practices. I would be concerned if such memorandums were not present, as this would demonstrate that no learnings had been taken forward from the trial embankment. In my view, the presence of these memorandums indicated good quality control and assurance.

171 As part of the trial embankment, the left end of the embankment at the first monolith joint was cut back with an excavator to expose lift joint so that they could be visually inspected by the Dr Schrader following high pressure water blasting of the surface. I recall that Dr Schrader's conclusions from this inspection were that the lift joints were generally bonded and the few joints that showed de-bonding were not continuous for the entire lift surface. This gave the Design Team confidence that the specification requirements for the lift joints were appropriate.

RCC Dam Construction Specifications

172 The Specification consisted of a number of sections, covering all of the construction elements of the project and provided the conditions to meet the design, including the quality control requirements.

173 Section 11 of the Specification (**DNR.003.8385**) was prepared on 22 April 2004 by Dr Schrader, reviewed by me and approved by Andreas Neumaier, Steve Johnson and Mark Hamilton. It sets out detail for the RCC Dam Construction including the RCC mix, program, construction methodology, equipment, placement, treatment, quality and design.

174 Section 11 of the Specification (**DNR.003.8385**), in particular Section 11.10, sets out the requirements for keeping the surface of the RCC lift joints clean.

175 In any concrete dam the quality of construction lift joints is important for achieving the design requirements. Given that an RCC dam has many lift joints, and the placement of RCC is continuous, controlling the quality of lift joints is important. Dr Schrader, specified a Lift Joint Quality Index (**LJQI**) to be followed to monitor and ensure adequate quality control of lift joints. Dr Schrader incorporated this index into the Specification for Paradise Dam and this was adopted as the main quality control measure for lift joint quality.

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Use of bedding mix

176 Bedding mix was used during RCC placement for different reasons. The first was that every RCC lift had a specified minimum amount of bedding mix placed at the very upstream face as shown in the construction drawings. This was to ensure that there was very low permeability of the RCC in the immediate zone behind the membrane. Although this is shown as 0.6m on the drawing, I believe in practice it was significantly more than this.

177 In addition, on every lift surface bedding mix was placed from upstream to downstream for a width of 0.6 metres on either side where the lift meets the foundation rock. The purpose of that bedding mix was to avoid ingress of groundwater from the foundation into the lift surface (refer to **DNR.013.7361** (at **DNR.013.7362**) which is a copy of an email chain between Tim Griggs and I dated between 15 and 22 December 2004 regarding the bedding mix location and width adjacent to the foundation).

178 Dr Schrader included, at Section 11.10.3 of Specification 11, the use of bedding mix to treat cold joints, and the use of bedding mix to improve the LJQI for any individual lift joint. If the LJQI assessment of the lift joint was that it was a poor-quality lift joint, then remedial action was taken to improve it.

179 That remedial action involved placing bedding mix on the upstream side of the lift surface to increase the shear strength of the lift joint (through added cohesion) and allow placement of the next RCC lift. Generally speaking, the poorer the quality of the lift joint, the more bedding mix that was used.

180 **SUN.010.002.0027** is a copy of a memorandum from Dr Schrader to a group of project staff dated 2 August 2004. I cannot specifically recall this memorandum and I do not recall this change ever being implemented. Any change such as the one being recommended by Dr Schrader in this memorandum would have required my authority to implement it and a documented formal change to the Specification by revision to the Specification or formal minutes approving the change and I do not recall that occurring.

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Construction Phase

181 Early construction commenced in late 2003, which included the construction of the camp and access roads, and began to progress further in 2004 with the excavation of the diversion channel. There was some preparatory work to be done on-site before full construction could begin, such as the RCC mix verification and the trial embankment (discussed above). Construction of the RCC dam ran from about July 2004 to August 2005 (refer to Figure 6 of the August & September 2005 Quality Control Report).

182 Some of the key personnel during the Construction Phase included:

(a) Mark Hamilton as the Alliance Project Manager.

(b) Steve Johnson (initially) and Bruce Embery (subsequently and for the majority of the Construction Phase) as Construction Manager.

