URS

Report

Dams and Weirs Capital Works Program

AUSTRALIA

Dams and Weirs Capital Works Program

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Seqwater

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1 INTRODUCTION

URS Australia Pty Ltd (URS) was engaged by Seqwater to develop a Capital Works Program to deliver on the Dam Safety Risk Management Strategy developed as an output to the Portfolio Risk Assessment that URS completed for Seqwater's 26 referable dams and Mt Crosby Weir. Seqwater's portfolio of 26 water storage assets fulfill multiple functions, including:

- the storage of raw water to be treated to drinking water quality
- the storage of raw water for irrigation and environmental purposes
- flood mitigation
- hydro power generation
- recreation

The purpose of the Capital Works Program is to provide Seqwater with an overview of the required upgrades identified under the organisations Dam Safety Management Program. These have been prioritised as part of the outcomes of the Seqwater Referable Dam Portfolio Risk Assessment including the development of a capital program for the next 13 years, to reduce dam safety risks as set out in the Dam Safety Management Strategy. The Dams Asset Portfolio Capital Works Program is intended to be used as a source document for development of the Asset Portfolio Master Plan which will be a core part of Seqwater's economic regulation review submission.

The primary driver for the Dams Asset Portfolio Capital Works Program is to satisfy regulatory compliance, namely dam safety and to manage Seqwater's business risks associated with ownership of a large portfolio of dams.

2 BACKGROUND

2.1 Seqwater Dam Safety Management Program

In 2008, Seqwater assumed ownership and responsibility for the operation of 26 referable dams from various Southeast Queensland councils, the South East Queensland Water Corporation, Aquagen and SunWater. Some of these dams are more than 100 years in age with varying structural condition. As required by the Queensland Guidelines on Dam Safety Management (2002), a Dam Safety Management Program was prepared and implemented by Seqwater. Since 2008, Seqwater has embarked on an investigation and review program to better understand the key risks within their dam portfolio and has undertaken upgrade works and repairs to a number of dam assets to reduce their risk profiles in the short term.

As part of the Seqwater Dam Safety Management Program, a program of investigations has been undertaken since 2009 to assess the compliance of the referable dams with the DEWS Guidelines on Acceptable Flood Capacity (AFC), initially published in 2007 and revised in 2013. This program has identified that 12 of the 26 referable dams owned and operated by Seqwater require flood capacity upgrades to comply with the Guidelines. In parallel with the AFC assessment program, the Seqwater Dam Safety Management Program has also identified a number of other dam safety issues relating to earthquake and piping.

Recognising that the fall-back method specified by the AFC guidelines may result in a higher design requirement and consequent higher cost of a dam upgrade, Seqwater has adopted the alternative risk assessment procedure (incorporating ALARP). The risk assessment procedure also provides more detail to allow the prioritisation of the various upgrades. This procedure requires that the risk assessment be carried out in accordance the following guidelines:

- Australian National Committee on Large Dams (ANCOLD) Guidelines on Selection of Acceptable Flood Capacity for Dams (ANCOLD, 2000)
- ANCOLD Guidelines on Assessment of the Consequences of Dam Failure (ANCOLD, 2000)
- DEWS Guidelines for Failure Impact Assessment of Water Dams (DEWS 2012) (for the dam breach sizes and timings and the estimation of population at risk);
- ANCOLD Guidelines on Risk Assessment (ANCOLD, 2003) (with particular attention to the quantitative studies at advanced or very advanced levels).

2.2 Referable Dams Portfolio Risk Assessment

The investment forecast in dams reflects the outcomes of the Referable Dams Portfolio Risk Assessment (PRA), completed in November 2013. The objective of the Portfolio Risk Assessment (PRA) study for the 26 referable dams and Mt. Crosby Weir was to provide Seqwater with an understanding of the major dam safety risks within the portfolio and also to provide a management tool for prioritising future risk reduction works. The Seqwater Dam Portfolio Risk Assessment Dam Safety Risk Management Strategy report (URS 2013) defines the current:

- societal risk as plotted on the ANCOLD F-N curve for each Dam relative to the Limit of Tolerability,

- individual risk associated with each dam,
- economic risk for each dam, and
- environmental risks for each dam.

Discussion on Seqwater's regulatory obligations is presented below in Section 2.2.

A key outcome of the risk assessment was that a number of dams in the portfolio exceed the ANCOLD and DEWS defined limit of tolerability for societal risk, as shown in Figure 2-1, and the ANCOLD defined limit for individual risk, as shown in Figure 2-2, and therefore are considered to pose an unacceptable level of risk based on the current assessment. Further discussion on the ANCOLD guidelines is presented in Section 2.2 below.

A dam safety risk reduction strategy was developed by URS in consultation with the PRA Expert Panel, Seqwater staff and DEWS Dam Safety staff. Details of the workshop attendees are provided on page 7 of the Seqwater Dam Portfolio Risk Assessment Dam Safety Risk Management Strategy report (URS 2013). This strategy considers a staged upgrade approach to manage the financial impacts to Seqwater's business while proactively managing the key dam safety risks within a nominated timeframe. This approach is consistent with that adopted by a number of other water authorities across Australia and internationally.