(c) I took on a role as design co-ordinator to ensure that the design intent was met during the Construction Phase. To assist me in doing so, Tim Griggs was our on-site design presence (discussed further below).

(d) Rob Frazer had various responsibilities and I recall that a key part of his role was Construction quality manager.

(e) Jose Lopez and Robert Montalvo as RCC quality engineers. I discuss their involvement below. I believe they reported to Rob Frazer.

(f) Matt Landers as RCC Area Manager. I recall he left the project part way thorough, and there was some restructuring around the RCC Area Manager role.

(g) Dr Schrader took on more of an RCC consultant role during the Construction Phase. He continued to provide expert advice on RCC and attended site on a regular basis to monitor placement quality and guide improvements where necessary.

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Construction quality control and assurance

183 **DNR.003.8385** (at **DNR.003.8497**) is a copy of Section 12 of the Specification. It was prepared on 27 April 2004 by Dr Schrader, reviewed by me and approved by Andreas Neumaier, Steve Johnson and Mark Hamilton. This document sets out a system for Quality Control (**QC**) and Quality Assurance (**QA**) of RCC (and also pre-cast panel concrete and conventional concrete) during the construction phase, including roles and responsibilities and testing.

184 Golder were subcontracted to undertake the various insitu and laboratory testing associated with the quality assurance process. This included sampling the RCC and making cylinders, checking density with nuclear gauge and monitoring the results with aggregate tests and so on (see section 12.3 of the Specifications).

185 In addition to this, the various batching facilities supplied and operate by Wagner had monitoring gauges as recommended by Dr Schrader in order to monitor overall quantities of inputs to the RCC mix. This was to have continuous real-time data on the RCC mix being batched by Wagner.

186 As illustrated by Section 12 of the Specification, a key element of RCC placement was QA and QC. My recollection is that the Alliance tried to source a number of RCC quality engineers locally as part of the procurement process for quality control laboratory services but that no adequately qualified and experienced people were able to be sourced due to the lack of recent RCC projects in Australia.

187 My recollection is that the Alliance's RCC experts were asked if they knew of anyone available and suitable for this role. Dr Schrader recommended a number of potential candidates for the RCC quality engineer role. As a result of this process, Jose Lopez and Robert Montalvo were put forward for the RCC quality engineer role in order to cover both day and night shifts continuously. They had undertaken similar roles on other RCC dam projects internationally. Based on their experience and the fact that they had been recommended by Dr Schrader as excellent candidates, the key Alliance members, including myself, considered that they were appropriate for this role.

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188 Jose Lopez and Robert Montalvo oversaw RCC placement for the entirety of the Construction Phase from a quality perspective. Construction generally involved day and night shifts, so one would always be present for the RCC placement. Part of their role included helping to train the people that were going to be working on the RCC lift surface in terms of cleaning, placement techniques and processes and coaching for continuous improvement.

189 For every RCC lift, Mr Lopez and/or Mr Montalvo would sign off on key hold points in the Placement of RCC Checklist (see **SUN.113.005.0202** below), which involved inspecting and assessing the lift using the LJQI, which would then generate a numerical score for the lift.

190 The score produced a rating ranging from Excellent, to Good, to Fair, to Poor, to Very Bad. To be an acceptable lift it needed to achieve a score as stated in Section 11.10 of the Specification. The LJQI considered characteristics such as surface segregation, rain, curing, maturity, surface tightness and condition, surface flatness and delivery method.

191 Any non-conformances or issues would be identified, and actions were taken to close out these non-conformances. I recall that if identified non-conformances had design implications then the design team became involved by a formal NCR process (refer to **SUN.021.001.6730** for an example of an NCR process). Otherwise my understanding was that the issues would be addressed immediately on-site by Jose Lopez or Robert Montalvo directing the contractor to remedy any issue (for example, by directing the removal and replacement of any unacceptable RCC placed or the placement of bedding mix to repair any surface segregation identified). This immediate feedback and response to any identified issues by the RCC Engineers was important and appropriate given the continuous nature of RCC placement.