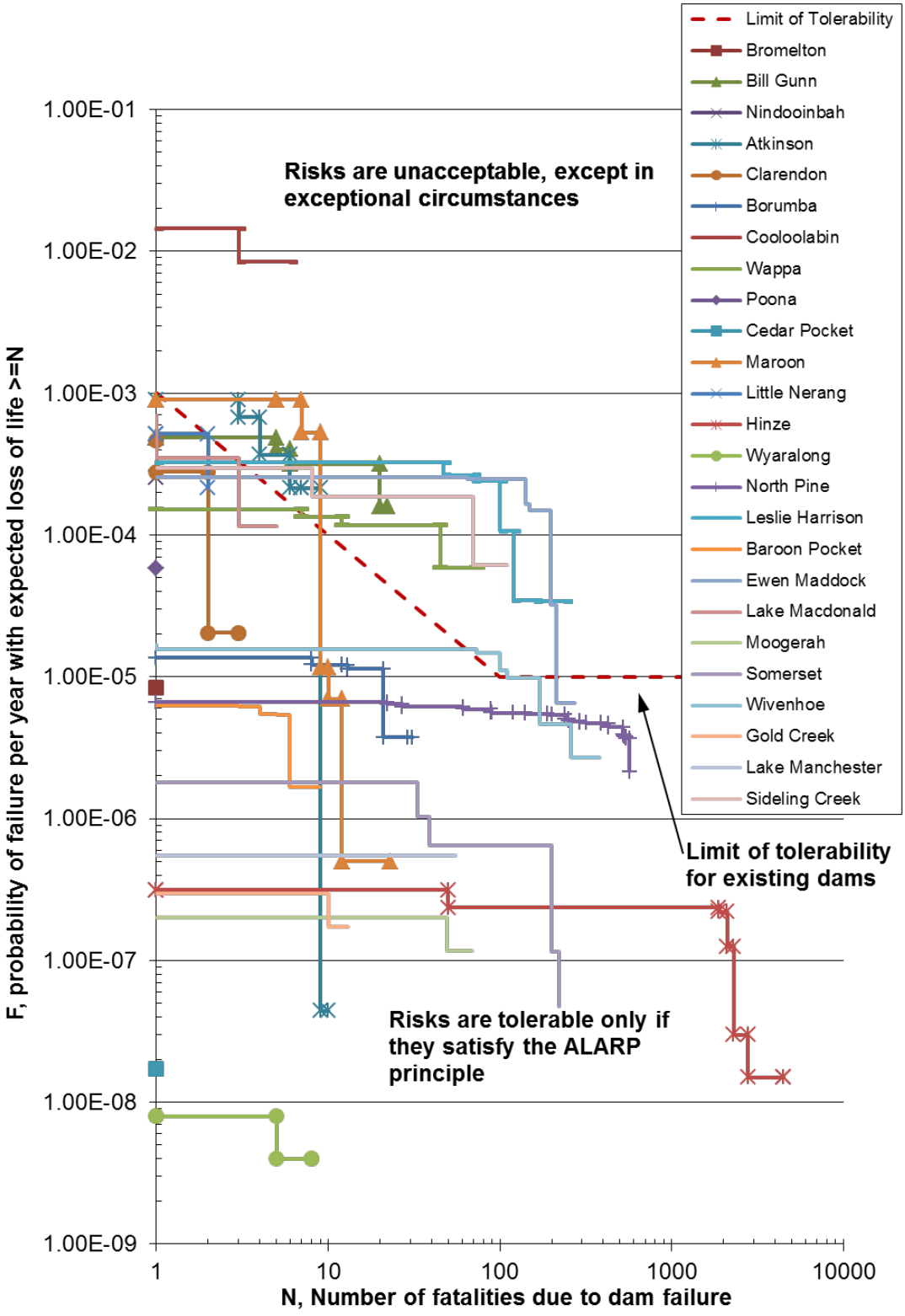

Figure 2-1 Seqwater Existing Portfolio of Dams F-N Curve

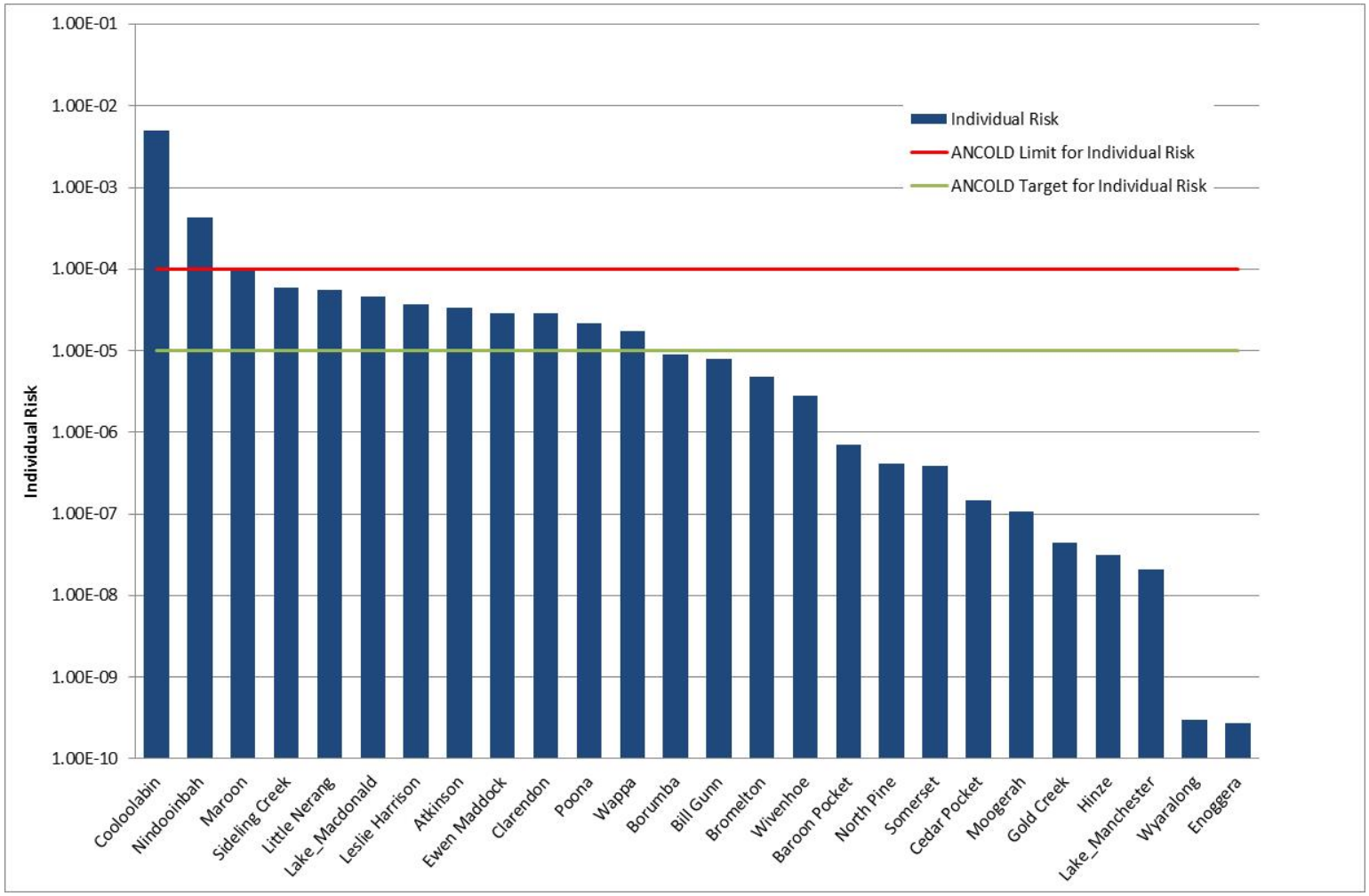

Figure 2-2 Seqwater Existing Portfolio of Dams - Individual Risk

3 DAMS CAPITAL WORKS PROGRAM

3.1 Methodology

The capital expenditure in the 13 year Dam Safety Capital Works Program was developed using the following methodology:

- A preliminary capital and operating expenditure budget for dams investments was developed based on the outcomes of the Dams PRA and in-line with other dam portfolio asset owners for the following investment drivers:
  - Improvements
  - Compliance
  - Growth
  - Flood mitigation
- A workshop with Seqwater was conducted on 9 April 2014 to review the timing of the capital and operating expenditure budgets for the defined projects to even out the rate of expenditure.

3.2 Investment Drivers

3.2.1 Improvements

There is no capital expenditure in the 13 year Dam Safety Capital Works Program that is associated with upgrading service outcomes to improve asset efficiency, reliability or increase the anticipated life of an asset to prevent service non-compliance or capacity shortfall.

3.2.2 Compliance

There is $570M of capital expenditure in the 13 year Dam Safety Capital Works Program that is associated with meeting legislative obligations. An overview of current Australian dam safety regulatory requirements is provided in Section 4.0.

3.2.3 Growth

There is no capital expenditure in the 13 year Dam Safety Capital Works Program associated with increasing the capacity of assets or construction of new assets, to meet growth in demand, or to provide additional security of supply.

3.2.4 Flood Mitigation

There is approximately $100M of capital expenditure in the 13 year Dam Safety Capital Works Program that is associated with flood mitigation for Wivenhoe and Somerset Dams. The forecast works would maintain the current estimated flood mitigation within the reservoirs for large floods, and would provide additional flood protection for extreme flood events.

3.2.5 Expected Future Requirements

There are not expected to be any changes to the regulatory framework in which Seqwater operates and manages its dams and weirs, in the foreseeable future.

4 AUSTRALIAN DAM SAFETY REGULATION

Throughout Australia, dam safety regulatory arrangements are in place in Victoria, New South Wales, Queensland, Tasmania and the Australian Capital Territory. As yet, there is no dam safety regulation in Western Australia, South Australia or the Northern Territory.

4.1 Queensland Dam Safety Regulation - Regulatory Framework

The Department of Energy and Water Supply (DEWS) regulate dam safety in Queensland under the Water Supply (Safety and Reliability) Act 2008. The Act details the provisions for referable dams and the process for determining whether a dam is referable or not. Dam owners are required to check whether their dam is subject to this legislation. The Act requires owners of particular dams to assess the impacts of dam failure on the safety of populations downstream of the dam by way of a dam failure impact assessment to determine whether the dam is a referable dam. The Act also provides for regular ongoing assessment of the potential threat to people from unexpected flooding caused by a failure of one of these dams. Dam failure impact assessments have been carried out for the 26 referable dams owned by Seqwater.

Under the Act, DEWS has the ability to impose dam safety conditions on Seqwater for each referable dam. Dam Safety Conditions have been issued to Seqwater for all 26 referable dams: Under Condition DS – General:

1. *The dam is to be kept safe, be maintained and operated in accordance with the following guidelines issued in Queensland under the Water Supply (Safety and Reliability) Act 2008 (where specifically referred to in this dam safety condition schedule):*
   - Queensland Dam Safety Management Guidelines (current issue is February 2002)
   - Guidelines for Failure Impact Assessment of Water Dams (current issue is 2012)
   - Guidelines on Acceptable Flood Capacity for Dams (current issue is January 2013).
2. *The current Dam Safety Regulator in the State of Queensland is the Chief Executive, Department of Energy and Water Supply (DEWS) or the Department's Delegate Officers.*
3. *The Guidelines on Acceptable Flood Capacity for Dams (2013) requires that "Dam owners should ensure that their dam can safely pass floods up to the Acceptable Flood Capacity".*

The Queensland Dam Safety Management Guidelines (2002) state that:

"In Queensland, under the Water Act 2000 and common law, responsibility for the safety of a dam rests with the dam owner. Dam owners may be liable for loss and damage caused by the failure of a dam or the escape of water from a dam. Consequently, dam owners need to be committed to dam safety and have an effective dam safety management program. A dam safety management program is intended to minimise the risk of a dam failing and to protect life and property from the effects of such a failure should one occur."

These guidelines also state that:

- "*Dam safety management requires that critical uncertainties are recognised, investigated and resolved to acceptable risk levels."*

- *"There are a number of situations that may require remedial action at a dam. These situations can vary from a minor deficiency in the dam, to a major incident or even dam failure. Deficiencies include … Inappropriate or deficient design or construction."*
- *"Remedial action is required in response to a deficiency, incident or dam failure."*

A number of existing dams in the Seqwater Referable Dam Portfolio do not satisfy the requirements of the DEWS Acceptable Flood Capacity Guidelines (2013) or the DEWS Dam Safety Management Guidelines (2002). In addition these dams do not satisfy the requirements of the various ANCOLD Guidelines including Acceptable Flood Capacity, Design for Earthquake and Risk Assessment.

Remedial action is required in response to those deficiencies. As recommended by the PRA, that remedial action is a key priority under the Seqwater Dam Safety Risk Management Strategy and the Dam Improvement Program..

4.2 Australian practice and industry

Risk criteria have been developed for assessing the tolerability of risks for Seqwater's portfolio of dams. These are based on the ANCOLD Guidelines on Risk Assessment (ANCOLD 2003) for life safety risks (societal risk and individual risk).

The ANCOLD Guidelines on Risk Assessment (2003) provide criteria for assessing the tolerability of life safety risks based on societal risk and individual risk. For existing dams, the tolerable risk criteria are summarised as follows:

- *A societal risk that is higher than the limit of tolerability line is unacceptable except in exceptional circumstances;*
- *An individual risk to the person or group which is most at risk that is higher than 10^{-4} per annum is unacceptable except in exceptional circumstances; and,*
- *Risks are to be lower than the limit of tolerability to an extent determined in accordance with the ALARP principle*

5 AUSTRALIA AND INTERNATIONAL DAM SAFETY PRACTICE

The assessment of societal risk has been developed and utilised by the Owners of various major infrastructure assets including dams, nuclear power stations, and oil and gas facilities since the 1970s. The ANCOLD dam safety guidelines outline that dam safety upgrade works, be conducted as recommended by the guidelines and consistent with current dam safety practice. Examples of current dam safety practice for performing portfolio risk assessment and subsequent works within a dams portfolio are described below.

5.1 State Water, NSW

The NSW State Water Corporation completed a Portfolio Risk Assessment study in 2002, where short-term, medium-term and long-term risk reduction targets were developed. As recommended from the risk assessment, the State Water Dam Safety Upgrade Program (DSUP) involved the progressive upgrading of seven State Water dam structures starting from 2006 to present. Stage 1 of the DSUP involved reducing societal risks below the limit of tolerability in order to satisfy the Dam Safety Committee medium term target. Stage 2 upgrade works are intended to satisfy the Dam Safety Committee long-term target of flood capacity reaching the fallback criteria. The Stage 1 upgrades are largely now completed and State Water plan to carry out the Stage 2 long term upgrade for Wyangala Dam (construction beyond 2017). The Stage 2 upgrades of the other dams are not proposed at this stage and it is likely they will be assessed as satisfying the Dam Safety Committee long term target based on ALARP considerations. The revised PRA study completed in 2012 identified two new upgrades, Rydal and Oberon Dam, and State Water are proposing construction of these upgrades in 2016-2017.

5.2 Goulburn Murray Water, VIC

The Goulburn-Murray Water (G-MW) Dam Improvement Program commenced in 2000 with the completion of a portfolio risk assessment of five priority dams. The risk assessment identified that three of the five dams had unacceptable risks (one of the dams had already been upgraded). Upgrade works for the three dams were completed by 2006. In 2001 G-MW completed a risk assessment of their remaining seven dams as well as a business critical weir. The risk assessment identified that five of the seven dams and the weir had unacceptable risks. Four of the dams were upgraded and one of the dams decommissioned and the weir was also upgraded. All of the capital works were completed by 2009.

The G-MW approach to upgrading dams involved developing a staged approach and assessing the costs and benefits of staging upgrade works compared to completing a full upgrade. The Stage 1 works typically involved reducing societal risk below the limit of tolerability and individual risk below the ANCOLD defined limit. It also involved consideration of business risks within the G-MW business risk framework. Stage 2 upgrades involved achieving ALARP and Stage 3 involved full standards based upgrades. The upgrades completed to date all achieve the Stage 1 upgrade and a number of them have achieved Stage 2 (ALARP).

5.3 Melbourne Water, VIC

Melbourne Water completed a dam safety risk assessment of their 16 dams in 2008. The risk assessment identified a number of dams had risks that were unacceptable based on the

ANCOLD defined limit of tolerability and individual risk criteria. Melbourne Water implemented a range of short term risk reduction actions at a number of their dams including reservoir restrictions to reduce risks below the limit of tolerability where possible. Melbourne Water's capital funding is allocated in five yearly water plan cycles. Three of the high risk dams that could not have risk reduction actions implemented were upgraded in the 2008-2013 Water Plan.

In 2009 Melbourne Water also commenced a program of investigations and studies to improve understanding of the existing risks, as the risk assessment had been based on a range of data much of which was incomplete or out of date. A particular focus was on the hydrology and dam break modelling for a number of the dams which had last been completed in 1994. As a result of updating the hydrology and dam break modelling the risk for three of the dams that had been identified as having unacceptable risks were reduced and the result was the dams now fell below the ANCOLD defined limit of tolerability. This, along with the short term reservoir level restrictions, has allowed Melbourne Water to delay upgrade works to fit within the water plan cycles. Melbourne Water also completed a targeted and comprehensive geotechnical and geological investigation at one of the dams which showed that the probability of failure of the key failure mode identified in the risk assessment had been conservatively estimated and subsequently, with the help of the additional data collected, the risk dropped below the limit of tolerability.

In the 2013-2018 Water Plan Melbourne Water are upgrading one of the dams with a high societal risk that has been operated with a reservoir restriction since 2008. Two more dams are programmed for upgrades in the 2018-2023 Water Plan. Melbourne Water's approach to upgrades has been to complete upgrades that satisfy the ALARP principle.

5.4 U.S. Dams Practice

Major dam owners in the United States are now embracing risk-informed decision making with their dam safety programs. The U.S. Bureau of Reclamation has been using risk based decision making for over fifteen years to prioritise their dam safety issues across their 300 high hazard dam inventory. Their periodic inspection program includes a Comprehensive Facility Review (CFR) and detailed risk assessment every five years. Consultant review boards are utilised to address the most serious issues.

The U.S. Army Corps of Engineers use quantitative risk assessments throughout their 600 dam inventory to prioritise dam safety risk issues. A Dam Safety Action Classification (DSAC) is used for setting rating to set priorities.

The Federal Energy Regulatory Commission (FERC), a nationwide regulator for thousands of public and private power producers, has also embraced risk-informed decision making for hydropower projects. They have supported the Potential Failure Mode Analysis (PFMA) process for over ten years but are now moving more towards quantitative risk assessment in line with Australian Practice. The PFMA process is similar to the event trees used in the PRA, as described in more detail in the Preface of the Seqwater Referable Dams PRA Report (URS 2013).

6 SEQWATER REFERABLE DAMS PRA

The Referable Dams PRA was conducted to provide Seqwater with an understanding of the major dam safety risks within the portfolio and also to provide a management tool for prioritising future risk reduction works. The PRA was conducted in accordance with ANCOLD risk assessment guidelines, which consisted of reviewing the available information for each dam (refer to Appendix A), identifying conceivable failure modes, and considering the following loading conditions:

- Flood
- Earthquake
- Normal operating condition

The PRA Strategy Report provides an overview of the existing dam safety risk for each of the 26 dams and Mt. Crosby Weir in Seqwater's portfolio. The PRA Strategy Report summarises the risk assessment process, the results of the assessment of the existing risk for each structure, an initial high level assessment of potential risk reduction works and further works that should be undertaken to better understand the dam safety risks, and potential reductions to the risk profile for the proposed risk reduction works.

An outcome of the PRA was the recommendation that Seqwater should adopt a risk based decision making process to prioritise risk reduction actions with a long term objective of targeting ALARP upgrades as it is not possible to implement all risk reduction actions immediately (due to logistics, funding, time constraints, resource availability, etc.). Consequently, there is a need to perform dam safety upgrade actions to reduce risk in the short to medium term until long term risk-based fixes can be implemented. The need to implement interim measures requires establishment of useful target risk levels. Five levels of risk targets were developed in consultation with a select group of experienced dam practitioners as part of the expert technical panel as follows.