192 Jose Lopez and Robert Montalvo compiled individual Design Inspection Test Plans for the RCC (**RCC ITPs**) and produced monthly quality control reports. The reports were detailed and comprehensive. In particular, they verified that lifts had been laid appropriately, assessed their quality, indicated whether there was a cold joint, determined if any remedial action was necessary, and provided a batch supply record which would identify the volume of bedding mix that was

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placed at that particular location (elevation and chainage as shown on the RCC ITP). The final quality control report which summarises all of the RCC quality records for the dam is the August & September 2005 Quality Control Report (**ALC.002.001.0750**).

193 Based on this quality assurance and control system, as well as my own visual confirmation of the system being implemented on site during my regular site visits, I was satisfied that the construction was performed in accordance with design intent.

194 One matter that appears relevant to observe is the volume of bedding mix placed in the dam. As per the Specification, RCC lifts were 310mm, and the bedding mix thickness was 25mm, therefore if the entire lift surface was covered in bedding mix, it would correspond to approximately 8%. I note that Section 8.2 (Table 29) of the final Quality Control Report for August and September 2005 (**ALC.002.001.0750**) records a total of 8,526 cubic metres of bedding mix was placed. This corresponds to an average bedding mix/ RCC volume ratio equal to 2.14%. Excluding the areas of higher bedding mix placement (e.g., foundations and upper portion of the dam), the minimum bedding mix ratio was around 1.6% in the rest of the dam. Based on my calculations, 1.6% would correspond to an average of about 20% of the RCC lift surfaces of the Dam being covered in bedding mix. It is important when assessing the shear strength of the dam as constructed to take into consideration the very significant additional cohesion such amount of bedding mix will provide to the lift joints as the use of bedding mix to improve cohesion is part of the design requirements to ensure the required shear strength, and is captured by the Specification.

195 I recall that as part of the process for the Paradise Dam asset being transferred to SunWater, a Due Diligence Process occurred involving various SunWater people and Mr Brian Forbes. There appears to be a number of records of this process (**SUN.016.014.1266** and **SUN.020.003.6637**). The second reference relates to going to site and the second refers to a Due Diligence Workshop that occurred at site. Although this record does not mention it, I recall that Mr Brian Forbes was part of this team. Mr Brian Forbes, is a well-known Australian RCC expert. The report of this Due Diligence Workshop makers positive comments on the organisation of construction, the quality system and records, and their

observations on the lift joint preparation and RCC placement while on site.

Quality control memorandums

196 There are a number of memorandums relating to the quality of RCC placement. I was taken to a series of these memorandums during my interview with Counsel Assisting on 13 February 2020, which included the following:

(a) **DNR.020.019.1068**;

(b) **SUN.009.002.0147** (at **SUN.009.002.0153**);

(c) **SUN.009.002.0147** (at **SUN.009.002.0157**);

(d) **SUN.009.002.0147** (at **SUN.009.002.0163**);

(e) **SUN.009.002.0147** (at **SUN.009.002.0167**);

(f) **SUN.009.002.0147** (at **SUN.009.002.0175**);

(g) **SUN.009.002.0147** (at **SUN.009.002.0177**);

(h) **SUN.009.002.0147** (at **SUN.009.002.0185**);

(i) **SUN.009.002.0203** (at **SUN.009.002.0215**);

(j) **SUN.009.002.0203** (at **SUN.009.002.0221**);

(k) **SUN.009.002.0203** (at **SUN.009.002.0225**); and

(l) **SUN.009.002.0203** (at **SUN.010.002.0277**).

197 In interpreting these memorandums it is important to understand the RCC placement schedule. Following the trial embankment, RCC placement commenced high up on the right abutment, using the mobile conveyer and at this point was low production. As the dam height was much lower at this location, it was used to continue to improve construction methodology and processes, prior to the high capacity production of RCC in the primary spillway area. Even in early period of placement of RCC in the primary spillway area, it was predominantly around filling large holes, or undulations in the foundation.

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This RCC was again delivered by various means and was low production.