- Target 1 – reduce risks below ANCOLD Limit of Tolerability and individual risk limit
  - The Target 1 objective is to reduce the risks below the limit of tolerability, but not necessarily satisfy ALARP. For societal risks, this requires the F-N curve to plot below the limit of tolerability for existing dams
  - For individual risk, this requires the individual risk to the person or group which is most at risk to be less than 10-4 per annum
- Target 2 – reduce the probability of failure below 1 in 10,000 AEP for individual failure modes
- Target 3 – reduce economic risk to a tolerable business limit
- Target 4 – achieve 65% Acceptable Flood Capacity (AFC) to meet regulatory requirements:
  - 25% AFC (or at least 1:2,000 AEP for erodible dam embankments) by 1 October 2015
  - 65% AFC by 1 October 2025
  - 100% AFC by 1 October 2035

- Target 5 – achieve As Low as Reasonably Practical (ALARP) position or standards-based criteria for dam safety.
  - Standards based criteria represent industry best practice standards based on engineering design. In terms of specific dam safety criteria:
    - For flood capacity, the ANCOLD fallback flood capacity criteria as described in ANCOLD Guidelines on Flood Capacity (2000).
    - Fully intercepting filters on embankment dams where there is the potential for loss of life;
    - Industry accepted practice for factors of safety for the stability of concrete gravity and embankment dams for normal, flood and earthquake loading (e.g. US Army Corps of Engineers, ANCOLD Guidelines for Earthquake).

It was agreed during the PRA that the focus of the first stage risk reduction strategy was to reduce the existing risk at all dams to be below the limit of tolerability and below the individual risk limit as defined by ANCOLD (Target 1), to reduce extreme business risks to a level of tolerability for the business (Target 3), and to achieve AFC compliance by the DEWS regulatory requirements (Target 4).

The PRA recommends a dam upgrade program across the portfolio of 26 dams, which will deliver compliance with the Queensland Dam Safety Management Guidelines (2002) and the Acceptable Flood Capacity Guidelines (2013). The assessment has identified upgrade works required for 14 dams across the region from 2012 until 2035, required for safety, flood mitigation and compliance. The high priority upgrades have been scheduled into the early years of the investment forecast, tailing off after about year 2025.

A Timing of Actions Table (URS 2013) was developed for the Seqwater Dams PRA to provide a basis for assigning a level of urgency and time, in years from 30 July 2013. The table was developed based in conjunction with the expert technical panel and the experience of URS on similar PRAs for other large dam owners in Australia. The level of urgency and timing of actions reflects:

- The existing dam safety risk of the structure.
- Whether the key failure modes will deteriorate significantly over time.
- The estimated time required to complete action, varying from “as soon as practical” to more than 10 years.
- The time required to implement the action (e.g. large upgrades may require lengthy investigations, design, and approval processes prior to construction.

The forecast capital expenditure was developed to be consistent with the timing of actions table from the PRA Strategy Report.

7 MAJOR INVESTMENTS

Total forecast capital expenditure on Dam Safety Capital Works Program is of the order of $570M over 13 years, across 56 projects. There are 24 projects with forecast expenditure greater than $2 million. The expenditure profile for this asset group is presented in Figure 7-1, over a prioritised timeline. All forecast expenditure is for the Compliance investment driver. The ten highest value projects, which account for nearly 90% of the $570M capital expenditure, are summarised in Table 7-1.

Table 7-1 Summary of key Water Storage projects sorted by Commission Year

Project	Driver	Forecast Capex	Commission Year	% of 13 Capital Expenditure
Maroon Dam – Stage 1 Upgrade – Filter Berm and Grout Curtain	Compliance	$10M	2016	2%
Lake Macdonald Dam – New Dam	Compliance	$60M	2018	11%
Sideling Creek Dam – Filter Buttress and Spillway Wall Raise	Compliance	$45M	2019	8%
Somerset Dam – Abutment Protection Works	Compliance	$45M	2020	8%
Leslie Harrison Dam – Stage 1 Upgrade – Filter Buttress and Crest Reconstruction	Compliance	$55M	2020	10%
North Pine Dam – Stage 2 Upgrade – Saddle Dam 1 Filter Buttress, Dam Parapet Wall and Bridge Raise	Compliance	$100M	2022	18%
Wivenhoe Dam – Saddle Dam Filter Buttresses and Spillway Upgrade	Compliance	$50M	2024	9%
Maroon Dam – Stage 2 Upgrade – Extend Berm and Parapet Wall Upgrade	Compliance	$35M	2025	6%
Leslie Harrison Dam – Stage 3 Upgrade – Raise Dam, Outlet Works Modifications, and Spillway Upgrade	Compliance	$28M	2025	5%
Somerset Dam – Dam Stabilisation Works	Compliance	$70M	2027	12%

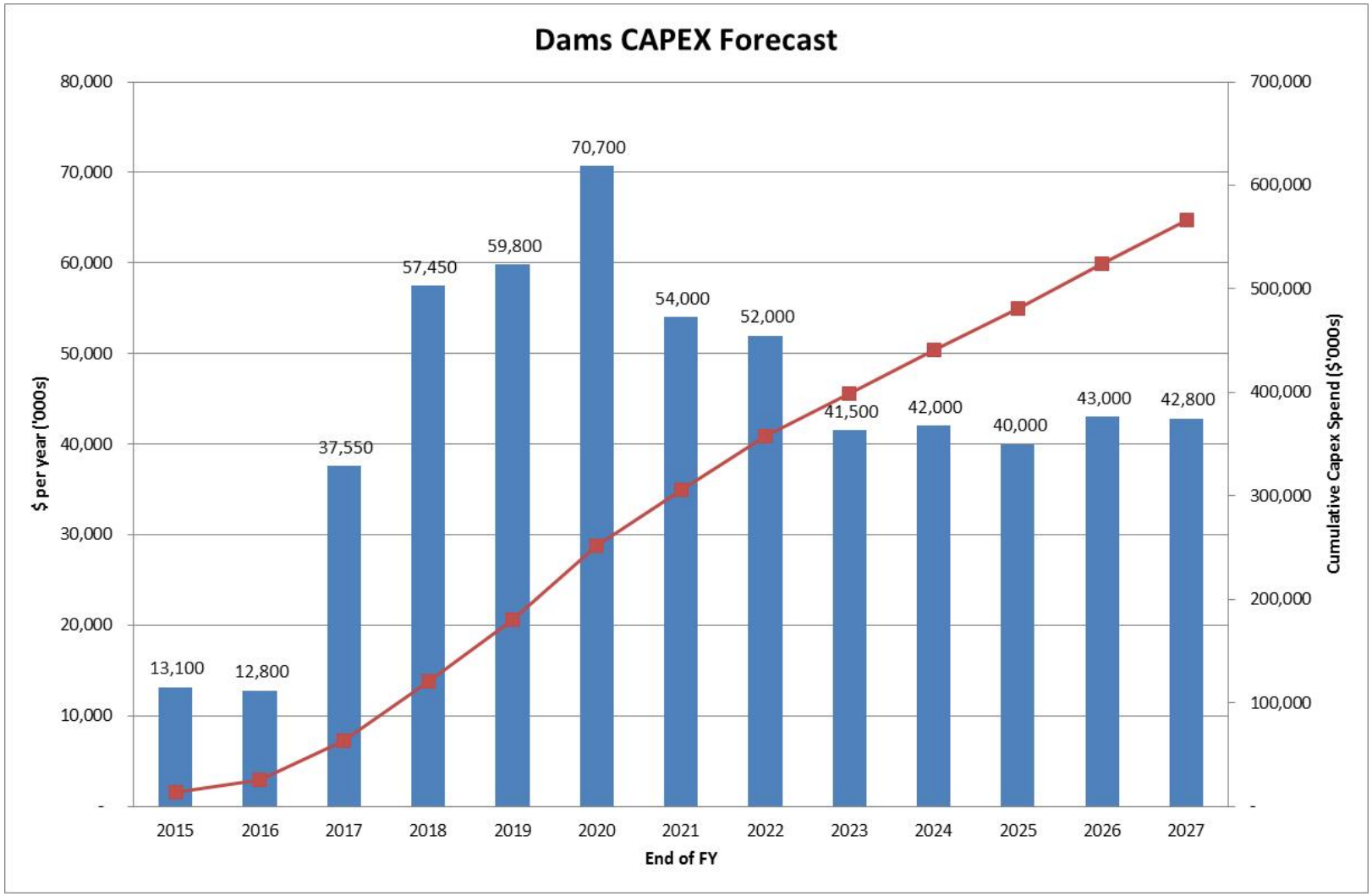

Figure 7-1 Expenditure profile for Water Storage Assets over 13 years

7.1 Discussion

The forecast Capex expenditure is consistent with the recommendations of the PRA and the timelines agreed with the expert review panel. A short discussion is provided below for each of the major Capex expenditures over the next 13 years.

- Lake Macdonald Dam – the dam has a number of dam safety issues, and several with continually deteriorating condition, particularly the structural elements associated with the spillway slabs and walls. The societal risk for the dam plots above the ANCOLD limit of tolerability, which is considered unacceptable and action should be taken to reduce the risk.
- Leslie Harrison Dam – Leslie Harrison Dam is a key storage asset for the delivery of water to the southeast area. The dam has a large population at risk downstream of the dam. The societal risk for the dam plots an order and half magnitude above the ANCOLD limit of, which is considered unacceptable and action should be taken to reduce the risk.
- North Pine Dam – North Pine Dam is a key storage asset for the delivery of water to the north Brisbane area. The dam has a large population at risk downstream of the saddle dams and main dam. The societal risk for the dam plots just below the ANCOLD limit of tolerability. However, the risks of dam failure increase significantly should the spillway gates malfunction.
- Somerset Dam – the Dam Safety Review (URS 2014), showed that the potential risks to the dam abutments due to overtopping during an extreme flood event are higher than assessed during the PRA. The societal risk for the dam increased from an order magnitude below the ANCOLD limit of tolerability to plotting above the limit of tolerability, which is considered unacceptable and action should be taken to reduce the risk. As such, the timeline for reducing the risks at Somerset Dam was modified from within 20 years to within 5 years.
- Wivenhoe Dam – Wivenhoe Dam is the largest dam asset in Seqwater's portfolio, and has one of the largest populations at risk. The Dams PRA showed that Wivenhoe Dam plots above the ANCOLD limit of tolerability and this risk is considered unacceptable and action should be taken to reduce the risk. A loss of the Wivenhoe main dam or any of the saddle dams could be catastrophic to downstream areas and in Seqwater's ability to supply water to the Brisbane area.

Potential future challenges to maintaining a lowered risk profile across the dams portfolio, include:

- Increased future development downstream, which increases the population at risk (and potential loss of life), and increases the plotting position of particular dams above the ANCOLD limit of tolerability. As an example, North Pine Dam currently plots just below the ANCOLD limit of tolerability; however, an increased population at risk could move it above the line.
- Changes in the methodology for estimating the probability of extreme floods, in particular the Probable Maximum Precipitation (PMP). A revision to the methodology is currently being considered. Increases or decreases to how probabilities of extreme rainfall are estimated could change the flood overtopping risk profiles.

- Changes to the ANCOLD limit of tolerability for existing dams. The current limit of tolerability line, as shown in Figure 2-1, extends from F-N ordinates of 1 fatality (N) and probability (F) of 1E-03, diagonally to ordinates 100 fatalities and 1E-05, then it truncates and extends horizontally along the 1E-05 probability. There is the potential for the horizontal portion of the line to be removed and the diagonal line extended. This extension would cause North Pine Dam to plot above the ANCOLD limit of tolerability.
- The As Low as Reasonably Practical (ALARP) principle (Target 5) was not considered as part of the Dams PRA, given the current risk profile across the portfolio. The ALARP principle allows a dam owner to test whether further risk reduction works are justified. In order to satisfy the test, the dam owner needs to demonstrate gross disproportion between:
  - The sacrifice – the money, time and trouble required to implement risk reduction measures, and
  - The reduction in risk that would be achieved by those measures.

  Seqwater would test the ALARP principle as part of subsequent risk assessment processes once all dams have achieved Targets 1, 3 and 4.

8 REFERENCES

ANCOLD 2000, Australian National Committee on Large Dams, *Guidelines on Selection of Acceptable Flood Capacity for Dam*; March 2000.

ANCOLD 2000, Australian National Committee on Large Dams, *Guidelines on Assessment of the Consequences of Dam Failure*; May 2000.

ANCOLD 2003, Australian National Committee on Large Dams, *Guidelines on Risk Assessment*; October 2003.

DEWS 2012, Queensland Government, Department of Energy and Water Supply, *Guidelines for Failure Impact Assessment of Water Dams*, 2012.

DEWS 2013, Queensland Government, Department of Energy and Water Supply, *Guidelines on Acceptable Flood Capacity for Water Dams*, January 2013.

NR&M 2002, Queensland Government, Natural Resources & Mines, *The Queensland Dam Safety Management Guidelines*, February 2002.

URS 2013, *Seqwater Dams Portfolio Risk Assessment, Dam Safety Risk Management Strategy*, 22 November 2013.

URS 2014, *Somerset Dam Safety Review*, 2014.

9 LIMITATIONS

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Seqwater and only those third parties who have been authorised in writing by URS to rely on this Report.

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Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

APPENDIX A AVAILABLE SEQWATER DAM PORTFOLIO INFORMATION

Water Storage	Key Reports
Atkinson Dam	• 2007 Condition Assessment Report • Dam Break Assessment including inundation maps (SunWater 2004) • Dam Failure Impact Assessment (SunWater 2007) • 2000 Data Book • Design drawings of: – Main embankment – Spillway – Drainage Channel – Outlet conduit to Buaraba Creek – Outlet conduits to Brightview Weir – Natural surface contour plans • Construction Report (1971) • Emergency Action Plan (2011) • Facility Asset Management Plan (2012) • Design Flood Hydrology Report (Sun Water 2003) • Comprehensive Inspection Reports (2009) • Annual Inspection Reports (2007, 2008, 2010) • Piezometer readings from 1970-2012 • O&M Manual (2010) • Safety Inspection Photos • 'Plan on a Page' document • Routine surveillance reports 2008-2012 • Safety Review (Engineering Services 2000) • Standard Operating Procedures Manual (2011) • Acceptable Flood Study Review (Seqwater 2010) • Foundation Investigation Report (SunWater 2005)
Baroon Pocket Dam	• Preliminary Review of Acceptable Flood Capacity (Seqwater, 2009) • Spillway Capacity Upgrade Assessment (John Wilson & Partners Pty Ltd, 2005) • 2007 Condition Assessment Report • Failure Impact Assessment (John Wilson & Partners Pty Ltd, 2004) • Dam Safety Condition Schedule (2007 & 2008) • Dam Safety Review (SunWater, 2007) • 2008 Data Book • Design Report – Main Dam, Saddle Dam, Spillway (John Wilson & Partners Pty Ltd, 1987) • Construction Report (John Wilson & Partners Pty Ltd, 1989) • Construction Photos • Design/as-constructed drawings of:

Water Storage	Key Reports
	– Main embankment – Saddle dam – Foundation treatment – Spillway – Intake & outlet conduit • Emergency Action Plan (2012) • Annual Inspection Reports (2002 - 2011) • Instrumentation Records (1988 – 2012) • O&M Manual (2010) • 'Plan on a Page' document (Seqwater, 2010) • Standard Operating Procedures Manual (2011) • Dam Safety Audit (2007)
Bill Gunn Dam	• Condition Assessment of Bulk Water Assets (SunWater, 2007); • Dam Break Analysis (SunWater, 2003); • Dam Safety Condition Schedules (Queensland Government, 2007); • Data Book (Earthtech, 2001); • Design Drawings (Incomplete Set); • Emergency Action Plan (Seqwater, 2011); • Facility Assets management Plan Bill (Seqwater, 2011); • Design Flood Hydrology Report Based on revised PMP Estimates (SunWater, 2004); • Dam Inspections (Seqwater, 2007 to 2011); • Five Yearly Comprehensive Dam Safety Inspection (SunWater, 2007); • Instrumentation Data – Calibration Certificates – Deformation Surveys – Seepage – Piezometers – Inclinometer • Operation and Maintenance Manual (Seqwater, 2010); • Photos (from Site Inspections); • Plan on a Page (Seqwater, 2010); • Comprehensive Risk Assessment (SunWater, 2006); • Routine Surveillance Results 2008 to April 2012, (Seqwater); • Dam Safety Review (Earthtech, 2001); and • Standard Operating Procedures (Seqwater, 2011)
Borumba Dam	• Condition Assessment of Bulk Water Assets (SunWater, 2007) • Dam Break Analysis (SunWater, 2004) • Dam Safety Condition Schedules (Queensland Government, 2009) • Borumba Dam Amended Dam Safety