198 Most of these quality memorandums cover the period from June to October 2004, when according to Figure 6 of the August & September 2005 Quality Control Report (**ALC.002.001.0750**), only about 5% of the RCC was placed.

199 The high production period from November 2004 to May 2005, which was when the main conveyor was operational and placement was occurring in the primary spillway area, which was when approximately 85% of the RCC was placed. During this period, very few quality memorandums addressing quality issues appear to have been produced by the quality control engineers.

RCC Placement

200 Due to various construction delays, the main RCC production in the primary spillway region took place from about October 2004 until about April 2005. I note Figure 6 (page 14) of the final Quality Control Report (for August and September 2005, referred to above) records the timeline for RCC placement.

201 The original Construction program intended to undertake the bulk of the RCC placement in the cooler, drier months, although some of the RCC was always going to be placed in the hotter, wetter months. Section 11.8 of the Specification (referred to above) also refers to this. However, as I mentioned above, the final RCC placement program had the bulk of the RCC placed in the hotter, wetter months.

202 Generally speaking, the hotter it is the less time you have to place each RCC lift layer to ensure a 'live' lift surface. Placing RCC in hotter weather therefore required some adjustments, which, based on my recollection occurred. For example, Dr Schrader undertook further thermal analysis to determine the thermal stresses and to determine that the spacing of monolith joints was acceptable (monolith joints allow thermal expansion and contraction and therefore avoids unwanted cracking).

203 I recall there was also further laboratory testing undertaken under the supervision of Jose Lopez and Robert Montalvo to re-analyse the length of time an RCC lift joint would be 'live' (i.e.. the time within which to place RCC lifts).

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Other measures that were implemented included spraying and shading of the stockpile and shading of the conveyor system to reduce the impact of temperatures on the mix. Also there was a slight increase in water content agreed by Dr Ernie Schrader to improve workability, this is indicated in the Monthly Quality Control Reports.

Design verification

On-site design presence

204 In order to ensure that construction followed the design intent, full time design presence was provided on site. This design presence on site was discussed with the Regulator during a meeting on 19 February 2004 (**DNR.020.019.2606** at **DNR.020.019.2609** and **DNR.020.019.2606** at **DNR.020.019.2607**)

205 Tim Griggs was our on-site presence from the design team during the Construction Phase and was stationed at Paradise Dam full-time from March 2004 until July 2005. Mr Griggs was then replaced on-site by William Curlewis (who was also from Hydro Tasmania).

206 I also attended the site roughly every 2 months, for around 2 weeks (on average) at a time. When on-site I would run through the records that Tim Griggs had been keeping on the Construction work that had been done, I would look at the quality control records (including in respect of RCC) and have discussions with the RCC quality control engineers. I would also conduct an overall inspection of the site. With respect to RCC generally, when I was on-site I remember observing lift joints being assessed and rated and bedding mix being placed, but generally depended on the RCC quality control engineers in relation to quality control of the RCC.

207 If there were any outstanding issues that needed to be addressed I would discuss them with the relevant Construction personnel.

208 As part of this verification process, we prepared ITPs throughout the Construction Phase to confirm that components had been inspected as per the design. Tim Griggs would complete the design ITPs and sign off on them (this was related to civil and structural works other than the RCC placement which

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was supervised from a quality perspective by RCC engineers Jose Lopez and Robert Montalvo). If I was on-site then I would sometimes sign off on the design ITPs as well.

209 **DNR.020.019.2601** is a copy of a memorandums from me to Tim Griggs (copying Steve Johnson and Andreas Neumaier) dated 27 February 2004 setting out Mr Griggs' expected role and responsibilities as our design presence on-site during the Construction Phase. Based on my observations and knowledge, Mr Griggs completed each of the six steps as envisaged in the document except for the first step in respect of RCC.

210 This is because Jose Lopez and Robert Montalvo arrived on-site in about May 2004 prior to Construction commencing. Since they were on-site from the beginning of RCC placement, and they had the recognised experience for RCC quality control, it was agreed that they would be responsible for providing the assurance that construction was in accordance with the specification in respect of RCC.