Water Storage	Key Reports
	Conditions (Queensland Government, 2009) • Data Book (Unknown, 2000) • Initial Raising of Borumba Dam (Queensland Department of Natural Resources, 1998) • Design Drawings (780+ Sheets) • Emergency Action Plan (Seqwater, 2011) • Design Flood Hydrology Report Based on revised PMP Estimates (SunWater, 2003) • Borumba Dam- Hydraulic Assessment- Draft (Aurecon, 2012) • Requested Final • Dam Inspections (Seqwater, 2005 to 2011) • Five Yearly Comprehensive Dam Safety Inspection (Seqwater, 2010) • Instrumentation Data • Deformation Survey • Missing Data (currently requesting) • SunWater Comprehensive Risk Assessment Report (2008) details the following instrumentation at Borumba. – 11 x collimation stations – 7 x offset stations – 34 x level stations – 29 x deformeters – 1 x axial movement • Borumba Dam- Site Inspection to Assess LA Slope Instability (AECOM, 2011)-Draft • Newspaper Clippings (Various Publications dating back to 1995) • Operation and Maintenance Manual (Seqwater, 2010) • Photos (from Site Inspections) • No Construction Photos • Plan on a Page (Seqwater, 2010) • Comprehensive Risk Assessment (SunWater, 2008) • Borumba Dam Spillway Risk Assessment (SunWater, 2001) • Routine Surveillance Results 2008 to April 2012, (Seqwater) • Borumba Dam Safety Review (SWP, 2000) • Standard Operating Procedures (Seqwater, 2011) • Borumba Dam Spillway Adequacy Assessment (SunWater, 2004) • Borumba Dam Spillway Model Study (SunWater, 2008) • Borumba Dam Spillway Erosion (Eades and Richardson, ----) • Borumba Dam- Stage 1 Spillway Capacity Upgrade- Volume 1 & 2 (SunWater, 2008)

Water Storage	Key Reports
	• Investigation of Borumba Dam Spillway Undermining and Cracking in Plunge Pool Batter Shotcrete (SunWater, 2001) • Construction Report Borumba Dam Stage 1 Spillway Capacity Upgrade- 50%AFC (SunWater, 2009) • Borumba Dam- Site Inspection to Assess LA Slope Instability (AECOM, 2011)-Final • Borumba Dam Damage Remediation Works- Detailed Design Report (Aurecon, 2012)
Clarendon Dam	• 2007 Condition Assessment Report • Dam Break Assessment including inundation maps (SunWater 2004) • 2002 Data Book • Design drawings of: – Main embankment – Spillway – Outlet conduit – Outlet tower – Inlet structure • Natural surface contour plans • Limited as constructed plans of main embankment and outlet works • Emergency Action Plan (2011) • Facility Asset Management Plan (2012) • Design Flood Hydrology Report (Sun Water 2004) • Comprehensive Inspection Reports (2000, 2005, 2010) • Annual Inspection Reports (2007, 2008, 2009) • First Fill Inspection Report (2011) • Piezometer reading from 1998-2012 • Deformation survey results 1992-2011 • O&M Manual (2010) • Post construction site photographs • 'Plan on a Page' document • Routine surveillance reports 2008-2012 • Dam Safety Review (SunWater 2002) • Standing Operating Procedures (2011)
Cooloolabin Dam	• 2007 Condition Assessment Report • Five Year Comprehensive Dam Safety Inspection Report (Seqwater 2010) • South Maroochy River Dam Spillway Study (WRM Water & Environment, 2009) • Water Balance and Review of Dam Level Data (2004) • Geotechnical Investigations Cooloolabin Dam (Coffey & Partners, 1978) • Poona, Cooloolabin, and Wappa Dam and Intake Weir Geotechnical Report (Gutteridge

Water Storage	Key Reports
	Haskins & Davey, 1998) – includes seismic study & slope stability analysis • 1999 Data Book • Design drawings of: – Main embankment – Saddle dams A, B, C, D, & E – Spillway – Intake tower & 600mm outlet conduit and scour outlet & 750mm conduit • Emergency Action Plan (2011) • Failure Impact Assessment (GHD, 2002) • Dam Break Assessment (GHD, 1998) • Annual Inspection Reports (2007 - 2011) • Piezometer readings from 2009-2012 • Settlement readings from 2009 - 2011 • O&M Manual (2010) • Safety Inspection Photos • 'Plan on a Page' document • Routine surveillance reports 2009-2012\ • Standard Operating Procedures Manual (2011)
Ewen Maddock Dam	• Ewen Maddock Dam data Book; • Design drawings available including general arrangements of the following; – Embankment – Spillway – Outlet tower etc; • Emergency Action Plan (2012); • Acceptable Flood Capacity (GHD, 2009) • Dam Safety and Acceptable Flood Capacity (GHD, 2010) – Draft • Failure Impact Assessment (PB, 2005) – Draft • Ewen Maddock Dam Seismic Hazard Assessment (ES&S, 2010) • Annual Dam Safety Inspection Reports (2009, 2011 & 2012) • Site photos from 2008 – 2012 and Stage 1 AFC upgrade works • Standard Operating Procedures (2011)
Lake Macdonald	• Lake Macdonald Safety Upgrade Option Selection and Concept Design (URS 2014) • Data Book: – Lake Macdonald Dam - Data Book (JWP, 2004) – Lake Macdonald Dam Data Book (Seqwater, 2012) • Various drawings: – As-constructed (JWP, ~1965) – For construction (JWP, ~1979) – Investigative (URS, 2012) • Emergency Action Plan (Seqwater, 2012)

Water Storage	Key Reports
	• Operation and Maintenance Manual (Seqwater, 2010) • Standing Operating Procedures (Seqwater, 2011) • 'Plan on a Page' (Seqwater, 2010) • Lake Macdonald AFC Review and Concept Design (URS, 2012) • Lake Macdonald Dam Spillway Adequacy Assessment (WorleyParsons, 2008) • Lake Macdonald Failure Impact Assessment (WorleyParsons, 2008) • Condition Assessment of Bulk Water Assets (Cardno, 2007) • Lake Macdonald Dam – Dam Break Flood Study (JWP, 2001) • Annual Dam Safety Inspection Reports: – JWP – 2003, 2004, 2007 – Seqwater – 2008, 2009, 2012 • Five Year Comprehensive Dam Safety Inspection Report (Seqwater, 2011) • Routine Surveillance Reports (Seqwater, 2008-2012) • Dam Safety Condition Schedules (Queensland Government): – Lake Macdonald Dam – Dam Safety Conditions (2003) – Lake Macdonald Dam – Amended Dam Safety Conditions (2009) • Instrumentation Data: – Annual deformation survey (2009-2012) – 19 standpipe piezometers d/s of embankment (2000-2012) + 4 recently installed piezometers on crest (2011-2012) – 2 v-notch seepage weirs (1989-2011) • Lake Macdonald Dam Instrumentation Investigation (Seqwater, 2010) DRAFT • Photographs from site inspections (2007-2012) — No construction photos available
Leslie Harrison Dam	• Acceptable Flood Capacity Study (GHD, 2011). • Condition Assessments: – Condition Assessment of Bulk Water Assets (Cardno, 2007) – Assessment of Remaining Corrective Actions on Leslie Harrison Dam – Leslie Harrison Dam Stability (GHD, 2008). – Preliminary Analysis of Intake Tower of Leslie Harrison Dam – Leslie Harrison Dam Stability (GHD, 2008). – Comprehensive Dam Safety Inspection (SunWater, 2006). – Comprehensive Inspection Report (Public

Water Storage	Key Reports
	Works, NSW Water Solutions, 2012) – Comprehensive Surveillance Report (Public Works, NSW Water Solutions, 2011) – Annual Dam Safety Inspection 2010 (Seqwater, 2010). – Annual Dam Safety Inspection 2010 (Seqwater, 2009). – Annual Dam Safety Inspection (Seqwater, 2008) – Annual Dam Safety Inspection (SunWater, 2007). – Redland Shire Council Dam Safety Audit (2007). • Failure Impact Assessment (GHD, 2002) • Data Book, including: – Leslie Harrison Dam Data Book (Seqwater, 2009) – Leslie Harrison Dam Electrical and Control System Report (Electro80, 2009) – Raising of Leslie Harrison Dam Design Report (John Wilson & Partners, 1980) • Gate control upgrade project 2011, including: – Scope of Works – Design Drawings – Functional Specifications • Design drawings, dated 1963, 1982, 1984. • Emergency Action Plan (Seqwater, 2011). • Spillway Investigations – Geotechnical/Geological Report (GHD, 2003). • Probable Maximum Flood Revision (GHD, 2003). • Yield Analysis for Leslie Harrison Dam (Department of Natural Resources State Water Projects, Engineering Services, 2000) • Yield Analysis for Leslie Harrison Dam (SunWater, 2005) • Instrumentation outputs, including: – Piezometer readings – Seepage monitoring – Deformation surveys – Inclinometer readings • Photos – various from site inspections (2007-2012). • Plan on a Page rev 1 (Seqwater, 2010). • Report on Risk Assessment (GHD, 2002). • Cost estimate for preliminary design of upgrading of the Leslie Harrison Dam (Redland Shire Council, 1999). • Safety Review – Gates test operation, supplementary report (JWP, 2000). • Standing Operating Procedures (Seqwater, 2011)

Water Storage	Key Reports
Little Nerang Dam	• Condition Assessment of Bulk Water Assets – Little Nerang Dam (Cardno, 2007) • Little Nerang Dam Acceptable Flood Capacity Assessment (SKM, 2009) • Dam Safety Condition Schedule (2009) • Information Notice Changing Safety Conditions for Little Nerang Dam (DNRW, 2009) • Design Flood Hydrology (Seqwater, 2009) • Data Book (2004) – Original Geological Report (1950) – Original Design Report – Original Construction Report • Drawings (as-built) – General Arrangement – Monolith sections/elevations – Inlet screen & pipe – Spillway & outlet tunnel – Log of test holes – Crest gates seal modifications – 34” diam main – 24” diam main • Emergency Action Plan (Seqwater 2011) • Annual Dam Safety Inspection (2009 & 2011) • Comprehensive Inspection Report (GHD, 2008) • Compliance with Dam Safety Conditions, letter (Seqwater, 2012) • Piezometer Readings (1994 – 2012) • Seepage data (2009 – 2011) • Hinze Dam – Little Nerang Dam Water Supply System (Cardno, 2003) • O&M Manual (Seqwater 2010) • Safety Inspection Photos (2007 – 2011) • ‘Plan on a Page’ document • Routine Surveillance Reports (2009 – 2012) • Standard Operating Procedures (Seqwater 2011)
Maroon Dam	• Construction Photos (1969 – 1972) • Embankment and Foundation Paper (1975) • Maroon Dam, Dam Break Analysis (SunWater, 2004) • Design Flood Hydrology Based on Revised PMP Estimates (SunWater, 2004) • Dam Safety Condition Schedule (2007 & 2009) • Information Notice Changing Safety Conditions For Maroon Dam, letter (Department of Natural Resources and Water, 2009) • Burnett Creek AMTD 23.5km Safety Review (SunWater, 1990) • Report on Geological Investigations for Maroon Dam Safety Evaluation, Volumes 1, 2a, & 2b

Water Storage	Key Reports
	(Water Resources, 1990) • Addendum to Report on Geological Investigations for Maroon Dam Safety Evaluation (Water Resources, 1991) • Report of the Consultation on Exposed Foundations (Coffey and Hollingsworth, 1969) • Data Book (1999) • Spillway Adequacy Report (GHD, 2011) • Acceptable Flood Capacity Concept Design (GHD, 2011) • Parapet Wall Detailed Design and Embankment Stability Review (GHD, 2012) • Maroon Dam AFC Upgrade Geotechnical Factual Report (GHD, 2012) • Residual Shear Strength of Maroon Dam Slip Planes (RJ Stewart, 1971) • Drawings (as-built) – General Arrangement – Embankment – Outlet works – Spillway – Foundations – Log of test holes • Emergency Action Plan (Seqwater, 2011) • Annual Dam Safety Inspection (2012) • Routine Surveillance Reports (2008 – 2012) • Condition Assessment of Bulk Water Assets (SunWater, 2007) • Report on Design Checks for Structural Components (Engineering Services, 1999) • Piezometer Readings (1998 – 2012) • Settlement measurements (1999 – 2012) • Inclinometer data (1990 – 2012) • V-notch weir data (1998 – 2012) • O&M Manual (Seqwater 2010) • Safety Inspection Photos (2007 – 2011) • 'Plan on a Page' document • Standard Operating Procedures (Seqwater 2011)
Moogerah Dam	• Condition Assessment Moogerah Dam (SunWater, 2007). • Moogerah Dam Break Analysis (SunWater, 2004). • Moogerah Dam Data Book 1. • Moogerah Dam AFC Upgrade Peer Review Panel (SunWater, 2012). • Moogerah Dam Emergency Action Plan. • Moogerah Dam Workplace Health and Safety Risks: 2009 – 2010. • Moogerah Dam Seismic Study 1999. • Moogerah Dam Spillway Adequacy Assessment

Water Storage	Key Reports
	(SunWater, 2005). • Design Flood Hydrology Based on July 2003 Revised PMP Estimates (SunWater, 2003). • Moogerah Dam Design Flood Hydrology Based Revision (SunWater, 2002). • Moogerah Dam Safety Review (1999). • Moogerah Comprehensive Safety Inspection (SunWater, 2007). • Moogerah Dam Acceptable Flood Capacity Assessment (Worley Parsons, 2011). • Moogerah Dam Five Year Comprehensive Dam Safety Inspection 2007 and 2011. • Annual Dam Safety Inspection 2008 – 2011. • Moogerah Dam comprehensive inspection 15/12/11. • Moogerah O&M Manual 2010. • Moogerah Dam Plan on a Page. • Daily Moogerah Dam Surveillance Results (2008-2012). • Moogerah Dam Standard Operating Procedures 2011. • Moogerah Dam Safety Upgrade – Basis of Design Memo. • Moogerah Dam Safety Upgrade – Concept Design Review Report. • Moogerah Dam Safety Upgrade – Geotechnical Investigation Report (Aurecon, 2013) • Moogerah Dam Safety Upgrade – Preliminary Design Report (Entura, 2013) • Moogerah Dam AFC Upgrade Expert Review Panel – Report No. 4 (SunWater, 2013) • Instrumentation: – Deformation Tabulations. – Movement Points. – Rainfall Res Levels. • Construction Photos. • Drawings: – General Layout as Constructed. – Foundation Cross Section and Bore Logs. – Foundation Rock Contours. • Moogerah Dam Horizontal Movement.
Mt. Crosby Weir	• Mt. Crosby Weir Operational Works at Weir and Intake (URS, 2014) • Condition Assessments: – Condition Assessments of Bulk Water Assets (Cardno, 2007). – Preliminary condition assessment (Expert Review Inspection Panel, 2007). – Mt Crosby Weir Structural Assessment – Weir Foundation Investigation (SMEC,

Water Storage	Key Reports
	2008). – Mt Crosby Weir Structural Assessment – Weir Stability (SMEC, 2008). – 2 No. 6 monthly Condition Inspections (Seqwater, 2010). – 2 No. Mt Crosby Weir and Bridge Inspection Reports (SMEC, 2012). – Annual condition inspection (Seqwater, 2012). • Dam Break Analysis (WRM Water & Environment, 2007). • Data Book, including: – Mount Crosby Weir Overbridge – Vehicle Load Capacity Report (Brisbane City Council, 1996). – River Survey (Michel Group Services, 2007). – Mt Crosby Weir Contingencies Plan (Brisbane Water, 2007). – Feasibility Report for Raising Mount Crosby Weir (SunWater, 2006). – Preliminary Assessment of Potential Options and Hydraulic Impacts of the Mt Crosby Weir Upgrade (WRM Water & Environment, 2007). • Drawings, including: – Original design drawings (dated 1925). – Topographic survey drawings at downstream left bank in location of remedial works (dated 2007). – Bathymetric survey drawings (dated 2007). • Emergency Action Plan (Brisbane Water, 2008). • Geotechnical Drilling – Factual Report (City Design, 2007). • Operation & Maintenance Manuals, including: – Mt Crosby Weir Operations and Maintenance Manual (SMEC, 2008) – Operation & Maintenance Manual (Seqwater, 2012). • Photos – various from site inspections (2009-2012). • Reports relating to the potential upgrade of Mt Crosby Weir, including: – Initial Advice Statement, terrestrial flora and fauna – for proposed raising of weir (Biodiversity Assessment and Management Pty Ltd, 2006). – Initial Advice Statement, Mt Crosby Weir Raising (MWH, 2006). – Feasibility Report for Raising Mount Crosby Weir (SunWater, 2006). – Hydraulic Impact Assessment of the Mt Crosby Weir Upgrade (WRM Water &