Peer Review of Design

211 As I mentioned earlier when discussing the review process for the Alliance, there were also a number of independent expert (peer) design reviews undertaken which formed a design verification function. These took place during the Detail Design Phase between January 2004 and August 2004 (**DNR.010.0929** at **DNR.010.0945, DNR.010.0929** at **DNR.010.0937, DNR.010.0929** at **DNR.010.0952, DNR.010.0929** at **DNR.010.0958, DNR.010.0918** and **HYT.519.003.0008** are copies of the peer reviews undertaken). Section 11 (pages 51 to 56) of the Final Design Report (discussed below) sets out the particular peer reviews undertaken and summarises the recommendations made by those peer reviews and how the recommendations were addressed and incorporated into the design.

2006 Core Testing

212 The drilling of a core occurred after completion of construction, under Dr Schrader's direction, and was contemplated as a requirement of the Specification (DNR.003.8520).

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213 I recall this was carried out by Robert Montalvo in consultation with Dr Schrader who directed Robert Montalvo how to carry out the coring and then the testing required of it.

214 I can recall after the coring was completed, testing was carried out on the core. The results of that testing was then reduced to a written report by Robert Montalvo. I recall requesting Dr Schrader to review and finalise the report prepared by Robert Montalvo based on his interpretation of the results, given his RCC expertise. I have searched my email records and enclose a number of emails I have found that appear related to this core testing, results received and the reporting of those results at **SCE.023.0001, SCE.024.0001, SCE.025.0001, SCE.026.0001, SCE.027.0001, SCE.028.0001, SCE.029.0001, SCE.030.0001, SCE.031.0001** and **SCE.032.0001**.

Final Design Report

215 In November 2005 following construction (which is discussed below), the Alliance prepared a document titled "Burnett River Dam – Final Design Report" (**Final Design Report**) (**ALC.002.001.0950**). The document was prepared by Tim Griggs, Stuart Marshall (who was from Hydro Tasmania in mechanical design) and Mike Wallis, although I recall tasking Tim Griggs with the primary responsibility for preparing it. I note this version of the document records Matthew Taylor (who was a mechanical engineer from Walter) as a reviewer. However, there were multiple people who reviewed the document during its preparation, including myself.

216 The purpose of the Final Design Report was to describe any modifications made to the design after the Detail Design Report (that is, during construction). The Final Design Report served as an addendum to the Detail Design Report. Therefore, it needs to be read in conjunction with the Detailed Design Report.

Final certification

217 I did not provide, and it was not my role to provide, design certification for the verification of the entire design of the project. I only signed off on those components which I lead the design of, and in all cases this was also signed off by Andreas Neumeir, the Design Manager.

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218 At the conclusion of the Construction Phase, the Final Design Report was prepared (discussed above) and a certification was given by me, dated 5 October 2005, which certified that the works as constructed had been undertaken in a manner which met the design requirements of the dam and that the dam was ready for impoundment (filling). As indicated on the document, this certification was based upon the presence and quality records of others on site. (Refer **SUN.126.001.0001**)

219 Following this, impoundment of the dam commenced.

220 I prepared a further memorandum entitled Design Sign-off for Practical Completion dated 25 November 2011 **SUN.126.001.0001** in which I certified that, subject to the completion of remedial works associated with precast panels as indicated by the document, that the dam was at 'Practical Completion' and the dam could be safely filled to Full Supply Level. This was based on inspection of completed works, and review of instrumentation data as indicated by the document, which demonstrated that the dam was performing as intended at the time.

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OATHS ACT 1867 (DECLARATION)

I, Richard Ian Herweynen, do solemnly and sincerely declare that:

1 This written statement by me dated 12 March 2020 is true to the best of my knowledge and belief; and

2 I make this statement knowing that if it were admitted as evidence, I may be liable to prosecution for stating in it anything I know to be false.

And I make this solemn declaration conscientiously believing the same to be true and by virtue of the provisions of the *Oaths Act 1867*.

Signature

Taken and declared before me at Brisbane this 12th day of March 2020.

Taken by Shana Webster

~~Justice of the Peace / Commissioner for Declarations~~ / Lawyer