Water Storage	Key Reports
	Environment, 2007). – Preliminary Assessment of Potential Options and Hydraulic Impacts of the Mt Crosby Weir Upgrade (WRM Water & Environment, 2007). – Raising Mount Crosby Weir Appraisal Study (Maunsell, 2007).
North Pine Dam	• GHD, North Pine Dam Annual Inspection, Oct 2004 • GHD, Geotechnical Investigations – North Pine Dam, Factual Report on Geotechnical Investigation, December 1997 • GHD, North Pine Dam Safety Review, Sept 2000. • GHD, Repairs to North Pine Saddle Dams and Right Abutment, Preliminary Design Report, Jan 1999. • Hydro-Electric Corporation, Comprehensive Dam Safety Inspection, July 2010. • Seqwater, North Pine Dam Annual Dam Safety Inspection, Aug 2011. • Seqwater, North Pine Dam Annual Dam Safety Inspection, Oct 2008. • Seqwater, North Pine Dam Annual Dam Safety Inspection, Sept 2009. • Seqwater, North Pine Dam Deformation Survey Report, March 2012. • Seqwater, Emergency Action Plan, Sept 2011. • Seqwater, North Pine Dam Inspection Report, Jul 2006. • Seqwater, Peizometer Data. • Sun Water, Final Report Design Flood Hydrology, Oct 2007. • URS, North Pine Dam Acceptable Flood Capacity Report, 9 February 2012. • W.A.L Webber (Design), R.Gibbs/J. Mulheron (Construction), Design & Construction Report, Date unknown
Poona Dam	• Condition Assessment Report, Maroochy Shire Council (Draft 2007) • South Maroochy River Dam Break Assessment, GHD (1998) • Failure Impact Assessment Poon Dam, GHD (2002) • Poona Dam Data Book (1999) • Limited design drawings • Poona Dam Emergency Action Plan, Seqwater (2011) • South Maroochy River Dam Spillway Study, WRM (2009) • Poona Dam Comprehensive Dam Safety Inspection Report, GHD (2007)

Water Storage	Key Reports
	• Poona Dam Annual Dam Safety Inspection, GHD (2007) • Poona Dam Annual Dam Safety Inspection, Seqwater (2009) • Poona Dam Five Year Comprehensive Dam Safety Inspection Report, Seqwater (2010) • Poona Dam Annual Dam Safety Inspection, Seqwater (2011) • Record of piezometers, reservoir level, deformation surveys and seepage flows • Details of 21 Purli Rd seepage issue • Poona Dam Operation and Maintenance Manual, Seqwater (2010) • Routine Surveillance Results, Seqwater (2008-2012) • Poona Dam Safety Assessment, GHD (1999) • Poona Dam Standing Operating Procedures, Seqwater (2011)
Sideling Creek Dam	• 'Plan on a Page' (Seqwater, 2010) • Various drawings • Dam Safety Condition Schedule (Queensland Government, 2009) • Dam Action Plans and Manuals: – Dam Safety and Instruction Manual – Sideling Creek Dam (Pine Rivers Shire Council, 2006) – Dam Safety Data Book – Sideling Creek Dam (Pine Rivers Shire Council, 2006) – Emergency Action Plan (Seqwater, 2012) – Standing Operating Procedures (Seqwater, 2012) – Operation and Maintenance Manual (Seqwater, 2010) • AFC, FIA and Hydrology Reports: – Acceptable Flood Capacity (GHD, 2009) – DRAFT – Flood Hydrology (GHD, 2009) [supersedes above report] – Acceptable Flood Capacity Study (GHD, 2010) – DRAFT – Review of Hydraulic Design of Spillway (JWP, 1989) – Lake Kurwongbah Yield Assessment (JWP, 2007) – Failure Impact Assessment of Lake Kurwongbah (Sideling Creek Dam) (JWP, 2004) • Safety Reviews and Inspections: – Pine Rivers Shire Council Dam Safety Audit (2007) – Sideling Creek Dam Safety Review (JWP, 1995)

Water Storage	Key Reports
	– Five Year Comprehensive Dam Safety Inspection (URS, 2012) – Annual Dam Safety Inspection Reports (Seqwater, 2009-2012) – Routine Surveillance Reports (Seqwater, 2009-2012) • Condition Assessments of Bulk Water Assets (Cardno, 2007): – Sideling Creek Dam – Lake Kurwongbah Intake • Instrumentation Data: – Annual deformation survey (2009-2013) – Seepage (2011-2013) • Photographs from site inspections (2007-2012) – No construction photos available
Somerset Dam	• Somerset Dam Safety Review (URS, 2014) • GHD, Scoping Report for Installation of Piezometers to Monitor Uplift in the Foundations, Jan 1999 • Entura, Acceptable Flood Capacity and Concept Design Report, Dec 2011 • Seqwater, Piezometer Data. • GHD, Somerset Dam Safety Review, Sept 2000 • SMEC, Somerset Dam Crack Investigation, Jul 2008 • Seqwater, Design Flood Hydrology, Oct 2009 • Seqwater, Emergency Action Plan, Dec 2011. • Seqwater, Somerset Dam Data Book, 2009 • Seqwater, Somerset Dam Deformation Survey Report, February 2012. • Cascade Failure of Somerset and Wivenhoe Dams, 14 February 2013. • Original drawings and construction photographs were also reviewed.
Wappa Dam	• Condition Assessment Report (South East Queensland Water Infrastructure 2007) • Dam Safety Conditions (2009) • Data Book (1999) • Limited drawings of embankment, outlet tower and spillway • Emergency Action Plan (2011) • South Maroochy River, Dam Break Assessment (GHD 1999) • South Maroochy River, Failure Impact Assessment Wappa Dam (GHD 2002) • South Maroochy River Dam Spillway Study (WRM 2009) • Comprehensive Dam Safety Inspection, Wappa Dam (GHD 2007) • Comprehensive Dam Safety Inspection, Wappa

Water Storage	Key Reports
	Dam (Seqwater 2010) • Annual Inspection Reports 2007, 2008, 2009, 2011 • Deformation surveys (2009-2011) • Seepage and reservoir level monitoring results (2009-2012) • The Raising of Wappa Dam Design Reports (John Mulholland August 1982, April 1983, July 1983) • Maroochy Water Services Dam Safety Audit (Queensland Government, Natural Resources and Water, 2007) • Wappa Dam Value Management Study (GHD 1996) • Wappa Dam Operation and Maintenance Manual (2010) • Site photos 2008-2011 • Routine Surveillance Reports 2008-2012 • Safety Review Report Part 1 (Maroochy Shire Council 1996) • Wappa Dam Safety Assessment (Maroochy Shire Council 1999) • Wappa Dam Standing Operating Procedures (Seqwater 2011)
Wivenhoe Dam	• Department of Primary Industries , Water Commercial Engineering Services, Wivenhoe Dam Design Drawings, Volume 2, Sept 1995 • Department of Primary Industries, Water Commercial Engineering Services, Wivenhoe Dam Design Report, Volume 1, Sept 1995 • Department of Primary Industries, Water Commercial Engineering Services, Post Construction Report, Sept 1995 • GHD, Wivenhoe Dam Annual Inspection, Nov 2004 • Seqwater, Data Book, Oct 2009 • Seqwater, Emergency Action Plan, Sept 2011 • Seqwater, Wivenhoe Dam Annual Dam Safety Inspection 2011, Oct 2011 • Seqwater, Wivenhoe Dam Annual Dam Safety Inspection, Nov 2008 • Seqwater, Wivenhoe Dam Annual Dam Safety Inspection, Oct 2009 • Seqwater, Wivenhoe Dam Comprehensive Inspection, July 2006 • Seqwater, Wivenhoe Dam Five Year Comprehensive Inspection Report, Sept 2010 • Seqwater, Wivenhoe Dam Post Jan 2011 Flood Event Embankment Analysis, June 2010 • SunWater Engineering, Review of Record Testing of Zone 1A Material During the

Water Storage	Key Reports
	Construction of Wivenhoe Dam, Sept 2001 • W.D. Weeks, Design Flood Study, May 1983 • Wivenhoe Alliance, Dam Failure Analysis of Wivenhoe Dam, Oct 2005 • Wivenhoe Alliance, Design Discharge and Downstream Impact of the Wivenhoe Dam Upgrade, Sept 2005 • Wivenhoe Alliance, Design Discharges & Downstream Impacts of the Wivenhoe Dam Upgrade, Sept 2005 • Wivenhoe Alliance, Existing Embankment Design & Construction Report, June 2003 • Wivenhoe Alliance, Phase 1 Geotechnical Report, Nov 2005 • Wivenhoe Alliance, Right Abutment Auxiliary Spillway Design & Construction Report, Dec 2005 • Wivenhoe Alliance, Wivenhoe Dam Flood Security Upgrade Existing Dam Spillway Design & Construction Report, Oct 2004 • Original drawings and drawings prepared for the Stage 1 Upgrade completed in 2005 were also reviewed.

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